Hydrogeology of Naval Submarine Base Bangor and Vicinity, Kitsap County, Washington

By S.C. Kahle

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in)	25.4	millimeter
foot (ft)	0.0348	meter
mile (mi)	1.609	kilometer
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer
gallon (gal)	3.785	liter
acre-foot (acre-ft)	1,233	cubic meter
inch per day (in/d)	25.4	millimeter per day
foot per day (ft/d)	0.3048	meter per day
square foot per day (ft^2)	0.09290	square meter per day
cubic foot per day (ft^3/d)	0.028317	cubic meter per day
gallon per minute (gal/min)	0.06308	liter per second
gallon per day (gal/d)	0.003785	cubic meter per day

Temperature: To convert temperature given in this report in degrees Fahrenheit (°F) to degrees Celsius (°C), use the following equation: °C = 5/9(°F-32).

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

A study of the hydrogeology of Naval Submarine Base Bangor and vicinity was conducted to provide the U.S. Navy with knowledge of the hydrogeologic framework and directions of ground-water movement. This information is needed to aid in the remediation of contaminated shallow ground water and soil and to manage the increasingly used ground-water resource. The base is located along Hood Canal, Kitsap County, western Washington State. The hydrogeologic framework consists of glacial and interglacial deposits up to 1,800 feet thick. A map of the surficial geology of Naval Submarine Base Bangor and vicinity was generated and used with drillers' logs for more than 400 inventoried wells to construct 12 hydrogeologic sections. Ten hydrogeologic units were delineated. They are, from youngest to oldest, the Shallow aquifer, the Vashon till confining unit, the Vashon aquifer, the Upper confining unit, the Permeable interbeds, the Sea-level aquifer, the Lower confining unit, the Deep aquifer, the Basal confining unit, and the Undifferentiated deposits.

Maps of the top altitude, thickness, and areal extent of each of the nine youngest hydrogeologic units indicate that the altitudes of the tops range from 800 feet below sea level to 500 feet above sea level, thicknesses range from near zero feet to more than 500 feet, and units are missing locally.

Maps of water levels in wells indicate that ground water moves from inland areas of higher altitude toward streams or nearshore areas of lower altitude, including Hood Canal, Dyes Inlet, Liberty Bay, or Port Orchard. Water levels in closely spaced wells completed at different depths indicate that ground water moves downward in high topography inland areas, and upward in low topography nearshore areas.

INTRODUCTION

Naval Submarine Base Bangor (SUBASE Bangor) is a U.S. Navy installation of about 11 square miles (mi^2) that has been in operation since 1944. It is located along Hood Canal in Kitsap County, Wash. (fig. 1). As a result of past activities on SUBASE Bangor, about 10 percent of the base contains sites with contaminated soil and shallow ground water. Several of these sites are currently (1996) in remediation, and others will be in the near future. Contaminants include ordnance chemicals, metals, chlorinated hydrocarbons, petroleum hydrocarbons, pesticides, and polychlorinated biphenyls (PCBs). The contaminated sites have been studied as individual units, rather than addressing contamination and remediation on a larger scale.

The U.S. Navy recognizes that an understanding of the ground-water flow system of SUBASE Bangor and surrounding areas is a prerequisite for understanding how contaminated water could flow from shallow to deep aquifers, and how changes in use of deep ground water could affect contaminant pathways and possibly cause intrusion of seawater in nearshore areas. In addition, the U.S. Navy also recognizes the need for a thorough understanding of the ambient quality of ground water in the area. As a result, the U.S. Geological Survey (USGS), at the request of SUBASE Bangor, began an investigation of the hydrology and water quality of SUBASE Bangor and vicinity in 1993, in cooperation with the Department of the Navy Engineering Field Activity, Northwest Naval Facilities Engineering Command (EFANW). This report describes the hydrogeology of the study area and is one of four reports to be published as part of the entire investigation. Topics of the other reports are (1) the estimated ages of ground water,, (2) the ambient quality of ground water, and (3) the numerically simulated characteristics of the present and future ground-water flow system.

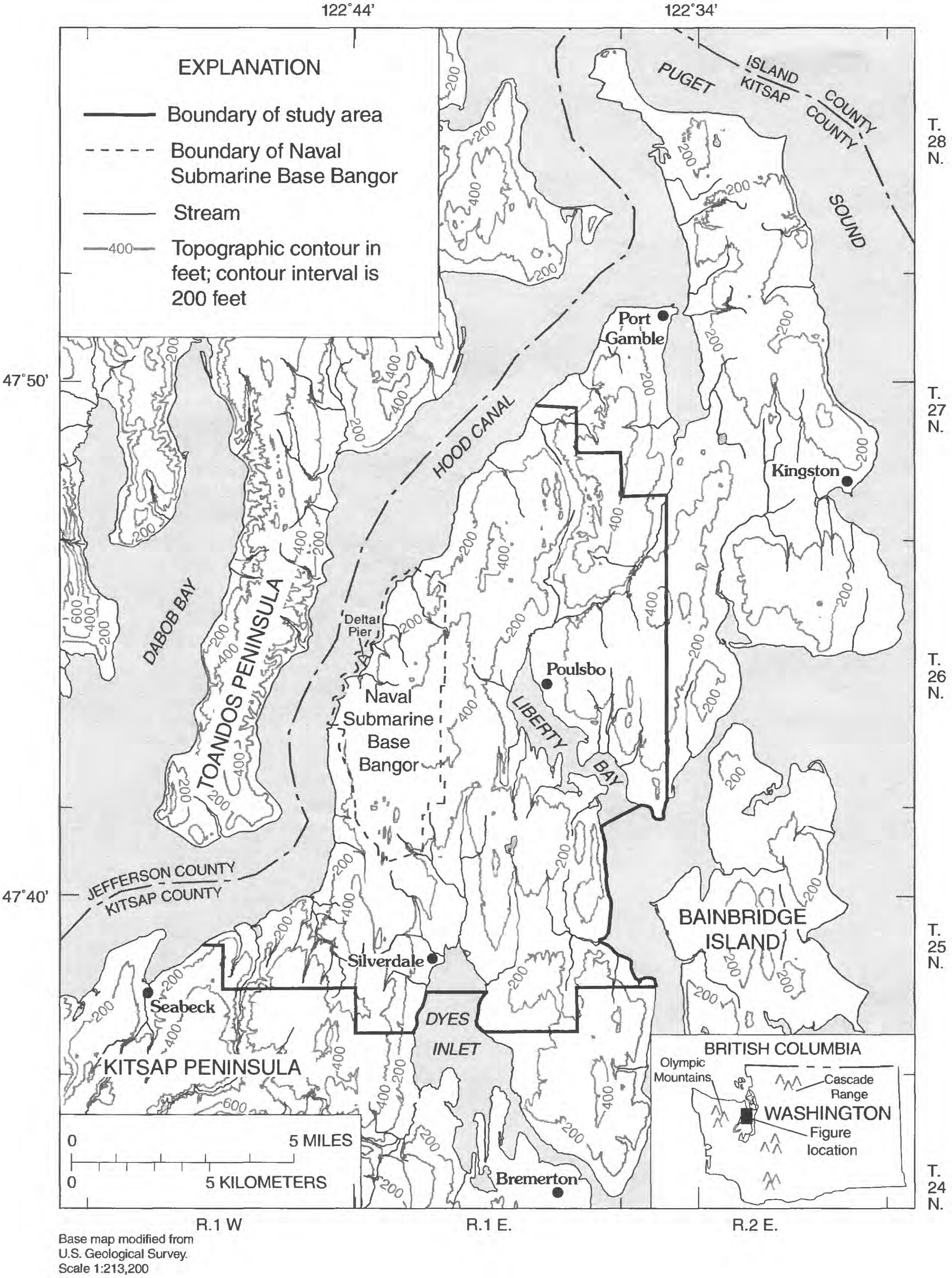


Figure 1. Map showing location of the study area.

The objectives of this part of the investigation are to (1) define the physical framework of the hydrogeologic system of SUBASE Bangor and vicinity and (2) describe the flow of ground water within that hydrogeologic system. Findings of this part of the investigation form the basis for the numerical simulation of the ground-water flow system.

Description of the Study Area

The study area is located on the Kitsap Peninsula of the Puget Sound Lowland in northwest Kitsap County (fig. 1). It includes SUBASE Bangor (11 mi^2) and surrounding land that together cover a total area of about 85 mi^2. The study area was selected to include hydrologic boundaries that could be used as model boundaries in the numerical simulation of the ground-water flow system to be described in a subsequent report. The peninsula is surrounded by saltwater and has a hydrologic setting similar to that of an island. Many coastal areas are steep, with altitudes ranging from sea level to 500 feet (ft) or more above sea level. Inland, slopes are moderate, and many areas are nearly flat. Glacial and interglacial deposits that make up much of the subsurface of the study area are exposed in cliffs along many shorelines. The deposits consist primarily of alternating layers of glacial till, sand and gravel, and silt and clay. Bedrock, which underlies the glacial and interglacial deposits, is estimated to be at about 600 to 1,800 ft below land surface (Jones, 1996).

The study area is incised by short streams that flow from the interior of the peninsula to Puget Sound (Hood Canal, Dyes Inlet, and Liberty Bay). Most streams flow year-round and are fed by springs and surface runoff after storms. Where cliffs are present along the coastline, springs and seeps discharge water directly onto the beach and into Puget Sound.

The study area has a temperate maritime climate. Mean annual precipitation ranges from about 30 inches per year (in/yr) in the northeastern part of the study area to about 60 in/yr in the southwestern part (Kitsap County Ground Water Advisory Committee and others, 1991). Precipitation amounts are in large part controlled by the Olympic Mountains to the west and the Cascade Range to the east that impede the flow of humid air masses that are generated over the Pacific Ocean. In general, precipitation reaches a minimum during midsummer and a maximum during the late fall and early spring. The mean monthly temperature in the study area ranges from about 39 degrees Fahrenheit (°F) in January to 64°F in July and August (Owenby and Ezell, 1992). At times, winter temperatures are sufficiently low for a few inches of snow to accumulate. However, snow accumulation usually is not significant.

Approximately 47 percent of the study area is covered by coniferous and deciduous forests and approximately 13 percent by urban and military development. The remaining 40 percent of the study area is covered by non-forest vegetation, which includes agricultural and natural vegetative cover.

The population of the study area is concentrated in the two medium-sized towns of Silverdale and Poulsbo (fig. 1), with 1990 populations of 7,660 and 4,848, respectively (U.S. Bureau of the Census, 1992). Outside these towns, the countryside is rural and semirural, and many homes obtain potable water from individual wells instead of public supply systems. From 1970 to 1990, the study-area population increased by about 150 percent. The increase in population is expected to continue, with a growth from about 39,000 inhabitants in 1990 to about 76,000 in 2020 (U.S. Bureau of the Census, 1992; Puget Sound Council of Governments, 1988). The resident population of SUBASE Bangor was 2,830 in 1993. This population has been projected to increase to 6,372 in 2012 as additional residential housing is constructed on base (Parametrix, Inc., 1994).

Purpose and Scope

The purpose of this report is to describe the hydrogeologic framework of the study area and to describe the ground-water flow within it. The topics covered in this report include the geologic history of the study area, the surficial geology of SUBASE Bangor, the physical characteristics of individual hydrogeologic units, seasonal ground-water level fluctuations, and ground-water levels and flow directions. Specific products of this report include a map of the surficial geology of SUBASE Bangor, a map of the generalized surficial geology of the entire study area, hydrogeologic sections correlating units at depth; maps of the top altitude, areal extent, and thickness of the hydrogeologic units; maps of water levels in the major aquifers; and hydrographs of water levels in selected wells.

Previous and Concurrent Investigations

The hydrogeology and ground-water resources of Kitsap County were first described by Sceva (1957), and Garling and others (1965). Later ground-water resource studies provided updated information about ground-water availability and quality in the part of Kitsap County covered by the present investigation (Hansen and Molenaar, 1976; Lum, 1979; Hansen and Bolke, 1980; Dion and Sumioka, 1984). The latest comprehensive update of the water resources of Kitsap County was prepared by the Kitsap County Ground Water Advisory Committee and others (1991) as part of the Kitsap County ground-water management plan. The hydrogeology of Kitsap County relative to land-use development and long-range planning is described by Molenaar (1993).

The hydrogeology of SUBASE Bangor was first studied in detail during the 1970's in preparation of the construction of an offshore dry dock called Delta Pier (for example, Shannon and Wilson, Inc., 1973; Shannon and Wilson, Inc. and others, 1975; Dames and Moore, 1974a-b; Haley and Aldrich, Inc. 1975; and Noble, 1975a-b, 1976). To enable the construction of Delta Pier, large volumes of ground water were removed to reduce pressures in local aquifers. A summary that describes the effects of the pressure reduction on the ground-water flow system on SUBASE Bangor was provided by Paterson (1981). Results of geotechnical investigations at the dry-dock site are presented by Kinner and Dugan (1982); the artesian pressure relief system used during construction is described by Kinner and Stimpson (1983). Noble (1989) summarized the generalized hydrogeologic framework and flow system of SUBASE Bangor, based on available hydrogeologic studies at that time. From the late 1980's to the present, many hydrologic studies have been done at individual sites on SUBASE Bangor with shallow ground-water and soil contamination. Two of those studies (Hart Crowser, Inc., 1988, 1989) provide detailed summaries of hydrogeologic and water-quality information known at the time of their publication. The Comprehensive Water System Plan for SUBASE Bangor (Parametrix, Inc., 1994) summarizes the hydrogeology of SUBASE Bangor and closely follows the earlier work of Noble (1976 and 1989).

Concurrent with the present investigation, Becker (with Robinson and Noble, Inc.) updated the hydrogeologic framework and water budget of the aquifers at and near SUBASE Bangor (Becker, 1995a). The updated information was incorporated into a three-dimensional ground-water flow model, to assess water availability in the area (Becker, 1995b). These studies were commissioned by the Kitsap County Public Utility District No. 1. Data and other information were exchanged by personnel from Robinson and Noble, Inc. and the USGS during Becker's work and the present USGS investigation. More than 100 site-specific investigations for water-supply wells located throughout Kitsap County have been done by Robinson and Noble, Inc. (formerly Robinson and Roberts or Robinson, Noble, and Carr, Inc.) from 1952 to the present.

A comparison chart (fig. 2) summarizes and compares original work done on SUBASE Bangor and the surrounding area. Figure 2 shows the hydrogeologic unit symbols and the terminology used in those studies. The units listed under each author are also compared with approximate geologic ages (in years), and with the hydrogeologic units identified during this study.

Methods of Investigation

Wells and springs were inventoried to acquire data throughout the study area. Between November 1993 and July 1994, 489 sites—wells, piezometers, test holes, borings, and springs—were inventoried (plate 1). Physical and hydrologic data for these sites are contained in Appendix 1. Criteria for site selection included availability of a driller's report for a well (obtained from Washington Department of Ecology, SUBASE Bangor, or Robinson and Noble, Inc.) having lithologic information and vertical distribution of well openings, and permission from the owner or tenant to visit the site. Where possible, two relatively shallow wells and two relatively deep wells were inventoried in each square-mile section. In some areas, fewer—or possibly more—than four wells per section were inventoried due largely to the amount of development in the area. On SUBASE Bangor, every accessible well (production, test, and recharge) associated with the construction of Delta Pier or with water supply was inventoried. Several offshore borings with detailed lithologic information were also inventoried—locations were obtained from consultant reports provided by SUBASE Bangor. Only about one quarter of the many shallow monitoring wells associated with contaminated sites on SUBASE Bangor were inventoried.

All inventoried sites were plotted on 1:24,000-scale topographic maps. Altitudes of the land surface at each site, accurate to plus or minus 10 ft, were determined from those maps. Some wells in the study area also have surveyed altitudes, accurate to 0.1 ft, obtained from consultant reports. Other information gathered included the name of the landowner or tenant, primary use of the water, and construction details of the site. The depth to water in wells was measured using a graduated steel tape and is accurate to plus or minus 0.02 ft. Buried well heads or otherwise difficult access precluded water-level measurement in some wells.

Climate units and approximate age (years)	Sceva, 1957 (Kitsap County)	Garling and others, 1965 (Kitsap Peninsula)	Noble, 1975a-b, 1976; Paterson, 1981 (SUBASE)		Hansen and Bolke, 1980 (Kitsap Peninsula)	Noble, 1989 (SUBASE)	Hart Crowser, 1988, 1989 (SUBASE)	Kitsap County Ground Water Advisory Committee and others, 1991 (Kitsap County)	Becker, 1995a (SUBASE)	THIS STUDY
	REFERENCE (STUDY AREA)									
Holocene	Alluvium	Alluvium	Alluvium	--	Upper unit: --	--	--	Qn1, alluvium and recessional deposits	--	Qvr, Shallow aquifer
--11,000--	A, recessional outwash	Qvr, recessional outwash	Qvr, recessional outwash				Qvr/perched ground-water zone		Qvr, recessional outwash	
Vashon Stade of Fraser Glaciation	B, till	Qvt, till	Qvt, till			9	Qvt, till	Qg1, till	Qvt, till	Qvt, Vashon till confining unit
	C, advance outwash	Qva, advance outwash	Qva, advance outwash	perched aquifer	Upper sand-and-gravel water-bearing strata	8	Qva, advance outwash/shallow aquifer	Qg1a, advance outwash/ shallow aquifer	Qva, perched aquifer	Qva, Vashon aquifer
	D, Puyallup sand	Qc, Colvos Sand	Qve, Esperance Sand							
			Qvl, Lawton Clay	--	--				UC, upper confining unit	QC1, Upper confining unit
--22,000-- Olympia Nonglacial Interval --30,000--	--	--	--		Middle unit: silt and clay	--	Qk, Kitsap Formation; includes intermediate ground-water zone	Qn2, 1st nonglacial deposits		
Possession Glaciation			Salmon Springs Drift: Qst, till; Qsu, undifferentiated deposits			7		Qg2, 2nd glacial deposits		
						6				
--90,000--	Orting Gravel: E, Kitsap clay member	Qg/Qk, unnamed gravel/Kitsap formation	Devil's Hole Formation: Qdh1, upper	semi-perched aquifer		5		Qn3, 2nd nonglacial deposits	SPA, semi-perched aquifer	QC1pi, Permeable interbeds
Whidbey Nonglacial Interval			Qdh2, middle	--		4			LC, lower confining unit	
			Qdh3, lower	sea-level aquifer		3	Qos, older sand and gravel/sea-level aquifer		SLA, sea-level aquifer	QA1, Sea-level aquifer
-140,000?- Double Bluff Glaciation	F, Orting gravel member	Qss, Salmon Springs(?) Drift	Bangor Formation: Qb1, upper	--	Lower unit: --	2		Qg3, 3rd glacial deposits/ sea-level aquifer	DC, deep confining unit	QC2, Lower confining unit
			Qb2, lower	deep aquifer	1st lower sand-and-gravel water-bearing strata				DA, deep aquifer	QA2, Deep aquifer
-250,000?-	G, Admiralty Drift	Qpu, pre-Salmon Springs(?) deposits	Qfb, Fletcher Bay Formation		--	1	Qoc, older clay and silt	Qn4, 3rd nonglacial deposits	BC, basal confining unit	QC3, Basal confining unit
	pre-Orting deposits, undifferentiated		--	--	2nd lower sand-and-gravel water-bearing strata; --	--	--	Qg4, 4th glacial deposits/deep aquifer; Qg4m, marine/glaciomarine deposits; Qn5, 4th nonglacial deposits; Qg5, 5th glacial deposits; Qn6, ancient nonglacial deposits	--	QU, Undifferentiated deposits

Figure 2. Hydrogeologic unit labels and terminology used in ground-water studies of Naval Submarine Base Bangor (SUBASE) and certain adjacent areas. Climate units and approximate ages are from Blunt and others (1987) and Berger and Easterbrook (1993). [--, deposits not present in area of study or not differentiated from younger or older deposits].

In addition to the water levels measured during the inventory phase of this study, all accessible wells were revisited during two week-long water-level measurement periods, one in August 1994, and one in April 1995. Water levels in 35 wells were measured monthly from November 1994 through March 1996. All water-level measurements are included in Appendix 2.

Two geologic maps were produced during this study, one of the generalized surficial geology of the study area (plate 1; scale 1:40,000) and one of the surficial geology of SUBASE Bangor (plate 2; scale 1:12,000). The surficial geologic map of SUBASE Bangor was produced by Richard K. Borden during this investigation and is based on original field mapping done in May and June 1995. The mapping and an accompanying report, included in its entirety as Appendix 3, were done under contract with the U.S. Geological Survey during the present investigation to understand better the local stratigraphy. Detailed geologic mapping of SUBASE Bangor had not been available previously. The methods associated with producing the map and a thorough description of the surficial geology of SUBASE Bangor are contained in Appendix 3. Other data collected during the field mapping include locations of springs and seepage faces (shown on plate 2), bedding attitudes, fracture orientations and densities, flow-direction indicators, and information relating to lateral and vertical facies relations of the surficial geologic units (Appendix 3).

The generalized surficial geologic map of the study area (plate 1) was compiled from the surficial geologic map of SUBASE Bangor (plate 2); the geologic map of Kitsap County (Deeter, 1979); the geologic map of surficial deposits in the Seattle 30'-by-60' quadrangle (Yount, Minard, and Dembroff, 1993); and the map of coastal geology for Kitsap County (Washington Department of Ecology, 1978). Locations of marsh deposits (Qm) on SUBASE Bangor were added to the generalized surficial geologic map (plate 1) on the basis of recent soil mapping (J. Smith, Soil Conservation Service, written commun., 1994).

The generalized surficial geologic map of the study area and the subsurface lithologic information from drillers' or geologists' logs were used to construct the hydrogeologic sections shown on plates 3 and 4. Twelve sections were constructed at a scale of 1:24,000 (with a vertical exaggeration of 10 times the horizontal), using data from 177 wells. Correlations were made from well to well and were inferred where well data were sparse. Because none of the inventoried wells in the study area went into bedrock, the bedrock surface shown on the sections was interpolated from a map of the thickness of unconsolidated deposits in the Puget Sound Lowland (Jones, 1996). After the major hydrogeologic units were identified and the sections were correlated, the data from the sections were extrapolated and used in conjunction with the data from the remaining inventoried wells to construct maps of the extent and top (altitude) of each unit. Altitude contours of the top of each unit were hand drawn at the 1:24,000 scale. After the hydrogeologic sections and the maps of the extent and top of units were completed, they were digitized and reduced to a scale of 1:40,000. Thickness maps of the hydrogeologic units were then hand contoured at the 1:40,000 scale using thickness values from inventoried wells and thickness values from the hydrogeologic sections, as well as values computed by subtracting top (altitude) values of intersecting contour lines of two sequential top maps. Finally, the maps of top of unit (altitude), extent of unit, and thickness of unit were compiled using geographic information system (GIS) techniques. The resulting maps are shown on plates 5-6 at a scale of 1:62,500.

Well- and Spring-Numbering System

In Washington, wells and springs are assigned numbers that identify their location within a township, range, section, and 40-acre tract. Number 26N/01E-12Q01 (fig. 3) indicates that the well is in Township 26 North and Range 1 East, north and east of the Willamette Base Line and Meridian, respectively. The numbers immediately following the hyphen indicate the section (12) within the township; the letter following the section gives the 40-acre tract of the section, as shown on figure 3. The two-digit sequence number (01) following the letter indicates that the well was the first one inventoried by USGS personnel in that 40-acre tract. An "S," "D," or "P" following the sequence number indicates that the site is a spring, deepened well, or piezometer in a well, respectively. In the plates of this report, wells and springs are identified individually by only the section and 40-acre tract, such as 12Q01; township and range are shown on the map borders.

Acknowledgments

The author thanks the many private well owners and water districts in the study area who provided access to their wells during this study. Martin B. Sebren and other personnel of the Kitsap Public Utility District provided water-level data and drillers' logs for numerous public-supply wells. Special thanks go to Patricia L. Kelly, Beverly A. Pavlicek, and Arthur K. Schick, all with

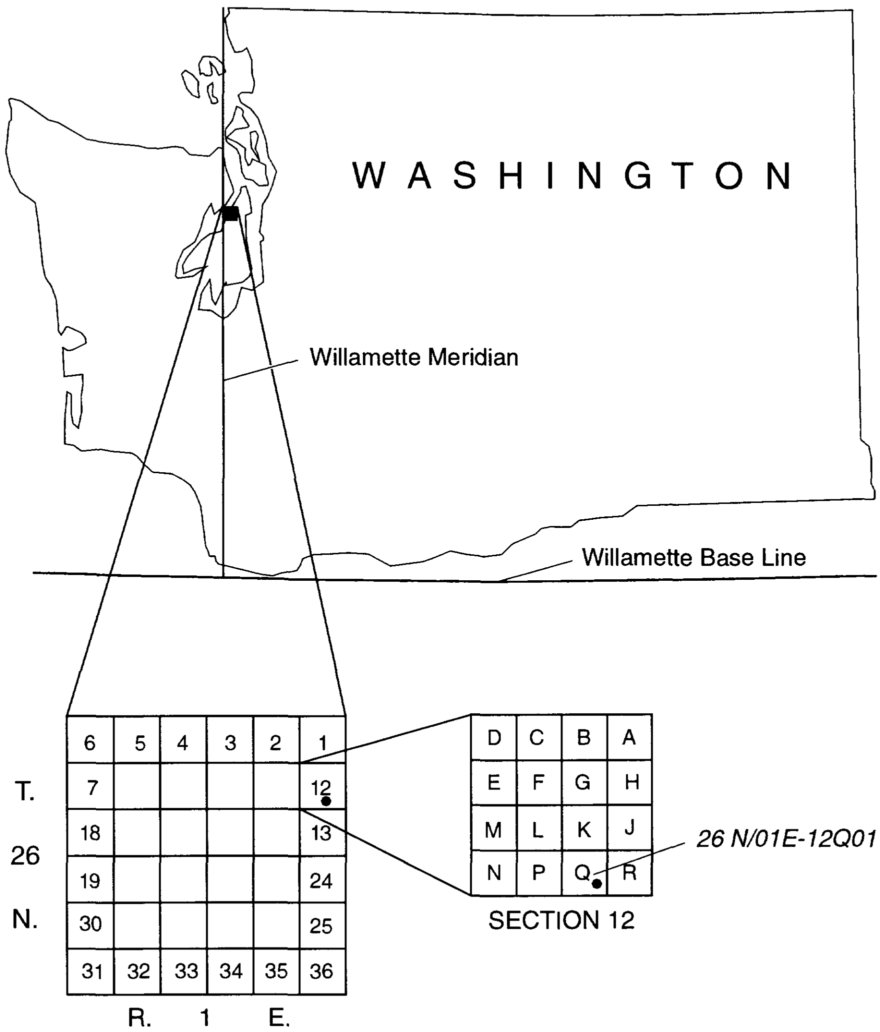


Figure 3. Well- and spring-numbering system used in Washington.

SUBASE Bangor, who assisted in many aspects of this study, including providing loan copies of many reports associated with the investigation and remediation of sites on SUBASE, assisting in the acquisition of historical and current water-level data, and helping with logistics during field work. The timely geologic mapping of SUBASE Bangor, done by Richard K. Borden, greatly improved the understanding of the stratigraphy in the area and strengthened the interpretations presented in this report. The author gratefully acknowledges Joseph E. Becker of Robinson and Noble, Inc., for providing loan copies of lithologic and geophysical logs for test wells on SUBASE Bangor with associated field notebooks and water-level data, and many reports associated with production and test wells throughout the study area.

HYDROGEOLOGY

Geologic Setting

The recent geologic history of the Puget Sound Lowland, including the study area, has consisted of repeated advances and retreats of continental glaciers that modified the pre-existing landscape. At least six different glacial and intervening interglacial (nonglacial) periods have been proposed for the Puget Sound Lowland over approximately the last 2 million years (Easterbrook and others, 1982; Blunt and others, 1987). During that time, deposits greater than 3,000 ft thick in places (Jones, 1996) accumulated in the Puget Sound Lowland. Because the principal hydrogeologic units within the study area are composed of the relatively young glacial and interglacial deposits, the earlier geologic history of the region will not be presented in this report. The reader is referred to Burns (1985), and Alt and Hyndman (1995) for descriptive accounts of earlier geologic processes, in addition to the relatively recent glacial and interglacial processes involved in the formation of the Puget Sound Lowland.

The effects of the most recent Pleistocene glaciation on the topography of the Puget Sound Lowland is evident in the study area in the form of numerous small north-south trending hills (those that are located at the south end of SUBASE Bangor, plate 2) and many small generally north-south trending streams (plate 1a). The nearly north-south orientation of these landforms was caused by scouring of the landscape by overriding glacial ice whose movement was from the north to the south.

Each successive glaciation in the Puget Sound Lowland resulted in the deposition of vast quantities of unconsolidated material. They were deposited by meltwater streams, ice-dammed lakes, directly by glaciers, or (in the case of interglacial periods) by rivers similar to those that exist today. Glacial deposits generally consist of outwash sand and gravel, lacustrine silt and clay, or till (an unusually hard and poorly sorted mixture of varying amounts of silt, sand, gravel, or boulders). Ice-contact deposits are often included with till; these deposits are generally composed of poorly bedded silt, sand, and gravel that are deposited adjacent to the glacier, but not necessarily below it. Interglacial deposits generally consist of clay, silt, or sand alluvium interbedded with discontinuous lenses of sand and gravel, or peat.

The rock types found within glacial deposits of the Puget Sound Lowland—including granite, andesite, and metasediments—generally are from British Columbia, whereas the rock types found within interglacial deposits often are from more local sources. The interglacial deposits in the study area have considerable quantities of basalt and basaltic sandstone from the eastern Olympic Mountains, west of the study area. Additionally, the interglacial deposits observed along Hood Canal are coarser grained than interglacial deposits located toward the center of the Puget Sound Lowland because of proximity to the Olympic Mountains. The presence of peat, organic-rich silt beds, and dispersed organic material is also characteristic of interglacial deposits.

The youngest deposits in the study area (shown on the map of generalized surficial geology, plate 1b) are alluvium (Qal), which includes stream, beach, and landslide deposits; and marsh deposits (Qm), which includes bog deposits and peat. Together, Qal and Qm cover about 5 percent of the study area. These deposits, which in many cases are still being formed today, are generally thin and discontinuous.

Deposits of the Vashon Stade of the Fraser Glaciation—the most recent glaciation in the Puget Sound Lowland—account for most of the surficial exposures in the study area. As the Vashon glacier advanced southward, large quantities of sand and gravel were deposited by meltwater. These deposits, the Vashon advance outwash, are designated Qva and typically consist of stratified sand or sand and gravel, with lenses of silt and clay. The unit is exposed in many drainages and in coastal areas where the overlying Vashon till has been eroded (plate 1b). The Vashon till, designated Qvt, was deposited directly by the overriding Vashon glacier; it covers much of the land surface in the study area (plate 1b). The Vashon recessional outwash, designated Qvr, was deposited by meltwater streams emanating from the receding Vashon glacier; the unit is present in many drainages followed by present-day streams (plate 1b). The surficial exposures of the Qva, Qvt, and Qvr cover about 11, 71, and 9 percent of the study area, respectively.

The oldest deposits in the study area that are exposed at land surface are referred to as Older deposits (Qod) on the map of generalized surficial geology (plate 1b). The Older deposits cover only 4 percent of the study area. Most exposures of this unit are composed of early Vashon glaciolacustrine silt and clay (Lawton Clay, fig. 2) or older interglacial silt, sand, gravel, and peat (deposits of the Whidbey Nonglacial Interval, fig. 2). The unit may also include thin or discontinuous deposits of intermediate age (deposits of the Olympia Nonglacial Interval or the Possession Glaciation, fig. 2). Deposits of the Double Bluff Glaciation (Double Bluff Drift), or older deposits, are not found at land surface in the study area.

Hydrogeologic Units

The surficial geologic units described previously and the deposits at depth were differentiated into aquifers and confining beds based on their areal extent and general water-bearing characteristics. An aquifer is saturated geologic material that is sufficiently permeable to yield water in significant quantities to a well or spring, whereas a confining bed has lower permeabilities that restrict the movement of ground water and limit the usefulness of the unit as a source of ground water. Generally, well-sorted coarse-grained deposits have higher permeabilities than do fine-grained or poorly sorted deposits. In the Puget Sound Lowland, saturated glacial outwash or coarse-grained interglacial deposits form the aquifers, whereas deposits such as till, fine-grained interglacial deposits, or glaciolacustrine deposits form the confining beds. The aquifers and confining beds identified herein are referred to as hydrogeologic units because the differentiation takes into account both the geologic and hydraulic characteristics of the units. Ten hydrogeologic units were identified in the study area (from youngest to oldest):

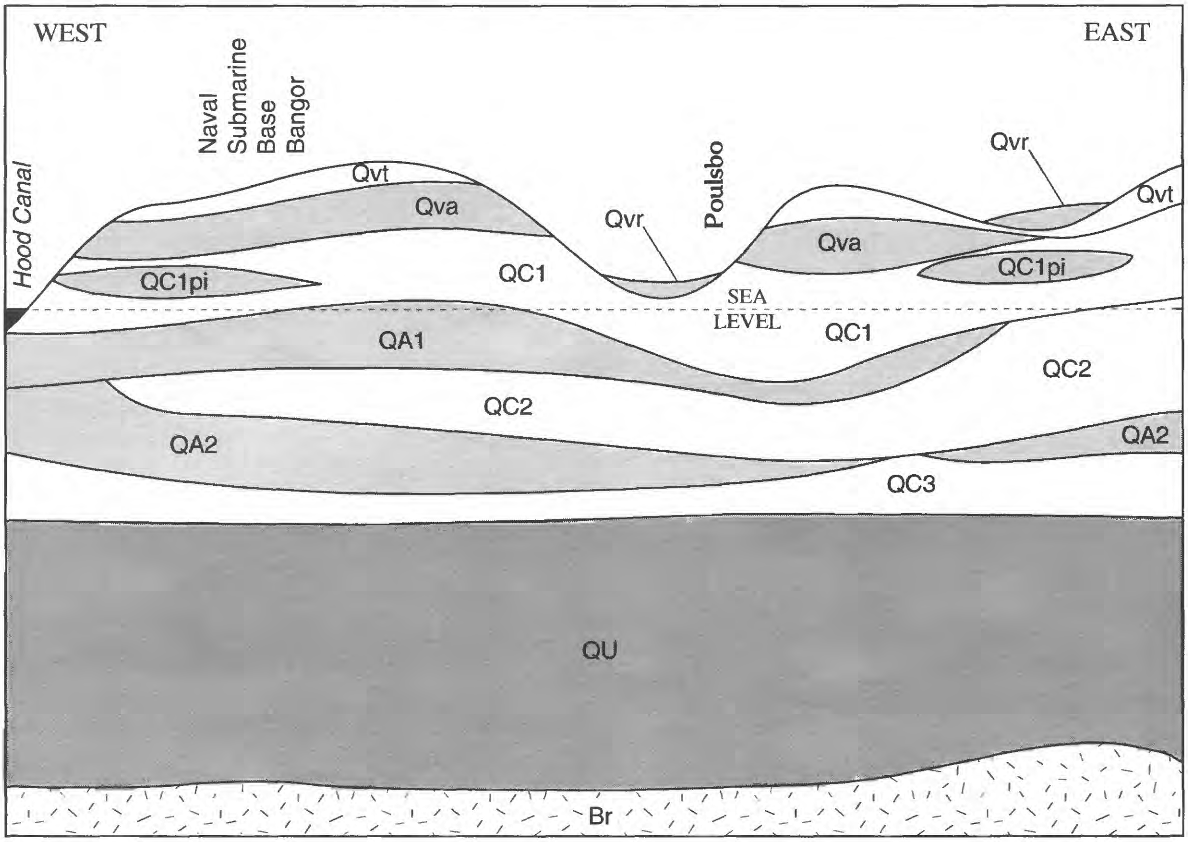
- Shallow aquifer (Qvr);
- Vashon till confining unit (Qvt);
- Vashon aquifer (Qva);
- Upper confining unit (QC1), locally includes Permeable interbeds (QC1pi);
- Sea-level aquifer (QA1);
- Lower confining unit (QC2);
- Deep aquifer (QA2);
- Basal confining unit (QC3); and
- Undifferentiated deposits (QU).

Previously accepted and published nomenclature associated with the Vashon Drift was used for the upper three hydrogeologic units—Qvr, Qvt, and Qva. These hydrogeologic units correlated closely with the Vashon-age geologic units described previously. Because the deeper geologic units were more variable in terms of grain size and water-bearing characteristics, they were subdivided into hydrogeologic units using names that refer to the type of unit: aquifer (A) or confining bed (C), with a number following the letter to indicate the first (1), second (2), or third (3) aquifer or confining unit below the Vashon-age deposits.

A simplified conceptual hydrogeologic section through the study area (fig. 4) shows the general geometry of the hydrogeologic units identified during this study. As shown on figure 4, the ground-water system is composed of alternating layers of permeable units (aquifers Qvr, Qva, QC1pi, QA1, and QA2) and less-permeable units (confining units Qvt, QC1, QC2, and QC3) overlying thick undifferentiated sedimentary deposits (QU) and bedrock (Br). The lithologic and hydrologic characteristics of the hydrogeologic units are summarized in a chart (fig. 5) that includes the range of typical thicknesses for each unit and the number of inventoried wells open to each unit.

The hydrogeologic units are shown in detail on 12 hydrogeologic sections. Sections A-A' through H-H' are oriented west-east (plate 3), and sections I-I' through L-L' are oriented south-north (plate 4). Maps showing the top altitude, thickness, and areal extent of units Qvt, Qva, QC1, QC1pi, QA1, QC2, and QA2 were also prepared (plates 5 and 6). A map of top altitude and areal extent of QC3 is included on plate 6; thickness of QC3 is not shown due to a lack of data. A map of top altitude, thickness, and areal extent was not generated for Qvr due to the limited areal extent and relative thinness of the unit compared to the other hydrogeologic units. Maps were not generated for QU or bedrock (shown on the hydrogeologic sections, plates 3 and 4) due to a lack of data.

Considerable variation in occurrence and thickness of units is illustrated on the hydrogeologic sections (fig. 4; plates 3 and 4). The hydrogeologic units consisting of Vashon-age deposits (the Shallow aquifer, Qvr; the Vashon till confining unit, Qvt; and the Vashon aquifer, Qva) are generally more easily recognized and correlated than older units because of surface or near-surface exposures and the fact that they have not undergone as much erosion, burial, or deformation. The hydrogeologic units are commonly heterogeneous and locally discontinuous, resulting in tentative correlations in many places. In general, the deeper are the units, the less certain are the correlations.



EXPLANATION

☐	Less permeable units	QC1	Upper confining unit	QA2	Deep aquifer
▒	Permeable units	QC1pi	Permeable interbeds	QC3	Basal confining unit
Qvr	Shallow aquifer	QA1	Sea-level aquifer	QU	Undifferentiated deposits
Qvt	Vashon till confining unit	QC2	Lower confining unit	Br	Bedrock
Qva	Vashon aquifer				

Figure 4. Simplified conceptual hydrogeologic section through Naval Submarine Base Bangor and vicinity, Kitsap County, Washington. Permeable units include sand and gravel outwash and alluvium; less permeable units may include till, silt, clay, and cemented silt, sand, and gravel.

Hydrogeologic unit	Unit label	Range of thickness [average thickness] (feet)	Lithology and hydrologic characteristics	Number of inventoried wells open to unit
Shallow aquifer	Qvr	4-74 [25]	Discontinuous unconfined aquifer consisting of sand, gravel, and silt (Vashon recessional outwash with small amounts of stream, beach, or landslide deposits). Unit includes lenses of silt and clay.	4 (and 1 spring)
Vashon till confining unit	Qvt	3-134 [45]	Low-permeability unit consisting of compacted and poorly sorted silt, sand, and gravel (Vashon till) and a locally occurring sandy clay beneath the till. Unit includes water-bearing lenses of sand and gravel.	19
Vashon aquifer	Qva	5-497 [98]	Unconfined aquifer consisting of sand or sand and gravel (Vashon advance outwash). Unit is confined locally where it is fully saturated and overlain by till. Unit includes lenses of silt and clay.	170
Upper confining unit	QC1	17-493 [200]	Low-permeability unit consisting mostly of glaciolacustrine silt and clay (Lawton Clay) and underlying nonglacial iron-oxide cemented sand, silt, and gravel, with lenses of silty peat and dispersed organic detritus (upper Whidbey Formation). Unit may include fine-grained facies of Vashon advance outwash, clay and gravelly clay (Olympia (?) nonglacial deposits), and/or thin and discontinuous till and outwash sand (Possession Drift). Permeable interbeds (QC1pi) are sand and gravel zones within QC1 that are sufficiently thick to delineate.	59
Permeable interbeds	(QC1pi)	7-104 [29]		71
Sea level aquifer	QA1	20-231 [110]	Confined aquifer consisting mostly of nonglacial sand and gravel with minor silt interbeds (Whidbey Formation). Base of unit may contain older sand and gravel outwash (Double Bluff Drift).	120
Lower confining unit	QC2	40-545 [140]	Low-permeability unit consisting of sandy silty clay (lower Whidbey Formation) and glacial sand and gravel with significant silt and clay layers (upper Double Bluff Drift). Where unit is absent, the sea level aquifer and the deep aquifer are in direct hydraulic connection.	1
Deep aquifer	QA2	15-231 [120]	Confined aquifer consisting of sand and gravel outwash with minor silt (Double Bluff Drift).	24
Basal confining unit	QC3	170-300 [210]	Low-permeability unit consisting of blue clay and silt with some gravel.	0
Undifferentiated deposits	QU	unknown	Undifferentiated deposits overlying bedrock.	2

Figure 5. Lithologic and hydrologic characteristics of the hydrogeologic units of Naval Submarine Base Bangor and vicinity, Kitsap County, Washington. Range-of-thickness values are based on observed thicknesses of units derived from lithologic logs of inventoried wells.

Description of Hydrogeologic Units

The Shallow aquifer (Qvr) is a discontinuous and thin unconfined aquifer consisting of sand, gravel, and silt with lenses of silt and clay (plates 3 and 4). Qvr is composed mostly of recessional outwash, but may include younger stream, beach, or landslide deposits. Of the four inventoried wells open to this unit, one is used for monitoring purposes, two are used as single-family water supplies, and one is unused due to a lack of water in the well following several years of use. Water from the one inventoried spring in Qvr is used to supplement a local water supply.

The Vashon till confining unit (Qvt) is a low-permeability unit consisting mostly of till (compacted and poorly sorted silt, sand, and gravel) with a locally occurring sandy clay at the base. Nineteen inventoried wells are open to water-bearing lenses within Qvt. Yields are generally small, and many of the inventoried wells in this unit are old dug wells that tend to go dry in late summer. In fact, eight of the inventoried wells in Qvt are unused due to small or unreliable yields. The unit mantles much of the study area (plates 3 and 4), with tops ranging in altitude from slightly less than sea level to more than 500 ft above sea level. Thicknesses of Qvt vary widely, but are generally 10 to 100 ft; thicknesses of 80 ft or more tend to be present in inland areas (plate 5a).

The Vashon aquifer (Qva) consists of well-sorted sand or sand and gravel with lenses of silt and clay. Most of the unit is unconfined, but confined ground-water conditions exist where the unit is fully saturated and is overlain by Qvt. Qva is the most widely used aquifer in the study area, with 170 inventoried wells open to the unit, including 12 public supply wells that each serve five or more homes. The top of the unit ranges from sea level to slightly more than 500 ft above sea level. The unit is not present in some nearshore areas along Hood Canal, Dyes Inlet, and Liberty Bay (plate 5b), likely due to erosion of the unit through geologic time. The thickness of Qva is commonly 20 to 200 ft; however, thicknesses are almost 300 ft near the eastern boundary of SUBASE Bangor (plate 5b). The mapped extent of Qva may include older sands, where thicknesses are nearly 500 ft in the southern part of the study area, west of Dyes Inlet (hydrogeologic section H-H', plate 3). In earlier reports, the Vashon aquifer has been referred to as the Perched aquifer (Noble, 1975a-b, 1976; Paterson, 1981) and the Shallow aquifer (Hart Crowser, Inc., 1988, 1989; Kitsap County Ground-Water Advisory Committee and others, 1991).

The Upper confining unit (QC1) is a thick and extensively occurring low-permeability unit consisting mostly of early Vashon glaciolacustrine silt and clay (Lawton Clay) and underlying interglacial deposits—silt, sand, and gravel with numerous lenses of silt and clay or silty peat (upper Whidbey Formation). Dispersed organic detritus and iron-oxide cementation are common within these interglacial deposits. In some parts of the study area, QC1 includes interglacial clay and gravelly clay—perhaps deposited during the Olympia Nonglacial Interval—as well as thin and discontinuous lenses of Possession-age till and outwash sand. The top of QC1 ranges from more than 100 ft below sea level to more than 400 ft above sea level (plate 5c). Thickness is generally 100 to 300 ft, but exceeds 500 ft in places (plate 5c). Although the permeabilities of the material in QC1 are generally low, 59 inventoried wells are open to numerous coarse water-bearing lenses that produce sufficient amounts of water for domestic purposes. The upper Whidbey Formation component of QC1 roughly correlates to the Kitsap Formation of earlier reports (for example, Garling and others, 1965, and Hart Crowser, Inc., 1988 and 1989—see figure 2).

Locally continuous and mappable zones of sand and gravel within the Upper confining unit, are referred to as the Permeable interbeds (QC1pi). These interbeds were identified where data were sufficient to recognize and correlate interbeds generally 10 to 50 ft thick. Although the permeable interbeds are generally mapped as isolated lenses of coarse-grained material (plate 5d), the deposits comprising the unit may be part of a complicated system of braided channels; as such, the unit may be more connected than indicated by the available data. Small areas of QC1pi with thicknesses ranging from 60 to 119 ft were identified in several locations throughout the study area (plate 5d). The top of the unit ranges from more than 50 ft below sea level to more than 150 ft above sea level (plate 5d). In the vicinity of SUBASE Bangor, the permeable interbeds have previously been called the semi-perched aquifer (Noble, 1975a-b, 1976; Paterson, 1981; Becker, 1995a—see figure 2).

The Sea-level aquifer (QA1) is an extensive and widely used confined aquifer; 121 inventoried wells are open to this unit, 18 of which serve five or more homes. QA1 consists mostly of nonglacial sand and gravel with minor silt interbeds (deposited during the Whidbey Nonglacial Interval, fig. 2). QA1 may include older glacial sand and gravel outwash (deposited during the Double Bluff Glaciation) near its base. The top of the Sea-level aquifer ranges from more than 300 ft below sea level to slightly above sea level (plate 6a). Typical thicknesses are 40 to 140 ft; however, areas with thicknesses greater than

150 ft are present in several places (plate 6a). QA1 is generally less than 50 ft thick in much of the southeast part of the study area (plate 6a). The term "sea-level aquifer" has been used in many ground-water studies of SUBASE Bangor and adjacent areas (fig. 2).

The Lower confining unit (QC2) is a low-permeability unit consisting of interglacial sandy silty clay (lower Whidbey Formation) and glacial sand and gravel with significant amounts of silt and clay layers (upper Double Bluff Drift). As shown on plate 6b, QC2 exists throughout much of the study area, but is absent in places on SUBASE Bangor. The unit may be absent elsewhere, but data were not sufficient to identify those areas. Only one inventoried well is open to this unit. The top of the unit ranges from more than 400 ft below sea level to slightly less than 100 ft below sea level (plate 6b). QC2 is commonly 80-160 ft thick, but thicknesses as great as 559 ft exist in the southern part of the study area below Dyes Inlet (plate 6b).

The Deep aquifer (QA2) is a confined aquifer composed of sand and gravel outwash with minor silt—presumably Double Bluff Drift. Twenty-four inventoried wells are open to this unit, most of which are public supply wells or test wells. On the basis of the rather limited well data for this unit, thicknesses are generally 100 to 160 ft. Thicknesses greater than 200 ft can be found in the northern and southern parts of the field area (plate 6c). The top of the Deep aquifer ranges from more than 800 ft below sea level to slightly less than 200 ft below sea level (plate 6c).

The Basal confining unit (QC3) is a low-permeability unit composed of clay and silt with some gravel. The clay is commonly described as "blue" by drillers. Although several deep wells have been drilled through this unit, no inventoried wells are open to it. The top of the Basal confining unit ranges from more than 1,000 ft below sea level to slightly less than 300 ft below sea level (plate 6d). Thickness of the unit is largely unknown, but is probably more than 100 ft in most areas (plates 3 and 4).

The Undifferentiated deposits (QU) underlie the hydrogeologic units described above and overlie bedrock; thicknesses probably range from 100 to more than 700 ft (plates 3 and 4). Little is known about these deposits; only two inventoried wells are open to this unit. Wells may tap coarse-grained material within QU at other locations, but the lack of wells penetrating this unit within the study area makes identification of such deposits nearly impossible.

The hydrogeologic units of the study area presented above can be roughly correlated to the more regional hydrogeologic unit assignments made for the Puget Sound aquifer system (covering 17,616 mi^2) during the U.S. Geological Survey's recent Puget Sound Regional Aquifer System Analysis (RASA) (J.J. Vaccaro, U.S. Geological Survey, written commun., 1996). The Shallow aquifer (Qvr) and the Vashon till confining unit (Qvt) are roughly equivalent to the surficial semi-confining unit; the Vashon aquifer (Qva) is equivalent to the Fraser aquifer; the Upper confining unit (QC1) and the Permeable interbeds (QC1pi) are roughly equivalent to the confining unit; and the older units (QA1, QC2, QA2, and QC3) are roughly equivalent to the Puget aquifer (J.J. Vaccaro, U.S. Geological Survey, written commun., 1996).

Hydraulic Properties

Hydraulic conductivity is a measure of a material's ability to transmit water and in unconsolidated sediment is dependent on the size, shape, distribution, and packing of the particles. Because these characteristics vary greatly within each hydrogeologic unit, hydraulic conductivity values also vary greatly.

Values of horizontal hydraulic conductivity were estimated for the hydrogeologic units using drawdowns that were observed after pumping wells for periods that ranged from 1 to 24 hours. Only data from those wells that had a driller's log containing discharge rate, time of pumping, drawdown, static water level, well-construction data, and lithologic log were used.

Two different sets of equations were used to estimate hydraulic conductivity, depending on how the well was finished. For wells that had a screened or perforated interval, the modified Theis equation (Ferris and others, 1962) was first used to estimate transmissivity at the pumped interval. Transmissivity is the product of horizontal hydraulic conductivity and thickness of the part of the hydrogeologic unit supplying water to the well. The modified equation is

$$s = \frac{Q}{4\pi T} \ln \frac{2.25Tt}{r^2 S} , \qquad (1)$$

where

s = drawdown in the well, in feet;

Q = discharge, or pumping rate, of the well, in ft^3/d;

T = transmissivity of the hydrogeologic unit, in ft^2/d;

t = length of time the well was pumped, in days;

r = radius of the well, in feet; and

S = storage coefficient, a dimensionless number, assumed to be 0.0001 for confined units and 0.1 for unconfined units.

The use of equation 1 for unconfined aquifers assumes that the water table is not drawn down significantly below the top of the well screen.

A computer program was used to solve equation 1 for transmissivity (T) using Newton's iterative method (Carnahan and others, 1969). The difference in computed transmissivity between using 0.1 and 0.0001 for the storage coefficient is a factor of only about 2. Next, the following equation was used to calculate horizontal hydraulic conductivity:

$$K_h = \frac{T}{b} \qquad (2)$$

where

K_h = horizontal hydraulic conductivity of the geologic material in the vicinity of the well opening, in feet per day; and

b = thickness, in feet, approximated using the length of the open interval as reported in the driller's report.

The use of the length of a well's open interval for b may overestimate values of K_h because the equations assume that all the water flows horizontally within a layer of this thickness. Although some of the flow will be outside this region, the amount can be expected to be small because in most sedimentary deposits, vertical flow is inhibited by layering.

A second equation was used to estimate hydraulic conductivities using data for wells having only an open end, and thus no vertical dimension to the open interval. Bear (1979) provides an equation for hemispherical flow to an open-ended well just penetrating a hydrogeologic unit. When modified for spherical flow to an open-ended well within a unit, the equation becomes

$$K_h = \frac{Q}{4\pi s r} \quad . \qquad (3)$$

Equation 3 is based on the assumption that horizontal and vertical hydraulic conductivities are equal, which is not likely for the deposits within the study area. The results of violating this assumption probably is an underestimate of K_h by an unknown amount.

Values of horizontal hydraulic conductivity were calculated with data from those wells for which the data were available (Appendix 1), and statistical summaries were prepared by hydrogeologic unit (table 1). Data were unavailable for the Lower and Basal confining units (QC2 and QC3). With the exception of Qvt and QC1, the median hydraulic conductivities are similar in magnitude to values reported by Freeze and Cherry (1979) for similar materials. Of significance is the fact that the respective median values for the aquifers (Qvr, Qva, QC1pi, QA1, and QA2), 66 ft/d, 51 ft/d, 34 ft/d, 43 ft/d, and 21 ft/d, are similar (table 1). The medians of estimated hydraulic conductivities of Qvt and QC1 (28 and 9.7 ft/d, respectively), are probably higher than is typical for most of the material in these units because data for confining units usually are zones where lenses of coarse material exist. Hydraulic conductivity values for the majority of QC2 and QC3 would likely be one or more orders of magnitude smaller than those for the aquifers. Maps of horizontal hydraulic conductivities, by hydrogeologic unit, were constructed in order to identify areal distributions in the hydraulic conductivity values. However, because no patterns were observed, the maps of hydraulic conductivities were not included in this report.

Transmissivities estimated using specific-capacity data (discharge rate, time of pumping, drawdown, and static water level) contained in drillers' logs were compared with transmissivities determined from published aquifer tests (Becker 1995a, and miscellaneous consultant reports); only 16 inventoried wells had specific-capacity data and published aquifer tests. The ratios of transmissivities determined from aquifer tests to transmissivities estimated from specific-capacity data ranged from about 0.5 to 7, with a median of 3. A similar comparison using data from more than 1,000 wells indicated that transmissivities determined from aquifer tests are generally larger, albeit with considerable range, than those estimated using specific-capacity data (Prudic, 1991).

Table 1.--*Summary of estimated horizontal hydraulic conductivities of selected hydrogeologic units of Naval Submarine Base Bangor and vicinity*

[Hydrogeologic unit: Qvr, Shallow aquifer; Qvt, Vashon till confining unit; Qva, Vashon aquifer; QC1, Upper confining unit; QC1pi; Permeable interbeds; QA1, Sea-level aquifer; and QA2, Deep aquifer; --, not determined]

Hydro-geologic unit	Number of wells	Hydraulic conductivity (feet per day)				
		Mini-mum	25th percen-tile	Median	75th percen-tile	Maxi-mum
Qvr	2	22	--	66	--	110
Qvt	2	9.4	--	28	--	47
Qva	115	0.40	19	51	120	2,400
QC1	36	0.40	4.4	9.7	70	800
QC1pi	60	0.40	20	34	140	650
QA1	71	0.18	12	43	120	6,100
QA2	11	3.2	15	21	50	69

GROUND WATER

Temporal changes in water levels in an aquifer depend on the geometry and the hydraulic properties of the aquifer and on the areal and temporal distribution of recharge and discharge. When recharge is greater than discharge, the quantity of water stored in an aquifer will increase, and water levels will rise. When discharge is greater than recharge, the quantity of water stored will decrease, and water levels will fall.

Ground-water levels typically rise and fall with seasonal changes in recharge to the ground-water system. Recharge to the ground-water system in most local areas is primarily from the infiltration of precipitation, which is generally greatest during October through March. Previous studies in western Washington have shown that water levels in wells generally rise from October through March and fall from April through September. Water levels in shallow wells generally show a fairly pronounced rise due to the increased recharge. Water levels in deeper wells generally show a less pronounced and a more delayed increase, due to greater travel times required for recharge near the surface to propagate to deeper parts of the ground-water system, and due to attenuation by storage and discharge at the intermediate depths.

In addition to seasonal and long-term variability in water levels, which are caused by variability in precipitation and recharge, short-term variability can be caused by intermittent pumping from a measured well, pumping from wells near a measured well, or marine tides in Puget Sound. Ground-water levels can respond to tides resulting from a hydraulic connection between the aquifer and the seawater of Puget Sound or from tidal loading on top of a confining unit above the aquifer. Ground-water levels in nearshore wells rise with rising tides and decline with decreasing tides. The magnitude of tidal range along Hood Canal is about 13 ft (Mofjeld and Larsen, 1984; M. van Heeswijk, U.S. Geological Survey, written commun., 1996). Based on tidal coefficients developed for SUBASE Bangor (Paterson, 1981), maximum water-level fluctuations are about 4 to 5 ft along the shoreline and generally are less than 0.1 ft 1.5 mi inland.

Ground-Water Levels

Ground-water levels in 35 wells in the study area were measured monthly from November 1994 through March 1996 in order to observe seasonal variations in hydraulic heads in the hydrogeologic units. The number of wells in which water levels were measured, by hydrogeologic unit, are shown below:

Hydrogeologic unit	Number of wells
Vashon aquifer (Qva)	9
Upper confining unit (QC1)	3
Permeable interbeds (QC1pi)	4
Sea-level aquifer (QA1)	15
Deep aquifer (QA2)	4

Hydrographs of ground-water levels were generated for all monthly-measured wells. Selected hydrographs of water levels in wells in the Vashon aquifer, the Permeable interbeds, the Sea-level aquifer, and the Deep aquifer—the three most productive hydrogeologic units in the study area—illustrate seasonal and long-term water-level changes observed in the study area (plate 7).

Except for one well which had been pumped prior to several measurements (25N/01E-08J02), hydrographs that showed the obvious short-term effects of pumping or tides are not shown on plate 7. All monthly water-level measurements, however, are included in Appendix 2, with notations regarding the status of the water level (e.g., recently pumped, nearby pumping, or affected by tides).

In order to compare monthly precipitation with hydrographs of water levels, graphs of monthly precipitation for Bremerton and Wauna, Washington—the two nearest precipitation stations on the Kitsap Peninsula with long-term records—is included on plate 7e. The graph for October 1993 through February 1996 (National Oceanic and Atmospheric Administration, 1995) shows increasingly wetter winters from 1993 to 1996.

Hydrographs of water levels in wells completed in the Vashon aquifer show seasonal variations ranging from about 2 to 7 ft (plate 7a). Water levels generally were highest in spring and lowest in fall. Hydrographs for wells 26N/01E-33G01 and 25N/01E-07K01, 174 and 147 ft deep, respectively, show water-level variations of 6 to 7 ft, which is common for the Vashon aquifer. In contrast, the hydrograph for well 26N/01E-29P01, which is completed deeper in the aquifer (206 ft), shows a less pronounced seasonal and overall variation of less than 3 ft, perhaps due to textural differences of overlying material.

When the water level in well 26N/01E-33G01 is compared to monthly precipitation (plate 7e), a lag of about 3 months between periods of highest precipitation (November through March) and highest water levels (February through June) is apparent. Water levels in well 25N/01E-07K01 have a lag of about 6 months. The lag between variations in precipitation and water levels in well 26N/01E-29P01 is difficult to ascertain because of the small seasonal variability, the long-term rise, and the monthly variability of water levels in that well. Each of the hydrographs for wells in the Vashon aquifer shows an upward trend during the measurement period (November 1994 to March 1996), likely due to the larger quantities of precipitation that fell in late 1995 than in late 1994 (plate 7e).

Hydrographs of water levels in wells completed in the Permeable interbeds (QC1pi) show seasonal variations ranging from about 3 to 4 ft, with higher water levels existing in early spring about 4 months after the greatest precipitation (plate 7b). Well 25N/01E-08J02 shows considerable month-to-month variation, and as noted on the hydrographs, the well had been pumped prior to four of the monthly water-level measurements. Excluding these four measurements, the hydrographs show similar seasonal fluctuation and lag between greatest precipitation and highest water level.

Hydrographs of water levels in wells completed in the Sea-level aquifer (QA1) (plate 7c) generally had month-to-month and overall water-level fluctuations of less than 3 ft and a small long-term rise through the measurement period. Some of the small month-to-month variability in wells 27N/01E-33B03 and 25N/01E-06D04 could be attributed to tides; both wells are located only about one-half mile or less from the shore.

Hydrographs of water levels in wells completed in the Deep aquifer (QA2) (plate 7d) generally show no seasonal variation, but do show an upward trend in water levels during the measurement period, likely due to the yearly increases in precipitation mentioned previously. The hydrograph for well 26N/01E-32L04—an unused well—shows some month-to-month variability, and water levels in that well may have been affected by pumping from well 26N/01E-32L05, which was pumped at least weekly at the time of this study (see plate 1 for location of wells). The hydrograph of water levels in well 26N/01E-31B02 shows one anomalously high water level in September 1995.

Ground-Water Flow Directions

To estimate directions of horizontal ground-water flow, water-level contour maps were drawn for individual aquifers. The directions of flow were inferred to be from higher to lower water levels and perpendicular to the water-level contours. Water-level maps were prepared for the Vashon aquifer (Qva), the Permeable interbeds (QC1pi), and the Sea-level aquifer (QA1) (plate 7a-c). Ground-water levels mostly from the April 1995 week-long measurement period were used to construct the contour maps of hydraulic head, or altitude of water level; water levels measured at the time of drilling, during the well inventory, or during August 1994 were used for areas for which April measurements were unavailable or sparse. Water-level contours are dashed or queried where least certain, and are not shown where data are lacking. Generalized horizontal flow directions of ground water within the three units listed above are shown with arrows on the contour maps (plate 7a-c). Because the units are heterogeneous and complex, the mapped heads and directions of horizontal flow are considered to be regional in nature; conditions may vary locally.

Ground-water flow in the Vashon aquifer (Qva) generally moves from topographically high areas to low areas—Hood Canal, Dyes Inlet, Liberty Bay, and several small creeks (plate 7a). Water levels range from near sea level in nearshore areas to greater than 400 ft just east of the central part of SUBASE Bangor. Gradients are highly variable, but most are in the range of 50 to 600 ft/mi. There is a north-south trending ground-water divide along the western part of the study area, with ground water moving eastward toward Liberty Bay or Dyes Inlet on one side and westward toward Hood Canal on the other side. In the area east of Liberty Bay, the direction of flow is southwestward toward the bay.

The direction of ground-water flow within the Permeable interbeds (QC1pi) is generally similar to flow within the Vashon aquifer, with ground water moving from inland areas toward Hood Canal, Liberty Bay, or Dyes Inlet. Because the unit is discontinuous, ground water commonly moves to and from adjacent units. However, ground-water movement within the unit may be better connected than can be determined with the available data due to the possible connected nature of the unit explained previously. Water levels in the unit range from near sea level in nearshore areas to slightly more than 250 ft in an area west of Liberty Bay (plate 7b). Ground water moves toward Dyes Inlet in the south-central part of the study area, toward Hood Canal on the western part, and toward Liberty Bay in the central part. Ground water moves radially outward from an area of high water levels in the southwest part of the study area. Gradients range from about 50 to 300 ft/mi.

Ground water in the Sea-level aquifer generally moves from inland areas to coastal areas (Hood Canal, Liberty Bay, and Port Orchard). Ground water in the southern part of this unit probably flows toward Dyes Inlet; however, there are no water-level data in this area to support this. Water levels range from about sea level near coastlines to more than 100 ft in the north and south-central parts of the study area, and more than 200 ft along the northeast part of the study area (plate 7c). Gradients vary throughout the study area—gradients near Delta Pier range from about 50 to 100 ft/mi. Generally, gradients are flatter in the inland areas, where they are about 40 ft/mi or less. A mostly north-south trending ground-water divide exists in the west-central part of the study area, with ground water moving west toward Hood Canal on one side of the divide, and east toward Liberty Bay on the other side. East of Liberty Bay, flow is southwest toward the bay.

Water levels in the Sea-level aquifer may have local anomalies where the underlying Lower confining unit is missing and the Sea-level aquifer is in direct hydraulic connection with the Deep aquifer. This appears to be the case near the southern part of SUBASE Bangor, where the 60-ft contour moves inland and northward (plate 7c). This area of anomalously low-water levels coincides fairly well with two areas where the Sea-level aquifer and the Deep aquifer are connected. In this area of low-water levels, more ground water may move downward into the Deep aquifer (QA2) than in areas where the confining unit is not missing. This flow pattern may exist elsewhere within the Sea-level aquifer, but was not apparent from the available data.

Directions of vertical flow were determined using the maps of water levels in the major aquifers and water levels in closely-spaced wells. In general, vertical flow is downward in the inland or higher altitude areas. In these areas, water-level contours are considerably higher in the Vashon aquifer than in the deeper Sea-level aquifer. Also, observed water levels in closely-spaced wells (for example, 26N/01E-07J01 and 07J02, and 26N/01E-19F01 and 19F01P1) decreased with depth, indicating downward flow. In a narrow strip along the coast, vertical flow is generally upward as evidenced by flowing wells located along Liberty Bay (26N/01E-26M02 and 26N/01E-27G03), Dyes Inlet (25N/01E-20A01 and 25N/01E-21C04), and Hood Canal (25N/01W-12N01 and 25N/01W-14E07). Also, the water level in well 26N/01W-25B02 (completed in the Sea-level aquifer) is lower than the water level in the nearby deeper well 26N/01W-25B02P1 (completed in the Deep aquifer).

SUMMARY AND CONCLUSIONS

The hydrogeologic framework of Naval Submarine Base Bangor and vicinity, Kitsap County, Washington, consists of alternating layers of permeable units (aquifers) and less-permeable units (confining beds) consisting of unconsolidated glacial and interglacial deposits. Ten hydrogeologic units were identified during this investigation: Shallow aquifer (Qvr), Vashon till confining unit (Qvt), Vashon aquifer (Qva), Upper confining unit (QC1) (locally includes Permeable interbeds (QC1pi)), Sea-level aquifer (QA1), Lower confining unit (QC2), Deep aquifer (QA2), Basal confining unit (QC3), and Undifferentiated deposits (QU).

The Shallow aquifer is a discontinuous and thin, generally 10 to 40 feet thick, unconfined aquifer composed mostly of recessional outwash sand, gravel, and silt with lenses of silt and clay. The Vashon till confining unit is a low-permeability unit consisting of compacted and poorly sorted silt, sand, and gravel. Mantling much of the study area, it is generally 10 to 100 feet thick, and the top (altitude) of the unit ranges from slightly below sea level to more than 500 feet above sea level. The Vashon aquifer is a widely used, generally unconfined aquifer consisting of advance outwash sand or sand and gravel, with silt and clay lenses. It is typically 20 to 200 feet thick; the top of the unit ranges from near sea level to slightly more than 500 feet above sea level. The Upper confining unit is a thick (typically 100 to 300 feet) extensive, generally low-permeability unit consisting mostly of glaciolacustrine silt and clay and underlying interglacial deposits (silt, sand, and gravel, with numerous lenses of silt and clay and silty peat). The top of the unit ranges from more than 100 feet below sea level to more than 400 feet above sea level. The Permeable interbeds are locally continuous and mappable zones of sand and gravel within the Upper confining unit. The top of the interbeds ranges from more than 50 feet below sea level to more than 150 feet above sea level; the thickness of the unit is typically 10 to 50 feet.

The Sea-level aquifer is a widely used confined aquifer that exists throughout the study area. It is composed of nonglacial sand and gravel with minor silt interbeds and older glacial sand and gravel near its base. The top of the Sea-level aquifer ranges from more than 300 feet below sea level to slightly above sea level; thickness of the unit is typically 40 to 140 feet. The Lower confining unit is a low-permeability unit consisting of interglacial sandy silty clay and glacial sand and gravel with significant amounts of silt and clay layers. The top of the unit ranges from more than 300 feet below sea level to slightly less than 100 feet below sea level; thickness of the unit is generally 80 to 160 feet. The Deep aquifer is a confined aquifer composed of glacial sand and gravel with minor silt, generally 100 to 160 ft thick; the top of the unit ranges from more than 800 feet below sea level to slightly less than 200 feet below sea level. The Basal confining unit is a low-permeability unit composed of clay and silt with some gravel; it is probably greater than 100 feet thick in most places, and the top of the unit ranges from more than 1,000 feet below sea level to slightly less than 300 feet below sea level. The Undifferentiated deposits underlie the hydrogeologic units listed above and overlie bedrock; thicknesses exceed 700 feet in places.

Medians of horizontal hydraulic conductivities, estimated using pumping rate and water-level drawdowns reported by drillers, are 66 feet per day (ft/d) for the Shallow aquifer, 28 ft/d for the Vashon till confining unit, 51 ft/d for the Vashon aquifer, 9.7 ft/d for the Upper confining unit, 34 ft/d for the Permeable interbeds, 43 ft/d for the Sea-level aquifer, and 21 ft/d for the Deep aquifer. The hydraulic conductivities for the confining units are probably higher than is typical for most of the materials in the units because data for confining units are available only from locations where lenses of coarse material exist.

Ground-water levels, measured monthly in 35 wells from November 1994 through March 1996, indicate that seasonal variations in water levels generally range from 2 to 7 feet in the Vashon aquifer, from 3 to 4 feet in the Permeable interbeds, and are generally less than 3 feet in the Sea-level aquifer and less than 2 feet in the Deep aquifer. Highest water levels generally existed in the spring, and most hydrographs showed an upward trend in water levels during the measurement period, likely due to the high precipitation during and just prior to the measurement period.

The vertical component of ground-water flow within the hydrogeologic units identified during this investigation is generally downward in inland areas of high topography and upward in nearshore and other areas of low topography. In the Vashon aquifer, ground-water flow closely follows surface topography, moving from high areas to low areas. Water levels in the Vashon aquifer range from near zero in nearshore areas to more than 400 feet inland; gradients range from about 50 to 600 feet per mile (ft/mi). In the Permeable interbeds, ground-water flow is generally from inland areas to coastal areas, with movement into adjacent hydrogeologic units where the Permeable interbeds are discontinuous. Water levels generally range from near zero to 250 feet, and gradients range from 50 to 300 ft/mi. Ground water in the Sea-level aquifer also moves from inland areas to coastal areas. Water levels vary from near zero to more than 200 feet, and gradients range from 40 to 100 ft/mi. A north-south trending ground-water divide exists in the west-central part of the study area, with ground water moving toward Hood Canal on one side and toward Liberty Bay on the other. In the south-central part of the study area, ground water generally moves toward Dyes Inlet. On the east side of Liberty Bay, ground water moves westward toward the bay.

SELECTED REFERENCES

Alt, David, and Hyndman, D.W., 1995, Northwest exposures, a geologic story of the northwest: Missoula, Mont., Mountain Press Publishing Company, 443 p.

Anderson, H.W., Jr., 1968, Ground-water resources of Island County, Washington: Olympia, Wash., Washington Department of Water Resources, Water-Supply Bulletin 25, part II, 317 p.

Bear, Jacob, 1979, Hydraulics of groundwater: New York, McGraw-Hill, 569 p.

Becker, J.E., 1995a, Hydrogeologic analysis of the Bangor aquifer systems, Kitsap County, Washington: Tacoma, Wash., Robinson and Noble, Inc., [about 150] p.

———1995b, Quantitative flow system analysis through numerical modeling techniques of the Bangor aquifer systems, Kitsap County, Washington: Tacoma, Wash., Robinson and Noble, Inc., [about 190] p.

Berger, G.W. and Easterbrook, D.J., 1993, Thermoluminescence dating tests for lacustrine, glaciomarine, and floodplain sediments from western Washington and British Columbia: Canadian Journal of Earth Science, v. 30, p. 1815-1828.

Blunt, D.J., Easterbrook, D.J., and Rutter N.W., 1987, Chronology of Pleistocene sediments in the Puget Lowland, Washington, *in* Selected Papers on the Geology of Washington: Olympia, Wash., Washington Division of Geology and Earth Resources, Bulletin 77, p. 321-353.

Bovay Engineers, Inc., 1975, Hydrogeologic investigation, supplement no. 17, project no. 1, contract no. N. 68248-C-0005, Trident Support Site, Naval Torpedo Station, Bangor Annex, Keyport, Washington: Spokane, Wash., Bovay Engineers, Inc., [about 500 p.].

Bretz, J Harlan, 1910, Glacial lakes of Puget Sound, preliminary paper: Journal of Geology, v. 18, no. 5, p. 448-458.

———1913, Glaciation of the Puget Sound region: Olympia, Wash., Washington Geological Survey Bulletin 8, 244 p.

Burns, R.E., 1985, The shape and form of Puget Sound: Seattle, Wash., University of Washington Press, 100 p.

Carnahan, B., Luther, H.A., and Wilkes, J.O., 1969, Applied numerical methods: New York, John Wiley and Sons, Inc., 604 p.

Crandell, D.R., Mullineaux, D.R., and Waldron, H.H., 1965, Age and origin of the Puget Sound trough in western Washington: U.S. Geological Survey Professional Paper 525-B, p. B132 to B136.

Dames and Moore, Inc., 1974a, Interim Report, Phase II, Geotechnical Studies and Review of Environmental Effects, Explosive Handling Wharf 1, Bangor Annex, Naval Torpedo Station Keyport: Seattle, Wash., Dames and Moore, Inc., 23 p., 8 plates.

———1974b, Report of Geologic Evaluation and Stability Analysis, Proposed Delta Sites, Bangor Annex, Naval Torpedo Station Keyport: Seattle, Wash., Dames and Moore, Inc., 20 p., 5 plates.

Deeter, J.D., 1979, Quaternary geology and stratigraphy of Kitsap County, Washington: Bellingham, Wash., Western Washington University, unpublished Master of Science thesis, 175 p, 8 plates.

Dion, N.P., 1974, A proposal for the investigation of possible ground-water contamination in the Bangor area, Kitsap County, Washington: U.S. Geological Survey Open-File Report, 24 p.

Dion, N.P., Olsen, T.D., and Payne, K.L., 1988, Preliminary evaluation of the ground-water resources of Bainbridge Island, Kitsap County, Washington: U.S. Geological Survey Water-Resources Investigations Report 87-4237, 82 p.

Dion, N.P., and Sumioka, S.S., 1984, Seawater intrusion into coastal aquifers in Washington, 1978: Olympia, Wash., Washington Department of Ecology, Water-Supply Bulletin 56, 13 p.

Drost, B.W., 1982, Water resources of the Gig Harbor Peninsula and adjacent areas, Washington: U.S. Geological Survey Water-Resources Investigations Report 81-1021, 148 p.

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

———1986, Stratigraphy and chronology of Quaternary deposits of the Puget Lowland and Olympic Mountains of Washington and the Cascade Mountains of Washington and Oregon: Quaternary Science Reviews, v. 5, p. 145-159.

———1994, Chronology of Pre-Late Wisconsin Pleistocene sediments in the Puget Lowland, Washington: Washington Division of Geology and Earth Resources, Bulletin 80, p. 191-206.

Easterbrook, D.J., Blunt, D.J., and Rutter, N.W., 1982, Pleistocene glacial and interglacial chronology in western Washington: Geological Society of America Abstracts with Programs, v. 14, no. 4, p 161.

Easterbrook, D.J., Briggs, N.D., Westgate, J.A., and Gorton, M.P., 1981, Age of the Salmon Springs Glaciation in Washington: Geology, v. 9, p. 87-93.

Ferris, J.G., Knowles, D.B., Brown, R.H., and Stallman, R.W., 1962, Theory of aquifer tests: U.S. Geological Survey Water-Supply Paper 1536-E, 174 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, N.J., Prentice-Hall, 604 p.

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

Gower, H.D., 1978, Tectonic map of the Puget Sound region, Washington, showing locations of faults, principal folds, and large-scale Quaternary deformation: U.S. Geological Survey Open-File Report 78-426, 1 plate, scale 1:250,000, 90 p.

Haley and Aldrich, Inc., 1975, Drydock Trident Support Site, Bangor, Preliminary Engineering Study, Vol. 2, Site Investigation, Part A: Cambridge, Mass., Haley and Aldrich, Inc., [about 400 p.]

Hall, J.B., and Othburg, K.L., 1974, Thickness of unconsolidated sediments, Puget lowland, Washington: Olympia, Wash., Washington Department of Natural Resources, Geologic Map GM-12, scale 1:250,000, 1 plate, 3 p.

Hansen, A.J., Jr., and Bolke, E.L., 1980, Ground-water availability on the Kitsap Peninsula, Washington: U.S. Geological Survey Water-Resources Investigations, Open-File Report 80-1186, 65 p.

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

Hart Crowser, Inc., 1988, Current situation report, site A, Naval Submarine Base Bangor, Wash.: Seattle, Wash., Hart Crowser, Inc. 2 v.

———1989, Current situation report, sites C, D, E, F, 5, 6, 11, 12, 24, and 25, SUBASE Bangor, Bangor, Washington: Seattle, Wash., Hart Crowser, Inc., 2 v.

Johnson Controls, 1992, SUBASE Bangor wetlands report and maps: Naval Submarine Base Bangor, Silverdale, Washington, Johnson Controls, [about 100 p.].

Johnson, S.Y., Potter, C.J., and Armentrout, J.M., 1994, Origin and evolution of the Seattle fault and Seattle basin, Washington: Geology, v. 22, p. 71-74.

Jones, M.A., 1996, Thickness of unconsolidated deposits in the Puget Sound Lowland, Washington and British Columbia: U.S. Geological Survey Water Resources Investigation Report 94-4133, 1 plate, scale 1:500,000.

Joseph, N.L., 1989, Geologic guide book for Washington and adjacent areas: Washington Division of Geology and Earth Resources, Information Circular 86, 369 p.

Kinner, B.K. and Dugan, J.P.,Jr., 1982, Geotechnical investigations for Trident Drydock: Journal of the Boston Society of Civil Engineers Section, American Society of Civil Engineers, vol. 68, p.237-274.

Kinner, B.K. and Stimpson, W.E., 1983, Artesian pressure relief for Trident Drydock: Journal of Construction Engineering and Management, American Society of Civil Engineers, v. 109, no. 1, p. 74-88.

Kitsap County Ground Water Advisory Committee, Economic and Engineering Services, Inc., Hart Crowser Inc., Pacific Groundwater Group, and Robinson and Noble, Inc., 1991, Kitsap County ground water management plan, Grant no. 1, Background data collection and management issues: Olympia, Wash., Economic and Engineering Services, Inc., 2 v.

Lea, P.D., 1984, Pleistocene glaciation at the southern margin of the Puget Lobe, western Washington: Seattle, Wash., University of Washington, Master of Science thesis, 96 p.

Lum, W.E., II, 1979, Water resources of the Port Madison Indian Reservation, Washington: U.S. Geological Survey Water-Resources Investigations Report 78-112, 73 p.

Manson, C.J., 1984, Index to geological and geophysical mapping of Washington 1899-1983: Washington Division of Geology and Earth Resources, Information Circular 77, 83 p.

Manson, C.J., 1986, Thesis on Washington geology 1901-1985: Washington Division of Geology and Earth Resources, Information Circular 80, 409 p.

Manson, C.J., 1994, Geologic and geophysical mapping of Washington 1984 through 1993 and theses on the Geology of Washington 1986 through 1993: Washington Division of Geology and Earth Resources, Open-File Report 94-2, 41 p.

Mofjeld, H.O. and Larsen, L.H., 1984, Tides and tidal currents of the inland waters of western Washington: Seattle, Wash., National Oceanic and Atmospheric Administration, Technical Memorandum ERL PMEL-56, 52 p.

Molenaar, Dee, 1993, Geohydrology of Kitsap County, Washington, relative to land-use development and long-range planning: Burley, Wash., 64 p., 1 plate.

National Oceanic and Atmospheric Administration, 1995, Climatological data annual summary, Washington: Asheville, N.C., National Climatic Data Center, v. 99, no. 13, 35 p.

Noble, J.B., 1975a, Geohydrologic investigation for a water supply for Trident Support site: Tacoma, Wash., Robinson and Noble, Inc., [10] p.

——— 1975b, Contribution to hydrogeologic investigation, Trident, Bangor Annex, Kitsap County, Washington: Tacoma, Wash., Robinson and Noble, Inc., 12 p.

———1976, Construction of Trident wells 501-504 (blue wells) and related hydrogeology: Tacoma, Wash., Robinson and Noble, Inc., 22 p.

———1989, The Trident aquifer study at Bangor, Kitsap County, *in* Galster, R.W., ed., Engineering Geology in Washington: Washington Division of Geology and Earth Resources, Bulletin 78, v. 2, p. 983-988.

———1990, Proposed revision of nomenclature for the Pleistocene stratigraphy of coastal Pierce County, Washington: Washington Division of Geology and Earth Resources, Open-File Report 90-4, 54 p.

Owenby, J.R., and Ezell, D.S., 1992, Monthly station normals of temperature, precipitation, and heating and cooling degree days, 1961-1990, Climatography of the United States no. 81: Asheville, N.C., National Oceanic and Atmospheric Administration, [30] p.

Parametrix, Inc., 1994, Comprehensive Water System Plan, Naval Submarine Base, Bangor: Bremerton, Wash., Parametrix, Inc., [about 500] p.

Paterson, W.D., 1981, Ground-water hydrology at the Naval submarine base, Bangor, Washington: Tacoma, Wash., Robinson, Noble, and Carr, Inc., vols. 1 and 2.

Prudic, D.E., 1991, Estimates of hydraulic conductivity from aquifer-test analyses and specific-capacity data, Gulf Coast regional aquifer systems, south-central United States: U.S. Geological Survey Water-Resources Investigations Report 90-4121, 38 p.

Puget Sound Council of Governments, 1988, Population and employment forecasts: Seattle, Wash., Puget Sound Council of Governments, Information Center, [about 200] p.

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

Shannon and Wilson, Inc., 1973, Subsurface investigation, Trident Support Complex, Bangor Annex, Washington: Seattle, Wash., Shannon and Wilson, Inc., 126 p.

Shannon and Wilson, Inc., Robinson and Noble, Inc., and Battelle, Pacific Northwest Laboratories, 1975, Hydrogeology investigation--Trident support site, Bangor Annex, NTS, Keyport, Washington, Supplement no. 14: Seattle, Wash., Shannon and Wilson, Inc., prepared for Bovay Engineers, Inc., Spokane, Washington, [44] p.

Thorson, R.M., 1980, Ice-sheet glaciation of the Puget lowland, Washington, during the Vashon Stade (late Pleistocene): Quaternary Research, v. 13, no. 3, p. 303-321.

Thorson, R.M., 1989, Glacio-isostatic response of the Puget Sound area, Washington: Geological Society of America Bulletin, v. 101, p. 1163-1174.

Tracy, J.V., and Dion, N.P., 1976, Evaluation of ground-water contamination from cleaning explosive projectile casings at the Bangor Annex, Kitsap County, Washington, phase II: U.S. Geological Survey Water-Resources Investigations Report 62-75, 44 p.

U.S. Bureau of the Census, 1992, 1990 Census of population and housing, *in* Summary Tape File 1A on CD-ROM: Washington D.C., U.S. Bureau of the Census.

Vanderwal, K.S., 1985, Compositional and textural variations in the Vashon till and underlying drifts in the northern and central Puget lowland, Washington: Seattle Wash., University of Washington, Master of Science thesis, 110 p.

Washington Department of Ecology, 1978, Coastal zone atlas of Washington, Volume 10: Olympia, Wash., Washington State Department of Ecology, DOE 77-21-10, 49 p.

Winter, T.C., 1975, Delineation of buried glacial-drift-aquifers: U.S. Geological Survey Journal of Research, v. 3, no. 2, Mar-Apr., p. 137-148.

Yount, J.C. and Gower, H.D., 1991, Bedrock geologic map of the Seattle 30' by 60' quadrangle, Washington: U.S. Geological Survey Open-File Report 91-147, 37 p., 4 plates, scale 1:100,000.

Yount, J.C., Minard, J.P., and Dembroff, G.R., 1993, Geologic map of surficial deposits in the Seattle 30' by 60' quadrangle, Washington: U.S. Geological Survey Open-File Report 93-233, 2 plates, scale 1:100,000.

Appendix 1.--*Physical and hydrologic data for the inventoried sites on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington*

[Hydrogeologic unit that the well is open to: Qvr, Shallow aquifer; Qvt, Vashon till confining unit; Qva, Vashon aquifer; QC1, Upper confining unit; QC1pi, Permeable interbeds; QA1, Sea level aquifer; QC2, Lower confining unit; QA2, Deep aquifer; QU, Undifferentiated deposits; Multiple, well is screened in more than one hydrogeologic unit; Boring, uncased hole drilled for lithologic information only. Altitudes accurate to 0.1 feet were surveyed; values were obtained from consultant reports. "Depth of well" is the depth of the finished well; "depth of hole" is the total depth to which the hole was drilled. Depth of hole is included if the hole was never completed as a well, or if the depth of the hole is 5 or more feet greater than the depth of the completed well. Use of water: C, commercial; D, dewater; F, fire; H, domestic; I, irrigation; P, public supply; T, institutional; U, unused; and Z, other. Type of log: C, caliper; D, driller's; E, electric; G, geologist; I, induction; J, gamma ray; N, neutron; and Z, other. Navy identifier: --, site not located on SUBASE Bangor. Other: gal/min, gallons per minute; --, not determined]

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
25N/01E-01F02	47°41′19″	122°37′12″	Qva	180	69	30	28	44	H	D	--
25N/01E-01N01	47°40′50″	122°37′23″	QA1	165	447	15	116	5.8	H	D	--
25N/01E-02A01	47°41′28″	122°37′37″	QC1pi	60	63	20	30.6	29	C	D	--
25N/01E-02E02	47°41′24″	122°38′42″	Qva	350	74	20	14.5	33	H	D	--
25N/01E-02J02	47°41′06″	122°37′55″	QU	200	1,070/1,147	206	66.5	21	P	D	--
25N/01E-02J03	47°41′06″	122°37′55″	QU	200	1,030/1,049	805	80	35	P	D	--
25N/01E-02Q01	47°40′56″	122°38′14″	Qva	340	68	20	15	32	H	D	--
25N/01E-03B01	47°41′38″	122°39′16″	QC1pi	310	399/422	15	25	29	H	D	--
25N/01E-03E01	47°41′13″	122°40′06″	Qva	370	336	1,590	46	0.40	P	D	--
25N/01E-03E02	47°41′14″	122°40′09″	Qva	350	328	880	51	140	P	D, J	--
25N/01E-03E03	47°41′13″	122°40′09″	Qva	350	185/192	170	18	190	P	D	--
25N/01E-03E04	47°41′14″	122°40′11″	Qva	350	192	143	22	110	P	D	--
25N/01E-03K01	47°41′06″	122°39′14″	Qva	300	57	25	17	73	H	D	--
25N/01E-04C01	47°41′35″	122°41′05″	QA1	195	289	15	1	880	H	D	--
25N/01E-04M02	47°41′08″	122°41′10″	Qva	140	95	40	1	2,400	H	D	--
25N/01E-04M03	47°41′05″	122°41′20″	Qvt	180	60	15	13	47	H	D	--
25N/01E-05A03	47°41′31″	122°41′29″	Qva	290	72	10	9	57	H	D	--
25N/01E-05A04	47°41′31″	122°41′43″	Qva	260	98	12	5	75	H	D	--
25N/01E-05J01	47°41′07″	122°41′44″	QC1	220	214	325	38	130	P	D	--
25N/01E-05K01	47°41′08″	122°42′05″	Qva	260	118	11	3	110	H	D	--
25N/01E-05P01	47°40′57″	122°42′08″	QC1pi	246	250/640	--	--	--	Z	D, J, I, E	TH8 shallow
25N/01E-05P01P1	47°40′57″	122°42′08″	QA1	246	395/640	--	--	--	Z	-	TH8 deep

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
25N/01E-05Q01	47°40′46′′	122°42′04′′	QC1pi	160	157	20	2	540	H	D	--
25N/01E-05Q02	47°40′58′′	122°41′53′′	Qva	175	54	15	15	51	H	D	--
25N/01E-05R02	47°40′58′′	122°41′43′′	QC1pi	210	179	15	13	30	H	D	--
25N/01E-06D01	47°41′29′′	122°43′45′′	Qva	360	207	35	15	--	U	D	NAD No.5
25N/01E-06D02	47°41′36′′	122°43′50′′	QC1	355	286	--	--	--	U	D	NAD No.4
25N/01E-06D04	47°41′31′′	122°44′00′′	QA1	294.1	362/713	--	--	--	Z	D, I, E	TH17
25N/01E-06E01	47°41′12′′	122°43′53′′	QA1	305	312	20	27	31	H	D	--
25N/01E-06H01	47°41′13′′	122°42′50′′	Qva	297	166/208	--	--	--	Z	D	MW-3
25N/01E-06J01	47°41′10′′	122°42′47′′	Qva	280	86	--	--	--	Z	D	MW-4
25N/01E-06J02	47°41′07′′	122°42′48′′	Qva	250	95/103	--	--	--	Z	D	MW-6
25N/01E-06L02	47°41′00′′	122°43′30′′	QA1	320	384	16	15	26	T	D	--
25N/01E-07A01	47°40′35′′	122°42′47′′	QC1pi	320	305/337	164	14.6	170	P	D	--
25N/01E-07C02	47°40′36′′	122°43′38′′	QA1	350	371	12	8	37	H	D	--
25N/01E-07C03	47°40′36′′	122°43′26′′	QA1	305	386	6.5	105	2.7	H	D	--
25N/01E-07D01	47°40′44′′	122°43′58′′	QA1	275	304	30	27	52	H	D	--
25N/01E-07E02	47°40′28′′	122°44′00′′	QC1pi	370	304	10	1.5	350	H	D	--
25N/01E-07H04	47°40′20′′	122°42′47′′	Qva	290	132	20	6	170	H	D	--
25N/01E-07J01	47°40′08′′	122°42′49′′	Qva	245	83	30	4	210	H	D	--
25N/01E-07J02	47°40′19′′	122°42′47′′	QC1pi	285	260	10	30	15	H	D	--
25N/01E-07K01	47°40′10′′	122°43′12′′	Qva	320	147	20	7	76	H	D	--
25N/01E-07N01	47°39′56′′	122°43′57′′	Qva	410	86	14	.5	1,400	H	D	--
25N/01E-07N02	47°40′04′′	122°44′01′′	QC1pi	425	297/312	--	--	--	P	D	--
25N/01E-07N02D1	47°40′04′′	122°44′01′′	QC1pi	425	358	23	23	16	P	D	--
25N/01E-07P02	47°40′03′′	122°43′31′′	QC1pi	315	297	20	33	27	H	D	--
25N/01E-07Q03	47°39′55′′	122°43′18′′	QC1pi	300	252	15	3	260	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
25N/01E-07Q04	47°39′58″	122°43′12″	Qva	360	--	15	8	45	P	D	--
25N/01E-07R01	47°40′03″	122°42′49″	Qva	270	80	32	10	150	H	D	--
25N/01E-08J02	47°40′09″	122°41′32″	QC1pi	150	168	30	19	75	H	D	--
25N/01E-08L02	47°40′10″	122°42′24″	Qva	270	113	16	18	45	H	D	--
25N/01E-08L03	47°40′12″	122°42′11″	Qva	260	106	16	13	63	H	D	--
25N/01E-08L04	47°40′05″	122°42′20″	Qva	245	70	10	16	29	H	D	--
25N/01E-08Q03	47°40′00″	122°42′01″	QC1pi	245	300/317	170	59	20	U	D	--
25N/01E-09H01	47°40′31″	122°40′25″	QA1	205	280	40	67	12	P	D	--
25N/01E-09J01	47°40′10″	122°40′29″	QC1	155	183	20	82	11	H	D	--
25N/01E-09J01D01	47°40′10″	122°40′29″	QA1	155	255	10	63	6.4	H	D	--
25N/01E-09J02S	47°40′09″	122°40′27″	Qvt	185	--	--	--	--	U	-	--
25N/01E-09N02	47°40′03″	122°41′15″	QC1pi	55	84	--	--	--	I	D	--
25N/01E-10A03	47°40′33″	122°39′08″	QC1pi	300	342	12	106	12	H	D	--
25N/01E-10D01	47°40′39″	122°40′02″	Qva	415	330/623	550	26	210	P	D	--
25N/01E-10N01	47°40′05″	122°40′08″	QA1	345	483/539	100	76.8	33	P	D, J	--
25N/01E-11M01	47°40′08″	122°38′39″	QC1pi	200	225	8	50	7.1	H	D	--
25N/01E-12N01	47°40′00″	122°37′27″	QC1	260	267	15	11	64	H	D	--
25N/01E-12N02	47°39′58″	122°37′23″	Qva	275	85	20	10	--	H	D	--
25N/01E-13D01	47°39′42″	122°37′19″	QC1	260	423	5	9.9	7.6	H	D	--
25N/01E-13D02	47°39′49″	122°37′23″	QC1	280	303	60	28	55	H	D	--
25N/01E-13L02	47°39′25″	122°37′08″	Qvt	140	89	2	13	9.4	H	D	--
25N/01E-13L03	47°39′25″	122°37′08″	QC1	140	294	--	--	--	U	D	--
25N/01E-13M03	47°39′16″	122°37′35″	QC1	135	159	5	79	1.2	U	D	--
25N/01E-14A01	47°39′50″	122°37′54″	QC1	110	102	10	70	6.0	H	D	--
25N/01E-14E02	47°39′30″	122°38′44″	Qva	140	79	6	49	2.5	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
25N/01E-14J02	47°39′23″	122°37′52″	QA1	80	346	16	30	12	U	D	--
25N/01E-14Q03	47°39′03″	122°38′16″	QA2	85	560/1,009	307	93.5	17	P	D	--
25N/01E-15A01	47°39′52″	122°39′02″	Qva	190	99	6	67	3.6	H	D	--
25N/01E-15D01	47°39′42″	122°40′02″	Multiple	325	1,000/1,194	225	66	20	P	D	--
25N/01E-15J02	47°39′21″	122°38′57″	Qva	125	77	7	57.8	5.4	H	D	--
25N/01E-15J03	47°39′28″	122°39′09″	Qva	150	152	12	108	5.0	H	D	--
25N/01E-16J01	47°39′16″	122°40′15″	QC1pi	210	280/294	408	61.3	100	P	D	--
25N/01E-17B01	47°39′46″	122°41′56″	Qva	225	90/102	20	20	61	H	D	--
25N/01E-17C02	47°39′44″	122°42′08″	Qva	190	51	10	26	17	U	D	--
25N/01E-17C03	47°39′42″	122°42′20″	Qva	210	53	10	4	38	H	D	--
25N/01E-17F02	47°39′39″	122°42′21″	Qva	220	98	32	10.8	42	H	D	--
25N/01E-17G01	47°39′32″	122°41′52″	QC1pi	185	193	16	6	130	H	D	--
25N/01E-17N01	47°39′12″	122°42′34″	Qva	185	71	25	24	51	I	D	--
25N/01E-17N02	47°39′12″	122°42′34″	Qva	190	61	10	9	54	U	D	--
25N/01E-18B01	47°39′41″	122°43′06″	Qva	290	160	20	2	360	H	D	--
25N/01E-18C02	47°39′44″	122°43′33″	QC1pi	320	195	7	15	22	H	D	--
25N/01E-18D03	47°39′45″	122°43′43″	QC1pi	380	382/400	30	3	100	P	D	--
25N/01E-18H01	47°39′28″	122°42′54″	QA2	320	868/1,064	515	32.1	69	P	D, J, I, Z	--
25N/01E-18H02	47°39′38″	122°42′57″	Qva	330	169	18	10	110	H	D	--
25N/01E-18J03	47°39′22″	122°42′52″	Qva	285	52	10	12	41	H	D	--
25N/01E-18L01	47°39′26″	122°43′38″	QC1pi	455	341	10	20	22	H	D	--
25N/01E-19D01	47°38′58″	122°44′00″	QC1	465	315	--	--	--	U	D	--
25N/01E-19H02	47°38′37″	122°43′02″	QA1	370	601	--	--	--	T	D, G, J	--
25N/01E-19P01	47°38′19″	122°43′41″	Qva	490	237	10	2	120	H	D	--
25N/01E-19P02	47°38′14″	122°43′25″	QA2	530	996/1,200	160	21	29	P	D, J, I, Z	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
25N/01E-19R02	47°38′10′′	122°42′49′′	Qva	340	228	8	2	210	H	D	--
25N/01E-20A01	47°38′56′′	122°41′45′′	Qva	40	32	--	--	--	U	-	--
25N/01E-20F01	47°38′46′′	122°42′25′′	QC1pi	200	264	350	53.9	120	P	D	--
25N/01E-20L02	47°38′25′′	122°42′09′′	Qva	105	52	30	12	130	U	D	--
25N/01E-20N01	47°38′12′′	122°42′37′′	Qva	220	119	26	17	43	H	D	--
25N/01E-21C04	47°38′54′′	122°40′52′′	QC1pi	5	58	30	0	--	H	D	--
25N/01E-21R02	47°38′10′′	122°40′15′′	QC1pi	30	55	12	1.4	490	H	D	--
25N/01E-22F01	47°38′37′′	122°39′53′′	Multiple	95	450/1,193	--	--	--	P	D	--
25N/01E-22F02	47°38′37′′	122°39′53′′	QC1pi	95	198.6	280	106.5	23	P	D	--
25N/01E-22J01	47°38′27′′	122°39′14′′	QA2	200	892/947	350	52	62	P	D, J, I	--
25N/01E-22K01	47°38′28′′	122°39′33′′	QC1	80	79	20	10	120	H	D	--
25N/01E-23D01	47°39′00′′	122°38′54′′	QC1	80	108	12	8	75	H	D	--
25N/01E-23J01	47°38′25′′	122°37′41′′	QA1	150	359	4	164	0.54	H	D	--
25N/01E-23N01	47°38′16′′	122°38′38′′	QC1pi	256.90	900/1,000	20	11	--	U	D, I, J	--
25N/01E-23N02	47°38′16′′	122°38′38′′	QA2	256.90	840/1,000	134	88	7.6	U	D	--
25N/01E-24D02	47°38′51′′′	122°37′29′′	QA1	150	522	380	32	290	U	D	--
25N/01E-24P01	47°38′14′′	122°37′10′′	QA2	275	822	50	108	3.2	P	D	--
25N/01E-26L01	47°37′32′′	122°38′20′′	QA1	161.65	380/582	508	75.8	93	P	D	--
25N/01E-27B01	47°37′59′′	122°39′33′′	QC1pi	205	271	20	62	7.2	H	D	--
25N/01E-27R01	47°37′27′′′	122°39′07′′	QC1pi	180	156	10	26	17	H	D	--
25N/01E-29D01	47°38′08′′	122°42′29′′	QA2	160	688/706	--	--	--	P	D, J, I	--
25N/01E-29M01	47°37′39′′	122°42′41′′	Qva	205	108	10	10	51	H	D	--
25N/01E-30C02	47°38′08′′	122°43′26′′	Qva	520	489/500	8.5	19	9.0	H	D	--
25N/01E-30C03	47°38′04′′	122°43′36′′	Qva	480	208/213	3.5	10	8.4	H	D	--
25N/01E-30D02	47°38′03′′	122°43′50′′	Qva	440	391	32	63	5.8	P	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
25N/01E-30D03	47°38′02″	122°43′43″	Qva	460	410	33	80	4.6	P	D	--
25N/01W-01A01	47°41′37″	122°44′10″	Qva	240	17	--	--	--	U	-	--
25N/01W-01A02	47°41′36″	122°44′06″	Qva	240	63	15	13.3	52	H	D	--
25N/01W-01B02	47°41′30″	122°44′35″	QA1	70	119	20	.2	6,100	H	D	--
25N/01W-01G05	47°41′24″	122°44′27″	QA1	180	178	20	1	1,200	H	D	--
25N/01W-01H01	47°41′18″	122°44′02″	QA1	240	262	10	4	130	H	D	--
25N/01W-01K03	47°41′07″	122°44′37″	Qva	70	71	10	6	84	H	D	--
25N/01W-12J01	47°40′07″	122°44′03″	QC1pi	425	360	20	6	170	H	D	--
25N/01W-12K04	47°40′12″	122°44′40″	QC1pi	220	204	30	7.5	200	P	D	--
25N/01W-12L02	47°40′18″	122°44′53″	QA1	30	86	15	52	12	H	D	--
25N/01W-12N01	47°39′59″	122°45′12″	QC1	10	182	8	105	3.1	H	D	--
25N/01W-12Q01	47°40′03″	122°44′25″	QC1pi	280	275	30	14	19	P	D	--
25N/01W-12R01	47°39′56″	122°44′08″	QC1pi	420	362	10	3	170	H	D	--
25N/01W-12R02	47°39′59″	122°44′05″	Qva	425	100	--	--	--	H	D	--
25N/01W-13A01	47°39′48″	122°44′17″	QC1	380	268	10	3	84	H	D	--
25N/01W-13K01	47°39′21″	122°44′22″	Qva	410	73	12	28	20	H	D	--
25N/01W-13L01	47°39′17″	122°44′41″	QA1	350	411	20	1	1,100	P	D	--
25N/01W-13L02	47°39′19″	122°44′41″	QC1pi	350	317	10	5	24	H	D	--
25N/01W-13R02	47°39′11″	122°44′20″	QC1	410	160	20	17	36	H	D	--
25N/01W-14E07	47°39′39″	122°46′21″	QA1	15	149	320	13	280	H	D	--
25N/01W-14F04	47°39′40″	122°46′12″	QA1	45	198	40	86.4	28	H	D	--
25N/01W-14G02	47°39′36″	122°45′54″	QA1	215	520	20	4	310	P	D	--
25N/01W-14G03	47°39′36″	122°45′43″	QC1	245	106	6.75	31	9.9	H	D	--
25N/01W-14G04S	47°39′40″	122°45′56″	Qva	100	--	--	--	--	H	-	--
25N/01W-15J03	47°39′19″	122°46′45″	Qva	30	77	14	13	91	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
25N/01W-15L01	47°39′21″	122°47′30″	QA1	10	132	27	11	50	H	D	--
25N/01W-15N02	47°39′07″	122°47′46″	QA1	240	270	20	2	560	H	D	--
25N/01W-15Q03	47°39′11″	122°47′09″	QA1	95	173	14.5	1	860	H	D	--
25N/01W-22C02	47°38′57″	122°47′16″	QA1	150	166	20	2	130	H	D	--
25N/01W-22E01	47°38′48″	122°47′35″	QA1	269	364/500	720	21.3	360	P	D, J	--
25N/01W-22F01	47°38′41″	122°47′17″	QA1	240	325	15	20	37	H	D	--
25N/01W-22N01	47°38′12″	122°47′34″	QA1	300	258	20	0	--	H	D	--
25N/01W-23G01	47°38′47″	122°45′38″	Qva	440	182	24	3	210	P	D	--
25N/01W-23K03	47°38′24″	122°45′47″	QC1pi	510	253	16	--	--	H	D	--
25N/01W-23K04	47°38′35″	122°45′40″	QC1pi	500	255	10	2	140	P	D	--
25N/01W-24A01	47°38′56″	122°44′03″	QC1pi	450	377	8	10	50	H	D	--
25N/01W-24B02	47°38′50″	122°44′31″	QC1pi	330	311	14	3	650	P	D	--
25N/01W-24H01	47°38′43″	122°44′09″	QC1pi	380	377	15	20	46	H	D	--
25N/01W-24J02	47°38′31″	122°44′04″	Qva	390	278	60	5	620	P	D	--
25N/01W-24N02	47°38′13″	122°45′03″	QC1	450	189	18	3	340	H	D	--
25N/02E-19N02	47°38′22″	122°36′21″	QA2	135	781	765	111	54	P	D, N	--
25N/02E-19N03	47°38′22″	122°36′21″	QA1	135	523	--	--	--	P	-	--
26N/01E-01D01	47°46′37″	122°37′30″	QC1pi	430	315	10	50	8.6	H	D	--
26N/01E-01N01	47°46′07″	122°37′27″	QC1pi	360	284	191	30	350	H	D	--
26N/01E-02G02	47°46′29″	122°38′11″	Qva	95	43	60	11	290	H	D	--
26N/01E-02K01	47°46′13″	122°38′12″	QC1pi	290	304	16	24	26	H	D	--
26N/01E-02K02	47°46′14″	122°37′58″	QA1	210	277	22	48	20	I	D	--
26N/01E-02L02S	47°46′20″	122°38′31″	Qvr	95	--	--	--	--	P	-	--
26N/01E-02L03	47°46′13″	122°38′22″	QA2	85	525/538	600	112	21	P	D,G	--
26N/01E-02L04	47°46′14″	122°38′22″	Qva	85	--/20	--	--	--	U	-	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-02L05	47°46′13″	122°38′24″	QA1	80	312/320	--	--	--	P	D	--
26N/01E-03F02	47°46′27″	122°39′45″	QC1	410	331	20	42	11	H	D	--
26N/01E-03N02	47°46′01″	122°39′59″	Qva	395	117	15	.5	1,300	H	D	--
26N/01E-03N03	47°46′06″	122°39′58″	QC1	390	282	60	6	280	H	D	--
26N/01E-03N04	47°46′07″	122°40′06″	Qva	390	144	25	50	11	H	D	--
26N/01E-04B01	47°46′49″	122°40′33″	QA2	280	687	300	52.3	45	P	D	--
26N/01E-04B02	47°46′48″	122°40′33″	Multiple	300	690/765	50	70.8	4.3	U	D, J, I, Z	--
26N/01E-04C01	47°46′47″	122°40′58″	QC1pi	190	271	20	37	25	H	D	--
26N/01E-04E03	47°46′38″	122°41′15″	QA1	120	293	30	35	41	H	D	--
26N/01E-04L01	47°46′18″	122°41′04″	Qva	250	104	12	27	4.6	H	D	--
26N/01E-04M01	47°46′17″	122°41′24″	QC1	170	92	10	63	3.2	H	D	--
26N/01E-05J02	47°46′18″	122°41′29″	QC1	165	95	11	63	2.8	H	D	--
26N/01E-05K01	47°46′14″	122°42′02″	QA1	120	360	--	--	--	U	D	--
26N/01E-05K02	47°46′23″	122°41′49″	QA1	120	420	147	214	12	U	D	--
26N/01E-05P01	47°46′02″	122°42′14″	Qva	97.12	87/113	--	--	--	Z	D	A-MW31
26N/01E-05Q01	47°46′10″	122°41′56″	QC1	140	100	--	--	--	Z	D	A-MW30
26N/01E-06R01	47°46′06″	122°42′48″	Qvr	10	52	--	--	--	Z	D	50-MW-2
26N/01E-07J01	47°45′24″	122°42′54″	QC1pi	119.88	76/130	--	--	--	Z	D	CW-MW32
26N/01E-07J02	47°45′23″	122°42′54″	QC1	119.46	42	--	--	--	Z	D	CW-MW33
26N/01E-07R03	47°45′19″	122°42′57″	QC1	122.20	92/114	--	--	--	Z	D	CW-MW30
26N/01E-07R04	47°45′18″	122°42′56″	QC1	122.23	38	--	--	--	Z	D	CW-MW31
26N/01E-08B01	47°45′47″	122°41′59″	QC1	177.90	92	--	--	--	Z	D	A-MW21
26N/01E-08B02	47°45′54″	122°41′58″	QC1	163.36	85	--	--	--	Z	D	A-MW33
26N/01E-08C01	47°45′49″	122°42′08″	QC1	151.90	64/98	--	--	--	Z	D	A-MW20
26N/01E-08C02	47°46′00″	122°42′09″	Qva	155	123/136	--	--	--	Z	D	A-MW44

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-08F01	47°45′38″	122°42′16″	QA1	183.6	566	--	--	--	U	D, J, I, E	TH15
26N/01E-08M01	47°45′21″	122°42′32″	QA2	205	537/1,205	--	--	--	Z	D, J, I, E	TH3
26N/01E-08N01	47°45′10″	122°42′29″	Qva	253.05	30	--	--	--	Z	D	CE-MW27
26N/01E-08N02	47°45′09″	122°42′28″	QC1	253.31	73	--	--	--	Z	D	CE-MW28
26N/01E-08N03	47°45′10″	122°42′28″	QC1	253.19	97/106	--	--	--	Z	D	CE-MW29
26N/01E-08N04	47°45′16″	122°42′42″	QC1	143.77	76	--	--	--	Z	D	CW-MW26
26N/01E-08N05	47°45′17″	122°42′44″	Qva	142.79	58	--	--	--	Z	D	CW-MW27
26N/01E-08P01	47°45′09″	122°42′24″	Qva	276.30	50/56	--	--	--	Z	D	CE-MW26
26N/01E-09C01	47°45′59″	122°41′01″	Qva	315	80	--	--	--	U	-	--
26N/01E-09C02	47°45′59″	122°41′01″	QA1	309	538	10	0	--	P	D	--
26N/01E-09E01	47°45′36″	122°41′10″	QC1pi	340	301/310	8	140	0.54	H	D	--
26N/01E-09F01	47°45′44″	122°40′58″	QC1pi	370	307	30	31	22	H	D	--
26N/01E-09G03	47°45′44″	122°40′30″	Qva	380	126	20	4.5	120	H	D	--
26N/01E-09K02	47°45′22″	122°40′35″	Qva	390	108	20	2	560	H	D	--
26N/01E-09R02	47°45′19″	122°40′11″	Qva	330	68	25	9	140	H	D	--
26N/01E-10D01	47°45′52″	122°39′57″	Qva	350	116	40	0	--	H	D	--
26N/01E-10H02	47°45′43″	122°39′02″	Qva	195	126	16	31	21	H	D	--
26N/01E-10M01	47°45′25″	122°40′02″	Qva	320	97	40	3	380	H	D	--
26N/01E-10M02	47°45′26″	122°40′02″	Qva	320	89	--	--	--	U	-	--
26N/01E-10N03	47°45′11″	122°40′06″	Qva	300	56	14	14	63	H	D	--
26N/01E-10N04	47°45′11″	122°40′05″	Qvt	300	18	--	--	--	U	-	--
26N/01E-11F02	47°45′33″	122°38′20″	Qva	120	94	55	4	780	H	D	--
26N/01E-11J01	47°45′29″	122°37′41″	QC1	170	311	4	198	0.40	H	D	--
26N/01E-11L02	47°45′28″	122°38′16″	QA1	90	235	25	125	8.6	H	D	--
26N/01E-11L03	47°45′26″	122°38′22″	Qva	120	95	15	10	37	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-12C02	47°45′49″	122°36′59″	QC1pi	212	150	40	15	140	H	D	--
26N/01E-12C03	47°45′57″	122°36′59″	QA1	250	448	42	13	110	C	D	--
26N/01E-12D01	47°45′56″	122°37′20″	Multiple	310	454	16	5	30	H	D	--
26N/01E-12Q01	47°45′10″	122°36′43″	QC1	365	169	--	--	--	U	-	--
26N/01E-13B01	47°45′04″	122°36′42″	QC1pi	370	313/320	311	36	170	P	D	--
26N/01E-13C03	47°44′58″	122°37′11″	QC1pi	380	265	40	7	310	H	D	--
26N/01E-13D01	47°45′01″	122°37′24″	QC1pi	350	272	30	44	17	H	D	--
26N/01E-13D02	47°45′01″	122°37′26″	QC1	343	--	--	--	--	H	-	--
26N/01E-13F02	47°44′43″	122°37′09″	QC1pi	390	310	--	--	--	P	D	--
26N/01E-13H04	47°44′47″	122°36′34″	Qva	330	124	18	25	8.7	H	D	--
26N/01E-14C01	47°45′07″	122°38′21″	QC1	35	323	5	40	6.2	H	D	--
26N/01E-14R01	47°44′22″	122°37′39″	QC1	280	138	7	40	6.3	H	D	--
26N/01E-15C02	47°45′05″	122°39′44″	Qva	230	124	15	40	17	H	D	--
26N/01E-15C03	47°45′06″	122°39′42″	Qvt	230	--	--	--	--	U	-	--
26N/01E-15P02	47°44′17″	122°39′37″	Qva	100	91	20	27	36	H	D	--
26N/01E-15P03	47°44′17″	122°39′35″	Qvt	75	20	--	--	--	H	-	--
26N/01E-16D02	47°44′55″	122°41′17″	Qva	420	126	10	16	15	H	D	--
26N/01E-16F03	47°44′44″	122°41′02″	Qva	430	151	14	14	27	H	D	--
26N/01E-16F04	47°44′45″	122°40′57″	Qva	425	139	16	19	20	H	D	--
26N/01E-16H01	47°44′53″	122°40′19″	Qva	320	104	30	14	55	H	D	--
26N/01E-16H02S	47°44′42″	122°40′10″	Qvt	250	--	--	--	--	H	-	--
26N/01E-16N03	47°44′27″	122°41′16″	Qva	435	177	15	14.6	48	H	D	--
26N/01E-17A01	47°45′07″	122°41′27″	QA1	403.8	800	--	--	--	Z	D, I, J, E	TH10
26N/01E-17C01	47°45′04″	122°42′10″	QC1	340	144/242	--	--	--	Z	D	BG01
26N/01E-17D01	47°45′07″	122°42′38″	Qvt	203.60	8/16	--	--	--	Z	D	CE-MW34

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-17D02	47°45′08″	122°42′38″	QC1	202.59	53/92	--	--	--	Z	D	CE-MW35
26N/01E-17D03	47°45′07″	122°42′39″	QC1	202.75	82	--	--	--	Z	D	CE-MW36
26N/01E-17K01P1	47°44′36″	122°41′58″	Qva	400	235/765	--	--	--	Z	D, J, I, E, C	TH16 shallow
26N/01E-17K01P2	47°44′36″	122°41′58″	QA2	400	765	--	--	--	Z	-	TH16 deep
26N/01E-17N01	47°44′19″	122°42′41″	Multiple	363	710	--	--	--	Z	D, J, I, E	TH4A
26N/01E-17N02	47°44′20″	122°42′41″	Qva	362	260	--	--	--	U	-	TH4B
26N/01E-18B01	47°45′06″	122°43′22″	Boring	-68	--/240	--	--	--	U	D	16E
26N/01E-18F01	47°44′50″	122°43′28″	QA1	10	325	--	--	--	Z	D	B-8
26N/01E-18K01	47°44′30″	122°43′21″	QA1	210	345	--	--	--	P	D	504
26N/01E-18L01	47°44′40″	122°43′33″	QA1	14	325	--	--	--	U	D	B-1
26N/01E-18L02	47°44′41″	122°43′25″	QA1	123	422	--	--	--	Z	D	B-7
26N/01E-18L03	47°44′35″	122°43′29″	Boring	123	--/235	--	--	--	U	D	B305
26N/01E-18L04	47°44′38″	122°43′33″	QA1	19.5	185			1,000	34	0.18	DDWRP-1
26N/01E-18L05	47°44′35″	122°43′35″	QA1	25	--			--	--	--	D-WRP-2
26N/01E-18L06	47°44′31″	122°43′37″	QA1	34	200			1,000	29	0.21	DDWRP-3
26N/01E-18L07	47°44′35″	122°43′35″	QA1	17	170	--	--	--	U	G	401 A
26N/01E-18L07P1	47°44′35″	122°43′35″	QA1	17	161/170	--	--	--	U	G	401 A
26N/01E-18L08	47°44′38″	122°43′33″	QA1	15	149	--	--	--	U	G	401 D
26N/01E-18M01	47°44′30″	122°43′42″	Boring	-16	--/302	--	--	--	U	D	B121A
26N/01E-18M02	47°44′38″	122°43′57″	Boring	-129	--/278	--	--	--	U	D	B206
26N/01E-18M03	47°44′31″	122°43′48″	QA1	-45	75	--		--	--	U	DWS 1
26N/01E-18M04	47°44′38″	122°43′45″	QA1	-68	--/70	--		--	--	U	DWS 7
26N/01E-18N01	47°44′16″	122°43′53″	QA1	14	333	--		--	--	Z	DB-2
26N/01E-18N02	47°44′19″	122°43′44″	QA1	50	349	--		--	--	U	GB-5
26N/01E-18P01	47°44′27″	122°43′36″	Boring	89	--/452	--	--	--	U	D	B302

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-18P02	47°44′25″	122°43′41″	QA1	42.5	208	1,000	24	0.26	D	D	WRP-4
26N/01E-18P03	47°44′16″	122°43′36″	QA1	90	308	--	--	--	P	D	501
26N/01E-18P04	47°44′18″	122°43′33″	QA1	130	364	--	--	--	P	D	502
26N/01E-18P05	47°44′23″	122°43′27″	QA1	175	382	--	--	--	U	D	Old 503
26N/01E-18P06	47°44′24″	122°43′28″	QA1	175	376	550	110	27	P	D	New 503
26N/01E-19C01	47°44′03″	122°43′40″	QA1	95	330/543	--	--	--	Z	D	B-6 shallow
26N/01E-19C01P1	47°44′03″	122°43′40″	QA2	95	543	--	--	--	Z	-	B-6 deep
26N/01E-19D01	47°44′11″	122°44′00″	QA1	22	325	--	--	--	Z	D	B-3
26N/01E-19F01	47°43′51″	122°43′36″	QA1	134	205/550	--	--	--	Z	D, J, I, E	TH5 shallow
26N/01E-19F01P1	47°43′51″	122°43′36″	QA1	134	215/550	--	--	--	Z	-	TH5 deep
26N/01E-19M01	47°43′37″	122°43′48″	Qvt	100	14	--	--	--	Z	D	D-MW30
26N/01E-19M02	47°43′41″	122°43′46″	Qvt	95	10	--	--	--	Z	D	D-MW31
26N/01E-19M03	47°43′37″	122°43′46″	QC1	100	96	--	--	--	Z	D	D-MW32
26N/01E-19M04	47°43′43″	122°43′45″	QC1pi	95	76	--	--	--	Z	D	D-MW33
26N/01E-19P01	47°43′33″	122°43′28″	Qvt	205	17	--	--	--	Z	D	D-MW20
26N/01E-19P02	47°43′32″	122°43′30″	Qva	206.09	40	--	--	--	Z	D	D-MW21
26N/01E-19P03	47°43′33″	122°43′29″	QC1	207.43	84/92	--	--	--	Z	D	D-MW22
26N/01E-19Q01	47°43′25″	122°43′14″	QA2	295	601	--	--	--	Z	D	1B-2
26N/01E-19Q02	47°43′24″	122°43′14″	QA1	295	446	--	--	--	Z	D, J	1A-1
26N/01E-19Q03	47°43′30″	122°43′14″	QA1	305	445	--	--	--	Z	D	1C-1
26N/01E-20E01	47°43’56″	122°42′37″	Boring	370	--/13	--	--	--	U	D	SWFPAC B7
26N/01E-20J01	47°43’38″	122°41′33″	Qva	440	226	20	5	59	H	D	--
26N/01E-20M01	47°43’39″	122°42′37″	Boring	385	--/26	--	--	--	U	D	SWFPAC B4
26N/01E-20N01	47°43’23″	122°42′37″	Boring	400	--/30	--	--	--	U	D	SWFPAC B1
26N/01E-20R01	47°43’35″	122°41′32″	Qva	445	54	--	--	--	U	-	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-20R03	47°43′32″	122°41′38″	Qva	450	527	--	--	--	Z	D, J, I, E	TH9
26N/01E-20R04	47°43′35″	122°41′33″	Qva	445	261	22	2	370	H	D	--
26N/01E-21E04	47°43′50″	122°41′10″	Qva	450	60	10	44	13	H	D	--
26N/01E-21J02	47°43′40″	122°40′10″	QA1	250	318	20	0	--	H	D	--
26N/01E-21N01	47°43′25″	122°41′16″	Qva	425	210	13	17	19	H	D	--
26N/01E-22D02	47°44′06″	122°39′54″	QA1	95	440	175	51	100	P	D	--
26N/01E-22M03	47°43′48″	122°40′08″	Qva	190	106	30	8	56	H	D	--
26N/01E-22N02	47°43′25″	122°40′09″	Qvt	270	17	--	--	--	U	-	--
26N/01E-22N03	47°43′25″	122°40′09″	Qva	270	105	12	30	16	H	D	--
26N/01E-22P01	47°43′25″	122°39′36″	QA1	100	175	30	12	130	H	D	--
26N/01E-22P02	47°43′29″	122°39′42″	Qva	110	87	10	20	5.8	H	D	--
26N/01E-24B02	47°44′04″	122°36′55″	Qva	320	118	15	30	23	H	D	--
26N/01E-24B03	47°44′07″	122°36′41″	QC1pi	260	105	15	19	38	H	D	--
26N/01E-24B04	47°44′07″	122°36′38″	Qvt	250	--	--	--	--	U	-	--
26N/01E-24G01	47°43′53″	122°36′46″	QC1pi	250	332/429	15	84.3	0.40	H	D	--
26N/01E-24K01	47°43′41″	122°36′47″	QC1	202	353	20	118	9.5	H	D	--
26N/01E-25B01	47°43′13″	122°36′49″	QC1	143	160	--	--	--	U	-	--
26N/01E-25B02	47°43′13″	122°36′50″	QC1pi	140	223	28	54	25	H	D	--
26N/01E-25G05	47°43′07″	122°36′41″	QC1pi	110	189	30	32	23	H	D	--
26N/01E-25L06	47°42′51″	122°37′04″	Qva	30	71	30	27	54	H	D	--
26N/01E-25N04	47°42′35″	122°37′32″	Qva	30	68	7	35	4.2	H	D	--
26N/01E-26M02	47°42′44″	122°38′45″	QC1pi	10	64	15	33	20	H	D	--
26N/01E-26Q02	47°42′40″	122°38′11″	QC1	20	183	25	10	120	U	D	--
26N/01E-26Q03	47°42′39″	122°38′10″	QA1	20	242	18	4	120	H	D	--
26N/01E-27B02	47°43′18″	122°39′28″	Qva	70	64	7	7	50	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-27F02	47°43′08′′	122°39′34′′	QC1pi	130	200	15	5.5	140	H	D	--
26N/01E-27G03	47°43′02′′	122°39′14′′	Qva	18	80	15	16.4	44	H	D	--
26N/01E-27N01	47°42′32′′	122°40′08′′	QC1pi	350	242	12.5	17.2	45	H	D	--
26N/01E-27N02	47°42′38′′	122°40′07′′	QC1pi	340	217	30	13.6	140	H	D	--
26N/01E-28D01	47°43′18′′	122°41′21′′	Qva	410	183	40	7	180	H	D	--
26N/01E-28E02	47°43′03′′	122°41′21′′	Qva	420	217	22	1	1,300	H	D	--
26N/01E-28J01	47°42′45′′	122°40′12′′	QA1	340	471	335	43.7	240	H	D,G	--
26N/01E-28N02	47°42′34′′	122°41′09′′	Qva	395	188	30	5	330	H	D	--
26N/01E-29D01	47°43′14′′	122°42′40′′	Boring	401	--/21	--	--	--	U	D	SWFPAC B12
26N/01E-29N01	47°42′41′′	122°42′29′′	Multiple	365	660/918	--	--	--	Z	D, J, I, E	TH7
26N/01E-29P01	47°42′39′′	122°42′15′′	Qva	410	206/265	--	--	--	Z	D	BG02
26N/01E-29R01P1	47°42′43′′	122°41′38′′	Qva	415	390/820	--	--	--	Z	D, J, I, E, C	TH13 shallow
26N/01E-29R01P2	47°42′43′′	122°41′38′′	QA1	415	546/820	--	--	--	Z	-	TH13 medium
26N/01E-29R01P3	47°42′43′′	122°41′38′′	QA2	415	820	--	--	--	Z	-	TH13 deep
26N/01E-30B01P1	47°43′22′′	122°43′19′′	QC1pi	270	318/650	--	--	--	Z	D, J, I, E,C	TH12 shallow
26N/01E-30B01P2	47°43′22′′	122°43′19′′	QA1	270	440/650	--	--	--	Z	-	TH12 medium
26N/01E-30B01P3	47°43′22′′	122°43′19′′	QA2	270	650	--	--	--	Z	-	TH12 deep
26N/01E-30D01	47°43′21′′	122°43′57′′	QA1	116	334	--	--	--	Z	D, J	TH 6
26N/01E-30L01	47°42′45′′	122°43′33′′	QC1pi	325	331	156	22.75	140	F	D	SWFPAC 6610
26N/01E-31A03	47°42′28′′	122°42′58′′	QA1	340	586	--	--	--	Z	D, J	2C-1
26N/01E-31B01P1	47°42′27′′	122°43′13′′	QC1pi	355	303/810	--	--	--	Z	D, J, I ,E, C	TH11 shallow
26N/01E-31B01P2	47°42′27′′	122°43′13′′	QA1	355	650/810	--	--	--	Z	-	TH11 medium
26N/01E-31B01P3	47°42′27′′	122°43′13′′	QA2	355	810	--	--	--	Z	-	TH11 deep
26N/01E-31B02	47°42′28′′	122°43′06′′	QA2	350	783	--	--	--	Z	D	2B-2
26N/01E-31B03	47°42′29′′	122°43′07′′	QA1	350	581/591	--	--	--	Z	D, J	2A-1

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-31B04P1	47°42′20″	122°43′18″	Qva	369.46	133/210	--	--	--	Z	D	F-MW44S
26N/01E-31B04P2	47°42′20″	122°43′18″	Qva	369.46	183/210	--	--	--	Z	D	F-MW44
26N/01E-31C01P1	47°42′17″	122°43′29″	Qva	340	125/199	--	--	--	Z	D	F-MW43S
26N/01E-31C01P2	47°42′17″	122°43′29″	Qva	340	171/199	--	--	--	Z	D	F-MW43
26N/01E-31E01	47°42′14″	122°43′50″	QA1	340	435/832	--	--	--	Z	D, J, I, E	TH2 shallow
26N/01E-31E01P1	47°42′14″	122°43′50″	QA2	340	832	--	--	--	Z	-	TH2 deep
26N/01E-31G01	47°42′14″	122°43′19″	QC1	360	227	--	--	--	Z	D	E-MW-21LB
26N/01E-31G02	47°42′13″	122°43′14″	Qva	358	200	--	--	--	Z	D	E-MW-24LB
26N/01E-31G03	47°42′11″	122°43′18″	Qva	369.4	177/239	--	--	--	Z	D	F-MW38
26N/01E-31H01	47°42′09″	122°42′57″	Qva	340.3	157/178	--	--	--	Z	D	F-MW36
26N/01E-31H02	47°42′16″	122°42′51″	Qva	348.1	157/188	--	--	--	Z	D	F-MW46
26N/01E-31J01	47°42′04″	122°42′56″	Qva	357	102	--	--	--	Z	D	USGS 15
26N/01E-31J03	47°42′02″	122°42′58″	Qva	354.7	161/200	--	--	--	Z	D	F-MW27
26N/01E-31J04	47°41′58″	122°42′55″	Qva	325.2	117/156	--	--	--	Z	D	F-MW45
26N/01E-31K01	47°42′02″	122°43′08″	Qva	382	190/238	--	--	--	Z	D	F-MW40
26N/01E-31R01	47°41′39″	122°42′53″	Multiple	410	669	--	--	--	P	D, J	505 (TH18)
26N/01E-32E01	47°42′05″	122°42′44″	Qva	310	144/154	--	--	--	Z	D	USGS 12
26N/01E-32E02	47°42′05″	122°42′42″	Qva	306.7	132/161	--	--	--	Z	D	F-MW26
26N/01E-32E03	47°42′06″	122°42′34″	Qva	326.80	82	--	--	--	U	D	F-MW23
26N/01E-32E04	47°42′12″	122°42′35″	Qva	316	78/84	--	--	--	U	D	F-MW30
26N/01E-32E05	47°42′06"	122°42′33″	Qvt	326.80	48	--	--	--	U	D	F-MW22
26N/01E-32K01	47°41′52"	122°41′55″	QA2	280	685/690	350	82	20	U	D	NAD NO.1
26N/01E-32K02	47°42′00"	122°41′55″	Qva	300	168/186	--	--	--	U	D	16MW2
26N/01E-32K03	47°41′59"	122°41′53″	Qva	318.68	156/168	--	--	--	Z	D	16MW4
26N/01E-32K04	47°41′59"	122°41′55″	Qva	316.82	153/164	--	--	--	Z	D	16MW7

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-32K05	47°41′53″	122°42′02″	Qva	275	44	--	--	--	Z	D	27-MW1
26N/01E-32K06	47°41′52″	122°42′00″	Qva	275	41	--	--	--	Z	D	28-MW1
26N/01E-32L02	47°42′02″	122°42′11″	Qva	290	113	78	17	--	U	-	NAD NO.3
26N/01E-32L03	47°41′58″	122°42′22″	Multiple	275	570/700	550	--	--	U	D	NAD NO.2
26N/01E-32L04	47°42′01″	122°42′11″	QA2	285	1,000	--	--	--	Z	D, J, E, I	TH1
26N/01E-32L05	47°42′02″	122°42′11″	QA1	290	412	--	--	--	U	D	1181
26N/01E-32M01	47°42′00″	122°42′35″	Qva	321.8	82	--	--	--	U	D	F-MW29
26N/01E-32P01	47°41′50″	122°42′08″	Qva	275	45	--	--	--	Z	D	10-MW1
26N/01E-32Q01	47°41′39″	122°41′56″	Qvt	255	22	--	--	--	U	D	--
26N/01E-32Q03	47°41′45″	122°41′54″	Qva	273.34	22	--	--	--	Z	D	25MW1
26N/01E-32Q04	47°41′40″	122°41′57″	Qvt	269.30	22	--	--	--	Z	D	25MW3
26N/01E-32Q05	47°41′45″	122°41′59″	Qva	271.15	104/116	--	--	--	Z	D	25MW5
26N/01E-32Q06	47°41′43″	122°41′57″	Qva	270.27	101/114	--	--	--	Z	D	25MW7
26N/01E-32Q07	47°41′48″	122°42′02″	Qva	275	51	--	--	--	Z	D	29-MW1
26N/01E-32Q08	47°41′39″	122°41′55″	Qva	255	51	25	10	65	H	D	--
26N/01E-33A02	47°42′21″	122°40′27″	Qva	265	118	10	3.5	140	H	D	--
26N/01E-33E01	47°42′18″	122°41′24″	Qva	350	159	30	1	1,000	P	D	--
26N/01E-33G01	47°42′13″	122°40′46″	Qva	260	174	40	33	30	H	D	--
26N/01E-33P03	47°41′39″	122°41′00″	Qva	190	90	40	38	51	H	D	--
26N/01E-34D01	47°42′27″	122°40′00″	QC1pi	260	168	50	25	53	H	D	--
26N/01E-34E01	47°42′06″	122°39′54″	QC1pi	180	99	10	30	20	H	D	--
26N/01E-34H01	47°42′11″	122°39′03″	Qva	190	43	17	30	11	H	D	--
26N/01E-34P02	47°41′39″	122°39′43″	QC1	350	209	6	22	6.0	H	D	--
26N/01E-34R01	47°41′42″	122°39′09″	QC1pi	318	383	20	134	6.3	H	D	--
26N/01E-35B03	47°42′22″	122°38′10″	QA1	42	164	50	15	180	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/01E-35N01	47°41′50″	122°38′35″	QC1	160	304	4	136	0.54	H	D	--
26N/01E-36M01	47°42′02″	122°37′33″	QA2	10	746/783	345	184	13	P	D	--
26N/01E-36P01	47°41′48″	122°37′14″	QA1	16	365/380	--	--	--	U	D	Keyport No.1
26N/01E-36P03	47°41′50″	122°37′12″	QC2	19	535	76	--	--	U	D	Keyport No.3
26N/01E-36P04	47°41′50″	122°37′15″	Multiple	10	1,036	--	--	--	U	D	Keyport No.4
26N/01E-36P05	47°41′48″	122°37′17″	QA2	20	802	1,040	--	--	P	D	Keyport No.5
26N/01W-24A01	47°44′11″	122°44′12″	QA1	80	380	--	--	--	Z	D	B-4
26N/01W-24H01	47°44′02″	122°44′11″	QA1	105	126/133	--	--	--	U	D	Small-craft dock
26N/01W-25A02	47°43′12″	122°44′20″	QA1	110	270	--	--	--	Z	D	3A-1
26N/01W-25B02	47°43′12″	122°44′27″	QA1	112.4	295/525	--	--	--	Z	D, J, I, E	TH14 shallow
26N/01W-25B02P1	47°43′12″	122°44′27″	QA2	112.4	510/525	--	--	--	Z	-	TH14 deep
26N/01W-25G01	47°43′00″	122°44′34″	QA1	120	164	40	10	180	P	D	--
26N/01W-25G02	47°43′06″	122°44′32″	QA1	118	279	250	73.8	43	P	D	--
26N/01W-25G03	47°42′58″	122°44′38″	Qva	120	98	8	7	23	H	D	--
26N/01W-25L01	47°42′48″	122°44′46″	QA1	90	148	30	25	59	U	D	--
26N/01W-25L02	47°42′48″	122°44′47″	QA1	90	128	31	19	100	H	D	--
26N/01W-36A01	47°42′18″	122°44′08″	QA1	228.08	198/203	--	--	--	Z	D	F-MW47
26N/01W-36C01	47°42′27″	122°44′43″	QA1	130	165	16	8	88	H	D	--
26N/01W-36J01	47°41′58″	122°44′08″	QA1	220	197	14	8.6	100	H	D	--
26N/01W-36J02	47°42′01″	122°44′19″	QC1	145	67	13.5	1	800	H	D	--
26N/01W-36R02	47°41′42″	122°44′04″	Qva	250	43	12	10	74	H	D	--
26N/01W-36R03	47°41′47‴	122°44′17″	QA1	205	281	20	17	58	H	D	--
26N/02E-06A02	47°46′45″	122°35′21″	Qva	122	105	20	19	51	H	D	--
26N/02E-06G01	47°46′36″	122°35′39″	Qva	190	110	11	27	8.8	H	D	--
26N/02E-06K02	47°46′15″	122°35′31″	QA1	250	341	6	168	2.4	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
26N/02E-06R02	47°46′06″	122°35′21″	QA1	230	351	9	145	2.4	H	D	--
26N/02E-07E01	47°45′36″	122°36′15″	QA1	290	365	14	41	200	H	D	--
26N/02E-07L02	47°45′31″	122°35′45″	Qva	310	92	15	9	--	H	D	--
26N/02E-07R03	47°45′08″	122°35′12″	QA1	380	421	6	210	1.2	H	D	--
26N/02E-18A06	47°45′04″	122°35′04″	QC1	350	226	5	30	6.3	H	D	--
26N/02E-18G04	47°44′53″	122°35′22″	Qva	330	68	8	40	4.4	H	D	--
26N/02E-18H04	47°44′50″	122°35′09″	QA1	330	315	25	5	270	H	D	--
26N/02E-19B03	47°44′12″	122°35′36″	Qvr	350	50	--	--	--	H	-	--
26N/02E-19B04	47°44′10″	122°35′35″	Qvr	350	50	12	3	110	U	D	--
26N/02E-19B04D01	47°44′10″	122°35′35″	QC1	350	410	10	122	3.3	H	D	--
26N/02E-19G01	47°44′00″	122°35′28″	QC1	330	193	10	14	28	U	D	--
26N/02E-19G02	47°43′55″	122°35′25″	QA1	345	346	13	9	68	H	D	--
26N/02E-19J03	47°43′39″	122°35′03″	Qvr	270	64	18	10	22	H	D	--
26N/02E-30A05	47°43′21″	122°35′05″	QA1	280	259	15	9	42	H	D	--
26N/02E-30H02	47°43′07″	122°35′07″	QA1	217	237	15	16	47	H	D	--
26N/02E-30N03	47°42′32″	122°36′18″	Qva	55	62	38	12	170	H	D	--
26N/02E-30N03D01	47°42′32″	122°36′18″	Qva	55	113	40	31	67	H	D	--
26N/02E-31F02	47°42′16″	122°35′42″	Qva	140	176	18	28.83	15	H	D	--
26N/02E-31G01	47°42′12″	122°35′22″	QA1	210	180	6	10	23	H	D	--
26N/02E-31J03	47°42′01″	122°35′02″	Qva	42	48	8	17	15	H	D	--
27N/01E-22J01	47°48′52″	122°39′06″	Qva	40	96	20	10	120	H	D	--
27N/01E-22Q04	47°48′40″	122°39′28″	QC1pi	120	95	22	20	27	H	D	--
27N/01E-22Q05	47°48′39″	122°39′27″	QA1	120	239	14	13	55	H	D	--
27N/01E-23B01	47°49′20″	122°38′07″	QC1pi	140	129	20	27	37	H	D	--
27N/01E-23C01	47°49′19″	122°38′29″	QA1	80	401	14	274	2.1	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
27N/01E-23D01	47°49′24″	122°38′49″	Qva	45	79	40	1	2,400	H	D	--
27N/01E-23D02	47°49′19″	122°38′51″	Qva	40	57	14	0	--	H	D	--
27N/01E-23M01	47°48′49″	122°38′42″	QA1	115	302	50	39	65	H	D	--
27N/01E-26D01	47°48′24″	122°38′49″	QA1	230	467	8	310	0.94	H	D	--
27N/01E-26E01	47°48′09″	122°38′35″	QA1	335	565	120	72	46	H	D	--
27N/01E-26H01	47°48′18″	122°37′48″	QC1pi	240	203	17	40	9.6	H	D	--
27N/01E-26R01	47°47′52″	122°37′36″	Qva	175	97	5	37	6.0	H	D	--
27N/01E-27E01	47°48′12″	122°39′58″	QA1	225	321	--	--	--	U	D	--
27N/01E-27E03	47°48′12″	122°39′52″	QA1	220	259	--	--	--	U	D	--
27N/01E-27E04	47°48′12″	122°39′52″	QC1	220	264	--	--	--	P	D	--
27N/01E-27J01	47°48′06″	122°39′08″	Qva	290	185	520	56.5	140	P	D	--
27N/01E-27J02	47°48′07″	122°39′08″	QA1	290	466/976	470	106	41	P	D, I	--
27N/01E-27N01	47°47′49″	122°39′51″	Qva	360	134	15	23	26	H	D	--
27N/01E-27N02	47°47′52″	122°40′03″	Qva	285	95	45	20	63	H	D	--
27N/01E-27R02	47°47′54″	122°39′00″	Qvt	285	20	--	--	--	H	-	--
27N/01E-27R03	47°47′54″	122°39′00″	QC1	285	257	12	107	4.7	H	D	--
27N/01E-28J02	47°47′59″	122°40′24″	QA1	180	244	20	54	17	H	D	--
27N/01E-28K02	47°48′05″	122°40′39″	QA1	42	150	14	82	9.4	H	D	--
27N/01E-28K03	47°48′05″	122°40′40″	QA1	40	108	14	16	44	H	D	--
27N/01E-28K04	47°47′58″	122°40′48″	QA1	75	108	32	31	50	H	D	--
27N/01E-33B02	47°47′29″	122°40′45″	QC1	160	138	40	44	44	H	D	--
27N/01E-33B03	47°47′40″	122°40′37″	QA1	190	270	15	--	--	H	D	--
27N/01E-33B04S	47°47′31″	122°40′50″	Qvt	130	--	--	--	--	U	-	--
27N/01E-33F02	47°47′25″	122°40′56″	Qva	100	142	20	25	22	H	D	--
27N/01E-33P02	47°46′51″	122°40′52″	QA1	170	274	10	80	5.0	H	D	--

Appendix 1.--*Physical and hydrologic data for the inventoried wells and springs on Naval Submarine Base Bangor (SUBASE Bangor) and vicinity, Kitsap County, Washington--Continued*

Local well number	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Hydro-geologic unit	Altitude of land surface (feet)	Depth of well/ depth of hole (feet)	Discharge (gal/min)	Draw-down (feet)	Estimated horizontal hydraulic conductivity (feet per day)	Primary use of water	Type of log available	Navy identi-fier
27N/01E-34K02	47°47′03″	122°39′19″	QC1	325	267	14	6	120	H	D	--
27N/01E-34L01	47°47′10″	122°39′45″	Qva	385	100	32	6	88	H	D	--
27N/01E-34L02	47°47′10″	122°39′46″	Qva	385	96	32	11	43	H	D	--
27N/01E-34M01	47°47′10″	122°39′55″	QC1	395	505	11	188	2.4	U	D	--
27N/01E-35C01	47°47′34″	122°38′21″	QC1	375	358	20	60	4.4	H	D	--
27N/01E-35E01	47°47′20″	122°38′51″	QC1	290	205	25	84	6.6	H	D	--
27N/01E-35E02S	47°47′26″	122°38′37″	Qvt	360	--	--	--	--	H	-	--
27N/01E-35H01	47°47′18″	122°37′38″	QA1	170	201	30	52	28	H	D	--
27N/01E-35J01	47°47′15″	122°37′37″	Qva	170	82	10	41	5.4	H	D	--
27N/01E-35N01	47°46′56″	122°38′33″	QC1pi	380	326	15	32	11	H	D	--
27N/01E-36E01	47°47′23″	122°37′26″	Qva	215	84	12	18	16	H	D	--
27N/01E-36J03	47°47′06″	122°36′21″	Qva	340	120	10	17	27	H	D	--
27N/01E-36J04	47°47′10″	122°36′28″	QC1pi	370	246	15	3	280	H	D	--
27N/02E-31H01	47°47′28″	122°35′21″	Qva	115	57	5	16	14	H	D	--
27N/02E-31K01	47°47′05″	122°35′34″	Qva	265	137	8	6	35	H	D	--
27N/02E-31N01	47°46′51″	122°36′17″	QC1	295	117	7	9.5	46	H	D	--
27N/02E-31R03	47°46′55″	122°35′01″	QA1	170	460	35	127.9	6.4	H	D	--

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington*

[Water level: --, not determined. Status: --, static; D, dry; F, flowing; O, obstruction; P, pumping; R, recently pumped; S, nearby pumping; X, affected by tides; and Z, other. Water-level measurement method: A, airline; H, calibrated pressure gage; R, reported; S, steel tape; T, electric tape; and Z, other]

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-01N01	02-24-94	144.32	R	S
	08-24-94	147.35	--	S
	04-13-95	144.53	R	S
25N/01E-02A01	03-23-94	16.26	--	S
	08-24-94	19.25	--	S
	04-13-95	16.15	--	S
25N/01E-02E02	04-05-94	31.80	--	S
	08-26-94	31.95	--	S
	04-10-95	27.19	--	S
25N/01E-02J02	08-22-94	198.3	R	T
	04-14-95	193.8	R	R
25N/01E-02Q01	03-23-94	33.18	--	S
	08-24-94	33.70	--	S
	04-13-95	30.25	--	S
25N/01E-03E01	08-23-94	183.2	R	R
	04-11-95	181	R	R
25N/01E-03E02	08-23-94	168.7	R	R
	04-11-95	166	R	R
25N/01E-03E03	08-23-94	167.1	R	R
	04-11-95	164	R	R
25N/01E-03E04	08-23-94	167.0	R	R
	04-11-95	164.8	R	R
25N/01E-03K01	04-05-94	22.61	--	S
	08-25-94	23.27	--	S
	04-10-95	18.86	--	S
25N/01E-04C01	04-12-94	144.13	--	S
	08-24-94	146.24	--	S
	12-01-94	145.86	--	S
	12-27-94	143.55	--	S
	01-24-95	144.09	--	S
	02-28-95	144.40	--	S
	04-10-95	143.98	--	S
	05-26-95	143.85	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-04C01	02-28-95	144.40	--	S
	04-10-95	143.98	--	S
	05-26-95	143.85	--	S
	06-20-95	144.28	--	S
	07-19-95	149.78	R	S
	08-21-95	145.60	--	S
	09-18-95	144.79	R	S
	10-24-95	146.90	--	S
	01-22-96	148.27	--	S
	02-23-96	148.47	P	S
	03-25-96	143.75	--	S
25N/01E-04M03	04-12-94	2.09	--	S
	08-24-94	5.82	--	S
	04-12-95	-.25	--	S
25N/01E-05A04	04-07-94	20.01	--	S
	08-24-94	21.54	--	S
	04-12-95	17.40	--	S
25N/01E-05J01	08-23-94	163.9	R	R
	04-12-95	162.2	R	R
25N/01E-05K01	04-12-94	82.60	--	S
	08-24-94	82.69	--	S
	04-12-95	78.05	--	S
25N/01E-05Q01	11-16-93	95.23	R	S
	08-23-94	95.90	--	S
	04-12-95	94.97	--	S
25N/01E-05R02	11-16-93	142.27	--	S
	08-24-94	143.27	--	S
	04-12-95	142.25	--	S
25N/01E-06D04	01-07-94	262.51	--	S
	01-24-94	262.69	--	S
	06-01-94	262.97	--	S
	06-27-94	262.69	--	S
	08-24-94	262.96	--	S
	12-01-94	262.82	--	S
	12-27-94	262.69	--	S
	01-24-95	262.69	--	S
	02-28-95	262.57	--	S
	03-20-95	262.60	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-06D04	05-24-95	262.06	--	S
	06-19-95	262.12	--	S
	07-19-95	261.97	--	S
	08-25-95	262.05	--	S
	09-22-95	262.01	--	S
	10-25-95	261.86	--	S
	11-20-95	262.18	--	S
	01-23-96	261.93	--	S
	02-23-96	261.75	--	S
	03-27-96	261.47	--	S
25N/01E-06E01	04-11-94	269.76	--	S
	08-22-94	274.16	--	S
	04-13-95	269.57	--	S
25N/01E-06H01	08-23-94	115.72	--	S
	04-13-95	113.05	--	S
25N/01E-06J02	08-23-94	46.24	--	S
	04-13-95	42.04	--	S
25N/01E-06L02	04-11-94	290.68	--	S
	08-22-94	295.37	--	S
	04-13-95	294.01	--	S
25N/01E-07A01	11-12-93	230.9	--	R
	08-24-94	230.5	R	R
	04-13-95	228.1	R	R
25N/01E-07C02	11-16-93	276.43	--	S
	08-22-94	276.61	--	S
	04-11-95	276.91	--	S
25N/01E-07C03	11-17-93	250.98	--	S
	08-22-94	252.28	--	S
25N/01E-07D01	11-17-93	230.74	--	S
	08-22-94	231.46	--	S
	12-02-94	231.23	--	S
	12-27-94	231.64	--	S
	01-24-95	231.07	--	S
	02-22-95	232.20	--	S
	03-22-95	230.49	--	S
	04-11-95	230.79	--	S
	05-26-95	230.98	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-07D01	06-20-95	231.10	--	S
	07-19-95	232.61	R	S
	08-22-95	231.09	R	S
	09-18-95	231.18	--	S
	10-24-95	234.72	--	S
	01-22-96	233.68	--	S
	02-22-96	230.39	--	S
	03-25-96	232.34	--	S
25N/01E-07E02	11-18-93	268.20	--	S
	08-22-94	268.76	--	S
	04-11-95	269.49	--	S
25N/01E-07H04	04-12-94	89.46	--	S
	08-22-94	89.07	--	S
	04-11-95	85.15	--	S
25N/01E-07J01	04-05-94	59.89	R	S
	08-23-94	59.86	--	S
	04-13-95	54.51	--	S
25N/01E-07K01	08-23-94	114.62	--	S
	11-21-94	115.24	--	S
	12-27-94	115.46	--	S
	01-24-95	114.98	--	S
	02-22-95	114.14	--	S
	03-22-95	112.70	--	S
	04-11-95	111.56	R	S
	05-24-95	109.40	--	S
	06-20-95	108.82	--	S
	07-19-95	108.33	--	S
	08-22-95	108.36	--	S
	09-18-95	108.74	R	S
	10-24-95	109.17	--	S
	11-21-95	109.37	--	S
	01-22-96	109.40	--	S
	02-23-96	109.05	--	S
	03-25-96	107.78	--	S
25N/01E-07P02	03-09-95	206.74	--	S
25N/01E-07Q03	03-07-95	198.15	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-08J02	11-18-93	66.69	--	S
	08-24-94	67.72	--	S
	12-02-94	66.39	--	S
	12-27-94	64.67	--	S
	01-24-95	64.13	--	S
	02-22-95	63.13	--	S
	03-22-95	62.54	--	S
	04-12-95	62.55	R	S
	05-26-95	65.09	--	S
	06-20-95	64.26	--	S
	07-19-95	67.94	R	S
	08-22-95	65.54	R	S
	09-18-95	66.09	R	S
	10-24-95	65.63	--	S
	11-21-95	65.62	--	S
	01-22-96	63.62	--	S
	02-22-96	63.04	--	S
	03-25-96	62.96	--	S
25N/01E-08L02	11-17-93	80.27	--	S
	08-23-94	79.83	--	S
	11-22-94	80.31	--	S
	12-27-94	79.98	--	S
	01-24-95	79.37	--	S
	02-22-95	78.53	--	S
	03-22-95	77.00	--	S
	04-12-95	75.98	R	S
	05-24-95	75.27	--	S
	06-20-95	75.44	--	S
	07-19-95	75.49	--	S
	08-22-95	75.92	R	S
	09-18-95	76.35	--	S
	10-24-95	76.74	--	S
	11-22-95	77.06	--	S
	01-22-96	76.60	--	S
	02-22-96	75.78	--	S
	03-25-96	74.78	--	S
25N/01E-08L04	03-03-95	37.73	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-08Q03	11-17-93	155.36	--	S
	08-23-94	156.05	--	S
	11-22-94	155.78	--	S
	12-27-94	154.55	--	S
	01-24-95	154.42	--	S
	02-22-95	153.99	--	S
	03-22-95	153.45	--	S
	04-12-95	153.77	--	S
	05-24-95	154.39	--	S
	06-20-95	154.51	--	S
	07-19-95	155.14	--	S
	08-22-95	154.67	--	S
	09-18-95	155.15	--	S
	10-24-95	154.93	--	S
	11-21-95	154.87	--	S
	01-22-96	153.74	--	S
	02-22-96	153.32	--	S
	03-25-96	153.57	--	S
25N/01E-09H01	04-15-94	77.8	--	T
25N/01E-09J01D01	11-18-93	108.48	R	S
	08-26-94	111.88	--	S
	04-12-95	103.37	R	S
25N/01E-09N02	03-09-95	.99	--	S
25N/01E-10A03	04-15-94	213.52	R	S
	08-25-94	224.96	R	S
	04-10-95	219.06	R	S
25N/01E-10D01	08-23-94	236.7	R	R
	04-11-95	234.1	R	R
25N/01E-10N01	08-25-94	274.1	--	R
	04-11-95	294.2	R	R
25N/01E-12N01	02-24-94	190.63	--	S
	08-25-94	191.23	--	S
	04-13-95	184.94	--	S
25N/01E-12N02	02-24-94	51.98	--	S
	08-25-94	50.86	--	S
	04-14-95	47.92	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-13D01	04-19-94	159.10	--	S
	04-19-95	154.13	--	S
25N/01E-13L02	03-22-94	24.37	--	S
	08-25-94	25.25	--	S
	04-13-95	17.72	--	S
25N/01E-14A01	03-23-94	11.74	--	S
	08-26-94	17.46	--	S
	04-14-95	8.32	--	S
25N/01E-14E02	03-28-94	7.50	--	S
	08-25-94	15.23	--	S
	04-10-95	7.92	R	S
25N/01E-14J02	04-05-94	-4.15	--	S
	08-26-94	4.35	--	S
	04-13-95	-6.78	--	Z
25N/01E-14Q03	08-26-94	59.53	R	S
	03-03-95	50.3	R	R
25N/01E-15D01	08-24-94	286.8	R	R
	04-12-95	276.8	R	R
25N/01E-15J02	03-28-94	8.25	--	S
	08-25-94	17.82	R	S
	04-10-95	5.96	--	S
25N/01E-15J03	04-05-94	15.88	--	S
	08-25-94	19.78	--	S
	04-10-95	15.14	R	S
25N/01E-16J01	08-23-94	144.8	R	R
	04-11-95	124.9	R	R
25N/01E-17B01	02-23-94	50.00	--	S
	08-23-94	50.10	--	S
	04-11-95	43.89	--	S
25N/01E-17C02	12-07-93	10.38	--	S
	08-23-94	9.53	--	S
	04-12-95	2.90	--	S
25N/01E-17F02	04-12-94	51.10	--	S
	08-23-94	48.63	--	S
	04-10-95	45.70	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-17G01	04-07-94	114.91	--	S
	08-23-94	116.70	--	S
	04-10-95	114.07	--	S
25N/01E-17N01	12-07-93	31.62	--	S
	08-23-94	31.04	--	S
	04-11-95	27.36	--	S
25N/01E-17N02	04-11-94	29.99	--	S
25N/01E-18B01	11-18-93	133.86	--	S
	08-23-94	132.94	--	S
	04-13-95	126.54	--	S
25N/01E-18C02	11-18-93	173.75	--	S
	08-26-94	174.00	--	S
	04-12-95	170.76	--	S
25N/01E-18D03	03-03-95	250.11	--	S
25N/01E-18H01	08-23-94	289.9	R	R
	04-12-95	285.0	R	R
25N/01E-18H02	03-03-95	146.63	--	S
25N/01E-18J03	12-08-93	37.41	--	S
	08-23-94	32.45	--	S
	04-11-95	20.18	--	S
25N/01E-18L01	03-30-94	296.90	--	S
	08-23-94	299.69	--	S
	04-10-95	297.29	--	S
25N/01E-19P01	04-05-94	217.62	--	S
	08-25-94	216.93	--	S
	04-10-95	215.16	--	S
25N/01E-19P02	08-24-94	476.45	R	R
	04-12-95	470.65	R	R
25N/01E-19R02	03-30-94	212.82	--	S
	08-25-94	213.10	--	S
25N/01E-20A01	12-08-93	--	F	R
	08-22-94	-6.94	--	Z
	04-12-95	-8.31	--	Z

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-20F01	08-24-94	174.2	R	R
	04-12-95	146.8	R	R
25N/01E-20L02	12-08-93	17.20	--	S
	04-12-95	12.56	--	S
25N/01E-21C04	03-28-94	--	F	R
25N/01E-21R02	03-22-94	26.29	--	S
	08-26-94	28.62	--	S
	04-10-95	26.66	--	S
25N/01E-22F01	08-23-94	39.5	R	R
25N/01E-22F02	08-23-94	58.6	R	R
	04-11-95	50.2	R	R
25N/01E-22J01	04-11-95	150	--	A
25N/01E-23D01	12-09-93	73.79	--	S
	08-26-94	74.73	--	S
	04-10-95	72.67	--	S
25N/01E-23J01	12-09-93	115.16	--	S
	08-26-94	123.94	--	S
	04-10-95	112.44	--	S
25N/01E-23N02	05-19-94	218.60	--	S
	08-23-94	230.39	--	S
	04-11-95	218.78	--	S
25N/01E-24D02	04-06-94	109.11	--	S
25N/01E-26L01	05-18-94	116.30	--	S
	08-23-94	123.26	--	S
	04-11-95	112.50	--	S
25N/01E-27B01	12-08-93	184.32	--	S
	08-26-94	185.29	--	S
	04-10-95	183.76	--	S
25N/01E-27R01	12-09-93	118.24	--	S
	08-26-94	121.69	R	S
	04-10-95	119.07	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01E-29D01	01-08-94	111.5	--	R
	08-23-94	116.5	R	R
	04-10-95	119.67	--	S
	04-12-95	110.4	R	R
25N/01E-29M01	12-08-93	83.50	--	S
	08-26-94	85.25	--	S
	04-14-95	81.05	--	S
25N/01E-30C03	12-08-93	188.08	R	S
	08-22-94	187.33	--	S
	04-14-95	184.39	--	S
25N/01E-30D02	04-04-94	315.53	--	S
	08-26-94	315.94	--	S
	04-11-95	316.28	--	S
25N/01E-30D03	04-07-94	326.87	R	S
25N/01W-01A01	12-29-93	12.94	--	S
25N/01W-01A02	12-29-93	28.90	--	S
25N/01W-01B02	03-20-95	57.5	--	R
	04-19-95	53.93	--	S
25N/01W-01G05	12-29-93	157.82	--	S
	08-22-94	158.49	--	S
	04-12-95	157.10	--	S
25N/01W-01H01	12-29-93	203.00	--	S
	08-22-94	203.90	--	S
	04-14-95	202.55	--	S
25N/01W-01K03	12-29-93	50.57	--	S
	08-24-94	51.57	--	S
	04-12-95	49.85	--	S
25N/01W-12K04	03-15-95	165.60	P	S
25N/01W-12L02	02-11-94	28.80	--	S
	08-22-94	30.73	--	S
	12-02-94	26.18	--	S
	12-27-94	26.08	--	S
	01-24-95	28.93	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01W-12L02	02-22-95	28.68	--	S
	03-22-95	25.80	--	S
	04-12-95	27.88	--	S
	05-26-95	33.81	P	S
	06-20-95	28.54	--	S
	07-19-95	28.47	--	S
	08-22-95	28.90	--	S
	09-18-95	28.52	--	S
	10-24-95	29.28	--	S
	11-21-95	28.05	--	S
	01-22-96	27.74	--	S
	02-22-96	27.02	--	S
	03-25-96	28.25	--	S
25N/01W-12N01	01-03-94	--	F	R
25N/01W-12Q01	03-03-95	231.50	--	S
25N/01W-12R01	01-03-94	330.83	--	S
	08-22-94	332.67	--	S
	04-12-95	330.37	--	S
25N/01W-12R02	03-22-95	76.47	--	S
25N/01W-13A01	03-03-95	213.10	--	S
25N/01W-13K01	03-21-94	20.10	--	S
25N/01W-13L01	03-25-94	311.17	--	S
	08-25-94	313.50	--	S
	04-13-95	311.00	--	S
25N/01W-13L02	03-25-94	268.32	--	S
	08-22-94	267.54	--	S
	04-12-95	266.07	--	S
25N/01W-13R02	03-21-94	125.02	--	S
	08-22-94	125.65	--	S
	04-12-95	125.40	--	S
25N/01W-14E07	04-01-94	--	F	R
25N/01W-14F04	04-11-94	24.61	--	S
	08-22-94	25.62	--	S
	04-14-95	23.95	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01W-14G02	04-11-94	198.84	--	S
	08-24-94	199.47	--	S
	04-13-95	197.83	R	S
25N/01W-15J03	04-01-94	23.92	--	S
	08-24-94	25.72	--	S
	04-14-95	23.14	--	S
25N/01W-15L01	08-11-94	-10.39	--	Z
	08-22-94	-9.45	--	Z
	04-11-95	-11.62	--	Z
25N/01W-15N02	04-11-94	235.14	--	S
	08-24-94	237.07	--	S
	04-14-95	234.33	--	S
25N/01W-15Q03	04-01-94	103.73	--	S
	08-24-94	104.30	--	S
	04-14-95	103.24	--	S
25N/01W-22E01	08-22-94	228.5	S	T
	04-14-95	226.3	S	R
25N/01W-22N01	08-24-94	229.50	--	S
	04-14-95	228.45	--	S
25N/01W-23G01	05-06-94	150.85	--	S
	08-24-94	152.90	R	S
	04-11-95	150.61	--	S
25N/01W-23K03	04-22-94	225.43	--	S
	08-24-94	225.75	--	S
	04-11-95	225.75	--	S
25N/01W-23K04	04-22-94	213.40	--	S
	08-24-94	211.29	--	S
	04-11-95	210.99	--	S
25N/01W-24A01	03-25-94	346.87	--	S
	08-22-94	347.16	--	S
	04-12-95	347.06	--	S
25N/01W-24B02	04-22-94	276.07	--	S
	08-24-94	277.30	--	S
	04-11-95	276.68	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
25N/01W-24H01	04-22-94	321.62	--	S
	08-24-94	322.84	--	S
	04-11-95	322.14	--	S
25N/01W-24J02	04-10-95	259.27	P	S
25N/01W-24N02	04-22-94	158.46	--	S
	08-24-94	158.87	--	S
	04-14-95	158.15	--	S
25N/02E-19N02	03-21-94	132.0	R	R
	08-26-94	158.92	--	S
	04-03-95	132.5	--	R
25N/02E-19N03	03-21-94	172.4	R	R
	08-26-94	211.09	--	S
	03-15-95	105.3	--	R
	04-18-95	180.1	R	R
26N/01E-01D01	12-04-93	257.38	--	S
	08-26-94	258.68	--	S
	04-11-95	257.65	--	S
26N/01E-01N01	12-15-93	177.63	--	S
	08-26-94	178.20	--	S
	04-11-95	177.60	--	S
26N/01E-02G02	12-08-93	3.08	--	S
	08-23-94	4.18	--	S
	04-11-95	3.43	--	S
26N/01E-02K01	12-08-93	131.06	--	S
	08-23-94	141.18	--	S
	04-11-95	126.54	--	S
26N/01E-02K02	12-08-93	121.79	--	S
	08-24-94	145.85	--	S
	12-01-94	122.40	--	S
	12-28-94	121.10	--	S
	01-23-95	120.48	--	S
	02-22-95	119.91	--	S
	03-22-95	119.42	--	S
	04-11-95	119.17	--	S
	05-26-95	119.16	--	S
	06-20-95	119.40	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-02K02	07-18-95	119.79	--	S
	08-21-95	134.78	R	S
	09-19-95	126.08	R	S
	10-24-95	139.14	R	S
	11-21-95	127.72	--	S
	01-22-96	121.86	--	S
	02-22-96	121.01	--	S
	03-27-96	120.33	--	S
26N/01E-02L03	08-26-94	15.9	R	R
	04-11-95	17.1	--	R
26N/01E-02L05	08-24-94	16.9	R	R
	04-10-95	18	--	R
26N/01E-03N02	12-09-93	94.35	--	S
	08-22-94	94.78	--	S
	04-11-95	93.07	--	S
26N/01E-03N03	12-09-93	240.35	--	S
	08-22-94	241.54	--	S
	04-11-95	242.18	--	S
26N/01E-03N04	12-09-93	107.22	R	S
	08-22-94	106.00	--	S
	04-12-95	104.61	--	S
26N/01E-04B01	04-14-95	293.3	R	R
26N/01E-04C01	12-15-93	173.28	--	S
	08-24-94	176.43	R	S
	04-10-95	173.38	--	S
26N/01E-04E03	12-15-93	64.92	--	S
	08-25-94	67.76	--	S
	04-10-95	64.95	--	S
26N/01E-04L01	12-15-93	45.65	--	S
	08-24-94	45.70	R	S
	04-12-95	44.27	--	S
26N/01E-04M01	12-09-93	.59	--	S
	08-24-94	2.02	--	S
	11-21-94	2.39	--	S
	12-28-94	.45	--	S
	01-23-95	.60	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-04M01	02-22-95	.13	--	S
	03-22-95	-.34	--	S
	04-10-95	-.64	--	S
	05-26-95	1.02	--	S
	07-18-95	.19	--	S
	08-21-95	-.08	--	S
	09-19-95	.09	--	S
	10-24-95	-.18	--	S
	11-21-95	-.42	--	S
	02-22-96	16.33	Z	S
	02-23-96	--	F	R
	03-25-96	--	F	R
26N/01E-05J02	12-15-93	1.71	--	S
	08-24-94	3.50	--	S
	04-10-95	.78	--	S
26N/01E-05P01	08-22-94	62.28	--	S
	04-11-95	60.80	--	S
26N/01E-05Q01	08-22-94	91.58	--	S
	04-11-95	91.61	--	S
26N/01E-06R01	08-25-94	5.37	--	S
	04-11-95	7.44	--	S
26N/01E-07J01	08-23-94	65.11	--	S
	04-11-95	64.63	--	S
26N/01E-07J02	08-23-94	8.82	--	S
	04-11-95	4.26	--	S
26N/01E-07R03	08-23-94	36.00	--	S
26N/01E-07R04	08-23-94	14.60	--	S
	04-11-95	7.76	--	S
26N/01E-08B01	08-22-94	76.05	--	S
	12-02-94	76.50	--	S
	01-24-95	76.42	--	S
	02-28-95	76.40	--	S
	03-20-95	75.05	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-08B01	04-11-95	75.30	--	S
	05-24-95	74.52	--	S
	06-19-95	74.35	--	S
	07-19-95	74.06	--	S
	08-25-95	74.07	--	S
	09-22-95	74.00	--	S
	11-20-95	74.20	--	S
	01-23-96	73.74	--	S
	03-27-96	72.45	--	S
26N/01E-08B02	08-22-94	77.79	--	S
	04-11-95	77.59	--	S
26N/01E-08C01	08-22-94	54.87	--	S
26N/01E-08C02	08-22-94	103.46	--	S
	04-11-95	103.51	--	S
26N/01E-08M01	12-29-93	189.83	--	S
	03-29-94	190.21	--	R
	08-24-94	190.84	--	S
	04-10-95	189.23	--	S
26N/01E-08N01	08-23-94	23.27	--	S
	04-11-95	18.34	--	S
26N/01E-08N02	08-23-94	21.90	--	S
	04-11-95	18.29	--	S
26N/01E-08N03	08-23-94	22.73	--	S
26N/01E-08N05	08-23-94	11.92	--	S
	04-11-95	9.67	--	S
26N/01E-08P01	08-23-94	24.50	--	S
	04-11-95	21.56	--	S
26N/01E-09C01	04-21-94	32.78	--	S
	08-23-94	32.67	--	S
	04-14-95	28.16	--	S
26N/01E-09C02	04-22-94	264.6	--	T
	08-23-94	268.60	--	S
	04-14-95	263.50	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-09E01	12-21-93	151.97	R	S
	08-24-94	172.61	R	S
	04-11-95	165.2	--	R
26N/01E-09F01	12-21-93	146.19	--	S
	08-24-94	147.44	R	S
	11-21-94	147.50	--	S
	12-28-94	147.28	--	S
	01-24-95	146.85	--	S
	02-22-95	145.88	--	S
	03-22-95	153.43	--	S
	04-10-95	145.15	--	S
	05-26-95	146.17	P	S
	06-20-95	149.70	P	S
	07-18-95	154.44	--	S
	08-21-95	154.72	P	S
	09-19-95	145.24	--	S
	10-24-95	147.05	--	S
	11-21-95	144.71	--	S
	01-22-96	144.51	--	S
	02-22-96	143.83	--	S
	03-25-96	143.56	--	S
26N/01E-09G03	04-07-94	97.75	--	S
	08-22-94	97.62	--	S
	11-21-94	97.89	--	S
	12-28-94	98.23	--	S
	01-23-95	97.69	--	S
	02-28-95	98.67	R	S
	03-22-95	98.15	--	S
	04-11-95	96.17	--	S
	05-26-95	94.49	--	S
	07-18-95	93.18	--	S
	08-21-95	92.74	--	S
	09-19-95	92.51	--	S
	10-25-95	92.47	--	S
	11-21-95	92.10	--	S
	01-22-96	94.40	--	S
	02-22-96	92.77	--	S
	03-27-96	95.47	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-09K02	04-07-94	93.07	--	S
	08-22-94	92.83	--	S
	04-10-95	89.40	--	S
26N/01E-09R02	12-21-93	49.10	--	S
	08-22-94	49.39	--	S
	04-10-95	44.83	S	S
26N/01E-10D01	12-21-93	86.41	--	S
	08-22-94	86.66	--	S
	04-11-95	84.55	--	S
26N/01E-10H02	12-28-93	64.41	--	S
	08-24-94	64.17	--	S
	04-11-95	60.67	--	S
26N/01E-10M01	12-28-93	42.08	--	S
	08-22-94	42.41	--	S
	04-11-95	38.38	--	S
26N/01E-10M02	12-28-93	39.14	--	S
	08-22-94	39.40	--	S
26N/01E-10N03	12-21-93	11.66	--	S
	08-25-94	12.27	R	S
	04-10-95	6.62	--	S
26N/01E-10N04	12-21-93	12.04	--	S
	08-25-94	14.06	--	S
	04-10-95	6.78	--	S
26N/01E-11J01	04-07-94	170.03	R	S
	04-11-95	131.27	--	S
26N/01E-11L02	12-28-93	29.75	--	S
	08-24-94	87.10	R	S
26N/01E-11L03	12-28-93	64.95	--	S
	08-23-94	62.17	--	S
	04-11-95	56.65	--	S
26N/01E-12C02	12-14-93	4.70	--	S
	08-24-94	4.49	--	S
26N/01E-12C03	12-28-93	189.50	--	S
	08-25-94	183.86	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-12D01	12-14-93	85.46	--	S
	04-11-95	82.79	--	S
26N/01E-13B01	08-24-94	121.3	R	R
	04-11-95	117.5	--	R
26N/01E-13D01	04-01-94	110.56	--	S
	08-26-94	112.35	--	S
	04-06-95	107.86	--	S
26N/01E-13D02	04-01-94	97.09	R	S
	08-26-94	98.80	--	S
	04-11-95	94.34	--	S
26N/01E-13F02	08-22-94	162.2	R	R
	04-11-95	161.8	--	R
26N/01E-13H04	12-08-93	79.78	--	S
	08-26-94	80.73	--	S
	04-11-95	73.62	--	S
26N/01E-14C01	04-06-94	--	F	R
	08-11-94	--	F	R
	04-13-95	--	F	R
26N/01E-14R01	12-28-93	53.97	--	S
	08-23-94	54.20	--	S
	04-11-95	53.53	--	S
26N/01E-15C02	01-04-94	67.81	--	S
	08-23-94	67.51	--	S
	04-10-95	63.34	--	S
26N/01E-15C03	01-04-94	82.76	--	S
	08-23-94	81.91	--	S
	04-10-95	77.56	--	S
26N/01E-15P02	12-30-93	47.85	--	S
	08-23-94	49.12	--	S
	04-11-95	45.72	R	S
26N/01E-15P03	12-30-93	6.95	--	S
	08-23-94	9.90	--	S
	04-11-95	5.86	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-16D02	04-07-94	104.77	R	S
	08-25-94	105.18	--	S
	04-12-95	104.84	--	S
26N/01E-16F03	01-04-94	125.01	--	S
	08-24-94	125.99	--	S
	04-10-95	125.87	--	S
26N/01E-16F04	04-06-94	101.19	--	S
	08-25-94	101.92	--	S
	04-10-95	101.92	--	S
26N/01E-16H01	01-04-94	68.41	--	S
	08-22-94	67.98	--	S
	04-10-95	65.17	--	S
26N/01E-16N03	04-06-94	129.79	--	S
	08-25-94	130.44	--	S
	11-21-94	131.08	--	S
	12-28-94	130.67	--	S
	01-23-95	130.59	--	S
	02-28-95	130.67	--	S
	03-22-95	130.06	--	S
	04-10-95	130.31	--	S
	05-26-95	130.40	--	S
	06-20-95	130.56	--	S
	02-22-96	129.69	--	S
	03-25-96	130.13	--	S
	07-18-95	133.43	R	S
	08-22-95	130.26	--	S
	09-19-95	130.15	--	S
	10-25-95	129.93	--	S
	11-21-95	129.93	--	S
	01-22-96	129.90	--	S
	02-22-96	129.69	--	S
	03-25-96	130.13	--	S
26N/01E-17A01	01-06-94	357.4	--	R
	03-29-94	358.0	--	R
	08-24-94	358.29	--	S
	12-05-94	358.56	--	S
	12-27-94	356.98	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-17A01	01-24-95	357.23	--	S
	03-20-95	356.60	--	S
	04-10-95	356.69	--	S
	05-24-95	356.77	--	S
	06-19-95	357.00	--	S
	08-25-95	357.59	--	S
	09-22-95	357.78	--	S
	11-20-95	357.17	--	S
	02-05-96	356.18	--	S
	02-23-96	356.20	--	S
26N/01E-17C01	08-23-94	52.46	--	S
	12-02-94	52.40	--	S
	12-28-94	51.50	--	S
	01-24-95	50.79	--	S
	02-28-95	49.95	--	S
	03-20-95	49.50	--	S
	04-11-95	49.38	--	S
	05-24-95	49.93	--	S
	06-19-95	50.43	--	S
	07-19-95	51.05	--	S
	08-25-95	51.55	--	S
	09-21-95	52.01	--	S
	11-20-95	52.00	--	S
	01-23-96	50.86	--	S
	02-05-96	356.18	--	S
	02-23-96	50.00	--	S
	03-27-96	50.00	--	S
26N/01E-17D01	08-23-94	--	D	S
	04-11-95	1.39	--	S
26N/01E-17D02	08-23-94	27.58	--	S
	04-11-95	25.08	--	S
26N/01E-17D03	08-23-94	15.11	--	S
	04-11-95	12.29	--	S
26N/01E-17N01	01-06-94	347.58	--	S
	03-29-94	345.8	--	R
	08-24-94	347.39	--	S
	04-10-95	340.51	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-18F01	01-06-94	3.43	--	S
	04-12-95	1.51	--	S
26N/01E-18K01	04-21-94	191.44	R	S
	08-22-94	184.77	--	S
	04-12-95	183.01	--	S
26N/01E-18L02	01-06-94	121.90	--	S
	08-24-94	122.17	--	S
	04-12-95	112.74	--	S
26N/01E-18L04	01-06-94	10.85	--	S
	06-02-94	8.5	--	R
	08-24-94	17.97	X	S
	04-12-95	1.01	X	S
26N/01E-18L05	01-06-94	17.04	X	S
	06-02-94	15.2	--	R
	08-24-94	23.99	X	S
	04-12-95	6.64	X	S
26N/01E-18L06	01-06-94	26.37	X	S
	06-02-94	24.2	--	R
	08-24-94	32.93	X	S
	04-12-95	13.25	X	S
26N/01E-18N01	12-29-93	6.31	X	S
	08-25-94	10.17	X	S
26N/01E-18P02	01-06-94	35.43	X	S
	06-02-94	31.8	--	R
	08-24-94	41.13	X	S
	04-12-95	20.01	X	S
26N/01E-18P03	04-21-94	75.67	R	S
	08-22-94	71.19	--	S
	04-12-95	68.81	--	S
26N/01E-18P04	04-21-94	116.62	R	S
	08-22-94	111.55	--	S
	04-12-95	109.10	--	S
26N/01E-18P06	04-21-94	159.63	R	S
	08-22-94	153.87	--	S
	04-12-95	151.64	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-19C01	12-29-93	82.29	X	S
	05-25-94	84.8	--	R
	08-25-94	85.62	X	S
	04-12-95	73.90	X	S
26N/01E-19C01P1	12-29-93	78.05	--	S
	05-25-94	75.8	--	R
	08-25-94	77.34	--	S
	04-10-95	72.26	X	S
26N/01E-19D01	12-29-93	11.97	X	S
	05-25-94	14.5	--	R
	08-25-94	15.60	X	S
	04-12-95	1.28	X	S
26N/01E-19F01	12-29-93	78.06	--	S
	05-25-94	77.6	--	R
	08-25-94	77.82	--	S
	12-01-94	75.73	--	S
	12-28-94	74.76	--	S
	01-24-95	74.87	--	S
	02-28-95	75.05	--	S
	03-20-95	74.48	--	S
	04-14-95	74.53	X	S
	05-24-95	75.79	--	S
	06-19-95	76.10	--	S
	07-19-95	76.06	--	S
	08-25-95	76.53	--	S
	09-22-95	76.91	--	S
	10-25-95	75.93	--	S
26N/01E-19F01	11-20-95	75.43	--	S
	01-23-96	74.34	--	S
	03-27-96	73.64	--	S
26N/01E-19F01P1	12-29-93	90.9	--	R
	05-25-94	92.2	--	R
	08-25-94	91.89	--	S
	12-01-94	88.89	--	S
	12-28-94	86.79	--	S
	01-24-95	87.84	--	S
	02-28-95	87.81	--	S
	03-20-95	87.08	--	S
	05-24-95	88.62	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-19F01P1	06-19-95	88.31	--	S
	07-19-95	90.05	--	S
	08-25-95	87.89	--	S
	09-22-95	88.39	--	S
	10-25-95	87.18	--	S
	11-20-95	86.60	--	S
	02-23-96	85.80	--	S
	03-27-96	85.01	--	S
26N/01E-19M01	08-25-94	12.25	--	S
	04-13-95	6.34	--	S
26N/01E-19M02	04-13-95	2.42	--	S
26N/01E-19M03	08-25-94	33.75	--	S
	04-13-95	32.47	--	S
26N/01E-19M04	08-25-94	26.02	--	S
	04-13-95	24.64	--	S
26N/01E-19P01	08-25-94	8.28	--	S
	04-13-95	3.48	--	S
26N/01E-19P02	08-25-94	5.90	--	S
	04-13-95	3.32	--	S
26N/01E-19P03	09-25-94	3.95	R	S
26N/01E-19Q01	05-06-94	244.72	--	S
	08-25-94	245.50	--	S
	04-12-95	243.43	--	S
26N/01E-19Q02	04-22-94	245.27	--	S
	08-25-94	246.21	--	S
	04-12-95	243.55	--	S
26N/01E-19Q03	04-06-94	241.60	--	S
	08-25-94	242.92	--	S
	04-12-95	240.00	--	S
26N/01E-20J01	03-08-94	205.29	--	S
	08-26-94	205.61	--	S
	04-10-95	206.08	--	S
26N/01E-20R01	03-08-94	53.37	--	S
	08-26-94	50.72	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-20R03	03-06-94	212.0	--	R
	04-06-94	213.02	--	S
	08-23-94	212.51	--	S
	04-12-95	212.58	--	S
26N/01E-20R04	03-08-94	206.91	--	S
	08-26-94	207.23	--	S
	11-22-94	207.87	--	S
	12-28-94	208.70	--	S
	01-24-95	207.61	--	S
	02-28-95	208.00	--	S
	03-22-95	207.32	--	S
	04-10-95	207.72	--	S
	06-20-95	207.73	P	S
	07-18-95	207.00	--	S
	08-22-95	207.14	--	S
	09-19-95	208.71	R	S
	10-25-95	206.63	--	S
	11-21-95	206.69	--	S
	01-22-96	206.58	--	S
	02-22-96	206.35	--	S
	03-25-96	208.33	--	S
26N/01E-21E04	03-02-94	4.52	--	S
	08-25-94	9.47	--	S
	11-22-94	9.13	--	S
	12-28-94	7.58	--	S
	01-23-95	3.83	--	S
	02-28-95	2.87	--	S
	03-22-95	2.40	--	S
	04-10-95	3.40	--	S
	05-26-95	4.34	--	S
	06-20-95	5.12	--	S
	07-18-95	6.32	R	S
	08-22-95	6.12	R	S
	09-19-95	6.21	--	S
	10-25-95	7.93	--	S
	11-21-95	5.66	--	S
	01-22-96	1.79	--	S
	02-22-96	1.25	--	S
	03-25-96	2.50	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-21N01	03-03-94	179.89	--	S
	08-25-94	180.50	R	S
	04-10-95	181.02	--	S
26N/01E-22D02	08-25-94	81.74	--	S
	04-13-95	80.00	--	S
26N/01E-22M03	03-03-94	77.32	R	S
	08-26-94	76.66	--	S
	04-10-95	74.50	--	S
26N/01E-22N02	03-01-94	2.23	--	S
	08-26-94	7.20	--	S
	04-10-95	3.04	--	S
26N/01E-22N03	03-01-94	75.17	--	S
	08-26-94	79.07	--	S
	04-11-95	73.54	--	S
26N/01E-22P01	03-01-94	75.83	--	S
	08-25-94	77.24	--	S
	11-22-94	76.55	--	S
	12-27-94	75.37	--	S
	01-23-95	75.67	--	S
	02-28-95	75.25	--	S
	03-22-95	74.63	--	S
	04-10-95	75.15	--	S
	05-26-95	76.02	--	S
	06-20-95	75.83	--	S
	07-18-95	76.69	R	S
	08-21-95	76.13	--	S
	09-19-95	76.51	--	S
	10-24-95	76.25	--	S
	11-21-95	75.83	--	S
	01-22-96	75.37	--	S
	02-22-96	75.05	--	S
	03-25-96	75.42	--	S
26N/01E-22P02	03-03-94	46.10	--	S
	08-25-94	46.42	--	S
	04-10-95	44.28	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-24B02	12-09-93	70.00	--	S
	08-26-94	68.04	--	S
	04-12-95	64.16	--	S
26N/01E-24B03	12-28-93	13.99	--	S
	08-26-94	14.96	--	S
	04-11-95	8.50	--	S
26N/01E-24B04	12-28-93	3.78	--	S
	08-26-94	9.30	--	S
	04-11-95	2.06	--	S
26N/01E-24G01	08-11-94	-1.56	--	S
	04-13-95	-4.4	--	H
26N/01E-24K01	12-15-93	112.16	--	S
	08-25-94	117.74	R	S
	04-10-95	110.32	--	S
26N/01E-25B01	12-28-93	122.90	--	S
	08-25-94	123.08	--	S
	04-10-95	121.65	--	S
26N/01E-25B02	12-28-93	118.79	--	S
	08-25-94	118.98	--	S
	04-10-95	117.55	--	S
26N/01E-25G05	12-29-93	98.88	--	S
	08-25-94	99.17	--	S
	04-10-95	97.49	--	S
26N/01E-25L06	03-02-94	18.80	--	S
	08-24-94	20.32	--	S
	04-10-95	17.32	--	S
26N/01E-25N04	12-16-93	22.89	--	S
	08-24-94	25.05	S	S
	04-10-95	18.30	--	S
26N/01E-26M02	03-01-94	--	F	R
26N/01E-26Q02	03-02-94	14.41	--	S
	08-22-94	17.70	--	S
	04-10-95	12.52	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-26Q03	03-02-94	10.89	--	S
	08-22-94	14.27	--	S
	04-10-95	11.23	--	S
26N/01E-27B02	03-02-94	35.62	--	S
	08-23-94	38.12	--	S
	04-10-95	35.63	--	S
26N/01E-27F02	03-01-94	113.02	--	S
	04-10-95	112.44	--	S
26N/01E-27G03	03-02-94	--	F	R
	08-16-94	2.55	--	S
	04-13-95	-1.7	--	Z
26N/01E-27N01	03-03-94	111.06	--	S
	08-22-94	111.90	--	S
	04-11-95	109.14	--	S
26N/01E-27N02	03-03-94	107.54	--	S
	08-22-94	108.70	--	S
	04-10-95	106.30	--	S
26N/01E-28D01	03-08-94	153.65	--	S
	08-23-94	154.00	--	S
	04-10-95	154.33	--	S
26N/01E-28E02	03-03-94	178.60	--	S
	08-23-94	181.78	--	S
	04-14-95	184.78	--	S
26N/01E-28N02	03-08-94	151.18	--	S
	08-23-94	151.68	--	S
	04-19-95	150.90	--	S
26N/01E-29N01	01-06-94	301.3	--	R
	03-29-94	301.1	--	R
	08-24-94	301.15	--	S
	04-10-95	300.61	--	S
26N/01E-29P01	08-23-94	152.04	--	S
	12-02-94	152.16	--	S
	12-28-94	152.08	--	S
	01-24-95	152.36	--	S
	02-28-95	152.48	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-29P01	03-20-95	151.63	--	S
	04-13-95	151.86	--	S
	05-24-95	151.51	--	S
	06-19-95	150.23	--	S
	07-19-95	150.60	--	S
	08-25-95	150.40	--	S
	09-22-95	150.15	--	S
	10-25-95	149.80	--	S
	11-20-95	150.33	--	S
	01-23-96	149.98	--	S
26N/01E-30B01P1	12-29-93	186.4	--	T
	05-25-94	186.6	--	R
	08-25-94	186.65	--	S
	12-01-94	186.07	--	S
	12-28-94	185.89	--	S
	01-24-95	186.15	--	S
	02-28-95	186.39	--	S
	03-20-95	186.18	--	S
	04-18-95	185.20	--	S
	05-24-95	185.89	--	S
	06-19-95	185.97	--	S
	07-19-95	186.07	--	S
	08-25-95	185.99	--	S
	09-22-95	186.09	--	S
	10-25-95	185.56	--	S
	11-20-95	185.43	--	S
	01-23-96	185.38	--	S
	02-23-96	184.18	--	S
	03-27-96	185.26	--	S
26N/01E-30B01P2	12-29-93	209.2	--	T
	05-25-94	209.0	--	R
	08-25-94	209.26	--	S
	12-01-94	206.68	--	S
	12-28-94	207.31	--	S
	01-24-95	207.32	--	S
	02-28-95	207.57	--	S
	03-20-95	206.89	--	S
	04-14-95	206.57	--	S
	04-18-95	203.70	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-30B01P2	05-24-95	207.54	--	S
	06-19-95	207.42	--	S
	07-19-95	207.89	--	S
	09-22-95	207.66	--	S
	10-25-95	206.73	--	S
	11-20-95	206.59	--	S
	01-23-96	208.07	--	S
	02-23-96	205.82	--	S
	03-27-96	205.97	--	S
26N/01E-30B01P3	12-29-93	206.8	--	T
	05-25-94	196.6	--	R
	08-25-94	204.07	--	S
	12-01-94	205.35	--	S
	12-28-94	204.46	--	S
	01-24-95	205.35	--	S
	02-28-95	205.48	--	S
	03-20-95	204.88	--	S
	04-14-95	204.84	--	S
	04-18-95	206.84	--	S
	05-24-95	205.24	--	S
	06-19-95	205.15	--	S
	07-19-95	205.40	--	S
	08-25-95	204.97	--	S
	09-22-95	205.41	--	S
	10-25-95	204.76	--	S
	11-20-95	204.70	--	S
	01-23-96	205.97	--	S
	02-23-96	203.82	--	S
	03-27-96	203.65	--	S
26N/01E-30D01	01-06-94	56.40	--	S
	08-24-94	56.23	--	S
	04-12-95	52.41	--	S
26N/01E-30L01	04-06-94	247.63	--	S
	08-22-94	248.80	--	S
	04-12-95	247.82	--	S
26N/01E-31A03	05-06-94	304.78	--	S
	08-25-94	305.38	--	S
	04-12-95	304.20	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-31B01P1	01-07-94	270.5	--	R
	06-01-94	270.9	--	R
	08-26-94	270.77	--	S
	04-18-95	270.34	--	S
26N/01E-31B01P2	08-26-94	306.25	--	S
	04-10-95	305.19	--	S
	04-18-95	304.91	--	S
26N/01E-31B01P3	01-07-94	308.0	--	R
	06-01-94	308.0	--	R
	08-26-94	308.30	--	S
	04-10-95	306.81	--	S
	04-18-95	306.91	--	S
26N/01E-31B02	05-06-94	294.32	--	S
	08-25-94	294.95	--	S
	12-01-94	294.27	--	S
	12-27-94	294.18	--	S
	01-24-95	294.29	--	S
	03-03-95	293.95	--	S
	03-20-95	293.57	--	S
	04-12-95	293.56	--	S
	05-26-95	293.85	--	S
	06-19-95	293.88	--	S
	08-25-95	293.89	--	S
	09-22-95	293.04	--	S
	11-20-95	293.90	--	S
	01-23-96	293.44	--	S
	02-23-96	293.09	--	S
26N/01E-31B03	05-06-94	294.90	--	S
	08-25-94	295.56	--	S
	04-12-95	294.16	--	S
26N/01E-31B04P1	08-22-94	126.18	--	S
	04-12-95	125.62	--	S
26N/01E-31B04P2	08-22-94	126.21	--	S
	04-12-95	125.75	--	S
26N/01E-31C01P1	08-22-94	119.16	--	S
	04-12-95	117.58	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-31C01P2	08-22-94	119.25	--	S
	04-12-95	117.53	--	S
26N/01E-31E01	04-07-94	--	O	S
26N/01E-31E01P1	04-07-94	--	O	S
26N/01E-31G01	08-23-94	131.45	--	S
	04-12-95	131.25	--	S
26N/01E-31G02	08-23-94	118.00	--	S
	04-12-95	117.65	--	S
26N/01E-31H02	08-22-94	100.33	--	S
	04-11-95	98.78	--	S
26N/01E-31J03	08-22-94	106.28	--	S
	04-12-95	104.93	--	S
26N/01E-31J04	08-22-94	75.01	--	S
	04-12-95	72.91	--	S
26N/01E-31K01	08-22-94	134.99	--	S
	04-12-95	134.00	--	S
26N/01E-31R01	04-21-94	382.68	--	S
	08-22-94	389.13	--	S
	04-12-95	382.03	--	S
26N/01E-32E01	08-26-94	57.53	--	S
	04-12-95	55.15	--	S
26N/01E-32E02	08-22-94	55.95	--	S
26N/01E-32K03	08-24-94	65.47	--	S
26N/01E-32L03	07-07-94	205.81	--	S
	08-23-94	206.00	--	S
	04-12-95	205.60	--	S
26N/01E-32L04	01-07-94	221.34	--	S
	06-01-94	221.4	--	R
	06-27-94	221.24	--	S
	08-24-94	221.65	--	S
	12-01-94	220.87	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-32L04	12-27-94	220.49	--	S
	01-24-95	220.87	--	S
	02-28-95	220.86	--	S
	03-20-95	220.33	--	S
	04-14-95	220.30	--	S
	05-24-95	220.74	--	S
	06-19-95	220.51	--	S
26N/01E-32L04	07-19-95	220.74	--	S
	08-25-95	220.53	--	S
	09-22-95	220.62	--	S
	10-25-95	220.26	--	S
	11-20-95	220.30	--	S
	01-23-96	220.25	--	S
	02-23-96	219.46	--	S
	03-27-96	219.40	--	S
26N/01E-32L05	07-12-94	227.66	--	S
	08-25-94	232.61	--	S
26N/01E-32Q01	03-03-94	16.00	--	S
	08-23-94	17.84	--	S
	04-10-95	13.58	--	S
26N/01E-32Q03	08-24-94	20.15	--	S
	12-02-94	19.92	--	S
	12-27-94	18.14	--	S
	01-24-95	17.25	--	S
	02-28-95	15.22	--	S
	03-20-95	14.20	--	S
	04-13-95	13.99	--	S
	05-24-95	15.82	--	S
	06-19-95	16.14	--	S
	07-19-95	16.51	--	S
	08-25-95	16.68	--	S
	09-22-95	17.27	--	S
	10-25-95	17.34	--	S
	11-20-95	16.93	--	S
	01-23-96	14.15	--	S
	02-23-96	14.73	--	S
	03-27-96	14.33	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-32Q04	08-24-94	18.23	--	S
	04-13-95	13.72	--	S
26N/01E-32Q05	08-24-94	19.49	--	S
	04-13-95	14.64	--	S
26N/01E-32Q06	08-24-94	18.66	--	S
	04-13-95	13.46	--	S
26N/01E-32Q08	03-03-94	16.30	--	S
	08-23-94	17.87	--	S
	04-10-95	13.90	--	S
26N/01E-33A02	03-08-94	32.53	--	S
	08-22-94	33.54	--	S
	04-10-95	30.24	--	S
26N/01E-33G01	03-08-94	20.20	--	S
	08-22-94	21.39	--	S
	11-22-94	22.45	--	S
	12-27-94	21.40	--	S
	01-24-95	20.18	--	S
	02-28-95	18.07	--	S
	03-22-95	16.56	--	S
	04-10-95	16.02	--	S
	05-24-95	16.41	--	S
	06-20-95	17.35	--	S
	07-18-95	18.30	--	S
	08-21-95	18.99	--	S
	09-19-95	19.71	--	S
	10-24-95	20.30	--	S
	11-21-95	20.37	--	S
	01-22-96	18.59	--	S
	02-22-96	16.58	--	S
	04-03-96	16.02	--	S
26N/01E-33P03	03-08-94	--	F	R
26N/01E-34D01	03-02-94	27.20	--	S
	08-22-94	28.04	--	S
	04-14-95	25.18	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-34E01	03-02-94	1.83	--	S
	08-22-94	4.20	--	S
	04-11-95	2.1	--	S
26N/01E-34H01	03-01-94	1.51	--	S
	08-22-94	3.08	--	S
26N/01E-34P02	02-24-94	167.65	R	S
	08-24-94	167.15	--	S
	04-10-95	166.38	--	S
26N/01E-34R01	03-01-94	263.61	R	S
	08-22-94	265.26	R	S
	04-11-95	264.15	--	S
26N/01E-35B03	04-19-94	44.32	--	S
	08-22-94	47.04	--	S
	04-11-95	44.6	--	S
26N/01E-35N01	03-03-95	136.69	--	S
26N/01E-36M01	08-22-94	-16.2	--	R
26N/01W-24A01	01-06-94	67.89	--	S
	08-24-94	68.86	--	S
	04-12-95	58.42	--	S
26N/01W-25A02	04-22-94	66.82	--	S
	08-25-94	66.45	--	S
	04-12-95	65.66	--	S
26N/01W-25B02	12-29-93	107.45	--	S
	05-25-94	112.9	--	R
	08-25-94	110.40	--	S
	12-02-94	106.40	--	S
	12-28-94	108.84	--	S
	01-24-95	107.95	--	S
	02-28-95	108.55	--	S
	03-20-95	108.75	--	S
	04-12-95	112.62	--	S
	05-26-95	111.11	--	S
	06-19-95	109.43	--	S
	07-19-95	109.17	--	S
	08-25-95	108.71	--	S
	09-22-95	110.65	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01E-34E01	03-02-94	1.83	--	S
	08-22-94	4.20	--	S
	04-11-95	2.1	--	S
26N/01E-34H01	03-01-94	1.51	--	S
	08-22-94	3.08	--	S
26N/01E-34P02	02-24-94	167.65	R	S
	08-24-94	167.15	--	S
	04-10-95	166.38	--	S
26N/01E-34R01	03-01-94	263.61	R	S
	08-22-94	265.26	R	S
	04-11-95	264.15	--	S
26N/01E-35B03	04-19-94	44.32	--	S
	08-22-94	47.04	--	S
	04-11-95	44.6	--	S
26N/01E-35N01	03-03-95	136.69	--	S
26N/01E-36M01	08-22-94	-16.2	--	R
26N/01W-24A01	01-06-94	67.89	--	S
	08-24-94	68.86	--	S
	04-12-95	58.42	--	S
26N/01W-25A02	04-22-94	66.82	--	S
	08-25-94	66.45	--	S
	04-12-95	65.66	--	S
26N/01W-25B02	12-29-93	107.45	--	S
	05-25-94	112.9	--	R
	08-25-94	110.40	--	S
	12-02-94	106.40	--	S
	12-28-94	108.84	--	S
	01-24-95	107.95	--	S
	02-28-95	108.55	--	S
	03-20-95	108.75	--	S
	04-12-95	112.62	--	S
	05-26-95	111.11	--	S
	06-19-95	109.43	--	S
	07-19-95	109.17	--	S
	08-25-95	108.71	--	S
	09-22-95	110.65	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/01W-36A01	07-19-95	166.76	--	S
	08-25-95	168.25	--	S
	09-22-95	169.23	--	S
	10-25-95	167.29	--	S
	11-20-95	170.80	--	S
	01-23-96	165.97	--	S
	02-23-96	162.85	--	S
	03-27-96	162.70	--	S
26N/01W-36C01	01-07-94	129.74	--	S
	08-22-94	131.12	--	S
	12-02-94	129.68	--	S
	12-27-94	129.14	--	S
	01-24-95	129.78	--	S
	02-22-95	129.83	--	S
	03-22-95	128.98	--	S
	04-12-95	130.12	--	S
	05-26-95	130.94	--	S
	06-20-95	130.57	--	S
	07-19-95	130.49	--	S
	08-22-95	130.72	--	S
	09-18-95	131.99	--	S
	10-24-95	130.93	--	S
	11-21-95	130.13	--	S
	01-22-96	134.01	--	S
	02-22-96	129.30	--	S
	03-25-96	130.27	--	S
26N/01W-36R02	03-21-94	19.43	--	S
	08-22-94	21.54	--	S
	04-12-95	17.30	--	S
26N/01W-36R03	03-21-94	193.08	--	S
	08-22-94	195.22	--	S
	04-12-95	194.08	--	S
26N/02E-06A02	12-07-93	6.80	--	S
	08-25-94	8.18	R	S
	04-13-95	5.12	--	S
26N/02E-06G01	12-07-93	57.53	--	S
	08-25-94	60.47	R	S
	04-13-95	57.27	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/02E-06R02	12-07-93	175.11	--	S
	08-25-94	176.05	--	S
	04-13-95	174.99	--	S
26N/02E-07L02	12-28-93	56.01	--	S
	08-24-94	55.90	--	S
	04-13-95	54.54	--	S
26N/02E-07R03	12-08-93	184.50	--	S
	08-24-94	186.36	--	S
	04-13-95	181.58	--	S
26N/02E-18A06	12-08-93	145.85	--	S
	08-24-94	146.57	R	S
	04-19-95	143.48	R	S
26N/02E-18H04	03-08-94	73.26	--	S
	08-24-94	74.68	--	S
	04-11-95	69.48	--	S
26N/02E-19B03	12-14-93	34.80	--	S
	08-24-94	32.69	--	S
	04-11-95	27.82	--	S
26N/02E-19B04D01	12-14-93	148.36	--	S
	08-24-94	166.38	R	S
	04-11-95	146.78	--	S
26N/02E-19G01	12-15-93	138.75	--	S
	08-24-94	138.03	--	S
	04-14-95	137.00	--	S
26N/02E-19G02	12-16-93	278.10	--	S
	08-24-94	278.82	--	S
	04-11-95	279.45	--	S
26N/02E-19J03	12-14-93	20.18	--	S
	08-24-94	20.13	--	S
	04-11-95	15.69	--	S
26N/02E-30A05	12-29-93	226.48	--	S
	08-24-94	228.51	--	S
	04-11-95	226.8	--	S
26N/02E-30H02	12-16-93	180.34	--	S
	08-24-94	180.62	--	S
	04-11-95	180.35	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
26N/02E-30N03D01	12-16-93	37.38	--	S
	08-24-94	38.18	--	S
	04-11-95	37.02	--	S
26N/02E-31F02	12-16-93	130.77	--	S
	08-25-94	129.28	--	S
	04-11-95	127.49	--	S
26N/02E-31G01	12-29-93	161.76	--	S
	08-25-94	161.77	--	S
	04-11-95	159.76	--	S
26N/02E-31J03	03-31-94	27.36	--	S
	04-11-95	26.72	--	S
27N/01E-22Q04	02-23-94	48.32	--	S
	08-25-94	53.58	--	S
	04-10-95	47.11	--	S
27N/01E-22Q05	03-22-94	96.64	--	S
	08-25-94	99.25	--	S
	04-13-95	96.61	--	S
27N/01E-23D01	03-22-94	47.04	--	S
	08-25-94	47.74	--	S
	04-13-95	46.56	--	S
27N/01E-23D02	03-22-94	41.29	--	S
	08-25-94	41.97	--	S
	04-13-95	40.52	--	S
27N/01E-23M01	01-25-94	48.82	R	S
	08-25-94	51.94	--	S
	04-13-95	46.45	--	S
27N/01E-26D01	02-03-94	133.95	--	S
	08-25-94	146.59	R	S
	04-13-95	132.62	--	S
27N/01E-26R01	04-04-94	37.33	R	S
	08-25-94	34.35	R	S
27N/01E-27E04	08-22-94	127.9	--	T
27N/01E-27J01	08-22-94	117.8	R	T
	04-14-95	108.3	R	R

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
27N/01E-27J02	08-22-94	176.2	--	T
	04-14-95	174.4	--	R
27N/01E-27N01	03-30-94	86.67	--	S
	08-23-94	87.67	--	S
	04-13-95	85.23	--	S
27N/01E-27N02	03-30-94	27.85	--	S
	08-23-94	29.77	--	S
	04-13-95	26.07	--	S
27N/01E-27R02	03-30-94	2.66	--	S
	08-23-94	15.44	--	S
	04-13-95	1.67	--	S
27N/01E-27R03	03-30-94	124.38	--	S
	08-23-94	126.50	--	S
	04-11-95	120.91	--	S
27N/01E-28J02	03-31-94	176.15	R	S
	08-23-94	177.52	--	S
	04-19-95	176.42	--	S
27N/01E-28K02	03-31-94	37.38	--	S
	08-23-94	37.29	--	S
	04-13-95	36.82	R	S
27N/01E-28K03	03-31-94	40.69	--	S
	08-23-94	41.08	--	S
	04-13-95	40.2	--	S
27N/01E-28K04	04-07-94	69.89	--	S
	08-23-94	72.75	--	S
	04-13-95	69.56	--	S
27N/01E-33B02	12-16-93	71.17	--	S
	05-24-94	72.30	R	S
	08-24-94	72.3	--	R
	04-11-95	66.13	--	S
27N/01E-33B03	12-16-93	162.92	--	S
	08-23-94	163.12	R	S
	11-21-94	163.43	--	S
	12-28-94	163.12	--	S
	01-23-95	162.82	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
27N/01E-33B03	02-22-95	163.03	--	S
	03-22-95	162.43	--	S
	04-13-95	162.40	--	S
	05-26-95	162.74	--	S
	06-20-95	163.13	--	S
	07-18-95	163.90	--	S
	08-21-95	162.97	--	S
	09-19-95	163.25	--	S
	10-24-95	163.08	--	S
	11-21-95	163.00	--	S
	01-22-96	162.96	--	S
	03-27-96	162.49	--	S
27N/01E-33F02	01-25-94	94.16	--	S
	08-23-94	95.79	--	S
	04-13-95	94.64	--	S
27N/01E-33P02	12-17-93	173.00	--	S
	08-23-94	173.23	--	S
	11-21-94	173.36	--	S
	12-28-94	172.73	--	S
	01-23-95	172.82	R	S
	02-22-95	172.70	--	S
	03-22-95	172.04	--	S
	04-12-95	172.22	--	S
	05-26-95	172.85	--	S
	06-20-95	173.25	--	S
	07-18-95	172.83	--	S
	08-21-95	173.87	--	S
	09-19-95	173.11	--	S
27N/01E-34K02	03-24-94	183.58	--	S
	08-23-94	186.74	R	S
	04-12-95	184.04	--	S
27N/01E-34L01	12-17-93	84.17	--	S
	08-23-94	83.85	--	S
	04-12-95	79.69	--	S
27N/01E-34L02	12-17-93	79.96	--	S
	08-23-94	79.65	--	S
	04-12-95	74.51	--	S

Appendix 2.--*Water levels in inventoried wells, Naval Submarine Base Bangor and vicinity, Kitsap County, Washington--Continued*

Local well number	Date	Water level (feet below land surface)	Status	Water-level measurement method
27N/01E-34M01	12-19-93	295.66	--	S
27N/01E-35C01	12-17-93	255.04	--	S
	08-25-94	255.70	--	S
	04-13-95	252.98	--	S
27N/01E-35E01	12-16-93	145.07	--	S
	08-23-94	151.97	--	S
	04-11-95	145.10	--	S
27N/01E-35H01	12-29-93	24.40	--	S
	08-25-94	25.41	R	S
	04-14-95	22.06	R	S
27N/01E-35N01	03-22-94	261.98	--	S
	08-23-94	262.62	--	S
	04-12-95	262.59	R	S
27N/01E-36E01	12-29-93	54.65	--	S
	08-23-94	54.28	--	S
	04-14-95	50.52	--	S
27N/01E-36J03	12-28-93	82.72	--	S
	08-25-94	83.40	--	S
	04-14-95	82.22	--	S
27N/02E-31H01	12-28-93	19.98	--	S
	08-25-94	20.51	--	S
	04-14-95	17.69	--	S
27N/02E-31N01	03-31-94	104.03	--	S
	08-25-94	104.08	--	S
	04-14-95	102.34	--	S
27N/02E-31R03	12-28-93	78.29	--	S
	08-25-94	78.43	--	S
	04-13-95	76.64	--	S

Appendix 3.--Report accompanying geologic map of Naval Submarine Base Bangor, by Richard K. Borden, RPG, July 1995. The surficial geology map (including locations of springs or seepage faces and outcrops) referred to in this appendix has been reproduced using geographic information system techniques and is included in this report on plate 2.

1.0 INTRODUCTION

This report presents the results of the geologic mapping project at Naval Submarine Base, Bangor, Washington (Subase). It is accompanied by a 1:12,000 scale surficial geology map of the Subase. The mapping was conducted for the United States Geological Survey (USGS) under Task Order 1434WR-95-SA-0605. Field work was conducted between May 30, 1995 and June 27, 1995.

The Subase is located on Hood Canal in the west-central Puget Lowland, and covers approximately eleven square miles. It is underlain by a thick sequence of unconsolidated Quaternary glacial and nonglacial sediments.

1.1 Previous Studies

Several studies of the surficial geology at Subase Bangor have already been conducted. However, these studies were either conducted at a reconnaissance scale or covered only a small portion of the Subase. Shannon and Wilson produced a 1:24,000 scale reconnaissance geologic map of the entire Subase in 1973. Hart Crowser completed a 1:6000 scale map of the extreme northern end of the Subase in 1991; and URS produced a 1:56,000 scale geologic map of the entire Subase in 1993. The URS map appears to have been a modification of the original Shannon and Wilson map based upon new boring log data.

The Subase is also covered by the Geologic Map of Surficial Deposits in the Seattle 30' by 60' Quadrangle (Yount et al 1993). This map was produced at a scale of 1:100,000 and, in the vicinity of the Subase, was based upon preexisting maps. The Subase is not covered by the Coastal Zone Atlas of Washington (WDOE 1978), but the shoreline immediately to the north and south of the Subase boundaries was mapped.

The results of the present study are compared to these preexisting maps in Section 8.0 of this report.

1.2 Field Procedures

Geologic data were plotted on a 1:12,000 scale base map made from two USGS 7.5' Quadrangles. Outcrops and other data were located on the map relative to topographic and cultural features. An altimeter, a brunton compass, a clinometer and a hip chain were all used to help locate data points. Field efforts were concentrated along the shoreline, in stream beds, along roads and in areas of new construction, because these locations contained the best exposures.

Detailed measured sections were made in areas with sufficient exposure. The locations of these measured sections are shown on Figure 1-1. Outcrops were plotted on the map as either glacial till; glaciolacustrine silt and fine sand; glacial outwash sand and gravel; or nonglacial silt, sand and gravel. No attempt was made to differentiate between Vashon and preVashon glacial drift at the outcrop scale because of the lack of reliable stratigraphic indicators at mesoscopic scales. For the same reason, geologic data from borings are plotted on the map as either till; sand and gravel; or silt and clay. By presenting the information in this way, the raw data used to make stratigraphic interpretations are clearly visible on the map.

The lack of outcrop on the Subase required that most contacts be located by float and soil mapping. A four-foot hand auger was used during the float mapping to collect relatively unweathered material from the subsurface. The locations of the auger holes are not plotted on the map.

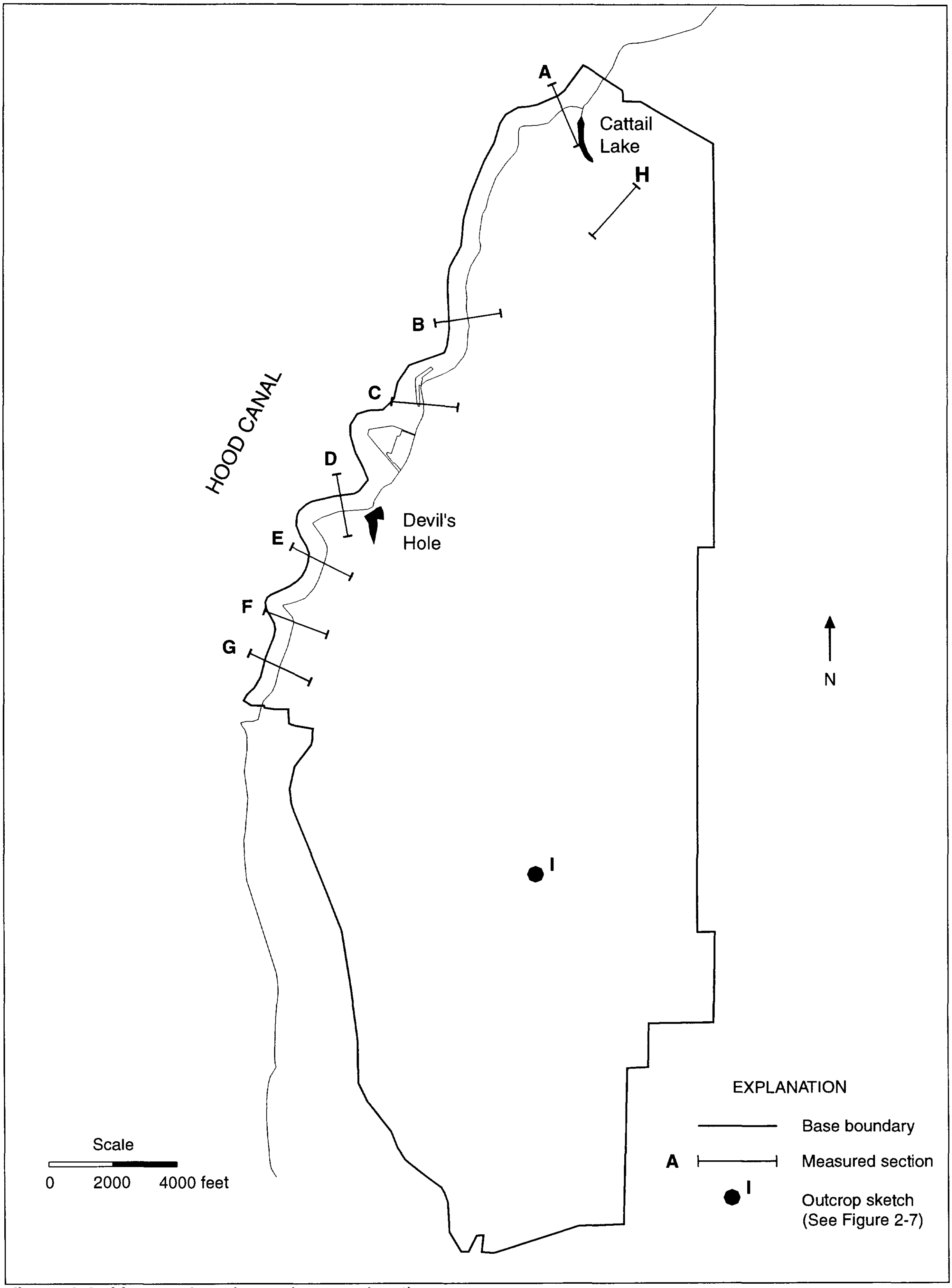


Figure 1-1. Measured section and outcrop location.
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Other data that were collected during the field work include spring locations, bedding attitudes, fracture orientations and densities, flow direction indicators, and information relating to lateral and vertical facies relationships. These data are either plotted on the map or presented in this report.

2.0 STRATIGRAPHY

Subase Bangor is underlain by a thick sequence of unconsolidated Quaternary glacial and nonglacial sediments. Table 2-1 summarizes the stratigraphic units that are exposed on the Subase. Most of the exposed section is composed of Vashon drift, but PreVashon glacial drift and Nonglacial sediments crop out near sea level along Hood Canal.

Table 2-1. Summary of Stratigraphic Units

UNIT	THICKNESS	HYDROLOGIC PROPERTIES	REGIONAL CORRELATION
Vashon Recessional Outwash	0 to 40 feet typically 0 feet	highly permeable	Vashon Recessional Outwash
Vashon Till and Ice Contact Deposits	0 to 120 feet highly variable	variable, till diamicton is impermeable and glacio-fluvial ice contact deposits are moderately permeable	Vashon Till
Vashon Advance Outwash	0 to 200 feet typically 150 feet in south and less than 100 feet in north	highly permeable	Vashon Advance Outwash
Vashon Glaciolacustrine Deposits	0 to more than 100 feet typically 50 feet in south and greater than 100 feet in north	impermeable	Lawton Clay
PreVashon Glacial Drift	0 to 50? feet highly variable	variable, outwash sand is moderately to highly permeable and till is impermeable	Possession Drift
Nonglacial Sediments	Bottom not exposed, greater than 60 feet	variable, impermeable to highly permeable depending on percentage of silt interbeds in section	Whidbey Formation

2.1 Nonglacial Sediments

The oldest unit exposed at Subase Bangor is a sequence of interbedded fluvial sands, gravels and silts that is believed to be of nonglacial origin. The unit is well exposed in the sea cliffs along Hood Canal and is shown on five measured sections (Figures 2-1 through 2-5). This unit is at least sixty feet thick.

The Nonglacial sediments are predominantly composed of thick-bedded to massive, cross-bedded sands, gravelly sands and sandy gravels, with minor silt and peat interbeds. The gravels are made up of well-rounded pebbles and cobbles up to five inches in diameter. Silt and clayey silt interbeds typically comprise about ten percent of the section. The silt interbeds seldom exceed three feet in diameter, are laminated to massive, and commonly contain peat or peaty silt. Most silt interbeds are laterally continuous for tens of feet but some interbeds are continuous for several hundred feet.

Unoxidized nonglacial silts, clayey silts and sands are usually very dark grey to black (2.5Y 3/0 to 10YR 2/1 on a Munsell color chart). When oxidized these materials generally turn dark reddish brown to dark olive grey (5YR 3/2 to 5Y 3/2).

Exposures of the nonglacial unit tend to be relatively unoxidized north of Devils Hole and moderately to intensely oxidized south of Devils Hole. In addition to being more lightly colored, the oxidized sediments are usually iron oxide stained or cemented. Lithic sand grains are also commonly altered to clay and many of the cobbles and gravels have thick weathering rinds in the oxidized areas. This intense oxidation may have resulted from long-term subaerial exposure at some time after the unit was deposited.

Evidence supporting a nonglacial origin for this unit includes the presence of peat and organic-rich silt beds, the prevalence of north-directed flow indicators, and the high percentage of sand and gravel with an Olympic Mountain source.

Most nonglacial outcrops are oriented north-south or northeast-southwest. North-dipping cross-bedding predominates on these exposures and south-dipping cross-bedding is exceedingly rare. On the few outcrop faces oriented roughly east-west cross-bedding tends to dip both east and west. These data seem indicative of a predominantly north or northeasterly flow direction during deposition. This is consistent with flow from the Olympic Mountains into the Puget Lowland during a nonglacial period. During a glacial period, when the Puget Lowland is filled with glacial ice, the predominant flow direction wasto the south.

Dark grey to black basalt is the most abundant rock type in the Nonglacial sediments. Gabbro and basaltic sandstone are also relatively common. These rocks are derived from the Blue Mountain Unit and the Crescent Formation that are exposed in the eastern Olympic mountains about eight miles to the west of the Subase (Suczek et al 1994). The sands in the nonglacial formation are predominantly composed of basaltic lithic fragments. Quartz seldom makes up more than 25 percent of the sand. Unlike the overlying glacial deposits, the nonglacial sediments do not contain muscovite or felsic intrusive rocks that are indicative of a northerly source. Samples collected from the Nonglacial unit are lithologically very similar to samples collected from the modern Quilcene, Dosewallips and Duckabush Rivers that drain the eastern Olympics Mountains. Nonglacial sediments at the Subase tend to be more coarse-grained than comparible sediments near the center of the Puget Lowland. This is also indicative of the close proximity of the Olympic Mountain source area.

The nonglacial sediments are thought to correlate with the Whidbey Formation as defined by Easterbrook (1968). The Whidbey Formation is about 100,000 years old.

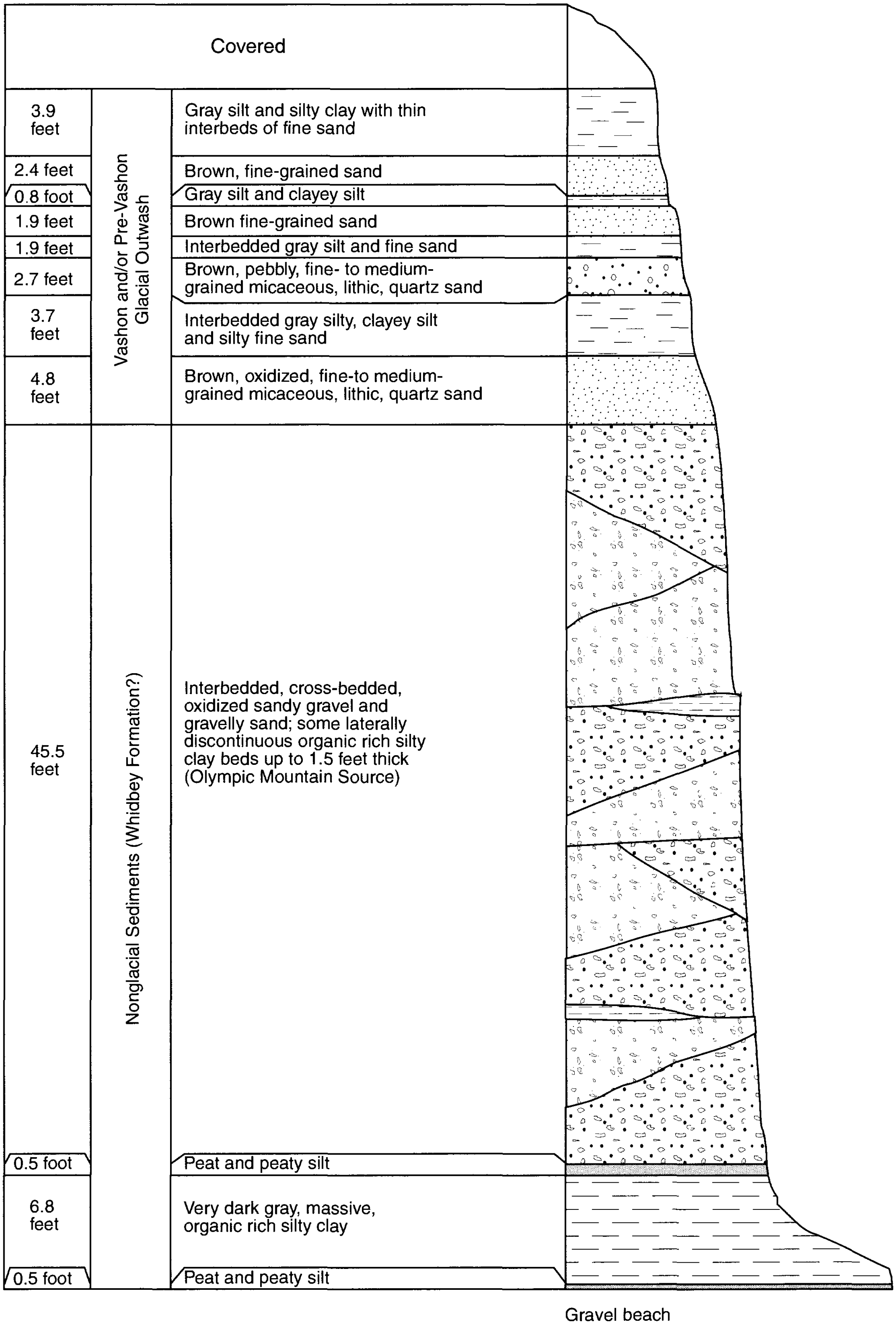

Figure 2-1. Measured Section B
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	Vashon Till	Covered slope with Vashon till float
15 feet	Vashon and/or Pre-Vashon Glacial Outwash	Covered slope with glacial outwash sand float
1 foot		Brown silty fine-grained sand
1 foot		Gray silt with dropstones
1.9 feet		Silty fine- to medium-grained brown micaceous lithic quartz sand
2.2 feet		Gray laminated silty fine sand grading upward to silty clay
1.5 feet	Nonglacial Sediments (Whidbey Formation?)	Dark gray, fine to medium sand
5.4 feet		Cross-bedded sand and gravelly sand with dark gray silt layers between cross bed sets (Olympic Mountain Source)
2.9 feet		Dark gray, fine- to medium-grained sand, gravelly at base
2.0 feet		Gray silty fine sand
14.6 feet		Interbedded dark gray sandy gravel and gravelly sand (Olympic Mountain Source)
0.8 foot		Very dark gray clayey silt
2.7 feet		Interbedded, dark gray sandy gravel and gravelly sand
1 foot		Very dark gray, massive silt
1 foot		Massive sandy gravel
29.3 feet		Covered by fill and colluvium

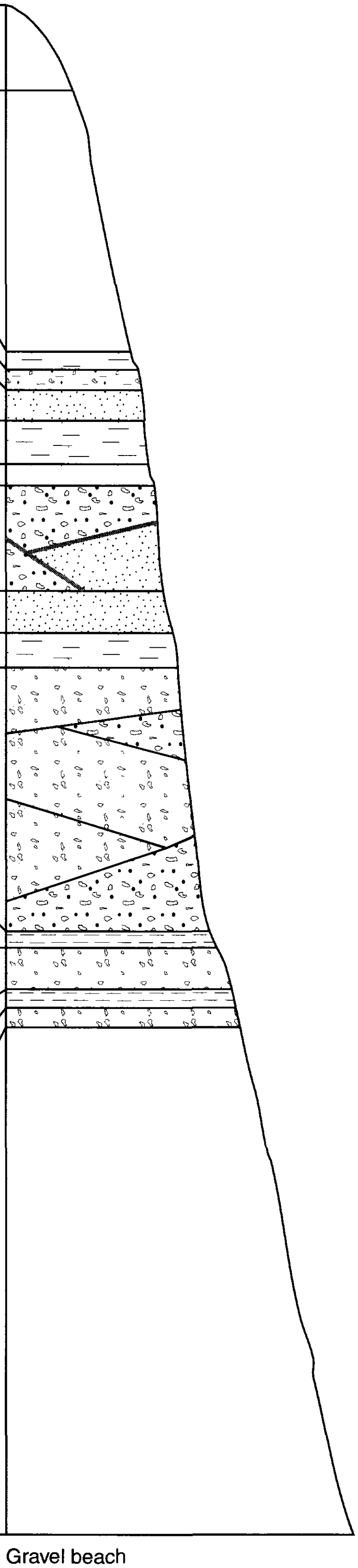

Figure 2-2. Measured Section C
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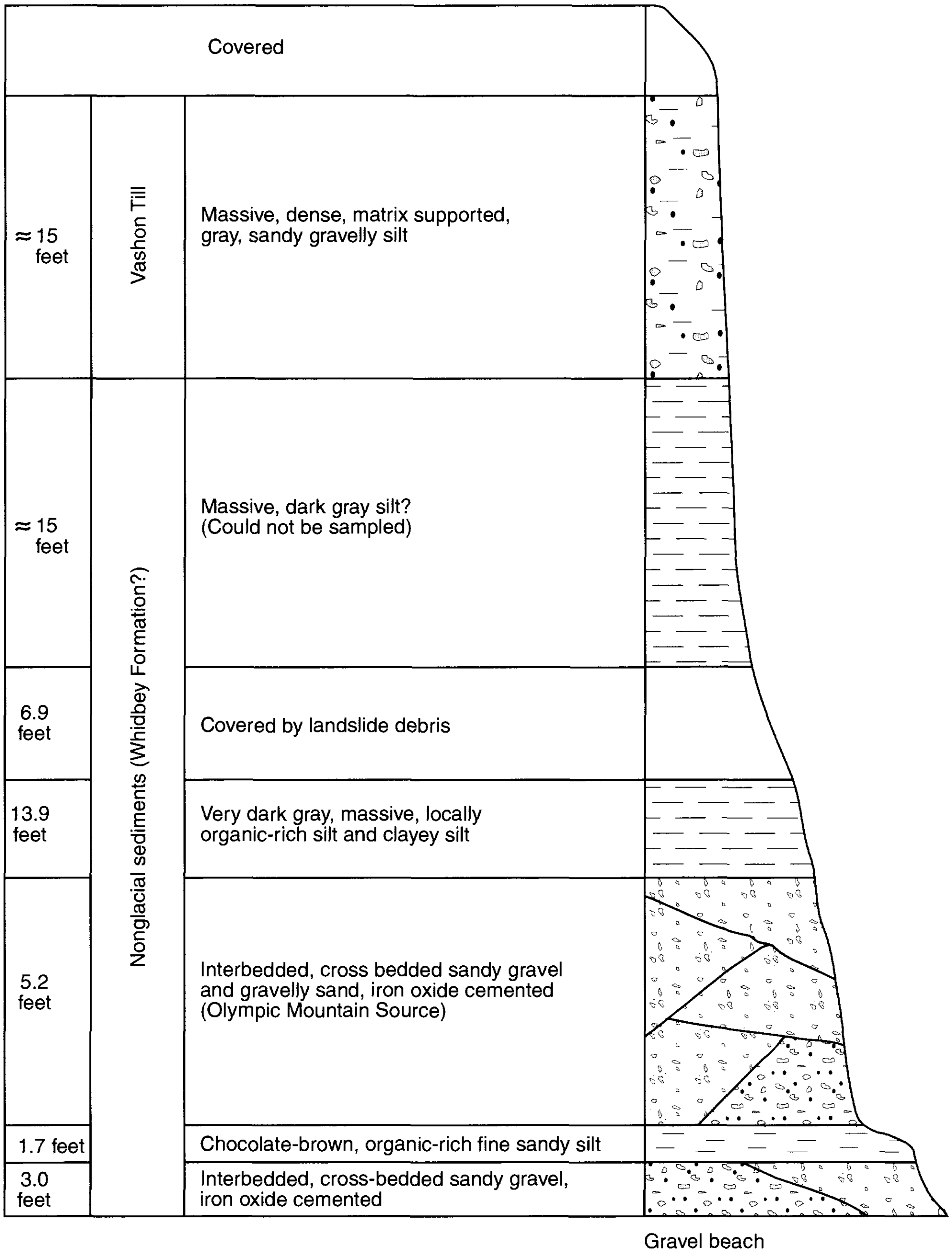

Figure 2-3. Measured Section D

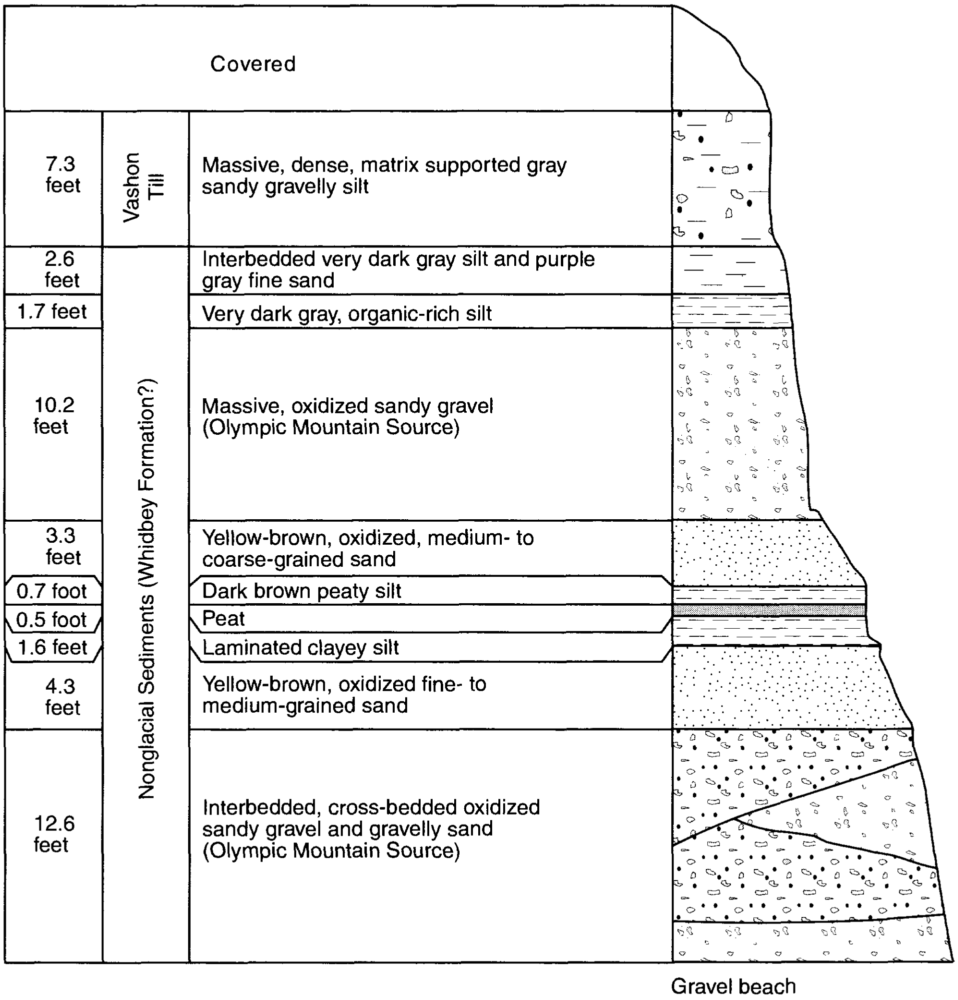

Figure 2-4. Measured Section E

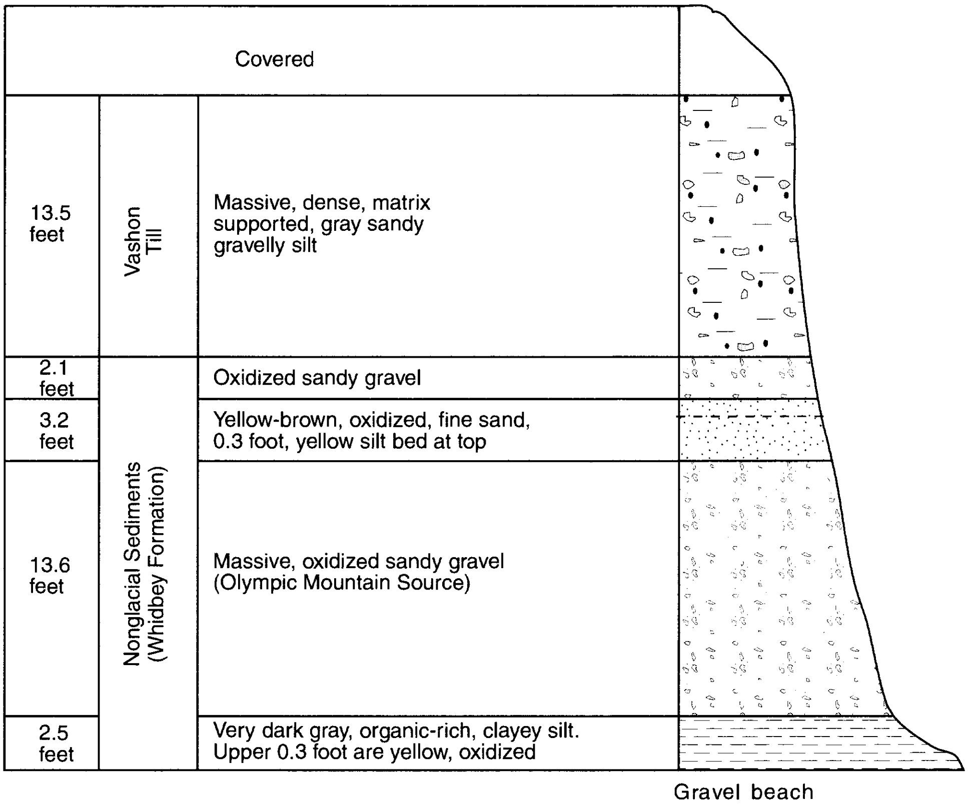

Figure 2-5. Measured Section G

2.2 PreVashon Glacial Drift

PreVashon glacial drift is exposed above the Nonglacial sediments in some areas. The character of the drift is variable and at any given location it may be represented by till, outwash sand, or interbedded sand and silt. The thickness of this unit is poorly constrained but it does not exceed fifty feet anywhere.

PreVashon glacial till is composed of very dense, poorly-sorted, matrix supported, clayey, sandy, gravelly, silt. Gravel only makes up about ten to twenty percent of the till. Clasts are well-rounded to subround and seldom exceed an inch in diameter. The till is dark grey (7.5YR 4/0 and 2.5Y 4/0).

PreVashon glacial outwash is composed of well-sorted, fine- to medium-grained sand or interbedded grey silt and sand. This unit is present in two measured sections (Figures 2-1 and 2-2). The sand is predominantly composed of quartz with fewer than thirty percent lithic fragments and minor amounts of muscovite. The sand is olive grey to dark olive grey (5Y 4/2 to 5Y 3/2) if unoxidized, and olive brown to dark yellowish brown (2.5Y 4/3 to 10YR 3/4) if oxidized.

The PreVashon glacial drift is thought to correlate with the Possession Drift as defined by Easterbrook (1968). The Possession Drift is about 80,000 years old.

2.3 Vashon Glaciolacustrine Deposits

Glaciolacustrine deposits mark the base of the Vashon drift. The glaciolacustrine deposits are composed of interbedded silts, clayey silts, fine sandy silts and fine sands. The unit thickens from about fifty feet in the south to more than 100 feet in the vicinity of the Cattail Lake drainage on the northern boundary of the Subase. Figure 2-6 is a measured section made in the Cattail Lake area. The silt beds are typically massive, but appear laminated on weathered surfaces. Some silt beds contain isolated pebbles and small cobbles that may be dropstones. The interbedded sands are well-sorted, fine- to medium-grained, micaceous, lithic, quartz sands. Unoxidized silts and sands are dark grey (7.5YR 4/0).

These glaciolacustrine deposits correlate with the Lawton Clay member of the Vashon drift as defined by Mullineaux and others (1965). The Lawton Clay was deposited in large proglacial lakes that formed after the Vashon ice sheet had advanced into the northern Puget Lowland about 15,000 years ago. At the type section in Seattle, the Lawton Clay is underlain by nonglacial sediments of Olympia age (about 30,000 years old). No comparable Olympia age sediments have been observed on Subase Bangor. This area may have been subject to erosion rather than deposition during Olympia time. The contact between the glaciolacustrine deposits and the overlying Vashon advance outwash is gradational. The glaciolacustrine sequence tends to coarsen upward, becoming progressively more sandy.

2.4 Vashon Advance Outwash

A thick, homogenous Vashon advance outwash sequence is exposed above the Vashon glaciolacustrine deposits. This unit is typically 150 feet thick but may be up to 200 feet thick in places.

About ninety percent of the sequence is composed of well-sorted, fine- to medium-grained sand. The sand is predominantly composed of quartz with fewer than thirty percent lithic fragments and with minor amounts of muscovite. Sandy gravel and gravelly sand occurs in isolated pods and lenses in the outwash sand and makes up less than ten percent of the section. The gravels are well rounded and seldom exceed three inches in diameter. The clasts are a mixture of felsic intrusives, dacites, andesites, basalts and metasediments indicative of a predominantly northern source. Rare, thin, discontinuous silt beds are scattered throughout the sequence, but are most common at the base, near the contact with the underlying Vashon glaciolacustrine deposits. The sand is olive grey to dark olive grey (5Y 4/2 to 5Y 3/2) if unoxidized and olive brown to dark yellowish brown (2.5Y 4/3 to 10YR 3/4) if oxidized.

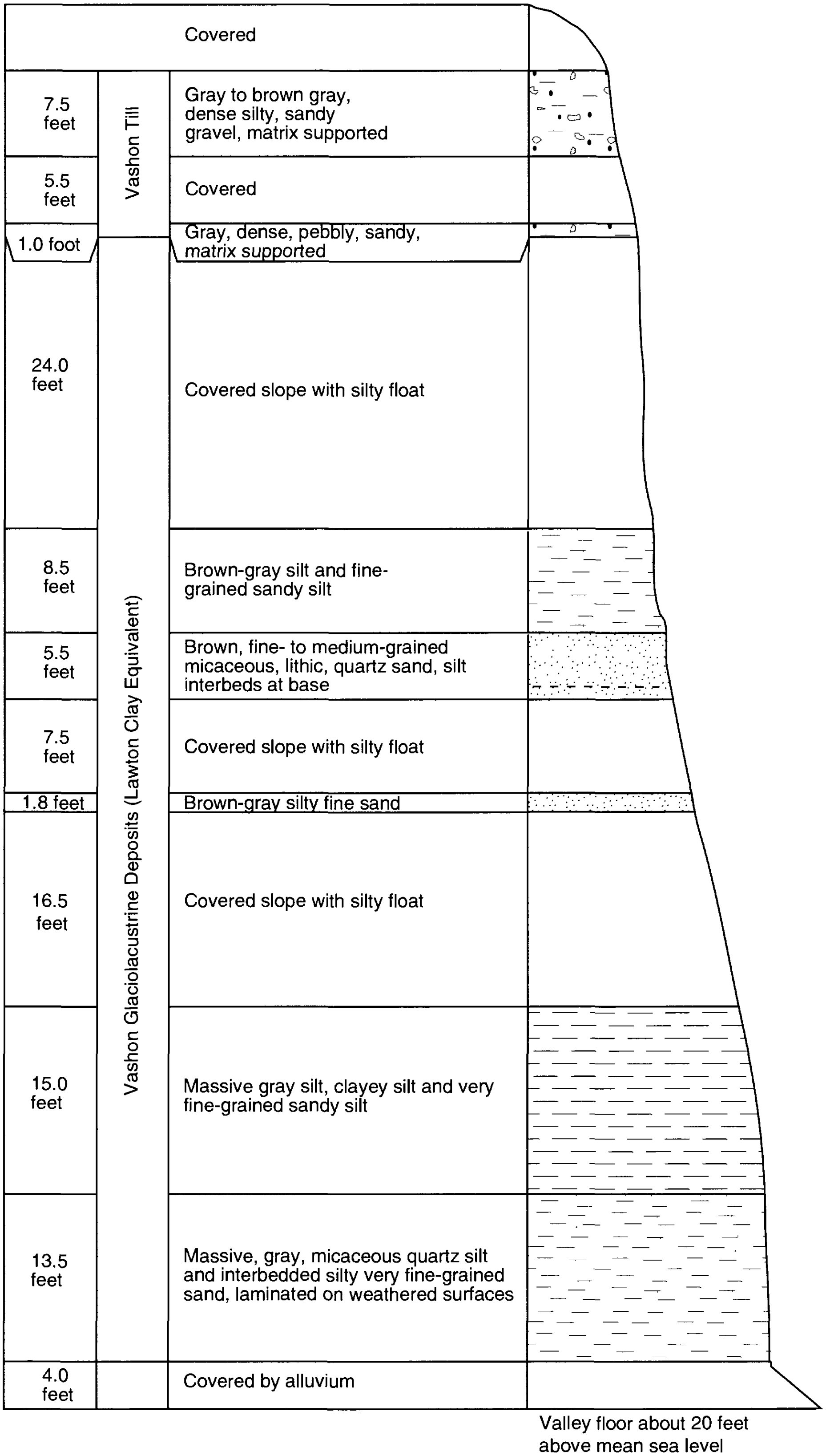

Figure 2-6. Measured Section H
(Reduced from original to fit page)

2.5 Vashon Till and Ice Contact Deposits

Vashon till and interbedded glaciolacustrine and glaciofluvial sediments cover most of the surface of Subase Bangor. This unit varies from zero to greater than one hundred feet in thickness.

Figure 2-7 is a sketch of a till outcrop showing typical facies relationships between the till diamicton facies and associated stratified ice contact facies. All of these deposits are very dense and appear to have been compacted by glacial ice. On boring logs all of these facies are probably designated as Vashon till, but only the massive, matrix supported diamicton was deposited directly by glacial ice. The other, more stratified, facies were probably deposited in subglacial and englacial streams and lakes.

The till is composed of very dense, poorly-sorted, matrix supported, sandy, gravelly silt. Gravel typically comprises about twenty percent of the till. Clasts vary from pebble to boulder size and are generally well rounded to subround. The till is usually dark grey (7.5YR 4/0 and 2.5Y 4/0).

Glaciofluvial ice contact deposits are typically composed of medium dense to dense, crudely to well-bedded, clast supported, poorly- to well-sorted, sandy gravels and gravelly sands with extremely variable silt contents. Glaciolacustrine ice contact deposits are typically composed of stiff to very stiff, thin- to thick-bedded silt and fine sandy silt. These stratified deposits commonly occur as inclusions within the till diamicton or themselves host till diamicton inclusions. The stratified deposits tend to be more oxidized than the till, but less oxidized than true outwash gravels and sands. They are usually dark grey to olive grey (5Y 4/1 to 5Y 4/2).

2.6 Vashon Recessional Outwash

Thin, laterally discontinuous layers of Vashon recessional outwash cover the till in some areas. The recessional outwash is seldom more than ten feet thick. It is generally composed of medium- to coarse-grained sand and gravelly sand.

2.7 Holocene Deposits

Holocene deposits include beach sands and gravels, alluvium, colluvium, peat and fill material. These sediments seldom exceed ten feet in thickness and, except for beach gravels are not laterally continuous.

3.0 OUTCROP DISTRIBUTION

3.1 Nonglacial Sediments

Nonglacial sediments are exposed in the sea cliffs along Hood Canal and in some of the stream valleys within a half mile of the coast. The exposures are not continuous along Hood Canal because in many areas the Vashon till is exposed at sea level. Figure 3-1 summarizes the distribution of the Nonglacial sediments in the measured sections along the coast. Based upon these measured sections and other outcrops, the contact between the Nonglacial sediments and the overlying PreVashon glacial drift varies between 55 and 80 feet above sea level.

3.2 PreVashon Glacial Drift

Exposures of PreVashon glacial drift occur near the shoreline between elevations of 55 and about 110 feet above sea level.

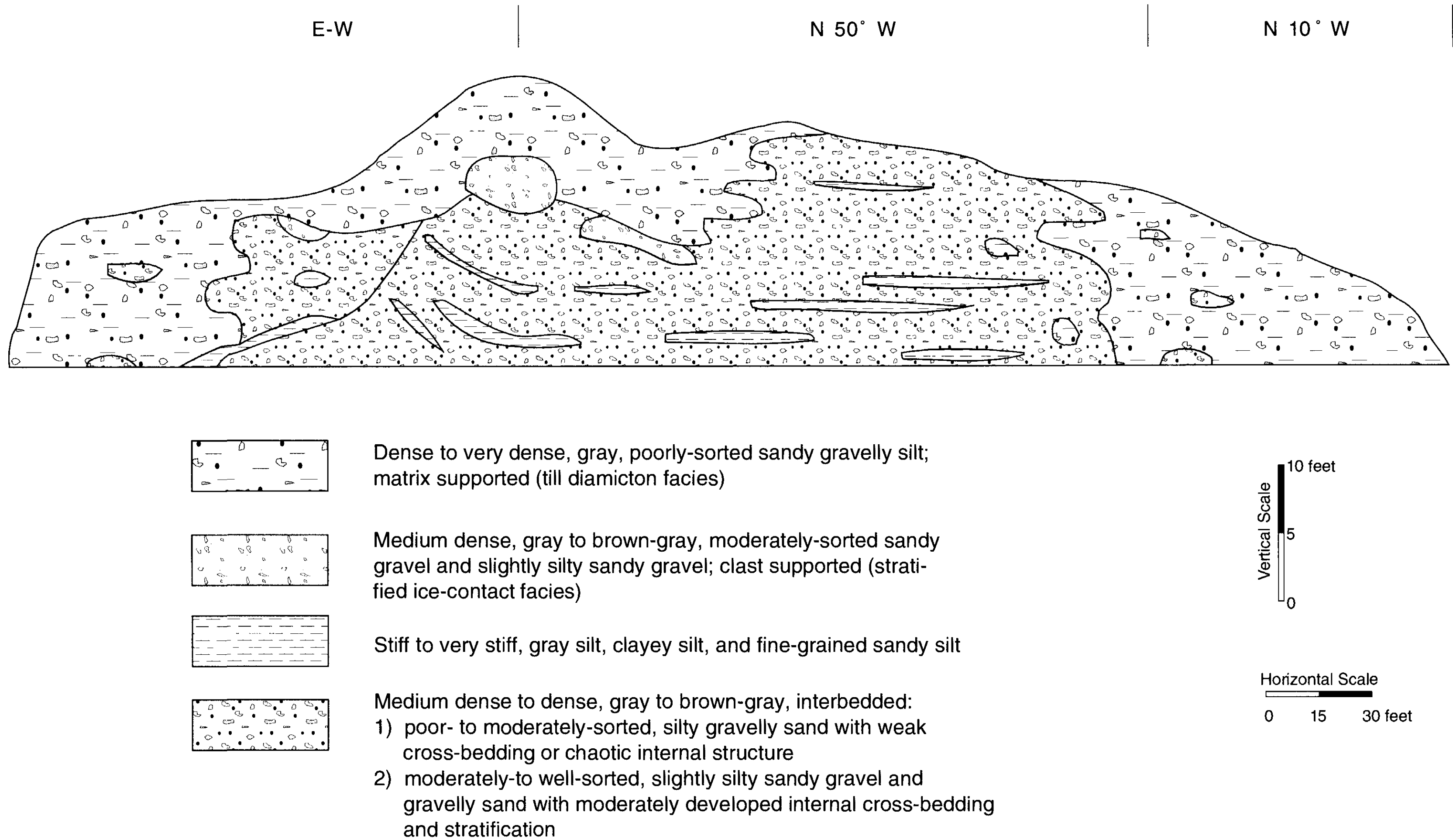

Figure 2-7. Sketch of Outcrop I
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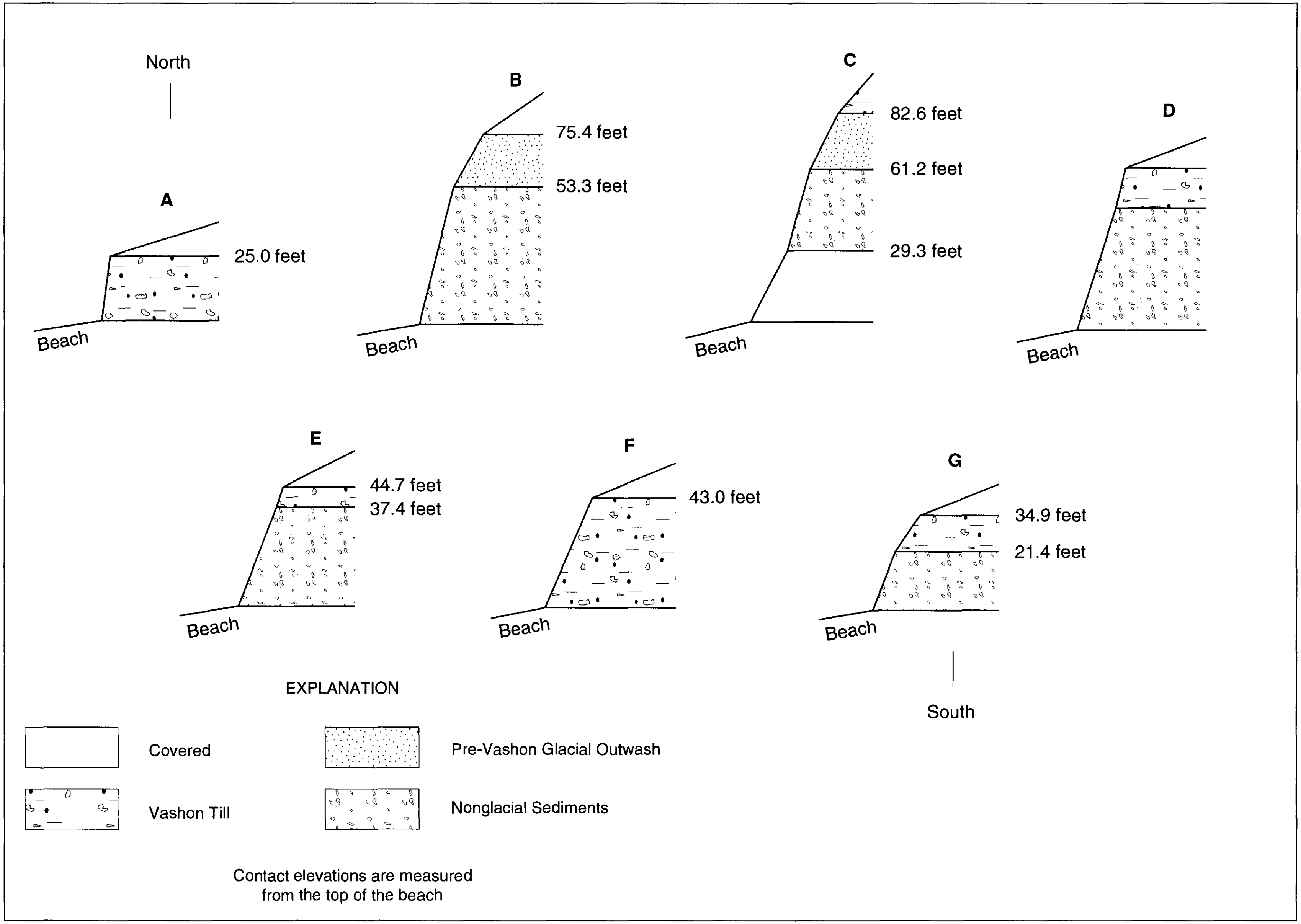

Figure 3-1. Summary of measured Sea Cliff Sections
(Reduced from original to fit page)

Two outcrops of PreVashon till were identified. One is located on the northern boundary of T.26N., R.1E. Section 18 at an elevation of about one hundred feet above sea level. This till outcrop is seventy feet below the lowest outcrop of Vashon glaciolacustrine deposits in the same drainage. The other PreVashon till outcrop is exposed near the center of Section 18 at an elevation of about 75 feet above sea level. It is directly overlain by fifteen feet of outwash sand and is thirty feet below the lowest exposure of Vashon glaciolacustrine deposits in the same drainage.

A twenty foot section of PreVashon glacial outwash is exposed at the top of the sea cliffs in T.26N., R.1E. Section 18 (Sections B and C on Figure 3-1). Outwash sand float at the intersection of T.26N., R.1E. Sections 19 and 30, and T.26N., R.1W. Sections 24 and 25 is also believed to be PreVashon glacial drift. This interpretation is based upon the float's position immediately northwest of Vashon glaciolacustrine deposits, and because a boring made through the outwash sand showed that it is resting immediately upon Nonglacial sediments.

3.3 Vashon Glaciolacustrine Deposits

Vashon glaciolacustrine deposits are generally exposed within a mile of the Hood Canal shoreline. South of the center of Section 18, glaciolacustrine outcrops occur between about 100 and 160 feet above sea level. The glaciolacustrine sediments thicken dramatically to the northeast, so that in the Cattail Lake area outcrops occur between twenty feet and 310 feet above sea level. The glaciolacustrine exposures are laterally continuous except where covered by Vashon till.

3.4 Vashon Advance Outwash

Vashon advance outwash is exposed in erosional windows through the overlying till which blankets most of the Subase. There are six distinct outwash "windows" on the Subase, separated from one another by Vashon till. The contact between the till and the outwash varies between 150 and 360 feet above sea level, but the most common elevation of the contact is about 300 feet above sea level. The elevation of the till/outwash contact tends to decrease towards Hood Canal.

Four of the Vashon advance outwash exposures form a linear pattern about one mile from, and parallel to, the Hood Canal coastline. The outwash "windows" are located in areas where the topography dips steeply toward the coast, and streams have incised deeply into the Quaternary section.

The two inland Vashon advance outwash exposures are both located in stream valleys that have cut into the upland plateau in the center of the base. These stream valleys have again formed erosional "windows" through the overlying Vashon till.

3.5 Vashon Till and Ice Contact Deposits

Vashon till and ice contact deposits are exposed over about seventy-five percent of the Subase. The till is exposed at all elevations, from sea level along Hood Canal, up to 460 feet on the eastern boundary of the Subase. The till encountered just offshore on the bottom of Hood Canal is also probably Vashon till. It is unlikely to be Possession till as proposed by Noble (Noble 1989). As described in Section 3.4, the only places the till is missing is where it has been eroded away to expose the underlying sediments.

The lower contact of the Vashon till tends to mimic the broad topographic features of the area that were present at the end of the last ice age. On the eastern and central portions of the Subase, where topography undulates between 350 and 450 feet above sea level, the exposed contact varies between 280 and 360 feet above sea level. Where topography slopes broadly towards Hood Canal, the lower contact of the Vashon till also slopes towards Hood Canal. Calculations made from exposures of the lower contact indicate that the bottom of the till dips about four degrees to the northwest as it approaches Hood Canal. The Vashon till contact does not mimic erosional features that have formed since the end of the last ice age. Thus, the till contact does not dip into incised stream valleys along the coast or on the southeastern boundary of the Subase.

3.6 Vashon Recessional Outwash

The Vashon till is topped in places by small isolated lenses of Vashon recessional outwash. Most of these lenses are too thin, irregular and limited in exposure to show on the map.

3.7 Holocene Deposits

Holocene alluvium has been deposited in most of the stream valleys on the Subase. The alluvium is most laterally extensive on the deltas that these streams are building into Hood Canal. Beach deposits are most extensive on points and spits.

4.0 GEOMETRIC RELATIONSHIPS BETWEEN STRATIGRAPHIC UNITS

The contact between the Nonglacial sediments and the overlying PreVashon glacial outwash is generally flat-lying and conformable. The contact between Vashon glaciolacustrine deposits and the underlying PreVashon glacial sediments also appears to be flat-lying and conformable beneath the majority of the Subase. However, in the vicinity of the Cattail Lake drainage, the glaciolacustrine deposits thicken dramatically and the lower contact dips below sea level. It is not known if the lower glaciolacustrine contact cuts down section through the PreVashon drift to the Nonglacial sediments or if the entire sedimentary sequence is downwarped in this area.

In general the contact between the Vashon glaciolacustrine deposits and the Vashon advance outwash is conformable. To the south the contact is elatively flat-lying. In the vicinity of the Cattail Lake drainage, however, the upper contact warps upward, and the overlying Vashon advance outwash thins to less than 100 feet over the thickened glaciolacustrine section.

The base of the Vashon till is steeply dipping and in unconformable contact with the underlying Quaternary sediments near Hood Canal. The till contact cuts down-section several hundred feet as it approaches the shoreline. In fact, the lower contact of the Vashon till cuts through the entire exposed Quaternary section. In the interior of the Subase, the till appears to rest conformably on Vashon advance outwash.

5.0 STRUCTURAL GEOLOGY

Very few structural features were observed in the unconsolidated Quaternary sediments at Subase Bangor. Most bedding attitudes are subhorizontal, and fractures and clastic dikes are very rare.

5.1 Bedding Attitudes

Only sixteen reliable measurements of bedding attitude could be made because of the paucity of outcrops and the massive nature of many of the units. Most beds are subhorizontal and no beds dip more than 30 degrees. Almost all of the measurements were made in the Vashon glaciolacustrine deposits and the nonglacial sediments. Bedding attitudes were not plotted on the map because all of the dips of greater than five degrees are believed to be related to rotational slump blocks, and so are very localized features. The bedding attitudes were plotted on a stereonet instead. Figure 5-1 is a plot of poles to bedding planes made on a Schmidt equal area net. The plot shows that most of the bedding attitudes are clustered around the horizontal. Almost all of the

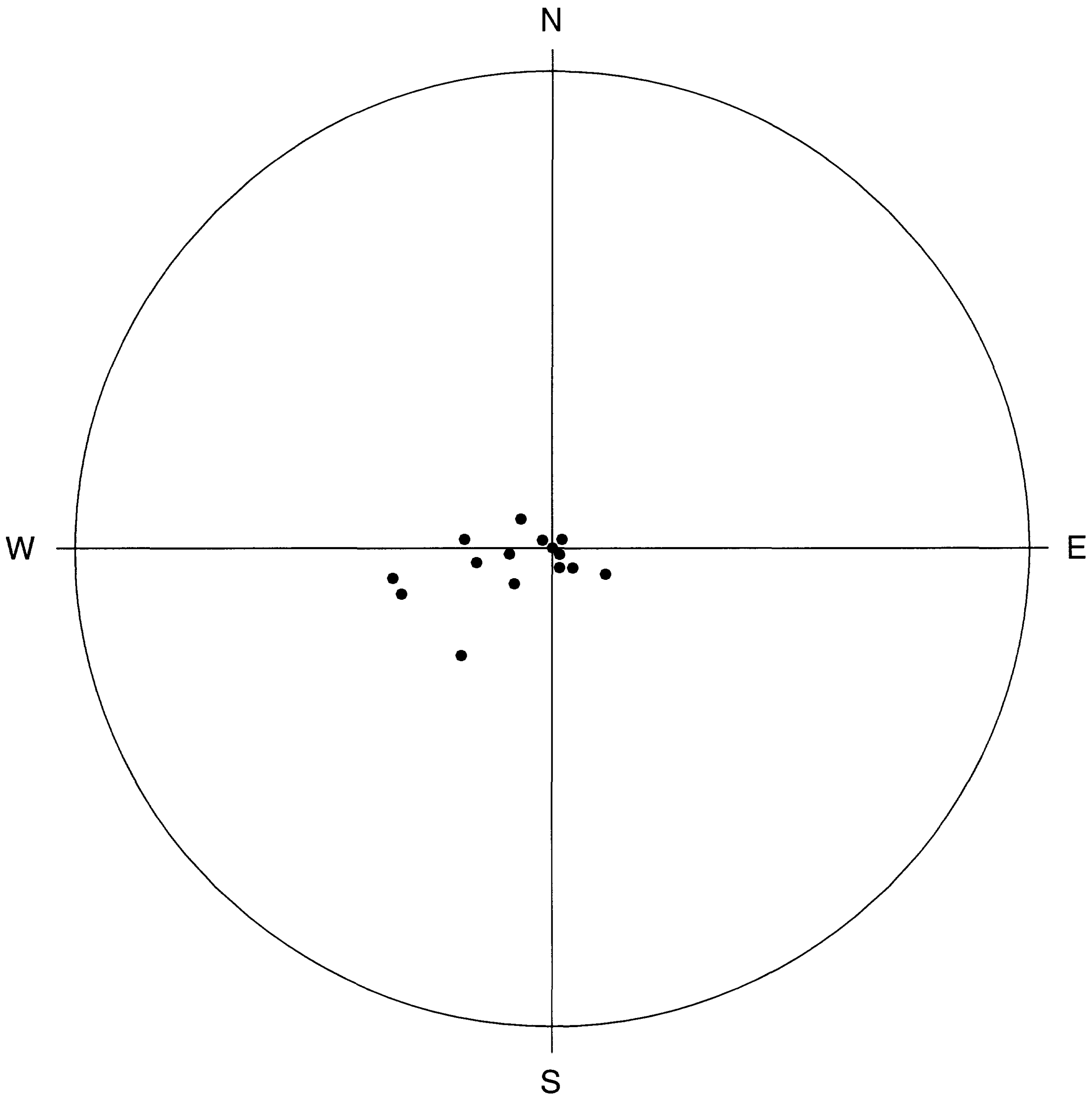

Figure 5-1. Stereographic Projection of Poles to Bedding Planes (Schmidt Net)

more steeply dipping attitudes strike north or northwest, and dip to the east. These attitudes are consistent with rotation about north to northwest striking, and westward dipping, listric slump faults. These slump features are discussed in more detail in Section 7.2.

5.2 Fractures

Fractures were only observed in the Vashon glaciolacustrine deposits and in the PreVashon till. These may be the only units that are indurated enough to behave in a brittle manner. Even in these two units the fractures are uncommon. They tend to be subvertical, but insufficient data are available to make any generalizations about strike orientations. The observed fracture density is so low in these two units that the fractures probably do not decrease their aquitard properties significantly.

5.3 Clastic Dikes

Only two clastic dikes were observed on the Subase, one hosted by the Nonglacial sediments and the other hosted by PreVashon glacial outwash. The largest is exposed in the sea cliff immediately west of Devils Hole. This clastic dike is composed of dark grey, nonglacial clay with pockets of gravelly clay. It is 16 to 22 inches thick and laminated parallel to the sides of the dike. It, is generally oriented N.12 E., 82 W.. The clastic dike is difficult to trace at the top of the cliff, but it appears to truncate against Vashon till that directly overlies the Nonglacial sediments in this area.

The second clastic dike is exposed in a cliff immediately east of the Delta Refit Pier and is contained within PreVashon glacial sediments. This dike is composed of grey clay and is only about 0.5 inches wide. It is oriented N.14 W., 65 E..

It is difficult to make any conclusions about the significance of these clastic dikes because of the small number that were observed. However, they are not thought to be laterally continuous and so probably do not influence groundwater movement significantly.

6.0 HYDROGEOLOGY

6.1 Hydrostratigraphy

Table 2-1 summarizes the hydrologic properties of each of the stratigraphic units. The most significant aquifer exposed above sea level is hosted by Vashon advance outwash. The base of the Vashon advance aquifer is defined by the top of the Vashon glaciolacustrine deposits. The thick silt beds of the glaciolacustrine unit, in conjunction with the PreVashon till, act as an aquitard separating Vashon advance outwash sands above from the Nonglacial gravels below. Beneath most of the Subase the bottom of the aquifer is located about 150 feet above sea level. In the northern part of the Subase, in the vicinity of the Cattail Lake drainage, the base of the Vashon advance aquifer varies between 200 and 300 feet above sea level. The top of the Vashon advance aquifer is either defined by a water table within the outwash sequence, or, if the entire outwash sequence is saturated, by the contact with the overlying Vashon till.

The sands and gravels of the Nonglacial unit host a second much less productive aquifer. The top of this aquifer is typically fifty feet above sea level and is marked by the base of either the PreVashon glacial drift, Vashon glaciolacustrine deposits or by the Vashon till. The base of the Nonglacial aquifer is not exposed. In areas where the PreVashon glacial drift is represented by outwash sands and gravels it may act as part of the Nonglacial aquifer.

6.2 Springs

Spring and seepage faces are shown on the geologic map. In many cases this is a simplification of the actual geometry of seepage faces. If the seep covers a large area, the spring symbol was placed at the highest point on the seepage face. All of the major springs within the study area are associated with the Vashon advance aquifer. The few springs that are found in the Vashon till and the Nonglacial aquifer all have relatively low flow rates.

Figure 6-1 shows the western limit of the Vashon advance aquifer and shows the locations and elevations of springs associated with the aquifer. Most springs are located immediately above the Vashon advance outwash/ Vashon glaciolacustrine contact. However, the largest springs are located at points were deeply incised stream valleys intersect the water table within the Vashon advance outwash. All water flowing westward in this aquifer must either discharge through these springs or flow through the Vashon till and Vashon glaciolacustrine aquitards.

6.3 Groundwater Flow Regime

The springs on Figure 6-1 indicate places where the water table in the Vashon advance aquifer intersects the ground surface. As such they can be used to construct an approximate potentiometric surface and to make a rough estimate of horizontal gradients. As expected, the groundwater flow direction appears to be to the northwest, towards Hood Canal. Gradients on the western margin of the Vashon advance outwash aquifer are up to 500 feet per mile.

The actual groundwater flow pattern on the western margin of the aquifer is probably much more complex. There is most likely a pattern of radial flow towards the springs in the deeply incised valleys. This type of topographically influenced flow regime has been documented in numerous studies (Dunne 1990).

The radial flow patterns are further accentuated by stratigraphic controls. In areas where the Vashon till has not been breached by erosion, and so drapes down to Hood Canal, the western limit of the Vashon advance aquifer is defined by the contact between the Vashon till and the Vashon glaciolacustrine deposits. In effect, the aquifer pinches out to the west between the overlying till aquitard and the underlying glaciolacustrine aquitard. Westward groundwater flow in these areas would be severely impeded. Instead, groundwater would tend to flow to the north and south, towards the erosional windows in the Vashon till and the deeply incised stream valleys. Figure 6-1 shows the areas on the Vashon advance aquifer margin where this type of flow pattern would be anticipated (dashed lines).

7.1 SURFICIAL PROCESSES

7.1 Seepage Erosion

Seepage erosion and channel bank erosion are the dominant surficial processes operating in the Vashon advance outwash exposures. Rapidly eroding, unstable sand cliffs are exposed above several of the springs in the outwash. The outwash sand has very little cohesion and contains very little gravel so it is susceptible to erosion and entrainment at the seepage face. The cliff faces are eroding so rapidly that they cannot be stabilized by vegetation. Seepage erosion also tends to oversteepen valley walls making them more susceptible to mass wasting phenomenon like slumping, debris slides, soil creep and tree throw.

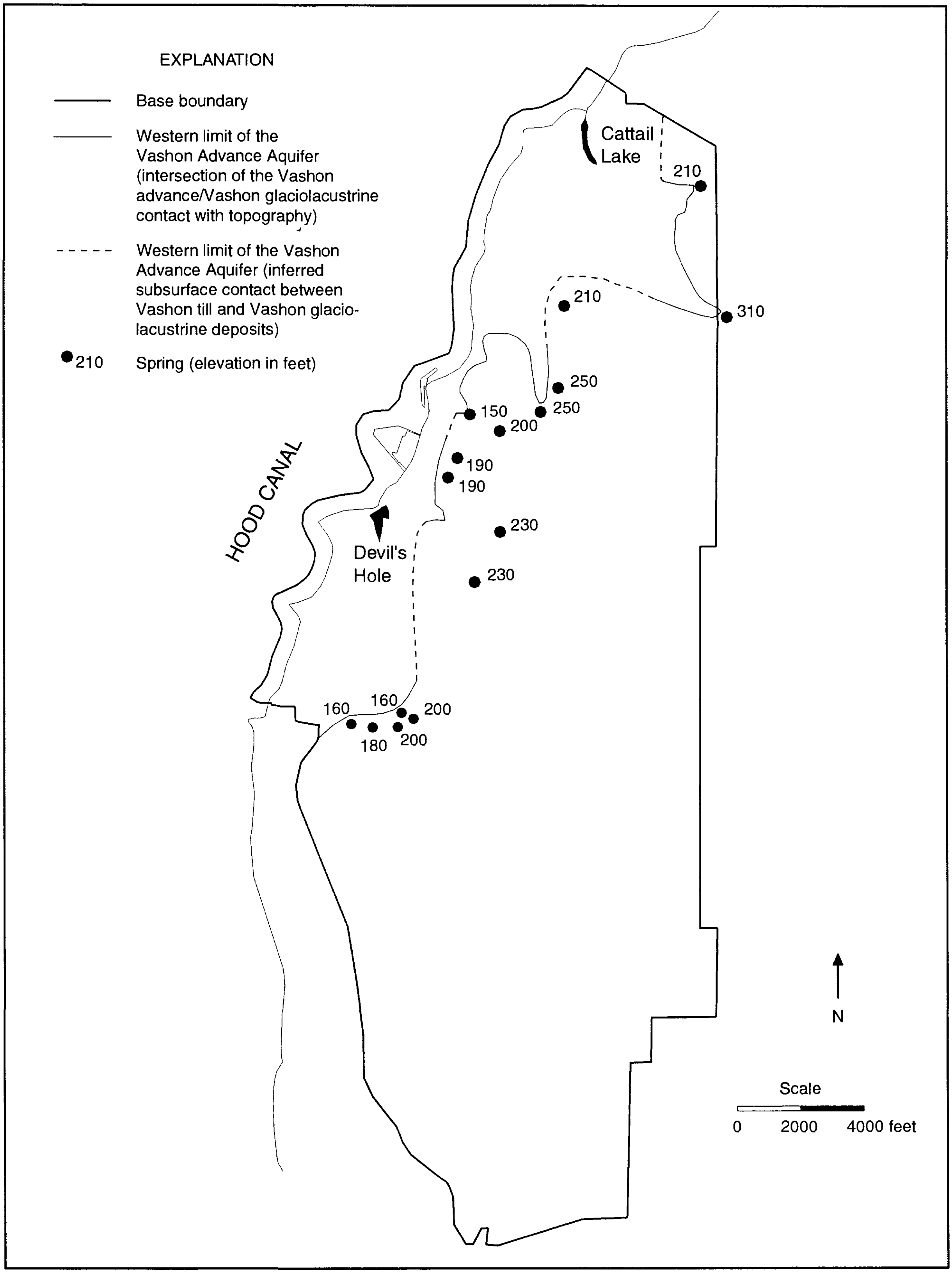

Figure 6-1. Western limit of the Vashon Advance Aquifer (Reduced from original to fit page)

7.2 Slump Blocks

Slump blocks are most commonly associated with cohesive units such as the Vashon glaciolacustrine deposits and to a lesser extent with the Vashon till and the Nonglacial sediments. Slumping is most prevalent on oversteepened slopes along the Hood Canal shoreline and on the sides of deeply incised valleys. As discussed in Section 5.1, shallow listric slump faults rotate the bedding in the slump block towards the plane of the fault. Slump block fault scarps were observed much less often than rotated bedding. Fault scarps tend to be oriented parallel to the shoreline or to the stream valley walls. The most well developed slump features are visible along the shoreline in the vicinity of the Delta Refit Pier and the Explosive Handling Wharf (T.26N., R.1E. Section 18).

7.3 Debris Slides

Debris slides are most common in Nonglacial sediments and Vashon till exposed along the shoreline, and to a lesser extent in Vashon outwash sands exposed in deeply incised stream valleys. Debris slides are initiated when the sea cliffs are undercut and oversteepened by wave erosion, or when valley walls are oversteepened by seepage and channel bank erosion. They tend to be smaller scale features than the slump blocks.

7.4 Landscape Evolution

Immediately after deglaciation about 13,000 years ago the entire area was probably covered by Vashon till topped by small isolated lenses of Vashon recessional outwash. The till surface was fairly regular and sloped gently from the upland plateau at approximately 400 feet above sea level to below sea level in Hood Canal. Erosion was concentrated at the ancestral Hood Canal shoreline and on top of the Vashon till as it sloped down from the upland plateau. Erosion rates were probably relatively slow until the Vashon Till was breached by stream or wave erosion and the underlying Vashon advance outwash was exposed. Once these outwash sands were exposed, seepage and channel bank erosion rapidly excavated valleys into the outwash sands and undercut the till. A positive feedback mechanism was also initiated, because as the valleys were deepened, groundwater flow become even more focused, providing more water for erosion. Rapid downcutting and headward erosion of these valleys is continuing today. Groundwater flow and erosion have been concentrated in these valleys, leaving erosional remnants of till extending from the plateau to the shoreline in some places. The shoreline is also actively retreating today through a combination of wave erosion and mass wasting processes such as slumping and debris flows.

8.0 COMPARISON TO PREVIOUS STUDIES

As described in Section 1.1 there have been several previous studies of surficial geology at the Subase. The present study agrees most closely with the map generated by Shannon and Wilson in 1973. The 1973 map identifies most of the large Vashon advance outwash exposures delineated by the present study. However, the two smaller Vashon advance outwash exposures on the southeastern side of the Subase are not shown on the Shannon and Wilson map. The Shannon and Wilson map also identified many of the Vashon glaciolacustrine deposits, but tended to underestimate the size of the exposures in the north.

The 1991 study by Hart Crowser was restricted to the northern boundary of the Subase. This map also greatly underestimated the size of the Vashon glaciolacustrine deposits. The geologic map in the 1993 report by URS appears to have been largely based on the Shannon and Wilson map. However, many of the sand and gravel exposures that were correctly named Vashon advance outwash on the earlier map were incorrectly renamed Vashon recessional outwash on the URS map. All three of these previous studies tended to overestimate the extent of the Vashon recessional outwash.

The Coastal Zone Atlas of Washington (Washington State Department of Ecology, 1978) shows that Vashon till is present on the Hood Canal coastline at the northern and southern base boundaries. The present study confirms the presence of Vashon till at the northern coastal boundary; but at the southern boundary there is a thin layer of nonglacial gravel exposed beneath the Vashon till that is not shown on the atlas.

The Geologic Map of Surficial Deposits in the Seattle 30' by 60' Quadrangle (Yount et al 1993) generally indicates Vashon till exposures along the base boundaries away from Hood Canal. It correctly identifies Vashon advance outwash on the northeastern Subase boundary but underestimates the extent of the outwash exposure. The smaller Vashon advance outwash exposures on the southeastern side of the base are not identified on the 1993 map, nor are the Vashon advance outwash exposures identified on the southwestern base boundary near Bangor and Olympic View.

9.0 CONCLUSIONS

Six major stratigraphic units could be distinguished during the mapping project at Subase Bangor: Nonglacial sediments, PreVashon glacial drift, Vashon glaciolacustrine deposits, Vashon advance outwash, Vashon till and Vashon recessional outwash. Based upon stratigraphic position and lithologic characteristics, the Nonglacial sediments are thought to correlate with the Whidbey Formation, the PreVashon glacial drift is thought to correlate with the Possession Drift, and the Vashon glaciolacustrine deposits are believed to correlate with the Lawton Clay.

The Vashon till covers about seventy-five percent of the Subase. The older Quaternary sediments are only exposed in erosional windows through the till. Most of the units are in conformable contact with one another, but the Vashon till is in unconformable contact with the underlying units and cuts down section several hundred feet as it approaches Hood Canal.

The most important exposed aquifer is hosted in the Vashon advance outwash. Vashon glaciolacustrine deposits define the base of the aquifer and control the location of many of the springs in the area. All of the large springs on the Subase are contained within Vashon advance outwash.

10.0 REFERENCES

Dunne, T., 1990, Hydrology, Mechanics and Geomorphic Implications of Erosion by Subsurface Flow; in Groundwater Geomorphology: The Role of Groundwater in Earth-Surface Processes and Landforms, GSA Special Paper 252, 28 p.

Easterbrook, D.J., 1968, Pleistocene Stratigraphy of Island County, Washington: Washington Department of Water Resources Water-Supply Bulletin 25, part 1, 34 p.

Hart Crowser, Inc., 1991, Final Remedial Investigation/Feasibility Study, Site A, Naval Submarine Base Bangor, Washington, vol. 1.

Mullineaux, D.R., Waldron, H.H., and Rubin, M., 1965, Stratigraphy and Chronology of Late Interglacial and Early Vashon Glacial Time in the Seattle Area, Washington, U.S. Geological Survey Bulletin 1194-0, 10 p.

Noble, J.B., 1989, The Trident Aquifer Study at Bangor, Kitsap County; in Engineering Geology in Washington, Washington Division of Geology and Earth Resources Bulletin 78, v. 2, p. 983-988.

Shannon and Wilson, Inc., 1973, Subsurface Investigation, Trident Support Complex, Bangor Annex, Washington, 126 p.

Suczek, C.A., Babcock, S., and Engebretson, D.C., 1994, Tectonostratigraphy of the Crescent Terrane and Related Rocks, Olympic Peninsula, Washington; in Geologic Field Trips in the Pacific Northwest: 1994 Geological Society of America Annual Meeting, v. 1, p. 1H-1 - 1H-11.

URS, 1993, Final Remedial Investigation/Feasibility Study, Operable Unit 4, Site C, Naval Submarine Base, Bangor, vol. 1, about 200 p.

Washington Department of Ecology, 1978, Coastal Zone Atlas of Washington, Volume 10: Washington State Department of Ecology, DOE 77-21-10, 49 p.

Yount, J.C., Minard, J.P. and Dembroff, G.R., 1993, Geologic Map of Surficial Deposits in the Seattle 30' by 60' Quadrangle, Washington: U.S. Geological Survey Open-File Report 93-233, scale 1:100,000, 2 plates.

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