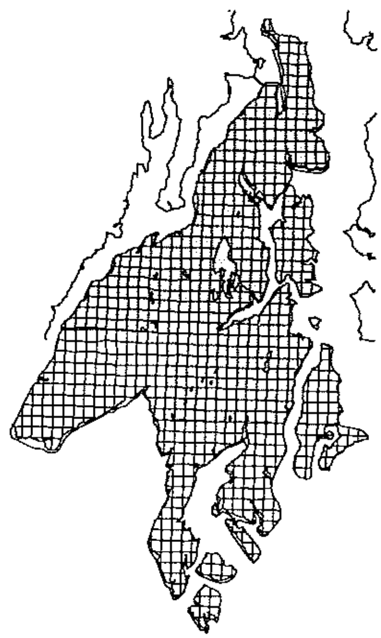
Kitsap County Initial Basin Assessment

October 1997

Open File Technical Report No. 97-04



Prepared by:
Kitsap Public Utility District

in association with:
Economic and Engineering Services, Inc., Pacific Groundwater Group, Inc.
Robinson & Noble, Inc., KCM, Inc.

Prepared in cooperation with
Washington State Department of Ecology
NW Regional Office
Water Resource Program
3190 160th Avenue SE
Bellevue, WA 98008

KITSAP COUNTY INITIAL BASIN ASSESSMENT October 1997

With the multitudes of lakes, streams, and rivers, Washington State seems to have an abundance of water. The demand for water resources, however, has steadily increased each year, while the water supply has stayed the same, or in some cases, appears to have declined. This increased demand for limited water resources has made approving new water uses complex and controversial.

To expedite decisions about pending water rights, it is vital to accurately assess the quality and quantity of our surface and ground water. The Washington State Department of Ecology (Ecology) recognizes that water right decisions must be based on accurate scientific information.

Ecology is working with consultants and local governments to conduct special studies called Initial Watershed or Basin Assessments throughout the State. The assessments describe existing water rights, streamflows, precipitation, geology, hydrology, water quality, fisheries resources, and land use patterns.

The assessments evaluate existing data on water which will assist Ecology to make decisions about pending water right applications. The assessments do not affect existing water rights.

This report summarizes information detailed in the Kitsap County Initial Basin Assessment and represents the most current (1996) compilation, review, and analysis of water resources data including a peer review of the assessment (August 1996) for Kitsap County (County). Kitsap County is part of the Kitsap Peninsula Basin which has been designated by the state as Water Resource Inventory 15 (WRIA 15). This assessment was initiated and funded by Kitsap Public Utility District and conducted under a Memorandum of Agreement with Ecology.

This report summarizes information presented in the detailed Ecology Open File Technical Report No. 97-04. It also presents some actions that could be taken in response to the results of this assessment.

Economic and Engineering Services, Inc.

Kramer, Chin, and Mayo

Pacific Groundwater Group

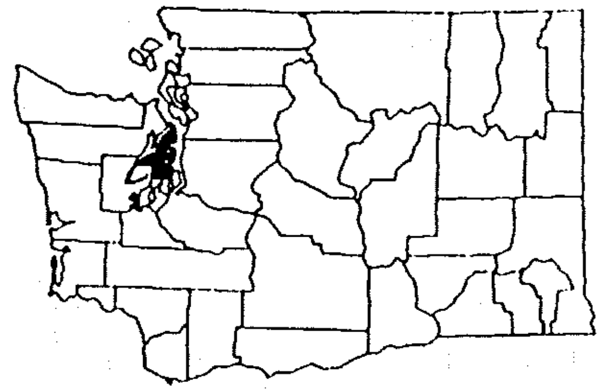
Robinson and Noble, Inc.

In Cooperation With

Washington State Department of Ecology

Funded By Kitsap Public Utility District

Kitsap County Watershed Location Map



What do we know about the Kitsap County Basin?

Kitsap County encompasses almost 400 square miles and occupies a peninsula and several islands in Puget Sound. It is bounded on the east and north by Puget Sound and Admiralty Inlet, and on the west by Hood Canal. The County is adjoined by Pierce and Mason Counties on the south, Jefferson County on the west, and King County on the east.

Because of the physiography of the County and the dominance of localized ground water and surface water flow systems, the most logical method for study of the hydrology or water resources is by subdividing the county into smaller subareas. Based upon the local geology, hydrology, and topography, 18 subareas have been identified within the County. Exhibit 1, on the following page, shows the 18 subareas designated for detailed water resource assessment. The designation of these subareas involved evaluation of both surface and subsurface information.

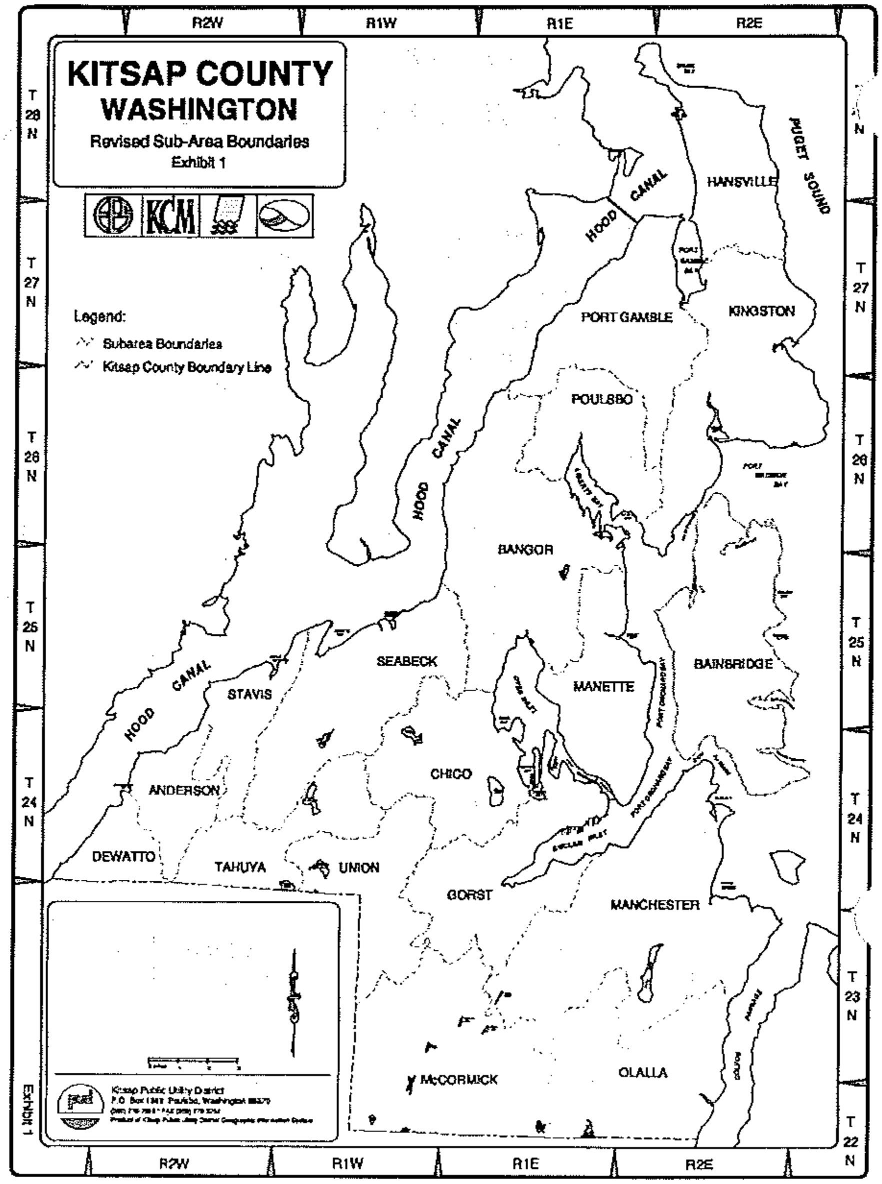
What are the water allocation issues?

- ❑ Ecology needs to make decisions on 220 pending (December 1995) water right applications located within the County. Accurate data are essential to making these water allocation decisions. If the decision is not to allocate, then infrastructure planning must be adjusted accordingly. Currently, there are 200 ground water applications for 41,530 gpm (92.5 cfs) and 20 surface water applications for 1616 gpm (3.6 cfs).

- There is no evidence of extensive seawater intrusion in the County, but localized seawater intrusion is found in a few areas such as Jefferson Beach (Kingston Subarea).

- Aquifer water levels since 1990 in general have followed precipitation trends. The period from 1991 through 1994 was generally characterized by below average precipitation and decreasing water levels. Water levels in 1995 and 1996 seem to respond to an above average period of precipitation. Long term water level data are generally not available, therefore detailed correlation between climate, water use and ground water system response will be conducted in the future.

- While there are no large river systems in the County, there are many small streams which are highly influenced by ground water and support a variety of fish populations. Escapements (the number of salmonids that make it back to spawn) in many creeks are generally not documented. Limited data has been collected with fish health in mind. Existing information does not provide an in-depth assessment of the overall fisheries habitat within the County, although studies by tribes are ongoing.



- Maintenance of streamflows necessary to preserve instream resources is a major concern. The state has set minimum instream flows for 14 rivers and creeks; established approximately 32 year-round closures, and 10 partial closures of streams, lakes, and drainage systems in Kitsap County. Prior to 1990, only five control points (established measurement locations as per Chapter 173-515 WAC) had associated gaging stations. Several of the original five gaging stations are no longer active. Approximately 20 other gaging stations have been established since 1990 at or near established control locations. Major drainages with regulatory closures include Big Beef Creek and the Union, Tahuya, and Dewatto Rivers.

- Several subareas appear to have sufficient data to make allocation decisions. In most subareas, additional data will probably be needed to resolve current water allocation issues and provide a basis for prudent water allocation decisions.

Where does the water come from?

Precipitation provides the sole source of water for all of the streams, lakes, springs, and other surface waters and ground water within the County. Some of this water evaporates or is used by plants, some flows into the streams and rivers, and the rest infiltrates into the soil to become ground water. Some segments of streams and rivers gain water from ground water that seeps into the channel. Other segments lose water that leaks through the streambed into the ground. The County has a characteristically marine climate typified by short, cool, dry summers, and prolonged, mild, wet winters. Winter storm generally approach the

County from the southwest. The southwestern portion of the County receives relatively high winter rainfall from storms which enter the area through a topographic gap between the Olympic Mountains and the Black Hills. The northern portion of the Kitsap Peninsula experiences drier winter weather because it is situated in the rain shadow of the Olympic Mountains.

Precipitation varies over the County from just under 30 inches/year in the north to almost 70 inches/year in the southwest. On a seasonal basis, 79 percent of the precipitation at the Bremerton Fire Station occurs in the six-month period from October through March. Additionally, total rainfall for the driest months of June, July, and August is seven percent of the annual total.

What are the major surface water sources?

Although surface water is not the primary source of supply, the County contains a multitude of creeks, only a few of which drain extensive land areas.

Surface water development in the County is primarily based on individual stream diversion rather than large dams with associated reservoirs. Casad Dam, located at McKenna Falls on the Union River, is the only major diversion structure in the entire County.

What are the major ground water sources?

Ground water is the dominant and most important source of supply in the County. Twenty-eight "principal aquifers" have been identified as an integral part of this assessment. The current level of knowledge and understanding for each aquifer varies considerably because of the complex hydrogeology of the area. A conceptual model and stratigraphic sequence of the 15 identified hydrogeologic units is presented in Chapter 5 of the assessment. Most of the aquifers are near or below sea level and are comprised of pre-Vashon geologic units. Perched aquifers occur throughout the County, making it difficult to distinguish aquifer characteristics and establish definitive boundaries. It is highly likely that additional, yet-to-be discovered, major aquifers exist within the County.

How are surface and ground water connected?

In areas where both surface water and ground water are used, the connections between the two sources become important. In some instances, ground water flows from the aquifer to the surface water, while in others, the reverse occurs. Ground water provides the base flow in the rivers and creeks which constitutes total flow during dry periods when there is no rain to contribute to the flow.

Hydraulic continuity refers to the interconnection between water bearing units, including ground water and surface water. Hydraulic continuity typically occurs where ground water discharges to surface water, such as in spring-fed lakes and gaining rivers; or where surface water discharges to ground water, such as from riverbed seepage to an adjacent alluvial aquifer. Where hydraulic continuity exists, changing hydraulic conditions in a ground water body will result in changes to connected surface water bodies.

How does land use affect water?

Land use practices can have profound effects on the amount and quality of water moving through the County.

From a regional viewpoint, the County contains abundant forestry areas and numerous government owned and operated facilities, including the Trident Submarine Base at Bangor, Keyport Naval Undersea Warfare Center, Puget Sound Naval Shipyard, Department of Defense Supply Center, and the Manchester Fuel Depot.

Outside of the urbanized centers of Bremerton, Port Orchard, Silverdale, Poulsbo, Kingston, and Bainbridge Island, the County is generally characterized by scattered, small communities, homes on acreage, and large parcels of undeveloped land. Low density, single-family dwellings and small farms are scattered throughout the County, and there are large areas of pasture and forest land.

Satellite imagery data show approximately 10 percent of the County in a developed state. The remaining area is largely coniferous forest (50 percent), other natural cover (35 percent), or mixed forest land (5 percent).

An analysis of land use codes utilized by the County Assessor shows a similar pattern with about 75 percent open, forested, or rural, and another 10 percent classified as suburban. According to the Assessor's data, about 14 percent of the area is classified as urban, commercial, or industrial.

Although nearly 90 percent is rural and forested, the County is ranked second only to King County in overall population density, with 562 persons per square mile in 1995.

The County ranks sixth in total population (220,600 in 1995) and has experienced a 31 percent increase in population since 1985, ranking eighth in growth in the State.

The highest growth is projected for the Manette, Gorst, and Manchester subareas. Lowest population growth is predicted for the Stavis, Tahuya, Anderson, and Dewatto subareas.

What are the water quality issues?

Ground water throughout the County is generally of good quality and suitable for most purposes. With only a few exceptions, water sampled from over 1,100 wells located throughout the County was within State drinking water standards. Aesthetic standards for iron and manganese were frequently exceeded, as is typical for glacial aquifers of Western Washington. Ground water quality testing associated with sites of known contamination (such as landfills, the three major military installations, and the Wycoff Wood Preservation Facility) indicates only local perched aquifers have been affected so far.

Time series evaluation of water quality data was performed as part of the Kitsap County Ground Water Management Plan (GWMP) in 1991. The analysis employed water quality data provided by the EPA (including data from the USGS and from Group A wells), by Ecology (Group A), by the Washington Department of Health (Group A and B wells), and by the Bremerton Kitsap County Health District. Data collected at known ground water contamination sites were not included in these trend analyses. In general, the time series evaluations indicated no significant trends.

Are fish resources stable?

Escapements in many creeks in the County are generally not documented. Chum salmon returning during late November through December are considered healthy in the Hood Canal. Early-arriving chum salmon are considered depressed. Escapements in this region have ranged from 500 to 8,000 fish. Other salmon species are less abundant in County creeks.

The status of salmonid populations in the County is a concern to all agencies and organizations involved in water resources. Because of the poor returns of coho and chinook salmon to Hood Canal, there have been restrictions placed on harvesting these stocks.

A major factor in the decline of coho salmon stocks has been the reduced summer and fall flows in small streams associated with drought cycles. Some small streams have become unable to support coho production similar to the levels supported prior to 1975. For example, the average annual rainfall for Seabeck over the last 16 years (55.93) has been four inches less than the long-term average of 59.92 inches.

Fish habitat quality is greatly reduced by nonpoint pollution. Storm water runoff from construction sites, roadways, and cleared land continues to cause both erosion and siltation of streams removing critical juvenile rearing habitat. Other factors affecting the survival of all salmonid species are the influence of hatchery fish on natural spawning stocks and the interception of fish returning to the Kitsap Peninsula. The impact of harvest on returning adults was well demonstrated by the fishing closure in 1994 and the subsequent, significant increase in coho adults spawning in the streams of Hood Canal in the fall and winter of 1994/95.

Existing fisheries habitat information for much of the County is limited and does not provide a sufficient basis for an in-depth assessment.

How have streamflows and water levels changed?

The ability to conduct annual streamflow trend analyses throughout the County is also severely limited. Data records are short, available only for isolated periods, and/or available only prior to the rapid water resource development which began in the early 1970s. Long-term data records (those over 25 years) are best suited to streamflow trend analysis.

Several different techniques were used to assess trends in minimum streamflows (summer low flows). The minimum flow analyses were limited by available data.

Comparison of regulatory instream flow requirements and historic flow curves for a few rivers and creeks showed that current instream flow requirements were not satisfied to varying degrees throughout the year.

It should be noted that in establishing instream flows by regulation, Ecology recognizes that the recommended regulatory flows are not, and probably have never been met, 100 percent of the time. The intent of the regulation, however, is to protect streams from further depletion (for instance, through subsequent appropriations) when flows approach or fall below the recommended discharges.

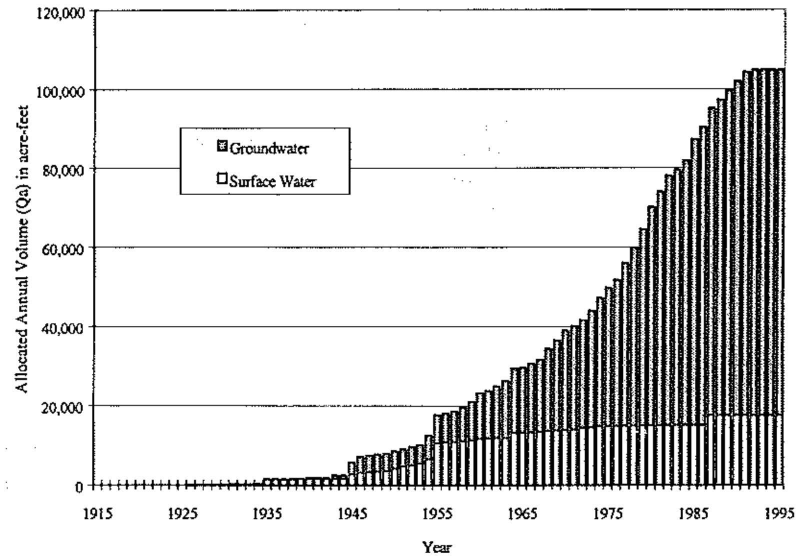
Water level trend analysis was accomplished utilizing data from a subset of the wells in the GWMP monitoring network. Hydrographs for 149 wells were developed. An exhaustive review of in-well and regional production data has not been conducted.

What are water rights?

The State of Washington manages ground water and surface water withdrawals through a system of permits. Water withdrawals for all but limited small ground water uses must be authorized by Ecology. Upon receiving an application for a water right, Ecology conducts an extensive evaluation, which is currently taking in excess of five years, to determine whether or not they should issue a permit to develop the water resource. Water right certificates are issued after the water appropriation has been perfected (actually put to beneficial use). Water rights established through the permit system have been recognized by existing water laws since 1917 for surface water and 1945 for ground water.

A water right is a legal authorization to use a certain amount of public water for specific beneficial purposes. State law requires every user of streams, lakes, springs, and other surface waters to obtain a water right permit before using these waters. People who use ground water also need a water right permit unless they use 5,000 gallons or less each day for one or more of the following purposes: watering stock, watering a lawn or garden less than one-half acre in size, or a single, group domestic, or industrial water supply.

Exhibit 2
Historic Growth of Water Allocations



Three categories of water rights, although recognized, can not be quantified as a part of this assessment. The first category relates to ground water withdrawals in small quantities (i.e., exempt from permit requirements pursuant to RCW 90.44.050). The second and third categories relate to federal reserved rights associated with either US Reservations (e.g., military) or Indian Reservations.

What are water right claims?

Not all uses of water developed before 1917 for surface water and 1945 for ground water were registered as part of the water rights process. To preserve active water withdrawals developed prior to these two dates, the State required individuals to register withdrawals during a "claims period" between 1969 and 1974.

A water right claim is not an authorization to use water, but rather a statement of claim to a water withdrawal generally developed prior to 1917 or 1945. In most cases, the validity of existing claims has not been determined.

A water right claim is just a claim for a right to use water. A water right claim on file with Ecology may or may not represent a valid water right. The validity of a claim cannot be determined until the court rules on it through an adjudication process.

Why are water rights important?

The basis for water rights is "first in time, first in right." This means people with older, or senior, rights get to use the water first when there is not enough for everyone. The water rights program ensures that Washington's water resources are appropriately allocated and managed. By effectively managing the allocation of new water rights, senior water rights can be protected.

Exhibit 2 shows the historic growth of water rights and annual allocations over the past 80 years throughout the County. This graph dramatically illustrates the rapid pace of increased water resource development that

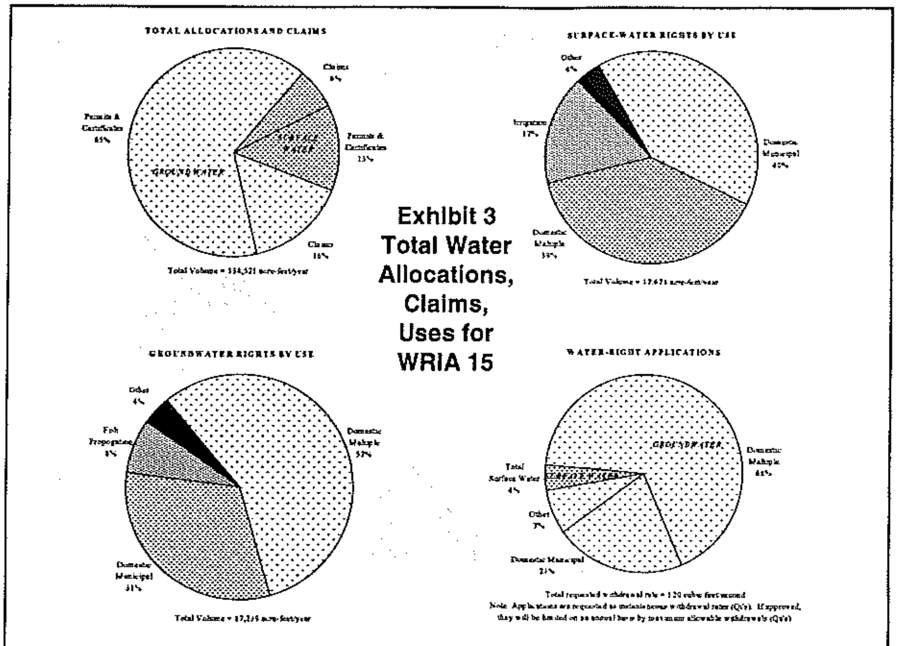


**Exhibit 3
Total Water Allocations, Claims, Uses for WRIA 15**

occurred in the 1970s and 1980s. It also shows that since 1990 very few ground water right allocations were made.

How is water currently allocated and what new uses are proposed?

Exhibit 3 displays the total allocation, claims, and uses of ground and surface water rights.

Currently, ground water withdrawals dominate water rights (and to a lesser extent, water right claims). Ground water rights represent 83 percent of current total allocations, and ground water claims account for 71 percent of current total claims. Issued water rights exceed water right claims for both ground water and surface water.

Ground water resources are also primarily allocated for domestic multiple (57 percent) and municipal (31 percent) use. Fish propagation comprises eight percent and other uses comprise the remaining four percent.

Water resources associated with water right claims appear to be primarily associated with irrigation. Based on the irrigated acreages and the formulas for water-duty assignments, at least 49 percent of the surface water claims and 91 percent of the ground water claims can be attributed to irrigation.

Surface water resources are primarily allocated for municipal (40 percent) and domestic multiple (39 percent) use. Irrigation uses comprise 17 percent and other uses comprise the remaining four percent.

There are 220 pending applications for new water rights within the County on file with Ecology.

Applications for ground water rights comprise the majority of potential future water allocations. Presently, 200 ground water applications exist for 41,530 gpm (92.5 cfs) and 20 surface water applications exist for 3.6 cfs. Exhibit 3 also shows the distribution of these applications. The majority of the total quantity requested (68 percent) is for domestic multiple ground water withdrawals. Municipal ground water withdrawals account for 21 percent of the total quantity requested, and other ground water withdrawals account for seven percent. Surface water applications account for only four percent of the total quantity. The current total surface water request is primarily divided between irrigation (31 percent), municipal (27 percent), domestic multiple (23 percent), and fish propagation (17 percent) uses.

What are the conflicts in the County?

Water use conflicts occur when available water supply is unable to satisfy existing water rights, claims, new appropriations, and, at the same time, maintain sufficient water quality as well as aquatic habitat.

Balancing these competing needs is complex. For example, where recommended instream flows are not met more than 50 percent of the time during the lowest flow periods in late summer and early fall, additional water allocations may not be available from shallower aquifers during these months.

Comprehensive, long-term streamflow data are lacking in most areas of the County. Therefore, it is difficult to quantify and evaluate water availability from contributing aquifers.

The interconnection between surface and ground water and the effect of ground water withdrawals on streamflows in much of the County is not well known or understood. In areas draining to streams, administratively closed to protect habitat, or that have recommended flow limitations, the interconnection between ground and surface water will have to be evaluated when deciding on new allocations. Monitoring for seawater intrusion should be continued and expanded.

An analysis of land use, population projections, and water demand indicates that the County will have significant urban growth in some subareas (Manette, Gorst, Manchester), while other subareas will remain rural with relatively low growth (Anderson, Dewatto, Stavis, and Tahuya).

New water rights will need to be granted for existing public water systems. For the most part, these do not appear to be large increases over existing rights (certificates). Much of the forecasted demand may be covered under existing water right applications.

Identifying areas where additional water rights will be required is key to effectively prioritizing studies to support water right allocation decisions in the County. Future assessment efforts should focus first on subareas such as Bainbridge, Kingston, and Manchester. These subareas will be accommodating significant population growth and will require improved data and better information on which to base water allocation decisions.

A summary of average day water demand for the County developed for the GWMP is displayed on Exhibit 4. The water demand uses include municipal and domestic, commercial/industrial, irrigation, fish propagation, and stock watering. Instream uses are not included.

The total average day water resource requirement was about 31 MGD in 1990. It is projected to increase to approximately 45 MGD by 2020. This assumes water consumption habits and lifestyles will not change. If an increase in multi-family housing units occurs in the urban areas of the County, and a municipal and domestic water conservation program is initiated, then the average day demand in 2020 is projected to be about 39 MGD. An additional water resource requirement of 8 to 13 MGD (8,961 to 14,600 acre feet per year) over 1990 average day supply will be needed by 2020.

Total peak day demand was approximately 74 MGD in 1990. By 2020, peak day demand is anticipated to reach almost 100 MGD. The additional water resource requirement for a peak day in 2020 would be approximately 26 MGD over the 30-year forecast period.

Recent population growth has exceeded projections used by the GWMP so these demand projections are probably low.

What are the water balance components?

A water balance is an assessment of the major components of a hydrologic system and includes the interactions between surface water and ground water systems.

The components of a simplified water balance equation can be expressed as:

Precipitation=Evapotranspiration+Runoff+Recharge

Exhibit 5 summarizes the estimates of water balance components for Kitsap County.

Where do we go from here?

Finally, Exhibit 6, provides a summary for each of the 18 subareas within Kitsap County.

Several factors can be considered in making water right decisions. They include: potential for stream-aquifer continuity, potential for seawater intrusion, degree of water resource allocation, ground water level trends, streamflow trends, and the impact on fish due to changes in habit and water quality.

This Initial Basin Assessment does not provide a complete picture of water resources in Kitsap County. It acknowledges that additional data collection and more in-depth analysis of information will be required to make some future water right decisions.

Ecology wants to hear your

Exhibit 4

1990-2020 Average Day Water Demand

Average Day Water Demand Uses	1990 *MGD	1990 Percent	2020 *MGD	2020 Percent
Municipal	19.55	63%	30.43	68%
Domestic/Single Family	4.89	16%	7.61	17%
Commercial/ Industrial	0.27	1%	0.27	1%
Irrigation	1.18	4%	1.18	3%
Fish Propagation	5.20	17%	5.20	12%
Stock Watering	0.04	0%	0.04	0%
TOTALS:	31.13	100%	44.73	100%

*Note: MGD = Million Gallons Per Day
Source: **Volume 1 GWMP, 1991, Table II-9, pg. II-67**

opinions and ideas on these and other water allocation issues and proposed actions. Usually, a combination of actions is required to effectively manage water resources and meet the challenges and opportunities facing all of the stakeholders involved.

While mandated by law to protect instream water use and existing water rights, Ecology also is responsible for making decisions on applications for new water rights. The public's opinion is important to Ecology in making program decisions governing water use. Ecology invites public input on future steps to be taken. Ecology will also work with people who have applied for new water rights and discuss options for processing their applications.

What additional information is available?

If you would like to learn more about water issues in the Kitsap County Basin, the following are some of the studies and technical reports that are available:

Dion, N.P., Olsen, T.D., and Payne, K.L. 1988, Preliminary Evaluation of the Ground Water Resources of Bainbridge Island, Kitsap County, Washington, US Geological Survey Water Resources Investigations Report 87-4237.

Becker, J.E., 1995, Hydrogeological Analysis of the Bangor Aquifer System, Kitsap County, Washington.

Ecology, Department of, 1981, Chapter 173-515 WAC, Instream Resources Protection Program Kitsap Water Resource Inventory Area (WRIA) 15.

Economic and Engineering Services, Inc. (EES), November 3, 1992, Kitsap County Coordinated Water System Plan Regional Supplement (CWSP).

Garling, M.E., Molenaar, D.E. and others, 1965, Water Resources and Geology of the Kitsap Peninsula and Certain Adjacent Islands: Washington State Division of Water Resources, Water Supply Bulletin No. 18, 309 p., 5 plates.

Hansen, A.J., and Bolke, E.L., 1980, Ground Water Availability on the Kitsap Peninsula, Washington: US Geological Survey Water Resources Investigations Open File Report 80-1186.

Kitsap County Phase I Basin Assessment Reference File

Kitsap GWAC et al., 1991, Kitsap County Ground Water Management Plan, Background Data Collection and Management Issues, Volume I and II.

Lestelle, L.C., and others, December 1993, Evaluation of Natural Stock Improvement Measures for Hood Canal Coho Salmon: Point No Point Treaty Council, Technical Report TR 93-1, 173 p.

Robinson and Noble, Inc., November 1992, Investigation of Impacts on Dogfish Creek from the Use of the City of Poulsbo's Pugh Road Well.

Sceva, J.E., 1957, Geology and Ground Water Resources of Kitsap County, Washington, US Geological Survey Water Supply Paper 1413.

Williams, R.W., R.M. Laramie, J.J. Adams, 1975, A Catalog of Washington Streams and Salmon Utilization, Vol. 1, Puget Sound Region, Washington Department of Fisheries, Olympia, WA.

AGI Technologies, November 18, 1996, North Perry Avenue Water District Wellhead Protection Investigation. Report prepared for North Perry Avenue Water District, Bremerton, WA.

AGI Technologies, October 8, 1996, Final Report Gorst Creek Basin Study Phase I. Report prepared for City of Bremerton Public Works, Bremerton, WA.

For more information... Contact Raymond Hellwig at (206) 649-7096 (voice), (206) 649-4259 (TDD), or write to the Department of Ecology, 3190-160th Ave. SE, Bellevue, Washington 98008-5452.

Ecology does not discriminate in its services. If you have special communications needs, contact Lisa Newman at (360) 407-6604 (voice) or (360) 407-6006 (TDD).

EXHIBIT 6

Kitsap County Initial Basin Assessment Summary and Action Plan

Kitsap County Basin Subarea	Area Square Miles	Dominant Land Use Population Density: Area Pattern	Dominant Land Use Population Density: 1990 Density	Projected Annual Growth Rate	Known Water Quality Threats	Established Year-Round Stream Closures	Subarea Stream-Aquifer *Continuity Probability	Relative Seawater Intrusion Potential	Average Rainfall	Water Resource **Relative Development	Pending Water Development Applications (Max. Withdrawal)	Percent of Total Inflow
Hansville	18.5	Rural	160	2.5%	Minimal	Little Boston Creek	RH-Hansville Aquifer RL-Sea Level Aquifer	No Hansville Aquife Yes Sea Level Aquifer	30	8%	Ground Water = 301 gpm Surface Water = 0	3%
Kingston	30.7	Rural Suburban	295	3.3%	Minimal	Grovers Creek (Seasonal) Thompson Creek Cowling Creek and Smaller Streams	RL-Kingston Aquifer Port Gamble South RH-Suquamish - Miller Bay Aquifer	Yes If Excessive Ground Water Development Occurs	34	24%	Ground Water = 3030 gpm Surface Water = 0.5 cfs	17%
Port Gamble	19.1	Rural	220	4.2%	Negligible	Gamble Creek	RH-Edgewater Aquifer RH-Port Gamble Aquifer	Yes Edgewater and Port Gamble Aquifers	36	11%	Ground Water = 3355 gpm Surface Water = 0.1 cfs	26%
Poulsbo	18.7	Suburban Urban	450	3.7%	Minimal	Dogfish Creek and Johnson Creek	RL-Poulsbo Aquifer RH-Other Perched Aquifer	Yes If Excessive Ground Water Development in Coastal Area	37	19%	Ground Water = 2792 gpm Surface Water = 0	20%
Bangor	35.7	Commercial Rural Urban	636	2.2%	Past Land Use Contaminated Sites	Strawberry Creek Barker Clear Creek, and Scandia Creek	RH-Island Lake Aquifer Varies Between Four Aquifer Systems	Varies Between Four Aquifer Systems	41	23%	Ground Water = 8142 gpm Surface Water = 0	28%
Bainbridge Island	29.1	Suburban Surban Rural	540	2.6%	Urban Development. Otherwise Minimal	Two Small Unnamed Stream Tributary to Murdan Cove Fletcher Bay	RH-Meadowmeer Aquifer Varies Between Six Aquifers, But RL	No - Meadowmeer Aquifer; Varies Between Six Aquifers Depending Upon Ground Water Development	35	30%	Ground Water = 3384 gpm Surface Water = 0.97 cfs	22%
Manette	17.7	Urban Commercial	2,000	3.2%	Urban and Commercial Development	Steel and Mosher Creeks	Varies Between Three Aquifers, but RL	Bucklin Hill Aquifer Minimal. Varies Between Three Aquifer Systems	40	43%	Ground Water = 2803 gpm Surface Water = 0.97 cfs	23%
Chico	19.7	Rural Commercial	480	2.5%	Urban/ Suburan	Chico/Kitsap Creeks. Unnamed Kitsap Lake Tributary	Aquifers Not Well Understood; Potential Continuity Unknown	Not Well Understood; Possible Coastal Area If Excessive Ground Water Developed	53	7%	Ground Water = 296 gpm Surface Water = 0	1%
Seabeck	27.3	Rural	130	1.2%	Minimal	Big Beef Anderson and Seabeck Creeks	Varies Between the Three Aquifers; RL Except Perched Aquifer	Varies Between Three Aqufiers; Not Possible Perched Aquifers	57	10%	Ground Water = 2524 gpm Surface Water = 0	7%
Stavis	10.2	Rural	75	1.1%	Minimal	None	Not Understood. RH for Perched Aquifers	No Major Aquifer Identified. Not Possible Perched Aqufiers	64	3%	Ground Water = 165 gpm Surface Water = 0	1%
Manchester	45	Rural Urban	660	2.5%	Urban Land Development	Curley (seasonal) Blackjack, Sullivan, Beaver, Salmonberry Creeks	Varies Between Six Aquifers. RH for Wilson and North Lake Aquifers	Varies Between Six Aqufiers. Possible in Port Orchard/Yukon Aqufiers if Excessive Supply Developed	43	24%	Ground Water = 7831 gpm Surface Water = 0.91 cfs	20%
Gorst	23.5	Industrial Urban Commercial	1,160	3.2%	Urban Suburban Commercial Lt. Industry	Anderson and Ross Creeks Union River,	Varies Between Two Aquifers	If Excessive Ground Water Supply Developed	51	18%	Ground Water =1470 gpm Surface Water = 0	6%
Union	18.5	Rural	52	2.5%	Minimal	Mission Lake, and Little Mission Creek	No Major Aquifer Identified. RH for Perched Aqufiers; Not Understood	Not Possible Perched Aqufiers. Little Potential Exists	58	15%	Ground Water =564 gpm Surface Water = 0	3%
Tahuya	14	Rural	57	1.1%	Minimal	Tahuya River	Not Understood. RH For Perched Aquifers	Not Possible Perched Aquifers. Little Potential	62	1%	Ground Water =642 gpm Surface Water = 0	3%
Anderson	8.3	Rural	12	1.1%	Minimal	Harding Creek	Not Understood. RH for Perched Aquifers	Not Possible Perched Aquifers. Not Understood	66	<1%	Ground Water = 0 gpm Surface Water = 0	0%
Olalla	25.4	Rural Suburban	340	3.9%	Strandley Scrap Metal; Olalla Landfill	Purdy and Burley Creek	Not Understood. RH for Perched Aquifers	Not Possible Perched Aquifers. Not Understood	44	11%	Ground Water = 1651 gpm Surface Water = 0	7%
McCormick	33	Rural	120	2.2%	Land Use Patterns Minimal	Minter Creek	Not Understood. RH for North Lake Aquifer and Other Perched Aquifers	Not Possible Perched Aquifers. Low Potential	52	2%	Ground Water = 2080 gpm Surface Water = 0	5%
DeWatto	6.4	Rural	21	1.1%	Minimal	DeWatto River	Not Understood. RH for Perched Aquifers	Not Possible Perched Aquifers. Not Understood	66	<1%	Ground Water = 0 gpm Surface Water = 0.1 cfs	0%

Contents

Exhibits

Appendices

Section 1 Introduction

1.1 Initial Watershed Assessments

The Washington Department of Ecology (Ecology) Water Resources Program (Program) is charged with managing the State's water resources to ensure they are protected and used to the greatest extent possible for the public's benefit. One of the components of this water management is permitting for the use of surface and ground water. Historically, the Program has evaluated most water right applications on a case-by-case basis. This has increasingly become an inefficient way to deal with the large numbers of applications received. Furthermore, individual permit review usually required relying on the results of relatively short duration pump tests in order to make long-term resource decisions. This approach frequently has resulted in ignoring the cumulative impacts that many individual pumping wells may have on aquifer systems and surface water flows. Sixteen Initial Watershed Assessments (IWAs) were conducted in certain parts of the State in an effort to evolve the decision-making process on water right applications to consider the environmental health of water resources over a wide area.

These assessments focused on assembling and reviewing existing information; no new data were collected. The information assembled was chosen to broadly indicate the overall condition of water resources within the area. The information included ground water, surface water, climatic, hydrogeology, water demand, allocated water (rights and claims), and water quality, as well as the relative health of area aquatic ecosystems.

1.2 Kitsap County Portion of Water Resource Inventory Area 15

The State of Washington is divided into 62 Water Resource Inventory Areas (WRIAs) delineating the major drainage networks that flow into the Columbia River, the Pacific Ocean, and Puget Sound **(Exhibit 1-1)**.

Most IWAs are being conducted for an entire WRIA. Kitsap County (County) makes up a large portion of WRIA 15, with smaller portions of the area located in King, Mason, and Pierce Counties, as shown on **Exhibit 1-1**. A combination of the demographics and hydrogeographic properties of this particular WRIA, the political boundaries, funding, and the location and extent of data have narrowed the initial scope of this IWA to Kitsap County (County). Kitsap Public Utility District (KPUD) has funded the direct, and most of the indirect, expenditures of this effort and manages much of the County's water data. Although initial efforts are limited to the County boundaries, future efforts will expand this IWA to the full WRIA 15 boundaries when funding has been identified.

This assessment has been conducted in accordance with the January 1995, Memorandum of Agreement (MOA) between Ecology and KPUD (See Appendix A). For consistency with the

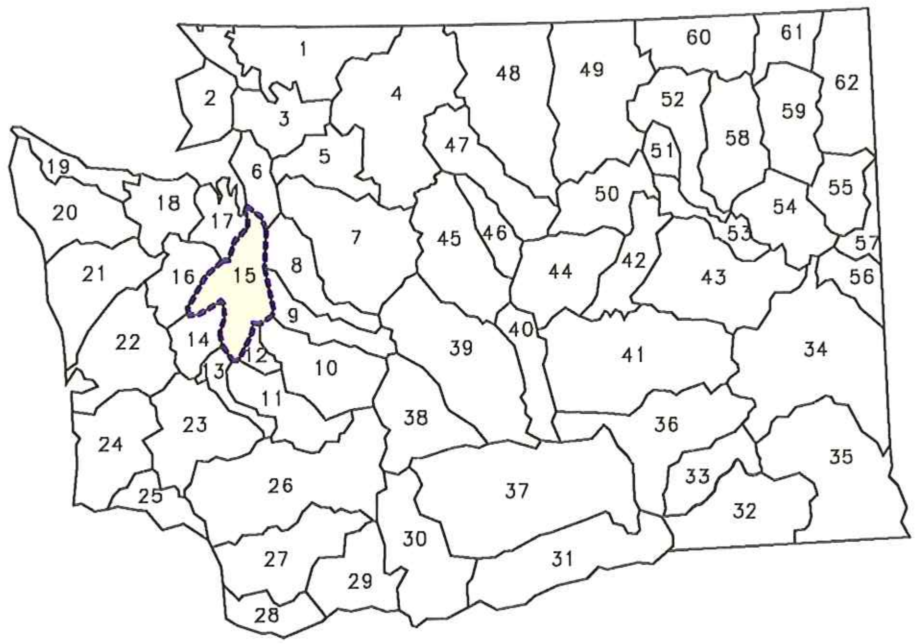
MOA, this assessment is referred to as a "Basin" rather than "Watershed."

1.3 Information Sources

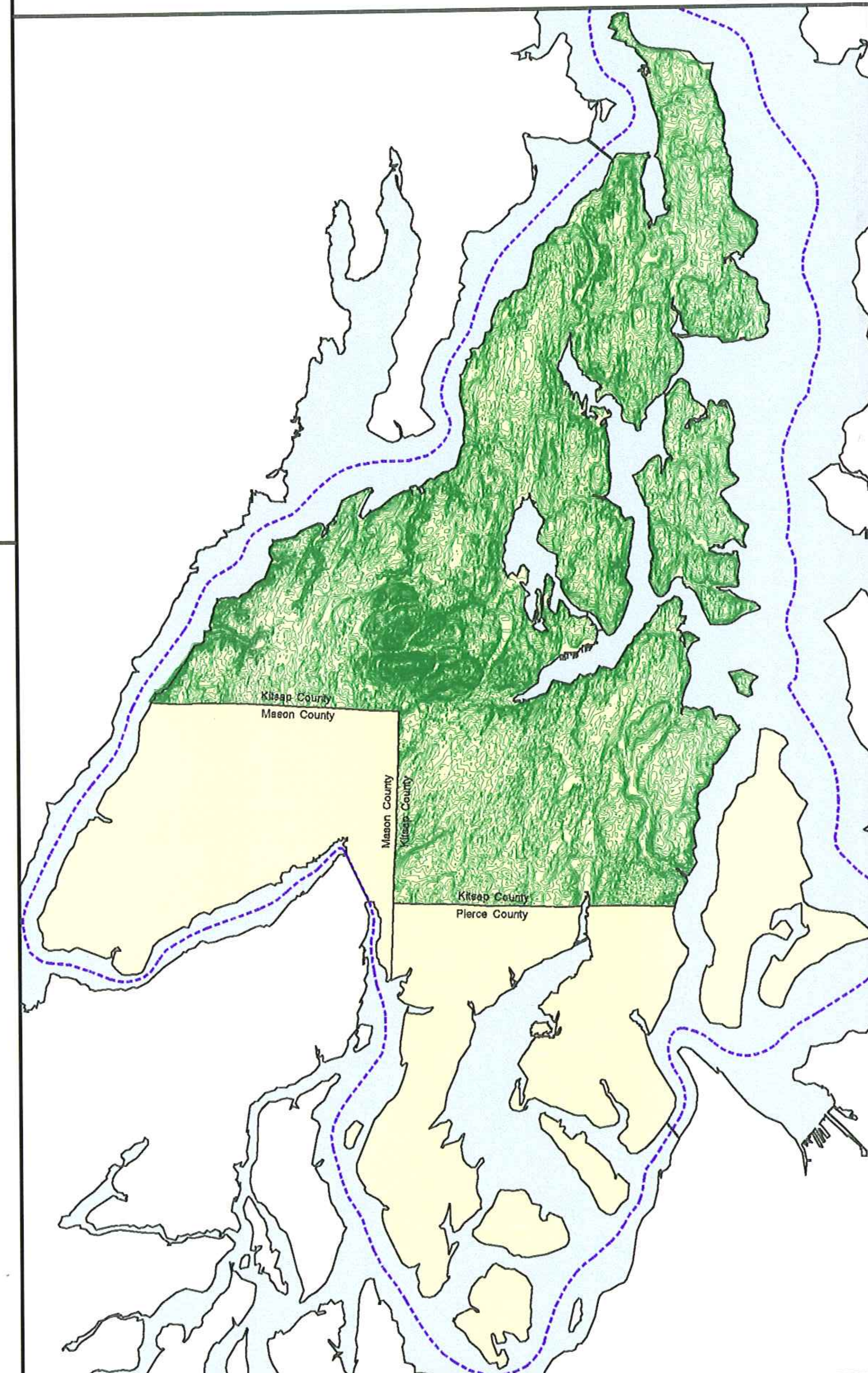
Information sources for this assessment are primarily published documents. As indicated by the partial Reference listing (Appendix D) and the Fish and Habitat Annotated Bibliography (Appendix E), the water and related resources for much of the County have been extensively studied and investigated. The most comprehensive County-wide work in recent years has been done (and is on-going) as part of the Kitsap County Ground Water Management Plan (GWMP) process. The GWMP was initiated in 1986. Volumes I and II, April 1991 (Background Data Collection and Management Issues) for the GWMP and subsequent data collection and analysis have been a primary data source for this assessment, except for Section 8, Fisheries Habitat and Stream Assessment.

This assessment recognizes that additional unpublished sources of data exist for areas throughout the County. Water purveyors, County and Tribal offices, and consultants are just a few of the organizations which may have valuable data that was not identified and therefore was not incorporated into this initial assessment but which should be part of subsequent, subarea assessments.

State of Washington Water Resources Inventory Areas



Water Resources Inventory Area 15



General Location of Water Resources Inventory Area Fifteen

Exhibit 1-1

Legend:

- Water Resources Inventory Area 15
- Water
- W.R.I.A. 15 boundary
- Elevation contours at 20 foot intervals

Primary Map Sources and Original Scales:

U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
WSDNR Hydrography 1:24,000
Washington Aministrative Code Volume 3, Title 173, page 1045
Puget Sound Regional Council:
Satellite Remote Sensing Project
Land Cover and Change Detection, April 1994
Kitsap Public Utility District Water Resources Database.

* If photo copied in black and white, some loss of data may occur. *

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Section 2
Basin Description

2.1 Area Description

Kitsap County (County), shown in **Exhibit 2-1**, encompasses approximately 400 square miles, and occupies a peninsula and several islands in Puget Sound. It is bounded on the east and north by Puget Sound and Admiralty Inlet, and on the west by Hood Canal. The County is adjoined by Pierce and Mason Counties on the south, Jefferson County on the west, and King County on the east.

The physiographic and topographic characteristics of the county are similar to much of the surrounding Puget Sound area consisting of remnants of a glacial drift plain. The surface is composed of generally flat-topped rolling hills and ridges (drumlinal hills) which rise to approximately 400 to 600 feet above mean sea level (MSL), and are separated by long valleys and marine embayments. The Green and Gold Mountains are a prominent group of rugged volcanic rock hills in the west-central portion of the County which rise to an elevation of approximately 1,700 feet above MSL. Much of the upland areas terminate along the coast in steep bluffs created by wave action. Since the close of the last glaciation (Vashon Glaciation), the landscape has been slightly modified by stream erosion, landslides, and wave action. Upland areas occupy approximately 75 percent of the County, flat valley floors occupy about 5 percent of the County, and the remaining 20 percent is occupied by transitional valley slopes, sea cliffs, and the Green and Gold Mountain area.

The uplands are predominantly recharge areas in which water percolates downward to water bearing strata and eventually migrates to discharge areas. Numerous surface water drainage features, such as Gorst and Big Beef Creeks, provide internal drainage for the shallow ground water systems that occur within the uplands. The larger drainage features within or adjoining the County such as Liberty Bay, Sinclair and Dyes Inlets, Hood Canal, and Puget Sound, are predominantly regional discharge areas for the deep ground water that originates within the uplands. Much of the discharge is submerged in Hood Canal, Puget Sound, and their inlets.

2.2 Subareas

Due to the physiography of the County and the dominance of localized ground water and surface water flow systems, the most logical method for study of the hydrology or water resources is to subdivide the County into smaller subareas. Based upon the local geology, hydrology, and topography, 18 subareas have been identified within the County. When identifying a subarea, the surface water drainages were integrated with identified ground water features or explicit aquifers. This enables the ground water/surface water budget and interrelationships to be considered as a distinct hydrologic system with reasonable control over estimates of inflow and outflow. **Exhibit 2-1** shows the 18 subareas designated for this basin assessment. The subareas are listed below:

Kitsap County Subareas	
1. Hansville	10. Stavis
2. Kingston	11. Manchester
3. Port Gamble	12. Gorst
4. Poulsbo	13. Union
5. Bangor	14. Tahuya
6. Bainbridge	15. Anderson
7. Manette	16. Olalla
8. Chico	17. McCormick
9. Seabeck	18. Dewatto

The designation of these subareas involved evaluation of both surface and subsurface information. The County aquifer map was overlain by the watershed boundary map developed during the Phase 1 hydrogeologic study of the Kitsap Ground Water Management Plan (GWMP). Based upon these two maps, probable ground water/surface water interactions and other hydrologic data were utilized to define subareas for future study. The boundaries of the 18 subareas are generally defined by the topographic divide between surface water drainages, but in most cases, several surface drainages have been combined. Combinations of surface drainages were based primarily on identified, underlying principal aquifers. Major aquifers were included in a single subarea, although there are instances where the local topography dictated that an aquifer overlap into more than one subarea. This occurred in the North Lake and Bucklin Hill aquifers, with minor overlaps in the Seabeck system, Port Gamble, Port Gamble South, and Port Orchard Deep Aquifers. Additionally, in some instances, a physiographic boundary containing several aquifers and surface drainages were combined to make a single, logical study area. A review of the original subarea boundaries which are used throughout this initial basin assessment revealed that several streams originated in one subarea and drained into another. Revisions to subarea boundaries have been made to resolve this problem. Future studies and evaluations will use the revised subarea boundaries **(Exhibit 2-1a)**.

2.3 Land Cover and Land Use

From a regional viewpoint, Kitsap County contains abundant forestry areas. The County contains numerous government owned and operated facilities, including Submarine Base Bangor, Keyport Naval Undersea Warfare Center, Puget Sound Naval Shipyard, Department of Defense Supply Center, and the Manchester Fuel Depot. Outside of the urbanized centers of Bremerton, Port Orchard, Silverdale, Poulsbo, Kingston, and Bainbridge Island, the County is generally characterized by scattered, small communities, homes on acreage, and large parcels of undeveloped land. Low density, single-family dwellings and small farms are scattered throughout the County, and there are large areas of pasture and forest land.

Kitsap County is working toward compliance with the requirements of the Growth Management Act. The County is currently developing a new comprehensive plan to meet the County's needs and the requirements of the GMA and the Central Puget Sound Growth Management Hearings Board October, 1996 Final Decision and Order (Consolidated Case No. 95-3-0039). The Board of County Commissioners approved the new plan in October 1996 and it has been forwarded to the state for review (see **Exhibit 2-2** for the associated land use map).

The maximum residential density within the designated rural area outside the UGAs would be one unit per five acres. Sizable portions of the rural area would be designated for development at densities not to exceed one unit per ten acres and one unit per twenty acres. The plan does contain two provisions, a "Grandfather Clause" and a Rural Infill Area, that would allow certain property owners to obtain a maximum density of one unit per two and one half acres if they meet certain criteria.

The plan will increase development in designated urban areas. Shoreline development would be restricted to one dwelling unit per acre. Urban development would be concentrated in the central portion of the county near Sinclair and Dyes Inlets and Liberty Bay. Concentration of development adjacent to these areas could further degrade the water quality of each. Streams and creeks in the central portion of the county would experience continuation (or possibly exacerbation) of present, periodic water quality problems.

The plan would allow for less rural residential development outside the urban area as compared to other alternatives that were considered. The Rural Infill and Grandfather provisions of the plan will allow for increased densities (one dwelling unit per two and one half acres) in the rural areas. The 50% open space requirement in the Rural Infill Area would mitigate most of the impacts to water resources caused by the increased density. It is expected that water quality impacts relative to surface resources (streams, creeks, lakes, wetlands, flooded areas) and groundwater resources would be lessened due to the less intense development associated with the plan.

Although there are no Forest Resource designation under this plan, 55,238 acres are designated as Rural Forest with a density of one dwelling unit per twenty acres. In addition, major stream corridors and sensitive areas are designated as Rural Low Density Residential with development allowed at a density of one dwelling unit per ten acres. Areas affected by these designations include stream corridors, drainage basins, wetland areas, and other sensitive areas.

In the urban areas, sensitive areas are designated as Urban Restricted with residential development allowed at from one to five dwelling units per acres. The net effect on water resources, therefore, would be a lessening of the potential for water quality and water quantity impacts. The plan is expected to have less impact on the water quantity and quality of streams, creeks, lakes, wetlands, flooded areas, and groundwater than most other alternatives that were considered during plan development.

Waterfront development could occur throughout the county. The density of such waterfront development with a maximum density of one dwelling unit per acre would be substantially less than other alternatives that were considered. Additional growth will result in some degradation of surface water quality and possibly groundwater quantity and quality.

Analysis of land cover from satellite imagery (Kitsap PUD, 1994) show approximately 10 percent of the County in a developed state. The remaining area is largely coniferous forest (50 percent), other natural cover (34 percent), or mixed forest land (5 percent) **(Exhibits 2-3 and 2-4)**.

An analysis of land use codes utilized by the County Assessor show a similar pattern with about 75 percent open, forested, or rural, and another 10 percent classified as suburban. According to County Assessor's data, about 14 percent of the area is classified as urban, commercial, or industrial **(Exhibit 2-5)**.

2.4 Climate

The Kitsap Peninsula has a characteristically marine climate which is typified by short, cool, dry summers and prolonged, mild, wet winters. This seasonal variation results from the position of the Pacific High, a high pressure air mass that varies in position seasonally along the Pacific Coast. The Pacific High reaches its northernmost position during the summer months and brings with it typically clear and sunny days. During the winter months, the Pacific High recedes to the south and is replaced by a low pressure system associated with rainstorms which cover paths several hundred miles in width. Transitions between the wet and dry seasons occur in early fall and late spring.

Winter storms generally approach western Washington from the southwest. The southwestern portion of the Kitsap Peninsula receives relatively high winter rainfall from storms which enter the area through a topographic gap between the Olympic Mountains and the Black Hills. Locally elevated precipitation occurs in the vicinity of the Green and Gold Mountains due to orographic effects. The northern portion of the Peninsula experiences drier winter weather because it is situated in the rain shadow of the Olympic Mountains. Wet and dry seasons in the northern areas of the Peninsula are less distinct. More detailed descriptions of precipitation patterns on the Peninsula are found in Section 7.

Temperatures on the Kitsap Peninsula are moderated by the Pacific Ocean and local marine waters. Temperatures infrequently drop below freezing, or exceed 80°F.

2.5 Water Balance

A water balance is an assessment of the major components of a hydrologic system and includes the interactions between surface water and ground water systems.

A water balance assessment provides a general understanding of the magnitude of the recharge and discharge components. It does not provide an accurate assessment of surface water/ground water interactions and quantities, and should not be relied on as the sole tool for ground water management. The components of a simplified water balance equation can be expressed as:

$$\text{Precipitation} = \text{Evapotranspiration} + \text{Runoff} + \text{Recharge}$$

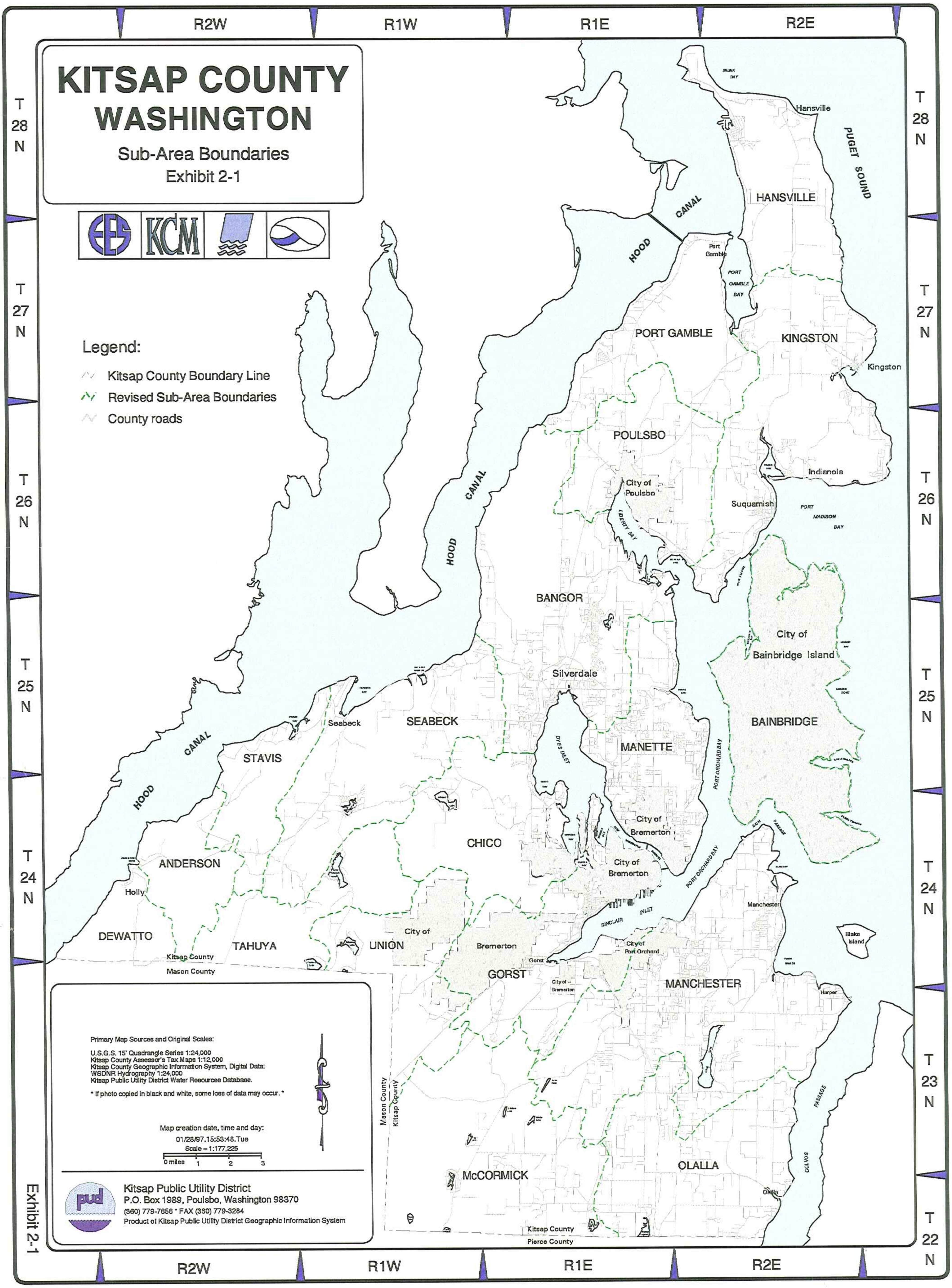
Appendix I further discusses water balance, outlines Kitsap County water balance components and provides a conceptual hydrologic cycle for Kitsap County **(Exhibit I-1)**.

2.6 Population

Although the land cover and land use discussion under 2.3 correctly indicates that a large part of the County is rural and forested, it is important to note that the County is second, only to King

County, in population density of all counties in the State, as shown on **Exhibit 2-6**, with 562 persons per square mile in 1995.

The County ranks sixth in total population (220,600 in 1995) and has experienced a 31 percent increase in population since 1985, ranking 8th in the State (see **Exhibit 2-6**).



KITSAP COUNTY
WASHINGTON
Sub-Area Boundaries
Exhibit 2-1
Legend:
Kitsap County Boundary Line
Revised Sub-Area Boundaries
County roads
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
Hansville
HANSVILLE
Port Gamble
PORT GAMBLE BAY
PORT GAMBLE
KINGSTON
Kingston
POULSBO
City of Poulsbo
LIBERTY BAY
Indianola
Suquamish
PORT MADISON BAY
BANGOR
City of Bainbridge Island
Silverdale
BAINBRIDGE
Seabeck
SEABECK
STAVIS
MANETTE
DYES INLET
PORT ORCHARD BAY
City of Bremerton
CHICO
ANDERSON
City of Bremerton
Holly
Manchester
SINCLAIR INLET
DEWATTO
TAHUYA
City of
UNION
Bremerton
Blake Island
Kitsap County
Mason County
City of Port Orchard
Gorst
GORST
MANCHESTER
Harper
COLVOS PASSAGE
Mason County
Kitsap County
McCORMICK
OLALLA
Olalla
Kitsap County
Pierce County
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/28/97.15:53:48.Tue
Scale = 1:177,225
0 miles 1 2 3
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(360) 779-7656 * FAX (360) 779-3284
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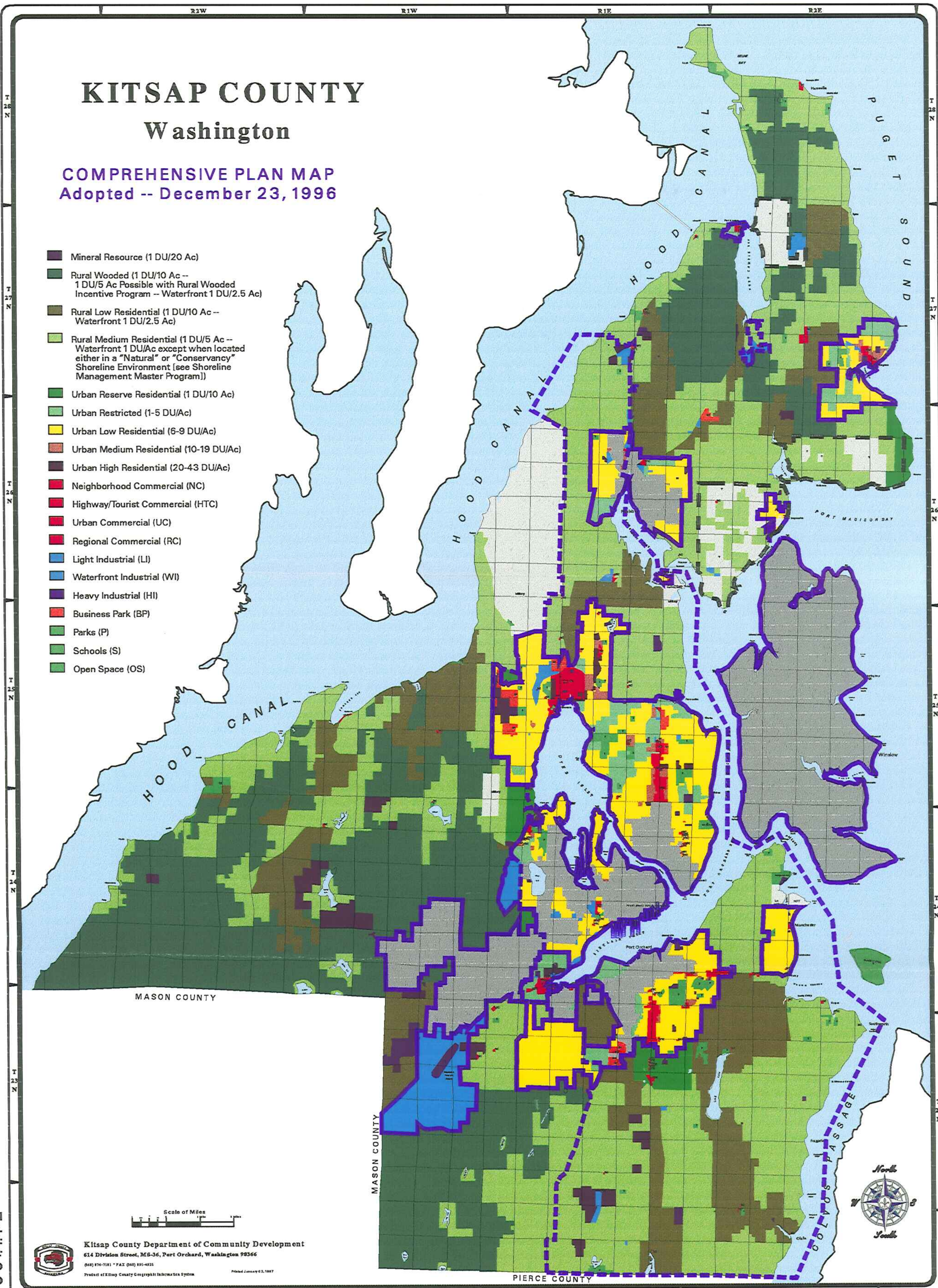
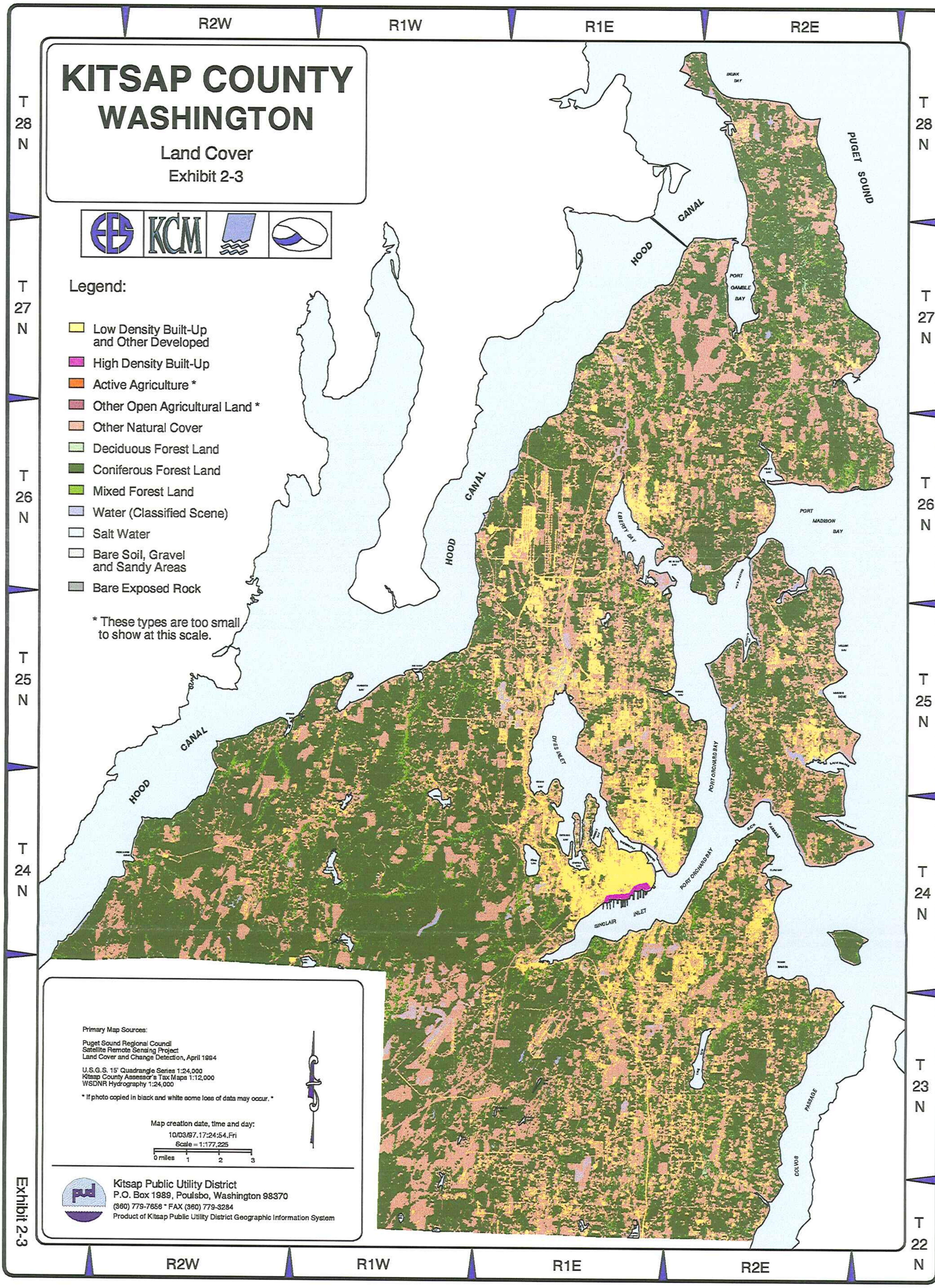
Exhibit 2-1



KITSAP COUNTY
Washington
COMPREHENSIVE PLAN MAP
Adopted -- December 23, 1996
Mineral Resource (1 DU/20 Ac)
Rural Wooded (1 DU/10 Ac -- 1 DU/5 Ac Possible with Rural Wooded Incentive Program -- Waterfront 1 DU/2.5 Ac)
Rural Low Residential (1 DU/10 Ac -- Waterfront 1 DU/2.5 Ac)
Rural Medium Residential (1 DU/5 Ac -- Waterfront 1 DU/Ac except when located either in a "Natural" or "Conservancy" Shoreline Environment [see Shoreline Management Master Program])
Urban Reserve Residential (1 DU/10 Ac)
Urban Restricted (1-5 DU/Ac)
Urban Low Residential (6-9 DU/Ac)
Urban Medium Residential (10-19 DU/Ac)
Urban High Residential (20-43 DU/Ac)
Neighborhood Commercial (NC)
Highway/Tourist Commercial (HTC)
Urban Commercial (UC)
Regional Commercial (RC)
Light Industrial (LI)
Waterfront Industrial (WI)
Heavy Industrial (HI)
Business Park (BP)
Parks (P)
Schools (S)
Open Space (OS)
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
HOOD CANAL
PUGET SOUND
PORT MADISON BAY
DYES INLET
MASON COUNTY
PIERCE COUNTY
COLVOS PASSAGE
Winslow
Manchester
Port Orchard
North
South
W
E
Scale of Miles
Kitsap County Department of Community Development
614 Division Street, MS-36, Port Orchard, Washington 98366

Exhibit 2-2



KITSAP COUNTY
WASHINGTON
Land Cover
Exhibit 2-3
Legend:
Low Density Built-Up and Other Developed
High Density Built-Up
Active Agriculture *
Other Open Agricultural Land *
Other Natural Cover
Deciduous Forest Land
Coniferous Forest Land
Mixed Forest Land
Water (Classified Scene)
Salt Water
Bare Soil, Gravel and Sandy Areas
Bare Exposed Rock
* These types are too small to show at this scale.
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
PASSAGE
COLVOS
Primary Map Sources:
Puget Sound Regional Council
Satellite Remote Sensing Project
Land Cover and Change Detection, April 1994
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
WSDNR Hydrography 1:24,000
* If photo copied in black and white some loss of data may occur. *
Map creation date, time and day:
10/03/97.17:24:54.Fri
Scale = 1:177,225
0 miles 1 2 3
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Exhibit 2-3

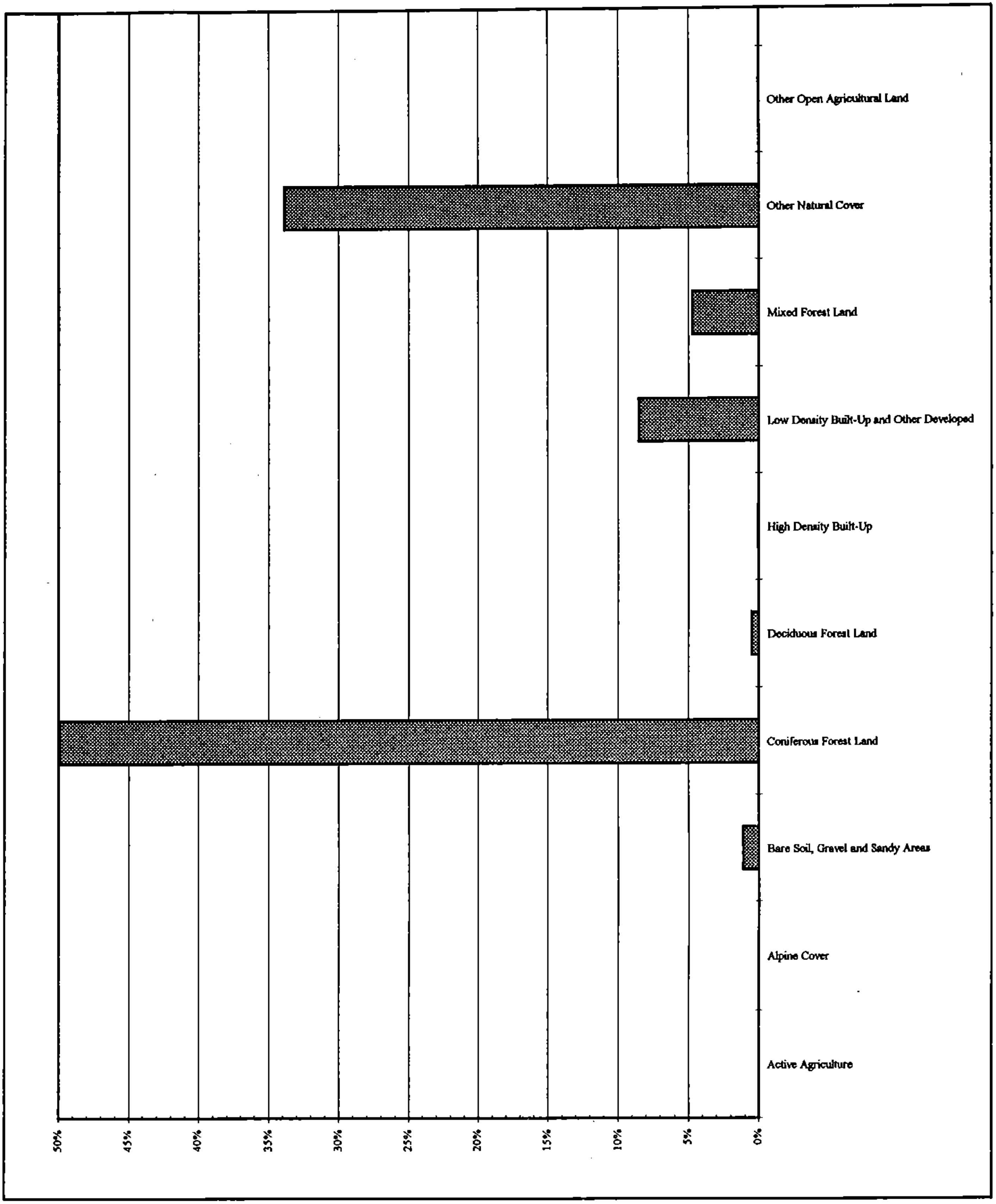


Exhibit 2-4
Kitsap County Land Cover
(Satellite Data)
Source: Puget Sound
Regional Council (1994)

Kitsap County
Initial Basin Assessment

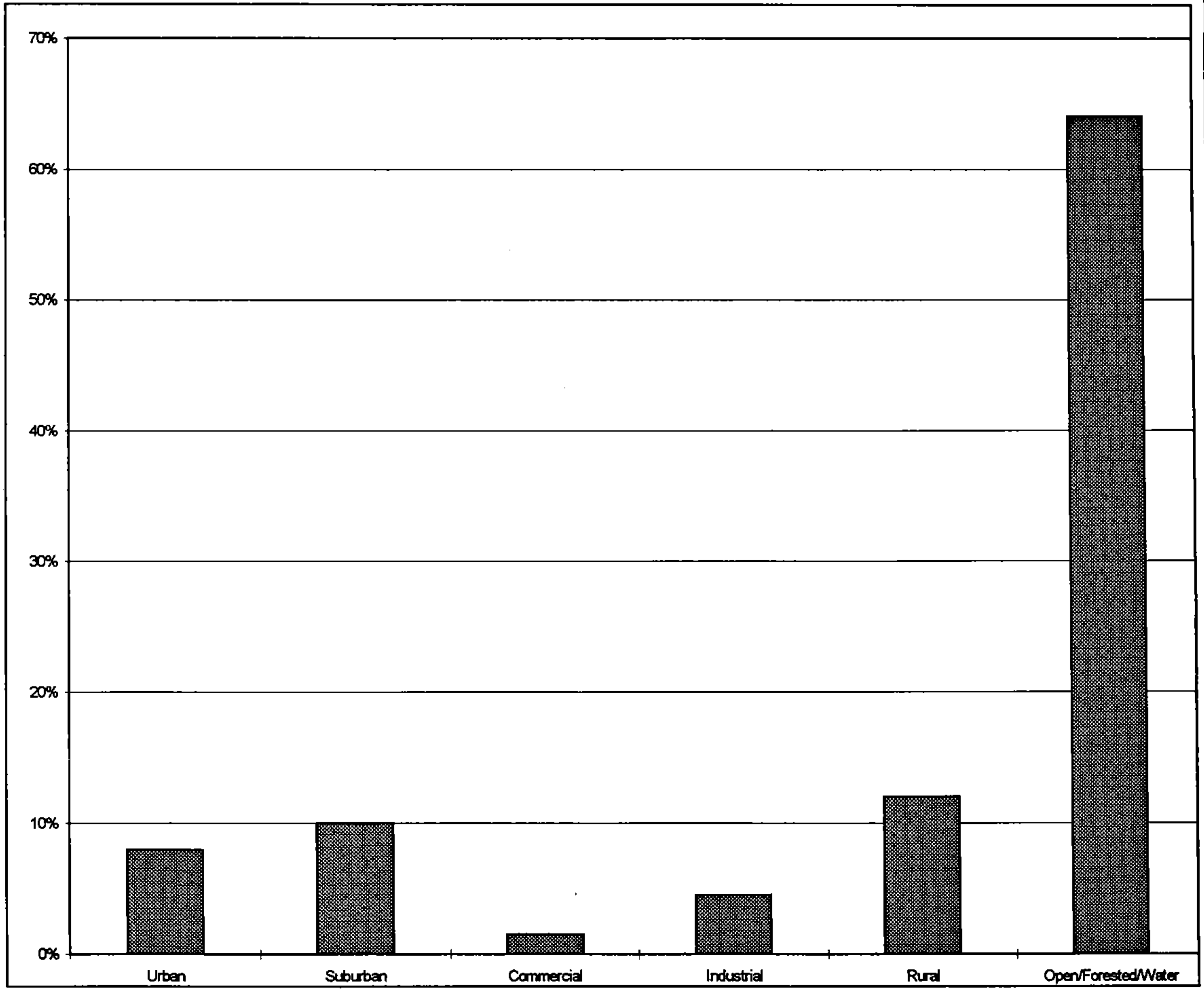


Exhibit 2-5
Kitsap County Land Use -
Assessor Data
Source: Kitsap County
DCD-GIS (1994)

Kitsap County
Initial Basin Assessment

County	Area Sq. Miles	1985 Population	1985 Density	1995 Population	1995 Density	Population Change
1 King	2130.9	1,346,400	632	1,613,600	757	267,200
2 Kitsap	392.7	167,800	427	220,600	562	52,800
3 Clark	627.1	203,400	324	291,000	464	87,600
4 Pierce	1675.9	524,900	313	660,200	394	135,300
5 Island	211.6	49,200	233	68,900	326	19,700
6 Thurston	714.0	139,500	195	189,200	265	49,700
7 Snohomish	2098.2	373,000	178	525,600	251	152,600
8 Spokane	1758.3	354,300	202	401,200	228	46,900
9 Cowlitz	1143.9	79,600	70	89,400	78	9,800
10 Benton	1722.1	105,200	61	131,000	76	25,800
11 Whatcom	2126.2	116,000	55	148,300	70	32,300
12 San Juan	179.3	8,900	50	12,300	69	3,400
13 Skagit	1734.6	68,200	39	93,100	54	24,900
14 Yakima	4271.1	182,500	43	204,000	48	21,500
15 Mason	962.3	34,800	36	45,300	47	10,500
16 Walla Walla	1267.3	48,400	38	52,700	42	4,300
17 Clallam	1752.5	52,600	30	63,600	36	11,000
18 Grays Harbor	1909.8	63,900	33	67,700	35	3,800
19 Franklin	1259.7	35,700	28	44,000	35	8,300
20 Asotin	633.4	17,000	27	19,100	30	2,100
21 Lewis	2449.1	56,500	23	65,500	27	9,000
22 Grant	2680.2	49,900	19	64,500	24	14,600
23 Pacific	908.2	17,500	19	20,800	23	3,300
24 Chelan	2925.8	48,500	17	60,000	21	11,500
25 Whitman	2165.5	39,600	18	40,500	19	900
26 Douglas	1839.3	22,900	12	29,600	16	6,700
27 Stevens	2481.2	30,100	12	35,400	14	5,300
28 Wahkiakum	260.7	3,700	14	3,700	14	0
29 Jefferson	1805.2	17,500	10	25,100	14	7,600
30 Kittitas	2320.0	25,000	11	30,100	13	5,100
31 Klickitat	1907.8	16,700	9	18,100	9	1,400
32 Adams	1893.5	13,800	7	15,200	8	1,400
33 Pend Oreille	1402.0	9,100	6	10,700	8	1,600
34 Okanogan	5300.6	31,700	6	36,900	7	5,200
35 Skamania	1672.3	7,900	5	9,550	6	1,650
36 Columbia	859.5	4,100	5	4,200	5	100
37 Lincoln	2305.5	9,700	4	9,700	4	0
38 Garfield	712.8	2,500	4	2,350	3	-150
39 Ferry	2202.0	6,100	3	7,100	3	1,000
TOTAL	66,662	4,384,100	66	5,429,800	81	1,045,700

Notes: Population Data Source: Office of Financial Management Forecasting Division 6/30/95
Area Data Source: 1991 Washington State Yearbook

EXHIBIT 2-6
Washington State
Population Density

Section 3 Precipitation

3.1 Introduction

Quantification of precipitation is an important component of the watershed assessment process. Precipitation provides the input that supplies stream runoff and ground water recharge. Variation in precipitation must be taken into account when assessing trends in streamflow and ground water levels. Long-term values for precipitation, averaged over specific subareas, are necessary for performing subarea water-budget analyses. A discussion of the spatial distribution and temporal trends of precipitation within Kitsap County (County) is presented below.

3.2 Spatial Distribution

A long term average isohyetal map of Kitsap County **(Exhibit 3-1)** was compiled based on that precipitation data from 21 gages on and surrounding the Kitsap Peninsula. The isohyetal map shows that average precipitation varies over the County from just under 30 inches/year in the north to almost 70 inches/year in the southwest. The accuracy of precipitation estimates is believed to be relatively high in most areas (+ 5%), with the exception of the Green-Gold Mountains where orographic effects are likely significant and precipitation gages are absent. The Green-Gold Mountains occupy portions of the Chico, Gorst, Tahuya, and Union sub-basins. The degree of error caused by orographic effects in these sub basins is unknown. The isohyetal map shows dashed contours in the area to reflect this uncertainty, as well as slightly elevated precipitation associated with orographic effects measured at the McKenna Falls gage. It should be noted that this analysis of available data suggests that precipitation on the northern tip of the Peninsula (at Hansville) is higher and less in the Southwest portion of the County, than shown in the Kitsap County Ground Water Management Plan (GWMP) (1991), and closer to the values shown by Garling (1962).

A summary of precipitation monitoring stations in the County is presented in **Exhibit 3-2**. A summary of the data used to prepare the isohyetal map is included in **Exhibit 3-3**. Fourteen of the gaging stations which lie within the County had adequate data and were used in the analysis. The other seven stations are regional monitoring points that are located in Jefferson, King, Mason, and Pierce Counties. Most of the monitoring stations within the County are relatively new and consequently have relatively short-term records. Three long-term stations exist including the Bremerton Fire Station, McKenna Falls, and Seabeck-Monroe. The long-term records at Bremerton Fire Station and McKenna Falls were used to normalize annual values from short-term records (1991-1993) at the other stations to the long-term average. Normalization involved determining the annual percent departure from the long-term average for the Bremerton and McKenna Falls stations, and adjusting 1991-1993 annual values from the other stations by these average percent departures to obtain values representative of the long-term average. The normalized values are presented as "adjusted" values in **Exhibit 3-3**. The "plot" values in **Exhibit 3-3** represent an average of the adjusted values for 1991-1993 or long-term values for those stations in Kitsap County where long-term data are available. The plot values also include the data for the regional stations for the period 1951-1980. The plot values were processed through a contouring package (SURFER-mincurve fitting technique) to produce the isohyetal map shown in **Exhibit 3-1**. The locations of the precipitation gaging stations are also presented on **Exhibit 3-1**.

3.2.1 Precipitation Trends

Temporal variation and trends in precipitation occur on seasonal, short-term, and long-term scales. On a seasonal basis, 79 percent of the precipitation at the Bremerton Fire Stations occurs in the six-month period from October through March. Additionally, total rainfall for the driest months of June, July, and August is seven percent of the annual total. Departures from these seasonal statistics, such as "dry winters" or "wet summers" occur.

Long-term precipitation trends are demonstrated on **Exhibit 3-4**, which presents precipitation at the Bremerton Shipyard between 1900-1951 followed by precipitation at the Bremerton Fire Station between 1952-1994 (data were missing for March 1993, but were estimated based on other gages). An obvious difference exists between the two records, as record averages show significant contrast (36.2 in/yr. and 51.5 in/yr., respectively). The explanation for this discrepancy may be related to faulty data at one of the gages. The Bremerton Shipyard record average appears to be inconsistent with other gage averages on the isohyetal map. Additional comparison with long term data at Seattle confirms this difference and shows that it is not related to climatic causes.

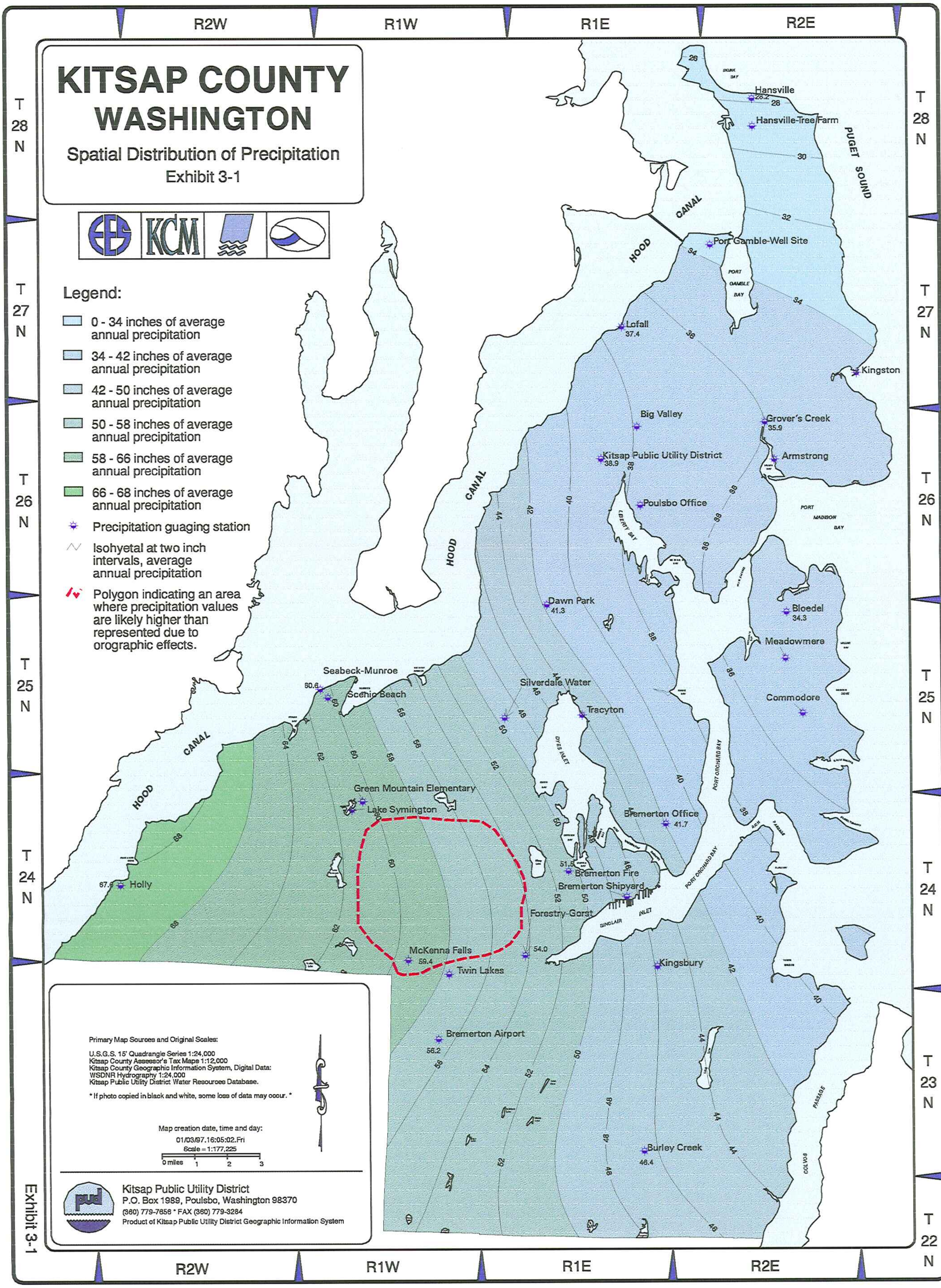
Despite questions regarding the accuracy of the Shipyard data, the entire record can be used to discern temporal trends. Above-average precipitation is shown on **Exhibit 3-4** between 1900-1910, and an overall declining trend is noted between 1910-1944. Short-term variations occur over periods of several years, and are also demonstrated on **Exhibit 3-4**. Between 1957-1983, short-term (3-8 year) "sawtooth" cycles are noticeable which begins with below-average precipitation, build up to above-average values, and then drops back down again. During this period, the largest departures from the long-term average occurred in the early 1970s (above average) and the late 1970s (below average). Other short-term variations generally do not follow discernible patterns.

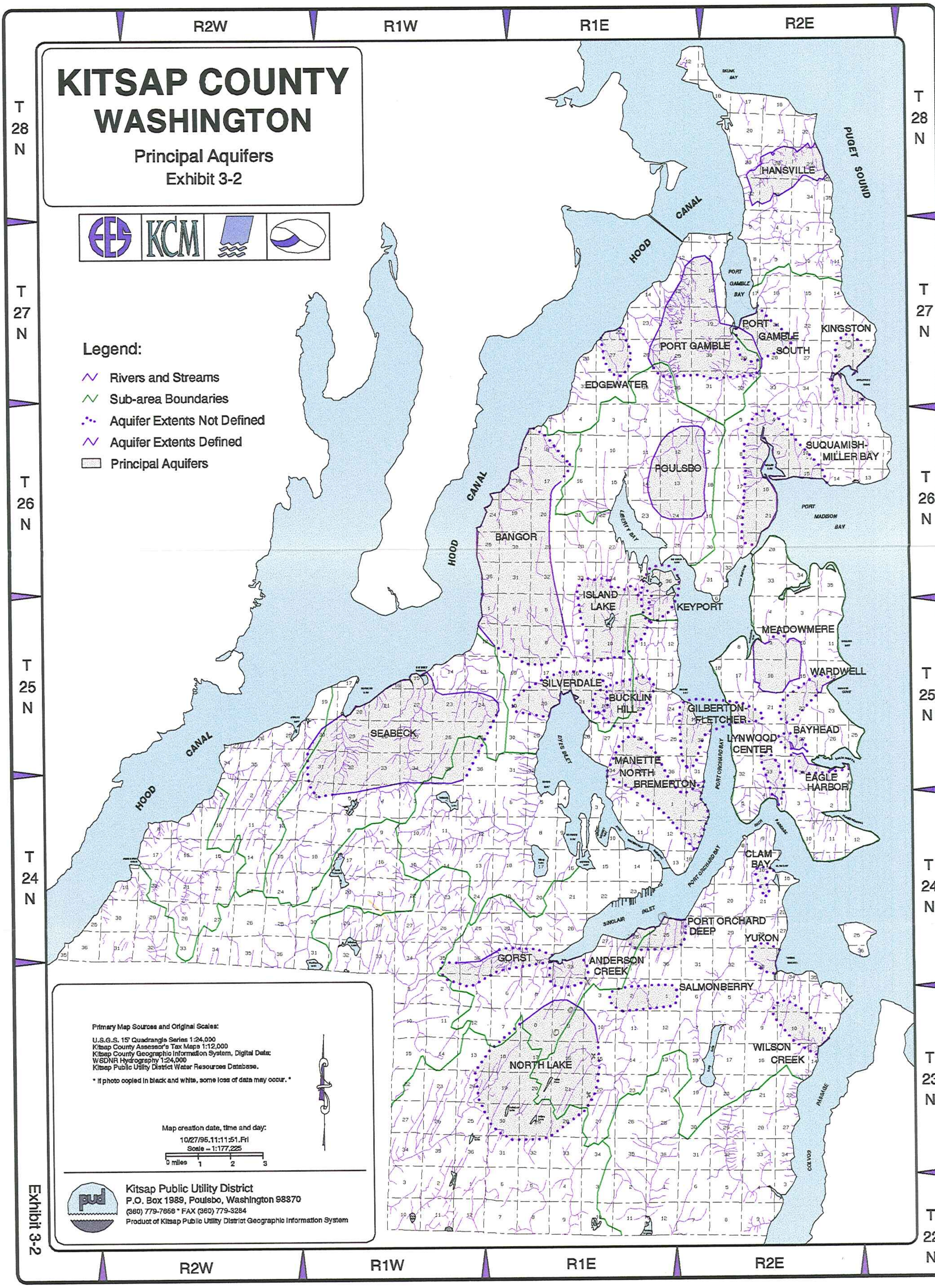
Recent (post-1991) precipitation trends are compared to ground water level and streamflow trends in other sections of this report (Sections 4 and 5). It is worth noting that precipitation data from the Bremerton Fire Station show a decreasing trend between 1991-1993, followed by relatively high rainfall years in 1994 and 1995. Decreasing rainfall between 1990-1993 may be correlated to other observed trends.

Similar precipitation trends are observed among the Bremerton Fire Station, Seabeck-Monroe, and McKenna Falls gages. **Exhibit 3-5**, a comparison plot of precipitation records, shows relative agreement between the gages. One exception occurs at the Seabeck-Monroe gage after 1984. Post-1984 data show a cumulative departure from the long-term annual average which is not evident (or less pronounced) at the other two gages.

3.3 Fog Drip

In areas of the Pacific Northwest, fog drip (condensation of fog on vegetation) can be a significant source of precipitation input. However, research by the USGS indicates that fog drip is not a significant source of precipitation in the Puget Lowland (personal communication, Bill Bidlake, 1996).


KITSAP COUNTY
WASHINGTON
Spatial Distribution of Precipitation
Exhibit 3-1
Legend:
0 - 34 inches of average annual precipitation
34 - 42 inches of average annual precipitation
42 - 50 inches of average annual precipitation
50 - 58 inches of average annual precipitation
58 - 66 inches of average annual precipitation
66 - 68 inches of average annual precipitation
Precipitation guaging station
Isohyetal at two inch intervals, average annual precipitation
Polygon indicating an area where precipitation values are likely higher than represented due to orographic effects.
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
Hansville 28.2
Hansville-Tree Farm
Port Gamble-Well Site
Lofall 37.4
Kingston
Big Valley
Grover's Creek 35.9
Armstrong
Kitsap Public Utility District 38.9
Poulsbo Office
Dawn Park 41.3
Bloedel 34.3
Meadowmere
Commodore
Seabeck-Munroe
60.6
Scenic Beach
Silverdale Water
Tracyton
Green Mountain Elementary
Lake Symington
Bremerton Office 41.7
51.6
Bremerton Fire
Bremerton Shipyard
Forestry-Gorst
67.9
Holly
McKenna Falls 59.4
54.0
Twin Lakes
Kingsbury
Bremerton Airport 56.2
Burley Creek 46.4
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/03/97.16:05:02.Fri
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 3-1



KITSAP COUNTY
WASHINGTON
Principal Aquifers
Exhibit 3-2
Legend:
Rivers and Streams
Sub-area Boundaries
Aquifer Extents Not Defined
Aquifer Extents Defined
Principal Aquifers
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
HANSVILLE
PORT GAMBLE
PORT GAMBLE SOUTH
KINGSTON
EDGEWATER
SUQUAMISH-MILLER BAY
POULSBO
BANGOR
ISLAND LAKE
KEYPORT
MEADOWMERE
WARDWELL
SILVERDALE
BUCKLIN HILL
GILBERTON-FLETCHER
SEABECK
BAYHEAD
LYNWOOD CENTER
MANETTE-NORTH BREMERTON
EAGLE HARBOR
CLAM BAY
PORT ORCHARD DEEP
YUKON
GORST
ANDERSON CREEK
SALMONBERRY
NORTH LAKE
WILSON CREEK
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
10/27/95.11:11:51.Fri
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 3-2

Station #	Status	Data Type	Full Station Name	Local #	Altitude	Lat/Long	Contact	Organization
02	Inactive	Logger	Apex Airport		300	473930 1224320	Bill Bidlake	USGS
03	Active	24 - Hour Total	Indianola-Armstrong	26N/02E-09Q		474523 1223259	Herb Armstrong	ADA Engineering
04	Active	24 - Hour Total	City Of Poulsbo-Big Valley Well Site	26N/01E-02L	80	474611 1223830	Gary Thompson	City of Poulsbo Public Works
05	Active	24 - Hour Total	Bloedel Reserve - Shop	25N/02E-03E		474116 1223224	Joe Piecuch	Bloedel Reserve - Shop
06	Active	Logger	Bremerton National Airport	23N/01W-11J	436	472931 1224554	Linda	Port of Bremerton
07	Active	Logger	Bremerton Fire Station #2 - NOAA	24N/01E-16K	107	473408 1224053	Jim ?	Western Region Climate Center
08	Active	24 - Hour Total	Bremerton Water Dept. Office	24N/01E-12C		473529 1223704	Fred Rienke	Bremerton Water Utilities
09	Inactive	Monthly Totals	Bremerton Shipyard	24N/01E-23F		473329 1223833	N/A	Puget Sound Naval Shipyard
10	Active	24 - Hour Total	Fish Pro - Burley Creek Hatchery	23N/01E-36D	140	472637 1223740	Ken Ferjancic	FishPro Farms, Inc
11	Inactive	Logger	Cattail Lake		400	474525 1224100	Bill Bidlake	USGS
12	Active	Logger	Commodore Middle School	25N/02E-22J		473834 1223113	Doug Olson	Commodore Middle School
13	Active	24 - Hour Total	Coulter Creek Hatchery	22N/ -09	10	472427 1224901	Ted Thgesen	Hatchery
14	Inactive	24 - Hour Total	Jim Crouch	25N/01E-11F	220	474019 1223825	Jim Crouch	Private
15	Active	24 - Hour Total	Poulsbo - Danielson				Don Danielson	Private
16	Active	24 - Hour Total	Dawn Park	25N/01E-05G	255	474119 1224157	Henry Aus	Silverdale Water District
17	Active	Logger	Bangor - Delta Pier				Beverly Pavlicek	Navy
18	Active	24 - Hour Total	Utility Forestry Office - Domsea			473534 1223825	Fred Rienke	Bremerton Water Utilities
19	Inactive	Logger	Gamble Creek		60	474740 1223500	Bill Bidlake	USGS
20	Active	Logger	Grapeview - NOAA				Jim ?	Western Region Climate Center
21	Inactive		Green Mountain Elementary		449	473553 1224907		
22	Active	24 - Hour Total	Grover's Creek Hatchery	26N/02E-04L	57	474623 1223324	Char Ives	Suquamish Tribe
23	Inactive	24 - Hour Total	Hansville Water District Office	28N/02E-17K	190	475507 1223409	N/A	Hansville Water District Office
24	Active	24 - Hour Total	Hansville - Hood Canal Nurseries	28N/02E-20G	230	475422 1223407	Mike Driscol	Pope Resources
25	Active	24 - Hour Total	Holly Beach Club	24N/02W-19F	15	473327 1225839	Howard Clark	Holly Beach Club
26	Active	24 - Hour Total	Illahee-Barney Bernhard	25N/02E-31D	347	473706 1223608	Barney Bernhard	Private
27	Active	24 - Hour Total	Port Orchard - Kingsbury	24N/01E-36F	295	473138 1223717	John Kingsbury	Consulting Forester
28	Active	24 - Hour Total	Port of Kingston - Port Office	27N/02E-25N	10	474746 1222946	Gail Buchanan	Port of Kingston
01	Active	24 - Hour Total	Kitsap Public Utility District Office	26N/01E-10N	275	474518 1223954	Jim LeCuyer	Kitsap PUD #1
29	Inactive	24 - Hour Total	Lake Symington - Freds House	24N/01W-34G		473542 1224941	Fred Rienke	Bremerton Water Utilities
30	Active	24 - Hour Total	Lofall Ferry Dock	27N/01E-22K	10	474855 1223915	Jack Herrell	Private
31	Active	24 - Hour Total	Casad Dam - McKenna Falls			473138 1224711	Fred Rienke	Bremerton Water Utilities
32	Active	24 - Hour Total	Meadowmeer	25N/02E-10N	160	474001 1223224	Gary Dufner	Meadowmeer Golf Course
33	Active	Logger	Minter Creek Hatchery - NOAA			472222 1224206	Jim ?	Western Region Climate Center
34	Active	24 - Hour Total	Olalla - Phillip Carlstroem	22N/02E-05B	345	472558 1223423	Phillip Carlstroem	Private
35	Active	24 - Hour Total	Port Gamble - Pope & Talbot Well	27N/02E-07C	275	475109 1223543	Shawn Russell	Pope Resources
36	Active	24 - Hour Total	City of Poulsbo - Office	26N-01E-23C		474405 1223818	Gary Thompson	City of Poulsbo Public Works
37	Inactive	24 - Hour Total	Scenic Beach State Park	25N/01W-19H		473840 1225035	Mike James	WA State Parks Department
38	Inactive	24 - Hour Total	Seabeck - Munroe	25N/01W-19B		4738541225054	Frank Munroe	N/A
39	Active	24 - Hour Total	Silverdale Water District-Wixon Site	25N/01E-19L	534	473814 1224332	Henry Aus	Silverdale Water District
40	Active	24 - Hour Total	Stavis Bay - Wayne Bernhard	25N/02W-35P	340	473648 1225317	Wayne Bernhard	Private
41	Active	24 - Hour Total	Tracyton-Dahl		25	473822 1224028	Harold Dahl	Private
42	Active	24 - Hour Total	Bremerton Twin Lakes at well #20	24N/01W-35R		473117 1224533	Fred Rienke	Bremerton Water Utilities
43	Active	Logger	Kingston Jr. High	27N/02E-27Q	80			
44	Active	Logger	Orchard Heights Elementary				Palmeia Graziana	Whether Net
45	Active	24 - Hour Total	Point Bolin - George Bechtel	25N/02E-06A	30		George Bechtel	Master Gardners
46	Active	24 - Hour Total	Hansville Road - Joanne Clark				Joanne Clark	Master Gardners
47	Active	24 - Hour Total	Keyport Base - Pier 1	26N/01E-36K	15	474158 1223648	Mike Scott	NUWES
48	Active	24 - Hour Total	Boyce Creek - Guillemot Cove	25N/02W-34R	15		Jim Snell	Master Gardners

EXHIBIT 3-2

Summary of Precipitation Monitoring Stations

Kitsap County
Initial Basin Assessment

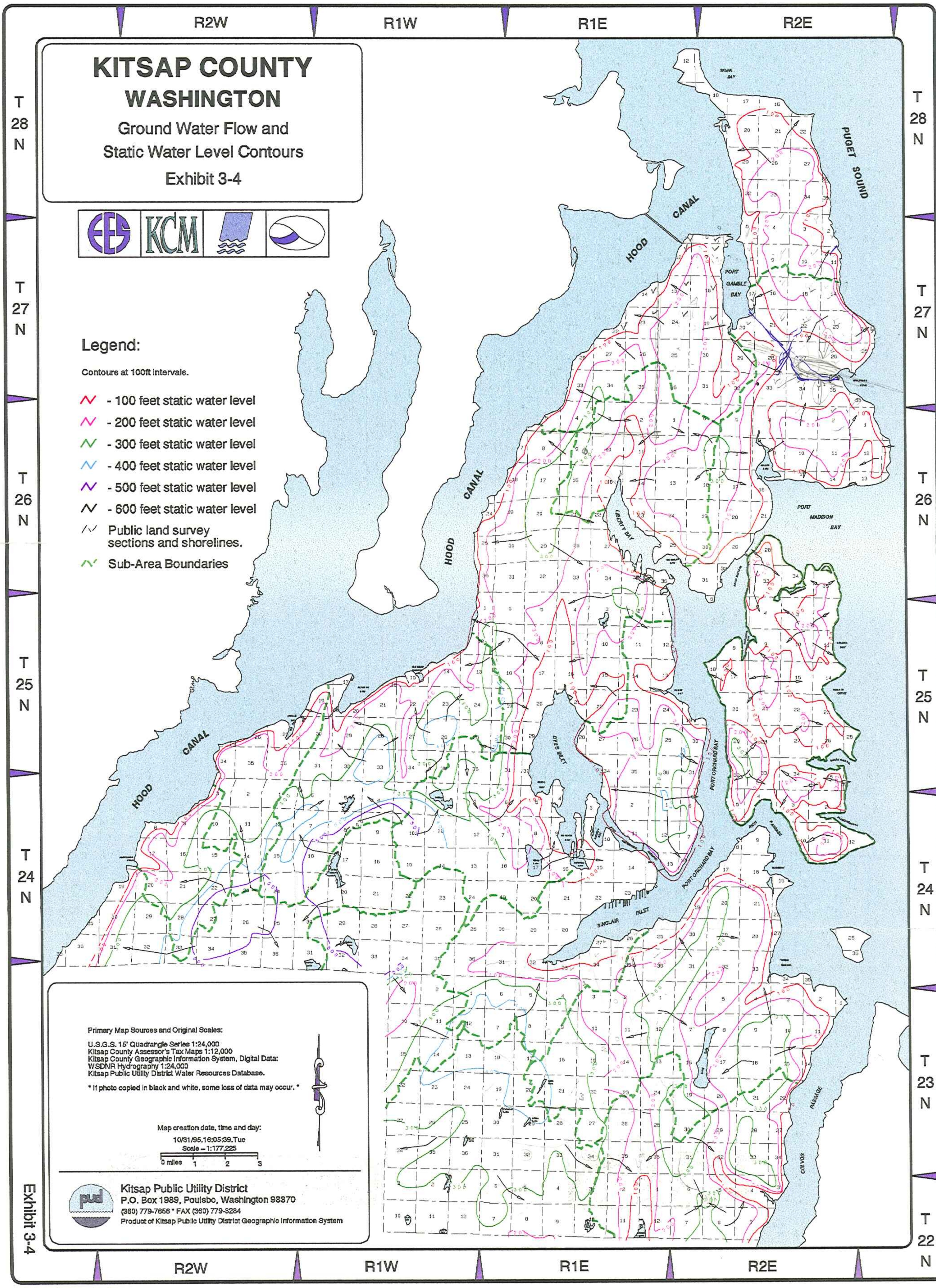
Kitsap County Stations	1991	1992	1993	Adjusted 1991 Values	Adjusted 1992 Values	Adjusted 1993 Values	Plot Values
Bloedel	33.22	34.57	30.43	31.5	35.0	36.41	34.3
Bremerton Airport	61.69	54.67	45.71	58.6	55.4	54.70	56.2
Bremerton Fire	53.77	50.43	-	51.1	51.1		51.5
Bremerton Office	44.02	40.52	35.31	41.8	41.1	42.25	41.7
Burley Creek	-	46.49	38.19		47.1	45.70	46.4
Dawn Park	39.99	41.03	37.11	38.0	41.6	44.41	41.3
Forestry-Gorst	56.87	-	-	54.0			54.0
Grover's Creek	30.15	36.44	35.36	28.6	36.9	42.31	35.9
Hansville	26.12	27.25	26.78	24.8	27.6	32.05	28.2
Holly	69.28	65.15	59.22	65.8	66.0	70.86	67.6
KPUD	36.58	39.83	34.73	34.7	40.4	41.56	38.9
Lofall	-	-	31.23			37.37	37.4
McKenna Falls	63.03	59.02	49.64	59.8	59.8	59.40	59.4
Seabeck-Munroe	-	-	-				60.6
Regional Stations							
Wauna							52.0
Quilcene							55.6
Chimucum							29.9
Grapeview							52.3
SeaTac							38.6
U of Wash.							35.5
Everett							36.2

Notes:

1) Adjusted precipitation values for 1991, 92, and 93 were derived from long-term records for Bremerton Fire Station and McKenna Falls gaging stations (i.e. period 1959 - 1988). Long-term averages for these gaging stations were used to normalize the short-term records for the other stations.
2) The "plot values" reflect an average of the adjusted values or long-term values for those stations where long-term data were available (i.e. Bremerton Fire Station, McKenna Falls, and Seabeck Munroe).
3) The Kitsap monitoring stations were supplemented with regional data from other reporting stations. The period of record used for the regional stations was 1951 - 1980.

EXHIBIT 3-3

Summary of Precipitation Data for Isohyetal Map


KITSAP COUNTY
WASHINGTON
Ground Water Flow and
Static Water Level Contours
Exhibit 3-4
Legend:
Contours at 100ft intervals.
- 100 feet static water level
- 200 feet static water level
- 300 feet static water level
- 400 feet static water level
- 500 feet static water level
- 600 feet static water level
Public land survey sections and shorelines.
Sub-Area Boundaries
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
10/31/95.16:05:39.Tue
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
R2W
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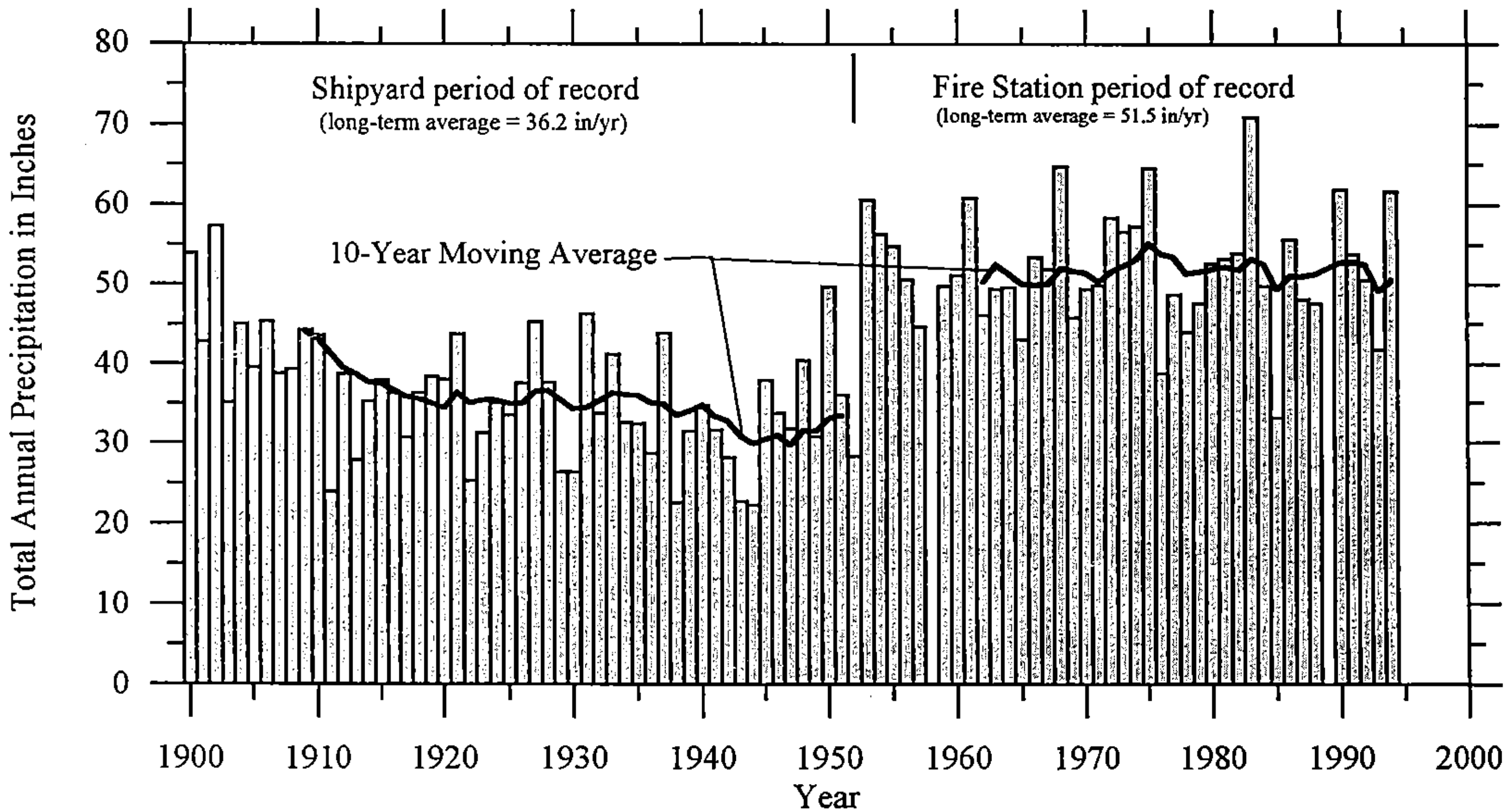
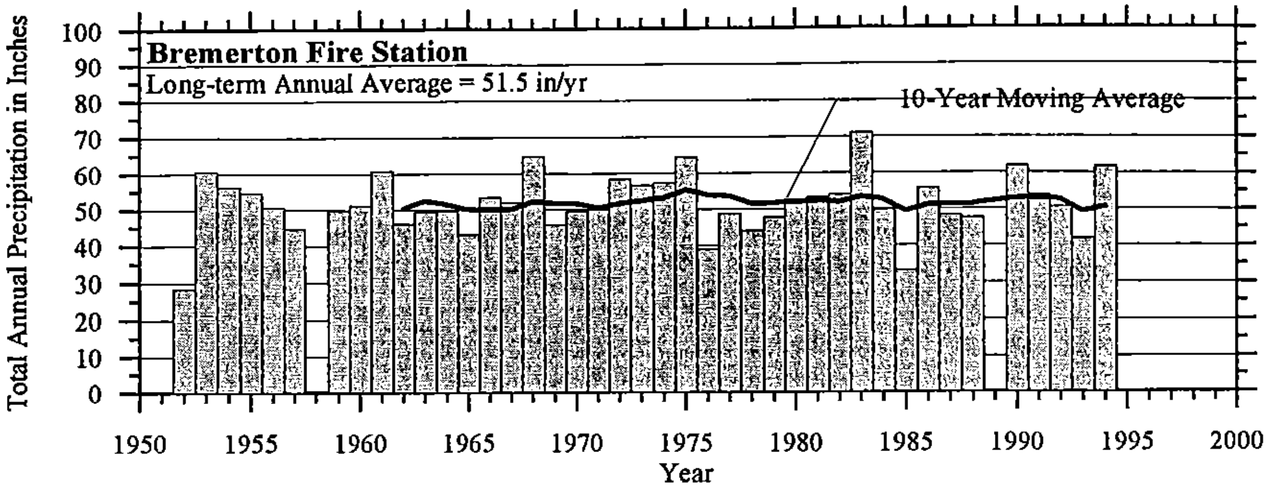
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
LIBERTY BAY
PORT MADISON BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
Exhibit 3-4

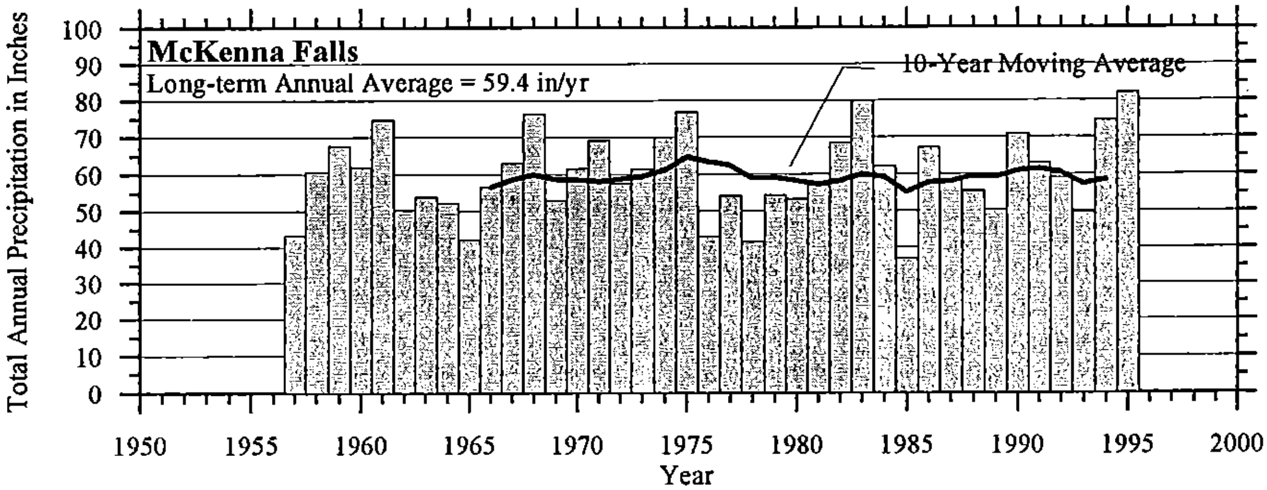
EXHIBIT 3-4
Total Annual Precipitation at Bremerton
(Shipyard and Fire Station records combined)

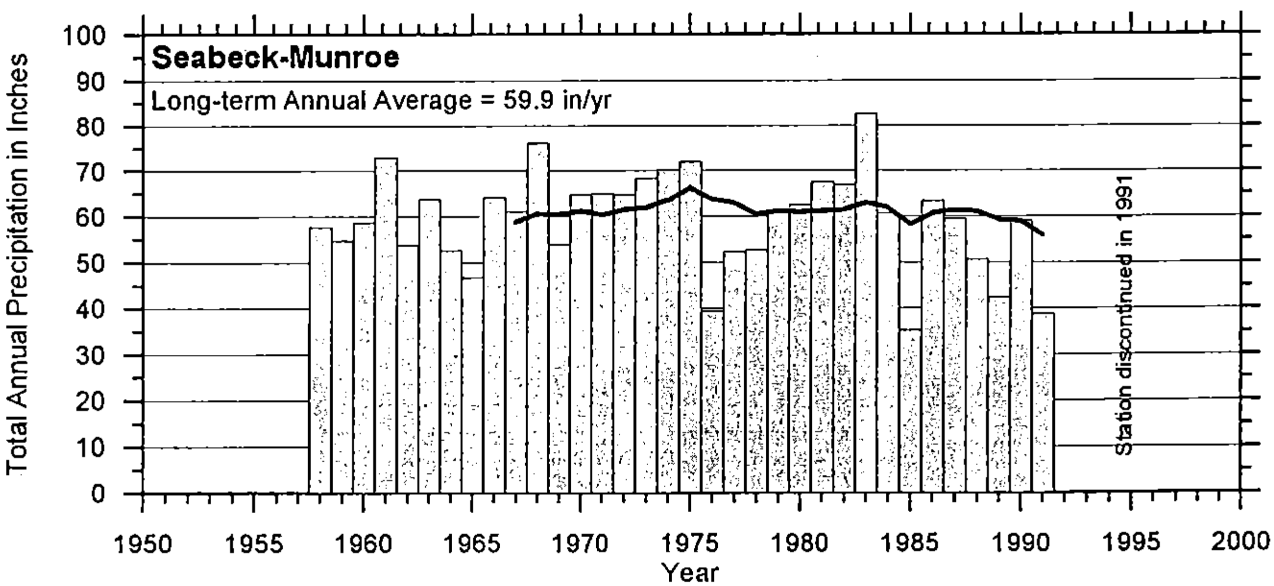
Kitsap County
Initial Basin Assessment

Data Source: US Weather Service









Data Source: US Weather Service

EXHIBIT 3-5

Long-Term Precipitation Trends Comparison of Fire Station, McKenna Falls, and Seabeck-Munroe Data

Kitsap County
Initial Basin Assessment

Section 4
Surface Water Hydrology

4.1 Description of Drainage Network

The Kitsap Peninsula contains a multitude of creeks, only a few of which drain extensive land areas. The largest drainages in the Water Resources Inventory Area (WRIA) include the Tahuya River, Union River, and Dewatto Creek. The Kitsap WRIA in total includes approximately 521 identified rivers and creeks providing over 665 linear miles of drainage. In general, drainages on the western side of the Peninsula are larger than those on the eastern side. Excellent detailed descriptions of the river systems and most tributary streams in the Kitsap Peninsula may be found in the November 1975 Washington Department of Fisheries publication, "A Catalog of Washington Streams and Salmon Utilization; Volume 1, Puget Sound Region." That publication was a principal source of information for the brief drainage network overview presented above.

This section provides an evaluation of streamflow data for drainages within Kitsap County (County). Data from streams with headwaters in the County but with watersheds primarily in other portions of the WRIA (e.g., Dewatto River) are not evaluated because they are not representative of County conditions. A map of rivers and streams in the County is presented as **Exhibit 4-1**.

The County's surface water development is primarily based on individual stream diversions rather than large dams with associated reservoirs. The Casad Dam, located at McKenna Falls on Union River, is the only major diversion structure in the County, and is used for municipal supply by the City of Bremerton. The Dam provides about 60 percent of the City's water supply (pers. comm., F. Reinke, 1995). The geographic distribution of surface water rights in the County is included in Section 8.2.3. In addition, a number of small dams have been identified throughout the County (e.g., Big Beef Creek, Gorst Creek, Barker Creek, tributaries to the Tahuya River and Sinclair Inlet, and on Bainbridge Island). These dams are assumed to be associated with small, private diversions and lake enhancements (e.g., Lake Symington on Big Beef Creek).

4.2 Established Regulatory Instream Flows

Instream flow regulations, and other rules which limit surface water withdrawals in the Kitsap WRIA, are published in the Washington Administrative Code (WAC) Chapter 173-515, titled "Instream Resources Protection Program - Kitsap Water Resource Inventory Area (WRIA) 15." These rules were promulgated in 1981 pursuant to the Revised Code of Washington (RCW) Chapter 90.54 (Water Resources Management Act of 1971), Chapter 90.22 RCW (Minimum Water Flows and Levels), and Chapter 173-500 WAC (Water Resources Management Program). A copy of Chapter 173-515 WAC is included in Appendix B of this report.

Instream flows have been established for 18 locations in the Kitsap WRIA, 14 of which occur within the County. The instream flows are established on a bi-weekly basis over the periods specified in WAC Chapter 173-515 (Appendix B). The locations of control points (established measurement location as per Chapter 175-515 WAC) and stream reaches regulated for instream flows within the County are shown on **Exhibit 4-2**. Only six control points (five within Kitsap County) have associated stream gaging stations, several of which are no longer active. General comments by various hydrogeologists that some of the minimum instream flows in Kitsap County may have been set unrealistically high seems to have been confirmed by a recent study of the Gorst Creek basin by AGI Technologies. As more data and analysis on county streams is submitted as part of the Basin Assessment open file, the state Department of Ecology could take action to set more valid minimum instream flows where appropriate. This action would require new rulemaking in accordance with Chapter 34.05 RCW.

Regulatory closures have been established for 67 streams, lakes and drainage systems in the Kitsap WRIA, as presented in WAC Chapter 173-515 (Appendix B). Thirteen streams have partial closures with instream flow requirements during other times of the year. The remainder of closures are applied year-round. In Kitsap County alone, there are approximately 32 year-round closures and ten partial closures. Major drainages with regulatory closures include Union, Tahuya, Dewatto Rivers and Big Beef Creek. A complete summary of closures and instream flow requirements for the County is presented in **Exhibit 4-3**.

4.3 Quantification of Streamflow

Streamflow data considered in this preliminary assessment include long-term data collected by the US Geological Survey (USGS), recent data collected by Kitsap Public Utility District (KPUD), and miscellaneous or short-term data collected by tribal organizations and various other parties. This assessment is limited to streams which occur within the County. A summary of continuous stream gaging stations within the County is presented in **Exhibit 4-4**. In total, the USGS has established ten continuous recording stream gage sites in the County and currently maintains a gage at only one of these sites (Big Beef Creek during the low flow period). Streamflow measurements were initiated by the KPUD at nine sites within the County beginning as early as 1990 **(Exhibit 4-4)**. Additional sites have been added since then. In some cases (at both new gage sites and former USGS sites), rating curves are still being established and reported flow rates may involve some inaccuracy.

The quality of data for the nine KPUD gaging stations for the period from 1990 to 1994 is limited by the accuracy of the rating curve analysis used to produce the discharge estimates. Rating curves for these stations during this time period were developed on the basis of simplified best curve fits on log-log graph paper. The rating curves did not incorporate shift factors and other corrections which reflect changing conditions within the stream channel. Since 1994, KPUD has been using standard USGS protocol for streamflow surveys, rating curve analysis, and computation of streamflow records.

Recent data from several of the KPUD gaging stations may also be effected by poor hydraulic control. A USGS review of gaging stations on Chico, Gorst, and Barker Creeks indicated various problems associated with backwater conditions, unstable channel morphology, and debris buildup. KPUD plans to relocate these stations at more suitable control points in 1998.

KPUD is currently using Western Hydrologic Systems software for storage, analysis, and retrieval of streamflow data and for maintenance of rating curves. USGS personnel are providing oversight and review of KPUD's streamflow monitoring program.

The main objectives in reviewing and quantifying the streamflow data were:

- To assess whether there is any obvious indication of declining annual streamflows and summer low-flows; and
- To compare actual streamflows to the established regulatory instream flows and to assess the frequency with which the regulatory instream flows are actually met.

Streamflow data are published by the USGS following a "water year" convention - where water year 1990, for example, begins on October 1, 1989, and ends September 30, 1990. The water year convention is useful to many aspects of hydrologic analysis, but may confuse readers not familiar with the convention. To minimize confusion, all data presented for this section are expressed based on the calendar year convention (January 1 through December 31).

Streamflow data were processed in several ways to achieve the objectives listed above. Average and minimum annual flows were evaluated in time-series plots along with annual precipitation at Bremerton. Where only recent data were available (i.e. post-1990), continuous streamflow hydrographs were plotted directly from KPUD records and evaluated for trends over time. Historic flow exceedence probabilities were calculated based on USGS records and plotted over the calendar year. Recent (post-1990) hydrographs were plotted along with the historic flow exceedence probabilities for purposes of comparison. Finally, regulatory minimum instream flow requirements (listed in WAC 173-515) were compared to historic and recent streamflows by plotting the annual flow requirements together with flow exceedence probability curves and recent hydrographs.

Some of the streamflow data collected within the County were unsuitable for the analyses described above. Non-continuous flow data (spot measurements) have been collected for various streams in the County, but are not sufficient for these analyses. Appendix C presents spot measurement data collected by the Suquamish Tribe, KPUD, and various other parties. In addition, continuous data collected at two KPUD gages and three USGS gages were not used for the analyses described above. KPUD data records from Anderson Creek #96 and Anderson Creek #272 were too short (less than one year) for such analyses. USGS data from the Union and Tahuya Rivers near Bremerton and from Huge Creek were not used for reasons discussed in Appendix C.

4.4 Streamflow Trends and Critical Indicators

Time series trends were analyzed for nine gages in the WRIA to assess whether there are any indications of declining streamflow over time. Trends in average annual streamflow and minimum streamflows (summer low flow) were addressed. In addition, recent flow hydrographs were compared to historic streamflow statistics to detect changes over time. Finally, flow data from gages with regulatory flow requirements were assessed to ascertain the extent to which recent (and historic) flows satisfy the regulatory requirements.

The following three sections assess trends in average annual streamflows, trends in minimum streamflows, and compliance with instream flow requirements. A fourth section is presented to summarize the conclusions.

4.4.1 Annual Streamflow Trend Analysis

Annual precipitation and annual streamflow volumes are hydrologically related. In a natural system, precipitation which does not emerge as streamflow must be attributed to either evapotranspiration, losses to ground water which emerges outside the drainage basin, or changes in the volume of ground water storage. Human development activities may significantly affect annual streamflow volumes, independent of climatic fluctuations. Basin land development activities such as logging, paving, construction, and other creation of impervious areas will cause an increase in the annual volume of runoff, reduce plant transpiration, and decrease infiltration to ground water. Water development activities, particularly withdrawals from streams or from shallow ground water, will cause a decrease in the annual volume of runoff, especially if the water-use is consumptive (e.g. sewage discharge to sea) or if water is exported outside the drainage basin.

Development activities may also influence the timing of runoff, and might cause annual flows to increase but simultaneously cause minimum flows to decrease. For example, if large areas of a basin were paved and converted to impervious surfaces, the annual streamflow volume would increase because more of the rainfall would go directly to runoff. Simultaneously, however, the minimum annual flows would decrease because less of the rainfall would infiltrate to ground water which is the source of stream base flows during periods of no rain. This sub-section of the report deals with an assessment of annual flow volumes only. Minimum flows are presented and discussed in Section 4.4.2.

Annual average streamflow volumes were plotted over time for Chico, Burley, Big Beef, Dogfish, and Gold Creeks **(Exhibits 4-5 through 4-9)**. The plots present streamflow data from USGS records, streamflow data from more recent KPUD records (where available), and annual precipitation measured at Bremerton. Trends in annual streamflow volumes were assessed and compared with precipitation. As mentioned above, precipitation is a necessary component in considering potential causes for changes in annual streamflow.

In general, the utility of the annual streamflow trend analysis is limited by the quantity of available data. Data records are short, available only for isolated periods, and/or available prior to the rapid water-resource development which began in the early 1970s **(Exhibit 8-1)**. Long-term data records (over 25 years) are best suited to streamflow trend analysis given inherent natural variabilities in the timing of precipitation and associated antecedent soil saturation.

Discernible trends in annual average streamflow are not evident over the period of record for Chico Creek near Bremerton **(Exhibit 4-5)** and Burley Creek at Burley **(Exhibit 4-6)**. Identification of long-term trends is difficult for both data sets because short isolated periods of record are separated by longer periods of no available data. For Chico Creek, two isolated periods of record (1948-49 and 1992-94) are too short to draw conclusions about streamflow trends. For Burley Creek, there are no discernible differences in annual average streamflow between the three isolated periods of available record.

A declining trend in annual average streamflow is indicated for the 11-year period of record (1970-80) at Big Beef Creek near Seabeck **(Exhibit 4-7)**. Annual average streamflows associated with years of similar precipitation appear to be higher in the early 1970s then in the late 1970s. It should be noted that 11-year record is relatively short, and conclusions should be drawn with caution. Such a short record may not account for natural variability in the timing of precipitation, a factor which controls how much precipitation goes to runoff versus recharge.

A relatively long period of record is available for Dogfish Creek near Poulsbo **(Exhibit 4-8)**. A fairly stable average annual streamflow trend is apparent during the 1948-70 continuous record, followed by similar average streamflows in the short isolated period between 1991 and 1996. A comparison of annual precipitation values for years of similar average annual streamflow was performed in an attempt to discern whether equivalent streamflows required increased precipitation input over time. Such a trend would imply either precipitation loss to runoff or withdrawal, or increased ground water recharge. Although there was a slight suggestion of this type of trend, the data contained too much noise to make reliable conclusions. It should also be noted that differences in rating curve error between the two periods of record may account for relatively high estimates of post-1990 flows (see Section 4.4.2). If this is the case, reduced annual streamflow over time is even more likely. Re-evaluation of the rating curves and additional analysis of the precipitation and annual streamflow data is required to improve the accuracy of the conclusions above.

A similarly long period of record is available for Gold Creek near Bremerton **(Exhibit 4-9)**. Visual inspection of the annual average streamflow data does not suggest a significant trend over the period of record (1946-69). Precipitation, however, exhibits a slightly increasing trend between 1957 and 1969 which is not reflected in the streamflow data. A more sophisticated analysis is required to better evaluate the role of precipitation in this case.

4.4.2 Minimum Flows and Trend Analysis

Trends in minimum flows may differ from trends in annual flows, due to changes in land use and the timing of rainfall events. Under certain scenarios of basin land development, for example, it is possible that average annual flows could increase over time while minimum daily flows could decrease over the same period (see discussion, Section 4.4.1). This section attempts to identify trends in minimum streamflows (and summer low-flows) using simple visual analysis of flow data. Annual precipitation was not considered in assessing minimum flow trends. Adjustment of minimum flows (and summer low-flows) for climatic variability requires a sophisticated analysis which incorporates the cumulative influences on antecedent soil moisture conditions. Such an analysis was beyond the scope of this assessment.

Trends in minimum streamflows were assessed by three different methods. For the five gages analyzed above, streamflow data were processed to identify the minimum daily average flow for each year ("minimum daily flow"), and these values were plotted over time. In addition, changes in the minimum flow regime for three of these gages (Chico, Burley and Dogfish Creeks) were assessed by comparing streamflow probability statistics for earlier periods of record (based on USGS gaging) with annual hydrographs from recent (KPUD) gaging. Finally, minimum streamflow trends between 1990 and 1994 were assessed by inspection of continuous hydrographs based on KPUD gaging data.

Trends in minimum daily flow are assumed to be similar to trends in seven-day low flow, a measure of the average flow recorded during any continuous seven-day period. This relation is commonly the case for basins without large, sporadic stream diversions (such as diversions for agricultural irrigation). Initial inspection of average daily flow data did not reveal any anomalous single day low flow during the summer months. Comparison of one-day and seven-day minimum flows for Big Beef Creek over 24 years of record showed that although 1-day minimum flows were less than seven-day flows, differences between the two flows were generally small.

Streamflow probability statistics are a measure of the occurrence probability of any particular streamflow during the calendar year. In this assessment, streamflow probability statistics ("exceedence probabilities") were calculated for weekly average flows based on data collected over the entire stream gage record. For instance, a 90 percent exceedence probability indicates that for a given week, the average flow is likely to exceed this value nine times in every ten years. Similarly, the 50 percent exceedence probability indicates that for a given week, the average flow is likely to exceed this value once in every two years. Streamflow probability statistics for selected streams are discussed below and in Section 4.4.3.

It should be noted that reports of declining baseflows are common for streams throughout the Puget lowlands, including the Kitsap Peninsula. Such reports are largely anecdotal and data are generally unavailable to substantiate these reports. Fisheries habitat studies on the Kitsap Peninsula are known to cite anecdotal evidence of declining summer flows (see Section 8). In this report, trend analysis is limited by the quantity and quality of available data. Data from three of the five gages (Chico, Burley and Dogfish creeks) contain short, isolated periods of record which are insufficient for trend analysis. Minimum flow trends were largely inconclusive for these three gages. Declining trends were suggested at the Big Beef and Gold creek gages.

Inspection of annual minimum daily flows over time **(Exhibits 4-5 through 4-9)** shows varying trends between gages. No discernible trends in minimum streamflows were observable for Chico Creek at Bremerton **(Exhibit 4-5)** and Burley Creek at Burley **(Exhibit 4-6)**. For Chico Creek, three of the most recent four years of record (1991-94) show minimum streamflows substantially lower than previous record (1961-74). Although this comparison implies declining low flows, a trend cannot be established due to the brevity of the recent record. Recent record at Burley Creek (1991-94) suggests increased minimum flows relative to previous record. However, the four-year period is too short on which to base solid conclusions. The disparity between minimum flows measured by the USGS and by the KPUD (post-1990) suggests that there may be a slight discrepancy between rating curves for the two periods of record.

Minimum daily flows on Big Beef Creek near Seabeck show a slightly declining trend between 1969 and 1994 **(Exhibit 4-7)**. These data were collected entirely by the USGS, thus eliminating the potential for differential measurement error between the two data collection agencies. Minimum daily flows on Dogfish Creek near Poulsbo show no apparent decline between the two periods of record (1947-71 and 1991-94, **(Exhibit 4-8)**). Similar to Chico and Burley Creeks, however, conclusions are limited due to the relatively short recent record. Minimum daily flows on Gold Creek near Bremerton show a declining trend between 1946 and 1970 **(Exhibit 4-9)**. This historic decline appears to be on the order of 0.1 to 0.2 cfs, approximately 25 to 50 percent of the 1946-1970 minimum daily flow average. Data were not available to assess whether the declining trend has extended to present times.

The conclusions gained from the minimum daily flow analysis are generally supported by comparisons between historic (USGS) streamflow statistics and recent (post-1990; KPUD) streamflow hydrographs. The comparisons are presented on **Exhibits 4-10 through 4-12**. **Exhibit 4-10** presents recent streamflow hydrographs for Chico Creek overlain on 1947-74 weekly streamflow exceedence probabilities. The plot shows that recent flows were consistently less than the statistical 1-in-10-year low flow (90 percent exceedence) between May and mid-October during one of the four years of record; and were intermittently less than the 1-in-10 year low flow during the summer months for two of the recent years. Years showing intermittent summer flows below the 1-in-10 year low flow, however, also show remaining summer low-flows generally between the 10 percent and the 90 percent exceedence probability curves. Intermittent low baseflows contribute to the apparently reduced minimum daily flows between 1991-94 shown on **Exhibit 4-5**. Due to the short period of recent record, additional flow data must be collected to determine whether this reduced condition is representative and whether it is related to a change in baseflow regime (e.g. added variability) or to a consistent reduction in ground water discharge.

A similar comparison for Burley Creek is presented on **Exhibit 4-11**, based on 1947-65 streamflow statistics. The comparison shows that recent summer low-flows range between the 10 percent and 50 percent exceedence curves for historic summer low flows. The same comparison for Dogfish Creek shows that recent summer streamflows exhibit considerable variation relative to exceedence probability curves. **Exhibit 4-12** shows that over four years of recent record, streamflows exceeded the 10 percent exceedence probability curve during significant portions of three of four summers and fell near or below the 90 percent exceedence probability curve during portions of two of four summers.

Recent trends in summer low-flows were assessed based on continuous hydrographs from the seven gages currently monitored by the KPUD **(Exhibit 4-4)**. **Exhibits 4-13 through 4-19** present (post-1990) average daily streamflow versus time for the seven gages. Relatively stable trends are noted on Chico, Clear, and Burley Creeks **(Exhibits 4-13 through 4-15)**. Variability obscures any noticeable or significant trend on Dogfish Creek

(Exhibit 4-16). A noticeable decline is apparent on the Barker Creek hydrograph **(Exhibit 4-17)**, and variability of summer streamflow tends to obscure any observable trend on Gorst Creek **(Exhibit 4-18)**. Finally, the data record for Blackjack Creek **(Exhibit 4-19)** is too short to draw significant conclusions.

It must be emphasized that the periods of record used for the above assessment are too short to indicate long-term trends. Climatic variability may be partially accountable for observed short-term trends. Recent precipitation exhibits a downward trend between 1990 and 1993, followed by an above average value in 1994 (discussed in Section 3.2). Recent (short-term) declines in summer low-flows are not conclusive indicators of additional stress on the hydrologic system, but they do suggest that increased attention is warranted. Continued data collection is required for all seven gages to make defensible conclusions pertaining to current low flow trends.

4.4.3 Regulatory Instream Flows and Actual Flows

An assessment was made to compare flow statistics and recent hydrographs to regulatory instream flow requirements. Three of the gages with available streamflow data are currently associated with regulatory instream flow requirements. One of these gages is coincident with the instream flow control points specified in WAC 173-515, and two are located near to specified control points **(Exhibit 4-2)**. Historic USGS streamflow data are available for two of the gages (Big Beef Creek and Tahuya River at Belfair), and recent KPUD streamflow data are available for one gage (Gorst Creek). Probability statistics derived from USGS streamflow data are compared to regulatory instream flow requirements on **Exhibits 4-20 and 4-21**. Recent streamflow hydrographs are compared to regulatory instream flow requirements on **Exhibit 4-22.**

It should be noted that in establishing instream flows by regulation, Ecology recognizes that the recommended regulatory flows are not, and probably have never been met, 100 percent of the time. The intent of the regulation, however, is to protect streams from further depletion (e.g. through subsequent appropriations) when flows approach or fall below the recommended discharges.

Big Beef Creek is subject to minimum instream flow requirements between November 15 and May 15. A stream closure is in effect at other times. Streamflow probability statistics for Big Beef Creek between 1969-1993 **(Exhibit 4-20)** suggest that instream flow requirements would not have been met on any given week during the period of record in more than 50 percent (and less than 90 percent) of all years. It should be noted that these statistics compare the instream flow requirements to a period of record that begins before the requirements were enacted.

The Tahuya River is subject to minimum instream flow requirements between November 1 and June 15, and a stream closure exists at other times. Streamflow probability statistics for the available record (1945-1956) suggest that current instream flow requirements would not have been met on any given week between mid February and late November in more than 50 percent of all years **(Exhibit 4-21)**. Additionally, the requirements would not have been met on any given week between early May and the beginning of closure (July 1) in over 90 percent of all years.

Gorst Creek is subject to minimum instream flow requirements throughout the year. Recent hydrographs on Gorst Creek **(Exhibit 4-22)** show that instream flow requirements were not met during portions of the year for all recorded years (1990-1994). Instream flow requirements were not met for three of the four years during the late spring and summer (May through September). Instream flows were not met during all four years in late December, and were not met during all four years between major runoff events between January and May.

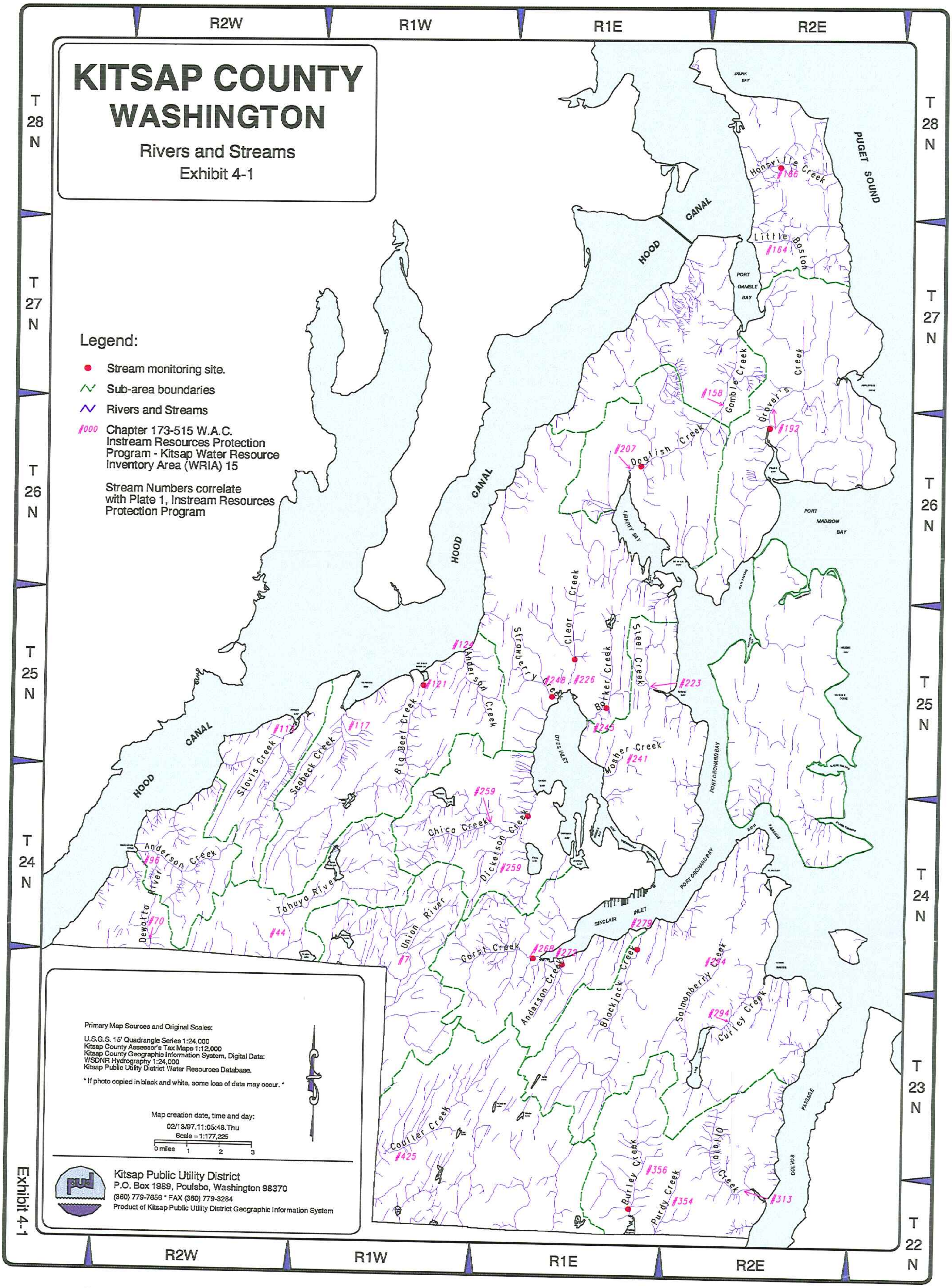
4.4.4 Summary of Streamflow Analyses

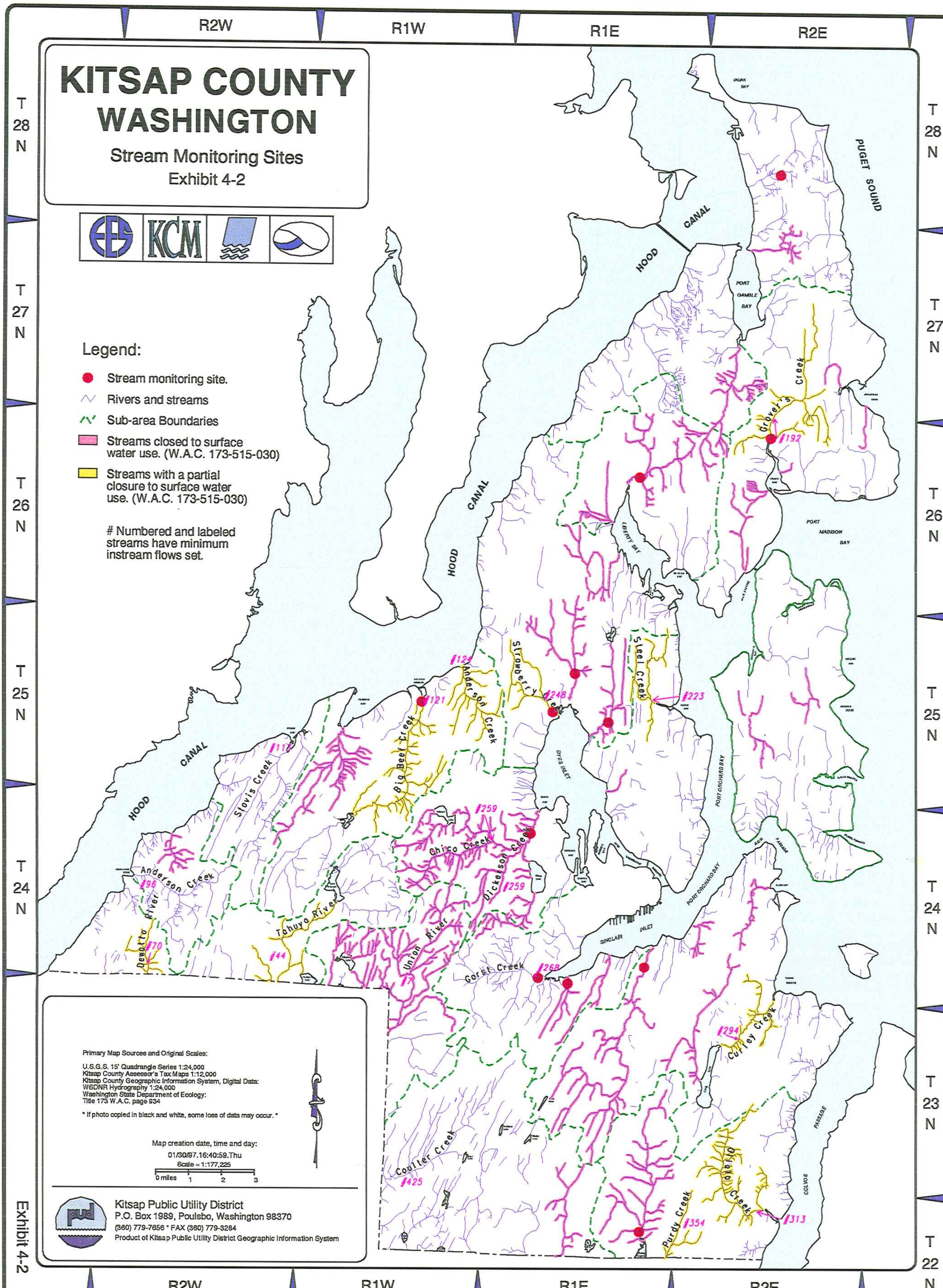
The reliability of the annual average streamflow trend analysis is limited by availability of streamflow data. No trends were evident for Chico and Burley Creeks, however, available data did not support an intensive analysis. A declining trend was suggested for Big Beef Creek, however the ten-year period of record is not of sufficient length to decipher long-term trends. Relatively stable streamflow trends were suggested for both Dogfish and Gold Creeks, and a more sophisticated analysis is recommended to determine if a decline in runoff efficiency (ratio of annual streamflow to precipitation) has occurred.

Several different techniques were used to assess trends in minimum streamflows (summer low-flows). The minimum flow analyses were limited by the quantity and quality of available data. Long-term minimum flow trends were not evident for Dogfish and Burley Creeks. The Burley Creek data suggests a possible discrepancy between the USGS and KPUD rating curves which should be investigated. Minimum flows on Big Beef Creek showed a slight decline, and minimum flows on Gold Creek showed significant decline. Minimum flows at Chico Creek showed potential indications of decline which warrant further attention.

Short-term assessment of recent (post-1990) minimum flow trends showed stable trends at Chico and Clear Creeks, slightly declining trend on Burley Creek, and a declining trend on Barker Creek. Variability of summer low flows obscure any short-term trends on Dogfish and Gorst Creeks. Short-term trends should not be interpreted as indications of long-term trends, especially since stretches of low precipitation appear to occur during the period of record. Short-term trends indicate the need for additional streamflow monitoring and future assessment of longer trends.

Comparison of regulatory instream flow requirements and historic flow exceedence probability curves for Big Beef Creek and Tahuya River showed that current instream flow requirements were not satisfied to varying degrees throughout the year either recently or historically (before the requirements were enacted). Comparisons between recent (post-1990) hydrographs and instream flow requirements on Gorst Creek showed that the requirements were not met during much of the year throughout this (short) period of record.


KITSAP COUNTY
WASHINGTON
Rivers and Streams
Exhibit 4-1
Legend:
Stream monitoring site.
Sub-area boundaries
Rivers and Streams
#000 Chapter 173-515 W.A.C. Instream Resources Protection Program - Kitsap Water Resource Inventory Area (WRIA) 15
Stream Numbers correlate with Plate 1, Instream Resources Protection Program
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
SINCLAIR INLET
PORT ORCHARD BAY
COLVOS PASSAGE
Hansville Creek #166
Little Boston #164
Gamble Creek #158
Grovers Creek #192
Dogfish Creek #207
Clear Creek #226
Strawberry Creek #248
Barker Creek #245
Steel Creek #223
Mosher Creek #241
Anderson Creek #124
Big Beef Creek #121
Seabeck Creek #117
Stavis Creek #112
Chico Creek #259
Dickerson Creek #259
Anderson Creek #96
Dewatto River #70
Tahuya River #44
Union River #7
Gorst Creek #268
Anderson Creek #272
Blackjack Creek #279
Salmonberry Creek #284
Curley Creek #294
Coulter Creek #425
Burley Creek #356
Purdy Creek #354
Olalla Creek #313
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
02/13/97.11:05:48.Thu
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 4-1


KITSAP COUNTY
WASHINGTON
Stream Monitoring Sites
Exhibit 4-2
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
Legend:
Stream monitoring site.
Rivers and streams
Sub-area Boundaries
Streams closed to surface water use. (W.A.C. 173-515-030)
Streams with a partial closure to surface water use. (W.A.C. 173-515-030)
Numbered and labeled streams have minimum instream flows set.
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
PASSAGE
Grovers Creek
#192
Strawberry Creek
#248
Steel Creek
#223
Anderson Creek
#124
#121
Big Beef Creek
Stavis Creek
#112
Chico Creek
#259
Dickerson Creek
#259
Anderson Creek
#96
Dewatto River
#70
Tahuya River
#44
Union River
#77
Gorst Creek
#268
Curley Creek
#294
Coulter Creek
#425
Purdy Creek
#354
Olalla Creek
#313
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Washington State Department of Ecology:
Title 173 W.A.C. page 934
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/30/97.16:40:59.Thu
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 4-2

STREAM NO.	NAME	CLOSURE PERIOD	MISF PERIOD	MISF GAGING STATION	DATE	SUBAREA	TRIBUTARY TO	COUNTY
7	UNION RIVER	ALL YEAR	NONE	YES		UNION	LYNCH COVE	KITSAP, MASON[1]
12	MISSION CREEK	ALL YEAR	NONE	NO	12/5/51	UNION	HOOD CANAL	KITSAP, MASON
44	TAHUYA RIVER	6/15 - 10/15	10/16-6/14	YES		TAHUYA	LYNCH COVE	KITSAP, MASON[1]
70	DEWATTO RIVER	6/15 - 10/31	11/1-6/14	YES		DEWATTO	HOOD CANAL	KITSAP, MASON[1]
96	ANDERSON CREEK	NONE	ALL YEAR	NO		ANDERSON	ANDERSON COVE	KITSAP
101	HARDING CREEK	ALL YEAR	NONE	NO		ANDERSON	HOOD CANAL	KITSAP
113	STAVIS CREEK	NONE	ALL YEAR	YES		STAVIS	STAVIS BAY	KITSAP
117	SEABECK CREEK	ALL YEAR	NONE	NO	8/27/54	SEABECK	SEABECK BAY	KITSAP
121	BIG BEEF CREEK	5/15 - 10/31	11/1-5/14	YES		SEABECK	HOOD CANAL	KITSAP
124	ANDERSON CREEK	6/1 - 10/31	11/1-5/31	NO		SEABECK	HOOD CANAL	KITSAP
158	GAMBLE CREEK	ALL YEAR	NONE	NO	8/15/75	PORT GAMBLE	PORT GAMBLE	KITSAP
164	LITTLE BOSTON	ALL YEAR	NONE	NO		HANSVILLE	PORT GAMBLE	KITSAP
181	UNNAMED STREAM	ALL YEAR	NONE	NO		KINGSTON	APPLE TREE COVE	KITSAP
184	UNNAMED STREAM	ALL YEAR	NONE	NO		KINGSTON	APPLE TREE COVE	KITSAP
190	UNNAMED STREAM	ALL YEAR	NONE	NO		KINGSTON	PUGET SOUND	KITSAP
192	GROVER'S CREEK	6/1 - 10/15	10/16-5/31	NO		KINGSTON	MILLER BAY	KITSAP
196	COWLING CREEK	ALL YEAR	NONE	NO		KINGSTON	MILLER BAY	KITSAP
198	THOMPSON CREEK	ALL YEAR	NONE	NO		KINGSTON	PORT ORCHARD	KITSAP
207	DOGFISH CREEK	ALL YEAR	NONE	NO	8/21/75	POULSBO	LIBERTY BAY	KITSAP
208	JOHNSON CREEK	ALL YEAR	NONE	NO		POULSBO	LIBERTY BAY	KITSAP
213	SCANDIA CREEK	ALL YEAR	NONE	NO		BANGOR	LIBERTY BAY	KITSAP
223	STEELE CREEK	6/1 - 10/15	10/16-5/31	NO		MANETTE	PORT ORCHARD	KITSAP
241	MOSHER CREEK	ALL YEAR	NONE	NO		MANETTE	DYES INLET	KITSAP
245	BARKER CREEK	ALL YEAR	NONE	NO	2/21/61	BANGOR	DYES INLET	KITSAP
246	CLEAR CREEK	ALL YEAR	NONE	NO	7/27/53	BANGOR	DYES INLET	KITSAP
248	STRAWBERRY CREEK	6/1 - 10/31	11/1-5/31	NO		BANGOR	DYES INLET	KITSAP
259	CHICO CREEK	ALL YEAR	NONE	NO	11/3/52	CHICO	CHICO BAY	KITSAP
259	DICKERSON CREEK	ALL YEAR	NONE	NO		CHICO	CHICO BAY	KITSAP
259	KITSAP CREEK	ALL YEAR	NONE	NO	7/2/42	CHICO	CHICO CREEK	KITSAP
259	UNNAMED STREAM	ALL YEAR	NONE	NO	12/8/52	CHICO	KITSAP LAKE	KITSAP
268	GORST CREEK	NONE	ALL YEAR	NO		GORST	SINCALIR INLET	KITSAP
272	ANDERSON CREEK	ALL YEAR	NONE	NO		GORST	SINCLAIR INLET	KITSAP
275	ROSS CREEK	ALL YEAR	NONE	NO		GORST	SINCLAIR INLET	KITSAP
279	BLACKJACK CREEK	ALL YEAR	NONE	NO	4/5/60	MANCHESTER	SINCLAIR INLET	KITSAP
285	SULLIVAN CREEK	ALL YEAR	NONE	NO	5/9/75	MANCHESTER	SINCLAIR INLET	KITSAP
289	BEAVER CREEK	ALL YEAR	NONE	NO		MANCHESTER	RICH PASSAGE	KITSAP
294	CURLEY CREEK	6/15 - 10/15	10/16-6/14	NO		MANCHESTER	PORT ORCHARD	KITSAP
294	SALMONBERRY CREEK	ALL YEAR	NONE	NO	1/7/48	MANCHESTER	LONG LAKE	KITSAP
313	OLALLA CREEK	6/1 - 10/15	10/16-5/31	NO		OLALLA	COLVOS PASSAGE	KITSAP
354	PURDY CREEK	6/1 - 10/31	11/1-5/31	YES		OLALLA	HENDERSON BAY	KITSAP, PIERCE[1]
356	BURLEY CREEK	ALL YEAR	NONE	NO	5/10/51	OLALLA	BURLEY LAGOON	KITSAP
367	MINTER CREEK	ALL YEAR	NONE	NO	12/28/73	MCCORMICK	HENDERSON BAY	KITSAP, PIERCE
425	COULTER CREEK	NONE	ALL YEAR	NO		MCCORMICK	NORTH BAY	KITSAP, PIERCE[1]
434	UNNAMED STREAM	ALL YEAR	NONE	NO		BAINBRIDGE	MURDEN COVE	KITSAP
461	UNNAMED STREAM	ALL YEAR	NONE	NO		BAINBRIDGE	FLETCHER BAY	KITSAP
510	JUDD CREEK	ALL YEAR	NONE	NO	5/10/51	VASHON	QUARTERMASTER HARBOR	KING
514	FISHER CREEK	ALL YEAR	NONE	NO		VASHON	QUARTERMASTER HARBOR	KING
530	JOD CREEK	ALL YEAR	NONE	NO		VASHON	COLVOS PASSAGE	KING
540	NEEDLE CREEK	ALL YEAR	NONE	NO		VASHON	COLVOS PASSAGE	KING
	MISSION LAKE	ALL YEAR	OT APPLICABLE		7/19/78	UNION	MISSION CREEK	KITSAP

[1] Minimum Instream Flow control point is located in this county.

Notes:
Chapter 175-515 WAC; Plate I.

EXHIBIT 4-3

Minimum Instream Flow (MISF) Requirements and Stream Closures in Kitsap County

Kitsap County
Initial Basin Assessment

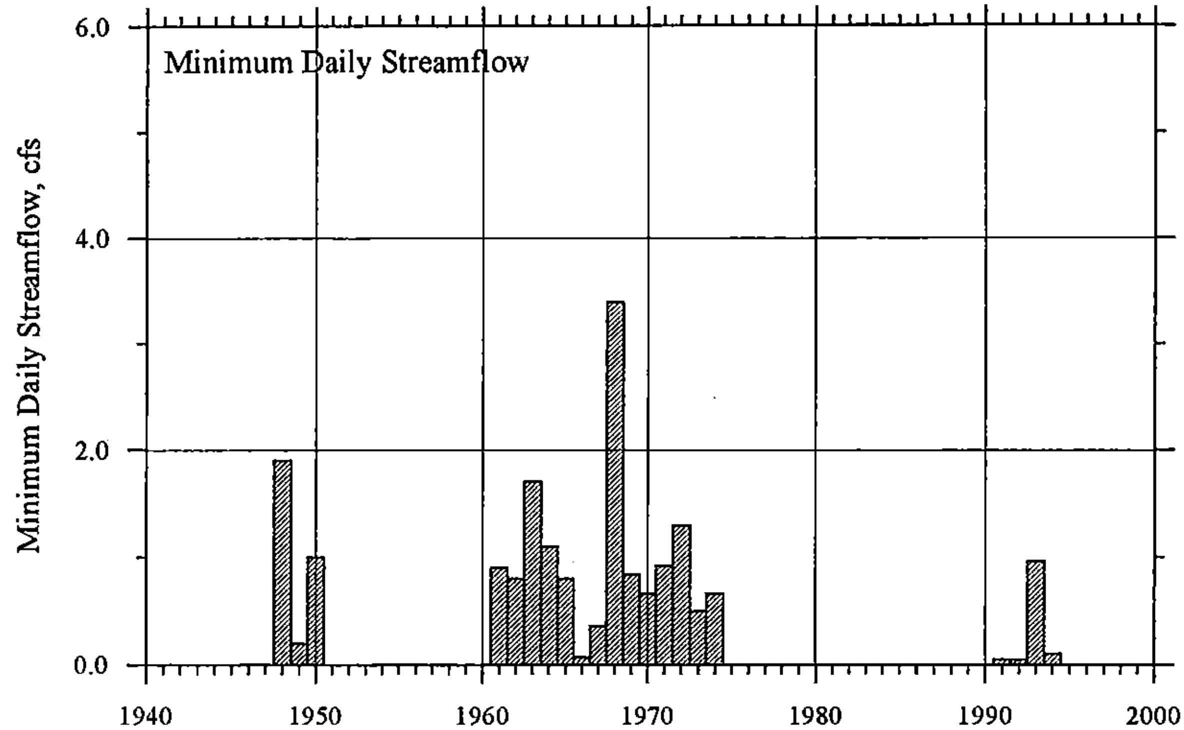
USGS STATION ID	STATION NAME	USGS RECORD	PUD RECORD	REGULATORY STATUS	COMMENTS
12063000	Union River near Bremerton	1945-59	N/A		
12063500	Union River near Belfair	1945-56	N/A	IRPP (inactive gage)	
12064500	Mission Creek near Bremerton	1945-53	N/A		
12065500	Gold Creek near Bremerton	1945-70	N/A		
12066000	Tahuya River near Bremerton	1945-56	N/A		
12067500	Tahuya River near Belfair	1945-56	N/A	IRPP (see comment)	gage is near specified IRPP gage
12067000	Panther Creek near Bremerton	1945-53	N/A		
12069550	Big Beef Creek near Seabeck (#121)	1969-present	N/A	IRPP (active gage)	gaging limited to summer flows since 1980.
12070000	Dogfish Creek near Poulsbo (#207)	1947-71	1990-Present		
12072000	Chico Creek near Bremerton (#259)	1947-74	1991-Present	IRPP (see comment)	gage is near specified IRPP control point
12072500	Blackjack Creek at Port Orchard (#279)	1947-50	1993-Present		
12073000	Burley Creek at Burley (#356)	1947-65	1990-Present		
12073500	Huge Creek near Wauna	1947-Present	N/A		
	Clear Creek (#246)	N/A	1992-Present		
	Barker Creek (#245)	N/A	1991-Present		
	Gorst Creek near Gorst (#268)	N/A	1990-Present	IRPP (see comment)	gage is near specified IRPP control point
	Anderson Creek near Holly (#096)	N/A	1/95-Present	IRPP (see comment)	gage is upstream of IRPP control point
	Anderson Creek near Bremerton (#272)	N/A	1/95-Present		
	Strawberry Creek (#248)	N/A	3/91-Present		
	Gamble Creek	N/A	1994-Present		Bangor study
	Johnson Creek	N/A	1994-Present		Bangor study

Note: IRPP (instream regulatory protection program) indicates that minimum instream flows are designated for that gage (or associated steam stretch) in WAC 173-515. Some streams (e.g. Gorst Creek) have IRPP requirements without designated IRPP monitoring gages.

EXHIBIT 4-4

Summary of Stream Gaging Stations in Kitsap County

Kitsap County
Initial Basin Assessment



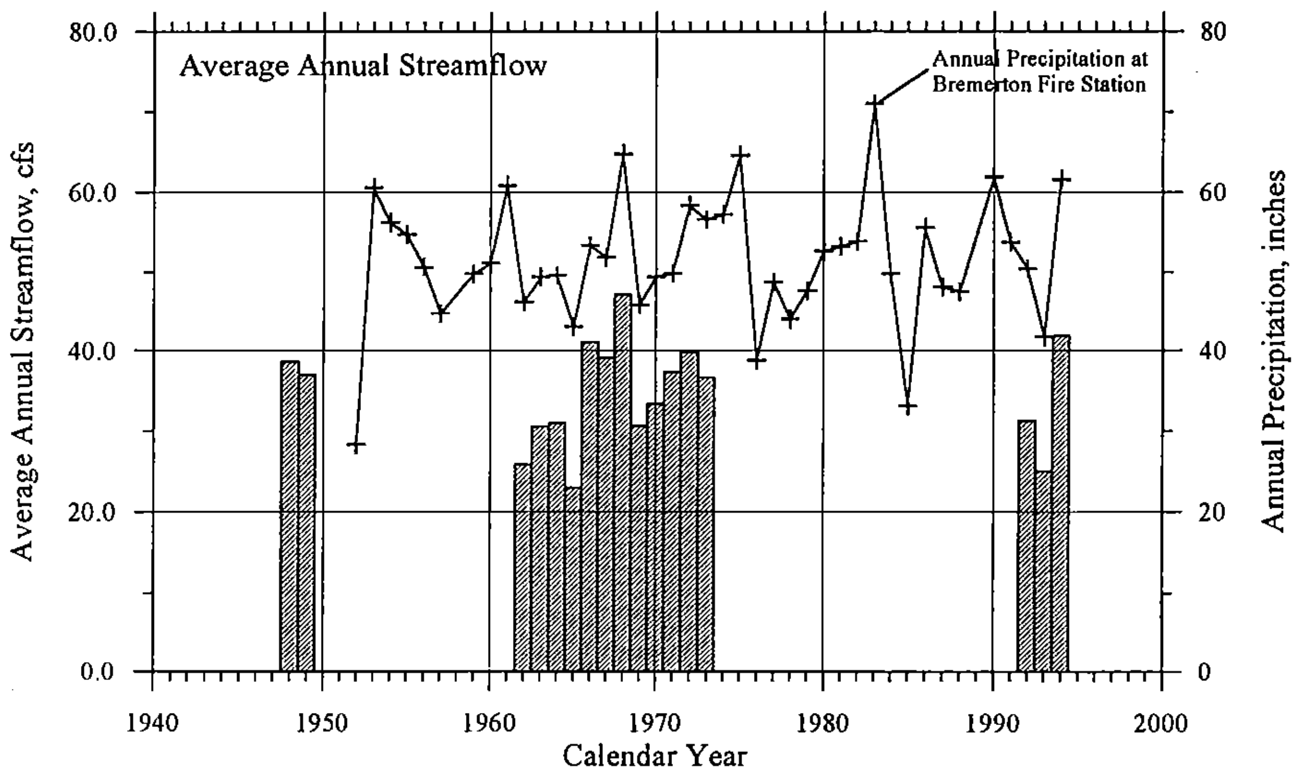
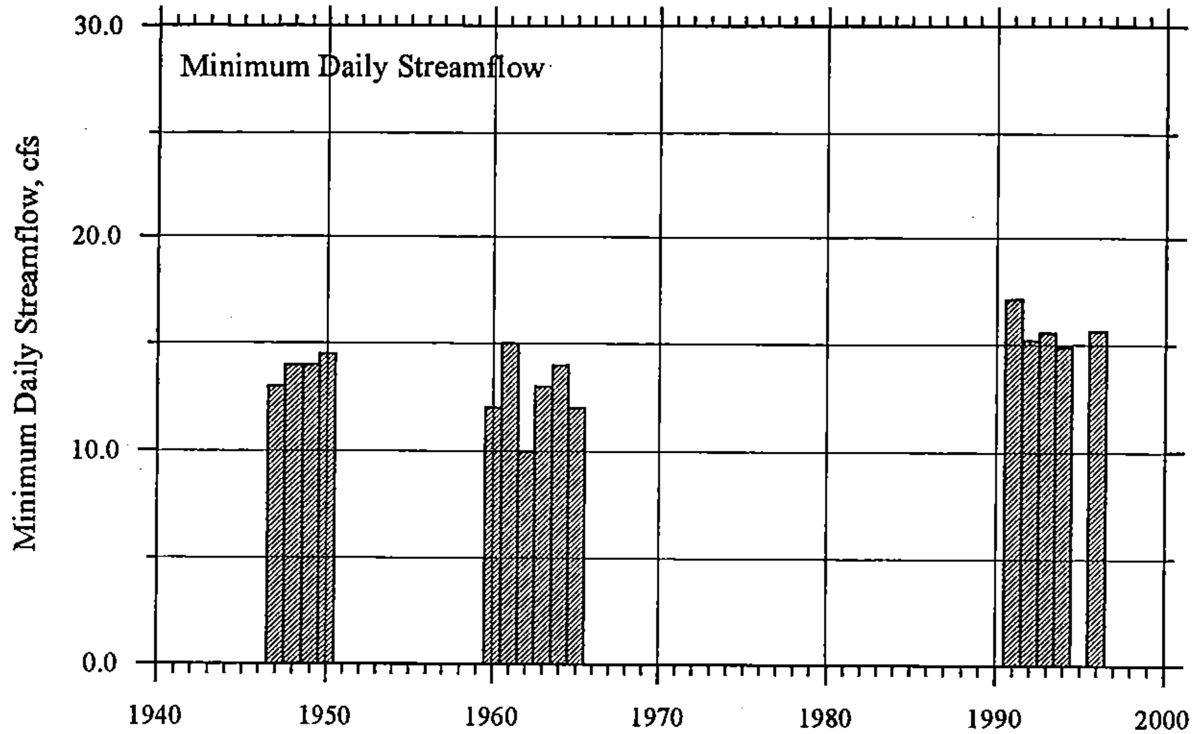


EXHIBIT 4-5

Average and Minimum Flow Trends
Chico Creek near Bremerton (#259)

Kitsap County
Initial Basin Assessment



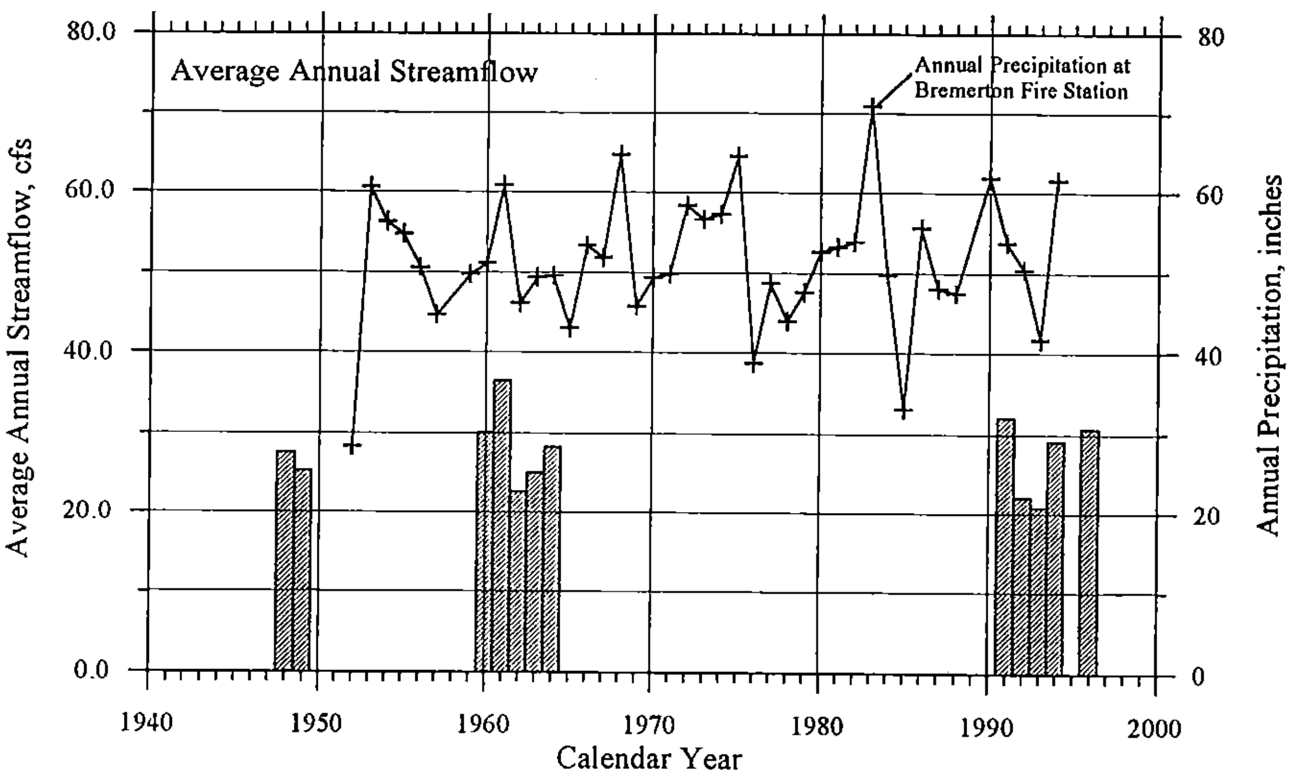
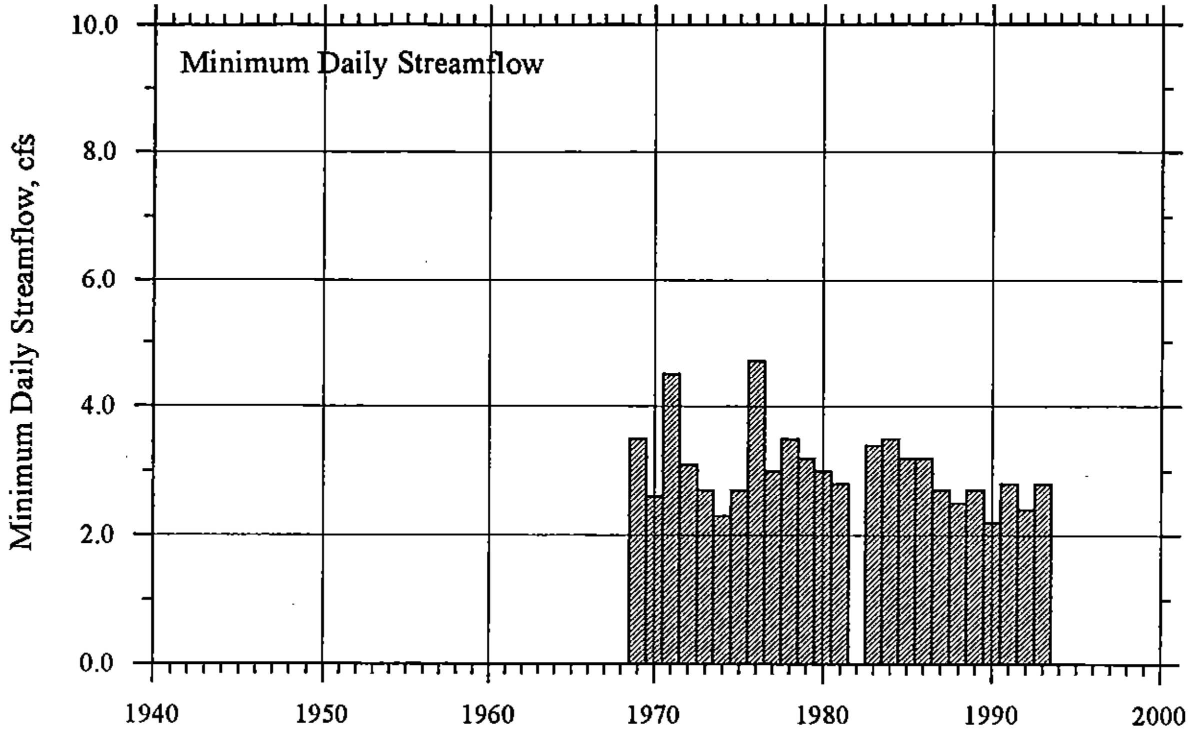


EXHIBIT 4-6

Average and Minimum Flow Trends
Burley Creek at Burley (#356)

Kitsap County
Initial Basin Assessment



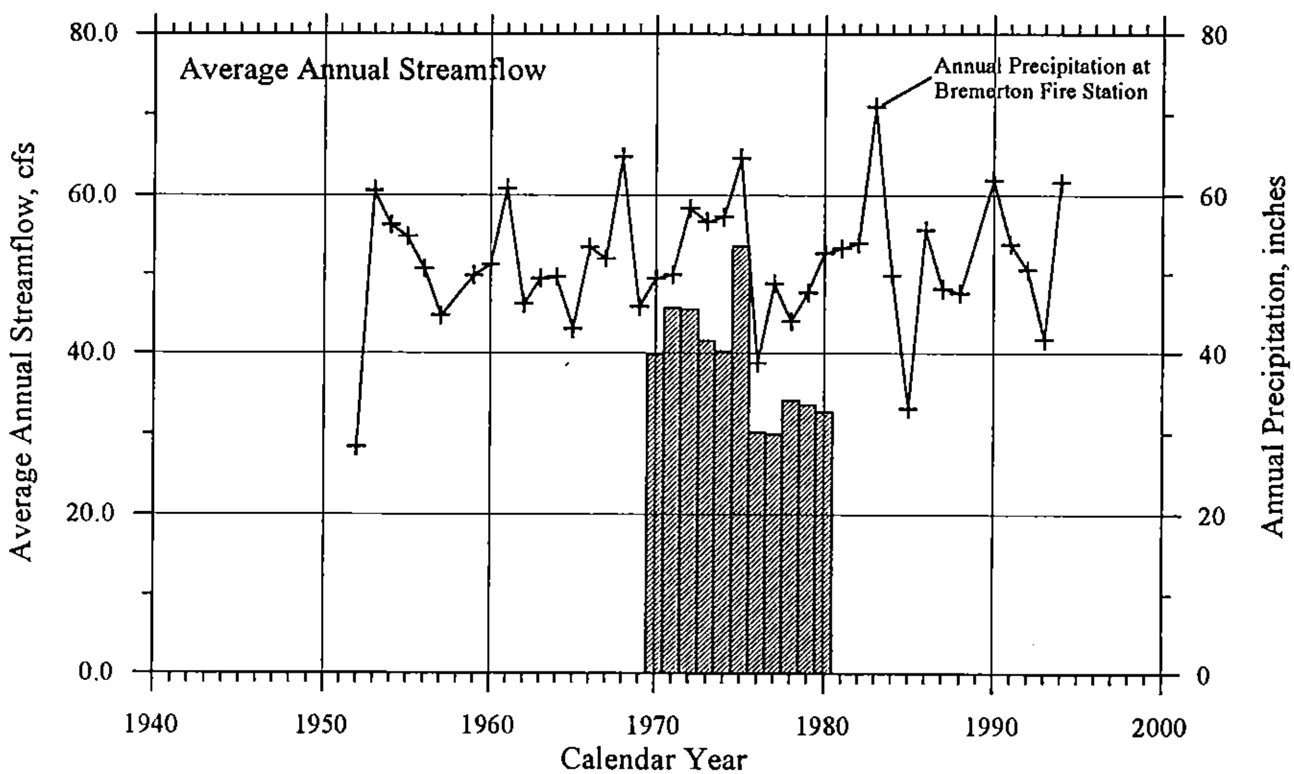


EXHIBIT 4-7

Average and Minimum Flow Trends
Big Beef Creek near Seabeck (#121)

Kitsap County
Initial Basin Assessment

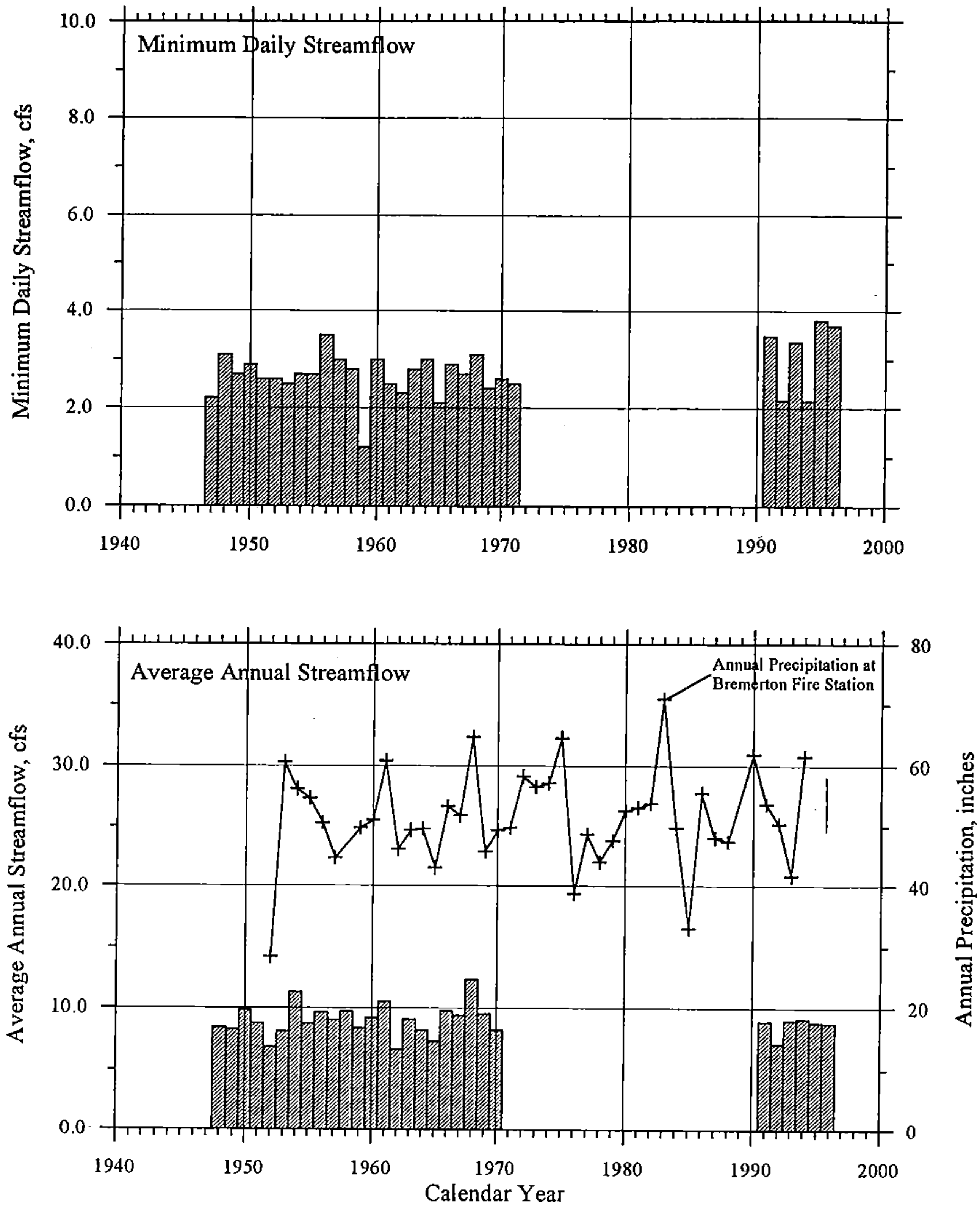
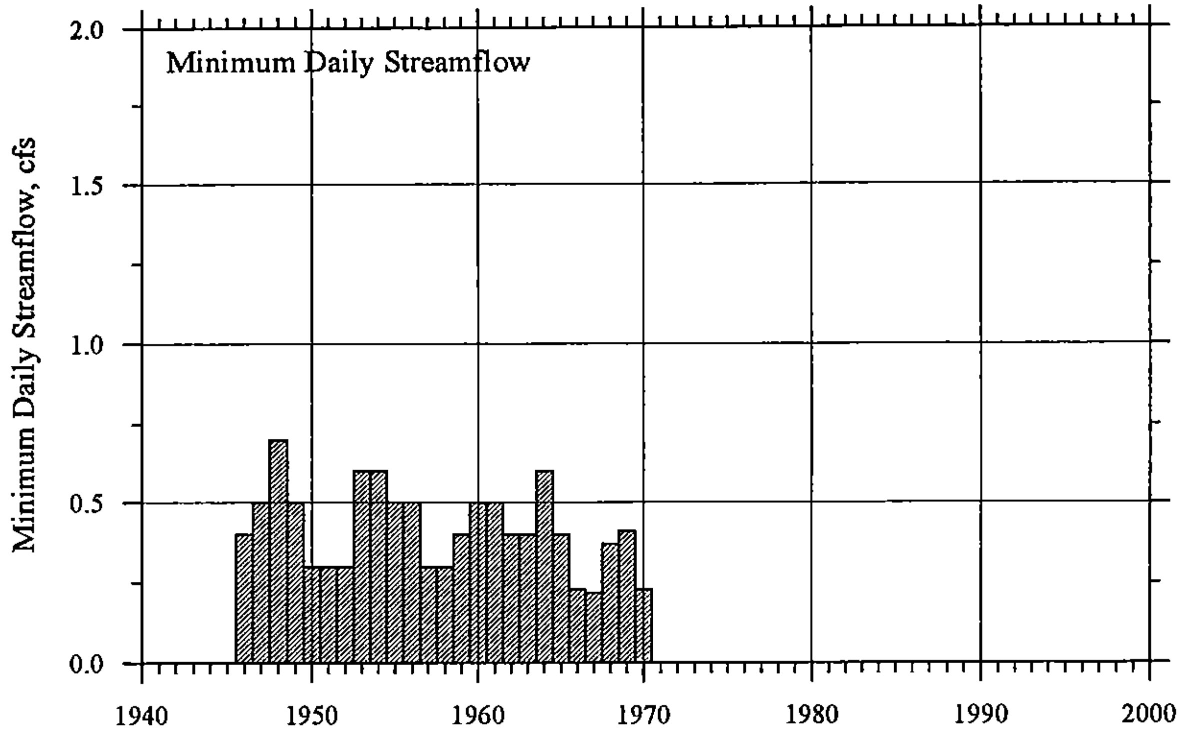


EXHIBIT 4-8

Average and Minimum Flow Trends Dogfish Creek near Poulsbo (#207)

Kitsap County
Initial Basin Assessment



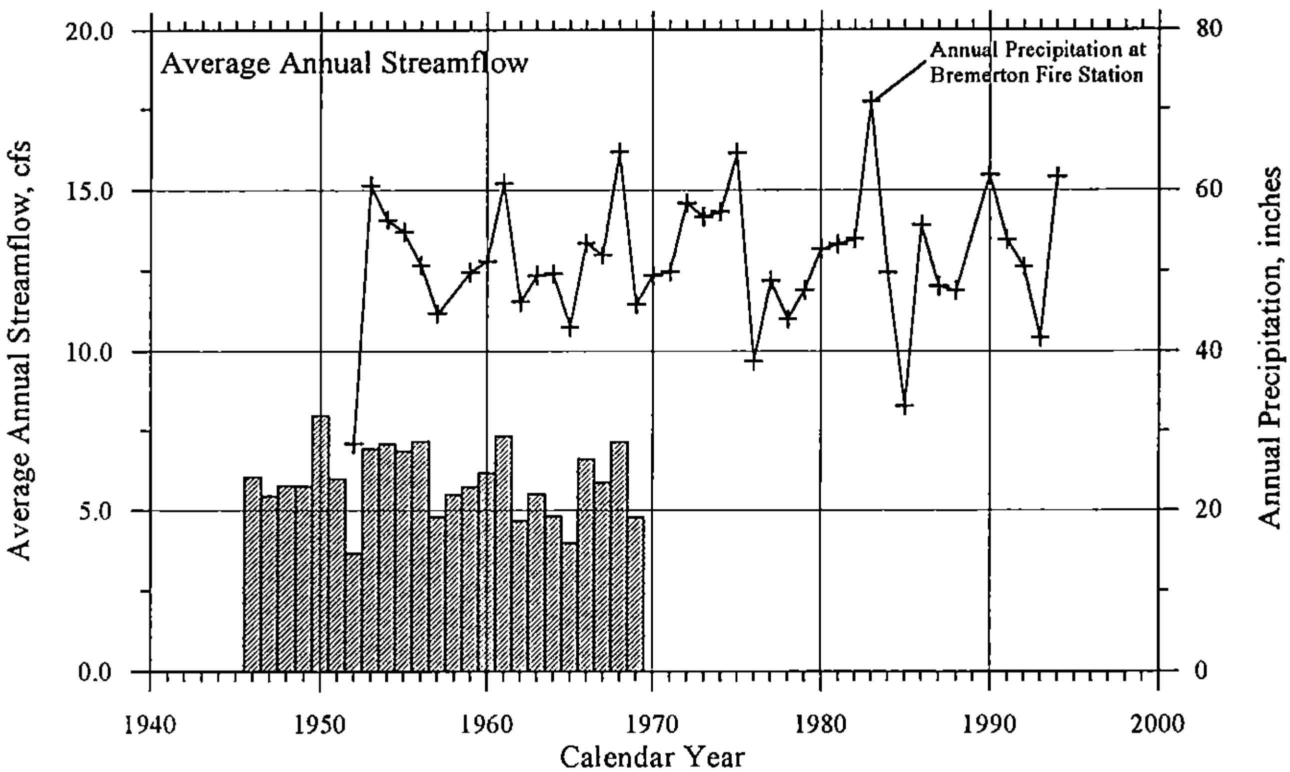


EXHIBIT 4-9

Average and Minimum Flow Trends
Gold Creek near Bremerton (#44)

Kitsap County
Initial Basin Assessment

Period of Record for Flow Exceedance Curves:
1947 - 1950
1961 - 1974
Period of Record for Recent Flow Hydrographs:
3/91 - 8/94

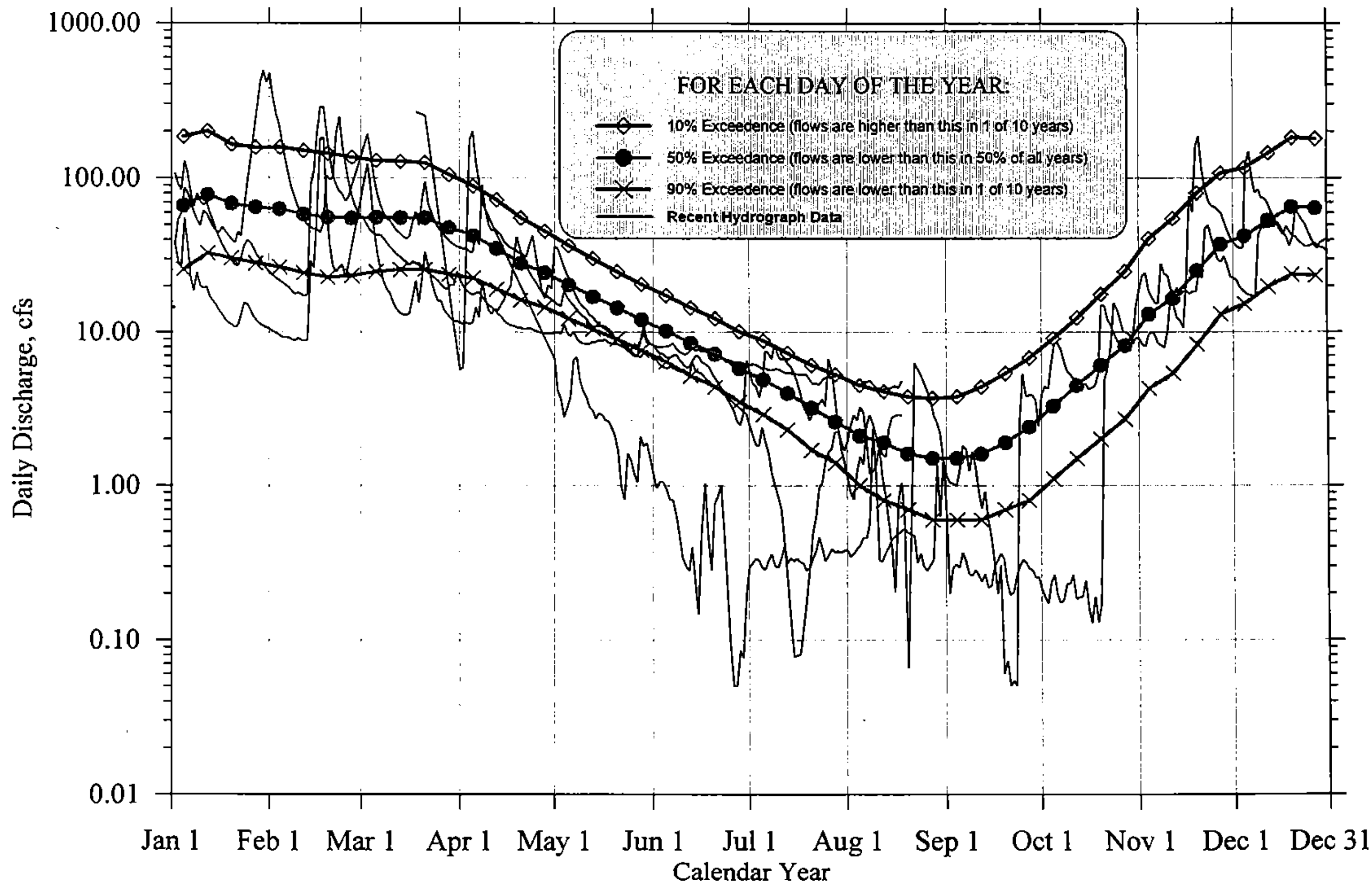


EXHIBIT 4-10
Flow Exceedence Probabilities and Recent Hydrographs
Chico Creek near Bremerton (#259)

Kitsap County
Initial Basin Assessment

Period of Record for Flow Exceedance Curves:
1947 - 1950
1960 - 1965
Period of Record for Recent Hydrographs:
10/90 - 9/94

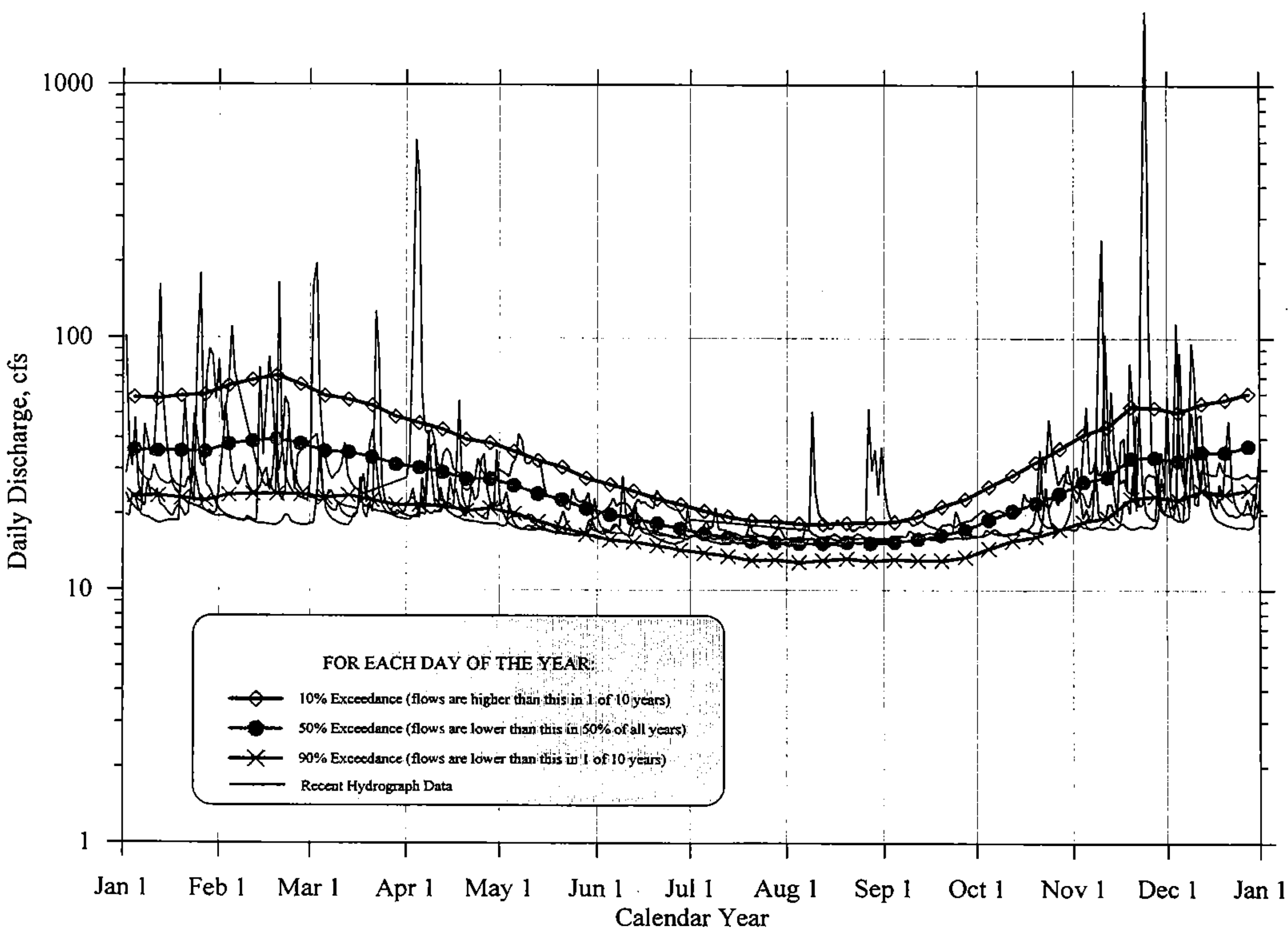


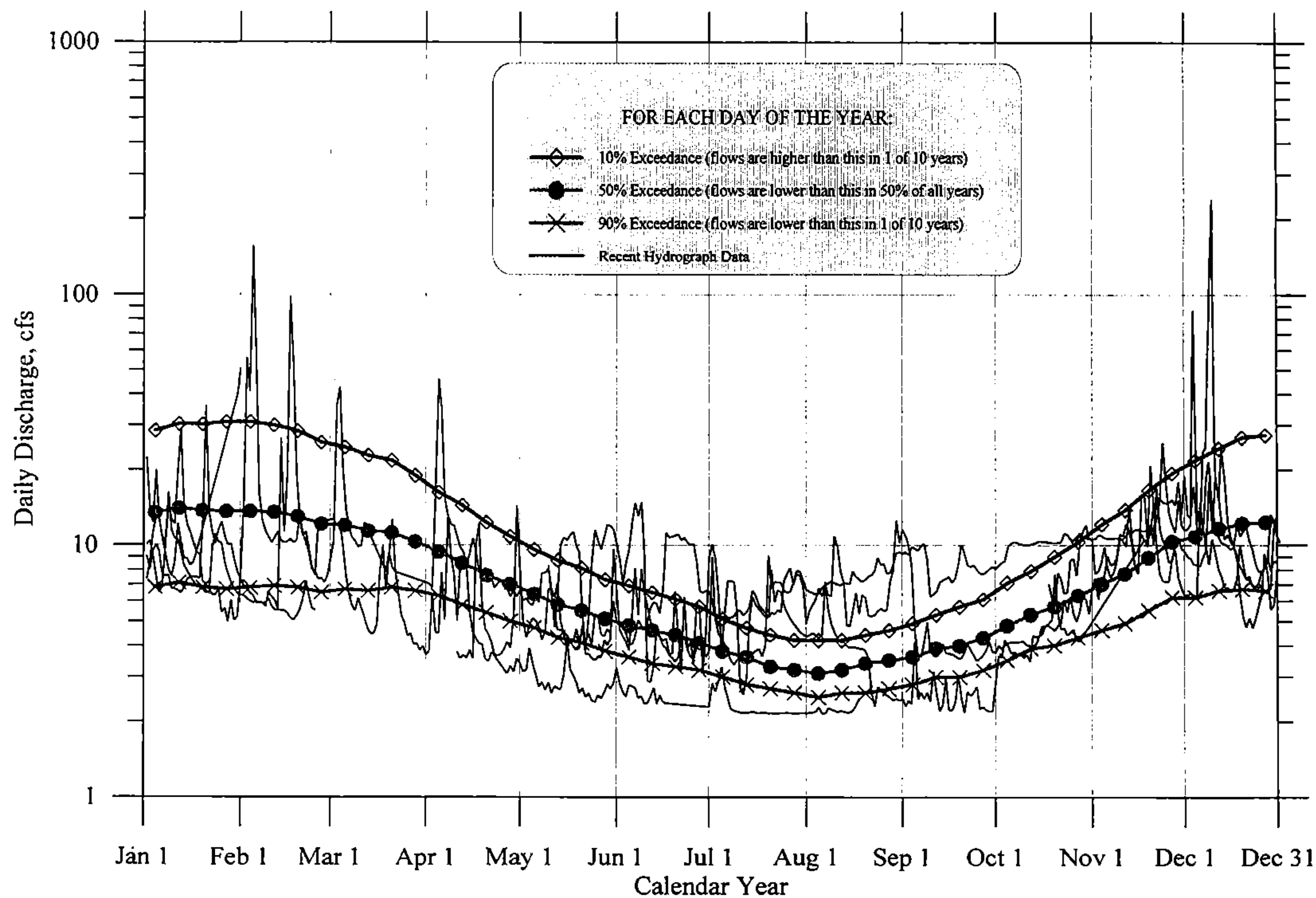
EXHIBIT 4-11
Flow Exceedance Probabilities and Recent Hydrographs
Burley Creek at Burley (#356)

Kitsap County
Initial Basin Assessment

Period of Record for Flow Exceedence Curves:
1947 - 1971
Period of Record for Hydrographs:
10/90 - 8/94

EXHIBIT 4-12
Flow Exceedence Probabilities and
Recent Hydrographs
Dogfish Creek near Poulsbo (#207)

Kitsap County
Initial Basin Assessment



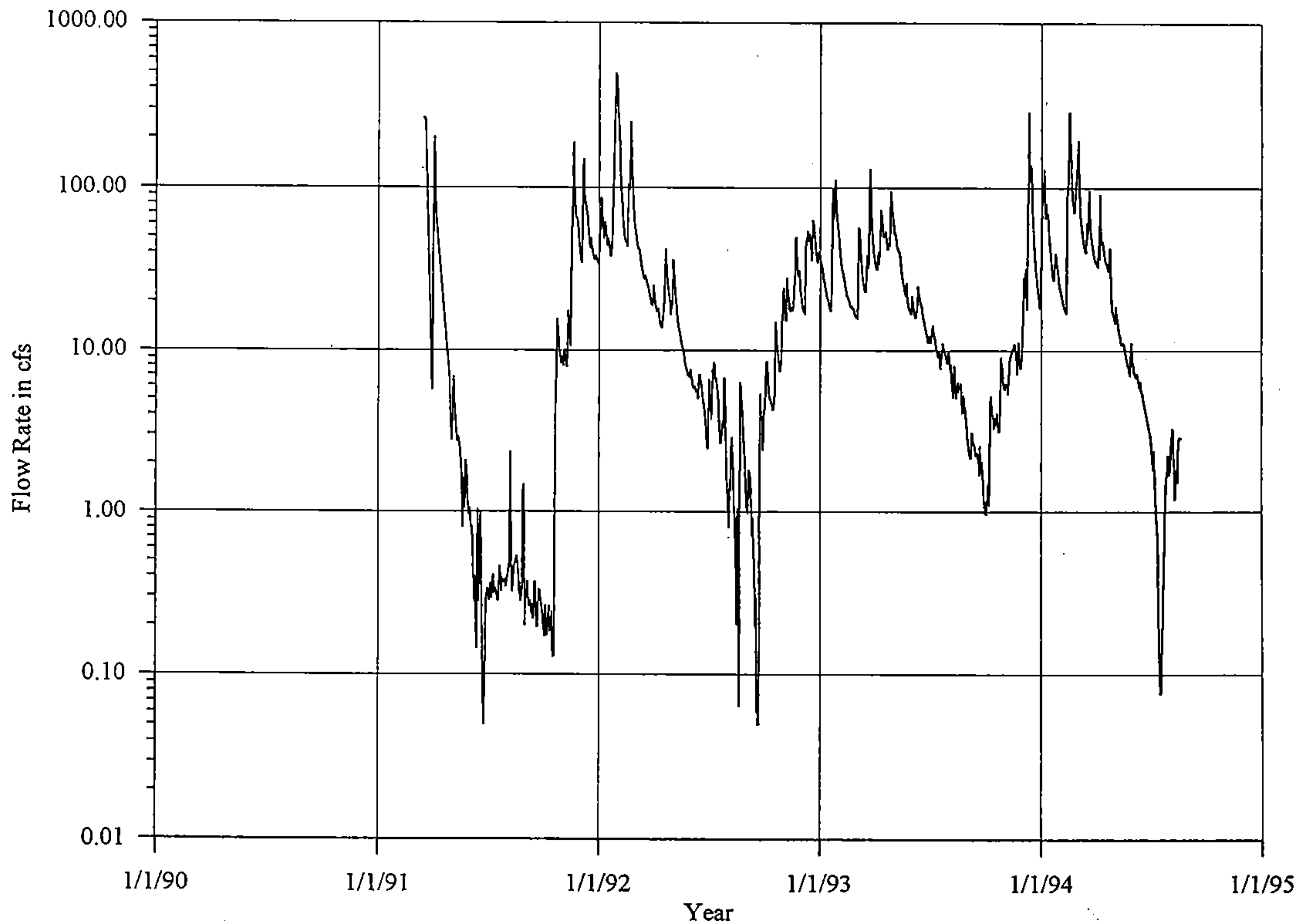


EXHIBIT 4-13
Streamflow Hydrograph
for Chico Creek (#259)

Kitsap County
Initial Basin Assessment

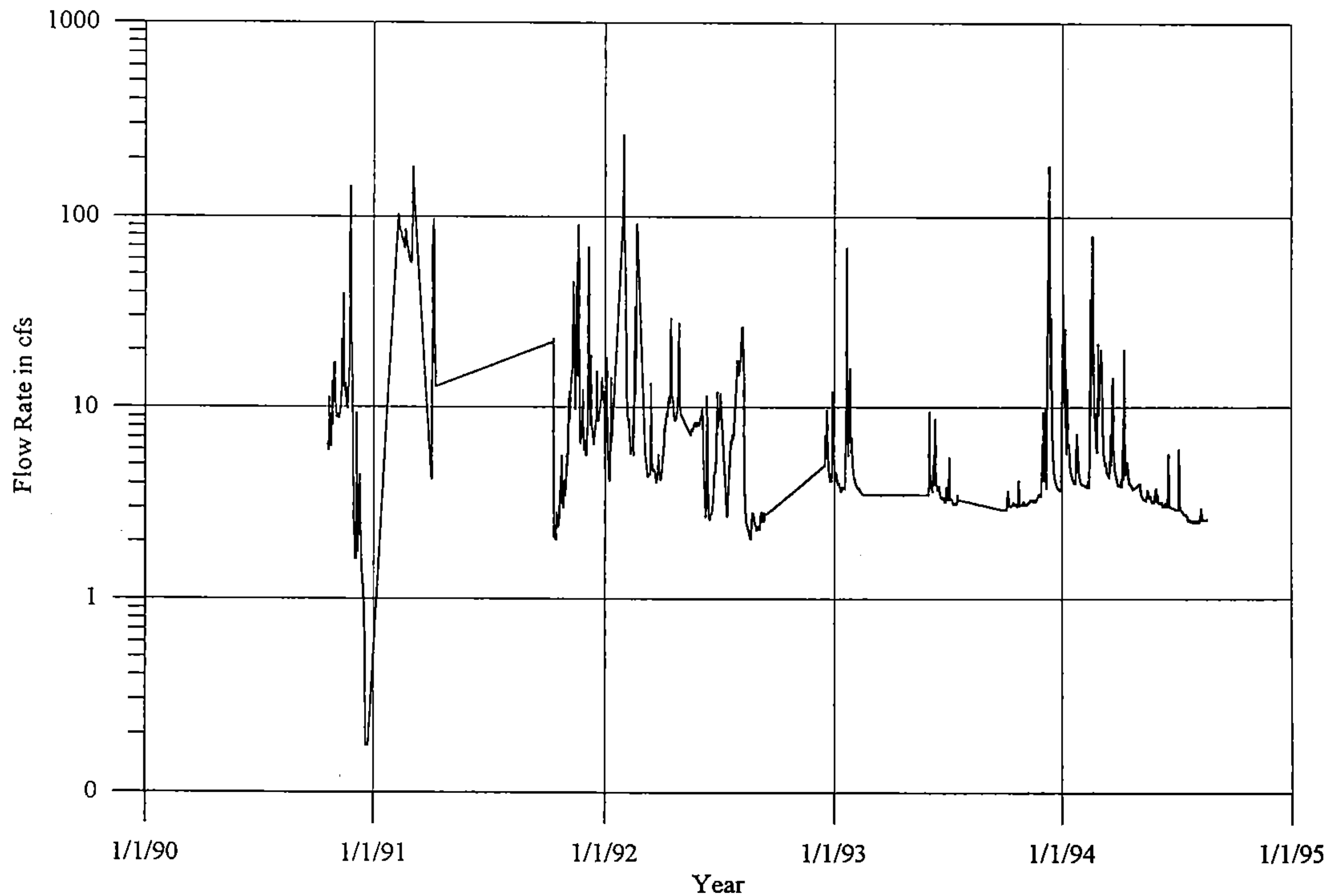
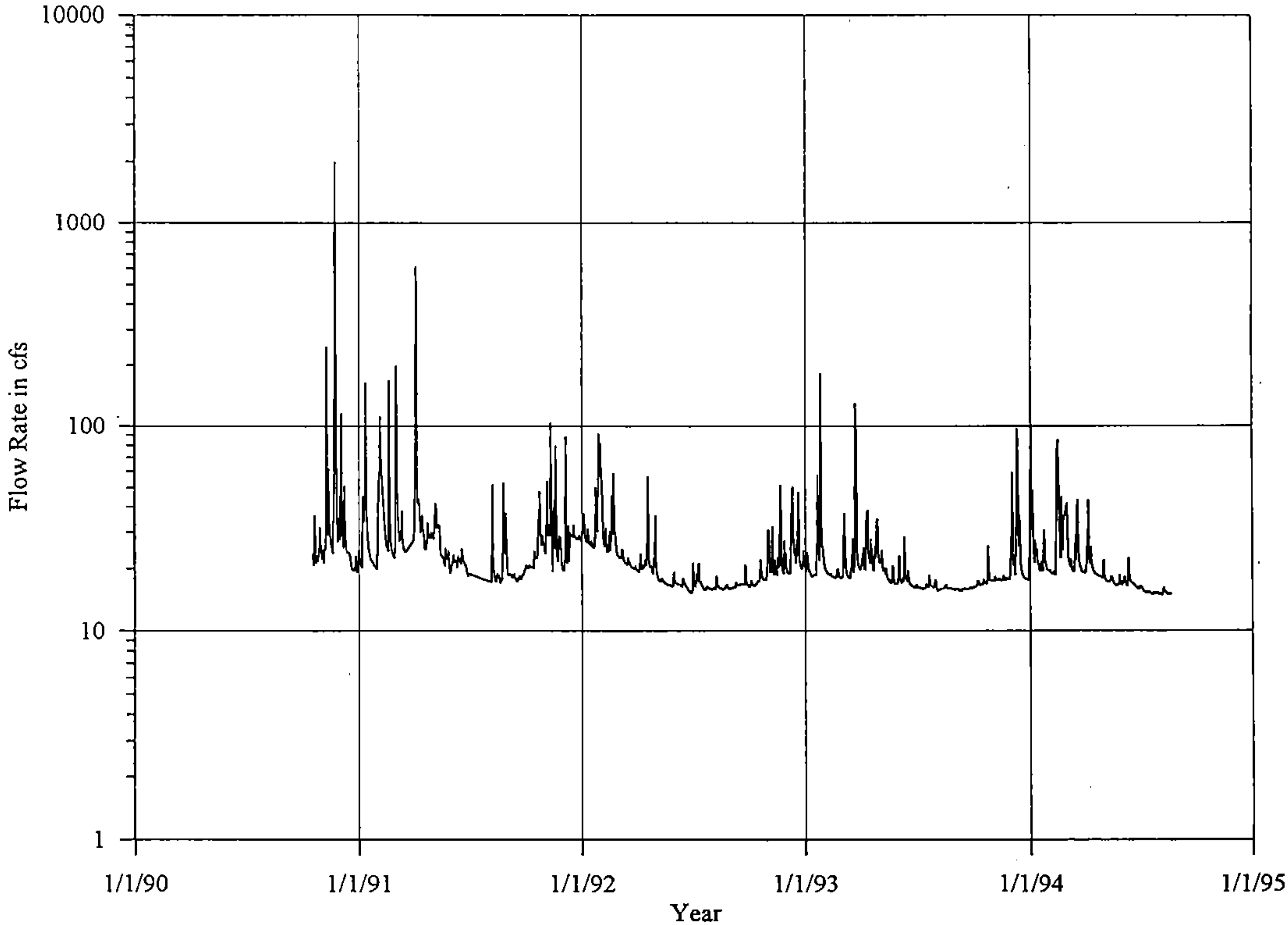


EXHIBIT 4-14
Streamflow Hydrograph
for Clear Creek (#246)

Kitsap County
Initial Basin Assessment

EXHIBIT 4-15
Streamflow Hydrograph
for Burley Creek (#356)

Kitsap County
Initial Basin Assessment



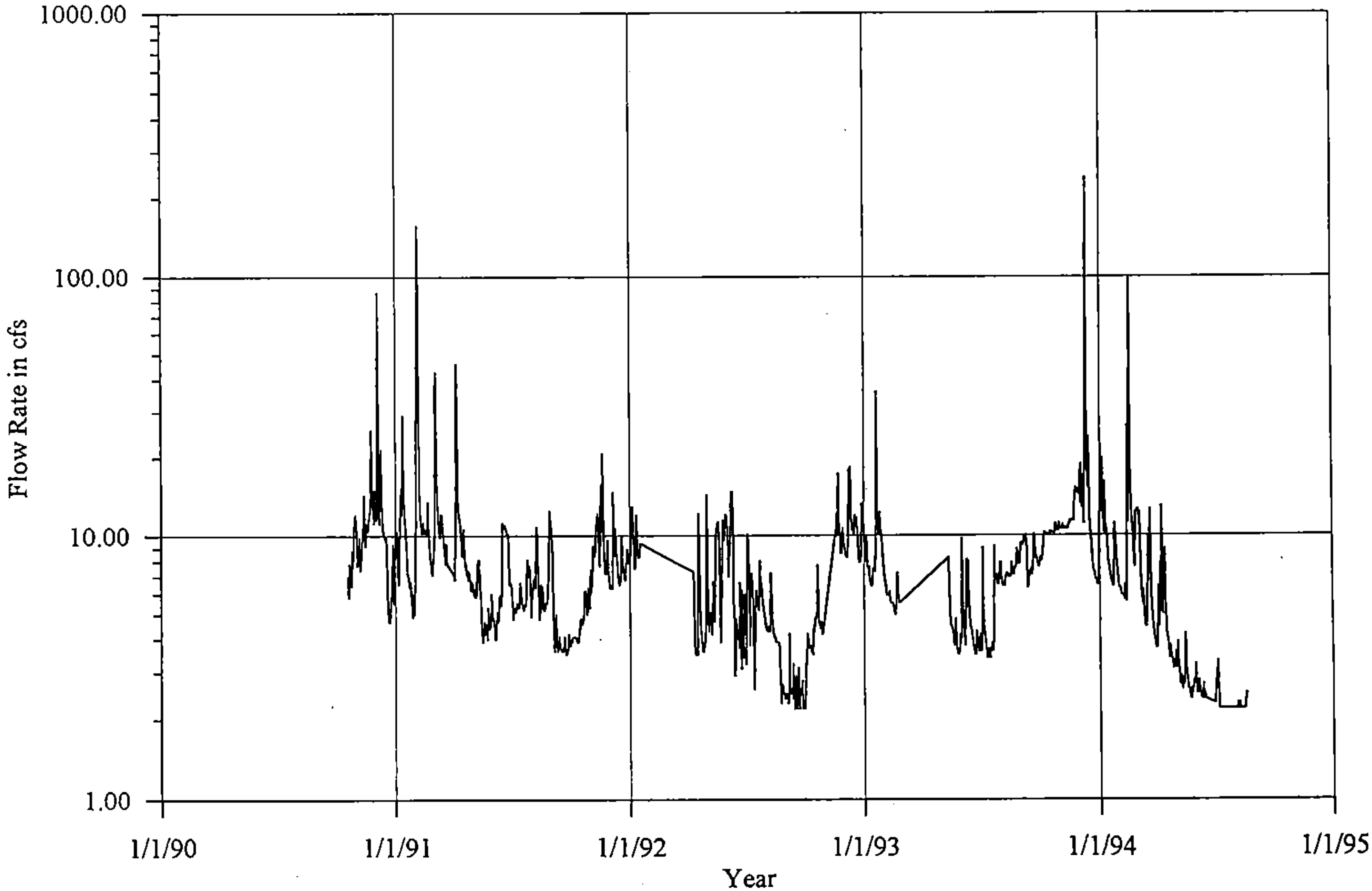
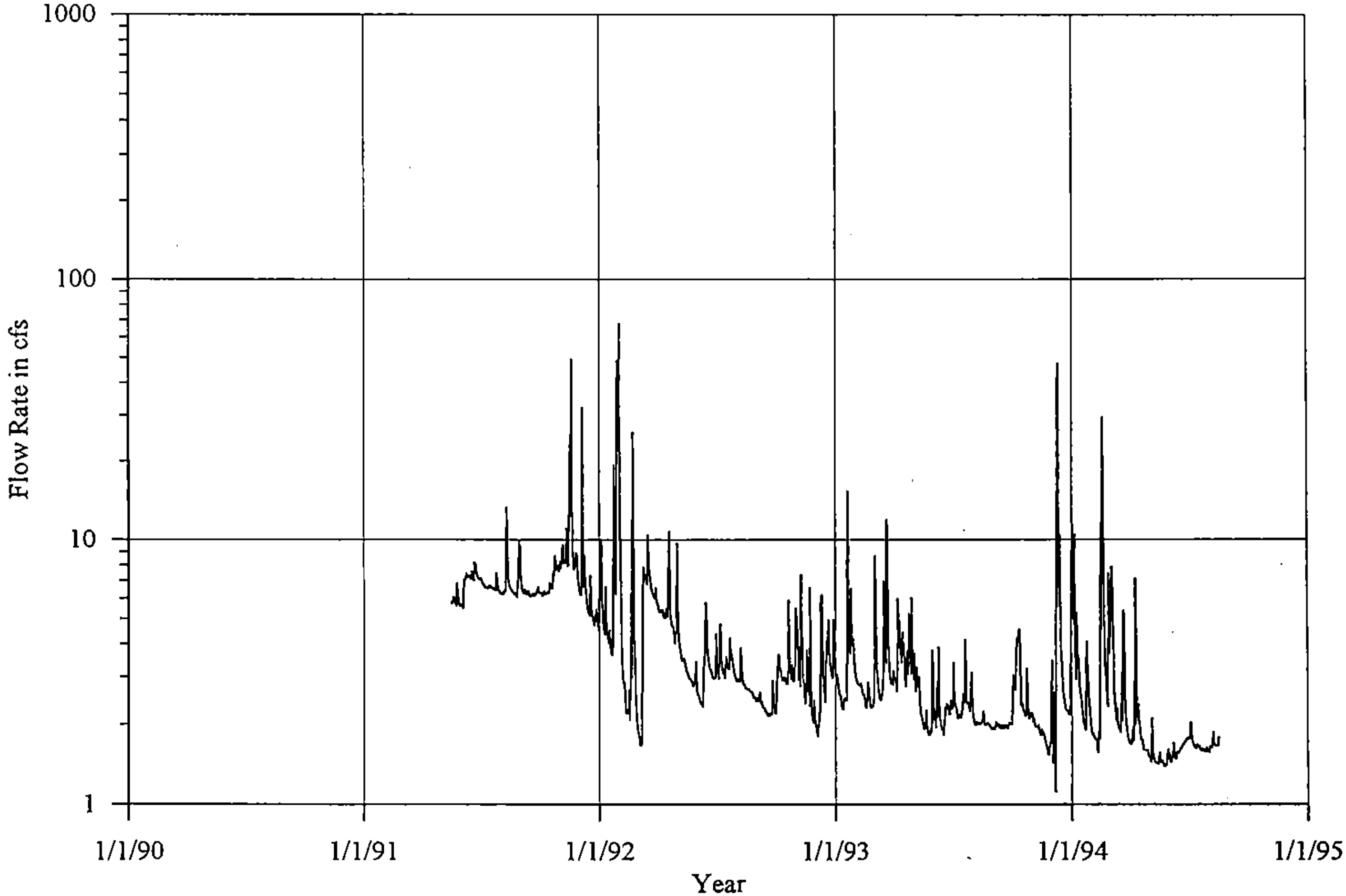


EXHIBIT 4-16
Streamflow Hydrograph
for Dogfish Creek (#207)

Kitsap County
Initial Basin Assessment

EXHIBIT 4-17
Streamflow Hydrograph
for Barker Creek (#245)

Kitsap County
Initial Basin Assessment



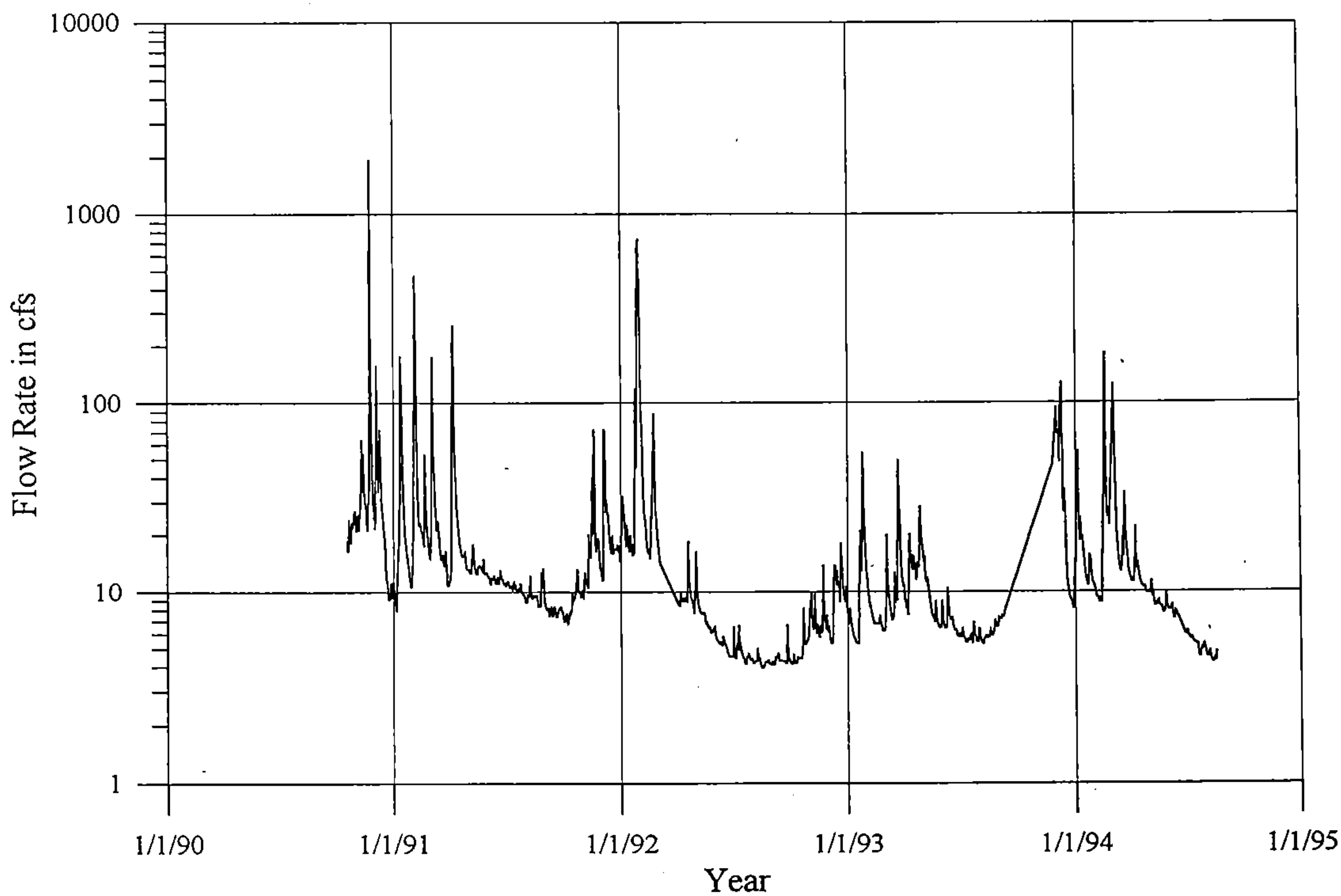


EXHIBIT 4-18
Streamflow Hydrograph
for Gorst Creek (#268)

Kitsap County
Initial Basin Assessment

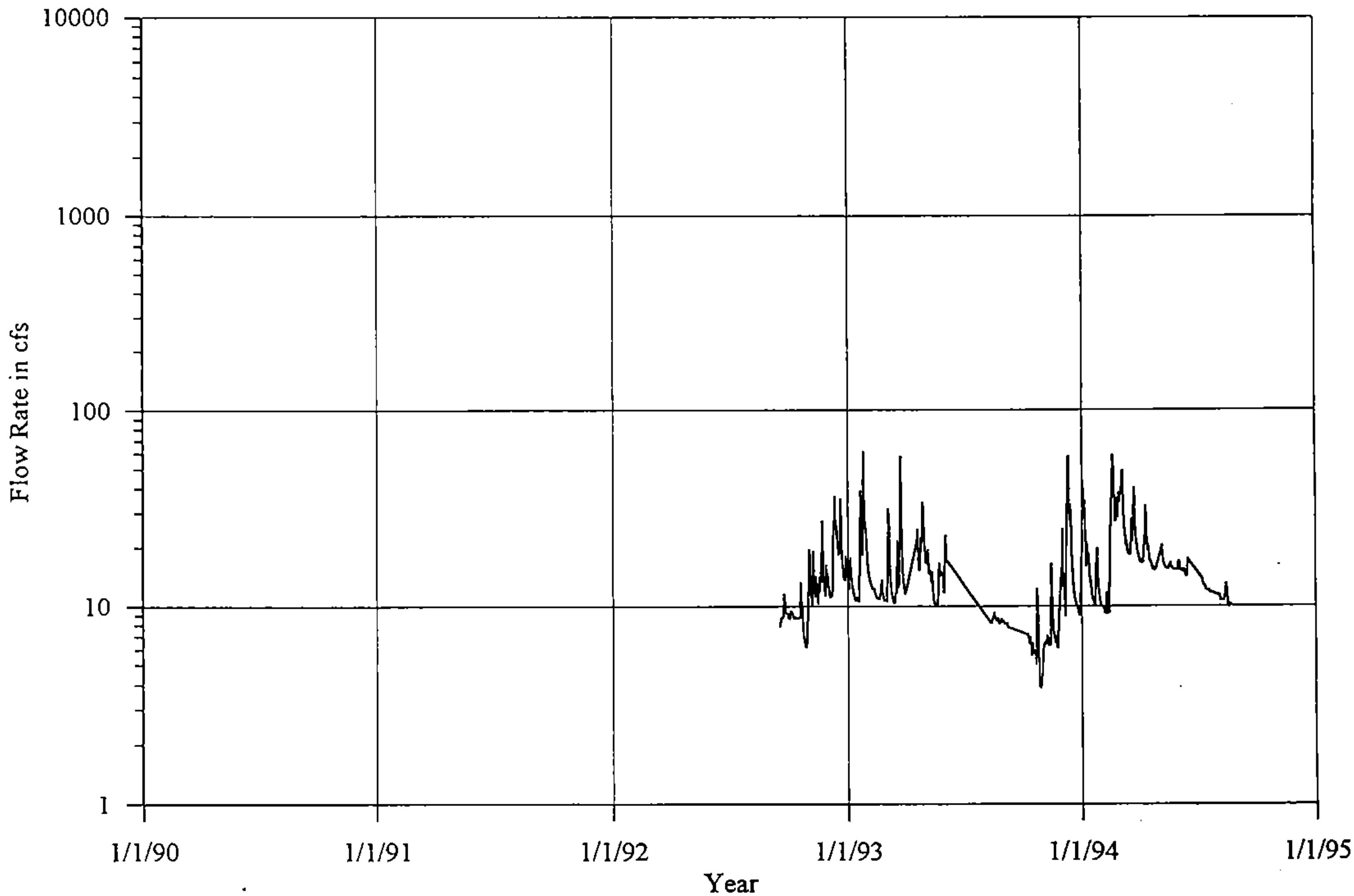


EXHIBIT 4-19
Streamflow Hydrograph
for Blackjack Creek (#279)

Kitsap County
Initial Basin Assessment

Period of Record:
1969 - 1992

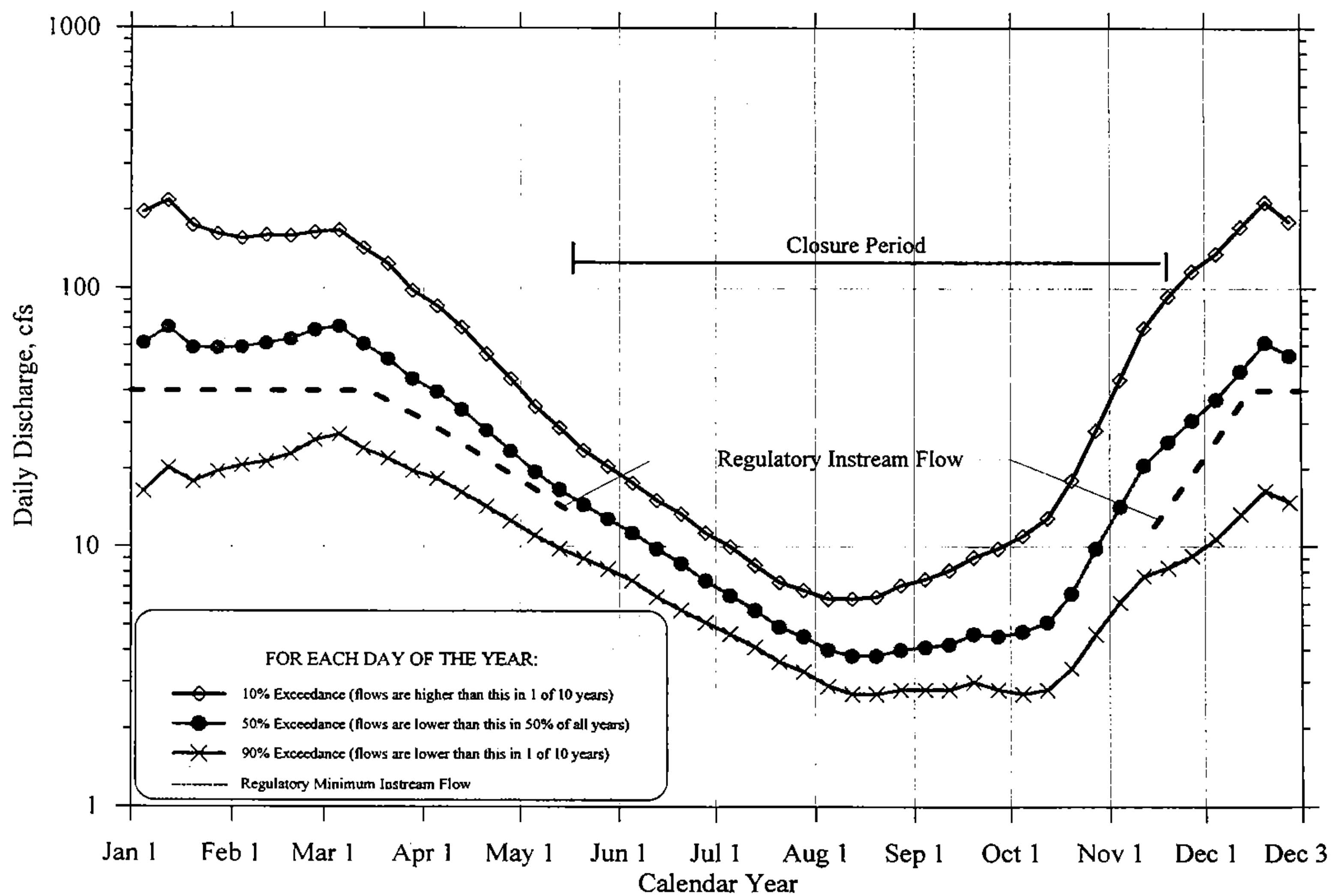
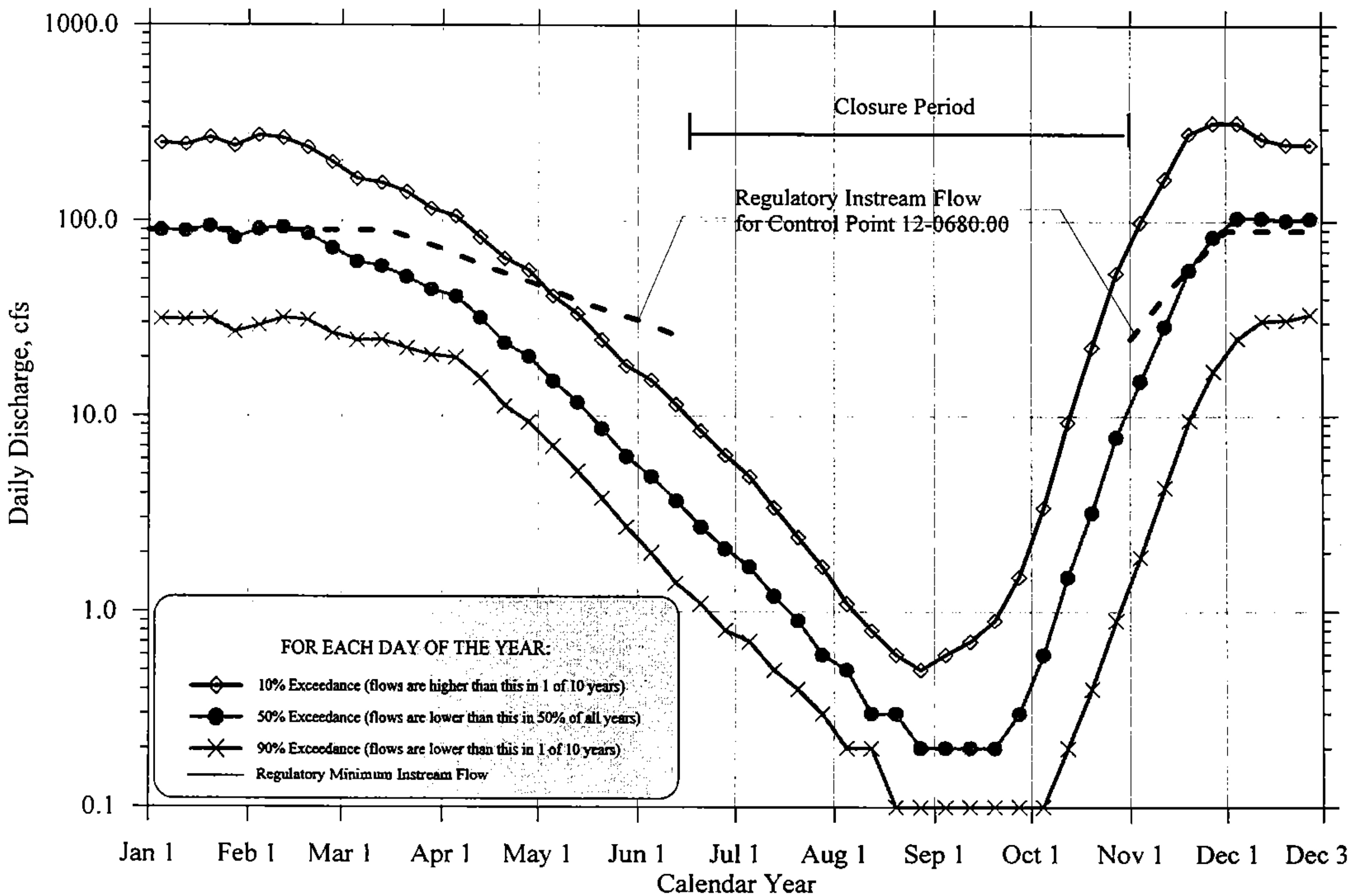


EXHIBIT 4-20
Instream Flows and
Flow Exceedence Probabilities
Big Beef Creek near Seabeck (#121)

Kitsap County
Initial Basin Assessment



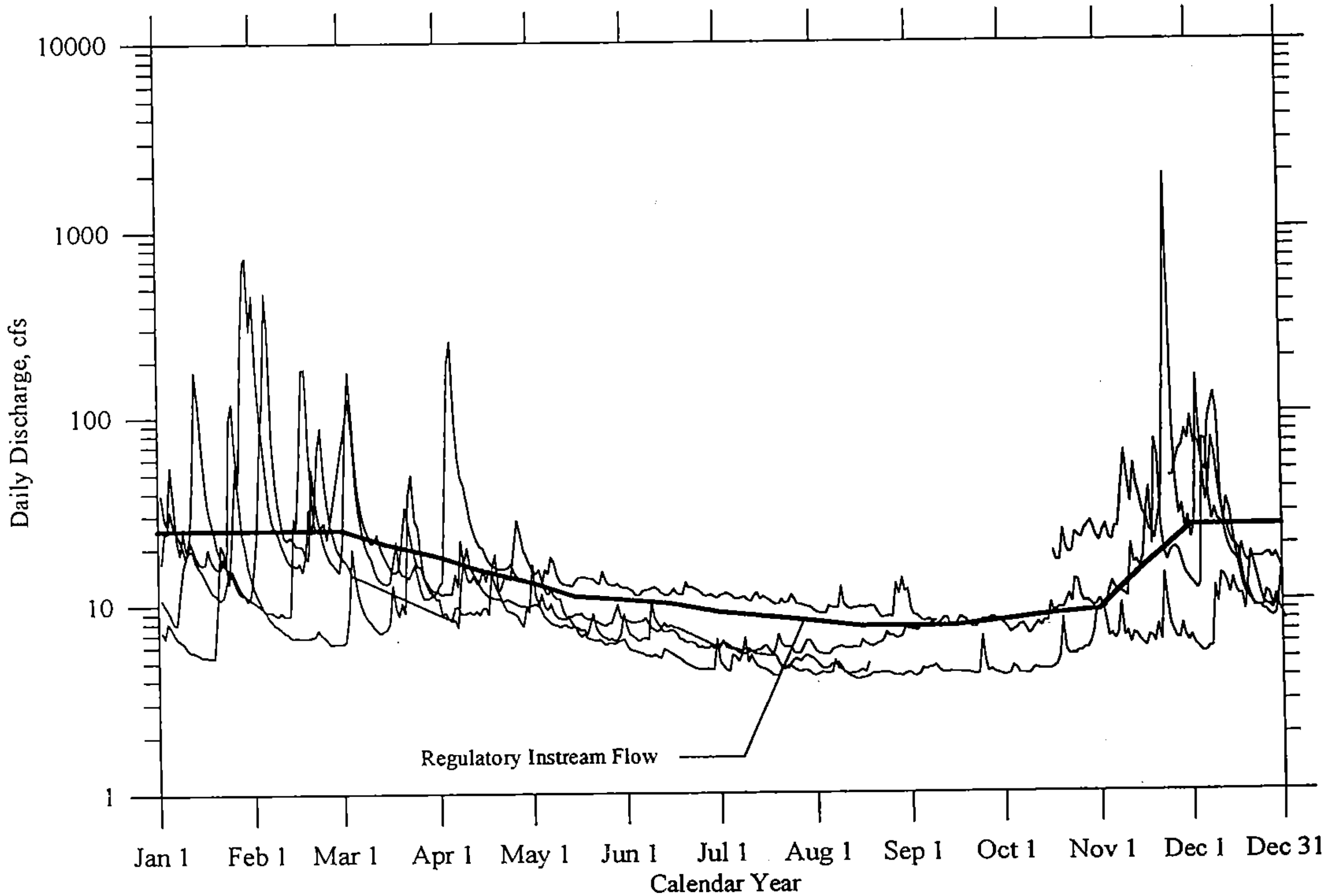
Period of Record:
1945 - 1956

EXHIBIT 4-21
Instream Flows and
Flow Exceedence Probabilities
Tahuya River near Belfair (#044 Confluence #3)

Kitsap County
Initial Basin Assessment

EXHIBIT 4-22
Instream Flows and
Recent Flow Hydrographs
Gorst Creek near Gorst (#268)

Kitsap County
Initial Basin Assessment



Section 5 Hydrogeology

5.1 General Hydrogeology

The general geology, hydrogeology, and water resources of Kitsap County have been described by others (Sceva, 1954, Garling, 1965). Much of the discussion in this section is excerpted from the Kitsap County Ground Water Management Plan (GWMP); Volumes I and II (EES, et al., 1991). Kitsap County (County) lies in the center of the Puget Sound Lowland (Lowland). The Lowland lies between the Olympic Mountains to the west and the Cascade Range to the east. The Lowland is part of a large glacial drift plain formed by multiple glaciations over the area. This history of complex glacial erosion and deposition events, separated by long periods of non-glacial deposition, has created a very complex mixture of unconsolidated sediments beneath the area. This sediment blanket ranges in thickness from zero to over 3,600 feet. It overlays an irregular bedrock surface which is exposed in the central and eastern portions of the county on south Bainbridge Island, Bremerton, Port Orchard, and the Green and Gold Mountain highlands.

The majority of ground water in the County is contained in the unconsolidated sediments. A conceptual model of unconsolidated sediments is depicted in **Exhibit 5-1a**, a generalized hydrogeologic cross-section for the County. The exhibit shows a layered system of water-bearing units (aquifers) and low permeability units which retard water flow (aquitards). For the purpose of simplification, aquifers and aquitards are generalized into regionally extensive units. In actuality, textural variability within the units may result in a more complex assemblage of interfingered aquifers and aquitards occurring on scales ranging from regional to local. **Exhibit 5-1b** provides nomenclature and regional correlation of the associated stratigraphy.

The ground water flow system is recharged by precipitation falling on the land surface. Precipitation also becomes surface runoff to the County's rivers and streams, evaporation from above-ground surfaces, and transpiration from plants that intercept water infiltrating the root zone. Ground water recharge is areally distributed throughout the county, whereas ground water discharge is concentrated around surface-water features such as streams, rivers, lakes, wetlands, and marine bodies. Discharge tends to occur at lower elevations to both surface water and springs, but also occurs to wells regardless of their location.

Ground water flow within aquifers is predominantly horizontal, beginning at recharge areas and flowing towards discharge areas. Ground water flow between aquifers is predominantly vertical, and typically much slower due to the lower permeability of aquitards. In portions of Kitsap County, uppermost (shallow) aquifers are commonly "perched" above aquitards and local in areal extent. Perched conditions occur where unsaturated sediments separate the bottom of the aquitard from the regional water table below. Ground water in perched aquifers reaches deeper aquifers either by slowly percolating through the underlying aquitard or by flowing (more quickly) around it's edge. The deeper sediments are typically fully saturated, especially below sea-level. Although vertical flow across aquitards is typically slow, discontinuities within aquitards (windows) allow more rapid transfer.

In coastal areas, aquifers below sea-level are exposed to marine water bodies. This allows for potential interaction between the fresh water flowing within the aquifer and adjacent seawater. In some cases, seawater can be found in inland locations within the aquifer. The saltwater occurs as a "wedge" along the coast, and the interface between salt and fresh water is often diffuse. The position of the saltwater wedge depends on water levels (hydraulic head) within the aquifer, and can be influenced by pumpage. Discussion of seawater intrusion can be found in Section 5-6.

The geologic units in the County range in age from Tertiary (1.6 - 66 million years before present) to Recent. Two lithified rock units of Tertiary age are exposed in the County. The oldest is the unnamed igneous rocks that compose the Gold and Green Mountains west of Bremerton. These rocks have been age dated at between 50 and 55 million years (Duncan, 1982) and may be correlative with the Crescent Formation (Tabor and Cady, 1978) located on the Olympic Peninsula. The younger lithified geologic unit is the Blakeley Formation, which is between 20 and 40 million years old (Fulmer, 1954). The unit consists of a thick sequence of marine and non-marine sandstone, shale, and conglomerate. The Blakeley Formation is exposed on the southern portion of Bainbridge Island, across Rich Passage around Point Glover, and north of Bremerton at Rocky Point and Sulfur Spring. Bedrock units are not major sources for ground water in the County.

The Tertiary rock units are overlain by a thick sequence of glacial and inter-glacial deposits of Pleistocene age. Much of the upland area of the County is mantled by a veneer of glacial till with the valleys containing predominantly glacial outwash and Recent alluvium. Nearly all of the region's ground water is produced from these Quaternary (Recent and Pleistocene) sediments.

In the Pleistocene Epoch of the last 15 million years, the Lowland was occupied by at least five successive continental ice sheets. The youngest of these, which receded about 15,000 years ago, was the Vashon Stade of the Fraser Glaciation. During this period, an ice sheet 1,000 to 1,400 feet thick covered Kitsap County.

5.2 Geologic Units

Geologic units have been identified based on the interpretation of the County's deeper well logs. A superpositioned sequence of the 15 identified units is presented in **Exhibit 5-1b**. The oldest units (Tv or Tb) have a "T" designator indicating Tertiary age. All others have a "Q" designator, indicating Quaternary age. Both of these designators are according to geologic mapping convention. The "Q" units are further subdivided as to nonglacial deposits ("n") and glacial deposits ("g"). These are then designated 1, 2, 3, etc., with the numerals ranking each similar deposit from younger to older. Thus, Qn3 is the third nonglacial (interglacial) deposit which underlies the second youngest glacial deposit (Qg2).

Glacial units, designated by the letter "g," are generally coarse grained materials (sand and gravel) deposited in high energy environments such as meltwater streams and margins of glaciers. Most major aquifer zones occur within these coarse-grained, glacial deposits. Nonglacial units, designated by the letter "n," are generally fine-grained materials (silt and clay) that were deposited in low energy environments such as still or deep water. A few aquifer zones occur within the nonglacial units, but they typically have low yields.

All Quaternary glacial and non-glacial units in the County are discontinuous in nature. Rarely, if ever, is the entire sequence found at one place. A unit, or several units, are generally absent at specific locations due to the complex erosional and depositional history of the area. The depth ranges quoted in the following description of geologic units, refer to the maximum known elevation of the top and the bottom of the unit respectively. The range is not implied to represent the total, or maximum, thickness of the unit or preclude the identification of the top or bottom of the unit outside this stated range.

Names originating from glacial stratigraphic descriptions (i.e., Salmon Springs Drift) would be more traditional but are not advised due to the uncertain state of the stratigraphic nomenclature at this time. Nonetheless, **Exhibit 5-1** does give suggested regional correlation for the units designated. These units, from oldest to youngest, are described below. To aid the reader, seven generalized geologic cross sections from the GWMP are presented as **Exhibits 5-19 through 5-25** to show the relative position, thickness, and areal extent that is typical of the units. The location of the cross sections is given on **Exhibit 5-2.**

Unit Tv represents the Tertiary volcanic rocks correlated with the Crescent Formation found on the Olympic Peninsula. The unit consists mostly of basaltic lava flows and diabases of unknown thickness. This rock crops out west of Bremerton, forming the Gold and Green Mountains, which are the highest points in the County. Although several wells have been drilled in unit Tv, none are known to be major producers of ground water.

Unit Tb is the Blakeley Formation which consists of a thick sequence (8,000 feet) of marine and non-marine sandstone, shale, and conglomerate. This unit is exposed on wave-cut platforms along the south shore of Sinclair Inlet and both shores of Rich Passage. The unit also is exposed on the north end of Rocky Point and on Bainbridge Island. Like the Tv unit, this unit is not a significant source of ground water.

Unit Qn6 is the oldest recognized unconsolidated unit above the previously mentioned lithified rocks. This nonglacial unit, of late Tertiary or early Pleistocene age, is of unknown area extent and thickness. It is not a ground water source and is not correlative with any unit identified in other ground water studies located outside the County area. This unit has been informally termed the Fletcher Bay formation (Noble, 1990).

Unit Qg5 is the oldest glacial unit encountered. This unit is of unknown areal extent and is up to 100 feet thick. This unit has been found to be highly productive when penetrated, as in the City of Bainbridge Island deep well located at Fletcher Bay. The unit has been tentatively identified in approximately 12 other locations throughout the County. Unit Qg5 is located quite deep, occurring at elevations between -600 to -900 feet mean sea level (MSL).

Unit Qn5, the fifth interglacial deposit, is generally a fine grained formation consisting of silt and clay with occasional peat and wood. The unit is believed to be up to 600 feet thick. There is insufficient deep well data to define the areal extent of the unit. The unit generally has very low ground water productivity.

Unit Qg4 is a glacial deposit of the fourth oldest episode of glaciation. This unit is up to 150 feet thick and has numerous wells completed in it throughout the County. The unit is a complex mixture of several sediment types ranging from sand and gravel to fine grained glacial lake deposits. It is capable of producing ground water yields ranging from 25 to 700 gpm. Outside of the Port Orchard area, this unit is commonly not utilized as a major water producer and is generally bypassed to tap the deeper unit Qg5.

Interbedded with Qg4 is a marine or glaciomarine deposit, designated unit Qg4m. Clam shells of marine origin have been noted in some wells that penetrated Qg4m. The unit, which may be up to 100 feet thick, has an unknown but probably limited extent. The unit is generally located in the central portion of the County from Bangor to Bainbridge Island.

Unit Qn4 is a nonglacial deposit of the fourth interglacial episode. This fine grained deposit, up to 200 feet thick, is laterally extensive and is found throughout the central and southern Lowland. It is probably correlative to the Clover Park Formation (Noble, 1990) of the southern Puget Sound area. Because of its fine grained nature, unit Qn4 is generally an aquitard which restricts flow between the Qg4 and Qg3 aquifers. Qn4 does not yield substantial amounts of ground water.

Unit Qg3 represents the deposits of the third oldest glacial episode. This unit generally consists of sand, sand and gravel, and till. The unit is found between 200 feet above or below sea level and is up to 200 feet thick. This extensive unit is an extremely important aquifer for the County. A large percentage of the wells in the County are completed in this unit. The unit is tentatively correlated with the Double Bluff Drift (Easterbrook, 1968) to the north.

Unit Qn3 is an interglacial deposit of fine grained material (clay, silt, sand and sometimes peat) and generally acts as an aquitard. The unit is intermittently present throughout the County. Wells are very rarely completed in this unit, and the few that are have low yields. The unit is up to 300 feet thick. This unit can likely be correlated in the southern part of the County with the Kitsap Formation (Garling and others, 1965) and the Whidbey Formation (Easterbrook, 1968) to the north.

Unit Qg2, sometimes referred to as the mid-cliff drift, has sporadic deposits throughout the County. The formation is generally poorly sorted and contains sand, gravel silt, and clay. It is generally found from +100 to +300 feet MSL and is up to 150 feet thick. This unit is not very extensive and only a relatively small amount of wells are completed in this unit. This elusive formation is likely correlative with the Possession Drift of Easterbrook and others (1967).

Unit Qn2 is a fine grained, interglacial deposit up to 150 feet thick. The unit is generally an aquitard with very few wells completed in it. The unit is probably correlative with the unnamed sediments below the Lawton clay of Mullineaux (1965) which have been designated as the Discovery Formation by Noble (1990).

Unit Qgla was deposited by meltwaters from the advancing glaciers during the last (Vashon) glacial episode. This thick extensive unit of sand and sand with gravel is up to 250 feet thick. Numerous wells, both public and domestic, are completed in this productive aquifer. This unit can be correlated with confidence to the Colvos and Esperance sands.

Unit Qgl is Vashon glacial drift. This unit was deposited as a veneer of till over the entire County as the ice flowed south. Qgl yields minor amounts of ground water in perched aquifer systems. This unit covers the largest amount of surface area of all geologic units in the County. When present, its thickness varies dramatically up to 200 feet.

The Vashon recessional deposits have been included in unit Qgl. These deposits are usually less than 50 feet in thickness and often much thinner. Some shallow domestic wells are completed in this localized unit in a few areas in the County.

All deposits younger than the Vashon glaciation are also grouped into unit Qnl. These consist of peat and recent alluvium, both of which are generally thin. The recent alluvium can be a source of ground water in some valley floors, particularly if in hydraulic continuity with surface water.

5.3 Principal Aquifers

Within the County, the more permeable zones that are aquifers are separated by finer grained, less permeable layers called aquitards, which generally conduct ground water, albeit at a significantly slower rate. Since the key phrase in defining an aquifer-- "to yield economically significant quantities" -- is highly qualitative, the explicit identification of aquifers is difficult. For example, a water bearing zone that produces several gallons per minute for a domestic well would hardly be considered an aquifer for a city that requires several hundred gallons per minute.

Principal aquifers throughout the County were initially defined and identified in the Kitsap County Ground Water Management Plan (GWMP); Volumes I and II (EES, et al., 1991). An aquifer is defined as "a geologic unit which contains sufficient saturated, permeable material to conduct ground water and to yield economically significant quantities of water to wells and springs" (Glossary of Geology, 1977). These principal aquifers were determined by the following characteristics: several proven, major water supply wells or springs, primarily drilled by the large purveyors; sufficient test data to evaluate aquifer characteristics; and sufficient correlation of geologic characteristics to justify the assumption of continuity between wells. The definition of aquifer boundaries was accomplished by interpretation of the geologic data available for wells in proximity to the major production areas. In those instances where the presence or absence of the aquifer can be confidently identified, the boundary is represented by a solid line. Where insufficient data exist to accurately define the boundary, an interpretation was made and the boundary represented by a dashed line. As can be seen in **Exhibit 5-2**, in many cases aquifers are bounded by dashed lines. In several locations, the principal aquifer area comprises two or more vertically separated aquifers. For example, the Kingston Aquifer System is actually comprised of at least three primary production zones in hydrostratigraphic layers Qg3, Qg4, and Qg5 (as discussed in Section 5.2). This listing by no means implies a complete identification of all aquifers within the County.

In 1991, the Kitsap County GWMP (Volume I) identified 27 principal aquifers. The identified aquifers ranged from near-surface units at elevations as high as +300 feet MSL to aquifers identified at elevations below -900 feet MSL and are comprised of pre-Vashon geologic units. Since these units were defined in 1989, several of them have been subject to more intensive hydrogeologic study to better define their characteristics as well as their vertical and lateral extent. Additionally, new aquifer systems have been identified through ground water exploration programs. At the present time, 28 principal aquifers are identified and their location is shown on **Exhibit 5-2,** with general information provided in **Exhibit 5-3.**

It should be noted that it is unlikely that all the aquifers in the County have been identified. Even with an improved definition of the principal aquifers the level of understanding varies considerably between aquifers. Many of the areas in the County lack enough information to make principal aquifer distinction. Also, in all subareas of the County, many aquifer zones are known to exist but are not designated as principal aquifers. Perched aquifers are saturated zones with an impermeable bottom that are underlain by additional permeable, unsaturated materials. Perched aquifers are capable of producing water to wells, although some are quite large (encompassing several square miles), they are generally localized and are laterally discontinuous on a County and subarea scale.

The description of each principal aquifer which follows are excerpted from the GWMP Volume I), 1991. The descriptions include some new information where available. The reader should refer to the cited references if more details on specific aquifers is desired. Most of the references will include some level of aquifer characterization data, such as aquifer head, transmissivity, and storage coefficient. **Exhibits 5-19 to 5-25** provide generalized geologic cross sections which show the stratigraphic relationship between the hydrostratigraphic units (discussed in Section 5.2) and the principal aquifers that are discussed below. For greater cross-section detail and discussion refer to the GWMP. Location of the cross sections are shown on **Exhibit 5-2.**

Hansville Aquifer

The Hansville Aquifer was evaluated in 1990 (Robinson & Noble, January 1990) for the Hansville Water District (now part of KPUD's North Peninsula Water System). The study assessed hydrology of the area, the vulnerability of the aquifer to future land uses, and alternatives for future ground water development. Two principal aquifers were actually identified. A perched aquifer, the Hansville Aquifer, supplied water to the spring collectors of the old Hansville Water District system. The Hansville Aquifer occurs above +200 feet MSL, within the Qgla hydrostratigraphic unit, and the unit is exposed at the surface in some areas (GWMP, Vol. I & II). A Sea Level Aquifer was also identified that occurs from +50 to -100 feet MSL in the Qg3 unit. Water quality of the Sea Level Aquifer is typically poor in that area (Fe/Mn/Cl).

Kingston Aquifer System

The Kingston Aquifer System is characterized by complicated geology and is actually comprised of three or more aquifers (Robinson and Noble, Oct. 1988, personal communication, M. Sebren, KPUD). The shallow aquifer (Qg3) generally occurs -25 to

-150 feet MSL and tends to occur in the northern portion of the area. The middle aquifer (Qg4) occurs between -240 and -300. The deep aquifer (Qg5) generally occurs between -600 to -725 MSL and is only well documented in the southern portion of the area. More information is needed to determine the level of continuity(if any) between the two deeper aquifers as well as the characteristics of the leaky aquitard separating them. The aquifer boundaries are reasonably well known to the west. The north and south boundaries are less certain but may extend further in both directions.

Port Gamble South Aquifer

Port Gamble South Aquifer is composed primarily of sand that occurs from approximately -50 to -175 feet MSL in the Qg2 hydrostratigraphic unit and produces moderate amounts of water. The aquifer likely does not extend much further southeast than is indicated on **Exhibit 5-2**. The other boundaries of the aquifer are less certain but apparently overlap with those of the Port Gamble Aquifer to the west and northwest. The elevation (production zone) of the aquifer has similarities with the Port Gamble Aquifer. Further study of the two aquifers was undertaken by KPUD in early 1996 (in progress). (**Exhibit 5-19** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.)

Port Gamble Aquifer

Drilling and testing of wells (PUD 1993, 1994) immediately west of Port Gamble Bay helped to document the presence of the Port Gamble Aquifer. The aquifer is defined as a substantial sand aquifer which extends from approximately +100 feet to below -220 feet MSL and is interpreted to be located in the Qg1a hydrostratigraphic unit. Test pumping demonstrated well capacities in excess of 1 million gallons per day (Robinson & Noble, March, 1994).

Previous investigation on the lateral extent of the unit was accomplished based upon the evaluation of local domestic and public well logs surrounding the area (AGI, 1989; Robinson & Noble, 1994). Subsequent study of the Port Gamble area by KPUD in 1996 in progress) has added some additional understanding. The north, west and east boundaries of the aquifer have been reasonably well defined as shown on **Exhibit 5-2**. Significant changes in these boundaries are not anticipated. The southern portion of the east boundary, and the southern boundary of this aquifer require additional study and these portions of the aquifer boundary could change significantly as better data are obtained. The Port Gamble and Port Gamble South Aquifers have similar elevations (production zones) and overlapping boundaries at the south end of Gamble Bay. Further evaluation is required to determine the relationships between the aquifers.

Edgewater Aquifer

This sand and gravel aquifer occurs from approximately +130 feet to -170 feet MSL in unit Qg3 and has pockets of very high productivity (Robinson and Noble, November 1987). The boundaries of the aquifer are poorly defined, but the formation may be hydrostratigraphically related to the Bangor Aquifer System located to the southwest. (**Exhibit 5-19** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.)

Suquamish - Miller Bay Aquifer System

This aquifer system contains several potentially high-yield zones at various depths. The aquifer is contained within the Qg3 unit and is located from sea level to -300 feet MSL. The aquifer thickness and productivity are highly variable. The lateral extent is reasonably well defined to the east and west but less clear on the north and south. (**Exhibit 5-20** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.) Hydrogeologic characterization information is contained in the GWMP, 1991 and miscellaneous consultant reports (Robinson & Noble, AGI).

Poulsbo Aquifer

The characteristics of the Poulsbo Aquifer were refined in 1992 as part of the investigation of the potential for impacts on Dogfish Creek associated with pumping of the City of Poulsbo's Pugh Road Well (Robinson and Noble, November 1992). Based upon an evaluation of local domestic and public well log data, the Poulsbo Aquifer was found to occur from +225 to +50 feet MSL in the Qg3 unit. The aquifer has an areal extent of approximately 5 square miles. This study also concluded that the Poulsbo Aquifer has a relatively low continuity with Dogfish Creek because of the occurrence of a significant aquitard between the two. (**Exhibit 5-20** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.)

Bangor Aquifer System

Hydrogeologic analysis and a three-dimensional, numerical ground water model have been completed for the Bangor Aquifer System through studies commissioned by KPUD (Robinson & Noble; Becker, 1995). The aquifer system consists of three interrelated aquifers labeled in previous works as: the semi-perched, the sea level, and the deep. The upper two aquifers exist in a channel deposit that extends across the Bangor Naval Submarine Base. The channel is interpreted to be part of the Qn3 and Qg3 units. The deep aquifer generally occurs in the Qg4 unit. The aquifer system occurs from approximately +100 to -300 feet MSL. (**Exhibit 5-20** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.)

Keyport Aquifer

The Keyport Aquifer occupies a small area centered on the Naval Undersea Center. The aquifer consists primarily of sand and gravel and occurs between -675 and -800 feet MSL in units Qg5 and Qn6. There are only several deep wells that define the aquifer and therefore, the lateral extent of the aquifer is not well defined. However, water level and production information indicate that the areal extent of the aquifer may be significantly larger than that shown on **Exhibit 5-2**. **Exhibit 5-21** shows a generalized hydrogeologic cross section through the vicinity of the aquifer. Hydrogeologic characterization information is contained in the GWMP, 1991 and miscellaneous consultant reports.

Island Lake Aquifer

In 1990, the Island Lake Aquifer was reevaluated as part of a study for Silverdale Water District (Robinson and Noble, Jan. 1991). The study was initiated to evaluate whether water level declines in Island Lake were related to pumping from Silverdale's nearby Island Lake Well. The local surficial and subsurface geology was studied, and a geologic model, which demonstrated a partial connection (separated by a leaky confining layer) between the lake and the aquifer, was proposed. As a result of this study, the Island Lake Aquifer was found to occur from approximately +150 feet MSL to sea level in geologic units Qg2 and Qg3. The lateral extent of the aquifer, as seen on **Exhibit 5-2,** is approximately 3 square miles. The Department of Ecology (Ecology), being concerned about declining water levels, has halted further water development from this system. (**Exhibit 5-21** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.)

Meadowmeer Aquifer

As part of an aquifer definition and protection study in 1990, the Meadowmeer Aquifer was better defined (Purdy, Nov. 1990). The aquifer occurs from +125 to +70 feet MSL in the geologic unit designated Qg2. The northern and southern limits of the aquifer are dictated by topography and are drawn along the 70-foot elevation contour. The remaining boundaries are drawn based upon well log information. The recharge area for the Meadowmeer Aquifer has been estimated to be about 2.5 square miles.

Wardwell Aquifer System

The Wardwell Aquifer System contains two zones with differing heads (Robinson and Noble, Aug. 1988). The shallow zone is located between -75 and -175 feet MSL in unit Qg3. The deep zone is located between -650 to -975 feet MSL in unit Qg5. More information is needed to determine the level of continuity between the two zones as well as the characteristics of the leaky aquitard which separates the zones. The lateral extent of both zones is poorly understood except for the southwest portion of the deep zone. **Exhibit 5-25** shows a generalized hydrogeologic cross section through the vicinity of the aquifer system.)

Gilberton - Fletcher Bay Aquifer System

The hydrogeology of the Gilberton-Fletcher Bay Aquifer System is relatively complex, consisting of two aquifer zones (Robinson and Noble, 1978). The shallow zone, which lies between -300 and -650 feet MSL, occurs mostly in unit Qg4. It is found on both Bainbridge Island and the Manette peninsula. The deep zone, which lies between -850 and -900 feet MSL, occurs in unit Qg5. The deep aquifer zone is found only on Bainbridge Island. Our understanding of the areal extent of the aquifers is improving.

Wellhead protection and related studies for the North Perry Avenue Water District and Bremerton Water Utilities (AGI, October 1996, November 1996) have further refined the Gilberton-Fletcher Bay Aquifer System. Those studies did not address the Fletcher Bay portion of the system, they have subdivided the Gilberton Aquifer System into two irregularly-shaped aquifers called Meadowdale and Parkwood East. The Meadowdale Aquifer is located from -150 to -450 feet MSL with transmissivity that ranges between 5,000 and 39,000 gpd/ft. The Parkwood East Aquifer is encountered from -450 to -650 feet MSL and has transmissivity that ranges from 1,200 to 36,000 gpd/ft. The Parkwood East Aquifer includes the GWMP 1991 Bucklin Hill Aquifer. Modifications to the principal aquifer map (**Exhibit 5-2**) have not been made at this time but should be considered in the future to reflect new aquifer interpretations. (**Exhibit 5-25** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.)

Bucklin Hill Aquifer

This deep aquifer is located between -400 to -700 feet MSL and occurs within unit Qg5. Additionally, the aquifer appears to occur beneath the shallower Silverdale Aquifer in some areas. Recent study of the aquifer for the North Perry Avenue Water District and Bremerton Water Utilities (AGI, October 1996, November 1996) have referred it as the Parkwood East Aquifer. Those studies suggest that the aquifer is irregularly-shaped and has greater areal extent than the GWMP 1991 definition of the Bucklin Hill Aquifer. The Parkwood East Aquifer extends further west toward Port Orchard Bay than did the original Bucklin Hill Aquifer. The Parkwood East Aquifer is encountered from -450 to -650 feet MSL and has transmissivity that ranges from 1,200 to 36,000 gpd/ft (AGI, November 1996) (GWMP, 1991). (**Exhibit 5-22** shows a generalized hydrogeologic cross section through the vicinity of the aquifer.)

Silverdale Aquifer

This aquifer, located at the head of Dyes Inlet, is moderately productive and occurs between sea level and -250 feet MSL in unit Qg4. The southwest edge of the aquifer is the only well-defined boundary.

Seabeck Aquifer System

The Seabeck Aquifer System, formerly named the Big Beef Aquifer, has been more fully characterized as a result of further test well drilling and development of a Seabeck Aquifer Protection Plan. The aquifer occurs from +100 feet above to -250 feet MSL, mostly in the Qg3 unit. Detailed study has defined the hydraulic gradient and probable recharge area for this aquifer system (Purdy, 1995). Estimates have been made of ground water infiltration based upon an analytical computer model of the aquifer system calibrated to the observed water level information from the aquifer. The recharge area of the Seabeck Aquifer System is approximately 20 square miles. (**Exhibit 5-22** shows a generalized hydrogeologic cross section through the vicinity of the aquifer system.)

Bayhead Aquifer

The Bayhead Aquifer is found at the head of Eagle Harbor on Bainbridge Island. This sand and gravel aquifer occurs from sea level to -150 feet MSL in unit Qg3. The aquifer boundaries are well defined on the north and east but poorly defined to the west and south. Hydrogeologic characterization information is contained in consultant reports (Robinson & Noble).

Eagle Harbor Aquifer

This aquifer, formerly named the Creosote Aquifer, occurs between -600 and -800 feet below sea level in units Qg4 and Qn5. The lateral extent of this deep aquifer is poorly defined, except for the southern edge which is controlled by consolidated bedrock. Hydrogeologic characterization information is contained in consultant reports (Robinson & Noble).

Lynwood Center Aquifer

This sand and gravel aquifer system occurs from approximately -25 to -125 feet MSL within unit Qg3. The wells in this unit produce moderate amounts of water. The lateral extent of the Lynwood Center Aquifer is poorly defined. Hydrogeologic characterization information is contained in consultant reports (Robinson & Noble).

Manette-North Bremerton Aquifer

This aquifer is located in the Qg3 unit and occurs between sea level and -250 feet MSL. This aquifer has a substantial lateral extent, however, the boundaries are poorly defined. Study of aquifers in the area for the North Perry Avenue Water District and Bremerton Water Utilities (AGI, October 1996, November 1996,) have referred to a portion of the Manette-North Bremerton Aquifer as the Sea Level Aquifer. The Sea Level Aquifer occurs from 50 to -150 feet MSL, is discontinuous and has transmissivity ranges from 3,100 to 23,000 gpd/ft.

Clam Bay Aquifer

This rather small, silty sand and gravel aquifer is located at the head of Clam Bay in the Manchester area and is situated in unit Qg3 from a depth of sea level to -150 feet MSL. The lateral extent of this aquifer is limited by the occurrence of surrounding bedrock. Hydrogeologic characterization information is contained in consultant reports (Robinson & Noble).

Port Orchard Deep Aquifer System

This deep, sand and gravel aquifer system is found between -650 to -1,100 feet MSL in the Qg5 unit (GWMP, 1991). Due to the depth of the unit, the lateral extent of the aquifer is poorly understood. Recent work in the Annapolis area distinguishes upper and lower portions of this aquifer which are separated by a leaky aquitard (AGI, 1994).

Yukon Aquifer

This small aquifer, located in the Manchester area, consists of a sand and gravel zone between sea level and -150 feet MSL in unit Qg3 (GWMP, 1991). The northern boundary of the aquifer is moderately well defined, but the lateral extent in other areas is poorly understood.

Anderson Creek Aquifer System

The Anderson Creek Aquifer System was previously defined as a portion of the North Lake - Bremerton South Aquifer (GWMP, 1991). It now refers only to the deep aquifer defined entirely by the City of Bremerton wells in their Anderson Creek wellfield. The aquifer is located between -450 and -525 feet MSL within unit Qg5. In recent studies by Bremerton Water Utilities (AGI, November 1996) the Anderson Creek Aquifer System is referred to as the deep artesian aquifer. The aquifer may have a large areal extent to the south and has tentatively been correlated with deep wells in the Port Orchard area. Those studies also define a sea level aquifer from 100 to -250 feet MSL in unit Qg3, a Shallow Artesian Aquifer from -100 to -250 feet MSL in unit Qg4 and a Lower deep Artesian Aquifer below -650 feet MSL in previously unidentified unit Qg6.

Gorst Aquifer System

Considerable new work has been completed in the Gorst subarea on the Gorst Aquifer System (GWMP, 1991)by Bremerton Water Utilities (KPUD sponsored study by AGI, October 1996, November 1996) including new evaluation of hydrology and hydrogeology of the basin.

Four 'effective' aquifers were identified in the area that was previously identified and is generally shown by the Gorst principal aquifer (GWMP, 1991). These aquifers are encountered from about 250 to -100 feet MSL and are called the Upland Aquifer, the Twin Lakes Aquifer, the Gorst Creek Valley Aquifer and the Sea Level Aquifer. All of these aquifers, except for the Upland Aquifer, are defined as being within the Gorst Aquifer System. The Upland Aquifer underlies that Sunnyslope Uplands to the south. The area is complex and includes glacial and inter-glacial hydrostratigraphic units Qg1a through Qg4.

Salmonberry Aquifer

This sand and gravel aquifer is encountered in the Qg4 unit between -150 and -250 feet MSL. The lateral extent of this aquifer is poorly defined. Recent work has suggested that this aquifer is the middle zone of an aquifer system with three lithologically similar water bearing zones (AGI, 1994). This aquifer has been tentatively correlated with portions of the Anderson Creek Aquifer System (AGI, October 1996).

Wilson Creek Aquifer

This small, shallow sand and gravel aquifer occurs within unit Qg2 at an elevation between +150 to +50 feet MSL. The aquifer is primarily defined by Manchester Water District wells and the areal extent of the aquifer is poorly understood. Hydrogeologic characterization information is contained in GWMP, 1991, and consultant reports (Robinson & Noble).

North Lake Aquifer

The North Lake Aquifer boundaries were refined as part of preliminary hydrogeologic study of the area (Purdy, personal communication). The aquifer exists within the Qg1a and Qg2 units between +300 and +150 feet MSL. The lateral extent of the aquifer is based primarily upon the wells utilized by the McCormick Woods area developments and other private domestic wells. This aquifer is referred to as the Upland Aquifer in recent studies by Bremerton Water Utilities (AGI, October 1996).

5.4 Ground Water Flow System

Ground water flow within the County is controlled by a large number of factors including water level elevation, topography, geology, soil properties, recharge rates, and recharge/discharge features. Ground water systems are usually composed of several types of flow cells. Localized flow cells often exist in shallow ground water zones where the distance between recharge and discharge areas may be on the order of a mile or less. Larger regional flow cells occur within the deeper ground water zones where the distance between the recharge and discharge areas may be miles to tens of miles.

Topography and geology can have profound effects on water levels and ground water movement. Where local relief is negligible and soil properties are uniform, regional flow systems will predominate. On the other hand, where there is significant local relief and complex geology, such as layering of high and low permeability material, then primarily local flow systems will develop in the shallow ground water zones. Geologic heterogeneity can affect the interrelationship between local and regional flow cells, the surficial pattern of recharge and discharge areas, and the quantities of flow that are discharged through the system.

Ground water movement within the flow system is three dimensional in nature. Regional ground water flow systems with significant layering of hydrostratigraphic units show predominantly horizontal flow within aquifers and vertical flow across aquitards. Ground water flow occurs from areas of high hydraulic head (or water level) to areas of low hydraulic head. **Exhibit 5-1a** generally depicts these flow relations between aquifers and aquitards. Water-level maps typically present equipotential lines, contour lines which define where hydraulic head is equal. Flowlines define the direction of ground water movement within the system and are oriented perpendicular to the ground water elevation contours.

Exhibit 5-4 shows ground water elevation contours and flow direction in the shallow aquifer systems. The shallow aquifer systems are comprised of Vashon glacial drift (Qgl) and Vashon advance deposits (Qgla), which include Vashon advance outwash (Colvos sand and Esperance sand). Approximately 25 percent of Kitsap County residents are served by domestic wells. The vast majority of these wells are screened in shallow aquifer systems. Vertical ground water flow between shallow and deeper aquifers is generally downward in recharge areas and upward in discharge areas. Sufficient data was not available to assess the flow within deeper water bearing zones over the majority of the county. Detailed reports specific to particular subareas, however, have been conducted and much work is in progress. The subareas with completed studies include Bangor, Seabeck, and Manchester (Becker, 1995a, b; Purdy, 1995b; AGI, 1994), and subareas with in-progress studies include Port Gamble, Gorst, and Manette. These studies contain potentiometric surface and ground water flow maps for sea level and deeper aquifers. In general, the ground water flow is from the center of the peninsula toward the shoreline.

5.5 Ground Water Recharge

Ground water recharge occurs when water infiltrated into the soil passes through the root zone and migrates downward to a local or regional water table. Rates of recharge are dependent on a variety of factors, including: soil infiltration potential, incident precipitation, and features of the land surface such as vegetation and slope. Physiography and subsurface conditions control whether recharge at the land surface (areal recharge) continues downward to deeper aquifers or discharges to local surface water bodies. The following sections describe the processes of soil infiltration, areal recharge, and deep recharge as they occur in Kitsap County. The distribution of soil infiltration potential is described qualitatively, wheras areal recharge is quantitatively estimated on a sub-area basis. Finally, approaches to evaluating recharge to deep regional aquifers are discussed.

5.5.1 Soil Infiltration Potential

Infiltration potential is a measure of a soils capacity to transmit water. The infiltration potential of surficial soils on the Kitsap Peninsula has been assessed based on soil properties identified in a soil survey by the USDA (1980). The USDA soil survey identified sixty three different "soil map units" based on grain size, typical soil profile, and surface slope. These units were further divided into four "hydrologic soil groups" to distinguish the runoff and infiltration properties of County soils. The "hydrologic soil groups" are based on field classification and laboratory testing of soils, and are described below:

Group A soils have a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B soils have a moderate infiltration capacity when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained to well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C soils have a slow infiltration rate when thoroughly wet. These consist of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D soils have a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Exhibit 5-5 presents a location map of soils identified as having high to moderate infiltration potentials (Groups A and B). In Kitsap County, Group A soils are much more common than Group B soils, and are particularly prevalent in the northern County above Suquamish. Group A soils typically occur where advance and recessional glacial outwash is exposed at the land surface. Where Vashon till is largely absent (e.g., north of Suquamish), Vashon advance outwash deposits are exposed. Vashon recessional outwash deposits are exposed in areas such as the valleys of Gorst Creek and north of Lynwood Center on Bainbridge Island. Group B soils are identified in the vicinities of the Green-Gold Mountains, East Bremerton and Big Valley (north of Poulsbo).

The USDA did not attempt to quantify actual rates of water transmission associated with hydrologic soil groups. Soil groupings are relative, and thus reflect relative rates of soil water transmission. Although transmissive soils (Groups A and B) will infiltrate water more quickly than less transmissive soils (Groups C and D), the total volume infiltrated to a particular soil unit may ultimately be controlled by water loading rates. Where incident precipitation is considerably less than the infiltration capacity of local soils, actual infiltration volumes may be rainfall controlled.

Infiltration rate can be related to ground water vulnerability from surface contamination. Where subsurface conditions allow rapid, unimpeded infiltration from the root zone to the water table, spills and leaks on the land surface can be transported to the water table relatively quickly. Greatest concern is warranted where rapid infiltration occurs to a regional water table.

5.5.2 Areal Ground Water Recharge

Areal ground water recharge occurs via downwards transmission of water infiltrated at the land surface. In this assessment, areal recharge is defined as all water which passes beyond the root zone. Rates of areal recharge vary depending on incident precipitation, the infiltration potential of surficial soils, evapotranspiration from plant cover, and subsurface soil properties. Long term average precipitation varies from about 26 to 68 inches/year across the County (Section 3). Infiltration potential varies across the County because surficial soils are derived from low permeability till, relatively high permeability outwash, and other original materials. Water not infiltrated to soils will occur as surface runoff. Evapotranspiration depends on plant type, water storage capacity in the root zone, and the timing of precipitation and temperatures. Finally, subsurface soils may restrict or facilitate the downward flow of soil water depending on their permeability and saturation.

Areal recharge can be limited either by soil properties or by available infiltration (water not taken up by evapotranspiration). In the first case, a low-permeability soil layer located at or beneath the land surface can restrict recharge to underlying aquifers. For example, a shallow till layer may restrict downward flow of recharge even though the soil horizon above the till can accommodate all infiltration passing through the root zone. In this case, locally perched conditions occur above the till. A portion of the ground water passes vertically through the till, while the remainder flows above the till surface (as shallow interflow) towards streams and lowlands.

Where areal recharge is limited by available infiltration, precipitation rates are insufficient to approach the infiltration capacity of the soils above the water table. Some areas of the County have surficial and subsurface soils which can accommodate greater fluxes than the precipitation entering the root zone. Additionally, a portion of this precipitation is removed from the root zone by evapotranspiration, further reducing the water available to areal recharge.

Rates of areal recharge are typically estimated using a soil-moisture balance. In this approach, areal recharge is equivalent to precipitation minus water "lost" to runoff and evapotranspiration. Typically, only a portion of areal recharge is available for ground water development. Areal recharge which becomes shallow interflow may never reach underlying aquifers, ultimately discharging to springs and surface water features. Areal recharge which reaches uppermost aquifers may follow shallow flow paths to discharge to streams, wetlands, lakes and springs, or deeper flow paths to discharge to marine waters. Evaluation of proposed ground water development must consider the impact on stream baseflows, wetlands and the potential for seawater intrusion.

A soil-moisture balance was used to estimate areal recharge for each sub-area in the County. Estimated rates range from 10 to 34 in/yr, and are documented in **Exhibit 5-6 a and b**. The balance employs a computerized soil-moisture accounting procedure which calculates inflow from precipitation, outflow to evapotranspiration, change in storage, and outflow to areal recharge for the root zone over four time periods per month. During times when the moisture capacity of the root zone is full, the portion of precipitation entering the root zone not lost to evapotranspiration is attributed to areal recharge.

Climatic inputs (temperature and rainfall) are distributed evenly over four "weeks" of the month. Average monthly temperature was assumed equivalent to long-term averages from the Bremerton weather station. Monthly rainfall was estimated by multiplying average annual rainfall for each sub-area (see isohyetal map in Section 3) by a monthly weighting index based on long-term precipitation records from Bremerton. Approximately 20 percent of the precipitation input was assumed lost to storm runoff. This value is consistent with studies performed by the USGS in Kitsap and King Counties. Preliminary streamflow separation for catchments in the Bangor sub-area (Gamble and N. Fork Johnson creeks) showed that storm runoff represents between 17-23 percent of total precipitation (personal communication, Bill Bidlake, 1996). Studies conducted in South King County (Woodward et al, 1995), also suggested storm runoff values averaging around 20 percent of total precipitation.

Evapotranspiration (water evaporated by soil and transpired by plants) was estimated on a weekly basis using the Blaney-Criddle method (Dunne and Leopold, 1978). This method uses crop, latitude and temperature to calculate potential evapotranspiration. The weekly soil moisture balance was used to relate potential to actual evapotranspiration. In this balance, actual evapotranspiration equals potential as long as rainfall is sufficient to keep the soil moist enough to provide plants with sufficient water. When the soil is drier, the actual rate decreases below the potential rate. A linear function based on the ratio of actual water content to soil moisture holding capacity was used to relate actual to potential evapotranspiration. The relation (described below) is one of at least five methods reported in Dunne and Leopold (1978).

When precipitation is equal to or greater than potential evapotranspiration:

$$ET = PET$$

When precipitation is less than potential evapotranspiration:

$$ET = PET \quad (\text{if } SM/SMC \geq 0.75) \qquad \text{or,} \qquad ET = PET * 1.333 * (SM/SMC) \quad (\text{if } SM/SMC < 0.75)$$

Where:

ET = Actual evapotranspiration (in/yr)

PET = Potential evapotranspiration (in/yr), calculated by the Blaney-Criddle method

SM = Soil moisture content from the previous week (in)

SMC = Soil moisture holding capacity (in)

The soil moisture holding capacity over the Kitsap Peninsula varies and has not been delineated per sub-area. ET was calculated for all 18 sub-areas using a holding capacity of six inches. This value represents a loam soil with rooting depths on the order of 3 feet. Representative "crop factors" for grass were used in the soil moisture budget. Although much of the peninsula is vegetated by coniferous trees, accurate crop factors for coniferous trees are not available for the Puget Lowland climate. Crop factors for grass are generally greater than for coniferous trees, and use of the grass crop factor may overestimate ET.

Resulting estimates of ET are presented in **Exhibit 5-6 a and b**, and vary from 14 to 19 in/yr on a sub-area basis. The accuracy of ET estimates is difficult to quantify. Sensitivity analyses were performed for both soil moisture holding capacity and runoff. Soil moisture holding capacity was varied from four to eight inches, and runoff was varied from 15 to 25 percent. The comparisons were made for two low-precipitation sub-areas (Hansville and Kingston) and two high-precipitation sub-areas (Anderson and Dewatto). Higher holding capacities would allow for more ET, whereas higher runoff values would allow for less ET. In all cases, varying soil moisture holding capacity caused less than two inches change in estimated ET. Varying runoff caused less than 1.5 inches change in the low precipitation sub-areas and less than three inches change in the high precipitation sub-areas.

Estimates of ET have been made for selected portions of the Kitsap Peninsula using other approaches. The USGS calibrated their "Deep Percolation Model (DPM)" to rainfall and runoff conditions in several catchments within the Bangor sub-area. The DPM is a sophisticated approach which calculates both the transpirative and evaporative components of ET individually. Preliminary estimates of ET for the Johnson Creek and Gamble catchments averaged 22 in/yr (personal communication, Bidlake, 1996). This value, if assumed representative of the whole sub-area, is six in/yr higher than the value estimated with the soil moisture budget. The higher value may be due to the fact that evaporation from wet vegetative surfaces is higher than transpiration when the surfaces are dry. The USGS DPM estimates are currently under review, after which they will be issued in publication.

Assessments of PET in the Bangor and Seabeck sub-areas were performed by Robinson & Noble (Becker, 1995b and Purdy, 1995). R&N estimated PET using the method of Thornthwaite (Dunne and Leopold, 1978), and calculated values of 21 in/yr for both basins. The values of PET are larger than values of actual ET estimated with the Blaney-Criddle soil moisture budget (above). This is because PET is not reduced during periods when low soil moisture content limits plant uptake. R&N's PET estimate for the Bangor area compares favorably to the USGS preliminary estimate, although the USGS estimate is higher for different reasons.

5.5.3 Deep Ground Water Recharge

Ground water availability in deep, regional aquifers is of major interest on the Kitsap Peninsula. Wells used for public supply and fish production typically withdraw water from deep regional aquifers. Deep aquifers are more likely to discharge to marine waters, and therefore less likely to show relatively high hydraulic continuity with rivers and streams. On the Kitsap Peninsula, where rivers typically show a net inflow from ground water discharge, deep recharge is likely limited to a small portion of areal recharge. The deep recharge passes from surficial aquifers downward through underlying aquitards. A higher proportion of areal recharge likely discharges to local springs and surface water bodies. The availability of ground water beneath the County is controlled by these recharge pathways and possibly, in the case of deep aquifers, by ground water subflow from distant recharge areas.

Recharge to deep aquifers is typically estimated using ground water flux analyses, computer modeling, or the water balance approach. In the water balance, deep recharge is considered to be the "unknown" term, and is calculated based on an accounting of other "known" (measured or estimated) components of the hydrologic cycle. The effectiveness of water balance analysis is limited where more than one term is unknown, or where compounded error associated with "known" terms overshadows the "unknown" term. Additionally, deep recharge estimates from the water balance do not differentiate how the recharge is distributed between (deep) aquifers.

Water balances are commonly based on the assumption of dynamic equilibrium - that is, over the long-term hydrologic systems are in steady state. In steady state, inflows are equivalent to outflows with negligible changes in system storage. The following water balance equation can be used to estimate deep recharge for sub-areas in Kitsap County:

$$P + S_{in} = SF + D + ET + W + G_m + S_{out} + MISC$$

Where: P = precipitation input to the sub-area

SF = total flow in sub-area streams (baseflow + storm runoff)

D = stream diversions

ET = evapotranspiration averaged over the sub-area

W = ground water withdrawals by wells

G_m = ground water discharging to marine waters (via deep recharge)

$S_{in,out}$ = ground water subflow entering, exiting the sub-area

MISC = miscellaneous outflows

The water balance assumes that ground water subflow across sub-area boundaries is negligible. This is consistent with the choice of sub-area boundaries, which follow surface-water and shallow ground-water divides. However, water-level data from deep aquifers are insufficient to confirm that sub-area boundaries conform to deep ground water divides. In some areas, subflow across sub-area boundaries may introduce inaccuracies to the water balance. The water balance also assumes that miscellaneous outflows such as coastal springflow and evaporation from seeps, riparian areas, lakes and wetlands are negligible.

The applicability of water balance analysis was severely limited for most (16 of 18) sub-areas by availability of streamflow data. Where streamflow data are lacking, the water balance equation includes two unknowns and cannot be solved for deep recharge. The term total streamflow (storm runoff + baseflow) eliminates the need to estimate ground water discharge to streams baseflow. However, in most sub-areas, available data were insufficient to provide representative values of total streamflow. Optimally, sub-areas would be equipped with stream gages which afford coverage of the majority of the subarea. In addition, data records should be long enough to provide a representative average over time. Although gages in these 16 sub-areas are generally located near the mouths of streams, sub-area coverage is typically inadequate to be considered representative (i.e. less than 50% of the drainage area). Additional analysis, such as hydrologic modeling, could be used to estimate streamflows on ungaged catchments and increase the applicability of water balance assessment. The USGS is currently applying such an approach in the Bangor sub-area (pers. comm., B. Bidlake, USGS).

Sufficient streamflow data were available in the Chico and Seabeck sub-areas, however application of the water balance showed that the potential errors currently associated with the "known" terms overshadowed the magnitude of the residual (deep recharge) term. Precipitation and streamflow data can be as accurate as ± five percent. Precipitation accuracy is reduced in the Chico sub-area, where undocumented orographic effects near the Green-Gold Mountains are likely significant. Streamflow accuracy may suffer where significant portions of the watershed are not gaged and hydrologic modeling has not been performed. A comparison of runoff efficiency (total annual streamflow divided by annual precipitation, in like units) for 13 streams is presented in **Exhibit 5-7**, and shows high variability with values ranging from 33 to 89 percent. Runoff efficiency values may be influenced by steepness of the catchment, soil permeability, variability in stream-aquifer continuity, and the occurrence of ground water subflow to/from external sub-areas. Where these factors are not accounted for, additional error in the total streamflow term may result. Gaged coverage is approximately 52 percent in the Seabeck sub-area, and 78 percent in the Chico sub-area.

Other potential sources of error are associated with estimation of evapotranspiration (described in the preceding section) and withdrawals/ diversions. Potential error associated with evapotranspiration estimates may be relatively high (± 30 percent). Well withdrawals and stream diversions are difficult to estimate. While these withdrawals appear to represent a relatively small portion of the overall water balance (based on water rights allocations in Section 4), potential error in the withdrawal estimates is relatively high. The fact that cumulative potential error surpassed the water balance residual (deep recharge) suggests that the water balance approach may be inherently limited in some sub-areas. Preliminary analysis suggests that under typical Puget Sound conditions and assuming most-accurate estimates, the water balance approach is viable only where runoff efficiency and evapotranspiration are sufficiently low that deep recharge is at least 30-40 percent of precipitation.

Water balance analyses have been performed by other researchers and consultants for areas on the Kitsap Peninsula.

Recharge to individual deep aquifers can be evaluated using estimates of flux between aquifers or within aquifers. Flux between aquifers is estimated based on vertical gradients between aquifers and estimates of aquitard permeability, whereas flux within aquifers is estimated based on horizontal gradients and aquifer permeability. The accuracy of permeability estimates is sometimes as low as ± one order of magnitude. Flux estimates vary proportionally, and therefore associated recharge ranges can be rather large. Use of flux estimation on the Kitsap Peninsula is also complicated by the fact that hydrogeologic data is typically insufficient to characterize conditions in deep aquifers/aquitards required for the analysis. This may, in part, be due to locally complex environments of deposition resulting in non-layered hydrostratigraphy. Flux estimates can be used in conjunction with water balances as a check on the water balance results and to differentiate recharge to successive layered aquifers.

Recharge to deep aquifers can be estimated by numerical modeling(an expensive process) for areas where sufficient hydrogeologic data are available to characterize the ground water flow system. Modeling allows direct evaluation of ground water availability, because impacts associated with pumping can be estimated. Data requirements for modeling include aquifer/aquitard occurrence and properties, water-level elevations, occurrence of surface water features (streams, lakes, wetlands, seawater bodies), and estimates of areal recharge. Numerical modeling can be used to evaluate stream/aquifer continuity, seawater intrusion, and general flow system response to pumping.

5.6 Ground Water - Surface Water Interaction

Hydraulic continuity refers to the interconnection between water bearing units, including ground water and surface water. An aquifer is typically in hydraulic continuity with lakes, streams, rivers, or other surface water bodies where saturation is continuous to the edge of these water bodies. Hydraulic continuity typically occurs where ground water discharges to surface water, such as in spring-fed lakes and gaining rivers (rivers that receive ground water); or where surface water discharges to ground water, such as from riverbed seepage to an adjacent alluvial aquifer. Where hydraulic continuity exists, changing hydraulic conditions in a ground water body will result in changes to connected surface water bodies. Pumping a well may result in reduced ground water discharge to adjacent surface water or increased seepage from surface water. Similarly, where hydraulic continuity exists, lowering the water level in a river or lake will result in decreased seepage to ground water or increased discharge from adjacent aquifers.

Determining or predicting cause-and-effect stream/aquifer relations can be simple or complex depending on hydrogeologic conditions. In the case of ground water withdrawals, potentially impacted surface water bodies must first be identified. Because shallow aquifers are generally dominated by local ground water flow systems, withdrawals from shallow wells are more likely to influence local surface water bodies. Most simplistically, a shallow well in an alluvial aquifer will likely affect flow in an adjacent river or stream. For the purpose of this report, this example shows a "relatively high degree" of hydraulic continuity. Deeper aquifers are more typically part of regional flow systems. The effects of pumping from a deep confined aquifer could therefore be manifested on distant river reaches, discharge rates to coastal seawater bodies typical of Kitsap County, or could be spread diffusely over a large area to affect numerous surface water bodies. For the purpose of this report, such a situation represents a "relatively low degree" of hydraulic continuity.

The timing and magnitude of stream/aquifer interactions depends on many factors, including: the distance between the well and the surface water body; the geometry and hydraulic properties of aquifers and aquitards between the well and the surface water body; patterns of ground water flow and recharge; and the hydraulic properties of riverbeds and lakebeds. Based on these factors, ground water withdrawals may affect surface water bodies almost instantaneously or may be delayed by months, years, or even decades.

Specific studies conducted in the Manchester, Seabeck and Bangor subareas (AGI, 1994; Purdy, 1995b; Becker, 1995a, b) investigated the ground water - surface water interaction. In the Annapolis area of the Manchester subarea, the perched aquifers (A1 and A2) discharge as baseflow to streams in the area. Aquifers near or below sea level (A3, A4, A5, and A6) appear to discharge to Sinclair Inlet or infiltrate downward. In the Seabeck subarea, the shallow, perched aquifers were found to directly contribute to the baseflow of the streams, whereas the deeper Seabeck Aquifer System does not. In the Bangor study it was found that the upper two aquifers (Perched and Semi-Perched) lose ground water to streams and lakes. The Sea Level and Deep Aquifers discharge largely to Hood Canal. Studies accomplished in the Gorst Subarea by the City of Bremerton (AGI, 1996) demonstrates that the Sunnyslope Upland Aquifer discharges to local streams and the Twin Lakes Aquifer. The Twin Lakes Aquifer partially discharges to Gorst Creek and the Union River. The Twin Lakes, Gorst Creek Valley, and Sea Level Aquifers are in communication with each other and Sinclair Inlet.

5.7 Seawater Intrusion

Seawater intrusion is the inland movement of marine water into an adjacent coastal aquifer. In aquifers that are hydraulically connected to the sea, the boundary between fresh ground water and seawater is marked by a transition zone referred to as the "zone of diffusion." The position of this boundary largely depends on the properties of the aquifer and the amount of fresh ground water flushing through the system. The zone of diffusion extends to greater depths further inland, thus forming a characteristic "seawater wedge" within the aquifer. Freshwater overlies the (denser) seawater, and higher salinities occur with greater depth.

The position of the zone of diffusion depends on the dynamic balance between sea level and water levels in the aquifer. The rate of ground water flow is also controlled by water levels in the aquifer. The fact that the zone of diffusion is not a sharp interface, but is rather a mixing zone, is due to shifts in the equilibrium which result from diurnal variations in sea level (tides) and longer-term variations in ground water levels. The zone of diffusion can migrate inland when ground water levels reach a seasonal low, and recede seaward when ground water levels recover.

The dynamic balance between freshwater and seawater can be altered by human activities which influence ground water levels. Ground water levels are lowered by pumping and by land use practices which reduce recharge to underlying aquifers. Both of these activities intercept water which would naturally flow through the aquifer and contribute to freshwater flow "flushing out" seawater along the zone of diffusion. Lowered ground water levels will cause the seawater wedge to migrate landward, causing "lateral intrusion." If pumping (and localized aquifer drawdown) occurs directly above the zone of diffusion, deep seawater can be drawn upward towards the pumped well, a process called "upconing."

Seawater intrusion is indicated by increasing salinity in ground water. Monitoring for seawater intrusion often involves regular measurement of electrical conductivity or chloride concentration in wells. Although seawater intrusion is a reversible process, longer periods of time are typically required to flush saline water out of the system than for intrusion to occur. Reversal is especially slow where intrusion occurs on a regional scale. Prevention of seawater intrusion is by far the preferred option.

There is no evidence of extensive seawater intrusion in Kitsap County. Evidence for localized seawater intrusion is found in a few areas such as Jefferson Beach (Kingston subarea). Elevated chloride and electric conductivity, indicator parameters for seawater intrusion, occur in several coastal areas (Sections 5.10.1 and 5.10.2). Although relatively high, chloride and specific conductance in coastal areas are generally not high enough to suggest significant seawater intrusion. Analysis of chloride and electrical conductivity (as an indicator of sewater intrusion) is included in Section 5-10.

5.8 GWMP Ground Water Monitoring Network

The GWMP established an extensive network of monitoring sites throughout the County in 1990. The network which includes wells for monitoring water levels, water quality, and water use, will continue to be expanded and upgraded over time.

5.8.1 Water Levels

Approximately 100 wells were identified within the County for water level monitoring under the GWMP. The sites were selected to provide coverage within the principal aquifer systems as well as other areas where trend data was generally absent. Wells selected for the network are completed over a wide range of depths to assess trends in both shallow, intermediate, and deep ground water flow systems.

In addition to the wells used for water level monitoring by the GWMP program, other wells are being incorporated into the network on an on-going basis. Over 150 wells make up the current network that the PUD has access to. Water purveyors throughout the County are expanding their monitoring efforts to include wells that were not monitored in the past. It is hoped that these new wells and data can be coordinated into a better monitoring network for the future.

The GWMP established a protocol under which purveyors would voluntarily collect and distribute the computerized water level data to a KPUD data-base management system. The basic plan called for water levels to be measured on a monthly basis using electric well sounders. The responsibility for the success of the water level monitoring network was to be shared between local purveyors and KPUD personnel, though each water purveyor is primarily responsible for collecting data for their systems. KPUD collects water level data from wells that they operate as well as certain other public and private wells that are a part of the network. The monitoring network has been generally successful but has fallen short of its goals in certain areas of the county.

5.8.2 Water Quality

Water quality data provide a basis for understanding the natural variability of ground water quality, assessing land use impacts and health concerns, and evaluating trends associated with ground water development. Major anion/cation chemistry can be used to gain a better understanding of regional flow systems. Biological, inorganic, and organic parameters can be used to assess potential water quality problems associated with industrial, agricultural, and residential contaminant sources. Indicator parameters such as nitrate, chloride, and electrical conductance (EC) can be used to evaluate impacts associated with septic systems or seawater intrusion within coastal areas.

A considerable amount of water quality data has been developed for Kitsap County as part of special studies, compliance monitoring programs, building permit requirements, and other on-going efforts. A summary of some of the many water quality data sources is presented in Section 5.10.

Both spatial and temporal water quality data are needed to assess regional water quality conditions and changes in water quality over time. Water quality data collected as part of the Ground Water Management Program, KPUD's private well sampling program, and Bremerton Kitsap County Health Department (BKCHD) building permit requirements, provide valuable data for characterizing the spatial distribution of water quality. Washington Department of Health (WDOH) compliance monitoring requirements for water purveyors provide useful data for assessing temporal trends in water quality. In addition, on-going sampling of selected wells by KPUD provides useful time series data.

Future monitoring efforts will be directed towards expanding time series sampling in order to assess long-term trends in water quality. This will be particularly true in coastal areas where there is potential for seawater intrusion or in urbanizing areas where land use impacts are of concern.

5.8.3 Water Use

Water use data are of critical importance in evaluating water resource issues associated with potential overdraft of aquifer systems, seawater intrusion, sustainable ground water yield, and water balance relationships. Most water purveyors within the County collect water production data from metering systems that are installed at the wellhead or the surface source. The frequency of data collection and methods of reporting the data vary widely depending upon the individual requirements of the water system. The amount of water use by private domestic and group B water system wells is currently unknown because a standardized method of evaluation has not been established (most are restricted to 5000 gallons/day under the current water right permitting process).

Recognizing the need to facilitate and standardize the reporting of water use data, the Kitsap GWMP in 1990 developed a computerized software package for entering and managing data. The water use package was distributed to the purveyors along with PC computer systems and spreadsheet software. The computer package included options for data entry, reporting, plotting, and transfer. The original program has been modified considerably. Purveyors and others that collect water use data, as well as water level and quality data, have customized the format to meet their needs, which has required some modification in operating the central data bank. Although extensive, valuable data has been collected through this program, the lack of participation by some purveyors has been disappointing. The program will continue to be revised to encourage wider participation and more comprehensive analysis.

5.9 Water Level Trends

Water level monitoring provides a basis for evaluating impacts on the ground water system that may be associated with ground water development, land use changes, and precipitation patterns. Water levels are affected primarily by climatic trends and amount of ground water withdrawal. Climatic trends include changes in precipitation and drought periods, ground water withdrawal includes water pumped from public and *private* wells. Seasonal water level changes (months) and long-term water level changes (years to decades) are typically caused by these primary factors. The importance of water level trend data cannot be overemphasized. The data is required to understand the seasonal variations in aquifer levels, to evaluate the effects of pumping on aquifer levels, to identify areas where possible overdraft (mining) of an aquifer is occurring, and to assess areas where seawater intrusion or stream depletion may be of concern.

Seasonal and long-term trends in water levels are superimposed in all water level hydrographs. Fluctuation in water levels result from changes in rainfall, barometric pressure, marine tide, local pumping, and other factors that cause seasonal and long-term water level trends. The hydrograph shows the averaged effect of all such factors on the water levels in a well or aquifer with time. Amounts of water level fluctuation from strictly natural factors can vary from a few inches to ten or more feet from seasonal factors, and similar effect can be produced from drought or wet conditions that may occur over years or decades. Water level trends should be evaluated with climatic as well as manmade factors in mind. Parameters that effect seasonal and long-term trends in water levels are superimposed on water-level hydrographs to assist analysis

Water naturally discharges from aquifers at a rate which is controlled to a large extent by the amount of recharge. In a geological area like Kitsap County, some fresh water flows directly from aquifers to seawater. Aquifer mining and over-drafting are general terms used to denote the condition caused by extracting more water from an aquifer than is being recharged. Well pumping can cause aquifer levels to drop without causing mining to occur. A lowered aquifer water level reduces the differential pressure between the aquifer and Hood Canal or Puget Sound. The reduced differential pressure results in a decreased flow from the aquifer to seawater. When the reduced flow to sea balances the increased extraction through wells, the aquifer water level will stabilize at a new lower level. If extraction reaches too great a rate, a steady lowering of the aquifer water level will occur over time, causing over-drafting or mining.

Over-drafting ground water from the shallower aquifers can have an adverse impact on surface waters and wetlands. In an aquifer in continuity with a stream, a reduced differential hydraulic gradient may cause a decrease in flow from the aquifer to the stream or wetland.

To determine if mining is occurring, monitoring must be conducted over an extended period of time. The County has numerous shallow and deep aquifers, some of which may be connected vertically as well as horizontally. As a result, determining with accuracy the amount of water that can be safely withdrawn from an individual aquifer before over-drafting will occur is complex. Monitoring aquifer water levels is important to prevent over-drafting. Predicting the capacity of the County's aquifers is difficult and expensive using existing data and analysis capabilities. Changing factors, such as land use modifications which impact recharge rates, complicate the process. The current best means of detecting aquifer overdraft conditions are to record and analyze static water level over a period of time and to relate these trends to pumping and precipitation.

Data that was collected by the GWMP monitoring network and on file with KPUD as of January 1, 1997 was used to compile a set of 149 water-level hydrographs for this basin assessment. The data includes water level and production information collected by water purveyors such as Bremerton Water Utilities, City of Bainbridge Island, Silverdale Water District, and Kitsap PUD, just to name a few. The data also includes information from private groups and individuals.

Wells with hydrographs that are presented in this assessment are listed in **Exhibit 5-8**. The exhibit lists the wells sorted by subarea and includes the principal aquifer the well is completed in (if identified), the unique well identification number, well location, owner and well name, year drilled, the site elevation, and the well's completion elevation. Hydrographs for each well are presented in Appendix H. **Exhibit 5-9** shows the geographic distribution of the well and where the wells are located relative to principal aquifers and subareas.

Most of the hydrographs show water level elevation (in feet above mean sea level) versus time. About 30 hydrographs for Bremerton Water Utility and Silverdale Water District are in depth to water below measuring point versus time, instead of elevation, and are so noted in the remarks. The hydrographs typically show static (non-pumping) water level, but may also include pumping water levels (where noted). The water level and time scales for each hydrograph were selected to fit the specific data set for each well and therefor the scales may vary considerably from one hydrograph to the next. Most of the hydrographs were prepared by KPUD, though some are copied from other reports. Some of the hydrographs include a bar-graph of monthly total production data when the data was sufficient to warrant presentation. Note that gaps in a particular hydrograph's record may indicate that data was not collected for that time period, data was not reported to KPUD, well production was zero, KPUD has yet to process some of the data in its files, or a combination of factors.

The quality of available water-level and production data varies considerably. Few wells prior to 1985 have water level records that were accurately collected and recorded on a regular basis. Some examples of older wells with better-than-average water level records are AAA728, AAA111 and AAC759 (**Exhibit 5-8** and Appendix H page numbers 40, 61 and 70). For most of the well hydrographs, the historical data consist of a single static water level at the time of well construction, followed by occasional to monthly water levels that began in the 1990 time frame and continue to present. Therefore, water level data, was reviewed over two time periods: 1) for water year 1991 to 1996 and 2) over the entire period of record that includes all historical water-level records (i.e.: the earliest static water level and or the construction static water level). The trends were reviewed taking into account geographic location and completion elevation. An exhaustive review comparing in-well and regional production data, precipitation, and water levels has not been conducted. A more comprehensive review of individual wells is recommended when in-depth assessments are completed for specific subareas.

5.9.1 Apparent Change In Water Level Elevation For Water Year 1991 To 1996

Water years 1991 to 1996 are a period when more water level data from potable wells was collected for more wells throughout the county than at any other time in county history. This is a direct result of the GWMP which increased the awareness of the importance of water level trend data for the evaluation of water resources. Water level data from water years 1991 to 1996 and the associated water level trends can be compared for many parts of the county. The water year convention is used because it reasonably correlates with natural climatic variations of wet and dry seasons. Water year refers to the time period beginning on October 1st of a year and ending on September 30th of the following year (e.g., water year 1991 began on October 1, 1990 and ended on September 30, 1991).

Of the 149 hydrographs, 71 had records for water years 1991 through 1996. Apparent change in water level was determined for each hydrograph by selecting the highest level on record (rounded to the nearest foot) for both water years 1991 and 1996. These values are listed in **Exhibit 5-8** as apparent change in water level elevation from water year 1991 to 1996. The apparent change in water level elevation for the entire period of record is also listed.

It should be noted that in some cases it is likely that the data set for a well may not include the 'true' highest water level for the water year. The water level changes are called 'apparent' because of these types of uncertainties in the data set for each well. Also the error bounds for this discussion of apparent change in water level was assumed to be plus or minus one foot and therefor, a plus or minus one foot change is considered no change for the time period. Based on this interpretation, hydrographs of 33 out of 71 wells (46 percent) had little or no change in water level. Records for 19 wells (27 percent) showed declines of 2 to 10 feet, and 2 wells (3 percent) suggest declines of greater than 10 feet. Hydrographs of 15 wells (21 percent) indicate the water levels have risen from 2 to 10 feet, and 2 wells (3 percent) have risen greater than 10 feet. Putting it in slightly different terms, 30 percent of the records have shown declines while 70 percent have risen or stayed the same. The reader is encouraged to review individual hydrographs in Appendix H. Many of the hydrographs that lacked water year 1996 data, and are therefore are not figured into the percentages above, have trends that would likely have included them with hydrographs that have risen. It is anticipated that future data will show that a significantly greater percentage of wells will of have rises in water levels for water years 1991 to 1996 due to the winter of 1995 and 1996 that supplied substantial recharge compared to previous years. Effects on hydrographs by precipitation are discussed further in Section 5.9.3.

Exhibit 5-10 presents a scatter-plot of apparent change in water level versus the completion elevation for the 71 wells with water year 1991 to 1996 data (wells without known completion elevations are not shown). As previously discussed, wells showing higher water levels or lower water levels than in the past are found throughout the county and at a wide range of completion elevations. In general, of wells completed at or above sea level, about twice as many have risen more than 1 foot since 1991 than have declined by the same amount. Of the wells completed at or below sea level, about 40 percent have risen more than 1 foot and 60 percent have declined by the same amount since 1991.

To look at the change in water level versus completion elevation on a geographical basis, the data set for **Exhibit 5-10** was separated by subareas and is shown **in Exhibits 5-11A through 5-11O** (wells without known completion elevations are not shown). Individual well identification numbers are shown on the exhibits for cross-referencing with **Exhibit 5-8.**

Evaluating where and why water levels have risen is as important as where water levels have declined. Two wells completed below sea level in the Bangor subarea are the only ones which show notable (10 feet or greater) declines **(Exhibit 5-11D)** during water years 1991 to 1996.

An important aside to **Exhibits 5-11A-O** is the identification of subareas that may not be adequately monitored for water level data. Subareas that do not have hydrographs presented in this assessment are Hansville, and Stavis. The Manette, Union, Tahuya, Olalla, McCormick and Dewatto subareas have only one to several hydrographs. KPUD plans to add wells to the network in the Hansville subarea. The low population densities of the Union, Tahuya and Dewatto subareas will probably delay addition of monitoring wells in those areas. In the Manette subarea, Bremerton Water Utilities and North Perry Avenue Water District have conducted wellhead protection and related studies which include summaries of water level and related data. Data for the Manette subarea will probably be available in the near future (personal communication Doug Dow, AGI Technologies).

5.9.2 Apparent Changes In Water Level Elevation For All of Record

To evaluate the apparent changes in water level over the entire period of record requires that some assumptions be made that are not necessarily needed for review of water year 1991 to 1996 data. The primary assumption is that the original static water level of record was referenced to the same measuring point (MP) as the subsequent measurements. The subsequent measurements may be separated in time by a year or two or as much as several decades. For hydrographs in this basin assessment water level records from one well to the next vary over a considerable time span, ranging from 2 to 3 years of record to over 30 years of record. The standard MP is typically the top of the well casing. However, the MP may change several times, particularly for wells that are several decades old and may be quite different from the measuring point used with the current monitoring program. This uncertainty is not as great for wells in the GWMP network and for the records that began in 1990-1991. In addition, water level measurements collected at the time of construction are usually reported to the nearest foot (the nearest 0.1 foot is desirable), and are subject to error because of poorly calibrated equipment and collection practices. Despite these limitations, the following review of the trends was attempted if only to look for geographically specific areas where water level declines may be significant. See Appendix H for individual well hydrographs. For the entire water level record of the 149 hydrographs, the following are general observations of the apparent change in water levels. Hydrographs of 23 out of 149 wells (15 percent) had little or no change in water level. Records for 50 wells (34 percent) showed declines of 2 to 10 feet, and 30 wells (20 percent) suggest declines of greater than 10 feet. Hydrographs of 34 wells (23 percent) indicate the water levels have risen from 2 to 10 feet, and 12 wells (8 percent) have risen greater than 10 feet. Therefor about 46 percent of the hydrograph records show no apparent trend or a rising trend over their period of record and about 54 percent have shown a decline over their period of record. Scatter plots of the apparent changes in water level are shown on **Exhibit 5-10**, and are broken down by subarea on **Exhibits 5-11A to 5-11O**.

The Kingston, Poulsbo, Bangor, Bainbridge, Chico, and Manchester subareas have one or more hydrographs that suggest apparent declines in water level of 10 feet or more. These apparent declines involve aquifers above and below sea level. In the Kingston subarea wells with large declines are AAB406, AAA014 and AAA710. All three wells have completion elevations generally -100 to -300 feet MSL. Water levels have declined in these areas primarily in response to ground water withdrawl for potable supply and to a lesser extent for fish propagation. Currently all three hydrographs suggest that declines have moderated and a new equilibrium may have been established for the aquifers involved.

In the Poulsbo subarea, well AAB254 has declined according to records through 1994. The Bangor subarea has the most records for wells which show larger declines. The wells include AAA728, AAA730, AAA734, AAA746, AAA748, AAA749 AAC629 and AAA639. The wells range in elevation from 200 to -200 feet MSL. Most of the wells are associated with centers of ground water withdrawal except AAC629 and AAC639. As in the Kingston subarea, aquifers may have established new equilibrims, though mining is not ruled out as a factor.

The Bainbridge subarea has a good record set for one well (AAA111) completed below -800 MSL, where water levels have declined but apparently stabilized at their lower level. Wells AAA112, AAB455 and other deep wells on the island have apparent declines which need further review. In the Chico subarea well AAB476 shows a decline and it is not associated with nearby withdrawal.

In the Manchester subarea hydrographs AAA119, AAA118, and AAB486 (all with completion elevations near sealevel) have notable declines. Well AAA117, is completed below -1000 MSL and also has an apparently large decline.

5.9.3 Comparison With Precipitation Trends

To evaluate the degree to which the water level trends are related to climate, precipitation trends were compared with non-pumping water level trends. Three example hydrographs, **Exhibits 5-12, 5-13, and 5-14**, were developed to show relationships between precipitation and non-pumping water levels. The location of the wells can be seen on **Exhibit 5-9**. Precipitation was plotted using data taken from the NOAA station at the Bremerton Fire Station. Although precipitation gages exist nearer to two of the examined wells, the Bremerton data was presented for each well because over the period of record the precipitation data is more complete at Bremerton. It should be pointed out that the magnitude of precipitation is different at local gages that are relatively close to the wells (i.e.: 1991-1996 water year precipitation averages at Bremerton, Grovers Creek and Bloedel Reserve precipitation stations were 56.6, 39.4 and 37.7 inches per year respectively).

Precipitation was plotted three different ways: 1) as annual precipitation over a water year, 2) effective precipitation for a water year, and 3) monthly effective precipitation. Annual precipitation over a water year is the total precipitation recorded at the Bremerton Fire Station for the water year. The water year convention is used because it reasonably correlates with local natural climatic variations of wet and dry seasons. Water year refers to the time period beginning on October 1st of a year and ending on September 30th of the following year (e.g., water year 1991 began on October 1, 1990 and ended on September 30, 1991). The long-term average water year precipitation for the period 1952 to 1996 was 52.1 in/yr at the Bremerton Fire Station.

Effective precipitation as used herein is the total precipitation minus evapotranspiration. Effective precipitation is therefore the amount of rainfall that is potentially available to surface and ground water systems. The term total inflow is also used for effective precipitation. For this discussion, all rainfall from June to September is assumed to be lost to evapotranspiration. Thus, only a percentage of the precipitation during the "wet" season is included for effective precipitation. The depletion of soil moisture content, assumed in this analysis to be 5 inches, is factored into and shown graphically as a linear accumulative progression of 1 inch per month for each month from June to September (totaling 5 inches by the end of October). The first 5 inches of rainfall after October 1 are taken up as soil moisture recharge.

Production data is included in **Exhibits 5-12 and 5-14** for comparison with the water-level hydrographs and precipitation trends. The production data indicates that for each well the annual production rate has been fairly uniform over the period of record shown. On a month to month basis the production data shows the typical pattern of relatively low production in the winter months and higher production rates during summer months when there is greater demand due to irrigation.

Exhibit 5-12 presents data for KPUD's Eldorado Hills Well 4 (AAB471) located in T25N/R1E-31B in the Chico subarea. The well is completed at an elevation of +301 to +311 feet MSL in an as yet unnamed perched aquifer. The water levels suggest a strong correlation with annual and effective precipitation. For Example, between 1992 and 1994, when rainfall was below normal, water levels declined approximately 6 feet. In 1995 during a period of above normal rainfall, water levels rose approximately 4 feet. During the period of record, in-well production has generally been increasing, yet water levels have risen in 1995.

Exhibit 5-13 shows data for Island Center Well (AAA110) located in T25N/R2E-21G in the Bainbridge Island subarea. The well is completed at an elevation of -83 to -98 feet

MSL, possibly in the sea level zone of the Wardwell Aquifer System. The water levels suggest a strong correlation with seasonal precipitation variations with a several month time lag. The onset of effective precipitation each year is reflected in rises in water levels, and the declines in water levels correlate with the periods of no effective precipitation. This hydrograph illustrates the rapid response in water levels to precipitation trends typical for some aquifers in Kitsap County. The seasonal variations in water levels seen in this well could also be influenced by seasonal production trends. Since no production data is available for this well, the effect of pumping can not be evaluated.

Exhibit 5-14 shows data for KPUD's Ritter Lane Well (AAA015) which is located in T27N/R2E-29J in the Port Gamble subarea. The well is completed at an elevation of -102 to -159 feet MSL in the Port Gamble South Aquifer. The water level data for this well shows a "noisy" record, probably because many of the static water levels are effected by recovery from recent well pumping. Despite the variable data, the overall water level trend suggests a general correlation with annual and effective precipitation. The rise from early 1990 to early 1991, and the subsequent overall downward pattern until a rise in 1995, are correlative to precipitation trends. The annual in-well production increased from 1990 to 1994, and since 1994 has remained fairly steady. Despite production variations, the water levels appear to respond to long-term precipitation trends and not pumping trends.

The reader is encouraged to look through other hydrographs in Appendix H for wells which have accompanying production data. As in the above examples, a significant number of hydrographs show water level trends which may be contrary to in-well production trends and can be intuitively correlated with wetter or dryer water years. Even without the benefit of comparing local precipitation data to water levels, an appreciation of the importance of precipitation to recharge can be seen.

5.10 Water Quality

Water quality concerns in Kitsap County were assessed by assembling five water quality databases into a single "study database," and evaluating the geographic occurrence of selected water quality parameters. The databases are individually associated with specific ground water sampling programs, and vary with regard to water quality parameters analyzed and the number of sampling events per well. The table below summarizes the databases compiled for this analysis. Most of the ground water analyses were based on a single sampling event. Time series analyses were not performed as part of this water quality assessment, although data series based on multiple sampling events have been evaluated in other reports. Discussions of existing time-series analyses are included in this section.

Data Source	Sampling Program	Number of Wells	Number of Samples	Analytical Parameters
Kitsap PUD	private well sampling program	~1,000	~1,000	conductivity, nitrate, iron, manganese, temperature, pH, BacT
Bremerton-Kitsap County Health Department	new wells (building permit requirements)	~1,000	~1,000	iron, manganese, conductivity, chloride, nitrate, coliform bacteria
USGS	Bainbridge Island Study	46	~400	chloride
USGS WATSTORE (1988 database dump)	various programs	unknown	~3,000	various parameters
Kitsap County Ground Water Management Plan	wet season/ dry season sampling of purveyors wells	67	134	State drinking water organic, inorganic, and bacterial required analyses

The County's ground water is generally of good quality and suitable for most purposes. A comparison of reported water quality results (from the study database) to State drinking water standards was performed and is summarized in **Exhibit 5-26**. With only a few exceptions, most of the water sampled was within State drinking water standards for the constituents evaluated. Standards for iron and manganese were frequently exceeded, as is expected for glacial aquifers of western Washington. Appendix J contains summaries of water quality problems associated with the various National Priority List and Superfund and other hazardous waste sites in the county.

Water quality parameters that are commonly measured and are useful in evaluating ground water quality on a regional basis are chloride, specific conductance, nitrate, iron and manganese. Geographic distribution plots were prepared for each of these parameters. Chloride and specific conductance are commonly used as indicators of seawater intrusion (specific conductance is a measure of total dissolved solids). High concentrations of nitrate typically indicate contamination from sewage, animal wastes, and/or fertilizer applications. Iron and manganese occur from natural sources, and can compromise aesthetic qualities of water at higher concentrations.

Exhibit 5-15 is a geographic distribution plot showing the locations of sampled wells in the study database. Nearly all of these wells were sampled for the five parameters discussed above. Geographic distribution plots are shown in **Exhibits 5-16, 5-17, and 5-18** for chloride, specific conductance, iron and manganese, and were prepared by plotting the location of wells with analyte concentrations above selected cutoff limits. Where individual wells were sampled multiple times, as in the United States Geological Survey (USGS) Bainbridge Island Study, the maximum recorded value was plotted. Concentration values are displayed on the plots adjacent to the well symbols.

5.10.1 Chloride

Chloride concentrations are plotted for samples with over 50 mg/l on **Exhibit 5-16**. The State drinking water maximum contaminant level (MCL) is 250 mg/l, above which water begins to taste salty. Concentrations of 50 mg/l (Dion et. al., 1994) and 100 mg/l (Sinclair & Garrigues, 1994 and Dion & Sumioka, 1984) have been proposed as a threshold for identifying seawater intrusion. Non-intruded ground water typically contains 30 mg/l or less, while chloride concentrations in highly-intruded ground water can approach 19,000 mg/l, the average concentration of seawater (Hem, 1985; Sinclair & Garrigues, 1994). The majority of wells sampled in the study database (87 percent) had maximum chloride concentrations of 10 mg/l or less.

Based on the chloride data, seawater intrusion does not appear to be a serious (or extensive) problem in Kitsap County. **Exhibit 5-16** shows only 11 wells, out of 752 sampled with chloride concentrations above 100 mg/l. Some of these wells are located along the coast and are most likely affected by localized seawater intrusion. Examples include relatively high chloride concentrations near Eglon (1425 mg/l), west of Winslow (351 mg/l), and near Jefferson Beach (270 mg/l). Relatively high chloride concentrations, however, are also found in inland locations such as near Panther Lake and one mile west of Miller Bay. The apparent lack of correlation between high chloride concentrations and distance from the coast may partly be related to the fact that the distribution plot does not distinguish between completion aquifers of wells. High chloride concentrations in aquifers not coupled with coastal water can be due to connate or stagnant waters. More extensive analysis would be required to postulate a cause of high chloride concentrations in inland locations.

5.10.2 Electrical Conductivity

Electrical conductivity (EC) values are plotted for samples which measured over 250 umhos/cm on **Exhibit 5-16**. EC is commonly used as a measure of total dissolved solids (TDS). In ground water, the primary contributors to TDS typically include calcium, magnesium, sodium, bicarbonate, sulfate, chloride and silica. Water with high TDS can corrode plumbing, may taste bad, and can have laxative affects. People on salt restricted diets are warned to avoid water with high TDS due to the potential for high sodium content. High TDS (i.e. high EC) can occur in ground water from a number of sources, including seawater intrusion. EC is a less accurate indicator of seawater intrusion than chloride, however, because a variety of constituents may be responsible for high values. A comparison between EC values and chloride concentrations for samples in the study database revealed a poor correlation between the two constituents. For this reason, selection of an empirical EC threshold for identifying seawater intrusion (e.g., correlative with 100 mg/l chloride) was not possible. The State (secondary) drinking water MCL for electrical conductivity is 700 umhos/cm, based on aesthetic (rather than health) considerations. Seawater, in comparison, measures approximately 50,000 umhos/cm.

The geographic distribution of electrical conductivity values **(Exhibit 5-16)** shows that samples with EC values exceeding 250 umhos/cm most commonly occur in wells along the coast. This pattern appears to be directly associated with freshwater/seawater relationships that occur along the margins of coastal aquifers. Although EC values of 250 umhos/cm are not indicators of seawater intrusion, their occurrence along the coast suggests that they are associated with the zone of diffusion (mixing zone) which forms a transition between fresh ground water flowing towards the sea and underlying seawater. Higher EC values, some of which occur in similar locations to high chloride values, may be indicators of localized seawater intrusion. Similar to chloride, high EC values are not limited to coastal locations. Particularly high EC values (e.g., greater than or near 1,000 umhos/cm) occured in 5 of the 776 wells sampled, at locations near Jefferson Point, along Fletcher Bay (on Bainbridge Island), northeast of Four Corners, near Panther Lake, and west of Wildcat Lake.

5.10.3 Nitrate

The geographic distribution of nitrate can reflect the occurrence of ground water contamination from sewage, animal waste, industrial waste, and/or nitrogen rich fertilizers. The State primary drinking water MCL for nitrate (N) is 10 mg/l. Concentrations above this limit can inhibit the oxygen-carrying capacity of blood and may cause methemoglobinemia (blue baby syndrome) in infants. Precipitation typically contains between 0.3 and 2.5 mg/l, although coastal areas commonly show values between 0.15 and 0.5 mg/l (Matthess, 1982). Concentrations above typical rainfall values are often considered to be impacted by human (or animal waste) sources of contamination. For the purpose of this analysis, nitrate concentrations above 4 mg/l will be treated as indicators of contamination, and concentrations above 10 mg/l will be highlighted as cause for special concern.

Nitrate concentrations are plotted for samples with over 2.5 mg/l on **Exhibit 5-17**. The exhibit shows that fourteen wells (out of 765 wells sampled for nitrate) had concentrations exceeding 4 mg/l and four wells had concentrations exceeding 10 mg/l. The well locations are scattered throughout the County, and do not appear to be associated with higher concentrations of population. The "spotty" distribution of samples with nitrate concentrations above 2.5 mg/l (relative to all wells sampled for nitrate) reflects the localized nature of nitrate contamination. Localized contamination is a typical mode of occurrence for high nitrate concentrations. This is likely a function of the localized nature of sources, dilution over the ground water flow path, and (possibly) microbial degradation in organic rich sediments.

The geographic representation of nitrate concentrations shown on **Exhibit 5-17** does not distinguish between the source aquifers of ground water samples. High nitrate concentrations are considered more likely in shallow aquifers due to surficial (or shallow sub-surface) sources of contamination. A comparison between nitrate concentration and well depth did not show any visible correlations (nor did nitrate concentration versus well completion elevation). Conclusions could not be drawn as to whether the local occurrences of nitrate contamination in the County are restricted to shallow aquifers.

5.10.4 Iron and Manganese

Iron and manganese are commonly occurring constituents of ground water in western Washington. They are derived naturally from the weathering of minerals within the ground water flow system. Although manganese is much less abundant than iron in rocks and minerals, the two are similar in chemical behavior and are frequently found in association. The solubility of iron and manganese is strongly influenced by the pH and oxidation state of ground water. Dissolved iron and manganese are typically limited to trace concentrations in oxygenated ground water, but occur at significant concentrations under reducing conditions. Anthropogenic ground water contamination which alters the pH and oxidation state of ground water (e.g., landfill leachate) can cause particularly high concentrations of iron and manganese. Iron and manganese are regulated as secondary (aesthetic) contaminants to drinking water, with MCL's of 0.3 mg/l and 0.05 mg/l, respectively. Concentrations above these MCL's are generally not considered health problems, but can encrust plumbing and stain laundry.

Iron concentrations are plotted for samples with over 0.3 mg/l on **Exhibit 5-18**. The exhibit shows that many wells within the County had iron concentrations exceeding the State MCL. The majority of these wells (92 percent) had concentrations below 1 mg/l. There is no apparent pattern to the locations of samples which exceeded the MCL, nor is there an apparent pattern to the locations of samples with relatively high (greater than 1 mg/l) iron concentrations. Iron concentrations were not differentiated by aquifer of occurrence, however an initial evaluation was made to determine whether iron was any more prevalent at identifiable depths or elevation zones. Comparison of iron concentration versus well depth (and well completion elevation) did not reveal any pattern in the vertical distribution of iron concentrations above the MCL.

Manganese concentrations are plotted for samples with over 0.05 mg/l on **Exhibit 5-18**. The exhibit shows that while exceedences of the manganese MCL are common, they are not as plentiful as exceedences of the iron MCL. It is worth noting that several areas which showed exceedences of the iron MCL (west of Dyes Inlet, the northern half of Bainbridge Island, south of Fernwood and the northernmost tip of the peninsula) did not show proportional exceedences of the manganese MCL. The majority of samples which exceeded the manganese MCL (93 percent) had concentrations below 0.2 mg/l. Similar to iron, there is no apparent pattern to the locations of samples which exceeded the MCL, nor is there an apparent pattern to the locations of samples with relatively high (greater than 0.2 mg/l) manganese concentrations. Differentiation of aquifers was not included as part of this manganese evaluation.

5.10.5 Time-Series Analyses

Long-term water quality monitoring is generally lacking in Kitsap County, however, several studies have made comparisons of selected water quality parameters over time. The USGS Bainbridge Island study evaluated long-term trends in chloride concentration in 26 wells based on four sampling events between 1967 and 1985. The study also evaluated seasonal trends by monitoring chloride in 22 observation wells on a monthly basis between October 1984 to September 1985. In both cases, the USGS found no significant changes in chloride concentration over the periods of record. The study notes, however, that seawater intrusion constitutes a potentially serious threat to the ground water resources of the island; and suggests that water levels and chloride concentrations should be monitored on a continuing basis. This conclusion is equally true for the rest of the County, which has a similar hydrogeologic framework.

Seawater intrusion (and partial recovery) was documented at the Bangor Submarine Base during construction of the Delta Pier. The Bangor Aquifer System was temporarily dewatered and the resulting water level declines and seawater intrusion were monitored. Following completion of construction, the dewatering wells were turned off and chloride concentrations returned to near-background levels in most wells. The relatively quick reduction of chloride concentrations (in all but one well) may have been aided by diversion of part of the dewatering discharge to an injection well upgradient which could have provided additional "flushing" of the aquifer system. Changes to the flow system, associated with increased withdrawals and ground water discharge from deep "pressure relief" wells, may account for the continued elevated chloride concentrations in the single well.

Time series evaluation of water quality data from Kitsap County was performed as part of the Kitsap County GWMP in 1991. The analysis employed water quality data provided by the EPA (including data from the USGS and from Group A wells), by Ecology (Group A wells), by DOH (Group A and B wells), and by the BKCHD. The data generally ranged from the late 1970s to the late 1980s, although data from the early 1970s were available in some cases. Volumes I and II of the GWMP designated the five sub-areas (Hansville-Indianola, Bainbridge Island, Poulsbo-Bremerton, West Kitsap, and South Kitsap) for which water quality data were plotted on a quarterly basis for trend analysis. Data from multiple wells were plotted (individual wells were not distinguished), although in many cases time series data were available for only one well within a given subarea. Trend analyses were performed for a number of major inorganic and trace metal constituents. The trend analyses were based on statistical regressions of all available quarterly data. Data collected at known ground water contamination sites were not included in the trend analyses, which were intended to reflect trends in regional (background) conditions rather than localized, discrete areas. In general, the analyses found no significant trends in any of the indicator parameters evaluated. Very few observations above MCL's were found, with the exception of naturally occurring iron and manganese.

Exhibit 5
Conceptual Hydrologic Cycle for Kitsap County

Precipitation (PPT)

The average annual rainfall for Kitsap County is 48"
The rain shadow from the Olympic Mountains is the reason for the 26–68" range of average rainfall. On average, 316,000,000,000 gallons rain fall on Kitsap County yearly.

Evapotranspiration (ET)

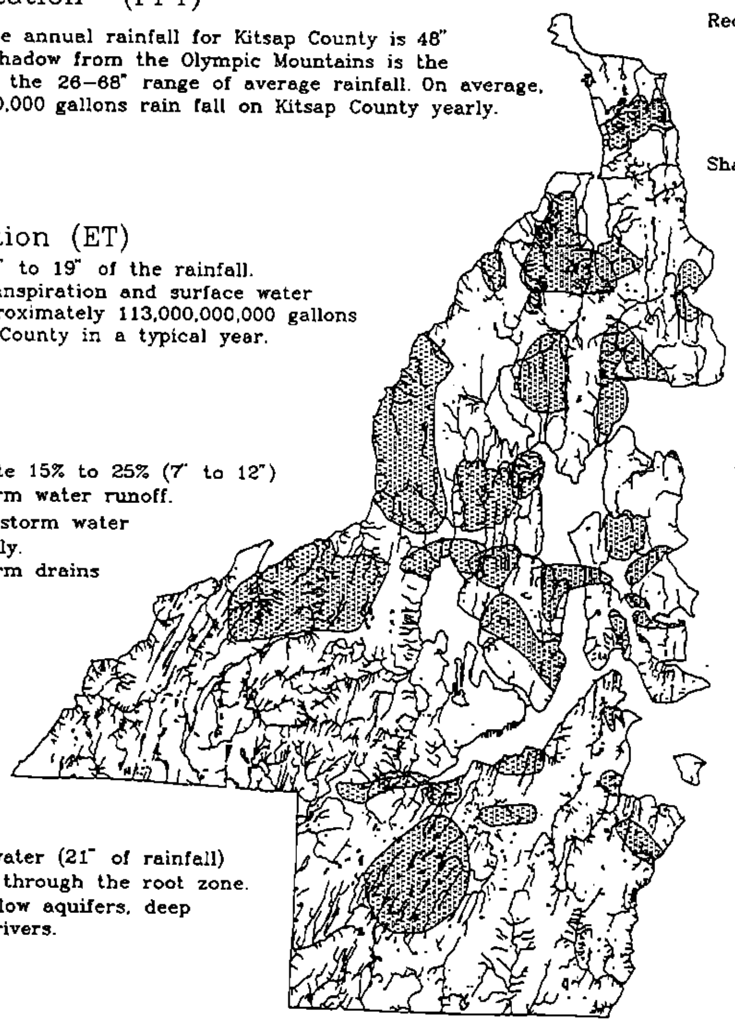
The range of ET is 14" to 19" of the rainfall.
Between vegetation transpiration and surface water body evaporation, approximately 113,000,000,000 gallons of water leave Kitsap County in a typical year.

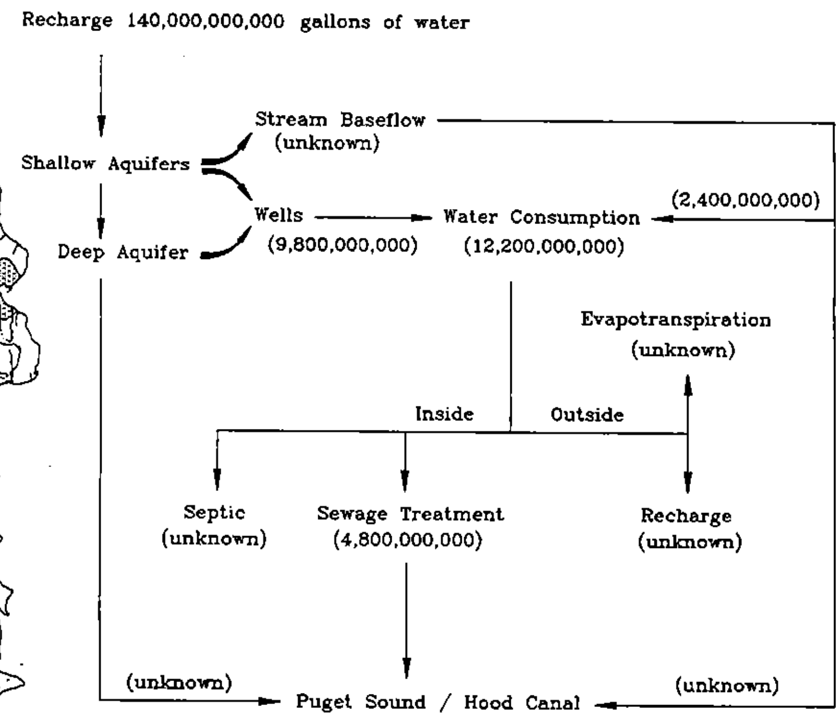
Storm Water Runoff

Studies in the Puget Sound Area indicate 15% to 25% (7" to 12") of rainfall passes quickly to sea as storm water runoff.
Approximately 63,000,000,000 gallons of storm water runs off the County's land mass annually.
The split in storm water runoff via storm drains verses streams is <u>unknown</u>.

Recharge

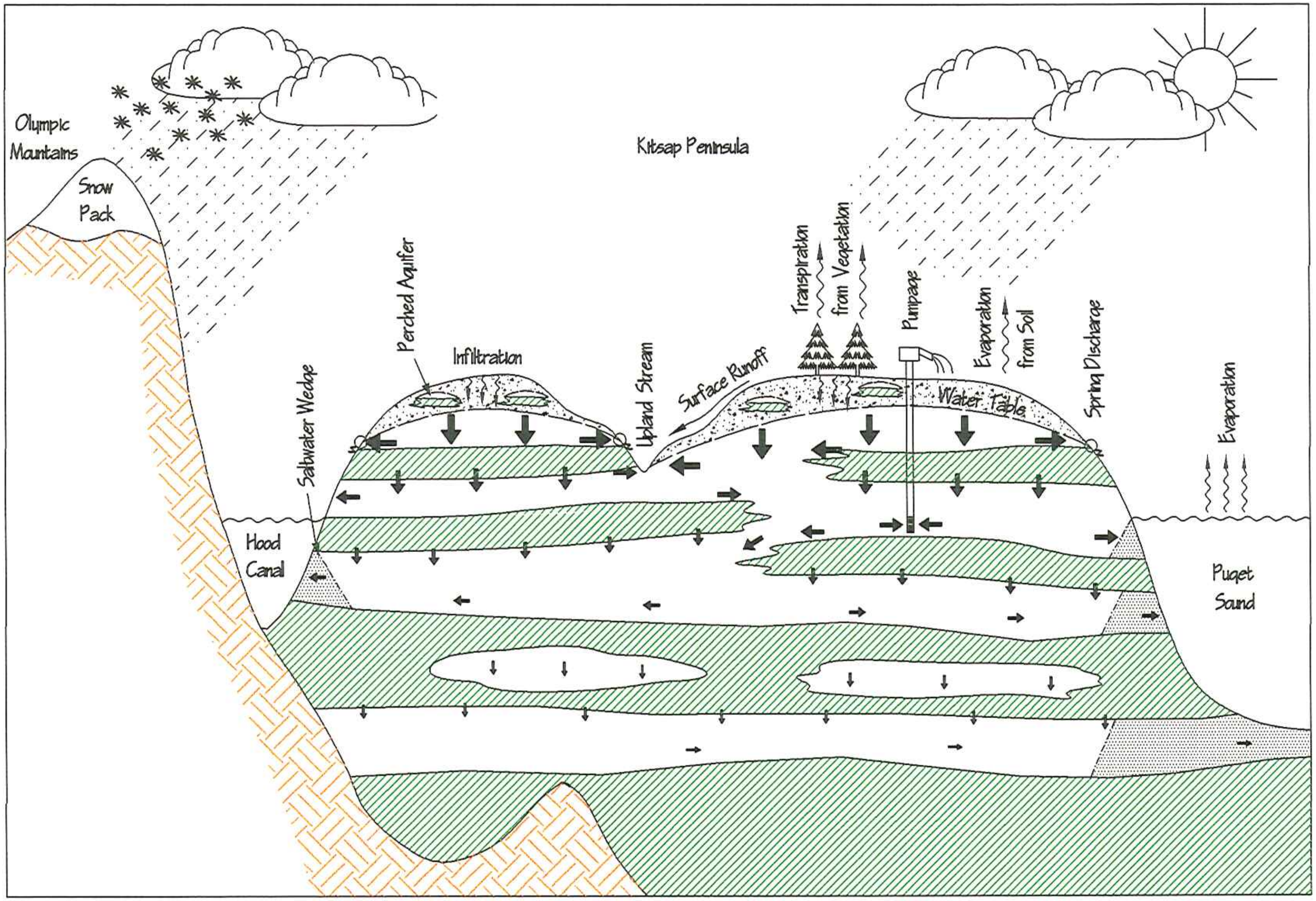
Approximately 140,000,000,000 gallons of water (21" of rainfall) annually inflitrates in the soil and passes through the root zone. This provides the source of water for shallow aquifers, deep aquifers, and base flows for streams and rivers.





Water Consumption

1995 Consumption is estimated at 12,200,000,000 gallons
2020 Consumption is projected at 15,000,000,000 gallons



LEGEND

Unsaturated Zone
Aquifer
Aquitard
Bedrock
Zone of Saltwater Intrusion
Ground Water Flow (symbol size indicates relative amount of flow)

Exhibit 5-1A
Conceptual Hydrogeologic Model of Kitsap County

Kitsap County
Initial Basin Assessment

Unit	This Study	Suggested Regional Correlation
Qn1	Recent alluvium and peat deposits younger than Vashon.	Quatemary alluvium
Qg1	Vashon glacial till	Vashon till
Qgla	Vashon advance deposits	Vashon advance outwash Colvos sand, Esperance sand
Qn2	First interglacial deposits	Unnamed deposits below the Lawton Clay (Mullineaux, 1965)
Qg2	Second glacial deosits (Mid-cliff drift)	Possession Drift (Easterbrook, 1968)
Qn3	Second interglacial deposits	Whidbey Formation (Easterbrook, 1968) Kitsap Formation (Garling and others, 1965)
Qg3	Third glacial deposits (Sea level drift)	Double Bluff Drift (Easterbrook, 1968)
Qn4	Third interglacial deposits	Uncertain
Qg4	Fourth glacial deposits	Uncertain
Qg4m	Marine/glaciomarine deposits	Uncertain
Qn5	Fourth interglacial deposits	Uncertain
Qg5	Fifth glacial deposits	Uncertain
Qn6	Ancient non-glacial Pleistocene deposits	Uncertain
Tb	Blakeley Formation (Tertiary)	Blakeley Formation (Weaver, 1912)
Tv	Volcanic Rocks (Tertiary) (Arnold, 1906)	Crescent Formation (?)

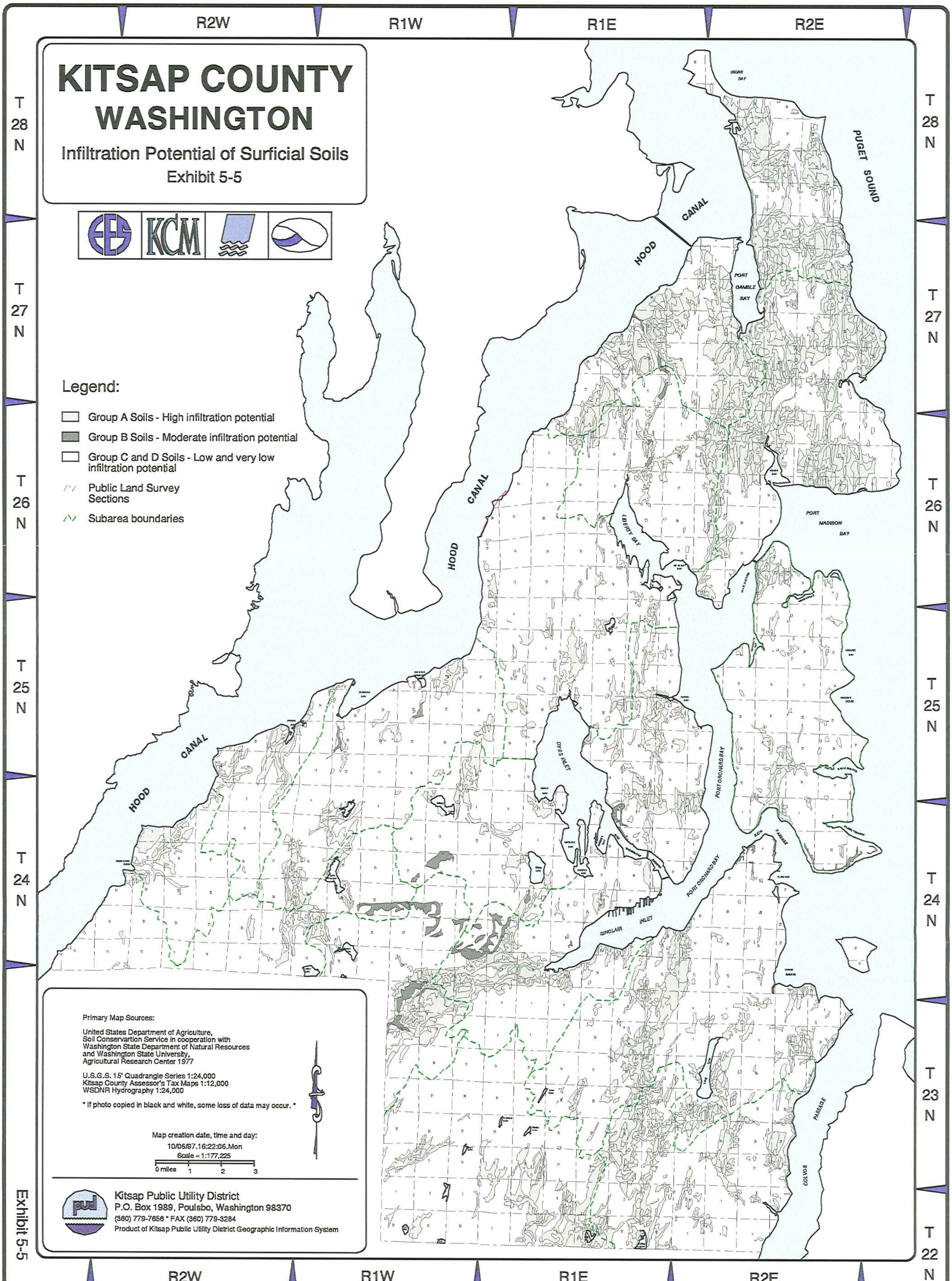
EXHIBIT 5-1B

Nomenclature and Regional Correlation of Stratigraphy

Kitsap County Principal Aquifers				
Aquifer	Subarea	Hydrogeo Units	Approx. Elevations (1)	Aquifer Transmissivity (2)
Hansville	Hansville	Qg1a	250	440
Kingston System	Kingston	Qg3/Qg4/Qg5	-25 / -240 / -600	10,000 - 80,000
Port Gamble South	Kingston	Qg2	-50	12,000
Port Gamble	Port Gamble	Qg1a	100	388,000
Edgewater	Port Gamble	Qg3	130	30,000
Suquamish-Miller Bay System	Kingston	Qg3	0	17,500 - 68,000
Poulsbo	Poulsbo	Qg3	225	170,000
Bangor System	Bangor	Qn3/Qg3/Qg4	-- / -50 / -200	9,000 - 244,000
Keyport	Bangor	Qg5/Qn6	-675	4,200 - 80,000
Island Lake	Bangor	Qg2/Qg3	150	50,000 - 250,000
Meadowmere	Bainbridge	Qg2	125	190,000
Wardwell System	Bainbridge	Qg3/Qg5	-75 / -650	20,000 - 60,000
Gilberton-Fletcher Bay System	Manette/Bainbridge	Qg4/Qg5	-300 / -850	5,000 - 39,000
Bucklin Hill	Bangor	Qg5	-400	3,000 - 56,000
Silverdale	Bangor	Qg4	0	3,500 - 18,000
Seabeck System	Seabeck	Qg3	100	32,000 - 164,000
Bayhead	Bainbridge	Qg3	0	3,000 - 15,000
Eagle Harbor	Bainbridge	Qg4/Qn5	-600	1,300 - 7,500
Lynwood Center	Bainbridge	Qg3	-25	4,400 - 15,000
Manette-N. Bremerton	Manette	Qg3	0	2,100 - 17,000
Clam Bay	Manchester	Qg3	0	1,400 - 21,000
Port Orchard Deep System	Manchester	Qg5	-650	6,200 - 8,000
Yukon	Manchester	Qg3	0	1,600 -2,700
Anderson Creek System	Gorst	Qg3/Qg4/Qg6	100 / -100 / -650	24,000 - 82,000
Gorst System	Gorst	Qg1a/Qg3/Qg4	Variable	25,000 - 110,000
Salmonberry	Manchester	Qg4	-150	3,000 - 18,000
Wilson Creek	Manchester	Qg2	150	71,000
North Lake	McCormick	Qg1a	300	56,000 - 135,000
Footnotes				
(1) Approximate elevation of the top of the Aquifer. Multiple elevations indicate multiple aquifers within a given aquifer system.				
(2) Transmissivity in gpd/ft from various sources including GWMP Vol. II, 1991. Refer to Appendix D.				

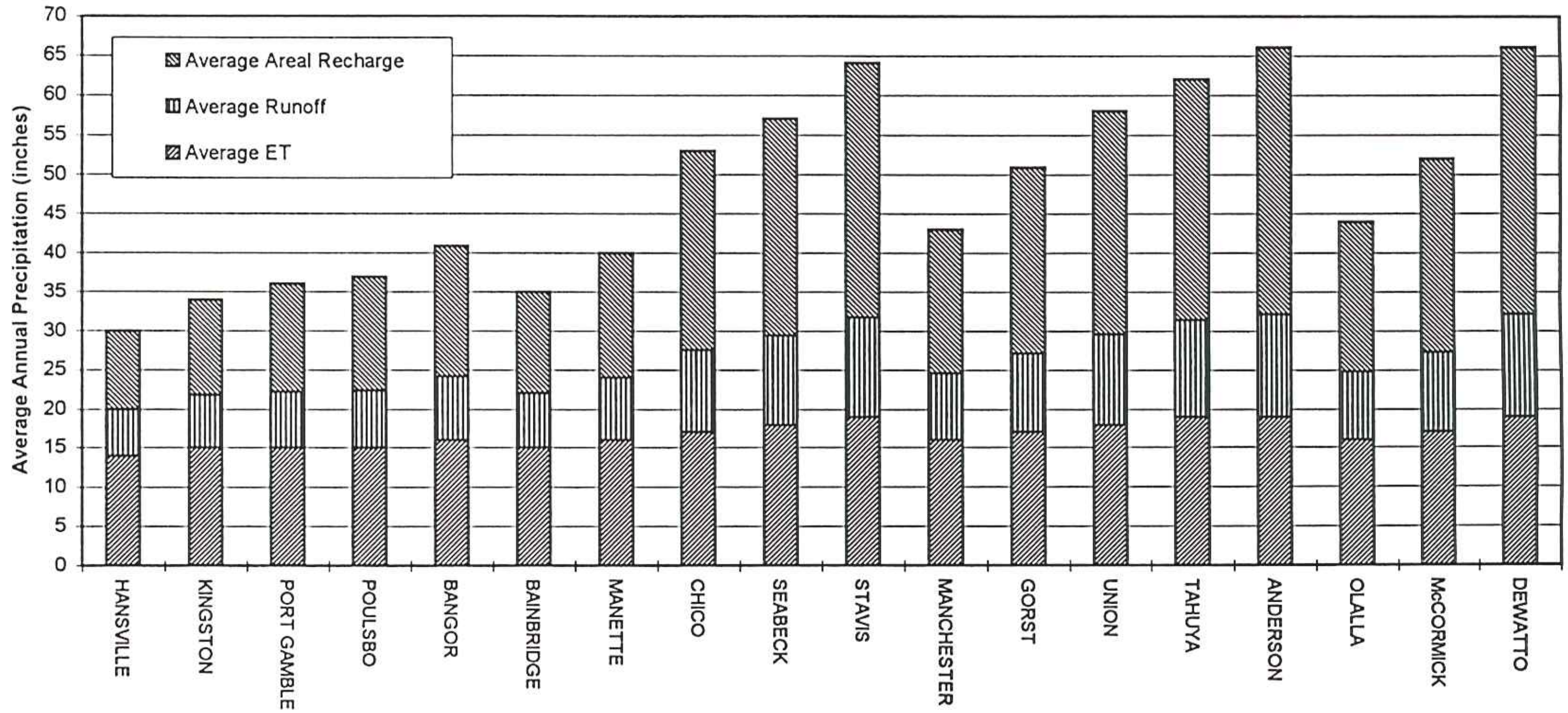
EXHIBIT 5-3

List of Principal Aquifers Identified in Kitsap County



KITSAP COUNTY
WASHINGTON
Infiltration Potential of Surficial Soils
Exhibit 5-5
Legend:
Group A Soils - High infiltration potential
Group B Soils - Moderate infiltration potential
Group C and D Soils - Low and very low infiltration potential
Public Land Survey Sections
Subarea boundaries
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
Primary Map Sources:
United States Department of Agriculture, Soil Conservation Service in cooperation with Washington State Department of Natural Resources and Washington State University, Agricultural Research Center 1977
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
WSDNR Hydrography 1:24,000
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
10/06/97.16:22:06.Mon
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 5-5

Distribution of Precipitation by Subarea



Note: Average Areal Recharge provides base flows for streams and recharge to aquifers.

Data Source: Pacific Groundwater Group, United States Geologic Survey, Robinson and Noble

Exhibit 5-6b
Distribution of Precipitation by Subarea

Kitsap County
Initial Basin Assessment

USGS ID	Station Name	Elevation (feet-MSL)	Drainage Area (mi^2)	Average otal Runoff (in)	Average Precip (in)	Total Runoff as % of Precip.
12063000	Union River near Bremerton	395	3.2	52	59	89%
12064500	Mission Creek near Bremerton	513	1.9	45	61	74%
12065500	Gold Creek near Bremerton	751	1.5	52	60	87%
12066000	Tahuya River near Bremerton	540	6.0	49	61	81%
12067000	Panther Creek near Bremerton	486	1.0	39	62	63%
12069550	Big Beef Creek near Seabeck	40	13.8	37	58	64%
12070000	Dogfish Creek near Poulsbo	20	5.0	24	37	65%
12072000	Chico Creek near Bremerton	50	15.3	30	53	56%
12072500	Blackjack Creek at Port Orchard	30	14.5	18	48	38%
12073000	Burley Creek at Burley	10	10.7	35	47	73%
	Barker Creek near Silverdale		4.0	14	41	33%
	Gorst Creek at Gorst		9.1	30	55	54%
	Clear Creek near Silverdale		8.1	19	44	43%

Notes:

* Average total runoff includes stormwater and baseflow to streams.

- Streamflow data sources include USGS records and KPUD files.
- Average precipitation values estimated from precipitation isohyetal map presented in Exhibit 3-1.

Exhibit 5-7

Total Runoff Statistics for Gaging Stations in Kitsap County

Kitsap County
Initial Basin Assessment

EXHIBIT 5-8 Table of Wells with Water Level Hydrographs - Sorted by Subarea

Hydrograph Page Number	Subarea	Principal Aquifer	Dept of Ecology Unique Site Identification Tag Number	Location by Township/ Range-Section	Owner and Well Name	Year Drilled	Approximate Site Elevation, ft MSL	Top of Completion Elevation, ft MSL	Initial water level elevation	Highest recorded water level elevation in Water Year 1991	Highest recorded water level elevation in Water Year 1996	Water level elevation at end of record if other than WY 1996	Apparent change in water level elevation from WY 1991 To WY 1996	Apparent change in water level elevation for all of record	Remark
1	Kingston	Suquamish-Miller Bay	AAA014	26N/02E-10N	KPUD Indianola #6	1983	175	-133	22	13	12		-1	-10	
2	Kingston	Not in a Principal Aquifer	AAA013	26N/02E-11P	Wise Acres	1982	236	-69	84	80	79		-1	-5	
3	Kingston	Suquamish-Miller Bay	AAA710	26N/02E-16L	KPUD Augusta #3	1986	58	-221	25	6	16		10	-9	
4	Kingston	Suquamish-Miller Bay	AAA715	26N/02E-17F	KPUD Waggoner	1986	280	32	87	84	83		-1	-4	
5	Kingston	Suquamish-Miller Bay	AAA713	26N/02E-20H	KPUD Pine St. #2	1985	303	-123	71	71	72		1	1	
6	Kingston	Suquamish-Miller Bay	AAA711	26N/02E-29H	KPUD Balzow	1982	121	-101	64	ND	60			-4	
7	Kingston	Port Gamble South	AAA016	27N/02E-20L	KPUD Gamblewood #1	1967	42	-87	35	35	37		2	2	
8	Kingston	Kingston	AAA011	27N/02E-35K	KPUD Kingston Observation Well	1988	120	-604	24	22	23		1	-1	
9	Kingston	Kingston	AAA012	27N/02E-35K	KPUD Kingston Well #5	1989	122	-623	24	22	21		-1	-3	
10	Kingston	Kingston	AAA106	26N/02E-10N	KPUD Kingston Well # 4	1984	166	-26	38	ND	36			-2	
11	Kingston	Kingston	AAA107	27N/02E-25E	KPUD Kingston Well #3	1980	217	-258	33	ND	30			-3	
12	Kingston	Port Gamble South/Port Gamble	AAA706	27N/02E-20L	KPUD Gamblewood Well #2	1976	43	-27	36	ND	35			-1	
13	Kingston	Kingston	AAA707	27N/02E-35K	KPUD Kingston Well #6	1992	120	-622	17	ND	19			2	WL records for WY 1992 to 1996
14	Kingston	Suquamish-Miller Bay	AAA716	26N/02E-08Q	KPUD Lincoln Road Well #1	1982	230	-338	46	ND	65			19	
15	Kingston	Suquamish-Miller Bay	AAA718	26N/02E-21L	Suquamish Shores Well	1968	128	-132	75	ND	73			-2	
16	Kingston	Not in a Principal Aquifer	AAA722	26N/02E-01Q	KPUD Jefferson Point Well	1992	171	-56	19	ND	16			-3	WL records for WY 1992 to 1996
17	Kingston	Kingston	AAB401	27N/02E-25E	KPUD Kingston Well #2	1975	263	-19	22	ND	20			-2	
18	Kingston	Suquamish-Miller Bay	AAB406	26N/02E-10R	KPUD Indianola Well #1A	1984	107	-164	29	9	10		1	-19	
19	Kingston	Not in a Principal Aquifer	AAB408	26N/02E-10Q	DOE Observation Well #2 in Indianola	1977	149	104	131	ND	131			0	
20	Kingston	Not in a Principal Aquifer	AAB454	26N/02E-20H	KPUD Dug Well near Suquamish	ND	ND	ND	98	ND	94			-4	WL records for WY 1995 to 1996 Data are depth of water
21	Kingston	Port Gamble South	AAB464	26N/02E-01C	Wolfle Elementary School Well	1951	140	-144	25	ND	38			13	Very limited data
22	Kingston	Kingston	AAC601	27N/02E-26A	KPUD Kingston Well #7	1994	282	-237	30	ND	31			1	WL records for WY 1994 to 1996
23	Kingston	Not in a Principal Aquifer	AAC720	27N/02E-16H	KPUD Hansville Highway Test Well	1993	303	-827	31	ND	34			3	WL records for WY 1993 to 1996
24	Kingston	Not in a Principal Aquifer	AAC864	27N/02E-23H	Schmid Water System Well	1987	335	-16	9	ND	7			-2	
25	Kingston	Kingston (?)	ACD385	26N/02E-01C	KPUD Newellhurst Well #2	1977	123	-389	22	ND	20			-2	Very limited data
26	Port Gamble	Not in a Principal Aquifer	AAA104	26N/01E-04B	KPUD Vinland View #2	1985	334	-314	43	43	42		-1	-1	
27	Port Gamble	Edgewater	AAA103	27N/01E-27J	KPUD Edgewater #4	1987	290	130	192	184	183		-1	-9	
28	Port Gamble	Edgewater	AAA102	27N/01E-27J	KPUD Edgewater #3	1979	209	-112	116	118	117		-1	1	
29	Port Gamble	Port Gamble/Port Gamble South	AAA015	27N/02E-29J	KPUD Ritter Lane	1990	163	-102	66	67	65		-2	-1	
30	Port Gamble	Not in a Principal Aquifer	AAA996	26N/02E-06C	Sundquist Well	1989	240	69	153	ND	149			-4	
31	Port Gamble	Port Gamble	ABB943	27N/02E-19Q	KPUD Port Gamble Production Well #1	1994	235	-110	49	ND	50			1	WL records for WY 1994 to 1996
32	Poulsbo	Not in a Principal Aquifer	AAA398	26N/01E-09K	Nardo Domestic Well	1978	387	284	300	ND	303			3	
33	Poulsbo	Not in a Principal Aquifer	AAB254	26N/01E-02L	City of Poulsbo Big Valley Well #1	1976	80	-222	80	67	ND	64	-3	-16	WL records end in early WY 1995
34	Poulsbo	Poulsbo	AAB481	26N/01E-13B	City of Poulsbo Lincoln Road Well	1967	373	75	260	250	ND	258		-2	WL records end in WY 1995
35	Poulsbo	Poulsbo	AAB482	26N/01E-13F	City of Poulsbo Pugh Road Well	1988	403	123	248	245	243		-2	-5	
36	Poulsbo	Not in a Principal Aquifer	AAC682	26N/01E-02L	City of Poulsbo Big Valley Well #2	1993	80	-374	62	ND	ND	66		4	WL records for WY 1993 to 1995
37	Poulsbo	Not in a Principal Aquifer	AAC899	26N/01E-03P	Highland View Well	1989	373	85	151	ND	ND	151		0	WL records end in WY 1995
38	Bangor	Keyport	AAA002	25N/01E-02K	KPUD Keyport Production # 2	1988	230	-698	40	38	38		0	-2	
39	Bangor	Keyport	AAA001	25N/01E-36M	KPUD Keyport Production #1	1975	8	-694	38	34	33		-1	-5	
40	Bangor	Silverdale	AAA728	25N/01E-22F	Silverdale WD Selbo Rd Well	1975	103	-39	28	46	48		-2	-20	Data are depth of water
41	Bangor	Silverdale	AAA729	25N/01E-16J	Silverdale WD Chena Well 2	1985	203	-48	112	104	106		-2	6	Data are depth of water
42	Bangor	Silverdale	AAA730	25N/01E-20C	Silverdale WD Provost Well	1963	190	-56	132	119	144		-25	-12	Data are depth of water
43	Bangor	Silverdale	AAA731	25N/01E-19H	Silverdale WD Dickey School Well	1978	371	-129	315	318	311		7	4	Data are depth of water
44	Bangor	Not in a Principal Aquifer	AAA732	25N/01E-19L	Silverdale WD Wixon Well	1990	536	-229	481	484	468		16	13	WL records for WY 1992 to 1996 Data is depth of water
45	Bangor	Not in a Principal Aquifer	AAA733	25N/01E-29D	Silverdale WD Hess Well	1979	166	-341	110	107	110		-3	0	Data are depth of water
46	Bangor	Island Lake	AAA734	25N/01E-03B	Silverdale WD Spirit Ridge Well #4	1985	372	82	165	178	177		1	-12	Data are depth of water
47	Bangor	Bangor	AAA735	25N/01E-05J	Silverdale WD Dawn Park Well	1968	239	42	158	164	163		1	-5	Data are depth of water
48	Bangor	Not in a Principal Aquifer	AAA736	25N/01E-18H	Silverdale WD Westwind Well	1991	329	-421	268	268	271		-3	-3	Data are depth of water
49	Bangor	Silverdale	AAA746	25N/01E-16R	Silverdale WD Chena Well #1	1963	197	-8	99	117	120		-3	-21	Data are depth of water
50	Bangor	Not in a Principal Aquifer	AAA747	25N/01E-15D	Silverdale WD Ridgetop Well	1991	313	-484	269	269	274		-5	-5	Data are depth of water
51	Bangor	Island Lake	AAA748	25N/01E-10N	Silverdale WD Bucklin Ridge Well	1976	315	-154	214	215	227		-12	-13	Data are depth of water
52	Bangor	Island Lake	AAA749	25N/01E-10D	Silverdale WD Island Lake Well	1985	420	145	219	233	232		1	-13	Data are depth of water
53	Bangor	Bangor	AAB572	25N/01E-07A	Silverdale WD Frontier Wood Well	1993	305	31	231	ND	220			11	WL records for WY 1993 to 1996 Data are depth of water
54	Bangor	Not in a Principal Aquifer	AAC006	25N/01E-35D	Lundberg Domestic Well	ND	130	ND	121	ND	124			3	WL records for WY 1994 to 1996

EXHIBIT 5-8 (cont.) Table of Wells with Water Level Hydrographs - Sorted by Subarea

Hydrograph Page Number	Subarea	Principal Aquifer	Dept. of Ecology Unique Site Identification Tag Number	Location by Township/ Range-Section	Owner and Well Name	Year Drilled	Approximate Site Elevation, ft MSL	Top of Completion Elevation, ft MSL	Initial water level elevation	Highest recorded water level elevation in Water Year 1991	Highest recorded water level elevation in Water Year 1996	Water level elevation at end of record if other than WY 1996	Apparent change in water level elevation from WY 1991 To WY 1996	Apparent change in water level elevation for all of record	Remark
55	Bangor	Bangor (?)	AAC454	26N/01W-36Q	John Farbank Domestic Well	1976	133	-6	20	ND	ND	17		-3	WL records end in WY 1995
56	Bangor	Bangor	AAC607	25N/01E-06L	KPUD Cougar Valley Elem. School Well	1988	330	-44	40	ND	36			-4	
57	Bangor	Bangor	AAC639	26N/01E-29N	Subase Bangor TH-7	1974	381	7	77	70	67		-3	-10	
57	Bangor	Bangor	AAC629	26N/01E-20R	Subase Bangor TH-9	1975	466	168	254	245	242		-3	-12	
57	Bangor	Bangor	AAC635	26N/01E-31B	Subase Bangor TH-11S	1976	356	86	92	86	85		-1	-7	
57	Bangor	Bangor	TH-11D	26N/01E-31B	Subase Bangor TH-11D	1976	356	-408	53	50	47		-3	-6	
58	Bainbridge	Meadowmeer	AAC826	25N/02E-09G	N. Bainbridge WC #1	1977	124	67	85	90	92		2	7	
59	Bainbridge	Meadowmeer (?)	AAA113	25N/02E-09K	N. Bainbridge WC #6	1979	57	-46	36	33	41		8	5	
60	Bainbridge	Meadowmeer	AAC832	25N/02E-11E	N. Bainbridge WC #8	1985	351	171	213	190	188		-2	-25	
61	Bainbridge	Gilberton-Fletcher Bay	AAA111	25N/02E-20K	KPUD Fletcher Bay Obs Well	1973	80	-850	27	ND	16			-11	
62	Bainbridge	Wardwell (?)	AAA110	25N/02E-21G	Island Center Test Well	1975	300	-83	104	103	101		-2	-3	
63	Bainbridge	Not in a Principal Aquifer	AAA239	25N/02E-22R	City of Bainbridge Is. High School #3	1980	266	75	139	137	136		-1	-3	
64	Bainbridge	Eagle Harbor	AAA109	25N/02E-34F	Island Utility Well 1 Deep	1988	144	-734	39	36	32		-4	-7	
65	Bainbridge	Not in a Principal Aquifer	AAA108	25N/02E-34F	Island Utility Monitor Well	1987	144	19	51	49	48		-1	-3	
66	Bainbridge	Not in a Principal Aquifer	AAA238	25N/02E-35J	Bill Point Water Co. #3	1974	139	-11	20	10	10		0	-10	
67	Bainbridge	Wardwell	AAA112	25N/02E-15J	Gail Cool - Meig's Farm Deep Well	1988	42	-935	32	ND	ND	16		-16	WL records end in WY 1995
68	Bainbridge	Not in a Principal Aquifer	AAB455	25N/02E-09G	No. Bainbridge Water Co. Well #9	1992	133	-1001	42	ND	18			-24	WL records for WY 1993 to 1996. Very limited data
69	Bainbridge	Meadowmeer	AAC447	25N/02E-16A	Meadowmeer Well #1	1961	231	98	ND	111	ND	111		0	WL records end in WY 1995
70	Bainbridge	Not in a Principal Aquifer	AAC606	26N/02E-33B	Bloedel Reserve Deep Well	1995	180	-1030	27	ND	28			1	WL records for WY 1995 to 1996
71	Bainbridge	Not in a Principal Aquifer	AAC759	26N/02E-33B	Bloedel Reserve Farm Well	ND	165	123	153	150	154		4	1	Much better than average data set for a shallow aquifer
72	Bainbridge	ND	SBWS #1	24N/02E-04A	South Bainbridge WS #1	ND	60	ND	42	42	ND	55		13	WL records end in WY 1994. Site ID 473615122324101
73	Bainbridge	ND	SBWS #3	24N/02E-04A	South Bainbridge WS #3	ND	20	ND	-18	-18	ND	-20		-2	WL records WY 1991 to 1994. Site ID 473622122324301
74	Bainbridge	ND	SBWS #6	24N/02E-04A	South Bainbridge WS #6	ND	40	ND	2	2	ND	-4		-6	WL records WY 1991 to 1994. Site ID 473623122324101
75	Bainbridge	ND	SBWS#7	24N/02E-04A	South Bainbridge WS #7	ND	100	ND	26	26	ND	22		-4	WL records for WY 1991 to 1992
76	Manette	Not in a Principal Aquifer	4737071223859	25N/01E-34A	Campbell Domestic Well	ND	115	ND	104	ND	106			2	WL records for WY 1994 to 1996
77	Chico	No Defined P.A. for Subarea	AAB471	25N/01E-31G	KPUD Eldorado Hills #4	1990	540	311	334	339	338		-1	4	
78	Chico	No Defined P.A. for Subarea	AAB476	25N/01E-31H	KPUD Eldorado Hills #3	1969	185	-135	111	89	90		1	-21	
79	Seabeck	Not in a Principal Aquifer	AAA114	24N/01W-06R	KPUD Camp David Well 1	1977	443	333	395	406	408		2	13	
80	Seabeck	Seabeck	AAC835	25N/01W-20Q	Seabeck Conference Center	1987	75	-54	43	ND	42			-1	
81	Seabeck	Seabeck	AAA232	25N/01W-21M	Guava Well 3	1977	239	-51	43	ND	41			-2	
82	Seabeck	Seabeck	AAA235	25N/01W-21P	KPUD Seabeck Well 1	1991	329	-90	60	60	60		0	0	
83	Seabeck	Seabeck	AAA005	25N/01W-22A	Big Beef TH-2	1980	33	-133	44	43	39		-4	-5	
84	Seabeck	Seabeck	AAC809	25N/01W-22C	Jan Smith Domestic Well	1984	137	-9	20	ND	19			-1	
85	Seabeck	Seabeck	AAC799	25N/01W-22E	KPUD Seabeck Well 2	1991	269	-50	45	45	43		-2	-2	
86	Seabeck	Seabeck	AAA003	25N/01W-24J	Harbor WC Greystone	1986	402	130	151	147	146		-1	-5	
87	Seabeck	Seabeck	AAA875	25N/01W-27G	Dlugosh Water System Well	1993	308	-22	47	ND	52			5	WL records for WY 1993 to 1996
88	Seabeck	Seabeck	AAA990	25N/01W-28C	KPUD Seabeck Well #3	1993	440	-70	74	ND	72			-2	WL records for WY 1993 to 1996
89	Seabeck	Seabeck	AAB274	25N/01W-26F	Woodland Heights Well	1991	535	294	328	ND	330			2	
90	Seabeck	Seabeck	AAB607	25N/01W-32E	Ellis Domestic Well	1992	276	-8	112	ND	122			10	WL records for WY 1993 to 1996
91	Seabeck	Seabeck	AAC318	25N/01W-15L	John Schold Domestic Well	1981	20	-65	23	ND	21			-2	
92	Seabeck	Seabeck	AAC377	25N/01W-25E	KPUD Newberry Hill Water Sys. Well #1	1994	502	-101	72	ND	71			-1	WL records for WY 1995 to 1996
93	Seabeck	Bangor (?)	AAC451	25N/01W-01A	Smith Domestic Well	1977	217	9	29	ND	ND	24		-5	WL records end in WY 1995
94	Seabeck	Seabeck	AAC547	25N/01W-21C	Collier Domestic Well	1993	40	-22	48	ND	50			2	WL records for WY 1993 to 1996
95	Seabeck	Seabeck	AAC707	25N/01W-34H	Dolen Domestic Well	1993	420	82	111	ND	114			3	WL records for WY 1993 to 1996
96	Seabeck	Seabeck (?)	AAC807	24N/01W-04M	KPUD Green Mt. Elem. School Well	1991	461	323	344	344	345		1	1	
97	Seabeck	Seabeck	ABC665	25N/01W-27G	Miguelo Water System Well	1993	434	14	65	ND	66			1	WL records for WY 1994 to 1996
98	Manchester	Wilson Creek	AAA119	23N/02E-11K	Harbor WC Southworth #2	1980	222	-1	206	188	ND	181		-25	WL records end in WY 1994
99	Manchester	Port Orchard Deep	AAA117	24N/01E-25Q	Annapolis WD #1-B	1965	111	-1018	77	68	ND	58		-19	WL records end in WY 1994
100	Manchester	Not in a Principal Aquifer	AAA118	24N/01E-36B	Annapolis WD Karcher Springs 16	1979	232	-29	146	ND	ND	131		-15	WL records end in WY 1994
101	Manchester	Clam Bay	AAB460	24N/02E-16K	Navy, Manchester #5	1988	22	-80	17	10	13		3	-4	
102	Manchester	Clam Bay	AAA120	24N/02E-16L	Manchester WD Watauga Beach #2	1988	65	-53	5	-3	5		8	0	
103	Manchester	North Lake	AAA639	23N/01E-10B	Banigan Domestic Well	1969	200	95	175	ND	183			8	WL records for WY 1992 to 1996
104	Manchester	Not in a Principal Aquifer	AAB483	24N/02E-22M	Manchester Water District Well #1	1988	60	-54	41	43	43		0	2	

EXHIBIT 5-8 (cont.) Table of Wells with Water Level Hydrographs - Sorted by Subarea

Hydrograph Page Number	Subarea	Principal Aquifer	Dept. of Ecology Unique Site Identification Tag Number	Location by Township/ Range-Section	Owner and Well Name	Year Drilled	Approximate Site Elevation, ft MSL	Top of Completion Elevation, ft MSL	Initial water level elevation	Highest recorded water level elevation in Water Year 1991	Highest recorded water level elevation in Water Year 1996	Water level elevation at end of record if other than WY 1996	Apparent change in water level elevation from WY 1991 To WY 1996	Apparent change in water level elevation for all of record	Remark
105	Manchester	Not in a Principal Aquifer	AAB486	24N/02E-29Q	Manchester Water District Well #4	1973	220	29	158	127	129		2	-29	
106	Manchester	Wilson Creek (?)	AAB487	23N/02E-10C	Manchester Water District Well #5	1971	320	16	174	169	168		-1	-6	
107	Manchester	Yukon Harbor	AAB488	24N/02E-33G	Manchester Water District Well #6	1979	185	-294	45	39	37		-2	-8	
108	Manchester	Yukon Harbor	AAB489	24N/02E-33G	Manchester Water District Well #7	1983	185	-291	47	38	38		0	-9	
109	Manchester	Wilson Creek	AAB490	23N/02E-10C	Manchester Water District Well #8	1985	358	149	204	198	198		0	-6	
110	Manchester	Wilson Creek	AAB491	23N/02E-10C	Manchester Water District Well #9	1987	350	77	211	207	207		0	-4	
111	Manchester	Not in a Principal Aquifer	AAB492	24N/02E-21B	Manchester Water District Well #10	1988	220	-109	50	51	53		2	3	
112	Manchester	Not in a Principal Aquifer	AAB493	24N/02E-21B	Manchester Water District Well #11	1989	220	-34	102	100	95		-5	-7	
113	Manchester	Not in a Principal Aquifer	AAC824	23N/02E-15R	KPUD Driftwood Cove Well 2	1990	360	236	268	268	273		5	5	
114	Manchester	Salmonberry	ABV298	23N/01E-01K	KPUD Salmonberry Monitor Well	1995	340	-530	102	ND	102			0	WL records for WY 1995 to 1996
115	Manchester	Port Orchard Deep (?)	PO#6	24N/01E-25E	City of Port Orchard Well #6	ND	20	ND	6	6	7		2	2	Converted from pressure gage readings. Site ID 473227122373701
116	Manchester	Port Orchard Deep	PO#7	24N/01E-26K	City of Port Orchard Well #7	1962	20	-759	22	20	42		5	46	Converted from pressure gage readings. Site ID 473223122382201 Large anomaly in record
117	Manchester	Salmonberry	PO#8	23N/01E-02M	City of Port Orchard Well #8	1986	250	-180	104	100	99		1	5	Data are depth to water
118	Gorst	Gorst	AAC857	23N/01W-02F	City of Bremerton BR-7	1989	268	207	40	ND	ND	39		1	Used WL records in WY 92 to 95 Data are depth of water
118	Gorst	Gorst	AAA775	24N/01W-36R	City of Bremerton BR-9	1992	240	199	55	ND	ND	50		5	Used WL records in WY 93 to 95 Data are depth of water
118	Gorst	Gorst	AAC858	23N/01W-02B	City of Bremerton OTL	ND	262	148	45	ND	ND	37		8	Used WL records in WY 93 to 95 Data are depth of water
118	Gorst	Gorst	AAC856	23N/01W-02A	City of Bremerton BR-6	1989	316	213	84	ND	ND	85		-1	Used WL records in WY 91 to 93 Data are depth of water
118	Gorst	Gorst	AAB913	24N/01W-36R	City of Bremerton Well 15	1980	200	-68	1	ND	ND	23		-22	Used WL records in WY 92 to 95 Data are depth of water
118	Gorst	Gorst	AAB914	24N/01W-36R	City of Bremerton Well 17	1982	200	-58	0	0	ND	2		-2	Used WL records in WY 91 to 95 Data are depth of water
118	Gorst	Gorst	AAC845	24N/01W-35R	City of Bremerton Well 18, at Twin Lks	1988	279	59	36	36	ND	34		2	Used WL records in WY 91 to 95 Data are depth of water
118	Gorst	Gorst	AAB919	24N/01W-36R	City of Bremerton Well 19	1988	220	62	10	10	ND	15		-5	Used WL records in WY 91 to 95 Data are depth of water
118	Gorst	Gorst	AAB690	23N/01W-01B	City of Bremerton Well 16	1981	335	-35	120	120	ND	115		5	Used WL records in WY 91 to 95 Data are depth of water
118	Gorst	Gorst	AAB921	24N/01W-35R	City of Bremerton Well 20, at Twin Lks	1990	276	68	32	32	ND	21		11	Used WL records in WY 91 to 95 Data are depth of water
119	Gorst		AAC774	23N/01W-01H	City of Bremerton BR-8	1992	394	344	27	ND	ND	22		5	Used WL records in WY 93 to 95 Data are depth of water
119	Gorst	Gorst	AAC776	24N/01E-31L	City of Bremerton BR-10	1992	169	96	42	ND	ND	31		11	Used WL records in WY 92 to 95 Data are depth of water
119	Gorst	Gorst	AAC746	23N/01W-02P	City of Bremerton BR-2	1987	344	284	31	ND	ND	32		-1	Used WL records in WY 93 to 95 Data are depth of water
119	Gorst	Gorst	AAC749	23N/01W-11A	City of Bremerton BR-1	1987	440	364	49	ND	ND	46		3	Used WL records in WY 93 to 95 Data are depth of water
119	Gorst		AAA773	23N/01W-01K	City of Bremerton BR-11	1992	378	315	66	ND	ND	64		2	Used WL records in WY 93 to 95 Data are depth of water
119	Gorst	Gorst	AAC748	23N/01W-01E	City of Bremerton BR-4	1987	342	229	93	ND	ND	87		6	Used WL records in WY 92 to 95 Data are depth of water
119	Gorst	Gorst	AAC747	23N/01W-02L	City of Bremerton BR-3	1987	320	188	117	ND	ND	116		1	Used WL records in WY 92 to 95 Data are depth of water
120	Gorst	Gorst	AAB906	24N/01E-31F	City of Bremerton TW-2A	1988	114	-66	2	2	ND	4		-2	Used WL records in WY 91 to 94 Data are depth of water
120	Gorst	Gorst	AAB907	24N/01E-31F	City of Bremerton TW-2B	1988	114	79	5	5	ND	4		1	Used WL records in WY 91 to 95 Data are depth of water
121	Union	No Defined P.A. for Subarea	AAC839	23N/01W-02M	KPUD Union Acres Well	1987	220	81	156	ND	170			14	
122	Tahuya	No Defined P.A. for Subarea	AAA115	24N/01W-19A	Tahuya Well 2	1966	622	558	572	568	ND	573		1	WL records end in water year 1995
123	Olalla	No Defined P.A. for Subarea	AAA228	22N/02E-07C	Harbor WC Pacific Ventures	1985	301	179	220	217	ND	207		-13	WL records end in WY 1994
124	Olalla	No Defined P.A. for Subarea	AAA227	22N/02E-08R	Harbor WC Alpinewood N. #2	1987	338	150	208	216	215		-1	7	
125	Olalla	No Defined P.A. for Subarea	AAA236	23N/01E-35G	Harbor WC Woodland Ranch #4	1974	211	-316	145	144	146		2	1	
126	McCormick	Not in a Principal Aquifer	AAA229	22N/01E-10C	Harbor WC Spruce Rd. #2	1988	372	94	224	229	229		0	5	
127	McCormick	North Lake (?)	AAA230	23N/01E-31H	Harbor WC Wicks Lake #2	1979	435	263	312	321	321		0	9	
128	McCormick	Not in a Principal Aquifer	AAC825	23N/01E-34B	Christian Lighthouse Well	1979	430	300	346	ND	361			15	
129	Dewatto	No Defined P.A. for Subarea	AAA007	24N/02W-19G	Holly Water Well 1	1967	15	-139	19	ND	20			1	Used WL records in WY 92 to 96
130	Dewatto	No Defined P.A. for Subarea	AAA008	24N/02W-19K	Holly Water Well 2	1988	183	57	92	96	98		2	6	

EXHIBIT 5-8 (cont.) Table of Wells with Water Level Hydrographs - Sorted by Subarea

Hydrograph Page Number	Subarea	Principal Aquifer	Dept of Ecology Unique Site Identification Tag Number	Location by Township/ Range-Section	Owner and Well Name	Year Drilled	Approximate Site Elevation, ft MSL	Top of Completion Elevation, ft MSL	Initial water level elevation	Highest recorded water level elevation in Water Year 1991	Highest recorded water level elevation in Water Year 1996	Water level elevation at end of record if other than WY 1996	Apparent change in water level elevation from WY 1991 To WY 1996	Apparent change in water level elevation for all of record	Remark

Notes:

Hydrographs are shown in Appendix H and are organized by hydrograph page number

ND means no data or parameter is unknown

Subareas are one of eighteen areas as discussed in Section 2.

Principal Aquifers are discussed in Section 5.3 and are shown on Exhibit 5.2.

No Defined P.A. for Subarea or Not in a Principal Aquifer refers to Principal Aquifers as defined in Section 5.2.

Dept. of Ecology Unique Site Identification Tag Number refers to the metal identification tag attached to each well, with some exceptions as noted.

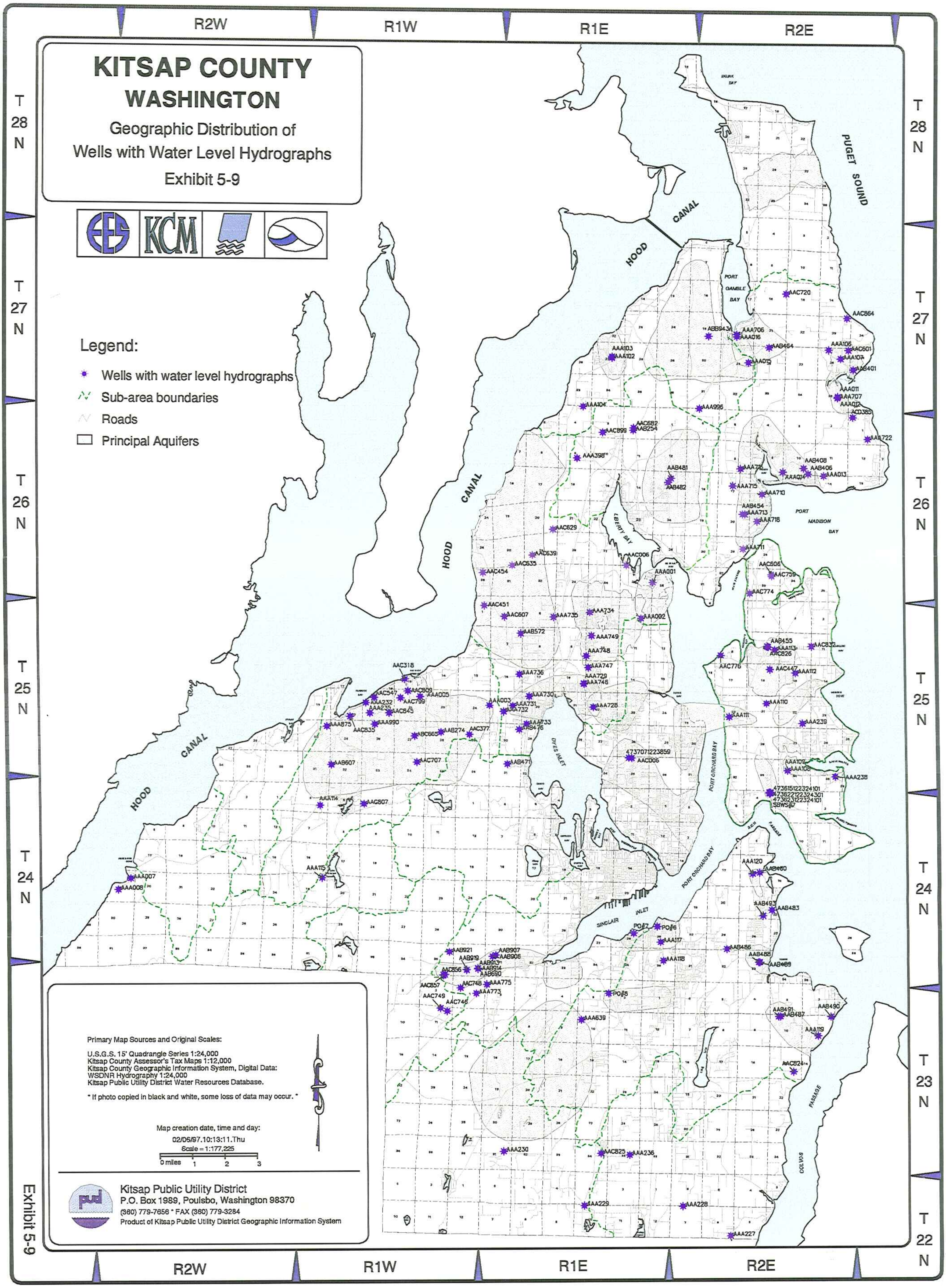
Initial Water Level Elevation is the water level at the time of well construction, or at the beginning of water level record if the construction water level is not available.

Top of Completion Elevation refers to the highest elevation that the well is open to water-bearing, aquifer materials.

Water Year (WY) refers to the time period beginning on October 1st of a year and ending on September 30th of the following year (i.e.: water year 1991 began on October 1, 1990 and ended on September 30, 1991).

Elevations and water levels are in feet above or below mean sea level. Exceptions are for those wells where the levels have not been converted to elevations as noted in *Remarks*.

Apparent change in water level are negative if the water level has declined and positive if the water level has risen.



KITSAP COUNTY
WASHINGTON
Geographic Distribution of
Wells with Water Level Hydrographs
Exhibit 5-9
KCM
Legend:
Wells with water level hydrographs
Sub-area boundaries
Roads
Principal Aquifers
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
SINCLAIR INLET
PORT ORCHARD BAY
RICH PASSAGE
COLVOS PASSAGE
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
02/06/97.10:13:11.Thu
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 5-9

Exhibit 5-10. Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

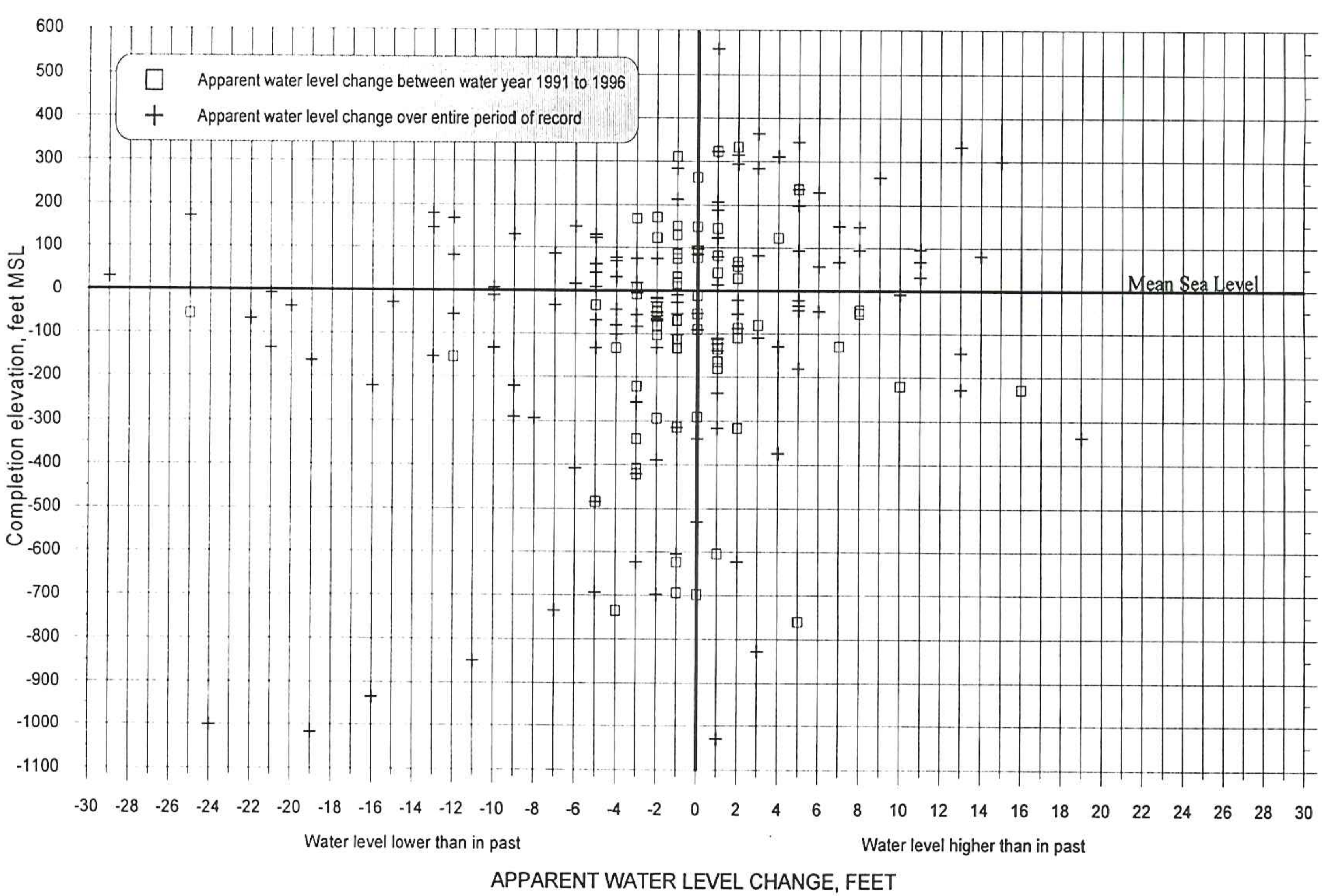


EXHIBIT 5-10
Apparent Change In Water Levels
For Wells In Kitsap County

Kitsap County
Initial Basin Assessment

Exhibit 5-11A. Kingston Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

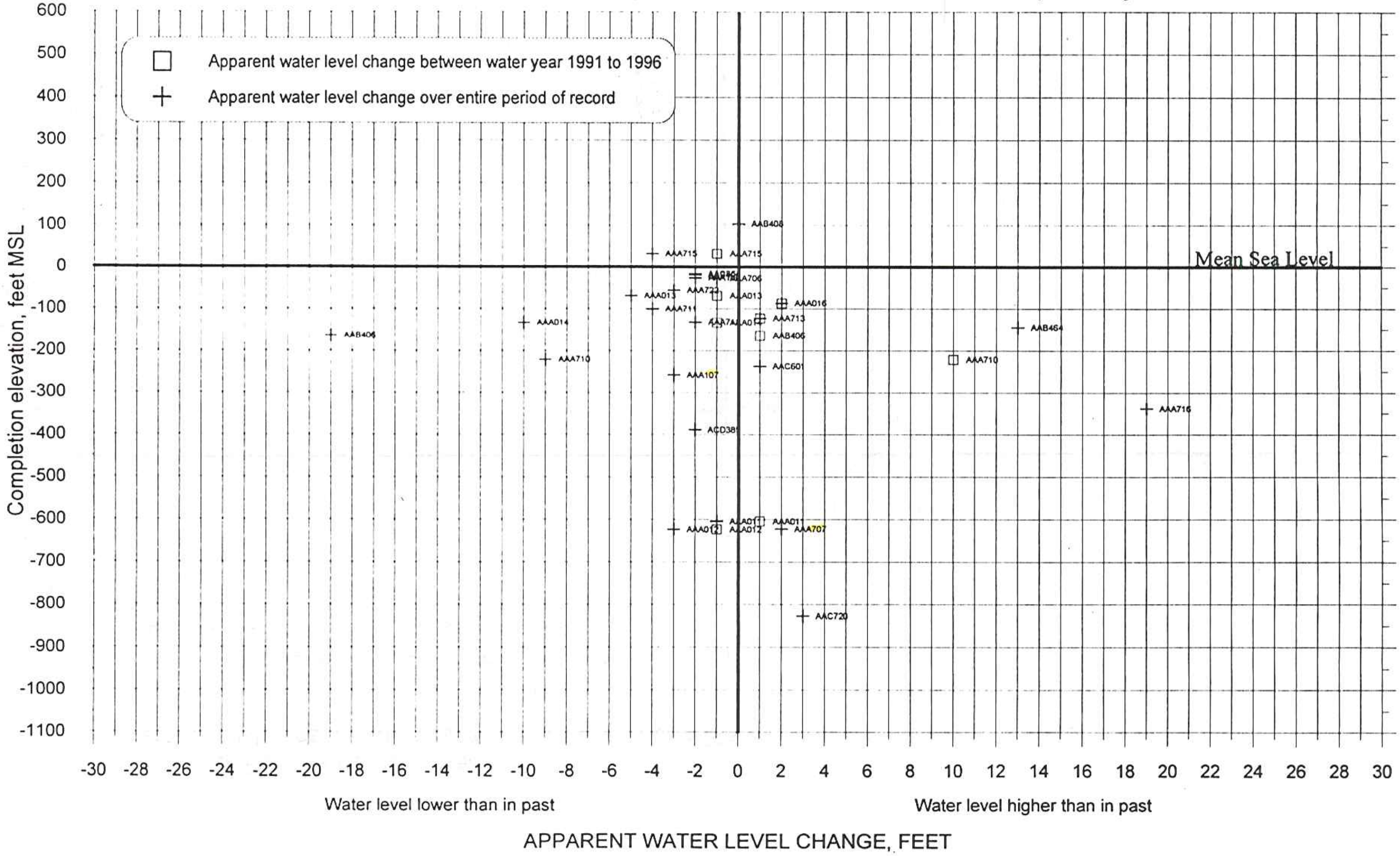


Exhibit 5-11B. Port Gamble Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

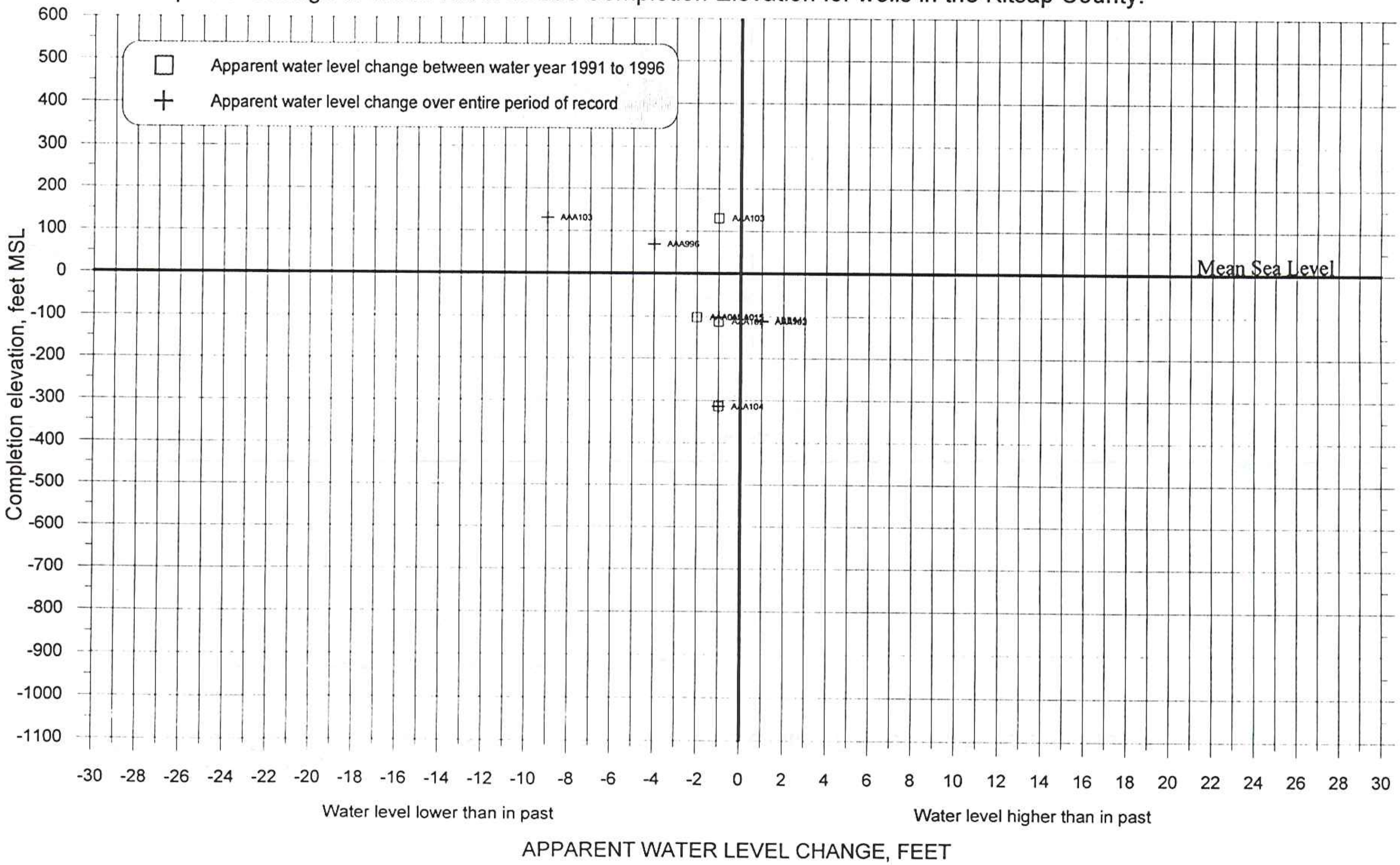


Exhibit 5-11C. Poulsbo Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

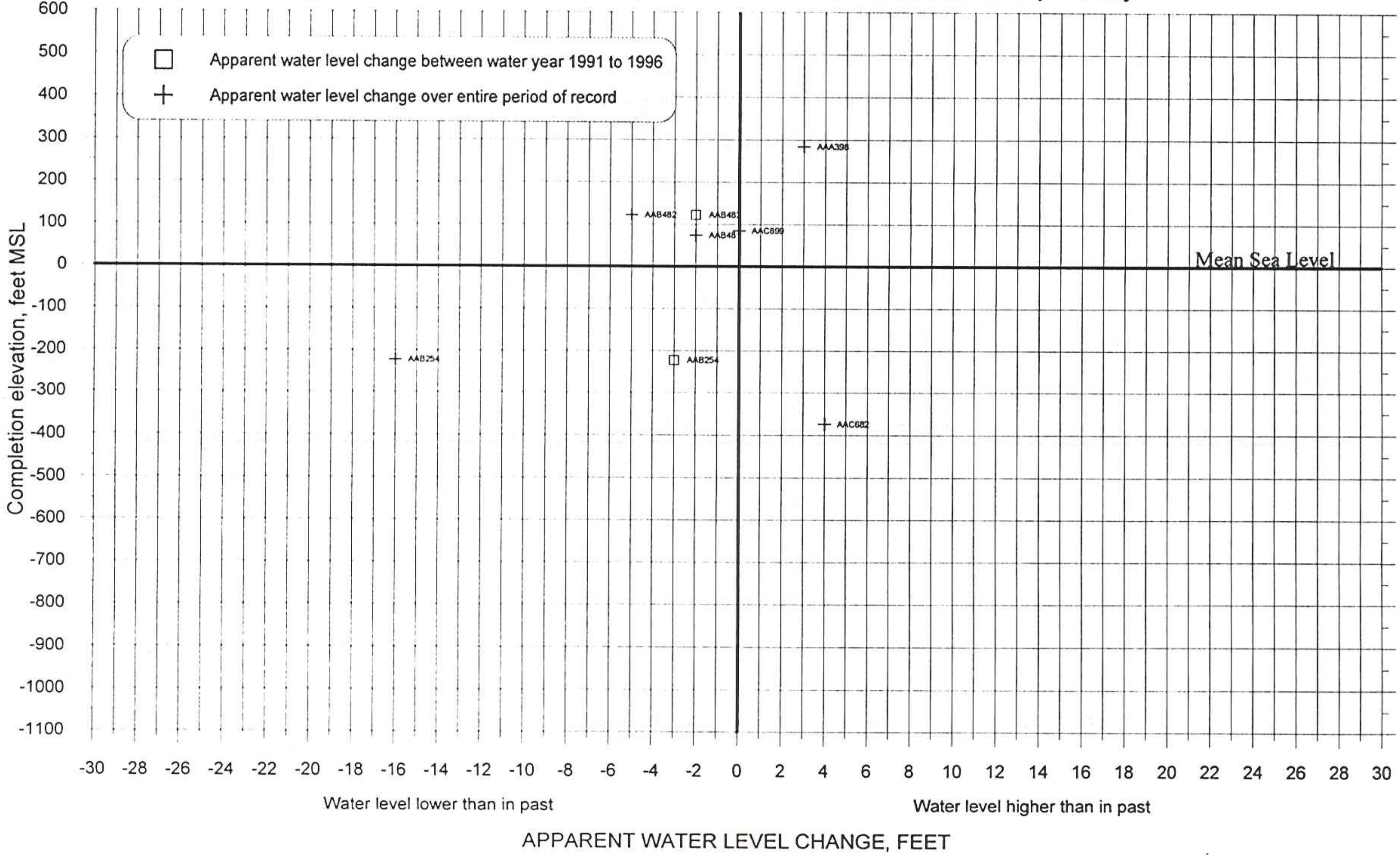


Exhibit 5-11D. Bangor Subarea

Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

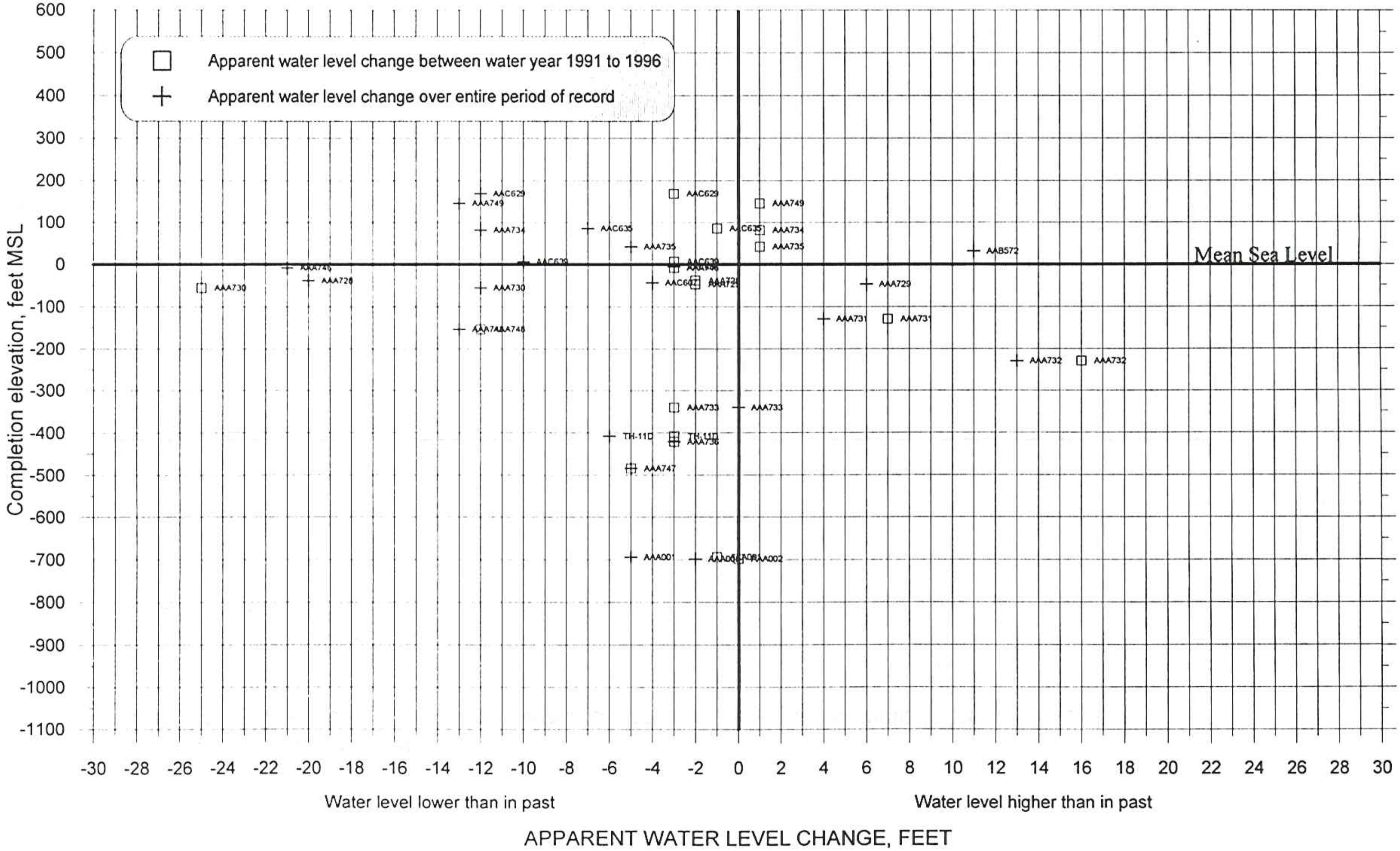
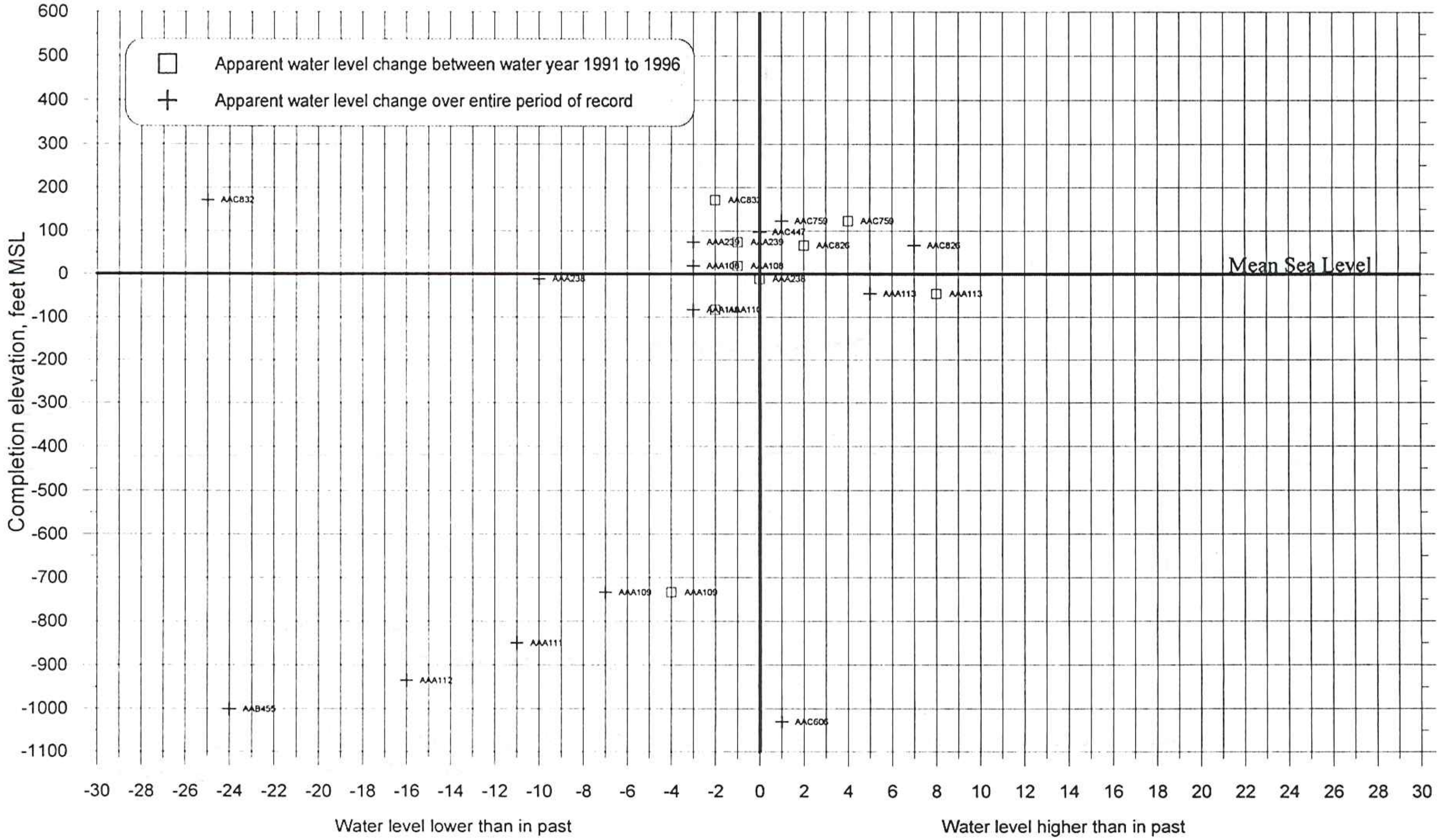


Exhibit 5-11E. Bainbridge Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.



APPARENT WATER LEVEL CHANGE, FEET

Exhibit 5-11F. Manette Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

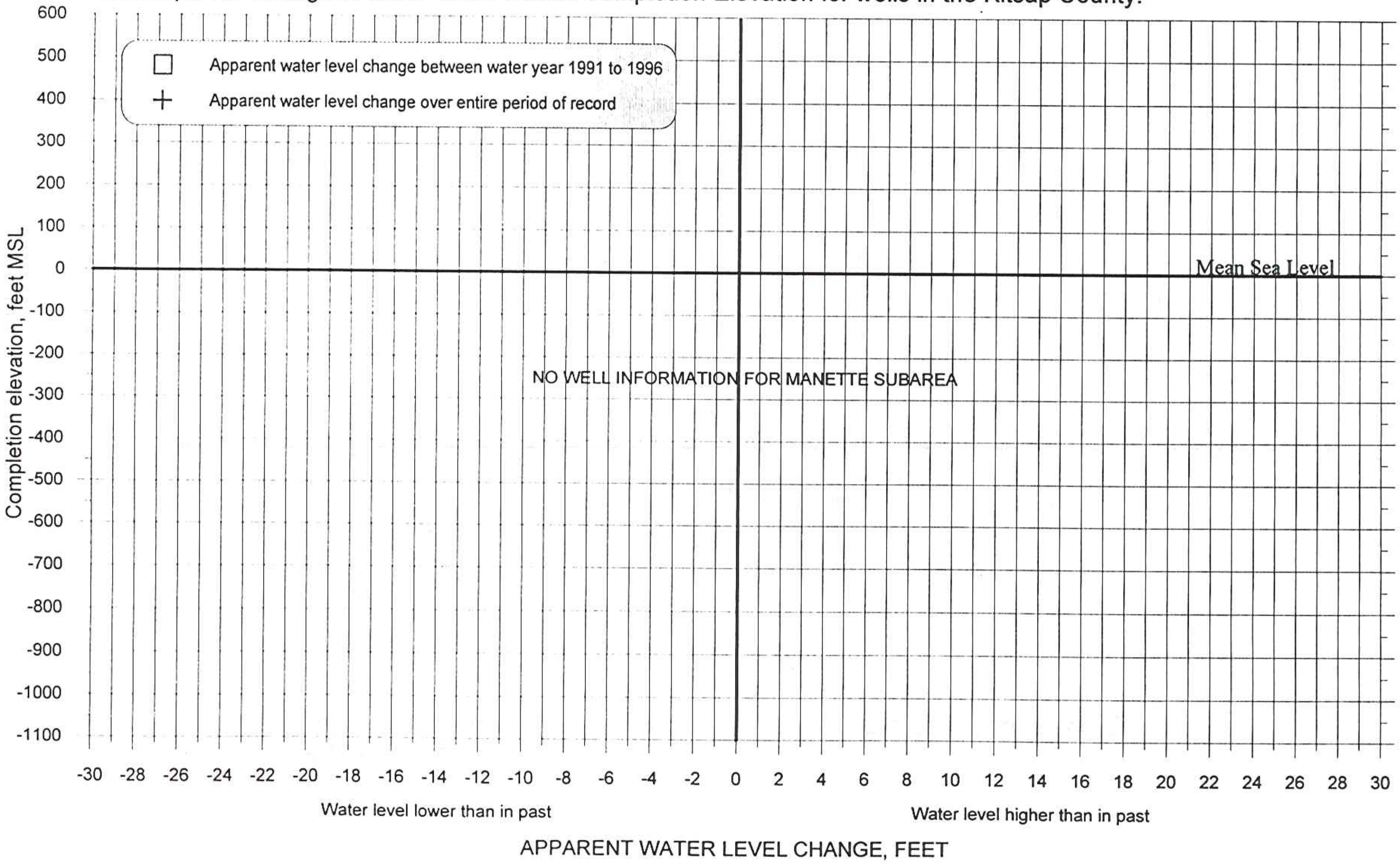


Exhibit 5-11G. Chico Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

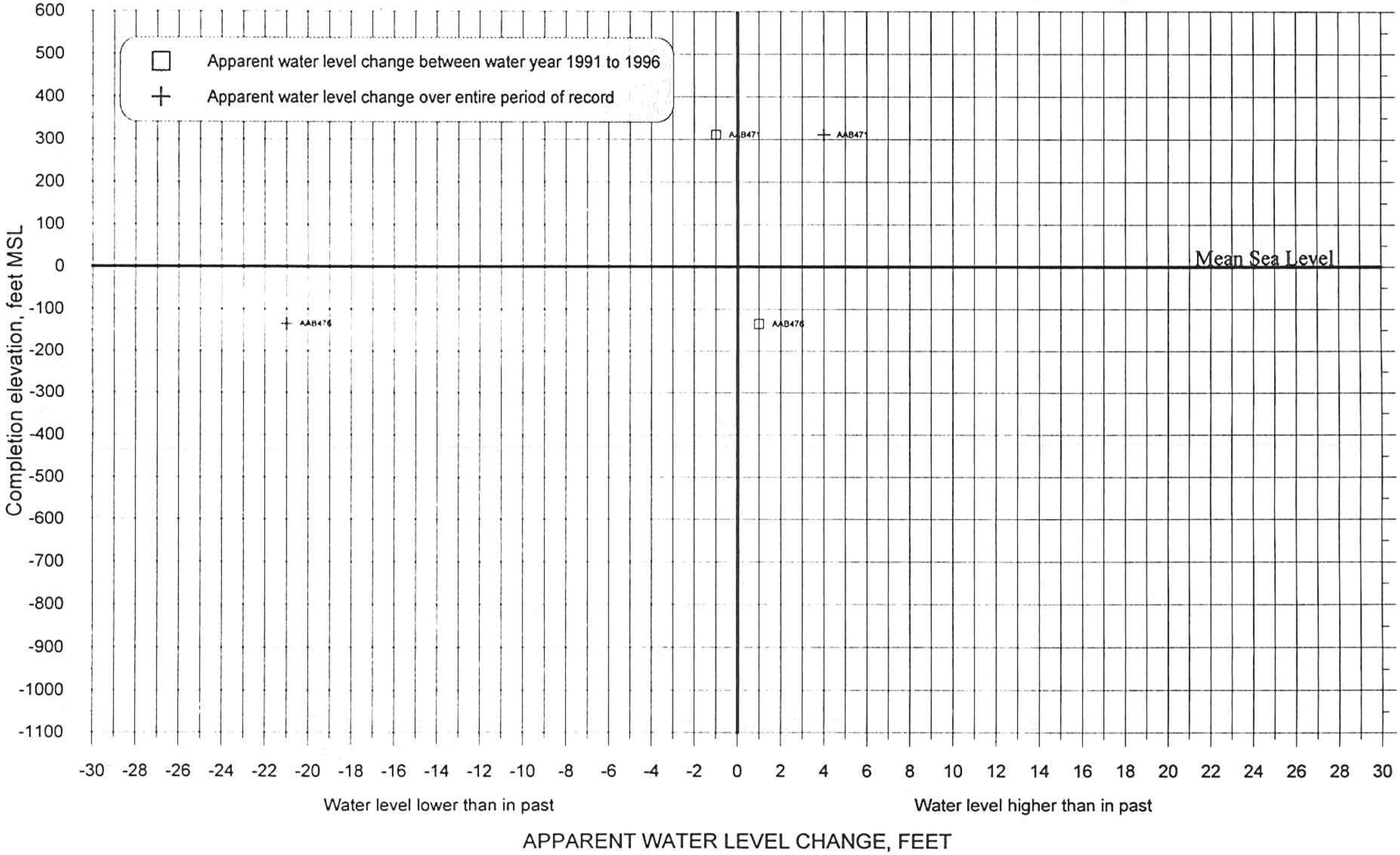


Exhibit 5-11H. Seabeck Subarea

Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

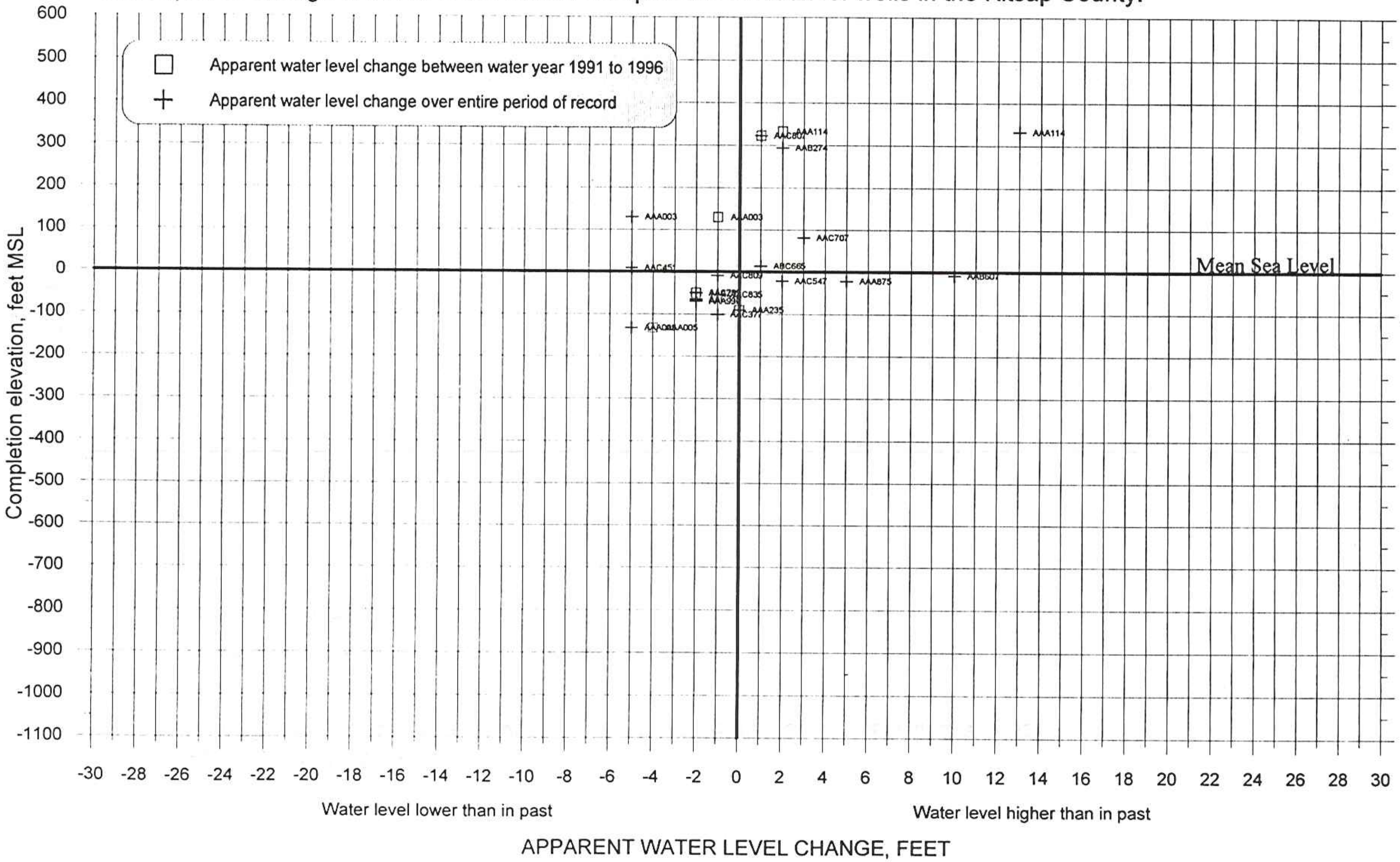


Exhibit 5-11I. Manchester Subarea

Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

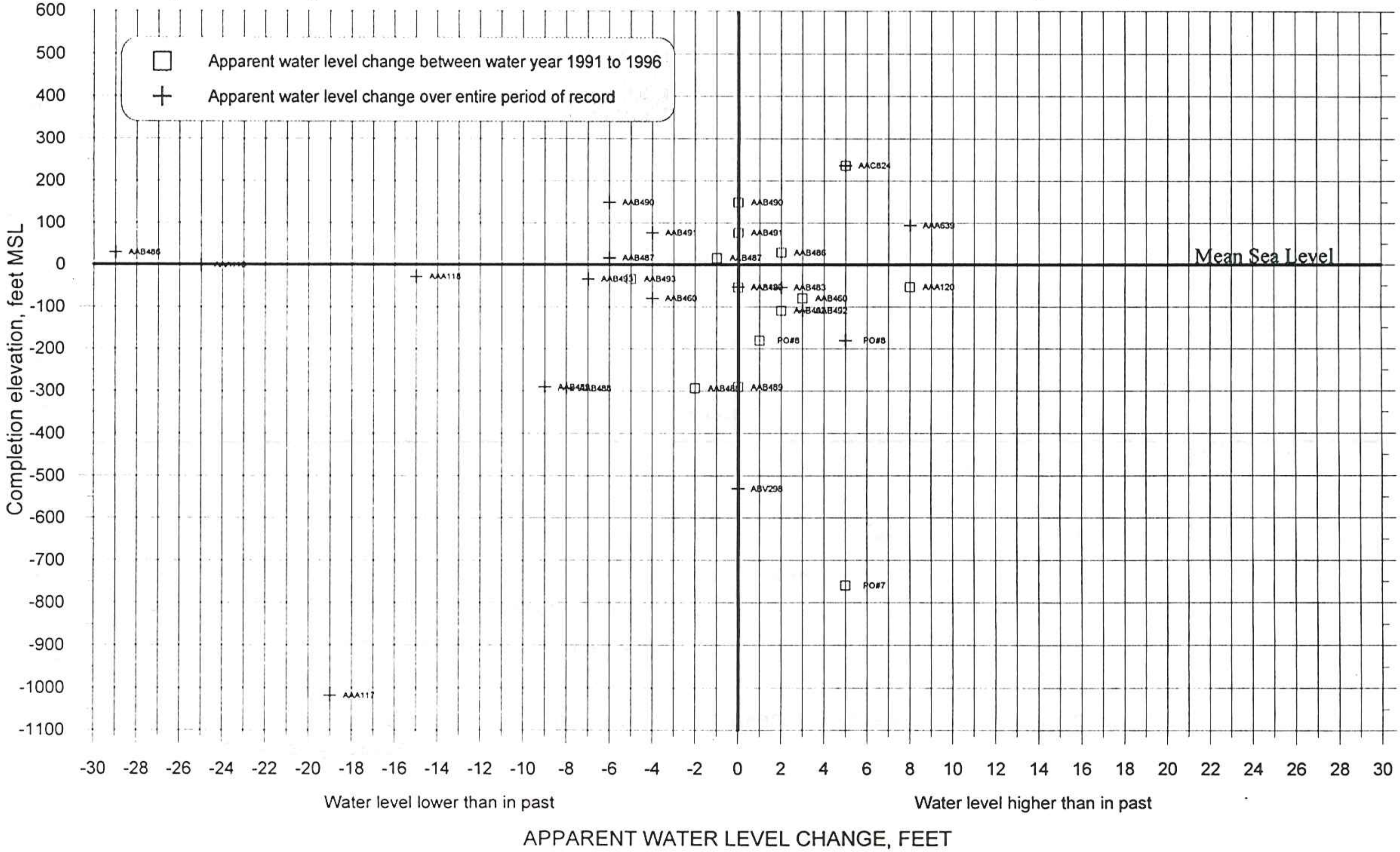


Exhibit 5-11J. Gorst Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

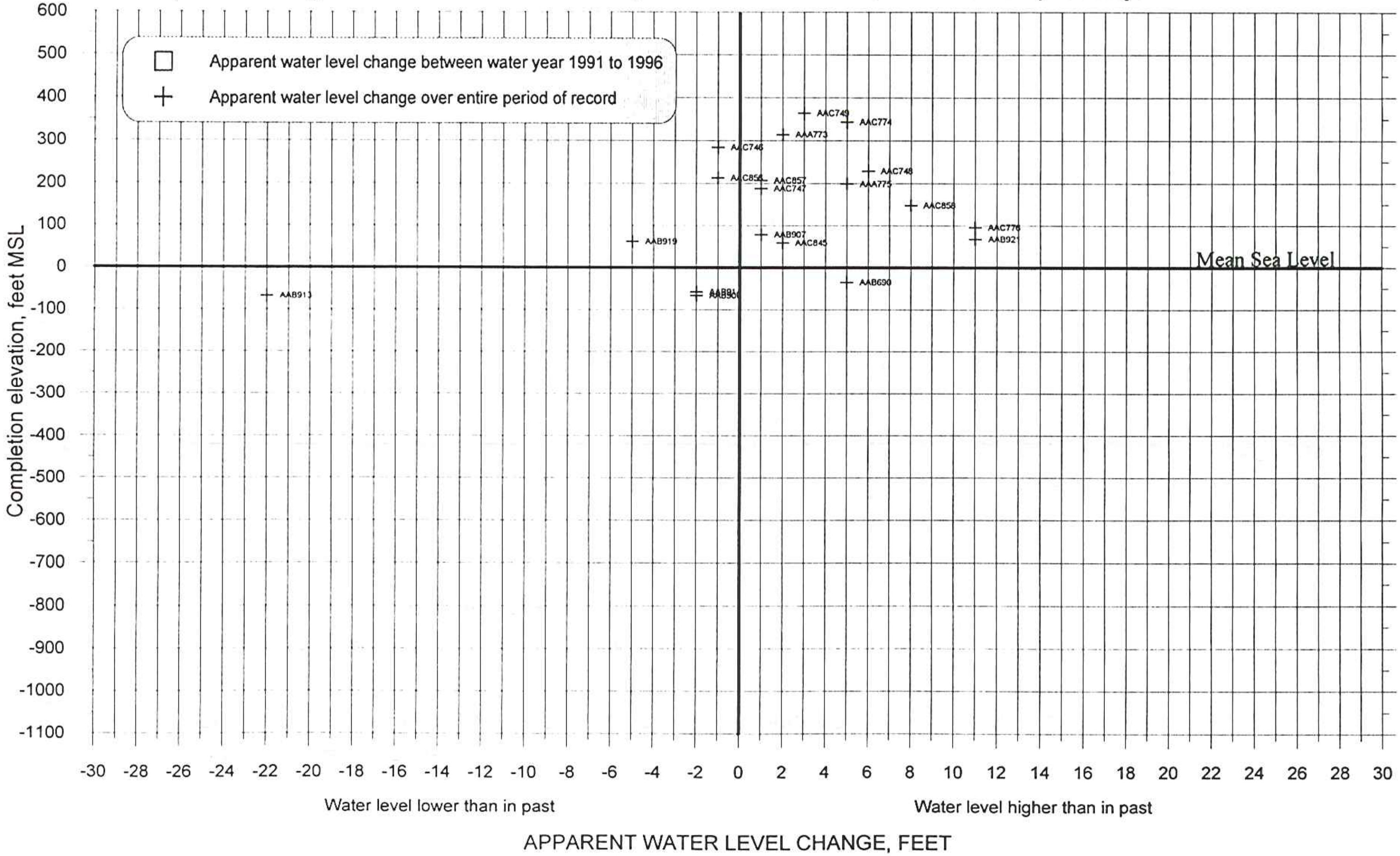


Exhibit 5-11K. Union Subarea

Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

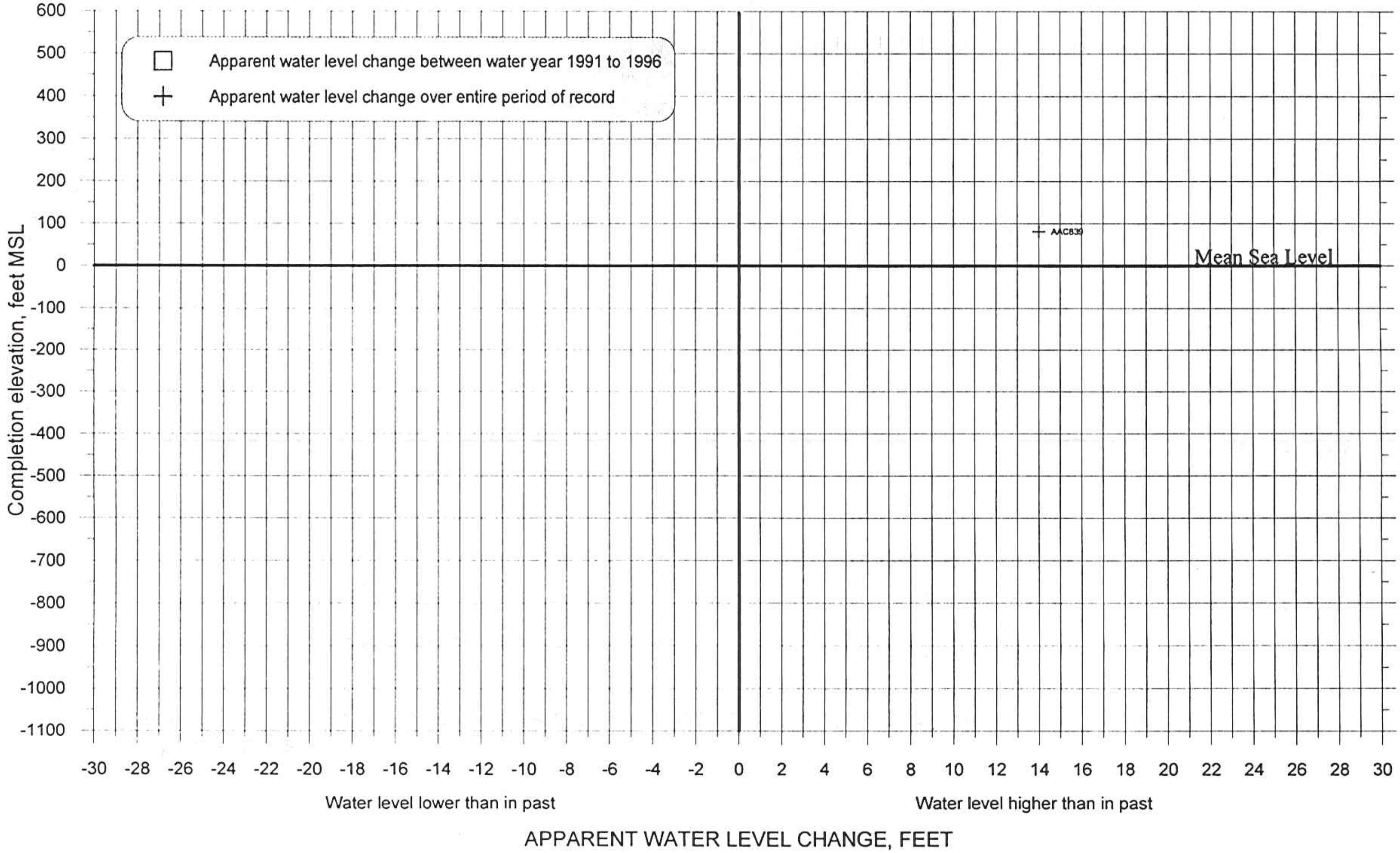


Exhibit 5-11L. Tahuya Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

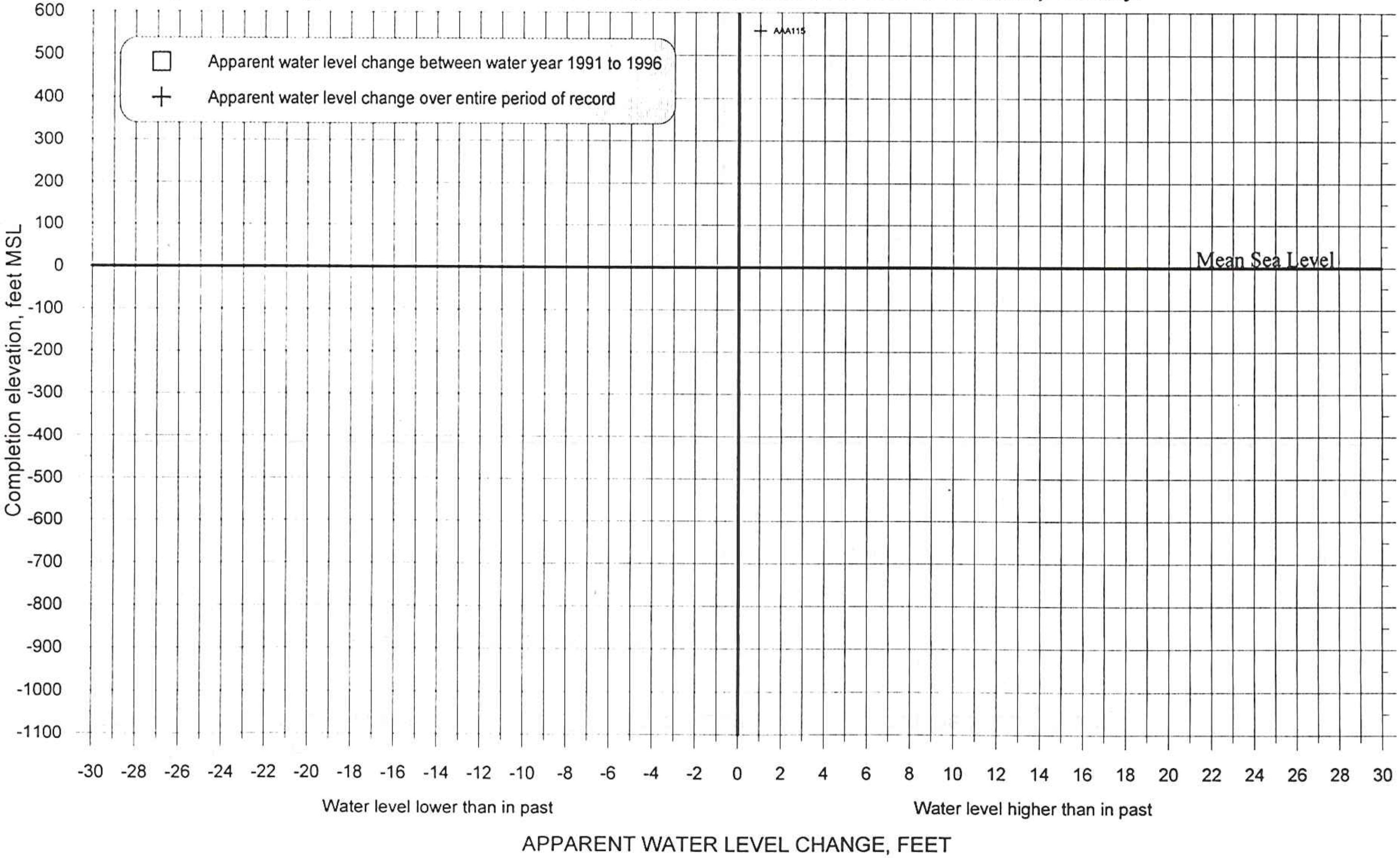


Exhibit 5-11M. Olalla Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

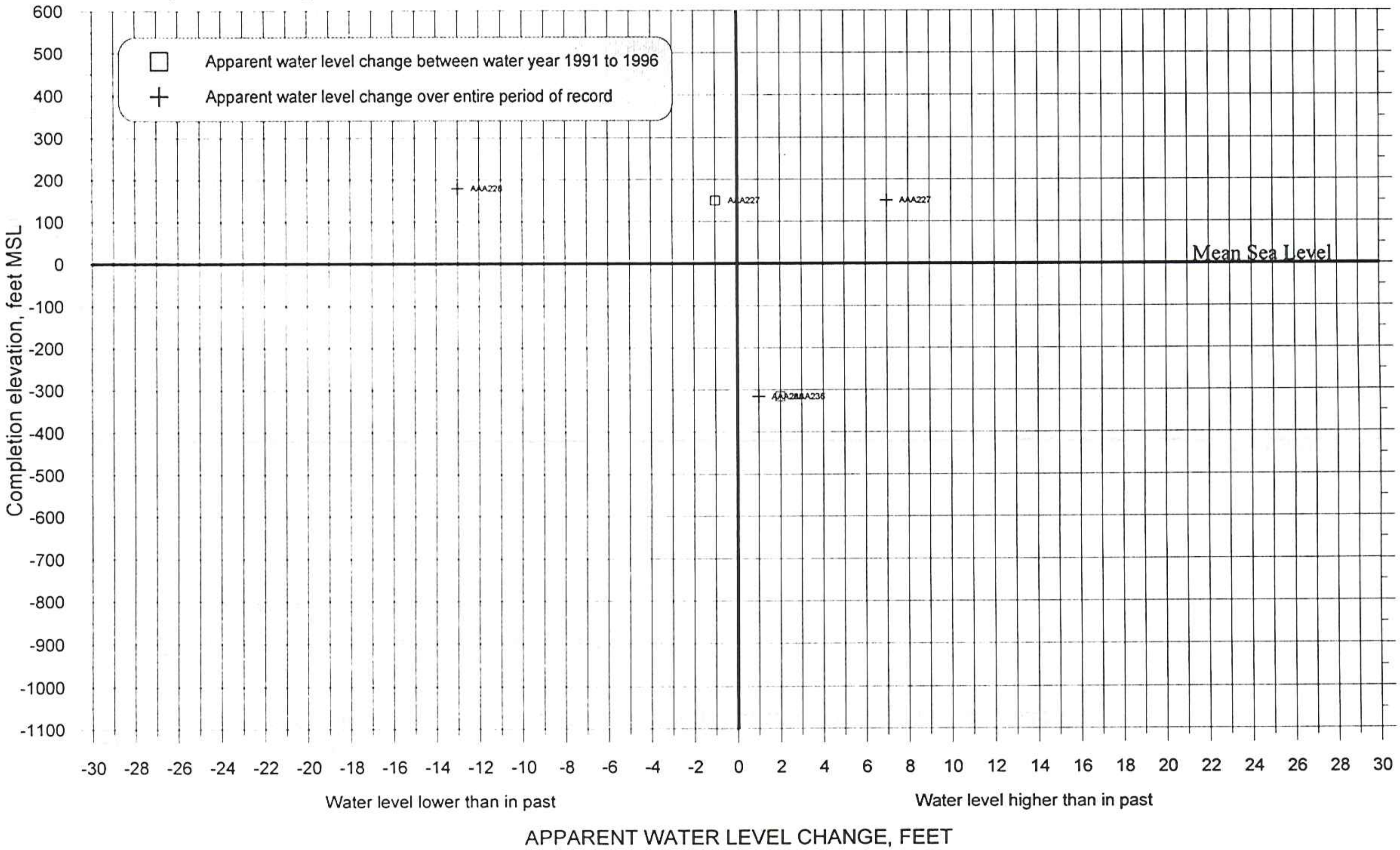


Exhibit 5-11N. McCormick Subarea

Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

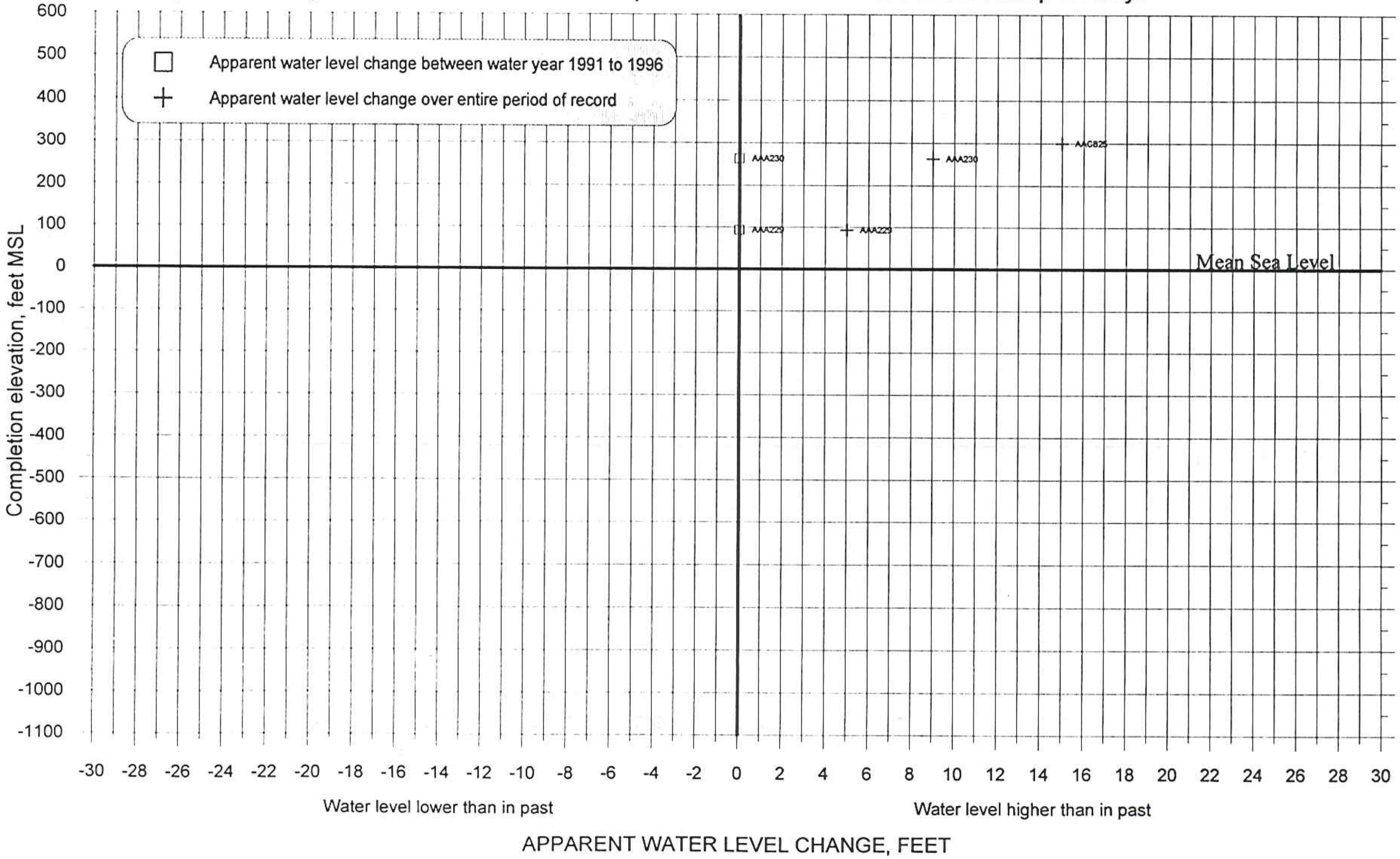


Exhibit 5-11O. Dewatto Subarea
Scatterplot of Change in Water Level versus Completion Elevation for wells in the Kitsap County.

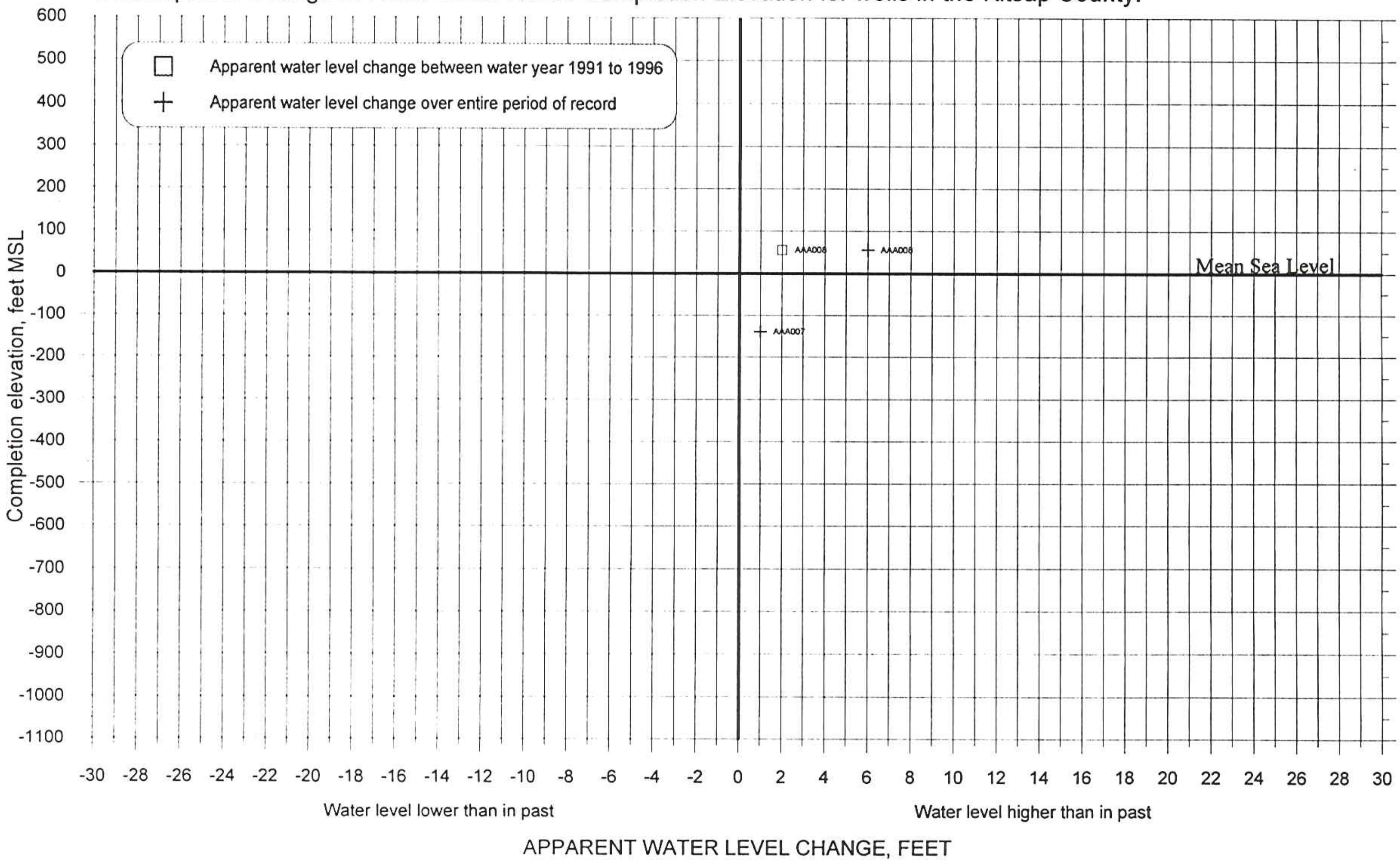
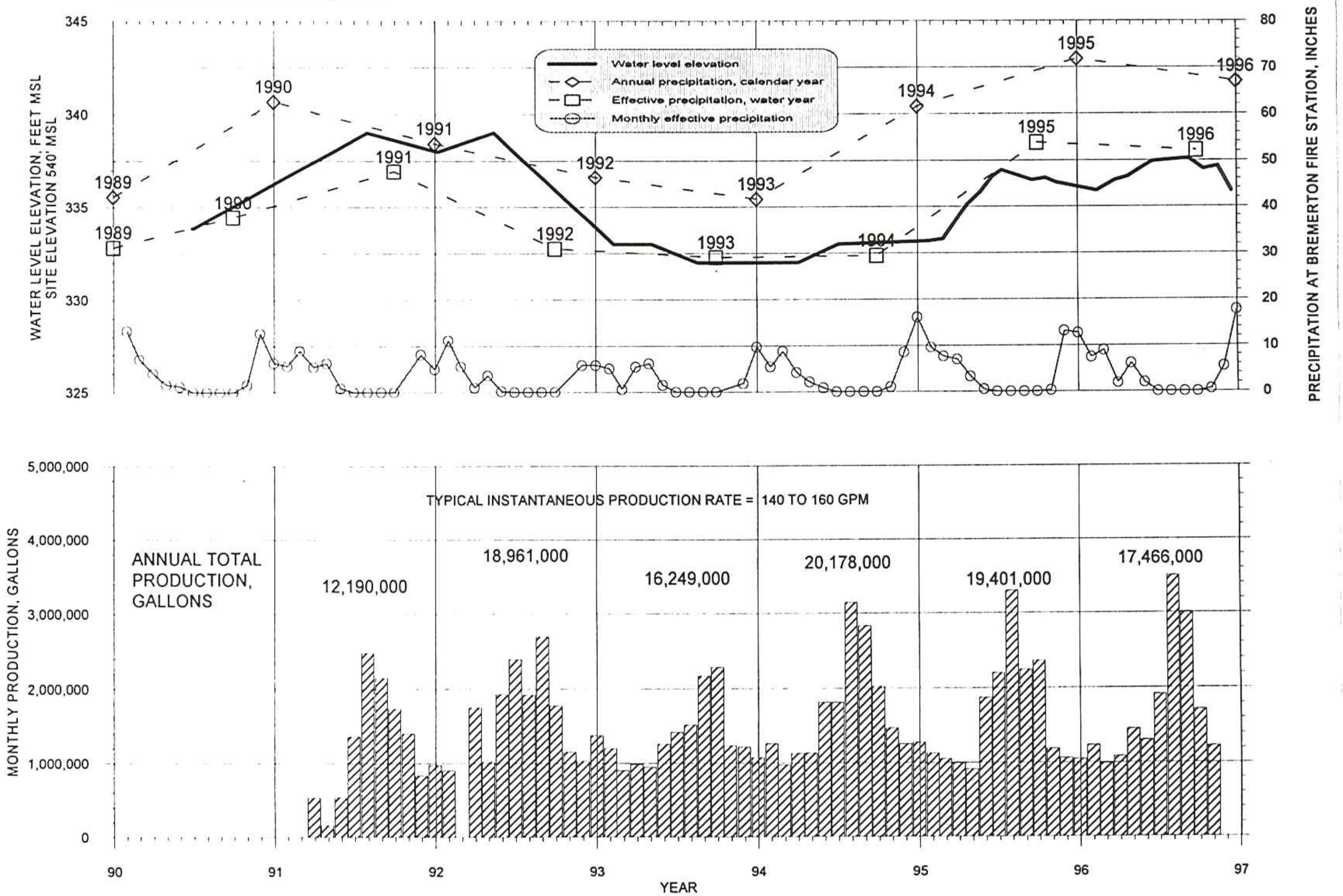


EXHIBIT 5-12. COMPARISON OF HYDROGRAPH OF ELDORADO HILLS WELL 4 (AAB471) WITH PRECIPITATION AT BREMERTON.
Precipitation at Bremerton from 1952 to 1996 averaged 52.1 in/yr for the calendar year. Effective precipitation in a water year averaged 36.2 in/yr.
Well location T25N/R01E-31G. Completion elevation 301 TO 311' MSL.
Construction SWL 334' MSL, 7/2/90.

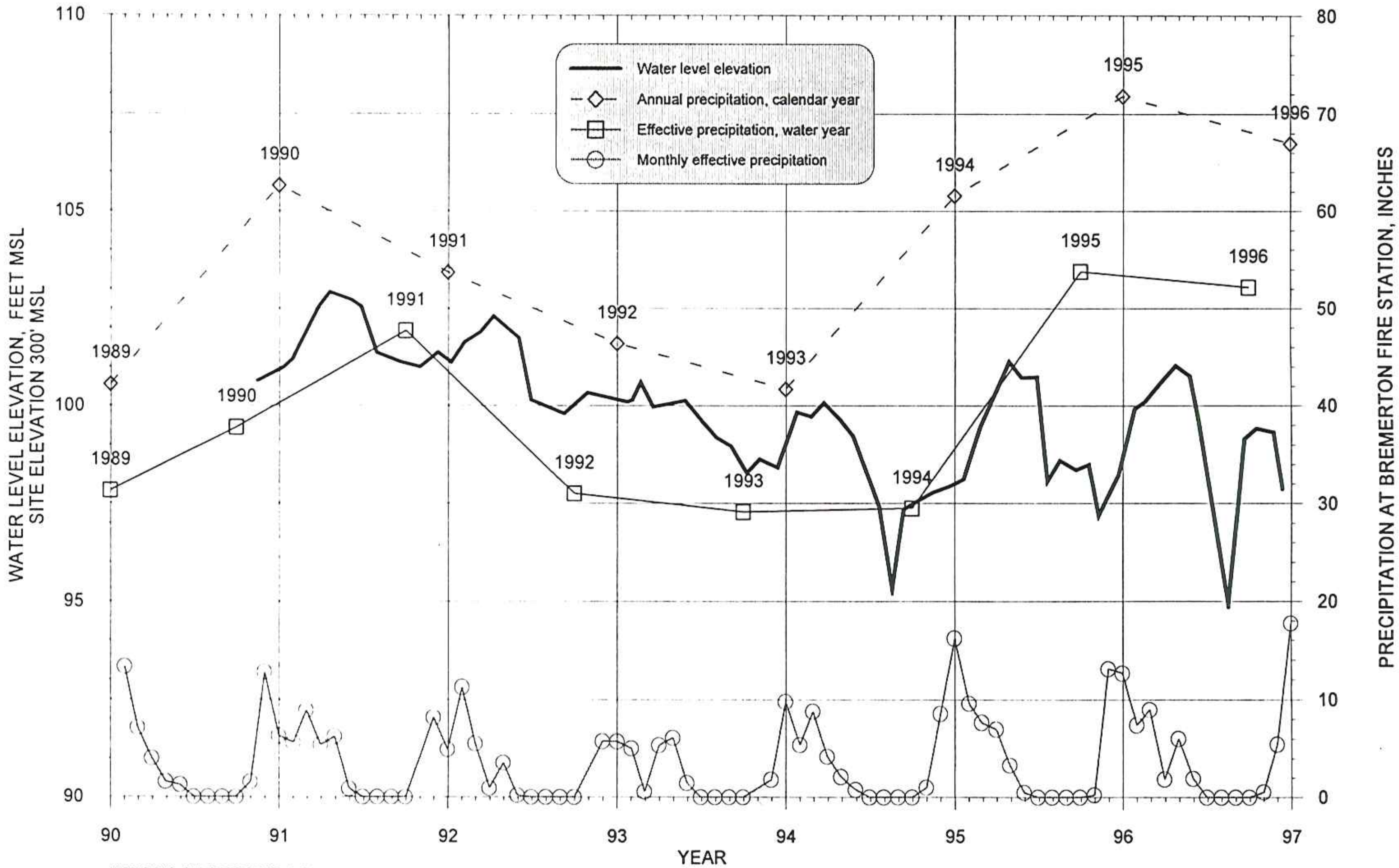


KITSAP PUD EX5-12 GRF 2/6/97 M Sebren

EXHIBIT 5-12
Comparison of Water Level Trend in the Eldorado Hills Well 4 (AAB471) with Precipitation at Bremerton

Kitsap County
Initial Basin Assessment

EXHIBIT 5-13. COMPARISON OF HYDROGRAPH OF ISLAND CENTER TEST WELL (AAA110) WITH PRECIPITATION AT BREMERTON.
Precipitation at Bremerton from 1952 to 1996 averaged 52.1 in/yr for a calendar year. Effective precipitation for a water year averaged 36.2 in/yr.
Well location T25N/R02E-21G. Completion elevation -83' TO-98' MSL.
Construction SWL 104.4' MSL, 4/25/75.

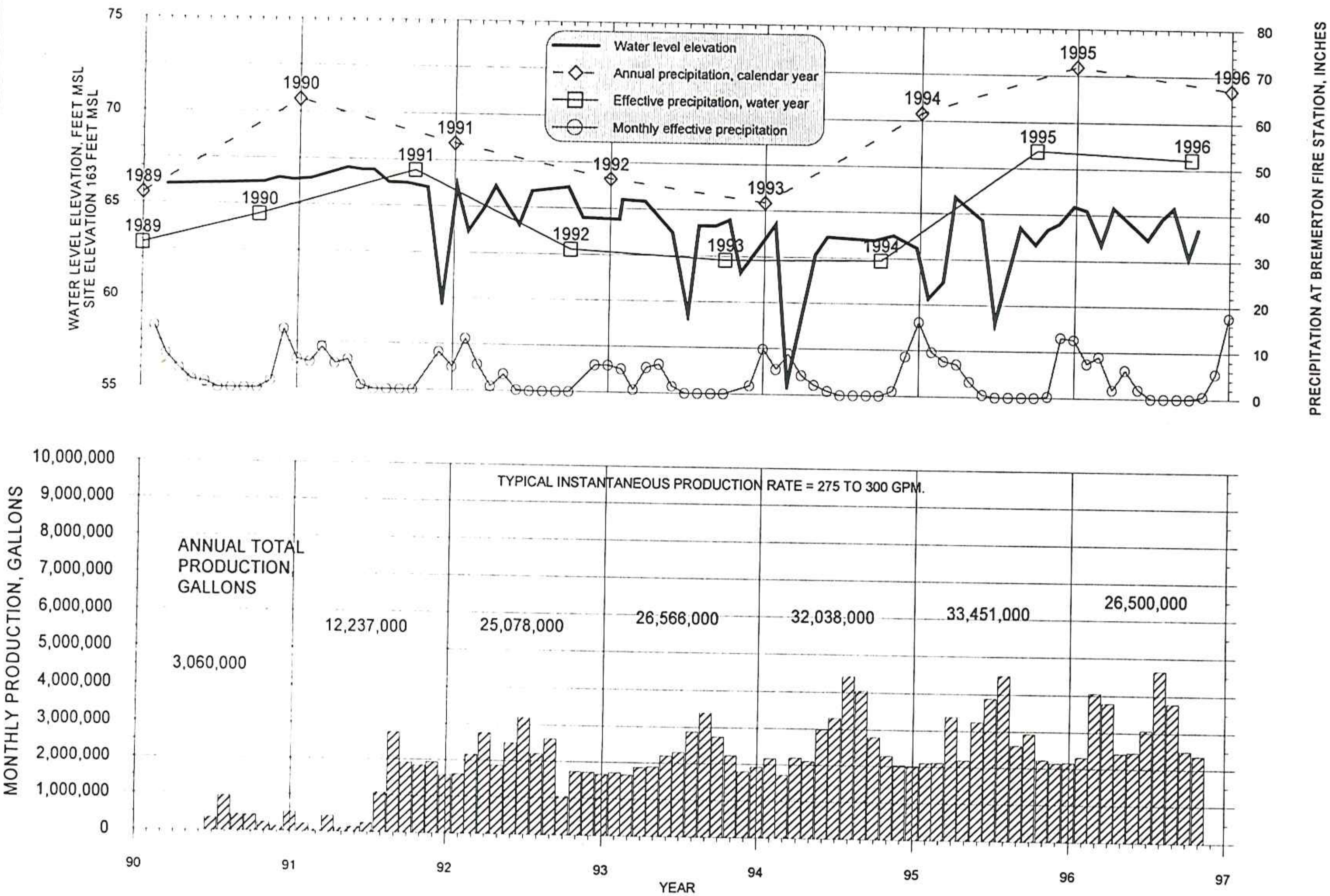


KITSAP PUD EX5-13 GRF 2/6/97 M Sebren

EXHIBIT 5-13
Comparison of Water Level Trend in the Island Center Well (AAA110) with Precipitaton at Bremerton

Kitsap County
Initial Basin Assessment

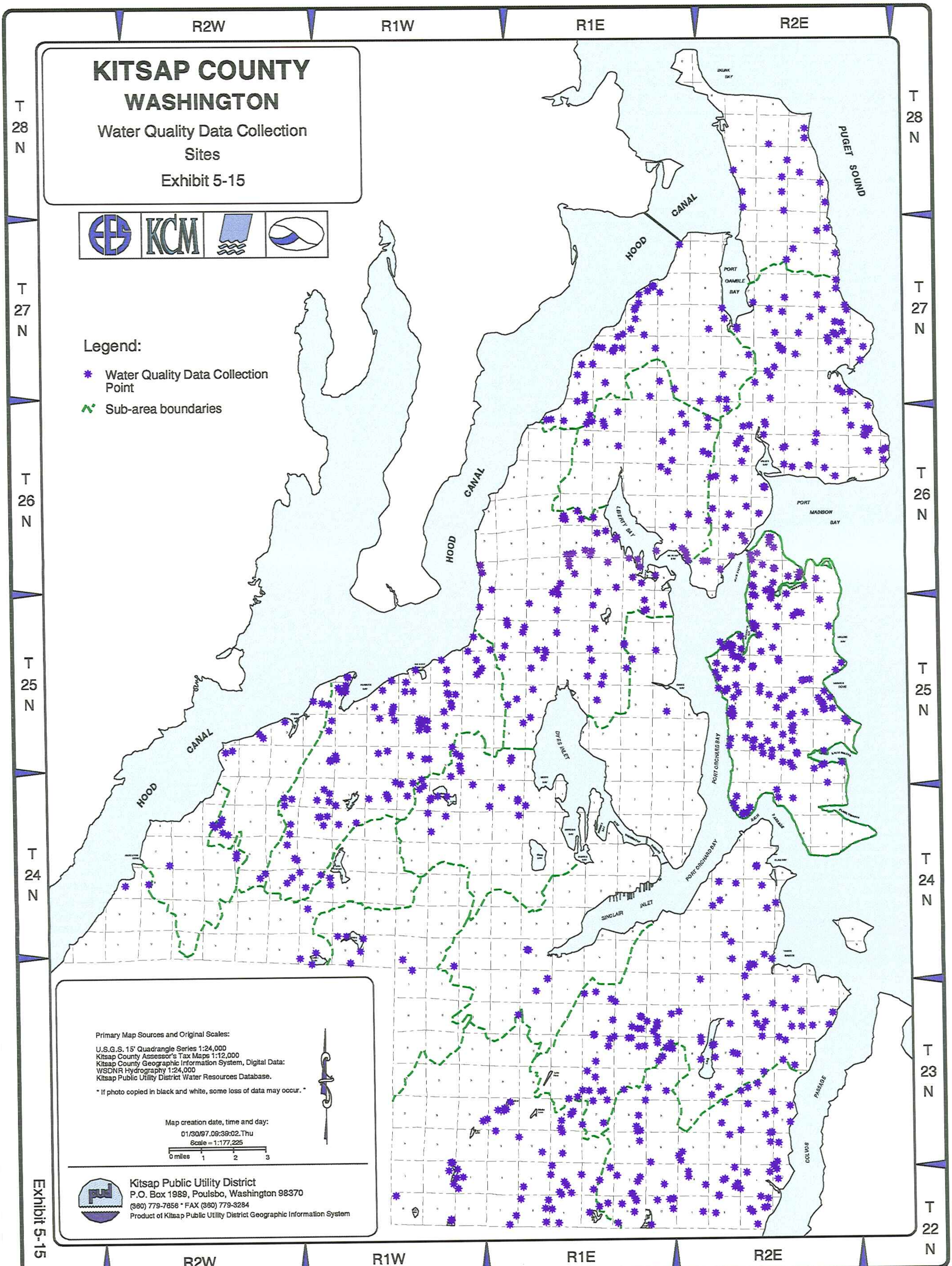
EXHIBIT 5-14. COMPARISON OF HYDROGRAPH OF RITTER LANE WELL (AAA015) WITH PRECIPITATION AT BREMERTON.
Precipitation at Bremerton from 1952 to 1996 averaged 52.1 in/yr for the calendar year. Effective precipitation in a water year averaged 36.2 in/yr.
Well location T27N/R02E-29J. Completion elevation -102 TO -159' MSL.
Construction SWL 66' MSL, 2/27/90.



KITSAP PUD EX5-14 GRF 2/6/97 M Sebren

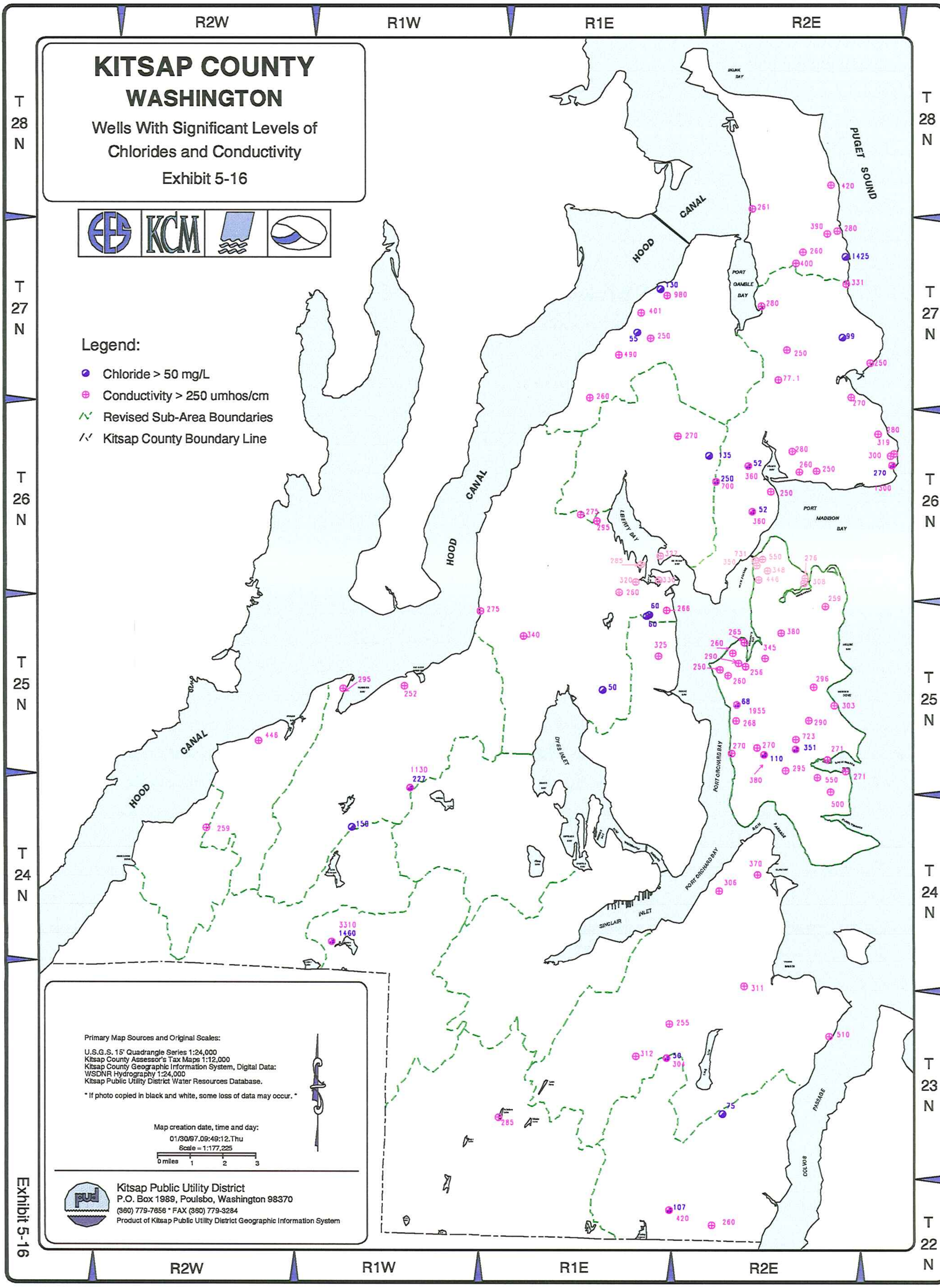
EXHIBIT 5-14
Comparison of Water Level Trend in the Ritter Lane Well (AAA015) with Precipitaton at Bremerton

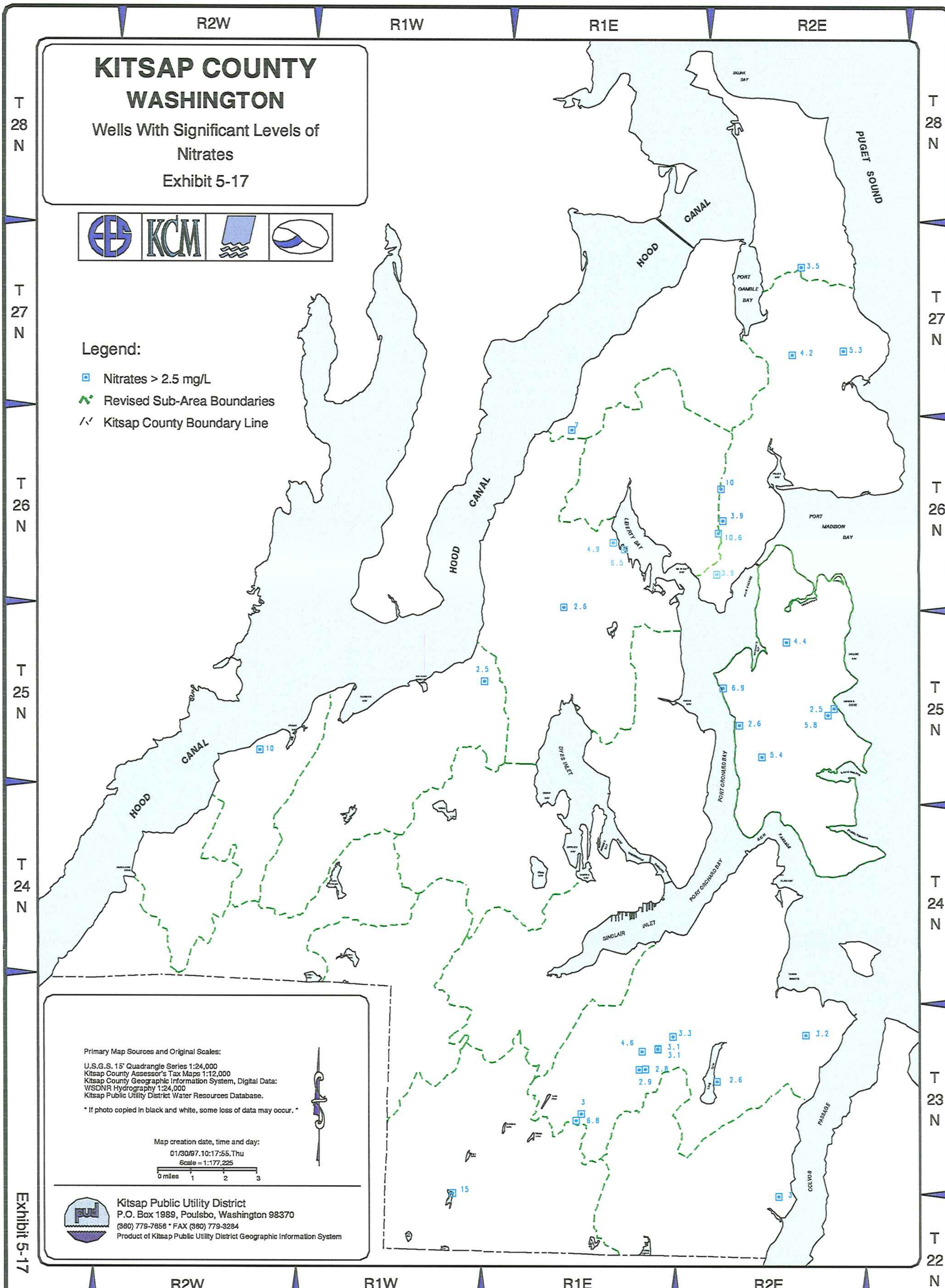
Kitsap County
Initial Basin Assessment

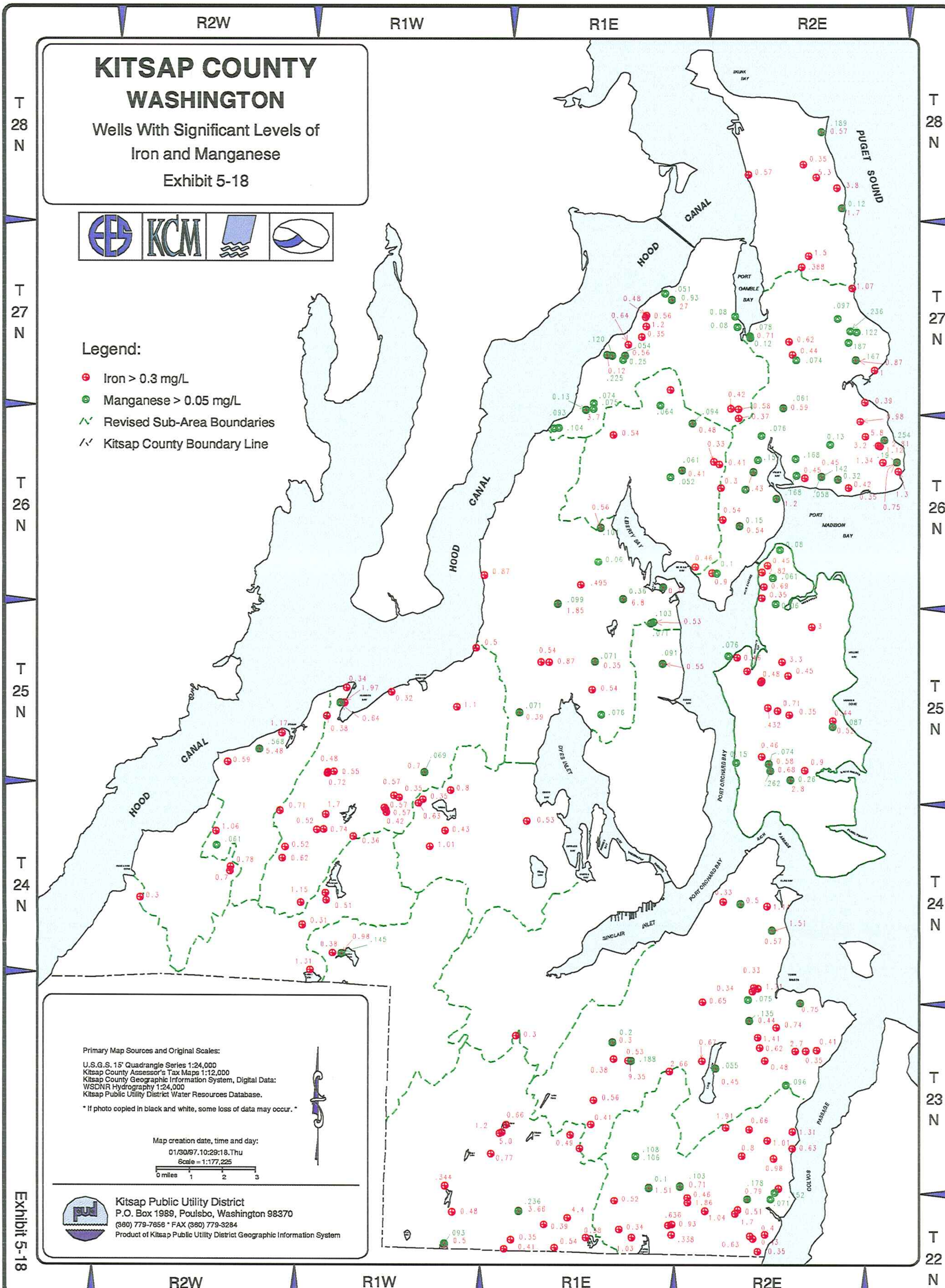


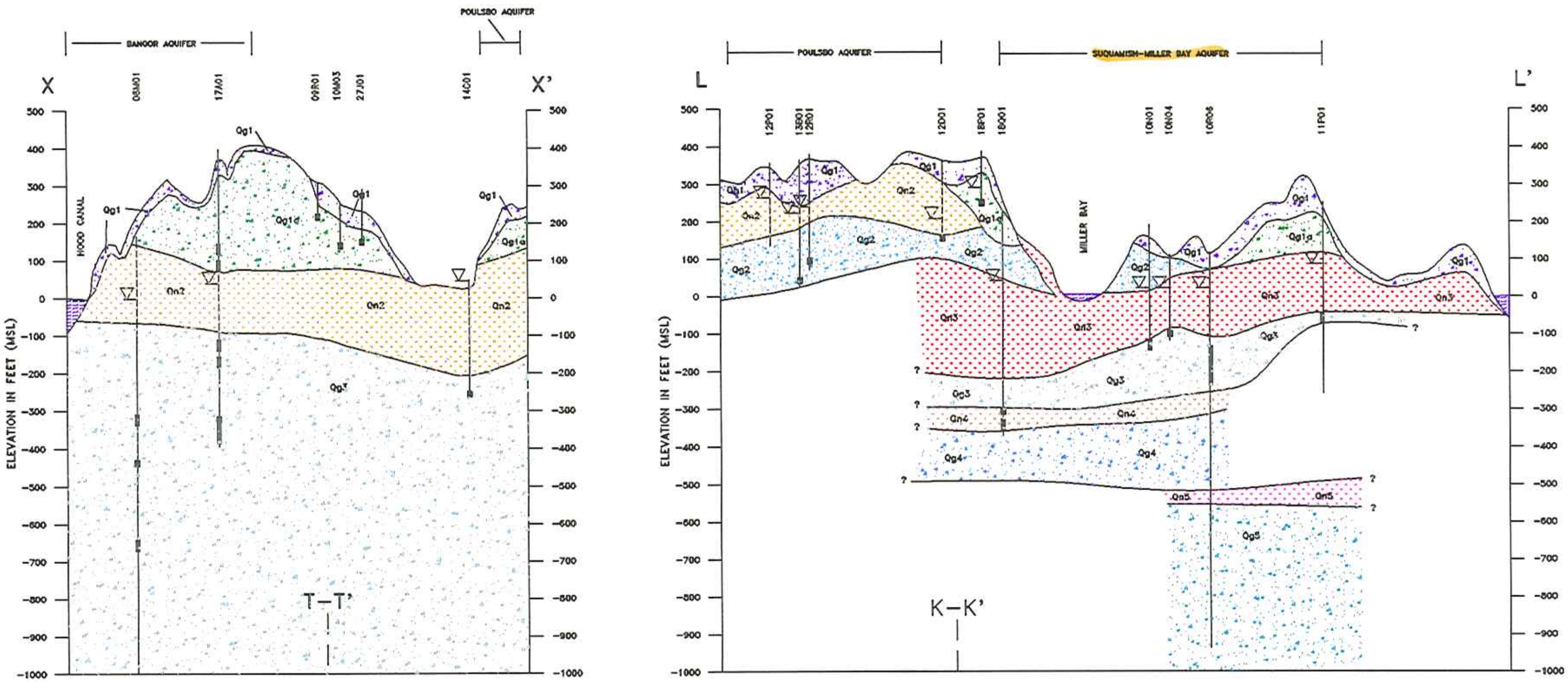
KITSAP COUNTY
WASHINGTON
Water Quality Data Collection Sites
Exhibit 5-15
Legend:
Water Quality Data Collection Point
Sub-area boundaries
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
COLVOS PASSAGE
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/30/97.09:39:02.Thu
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System

Exhibit 5-15


KITSAP COUNTY
WASHINGTON
Wells With Significant Levels of Chlorides and Conductivity
Exhibit 5-16
Legend:
Chloride > 50 mg/L
Conductivity > 250 umhos/cm
Revised Sub-Area Boundaries
Kitsap County Boundary Line
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
LIBERTY BAY
PORT MADISON BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/30/97.09:49:12.Thu
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 5-16


KITSAP COUNTY
WASHINGTON
Wells With Significant Levels of Nitrates
Exhibit 5-17
Legend:
Nitrates > 2.5 mg/L
Revised Sub-Area Boundaries
Kitsap County Boundary Line
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
LIBERTY BAY
PORT MADISON BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
3.5
4.2
5.3
7
10
3.9
10.6
4.9
6.5
3.9
2.6
4.4
2.5
6.9
2.6
2.5
5.8
5.4
10
4.6
3.3
3.1
3.1
2.8
2.9
2.6
3.2
3
6.8
15
3
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/30/97.10:17:55.Thu
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 5-17


KITSAP COUNTY
WASHINGTON
Wells With Significant Levels of
Iron and Manganese
Exhibit 5-18
Legend:
Iron > 0.3 mg/L
Manganese > 0.05 mg/L
Revised Sub-Area Boundaries
Kitsap County Boundary Line
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/30/97.10:29:18.Thu
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 5-18



CROSS SECTION LEGEND

27E01 Local Well Number

Aquifer Zone and Name

Static Water Level Elev.

X–X' Cross Section Intersect

Perforated or Screened Interval

HORIZONTAL SCALE IN FEET
0 4000 8000
0 200 400
VERTICL SCALE IN FEET
VERTICAL EXAGGERATION X 20

KITSAP COUNTY
GROUNDWATER MANAGEMENT PLAN, 1991

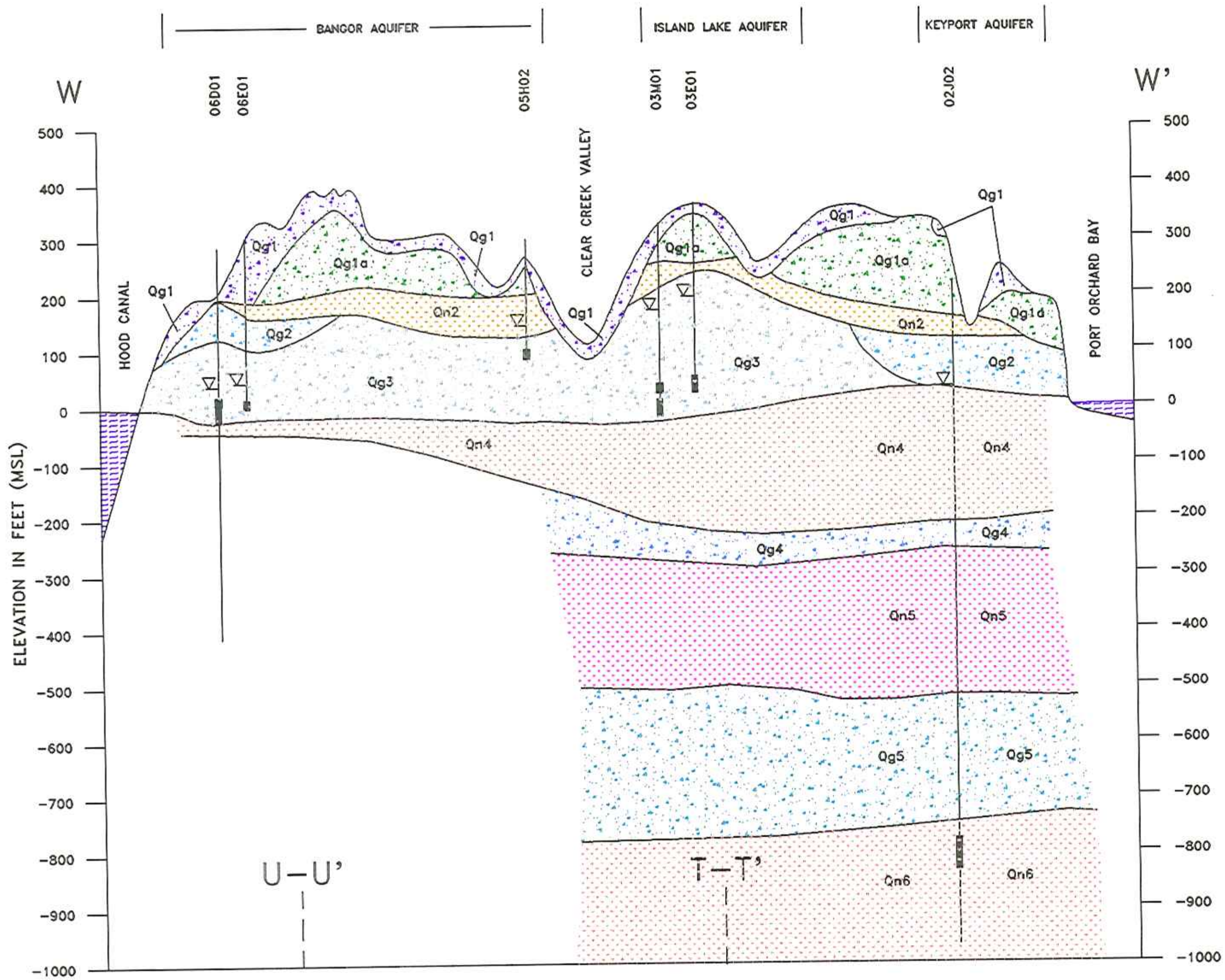
* If photo copied in black and white, some loss of data may occur. *

P:\BASINDOC\VERSION3\DRAWINGS\X-LDWG

EXHIBIT 5-20

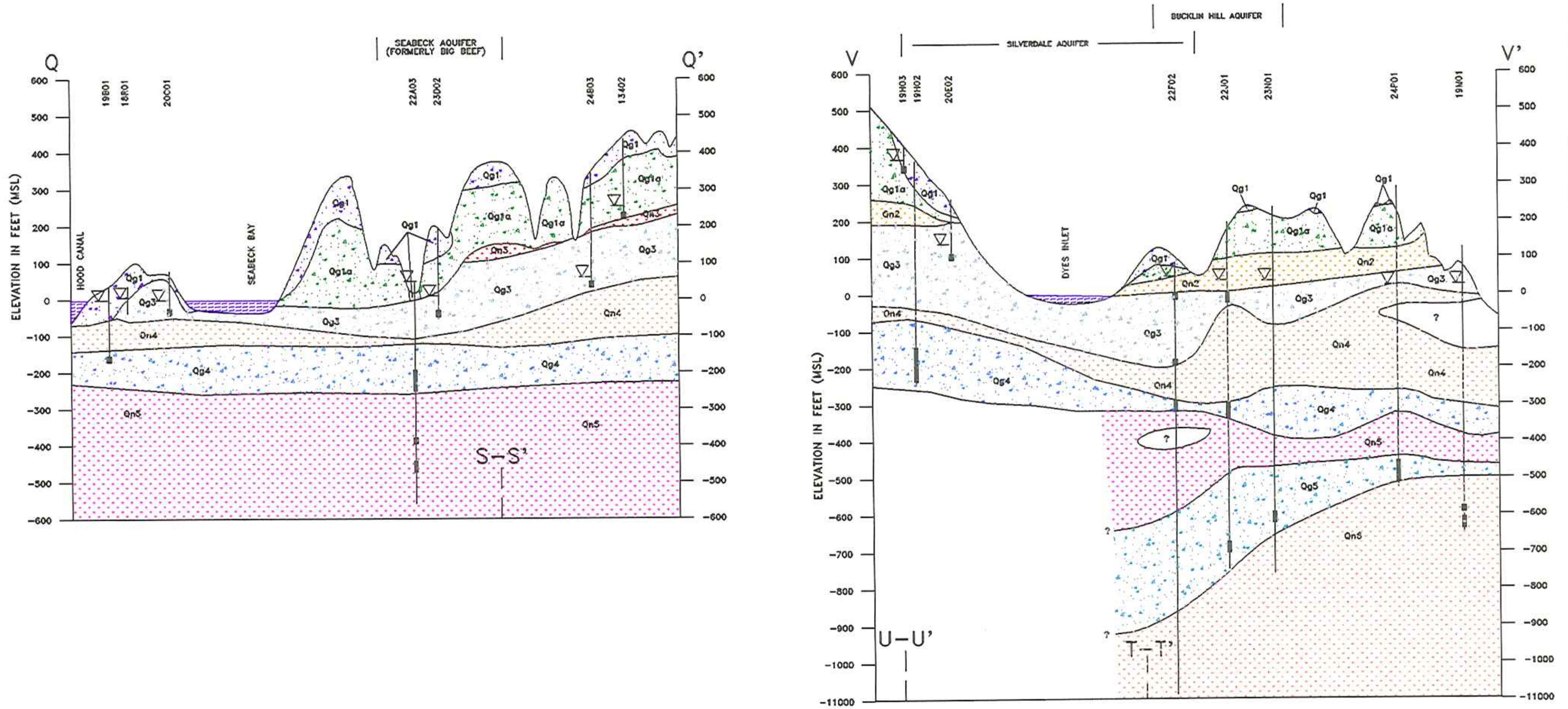
Hydrogeologic
Cross Sections X–X & L–L'
(Edgewater to Jefferson Beach)

Kitsap County
Initial Basin Assessment



CROSS SECTION LEGEND	HORIZONTAL SCALE IN FEET 0 4000 8000 0 200 400 VERTICL SCALE IN FEET VERTICAL EXAGGERATION X 20	**EXHIBIT 5-21** Hydrogeologic Cross Section W-W' (Bangor to Keyport)
27E01 Local Well Number Static Water Level Elev. Perforated or Screened Interval Aquifer Zone and Name W-W' Cross Section Intersect	KITSAP COUNTY GROUNDWATER MANAGEMENT PLAN, 1991 * If photo copied in black and white, some loss of data may occur. *	Kitsap County Initial Basin Assessment

P:\BASINDOC\VERSION3\DRAWINGS\W-W.DWG



CROSS SECTION LEGEND

27E01	Local Well Number	Aquifer Zone and Name	
▽	Static Water Level Elev.	V–V'	Cross Section Intersect
▮	Perforated or Screened Interval		

HORIZONTAL SCALE IN FEET

0 4000 8000

0 200 400

VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION X 20

KITSAP COUNTY
GROUNDWATER MANAGEMENT PLAN, 1991

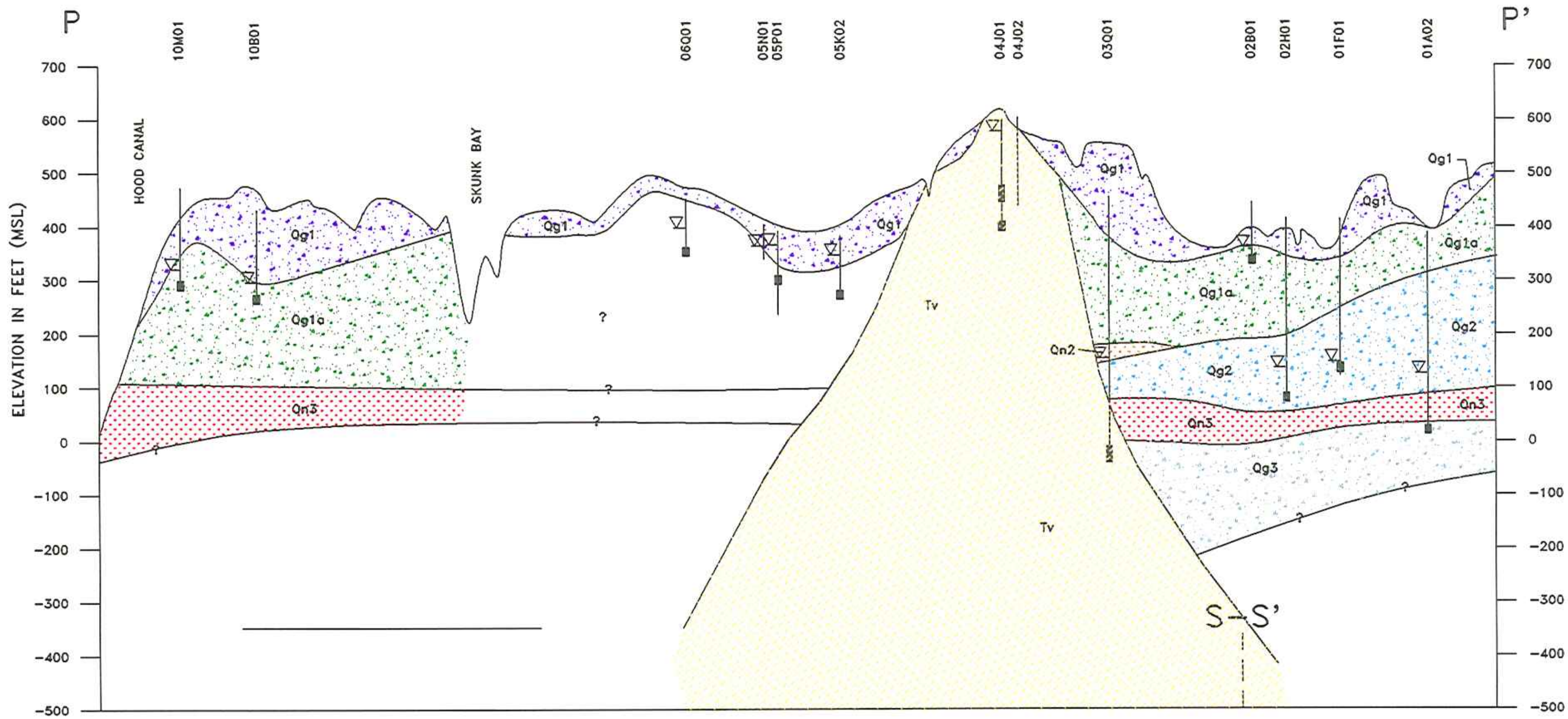
* If photo copied in black and white, some loss of data may occur. *

P:\BASINDOC\VERSION3\DRAWINGS\Q-V.DWG

EXHIBIT 5-22

Hydrogeologic
Cross Sections Q–Q' & V–V'
(Seabeck to Gilberton)

Kitsap County
Initial Basin Assessment



CROSS SECTION LEGEND

27E01	Local Well Number	Aquifer Zone and Name
▽	Static Water Level Elev.	P–P'
▮	Perforated or Screened Interval	Cross Section Intersect

HORIZONTAL SCALE IN FEET
0 4000 8000
0 200 400
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION X 20

KITSAP COUNTY
GROUNDWATER MANAGEMENT PLAN, 1991

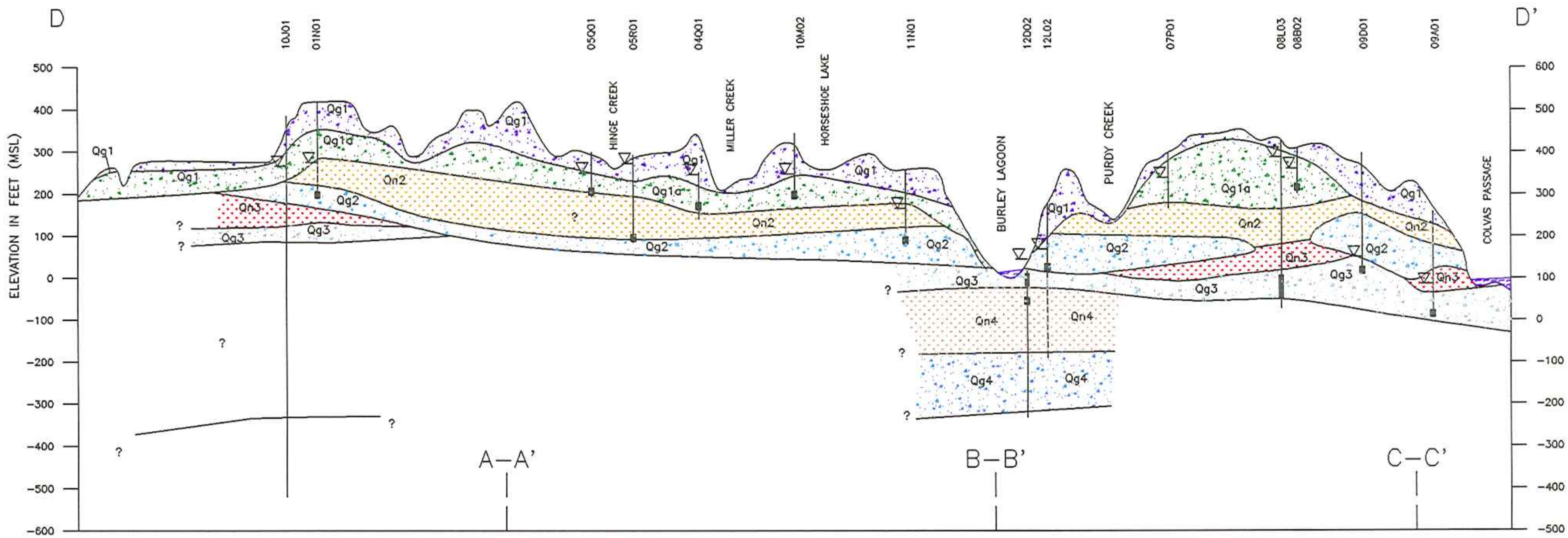
* If photo copied in black and white, some loss of data may occur. *

P:\BASINDOC\VERSION3\DRAWINGS\P-P.DWG

EXHIBIT 5-23

Hydrogeologic
Cross Section P–P'
(Nellita to Wild Cat Lake)

Kitsap County
Initial Basin Assessment



CROSS SECTION LEGEND

27E01 Local Well Number

▽ Static Water Level Elev.

▮ Perforated or Screened Interval

| Aquifer Zone and Name |

D–D'

Cross Section Intersect

HORIZONTAL SCALE IN FEET
0 4000 8000

0 200 400
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION X 20

KITSAP COUNTY
GROUNDWATER MANAGEMENT PLAN, 1991

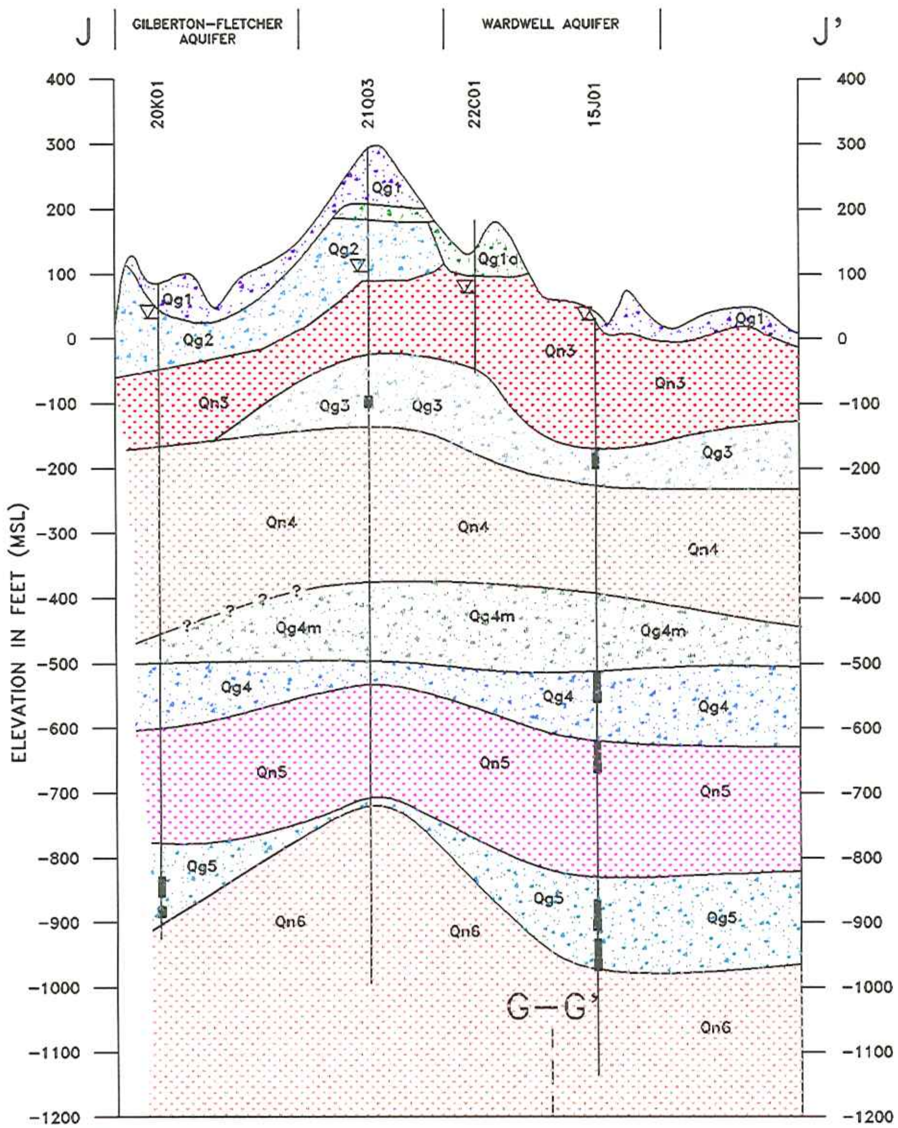
* If photo copied in black and white, some loss of data may occur. *

P:\BASINDOC\VERSION3\DRAWINGS\D-D.DWG

EXHIBIT 5-24

Hydrogeologic
Cross Section D–D'
(Fern Lake to Olalla)

Kitsap County
Initial Basin Assessment



CROSS SECTION LEGEND

27E01	Local Well Number	Aquifer Zone and Name	
▽	Static Water Level Elev.	J–J'	Cross Section Intersect
▮	Perforated or Screened Interval		

HORIZONTAL SCALE IN FEET
0 4000 8000
0 200 400
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION X 20

KITSAP COUNTY
GROUNDWATER MANAGEMENT PLAN, 1991

* If photo copied in black and white, some loss of data may occur. *

P:\BASINDOC\VERSION3\DRAWINGS\J–J.DWG

EXHIBIT 5-25

Hydrogeologic
Cross Section J–J'
(Bainbridge Island)

Kitsap County
Initial Basin Assessment

Constituent	MCL	Units	Total Number of Samples	Samples Exceeding MCL	Percent Exceeding MCL
Arsenic-As	0.05	mg/L	638	6	0.9%
Barium-Ba	1	mg/L	634	1	0.2%
Cadmium-Cd	0.01	mg/L	635	3	0.5%
Chloride-Cl	250*	mg/L	752	4	0.5%
Chromium-Cr	0.05	mg/L	642	1	0.2%
Color	15*	C.U.	632	57	9.0%
Conductivity	700	umhos/cm	776	7	0.9%
Fluoride-F	2*	mg/L	640	6	0.9%
Iron-Fe	0.3*	mg/L	749	214	28.6%
Lead-Pb	0.05	mg/L	644	4	0.6%
Manganese-Mn	0.05*	mg/L	748	196	26.2%
Mercury-Hg	0.002	mg/L	640	7	1.1%
Nitrate-NO3-N	10	mg/L	765	5	0.7%
Selenium-Se	0.01	mg/L	635	7	1.1%
Sulfate-SO4	250*	mg/L	170	0	0.0%
Turbidity	1	NTU	644	284	44.1%

MCL-Maximum Contaminant Level

*Secondary Maximum Contaminant Level (SMCL). Secondary contaminant levels set for aesthetic, cosmetic, and technical reasons and are not health threating at the SMCL.

EXHIBIT 5-26

Comparison of Inorganic Water Quality

Section 6
Water Demand

6.1 Land Use

Land use within Kitsap County (County) can be categorized largely as rural (e.g., forest, agricultural, open space). According to satellite interpretation and County Assessor data, the County is nearly 90 percent rural land. **(Exhibits 2-3, 2-4, and 2-5)**. However, there are several highly urbanized centers with their associated population, commercial centers, and industrial areas at various locations along the transportation corridors of the County. Kitsap County ranks second only to King County as the most densely populated county in the State with 562 people per square mile of land.

Land use was evaluated using both County Assessor Data and satellite imaging. Because urban areas include some sections with high vegetation, the data sets do not exactly compliment each other. The general assessment that the county is approximately 90% "rural" is supported by both approaches.

Examination of land use within the various subareas based on County Assessor data, clearly shows the extent of the urban centers. For example, the Bainbridge subarea (Bainbridge Island) has combined urban and suburban land use types (not forested, open space, or natural cover) equaling 32 percent, Manette (which includes East Bremerton) has 45 percent, Manchester has 28 percent, Gorst has 25 percent, Olalla has 22 percent, Bangor has 21 percent, Poulsbo and Kingston both have 17 percent. In contrast, the Anderson subarea has about 1 percent in urban and suburban land use types, Tahuya and Union are under 5 percent, and Seabeck, Stavis, McCormick, Hansville, Chico, Dewatto, and Port Gamble are between 5 and 15 percent **(Exhibit 6-1)**.

Land cover data (satellite data) shows areas in forest, natural cover, and mixed forest to vary from 98 percent of the land in the Anderson subarea to about 71 percent for the Manette subarea. Specifically, the following subareas have over 90 percent of the land in forest, natural cover, or mixed forest: Anderson, Hansville, Kingston, McCormick, Olalla, Port Gamble, Seabeck, Stavis, Tahuya, Union, and Dewatto. Subareas with between 80 and 90 percent include Bainbridge, Chico, Manchester, and Poulsbo. Those between 70 and 80 percent include: Bangor, Gorst, and Manette **(Exhibit 6-2)**.

6.2 Population

Population forecasts are constantly being updated and derived through a variety of means. Forecasts were used in development of Volume 1 of the 1991 Ground Water Management Plan (GWMP) and in the development of the 1991 Coordinated Water System Plan (CWSP). Since those documents were prepared, planning activity under the Growth Management Act (GMA) has been initiated. Because of the specific requirements of the GMA, considerable attention has been focused on the methodology and basis for the County's forecast. As of October 1995, there were still significant issues to be resolved.

According to Washington State Office of Financial Management (OFM), population projection for the year 2015, range from 280,910 to 337,089 (11/17/95 preliminary OFM projections). Population for the County in 1990 was 184,500. These numbers yield and average yearly growth rate for the County between 2.1 percent and 3.3 percent. The annual percentage change in population for Kitsap County from 1990 to 1994 was 3.1% (SounData, March/April 1995). Kitsap County population increased by 31.47% for the ten years between April 1, 1985 and April 1, 1995 (OFM 6/30/95 report).

6.3 Water Use

Water use patterns were reviewed during the development of Volume 1 of the GWMP (1991). Since that time, there have been no comprehensive reevaluations. According to the GWMP, on a County-wide basis, about 80 percent of water use, excluding instream uses, is municipal, domestic, or single family supply. Fish propagation is the next largest user with about 17 percent. **(Exhibit 6-3).** This pattern does vary somewhat seasonally, with irrigation demanding a slightly higher percentage during the summer, but the general dominance of municipal/domestic use remains the same.

Based on 1990 census data, population density has been calculated by subarea and is shown in **Exhibit 6-4**. The patterns of density have no doubt changed somewhat over the last six years. However, the general pattern of rural and urban density has remained.

As population density and land use varies throughout the County, so does the water use pattern for a given area. The pattern described above is predominant in the more urban areas of the County (central portions). In the more rural areas fish propagation is the dominant water use (50 to 80 percent). Municipal and domestic water use drops to between 20 and 40 percent in rural areas.

6.4 Current and Future Demand

A summary of average and peak day water demand for the County was provided in Volume I of the GWMP and is graphically depicted in **Exhibit 6-5**. The water demand projections shown include municipal and domestic, commercial/industrial, irrigation, fish propagation, and heat exchange. Instream uses are not included.

The total, average day, existing water resource requirement was about 31 MGD in **1990 (Exhibit 6-3 and 6-5)**. It is projected to increase to approximately 45 MGD by 2020, assuming water consumption habits and lifestyles do not change from existing conditions. If an increase in multi-family housing units is assumed to occur in the urban areas of the County, and a municipal and domestic water conservation program is initiated or expanded at the County and local utility levels, then the average day demand in 2020 is projected to be about 39 MGD. An additional water resource requirement of 8 to 13 MGD (9,125 to 14,600 Acre Feet per year) over 1990 production quantities is estimated to be necessary by the year 2020 to support the average day demand.

Total peak day demand was approximately 74 MGD in 1990 **(Exhibit 6-5)**. By 2020 peak day demand is anticipated to reach nearly 114 MGD (existing life styles) or 100 MGD (with conservation). The additional water resource requirement, over 1990 numbers, for a peak day in 2020 would be approximately 26 MGD. The GWMP water demand projections were based on a population projection for 2015 of approximately 275,000, which is lower than the more current OFM projections listed above. Water demand therefore, is expected to be correspondingly greater **(Exhibit 6-5)**.

The Department of Ecology defines non-consumptive use of water as a use that returns the same quantity and quality of water to the source (e.g., a hydroelectric power project). Kitsap County has no significant non-consumptive water use projects and none are currently planned.

6.5 Water Reuse in Kitsap County

Millions of gallons of secondary treated wastewater effluent and fish farm discharge, flow to the sea from Kitsap County every day. Other than providing grounds irrigation at the treatment plants, no large-scale reuse projects are currently in place in the County. Over the next several years, the potential exists for several water reuse projects to be in operation in the County for applications, such as irrigation, which do not require drinking water quality standards. The City of Bremerton is conducting a feasibility study of reuse options including golf course irrigation and industrial uses (Kathleen Cahall, Bremerton Public Works). Kitsap County Public works is looking for opportunities for reuse from its treatment plants (George Mason, Kitsap County Public Works). Annapolis Water District is conducting a study to evaluate the feasibility of a reuse project in its area (Dennis Coburn, Annapolis Water District).

Sources of Waste Water in Kitsap County

The following is a summary of the amount of waste water generated in Kitsap County by various sources. The first set of data shows where water is being used and therefore gives an indication of where reuse efforts might be focused.

Category	MGD	Percentage
Municipal/Domestic	17.06	51%
Commercial	5.07	15%
Industrial	3.52	11%
Irrigation	2.21	7%
Fish Farming	5.20	16%
Stock Watering	0.02	0.06%
Total	33.08	

NOTES: Water usage in Kitsap County (1992 data)
Data extrapolated from GWMP Vol. 1, , Table II-9
Industrial includes Puget Sound Naval Ship Yard.
Irrigation relates only to farming practices.

Not all of the water currently being used in the county is available for reuse. Water discharged to on-site septic fields is not available for processing but is effectively being recycled.

Wastewater Treatment Plants

Eight secondary wastewater treatment plants are in operation in Kitsap County. They discharge as follows:

Plant	Operator	Design Discharge (Avg. MGD*)	Actual Discharge 1995 (Avg. MGD)
City of Bremerton	City of Bremerton	10.1	6.0
Central Kitsap Plant	Kitsap County	4.8	3.593
Annapolis	Sewer District #5	2.8	1.815
Manchester	Kitsap County	0.233	.1856
Winslow	City of Bainbridge Is.	1.0	0.5
Suquamish	Kitsap County	0.2	.1735
Kingston	Kitsap County	0.15	.0994
	Totals	19.283	13.2611

* Bremerton Plant limit is on the maximum monthly average flow.
NOTE: The Port of Bremerton Industrial Park has a treatment plant with a capacity of 72,000 GPD and a current discharge rate of approximately 20,000 GPD. The discharge goes to a septic field so it is not included in the totals above.

Exhibit 6.6 provides a map of sewage treatment plant locations.

Several factors must be considered when evaluating the practicality of reusing water:

- The cost of further treating wastewater effluent to meet standards for specific reuse applications.
- The availability and cost of water from other sources.
- The expense of transferring water between water processing sites and reuse sites.
- The volume of water available for reuse at a given location versus the demand for reused water in the vicinity.
- Public acceptance of reused water for the uses proposed.
- Regulatory and policy barriers to reuse.
- Quality control.

6.6 Summary and Implications for Future Allocations

This section has provided an overview of the general character of the County, which gives some indications of likely patterns of water use, and general indications of demand for the future. This section has not provided a much needed analysis of demand by subarea, because at this time (October 1995) population growth figures are a focus of controversy, and under revision with respect to allocations to subareas.

New sources and water rights for some existing public water systems will be needed in the future. While this statement seems apparent, given the general growth expected, the size and extent (geographical) of this need is unknown. For example, it is not known whether existing rights for various purveyors are adequate for future needs. It is not known whether specific areas (such as Bainbridge Island) pose significant water rights questions because of a collective deficiency of water rights within that area compared with predicted demand. It is also not known what percentage of population in each of the subareas can be expected to be served by public water supplies, and which can be expected to be served by private domestic wells.

Clearly, follow up studies will be required. Existing supply versus demand, data requirements, funding, etc. will be evaluated to set appropriate priorities for future studies by subarea. For example, if specific subareas show significant discrepancies when future demand is compared with existing capacity (water rights), then priority for future supply study should be focused in areas which could provide for the increased demand. If studies raise significant policy issues relating to use of private wells, integration of water systems, etc., then these issues can be given priority and addressed in the appropriate forum.

Kitsap County Land Use Classified Other than Urban or Suburban

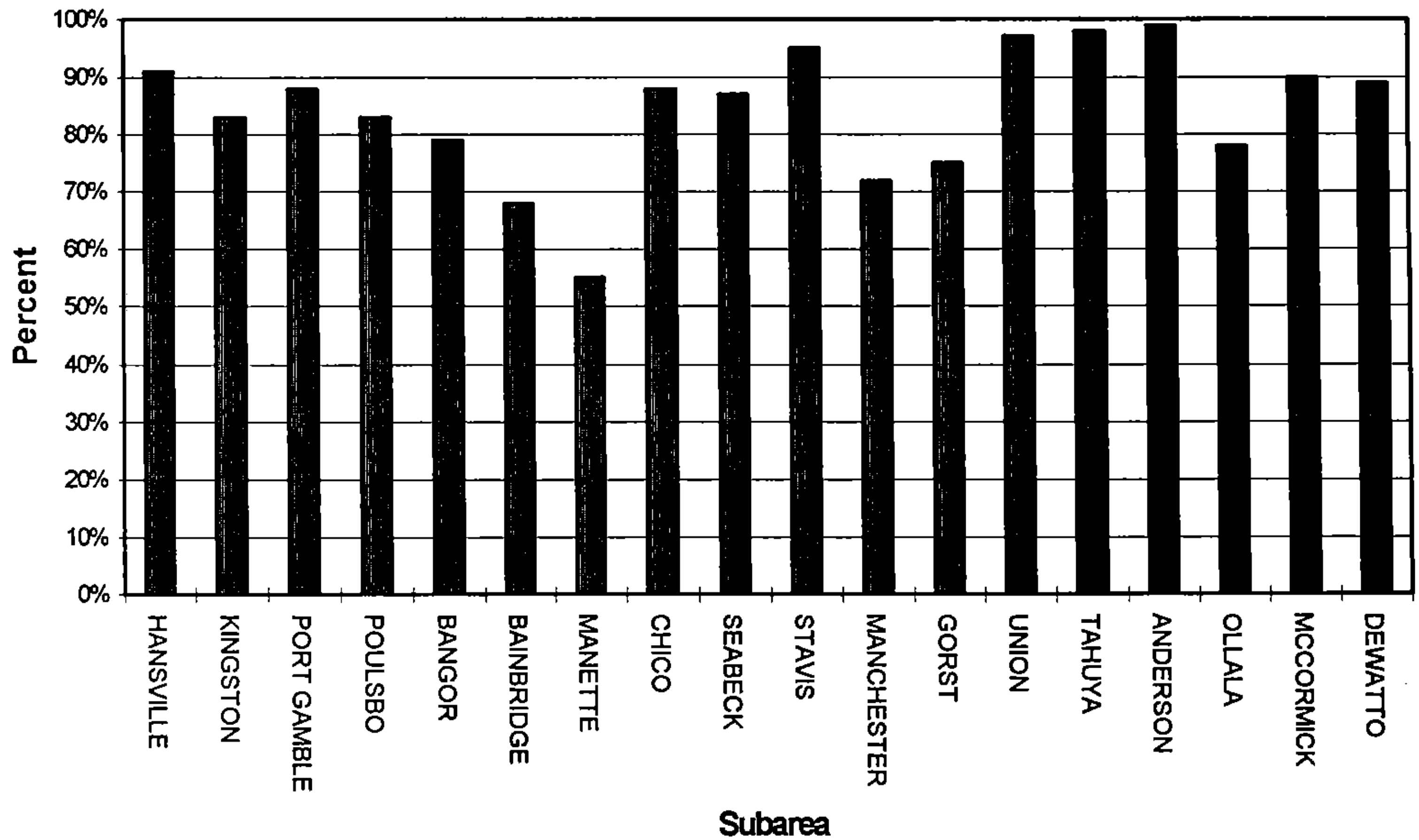


Exhibit 6-1
Classified Land Use Other Than Urban or Suburban
Source: Kitsap County DCD/GIS

Kitsap County
Basin Assessment Program

Kitsap County Land Cover (By Satellite) Classified as Forested or Natural Cover

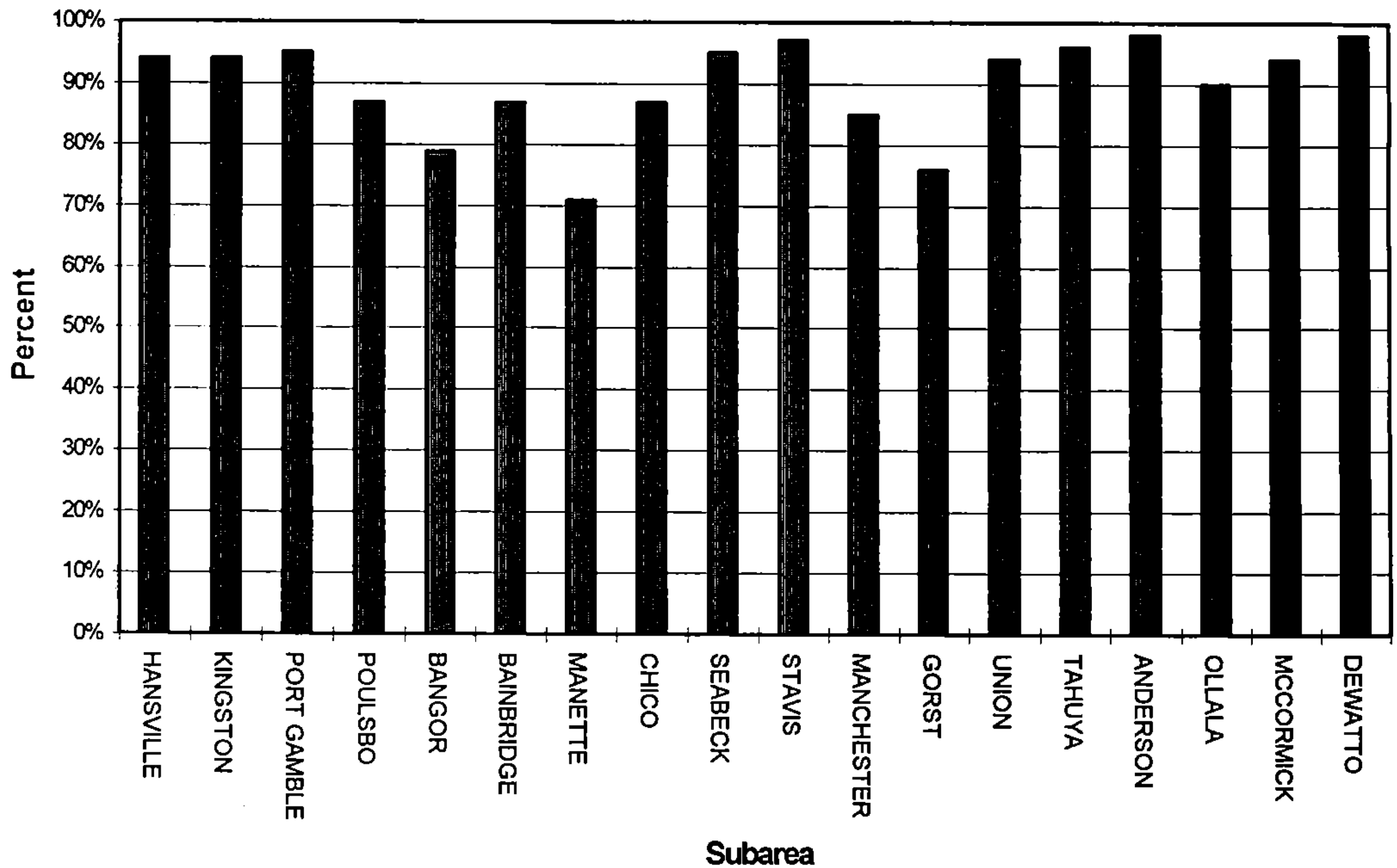


Exhibit 6-2
Kitsap Subarea - Forested and Natural Cover
Source: Puget Sound Regional Council 1992

Kitsap County
Basin Assessment Program

County-Wide Water Use in Million Gallons Per Day		
Classification	**1990**	**2020**
Municipal	19.55	30.43
Domestic / Single Family	4.89	7.61
Commercial / Industrial	0.27	0.27
Irrigation	1.18	1.18
Fish Propagation	5.20	5.2
Stock Watering	0.04	0.04
Totals	**31.13**	**44.73**
Water Use in Percent of Total		
Municipal	63%	68%
Domestic / Single Family	16%	17%
Commercial / Industrial	1%	1%
Irrigation	4%	3%
Fish Propagation	17%	12%
Stock Watering	0%	0%
Totals	**100%**	**100%**

EXHIBIT 6-3
Kitsap County Water Use
Source: Groundwater Management Plan (1991)
Volume 1 - Table II-9

Kitsap County Population Density				
Subarea	1990	Proposed Population Change	2014	Annual Growth Rate
HANSVILLE	2,619	1,100	3,719	2.5%
KINGSTON	9,082	5,200	14,282	3.3%
PORT GAMBLE	4,247	3,297	7,544	4.2%
POULSBO	8,478	5,669	14,147	3.7%
BANGOR	22,718	7,880	30,598	2.2%
BAINBRIDGE	15,736	6,820	22,556	2.6%
CHICO	9,466	3,975	13,441	2.5%
SEABECK	3,653	648	4,301	1.2%
STAVIS	780	133	913	1.1%
MANCHESTER	29,699	12,147	41,846	2.5%
GORST / MANETT	63,312	35,334	98,646	3.2%
UNION	858	346	1,204	2.5%
TAHUYA	799	136	935	1.1%
ANDERSON	110	19	129	1.1%
OLALLA	8,663	6,065	14,728	3.9%
MCCORMICK	4,049	1,467	5,516	2.2%
DEWATTO	137	23	160	1.1%
Total	184,406	90,259	274,665	2.9%

EXHIBIT 6-4

Population Density by Subarea

Source: Kitsap County DCD

Taken from GWMP 1991 Vol. I.
Recent OFM data for Average Day Demand has been added.

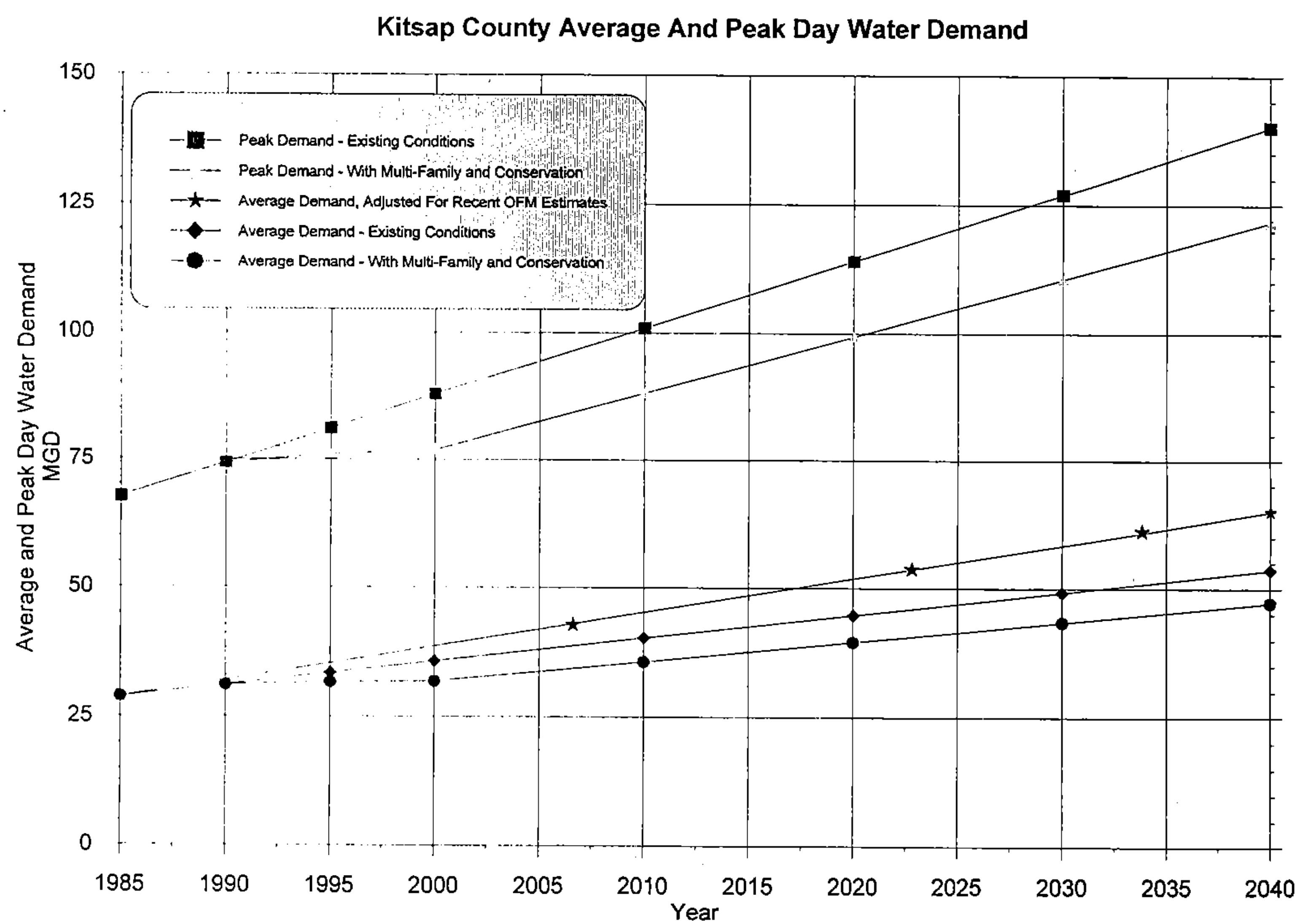
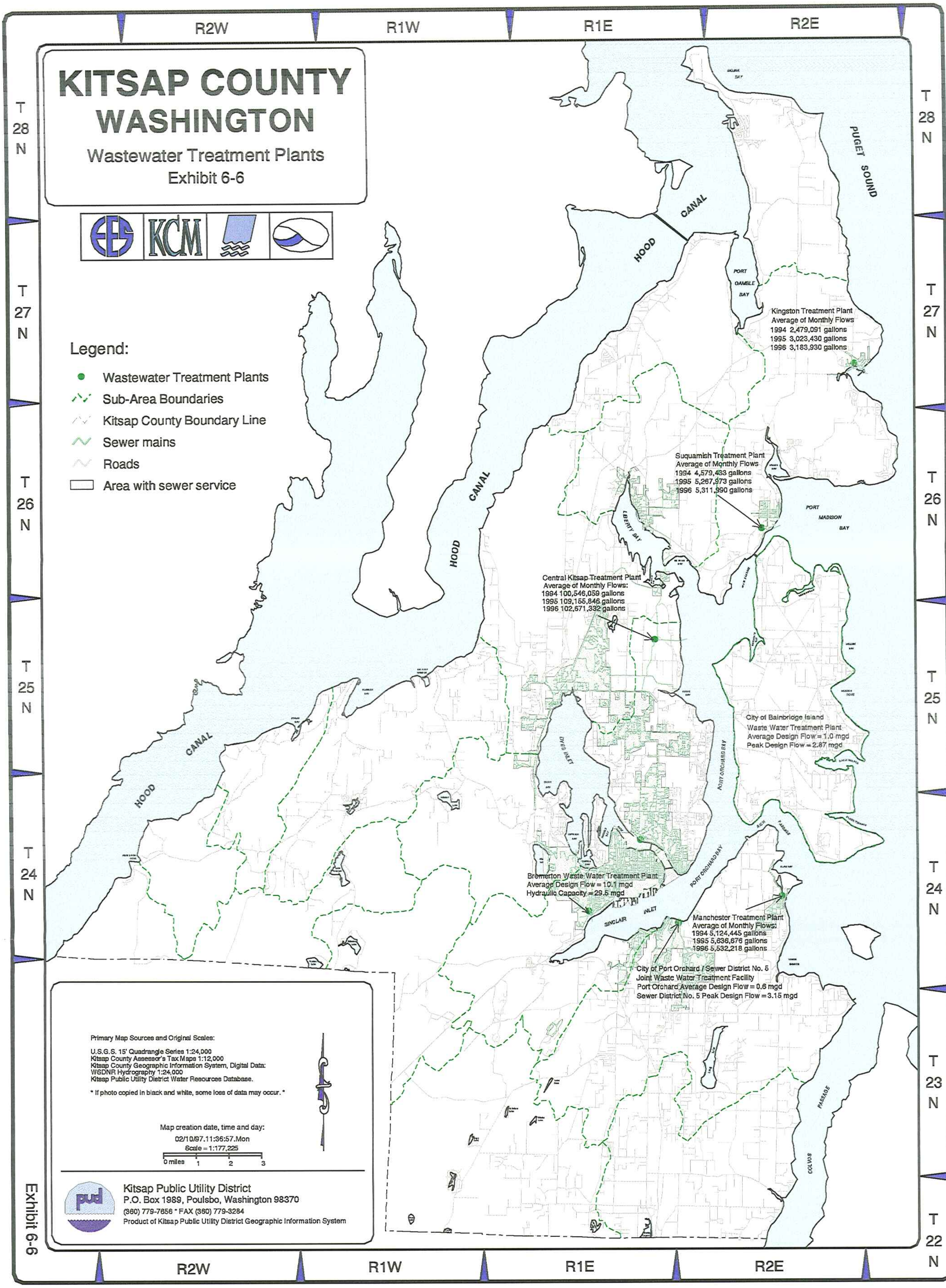


EXHIBIT 6-5

Average And Peak Day Water Demand

Kitsap County
Initial Basin Assessment



KITSAP COUNTY
WASHINGTON
Wastewater Treatment Plants
Exhibit 6-6
Legend:
Wastewater Treatment Plants
Sub-Area Boundaries
Kitsap County Boundary Line
Sewer mains
Roads
Area with sewer service
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
COLVOS PASSAGE
Kingston Treatment Plant
Average of Monthly Flows
1994 2,479,091 gallons
1995 3,023,430 gallons
1996 3,183,930 gallons
Suquamish Treatment Plant
Average of Monthly Flows
1994 4,579,433 gallons
1995 5,267,973 gallons
1996 5,311,990 gallons
Central Kitsap Treatment Plant
Average of Monthly Flows:
1994 100,546,059 gallons
1995 109,155,846 gallons
1996 102,671,332 gallons
City of Bainbridge Island
Waste Water Treatment Plant
Average Design Flow = 1.0 mgd
Peak Design Flow = 2.87 mgd
Bremerton Waste Water Treatment Plant
Average Design Flow = 10.1 mgd
Hydraulic Capacity = 29.5 mgd
Manchester Treatment Plant
Average of Monthly Flows:
1994 5,124,445 gallons
1995 5,636,676 gallons
1996 5,532,218 gallons
City of Port Orchard / Sewer District No. 5
Joint Waste Water Treatment Facility
Port Orchard Average Design Flow = 0.6 mgd
Sewer District No. 5 Peak Design Flow = 3.15 mgd
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
02/10/97.11:36:57.Mon
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 6-6

Section 7 Fisheries Habitat and Water Quality Assessment

7.1 Resources

Rivers and other streams in Kitsap County (County) with salmonid use are shown on **Exhibits 7-1 through 7-3**. The fisheries assessment and stream water quality information available for the County are summarized in the attached matrix table **(Exhibit 7-2)** and annotated bibliography (Appendix E). Information on **Exhibit 7-2** is organized first by the large watersheds identified under the Nonpoint Rule (WAC 400-12) for the watershed planning process. Surface waters within these watersheds are organized within the subareas developed for this project. The agency which sponsored each study and the author(s) of each report are identified, as well as the parameters investigated. The annotated bibliography is organized by author of the report, or agency which sponsored the study if no author is cited. Streamflow trends are discussed in Section 4 and miscellaneous measurements are presented in Appendix C.

Existing information for much of the County is limited and does not provide an in-depth assessment of the overall availability of habitat for utilization by the many fish populations identified. While many sources were reviewed, the primary comprehensive sources are listed below.

- Data on fish stocks is contained primarily in the State Salmon and Steelhead Stock Inventory (SASSI 1994) and the Washington Rivers Information System Database (see Appendix E). However, escapements (the number of salmonids that make it back to spawn) to many creeks in Kitsap County are generally not documented

- The systematic collection of habitat information has only recently been initiated through habitat assessment surveys sponsored primarily by the Northwest Indian Fisheries Commission and initiated through the Timber Fish and Wildlife Program.

- Water quality information has been documented primarily through the watershed planning process (WAC 400-12), which requires a watershed characterization and water quality assessment. Water quality information is generally limited to fecal coliform bacteria concentration and documentation of the State health standards. Little data has been collected with fish health in mind.

- Watershed plans completed in the last few years include a characterization of stream corridors conducted by the Puget Sound Cooperative River Basin Team (PSCRBT). These watershed characterizations contain a qualitative discussion of fisheries resources and major stream systems have been evaluated for potential sources of nonpoint pollution and riparian habitat conditions. Where watershed characterizations have not been completed, the WRISD by the Washington Department of Fish and Wildlife provides the most in-depth information of salmon utilization, though some of the information may not be current.

- Kitsap Public Utility District No. 1 (KPUD) has completed assessments of some of the subareas within the County in the last few years. The fisheries aspect of these studies has been limited, in most cases, to the review of existing data and has not involved extensive fisheries habitat surveys.

It is important at this level of evaluation to point out the definition of fish habitat assessment in relation to much of the work which has been referenced in this study. An accurate assessment of habitat, as has been completed on the large river systems and their tributaries outside WRIA 15, is a very complex study. The reference to habitat does not simply evaluate riparian cover and general stream bank conditions. These in-depth habitat assessments include a review of the ratio of pools to riffles, the quality of the streambed material in terms of gravels and fines and the abundance of desirable benthos as a food base. In addition, the reference in this document to published data refers to technical documents and publications which have gone through a review process. Newspaper and magazine articles do not qualify as published data.

7.2 Fisheries Assessment

While there are no large river systems within the boundaries of the County, there are many small streams which are highly influenced by ground water. These small streams collectively have supported populations of coho and chum salmon and searun cutthroat trout. There has been some limited natural production of chinook in Kitsap County drainages. Reduced flows in the late summer and early fall significantly influence the productivity of these streams for coho and cutthroat and impact the availability of spawning habitat for fall chinook.

The anadromous fish stocks of the Kitsap Peninsula utilize two distinct major watersheds, Hood Canal on the West and Puget Sound on the East. On the East side, the coho management is for hatchery coho, while coho on the Hood Canal side are being managed for natural (wild) production. The implication of these two different management systems is that Hood Canal stocks are at reduced levels. These reduced levels are controlling the harvest and fishing regulations in the Straight of Juan De Fuca and off the Coast of Washington and coho are being considered for listing by the National Marine Fisheries Service (NMFS). On the Puget Sound side of Kitsap Peninsula there are more abundant returns of coho and seasons are only impacted by closures to protect Hood Canal stocks.

If water allocation causes a reduction in critical flows for coho production on the Hood Canal side of Kitsap Peninsula, the impact on a listed species could require action to reduce withdrawal or implement mitigating measures.

Chinook stocks on both sides of the peninsula are managed for hatchery stocks.

Following is a brief summary which describes the fisheries habitat within the major stream systems for each subarea. Quantitative stream habitat assessment surveys, such as those initiated through the Timber Fish and Wildlife Program, are also noted.

7.2.1 Fisheries Habitat Within the Major Stream Systems

Upper Hood Canal Watershed -Hansville, Port Gamble, Bangor, Seabeck, Stavis, Anderson Subarea

Hansville - No information was found regarding fisheries habitat within this subarea.

Port Gamble - Gamble Creek is accessible to salmonids for nearly four miles, with suitable spawning in the upper one-half of the stream and excellent rearing habitat throughout (Williams, et. al., 1975). The habitat of a tributary downstream of Rova Road which used to support salmon has been extremely impacted and is now too degraded to support fish (PSCRBT 1993).

Stream surveys were conducted by the Northwest Indian Fisheries Commission along Gamble Creek in 1990.

Bangor - The Bangor subarea includes drainages into the Upper Hood Canal Watershed, Liberty Bay Watershed, and Dyes Inlet Watershed. For simplicity, creeks which drain into other watershed areas (i.e., Big and Little Scandia Creeks, Clear Creek, Barker Creek, Strawberry Creek) are included here.

Clear and Barker Creeks have important runs of chum and coho (WRISD, Williams, et. al., 1975). Coho and chum salmon have also been noted in Strawberry Creek. Low summer flows affect production of coho in these drainages.

Coho and chum salmon as well as cutthroat trout are known to utilize both Big and Little Scandia Creeks. The Scandia Creeks are impacted primarily by poor riparian zone management resulting in little or no streamside vegetation and heavy sedimentation.

There are two major drainages within the Bangor Naval Submarine Base, Devil's Hole Lake and Cattail Lake. Fisheries management plans have been developed for both of these drainages. Streamflow from the main stem entering Devil's Hole Lake averages 4.0 cfs. Devil's Hole Lake and the main stem both contain good fish habitat and have adequate riparian habitat. A fish ladder constructed in 1981 allows fish passage into and out of the lake from Hood Canal. The lake contains native cutthroat trout and coho salmon. A small hatchery was used to raise coho salmon, and a net pen in the lake allows rearing the juvenile coho to a larger release size. Cattail Lake drains into Hood Canal by culverts that do not allow fish passage. However, Cattail Lake and its feeder streams are well vegetated and provide good fish habitat.

Seabeck - One of the most important streams in the County is Big Beef Creek located within the Seabeck subarea. Big Beef Creek is used as an indicator stream for Hood Canal coho and chinook stocks. The University of Washington has a research station situated at the mouth of the creek. There is a barrier weir which controls the upstream and downstream movement of fish in this system. Returning adults and juveniles out-migrating are counted as they pass through the system. Based on the numbers of juveniles counted in relation to the number of adults which spawned in the watershed, an estimate of adult return is calculated. This information is used to forecast the entire Hood Canal salmon escapement and projected adult return.

At one time, Big Beef and Seabeck Creeks provided exceptional spawning and rearing habitat for salmon (Williams, et. al., 1975). Sections of Big Beef Creek still contain good habitat, however, development has degraded the stream. Construction of Lake Symington resulted in waters being warmed by the impoundment and thereby increased downstream temperatures and degraded habitat. Seabeck Creek provides fairly good habitat but low streamflows limit fish production.

Little Anderson Creek has fair habitat for coho and chum salmon production. This stream is probably one of the most impacted streams in the watershed. Development in the area has resulted in large amounts of sedimentation. Little Beef Creek is known to have some chum salmon and resident trout production.

Habitat surveys have been conducted along Big Beef and Seabeck Creeks by the Timber Fish and Wildlife Monitoring Program (1990-1990), and on Big Beef Creek by the Washington Department of Fisheries (1984) and the University of Washington (1991) (Tabor and Knudsen, 1993). Little Anderson Creek was surveyed in 1993 by the Northwest Indian Fisheries Commission. Methodology of the surveys varied according to the agency.

Stavis - The Stavis subarea is largely undeveloped and provides excellent habitat for spawning and rearing salmon. Several years ago, pink salmon were witnessed migrating up this creek (PSCRBT 1993). Protection of this Creek is very important as it is one of the few "semi-pristine" stream systems left in the Puget Sound area.

Boyce Creek is a 2.2 mile long stream which drains into Frenchman's Cove. Boyce Creek is known to be utilized by both coho and chum salmon.

A habitat survey was conducted along Stavis and Boyce Creeks by the Northwest Indian Fisheries Commission in 1993.

Anderson - Because there has been a limited amount of development within the Big Anderson Creek drainage, the return of coho to this system has been an important factor in the abundance of coho in Hood Canal. While logging activities have altered the area, the riparian cover and in-stream habitat is in good condition. The Creek supports both an early and a late run of chum salmon.

Harding Creek drains into Hood Canal north of Tekiu Point. This Creek is known to be utilized by both chum and coho salmon, as well as resident searun cutthroat trout.

The Northwest Indian Fisheries Commission has recently completed habitat surveys of Big Anderson and Harding Creeks.

Bainbridge Island Watershed and Subareas

The streams on Bainbridge Island are typical of small, low-gradient streams in the Puget Sound area. Natural limiting factors for successful salmon reproduction are stream size, passage barriers, and lack of suitable spawning gravels. None of the streams have been officially named. Fletcher Bay drainages support out-migrating searun cutthroat trout, coho and chum salmon. Stream No. 0344 which drains into Manzanita Bay supports cutthroat trout, coho, and chum salmon. Coho and cutthroat trout utilize the largest stream in the Port Madison drainage. The primary stream (No. 0321) which drains into Murden Cove contains some of the best fish habitat on the Island and supports cutthroat trout, coho, and chum salmon. All of the streams in the Blakely Harbor drainage, except the one draining Mac's Dam, have insufficient flow to support salmonids. The Mac's Dam stream supports coho and cutthroat trout. Chum salmon and cutthroat trout have been identified in stream No. 0324 in the Eagle Harbor drainage. There is no flow data available for any of the Bainbridge Island streams.

Liberty/Miller Bay Watershed - Kingston, Poulsbo Subareas

Kingston - The Suquamish Tribe operates a fish culture facility on Grovers Creek which drains into Miller Bay. Coho, chum, and chinook salmon which return to this facility are used as the source of eggs for enhancement activities on several small streams. The Suquamish Tribe operates another hatchery along Cowling Creek which provides a source of chum eggs

Martha John Creek, which is a tributary to Miller Lake Creek, supports a year-round population of resident cutthroat trout, chum and coho salmon. In some years, Martha John Creek has a very healthy run of coho.

Chum and coho production has been reported in several of the smaller independent drainages. Natural limiting factors within the Kingston subarea are the small size and restricted accessibility of the streams.

Poulsbo - Coho and chum salmon are the predominant species found in Dogfish Creek, however, chinook also have been noted to return (Williams, et. al., 1975). The Suquamish Tribe stocks chinook in Dogfish Creek. Johnson Creek supports chum and coho salmon as well as trout species. Coho salmon and cutthroat trout have been noted in both Lemolo and Klebeal Creeks. Big and Little Scandia Creeks drain into Liberty Bay but are considered part of the Bangor subarea and are discussed in that section.

Dyes Inlet Watershed - Manette, Chico Subareas

Manette - Limited documented information is available for creeks in this drainage.

Chico - Chico Creek has an important run of both coho and chum salmon, with spawning occurring throughout the entire mainstream and lower portions of all tributaries. Low summer and fall flows impact production in this drainage. Some years the low flow conditions have extended into late fall and have interfered with the up-stream migration of the early portion of the major chum run to Chico Creek.

Low summer and fall flows have affected production of coho and chum salmon in these drainages. Diversion of additional water from streams during low flow periods would be particularly detrimental.

Sinclair Inlet Watershed - Gorst, Manchester Subareas

Gorst - Gorst Creek which drains into Sinclair Inlet is part of the City of Bremerton's water supply and restrictions are in place regarding development within the watershed. A fish lader is installed in Gorst Creek. Coho and chum salmon have been noted to utilize Anderson Creek where a fish ladder was installed in 1994 through a cooperative effort between the City of Bremerton and Trout Unlimited.

The Suquamish Tribe has a cooperative effort with a sport fishing organization for the rearing and release of approximately 2 million chinook juveniles into Gorst Creek. This release provides a terminal fishery for both the Tribe and sport fishermen.

Manchester - Streams in this area are extremely important for chum and coho salmon (Williams, et. al., 1975). The lower two miles of Blackjack Creek and the lower 1.25 miles of Curley Creek are utilized by early stocks of chum salmon. Blackjack, Curley, and Salmonberry Creeks are important coho areas. Blackjack and Curley Creeks have had occasional plants of coho made. Coho have been reared in Clam Bay, and chum salmon have been reared in a pond on Beaver Creek.

Burley Minter Watershed - Olalla Subarea

Olalla - Burley Creek has returns of coho and chum salmon, and as of 1975, the only wild stock of chinook salmon in Henderson Bay drainage. Both early and late chum salmon runs were returning to this Creek. Returns of coho and chum salmon to Purdy Creek were reported in 1975 to be below their potential (Williams, et. al., 1975). Personal communications with Washington State Department of Fish and Wildlife (WDFW) indicate a natural run of chinook continue to utilize Burley Creek. However, water quality conditions in the estuary when adults are returning often result in fish kills due to low dissolved oxygen.

Olalla Creek supports returns of coho salmon. Habitat deterioration from past logging and current farming practices has occurred. Olalla Creek has received plants from the Minter Creek Hatchery, however, production has been predominantly natural. Due to the small size of the stream, all future water diversions should be carefully examined prior to approval (Williams, et. al., 1975).

Mason County Drainages - Tahuya, Union, McCormick Subareas

Tahuya - The Tahuya River has very important runs of coho and chum salmon, as well as moderate chinook production. Chinook salmon production is limited to the lower four miles of the river due to flow conditions and accessibility during migration. Three distinct stocks of chum salmon return annually to the Tahuya River; an early run during September and early October in the lower three miles of the river; an entirely intertidal run in late October and early November, and a late run during November; and December.

The last run utilizes the upper river area from miles 5 to 10, as well as lower reaches of a few tributaries (Williams, et. al., 1975). Low summer flows is a limiting factor for coho production.

Habitat surveys have been conducted along the Tahuya River, Little Tahuya, Gold, Panther, and Tin Min Creeks by the Washington Department of Wildlife (1984), Washington Department of Fisheries (1984), US Fish and Wildlife Service (1992-93), Northwest Indian Fisheries Commission (1990), Point No Point Treaty Council (1992), and Washington State Department of Ecology (1974, 1992-93). Methodology of the surveys varied with agency (Tabor and Knutsen, 1993).

The primary land use in the drainage is commercial and private forest land. The major source of sediment found within the stream corridors of the river and tributaries are the boot-leg or illegal trails and crossings used for off-road recreation.

Union - Coho and chum salmon are produced in the Union River and Big Mission Creek. A small chinook run returns to the lower two miles of the Union River Mckenna Falls, located between river mile 6 and 7, is a natural barrier to salmon production in the upper reaches of the Union River. Low streamflow during the summer months in the Big Mission Creek limit salmon production there. Strict adherence to the fisheries code relative to hydraulic projects, and close evaluation of any proposals for removal of water from the streams is essential for maintaining the existing high production of these streams (Williams, et. al., 1975).

Habitat surveys have been conducted along the Union River, Big Mission and Bear Creeks by Point No Point Treaty Council (1992), Washington Department of Fisheries (1984), US. Fish and Wildlife Service (1992), and Washington Department of Ecology (1970 and 1992). Survey methodology varied with the agency (Tabor and Knutsen, 1993).

McCormick - The Minter Creek Hatchery provides annual releases of chinook and coho fingerlings to many of the streams of the Kitsap Peninsula and other Puget Sound river systems. Natural production of chinook totals approximately 600 spawners annually, plus a small population of wild chum salmon (Williams, et. al., 1975).

Dewatto Subarea

The Dewatto River produces important runs of steelhead, coho and chum, as well as a small chinook population. Three distinct stocks of chum salmon enter Dewatto River at different times of the year and spawn in different sections of the stream. The earliest run enters the lower 2 miles of the river during September with as many as 4,000 spawners per year (Williams, et. al., 1975). A second run enters in late November and spawn in tributaries and mainstream areas above mile 1.5. The third run enters in late December and early January and spawns intertidally and in the lowermost portion of the stream. Thomas Creek, a small creek to the north of the Dewatto River, is known to support coho and chum salmon, as well as resident Trout (PSCRBT 1993).

Stream surveys have been conducted along the Dewatto River by the Northwest Indian Fisheries Commission (1989), Washington Department of Wildlife (1984), and the US. Fish and Wildlife Service (1992) (Tabor and Knudsen 1993). Survey methodology varied with agency.

Summary

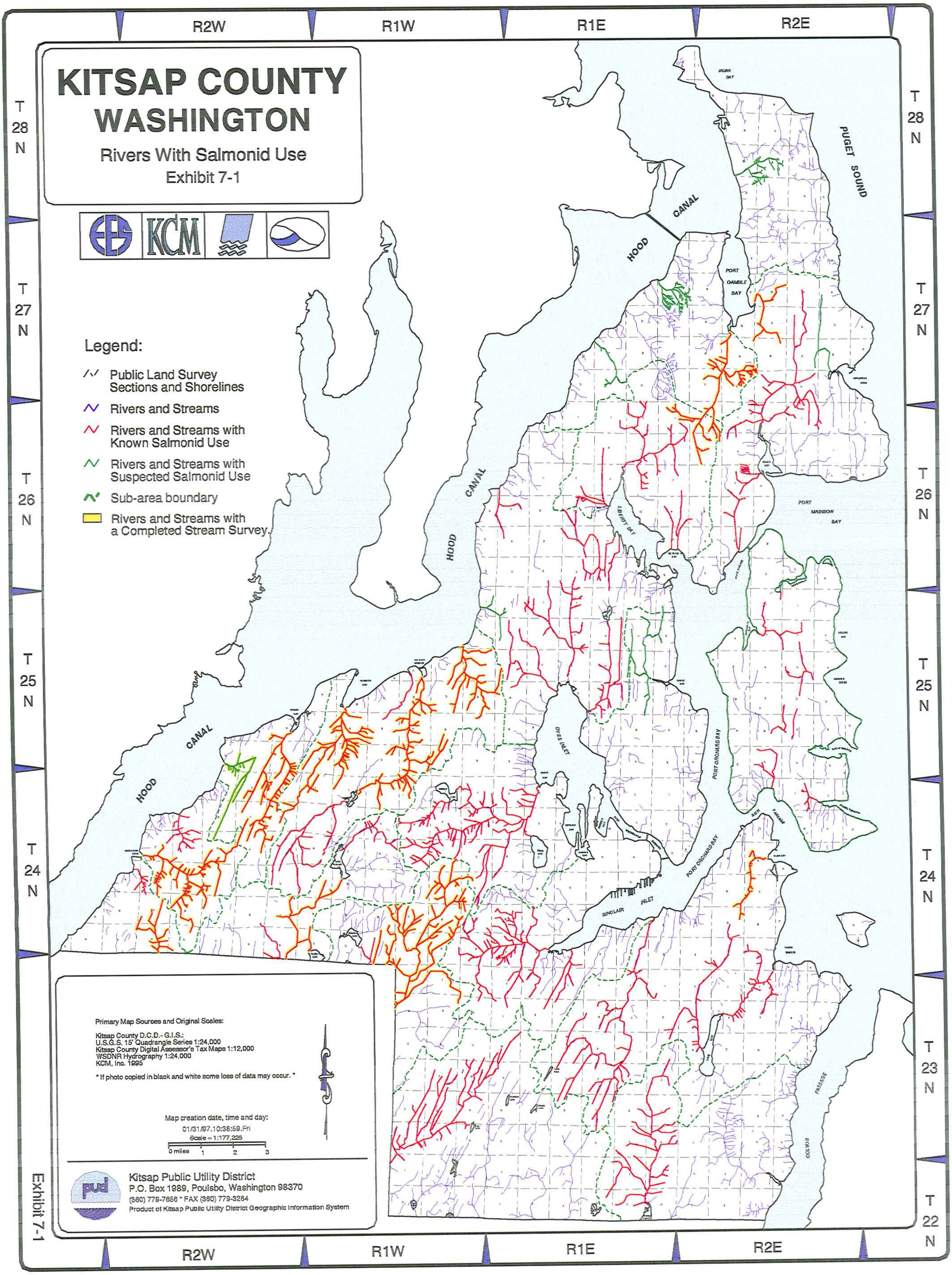
In the early 1990s, coho stocks in creeks from Port Gamble to Anderson Creek were considered depressed due to a short-term severe decline in spawning escapements, as evidenced by trap counts at Big Beef Creek (SASSI 1993). Escapements (the number of salmonids that make it back to spawn) to many creeks in the County are generally not documented. Chum salmon returning during late November through December are considered healthy in the County portion of Hood Canal. Early-arriving chum salmon are considered depressed. Escapements in this region have ranged from 500 to 8,000 fish. Other salmon species are less abundant in the County creeks and their status was not documented in the (SASSI) report.

Current status of salmonid populations in the County is a concern to all the agencies and organizations involved in water resources. Because of the poor returns of coho and chinook to Hood Canal there have been restrictions placed on the harvest of these stocks. The total closure of commercial and sport fishing for salmon in the Straight of Juan de Fuca in 1994 was due primarily to the status of Hood Canal coho. At the present time, the National Marine Fisheries Service (NMFS) is considering listing the Puget Sound coho stocks as threatened under the Endangered Species Act (ESA).

A major factor in the decline of coho stocks has been the reduced summer and fall flows in small streams associated with urban growth and the drought cycles which have been evident as shown in the precipitation data in Section 3. Although the general trend in the greater Puget Sound Basin shows rainfall has been near the long-term average, there are individual trends which have impacted the availability of the small streams to support a level of coho production similar to the period prior to 1975. All three gages shown on **Exhibit 3-5** indicate a drought condition from 1975 to 1978. In addition, the annual rainfall at all three stations was equal to, or below, the long-term average approximately 70 percent of the time from 1975 to 1994. The overall trend during this period does not fall into a drought condition. However, the recording station at Seabeck-Monroe shows a decline in precipitation in the period following 1984. In addition, if the average annual rainfall for the Seabeck gage is calculated for the last 16 years this average is five inches less than the long-term average. This decline in rainfall since 1975 is a situation that fisheries evaluators have commented on in other areas of Western Washington.

Exhibit 7-3 indicates the wetlands that have been included in the US Fish & Wildlife Service National Wetlands Inventory. This summary only includes those wetlands of significance that have been delineated and documented. There are, however, a large number of additional smaller wetlands, associated with small streams and watersheds, that are critical to the continued function of these systems in supporting the salmon and trout populations that utilize these watersheds. These areas, adjacent to the streams and at the headwaters, are the point of transfer from groundwater aquifers to a surface water system. The wetlands are additional indicators of the health of the watershed. When combined with the known wetlands, as shown on the exhibit, it is evident that these areas play an important role in the health of the groundwater/surface water interface.

The quality of fish habitat is greatly reduced by non-point pollution. Stormwater runoff from construction sites, roadways, and cleared land continue to cause siltation of streams removing critical juvenile rearing habitat. Other factors which are affecting the survival of all salmonid species are the influence of hatchery fish on natural spawning stocks and interception in the Alaska and Canadian ocean fisheries of fish returning to this area. The impact of the harvest on returning adults was well demonstrated by the closure in 1994 and the significant increase in coho adults spawning the streams of Hood Canal in the fall and winter of 1994/1995.



KITSAP COUNTY
WASHINGTON
Rivers With Salmonid Use
Exhibit 7-1
Legend:
Public Land Survey Sections and Shorelines
Rivers and Streams
Rivers and Streams with Known Salmonid Use
Rivers and Streams with Suspected Salmonid Use
Sub-area boundary
Rivers and Streams with a Completed Stream Survey
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
LIBERTY BAY
PORT MADISON BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
Primary Map Sources and Original Scales:
Kitsap County D.C.D.- G.I.S.:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Digital Assessor's Tax Maps 1:12,000
WSDNR Hydrography 1:24,000
KCM, Inc. 1995
* If photo copied in black and white some loss of data may occur. *
Map creation date, time and day:
01/31/97.10:38:59.Fri
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 7-1

Exhibit 7-2

Summary Matrix of Water Quality & Fisheries Habitat Assessments in Kitsap County

Kitsap County Initial Basin Assessment

EXHIBIT 7-2

Summary Matrix of water quality and fisheries habitat assessments in Kitsap County.

					Water				Sediment		Biological			Habitat	Flow
Watershed	Subarea	Surface Water Body	Agency/Author	Year	Conven.	Nutrients	Inorganic	Organic	Inorganic	Organic	Bacteria	Shellfish	Fish	Survey	Data
Upper Hood Canal	Hansville	Ground Surface	Kitsap Co. Public Works/CH2M Hill	1993	X	X	X	X			X				
		Ground Surface	Kitsap Co. Landfill/Parametrix	1993		X	X	X			X				
		Shoreline	DOH/Patrick	1991								X			
Upper Hood Canal	Port Gamble	Gamble Cr.	PSCRBT	1993									s D		
		Gamble Cr.	NWIFC/Tabor	1990										2	
		Gamble Cr.	WDF/Williams	1975									s D	X	
		Gamble Creek, and tributary	USGS/Williams J.R.	1989											Yes
		Jump Off Joe Creek	PSCRBT	1993									o		
		Bay Stream	Pope & Talbot/Applied Geotech	1990	X										
		Bay	EPA/ Crecelius	1989											
		Bay	DOE/Yake	1987	X		X	X	X	X					
		Shoreline Streams	DOH	1987,88,89,90							X	X			
		Stream Shoreline Bay	Port Gamble Tribe/Lukes	1990							X				
		Shoreline	PNPTC/Pentilla	1986									V.		
		Shoreline	S'Klalla Tribe/Kocan	1987			X	X	X	X			V		
		Bay	PNPTC/Plews	1989								X			
		Bay	PNPTC/Plews	1988								X			
Upper Hood Canal	Bangor	Devils Lk	PSCRBT	1993									s D		
		Cattail	PSCRBT	1993									s D		
		Shoreline	DOH	1993								X			
		Bangor Site C upland	Navy	1993					X	X					
		wetlandgroundBangor Site D	Navy	1994a		X	X	X	X	X					
		wetlandgoundBangor Site F	Navy	1994b		X	X	X	X	X					
		fresh	Navy	1978-89	X	X	X				X				
		lakewetlandground	Navy/URS	1991-92a			X	X	X	X					
		King Spit	DOE	1975-1992	X										
		King Spit	EPA	1975-1992	X	X					X				
Upper Hood Canal	Seabeck	Big Beef Creek	PSCRBT	1993									s D		
		Big Beef Creek	WDFUW, NWIFCWDE/Tabor	1974-91										2, 3, 8, 9	
		Big Beef Creek	WDF/Williams	1976									s D	X	
		Little Anderson	PSCRBT	1993									s D o		
		Little Anderson	USFWS/Tabor	1993										2	
		Little Anderson	WDF/Williams	1975									s D	X	
		Little Anderson, Big Beef Creeks	USGS/Williams J.R.	1989											Yes
		Little Beef Cr	PSCRBT	1993									s D o		
		Seabeck Creek	PSCRBT	1993									s D		
		Seabeck Creek	NWIFC/Tabor	1989-90										2	
		Seabeck Creek	DOE/Plotnikof	1992	X										
		Seabeck BayBig Beef BayLittle Beef Bay	DOH	1989							X	X			
		Seabeck	WDF/Williams	1976									s D	X	
Upper Hood Canal	Stavis	Stavis Creek	USFWS/Tabor	1993										2	
		Stavis Creek	PSCRBT	1993									s D		
		Stavis Creek	WDF/Williams	1975									s D	X	
		Boyce Creek	USFWS/Tabor	1993										2	
		Stavis Bay	DOH	1993a							X	X			
Upper Hood Canal	Anderson	Big Anderson Creek	PSCRBT	1993									s D		
		Big Anderson Creek	USFWS/Tabor	1994										2	
	Anderson cont.	Harding Creek	USFWS/Tabor	1993										2	
		Big Anderson Creek	WDF/Williams	1975									s D	X	
		Big Anderson, Harding Creeks	USGS/Williams J.R.	1989											Yes
		Harding Creek	PSCRBT	1993									s D o		
Upper Hood Canal	Other	Thomas Creek	PSCRBT	1993									s D o		
		Holly shoreline	DOH	1993b							X	X			
		North Fork Dewatto River	WDF/ William	1976									s		
		North Fork Dewatto River, Thomas Creek	USGS/Williams J.R.	1989											Yes
		Dewatto River	NWIFC, USFWS, WDW / Tabor	1990										6, 7	
Dyes Inlet	Bangor	Barker Creek	DOE/EES	1991									s		X
		Barker Creekother streams	BKCHD/EES	1991	X		X	X			X	X			
		Strawbry Creekother streams	BKCHD/EES	1991	X		X	X			X	X	s		

Exhibit 7-2 cont.

Summary Matrix of Water Quality & Fisheries Habitat Assessments in Kitsap County

EXHIBIT 7-2

Summary Matrix of water quality and fisheries habitat assessments in Kitsap County.

Watershed	Subarea	Surface Water Body	Agency/Author	Year	Water				Sediment		Biological			Habitat	Flow	Water Quality
					Conven.	Nutrients	Inorganic	Organic	Inorganic	Organic	Bacteria	Shellfish	Fish	Survey	Data	Violation
Dyes Inlet	Bangor cont.	Barker, Clear, Strawbry, Creeks	USGS/Williams J.R.	1989											Yes	
		Clear Creekgroundsediment	Navy/PTI	1990	X		X	X	X	X						
Dyes Inlet	Chico	Chico Creek	Suquam/EES	1991											Yes	
		Chico Creekother streams	BKCHD/EES	1991	X						X		s D			
		Chico, Wildcat, Lost, DickersonKitsap Creeks	USGS/Williams J.R.	1989											Yes	
		Oyster Bay	City of Brmrtn/Tetra Tech	1990					X	X						
Dyes Inlet	Manette	Mosher Creekother streams	BKCHD/EES	1991	X						X					
		Dyes Inlet Jackson Park	EPA/Tetra Tech	1988	X	X	X	X								
		Dyes Inlet Jackson Park	EPA/PTI	1990	X	X	X	X			X					
		Dyes Inlet Jackson Park	DOH/PTI	1990								X				
Dyes Inlet	General	Dyes Inlet	DOH/EES	1991	X							X				
		Dyes Inlet	DOE/PTI	1990					X	X		X	X			
		Dyes Inlet	EPA/Crecelius	1989												Yes (fish tissue)
		Dyes Inlet	WDF/PTI	1990										X		
Sinclair Inlet	Gorst	Gorst Creek	Kitsap Co.	1990									s D			
		Ross, AndersonCreeks	Kitsap Co.	1990									s			
		Gorst, Parish Creeks	USGS/Williams J.R.	1989											Yes	
		Gorst, Wright Creeks	BKCHD/Greiner	1993							X					Yes
		Sinclair Inlet	EPA/Tetra Tech	1988					bioassay							
		Sinclair Inlet	EPA/Crecelius	1989												Yes (fish tissue)
		Gorst, McCormick, Anderson Creeks	Kitsap Co./Envirovision	1991	X	X					X				Yes	
Sinclair Inlet	Manchester	Blackjack Ruby Creeks	Kitsap Co.	1990									s D			
		Ruby Creek	Kitsap Co./Envirovision	1991	X	X					X				Yes	
		Blackjack Annapolis Beaver, Salmon-berry, Curley Creeks	USGS/Williams J.R.	1989											Yes	
		Blackjack Beaver, Annapolis Creeks	BKCHD/Greiner	1993							X					Yes
		Blackjack Creek	WDF/Williams	1975											Yes	
		Beaver, Curley, Salmon-berry Creeks	WDF/Williams	1975									s			
		Beaver Creek	Suquam./Envirovision	1991										X		
		Annapololis Cr.	PSCRBT/Envirovision	1990									s		Yes	
		Olney Creek	Kitsap Co.	1990									s			
Lower Hood Canal	Tahuya	Tahuya River	PSCRBT	1991									s D			
		Gold, Tin Mine, other tributary Creeks	WDF/Williams	1975									s			
		Tahuya River, Gold, Panther, Tin Mine, other Creeks	WDW, NWIFC, USFWS, PNPTC, / Tabor	1990										2, 3, 5, 7, 9, 10		
		Gold, Panther Creeks	USGS/Williams J.R.	1989											Yes	
Lower Hood Canal	Union	Union River, Courtney, Hazel, Big Mission Creeks	WDF/Williams	1975									s			
		Union River, Big Mission, Bear Creeks	PNPTC, USFWS,WDF/Tabor	1990										2, 3, 5, 9, 10		
		Union River, Courtney, Mission Creeks	USGS/Williams J.A.	1989									s		Yes	
Burley/Minter Watershed	McCormick	McCormick, Coulter, Rocky, Minter Creeks	WDF/Williams	1975									s			
		Minter Creek	Ecology/Dickes	1993							X					Yes
Burley/Minter Watershed	Olalla	Burley, Purdy, Olalla Creeks	WDF/Williams	1975									s			
		Burley, Bear, Creek	USGS/Williams J.R.	1989											Yes	
		Purdy, Burley Creek	Ecology/Dickes	1993							X					Yes
Bainbridge Island	Bainbridge	Fletcher Bay streams	PSCRBT	1995									s D			
		Manzanl, Bay streams	PSCRBT	1995									s D			
		Port Madison streams	PSCRBT	1995									s D			
		Murden Cove streams	PSCRBT	1995									s D			
		Eagle Harbor streams	PSCRBT	1995									s D			
		Eagle Harbor	BKCHD	1988							X	X				Yes
		Eagle Harbor marinas	BKCHD/Daniels	1992	X						X					
		Eagle Habor	EPA/Yake...	1988	X				X	X	X	X				Yes
		Blakely Harbor streams	P.B.Mill/Jones...	1992	X	X	X				X					Yes
		Blakely Harbor	P.B.Mill/Jones...	1990	X											
		Blakely Harbor streams	PSCRBT	1995									s D			
Liberty/Miller Bay	Kingston	Grovers, Cowling, Klebeal Creeks	PSCRBT	1994									s D			
		Grovers Creek, other tribs	USGS/Williams J.R.	1989											Yes	

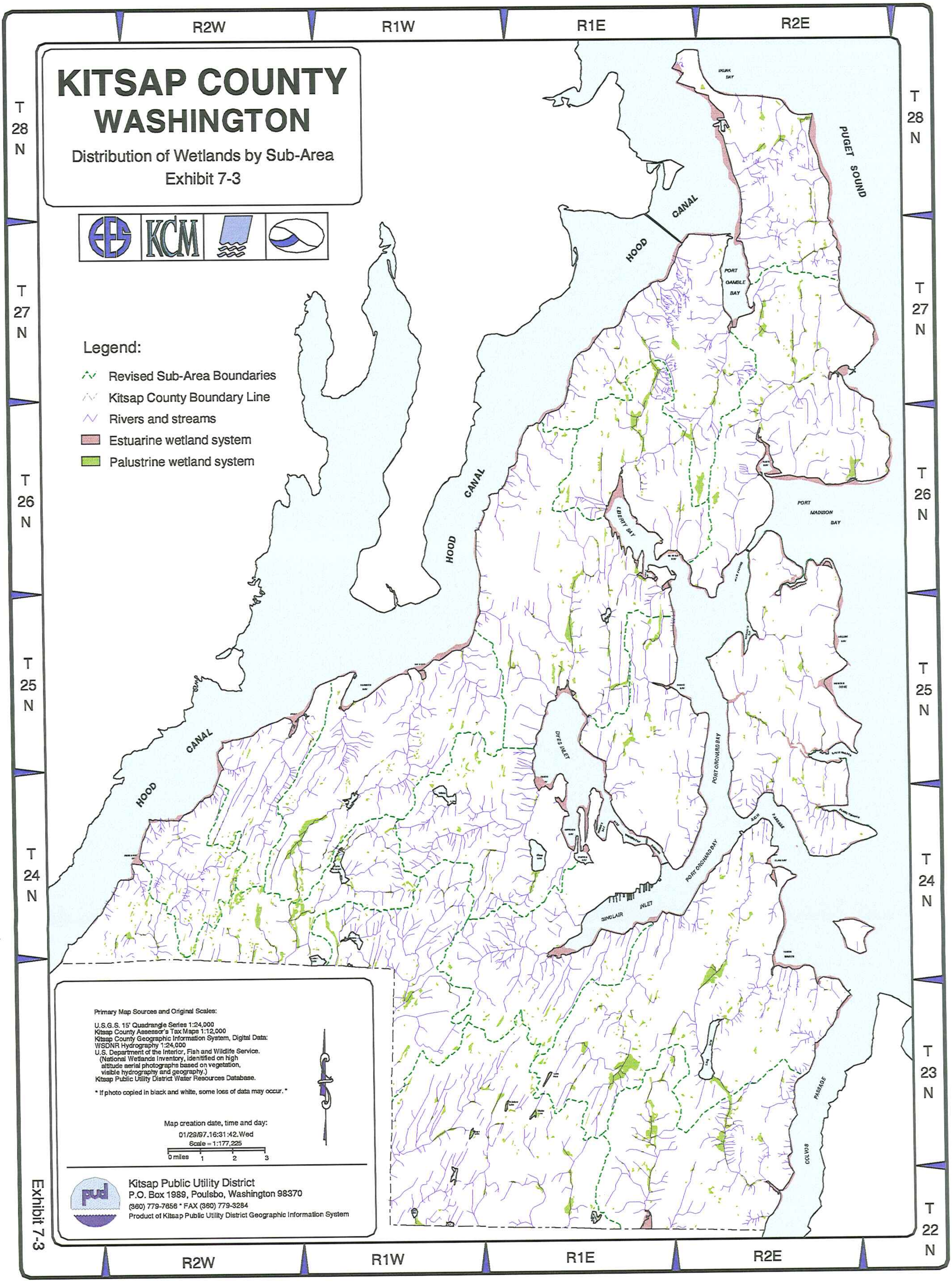
Exhibit 7-2 cont.
Summary Matrix of Water Quality & Fisheries Habitat Assessments in Kitsap County

EXHIBIT 7-2

Summary Matrix of water quality and fisheries habitat assessments in Kitsap County.

					Water				Sediment		Biological			Habitat	Flow	Water Quality
Watershed	Subarea	Surface Water Body	Agency/Author	Year	Conven.	Nutrients	Inorganic	Organic	Inorganic	Organic	Bacteria	Shellfish	Fish	Survey	Data	Violation
Liberty/ Miller Bay cont.	Kingston cont.	Kiebeal Creek	BKCHD	1994							X					
		Miller Bay	Suquam. Tribe/ FishPro	1988	X	X			X	X	X					
		Grovers Creek tributary	Kitsap Co.	1993	X	X	X	X								
		Grovers Creek, Miller Bay	Suquam. Tribe/ Meyers	1994	X	X	X	X	X	X	X	X				Yes (bacteria)
		Cowling, Grovers Creek	Suquam. Tribe/ Simenstd	1989						benthic invert.s						
		Miller Bay	DOH	1992	X						X					
		Miller Lake Creek	PSCRBT	1993									s D			
		Martha John Creek	PSCRBT	1993									s D			
Liberty/ Miller Bay	Poulsbo	Dogfish, Big & Little Scandia, Johnson, Lemolo	PSCRBT	1994									s D			
		Dogfish Creek, other tribs	USGS/ Williams J.R.	1989											Yes	
		Dogfish	WDF/ Williams	1975									s D		Yes	
		surface drainages	City of Poulsbo	1993							X					Yes
		Dogfish Creek Liberty Bay	BKCHD/ Struck	1988					X		X					Yes
		Dogfish Bay, Liberty Bay	US Navy/ URS	1993	X		X	X	X	X		X				Yes
		Liberty Bay	BKCHD/ Daniels	1992	X					X	X					Yes
		Liberty Bay	DOH/ Melvin	1991	X						X					Yes
		Liberty Bay	DOH/ Seabloom	1989	X						X					Yes
		Liberty Bay	EPA/ Crecelius	1989												Yes (fish tissue)
		Liberty Bay, Agate Passage	DOH	1994	X						X					
		Liberty Bay	DOH	1983	X						X	X				Yes
		Liberty Bay	DOH	1986	X						X					Yes
Liberty/ Miller Bay	Poulsbo cont.	Lemolo Bay	DOH	1993, 1994							X					
		Lemolo, Agate Passage	DOH	1994							X					
		Virginia Point	Ecology	1992	X	X					X					Yes
		Agate Passage	DOH	1993	X						X					

s	Use known, salmonid
D	Use known, other
o	Use unknown but potential exists
	Seafish
	Habitat Survey Methods are coded according to the following type:
	1. U.S. Forest Service, Hankin-Reeves methodology
	2. NWIFC, PNPTC ambient monitoring
	3. WDF physical habitat surveys
	4. USFWS instream flow incremental methodology
	5. USFWS, Skok. Tribe supplementation surveys
	6. Jefferson County surveys
	7. WDW wetted perimeter surveys
	8. UW-CSS coho research
	9. WDE lake surveys
	10. WDE lake monitoring
	X. unknown.


KITSAP COUNTY
WASHINGTON
Distribution of Wetlands by Sub-Area
Exhibit 7-3
Legend:
Revised Sub-Area Boundaries
Kitsap County Boundary Line
Rivers and streams
Estuarine wetland system
Palustrine wetland system
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
LIBERTY BAY
PORT MADISON BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
COLVOS PASSAGE
Primary Map Sources and Original Scales:
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
U.S. Department of the Interior, Fish and Wildlife Service.
(National Wetlands Inventory, idenitified on high altitude aerial photographs based on vegetation, visible hydrography and geography.)
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
01/29/97.16:31:42.Wed
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 7-3

Section 8 Water Allocations

The State of Washington manages ground water and surface water withdrawals through a system of permits. Water withdrawals for all but limited small ground water uses must be authorized by Department of Ecology (Ecology). Upon receiving an application for a water right, Ecology conducts an evaluation, which may currently take in excess of five plus years, to determine whether or not they should issue a permit to develop the water resource. Water right certificates are issued after the water withdrawal has been perfected (actually put to beneficial use). In this report, permits and certificates are collectively referred to as water rights. Water rights have been recognized by existing water laws since 1917 for surface water and 1945 for ground water. Not all uses of water developed before these dates were registered as part of the water-rights process. In order to preserve active withdrawals developed prior to these two dates, the State required individuals to register withdrawals during a "claims period" between 1969 and 1974. A water-right claim is not an authorization to use water, but rather a statement in claim to a water withdrawal developed prior to 1917 or 1945 and uses developed under RCW 90.44.050 from 1945 through the Claims Registration Act. All claims are valid if they are on Ecology's registry. However, only the courts can decide through a formal adjudication whether or not the claims represent a vested right. The Washington State Legislature has reopened the Claims Registry from September 1, 1997, to June 30, 1998.

Quantities of water allocations are not necessarily equal to quantities of water use. Allocations state maximum legally permissible quantities of withdrawal. Some studies have shown that permissible quantities are seldom used and a significant discrepancy can exist between allocation and use. A distinction between allocation and use must be drawn in assessing stress on the hydrologic system due to withdrawals. Actual use cannot be enumerated through water-allocation statistics, but must be arrived upon by surveying major water users and estimating the sum of minor uses. Although total allocation may differ from actual use, total allocation is a significant value because it represents the maximum legally permissible withdrawal from the hydrologic system.

8.1 Instream Resource Protection Program - Kitsap (WRIA)

The Instream Resource Protection Program (IRPP) for the Kitsap Water Resource Inventory Areas (WRIA) (Chapter 173-515 WAC) was enacted in 1981. The intent of Chapter 90.54 RCW and Chapter 90.22 RCW, is to retain base flows in perennial streams, rivers and lakes at levels necessary to protect wildlife, fish, scenic, aesthetic, recreation, environmental and navigational values. Due to the large number of control stations and associated limitations, it is a very complex law to administer.

The IRPP for the Kitsap WRIA establishes instream flow requirements at 18 control stations within the WRIA. The IRPP also lists 71 streams, lakes, or drainage systems which are closed to diversions year-round or during specific periods of the year. Thirteen of these are seasonal closures on streams which have instream flow requirements during other times of the year. Additional discussion of these regulatory requirements is provided in Section 4.2 of this report.

The IRPP is based on Ecology's methodology for selecting minimum instream flow requirements. This methodology involved statistical analysis of streamflow records and consideration of other instream values. In choosing streams for regulatory protection, each stream was rated by Ecology and the Departments of Fisheries and Game (now Department of Fish and Wildlife). A stream rated to have greater environmental and scenic values required higher levels of flow protection. Ecology could initiate a review of the IRPP whenever new information, changing conditions, or statutory modifications make it necessary to consider revision. Rule making would be required.

An instream flow established under an IRPP is effectively a water right, senior to all water rights issued thereafter. The subject IRPP states that from its establishment forward, all consumptive water rights shall be expressly subject to the instream flows, and that no surface water right granted thereafter shall be in conflict with the instream flows and closures established in that chapter. With respect to ground water, the IRPP states that future withdrawals will be affected by these regulations only if determined to have clear adverse impacts upon surface water contrary to the IRPP intents. The IRPP also states that no water rights in existence at the time of its establishment shall be affected.

It should be noted that the minimum instream flow requirements specified in the IRPP collectively represent the largest quantifiable water right currently in existence. Individually allocated (private) water rights are compared to minimum instream flow requirements on a subarea basis in Section 8.2.5. Other water rights such as federal reserve, tribal, and exempt rights, are discussed in Section 8.3.

8.2 Water Rights and Claims

Water permits and certificates within the Kitsap WRIA are recorded in Ecology's Water Rights Information System (WRIS) database. The database contains specific information for each entry, including: point of withdrawal or diversion, date of application and approval, maximum allowable withdrawal, purpose(s) of use, and irrigated acreages where applicable. There are 12,500 surface water permits/certificates which were issued statewide that have no annual quantity specified on the document. For this reason, discussion of surface water permits and certificates as annual withdrawals may involve some underestimation. Withdrawal quantities are also often unspecified for a large number of claims. Estimation techniques (described below) were used to approximate total annual quantities associated with claims.

This section presents several analyses based on data obtained from the WRIS database. Some of the more generalized analyses (water rights vs. time; water rights by use; water right applications by use) present data for the entire WRIA. Conclusions of these analyses may differ from similar analyses specific to Kitsap County (County); however, County-wide data could not be extracted from the WRIS output files provided by Ecology. Spatial analyses of WRIS data, however, allowed evaluation on a County-wide basis. Analysis of the geographic distribution of water rights, claims and applications, and comparison between allocations and total inflows were confined to the County.

Water right permits and certificates are issued with permissible quantities of instantaneous and annual withdrawals. The instantaneous allocation (Qi) represents the limit on the rate at which the system may divert/withdraw water from the source. Qi's are expressed in cubic feet per second (cfs) for surface water and gallons per minute (gpm) for ground water (448.8 GPM=1 CFS). The annual allocation (Qa) represents the maximum amount of water allowed over a year's time for a specified use(s), and is expressed in acre-feet per year (af/yr.). Research of water right records indicates that for most permits/certificates, the Qa does not represent a continuous withdrawal throughout the year at the maximum authorized Qi; rather, it generally represents the total of intermittent withdrawals at rates approaching or equal to the authorized Qi. The implications of this difference are greatest for certain surface water withdrawals. Some rates of withdrawal also vary seasonally as a function of demand. Municipal withdrawals are typically correlated to residential demand, and irrigation diversions (though uncommon in Kitsap County) often divert their entire allocated Qa from streams during the summer growing season (approximately 4-6 months).In addition the effect of a surface diversion is immediately imposed on a stream. In contrast, the effects of ground water pumping on streamflows while sometimes rapid, are frequently delayed and spread out over time.

8.2.1 Water Rights and Claims Over Time

The cumulative increase in water permits and certificates over time in the Kitsap WRIA is shown in **Exhibit 8-1**. This cumulative increase has also increased the stress on the hydrologic system due to withdrawals. Quantities are reported as maximum allowable withdrawal volumes (Qa) in af/yr. As previously mentioned, the surface water allocations may be underestimated due to database entries without registered Qa values. Reported Qa's for surface water rights in the Kitsap WRIA have grown to 17,673 af/yr. from the first registered right in 1919 to 1992, the priority date of the last-issued surface water right. Reported Qa's for ground water permits/certificates have grown to 87,239 af/yr. from the earliest priority right in 1920 to 1994, the priority date of the last-issued ground water right. Note that since 1990, cumulative ground water allocations have not significantly increased, inkeeping with the fact that water rights have not generally been issued.

Many claimed water rights have been in use long before the first water rights were granted. Water was claimed primarily for agricultural purposes, yet claim quantities were not always consistent with potentially irrigable acreages. In order to better estimate irrigation claims and assign water duties to the claims, the following irrigation relation was applied:

Qi = Acreage x 9 gpm = Acreage x 0.02 cfs

Qa = Acreage x 2 af/yr.

Claims for domestic and stock uses, which include up to half an acre non-commercial lawn and garden, were assigned a Qi of 0.02 cfs and a Qa of 0.5 af/yr. These approximations are consistent with Ecology's current allocation processes for water rights issued in Western Washington (Culvert, 1994). Claims within the WRIA, based on these water duty assignments, are summarized in the following table. Comparisons between current claims and permits/certificates are also summarized in the following table and presented graphically on **Exhibit 8-2**.

	Rights			Claims			Totals
	Qi cfs (gpm)	Qa af/yr	Irrigated Acres	Qi cfs (gpm)	Qa af/yr	Irrigated Acres	Qa af/yr
Surface Water	131.7 (59,107)	17,673 (11,014 gpm)*	3,085	104 (46,675)	8,702 (5,385 gpm)*	3,489	26,375
Ground Water	297.2 (133,383)	87,239 (53,856 gpm)*	1,039	310 (139,128)	20,907 (12,970 gpm)*	5,428	108,146
Totals	428.9 (192,490)	104,912 (64,870 gpm)*	4,124	414 (185,803)	29,609 (18,355 gpm)*	8,917	134,521

gpm= gallons per minute, cfs= cubic feet per second, af/yr= acre feet per year

* Value represent continuous average or continuous instantaneous rate required to produce annual allocations.

Currently, ground water withdrawals dominate water rights (and to a lesser extent water-right claims) within the Kitsap WRIA. Ground water rights (as Qa) account for 83 percent of current total allocations, and ground water claims (as Qa) account for 71 percent of current total claims. Issued water rights exceed water right claims for both ground water and surface water. Note that, due to differences in the regulatory function of annual withdrawals (Qa's) and instantaneous withdrawals (Qi's) discussed above, values of Qa do not bear a consistent relationship to values of Qi.

As previously mentioned, the quantity of water allocated within the County differs from the quantity allocated within the WRIA. Comparison between current water allocations for the WRIA (above) and the County (discussed in Section 8.2.5) show that County-wide ground water rights account for 73 percent of WRIA ground water rights, and

County-wide surface water rights account for 50 percent of WRIA surface water rights (as Qa). Similar comparison shows that County-wide ground water claims account for 67 percent of WRIA ground water claims, and County-wide surface water claims account for 16 percent of WRIA surface water claims.

8.2.2 Water Rights and Claims by Use

All water rights are registered by purpose of use. Within the WRIS database, water rights typically have one, if not several, stated purposes. Examining the distribution of water rights by purpose provides understanding of how water is used within the WRIA. Discerning the major uses can assist in formulating policy for water conservation and water-rights administration.

In order to present water rights by use, current permits and certificates were classified according to the larger of their stated purposes. The relative distribution of surface water rights by use in the WRIA is presented on **Exhibit 8-2b**. Percentages of total use are calculated in terms of maximum allowable annual withdrawals (Qa's). Surface water resources in the WRIA are primarily allocated for municipal (40 percent) and domestic multiple (39 percent) use. Irrigation uses comprise 17 percent of the total Qa, and other uses comprise the remaining 4 percent.

The relative distribution of ground water rights by use is presented on **Exhibit 8-2c**. Ground water resources in the WRIA are also primarily allocated for domestic multiple (57 percent) and municipal (31 percent) use. Fish propagation comprises 8 percent of the total Qa, and other uses comprise the remaining 4 percent.

Water resources associated with water rights claims appear to be primarily associated with irrigation use. This reflects the historical circumstances of claims registration. Based on the irrigated acreages and the formulas for water-duty assignments discussed above, at least 49 percent of the surface water claims (as Qa) and 91 percent of the ground water claims (as Qa) can be attributed to irrigation. Percentages attributable to irrigation would be greater, however irrigated acreages are not reported on a number of claims. The portion of claimed water resources not attributable to irrigation is assumed to be for domestic or stock purposes.

8.2.3 Spatial Distribution of Water Rights and Claims

Evaluation of the spatial distribution of water rights and claims provides a rough approximation of where water is used within the study area. This section discusses and presents the geographic distribution of water rights and claims throughout the County. **Exhibits 8-3 through 8-6** are maps of total water rights and claims on a section-by-section (square mile) basis throughout the County. **Exhibit 8-7b** summarizes the volumes of water rights and claims (as Qa) on a subarea basis.

The spatial distribution of surface water rights (permits/certificates) and claims are depicted in **Exhibits 8-3 and 8-4**. Surface water rights **(Exhibit 8-3)** occur primarily in the eastern portions of the County, and are variably distributed among the County's smaller and larger streams. The largest surface water allocations occur in the Union and Bangor subareas **(Exhibit 8-7b)**. The distribution of surface water claims also shows higher concentrations in eastern portions of the County. The largest (total) surface water claims occur in Manchester and Stavis subareas **(Exhibit 8-7b).**

The spatial distribution of ground water rights (permits/certificates) and claims are depicted in **Exhibits 8-5 and 8-6**. Ground water rights are largely associated with population density, and primarily occur in the eastern portions of the County. The largest ground water allocations occur in the Manchester and Manette subareas **(Exhibit 8-7b)**. Other subareas with relatively large ground water allocations include Bangor, Gorst, Bainbridge and Kingston. Ground water claims **(Exhibit 8-6)** are more evenly distributed throughout the eastern County.

8.2.4 Water Right Applications

There are currently 220 applications for new water rights within the Kitsap WRIA on file with Ecology (1995). Maximum withdrawal information for water right applications is generally limited to instantaneous extraction rates (Qi), largely because Ecology has not made final decisions as to maximum allowable annual withdrawals. The table presented below provides a summary of water-right applications in the Kitsap WRIA, expressed as Qi. Applications cannot be directly compared to allocations where allocations are reported as Qa.

Source	Number of Applications	Total Qi (cfs) / (GPM)
Surface Water	20	5.2 / 2,334
Ground Water	200	114.9 / 51,567
Total	220	120.1 / 53,901

Applications for ground water rights comprise the largest component of potential future water allocations. Currently, 200 ground water applications exist for 51,567 gpm and 20 surface water applications exist for 5.2 cfs. **Exhibit 8-2d** shows the distribution of applications by stated purpose. The majority of the total requested Qi (68 percent) is for domestic multiple use. Municipal use account for 21 percent of the total requested Qi, and other uses account for 7 percent. Surface water applications account for only 4 percent of the total requested Qi. The current total surface water request is primarily divided between irrigation (31 percent), municipal (27 percent), domestic multiple (23 percent), and fish propagation (17 percent) uses.

Evaluation of the distribution of water right applications shows where additional demand is occurring. The geographic distribution of water-rights applications is presented in **Exhibits 8-8 and 8-9**. Surface water applications **(Exhibit 8-8)** occur within about ten (square-mile) sections within the County. Sections containing the largest surface water requests occur along Grover's Creek (north of Indianola), near Barker Creek (east of Silverdale), near Gazzam Lake (on western Bainbridge Island), and along Annapolis Creek (east of Port Orchard). The Manette, Bainbridge, Manchester and Kingston subareas have the largest requests (as Qi) for surface water rights **(Exhibit 8-7b)**. Ground water applications **(Exhibit 8-9)** are predominantly distributed throughout the eastern County. The Bangor and Manchester subareas have the largest requests (as Qi) for ground water rights **(Exhibit 8-7b)**. Isolated applications for relatively large allocations may be associated with small communities or fish propagation facilities.

8.2.5 Comparisons Between Allocations and Total Inflows

The relative degree of water resource development for each subarea within the County can be roughly indicated by comparing water allocations to "total water inflow". Total inflow (TI) was estimated for each subarea by calculating the precipitation input (P) from the isohyetal map (discussed in Section 3), and subtracting a value for evapotranspiration (ET). Estimation of ET was based on Blaney-Criddle evaluation of potential evapotranspiration and a soil moisture balance, as described in Section 5.8.4. The remaining water (P-ET) is found in either the ground water or surface water flow system and, for the purpose of this analysis, is considered "available" to support a wide variety of hydrologic and environmental values. A portion of this total inflow is available for water supply development, while the remainder (and likely the majority) must be maintained to support baseflows in streams and provide sufficient ground water flux to prevent saltwater intrusion along the coast.

Exhibit 8-7b summarizes the relative degree of water resource development in each of the 18 subareas designated within the County. The exhibit also presents the precipitation, evapotranspiration, water rights and water claims data used to make the comparisons. Values of relative development range from less than one percent to just over 40 percent. The Manette and Bainbridge subareas have the highest degrees of water resource development, whereas the Anderson, Dewatto, Tahuya and McCormick subareas have the lowest degrees of water resource development. Relative development for most (11 of 18) of the subareas is between 5 and 25 percent. It should be noted that the relative development percentage for the Gorst, Union, Chico, and Tahuya subreas may be overestimated, since the isohyetal map used to calculate the precipitation input does not show elevated (orographic) rainfall in the Green-Gold Mountains. As discussed in Section 3, precipitation data from the mountains were not available as input to the isohyetal contouring package.

Exhibit 8-7b also indicates whether there are minimum instream flow requirements and/or stream closures in effect for each subarea. In many cases, not all of the streams in a subarea have regulatory protection. The regulatory protections, therefore are not a complete indication of total instream flow needs.

8.3 Undetermined Water Rights

Three categories of water rights, although recognized, can not be quantified as a part of this assessment. The first category relates to ground water withdrawals in small quantities (i.e., exempt from permit requirements pursuant to RCW 90.44.050). This category would include all small withdrawal (not to exceed 5,000 gpd) wells that were constructed and put to use prior to July 1, 1974, and upon which no water right claim was filed under Chapter 90.14 RCW; and any such wells put to beneficial use after June 30, 1974, without having a standard permit.

The second and third categories relate to federal reserved rights associated with either US Reservations (e.g., military) or Indian Reservations. Any appropriation of surface and ground water in Washington is subject to the federal reserved water rights on military and Indian reservations, and may be affected by Indian Tribe aboriginal water rights. The doctrine of reserved water rights combines both the common law riparian water rights doctrine and prior appropriation. Under the doctrine of reserved water right, when a federal reserve (e.g. military, Indian) is created, there is an implied reservation of water to fulfill the purpose of the reservation. The priority date of the water right is the date the reservation is created. Use of water does not create and disuse does not destroy or suspend a federally reserved water right.

Another source of Indian water rights may be tribal aboriginal water rights. It is claimed that, when an Indian tribe has never moved from its aboriginal area, and its tribal title has never been extinguished, the tribe holds an unbroken and unfettered property right to the use and occupancy of the land and the water. The priority date for aboriginal water rights is considered to be "time immemorial" and like reserved water rights cannot be lost or destroyed by non-use. In Kitsap County, the Tribes claim Indian aboriginal water rights including the right to an adequate water supply to maintain an Indian fishery.

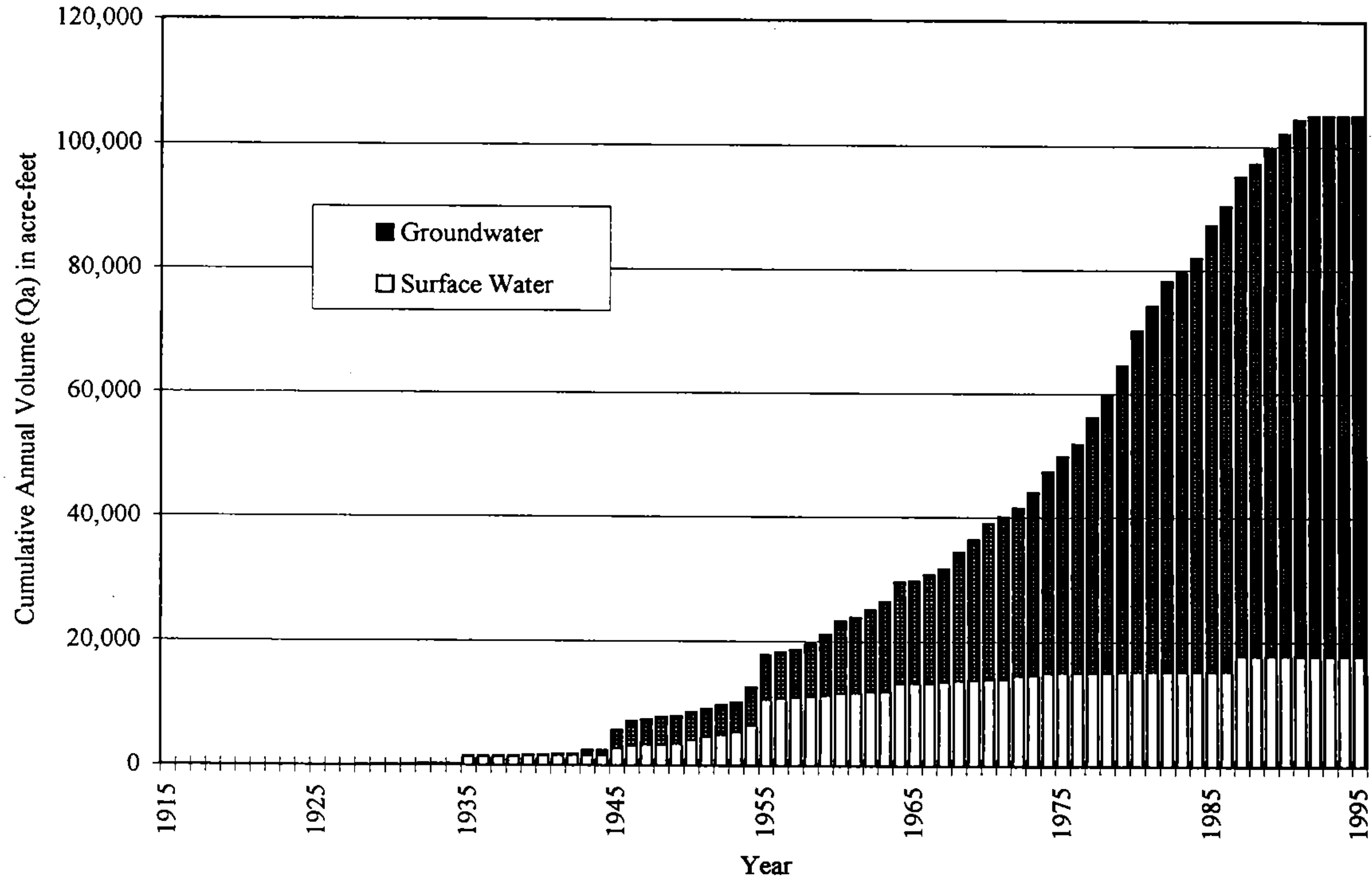
Indian, aboriginal water rights may take priority over state-issued water rights. Federal reserve water rights may take priority over state-issued rights appropriated subsequent to the establishment of the federal facility or creation of an Indian reservation. These brief summaries of federally and treaty protected water rights are not intended to be exhaustive statements of federal and Indian water rights, but are presented in order to give a general overview of aboriginal and federal reserve water rights.

The above described water rights can be determined with certainty only through the State's general adjudication process (see RCW 90.01.110.243 and RCW 90.44.220) or in some cases through the federal court system.

Exhibit 8-1

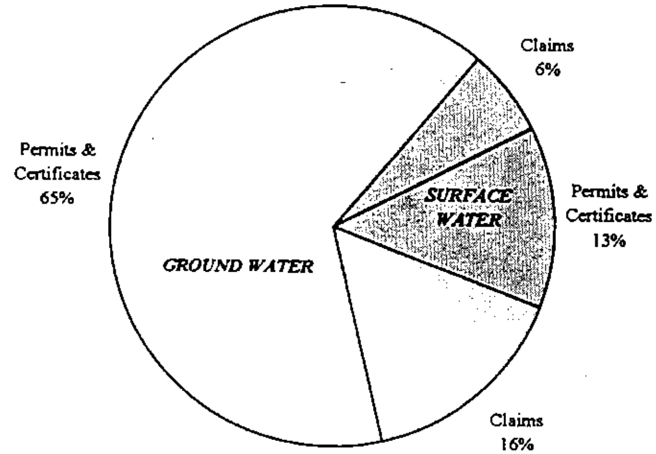
Water Rights vs. Time

Kitsap County
Initial Basin Assessment



8-2a

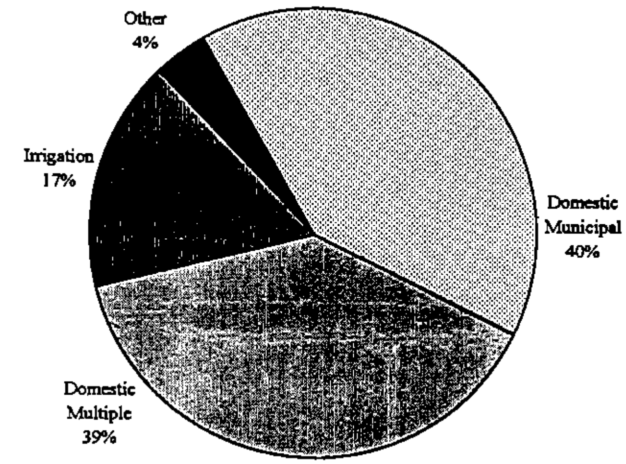
TOTAL ALLOCATIONS AND CLAIMS



Total Volume = 134,521 acre-feet/year

8-2b

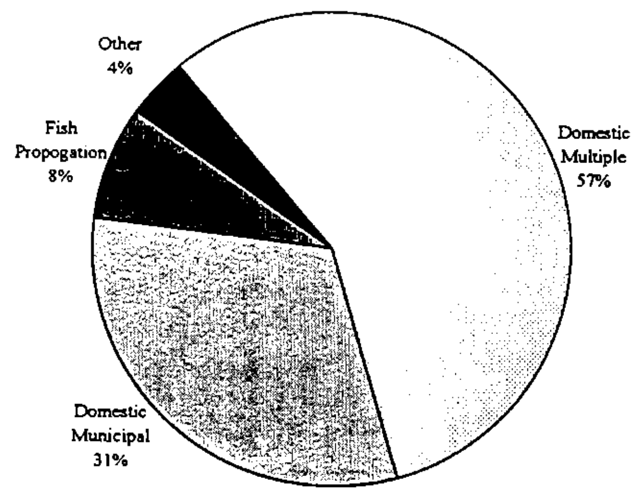
SURFACE-WATER RIGHTS BY USE



Total Volume = 17,673 acre-feet/year

8-2c

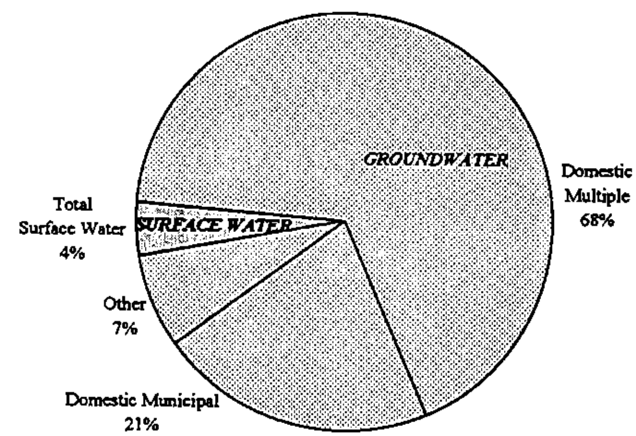
GROUNDWATER RIGHTS BY USE



Total Volume = 87,239 acre-feet/year

8-2d

WATER-RIGHT APPLICATIONS

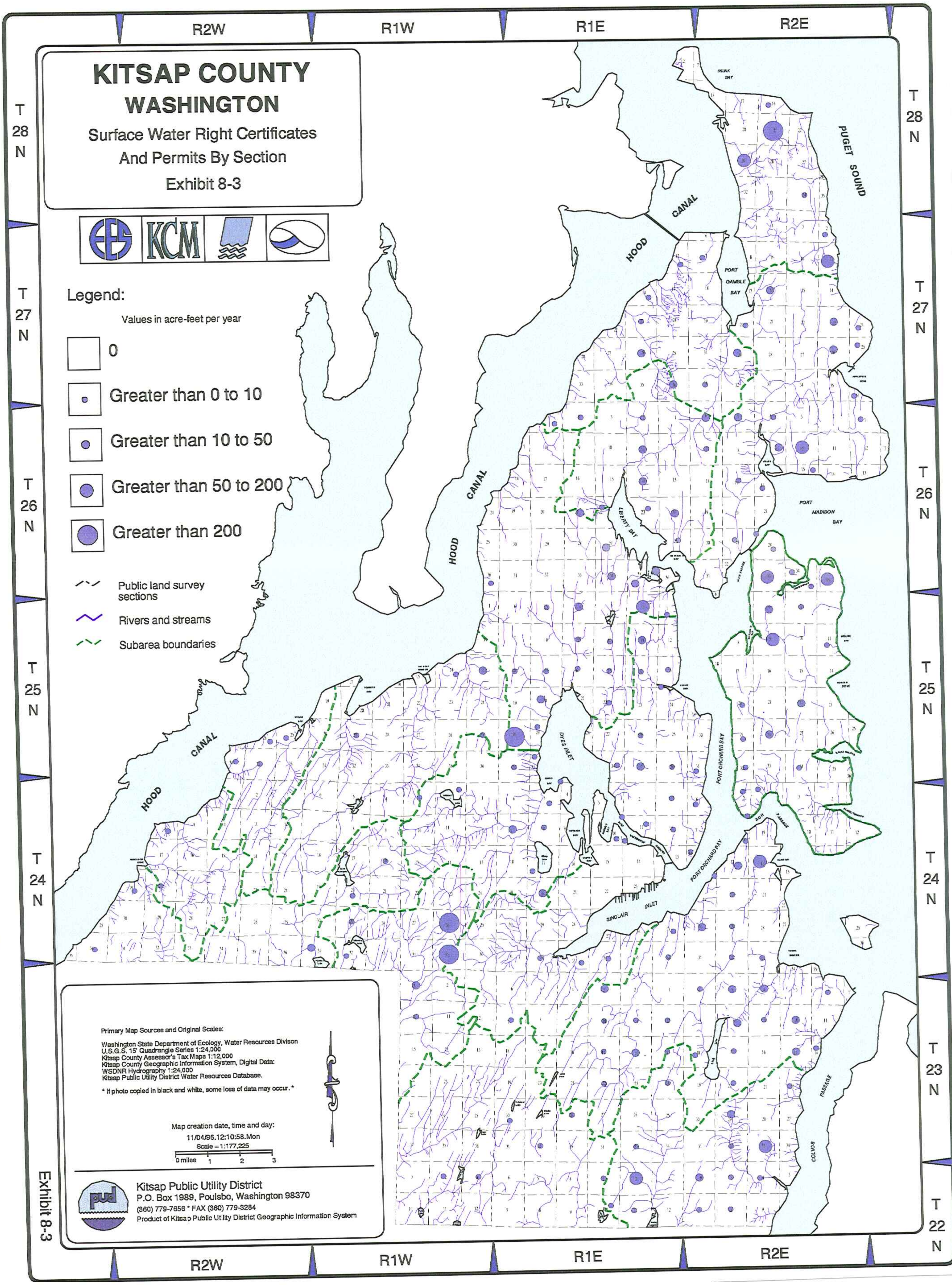


Total requested withdrawal rate = 120 cubic feet/second (53,880 GPM)
Note: Applications are requested as instantaneous withdrawal rates (Qi's). If approved, they will be limited on an annual basis by maximum allowable withdrawals (Qa's).

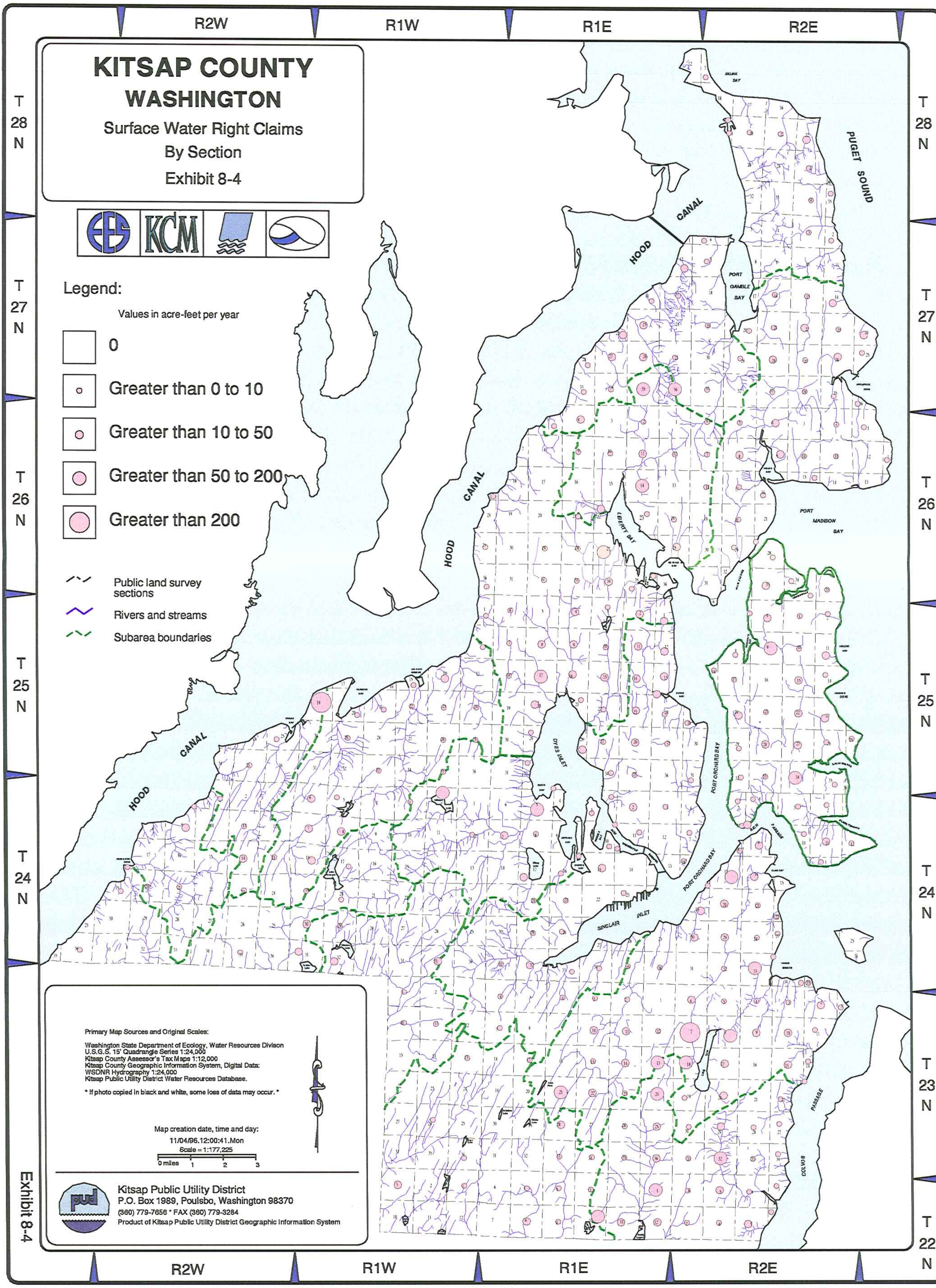
Exhibit 8-2(a-d)

Total Allocations and Claims, Surface-Water Rights, Ground-Water Rights, and Water-Right Applications

Kitsap County
Initial Basin Assessment



KITSAP COUNTY
WASHINGTON
Surface Water Right Certificates
And Permits By Section
Exhibit 8-3
Legend:
Values in acre-feet per year
0
Greater than 0 to 10
Greater than 10 to 50
Greater than 50 to 200
Greater than 200
Public land survey sections
Rivers and streams
Subarea boundaries
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
COLVOS PASSAGE
Primary Map Sources and Original Scales:
Washington State Department of Ecology, Water Resources Divison
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
11/04/96.12:10:58.Mon
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 8-3


KITSAP COUNTY
WASHINGTON
Surface Water Right Claims
By Section
Exhibit 8-4
Legend:
Values in acre-feet per year
0
Greater than 0 to 10
Greater than 10 to 50
Greater than 50 to 200
Greater than 200
Public land survey sections
Rivers and streams
Subarea boundaries
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
LIBERTY BAY
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DYES INLET
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0 miles 1 2 3
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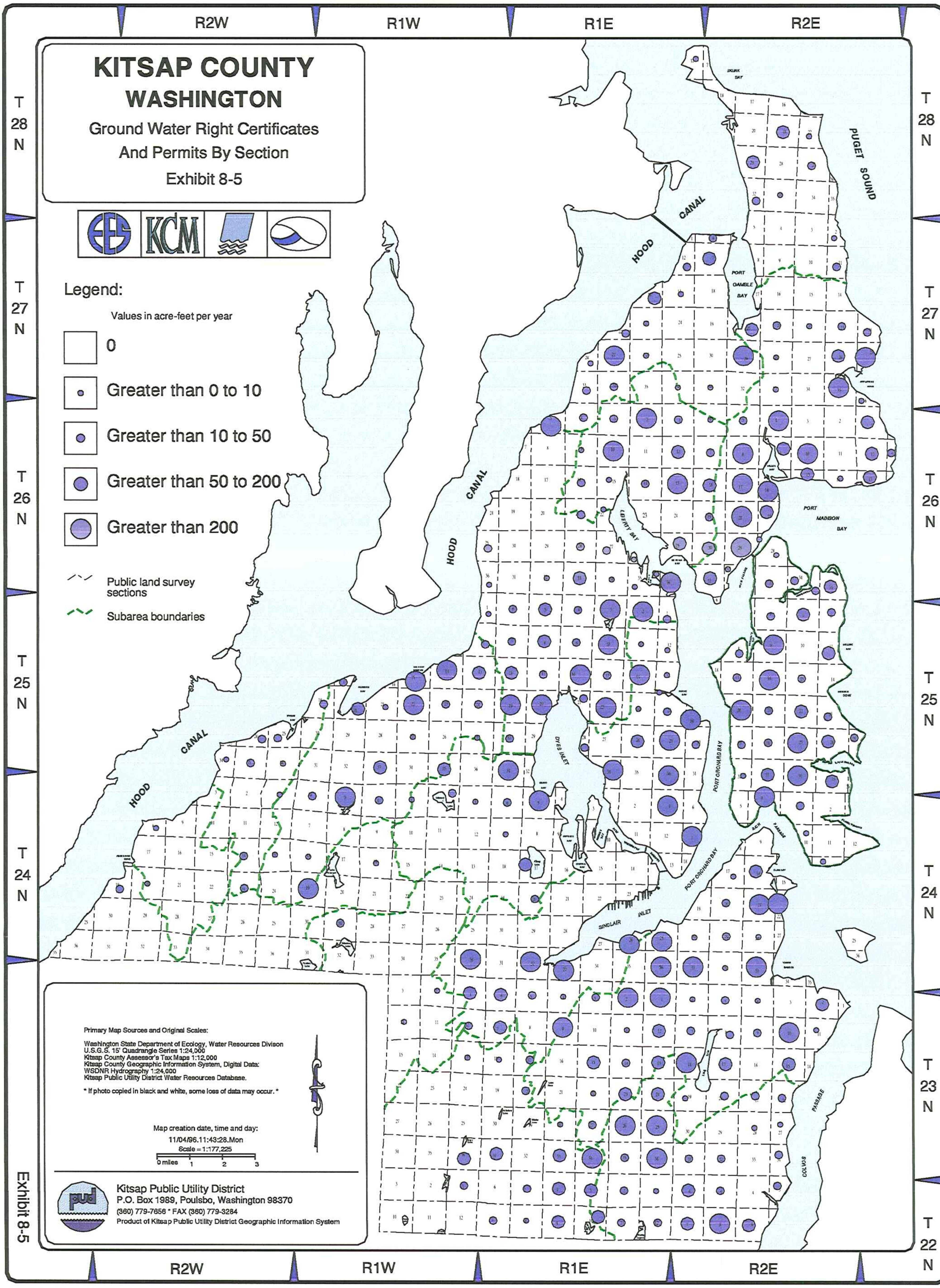
Product of Kitsap Public Utility District Geographic Information System
Exhibit 8-4



KITSAP COUNTY
WASHINGTON
Ground Water Right Certificates
And Permits By Section
Exhibit 8-5
Legend:
Values in acre-feet per year
0
Greater than 0 to 10
Greater than 10 to 50
Greater than 50 to 200
Greater than 200
Public land survey sections
Subarea boundaries
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
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Primary Map Sources and Original Scales:
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Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
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Kitsap Public Utility District
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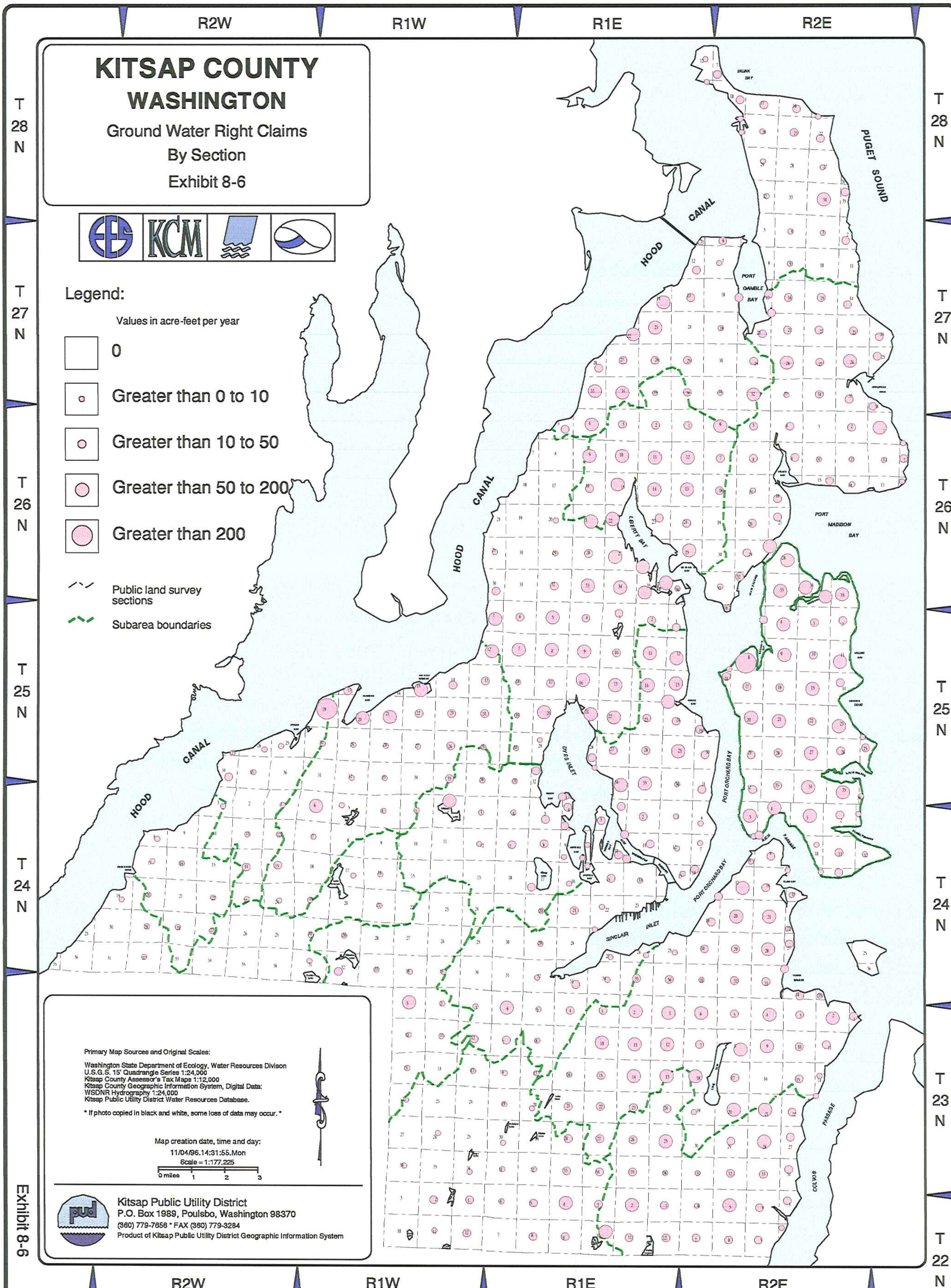
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 8-5


KITSAP COUNTY
WASHINGTON
Ground Water Right Claims
By Section
Exhibit 8-6
Legend:
Values in acre-feet per year
0
Greater than 0 to 10
Greater than 10 to 50
Greater than 50 to 200
Greater than 200
Public land survey sections
Subarea boundaries
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
PUGET SOUND
HOOD CANAL
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
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WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
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Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
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(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 8-6

EXHIBIT 8-7a

Estimated Water Balance by Subareas

Kitsap County
Initial Basin Assessment

Subarea Name	Drainage Area (A) (square miles)	Average Precipitation (P) (inches/yr)	Total Precip. Inflow (ac-ft/yr)	Average ET (inches/yr)	Total ET (ac-ft/yr)	Total Net Inflow TI=P-ET (inches/yr)	Total Net Inflow TI=P-ET (ac-ft/yr)	Average Runoff (inches/yr)	Total Runoff (ac-ft/yr)	Average Areal Recharge (inches/yr)	Total Areal Recharge (ac-ft/yr)
HANSVILLE	16.5	30	26,500	14	12,400	16	14,100	6	5,300	10	8,800
KINGSTON	30.7	34	55,700	15	24,600	19	31,200	7	11,100	12	20,000
PORT GAMBLE	19.1	36	36,600	15	15,200	21	21,300	7	7,300	14	14,100
POULSBO	18.7	37	36,900	15	15,000	22	22,000	7	7,400	15	14,500
BANGOR	35.7	41	78,100	16	30,500	25	47,600	8	15,600	17	32,000
BAINBRIDGE	29.1	35	54,400	15	23,300	20	31,100	7	10,900	13	20,200
MANETTE	17.7	40	37,800	16	15,100	24	22,700	8	7,600	16	15,100
CHICO	19.7	53	55,800	17	17,900	36	37,900	11	11,200	25	26,700
SEABECK	27.3	57	83,000	18	26,200	39	56,800	11	16,600	28	40,200
STAVIS	10.2	64	34,900	19	10,400	45	24,500	13	7,000	32	17,500
MANCHESTER	45.0	43	103,200	16	38,400	27	64,800	9	20,600	18	44,200
GORST	23.5	51	63,900	17	21,300	34	42,600	10	12,800	24	29,800
UNION	16.5	58	51,000	18	15,800	40	35,100	12	10,200	28	25,000
TAHUYA	14.0	62	46,300	19	14,200	43	32,100	12	9,300	31	22,800
ANDERSON	9.3	66	32,700	19	9,400	47	23,300	13	6,500	34	16,800
OLALLA	25.4	44	59,600	16	21,700	28	37,900	9	11,900	19	26,000
McCORMICK	33.0	52	91,500	17	29,900	35	61,600	10	18,300	25	43,300
DEWATTO	6.4	66	22,500	19	6,500	47	16,000	13	4,500	34	11,500
TOTALS	397.9		970,400		347,800		622,600		194,100		428,500

Notes:
- Precipitation values are based on the isohyetal map presented in Exhibit 3-1.
- Evapotranspiration values are based on a Blaney-Criddle analysis as described in Section 5.5.
- Runoff consists of the stormwater component of hydrograph. Storm water runoff is assumed to be 20 percent of total precipitation (see Section 5.5).
- Areal recharge represents the total recharge to shallow and deep aquifers. A portion of the shallow aquifer recharge provides baseflow to streams.
- Potential error in individual water balance components is described in Section 5.5.
- Exhibit 5-6 provides this data in inches per year.

EXHIBIT 8-7b

Comparisons of Total Inflow, Current Water Allocations, and Pending Applications

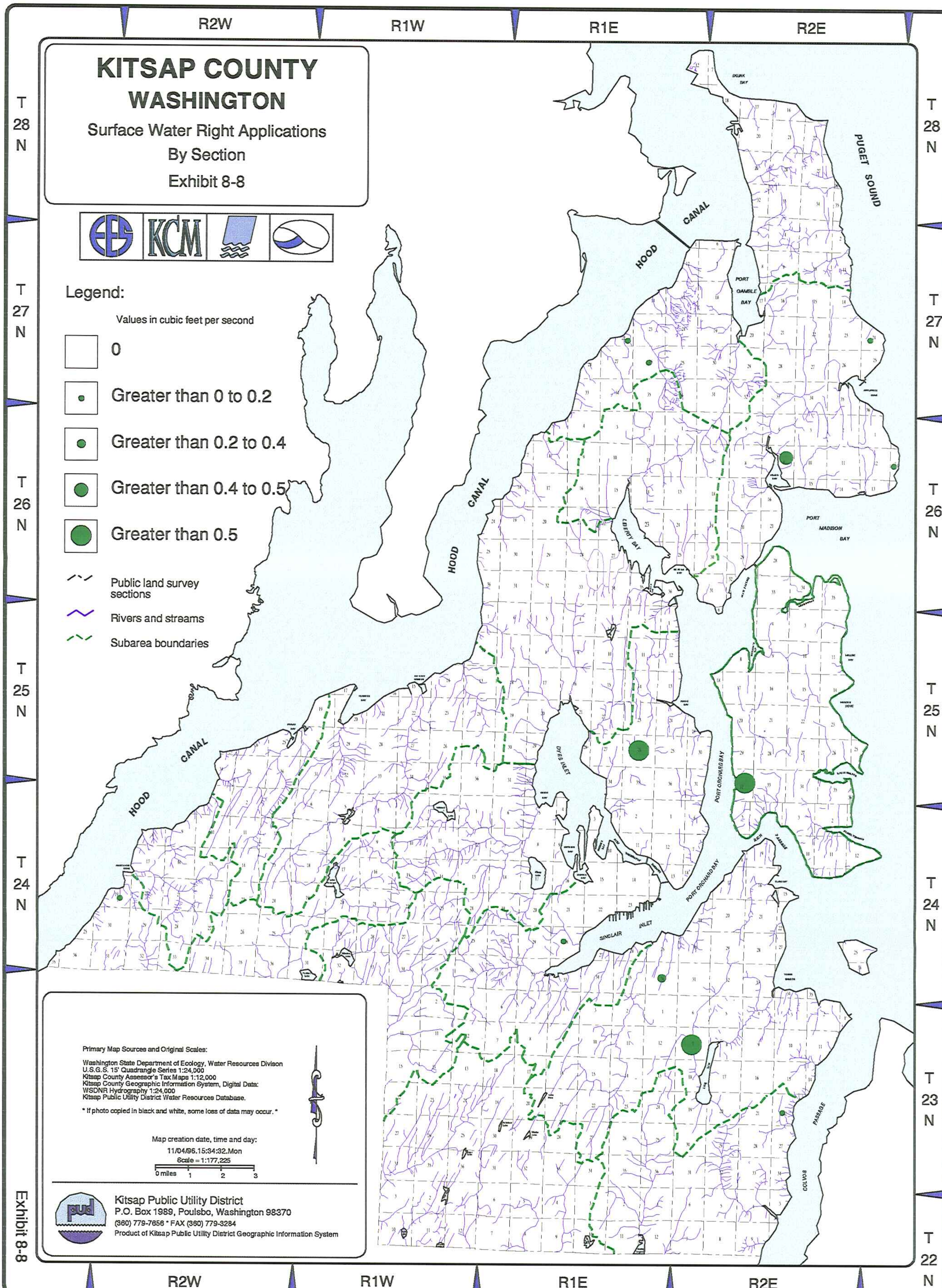
Kitsap County
Initial Basin Assessment

Subarea Name	Total Inflow (TI) =(P-ET)*A (ac-ft/yr)	Groundwater		Surface Water		Total Rights and Claims (TA) (ac-ft/yr)	Relative Development (TA/TI)	MISF Requirements		Pending Applications			
		Rights (ac-ft/yr)	Claims (ac-ft/yr)	Rights (ac-ft/yr)	Claims (ac-ft/yr)			MISF Established (Y/N)	Closed (Y/N)	Groundwater (GPM)	Surface Water (cfs)	Total Appl. (GPM)	Percent of Total Inflow
HANSVILLE	14,100	348	311	463	1	1,123	8%	no	yes	301	0.0	301	3%
KINGSTON	31,200	6,284	969	187	51	7,491	24%	yes	yes	3030	0.5	3,250	17%
PORT GAMBLE	21,300	1,353	813	87	100	2,354	11%	no	yes	3355	0.1	3,395	26%
POULSBO	22,000	2,564	1,291	144	142	4,142	19%	no	yes	2792	0.0	2,794	20%
BANGOR	47,600	7,992	1,724	1,047	73	10,836	23%	yes	yes	8142	0.0	8,142	28%
BAINBRIDGE	31,100	6,354	2,481	383	0	9,218	30%	no	yes	3884	1.0	4,333	22%
MANETTE	22,700	8,695	815	124	66	9,701	43%	yes	yes	2803	1.0	3,251	23%
CHICO	37,900	2,198	254	94	22	2,568	7%	no	yes	296	0.0	296	1%
SEABECK	56,800	4,503	812	369	111	5,795	10%	yes	yes	2524	0.0	2,524	7%
STAVIS	24,500	147	301	10	200	658	3%	yes	no	165	0.0	165	1%
MANCHESTER	64,800	12,676	2,322	322	256	15,576	24%	yes	yes	7831	0.9	8,228	20%
GORST	42,600	7,123	294	124	19	7,560	18%	yes	yes	1470	0.0	1,470	6%
UNION	35,100	34	144	5,164	52	5,394	15%	no	yes	564	0.0	564	3%
TAHUYA	32,100	185	19	15	46	265	1%	yes	yes	642	0.0	642	3%
ANDERSON	23,300	7	22	7	12	48	<1%	yes	yes	0.0	0.0		0%
OLALLA	37,900	2,717	999	209	179	4,105	11%	yes	yes	1651	0.0	1,651	7%
McCORMICK	61,600	901	401	25	66	1,393	2%	no	yes	2080	0.0	2,080	5%
DEWATTO	16,000	28	5	12	1	46	<1%	no	yes	0.0	0.1	22	0%
TOTALS	622,600	64,109	13,978	8,787	1,398	88,271				41,530	3.6	43,108	

Notes:

- Water rights allocations based on Water Rights Information System (WRIS) data obtained from Dept. of Ecology, Water Resources Division.
- Total water rights quantities are for Kitsap County rather than Kitsap WRIA.
- **Relative development** is a gross measure of the amount of water allocated and claimed relative to total inflow to the hydrologic system (precipitation minus evapotranspiration).
- MISF requirements identify those streams where minimum instream flows have been set and streams that are closed to further appropriation.
- Application quantity represent instantaneous withdrawal rates (Qi) expressed in gallons per minute (GPM) for ground water applications and cubic feet per second(cfs) for surface water applications. If approved, they will be limited on an annual basis by the maximum allowable withdrawal (Qa) which will be set by Ecology.

-TA = Total allocation
-TI = Total Inflow


KITSAP COUNTY
WASHINGTON
Surface Water Right Applications
By Section
Exhibit 8-8
Legend:
Values in cubic feet per second
0
Greater than 0 to 0.2
Greater than 0.2 to 0.4
Greater than 0.4 to 0.5
Greater than 0.5
Public land survey sections
Rivers and streams
Subarea boundaries
R2W
R1W
R1E
R2E
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
T 22 N
HOOD CANAL
PUGET SOUND
PORT GAMBLE BAY
PORT MADISON BAY
LIBERTY BAY
DYES INLET
PORT ORCHARD BAY
SINCLAIR INLET
RICH PASSAGE
COLVOS PASSAGE
Primary Map Sources and Original Scales:
Washington State Department of Ecology, Water Resources Divison
U.S.G.S. 15' Quadrangle Series 1:24,000
Kitsap County Assessor's Tax Maps 1:12,000
Kitsap County Geographic Information System, Digital Data:
WSDNR Hydrography 1:24,000
Kitsap Public Utility District Water Resources Database.
* If photo copied in black and white, some loss of data may occur. *
Map creation date, time and day:
11/04/96.15:34:32.Mon
Scale = 1:177,225
0 miles 1 2 3
Kitsap Public Utility District
P.O. Box 1989, Poulsbo, Washington 98370
(360) 779-7656 * FAX (360) 779-3284
Product of Kitsap Public Utility District Geographic Information System
Exhibit 8-8

Section 9 Subarea Characteristics and Water Availability Summary

Water Right Decision Considerations

Water right decisions, by law, are based on: availability of water for appropriation, the proposed use being beneficial, non-impairment of existing rights, and no resulting detriment to the public welfare. In addition, in making water right decisions, consideration is given to existing basin management plans, stream closures, instream flows, hydraulic continuity, seawater intrusion, protests, and availability of alternative water supplies. Water rights decisions require sufficient understanding of the hydrologic system and consideration of potential impairment to existing (senior) water rights. Given the multitude of drainage systems in Kitsap County (County), water rights decisions are best evaluated on a subarea basis, as subareas generally represent discrete portions of the hydrologic system with little hydrologic interaction. Optimally, decisions should be based on direct quantification of water availability within a given subarea. However, direct quantification of ground water availability is limited by the complexity of subsurface conditions relative to current levels of hydrogeologic characterization. In addition, direct quantification of surface water availability is inherently limited by the spatial and temporal variability of precipitation and evapotranspiration. Therefore, determination of water availability must be based on a best understanding of the hydrologic system and indirect indicators of water availability. Within each subarea discussion, considerations for making water allocation decisions are presented. For specific water right decisions, additional, individual considerations and local conditions will have to be taken into account.

Data gaps - summary information and relative importance to future water rights decisions

Nature and severity of data gaps

All subareas have data gaps which vary in degree. The data, which can be organized into data sets, combine to provide a level of understanding of water resources in both a static and dynamic sense.

The level of understanding is likely to never reach a perfect state. Acknowledgment of data gaps, therefore, is an important part of an assessment process. Also, recognition of the magnitude and context of these gaps is critical to a decision making framework.

Outlined below are key elements of the decision making framework for water rights and a description of the data sets of this assessment which support it. The general relationship of these data to the framework is also described. This information provides a general outline for identifying work that will be needed to fill the data gaps.

Data gaps and necessary data gathering activity

Data gaps have been categorized into the following areas of data need:

- Aquifer Analysis
- Hydraulic Continuity and streamflows
- Seawater Intrusion
- Precipitation
- Water Balance
- Fisheries Resource and Habitat Quality
- Current and Future Water Demand

To address the data needs in each subarea, the specifics of the subarea and relationship and status of all data sets need to be considered. For example, in an area where little is known about groundwater movement, and there are a limited number of pending applications for small quantities of water, yet the level of development is quite low, a modest effort at aquifer analysis might be adequate. By contrast, a similar situation where there are indications of over allocation (e.g., decreasing water levels or interference), would prompt a more focused and intensive groundwater investigation.

Water rights decision framework

All water right applications in the State are investigated by evaluating four areas, (sometimes referred to as "tests") (RCW 90.03.290). They are:

1. ". . . .what water, if any, is available for appropriation. . . . "
2. ". . . . to what beneficial use or uses it can be applied."
3. " . . . . the application will not impair existing rights . . . ."
4. ". . . . the application will not . . . be detrimental to the public welfare . . . ."

Not much has been written on these tests. Perhaps that is because of the need for flexibility in decision making and because the "tests" are sufficient for their purpose which is to provide a priority listing of access to available water. Flexibility is necessary due to the varied hydrological conditions throughout the state and differences between water uses. The Department of Ecology is administratively responsible to interpret data and administer these tests.

The data needs outlined in this document are perceived as areas where additional data would help address one or more of the basic tests mentioned above. The relationship of data categories to the tests are outlined in **Exhibit 9-1**.

Relationship of data gaps to decision framework

A major question for decision makers is: "How significant is the data gap when compared to available data and the potential impact of the proposed allocation?" The significance of the data gaps relative to water rights decisions can be evaluated according to their relationship with other data sets and data gaps (level of understanding), and in relationship to indicators of over allocation.

In general, the significance of data gaps are directly related to the degree or assumed degree of water allocation. In other words, if the degree of water allocation is high in a subarea, it would be expected that the data gap would take on more significance or be more important. Thus, more data is likely to be required.

The significance of data gaps, however, can be increased or decreased by the relative level of other information (data sets). For example, a gap in fisheries data might be less significant if the level of aquifer understanding were high, and the impact of the proposed withdrawal were known to a higher degree. **Exhibit 9-2** outlines water rights decision data requirements.

Summary of findings

As a result of this Assessment, the relative importance of the data gaps in each of the subareas should be established. **Exhibit 9-3** suggest a format that could be used by Ecology to indicate the importance and degree of resources that should be applied to fill in the data gaps for a specific subarea as part of follow-on assessments.

Subarea Evaluations

The hydrologic characteristics of the principal aquifers within the 18 subareas have been discussed, in part, in preceding sections of this assessment. This section provides more in-depth descriptions of the hydrologic characteristics of the subareas, specifically in regard to information necessary for making water right decisions. Several factors can be considered in making water right decisions. Analysis should include factors such as: the potential for stream-aquifer continuity, the potential for seawater intrusion, and the degree of water resource allocation. Additional indicators that reflect the "health" of the hydrologic system include: ground water level trends, streamflow trends, and the health of the fisheries resource.

The following sub-sections apply the tests described above to each of the Kitsap subareas. Available data and degrees of hydrologic understanding vary between subareas. In addition, each sub-section includes a description of general subarea characteristics (land-use development, aquifers, soils, precipitation, and drainage), a recommendation for making allocation decisions, and other recommendations for additional hydrologic evaluation and water resource management.

Washington Department of Fish and Wildlife (WDFW) has not developed a standardized method for cataloging habitat and water quality information on small streams. Unlike the major salmon producing streams such as the Union and the Tahuya Rivers, the smaller systems are usually evaluated on the basis of presence or absence, and as in the other subareas, there is limited information on resident salmonids.

Because of the specific requirements of the Growth Management Act, considerable changes have occurred in the County's population forecast and comprehensive plan allocations. As of October 1997, significant issues remained to be resolved. Discussion in this document of population density, land cover, and land use has provided an overview of the general character of the County, which gives some indications of likely patterns of water use, and general indications of demand for the future. This document has not provided a much needed analysis of demand by subarea, because at this time (October 1997), the County Comprehensive Plan has been rejected by the Growth Management Hearings Board, urban growth areas are being re-designated, and population allocation figures may change.

New sources and water rights for some existing public water systems will be needed in the future. While this statement seems apparent, given the general growth expected, the size and extent (geographical) of this need is unknown. For example, it is not known whether existing rights for various purveyors are adequate for future needs. It is also not known what percentage of population in each of the subareas can be expected to be served by public water supply, and which can be expected to be served by private domestic wells.

Clearly, follow up studies will be required. Existing supply versus projected demand, data requirements, funding, etc. will be evaluated to set appropriate priorities for future studies by subarea. For example, if specific subareas show significant deficiencies when future demand is compared with existing capacity (water rights), then priority for future supply study should be focused in areas which could provide the increased demand. If studies raised significant policy questions relating to water resource management, then these issues can be addressed in the appropriate forum.

Recommendations

With any follow-up study, the following recommendations should be considered for all subareas:

- ❑ Additional analysis of land use, population, public water system capacity, and future demand
- ❑ Develop more comprehensive aquifer descriptions including:
    - Discussions of general aquifer/aquitard properties and characteristics.
    - A description of hydraulic relationships of recharge and discharge (including an adequate understanding of the hydraulic head relationships, gradients, and flows) between aquifers, within aquifer systems, and with surface water.

- Estimates of the ranges of T, K, S, or Sy for various aquifers and aquitards.

- An evaluation to identify recharge areas.

- Justification for estimates of aquifer boundaries, including summary tables of the wells used to establish boundaries for the principal aquifers, and relevant test data.

- An outline of the data used for geologic interpretation of aquifers, indicating sources and level of confidence.

❑ Evaluate the options of all water rights including those recently not in use.

❑ Develop a more accurate flow balance for each subarea, with particular attention to estimates of runoff.

❑ Identify desired, future monitoring sites.

❑ Conduct a more detailed analysis of water quality data for each subarea.

❑ Conduct an analysis of land use, population, public water system capacity, and the ability to meet future demand.

❑ Incorporate estimates of commercial/industrial water demand growth and single family vs. multi-family construction trends when they are available.

❑ Develop an estimate of actual water production from exempt wells and estimates of future changes in exempt well production, when post comprehensive land use projections become available.

❑ Enhance estimates of the degree of water resource allocation.

❑ Develop more comprehensive tracking and analysis of water levels in the various aquifers and evaluate the correlation of water level trends with the various causative factors (e.g. precipitation, production, land use change, etc.).

9.1 Hansville Subarea

The Hansville subarea is located at the northernmost extent of the County. The Hansville subarea is one of the most rural and forested subareas in the County. According to satellite data (1994) analyzed by Kitsap Public Utility District No. 1 (KPUD), the Hansville subarea covers approximately 17 square miles (about 4 percent of the County) and is about 94 percent forested or natural cover. An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Hansville subarea has one of the lowest population densities of the County's subareas. Based on 1990 census data, the area had a population density of about 160 persons/square mile.

A detailed study in the Hansville subarea identified the Hansville and Sea Level Aquifers (Robinson and Noble, January 1990). The study concentrated on the Hansville Aquifer and defined the boundaries of this perched aquifer. The Hansville perched aquifer has a recharge area of approximately three square miles and is found above +200 feet mean sea level (MSL). Less is known about the extent and characteristics of other perched aquifers or the Sea Level Aquifer which occur between +50 to -100 feet MSL.

No detrimental ground water quality trends have been identified. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits in some wells in the Hansville subarea. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. Existing data provide no evidence for significant nitrate contamination of the ground water beneath the Hansville subarea.

Surficial soils in the Hansville subarea are primarily Group A (very high infiltration potential), although areas of Group C and D soils (low to very low infiltration potential) occur. Precipitation is low relative to the rest of the County, ranging from about 26 to 33 inches/year. Drainage in the subarea occurs to a number of small streams, none of which have catchments larger than 2.5 square miles.

Existing and proposed land-use do not appear to represent significant threats to the water quality of this subarea.

9.1.1 Stream-Aquifer Continuity

The Hansville Aquifer is in relatively high continuity with surface water (Robinson and Noble, January 1990). The Hansville Aquifer is located within parts of six small drainage basins. Continuity between all streams and the Sea Level Aquifer is not well understood.

Under WAC 173-515-040, year-round closure of one stream, Little Boston Creek, has been established in the Hansville subarea. Little Boston Creek is located to the south of the Hansville Aquifer and appears to be in relatively low continuity with the Hansville Aquifer. It may be locally in continuity with the Sea Level Aquifer. Continuity may also exist between shallow ground water and non-closure streams with salmonid populations.

9.1.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the Hansville Aquifer because the entire aquifer occurs considerably above sea level. Seawater intrusion could occur in the Sea Level Aquifer if excessive ground water development were to occur. Elevated chloride concentrations are documented in only one location (south of Eglon) (Section 5.10.1). Relatively high values of electrical conductivity occur in various coastal and inland locations (Section 5.10.2). Although relatively high, they are not sufficiently high to suggest significant seawater intrusion is a wide spread problem throughout the subarea.

9.1.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Hansville subarea is relatively low compared to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 8 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. Streamflows in the subarea are not subject to minimum instream flow requirements. Protection of streamflows is accomplished through a regulatory closure of Little Boston Creek.

Total inflow to the hydrologic system is estimated to be 14,100 acre-feet/year. Water right allocations in the Hansville subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 811 acre-feet per year. Ground water permits and certificates comprise 43 percent of these allocations. Water right claims in the subarea are on the order of 312 acre-feet/year. The claims are almost entirely registered for ground water sources.

9.1.4 Ground Water Level Trends

Insufficient data exist to evaluate ground water level trends in the Hansville subarea.

9.1.5 Streamflow Trends

No long-term streamflow data exist within the subarea. Only spot measurements of low flow are available.

9.1.6 Fisheries and Habitat

Although data on the small streams of this subarea is limited, a number of creeks which probably support populations of resident cutthroat trout. The importance of these small streams should not be overlooked and they should at least be cataloged by the County for future reference.

9.1.7 Allocation Decision Considerations

The Hansville subarea, one of the most rural subareas, has one of the lowest population densities in the County. Although the Hansville subarea has the least amount of rainfall in the County, the relative level of development of the water resource is very low at about 7 percent of estimated total inflow. Currently, ground water applications for the Hansville subarea request 301 GPM (0.7 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 3 percent of the total in flow. There are no surface water applications pending in the subarea.

Additional ground water development from the Hansville Aquifer will ultimately be limited by available recharge, given the limited areal extent of the recharge area and available precipitation. To accurately determine the total availability of additional ground water from the aquifer, more data collection and analysis will be required.

Available information for the Sea Level Aquifer is marginal for making additional water right decisions. Questions concerning the potential for seawater intrusion needs to be evaluated.

Water right allocation decisions in the Hansville subarea need to address hydraulic continuity and seawater intrusion concerns.

9.1.8 Recommendations

- ❑ Make significant development of the Hansville Aquifer contingent on water level monitoring and a water budget analysis which compares estimated recharge to current allocations.
- ❑ Require hydrogeologic characterization for the Sea Level Aquifer, including evaluation of stream-aquifer continuity and the potential for seawater intrusion. If the aquifer has a high seawater intrusion potential, water level and water quality monitoring should accompany ground water development.
- ❑ Collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).
- ❑ Catalogue the fisheries resource of the subarea.
- ❑ Install a stream gage in the subarea if favorable conditions can be found. A probable location would be KPUD's spring site No. 2 on Hansville Creek.
- ❑ Include water level monitoring of suitable wells in the Hansville and Sea Level Aquifers as part of the GWMP water level monitoring network.

9.2 Kingston Subarea

The Kingston subarea is located in the north portion of Kitsap County. The Kingston subarea is one of the more rural and forested subareas in the County. A growing commercial and suburban area does exist in the vicinity of the ferry terminal in the unincorporated town of Kingston. Covering approximately 31 square miles (about 8 percent of the County), the Kingston subarea is about 94 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Kingston subarea has a moderately low population density relative to the other County subareas. Based on 1990 census data, the area had a population density of about 295 persons/square mile.

Three principal aquifers have been identified in the Kingston subarea: the Kingston Aquifer System, Suquamish-Miller Bay Aquifer System, and the Port Gamble South Aquifer (GWMP Vols. I and II). Discontinuous perched aquifers also exist in the subarea. The Port Gamble and Port Gamble South Aquifers particularly overlap into Port Gamble subarea. The Suquamish Tribe and KPUD are conducting on-going data collection and aquifer analysis on the Suquamish-Miller Bay System, Port Gamble South Aquifer, and the Kingston System. A number of studies provide varying amounts of hydrogeologic characterization information for these aquifers (GWMP 1991, AGI, 1989, Robinson & Noble, 1994).

The ground water in the Kingston subarea is generally of good quality and suitable for most purposes. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits in some wells throughout the Kingston subarea. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. There is no evidence of significant nitrate contamination beneath the Kingston subarea. However, some localized nitrate and seawater contamination has been documented.

Surficial soils in the Kingston subarea are almost evenly distributed between Group A and Groups C and D. The soils, therefore, range from having very high infiltration potentials to very low infiltration potentials. Precipitation is low relative to the rest of the County, ranging from about 31 to 37 inches/year. Drainage in the subarea occurs primarily to Grovers and Thompson creeks. A number of other creeks drain relatively small catchments of the subarea.

Development and the location of urban activities in direct proximity to the Kingston Aquifer System could result in threats to aquifer quality. Most of the urban area is or is proposed to be sewered, and urban runoff will go to Puget Sound unless diverted to recharge. Most of the subarea is expected to remain suburban or rural with minimal threats to ground water other than those associated with private domestic land uses. The existence of a major transportation route through the recharge area does represent a risk to the aquifer.

9.2.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity varies between the three aquifers identified. Two aquifers in the subarea, the Kingston Aquifer System and Port Gamble South, are located entirely below sea level and have relatively low potential for continuity. The Suquamish-Miller Bay Aquifer System, located from sea level to 300 feet below sea level, does have potential for continuity to Grovers Creek and other streams discharging into Miller Bay. The characteristics of the possible continuity are not well understood. The potential for surface water continuity with perched aquifers is relatively high.

Instream flows have been established for Grovers Creek under WAC 173-515-030 during portions of the year. A seasonal stream closure has also been established for Grovers Creek. Year-round closures have been established for Thompson Creek, Cowling Creek, and several smaller streams in the subarea.

9.2.2 Seawater Intrusion Potential

Seawater intrusion could occur in the aquifers in the subarea if excessive ground water development were to occur. There is no evidence of extensive seawater intrusion beneath the Kingston subarea; however, relatively high values of electrical conductivity (EC) at coastal locations suggest that ground water quality is affected by nearby seawater. Elevated chloride concentrations also tend to occur in coastal locations, but (similar to EC) may occur at inland areas and therefore are not necessarily indicative of seawater intrusion. Significant localized seawater intrusion has been identified in the Jefferson Beach vicinity where the wells are generally shallow and have completion elevations that range from slightly above to slightly below sea level.

9.2.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Kingston subarea is relatively high in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 24 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. In addition, minimum instream flow requirements and regulatory closures may also limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 31,200 acre-feet/year. Water right allocations in the Kingston subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 6,471 acre-feet per year. Ground water permits and certificates comprise 97 percent of these allocations. Water right claims in the subarea are on the order of 1,020 acre-feet/year. Approximately 95 percent of this volume is claimed from ground water sources.

9.2.4 Ground Water Level Trends

The apparent water level trends for water years 1991 through 1996 show a relation to natural variability in precipitation for aquifers located above and below sea level. Apparent water level declines of 10 feet or more have been identified in the Suquamish-Miller Bay Aquifer System (KPUD monitoring data, wells AAB406, AAA014 and AAA710). All three wells have completion elevations generally -100 to -300 feet MSL. Probable causes of declines include precipitation deficits, ground water withdrawal for potable supply and to a lesser extent for fish propagation. Currently all three hydrographs suggest that declines have moderated and a new equilibrium may have been established for the aquifers involved.

9.2.5 Streamflow Trends

Though no long-term streamflow data exist within the subarea and no stations are monitored on a continuous basis, the Suquamish Tribe has established on-going streamflow monitoring at a number of sites in the subarea. Spot measurements for stream flow (primarily low - flow measurements) are available .

9.2.6 Fisheries and Habitat

With the exception of a small, unnamed creek which enters the east side of Port Gamble Bay, there is a limited amount of data on the quality of fisheries habitat in the Kingston subarea. Information concerning flow and water quality on Grovers Creek is available. It is the major source of water for the Suquamish Tribal hatchery. The hatchery is located within 400 yards of the high tide level of Miller Bay, and there is a total blockage to any migration beyond that point. The only data on the stream are in the environmental impact studies for two proposed large projects. Logging and agricultural practices have reduced the quality of the habitat.

9.2.7 Allocation Decision Considerations

The Kingston subarea has a moderately low population density relative to the other County subareas. Water resource development in this subarea, which is 24 percent of total inflow, is the fourth highest in the County. Currently, water right applications for the Kingston subarea request 3250 GPM (7.2 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 17 percent of the in flow. Ground water applications comprise 93 percent of these applications.

Additional data will be needed to make most water rights decisions for the Suquamish-Miller Bay Aquifer System. The cause for water-level declines in this aquifer system should be identified, and improved understanding of stream-aquifer continuity is warranted.

Available data for various production zones that make up the Kingston Aquifer System and Port Gamble South Aquifer could be improved. Upon further analysis of certain portions of these aquifers, adequate data may exist to enable Ecology to make water right decisions. Questions remain concerning seawater intrusion potential and sustainable yield.

9.2.8 Recommendations

- ❑ Continue comprehensive water level monitoring network for the subarea in coordination with Tribal efforts.

- ❑ Conduct preliminary evaluation of KPUD and Tribal data for the Suquamish/Indianola area.

- ❑ Continue periodic water quality monitoring of KPUD subarea wells, monitoring of coastal wells at Jefferson Beach and other areas of interest, and coordinate with Tribal efforts in coastal locations to provide early warning for potential seawater intrusion.

- ❑ Collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).

- Catalogue the fisheries resource of the subarea.

- The Suquamish Tribe (Grovers Creek) should continue making spot measurements of flow and recording at least daily staff gage readings.

9.3 Port Gamble Subarea

The Port Gamble subarea is located in the northern portion of the County along Hood Canal. The Port Gamble subarea is among the more rural and forested subareas in the County. Covering approximately 19 square miles (about 5 percent of the County), the Port Gamble subarea is about 95 percent forested or natural cover (Satellite data analysis- KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in rural, forested, or open space categories.

The Port Gamble subarea has a moderately low population density compared to other subareas in the County. Based on 1990 census data, the area had a population density of about 220 persons/square mile.

Three principal aquifers have been identified in the subarea: Edgewater, Port Gamble, and Port Gamble South Aquifers. The Port Gamble and Port Gamble South Aquifers partially overlap into the Kingston subarea. The extent of the Edgewater Aquifer is poorly defined (GWMP Vol. I and II). The Port Gamble Aquifer is newly identified (Robinson and Noble, March 1994) with a recharge area of approximately eight square miles. Discontinuous perched aquifers also occur in the subarea. The cited references contain varying amounts of hydrogeologic characterization data for these aquifers.

The ground water in the Port Gamble subarea is generally of good quality and suitable for most purposes. Limited water quality data were available from the northern and central portions of the subarea. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits in areas of data availability throughout the Port Gamble subarea. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. Existing data provide no evidence of nitrate contamination beneath the Port Gamble subarea.

Surficial soils in the Port Gamble subarea are largely Group A (very high infiltration potential), although significant areas of Group C and D soils (low to very low infiltration potential) occur. Precipitation is moderately low relative to the rest of the County, ranging from about 33 to 41 inches/year. The primary drainages in the subarea (Gamble Creek and an unnamed creek) originate outside of the subarea. Several other creeks with smaller catchments drain to Port Gamble Bay and Hood Canal. A review of the original subarea boundaries which are used throughout this initial basin assessment revealed that several streams originated in one subarea and drained into another. Revisions to subarea boundaries have been made to resolve this problem. Future studies and evaluations will use the revised subarea boundaries **(Exhibit 2-1a)**.

Exhibit C-13 of GWMP, Vol. III, Appendix C shows a large surface mine overlying a part of the Edgewater Aquifer, as well as an adjacent wetland. This may constitute a threat to the aquifer. Based on existing and proposed future land use patterns, threats to the newly identified Port Gamble Aquifer appear negligible.

9.3.1 Stream-Aquifer Continuity

Because they have zones located above sea level, both the Edgewater and Port Gamble Aquifers have relatively high potential to be in continuity with surface water. This potential continuity should be investigated. Perched aquifers in the subarea are also likely to be in continuity with surface water.

A year-round stream closure has been established for Gamble Creek under Chapter 173-515 WAC.

9.3.2 Seawater Intrusion Potential

The potential for seawater intrusion in the subarea exists. Seawater intrusion could occur in the Edgewater and Port Gamble Aquifers if excessive ground water development were to occur. Seawater intrusion is not possible for the perched aquifers because these aquifers occur above sea level. There is no evidence for extensive seawater intrusion beneath the Port Gamble subarea. However, relatively high values of EC and chloride along Hood Canal suggest that ground water quality is affected by nearby seawater.

9.3.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Port Gamble subarea is moderate relative to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 11 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. No minimum instream flow requirements have been established in the subarea. Protection of streamflows is accomplished through regulatory closures.

Total inflow to the hydrologic system is estimated to be 21,300 acre-feet/year. Water right allocations in the Port Gamble subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 1,440 acre-feet per year. Ground water permits and certificates comprise 94 percent of these allocations. Water right claims in the subarea are on the order of 913 acre-feet/year. Approximately 89 percent of this volume is claimed from ground water sources.

9.3.4 Ground Water Level Trends

A hydrograph of well AAA103 shows no apparent water level decline in the Edgewater Aquifer for water years 1991 to 1996 but a possible 10 foot decline since late 1987 (KPUD monitoring data). Natural variability in precipitation is a probable factor in the apparent long-term decline, and has yet to be evaluated. Lack of long-term data for other wells in the Port Gamble Aquifer will hamper an analysis of water level trends.

9.3.5 Streamflow Trends

No long-term streamflow data exist within the subarea. Only spot measurements of low flow in streams are available (see Appendix C).

9.3.6 Fisheries and Habitat

With the exception of Gamble Creek, there is a limited amount of data on the quality of fisheries habitat in the Port Gamble subarea. The summary data documented by Puget Sound Cooperative River Basin Team (PSCRBT 1993) indicates that a tributary of Gamble Creek which once supported salmon has limited utilization and that habitat degradation has occurred.

9.3.7 Allocation Decision Considerations

The Port Gamble subarea has a moderately low population density compared to other subareas in the County. The subarea has a moderate level of development of the water resource at 11 percent of total inflow. Currently, water right applications for the Port Gamble subarea request 3395 GPM (7.6 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 26 percent of the total inflow. Ground water applications comprise 99 percent of the requested withdrawal.

Apparent water level declines in the Edgewater Aquifer may limit the potential for additional supply.

Based on preliminary studies, the Port Gamble Aquifer shows good potential for additional supply. Additional information is needed to better estimate the total amount of resource available.

9.3.8 Recommendations

- ❑ Conduct a hydrogeologic study and test drilling program to better define the extent, potential, and characteristics of the Port Gamble Aquifer.
- ❑ Make arrangements, prior to conclusion of the Bangor Study, with the United States Geological Survey (USGS) to continue measurement of surface water flows on Gamble Creek using equipment erected by the USGS for the Bangor Study.
- ❑ Collect water levels for both aquifers to determine long-term trends.
- ❑ Add additional wells to the water level monitoring network for the subarea.

- ☐ Continue collecting wet season/dry season chloride data from production wells in the Gamblewood and Vinland water systems to evaluate seawater intrusion potential.

9.4 Poulsbo Subarea

The Poulsbo subarea is located in the north-central portion of Kitsap County. The Poulsbo subarea is an urbanizing subarea. Covering approximately 19 square miles (about 5 percent of the County), the Poulsbo subarea is about 87 percent forested or natural cover (Satellite data analysis- KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories with about 7 percent in urban classification.

The Poulsbo subarea has a medium population density compared with the rest of the County's subareas. Based on 1990 census data, the area had a population density of about 450 persons/square mile.

A hydrogeologic study of the Poulsbo Aquifer, the only principal aquifer so far identified in the subarea, has been conducted for the City of Poulsbo (Robinson and Noble, November 1992). Discontinuous perched aquifers also occur in the subarea. Cited references contain hydrogeologic characterization information for the aquifer.

No detrimental water quality trends have been noted. The ground water in the Poulsbo subarea is generally of good quality and suitable for most purposes. Only limited water quality data were available in the southwestern portion of the subarea. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits at various locations within the Poulsbo subarea. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. There is no evidence of nitrate contamination beneath the Poulsbo subarea. Elevated nitrate concentrations are noted along the boundary between the Poulsbo and Kingston subareas.

Surficial soils in the Poulsbo subarea are predominantly classified as Group C or D, and, therefore, have low to very low infiltration potentials. Precipitation is moderately low compared to the rest of the County, ranging from about 36 to 41 inches/year. Drainage in the subarea occurs primarily to Dogfish and Johnson creeks. A number of other creeks (some with very small catchments) drain to Liberty Bay.

The proposed growth scenarios for lands overlying the Poulsbo Aquifer shows an increase in urban and semi-urban development. Although part of the aquifer area will likely be sewered, threats to the aquifer will result from stormwater and drainage impacts on recharge and water quality. Additionally, the urban activities and development can present potential threats to the underlying aquifer.

9.4.1 Stream-Aquifer Continuity

A study of the stream-aquifer continuity for the Poulsbo Aquifer (Robinson and Noble, November 1992) showed that the aquifer has relatively low continuity with Dogfish Creek due to the occurrence of thick, fine-grained aquitard. The perched aquifers are likely to be in continuity with surface water in the subarea.

Year-round stream closures have been established for Dogfish and Johnson Creeks under Chapter 173-515 WAC.

9.4.2 Seawater Intrusion Potential

The perched and Poulsbo Aquifers occur entirely above sea level. Seawater intrusion is not possible for these aquifers. There is no evidence for extensive seawater intrusion beneath the Poulsbo subarea. Based on hydrogeologic considerations, seawater intrusion could constitute a threat to coastal areas if excessive ground water development were to occur.

9.4.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Poulsbo subarea is moderate relative to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 19 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. No minimum instream flow requirements have been established in the subarea. Protection of streamflows is accomplished through regulatory closures.

Total inflow to the hydrologic system is estimated to be 22,000 acre-feet/year. Water right allocations in the Poulsbo subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 2,708 acre-feet per year. Ground water permits and certificates comprise 95 percent of these allocations. Water right claims in the subarea are on the order of 1,433 acre-feet/year. Approximately 90 percent of this volume is claimed from ground water sources.

9.4.4 Ground Water Level Trends

Short-term (water year 1991 to 1996) apparent water level trends for wells in the Poulsbo Aquifer suggest water levels have declined several feet (wells AAB481, AAB482). A single hydrograph for a deep well completed below the Poulsbo Aquifer at -200 feet MSL (AAA254) suggests a decline of approximately 16 feet between 1976 and 1995 (1976 to 1990 was a period of no data). Between water year 1991 to 1995 the apparent decline was about 1 to 3 feet for the deep well. Unfortunately no other data are available from other deep wells to substantiate aquifer changes.

9.4.5 Streamflow Trends

KPUD is currently collecting streamflow data for Dogfish Creek. Earlier data were collected continuously by the USGS between 1948 and 1970. The data show a relatively stable annual streamflow trend, although there is some suggestion that, in later years, higher rainfalls may have been required to get similar streamflow volumes (Section 4.4.1). The data do not suggest discernible trends in minimum flow. Dogfish Creek is protected by a regulatory stream closure under Chapter 173-515 WAC.

Only spot measurements of low flow are available for other streams (see Appendix C).

9.4.6 Fisheries and Habitat

Coho, chinook, and chum salmon are the predominant species found in Dogfish Creek. Chinook and chum salmon are currently stocked in Dogfish Creek by the Suquamish Tribe. Johnson Creek supports chum and coho salmon, as well as trout species. Coho salmon and cutthroat trout have been noted in both Lemolo and Klebeal Creeks.

Some data are available on Dogfish Creek from the Suquamish chinook salmon enhancement for a terminal Tribal fishery in Liberty Bay. Limited quantified data is available on the actual habitat of the streams in this unit and low flow data should be collected.

9.4.7 Allocation Decision Considerations

The Poulsbo subarea has a medium population density compared with the rest of the County's subareas. The relative level of development of the water resource is moderate at 19 percent of total inflow. Ground water right applications for the Poulsbo subarea request 2794 GPM (6.2 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 20 percent of the total inflow.

The available information on the Poulsbo Aquifer does address stream-aquifer continuity but does not resolve the quantity of water available from the aquifer. The Poulsbo Aquifer's lateral extent and usage suggests limited potential for additional future supply. Apparent water-level declines in a deep aquifer in the subarea should also be reviewed.

Available information for the perched aquifers is less than adequate for making water right decisions. Questions concerning potential stream-aquifer continuity need to be resolved in order to make additional water right decisions.

9.4.8 Recommendations

- ❑ Evaluate the subarea for the existence of other aquifers.
- ❑ Continue the established ground and surface water monitoring network.
- ❑ KPUD, Tribe, and others should continue to collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).

- Catalogue the fisheries resource of the subarea.

- Collect water quality data in coastal locations to evaluate seawater intrusion potential.

9.5 Bangor Subarea

The Bangor subarea is located in the central portion of Kitsap County. It is a growing area that includes the unincorporated urban center of Silverdale, the United States Navy's Subase Bangor, and the Keyport Naval Undersea Center. The Bangor subarea covers approximately 36 square miles (about 9 percent of the County). Silverdale is the largest unincorporated urban area in the County and the largest commercial center. An industrial area is developing west of Silverdale. Because of Silverdale and the cleared sections on the Subase, the forest and natural cover for the area is only about 80 percent (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows a significant amount of land (about 35 percent) as industrial, but shows over half of the remaining land in open, forested, or water classifications with only 10 percent in an urban classification.

The Bangor subarea has a medium population density compared to other County subareas. Based on 1990 census data, the area had a population density of about 636 persons/square mile.

Four principal aquifers have been identified in the Bangor subarea: the Island Lake, Silverdale, and Keyport Aquifer, and the Bangor Aquifer System. Substantial amounts of data have been collected while studying the Island Lake Aquifer (Robinson and Noble, January 1991). The boundaries of the Silverdale and Keyport Aquifers are not well defined. A comprehensive evaluation of the Bangor Aquifer System, including a three-dimensional numerical model, has been completed (Becker, 1995a, 1995b). Numerical modeling of the Bangor Aquifer System by the USGS is in progress. The Bucklin Hill Aquifer is described in the Manette subarea section (9.7). The cited references contain considerable hydrogeologic characterization information for these aquifers.

The ground water in the Bangor subarea is generally of good quality and suitable for most purposes. Iron and manganese concentrations which exceed recommended aesthetic limits occur throughout the Bangor subarea. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. Nitrate concentrations did not exceed primary drinking water standards in any of the Bangor subarea wells sampled. Several wells along Liberty Bay had concentrations which appeared to be affected by localized nitrate contamination.

Surficial soils in the Bangor subarea are predominantly classified as Group C or D, and therefore, have low to very low infiltration potentials. Precipitation is average compared to the rest of Kitsap County, with annual values between 37 and 49 inches/year. Drainage in the subarea occurs primarily to Strawberry, Clear, Scandia, and Barker Creeks. Numerous other streams in the subarea have more limited catchments.

The larger threats to the Bangor subarea aquifers probably relate to past land use activities rather than future authorized land uses. However, assuming that the remediation programs for the various identified contamination sites (e.g., those on the Bangor Subase and Keyport) are successful, the threats should be reduced to a large degree. The rail system to Subase Bangor could be of concern. In recent years it has not been used for transporting materials which are potential hazards to the aquifer. The continuing increase in urbanization of the Silverdale area creates a need for monitoring to assure that the underlying Silverdale Aquifer is adequately protected.

9.5.1 Stream-Aquifer Continuity

Potential for stream-aquifer continuity varies between the four aquifers identified. The Island Lake Aquifer, located primarily above sea level, has varying degrees of continuity with surface water in Island Lake and Barker Creek. The Silverdale and Keyport Aquifers, located below sea level, have relatively low continuity with surface water. The continuity of the Bangor Aquifer System is variable for different zones within the system. The perched aquifer of the Bangor Aquifer System is in relatively high continuity with surface water. The Sea Level and Semi-perched Aquifers of the Bangor Aquifer System have relatively low continuity with surface water (Becker, 1995a). The Deep Aquifer has relatively low continuity with surface water.

Instream flows have been established for Strawberry Creek under WAC 173-515-030. Seasonal or year-round stream closures have been also been established for Strawberry, Barker, Clear, and Scandia Creeks.

9.5.2 Seawater Intrusion Potential

The potential for seawater intrusion varies between the four aquifers identified. Seawater intrusion is not possible for the perched and Island Lake Aquifers because these aquifers occur above sea level. Seawater intrusion could occur in the Keyport and Silverdale aquifers, and Bangor Aquifer Systems if excessive ground water development were to occur. There is no evidence for extensive seawater intrusion beneath the Bangor subarea. However, relatively high values of EC along Liberty Bay suggests that ground water quality is affected by nearby seawater and some chloride values above background levels have been observed in the Keyport Aquifer (KPUD data). Seawater intrusion (high chloride concentrations) was documented in the Sea Level Aquifer of the Bangor Aquifer System during the dewatering event for dry-dock construction at Bangor Subase (Paterson, 1981). Chloride concentrations in the Subase wells have generally returned to near-background levels (Becker, 1995b).

9.5.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Bangor subarea is moderately high compared to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 23 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. An important further note is that these totals do not include unquantified federal rights for the Bangor Subase or Keyport Naval Undersea Center. In addition, minimum instream flow requirements and regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 47,600 acre-feet/year. Water right allocations in the Bangor subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 9,039 acre-feet per year. Ground water permits and certificates comprise 88 percent of these allocations. Water right claims in the subarea are on the order of 1,797 acre-feet/year. Approximately 96 percent of this volume is claimed from ground water sources.

9.5.4 Ground Water Level Trends

Over the short-term (water year 1991 to 1996) only several well hydrographs have notable declines. However, a relatively large number of hydrographs for wells in the Bangor subarea have long-term declines of 10 feet or more. These wells include AAA728, AAA730, AAA734, AAA746, AAA748, AAA749 AAC629 and AAA639. Most of the wells are associated with centers of ground water withdrawal, but natural variability in precipitation is also an important factor in the declines. Data show a decline in water levels in the Island Lake Aquifer (Robinson and Noble, January 1991). At this time, long-term data already collected for the Silverdale and Keyport Aquifers have not been formally evaluated. Water levels in the Bangor Aquifer System showed relatively stable water levels in all aquifers from 1981 to 1993. Since 1993, a decline of 2 to 5 feet has occurred which appear to be solely a result of corresponding changes in precipitation (Becker, 1995a).

9.5.5 Streamflow Trends

No long-term streamflow data exist within the subarea. KPUD is currently collecting streamflow data for Barker and Clear Creeks. Silverdale Water District records staff gage readings twice daily, Monday through Friday on Strawberry Creek. Short-term continuous streamflow records for Barker Creek (1991-1994) indicate a decline in (summer) minimum flows which may be attributable to climatic or other causes. Short-term, continuous streamflow records on Clear Creek (1991-94) show relatively stable trend in (summer) minimum flows. Barker Creek is protected year-round by regulatory stream closure under Chapter 173-515 WAC.

Only spot measurements are available for other streams.

9.5.6 Fisheries and Habitat

The Bangor subarea includes drainages into the Upper Hood Canal Watershed, Liberty Bay Watershed, and Dyes Inlet Watershed. For simplicity, creeks which drain into other watershed areas (i.e., Big and Little Scandia Creeks, Clear Creek, Barker Creek, Strawberry Creek) are included here.

Clear and Barker Creeks have important runs of chum and coho (Williams, et. al., 1975). Coho and chum salmon have also been noted in Strawberry Creek. Low summer flows affect production of coho and chum salmon in these drainages.

Coho and chum salmon as well as cutthroat trout are known to utilize both Big and Little Scandia Creeks. The Scandia Creeks are impacted primarily by poor riparian zone management resulting in little or no streamside vegetation and heavy sedimentation.

There are two major drainages within the Bangor Subase, Devil's Hole Lake, and Cattail Lake. Fisheries management plans have been developed for both of these drainages. Stream flow from the main stem entering Devil's Hole Lake averages 4.0 cfs. A second smaller stream has been diverted. Devil's Hole Lake and main stem both contain good fish habitat and have adequate vegetation. A fish ladder constructed in 1981 allows fish passage into and out of the lake from Hood Canal. The Lake contains native cutthroat and coho salmon. A net pen in the lake allows rearing the juvenile coho to a larger release size. Cattail Lake drains into Hood Canal by culverts that do not allow fish passage. However, Cattail Lake and its feeder streams are well vegetated and provide good fish habitat.

Stream flows were recorded for the west fork of Clear Creek from 1947 through 1975. Three measurements were recorded on the mainstream above the confluence of the west fork of Clear Creek in 1975. Flows ranged from 2.2 to 4.6 cfs in the west fork and 0.6 to 1.4 in the main stem. Barker Creek has flows recorded at the outlet of Island Lake ranging from zero to 0.1 cfs from 1969 through 1971. Stream flows recorded in Strawberry Creek for the summer and fall of 1971 ranged from 1.5 to 1.7 cfs. No flow data is available for Big or Little Scandia Creeks.

9.5.7 Allocation Decision Considerations

The Bangor subarea has a medium population density compared to other County subareas. The relative level of development of the water resource is high at 23 percent of total inflow. Ground water applications for the Bangor subarea currently request 8142 GPM (18.1 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 28 percent of the total inflow. There are no surface water applications pending in the subarea.

Information gained from existing studies on the Bangor Aquifer System will help Ecology make informed water rights decisions. Water levels in most aquifers may be in equilibrium with current withdrawals and precipitation trends. Existing data suggest that additional ground water may be available from the aquifer system which could be used for future appropriations.

Information collected by Silverdale Water District since 1992 for the Island Lake Aquifer has not been formally reviewed. Historical water level declines and stream-aquifer continuity are concerns for the area. The water level and production trends for the Island Lake Aquifer should be evaluated to provide information for water right decisions.

Available information for the Keyport and Silverdale Aquifers is insufficient for making water right decisions. Questions regarding water level trends and seawater intrusion need to be resolved for both aquifers concurrent with ground water development in order to make water rights decisions.

9.5.8 Recommendations

- Complete a comprehensive hydrogeologic analysis of the Silverdale, Keyport, and Island Lake Aquifers. The existing water level data for the Island Lake Aquifer should be compiled, evaluated, and compared them with precipitation trends.
- Continue and expand hydrogeologic data collection network.
- KPUD, Tribe, and others should continue to collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).
- Catalogue the fisheries resource of the subarea.
- Continue to collect water quality data in coastal locations to evaluate seawater intrusion potential.
- Include when available the data and analysis developed by USGS for the ongoing Bangor area study
- Evaluate the extent of the other aquifers in the subarea outside of the Bangor Aquifer System. Specifically the deep, below sea level aquifers in the vicinity of the Island Lake Aquifer.

9.6 Bainbridge Island Subarea

The Bainbridge Island subarea encompasses the entire island located in east-central portion of Kitsap County. The Bainbridge subarea is mainly suburban but it does have significant areas of forest and natural cover. The subarea has a growing commercial area near historic Winslow and scattered small industrial areas. Covering approximately 29 square miles (about 7 percent of the County), the Bainbridge subarea is about 87 percent forested or natural cover (Satellite data analysis - KPUD, 1994). Reflecting the incorporation of the Island as a city, an evaluation of land use types classified by the County Assessor shows 100 percent of the island as urban in classification. The City, however, has zoned 48 percent of the island at one unit per 2.5 acres.

The Bainbridge subarea has a medium population density relative to the other County subareas. Based on 1990 census data, the area had a population density of about 540 persons/square mile.

Six principal aquifers have been identified in the subarea: Meadowmeer Aquifer, Eagle Harbor Aquifer, Bayhead Aquifer, Lynwood Center Aquifer, Wardwell Aquifer System, and Gilberton-

Fletcher Bay Aquifers System (GWMP, 1991). A comprehensive evaluation of the Meadowmeer Aquifer has been completed (Purdy, 1990). Various studies have been accomplished on the other aquifers and hydrogeologic characterization. Information is contained in numerous consultant reports (Robinson & Noble and others). The USGS has performed a study for the shallow ground water system on Bainbridge Island (Dion and others, 1988).

The ground water in the Bainbridge Island subarea is generally of good quality and suitable for most purposes. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits in wells throughout the Bainbridge Island subarea. Exceedences of the manganese MCL are less common than exceedences of the iron MCL. Existing data suggest that several areas may have greater likelihood of high iron concentrations. These areas include: an east-west band between Westwood and Eagle Harbor, a band extending between Murden Cove and Manzanita Bay, and the Port Madison Peninsula. Nitrate concentrations did not exceed primary drinking water standards in any of the Bainbridge Island wells considered. Several wells had concentrations which appeared to be affected by nitrate contamination.

Surficial soils in the Bainbridge Island subarea are predominantly classified as Group C or D, and, therefore, have low to very low infiltration potentials. Precipitation is moderately low compared to the rest of the County, ranging from about 34 to 39 inches/year. Most of the streams in the subarea have relatively small catchments.

Development and the location of urban activities in direct proximity to some of the aquifers on Bainbridge Island could result in threats to aquifer quality. While there is one historic landfill on the Island, and there are contaminated sites near (and under) the shoreline in Eagle Harbor, these are predominately in urban areas. Most of the urban area is, or is proposed to be, sewered and urban runoff will go to Puget Sound unless diverted to recharge. Most of the subarea is expected to see limited development in the near term with minimal threats to ground water other than those associated with private domestic land uses. The existence of a major transportation route through the island does represent a risk to some of the aquifers, and should be considered when developing sources for municipal/domestic supply.

9.6.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity varies between the six aquifers identified. Studies suggest that the Meadowmeer Aquifer is in relatively high continuity with small unnamed streams (Purdy, 1990). Because all the other aquifers occur below sea level, the potential for stream-aquifer continuity for the Eagle Harbor, Bayhead, Lynwood Center, Wardwell System, and Fletcher Bay System is relatively low.

Year-round stream closures have been established for two small unnamed streams that are tributary to Murden Cove and Fletcher Bay.

9.6.2 Seawater Intrusion Potential

The potential for seawater intrusion varies between the six aquifer systems identified.

Seawater intrusion is not possible for the Meadowmeer Aquifer and other perched aquifers, because these aquifers occur above sea level. Seawater intrusion could occur in the Eagle Harbor, Bayhead, Lynwood Center, Wardwell System, and Fletcher Bay System if excessive ground water development were to occur. However, there is no evidence for significant seawater intrusion beneath the Bainbridge Island subarea. Time trend analyses of chloride levels in individual wells did not indicate that seawater intrusion was occurring (Dion and others, 1988). Relatively high values of electrical conductivity and chloride along the coast, however, suggest that ground water quality is affected by nearby seawater. Individual wells with high EC and chloride values may reflect localized seawater intrusion.

9.6.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Bainbridge Island subarea is relatively high in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 30 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. Streamflows in the subarea do not have minimum instream flow requirements. Protection of streamflows is accomplished through regulatory closures.

Total inflow to the hydrologic system is estimated to be 31,100 acre-feet/year. Water right allocations in the Bainbridge Island subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 6,737 acre-feet per year. Ground water permits and certificates comprise 94 percent of these allocations. Water right claims in the subarea are on the order of 2,481 acre-feet/year, all of which, is claimed from ground water sources.

9.6.4 Ground Water Level Trends

Water level trends in all aquifers show a relation to natural variability in precipitation. In the Fletcher Bay Aquifer System, a single hydrograph (well AAA111, completed below -800 MSL), has shown notable long-term declines of over 10 feet, though water levels may have now stabilized at their lower level. Wells AAA112, AAB455 and other deep wells on the island have apparent declines which need further review Data has not been evaluated for the Wardwell Aquifer System, Lynwood Center, and Bayhead Aquifers.

One well (AAC832), believed to be in the Meadowmeer Aquifer, with a completion elevation above sea level has shown a notable decline in water level.

9.6.5 Streamflow Trends

No long-term streamflow data exist within the subarea. Spot measurements of low flow are available for some streams. (Garling and Others, 1965, City of Bainbridge Island, City Watershed Assessment Group).

9.6.6 Fisheries and Habitat

Although there are no large streams on Bainbridge Island, there are four streams which support anadromous salmonid populations. All of the streams of the Island are presently being cataloged for the purpose of revising the stream classifications and as part of the activities of the City's Watershed Assessment Group. Water quality data in addition to fisheries habitat are being collected.

Most streams appear to have suffered from the impact of development and below average rainfall. In addition, unauthorized withdrawal of water for irrigation may be occurring on most of the streams on Bainbridge Island (comments in public hearing for Comprehensive Plan).

9.6.7 Allocation Decision Considerations

The Bainbridge subarea has a medium population density relative to the other County subareas. The relative level of development of the water resource is second highest in the County at 30 percent of total inflow. Currently, water right applications for the Bainbridge Island subarea request 4333 GPM (9.7 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 22 percent of the total inflow. Ground water applications comprise 90 percent of these applications.

Available information for the Fletcher Bay Aquifer System, Wardwell Aquifer System, Lynwood Center, Eagle Harbor, and Bayhead Aquifers require more formal review than the current assessment. Individual study has been conducted on the Meadowmeer Aquifer and sufficient data may be available to make water right decisions. Questions regarding water level trends and seawater intrusion need to be resolved for these aquifers in order to make water right decisions.

9.6.8 Recommendations

- ❑ Complete a comprehensive hydrogeologic analysis of below sea level aquifers to complement the USGS study.
- ❑ Continue and expand hydrogeologic data collection network.
- ❑ Install stream gages in the subarea if favorable conditions exist.
- ❑ Collect and document stream flow, temperature, and dissolved oxygen for appropriate large streams during the low flow period from mid-June to the end of September (or until the fall rains begin).
- ❑ Catalogue the fisheries resource of the subarea.

9.7 Manette Subarea

The Manette subarea is located in the east-central portion of Kitsap County. The Manette subarea is the most urbanized subarea in the County. Covering approximately 18 square miles (about 5 percent of the County), the Manette subarea is about 70 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows a lower total percentage of the area in suburban, forested, or open space categories (62 percent) than the satellite data. Urban and commercial classifications for this area are the highest in the County at 37 percent.

The Manette subarea has the highest population density of the County's subareas. Based on 1990 census data, the area had a population density of about 2,000 persons/square mile.

Three principal aquifers have been identified in the subarea: Bucklin Hill Aquifer, Gilberton-Fletcher Aquifer System, and Manette-Bremerton North Aquifer. The extent of the Bucklin Hill Aquifer is poorly defined. The Gilberton-Fletcher Aquifer System is a two-aquifer system (GWMP, 1991). The extent of the aquifer system is poorly defined. The boundaries of Manette-Bremerton North Aquifer are not well defined. Additional study is being accomplished on all of these aquifers (AGI, 1996) and hydrogeologic characterization information is available.

Ground water quality data from the Manette subarea are only available from several wells in the northern portion of the subarea. Much quality data, required by State and local health departments, that is taken by major purveyors of the subarea was not reviewed. General statements as to water quality in the subarea are limited by data availability. The occurrence of iron and manganese in the Manette subarea appears to be similar to neighboring subareas, based on the limited amount of water quality data that was reviewed. The data do not reveal nitrate contamination, and are insufficient to characterize seawater intrusion.

Surficial soils in the Manette subarea are largely Groups C and D (low to very low infiltration potentials), although localized areas of Group A soils (very high infiltration potential) occur. Precipitation is average compared to the rest of the County, ranging from about 37 to 46 inches/year. Drainage in the subarea occurs to Steel Creek and many other small streams.

The present high urban and commercial development in the Manette subarea is expected to increase substantially, resulting in a commensurate increase in threats to the three aquifers identified in this subarea. The threats include stormwater and drainage impacts, increased potential for transportation material spills, potentially adverse impacts from urban and associated commercial service activities, and reductions in recharge as impervious surface increases.

9.7.1 Stream-Aquifer Continuity

The Gilberton-Fletcher Bay System and Bucklin Hill Aquifer, both located greater than 300 feet below sea level, have relatively low potential for stream-aquifer continuity. Potential continuity between the Manette-Bremerton North Aquifer, located from sea level to 250 feet below sea level, and surface water is not well understood.

Instream flows have been established for Steel Creek during portions of the year under WAC 173-515-030. Seasonal or year round stream closures have been also been established for Steel and Mosher Creeks.

9.7.2 Seawater Intrusion Potential

The potential for seawater intrusion varies between the three aquifer systems identified. Seawater intrusion could occur in all aquifers if excessive ground water development were to occur. The potential for seawater intrusion for the Bucklin Hill Aquifer is relatively low, because it is located inland and 400 to 700 feet below sea level.

9.7.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Manette subarea is relatively high in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 43 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. This is the highest value of all subareas which range from less than 1 to 43 percent. In addition, minimum instream flow requirements and regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 22,700 acre-feet/year. Water right allocations in the Manette subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 8,819 acre-feet per year. Ground water permits and certificates comprise 99 percent of these allocations. Water right claims in the subarea are on the order of 881 acre-feet/year. Approximately 93 percent of this volume is claimed from ground water sources.

9.7.4 Ground Water Level Trends

Unfortunately, no water-level hydrographs for the Manette subarea are included in this basin assessment. There are many important wells in portions of the Manette subarea that are operated by Bremerton Water Utilities and North Perry Avenue Water District. Studies are being completed by those purveyors to evaluate the water resources in their portions of the Manette subarea (AGI, in progress). The studies will presumably include review of water-level trend data.

9.7.5 Streamflow Trends

No long-term streamflow data exist within the subarea. Only spot measurements of low flow are available. (Garling and Others, 1965).

9.7.6 Fisheries and Habitat

Limited fisheries or stream flow information is available for creeks in this subarea.

9.7.7 Allocation Decision Considerations

The Manette subarea has the highest population density of the County's subareas. The relative development of the water resource is highest in the county at 43 percent of total inflow. Water right applications for the Manette subarea request 3251 GPM (7.2 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 23 percent of the total inflow. Ground water applications comprise 86 percent of the requested withdrawal.

Current studies in this subarea may provide insight on questions concerning water level trends, water usage and other data required for water right decisions.

9.7.8 Additional Recommendations

- ☐ Characterize and define areal extents of all aquifers.
- ☐ Conduct a study of recharge and production potential for all aquifers.
- ☐ Continue and expand hydrogeologic data collection network.
- ☐ Catalogue the fisheries resource of the subarea.
- ☐ Collect and document streamflow, temperature, and dissolved oxygen during low flow period from mid-June to the end of September (or until the fall rains begin).
- ☐ Install a stream gage in the subarea if favorable conditions exist.
- ☐ Collect water quality data in coastal locations to evaluate seawater intrusion potential.
- ☐ Expand water quality data and analysis.

9.8 Chico Subarea

The Chico subarea is located in south-central portion of Kitsap County. The Chico subarea is a largely rural and forested subarea. Covering approximately 20 square miles (about 5 percent of the County), the Chico subarea is about 87 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows the effect of the Silverdale area expansion. The Assessor's data show an additional 20 percent of the land as urban in classification over that provided by satellite data. This could be reflective of land poised for development in the area.

The Chico subarea has a medium population density relative to the other County subareas. Based on 1990 census data, the area had a population density of about 480 persons/square mile.

No principal aquifer has yet been identified in the subarea. Based on the wells drilled, perched and shallow aquifers reliably supply groundwater in the subarea. Understanding of the perched and shallow ground water systems in the subarea is limited.

Available ground water quality data from the Chico subarea are limited to the northern portions of the subarea. In general, ground water in this portion of the subarea is of good quality and suitable for most purposes. Iron concentrations which exceed recommended aesthetic limits are common on the Kitsap County as a whole, and occur in areas of the Chico subarea where water quality data are available. High manganese concentrations were not encountered from wells sampled in the subarea. There is no apparent pattern to the areal distribution of documented high iron concentrations. Existing data provided no evidence of nitrate contamination beneath the Chico subarea.

Surficial soils in the Chico subarea are predominantly classified as Groups C or D, and, therefore, have low to very low infiltration potentials. Precipitation is average relative to the rest of the County, ranging from about 48 to 59 inches/year. Drainage in the subarea occurs primarily to Chico Creek and its many tributaries. A few other small streams occur within the subarea.

Threats to aquifers in the Chico subarea stem mainly from urban and suburban development around urban centers of Bremerton and Silverdale, and from transportation along major transportation routes to and around Bremerton and on the west side of Dyes Inlet to Silverdale.

9.8.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity of the perched and shallow aquifers in the subarea appears relatively high. Deeper aquifers are likely to occur beneath the subarea. However, deep aquifers have yet to be identified and issues such as continuity between surface and ground waters cannot currently be addressed. Streamflow depletion from ground water pumping is of greatest concern for streams with regulatory closures. Year-round closures have been established for Chico Creek, Kitsap Creek, and an unnamed stream tributary to Kitsap Lake under Chapter 173-515 WAC.

9.8.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the perched aquifers, because these aquifers occur well above sea level. The potential for seawater intrusion in other ground water systems in the subarea is not known. There is no evidence of seawater intrusion beneath the Chico subarea. Based on hydrogeologic considerations, however, seawater intrusion could constitute a threat to coastal areas if excessive ground water development were to occur.

9.8.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Chico subarea is relatively low in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 7 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. No minimum instream flow requirements have been established in the subarea. Protection of streamflows is accomplished through regulatory closures.

Total inflow to the hydrologic system is estimated to be 37,900 acre-feet/year. Water right allocations in the Chico subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 2,292 acre-feet per year. Ground water permits and certificates comprise 96 percent of these allocations. Water right claims in the subarea are on the order of 276 acre-feet/year. Approximately 92 percent of this volume is claimed from ground water.

9.8.4 Ground Water Level Trends

Water level trends in perched aquifers show a relation to natural variability in precipitation (Section 5.8.3). The hydrograph for well AAB476 (completed below sea level) has an apparent long-term decline of over 20 feet. The decline is likely related to ground water withdrawal but a likely withdrawal point is not readily apparent. Little other water level data for the subarea has been compiled or evaluated.

9.8.5 Streamflow Trends

KPUD is currently collecting streamflow data for Chico Creek. Earlier data were collected by the USGS over 14 years between 1948 and 1973. Comparison of early and current (1991-1995) data indicate no discernible trends in average annual streamflow over the period of record. Relatively low minimum streamflows in recent years (1991-1995) warrant greater attention. Chico Creek is protected by year-round regulatory stream closure under Chapter 173-515 WAC.

Only spot measurements of low flow are available for other streams (see Appendix C and Garling and Others, 1965).

9.8.6 Fisheries and Habitat

The Chico subarea has four streams (Chico, Dickerson, Kitsap, and unnamed) which support significant returns of anadromous salmonids. In addition, there are a number of small streams which probably support resident salmonids.

The four streams which support salmon returns are suffering from the results of urban growth, variability of recent precipitation, and reduced flows during late summer and early fall. Storm water peaks have also caused significant flooding in some areas during major events.

9.8.7 Allocation Decision Considerations

The Chico subarea has a moderate population density relative to the other County subareas. The relative level of development of the water resource is low at 7 percent of total inflow. Ground water applications for the Chico subarea currently request 296 gpm (0.7 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 1 percent of the water resource. There are no surface water applications pending in the subarea.

Available information for the perched and shallow aquifers in the subarea are insufficient for making additional water right decisions. Questions concerning water level trends, stream-aquifer continuity, and seawater intrusion need to be resolved for the perched and shallow aquifers in the subarea in order to make water right decisions. However, given the relatively low level of water resource allocation, ground water development of deeper aquifers may be possible while simultaneously gathering data and conducting analysis.

9.8.8 Recommendations

- ❑ Conduct a preliminary hydrogeologic evaluation of the subarea to determine ground water development potential.

- ❑ Continue to collect and document stream flow of Chico Creek and add flow observation on the smaller creeks. For all pertinent creeks, measure temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).

- ❑ Catalogue the fisheries resource of the subarea.

- ❑ Collect water quality data in coastal locations to evaluate seawater intrusion potential.

9.9 Seabeck Subarea

The Seabeck subarea is located in the southwest portion of Kitsap County along the shoreline of Hood Canal. The subarea is one of the most rural and forested in the County. Covering approximately 27.3 square miles (about 7 percent of the County), the Seabeck subarea is about 95 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Seabeck subarea has one of the lowest population densities of the County's subareas. Based on 1990 census data, the area had a population density of about 130 persons/square mile.

An extensive study has been completed in the Seabeck subarea identifying three aquifers: the Seabeck Aquifer System, Perched Aquifers, and Bedrock Aquifer (Purdy, 1995 a, b). The study of the Seabeck Aquifer System indicates that it is extensive (20 square miles) and productive (wells yield up to 1200 gpm). Less is known about extent and characteristics of the Perched and Bedrock Aquifers. The Perched Aquifers tend to be local and discontinuous, and are generally found above 100 feet MSL. The Bedrock Aquifer occurs in the southern portion of the subarea, and provides only low well yields.

The ground water quality in the Seabeck subarea is generally of good quality and suitable for most purposes. Iron concentrations which exceed recommended aesthetic limits are common in the County as a whole, and occur in areas of the Seabeck subarea where water quality data are available. Exceedences of the manganese MCL are less common than exceedences of the iron MCL. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. Exceedences of the iron MCL are notably absent in the general vicinity of lower Big Beef Creek. Existing data provide no evidence of nitrate contamination beneath the Seabeck subarea.

Surficial soils in the Seabeck subarea are predominantly classified as Groups C or D, and, therefore, have low to very low infiltration potentials. Precipitation is high compared to the rest of the County, ranging from about 48 to 64 inches/ year. Precipitation may be considerably higher on the northern side of Green Mountain due to orographic effects. Drainage in the subarea occurs primarily to Big Beef, Seabeck, and Anderson Creeks. Several other creeks (Little Beef, Spring, Johnson) drain relatively small catchments of the subarea.

9.9.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity varies between the three aquifer identified. Studies suggest relatively low continuity between the Seabeck Aquifer System and surface water (Purdy, 1995a). The Perched Aquifers, however, are in relatively high continuity with surface water such as Big Beef Creek (Purdy, 1995a). Continuity between the Bedrock Aquifer and surface water is not well understood.

Instream flows have been established for Big Beef and Anderson Creeks during portions of the year under WAC 173-515-030. Seasonal or year-round stream closures have also been established for Big Beef, Anderson, and Seabeck Creeks.

9.9.2 Seawater Intrusion Potential

The potential for seawater intrusions varies between the three aquifer systems identified. Seawater intrusion is not possible for the perched aquifers, because these aquifers occur considerably above sea level. Seawater intrusion could occur in the Seabeck Aquifer System if excessive ground water development were to occur. The aquifer system occurs between 100 feet above sea level and 250 feet below sea level. The Bedrock Aquifer is not developed as a significant ground water source in coastal areas, and therefore, is not likely to experience seawater intrusion (Purdy, 1995 a, b).

There is no evidence of significant seawater intrusion beneath the Seabeck subarea based on assessment of ground water samples analyzed for chloride and EC (Section 3.9).

9.9.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Seabeck subarea is moderate relative to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 10 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. In addition, minimum instream flow requirements and regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 50,966 acre-feet/year. Water right allocations, reported as maximum annual withdrawals (Qa's), are on the order of 4,872 acre-feet/year. Ground water permits and certificates comprise 92 percent of these allocations. Water right claims in the subarea are on the order of 923 acre-feet/year. Approximately 88 percent of this volume is claimed from ground water sources.

Water balance analysis of the Seabeck subarea (Purdy, 1995b) suggests that estimated current ground water use represents a small percentage (9 percent to 15 percent) of the estimated ground water resource. This percentage was arrived at by comparing the recharge of the ground water system to the usage in the area.

9.9.4 Ground Water Level Trends

Water level trends in all aquifers show a relation to natural variability in precipitation. Long-term water level data for well AAA005 indicate a decline of 5 feet in the Seabeck Aquifer System since 1980, with much of the decline likely due to precipitation trends (Purdy, 1995b). Short-term data (water years 1991 to 1996) from wells completed both above and below sea level indicate variable but stable water levels.

9.9.5 Streamflow Trends

A declining trend in average annual stream flow is suggested for the ten-year period (1970- 1980) at Big Beef Creek near Seabeck. This period of record is too short to evaluate long-term trends. Minimum annual (daily average) flows show a slightly declining trend between 1969 and 1993. Big Beef Creek is protected by regulatory stream closure between May 15 and October 31, and by minimum instream flow requirements during the rest of the year (Chapter 173-515 WAC). Streamflow statistics indicate that summer minimum instream flow requirements were not met in 50 percent of all years between early August and mid-October, for the years 1970 to 1993.

Only spot measurements of low flow are available from other streams within the subarea. Visual observations during fisheries assessments indicate the lower reach of Seabeck Creek is occasionally dry from the period of mid-June until the fall rains begin.

9.9.6 Fisheries and Habitat

The streams within the Seabeck subarea have the most current and detailed information in the County from the standpoint of fisheries utilization criteria. Utilization by anadromous salmonids is well documented and the stream habitat is also cataloged (Tabor and Knudsen, 1993; Lestell and others, 1993). However, small streams which feed into lakes in the subarea have less information available and little emphasis has been placed on resident salmonids, particularly resident cutthroat trout. Big Beef Creek continues to be monitored for the purpose of predicting salmon returns to Hood Canal.

Limited returns of coho salmon to Hood Canal and the Puget Sound Basin have resulted in a total closure of the sport and commercial salmon fishery in 1994 and 1995.

Seasonal monitoring data for all the streams in the subarea for temperature and dissolved oxygen is not available as published or documented data.

9.9.7 Allocation Decision Considerations

The Seabeck subarea has one of the lowest population densities of the County's subareas. The relative level of development of the water resource is moderate at 10 percent of total inflow. Currently, ground water applications in the Seabeck subarea are requesting 2524 GPM (5.6 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 7 percent of total inflow. There are no surface water applications pending in the subarea.

The information gained from existing studies on the Seabeck Aquifer System appears to be adequate to make informed water rights decisions for the sea level aquifer. Analysis indicates that ground water exist which Ecology could consider in making water right decisions. In addition, demand in the subarea is currently low. However, relatively small declines in ground water levels and streamflows (Big Beef Creek) have been observed. Monitoring would provide additional insight on the role of climatic variability on observed trends. Mitigation proposals will be required and evaluated if the application for water resource development indicates impairment on stream flows or seawater intrusion.

Available information for the Perched and Bedrock Aquifers is insufficient for making additional water rights decisions. Questions concerning potential stream-aquifer continuity need to be resolved for the sea level and perched aquifers in order to make water rights decisions.

9.9.8 Recommendations

- ❑ Evaluate the data collected from the current Seabeck Aquifer System monitoring network periodically, as water development occurs to insure that the aquifer system is not over-utilized. Data collection should include water levels and coastal chloride and EC measurements.

- ❑ Evaluate recharge management and enhancement strategies for the Seabeck Aquifer System.

- ❑ Collect additional data to refine understanding of the potential for stream-aquifer continuity before additional development of the Perched and Bedrock Aquifers occurs.

- ❑ Collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).

- ❑ Catalogue the fisheries resource of the subarea.

9.10 Stavis Subarea

The Stavis subarea is located in the western portion of the County along the shoreline of Hood Canal. The Stavis subarea is one of the most rural and forested subareas in Kitsap County. Covering approximately 10 square miles (about 2.5 percent of the County), the Stavis subarea is about 97 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Stavis subarea has one of the lowest population densities of the County's subareas. Based on 1990 census data, the area had a population density of about 75 persons/square mile.

Very little data from deep wells is available and no principal aquifer designations have been made. Based on the wells drilled, perched and shallow aquifers exist in the subarea but these aquifers are not well understood.

The ground water in the Stavis subarea is generally of good quality and suitable for most purposes. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits at various locations within the Stavis subarea. Exceedences of the manganese MCL are much less common than exceedences of the iron MCL. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. Existing data provide no evidence for significant nitrate contamination beneath the Stavis subarea. One well is documented as having a nitrate concentration at the MCL.

Surficial soils in the Stavis subarea are predominantly classified as Group C or D, and, therefore, have low to very low infiltration potentials. Group A soils (very high infiltration potential) are associated with drainages near to the coast. Precipitation is high compared to the rest of the County, ranging from about 60 to 67 inches/year. Drainage in the subarea occurs primarily to Stavis and Boyce Creeks. Several other Creeks drain relatively small catchments of the subarea.

Existing and projected land use patterns pose no serious threat to the ground water.

9.10.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity of the perched aquifers in the subarea is likely to be relatively high. Continuity between streams and deeper ground water systems in the subarea is not understood.

Instream flows have been established for Stavis Creek during portions of the year under WAC 173-515-030.

9.10.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the perched aquifers, because these aquifers occur well above sea level. The potential for seawater intrusion in other ground water systems in the subarea is not understood. There is no evidence of seawater intrusion beneath the Stavis subarea. Based on hydrogeologic considerations, seawater intrusion could constitute a threat to coastal areas if excessive ground water development were to occur.

9.10.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Stavis subarea is relatively low in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 3 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. No minimum instream flow requirements have been established in the subarea. Protection of streamflows is accomplished through regulatory closures.

Total inflow to the hydrologic system is estimated to be 24,500 acre-feet/year. Water right allocations in the Stavis subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 157 acre-feet per year. Ground water permits and certificates comprise 94 percent of these allocations. Water right claims in the subarea are on the order of 501 acre-feet/year. Approximately 60 percent of this volume is claimed from ground water sources.

9.10.4 Ground Water Level Trends

Unfortunately no water level data for the subarea have been compiled or evaluated.

9.10.5 Streamflow Trends

No long-term streamflow data exist within the subarea. Only spot measurements of low flow (see Appendix C and Garling and Others, 1965) are available from streams within the subarea.

9.10.6 Fisheries and Habitat

The Stavis Creek subarea is largely undeveloped and provides excellent habitat for spawning and rearing salmon. Protection of this creek is very important as it is one of the few "semi-pristine" stream systems left in the Puget Sound area.

Boyce Creek is a 2.2 mile long stream which drains into Frenchman's Cove. Boyce Creek is known to be utilized by both coho and chum salmon.

Harding Creek drains into Hood Canal north of Tekiu Point. This creek is known to be utilized by both chum and coho salmon, as well as resident Trout.

9.10.7 Allocation Decision Considerations

The Stavis subarea has one of the lowest population densities of the County's subareas. The relative level of development of the water resource is very low at 3 percent of total inflow. Ground water right applications for the Stavis subarea currently request 165 gpm (0.4 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 1 percent of total inflow. There are no surface water applications pending in the subarea.

Although no principal aquifer has been delineated in this subarea, the probability that aquifers are present is high. Because the water usage in the subarea is minimal, and the precipitation rate is high, ground water may be available for future water right decisions. The amount of available information for the perched and other aquifers is minimal. Questions regarding potential stream-aquifer continuity and seawater intrusion need to be resolved as the resource is developed.

9.10.8 Recommendations

- ❑ Include a few wells from the subarea in the monitoring network to establish baseline ground water conditions in the subarea.
- ❑ Conduct an initial hydrogeologic assessment to identify the aquifers in the subarea.
- ❑ Conduct a test drilling program to establish aquifer characteristics.
- ❑ Continue the gauging of Anderson Creek and add gauging sites where conditions are favorable.
- ❑ Collect temperature and dissolved oxygen during the low flow period from mid-June to the end of September where conditions are favorable (or until the fall rains begin
- ❑ Catalogue the fisheries resource of the subarea.
- ❑ Collect water quality data in coastal locations to evaluate seawater intrusion potential.

9.11 Manchester Subarea

The Manchester subarea is located in the southeast portion of Kitsap County. The Manchester subarea is a largely rural and forested subarea. Covering approximately 45 square miles (about 11 percent of the County), the Manchester subarea is about 85 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Manchester subarea has a medium population density relative to the other County subareas. Based on 1990 census data, the area had a population density of about 660 persons/square mile.

Six principal aquifers have been identified in the large complex area that makes up the Manchester subarea: Port Orchard Aquifer System, Salmonberry, Clam Bay, Yukon, North Lake, and Wilson Creek Aquifers (GWMP, 1991). (Note that the Port Orchard System extends into the Gorst subarea, and the North Lake aquifer extends into the Gorst and McCormick subareas.) Besides these identified aquifers, there are discontinuous perched aquifers in the subarea. A preliminary study of the Port Orchard System and Salmonberry Aquifer has been completed (AGI, December, 1994). A number of studies provide varying amounts of hydrogeologic characterization information for these aquifers (GWMP 1991, AGI, 1989, Robinson & Noble, 1994).

Surficial soils in the Manchester subarea are largely classified as Group C or D (low to very low infiltration potential), although a north-south trending band of Group A soils (very high infiltration potential) occurs south of Annapolis. Precipitation is average compared to the rest of Kitsap County, ranging from about 38 to 53 inches/year. Drainage in the subarea occurs primarily to Blackjack, Curley and Salmonberry creeks (the latter two drain inland to Long Lake). Numerous other creeks drain relatively small catchments of the subarea.

No detrimental ground water quality trends have been noted in the aquifers in the Manchester subarea. The ground water in the Manchester subarea is generally of good quality and suitable for most purposes. Iron and manganese, which are naturally occurring ground water constituents, sporadically occur at concentrations above recommended aesthetic limits in wells throughout the Manchester subarea. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. There is no evidence for extensive nitrate contamination beneath the Manchester subarea, however localized contamination has been documented. Among the detections of elevated nitrate concentrations, a particular grouping of slightly elevated concentrations (<5 mg/l) is noted in the area southeast of Fernwood.

The potential impact from future land conversion and urban activities pose several threats. Stormwater drainage can impact ground water recharge quantity and quality. Improperly maintained septic systems can provide a contamination source. Commercial and industrial activities are located along the shoreline and, for the most part, do not represent significant threats to the aquifers, except in those areas were the activity is located directly over an aquifer and where susceptibility to contamination is high.

9.11.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity varies between the six aquifer systems identified. The Wilson (perched) and North Lake Aquifers are located entirely above sea level and are likely in relatively high continuity with surface water in the subarea. There is the relatively high potential for stream-aquifer continuity for the Clam Bay and Yukon Aquifers, both located from sea level to 150 feet below sea level. There is relatively low potential for continuity between the Port Orchard System or Salmonberry Aquifer and surface water, because these aquifers occur below 150 feet below sea level.

Instream flows have been established for Curley Creek during a portion of the year under WAC 173-515-030. A seasonal stream closure has also been established for Curley Creek. Year-round stream closures have been established for Blackjack, Sullivan, Beaver, and Salmonberry Creeks.

9.11.2 Seawater Intrusion Potential

The potential for seawater intrusions varies between the six aquifer systems identified. Seawater intrusion is not possible for the perched aquifers (Wilson Creek and North Lake), because these aquifers occur considerably above sea level. There is potential for seawater intrusion in the Port Orchard System and Yukon Aquifer if excessive ground water development were to occur. The Salmonberry Aquifer has relatively less potential for seawater intrusion at its inland location. Well testing of the Clam Bay Aquifer shows a high susceptibility to seawater intrusion (Robinson and Noble, August 1992).

There is no evidence for significant seawater intrusion beneath the Manchester subarea. Relatively high values of electrical conductivity occur at several coastal locations and in an inland area southeast of Fernwood. Elevated chloride concentrations were documented at two inland locations. Seawater intrusion could constitute a threat to coastal areas if excessive ground water development were to occur.

9.11.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Manchester subarea is moderately high in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 24 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. In addition, minimum instream flow requirements And regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 64,800 acre-feet/year. Water right allocations in the Manchester subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 12,998 acre-feet per year. Ground water permits and certificates comprise 98 percent of these allocations. Water right claims in the subarea are on the order of 2,578 acre-feet/year. Approximately 90 percent of this volume is claimed from ground water sources.

9.11.4 Ground Water Level Trends

Water level trends in all aquifers show a relation to natural variability in precipitation. In addition, long-term water level declines have been identified in some areas. In the Manchester subarea hydrographs AAA119, AAA118, and AAB486 (all with completion elevations near sealevel) have notable declines. Well AAA117, is completed below -1000 MSL and also has an apparently large decline. Water level declines of 15 to 30 feet in the Port Orchard System and Salmonberry Aquifer (AGI, December 1994) may be cause for concern. Water levels in the North Lake Aquifer appear to be stable relative to seasonal and annual precipitation trends (Robinson and Noble, February 1994). Some water level data is available for the Clam Bay, Yukon, and Wilson Creek Aquifers but trend analysis has not been accomplished for those aquifers.

9.11.5 Streamflow Trends

No long-term streamflow data exist within the subarea. KPUD is currently collecting streamflow data for Blackjack Creek. Blackjack Creek is protected by year-round regulatory stream closure under Chapter 173-515 WAC.

Only spot measurements of low flow are available from other streams within the subarea. (See Appendix C and Garling and Others, 1965).

9.11.6 Fisheries and Habitat

There are a number of streams which support anadromous salmonids in the Manchester subarea (Blackjack Creek, Annapolis Creek, Beaver Creek, and Curley Creek). However, with the exception of Beaver Creek (tributary to Clam Bay), there is limited documentation which quantifies the condition of the habitat on these streams.

9.11.7 Allocation Decision Considerations

The Manchester subarea has moderate population density relative to other subareas. The subarea has the third highest level of development of the water resource, at 24 percent of total inflow. Currently, water right applications for the Manchester subarea request 8228 gpm (18.3 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 20 percent of the total inflow. Ground water applications comprise 95 percent of these applications.

Information gained from previous studies in the subarea appear to be adequate to make informed water right decisions on some of the aquifers. Water level declines in the Port Orchard System and Salmonberry Aquifers suggest the aquifers are developed at or near capacity. The relatively small extent of the Clam Bay, Yukon, and Wilson Creek Aquifers may restrict the future development potential for these aquifers. Any future development from the Wilson Creek Aquifer must also address stream-aquifer continuity.

Available information for the North Lake Aquifer requires assessment and questions regarding potential stream-aquifer continuity need to be resolved, in order to make water right decisions.

9.11.8 Recommendations

- ❑ Coordinate with the major purveyors of the area to enhance the water level monitoring efforts so that all the major aquifers of the area are appropriately monitored..

- ❑ Conduct more detailed studies of all aquifers within the Manchester subarea.

- ❑ Collect and analyze stream flow (except for Blackjack Creek which is permanently monitored), temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).

- ❑ Catalogue the fisheries resource of the subarea.

- ❑ Collect water quality data in coastal locations to evaluate seawater intrusion potential.

- ❑ Expand water quality data and analysis.

9.12 Gorst Subarea

The Gorst subarea is located in the south-central portion of Kitsap County surrounding Sinclair Inlet. The Gorst subarea is an urbanizing subarea that includes the City of Bremerton, the Bremerton Naval Shipyard And Supply Center, and an industrial park at the Bremerton Airport. Covering approximately 24 square miles (about 6 percent of the County), the Gorst subarea is about 76 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories. However, urban and commercial classifications make up about 17 percent of the Assessor codes.

The Gorst subarea has one of the higher population densities of the County's subareas. Based on 1990 census data, the area had a population density of about 1,150 persons/square mile.

Two principal aquifers were identified in the subarea, the Gorst Aquifer System and Anderson Creek Aquifer Systems (GWMP, 1991). Considerable new work has been completed in the Gorst subarea by Bremerton Water Utilities (KPUD sponsored study by AGI, October 1996, November 1996) including new evaluation of hydrology and hydrogeology of the basin. Four 'effective' aquifers were identified in the area that is generally shown by the Gorst principal aquifer. Several studies of the Anderson Creek Aquifer System have been accomplished (Robinson and Noble, AGI), and the definition and lateral extent of the aquifer is improving.

Ground water quality data from the Gorst subarea were available from several wells. Existing data on which to base general statements on water quality in the subarea were not compiled and reviewed for this assessment but data regarding the Gorst and Anderson Creek Aquifer Systems is available through Bremerton Water Utilities. .

Surficial soils in the Gorst subarea are largely classified as Group C or D (low to very low infiltration potential), although a east-west trending band of Group A and B soils (high to very high infiltration potential) roughly follows Gorst Creek. Precipitation is average compared to the rest of the County, ranging from about 44 to 57 inches/year. Drainage in the subarea occurs primarily to Gorst, Ross, and Anderson Creeks (and associated tributaries). A few other creeks drain relatively small catchments of the subarea.

The eastern portion of the Gorst Aquifer System will be subjected to increased ground water quality threats associated with a continuing increase of urban, suburban, commercial and light industrial growth. The threats will be alleviated somewhat if proposed sewers are installed.

9.12.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity varies between the two aquifer systems identified. Because the Anderson Creek Aquifer System occurs from 450 to 525 feet below sea level, potential for continuity between surface water is relatively low. Earlier studies suggest a potential for continuity between the Gorst Aquifer System and surface water bodies of Gorst Creek and Twin Lakes (Robinson and Noble, May 1988). More recent analysis has demonstrated continuity between the Gorst Aquifer System and Gorst Creek (AGI, October 1996).

Instream flows have been established for Gorst Creek under WAC 173-515-030. Year-round stream closures have been also been established for Anderson and Ross Creeks.

9.12.2 Seawater Intrusion Potential

Seawater intrusion could occur in both the Anderson Creek and Gorst Aquifer Systems if excessive ground water development were to occur. Existing data provide no evidence for seawater intrusion beneath the Gorst subarea.

9.12.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Gorst subarea is moderate relative to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 18 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. Minimum instream flow requirements And regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 42,600 acre-feet/year. Water right allocations in the Gorst subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 7,247 acre-feet per year. Ground water permits and certificates comprise 98 percent of these allocations. Water right claims in the subarea are on the order of 313 acre-feet/year. Approximately 94 percent of this volume is claimed from ground water sources.

9.12.4 Ground Water Level Trends

Long-term water level data for the Gorst and Anderson Creek Aquifer Systems has been collected (primarily by Bremerton Water Utilities) but have not been compiled or evaluated as of this report. Short-term water level data since 1991 tends to show variable water levels for Gorst Aquifer System wells with no apparent declines over the short time period.

9.12.5 Streamflow Trends

No long-term streamflow data exist within the subarea. KPUD is currently collecting streamflow data for Gorst and Anderson Creeks. Short-term continuous streamflow records for Gorst Creek (1991-1994) suggest a possible decline in (summer) minimum flows. The cause of this decline cannot be determined given the short period of record. The records also show that instream flows were not met during significant portions of all (four) recorded years. Recent studies of the area (AGI, 1996) indicate minimum instream flows are set at unrealistically high values. Instream flows have been established for Gorst Creek under WAC 173-515-030.

Only spot measurements of low flow are available from other streams within the subarea. (See Appendix C and Garling and Others, 1965)

9.12.6 Fisheries and Habitat

Gorst Creek which drains into Sinclair Inlet is part of the City of Bremerton's water supply and restrictions are in place regarding development within the subarea. The Suquamish Tribe has a cooperative effort with a sport fishing organization for the rearing and release of approximately 2 million chinook juveniles into Gorst Creek. This release provides a terminal fishery for both the Tribe and sport fishermen.

Coho and chum salmon have been noted to utilize Anderson Creek.

9.12.7 Allocation Decision Considerations

The Gorst subarea has one of the higher population densities of the County's subareas. The relative level of development of the water resource is moderate at 19 percent of total inflow. Ground water applications for the Gorst subarea currently request 1470 GPM (3.3 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 6 percent of the total inflow. Surface water applications pending in the subarea are less than 0.1 cfs.

Current information on the Gorst and Anderson Creek Aquifer Systems appears to be adequate for making additional water right decisions. Information gained from the ongoing study of the Gorst Aquifer System has provided insight regarding that aquifer. Available information for the Anderson Creek Aquifer System is marginal. Proposed studies in the neighboring Manchester subarea may provide some insight on the aquifer's lateral extent and potential for additional supply.

9.12.8 Recommendations

- ☐ Continue water level monitoring on both aquifers.
- ☐ Conduct additional studies (over that which is in progress) for both of these very important aquifers. Study should include a test drilling program.

- ❑ KPUD, City of Bremerton, the Tribe and others should continue to collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin) as enhancement to work in progress by the City of Bremerton.

- ❑ Catalogue the fisheries resource of the subarea.

- ❑ Collect water quality data in coastal locations to evaluate seawater intrusion potential.

- ❑ Expand water quality data and analysis.

9.13 Union Subarea

The Union subarea is located in the southern portion of Kitsap County along the border of Mason County. The Union subarea is one of the more rural and forested subareas in the County. Covering approximately 17 square miles (about 4 percent of the County), the Union subarea is about 94 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Union subarea has one of the lowest population densities of the County's subareas. Based on 1990 census data, the area had a population density of about 52 persons/square mile.

No principal aquifer has been identified in the subarea. Based on existing wells perched and shallow aquifers exist in the subarea. There is a limited amount of understanding of the perched and shallow ground water systems in the subarea and no understanding of deep ground water systems.

Ground water quality data from the Union subarea were available only from a few wells in the northern portion of the subarea. Existing data on which to base general statements on water quality in the subarea are insufficient. Existing data provide no evidence of nitrate contamination beneath the Union subarea.

Surficial soils in the Union subarea are largely classified as Group C or D (low to very low infiltration potential), although an area of Group A and B soils (high to very high infiltration potential) occurs in the vicinity of the upper stretches of the Union River near the Kitsap County Airport. Precipitation is moderately high compared to the rest of the County, ranging from about 57 to 62 inches/year. Precipitation may be considerably higher in the vicinity of the Green-Gold Mountains due to orographic effects. Drainage in the subarea occurs primarily to the Union River and Mission Creek (including tributaries). The catchments of these two streams occur mainly outside the County.

Existing and projected land use patterns pose no serious threat to the ground water.

9.13.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity of the perched aquifers in the subarea is relatively high. Continuity between the other ground water systems in the subarea is not known.

Year-round closures have been established for the Union River, Mission Creek, Little Mission Creek, and Mission Lake under WAC 173-515-040.

9.13.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the perched aquifers, because these aquifers occur well above sea level. There is little potential (and no evidence) for seawater intrusion beneath the Union subarea due to its inland location.

9.13.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Union subarea is moderate relative to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 15 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. Streamflows in the subarea are not allocated as minimum instream flow requirements. Protection of streamflows is accomplished through regulatory closures.

Total inflow to the hydrologic system is estimated to be 35,100 acre-feet/year. Water right allocations in the Union subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 5,198 acre-feet per year. Ground water permits and certificates comprise 1 percent of these allocations. Water right claims in the subarea are on the order of 196 acre-feet/year. Approximately 74 percent of this volume is claimed from ground water sources.

9.13.4 Ground Water Level Trends

Unfortunately the amount of water level data for the subarea is very limited. No comments on water level trends are possible at this time

9.13.5 Streamflow Trends

Streamflow data were collected for the Union River by the USGS between 1945 and 1959. Although the Union River is closed to further appropriations, comparison of the historic data to present instream flow requirements (WAC 173-515-040) shows that instream flows would not have been met during 50 percent of all years between mid-May and mid-September.

Only spot measurements of low flow are available from other streams within the subarea. (Garling and Others, 1965)

9.13.6 Fisheries and Habitat

Coho and chum salmon are produced in the Union River and Big Mission Creek. A small chinook run returns to the lower two miles of the Union River. McKenna Falls located between river mile 6 and 7, is the most limiting factor for salmon production in the upper reaches of the Union River. Low streamflow during the summer months in the Big Mission Creek limit salmon production there.

Recent habitat surveys have been conducted along the Union River, Big Mission, and Bear Creeks by Point No Point Treaty Council (1992), Washington Department of Fisheries (1984), US. Fish and Wildlife Service (1992), and Washington Department of Ecology (1970 and 1992).

9.13.7 Allocation Decision Considerations

The Union subarea has one of the lowest population densities of the County's subareas. The relative level of development of the water resource is moderate at 15 percent of total inflow. Ground water right applications for the Union subarea currently request 564 GPM (1.3 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 3 percent of the total inflow. There are no surface water applications pending in the subarea.

Although no principal aquifer has been delineated in this subarea, the possibility that significant aquifers are present is high. Because water production in the area is minimal and the precipitation rate is high, ground water is probably available for appropriation.

Limited information is available concerning stream-aquifer continuity in the subarea, so associated concerns need to be considered when making water right decisions for shallow aquifers.

9.13.8 Recommendations

- ❑ Increase water level monitoring network to establish baseline ground water conditions in the subarea.
- ❑ Conduct an initial hydrogeologic assessment to identify the aquifers in the subarea. Include a test drilling program if appropriate.
- ❑ Re-establish Union River gauging station and collect and document stream flow, of other major streams. Include temperature and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).
- ❑ Catalogue the fisheries resource of the subarea.

- ☐ Complete recommendations in cooperation with Mason County where appropriate.

9.14 Tahuya Subarea

The Tahuya subarea is located in the southwestern portion of Kitsap County along the Mason County border. The Tahuya subarea is a rural and forested subarea. Covering approximately 14 square miles (about 4 percent of the County), the Tahuya subarea is about 96 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Tahuya subarea has one of the lowest population densities of the County's subareas. Based on 1990 census data, the area had a population density of about 57 persons/square mile.

No principal aquifer has been identified in the subarea. Based on the wells drilled, perched and shallow aquifers exist in the subarea. There is a limited amount of understanding of the perched and shallow ground water systems in the subarea and no understanding of deep ground water systems.

Ground water quality data from the Tahuya subarea are available only from a few wells. Existing data on which to base general statements on water quality in the subarea are insufficient.

Surficial soils in the Tahuya subarea are predominantly classified as Group C or D (low to very low infiltration potential), although localized areas of Group A and B soils (high to very high infiltration potential) occur. Precipitation is high compared to the rest of the County, ranging from about 58 to 66 inches/year. Precipitation may be considerably higher in the vicinity of the Green-Gold Mountains due to orographic effects. Drainage in the subarea occurs primarily to the Tahuya River and its tributaries, some of which flow into Tahuya Lake.

Existing and projected land use patterns pose no serious threat to the ground water.

9.14.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity of the perched aquifers in the subarea is relatively high. Continuity between the other ground water systems in the subarea is not understood.

Instream flows have been established for the Tahuya River during portions of the year under WAC 173-515-030. A seasonal stream closure has been also been established for the Tahuya River.

9.14.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the perched aquifers, because these aquifers occur well above sea level. There is little potential (and no evidence) for seawater intrusion beneath the Tahuya subarea due to its inland location.

9.14.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Tahuya subarea is relatively low in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 1 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. Minimum instream flow requirements And regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 32,100 acre-feet/year. Water right allocations in the Tahuya subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 200 acre-feet per year. Ground water permits and certificates comprise 93 percent of these allocations. Water right claims in the subarea are on the order of 65 acre-feet/year. Approximately 29 percent of this volume is claimed from ground water sources.

9.14.4 Ground Water Level Trends

No long-term water level data for the subarea have been compiled or evaluated.

9.14.5 Streamflow Trends

Streamflow data were collected for the Tahuya River by the USGS between 1945 and 1956. According to the historic data, current instream flow requirements would not have been met during 50 percent of all years between mid February and late November. The Tahuya River is currently protected by regulatory stream closure between June 15 and October 15. Instream flow requirements in effect during this period would not have been met during 90 percent of all years. (See Appendix C).

Only spot measurements of low flow are available from other streams within the subarea. (Garling and Others, 1965)

9.14.6 Fisheries and Habitat

The Tahuya River has very important runs of coho and chum salmon, as well as moderate chinook production. Chinook salmon production is limited to the lower four miles of the river due to flow conditions and accessibility during adult migration. Low summer flows is a limiting factor for coho production.

Recent habitat surveys have been conducted along the Tahuya River, and Little Tahuya, Gold, Panther, and Tin Mine Creeks by the Washington Department of Wildlife (1984), Washington Department of Fisheries (1984), US Fish and Wildlife Service (1992-93), Northwest Indian Fisheries Commission (1990), Point No Point Treaty Council (1992), and Washington State Department of Ecology (1974, 1992-93).

9.14.7 Allocation Decision Considerations

The Tahuya subarea has one of the lowest population densities of the County's subareas. The relative level of development of the water resource is very low at 1 percent of total inflow. Ground water right applications for the Tahuya subarea currently request 642 GPM (1.4 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 43 percent of total inflow.

Information on stream-aquifer continuity in the subarea is limited. This needs to be considered when making additional water right decisions for shallow aquifers.

9.14.8 Recommendations

- ☐ Include a few wells in the monitoring network to establish baseline ground water conditions in the subarea.
- ☐ Conduct an initial hydrogeologic assessment to identify the aquifers in the subarea. Include a test drilling program if appropriate.
- ☐ Re-establish regular monitoring of the Tahuya River, including temperature and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin). Include other streams if practical.
- ☐ Catalogue the fisheries resource of the subarea.
- ☐ Complete recommendations in cooperation with Mason County where appropriate.

9.15 Anderson Subarea

The Anderson subarea is located in the southwest portion of Kitsap County along Hood Canal. The Anderson subarea is one of the most rural and forested subareas in the County. Covering approximately nine square miles (about 2 percent of the County), the Anderson subarea is about 98 percent forested or natural cover (Satellite data analysis- KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Anderson subarea has the lowest population density of the County's subareas. Based on 1990 census data, the area had a population density of about 12 persons/square mile.

No principal aquifer has been identified in the subarea. Based on the wells drilled, perched and shallow aquifers exist in the subarea. There is a limited amount of understanding of the perched and shallow ground water systems in the subarea but no understanding of deep aquifer systems.

Ground water quality data are available only from the northeastern portion of the Anderson subarea. In general, ground water in the Anderson subarea is of good quality and is suitable for most purposes. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits at various locations within the Anderson subarea. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. Existing data provided no evidence of nitrate contamination beneath the Anderson subarea.

Surficial soils in the Anderson subarea are predominantly classified as Group C or D (low to very low infiltration potential), although Group A soils (very high infiltration potential) occur in the vicinity of Tekiu Point. Precipitation is high compared to the rest of the County, ranging from about 65 to 68 inches/year. Drainage in the subarea occurs primarily to the Anderson and Harding Creeks. Several other creeks drain relatively small catchments of the subarea.

Existing and projected land use patterns pose no serious threat to the ground water.

9.15.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity of the perched aquifers in the subarea is relatively high. Continuity between the other ground water systems in the subarea is not understood.

Instream flows have been established for Anderson Creek under WAC 173-515-030. A year-round stream closure has also been established for Harding Creek.

9.15.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the perched aquifers, because these aquifers occur well above sea level. The potential for seawater intrusion in other ground water systems in the subarea is not known. Seawater intrusion has not been identified as a problem based on available water quality data. Nevertheless, seawater intrusion could threaten the quality of coastal ground water if excessive ground water development were to occur in the subarea.

9.15.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Anderson subarea is the lowest in comparison to all the other subareas in the County. Based on the analysis presented in Section 8.2.5, less than 1 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from (also) less than 1 to 43 percent. In addition, minimum instream flow requirements And regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 23,300 acre-feet/year. Water right allocations in the Anderson subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 14 acre-feet per year. Ground water permits and certificates comprise 51 percent of this allocated volume. Water right claims in the subarea are on the order of 34 acre-feet/year. Approximately 64 percent of this volume is claimed from ground water.

9.15.4 Ground Water Level Trends

Two wells in the Holly area are being monitored. No formal assessment has been made of the data.

9.15.5 Streamflow Trends

KPUD is currently collecting streamflow data for Big Anderson Creek. Stream flows have been recorded at several locations along Big Anderson Creek; the north fork, south fork, and two locations near the mouth.

No long-term streamflow data exist within the subarea. Only spot measurements of low flow are available from streams within the subarea. (See Appendix C and Garling and Others, 1965)

9.15.6 Fisheries and Habitat

Because there has been a limited amount of development within the Big Anderson Creek drainage the return of coho to this system has been an important factor in the abundance of coho in Hood Canal. While logging activities have altered the area, the riparian cover and instream habitat is in good condition. The creek supports both an early and a late run of chum salmon.

The Northwest Indian Fisheries Commission has recently completed habitat surveys of Big Anderson and Harding Creeks.

9.15.7 Allocation Decision Considerations

The Anderson subarea has the lowest population density of the County's subareas. The relative level of development of the water resource is the lowest in the County at less than one percent of total inflow. There are currently no water right applications for the Anderson subarea.

Due to the large amount of rainfall in the subarea, it has substantial potential for ground water production. As deeper production and test wells are drilled, associated data should be analyzed for water level trends and seawater intrusion. Limited information is available concerning stream-aquifer continuity in the subarea so associated concerns should be considered when making additional water right decisions for the shallow aquifers.

9.15.8 Recommendations

- ☐ Include a few wells in the monitoring network to establish baseline ground water conditions in the subarea.

- Conduct an initial hydrogeologic assessment to identify the aquifers in the subarea.
- Conduct a test drilling program to establish aquifer characteristics.
- Collect and document stream flow, temperature and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin) in streams with favorable conditions for monitoring.
- Catalogue the fisheries resource of the subarea.
- Collect water quality data in coastal locations to evaluate seawater intrusion potential.

9.16 Olalla Subarea

The Olalla subarea is located in the southeastern portion of Kitsap County along Colvos Passage. The Olalla subarea is mostly rural and forested with some urbanizing locations. Covering approximately 25 square miles (about 6 percent of the County), the Olalla subarea is about 90 percent forested or natural cover (Satellite data analysis- KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Olalla subarea has a moderately low population density compared to the County's other subareas. Based on 1990 census data, the area had a population density of about 340 persons/square mile.

No principal aquifer has been identified in the subarea. Based on the wells drilled, perched and shallow aquifers exist in the subarea. There is a limited amount of understanding of the perched and shallow ground water systems in the subarea and no understanding of deeper systems.

The ground water in the Olalla subarea is generally of good quality and suitable for most purposes. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits in wells throughout the Olalla subarea. Exceedences of the manganese MCL are less common than exceedences of the iron MCL. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. There is no evidence for extensive nitrate contamination beneath the Olalla subarea.

Surficial soils in the Olalla subarea are largely classified as Group C or D (low to very low infiltration potential), although localized areas of Group A soils (very high infiltration potential) occur (especially in the western subarea). Precipitation is average compared to the rest of the County, ranging from about 42 to 49 inches/year. Drainage in the subarea occurs primarily to Burley, Olalla, and Purdy Creeks. In addition, several creeks with relatively small catchments drain into Colvos Passage.

Based on existing and future land-use projects, it appears that existing hazardous waste sites (e.g., Strandley Scrap Metal) and the Olalla dump site provide the largest threats to water resources in this subarea.

9.16.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity of the perched aquifers in the subarea is relatively high. Continuity between the other ground water systems in the subarea is not understood.

Instream flows have been established for Purdy Creek during portions of the year under WAC 173-515-030. Seasonal or year-round stream closures have been also been established for Purdy, Burley and Olalla Creeks.

9.16.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the perched aquifers, because these aquifers occur well above sea level. The potential for seawater intrusion in other ground water systems in the subarea is not well understood. There is no evidence of seawater intrusion beneath the Olalla subarea. Relatively high values of electrical conductivity and chloride are limited to inland locations. Based on hydrogeologic considerations, however, seawater intrusion could constitute a threat to coastal areas if excessive ground water development were to occur.

9.16.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Olalla subarea is moderate relative to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 11 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. In addition, minimum instream flow requirements and regulatory closures may limit water availability in this area.

Total inflow to the hydrologic system is estimated to be 37,900 acre-feet/year. Water right allocations in the Olalla subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 2,926 acre-feet per year. Ground water permits and certificates comprise 93 percent of these allocations. Water right claims in the subarea are on the order of 1,178 acre-feet/year. Approximately 85 percent of this volume is claimed from ground water sources.

9.16.4 Ground Water Level Trends

Water level trends in the limited number of available hydrographs show a relation to natural variability in precipitation. Water level data suggests a decline of about 13 feet in one well (AAA228) in the shallow ground water system since 1985 (KPUD monitoring data). Other wells completed above and below sea level have shown variable water levels but no obvious declining trends overall.

9.16.5 Streamflow Trends

KPUD is currently collecting streamflow data for Burley Creek. Earlier data were collected by the USGS over nine years between 1947 and 1964. The combined data record is comprised of short, isolated periods of record. There are no discernible trends in the streamflow data for Burley Creek. Burley Creek is protected by a year-round regulatory closure under Chapter 173-515 WAC.

Only spot measurements of low flow are available for other streams within this subarea (See Appendix C and Garling and Others, 1965).

9.16.6 Fisheries and Habitat

Burley Creek and Purdy Creek have returns of coho, chinook, and chum salmon. However, development and agriculture practices in the subareas are probably limiting the number of adult fish which return. Olalla Creek supports returns of coho and chum salmon. Habitat deterioration from past logging and current farming practices has occurred and is limiting the production of both streams. There is no current published habitat data for these subareas.

9.16.7 Allocation Decision Considerations

The Olalla subarea has one of the lower population densities of the County's subareas. The relative level of development of the water resource is moderate. Water rights and claims in the subarea total 4,105 af/yr. Comparing this amount with the estimated total inflow of 37,900 af/yr., the relative development is 11 percent of total inflow **(Exhibit 4-7)**. Ground water right applications for the Olalla subarea currently request 1651 GPM (3.7 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 7 percent of total inflow. Surface water applications pending in the subarea are less than 0.1 cfs.

Limited information is available concerning stream-aquifer continuity, or seawater intrusion in the subarea. The subarea may have potential for additional supplies but additional data will probably be required for most water right decisions.

9.16.8 Recommendations

- ☐ Continue to monitor wells in the subarea and add wells in appropriate aquifers to the monitoring network.

- ☐ Conduct an initial hydrogeologic assessment to identify the aquifers in the subarea with a test drilling program if appropriate.

- ☐ Collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).

- ☐ Catalogue the fisheries resource of the subarea.
- ☐ Collect water quality data in coastal locations to evaluate seawater intrusion potential.

9.17 McCormick Subarea

The McCormick subarea is located in south-central portion of Kitsap County along the border of Mason County. The McCormick subarea is a rural and forested subarea. Covering approximately 33 square miles (about 8 percent of the County), the McCormick subarea is about 94 percent forested or natural cover (Satellite data analysis- KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The McCormick subarea has one of the lowest population densities of the County's subareas. Based on 1990 census data, the area had a population density of about 120 persons/square mile.

The North Lake Aquifer is the only principal aquifer identified in the subarea. The aquifer boundaries were recently refined (Robinson and Noble, February 1994). Aquifer characterization information is contained in miscellaneous consultant reports (Robinson & Noble).

The ground water in the McCormick subarea is generally of good quality and suitable for most purposes. Iron and manganese, which are naturally occurring ground water constituents, occur at concentrations above recommended aesthetic limits in wells throughout the McCormick subarea. Exceedences of the manganese MCL are much less common than exceedences of the iron MCL. There is no apparent pattern to the areal distribution of documented high iron and manganese concentrations. Existing data provide no evidence for nitrate contamination beneath the McCormick subarea. Localized contamination has been documented at one well within the subarea.

Surficial soils in the McCormick subarea are predominantly classified as Group C or D (low to very low infiltration potential), although localized areas of Group A soils (very high infiltration potential) occur (especially in the eastern subarea). Precipitation is average compared to the rest of the County, ranging from about 50 to 57 inches/year. Drainage in the subarea occurs primarily to Coulter Creek and Rocky Creek (including tributaries). Both of these streams discharge to Case Inlet, which is located in Mason County. A number of small streams in the subarea drain to small inland wetlands or marshes.

Existing and projected land-use patterns for the subarea will result in minimum threats to its underlying ground water.

9.17.1 Stream-Aquifer Continuity

The potential for continuity of the North Lake Aquifer with other perched aquifers and with streams such as Anderson and Coulter Creeks is relatively high, but is not well understood. Continuity between the other ground water systems in the subarea and surface water is also not well understood.

A year round stream closure has been established for Minter Creek under Chapter 173-515 WAC.

9.17.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the North Lake and perched aquifers, because these aquifers occur well above sea level. There is little potential (and no evidence) for seawater intrusion beneath the McCormick subarea due to its inland location.

9.17.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the McCormick subarea is relatively low in comparison to other subareas in the County. Based on the analysis presented in Section 8.2.5, approximately 2 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from less than 1 to 43 percent. Streamflows in the subarea are not allocated as minimum instream flow requirements. Protection of streamflows is accomplished through regulatory closures.

An important note relative to resource allocation in this subarea relates to the waters of Coulter Creek which is an important drainage basin in the subarea. A settlement agreement between Peter E. Overton, et al. and Washington State Department of Fisheries, both groups with major interests in the water resources of the basin, is cited in WAC 173-515-040. The WAC indicates that Ecology intends to give full consideration to the agreement in the event of any future water right actions involving said parties, and presumably others in the basin. This could have significant impacts on future resource allocations in the subarea.

Total inflow to the hydrologic system is estimated to be 61,600 acre-feet/year. Water right allocations in the McCormick subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 926 acre-feet per year. Ground water permits and certificates comprise 97 percent of these allocations. Water right claims in the subarea are on the order of 467 acre-feet/year. Approximately 86 percent of this volume is claimed from ground water sources.

9.17.4 Ground Water Level Trends

Evaluation of water level trends show a large seasonal variation in water levels of up to 5 feet (Robinson and Noble, February 1994). More recent data indicates some seasonal variations may exceed 10 feet. The available data suggest no overall declining trends for any wells with records.

9.17.5 Streamflow Trends

Spot streamflow data from 1979 to present has been collected on Coulter Creek for Peter E. Overton (Robinson and Noble). Only spot measurements of low flow are available from streams within the subarea (Garling and Others, 1965).

9.17.6 Fisheries and Habitat

The Minter Creek Hatchery provides annual releases of chinook and coho salmon fingerlings to many of the streams of the County and other Puget Sound river systems. Natural production in the stream is limited by the number of adults allowed to pass upstream beyond the hatchery. The creek also produces searun cutthroat trout. There are no published data available on any of the remaining small streams within this subarea.

9.17.7 Allocation Decision Considerations

The McCormick subarea has one of the lowest population densities of the County's subareas. The relative level of development of the water resource is very low at 2 percent of total inflow. Ground water right applications for the McCormick subarea currently request 2080 GPM (4.6 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 5 percent of total inflow. There are no surface water applications pending in the subarea.

The North Lake Aquifer shows potential for development. However, the continuity of the North Lake Aquifer, located above sea level, with surface water may limit the sustainable yield of the aquifer. Questions concerning stream-aquifer continuity need to be considered when making additional water rights decisions.

9.17.8 Recommendations

- ☐ Conduct a detailed study of the North Lake Aquifer focusing on areal extent and surface water continuity.

- ☐ Collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).

- ☐ Catalogue the fisheries resource of the subarea.

- ☐ Complete recommendations with cooperation from Mason County where appropriate.

9.18 Dewatto Subarea

The Dewatto subarea is located in the southwest portion of Kitsap County along Hood Canal. The Dewatto subarea is one of the most rural and forested subareas in the County. Covering approximately 6 square miles (about 2 percent of the County), the Dewatto subarea is about 98 percent forested or natural cover (Satellite data analysis - KPUD, 1994). An evaluation of land use types classified by the County Assessor shows about the same total percentage of the area in suburban, forested, or open space categories.

The Dewatto subarea has one of the lowest population densities of the county's subareas. Based on the 1990 census data, the area has a population density of about 21 persons per square mile.

No principal aquifer has been identified. Based on the wells drilled, perched and shallow aquifers exist in the subarea. There is a limited understanding of the perched and shallow ground water systems in the subarea but no understanding of deep systems.

Ground water quality data from the Dewatto subarea are only available from a few wells. Existing data on which to base general statements on water quality in the subarea are insufficient.

Surficial soils in the Dewatto subarea are predominantly classified as Group C or D, and, therefore, have low to very low infiltration potentials. Precipitation is very high relative to the rest of the County, ranging from about 66 to 68 inches/year. Drainage in the subarea occurs to the headwaters of Dewatto River (most of its catchment occurs outside Kitsap County), and to several other creeks with relatively small catchments.

Existing and projected land use patterns pose no serious threat to the ground water.

9.18.1 Stream-Aquifer Continuity

The potential for stream-aquifer continuity of the perched aquifers in the subarea is relatively high. Continuity between the other ground water systems in the subarea is not known.

The Dewatto subarea includes several small streams which are tributary to Hood Canal, and may also include a portion of the headwaters to the Dewatto River. Seasonal instream flows and a seasonal closure have been established for the Dewatto River under Chapter 173-515 WAC.

9.18.2 Seawater Intrusion Potential

Seawater intrusion is not possible for the perched aquifers, because these aquifers occur well above sea level. The potential for seawater intrusion in other ground water systems in the subarea is not well understood.

9.18.3 Relative Degree of Water Resource Allocation

The degree of water resource allocation in the Dewatto subarea is very low compared to other subareas in the County. Based on the analysis presented in Section 8.2.5, less than 1 percent of total inflow (precipitation minus evapotranspiration) to the hydrologic system is associated with water right permits, certificates, and claims. Values for other subareas range from (also) less than 1 t to 43 percent. Streamflows in the subarea are not allocated as minimum instream flow requirements. Protection of streamflows is accomplished through regulatory closures.

Total inflow to the hydrologic system is estimated to be 16,000 acre-feet/year. Water right allocations in the Dewatto subarea, reported as maximum allowable annual quantities (Qa's), are on the order of 40 acre-feet per year. Ground water permits and certificates comprise 69 percent of these allocations. Water right claims in the subarea are on the order of 6 acre-feet/year. Approximately 85 percent of this volume is claimed from ground water sources.

9.18.4 Ground Water Level Trends

Water level data is only available for two well in the Holly area. No long-term water level data for the subarea is available. Short-term data for water years 1991 to 1996 show variable water levels but no declining trends.

9.18.5 Streamflow Trends

The Dewatto subarea includes several small streams which are tributary to Hood Canal, and also includes a small portion of the headwaters to the Dewatto River. No long-term streamflow data exist within the subarea, however historic data are available from a gauging station located 1.8 miles from the mouth of the Dewatto River (1947-1954 and 1958-1974). These data were not evaluated for this study because streamflows at the gage are primarily influenced by the drainage basin outside of the County. Seasonal instream flows and a seasonal closure have been established for the Dewatto River under Chapter 173-515 WAC. (Garling and Others, 1965)

Only spot measurements of low flow are available from other streams within the subarea.

9.18.6 Fisheries and Habitat (Including Surface Water Quality)

The Dewatto River produces very important runs of coho and chum salmon, as well as a small chinook salmon population. Three distinct stocks of chum salmon enter Dewatto River different times of the year and spawn in different sections of the stream. The earliest run enters the lower two miles of the river during September, with as many as 4,000 spawners per year (Williams, et al., 1975). A second run enters in late November and spawn in tributaries and mainstream areas above mile 1.5. The third run enters in late December and early January and spawns intertidally and in the lowermost portion of the stream. Thomas Creek, a small creek to the north of the Dewatto River, is known to support coho and chum salmon, as well as resident trout (PSCRBT, 1993).

Stream surveys have been conducted along the Dewatto River by the Northwest Indian Fisheries Commission (1989), Washington Department of Wildlife (1984), and the US. Fish and Wildlife Service (1992) (Tabor and Knudsen, 1993). Survey methodology varied with agency.

9.18.7 Allocation Decision Considerations

The Dewatto subarea has one of the lowest population densities of the County's subareas. The relative level of development of the water resource is very low at less than 1 percent of total inflow. Surface water right applications for the Dewatto subarea currently request 45 GPM (0.1 cfs) of maximum instantaneous withdrawal (Qi), or a maximum of an additional 1 percent of the total inflow. There are no ground water applications pending in the subarea.

Due to the large amount of rainfall in the subarea and minimal ground water development, there is potential for ground water development. However, limited information is available concerning stream-aquifer continuity and seawater intrusion in the subarea. These concerns need to be considered when making additional water right decisions.

9.18.8 Recommendations

- ❑ Include a few wells in the monitoring network to establish baseline ground water conditions in the subarea.
- ❑ Conduct an initial hydrogeologic assessment to identify the aquifers in the subarea with a test drilling program if applicable.
- ❑ Collect and document stream flow, temperature, and dissolved oxygen during the low flow period from mid-June to the end of September (or until the fall rains begin).
- ❑ Catalogue the fisheries resource of the subarea.
- ❑ Collect water quality data in coastal locations to evaluate seawater intrusion potential.
- ❑ Complete recommendations in a cooperative effort with Mason County where appropriate.

Data Gap Category	Data Gathering Activity	Relative Importance
Aquifer Analysis	Water Level Monitoring / Aquifer Testing	Aquifer water levels and trends when compared to associated precipitation and well production provide direct and vital data for allocation decisions. Pump tests provide additional, helpful insights to aquifer capacity.
Streamflow and Hydraulic Continuity	Water level monitoring / Streamflow aquifer testing	Because minimum instream flow requirements and streamflow impact on fish represent what is frequently very large and senior water rights, data on streamflow, and hydraulic continuity is vital for allocation decisions. Inversely related to amount and quality of seasonal and annual streamflow data (e.g. level of understanding) and directly related to the degree of allocation, and directly related to the degree of continuity of proposed allocation.
Seawater Intrusion	Water Quality Monitoring (Chloride levels in coastal wells)	Data from monitoring for sea water intrusion provides an early warning that water right allocations in an area without mitigation are reaching their limits. The data is important in areas where sea water intrusion is possible.
Precipitation	Precipitation Monitoring	Precipitation data is important to establish overall water availability limits and for analyzing trends, such as aquifer water levels, and stream flows
Water Balance	Precipitation / Runoff / Recharge / ET evaluations and data	Water balance is helpful in estimating, on a general scale, the amounts of water involved in the various parts of the hydrologic cycle. A water balance provides a big picture evaluation of water availability that improves as data increases in quantity and quality.
Fisheries Resource and Fisheries Habitat Quality	Stock Status by Species Water Quality / Streambed	As noted in streamflow above, water requirements for fish represent an enormous, senior water right. Data on the fishery resource and fish habitat are important in evaluating how that "water right" is being met. Inversely related to the level of knowledge of the fisheries resource and the health of critical or indicator species.
Current and Future Demand	Source Metering / Customer Metering / Growth projections	Current demand or production is important for evaluating the extent to which existing water rights are being used and their current and future impact on aquifer levels. Future demand is helpful in evaluating quantities requested in some water right applications.

EXHIBIT 9-1

Relative Importance of Data Gaps to Allocation Decisions

Exhibit 9-2

Water Rights Decision Data Requirements

Kitsap County Initial Basin Assessment

Water Right Decisions Data Requirements

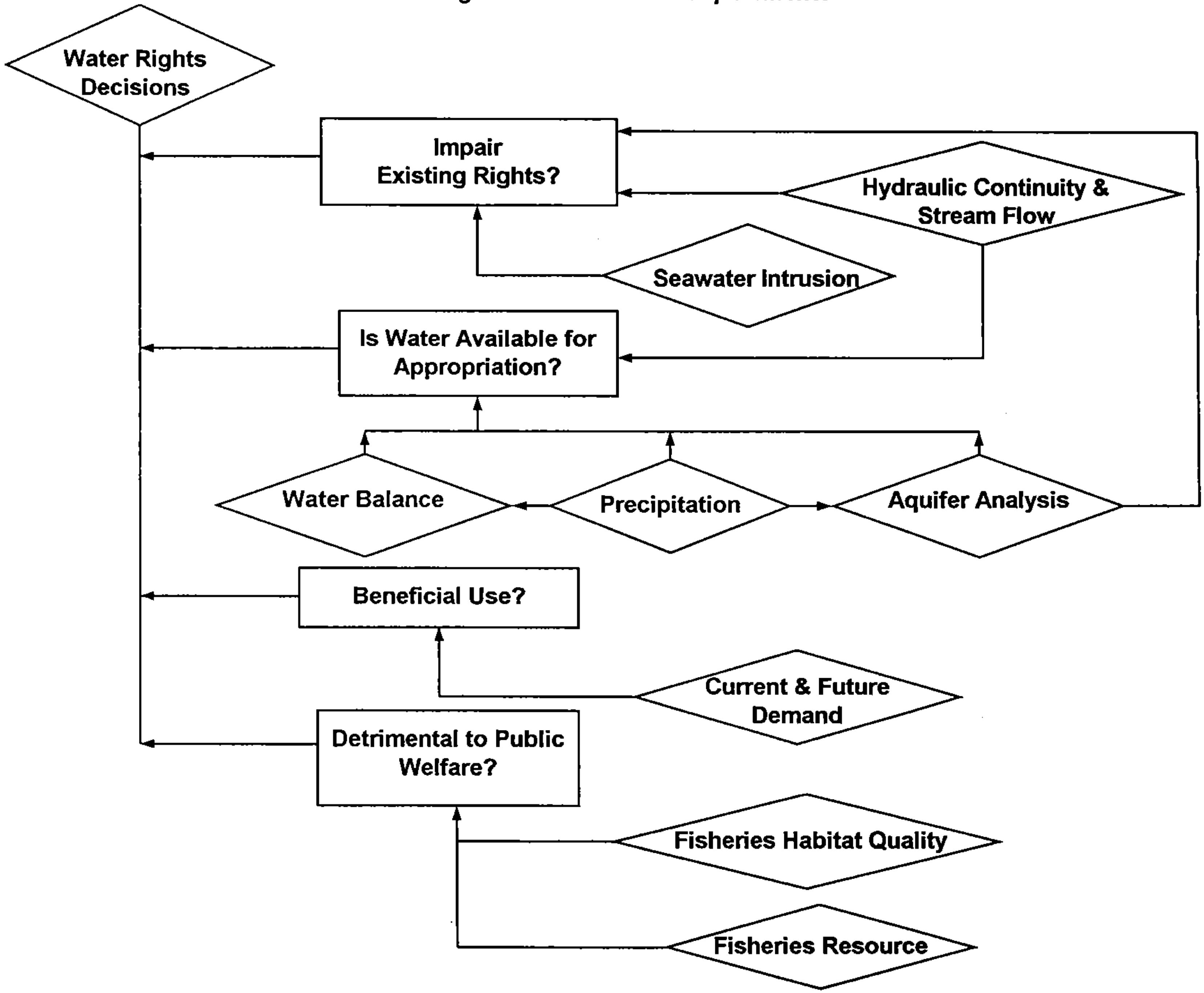


Exhibit 9-3

Data Gaps
Relative Importance to Additional
Water Rights Allocations

Kitsap County
Initial Basin Assessment

DATA GAPS

Relative Importance to Additional Water Right Allocations

Subarea Name	High	Med.	Low	Comments
Aquifer Analysis				
Aquifer				
Aquifer				
Aquifer				
Aquifer				
Precipitation				
Water Balance				
Fisheries Habitat Quality & Fisheries Resource				
Resource				
Habitat				
Current and Future Demand				
Current				
Future				
Seawater Intrusion				
Coastal Areas				
Hydraulic Continuity and Stream Flow				

Appendix A
Memorandum of Agreement with Ecology

P. U. D. #1

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

P.O. Box 47600 • Olympia, Washington 98504-7600 • (206) 407-6000 • TDD Only (Hearing Impaired) (206) 407-6006

February 1, 1995

Mr. Thomas D. Mortimer, Jr.
Attorney at Law
1001 4th Avenue Plaza, Suite 3258
Seattle, Washington 98154

Dear Mr. Mortimer:

I have reviewed and signed the enclosed Memorandum of Agreement between P.U.D. No. 1 of Kitsap County and the Department of Ecology. I have done so with the understanding that the P.U.D. is willing to look for ways to cover the whole water inventory area, as this will need to be completed to proceed effectively.

Sincerely,

Carol L. Fleskes

Carol Fleskes
Program Manager
Water Resources and Shorelands

CF:ln
Enclosure

cc: Senator Bob Oke
Steve Hirschey
Dave Siburg
Marc Horton

Appendix B
Instream Resources Protection Program—Kitsap WRIA 15

MEMORANDUM OF AGREEMENT

BETWEEN

THE DEPARTMENT OF ECOLOGY
AND
P.U.D. NO. 1 OF KITSAP COUNTY

I
INTRODUCTION

This MEMORANDUM OF AGREEMENT (hereafter referred to as "MOA") is entered into by and between the Washington State Department of Ecology (hereafter referred to as "ECOLOGY") and P.U.D. No. 1 of Kitsap County (hereafter referred to as KPUD) with reference to the following:

II
RECITALS

Whereas, ECOLOGY has announced that pending and/or future water right application decisions will be made only after the completion of basin assessments which are intended to determine the environmental health, hydrologic status, and appropriate resource management approach for watersheds in question; and

Whereas, ECOLOGY has described the basin assessment process as involving three phases: Phase I which involves the expedited collection and analysis of available data relating to hydrology, climate, water uses, water rights, claims to rights, land use, and hydrogeology within a watershed; Phase II which involves filling data gaps and addressing analytical issues which are impeding timely decisionmaking on water right applications; and Phase III which involves implementation of a resource management plan and issuance of water rights employing defined criteria and objectives; and

Whereas, when completed, the basin assessment process should allow ECOLOGY to determine the amount of water available for appropriation, better manage the resource relative to fisheries, habitat, and related instream needs, and render timely decisions on pending and future municipal and private water right applications; and

Whereas, ECOLOGY has announced it is willing to form partnerships with qualified local governments/utilities in order to facilitate the timely completion of basin assessments; and

Whereas, ECOLOGY has stated the need for a basin assessment to be conducted within the Kitsap Basin, to be defined hereafter and for purposes of this agreement as limited to those portions of WRIA 15 which fall within the corporate boundaries of Kitsap County; and

Whereas, a cooperative and coordinated effort by ECOLOGY and KPUD to complete a Basin Assessment in this area will benefit KPUD, ECOLOGY, Tribes, and other public and private parties in the County by clarifying the water right allocation status of the study area and agency resource management approach; and

Whereas, KPUD has been authorized by the Kitsap County Commission to undertake regional water resource development and management initiatives within the county; and

Whereas, KPUD represents that it is fully qualified and capable of providing the technical assistance, expertise, and financial resources required to undertake and complete a watershed assessment in cooperation with ECOLOGY and in a manner consistent with the scope of work approved by Ecology herein described;

NOW THEREFORE, in consideration of the RECITALS hereinabove stated and by the authority of ECOLOGY and KPUD, it is hereby agreed as follows:

II
GOALS AND OBJECTIVES

The goals and objectives of this agreement are to:

Authorize KPUD, through a cooperative process and partnership involving ECOLOGY, to undertake a comprehensive watershed assessment of the surface and groundwater resources of Kitsap County Basin. The goal of the assessment effort shall be to develop sufficient resource data, within the context of an agreed-to technical methodology and analytical foundation, to enable ECOLOGY to: (1) determine the overall environmental health and hydrologic status of the basin's water resources; (2) make pending and future water allocation decisions; (3) determine the manner in which the basin's instream flow resources will be protected and managed until such time a regional planning process is undertaken; and (4) identify and resolve data-related questions and/or issues requiring further study and resolution.

III
TERMS AND CONDITIONS

In order to achieve the goals and objectives of the agreement, ECOLOGY and KPUD agree that all rights and obligations of the parties shall be subject to and governed by the TERMS AND CONDITIONS contained in the text of this agreement and described as follows:

A. Performance of Basin Assessment - KPUD Authority and Role: ECOLOGY and KPUD agree that KPUD has been authorized by the Kitsap County Commission to assume responsibility for providing ECOLOGY with the technical assistance, expertise, and data collection capacity required to complete a watershed assessment of the ground and surface water resources of the Kitsap Basin. KPUD agrees to perform all tasks subject to this agreement, in a cooperative and collaborative manner with ECOLOGY.

A(1) PUD Tasks/Responsibilities: Pursuant to this agreement, the parties agree that KPUD shall perform and complete all data collection, study tasks, and reports, agreed to by the parties and/or as stated in the Scope of Work (Attachment A) which are required to successfully complete a Phase I and Phase II Basin Assessment within the study area. KPUD agrees to undertake these tasks and responsibilities with the understanding that the performance of such tasks will result in technical conclusions sufficient to: (1) enable ECOLOGY to determine its resource management approach to the Basin until a regional planning process is completed; and (2) render water right decisions re: pending and future applications. The parties further agree that KPUD will assume primary responsibility for drafting and preparation of a Phase I Kitsap Basin Assessment report, which shall be subject to review and concurrence of ECOLOGY.

A(2) KPUD Project Management: For purposes of this agreement, KPUD has designated Mr. Bill Hahn, Assistant Manager - KPUD, as project manager. In this capacity, Mr. Hahn shall assume primary responsibility for the execution and/or delegation of all tasks assumed within the Scope of Work, coordinate and communicate with ECOLOGY regarding project and performance issues, and supervise the actions and work products of KPUD subcontractors retained to assist in the performance of this agreement. Mr. Dave Siburg, KPUD Manager, shall act as principal in charge of the project, responsible for general oversight and quality control.

B. ECOLOGY Performance/Agreement: ECOLOGY agrees that the methology, data, and/or technical conclusions that result from the performance of KPUD tasks described in the Scope of Work and/or subsequent additions, shall be used by ECOLOGY for the purpose of: (1) completing and issuing a Phase I watershed assessment of Kitsap Basin ground and surface water sources; (2) determining whether sufficient data exists to enable ECOLOGY to make pending and water right decisons and/or resolve water right claims within the prescribed area of WRIA 15; and (3) authorizing KPUD to undertake additional Phase II studies, data collection, analysis, and/or interpretation for the purpose of reaching closure and/or resolution to data issues and analytical gaps resulting from the Phase I report. ECOLOGY further agrees to provide support services and/or perform all tasks assigned to ECOLOGY personnel as specified in the scope of work.

Pursuant to this commitment, ECOLOGY agrees it shall review all data, technical conclusions, analysis, and reports provided by KPUD pursuant to this agreement for purposes of comment, concurrence, and/or formal approval. ECOLOGY further agrees that it shall provide KPUD with all possible assistance, cooperation, and direction in the performance and completion of all tasks described in the attached Scope of Work and/or determined by KPUD and ECOLOGY as required to complete the basin assessment effort.

B(1) ECOLOGY Project Management: For purposes of this agreement, ECOLOGY agrees to designate Mr. Steve Hirschey, ECOLOGY NWRO - Water Resource Section Supervisor as ECOLOGY project manager for the Kitsap Basin Assessment effort. In this capacity, Mr. Hirschey shall assume responsibility for ECOLOGY project oversight, coordination and communication with KPUD, Tribes, and other affected parties, management and direction of ECOLOGY staff assigned to the project, and final review, approval, and/or concurrence of all project related data sets, technical conclusions, analysis, and reports.

B(2) ECOLOGY Staff Committment: ECOLOGY agrees that in order to facilitate the timely and cooperative completion of the initial watershed assessment, ECOLOGY shall assign Mr. Jerry Liszak, ECOLOGY NWRO Hydrologist, to commit up to 150 hours to assist and support KPUD staff and contractors in the performance of their tasks.

B(3) Tribal Relations/Cooperation: ECOLOGY agrees for purposes of this agreement that ECOLOGY staff shall assume primary responsibility for facilitating communication and cooperation with interested Tribes and their staff during the course of the project. Such responsibilities may include:

- responding to Tribal requests to review data sets and other information resulting from the Phase I study effort;
- soliciting Tribal expertise and comment on data and other project-related work products; and
- soliciting Tribal data relevant to the study effort and coordinating the integratation of such material into the study process.

C. Geographic Scope of Basin Assessment Effort: KPUD and ECOLOGY agree that the geographic scope of the assessment effort shall be limited to all portions of WRIA 15 which fall within the corporate boundaries of Kitsap County. The scope of the basin assessment effort may be expanded at the request of affected and/or interested counties willing to provide funding support.

D. KPUD - ECOLOGY Personal Performance: The parties agree that the performance of all activities undertaken by KPUD and/or assigned and identified in the Scope of Work shall be accomplished personally by KPUD, KPUD's employees, and KPUD's subcontractors. ECOLOGY shall not provide typing, copying, data collection, drafting, or other personal and professional services except as otherwise provided in writing herein.

E. Scope/Workplan Changes: Team members may propose and implement changes to Scope/workplan tasks and timelines once the project is underway upon receiving the joint written approval of Siburg and Hirschey.

F. Period of Performance: Performance of tasks identified in the attached Scope of Work pertaining to the completion of Phase I shall be completed no later than March 15, 1995, and such performance shall be undertaken and completed in a manner so as to assure expeditious completion in accordance with the purposes of this agreement. The period of performance for tasks determined by ECOLOGY and KPUD to address Phase II issues and/or data and analytical gaps, shall be determined by mutual agreement by the parties subsequent to review and adoption of the Phase I report.

G. Collection and Sharing of Data: ECOLOGY and KPUD agree upon request, to provide each other in a timely manner, all relevant data, studies, and information relative to the performance of all tasks described in the Scope of Work, in addition to the performance of other and/or supplemental data collection, and project phases agreed to by the parties.

H. Ownership of Work Product: ECOLOGY and KPUD agree each party has a full property interest and right to the data, materials, and reports developed, collected, and/or prepared by the parties pursuant to this agreement. The parties further agree that KPUD shall retain, for its purposes, a complete set of all data, materials, and reports developed, collected, and/or prepared by the parties.

I. Project Fundings/Costs: KPUD agrees to bear all KPUD staff and contractor costs associated with performance of its tasks as described by Scope of Work, including preparation of a (Phase I) watershed assessment report and the development of additional data/study material as agreed to by the parties. ECOLOGY agrees to bear all costs associated with agency in-kind contributions, staff time, and other ECOLOGY expenses incurred as a result of its performance under this agreement.

J. Dispute Resolution: The Parties agree any dispute arising under this agreement shall be submitted to the ECOLOGY Water Resource Program Manager (Program Manager), and Dave Siburg, KPUD Manager for joint discussion and resolution. Decisions by the Program Manager and Mr. Siburg shall be reduced to writing with signed copies furnished to the parties. Disputes shall be submitted to the Program Manager and Mr. Siburg in written form and decided within 15 days of the date of submission. Prior to a decision, the parties shall be afforded the opportunity to make an oral presentation to the Program Manager and Mr. Siburg, and provide documentation/material which supports their respective claims.

K. Public/Agency Access to Data: The parties agree that ECOLOGY shall bear sole responsibility for responding to general public, state, tribal, and federal agency requests for the data and related work products collected and/or developed pursuant to this agreement, as well as all related costs and expenses incurred.

L. Changes/Modifications/Amendments: This agreement may be amended, expanded, or modified to include additional tasks, data collection efforts, and basin assessment phases upon mutual consent of the parties. Any changes, modifications, or amendments to this agreement shall be in writing and approved by the parties.

M. Indemnification: Each party shall defend, protect, and hold harmless the other party from and against all claims, suits, and/or actions arising from any negligent or intentional act or omission of that party's employees, agents, and/or authorized subcontractor(s) while performing this agreement.

N. Termination: Except as otherwise provided in this agreement, either party may terminate this agreement upon 30 days written notification.

IN WITNESS WHEREOF, the parties have executed this agreement.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

Carol L. Fleskes

Carol Fleskes
Water Resource Program Manager
Department of Ecology

January 31, 1995
Month Date Year

P.U.D. NO. 1 OF KITSAP COUNTY

David Siburg

David Siburg
Manager
P.U.D. No. 1 of Kitsap County

January 17 1995
Month Date Year

Chapter 173–515 WAC

INSTREAM RESOURCES PROTECTION PROGRAM— KITSAP WATER RESOURCE INVENTORY AREA (WRIA) 15

WAC 173–515–010 General provision. These rules apply to waters within the Kitsap water resource inventory area (WRIA) 15 as defined in WAC 173–500–040. This chapter is promulgated pursuant to chapter 90.54 RCW (Water Resources Act of 1971), chapter 90.22 RCW (minimum water flows and levels), and in accordance with chapter 173–500 WAC (water resources management program). [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81–16–003 (Order DE 80–45), § 173–515–010, filed 7/24/81.]

WAC 173–515–020 Purpose. The purpose of this chapter is to retain perennial rivers, streams, and lakes in the Kitsap water resource inventory area (WRIA) 15 with instream flows and levels necessary to provide for preservation and protection of wildlife, fish, scenic, aesthetic and other environmental values, recreational and navigational values, and to preserve water quality. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81–16–003 (Order DE 80–45), § 173–515–020, filed 7/24/81.]

WAC 173–515–030 Establishment of instream flows. (1) The following instream flows are established for each stream listed, from the point of influence of mean high tide at low flow to the stream's headwaters including tributaries except where indicated otherwise. Monitoring will take place at the control locations indicated.

INSTREAM FLOWS IN THE KITSAP WATER RESOURCE INVENTORY AREA (WRIA) 15

*WAC 173–515–040(2) closes certain streams to additional consumptive appropriations during specific time periods. These closures are indicated by asterisks in the following table. Such closures supersede the indicated instream flow. The Union River closure extends upstream to McKenna Falls (RM 6.7).

**Stream numbers correlate with Plate I, instream resources protection program, Kitsap water resource inventory area (WRIA) 15.

Stream Number**		#7	#44	#60
Stream Name		Union River	Tahuya River	Rendsland Cr.
Gage Number		12–0635.00	12–0680.00	
River Mile		2	2.5	near mouth
Sec., Twp., Rge.		20,23N.,1W.	12,22N.,3W.	19,22N.,3W.
Month	Day	cfs	cfs	cfs
Jan.	1	65*	90	18
	15	65*	90	18
Feb.	1	65*	90	18
	15	65*	90	18
Mar.	1	59*	90	18
	15	53*	90	18
Apr.	1	48*	72	18
	15	44*	58	16
May	1	40*	47	13.5
	15	36*	38	12
June	1	33*	31	10*
	15	29*	25*	9*
July	1	27*	18*	8*
	15	24*	12*	7*
Aug.	1	22*	8.5*	6*
	15	20*	5.5*	5*
Sept.	1	20*	5.5*	5*
	15	20*	5.5*	5*
Oct.	1	20*	7*	5*
	15	20*	13*	7*
Nov.	1	27*	25	9.5
	15	35*	48	13
Dec.	1	47*	90	18
	15	65*	90	18

Stream Number**		#70	#96	#113
Stream Name		Dewatto River	Anderson Cr.	Stavis Cr.
Gage Number		12–0685.00		12–0695.00
River Mile		1.5	0.1	0.75
Sec., Twp., Rge.		23,23N.,3W.	17,24N.,2W.	25,25N.,2W.
Month	Day	cfs	cfs	cfs
Jan.	1	75	10.5	15
	15	75	10.5	15
Feb.	1	75	10.5	15
	15	75	10.5	15
Mar.	1	75	10.5	15
	15	75	10.5	15
Apr.	1	60	10.5	14
	15	49	10	13

Stream Number**	#70	#96	#113
Stream Name	Dewatto River	Anderson Cr.	Stavis Cr.
Gage Number	12-0685.00		12-0695.00
River Mile	1.5	0.1	0.75
Sec., Twp., Rge.	23,23N.,3W.	17,24N.,2W.	25,25N.,2W.

Month	Day	cfs	cfs	cfs
May	1	39	9	12
	15	32	8.5	11
June	1	25	8	10
	15	22*	7.5	9.5
July	1	20*	7	9
	15	17.5*	6.5	8
Aug.	1	15.5*	6	7.5
	15	13.5*	6	7
Sept.	1	13.5*	6	7
	15	13.5*	6	7
Oct.	1	13.5*	6.5	7
	15	17*	7	8.5
Nov.	1	21	8	10.5
	15	39	8.5	12.5
Dec.	1	75	9.5	15
	15	75	10.5	15

Stream Number**	#121	#124	#192
Stream Name	Big Beef Cr.	Anderson Cr.	Grover's Cr.
Gage Number	12-0695.50		
River Mile	0.25	near mouth	near mouth
Sec., Twp., Rge.	22,25N.,1W.	13,25N.,1W.	4,26N.,2E.

Month	Day	cfs	cfs	cfs
Jan.	1	40	8	5.5
	15	40	8	5.5
Feb.	1	40	8	5.5
	15	40	8	5.5
Mar.	1	40	8	5.5
	15	40	8	5.5
Apr.	1	31	8	5.5
	15	24	6	4.5
May	1	18	4.5	4
	15	14*	3.5	3.5
June	1	11*	3*	3*
	15	8.5*	2*	2.5*
July	1	6.5*	1.5*	2.5*
	15	5*	1.5*	2*
Aug.	1	4*	1*	2*
	15	4*	1*	2*
Sept.	1	4*	1*	2*
	15	4.5*	1*	2.5*
Oct.	1	5.5*	1.5*	3*
	15	6*	1.5*	3.5*
Nov.	1	7*	2.5*	4
	15	12	4.5	4.5
Dec.	1	22	8	5.5
	15	40	8	5.5

Stream Number**	#223	#248	#259
Stream Name	Steel Creek	Strawberry/ Kochs/Cooks	Dickerson Cr.
Gage Number			
River Mile	near mouth	near mouth	Confluence with Chico Cr.
Sec., Twp., Rge.	14,25N.,1E.	20,25N.,1E.	8,24N.,1E.

Month	Day	cfs	cfs	cfs
Jan.	1	6	7	3*
	15	6	7	3*
Feb.	1	6	7	3*
	15	6	7	3*
Mar.	1	6	7	3*
	15	6	7	3*
Apr.	1	6	7	2.5*
	15	5	5.5	2.5*
May	1	4.5	4.5	2*
	15	4	3.5	2*
June	1	3.5*	2.5*	1.5*
	15	3*	2*	1.5*
July	1	3*	1.5*	1.5*
	15	2.5*	1.5*	1.5*
Aug.	1	2.5*	1*	1*
	15	2.5*	1*	1*
Sept.	1	2.5*	1*	1*
	15	3*	1*	1*
Oct.	1	3.5*	1*	1*
	15	4*	1.5*	1.5*
Nov.	1	4.5	2.5	1.5*
	15	5	4	1.5*
Dec.	1	6	7	3*
	15	6	7	3*

Stream Number**	#259	#268	#294
Stream Name	Chico Cr.	Gorst Cr.	Curley Cr.
Gage Number			
River Mile	near mouth	0.1	0.1
Sec., Twp., Rge.	5,24N.,1E.	32,24N.,1E.	4,23N.,2E.

Month	Day	cfs	cfs	cfs
Jan.	1	15*	25	40
	15	15*	25	40
Feb.	1	15*	25	40
	15	15*	25	40
Mar.	1	15*	25	40
	15	15*	21	40
Apr.	1	15*	18	31
	15	13.5*	15	25
May	1	12*	13	20
	15	11*	11	16
June	1	10*	10.5	12.5
	15	9*	10	10*
July	1	8.5*	9	8*
	15	8*	8.5	6.5*
Aug.	1	7.5*	8	5*
	15	7*	7.5	5*

Stream Number**	#259	#268	#294
Stream Name	Chico Cr.	Gorst Cr.	Curley Cr.
Gage Number			
River Mile	near mouth	0.1	0.1
Sec., Twp., Rge.	5,24N.,1E.	32,24N.,1E.	4,23N.,2E.

Month	Day	cfs	cfs	cfs
Sept.	1	7*	7.5	5*
	15	7*	7.5	5*
Oct.	1	7*	8	5*
	15	8*	8.5	8*
Nov.	1	9*	9	14
	15	11.5*	15	23
Dec.	1	15*	25	40
	15	15*	25	40

Stream Number**	#313	#321	#354
Stream Name	Olalla Cr.	Crescent Cr.	Purdy Cr.
Gage Number			12-0728.00
River Mile	near mouth	near mouth	0.1
Sec., Twp., Rge.	4,22N.,2E	32,22N.,2E.	24,22N.,1E.

Month	Day	cfs	cfs	cfs
Jan.	1	13	9	7
	15	13	9	7
Feb.	1	13	9	7
	15	13	9	7
Mar.	1	13	9	7
	15	13	9	6
Apr.	1	13	9	5.5
	15	11	7.5	5
May	1	9.5	7	4.5
	15	8.5	6	4
June	1	7.5*	5*	3.5*
	15	6.5*	4.5*	3*
July	1	5.5*	4*	3*
	15	5*	3.5*	2.5*
Aug.	1	5*	3.5*	2.5*
	15	5*	3.5*	2.5*
Sept.	1	5*	3.5*	2.5*
	15	6*	4*	3*
Oct.	1	7*	5*	3*
	15	8*	5.5*	3.5*
Nov.	1	9	6.5	4.5
	15	11	7.5	5.5
Dec.	1	13	9	7
	15	13	9	7

Stream Number**	#369	#415	#425
Stream Name	Lackey Cr.	Rocky Cr.	Coulter Cr.a/
Gage Number			
River Mile	near mouth	0.1	0.1
Sec., Twp., Rge.	31,21N.,1E.	27,22N.,1W	9,22N.,1W.

Month	Day	cfs	cfs	cfs
Jan.	1	5	18	18
	15	5	18	18
Feb.	1	5	18	18
	15	5	18	18
Mar.	1	5	18	18
	15	4.5	18	18
Apr.	1	4	14.5	18
	15	3.5	11.5	17
May	1	3	9	16.5
	15	2.5	7.5	15.5
June	1	2.5*	6*	15
	15	2*	5.5*	14.5
July	1	2*	5*	13.5
	15	2*	4.5*	13
Aug.	1	1.5*	4.5*	13
	15	1.5*	4*	13
Sept.	1	1.5*	4*	13
	15	1.5*	4*	13
Oct.	1	2*	4*	13
	15	2*	5*	14
Nov.	1	2*	6	15
	15	2.5*	7	16.5
Dec.	1	3	18	18
	15	4	18	18

a/ Relating to the waters of Coulter Creek, the department is cognizant of a settlement agreement resulting from Cause No. 14262, in the superior court of the state of Washington for Mason County, "*Peter E. Overton, et al., v. Washington Department of Fisheries, et al.*"
Although the department of ecology was not a party in this litigation, the department will, to the extent possible, give full consideration to the intent of the settlement agreement in any future water right actions involving said parties: *Provided*, That, said actions must be consistent with the requirements of chapters 90.03 and 90.44 RCW, and satisfy the general intent of chapter 173-515 WAC.

(2) Instream flow hydrographs, as represented in the document entitled "instream resources protection program," shall be used for definition of instream flows on those days not specifically identified in WAC 173-515-030(1).

(3) All consumptive water rights hereafter established shall be expressly subject to instream flows and closures established in WAC 173-515-030(1) and 173-515-040 (1) through (3). Closures override the instream flows where both are shown except as provided in WAC 173-515-070. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-030, filed 7/24/81.]

WAC 173-515-040 Surface water closures. (1) The department, having determined there are no waters available for further appropriation, closes the following streams to further consumptive appropriation. These closures confirm surface water source limitations previously established administratively under authority of chapter 90.03 RCW and RCW 75.20.050.

Surface Water Closures

**Stream numbers correlate with Plate I, instream resources protection program, Kitsap water resource inventory area (WRIA) 15.

Stream Number** Stream or Lake Name Sec., Twp., Rge. at Mouth	Tributary to	Date of Original Closure
Stansberry Lake and tributaries Sec. 19, T.22N., R.1E.	Carr Inlet	5-17-66
Mission Lake and tributaries Outlet: NE1/4NW1/4 Sec. 32, T.24N.,R.1W.	Mission Creek	7-19-78
#12 Mission Creek and tributaries NW1/4NE1/4 Sec. 1, T.22N., R.2W.	Hood Canal	12-5-51
#57 Unnamed Stream and tributaries Sec. 20, T.21N., R.4W.	Hood Canal	11-3-48
#117 Seabeck Creek and tributaries SE1/4SW1/4 Sec. 20, T.25N., R.1W.	Seabeck Bay	8-27-54
#158 Unnamed Stream (Gamble Creek, Christianson Creek) and tributaries SW1/4SW1/4 Sec. 20, T.27N., R.2E.	Port Gamble	8-15-75
#207 Unnamed Stream (Dogfish Creek, Harding Creek) and tributaries NE1/4NE1/4 Sec. 15, T.26N., R.1E.	Liberty Bay	8-21-75
#245 Barker Creek and tributaries SW1/4SW1/4 Sec. 22, T.25N., R.1E.	Dyes Inlet	2-21-61
#246 Clear Creek and tributaries SE1/4SW1/4 Sec. 16, T.25N., R.1E.	Dyes Inlet	7-27-53
#259 Chico Creek and tributaries above confluence of Dickerson Creek, (excluding Wildcat Lake). Sec. 5, T.24N., R.1E.	Chico Bay	11-3-52
#259 Kitsap Creek and tributaries Sec. 5, T.24N., R.1E.	Chico Creek	7-2-42
#259 Unnamed Stream and tributaries SE1/4SW1/4 Sec. 17, T.24N., R.1E.	Kitsap Lake	12-8-52
#279 Blackjack Creek and tributaries NE1/4SE1/4 Sec. 25, T.24N., R.1E.	Sinclair Inlet	4-5-60
#285 Unnamed Stream (Sullivan Creek) and tributaries NE1/4SW1/4 Sec. 19, T.24N., R.2E	Sinclair Inlet	5-9-75
#294 Salmonberry Creek and tributaries NW1/4SE1/4 Sec. 18, T.23N., R.2E.	Long Lake	1-7-48
#356 Burley Creek and tributaries, SW1/4NW1/4 Sec. 12, T.22N., R.1E.	Burley Lagoon	5-10-51
#367 Minter Creek and tributaries SW1/4NE1/4 Sec. 29, T.22N., R.1E.	Henderson Bay	12-28-73
#402 Unnamed Stream (Dutcher Creek) and tributaries NE1/4NE1/4 Sec. 15, T.21N., R.1W.	Dutcher Cove	3-10-54
#510 Judd Creek and tributaries NE1/4NE1/4 Sec. 18, T.22N., R.3E.	Quartermaster Harbor	5-10-51

(2) The department has determined that (a) certain streams exhibit low summer flows and have a potential for drying up or inhibiting anadromous fish passage during critical life stages, and (b) historic flow regimes and current uses of certain other streams indicate that no water is available for additional appropriation. Based upon these determinations and in accordance with the general intent of RCW 75.20.050, the following streams are closed to further appropriation for the periods indicated:

New Surface Water Closures

**Stream numbers correlate with Plate I, instream resources protection program, Kitsap water resource inventory area (WRIA) 15.

Stream Number** Stream Name Sec., Twp., Rge. at Mouth	Tributary to	Period of Closure
#7 Union River and tributaries from the mouth to McKenna Falls (R.M. 6.7) SE1/4SW1/4 Sec. 29, T.23N., R.1W.	Hood Canal	All year
#44 Tahuya River and tributaries SE1/4SE1/4 Sec. 22, T.22N., R.3W.	Hood Canal	June 15-Oct. 15
#60 Rendsland Creek and tributaries NW1/4NW1/4 Sec. 19, T.22N., R.3W.	Hood Canal	June 1-Oct. 31
#70 Dewatto River and tributaries NW1/4SE1/4 Sec. 27, T.22N., R.3W.	Hood Canal	June 15-Oct. 31
#121 Big Beef Creek and tributaries SW1/4SE1/4 Sec. 15, T.25N., R.1W.	Hood Canal	May 15-Oct. 31
#124 Anderson Creek and tributaries NW1/4NW1/4 Sec. 13, T.26N., R.1W.	Hood Canal	June 1-Oct. 31
#192 Grover's Creek and tributaries NW1/4SW1/4 Sec. 4, T.26N., R.2E.	Puget Sound	June 1-Oct. 15
#223 Unnamed Stream (Steel Creek) and tributaries SE1/4SE1/4 Sec. 14, T.25N., R.1E.	Port Orchard	June 1-Oct. 15
#248 Unnamed Stream and tributaries (Strawberry/Cook's/Koch's Creek) SE1/4NE1/4 Sec. 20, T.25N., R.1E.	Dyes Inlet	June 1-Oct. 31
#259 Dickerson Creek and tributaries SW1/4NW1/4 Sec. 7, T.24N., R.1E.	Chico Creek	All year

Stream Number** Stream Name Sec., Twp., Rge. at Mouth	Tributary to	Period of Closure
#259 Chico Creek and tributaries below confluence of Dickerson Creek SW1/4SW1/4 Sec. 5, T.25N., R.1E.	Chico Bay	All year
#294 Curley Creek and tributaries NE1/4NE1/4 Sec. 18, T.23N., R.2E.	Yukon Harbor	June 15–Oct. 15
#313 Olalla Creek and tributaries SE1/4NE1/4 Sec. 4, T.22N., R.2E.	Colvos Passage	June 1–Oct. 15
#321 Crescent Creek and tributaries SE1/4SW1/4 Sec. 32, T. 22N., R.2E.	Gig Harbor	June 1–Oct. 15
#354 Purdy Creek and tributaries NE1/4NW1/4 Sec. 12, T.22N., R.1E.	Henderson Bay	June 1–Oct. 31
#369 Lackey Creek and tributaries SE1/4SW1/4 Sec. 31, T.21N., R.1E.	Carr Inlet	June 1–Nov. 15
#415 Rocky Creek and tributaries SE1/4SE1/4 Sec. 27, T.22N., R.1E.	Case Inlet	June 1–Oct. 31

(3) In the Kitsap basin numerous small streams with estimated mean annual flow of 5 cfs or less have been identified as having high instream values for anadromous fish, aesthetics, water quality, and/or recreation. In accordance with the general intent of RCW 75.20-.050 the department has determined that the total natural flow of these streams is required for protection and preservation of instream resources, and that no water is available for additional consumptive appropriation. The natural flow, in effect, constitutes the minimum flow for protection of the instream resources. The following streams possess such characteristics and are therefore closed year-round to further consumptive appropriation.

New Surface Water Closures

**Stream numbers correlate with Plate I, instream resources protection program, Kitsap water resource inventory area (WRIA) 15.

Stream Number** Stream Name Sec., Twp., Rge. at Mouth	Tributary to
#13 Little Mission Creek and tributaries SE1/4NW1/4 Sec. 1, T.22N., R.2W.	Hood Canal
#18 Stimson Creek and tributaries NW1/4NW1/4 Sec. 11, T.22N., R.2W.	Hood Canal
#31 Unnamed Stream (Little Shoefly Creek) and tributaries SW1/4NW1/4 Sec. 17, T.22N., R.2W.	Hood Canal
#34 Shoefly Creek and tributaries SE1/4SW1/4 Sec. 18, T.22N., R.2W.	Hood Canal
#46 Caldervin Creek and tributaries NE1/4NE1/4 Sec. 28, T.21N., R.3W.	Hood Canal
#50 Hall Creek and tributaries Sec. 20, T.21N., R.3W.	Hood Canal
#52 Hoddy Creek and tributaries Sec. 20, T.21N., R.3W.	Hood Canal
#54 Fay Creek and tributaries Sec. 21, T.20N., R.3W.	Hood Canal
#55 Brown Creek and tributaries Sec. 21, T.20N., R.3W.	Hood Canal
#56 Unnamed Stream (West Creek) and tributaries Sec. 20, T.22N., R.3W.	Hood Canal
#101 Harding Creek and tributaries NW1/4SW1/4 Sec. 9, T.24N., R.2W.	Hood Canal
#164 Unnamed Stream (Little Boston Creek) and tributaries SW1/4SW1/4 Sec. 5, T.27N., R.2E.	Port Gamble
#181 Unnamed Stream and tributaries SE1/4SW1/4 Sec. 26, T.27N., R.2E.	Apple Tree Cove
#184 Unnamed Stream and tributaries NE1/4SW1/4 Sec. 36, T.27N., R.2E.	Apple Tree Cove
#190 Unnamed Stream and tributaries Sec. 9, T.26N., R.2E.	Puget Sound
#196 Cowling Creek and tributaries NW1/4NW1/4 Sec. 16, T.26N., R.2E.	Miller Bay
#198 Thompson Creek and tributaries SW1/4SE1/4 Sec. 29, T.26N., R.2E.	Port Orchard
#208 Johnson Creek and tributaries SE1/4NW1/4 Sec. 22, T.26N., R.1E.	Liberty Bay
#213 Scandia Creek and tributaries SW1/4NE1/4 Sec. 27, T.26N., R.1E.	Liberty Bay
#241 Mosher Creek and tributaries SW1/4NE1/4 Sec. 34, T.25N., R.1E.	Dyes Inlet
#272 Anderson Creek and tributaries SE1/4NE1/4 Sec. 33, T.24N., R.1E.	Sinclair Inlet
#275 Ross Creek and tributaries SE1/4SE1/4 Sec. 27, T.24N., R.1E.	Sinclair Inlet
#289 Beaver Creek and tributaries NW1/4SE1/4 Sec. 16, T.24N., R.2E.	Rich Passage
#322 North Creek and tributaries NE1/4SE1/4 Sec. 6, T.21N., R.2E.	Gig Harbor
#342 Unnamed Stream and tributaries NW1/4SE1/4 Sec. 10, T.21N., R.1E.	Henderson Bay
#343 Unnamed Stream (Meyer Creek) and tributaries SW1/4SW1/4 Sec. 2, T.21N., R.1E.	Hood Canal
#407 Unnamed Stream and tributaries SE1/4NW1/4 Sec. 2, T.21N., R.1W.	Vaughn Bay

Stream Number** Stream Name Sec., Twp., Rge. at Mouth	Tributary to
#434 Unnamed stream and tributaries SE1/4SE1/4 Sec. 15, T.25N., R.2E.	Murden Cove
#461 Unnamed Stream and tributaries SE1/4NE1/4 Sec. 20, T.25N., R.2E.	Fletcher Bay
#514 Unnamed Stream (Fisher Creek) and tributaries SW1/4NW1/4 Sec. 19, T.22N., R.3E.	Quartermaster Harbor
#530 Jod Creek and tributaries NW1/4NW1/4 Sec. 14, T.22N., R.2E.	Colvos Passage
#540 Needle Creek and tributaries NE1/4SE1/4 Sec. 13, T.23N., R.3E.	Colvos Passage

(4) Closures listed in WAC 173-515-040 (2) and (3) will supersede low flow surface water source limitations previously imposed by administrative authority pursuant to chapter 75.20 RCW.

(5) Lakes perennially tributary to closed streams are closed to further consumptive appropriation. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-040, filed 7/24/81.]

WAC 173-515-050 Groundwater. Future groundwater withdrawal proposals will not be affected by this chapter unless it is determined that such withdrawal would clearly have an adverse impact upon the surface water system contrary to the intent and objectives of this chapter. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-050, filed 7/24/81.]

WAC 173-515-060 Lakes. In future permitting actions relating to withdrawal of lake waters, lakes and ponds shall be retained substantially in their natural condition. Withdrawals of water which would conflict therewith shall be authorized only in those situations where it is clear that overriding considerations of the public interest will be served. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-060, filed 7/24/81.]

WAC 173-515-070 Exemptions. (1) Nothing in this chapter shall affect existing water rights, riparian, appropriative, or otherwise, existing on the effective date of this chapter, nor shall it affect existing rights relating to the operation of any navigation, hydroelectric or water storage reservoir or related facilities.

(2) If, upon detailed analysis, appropriate and environmentally sound proposed storage facilities are found to be compatible with this chapter, such facilities may be approved but will be subject to the establishment of appropriate protection flows for drought or low runoff periods.

(3) Domestic use for a single residence shall be exempt from the provisions of this chapter. If the cumulative effects of numerous single domestic diversions would seriously affect the quantity of water available for instream uses, then domestic in-house use shall be exempt if no alternative source is available.

(4) Stockwatering use, except that related to feedlots, shall be exempt from the provisions established in this chapter.

(5) Future rights for nonconsumptive uses may be granted. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-070, filed 7/24/81.]

WAC 173-515-080 Future rights. No right to divert or store public surface waters of the Kitsap water resource inventory area (WRIA) 15 shall hereafter be granted which shall conflict with the purpose of this chapter. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-080, filed 7/24/81.]

WAC 173-515-090 Enforcement. In enforcement of this chapter, the department of ecology may impose such sanctions as appropriate under authorities vested in it, including but not limited to the issuance of regulatory orders under RCW 43.27A.190 and civil penalties under RCW 90.03.600. [Statutory Authority: Chapters 43-.21B, 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-515-090, filed 6/9/88. Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-090, filed 7/24/81.]

WAC 173-515-095 Appeals. All final written decisions of the department of ecology pertaining to permits, regulatory orders, and related decisions made pursuant to this chapter shall be subject to review by the pollution control hearings board in accordance with chapter 43-.21B RCW. [Statutory Authority: Chapters 43.21B, 43-.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-515-095, filed 6/9/88.]

WAC 173-515-100 Regulation review. The department of ecology shall initiate a review of the rules established in this chapter whenever new information, changing conditions, or statutory modifications make it necessary to consider revisions. [Statutory Authority: Chapters 43.21B, 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-515-100, filed 6/9/88. Statutory Authority: Chapters 90.22 and 90.54 RCW. 81-16-003 (Order DE 80-45), § 173-515-100, filed 7/24/81.]

Appendix C
Miscellaneous Streamflow Measurements and Reports

Appendix C
Miscellaneous Streamflow Measurements and Reports

This appendix contains descriptions and probability statistic plots of miscellaneous streamflow data not presented in Section 6. These data include individual streamflow measurements made by a variety of investigators and continuous gaging performed by the USGS. Individual streamflow measurements are more common on the smaller streams, whereas continuous stream gages are typically established on the bigger streams. Individual measurements are described for each subarea in the text below. Probability statistic plots for the continous gages are presented for the Union River near Bremerton, Gold Creek near Bremerton, Huge Creek near Wauna, and the Tahuya River near Bremerton in **Exhibits C-1** through **C-4**. Data analysis in Section 6 of this report did not include the Tahuya River near Bremerton, because another gage (on the same stream) associated with an instream flow control point was considered more appropriate for analysis. Data from Huge Creek were not analyzed because the gage is outside of Kitsap County. Data from the Union River near Bremerton were not analyzed because of the relatively short available record. Data from Gold Creek were analyzed, however probability statistics were not discussed in Section 4.

The following text describes individual streamflow measurements by subarea. The text does not attempt to include all miscellaneous measurements, as the number of measurements is too large to fully document in this appendix. Nevertheless, the following text should provide a good idea of the major streamflow documentation performed in the Kitsap Basin. Many of the measurements discussed below are miscellaneous USGS measurements, or are referenced in the 1975 Williams document Catalog of Washington Streams, released by the Washington Department of Fisheries. Miscellaneous USGS streamflow measurements made in the 1940s and 1950s are published in several documents (Garling et al, 1965; USGS, 1953), but are too numerous to fully include in this appendix. The user is advised to refer to the documents for additional information. Selected recent USGS measurements are described below. In addition, series of individual flow measurements have been made on selected streams by the Kitsap County PUD and the Suquamish Tribe. These measurements, as well as some made by the USGS, are documented in **Exhibits C-5 and C-6**.

The Suquamish Tribe maintains extensive data from measurements taken on individual streams within and around the Port Madison Indian Reservation. Monitored streams include Snyder Creek, Klebeal Creek, Cowling Creek (and selected tributaries), Kitsap Creek, Indianola Creek, Okaquats Creek, and others. According to the Tribe (personal communication, David Fuller, 8/18/95), weekly measurements have been made on all streams within the reservation shown on USGS topographic maps since March of 1995. At the time of this writing, the existing data were not available. Periods of record cannot be reported, nor is it known which streams are monitored solely for stage and which have measurements made with a flow meter.

Kingston Subarea

Flow data for Grovers Creek were recorded periodically from 1947 through 1977. Year round data was collected in 1976 and ranged from 1.79 to 15.2 cfs. More recently, streamflow measurements have been made by the Suquamish Tribe, and have ranged from 1.46 cfs to 32.1 cfs **(Exhibit C-6)**. Two unnamed tributaries which drain into Miller Bay were also monitored in 1976 and 1977. Flows in these tributaries ranged from 0.11 to 3.0 cfs in 1976.

Port Gamble Subarea

Streamflows for several unnamed tributaries which drain into Port Gamble have been recorded from 1976 to 1977 (Williams and Riis 1989). Flow in what may be Gamble Creek (referenced in text as Port Gamble Inlet) ranged from 1.82 to 7.38 cfs. Two other tributaries had flows which were generally less than 1.0 cfs. The USGS operated a continuous streamflow gage on Gamble Creek from July, 1994 to May, 1996. KPUD installed a GS-93 Logger with encoder and float into the existing USGS stilling well and hutch, May 31, 1996.

Poulsbo Subarea

Flows were recorded periodically for several of the Liberty Bay drainages. Klebeal Creek (No. 0296) has flows recorded from 1958 through 1977, with the most complete record occurring in 1976. Flows in Klebeal Creek ranged from 0.21 to 3.45 for 1976. Johnson Creek has six flow measurements recorded from 1947 through 1974, ranging from 0.68 to 1.78 cfs. The USGS operated a continuous stream gage on Johnson Creek from July, 1994 to May, 1996. KPUD currently operates and maintains a stream gaging station at the site. An unnamed tributary draining into Lemolo Bay had streamflows recorded in November 1975 of 5.02 cfs. Four measurements in the west fork of Dogfish Creek in 1974 ranged from 2.66 to 3.34 cfs. KPUD currently maintains a continuous streamflow monitoring gage on the mainstem of Dogfish Creek. Individual measurements for rating curve development on Dogfish Creek are documented in **Exhibit C-5**.

Bangor Subarea

Streamflows were recorded for the west fork of Clear Creek from 1947 through 1975. Three measurements were recorded on the mainstream above the confluence of the west fork of Clear Creek in 1975. Flows ranged from 2.16 to 4.56 cfs in the west fork and 0.56 to 1.39 in the main stem. Barker Creek has flows recorded at the outlet of Island Lake ranging from zero to 0.1 cfs from 1969 through 1971. Continuous monitoring on the main stem of Clear Creek and on Barker Creek is currently being performed by KPUD (Section 4). Individual measurements for rating curve development on both these streams are documented on **Exhibit C-5**. Streamflows recorded in Strawberry Creek for the summer and fall of 1971 ranged from 1.48 to 1.7 cfs. More recent flows, measured by the Suquamish Tribe, KPUD and the USGS are also documented on **Exhibit C-5**. The Silverdale Water District has been taking twice-daily readings from a staff gage located on Strawberry Creek in downtown Silverdale since December of 1991. In addition, the USGS has been making periodic streamflow measurements on Scandia and Strawberry Creeks since 1991. Flow in the main stem of the small stream entering Devil's Hole Lake has been reported to average 4.0 cfs. Subsequent to these measurements, the USGS has been maintaining a continuous streamgage on Devil's Hole Creek since October, 1994.

Chico Subarea

Flows have historically been recorded from several locations along Chico Creek and its tributaries Wildcat, Lost, Dickerson, and Kitsap Creeks. The most complete records of flow are for the outlets of Kitsap and Wildcat Lakes along Kitsap and Wildcat Creeks from 1947 through 1971. Upstream of Kitsap Lake, the inlet creek has streamflows ranging from 1.04 to 5.26 cfs, while lake outlet flows have ranged from 0.08 to 25.2 cfs. Wildcat Creek flows have ranged from zero to 2.0 cfs upstream of the lake, and zero to 24.8 cfs downstream of the lake. Dickerson Creek has recorded flows from 1947 through 1961 ranging from 0.04 to 1.53 cfs. Flows recorded for Lost Creek in the fall and summer of 1961 ranged from 0.14 to 2.55 cfs. Flows have also been recorded at the gauging station near the mouth of Chico Creek several times since 1958 and have ranged from 0.24 to 15.7 cfs. In addition, continuous streamflow data from Chico Creek were collected by the USGS between 1948-49 and 1962-73 and are currently being collected by KPUD (Section 4). Individual measurements for rating curve development on Chico Creek are documented on **Exhibit C-5**.

Seabeck Subarea

In addition to the continuous streamflow data discussed in Section 4, periodic summer streamflows were recorded for Big Beef Creek from 1947 to 1968 (five recorded values). Summer flows for this time period averaged 4.13 cfs. The USGS has been making periodic streamflow measurements on Anderson Creek (#124) since 1991.

Stavis Subarea

A single streamflow measurement was obtained for Stavis Creek by KPUD. This measurement is documented in **Exhibit C-5**.

Manchester Subarea

Stream gaging records for Blackjack Creek are available from 1947 through 1950 at river mile 0.4. The data show the creek to be a very stable with a range of flows from 6.7 to 285 cfs (Williams et al. 1975). KPUD is currently collecting continuous flow data from Blackjack Creek (Section 4). Individual measurements for rating curve development on Blackjack Creek are documented on **Exhibit C-5**. Flow data for the other creeks in this subarea are more sporadic. Flows along Beaver Creek were collected at several places on one date, however seven measurements were made at river mile 0.4 from 1947 through 1967. Flows in Beaver Creek ranged from 0.44 to 7.72 cfs. Flows measured from 1947 through 1974 in Annapolis and Salmonberry Creeks ranged from 1.64 to 4.05 cfs and 1.29 to 3.35 cfs, respectively. The outlet of Long Lake was measured along Curley Creek in 1973 with flows ranging from 5.5 to 13.5 cfs.

Gorst Subarea

KPUD is currently performing continuous monitoring of Gorst Creek, and began continuous monitoring of Anderson Creek (#272) in February of 1995. Individual measurements used to develop rating curves for both these creeks are documented in **Exhibit C-5**. In addition, daily staff gage measurements are collected on Anderson Creek by the City of Bremerton.

Union Subarea

Periodic flow measurements have been made at the gauging station near the mouth of the Union River and at several locations along Big Mission Creek from 1942 through 1973. Measurements were typically made during the late summer and fall. Flows in the Union River ranged from 14.2 to 27.3 cfs. More complete (continuous) streamflow data are available from gages farther upstream on the Union River (Section 4 and **Exhibit C-1**). Flows at river mile 0.9 along Big Mission Creek ranged from 5.11 to 15.1 cfs. Flows of zero were recorded for Big Mission Creek both up and downstream of Mission Lake.

Tahuya Subarea

Flow data is available for Gold and Panther Creeks, which flow into tributary lakes to the Tahuya River. Miscellaneous measurements were made at the gauging station along Gold Creek (1.2 miles up from the mouth) in the spring and summer of 1975, and ranged from 0.43 to 2.19 cfs. More complete (continuous) streamflow data are available from Gold Creek for the period of record between 1945 and 1970 (Section 4 and **Exhibit C-2**). For Panther Creek, 13 of the 14 measurements made 0.5 mile south of Panther Lake between 1953 and 1970 were less than 1 cfs except on February 10, 1970, when flows of 2.19 cfs were recorded.

Anderson Subarea

Streamflows have been recorded at several locations along Big Anderson Creek (#96); the north fork, south fork and two locations near the mouth. Seven measurements were recorded in 1970, and eight measurements were recorded in 1971. Flows along the north and south forks of the creek ranged from 0.39 to 61.0 cfs, and 2.3 to 30.4 cfs, respectively. Streamflows measured 0.2 miles from the mouth ranged from 5.64 to 208 cfs, where flows measure 0.8 miles from the mouth ranged 4.02 to 74.0 cfs. The highest flows were recorded in December of 1970 at all four stations. KPUD has been collecting continuous streamflow data from Anderson Creek from a gage located approximately 1 mile from the mouth since December of 1994. Related streamflow measurements for rating curve development are documented in **Exhibit C-5**. One streamflow measurement of 4.85 cfs was recorded for Harding Creek in September of 1961.

Ollalla Subarea

Streamflows were measured in Purdy Creek at the gaging station near the mouth periodically from 1947 through 1979. Measurements were made year round in 1963, 1964, and 1978, and typically ranged from 1.60 to 8.79 cfs. One measurement made on January 17, 1964, recorded a flow of 33.8 cfs in Purdy Creek. Besides the continuous gaging data for Burley Creek presented in Section 4, periodic summer and fall streamflow measurements were collected at river mile 0.3 from 1951 through 1971. During this period, summer flows in Burley Creek ranged from 10.4 to 23.4 cfs. Continuous monitoring of Burley Creek is currently performed by KPUD (Section 4). Individual measurements for rating curve development on Burley Creek, as well as individual measurements on Ollalla Creek, are documented on **Exhibit C-5**. Summer flows were also periodically measured at Bear Creek, a tributary to Burley Creek, from 1947 through 1971. Bear Creek flows ranged from 2.25 to 3.36 cfs.

McCormick Subarea

Minter Creek has had flow data recorded periodically below river mile 2 from 1947 through 1971. The flows at this location in Minter Creek ranged from 5.53 to 11.8 cfs. A few individual flow measurements have been recorded in 1978 for the upper reaches of Minter and Huge Creeks (a tributary to Minter Creek) at or near the Kitsap - Pierce County line. Continuous gaging data for Huge Creek are presented in Section 6 and **Exhibit C-3**.

Dewatto Subarea

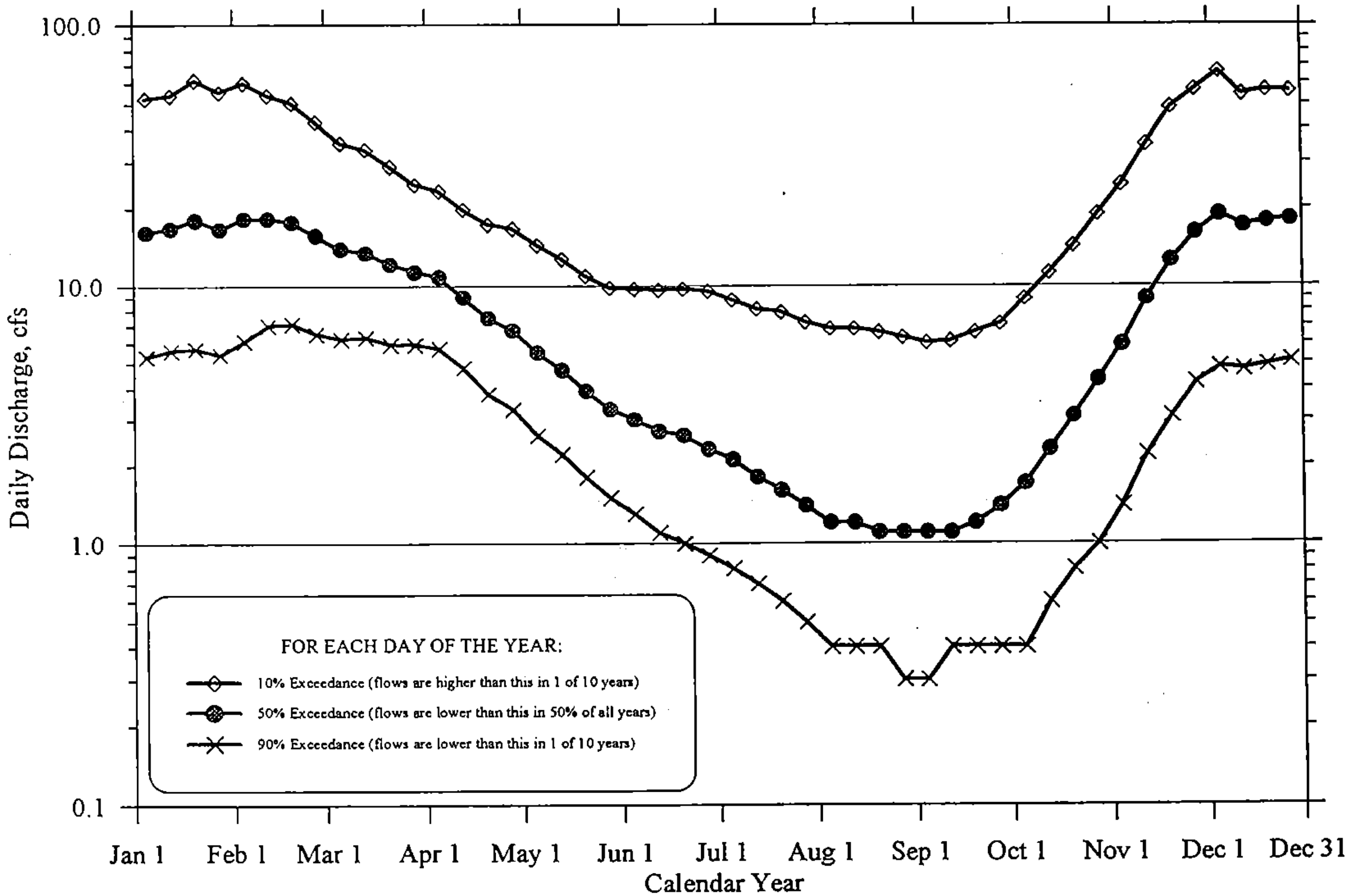
Streamflow data over a 22-year period are available from the gaging station located at river mile 1.8 of the Dewatto River. Mean streamflow has been 69.1 cfs, with a range of 9.0 to 2,160 cfs (Williams et al. 1975). The data are not presented graphically in this report because the river occurs almost entirely outside of Kitsap County.

LIST OF EXHIBITS

EXHIBIT C-1
Flow Exceedence Probabilities
Union River near Bremerton

Kitsap County
Initial Basin Assessment

Period of Record:
1945 - 1959



Period of Record:
1945 - 1970

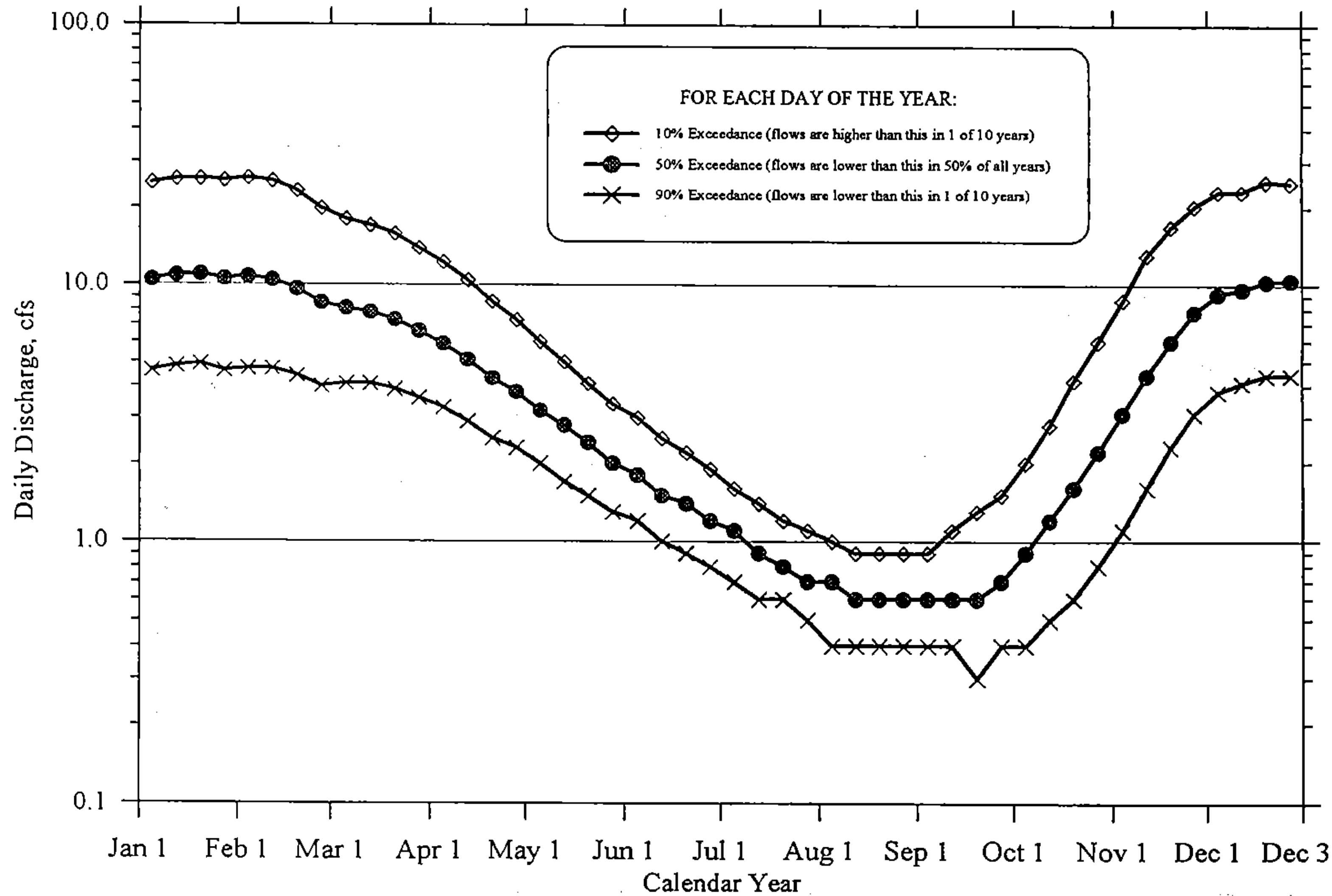


EXHIBIT C-2
Flow Exceedence Probabilities
Gold Creek near Bremerton

Kitsap County
Initial Basin Assessment

Period of Record:
1947 - 1969
1977 - 1993

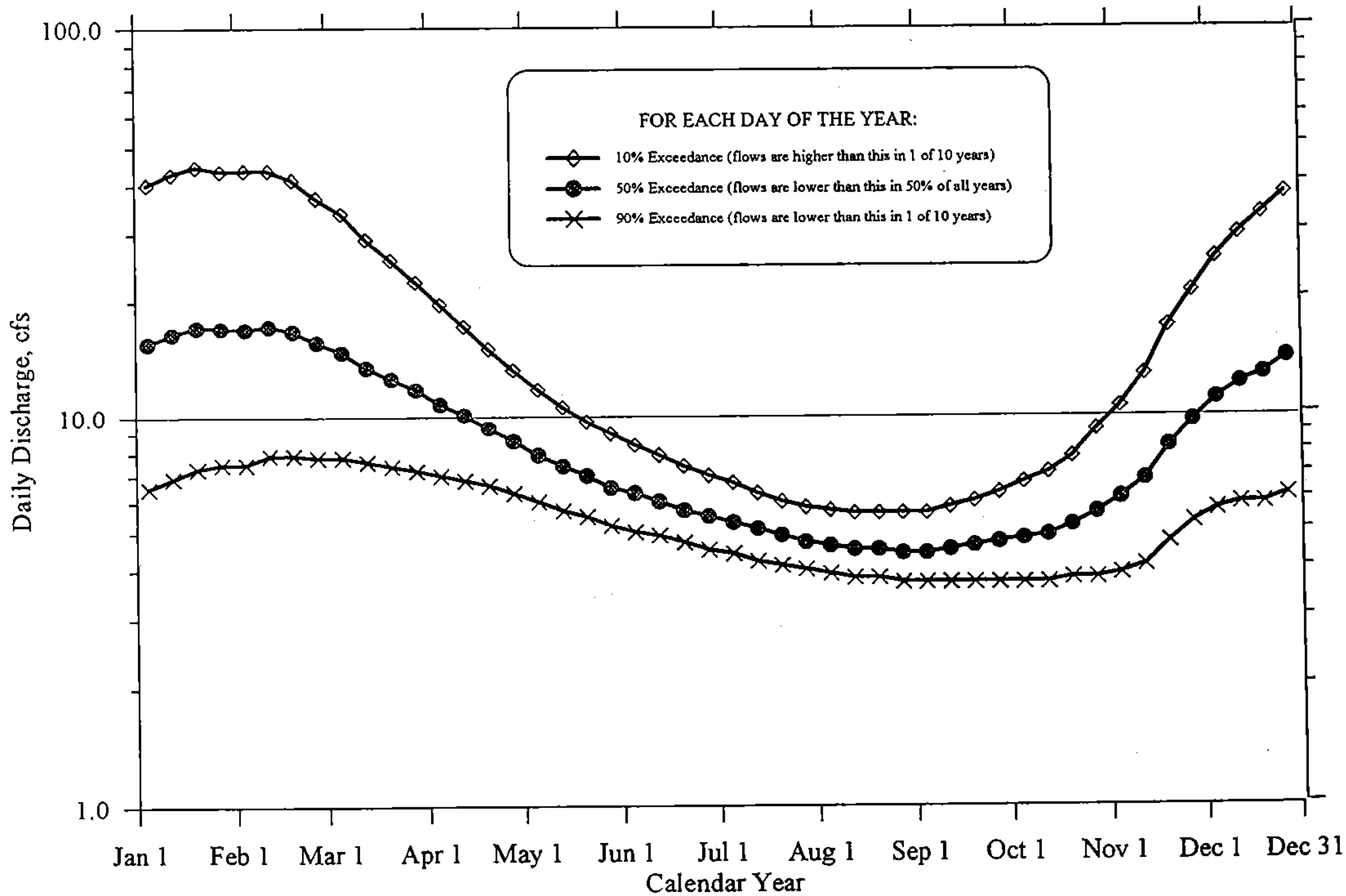


EXHIBIT C-3
Flow Exceedence Probabilities
Huge Creek near Wauna (#367)

Kitsap County
Initial Basin Assessment

Period of Record:
1945 - 1956

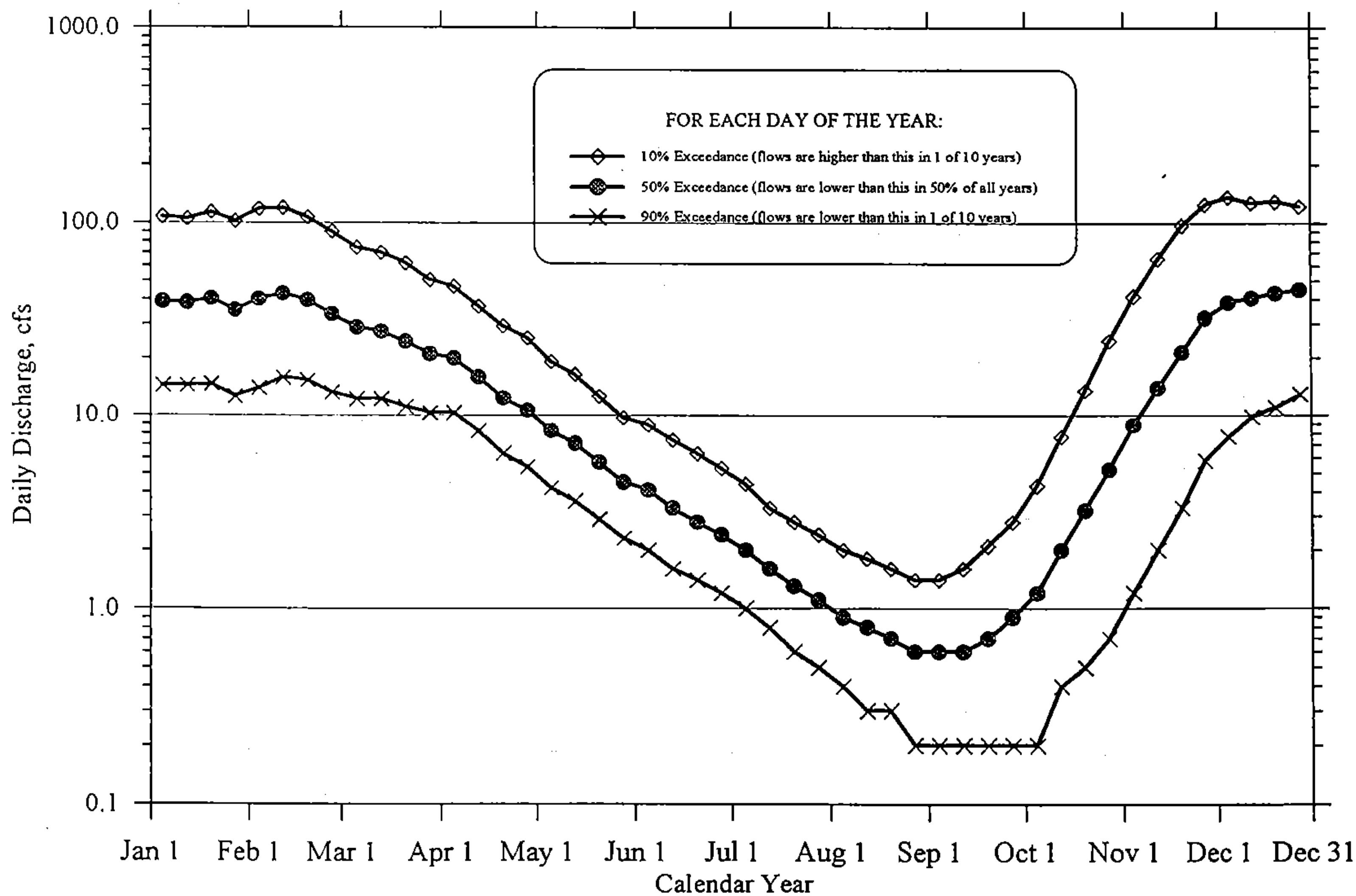


EXHIBIT C-4
Flow Exceedance Probabilities
Tahuya River near Bremerton

Kitsap County
Initial Basin Assessment

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	**Creek Name**	**Date**	**Stage (ft)**	**Flow (cfs)**	**Measurer**
WY95					
1	Anderson Creek (#096)	10/14/94	0.37	4.68	KPUD/JRL
2	Anderson Creek (#096)	10/26/94	0.42	6.91	KPUD/JRL
3	Anderson Creek (#096)	11/29/94	0.79	49.92	KPUD/JRL
4	Anderson Creek (#096)	12/1/94	0.93	81.88	KPUD/JRL
5	Anderson Creek (#096)	3/20/95	0.77	42.95	KPUD/JRL
WY96					
6	Anderson Creek (#096)	2/28/96	0.60	16.54	KPUD/JRL
7	Anderson Creek (#096)	3/7/96	0.55	11.54	KPUD/JRL
8	Anderson Creek (#096)	3/11/96	0.58	15.49	KPUD/MM
9	Anderson Creek (#096)	3/26/96	0.49	6.80	KPUD/MM
10	Anderson Creek (#096)	4/1/96	0.57	12.69	KPUD/MM
11	Anderson Creek (#096)	5/30/96	0.49	7.68	KPUD/MM
12	Anderson Creek (#096)	6/24/96	0.47	5.04	KPUD/MM
13	Anderson Creek (#096)	7/31/96	0.45	4.52	KPUD/MM
14	Anderson Creek (#096)	9/5/96	0.46	4.44	KPUD/MM
15	Anderson Creek (#096)	9/30/96	0.46	4.10	KPUD/MM
WY97					
16	Anderson Creek (#096)	10/30/96	0.50	7.33	KPUD/MM
17	Anderson Creek (#096)	11/26/96	0.60	16.44	KPUD/MM
18	Anderson Creek (#096)	12/25/96	0.87	57.84	KPUD/MM
19	Anderson Creek (#096)	1/8/97	0.72	24.50	KPUD/MM
WY92					
1	Anderson Creek (#272)	1/24/91	0.24	4.75	KPUD/JRL
2	Anderson Creek (#272)	2/4/91	0.90	21.31	KPUD/JRL
3	Anderson Creek (#272)	3/13/91	0.38	8.22	KPUD/JRL
4	Anderson Creek (#272)	4/23/91	0.30	5.47	KPUD/JRL
5	Anderson Creek (#272)	6/19/91	0.22	4.19	KPUD/JRL
6	Anderson Creek (#272)	7/19/91	0.20	3.75	KPUD/JRL
WY93					
7	Anderson Creek (#272)	11/20/91	0.40	8.03	TRIBE
8	Anderson Creek (#272)	1/8/92	0.30	5.11	TRIBE
9	Anderson Creek (#272)	1/23/92	0.53	12.81	TRIBE
10	Anderson Creek (#272)	3/4/92	0.33	5.83	TRIBE
11	Anderson Creek (#272)	9/17/92	0.18	3.24	TRIBE
WY94					
12	Anderson Creek (#272)	3/22/93	0.26	4.92	TRIBE
13	Anderson Creek (#272)	10/11/93	0.25	3.14	TRIBE
14	Anderson Creek (#272)	11/4/93	0.18	3.36	TRIBE
15	Anderson Creek (#272)	12/13/93	0.30	5.95	TRIBE
16	Anderson Creek (#272)	1/20/94	0.18	2.68	TRIBE
17	Anderson Creek (#272)	2/10/94	0.20	3.26	TRIBE
18	Anderson Creek (#272)	2/18/94	0.48	10.15	TRIBE
19	Anderson Creek (#272)	7/28/94	0.18	3.40	TRIBE
WY95					
20	Anderson Creek (#272)	12/28/94	1.20	31.42	TRIBE
21	Anderson Creek (#272)	1/10/95	NO GAGE	9.55	TRIBE
WY96					
1	Anderson Creek (#272)	11/2/95	0.70	3.05	BWU
2	Anderson Creek (#272)	11/30/95	1.18	16.57	BWU

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
3	Anderson Creek (#272)	1/11/96	0.82	7.71	BWU
4	Anderson Creek (#272)	2/27/96	0.85	7.53	KPUD/JRL
5	Anderson Creek (#272)	3/1/96	0.80	7.79	BWU
6	Anderson Creek (#272)	3/5/96	0.81	6.33	KPUD/JRL
7	Anderson Creek (#272)	3/11/96	0.83	6.87	KPUD/JRL
8	Anderson Creek (#272)	4/25/96	0.95	12.21	KPUD/JRL
9	Anderson Creek (#272)	5/27/96	0.71	4.99	KPUD/JRL
10	Anderson Creek (#272)	6/28/96	0.69	3.84	KPUD/JRL
11	Anderson Creek (#272)	7/29/96	0.69	3.26	KPUD/JRL
12	Anderson Creek (#272)	9/4/96	0.72	3.06	KPUD/JRL
13	Anderson Creek (#272)	9/6/96	0.70	3.09	KPUD/MM
14	Anderson Creek (#272)	9/26/96	0.70	2.94	KPUD/MM
WY97					
15	Anderson Creek (#272)	11/6/96	0.71	2.94	KPUD/JRL
16	Anderson Creek (#272)	12/2/96	0.81	5.91	KPUD/JRL
17	Anderson Creek (#272)	12/4/96	0.91	9.74	KPUD/JRL
18	Anderson Creek (#272)	1/8/97	0.92	9.65	KPUD/JRL
WY91					
1	Barker Creek (#245)	1/15/91	1.32	8.32	TRIBE
2	Barker Creek (#245)	2/4/91	2.26	67.89	TRIBE
3	Barker Creek (#245)	4/5/91	1.66	24.50	TRIBE
4	Barker Creek (#245)	6/17/91	1.12	5.46	KPUD/JRL
5	Barker Creek (#245)	8/16/91	1.50	3.03	TRIBE
WY92					
6	Barker Creek (#245)	11/1/91	2.00	3.86	TRIBE
7	Barker Creek (#245)	11/19/91	1.80	35.98	TRIBE
8	Barker Creek (#245)	1/9/92	1.10	4.38	TRIBE
9	Barker Creek (#245)	1/23/92	1.50	25.19	TRIBE
10	Barker Creek (#245)	1/29/92	2.00	60.75	TRIBE
11	Barker Creek (#245)	2/26/92	1.00	9.08	TRIBE
12	Barker Creek (#245)	3/18/92	1.00	6.61	TRIBE
13	Barker Creek (#245)	3/26/92	1.01	5.32	TRIBE
14	Barker Creek (#245)	4/14/92	1.00	4.70	TRIBE
15	Barker Creek (#245)	4/24/92	0.98	4.25	TRIBE
16	Barker Creek (#245)	6/8/92	0.90	3.38	TRIBE
17	Barker Creek (#245)	7/21/92	0.90	3.45	TRIBE
18	Barker Creek (#245)	8/7/92	0.92	3.54	TRIBE
WY93					
19	Barker Creek (#245)	1/20/93	1.62	43.62	TRIBE
20	Barker Creek (#245)	4/28/93	0.92	6.96	TRIBE
21	Barker Creek (#245)	7/26/93	0.82	2.75	TRIBE
22	Barker Creek (#245)	8/26/93	0.80	2.54	TRIBE
WY94					
23	Barker Creek (#245)	10/11/93	0.98	2.81	TRIBE
24	Barker Creek (#245)	12/13/93	3.00	16.10	TRIBE
25	Barker Creek (#245)	1/5/94	1.00	8.16	KPUD/JRL
26	Barker Creek (#245)	1/20/94	0.84	4.59	TRIBE
27	Barker Creek (#245)	2/10/94	0.82	4.75	TRIBE
28	Barker Creek (#245)	2/18/94	1.10	15.59	TRIBE
29	Barker Creek (#245)	2/23/94	1.20	5.77	TRIBE
30	Barker Creek (#245)	3/24/94	0.90	6.69	TRIBE

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
31	Barker Creek (#245)	5/5/94	0.80	4.60	TRIBE
32	Barker Creek (#245)	5/18/94	0.70	3.17	USGS/DTS
33	Barker Creek (#245)	7/20/94	0.75	2.15	USGS/DTS
34	Barker Creek (#245)	9/20/94	0.75	2.29	USGS/DTS
WY95					
35	Barker Creek (#245)	10/26/94	0.94	5.82	USGS/DTS
36	Barker Creek (#245)	12/28/94	1.15	29.74	TRIBE
37	Barker Creek (#245)	1/3/95	0.48	5.83	USGS/DTS
38	Barker Creek (#245)	1/10/95	1.10	20.02	TRIBE
39	Barker Creek (#245)	2/9/95	0.56	6.18	USGS/DTS
40	Barker Creek (#245)	3/22/95	0.84	14.99	KPUD/JRL
41	Barker Creek (#245)	3/30/95	0.60	4.85	USGS/DTS
42	Barker Creek (#245)	4/24/95	0.55	4.82	USGS/DTS
43	Barker Creek (#245)	5/16/95	0.49	3.33	USGS/DTS
44	Barker Creek (#245)	6/12/95	0.49	3.14	USGS/DTS
45	Barker Creek (#245)	6/22/95	0.50	3.60	KPUD/JRL
46	Barker Creek (#245)	7/17/95	0.48	2.55	USGS/DTS
47	Barker Creek (#245)	8/23/95	0.50	2.88	USGS/DTS
48	Barker Creek (#245)	9/12/95	0.50	2.99	USGS/DTS
WY96					
49	Barker Creek (#245)	11/1/95	0.51	3.13	USGS/DTS
50	Barker Creek (#245)	2/8/96	2.65	73.40	USGS/KPUD
51	Barker Creek (#245)	4/8/96	0.70	5.80	KPUD/JRL
52	Barker Creek (#245)	4/25/96	1.25	20.01	KPUD/JRL
53	Barker Creek (#245)	6/27/96	0.49	3.90	KPUD/JRL
54	Barker Creek (#245)	8/12/96	0.47	3.21	KPUD/JRL
55	Barker Creek (#245)	9/3/96	0.475	2.94	KPUD/JRL
WY97					
56	Barker Creek (#245)	11/7/96	0.52	3.78	KPUD/JRL
WY93					
1	Blackjack Creek (#279)	1/26/93	0.95	53.63	TRIBE
2	Blackjack Creek (#279)	3/15/93	0.34	14.27	TRIBE
3	Blackjack Creek (#279)	3/22/93	0.52	30.59	TRIBE
4	Blackjack Creek (#279)	4/26/93	0.64	37.25	TRIBE
5	Blackjack Creek (#279)	7/26/93	0.20	7.81	TRIBE
6	Blackjack Creek (#279)	9/13/93	0.20	7.75	TRIBE
7	Blackjack Creek (#279)	9/24/93	0.20	7.76	TRIBE
WY94					
8	Blackjack Creek (#279)	10/7/93	0.20	8.54	TRIBE
9	Blackjack Creek (#279)	11/4/93	0.16	6.04	TRIBE
10	Blackjack Creek (#279)	12/9/93	0.60	23.37	TRIBE
11	Blackjack Creek (#279)	1/4/94	1.06	45.45	TRIBE
12	Blackjack Creek (#279)	1/12/94	0.40	15.82	TRIBE
13	Blackjack Creek (#279)	2/17/94	1.16	77.22	TRIBE
14	Blackjack Creek (#279)	2/23/94	0.80	42.24	TRIBE
15	Blackjack Creek (#279)	3/10/94	0.54	17.70	TRIBE
16	Blackjack Creek (#279)	3/24/94	0.56	26.18	TRIBE
17	Blackjack Creek (#279)	4/8/94	0.82	45.70	TRIBE
18	Blackjack Creek (#279)	6/17/94	0.34	12.35	TRIBE
19	Blackjack Creek (#279)	7/28/94	0.30	10.30	TRIBE
20	Blackjack Creek (#279)	9/13/94	0.30	9.08	TRIBE

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
WY96					
21	Blackjack Creek (#279)	4/9/96	0.76	18.45	KPUD/MM
22	Blackjack Creek (#279)	5/21/96	0.98	21.48	KPUD/MM
23	Blackjack Creek (#279)	9/6/96	0.80	9.80	KPUD/MM *
24	Blackjack Creek (#279)	9/16/96	0.90	13.24	KPUD/MM
25	Blackjack Creek (#279)	9/26/96	0.80	8.08	KPUD/MM
WY97					
26	Blackjack Creek (#279)	10/28/96	0.90	14.31	KPUD/MM
27	Blackjack Creek (#279)	11/25/96	1.06	25.35	KPUD/MM
28	Blackjack Creek (#279)	12/4/96	1.64	56.37	KPUD/MM
29	Blackjack Creek (#279)	1/9/97	2.33	48.37	KPUD/MM /JRL
WY91					
1	Burley Creek (#356)	10/18/90	0.91	19.02	KPUD/JRL
2	Burley Creek (#356)	11/30/90	0.94	26.74	KPUD/JRL
3	Burley Creek (#356)	1/8/91	1.24	44.20	KPUD/JRL
4	Burley Creek (#356)	3/13/91	1.02	32.91	KPUD/JRL
5	Burley Creek (#356)	4/16/91	0.94	30.91	KPUD/JRL
6	Burley Creek (#356)	6/17/91	0.78	21.82	KPUD/JRL
7	Burley Creek (#356)	7/18/91	0.68	17.49	KPUD/JRL
WY92					
8	Burley Creek (#356)	1/27/92	2.20	129.14	KPUD/JRL
9	Burley Creek (#356)	1/31/92	2.00	109.67	KPUD/JRL
WY96					
10	Burley Creek (#356)	2/28/96	0.96	31.73	KPUD/JRL
11	Burley Creek (#356)	4/10/96	0.82	27.56	KPUD/MM&JRL
12	Burley Creek (#356)	4/15/96	0.90	30.72	KPUD/MM&JRL
13	Burley Creek (#356)	5/30/96	0.76	26.06	KPUD/MM
14	Burley Creek (#356)	6/13/96	0.70	22.35	KPUD/MM
15	Burley Creek (#356)	9/3/96	0.62	19.52	KPUD/MM
16	Burley Creek (#356)	9/23/96	0.62	18.20	KPUD/MM
17	Burley Creek (#356)	9/26/96	0.60	17.73	KPUD/MM
WY97					
18	Burley Creek (#356)	10/28/96	0.90	31.49	KPUD/MM
19	Burley Creek (#356)	11/25/96	1.10	34.56	KPUD/MM
20	Burley Creek (#356)	12/4/96	1.52	71.17	KPUD/MM
21	Burley Creek (#356)	1/6/97	1.20	43.65	KPUD/MM
WY91					
1	Chico Creek (#259)	3/7/91	1.00	79.40	KPUD/JRL
2	Chico Creek (#259)	4/23/91	0.30	29.62	KPUD/JRL
WY92					
3	Chico Creek (#259)	1/27/92	2.10	186.70	KPUD/JRL
4	Chico Creek (#259)	3/4/92	0.40	45.60	TRIBE
5	Chico Creek (#259)	3/19/92	0.52	22.74	TRIBE
6	Chico Creek (#259)	3/27/92	0.50	17.35	TRIBE
7	Chico Creek (#259)	4/14/92	0.42	14.91	TRIBE
8	Chico Creek (#259)	4/24/92	0.48	16.64	TRIBE
WY93					
9	Chico Creek (#259)	3/11/93	0.52	18.79	TRIBE
10	Chico Creek (#259)	3/23/93	1.50	110.31	TRIBE

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
11	Chico Creek (#259)	4/28/93	1.40	68.27	TRIBE
WY94					
12	Chico Creek (#259)	1/13/94	0.85	47.59	TRIBE
13	Chico Creek (#259)	2/18/94	1.90	184.10	TRIBE
14	Chico Creek (#259)	3/10/94	0.82	56.71	TRIBE
WY95					
15	Chico Creek (#259)	12/21/94	3.00	356.43	TRIBE
16	Chico Creek (#259)	1/10/95	1.10	116.89	TRIBE
17	Chico Creek (#259)	6/23/95	<0	5.85	KPUD/JRL
WY96					
18	Chico Creek (#259)	3/5/96	0.04	41.28	KPUD/JRL
19	Chico Creek (#259)	4/8/96	-0.22	20.35	KPUD/JRL
WY91					
1	Clear Creek (#246)	10/18/90	0.93	4.39	KPUD/JRL
2	Clear Creek (#246)	11/28/90	1.13	6.51	KPUD/JRL
3	Clear Creek (#246)	12/5/90	1.80	20.14	KPUD/JRL
4	Clear Creek (#246)	1/4/91	3.92	133.94	KPUD/JRL
5	Clear Creek (#246)	3/11/91	0.95	7.18	KPUD/JRL
6	Clear Creek (#246)	4/23/91	0.91	5.90	KPUD/JRL
7	Clear Creek (#246)	6/19/91	0.80	3.79	KPUD/JRL
8	Clear Creek (#246)	7/18/91	1.47	2.89	KPUD/JRL
WY92					
9	Clear Creek (#246)	3/19/92	0.72	8.10	TRIBE
10	Clear Creek (#246)	3/26/92	0.70	5.49	TRIBE
11	Clear Creek (#246)	4/12/92	1.02	6.19	TRIBE
12	Clear Creek (#246)	4/22/92	0.99	4.86	TRIBE
13	Clear Creek (#246)	5/28/92	0.90	3.86	TRIBE
14	Clear Creek (#246)	6/5/92	0.90	3.38	TRIBE
15	Clear Creek (#246)	6/25/92	0.79	3.08	TRIBE
16	Clear Creek (#246)	7/16/92	0.60	3.39	TRIBE
17	Clear Creek (#246)	8/7/92	1.36	3.02	TRIBE
18	Clear Creek (#246)	8/19/92	0.60	2.58	TRIBE
19	Clear Creek (#246)	9/17/92	0.64	3.53	TRIBE
WY93					
20	Clear Creek (#246)	12/11/92	1.20	15.72	TRIBE
21	Clear Creek (#246)	3/11/93	0.70	5.40	TRIBE
22	Clear Creek (#246)	3/23/93	1.26	20.22	TRIBE
23	Clear Creek (#246)	4/26/93	1.08	22.33	TRIBE
WY94					
24	Clear Creek (#246)	10/11/93	0.66	3.85	TRIBE
25	Clear Creek (#246)	1/4/94	2.40	48.85	TRIBE
26	Clear Creek (#246)	2/10/94	0.74	5.98	TRIBE
27	Clear Creek (#246)	2/18/94	1.60	22.04	TRIBE
28	Clear Creek (#246)	2/23/94	0.86	6.54	TRIBE
29	Clear Creek (#246)	3/10/94	0.80	9.07	TRIBE
30	Clear Creek (#246)	4/8/94	1.62	31.51	TRIBE
31	Clear Creek (#246)	5/17/94	0.74	3.78	USGS/DTS
32	Clear Creek (#246)	6/2/94	0.70	4.29	TRIBE
33	Clear Creek (#246)	7/14/94	0.70	3.21	TRIBE
34	Clear Creek (#246)	7/20/94	0.66	2.37	USGS/DTS
35	Clear Creek (#246)	7/28/94	0.60	2.97	TRIBE

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
36	Clear Creek (#246)	9/21/94	0.65	2.62	USGS/DTS
WY95					
37	Clear Creek (#246)	10/26/94	1.18	13.20	USGS/DTS
38	Clear Creek (#246)	12/28/94	2.30	57.70	TRIBE
39	Clear Creek (#246)	1/5/95	0.88	5.63	USGS/DTS
40	Clear Creek (#246)	1/10/95	1.80	33.71	TRIBE
41	Clear Creek (#246)	2/9/95	0.91	6.40	USGS/DTS
42	Clear Creek (#246)	3/29/95	0.95	8.39	USGS/DTS
43	Clear Creek (#246)	4/24/95	0.85	5.90	USGS/DTS
44	Clear Creek (#246)	5/16/95	0.76	4.64	USGS/DTS
45	Clear Creek (#246)	6/2/95	0.74	3.73	USGS/DTS
46	Clear Creek (#246)	6/19/95	0.76	4.15	KPUD/JRL
47	Clear Creek (#246)	7/19/95	0.70	2.89	USGS/DTS
48	Clear Creek (#246)	8/24/95	0.72	3.58	USGS/DTS
49	Clear Creek (#246)	9/12/95	0.77	4.09	USGS/DTS
WY96					
50	Clear Creek (#246)	11/1/95	0.76	3.48	USGS/DTS
51	Clear Creek (#246)	4/8/96	0.82	6.05	KPUD/JRL
52	Clear Creek (#246)	5/27/96	1.07	14.34	KPUD/JRL
53	Clear Creek (#246)	6/27/96	0.69	4.24	KPUD/JRL
54	Clear Creek (#246)	7/29/96	0.61	3.07	KPUD/JRL
55	Clear Creek (#246)	9/3/96	0.65	3.65	KPUD/JRL
WY97					
56	Clear Creek (#246)	11/7/96	0.68	4.68	KPUD/JRL
57	Clear Creek (#246)	1/7/97	1.40	13.54	KPUD/JRL
WY94					
1	Devils Hole #134	9/15/94	3.20	2.76	USGS/DTS
2	Devils Hole #134	9/21/94	3.24	2.66	USGS/DTS
WY95					
3	Devils Hole #134	10/4/94	3.13	2.61	USGS/DTS
4	Devils Hole #134	10/27/94	3.75	6.78	USGS/DTS
5	Devils Hole #134	11/30/94	4.66	17.00	USGS/DTS
6	Devils Hole #134	11/30/94	4.74	18.50	USGS/DTS
7	Devils Hole #134	12/1/94	4.13	9.91	USGS/DTS
8	Devils Hole #134	12/13/94	3.48	4.97	USGS/DTS
9	Devils Hole #134	1/5/95	3.51	4.87	USGS/DTS
10	Devils Hole #134	1/18/95	4.01	8.87	USGS/DTS
11	Devils Hole #134	1/31/95	4.82	21.10	USGS/DTS
12	Devils Hole #134	2/17/95	5.40	51.40	USGS/DTS
13	Devils Hole #134	3/29/95	3.60	5.32	USGS/DTS
14	Devils Hole #134	5/17/95	3.35	3.74	USGS/DTS
15	Devils Hole #134	7/17/95	3.28	3.20	USGS/DTS
16	Devils Hole #134	8/11/95	3.34	3.60	USGS/DTS
WY96					
17	Devils Hole #134	11/1/95	3.30	3.53	USGS/DTS
18	Devils Hole #134	3/27/96	3.42	4.25	USGS/DTS
WY97					
WY91					
1	Dogfish Creek (#207)	10/18/90	0.18	5.25	KPUD/JRL

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
2	Dogfish Creek (#207)	12/5/90	0.34	13.82	KPUD/JRL
3	Dogfish Creek (#207)	1/8/91	0.39	14.97	KPUD/JRL
4	Dogfish Creek (#207)	2/2/91	1.31	69.09	KPUD/JRL
5	Dogfish Creek (#207)	3/11/91	0.24	10.36	KPUD/JRL
6	Dogfish Creek (#207)	4/17/91	0.16	6.87	KPUD/JRL
7	Dogfish Creek (#207)	6/19/91	0.10	3.94	KPUD/JRL
8	Dogfish Creek (#207)	7/25/91	0.10	5.51	KPUD/JRL
9	Dogfish Creek (#207)	8/16/91	0.02	3.75	TRIBE
10	Dogfish Creek (#207)	9/23/91	0.08	4.51	TRIBE
WY92					
11	Dogfish Creek (#207)	11/19/91	0.45	18.76	KPUD/JRL
12	Dogfish Creek (#207)	11/20/91	0.30	13.20	TRIBE
13	Dogfish Creek (#207)	1/10/92	0.45	14.61	TRIBE
14	Dogfish Creek (#207)	1/29/92	0.90	62.26	TRIBE
15	Dogfish Creek (#207)	2/12/92	0.26	8.97	TRIBE
16	Dogfish Creek (#207)	2/26/92	0.26	10.70	TRIBE
WY93					
17	Dogfish Creek (#207)	12/11/92	0.38	14.94	TRIBE
18	Dogfish Creek (#207)	1/20/93	1.10	58.73	TRIBE
19	Dogfish Creek (#207)	2/24/93	0.25	10.65	TRIBE
20	Dogfish Creek (#207)	3/5/93	0.22	9.48	TRIBE
21	Dogfish Creek (#207)	4/26/93	0.28	11.30	TRIBE
22	Dogfish Creek (#207)	9/13/93	0.18	3.24	TRIBE
WY94					
23	Dogfish Creek (#207)	1/5/94	0.98	40.18	TRIBE
24	Dogfish Creek (#207)	1/13/94	0.32	11.45	TRIBE
25	Dogfish Creek (#207)	2/9/94	0.16	6.02	TRIBE
26	Dogfish Creek (#207)	2/17/94	0.80	42.44	TRIBE
27	Dogfish Creek (#207)	2/23/94	0.18	5.92	TRIBE
28	Dogfish Creek (#207)	3/24/94	0.12	7.43	TRIBE
29	Dogfish Creek (#207)	4/17/94	0.04	4.16	TRIBE
30	Dogfish Creek (#207)	5/5/94	0.10	6.74	TRIBE
31	Dogfish Creek (#207)	5/18/94	0.06	4.36	USGS/DTS
32	Dogfish Creek (#207)	7/19/94	-0.01	2.52	USGS/DTS
33	Dogfish Creek (#207)	9/20/94	0.02	2.61	USGS/DTS
WY95					
34	Dogfish Creek (#207)	10/5/94	0.03	2.64	KPUD/JRL
35	Dogfish Creek (#207)	10/5/94	0.03	2.61	USGS/DTS
36	Dogfish Creek (#207)	10/25/94	0.02	2.61	USGS/DTS
37	Dogfish Creek (#207)	12/28/94	0.85	40.68	TRIBE
38	Dogfish Creek (#207)	1/4/95	0.24	6.69	USGS/DTS
39	Dogfish Creek (#207)	1/10/95	1.00	30.29	TRIBE
40	Dogfish Creek (#207)	2/19/95	0.23	6.64	USGS/DTS
41	Dogfish Creek (#207)	3/22/95	0.41	16.40	KPUD/JRL
42	Dogfish Creek (#207)	3/29/95	0.21	8.22	USGS/DTS
43	Dogfish Creek (#207)	4/24/95	0.16	6.19	USGS/DTS
44	Dogfish Creek (#207)	5/16/95	0.10	4.06	USGS/DTS
45	Dogfish Creek (#207)	6/12/95	0.09	3.40	USGS/DTS
46	Dogfish Creek (#207)	6/19/95	0.10	3.97	KPUD/JRL
47	Dogfish Creek (#207)	7/17/95	0.06	2.56	USGS/DTS
48	Dogfish Creek (#207)	8/24/95	0.06	3.66	USGS/DTS
49	Dogfish Creek (#207)	9/12/95	0.06	3.48	USGS/DTS
WY96					

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
50	Dogfish Creek (#207)	10/31/95	0.15	3.28	USGS/DTS
51	Dogfish Creek (#207)	2/23/96	0.25	10.44	KPUD/JRL
	Dogfish Creek (#207)	4/23/96	3.83	E 200	SURVEY/DTS
52	Dogfish Creek (#207)	4/25/96	0.58	27.13	KPUD/JRL
53	Dogfish Creek (#207)	4/30/96	0.21	8.24	KPUD/JRL
54	Dogfish Creek (#207)	5/23/96	0.31	12.78	KPUD/JRL
55	Dogfish Creek (#207)	6/28/96	0.07	3.91	KPUD/JRL
56	Dogfish Creek (#207)	8/1/96	0.035	3.26	KPUD/BKCHD
57	Dogfish Creek (#207)	8/1/96	0.035	3.27	KPUD/KEITH F.
58	Dogfish Creek (#207)	8/29/96	0.03	2.97	KPUD/JRL
59	Dogfish Creek (#207)	9/30/96	0.06	3.54	KPUD/JRL
WY97					
60	Dogfish Creek (#207)	10/8/96	0.14	3.90	KPUD/MM/JRL
61	Dogfish Creek (#207)	12/2/96	0.60	24.78	KPUD/JRL
62	Dogfish Creek (#207)	12/4/96	0.93	50.71	KPUD/JRL
63	Dogfish Creek (#207)	1/3/97	0.94	48.06	KPUD/MM
64	Dogfish Creek (#207)	1/17/97	0.64	26.05	KPUD/MM/JRL
WY94					
1	Gamble Creek #158	5/17/94	4.04	1.55	USGS/DTS
2	Gamble Creek #158	5/25/94	3.87	0.92	USGS/DTS
3	Gamble Creek #158	6/16/94	3.89	0.80	USGS/DTS
4	Gamble Creek #158	7/19/94	3.69	0.62	USGS/DTS
5	Gamble Creek #158	7/28/94	3.65	0.57	USGS/DTS
6	Gamble Creek #158	9/20/94	3.77	0.67	USGS/DTS
WY95					
7	Gamble Creek #158	10/25/94	4.02	0.74	USGS/DTS
8	Gamble Creek #158	10/27/94	4.22	2.46	USGS/DTS
9	Gamble Creek #158	11/30/94	5.13	14.60	USGS/DTS
10	Gamble Creek #158	12/1/94	4.49	4.67	USGS/DTS
11	Gamble Creek #158	12/14/94	4.19	1.83	USGS/DTS
12	Gamble Creek #158	12/20/94	8.27	99.10	USGS/DTS
13	Gamble Creek #158	12/20/94	7.46	79.70	USGS/DTS
14	Gamble Creek #158	12/27/94	7.19	84.30	USGS/DTS
15	Gamble Creek #158	1/5/95	4.26	2.13	USGS/DTS
16	Gamble Creek #158	1/18/95	4.55	7.03	USGS/DTS
17	Gamble Creek #158	1/31/95	5.48	31.90	USGS/DTS
18	Gamble Creek #158	2/9/95	4.31	3.92	USGS/DTS
19	Gamble Creek #158	2/17/95	5.67	35.20	USGS/DTS
20	Gamble Creek #158	2/23/95	4.58	7.43	USGS/DTS
21	Gamble Creek #158	3/21/95	4.76	9.54	USGS/DTS
22	Gamble Creek #158	3/30/95	4.40	4.52	USGS/DTS
23	Gamble Creek #158	4/25/95	4.27	2.83	USGS/DTS
24	Gamble Creek #158	5/23/95	4.10	1.50	USGS/DTS
25	Gamble Creek #158	6/13/95	4.08	1.57	USGS/DTS
26	Gamble Creek #158	6/20/95	4.07	1.46	USGS/DTS
27	Gamble Creek #158	7/10/95	4.07	1.37	USGS/DTS
28	Gamble Creek #158	7/18/95	4.01	0.93	USGS/DTS
29	Gamble Creek #158	8/2/95	3.94	0.72	USGS/DTS
30	Gamble Creek #158	8/2/95	3.97	0.77	USGS/DTS
31	Gamble Creek #158	8/11/95	4.25	2.92	USGS/DTS
32	Gamble Creek #158	8/24/95	4.09	1.11	USGS/DTS

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
33	Gamble Creek #158	9/21/95	4.00	0.75	USGS/DTS
WY96					
34	Gamble Creek #158	10/6/95	4.11	1.20	USGS/DTS
35	Gamble Creek #158	10/17/95	4.19	1.61	USGS/DTS
36	Gamble Creek #158	10/31/95	4.15	1.02	USGS/DTS
37	Gamble Creek #158	11/8/95	4.78	9.35	USGS/DTS
38	Gamble Creek #158	12/1/95	4.33	3.01	USGS/DTS
39	Gamble Creek #158	12/12/95	5.45	24.30	USGS/DTS
40	Gamble Creek #158	12/14/95	5.39	21.40	USGS/DTS
41	Gamble Creek #158	1/9/96	4.57	6.51	USGS/DTS
42	Gamble Creek #158	2/8/96	5.72	30.20	USGS/KPUD
43	Gamble Creek #158	3/13/96	4.34	3.22	USGS/DTS
44	Gamble Creek #158	4/11/96	4.27	2.38	USGS/DTS
45	Gamble Creek #158	6/18/96	4.15	1.90	KPUD/JRL
46	Gamble Creek #158	7/24/96	4.07	1.31	KPUD/JRL
47	Gamble Creek #158	8/28/96	4.06	1.07	KPUD/JRL
48	Gamble Creek #158	9/30/96	4.13	1.22	KPUD/JRL
WY97					
49	Gamble Creek #158	11/25/96	4.35	3.02	KPUD/JRL
50	Gamble Creek #158	1/6/97	4.88	11.47	KPUD/JRL
WY91					
1	Gorst Creek (#268)	10/18/90	0.80	9.66	KPUD/JRL
2	Gorst Creek (#268)	11/30/90	0.87	30.13	KPUD/JRL
3	Gorst Creek (#268)	1/8/91	0.84	33.40	KPUD/JRL
4	Gorst Creek (#268)	2/4/91	2.10	192.29	KPUD/JRL
5	Gorst Creek (#268)	3/13/91	0.90	32.51	KPUD/JRL
6	Gorst Creek (#268)	4/16/91	0.85	31.38	KPUD/JRL
7	Gorst Creek (#268)	6/17/91	0.80	14.66	KPUD/JRL
8	Gorst Creek (#268)	7/25/91	0.68	12.40	KPUD/JRL
WY92					
9	Gorst Creek (#268)	11/20/91	1.00	55.17	TRIBE
10	Gorst Creek (#268)	12/2/91	0.70	11.45	TRIBE
11	Gorst Creek (#268)	1/23/92	1.23	81.31	TRIBE
WY93					
12	Gorst Creek (#268)	1/26/93	1.00	56.91	TRIBE
13	Gorst Creek (#268)	3/4/93	0.78	23.51	TRIBE
14	Gorst Creek (#268)	3/15/93	0.60	15.17	TRIBE
15	Gorst Creek (#268)	3/22/93	0.82	34.50	TRIBE
16	Gorst Creek (#268)	3/23/93	1.08	62.56	TRIBE
17	Gorst Creek (#268)	4/2/93	0.64	16.11	TRIBE
WY94					
18	Gorst Creek (#268)	10/7/93	0.65	9.64	TRIBE
19	Gorst Creek (#268)	11/4/93	1.00	10.18	TRIBE
20	Gorst Creek (#268)	12/9/93	1.41	25.77	TRIBE
21	Gorst Creek (#268)	1/5/94	1.40	47.09	TRIBE
22	Gorst Creek (#268)	1/13/94	0.80	20.76	TRIBE
23	Gorst Creek (#268)	2/18/94	1.20	60.13	TRIBE
24	Gorst Creek (#268)	9/13/94	0.28	8.99	TRIBE
WY95					
25	Gorst Creek (#268)	1/9/95	1.00	39.19	TRIBE
26	Gorst Creek (#268)	6/21/95	0.80	14.87	KPUD/JRL

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
WY96					
27	Gorst Creek (#268)	4/9/96	0.86	19.62	KPUD/MM
28	Gorst Creek (#268)	5/21/96	0.77	20.70	KPUD/MM
29	Gorst Creek (#268)	6/26/96	0.64	15.41	KPUD/MM
30	Gorst Creek (#268)	9/3/96	0.59	13.25	KPUD/MM
31	Gorst Creek (#268)	9/30/96	0.56	11.03	KPUD/MM
WY97					
32	Gorst Creek (#268)	10/28/96	0.64	13.80	KPUD/MM
33	Gorst Creek (#268)	12/4/96	1.23	76.19	KPUD/MM
WY97					
1	Hansville Creek (#166)	10/23/96	1.74	0.56	KPUD/MM-MBS
2	Hansville Creek (#166)	11/26/96	1.74	0.57	KPUD/JRL
3	Hansville Creek (#166)	12/17/96	1.77	0.62	KPUD/JRL
4	Hansville Creek (#166)	1/6/97	1.93	0.88	KPUD/JRL
WY94					
1	Johnson Creek #208	5/17/94	0.96	1.01	USGS/DTS
2	Johnson Creek #208	5/24/94	0.90	1.04	USGS/DTS
3	Johnson Creek #208	7/19/94	0.93	0.76	USGS/DTS
4	Johnson Creek #208	7/26/94	0.94	0.71	USGS/DTS
5	Johnson Creek #208	9/20/94	0.91	0.73	USGS/DTS
WY95					
6	Johnson Creek #208	10/4/94	0.84	0.61	USGS/DTS
7	Johnson Creek #208	10/25/94	0.86	0.72	USGS/DTS
8	Johnson Creek #208	10/26/94	0.99	1.48	USGS/DTS
9	Johnson Creek #208	10/26/94	1.45	11.90	USGS/DTS
10	Johnson Creek #208	11/10/94	0.98	1.32	USGS/DTS
11	Johnson Creek #208	11/30/94	1.49	8.34	USGS/DTS
12	Johnson Creek #208	12/1/94	1.18	2.12	USGS/DTS
13	Johnson Creek #208	12/13/94	1.03	1.60	USGS/DTS
14	Johnson Creek #208	12/19/94	2.14	41.70	USGS/DTS
15	Johnson Creek #208	12/20/94	1.92	32.80	USGS/DTS
16	Johnson Creek #208	12/27/94	2.12	52.80	USGS/DTS
17	Johnson Creek #208	1/4/95	0.81	1.61	USGS/DTS
18	Johnson Creek #208	1/19/95	0.98	3.26	USGS/DTS
19	Johnson Creek #208	1/31/95	1.54	16.40	USGS/DTS
20	Johnson Creek #208	2/8/95	0.89	1.78	USGS/DTS
21	Johnson Creek #208	2/23/95	1.05	3.31	USGS/DTS
22	Johnson Creek #208	3/21/95	1.17	4.59	USGS/DTS
23	Johnson Creek #208	3/28/95	0.90	2.25	USGS/DTS
24	Johnson Creek #208	5/3/95	0.80	1.37	USGS/DTS
25	Johnson Creek #208	5/17/95	0.73	1.09	USGS/DTS
26	Johnson Creek #208	6/14/95	0.72	1.05	USGS/DTS
27	Johnson Creek #208	7/18/95	0.65	0.77	USGS/DTS
28	Johnson Creek #208	8/2/95	0.66	0.85	USGS/DTS
29	Johnson Creek #208	8/24/95	0.72	1.03	USGS/DTS
30	Johnson Creek #208	9/14/95	0.69	0.92	USGS/DTS
WY96					
31	Johnson Creek #208	10/17/95	0.80	1.23	USGS/DTS
32	Johnson Creek #208	11/8/95	1.23	5.77	USGS/DTS

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
33	Johnson Creek #208	12/12/95	1.64	17.30	USGS/DTS
34	Johnson Creek #208	1/9/96	1.01	2.56	USGS/DTS
35	Johnson Creek #208	2/15/96	0.92	2.02	USGS/DTS
36	Johnson Creek #208	3/13/96	0.83	1.41	USGS/DTS
37	Johnson Creek #208	4/11/96	0.79	1.28	USGS/DTS
38	Johnson Creek #208	6/18/96	0.71	1.25	KPUD/JRL
39	Johnson Creek #208	8/6/96	0.67	0.95	KPUD/JRL
40	Johnson Creek #208	8/29/96	0.64	0.69	KPUD/JRL
WY97					
41	Johnson Creek #208	10/9/96	0.78	0.91	KPUD/JRL
42	Johnson Creek #208	11/18/96	0.78	1.37	KPUD/JRL
43	Johnson Creek #208	12/16/96	0.85	2.14	KPUD/JRL
44	Johnson Creek #208	1/8/97	0.76	4.46	KPUD/JRL
WY94					
1	Johnson Creek - N. Fork	5/17/94		0.33	USGS/DTS
2	Johnson Creek - N. Fork	5/24/94		0.21	USGS/DTS
3	Johnson Creek - N. Fork	7/19/94		0.06	USGS/DTS
4	Johnson Creek - N. Fork	7/26/94		0.04	USGS/DTS
5	Johnson Creek - N. Fork	9/22/94	0.80	0.05	USGS/DTS
WY95					
6	Johnson Creek - N. Fork	10/7/94	0.82	0.07	USGS/DTS
7	Johnson Creek - N. Fork	10/25/94	0.82	0.09	USGS/DTS
8	Johnson Creek - N. Fork	10/26/94	1.35	7.03	USGS/DTS
9	Johnson Creek - N. Fork	11/17/94	1.11	1.02	USGS/DTS
10	Johnson Creek - N. Fork	11/30/94	1.37	8.79	USGS/DTS
11	Johnson Creek - N. Fork	12/1/94	1.15	1.21	USGS/DTS
12	Johnson Creek - N. Fork	12/13/94	1.05	0.68	USGS/DTS
13	Johnson Creek - N. Fork	12/19/94	2.11	26.60	USGS/DTS
14	Johnson Creek - N. Fork	12/20/94	1.86	20.30	USGS/DTS
15	Johnson Creek - N. Fork	12/22/94	1.27	3.46	USGS/DTS
16	Johnson Creek - N. Fork	12/27/94	2.13	31.10	USGS/DTS
17	Johnson Creek - N. Fork	1/4/95	1.13	1.14	USGS/DTS
18	Johnson Creek - N. Fork	1/19/95	1.18	1.79	USGS/DTS
19	Johnson Creek - N. Fork	1/31/95	1.50	10.30	USGS/DTS
20	Johnson Creek - N. Fork	2/8/95	1.11	1.02	USGS/DTS
21	Johnson Creek - N. Fork	2/23/95	1.20	1.69	USGS/DTS
22	Johnson Creek - N. Fork	3/21/95	1.27	2.91	USGS/DTS
23	Johnson Creek - N. Fork	3/28/95	1.13	1.11	USGS/DTS
24	Johnson Creek - N. Fork	4/25/95	1.06	0.54	USGS/DTS
25	Johnson Creek - N. Fork	5/17/95	1.00	0.34	USGS/DTS
26	Johnson Creek - N. Fork	6/14/95	0.92	0.17	USGS/DTS
27	Johnson Creek - N. Fork	7/18/95	0.85	0.07	USGS/DTS
28	Johnson Creek - N. Fork	8/24/95	0.93	0.16	USGS/DTS
29	Johnson Creek - N. Fork	9/14/95	0.88	0.12	USGS/DTS
WY96					
30	Johnson Creek - N. Fork	10/17/95	1.00	0.32	USGS/DTS
31	Johnson Creek - N. Fork	11/8/95	1.34	5.18	USGS/DTS
32	Johnson Creek - N. Fork	12/12/95	1.58	13.80	USGS/DTS
33	Johnson Creek - N. Fork	12/14/95	1.60	15.80	USGS/DTS
34	Johnson Creek - N. Fork	1/11/96	1.11	1.11	USGS/DTS
35	Johnson Creek - N. Fork	3/13/96	1.07	0.72	USGS/DTS

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
36	Johnson Creek - N. Fork	4/11/96	1.02	0.49	USGS/DTS
37	Johnson Creek - N. Fork	6/18/96	1.00	0.37	KPUD/JRL
38	Johnson Creek - N. Fork	8/1/96	0.865	0.10	KPUD/JRL
39	Johnson Creek - N. Fork	8/1/96	0.865	0.11	KPUD/MBS
40	Johnson Creek - N. Fork	8/28/96	0.85	0.09	KPUD/JRL
WY97					
41	Johnson Creek - N. Fork	10/9/96	0.89	0.14	KPUD/JRL
42	Johnson Creek - N. Fork	11/18/96	1.00	0.37	KPUD/JRL
43	Johnson Creek - N. Fork	12/16/96	1.09	1.03	KPUD/JRL
44	Johnson Creek - N. Fork	1/7/97	1.19	2.63	KPUD/JRL
WY94					
1	Olalla Creek #313	10/4/93	1.31	4.05	KPUD/JRL
2	Olalla Creek #313	10/14/93	1.52	3.44	VOLUNTEER
3	Olalla Creek #313	10/15/93	1.71	6.83	VOLUNTEER
4	Olalla Creek #313	10/16/93	1.58	5.61	VOLUNTEER
5	Olalla Creek #313	10/17/93	1.54	5.12	VOLUNTEER
6	Olalla Creek #313	10/19/93	1.50	4.79	VOLUNTEER
7	Olalla Creek #313	10/23/93	1.79	11.05	VOLUNTEER
8	Olalla Creek #313	10/25/93	1.54		VOLUNTEER
9	Olalla Creek #313	10/28/93	1.50	5.27	VOLUNTEER
10	Olalla Creek #313	11/1/93	1.58	6.75	VOLUNTEER
11	Olalla Creek #313	11/3/93	1.54		VOLUNTEER
12	Olalla Creek #313	11/5/93	1.50	4.97	VOLUNTEER
13	Olalla Creek #313	11/7/93	1.50	4.63	VOLUNTEER
14	Olalla Creek #313	11/28/93	1.62	5.57	VOLUNTEER
15	Olalla Creek #313	11/29/93	2.00	14.59	VOLUNTEER
16	Olalla Creek #313	11/30/93	1.75	6.60	VOLUNTEER
17	Olalla Creek #313	12/1/93	2.45	33.01	VOLUNTEER
18	Olalla Creek #313	12/2/93	1.77	9.10	VOLUNTEER
19	Olalla Creek #313	12/3/93	1.66	6.64	VOLUNTEER
20	Olalla Creek #313	12/4/93	1.83	9.82	VOLUNTEER
WY92					
1	Strawberry Creek (#248)	1/23/91	0.82	10.41	TRIBE
2	Strawberry Creek (#248)	3/13/91	0.42	2.71	KPUD/JRL
3	Strawberry Creek (#248)	1/9/92	0.29	1.89	TRIBE
4	Strawberry Creek (#248)	3/4/92	0.40	2.99	TRIBE
5	Strawberry Creek (#248)	3/19/92	0.30	2.01	TRIBE
6	Strawberry Creek (#248)	3/27/92	0.30	1.76	TRIBE
7	Strawberry Creek (#248)	4/14/92	0.29	1.50	TRIBE
8	Strawberry Creek (#248)	4/24/92	0.28	1.51	TRIBE
9	Strawberry Creek (#248)	7/21/92	0.21	0.90	TRIBE
10	Strawberry Creek (#248)	8/7/92	0.22	0.88	TRIBE
11	Strawberry Creek (#248)	9/9/92	0.20	0.82	TRIBE
WY93					
12	Strawberry Creek (#248)	3/15/93	0.26	0.97	TRIBE
WY94					
13	Strawberry Creek (#248)	5/17/94	0.13	1.27	USGS/DTS
14	Strawberry Creek (#248)	7/18/94	0.14	1.02	USGS/DTS
15	Strawberry Creek (#248)	7/28/94	0.20	0.80	TRIBE

Exhibit C-5

Miscellaneous Streamflow Measurements
(Collected for Rating Curve Generation)

Plot #	Creek Name	Date	Stage (ft)	Flow (cfs)	Measurer
16	Strawberry Creek (#248)	9/21/94	0.13	0.84	USGS/DTS
WY95					
17	Strawberry Creek (#248)	10/26/94	0.35	3.73	USGS/DTS
18	Strawberry Creek (#248)	1/3/95	0.15	2.67	USGS/DTS
19	Strawberry Creek (#248)	2/10/95	0.13	2.65	USGS/DTS
20	Strawberry Creek (#248)	3/30/95	0.16	3.34	USGS/DTS
21	Strawberry Creek (#248)	4/24/95	0.14	2.60	USGS/DTS
22	Strawberry Creek (#248)	5/16/95	0.08	1.70	USGS/DTS
23	Strawberry Creek (#248)	6/12/95	0.08	1.49	USGS/DTS
24	Strawberry Creek (#248)	7/17/95	0.08	1.12	USGS/DTS
25	Strawberry Creek (#248)	8/23/95	0.09	1.45	USGS/DTS
26	Strawberry Creek (#248)	9/12/95	0.08	1.30	USGS/DTS
WY96					
27	Strawberry Creek (#248)	11/1/95	0.09	1.11	USGS/DTS
	Stavis Creek #113	9/29/94	0.71	6.32	KPUD/JRL

Date	Time	Post-Hatchery Staff Gage	Hatchery Staff Gage	Flow (CFS)	Comment	Source
Exhibit C-6 - Miscellaneous Streamflow Measurements from Grovers Creek						
1/15/91				12.57		TRIBE
2/6/91				29.03		TRIBE
4/8/91				15.43		TRIBE
4/23/91				4.27	new survey location	TRIBE
3/1/93	11:30 AM	27 cm		2.98		TRIBE
3/25/93	11:30 AM	36 cm		10.26		TRIBE
4/9/93		45 cm		21.46		TRIBE
4/23/93	1:00 PM	34 cm		10.87		TRIBE
5/6/93	11:00 AM	29 cm		5.93		TRIBE
5/10/93	2:30 PM	33 cm		9.64		TRIBE
5/19/93	10:00 AM	24 cm		2.49		TRIBE
5/26/93	2:30 PM	23 cm		1.88		TRIBE
6/1/93	9:00 AM	31 cm		7.57		TRIBE
6/7/93	1:00 PM	28 cm		5.36		TRIBE
6/15/93	9:00 AM	23 cm		2.69		TRIBE
4/24/93	2:30 PM	23 cm		1.89		TRIBE
7/12/93	9:30 AM	22 cm		1.47		TRIBE
7/27/93	9:00 AM	22.8 cm		1.71		TRIBE
7/29/93		24 cm		2.42	Tide - -1.2 @ 8:33 am	TRIBE
7/30/93	10:00 AM		1.68	5.29		TRIBE
8/19/93	11:00 AM		1.2	1.47	Tide - 0.0 @ 12:31 am	TRIBE
9/13/93			1.28	1.46		TRIBE
9/24/93				1.56		TRIBE
10/26/93		19 cm	1.38	2.19		TRIBE
12/14/93	2:30 PM		2.8	32.06		TRIBE
12/15/93	11:00 AM	45 cm	2.42	22.34	Tide 6.9 @ 12:19 pm	TRIBE

DOGFISH CREEK #207

GAGE LOCATION - Lat. 47°50'07", Long. 122°38'33", in 26N/01E-11N, Kitsap County, at intersection of Bond Road & St. Hwy. 305, NE corner; 100ft. downstream from historic US Geological Survey site "Dogfish Creek" near Poulsbo; gage #12070000.

DRAINAGE AREA - 5.01 sq. mi. (USGS report #84-144-A)

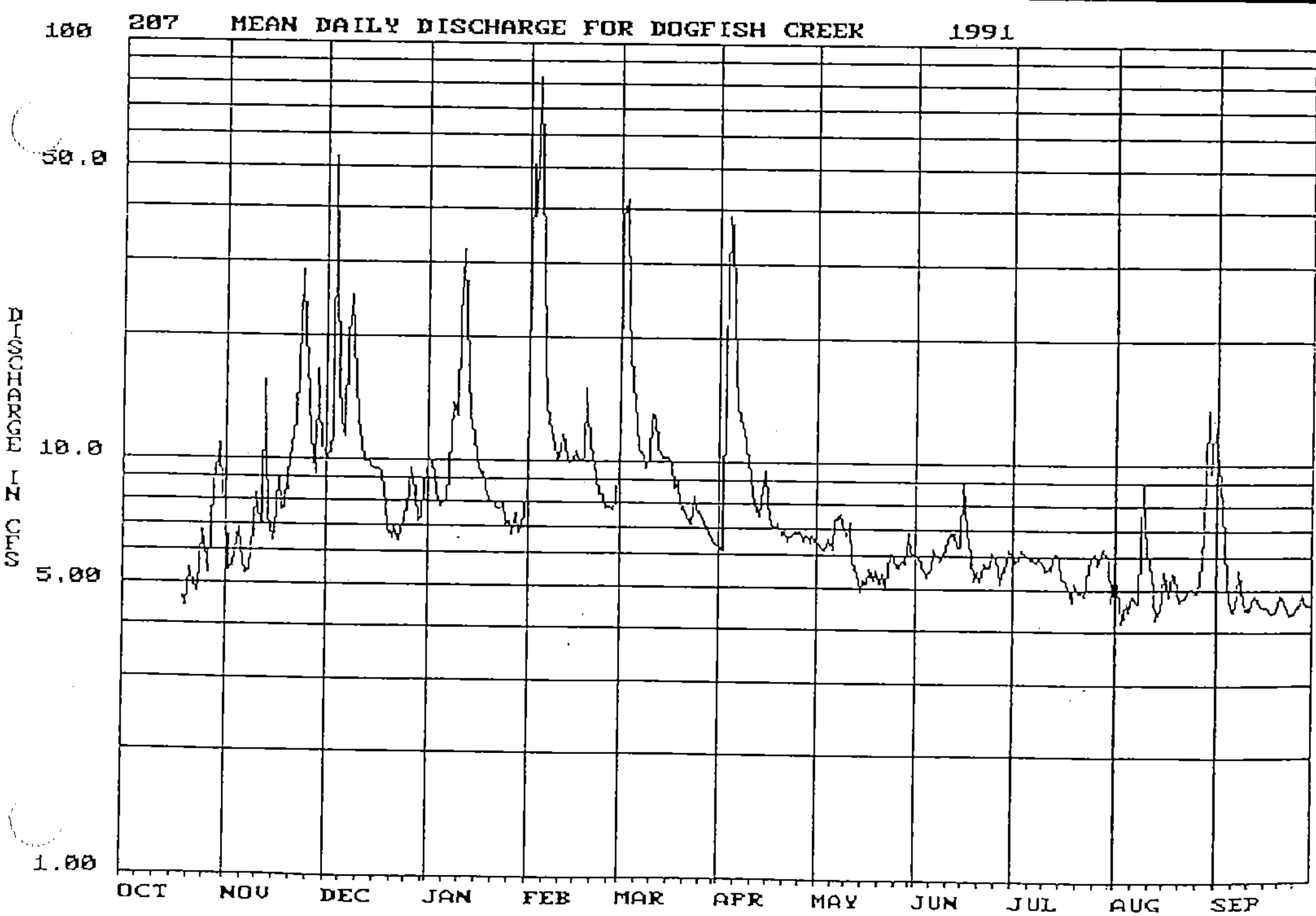
PERIOD OF RECORD - 10/19/90 to 9/30/91.

GAGE - Installation date 10/18/90. Instrumentation NW DL-2 Data Logger and 0-5PSIG Instrumentation NW Transducer in stilling well with hutch and ceramic staff gage. Datum of gage is ~20' above sea level.

REMARKS - Two flood events occurring December of '90 and March of '91 affected data logger performance. The original 0-2PSIG transducer proved to be unreliable and was replaced with a 0-5PSIG transducer 9/14/91. Gage location doesn't include contribution from south tributary originating at the Poulsbo Shopping Center area along St. Hwy. 305. 10 - flow measurements and 10 - station calibration visits were used to correct, estimate and shift the record.

EXTREMES FOR CURRENT YEAR - Maximum discharge of 132Cu.Ft./Sec. occurred 12/4/90 and 2/4/91; minimum discharge of 4.1Cu.Ft./Sec. occurred 9/24 & 9/25 of '91.

SUBMITTED BY - Kitsap Public Utility District #1, JRL



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

207 DOGFISH CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1990 TO SEP 1991

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1		7.8	10	10	15	11	6.3E	6.4	6.0	6.2	5.4E	11
2		5.5	10	10	52	39	6.2E	6.4	6.0	5.8	4.8E	9.1
3		5.5	11	9.4	39	43	18	6.3	5.8	6.0	4.2E	7.9
4		6.0	53	8.4	83	23	39	6.2	5.5	6.3	4.7E	5.3
5		6.9	16	7.8	49	16	36	6.6	5.4	6.1	4.5E	4.6
6		5.7	12	8.0	19	12	17	6.3	5.7	6.0	4.9E	4.5
7		5.4	11	8.0	14	11	14	7.5	6.2	6.0	4.8E	4.9
8		5.5	20	11	12	10	12	7.4	6.0	5.8	4.7E	5.6
9		6.0	25	14	11	9.7	12	7.6	5.9	6.0	9.0E	4.8
10		8.3	16	13	10	10	10	6.9	6.1	5.9	7.2E	4.6
11		7.5	12	22	11	13	8.5	6.8	6.7	5.6	5.8E	4.5
12		7.0	11	32	12	13	8.0	7.3	6.8	5.7	5.6E	4.7
13		15	10	16	10	11	7.5	5.9	6.8	5.7	4.3E	4.9
14		7.4	9.9	13	10	10	8.1	5.5	6.4	6.2	4.4E	4.6
15		6.4	9.8	12	10	10	9.6	5.0	6.4	6.0	4.9E	4.6
16		6.7	9.5	10	11	10	8.1	5.3	9.1	5.4	5.6E	4.6
17		9.1	9.6	9.4	10	10	7.2	5.2	6.9	5.3	4.9E	4[illegible]
18		7.6	9.4	9.4	10	8.7	7.0	5.7	6.0	5.1	5.5E	4[illegible]
19	4.7	7.6	7.7	8.3	15	9.0	7.2	5.3	5.3	4.8	5.4E	4.5
20	4.5	9.2	6.9	8.1	11	7.9	6.8	5.6	5.6	5.2E	4.8E	4.7
21	5.5	11	6.5	8.0	10	7.6E	6.9	5.3	5.3	5.0E	4.8E	4.9
22	5.3	12	6.9	7.8	9.3	7.4E	6.6	5.5	5.8	5.0E	4.9E	4.7
23	4.8	16	6.5	7.7	8.4	7.2E	6.7	5.1	5.7	4.9E	5.0E	4.6
24	4.9	29	6.9	8.0	8.4	8.3E	6.9	6.1	5.7	5.7E	5.1E	4.4
25	6.8	20	7.3	7.1	7.8	7.8E	6.9	6.1	6.2	6.0E	5.0E	4.5
26	6.2	14	7.7	7.2	7.9	7.5E	6.8	5.7	6.0	6.2E	5.0E	4.6
27	5.4	11	9.6	6.7	7.7	7.3E	6.5	5.7	5.2	5.8E	5.9E	4.7
28	8.7	9.3	8.5	7.5	8.1	7.0E	6.8	5.9	5.5	6.2E	6.9E	5.0
29	9.4	16	7.2	6.8	------	6.8E	6.5	5.8	5.8	6.3E	14	4.7
30	11	11	7.3	6.9	------	6.6E	6.7	6.9	6.2	6.0E	9.6	4.7
31	8.2	------	8.7	8.3	------	6.4E	------	6.2	------	4.8E	12	------
TOTAL	85.4	295.4	362.9	321.8	481.6	367.2	315.8	189.5	182.0	177.0	183.6	155.3
MEAN	6.57	9.85	11.7	10.4	17.2	11.8	10.5	6.11	6.07	5.71	5.92	5.18
MAX	11	29	53	32	83	43	39	7.6	9.1	6.3	14	11
MIN	4.5	5.4	6.5	6.7	7.7	6.4	6.2	5.0	5.2	4.8	4.2	4.4
AC-FT	169 *	586	720	638	955	728	626	376	361	351	364	308

CAL YEAR 1990	TOTAL*	743.7	MEAN	10.1	MAX	53	MIN	4.5	AC-FT	1,480
WTR YEAR 1991	TOTAL*	3,117.5	MEAN	8.98	MAX	83	MIN	4.2	AC-FT	6,180

* Incomplete Record

DOGFISH CREEK #207

GAGE LOCATION - Lat. 47'50'07", Long. 122'38'33", in 26N/01E-11N, Kitsap County, at intersection of Bond Road & St. Hwy. 305, NE corner; 100ft. downstream from historic US Geological Survey site "Dogfish Creek" near Poulsbo; gage #12070000.

DRAINAGE AREA - 5.01 sq. mi. (USGS report #84-144-A)

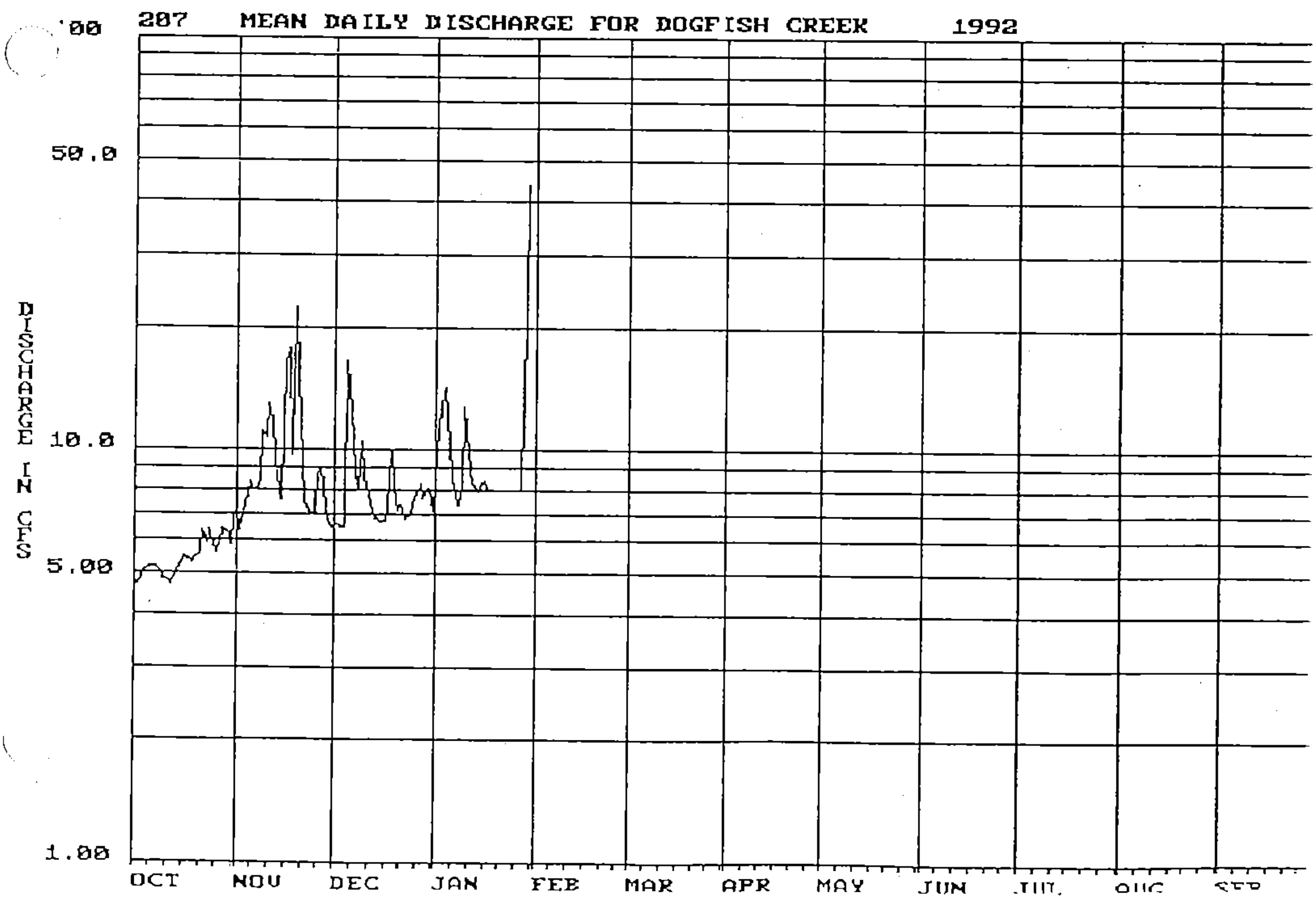
PERIOD OF RECORD - 10/1/91 to 1/30/92.

GAGE - Installation date 10/18/90. Instrumentation NW DL-2 Data Logger and 0-5PSIG Instrumentation NW Transducer in stilling well with hutch and ceramic staff gage. Datum of gage is ~20' above sea level.

REMARKS - The record from onset of flood (8.34" rain from 1/28 - 2/2) through end of WY92 will not be reported due to wide variance of raw data from gaging station with precipitation data collected at KPUD office and normal dry season hydrographs for same period from other close by drainages. Gage location doesn't include contribution from south tributary originating at the Poulsbo Shopping Center area along St. Hwy. 305. 6 - flow measurements and 12 - station calibration visits were used to correct, estimate and shift the record.

EXTREMES FOR REPORTED PERIOD - Maximum discharge of 96Cu.Ft./Sec. occurred 1/30/92; minimum discharge of 4.5Cu.Ft./Sec. occurred 10/2/91.

SUBMITTED BY - Kitsap Public Utility District #1, JRL



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

207 DOGFISH CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1991 TO SEP 1992

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	r	7.3	6.6	8.4				5.7	8.3	9.2	5.2	3.2
2	4.8	6.4	6.6	11				5.1	7.2	8.4	5.3	3.3
3	4.9	7.0	6.6	14				5.5	8.6	6.7	5.2	3.2
4	5.1	7.5	6.6	14				5.8	9.5	4.7	5.1	4.8
5	5.3	8.4	16	10				5.7	13	5.8	5.2	3.3
6	5.3	8.0	12	8.5				5.5	17	7.2	7.3	3.5
7	5.3	8.0	9.1	7.8				5.0	14	7.2	6.0	3.3
8	5.3	8.4	8.0	7.4				5.3	17	7.1	5.6	3.5
9	5.1	11	11	8.1			6.7	6.7	10	6.0	5.3	3.3
10	4.9	11	8.6	13			4.7	6.9	3.7	3.6	5.1	4.1
11	4.9	13	7.8	9.8			4.5	5.4	3.8	3.4	5.0	3.5
12	4.8	12	7.4	8.3			4.6	6.5	4.2	3.9	5.0	3.1
13	4.9	9.6	6.9	8.2			4.4	9.7	5.4	5.7	4.9	3.2
14	5.2	7.9	6.9	8.0			4.7	11	5.2	6.5	4.8	3.9
15	5.2	7.6	6.7	8.1			4.4	10	5.0	6.2	4.8	3.1
16	5.5	16	6.8	8.5			9.6	11	5.1	6.1	4.8	[illegible]
17	5.5	18	7.2	8.0			13	12	4.6	5.9	4.8	[illegible]
18	5.4	9.8	10	8.0			6.3	9.5	4.4	5.8	4.8	[illegible]
19	5.4	22	8.1	8.0			5.4	9.1	6.7	5.8	4.7	3.4
20	5.5	15	7.2	8.0			5.2	5.8	5.2	8.1	4.5	3.0
21	5.6	9.4	7.4	8.0			5.0	4.7	4.1	6.3	3.5	3.5
22	6.4	7.6	6.9	8.0			4.6	5.8	6.3	6.7	3.1	3.4
23	6.0	7.1	6.9	8.0			4.6	8.7	4.7	6.7	3.6	3.5
24	6.5	7.1	7.0	8.0			4.6	12	4.9	6.2	3.5	3.7
25	5.9	7.1	7.7	8.0			4.7	10	4.2	5.9	3.5	3.1
26	5.7	8.9	7.8	8.0			5.0	9.1	6.3	5.7	3.4	3.2
27	6.0	9.1	8.3	8.0			4.8	11	5.9	5.6	3.4	3.1
28	6.5	7.3	7.7	8.0			5.7	13	4.1	5.4	3.3	3.0
29	6.4	6.8	8.1	21			16	13	5.1	5.3	3.3	3.0
30	5.9	6.6	8.1	44	------		7.8	12	8.3	5.2	3.3	3.7
31	6.9	------	7.2		------		------	10	------	5.1	3.3	------
TOTAL	166.1	290.9	249.2	314.1			136.3	256.5	211.8	187.4	140.6	102.2
MEAN	5.54	9.70	8.04	10.5			6.20	8.27	7.06	6.05	4.54	3.41
MAX	6.9	22	16	44			16	13	17	9.2	7.3	4.8
MIN	4.8	6.4	6.6	7.4			4.4	4.7	3.7	3.4	3.1	3.0
AC-FT	329	577	494	623			270	509	420	372	279	203
	*			*	*	*	*					

CAL YEAR 1991	TOTAL*	706.2	MEAN	7.76	MAX	22	MIN	4.8	AC-FT	1,400
WTR YEAR 1992	TOTAL*	2,055.1	MEAN	6.94	MAX	44	MIN	3.0	AC-FT	4,080

* Incomplete Record

DOGFISH CREEK #207

GAGE LOCATION - Lat. 47`50'07", Long. 122'38'33", in 26N/01E-11N, Kitsap County, at intersection of Bond Road & St. Hwy. 305, NE corner; 100ft. downstream from historic US Geological Survey site "Dogfish Creek" near Poulsbo; gage #12070000.

DRAINAGE AREA - 5.01 sq. mi. (USGS report #84-144-A)

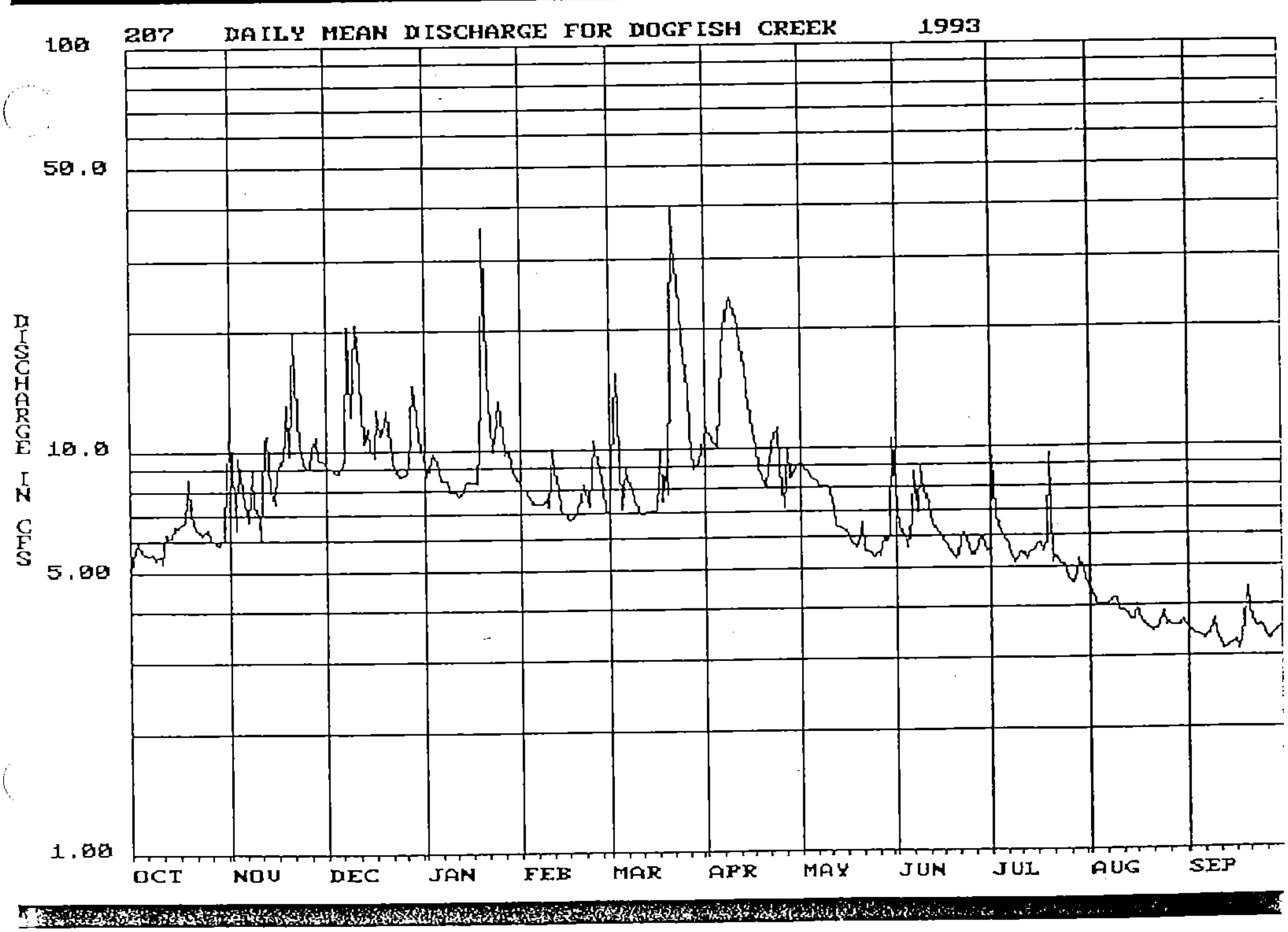
PERIOD OF RECORD - 10/1/92 to 9/30/93.

GAGE - Installation date 10/18/90. Instrumentation NW DL-2 Data Logger and 0-5PSIG Instrumentation NW Transducer in stilling well with hutch and ceramic staff gage. Datum of gage is ~20' above sea level.

REMARKS - Record estimated from 2/24 through 8/13. Gage location doesn't include contribution from south tributary originating at the Poulsbo Shopping Center area along St. Hwy. 305. 6 - flow measurements and 9 - station calibration visits were used to correct, estimate and shift the record.

EXTREMES FOR CURRENT YEAR - Maximum discharge of 65Cu.Ft./Sec. occurred 1/20/93; minimum discharge of 2.8Cu.Ft./Sec. occurred 9/9/93.

SUBMITTED BY - Kitsap Public Utility District #1, JRL



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

207 DOGFISH CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1992 TO SEP 1993

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.0E	12 E	9.3	9.3	8.1	7.1	11 E	9.3E	7.9E	5.7E	4.5E	3.5
2	5.5	9.0E	9.2	8.7	8.0	9.0E	11 E	9.1E	6.4E	9.6E	4.3E	3.5
3	6.1	6.5E	8.9	9.6	7.8	16 E	11 E	8.9E	6.2E	6.8E	4.1E	3.4
4	5.9	9.8E	8.9	9.8	7.7	13 E	10 E	8.7E	6.0E	6.3E	4.1E	3.4
5	5.6	8.0E	8.9	9.5	7.4	7.1	10 E	8.5E	5.7E	6.1E	4.1E	3.4
6	5.7	7.2E	9.2	8.5	7.4	9.0E	17 E	8.3E	6.7E	5.9E	4.1E	3.3
7	5.6	6.8E	9.5	8.5	7.4	8.5E	20 E	8.1E	8.8E	5.6E	4.1E	3.4
8	5.7	9.0E	20	8.5	7.4	8.0E	23 E	8.1E	7.0E	5.4E	4.2E	3.4
9	5.5	7.4E	12	8.0	7.6	7.5E	24 E	8.1E	8.9E	5.2E	4.2E	3.7
10	5.6	7.0E	21	7.9	7.3	7.1E	22 E	8.1E	7.8E	5.4E	4.0E	3.4
11	5.3	6.0	18	7.9	10 E	6.9E	20 E	7.8E	7.3E	5.5E	3.9E	3.3
12	6.2	11 E	13	7.8	9.0E	7.0E	18 E	7.1E	6.7E	5.5E	3.9E	3.1
13	6.2	11 E	11	8.0	8.0E	7.1E	16 E	6.4E	6.4E	5.3E	3.8E	3.1
14	6.2	8.0E	11	8.3	7.1E	7.1E	14 E	6.4E	6.3E	5.5E	3.7	3.2
15	6.6	7.5E	10	8.4	7.0	7.1E	12 E	6.3E	6.2E	5.6E	3.7	3.2
16	6.6	9.0E	9.7	8.4	6.9	7.1E	11 E	6.2E	5.9E	5.7E	4.1	3.7
17	6.7	9.5E	13	8.4	6.8	10 E	10 E	6.1E	5.8E	5.8E	3.7	[illegible]
18	6.8	9.6	11	8.3	6.9	7.5E	9.0E	5.8E	5.6E	5.5E	3.6	3.[illegible]
19	8.6	13	12	13	7.2	9.0E	8.5E	5.7E	5.5E	5.8E	3.5	3.7
20	7.0	9.8	13	36	7.5	7.8E	8.0E	5.8E	5.3E	9.7E	3.5	4.5
21	6.5	20	10	15	8.3	40 E	9.0E	6.5E	5.5E	5.2E	3.5	3.9
22	6.5	12	9.5	12	7.7	33 E	10 E	5.6E	6.2E	5.4E	3.5	3.6
23	6.2	10	9.0	9.9	7.2	26 E	11 E	5.6E	6.2E	5.2E	3.6	3.6
24	6.3	9.6	8.7	12	11 E	19 E	11 E	5.5E	5.7E	5.2E	3.9	3.6
25	6.5	9.0	8.6	13	10 E	17 E	9.0E	5.4E	5.5E	4.9E	3.6	3.5
26	6.1	9.1	8.8	11	9.0E	14 E	7.1	5.5E	5.5E	4.7E	3.6	3.4
27	6.0E	10	9.1	9.8	8.0E	11 E	10 E	5.5E	5.8E	4.6E	3.6E	3.3
28	5.9E	11	15	10	7.0E	9.0E	8.5E	6.1E	6.1E	4.9E	3.6E	3.4
29	6.0E	9.6	14	9.1	------	9.1E	8.8E	5.9E	5.8E	5.3E	3.6E	3.5
30	6.1E	9.5	11	8.6	------	9.3E	9.0E	6.1E	5.5E	5.0E	3.7	3.6
31	9.0E	------	10	8.3	------	10 E	------	11 E	------	4.7E	3.6	------
TOTAL	193.5	286.9	352.3	321.5	220.7	366.3	378.9	217.5	190.2	177.0	118.9	103.6
MEAN	6.24	9.56	11.4	10.4	7.88	11.8	12.6	7.02	6.34	5.71	3.84	3.45
MAX	9.0	20	21	36	11	40	24	11	8.9	9.7	4.5	4.5
MIN	5.0	6.0	8.6	7.8	6.8	6.9	7.1	5.4	5.3	4.6	3.5	3.1
AC-FT	384	569	699	638	438	727	752	431	377	351	236	205

CAL YEAR 1992	TOTAL*	832.7	MEAN	9.05	MAX	21	MIN	5.0	AC-FT	1,650
WTR YEAR 1993	TOTAL	2,927.3	MEAN	8.02	MAX	40	MIN	3.1	AC-FT	5,810

* Incomplete Record

DOGFISH CREEK #207

GAGE LOCATION - Lat. 47'50'07", Long. 122'38'33", in 26N/01E-11N, Kitsap County, at intersection of Bond Road & St. Hwy. 305, NE corner; 100ft. downstream from historic US Geological Survey site "Dogfish Creek" near Poulsbo; gage #12070000.

DRAINAGE AREA - 5.01 sq. mi. (USGS report #84-144-A)

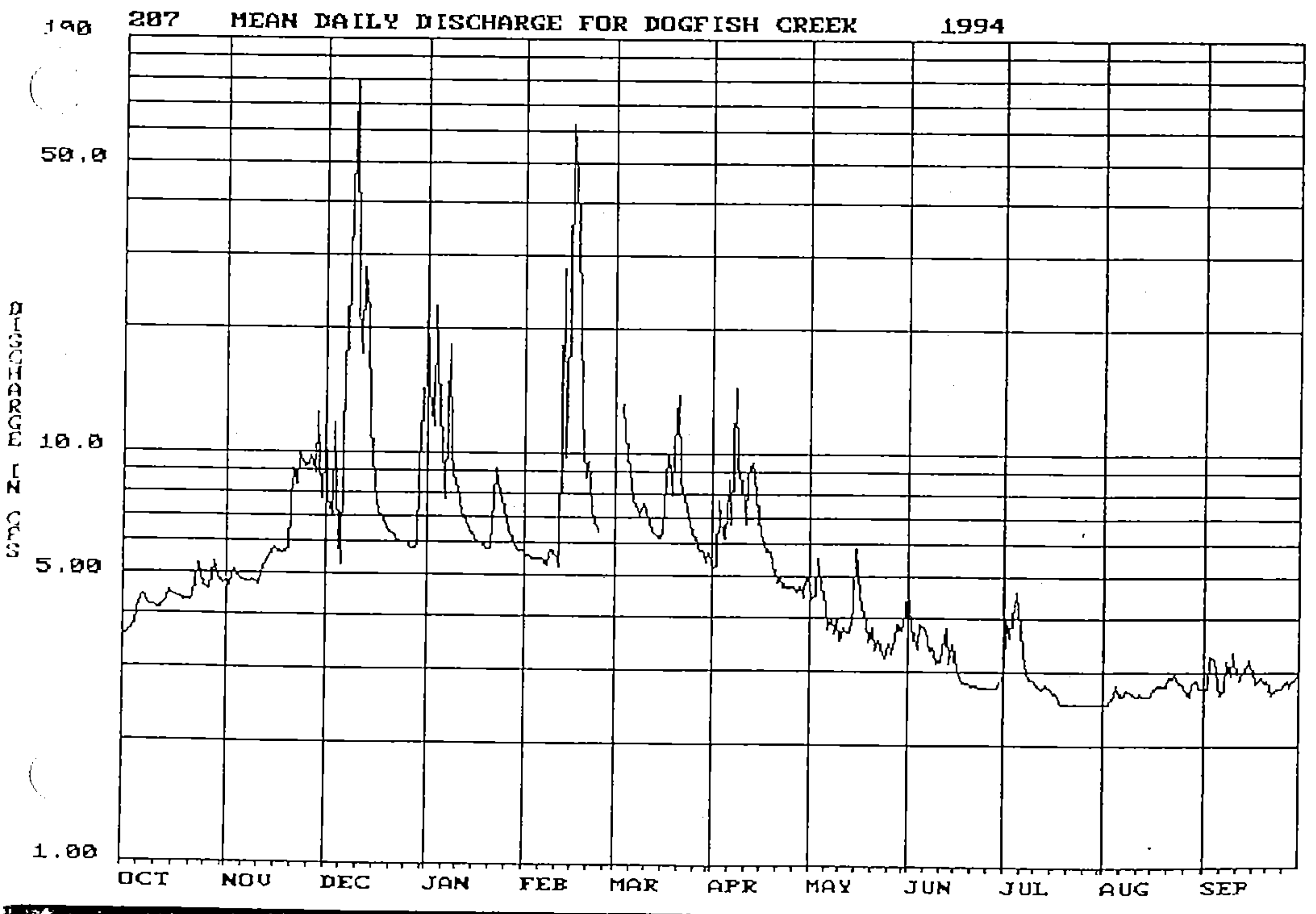
PERIOD OF RECORD - 10/1/93 to 9/30/94.

GAGE - Installation date 10/18/90. Instrumentation NW DL-2 Data Logger and 0-5PSIG Instrumentation NW Transducer in stilling well with hutch and ceramic staff gage. Datum of gage is ~20' above sea level.

REMARKS - Record estimated from 6/19 through 8/4. Missing record from 2/26 through 3/2. Gage location doesn't include contribution from south tributary originating at the Poulsbo Shopping Center area along St. Hwy. 305. 11 - flow measurements and 6 - station calibration visits were used to correct, estimate and shift the record.

EXTREMES FOR CURRENT YEAR - Maximum discharge of 121Cu.Ft./Sec. occurred 12/9/93; minimum discharge of 2.4Cu.Ft./Sec. occurred 8/19/94.

SUBMITTED BY - Kitsap Public Utility District #1, JRL



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

207 DOGFISH CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1993 TO SEP 1994

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.6	4.8	14	25	5.8	11 E	5.2	4.8	4.7	2.9	2.5E	2.7
2	3.6	4.7	7.7	14	5.6	12 E	5.4	4.5	3.9	4.0	2.5E	2.7
3	3.7	5.2	7.1	12	5.6	13	7.7	4.5	3.6	3.6	2.5E	3.3
4	3.7	5.1	12	23	5.5	13	6.4	5.6	3.4	4.0	2.7	3.2
5	4.0	4.9	6.1	13	5.5	9.9	6.3	4.9	3.9	4.7	2.8	2.8
6	4.3	4.9	5.4	8.6	5.5	8.5	8.7	4.3	3.8	3.8	2.6	2.7
7	4.5	4.8	17	7.8	5.5	7.8	6.8	3.8	3.8	3.3	2.6	2.7
8	4.4	4.8	19	18	5.4	7.3	14	4.0	3.4	3.0	2.7	3.2
9	4.2	4.9	40	9.9	5.8	7.1	9.5	3.7	3.4	2.9	2.7	2.9
10	4.2	4.8	80 E	8.4	5.7	7.6	8.5	4.0	3.1	2.9	2.6	3.3
11	4.2	4.8	22	8.2	5.6	7.2	6.8	3.5	3.2	2.8E	2.6	3.0
12	4.2	5.2	17	7.3	5.3	6.9	9.0	3.8	3.4	2.8E	2.6	2.9
13	4.3	5.4	28	6.8	28	6.5	9.6	3.8	3.8	2.7E	2.6	3.0
14	4.4	5.5	22	6.6	9.8	6.3	9.0	3.7	3.1	2.8E	2.6	3.1
15	4.6	5.8	12	6.4	21	6.3	7.1	4.3	3.5	2.7E	2.6	3.2
16	4.5	5.8	8.6	6.2	62	6.5	6.3	5.9	3.2	2.7E	2.6	3.0
17	4.4	5.7	7.6	6.1	49	8.6	6.1	4.6	2.9	2.7E	2.8	
18	4.4	5.7	7.0	6.0	23	10	5.8	4.3	2.8	2.6E	2.8	
19	4.3	5.7	6.8	6.0	12	7.9	5.8	4.0	2.8E	2.5E	2.8	2.9
20	4.4	5.8	6.6	5.8	8.8	10	5.1	3.5	2.8E	2.5E	2.8	2.8
21	4.4	9.2	6.3	5.9	9.6	14	4.9	3.8	2.8E	2.5E	2.9	2.9
22	4.4	8.4	6.3	7.7	7.4	8.7	5.1	3.4	2.8E	2.5E	2.9	2.7
23	5.4	10	6.1	9.3	6.8	7.8	4.8	3.5	2.8E	2.5E	3.0	2.7
24	5.3	9.5	6.0	8.0	6.4	7.0	4.8	3.3	2.8E	2.5E	2.8	2.7
25	4.7	9.3	6.0	7.8	7.0E	6.7	4.8	3.2	2.8E	2.5E	2.8	2.7
26	4.6	9.4	6.0	6.9	8.0E	6.2	4.8	3.5	2.8E	2.5E	2.7	2.8
27	4.6	9.8	5.9	6.5	9.0E	6.3	4.6	3.3	2.8E	2.5E	2.6	2.9
28	5.4	9.0	5.8	6.2	10 E	5.8	4.8	3.6	2.8E	2.5E	2.8	2.8
29	5.0	12	6.0	6.0	------	5.8	4.5	3.9	2.8E	2.5E	2.9	2.9
30	4.8	7.7	12	5.8	------	5.5	5.1	3.8	2.8E	2.5E	2.8	2.9
31	4.8	------	12	5.8	------	5.7	------	3.9	------	2.5E	2.7	------
TOTAL	137.3	198.6	424.3	281.0	344.6	252.9	197.3	124.7	96.5	89.4	83.9	87.1
MEAN	4.43	6.62	13.7	9.06	12.3	8.16	6.58	4.02	3.22	2.88	2.71	2.90
MAX	5.4	12	80	25	62	14	14	5.9	4.7	4.7	3.0	3.3
MIN	3.6	4.7	5.4	5.8	5.3	5.5	4.5	3.2	2.8	2.5	2.5	2.7
AC-FT	272	394	842	557	684	502	391	247	191	177	166	173

CAL YEAR 1993	TOTAL*	760.2	MEAN	8.26	MAX	80	MIN	3.6	AC-FT	1,510
WTR YEAR 1994	TOTAL	2,317.6	MEAN	6.35	MAX	80	MIN	2.5	AC-FT	4,600

* Incomplete Record

DOGFISH CREEK #207

GAGE LOCATION - Lat. 47°50'07", Long. 122°38'33", in 26N/01E-11N, Kitsap County, at intersection of Bond Road & Hwy. 305, NE corner; 100ft. downstream from historic US Geological Survey site "Dogfish Creek" near Poulsbo; gage #12070000.

DRAINAGE AREA - 5.01 sq. mi. (USGS report #84-144-A)

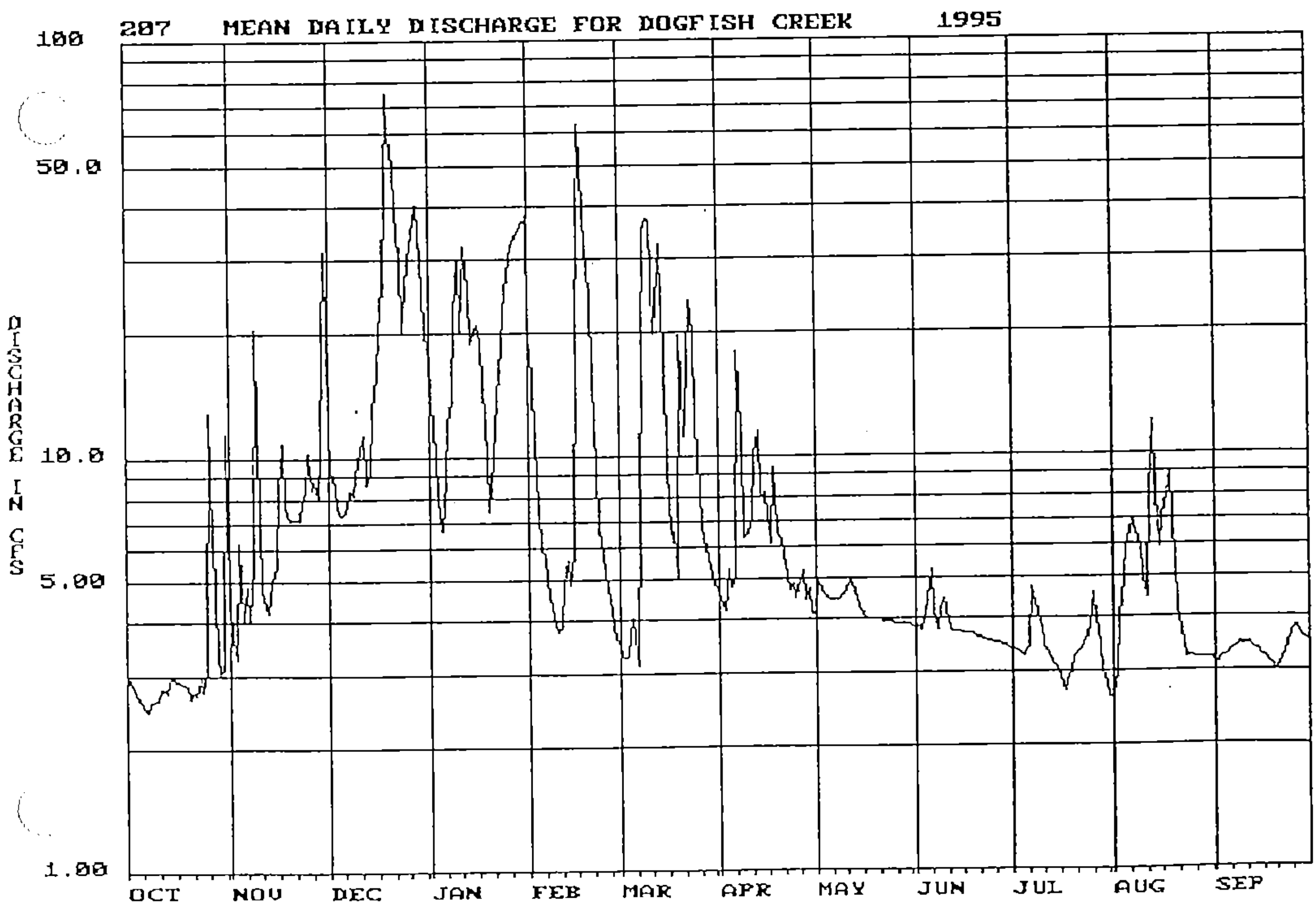
PERIOD OF RECORD - 10/1/94 to 9/30/95.

GAGE - Installation date 10/18/90. Instrumentation NW DL-2 Data Logger and 0-5 PSIG Instrumentation NW Transducer in stilling well with hutch and ceramic staff gage. Datum of gage is ~20' above sea level.

REMARKS - Record estimated from 5/1/95 through 9/30/95 due to changes in channel control at low flows. Record also estimated from 10/1/94 through 10/5/94, 12/17/94 through 2/1/95. Gage location doesn't include contribution from south tributary originating at the Poulsbo Shopping Center area along St. Hwy. 305. 16 - flow measurements and 4 - station calibration visits were used to correct, estimate and shift the record.

EXTREMES FOR CURRENT YEAR - Maximum discharge of 110 Cu.Ft./Sec. occurred 2/17/95; minimum discharge of 2.3 Cu.Ft./Sec. occurred 10/7/94.

SUBMITTED BY - Kitsap Public Utility District #1, JRL



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

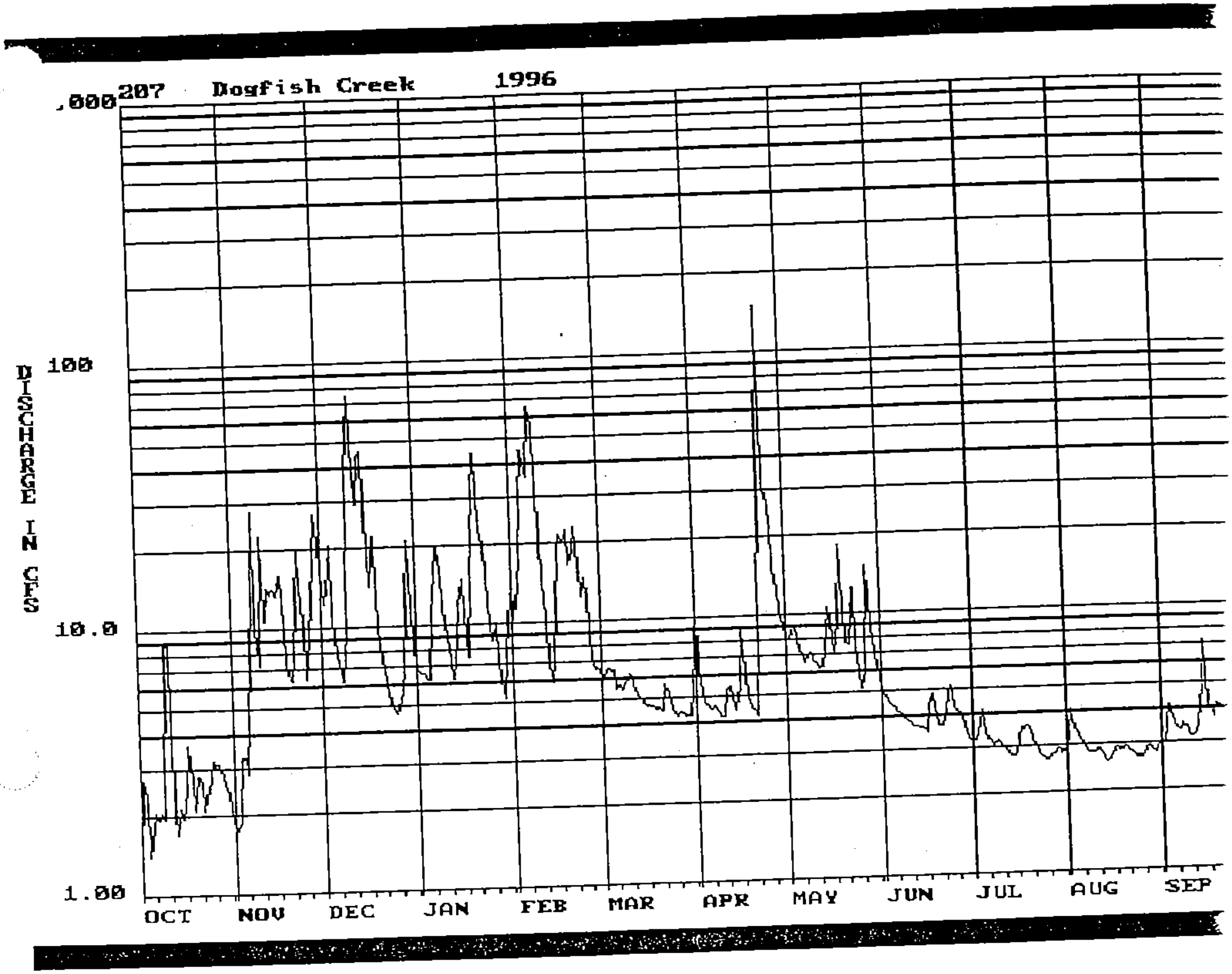
207 MEAN DAILY DISCHARGE FOR DOGFISH CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.0E	4.6	12	17 E	20 E	3.5	4.7	4.2E	3.9E	3.4E	2.6E	3.1E
2	2.9E	3.7	9.4	14 E	16	3.3	4.4	5.0	3.9E	3.4E	3.0E	3.2E
3	2.8E	3.3	8.7	10 E	11	3.3	4.2	4.8E	3.8E	3.4E	4.0E	3.2E
4	2.7E	6.3	7.6	8.0E	7.6	3.3	5.4	4.6E	4.2E	3.3E	5.0E	3.3E
5	2.6E	4.1	7.3	6.7	6.0	4.1	4.8	4.6E	4.5E	3.3E	6.0E	3.3E
6	2.5	4.9	7.4	9.0E	5.8	3.3	5.1	4.5E	5.3	3.5	6.5E	3.4E
7	2.5	4.1	7.7	12 E	5.1	3.1	18	4.5E	4.2E	4.8	7.0	3.4E
8	2.6	5.6	8.4	14 E	4.3	18	11	4.5E	3.8	4.4E	6.5E	3.5E
9	2.6	21	8.2	22 E	3.9	35	6.4	4.6E	4.3E	4.1E	6.0E	3.5E
10	2.6	6.9	9.8	30	3.8	37	6.5	4.6E	4.5	3.8E	5.0E	3.5E
11	2.8	4.9	11	20	3.8	37	7.1	4.8E	4.0E	3.5E	4.5	3.5E
12	2.8	4.4	11	32	5.0	20	10	5.0	3.8E	3.3E	8.0E	3.5
13	2.7	4.2	8.7	25 E	5.7	23	11	4.9E	3.8E	3.2E	12	3.4E
14	3.0	5.0	9.2	19 E	4.9	33	8.0	4.5E	3.8E	3.1E	8.0E	3.4E
15	2.9	5.6	13	20 E	5.8	17	8.2	4.2E	3.8E	3.0E	6.0	3.3E
16	2.9	8.6	16	21	20	9.5	7.2	4.1	3.7E	2.9E	7.0E	3.3E
17	2.9	11	20 E	19 E	63	6.5	6.2	4.1E	3.7E	2.7	8.0E	[illegible]
18	2.9	7.7	26	15 E	39	6.6	9.4	4.0E	3.7E	2.9E	6.0	[illegible]
19	2.8	7.1	75 E	10 E	32	5.1	6.5	4.0E	3.7E	3.0E	7.0E	[illegible]
20	2.7	7.1	60 E	7.5	25	19	6.3	4.0E	3.7E	3.3E	4.2E	3.0
21	2.8	7.1	50 E	10 E	15	11	5.8	4.0E	3.6E	3.3E	4.0E	3.0E
22	2.7	7.1	40 E	14 E	9.3	12	5.1	4.0E	3.6E	3.4E	3.5E	3.2E
23	3.0	8.0	30 E	16 E	6.8	24	4.8	4.0E	3.6E	3.5E	3.5	3.3E
24	2.7	8.3	20 E	22 E	5.9	20	4.9	4.0E	3.6E	3.7E	3.3E	3.5E
25	3.1	10	25 E	25 E	5.2	12	4.6	4.0E	3.6E	3.9E	3.3E	3.7E
26	13	8.5	30 E	30 E	4.5	8.3	5.0	4.0E	3.5E	4.6	3.2E	3.8E
27	6.5	8.9	35 E	32 E	3.9	6.7	5.3	4.0E	3.5E	4.0E	3.2E	3.8E
28	3.4	8.1	41 E	34 E	3.6	6.0	4.5	3.9E	3.5E	3.5E	3.2E	3.7E
29	3.0	11	35 E	35 E	------	5.7	4.8	3.9E	3.5E	3.0E	3.2E	3.6E
30	3.1	31	25 E	36 E	------	5.2	4.1	3.9E	3.5E	2.8E	3.2E	3.6E
31	12	------	20 E	38	------	4.9	------	3.9E	------	2.6	3.2E	------
TOTAL	110.5	238.1	687.4	623.2	341.9	406.4	199.3	133.1	115.6	106.6	159.1	101.5
MEAN	3.56	7.94	22.2	20.1	12.2	13.1	6.64	4.29	3.85	3.44	5.13	3.38
MAX	13	31	75	38	63	37	18	5.0	5.3	4.8	12	3.8
MIN	2.5	3.3	7.3	6.7	3.6	3.1	4.1	3.9	3.5	2.6	2.6	3.0
AC-FT	219	472	1,360	1,240	678	806	395	264	229	211	316	201

CAL YEAR 1994	TOTAL*	1,036.0	MEAN	11.3	MAX	75	MIN	2.5	AC-FT	2,050
WTR YEAR 1995	TOTAL	3,222.7	MEAN	8.83	MAX	75	MIN	2.5	AC-FT	6,390

* Incomplete Record



207 Dogfish Creek 1996
1,000
100
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1.00
DISCHARGE IN CFS
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JUL
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

207 Dogfish Creek

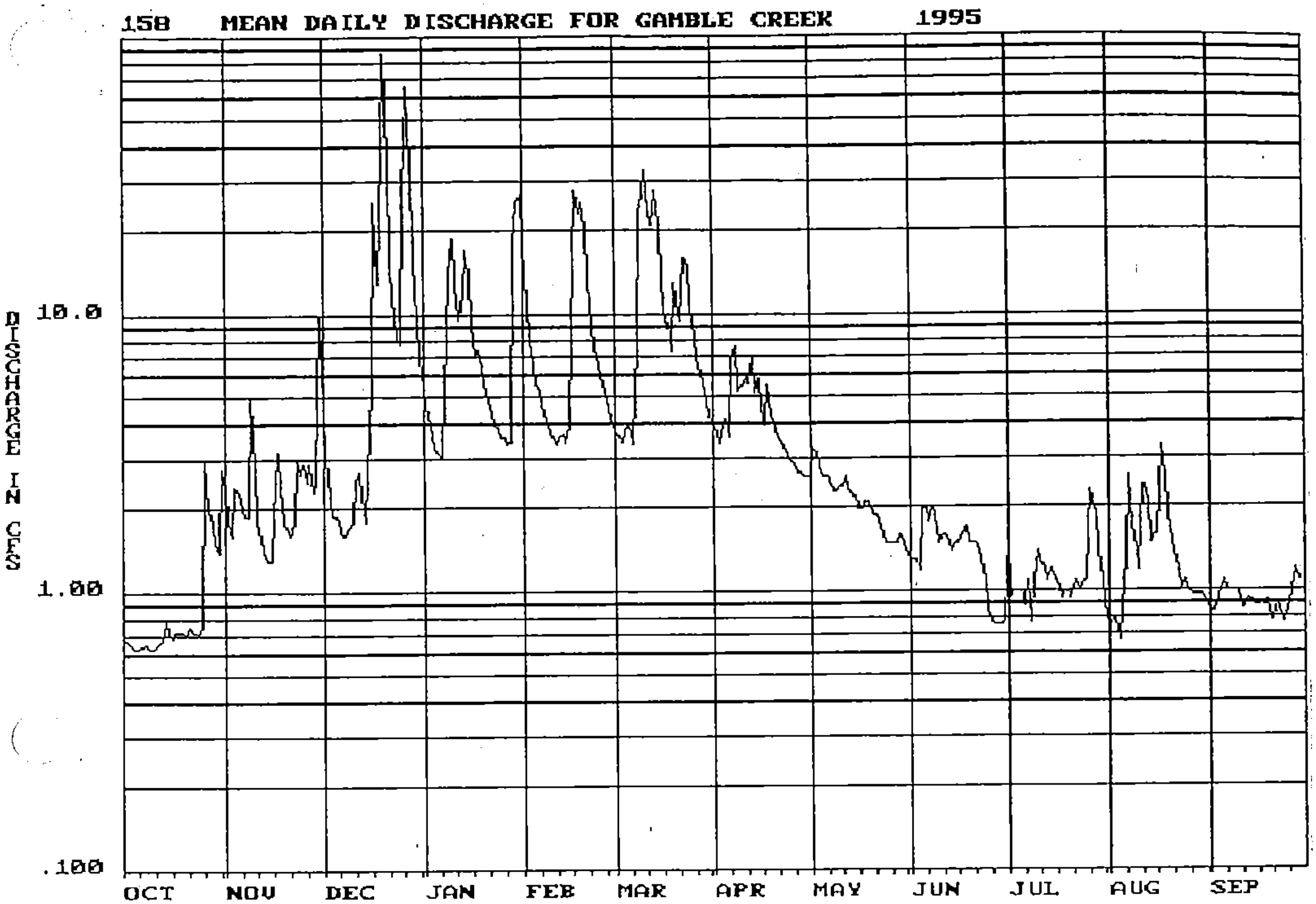
USGS #: 207

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1995 TO SEP 1996

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.5	4.3	16	7.7	14	6.8	11	7.9	5.4	3.6	3.3	3.5
2	5.7	4.3	13	6.7E	11	6.8	7.2	7.8	5.2	3.7	4.4	3.5
3	5.3	4.5	15	6.6E	13	7.3	5.8	8.4	4.9	3.8	4.2	4.5
4	3.8	6.5	22	6.4E	19	7.3	5.3	8.4	4.8	4.6	3.8	4.3
5	4.4	6.5	13	6.3E	55	7.1	5.1	7.3	4.7	4.1	3.6	4.0
6	4.7	5.9	10	11 E	50	6.1	5.1	6.8	4.6	3.7	3.5	3.9
7	4.6	10	9.6	16 E	43	6.2	5.2	6.5	4.6	3.7	3.3	3.8
8	4.7	33	9.1	20 E	82	6.1	4.9	6.9	4.5	3.5	3.3	4.0
9	4.6	12	12	16 E	66	6.3	4.8	7.0	4.4	3.6	3.3	3.9
10	11	9.8	48	12 E	22	6.9	4.7	6.6	4.3	3.6	3.3	3.7
11	11	26	75 E	9.0E	14	6.7	5.9	6.4	4.2	3.5	3.3	3.7
12	4.7	12	66	7.5E	11	6.1	6.1	6.2	4.2	3.4	3.3	3.7
13	4.2	15	34	6.3E	7.5	5.7	5.4	6.3	4.2	3.3	3.1	3.9
14	4.9	14	55	9.0E	6.6	5.6	5.0	8.2	4.1	3.2	3.1	5.2
15	4.6	15	57	12 E	7.8	5.4	6.1	9.9	4.1	3.2	3.1	7.1
16	5.4	14	19	15 E	20	5.2	9.9	7.7	4.0	3.3	3.3	4[illegible]
17	6.8	16	14	11 E	23	5.3	6.7	7.0	4.7	4.0	3.4	4[illegible]
18	5.6	14	23	7.5E	21	5.2	5.6	8.7	5.1	4.0	3.3	4.2
19	4.8	10	13	15	24	5.1	5.0	18	4.6	4.0	3.3	4.6
20	5.8	9.4	9.3	37	17	5.1	4.9	9.8	4.2	3.9	3.4	4.5
21	5.6	9.1	8.4	55	20	5.0	4.7	7.6	4.1	3.6	3.3	4.9
22	4.8	10	6.7	25	25	6.2	9.1	7.5	4.3	3.4	3.2	4.8
23	5.5	21	6.1	21	16	5.8	150 E	12	5.1	3.3	3.2	4.3
24	5.3	16	5.5	15	13	5.4	30 E	7.2	5.4	3.2	3.1	3.9
25	6.4	12	5.2	10	15	4.9	33	6.1	4.7	3.1	3.1	3.8
26	6.2	9.2	5.5	9.4	13	4.8	23	5.4	4.6	3.2	3.2	3.8
27	6.2	11	6.3	10	7.8	5.0	14	6.0	4.6	3.3	3.4	3.8
28	6.0	19	7.4	8.1	7.3	4.8	11	14	4.3	3.3	3.4	3.8
29	5.5	30	22	6.0	7.2	4.8	9.6	8.3	3.8	3.4	3.3	3.9
30	5.2	22	15	5.9	------	4.8	8.8	7.6	3.7	3.3	3.2	4.2
31	4.8	------	9.3	11	------	5.9	------	6.2	------	3.3	3.4	------
TOTAL	171.6	401.5	630.4	414.4	651.2	179.7	412.9	249.7	135.4	110.1	104.4	126.1
MEAN	5.54	13.4	20.3	13.4	22.5	5.80	13.8	8.05	4.51	3.55	3.37	4.20
MAX	11	33	75	55	82	7.3	150	18	5.4	4.6	4.4	7.1
MIN	3.5	4.3	5.2	5.9	6.6	4.8	4.7	5.4	3.7	3.1	3.1	3.5
AC-FT	340	796	1,250	822	1,290	356	819	495	269	218	207	250

CAL YEAR 1995	TOTAL*	1,203.5	MEAN	13.1	MAX	75	MIN	3.5	AC-FT	2,390
WTR YEAR 1996	TOTAL	3,587.4	MEAN	9.80	MAX	150	MIN	3.1	AC-FT	7,120

* Incomplete Record



158 MEAN DAILY DISCHARGE FOR GAMBLE CREEK 1995
DISCHARGE IN CFS
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

MEAN DAILY DISCHARGE FOR GAMBLE CREEK

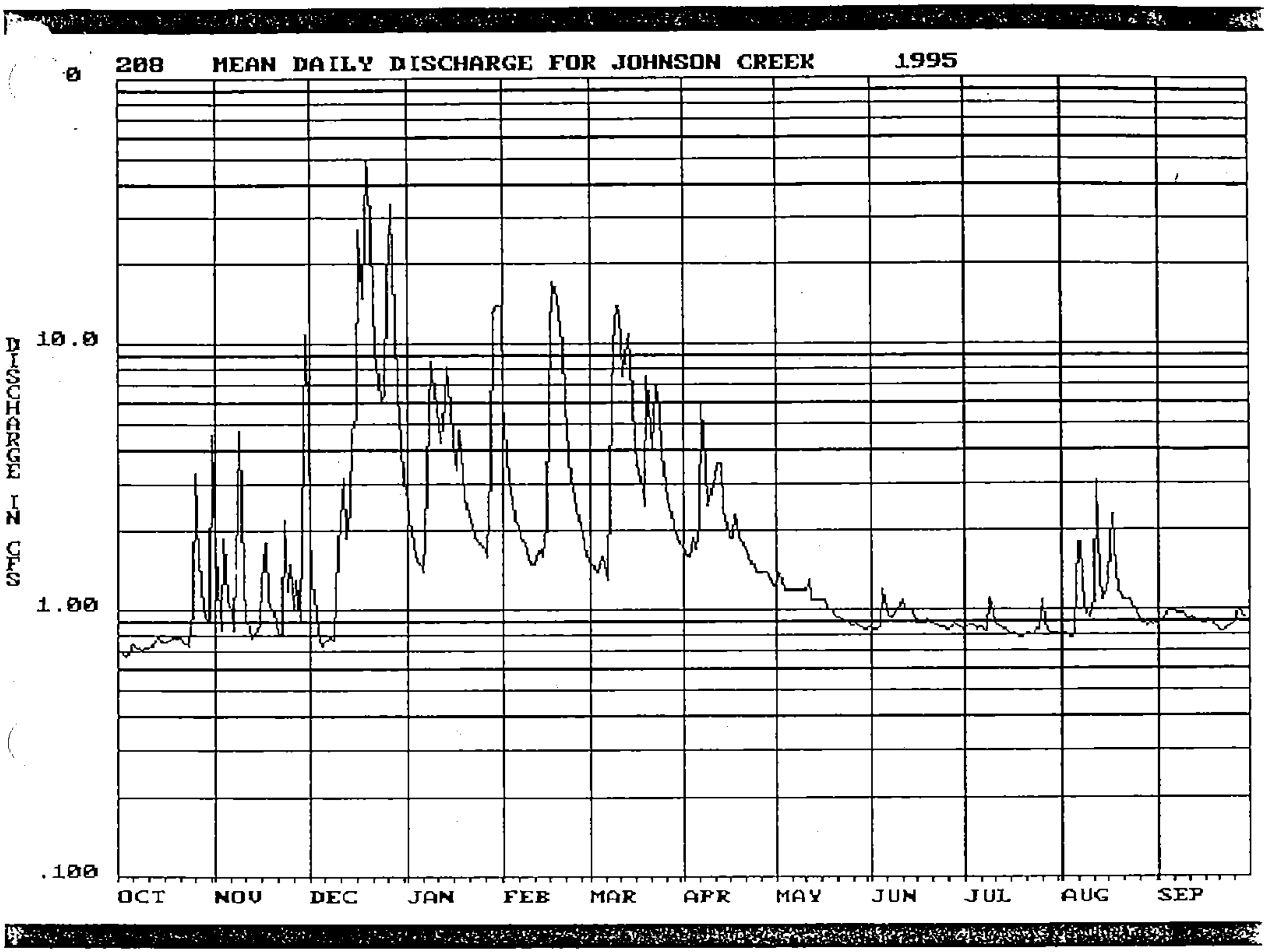
USGS #: 12069651

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.68	2.4	4.5	5.5	18	3.8	4.0	2.6	1.3	1.6	.76	.84
2	.68	1.8	3.1	4.7	11	3.7	3.7	3.3	1.3	.96	.79	.85
3	.66	1.6	2.2	4.0	8.2	3.5	3.4	3.2	1.3	1.0	.80	.89
4	.65	2.4	1.9	3.6	6.6	3.5	4.0	2.8	1.2	1.0	.67	1.0
5	.64	2.3	1.9	3.2	5.6	4.0	4.2	2.6	2.0	1.0	.86	1.1
6	.64	2.0	1.8	3.1	5.2	3.7	3.6	2.6	2.0	.90	1.3	1.0
7	.65	1.9	1.6	3.1	4.7	3.4	7.0	2.5	1.8	1.1	2.6	1.0
8	.66	1.9	1.6	8.6	4.2	7.9	7.7	2.3	2.0	.78	1.7	1.0
9	.64	5.0	1.7	14	3.8	23	5.3	2.3	1.9	1.1	1.4	1.0
10	.64	2.8	1.8	19	3.6	27	5.5	2.4	1.5	1.4	1.2	1.0
11	.65	1.8	2.5	13	3.4	33	6.0	2.4	1.6	1.3	2.4	.87
12	.67	1.6	2.7	9.8	3.6	23	5.7	2.6	1.6	1.2	2.4	.88
13	.68	1.4	2.2	12	3.7	21	7.1	2.4	1.5	1.1	2.1	.94
14	.79	1.3	1.8	17	3.5	28	5.2	2.2	1.4	1.2	1.5	.92
15	.72	1.3	2.6	14	3.9	21	5.9	2.2	1.5	1.1	1.6	.90
16	.70	1.9	5.5	9.2	8.7	13	4.5	2.0	1.5	1.1	1.6	[illegible]
17	.73	3.2	25	7.2	28	9.5	4.0	2.0	1.6	.95	3.3	[illegible]
18	.73	2.4	13	7.4	23	9.4	5.6	2.1	1.7	.99	2.6	.90
19	.73	1.8	39	6.6	25	7.4	4.3	2.1	1.5	1.0	1.9	.92
20	.72	1.7	88	5.6	21	13	3.9	2.0	1.5	.95	1.5	.79
21	.75	1.6	35	4.9	13	10	3.6	1.9	1.5	1.0	1.4	.79
22	.74	1.8	15	4.4	9.4	9.6	3.5	1.9	1.4	1.1	1.2	.91
23	.73	3.0	9.8	4.0	7.6	16	3.3	1.7	1.3	1.0	1.0	.82
24	.72	2.7	8.3	3.9	6.6	15	3.1	1.5	1.1	1.1	1.1	.78
25	.76	2.9	7.9	3.6	6.0	11	3.0	1.5	.86	1.1	1.0	.86
26	3.0	2.5	27	3.6	5.2	8.2	2.9	1.5	.78	2.3	.99	.91
27	2.0	2.9	66	3.4	4.6	7.0	2.7	1.5	.77	2.1	.98	1.1
28	1.8	2.3	35	3.5	4.1	6.1	2.7	1.5	.77	1.9	.98	1.2
29	1.5	2.5	16	18	------	5.7	2.6	1.6	.77	1.4	.97	1.1
30	1.4	10	9.7	25	------	4.8	2.6	1.5	.80	1.1	.94	
31	2.8	------	6.9	27	------	4.3	------	1.4	------	.90	.91	------
TOTAL	29.86	74.7	441.0	271.9	251.2	359.5	130.6	66.1	41.75	36.73	44.45	27.08
MEAN	.96	2.49	14.2	8.77	8.97	11.6	4.35	2.13	1.39	1.18	1.43	.93
MAX	3.0	10	88	27	28	33	7.7	3.3	2.0	2.3	3.3	1.2
MIN	.64	1.3	1.6	3.1	3.4	3.4	2.6	1.4	.77	.78	.67	.78
AC-FT	59	148	875	539	498	713	259	131	83	73	88	54*

CAL YEAR 1994	TOTAL*	545.56	MEAN	5.93	MAX	88	MIN	.64	AC-FT	1,080
WTR YEAR 1995	TOTAL*	1,774.87	MEAN	4.88	MAX	88	MIN	.64	AC-FT	3,520

* Incomplete Record



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208 MEAN DAILY DISCHARGE FOR JOHNSON CREEK 1995
DISCHARGE IN CFS
10.0
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

208 MEAN DAILY DISCHARGE FOR JOHNSON CREEK

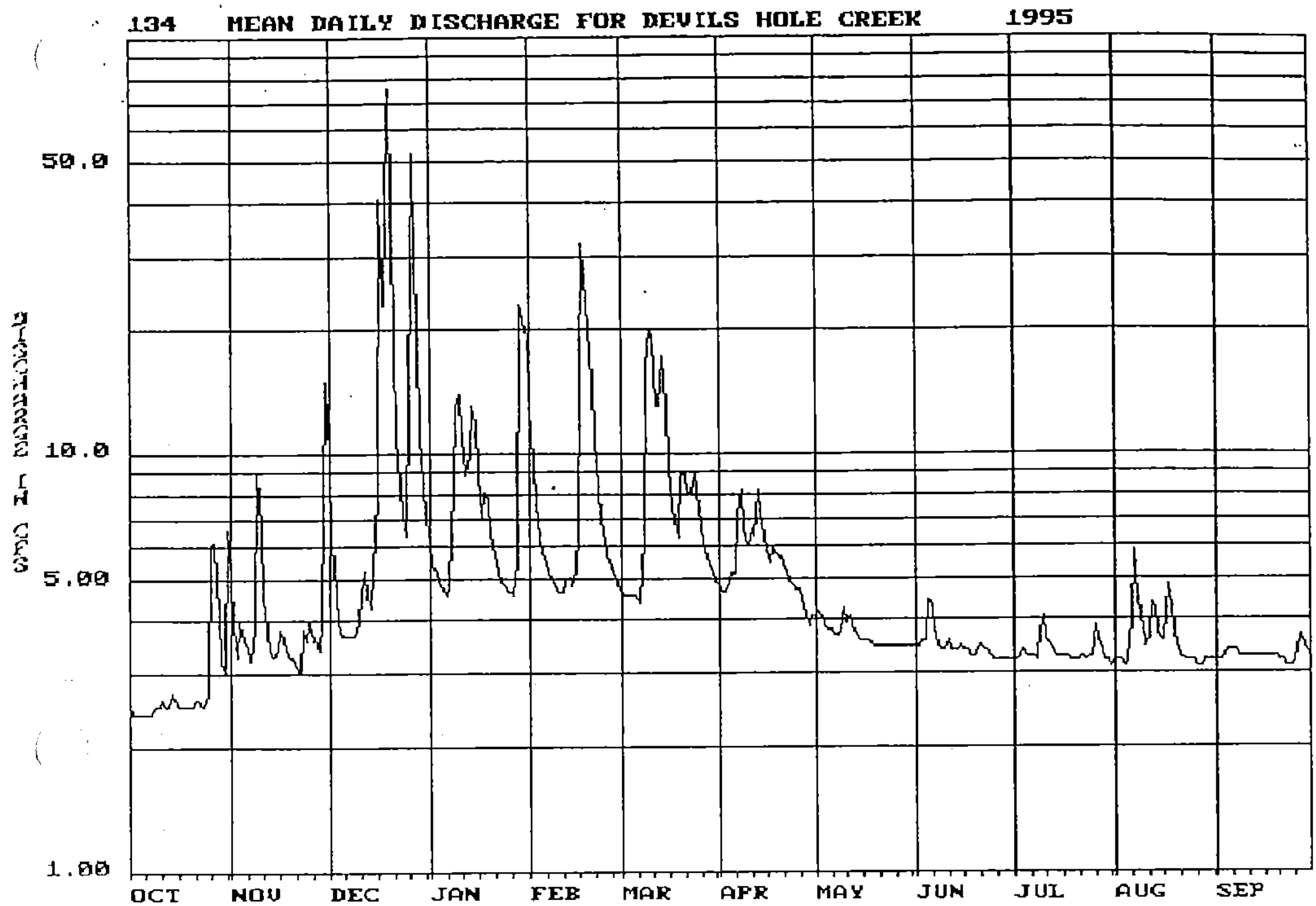
USGS #: 12070050

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.70	1.8	2.2	2.6	6.4	1.5	1.7	1.2	.86	.84	.83	.90
2	.71	1.2	1.3	2.2	3.9	1.5	1.6	1.4	.85	.87	.82	.92
3	.68	.85	.97	1.8	3.1	1.4	1.6	1.3	.85	.88	.81	.93
4	.67	1.9	.83	1.6	2.6	1.4	1.9	1.2	.87	.88	.80	1.0
5	.73	1.1	.74	1.5	2.2	1.6	1.7	1.2	1.2	.85	.82	.99
6	.75	1.0	.77	1.4	2.1	1.4	2.1	1.2	1.0	.86	1.8	.99
7	.73	.85	.78	1.9	1.9	1.3	6.1	1.2	.96	.85	1.8	.98
8	.73	2.5	.80	5.5	1.8	6.2	3.5	1.2	.94	.84	1.0	.98
9	.72	4.8	.78	8.7	1.6	10	2.5	1.2	.98	1.1	.94	.97
10	.73	1.3	1.7	6.8	1.5	14	2.8	1.2	1.0	.96	.94	.94
11	.73	.92	2.2	5.7	1.5	13	3.2	1.2	1.1	.89	1.1	.93
12	.74	.87	3.2	4.3	1.6	7.5	3.6	1.3	1.0	.86	3.1	.94
13	.78	.80	1.9	6.1	1.7	9.2	3.6	1.1	1.0	.86	1.3	.92
14	.80	.83	2.4	8.3	1.6	11	2.4	1.1	1.0	.85	1.1	.91
15	.77	.90	4.7	6.0	2.1	6.4	2.1	1.1	.96	.83	1.2	.90
16	.77	1.3	5.4	4.1	6.4	4.2	1.9	1.1	.90	.83	1.3	
17	.77	1.8	27	3.4	17	3.3	1.9	1.1	.90	.83	2.3	
18	.79	1.1	15	4.8	15	3.2	2.3	1.0	.90	.81	1.4	.91
19	.80	1.0	50	3.3	13	2.5	1.9	1.0	.92	.80	1.2	.88
20	.79	.99	44	2.7	10	7.6	1.8	.98	.90	.80	1.1	.87
21	.80	.83	15	2.3	5.9	4.8	1.7	.95	.90	.82	1.1	.85
22	.77	.83	9.5	2.1	4.0	4.1	1.6	.94	.88	.82	1.1	.84
23	.76	2.2	7.4	1.9	3.1	6.9	1.5	.92	.88	.81	1.1	.85
24	.74	1.2	6.2	1.8	2.7	5.7	1.5	.91	.86	.85	1.0	.87
25	1.0	1.5	6.5	1.8	2.4	3.9	1.4	.89	.86	.85	.97	.88
26	3.3	1.0	17	1.7	2.1	3.0	1.4	.88	.85	1.1	.91	.89
27	1.6	1.3	34	1.6	1.8	2.6	1.4	.89	.86	.88	.89	1.0
28	1.0	.93	12	3.5	1.6	2.3	1.4	.88	.89	.84	.87	.99
29	.95	1.9	6.5	13	------	2.1	1.3	.86	.87	.83	.89	.95
30	.91	11	4.3	14	------	1.9	1.3	.85	.86	.82	.88	
31	4.6	------	3.1	14	------	1.8	------	.85	------	.83	.89	------
TOTAL	31.32	50.50	288.17	140.4	120.6	147.3	64.7	33.10	27.80	26.74	36.26	26.80
MEAN	1.01	1.68	9.30	4.53	4.31	4.75	2.16	1.07	.93	.86	1.17	.92
MAX	4.6	11	50	14	17	14	6.1	1.4	1.2	1.1	3.1	1.0
MIN	.67	.80	.74	1.4	1.5	1.3	1.3	.85	.85	.80	.80	.84
AC-FT	62	100	572	278	239	292	128	66	55	53	72	53 *

CAL YEAR 1994	TOTAL*	369.99	MEAN	4.02	MAX	50	MIN	.67	AC-FT 734
WTR YEAR 1995	TOTAL*	993.69	MEAN	2.73	MAX	50	MIN	.67	AC-FT 1,970

* Incomplete Record


134 MEAN DAILY DISCHARGE FOR DEVILS HOLE CREEK 1995
DISCHARGE IN CFS
50.0
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

MEAN DAILY DISCHARGE FOR DEVILS HOLE CREEK

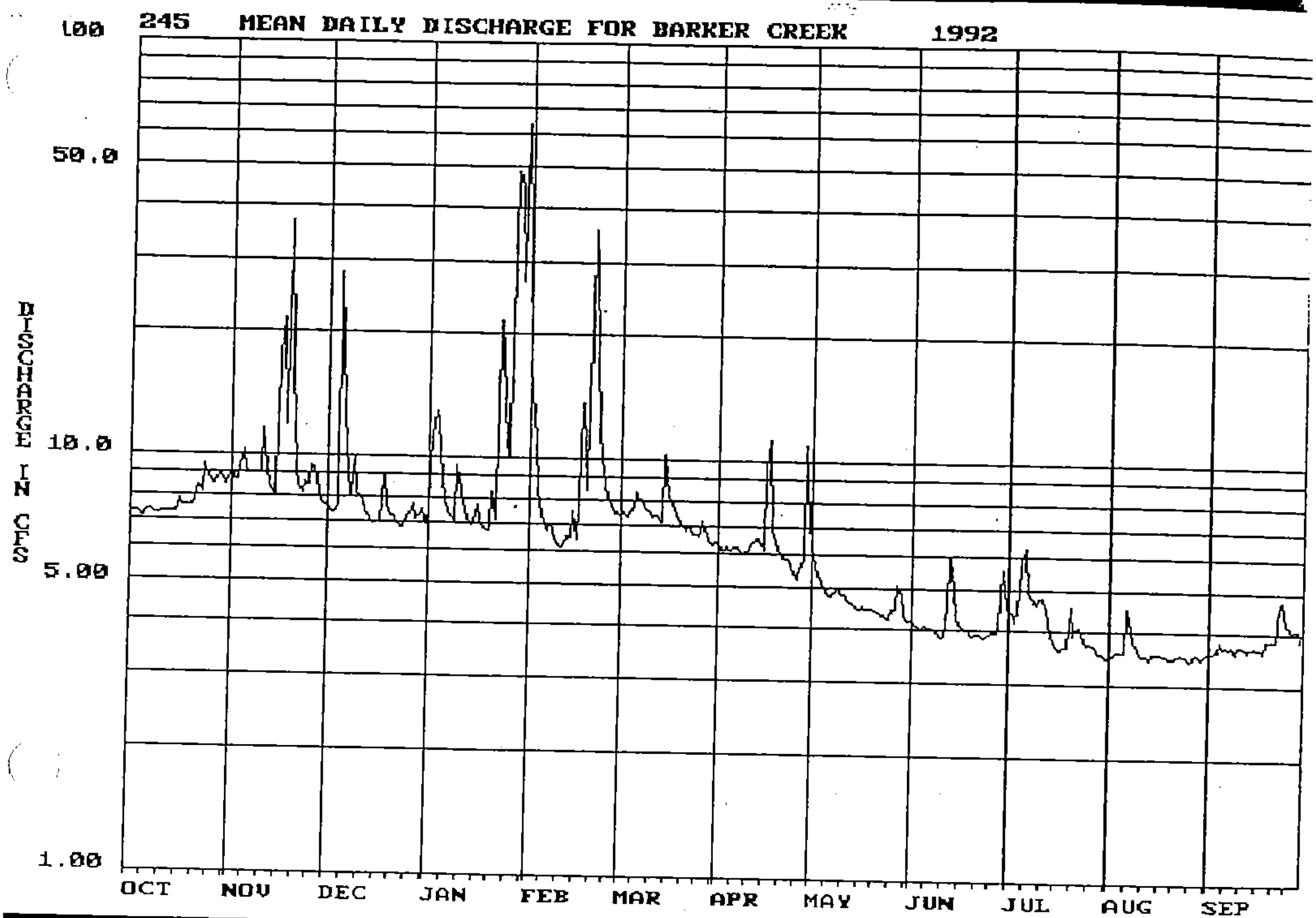
USGS #: 12069600

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.5	5.3	9.8	6.1	13	4.7	4.9	4.1	3.5	3.2	3.2	3.2
2	2.4	3.9	6.2	5.5	9.6	4.6	4.7	4.2	3.5	3.2	3.2	3.2
3	2.4	3.3	4.7	5.2	7.6	4.6	4.7	4.1	3.6	3.3	3.2	3.2
4	2.4	4.0	4.0	5.0	6.4	4.6	5.0	3.9	3.6	3.4	3.1	3.4
5	2.4	3.6	3.7	4.8	5.8	4.6	5.2	3.8	4.5	3.3	3.2	3.4
6	2.4	3.5	3.7	4.6	5.5	4.5	5.2	3.8	4.3	3.3	4.0	3.4
7	2.4	3.2	3.7	4.9	5.3	4.4	7.2	3.7	3.8	3.3	5.9	3.4
8	2.4	3.9	3.7	8.4	5.0	6.4	8.2	3.7	3.5	3.2	4.5	3.3
9	2.5	9.1	3.7	13	4.8	16	6.6	3.8	3.4	3.8	3.8	3.3
10	2.5	6.7	4.0	14	4.7	20	6.1	4.3	3.4	4.1	3.5	3.3
11	2.6	4.6	4.7	11	4.7	19	6.6	4.0	3.6	3.6	3.6	3.3
12	2.5	3.8	5.3	9.0	5.0	13	6.4	4.1	3.4	3.5	4.4	3.3
13	2.5	3.4	4.6	10	5.1	13	8.2	3.9	3.4	3.4	4.3	3.3
14	2.7	3.3	4.3	13	4.9	17	7.2	3.7	3.4	3.3	3.7	3.3
15	2.6	3.4	5.3	12	5.3	13	6.4	3.6	3.5	3.3	3.6	3.3
16	2.5	3.8	7.9	8.9	6.6	9.3	5.9	3.6	3.4	3.3	3.6	3
17	2.5	3.7	41	7.1	32	7.5	5.5	3.6	3.4	3.3	4.9	3
18	2.5	3.4	23	8.1	23	6.9	6.0	3.6	3.3	3.2	4.3	3.3
19	2.5	3.3	65	7.8	20	6.3	5.8	3.5	3.3	3.2	3.7	3.3
20	2.5	3.3	76	6.5	15	9.1	5.7	3.5	3.4	3.2	3.4	3.3
21	2.6	3.1	18	5.8	11	9.0	5.5	3.5	3.5	3.2	3.3	3.2
22	2.6	3.0	11	5.3	8.3	8.1	5.2	3.5	3.4	3.3	3.2	3.2
23	2.5	3.8	8.6	5.0	7.0	8.1	5.0	3.5	3.4	3.2	3.2	3.1
24	2.5	3.6	7.1	4.9	6.2	9.1	4.9	3.5	3.3	3.3	3.2	3.1
25	2.7	4.0	6.4	4.8	5.8	8.1	4.8	3.5	3.2	3.3	3.2	3.1
26	6.1	3.6	14	4.7	5.4	6.8	4.8	3.5	3.2	3.9	3.1	3.2
27	6.2	3.7	53	4.6	5.1	6.1	4.3	3.5	3.2	3.6	3.1	3.6
28	4.1	3.4	19	5.5	4.9	5.7	4.1	3.5	3.2	3.4	3.2	3.7
29	3.2	4.0	11	23	------	5.5	3.9	3.5	3.2	3.2	3.2	3.5
30	3.0	15	8.6	21	------	5.2	4.1	3.5	3.2	3.2	3.2	3.3
31	6.6	------	7.0	19	------	5.0	------	3.5	------	3.1	3.2	------
TOTAL	91.8	129.7	448.0	268.5	243.0	265.2	168.1	115.0	104.0	104.1	112.2	99.1
MEAN	2.96	4.32	14.5	8.66	8.68	8.55	5.60	3.71	3.47	3.36	3.62	3.30
MAX	6.6	15	76	23	32	20	8.2	4.3	4.5	4.1	5.9	3.7
MIN	2.4	3.0	3.7	4.6	4.7	4.4	3.9	3.5	3.2	3.1	3.1	3.1
AC-FT	182	257	889	533	482	526	333	228	206	206	223	197

CAL YEAR 1994	TOTAL*	669.5	MEAN	7.28	MAX	76	MIN	2.4	AC-FT	1,330
WTR YEAR 1995	TOTAL	2,148.7	MEAN	5.89	MAX	76	MIN	2.4	AC-FT	4,260

* Incomplete Record



245 MEAN DAILY DISCHARGE FOR BARKER CREEK 1992
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

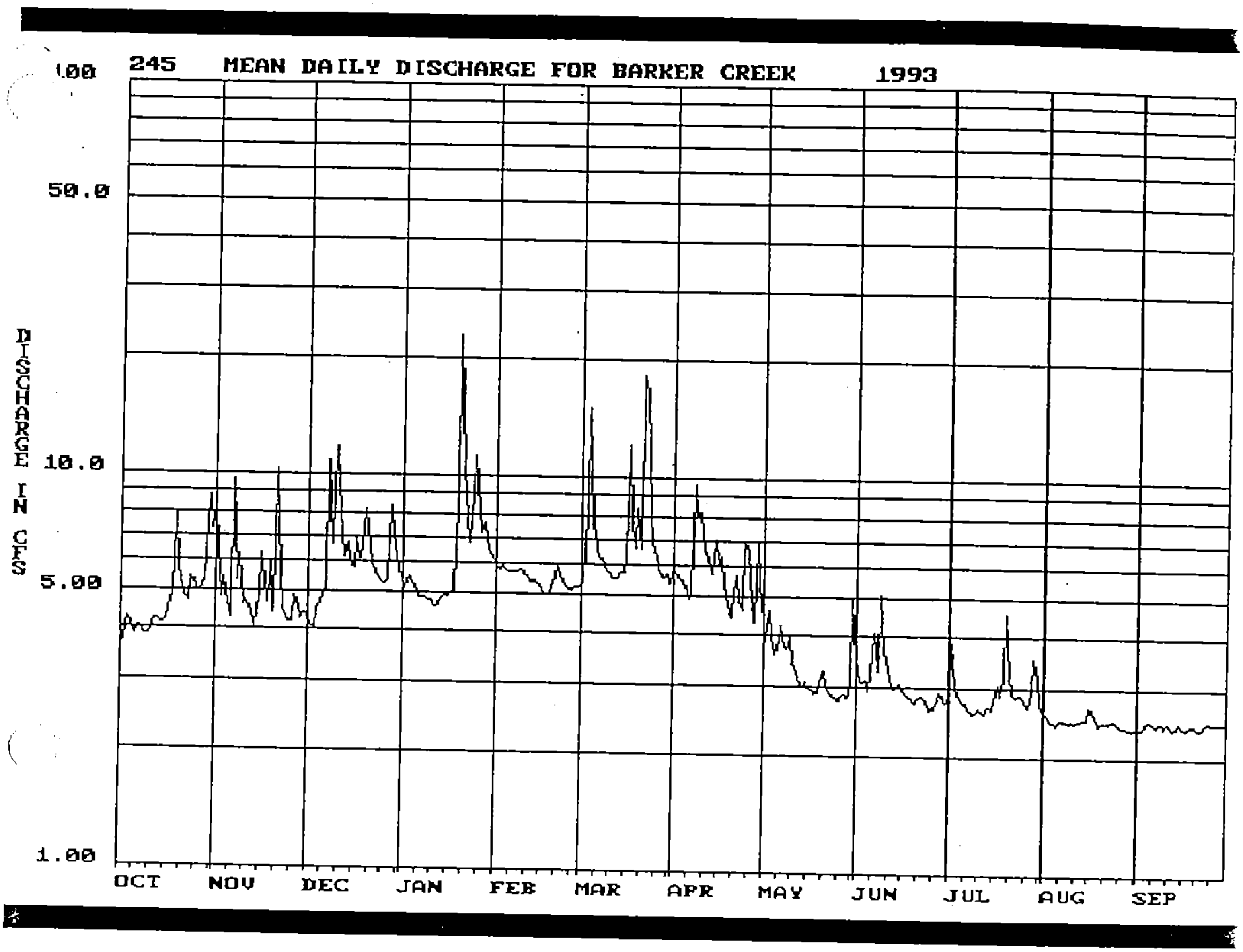
245 MEAN DAILY DISCHARGE FOR BARKER CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1991 TO SEP 1992

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1		9.2	7.6	7.6	17	7.4	6.3	6.3	4.2	4.4	3.5	3.6
2	7.3	8.8	7.4	11	14	7.5	6.2	5.7	4.1	4.4	3.5	3.6
3	7.3	8.8	7.4	13	11	7.3	6.2	5.4	4.1	4.2	3.6	3.6
4	7.3	9.5	7.6	12	8.4	7.5	6.2	5.1	4.0	5.0	3.6	3.8
5	7.1	10	28	8.9	7.4	7.7	6.2	5.0	4.1	5.9	3.6	3.7
6	7.3	9.2	13	7.9	7.0	8.4	6.3	4.9	4.1	6.4	4.6	3.7
7	7.4	9.1	9.0	7.5	6.8	8.1	6.3	4.8	4.1	5.0	4.1	3.7
8	7.3	9.1	8.1	7.2	7.0	7.9	6.1	5.0	4.0	4.8	3.8	3.7
9	7.3	9.1	10	7.1	6.5	7.7	6.1	5.0	4.0	4.7	3.7	3.6
10	7.3	9.1	8.2	9.6	6.3	7.5	6.1	4.9	3.9	4.8	3.6	3.7
11	7.3	12	7.9	8.3	6.2	7.4	6.2	4.9	3.9	4.8	3.5	3.7
12	7.4	9.3	7.8	7.5	6.3	7.4	6.5	4.8	4.6	4.7	3.5	3.7
13	7.3	8.5	7.3	7.2	6.5	7.3	6.5	4.7	6.0	4.3	3.4	3.6
14	7.3	8.2	7.1	6.9	6.5	7.2	6.5	4.6	5.1	3.9	3.5	3.7
15	7.3	8.1	6.9	7.0	7.5	10	6.2	4.6	4.3	3.7	3.6	3.7
16	7.9	17	7.0	7.8	6.5	8.2	9.7	4.5	4.1	3.7	3.5	3.7
17	7.6	22	7.0	7.1	7.9	8.1	11	4.6	4.1	3.6	3.5	3[illegible]
18	7.6	12	9.1	6.9	14	7.7	6.9	4.5	4.0	3.7	3.5	3[illegible]
19	7.6	37	7.6	6.8	8.5	7.3	6.5	4.5	4.0	3.7	3.5	3.8
20	7.6	16	7.3	6.8	13	7.1	6.2	4.5	3.9	4.6	3.5	3.8
21	8.1	9.4	7.3	8.3	36	6.9	5.9	4.4	3.9	3.9	3.5	3.9
22	8.5	8.4	7.0	7.1	29	6.9	6.0	4.4	3.9	4.1	3.5	3.8
23	8.2	8.2	6.9	21	12	6.9	5.9	4.4	3.9	4.1	3.6	4.8
24	9.5	8.7	6.8	18	10	6.7	5.6	4.3	3.9	3.9	3.5	4.8
25	8.9	8.6	7.3	11	8.7	6.7	5.5	4.3	3.9	3.7	3.5	4.2
26	8.7	9.5	7.4	10	8.2	6.6	5.3	4.5	4.0	3.8	3.4	4.2
27	8.6	9.4	7.7	33	7.8	7.2	5.7	4.5	4.0	3.7	3.6	4.1
28	8.9	8.3	7.2	50	7.5	6.7	5.8	5.2	4.1	3.6	3.6	4.1
29	9.0	7.9	7.4	46	7.5	6.5	11	4.9	5.6	3.5	3.5	4.1
30	8.6	7.7	7.5	27	------	6.3	7.3	4.4	4.6	3.5	3.5	3.8
31	8.8	------	6.9	64	------	6.4	------	4.2	------	3.5	3.6	------
TOTAL	236.3	328.1	260.7	459.5	301.0	228.5	198.2	147.8	126.4	131.6	111.4	115.6
MEAN	7.88	10.9	8.41	14.8	10.4	7.37	6.61	4.77	4.21	4.25	3.59	3.85
MAX	9.5	37	28	64	36	10	11	6.3	6.0	6.4	4.6	4.8
MIN	7.1	7.7	6.8	6.8	6.2	6.3	5.3	4.2	3.9	3.5	3.4	3.6
AC-FT	469 *	651	517	911	597	453	393	293	251	261	221	229

CAL YEAR 1991	TOTAL*	825.1	MEAN	9.07	MAX	37	MIN	6.8	AC-FT	1,640
WTR YEAR 1992	TOTAL*	2,645.1	MEAN	7.25	MAX	64	MIN	3.4	AC-FT	5,250

* Incomplete Record



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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

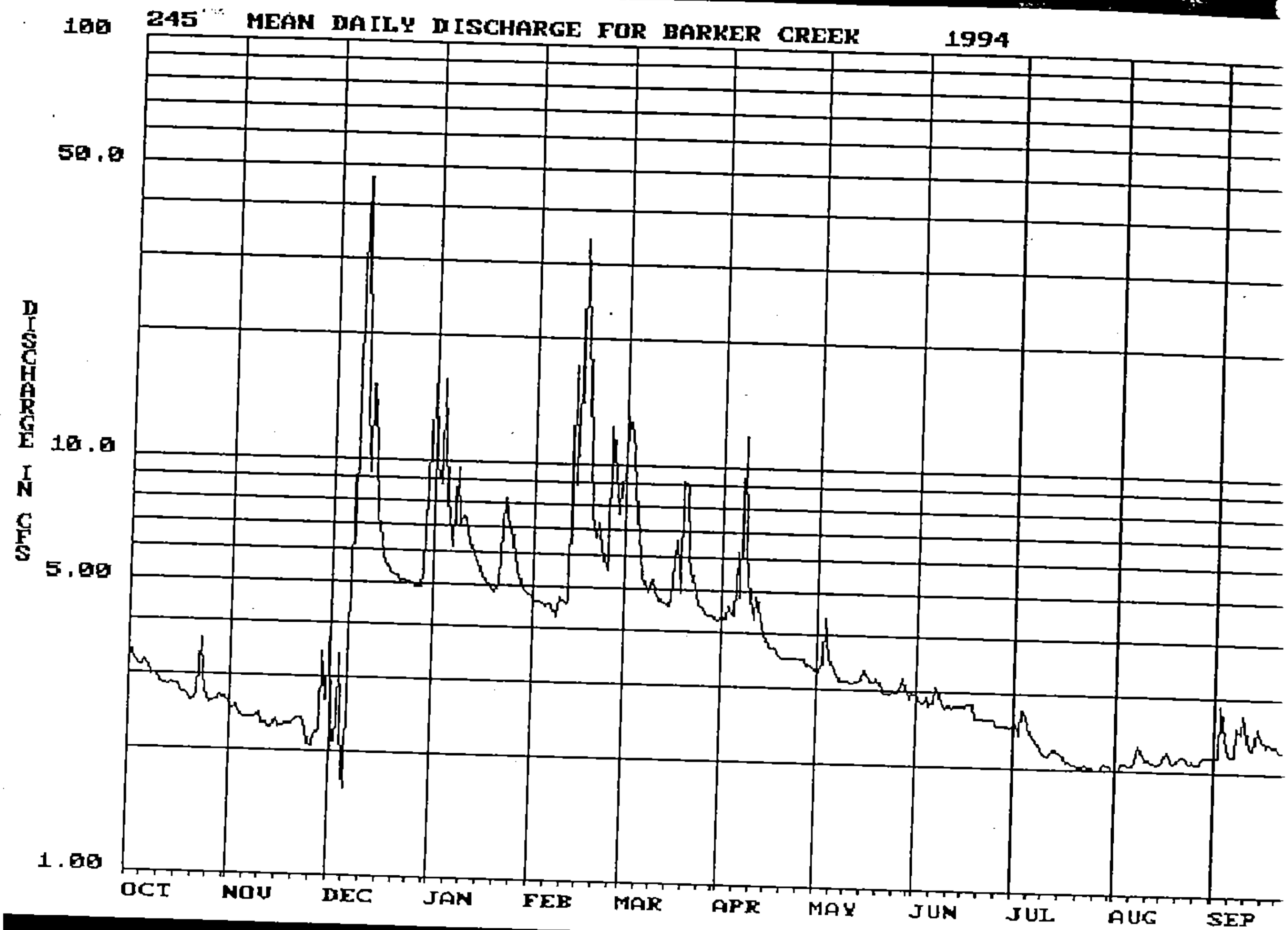
245 MEAN DAILY DISCHARGE FOR BARKER CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1992 TO SEP 1993

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.7	8.3	4.3	5.4	6.0	5.4	6.0	4.3	3.5	2.8	2.6	2.4
2	3.8	6.6	4.2	5.2	5.9	5.5	5.7	3.9	3.1	3.9	2.5	2.4
3	4.3	4.9	4.1	5.6	6.0	8.2	5.6	4.7	3.1	3.0	2.5	2.4
4	4.3	5.5	4.5	5.5	5.8	15	5.5	4.0	3.1	2.9	2.4	2.5
5	3.9	4.6	4.7	5.3	5.8	7.7	5.3	3.6	2.9	2.8	2.4	2.5
6	3.9	4.3	5.0	5.0	5.8	6.7	5.0	3.9	3.7	2.8	2.5	2.5
7	4.1	9.7	5.2	4.9	5.8	6.3	5.1	4.3	4.1	2.7	2.5	2.4
8	4.0	5.4	11	5.0	5.8	6.3	9.7	3.8	3.3	2.6	2.5	2.4
9	3.9	6.3	6.7	4.9	5.8	6.0	8.1	3.7	5.2	2.6	2.5	2.5
10	3.9	4.7	12	4.8	5.7	5.8	8.2	4.0	3.7	2.6	2.5	2.4
11	4.0	4.8	9.5	4.7	5.6	5.6	6.6	3.4	3.3	2.6	2.5	2.4
12	4.3	4.6	7.1	4.7	5.5	5.6	6.5	3.2	3.2	2.6	2.5	2.4
13	4.2	4.4	6.3	4.8	5.4	5.6	6.0	3.1	3.0	2.6	2.5	2.4
14	4.2	4.1	6.8	4.9	5.4	5.8	5.8	3.0	3.0	2.7	2.5	2.4
15	4.2	4.9	6.1	5.0	5.3	5.8	7.1	3.1	3.0	2.7	2.5	2.5
16	4.2	6.3	5.9	5.0	5.2	6.2	6.0	3.0	2.9	2.8	2.7	2.4
17	4.5	5.5	6.9	5.1	5.1	12	6.4	2.9	2.9	3.0	2.6	2[illegible]
18	4.9	4.7	6.2	5.1	5.0	7.6	5.4	2.9	2.8	2.9	2.5	2[illegible]
19	7.9	6.0	7.3	8.7	5.3	6.7	4.8	2.9	2.8	3.2	2.4	2.4
20	5.8	4.4	8.2	23	5.6	8.4	4.4	3.1	2.7	4.6	2.4	2.4
21	5.1	10	6.6	11	6.0	6.6	5.3	3.3	2.8	3.2	2.5	2.4
22	4.9	5.6	6.0	7.9	5.7	18	5.7	3.0	2.8	2.9	2.5	2.4
23	4.8	4.5	5.7	6.8	5.5	17	4.9	2.9	2.8	2.8	2.5	2.4
24	5.5	4.3	5.6	9.1	5.3	8.2	4.7	2.8	2.7	2.9	2.5	2.4
25	5.4	4.2	5.4	11	5.2	6.9	7.0	2.8	2.6	2.9	2.5	2.5
26	5.1	4.2	5.3	8.3	5.2	6.4	6.6	2.8	2.7	2.7	2.4	2.5
27	5.1	4.9	5.5	7.2	5.3	6.0	4.9	2.8	2.8	2.7	2.4	2.5
28	5.4	4.6	8.4	7.6	5.3	5.7	4.3	2.9	2.9	3.0	2.4	2.5
29	6.4	4.3	7.1	6.9	------	5.7	7.0	2.8	2.8	3.5	2.4	2.5
30	8.9	4.5	6.2	6.4	------	5.7	5.5	3.0	2.7	3.2	2.4	2.5
31	7.4	------	5.8	6.2	------	5.5	------	5.0	------	2.7	2.4	------
TOTAL	152.0	161.1	199.6	211.0	155.3	233.9	179.1	104.9	92.9	90.9	76.9	73.1
MEAN	4.90	5.37	6.44	6.81	5.55	7.55	5.97	3.38	3.10	2.93	2.48	2.44
MAX	8.9	10	12	23	6.0	18	9.7	5.0	5.2	4.6	2.7	2.5
MIN	3.7	4.1	4.1	4.7	5.0	5.4	4.3	2.8	2.6	2.6	2.4	2.4
AC-FT	301	320	396	419	308	464	355	208	184	180	153	145

CAL YEAR 1992	TOTAL*	512.7	MEAN	5.57	MAX	12	MIN	3.7	AC-FT	1,020
WTR YEAR 1993	TOTAL	1,730.7	MEAN	4.74	MAX	23	MIN	2.4	AC-FT	3,430

* Incomplete Record


245 MEAN DAILY DISCHARGE FOR BARKER CREEK 1994
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

245 MEAN DAILY DISCHARGE FOR BARKER CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1993 TO SEP 1994

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.5	2.5	4.2	17	4.7	9.9	4.3	3.3	3.0	2.5	2.0	2.2
2	3.3	2.5	2.0	9.7	4.7	13	4.4	3.3	2.8	2.5	2.0	2.2
3	3.2	2.5	2.4	8.9	4.7	12	4.7	3.5	2.8	2.4	2.1	2.9
4	3.2	2.5	3.4	16	4.6	11	4.5	4.4	2.9	2.8	2.1	2.4
5	3.1	2.4	1.7	8.3	4.6	7.6	4.4	3.5	2.8	2.6	2.1	2.2
6	3.2	2.4	1.6	6.5	4.6	6.0	6.2	3.4	2.8	2.4	2.1	2.2
7	3.2	2.4	5.9	6.3	4.5	5.4	4.9	3.3	3.1	2.4	2.1	2.2
8	3.0	2.4	6.5	9.7	4.3	5.1	12	3.2	3.0	2.3	2.3	2.5
9	3.0	2.4	27	7.0	4.8	5.0	6.3	3.1	2.8	2.3	2.2	2.5
10	2.9	2.4	47	7.4	4.7	5.3	4.9	3.1	2.8	2.2	2.1	2.7
11	2.9	2.3	13	7.3	4.6	5.0	4.4	3.1	2.8	2.2	2.1	2.4
12	2.8	2.3	9.4	6.3	4.7	4.7	4.9	3.1	2.8	2.1	2.1	2.3
13	2.8	2.3	15	6.0	17	4.8	4.4	3.1	2.8	2.2	2.1	2.3
14	2.9	2.3	11	5.8	9.0	4.7	4.2	3.1	2.8	2.2	2.1	2.5
15	2.9	2.4	7.4	5.5	16	4.6	3.9	3.2	2.8	2.2	2.1	2.4
16	2.8	2.3	6.5	5.3	35	4.8	3.8	3.3	2.8	2.2	2.1	2.4
17	2.7	2.3	5.8	5.2	21	5.9	3.7	3.2	2.8	2.1	2.2	[illegible]
18	2.7	2.3	5.5	5.0	11	6.6	3.7	3.2	2.8	2.1	2.1	[illegible]
19	2.7	2.3	5.3	5.0	7.6	5.0	3.6	3.1	2.6	2.1	2.1	2.5
20	2.6	2.3	5.4	4.9	6.7	9.3	3.5	3.2	2.6	2.0	2.1	2.3
21	2.6	2.4	5.3	5.2	7.2	9.0	3.5	3.2	2.6	2.0	2.2	2.3
22	2.7	2.4	5.1	7.0	6.3	6.0	3.5	3.0	2.6	2.0	2.2	2.2
23	3.7	2.4	5.1	8.2	5.9	5.4	3.5	2.9	2.6	2.0	2.2	2.2
24	3.0	2.2	5.1	7.0	5.6	5.0	3.5	3.0	2.6	2.0	2.1	2.2
25	2.6	2.1	5.1	7.0	12	4.7	3.5	3.0	2.6	2.0	2.1	2.2
26	2.6	2.1	5.1	6.0	9.6	4.6	3.5	3.0	2.5	2.0	2.1	2.3
27	2.6	2.2	5.0	5.5	7.7	4.5	3.5	3.0	2.5	2.0	2.1	2.2
28	2.6	2.2	5.0	5.2	9.0	4.4	3.4	3.2	2.5	2.0	2.1	2.3
29	2.7	3.4	5.4	5.0	------	4.4	3.4	3.1	2.5	2.1	2.2	2.3
30	2.7	2.7	8.6	4.9	------	4.4	3.4	2.9	2.5	2.0	2.2	2.4
31	2.6	------	11	4.8	------	4.3	------	3.0	------	2.0	2.2	------
TOTAL	89.8	71.6	251.8	218.9	242.1	192.4	131.4	99.0	81.9	67.9	65.9	70.1
MEAN	2.90	2.39	8.12	7.06	8.65	6.21	4.38	3.19	2.73	2.19	2.13	2.34
MAX	3.7	3.4	47	17	35	13	12	4.4	3.1	2.8	2.3	2.9
MIN	2.6	2.1	1.6	4.8	4.3	4.3	3.4	2.9	2.5	2.0	2.0	2.2
AC-FT	178	142	499	434	480	382	261	196	162	135	131	139

CAL YEAR 1993	TOTAL*	413.2	MEAN	4.49	MAX	47	MIN	1.6	AC-FT	820
WTR YEAR 1994	TOTAL	1,582.8	MEAN	4.34	MAX	47	MIN	1.6	AC-FT	3,140

* Incomplete Record

Clear Creek #246

GAGE LOCATION - Lat. 47'39'54"N, Long. 122' 40'52"W, in Kitsap County, at intersection of Silverdale Way NW & NW Wagga Way, NE corner, near historic USGS gage site approximately 1 mile up from mouth.

DRAINAGE AREA - 7.46 sq.mi. (USGS Water Supply Bulletin #18)

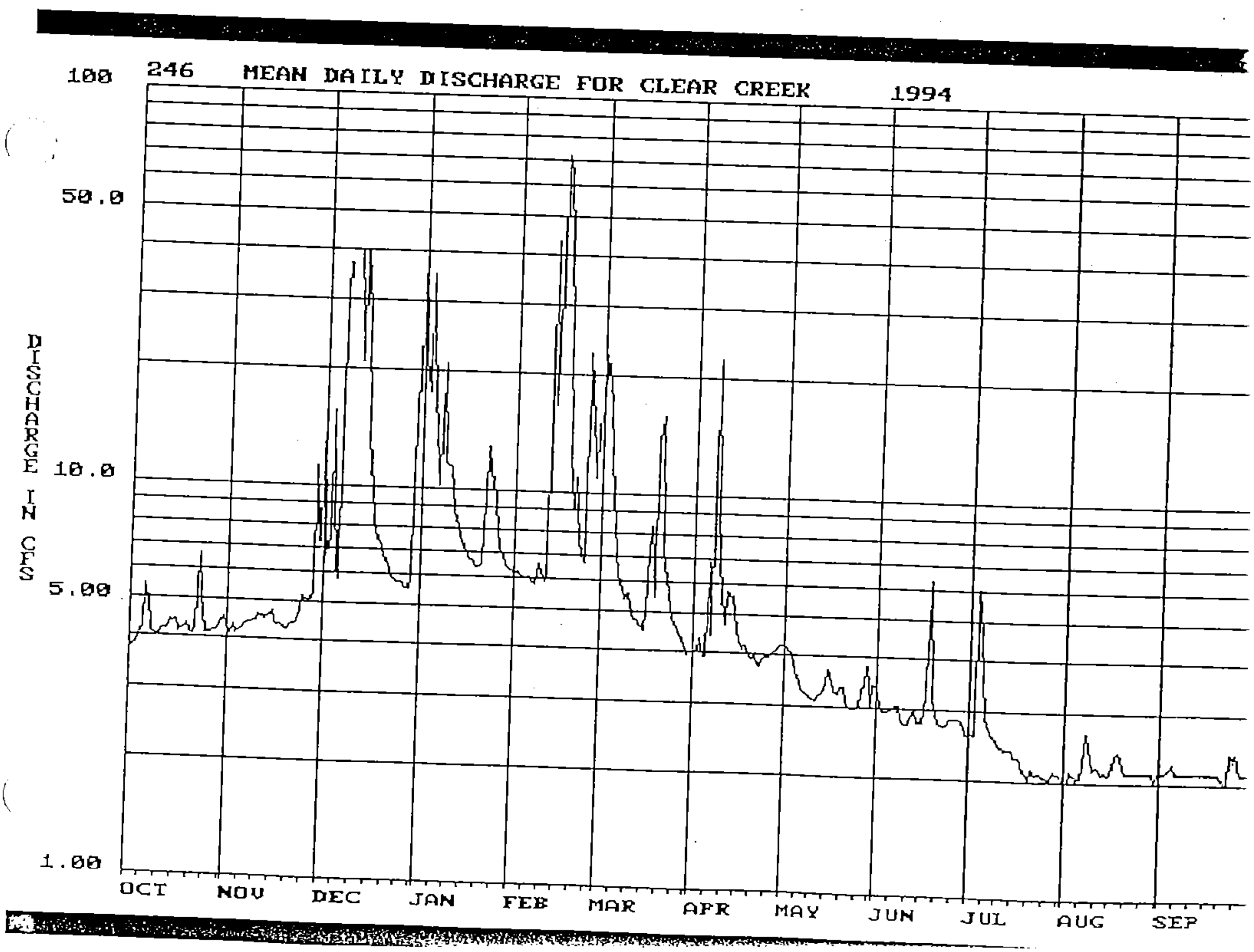
PERIOD OF RECORD - 10/1/93 to 9/30/94

GAGE - Installation date 10/1/90. Instrumentation NW DL-2 Data Logger and 0-5PSIG Instrumentation NW Transducer in stilling well with hutch and ceramic staff gage. Datum of gage is ~40' above sea level.

REMARKS - Record estimated 11/18/93 through 11/23/93, 4/27/94 through 5/3/94, 8/17/94 through 9/30/94. Flow exceeded rating 12/9&10/93 due to 3" precipitation event. 13 - flow measurements and 6-field calibration visits were used to correct, estimate and shift record.

EXTREMES FOR CURRENT YEAR - Maximum recorded discharge of 115Cu.Ft./Sec. occurred 2/16/94; minimum discharge of 1.8Cu.Ft./Sec. occurred 7/20/94.

SUBMITTED BY - Kitsap Public Utility District #1, JRL



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

246 MEAN DAILY DISCHARGE FOR CLEAR CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1993 TO SEP 1994

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.8	4.2	16	44	6.2	16	4.0	4.3E	3.4	2.6	2.0	2.1E
2	3.8	4.2	6.7	21	6.3	22	4.0	4.2E	3.1	2.6	2.0	2.1E
3	3.8	4.4	7.5	18	6.2	19	4.4	4.1E	2.9	2.6	2.1	2.1E
4	4.0	4.2	16	35	6.1	17	3.9	4.1	3.0	6.1	2.1	2.2E
5	4.2	4.3	6.2	17	6.1	9.7	3.9	3.7	2.9	4.7	2.0	2.3E
6	5.5	4.3	5.8	12	6.1	7.2	6.9	3.5	3.0	2.9	2.1	2.1E
7	5.0	4.4	31	10	6.0	6.3	4.5	3.3	3.0	2.7	2.2	2.1E
8	4.2	4.5	37	21	5.9	5.7	22	3.2	3.0	2.6	2.7	2.1E
9	4.1	4.5	r	12	6.6	5.5	9.3	3.2	2.8	2.6	2.3	2.1E
10	4.1	4.5	r	12	6.3	5.7	5.5	3.2	2.7	2.5	2.1	2.1E
11	4.2	4.7	40	11	6.0	5.2	4.8	3.2	2.8	2.5	2.2	2.1E
12	4.2	4.6	21	8.9	6.1	4.9	5.8	3.1	2.9	2.4	2.1	2.1E
13	4.2	4.6	40	8.0	44	4.8	5.6	3.2	3.0	2.4	2.1	2.1E
14	4.5	4.6	29	7.6	17	4.7	5.6	3.3	2.8	2.4	2.1	2.1E
15	4.4	4.8	13	7.3	35	4.6	4.6	3.4	2.8	2.4	2.1	2.1E
16	4.4	4.5	10	7.0	71	5.0	4.3	3.7	2.8	2.3	2.1	2.1E
17	4.2	4.4	8.2	6.7	66	7.4	4.1	3.4	3.2	2.3	2.4E	[illegible]
18	4.3	4.4E	7.4	6.7	27	8.4	4.2	3.3	6.4	2.3	2.4E	2.
19	4.4	4.4E	7.1	6.4	13	5.5	4.1	3.2	3.2	2.1	2.3E	2.1E
20	4.1	4.3E	6.7	6.4	9.1	14	3.9	3.4	2.9	2.1	2.1E	2.1E
21	4.1	4.4E	6.4	6.6	11	16	4.0	3.4	2.8	2.0	2.1E	2.1E
22	4.3	4.5E	6.1	9.6	7.8	7.2	3.8	3.1	2.7	2.1	2.1E	2.0E
23	6.6	4.5E	5.9	13	7.0	6.2	3.8	3.0	2.7	2.1	2.1E	2.0E
24	5.1	4.9	5.8	10	6.7	5.2	3.9	3.0	2.8	2.1	2.1E	2.4E
25	4.2	5.2	5.8	11	23	4.9	4.0	3.0	2.8	2.0	2.1E	2.3E
26	4.2	5.1	5.8	8.0	15	4.7	4.0	3.0	2.8	2.0	2.1E	2.4E
27	4.2	5.0	5.6	7.3	11	4.5	4.1E	3.3	2.8	2.0	2.1E	2.1E
28	4.2	5.3	5.6	6.9	15	4.3	4.1E	3.4	2.8	2.1	2.1E	2.1E
29	4.2	11	5.8	6.6	------	4.1	4.2E	3.8	2.7	2.1	2.1E	2.1E
30	4.4	7.3	17	6.4	------	4.0	4.3E	3.1	2.6	2.1	2.0E	2.1E
31	4.5	------	18	6.2	------	4.0	------	3.4	------	2.1	2.1E	------
TOTAL	135.4	146.0	396.4	369.6	452.5	243.7	155.6	105.5	90.1	77.8	66.5	63.9
MEAN	4.37	4.87	13.7	11.9	16.2	7.86	5.19	3.40	3.00	2.51	2.15	2.13
MAX	6.6	11	40	44	71	22	22	4.3	6.4	6.1	2.7	2.4
MIN	3.8	4.2	5.6	6.2	5.9	4.0	3.8	3.0	2.6	2.0	2.0	2.0
AC-FT	269	290	786 *	733	898	483	309	209	179	154	132	127

CAL YEAR 1993	TOTAL*	677.8	MEAN	7.53	MAX	40	MIN	3.8	AC-FT	1,340
WTR YEAR 1994	TOTAL*	2,303.0	MEAN	6.34	MAX	71	MIN	2.0	AC-FT	4,570

* Incomplete Record

Clear Creek #246

GAGE LOCATION - Lat. 47'39'54"N, Long. 122' 40'52"W, in Kitsap County, at intersection of Silverdale Way NW & NW Wagga Way, NE corner, near historic USGS gage site approximately 1 mile up from mouth.

DRAINAGE AREA - 7.46 sq.mi. (USGS Water Supply Bulletin #18)

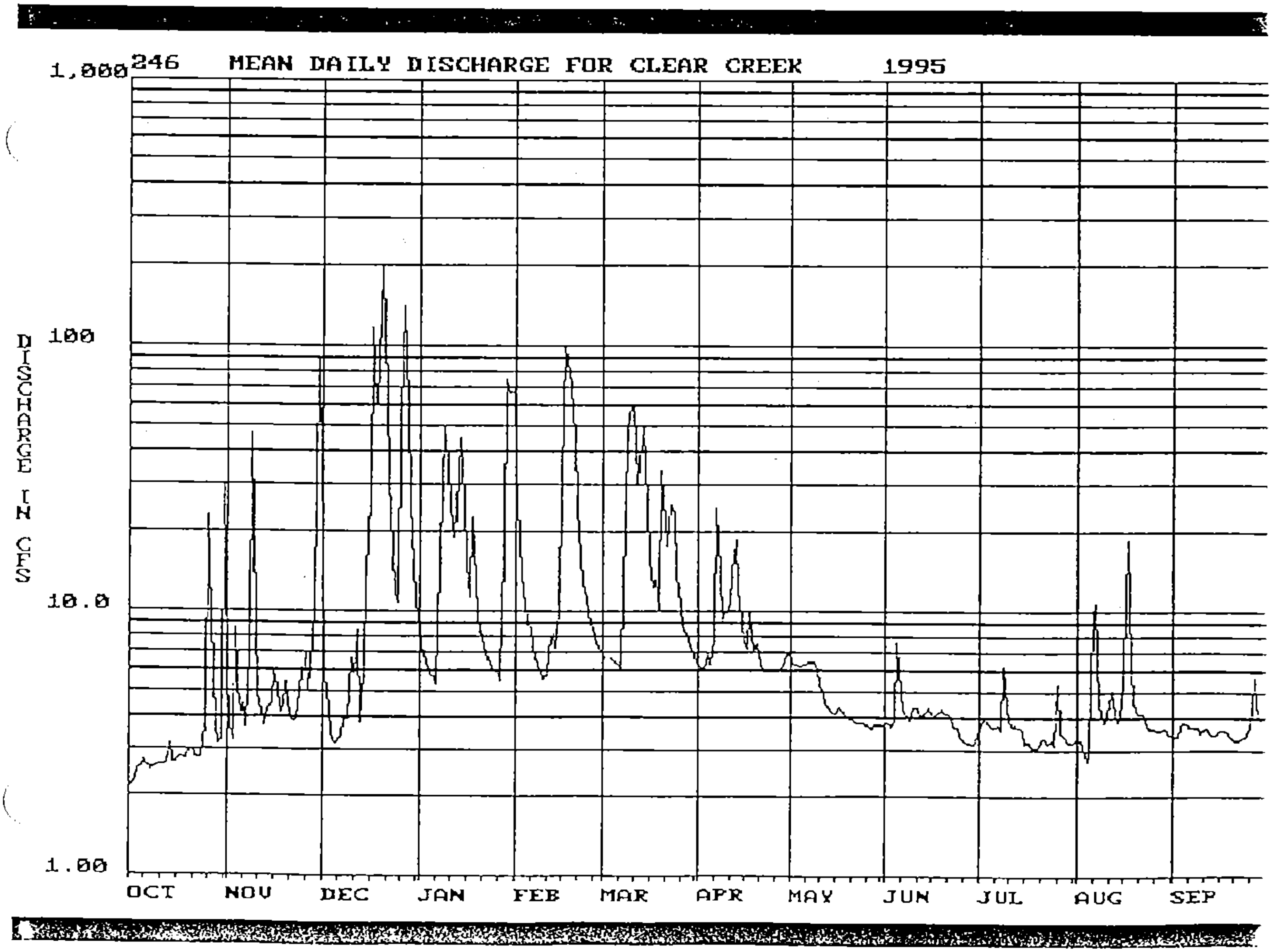
PERIOD OF RECORD - 10/1/94 to 9/30/95

GAGE - Installation date 10/1/90. Instrumentation NW DL-2 Data Logger and 0-5PSIG Instrumentation NW Transducer in stilling well with hutch and ceramic staff gage. Datum of gage is ~40' above sea level.

REMARKS - Record estimated 10/1/94 through 10/7/94, 11/23/94 through 11/28/94, 12/20/94, 4/29/95 through 5/3/95. 13 - flow measurements and 7 - field calibration visits were used to correct, estimate and shift record.

EXTREMES FOR CURRENT YEAR - Maximum recorded discharge of 226Cu.Ft./Sec. occurred 12/19/94; minimum discharge of 2.1Cu.Ft./Sec. occurred 10/1/94.

SUBMITTED BY - Kitsap Public Utility District #1, JRL



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

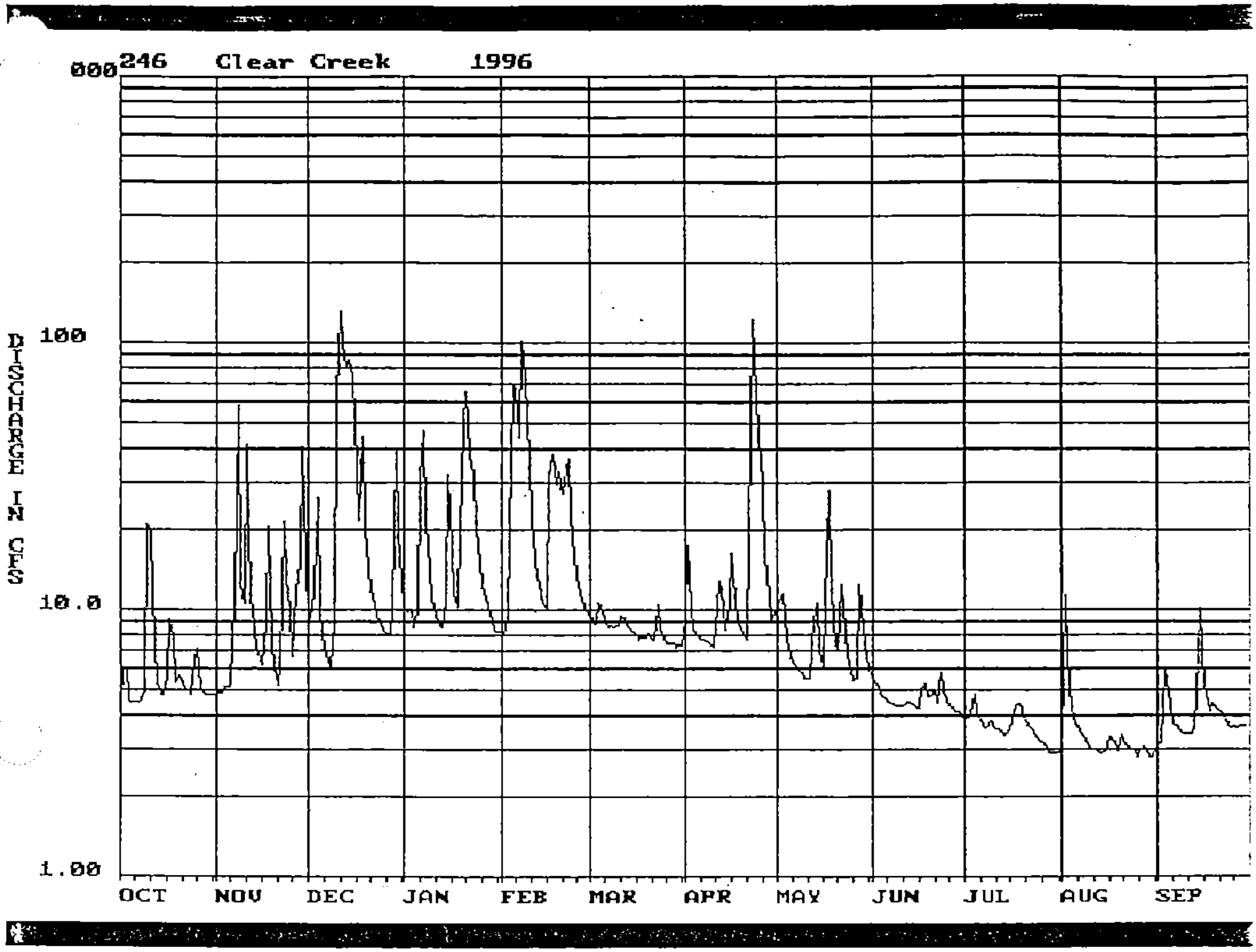
246 MEAN DAILY DISCHARGE FOR CLEAR CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.1E	6.4	17	8.7	35	7.0	6.4	7.0E	3.8	3.7	3.3	3.4
2	2.2E	3.7	5.9	7.4	19	6.8	6.2	6.5E	3.8	3.8	3.3	3.4
3	2.3E	3.3	4.3	6.7	14		6.1	6.4E	3.7	4.0	3.1	3.4
4	2.5E	8.6	3.5	6.1	11	6.7	7.0	6.3	3.9	3.9	2.7	3.9
5	2.6E	4.0	3.2	5.7	8.9	6.5	6.4	6.3	7.7	3.7	3.0	3.8
6	2.8E	4.5	3.3	5.4	8.9	6.3	8.0	6.4	5.0	3.7	9.8	3.7
7	2.6E	3.7	3.3	8.8	7.3	6.1	25	6.5	4.3	3.8	11	3.7
8	2.5	7.0	4.0	29	6.3	23	14	6.5	4.0	3.6	4.6	3.7
9	2.5	47	4.0	49	5.9	49	9.3	6.5	3.9	6.3	3.8	3.7
10	2.6	9.1	6.8	38	5.7	60	10	6.0	4.4	4.5	3.9	3.6
11	2.6	4.9	5.9	25	5.7	61	11	5.3	4.4	3.9	4.6	3.6
12	2.6	4.2	8.6	19	7.1	30	14	5.0	4.1	3.7	5.2	3.7
13	2.7	3.8	3.8	33	8.4	36	19	4.6	4.1	3.8	4.2	3.5
14	3.2	4.2	5.9	45	7.3	50	12	4.3	4.2	3.7	3.9	3.5
15	2.7	4.6	14	26	10	26	9.3	4.2	4.4	3.6	4.4	3.4
16	2.7	6.0	27	15	31	16	7.6	4.2	4.2	3.2	5.9	3.6
17	2.8	5.3	118	11	101	12	7.3	4.4	4.1	3.2	19	3[illegible]
18	2.8	4.2	61	23	79	13	9.9	4.3	4.2	3.1	6.4	3[illegible]
19	2.8	4.4	128	13	71	10	7.2	4.1	4.3	3.1	4.6	3.5
20	3.1	5.5	200 E	9.6	46	34	7.5	4.0	4.2	3.0	4.2	3.4
21	3.0	4.1	64	7.9	24	22	6.8	4.0	4.2	3.3	4.2	3.3
22	2.8	3.9	32	7.0	16	18	6.1	3.9	4.0	3.3	4.2	3.3
23	2.8	4.0E	17	6.7	13	25	6.0	3.9	3.7	3.2	3.9	3.4
24	2.8	5.0E	12	6.2	11	23	6.1	3.8	3.7	3.3	3.7	3.4
25	3.8	6.0E	11	6.0	9.8	14	6.1	3.8	3.4	3.2	3.6	3.6
26	23	7.0E	56	5.8	8.6	10	6.1	3.8	3.3	5.4	3.7	3.7
27	9.5	5.0E	143	5.6	7.7	9.0	6.1	3.7	3.2	3.5	3.6	5.7
28	3.6	8.0E	61	17	7.3	8.2	6.2	3.6	3.2	3.4	3.6	4.4
29	3.2	10	26	76	------	7.7	6.5E	3.8	3.1	3.3	3.6	4.0
30	3.3	90	15	68	------	7.3	7.0E	3.8	3.3	3.3	3.5	4.2
31	30	------	11	69	------	6.7	------	3.8	------	3.3	3.5	------
TOTAL	140.5	287.4	1,075.5	659.6	585.9	610.3	266.2	150.7	121.8	113.8	152.0	110.7
MEAN	4.53	9.58	34.7	21.3	20.9	20.3	8.87	4.86	4.06	3.67	4.90	3.69
MAX	30	90	200	76	101	61	25	7.0	7.7	6.3	19	5.7
MIN	2.1	3.3	3.2	5.4	5.7	6.1	6.0	3.6	3.1	3.0	2.7	3.3
AC-FT	279	570	2,130	1,310	1,160	1,210 *	528	299	242	226	301	220

CAL YEAR 1994	TOTAL*	1,503.4	MEAN	16.3	MAX	200	MIN	2.1	AC-FT	2,980
WTR YEAR 1995	TOTAL*	4,274.4	MEAN	11.7	MAX	200	MIN	2.1	AC-FT	8,480

* Incomplete Record



000246 Clear Creek 1996
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

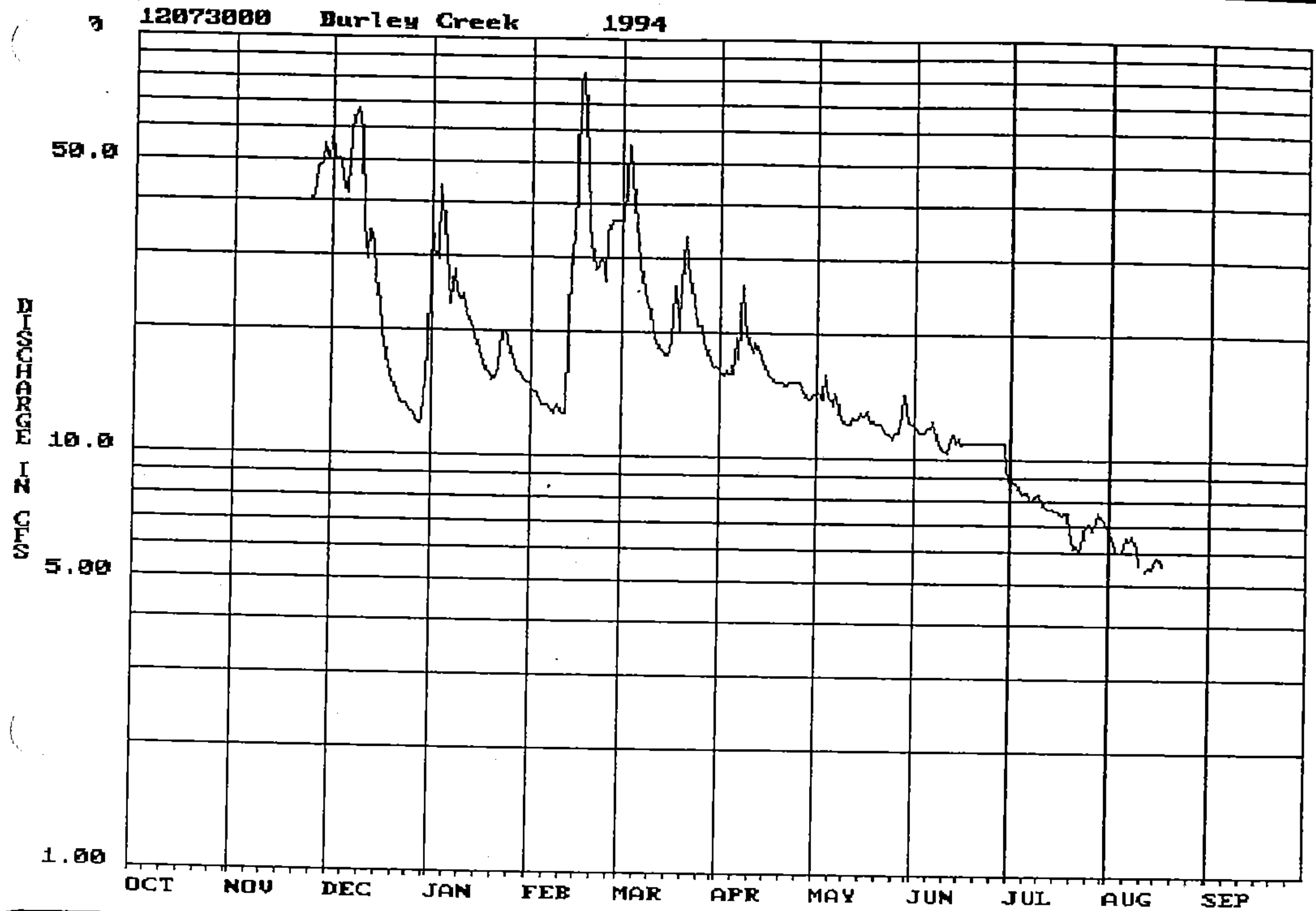
246 Clear Creek

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1995 TO SEP 1996

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.4	3.7	7.1	8.1	6.5	7.6	7.2	10	5.5	4.0	3.1	3.2
2	4.5	3.7	8.0	7.8	6.2	7.1	14	11	5.4	4.0	11	3.2
3	4.6	3.7	9.9	7.9	7.2	7.0	8.0	11	5.2	4.1	6.7	6.1
4	3.4	3.9	22	6.7	16	8.4	6.6	7.7	4.9	4.9	4.2	5.4
5	3.4	3.9	7.7	7.8	65	7.7	6.3	6.8	4.7	4.1	3.8	4.4
6	3.4	3.9	5.6	28	61	7.4	6.0	6.4	4.6	3.9	3.7	3.8
7	3.4	8.7	5.0	42	40	6.7	6.1	6.2	4.6	3.7	3.4	3.7
8	3.5	53	4.6	18	96	6.8	5.9	6.0	4.5	3.7	3.4	3.6
9	3.8	10	7.3	12	68	6.7	5.8	5.8	4.4	3.8	3.1	3.5
10	18	8.5	58	8.8	32	6.9	5.6	5.5	4.4	3.7	3.1	3.5
11	16	37	127	7.6	18	7.5	6.7	5.6	4.4	3.6	3.0	3.5
12	5.7	8.6	94	6.9	13	7.4	10	5.6	4.5	3.6	3.0	3.5
13	4.0	7.9	75	6.7	11	6.9	9.5	9.4	4.5	3.5	2.9	3.6
14	3.6	5.5	81	8.8	9.1	6.7	6.6	11	4.5	3.4	2.9	6.8
15	3.6	5.4	70	28	8.4	6.5	8.5	7.1	4.4	3.5	3.0	10
16	4.3	4.7	29	14	8.1	6.2	13	6.2	4.3	3.6	3.3	5.1
17	7.3	7.2	18	9.2	27	6.1	8.8	10	5.1	4.1	3.3	4[illegible]
18	6.2	17	39	8.3	34	6.1	7.2	28	5.3	4.5	3.2	4[illegible]
19	4.0	5.9	17	16	25	6.1	6.7	12	4.8	4.5	3.0	4.5
20	4.3	4.6	12	45	28	6.4	6.4	7.5	4.8	4.0	3.4	4.3
21	3.9	4.0	9.5	60	23	6.1	6.1	7.2	5.0	3.8	3.2	4.2
22	3.8	4.7	8.3	34	27	6.0	15	13	4.5	3.7	3.1	4.1
23	3.8	18	7.4	28	33	8.2	121	8.4	5.9	3.6	3.1	3.9
24	3.7	11	6.8	17	19	6.7	65	6.8	5.1	3.3	3.0	3.7
25	5.0	8.1	6.5	12	13	6.0	46	5.9	4.7	3.3	2.8	3.7
26	5.5	5.1	6.3	9.9	11	5.8	30	5.5	4.4	3.3	3.0	3.7
27	3.9	9.7	6.3	8.8	9.2	5.9	16	5.6	4.3	3.0	3.1	3.7
28	3.7	12	8.0	8.3	8.2	5.8	12	13	4.2	2.9	3.0	3.7
29	3.6	36	35	7.2	7.8	5.6	9.3	8.3	4.2	2.9	2.8	3.7
30	3.6	13	16	6.7	------	5.7	9.8	7.6	4.0	2.9	2.8	3.7
31	3.6	------	10	6.5	------	5.7	------	6.1	------	2.9	3.0	------
TOTAL	154.5	328.4	817.3	496.0	730.7	205.7	485.1	266.2	141.1	113.8	109.4	128.8
MEAN	4.98	10.9	26.4	16.0	25.2	6.64	16.2	8.59	4.70	3.67	3.53	4.29
MAX	18	53	127	60	96	8.4	121	28	5.9	4.9	11	10
MIN	3.4	3.7	4.6	6.5	6.2	5.6	5.6	5.5	4.0	2.9	2.8	3.2
AC-FT	306	651	1,620	984	1,450	408	962	528	280	226	217	255

CAL YEAR 1995	TOTAL*	1,300.2	MEAN	14.1	MAX	127	MIN	3.4	AC-FT	2,580
WTR YEAR 1996	TOTAL	3,977.0	MEAN	10.9	MAX	127	MIN	2.8	AC-FT	7,890

* Incomplete Record


3
12073000 Burley Creek 1994
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DISCHARGE IN CFS
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

12073000 Burley Creek

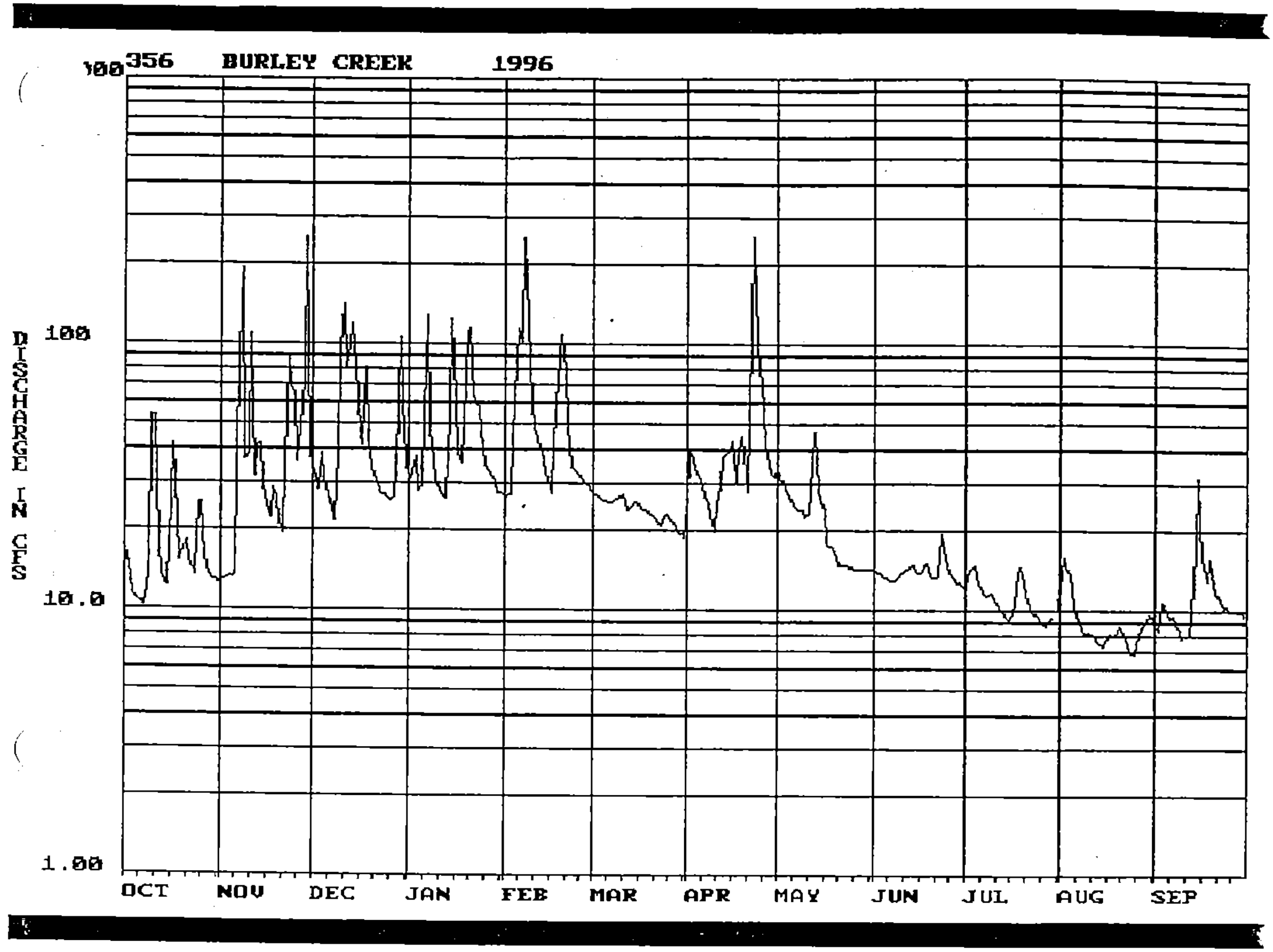
USGS #: 356

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1993 TO SEP 1994

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1			60	37	15	37	16	14	12	8.8	6.8	
2			51	31	14	37	16	14	12	9.0	6.4	
3			51	30	14	56	16	14	12	8.9	6.1	
4			50	44	13	56	16	16	12	8.6	6.0	
5			43	36	13	41	16	14	12	8.3	6.1	
6			42	26	13	33	19	14	12	8.4	6.5	
7			59	23	13	29	17	14	12	8.1	6.4	
8			64	28	13	25	26	13	11	8.0	6.7	
9			67	24	13	23	21	12	11	8.2	6.2	
10			60	24	13	22	19	12	11	8.3	5.7	
11			36	24	13	20	18	12	10	8.0	r	
12			29	22	13	19	19	12	11	7.7	5.5	
13			35	21	30	18	18	13	12	7.6	5.6	
14			32	20	29	18	17	13	11	7.7	5.5	
15			27	19	44	18	17	13	11	7.6	5.8	
16			23	18	79	18	16	13	11	7.6	5.9	
17			20	17	83	21	16	13	11	7.4	5.7	
18			17	16	52	26	16	12	11	7.5		
19			16	16	37	20	15	12	11	7.5		
20			15	15	30	26	15	12	11	6.8		
21			14	16	28	34	15	12	11	6.2		
22			14	18	29	29	15	12	11	6.3		
23			13	20	30	25	15	12	11	6.0		
24			13	20	26	22	15	11	11	6.7		
25		41	13	19	34	21	15	11	11	7.0		
26		44	13	17	37	21	15	12	11	7.1		
27		49	12	16	37	19	15	12	11	6.8		
28		50	12	16	37	18	14	13	11	7.2		
29		55	12	16	------	17	14	14	11	7.5		
30		51	16	15	------	17	14	12	9.6	7.3		
31		------	18	15	------	16	------	12	------	7.1		------
TOTAL		290	947	679	802	802	496	395	335.6	235.2	96.9	
MEAN		48.3	30.5	21.9	28.6	25.9	16.5	12.7	11.2	7.59	6.06	
MAX		55	67	44	83	56	26	16	12	9.0	6.8	
MIN		41	12	15	13	16	14	11	9.6	6.0	5.5	
AC-FT		575	1,880	1,350	1,590	1,590	984	783	666	467	192	
	*	*									*	*

CAL YEAR 1993	TOTAL*	1,237.0	MEAN	33.4	MAX	67	MIN	12	AC-FT 2,450
WTR YEAR 1994	TOTAL*	5,078.7	MEAN	19.2	MAX	83	MIN	5.5	AC-FT 10,070

* Incomplete Record


356 BURLEY CREEK 1996
DISCHARGE IN CFS
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

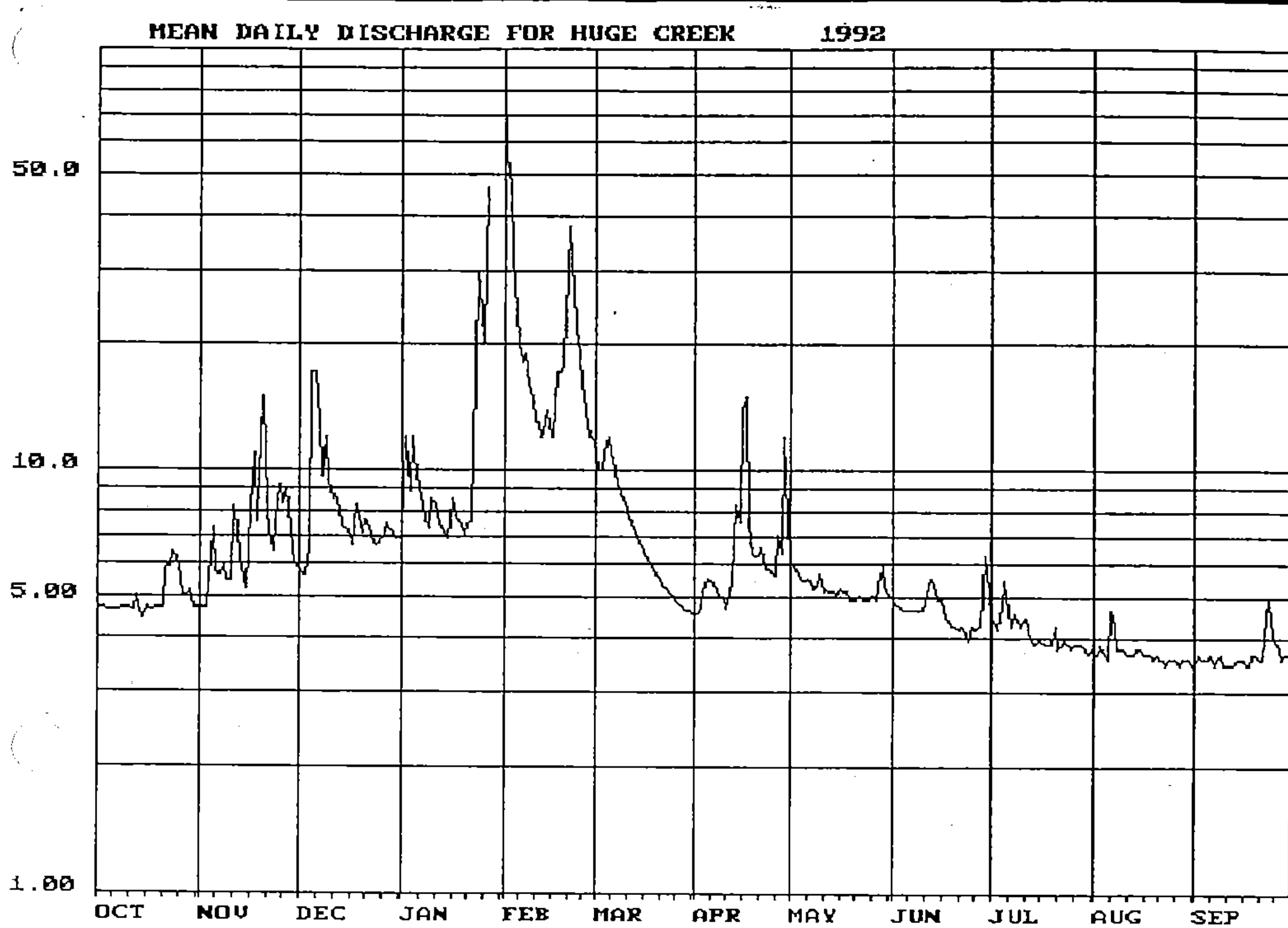
356 BURLEY CREEK

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1995 TO SEP 1996

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	14	13	35E	30	27	28E	25E	34	15E	12	12	8.8
2	16	13	32E	33	27	28E	40E	30	14E	14	16	8.5
3	13	13	29E	38	27	27E	37E	31	14E	14	15	11
4	11	13	39E	28	45	27E	34E	28	14E	15	14	10
5	11	14	31E	29	87	26E	32E	26	14E	13	10	9.9
6	11	14	27	55	115	26E	30E	25	13E	12	9.5	9.4
7	10	93	24	127	102	26E	27E	24	13E	12	9.1	9.5
8	11	192	22	49	252	26E	25E	24	13E	11	8.5	9.1
9	13	37	39	37	125	27E	23E	24	13E	12	8.2	8.4
10	54	39	96	31	60	27E	20E	23	14E	11	8.3	8.0
11	54	110	142	28	49	28E	25E	24	14E	11	8.2	8.1
12	18	32	82	27	45E	24E	30E	28	15E	10	8.0	8.1
13	14	42	99	27	41E	25E	38E	47	15E	10	7.7	9.7
14	13	42	119	55	37E	25E	39E	29	15	9.5	7.5	17
15	12	30	84	127	33E	26E	41E	26	14	9.3	7.4	32
16	25	25	46	62	29E	25E	43	24	14	9.5	8.0	16
17	42	22	42	39	28E	25E	31	18E	14	11	8.3	15
18	22	29	82	36	60E	24E	41	18E	15	14	8.1	13
19	15	26	42	49	90E	24E	45	17E	14	15	8.1	16
20	17	21	35	110	110E	23E	38	16E	14	13	8.8	13
21	18	19	32	115	80E	23E	29	15E	14	12	8.7	11
22	15	35	30	63	50E	22E	53	15E	14	10	8.0	11
23	14	89	28	61	35E	21E	256	15E	20	9.9	7.6	10
24	14	69	27	57	34E	22E	103	15E	17	9.8	7.0	10
25	25	65	27	41	33E	23E	82	15E	15	9.5	7.0	10
26	25	36	26	35	32E	23E	58	15E	14	9.1	7.6	10
27	16	48	27	34	31E	22E	41	14E	14	8.8	8.7	10
28	14	74	35	33	30E	21E	36	14E	13	9.0	8.6	9.9
29	13	250	105	30	29E	20E	33	14E	13	9.4	9.3	10
30	13	40E	60	28	------	20E	32	14E	12		9.8	9.7
31	13	------	37	28	------	19E	------	14E	------	10	9.6	------
TOTAL	576	1,545	1,581	1,542	1,743	753	1,387	676	427	335.8	282.6	342.1
MEAN	18.6	51.5	51.0	49.7	60.1	24.3	46.2	21.8	14.2	11.2	9.12	11.4
MAX	54	250	142	127	252	28	256	47	20	15	16	32
MIN	10	13	22	27	27	19	20	14	12	8.8	7.0	8.0
AC-FT	1,140	3,060	3,140	3,060	3,460	1,490	2,750	1,340	847	666 *	561	679

CAL YEAR 1995	TOTAL*	3,702.0	MEAN	40.2	MAX	250	MIN	10	AC-FT	7,340
WTR YEAR 1996	TOTAL*	11,190.5	MEAN	30.7	MAX	256	MIN	7.0	AC-FT	22,200

* Incomplete Record


MEAN DAILY DISCHARGE FOR HUGE CREEK 1992
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

MEAN DAILY DISCHARGE FOR HUGE CREEK

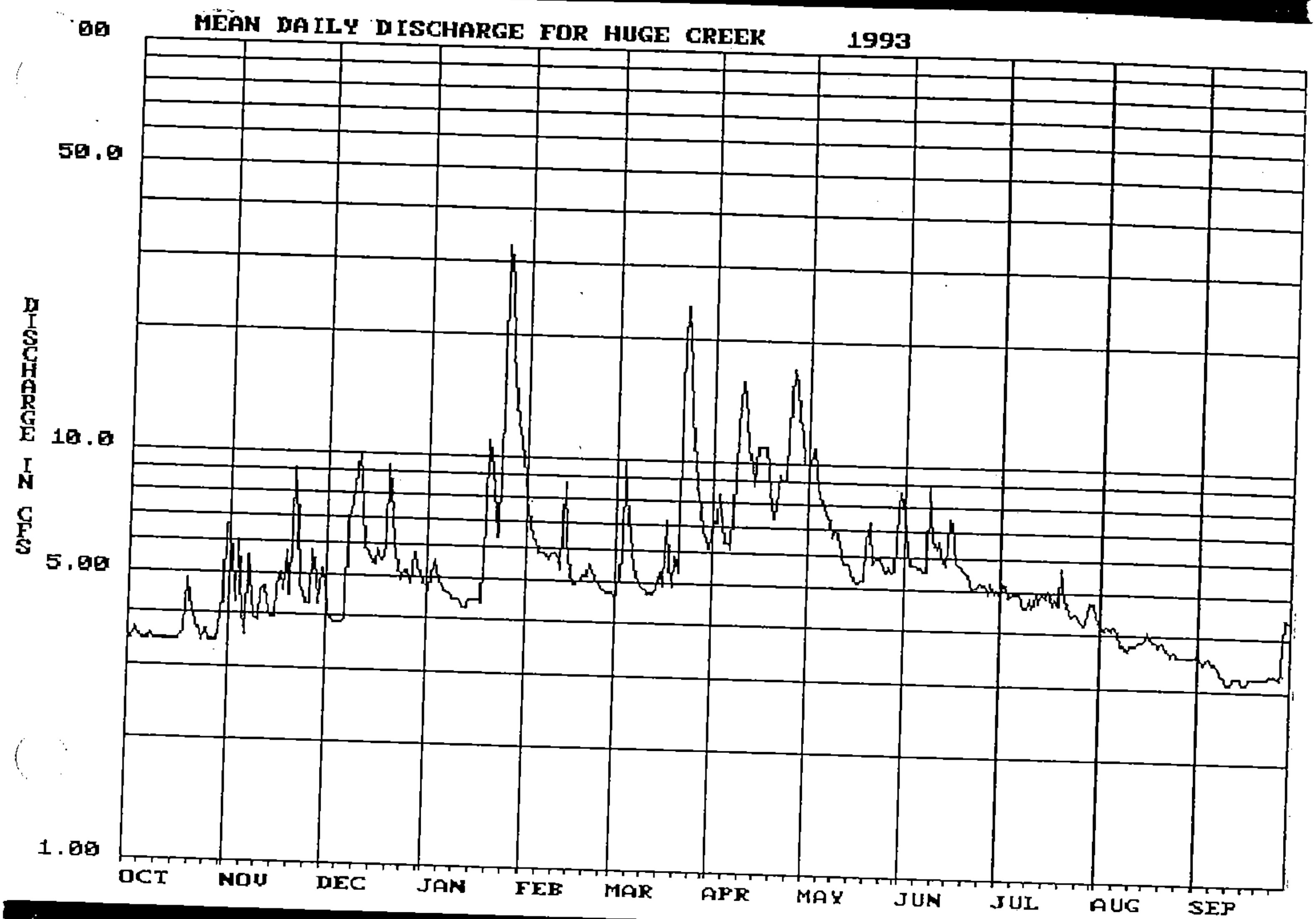
USGS #: 12073500

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1991 TO SEP 1992

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	4.8	4.8	5.9	7.2	84	11	4.6	6.1	5.0	4.5	3.7	3.5
2	4.8	4.8	5.7	12	57	10	4.6	6.0	4.9	4.3	3.7	3.7
3	4.8	4.8	5.7	9.0	47	10	4.8	5.9	4.8	4.2	3.9	3.6
4	4.7	5.5	6.6	12	32	11	5.2	5.6	4.8	4.9	3.7	3.6
5	4.7	7.3	17	9.8	24	12	5.6	5.5	4.7	5.5	3.6	3.6
6	4.7	5.8	17	9.1	20	11	5.5	5.6	4.7	4.7	4.7	3.7
7	4.7	5.7	13	8.3	18	10	5.4	5.5	4.7	4.3	4.3	3.5
8	4.7	6.0	9.7	7.6	19	9.3	5.3	5.3	4.7	4.6	3.8	3.6
9	4.8	5.5	12	7.3	16	8.9	5.1	5.4	4.7	4.3	3.8	3.7
10	4.8	5.5	9.4	8.6	15	8.4	5.0	5.7	4.7	4.3	3.8	3.5
11	4.8	8.2	8.6	8.4	13	8.0	4.8	5.2	4.9	4.5	3.7	3.5
12	4.7	7.4	8.8	7.5	13	7.6	5.1	5.3	5.4	4.2	3.7	3.5
13	5.1	6.1	8.1	7.3	12	7.3	5.6	5.2	5.6	4.0	3.7	3.5
14	4.6	5.6	7.4	7.0	13	7.0	8.3	5.2	5.2	3.9	3.8	3.6
15	4.5	5.3	7.3	6.9	14	6.8	7.6	5.1	5.0	4.0	3.8	3.6
16	4.8	8.1	7.0	8.6	12	6.5	14	5.3	5.0	4.0	3.7	[illegible]
17	4.8	11	6.7	8.2	12	6.3	15	5.2	4.7	3.9	3.7	[illegible]
18	4.7	7.6	8.3	7.6	17	6.1	7.5	5.2	4.4	3.9	3.7	3.5
19	4.8	12	7.8	7.4	17	5.9	6.4	5.0	4.3	3.9	3.6	3.7
20	4.8	15	7.2	7.1	18	5.7	6.3	5.0	4.3	4.3	3.7	3.7
21	4.8	8.2	7.7	7.5	30	5.6	6.3	5.0	4.2	3.8	3.6	3.6
22	5.9	7.1	7.4	7.6	38	5.4	6.6	5.1	4.3	3.9	3.6	3.6
23	6.0	6.5	6.9	17	27	5.3	5.9	5.0	4.1	4.0	3.5	4.6
24	6.5	7.7	6.7	30	22	5.2	5.9	5.0	4.0	3.9	3.6	5.0
25	6.2	9.3	6.8	24	19	5.1	5.8	5.0	4.3	3.8	3.6	4.1
26	6.0	8.4	6.9	20	16	5.0	5.7	5.1	4.2	3.9	3.6	4.0
27	5.1	9.1	7.5	47	14	4.9	7.1	5.0	4.3	3.9	3.5	3.8
28	5.1	7.3	7.3	r	12	4.8	6.4	5.4	4.3	3.9	3.6	3.6
29	5.2	6.4	7.2	r	12	4.7	12	6.0	6.3	3.8	3.6	3.7
30	4.8	6.0	6.9	r	------	4.7	7.8	5.4	5.2	3.7	3.6	3.7
31	4.8	------	6.9	r	------	4.6	------	5.1	------	3.8	3.5	------
TOTAL	155.5	218.0	257.4	320.0	663	224.1	201.2	165.4	141.7	128.6	115.4	111.4
MEAN	5.02	7.27	8.30	11.9	22.9	7.23	6.71	5.34	4.72	4.15	3.72	3.71
MAX	6.5	15	17	47	84	12	15	6.1	6.3	5.5	4.7	5.0
MIN	4.5	4.8	5.7	6.9	12	4.6	4.6	5.0	4.0	3.7	3.5	3.5
AC-FT	308	432	511	635 *	1,320	445	399	328	281	255	229	221

CAL YEAR 1991	TOTAL*	630.9	MEAN	6.86	MAX	17	MIN	4.5	AC-FT	1,250
WTR YEAR 1992	TOTAL*	2,701.7	MEAN	7.46	MAX	84	MIN	3.5	AC-FT	5,360

* Incomplete Record



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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

MEAN DAILY DISCHARGE FOR HUGE CREEK

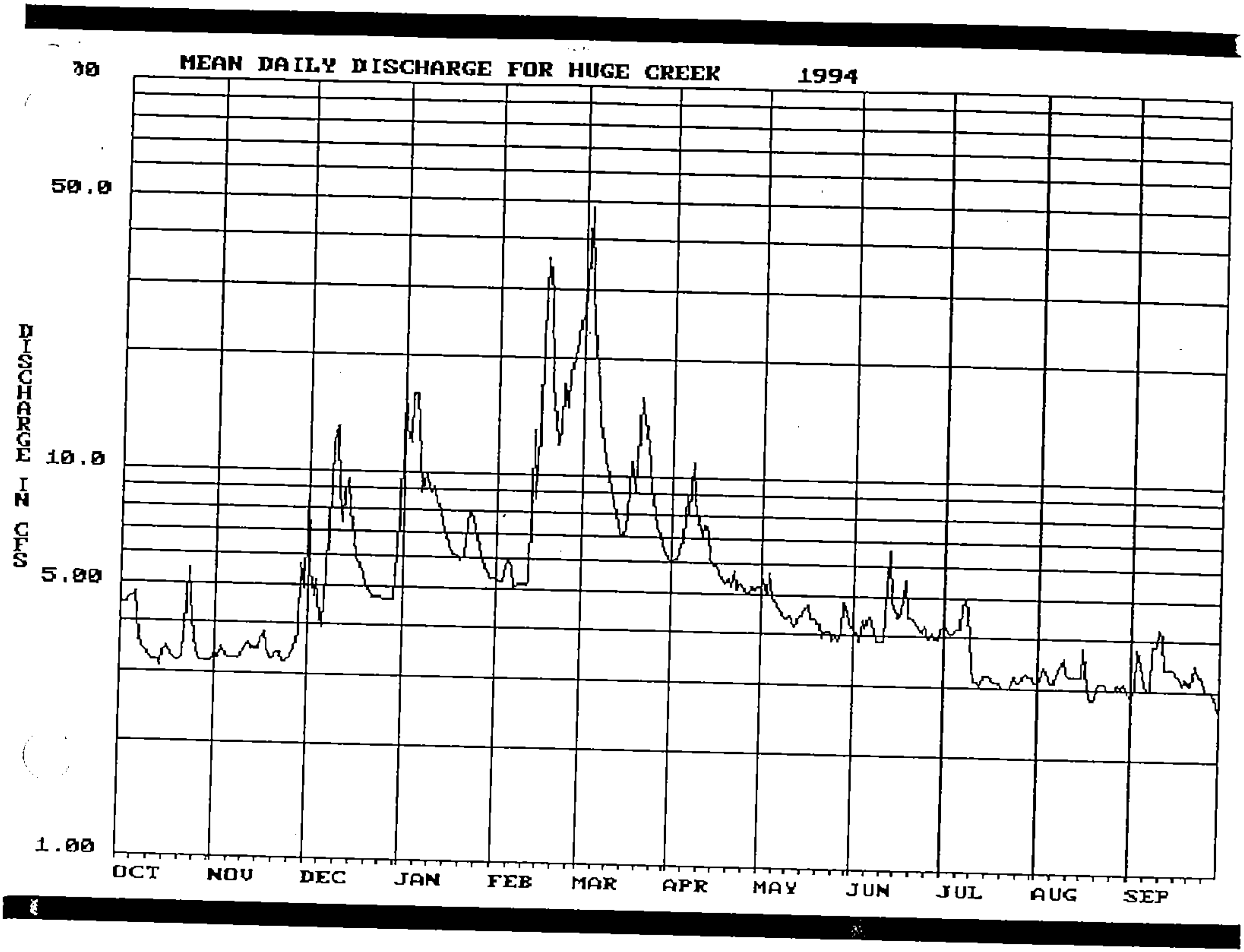
USGS #: 12073500

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1992 TO SEP 1993

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.5	6.6	4.6	4.8	8.0	4.6	7.2	10	7.7	4.9	4.2	3.7
2	3.5	5.3	4.1	4.7	6.9	4.7	7.2	10	6.3	5.3	4.1	3.5
3	3.7	4.3	3.9	5.4	6.4	6.0	8.4	11	5.8	5.2	4.2	3.5
4	3.6	6.1	3.9	5.6	6.3	9.9	7.2	9.6	5.8	4.9	4.1	3.6
5	3.5	4.0	3.9	5.0	5.9	7.2	6.4	8.3	5.8	5.0	4.2	3.5
6	3.5	3.6	3.9	4.7	5.9	6.0	6.4	8.0	5.7	5.0	4.1	3.5
7	3.5	5.6	4.0	4.7	5.9	5.5	6.2	7.6	5.6	5.0	3.8	3.4
8	3.6	4.4	6.9	4.6	5.7	5.1	9.4	7.4	5.6	4.6	3.8	3.3
9	3.5	4.0	7.6	4.5	5.9	5.0	12	6.7	9.0	4.6	3.7	3.2
10	3.5	3.9	9.0	4.5	5.9	4.9	16	7.0	6.7	4.9	3.8	3.1
11	3.5	4.6	10	4.5	5.7	4.8	13	6.7	6.3	4.6	3.8	3.1
12	3.5	4.7	7.4	4.3	5.4	4.8	11	6.1	6.6	5.0	3.8	3.2
13	3.5	4.3	5.9	4.3	8.8	4.8	9.9	5.8	5.9	4.8	3.9	3.2
14	3.5	4.0	5.8	4.5	6.4	4.9	8.9	5.8	5.8	5.0	3.9	3.2
15	3.5	4.0	5.6	4.5	5.3	5.4	11	5.5	7.5	4.9	4.0	3.1
16	3.5	4.7	5.4	4.5	5.0	5.0	11	5.3	7.3	5.1	4.1	[illegible]
17	3.5	5.1	5.9	4.5	5.0	7.2	11	5.2	5.9	4.7	3.9	[illegible]
18	3.7	4.6	5.5	4.4	5.1	5.5	11	5.2	5.8	4.9	3.9	3.2
19	4.9	5.7	6.0	7.2	5.2	5.0	8.5	5.3	5.7	4.7	3.8	3.2
20	4.3	4.5	9.4	11	5.2	5.9	7.4	6.6	5.6	5.8	3.9	3.2
21	4.0	9.2	7.1	9.4	5.6	5.4	7.9	7.3	5.5	4.9	3.8	3.2
22	3.8	6.9	6.1	7.3	5.4	15	9.4	5.8	5.1	4.7	3.7	3.2
23	3.6	4.8	5.4	6.4	5.1	24	9.1	6.0	5.1	4.4	3.6	3.2
24	3.5	4.5	5.0	14	5.0	17	9.2	6.0	5.2	4.5	3.7	3.3
25	3.7	4.3	5.2	33	4.9	13	12	5.8	5.3	4.4	3.6	3.3
26	3.5	4.3	5.2	27	4.8	10	17	5.5	5.2	4.3	3.6	3.3
27	3.5	5.8	4.9	18	4.8	8.9	16	5.7	5.0	4.2	3.6	3.2
28	3.5	5.0	5.8	14	4.8	7.7	13	5.5	5.3	4.5	3.6	3.4
29	3.7	4.3	5.3	12	------	6.8	12	5.6	5.0	4.8	3.6	4.5
30	4.4	5.2	5.2	11	------	6.5	10	7.9	5.1	4.8	3.6	4.4
31	6.6	------	4.9	9.0	------	6.2	------	8.7	------	4.4	3.6	------
TOTAL	116.6	148.3	178.8	263.3	160.3	232.7	304.7	212.9	178.2	148.8	119.0	101.0
MEAN	3.76	4.94	5.77	8.49	5.73	7.51	10.2	6.87	5.94	4.80	3.84	3.37
MAX	6.6	9.2	10	33	8.8	24	17	11	9.0	5.8	4.2	4.5
MIN	3.5	3.6	3.9	4.3	4.8	4.6	6.2	5.2	5.0	4.2	3.6	3.1
AC-FT	231	294	355	522	318	462	604	422	353	295	236	200

CAL YEAR 1992	TOTAL*	443.7	MEAN	4.82	MAX	10	MIN	3.5	AC-FT	880
WTR YEAR 1993	TOTAL	2,164.6	MEAN	5.93	MAX	33	MIN	3.1	AC-FT	4,290

* Incomplete Record



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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

MEAN DAILY DISCHARGE FOR HUGE CREEK

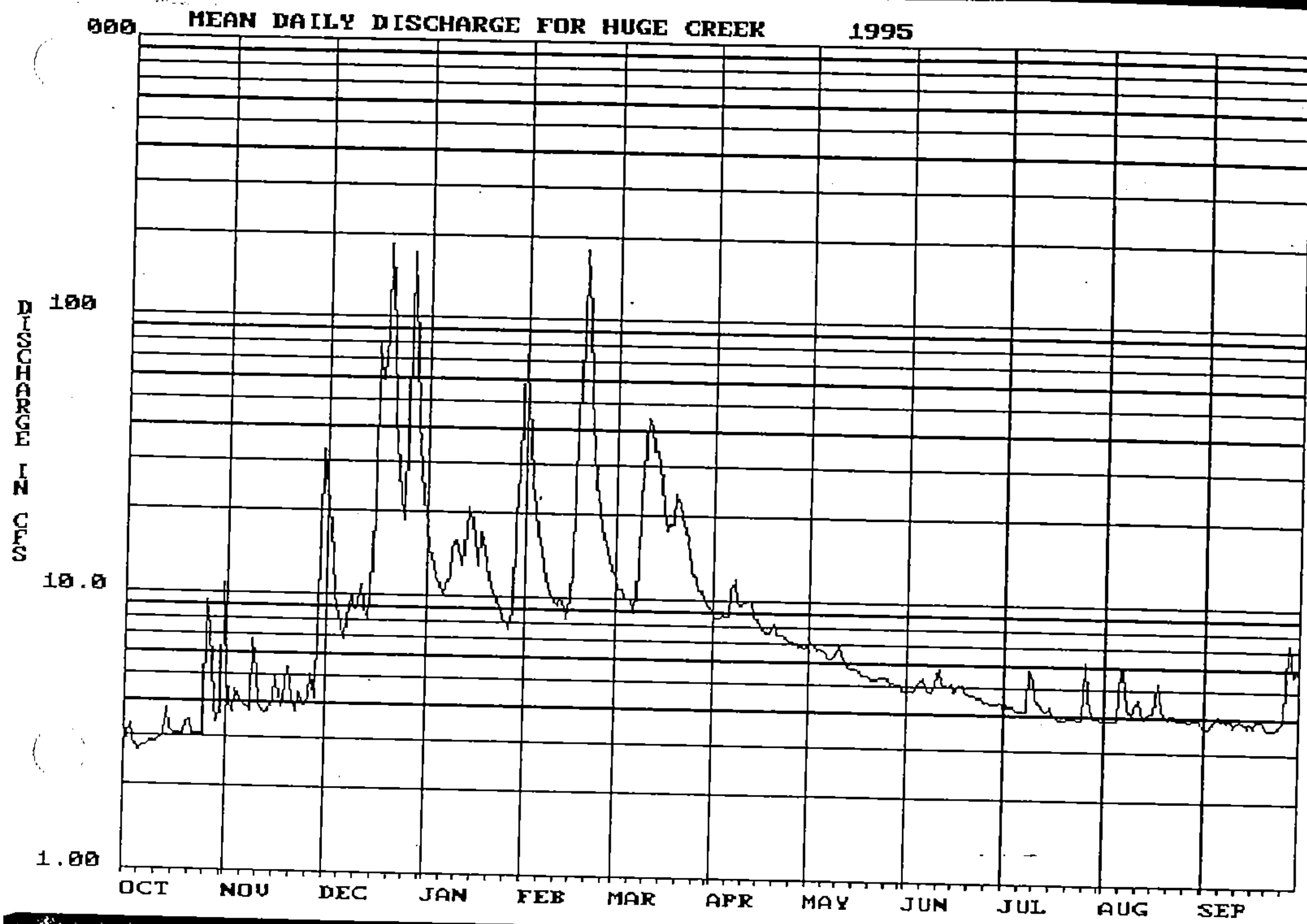
USGS #: 12073500

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1993 TO SEP 1994

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	4.5	3.4	9.9	17	5.4	26	6.0	5.3	4.1	4.3	3.1	2.9
2	4.5	3.3	5.5	13	5.3	30	6.2	5.5	4.1	4.2	3.3	3.0
3	4.5	3.5	4.8	12	5.3	49	6.2	5.1	3.9	4.1	3.4	3.8
4	4.6	3.4	5.2	16	5.8	30	6.7	5.7	4.4	4.1	3.2	3.5
5	4.7	3.3	4.2	16	6.0	21	6.9	5.0	4.2	4.2	3.1	3.1
6	4.8	3.3	4.0	11	5.8	17	9.1	4.8	4.5	4.2	3.1	3.0
7	3.7	3.3	5.5	9.0	5.1	14	8.1	4.7	4.5	4.9	3.3	3.0
8	3.5	3.3	6.9	10	5.2	12	11	4.5	4.1	5.0	3.4	3.9
9	3.4	3.3	12	9.6	5.2	11	8.9	4.4	3.9	4.7	3.6	3.9
10	3.3	3.4	13	9.0	5.2	10	7.7	4.4	3.9	3.4	3.3	4.3
11	3.2	3.5	8.8	9.3	5.2	9.3	7.1	4.5	3.9	3.1	3.2	4.1
12	3.2	3.6	7.4	8.5	5.3	8.5	7.6	4.2	4.6	3.1	3.2	3.4
13	3.2	3.5	8.9	8.0	13	8.0	7.3	4.2	6.6	3.0	3.2	3.4
14	3.1	3.5	9.6	7.4	8.7	7.2	6.2	4.5	4.9	3.2	3.2	3.4
15	3.4	3.5	7.9	6.9	13	7.0	6.0	4.5	4.7	3.2	3.2	3.4
16	3.5	3.7	6.8	6.5	22	7.3	6.0	4.7	4.5	3.2	3.8	[illegible]
17	3.4	3.8	6.0	6.2	36	9.1	5.7	4.8	4.6	3.1	3.0	[illegible]
18	3.3	3.5	5.7	6.2	29	11	5.5	4.4	5.6	3.1	2.8	[illegible]
19	3.2	3.3	5.4	6.1	17	9.2	5.4	4.4	4.5	3.1	2.8	3.1
20	3.2	3.3	5.1	6.0	14	11	5.5	4.3	4.5	3.0	3.0	3.1
21	3.3	3.4	4.9	6.1	12	16	5.3	4.3	4.4	3.0	3.1	3.1
22	3.8	3.4	4.8	7.4	13	15	5.8	4.0	4.3	3.0	3.1	3.5
23	5.5	3.2	4.8	7.9	17	13	5.2	4.1	4.2	3.0	3.1	3.3
24	4.6	3.2	4.8	7.8	15	11	5.4	4.1	4.1	3.2	3.0	3.3
25	3.7	3.3	4.8	7.1	18	9.3	5.3	3.9	4.3	3.1	3.0	3.1
26	3.4	3.4	4.7	6.5	20	8.1	5.1	4.0	4.0	3.1	3.0	3.0
27	3.2	3.5	4.7	6.1	22	7.4	5.1	3.9	4.1	3.2	3.1	3.0
28	3.2	3.8	4.7	5.8	25	7.1	5.3	4.1	4.0	3.3	3.0	3.0
29	3.2	5.7	4.7	5.6	------	6.7	5.2	4.9	4.0	3.2	3.1	3.0
30	3.2	5.0	6.2	5.4	------	6.3	5.3	4.6	4.2	3.2	3.1	2.9
31	3.2	------	8.0	5.4	------	6.2	------	4.3	------	3.1	2.9	------
TOTAL	114.5	106.6	199.7	264.8	359.5	413.7	192.1	140.1	131.6	108.6	97.6	98.9
MEAN	3.69	3.55	6.44	8.54	12.8	13.3	6.40	4.52	4.39	3.50	3.15	3.30
MAX	5.5	5.7	13	17	36	49	11	5.7	6.6	5.0	3.8	4.3
MIN	3.1	3.2	4.0	5.4	5.1	6.2	5.1	3.9	3.9	3.0	2.8	2.7
AC-FT	227	211	396	525	713	821	381	278	261	215	194	196

CAL YEAR 1993	TOTAL*	420.8	MEAN	4.57	MAX	13	MIN	3.1	AC-FT	835
WTR YEAR 1994	TOTAL	2,227.7	MEAN	6.10	MAX	49	MIN	2.7	AC-FT	4,420

* Incomplete Record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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

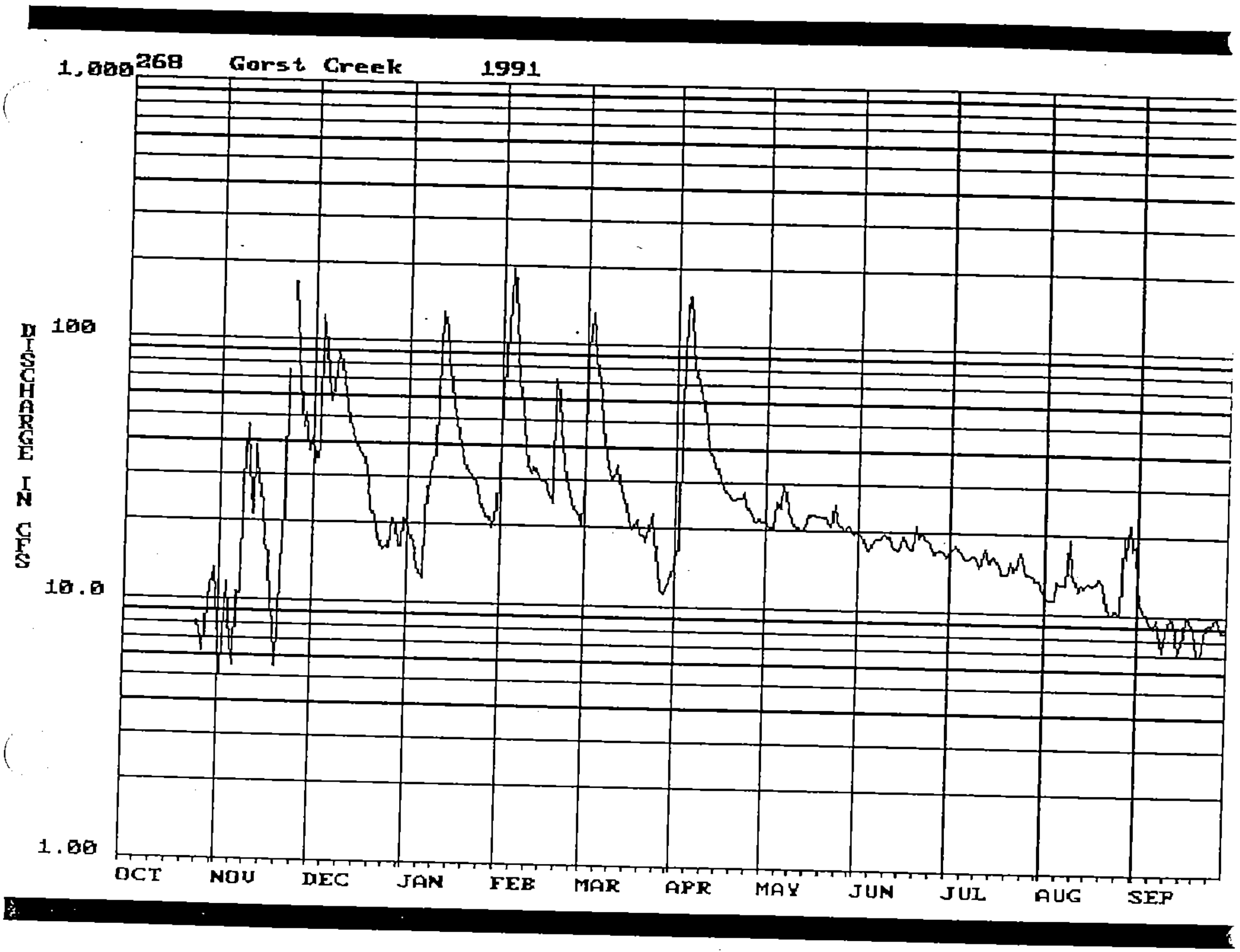
MEAN DAILY DISCHARGE FOR HUGE CREEK

USGS #: 12073500

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.7	5.3	24	18	68	12	8.8	7.1	4.9	4.2	3.9	3.8
2	3.1	3.9	21	15	37	11	8.7	7.2	4.9	4.4	3.9	3.7
3	3.3	3.7	14	13	26	11	8.7	6.9	4.9	4.3	3.9	3.8
4	2.9	4.5	10	12	21	10	8.9	6.7	5.0	4.3	3.9	4.0
5	2.7	4.1	8.4	11	17	10	8.8	6.8	5.2	4.2	3.9	4.1
6	2.7	4.0	7.6	10	15	9.5	8.8	6.6	5.4	4.2	6.1	4.0
7	2.8	3.9	6.9	11	13	9.0	11	6.4	5.1	4.2	5.9	4.0
8	2.8	3.8	8.1	12	11	13	12	6.3	4.9	4.2	4.3	3.9
9	2.9	6.8	10	15	10	22	9.9	6.4	4.8	5.9	4.1	4.0
10	2.9	5.1	9.0	16	9.7	36	9.8	6.6	5.2	5.4	4.3	3.8
11	2.9	4.0	9.4	15	9.5	45	9.9	6.9	5.9	4.6	4.6	3.9
12	3.0	3.8	11	13	10	42	10	6.3	5.2	4.4	4.2	4.0
13	3.1	3.7	9.0	17	9.2	34	10	6.1	5.1	4.3	4.0	3.9
14	3.8	3.8	8.2	21	8.5	34	8.8	5.8	5.0	4.2	4.1	3.8
15	3.2	4.2	10	19	10	27	8.6	5.8	5.2	4.3	4.2	3.9
16	3.1	5.0	20	16	13	21	8.1	5.8	4.9	4.1	4.2	3[illegible]
17	3.1	4.3	80	13	42	18	7.9	5.7	5.1	4.0	5.3	4[illegible]
18	3.1	3.9	60	17	86	19	7.7	5.5	5.1	3.9	4.3	4.0
19	3.1	4.6	86	15	179 r	19	7.7	5.5	4.9	3.9	4.1	4.0
20	3.4	5.4	184 r	13	106 r	24	8.4	5.5	4.8	3.9	4.0	3.8
21	3.5	4.1	86	11	54	22	7.6	5.3	4.7	4.0	4.1	3.7
22	3.1	3.8	44	10	35	20	7.6	5.3	4.7	4.0	4.1	3.7
23	3.1	4.4	29	9.7	26	18	7.5	5.3	4.6	4.0	4.0	3.7
24	3.1	4.1	22	8.9	21	15	7.4	5.4	4.6	3.9	4.0	3.8
25	3.1	4.0	19	8.4	18	13	7.3	5.4	4.5	3.9	4.0	3.9
26	9.5	4.2	42	8.0	16	12	7.2	5.4	4.5	6.3	4.0	4.0
27	7.4	5.1	174 r	7.7	14	11	7.1	5.1	4.4	4.6	3.9	7.4
28	4.0	4.2	79	8.8	13	11	7.0	5.2	4.4	4.1	4.0	7.4
29	3.4	7.8	42	19	------	10	6.9	5.0	4.4	4.0	4.0	5.8
30	3.7	33	29	29	------	9.7	6.8	5.1	4.5	4.0	4.0	6.0
31	11	------	22	74	------	9.5	------	4.9	------	3.9	3.8	------
TOTAL	115.5	162.5	1,184.6	486.5	897.9	577.7	254.9	183.3	146.8	133.6	131.1	127.6
MEAN	3.73	5.42	38.2	15.7	32.1	18.6	8.50	5.91	4.89	4.31	4.23	4.25
MAX	11	33	184	74	179	45	12	7.2	5.9	6.3	6.1	7.4
MIN	2.7	3.7	6.9	7.7	8.5	9.0	6.8	4.9	4.4	3.9	3.8	3.7
AC-FT	229	322	2,350	965	1,780	1,150	506	364	291	265	260	253

CAL YEAR 1994	TOTAL	3,269.5	MEAN	8.96	MAX	184	MIN	2.7	AC-FT	6,490
WTR YEAR 1995	TOTAL	4,402.0	MEAN	12.1	MAX	184	MIN	2.7	AC-FT	8,730



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268 Gorst Creek 1991
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

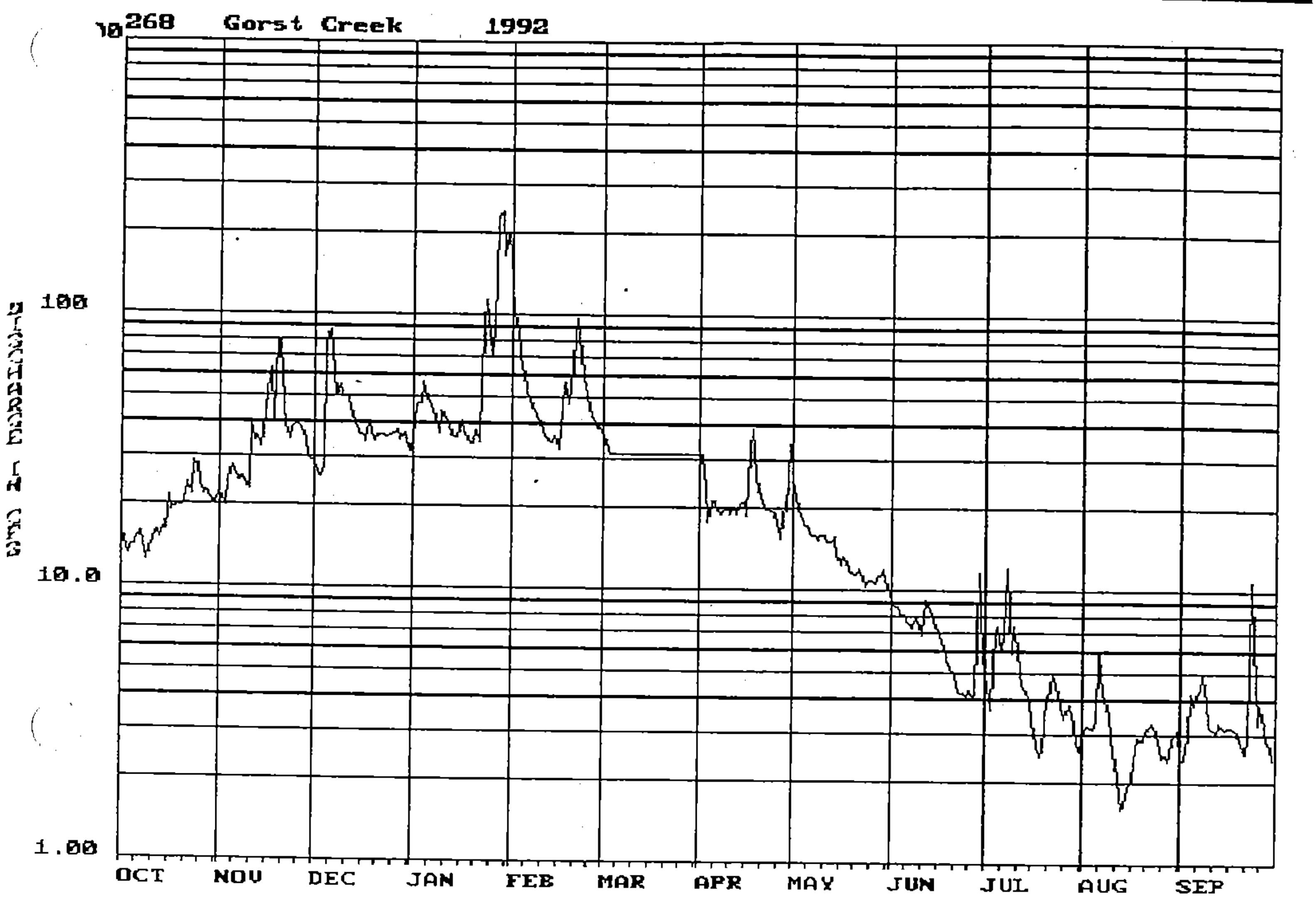
268 Gorst Creek

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1990 TO SEP 1991

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1		6.8	44	20	43	31	15	22	20	17	12	13
2		5.1	34	18	88	95	17	21	19	17	11	11
3		9.4	39	17	111	135	55	21	19	18	11	11
4		12	126	15	196	106	139	20	17	17	11	9.7
5		6.6	95	13	166	78	156	26	17	17	14	9.0
6		5.5	72	13	94	64	104	24	18	16	13	9.1
7		11	58	22	71	49	82	30	19	16	13	9.7
8		11	66	30	57	38	72	28	19	16	13	8.8
9		27	90	34	41	34	69	24	19	16	19	7.3
10		46	82	37	33	31	60	22	20	16	14	8.2
11		32	69	60	32	31	47	21	19	15	13	9.2
12		21	57	131	34	34	40	21	18	17	12	10
13		39	48	113	32	30	37	21	17	18	13	9.8
14		29	45	87	30	27	35	20	17	16	13	7.2
15		23	41	70	30	24	34	22	18	17	13	7.4
16		17	38	58	30	22	31	23	19	16	13	8.7
17		15	37	50	26	20	29	23	18	15	13	1[illegible]
18		9.2	35	44	25	20	28	23	17	14	13	[illegible]
19		8.3	29	38	73	22	27	23	17	14	14	9.2
20		5.6	22	34	64	19	26	23	21	14	13	8.1
21		13	22	32	46	19	26	23	19	16	12	7.1
22		23	19	31	35	18	26	22	20	15	10	7.1
23		75	16	30	30	20	26	21	19	15	10	8.4
24		r	16	28	27	23	28	25	19	17	10	9.2
25	8.2	169	16	25	24	18	25	22	18	16	11	9.5
26	7.6	90	16	23	23	14	23	21	17	14	10	9.3
27	6.2	68	21	22	22	12	22	20	17	14	20	10
28	9.7	46	20	22	20	11	22	20	17	14	17	9.9
29	11	52	17	20	------	12	22	21	17	14	22	8.8
30	13	38	17	21	------	13	22	20	16	13	18	8.8
31	10	------	21	29	------	13	------	20	------	13	18	------
TOTAL	65.7	913.5	1,328	1,187	1,503	1,083	1,345	693	547	483	419	274.2
MEAN	9.39	31.5	42.8	38.3	53.7	34.9	44.8	22.4	18.2	15.6	13.5	9.14
MAX	13	169	126	131	196	135	156	30	21	18	22	13
MIN	6.2	5.1	16	13	20	11	15	20	16	13	10	7.1
AC-FT	130	1,810	2,630	2,350	2,980	2,150	2,670	1,370	1,080	958	831	544
	*	*										

CAL YEAR 1990	TOTAL*	2,307.2	MEAN	34.4	MAX	169	MIN	5.1	AC-FT	4,580
WTR YEAR 1991	TOTAL*	9,841.4	MEAN	28.9	MAX	196	MIN	5.1	AC-FT	19,520

* Incomplete Record



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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

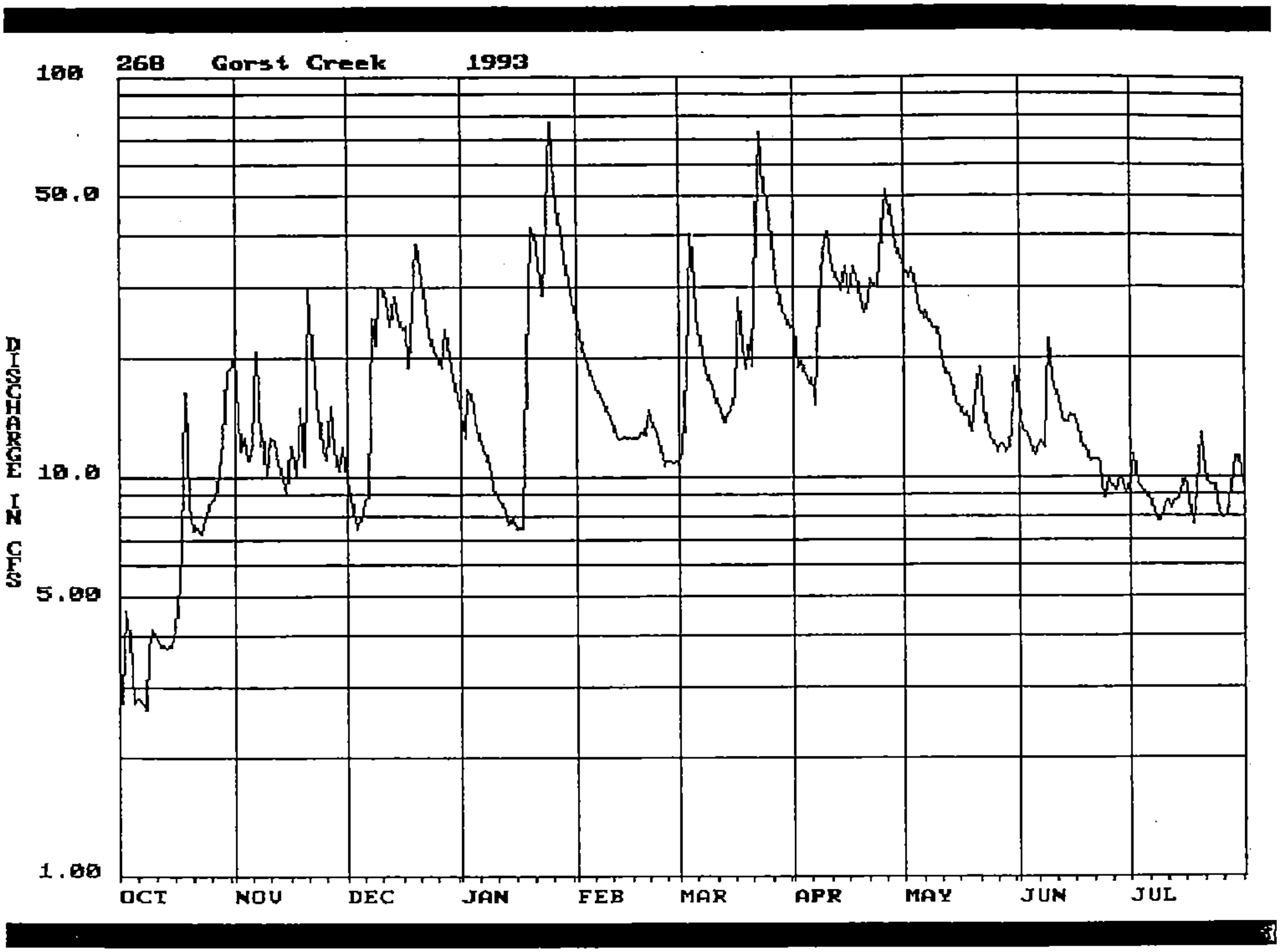
268 Gorst Creek

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1991 TO SEP 1992

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	16	22	28	35	132	37	31	25	9.3	4.9	3.0	2.4
2	15	21	27	47	103	34	31	22	8.9	4.1	3.3	2.4
3	13	20	26	48	88	32	23	20	8.8	3.7	3.2	3.0
4	14	25	27	57	72	31	18	18	8.3	7.3	3.1	4.3
5	14	28	79	50	60	31	21	17	8.2	7.4	3.4	3.8
6	15	26	88	48	53	31	21	17	7.8	6.0	6.1	4.3
7	16	25	61	45	49	31	20	16	7.6	7.1	4.3	4.4
8	14	25	51	41	47	31	19	16	7.4	12	4.1	5.0
9	13	24	55	37	43	31	19	15	8.1	6.0	3.6	4.0
10	14	23	51	45	40	31	20	16	7.4	7.5	2.9	3.3
11	15	40	50	43	37	31	19	16	7.0	6.3	2.4	3.2
12	16	35	49	39	36	31	20	15	9.2	5.0	2.1	3.0
13	15	35	43	37	36	31	19	15	8.8	4.4	1.6	3.3
14	16	33	39	36	35	31	21	16	8.3	4.3	1.7	3.2
15	16	37	37	36	36	31	21	14	7.8	3.9	2.0	3.2
16	21	53	36	41	33	31	19	13	7.2	3.4	2.0	3.2
17	19	64	35	38	38	31	32	13	6.9	2.7	2.4	
18	20	41	41	35	57	31	39	13	6.3	2.5	2.9	
19	20	80	36	34	48	31	26	12	5.7	2.6	2.9	3.0
20	20	78	34	34	55	31	24	12	5.2	4.2	2.9	2.8
21	22	47	36	38	83	31	21	12	5.0	4.1	3.1	2.6
22	24	39	36	35	98	31	20	12	4.5	5.0	3.2	3.0
23	22	35	36	92	73	31	20	11	4.2	4.9	3.3	11
24	29	38	36	113	60	31	19	10	4.3	4.2	3.1	6.5
25	29	40	36	83	51	31	19	11	4.1	3.8	2.6	3.3
26	24	40	37	70	46	31	17	11	4.3	3.5	2.5	3.8
27	22	38	38	132	42	31	16	11	4.0	3.8	2.5	3.2
28	22	34	36	232	39	31	21	11	4.2	3.8	2.4	2.9
29	21	31	37	238	39	31	20	11	12	3.3	2.8	2.7
30	20	29	35	169	------	31	35	12	6.0	2.7	3.0	2.4
31	21	------	32	199	------	31	------	10	------	2.6	3.1	------
TOTAL	578	1,106	1,288	2,227	1,629	971	671	443	206.8	147.0	91.5	109.5
MEAN	18.6	36.9	41.5	71.8	56.2	31.3	22.4	14.3	6.89	4.74	2.95	3.65
MAX	29	80	88	238	132	37	39	25	12	12	6.1	11
MIN	13	20	26	34	33	31	16	10	4.0	2.5	1.6	2.4
AC-FT	1,150	2,190	2,550	4,420	3,230	1,930	1,330	879	410	292	181	217

CAL YEAR 1991	TOTAL*	2,972.0	MEAN	32.3	MAX	88	MIN	13	AC-FT	5,890
WTR YEAR 1992	TOTAL	9,467.8	MEAN	25.9	MAX	238	MIN	1.6	AC-FT	18,780

* Incomplete Record


268 Gorst Creek 1993
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

268 Gorst Creek

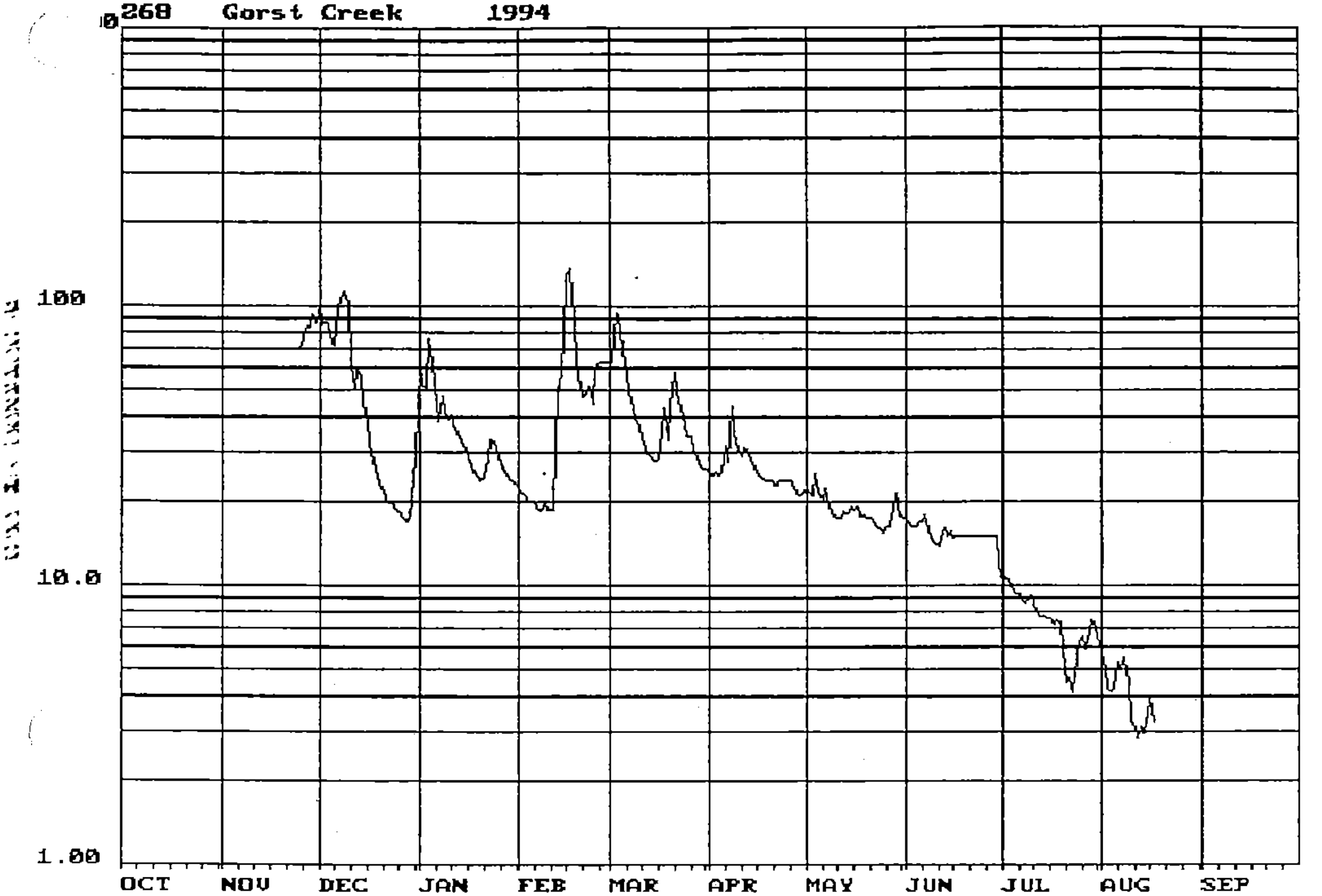
DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1992 TO SEP 1993

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.6	20	9.9	14	25	11	24	33	15	9.8	8.4	14
2	2.8	17	9.0	13	23	12	19	32	13	11	8.0	14
3	4.7	12	8.2	17	21	19	20	33	13	9.6	7.8	14
4	4.0	13	7.5	16	20	41	18	30	12	9.4	7.6	15
5	2.7	11	7.8	14	18	31	17	26	11	9.0	7.6	15
6	2.8	12	8.8	13	17	25	18	25	12	9.0	8.7	15
7	2.7	21	8.9	12	16	22	15	26	12	8.3	9.2	15
8	2.7	12	25	11	16	19	27	25	12	7.9	9.4	16
9	3.8	13	21	10	15	18	37	24	22	7.8	9.8	
10	4.2	10	30	9.1	14	17	41	24	18	8.3	9.4	
11	4.0	13	30	8.9	14	15	35	20	16	8.8	9.2	
12	3.8	12	28	8.7	13	15	32	18	15	8.4	9.1	
13	3.8	11	24	8.3	12	14	30	18	14	8.8	9.6	
14	3.8	10	29	7.7	13	14	29	17	14	8.9	9.4	
15	3.8	9.1	25	7.9	13	15	34	15	14	9.6	9.2	
16	4.2	12	23	7.5	13	16	29	15	14	10	11	
17	4.7	12	24	7.5	13	28	34	14	13	8.8	10	
18	6.6	10	19	7.5	13	21	32	15	12	7.7	10	
19	16	15	27	19	13	19	28	13	12	9.4	9.6	
20	8.6	11	38	42	13	22	26	16	11	13	10	
21	7.4	30	34	41	15	19	28	19	11	10	11	
22	7.5	21	29	34	14	43	31	15	11	9.6	11	
23	7.3	15	24	29	13	73	30	14	11	9.6	11	
24	8.0	13	22	45	12	52	30	13	8.9	9.6	14	
25	8.0	12	20	77	11	49	42	12	10	8.2	12	
26	8.8	11	20	62	11	39	52	12	9.5	7.9	13	
27	8.9	15	19	47	11	31	47	12	9.2	8.0	12	
28	10	12	23	42	11	28	41	12	10	9.5	12	
29	12	10	20	36	------	26	38	12	9.4	11	12	
30	18	12	18	31	------	25	36	13	9.1	11	14	
31	19	------	16	28	------	24	------	19	------	9.8	14	------
TOTAL	207.2	407.1	648.1	726.1	413	803	920	592	374.1	287.7	319.0	118
MEAN	6.68	13.6	20.9	23.4	14.8	25.9	30.7	19.1	12.5	9.28	10.3	14.8
MAX	19	30	38	77	25	73	52	33	22	13	14	16
MIN	2.6	9.1	7.5	7.5	11	11	15	12	8.9	7.7	7.6	14
AC-FT	411	807	1,290	1,440	819	1,590	1,820	1,170	742	571	633	234 *

CAL YEAR 1992	TOTAL*	1,262.4	MEAN	13.7	MAX	38	MIN	2.6	AC-FT	2,500
WTR YEAR 1993	TOTAL*	5,815.3	MEAN	17.0	MAX	77	MIN	2.6	AC-FT	11,530

* Incomplete Record

268 Gorst Creek 1994



KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

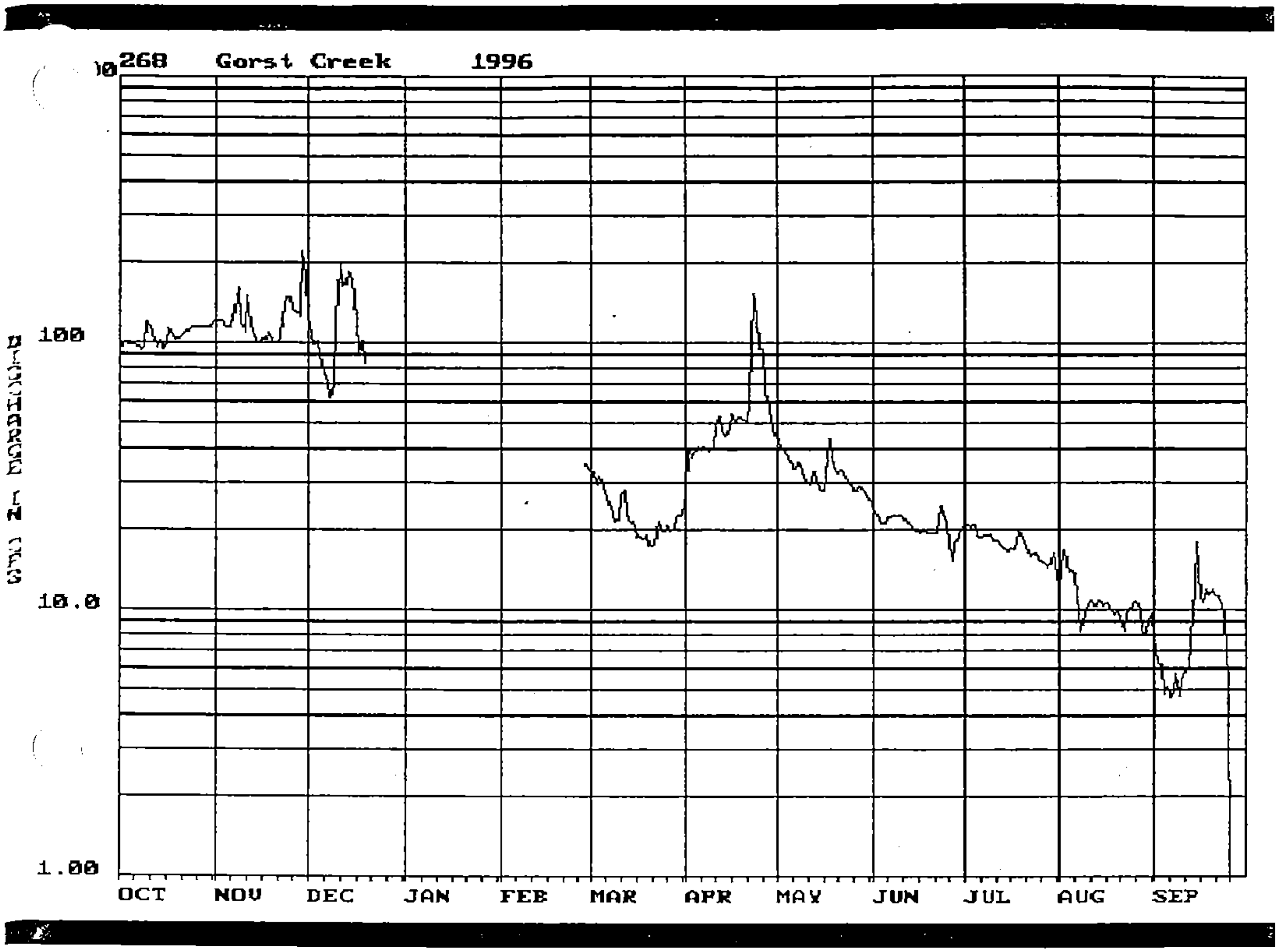
268 Gorst Creek

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1993 TO SEP 1994

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1			102	63	23	64	26	22	17	10	5.8	
2			87	53	22	64	25	22	17	11	5.0	
3			88	51	21	95	26	21	16	11	4.3	
4			86	76	20	95	25	25	17	10	4.2	
5			75	63	20	70	25	22	17	9.4	4.4	
6			73	45	20	57	32	20	17	9.4	5.3	
7			100	39	19	49	28	22	18	9.0	5.1	
8			108	48	19	43	44	20	16	8.7	5.6	
9			114	41	20	40	36	18	15	9.1	4.5	
10			102	40	19	38	31	18	14	9.2	3.3	
11			62	41	19	34	29	18	14	8.7	3.1	
12			50	37	19	31	31	18	15	8.0	2.9	
13			60	35	52	30	29	19	16	7.8	3.2	
14			56	33	50	29	28	18	15	7.9	3.0	
15			46	31	76	29	26	19	16	7.7	3.6	
16			39	29	132	29	25	19	15	7.7	3.9	
17			33	27	138	36	25	19	15	7.4	3.3	
18			28	26	89	44	24	18	15	7.6		
19			25	25	63	34	24	18	15	7.5		
20			23	24	52	44	24	18	15	5.9		
21			22	25	48	58	23	18	15	4.5		
22			21	29	49	51	23	17	15	4.7		
23			20	33	52	43	24	16	15	4.2		
24			20	33	45	38	24	16	15	5.6		
25		71	19	31	59	35	24	16	15	6.4		
26		77	19	28	64	35	24	16	15	6.6		
27		84	18	26	64	31	22	16	15	6.0		
28		86	17	25	64	29	22	19	15	6.9		
29		94	18	24	------	27	21	22	15	7.5		
30		88	24	24	------	26	21	18	12	7.0		
31		------	29	23	------	26	------	18	------	6.6		------
TOTAL		500	1,584	1,128	1,338	1,354	791	586	462	239.0	70.5	
MEAN		83.3	51.1	36.4	47.8	43.7	26.4	18.9	15.4	7.71	4.15	
MAX		94	114	76	138	95	44	25	18	11	5.8	
MIN		71	17	23	19	26	21	16	12	4.2	2.9	
AC-FT		992	3,140	2,240	2,650	2,690	1,570	1,160	916	474	140	
	*	*									*	*

CAL YEAR 1993	TOTAL*	2,084.0	MEAN	56.3	MAX	114	MIN	17	AC-FT	4,130
WTR YEAR 1994	TOTAL*	8,052.5	MEAN	30.3	MAX	138	MIN	2.9	AC-FT	15,970

* Incomplete Record


268 Gorst Creek 1996
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KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

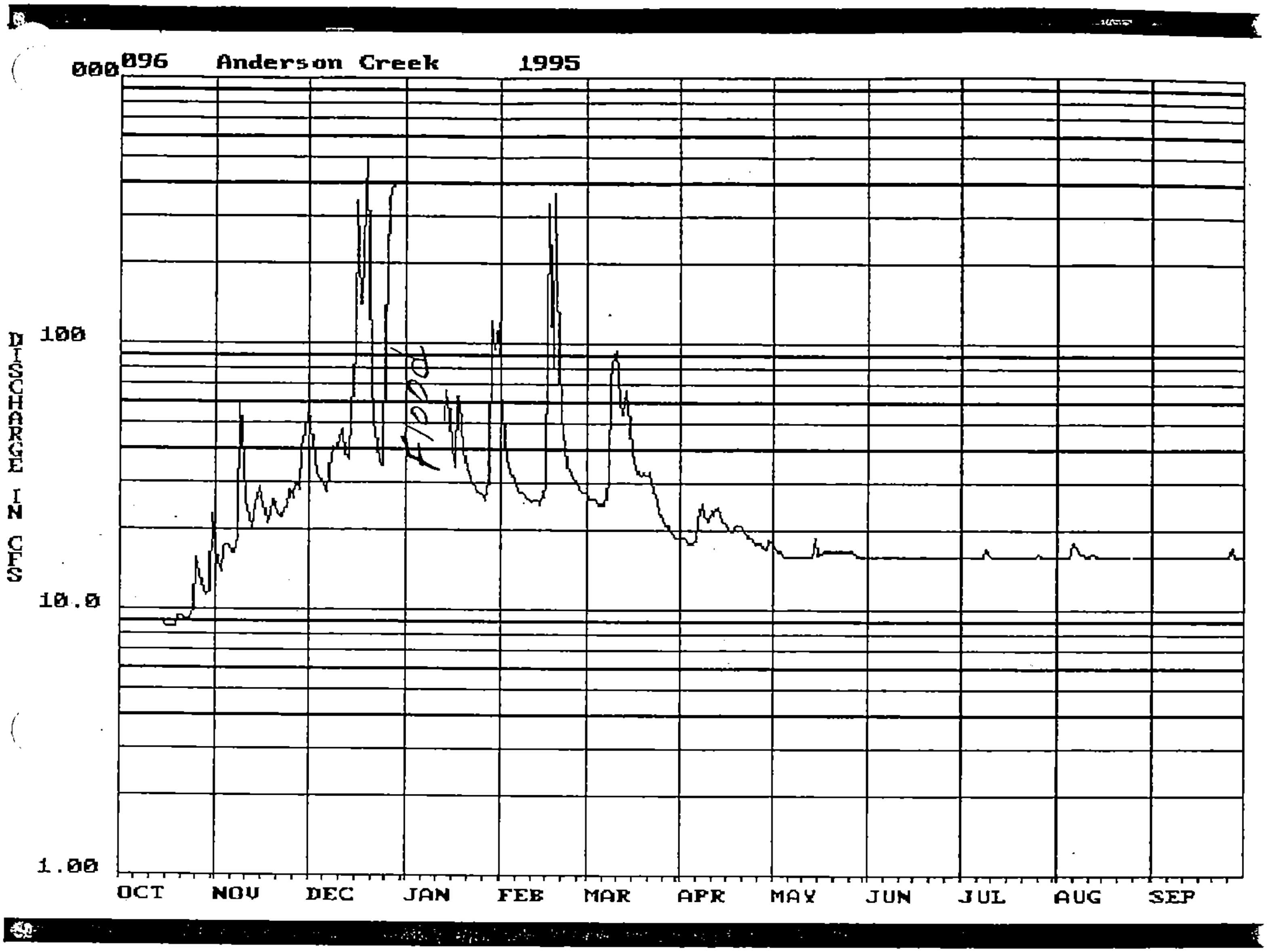
268 Gorst Creek

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1995 TO SEP 1996

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	95	121	125			34	27	45	24	21	12	7.9
2	99	121	109			32	40	41	23	21	17	6.3
3	101	121	99			30	38	40	22	21	17	6.3
4	100	118	103			32	39	38	21	21	14	4.9
5	99	115	89			29	41	37	21	19	14	5.2
6	98	115	79			28	40	34	22	19	14	4.7
7	97	135	71			25	41	34	22	19	9.6	5.0
8	94	161	63			24	40	36	23	19	8.4	5.7
9	97	120	71			22	40	34	23	19	9.7	4.8
10	119	111	123			22	40	31	23	18	10	5.5
11	116	151	199			27	50	30	22	18	11	5.9
12	100	119	164			29	53	30	22	18	10	6.2
13	98	111	167			23	47	33	21	17	10	7.6
14	102	102	185			22	46	30	20	17	11	12
15	96	100	176			21	48	29	20	17	10	18
16	100	105	121			19	55	28	20	17	11	11
17	114	104	92			19	51	32	19	17	10	11
18	106	109	103			19	53	44	20	20	9.9	12
19	105	103	84			19	53	37	20	19	9.8	12
20	105	101				18	53	34	20	18	10	12
21	108	100				18	51	33	19	17	9.3	11
22	109	107				18	63	34	19	16	8.4	11
23	112	142				21	154	32	25	16	9.7	10
24	113	149				20	128	30	23	16	10	9.5
25	116	150				20	95	30	22	16	11	5.4
26	115	134				21	95	28	17	15	11	0
27	115	133				20	67	28	15	15	10	0
28	115	128			35	20	58	29	18	15	8.2	0
29	115	219			34	22	51	28	19	15	8.2	0
30	115	179			------	23	45	28	21	16	9.3	.68
31	118	------			------	23	------	26	------	13	9.8	------
TOTAL	3,292	3,784	2,223		69	720	1,702	1,023	626	545	333.3	211.58
MEAN	106	126	117		34.5	23.2	56.7	33.0	20.9	17.6	10.8	7.05
MAX	119	219	199		35	34	154	45	25	21	17	18
MIN	94	100	63		34	18	27	26	15	13	8.2	0
AC-FT	6,530	7,510	4,410		137	1,430	3,380	2,030	1,240	1,080	661	420
			*	*	*							

CAL YEAR 1995	TOTAL*	9,299.00	MEAN	116	MAX	219	MIN	63	AC-FT 18,440
WTR YEAR 1996	TOTAL*	14,528.88	MEAN	49.1	MAX	219	MIN	0	AC-FT 28,820

* Incomplete Record


000096 Anderson Creek 1995
DISCHARGE IN CFS
100
10.0
1.00
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP

KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

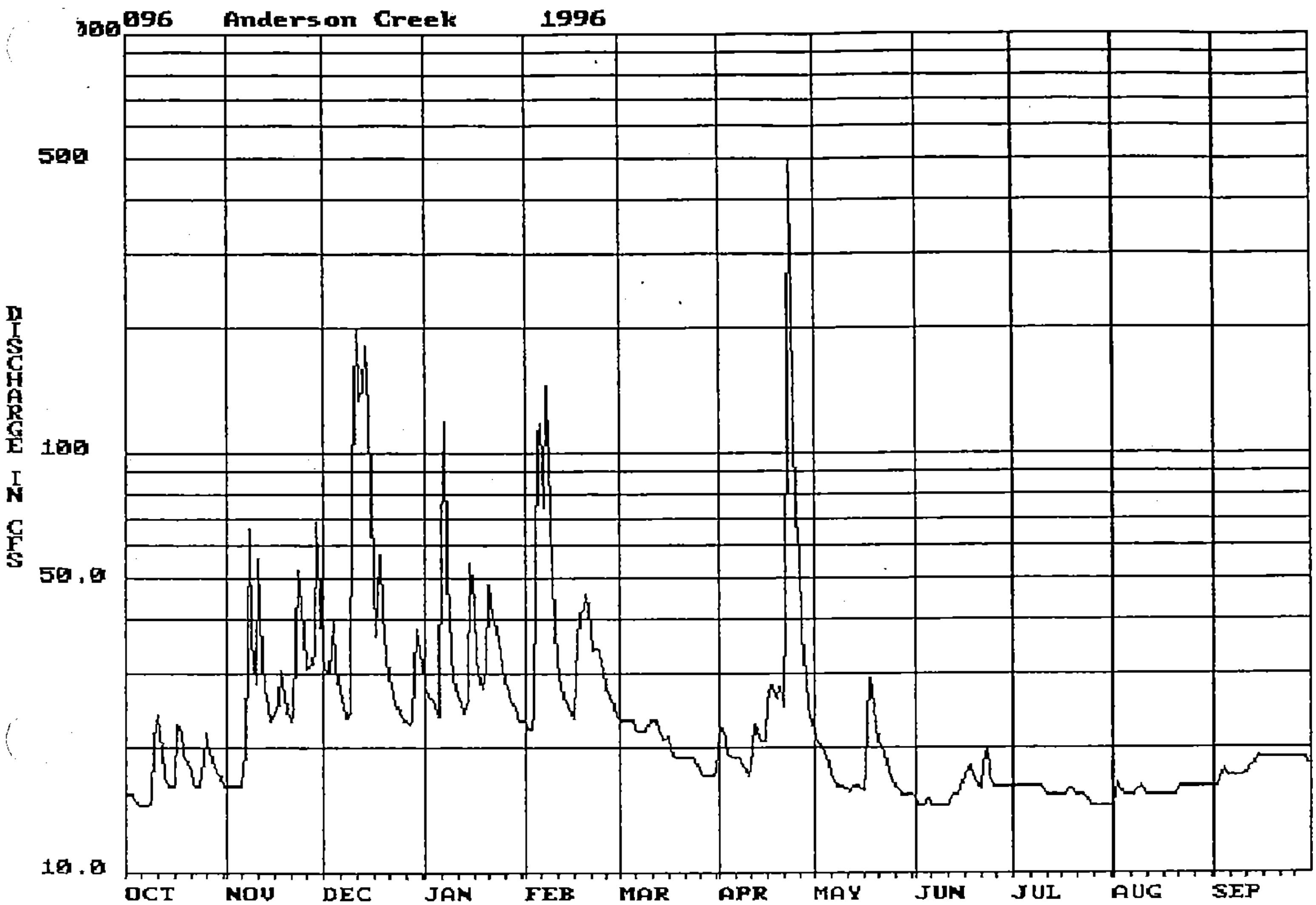
096 Anderson Creek

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1		17	58		70	28	19	18	16	16	16	16
2		15	49		45	27	19	17	16	16	16	16
3		14	37		37	26	18	17	16	16	16	16
4		17	32		33	26	18	17	16	16	16	16
5		18	31		32	25	18	16	16	16	16	16
6		17	29		30	25	18	16	16	16	18	16
7		16	28		28	25	22	16	16	16	18	16
8		18	34		28	30	25	16	16	16	17	16
9		61	41		27	76	23	16	16	17	16	16
10		36	41		26	90	22	16	16	16	16	16
11		25	45		25	96	24	16	16	16	16	16
12		22	48		26	62	23	16	16	16	16	16
13		20	38	52	26	55	25	16	16	16	17	16
14		25	37	67	25	67	23	16	16	16	16	16
15	9.2	29	55	54	27	51	22	19	16	16	16	16
16	8.7	26	97	40	31	39	21	16	16	16	16	16
17	8.7	23	350E	35	335E	34	20	16	16	16	16	
18	8.7	21	142	64	83E	33	20	17	16	16	16	
19	8.7	23	350E	52	370E	32	21	17	16	16	16	16
20	9.5	26	500E	39	94	33	21	17	16	16	16	16
21	9.5	23	76	34	54	33	21	17	16	16	16	16
22	9.3	22	51	32	41	33	19	17	16	16	16	16
23	9.3	24	42	30	35	28	19	17	16	16	16	16
24	9.3	24	36	28	32	26	19	17	16	16	16	16
25	10	28	35	28	31	24	18	17	16	16		16
26	16	26	104	27	30	22	18	17	16	17	16	16
27	14	30	350E	26	28	21	18	17	16	16	16	17
28	12	28	400E	31	28	21	17	17	16	16	16	16
29	11	40		120	------	20	17	16	16	16	16	16
30	12	47		96	------	19	19	16	16	16	16	16
31	23	------		120	------	19	------	16	------	16	16	------
TOTAL	188.9	761	3,136	975	1,677	1,146	607	515	480	498	486	481
MEAN	11.1	25.4	112	51.3	59.9	37.0	20.2	16.6	16.0	16.1	16.2	16.0
MAX	23	61	500	120	370	96	25	19	16	17	18	17
MIN	8.7	14	28	26	25	19	17	16	16	16	16	16
AC-FT	375	1,510	6,220	1,930	3,330	2,270	1,200	1,020	952	988	964	954
	*		*	*							*	

CAL YEAR 1994	TOTAL*	4,085.9	MEAN	54.5	MAX	500	MIN	8.7	AC-FT	8,100
WTR YEAR 1995	TOTAL*	10,950.9	MEAN	32.7	MAX	500	MIN	8.7	AC-FT	21,720

* Incomplete Record



096 Anderson Creek 1996
DISCHARGE IN CFS
500
100
50.0
10.0
OCT
NOV
DEC
JAN
FEB
MAR
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MAY
JUN
JUL
AUG
SEP

KITSAP PUBLIC UTILITY DISTRICT
WATER RESOURCE DIVISION

096 Anderson Creek

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1995 TO SEP 1996

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	15	16	32	28	23	23	22	22	15	16	15	16
2	15	16	30	27	22	23	22	20	15	16	16	16
3	15	16	30	26	22	23	21	20	15	16	16	17
4	15	16	40	25	24	23	19	20	15	16	15	18
5	15	16	31	24	109	23	19	18	15	16	15	17
6	15	16	27	65	117	22	19	17	15	16	15	17
7	15	19	25	119	75	22	19	17	15	16	15	17
8	15	67	23	51	146	22	18	16	15	16	16	17
9	15	36	24	34	70	22	18	16	15	16	16	17
10	21	28	86	29	40	23	17	16	15	16	16	17
11	24	57	200E	27	32	23	18	16	15	15	15	17
12	20	32	135	25	28	23	23	16	15	15	15	18
13	17	28	143	24	26	22	22	16	15	15	15	18
14	16	25	180E	26	25	21	21	16	15	15	15	19
15	16	23	127	55	24	21	21	16	16E	15	15	19
16	16	24	50	44	24	21	26	16	17E	15	15	19
17	23	26	37	32	30	20	28	18	18E	15	15	
18	22	31	57	28	42	19	27	29	18E	16	15	
19	19	27	42	28	43	19	26	27	17E	16	15	19
20	19	24	33	31	46	19	28	23	17E	15	15	19
21	17	23	29	49	38	19	25	20	16E	15	16	19
22	16	24	27	41	34	19	43	20	18E	15	16	19
23	16	53	25	39	34	19	500E	19	20E	15	16	19
24	16	49	25	36	34	19	124	17	17E	15	16	19
25	19	38	23	32	30	18	69	16	16	15	16	19
26	22	31	23	28	28	18	58	16	16	15	16	19
27	20	31	23	27	26	17	37	16	16	15	16	19
28	19	34	23	26	25	17	29	15	16	15	16	19
29	18	68	38	25	24	17	25	15	16	15	16	19
30	17	45	36	23	------	17	23	15	16	15	16	18
31	16	------	32	23	------	18	------	15	------	15	16	------
TOTAL	544	939	1,656	1,097	1,241	632	1,367	559	480	477	481	544
MEAN	17.5	31.3	53.4	35.4	42.8	20.4	45.6	18.0	16.0	15.4	15.5	18.1
MAX	24	68	200	119	146	23	500	29	20	16	16	19
MIN	15	16	23	23	22	17	17	15	15	15	15	16
AC-FT	1,080	1,860	3,280	2,180	2,460	1,250	2,710	1,110	952	946	954	1,080

CAL YEAR 1995	TOTAL*	3,139	MEAN	34.1	MAX	200	MIN	15	AC-FT	6,230
WTR YEAR 1996	TOTAL	10,017	MEAN	27.4	MAX	500	MIN	15	AC-FT	19,870

* Incomplete Record

Appendix D
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Appendix D References

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Robinson and Noble, Inc., October 1988, South Kingston Test Well for PUD No. 1 of Kitsap County.

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Robinson and Noble, Inc., January 1991, Island Lake Aquifer study of Silverdale Water District.

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Woodward et al, 1995. South King County Precipitation.

Appendix E
Fish and Habitat
Annotated Bibliography

Appendix E
Fish and Habitat Annotated Bibliography

Ames, Bob. September 1993. Liberty Bay Nonpoint Pollution Survey, Final Report. Bremerton-Kitsap County Health District, Division of Environmental Health, Bremerton, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Not Applicable

QA/QC: Not Applicable

This report documents nonpoint pollution source surveys conducted in January and August 1993. An on-site waste disposal system inventory was conducted along the northwestern shoreline of Liberty Bay to identify and correct failing on-site systems. A farm inventory was conducted by the Kitsap Conservation District as part of this study (see Garitone, J. 1993). No water quality sampling was done.

This report provides good information on nonpoint pollutant sources. A map is included that shows specific locations of the on-site systems surveyed.

Andersen, A. M. 1971. Spawning, growth, and spatial distribution of the geoduck clam, Panope generosa Gould, in Hood Canal, Washington. Ph.D. Thesis, University of Washington, Seattle, WA.

Andersen, H. M.. 1882-. How, when and where, on Hood Canal.

Anonymous. 1989. Port Gamble Bay Recreational Shellfish Sampling Project. Sponsored by the Hood Canal Coordinating Council.

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline
DATA TYPE:	Bacteriological, water, shellfish
DEPTHS:	
SAMPLE PERIOD:	June-Aug., Nov., Jan., Mar. 1989
SAMPLE FREQUENCY:	up to every other week
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Bremerton-Kitsap County Health Dept.
WQ STANDARDS MET:	Sometimes
QA/QC	Incomplete

COMMENTS: The project described in sufficient detail a community effort to monitor water quality in the Port Gamble area. Sampling design and methods are given. Some physical water quality parameters (dissolved oxygen, temperature, pH, flow) were to be taken in streams. The number of years of sampling by the project was not mentioned.

Data for only June through September 1989 were presented. One of three marine water stations violated the fecal coliform standard during one test period. Two of three shellfish stations exceeded the standard. High fecal coliform in Little Boston Creek originated upstream from residences (in attached letter from Holly Coccoli, PNPTC). A sampling station map is provided.

The number of samples was below that recommended to estimate fecal coliform bacteria in marine waters (15).

Applied Geotechnology, Inc. and CRK Environmental Mgmt. 1990. Supporting documentation: Pope & Talbot Dredged Sediment Landfill and Hog Fuel/Woodwaste Storage and Recycling Facility, Port Gamble, WA. Report prepared for Pope & Talbot, Inc., Port Gamble WA.

LOCATION:	Port Gamble
DATA TYPE:	Metals, inorganics, organics
HABITAT:	Marine sediments, surface water, stream
DEPTHS:	
SAMPLE PERIOD:	January 1990
SAMPLE FREQUENCY:	Once
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	EPA protocol
WQ STANDARDS MET:	No
QA/QC	Yes

COMMENTS: Appendix F of this report provides water and sediment quality data. EPA protocols were reportedly used in the sampling and analyses. Sediment samples from the two locations passed PSDDA guidelines for open-water disposal.

Among the 58 PSDDA chemicals tested, the existing storage pile contained two methylated phenols whose concentrations were between the PSDDA screening level and maximum level values. Other chemicals were at relatively low levels.

A single water sample was taken from a seep at the woodwaste storage pile and an intermittent stream uphill of the landfill. The quality of the woodwaste seep was typical of marine sediment mixed with decaying woodwaste, e.g. high chemical oxygen demand. The upstream sample was typical of water from precipitation or other terrestrial sources.

The report did not directly compare observed values with EPA or PSDDA criteria in a table format.

Bahls, P. and M. Ereth. 1994. Stream typing error in Washington Water Type Maps for watersheds of Hood Canal and the southwest Olympic Peninsula. Point No Point Treaty Council, Technical Report TR 94-2. Kingston, WA.

LOCATION:	Hood Canal
DATA TYPE:	Fish
HABITAT:	Freshwater streams
DEPTHS:	Not relevant
SAMPLE PERIOD:	April-June 1993
SAMPLE FREQUENCY:	Not relevant
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	Not relevant
QA/QC	Yes

COMMENTS: The Washington Department of Natural Resources maintains a Water Type mapping system that assigns an administrative classification to rivers and streams found within private and state-owned lands. The level of riparian protection afforded these streams during subsequent timberland management within the watershed is directly related to the classification category to which they are assigned. The purpose of this project report is twofold: to verify stream typing in selected watersheds to provide better fisheries resource protection, and to gain a better understanding of the extent of stream typing errors in the tribes' geographic area of interest. This report documents a number of mistaken classifications on the water type map for streams within the upper Hood Canal drainage. In addition there has been an underestimation of the number of miles of streams that provide accessible fish habitat. In Hood Canal, 46% of all fish bearing stream miles (types 1, 2 or 3) were incorrectly classified as non-fish bearing (type 4 or 5). Streams within the upper Hood Canal Watershed include Seabeck, Big Anderson, Harding and Little Anderson creeks. All proposed water type changes resulting from this study were subsequently approved by the DNR. Overall, the existing water type maps were found to greatly underestimate the occurrence of fish-bearing stream and other stream types in watersheds of Hood Canal and elsewhere on the Olympic Peninsula. As a result, fish resources are subject to habitat degradation because of inadequate protection afforded them during land use practices.

Bangor Naval Submarine Base. 1993. Naval Submarine Base, Bangor-Operable Unit 4. Kitsap County, Washington. November newsletter describing hazardous waste cleanup activities. Silverdale, WA.

LOCATION:	Bangor
DATA TYPE:	Metals, inorganics, organics
HABITAT:	Upland sediments
DEPTHS:	
SAMPLE PERIOD:	Not available
SAMPLE FREQUENCY:	Not available
SAMPLE DURATION:	Not available
ANALYTICAL METHODS:	Not available

WQ STANDARDS MET: Yes
QA/QC Not available

COMMENTS: Operable Unit 4 includes two of 22 potentially contaminated sites at the subase. Site C-East was contaminated by disposal of ordnance wastewater and sludge. Site C-West was contaminated by fill material from Site C-East.

Bangor Naval Submarine Base. 1994a. Naval Submarine Base, Bangor-Operable Unit 6 (Site D). Kitsap County, Washington. January newsletter describing hazardous waste cleanup activities. Silverdale, WA.

LOCATION: Bangor
DATA TYPE: Metals, inorganics, organics
HABITAT: Lagoon, wetlands, overflow ditch sediments & ground water
DEPTHS:
SAMPLE PERIOD: Not available
SAMPLE FREQUENCY: Not available
SAMPLE DURATION: Not available
ANALYTICAL METHODS: Not available
WQ STANDARDS MET: No
QA/QC Not available

COMMENTS: This site received wastewaters from demilitarization of ordnance containing TNT, RDX, and DNT. Contamination exceeded acceptable risk levels for human health. Cleanup alternatives, including ground water contamination, are discussed.

Bangor Naval Submarine Base. 1994b. Naval Submarine Base, Bangor-Operable Unit 2 (Site F). Kitsap County, Washington. February newsletter describing hazardous waste cleanup activities. Silverdale, WA.

LOCATION: Bangor
DATA TYPE: Metals, inorganics, organics
HABITAT: Wetlands, sediments, ground water
DEPTHS:
SAMPLE PERIOD: Not available
SAMPLE FREQUENCY: Not available
SAMPLE DURATION: Not available
ANALYTICAL METHODS: Not available
WQ STANDARDS MET: No
QA/QC Not available

COMMENTS: This site received wastewaters from demilitarization of ordnance including a small arms incinerator, TNT, and a burn trench. Contamination exceeded acceptable risk levels for human health and for small burrowing mammals. Cleanup alternatives are discussed.

Bangor Naval Submarine Base. 1994c. Unpublished water quality monitoring data at freshwater sites on the Bangor submarine base, 1978-1989. Data available on computer disk. Contact Marvin Frye or Jim Reeves at the Naval base.

LOCATION: Bangor
HABITAT: Freshwater
DATA TYPE: Metals, conventional, nutrients, inorganics, bacteriological
DEPTHS:
SAMPLE PERIOD: 1978-1989
SAMPLE FREQUENCY: 1 or 2 times per year
SAMPLE DURATION: Grab
ANALYTICAL METHODS: Not available
WQ STANDARDS MET: Unknown, no units of measure
QA/QC: No

COMMENTS: Data tables and graphs are available for 14 freshwater sampling stations on the Bangor Naval Base. Data include measurements of chromium, copper, iron, lead, nickel, silver, zinc, cadmium, mercury, total arsenic, fluoride, nitrate, nitrite, ammonia, nitrogen TK, pH, phosphate, total organic carbon, sulfate, total residue, turbidity, total coliform bacteria, and fecal coliform bacteria. A map shows the location of the sampling sites and a very brief description of the receiving water.

No text is attached that describes the objectives, methodology, or results of the data. Units of measurement were not provided.

Baranski, C. Personal communication March 1, 1995 (unpublished data sent to Debra Bouchard, KCM, Inc.). Washington Department of Fish and Wildlife, Olympia, WA.

Bax, N. J. 1983. The early marine migration of juvenile chum salmon (Oncorhynchus keta) through Hood Canal : its variability and consequences. Thesis (Ph.D.), University of Washington, Seattle, WA.

Bax, N. J., E. O. Salo, and B. P. Snyder. 1980. Salmonid outmigration studies in Hood Canal: final report, phase V, January to July 1979. Fisheries Research Institute, College of Fisheries, University of Washington. FRI-UW-8010.

Beck, R.W. July 1993. Comprehensive Surface Water Management Plan, Draft. Prepared for the City of Poulsbo, Poulsbo, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Not Applicable
QA/QC: Not Applicable

The Comprehensive Surface Water Plan for the City of Poulsbo describes surface water problems in the area and categorizes them into one of the following: drainage system problems, such as flooding, channel erosion, and substandard drainage systems; water quality problems; and environmental resource problems, such as fish habitat and passage problems. Surface water problems were identified through windshield surveys and historical studies. No water quality analysis was conducted as part of this planning process. A review of previously conducted water quality studies was provided.

Brown and Caldwell, Consultants, Inc., et al. 1993. Kitsap County Surface Water Management Program Interim Report. Prepared for the Department of Public Works, Kitsap County, WA.

LOCATION:	Kitsap County
DATA TYPE:	No data
HABITAT:	Surface and stormwater
DEPTHS:	Not relevant
SAMPLE PERIOD:	1993
SAMPLE FREQUENCY:	Not relevant
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	Not relevant
QA/QC	Yes

COMMENTS: This draft interim report describes the development of a surface water management program that integrates physical setting and characteristics of the resource, as well as characterizes the nature of surface and storm water issues and problems to be faced by the county. The report includes discussion of program scope including capital improvement projects, water quality monitoring, operations and maintenance, public education and involvement, source control, funding assistance and planning.

This newsletter briefly describes the studies at this site. Although concentrations of organic compounds and metals were measured, the Navy, EPA and Ecology determined the site was not hazardous to humans or wildlife and recommended no further action.

CH2M Hill. 1994. 1993 annual report. Hansville Landfill, Kitsap County, Washington. Prepared for Kitsap County Department of Public Works, Port Orchard, WA.

LOCATION:	Hansville, Middle Creek
HABITAT:	Ground water, surface water
DATA TYPE:	Volatile organic compounds, metals, conventional, fecal coliform
DEPTHS:	NA
SAMPLE PERIOD:	1993
SAMPLE FREQUENCY:	Quarterly
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	See report

WQ STANDARDS MET: No
QA/QC Yes

COMMENTS: This report on monitoring of the Hansville Landfill was prepared in accordance with the Hansville Landfill Closure Plan. Primary ground water and drinking standards were exceeded for vinyl chloride. Primary ground water standards were also exceeded for arsenic. Secondary standards were exceeded for chloride, pH, specific conductivity, iron, and manganese in some of the wells. Additionally, iron, nitrate-nitrogen, nitrite-nitrogen, sulfate, temperature, and barium were elevated compared to upgradient levels.

Cedarholm, C. J. 1972. The short-term physical and biological effects of stream channelization at Big Beef Creek, Kitsap County, Washington. MS Thesis, University of Washington, College of Fisheries.

Cedarholm, C. J. and K V. Koski. 1977. Effects of stream channelization on the salmonid habitat and populations of lower big Beef Creek, Kitsap County, Washington, 1969-1973. Washington Cooperative Fishery Research Unit, College of Fisheries, University of Washington.

Chew, K. 1970. Preliminary survey of macrofauna in Anderson Cove, Washington Boise Cascade Properties. Subject: Marine-fauna -- Washington-State -- Hood-Canal. Intertidal-fauna -- Washington-State -- Hood-Canal. Marine-fauna

Crecelius, et. al. 1989. 1988 Reconnaissance survey of environmental conditions in 13 Puget Sound locations. USEPA Report.

Daniels, Scott. January 1994. Letter to Jim Svensson of Kitsap County DCD with fecal coliform testing results from Klebeal Creek and the Suquamish Bingo Hall. Water Quality Program Manager, Bremerton-Kitsap County Health District, Bremerton, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: No

QA/QC: No
Three grab samples were collected from three sites on Klebeal (Thompson) Creek and one sample from the Suquamish Bingo Hall storm water detention basin. All three sites were identical to the sites sampled by the Kitsap County Department of Public Works on March 19, 1993 (no figure included). No replicates were taken. Samples were analyzed for fecal coliform bacteria. All samples were well below the State's Class AA freshwater standard of 50 colonies/100 ml for fecal coliform bacteria The highest fecal coliform count of 13 colonies/100 ml was observed upstream of the Bingo Hall.

Daniels, Scott. December 1992. Kitsap County Boat Waste Control Program Water Quality Monitoring Report. Water Quality Program Manager, Bremerton-Kitsap County Health District, Bremerton, WA.

WQ ANALYSIS: Yes
NONPOINT SOURCES IDENTIFIED: No
METHODS: Yes
QA/QC: No

During the summer of 1991, the Bremerton-Kitsap County Health District (BKCHD) completed a water quality study of four marina areas in Kitsap County. One of those marinas was the Port of Poulsbo. The purpose of the study was to determine if water quality degradation was occurring inside the marinas as a result of boat sewage discharges. Samples were collected from twelve stations within each marina and twelve stations outside each marina, every two weeks from June through September 1991. Samples were analyzed for fecal coliform bacteria. Temperature, dissolved oxygen, and salinity were measured also.

Fecal coliform concentrations inside the Port of Poulsbo marina were found to be significantly higher than those found outside the marina. Both parts of the state fecal coliform standard were violated on four of the seven sampling dates for samples collected inside the marina. No violations occurred for samples collected outside the marina. For all sampling data combined, the geometric mean of all fecal coliform concentrations inside the marina was 14.1 org/100 ml and 2.1 org/100 ml outside the marina. Dissolved oxygen levels were slightly lower inside the marina than outside the marina on almost all sampling dates. The State Class AA marine water quality standard for dissolved oxygen was violated on one date inside the marina.

Dempster, R. P. 1938. The seasonal distribution of plankton at the entrance to Hood Canal. MS Thesis, Zoology Department, University of Washington.

Department of Ecology. 1977. Coastal Zone Atlas of Washington - Chapter 10 - Kitsap County. Publication No. DOE 77-21-1 (v.1).

Dept. of Ecology. 1994. Marine water quality data. Computer data file from Skip Albertson, Ambient Monitoring Section, Dept. of Ecology, Olympia, WA. (206-407-6676).

LOCATION:	Hood Canal, Bangor, King Spit
HABITAT:	Marine water column
DATA TYPE:	Conventional
DEPTHS:	1 m intervals, down to 32 m
SAMPLE PERIOD:	Oct. 1975 to Sept. 1992
SAMPLE FREQUENCY:	Monthly
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Not analyzed
QA/QC	Not available

COMMENTS: Data available on computer disk (37 files, ASCII format) via Meg Sands, Kitsap County DCD. Parameters measured by CTD include depth, temperature, conductivity, salinity, pH, dissolved oxygen, % light. Prior to fall 1988 sampling occurred from April to November rather than the entire year. These data appear to be part of the EPA PCSTORET data file but the data set includes depths not included in the PCSTORET data file.

QA/QC information were not available. Data appears reasonable for tracking long-term (annual) but not short-term trends.

Dickes, B. 1993. Burley-Minter BMP Evaluation (in prep.).

DOH. 1993a. Annual Inventory of commercial and recreational shellfish areas in Puget Sound. Office of Shellfish Programs, Washington State Dept. of Health. 37 p. + maps.

LOCATION:	Puget Sound, Hood Canal
HABITAT:	Shoreline
DATA TYPE:	Bacteriological, water, shellfish
DEPTHS:	
SAMPLE PERIOD:	1993
SAMPLE FREQUENCY:	Annual
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	No
QA/QC	Not available

COMMENTS: Report summarizes classification of shellfish areas (Approved, conditionally approved, restricted, prohibited) in Puget Sound, including Hood Canal. Color maps show areas that have been classified. Detailed methodology was not provided.

The following areas within the Hood Canal portion of Kitsap County have been approved: Anderson Cove/Holly (20 acres), Frenchman's Cove (560 acres), Big Beef/Little Big Beef Harbors (220 acres), Port Gamble Bay (1,210 acres), Seabeck Bay (600 acres), and Stavis Bay 790 acres). Restricted areas were reported for within inner Seabeck Bay (110 acres) and an area adjacent to Port Gamble Bay. The restricted classification for inner Seabeck Bay was related to the marina.

Outbreaks of paralytic shellfish poisoning were described. One of the only areas remaining unaffected by PSP closures in recent years was that area south of Seabeck.

The DOH operates the sentinel mussel monitoring program as an early warning system for marine biotoxins. Sampling stations in the upper Hood Canal watershed are located at Lofall and Seabeck and are monitored semi-monthly to monthly.

Monitoring for amnesia shellfish poisoning (ASP) during 1991 and 1992 did not detect unsafe levels of demonic acid in Hood Canal or other parts of Puget Sound. Details of sampling were not provided.

DOH. 1993b. Unpublished database of paralytic shellfish poisoning records. Office of Shellfish Programs, Washington State Dept. of Health.

LOCATION:	Puget Sound, Hood Canal, Hood Point
HABITAT:	Shoreline
DATA TYPE:	Shellfish
DEPTHS:	
SAMPLE PERIOD:	1991-1993
SAMPLE FREQUENCY:	Variable
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Yes
QA/QC	Not available

COMMENTS: Tables indicate that bivalves at Hood Point and other areas of Hood Canal (Brinnon, Robbinswold, Hamma Hamma, Dosewallips, Seal Rock) have little or no toxin. Only one sample near Brinnon contained detectable levels of the toxin (1991).

DOH. 1993d. Sanitary survey of Port Gamble. Office of Shellfish Programs. Washington Department of Health.

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline
DATA TYPE:	Bacteriological, shellfish
DEPTHS:	
SAMPLE PERIOD:	1988, 1989, 1993
SAMPLE FREQUENCY:	Six times per year
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	"Systematic random sampling method"
WQ STANDARDS MET:	Mostly
QA/QC:	Yes

COMMENTS: This report describes the survey conducted to evaluate the shellfish growing area in Port Gamble Bay. During 1990-1993, one of 15 marine stations (i.e. Cedar Cove) did not meet the program criteria for fecal coliform bacteria. All five freshwater streams did not meet the criteria, although sampling effort was less frequent. Port Gamble Bay was approved as a shellfish growing site in 1993.

During 1989, the Cedar Cove station did not meet the standard (1 of 15 stations); one of three freshwater streams did not meet the standard.

During 1988, one of 15 stations did not meet the standard (station 4). Three streams showed slightly elevated fecal coliform levels.

DOH. 1993a. Shoreline survey of Hood Canal: Tekiu Point/Stavis Bay. Office of Shellfish Programs. Washington Department of Health. 6 p.

LOCATION:	Hood Canal, Tekiu Point to Stavis Bay
HABITAT:	Shoreline
DATA TYPE:	Bacteriological, shellfish, water, sewage systems
SAMPLE PERIOD:	June & July 1993
SAMPLE FREQUENCY:	Once
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Mostly, see discussion
QA/QC	Yes

COMMENTS: Survey examined area for actual and potential sources of pollution near shellfish growing areas. Map of survey area shows commercial shellfish beds, water quality sampling stations, and residences surveyed for sewage disposal systems.

No agricultural sites, industrial discharges, or marinas were identified in the area. Three of 35 residences (9%) had suspect sewage disposal systems. Ambient monitoring program indicated this area continued to meet standard for growing shellfish.

DOH. 1993b. Shoreline survey of Holly. Office of Shellfish Programs. Washington Department of Health. 7 p.

LOCATION:	Hood Canal, Holly to Tekiu Point
HABITAT:	Shoreline
DATA TYPE:	Bacteriological, shellfish, water, sewage systems
SAMPLE PERIOD:	June 1993
SAMPLE FREQUENCY:	Once
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Mostly, see discussion
QA/QC	Yes

COMMENTS: Survey examined area for actual and potential sources of pollution near shellfish growing areas. Map of survey area shows commercial shellfish beds, water quality sampling stations, and residences surveyed for sewage disposal systems.

No agricultural sites, industrial discharges, or marinas were identified in the area. Fourteen of 73 residences (19%) had suspect sewage disposal systems. Ambient monitoring program indicated this area continued to meet standard for growing shellfish. Recommended that the county consider establishing an on-site waste system maintenance program in shellfish growing areas. Failing or suspect sewage systems and greywater discharges should be corrected by the local health department.

DOH. 1989. Shoreline sanitary survey of Seabeck Bay, Big Beef Harbor, and Little Beef Harbor. Office of Shellfish Programs. Washington Department of Health. 7 p.

LOCATION:	Hood Canal, Seabeck Bay to Big Beef Harbor
HABITAT:	Shoreline

DATA TYPE:	Bacteriological, shellfish, water, sewage systems
SAMPLE PERIOD:	May 1989
SAMPLE FREQUENCY:	Once
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	No
QA/QC	Yes

COMMENTS: Survey examined area for actual and potential sources of pollution near shellfish growing areas. Map of survey area shows commercial shellfish beds, water quality sampling stations, and residences surveyed for sewage disposal systems. No agricultural sites, industrial discharges, or marinas were identified in the area. At most thirty-five of 129 residences (27%) had suspect sewage disposal systems. Recommended that failing or suspect sewage systems and greywater discharges be corrected.

DSHS. 1987. Water quality study of Port Gamble. Dept. of Social & Health Services, Shellfish Section. 7 p + appendix.

LOCATION:	Port Gamble
HABITAT:	Shoreline, creeks
DATA TYPE:	Bacteriological, Shellfish
DEPTHS:	
SAMPLE PERIOD:	9-26 March, 1987
SAMPLE FREQUENCY:	Twice daily
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	MPN, APHA
WQ STANDARDS MET:	Yes, but see discussion
QA/QC	Incomplete

COMMENTS: An intensive assessment of fecal coliform concentrations was conducted during a brief time period. This sampling period received relatively heavy rainfall.

At least 15 marine water samples were taken from 15 stations (ebb, flood, & slack tides) providing a total of 276 samples. Additionally, 22 samples were collected from the three major streams. Methodology followed that described by the American Public Health Association (APHA, A-1 Modified Method).

All marine and fresh water stations were found to have fecal coliform concentrations below the FC standard. Temperature, salinity, and tide stage were provided.

Three of seven shellfish samples (43%) contained fecal coliform concentrations that exceeded the Food and Drug Administration (FDA) criterion of < 230 organisms per 100 g tissue (note: units of concentration were not provided in the report; we assumed that concentrations were reported as number of organisms per 100 g tissue). This result was not discussed in the report.

The Shellfish Section recommended that the APPROVED classification for commercial harvest of shellfish remain in effect.

Dublanica, K., E.E. Knudsen, A. Ralph, and N. Gloman. 1993. Hood Canal fish, wildlife, and habitat information survey. Draft Report. Western Washington Fishery Resource Office and Ecological Services, U.S. Fish and Wildlife Service, Olympia, WA.

LOCATION:	Hood Canal
HABITAT:	Streams, marine waters, upland
DATA TYPE:	None
DEPTHS:	
SAMPLE PERIOD:	Not relevant
SAMPLE FREQUENCY:	Not relevant
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	Not relevant
QA/QC	Yes

COMMENTS: This report summarizes existing information needs, available information agencies were contacted during this survey.

The following information needs were noted for the east side of Hood canal: organic impact on shellfish resources at Bangor, stream survey for anadromous fish abundance, sedimentation and deposition rates throughout Hood Canal, effects of dry dock operations on fisheries, baseline water quality for Hood Canal and tributaries, inventory of upland wetlands, identification of important habitats for protection, inventory of faulty on-site sewage systems along the shoreline, impacts to water resources of pesticides from agricultural and forestry lands, inventory of abandoned roads which need corrective action, measure contaminants in Hood Canal sediments, surface water, and ground water, quantification of salmonid and wildlife habitat in relation to population effects.

Ebbesmeyer, C. C. 1973. Some observations of medium scale water parcels in a fjord: Dabob Bay, Washington. Ph.D. Thesis, Oceanography Department, University of Washington.

Eells, M. 1843-1907. The history of Hood Canal, Mason County, its discovery. Pub. Info.: Hood-Canal-(Wash). Mason-County-(Wash) -- History. Everett, Wash. Puget Press, 1960.

EPA. 1992. Generic quality assurance project plan guidance for bioassessment/biomonitoring programs. Office of Research and Development. U.S. EPA, Washington, D.C.

EPA. 1986. Quality criteria for water, 1986. U.S. EPA 440/5-86-001. Office of Water Regulations and Standards. Washington, D.C.

EPA. 1993. PCSTORET-EPA Seattle. 27 p.

LOCATION:	Hood Canal, Bangor, King Spit (47° 44' 52"N, 122° 43' 49")

DATA TYPE:	Conventional, bacteriological
HABITAT:	Marine, water column
DEPTHS:	0 m, 33 m, 98 m
SAMPLE PERIOD:	Oct. 1975 to Sept. 1992
SAMPLE FREQUENCY:	5-8 times/yr before '90, monthly beginning in '90
SAMPLE DURATION:	Discrete
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	No, see PSAMP 1993
QA/QC:	Not available

COMMENTS: Computer data file without descriptive text. These data are part of the Puget Sound Ambient Monitoring Program (PSAMP). This station near Bangor (and others in Hood Canal) is located in the middle of the canal. Parameters measured: depth, water temperature, turbidity, transparency (Secchi depth), conductivity, dissolved oxygen, pH, salinity, various forms of inorganic nitrogen, phosphorus, total coliform, fecal coliform, chlorophyll, and phaeophytin.

This data series is part of a long-term monitoring program organized by EPA but conducted by Dept. of Ecology. Sampling in recent years involved CTD casts rather than water bottle samples, therefore sampling now includes more depths than shown in this file. Contact Skip Albertson, Ambient Monitoring Section of DOE (407-6676) for more information.

Fish Pro. August 1988. Miller Bay Estuary Study. Prepared for the Council of Energy Resource Tribes and the Suquamish Tribe, Port Orchard, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Yes

QA/QC: No

The objective of this study was to design a baseline water quality and ecosystem assessment program to analyze and monitor the Miller Bay estuary over time. The report includes a characterization of the watershed, characterization of oceanographic conditions, and a baseline monitoring program design. The initial year of baseline monitoring was 1988.

Appendix I contained field notes and lab reports for some of the initial water, sediment, and shellfish tissue sampling as part of this study. However, documentation was inadequate and did not allow for appropriate data analysis. Routine sampling occurred in the months of December, January, February, March, and August. Two storm events were monitored between November and February. Water and sediment samples were collected from eight stations within the bay. Shellfish samples were collected from three stations within the bay. There were two fresh water samples collected near the mouth of Grovers Creek. Several key pages were missing from the methods section regarding sampling procedures.

Samples were analyzed for the following parameters: fecal coliform (shellfish and water), total coliform, conductivity, dissolved oxygen, total suspended solids, turbidity, temperature, nitrates, phosphates, and pH. Sediment samples were collected and analyzed for metals, pesticides, herbicides, total volatile solids, total organic carbon, EPA priority pollutants, and PCBs.

There are tables which exhibit the pollutants found in the sediment samples. No other data from the initial study conducted in 1988 was provided. The report does not summarize or discuss the data collected as part of the initial sampling effort. The authors recommend further analysis of the water quality data comparing the data with Puget Sound reference concentrations and the Apparent Effect Threshold (AET) concentrations for a variety of organisms.

This report contains good information and figures on drainages, soils, land use, nonpoint sources, and flow within the Bay. No QA/QC plan was included for the initial sampling effort.

Fraser, J., and S. G. Martin. 1992. The economic and biological feasibility study of rearing chinook salmon, chum salmon and Pacific oysters at the Squaxin Island, Port Gamble and Skokomish Reservations. Small Tribes Organization of Western, Federal Way, WA.

Garitone, J. 1993. Liberty Bay Inventory. Prepared for Bremerton-Kitsap County Health District. Kitsap Conservation District, Port Orchard, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Yes

QA/QC: Not Applicable

This inventory was done in conjunction with the Liberty Bay Nonpoint Pollution Survey (Ames 1993). A land use inventory was conducted in December 1992 and January 1993 to determine areas of agricultural activity within the Liberty Bay watershed. Agricultural areas prone to water quality degradation were identified and given a priority ranking, and BMPs were recommended. A map was developed indicating farm locations and ranking and is available for use at the Kitsap Conservation District.

The results of the inventory were summarized as follows in the River Basin Team report: Of the 126 agricultural sites identified, 21 were regarded as high priority, 47 were regarded as medium priority, and 58 were considered low priority. It was recommended that if a management plan for nonpoint source pollution is implemented for the area, immediate attention be given to the high priority sites in the inventory.

The Conservation District has been contracted to work with farmers on the high priority list. Most landowners have been contacted and some BMPs have been implemented.

Grellner, K.J. 1991. Dyes Inlet and Clear Creek Water Quality Assessment project Report. Bremerton-Kitsap County Health District. Technical Appendix B to Dyes Inlet/Clear Creek Watershed Action Plan.

Grellner, Keith. April 1994. Pilot Recreational Shellfish Program, Program Summary and Data Evaluation Report. Field Supervisor, Water Quality Program, Bremerton Kitsap County Health District, Bremerton, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: Yes

QA/QC: No
A baseline monitoring program was established utilizing trained volunteers to assemble information related to conditions which can affect the safety of shellfish for human consumption. Monitoring took place from February to September 1993. The following parameters were measured or observed: water temperature, water color, water clarity, fecal coliform (water), fecal coliform (tissue), paralytic shellfish poisoning (tissue), air temperature, precipitation, wind speed, and wind direction. Nine beaches were monitored twice a month (figure included showed approximate locations). Only one of these beaches (i.e., Illa Hee S.P. along Agate Passage) is in the Liberty Bay/Miller Bay Watershed.

Results of the pilot program showed that seven of the nine beaches met at least Part 1 of the State standards, and four of the nine met both parts for the project period. Potential sources of fecal coliform bacteria for each beach were discussed.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Hood Canal Advisory Commission. 1977. Hood Canal handbook: governmental agencies & laws, research, shoreline activities, commercial & recreational fishing, recreation. An initial report to the County Commissioners of Jefferson, Kitsap and Mason Counties on the shorelines and water uses of Hood Canal and the governmental agencies concerned with them.

Hood Canal Coordinating Council. 1986. Hood Canal regional planning policy. Silverdale, WA. (3133 NW Randall Way, Silverdale, WA 1986).

Hood Canal Project Report, prepared by Political Ecology Coordinated Study Program of the Evergreen State College, in cooperation with the Bureau of Sports Fisheries and Wildlife of the U.S. Department of Interior, and partially supported by a grant from the National Science Foundation. Evergreen State College. 321 p. illus., maps.

Jones, G. 1992. Letter and excerpts of Phase II proposal for consideration under the Shellfish Initiative Protection Project sent to M. Taylor, DOE, dated June 19, 1992. Port Gamble

S'klallam Tribe.

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline, upland
DATA TYPE:	None
DEPTHS:	
SAMPLE PERIOD:	Not relevant
SAMPLE FREQUENCY:	Not relevant
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	No
QA/QC	Not available

COMMENTS: The excerpt from the Phase II proposal documents general history of nonpoint pollution in Port Gamble Bay. On-site septic failures and agricultural animals are described as the primary contributors to nonpoint pollution in the bay. Although no farm inventory had been conducted, the tribe estimated approximately 20 commercial farms >15 acres, 50 commercial operations <15 acres, and nearly 100 non-commercial farms <5 acres. A fence was reportedly installed by the community to contain animals on the Moshener Farm, the first fencing project in the watershed.

Failure of on-site wastewater disposal systems around Port Gamble Bay have been documented since the 1970s. In 1975, the US Army Corps of Engineers noted widespread septic failures. Failure of bank slopes was caused by normal spring water action, but aggravated by septic tank effluent from residences above the bluff. The COE investigation concluded the soil geology of the bluff was not suitable for septic drainfield operations. By 1992, a community sewer plan had been adopted on the Reservation and constructions was proposed to begin in 1992.

The proposal noted a tribal water quality study along the Reservation shoreline in 1986 which found fecal coliform levels of 930/100 g in shellfish and 1,100/100 mL nearshore waters. No details were provided.

Kennedy, H. K. and K. James. 1981. Cultural resources: cultural resource assessment of the Big Beef Creek research facility, near Seabeck, Kitsap County, Washington. Office of Public Archeology, Institute for Environmental Studies, University of Washington. Report submitted to the US Fish and Wildlife Service, Ecological Services Branch, Olympia, WA.

Kitsap County. 1994. Final Environmental Impact Statement for Applewood, A Planned Unit Development. Port Orchard, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: No

METHODS: Not Applicable

QA/QC: Not Applicable

This report has information on both the proposed Applewood Development and the White Horse Development. The Applewood site contains two drainages. The north portion drains into Appletree Cove via two creeks. The southern portion drains to Grovers Creek and ultimately to Miller Bay via two creeks. A water quality management plan designed to adhere to Kitsap County Drainage Ordinance No. 117 and Erosion Control Ordinance No. 14-1992 was developed and referenced in Appendix C (see below). However, no water quality analyses were cited in this EIS. The only water quality data presented is cited from the Kitsap County Ground Water Management Plan 1992, which states that the present level of nitrates in the perched zone is 0.42 mg/L. This document speculates about impacts on water quality from the proposed development.

Kitsap County. 1993. Appendices to the Draft Environmental Impact Statement for Applewood, A Planned Unit Development. Port Orchard, WA.

WQ ANALYSIS: YES

NONPOINT SOURCES IDENTIFIED: No

METHODS: No

QA/QC: No

A report was prepared for Pope Resources by Harding Lawson Associates (see Appendix C) on the existing water quality conditions at the proposed Applewood property. The four onsite creeks were monitored at locations upgradient and downgradient of the property. Samples were collected on three occasions (October 1991, January 1992, April 1992) to represent low, moderate, and high flow conditions. Water samples were analyzed for the following parameters: flow, temperature, pH, dissolved oxygen, conductivity, ammonia-nitrogen, nitrite+nitrate-nitrogen, total nitrogen, total phosphorus, soluble reactive phosphorus, turbidity, total suspended solids, fecal coliform, copper, lead, nickel, and zinc. In addition, an analysis of pesticides and herbicides was conducted on samples collected in April. A figure with approximate site locations is included.

The authors concluded that the predevelopment water quality in the on-site creeks is good and that the majority of State surface water criteria were met. However, the following parameters failed to meet the criteria: dissolved oxygen concentrations were below the standard in 14 out of 21 measurements; and lead exceeded the criteria in 11 out of 21 measurements. The creek designated as #4 exceeded both parts of the fecal coliform criteria, both at the upstream and downstream station.

Kitsap County. 1992. Draft Environmental Impact Statement for White Horse, A Planned Unit Development. Port Orchard, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: No

METHODS: Not Applicable

QA/QC: Not Applicable

This planned development is located within three separate drainage basins: the Grovers Creek drainage basin; the Appletree Cove drainage basin; and the Miller Bay/Indianola drainage basin. The water section of the EIS has a discussion of potential water quality impacts but references the Appendices to the Draft for specific water quality information.

Kitsap County. 1992. Appendices to the Draft Environmental Impact Statement for White Horse, A Planned Unit Development. Port Orchard, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: No

METHODS: Not Applicable

QA/QC: Not Applicable

Three appendices in this volume are referenced in the water section of the Draft Environmental Impact Statement. These include the following reports prepared in June 1991: Storm Drainage Analysis by Pac-Tech Engineering (Appendix C); Ground water Analysis by Pacific Ground water (Appendix D); and Wetlands Analysis by Meyers Biodynamics (Appendix F). Each of these reports was reviewed. No water quality analysis were conducted as part of the three reports listed above. Speculation as to the water quality impacts was based on information contained in other sources (e.g., Kitsap County Ground Water Management Plan 1992). As required by SEPA, potential impacts on water quality were identified.

Kitsap County. 1992. Draft Environmental Impact Statement for Woods & Meadows II, The Plat and Planned Unit Development. Port Orchard, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: No

METHODS: Not Applicable

QA/QC: Not Applicable

The proposed development site for the 119.6-acre project has a ridge running through the easterly third. This ridge separates the site into two distinct drainage Subareas: the Liberty Bay/Miller Bay Subarea and the Upper Hood Canal Subarea. Surface water in the portion of the proposed project located in the Liberty Bay/Miller Bay Subarea is said to be confined to the site. No water quality analysis was conducted as part of this EIS. Several technical reports included in the technical appendices are cited in the water section. (The appendices were not provided and therefore not reviewed.) The document speculates about the impacts on water quality resulting from the proposed development.

Kitsap County. 1992. Draft Environmental Impact Statement for George's Corner Center. Port Orchard, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: No

METHODS: Not Applicable

QA/QC: Not Applicable

The proposed project for the George's Corner Center contains no well-defined stream channel; instead the drainage consists of wetlands. The site is located in two drainage basins. One basin drains into Port Gamble. The other basin drains into Grovers Creek and eventually discharges into Miller Bay. No water quality analysis was conducted as part of this EIS. No technical reports are cited in the water section. The document speculates about the impacts on water quality resulting from the proposed development.

Kitsap County Conservation District. August 1989. Final Report on Blackjack/Clear/Dogfish Creek Watersheds. Port Orchard, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: No

QA/QC: No

This report outlines the efforts of the Kitsap County Conservation District for work done on Blackjack, Clear, and Dogfish Creeks. Water samples were collected and analyzed for fecal coliforms. Replicate samples were collected. Unfortunately, there is no write up on the methodology used to collect the samples nor is there a map provided with the sampling locations. Water quality results are provided, but there is no discussion or summary of the results.

Kitsap County Conservation District. December 1988. Final Report on Sinclair Inlet, Liberty Bay, and Eagle Harbor. Port Orchard, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: No

QA/QC: No

Water quality samples were collected from Dogfish Creek, Little Scandia Creek and the two streams in the Keyport area and analyzed for fecal coliforms. Farmlands in need of best management practices were identified. A map with sample locations was provided as well as a sample summary. However, the write-up (which began on page 49) provided no discussion of methods, date of sample collection, or QA/QC .

Results of the monitoring found several violations in State water quality standards.

Kitsap County Conservation District. September 1990. Final Report on Blackjack Creek, Clear Creek, and Liberty Bay. Port Orchard, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: No

QA/QC: No

A figure showing station locations and a column graph with fecal coliform results is all that was provided for this report. Samples were collected in June and August of 1990. No replicates were taken.

Kitsap County Ground Water Advisory Committee, Economic and Engineering Services, Inc., Hart-Crowser, Inc. and Robinson & Noble, Inc. 1991. Kitsap County Ground Water Management Plan, Vol. 1 & 2 - Background data collection and management issues. Prepared in part under a Washington State Centennial Clean Water Fund grant.

LOCATION:	County wide
DATA TYPE:	Conventional, metals, inorganics, organics,
bacteriological	
HABITAT:	Ground water
DEPTHS:	
SAMPLE PERIOD:	1970-present
SAMPLE FREQUENCY:	~3 years or more
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	
WQ STANDARDS MET:	Yes
QA/QC	Yes

COMMENTS: Volume 1 provides a summary of the approach, major findings, and recommendations of an extensive effort to characterize the ground water resources of Kitsap County. Volume 2 presents several appendices of supporting information for the study and identified ground water sub areas. These two reports, prepared under Grant No. 1, focused on the collection and analysis of data used to characterize the ground water resources of Kitsap County. Deficiencies in the database are identified and recommendations are made to address resource issues and management strategies to be faced in the future. A geographic information based system of mapping the locations of known wells was developed. The report details findings on the hydrogeology of the resource, and describes trend analysis of precipitation, water quality and ground water recharge. The relevance of this information to overall water quality is that it provides a possible sampling network to better describe and track the characteristics of ground water, and its connectivity with surface water flows.

Ground water quality was sampled from a total of 554 wells, but most of these wells have been sampled only once or twice. Wells have been sampled and given different identifiers by various agencies making comparisons difficult.

Water quality conditions since 1970 were reported to be satisfactory. With the exception of site-specific occurrences of contamination, the available data does not indicate a trend of water quality degradation. Naturally occurring levels of iron and manganese were found to occasionally exceed state and federal criteria. However, iron and manganese are an aesthetic concern rather than a health concern. No significant or chronic bacteriological problem areas were identified.

Information regarding organic concentrations within ground water was limited. No evidence of saltwater intrusion along the coast was noted.

The authors recommended additional water quality data collected routinely throughout the area for inorganic, organic, and bacteriological parameters. Stream flow and precipitation monitoring is needed.

Kocan, R.M. 1987. Port Gamble herring embryo mortality study. School of Fisheries, University of Washington, Seattle, WA.

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline
DATA TYPE:	Herring
DEPTHS:	
SAMPLE PERIOD:	March 27-31, March 31-April 3, 1987
SAMPLE FREQUENCY:	
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	see report
WQ STANDARDS MET:	Not relevant
QA/QC	Yes

COMMENTS: Excessive herring mortality had been observed in Port Gamble Bay for several years. The Dept. of Fisheries noted that the excessive mortality was not related to predation, suffocation, desiccation, or thermal stress.

Sediment and water samples taken from sites known to have high mortality. Based on field and laboratory experiments, Kocan concluded that "it appears that some type of water

soluble toxic substance is present in Port Gamble Bay which can produce either embryo mortality or physical defects in those embryos which survive to hatching. Kocan mentioned several possible sources of toxic contaminants including exudate from macrophytes.

Lewis-Redford-Engineers, Seattle. Report on analysis of ferries and Hood Canal Bridge traffic and finances, 1952 to 1975. Seattle, 1962. Prepared for State of Washington Joint Committee on Highways (under earlier form of its name: Joint Fact-Finding Committee on Highways, Streets and Bridges. Washington (State). Legislature. Joint Committee on Highways.

Lukes, J. 1990. Preliminary Port Gamble water quality data. Letter to T. Parmenter, Port Gamble Tribal Office, dated May 8, 1990. Department of Health.

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline, bay, stream
DATA TYPE:	Bacteriological, water
DEPTHS:	
SAMPLE PERIOD:	Not available
SAMPLE FREQUENCY:	
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Mostly
QA/QC	Incomplete

COMMENTS: The author stressed that these data were preliminary and were not be used out of context in classification of the bay regarding shellfish harvests.

Fecal coliform bacteria were quantified at 17 shoreline stations, two offshore stations, and four freshwater stream stations. From three to seven replicates were made at each station. Standards were met at all stations except two freshwater stream stations (Port Gamble Creek and Martha John Creek).

Madej, M. A. 1978. Response of a stream channel to an increase in sediment load. MS Thesis, Department of Geology, University of Washington, Seattle, WA.

Manson, C. 1990. Bibliography of the geology and mineral resources of Kitsap County, Washington. Washington Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA.

Martinson, R. K. 1976. Salt-water fishery resources and shoreline development in the southern Hood Canal area, Washington. U.S. Geological Survey, Reston, Va.

May, C. Effects of urbanization on small streams in the Puget Sound basin. Applied Physics Lab, University of Washington, Seattle. Pers. communication.

LOCATION:	Puget Sound, Upper Hood Canal Watershed
HABITAT:	Streams

DATA TYPE: Metals, nutrients, conventional, flow, sediment size, macroinvertebrates
SAMPLE PERIOD: April 1994 to present
SAMPLE FREQUENCY: Approx. once or twice per year
SAMPLE DURATION: Grab
ANALYTICAL METHODS: Chemical analysis by Metro
WQ STANDARDS MET: Yes
QA/QC Not available

COMMENTS: The objective of this project is to evaluate the relationship between land development and stream habitat. Streams sampled in the Upper Hood Canal Watershed are Big Beef, Little Anderson, Big Anderson, Stavis, and Seabeck. Only a 150 m reach of each stream is sampled. Aerial photos are used to broadly characterize the riparian habitat within each stream basin. Sediment transport will be measured during peak winter flows.

Chris noted that Big Anderson Creek experienced heavy logging but stream habitat appeared to be relatively good. Stavis Creek was also heavily logged but high flows and high sediment loads have adversely affected this stream. Seabeck, Little Anderson, and Big Beef creeks appeared to be in reasonable condition, although residential development near Lake Symington has caused an increase in nutrient and metal concentrations in the creek. Contamination did not exceed water quality standards according to Chris.

McMurphy, C. J. 1980. Soil survey of Kitsap County area, Washington. US Department of Agriculture, Soil Conservation Service. Report prepared in cooperation with Washington Department of Natural Resources and Washington State University.

Melvin, D.J. May 1991. Growing Area Classification Report - Liberty Bay: An Evaluation of Current Sanitary Conditions Within the Liberty Bay Commercial Shellfish Growing Area. Washington State Department of Health, Office of Shellfish Programs, Olympia, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Yes

QA/QC: Yes

Marine samples were collected monthly from Liberty Bay between September 1988 and October 1990 in accordance with National Shellfish Sanitation Program (NSSP)protocols. An intensive water quality study was conducted in Liberty Bay on October 30 and 31 and November 1, 2, 6, and 7, 1989. Good documentation of methods and QA/QC is provided. Sampling stations are shown on a figure. Samples were analyzed for fecal coliforms.

The results showed that the area did not meet the NSSP criteria for a Conditionally Approved commercial shellfish growing area due to high bacteria counts which occur randomly throughout the approved portion of the growing area and major contamination

events which occur unpredictably. The report identified five potential sources of pollutants: 1) Dogfish Creek, 2) on-site waste disposal systems along the west shoreline of Liberty Bay, 3) stormwater runoff along the east shoreline of Liberty Bay, 4) sewage from boats in the four area marinas, and 5) the Superfund Hazardous Waste site on the Keyport Naval Undersea Warfare Engineering Station.

Melvin, D. 1994. Water quality overlying shellfish beds in Hood Canal. Dept. of Health. Letter and data file to J. Stoner, Kitsap County, dated May 12, 1994.

LOCATION:	Hood Canal, Kitsap County
HABITAT:	Shoreline
DATA TYPE:	Bacteriological, physical
DEPTHS:	Surface
SAMPLE PERIOD:	Jan 1988 to present
SAMPLE FREQUENCY:	six times per year
SAMPLE DURATION:	grab
ANALYTICAL METHODS:	MPN/100 mL, APC five tube fermentation method
WQ STANDARDS MET:	Mostly
QA/QC	Not available

COMMENTS: The Department of Health monitors water quality overlying commercial and, to a lesser extent, recreational shellfish beds in Hood Canal. Sampling is generally conducted when their is enough water over the beds to carry a boat. This water quality monitoring plus shoreline surveys are used by DOH to classify shellfish beds.

Within Kitsap County adjacent to Hood Canal, DOH maintains five sampling areas (Hood Canal #1, 2, 4, 5, and Port Gamble), of which each area includes 3-10 stations (30 total). Stations are located over known shellfish beds and areas suspected to have contamination. Most stations were sampled 1-2 times per year prior to 1992. Beginning in 1992, stations have been sampled six times per year. Several replicate samples are taken at each station corresponding to ebbing and flooding tides.

The data set includes the following information: sample area, station, date, time, fecal coliform MPN, tide phase, surface water temperature, surface salinity, time of high and low tides, height of high and low tides. Detailed maps that show station locations are available.

Fecal coliform bacteria have been measured since 1988. Highest fecal coliform counts were found in Port Gamble Bay where 1.7% of the samples (591) since 1988 exceeded 43 FC/100 mL. Only seven of 827 samples (0.8%) exceeded 43 FC/100 mL outside of Port Gamble.

Meyers, P., Suquamish Tribe, and J. Michaud, Envirovision. May 1994. Miller Bay Public Outreach and Water Quality Monitoring. Prepared for the Suquamish Tribe.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Yes

QA/QC: Yes

The purpose of the project was to provide communication with watershed residents about water quality issues, to collect baseline data to characterize Miller Bay, and to identify water quality problems. A two year monitoring plan was established from April 1991 to March 1993 with six locations along Grovers Creek. Methods and quality assurance plan are clearly documented. Figures are provided which show all monitoring site locations. All laboratory analysis was conducted by the Metro lab.

Water quality parameters measured were as follows: ammonia, orthophosphate, total phosphate, nitrate+nitrite-nitrogen, total suspended solids, fecal coliforms, enterococcus, turbidity, pH, conductivity, and dissolved oxygen. The following additional parameters were measured during storm events and for special analysis: metals by ICP, volatile organics, and selected organophosphorus pesticides. Additional data collected by volunteers or the project coordinator included: total settleable solids, flow, air temperature, water temperature, and precipitation.

The second year monitoring included sediment analysis for the following parameters: chlorinated pesticides, organophosphorus pesticides, metals, total organic carbon, percent solids, TPH, total coliform, fecal coliform, and grain size. Three sites were chosen for sediment monitoring in Grovers Creek and one in Miller Bay. In addition, shellfish samples were collected from two stations in Miller Bay. The bivalve tissue was analyzed for metals, lipids, and organic chemicals.

Much of the summary of results was written in the River Basin Team report (see item 17). The study showed that three of the stations along Grovers Creek exceeded the bacteria standard. The summer geometric mean bacteria concentrations were much higher than the winter average. Five stations had measured pH values below the standard. This may have been due to an improperly calibrated or poorly functioning pH meter.

A macroinvertebrate survey was conducted monthly in 1992 to 1993, utilizing citizen volunteers. Four sites were chosen in Grover's Creek—downstream of the hatchery; downstream of water quality station MAIN3 on Chris Lane; upstream of TRIB1 station; downstream of TRIB3 station. No discussion of results is provided.

Downstream total phosphorus concentrations were fairly high. The majority of the increase in total phosphorus occured between the stations at river mile 2.0 and river mile 0.5, suggesting there may be a nutrient source in this reach of the stream.

Storm event sampling for bacteria concentrations revealed river mile 2.0 had by far the greatest concentration of bacteria on two of the four sampling dates and a station on a tributary (river mile 2.05) had high concentrations on one of the dates. These stations had counts between 600 and 950 colonies/100 ml compared to below 200 colonies/100 ml at the rest of the stations.

The authors concluded that in general, Grovers Creek appears to be in very good condition in terms of water quality. Poor agricultural practices are likely the cause of the elevated bacteria concentrations.

Nosho, T. Y. 1971. The setting and growth of the Manila clam, Venerupis japonica (Deshayes), in Hood Canal, Washington.

O'Neill, S. 1993. Puget Sound Ambient Monitoring Program: progress report of the 1991-1992 fish monitoring task. Draft report. Marine Fish and Shellfish Program. Washington Department of Fish and Wildlife. Olympia, WA.

LOCATION:	Puget Sound, Hood Canal, Triton Cove
HABITAT:	Marine waters
DATA TYPE:	Fish, chemical
DEPTHS:	
SAMPLE PERIOD:	1991-1992
SAMPLE FREQUENCY:	Once per year
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	See report
WQ STANDARDS MET:	Yes
QA/QC:	Yes

COMMENTS: Trace elements (lead, copper, arsenic, and mercury) and trace organics (4,4-DDE, Bis(2-ethylhexyl phthalate)) were measured in rockfish muscle tissue from Triton Cove immediately west of Kitsap County and four other areas of Puget Sound (only copper rockfish sampled at Day Island). Samples consisted of six samples, each of which represented a composite of five rockfish. Arsenic in quillback rockfish from Triton Cove was high compared to other areas of Puget Sound but still below levels known to pose a heath threat to human consumers. All elements and organics compounds were detected in rockfish, except for lead. Concentrations were below levels known to pose a heath threat to human consumers.

Comparison of trace metals (ppm, wet weight) and organics (ppb, wet weight) in quillback rockfish muscle tissue from Triton Cove and other areas of Puget Sound. ND = not detected.

O'Neill, S, J.E. West, and S. Quinnell. 1994. Puget Sound Ambient Monitoring Program: progress report of the 1992-1993 fish monitoring task. Draft progress report. Marine Fish and Shellfish Program. Washington Department of Fish and Wildlife. Olympia, WA. In preparation.

LOCATION:	Puget Sound, Hood Canal, Triton Cove
HABITAT:	Marine waters
DATA TYPE:	Fish, chemical
DEPTHS:	
SAMPLE PERIOD:	1992-1993
SAMPLE FREQUENCY:	Once per year

SAMPLE DURATION: Grab
ANALYTICAL METHODS: See report
WQ STANDARDS MET: Yes
QA/QC: Yes

COMMENTS: Trace elements (lead, copper, arsenic, and mercury) and trace organics (PP-DDE, PCB-1260, Dieldrin) were measured in rockfish muscle tissue from Triton Cove immediately west of Kitsap County. Samples usually consisted of six samples each of which represented a composite of five rockfish. However in 1992, only two quillback and one copper rockfish composite samples could be obtained. Arsenic in quillback rockfish from Triton Cove was high compared to other areas of Puget Sound but still below levels known to pose a heath threat to human consumers. Lead, PP-DDE, and Dieldrin were not detected in rockfish at Triton Cove. Concentrations of other elements and organics were below levels known to pose a heath threat to human consumers.

Comparison of trace metals (ppm, wet weight) and organics (ppb, wet wt) in quillback rockfish muscle tissue from Triton Cove (Hood Canal) and other areas of Puget Sound. ND = not detected. Values shown on second line at each station are for copper rockfish. See report for more details.

Orsborn, J. F. 1992. Pilot study of the physical conditions of fisheries environments in river basins on the Olympic Peninsula : Based on an investigation of the South Fork Skokomish River Basin within the Olympic National Forest. Prepared for USDA Forest Service, Olympic National Forest, and the Hood Canal Ranger District.

Nelson, K.S. 1985?. Trident XV biological survey procedures manual. No agency cited.

LOCATION: Bangor
HABITAT: Nearshore marine waters
DATA TYPE: Metals, fish, shellfish
DEPTHS:
SAMPLE PERIOD: 1985
SAMPLE FREQUENCY: Variable
SAMPLE DURATION: Grab
ANALYTICAL METHODS: None
WQ STANDARDS MET: Not relevant
QA/QC No

COMMENTS: This report describes procedures used to collect data on marine fish, intertidal communities, and heavy metals in sediments and organisms on the Bangor submarine base. This manual was apparently developed by subase Bangor personnel, who took over responsibilities for data collection from the Naval Ocean Systems Center in 1985. This manual represents the 15th biosurvey of the Trident Biological Survey.

Maps of the sampling areas are provided. Some data are shown in tables but no written presentation of the results is given.

Nysewander, D. 1994. Annual report of marine bird and mammal monitoring in Puget Sound. Washington Department of Fisheries. In preparation.

LOCATION:	Puget Sound, Hood Canal
HABITAT:	Marine water
DATA TYPE:	Marine birds, mammals
DEPTHS:	
SAMPLE PERIOD:	1992-1993
SAMPLE FREQUENCY:	
SAMPLE DURATION:	
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	Not relevant
QA/QC	Not available

COMMENTS: This report summarizes bird densities by species in Hood Canal. See PSAMP (1993) for graphs. (waiting for reports)

Office of Financial Management. 1993. 1993 Data Book. Washington State Office of Financial Management, Olympia, WA.

LOCATION:	Washington State, Kitsap County
HABITAT:	Terrestrial
DATA TYPE:	Socio-economic
DEPTHS:	Not relevant
SAMPLE PERIOD:	1890-1993
SAMPLE FREQUENCY:	Annual
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	Not relevant
QA/QC	Not available

COMMENTS: This annual report documents economic and population status by county, including Kitsap County. Employment and wages by industry type are provided. In 1992, 43% of employees worked in the government, 4.6% in construction, and 0.9% in agriculture, forestry and fishing. Decadal trends in population are given. The population in Kitsap County has grown from 6,767 in 1900, to 75,724 in 1950, to 101,732 in 1970, and to 189,731 in 1990. The exponential growth of the population is an important factor in the water quality of the Upper Hood Canal watershed.

Palsson, W. 1994. Marine fishes of Hood Canal. Marine fish biologist, Washington Department of Fish and Wildlife. Olympia, WA. Personal communication.

LOCATION:	Hood Canal
HABITAT:	Marine waters
DATA TYPE:	Fishes
DEPTHS:	
SAMPLE PERIOD:	1970-1988

SAMPLE FREQUENCY: Monthly
SAMPLE DURATION: Not relevant
ANALYTICAL METHODS: Not relevant
WQ STANDARDS MET: Not relevant
QA/QC Not available

COMMENTS: Palsson described the monthly commercial (1970-1988) and recreational (1970-1985, boat-based catches only) catch and effort information available through the department. Commonly harvested species include flatfishes, Pacific cod, pollock, surf perches, rockfish, sculpins, ling cod, and dogfish. An artificial reef is located near Misery Point where rockfish and ling cod are targeted by recreational fishermen. Significant shore-based fishing occurs near the Hood Canal bridge.

Three biennial trawl surveys have been conducted for soft-bottom fishes (1987, 1989, 1991). Data from only the 1987 survey are available in report form.

Palsson, WA 1988. Bottomfish catch and effort statistics from boat-based recreational fisheries in Puget Sound, 1970-1985. Washington Department of Fisheries. Olympia, WA.

LOCATION: Puget Sound, Hood Canal
HABITAT: Marine waters
DATA TYPE: Fish
DEPTHS:
SAMPLE PERIOD: 1970-1985
SAMPLE FREQUENCY: Monthly
SAMPLE DURATION: Not relevant
ANALYTICAL METHODS: Not relevant
WQ STANDARDS MET: Not relevant
QA/QC Not available

COMMENTS: This report provides sport catch and effort statistics for bottomfish in Hood Canal.

Parametrix. 1994. Hansville Landfill: ground water, surface water, and landfill gas monitoring program. 1993 annual report. Prepared for Kitsap County Sanitary Landfill Inc., Bremerton, WA.

LOCATION: Hansville, Middle Creek
HABITAT: Ground water, surface water
DATA TYPE: Volatile organic compounds, metals, conventional,
fecal coliform
DEPTHS: NA
SAMPLE PERIOD: 1993
SAMPLE FREQUENCY: Quarterly, monthly
SAMPLE DURATION: Grab
ANALYTICAL METHODS: EPA method 8260, see report

WQ STANDARDS MET:	No
QA/QC	Yes

COMMENTS: This report on monitoring of the Hansville Landfill was prepared in accordance with the Hansville Landfill Closure Plan. State carcinogen levels were exceeded for vinyl chloride, 1,1-dichlorethane, and dissolved arsenic. State secondary levels were exceeded for specific conductivity, pH, chloride, manganese, and iron. State surface water standards were exceeded for dissolved oxygen and turbidity. Other volatile organic compounds that were detected include trichlorofluoromethane and carbon disulfide, although these chemicals were below carcinogen levels. Ground water flow was west-southwest to southwest.

Patrick, G. 1991. Potential contamination of Port Gamble Bay shellfish by the Hansville Landfill project. Response to letter of concern by C. Weller (PNPTC). Dept. of Health, dated September 24, 1991.

LOCATION:	Port Gamble S'kallam Indian Reservation
HABITAT:	Shoreline, Creek
DATA TYPE:	Metals, shellfish
DEPTHS:	
SAMPLE PERIOD:	Not available
SAMPLE FREQUENCY:	Once
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Yes
QA/QC	Incomplete

COMMENTS: The tribe was concerned about leachates from the Hansville landfill, which is located in the Middle Creek drainage, reaching shellfish beds in Port Gamble Bay. C. Weller noted that the maximum possible consumption of clams by an individual tribal member was ~24 lbs per year.

Arsenic, barium, cadmium, chromium, lead, and zinc were measured in two shellfish samples. Daily dose values were compared with EPA's reference dose (RFD) for each metal. Based on the assumed consumption rate by tribal members, the concentrations of these metals would not pose a health concern. The weakest part of this analysis was the lack of documentation for clam consumption by tribal members.

Patrick, G. 1994. Unpublished data on trace metal contamination in shellfish near Port Gamble and other areas of Puget Sound. Washington Department of Health, pers. comm. (206-753-1930).

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline
DATA TYPE:	Metals, shellfish
DEPTHS:	
SAMPLE PERIOD:	1992, 1993

SAMPLE FREQUENCY: Once
SAMPLE DURATION: Grab
ANALYTICAL METHODS: Not available
WQ STANDARDS MET: Yes
QA/QC Not available

COMMENTS: Three samples each containing a composite of 30 littleneck clams were taken from Port Gamble Bay (1992) and Misery Pt near Seabeck (1993) and 20 other areas of Puget Sound in 1992 and/or 1993 as part of the PSAMP program. These samples were analyzed for mercury, arsenic, copper, zinc, cadmium, and lead. Arsenic and cadmium levels were above average at Misery Pt compared to other areas of Puget Sound in 1993. Zinc levels were above average in Port Gamble Bay. Throughout Puget Sound trace metal concentrations tended to be higher in 1993 than 1992 except for mercury. A reports should be available in late 1994.

Comparison of trace metals in littleneck clams (ppm) from Hood Canal sites and selected other areas.

As	Cd	Cu	Pb	Hg	Zn	
Port Gamble ('92)	1.5	0.22	1.2	0.08	0.01‘	15.0
Misery Pt ('93)	2.3	0.37	0.86	0.04	0.01	13.0
Eagle Harbor ('93)	1.9	0.12	3.17	0.65	0.08	14.67
Liberty Bay ('93)	2.43	0.19	1.23	0.15	0.02(	13.33
Dyes Inlet ('93)	2.13	0.18	0.99	0.11	0.02	14.33
Narrows Pt ('92)	1.83	0.21	1.7	0.08	0.01	13.0

Pentilla, D. 1986. Analysis of Port Gamble herring spawn mortalities. Note to S. Ralph, Point No Point Treaty Council, dated October 15, 1986.

LOCATION: Port Gamble Bay
HABITAT: Shoreline
DATA TYPE: Herring
DEPTHS:
SAMPLE PERIOD: February-April, 1980 to 1986
SAMPLE FREQUENCY: Not available
SAMPLE DURATION: Not available

ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	See Kocan
QA/QC	Not available

COMMENTS: The note and an attached table describe the excessive mortality of herring spawn in the Port Gamble Bay area. Observed dead eggs ranged from 20% to 100% compared to typical dead egg percentage of ~5% in Puget Sound.

Plews, G. 1989. Shellfish relay from Dosewallips to Port Gamble Bay. Dept. Social and Health Services. Letter from Plews (DSHS) to L. Veneroso (PNPTC) dated 6 September, 1989.

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline, Offshore
DATA TYPE:	Bacteriological, shellfish
DEPTHS:	
SAMPLE PERIOD:	July 1989 to August 1989
SAMPLE FREQUENCY:	~twice per month
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	No
QA/QC	Incomplete

COMMENTS: The Port Gamble Tribe harvested clams from Brinnon, then transferred them to Port Gamble Bay in order to decontaminate the shellfish of fecal coliforms. Shellfish from Brinnon were contaminated (up to 54,000 FC/100 g). Little neck clams from Port Gamble Bay were below the national standard of 230 FC/100 g in July.

The letter notes that fecal coliform levels in transferred clams declined significantly but that they had not reached ambient levels. In late August, both Manila and little neck clams sampled from Port Gamble exceeded the national standard. In the middle of the testing program, a meeting between the Tribe and DOH led to the conclusion that the methodology may have been inadequate. Details were not given.

After subsequent testing, Plews noted that Port Gamble Bay may not be approved by DOH as a relay site. A final decision on the relay of the Brinnon shellfish would be made at a later date.

Plews, G. 1988. Shellfish relay from Dosewallips to Port Gamble Bay. Dept. Social and Health Services. Letter from Plews to R. Harder (PNPTC) dated 19 September, 1988.

LOCATION:	Port Gamble Bay
HABITAT:	Shoreline, Offshore
DATA TYPE:	Bacteriological, shellfish
DEPTHS:	
SAMPLE PERIOD:	Aug. 1 to Sept. 12, 1989
SAMPLE FREQUENCY:	~twice per month
SAMPLE DURATION:	Grab

ANALYTICAL METHODS: Not available
WQ STANDARDS MET: No
QA/QC Not available

COMMENTS: Contaminated clams were transferred to Port Gamble Bay in order to purge the clams of fecal coliforms. Fecal coliforms declined to acceptable levels after seven days, increased to unacceptable levels after 14-21 days, then again decreased after 42 days. Plews noted that this trend indicated that a source of contamination exists at the Port Gamble relay site. Further evaluation of the relay site was suggested.

Poulsbo, City of. 1993. Stormwater Fecal Coliform Test Results Data for Poulsbo, Washington. City of Poulsbo Engineering Department, Poulsbo, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: None Provided

QA/QC: None Provided

A stormwater quality study was conducted by the City of Poulsbo to determine fecal coliform concentrations in the city stormwater outfalls to Liberty Bay. Stormwater was collected from all city outfalls on various dates from January through March 1993. This study provided preliminary information on the fecal coliform concentrations in the city storm drain system during a period of little rain (i.e., less than one quarter inch of precipitation in the Poulsbo area).

Sampling results were placed into three categories: below 100 colonies/100 ml, between 100 and 500 colonies/100 ml, and above 500 colonies/100 ml. These results are exhibited on the City Comprehensive Storm Drain maps (scale 1" = 200'). No write-up of methods, QA/QC, or discussion of the results was provided. Samples containing greater the 500 colonies/100 ml were present in at least one sample at the following locations (according to the River Basin Team Report):

- o The Jensen Way NE drainage system at two locations: the intersection with NE Iverson Street and the intersection with Anderson Parkway
- o The Third Ave. NE system at three locations: the intersection with Moe Street; approximately 300 feet south of Moe Street where the Third Ave. NE system turns west through an alley; and where it crosses Front Street NE
- o The Sixth Ave NE system where it crosses Front Fjord Drive NE
- o The drainage system running through the Poulsbo High School property at two locations: NE Mesford Street and NE Hostmark.

Note: samples were evaluated using Class A state water quality standards. Liberty Bay is considered Class AA waters.

It was concluded that additional storm sampling needs to be conducted during periods of heavy rainfall to better characterize bacterial contributions from within the City. The most likely causes of high fecal coliform concentrations (in excess of 1,500 colonies/100 ml) are cross-connections between the sanitary sewer system and storm drainage system, and broken sewer lateral lines that leak into storm drain lines.

PSAMP. 1993. Fourth annual report of the Puget Sound Ambient Monitoring Program. Puget Sound Water Quality Authority. Olympia, WA. 89 p.

LOCATION:	Puget Sound, Hood Canal
HABITAT:	Marine water, sediments, freshwater
DATA TYPE:	Chemical, bacteriological, fish, shellfish
DEPTHS:	Various
SAMPLE PERIOD:	1989-1992
SAMPLE FREQUENCY:	Variable
SAMPLE DURATION:	Various
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Mostly
QA/QC	Yes

COMMENTS: This annual report summarizes chemical contamination of sediments and organisms, fecal contamination of marine waters, freshwaters, and shellfish, conventional water quality (nutrient enrichment, low dissolved oxygen, excessive acidity or alkalinity, and high water temperatures), threats to nearshore habitat, and biological resource abundance in Puget Sound. This document highlights those areas that have contamination problems and provides good references to more detailed data sources.

Sediments: Stations in Hood Canal occur in North Hood Canal (), outer Dabob Bay, Tekiu Point, South Hood Canal, and outer Lynch Cove at the end of Hood Canal. Elevated metal concentrations (cadmium) were found near Lynch Cove. In 1992, DOE classified sediments at Tekiu Point and South Hood Canal as toxic (25-26% mortality) to benthic organisms. Sediments at the North Hood Canal station were classified as marginally toxic (22% mortality). The reliability of these toxicity tests is under review.

Water column: The DOE monitored fecal coliform bacteria (monthly, one sample per station) in Hood Canal near Bangor and Sister's Point (southern Hood Canal). The Skokomish River is also monitored near its confluence with southern Hood Canal. Contamination was not reported in these areas.

Conventional water quality: Eutrophication and poor water circulation is described as a problem in Hood Canal, especially at the southern end south of Kitsap County. North Hood Canal near Bangor experienced oxygen violations (<7 mg/l) during 3%, 16%, and

45% of the sample periods at 0 m, 10 m, and 30 m during 1990-1992. Southern Hood Canal has lower oxygen levels.

Benthos: Benthic species abundance at Lynch Cove and Tekiu Point in 1992 were low compared to other areas of Puget Sound. Lynch Cove is known to suffer from low oxygen levels and contamination from the sewage discharge.

Fish: The Dept. of Fisheries reported that Quillback rockfish at Triton Cove contained arsenic levels that were higher than other areas, but still below levels of concern for humans. A number of salmon stocks in Hood Canal were described as depressed, whereas condition of other stocks was unknown.

Shellfish: The DOH measured shellfish for metal and organic compounds in Port Gamble Bay in 1990-1992. Contaminants in shellfish in Port Gamble Bay were below levels in shellfish from other areas and posed no heath threat. DOH monitoring of fecal coliform bacteria in shellfish (1989-1992) at Port Gamble Bay found that 20% of the shellfish contained moderate levels of bacteria (31-230 MPN) and 20% contained high levels (>230 MPN). Shellfish at Dosewallips State Park (immediately west of Kitsap County) contained high bacteria counts as a result of harbor seals. Fencing is now used to minimize seal haulouts in this area. Approximately 1,800 harbor seals inhabit Hood Canal. Dosewallips State Park has a high clam density compared to other sampled state parks.

Birds: Densities of various bird types within Hood Canal and other areas of Puget Sound are shown graphically (summer 1992, winter 1992-1993).

Puget Sound Cooperative River Basin Team. 1993. Upper Hood Canal Watershed, Kitsap County, Washington. Prepared for the Upper Hood Canal Watershed Management Committee. 190 p. + appendices.

LOCATION:	Upper Hood Canal Watershed, Kitsap County
HABITAT:	Upland, streams, shoreline, marine water
DATA TYPE:	Chemical, bacteriological, fish, shellfish, land use,
soils, geology	
DEPTHS:	
SAMPLE PERIOD:	~1973-1993
SAMPLE FREQUENCY:	Variable
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	Mostly
QA/QC	Yes (not available for reviewed reports)

COMMENTS: This comprehensive and well-written document summarizes available information on the Upper Hood Canal Watershed, including land-use and cover, socio-economic conditions, population and housing, geology, soils, surface and ground water hydrology, water quality, stream corridors, wetlands, fish and shellfish resources, wildlife, recreation, and various sources of nonpoint source pollution. Descriptions of nonpoint source pollution include pollution from forestry and agricultural practices, residences, solid waste disposal, Bangor Naval complex, Port Gamble Mill, Marinas, and net pens. Much of this information was entered into a geographic information system (GIS). Maps depicting this information are provided in the report.

The report contains substantial information. Newly collected data included an inventory of farms, which can contribute significantly to nonpoint pollution. Only 3% of the land was used for agricultural purposes. A total of 204 farms were identified, of which 62% were <6 acres and 6% were >20 acres. Animal density was highest on farms <6 acres (1.6 animals per acre). Approximately 50% of the farms occurred in the northern 30% of the watershed. Approximately 13% of the farms had uncontrolled access to streams, 24% allowed livestock access to wetlands, and 14% included streams corridors having poor conditions.

A soil survey indicated that all of the watershed consists of soils having severe limitations for on-site sewage disposal. The total incidence of on-site sewage failure in the watershed is unknown.

Most residential developments do not have adequate stormwater management facilities. Undocumented erosion occurs along the 180 miles of unimproved gravel and dirt roads.

The Hansville Sanitary Landfill operated from 1974 to 1989. Ground water monitoring from wells indicate the upper aquifer is contaminated with vinyl chloride and certain metals. Concentrations of vinyl chloride have declined since the installation of a permanent cap. Sampling of domestic wells in 1988 and 1991 revealed water quality in the lower aquifer was within acceptable limits. Additional sampling of surface water, ground water, and sediments was recommended by the Dept. of Ecology. The River Basin Team found several illegal garbage dumps that may contain toxic materials.

Twenty-two hazardous waste sites have been identified on the Bangor Naval Complex. Studies and cleanup activities are ongoing.

The Port Gamble Sawmill has made efforts to reduce pollution. The report describes additional measures that could be undertaken to reduce nonpoint source pollution.

Contamination from boats and marinas has not been examined. A NPDES permit is required for the coho salmon net pen facility in Port Gamble Bay but data on net pen effects on water quality were not described.

Puget Sound Cooperative River Basin Team. June 1994. Watershed Characterization for Liberty Bay/Miller Bay Watershed Area. Prepared for Kitsap County.

WQ ANALYSIS: None

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Not Applicable

QA/QC: Not Applicable

As part of the Watershed Action Plan development process, the River Basin Team provides the Watershed Management Committee with a characterization of the watershed, a description of beneficial uses of water and nonpoint sources of pollution (actual and potential) in the watershed, and an evaluation of some of the regulations or policies currently used to control nonpoint pollution in the watershed. This report does a good job of summarizing most of the available information. Completed and ongoing water quality studies are summarized and the conclusions reported. No additional water quality samples are collected as part of this study. Nonpoint sources of pollution were identified by windshield surveys and analysis of aerial photographs. GIS-generated maps included show base map, land cover, land use, subwatersheds, beneficial uses and stream types, generalized geology, general soils, soil limitation for septic tank absorption fields, wetlands and hydric soils, farm locations, and forest ownership.

Quinnell, S. and C. Schmitt. 1991. Abundance of Puget Sound demersal fishes: 1987 research trawl survey results. Progress Report No. 286. Washington Department of Fisheries. Olympia, WA.

LOCATION:	Puget Sound, Hood Canal.
HABITAT:	Marine waters
DATA TYPE:	Fish
DEPTHS:	
SAMPLE PERIOD:	1987
SAMPLE FREQUENCY:	Not relevant
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	Not relevant
QA/QC	Not available

COMMENTS: This report provides abundance estimates for groundfish in Hood Canal during 1987. Additional surveys were conducted in 1989 and 1991 but reports describing these data have not been prepared.

Ribic, C., and G. Swartzman. 1990. A proposal for the design and analysis of SUBASE Bangor heavy metal monitoring data. Final report. University of Washington, Center for Quantitative Science, Seattle, WA.

LOCATION:	Bangor
HABITAT:	Not relevant
DATA TYPE:	
SAMPLE PERIOD:	Not relevant
SAMPLE FREQUENCY:	Not relevant
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Statistical analyses
WQ STANDARDS MET:	Not relevant
QA/QC	Reasonable

COMMENTS: This report provides documentation for the training of Navy personnel in computers and statistical software for the purpose of analyzing metal data on the Bangor Submarine Base. The report does not contain water quality data and is of little value to the Initial Water Quality Assessment.

Roberts, R. W. 1979. Surface sediments [map], Department of Oceanography, University of Washington, Seattle.

Ross, H.S. 1994. Aquatic Habitat Restoration: A Technical Approach to Site Identification. Master's thesis submitted to the School of Marine Affairs, University of Washington, Seattle, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: No

METHODS: Not Applicable

QA/QC: Not Applicable

In this thesis the author presents a planning process that includes human values and natural characteristics for the purpose of identifying restoration sites in an estuarine environment. The Liberty Bay watershed is the study area chosen for the project. An ecological model is presented to evaluate estuarine systems, and political and economic feasibility. No water quality analysis was done.

Salo, E. O., et al. 1979. Trident dredging study : the effects of dredging at the U.S. Naval Submarine Base at Bangor on outmigrating juvenile chum salmon, Oncorhynchus keta, in Hood Canal, Washington: final report, February to July 1977. Fisheries Research Institute, College of Fisheries, University of Washington.

Salo, E. O. 1977. A preliminary study of the effects of pier lighting on fishes : final report, July 1976 to September 1976. Fisheries Research Institute, College of Fisheries, University of Washington, FRI-UW-7712. Sponsored by the U.S. Department of the Navy.

Salo, E. O. 1980. The effects of construction of naval facilities on the outmigration of juvenile salmonids from Hood Canal, Washington : final report, March 1, 1975 through July 31, 1979. Prepared for United States Navy, OICC Trident . Fisheries Research Institute, College of Fisheries, University of Washington. FRI-UW-8006.

SASSI. 1993. 1992 Washington State salmon and steelhead stock inventory. Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. Olympia, WA. 212 p.

LOCATION:	Puget Sound, Hood Canal
HABITAT:	Streams
DATA TYPE:	Salmon
DEPTHS:	

SAMPLE PERIOD: 1968-1991
SAMPLE FREQUENCY: Annual
SAMPLE DURATION: Not relevant
ANALYTICAL METHODS: Not relevant
WQ STANDARDS MET: Not relevant
QA/QC Incomplete

COMMENTS: This report review the status of salmon stocks in Puget Sound.

Coho stocks in creeks from Port Gamble to Anderson Creek are considered depressed due to a short-term severe decline in spawning escarpments, as evidenced by trap counts at Big Beef Creek. Escapements to most creek in Kitsap County are generally not documented.

Chum salmon returning during late November through December are considered healthy in the Kitsap County portion of Hood Canal. Early-arriving chum salmon are considered depressed. Escapements in this region have ranged from 500 to 8,000 fish.

Other salmon species are less abundant in Kitsap County creeks and their status was not described.

Sceva, J. E. 1954. Geology and ground water resources of Kitsap County, Washington. Prepared in cooperation with the State of Washington Department of Conservation and Development, Water Resources Division, and the U.S. Geological Survey, Water Resources Division, Ground Water Branch.

Schmitt, C., S. Quinnell, M. Rickey, and M. Stanley. 1991. Groundfish statistics from commercial fisheries in Puget Sound, 1970-1988. Progress Report No. 25. Washington Department of Fisheries. Olympia, WA.

LOCATION: Puget Sound, Hood Canal
HABITAT: Marine waters
DATA TYPE: Fish
DEPTHS:
SAMPLE PERIOD: 1970-1988
SAMPLE FREQUENCY: Monthly
SAMPLE DURATION: Not relevant
ANALYTICAL METHODS: Not relevant
WQ STANDARDS MET: Not relevant
QA/QC Not available

COMMENTS: This report provides catch statistics by month and gear type for groundfish in Hood Canal.

Schreiner, J. U. 1977. Salmonid outmigration studies in Hood Canal, Washington. MS Thesis , College of Fisheries, University of Washington, Seattle, WA.

Schreiner, J. U. et al. 1977. Salmonid outmigration studies in Hood Canal: final report, phase II. College of Fisheries, University of Washington, Fisheries Research Institute.

Science Applications International Corp. 1991. Site hazard assessment report, Hansville Landfill, Kitsap County, WA. Report prepared for the Washington Department of Ecology, Olympia, WA.

Seabloom, R.W., G. Plews, and F. Cox. 1989. The Effect of Sewage Discharges from Pleasure Craft on Puget Sound Waters and Shellfish Quality. Washington State Department of Health, Shellfish Section. Olympia, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Yes

QA/QC: None provided

In 1987 the State Department of Social and Health Services Shellfish Section, carried out an intensive study of five boating areas to determine the extent of contamination attributable to waste discharges from pleasure craft. Liberty Bay was one of the study sites. Eleven sampling stations were situated in and around the three marinas, and two sampling stations were located in the middle of the bay, approximately a quarter-mile offshore. Water temperature and salinity were measured in the field. Water samples were analyzed for fecal coliform bacteria and two enteric pathogens (i.e., salmonella and yersinia). Sediment and shellfish samples were analyzed for total and fecal coliform organisms.

The authors concluded that the water quality in Liberty Bay is greatly influenced by many nonpoint pollutant sources and thus contamination from boats could not be distinguished. Water quality in the bay failed to meet the State water quality standards on three days of the five-day boating weekend study. In addition, shellfish collected in and around the marinas were found to be contaminated. No evidence of pathogenic salmonella or yersinia bacteria was noted.

Shi, N. C. 1978. A study of the nearshore current observations in Hood Canal, Washington. MS Thesis , University of Washington, Seattle, Washington.

Simenstad, C. A. and W. J. Kinney. 1978. Trophic relationships of outmigrating chum salmon in Hood Canal, Washington, 1977 . University of Washington, Fisheries Research Institute, FRI-UW-7810. Prepared for Washington State Department of Fisheries.

Simenstad, C. A., et al. 1980. Prey community structure and trophic ecology of outmigrating juvenile chum and pink salmon in Hood Canal, Washington: a synthesis of three years' studies, 1977-1979. Fisheries Research Institute, College of Fisheries, University of Washington, Seattle.

Simenstad, C.A., J.R. Cordell, and L. Weitkamp. 1989. Epibenthos Assemblages of Cowing Creek and Two Reference Sites in Miller Bay, Washington, Relative to Proposed Adult

Chum Salmon Saltwater Recapture Facility. Prepared for the Suquamish Tribe by the University of Washington, Seattle, WA.

WQ ANALYSIS: Yes (benthic invertebrate)

NONPOINT SOURCES IDENTIFIED: No

METHODS: Yes

QA/QC: No

To assess the potential impact of the construction of a dam/fish passage facility, the authors sampled epibenthic organisms at Cowing Creek and two other reference sites in Miller Bay (at the mouth of Grovers Creek and at the mouth of an unnamed tributary). Samples were collected four times from December 1988 through May 1989. The composition and standing stock of the epibenthos in the intertidal area were documented at each of these sites.

Simmons, D. M. 1987. Directory of environmental education resources for the Hood Canal Region. Hood Canal Coordinating Council.

Smith, C. Personal communication March 9, 1995 (unpublished data sent to Debra Bouchard, KCM, Inc.). Chinook salmon escapement estimate in Kitsap County. Washington Department of Fish and Wildlife, Olympia, WA.

Struck, P. 1987. An evaluation of nonpoint bacterial contamination in Hood Canal, Kitsap County. Bremerton-Kitsap County Health Department. 52 p.

LOCATION:	Hood Canal and creeks, Kitsap County
HABITAT:	Shoreline, creeks
DATA TYPE:	Bacteriological, shellfish, water, septic systems
SAMPLE PERIOD:	Aug. 1986 to Feb. 1987
SAMPLE FREQUENCY:	Irregular
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	Not available
WQ STANDARDS MET:	No
QA/QC	Incomplete

COMMENTS: Good survey of fecal coliform contamination in marine waters and shellfish in Hood Canal extending from Holly to Driftwood Key. Samples taken at various tide and rainfall conditions, therefore summary does not reflect adverse pollution conditions (APC).

Twenty-four percent of marine water monitoring stations (7 of 29) and 31% of shellfish monitoring stations (5 of 16) in the main body of Hood Canal failed to comply with the AA standard for fecal coliform (FC) concentration. Port Gamble, which is classified as A water, had higher station violation rates of 73% (8 of 11) for water samples and 66% (4 of

6) for shellfish stations. Highest levels of fecal coliforms were observed in sheltered bays and coves, e.g., Holly, Kingspit, Lofall, Seabeck Bay, and Port Gamble Bay.

Three of the six larger freshwater streams (Little Anderson Creek, Seabeck Creek, and Port Gamble Creek) exceeded the FC standard. Irregular sampling of smaller creeks (0.5-3.0 cfs) indicated some loading of fecal coliforms, although the FC standard was met.

A shoreline sanitary survey indicated 5.8% (24 of 415) of on-site wastewater disposal systems were failing, a result that was related to age of the systems. Dye tests near Holly, Lonerock, and Salisbury Point indicated some homes along low bank areas contributed trace quantities of sewage effluent to surface waters.

Areas with the most significant livestock related problems were upper Big Beef Creek, Little Anderson Creek, and Port Gamble Creek.

The report briefly describes earlier work on water quality of Hood Canal. Hood Canal has poor vertical mixing of the water column and relatively little water exchange with outside water. Potential water quality problems include high temperature, low oxygen levels, and high concentrations of phosphates near the bottom. Examination of chemical and biological parameters near Bangor in 1973, as part of the Trident Navy Base EIS, revealed that nearly all samples met or exceeded applicable standards (except near Marginal Wharf).

A few inconsistencies in text were noted, e.g. the summary noted that several creeks exceeded the FC standard, whereas results section reported only one creek exceeded the FC standard. Review of a data table indicated the summary to be correct. The number of replicate samples for fecal coliform bacteria in water at each area (4 to 54) was sometimes below the recommended number (15 replicates).

Struck, P. 1988. Water Quality and Contaminant Sources in Liberty Bay, Sinclair Inlet, and Eagle Harbor. Bremerton-Kitsap County Health District,. Bremerton, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: Yes

QA/QC: Yes

Between September 1987 and February 1988, the Bremerton-Kitsap County Health District and the Kitsap Conservation District conducted a nonpoint water quality study of Sinclair Inlet, Liberty Bay, and Eagle Harbor. The Health District was responsible for marine water/sediment sampling and source characterization. The Conservation District was responsible for upland contamination and stream water quality sampling.

The report was summarized as follows in the River Basin Team Report:

The most severe nonpoint bacterial water quality problems were found in Liberty Bay. The greatest negative impact on beneficial use was also found in Liberty Bay and resulted in the restriction of commercial shellfish harvesting. Areas of Liberty Bay most effected by nonpoint bacterial pollution were the upper estuary area, near the Port of Poulsbo, Liberty Bay marinas, and the lower southwest corner of Dogfish Bay, near Keyport.

Sediment trace metal contamination in Liberty Bay has declined during the last decade. Reductions in levels of cadmium, lead, nickel, and zinc averaged over 50 percent in Liberty Bay. Levels of copper and mercury showed less significant reduction. No readily apparent explanation was found for the lack of change in Liberty Bay sediment copper and mercury levels. Most significant sediment contamination in Liberty Bay was observed near the Poulsbo and Liberty Bay marinas. Trace metal concentrations in Liberty Bay remain significantly elevated over Puget Sound reference areas.

Urban runoff was the most significant source of nonpoint bacterial contamination in Liberty Bay. Failing sewage disposal systems were also significant sources of fecal coliform in the bay.

Tabor, R.A., E.E. Knudsen, C. Weller. 1993. Review of habitat surveys of Hood Canal streams and lakes. U.S. Fish and Wildlife Service and Point No Point Treaty Council. Olympia, WA.

LOCATION:	Hood Canal
HABITAT:	Stream, lake
DATA TYPE:	Habitat characteristics
SAMPLE PERIOD:	Variable, 1974-1991
SAMPLE FREQUENCY:	Infrequent
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Variable
WQ STANDARDS MET:	Not reported
QA/QC	Not reported

COMMENTS: This report describes habitat surveys of creeks in the Upper Hood Canal Watershed. Surveys were conducted on Gamble, Big Beef, and Seabeck creeks by the Timber, Fish, and Wildlife Monitoring Program (1989-1990) and on Big Beef Creek by the Washington Department of Fisheries (1984) and the University of Washington (1991). Lake Symington was surveyed by the Department of Ecology in 1974. Types of data collected during these surveys was varied according to the agency.

Tetra Tech. 1988. Sinclair and Dyes Inlets Action Program: Initial Data Summaries and Problem Identification. Prepared for U.S. EPA.

URS Consultants, Inc., et al. 1994a. Final - Feasibility Study Report for Operable Unit 7 - SUBASE Bangor, Bremerton, WA. CTO-0058.

LOCATION:	Bangor
DATA TYPE:	Organics, metals, inorganics
HABITAT:	Lake, wetland, ground water
DEPTHS:	
SAMPLE PERIOD:	November 1991- November 1992
SAMPLE FREQUENCY:	Not obvious
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	See report
WQ STANDARDS MET:	No
QA/QC	Yes

COMMENTS: This report is addition to the six volume report describing assessment and remedies associated with water and soil contamination of the Superfund site on SUBASE Bangor.

Ground water and soils exceeded requirements for a number of organic and inorganic chemicals.

Cancer risk from beryllium in ground water was noted to be high at Site 7 and Devils Hole. Beryllium was found at naturally high levels in ground water throughout the Bangor Subase. Surface water at Devils Hole was found to pose a cancer risk via ingestion and dermal contact; the water was contaminated with arsenic. High levels of arsenic were found in various media throughout the Bangor Subase.

URS Consultants, Inc., et al. 1994b. Final - Remedial Investigative Report for Operable Unit 7 - SUBASE Bangor, Bremerton, WA. CTO-0058. and related six volumes of reports.

LOCATION:	Bangor
DATA TYPE:	Chemical
HABITAT:	Lake, wetland, ground water
DEPTHS:	
SAMPLE PERIOD:	November 1991- November 1992
SAMPLE FREQUENCY:	Not obvious
SAMPLE DURATION:	Grab
ANALYTICAL METHODS:	See report
WQ STANDARDS MET:	No
QA/QC	Yes

COMMENTS: This six volume report summarizes the approach, methods, results, and conclusions of the remedial investigation conducted for Operable Unit 7 as part of the Comprehensive Long-Term Environmental Action Navy (CLEAN) program. This area is an EPA Superfund site. Operable Unit 7 includes Cattail Lake, Hunter's Marsh, and Devil's Hole, which are areas that may be impacted by activities from upstream sites. Data were reported to have been validated in accordance with EPA's guidelines.

Chemicals of concern in the ground water include Arsenic, lead, aluminum, beryllium, nickel, vanadium, mercury, aldrin, Aroclor 1016, Aroclor 1260, TPH, benzene, toluene, Heptachlor epoxide, RDX, and automobile fuel.

Chemicals of concern in soils include lead, aroclor 1248, aroclor 1254, aroclor 1260, arsenic, benzo(a)pyrene, aldrin, mercury, aluminum, and DDT.

Chemicals of concern in clam tissue include arsenic.

University of Washington, 1993. Laboratory Analysis of Selected Parameters of Water Samples from Thompson Road Wetland. UW Department of Landscape Architecture, Seattle, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: No

QA/QC: No

Water quality samples were collected from the wetland along Thompson Road. Data presented in this report were poorly documented. There was no record of method of sample collection or analysis. One comment stated that some data were considered inaccurate due to the shallow depth of the station, but there was no documentation of depth, or why this would matter. Another comment stated that total phosphorus values were corrected to half of the previously recorded values, with no further explanation. Due to the poor documentation, the data presented in this report are not considered usable.

URS Consultants and Science Applications International Corporation. 1993. Final Remedial Investigation Report for the Comprehensive Long-Term Environmental Action Navy (CLEAN) Northwest Area. Prepared for Engineering Field Activity, Northwest; Naval Undersea Warfare Center, Division Keyport, WA. (Additional sections of this report can be found at Keyport, Central Kitsap, or Poulsbo Public Libraries).

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

'METHODS: Yes

QA/QC: Yes (though not provided for review)

In 1989 the Naval Undersea Warfare Center, Division Keyport was placed on the Superfund National Priorities List due to the presence of several hazardous waste disposal and spill sites which were known to exist on the facility. This intensive study was undertaken as part of the remedial action required by law. Monitoring took place from August 1989 to January 1992.

Marine waters were sampled in Liberty Bay and Dogfish Bay. Samples were analyzed for the following parameters; metals, volatile organic compounds, semivolatile organic compounds, organochlorine pesticides and PCBs, organophosphorus pesticides, chlorinated herbicides, and automobile fuel. Ground water and seeps were sampled and analyzed for the same parameters with the addition of total petroleum hydrocarbons. Marine sediment was analyzed for the same parameters minus the volatile organic compounds and with the addition of bioassays. Marine tissue samples were analyzed for metals, semivolatile organic compounds, organophosphorus pesticides, and automobile fuel. Stream sediment was analyzed for metals, semivolatile organic compounds, and automobile fuel.

Sampling methodology is clearly defined for each parameter. Figures with specific site locations are included. A data quality assurance evaluation report was included in Appendix F of the report. This appendix was not included in the materials sent and therefore could not be reviewed. However, it is likely that a report of this nature would follow appropriate quality assurance and quality control procedures.

The following information was summarized in the Puget Sound Cooperative River Basin Team report:

One of the waste disposal sites is identified as an industrial landfill located near Dogfish Bay. This landfill is in close proximity to commercial shellfish beds which are located in Dogfish Bay.

Pacific oysters, grown commercially in Dogfish Bay, and several species of clams were found to be acceptable for human consumption (Jennings 1994).

Test results on sediment samples collected from the Dogfish Bay station closest to the commercial growing area revealed concentrations of metals and organic compounds which exceeded maximum limits on the Puget Sound Estuary Program reference values.

Low to moderate ecological risk may be posed by the Area 1 landfill (Jennings 1994). Future monitoring/sampling is being designed to define the impact of Area 1 ground water on sediments and surface water in Dogfish Bay.

Wahl, T. R. and S. M. Speich. 1983. First winter survey of marine birds in Puget Sound and Hood Canal : December, 1982 and February, 1983 . Prepared for Washington Department of Game, Nongame Wildlife Program. Olympia, WA.

Washington Department of Ecology. 1981. Instream Resources Protection Program. Kitsap Water Resource Inventory Area 15. Prepared by Jeanne Holloman.

Washington State Department of Ecology. 1992. Ambient Monitoring of Marine Waters. (Data provided by Sharon Bell).

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: None provided

QA/QC: None provided

Virginia Point in Liberty Bay was monitored from May to October 1986, May to November 1987, October to December 1991, and January to September 1992. Samples were collected from the surface and a depth of either 23 or 33 feet. Parameters consistently analyzed were temperature, secchi depth, dissolved oxygen, percent saturation dissolved oxygen, pH, salinity, and fecal coliforms. Nutrient data are reported inconsistently as one or more of the following $NH_3 + NH_4$ - N dissolved, $NH_3 + NH_4$ - N total, NO_2 - N dissolved, NO_2 total, NO_3 - N total, $NO_2 + NO_3$ - N total, $NO_2 + NO_3$ - N dissolved, phosphorus total, phosphorus total ortho, and phosphorus dissolved ortho. Chlorophyll *a* and pheophytin are also reported for some dates. No figures with specific site locations are included. No methods or QA/QC write-up is provided.

Water quality as recorded on the spreadsheet meets state standards with the following exceptions: two fecal coliform samples, one sample collected on May 19, 1986 (110 colonies/100 ml), and another sample collected on June 1, 1992 (39 colonies/100 ml) exceed the state standard of 14 colonies/100 ml. Both samples were from the surface. Dissolved oxygen was reported below the state standard of 6.0 mg/L on September 21, 1987 at both the surface (5.1 mg/L) and at depth (4.3 mg/L).

Similar monitoring was conducted at Port Madison, south of buoy #65. Samples were collected here in December 1990, October to December 1991, and January to September 1992. No water quality standards were violated.

Washington (State) Dept. of Fish and Wildlife. 1996 Washington Rivers Information System (WARIS) Database. The WARIS Database is a statewide collection of natural resource data related to rivers and streams, and is the Washington component of the Northwest Environmental Database (NED). The database was originally designed for hydropower development and was expanded to provide administrators with natural resource data for planning on a local, statewide, and regional scale. The concept behind WARIS is to include data that are: (1) descriptive, (2) standardized geographically, (3) managed using a geographic information system (GIS), and (4) summarized by a ranking system to identify importance based on resource quality and critical resources.

WARIS is managed using Environmental Systems Research Institute's (ESRI) GIS software Arc/Info on a UNIX platform. The database includes the following: a 1:100,000 scale hydrographer layer, resident and anadromous fish, Priority Habitat and Species (PHS) fish, wildlife, and natural features data. Planned categories include recreation sites, cultural and historic features, and institutional constraints.

The WARIS began with the Pacific Northwest Rivers Study, a 1984 effort promoted by the Bonneville Power Administration (BPA) and the states of Idaho, Montana, Oregon, and Washington. The Washington State database is presently managed by the Washington Department of Fish and Wildlife (WDFW) in cooperation with Indian Tribes, and other state and federal agencies. The database is primarily funded by Bonneville Power Authority with WDFW providing indirect funding through updates, technical support, hardware and software support, and administration.

This document provides a description of the five data categories currently in WARIS: (1)anadromous, (2) resident fish, (3) PHS fish, (4) wildlife, and (5) rare plants and plant communities. These data are available in Arc/Info export format or on maps. A menu system designed for personal computers is being developed by the Idaho Fish and Game.

Resolutions and Limitations

WARIS is available statewide at 1:100,000 scale of resolution and is the product of 1989-1990 data collection efforts.

Resident fish information is generalized to a river reach. More site-specific resident fish information is not available through this data set.

The anadromous fish data represent a data compilation effort involving fish experts from many different agencies and organizations. However, the resident fish data were compiled largely by interviews with WDFW biologists, so it is less comprehensive. About 50 percent of the 1:100,000 scale streams have known resident fish resources that have been described; the rest are unknownWashington (State) Dept. of Fisheries. 1974. Bulkhead criteria for surf smelt (Hypomesus pretiosus) spawning beaches in Puget Sound, Hood Canal, Strait of Juan de Fuca, San Juan Islands, and the Strait of Georgia State of Washington Department of Fisheries.

Washington (State). Dept. of Fisheries. 1971. Criteria governing the design of bulkheads, land fills, and marinas in Puget Sound, Hood Canal, and Strait of Juan de Fuca for protection of fish and shellfish resources / State of Washington Department of Fisheries. Olympia, Wash.

Washington State Department of Health. March 1994. Sanitary Survey of Lemolo, Liberty Bay. Olympia, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: None provided

QA/QC: None provided

A sanitary survey of Lemolo, a small embayment within Liberty Bay, was completed in May 1994 by the State Department of Health. Five stations were monitored within the bay for fecal coliform bacteria. All stations within Lemolo Bay were reported to meet the Approved Area criteria.

Included in this report as attachments are the results of sanitary surveys conducted along the shoreline of Agate Passage and Port Madison. Four sites along Agate Passage and four sites in Port Madison were determined to be suspect or failing. Figures show water quality stations located in the sampling area, but no water quality results are discussed or presented.

Washington State Department of Health. April 1994. Letter to John Petrie, Coast Seafoods. Olympia, WA.

WQ ANALYSIS: No

NONPOINT SOURCES IDENTIFIED: No

METHODS: Not Applicable

QA/QC: Not Applicable

This letter notifies John Petrie of Coast Seafoods Company that DOH had decided to reclassify certain portions of the commercial shellfish growing area in Liberty Bay near Lemolo from restricted to approved. No water quality results were provided. The letter provides a legal description of the reclassified area.

Washington State Department of Health. April 1993. Shoreline Survey of Lemolo, Liberty Bay. Olympia, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: None Provided

QA/QC: None Provided

A shoreline survey of Lemolo was conducted in April 1993 by the State Department of Health. Nonpoint pollutant sources were evaluated for the classification of shellfish harvesting. No figure was included to identify where samples were taken. As was reported in the River Basin Team Report, the following sources were identified.

o Six on-site waste disposal sites were identified as failing or suspected of failing (12 percent of the surveyed sites).

o Three drainages out of five had elevated fecal coliform levels reaching Liberty Bay (540, 350, and 240 colonies/100 ml). The two largest levels were next to the shellfish growing area.

o One pasture was identified as a potential source of bacteria. A ditch below the pasture had a count of 540 colonies/100 ml.

o Other potential sources were identified as follows: the EPA Superfund site at Keyport Naval Undersea Warfare Engineering Station, approximately one mile south of the harvest area; the three marinas located on the east shore of Liberty Bay; possible lift stations malfunction/pump failures or breaks in sewer lines near the growing area.

Washington State Department of Health, and FDA Region X. 1986. Sanitary Survey of Liberty Bay, Preliminary Report. Olympia, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: Yes

METHODS: None Provided

QA/QC: None provided

An investigative survey to determine actual and potential pollution sources and the impact of these sources in Liberty Bay was conducted in December 1985. This survey included an evaluation of 13 marine stations throughout the length of the bay. Top and bottom temperatures, top and bottom salinities, total coliform, fecal coliform, and E coli bacteria sample results are reported for the marine stations. Eight stream stations were monitored for temperature, total coliform, fecal coliform, and E coli. Areas were surveyed during the rainy season under high and low tidal conditions. Figures were included that show locations of potential nonpoint pollutant sources and station locations. No QA/QC write-up is included.

Freshwater and ground water sources and tidal cycles were determined and their influence on the potential nonpoint pollution sources were identified in the Liberty Bay-Dogfish Creek subwatershed. Freshwater sampling results are poorly documented. It was concluded that the bay serves to provide a gradation of fecal coliform values from the head (Station 12) to the mouth (Station 11).

Surveys were conducted to examine potential sources of pollution. Results from the survey indicated that livestock farms along Dogfish Creek had a significant impact on water quality within the bay. Sources of fecal coliform contamination from the City of Poulsbo were suspected to be stormwater runoff, sewage cross-connections, or a combination of both. Marinas were also considered a significant source;

however, this potential source was not verified due to limited boating activities during the winter months. The shoreline survey was inconclusive to determine the impact of those houses using septic systems on fecal contamination within Liberty Bay.

According to the write-up by the River Basin Team, storm drains discharging from the city were monitored. In one case, a storm drain located in downtown Poulsbo contained fecal coliform concentrations of 2,400 colonies per 100 ml.

Washington State Department of Health, Office of Shellfish Programs. Monitoring data on disk for Agate Pass, Liberty Bay, Port Madison, and Miller Bay. Olympia, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: None Provided

QA/QC: None provided

The Department of Health has monitored Liberty Bay, Miller Bay, Agate Pass, and Port Madison in the past as part of their shellfish program. Water samples collected at these sites were analyzed for fecal coliform bacteria. Surface water temperature, surface water salinity, time of high and low tide, height of high and low tide, and tide phase were noted at the time of sample collection. Sampling periods for each of these sites are listed below.

Liberty Bay	1988	September to December
	1989	January to December
	1990	January to October
	1993	June to December
	1994	January and February
Agate Pass	1989	October
	1990	October
	1991	September
	1992	January to November
	1993	January to November
Miller Bay	1989	March and April
	1990	March, June, and October
	1991	September
	1992	January
Port Madison	1989	March, April, and October
	1990	March, June, and October
	1991	September
	1992	January, March, July to November

1993 January, April, June, August, November

Washington State Department of Social and Health Services. October 1983. Water Quality Study of Liberty Bay. Olympia, WA.

WQ ANALYSIS: Yes

NONPOINT SOURCES IDENTIFIED: No

METHODS: Yes

QA/QC: None provided

In October 1983 a water quality study of Liberty Bay was conducted by the office of Environmental Health Programs to re-evaluate the existing closure lines restricting harvest of shellfish. Ten sampling stations throughout the bay were sampled twice a day during one of two sampling runs. Temperature and salinity profiles were measured from the surface to a depth of 15 feet. Water samples were analyzed for fecal coliforms. Shellfish tissue samples were also taken from various stations. A map showing the locations of the sampling sites is provided.

One water sample exceeded both parts of the State standards for fecal coliform bacteria. No shellfish tissue samples exceeded the criteria.

Whitmus, C. J. and S. Olsen. 1979. The migratory behavior of juvenile chum salmon released from the Hood Canal hatchery at Hoodsport, Washington . Fisheries Research Institute, College of Fisheries, University of Washington.

Williams, J.R. and R.A. Riis. 1989. Miscellaneous streamflow measurements in the State of Washington, January 1961 to September 1985. U.S. Geological Survey Open-File Report 89-380. Tacoma, Washington.

This report is a compilation of previously published miscellaneous streamflow measurements made in Washington by U.S. Geological Survey personnel between January 1961 and September 1985. It is a supplement to a previous compilation of miscellaneous streamflow measurements made in Washington between 1890 and January 1961. Most of the data in this report were obtained through cooperative programs with the State of Washington Department of Ecology, although some data were obtained through the financial support of other State and Federal agencies or private and municipal utilities.

In general, the sites for which data are given in this report are not at gaging stations; however, some data are given for gaging station sites when the data were gathered outside the period of operation of the gage. The data that are given for each measurement site are stream name and the name of the stream to which it is tributary, latitude and longitude, county code, hydrologic unit code, land-line location, drainage area, and measurement dates and discharges.

All of the data in this report have been entered into a computerized database that includes the data for 1890-January 1961. The data can be retrieved in a variety of ways, such as by county, by hydrologic unit code, by river basin, or by size of drainage area.

Williams, R.W., R.M. Laramie, J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1, Puget Sound Region. Washington Department of Fisheries, Olympia, WA.

LOCATION:	Puget Sound, Kitsap County, WRIA 15
HABITAT:	Streams
DATA TYPE:	Salmon
DEPTHS:	
SAMPLE PERIOD:	~1961-1971
SAMPLE FREQUENCY:	Not provided
SAMPLE DURATION:	Not relevant
ANALYTICAL METHODS:	Not relevant
WQ STANDARDS MET:	Not provided
QA/QC	Reasonable

COMMENTS: This report describes known information (as of 1975) on the habitat of specific streams in the Puget Sound Region. Salmon harvests, spawning escapements, timing of life-history stages, and factors influencing salmon production are discussed (e.g., stream flow, physical barriers to migration, water quality, spawning and rearing area, and watershed development).

Port Gamble to Seabeck: Creeks are very small and short; 24 independent streams totaling only 48.2 miles. The three largest drainages include Port Gamble Creek, Little Anderson, and an unnamed creek near Lofall. Creeks are stable with narrow extremes in flow. In 1975, the watershed and stream cover in this area was considered generally favorable because development was moderate.

Numerous coho are found in Gamble Creek, Little Anderson Creek, and the unnamed creek near Lofall. Little Anderson has excellent chum production for its size. Other creeks support coho and chum salmon but these populations are smaller. Since streams are small, any application for consumptive diversion of water should be evaluated.

Big Beef Creek to Holly: Total miles within the 14 creeks in this area is 40.5 miles with over half in Big Beef Creek. Big Beef, Seabeck, Stavis, and Anderson creeks provide exceptional spawning, and rearing habitat for salmon. Other creeks have minor production. Big Beef Creek has annual returns of 3,000 coho and up to 3,500 chum salmon. Most coho production in Big Beef Creek occurs above Lake Symington, an artificial impoundment created for development of property. Total production of all creeks is approximately 3,800 coho and 4,500 chum salmon. A few chinook salmon may use Big Beef Creek. Anderson Creek supports both early and late spawning chum salmon; the early spawning chum in Hood Canal are considered depressed by SASSI (1993).

Quality of this area was considered excellent for salmon in 1975 except for Lake Symington and downstream where summer temperatures become too high for coho salmon. Both Anderson Creek and Big Beef Creek have undergone serious gravel bed scouring and have become silted in their upper sections due to land development activities.

Wilson, R. E. 1942. Radium content of core samples taken from Hood Canal. Ph.D. Thesis. University of Washington, Seattle, WA.

Wood, W. 1994. Standing crop and present harvest of shellfish on public beaches bordering Hood Canal within Kitsap County. Shellfish biologist, Washington Department of Fish and Wildlife. Brinnon, WA. Personal communication (206-586-1498).

LOCATION: Hood Canal, Kitsap County
HABITAT: Marine waters
DATA TYPE: Shellfish
DEPTHS: Not available
SAMPLE PERIOD: Not available
SAMPLE FREQUENCY: Annual
SAMPLE DURATION: Not relevant
ANALYTICAL METHODS: Not relevant
WQ STANDARDS MET: Not relevant
QA/QC Not available

COMMENTS: Shellfish harvest and standing crop data are available in tabular form from William Wood at the Brinnon Lab (206-586-1498). Data table provides population, recreational harvest, and tribal harvest data for littleneck, butter and cockle clams and oysters along public beaches greater than 1,000 ft in length. These beaches include Salisbury Pt, Kitsap, N. Bangor, N. Kitsap, DNR 40, Nellita, and Scenic Beach.

Yake, B. and D. Norton. 1987. Port Gamble Bay: a reconnaissance survey of sediment quality. Water Quality Investigations Section, Washington State Department of Ecology.

LOCATION: Port Gamble Bay
HABITAT: Benthos, sediment, water column
DATA TYPE: Metals, semivolatile organic compounds, pesticides, PCBs, conventional
DEPTHS: 5 m
SAMPLE PERIOD: March 23, 1987
SAMPLE FREQUENCY: Once
SAMPLE DURATION: Grab
ANALYTICAL METHODS: See report
WQ STANDARDS MET: Yes
QA/QC Yes

COMMENTS: The study was conducted three days after Washington Dept. of Fisheries reported substantial mortalities of herring spawn in 1987. Three stations were selected inside the Bay (see map) where herring mortality was known to occur. A control station was sampled in Bywater Bay. Methodology and laboratories that conducted the tests were described. Analytical measurements were made for a number of compounds.

Nearly all metals, pesticides, and organics collected at the three sites in Port Gamble Bay were near background (reference station) levels. Those compounds showing elevated concentrations (polynuclear aromatic hydrocarbons) were well below concentrations known to cause adverse biological impacts.

Yake and Norton agreed with one of Kocan's (1987) hypotheses, which was that the high herring mortality in Port Gamble Bay might have been caused by metabolites or decomposition products of algae.

Methodology was described in sufficient detail. Replicate samples for contaminants were taken at two of four stations. Only three marine sediment stations sampled by 0.1 m^2 VanVeen grab, i.e. a small area was sampled.

Yake, et. al. 1984. Chemical Contaminants in Clams and Crabs from Eagle Harbor, Washington, with Emphasis on PAHs.

Yake, W.E. 1985. Impact of Western Processing on Water Quality in Mill Creek. Washington Department of Ecology.

Yake, W. and D. Norton. 1986. Chemical Contamination of Ground Water, Intertidal Seepage and Sediments On and Near Wyckoff Company Property; Eagle Harbor, Bainbridge Island. Memo to Glynis Stumpf and Dave Bradley, 54 pp.

Yake, B., D. Norton, and M. Stinson. 1986. Application of the Triad Approach to Freshwater Sediment Assessment.

Yoshinaka, M. S. 1974. Hood Canal - priorities for tomorrow : an initial report on fish and wildlife, developmental aspects and planning considerations for Hood Canal, Washington . illustrations by Nancy Ellifrit. Portland, Or. : U.S. Dept. of the Interior, Fish and Wildlife Service.

Appendix F
Draft Ground Water Management Plan
Issue Paper Summary

Appendix F Draft Ground Water Management Plan Issue Paper Summary

1.0 Introduction

This appendix is an extract from the Draft Kitsap County Ground Water Management Plan, Volume III (Section 3 Issue Paper Summary). It is included as an appendix to the Basin Assessment because it addresses many of the threats to the ground water resources within Kitsap County. Issues are categorized by "action areas" such as "Ground Water Quality Protection," "Water Quantity," "Education," etc. This Draft Volume III of the Ground Water Management Plan is currently under review by effected local governments and open for comment by citizens of the County (Jan. 97).

2.0 Ground Water Quality Protection - Issues and Programs

2.1 Ground Water Recharge Area Protection (RP)

- ❑ The Washington Administrative Code states: "Counties and cities shall classify recharge areas for aquifers according to the vulnerability of the aquifer. Vulnerability is the combined effect of hydrogeological susceptibility to contamination and the contamination loading potential."An aquifer recharge area is defined as the surface area which receives rain and passes a portion downward where it is temporarily collected in an aquifer.

- ❑ The Kitsap County Historical Record of Ground Water Contamination contains many incidents of contamination in addition to the designated and proposed National Priority List (NPL) hazardous waste sites (frequently called superfund sites). The State Department of Ecology (Ecology) records document information on 98 leaking underground storage tanks. The Bremerton-Kitsap County Health District (BKCHD) has records on 46 investigations of significant pollution (Affected Media Contaminants Report). Seventeen percent of leaking underground storage tank reports and 41 percent of the Affected Media Contaminants Reports indicate that ground water has been contaminated at the affected site. An additional 24 sites have been assessed as posing a threat to ground water. The two data sets have some duplication of information. The total number of contaminated sites is probably around 120, of which 36 have resulted in confirmed ground water contamination problems. Data is not available on sum total of acreage contaminated in Kitsap County or the extent of contamination involved. Some of the sites are in the process of being cleaned up. Investigation needs to be conducted on the relationship between the 36 confirmed ground water problems, which appear to be related to shallow, unconfined, smaller aquifers and the potential threat to the principal aquifers.

- Communities have used various approaches to ground water protection. One approach emphasizes controlling aquifer recharge areas. Another approach involves systematically ranking and controlling existing and potential threats to ground water. Other approaches use computer generated, ground water models to evaluate the effects various land use management alternatives and other activities could have on ground water resources. Each approach has inherent benefits and disadvantages and not all approaches are appropriate for all areas of the country.

- Assessment of the suitability of sites for different land-use activities is based solely on the susceptibility of the aquifer to contamination, regardless of its present condition or use.

- The hydrogeological characteristics of an area, the nature of threats to ground water, the pattern of water use (e.g., discrete public well sites or dispersed private wells), and the general vulnerability of the area under consideration, should dictate the extent of protective measures required.

- It is difficult to identify aquifer recharge areas in locations where the geology is complex. Existing land use and ground cover, as well as soil permeability and overlying geologic material, are important factors for defining recharge areas. The recharge area of a deep aquifer is often smaller than the recharge area of the shallow aquifer above it. This situation occurs where a deep aquifer is overlain by consolidated rock or other impervious material and not by permeable soil and unconsolidated deposits. Recharge to a deep consolidated or bedrock aquifer tends to be complicated when intervening aquifers and confining layers exist.

- The primary goal is to prevent contamination of ground water from point and non-point pollution sources to the maximum extent practical and, if necessary, to restore ground water to a potable state, regardless of its present condition, use, or characteristics. To meet the overall goal of ground water recharge area protection, policies and practices should be based on a combination of several general factors :

  - County and City government officials should recognize that ground water is a precious and vulnerable natural resource, the protection of which is essential to the health, welfare and prosperity of the citizens of this county

  - Many human activities result in ground water contamination

  - Knowledge of the health effects of contaminants varies greatly, particularly for synthetic organic compounds

- Detectable quantities of a synthetic organic compounds in ground water is unnatural and undesirable

- The movement of contaminants in ground water is often difficult to ascertain and control

- Decontamination of ground water is difficult and expensive

- Kitsap County agencies should work to prevent further contamination of ground water from any source to the maximum extent practicable.

- Upon discovery of ground water contamination, appropriate actions by relevant agencies should be taken to prevent further contamination.

- All citizens of Kitsap County have the right to have their lawful use of ground water unimpaired by activities which would render ground water unsafe or un-potable.

- All citizens of Kitsap County have the duty to conduct their activities in such a manner as to prevent the release of contaminants into the ground water resources of the county.

- Documentation of any contaminants in the ground water which present a significant threat to human health, the environment, or the quality of life, should result in either passive or active cleanup. The best technology available or best management practices, taking cost to benefit considerations into account, should be utilized as appropriate, to meet established standards.

❑ County and city governments are required to identify critical recharge areas for protecting water quality as part of the Growth Management Act process. Most of the county is recharge area, but some recharge areas require more protection than others. Land use regulations and zoning ordinances, should be based on that principle. Kitsap County's ground water resources should include criteria for designating and mapping different levels of recharge area. The criteria should be used to generate a map that would provide a basic guide to the levels of recharge area. More importantly, compatible criteria for site specific evaluation must also be developed. Kitsap County should specify the requirements for protecting ground water recharge quality within each level from activities which involve hazardous materials that are a potential threat to ground water.

2.2 Sand and Gravel Mining (SG)

❑ Sand and gravel operations have the potential to impact ground water quality adversely, both as a result of the extraction process and in site reclamation. Sand and gravel mining within an aquifer recharge area will, at a minimum, increase the vulnerability of an aquifer to be contaminated because it decreases the distance between the ground water table and land surface. The primary effluent discharged at a sand and gravel mine operation is turbid rinse water. Generally, operators are required to collect waste water on-site in retention and settling ponds where the fine sediment settles out. The collected water is then allowed to infiltrate back to the water table. Often the excavation pit is a component of the treatment system. High concentrations of suspended solids in the wash water do not pose a serious ground water problem since sediment is unable to migrate beyond the immediate infiltration site. Even though the turbid wash water at a gravel mine is not a significant ground water pollutant, the excavation pit and the continual collection and infiltration of wash water do raise the potential for other sources of contaminant to migrate to the aquifer.

- ❑ Beyond the risks associated with active mining, one of the largest threats to ground water appears to be the excavation pit itself. Reclamation of a site may include refilling a pit as well as slope and drainage stabilization. Within the recharge areas of a vulnerable aquifer, the decision to fill or not fill an excavation is one of the most critical with regards to water quality. Excavation pits have been used both legally and illegally as dump sites for a variety of wastes. In the past, little care has been given to the classification of the material used as fill. Many community landfills have been developed in "reclaimed" gravel pits. Industries have used excavation pits as disposal sites for mixed wastes. Over the years it has not been uncommon to find pits used as "dumps" for a variety of potentially hazardous fill materials. In many cases, materials historically used to fill pits would today be classified as a dangerous waste, not inert material.

- ❑ The State Department of Natural Resources' low priority has precluded a push for stronger controls, and may indicate the department does not consider sand and gravel mines to be a significant threat to ground water.

2.3 Underground Storage Tanks (UT)

- ❑ Underground storage tanks (USTs) usually contain flammable motor fuels or heating oil, but may contain other compounds used by industry, government, or businesses. Contamination of soil and ground water by leaks from USTs and associated piping is becoming an increasingly prominent environmental, legal, and regulatory issue. The U.S. Environmental Protection Agency (EPA) estimates that 35 percent of all USTs could be leaking. The most common causes of leaks are structural failure, corrosion, improper fittings, improper installation, and natural phenomena. Leakage from underground storage tanks and associated piping often occurs without detection. Even relatively small amounts of certain compounds can have serious, adverse impacts on ground water quality.

- ❑ Once released from an underground storage tank, many volatile organic compounds and petroleum products can rapidly migrate through the soil to ground water. This problem is especially serious in areas with excessively permeable soils such as coarse sand and gravel.

- According to Ecology's printout of Leaking Underground Storage Tank (LUST) sites reported from January 1989 (dated March 26, 1992), in Kitsap County 63 sites with one or more leaking USTs have been identified. Remedial cleanup action has been completed at 12 of the sites and is ongoing at the others.

- Federal, State, and local regulations relating to USTs are very comprehensive and, if fully implemented and enforced, reduce the risk of degrading ground water quality through leaking USTs. Because of the great importance of ground water to Kitsap County residents, remaining concerns should be addressed and potential remedies identified where feasible.

- Additional concerns center on:

  - The capability of Ecology to administer the UST program in Kitsap County, in view of resource limitations;

  - Determination of whether a part or all of Kitsap County should have more stringent UST requirements than provided by State and federal regulations;

  - The lack of environmental review (SEPA compliance) for USTs with a capacity of 10,000 gallons or less;

  - The lack of an education or awareness program for owners of USTs which are exempt from federal and State regulations;

  - The lack of knowledge concerning the contamination potential presented by unused, underground home heating oil tanks.

- It is important to note that State and federal UST regulatory programs do not cover all USTs. Notable exceptions are:

  - Farm or residential UST systems of 1,100 gallons or less capacity used for storing motor fuel for non-commercial purposes, and

  - UST systems used for storing heating oil for consumptive use on the premises where stored, except that systems with a capacity of more than 1,100 gallons have a reporting requirement.

  - USTs with a capacity of 10,000 gallons or less are exempted from environmental review under SEPA.

- The first two exceptions noted above are subject to local regulatory authority under Article 79 of the Uniform Fire Code (UFC) which has been adopted by Kitsap County Ordinance.

2.4 Solid Waste Disposal (SW)

- Solid waste landfills can pose a threat to ground water quality due to leachate production. Leachate is water or other liquid that has been contaminated by dissolved or suspended materials due to contact with solid waste or gases therefrom. Leachate can be produced by rainfall percolating through landfill waste materials, addition of liquid wastes to a landfill, or a high water table which results in direct contact of the wastes and ground water.

- Leachate generally consists of a mixture of chemical and biological substances. The precise composition of the leachate generated by a solid waste facility is dependent on the nature of landfill materials. While landfill operators currently take steps to ensure that hazardous and dangerous wastes are not accepted for disposal, this was not the case until recent years. Therefore, the risk of potential contamination of ground water is higher in old landfills than in currently operated solid waste facilities that are complying with current laws and regulations. In addition to a lack of control over the type of wastes that were disposed of in old landfills, the siting of such landfills in the past in old gravel pits, gullies, or ravines, without regard to the ground water table relationship, increases the potential for ground water contamination.

- In Kitsap County's "Final Amendment to the 1990 Final Comprehensive Solid Waste Management Plan," fifteen closed or abandoned landfills have been identified throughout Kitsap County. Olympic View Sanitary Landfill is now the only operating mixed municipal solid waste (MMSW) facility in Kitsap County. The Morrison Demolition Landfill, an active construction and demolition waste landfill was closed in November, 1992.

- The potential for ground water contamination resulting from existing operational and future solid waste disposal landfills is reduced because of strict regulatory controls for operation and closure and stringent siting criteria for new landfills. There is, however, concern relating to the fifteen closed landfills that have been identified in Kitsap County as shown on Figure 8-1 and described on Table 8-1 of the June 1992 Final Amendment to the 1990 Final Comprehensive Solid Waste Management Plan for Kitsap County. The table indicates that seven of the fifteen landfills had accepted MMSW, demolition, and industrial wastes, and twelve of the fifteen have had no post-closure maintenance. The June 1992 Amendment, although very comprehensive in such areas as waste reduction and recycling and looking toward the future, does not directly address existing or potential contamination problems that may result from the closed landfills. The plan does show that twelve identified closed landfills are monitored by the

Bremerton Kitsap County Health District (BKCHD) on a limited basis, but for the most part, it appears that the impact of the closed landfills on ground water is not known. Fortunately, few, if any, of the landfills appear to overlay any of the principal aquifers.

2.5 Hazardous Materials (HM)

- Hazardous materials represent a variety of threats to drinking water supplies. Both surface and ground water sources can suffer if hazardous materials are introduced. Pollution can be much more severe for ground water, since contamination can be persistent and difficult to clean-up or mitigate. Hazardous materials are abundant. Seemingly harmless chemicals, that we come in contact with routinely, can become hazardous if introduced to an aquifer in sufficient quantities. Large quantities of potentially hazardous materials are produced, transported, consumed, and disposed of every day. Hazardous materials are in constant motion on rails and highways. The threat to water supplies is significant. Therefore, programs and regulations to control hazardous material production, transportation, storage, and disposal must be comprehensive.

- Definition: Hazardous Material: Any substance which has the possibility of being introduced into an aquifer in sufficient quantity and strength to threaten the aquifer's beneficial use.

- Four basic categories of contaminant pathways are typical of Kitsap County: home, commercial/industrial, agricultural, and transportation. Just as chemicals or hazardous materials can be characterized by type of user, contaminant pathways can be similarly characterized by source.

- Hazardous material regulatory and non-regulatory programs suffer from a lack of resources (money and staff). Local programs for information, education, and household waste control need to be expanded.

- For hazardous materials, monitoring for compliance is critical. Most of the regulatory programs cannot monitor a large percentage of the regulated community. Targeting the larger generators covers a significant portion of the generated waste, but leaves a tremendous gap in the regulatory net.

- Enforcement can tie up available resources and lower the number of contacts with the regulated community, inhibiting information flow and cooperative ventures. More important, once enforcement starts, the pathway to correcting a problem is a legal or adversarial process, which is time and resource consuming. It is difficult for an enforcement agent to be effective at education.

- ❑ Hazardous material transportation risk reduction needs to be improved by increased inspections of roads and roadbeds, vehicles, and containers which carry materials.

- ❑ Neither the State nor County restricts transport of hazardous materials in critical recharge areas such as wellhead protection zones.

- ❑ Currently, there are no regulations which require notification of first responder units and local government of highly toxic material shipments through the county.

- ❑ Although RCRA and SARA Title III require contingency planning, more comprehensive planning, which covers all hazardous material operations and provides for emergency response training, is needed.

- ❑ Septic disposal of hazardous materials does occur. Consequently, zoning to preclude concentrations of materials from contaminating aquifers may be necessary.

- ❑ A recent State Supreme Court decision will discourage clean up of contaminated sites voluntarily (without formal Ecology involvement). The decision states that after a site is cleaned-up, a business or industry cannot seek recovery of costs from responsible parties unless Ecology has been formally involved in the clean-up process. This will tend to inhibit voluntary clean-up actions which could be a key part of timely clean-up activity in the state. Legislation is needed to fix this deficiency.

- ❑ Some old landfills which were closed prior to implementation of Ecology's regulation may still pose a ground water threat and may need to be assessed to determine if action is needed.

- ❑ General education of the population on hazardous material handling, usage, and storage needs to be more pervasive. Efforts to educate small businesses would benefit from more money and government outreach efforts.

2.6 Fertilizers and Pesticides (FP)

- ❑ Pesticide use raises significant concern about long-term, chronic exposure from low concentrations in drinking water. Our knowledge of chronic health effects for humans is limited, but lab studies with animals and various studies looking at human exposure to pesticides suggest that cancers, tumors, birth defects, and other chronic illness are related to exposure to certain chemicals. In addition, there is the potential for adverse impacts on sensitive ecosystems and wildlife habitats where contaminated ground water discharges into surface water bodies.

- ❑ A significant concern with fertilizers are problems stemming from nitrates. Concerns have generally centered around the role nitrates play in methemoglobinemia. This ailment is a blood disorder caused by high levels of nitrates. It can affect people of all ages and has resulted in death. While the problem is relatively well understood, there are no accurate statistics on its occurrence. Even though there have been no deaths reported in Washington State during at least the last fifteen years, acute cases still occur. The drinking water standard for nitrates has been set at ten parts per million. Recent research suggests that older children and adults also may suffer other health effects from long-term exposure to nitrates. Excessive consumption of nitrates can result in gastroenteritis and diarrhea. Nitrates may be converted by the body into compounds known to be carcinogenic. High nitrates in ground water cannot be automatically attributed to fertilizer. Other potential sources include on-site sewage disposal and animal waste.

- The urban population is not trained in the proper use and disposal of pesticides and fertilizers. One study estimated that half of the pesticides used in the Puget Sound basin are used in urban areas. Pesticides applied to lawns, gardens, and street side trees can be washed by rain or sprinklers into storm or sanitary sewers where they are conveyed to streams, lakes, and Puget Sound.

- Home owner use, improper disposal of fertilizers and pesticides, and right-of-way maintenance deserves increased attention. Only a few active pesticide ingredients are approved for home and garden use. The active ingredient in some pesticides used by homeowners may be the same as those used by farmers and commercial applicators, but in lower concentrations.

- The Puget Sound Water Quality Authority (PSWQA) found that "a reduction in pesticide use and disposal will not occur until significant numbers of urban and suburban residents are educated about pest management, the use of pest-resistant species, and proper pesticide application. This will require both research to determine alternative pest management practices tailored to this region and methods to get these practices to the home user through education and marketing. Agencies or groups such as Cooperative Extension and the Washington Toxics Coalition have conducted some research on these topics, but more is needed. Some nurseries are knowledgeable about pest-resistant species and native plants, but need more information and an educated market in order to sell them. Very few garden store retailers and very few garden writers encourage people to design and care for lawns in a way that will reduce pesticide use."

- Wholesalers are not required to report information about sale of pesticides, but are required to keep records. State law would have to be changed to make reporting a requirement.

- Based on a lack of documented events, the threat of ground water contamination through fertilizer and pesticide use or misuse does not appear to be significant in Kitsap County. Some areas warrant attention in order to minimize the potential for contamination. Problems may exist and simply have not been detected. Extensive testing will be required for public water suppliers under provisions of the Safe Drinking Water Act.

- A major concern is a lack of awareness by the general public as to the potential for contamination through improper use or disposal of fertilizers and pesticides. Although Ecology's "Protecting Ground Water: A Strategy for Managing Agricultural Pesticides and Nutrients," April 1992, specifically addresses agricultural activities, the findings are generally applicable to the full spectrum of users and misusers. The core of the Strategy is research, education, and technical assistance.

2.7 Septic System Concerns (SS)

- On-site septic systems have been used in this country since the 1880s. Prior to World War II almost all of these systems were used in rural areas or locations adjacent to sewered areas of cities. After World War II the development community incorporated septic systems into building projects because they were economical to use and provided flexibility in planning growth outside urban areas. Problems associated with septic systems multiplied and became more apparent. As a result, considerable research was initiated to determine the causes of failures and to develop technology to prevent them. Although much improvement has occurred, some problems still remain and continued research is necessary. As the density of septic systems is increased, the risk of contamination is increased. As areas become sewered, septic systems will be taken out of use. Contamination from failing septic systems will be eliminated but recharge from all of the replaced septic systems will be lost.

- Disposal of sewage within the unsewered portions of Kitsap County has been accomplished almost exclusively through the use of conventional on-site sewage systems. Currently individual sewage disposal systems serve 50 percent of all single-family residences within the county. Little study has been accomplished to quantify the amount of on-site sewage system effluent that may be recharging the County's aquifers. A considerable quantity of water is probably involved.

- Evaluation of impacts associated with on-site sewage systems has been limited to residential land uses. Commercial, industrial, and institutional use of on-site sewage disposal systems can represent a two fold problem. First, some commercial, industrial, and institutional facilities, such as laundromats, restaurants, schools, and hospitals, generate large volumes of waste water. Waste water from large volume generators are typically discharged to one or more large on-site sewage systems. As with residential community systems, concentration of waste water in one discrete area can have a significant impact on the quality of underlying ground water in the immediate vicinity of the on-site sewage system.

- Under certain conditions and locations, such as islands and peninsulas with limited water resources, maintaining septic system recharge may become a serious consideration as the demand for ground water resources increases. Recharge that is occurring from septic systems helps to prevent seawater intrusion in areas along beach fronts where housing density is high and individual wells supply water.

- Studies that quantify the amount of ground water recharge from septic effluent (nationally and locally) are lacking. In addition, limited data is available on the number of on-site septic systems which are located above or near the major aquifers. Data is also lacking on the ratio of septic systems to sewer connections near aquifers that are not being considered for investigation in the Data Collection and Analysis Plan (DECAP). More data is needed to assess the impact that septic recharge has on the aquifers in Kitsap County. No existing data suggests that any of the principal aquifers are threatened with water quality or quantity problems related to on-site effluent.

- Sewering is often proposed as a remedial or preventive action to cope with ground water contamination by septic systems. Waste water collection, treatment, and discharge of effluent reduces the pollutant loading to ground water resources. Sewer systems, however, require significant capital cost for construction of the plant and sewer lines, financial infrastructure to support construction, and ongoing operation and maintenance. Sewer systems can have water quality impacts from plant effluent on receiving waters and re-use or disposal of bio-solids is also required. Diversion of waste water through sewers and out of ground water drainage basins can reduce recharge, which in turn may contribute to reduced stream flows and depletion of ground water in certain aquifers. On-site septic is more expensive than most sewer connection charges.

- The Growth Management Act requires the concentration of development in and around urban areas. Because of the concentration of such development, it is assumed that sewer systems will be the primary means of getting rid of waste water. Recharge in areas of concentrated growth that are sewered may therefore be reduced.

- Community on-site sewage systems are an excellent method of serving larger developments in semi-rural and rural areas as they provide recharge. Adequate management and maintenance is lacking for most installations.

- Maintenance and operation of on-site sewage systems is necessary for insuring their success, both in longevity and the affect they have on surface and ground water.

2.8 Well Construction and Decommissioning (WC)

- Resolving the issue of potential aquifer contamination by improper well construction or decommissioning involves ensuring that existing regulations pertaining to construction and decommissioning are followed. Problem well construction practices of the past may have resulted in wells that should be decommissioned. Given a sufficiently large work-force and ample budget, the Washington Department of Ecology (Ecology) could inspect every new well that is constructed; inspect every existing well that is decommissioned; locate, inspect and properly decommission wells that have been abandoned or were constructed before WAC 173-160 was adopted. In reality, however, Ecology has sufficient work-force and budget to inspect only a fraction of the wells constructed and decommissioned each year. The number of older wells in need of proper decommissioning can only be estimated. Few records exist for wells installed before submittal of drillers' logs became a legal requirement in 1973. The lack of records for older wells makes locating them largely a matter of chance, community memory, and detective work.

- The principal objective of proper decommissioning procedures is to restore, as far as practicable, the original hydrogeologic conditions at the well site. Proper decommissioning procedures entail sealing the well in such a way that water is excluded from the well and no vertical movement of water is possible. An improperly decommissioned well may serve as: (1) a conduit for contaminated ground or surface water, (2) permit continued running of water to the surface from a flowing artisan aquifer, (3) alter the pressure conditions within a confined aquifer which may enable water from separate aquifers to mix, possibly allowing poor quality water to mix with good, or (4) present a potential source for personal injury, loss of life and/or property damage at the surface.

- The casing in some of the older, deeper wells in the County are perforated at more than one aquifer level. Multi-aquifer taps effectively cross connect aquifers. The practice is no longer permitted for several reasons. Contamination of an upper aquifer can quickly be spread to a lower aquifer through a well which taps both. Water can be drained from an upper aquifer to a lower aquifer through a connecting well, adversely affecting water level.

- In order for any of the construction requirements to work adequately, there must be a better inspection and enforcement program by Ecology or an authorized representative. A representative of the Northwest Regional Office of Ecology (NW Office) estimated that the NW Office receives approximately 285 drillers' logs for new wells each month, or approximately 3,400 logs each year, from a seven-county area that includes Kitsap County. Of these new wells, only about 15 each month receive initial inspections; approximately 15 additional wells are inspected each month in response to complaints. The number of well inspections by Ecology is inadequate to ensure all well drillers use proper construction and sealing techniques, as well as make accurate well information reports.

- The most obvious problems include:
  - Lack of knowledge of how many unused and abandoned wells there are in Kitsap County and where they are located;
  - No process has been established to ensure that wells going out-of-service will be properly decommissioned;
  - The true degree of risk to ground water quality from unused, but not properly decommissioned wells.

3.0 Water Quantity Issues and Programs

3.1 Water Balance and Carrying Capacity (WB)

- The population in Kitsap County has grown rapidly in recent years and is expected to increase substantially in the future. Demand for water will increase with the population. Ground water provides over 80 percent of the water resource in Kitsap County. That percentage is expected to increase due to stream closures and the expense associated with processing surface water. Best estimates of the amount of ground water available is important to planning and evaluating what monitoring is prudent to track the actual impact of increased withdrawal on the county's aquifers. Evaluating the capacity and status of an aquifer system is complex. At best, currently developed mathematical models provide rough estimates of aquifer parameters. Water budgets cannot be rigorously used to asses resource availability because they do no allow provision of system response to additional withdrawals. One frequently used method to estimate the water resources of a basin is the Water Balance. The Basic Water Balance equation is:

  Precipitation = Evapotranspiration + Run-off + Recharge

- The water balance is not a fixed condition. It will change during a given year and from year to year. For the most part, precipitation will not vary significantly on an annual basis. The other components, however, can deviate dramatically from previous average values. Changes in run-off and evapotranspiration will change the water that is available to recharge ground water supplies. A rough estimate of the amount of ground water that can be extracted for beneficial use is sometimes referred to as Hypothetical Ground Water Yield (HGY). Potential Developable Yield, Hypothetical Developable Yield and Safe Sustainable Yield (SSY) are similar estimates of available ground water. SSY is a term used in State Law. HGY is the amount of water (expressed as a percentage of precipitation) that can be safely withdrawn from a ground water resource without resulting in over-drafting. HGY calculations estimate the percentage of precipitation that makes up recharges to ground water aquifers. Some experts feel 30 percent to 50 percent of recharge can be withdrawn without causing an overdraft of ground water resources, others recommend an even more conservative number. Each geographical area has different recharge characteristics due to soil, vegetation, climate, and precipitation differences. In Kitsap County it is estimated that 44 percent of the annual precipitation recharges the ground water (Grant 1 Vol. I).

Precipitation Disposition Estimates

36 percent	20 percent	44 percent
Evapotranspiration	Run-off	Ground water recharge

- ❑ Development can have a dramatic effect on recharge. It alters evapotranspiration and expands impervious surfaces thereby increasing run-off. Impervious surfaces, such as pavement and roofs, can reduce recharge. Diverting large scale run-off to recharge, can impact the ground water balance favorably. In some cases where run-off in cleared areas has been controlled, removal of vegetation has decreased evapotranspiration and increased recharge has resulted.

- ❑ If run-off is increased due to an increase in impervious surfaces, recharge diminishes. If the infiltration that is occurring from septic systems is eliminated when a sewer line is installed, recharge will decrease. Methods to mitigate these and other factors which degrade the water balance has not been developed. Water Quality concerns associated with enhancing recharge, complicate the process. Water demand estimates should drive water supply planning, in other words, if demand exceeds the projected supply, action to improve the SSY should be one of the options considered.

- ❑ The Data Collection and Analysis Plan (DCAP) for ground water (July 1989) and Volume 1 of the Kitsap County Ground Water Management Plan (Background Data Collection and Management Issues) identifies seven Kitsap County aquifers which may be showing signs of depletion. The studies indicate certain sections of the county could experience water supply problems early in the next century. These trend assessments are preliminary due to data limitations. Additional monitoring and analysis of county aquifers need to be conducted.

3.2 Mining/Over-Drafting (MO)

- ❑ Aquifer mining and over-drafting are general terms used to denote the condition caused by extracting more water from an aquifer than is being recharged. Over-drafting occurs whenever pumping exceeds the Safe Sustaining Yield (SSY) of an aquifer. Mining is the intentional over-drafting of an aquifer. When over-drafting activity continues unchecked, the volume of water in the affected aquifer will continue to be reduced until wells go dry and/or the natural outflow from the aquifer is decreased. Natural outflow is discharged into lakes and streams through springs and seeps on the surface of the land and through underwater vents to lakes or sea water. Adequate natural outflow is essential for sustaining stream base flows, maintaining lake levels, and preventing sea water intrusion.

- Water naturally discharges from aquifers at a rate which is controlled to a large extent by the amount of recharge. In a geological area like Kitsap County, some fresh water flows directly from aquifers to seawater. Well pumping can cause aquifer levels to drop without causing mining to occur. A lowered aquifer water level reduces the differential pressure between the aquifer and the Hood canal or Puget Sound. The reduced differential pressure results in a decreased flow from the aquifer to seawater. When the reduced flow to sea balances the increased extraction through wells, the aquifer water level will stabilize at a new lower level. If extraction reaches too great a rate, a steady lowering of the aquifer water level will occur over time, causing over-drafting.

- Over-drafting ground water from the shallower aquifers can have an adverse impact on surface waters and wetlands. To determine if over-drafting is occurring, careful monitoring must be conducted over an extended period of time and careful analysis of the data collected must be conducted. The County has many shallow and deep aquifers, some of which may be connected vertically as well as horizontally. As a result, determining with accuracy the amount of water that can be safely withdrawn from an individual aquifer before over-drafting will occur is perplexing. Monitoring aquifer capacity is important to prevent over-drafting. Predicting the capacity of a Kitsap County aquifer is difficult and expensive using existing data and analysis capabilities. Changing factors, such as land use modifications which impact recharge rates, complicates the process. The current best means of detecting an aquifer over-draft condition is to record and analyze static water level over a long period of time, and observe the strain on an aquifer which is caused by a sustained pumping test.

- Most corrective actions for over-drafting are triggered by persons who notice a drop in the water level of their well and notify Ecology. Once a bona fide over-drafting problem is verified, Ecology sets in motion the processes and procedures prescribed under the water laws of the State. This process is crisis oriented.

- Ecology cannot dictate all of the actions necessary to correct a problem. Under RCW 90.54.130 they can only recommend land use and other policies deemed necessary to protect ground and surface water resources. Many of the corrective actions necessary for preventing over-drafting can only be carried out through coordinated efforts at the local level. The process requires a commitment on the part of all of the involved entities to work together.

- Accurate and comprehensive ground water information is not yet available for some growth management decisions. Accurate accounting of water taken from County aquifers is limited. Historical aquifer water level data needs to be compared to data from the comprehensive monitoring program which is being established to detect the onset of over-drafting.

- Because of the lack of data, it is highly unlikely that all of the aquifers in the County have been identified. Additional well drilling and pumping data needs to be gathered, particularly in the west and south areas of the County. Because few deep wells have been drilled, the extent of the deep aquifers is not adequately known.

- Sufficient information on aquifers which Kitsap County shares with Pierce and Mason Counties is not available.

3.3 Seawater Intrusion (SI)

- Kitsap County consists of two islands and a peninsula which is almost completely surrounded by seawater. With over 200 miles of coastline, the potential for seawater intrusion is a significant concern, although few cases have been officially recorded to date. For the purpose of clarification, seawater intrusion is defined here as the underground displacement of freshwater by seawater and does not include geologically old waters with high mineral content.

- Small amounts of salt in freshwater (i.e., below 100 MG/L Cl.) is not considered harmful for human consumption and is difficult to detect by taste. Much smaller concentrations can contribute significantly to corrosion and cause damage to pumping equipment over time. The associated sodium contamination is of concern to people with high blood pressure. Early warning of contamination can be provided by a monitoring system because salt is fairly easy to detect in small amounts. Monitoring is typically conducted at selected domestic, public and specially drilled monitoring wells, located where movement of the freshwater/seawater interface can be detected.

- Public Health Service drinking water standards indicates two percent of seawater in fresh ground water will make it unusable. The State Department Of Health (DOH) has set a limit of 250 milligrams per liter(MG/L) chloride for potable water. Above this level, water is considered to be polluted.

- The fresh water/seawater interface position is determined by the difference between the hydraulic heads of seawater and freshwater and the volume of freshwater available. If the freshwater head (or height above sea level) is great and the aquifer water balance is adequate to maintain flow to seawater, the interface will be located off the shore line. As the freshwater head decreases, the interface layer becomes less vertical and moves inland. In this condition, seawater, being heavier, flows under the freshwater and pushes it up slightly forming a Ghyben-Herzberg lens (i.e., the lens is the underground freshwater that floats on top of the seawater). If the freshwater head is maintained, the interface layer will remain relatively static.

- The movement of ground water in an aquifer can be painfully slow. In such situations, it is difficult to flush seawater contamination from an aquifer and re-establish an original freshwater/seawater interface. Once contaminated, an aquifer may remain polluted for decades.

- On the Kitsap Peninsula, some movement of the boundary occurs due to seasonal fluctuations in recharge and tidal movement. If the freshwater head is lowered because the recharge rates drop and/or well pumping is excessive, seawater intrusion can occur. If the differential head is large, a small drop in the freshwater head will not have a great influence on the movement of the interface layer. If the differential head is small, a modest drop in the freshwater head can trigger a large movement of the interface layer and a large intrusion of seawater.

- While unsubstantiated reports exist on seawater intrusion, documentation of its occurrence in Kitsap County has not been established. The Bremerton-Kitsap County Health Department (BKCHD) has only one recent report of intrusion. That case, which occurred in the Hansville/Kingston area, was evaluated to be caused by seasonal fluctuation in ground water pressure.

- Seawater intrusion has been reported near the beach at sea level in the Lofall area. Other areas in which unofficial reports have been made are Presidents Point and Point Jefferson which are south of Kingston and some areas on Bainbridge Island. Seawater intrusion in these areas needs to be evaluated.

- Kitsap County does not have a program which monitors for indicators of seawater intrusion or its precursors. All local reports of seawater intrusion received by the BKCHD, DOH, the PUD, and other agencies are not filed and analyzed in one location.

- Seawater intrusion considerations are mentioned only briefly in the county's Growth Management Plan. Increased storm-water run-off, installation of sewer lines to replace septic systems, development of ground water sources near the shoreline and similar growth related actions are not evaluated for the impact they may have on seawater intrusion. Areas where seawater intrusion is an identified problem are not given a sensitive area classification.

- Current preventative strategies depend on data from existing wells to determine if intrusion is occurring. In areas where wells are a significant distance from the shoreline, intrusion already may be a problem by the time it is detected.

3.4 Stormwater Run-off, Retention and Recharge (SR)

- Stormwater run-off has historically been treated as a nuisance to be discarded. As a result, efficient drainage systems have been constructed to remove stormwater from highways, fields, farms, and residential, commercial and other land development. Much of the stormwater is rapidly discharged to creeks and the sea. If stormwater was effectively retained, the benefits could include supplemental recharge to aquifers, enhancement of stream base flows, control of stream peak flow, and reduction of stream bed erosion and the associated adverse impact on stream biota.

- Ground water recharge is defined as the addition of water to the zone of saturation. The term recharge is further generalized to include precipitation run-off (e.g., from housing developments or logging activities) that collects in detention or retention basins and, therefore, has the potential to increase the amount of water in an aquifer. Retention refers to water collected in retention ponds or natural basins where it can infiltrate to the subsurface, percolate in the zone of saturation, and become aquifer recharge.

- Stormwater run-off varies with soil type, degree of storm length and intensity, and changes in land use. Sandy or gravely soils accept more recharge and contribute less run-off than clay or glacial till. Heavy rains contribute proportionately more water to run-off than do light rains. Replacement of natural vegetation with impervious surfaces turns potential recharge into run-off. Run-off can be reduced (and recharge increased) by retention of stormwater in ponds or diversion into recharge enhancing areas such as a swale.

- Stormwater run-off is a highly variable quantity. Increases in impervious surfaces through activities such as soil compaction, paving, or roofing can increase run-off. Clear cutting or grading can increase run-off.

- Run-off which comes from roof tops, streets, drive ways, parking lots, and even residential yards may contain pollutants.

- Without careful planning and/or mitigating action, development can have negative impacts on retention and recharge. Undisturbed forest soils have the ability to retain precipitation and recharge ground water with a minimum of run-off. Retention is enhanced by vegetation and duff which retains precipitation, prevents run-off, and allows for maximum infiltration time. Depending on soil composition, the forest floor in undeveloped conditions readily absorbs water and little overland flow occurs even during very heavy rain events.

- Detention ponds are designed to temporarily hold and then release water at a slow rate in order to prevent the run-off from causing erosion and flooding. Retention ponds are designed to hold stormwater for a longer period, allowing it to infiltrate into the ground where it potentially can recharge ground water. Retention ponds also dissipate run-off through evaporation. Retention ponds tend to be significantly larger than detention facilities. Depending on soil types and contributing land uses, retention facilities often require more maintenance. Both types of impoundments create additional costs and take up development space.

- ❑ A lack of research and technology for diverting stormwater run-off to recharge is hampering more comprehensive programs. Practices and facilities for stormwater diversion are expensive. This is true for regional retention and treatment facilities and to a lesser extent for single family residences. Many stormwater quality and processing questions remain unanswered. Few model projects are available to serve as examples of what is cost effective. Without adequate data, it is difficult to justify some of the potential expenditures which could correct stormwater run-off problems.

- ❑ Planning for retention facilities should be part of comprehensive basin planning. Comprehensive drainage plans for each drainage basin have not been completed. An important objective of any comprehensive drainage plan is the prevention of damage caused by uncontrolled run-off.

3.5 Development Impact (DI)

- ❑ The cumulative impact of population driven demands on water and expansion of impervious surfaces are altering the natural water balance within watersheds.

- ❑ Rates of pumping and impervious surfaces have a cumulative affect on ground water. If both factors are increased at the same time, the aquifer will be depleted faster than if either factor were acting alone. A depletion trend in aquifer water levels may indicate that the original carrying capacity of an aquifer, Safe Sustainable Yield (SSY), has been exceeded. To compensate for an increase in water demand, recharge rates must be increased above pre-development rates if continuous aquifer decline is to be avoided. If an increased SSY is not established through increased recharge, action will be necessary. Alternatives to water use reduction or curtailing development include bringing water from an outside source to supplement the supply or water reuse.

- ❑ Additional water from an outside source can support higher development densities which will increase impervious surfaces, decrease recharge, and decrease the SSY of the local aquifer even further. New development in areas where the possibility of over-drafting exists must compensate for the loss in recharge. Examples of compensation include septic system recharge, roof run-off infiltration systems and stormwater retention facilities.

- Current Surface Water Management practices, which are applied to new developments, require that post development run-off attempt to meet pre-development run-off. However, mitigation is seldom totally effective. Two common methods of mitigating run-off are detention and retention ponds.

- Land use controls and technical processes specifically tailored for recharge preservation have not yet been incorporated into the County Comprehensive Plan. Specifically, aquifer recharge rates should be maintained when possible, the ratio of impervious surfaces to raw land should be kept low, and run-off should be reclaimed for use or recharge where feasible.

- EIS are reviewed on a case by case basis. The EIS process focuses on each individual project and not the cumulative impact many small or exempt projects may have on ground water quantity. The accumulative effects of many small land use conversions occurring in a drainage basin are not evaluated, because each assessment is done on a case by case basis.

3.6 Erosion Control (EC)

- Surface erosion is a term that relates to the movement and removal of soil by wind, stormwater, or a combination of the two. Other types of soil movement include land slides, stream bank erosion and erosion caused by freezing and thawing. The amount of vegetative cover, the shape and slope of the land, types of soils, climatic conditions and exposure time are among the factors that determine the amount of erosion that can occur.

- Run-off entering stream channels causes additional erosion as stream banks are under cut and the bed scoured out. Most of the soils carried away are silts and clays. When a granulated condition in the top layers of soil have been changed, run-off will increase and infiltration decrease.

- Specific scientific investigation is lacking on changes to infiltration rates as a result of the erosion process. Data is needed on the rate of erosion over time associated with development activities and the resulting impact on ground water quantities. Significant erosion can occur during development and then decrease quickly when work is completed and site landscaping is finished. After completion, major erosion problems can occur off site, particularly to stream channels if run-off is increased. If stormwater run-off is diverted from natural lakes, ponds. and wetlands to sewers and stormwater systems which dump to the sea, recharge can be adversely affected.

3.7 Hydraulic Continuity (HC)

- Hydraulic Continuity is "the interconnection between ground water (aquifers) and surface water sources. An aquifer is in hydraulic continuity with wetlands, lakes, streams, rivers or other surface water bodies whenever it is discharging to these water bodies. It is also in continuity if it is being recharged by surface water. Hydraulically connected ground water and surface water cannot be considered as independent resources. A withdrawal from one will have some effect on the other." Under Chapter 90.44 RCW, hydraulic continuity is described as any underground water that is "part of or tributary to the source of any stream or lake." Any activities that impact recharge to ground water (e.g., changes to infiltration, evapotranspiration, or runoff), may have an impact on hydraulically connected surface water.

- The Hydraulic Continuity policy developed by the Water Resources Forum states, "Since ground water is assumed to be in hydraulic connection with surface water bodies, this policy has statewide application. Case-by-case evaluations will be used to distinguish exceptions, i.e., those instances where ground water is truly confined. Ecology regional offices shall refer to this policy in making permit evaluations and decisions" (Draft Hydraulic Continuity Policy Paper, The Water Resources Forum). In Kitsap County the flow of ground water directly to seawater is common. That form of hydraulic continuity involves significantly different considerations than hydraulic continuity between ground water and fresh surface water and should be treated as an exception.

- Ground water and surface water within most areas of the State are in some form of natural interrelationship or hydraulic continuity. The more pressing issue is determining the degree of impact or the significance of the relationship one has on the other by withdrawal or alteration of other factors. Given the highly variable geologic conditions in Kitsap County, hydraulic continuity evaluations need to be aquifer specific.

- The Washington Administrative Code (WAC 173-515-10 through 173-515-100), regulates lakes and streams on the Kitsap peninsula to maintain safe levels and assure continuation of existing beneficial uses. In this WAC, the Washington State Department of Ecology (Ecology) has closed or partially closed most streams and lakes in the county to surface water withdrawal for domestic use.

- Specifically, on the Kitsap peninsula, Ecology has ordered three lake closures, 20 stream and river closures, and 16 partial closures of creeks, rivers and streams, and three partial lake closures. Thirty-two of the closed streams and creeks, which each have an estimated annual flow of 5 cfs or less, also have high instream values for anadromous fish, aesthetics, water quality, and/or recreation. In total, Ecology has closed or placed restrictions on 70 surface water bodies on the Kitsap Peninsula. The number of fully closed surface water bodies is 62. Thirty-nine of these are in Kitsap County. The rest are in Pierce and Mason Counties.

- Current technology and data available do not allow for readily cost-effective and timely determinations of risk regarding the hydraulic relationship between surface water and ground water. This is particularly true for the deeper and more complex systems that exist in the county. Beyond the recognition that continuity exists, the concern must not be about the risk of any impact, but about the risk of significant, negative impacts.

- While hydraulic continuity exists between surface and ground waters, a no impact policy is unattainable and in fact is meaningless. What needs to be determined is what the impact is, how much of an effect it will have on the effected surface or ground water, the timing of the impact, and whether senior water rights are involved.

- To make resource allocation decisions in general and particularly in situations where there is an identified significant hydraulic relationship between surface and ground water, policy guidance has to be given regarding what beneficial use has priority. This determination must be made by the legislature as it sets State policy.

3.8 Water Conservation (CN)

- Water resources to support future County growth will be partially dependent on recognizing the value of our ground water resources and the implementation of effective water conservation plans. Conservation of water is a tenet of State law, directed at both suppliers and consumers of water and local water plans must incorporate a conservation plan. Education on water conservation will be required at the private and public levels for proper water supply management. Water resources saved through conservation plans can be utilized to reduce the impact on our ground water resources, help maintain base stream flows, and delay the development of more costly water sources. Possible conservation measures include block-rate pricing structures, metering all Group A and B systems, encouraging homes and business to use low-flow fixtures and appliances, and innovative irrigation practices (drought tolerant species, xeriscaping, etc.).

- Homes and businesses can be furnished with low flow fixtures and appliances. A new water efficient home, which incorporates low flow fixtures and appliances, can reduce indoor consumption by as much as 35 percent over a non-conserving home, with no appreciable impact on lifestyle. Similar water saving devices and appliances can be installed in businesses.

- Major reductions in residential outdoor water is also possible with modifications in landscaping practices. Approximately thirty percent of domestic water use is for lawns and gardens. Typically, between 20 and 50 percent of water applied to landscaping either evaporates or runs off. More efficient irrigation practices, use of more drought tolerant plant species, better turf preparation, and alternative landscaping designs (xeriscape) that reduce high water consumption turf areas are all strategies that can be employed to lower outdoor demand. Efforts in California to work with nurseries on conservation measures such as customer education, low use irrigation devices, and low water use plants has been helpful.

- Recognizing the real value of water is an important step in implementing water conservation. Charges for water by many systems in Kitsap County is so low that encouraging conservation through a revised rate structures could be effective. Higher rates could provide capital for system conservation measures such as leak detection and correction. Block rates which increase commodity charges incrementally as consumption increases, have been successfully adopted in many areas in the west. Some systems do not have meters installed or do not use existing meters to set water charges. Conservation benefits and costs must be taken into account, including impact on hard to quantify benefits such as enhanced stream flow. Defining the true cost of water use would be helpful in identifying wasteful practices and in designing programs and incentives to foster more efficient water use.

- Inadequate information is available on the condition and age of the many water systems. Data on the number of connections and approximate population served by Group A systems is reliable. Few water systems have an organizational and financial base large enough to develop and carry out a comprehensive conservation plan. The rest of the water systems, most likely, will need both financial and technical assistance to carry out effective conservation efforts.

- A method of addressing conservation through rates is by implementing an increasing block structure. As more water is used a higher rate for each incremental amount is charged. Experience shows that raising the cost of water has an immediate effect on people, but they will return to their normal water use once they are accustomed to the higher rates.

- Conservation of water supplies is essential to the proper management of Kitsap County ground water resources. A uniform standard of efficiency or minimum acceptable practices to be achieved by all water purveyors and users has not been established. To ensure creditability, it will be necessary to develop standards for evaluating the costs and benefits of potential conservation measures. When possible, assessments should be based on field studies.

3.9 Water Reuse (RU)

- Water reuse is defined by the State as "use of reclaimed water, in compliance with Washington Department of Health and Ecology regulations, for a direct beneficial use". Reclaimed water is effluent from a waste-water treatment system that is adequately treated for reuse. The use of reclaimed water is becoming more accepted throughout the country as water resource managers and the public are made aware of the advantages. In its "Interim Solutions to

Public Water Supply needs," the State has identified water reuse as one of the strategies to meet future water requirements.

- Over 33 mgd of water are used in Kitsap County (1992 data). An estimated 10 to 15 mgd are potentially available for reuse. Reclaimed water has not been processed for potable uses in the County, but local projects have effectively used reclaimed water in applications such as crop irrigation, athletic field and golf course watering, industrial processes, and even ground water recharge. No large-scale reuse projects are currently in place in the County. A potential exists to reused water in the County in applications which do not require drinking water standards.

- Significant factors associated with the reuse of waste water include the costs of treatment and removal of contaminants, the infrastructure required to deliver the reuse water from processing to application sites, public acceptance of recycled water, regulatory and policy barriers to reuse, and quality control.

3.10 Water System Interties (IT)

- A system of interties between the major purveyors in the county would provide a number of benefits including provision of water between systems during an emergency and allowing purveyors to respond to situations such as aquifer over-drafting or sea water intrusion. A comprehensive system of interties connected to well fields with adequate source, would enable planners and elected officials to make growth management decisions based on a variety of appropriate considerations without being constrained by water source availability in the vicinity of designated urban areas. Interties may also facilitate implementing ground water recharge protection measures without undue impact on high density residential, commercial, and industrial areas.

- Although the Coordinated Water System Plan (CWSP) addresses eventual establishment of a system of interties, a comprehensive plan for developing interties has not been started. Current state law on interties may restrict their use as a water resource management tool. Water Right practices on point of use, as currently interpreted by the Department of Ecology (Ecology), could constrain or delay use of interties to respond to water resource management problems.

4.0 Water Rights Administration

4.1 Water Rights (WR)

- In 1971, the Legislature added to the State's water law the basic legislative policy guiding water allocation and use decisions. The Legislature declared that the proper utilization of water resources was necessary for promotion of the State's economic well-being and preservation of the State's natural resources and aesthetic values. The Legislature directed Ecology to develop a comprehensive State water resources program and adopt rules that would ensure that future water resource allocation and use would be consistent with the new policies. It was under this authority that Ecology filed WAC 173-515, Instream Resources Protection Program-Kitsap Water Resource Inventory Area (WRIA) 15 on July 24, 1981. This administrative rule is very important to the future appropriation and management of ground water in Kitsap County, particularly because of hydraulic continuity issues. The water rights process provides a framework for establishing the "first in time" basis for allocating water. It does not guarantee water will be available for all uses to which a right has been granted nor does it assure an applicant that their water allocation will not be curtailed or suspended at some time in the future.

- ❑ The current State water-right permitting process consumes large amounts of time and resources, does not take a comprehensive approach to water allocation, and is backlogged by years. The State needs a less time consuming, more efficient water rights management process so that Ecology can use its personnel in activities which produce more benefit.

- ❑ The Growth Management Act has set forth comprehensive requirements for utility (water) planning, development, coordination, and management. Cities, special purpose districts, and other providers are responsible for meeting the water supply requirements which are developed in the growth management process. The current water rights procedures frustrate water resource planning and development required by the growth management process.

4.2 The Ground Water (5000 GPD) Exemption(5K)

- ❑ Private domestic wells have traditionally served the water needs of single households and are exempt from the water rights permit process, if consumption is less than 5000 gallons per day (gpd). The exempt status has been deemed sufficient by BKCHD to serve up to 6 residences. Private well drilling has proliferated due to the failure of the water rights permitting process, raising concerns that construction of small systems will proliferate, create a threat to ground water resources, and cause unnecessary administrative burdens. Elimination of the exemption would be detrimental to many individuals and may adversely impact the ground water management process.

5.0 Monitoring - Data Collection and Management (DC)

- ❑ Long-term data for trend analysis is generally required to evaluate changes in the hydrogeologic system related to ground water development, land use changes, and climatic patterns. A comprehensive program of monitoring should include the collection of water level, water use, precipitation, stream flow and water quality data. Changes in the hydrogeologic system are usually quite subtle; therefore extended periods of monitoring are generally required to evaluate trends.

- The Division of Drinking Water within the Washington State Department of Health (WDOH) regulates public water systems and requires a wide variety of monitoring to ensure the quality of water supplies. For well supplies, this ongoing data collection targets coliform bacteria, inorganic and volatile organic chemicals, and pesticides. The monitoring requirements are based on the type and size of the system and on results from previous sampling. The Federal Safe Drinking Water Act (SDWA) is structured to add additional requirements for testing every three years.

- The Bremerton-Kitsap County Health District (BKCHD) is the repository for water quality data for public systems. All data obtained from the installation and testing of new wells (i.e., well log, pump test data, inorganic and bacterial analysis, and pump specification information) are forwarded to Kitsap Public Utility District (KPUD). KPUD visits each new well site to determine elevation and location. A Unique Well Identification Number, if not already assigned, is placed on the well at this time. This data is then entered into a data base and a hard copy is filed by geographic location. The process provides a valuable summary of basic water resource data for use by hydrogeologists and other water planners.

- As part of the Ground Water Management Program, KPUD has established a comprehensive network of monitoring sites throughout the county. The network includes wells for monitoring water level and water quality, stream gauging stations, and precipitation gages. KPUD has primary responsibility for gathering and maintaining water resource data for the County. KPUD is also assuming responsibility for data management and AutoCAD support activities at the local level to facilitate the orderly accumulation and management of accurate data. KPUD has established approximately 30 computerized data centers with local utilities, agencies, and others who will routinely report data within the County.

- KPUD is also involved in a private well sampling program. The program provides free water quality testing services to owners of private wells. The program will provide valuable information regarding private well drinking water quality as well as additional hydrogeologic data (well logs, water levels, etc.) that can be used to better manage ground water resources. These efforts will eventually allow analysis of water quality trends and land use patterns to identify areas potentially at risk from activities that impact water quality.

- Information obtained through the construction of new wells represents one of the more important sources of information for water resource management. To be of optimum benefit, several refinements must be made to procedures for filling out associated documents. These changes should include:

    - Addition of a vicinity map to assist locating well sites.
    - New procedure for accurate determination of well elevation.
    - Improved accuracy and consistency in recording geologic logs.

- Lacking standard operating procedures for data collection, the accuracy of all imported information must be assessed prior to use. Increased communications between agencies will assist in establishing standard methodology while reducing the risk of duplicate efforts.

- Efforts must be made to take advantage of all available sources of water resource information. The monitoring program can be enhanced by the participation of citizen monitoring groups; however agencies must first establish standardized collection and reporting procedures for these groups to follow.

- Relevant water resource data comes from a wide range of sources to cover a broad array of subjects. This diverse data must be maintained, transmitted amongst participating entities and, perhaps hardest of all, made to relate within an integrated database.

- Management of such a complex database requires development of a data dictionary to define characteristics of all included data. This may include: reporting agency, method of collection, date of collection, etc. This dictionary will enable users to determine whether a particular database will meet their needs.

6.0 Education - Ground Water Education Program (ED)

- Public understanding of ground water, ground water management, and water related issues is basic to solving present and future water problems. Unfortunately, most people are only vaguely aware of the role ground water plays in their lives. The goals of a ground water education program is to educate citizens with respect to the problems and complexities of supplying safe, affordable, and high quality drinking water from ground water sources.

- Programs for ground water resource education need to be enhanced and expanded. Public involvement and education on non-point pollution problems are included in local watershed management plans but the issue of ground water contamination is not specifically addressed. Ground water protection is part of the Puget Sound Water Quality Authority (PSWQA) plan but an education program is not included or funded.

- The problems associated with protecting ground water are long-term and the solutions will be long term as well. Ground water education must be funded and developed for the long term.

Appendix G
List of Acronyms

Appendix G
List of Acronyms and Abbreviations

5K	the Ground Water (5000 GPD) Exemption
AET	Apparent Effect Threshold
af/yr.	acre-feet per year
AGI	Applied Geotechnologies Incorporated
APA	Aquifer Protection Areas
APC	adverse pollution conditions
APHA	American Public Health Association
ARPA	Aquifer Recharge Protection Areas
ASP	amnesia shellfish poisoning
ASR	Aquifer Storage and Recovery
BacT	a sample for bacterial contamination
BKCHD	Bremerton-Kitsap County Health Department
BMPs	Best Management Practices
BOH	Board of Health
CARA	Critical Aquifer Recharge Area
CCWF	Centennial Clean Water Fund
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
Cl	Chloride
CLEAN	Comprehensive Long-Term Environmental Action Navy
CN	water conservation
County	Kitsap County
CSWMP	Comprehensive Solid Waste Management Plan
CWA	Clean Water Act
CWSP	Coordinated Water System Plan
DC	Monitoring - Data Collection and Management
DCAP	Data Collection and Analysis Plan
DCD	Department of Community Development
DECAP	Data Collection and Analysis Plan
DI	development impact
DNR	Washington State Department of Natural Resources
DNT	Dinitrotoluene
DOH	Washington State Department of Health
EC	electrical conductivity
Ecology (also DOE)	Washington State Department of Ecology
EES	Economic and Engineering Services
ED	Education - Ground Water Education Program
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ERUs	Equivalent Residential Units
ESA	Endangered Species Act
ESA	Environmentally Sensitive Area
ET	evapotranspiration
FC	fecal coliform

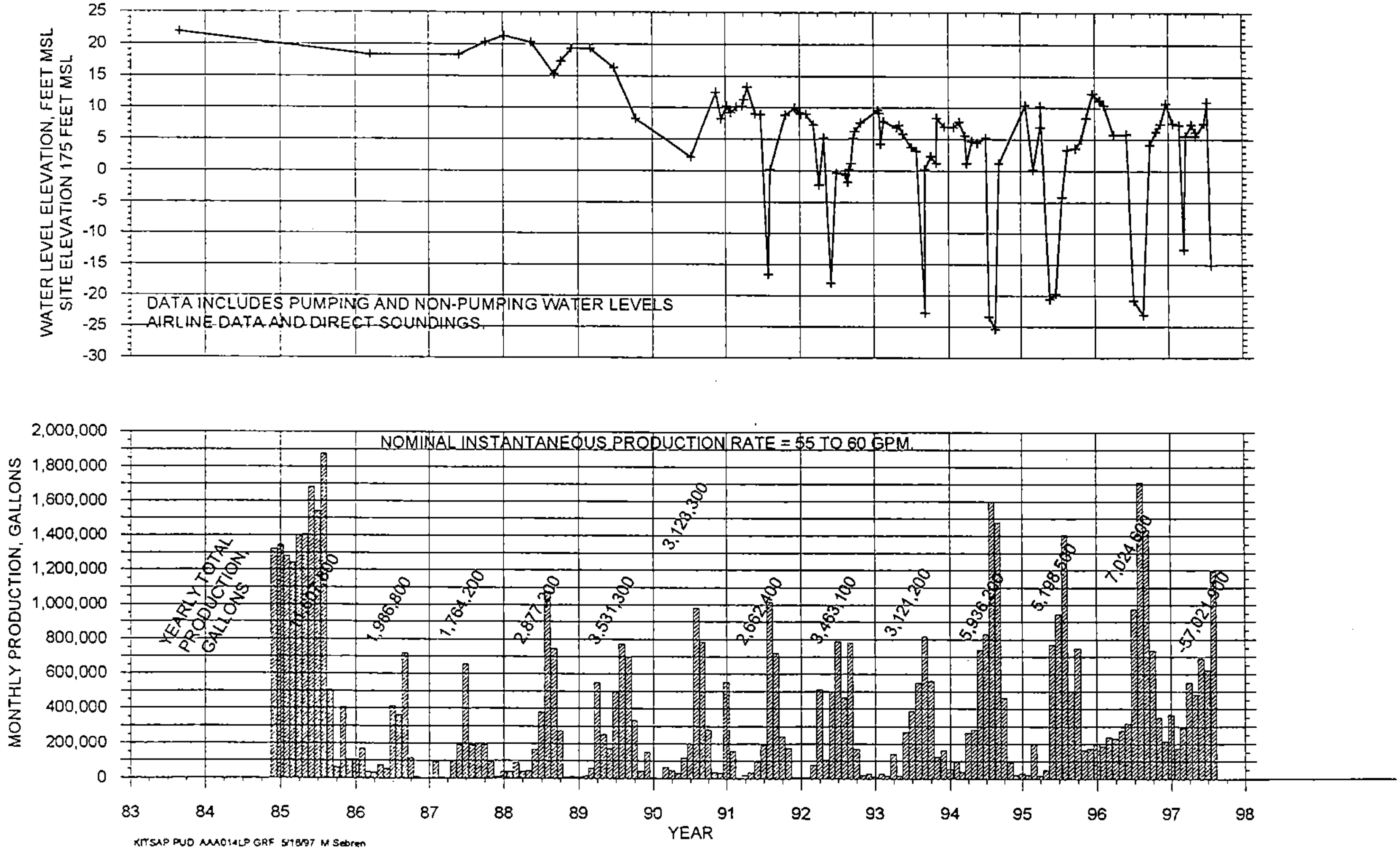
FDA	Food and Drug Administration
Fe	Iron
FP	fertilizers and pesticides
g	glacial deposits
GIS	Geographic Information System
GMA	Growth Management Act
gpd	gallons per day
gpm	gallons per minute
GWAC	Ground Water Advisory Committee
GWMA	Ground Water Management Area
GWMP	Ground Water Management Plan
HGY	Hypothetical Ground Water Yield
HM	hazardous material
ICP	inductively coupled plasma
IRP	Integrated Resource Planning
IRPP	Instream Resource Protection Program
IT	water system interties
IWAs	Initial Watershed Assessments
KCM	Kramer, Chin, and Mayo consulting firm
KPUD	Kitsap Public Utility District No. 1
KRPC	Kitsap Regional Planning Council
Lowland	Puget Sound Lowland
LUST	Leaking Underground Storage Tank
MCL	maximum contaminant level (legal limit)
MGD	million gallons per day
MG/L	milligrams per liter
MISF	minimum instream flow
MMSW	mixed municipal solid waste
Mn	Manganese
MO	aquifer mining and overdrafting
MOA	Memorandum of Agreement
MPN	most probable number (referring to BacT analysis
MSL	mean sea level
N	Nitrate
n	non-glacial deposit
ND	not detected
NMFS	National Marine Fisheries Service
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge
NPL	National Priority List (Superfund site)
NSSP	National Shellfish Sanitation Program
NWIS	National Water Information System
OFM	Office of Financial Management
OTA	United States Office of Technology Assessment
OUST	Office of Underground Storage Tanks
P	precipitation input
PCSTORET	an Environmental Protection Agency data file
PGG	Pacific Groundwater Group consulting firm
pH	measure of acid-base nature of a solution
PNPTC	Point-No-Point Treaty Council
ppb	parts per billion
ppm	parts per million
Program	Water Resources Program

PSAMP	Puget Sound Ambient Monitoring Program
PSCRBT	Puget Sound Cooperative River Basin Team
PSWQA	Puget Sound Water Quality Authority
PSP	paralytic shellfish poisoning
PSOG	Puget Sound Council of Governments
PSWQA	Puget Sound Water Quality Authority
PWS	public water system
Q	Quaternary
Qa	water right annual allotment in acre feet per year
Qi	water right allowable, instantaneous flow rate in GPM
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RFD	reference dose
R&N	Robinson and Noble consulting firm
RP	Recharge Area Protection
RU	water reuse
S	storage coefficient
SARA	Significant Aquatic Resource Areas
SARA	Superfund Amendments and Reauthorization Act
SASSI	State of Washington Salmon and Steelhead Stock Inventory
SCS	Soil Conservation Service
SDWA	Federal Safe Drinking Water Act
SEPA	State Environmental Policy Act
SG	Sand and Gravel Mining
SI	Seawater Intrusion
SMCRA	Surface Mining Control and Reclamation Act
SOC	Synthetic Organic Chemicals
SR	stormwater run-off, retention and recharge
SS	Septic System
SSWMP	Surface and Stormwater Management Program
SSY	Safe Sustainable Yield
SSY	Safe Sustaining Yield
SW	Solid Waste Disposal
Sy	specific yield
T	tertiary Age
T	transmissivity
TDS	Total Dissolved Solids
TI	total inflow
TK	total kendal, nitrogen
TNT	trinitrotoluene
TOT	time of travel
TPH	total petroleum hydrocarbons
TRIB	abbreviation for stream tributary
TSCA	Toxic Substance Control Act
UFC	Uniform Fire Code
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UT (or UST)	underground storage tanks
UTC	Utilities and Transportation Commission
UURHOT	unused underground residential heating oil tank
UWIN	Unique Well Identification Number
VOC	Volatile Organic Chemical
WAC	Washington Administrative Code

WATERPAK	Water Purveyors Association of Kitsap
WAT STORE	Water Data Storage Retrieval System
WB	water balance
WC	well construction and decommissioning
WDFW	Washington State Department of Fish and Wildlife
WDOH	Washington State Department of Health
WHPP	Wellhead Protection Program
WR	water rights
WRDMTF	Water Resource Data Management Task Force
WRIAs	Water Resource Inventory Areas
WRIS	Water Rights Information System
WSDA	Washington State Department of Agriculture
WSU	Washington State University
WUCC	Water Utility Coordinating Committee
WWUC	Washington Water Utility Council

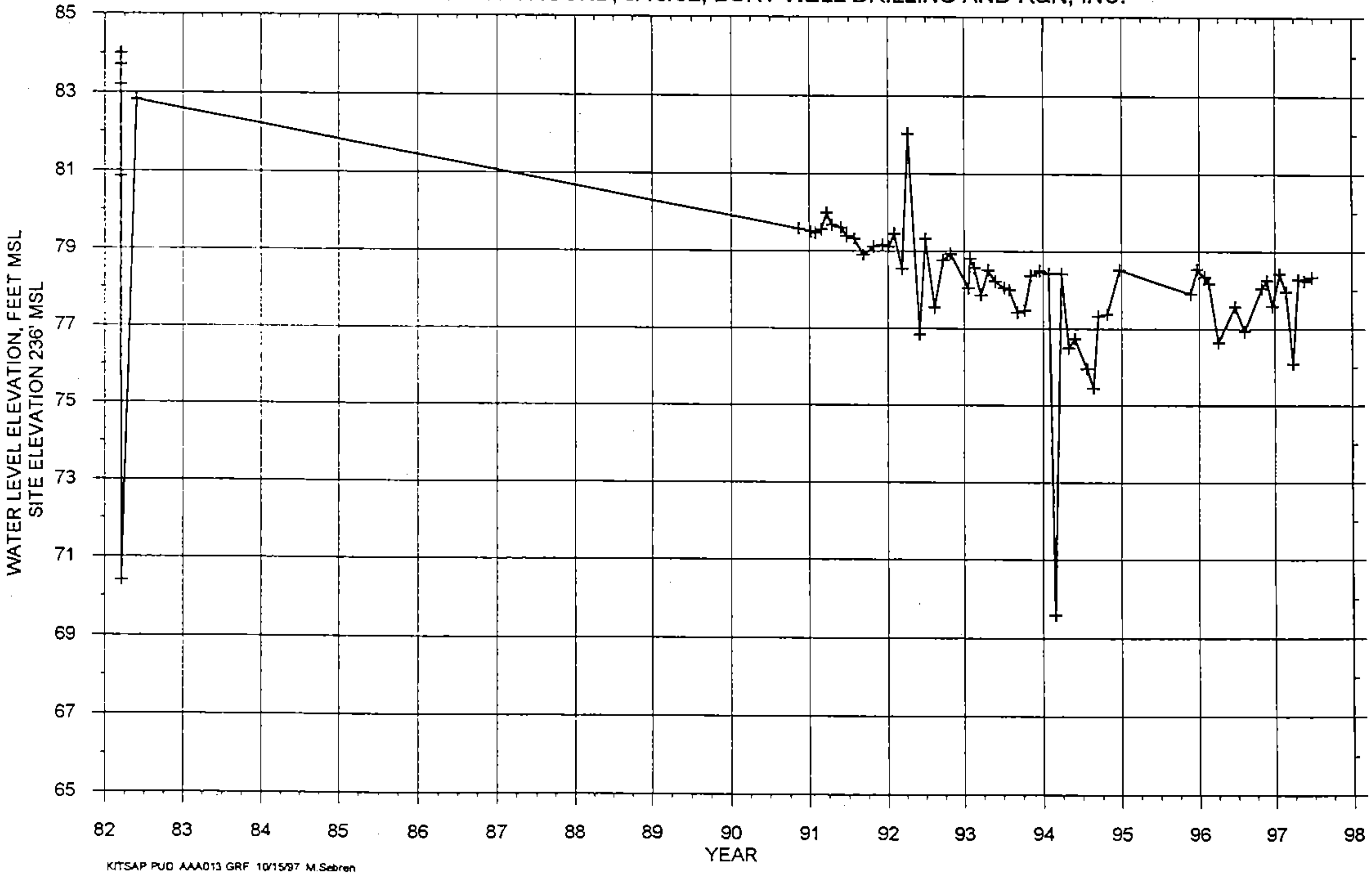
Appendix H
Water Level Hydrographs for Wells in Kitsap County

HYDROGRAPH AND PRODUCTION SUMMARY FOR INDIANOLA WELL 6 (AAA014).
T26N/R02E-10N. COMPLETION ELEVATION -133' TO -164' MSL.
CONSTUCTION SWL 21.9' MSL, 8/30/83, BURT WELL DRILLING AND R&N, INC.

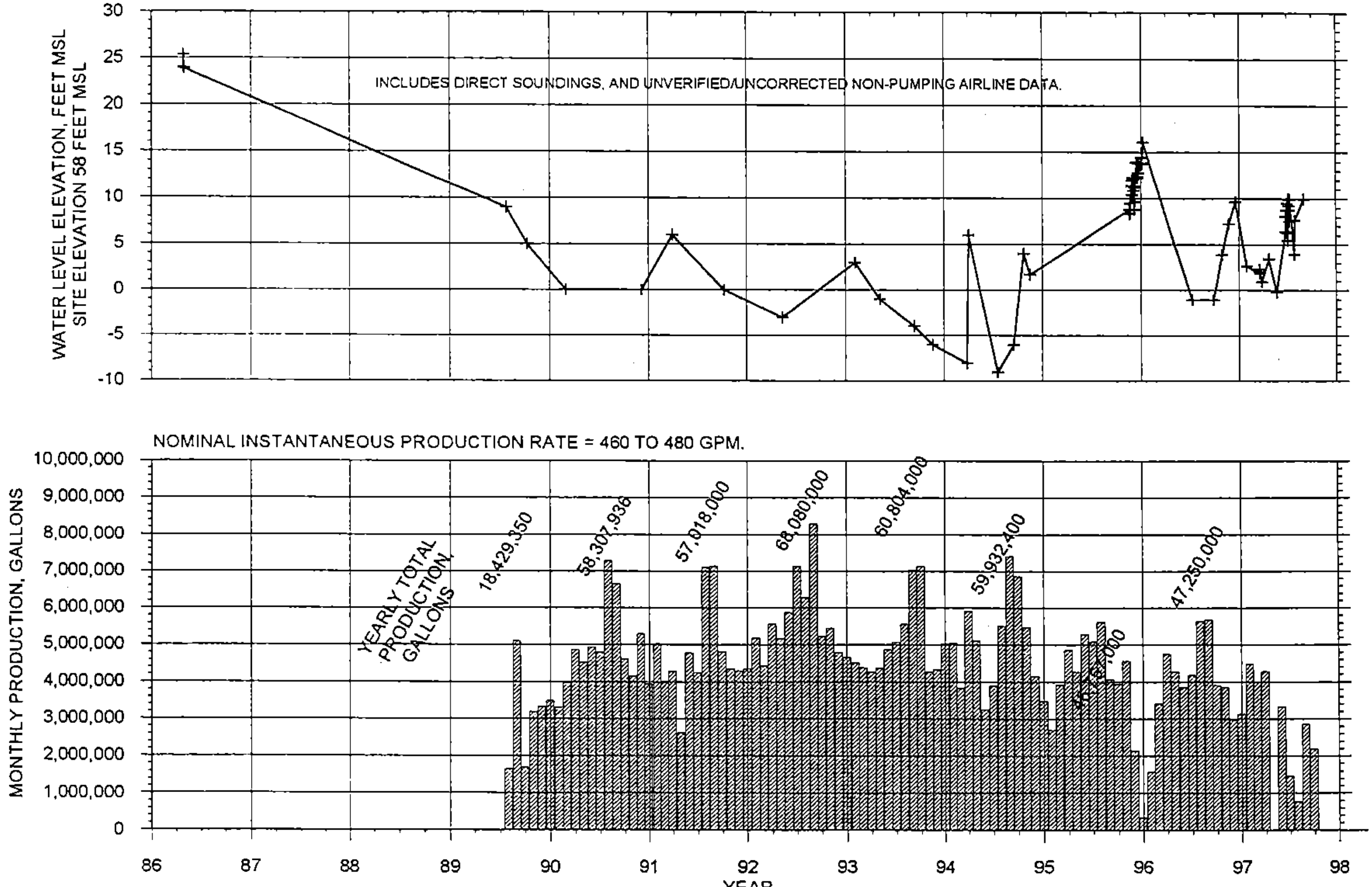


KITSAP PUD AAA014LP GRF 5/18/97 M Sebren

HYDROGRAPH OF WISE ACRES WELL (AAA013).
T26N/R02E-11P. COMPLETION ELEVATION -69' TO -89' MSL.
CONSTRUCTION SWL 152.8' BELOW GROUND, 3/15/82, BURT WELL DRILLING AND R&N, INC.

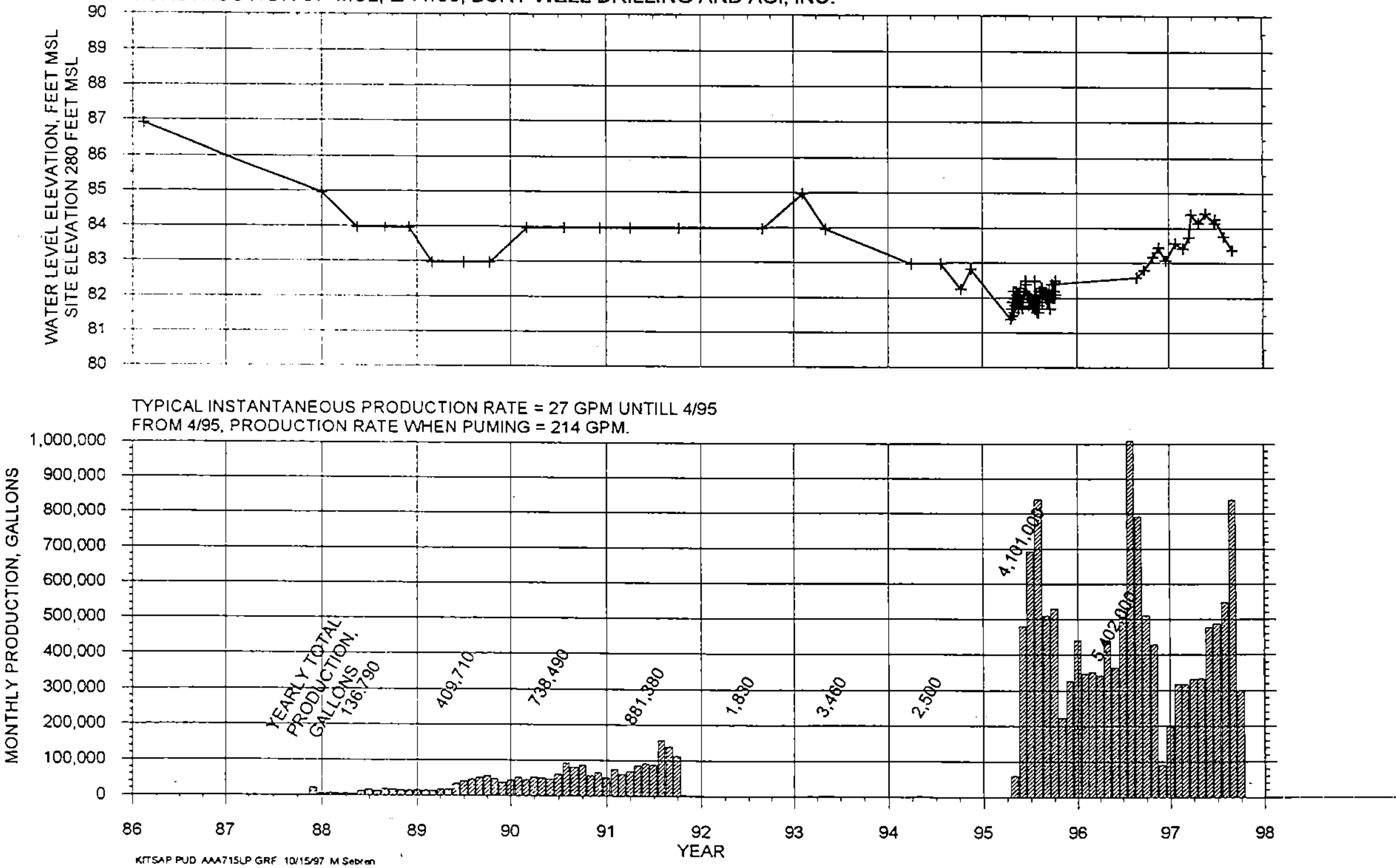


HYDROGRAPH AND PRODUCTION SUMMARY FOR AUGUSTA WELL 3 (AAA710).
T26N/R02E-16L. COMPLETION ELEVATION -221' TO -261' MSL.
CONSTRUCTION SWL 24' MSL, 4/29/86, BURT WELL DRILLING AND AGI, INC.

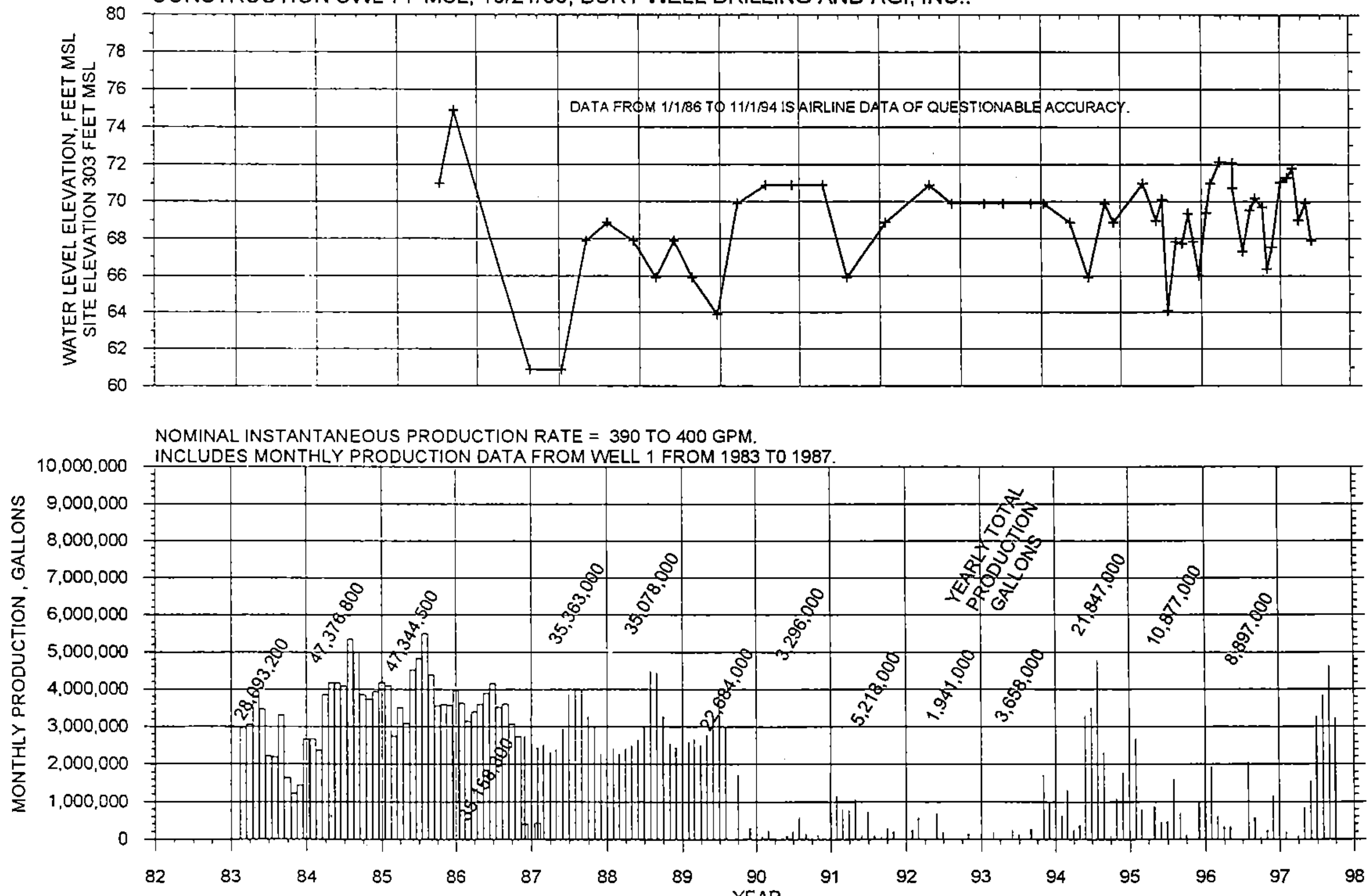


KITSAP PUD AAA710LP GRF 7/8/97 M Sebren

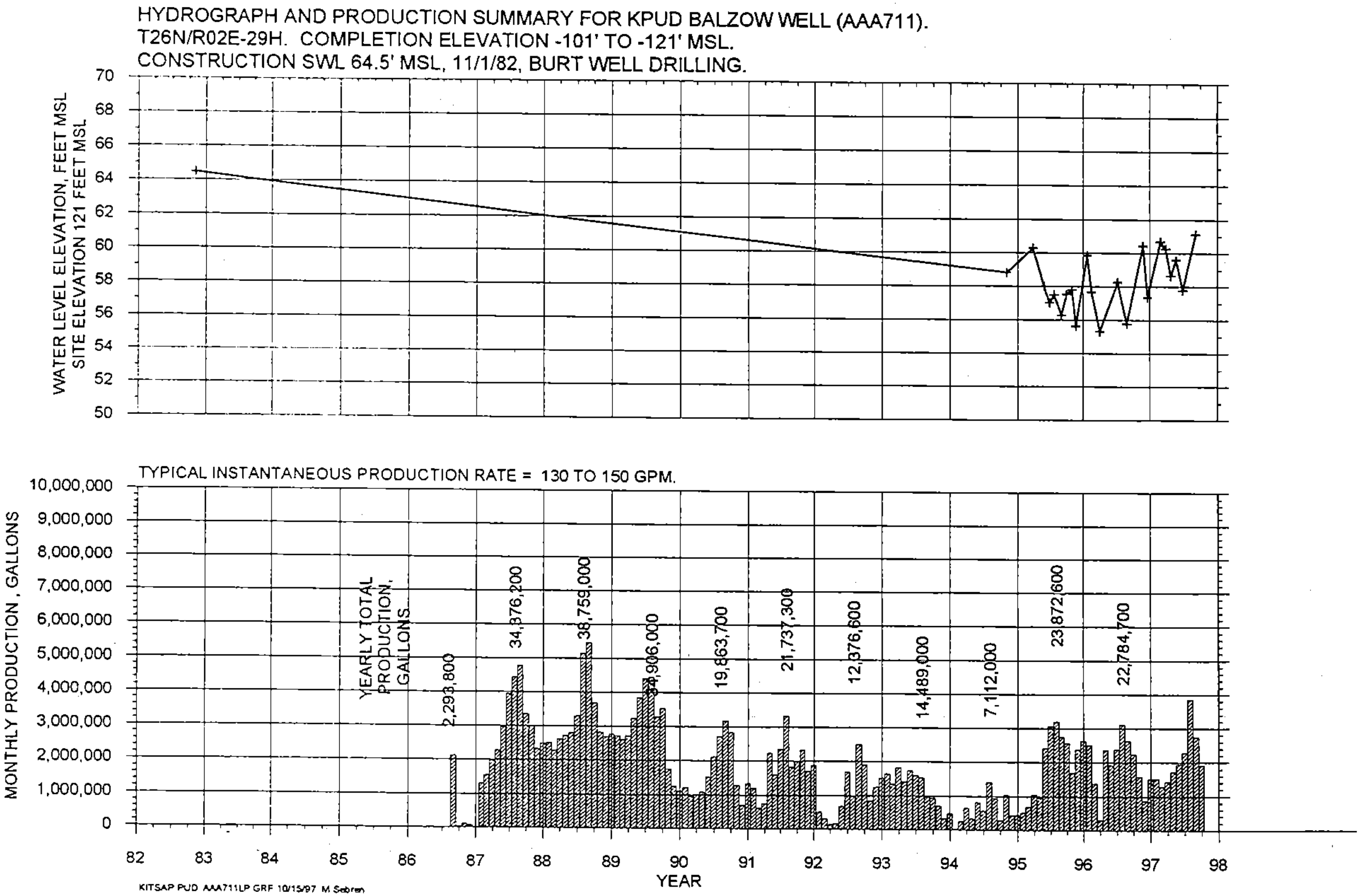
HYDROGRAPH AND PRODUCTION SUMMARY FOR WAGGONER WELL (AAA715).
T26N/R02E-17F. COMPLETION ELEVATION 22' TO 32' MSL.
CONSTRUCTION 87' MSL, 2/11/86, BURT WELL DRILLING AND AGI, INC.



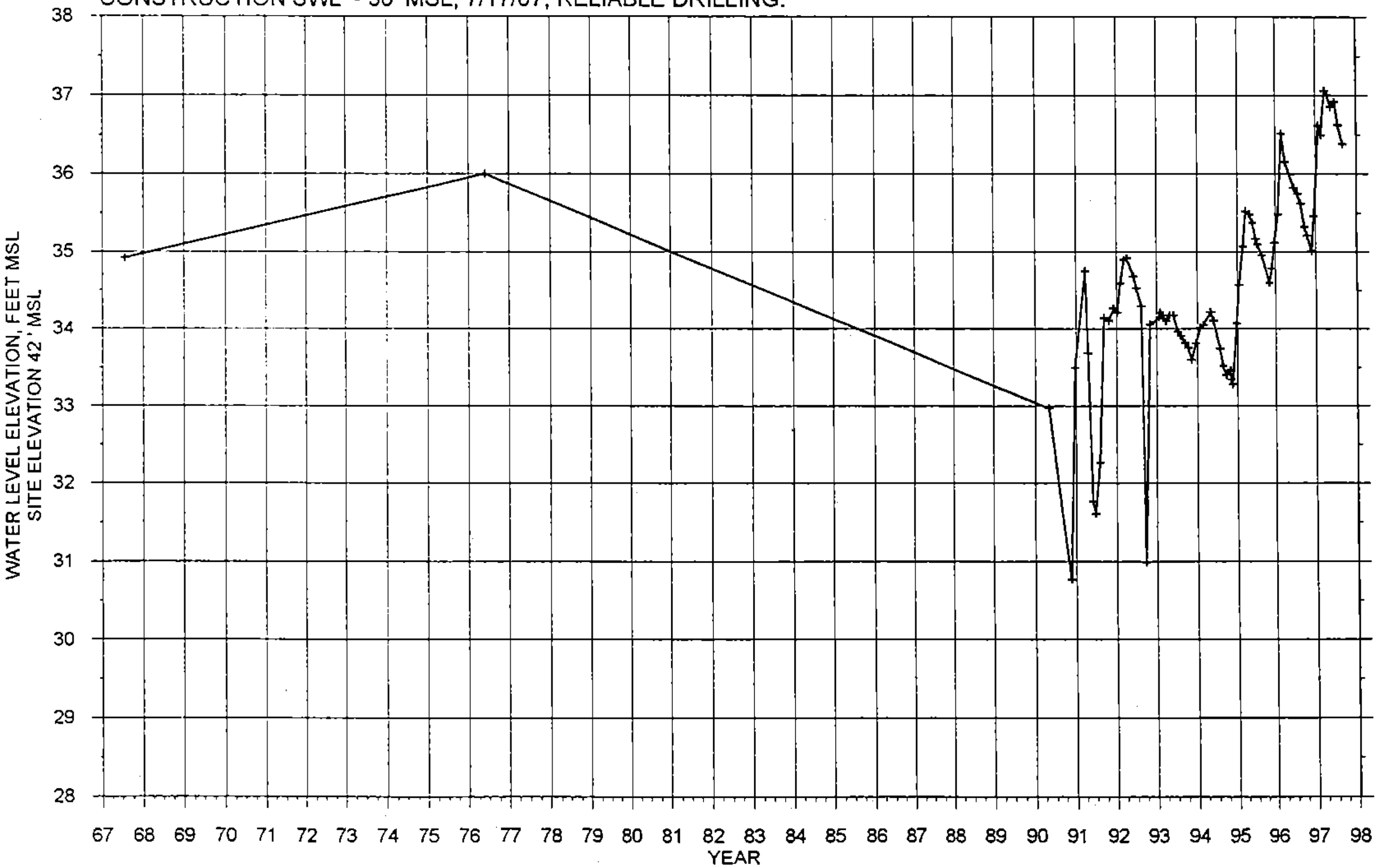
HYDROGRAPH AND PRODUCTION SUMMARY FOR PINE STREET WELL 2 (AAA713).
T26N/R02E-20H. COMPLETION ELEVATION -123' TO -156' MSL.
CONSTRUCTION SWL 71' MSL, 10/21/85, BURT WELL DRILLING AND AGI, INC..



KITSAP PUD AAA713LP GRF 10/15/97. M Sebren

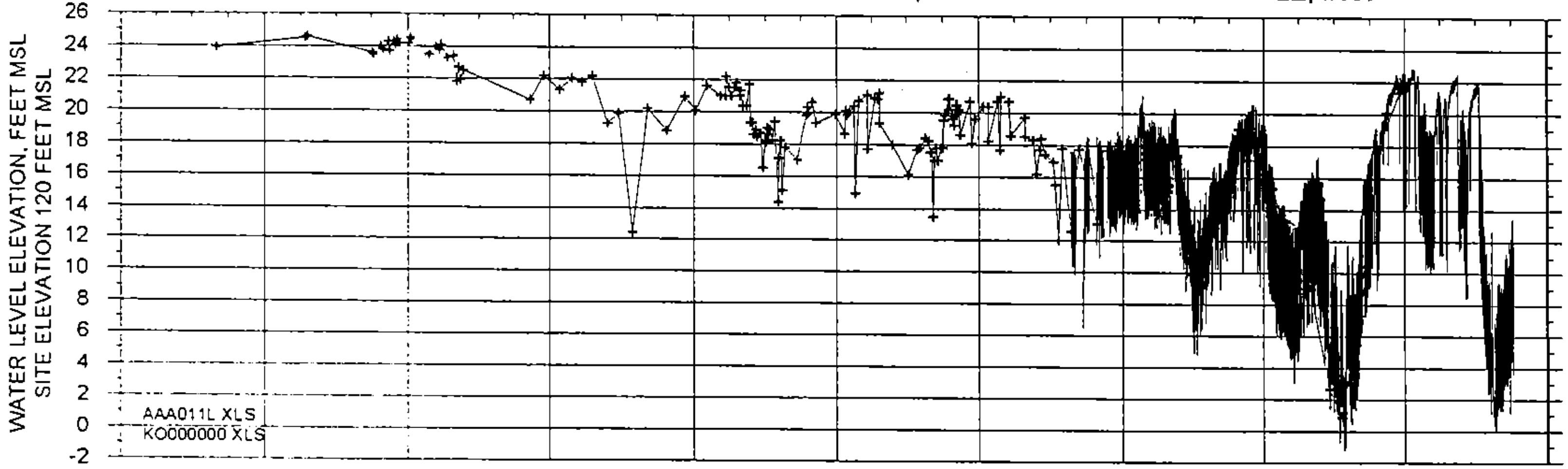

HYDROGRAPH AND PRODUCTION SUMMARY FOR KPUD BALZOW WELL (AAA711).
T26N/R02E-29H. COMPLETION ELEVATION -101' TO -121' MSL.
CONSTRUCTION SWL 64.5' MSL, 11/1/82, BURT WELL DRILLING.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION 121 FEET MSL
70
68
66
64
62
60
58
56
54
52
50
TYPICAL INSTANTANEOUS PRODUCTION RATE = 130 TO 150 GPM.
MONTHLY PRODUCTION, GALLONS
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
YEARLY TOTAL PRODUCTION, GALLONS
2,293,800
34,376,200
38,759,000
34,906,000
19,863,700
21,737,300
12,376,600
14,489,000
7,112,000
23,872,600
22,784,700
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
YEAR
KITSAP PUD AAA711LP GRF 10/15/97 M Sebren

HYDROGRAPH OF GAMBLEWOOD WELL 1 (AAA016).
T27N/R02E-20L. COMPLETION ELEVATION APPROX. -87' MSL.
CONSTRUCTION SWL ~ 36' MSL, 7/17/67, RELIABLE DRILLING.

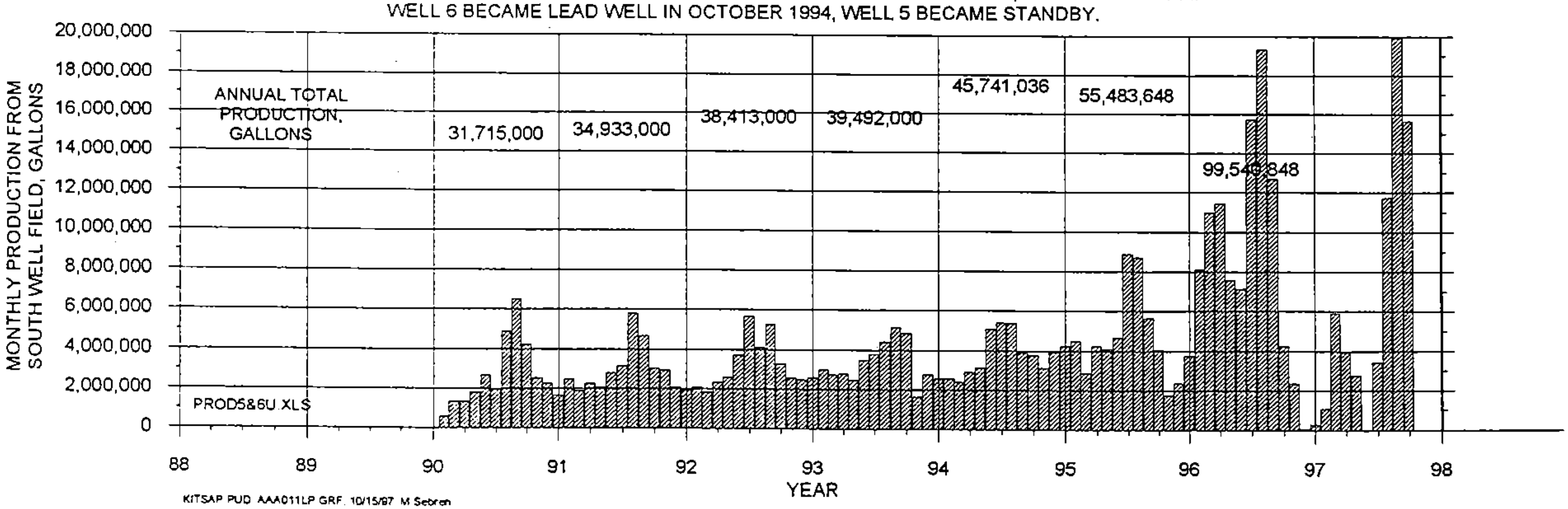


KITSAP PUD AAA016-2.GRF 10/15/97 M Sebren

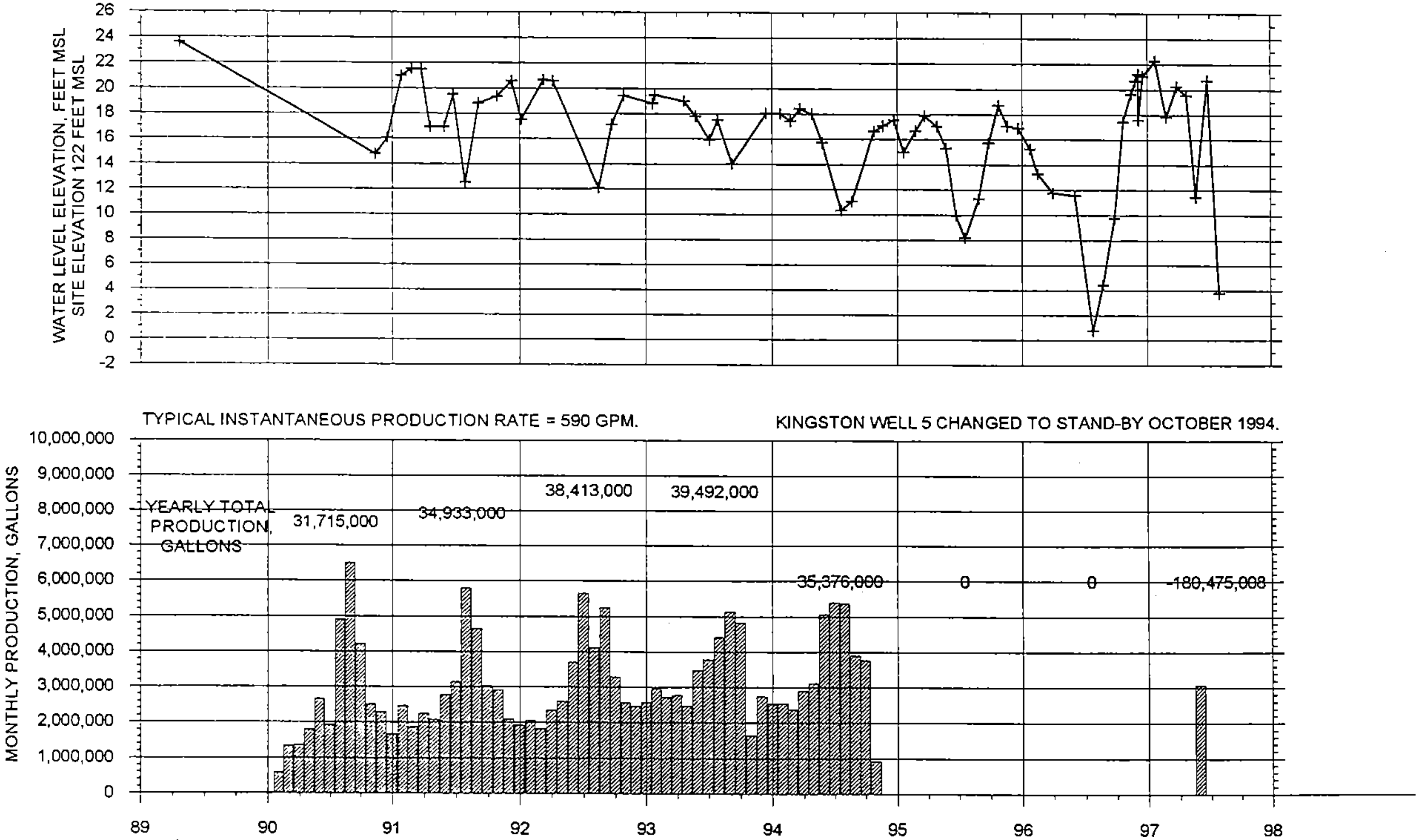
HYDROGRAPH OF KINGSTON OBSERVATION WELL (AAA011)
AND PRODUCTION SUMMARY FOR SOUTH KINGSTON WELL FIELD (WELL 5-AAA012 AND WELL 6-AAA707).
T27N/R02E-35K. COMPLETION ELEVATION -604' TO -725' MSL.
CONSTRUCTION SWL 24' MSL, 9/1/88, SCHNEIDER EQUIPMENT, INC. AND ROBINSON & N0BLE, INC.



TYPICAL INSTANTANEOUS PRODUCTION RATE: WELL 5 = 590 GPM, WELL 6 = 600 GPM.
WELL 6 BECAME LEAD WELL IN OCTOBER 1994, WELL 5 BECAME STANDBY.

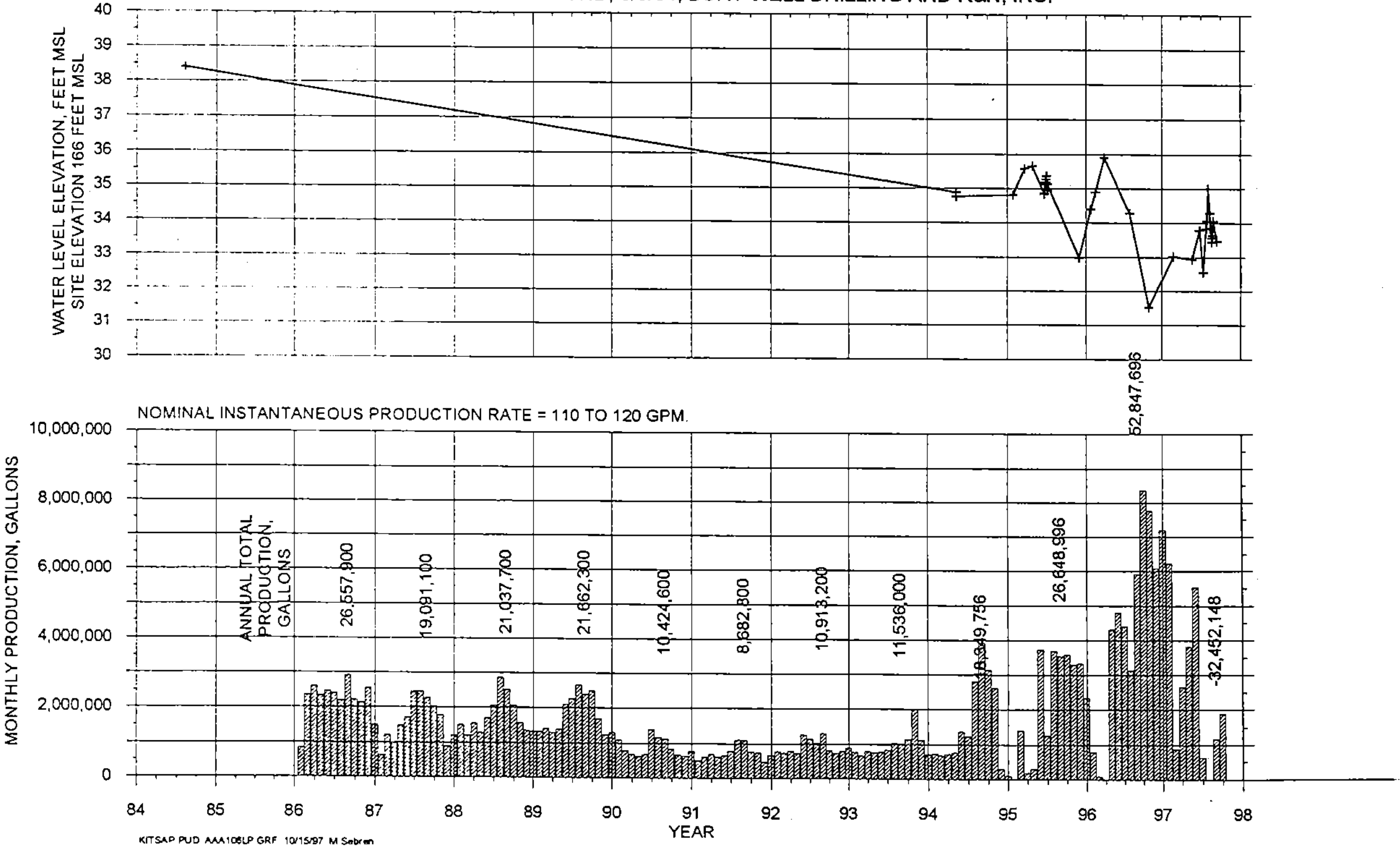


HYDROGRAPH AND PRODUCTION SUMMARY FOR KINGSTON WELL 5 (AAA012).
T27N/R02E-35K. COMPLETION ELEVATION -623' TO -684' MSL.
SWL AT CONSTUCTION 92.4 ' BELOW GROUND, 4/20/89, BURT WELL DRILLING AND ROBINSON & N0BLE, INC.

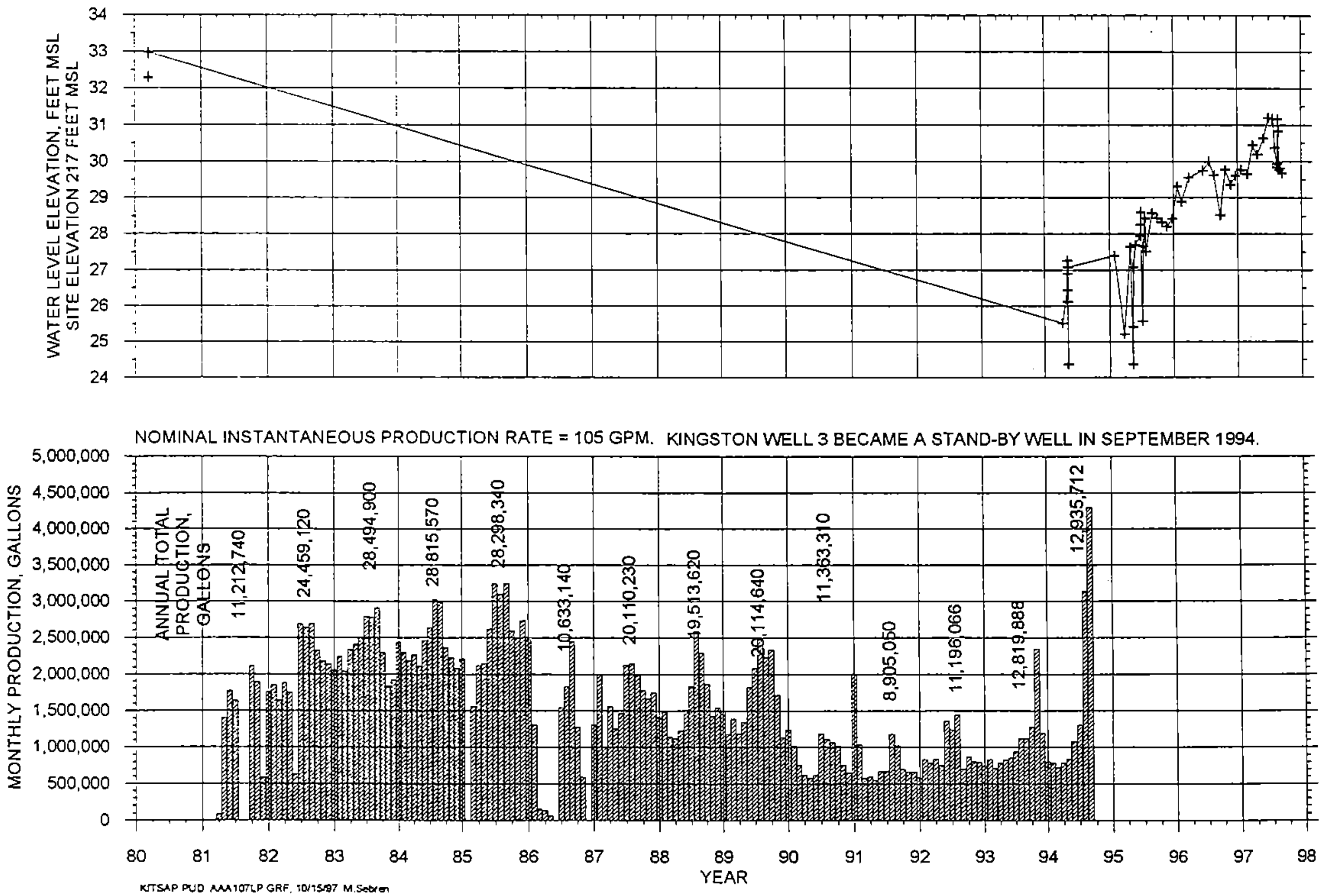


KITSAP PUD AAA012LP GRF 10/15/97 M Sebren

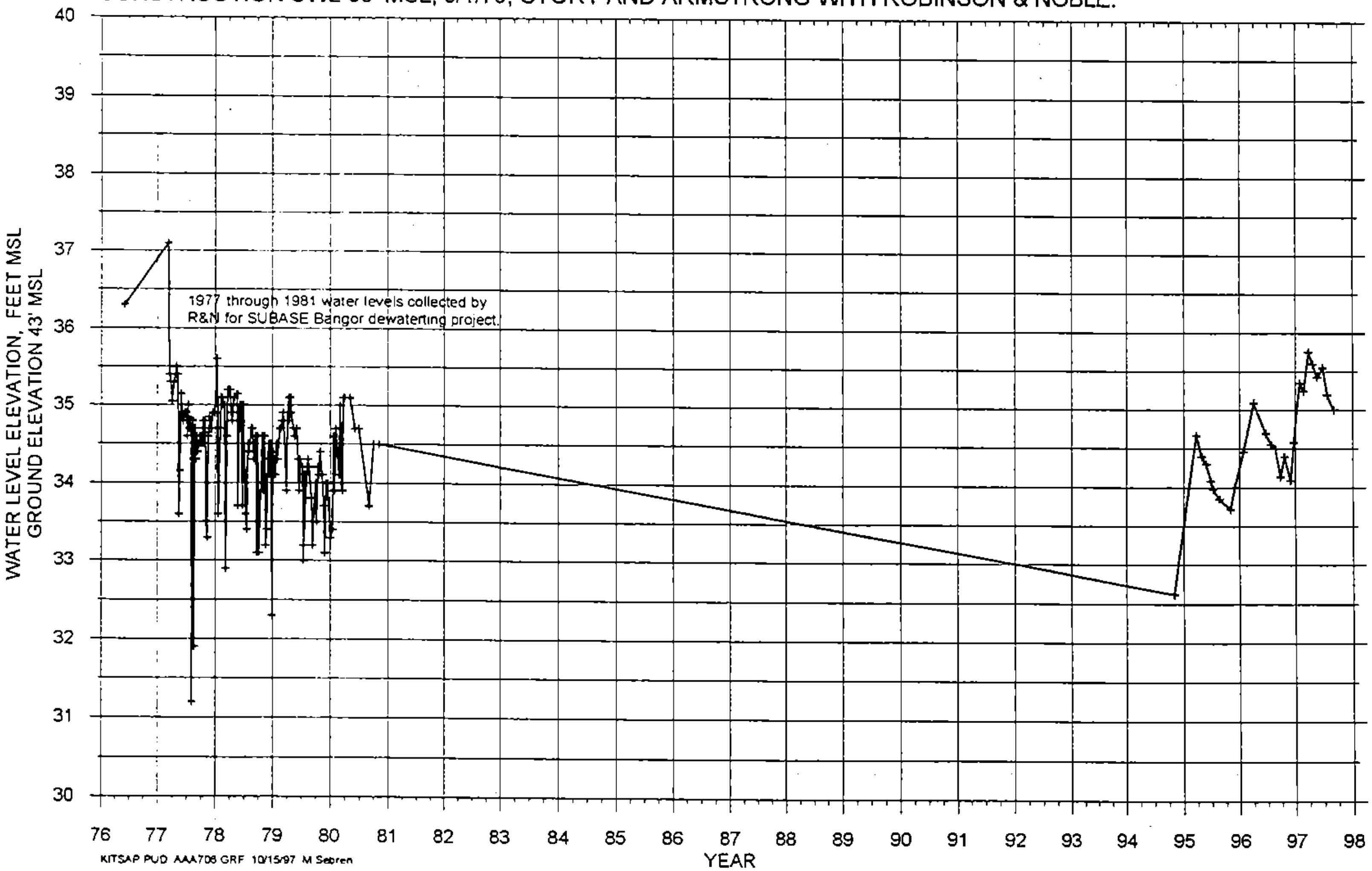
HYDROGRAPH AND PRODUCTION SUMMARY FOR KINGSTON WELL 4 (AAA106).
T26N/R02E-10N. COMPLETION ELEVATION -26' TO -36' MSL.
SWL AT CONSTUCTION 127.6 ' BELOW GROUND, 8/9/84, BURT WELL DRILLING AND R&N, INC.



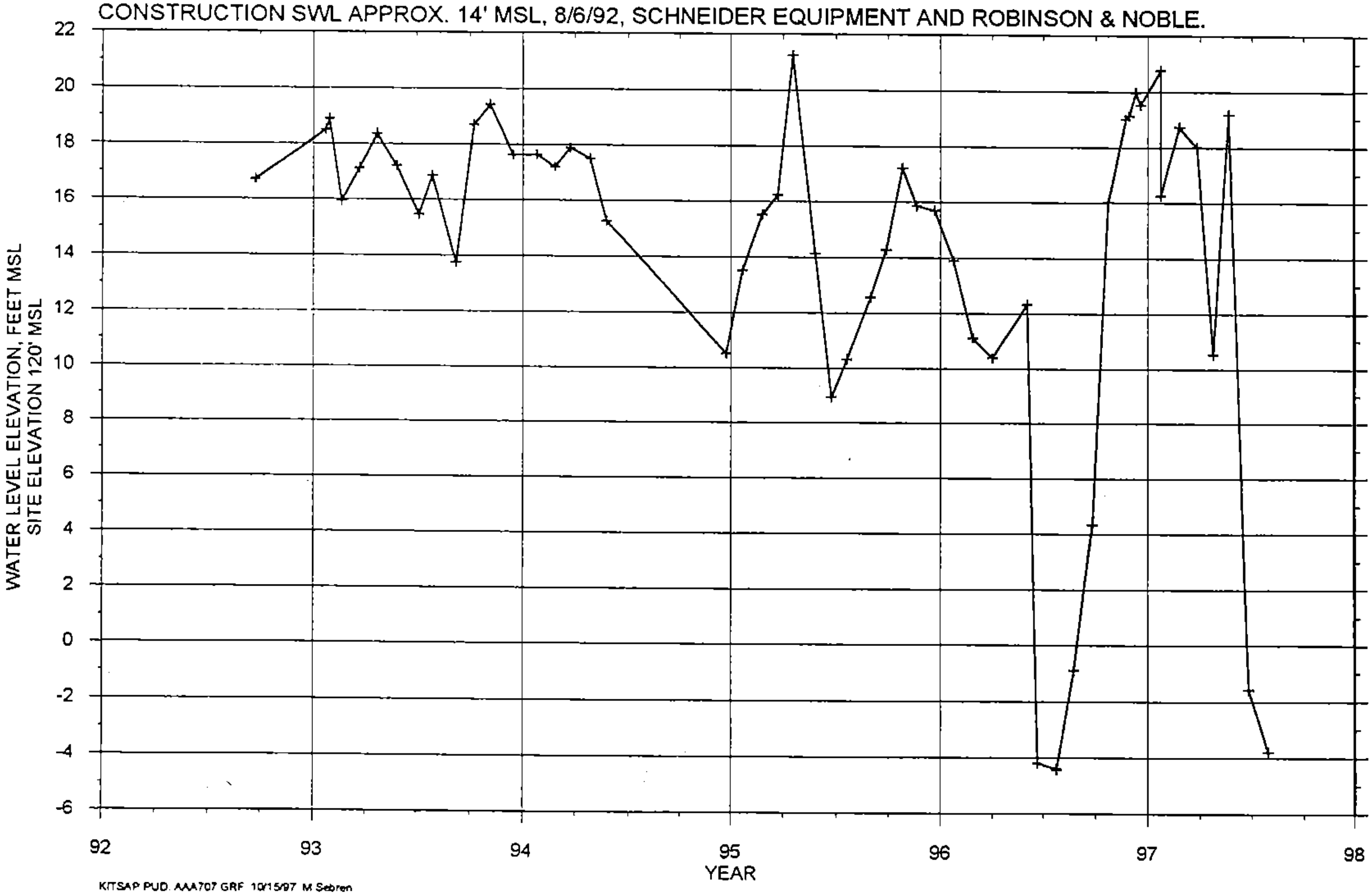
HYDROGRAPH AND PRODUCTION SUMMARY FOR KINGSTON WELL 3 (AAA107).
T27N/R02E-25E. COMPLETION ELEVATION -258' TO -268' MSL.
SWL AT CONSTUCTION 184.0 ' BELOW GROUND, 3/17/80, BURT WELL DRILLING AND ROBINSON & N0BLE, INC.



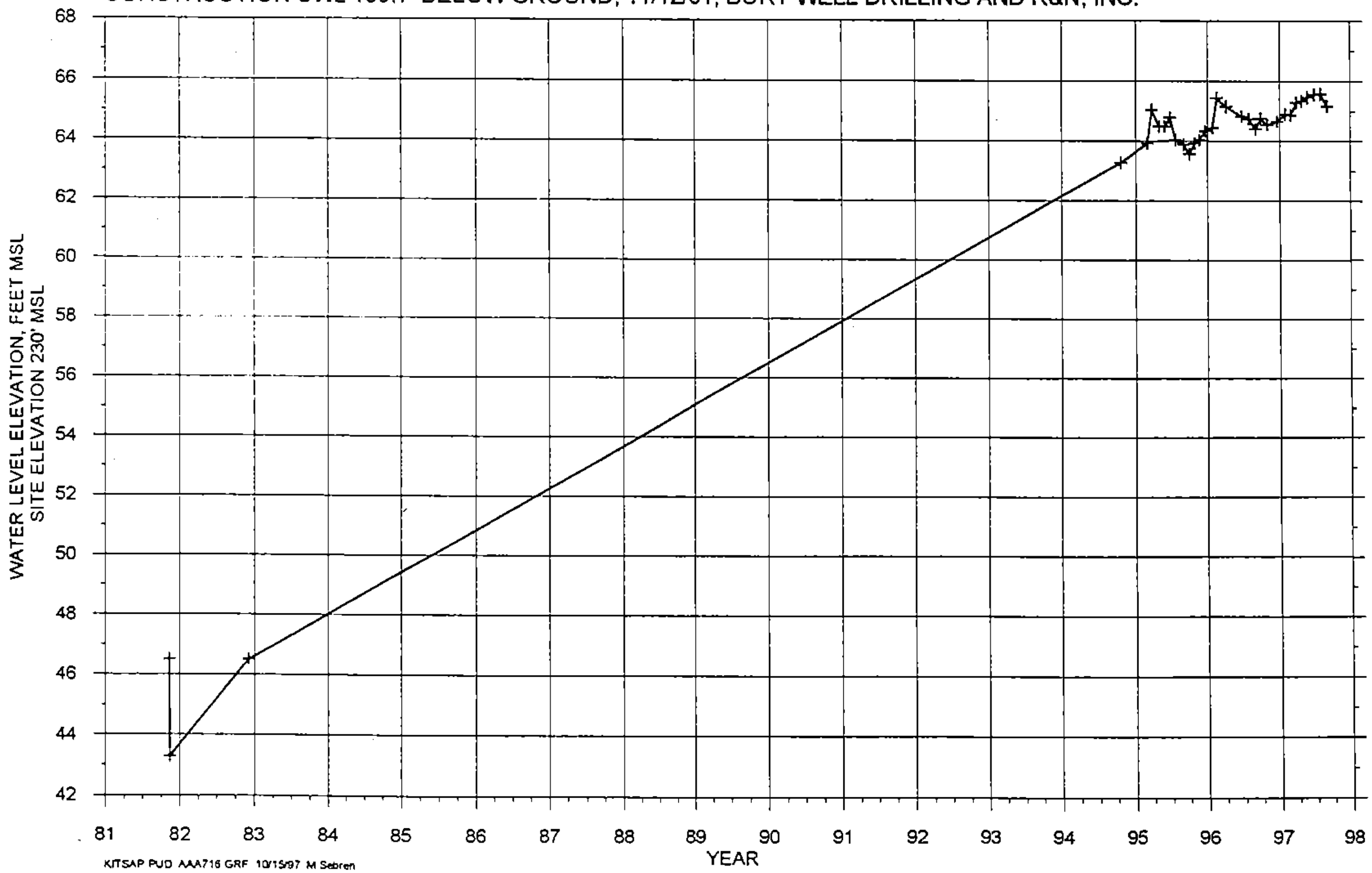
HYDROGRAPH OF KPUD GAMBLEWOOD WELL 2 (AAA706).
T27N/R02E-20L. COMPLETION ELEVATION -27.3 TO -64.6' MSL.
CONSTRUCTION SWL 36' MSL, 6/1/76, STORY AND ARMSTRONG WITH ROBINSON & NOBLE.

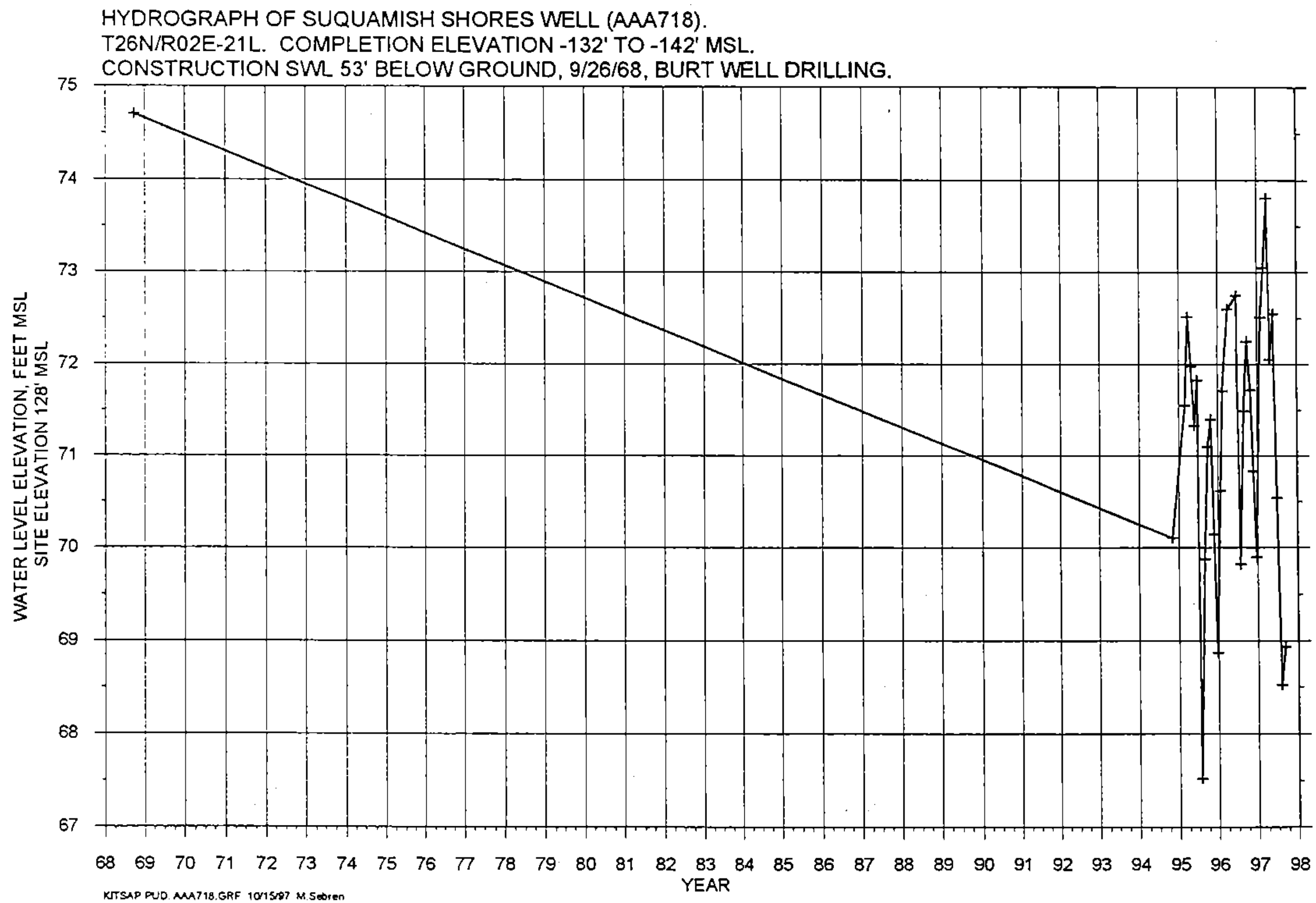


HYDROGRAPH OF KPUD KINGSTON WELL 6 (AAA707).
T27N/R02E-35K. COMPLETION ELEVATION -622 TO -687' MSL.
CONSTRUCTION SWL APPROX. 14' MSL, 8/6/92, SCHNEIDER EQUIPMENT AND ROBINSON & NOBLE.

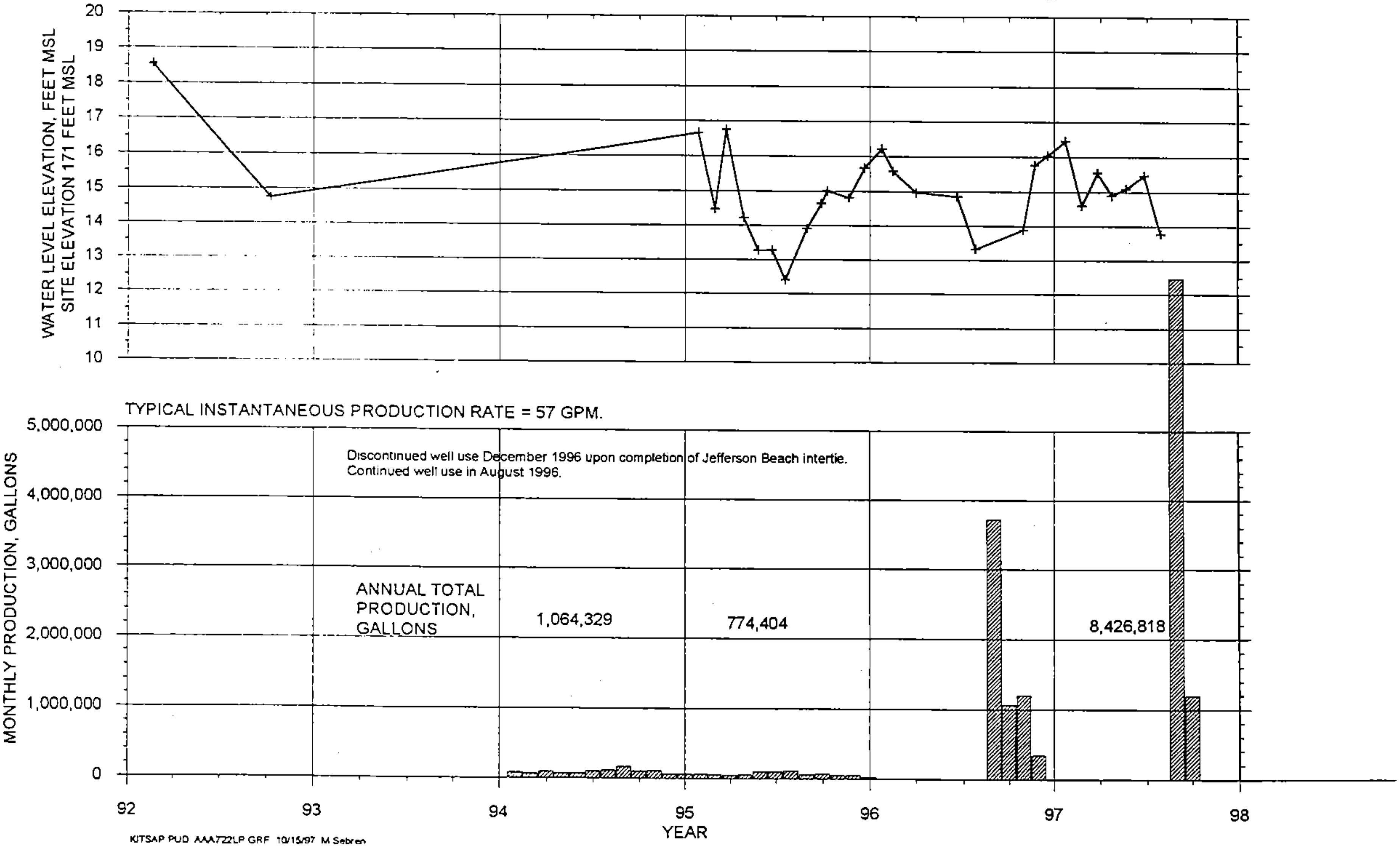


HYDROGRAPH OF LINCOLN ROAD WELL 1 (AAA716).
T26N/R02E-8Q. COMPLETION ELEVATION -338' TO -354' MSL.
CONSTRUCTION SWL 186.7' BELOW GROUND, 11/12/81, BURT WELL DRILLING AND R&N, INC.

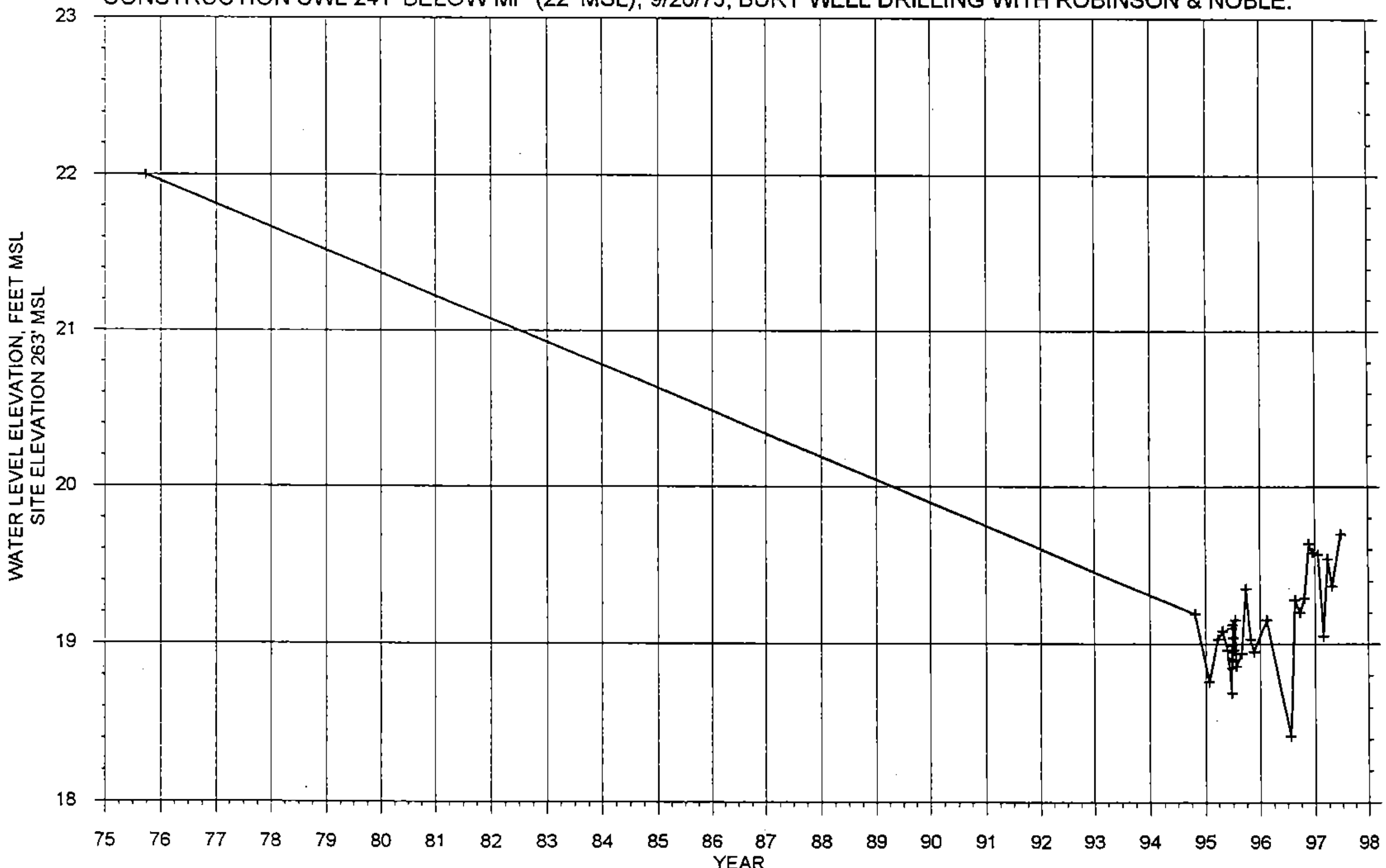



HYDROGRAPH OF SUQUAMISH SHORES WELL (AAA718).
T26N/R02E-21L. COMPLETION ELEVATION -132' TO -142' MSL.
CONSTRUCTION SWL 53' BELOW GROUND, 9/26/68, BURT WELL DRILLING.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION 128' MSL
75
74
73
72
71
70
69
68
67
68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98
YEAR
KITSAP PUD. AAA718.GRF 10/15/97 M.Sebren

HYDROGRAPH AND PRODUCTION SUMMARY FOR JEFFERSON POINT WELL (AAA722).
T26N/R02E-01Q. COMPLETION ELEVATION -56 TO -76' MSL.
CONSTRUCTION SWL 18.6' MSL, 2/20/92, GRESHAM WELL DRILLING AND ROBINSON & NOBLE.

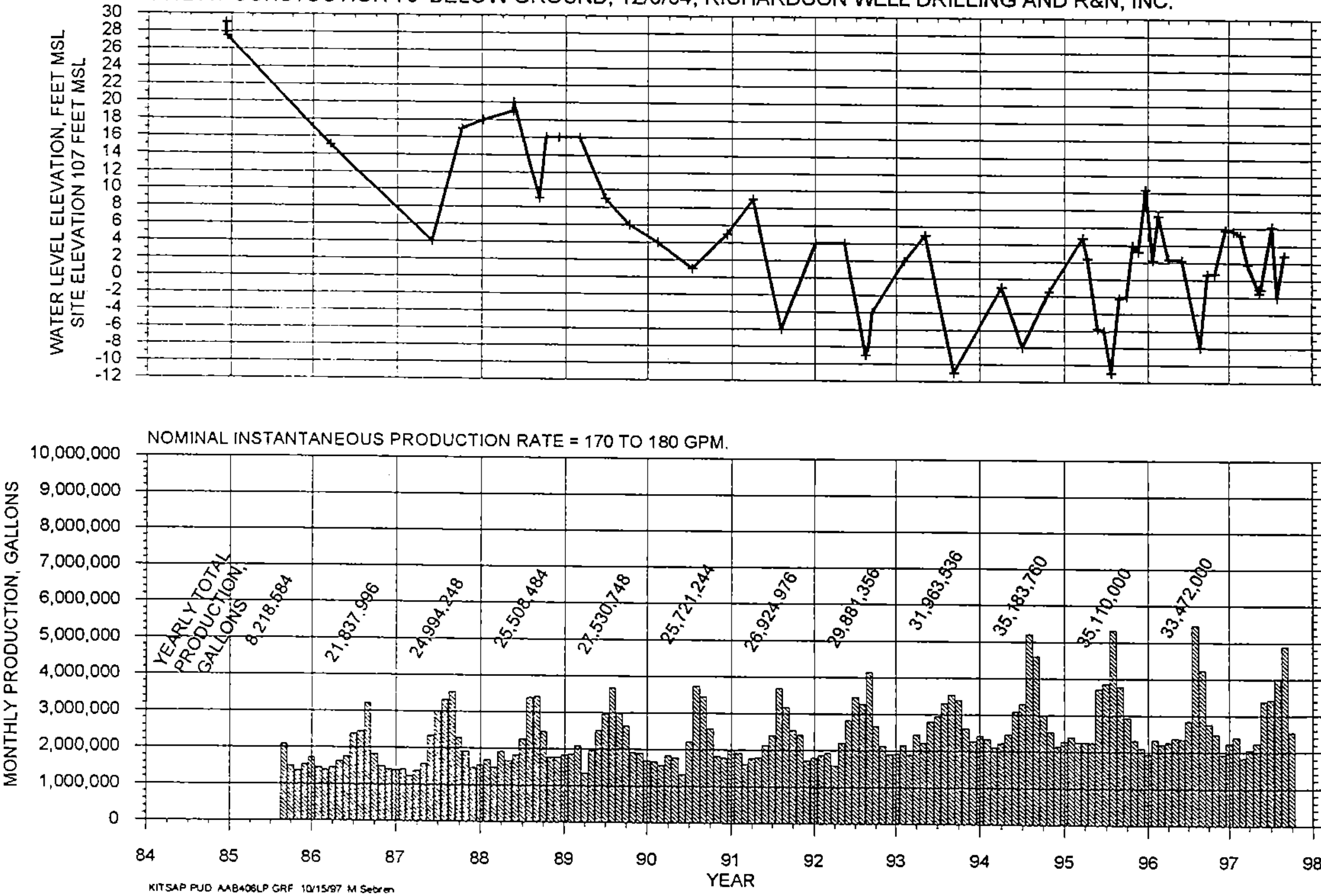


HYDROGRAPH OF KINGSTON WELL 2 (AAB401).
T27N/R02E-25E. COMPLETION ELEVATION -19 TO -40' MSL.
CONSTRUCTION SWL 241' BELOW MP (22' MSL), 9/26/75, BURT WELL DRILLING WITH ROBINSON & NOBLE.

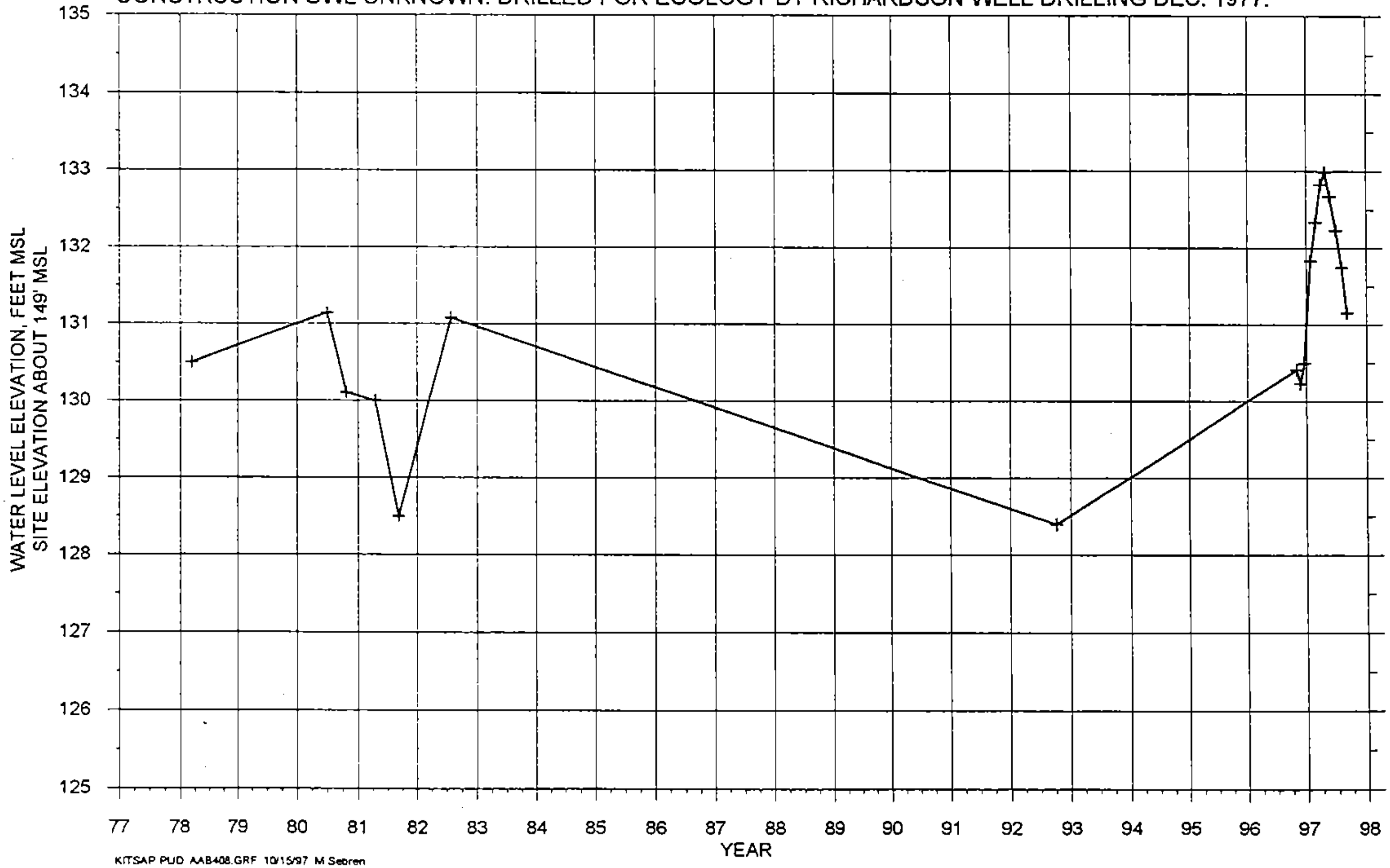


KITSAP PUD AAB401-2.GRF 10/15/97 M Sebren

HYDROGRAPH AND PRODUCTION SUMMARY FOR INDIANOLA WELL 1A (AAB406).
T26N/R02E-10R. COMPLETION ELEVATION -164' TO -289' MSL.
SWL AT CONSTUCTION 79' BELOW GROUND, 12/6/84, RICHARDSON WELL DRILLING AND R&N, INC.

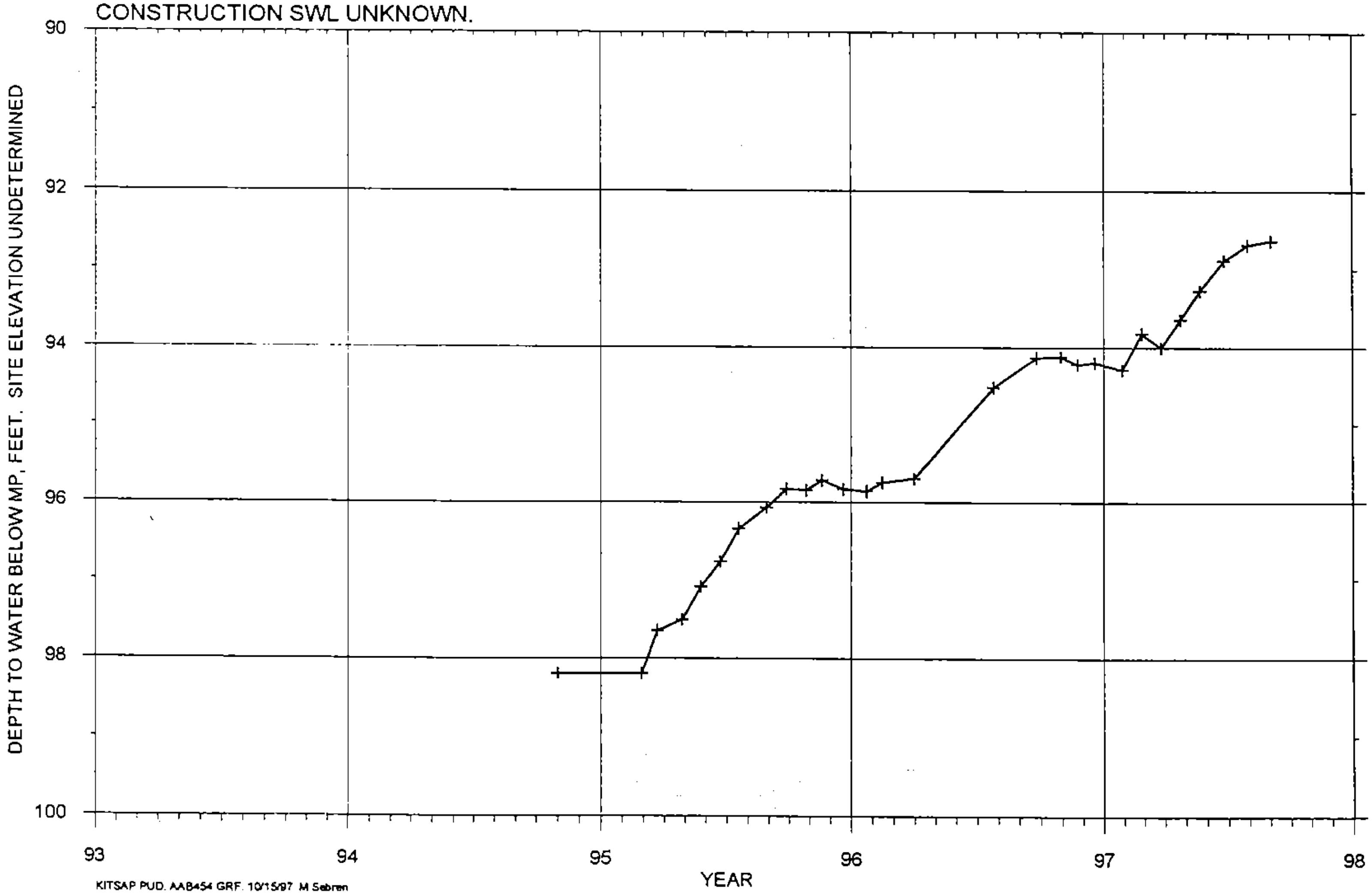


HYDROGRAPH OF DEPARTMENT OF ECOLOGY OBS WELL 2 IN INDIANOLA (AAB408).
T26N/R02E-10Q. COMPLETION ELEVATION APPROXIMATELY 104' MSL.
CONSTRUCTION SWL UNKNOWN. DRILLED FOR ECOLOGY BY RICHARDSON WELL DRILLING DEC. 1977.

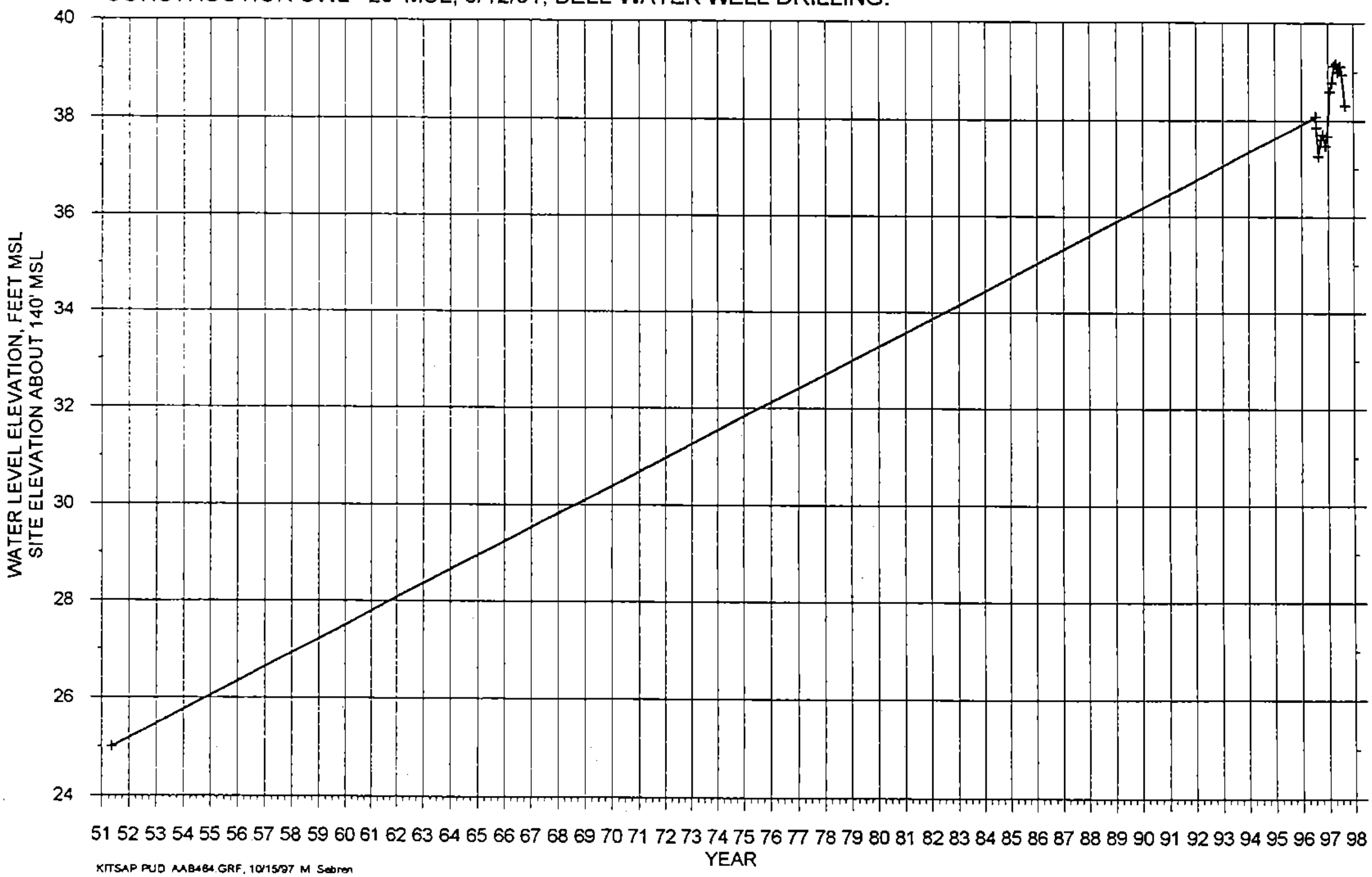


KITSAP PUD AAB408.GRF 10/15/97 M Sebren

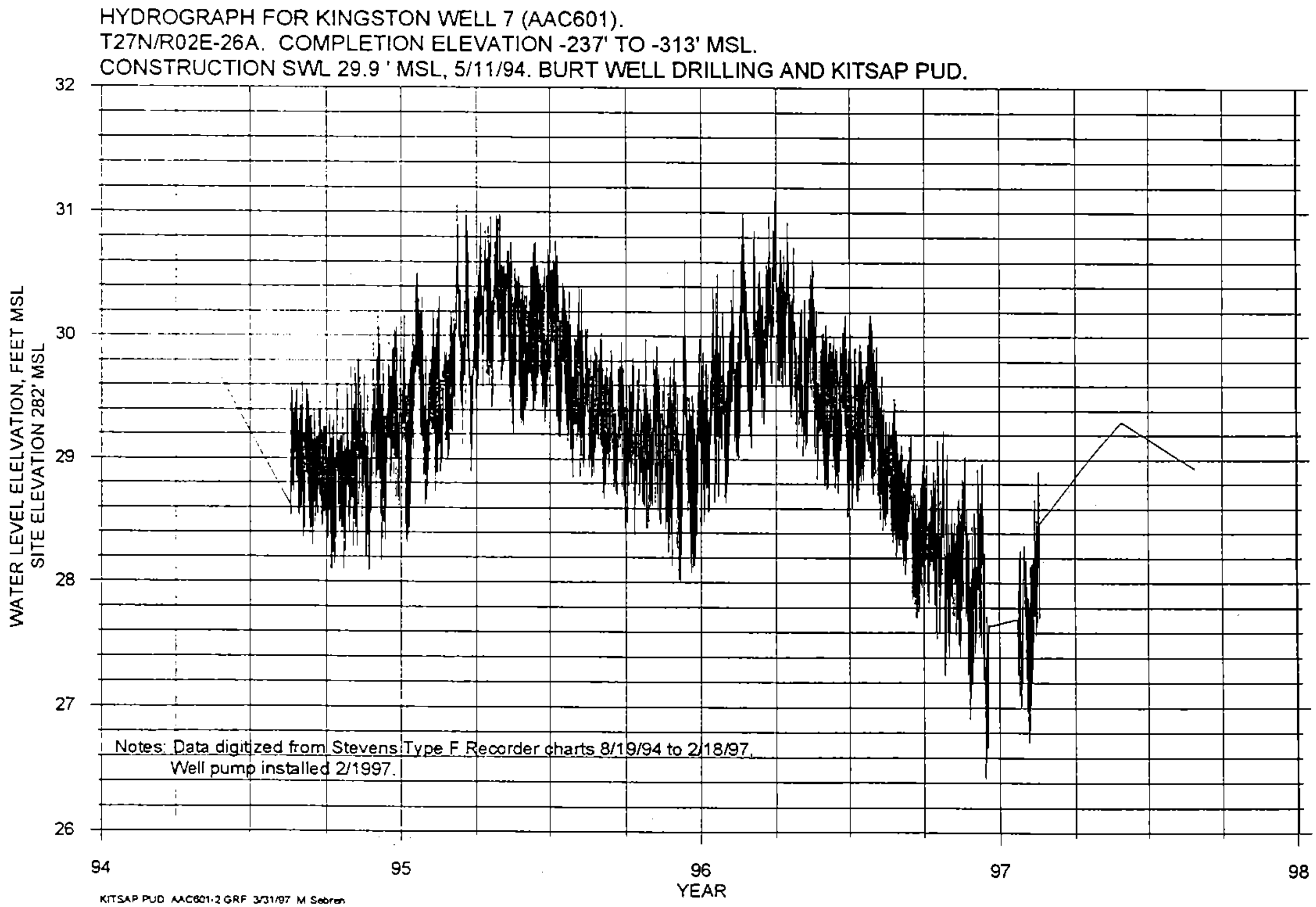
HYDROGRAPH OF KPUD DEEP DUG WELL NEAR SUQUAMISH (AAB454).
T26N/R02E-20H. COMPLETION ELEVATION UNDETERMINED.
CONSTRUCTION SWL UNKNOWN.



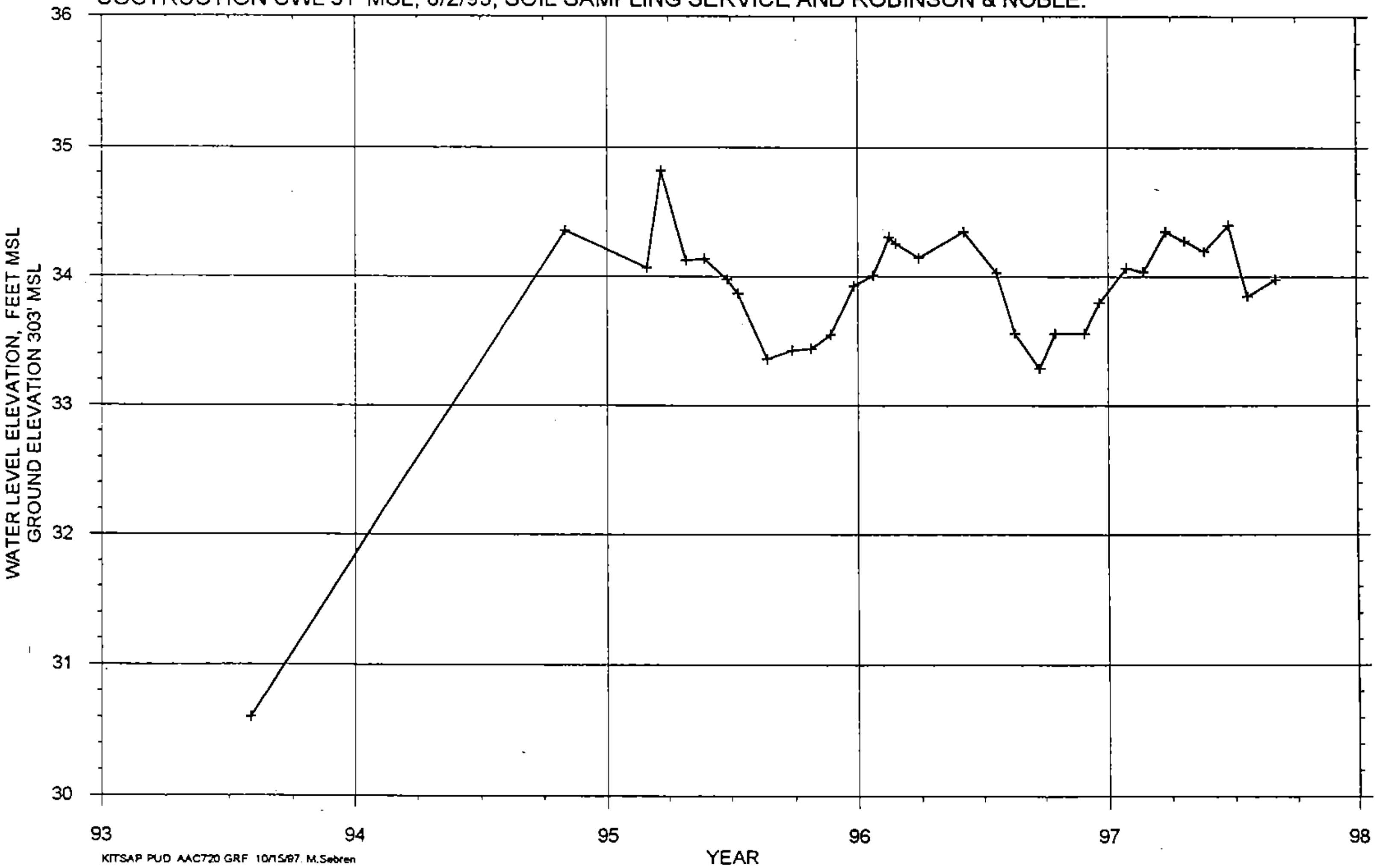
HYDROGRAPH OF WOLFLE ELEMENTARY SCHOOL WELL (AAB464).
T26N/R02E-01C. COMPLETION ELEVATION -144 TO -154' MSL.
CONSTRUCTION SWL ~25' MSL, 5/12/51, BELL WATER WELL DRILLING.



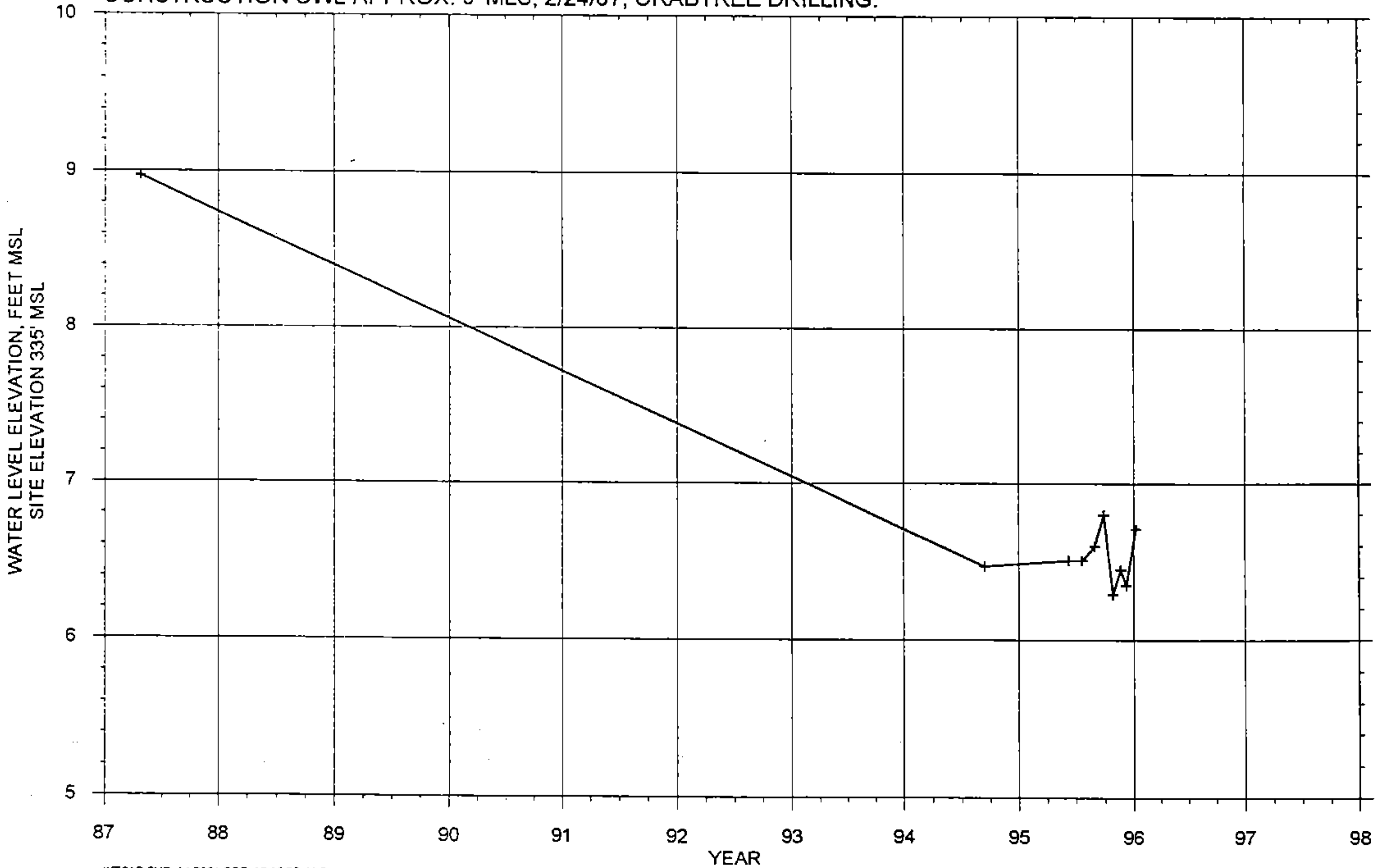
KITSAP PUD AAB464.GRF, 10/15/97 M. Sebren


HYDROGRAPH FOR KINGSTON WELL 7 (AAC601).
T27N/R02E-26A. COMPLETION ELEVATION -237' TO -313' MSL.
CONSTRUCTION SWL 29.9 ' MSL, 5/11/94. BURT WELL DRILLING AND KITSAP PUD.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION 282' MSL
32
31
30
29
28
27
26
94
95
96
97
98
YEAR
Notes: Data digitized from Stevens Type F Recorder charts 8/19/94 to 2/18/97.
Well pump installed 2/1997.
KITSAP PUD AAC601-2.GRF 3/31/97 M Sebren

HYDROGRAPH OF KPUD HANSVILLE HIGHWAY TEST WELL (AAC720).
T27N/R02E-16H. COMPLETION ELEVATION -827 TO -847' MSL.
COSTRUCTION SWL 31' MSL, 8/2/93, SOIL SAMPLING SERVICE AND ROBINSON & NOBLE.

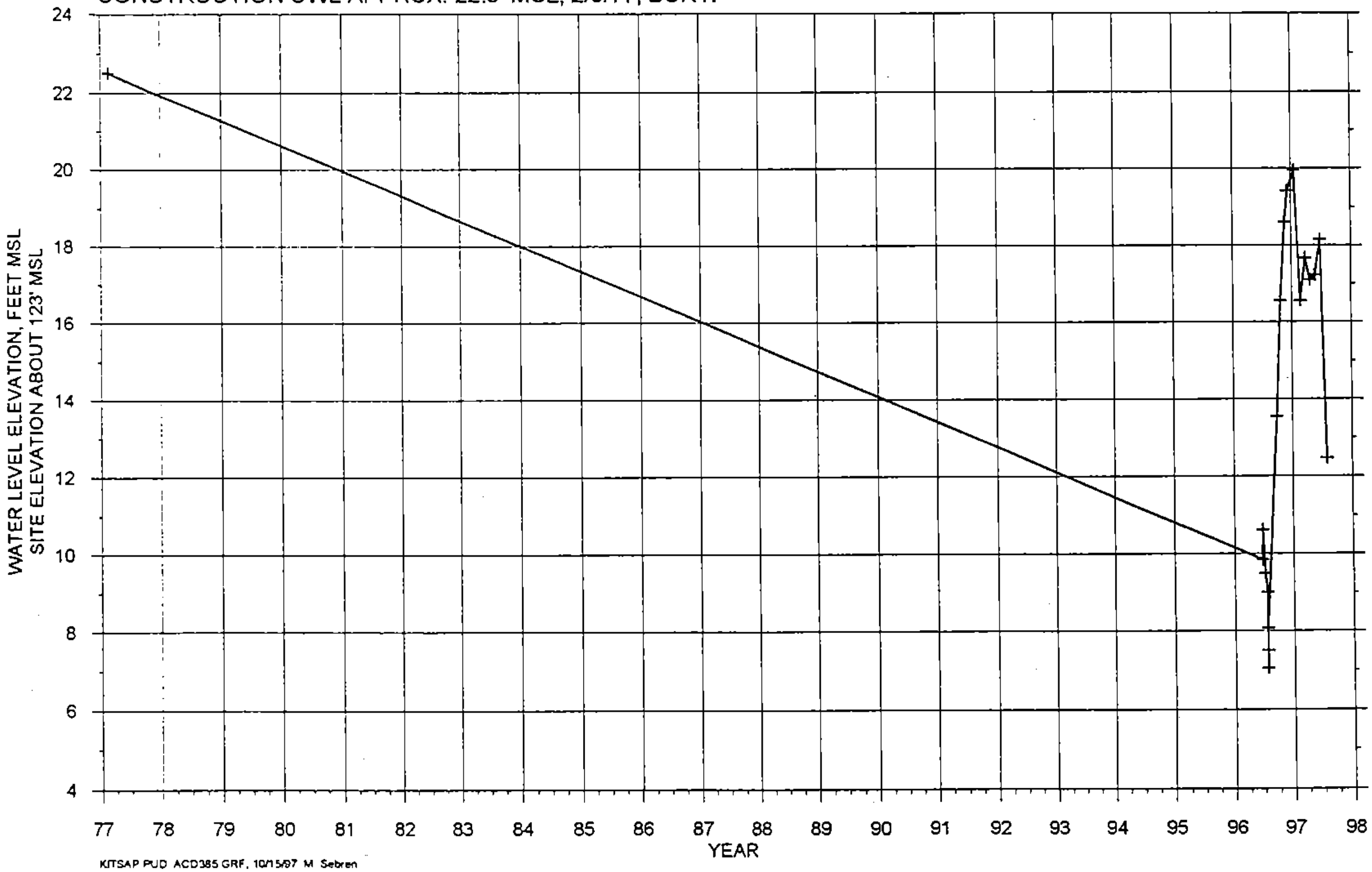


HYDROGRAPH OF SCHMID WATER SYSTEM WELL (AAC864).
T27N/R02E-23H. COMPLETION ELEVATION APPROX. -16 TO -21' MSL.
CONSTRUCTION SWL APPROX. 9' MLS, 2/24/87, CRABTREE DRILLING.

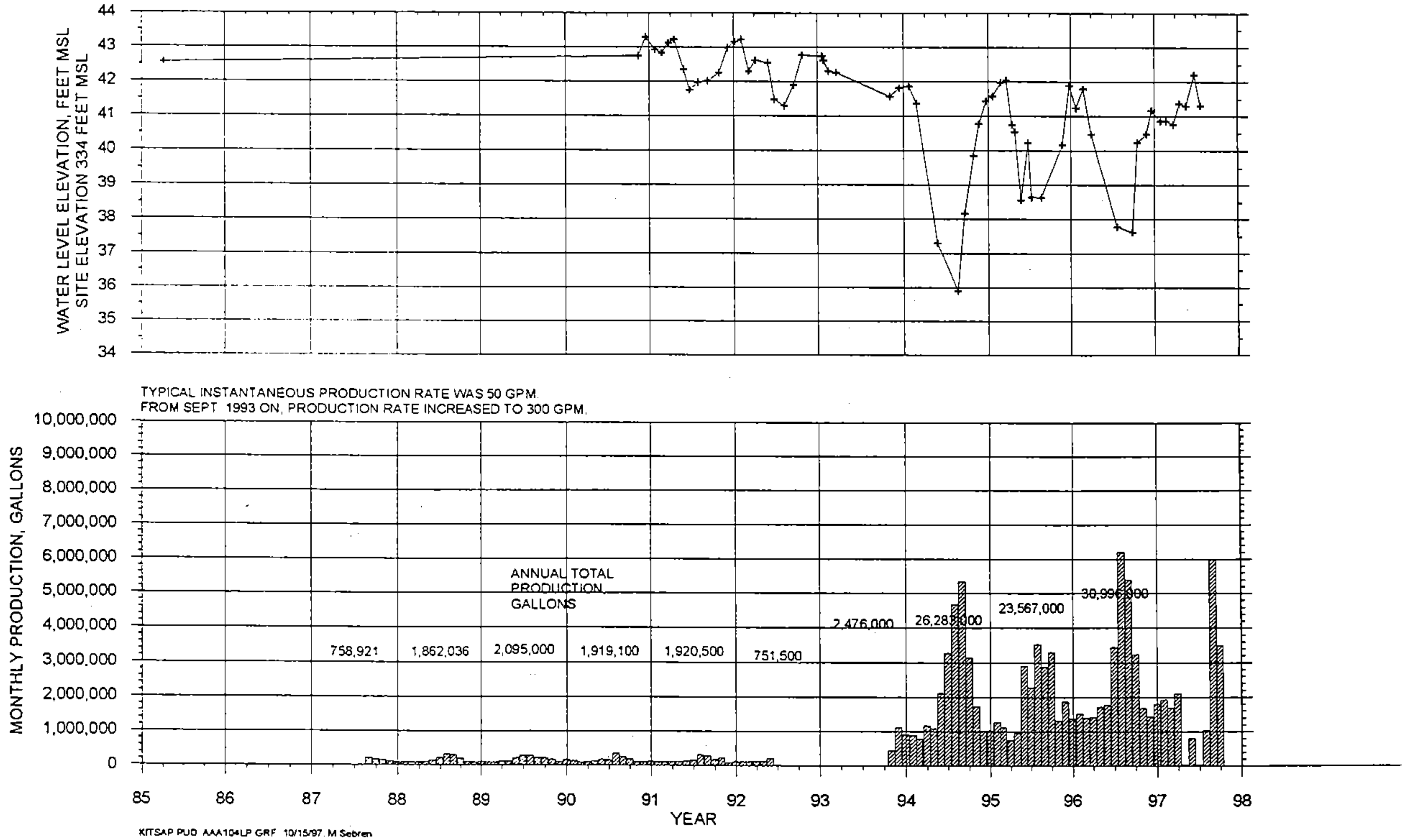


KITSAP PUD AAC864 GRF 10/15/97 M Sebren

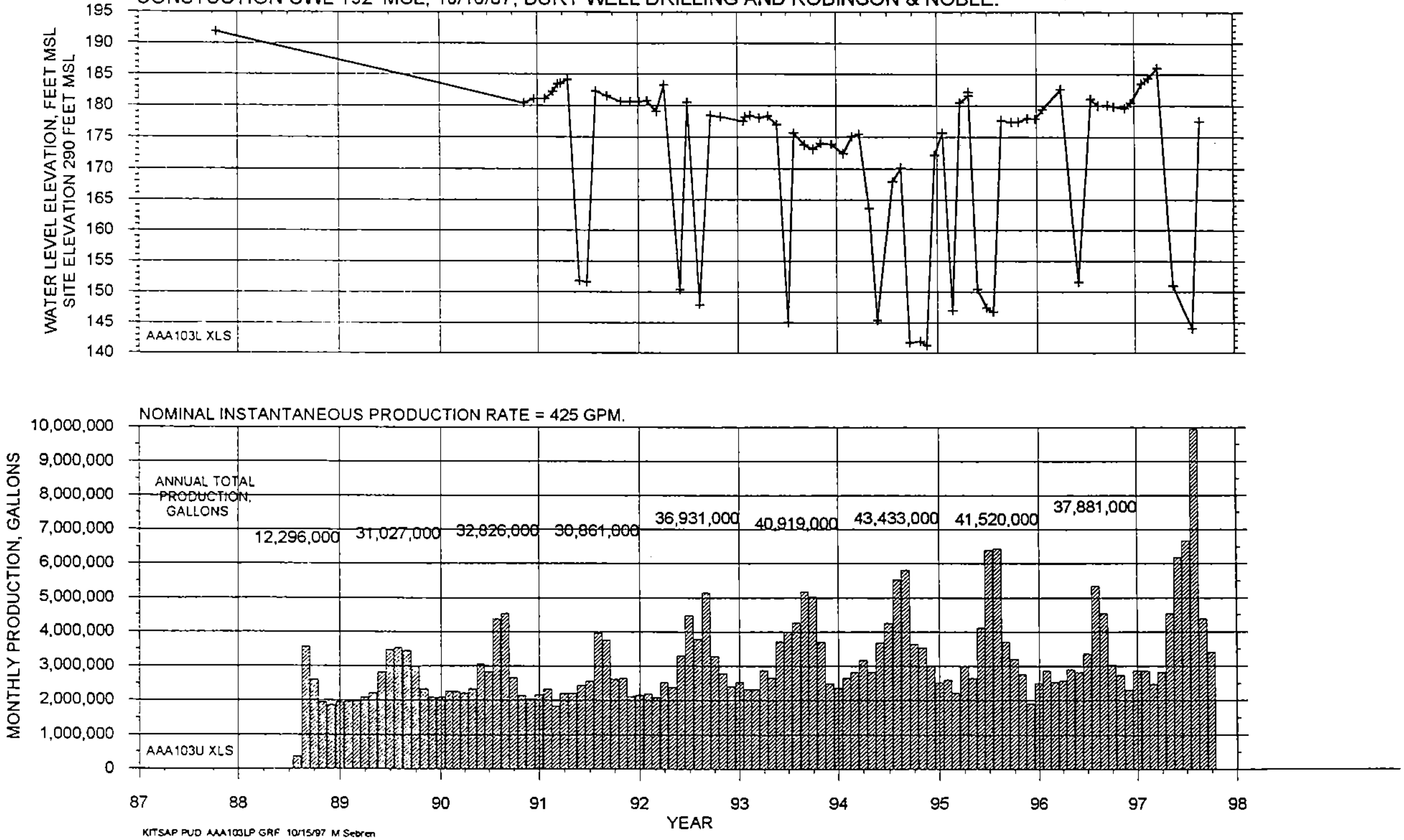
HYDROGRAPH OF KPUD NEWELLHURST WELL 2 (ACD385).
T26N/R02E-01C. COMPLETION ELEVATION APPROX. -389 TO -404' MSL.
CONSTRUCTION SWL APPROX. 22.5' MSL, 2/5/77, BURT.



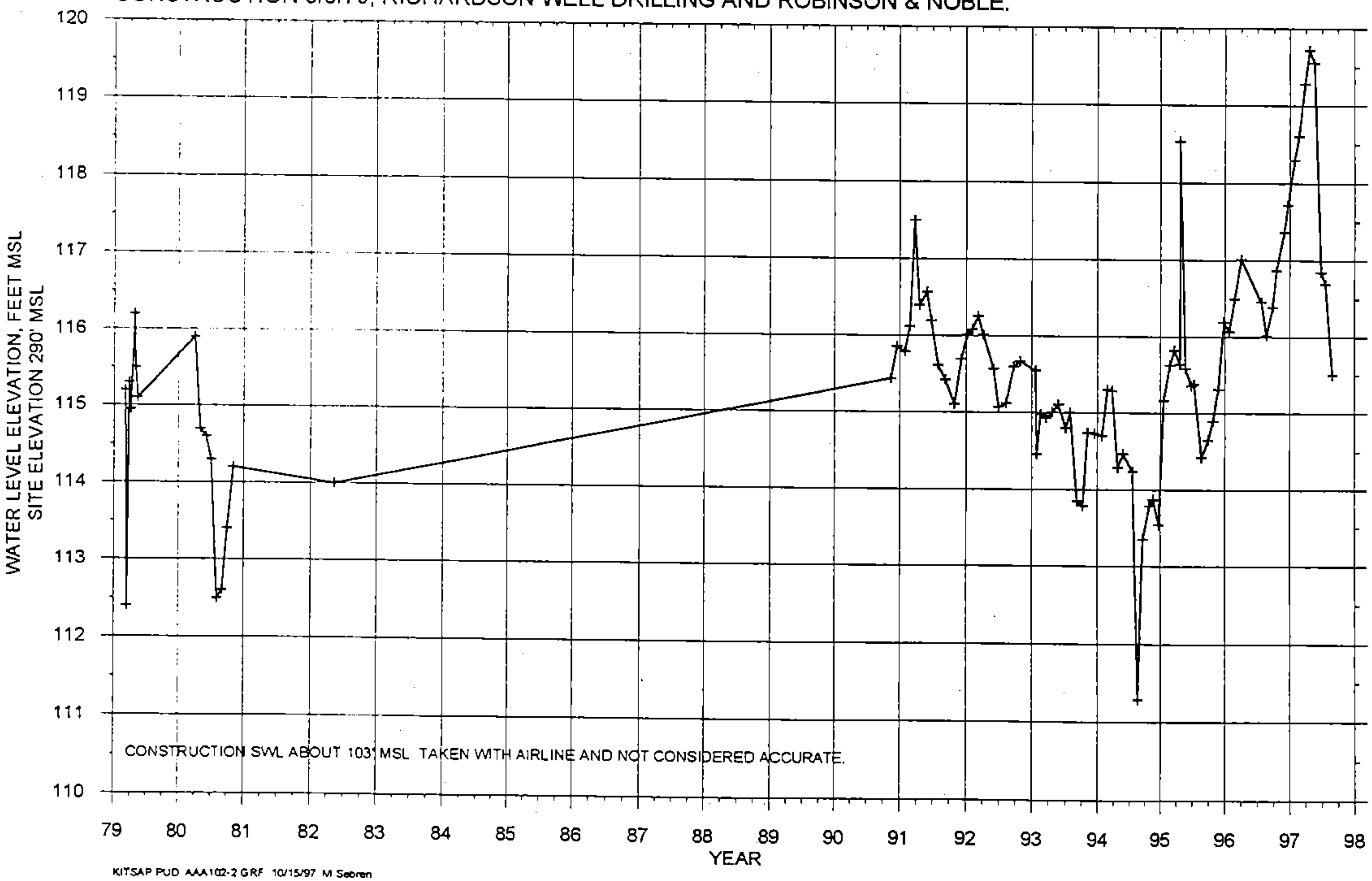
HYDROGRAPH AND PRODUCTION SUMMARY FOR VINLAND VIEW WELL 2 (AAA104).
T26N/R01E-4B. COMPLETION ELEVATION -314 TO -351' MSL.
CONSTRUCTION SWL 42.6' MSL, 4/8/85, BURT WELL DRILLING AND ROBINSON & NOBLE.



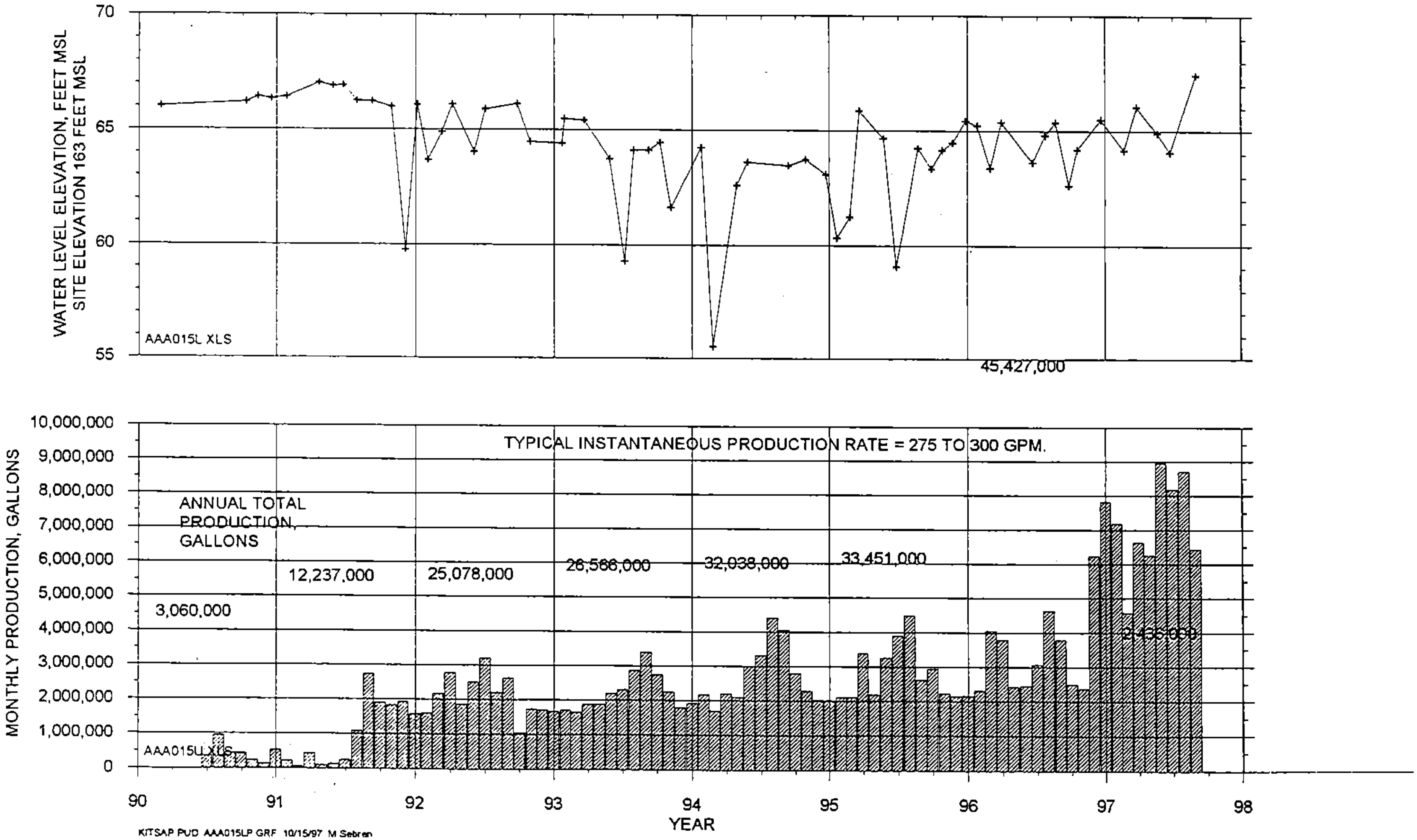
HYDROGRAPH AND PRODUCTION SUMMARY FOR EDGEWATER WELL 4 (AAA103).
T27N/R01E-27J. COMPLETION ELEVATION 110' TO 130' MSL.
CONSTUCTION SWL 192' MSL, 10/16/87, BURT WELL DRILLING AND ROBINSON & NOBLE.

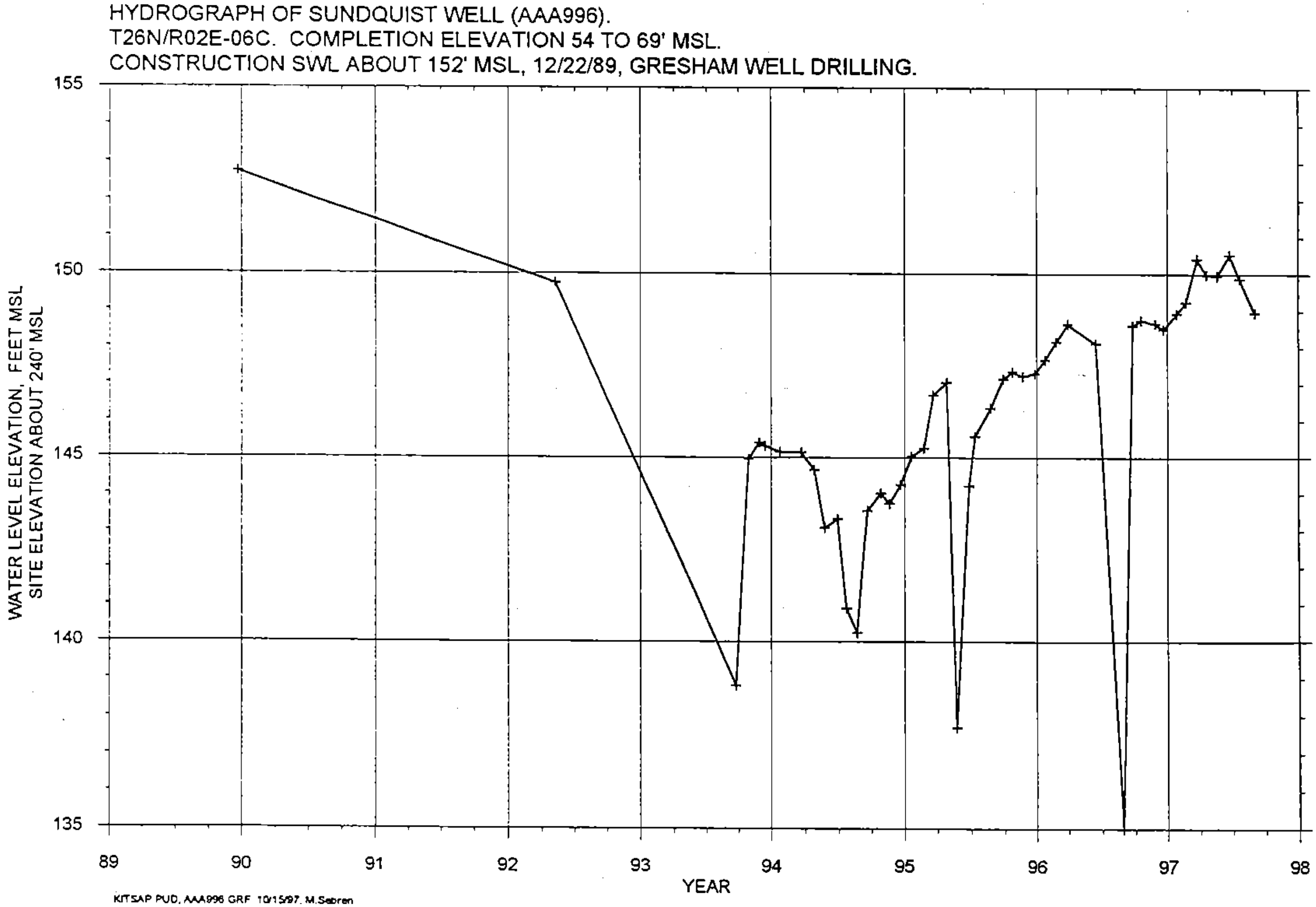


HYDROGRAPH OF EDGEWATER WELL 3 (AAA102).
T27N/R01E-27J. COMPLETION ELEVATION -112 TO -167' MSL.
CONSTRUCTION 3/6/79, RICHARDSON WELL DRILLING AND ROBINSON & NOBLE.

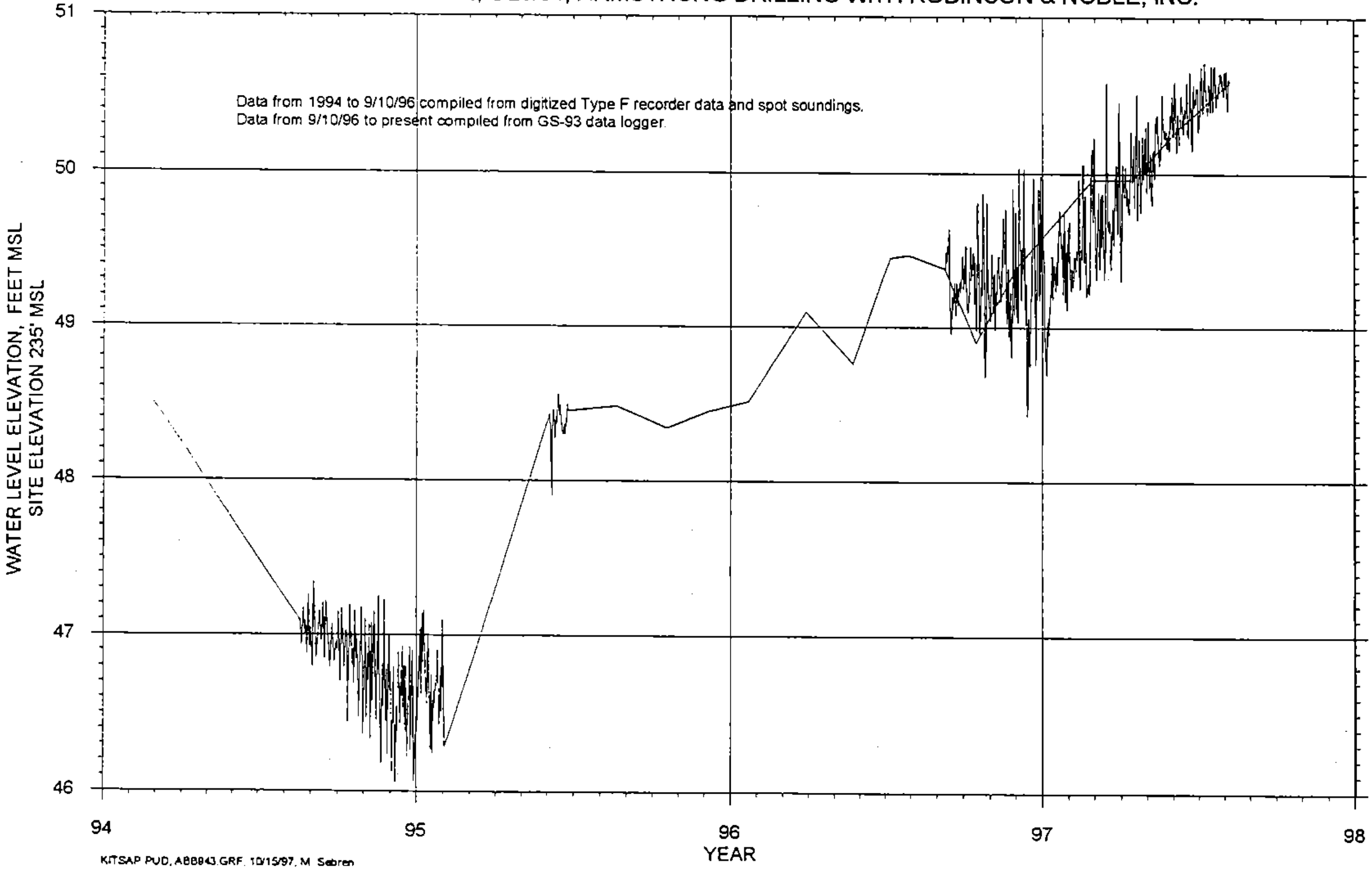


HYDROGRAPH AND PRODUCTION SUMMARY FOR RITTER LANE WELL (AAA015).
T27N/R02E-29J. COMPLETION ELEVATION -102 TO -159' MSL.
CONSTRUCTION SWL 66' MSL, 2/27/90, BURT WELL DRILLING AND ROBINSON & NOBLE.

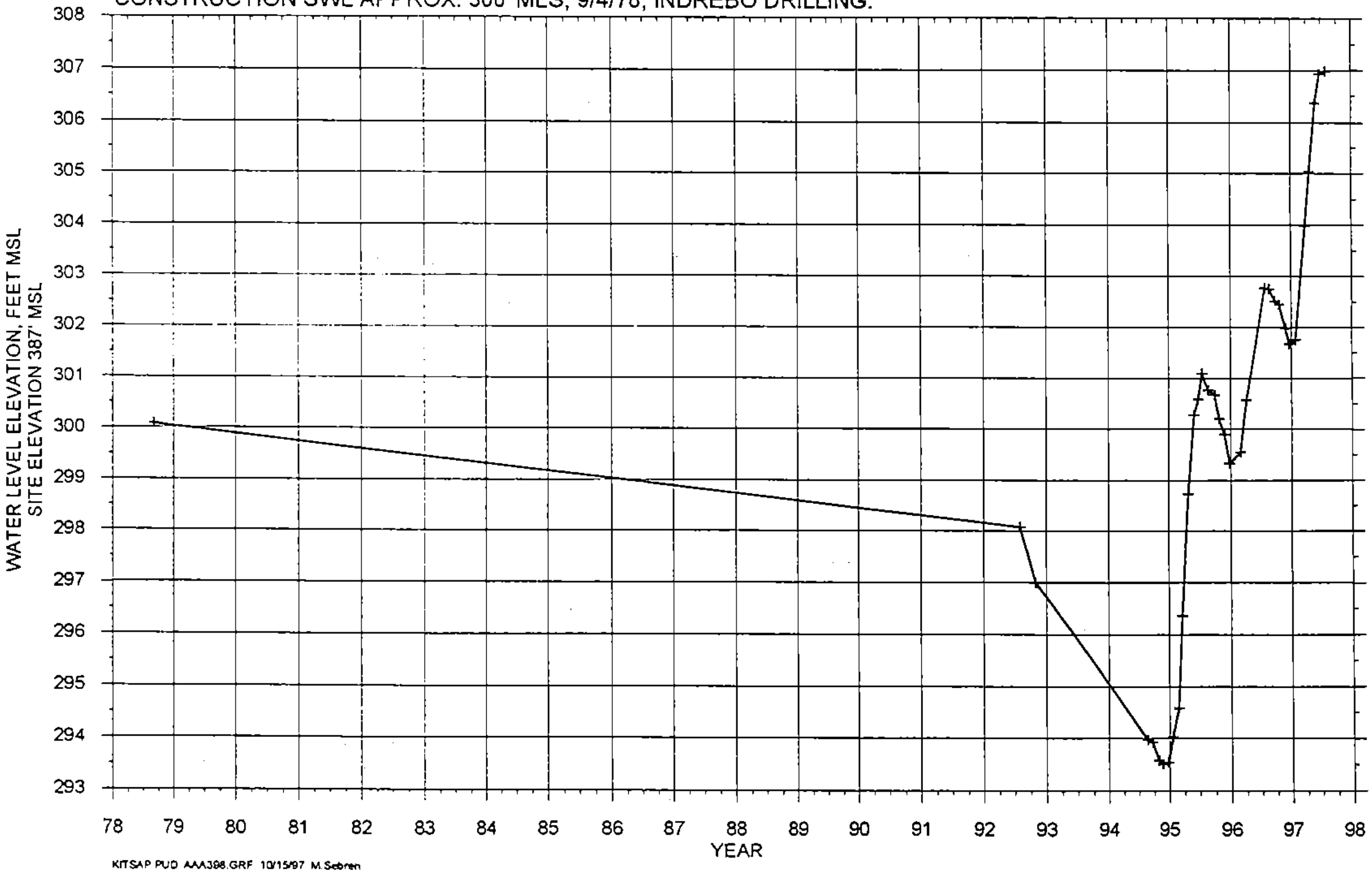



HYDROGRAPH OF SUNDQUIST WELL (AAA996).
T26N/R02E-06C. COMPLETION ELEVATION 54 TO 69' MSL.
CONSTRUCTION SWL ABOUT 152' MSL, 12/22/89, GRESHAM WELL DRILLING.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION ABOUT 240' MSL
155
150
145
140
135
89
90
91
92
93
94
95
96
97
98
YEAR
KITSAP PUD, AAA996 GRF 10/15/97, M.Sebren

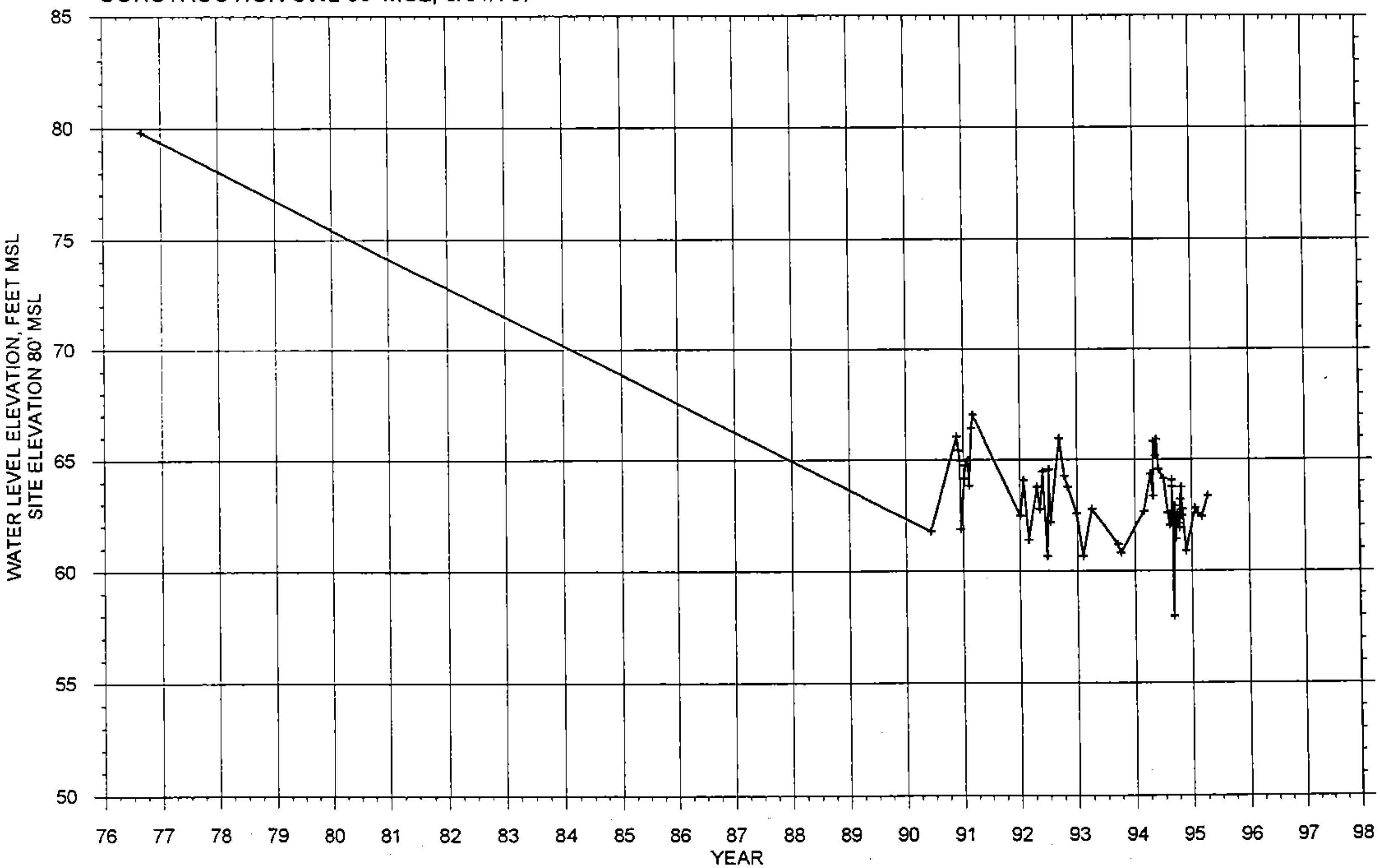
HYDROGRAPH OF PORT GAMBLE PRODUCTION WELL 1 (ABB943).
T27N/R02E-19Q. COMPLETION ELEVATION -110' TO -220' MSL.
CONSTRUCTION SWL = 48.5' MSL, 2/28/94, ARMSTRONG DRILLING WITH ROBINSON & NOBLE, INC.



HYDROGRAPH OF NARDO PRIVATE WELL (AAA398).
T26N/R01E-9K. COMPLETION ELEVATION 279 TO 284' MSL.
CONSTRUCTION SWL APPROX. 300' MLS, 9/4/78, INDREBO DRILLING.

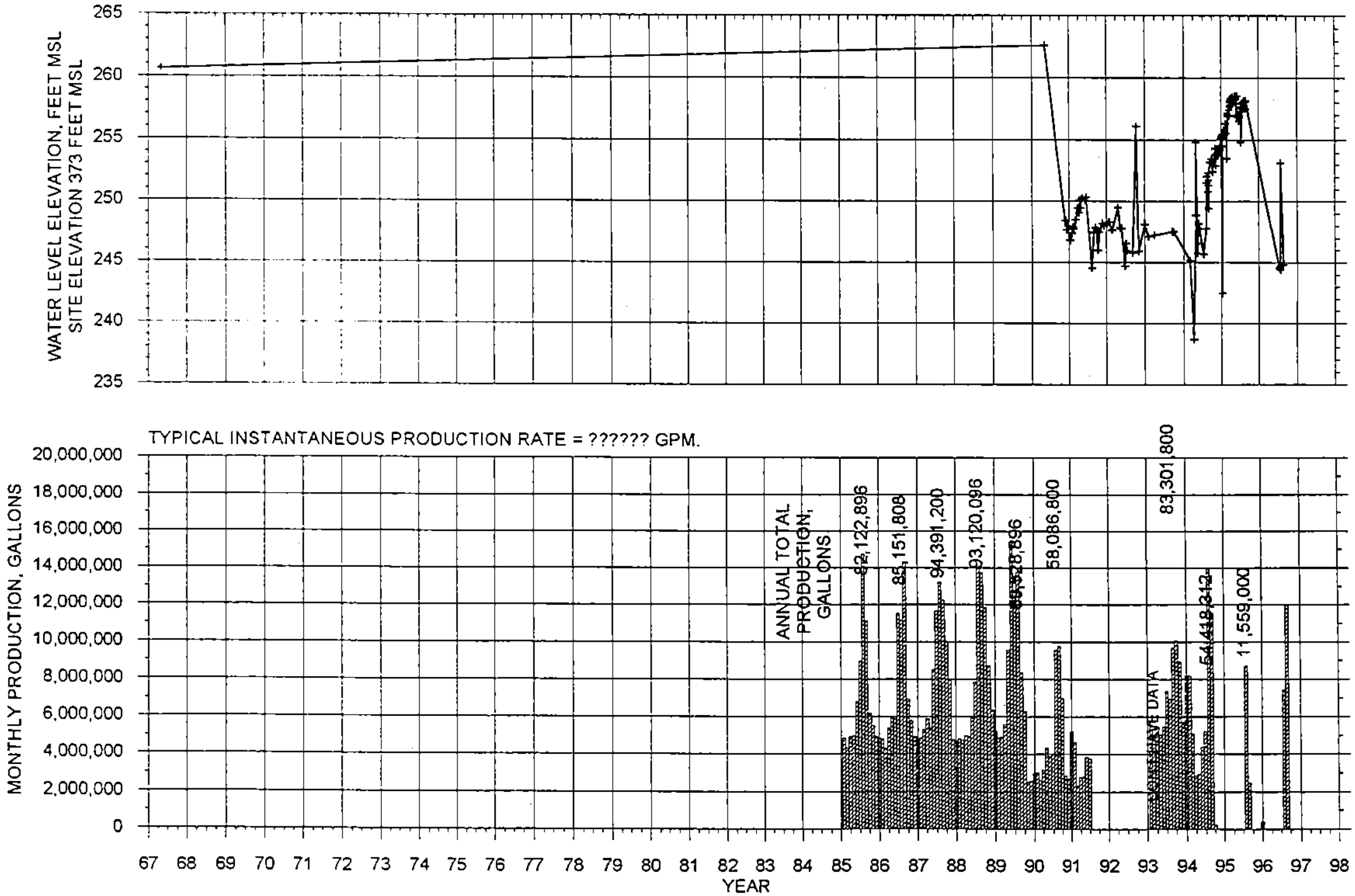


HYDROGRAPH OF CITY OF POULSBO BIG VALLEY WELL 1 (AAB254).
T26N/R01E-2L. COMPLETION ELEVATION -222 TO -232' MSL.
CONSTRUCTION SWL 80' MSL, 8/31/76.



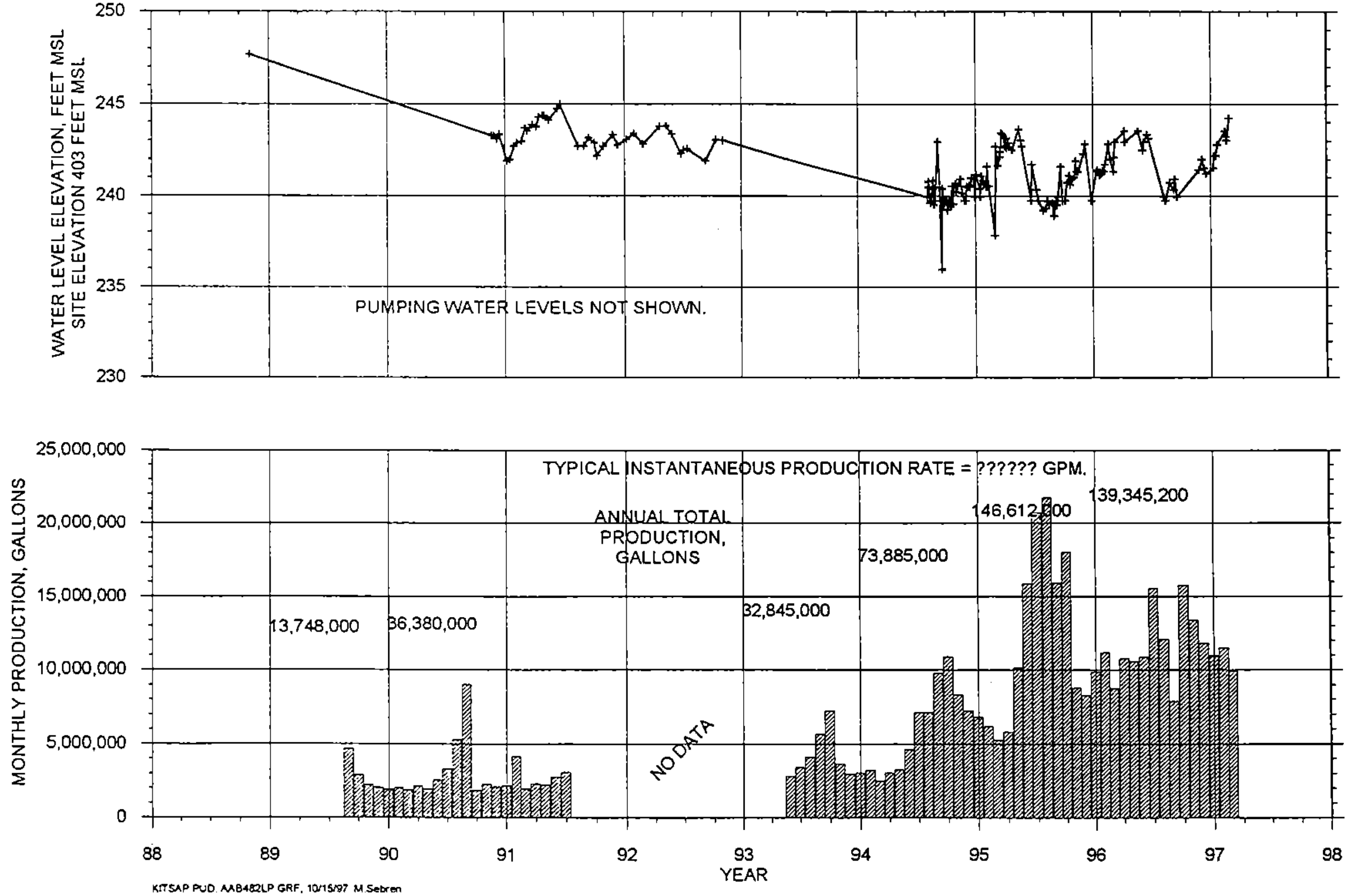
KITSAP PUD AAB254.GRF, 10/15/97 M. Sebren

HYDROGRAPH AND PRODUCTION SUMMARY FOR CITY OF POULSBO LINCOLN ROAD WELL (AAB481).
T26N/R01E-13B. COMPLETION ELEVATION 60 TO 75' MSL.
CONSTRUCTION SWL 260' MSL, 5/2/67, STOICAN DRILLING.

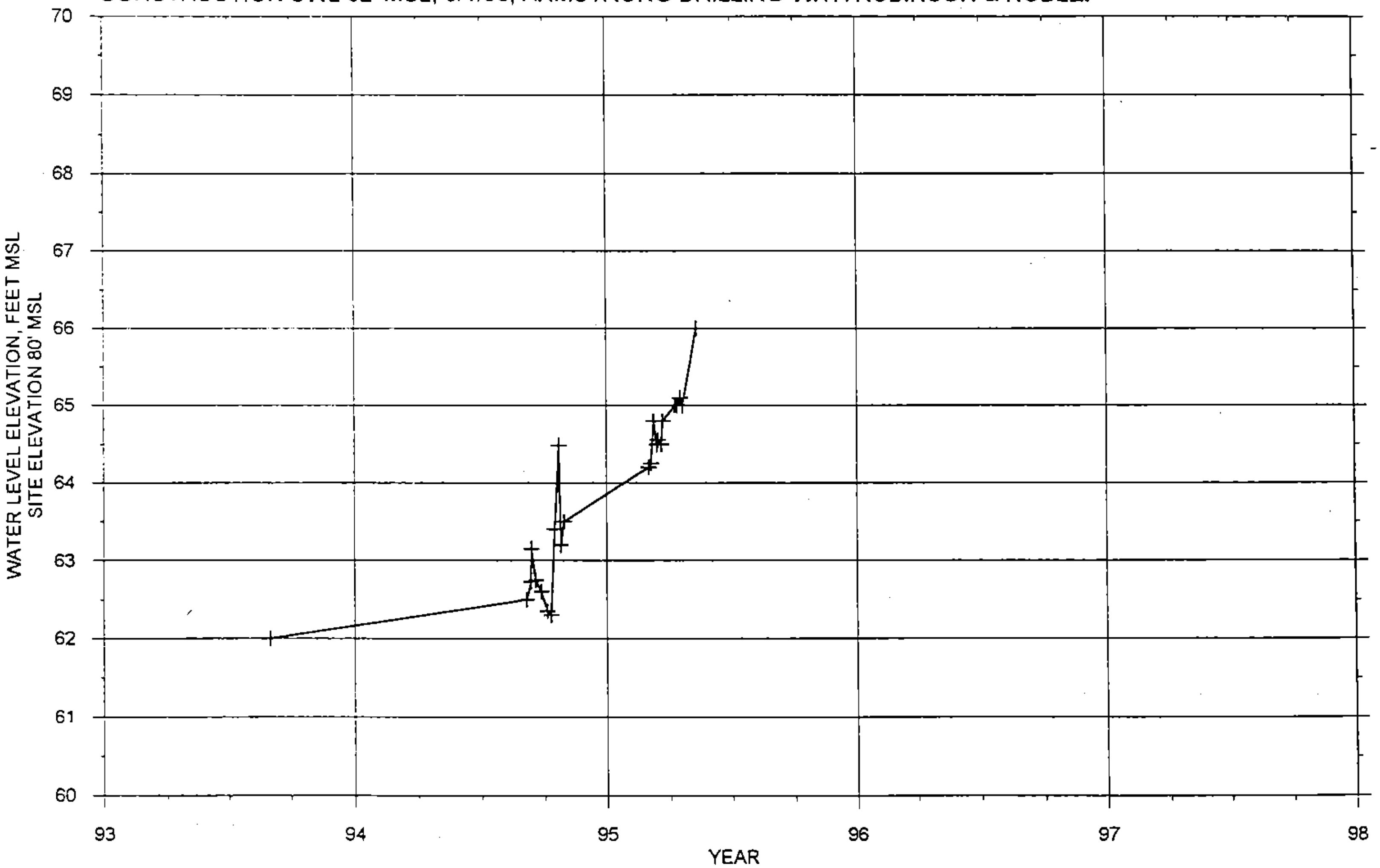


KITSAP PUD AAB481 GRF, 10/15/97 M Sebren

HYDROGRAPH AND PRODUCTION SUMMARY FOR CITY OF POULSBO PUGH ROAD WELL (AAB482).
T26N/R01E-13F. COMPLETION ELEVATION 93 TO 123' MSL.
CONSTRUCTION SWL 248' MSL, 11/3/88, BURT WELL DRILLING WITH ROBINSON & NOBLE.

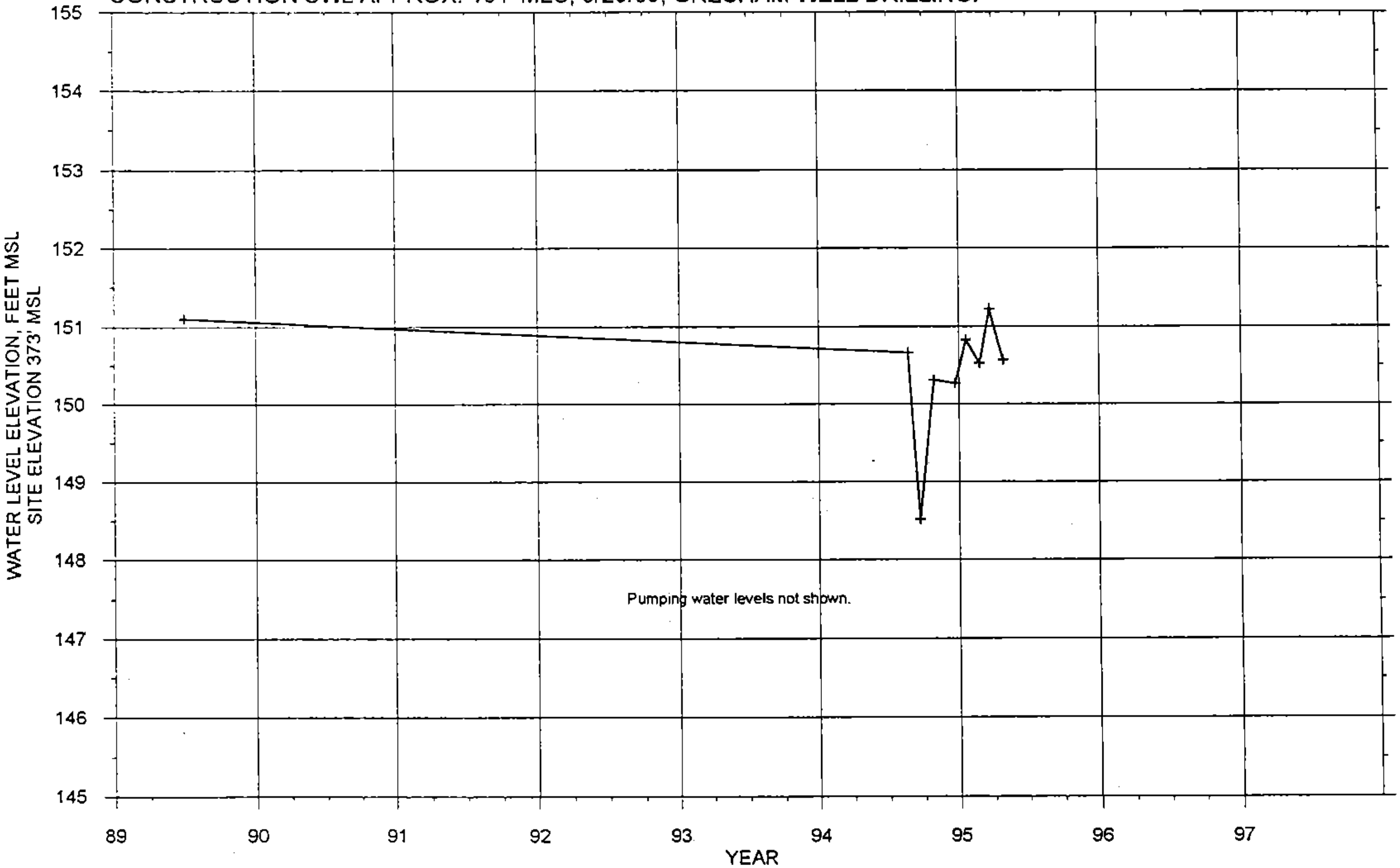


HYDROGRAPH OF CITY OF POULSBO BIG VALLEY WELL 2 (AAC682).
T26N/R01E-2L. COMPLETION ELEVATION -374 TO -435' MSL.
CONSTRUCTION SWL 62' MSL, 9/1/93, ARMSTRONG DRILLING WITH ROBINSON & NOBLE.



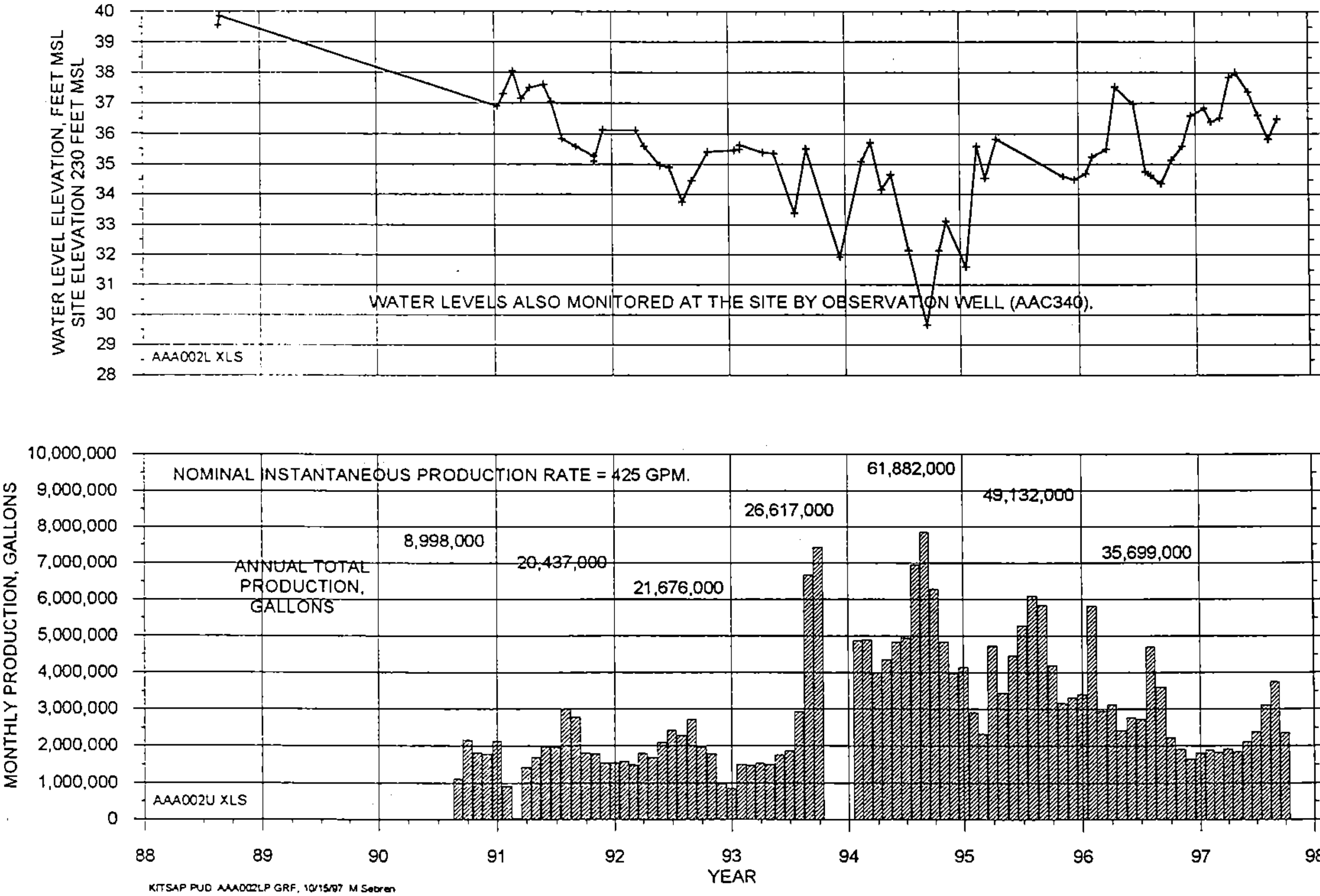
KITSAP PUD AAC682.GRF. 10/15/97 M. Sebren

HYDROGRAPH OF HIGHLAND VIEW WELL (AAC899).
T26N/R01E-3P. COMPLETION ELEVATION 75 TO 85' MSL.
CONSTRUCTION SWL APPROX. 151' MLS, 6/29/89, GRESHAM WELL DRILLING.

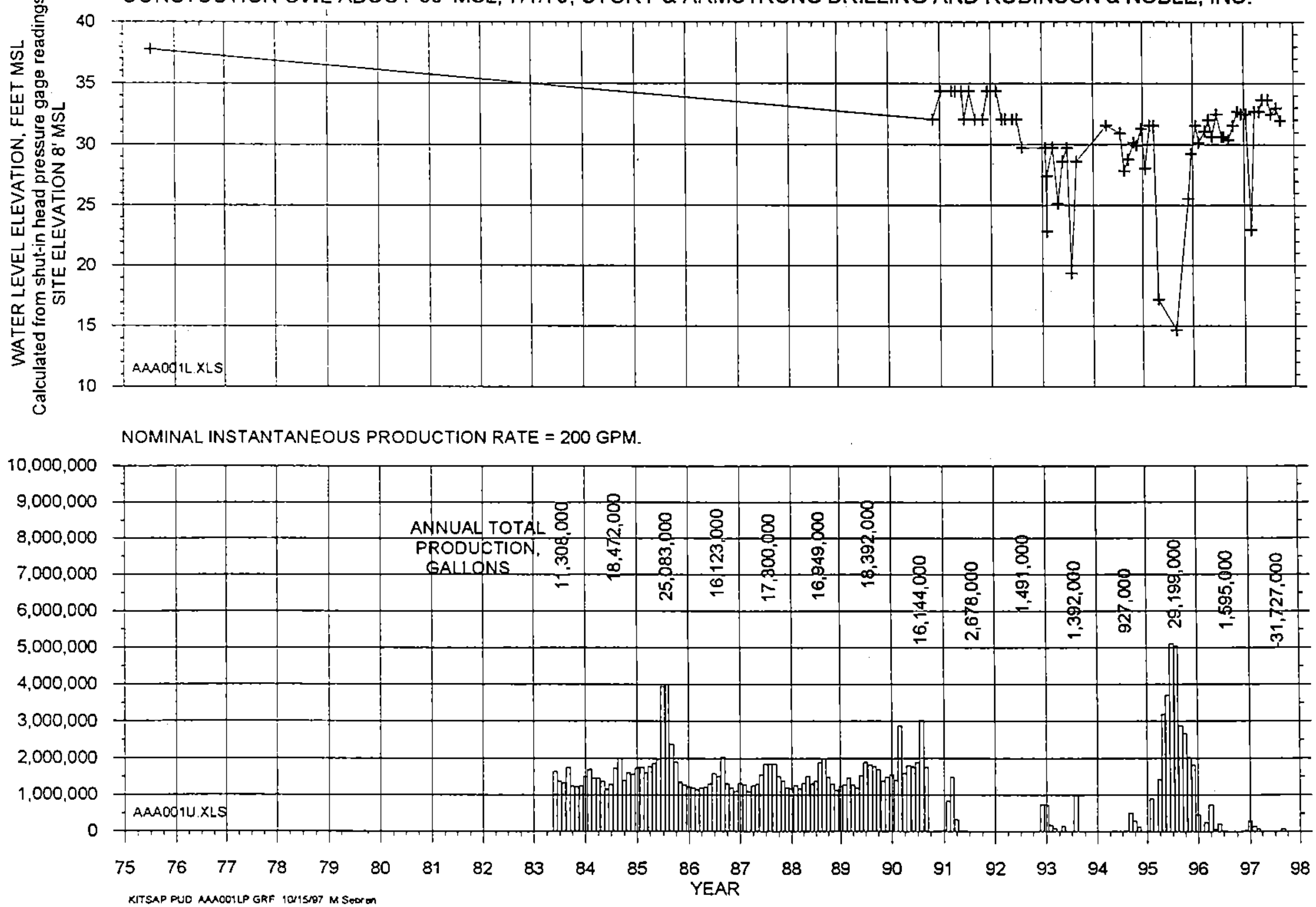


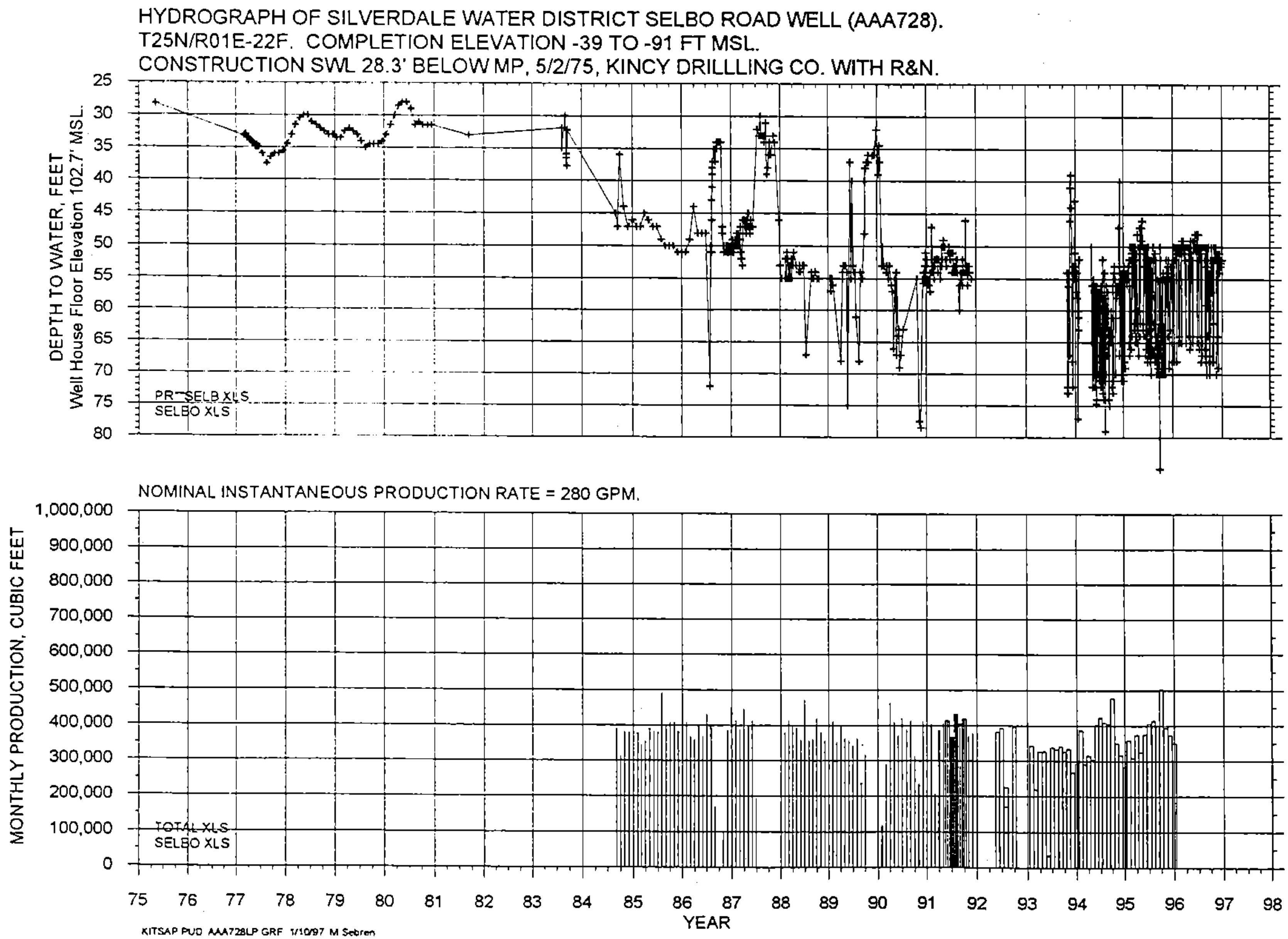
KITSAP PUD. AAC899 GRF. 10/15/97 M.Sebren

HYDROGRAPH AND PRODUCTION SUMMARY FOR KEYPORT PRODUCTION WELL 2 (AAA002).
T25N/R01E-2K. COMPLETION ELEVATION -698' TO -793' MSL.
CONSTUCTION SWL ABOUT 40' MSL, 8/29/88, BURT WELL DRILLING AND ROBINSON & NOBLE, INC.

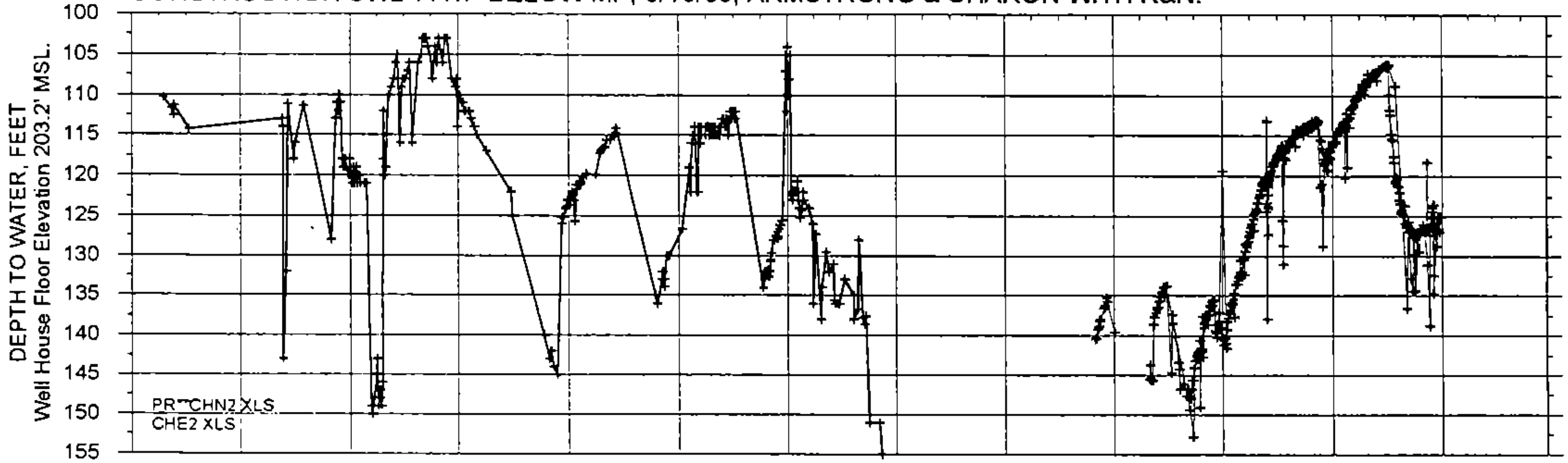


HYDROGRAPH AND PRODUCTION SUMMARY FOR KEYPORT PRODUCTION WELL 1 (AAA001).
T25N/R01E-36M. COMPLETION ELEVATION -694' TO -733' MSL.
CONSTUCTION SWL ABOUT 38' MSL, 7/1/75, STORY & ARMSTRONG DRILLING AND ROBINSON & NOBLE, INC.



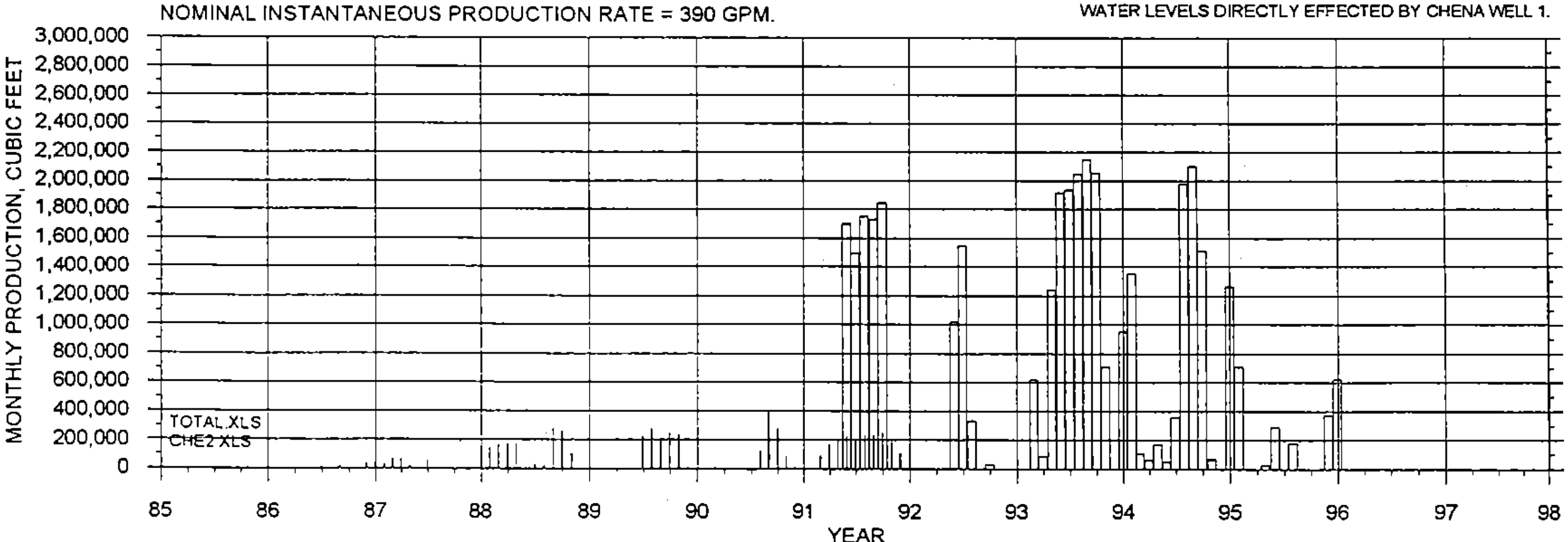

HYDROGRAPH OF SILVERDALE WATER DISTRICT SELBO ROAD WELL (AAA728).
T25N/R01E-22F. COMPLETION ELEVATION -39 TO -91 FT MSL.
CONSTRUCTION SWL 28.3' BELOW MP, 5/2/75, KINCY DRILLLING CO. WITH R&N.
DEPTH TO WATER, FEET
Well House Floor Elevation 102.7' MSL.
25
30
35
40
45
50
55
60
65
70
75
80
PR SELB XLS
SELBO XLS
NOMINAL INSTANTANEOUS PRODUCTION RATE = 280 GPM.
MONTHLY PRODUCTION, CUBIC FEET
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
TOTAL XLS
SELBO XLS
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98
YEAR
KITSAP PUD AAA728LP GRF 1/10/97 M Sebren

HYDROGRAPH OF SILVERDALE WATER DISTRICT CHENA WELL 2 (AAA729).
T25N/R01E-16J. COMPLETION ELEVATION -48 TO -67 FT MSL.
CONSTRUCTION SWL 111.7' BELOW MP, 5/16/85, ARMSTRONG & CHARON WITH R&N.



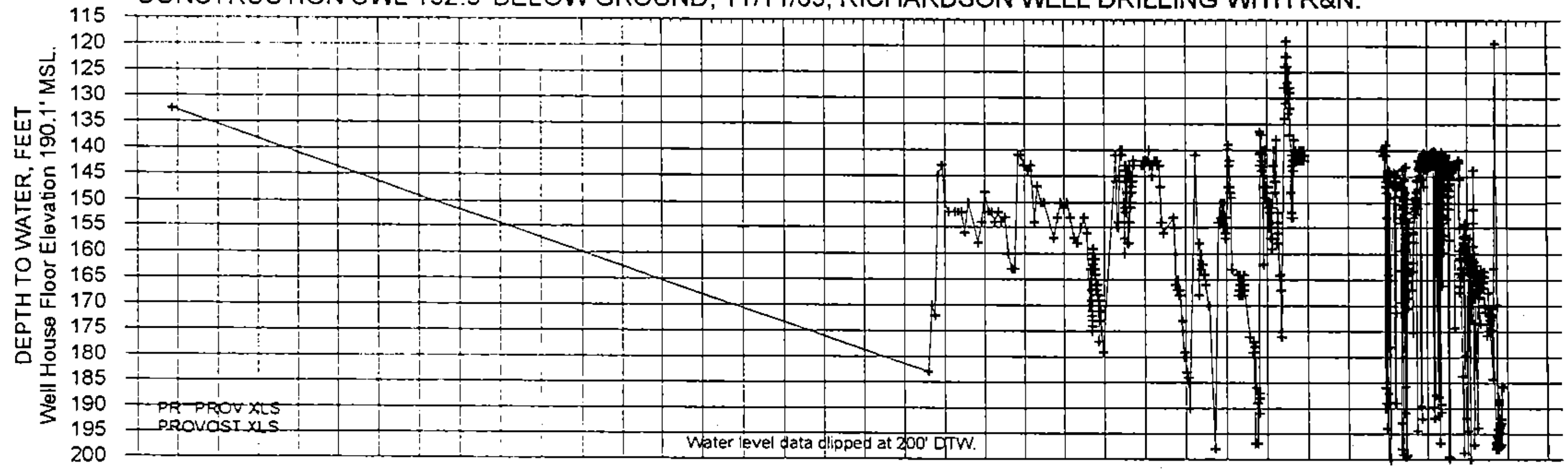
DATA INCLUDES "WATER LEVEL" AND "WATER VALLEY" DATA.
WATER LEVEL DATA CLIPPED AT AXIS LIMITS.
WATER LEVELS DIRECTLY EFFECTED BY CHENA WELL 1.

NOMINAL INSTANTANEOUS PRODUCTION RATE = 390 GPM.

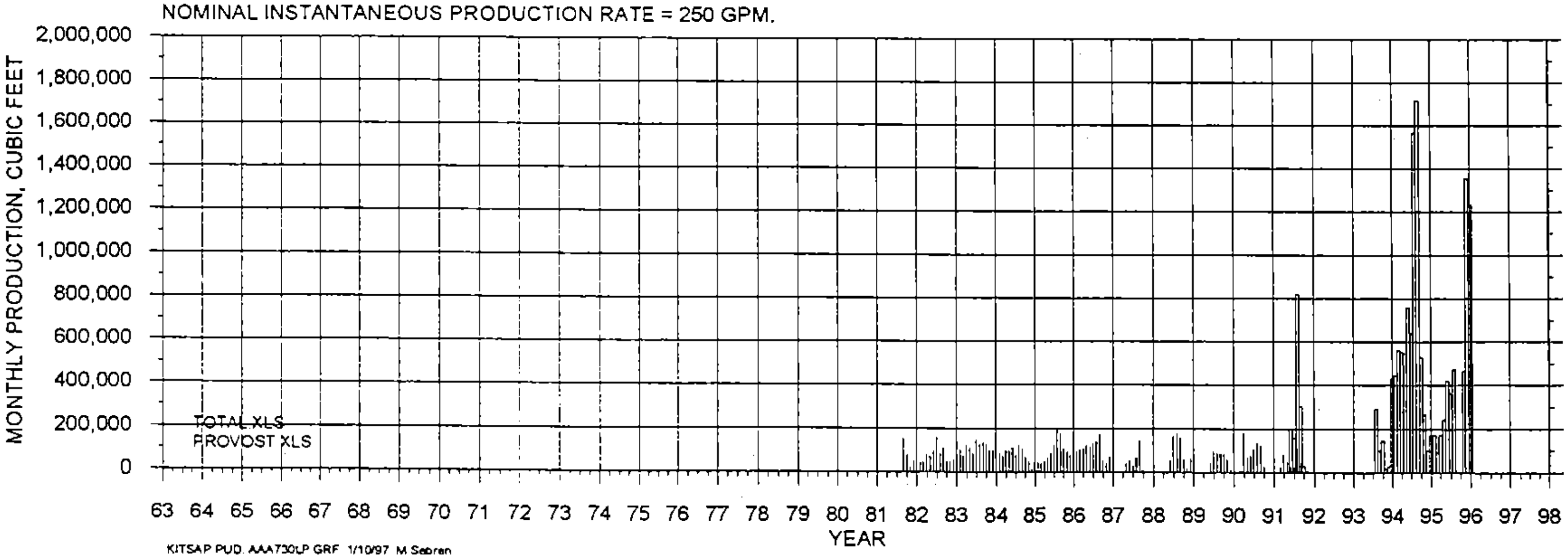


KITSAP PUD AAA729LP.GRF 1/10/97 M.Sebren

HYDROGRAPH OF SILVERDALE WATER DISTRICT PROVOST WELL (AAA730).
T25N/R01E-20C. COMPLETION ELEVATION -56 TO -74 FT MSL.
CONSTRUCTION SWL 132.5' BELOW GROUND, 11/11/63, RICHARDSON WELL DRILLING WITH R&N.

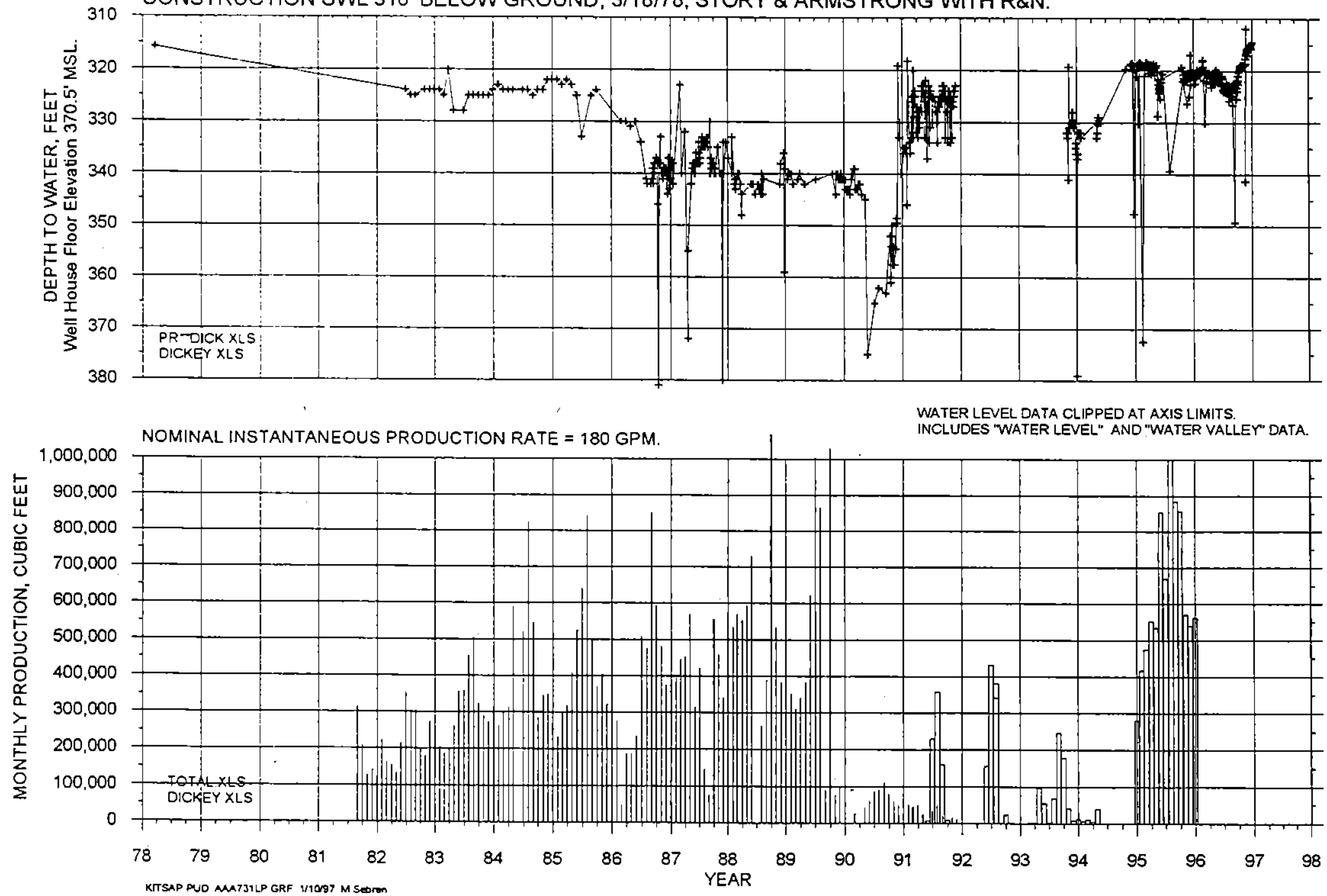


NOMINAL INSTANTANEOUS PRODUCTION RATE = 250 GPM.

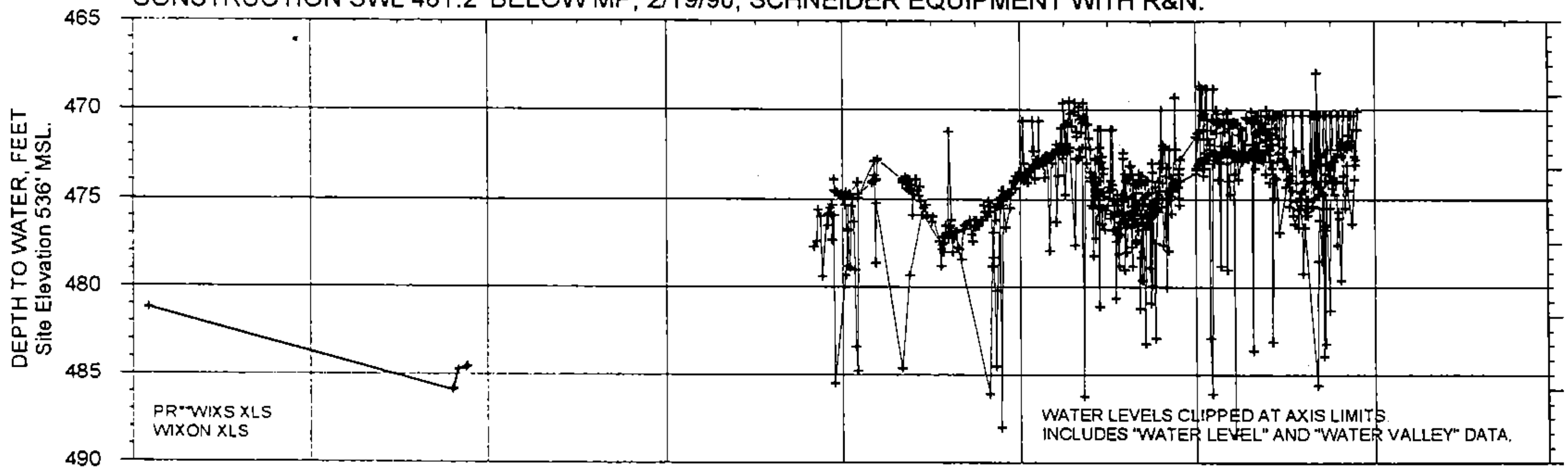


KITSAP PUD. AAA730LP GRF 1/10/97 M Sebren

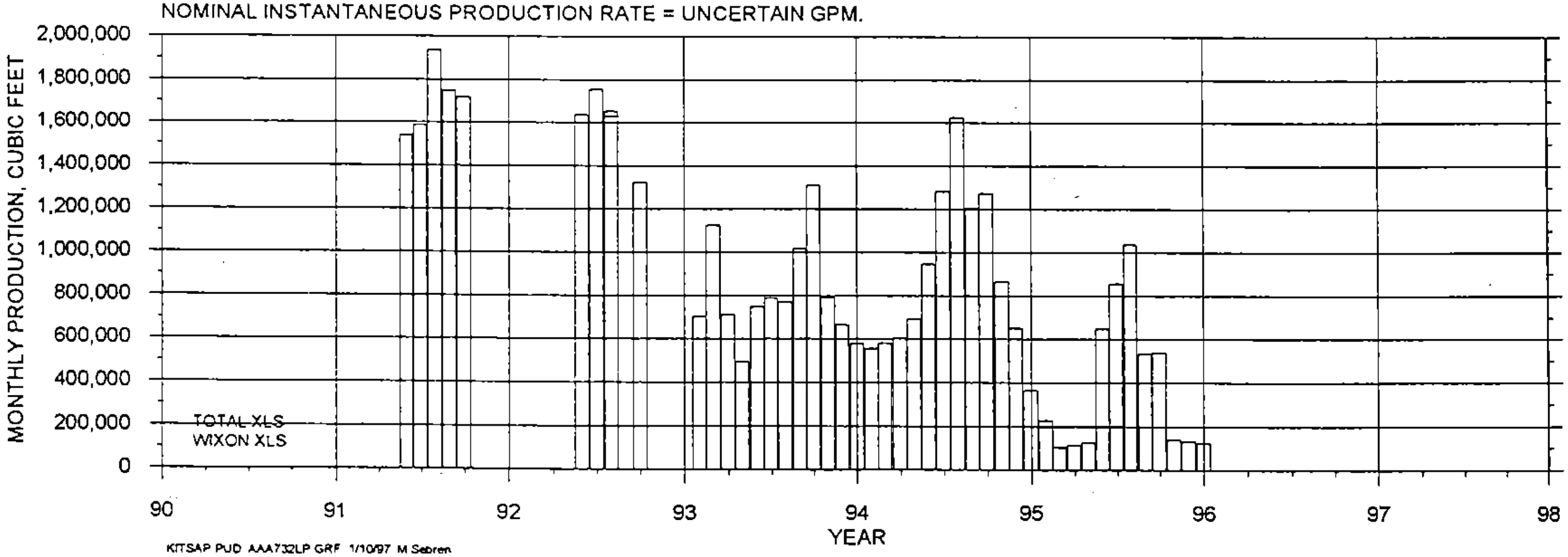
HYDROGRAPH OF SILVERDALE WATER DISTRICT DICKEY SCHOOL WELL (AAA731).
T25N/R01E-19H. COMPLETION ELEVATION -129 TO -225 FT MSL.
CONSTRUCTION SWL 316' BELOW GROUND, 3/18/78, STORY & ARMSTRONG WITH R&N.



HYDROGRAPH OF SILVERDALE WATER DISTRICT WIXON WELL (AAA732).
T25N/R01E-19L. COMPLETION ELEVATION -299 TO -434 FT MSL.
CONSTRUCTION SWL 481.2' BELOW MP, 2/19/90, SCHNEIDER EQUIPMENT WITH R&N.

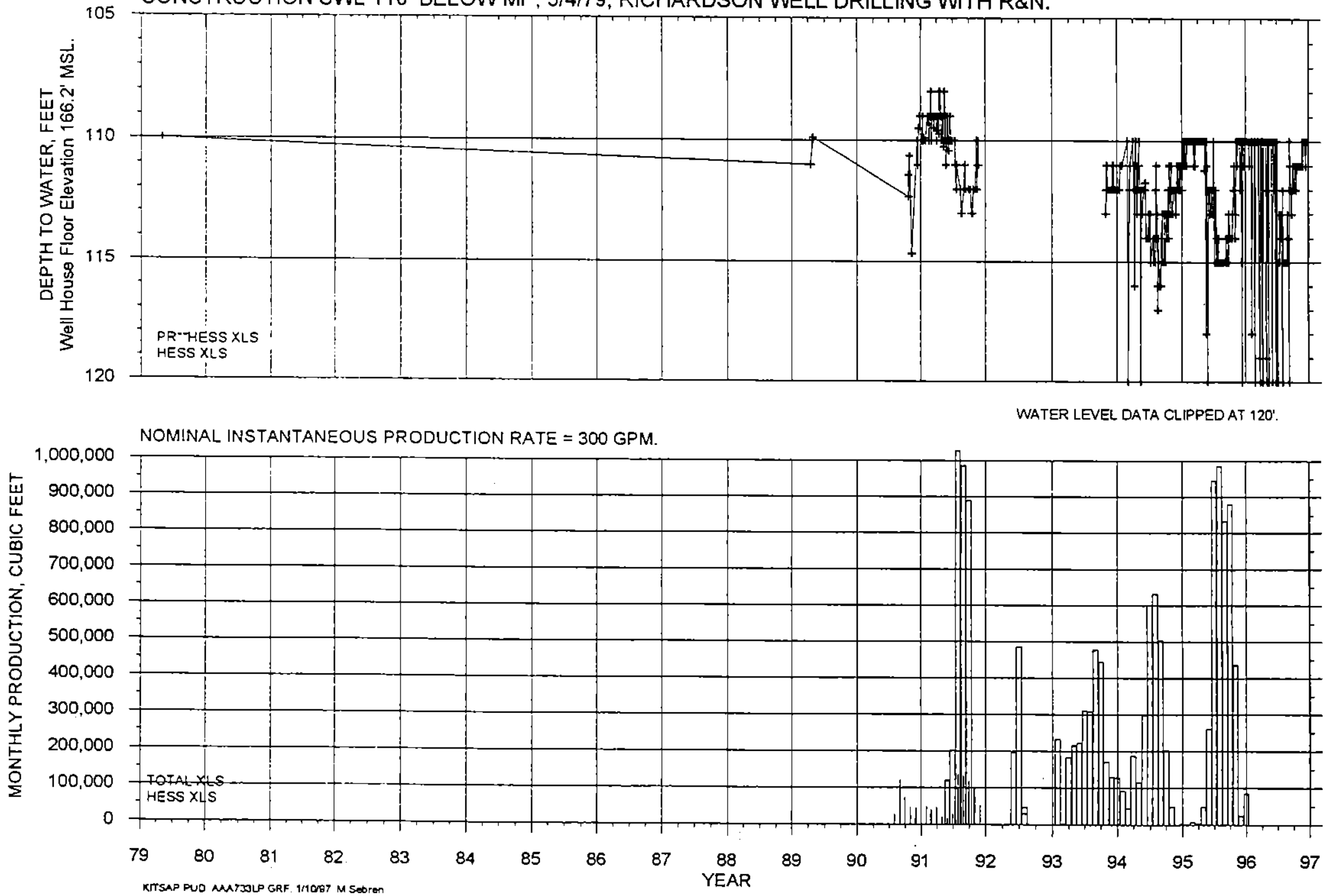


NOMINAL INSTANTANEOUS PRODUCTION RATE = UNCERTAIN GPM.

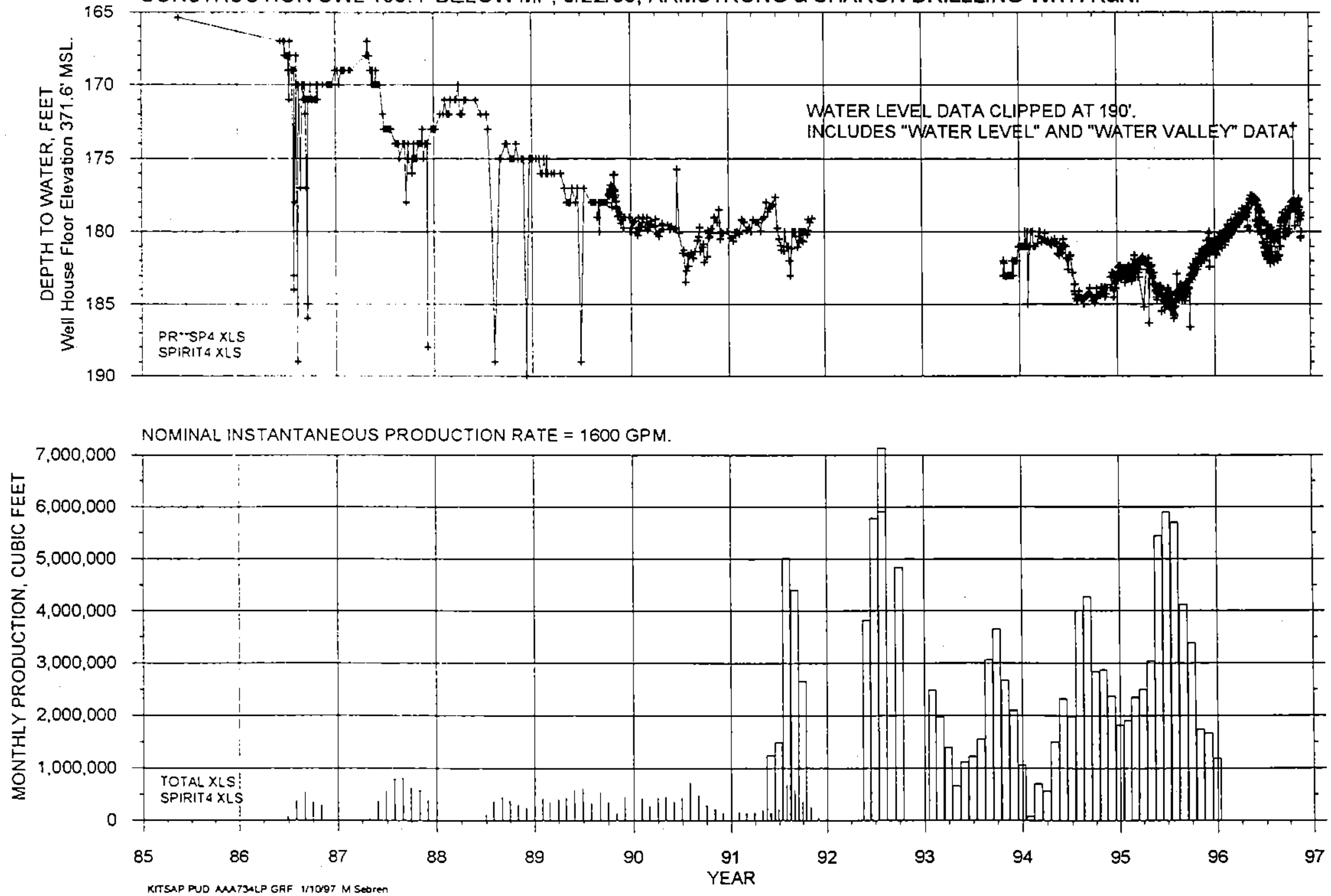


KITSAP PUD AAA732LP GRF 1/10/97 M Sebren

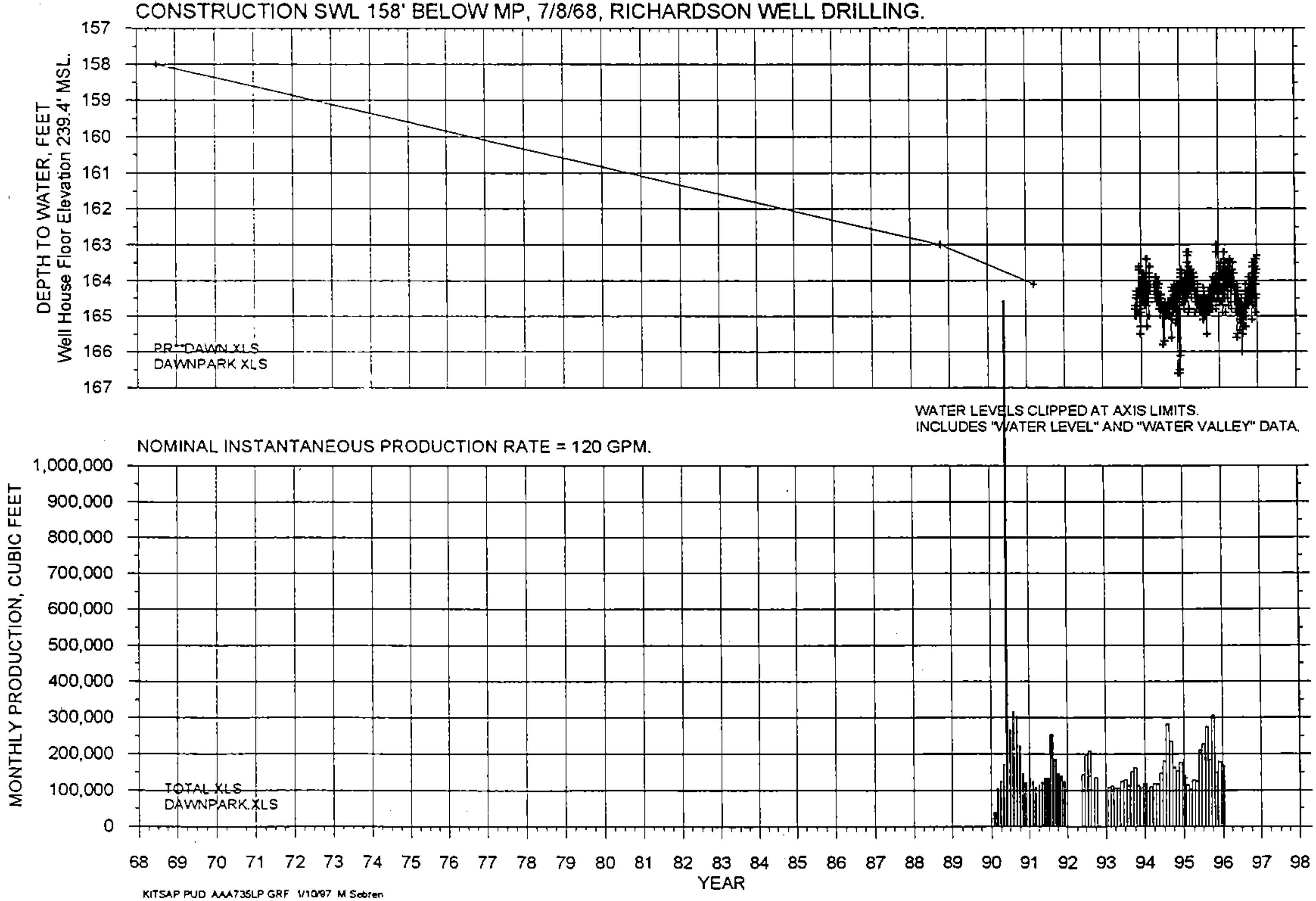
HYDROGRAPH OF SILVERDALE WATER DISTRICT HESS WELL (AAA733).
T25N/R01E-29D. COMPLETION ELEVATION -341 TO -451 FT MSL.
CONSTRUCTION SWL 110' BELOW MP, 5/4/79, RICHARDSON WELL DRILLING WITH R&N.



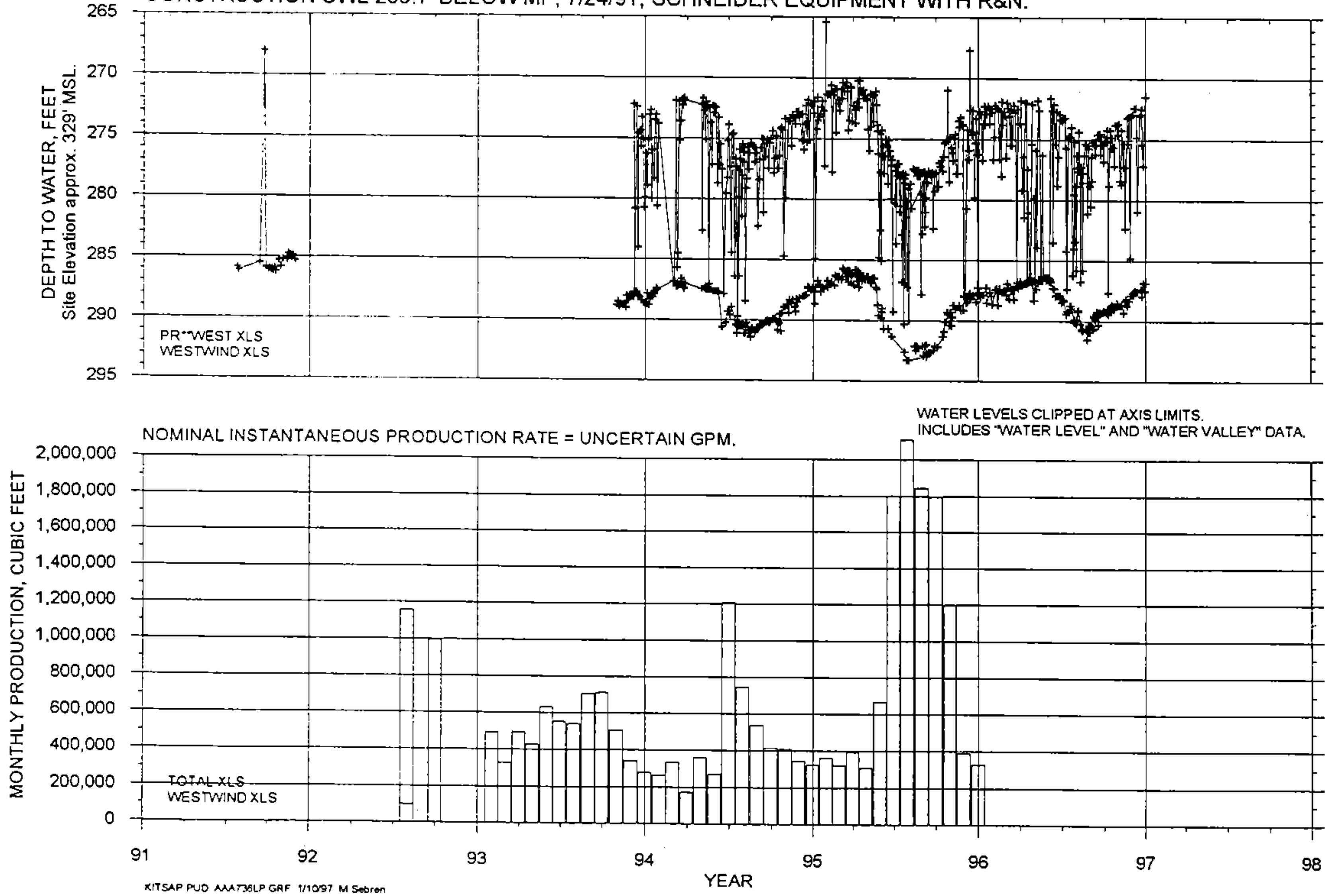
HYDROGRAPH OF SILVERDALE WATER DISTRICT SPIRIT WELL 4 (AAA734).
T25N/R01E-3B. COMPLETION ELEVATION 41 TO 82 FT MSL.
CONSTRUCTION SWL 165.4' BELOW MP, 5/22/85, ARMSTRONG & CHARON DRILLLING WITH R&N.



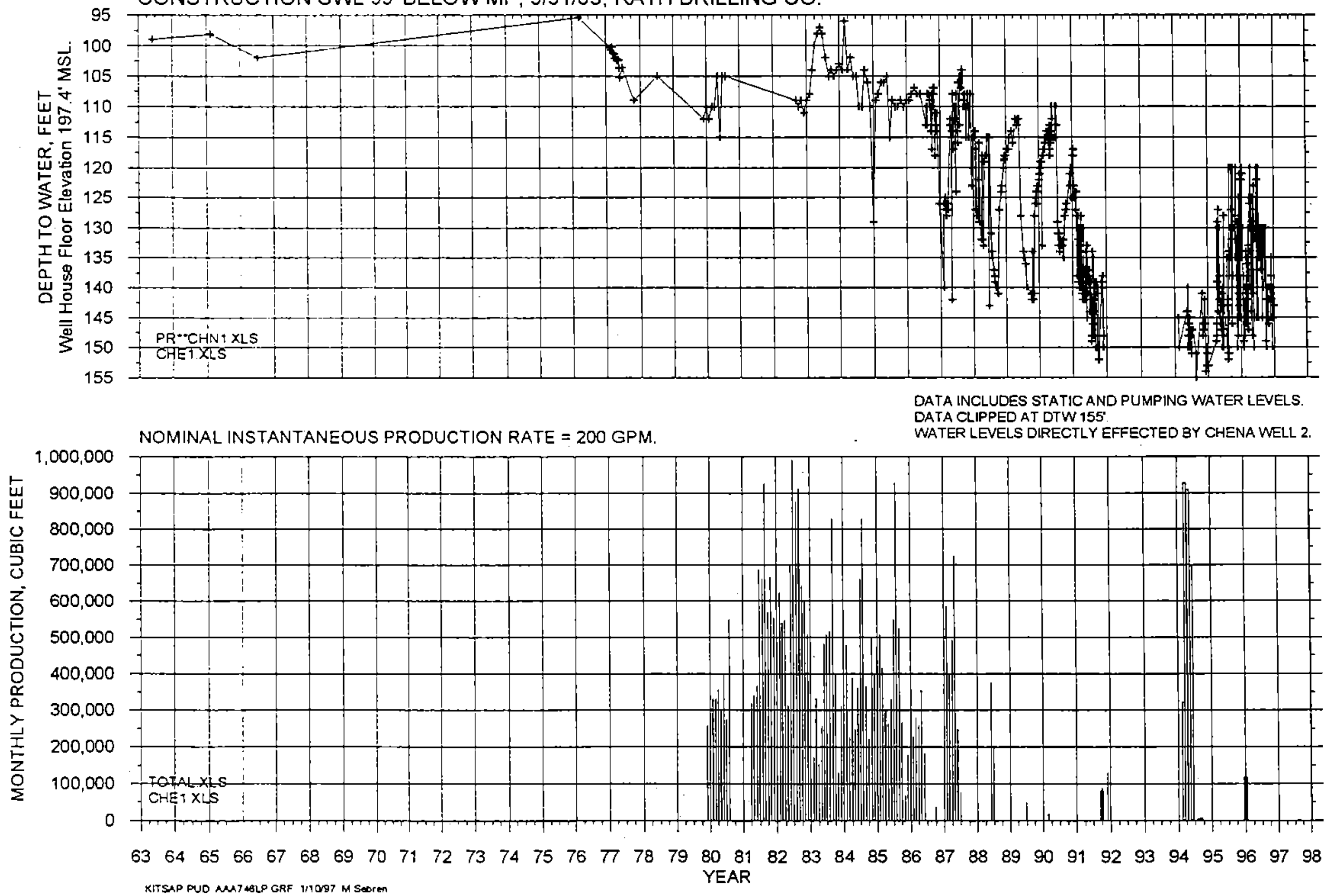
HYDROGRAPH OF SILVERDALE WATER DISTRICT DAWN PARK WELL (AAA735).
T25N/R01E-5J. COMPLETION ELEVATION 25 TO 42 FT MSL.
CONSTRUCTION SWL 158' BELOW MP, 7/8/68, RICHARDSON WELL DRILLING.



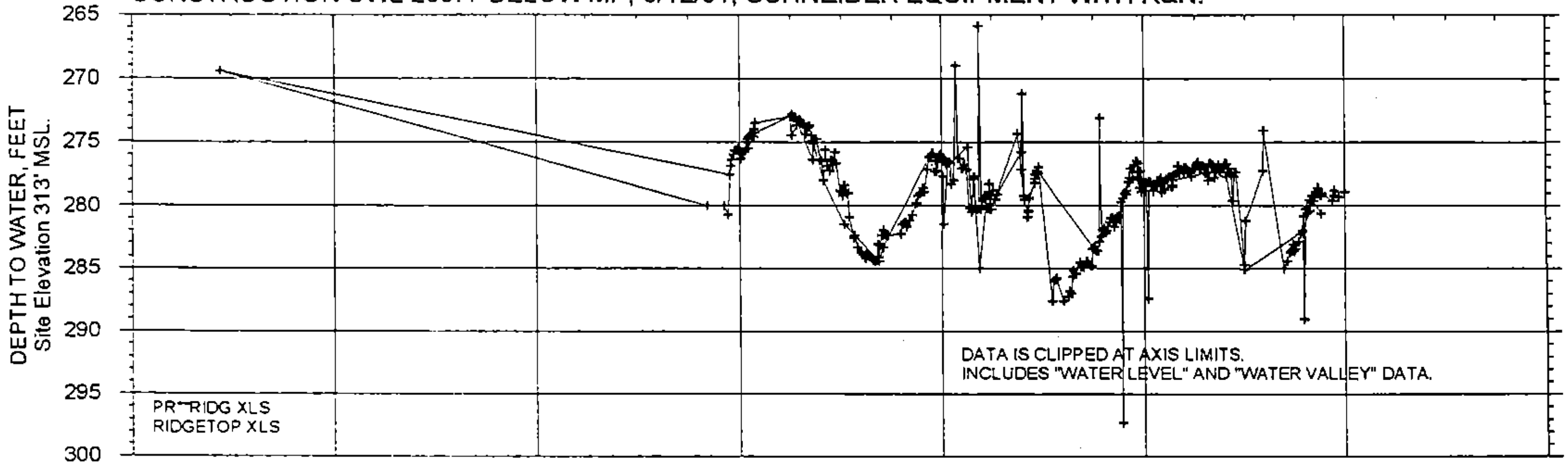
HYDROGRAPH OF SILVERDALE WATER DISTRICT WESTWIND WELL (AAA736).
T25N/R01E-18H. COMPLETION ELEVATION -421 TO -521 FT MSL.
CONSTRUCTION SWL 283.7' BELOW MP, 7/24/91, SCHNEIDER EQUIPMENT WITH R&N.



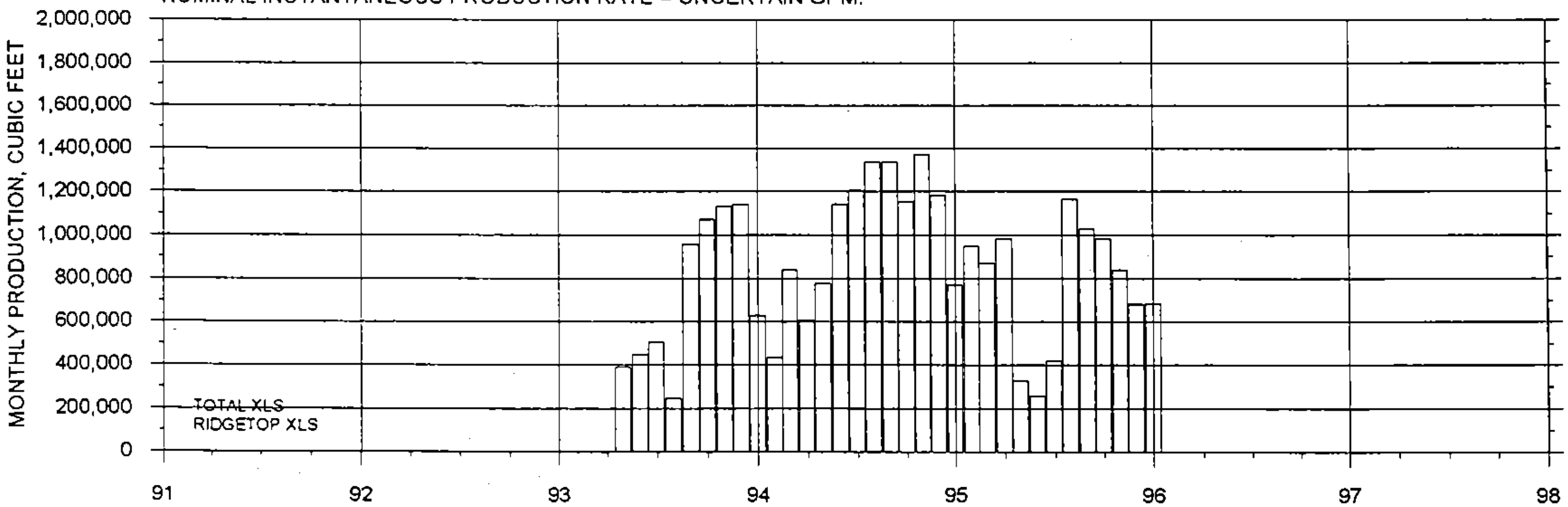
HYDROGRAPH OF SILVERDALE WATER DISTRICT CHENA WELL 1 (AAA746).
T25N/R01E-16R. COMPLETION ELEVATION -8 FT MSL.
CONSTRUCTION SWL 99' BELOW MP, 5/31/63, RATH DRILLING CO.



HYDROGRAPH OF SILVERDALE WATER DISTRICT RIDGETOP WELL (AAA747).
T25N/R01E-15D. COMPLETION ELEVATION -484 TO -666 FT MSL.
CONSTRUCTION SWL 269.4' BELOW MP, 6/12/91, SCHNEIDER EQUIPMENT WITH R&N.

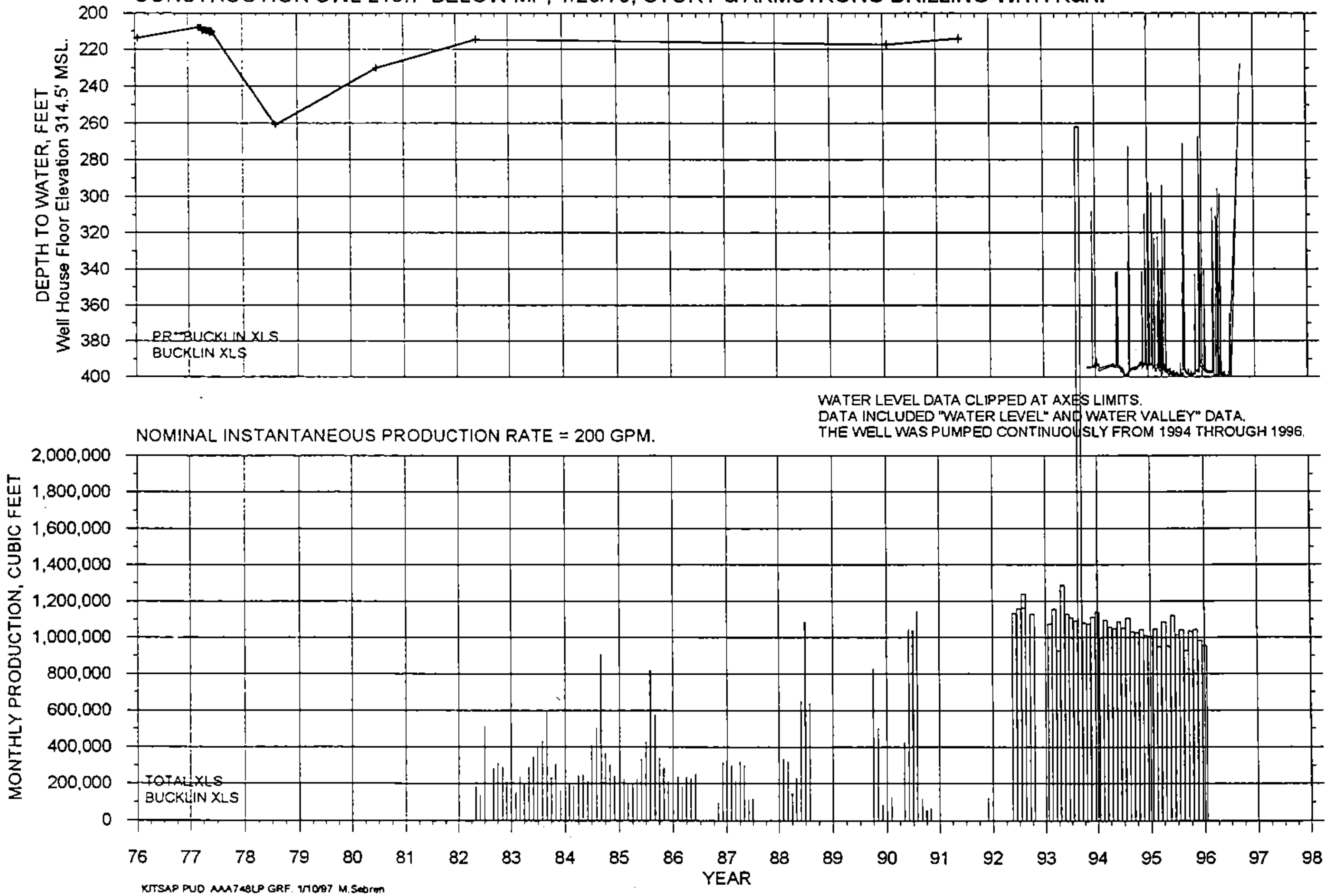


NOMINAL INSTANTANEOUS PRODUCTION RATE = UNCERTAIN GPM.

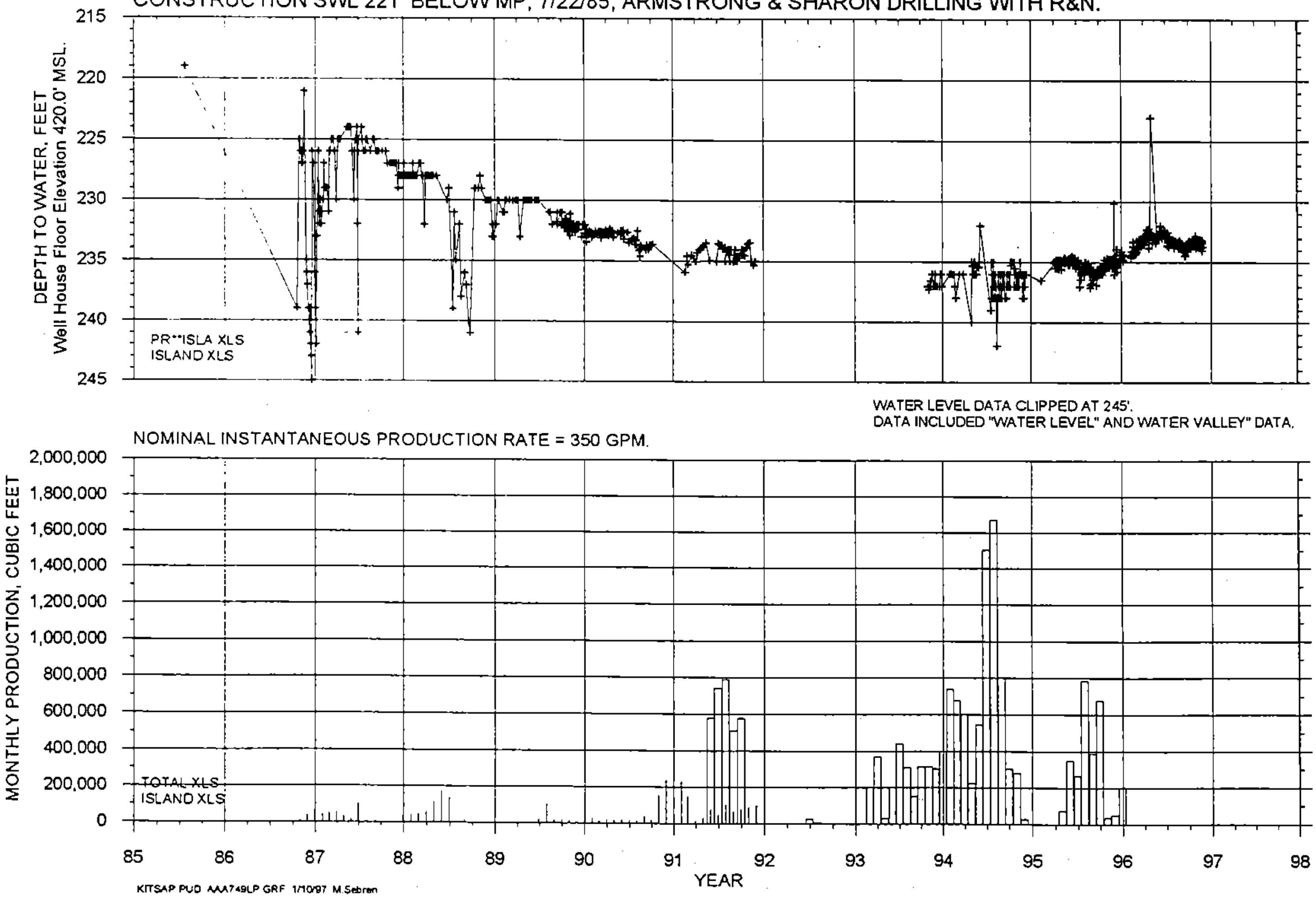


KITSAP PUD AAA747LP GRF 1/10/97 M.Sebren

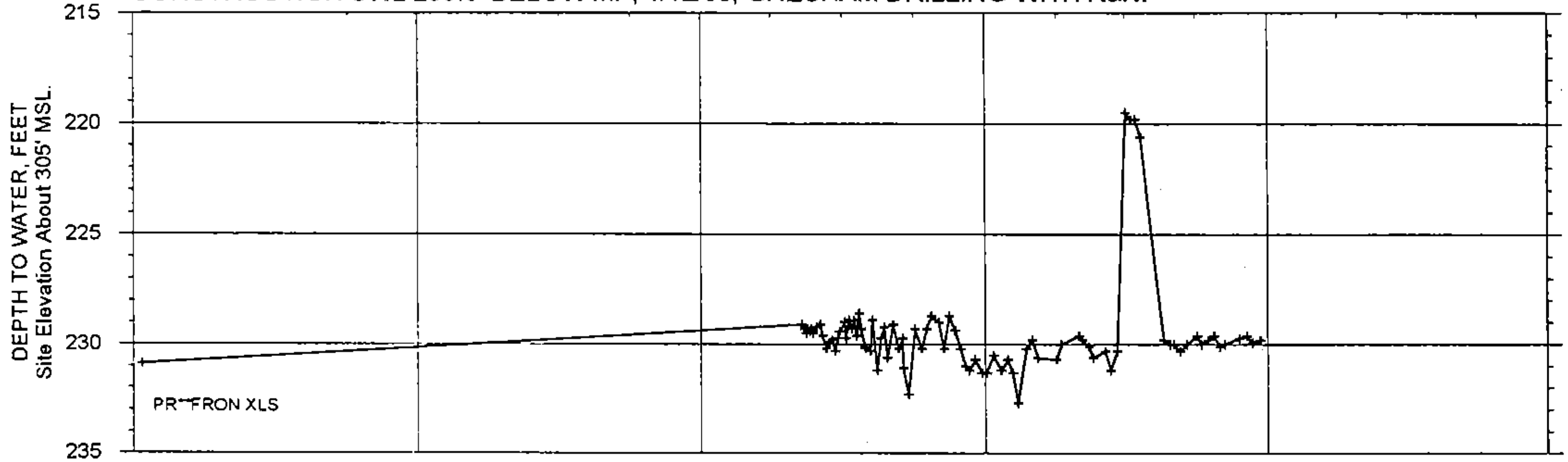
HYDROGRAPH OF SILVERDALE WATER DISTRICT BUCKLIN RIDGE WELL (AAA748).
T25N/R01E-10D. COMPLETION ELEVATION -154 TO -165 FT MSL.
CONSTRUCTION SWL 213.7' BELOW MP, 1/20/76, STORY & ARMSTRONG DRILLING WITH R&N.



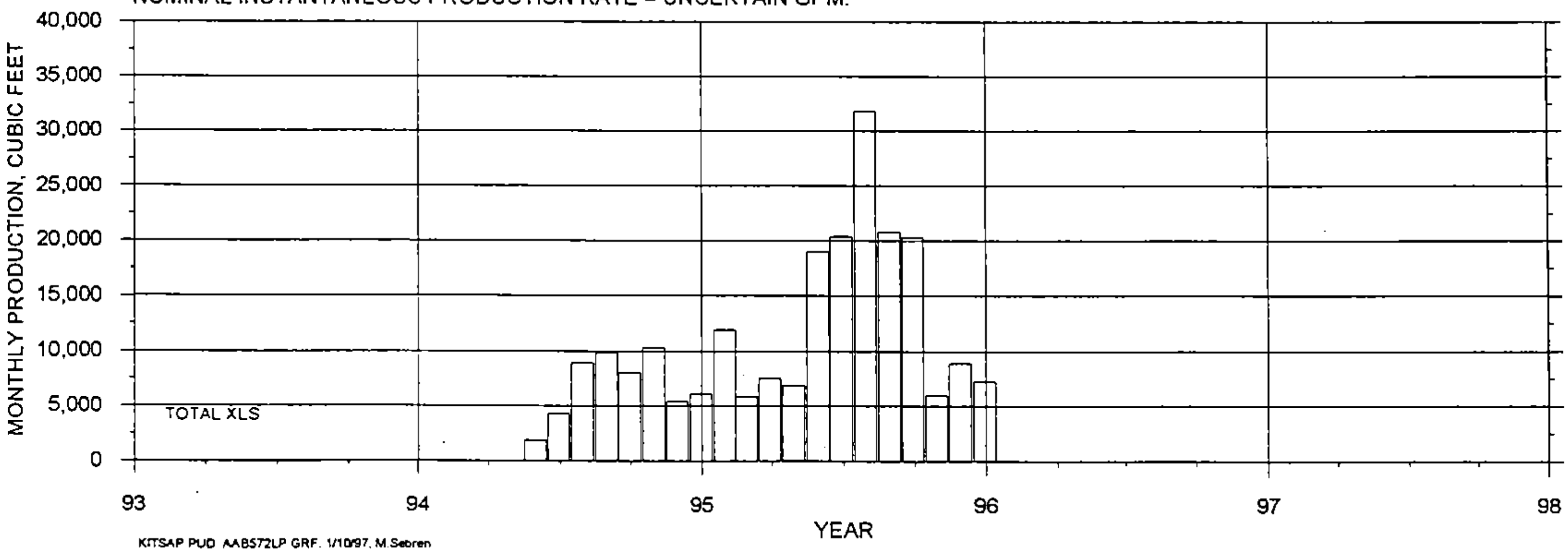
HYDROGRAPH OF SILVERDALE WATER DISTRICT ISLAND LAKE WELL (AAA749).
T25N/R01E-10D. COMPLETION ELEVATION 100 TO 145 FT MSL.
CONSTRUCTION SWL 221' BELOW MP, 7/22/85, ARMSTRONG & SHARON DRILLING WITH R&N.



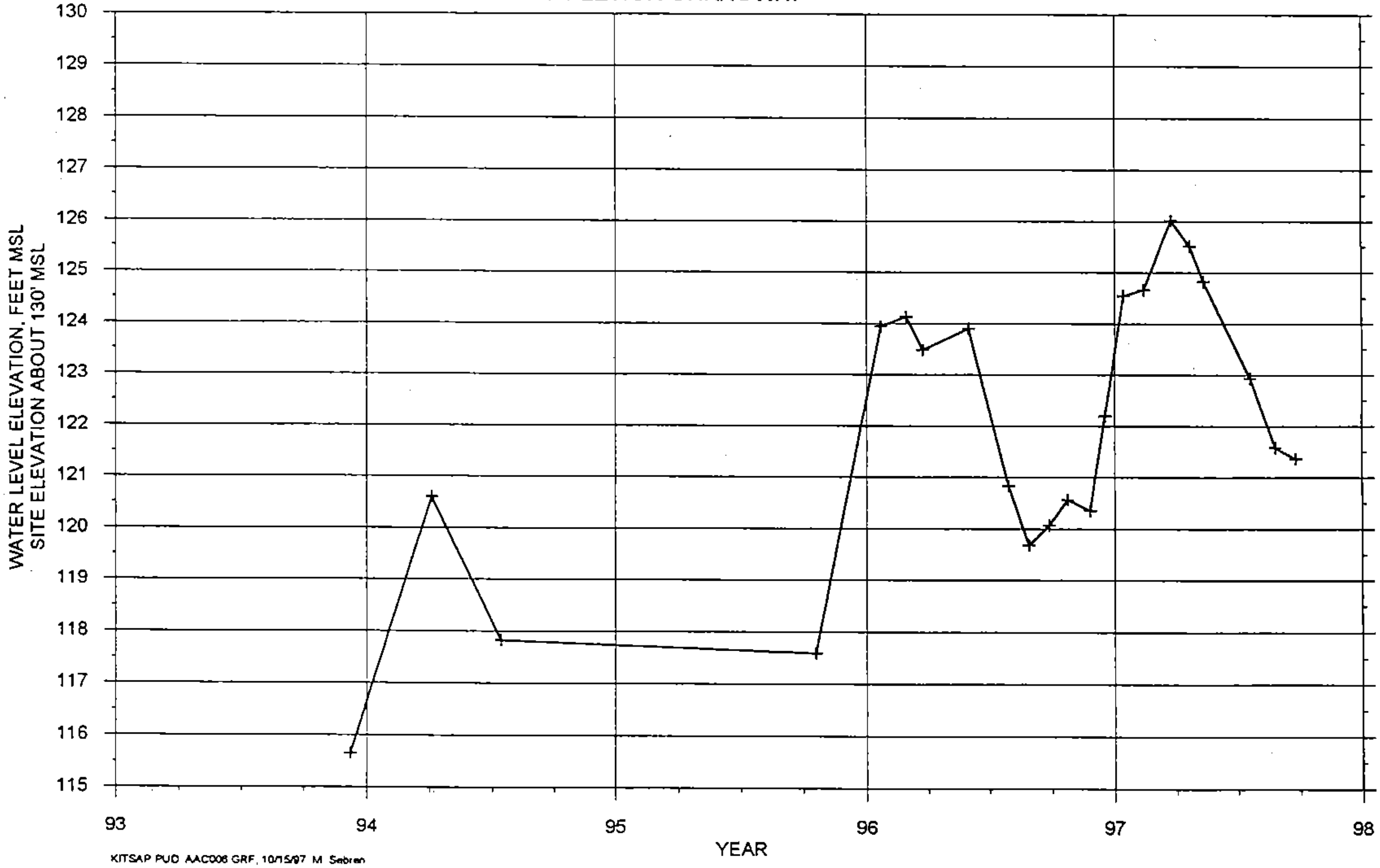
HYDROGRAPH OF SILVERDALE WATER DISTRICT FRONTIER WOOD WELL (AAB572).
T25N/R01E-7A. COMPLETION ELEVATION 10 TO 31 FT MSL.
CONSTRUCTION SWL 230.9' BELOW MP, 1/12/93, GRESHAM DRILLING WITH R&N.



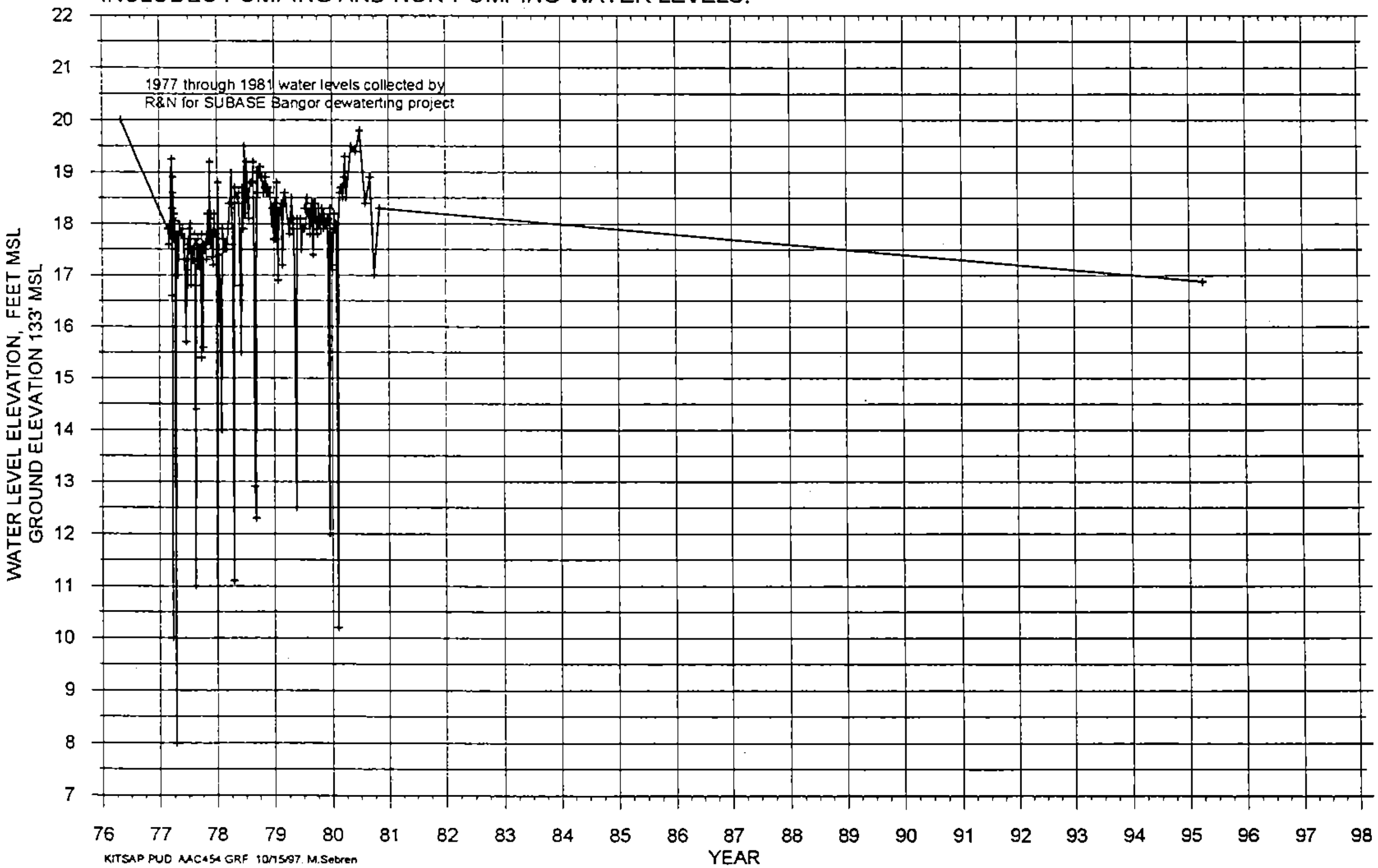
NOMINAL INSTANTANEOUS PRODUCTION RATE = UNCERTAIN GPM.



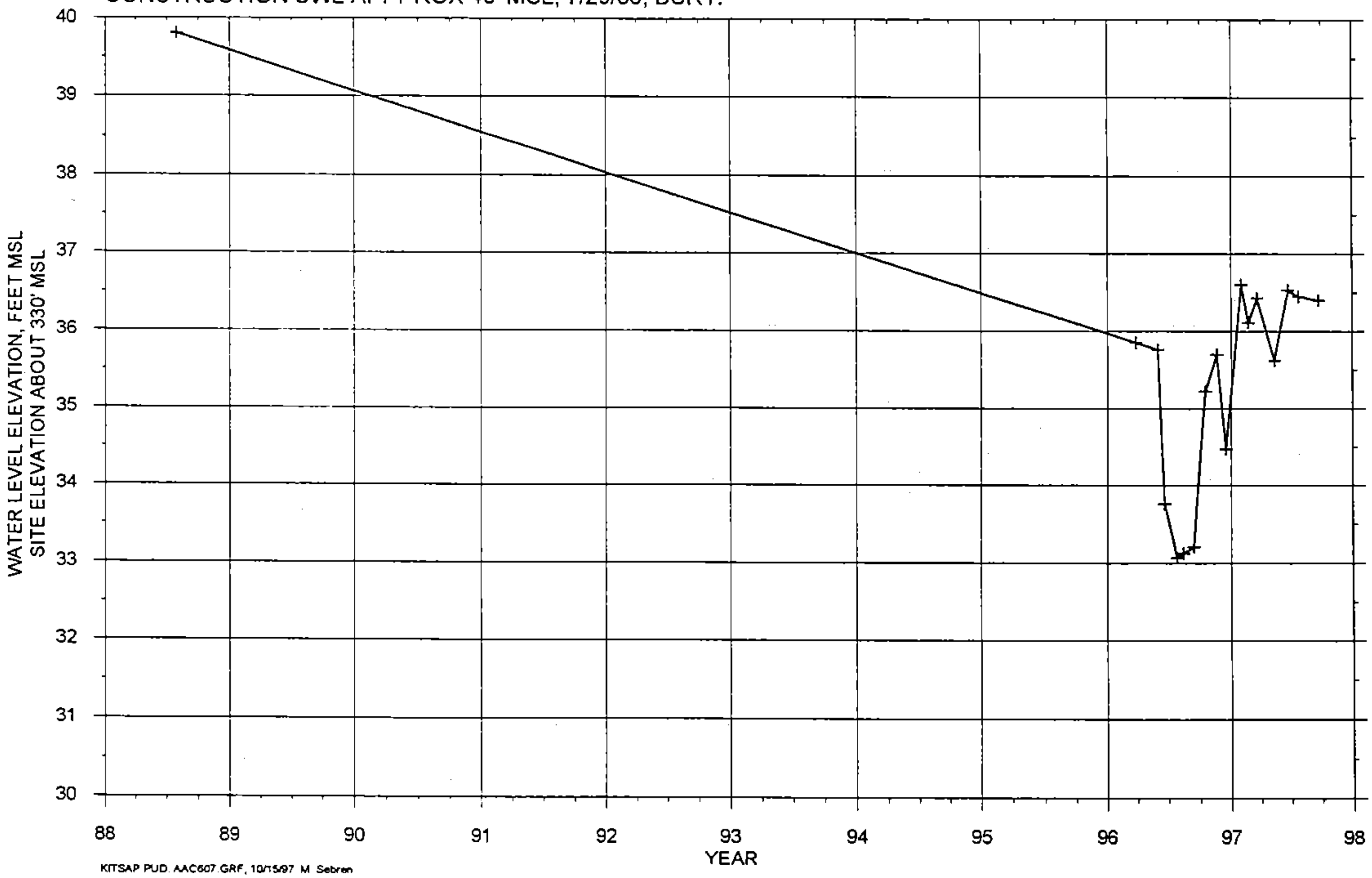
HYDROGRAPH OF LUNDBERG PRIVATE WELL (AAC006).
T25N/R01E-35D. WELL DEPTH AND COMPLETION UNKNOWN.

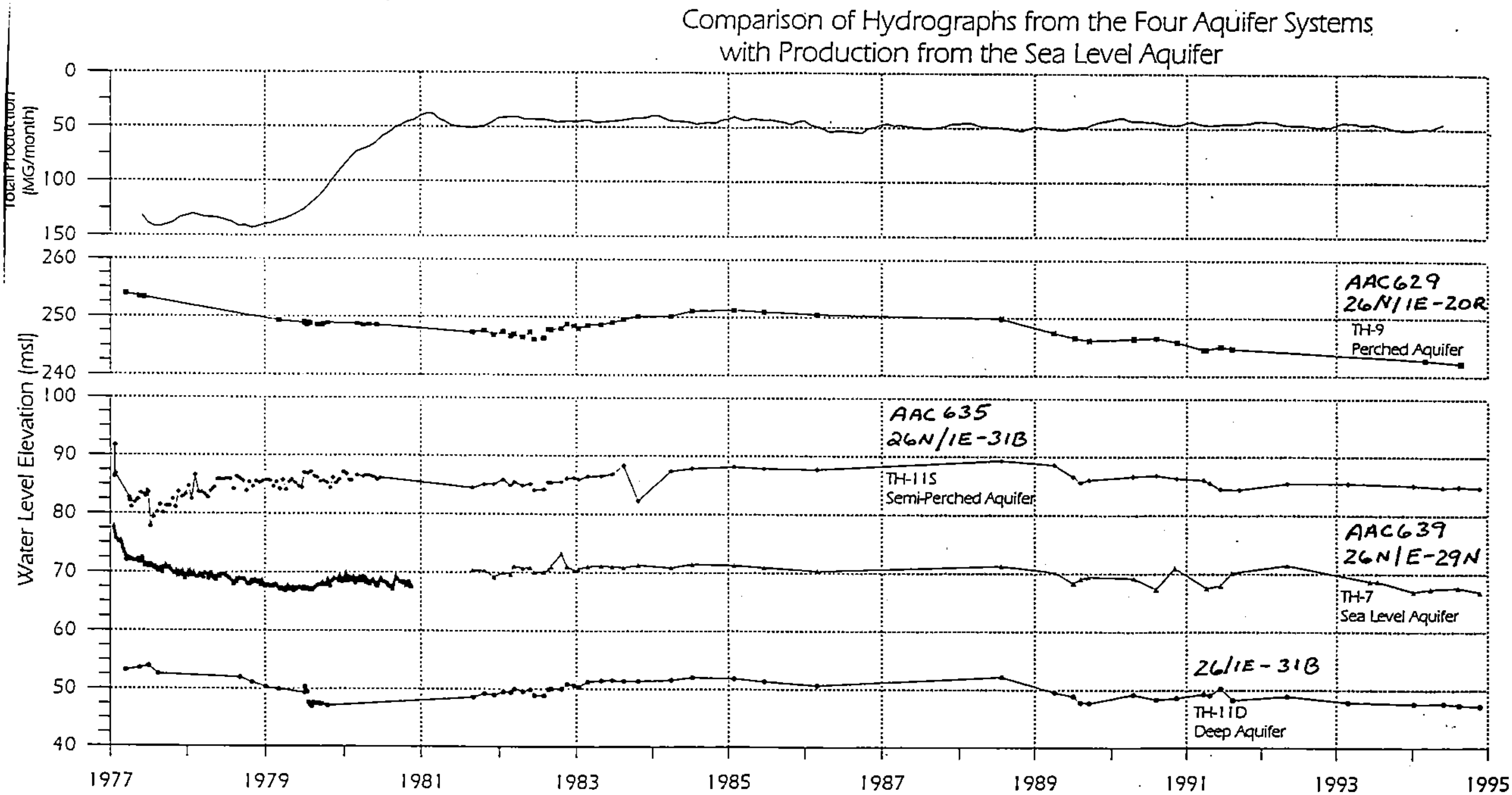


HYDROGRAPH OF JOHN FARBARIK WELL (AAC454).
T26N/R01W-36Q. COMPLETION ELEVATION -6 TO -11' MSL.
CONSTRUCTION SWL 20' MSL, 4/29/76, RELIABLE WELL DRILLING.
INCLUDES PUMPING AND NON-PUMPING WATER LEVELS.



HYDROGRAPH OF COUGAR VALLEY ELEMENTARY SCHOOL WELL (AAC607).
T25N/R01E-06L. COMPLETION ELEVATION -44 TO -54' MSL.
CONSTRUCTION SWL APPPROX 40' MSL, 7/29/88, BURT.

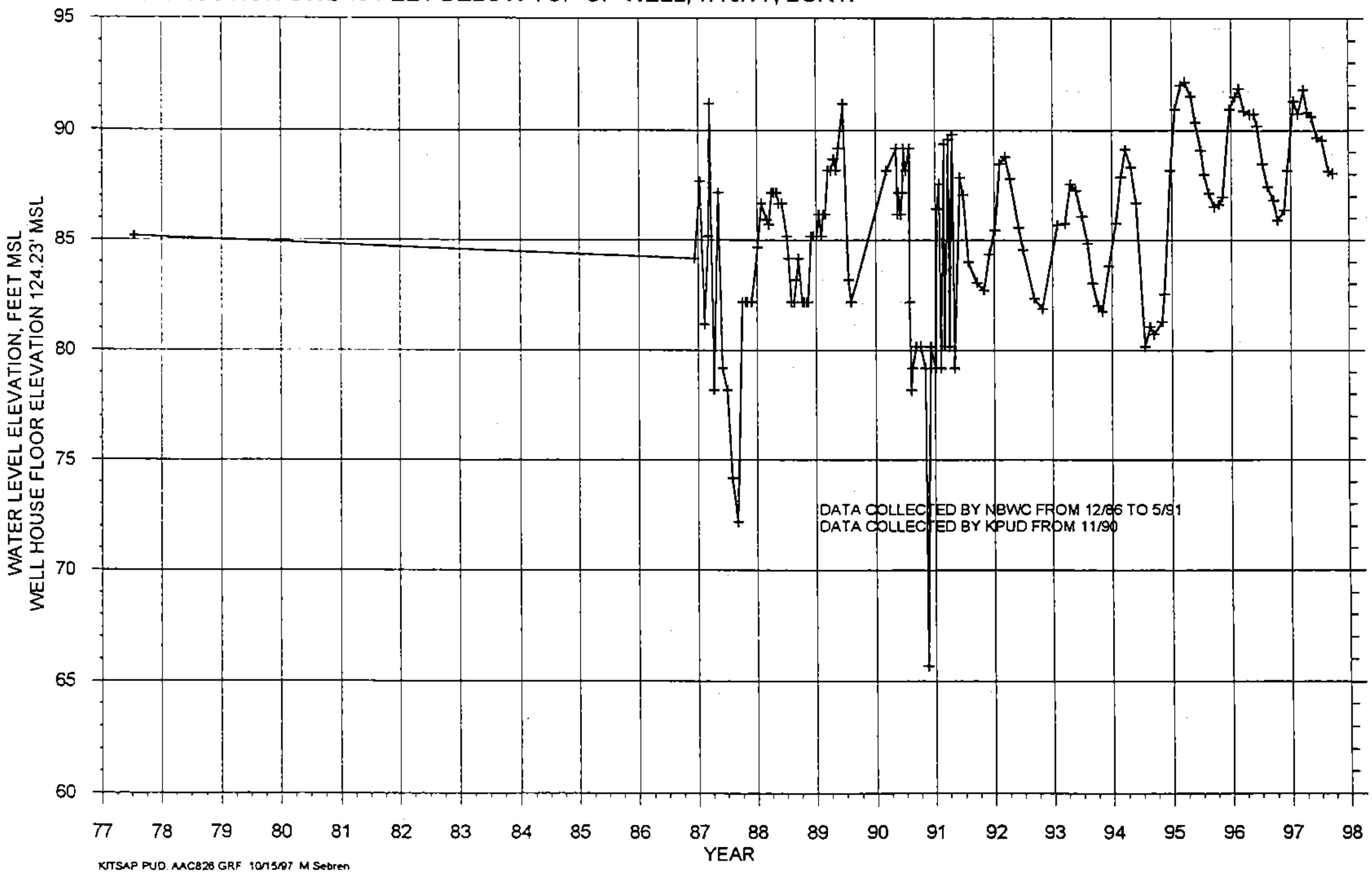




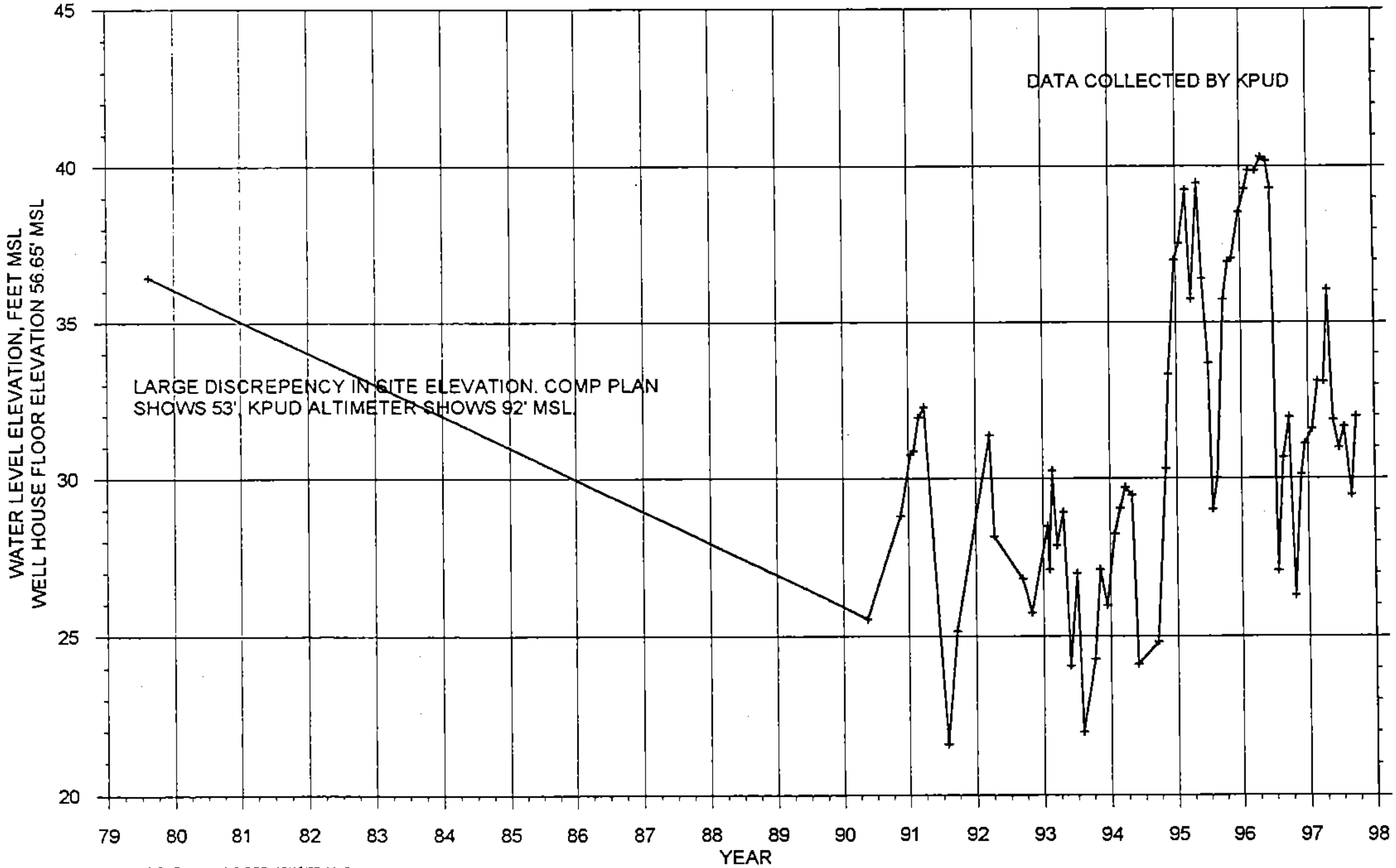
HYDROGEOLOGIC ANALYSIS
OF THE BANGOR AQUIFER SYSTEMS
KITSAP COUNTY, WASHINGTON

January, 1995

HYDROGRAPH OF NORTH BAINBRIDGE WATER COMPANY WELL 1 (AAC826).
T25N/R02E-9G. COMPLETION ELEVATION 62 TO 67' MSL.
CONSTRUCTION SWL 40 FEET BELOW TOP OF WELL, 7/15/77, BURT.

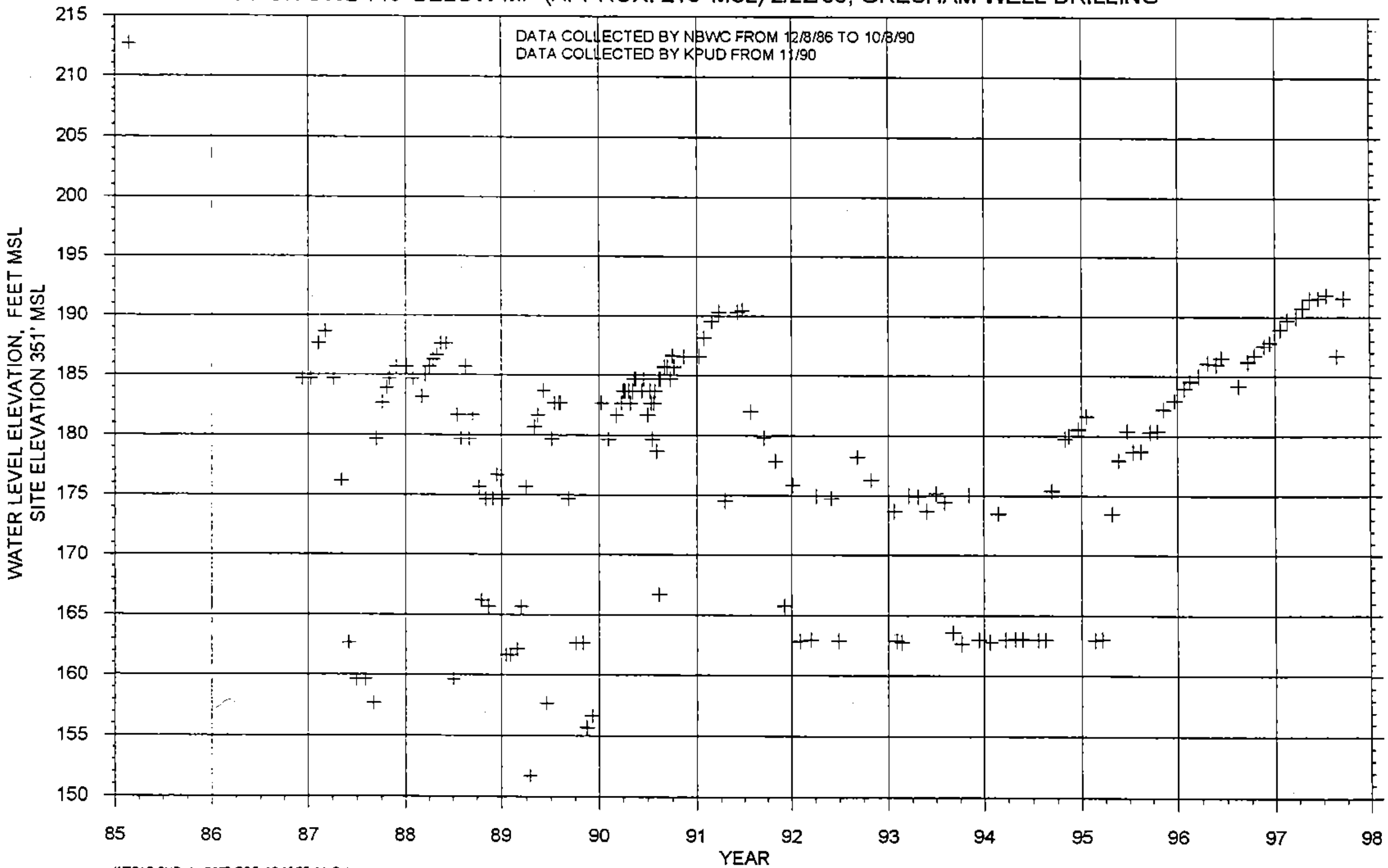


HYDROGRAPH OF NORTH BAINBRIDGE WATER COMPANY WELL 6 (AAA113).
T25N/R02E-9K. COMPLETION ELEVATION -46' TO -61' MSL.
CONSTRUCTION SWL 22.1' BELOW MP, 8/15/79, BURT.



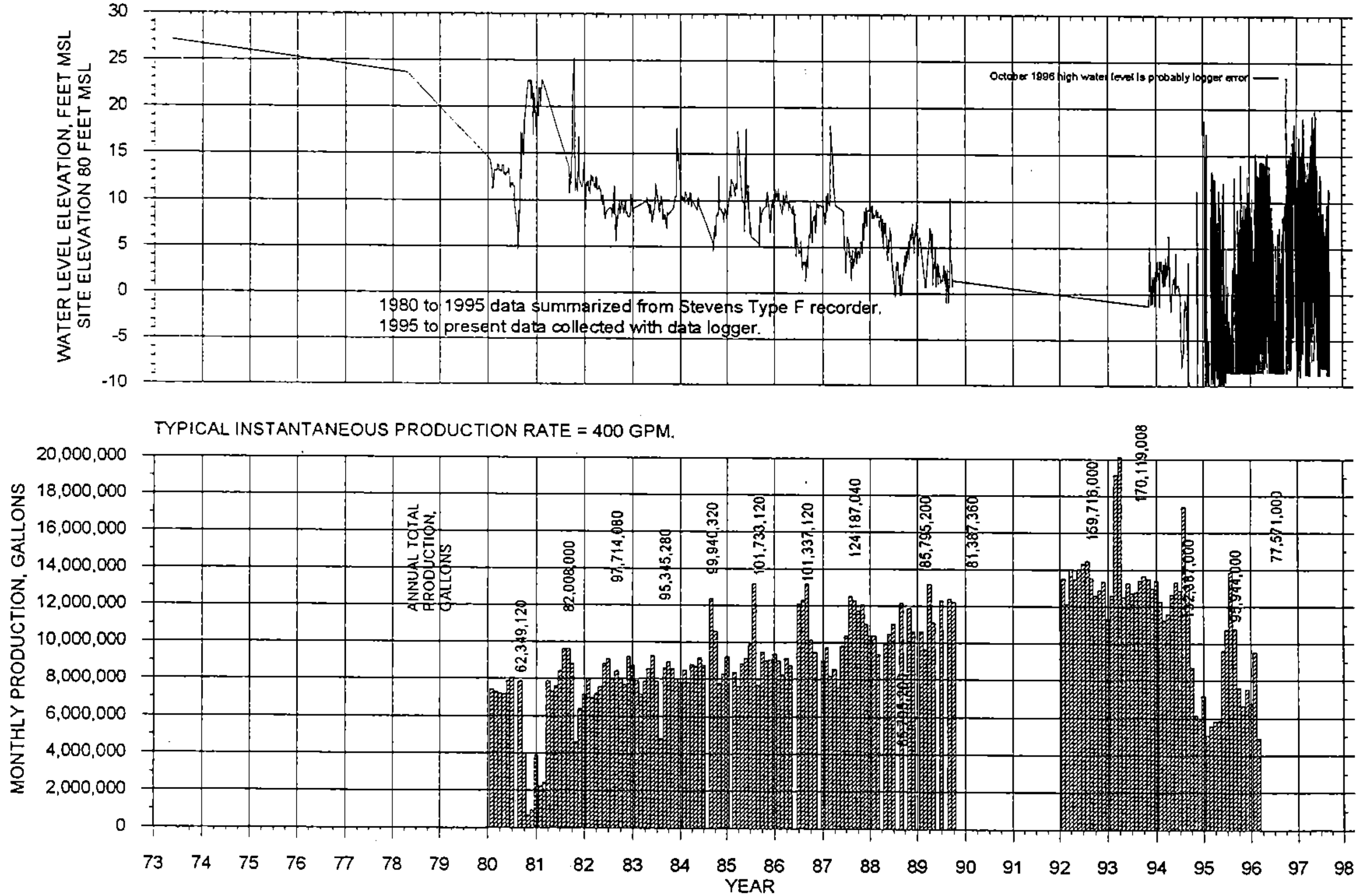
KITSAP PUD AAA113-2.GRF, 10/15/97 M. Sebren

HYDROGRAPH OF NORTH BAINBRIDGE WATER COMPANY WELL 8 (AAC832).
SCATTERGRAM OF PUMPING AND NON-PUMPING WATER LEVELS.
T25N/R02E-11E. COMPLETION ELEVATION 151' TO 171' MSL.
CONSTRUCTION SWL 140' BELOW MP (APPROX. 213' MSL) 2/22/85, GRESHAM WELL DRILLING



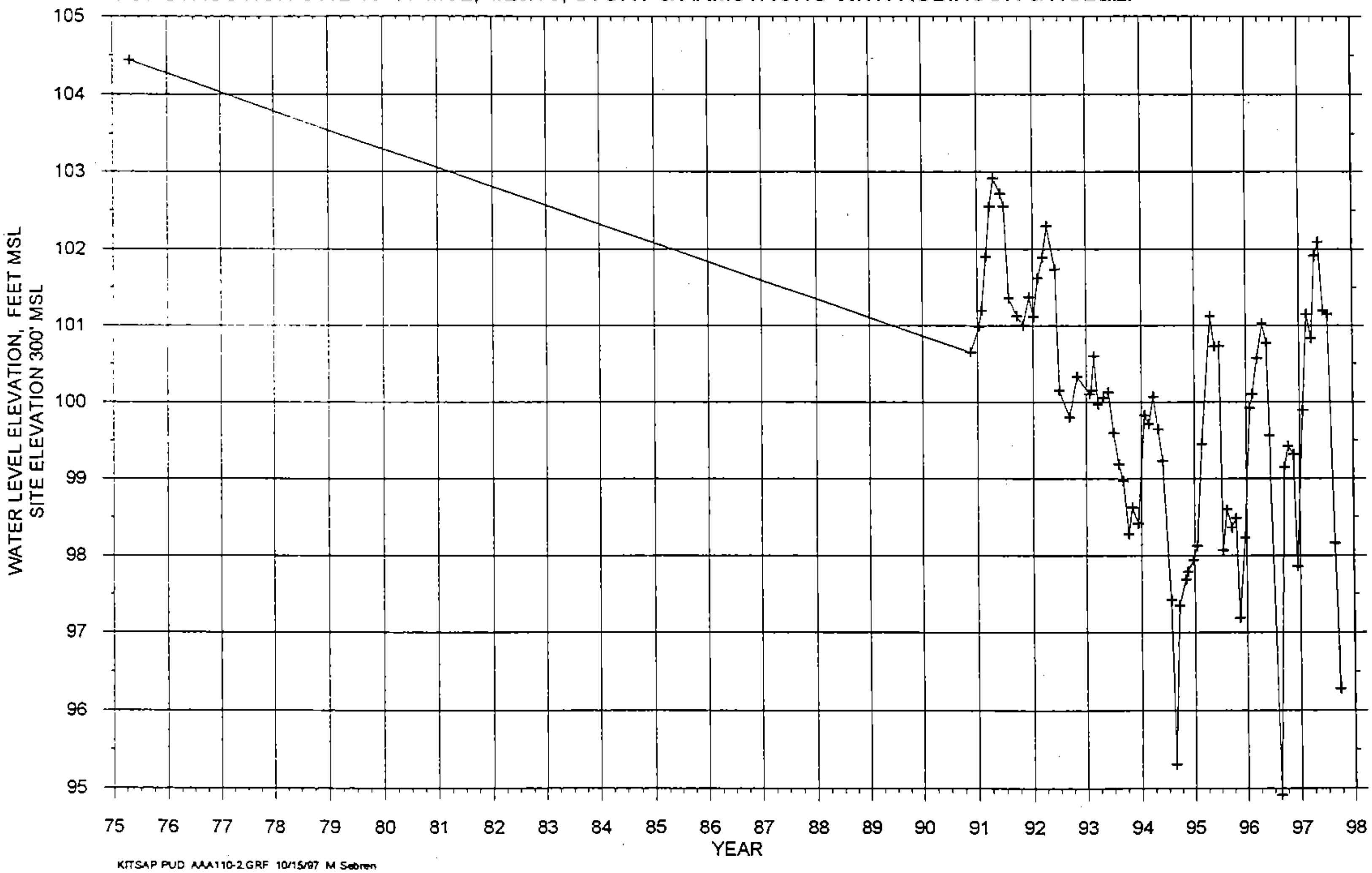
KITSAP PUD AAC832.GRF 10/15/97 M. Sebren

HYDROGRAPH FOR FLETCHER BAY OBSERVATION WELL (AAA111) AND
PRODUCTION SUMMARY FOR FLETCHER BAY PRODUCTION WELL (AAC733).
T25N/R02E-20K. COMPLETION ELEVATION -850 TO -930' MSL.
CONSTRUCTION SWL 27' MSL, 5/1/73, SOIL SAMPLING SERVICE AND ROBINSON & NOBLE.

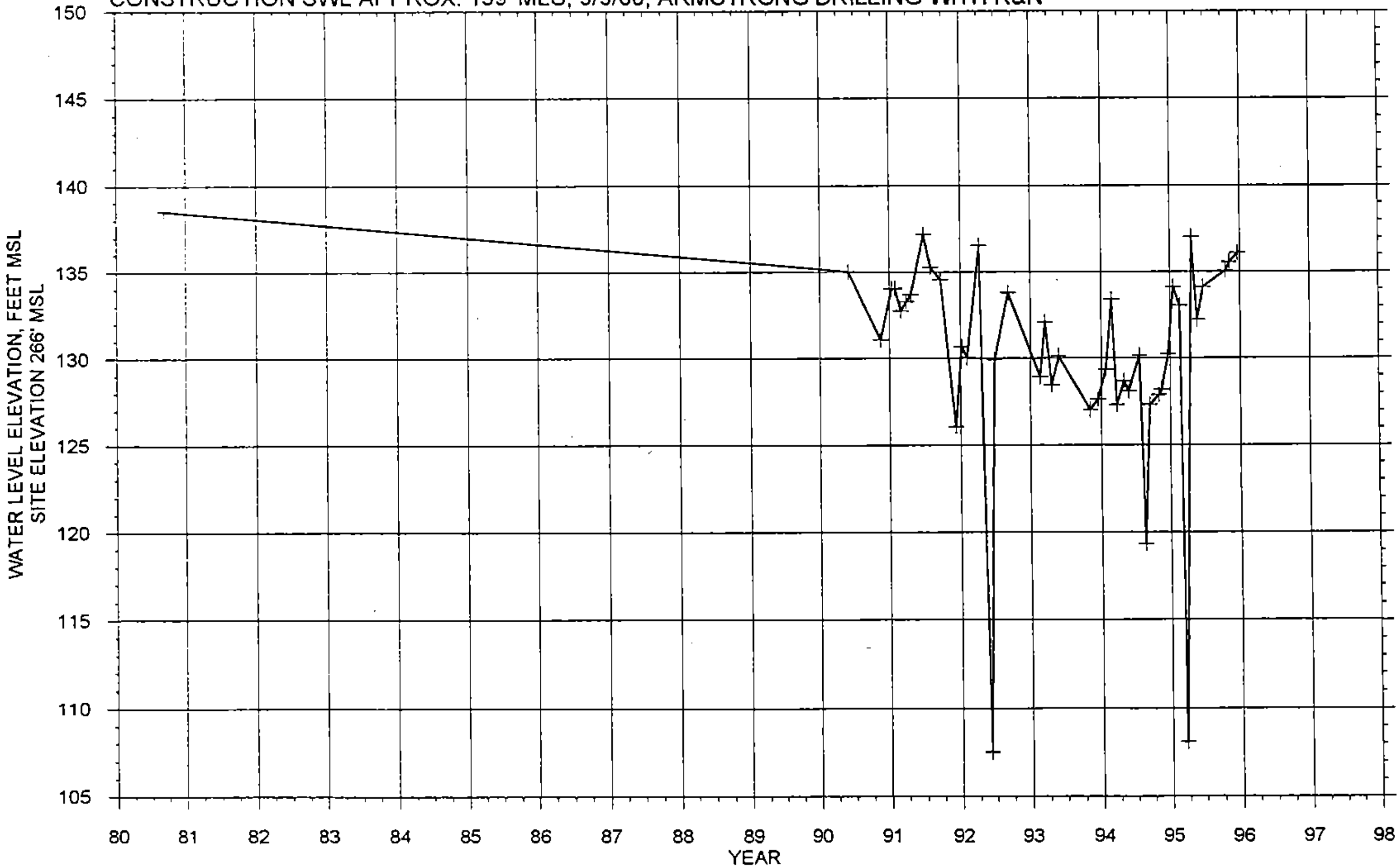


KITSAP PUD AAA111LP GRF 10/15/97 M Sebren

HYDROGRAPH OF ISLAND CENTER TEST WELL (AAA110).
T25N/R02E-21G. SCREEN ELEVATION -83' TO-98' MSL.
CONSTRUCTION SWL 104.4' MSL, 4/25/75, STORY & ARMSTRONG WITH ROBINSON & NOBLE.

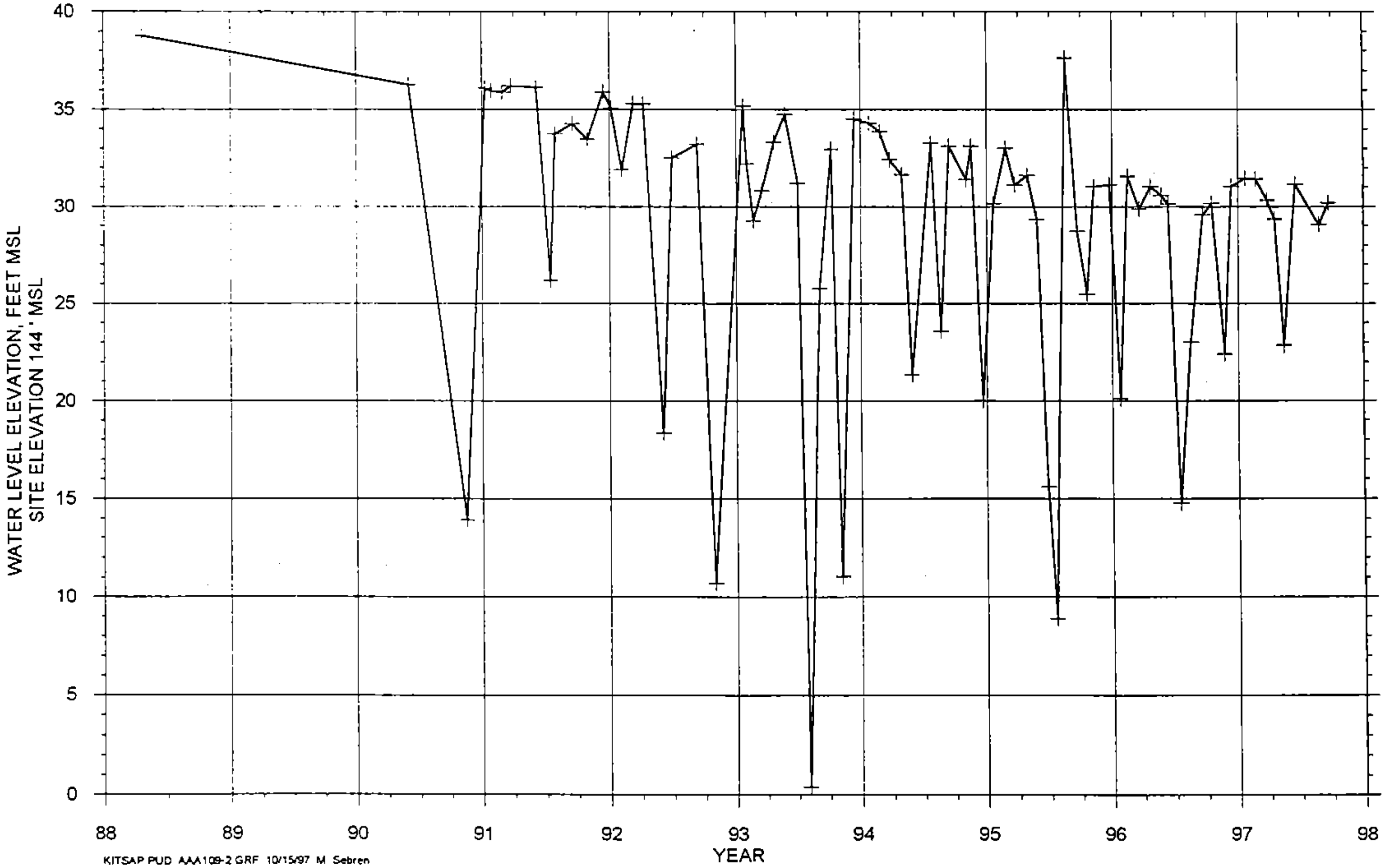


HYDROGRAPH OF BAINBRIDGE ISLAND HIGH SCHOOL WELL 3 (AAA239).
T25N/R02E-22R. COMPLETION ELEVATION 16 TO 75' MSL.
CONSTRUCTION SWL APPROX. 139' MLS, 9/9/80, ARMSTRONG DRILLING WITH R&N



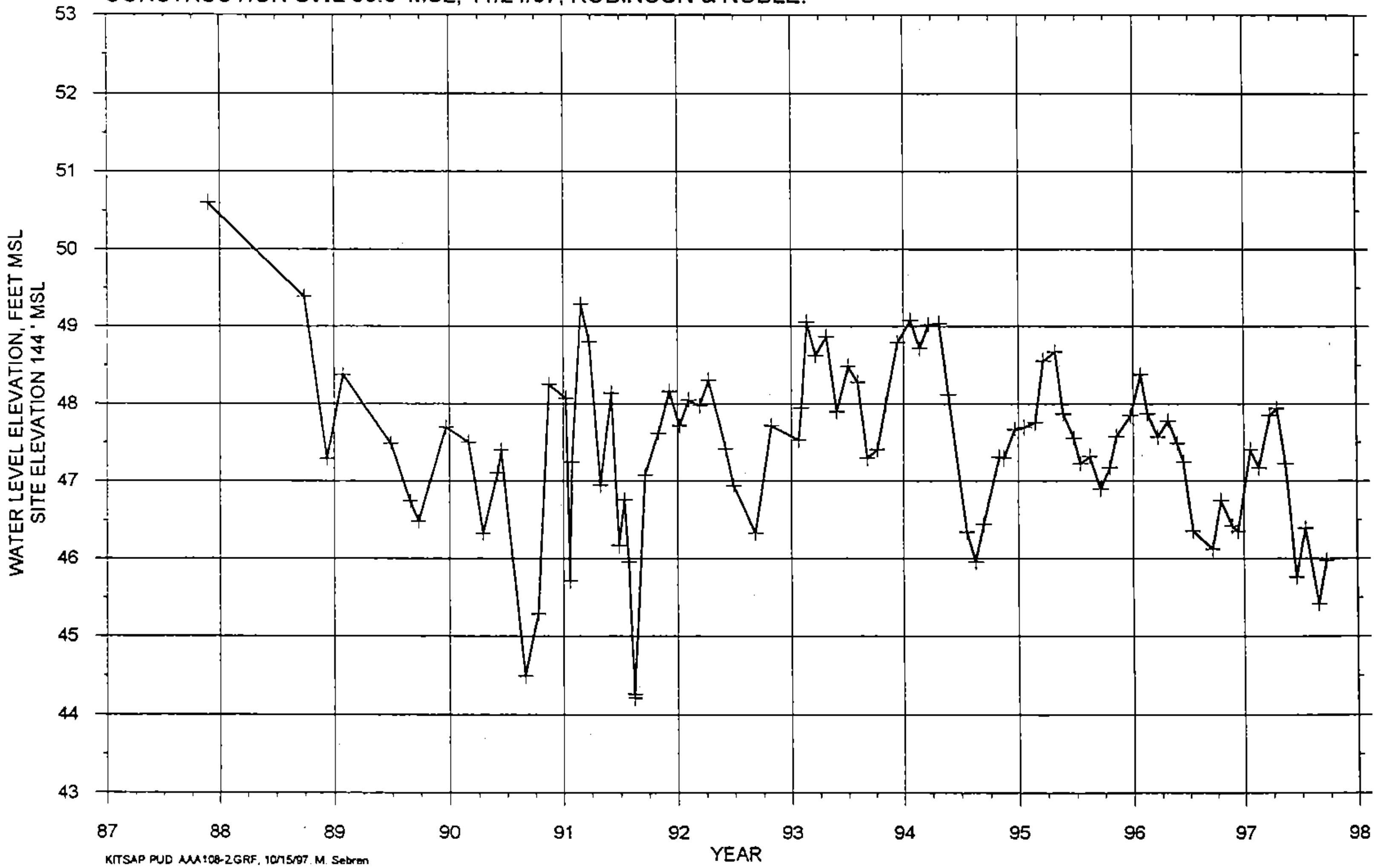
KITSAP PUD AAA239-2.GRF, 10/15/97 M. Sebren

HYDROGRAPH OF ISLAND UTILITY WELL 1 DEEP (AAA109).
T25N/R02E-34F. COMPLETION ELEVATION -734 TO -789' MSL.
CONSTRUCTION SWL 38.3' MSL, 3/21/88, BURT/OELKE WITH ROBINSON & N0BLE.

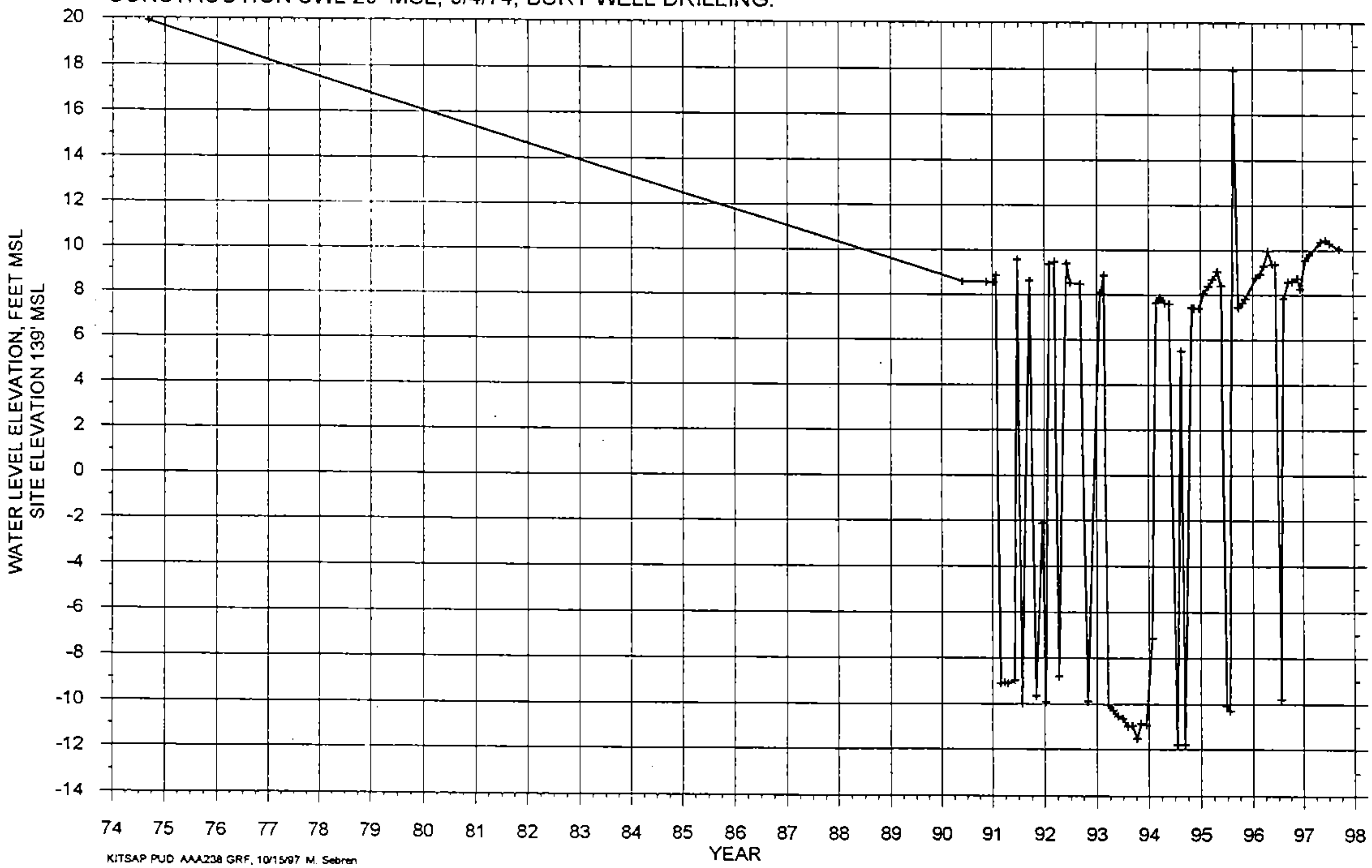


KITSAP PUD AAA109-2 GRF 10/15/97 M Sebren

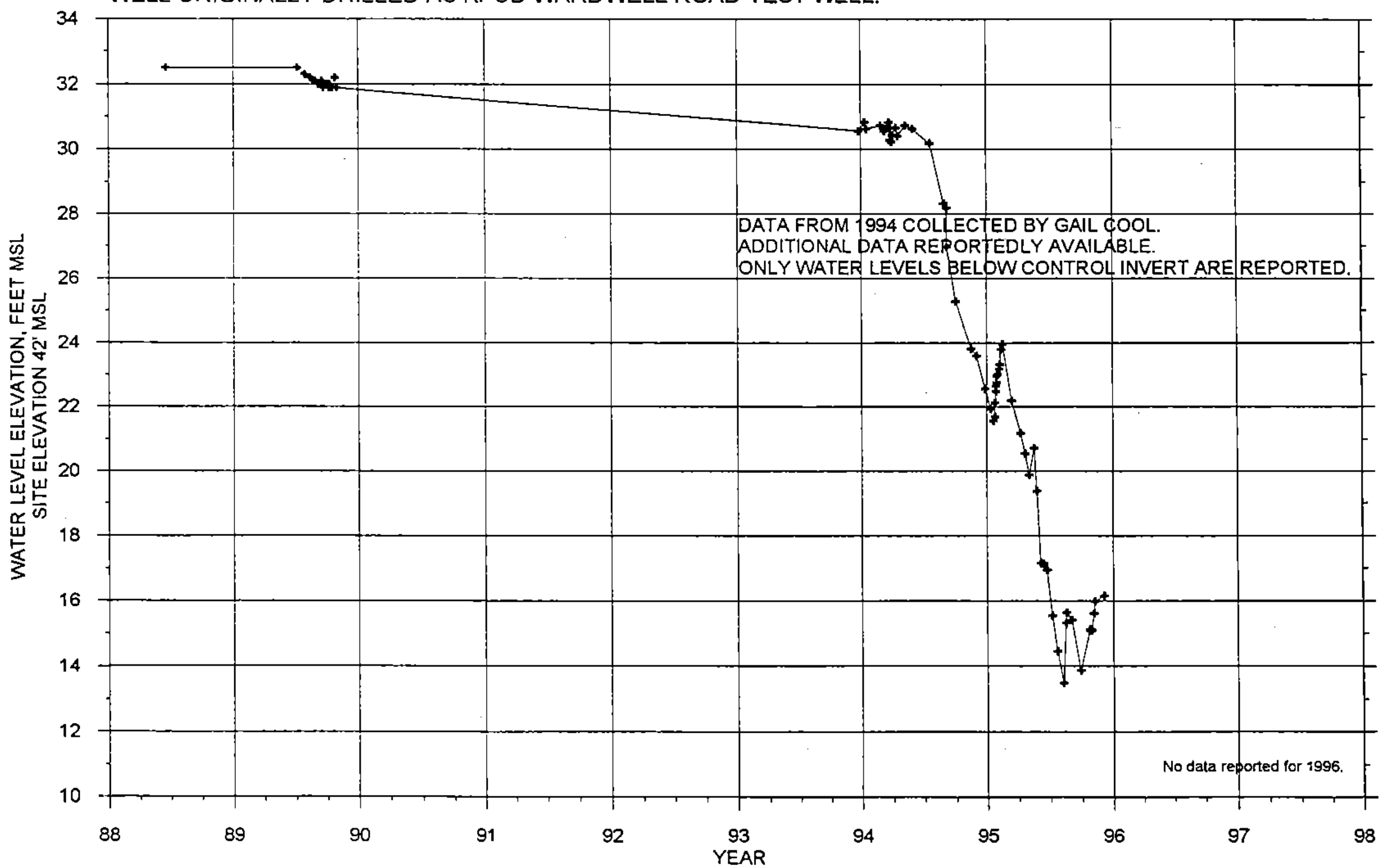
HYDROGRAPH OF ISLAND UTILITY MONITORING WELL (AAA108).
T25N/R02E-34F. COMPLETION ELEVATION 8 TO 19' MSL.
CONSTRUCTION SWL 50.6' MSL, 11/24/87, ROBINSON & NOBLE.



HYDROGRAPH OF BILL POINT WATER COMPANY WELL 3 (AAA238).
T25N/R02E-35J. COMPLETION ELEVATION -11' TO -21' MSL.
CONSTRUCTION SWL 20' MSL, 9/4/74, BURT WELL DRILLING.

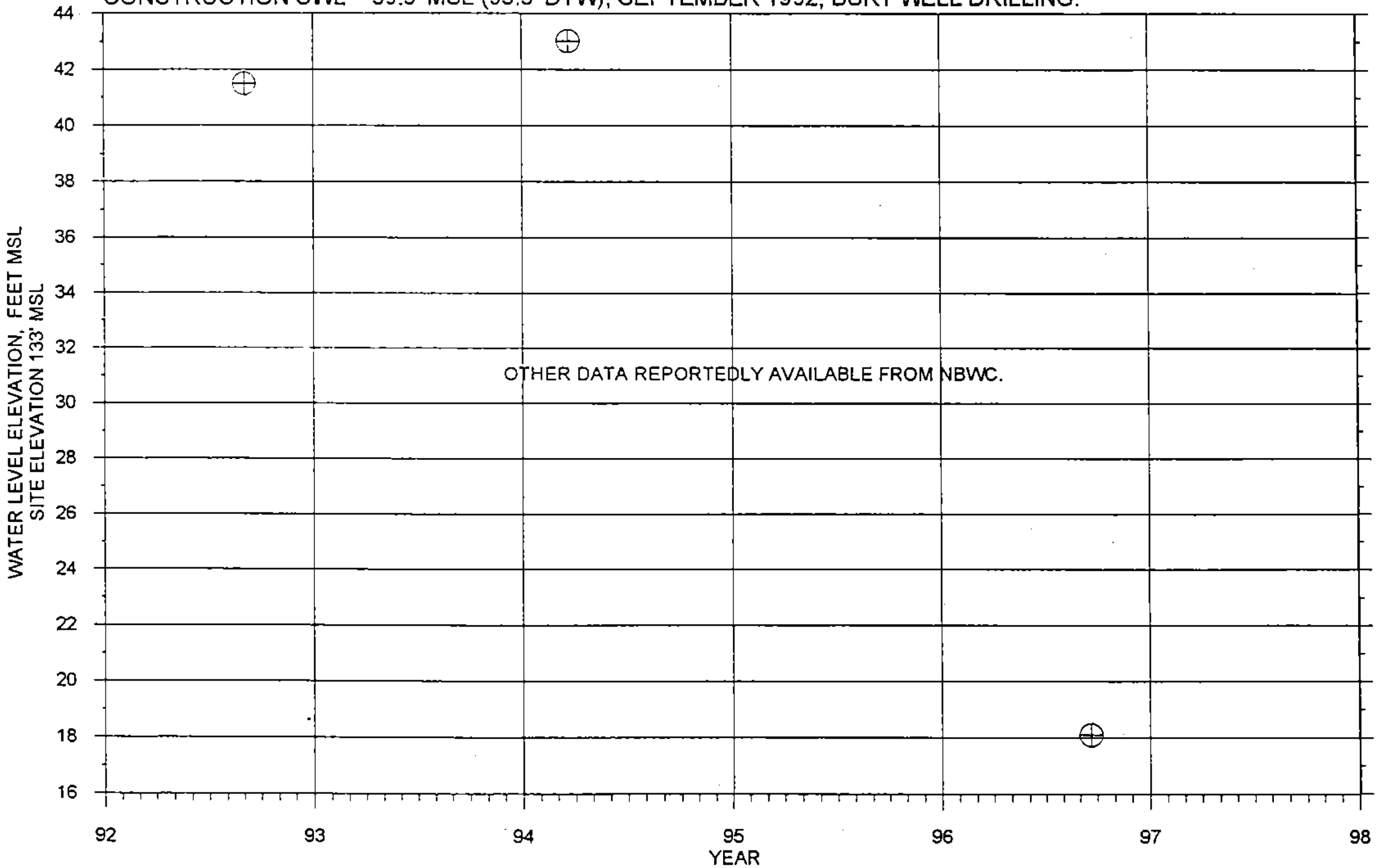


HYDROGRAPH OF GAIL COOL, MEIG'S FARM DEEP WELL (AAA112).
T25N/R02E-15J. COMPLETION ELEVATION -935 TO -980' MSL.
CONSTRUCTION SWL 30.5' MSL, 6/16/88, SCHNEIDER EQUIPMENT WITH ROBINSON & NOBLE.
WELL ORIGINALLY DRILLED AS KPUD WARDWELL ROAD TEST WELL.



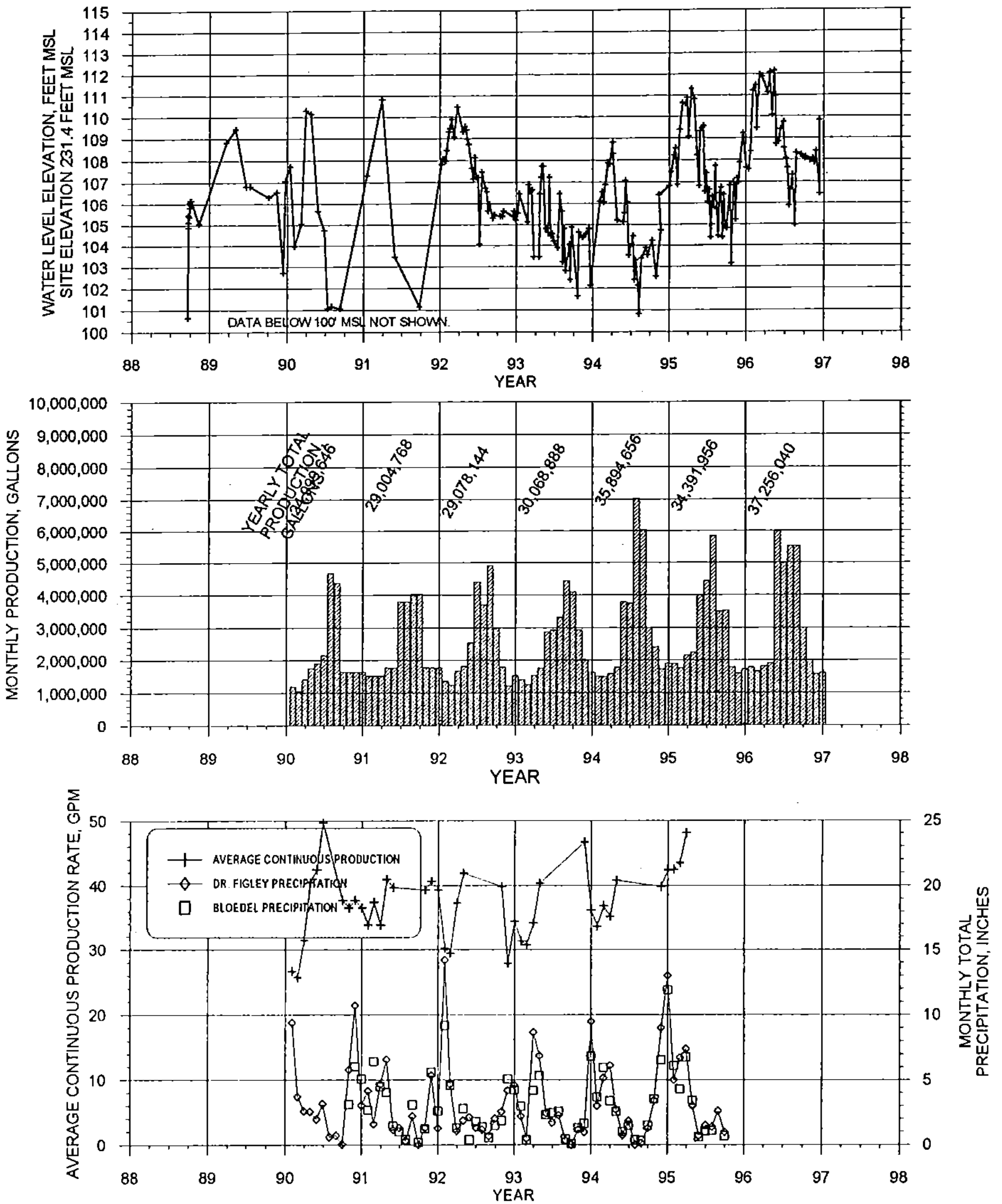
KITSAP PUD AAA112 GRF. 10/15/97 M.Sebren

HYDROGRAPH OF NORTH BAINBRIDGE WATER COMPANY WELL 9 (AAB455, G1-25782P).
T25N/R02E-9G. COMPLETION ELEVATION -1001' to -1182' MSL (120' OF SCREEN FROM 1134' TO 1315' BELOW GROUND).
CONSTRUCTION SWL = 39.5' MSL (93.5' DTW), SEPTEMBER 1992, BURT WELL DRILLING.



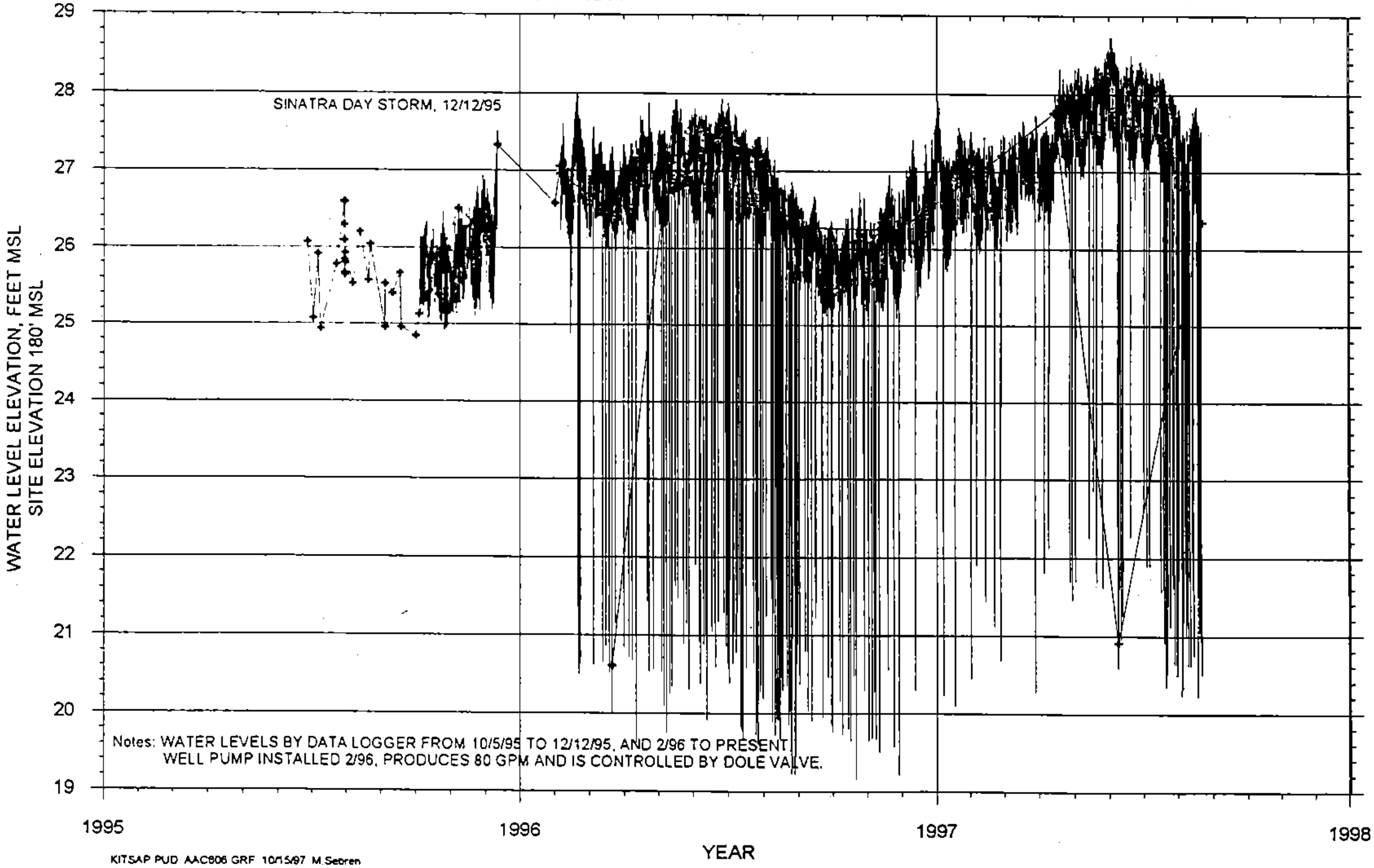
KITSAP PUD, AAB455 GRF, 10/15/97, M. Sabren

HYDROGRAPH OF PUMPING AND NON-PUMPING WATER LEVELS FOR MEADOWMEER WELL 1 (AAC447).
SUMMARY OF PRODUCTION TOTALS FOR WELLS 1 AND 2 (AAC447 AND AAC448).
SUMMARY OF PRECIPITATION AT SITE AND AT BLOEDEL RESERVE.
SITE LOCATION T25N/R02E-16A. COMPLETION ELEVATION OF WELL 1 APPROX. 88' TO 98' MSL.

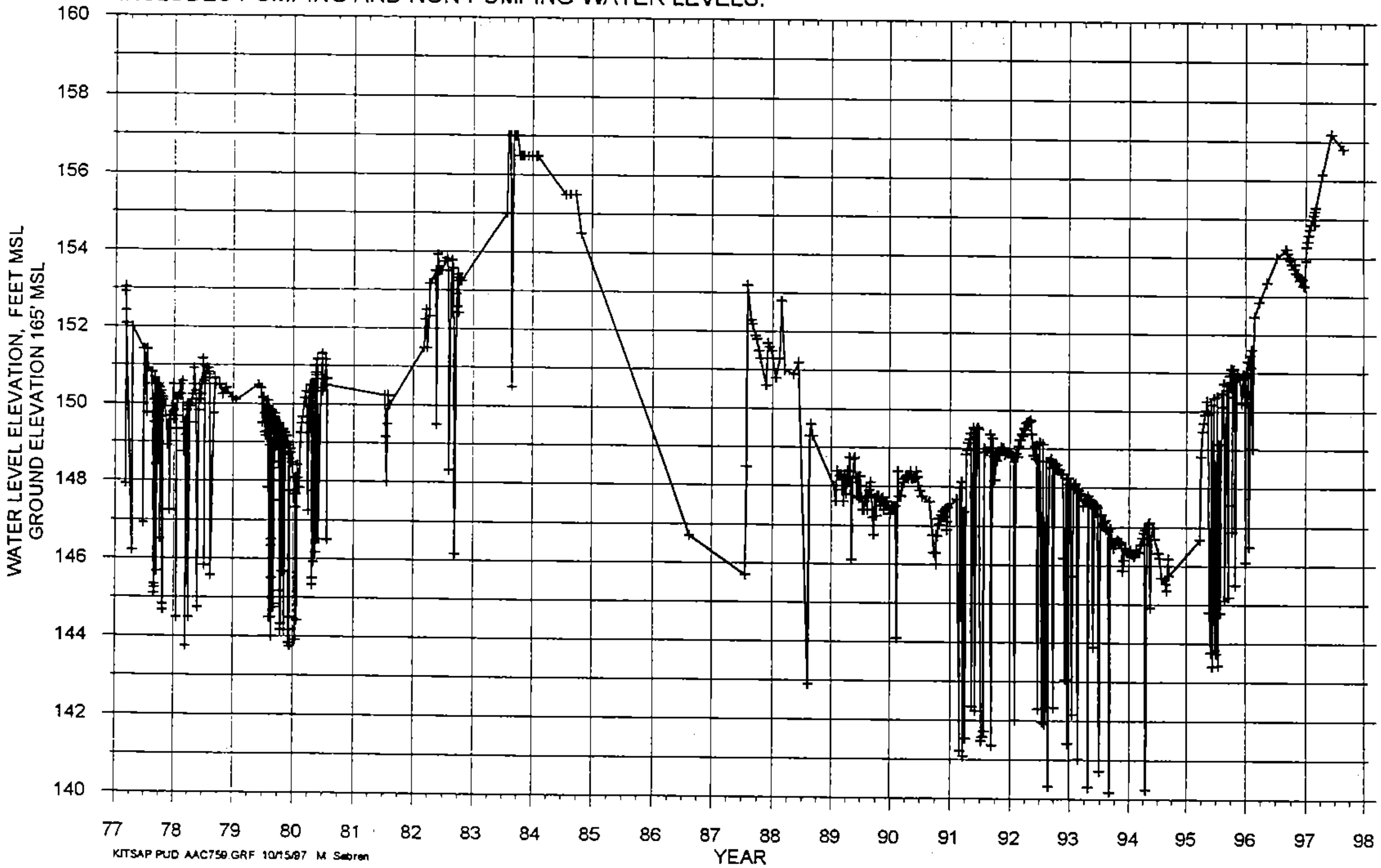


KITSAP PUD. AAC447X.GRF 10/15/97. M Sebren

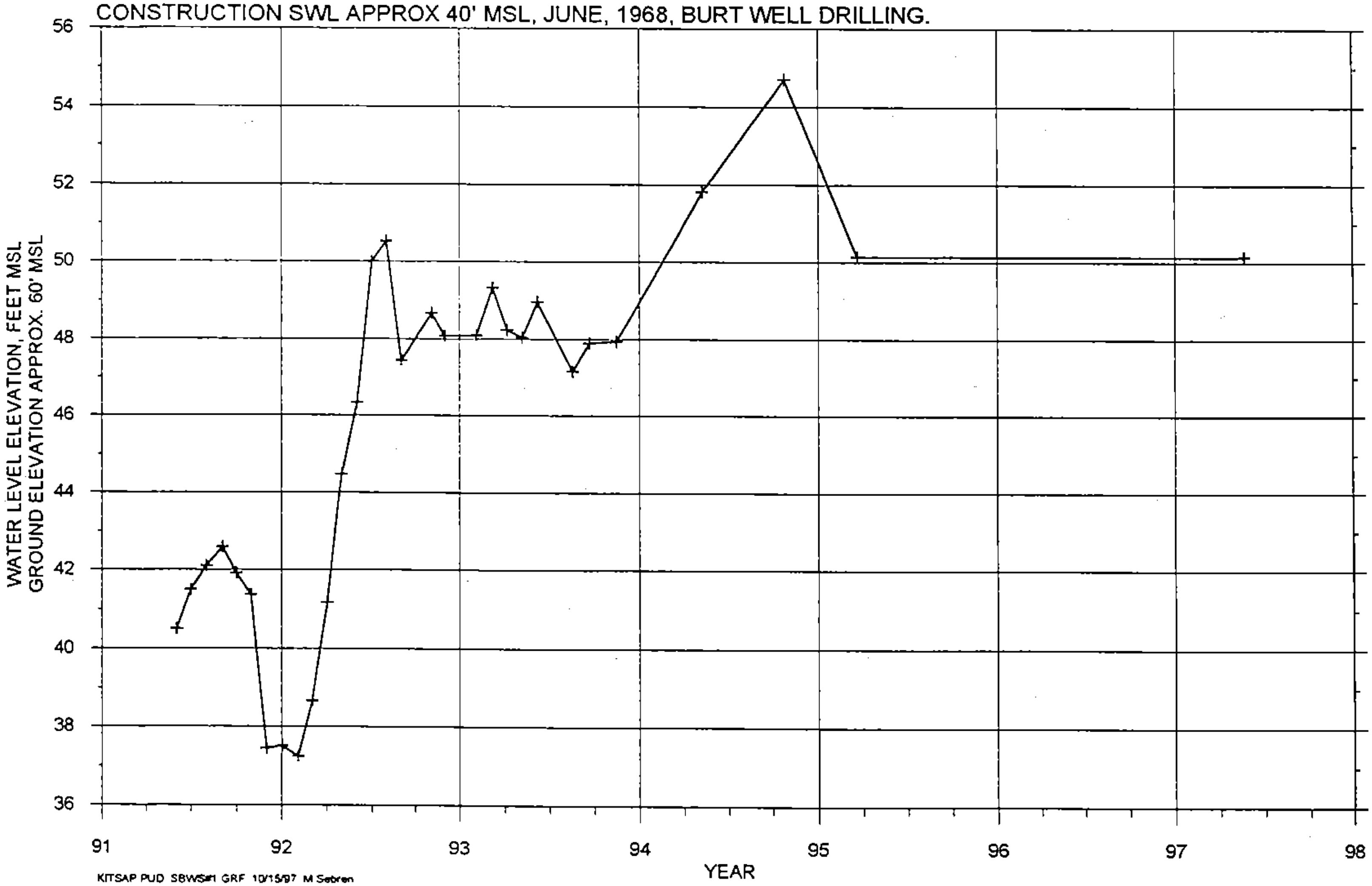
HYDROGRAPH OF BLOEDEL RESERVE DEEP WELL (AAC606).
T26N/R02E-33B. COMPLETION ELEVATION -1030 TO -1050' MSL.
CONSTRUCTION SWL 26.1' MSL, 6/28/95, SCHNEIDER EQUIPMENT AND ROBINSON & NOBLE.
PUMPING AND NON-PUMPING WATER LEVELS.



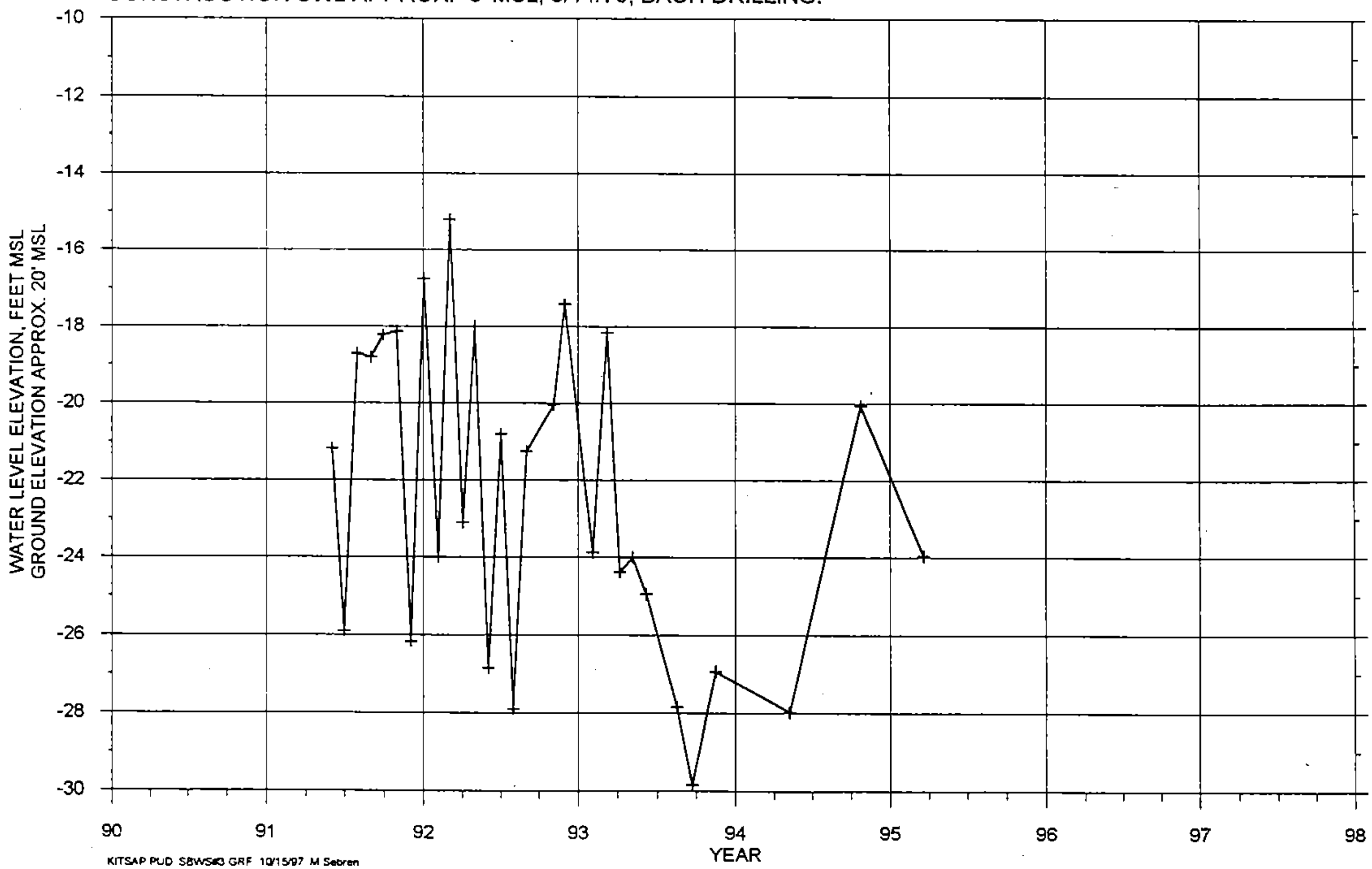
HYDROGRAPH OF BLOEDEL RESERVE FARM WELL (AAC759).
T26N/R02E-33B. COMPLETION ELEVATION 123' MSL.
INCLUDES PUMPING AND NON-PUMPING WATER LEVELS.



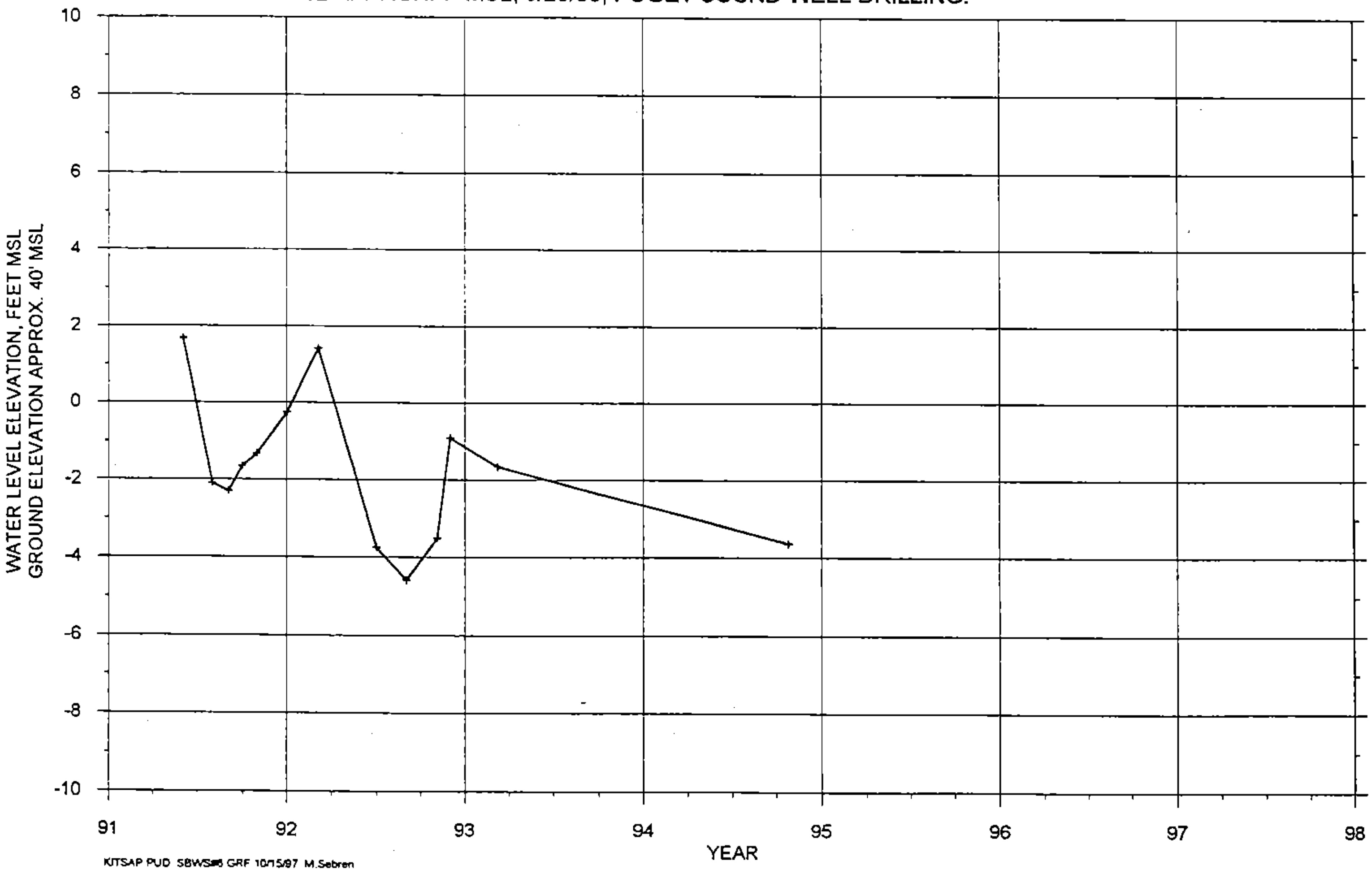
HYDROGRAPH OF SOUTH BAINBRIDGE WATER SYSTEMS WELL 1 (473615122324101?).
T24N/R02E-4A. COMPLETION ELEVATION -65' MSL.
CONSTRUCTION SWL APPROX 40' MSL, JUNE, 1968, BURT WELL DRILLING.



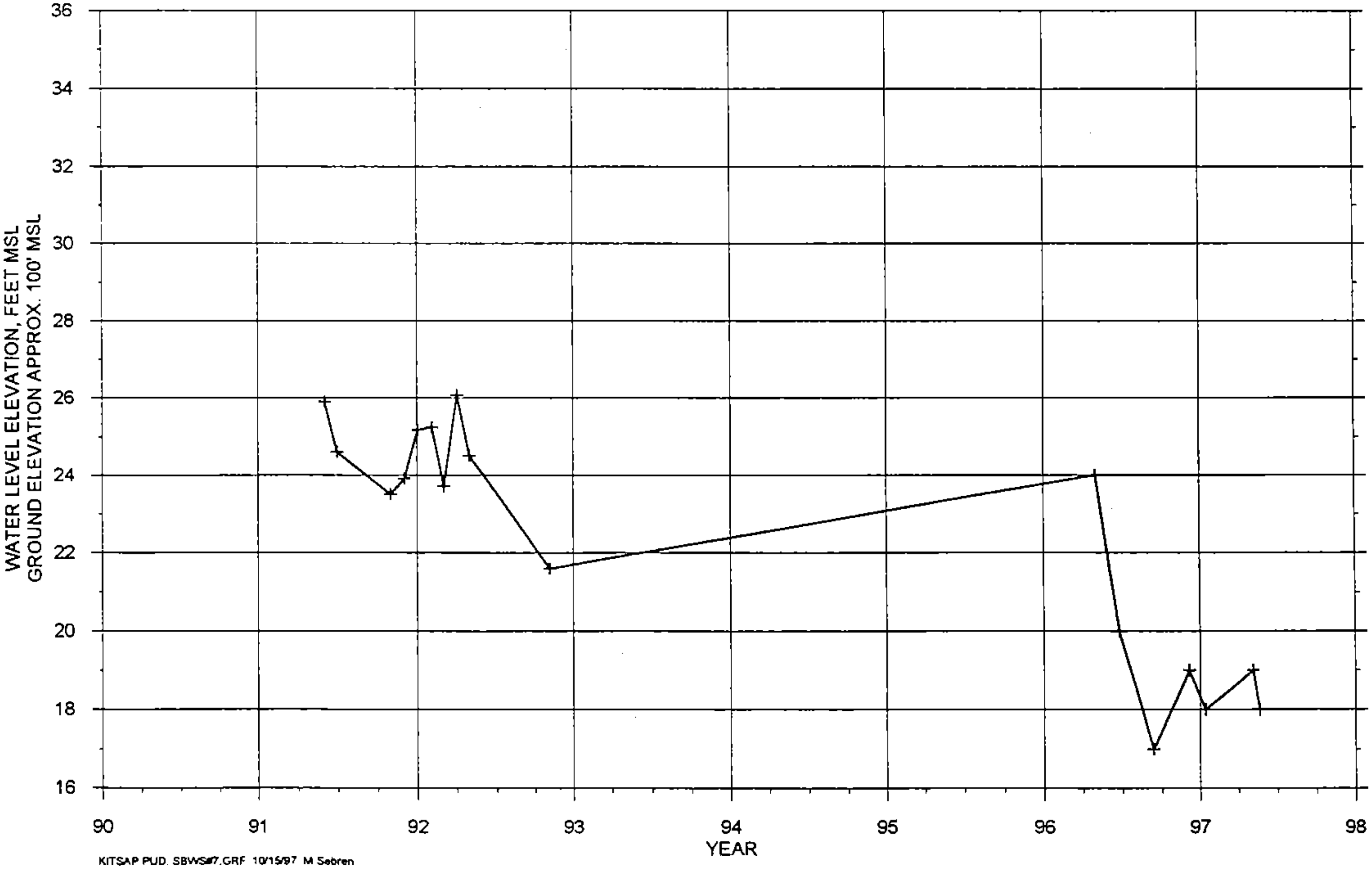
HYDROGRAPH OF SOUTH BAINBRIDGE WATER SYSTEMS WELL 3 (473622122324301).
T24N/R02E-4A. COMPLETION ELEVATION APPROX. -76 TO -85' MSL.
CONSTRUCTION SWL APPROX. -3' MSL, 3/14/79, BACH DRILLING.



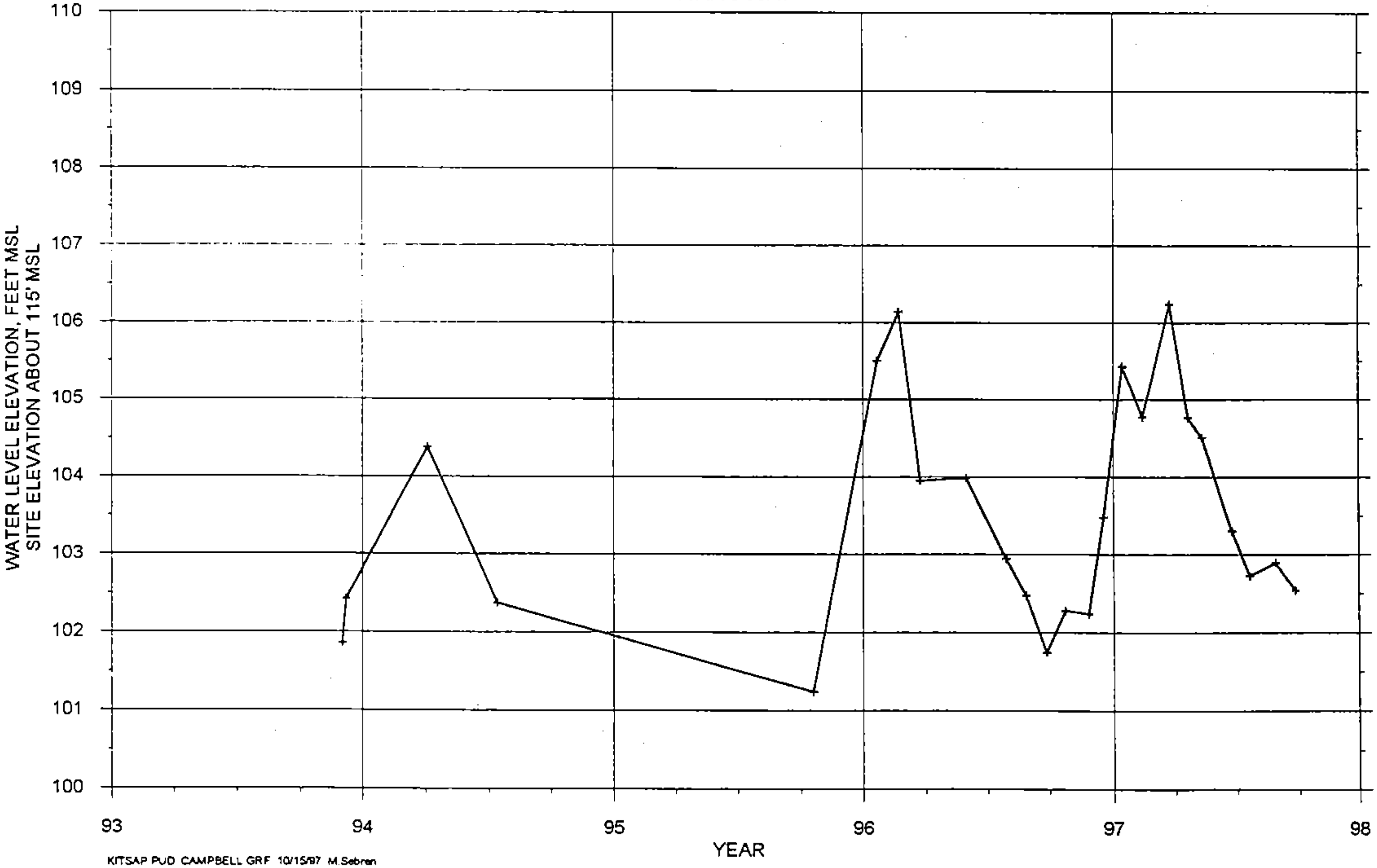
HYDROGRAPH OF SOUTH BAINBRIDGE WATER SYSTEMS WELL 6 (473623122324101).
T24N/R02E-4A. COMPLETION ELEVATION APPROX. -76 TO -86' MSL.
COSTRUCTION SWL APPROX. 7' MSL, 9/20/83, PUGET SOUND WELL DRILLING.



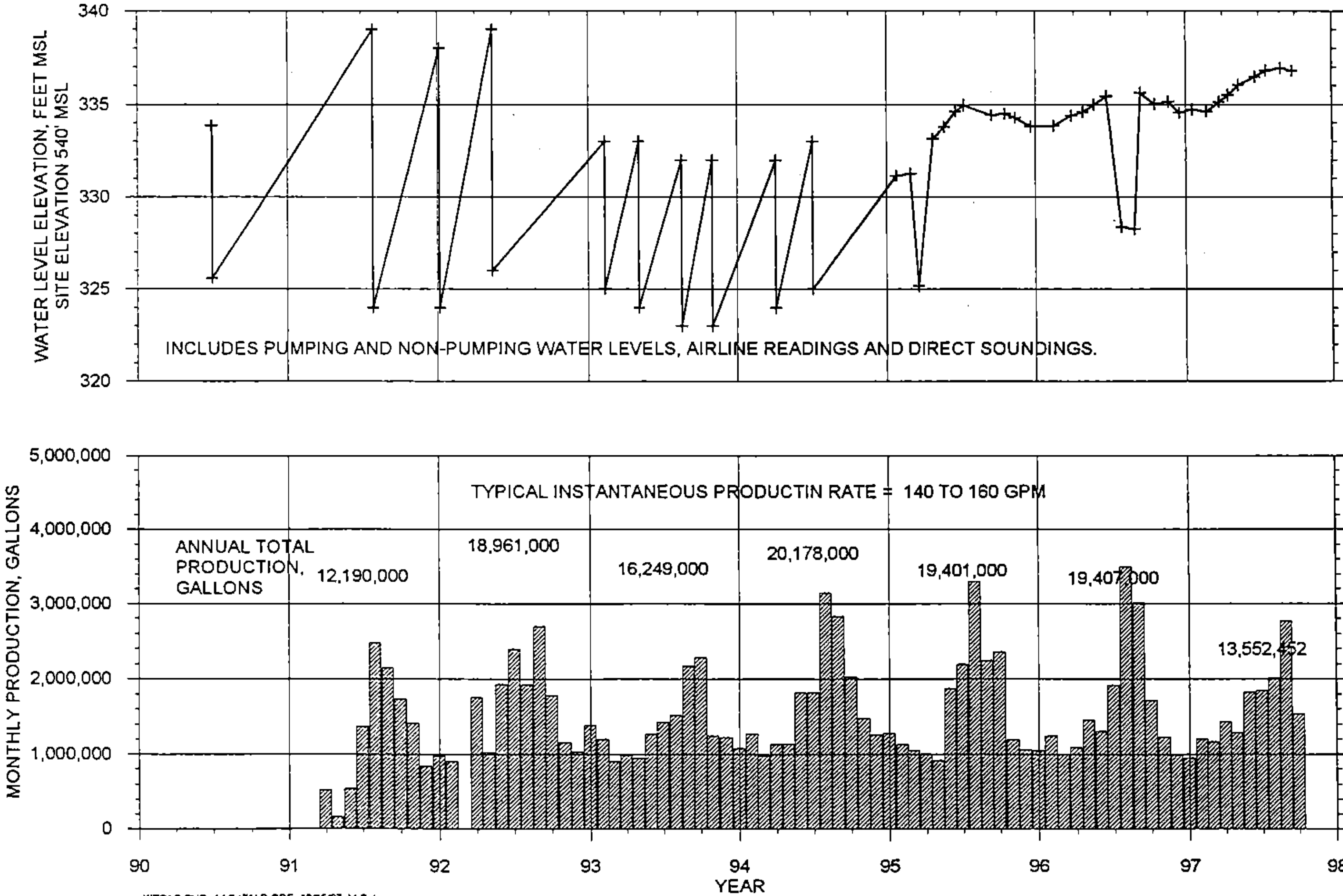
HYDROGRAPH OF SOUTH BAINBRIDGE WATER SYSTEMS WELL 7 (NO ASSIGNED ID).
T24N/R02E-4A. COMPLETION ELEVATION APPROX. -69 TO -89' MSL.
CONSTRUCTION SWL APPROX. 21' MSL, 1/28/91, DUCKWORTH DRILLING.

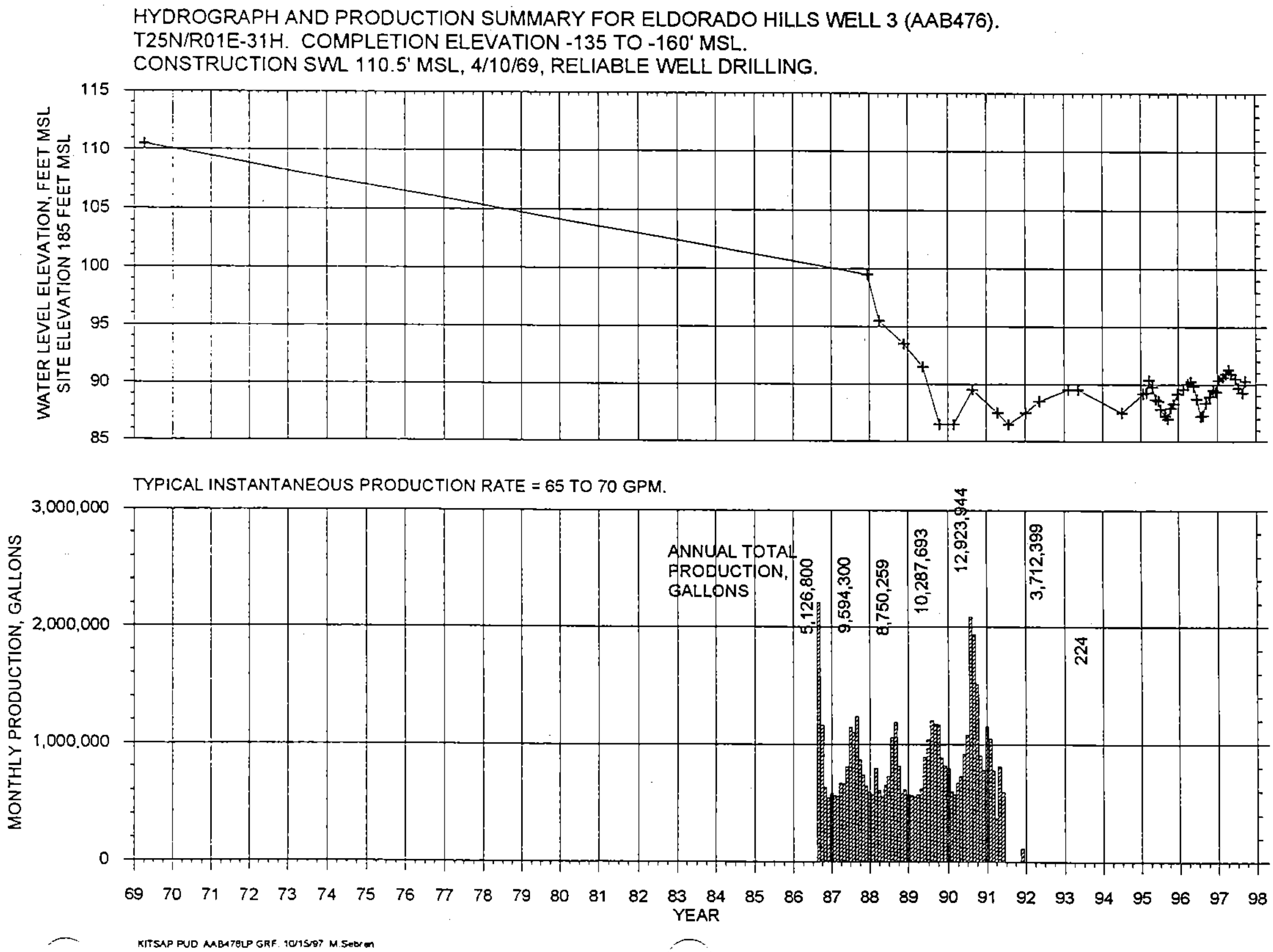


HYDROGRAPH OF CAMPBELL PRIVATE DUG WELL (4737071223859).
T25N/R01E-34A. WELL DEPTH AND COMPLETION UNKNOWN.



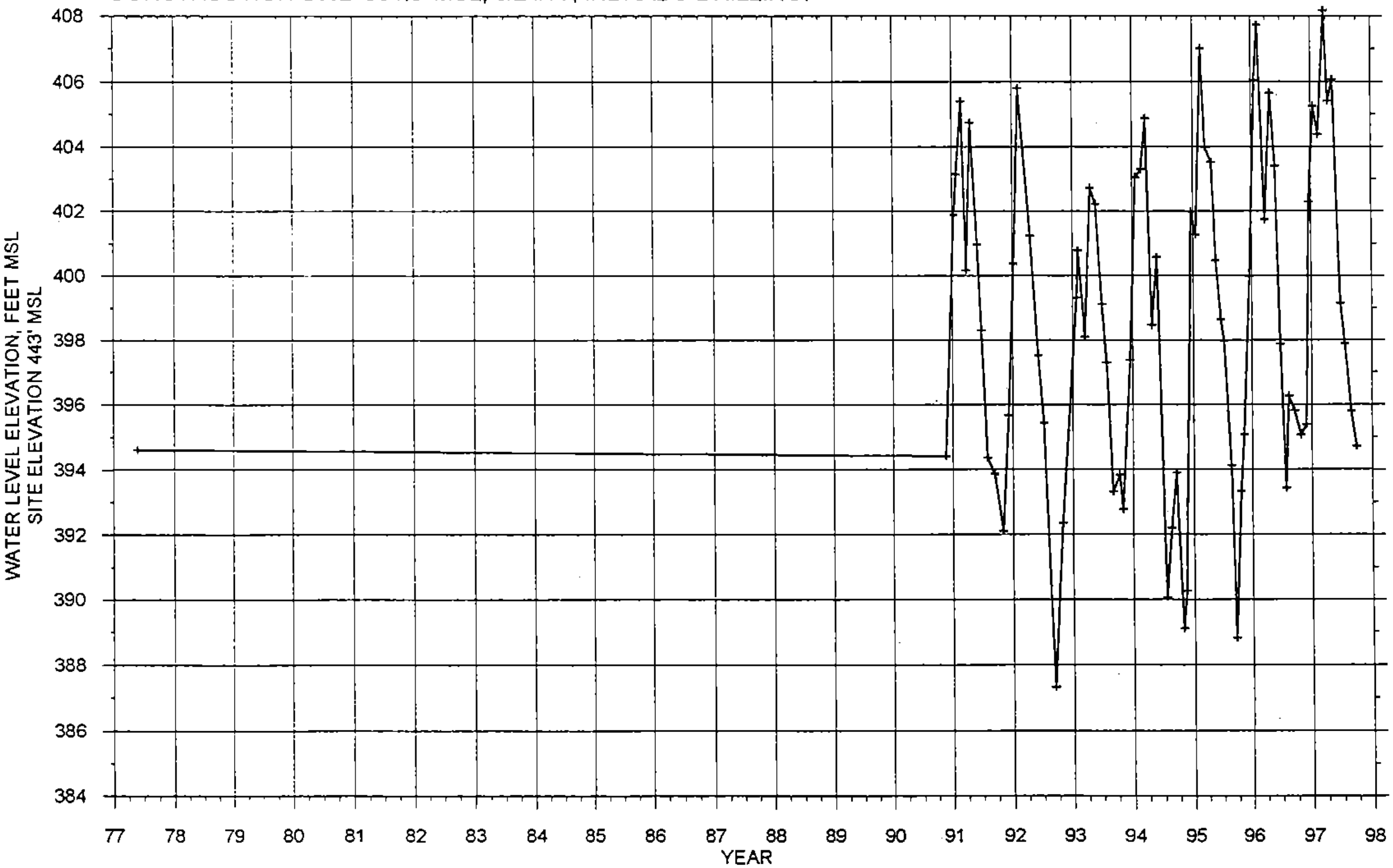
HYDROGRAPH AND PRODUCTION SUMMARY FOR ELDORADO WELL 4 (AAB471).
T25N/R01E-31G. COMPLETION ELEVATION 301 TO 311' MSL.
CONSTRUCTION SWL 333.9' MSL, 7/2/90, BURT WELL DRILLING AND ROBINSON & NOBLE





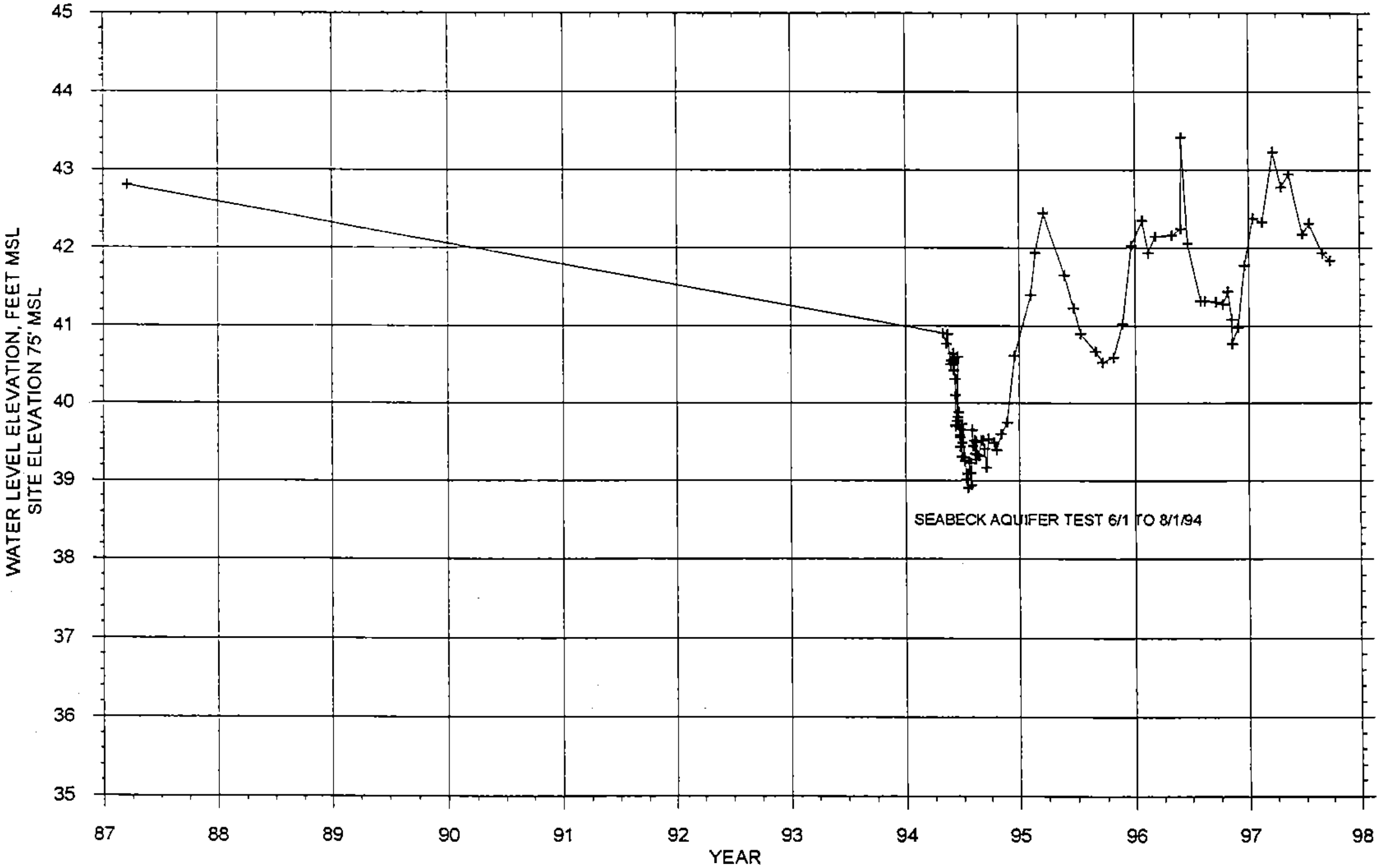
HYDROGRAPH AND PRODUCTION SUMMARY FOR ELDORADO HILLS WELL 3 (AAB476).
T25N/R01E-31H. COMPLETION ELEVATION -135 TO -160' MSL.
CONSTRUCTION SWL 110.5' MSL, 4/10/69, RELIABLE WELL DRILLING.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION 185 FEET MSL
115
110
105
100
95
90
85
TYPICAL INSTANTANEOUS PRODUCTION RATE = 65 TO 70 GPM.
MONTHLY PRODUCTION, GALLONS
3,000,000
2,000,000
1,000,000
0
ANNUAL TOTAL PRODUCTION, GALLONS
5,126,800
9,594,300
8,750,259
10,287,693
12,923,944
3,712,399
224
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98
YEAR
KITSAP PUD AAB476LP GRF. 10/15/97 M.Sebren

HYDROGRAPH OF CAMP DAVID WELL #1 (AAA114).
T24N/R01W-6R. COMPLETION ELEVATION 328 TO 333' MSL.
CONSTRUCTION SWL 394.6' MSL, 5/24/77, INDRABO DRILLING.



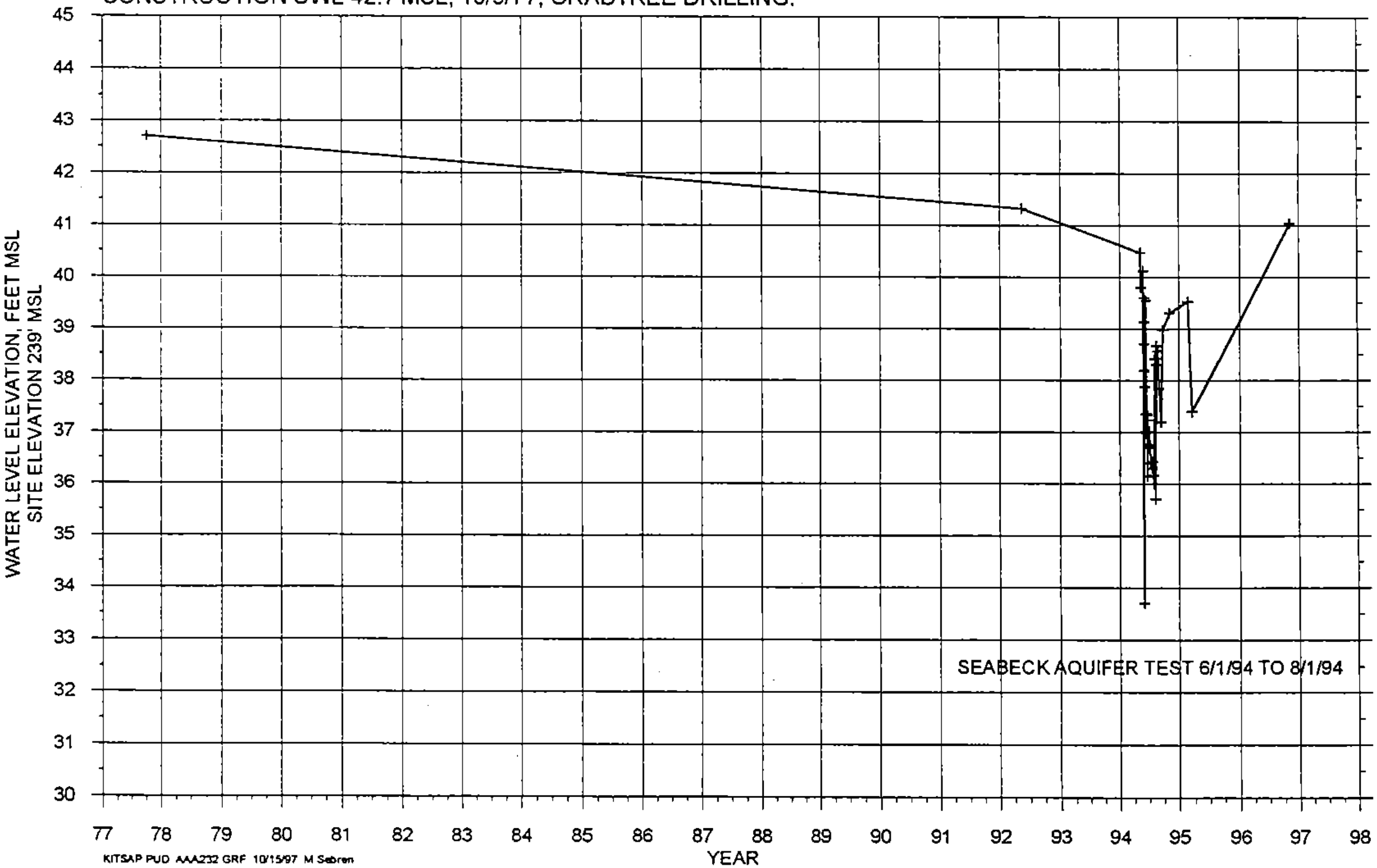
KITSAP PUD. AAA114.GRF. 10/15/97 M. Sebren

HYDROGRAPH OF SEABECK CONFERENCE CENTER WELL (AAC835).
T25N/R01W-20Q. COMPLETION ELEVATION -54 TO -64' MSL.
CONSTRUCTION SWL 42.8' MSL, 3/17/87, CRABTREE DRILLING.

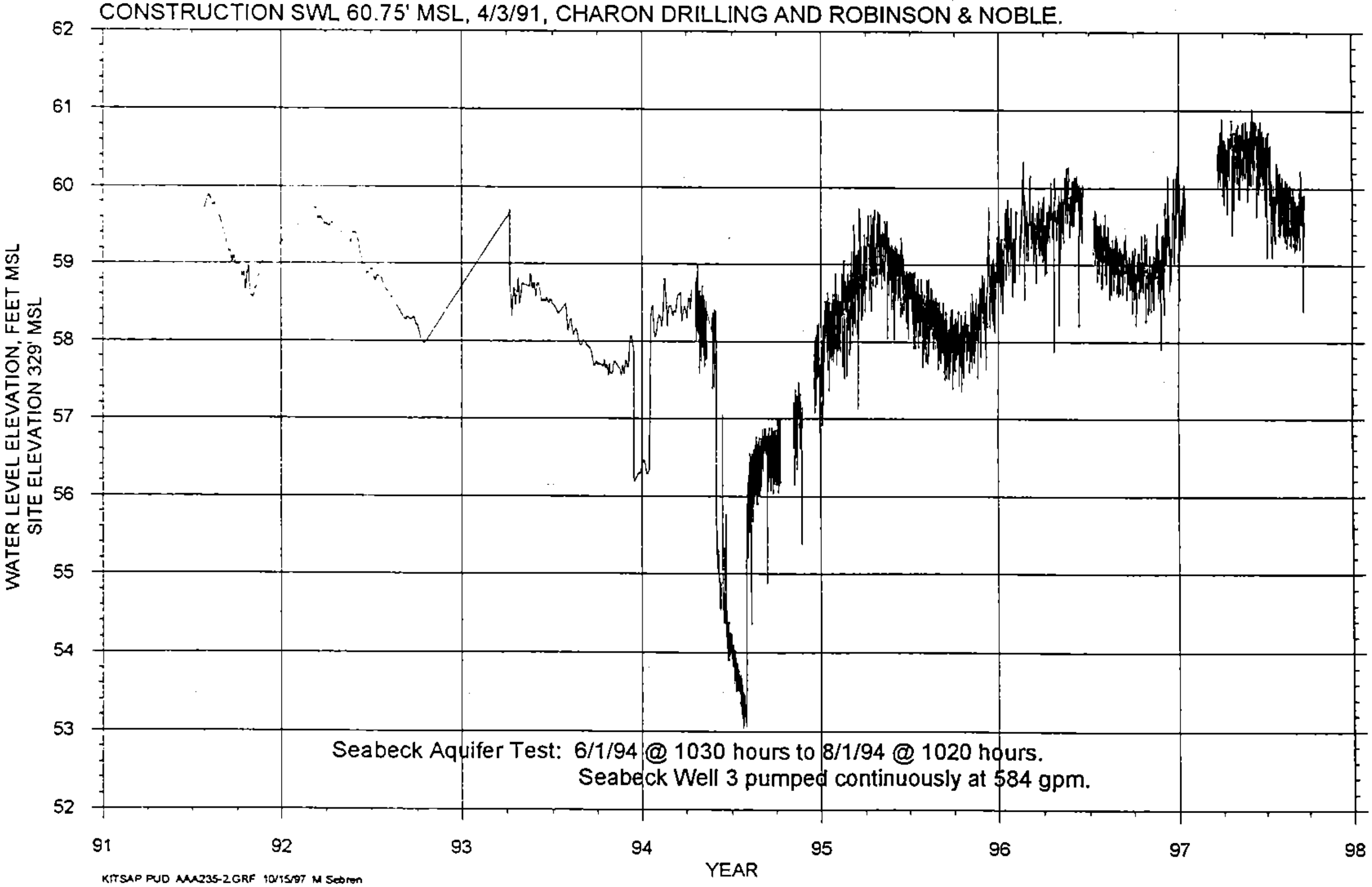


KITSAP PUD AAC835 GRF 10/15/97. M.Sebren

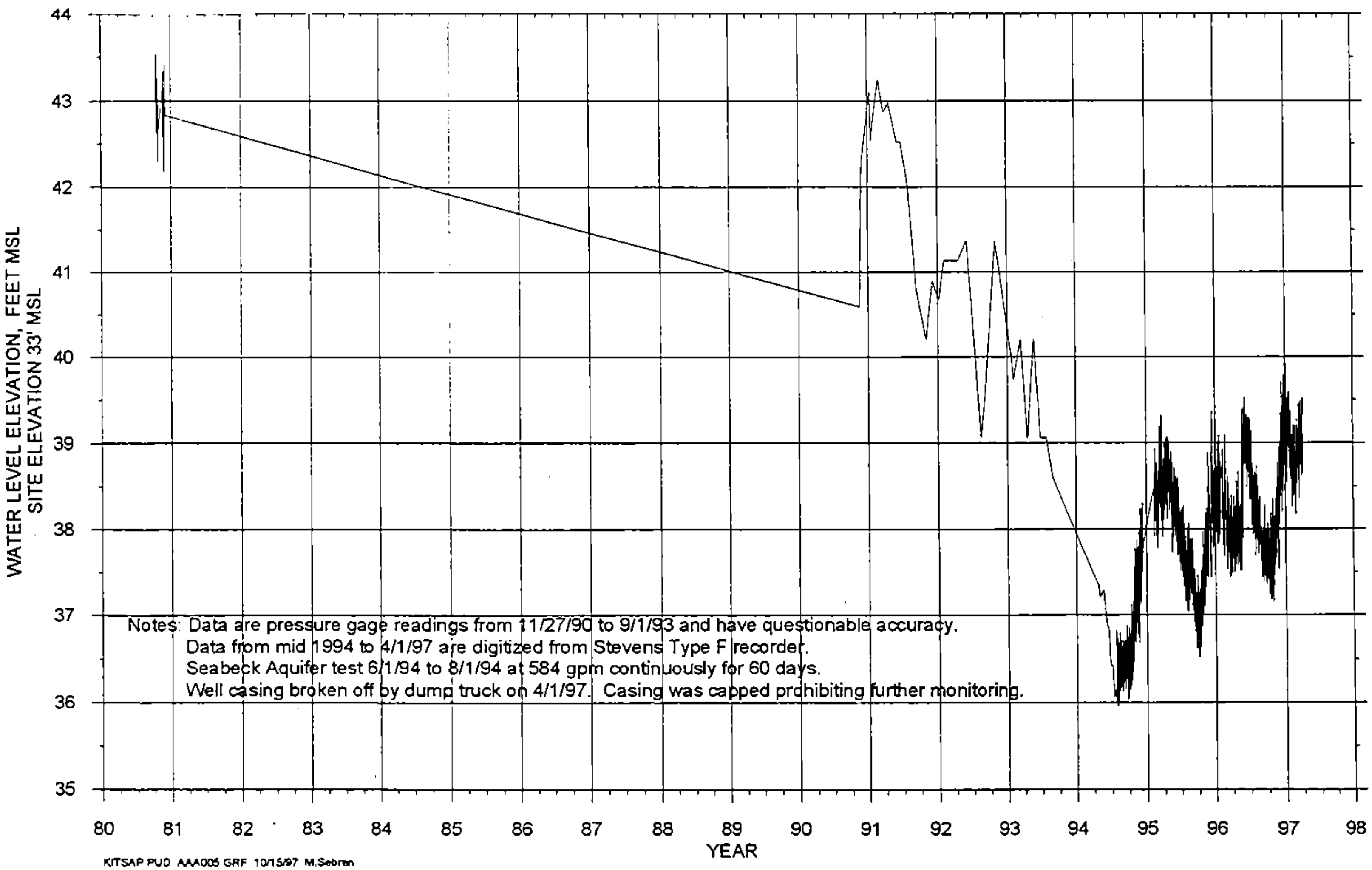
HYDROGRAPH OF GAUVA WELL 3 (AAA232).
T25N/R01W-21M. COMPLETION ELEVATION -51 TO -62' MSL.
CONSTRUCTION SWL 42.7'MSL, 10/5/77, CRABTREE DRILLING.



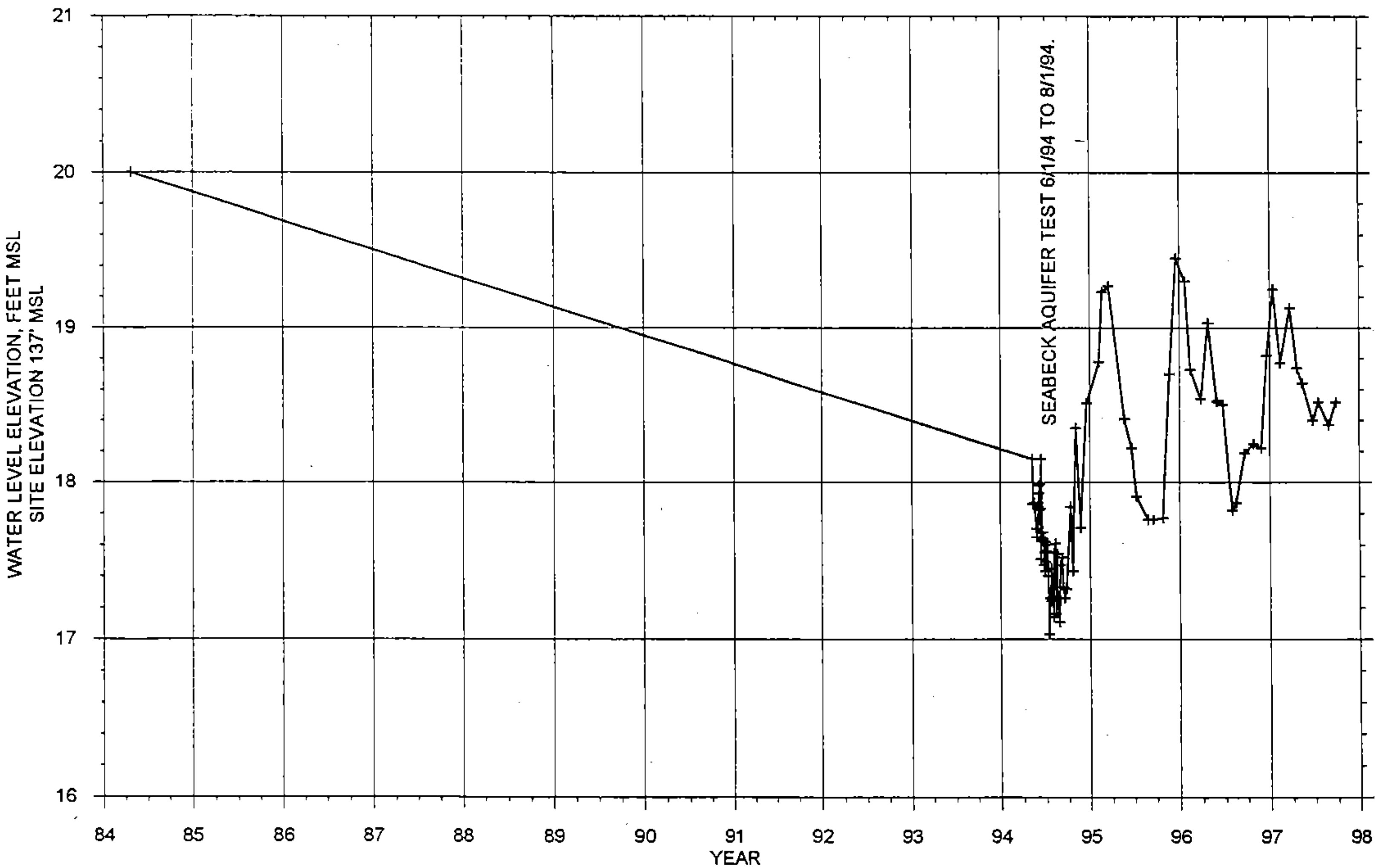
HYDROGRAPH OF SEABECK WELL 1 (AAA235).
T25N/R01W-19P. COMPLETION ELEVATION -90 TO -121' MSL.
CONSTRUCTION SWL 60.75' MSL, 4/3/91, CHARON DRILLING AND ROBINSON & NOBLE.



HYDROGRAPH FOR TEST HOLE 2 AT BIG BEEF CREEK (AAA005).
T25N/R01W-22A. COMPLETION ELEVATION -133' TO -187' MSL.
CONSTRUCTION SWL 43.3 ' MSL, SEPT. 1980, RICHARDSON WELL DRILLING AND ROBINSON & NOBLE, INC.

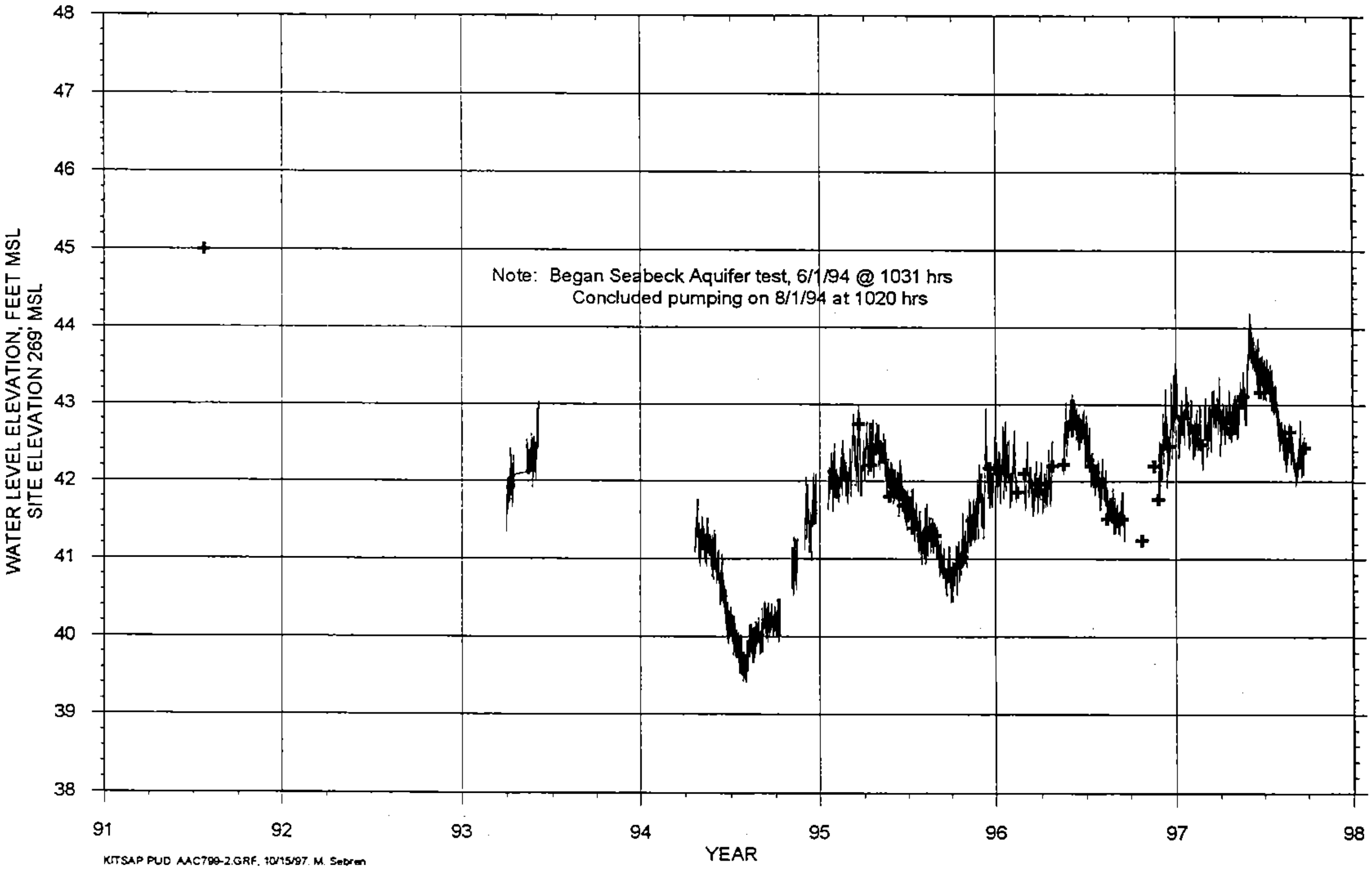


HYDROGRAPH OF JAN SMITH WELL (AAC809).
T25N/R01W-22C. COMPLETION ELEVATION -9 TO -29' MSL.
CONSTRUCTION SWL 20' MSL, 4/23/84, NICHOLSON WELL DRILLING.

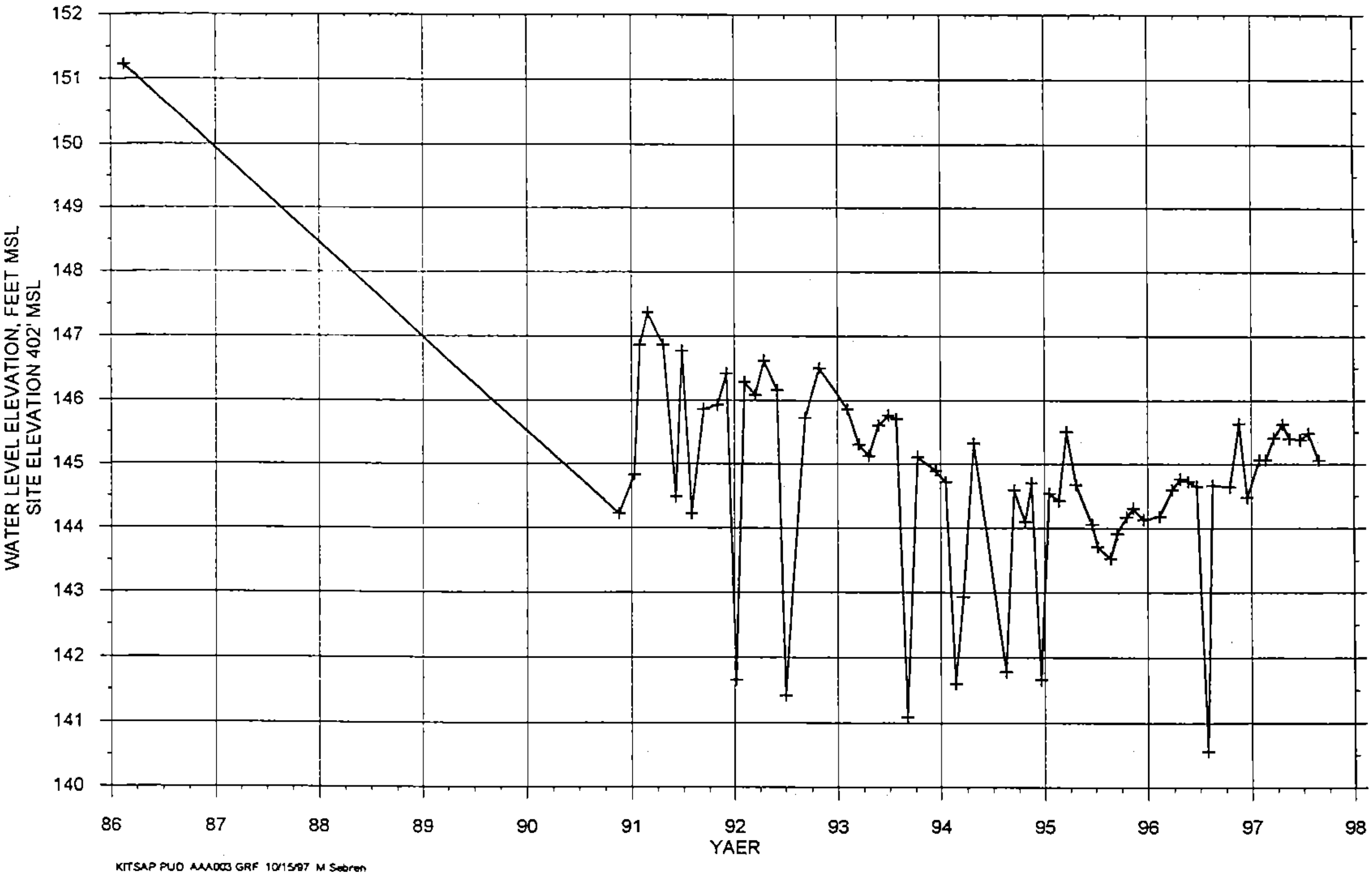


KITSAP PUD AAC809.GRF, 10/15/97 M. Sebren

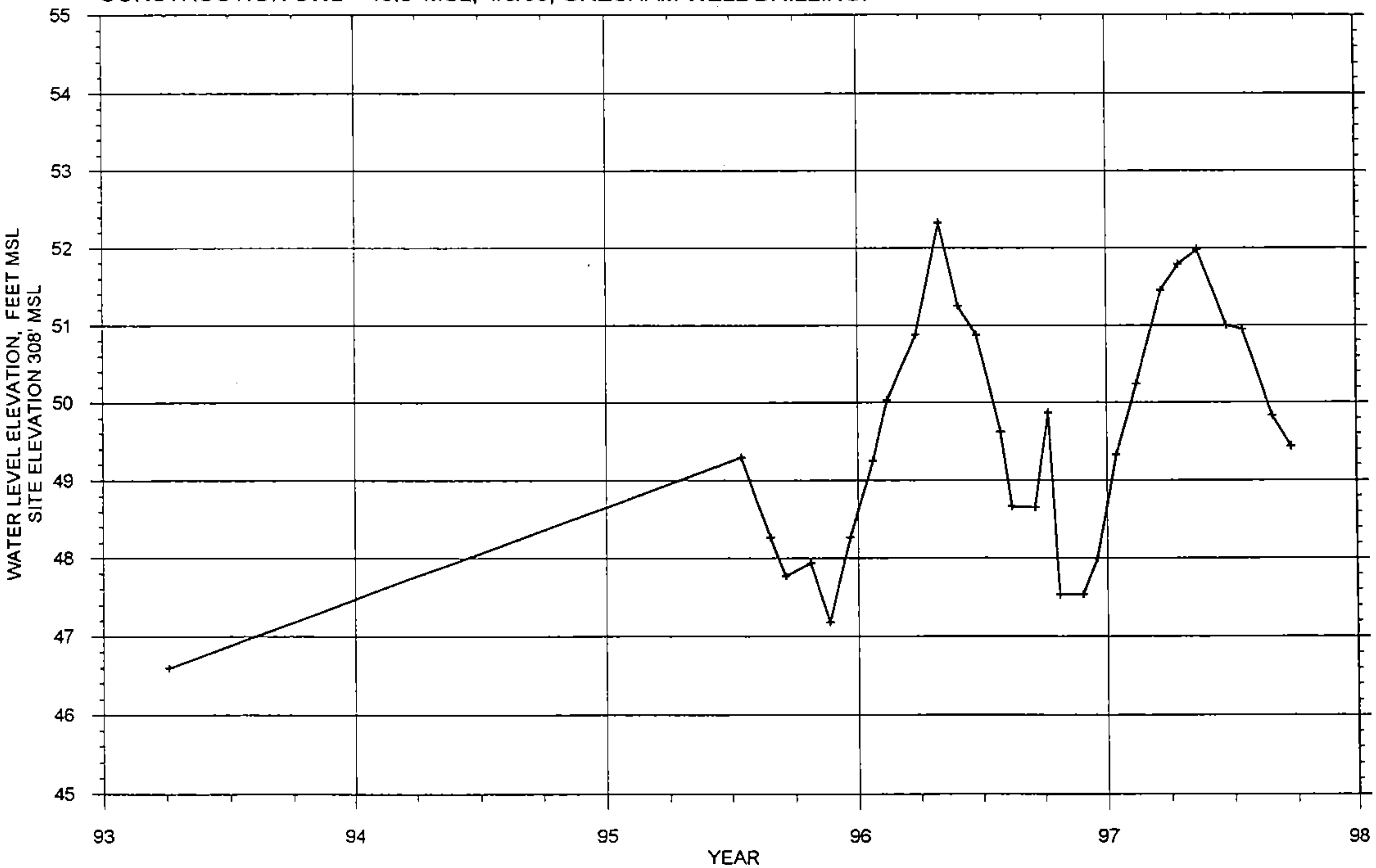
HYDROGRAPH OF SEABECK WELL 2 (AAC799).
T25N/R01W-22E. COMPLETION ELEVATION -50 TO -81' MSL.
CONSTRUCTION SWL 45' MSL, 7/24/91, CHARON DRILLING AND ROBINSON & NOBLE.



HYDROGRAPH OF HARBOR WATER COMPANY GRAYSTONE WELL (AAA003).
T25N/R01W-24J. COMPLETION ELEVATION 124 TO 130' MSL.
CONSTRUCTION SWL 151' MSL, 2/17/86, MATHEWS WELL DRILLING.

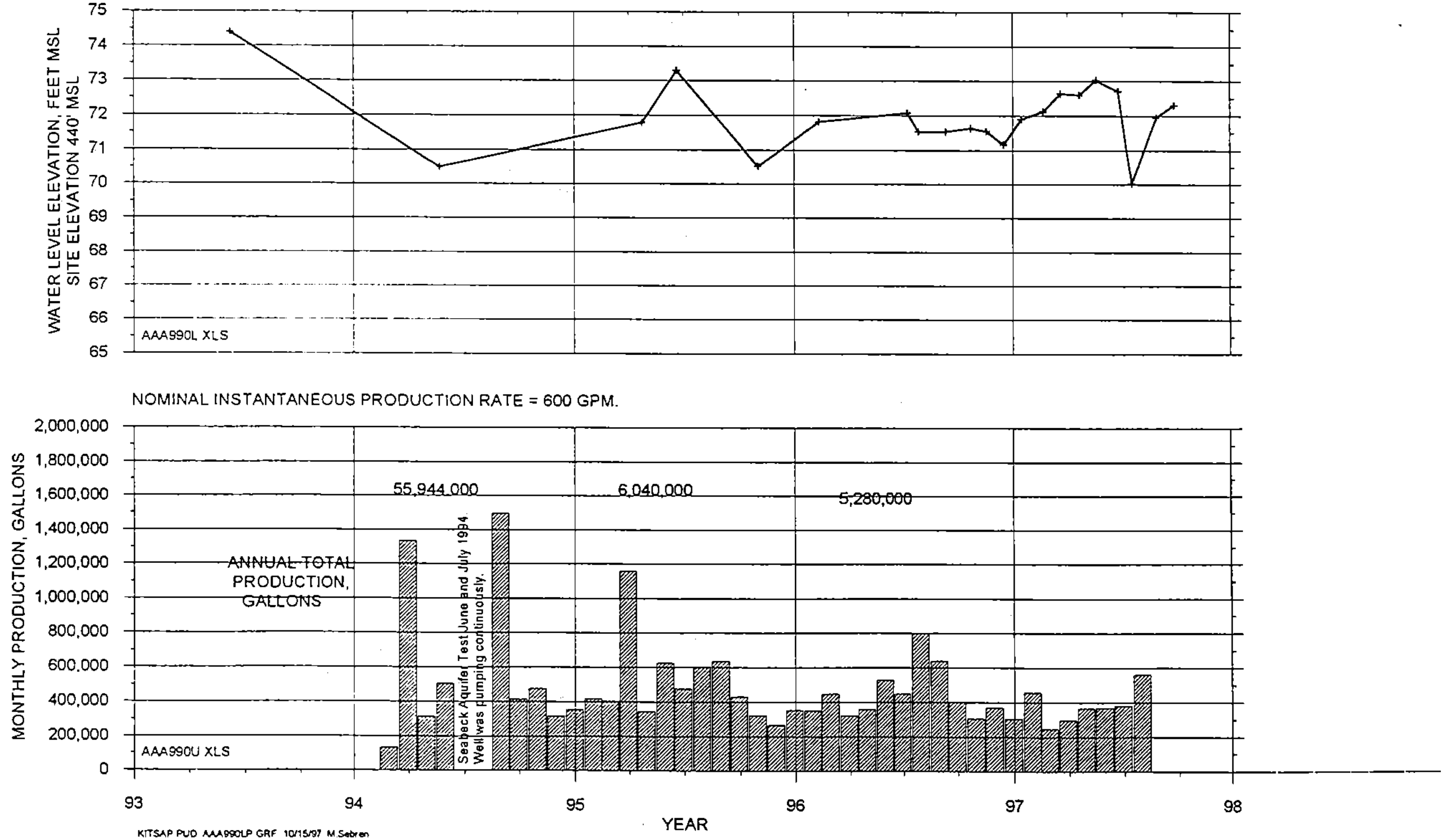


HYDROGRAPH OF DLUGOSH WATER SYSTEM WELL (AAA875).
T25N/R01W-27G. COMPLETION ELEVATION -22' MSL.
CONSTRUCTION SWL = 46.6' MSL, 4/6/93, GRESHAM WELL DRILLING.

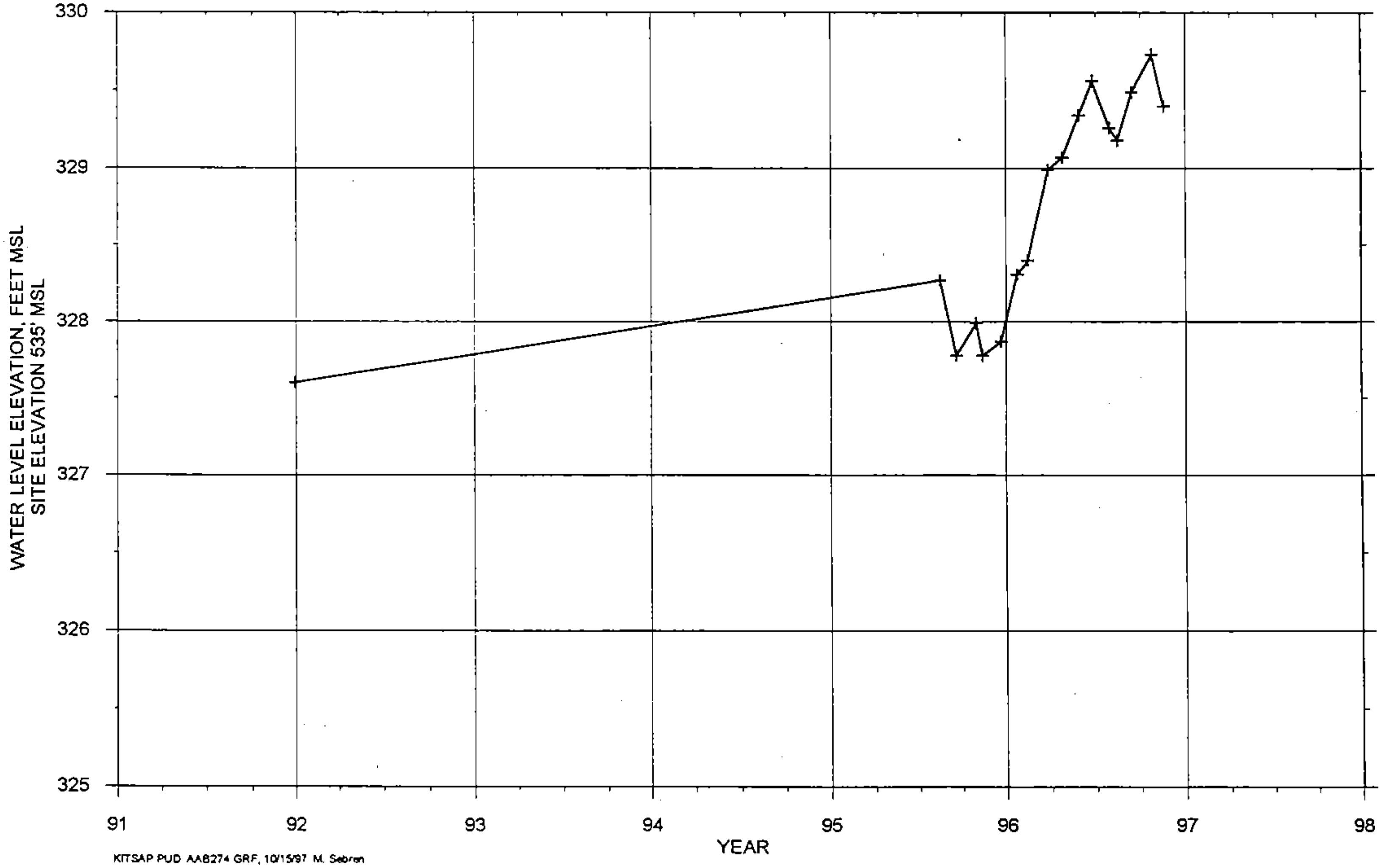


KITSAP PUD. AAA875.GRF 10/15/97 M Sebren

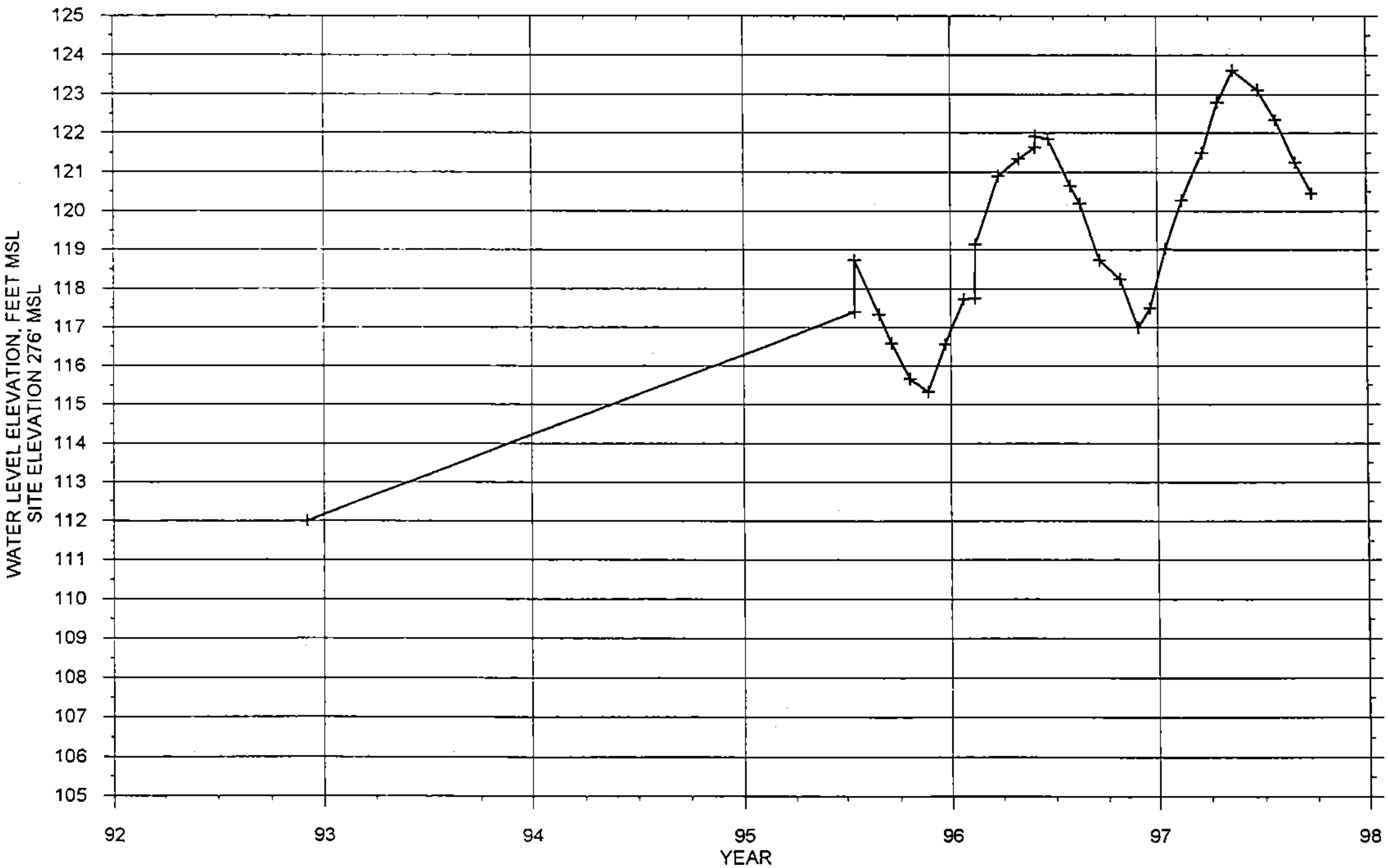
HYDROGRAPH AND PRODUCTION SUMMARY FOR SEABECK WELL 3 (AAA990).
T25N/R01W-28C. COMPLETION ELEVATION -70' TO -102' MSL.
CONSTUCTION SWL ~74' MSL, 6/9/93, HOLT TESTING AND ROBINSON & NOBLE, INC.



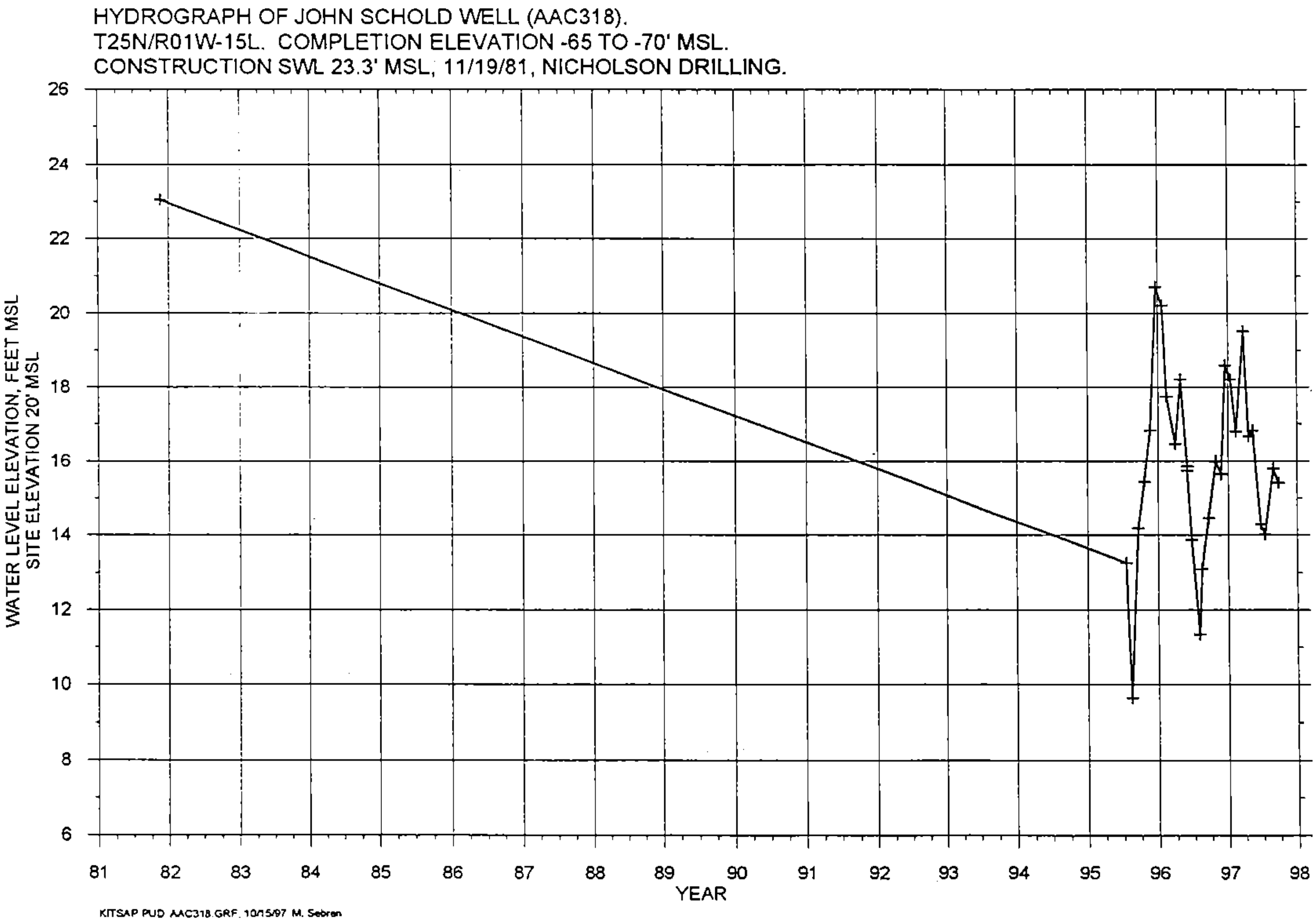
HYDROGRAPH OF WOODLAND HEIGHTS WELL (AAB274).
T25N/R01W-26F. COMPLETION ELEVATION 294 TO 278' MSL.
CONSTRUCTION SWL 327.6 FEET MSL, 12/30/91, NICHOLSON DRILLING INC.

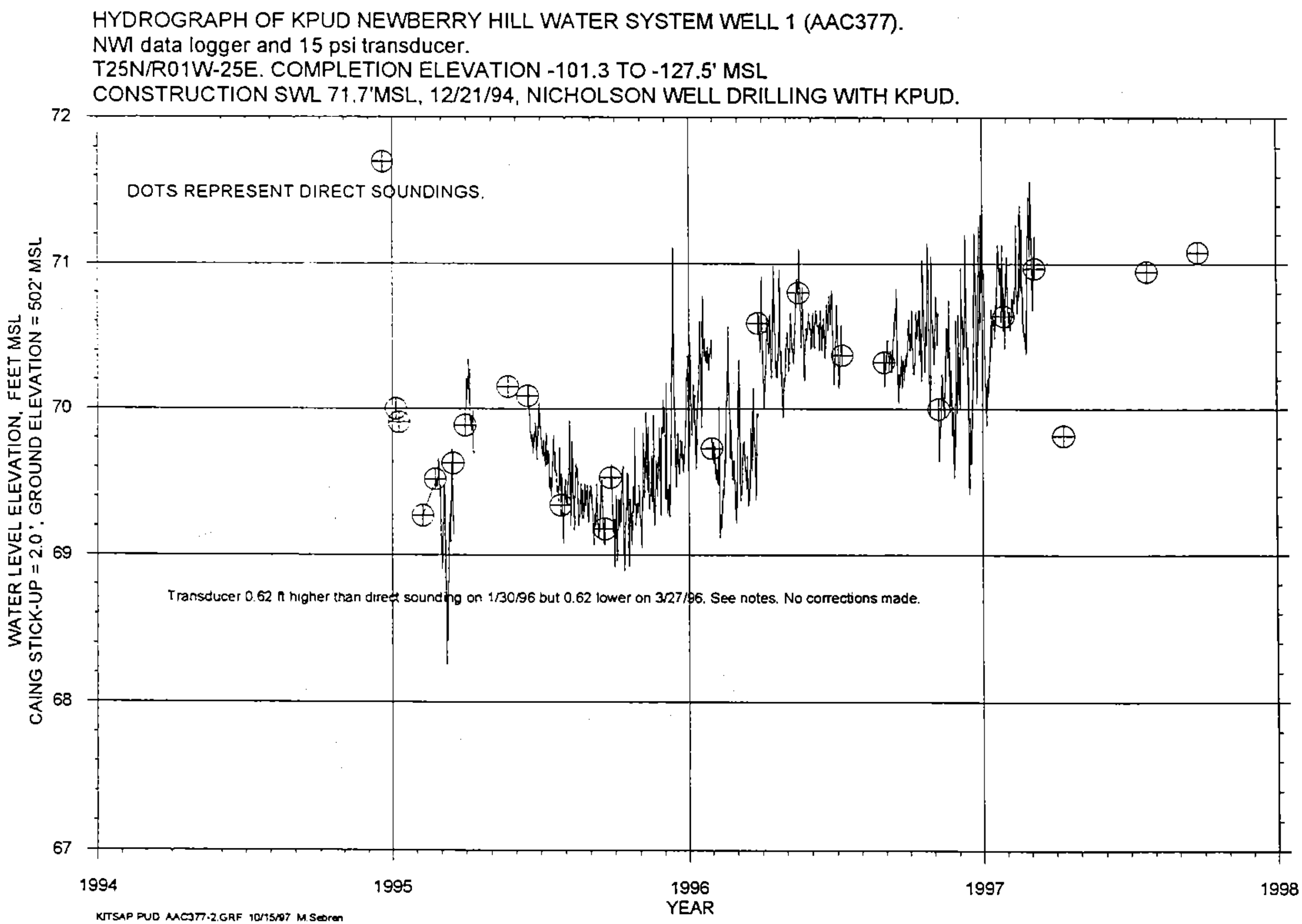


HYDROGRAPH OF ELLIS WELL (AAB607).
T25N/R01W-32E. COMPLETION ELEVATION -8 TO -13' MSL.
CONSTRUCTION SWL ROUGHLY 112' MSL, 12/92, DAVIS DRILLING.

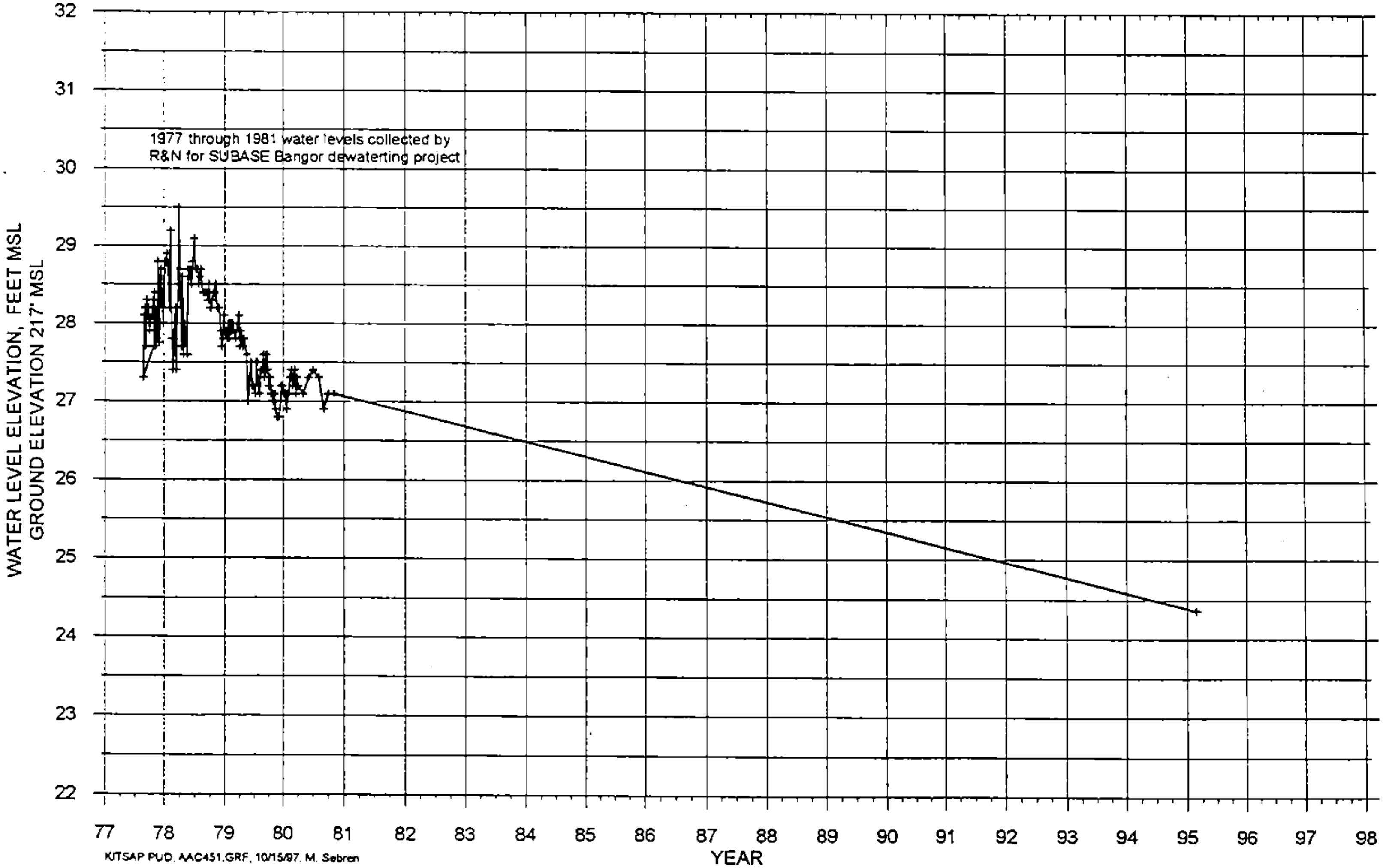


KITSAP PUD AAB607.GRF 10/15/97 M Sebren

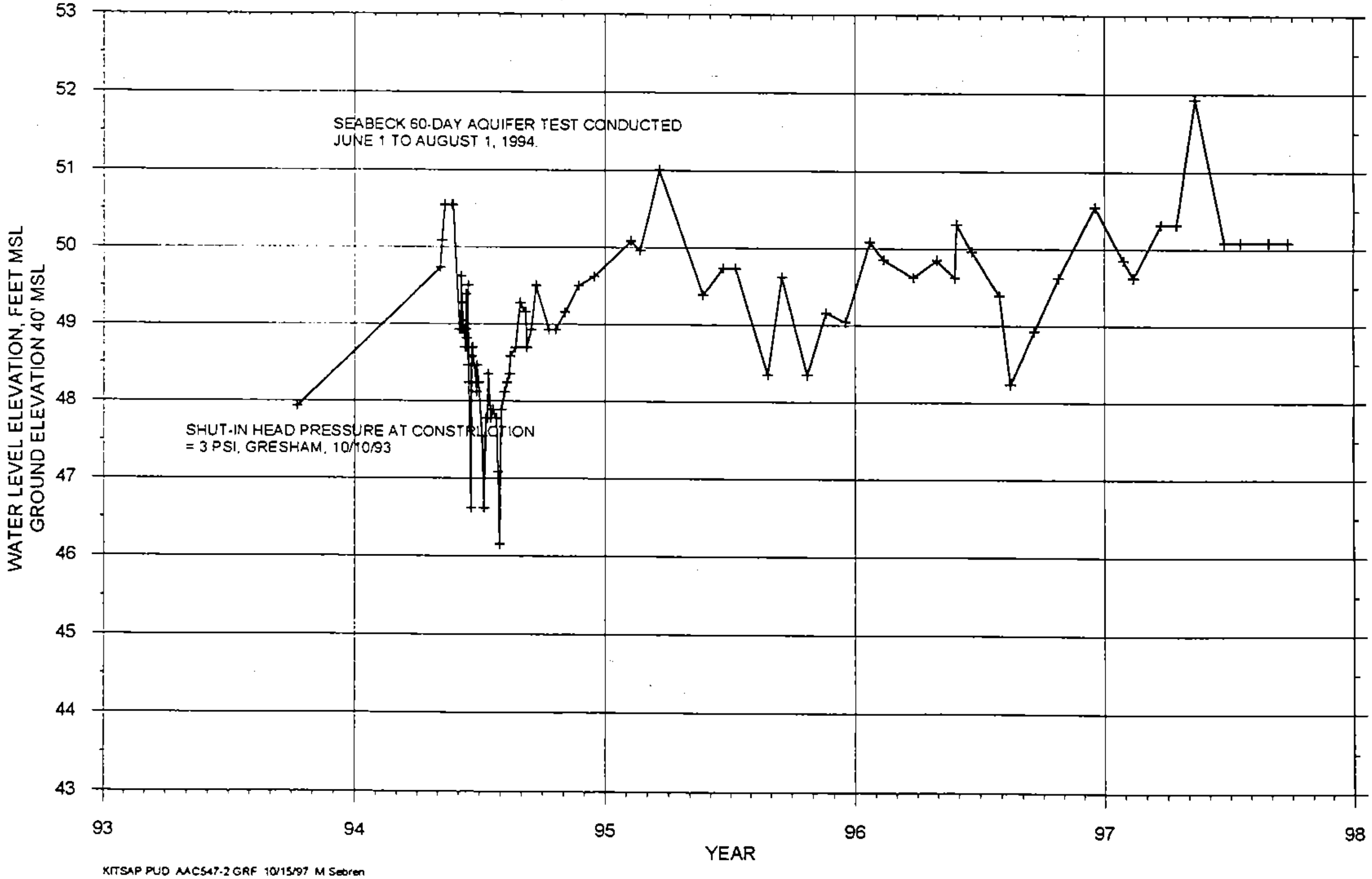

HYDROGRAPH OF JOHN SCHOLD WELL (AAC318).
T25N/R01W-15L. COMPLETION ELEVATION -65 TO -70' MSL.
CONSTRUCTION SWL 23.3' MSL, 11/19/81, NICHOLSON DRILLING.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION 20' MSL
26
24
22
20
18
16
14
12
10
8
6
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
YEAR
KITSAP PUD AAC318.GRF, 10/15/97 M. Sebren


HYDROGRAPH OF KPUD NEWBERRY HILL WATER SYSTEM WELL 1 (AAC377).
NWI data logger and 15 psi transducer.
T25N/R01W-25E. COMPLETION ELEVATION -101.3 TO -127.5' MSL
CONSTRUCTION SWL 71.7'MSL, 12/21/94, NICHOLSON WELL DRILLING WITH KPUD.
DOTS REPRESENT DIRECT SOUNDINGS.
Transducer 0.62 ft higher than direct sounding on 1/30/96 but 0.62 lower on 3/27/96. See notes. No corrections made.
WATER LEVEL ELEVATION, FEET MSL
CAING STICK-UP = 2.0', GROUND ELEVATION = 502' MSL
72
71
70
69
68
67
1994
1995
1996
1997
1998
YEAR
KITSAP PUD AAC377-2.GRF 10/15/97 M.Sebren

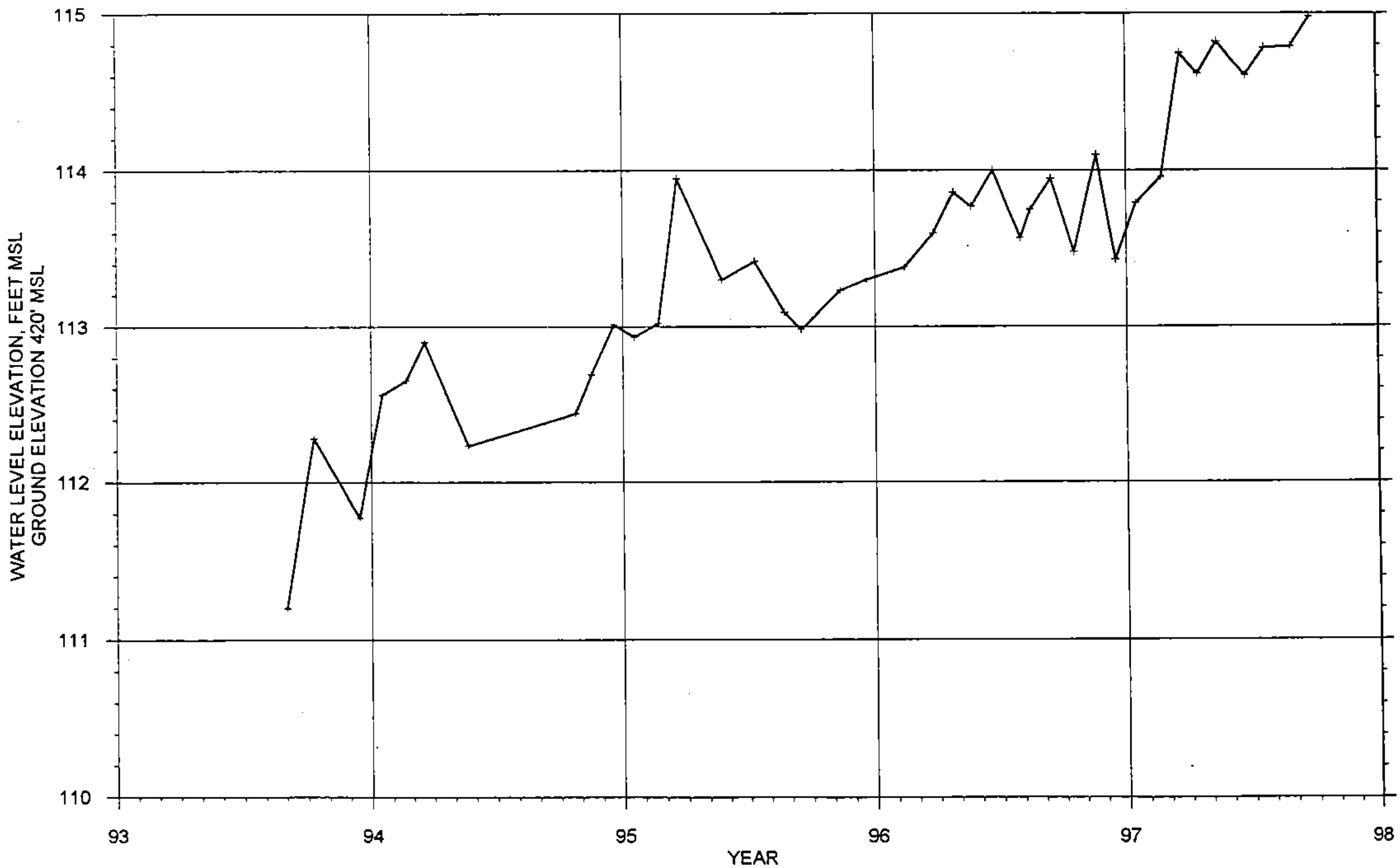
HYDROGRAPH OF SMITH WELL (AAC451).
T25N/R01W-1A. COMPLETION ELEVATION 4 TO 9' MSL.
CONSTRUCTION SWL 28' MSL, 12/8/77, INDREBO DRILLING.
INCLUDES PUMPING AND NON-PUMPING WATER LEVELS.



HYDROGRAPH OF COLLIER WELL (AAC547).
T25N/RO1W-21C. COMPLETION ELEVATION -22 TO -27' MSL.
CONSTRUCTION SWL 47.9' MSL, 10/10/93, GRESHAM WELL DIRLLING.

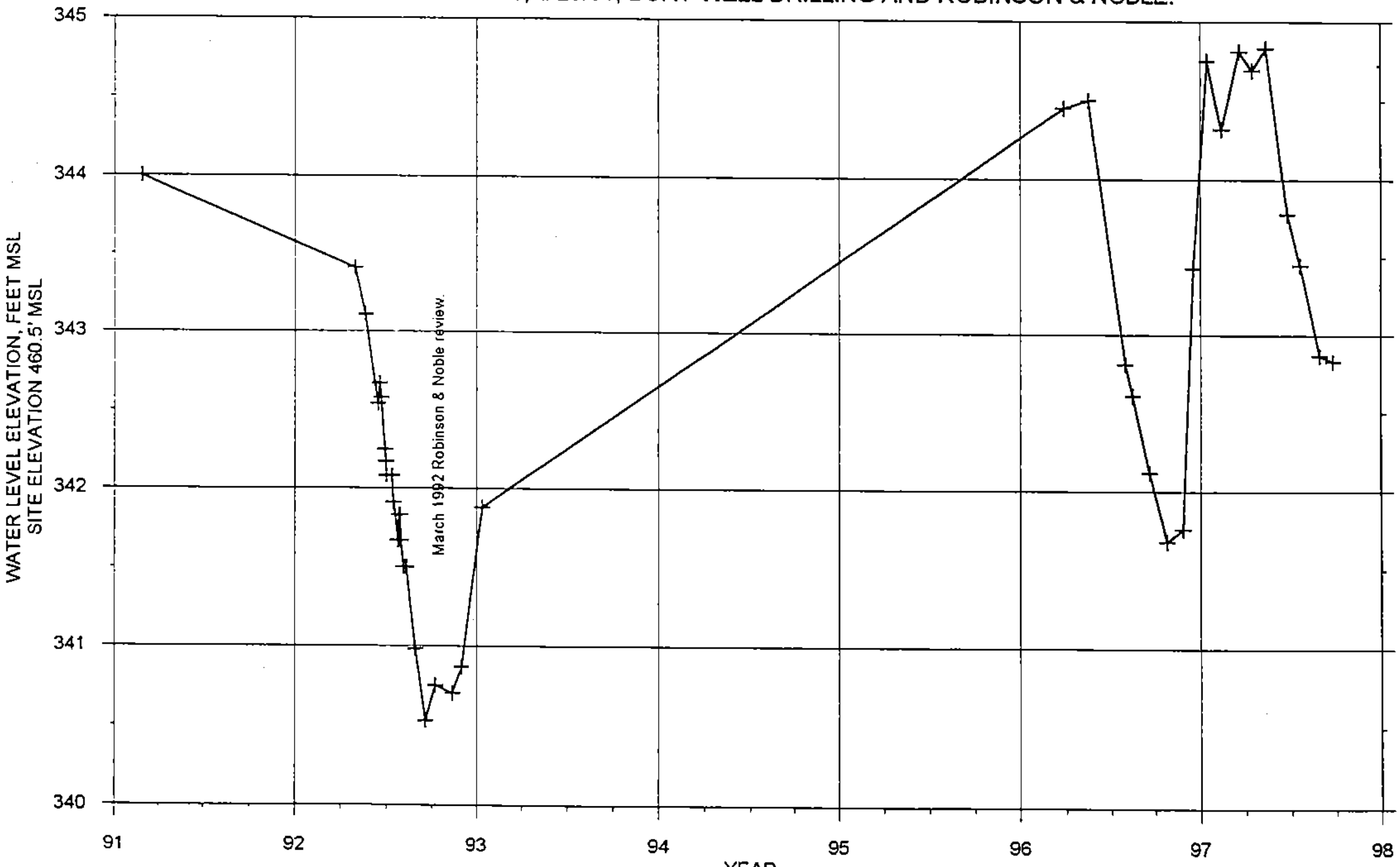


HYDROGRAPH OF DOLEN WELL (AAC707).
T25N/R01W-34H. COMPLETION ELEVATION 77 TO 82' MSL.
CONSTRUCTION SWL 111.2' MSL, 9/2/93, NICHOLSON DRILLING INC.



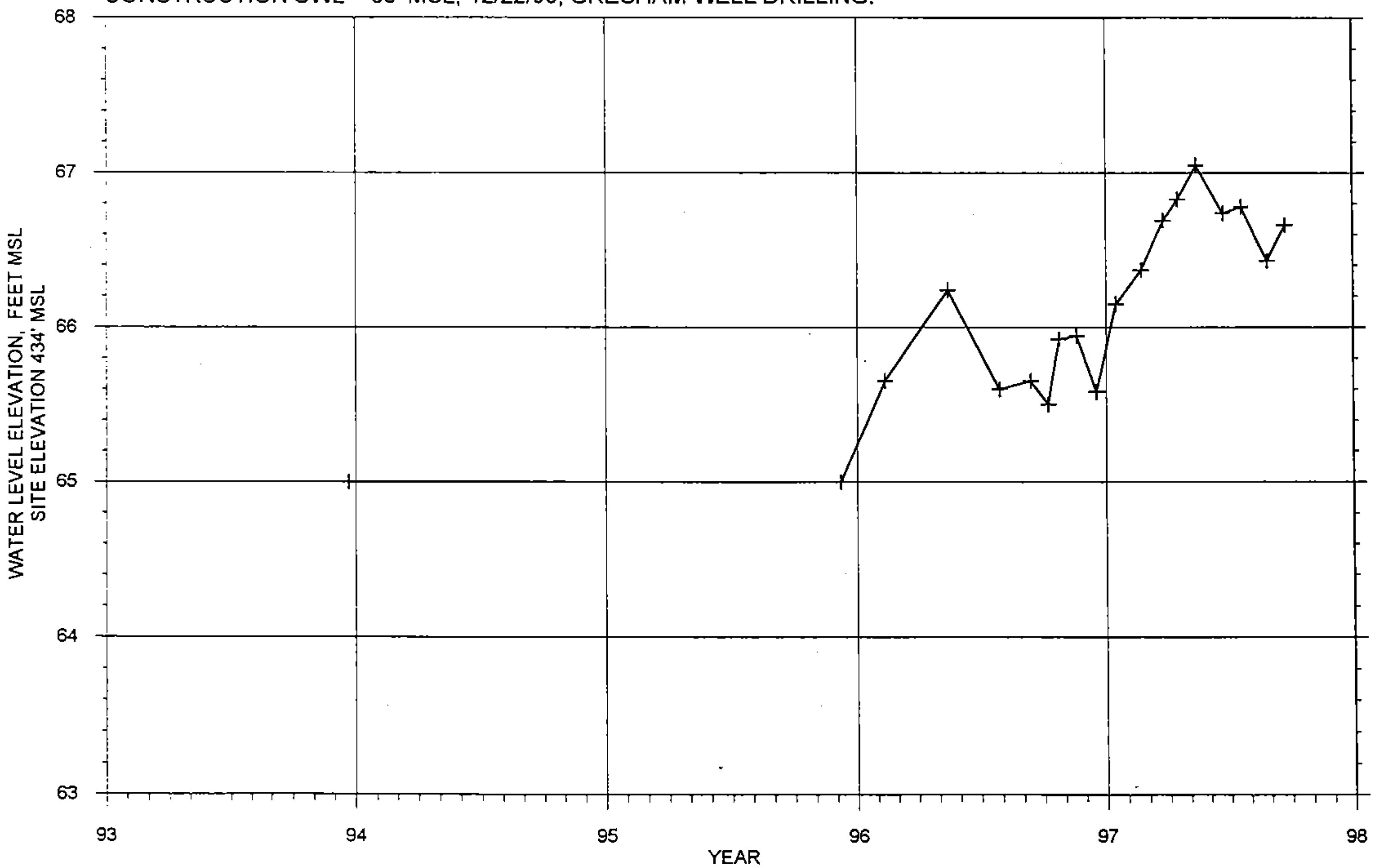
KITSAP PUD. AAC707-2.GRF. 10/15/97. M.Sebren

HYDROGRAPH OF GREEN MT ELEMENTARY SCHOOL WELL (AAC807).
T24N/R01W-04M. COMPLETION ELEVATION 313 TO 323' MSL.
CONSTRUCTION SWL 342 FEET MSL, 2/26/91, BURT WELL DRILLING AND ROBINSON & NOBLE.



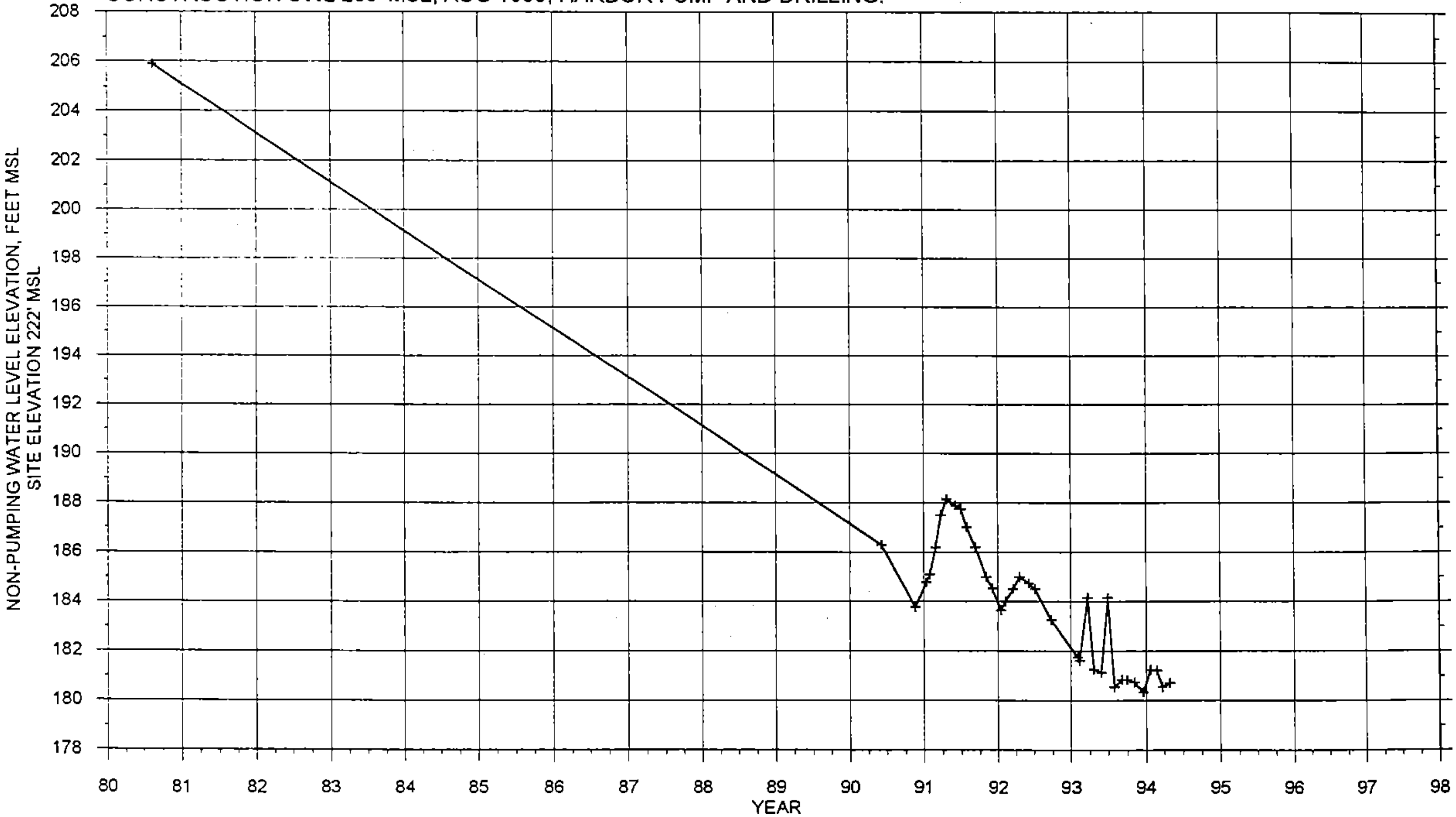
KITSAP PUD AAC807 GRF, 10/15/97 M Sebren

HYDROGRAPH OF MIGUELO WATER SYSTEM WELL (ABC665).
T25N/R01W-27G. COMPLETION ELEVATION 14 TO -26' MSL.
CONSTRUCTION SWL = 65' MSL, 12/22/93, GRESHAM WELL DRILLING.



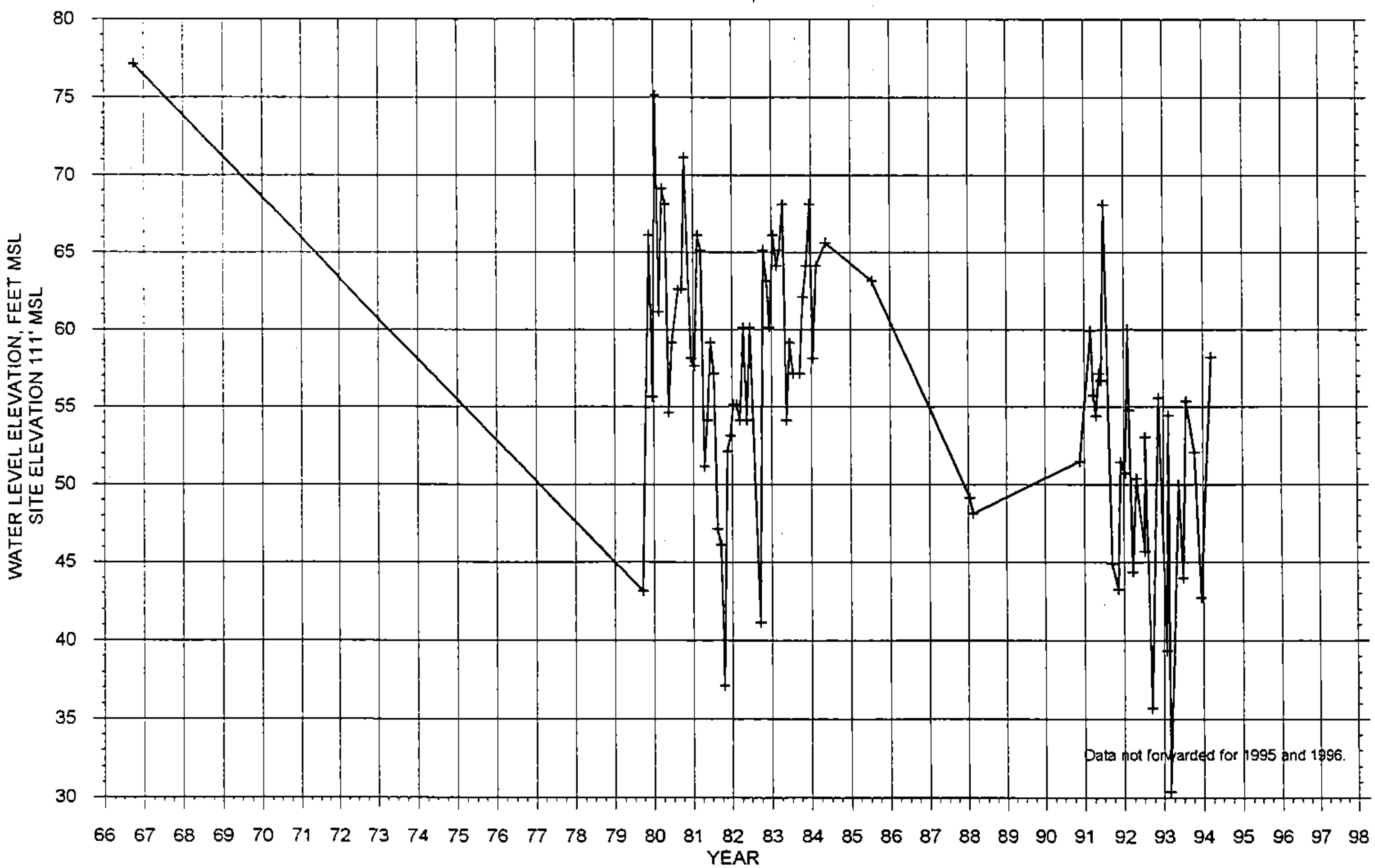
KITSAP PUD, ABC665.GRF 10/15/97, M Sebren

HYDROGRAPH OF HARBOR WATER COMPANY SOUTHWORTH WELL 2 (AAA119).
T23N/R02E-11K. COMPLETION ELEVATION -1' MSL.
CONSTRUCTION SWL 206' MSL, AUG 1980, HARBOR PUMP AND DRILLING.



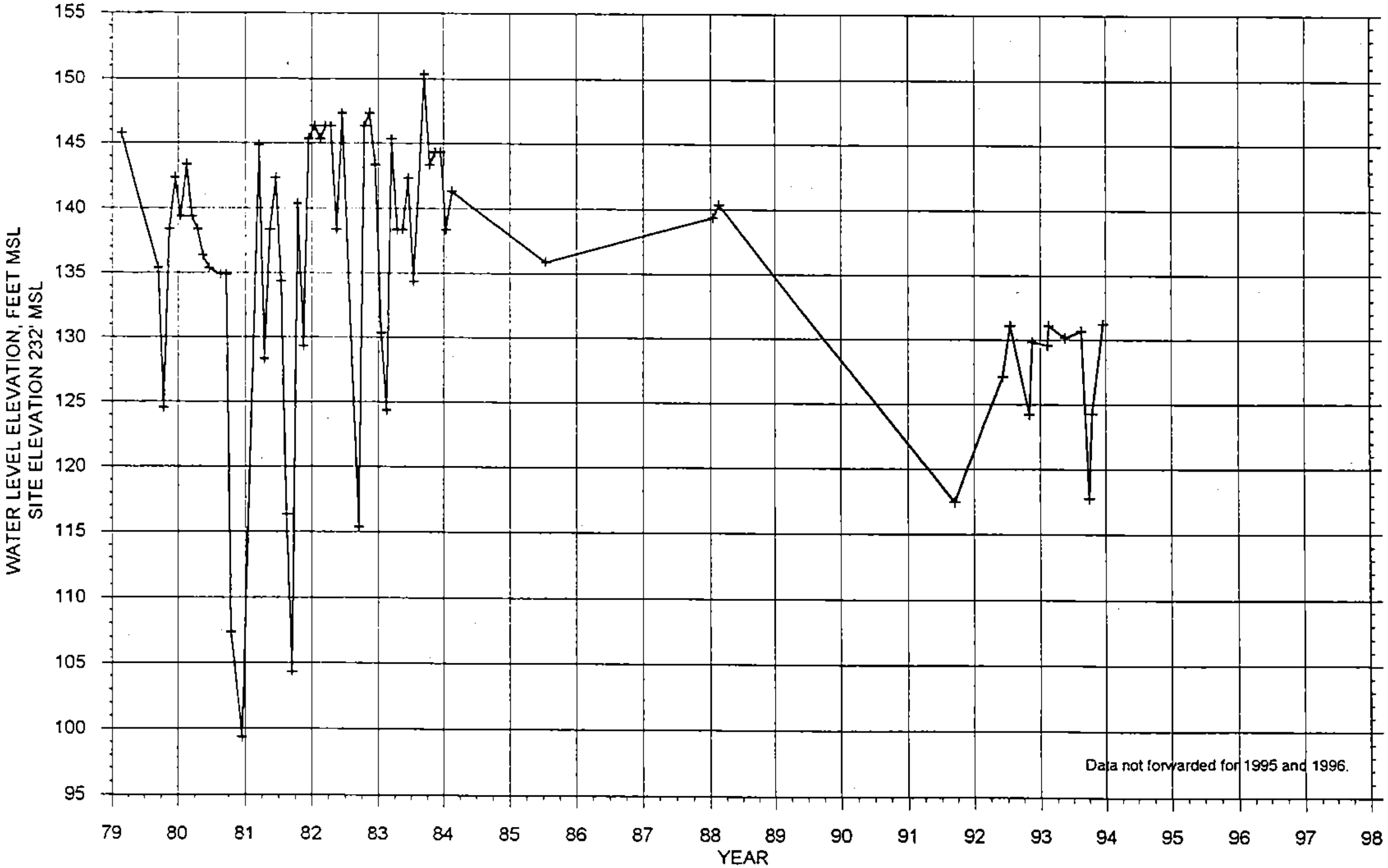
KITSAP PUD AAA119-2.GRF, 10/15/97 M.Sebren

HYDROGRAPH OF ANNAPOLIS WELL 1-B (AAA117).
T24N/R01E-25Q. COMPLETION ELEVATION -1018 TO -1133, MSL.



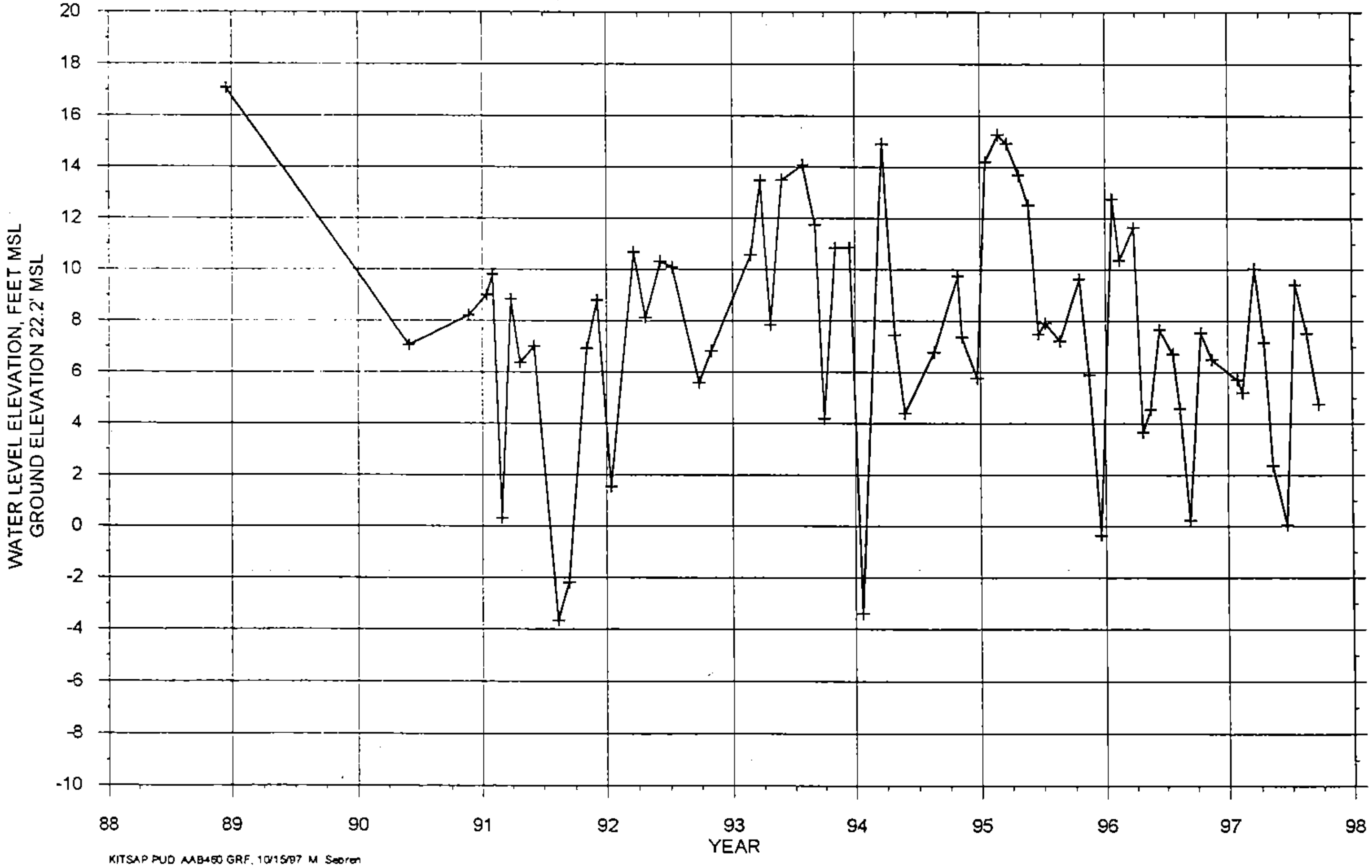
KITSAP PUD. AAA117-2.GRF. 10/15/97 M.Sebren

HYDROGRAPH OF ANNAPOLIS WELL 16 (AAA118).
T24N/R01E-36B. COMPLETION ELEVATION -29 TO -69' MSL.

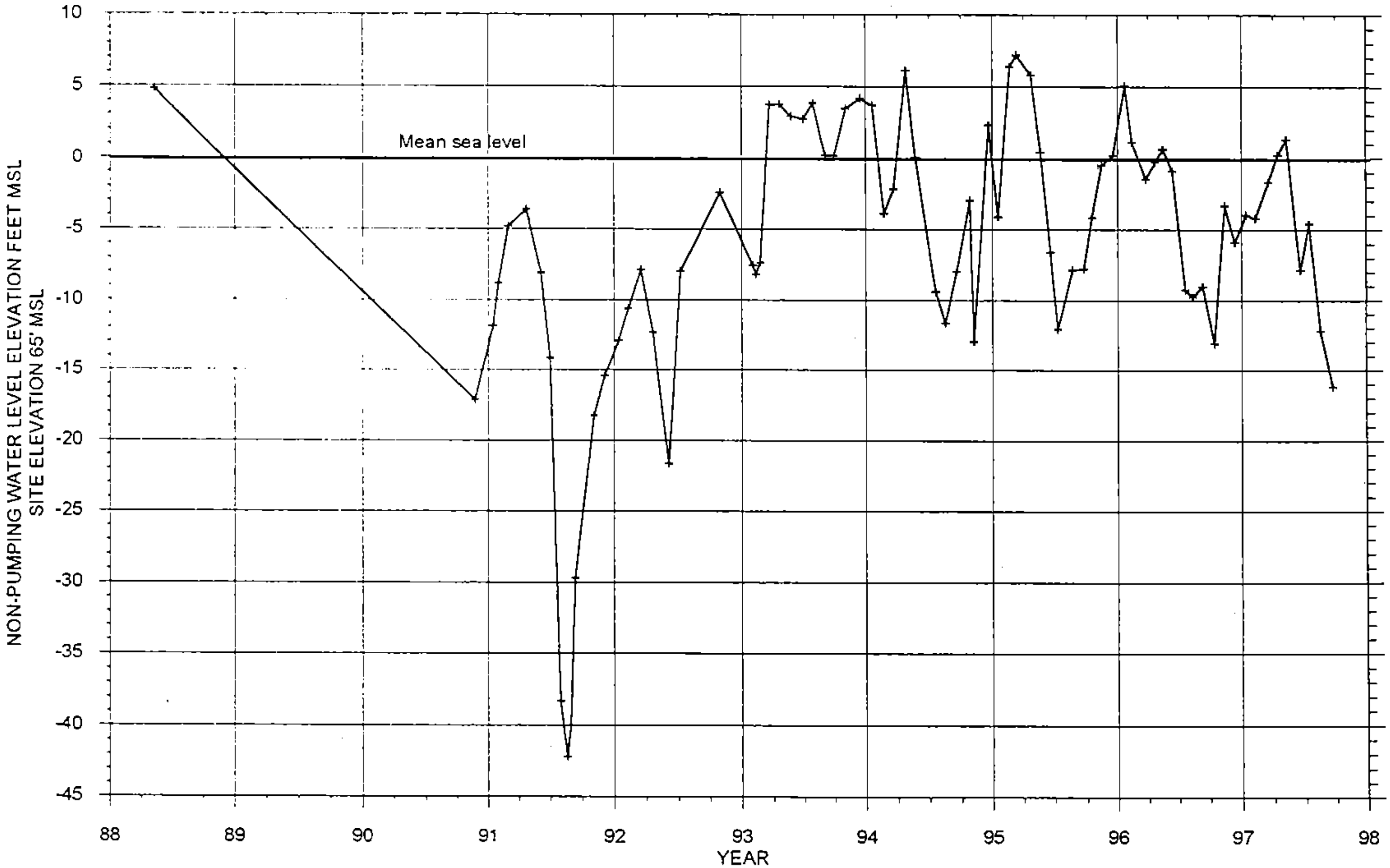


KITSAP PUD. AAA118-2.GRF 10/15/97 M Sebren

HYDROGRAPH OF NAVAL SUPPLY CENTER, MANCHESTER WELL 5 (AAB460).
T24N/R02E-16K. COMPLETION ELEVATION -80 TO -105' MSL.
CONSTRUCTION SWL 17.1' MSL, 12/16/88, ARMSTRONG DRILLING WITH RITTER HOUSE & ZEMAN.

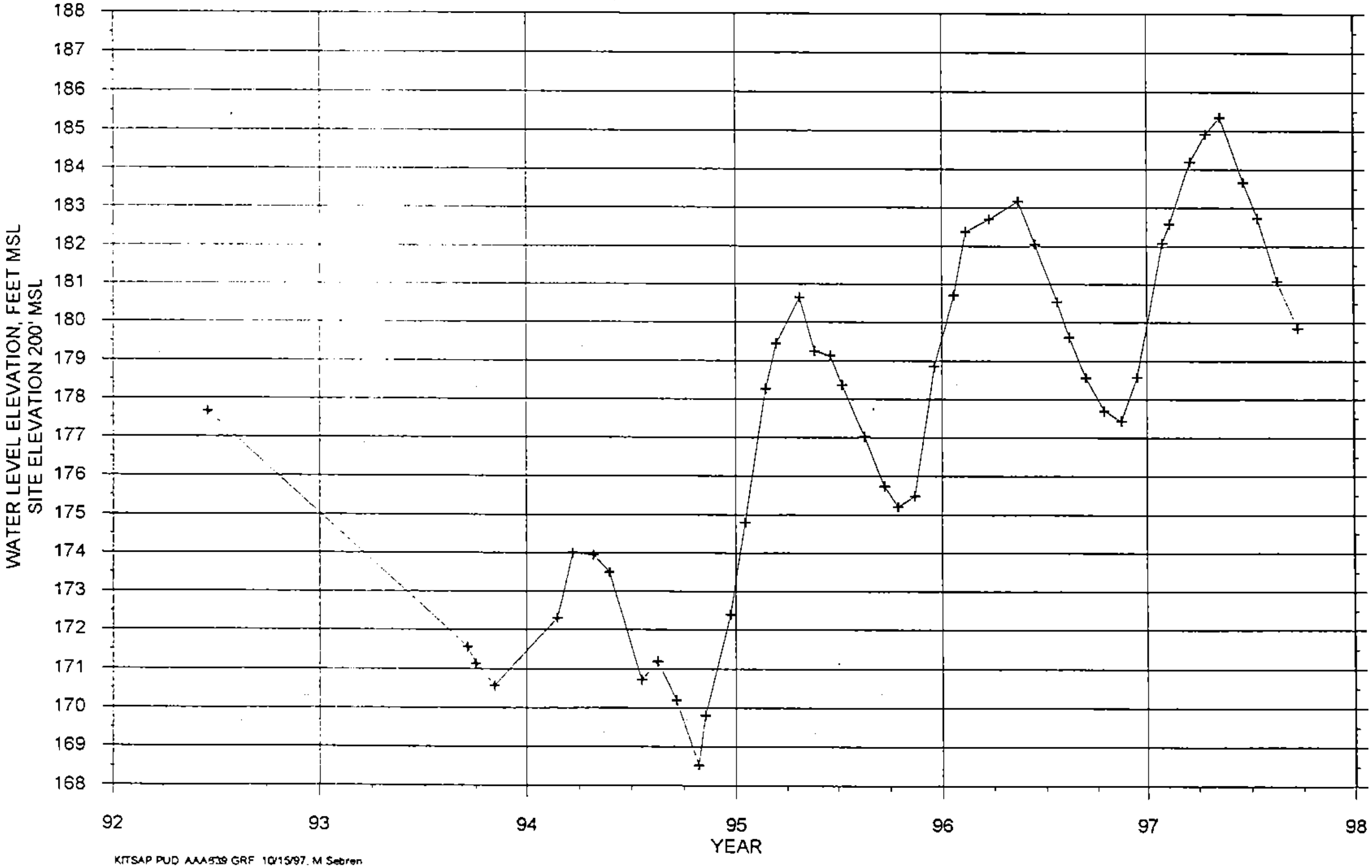


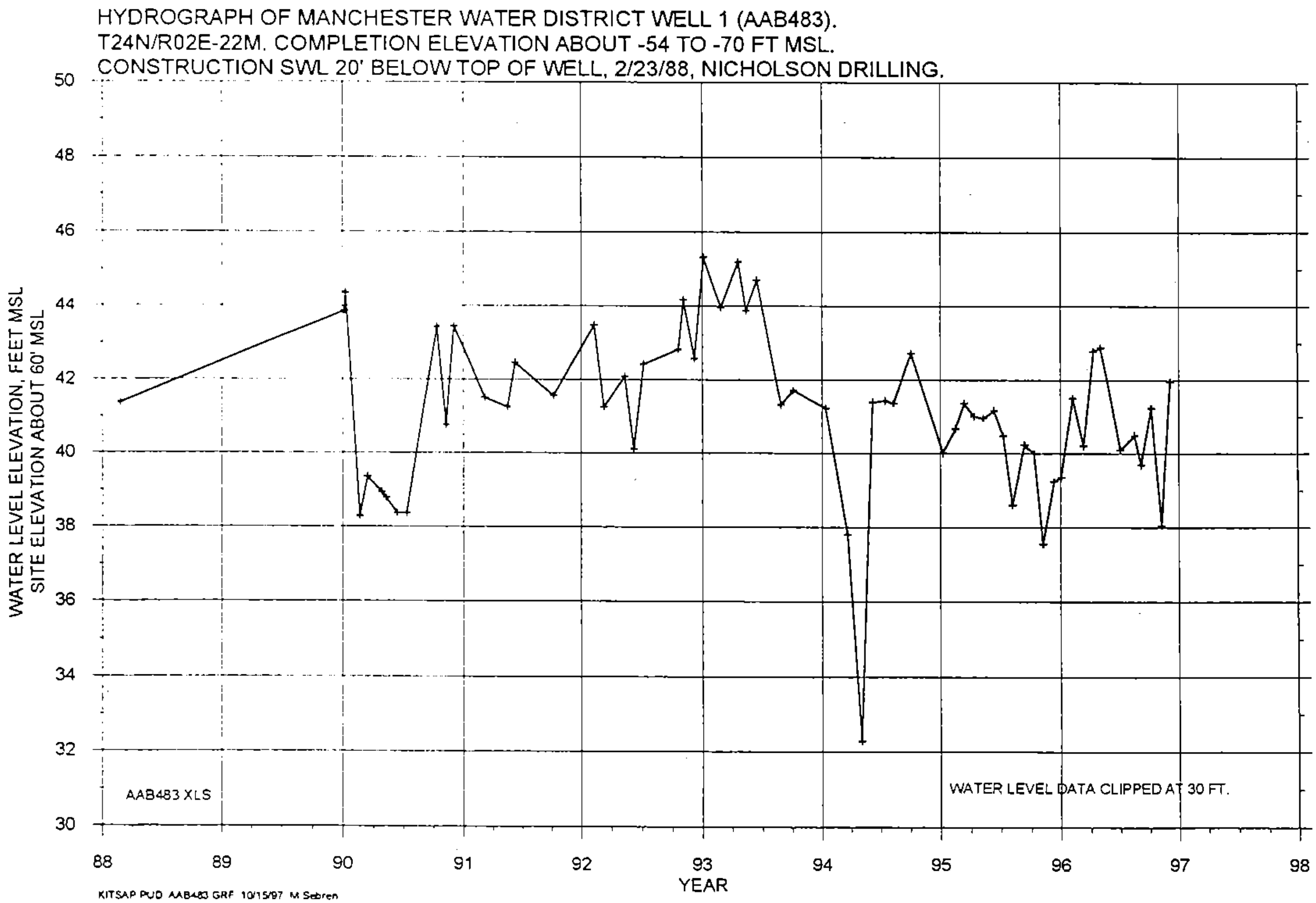
HYDROGRAPH OF WATAUGA BEACH WELL 2 (AAA120).
T24N/R02E-16L. COMPLETION ELEVATION -53 TO -69' MSL.
CONSTRUCTION SWL 4.8' MSL, 5/9/88, NICHOLSON WELL DRILLING.



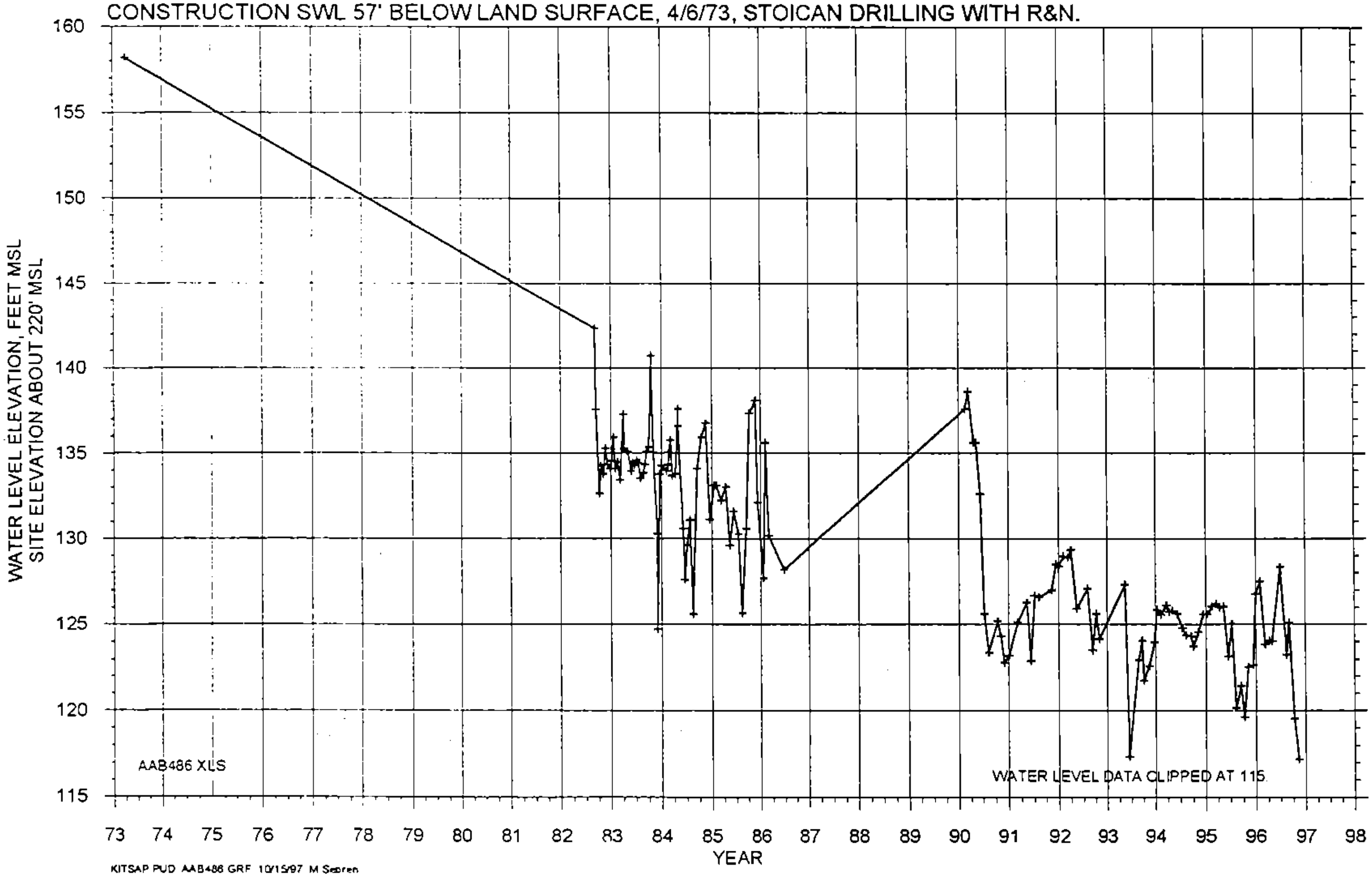
KITSAP PUD AAA120 GRF, 10/15/97 M. Sebren

HYDROGRAPH OF BANIGAN PRIVATE WELL (AAA639).
T23N/R01E-10B. COMPLETION ELEVATION ABOUT 91 TO 95' MSL.
CONSTRUCTION SWL ABOUT 175' MSL, 9/9/69, HARBOR PUMP & DRILLING.

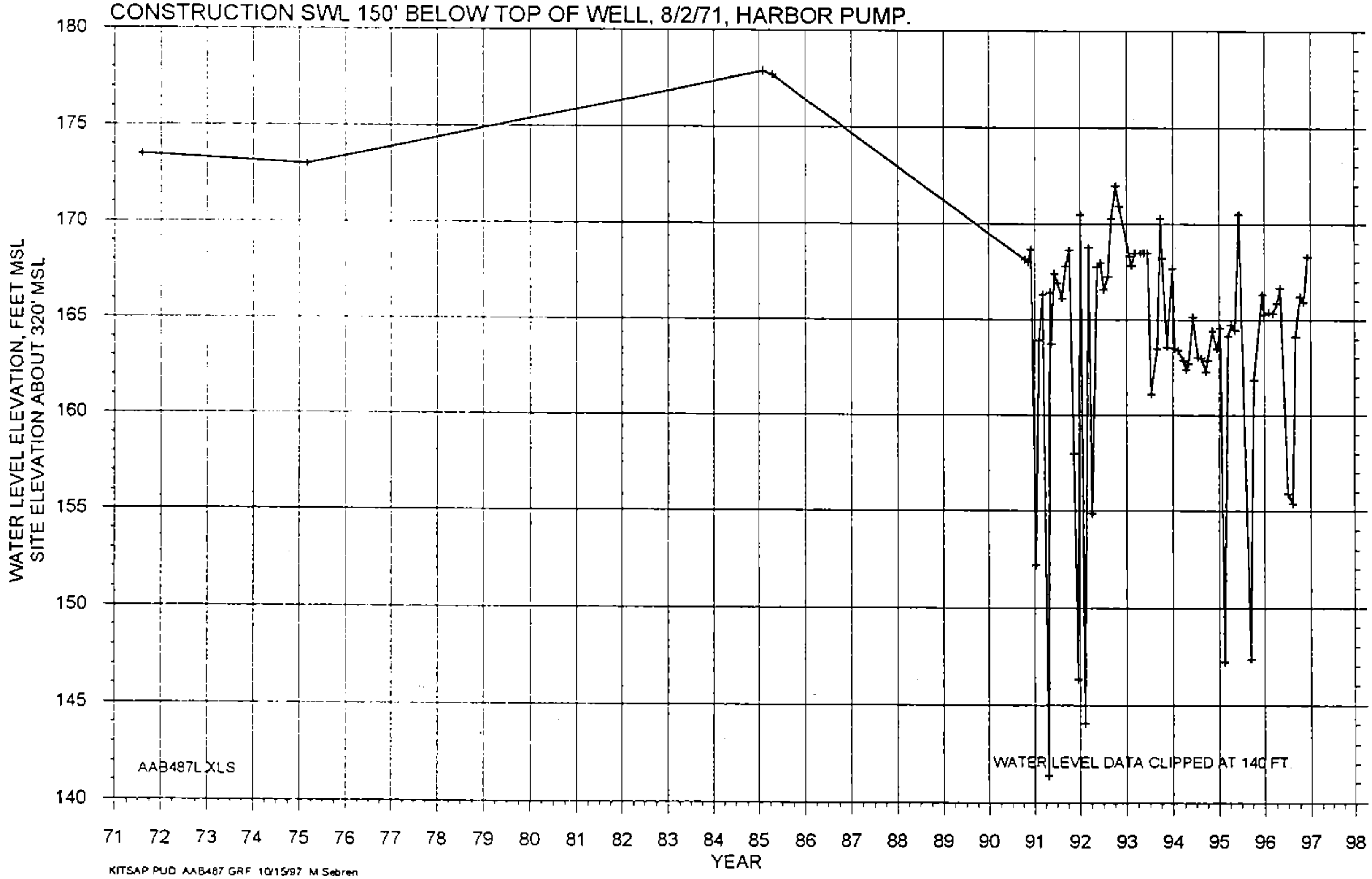



HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 1 (AAB483).
T24N/R02E-22M. COMPLETION ELEVATION ABOUT -54 TO -70 FT MSL.
CONSTRUCTION SWL 20' BELOW TOP OF WELL, 2/23/88, NICHOLSON DRILLING.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION ABOUT 60' MSL
50
48
46
44
42
40
38
36
34
32
30
AAB483 XLS
WATER LEVEL DATA CLIPPED AT 30 FT.
88
89
90
91
92
93
94
95
96
97
98
YEAR
KITSAP PUD AAB483 GRF 10/15/97 M Sebren

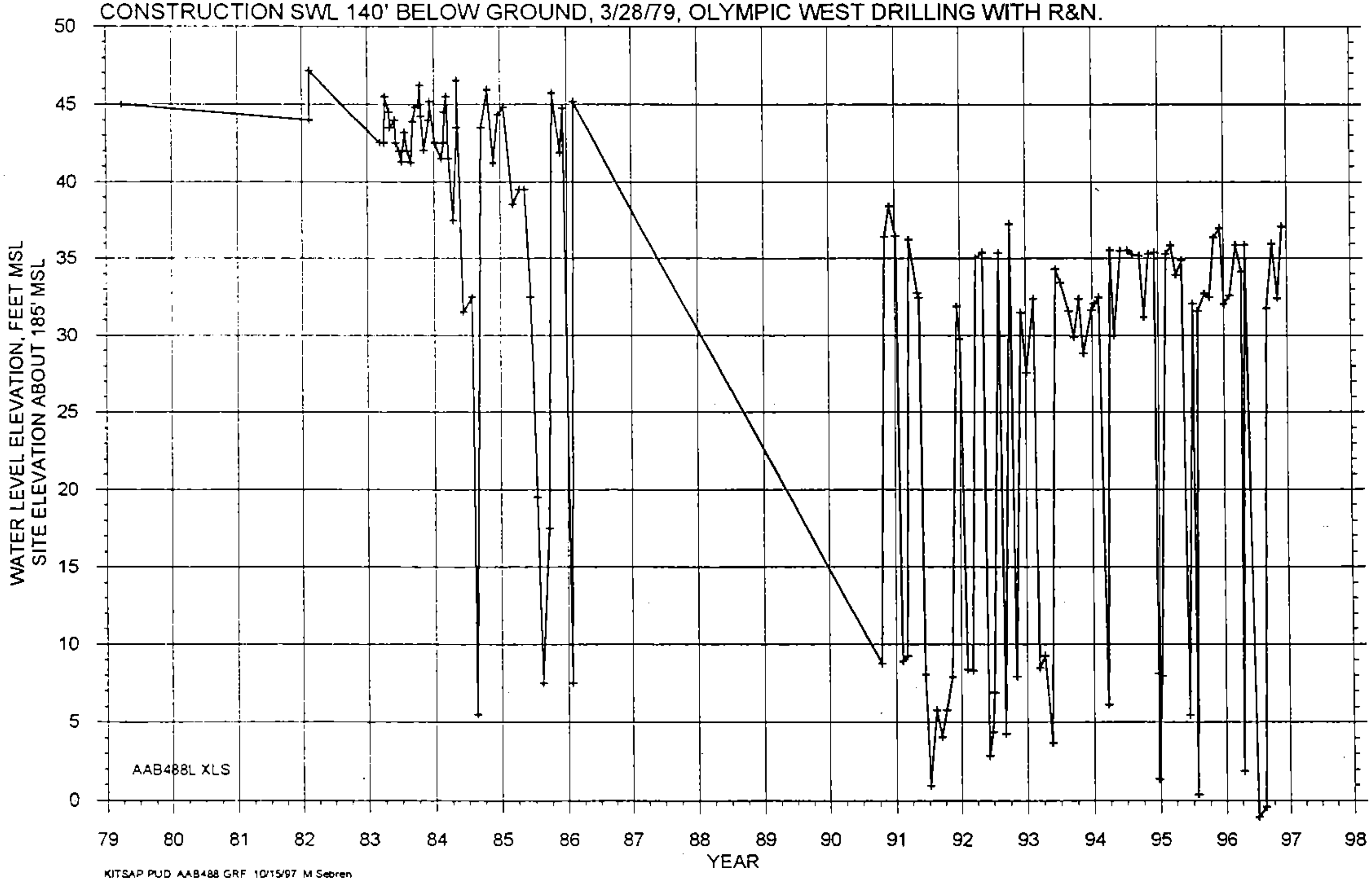
HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 4 (AAB486).
T24N/R02E-29Q. COMPLETION ELEVATION ABOUT 29 TO -30 FT MSL.
CONSTRUCTION SWL 57' BELOW LAND SURFACE, 4/6/73, STOICAN DRILLING WITH R&N.



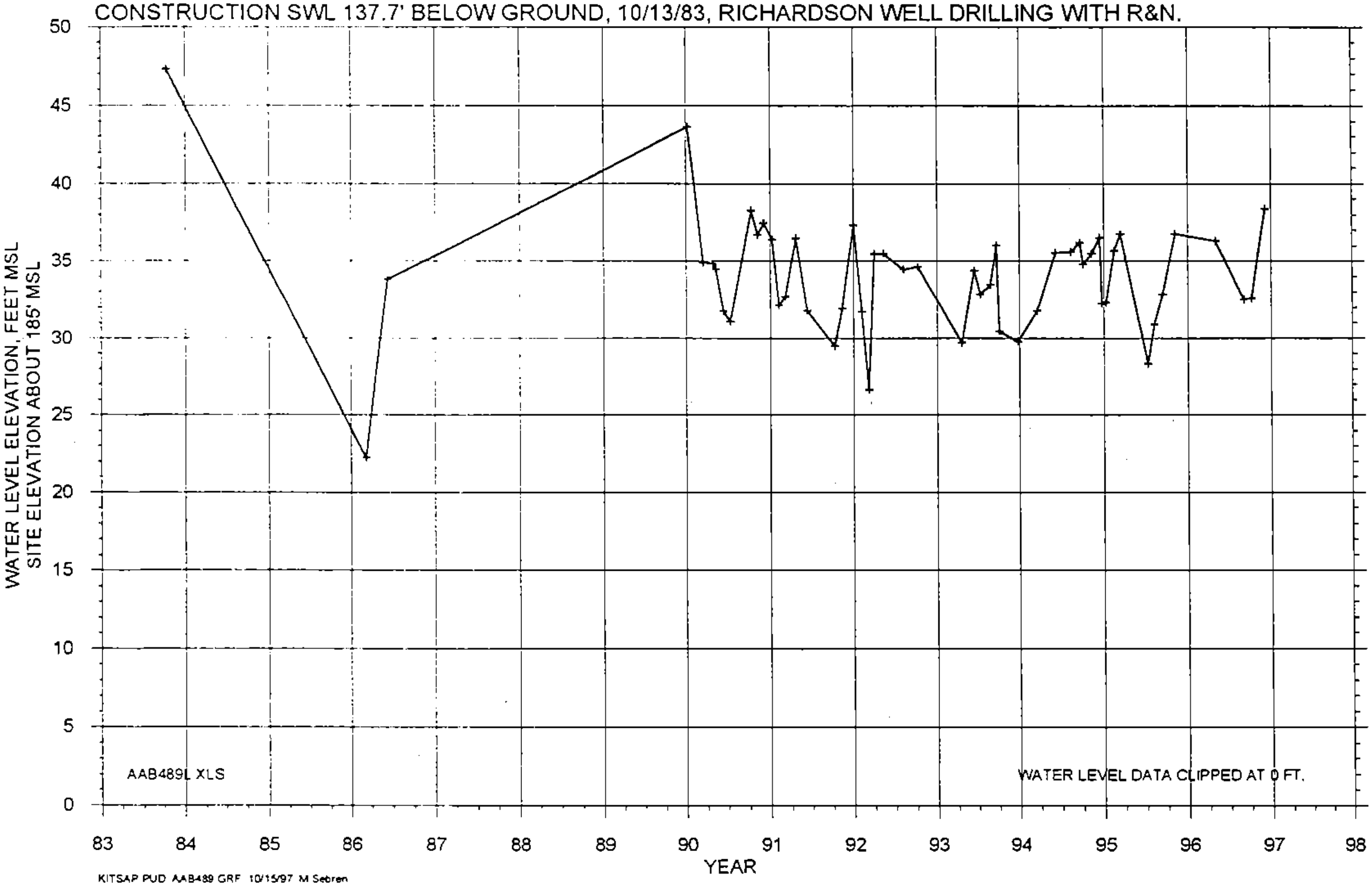
HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 5 (AAB487).
T23N/R02E-10C. COMPLETION ELEVATION ABOUT 6 TO 16 FT MSL.
CONSTRUCTION SWL 150' BELOW TOP OF WELL, 8/2/71, HARBOR PUMP.



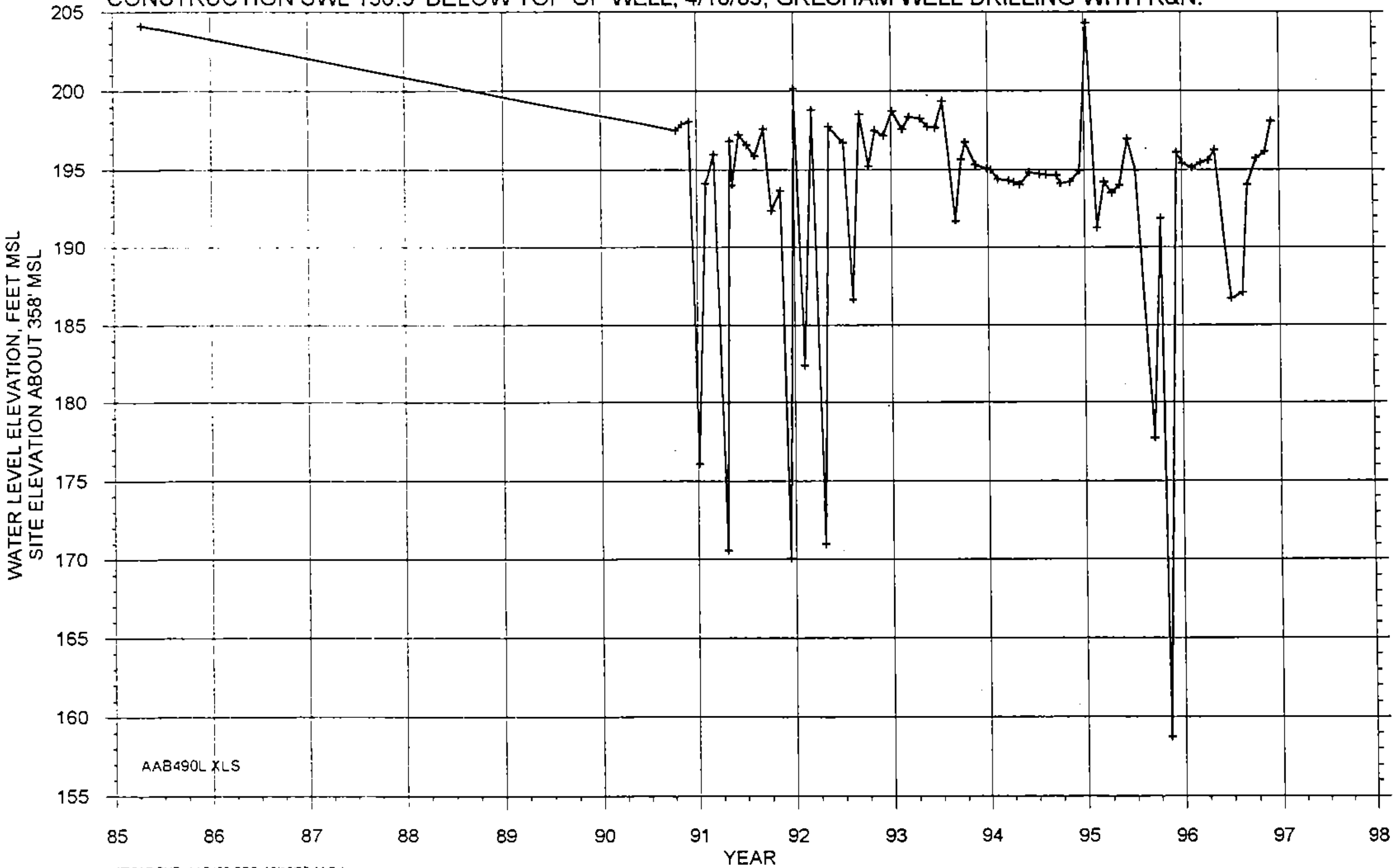
HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 6 (AAB488).
T24N/R02E-33G. COMPLETION ELEVATION ABOUT -294 TO -314 FT MSL.
CONSTRUCTION SWL 140' BELOW GROUND, 3/28/79, OLYMPIC WEST DRILLING WITH R&N.



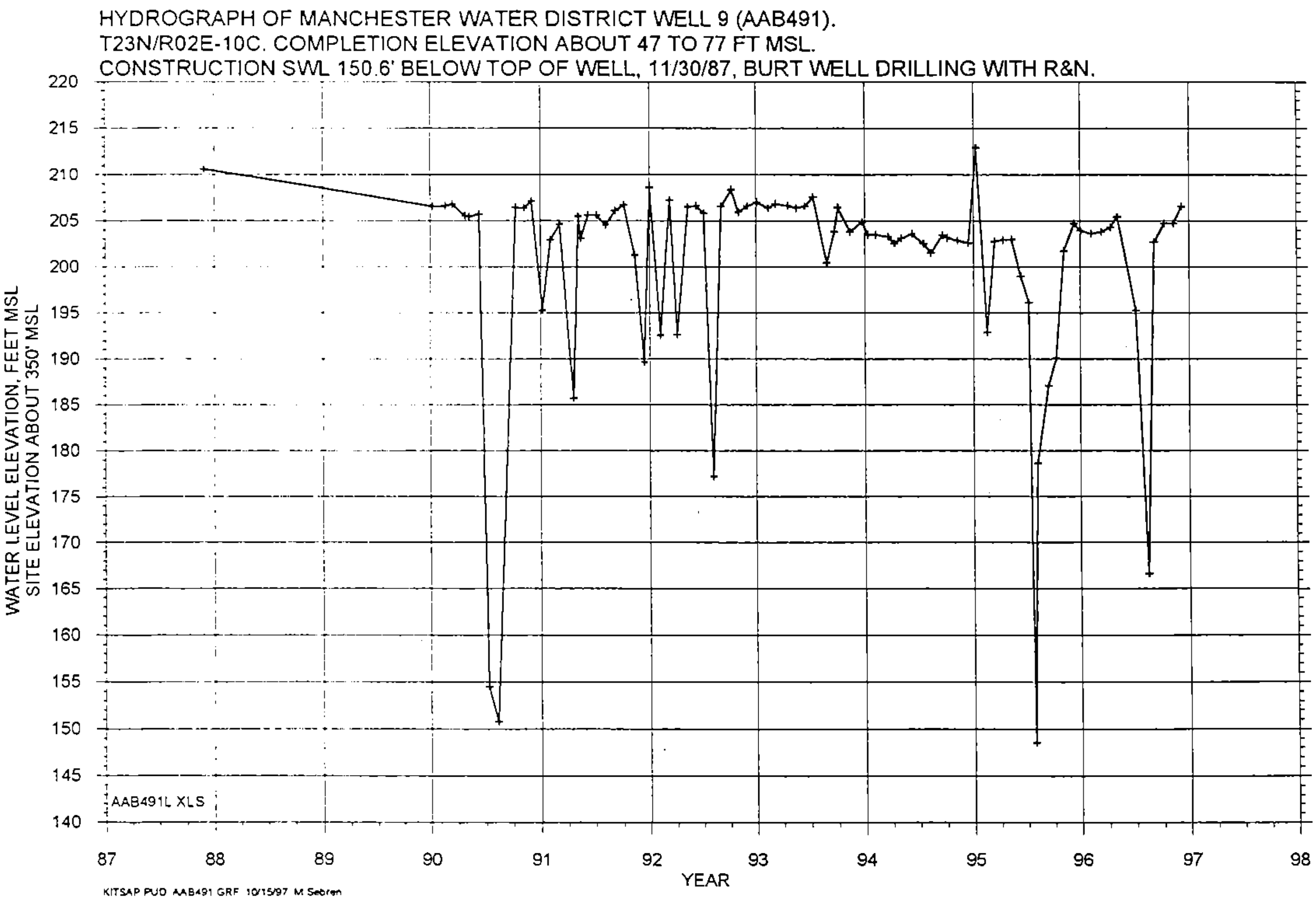
HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 7 (AAB489).
T24N/R02E-33G. COMPLETION ELEVATION ABOUT -291 TO -309 FT MSL.
CONSTRUCTION SWL 137.7' BELOW GROUND, 10/13/83, RICHARDSON WELL DRILLING WITH R&N.



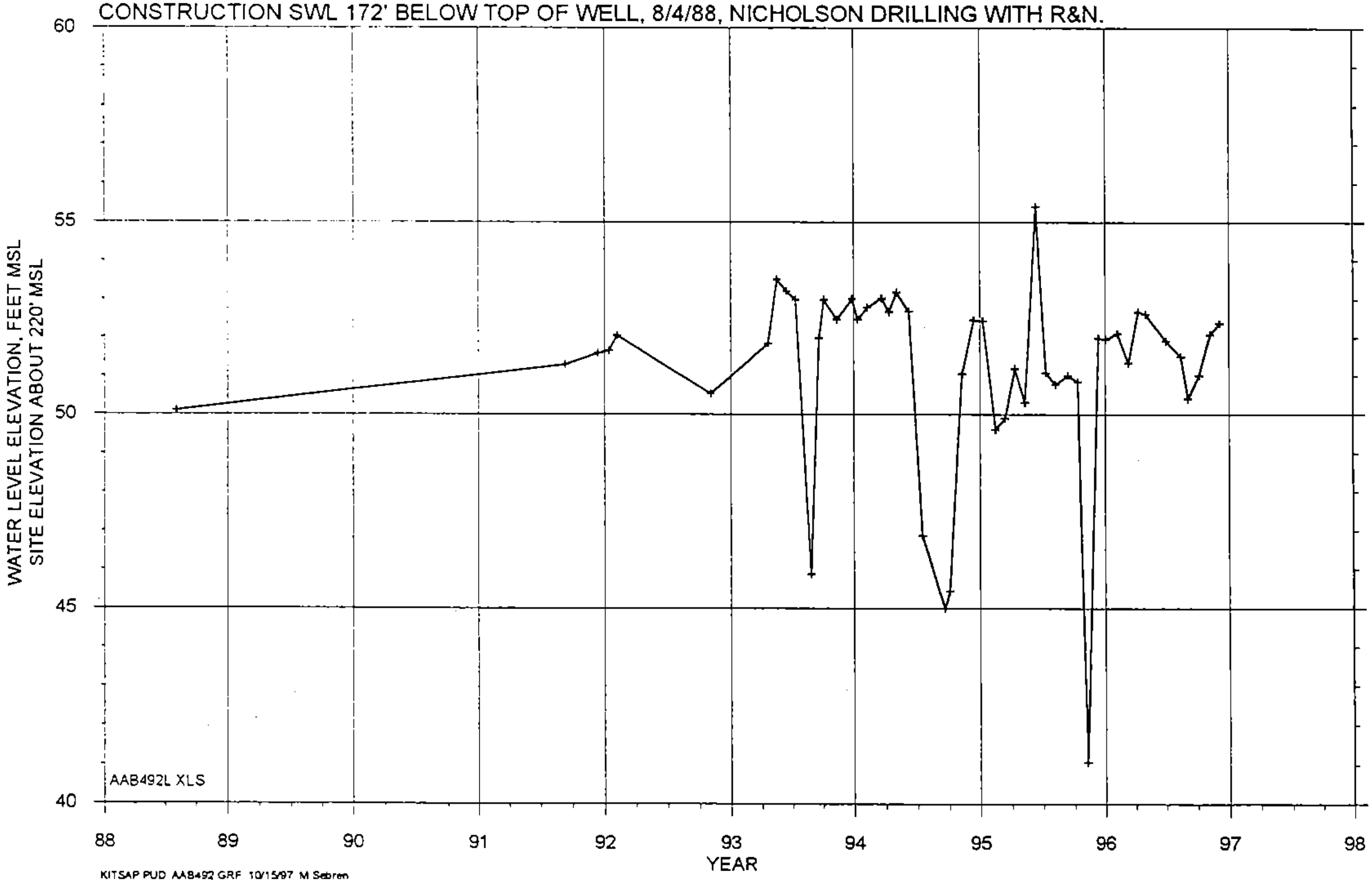
HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 8 (AAB490).
T23N/R02E-10C. COMPLETION ELEVATION ABOUT 133 TO 149 FT MSL.
CONSTRUCTION SWL 156.5' BELOW TOP OF WELL, 4/18/85, GRESHAM WELL DRILLING WITH R&N.



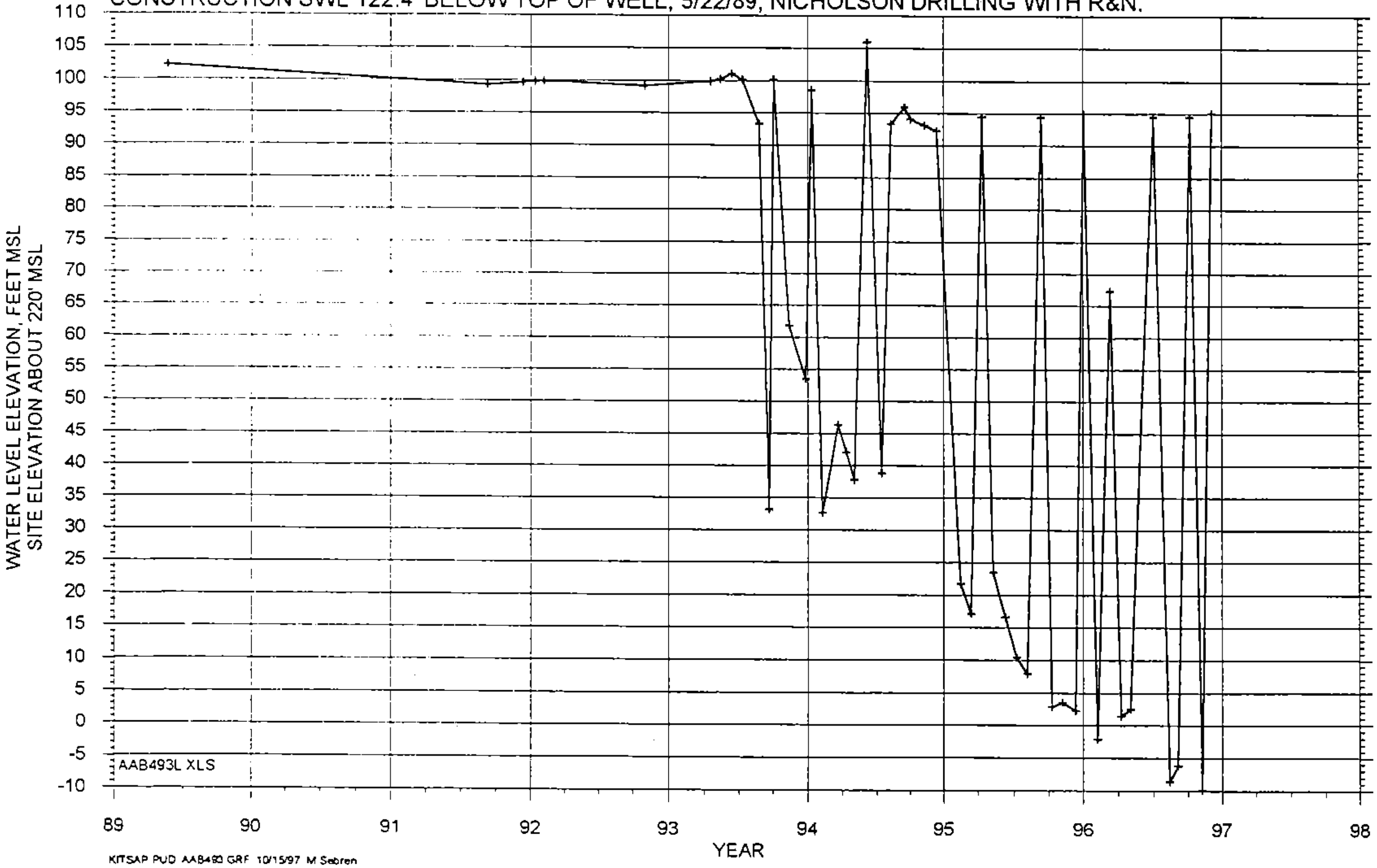
KITSAP PUD AAB490.GRF 10/15/97 M Sebren


HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 9 (AAB491).
T23N/R02E-10C. COMPLETION ELEVATION ABOUT 47 TO 77 FT MSL.
CONSTRUCTION SWL 150.6' BELOW TOP OF WELL, 11/30/87, BURT WELL DRILLING WITH R&N.
WATER LEVEL ELEVATION, FEET MSL
SITE ELEVATION ABOUT 350' MSL
220
215
210
205
200
195
190
185
180
175
170
165
160
155
150
145
140
AAB491L XLS
87
88
89
90
91
92
93
94
95
96
97
98
YEAR
KITSAP PUD AAB491 GRF 10/15/97 M Sebren

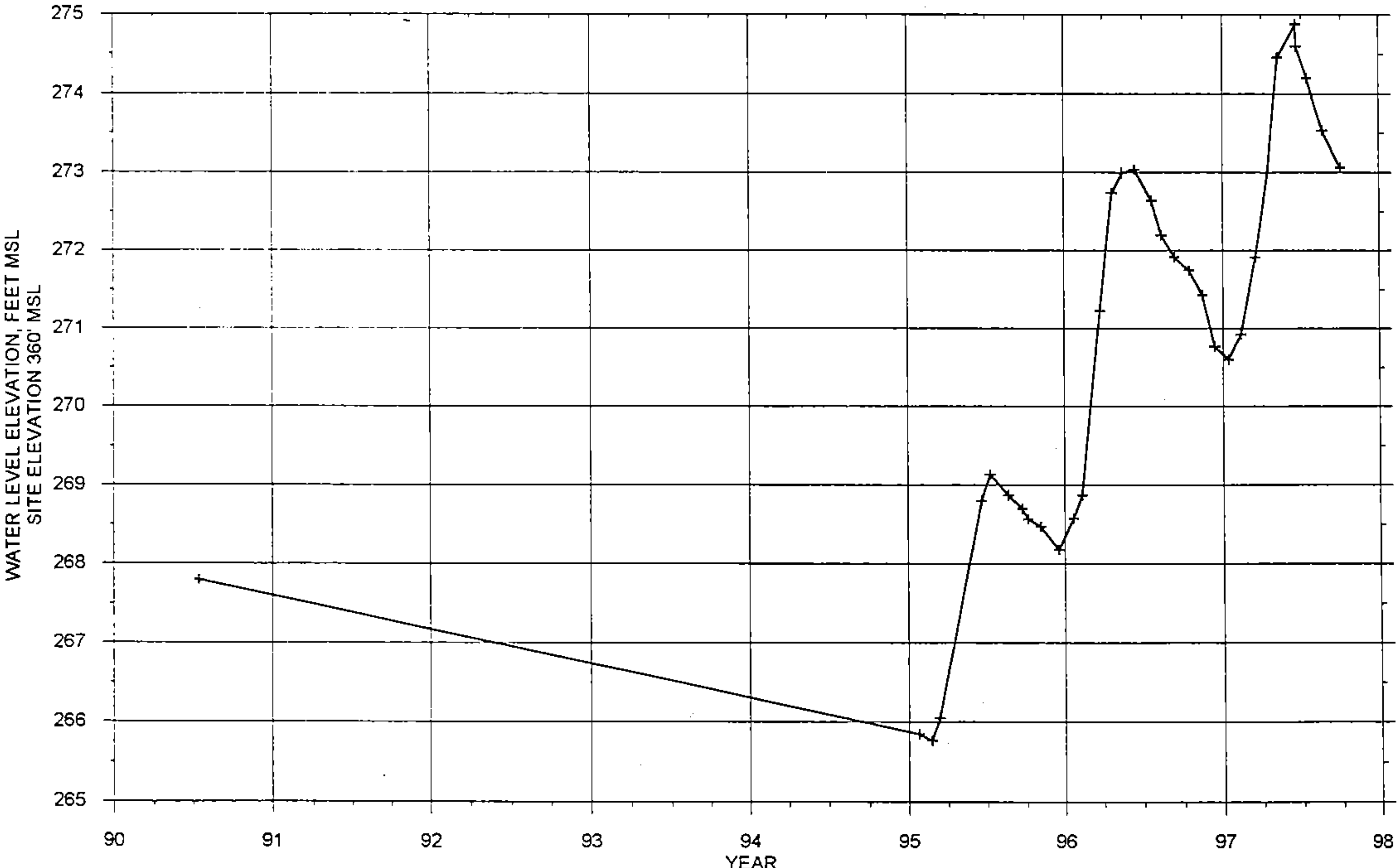
HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 10 (AAB492).
T24N/R02E-21B. COMPLETION ELEVATION ABOUT -109 TO -130 FT MSL.
CONSTRUCTION SWL 172' BELOW TOP OF WELL, 8/4/88, NICHOLSON DRILLING WITH R&N.



HYDROGRAPH OF MANCHESTER WATER DISTRICT WELL 11 (AAB493).
T24N/R02E-21B. COMPLETION ELEVATION ABOUT -34 TO -49 FT MSL.
CONSTRUCTION SWL 122.4' BELOW TOP OF WELL, 5/22/89, NICHOLSON DRILLING WITH R&N.

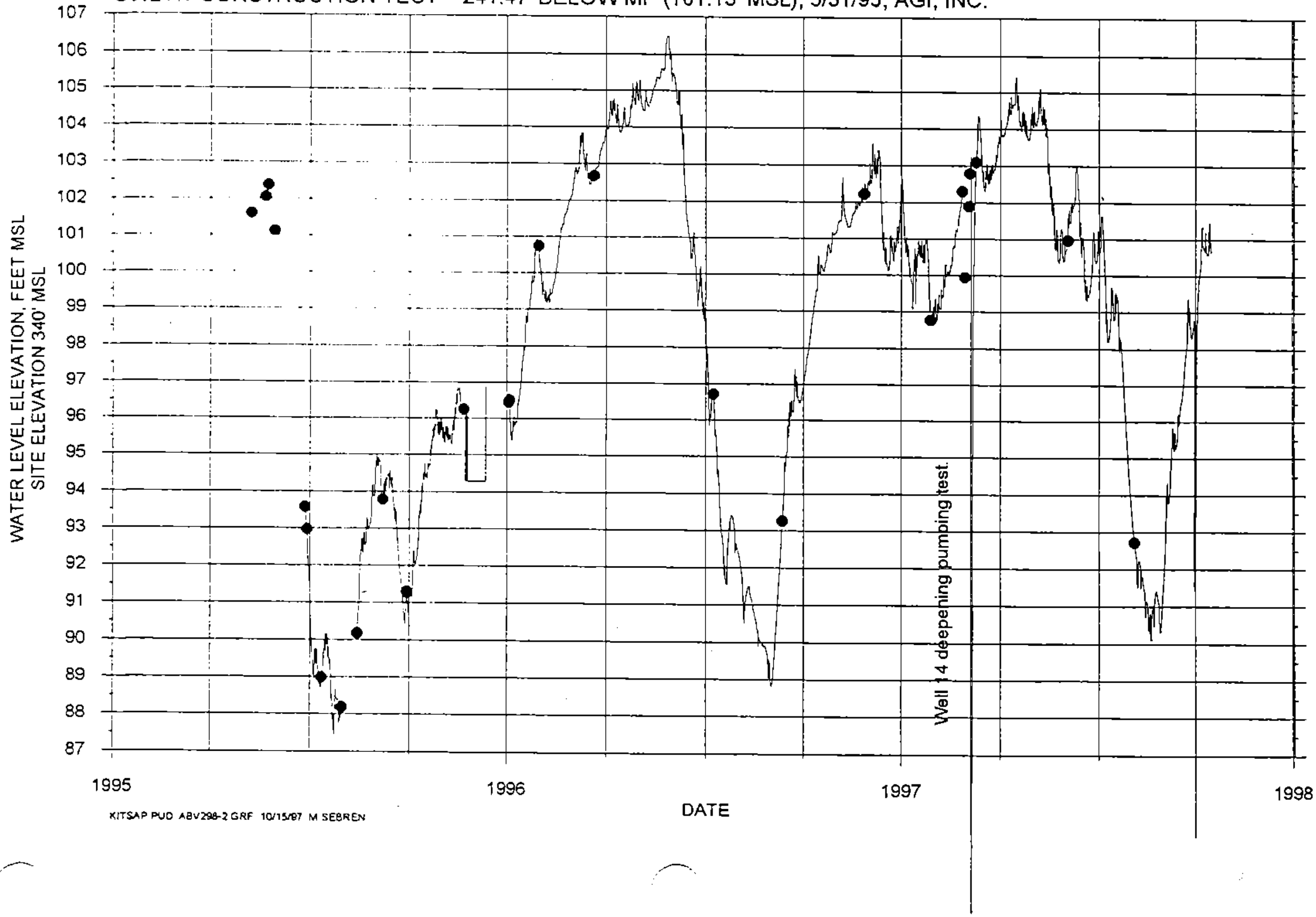


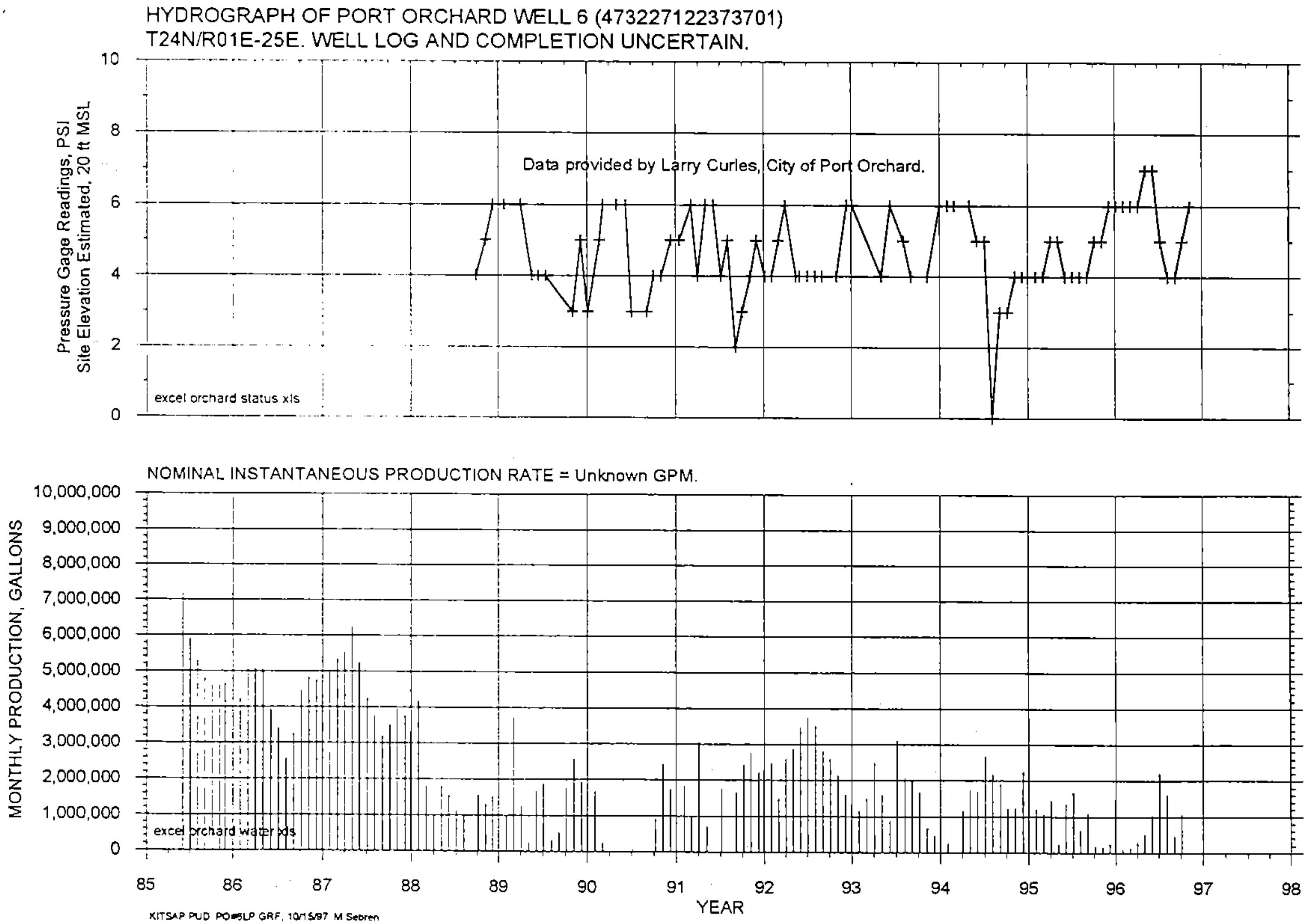
HYDROGRAPH OF DRIFTWOOD COVE WELL 2 (AAC824).
T23N/R02E-15R. COMPLETION ELEVATION 236 TO 226' MSL.
CONSTRUCTION SWL ABOUT 268' MSL, 7/16/90, NICHOLSON DRILLING.



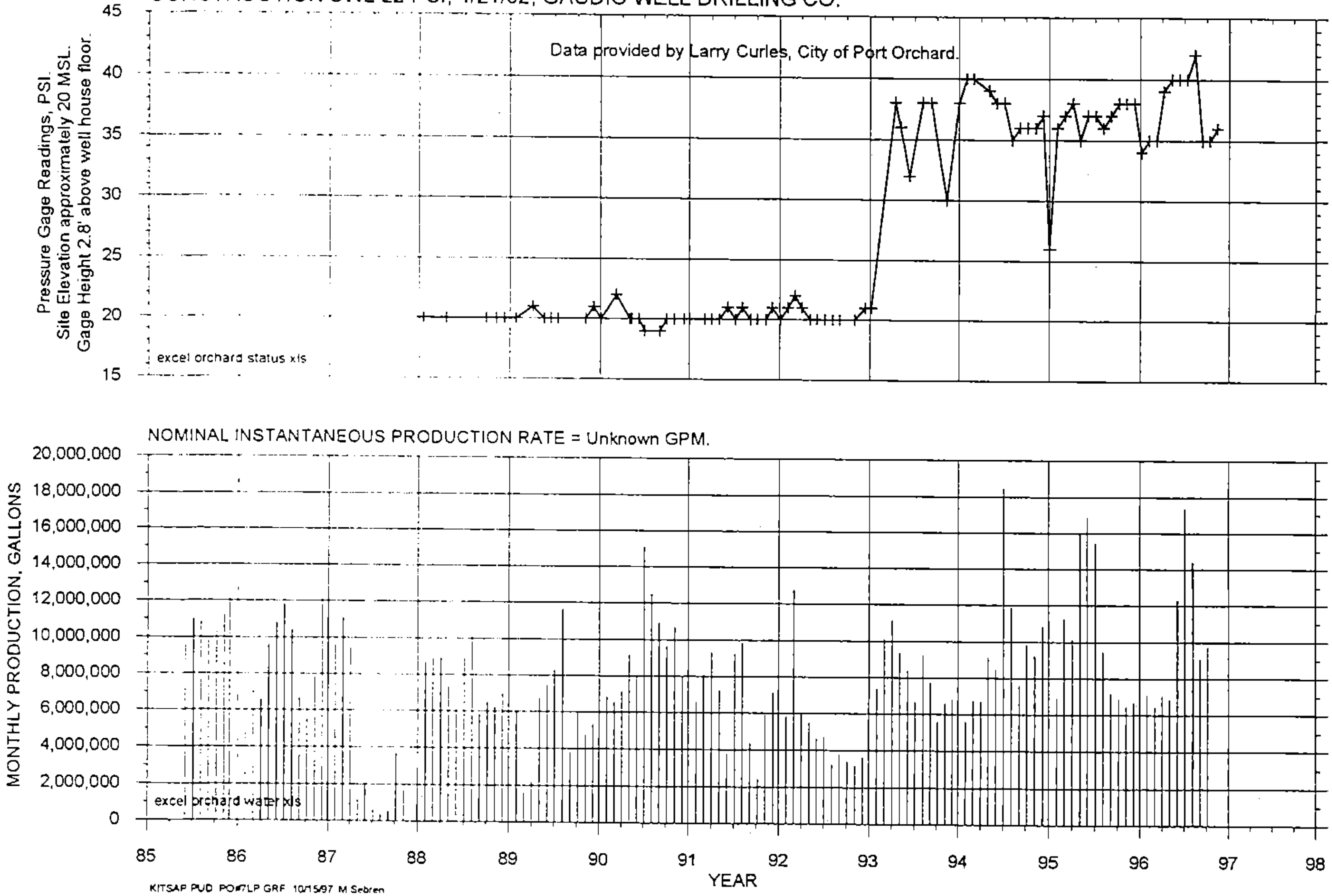
KITSAP PUD AAC824 GRF. 10/15/97 M. Sebren

HYDROGRAPH OF SALMONBERRY MONITOR WELL (ABV298)
AT ANNAPOLIS WATER DISTRICT SALMONBERRY WELL FIELD. T23N/R01E-1K.
DATA COLLECTED WITH GS-93 DATA LOGGER AND SPOT MEASUREMENTS INDICATED BY ASTERIS.
COMPLETION ELEVATION -530' TO -540' MSL.
SWL AT CONSTRUCTION TEST = 241.47' BELOW MP (101.13' MSL), 5/31/95, AGI, INC.

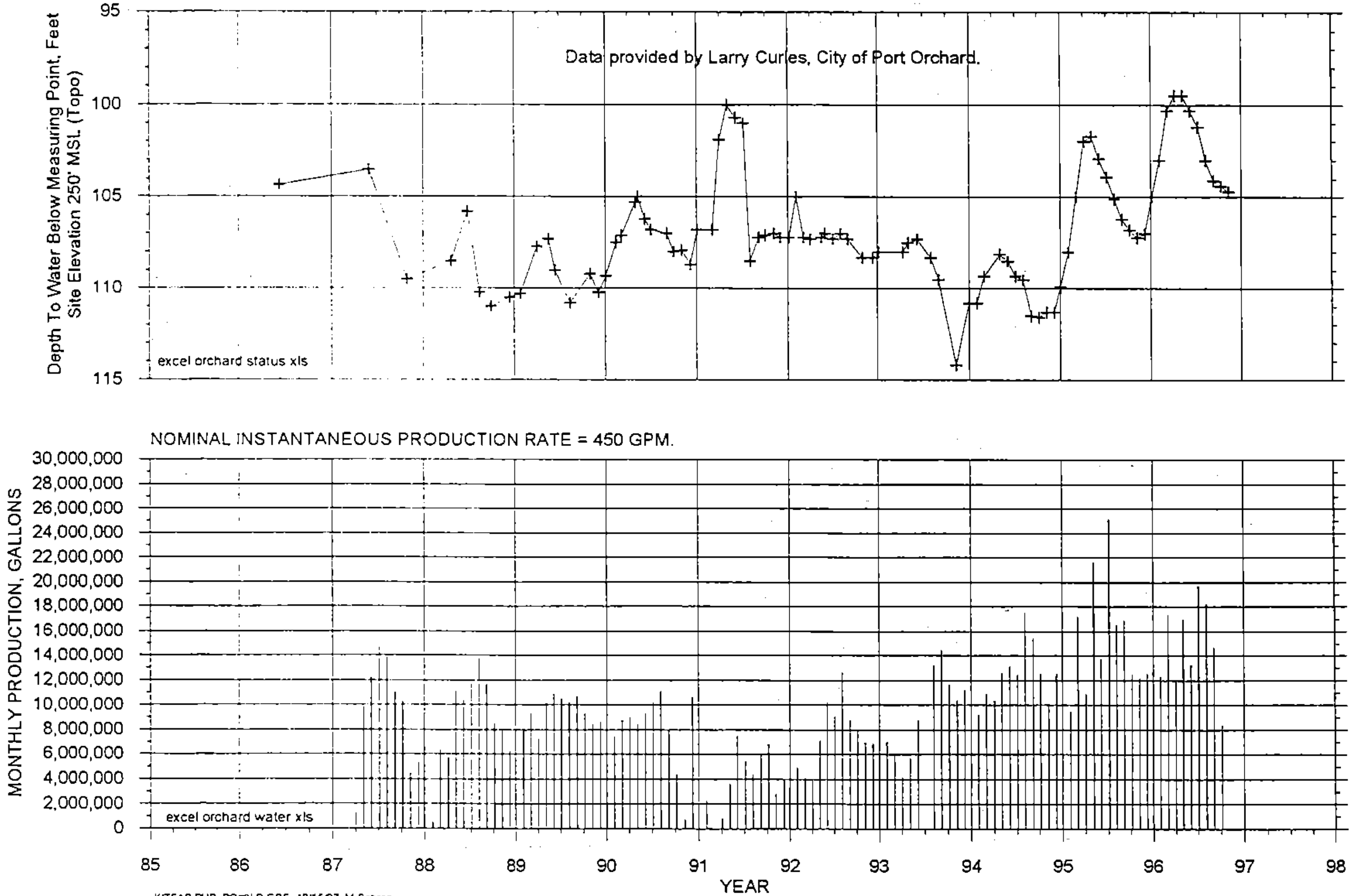



HYDROGRAPH OF PORT ORCHARD WELL 6 (473227122373701)
T24N/R01E-25E. WELL LOG AND COMPLETION UNCERTAIN.
Pressure Gage Readings, PSI
Site Elevation Estimated, 20 ft MSL
10
8
6
4
2
0
Data provided by Larry Curles, City of Port Orchard.
excel orchard status xls
NOMINAL INSTANTANEOUS PRODUCTION RATE = Unknown GPM.
MONTHLY PRODUCTION, GALLONS
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
excel orchard water xls
85
86
87
88
89
90
91
92
93
94
95
96
97
98
YEAR
KITSAP PUD PO#6LP GRF, 10/15/97 M Sebren

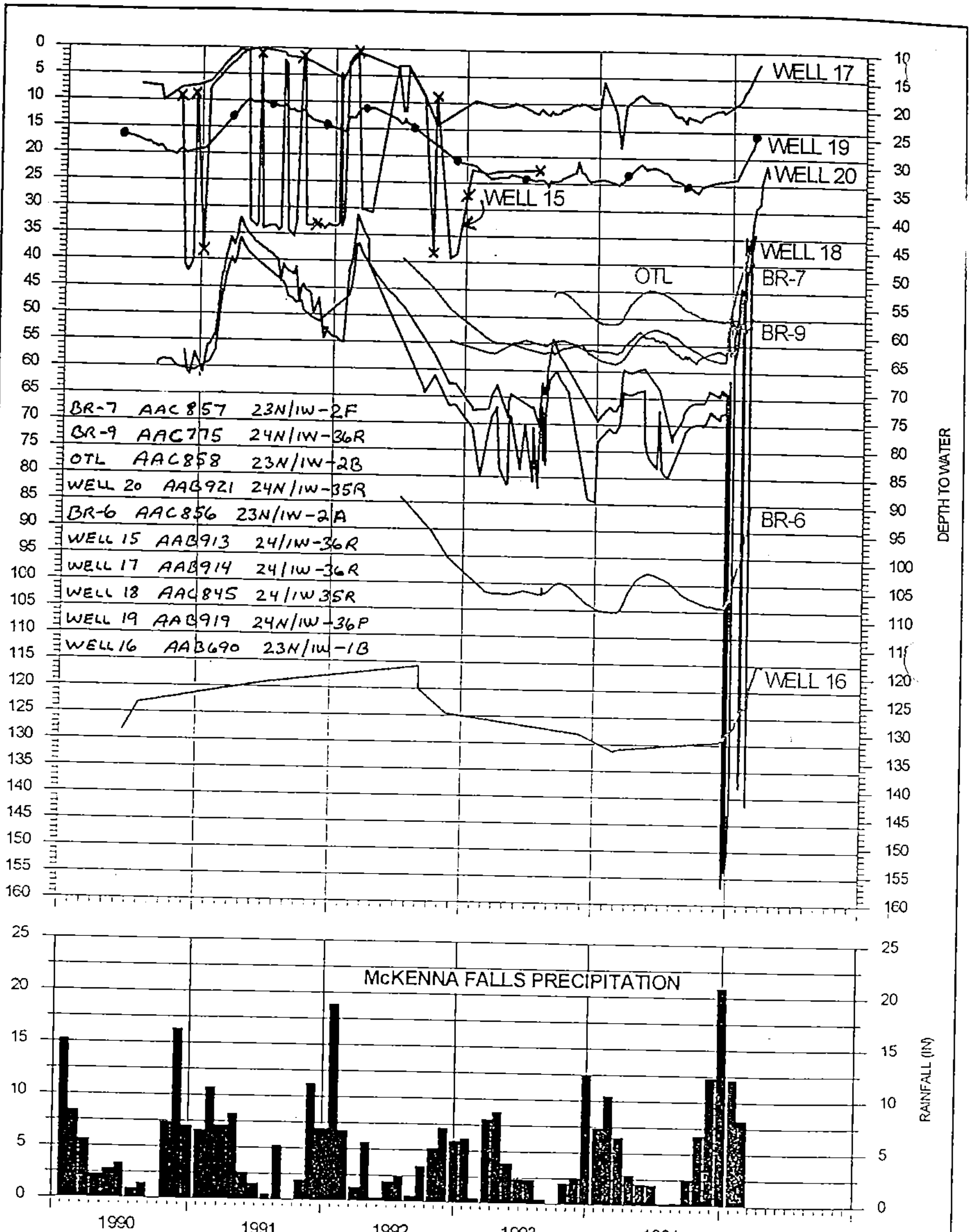
HYDROGRAPH OF CITY OF PORT ORCHARD WELL 7 (473223122382201).
T24N/R01E-26K. COMPLETION ELEVATION APPROXIMATELY -759 TO -794 FT MSL.
CONSTRUCTION SWL 22 PSI, 4/21/62, GAUDIO WELL DRILLING CO.



HYDROGRAPH OF CITY OF PORT ORCHARD WELL 8 (NO UNIQUE ID NUMBER)
T23N/R01E-2M. COMPLETION ELEVATION APPROXIMATELY -180 TO -252 FT MSL.
CONSTUCTION SWL APPROXIMATELY 148' MSL, 6/12/86, RAMLO WELL DRILLING WITH CARR / ASSOCIATES.



KITSAP PUD PO#8LP GRF 10/15/97 M Sebren

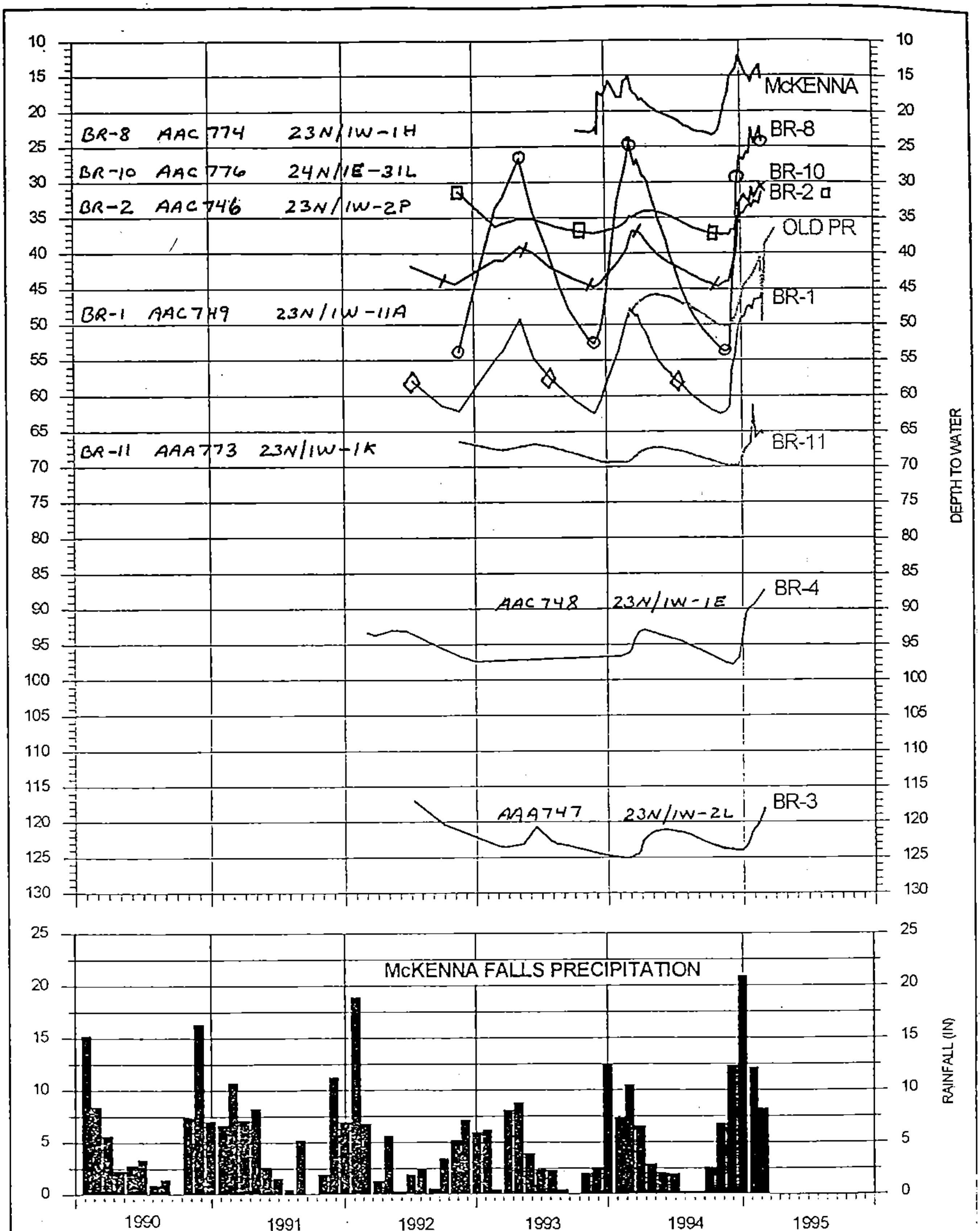


AGI TECHNOLOGIES

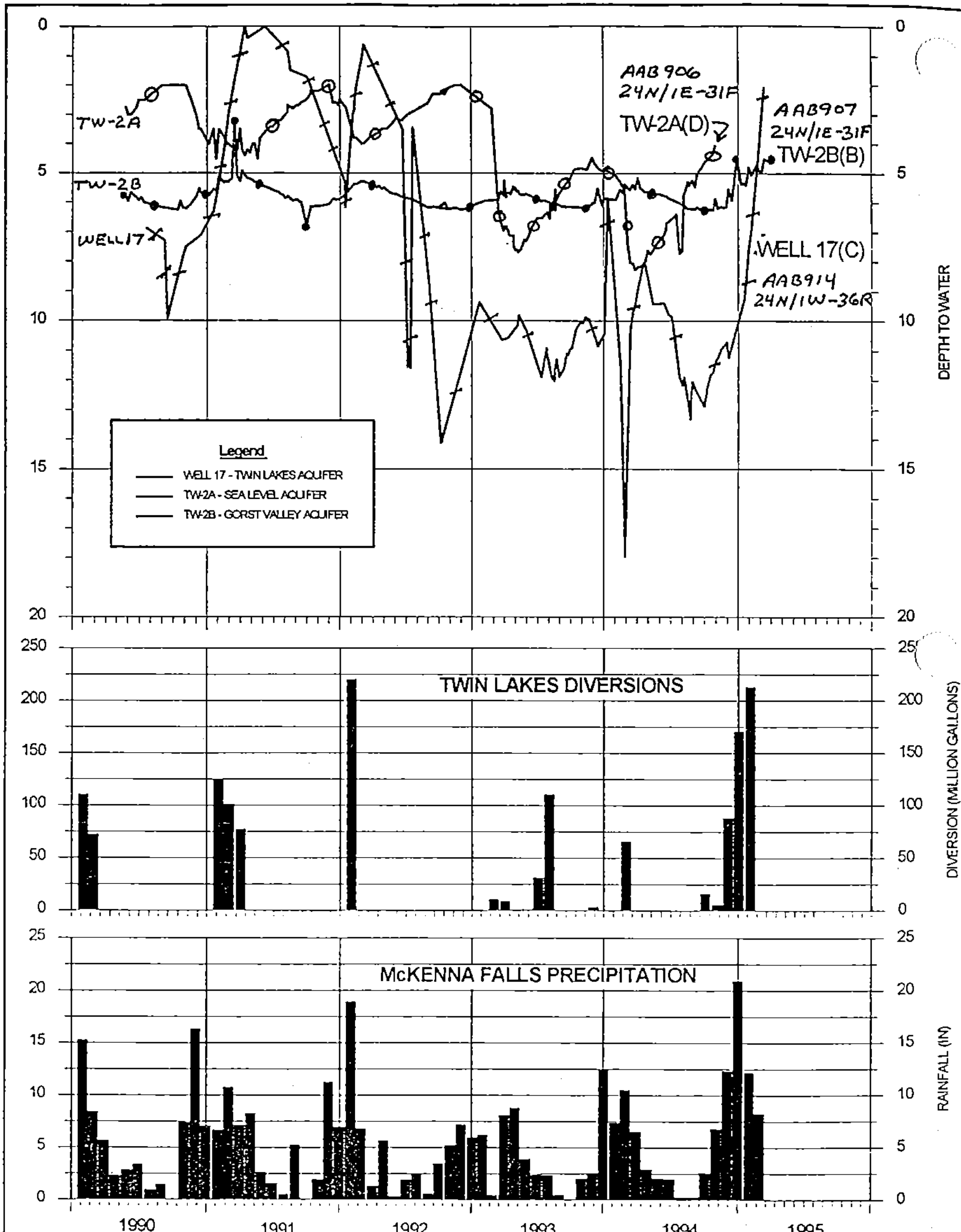
Gorst Creek Basin Study
City of Bremerton
Proj. No. 15,842.001

Pattern "C" Hydrographs
Twin Lakes Aquifer

Figure 4.8

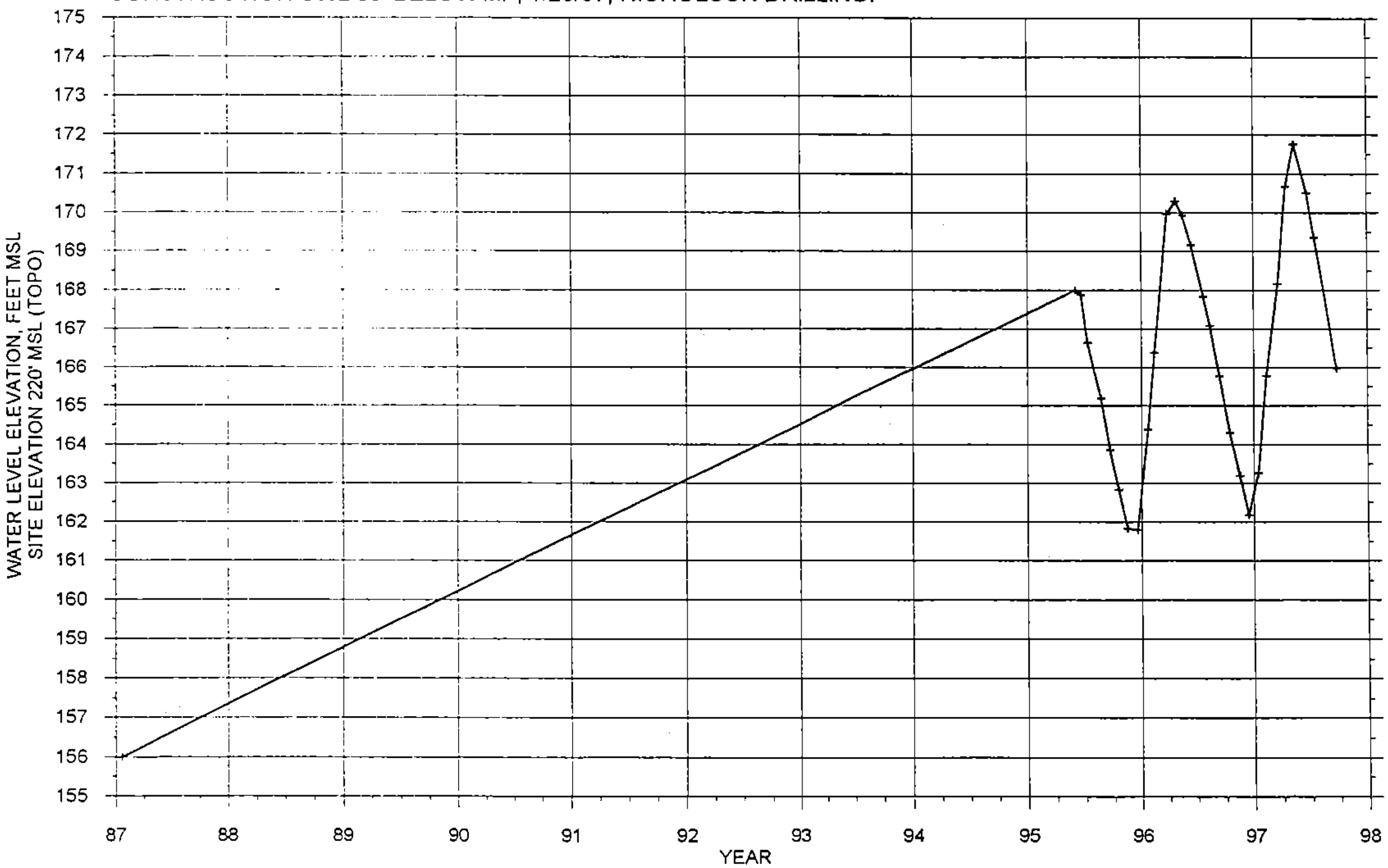


AGI TECHNOLOGIES	Gorst Creek Basin Study City of Bremerton Proj. No. 15,842.001	Pattern "A" Hydrographs Twin Lakes Aquifer	Figure 4.6



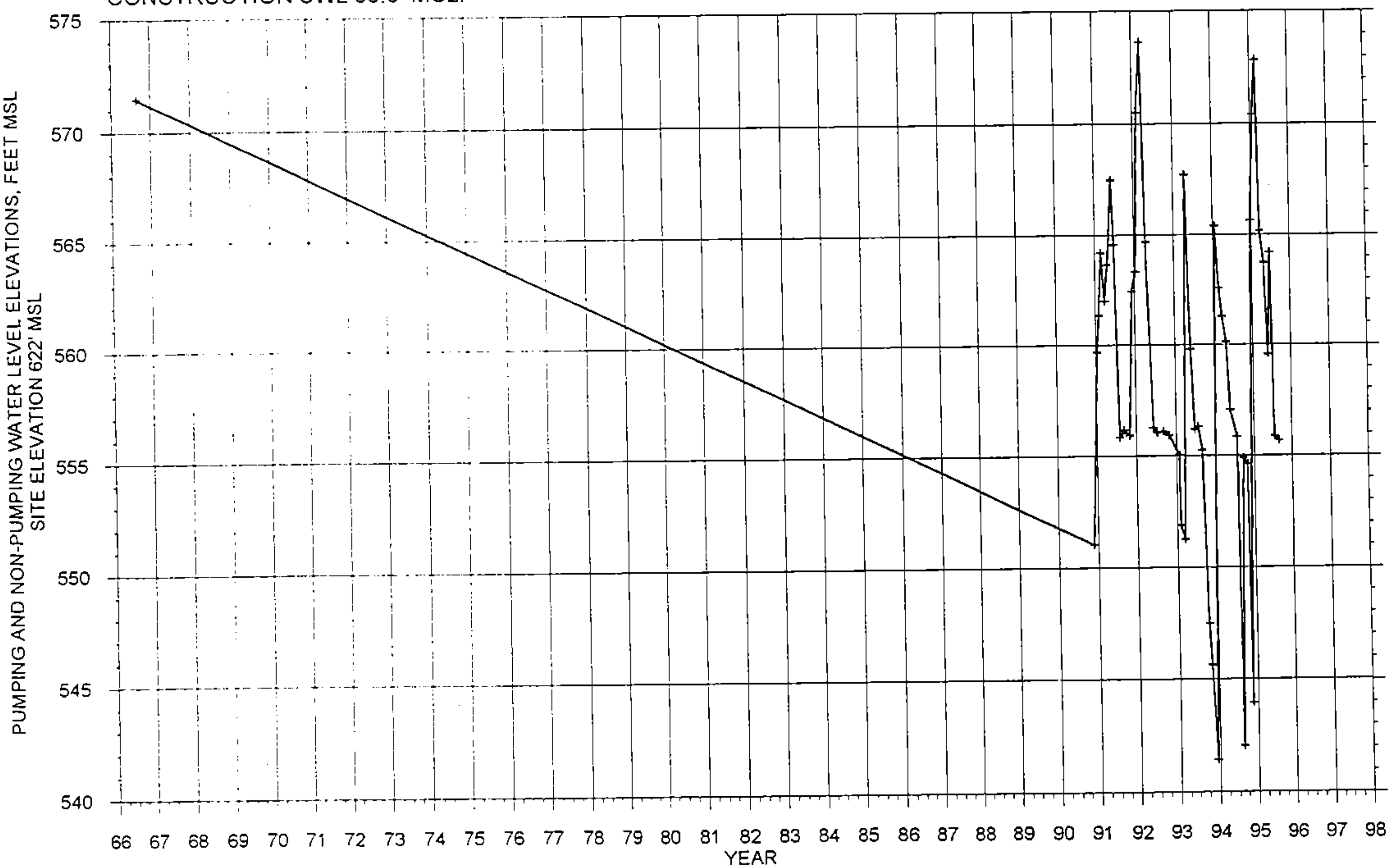
AGI TECHNOLOGIES	Gorst Creek Basin Study City of Bremerton Proj. No. 15,842.001	Comparison of Patterns "B", "C", and "D"	FIGURE 4.9

HYDROGRAPH OF UNION RIVER ACRES WELL (AAC839).
T23N/R01W-2M. COMPLETION ELEVATION 61 TO 80' MSL.
CONSTRUCTION SWL 65' BELOW MP, 1/20/87, NICHOLSON DRILLING.



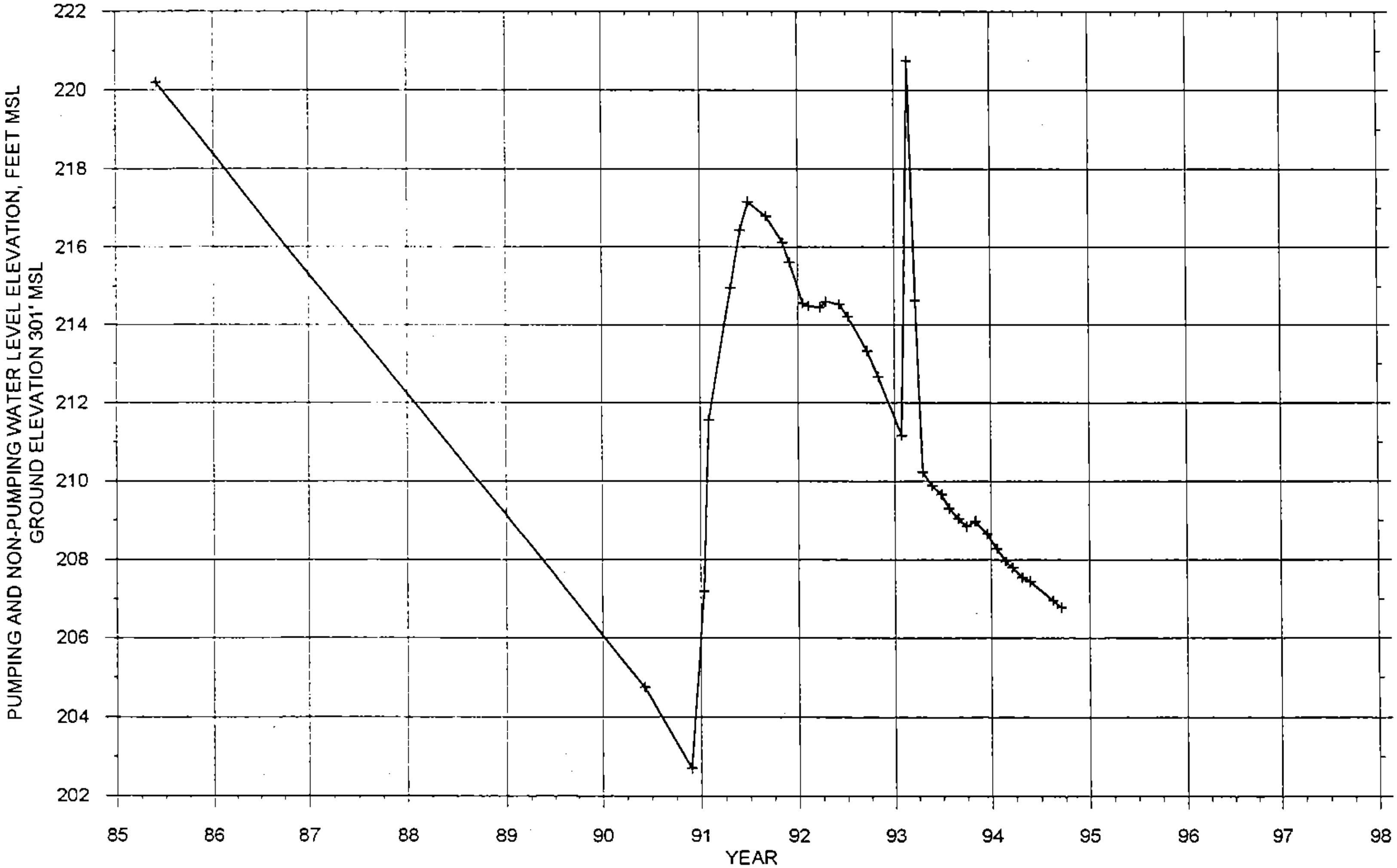
KITSAP PUD AAC839 GRF, 10/15/97 M. Sebren

HYDROGRAPH OF TAHUYA WELL 2 (AAA115).
T24N/01W-19A. COMPLETION ELEVATION 536 TO 558' MSL.
CONSTRUCTION SWL 53.5' MSL.



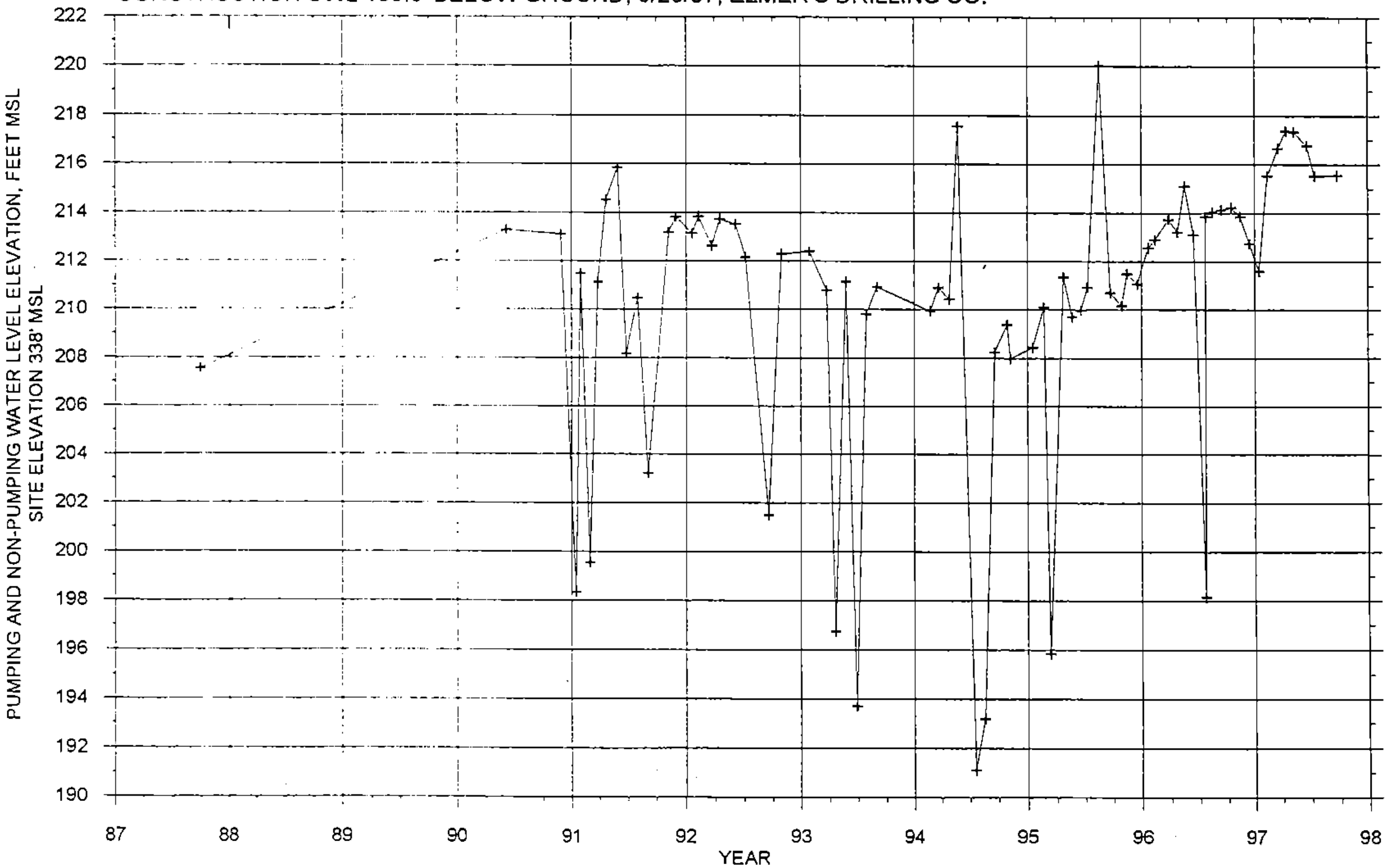
KITSAP PUD AAA115 GRF 10/15/97 M Sebren

HYDROGRAPH OF HARBOR WATER CO. PACIFIC VENTURES WELL (AAA228).
T22N/R02E-7C. COMPLETION ELEVATION 163 TO 179' MSL.
CONSTRUCTION SWL 220' MSL, 6/1/85, HICKS WELL DRILLING.



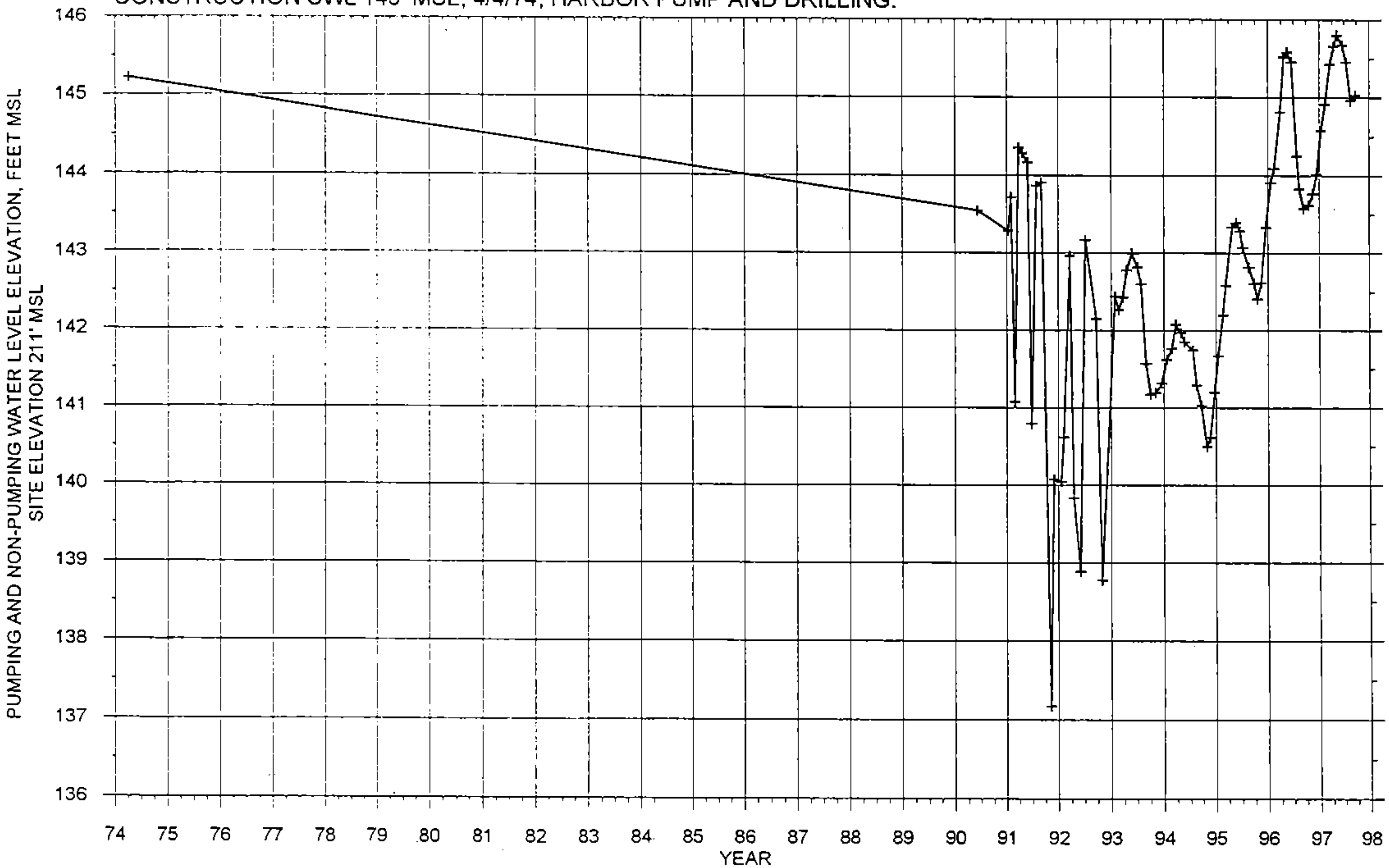
KITSAP PUD AAA228-2.GRF 10/15/97 M. Sebren

HYDROGRAPH OF HARBOR WATER CO. ALPINEWOOD NO. WELL 2 (AAA227).
T22N/RO2E-8R. COMPLETION ELEVATION 140 TO 150' MSL.
CONSTRUCTION SWL 130.5' BELOW GROUND, 9/28/87, ELMER'S DRILLING CO.



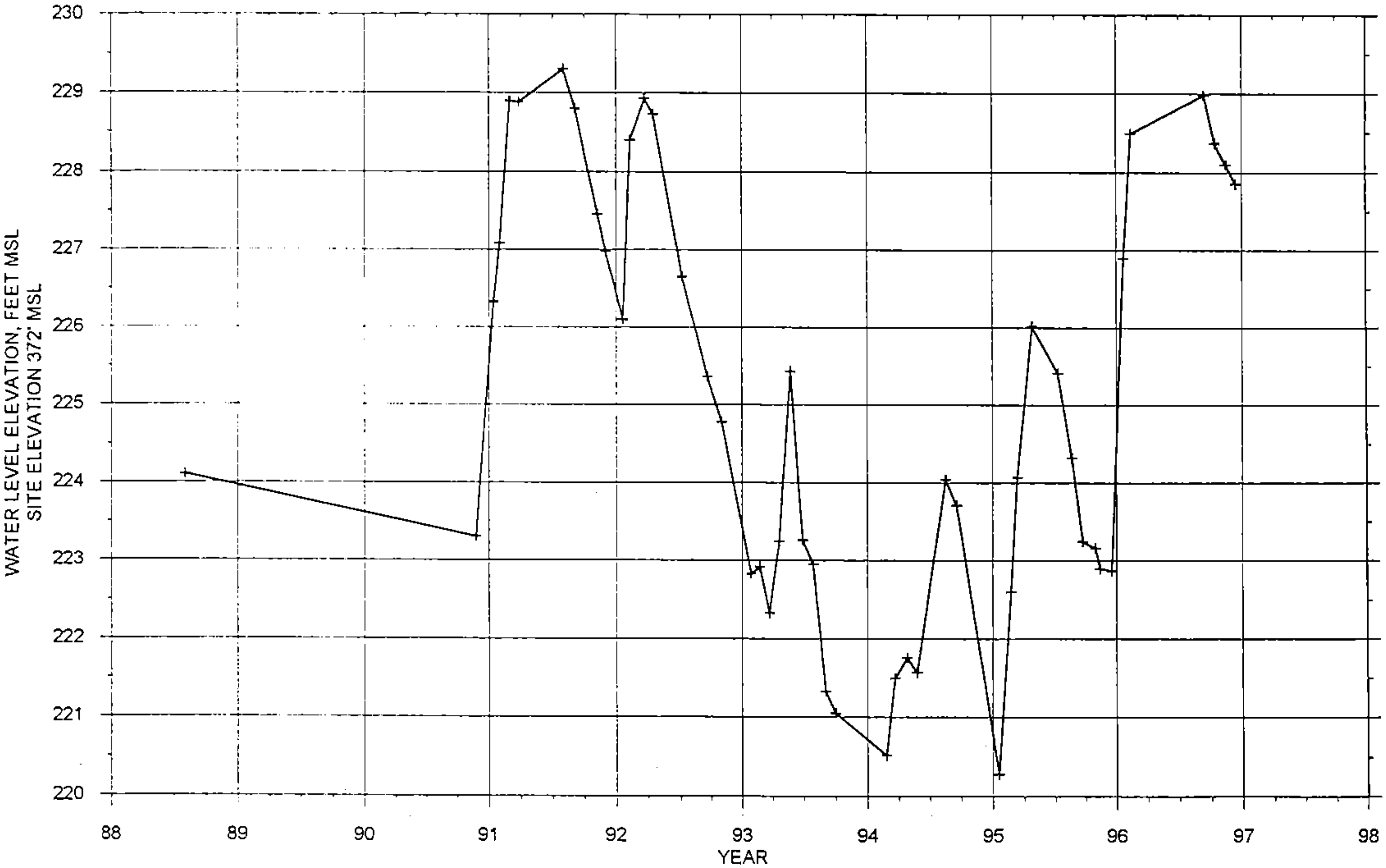
KITSAP PUD AAA227-2.GRF 10/15/97 M. Sebren

HYDROGRAPH OF HARBOR WATER CO. WOODLAND RANCE WELL 4 (AAA236).
T23N/R01E-35G. COMPLETION ELEVATION -316 TO -329' MSL.
CONSTRUCTION SWL 145' MSL, 4/4/74, HARBOR PUMP AND DRILLING.



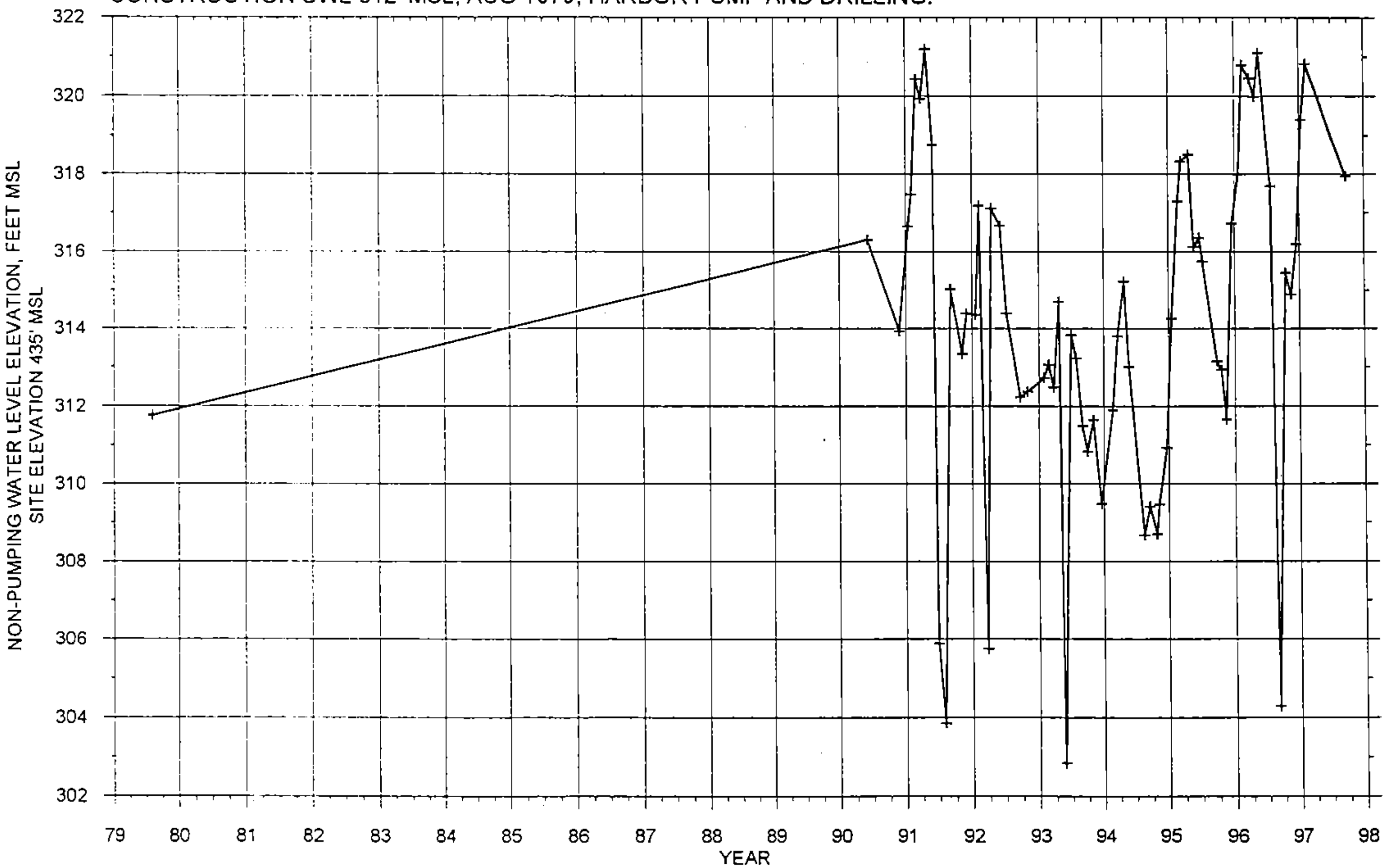
KITSAP PUD AAA236-2 GRF, 10/15/97 M Sebren

HYDROGRAPH OF HARBOR WATER CO. SPRUCE RD WELL 2 (AAA229).
T22N/R01E-10C. COMPLETION ELEVATION 94' TO 84' MSL.
CONSTRUCTION SWL 224' MSL, 8/1/88, HOLLAND PUMP CO. INC.



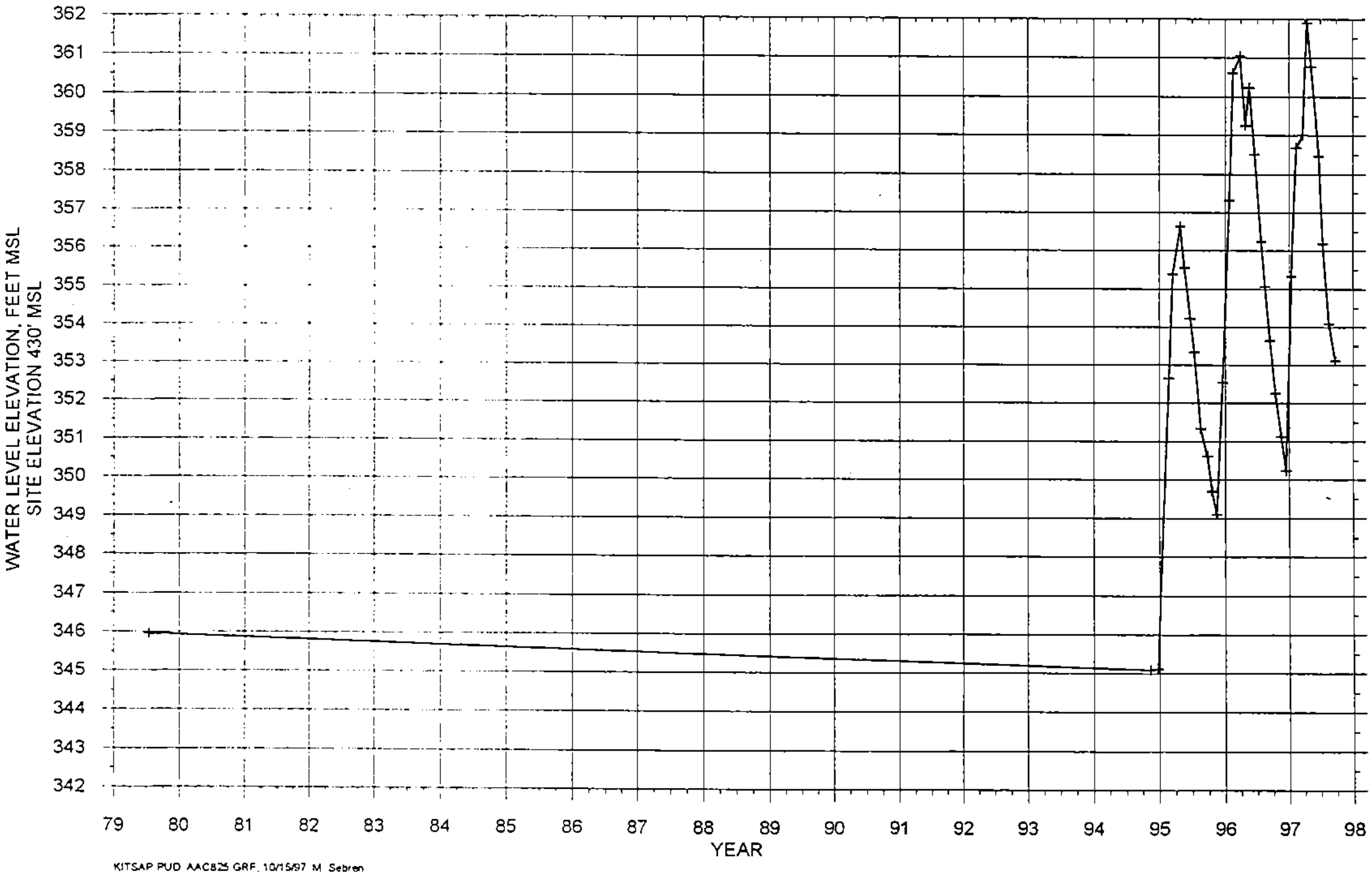
KITSAP PUD AAA229-2 GRF, 10/15/97 M. Sebren

HYDROGRAPH OF HARBOR WATER CO. WICKS LAKE WELL 2 (AAA230).
T23N/R01E-31H. COMPLETION ELEVATION 247 TO 263' MSL.
CONSTRUCTION SWL 312' MSL, AUG 1979, HARBOR PUMP AND DRILLING.

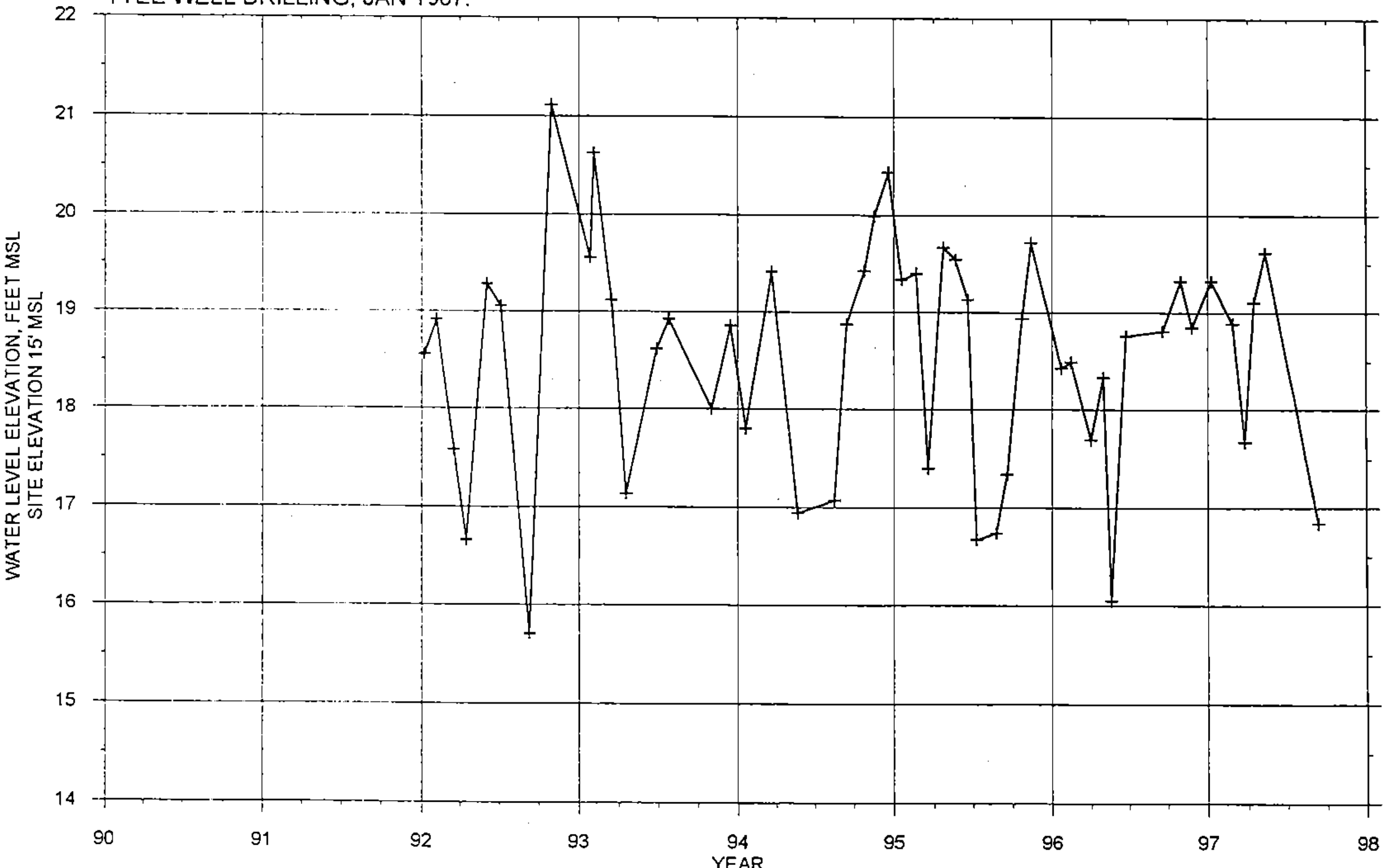


KITSAP PUD AAA230-2.GRF, 10/15/97 M. Sebren

HYDROGRAPH OF CHRISTIAN LITGHTHOUSE WELL (AAC825).
T23N/R01E-34B. COMPLETION ELEVATION 295 TO 300' MSL.
CONSTRUCTION SWL ABOUT 345' MSL, 7/17/79, NICHOLSON DRILLING.

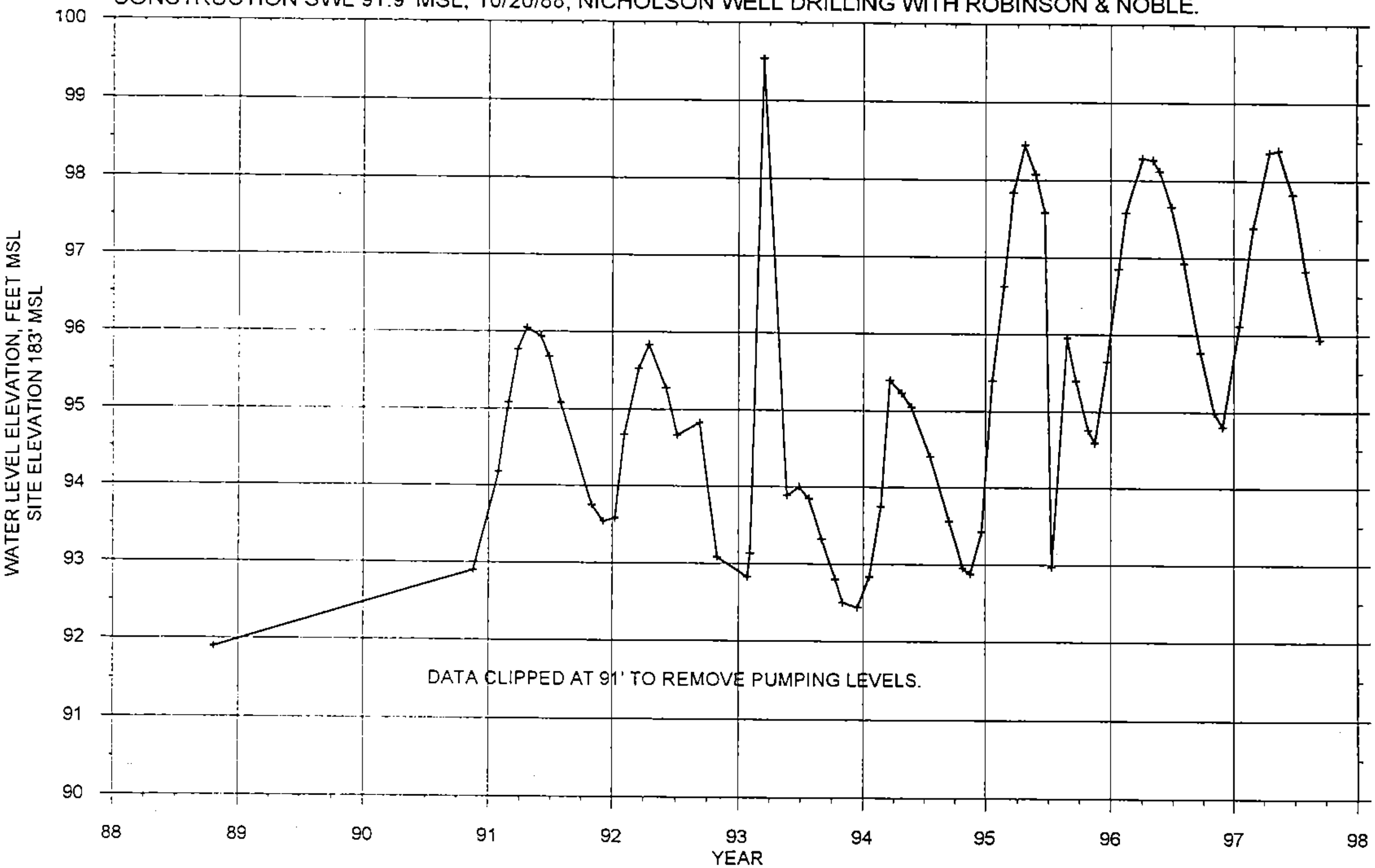


HYDROGRAPH OF HOLY WATER SYSTEM WELL #1 (AAA007).
T24N/02W-19G. COMPLETION ELEVATION -139' TO -142' MSL.
WELL FLOW AT CONSTRUCTION, SHUT-IN HEAD UNKNOWN.
TYEE WELL DRILLING, JAN 1967.



KITSAP PUD AAA007 GRF, 12/18/96 M Sebren

HYDROGRAPH OF HOLY WATER SYSTEM WELL #2 (AAA008).
T24N/R02W-19K. COMPLETION ELEVATION 46 TO 57' MSL.
CONSTRUCTION SWL 91.9' MSL, 10/20/88, NICHOLSON WELL DRILLING WITH ROBINSON & NOBLE.



KITSAP PUD AAA008.GRF, 10/15/97 M. Sebren

Appendix I
Kitsap County Water Balance

Appendix I
Water Balance

A water balance is an assessment of the major components of a hydrologic system and includes the interactions between surface water and ground water systems. A water balance assessment provides a general understanding of the magnitude of the recharge and discharge components. It does not provide an accurate assessment of surface water/ground water interactions and quantities, and should not be relied on as the sole tool for ground water management.

The components of a simplified water balance equation can be expressed as:

Precipitation=Evapotranspiration+Stormwater Runoff+Recharge

Kitsap County's water balance component estimates are:

Precipitation (rainfall) varies dramatically from less than 30 inches a year in the north portions of the County to more than 70 inches a year in the southwest with a long term county average of 48 inches a year. An evaluation of newly collected precipitation data in combination with existing long-term data, resulted in an estimate of 316 billion gallons of average annual rainfall. Rainfall either is evaporated, absorbed (and transpired) by plants, recharged to ground water, or diverted to stormwater runoff which moves to sea through storm drains, streams, or rivers.

Evapotranspiration (ET) is water that is returned to the atmosphere. It consists of the moisture that is transpired by plants and evaporated from hard surfaces and from surface water bodies. Evaluations conducted as part of the Initial Basin Assessment project estimate ET to be between 14 inches and 19 inches of rainfall. This equates to approximately 113 billion gallons of rainfall evaporating or being absorbed and transpired via vegetation in the County on an annual basis.

Runoff (storm water runoff) is the water that collects on the land surface or shallow subsurface and flows quickly to the streams, rivers, and other drainage systems. In Kitsap County, runoff quickly ends up in Puget Sound or Hood Canal and is lost for beneficial use. An accurate estimate of total annual stormwater runoff in Kitsap County is not available. However, studies in other areas of Puget Sound, estimate the total storm water run-off is between 15 percent and 25 percent of rainfall, which equates to an average annual volume of between 47 and 79 billion gallons. For this analysis 63 billion gallons is used.

Recharge is the portion of precipitation that is infiltrated into the ground past the root zone. Recharge percolates down through the soil until it reaches the water table or an impermeable surface. The estimated 140 billion gallons of remaining rainfall percolates beneath the root zone (recharges).

Some of the water that recharges will resurface through springs and seeps forming the base flow for streams and rivers. Estimates of total base flow for streams and rivers in the County have not been completed.

Diversion of surface water for beneficial use in Kitsap County is not extensive. The only major diversion is the City of Bremerton's Casad Dam which provides 1.8 billion gallons of water per year out of a total surface water use of approximately 2.4 billion gallons per year. Total surface water rights and claims in the County amount to 3.3 billion gallons of water per year.

Over 15,000 wells extract ground water for various uses. Annual extraction of ground water in the County is estimated at 9.8 billion gallons per year. Ground water rights and claims for the County total 25.4 billion gallons per year. Total water usage in 1995 is estimated to be approximately 12.2 billion gallons.

Some of the ground water that is extracted (as well as diverted surface water) is returned to the subsurface by irrigation and septic systems. Large quantities are processed through sewage treatment plants and discharged to sea. Total sewage treatment plant discharge is estimated to be over 4.8 billion gallons per year.

The remaining recharge flows to Puget Sound and the Hood Canal where it emerges underwater through submarine springs. The total amount of flow via this path has not been determined.

The amount of recharge is directly affected by the amount of stormwater runoff and evapotranspiration. If stormwater runoff is a large component of the water balance, less water will be available for recharging ground water supplies.

The water balance of an aquifer system is not a fixed condition. It will change seasonally and from year to year. All the components of the water balance can deviate dramatically over time from natural and/or human activities. Exhibit I-1 summarizes the estimates of water balance components for Kitsap County.

Exhibit I-1
Conceptual Hydrologic Cycle for Kitsap County

Precipitation (PPT)

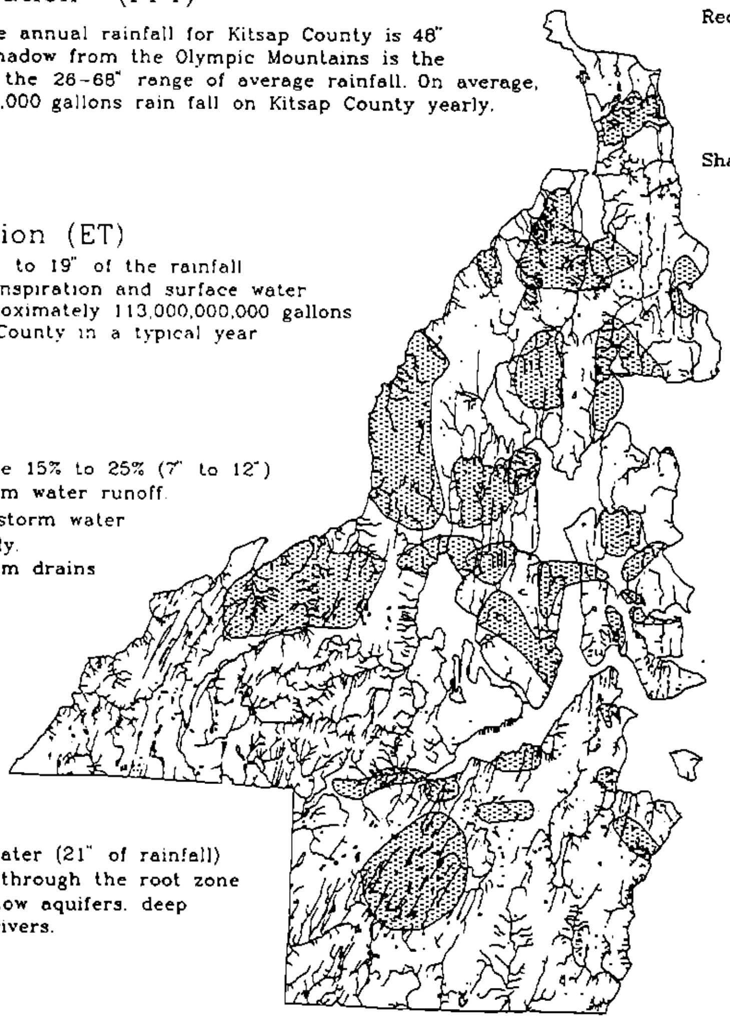
The average annual rainfall for Kitsap County is 48" The rain shadow from the Olympic Mountains is the reason for the 26-68" range of average rainfall. On average, 316,000,000,000 gallons rain fall on Kitsap County yearly.

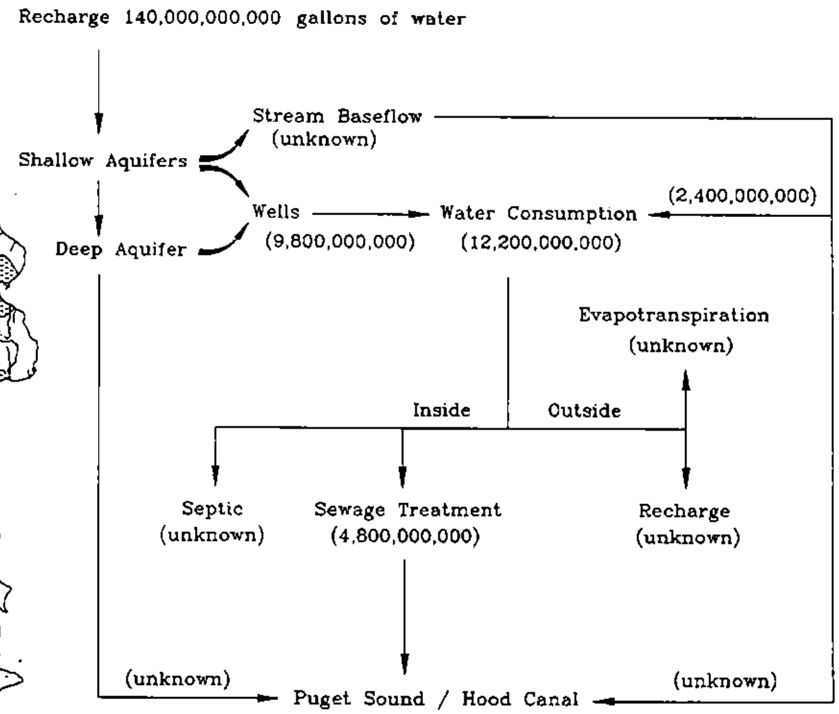
Evapotranspiration (ET)

The range of ET is 14" to 19" of the rainfall Between vegetation transpiration and surface water body evaporation, approximately 113,000,000,000 gallons of water leave Kitsap County in a typical year

Storm Water Runoff

Studies in the Puget Sound Area indicate 15% to 25% (7" to 12") of rainfall passes quickly to sea as storm water runoff. Approximately 63,000,000,000 gallons of storm water runs off the County's land mass annually. The split in storm water runoff via storm drains verses streams is <u>unknown</u>.





Recharge

Approximately 140,000,000,000 gallons of water (21" of rainfall) annually inflitrates in the soil and passes through the root zone This provides the source of water for shallow aquifers, deep aquifers, and base flows for streams and rivers.

Water Consumption

1995 Consumption is estimated at 12,200,000,000 gallons
2020 Consumption is projected at 15,000,000,000 gallons

Appendix J
Kitsap County Hazardous Waste Sites

WASHINGTON STATE DEPARTMENT OF ECOLOGY

DEPARTMENT OF ECOLOGY, TOXICS CLEANUP PROGRAM
SITE INFORMATION SYSTEM
LEGEND FOR: CONFIRMED & SUSPECTED CONTAMINATED SITES REPORT

Revised November 7, 1994

THIS REPORT IS SUBJECT TO REVISION

Within 90 days of learning of a potentially contaminated site, the Department of Ecology conducts an initial investigation of each site. If the initial investigation shows that further action is needed, the site will appear in the *Confirmed & Suspected Contaminated Sites (C&SCS) Report*. Once remedial action has been completed, the Toxics Cleanup Program's management determines the removal of a site from the *C&SCS Report*.

The *Hazardous Sites List* is a subset of the *C&SCS Report*. It contains those sites that have been ranked using the Washington Ranking Method.

PLEASE NOTE:
1. Site owners and operators do not necessarily agree with Ecology's determination of site status.
2. Ecology will update the site list continually as new information becomes available.

REPORT ORGANIZATION: The information in this report is sorted by county. Within each county, the data are sorted by site name.

SITE STAT CODE = ECOLOGY SITE STATUS: Indicates the current status of sites relative to the MTCA cleanup process. Code choices are:

1 = Awaiting Site Hazard Assessment (SHA)
2 = Ranked, Awaiting Remedial Action (RA)
3 = Remedial Action in progress
4 = Independent Remedial Action
5 = Construction Completed, Operation & Maintenance Underway
6 = RA Completed, Confirmational Monitoring Underway
7 = RA Conducted, residual contamination left on site; on-going institutional controls required
8 = RA and all activities completed (no monitoring)

IND SITE STAT = INDEPENDENT SITE STATUS: This column only applies to those sites undergoing an independent cleanup. Code choices are:

1 = Release report received, awaiting assessment by PLP (PLP = Potentially Liable Person)
2 = Independent Site Assessment or Interim RA Report received
3 = Final Independent RA Report received

WARM BIN#: Indicates the outcome of the WAshington Ranking Model (WARM). The WARM BIN Number will be a number between 1 and 5. A result of 1 indicates the greatest assessed risk to human health and to the environment. A result of 5 indicates the lowest assessed risk. A zero indicates that the site is either on the federal National Priorities List (NPL) or a sub-site or operable unit of an NPL site. NPL sites are ranked under the federal Hazard Ranking System (HRS).

AFFECTED MEDIA: For each site, there may be contaminant information for up to six environmental media: Groundwater, surface water, air, soil, sediments or drinking water.

The media status column and the numbered contaminant type columns may be coded:

C (Confirmed) - The presence of hazardous substances has been confirmed by laboratory analysis (or field determination in the case of petroleum contamination).

S (Suspected) - Due to preliminary investigations or the nature of business operations or manufacturing processes, certain contaminants are suspected to be present at the site.

R (Remediated) - Contaminants have been treated or removed to meet cleanup levels established for the site. (This status determination may only be made by Ecology.)

CONTAMINANT GROUPS--DEFINITIONS AND EXAMPLES:

NUMBERS 1 THROUGH 17 CORRESPOND TO THE CONTAMINANT NUMBERS ON THE ATTACHED REPORT.

1. **Base/Neutral/Acid Organics:** Hazardous substances typically included in the Base/Neutral/Acid fraction of EPA's priority pollutant compound list. Examples are: Acenaphthene; Hexachlorobenzene; Fluoranthene; 2,4-dinitro-toluene; Isophorone.

2. **Halogenated Organic Compounds:** Organic compounds, typically solvents, with one or more of the halogens (e.g., Chlorine, Bromine, Fluorine) incorporated into their structure. Examples are: Carbon Tetrachloride; Chloroform; Vinyl Acetate; 1,1,2,2-tetrachloroethane; freons.

3. **EPA Priority Pollutants - Metals and Cyanide:** Metals included in EPA's priority pollutant compounds list. Examples are: Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Cyanide, Lead, Mercury, Nickel, Selenium, Silver, Thallium and Zinc.

4. Metals - Other: Other non-priority pollutant metals. Examples are: Aluminum, Barium, Cobalt, Iron, Manganese and Tin.

5. Polychlorinated biPhenyls (PCBs): A specific "family" of aromatic chlorinated organic compounds, often referred to as "AROCLOR." Common types are: AROCLOR-1016, AROCLOR-1221, AROCLOR-1260.

6. Pesticides: Chemical agents used to control pests such as: fungicides, herbicides and insecticides. Examples are: Aldrin, Chlordane, Endrin, Diazinon, Folex, Malathion.

7. Petroleum Products: Crude oil and any fraction thereof. Each of these materials may consist of many specific chemical compounds. Examples are: Gasoline, diesel fuel, mineral oil.

8. Phenolic Compounds: Hazardous substances typically included in the acid extractable fraction of EPA's priority pollutant compound list. Examples are: 2,4,6-trichloro-phenol; Phenol; Cresols; Pentachlorophenol; Benzoic Acid.

9. Non-Halogenated Solvents: Organic solvents, typically volatile or semi-volatile, not containing any halogens. Examples are: Acrolein; Benzene; Toluene; Acetone; 4-Methyl-2-pentanone.

10. Dioxin: A family of more than 70 compounds of chlorinated dioxins. Examples: 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD); P-dioxin; Hexachlorodibenzo-p-dioxin; Polychlorinated dibenzo-para-dioxin (PCDD).

11. Polynuclear Aromatic Hydrocarbons (PAH): Hydrocarbons composed of two or more benzene rings. Examples are: Benzo-Fluoranthene; Chrysene; Anthracene; Acenapthene.

12. Reactive Wastes: Wastes that react violently upon contact with other substances (especially air or water) as defined by the Dangerous Waste Regulation (WAC 173-303-090(7)). They explode easily or are otherwise unstable. Examples: Peroxides; Metallic Sodium.

13. **Corrosive Wastes:** Wastes that are highly corrosive as defined by the Dangerous Waste Regulation (WAC 173-303-090(6)). Substances with very high (base) or very low (acid) pH. Examples: Nitric Acid, Sodium Hydroxide.

14. **Radioactive Wastes:** Wastes that emit more than background levels of radiation. Examples are: High and low level nuclear wastes; mixed nuclear wastes; Uranium mine tailings.

15. **Conventional Contaminants, Organic:** Unspecified organic matter that imposes an oxygen demand during its decomposition. This is reflected by elevated Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and/or Total Organic Carbon (TOC). Typically a component of municipal solid waste leachates, sewage, septage, food wastes, wood waste leachate and similar organic wastes.

16. **Conventional Contaminants, Inorganic:** Non-metallic inorganic substances or indicator parameters that may indicate the existence of contamination if present at unusual levels. Examples are: Chloride, Sulfur compounds, Nitrogen compounds, pH, conductivity, hardness and alkalinity.

17. **Asbestos:** All forms of Asbestos. Asbestos fibers have been used in products such as building materials, friction products, and heat-resistant materials.

Confirmed and Suspe[illegible] Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KITSAP	BAINBRIDGE ISLAND LANDFILL	VINCENT RD		3	2	1																			
		BAINBRIDGE	98110																						
							Groundwater	S			S				S	S									
							Soil	C			C				C	C	C		C				C	C	
							Surface Water	S	S	S						S	S		S				S	S	
	BAINBRIDGE MARINE SERVICES Inc	EAGLE HARBOR		1																					
		WINSLOW	98110																						
							Air	C			S	S			S		S								
							Groundwater	S			S	S			S		S								
							Sediment	S			S	S			S		S								
							Soil	C			C	C			S		S								
							Surface Water	S			S	S			S		S								
	BATTLE POINT PARK	11299 NE ARROW POINT DR		1																					
		BAINBRIDGE ISLAND	98110																						
							Drinking Water	S							S		S								
							Groundwater	S							S		S								
							Soil	C							C		S								
	BATTLE POINT SITE	VENICE LOOP RD & KIRK ST		1																					
		BAINBRIDGE ISLAND	98110																						
							Air	S	S	S	S		S		S	S			S						
							Groundwater	S	S	S	S		S		S	S			S						
							Sediment	S	S	S	S		S		S	S			S						
							Soil	C	S	S	S		S		C	S			S						
							Surface Water	S	S	S	S		S		S	S			S						
	BETHEL/FORMER TEXACO	BETHEL RD SE & S SEDGWICK RD		3		3																			
		PORT ORCHARD	98366																						
							Drinking Water	C							C										
							Groundwater	C							C										
							Soil	C							C										
	BREM-AIR Dspl	512 SHELDON BLVD		3		1																			
		BREMERTON	98310																						
							Air	S			S				S										
							Groundwater	C			C				C		C								
							Sediment	C			C				C		C								
							Soil	C			C				C		C								
							Surface Water	S			S				S		S								

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

Confirmed and Suspe[illegible] Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KITSAP	BAINBRIDGE ISLAND LANDFILL	VINCENT RD BAINBRIDGE	98110	3	2	1	Groundwater	S			S				S	S									
							Soil	C			C				C	C	C		C				C	C	
							Surface Water	S	S	S						S	S		S				S	S	
	BAINBRIDGE MARINE SERVICES Inc	EAGLE HARBOR WINSLOW	98110	1			Air	C			S	S			S		S								
							Groundwater	S			S	S			S		S								
							Sediment	S			S	S			S		S								
							Soil	C			C	C			S		S								
							Surface Water	S			S	S			S		S								
	BATTLE POINT PARK	11299 NE ARROW POINT DR BAINBRIDGE ISLAND	98110	1			Drinking Water	S							S		S								
							Groundwater	S							S		S								
							Soil	C							C		S								
	BATTLE POINT SITE	VENICE LOOP RD & KIRK ST BAINBRIDGE ISLAND	98110	1			Air	S	S	S	S		S		S	S			S						
							Groundwater	S	S	S	S		S		S	S			S						
							Sediment	S	S	S	S		S		S	S			S						
							Soil	C	S	S	S		S		C	S			S						
							Surface Water	S	S	S	S		S		S	S			S						
	BETHEL/FORMER TEXACO	BETHEL RD SE & S SEDGWICK RD PORT ORCHARD	98366	3		3	Drinking Water	C							C										
							Groundwater	C							C										
							Soil	C							C										
	BREM-AIR Dspl	512 SHELDON BLVD BREMERTON	98310	3		1	Air	S			S				S										
							Groundwater	C			C				C		C								
							Sediment	C			C				C		C								
							Soil	C			C				C		C								
							Surface Water	S			S				S		S								

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Drinking Water	S		S	S				S										
							Groundwater	S		S	S				S										
							Sediment	S		S	S				S										
							Soil	C		C	C				C										
							Surface Water	S		S	S				S										
KITSAP	DENO PROPERTY	3285 NORTHLAKE WY		1																					
		BREMERTON	98312																						
							Soil	C		S	S				C		S								S
							Surface Water	S			S				S										
	EAGLE HARBOR	CREOSOTE PLACE NE		3		0																			
		BAINBRIDGE	98110																						
							Groundwater	C			C	C			C	C			C						
							Sediment	C			C	C			C	C		C	C				C		
							Soil	C			C	C			C	C			C				C		
							Surface Water	C			C	C							C				C		
	EAGLE HARBOR E	CREOSOTE PL NE		3		0																			
		BAINBRIDGE	98110																						
							Sediment	C			C				C				C						
							Surface Water	C											C						
	EAGLE HARBOR W	CREOSOTE PL NE		3		0																			
		BAINBRIDGE	98110																						
							Sediment	C			C	C							C				C		
							Surface Water	C			C	C							C				C		
	EAGLE HARBOR WYCKOFF	CREOSOTE PL NE		3		0																			
		BAINBRIDGE	98110																						
							Groundwater	C			C	C			C	C			C						
							Sediment	C			C	C			C	C			C						
							Soil	C			C	C			C	C		C	C				C		
	EAGLE HARBOR WYCKOFF GW	CREOSOTE PL NE		3		0																			
		BAINBRIDGE	98110																						
							Groundwater	C			C	C			C	C			C						
	EVERGREEN PARK/BREMERTON	14TH ST & SHELDON BLVD		4	2	5																			
		BREMERTON	98310																						
							Groundwater	S		S	S				S		S								
							Sediment	S		S	S				S		S								
							Soil	C		C	C				C		C						S	S	

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

Confirmed and Suspected Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KITSAP	BREMERTON NATIONAL AIRPORT	8850 SW STATE HWY 3		2		5																			
		PORT ORCHARD	98366																						
							Groundwater	S		S	S	S			S		S								
							Soil	C		S	S	S			C		S								
	BREMERTON SCHOOL DIST/HADDON	LAFAYETTE AV & W 15TH ST		1	2																				
		BREMERTON	98312																						
							Soil	C			C				C		C								
	CHEVRON BULK Plt POULSBO	18218 FJORD DR NE		4	2																				
		POULSBO	98370																						
							Groundwater	C			C				C		C								
							Sediment	S							S		S								
							Soil	C							C		C								
							Surface Water	S							S		S								
	CHEVRON TANK FARM PORT WA NAR.	1310 HIGHLAND AV		4	2	2																			
		BREMERTON	98310-1852																						
							Groundwater	C			S				C		C								
							Sediment	C			C				C										
							Soil	C			S				C										
							Surface Water	C			C				C										
	CONSTITUTION AV LANDFILL	CONSTITUTION AV & PORTER		1																					
		BREMERTON	98312																						
							Drinking Water	S			S														
							Groundwater	S			S														
							Soil	S			S														
							Surface Water	S			S														
	COUNTRY JUNCTION STORE	5310 SE HWY 160		3		4																			
		PORT ORCHARD	98366																						
							Soil	C							C										
	DAY ROAD INDUSTRIAL PARK	DAY RD W & HWY 305		4	2	5																			
		BAINBRIDGE ISLAND	98110																						
							Drinking Water	S		S															
							Groundwater	C		C															
							Soil	S		S															
	DELS AUTOMOTIVE	6540 NEWTON ST		1																					
		SUQUAMISH	98392-9713																						
							Air	S		S	S				S										

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
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Confirmed and Susper[illegible] Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA: -	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Soil	C		C	C	S			C	C	C		C		S		C		
							Surface Water	S		S	S	S			S	S	S		S		S		S		
KITSAP	LOFTHUS BULK PLANT	510 SHELDON BLVD BREMERTON	98310-1756	2		1																			
							Air	S			S				S										S
							Groundwater	S			S				S		S								
							Sediment	S			S				S										
							Soil	C			S				C										
							Surface Water	C			C				C										
	LOVGREN GRAVEL PIT	7500 LOVGREN RD BAINBRIDGE ISLAND	98110	1	2																				
							Groundwater	S			S	S													
							Soil	C	C		C	C			C				C						
							Surface Water	C			C	C													
	MIKES PLACE AUTO WRECKING	15065 SILVERDALE WY NW SILVERDALE	98383	1																					
							Groundwater	S		S	S				S		S						S		
							Soil	C		S	S				C		S						S		
							Surface Water	S		S	S				S		S						S		
	NAVY CITY METALS INC	3805 ST HWY 3 W BREMERTON GORST	98310	4		3																			
							Air	S		S	S	S			S		S								
							Groundwater	S		S	S	S	S		S		S								
							Sediment	S		S	S	S	S		S		S								
							Soil	C		S	C	S	S		C		S								
							Surface Water	C		S	S	S	S		C		S								
	NORSELAND SITE	8651 ST HWY 3 SW PORT ORCHARD	98366	3		2																			
							Air	C		C					C	C	C						C		
							Soil	C		S					C	S	S						S		
	OLD BREMERTON GASWORKS & SESK	1725 PENNSYLVANIA AV BREMERTON	98310	3		1																			
							Groundwater	S	S		S				S	S			S						
							Sediment	C			S				S				C						
							Soil	C	C		S				S	C			C						
							Surface Water	S	S						S	S			S						

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

Confirmed and Suspected Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Surface Water	S		S	S				S		S								
KITSAP	FUDS FORT WARD	BAINBRIDGE ISLAND WINSLOW	98110	4			Soil	C							C										
	FUDS NAVAL RTS BATTLE POINT	BAINBRIDGE ISLAND WINSLOW	98110	4	1		Soil	C							C										
	HANSVILLE GENERAL STORE	7532 TWIN SPITS RD HANSVILLE	98340	3		3	Groundwater	C							C		C								
							Soil	C							C		C								
	HANSVILLE LANDFILL	31645 HANSVILLE RD NE HANSVILLE	98340	3		1	Air	C			C	C					C								
							Drinking Water	S			S	S													
							Groundwater	C		C	C	C													
							Sediment	C			C	C													
							Soil	S		S	S	S					S								
							Surface Water	C		S	C	C													
	JIMS AUTO WRECKING	23719 STOTTLEMEYER RD POULSBO	98370	1			Drinking Water	S			S				S										
							Groundwater	S			S				S										
							Sediment	S			S				S										
							Soil	C			S				C										
							Surface Water	C			S				C										
	KITSAP COUNTY NORTH GRAVEL PIT	PIONEER RD & LOFALL RD POULSBO	98370	1			Air	S		S					S	S	S		S						
							Drinking Water	S		S					S	S	S		S						
							Groundwater	S		S					S	S	S		S						
							Soil	C		S					C	S	S		C						
	LAMBERTS RADIATOR SHOP	3338 KITSAP WY BREMERTON	98312	2		1	Groundwater	S		S	S	S			S	S	S		S		S		S		
							Sediment	S		S	S	S			S	S	S		S		S		S		

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

Confirmed and Susper' Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Groundwater	S			S	S													
							Soil	S			S	S													
KITSAP	US NAVAL HOSPITAL BREMERTON	OLDING ROAD & SOUTH SHORE RD BREMERTON	98312-1898	1																					
							Air	S				S													
							Groundwater	S				S													
							Soil	S				S													
	USACE MANCHESTER ANNEX	7411 BEACH DR PORT ORCHARD	98366	3		0																			
							Soil	C			C		C		C			C	C						
	USN FISC MANCHESTER	ORCHARD PT LITTLE CL MANCHESTER	98353	4																					
							Groundwater	C				S	C		C										
							Soil	C				S	C		C										
							Surface Water	C				S	C		C										
	USN FISC MANCHESTER INDUSTRIAL	ORCHARD POINT MANCHESTER	98353	4																					
							Groundwater	C					S		C										
							Sediment	S					S												
							Soil	C					S		C										
							Surface Water	S					S												
	USN FISC MANCHESTER PCB	ORCHARD PT MANCHESTER	98353	4																					
							Groundwater	S					S												
							Sediment	S					S												
							Soil	C					C		C										
							Surface Water	S					S												
	USN JACKSON PARK	UNNAMED RD E OF ROOT RD BREMERTON	98312	3		0																			
							Groundwater	S			S	S			C										
							Soil	C			C	C			C				C					C	
	USN JACKSON PARK SHORELINE	UNNAMED RD E OF ROOT RD BREMERTON	98312	3		0																			
							Groundwater	C		C	C	C			C										
							Sediment	C	C		C	C							C						
							Soil	C	S	S	C	C	C	C	C				C						C

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

Confirmed and Suspected Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KITSAP	OLYMPIC VIEW SANITARY LDFL	10015 SW BARNEY WHITE RD PORT ORCHARD	98366	4		2																			
							Air	C		S					S		S						C	S	
							Drinking Water	C			C														
							Groundwater	C		C	C				S		C						S	S	
							Sediment	S			S				S										
							Soil	C		S	S				C		S						S	S	
							Surface Water	C		S	C				S		C						S	S	
	PACIFIC COAST HEMPHILL WINSLOW	500 WEAVER RD NW & WYATT NW WINSLOW	98110	1																					
							Groundwater	S							S										
							Soil	C							C										
							Surface Water	S							S										
	PIONEER QUARRY SITE PROPOSED	T24N R1E SEC 20 BREMERTON	98310	1																					
							Drinking Water	S			S														
							Groundwater	S			S														
							Soil	S			S														
							Surface Water	S			S														
	POULSBO YACHT CLUB	FJORD DR NE & 6TH AV POULSBO	98370	1																					
							Groundwater	S			S				S		S								
							Sediment	S			S				S		S								
							Soil	S			S				S		S								
							Surface Water	S			S				S		S								
	STONE PROPERTY	7480 BUCKLIN HILL RD NE BAINBRIDGE ISLAND	98110	2		4																			
							Drinking Water	S									S								
							Groundwater	S									S								
							Soil	S									S								
	STRANDLEY MANNING SITE	15225 WILLOW RD SE PORT ORCHARD	98366	3		3																			
							Sediment	C		C			C												
							Soil	C		C			C												
	US EPA MANCHESTER LABORATORY	7411 BEACH DR E MANCHESTER	98353	1																					
							Drinking Water	S			S	S													

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KITSAP	USN PSNS OUB	1ST ST BREMERTON	98314	3		0																			
							Groundwater	C	C	S	C	C	C	C	C	S	S	S	C	S	S	S	C	C	C
							Sediment	C			C	C	C	S	C	S			C					C	
							Soil	C	C	S	C	C	C	C	C	S	S	S	C	S	S	S	S	C	C
	USN PSNS OUB IA106	1ST ST BREMERTON	98314	6		0																			
							Groundwater	C							C										
							Soil	C							C										
							Surface Water	C							C										
	USN PSNS OUB IA588	1ST ST BREMERTON	98314	3		0																			
							Groundwater	C							C										
							Soil	C							C										
	USN PSNS OUC	1ST ST BREMERTON	98314	3		0																			
							Groundwater	S		S					C										
							Soil	S		S					C										
	USN PSNS TANKS	1ST ST BREMERTON	98314-5000	3		0																			
							Groundwater	C							C										
							Soil	C							C										
	USN SUBASE	US HWY 99 SILVERDALE	98315	3		0																			
							Groundwater	C	C	C	C			C	C								C		
							Sediment	C	C	C	C			C					C				C		
							Soil	C	C	C	C		C	C	C			C	C				C		
							Surface Water	C	C	C	C			C	C								C		
	USN SUBASE OU1 ORD DISP	CLEAR CR RD BLDG 1100 SILVERDALE	98315	5		0																			
							Groundwater	C	C																
							Soil	C	C		C		C	C											
							Surface Water	C	C																
	USN SUBASE OU2	CLEAR CREEK RD BLDG 110 SILVERDALE	98315	3		0																			

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

Confirmed and Suspected Contaminated Sites

May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Surface Water	C		C	C	C											C		
KITSAP	USN JACKSON PARK UPLAND	ROOT RD		3		0																			
		BREMERTON	98312																						
							Groundwater	S			S	S			C										
							Soil	C			C	C			C				C					C	
	USN KEYPORT	HWY 308		3		0																			
		KEYPORT	98345-0580																						
							Air	C		C							S								
							Drinking Water	S		S	S	S													
							Groundwater	C	C	C	C	C			C		C		S				S	S	
							Sediment	S		S	S	S			S				S				S		
							Soil	C	S	C	C	C			C		S		C	C					
							Surface Water	C	S	C	C	C			C		S		S				S	S	
	USN KEYPORT OU1	610 DOWELL ST		3		0																			
		KEYPORT	98345-0580																						
							Air	C		C							C								
							Groundwater	C	C	C	C	C	C	C		C	C		C				C	C	
							Sediment	C		S	C	C	C	C		C	S		C				S	S	
							Soil	C	C	C	C	C	C	C		C	C		C				C	C	
							Surface Water	C		C	C	C	C	C		C	S		C				S	C	
	USN KEYPORT OU2	610 DOWELL ST		3		0																			
		KEYPORT	98345-0580																						
							Groundwater	C		C	C	C			C		C								
							Sediment	C			C					S	C		S						
							Soil	C		C	C				C		C								
							Surface Water	C			C	C				S									
	USN PSNS	1ST ST		3		0																			
		BREMERTON	98314																						
							Groundwater	C	C	C	C	C			C		C		C			S			
							Sediment	C			C	C			S				C			S			
							Soil	C	C	C	C	C	C		C		C		C			S			C
							Surface Water	S	S	S	S	S			S		S		S			S			
	USN PSNS OUA	1ST ST		3		0																			
		BREMERTON	98314																						
							Groundwater	C	C		C	C	C	C	C	S	S		C	S	S			C	S
							Sediment	C	C		C	C	C	C	S	S			C						
							Soil	C	C		C	C	C	C	C	S	S		C	S	S			C	S

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
KITSAP	VIP LANDFILL	KITSAP WY & OYSTER BAY		1																					
		BREMERTON	98314																						
							Drinking Water	S			S														
							Groundwater	S			S														
	WARD RADIATOR	407 NAVAL AV		1																					
		BREMERTON	98312-4047																						
							Groundwater	S			S				S										
							Sediment	S			S				S										
							Soil	S			S				S										
							Surface Water	S			S				S										
	WOLF PROPERTY	983 OLNEY AV E		2		5																			
		PORT ORCHARD	98366																						
							Air	S		S		S			S		S							S	
							Groundwater	S		S		S			S		S							S	
							Sediment	C		S		S			C		S							S	
							Soil	C		S		S			C		S							S	
							Surface Water	C		S		S			C		S							S	
KITTITAS	115 MINI MART	EXIT 115 INTERSTATE 90		2		3																			
		KITTITAS	98934																						
							Groundwater	C							C										
							Soil	C							C										
	8TH & MAIN	8TH STREET & MAIN		4	2																				
		ELLENSBURG	98926																						
							Groundwater	C							C										
							Soil	C							C										
	ALPINE VENEER Plt	HWY 903		2		5																			
		RONALD	98940																						
							Soil	C							C										
	BIG B MINI MART	1611 CANYON RD		2		4																			
		ELLENSBURG	98926																						
							Groundwater	C							C										
							Soil	C							C										
							Surface Water	S							S										

CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

Confirmed and Suspected Contaminated Sites

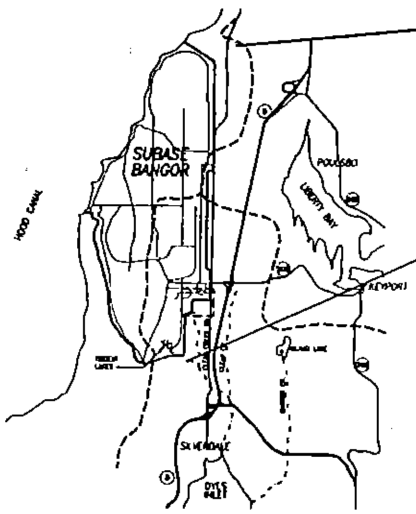
May 30, 1997

COUNTY	SITE NAME	LOCATION ADDRESS / CITY	ZIP CODE	SITE STAT CODE	IND SITE STAT	WARM BIN #	AFFECTED MEDIA:	STATUS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Groundwater	C	C		C													C	
							Soil	C	C		C													C	
							Surface Water	S																	
KITSAP	USN SUBASE OU3	CLEAR CREEK RD BLDG 110		6		0																			
		SILVERDALE	98315																						
							Groundwater	C			C	C					S								
							Soil	C			C		C					C							
	USN SUBASE OU6	CLEAR CREEK RD BLDG 110		3		0																			
		SILVERDALE	98315																						
							Groundwater	C	C		C														
							Soil	C	C		C														
							Surface Water	S	C		C														
	USN SUBASE OU7	CLEAR CREEK RD BLDG 110		3		0																			
		SILVERDALE	98315																						
							Groundwater	C		C	C		C	C		C	C		C						
							Sediment	C			C		C	C		C			C						
							Soil	C		C	C		C	C		C	C		C						
							Surface Water	C		C	C			C											
	USN SUBASE OU8	CLEAR CREEK RD BLDG 110		3		0																			
		SILVERDALE	98315																						
							Drinking Water	C		C	C	C					C								
							Groundwater	C		C	C	C					C								
	USN SUPPLY CENTER	N OF WYCOFF ST BETWEEN X & Y		3		0																			
		BREMERTON	98314																						
							Groundwater	C	C	C	C	C	C	C	C	S	C		C				C	C	
							Soil	C	C	C	C	C	C	C	C	S	C		C	S	S		C	C	C
	VETERANS HOME	1141 BEACH DR E		1																					
		RETSIL	98378																						
							Groundwater	S							S										
							Soil	C							C										
	VIKING PLATING	10373 NE STATE HWY 104		1																					
		KINGSTON	98346																						
							Groundwater	S		S	S										S				
							Sediment	S		S	S										S				
							Soil	S		S	S										S				
							Surface Water	S		S	S										S				

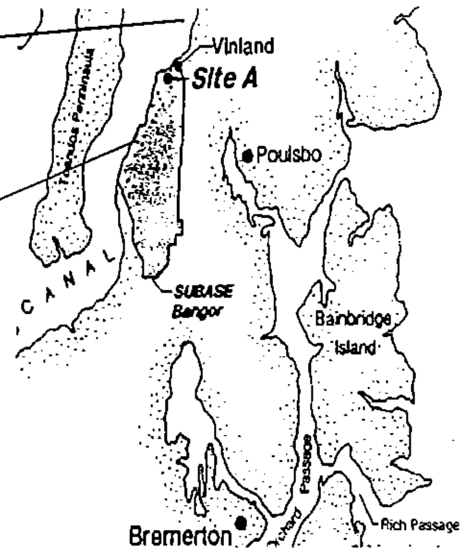
CONTAMINANT KEY: S-SUSPECTED, C-CONFIRMED, R-REMEDIATED, B-BELOW MCTA CLEANUP LEVELS
REFER TO ATTACHED LEGEND FOR EXPLANATION OF CODED DATA

SUBASE, Bangor

Operable Unit 1 (OU 1) Site A



Location Map



Site Map

WHERE: SUBASE, Bangor is located on Hood Canal, about 10 miles north of Bremerton. OU1 is a 12 acre area at the very northern end of the base, 2,000 feet south of Vinland.

WHY/HOW: Site A was used primarily as an ordnance burning area from 1962 to 1976. It was believed that burning ordnance was a harmless disposal practice. We know now that by doing so, toxic chemicals left on the ground are able to percolate into the ground with rain water. This is a concern because 80% of Kitsap Countys' drinking water comes from groundwater. Site A also received contaminated soil from Site F.

> *Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.*
>
> *We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.*

WHAT:

Found in the groundwater:

- RDX (also known as cyclonite or royal demolition explosives)

Found in the soil:

- TNT (trinitrotoluene)
- DNT (2,4 and 2,6-dinitrotoluene)
- RDX
- Lead

ACTIONS: A passive soil washing treatment was started in December 1994. Seven thousand cubic yards of soil were excavated and placed in a lined basin. Water is then sprinkled over the soil, percolates to the bottom, taking contamination with it, and

(Over)

routed through a system that cleans it using granular activated carbon. The water is recycled through the system. A more aggressive ground water pump and treatment system will start mid 1997. Some soil is being composted to naturally breakdown contaminants.

For more information, call Art Walther, Restoration Advisory Board Community Co-chair, at (360) 692-6075.

Detailed reports are available at two Kitsap County library branches: Central, 1301 Sylvan Way, Bremerton, and Poulsbo, 700 NE Lincoln.

Funding for this product was provided by a Public Participation Grant from the Washington Department of Ecology. These materials were reviewed for consistency with the purposes of the grant only; grant funding does not constitute endorsement of opinions.

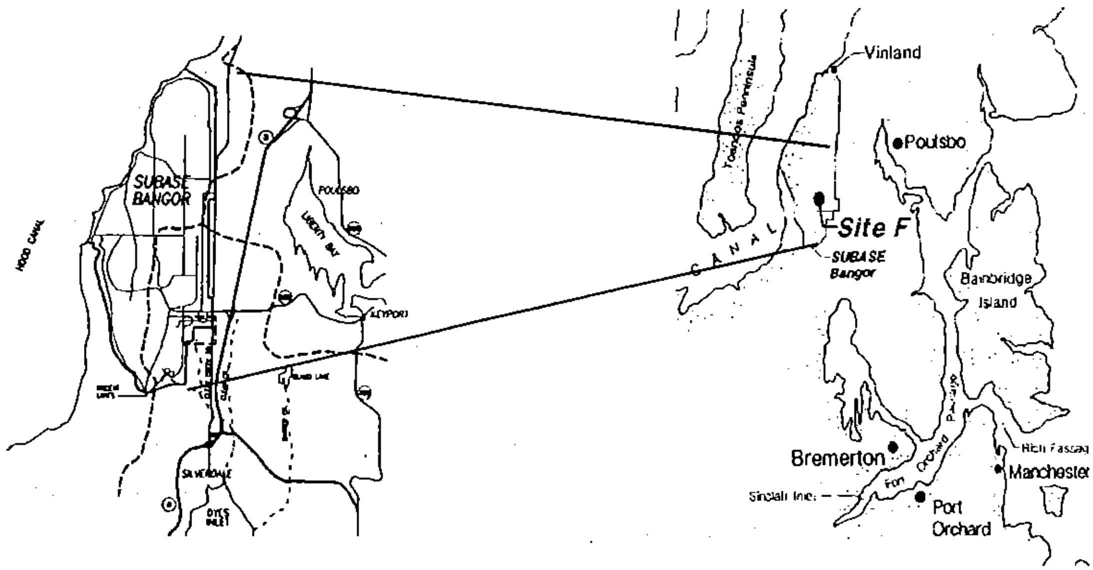
This information was generated as part of a community education project performed by Kitsap County's Restoration Advisory Boards.

The final design and layout of this fact sheet was produced and provided by Kitsap Public Utility District.

5/9/97

SUBASE, Bangor

Operable Unit 2 (OU 2) Site F



Location Map *Site Map*

WHERE: SUBASE, Bangor is located on Hood Canal, about 10 miles north of Bremerton. OU2 is 6,000 feet west of Olympic View Road, in the southern half of SUBASE. The total base size is 7,000 acres.

WHY/HOW: Since 1977, SUBASE has been commissioned as the Trident Submarine Launched Ballistic Missile System. The base was previously used for munitions handling, storage and demilitarization. Disposal of ordnance and other industrial wastes created the hazardous waste problems that are being addressed now. Site F was an unlined wastewater lagoon that received wastewater from demilling artillery shells between 1960 and 1971. In 1972 the upper portion of the soils were removed and taken to Site A, OU1, causing more contamination there All contaminated soil was not removed. Contamination has spread underground in a northwesterly direction towards Olympic View and Old Bangor. Left untouched, this toxic "plume" would reach the base boundary within 30 years.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

WHAT:

Found in the soil and groundwater:

- RDX (also known as cyclonite or royal demolition explosives)
- TNT (trinitrotoluene)

(Over)

- DNT (2,4 and 2,6-dinitrotoluene)
- 1,3,5-trinitrobenzene
- 1,3-dinitrobenzene
- Nitrate
- Manganese

ACTIONS: In 1994 SUBASE began pumping groundwater in order to stop the northwesterly movement of the plume. The extracted groundwater will be run through a granular activated carbon filter before being put back in the ground. The top 15 feet of soil will be removed and mixed with composting material to naturally breakdown contaminants.

For more information, call Art Walther, Restoration Advisory Board Community Co-chair, at (360) 692-6075.

Detailed reports are available at two Kitsap County library branches: Central, 1301 Sylvan Way, Bremerton, and Poulsbo, 700 NE Lincoln.

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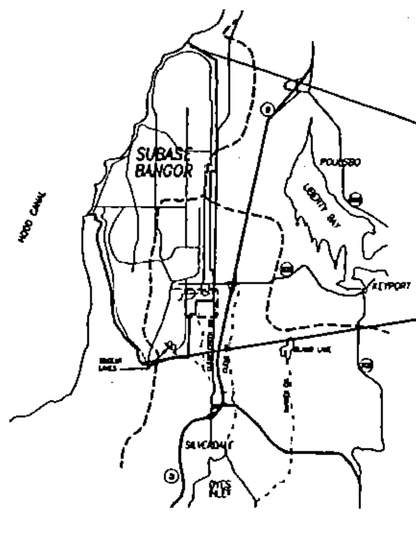
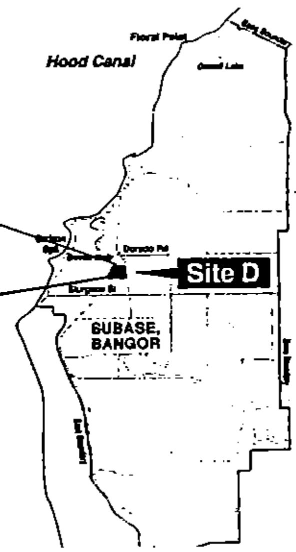
5/9/97

SUBASE, Bangor

Operable Unit 6 (OU 6) Site D



Location Map



Site Map

WHERE: SUBASE, Bangor is located on Hood Canal, about 10 miles north of Bremerton. OU6 is located in the west-central portion of the base, just east of Carlson Spit.

WHY/HOW: SUBASE was commissioned as the Trident Submarine Launched Ballistic Missile System in 1977. The base was previously used for munitions handling, storage and demilitarization from 1945 to the early 1970's. Disposal of ordnance and other industrial wastes created the hazardous waste problems that are being addressed now. Site D was used for ordnance detonation, burning and burial from 1946 to 1965. The burn trench is 20 feet wide and 200 feet long.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

WHAT:

Found in the soil (risks for human contact and small mammals):

- TNT (2,4,6-trinitrotoluene) (88% cause of risk)
- DNT (2,6, and 2,4-dinitrotoluene)
- 1,3,5-trinitrobenzene
- 1,2 and 1,3 and 1,4-dinitrobenzene
- nitrobenzene
- nitrotoluene

ACTIONS: 1,600 cubic yards of contaminated soil have been mixed with potato waste or apple pumice, wood chips, alfalfa and cow manure. Natural microbes then degrade the organic chemicals.

(Over)

Soils were treated in the Site F compost facility resulting in a cost savings. Cleanup was completed in April 1996.

For more information, call Art Walther, Restoration Advisory Board Community Co-chair, at (360) 692-6075.

Detailed reports are available at two Kitsap County library branches: Central, 1301 Sylvan Way, Bremerton, and Poulsbo, 700 NE Lincoln.

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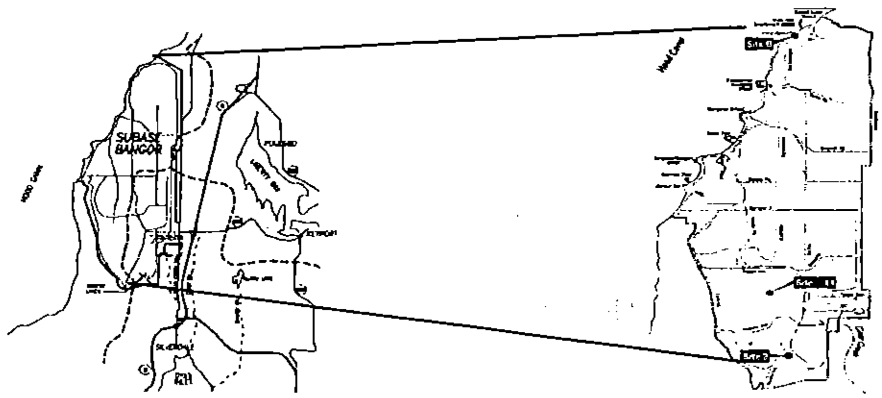
5/9/97

SUBASE, Bangor

Operable Unit 7 (OU 7) Sites B, 2, 11



Location Map *Site Map*

WHERE: SUBASE, Bangor is located on Hood Canal, about 10 miles north of Bremerton. OU7 includes sites located in three different areas.

SITE B: This site is located at Floral Point, at the very north end of the base. This area was used repeatedly for Pyrotechnics (flare burning) testing and municipal waste disposal.

Found in the soil: human contact risk, long-term potential

- PCB's (polychlorinated byphenols)
- benzo (b) fluoranthene
- benzo(k)fluoranthene
- benzo (a) anthracene
- benzo (g,h,i) perylene
- chrysene
- benzo (a,h) anthracene
- dibenzo (a,h) anthracene
- benzo (a) pyrene

> *Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.*
>
> *We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that*

Found in the groundwater: risk of contact and consumption, long-term potential

- Arsenic
- Petroleum
- Cadmium
- Lead
- Manganese
- Thallium
- Tetrachloroethene
- Bis (2-ethylhexyl phthalate)
- Chrysene

Note: This water is not fit for human consumption due to its high salt content. A vegetated soil cover

(Over)

will be constructed in June 1997 to reduce contact to the soils. Residential use will not be allowed.

SITE 2: This site is at the south end of the base. It was used as an unauthorized disposal area between the 1940's and the 1970's. In 1991 a buried drum with paint thinner residue was found.

Found in the soil: human contact risk
- PCB's (polychlorinated byphenols)

Found in the groundwater: human consumption risk
- Arsenic
- Heptachlor

About 5,000 cubic yards of contaminated soils and the drums were sent to an approved landfill.

SITE 11: This site is in the southern portion of the base. It was used as an acid pit and pesticide drum disposal area. Herbicides were dumped here.

Found in the soil: human contact risk
- DDT (pesticide)
- Beryllium
- Arsenic

Found in the groundwater: human consumption risk
- Antimony
- Arsenic
- Beryllium
- Benzene
- Otto fuel
- RDX (also known as cyclonite or royal demolition explosive)

About 400 cubic yards of contaminated soil were excavated and sent to an approved hazardous waste landfill. Drinking water wells will not be allowed in this area

For more information, call Art Walther, Restoration Advisory Board Community Co-chair, at (360) 692-6075.

Detailed reports are available at two Kitsap County library branches: Central, 1301 Sylvan Way, Bremerton, and Poulsbo, 700 NE Lincoln

Funding for this product was provided by a Public Participation Grant from the Washington Department of Ecology. These materials were reviewed for consistency with the purposes of the grant only; grant funding does not constitute endorsement of opinions.

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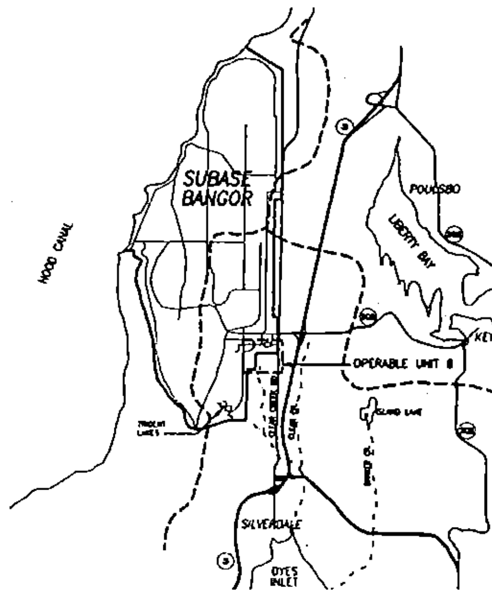
The final design and layout of this fact sheet was produced and provided by Kitsap Public Utility District.

5/9/97

SUBASE, Bangor

Operable Unit 8 (OU 8) Public Works Industrial Area



Site Map

WHERE: SUBASE, Bangor is located on Hood Canal, about 10 miles north of Bremerton. OU8 is located in the southeast corner of the base, near Trident Blvd. and Mountain View Road. It is the "Public Works and Industrial" area on base.

WHY/HOW: OU8 is an industrial public works area that has a gas station. An improperly installed overfill pressure line is believed to have leaked 20,000 gallons of fuel. This fuel is migrating underground through groundwater to an off-base well.

WHAT:
Found in the groundwater: a potential long-term risk for human consumption

- benzene
- DCA (1,2-dichloroethane)

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

ACTIONS: Because benzene was found in a newly drilled community well located just off-base, the neighborhood west of Clear Creek along Mountain View Road was connected to a public water system supply. The new well was never used. The potential threat to the private wells was traced to the fuel leak and degreasing compounds. The Navy will install a groundwater pump and treat system that will extract the contaminated water underground, strip the chemicals out of it with air and then put the clean water back in the ground. This system is expected to be operational by late Spring, 1997. It is estimated that the benzene levels will be reduced within 5 years and 15 years for DCA.

(Over)

For more information, call Art Walther, Restoration Advisory Board Community Co-chair, at (360) 692-6075.

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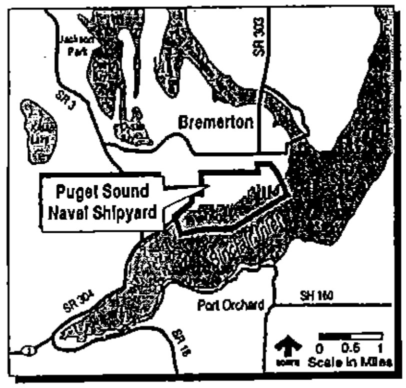
5/9/97

Puget Sound Naval Shipyard/Fleet Industrial Supply

Puget Sound Naval Shipyard - Operable Unit NSC (OU NSC) (FISC)-Site 12



Location Map

WHERE: Fleet Industrial Supply Center (FISC) is located within Puget Sound Naval Shipyard (PSNS), Bremerton. Both sit on the northern shore of Sinclair Inlet, but each one is a separate "Superfund" site.

WHY/HOW: FISC, a 28 acre area, was commissioned in 1967 because of an increased demand for Naval support in this region. Industrial activity is performed there. Much of the "land" was created though a gradual process of filling marshy areas and tideflats with contaminated soil and debris. About 80% of the area is paved over. Site 12 is at the south end of the shipyard and used to have an acid drain pit on site.

WHAT:

Chemicals found above regulatory criteria:

VOC's (volatile organic compounds)
- TCE (trichloroethene) in the groundwater

SVOC's (Semi-volatile organic compounds)
- bis(2-ethylhexyl) phthalate, +5 others in the groundwater
- *benzo(a)anthracene, +6 others in the soil
- Benzo(a)pyrene, +8 others in storm drain sediments
- bis(2-ethylhexyl)phthalate, +6 others in storm drain water

Pesticides and PCB's
- 4,4'-DDT, +11 others in the groundwater
- *PCB's., in storm drain sediments and the soil

Inorganics (Metals)
- Copper, +7 others in the groundwater
- *Arsenic and *Lead, +3 others in the soil

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

(Over)

- Arsenic, +9 others in storm drain sediments and storm water

TPH (total petroleum hydrocarbons)

- Motor Oil, +2 others in the groundwater
- *TPH + 3 others in the soil
- Diesel, +1 other in storm drain sediments, motor oil, +1 other in the storm drain water

*denotes chemical of concern. There are 17 more not listed. Only contamination in soil was considered a risk. Groundwater is not potable due to saltwater intrusion. Risks to the marine ecology are being studied under the PSNS Operable Unit B site.

ACTIONS: In 1993 the top 3 feet of fill was removed and taken to an approved hazardous waste landfill. All the storm drains will be cleaned out and repaired where needed and all exposed dirt will be paved over to reduce exposure. Monitoring will continue. All cleanup actions assume continued non-residential use of the site.

For more information, call Rich Yanss, Restoration Advisory Board Community Co-chair, at (360) 373-4081.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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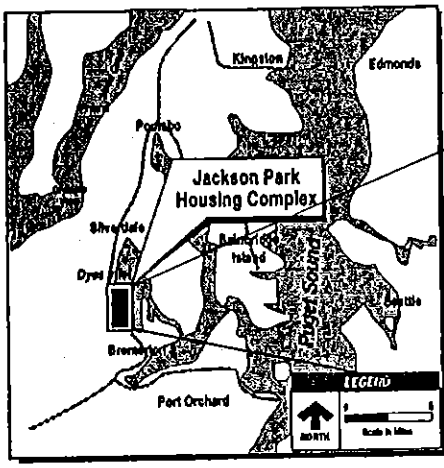
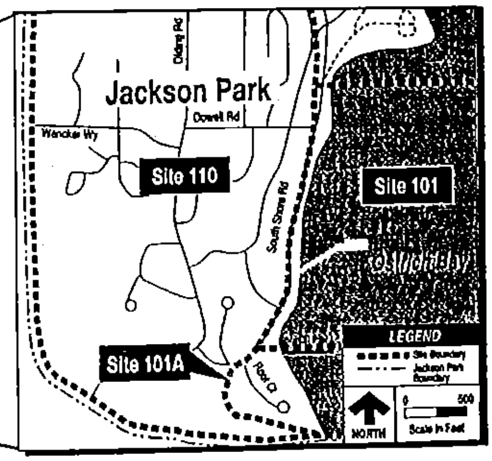
5/9/97

Jackson Park/Naval Hospital Complex

Operable Unit 1 (OU 1)-Site 101



Location Map



Site Map

WHERE: Located on the east shoreline of the Jackson Park complex, a 158 acre complex providing residential and medical services to Navy families, on the west side of Ostrich Bay, Bremerton.

WHY/HOW: Jackson Park was established in 1904 as a naval ammunition storage facility. Operations increased during World War II, including ordnance demilitarization. Munitions were taken apart at Site 101, inside a building. Then the inside of the building was hosed down, with the contaminated waste being piped directly into the bay. Arsenic was found along the former railroad bed, and may be the result of herbicide use. Beginning in 1965 the site was converted from industrial to residential use.

WHAT:

Found in the soil (0-2' deep):

- Arsenic
- Lead
- PAH (Polynuclear aromatic hydrocarbons)

Found in a seep at the shoreline:

- Arsenic
- Benzene
- Nickel
- Silver

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

ACTIONS: The Navy would like to combine a beautification/trail project with the cleanup project by regrading and capping the area. Testing will be done to find the source of the Benzene and TPH contamination.
A prior release from an upland gas station is considered a possible source.

(Over) →

For more information, call Field Ryan, Restoration Advisory Board Community Co-chair, at (360) 377-6782.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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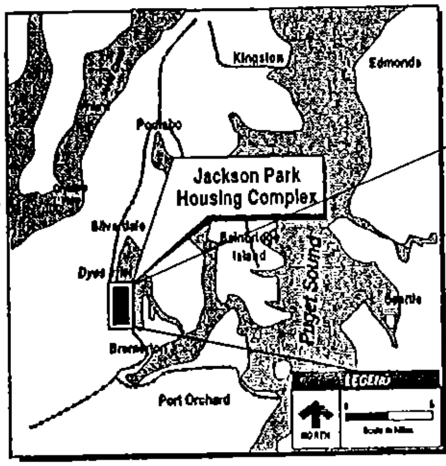
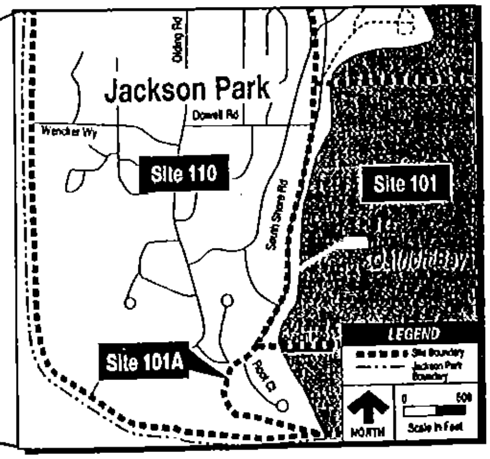
5/9/97

Jackson Park/Naval Hospital Complex

Operable Unit (OU 1)-Site 101-A



Location Map



Site Map

WHERE: The site is located along the south east shoreline of the Jackson Park Naval complex. Jackson Park is a 158 acre complex providing residential and medical services to Navy families. It is located on the west side of Ostrich Bay, Bremerton.

WHY/HOW: Jackson Park was established in 1904 as a naval ammunition storage facility. Operations increased during World War II and included ordnance demilitarization (burning munitions). An oil pier was at this site, with its companion tanks buried in the ground near it. Site 101-A also includes a former construction debris dumping area. Beginning in 1965 the complex was converted from industrial to residential use.

WHAT:

Found in the soil:

- Cadmium
- PAH (Polynuclear aromatic hydrocarbons);
  - Benzo (a) enthracene
  - Benzo (a) pyrene
  - Benzo (b) flouranthene
- Chrysene

Found in seeps at shoreline:

- Arsenic
- Lead
- Copper
- Bis (2-ethylhexy)phthalate

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

ACTIONS: In 1993-94, three small and two 100,000 gallon petroleum contaminated tanks, which were 15 feet below ground, were removed. Clean backfill was put in their place and compacted. Due to the close proximity to one of the housing units a wall was constructed to keep the remaining contaminated soil in place. Monitoring will continue at this site to keep track of the remaining contamination. The

(Over)

construction debris area was already covered with dirt and grass and is now used as a landscaping staging area for short-term storage of mulch, soil and gravel.

For more information, call Field Ryan, Restoration Advisory Board Community Co-chair, at (360) 377-6782.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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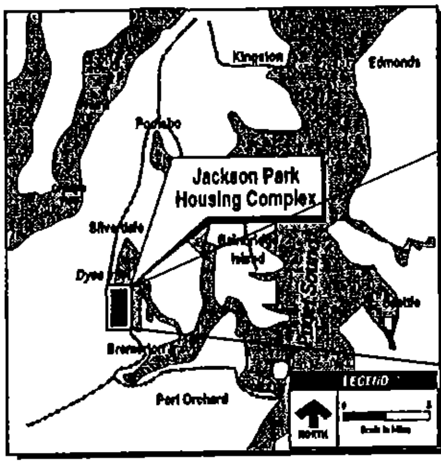
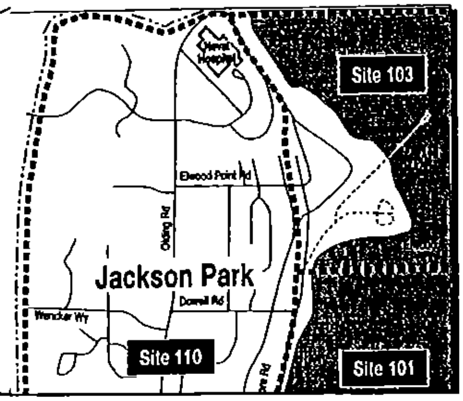
5/9/97

Jackson Park/Naval Hospital Complex

Operable Unit 1 (OU 1)-Site 103



Location Map



Site Map

WHERE: The site is located along the north east shoreline of the Jackson Park Naval complex. Jackson Park is a 158 acre complex providing residential and medical services to Navy families. It is located on the west side of Ostrich Bay, Bremerton. Site 103 is a former Suquamish tribe longhouse site also known as Elwood Point.

WHY/HOW: Jackson Park was established in 1904 as a naval ammunition storage facility. Operations increased during World War II and included ordnance demilitarization. It was common practice to take ordnance apart and then burn the powder not knowing hazardous chemicals would be the end result. Site 103 was used as one of these burn areas. Beginning in 1965, the complex was converted from industrial to residential use.

WHAT:

Found in the surface (0'-3') and subsurface soils (3'-12'):

- *Arsenic
- *PAH (Polynuclear aromatic hydrocarbons)*
  - Benzo (a) anthracene
  - Benzo (a) pyrene
  - Benzo (b) flouranthene
  - Benzo (k) flouranthene
- Chrysene
- DBA Dibenz (a,h) anthracine
- 1,2,3 (Indeno 1,2,3-cd pyrene)
- #PCB 1254 (polychlorinated byphenyl 1254)

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

**Contaminants of most concern (above state risk levels)*
#Found in subsurface soils only

(Over)

Found in seeps and outfalls along the shoreline:

- Arsenic
- Nickel
- Silver
- Vinyl Chloride
- TCE (Trichloroethene)
- 1,1-Dichloroethene

ACTIONS: Options include land use restrictions (no housing), cover with clean dirt, or excavate contaminated dirt and fill with clean dirt, and reduce erosion at the shoreline with "hard" and "soft" bulkheading. A beautification/improvement is also being considered. Paving over some contamination is planned in order to reduce human exposure.

For more information, call Field Ryan, Restoration Advisory Board Community Co-chair, at (360) 377-6782.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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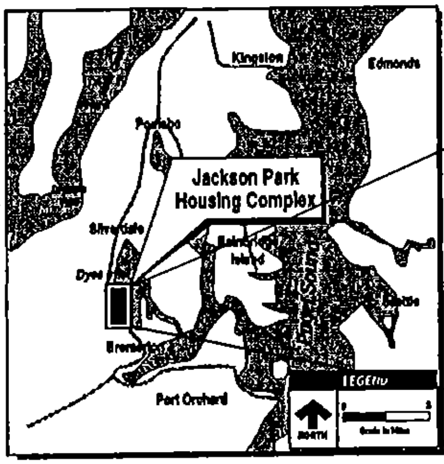
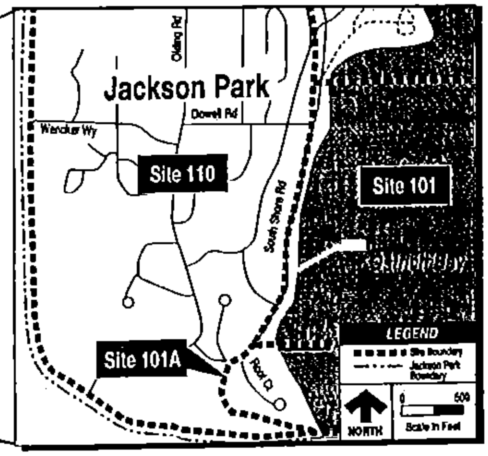
Jackson Park/Naval Hospital Complex

Operable Unit 1 (OU 1)-Site 110



Location Map



Site Map

WHERE: This site includes those areas in the center of the 158 acre complex which provides residential and medical services to Navy families, on the west side of Ostrich Bay, Bremerton.

WHY/HOW: Jackson Park was established in 1904 as a naval ammunition storage facility. Operations increased during World War II and included ordnance demilitarization (burning munitions). A railroad was used throughout the complex. Arsenic contamination was found along the former railroad track bed and may be a result of herbicide use.

Beginning in 1965, the complex was converted from industrial to residential use.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

WHAT:

Found in the soil:

- Arsenic
- Benzene

ACTIONS:

The soil with concentrations of Arsenic which exceeded state cleanup levels were excavated, including an area near the Jackson Park Elementary School. Other areas were paved over in 1993-94 to eliminate any possible exposure. Groundwater and soil sampling is planned to identify the source of the benzene. An upland gas station is a likely source. Benzene was recently found at a seep at the shoreline (See fact sheet for Site 101).

(Over)

For more information, call Field Ryan, Restoration Advisory Board Community Co-chair, at (360) 377-6782.

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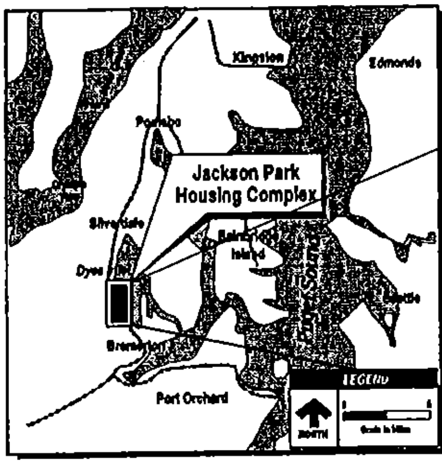
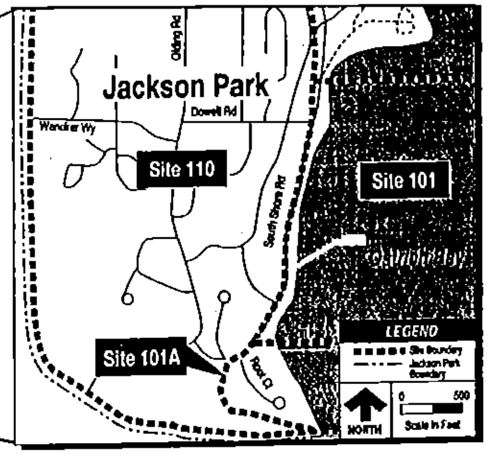
5/9/97

Jackson Park/Naval Hospital Complex

Operable Unit 2 (OU 2)-Sediments in Ostrich Bay



Location Map



Site Map

WHERE: Ostrich Bay, Bremerton is adjacent to the east side of the Jackson Park Naval complex, a 158 acre complex providing residential and medical services to Navy families. The bay is connected to Dyes Inlet to the north, and flushes through the Port Washington Narrows into Sinclair Inlet to the south.

WHY/HOW: Jackson Park was established in 1904 as a naval ammunition storage facility. Operations increased during World War II and included ordnance emilitarization. It was common practice to take ordnance apart and then burn the powder not knowing hazardous chemicals would be the end result. Ordnance dismantling was performed at Site 101, with wastes being hosed out of the buildings and piped directly into Ostrich Bay (OU2). Beginning in 1965 the site was converted from industrial to residential use.

WHAT:

Found in the bay sediments:

- Cadmium
- Mercury

Found in clams and crabs in the bay:

- 3-3 dichlorobenzedine[1]
- pentachlorophenol[1]
- antimony[2]
- vanadium[2]

[1] Cancer risk, no known source upland

[2] Non-cancer risks (toxic), no known source upland

Note: There were more chemicals found that do not have any state criteria to measure against. Those listed above pose the most risk to humans.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

ACTIONS: It is believed that most chemicals in the bay have come from past industrial practices at this base. Since the conversion of this complex to residential use, most sources of contamination have been removed. Further study of the site will help determine if capping the sediments with clean sediment from

(Over)

another area would be viable.

For more information, call Field Ryan, Restoration Advisory Board Community Co-chair, at (360) 377-6782.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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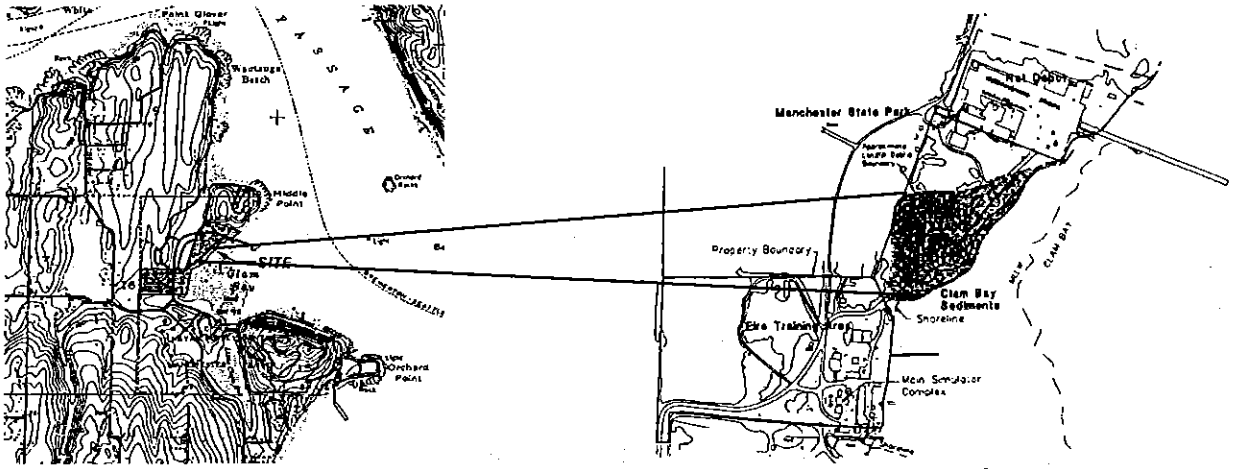
5/9/97

Manchester Annex
Landfill and Clam Bay Sediments



Location Map *Site Map*

WHERE: Located along Rich Passage, about 1.5 miles north of Manchester. The "Old Navy Dump" sits along the shoreline, with 5-6,000 cubic yards of waste having eroded onto the beach in Clam Bay.

WHY/HOW: From the early 1900's to 1960 the Navy owned 385 acres surrounding Clam Bay. The site was used for submarine net maintenance, fire fighter training and waste disposal. Although the Navy retains a fuel depot area, other acreage has been deeded to several entities including 110 acres to the State for Manchester State Park, 17 acres to the Environmental Protection Agency (EPA), and 23 acres to the National Oceanic and Atmospheric Administration (NOAA). Unfortunately the six acre dump was originally a tidal lagoon. About 70,000 cubic yards of industrial waste were sent here from PSNS between 1942 and 1962. Because of its location along the shoreline, contaminants are eroding directly into the bay from constant tidal action. Surface and groundwater also flush through the dump, with seeps draining onto the beach. Studies conclude that the site doesn't represent any risk to local drinking water wells. There is, however, harm to the marine environment. It has been determined that consumption of larger quantities of clams is not safe.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

WHAT:

Found in soil, groundwater, sediments/tideflats and shellfish.

- Lead
- Nickel
- Cadmium
- Copper

(Over) →

- Zinc
- Asbestos
- Vinyl chloride
- Dioxins and furans
- PCB's
- 2,4-dimethylphenol

ACTIONS: About 5-6,000 cubic yards of waste that has eroded onto the beach will be excavated and put on top of the inland portion of the site. Clean sand and sediments will be put in its place. An engineered cover (cap) will be put on the top of the dump to prevent human contact. A curtain drain on the uphill side will prevent water run-off from filtering through the dump and carrying contaminants out into Clam Bay. Clean rows of sediment will be put on the tideflats over the contaminated areas. Subsistence harvesting of shellfish will be restricted for several years, until tests show clams are safe to eat. An underground fuel tank was found in Manchester State Park and has been removed. No further cleanup is planned at the park.

For more information, call Bob Keivet, EPA, at (360) 753-9014.

Detailed reports are available at the Manchester Public Library, 8067 East Main Street, Manchester.

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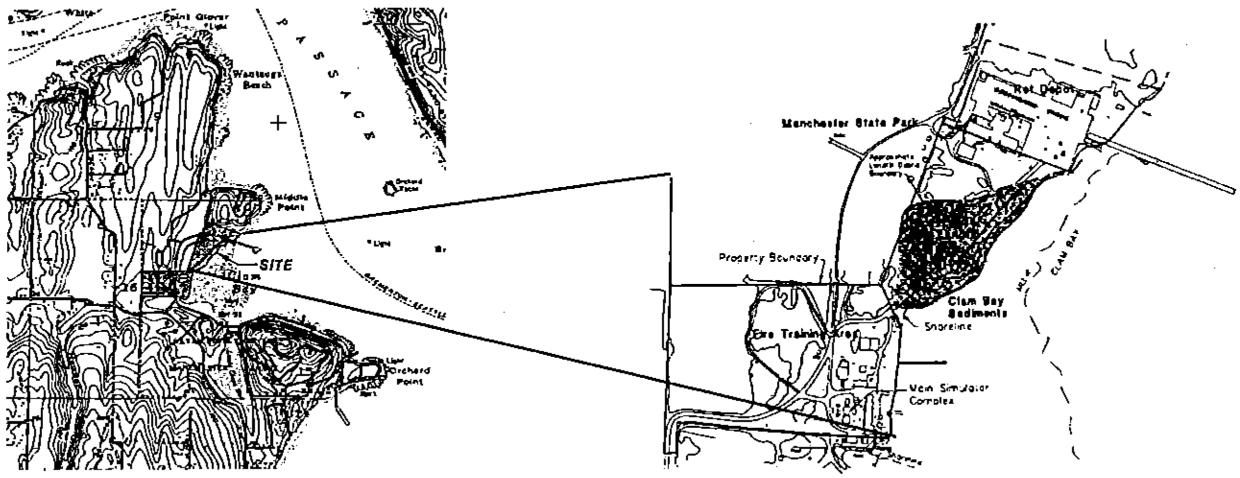
5 9 97

Manchester Annex
Fire Fighter Training Area



Location Map *Site Map*

WHERE: Located along Rich Passage, about 1.5 miles north of Manchester.

WHY/HOW: From the early 1900's to 1960 the Navy owned 385 acres surrounding Clam Bay. The site was used for submarine net maintenance, fire fighter training and waste disposal. Although the Navy retains a fuel depot area, other acreage has been deeded to several entities; including 110 acres to the State for Manchester State Park, 17 acres to the Environmental Protection Agency (EPA), and 23 acres to the National Oceanic and Atmospheric Administration (NOAA). Training for Navy fire fighters started on site in 1942. Simulators still on site mimicked ships for trainees. Waste oil used to start the "ship" fires contained polychlorinated byphenyls (PCB's) and when burned, broke down into other hazardous chemicals called dioxins.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

WHAT:

Found in soil and simulator debris:

- Dioxins

Found in underground tanks:

- Polychlorinated byphenyls (PCB's)

ACTIONS: Remove simulator debris and dirt contaminated with dioxin and take to an approved hazardous waste landfill. If it's found the simulators leaked toxins, they will be demolished, removed and any contaminated dirt removed. Underground oil tanks on site will be pumped, filled with sand and left in place. An underground fuel tank was found in Manchester State Park and has been removed. No further

(Over) →

cleanup is planned at the park.

For more information, call Bob Keivet, EPA, at (360) 753-9014.

Detailed reports are available at the Manchester Public Library, 8067 East Main Street, Manchester.

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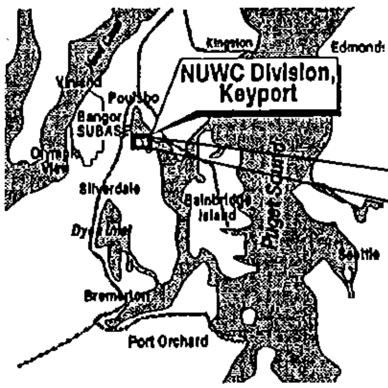
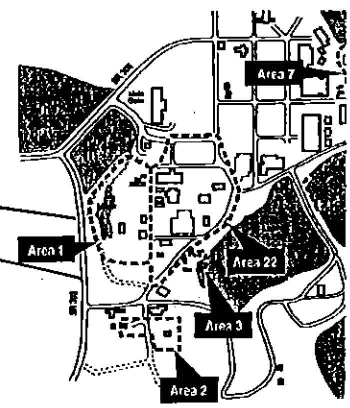
5/9/97

Naval Undersea Warfare Center (NUWC) Division, Keyport

Keyport Landfill, Operable Unit 1 (OU 1) - Area 1



Location Map



Site Map

WHERE: NUWC, Keyport is located on a small peninsula at the south end of Liberty Bay in northern Kitsap County. The seven acre landfill is in a marsh that sits near the head of Dogfish Bay, a southern portion of Liberty Bay.

WHY/HOW: This 340 acre base was commissioned in 1914 and was used as a torpedo test range. The facility continues to provide engineering support for a broad range of undersea weapons systems. OU1 was a marsh area where a variety of industrial wastes were dumped from about 1939 to 1973. Because the dump does not have a liner, groundwater flows through the site, flushing out into the tideflats to Dogfish Bay. Upper aquifers (down to 60' below the ground surface) are therefore contaminated, but the deeper aquifer (700' below the ground surface) that supplies the community's drinking water is protected by three thick layers of clay.

WHAT:

Found in the groundwater and surface water:

- *Vinyl Chloride
- 1,1-Dichloroethene
- *PCB's (Polychlorinated biphenyls)
- cis-1,2-Dichloroethene
- *TCE (Trichloroethene)
- trans-1,2- Dichloroethene
- 1,1-Dichloroethane

Found in the sediments:

- *PCB's
- Chromium
- Phenol
- Acenaphthene
- Lead
- Arsenic

Found in shellfish:

- *PCB's
- Cadmium
- Phenol
- Silver

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

(Over)

- Lead
- Arsenic
- Copper
- Zinc
- Beryllium

* Contaminants of most concern

ACTIONS: Several cleanup actions are being considered. A concentration of volatile organic compounds are at the sound end of the landfill. A technique called sparging involves injecting air into the ground, causing the chemicals to evaporate. This vapor is pumped out and treated before release into the air. Poplar trees could be planted, which take up large quantities of water, thus removing chemicals with the water. A wall may be installed that would catch contaminated groundwater and funnel it to gates with treatment filters. A sediment trap may be installed where the marsh drains into the tideflats, in order to stop the movement of PCB's into the bay. Expansion of the landfill cover (pavement) continued monitoring and land use restrictions are also being considered.

For more information, call Christine Gover, Restoration Advisory Board Community Co-chair, at (360) 297-8526.

Detailed reports are available at two Kitsap County library branches: Central, 1301 Sylvan Way, Bremerton, and Poulsbo, 700 NE Lincoln.

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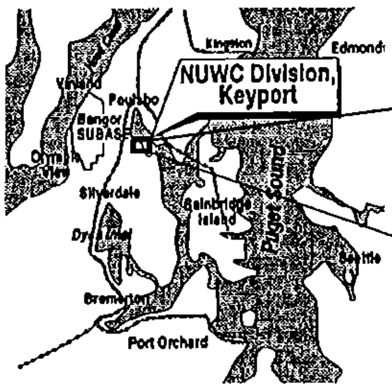
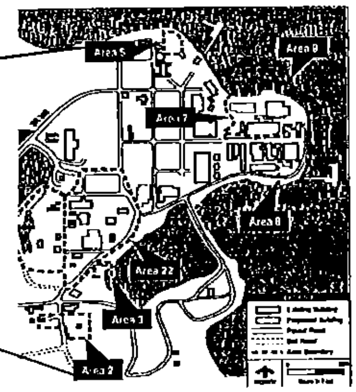
Naval Undersea Warfare Center (NUWC) Division, Keyport

Operable Unit 2 (OU 2) - Includes Areas 2, 3, 5, 8, 9



Location Map



Site Map

WHERE: NUWC, Keyport is located on a small peninsula at the south end of Liberty Bay in northern Kitsap County. The areas in OU 2 are located at several sites throughout the 340 acre base.

Area 2, Van Meter Road Spill Site:

Drum recycling and a plating waste spill contaminated this site with metals, solvents (including Trichloroethene), semi-volatile organics, vinyl chloride and Otto fuel. Continued monitoring will determine if the natural breakdown of these chemicals continues in the soil and groundwater.

Area 3, Otto Fuel Sump Leak:

An underground Otto fuel tank was found to be leaking in 1984, and was removed at that time. Soil and groundwater samples determined that no more action was needed.

Area 5, Sludge Disposal Area:

This 1/2 acre site was used for sludge disposal from the 1940's to the mid-1970's. Metals were found to be below levels of concern. No more action is needed at this site.

Area 8, Plating Shop Waste Spill:

The Plating Shop was built in 1936 and many spills have occurred. Plating wastes (chromium, cadmium, 1,1,1-trichloroethane (TCA), and trichloroethene (TCE) have leached into the soil and groundwater at this one acre site. Sumps and chromium contaminated dirt outside of the building were removed in 1992. Remaining contamination will be removed in 1998 after razing the old Plating Shop. Testing will continue to confirm that the sources of contamination have all been removed.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

(Over)

Area 9, Liberty Bay Shoreline:

This area includes about one mile of shoreline surrounding NUWC, excluding the landfill area. One test site along the northeast shore came up potentially toxic to marine organisms. This site was tested again and it was found that cleanup was not necessary.

For more information, call Christine Gover, Restoration Advisory Board Community Co-chair, at (360) 297-8526.

Detailed reports are available at two Kitsap County library branches: Central, 1301 Sylvan Way, Bremerton, and Poulsbo, 700 NE Lincoln.

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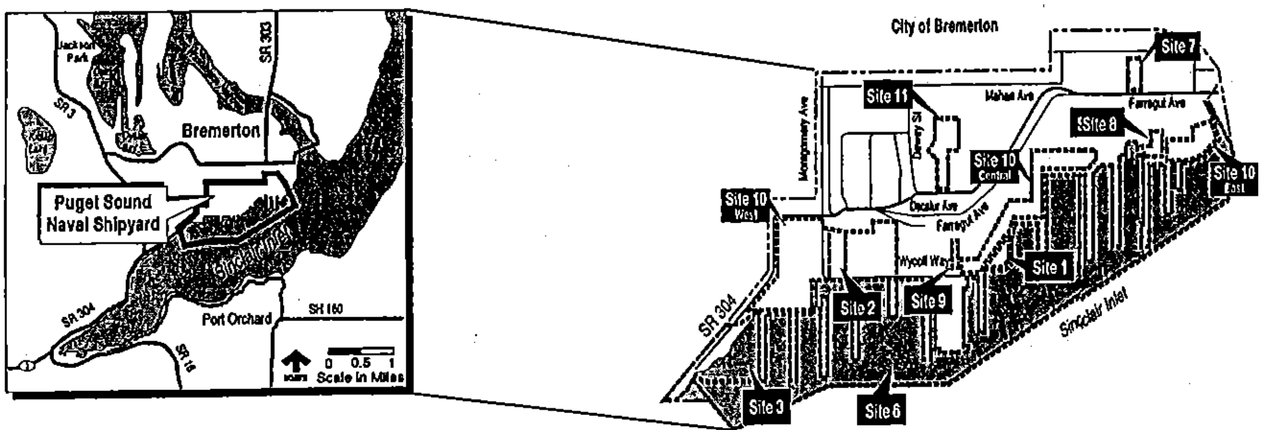
5/9/97

Puget Sound Naval Shipyard/Fleet Industrial Supply

Puget Sound Naval Shipyard -Operable Unit A (OU A)- Includes Site 3



Location Map *Site Map*

WHERE: Puget Sound Naval Shipyard (PSNS) is located in Bremerton, along the north shore of Sinclair Inlet. OUA is best known as the parking lot for the "Mighty Mo," on the southwest corner of the shipyard.

WHY/HOW: PSNS was established in 1891. Activities have included battleship repair, modernization, overhauls, shipbuilding and submarine decommissioning. Most of the "land" at the shipyard was created though a gradual process of filling marshy areas and tideflats. The fill materials included excavated soils, construction debris, and miscellaneous chemical-containing wastes. OUA was used for disposal of plating wastes.

WHAT: Found in the soils
(pose potential risk to humans):

- Lead
- cPAH (Polynuclear aromatic hydrocarbons)
- PCB's (polychlorinated byphenyls)
- Arsenic
- Mercury
- BEHP (bis-2-ethylhexylphthalate)

Found in the soils
(pose a potential risk to the ecology):

- Mercury
- Copper
- Phenol
- Zinc
- DDT (pesticide)
- DDD (pesticide)

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.

(Over)

Found in fish/shellfish (pose a potential risk to humans)

- PCB's (polychlorinated byphenyls) aroclor 1254 and 1260

Note: many more chemicals were found in amounts that exceed regulatory criteria, that were considered in the cleanup plan. Those listed above pose the most risk.

ACTIONS: All paved areas will be sealed and a bulkhead put along the shoreline to prevent further erosion. Habitat enhancement will either occur upland or in the marine environment. Long-term monitoring will confirm effects of these cleanup actions. Contaminated sediments connected with this site are being considered as part of the OUB study. All cleanup actions assume continued non-residential use of the site. Cleanup actions are scheduled for this summer.

For more information, call Rich Yanss, Restoration Advisory Board Community Co-chair, at (360) 373-4081.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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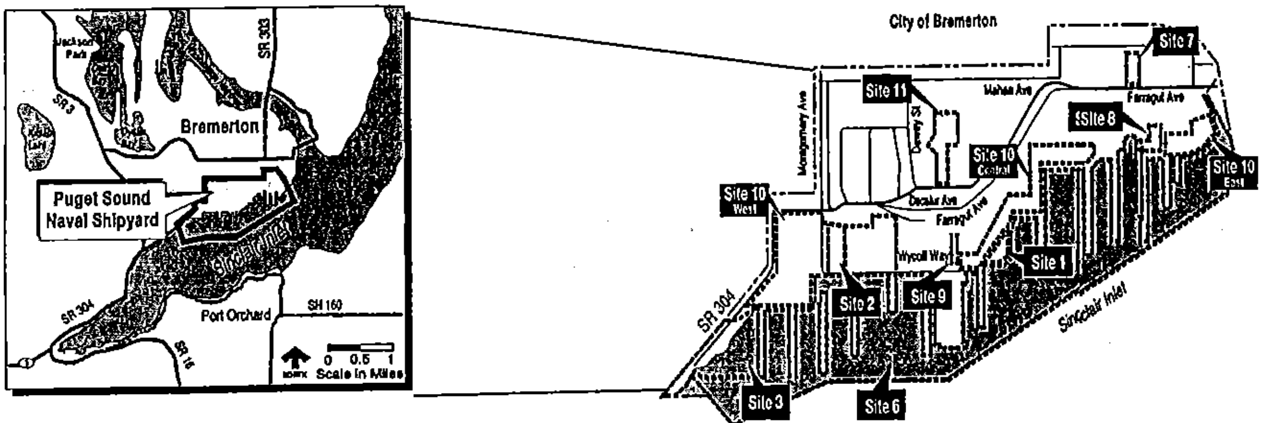
5/9/97

Puget Sound Naval Shipyard/Fleet Industrial Supply

Puget Sound Naval Shipyard -Operable Unit B (OU B)- Includes Sites 1, 2, 6, 7, 8, 9, 10 East, 10 Central, 10 West



Location Map *Site Map*

WHERE: Puget Sound Naval Shipyard (PSNS) is located in Bremerton. OUB involves most of the heavily industrialized waterfront area of the shipyard except for Site 12, which is the Fleet Industrial Supply Center, in the west central portion of the shipyard and OUA at the far southwest end. OUB also includes the Sinclair Inlet marine environment adjacent to the shipyard.

WHY/HOW: PSNS was established in 1891. Activities have included battleship repair, modernization, overhauls, shipbuilding and submarine decommissioning. Most of the "land" was created though a gradual process of filling marshy areas and tideflats with soil and debris, including some contaminated materials.

WHAT: Numerous organic and inorganic chemicals were found at OUB that exceed regulatory criteria. A detailed list can be found in the Remedial Investigation (*see "Detailed reports" below). More information concerning this site will become available after the Washington State Department of Ecology and the Environmental Protection Agency have commented on the Remedial Investigation (studies performed by the Navy). Contamination exists in the soil, groundwater, marine sediments and fish and shellfish.

> *Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.*
>
> *We have listed the chemicals that exceed state or federal levels and have noted which ones are of the most concern. We did not want to make any more judgements than that.*

ACTIONS: The State and Federal agencies are still assessing the significance of the findings that appear in the Remedial Investigation.
This information will be presented at a public meeting on June 24, 1997. Please call the RAB co-chair

(Over)

to confirm the date and time.

Note: Due to lack of citizen involvement, the communities that surround Sinclair Inlet are not part of the decision making process at this site. Increased involvement on the Restoration Advisory Board would ensure that the community's concerns would be considered in the clean up solution.

For more information, call Rich Yanss, Restoration Advisory Board Community Co-chair, at (360) 373-4081.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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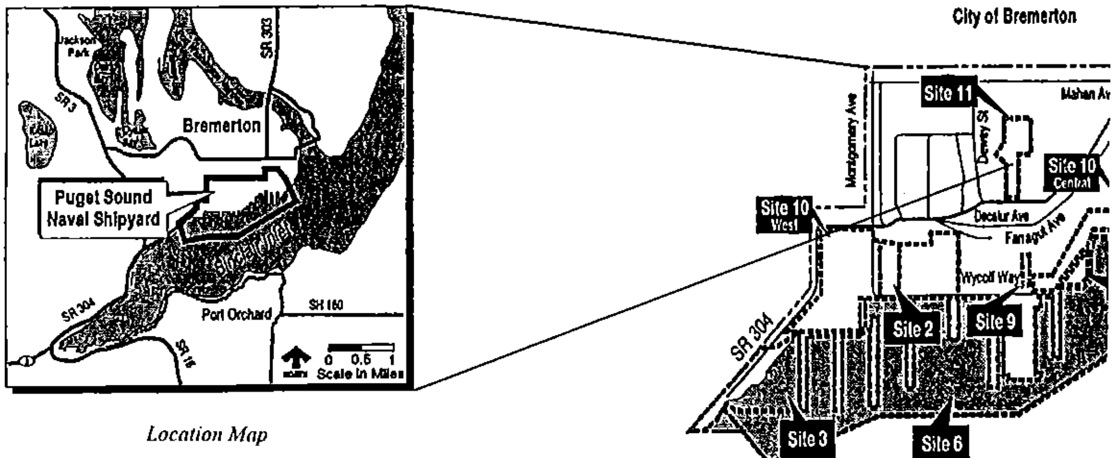
5/9/97

Puget Sound Naval Shipyard/Fleet Industrial Supply

Puget Sound Naval Shipyard -Operable Unit C (OU C)- Site 11



Location Map

Site Map

WHERE: Puget Sound Naval Shipyard (PSNS) is located in Bremerton, along the north shore of Sinclair Inlet. OUC is located upland, in the middle of the shipyard. It is also called Site 11.

WHY/HOW: PSNS was established in 1891. Activities have included battleship repair, modernization, overhauls, ship building and submarine decommissioning. Most of the "land" was created through a gradual process of filling marshy areas and tideflats with contaminated soil and debris. OUC is about 20 acres of land with one oil tank above ground and two below ground. These tanks were put in place between 1915 and 1919.

WHAT:

Found in the soil:

- Petroleum

ACTIONS: Two tanks have been pumped, cleaned, filled with sand and left in place. Another tank has been emptied and cleaned and then will be demolished. The technique used for cleaning the soil is called steam sparging. Steam is forced into the ground with injection wells, heating the soil to 200 degrees, lowering the viscosity and enabling it to be pumped out of the ground with extraction wells. The sparging started in the Fall of 1996. More injection wells will be added this year. Cleanup assumes continued industrial use of the site.

Listing chemicals found at hazardous waste sites is complicated at best. Finding a chemical doesn't automatically mean it needs to be cleaned up. It may be in very small amounts, in only a few areas or may occur in nature at similar levels. Sometimes contaminants are not even considered a risk, if it is thought no one can be exposed to them. For instance, if groundwater is contaminated, but no one has a drinking water well in that area, the contamination will be left.

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For more information, call Rich Yanss, Restoration Advisory Board Community Co-chair, at (360)

(Over)

373-4081.

Detailed reports are available at the Central Branch Library, 1301 Sylvan Way, Bremerton (360) 377-7601.

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5/9/97

Appendix K
Hazardous Material Generation Sites in Kitsap County

HID_NUM	HHANDLER	County	SIC	HGEN	HLOCSTRT1	HLOC_CITY	HLOC_ZIP
WAD982654162	AUTO SHOP THE	KITSAP	7532	2	11216 SUNRISE DR	BAINBRIDGE	98110
WA0000568998	BAINBRIDGE IS AUTO REPAIR	KITSAP	7538	2	8890 B MILLER RD NE	BAINBRIDGE	98110
WAD988488201	BAINBRIDGE ISLAND PARK BATTLE POINT	KITSAP	7999	2	ARROW POINT DR	BAINBRIDGE	98110
WAD988503314	BLUE SKY BUILDERS	KITSAP	2599	2	8040 DAY RD W	BAINBRIDGE	98110
WAD988518056	CRYSTAL CLEANERS	KITSAP	7210	2	323 HIGH SCHOOL RD NE STE 4	BAINBRIDGE	98110
WAD156900367	EAGLE HARBOR MARINA CONDO OWNERS ASSOC	KITSAP	4493	2	5834 WARD AVE NE	BAINBRIDGE	98110
WAD070978374	JERRYS AUTO REBUILD	KITSAP	7532	2	8890 MILLER RD NE	BAINBRIDGE	98110
WAD988522231	RAYS AUTOMOTIVE & TOWING	KITSAP	7538	2	7070 EAGLE HARBOR DR	BAINBRIDGE	98110
WA0000073064	SAGE MANUFACTURING	KITSAP	3949	2	8500 NE DAY RD	BAINBRIDGE	98110
WAD982653644	USEPA EAGLE HARBOR CLEANUP	KITSAP	9999	2	EAGLE HARBOR	BAINBRIDGE	98110
WAD982652208	WDOT WA STATE FERRIES BAINBRIDGE IS	KITSAP	4482	3	497 HARBORVIEW DR	BAINBRIDGE	98110
WAD988472197	WDOT WASHINGTON STATE FERRIES	KITSAP	4482	2	HWY 305 S END BAINBRIDGE IS	BAINBRIDGE	98110
WAD062779855	ISLAND CENTER AUTOMOTIVE	KITSAP	7532	2	9270 MILLER RD NE	BAINBRIDGE	981101459
WA0000230276	AQUABIOTICS CORP	KITSAP	2898	3	10750 ARROW PT DR	BAINBRIDGE	981101469
WAD988492682	VILLAGE SVC MART INC	KITSAP	5541	2	439 HIGH SCHOOL RD NE	BAINBRIDGE	981101624
WAD988506671	BAINBRIDGE IS SD TRANSPORTATION FAC	KITSAP	8211	3	9451 NE NEW BROOKLYN RD	BAINBRIDGE	981102999
WAD009248295	WYCKOFF EAGLE HARBOR SUPERFUND SITE	KITSAP	2491	2	5350 CREOSOTE PL NE	BAINBRIDGE	98110
WAD981774227	WDOT PIT I111	KITSAP	9621	2	GLENWOOD RD SW & SW LIDER RD	BELFAIR	98528
WAD988494464	ARCTIC RADIATOR SVC INC	KITSAP	7539	2	5460 HWY 303 NE	BREMERTON	98310
WAD988486163	CHEVRON USA INC SS 92862	KITSAP	5541	2	4221 WHEATON WAY	BREMERTON	98310
WAD988514535	GARYS TRACYTON GARAGE	KITSAP	7538	2	4970 MAY ST NW	BREMERTON	98310
WAD988513198	HARRISON MEMORIAL HOSPITAL	KITSAP	8062	2	2520 CHERRY ST	BREMERTON	98310
WAD988492047	KTBW TV	KITSAP	4833	2	GOLD MTN 4 MI W OF CY	BREMERTON	98310
WAD988501961	LEE FABRICATORS INC	KITSAP	3499	3	1725 PENNSYLVANIA AVE N	BREMERTON	98310
WA0000712919	PACIFIC COAST ENERGY COMPANIES	KITSAP	5171	2	1702 PENNSYLVANIA AVE	BREMERTON	98310
WAD027276179	PARK AVE CLEANERS	KITSAP	7216	1	421 PARK AVE	BREMERTON	98310
WAD040196057	TCL CLEANERS & LAUNDRY	KITSAP	7215	2	PERRY AVE MALL	BREMERTON	98310
WAD988482402	TOSCO SITE 03131	KITSAP	5541	2	4804 HWY 303	BREMERTON	98310
WAD051244648	WINFIELD CLEANERS	KITSAP	7216	2	1132 WHEATON WAY	BREMERTON	98310
WAD070970389	UPTOWN AUTO BODY REBILS INC	KITSAP	7532	3	708 PACIFIC AVE	BREMERTON	983101240
WAD988501938	L & R AUTOMOTIVE	KITSAP	7538	3	1112 PEARL ST	BREMERTON	983102838
WAD084400548	ALTERNATIVE AUTOBODY & REPAIR	KITSAP	7532	3	3940 WHEATON WAY	BREMERTON	983103538
WA0000137554	EAGLE HARDWARE & GARDEN 321	KITSAP	5251	2	4220 WHEATON WAY NE	BREMERTON	983103604
WAD988497418	JIFFY LUBE 795	KITSAP	7549	2	4810 WHEATON WAY AKA HWY 303	BREMERTON	983103605
WA0000015818	EAST TOWNE CLEANERS	KITSAP	7216	3	4207 WHEATON WAY STE D	BREMERTON	983103626
WAD988497947	KMART 3270	KITSAP	5399	2	4210 WHEATON WAY	BREMERTON	983103627
WA8170090007	USNAVY PSNS NAVSEADET PERA CV	KITSAP	9711	3	1305 IRONSIDES AVE	BREMERTON	983104924
WA0000232553	CENTRAL KITSAP SD 401 OLYMPIC HS	KITSAP	8211	3	7070 STAMPEDE BLVD NW	BREMERTON	983108927
WAD988517264	ARCO PRODUCTS CO 5810 PRESTIGE STA 5229	KITSAP	5541	2	2101 W 6TH ST	BREMERTON	98312
WAD982656233	BREMERTON CHRYSLER PLYMOUTH DODGE	KITSAP	5511	2	4525 AUTO CTR	BREMERTON	98312
WAD988491551	CARPENTERS DIP STRIPPING	KITSAP	7641	2	605 S CAMBRIAN	BREMERTON	98312
WAD988482139	CHEVRON USA INC SS 95166	KITSAP	5541	2	4399 KITSAP WAY	BREMERTON	98312
WAR000003186	FABRICARE CLEANERS	KITSAP	7216	2	5861 WERNER RD	BREMERTON	98312
WAD027274976	HASELWOOD BUICK GMC	KITSAP	5511	2	4117 KITSAP WAY	BREMERTON	98312
WA0000472753	HASELWOOD EXPO	KITSAP	5511	2	501 WESTHILLS BLVD	BREMERTON	98312

HID_NUM	HHANDLER	County	SIC	HGEN	HLOCSTRT1	HLOC_CITY	HLOC_ZIP
WA0000189480	HEARTLAND TOYOTA	KITSAP	5511	3	515 WEST HILLS BLVD	BREMERTON	98312
WAD988466025	J C TRANSMISSION INC	KITSAP	7538	2	5217 1ST ST	BREMERTON	98312
WAD988497509	KITSAP CO FAIR & PARKS WILDCAT LK	KITSAP	9199	3	9205 HOLLY RD NW	BREMERTON	98312
WAD981761372	KITSAP TRANSIT	KITSAP	4173	2	234 S WYCOFF AVE	BREMERTON	98312
WAD050168335	LONGS AUTO REBUILD INC	KITSAP	7532	3	815 S NATIONAL AVE	BREMERTON	98312
WA0000049239	P F R INDUSTRIES	KITSAP	7215	2	4203 KITSAP WAY	BREMERTON	98312
WAD980977649	PARR FORD	KITSAP	5511	1	5101 KEAN ST	BREMERTON	98312
WAD982655276	PARR IMPORTS INC	KITSAP	5511	2	5008 KEAN ST	BREMERTON	98312
WAD988519864	PARR MAZDA	KITSAP	5511	2	4949 KEAN ST	BREMERTON	98312
WA0000712943	RAINBOW AUTOBODY & PAINTING	KITSAP	7532	3	4320 HAWTHORNE AVE W	BREMERTON	98312
WAD988488425	THOMAS MOTORS INC	KITSAP	5511	2	5012 KEAN ST	BREMERTON	98312
WAD062733670	TODAY CHEVROLET	KITSAP	5511	3	5011 KEAN ST	BREMERTON	98312
WAD988517546	TOWN & COUNTRY AUTO REPAIR	KITSAP	7538	2	3420 CHICO WAY NW	BREMERTON	98312
WAD980976971	TREW AUTO BODY	KITSAP	7532	3	3700 K STREET	BREMERTON	98312
WAD988496766	UNITED PARCEL SVC BREMERTON	KITSAP	4215	2	8000 WERNER RD	BREMERTON	98312
WA3143600085	USNAVY NAV SEA DET	KITSAP	3494	3	307 S WYCOFF	BREMERTON	98312
WAD981774284	WDOT PIT I86	KITSAP	9621	2	6000 WILKERSON RD	BREMERTON	98312
WAD156898835	WEST HILLS HONDA	KITSAP	5511	2	520 WEST HILLS	BREMERTON	98312
WAD988496584	CHICO TOWING	KITSAP	3711	2	920 N WYCOFF AVE	BREMERTON	983120017
WA4170027268	USNAVY NAVAL HOSPITAL BREMERTON	KITSAP	8062	1	BOONE RD	BREMERTON	983121898
WAD988474771	KITSAP PENINSULA VOC SKILLS CTR	KITSAP	8249	2	101 NATIONAL AVE N	BREMERTON	983123108
WAD988489118	HOOVER OLDS CAD INC	KITSAP	5511	2	5100 KEAN ST	BREMERTON	983123344
WA0000230441	BREMERTON CY OF	KITSAP	7538	3	100 OYSTER BAY AVE	BREMERTON	983123442
WAD988486205	BREMERTON HOUSING AUTHORITY	KITSAP	9531	2	110 RUSSELL RD	BREMERTON	983123478
WAD988507901	B & B AUTO REPAIR INC	KITSAP	7538	2	299 NATIONAL AVE S	BREMERTON	983123679
WAD988490058	AABERG & FEEK INC	KITSAP	5013	2	405 S NATIONAL AVE	BREMERTON	983123698
WAD988498432	MIKES AUTO REPAIR	KITSAP	7538	2	934 N WYCOFF	BREMERTON	983123809
WAD988494852	U HAUL OF BREMERTON	KITSAP	7359	3	2804 KITSAP WAY	BREMERTON	983123950
WAD988494472	BAYVIEW SUBARU	KITSAP	5511	2	3888 W HWY 16	BREMERTON	983125064
WA2170023418	USNAVY PUGET SOUND NAVAL SHIPYARD	KITSAP	9711	1	1400 FARRAGUT AVE CODE 106.3	BREMERTON	983145001
WAD076646975	OLYMPIC COLLEGE	KITSAP	8222	2	1600 CHESTER AVE	BREMERTON	983371699
WAD988492781	HANSVILLE REPAIR	KITSAP	7538	2	7538 BUCK LAKE RD	HANSVILLE	983409705
WAD988523098	KEYPORT AUTO REPAIR	KITSAP	7538	2	1954 HWY 308	KEYPORT	98345
WA1170023419	USNAVY NUWC DIV KEYPORT	KITSAP	9711	1	610 DOWELL ST	KEYPORT	983457610
WA0000103911	AUTO SHOP THE	KITSAP	7538	2	10373 SR 104 NE BLDG F3	KINGSTON	98346
WAD988490314	KINGSTON MARINE IND LTD	KITSAP	3732	2	25864 WASHINGTON BLVD NE	KINGSTON	98346
WAD988485330	PRECISION AUTOMOTIVE	KITSAP	7538	2	6101 MINDER RD NE	KINGSTON	98346
WAD988522611	ZIMMER CONSTRUCTION CO INC	KITSAP	1623	2	6101 NE MINDER RD BLDG A	KINGSTON	98346
WAD038522116	KINGSTON AUTO PARTS	KITSAP	5531	2	10373 STATE HWY 104	KINGSTON	983460209
WAD009262700	POPE & TALBOT INC	KITSAP	2421	1	SAWMILL	PORT GAMBLE	98364
WAD988474169	WDOT HOOD CANAL BRG	KITSAP	9621	3	SR 104 BTWN MP 13.93 & 15.46	PORT GAMBLE	98364
WAD988522058	ALS USED CAR & TRUCKS	KITSAP	5511	2	6270 BETHEL RD SE	PORT ORCHARD	98366
WAD988517173	ARCO PRODUCTS CO 5517 PRESTIGE STA 5525	KITSAP	5541	2	3231 SE LUND AVE	PORT ORCHARD	98366
WAD981768641	BAY FORD	KITSAP	5511	3	1215 E BAY ST	PORT ORCHARD	98366
WA2170023426	FISC PS MANCHESTER FUEL DEPT	KITSAP	9711	1	7501 BEACH DR E	PORT ORCHARD	98366

HID_NUM	HHANDLER	County	SIC	HGEN	HLOCSTRT1	HLOC_CITY	HLOC_ZIP
WAD988522959	GOODYEAR TIRE & RUBBER CO 8832	KITSAP	7538	3	2995 MILE HILL DR	PORT ORCHARD	98366
WAD988504320	GRADENS MARKET & DELI	KITSAP	5411	1	5455 SIDNEY RD SW	PORT ORCHARD	98366
WAD980977367	GREY CHEVROLET HOVDEE	KITSAP	5511	1	4949 HOVDEE	PORT ORCHARD	98366
WAD095729554	KENS AUTO BODY INC SIDNEY AVE	KITSAP	7532	3	2005 SIDNEY AVE	PORT ORCHARD	98366
WAD988490967	KITSAP CO PUBLIC WKS S RD SHOP	KITSAP	9199	3	2339 CEDAR RD SE	PORT ORCHARD	98366
WAD988512380	KITSAP MARINE IND INC	KITSAP	4493	3	1595 SW BAY ST	PORT ORCHARD	98366
WAD062719414	LEANDER RESEARCH MFG & DIST INC	KITSAP	3471	1	12300 SW SIDNEY RD	PORT ORCHARD	98366
WAD988514568	NOWKAS AUTOMOTIVE	KITSAP	7537	2	4268 SE MILE HILL DR	PORT ORCHARD	98366
WAD988478921	ONE STOP CLEANING	KITSAP	7216	3	1610 BAY ST	PORT ORCHARD	98366
WAD988488615	PORT ORCHARD BP	KITSAP	5541	2	1350 BAY ST	PORT ORCHARD	98366
WAD070971916	SOUTH KITSAP S 402	KITSAP	8211	2	1962 HOOVER AVE SE	PORT ORCHARD	98366
WAD982656928	SOUTH KITSAP SD 402 CEDAR HGTS JHS	KITSAP	8211	2	2220 POTTERY AVE	PORT ORCHARD	98366
WAD982657041	SOUTH KITSAP SD 402 CENTRAL WHSE	KITSAP	8211	3	1695 MADRONA DR SE	PORT ORCHARD	98366
WAD982656985	SOUTH KITSAP SD 402 J SEDGEWICK JHS	KITSAP	8211	2	8995 SE SEDGEWICK RD	PORT ORCHARD	98366
WAD982656803	SOUTH KITSAP SD 402 MAINT DEPT	KITSAP	8211	3	1650 SE CEDAR RD	PORT ORCHARD	98366
WAD982656860	SOUTH KITSAP SD 402 MARCUS WHITMAN	KITSAP	8211	2	1887 MADRONA DR SE	PORT ORCHARD	98366
WAD100569706	SOUTH KITSAP SD 402 S KITSAP HS	KITSAP	8211	3	425 MITCHELL AVE	PORT ORCHARD	98366
WAD988479739	SOUTH PARK VILLAGE CLEANERS	KITSAP	7212	3	1742 VILLAGE LN SE	PORT ORCHARD	98366
WA8680030931	USEPA MANCHESTER LABORATORY	KITSAP	8734	2	7411 BEACH DR E	PORT ORCHARD	98366
WAT540012655	USWCOM PORT ORCHARD CO	KITSAP	4813	2	2386 SIDNEY RD	PORT ORCHARD	98366
WA0000148742	KITSAP AUTO WRECKING INC	KITSAP	5015	2	4949 MILE HILL DR	PORT ORCHARD	983662102
WAD988494670	KITSAP CO PUBLIC WKS MATERIAL LAB	KITSAP	9532	3	507 AUSTIN	PORT ORCHARD	983664699
WAD981770290	KITSAP CO PUBLIC WRKS	KITSAP	9511	3	614 DIVISION ST BULLARD	PORT ORCHARD	983664699
WAD988518304	BUDGET AUTO REPAIR	KITSAP	7538	3	250 BETHEL AVE	PORT ORCHARD	983665216
WAD988494480	BETHEL GARAGE INC	KITSAP	7539	2	6750 BETHEL RD SE	PORT ORCHARD	983669522
WAD981774524	WDOT AREA 2 MAINT HQ	KITSAP	9621	2	8293 SPRING CRK RD	PORT ORCHARD	983669613
WAD982659104	ALLIANT TECHSYSTEMS INC ESC	KITSAP	8711	2	1050 NE HOSTMARK ST	POULSBO	98370
WAD988489647	CHEVRON USA INC SS 94265	KITSAP	5541	2	18764 HWY 305	POULSBO	98370
WAD055732572	COURTESY FORD	KITSAP	5511	2	20081 VIKING AVE NW	POULSBO	98370
WA0000777797	COURTESY RV SVC	KITSAP	5561	3	19955 VIKING AVE NW BLDG 5	POULSBO	98370
WAD988522116	FRED HILL MATERIALS INC	KITSAP	3273	2	15978 TOTTEN RD NE	POULSBO	98370
WAD988500427	KITSAP CO PUBLIC WKS CK PLT	KITSAP	4952	3	12350 BROWNSVILLE HWY	POULSBO	98370
WAD988521191	NEIGHBORHOOD PAINTERS INC	KITSAP	1721	2	5823 NE MINDER RD	POULSBO	98370
WAD982656365	NORTH KITSAP HIGH SCHOOL POULSBO	KITSAP	8211	2	1780 NE HOSTMARK ST	POULSBO	98370
WAD988513743	NORTH KITSAP SD TRANS DEPT	KITSAP	4151	2	13655 FINN HILL RD	POULSBO	98370
WA0000049262	P F R INDUSTRIES	KITSAP	7215	2	18763 SR 305	POULSBO	98370
WAD988494803	TIDE CHEVROLET GEO INC	KITSAP	5511	2	19520 VIKING AVE NW	POULSBO	98370
WAD988484416	POULSBO FIRE DEPT STA 1	KITSAP	9224	2	911 NE LIBERTY RD	POULSBO	983700050
WAD988492815	LIBERTY BAY AUTO CTR	KITSAP	5521	2	20201 FRONT ST NE	POULSBO	983707636
WAD988496055	POULSBO AUTO & RV	KITSAP	5561	3	19705 VIKING AVE NW	POULSBO	983708347
WAD070045414	WASHINGTON VETERANS HOME	KITSAP	8051	1	1141 BEACH DR E	RETSIL	98378
WA5170027291	USNAVY BANGOR SUBMARINE BASE	KITSAP	9711	1	1101 TAUTOG CIRCLE	SILVERDALE	983151087
WAD988522777	ACTION AUTO REPAIR INC	KITSAP	7538	2	9549 SILVERDALE WAY NW	SILVERDALE	98383
WAD988524484	ALL TUNE & LUBE SILVERDALE	KITSAP	7538	3	10726 SILVERDALE WAY NW	SILVERDALE	98383
WAD988470415	CENTRAL KITSAP SD 401 CENTRAL KITSAP HS	KITSAP	8211	3	3700 NW ANDERSON HILL RD	SILVERDALE	98383

HID_NUM	HHANDLER	County	SIC	HGEN	HLOCSTRT1	HLOC_CITY	HLOC_ZIP
WAD988506887	CENTRAL KITSAP SD 401 MAINT DEPT	KITSAP	8211	3	9102 DICKEY RD NW	SILVERDALE	98383
WA0000232561	CENTRAL KITSAP SD 401 TRANSP DEPT	KITSAP	4151	3	10170 FRONTIER PL NW	SILVERDALE	98383
WAD988485082	CHEVRON USA INC SS 95277	KITSAP	5541	2	9571 SILVERDALE WAY NW	SILVERDALE	98383
WAD180258337	EXPRESSLY PORTRAITS SILVERDALE	KITSAP	7221	3	10315 SILVERDALE WAY NW	SILVERDALE	98383
WAD180065252	FIRESTONE TIRE & RUBBER CO	KITSAP	5531	1	9730 SILVERDALE WAY NW	SILVERDALE	98383
WAD981774581	WDOT PIT I82	KITSAP	9621	2	T25N R1E WM S19 SE 1/4 NW 1/4	SILVERDALE	98383
WAD988519195	PRECISION TUNE 41 5	KITSAP	7539	2	2600 RANDALL WAY NW 109	SILVERDALE	983839427
WA0000143016	KITS CAMERAS FO59	KITSAP	5946	2	SP 128 KITSAP MALL BLVD	SILVERDALE	983839446
WAD988496352	DELS AUTOMOTIVE SVC	KITSAP	7538	3	BROCKTON & NEWTON R HAND SIDE	SUQUAMISH	98392
WAD988496741	SUQUAMISH AUTO REPAIR	KITSAP	7538	2	18522 AUGUSTA AVE	SUQUAMISH	98392

Appendix L
Washington Rivers Information System Database

WASHINGTON RIVERS INFORMATION SYSTEM DATABASE

Data Manager: Martin Hudson
(360) 902-2487

General Description

The Washington Rivers Information System (WARIS) Database is a statewide collection of natural resource data related to rivers and streams, and is the Washington component of the Northwest Environmental Database (NED). The database was originally designed for hydropower development and was expanded to provide administrators with natural resource data for planning on a local, statewide, and regional scale. The concept behind WARIS is to include data that are: (1) descriptive, (2) standardized geographically, (3) managed using a geographic information system (GIS), and (4) summarized by a ranking system to identify importance based on resource quality and critical resources.

WARIS is managed using Environmental Systems Research Institute's (ESRI) GIS software Arc/Info on a UNIX platform. The database includes the following: a 1:100,000 scale hydrography layer, resident and anadromous fish, Priority Habitat and Species (PHS) fish, wildlife, and natural features data. Planned categories include recreation sites, cultural and historic features, and institutional constraints.

The Washington Rivers Information System began with the Pacific Northwest Rivers Study, a 1984 effort promoted by the Bonneville Power Administration (BPA) and the states of Idaho, Montana, Oregon, and Washington. The Washington State database is presently managed by the Washington Department of Fish and Wildlife (WDFW) in cooperation with Indian Tribes, and other state and federal agencies. The database is primarily funded by Bonneville Power Authority with WDFW providing indirect funding through updates, technical support, hardware and software support, and administration.

This document provides a description of the five data categories currently in WARIS: (1) anadromous, (2) resident fish, (3) PHS fish, (4) wildlife, and (5) rare plants and plant communities. These data are available in Arc/Info export format or on maps. A menu system designed for personal computers is being developed by the Idaho Fish and Game.

Resolutions and Limitations

WARIS is available statewide at 1:100,000 scale of resolution and is the product of 1989-1990 data collection efforts.

Resident fish information is generalized to a river reach. More site-specific resident fish information is not available through this data set.

The anadromous fish data represent a data compilation effort involving fish experts from many different agencies and organizations. However, the resident fish data were compiled largely by interviews with WDFW biologists, so it is less comprehensive. About 50 percent of the 1:100,000 scale streams have known resident fish resources that have been described; the rest are unknown.

Data Organization and Structure

Hydrography

The 1:100,000 scale hydrography line files serve as the base for WARIS. The hydrography layer is a digital reproduction of the rivers and streams on the 1:100,000 scale US Geological Survey (USGS) quadrangle maps. The hydrography layer was developed by the USGS Water Resources Division in Portland, Oregon, and is described in the digital line coverage STR100.

Descriptive resource data are related to the hydrography data by a unique code assigned to each stream reach. The code is a modified version of the EPA river reach code or number (RRN), extended from the original 1:250,000 scale format to a version suitable to 1:100,000 scale. The RRN consists of three parts: USGS hydrologic unit code (HUC), reach segment code (SEG) and reach mile code (RMI). The format is:

HUC	SEG	RMI
17110004	0027	01.34

e.g. 17110004002701.34

The hydrography layer and related tabular files are organized by the USGS hydrologic unit (a list of hydrologic units by river basin is in Appendix L). The hydrologic unit code (HUC) comprises the first 8 digits of the river reach number or code (RRN). The segment (SEG) and river mile (RMI) portions of the river reach code (SEGRMI) provide the relating mechanism between the hydrography layer and the tabular attribute files which describe the natural resources.

Shorelines of double-banked streams, braided streams, lakes, and reservoirs are stored in the coverage called banks. Stream centerlines run through these features to complete the stream network.

DATA STRUCTURE NAME: STR100

DATA STRUCTURE TYPE: Arc/Info line coverage

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	FNODE#	4	5	B	-	-------------------------
5	TNODE#	4	5	B	-	
9	LPOLY#	4	5	B	-	
13	RPOLY#	4	5	B	-	Arc attributes
17	LENGTH	4	12	B	3	
21	STR100#	4	5	F	-	
25	STR100-ID	4	5	B	-	-------------------------
29	STRTYPE	3	3	C	-	*Synthesis of the USGS MAJOR and MINOR codes

*Codes used to describe general stream types were synthesized from the USGS stream classification codes (MAJOR and MINOR) used for Digital Line Graph Attribute Coding Standards.

UN = uncoded feature
CH = channel in water
OW = open water
SH = shoreline
STE = ephemeral stream
STP = perennial stream
XP = excludes unlabeled polygons

AR = artificial water transport
GS = glacier/snowfield
PI = pipeline
STD = dry stream
STI = intermittent stream
WL = wetland

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
32	MAJOR1	6	6	I	-	-------------------------
38	MINOR1	6	6	I	-	Stream type codes from DLG
44	MINOR2	6	6	I	-	
50	MINOR3	6	6	I	-	-------------------------
56	RRN	17	17	C	-	River reach number
73	LEVEL	2	2	I	-	Stream hierarchy (250K)
75	FLAGS	5	5	C	-	250K stream typing system
80	STR-NAME	30	30	C	-	Stream names (incomplete)
110	STATE	4	4	C	-	Predominate state

DATA STRUCTURE: STR100 (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
114	STATE-2	4	4	C	-	Secondary state
118	COUNTY	15	15	C	-	Predominate county
133	COUNTY-2	15	15	C	-	Secondary county
148	QUAD100	26	26	C	-	Predominate 100K quad name
174	QUAD100-2	26	26	C	-	Secondary 100K quad name
200	QUAD75	25	25	C	-	Predominate 24K quad name
225	QUAD75-2	25	25	C	-	Secondary 24K quad name
250	CEN	4	5	B	-	Node ID of allocation center used to create steam linkage.
254	CUMLENGTH	4	12	F	2	Cumulative length in meters from the allocation center
258	SAVENEG	1	1	I	-	Flag on arcs blocked before allocation. Includes canals, aqueducts, and braids.
259	NONROUTE	4	4	F	2	Reaches assigned a negative allocation value. Indicates a non-linkage stream.
263	SINUOS	5	5	N	2	Sinuosity-ratio of stream length over straight line distance
268	PNTR#	5	5	I	-	Pointer used in the linkage system. Up and down stream
273	UHUC1	8	8	I	-	First upstream HUC unit
281	UPNTR1	5	5	I	-	First upstream reach (points to PNTR# of upstream reach)
286	UHUC2	8	8	I	-	Second upstream HUC unit

DATA STRUCTURE: STR100 (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
294	UPNTR2	5	5	I	-	Second upstream reach
299	UHUC3	8	8	I	-	Third upstream HUC unit
307	UPNTR3	5	5	I	-	Third upstream reach
312	UFLAG	1	1	I	-	Flag indicating more upstream reaches
313	DHUC	8	8	I	-	Downstream HUC unit
321	DPNTR	5	5	I	-	Downstream reach
			** REDEFINED ITEMS **			
56	HUC	8	8	I	-	USGS hydrologic unit code
64	SEG	4	4	I	-	Reach segment code
68	RMI	5	5	N	2	Reach mile
64	SEGRMI	9	9	N	2	Combined SEG and RMI to give a unique reach identifier
58	XRRN	15	15	N	2	Cross-basin relate code

Banks Hydrography

The banks hydrography layer contains double-banked streams and rivers, the shorelines of lakes and reservoirs, and the boundaries of glaciers. The coverage was developed by the USGS Water Resources Division in Portland, Oregon, and is described in the digital polygon coverage BANKS.

DATA STRUCTURE NAME: BANKS

DATA STRUCTURE TYPE: Arc/Info polygon coverage

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	AREA	4	12	F	3	Arc/Info attributes
5	PERIMETER	4	12	F	3	
9	BANKS#	4	5	B	-	
13	BANKS-ID	4	5	B	-	
17	MAJOR1	6	6	I	-	Feature type from USGS DLG's
23	MINOR1	6	6	I	-	
29	MINOR2	6	6	I	-	
35	MINOR3	6	6	I	-	
41	HUC	8	8	I	-	USGS hydrologic unit code

Anadromous Fish

The anadromous fish data contained in the Washington Rivers Information System represents current knowledge in the field. Updates to these data will continue during 1995, completion date unknown. Updates are normally a cooperative effort between WDFW and the Northwest Indian Fisheries Commission (NWIFC). Funding will be provided in part by the BPA, and the efforts to compile the data into a format usable for WARIS are being coordinated by WDFW.

Anadromous fish data are organized by the USGS hydrologic unit and are related to the STR100 hydrography layer by the identifier codes SEGRMI (within basin) XRRN (cross-basin). The files contain anadromous fish presence by reach, the upper extent of anadromous ranges, blockages to anadromous fish passage, passage facilities, and fish production facilities statewide. Data exist in two formats:

1. The Arc/Info point coverage ANADPTS containing anadromous fish upper extent locations, blockages, passage facilities, and production facilities. Each point includes descriptive attributes on species and feature presence.

2. The INFO files ANAD contain river reach codes with reach anadromous features, including species, blockages, production facilities, and passage facilities.

Refinements are planned for the INFO attribute file ANAD. These include: (1) determination of the proportion of anadromous use of the upper extent reaches, and (2) the determination of the reach mile distance of blockages, passage facilities, and production facilities.

DATA STRUCTURE NAME: ANAD

DATA STRUCTURE TYPE: INFO table

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	RRN	17	17	C	-	River reach number

The following items identify species presence by name. The species items are coded 1 if the reach is used by the species. Items with the suffix '-UP' are coded 1 if the reach is an upper extent of that species.

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
18	COHO	4	4	N	2	Coho salmon
22	COHO-UP	1	1	I	-	
23	CHUM	4	4	N	2	Chum salmon
27	CHUM-UP	1	1	I	-	
28	CHSP	4	4	N	2	Spring chinook
32	CHSP-UP	1	1	I	-	
33	CHSU	4	4	N	2	Summer chinook
37	CHSU-UP	1	1	I	-	
38	CHFA	4	4	N	2	Fall chinook
42	CHFA-UP	1	1	I	-	
43	CHUK	4	4	N	2	Unknown chinook
47	CHUK-UP	1	1	I	-	
48	SOCK	4	4	N	2	Sockeye
52	SOCK-UP	1	1	I	-	
53	PINK	4	4	N	2	Pink
57	PINK-UP	1	1	I	-	
58	STSU	4	4	N	2	Summer steelhead
62	STSU-UP	1	1	I	-	
63	STWI	4	4	N	2	Winter steelhead
67	STWI-UP	1	1	I	-	

DATA STRUCTURE: ANAD (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
68	STJU	4	4	N	2	Juvenile steelhead
72	STJU-UP	1	1	I	-	
73	STUK	4	4	N	2	Unknown steelhead
77	STUK-UP	1	1	I	-	
78	ATSA	4	4	N	2	Atlantic salmon
82	ATSA-UP	1	1	I	-	
83	WHST	4	4	N	2	White sturgeon
87	WHST-UP	1	1	I	-	
88	GRST	4	4	N	2	Green sturgeon
92	GRST-UP	1	1	I	-	
93	SMET	4	4	N	2	Smelt
97	SMET-UP	1	1	I	-	
98	SHAD	4	4	N	2	Shad
102	SHAD-UP	1	1	I	-	
103	BLOCK	4	4	C	-	*Blockage type present

*Blockage codes are as follows: first letter is either 'I' for impassable to all species or 'P' for passable to at least one. The next two letters are defined as:

B	= beaver dam	H	= chute	S	= screens
SS	= soil slump	L	= logjams	D	= dam
VB	= velocity barrier	F	= falls	T	= culvert
GB	= gradient barrier	M	= marsh	U	= unknown
DT	= dam with trap and haul	O	= ford	W	= weirs
G	= flood gate	P	= pipe	C	= cascades

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
107	PRODUCT	2	2	C	-	*Production facility type

*Production codes are as follows:

SC	= spawning channel	SP	= spawning pads	HT	= hatchery
OW	= over-winter pond	RP	= rearing pond	EB	= egg box
CP	= conditioning pond	NP	= net pens	ET	= egg tube

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
109	PROD_ID	3	3	I	-	ID number relating to a file on production facilities

DATA STRUCTURE: ANAD (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
112	PASSAGE	1	1	C	-	Y/N flag indicates passage facility presence
113	OUTPLANT	1	1	C	-	Y/N flag indicates anadromous fish planted above an impassable blockage
114	REV_DATE	8	8	C	-	Revision date
122	REV_WHO	40	40	C	-	Person updating data
162	NUMSPP	2	2	I	-	Total number of species
164	ACCESS	1	1	I	-	Flag indicating reach is accessible to anadromous fish
165	HATWATSRC	1	1	I	-	Flag indicating a reach that supplies water to production facilities
166	POTACCESS	1	1	I	-	Flag indicating potential access to reaches through engineered facilities
167	PLANACCESS	1	1	I	-	Flag indicating reaches for planned access through enhancement or restoration
168	SPECIALMGMT	1	1	I	-	Flag for upstream reaches of spring chinook waters
169	HYDROCAT	1	1	I	-	State Hydropower Plan codes for reach classification 1 = protected area 2 = sensitive area 3 = data available but not class 1 or 2 4 = unknown 3 & 4 combined = hydropower opportunity area

DATA STRUCTURE: ANAD (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
			** REDEFINED ITEMS **			
1	HYDROUNIT	8	8	I	-	USGS hydrologic unit code
9	SEGRMI	9	9	N	2	Four-digit reach segment and river reach mile
3	XRRN	15	15	N	2	Cross-basin relate code

DATA STRUCTURE NAME: ANADPTS

DATA STRUCTURE TYPE: Arc/Info point coverage

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	AREA	4	12	F	3	-------------------------
5	PERIMETER	4	12	F	3	Arc/Info attributes
9	ANADPTS#	4	5	B	-	
13	ANADPTS-ID	4	5	B	-	-------------------------
17	IDNUM	3	3	I	-	Unique point ID number

The following items have a value of 1 if the point is an upper extent reach of the particular species, otherwise the value is 0.

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
20	COHO-UP	1	1	I	-	Upper extent coho salmon
21	CHUM-UP	1	1	I	-	" " chum salmon
22	CHSP-UP	1	1	I	-	" " spring chinook
23	CHSU-UP	1	1	I	-	" " summer chinook
24	CHFA-UP	1	1	I	-	" " fall chinook
25	CHJU-UP	1	1	I	-	" " juvenile chinook
26	CHUK-UP	1	1	I	-	" " unknown chinook
27	SOCK-UP	1	1	I	-	" " sockeye salmon
28	PINK-UP	1	1	I	-	" " pink salmon
29	STSU-UP	1	1	I	-	" " summer steelhead
30	STWI-UP	1	1	I	-	" " winter steelhead
31	STJU-UP	1	1	I	-	" " juvenile steelhead
32	STUK-UP	1	1	I	-	" " unknown steelhead
33	ATSA-UP	1	1	I	-	" " atlantic salmon

PHS STRUCTURE: ANADPTS (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
34	WHST-UP	1	1	I	-	Upper extent white sturgeon
35	GRST-UP	1	1	I	-	" " green sturgeon
36	SMET-UP	1	1	I	-	" " smelt
37	SHAD-UP	1	1	I	-	" " shad
38	NUMSPP	2	2	I	-	Number of species
40	BLOCK	4	4	C	-	Blockage (see above codes)
44	PRODUCT	2	2	C	-	Production (see above codes)
46	PROD_ID	3	3	I	-	Relates to PRODUCTION below
49	PASSAGE	1	1	C	-	Y/N passage flag
50	OUTPLANT	1	1	C	-	Y/N flag for planted PASSAGE
51	COMMENTS	50	50	C	-	Comments
101	REV_DATE	8	8	C	-	Revision date
109	REV_WHO	40	40	C	-	Revision source

The tabular file PRODUCTION contains data on production facilities. The item PROD_ID provides the relation link between the ANADPTS coverage and the ANAD INFO file described above and this PRODUCTION description file.

DATA STRUCTURE NAME: PRODUCTION

DATA STRUCTURE TYPE: INFO table (relates to ANADPTS)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	PROD-ID	3	3	I	-	Relate item to ANADPTS
4	FACLNAME	40	40	C	-	Facility name
46	LOCATION	60	60	C	-	Location by water name
106	BASINAME	15	15	C	-	Basin name

DATA STRUCTURE: PRODUCTION (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
121	WRIASTRNO	10	10	C	-	WRIA stream number
131	OPERATOR	15	15	C	-	Facility operator(s)
161	WATERSRC	60	60	C	-	Water source
221	SPECIES	20	20	C	-	Species reared (anadromous and resident fish codes)
251	COMMENTS	50	50	C	-	Comments
259	HYDROUNIT	8	8	I	-	USGS hydrologic unit code

Anadromous fish data limitations are as follows:

1. Not all potential access areas (POTACCESS) have been designated in the database. However, the more important ones have.

2. Not all production facilities have a hatchery water source (HATWATSRC) identified.

3. None of the reaches have been assigned with a hydropower category of 3, indicating that enough information exists to conclude a resource conflict exists. This code would normally be assigned by traveling upstream of the impassable barriers and coding the reaches with a HYDROCAT = 3. This has not been completed due to the unpredictable linkage system in the STR100 1:100,000 scale hydrography layer. Corrections to STR100 are currently under way and the reaches will be reclassified when the project is completed.

4. Upper extent reaches are labeled as having fish present even though only the lower portion may be used. This may be modified in the future, possibly using dynamic segmentation to define migration routes for anadromous fish. At this time the point coverage describing upper extent can be used.

Resident Fish

The resident fish database design was based on processes and data types that were originally used in the Pacific Northwest Rivers Assessment Study. In the interest of improving objectivity, item types were reviewed and given more specific parameter definitions where necessary. The main objective is to minimize the number of items for which data were collected to only those most pertinent to river and stream reach quality assessment and critical resource identification.

Data were collected on resident fish species present in a reach and for population origins, planted or naturally reproducing. Relative values were calculated for each reach based on the recreation and/or management value of fish species present. A flag was added to indicate species of concern presence. The relative abundance of game fish present was evaluated. Data were also entered for habitat characteristics important to fish production (gradient, substrate, in-stream cover, riparian cover, and water quality limiting factors). For recreational value assessment the relative amount of angler use on a reach was evaluated.

An INFO file table describes resident fish populations and resources for each basin. Files for resident fish are placed in each basin and are related to the STR100 hydrography coverage using the SEGRMI item. Data were collected via an interview process with WDFW fish and habitat biologists. Consistency during the process was critical and maintained throughout. The biologists relied upon professional knowledge based on field surveys, research projects, and experience. They were encouraged to use reports and survey data when required or involved other professionals in the field who had knowledge of the area.

Data item values are in two formats: true/false flags and three descriptive categories. Each descriptive category was assigned a relative numeric value of high, medium, or low (1, 2, 3) based on that characteristic's importance for producing resident fish (e.g. GRADIENT categories were: 1 = greater than 4%, 2 = 1% through 4%, 3 = less than 1%). The assigned values for each item are not species-specific but are based on general trout habitat requirements taken from studies modeling stream habitat and trout production.

Due to structure problems in listing all 79 known resident fish species in Washington State, accessibility for mapping and analysis is rather difficult. To remedy this problem the files will be split into two sub-files, one for species and a second containing critical values and habitat information. This change will be completed during the next 12 months.

DATA STRUCTURE NAME: RESFISH

DATA STRUCTURE TYPE: INFO table

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	RRN	17	17	C	-	River reach number
18	REV_WHO	29	29	C	-	Data source or revisor
47	REV_DATE	8	8	C	-	Date of data collection
55	SP1	3	3	C	-	----------------------------
58	SP2	3	3	C	-	All known species present in
61	SP3	3	3	C	-	the reach--uses WDFW fish
64	SP4	3	3	C	-	species codes.

DATA STRUCTURE: RESFISH (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
67	SP5	3	3	C	-	
70	SP6	3	3	C	-	All known species present in the reach--uses WDFW fish species codes. (see Appendix K)
73	SP7	3	3	C	-	
76	SP8	3	3	C	-	
79	SP9	3	3	C	-	
82	SP10	3	3	C	-	-----------------------------
85	GRADNT	1	1	I	-	Percent gradient for a reach: 1 = > 4%, 2 = 1-4%, 3 = < 1%
86	SUBSTR	1	1	I	-	The average stream channel substrate. Values are based more on rearing habitat than on spawning habitat. 1 = boulders/rubble 2 = rubble/gravel 3 = gravel/fines
87	INCOV	1	1	I	-	In-stream cover: organic debris, undercut banks, pools caused by rocks, substrate rubble, turbulence, deep pools, brush piles, and aquatic vegetation. Also describes the percent of wetted area containing material that offers protection and concealment from swift currents, food, and shade. The percent of wetted area containing cover is averaged for the reach. 1 = > 50% of wetted area 2 = 25 - 50% of wetted area 3 = < 25% of wetted area

DATA STRUCTURE: RESFISH (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
88	RIPCOV	1	1	I	-	Description of organic cover and inorganic material on or above the bank that offers shading, protection from soil erosion, and escape cover or resting security for fish. Riparian cover is expressed as a percent of bank surface that is covered by vegetation or other cover materials and the degree of erosion control. 1 = > 50% of stream bank with little or no erosion 2 = 25 - 50% of stream bank and limited active erosion 3 = < 25% of stream bank and active erosion present
89	H2OQUAL	1	1	I	-	Assessment of water quality limiting factors: pollution, high temperatures, turbidity, dissolved gases, and low flows due to withdrawals or natural causes. 1 = no known limiting factors 2 = factors not annual in the occurrence or only mildly limiting 3 = factors present and are annually impacting fish populations
90	HABIMPT	1	1	C	-	A flag based on protection of upland and riparian areas to prevent major habitat impacts to downstream fishery resources. Upland or riparian areas received a T (true) or an F (false).

DATA STRUCTURE: RESFISH (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
90	HABIMPT (cont.)	1	1	C	-	T = > 1,500 feet elevation, AND slope 30 - 50%, AND adequate vegetation to prevent erosion F = all others
91	GFABUND	1	1	I	-	An assessment of game fish abundance in a reach relative to other reaches within a biologist's jurisdiction. 1 = high abundance 2 = intermediate abundance 3 = low abundance
92	ANGLUSE	1	1	I	-	A assessment of angler use of game fish in a reach relative to other reaches within a biologist's jurisdiction. 1 = high use 2 = intermediate use 3 = low use
93	GFVAL	1	1	I	-	Relative importance of game fish present in a reach. 1 = high: all native 2 = medium: introduced fish with active management 3 = low: introduced fish with no active management or game fish present
94	NGVAL	1	1	I	-	Relative importance of non-game fish present in a reach. 1 = high: native non-game fish of threatened, endangered, sensitive, or monitored status listed by Federal, State, or WDFW 2 = medium: all other native non-game fish

DATA STRUCTURE: RESFISH (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
94	NGVAL (cont.)	1	1	I	-	3 = low: introduced non-game fish
95	SPAWN	1	1	C	-	A flag to identify key reaches of known spawning areas. T = key reaches with spawning habitat critical to fish population perpetuation F = reaches where spawning habitat is absent
96	SPPCON	1	1	C	-	Presence of WDFW classified species of concern T = Dolly Varden/Bull Trout, Olympic Mudminnow, Pygmy Whitefish, and Searun Cutthroat F = the above are not present
97	ORIGIN	1	1	I	-	Population origin 1 = native population 2 = wild population with some historical stocking 3 = planted population
98	COMMENTS	50	50	C	-	Comments
148	SUMRANK	2	2	I	-	Sum of descriptive items
150	HABRANK	2	2	I	-	Sum of habitat parameters
152	SUMVAL	1	1	I	-	Grouped SUMRANK values 1 = outstanding 2 = substantial 3 = moderate 4 = low 5 = insufficient data

DATA STRUCTURE: RESFISH (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
153	CRITICAL	1	1	C	-	Flag for critical spawning or species of concern presence T = present F = not present
154	HYDROCAT	1	1	I	-	Hydropower classification 1 = protected area 2 = sensitive area 3 = data available but not 1 or 2 4 = unknown 3 & 4 = hydropower opportunity
156	DB.STATUS	1	1	I	-	Dolly Varden/Bull Trout 1 = historically present 2 = present, unknown status 3 = present, high risk 4 = present, moderate risk 5 = present, low risk 6 = present, no immediate risk
			** REDEFINED ITEMS **			
1	HYDROUNIT	8	8	I	-	USGS hydrologic unit code
9	SEGRMI	9	9	N	2	Four-digit reach segment and river reach mile
3	XRRN	15	15	N	2	Cross-basin relate code

The Washington Department of Fish and Wildlife produced two summary fields to provide managers with a means for determining management priorities: (1) a SUMMARY value that describes the overall quality of a reach for resident fish by assigning each reach a relative rank, and (2) a CRITICAL resources flag that identifies a reach as having either a species of concern or has critical spawning habitat.

Several different procedures for determining a summary value were explored and the options were reviewed by a panel of eight fish biologists. The one that preserved the most information while injecting the least bias was chosen. That summary process is as follows: Sum the values of each data item (those assigned a 1, 2, or 3 -- high, intermediate, or low). For example:

SUMMARY RANK = GRADIENT + SUBSTRATE + INSTREAM COVER + RIPARIAN COVER + WATER QUALITY + ORIGIN + GAME FISH VALUE + NONGAME FISH VALUE + ANGLER USE + GAME FISH ABUNDANCE

The possible range for SUMMARY RANK are 10 - 30. This value was calculated for reaches which data were complete. Ranks for all basins were pooled and a frequency distribution of SUMMARY RANK versus TOTAL MILES of river and stream lengths were examined to group the data into four classes:

Summary Value	Definition	Summary Rank Range
0	No Data	
1	Excellent Value	10 - 15
2	Substantial Value	16 - 20
3	Moderate Value	21 - 25
4	Low Value	26 - 30
5	Insufficient Data	

Applications can use the SUMMARY value to identify relative quality of river/ stream reaches for resident fish and use the CRITICAL RESOURCES flag to identify reaches that can not withstand alterations without jeopardizing rare or critical resources.

The only noteworthy limitation for these data is that a high proportion (53%) of the reaches are unknown, most of which are small tributaries.

Priority Habitats and Species Fish

The priority habitats and species files (PHSFISH) have recently been added to the WARIS database. They consist of Washington State priority habitat fish species presence. These data include both anadromous and resident fish.

DATA STRUCTURE NAME: PHSFISH

DATA STRUCTURE TYPE: INFO table

Species presence is defined if the reach is coded with a T; a blank space in the field indicates absence. The redefined item PHSFLAG is a composite of PHS fish presence by reach. A select on this item will pull all streams containing one or more species of PHS fish. The XRRN item provides the capability of using cross-basin selects.

DATA STRUCTURE: PHSFISH

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	RRN	17	17	C	-	River reach number
18	DB	1	1	C	-	Dolly Varden/Bull Trout
19	CCT	1	1	C	-	Coastal resident cutthroat
20	KOK	1	1	C	-	Kokanee salmon
21	RB	1	1	C	-	Rainbow trout
22	SCT	1	1	C	-	Searun cutthroat
23	SS	1	1	C	-	Steelhead, summer
24	SW	1	1	C	-	Steelhead, winter
25	SH	1	1	C	-	Steelhead, unknown
26	WCT	1	1	C	-	Westslope cutthroat
27	CC	1	1	C	-	Channel catfish
28	LMB	1	1	C	-	Largemouth bass
29	SMB	1	1	C	-	Smallmouth bass
30	WAL	1	1	C	-	Walleye
31	MNS	1	1	C	-	Mountain sucker
32	OMM	1	1	C	-	Olympic mudminnow
33	PGW	1	1	C	-	Pigmy whitefish
34	SAN	1	1	C	-	Sandroller
			** REDEFINED ITEMS **			
1	HYDROUNIT	8	8	I	-	USGS hydrologic unit code
9	SEGRMI	9	9	N	2	Combined reach segment and river reach mile

DATA STRUCTURE: PHSFISH (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
			** REDEFINED ITEMS **			
18	PHSFLAG	17	17	C	-	Composite presence flag
3	XRRN	15	15	N	2	Cross-basin relate code

Wildlife

The wildlife information in WARIS is a combination of existing databases at Washington Department of Fish and Wildlife. They include the following:

1. Wildlife Heritage (HRTG) Database - point occurrences of non-game species, focusing on rare, threatened, and endangered species. For more information contact Tom Owens at (360) 902-2489.

2. Spotted Owl Database - spotted owl occurrences and center of activity data. For more information contact Ann Potter at (360) 902-2496.

3. Habitat Conservation Areas (HCA) - US Forest Service (USFS) designated HCA. For more information contact the US Forest Service, Portland, Oregon.

4. Priority Habitats and Species (PHS) Database - mapped WDFW priority habitat and species areas. For information contact Terry Johnson (360) 902-2494.

The WILDLIFE database exists in two files, one is the main file containing one record per reach, and the second is a normalized file SPECIES containing all species which occur along a reach.

DATA STRUCTURE NAME: WILDLIFE

DATA STRUCTURE TYPE: INFO table

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	RRN	17	17	C	-	River reach number
18	HCAFLAG	1	1	I	-	Indicates reach overlap of USFS designated spotted owl habitat conservation area (HCA)

DATA STRUCTURE: WILDLIFE (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
19	FOREST	3	3	C	-	National Forest on which the HCA is located MBS = Mt. Baker Snoqualmie OLY = Olympic GIP = Gifford Pinchot WEN = Wenatchee OKA = Okanogan
22	HYDROCAT	1	1	I	-	Hydropower classification 1 = protected area 2 = sensitive area 3 = data available but not 1 or 2 4 = unknown 3 & 4 = hydropower opportunity
23	TEFLAG	1	1	I	-	Flag (0/1) indicating presence of state or federal threatened or endangered species
24	PHSSPPFLAG	1	1	I	-	Flag (0/1) indicating presence of a priority species within a specified buffer distance from a reach (See Appendix J)
25	PHSPOLY	1	1	I	-	Flag (0/1) indicating the overlap with a priority habitat or species polygon
			** REDEFINED ITEMS **			
1	HYDROUNIT	8	8	I	-	USGS hydrologic unit code
9	SEGRMI	9	9	N	2	Combined reach segment and river reach mile
3	XRRN	15	15	N	2	Cross-basin relate code

DATA STRUCTURE NAME: SPECIES

DATA STRUCTURE TYPE: INFO table

List of species and associated attributes by reach. More than one species can be listed per reach. The file has a one to many relationship with the STR100 river reach files.

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	SEGRMI	9	9	N	2	Extended EPA segment and river mile code
10	SPPCODE	6	6	C	-	Code indicating presence of a species within a specified buffer distance of a reach (See Appendix J)
16	INDEX	6	6	C	-	Nature Conservancy listed species code
22	OCCUR	3	3	I	-	Individual record number
25	SEQNO	2	2	I	-	Individual nest number within a multiple nest territory
27	DATAPT	3	3	I	-	Labels data point on a quad in Wildlife Heritage Database
30	CLASS	2	2	C	-	SA = special animal ZA = destroyed site
32	STASTAT	2	2	C	-	State protection status SE = state endangered ST = state threatened SS = state sensitive SC = state candidate SM = state monitor
34	FEDSTAT	2	2	C	-	Federal protection status FE = federal endangered FT = federal threatened FS = federal sensitive FC = federal candidate

DATA STRUCTURE: SPECIES (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
36	PHCLASS	1	1	C	-	Phylogenitic class A = invertebrate B = fish C = herptile D = bird E = mammal
37	PRIORT	2	2	I	-	Synthesis of protected status 1 = state endangered 2 = proposed state endangered 3 = state threatened 4 = proposed state threatened 5 = state sensitive 6 = proposed state sensitive 7 = state monitor 8 = proposed state monitor
39	COORD	1	1	I	-	Coordinate precision C = less than or equal to 1/4 mile and biologist confirmed U = less than or equal to 1/4 mi. but unconfirmed N = location known within one mile G = location known to general area
40	CRIT	5	5	C	-	Data entry criteria B = breeding site BOX = artificial nest site CF = cross-foster site (peregrines only) CR = communal roost E = eyrie H = hack site (peregrines only) IO = individual occurrence

DATA STRUCTURE: SPECIES (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
40	CRIT (cont.)	5	5	C	-	LEK = prairie grouse lex RLC = regular large concentration RSC = regular small concentration
45	YEAR	4	4	I	-	Year observation entered into Wildlife Heritage Database
49	TEBUFF	1	1	I	-	Flag (0/1) indicating a known T & E species site occurrence within 1000 feet
50	REFNO	4	4	I	-	Relate item to the Spotted Owl Database--one number per entry
54	SITENO	3	3	I	-	Relate item to the Spotted Owl Database--one number per entry
57	PHSSPP	1	1	I	-	Flag (0/1) indicating a known priority species occurrence within a specified buffer distance (See Appendix J)
58	HYDROCAT	1	1	I	-	Hydropower classification 1 = protected area 2 = sensitive area 3 = data available but not 1 or 2 4 = unknown 3 & 4 = hydropower opportunity

Priority Habitats and Species data and species listings are only available for commercial and private forest land at this time.

Natural Heritage Features

The natural features data in WARIS include rare plant and plant community information housed in the Natural Heritage Program of the Washington Department of Natural Resources. These data are point occurrences only and are called element occurrences. The point data were converted to an Arc/Info coverage and spatially related to the 1:100,000 scale hydrography layer to tag reaches with element occurrences present within specified distances from stream and river reaches.

Element occurrences were assigned to river reaches using two buffer distances. If the data point represented an individual occurance of a rare plant, those points were buffered with a 1000-foot circle and any reach intersecting that circle was assigned that element occurance. If the point represented a polygon feature or a plant community, the point was buffered with a 2640-foot radius circle and intersected with the river reaches.

DATA STRUCTURE NAME: NATFEAT

DATA STRUCTURE TYPE: INFO table

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
1	RRN	17	17	C	-	River reach number
18	IDXCODE	6	6	C	-	Element name abbreviation.
24	OCCUR	3	3	I	-	Element occurrence number. Both items together provide a relate key to Washington Natural Heritage Database managed by the Department of Natural Resources.
27	CLASS	2	2	I	-	Feature type SP = special plant PC = plant community NC = natural community or wetland
29	DATAPT	3	3	I	-	Unique element number by 7.5-minute quad map.
32	TRS	20	20	I	-	Township, range, section, and sub-section of an occurrence

DATA STRUCTURE: NATFEAT (continued)

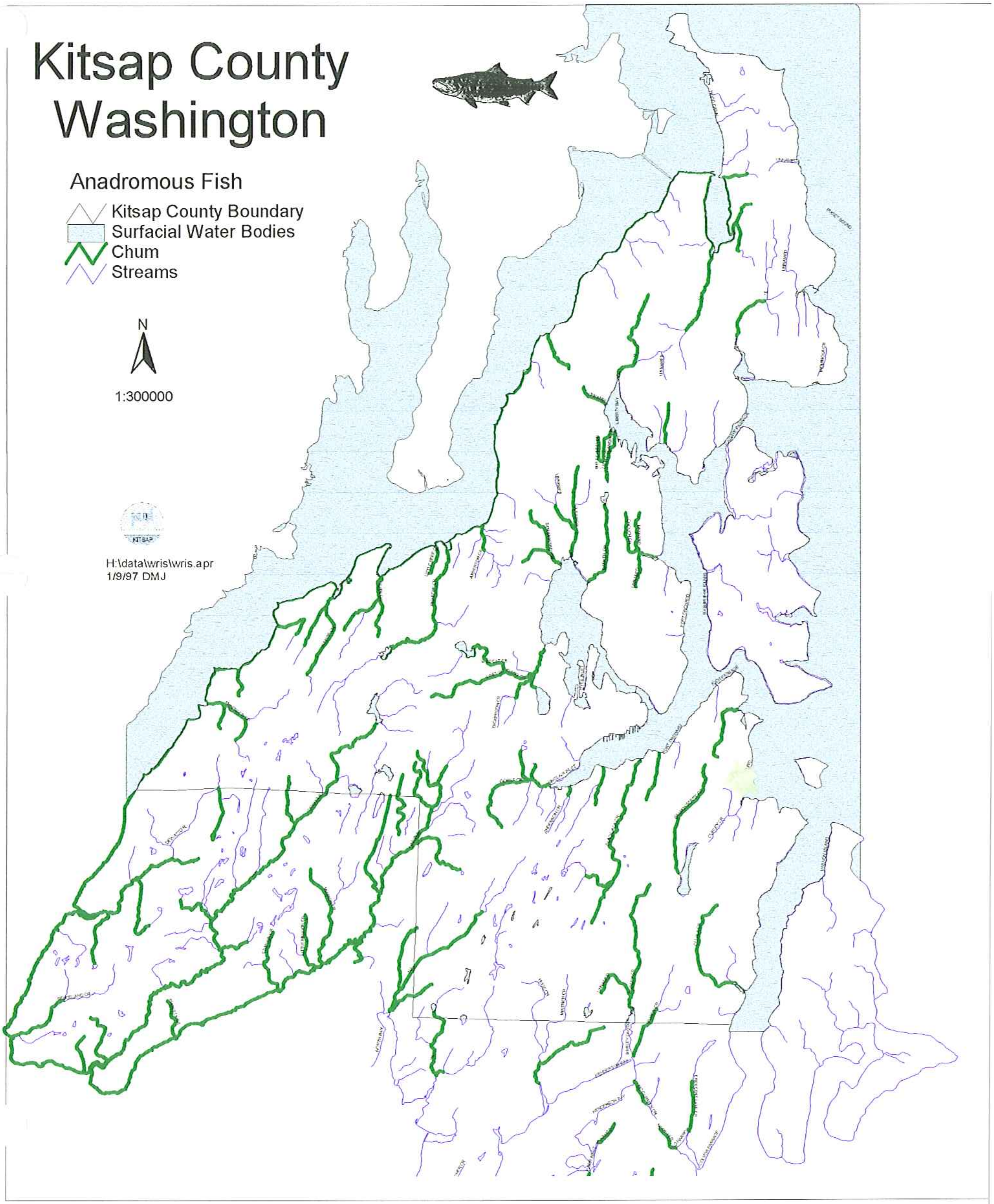
COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
52	STASTAT	2	2	C	-	State status SE = state endangered ST = state threatened SS = state sensitive
54	FEDSTAT	2	2	C	-	Federal status FE = federal endangered FT = federal threatened FS = federal sensitive FC = federal candidate FX = no federal status
56	PROTECT	1	1	C	-	The Nature Conservancy protection status with regard to land ownership and management 1 = preserved - a site legally protected (WA State, only federal wilderness areas) 2 = protected - site that is administrative designated, classified, registered,or otherwise recognized as a natural area 3 = unprotected
57	PRIORT	1	1	I	-	Synthesis of federal and state status (see above codes) 1 = SE & FC; 2 = SE & FX 3 = ST & FC; 4 = ST & FX 5 = SS & FC; 6 = SS & FX
58	SEQNO	1	1	I	-	Unique number for duplicate elements

DATA STRUCTURE: NATFEAT (continued)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	DESCRIPTION
59	COORD	1	1	C	-	Confirmation or coordinate precision C = confirmed - known within a 1/4 mile radius and is confirmed by the Natural Heritage Program U = unconfirmed - known within a 1/4 mile radius but has not been confirmed N = non-specific - known within a one mile radius, but was derived from a secondary source
60	OWNCODE	9	9	C	-	Land ownership
69	YEAR	4	4	I	-	Year of observation
73	EONAME	54	54	C	-	Element occurrence name
127	HYDROCAT	1	1	I	-	Hydropower protection designation in WA State Hydropower Development and Resource Protection Plan
128	BUFFDIST	5	5	I	-	Distance from a reach within which the element occurrence exists. 1000 feet (305 meters) - point occurrence data 2640 feet (805 meters) - polygon
			** REDEFINED ITEMS **			
1	HYDROUNIT	8	8	I	-	USGS hydrologic unit code
9	SEGRMI	9	9	N	2	Combined reach segment and river reach mile

DATA STRUCTURE: NATFEAT (continued)

All data for natural features exist as point locations in the Washington Natural Heritage Database. Therefore, the actual boundaries of the Natural Area Preserves, Natural Conservation Areas, and Research Natural Areas were not used. Because of this, a point location was buffered to 2640 feet to approximate an area polygon. Additionally, the point data for these areas are not current. Also some Natural Heritage features (plant communities and wetlands) exist on the ground as polygon features. Again, the areas were approximated with a 2640-foot buffer.


Kitsap County
Washington
Anadromous Fish
Kitsap County Boundary
Surfacial Water Bodies
Chum
Streams
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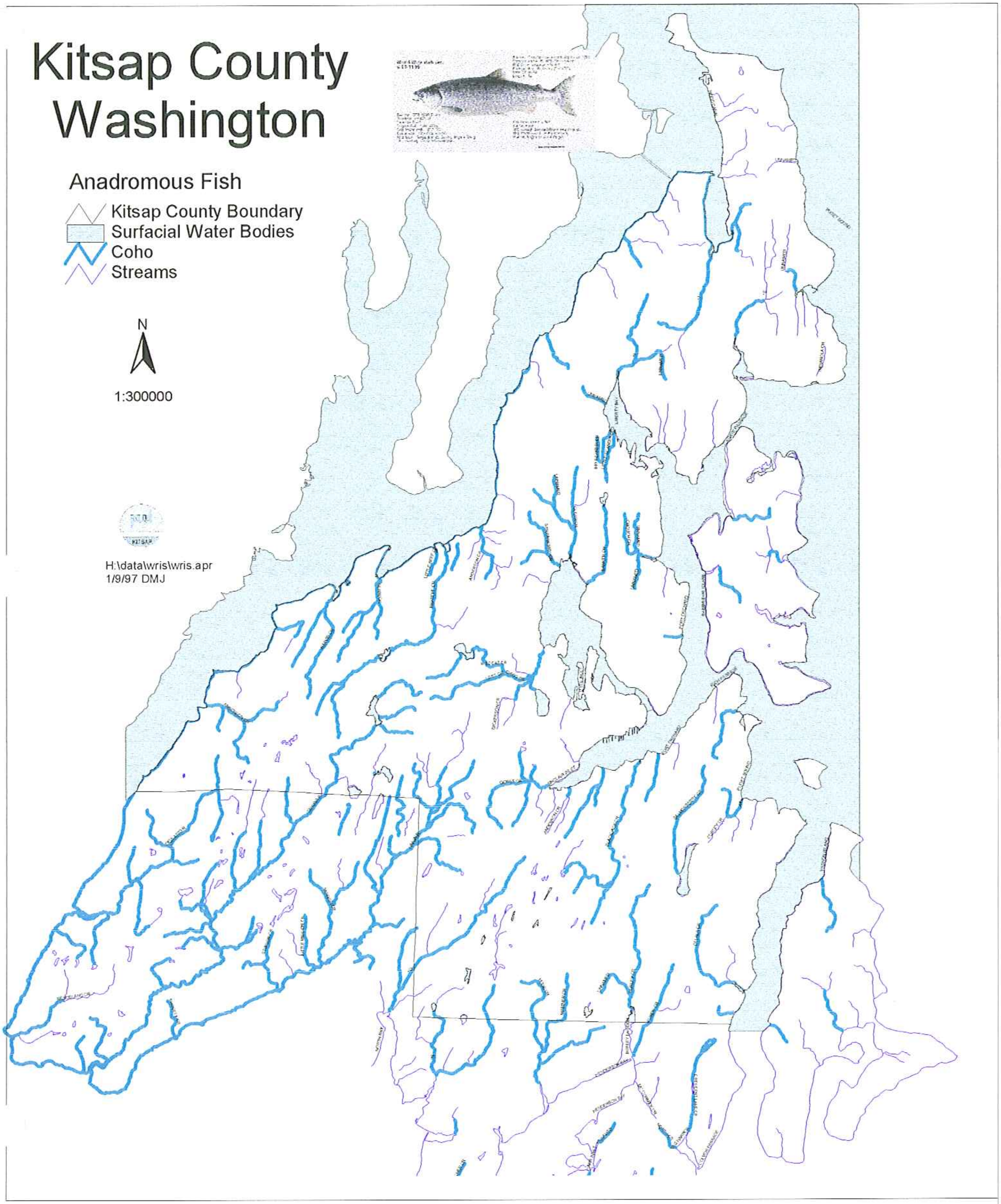
1/9/97 DMJ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Washington
Anadromous Fish
Kitsap County Boundary
Surfacial Water Bodies
Coho
Streams
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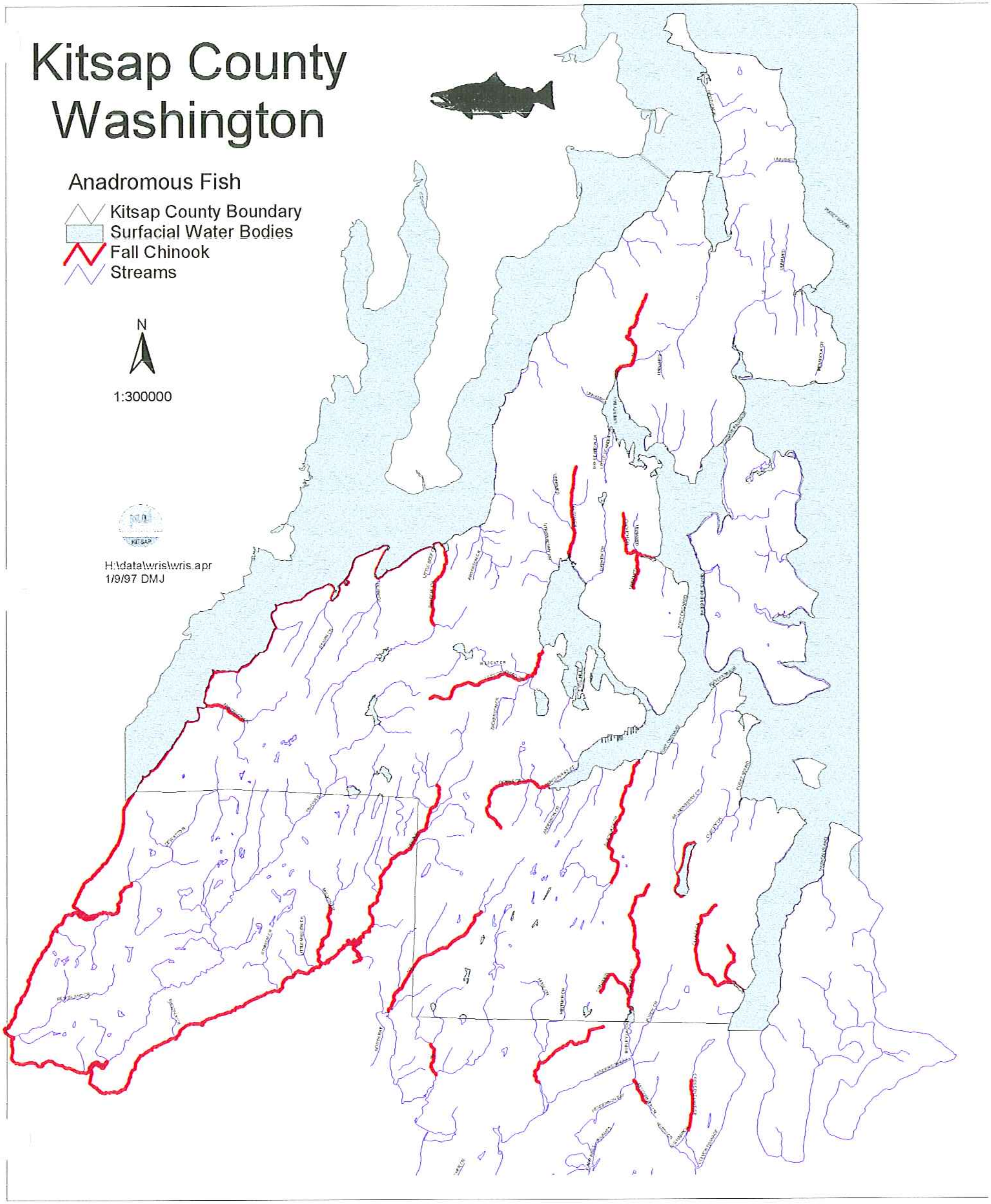
1/9/97 DMJ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Washington
Anadromous Fish
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Streams
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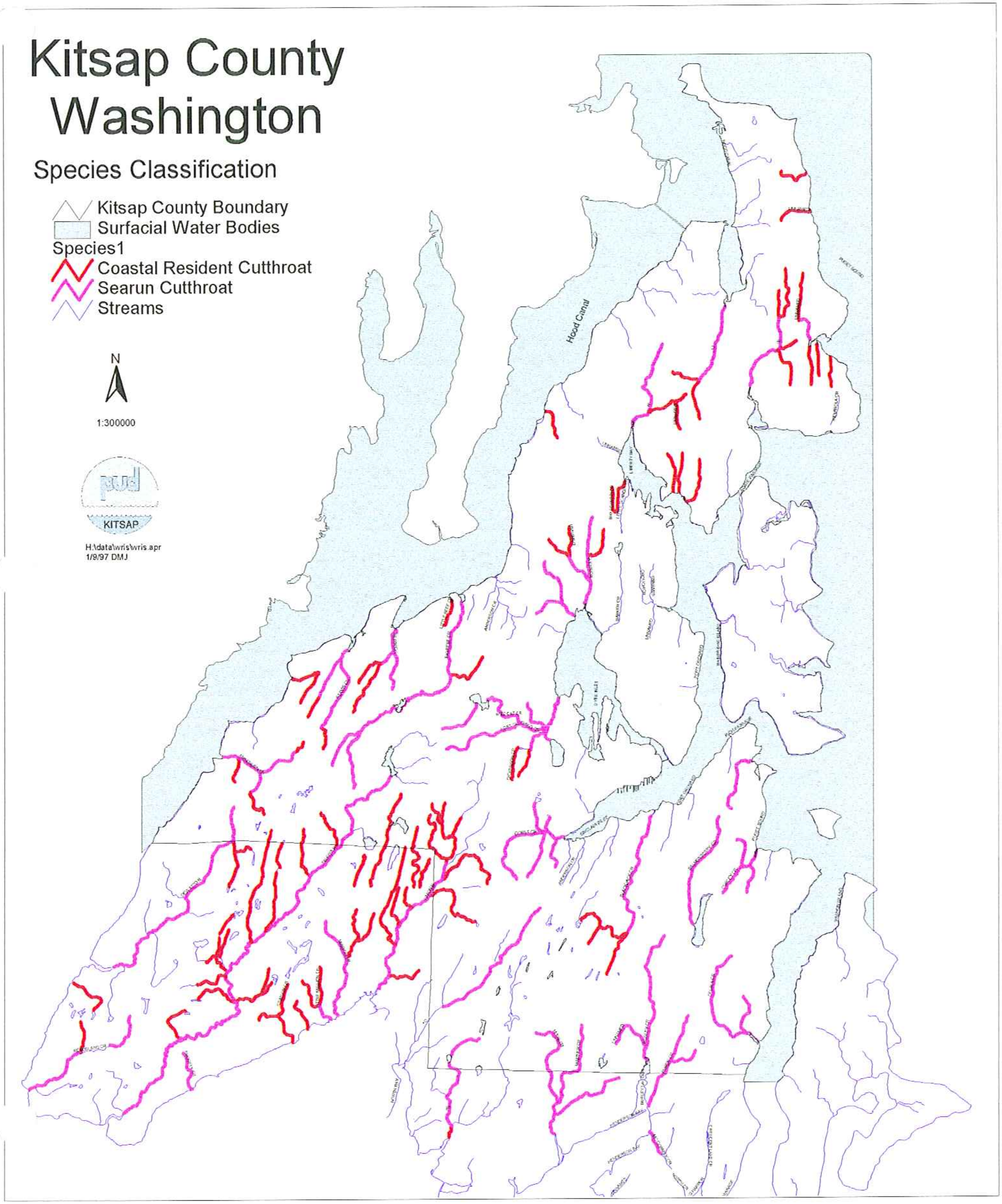
1/9/97 DMJ



Kitsap County
Washington
Species Classification
Kitsap County Boundary
Surfacial Water Bodies
Species1
Coastal Resident Cutthroat
Searun Cutthroat
Streams
N
1:300000
KITSAP
H:\data\wris\wris.apr
1/9/97 DMJ
Hood Canal

Kitsap County Washington

Species Classification

Kitsap County Boundary
Surfacial Water Bodies
Species2
Coastal Resident Cutthroat
Rainbow Trout
Searun Cutthroat
Streams

N

1:300000

KITSAP

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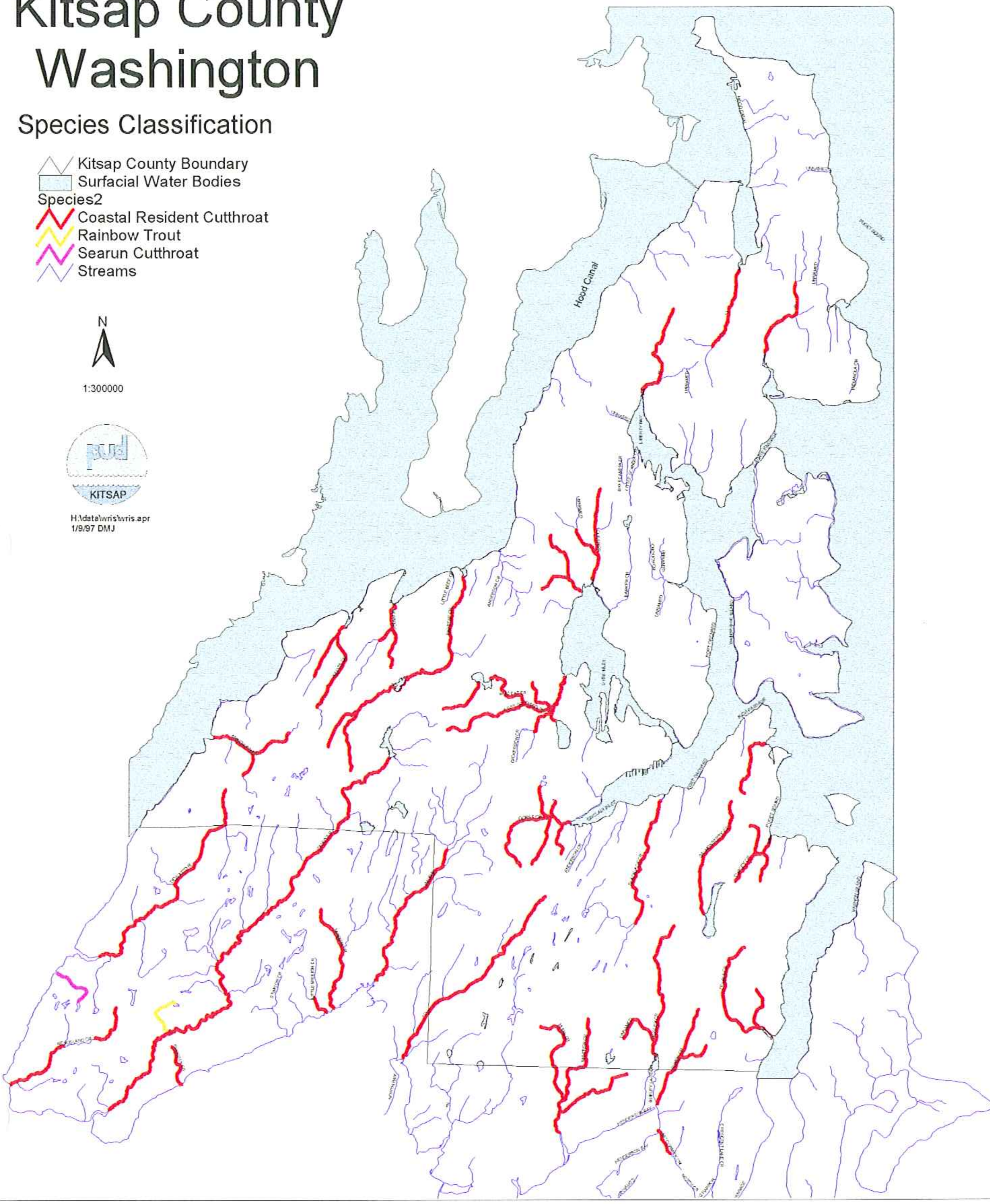
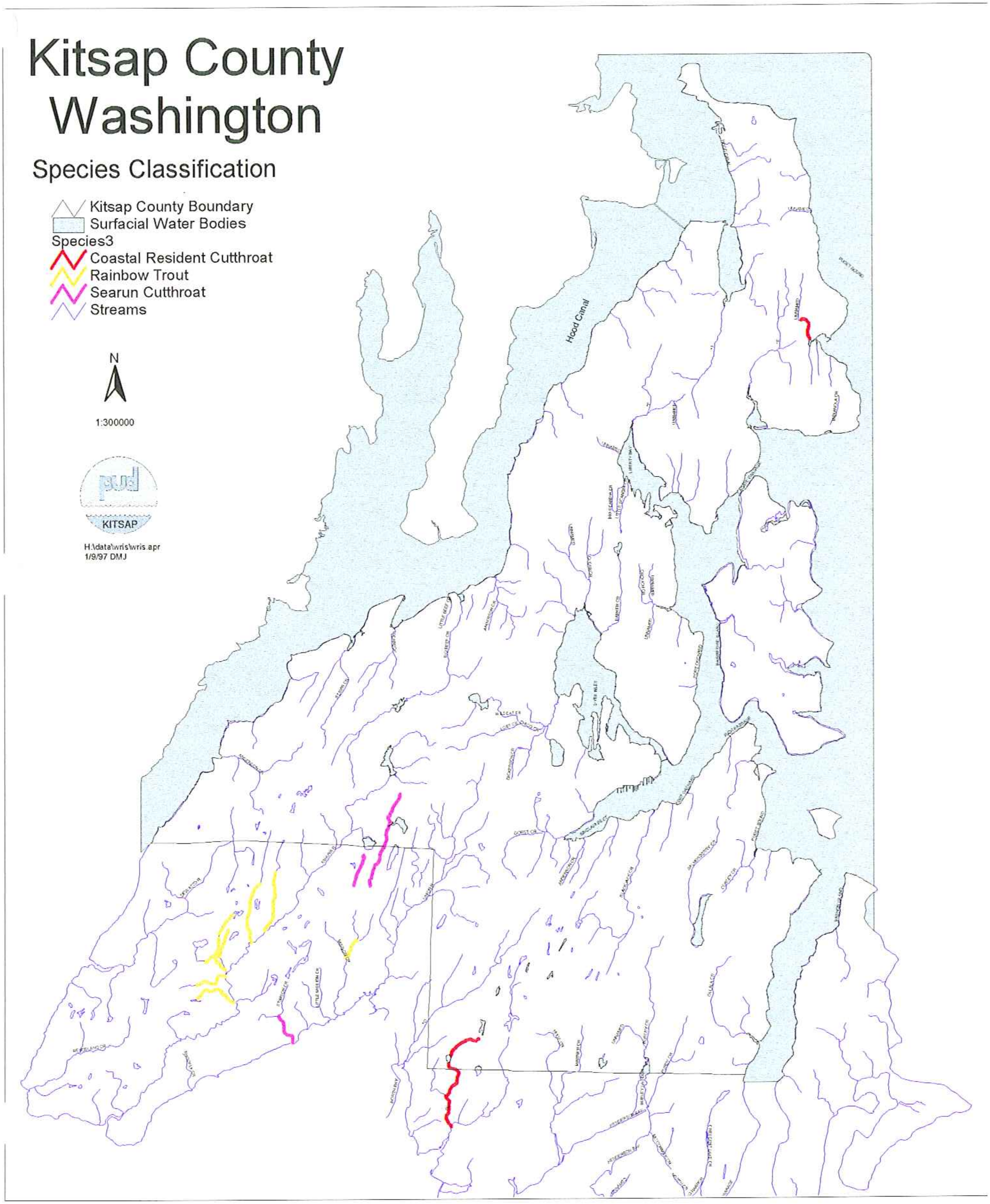
1/9/97 DMJ




Kitsap County
Washington
Species Classification
Kitsap County Boundary
Surfacial Water Bodies
Species3
Coastal Resident Cutthroat
Rainbow Trout
Searun Cutthroat
Streams
N
1:300000
KITSAP
H:\data\wris\wris.apr
1/9/97 DMJ
Hood Canal

Kitsap County Washington

Species Classification

Kitsap County Boundary
Surfacial Water Bodies
Species4
Rainbow Trout
Streams

N

1:300000

KITSAP

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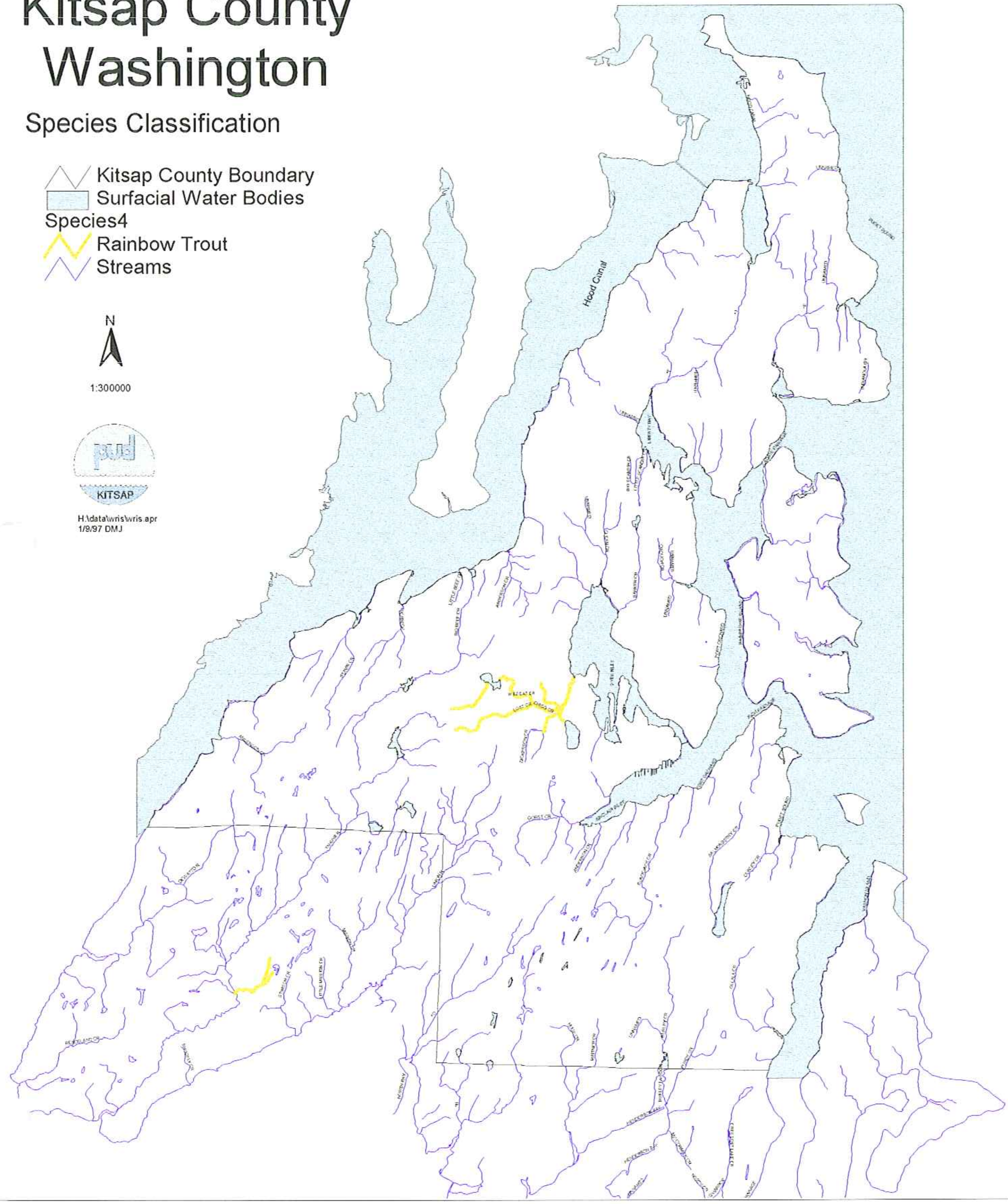
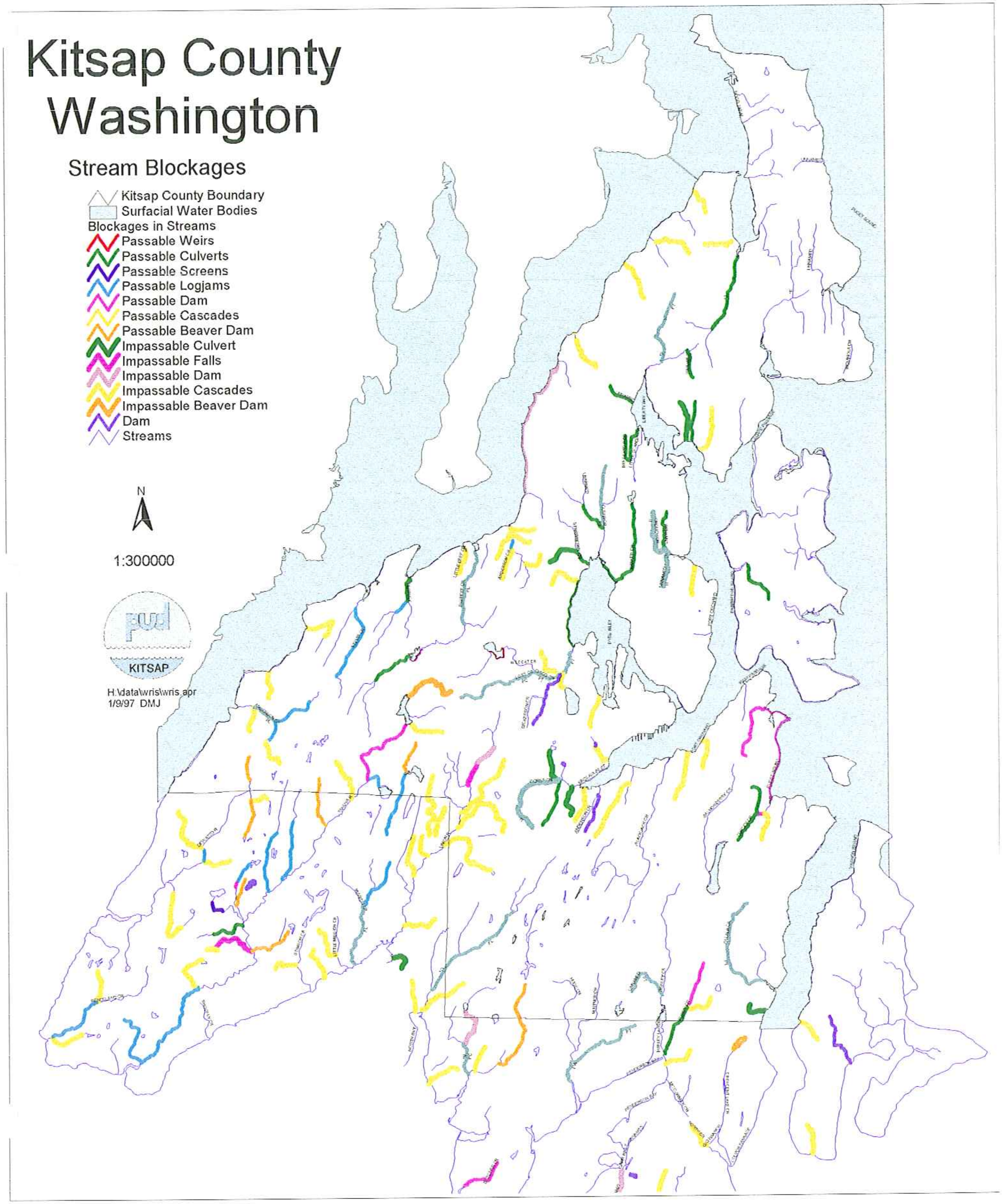
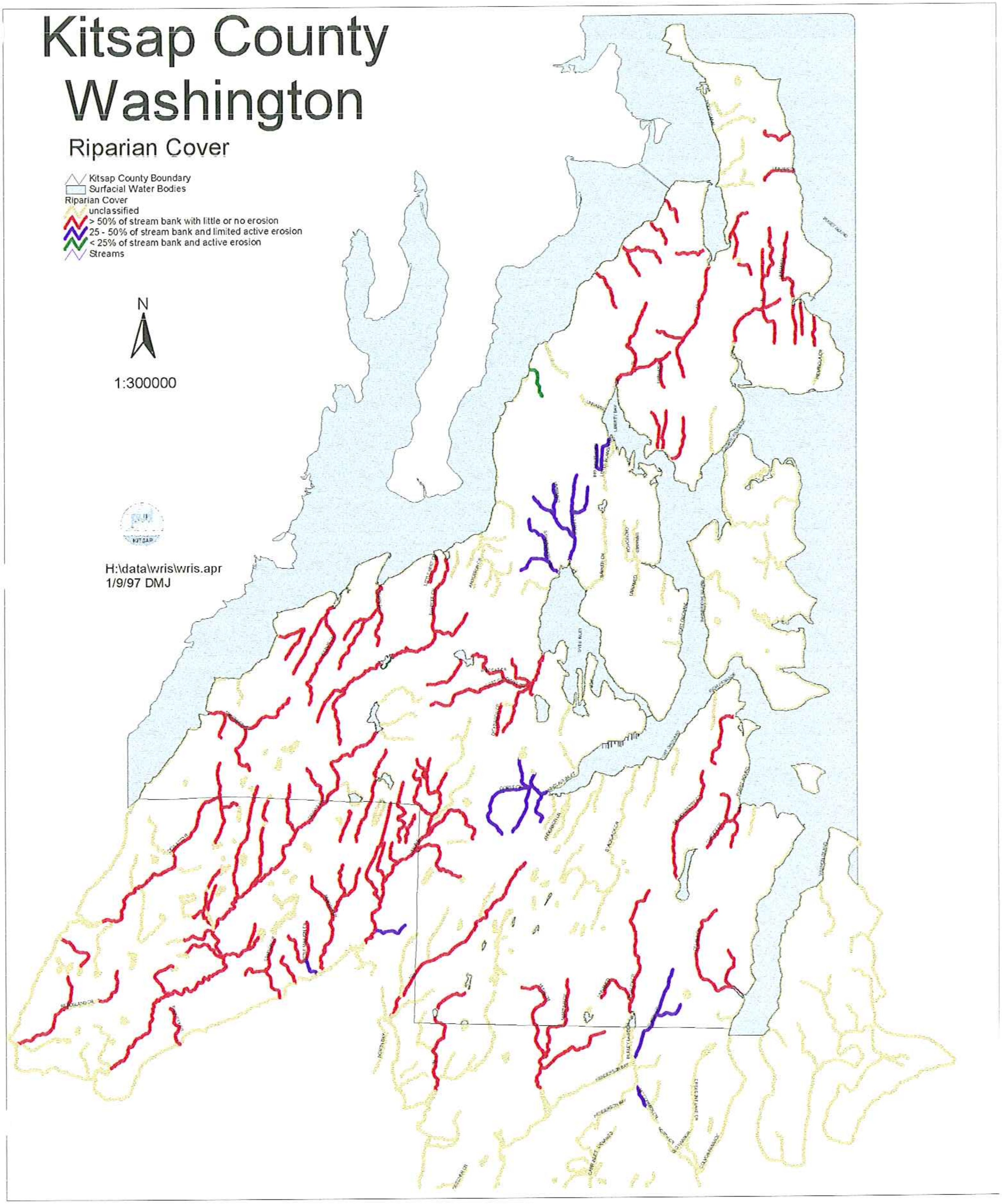
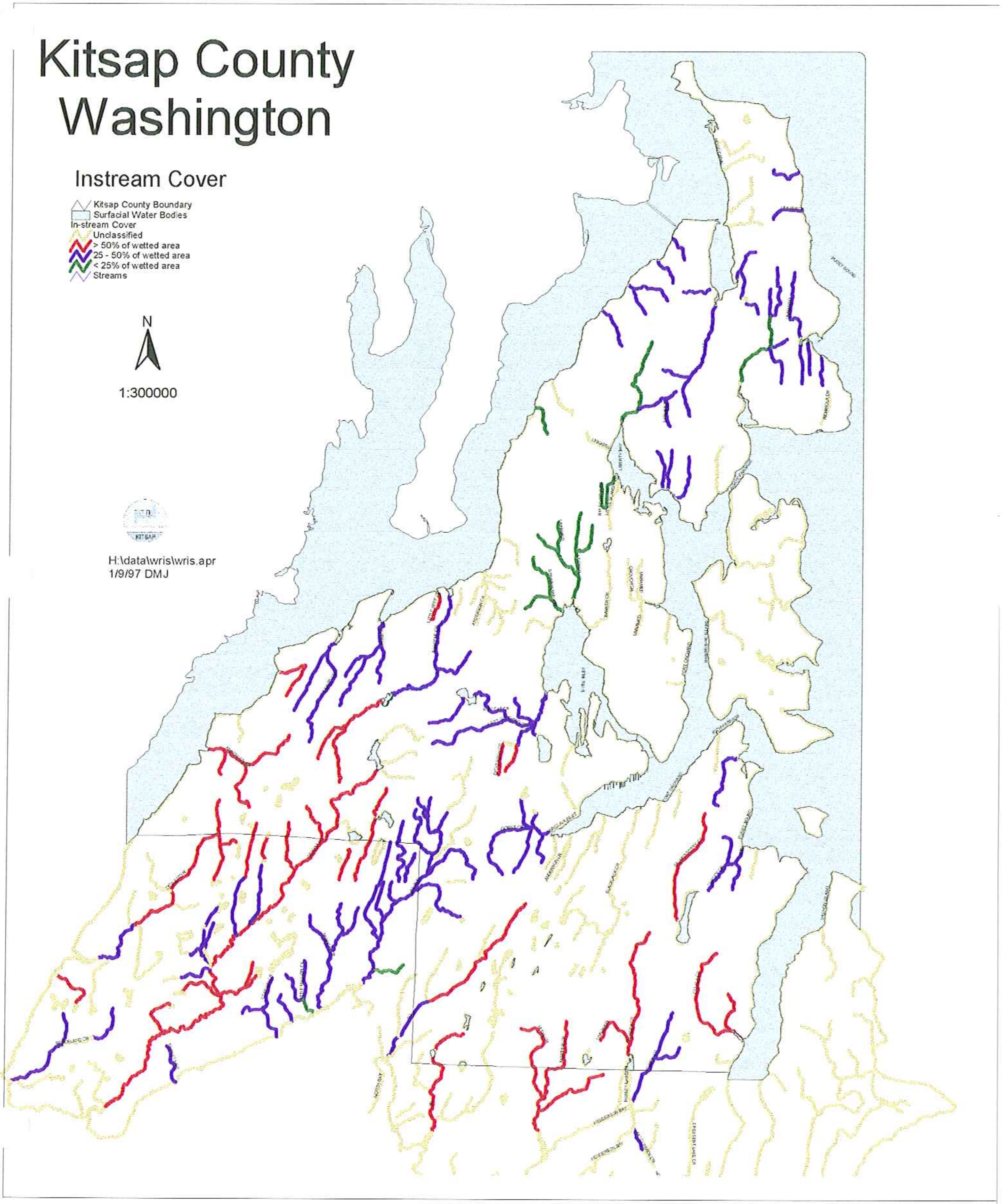
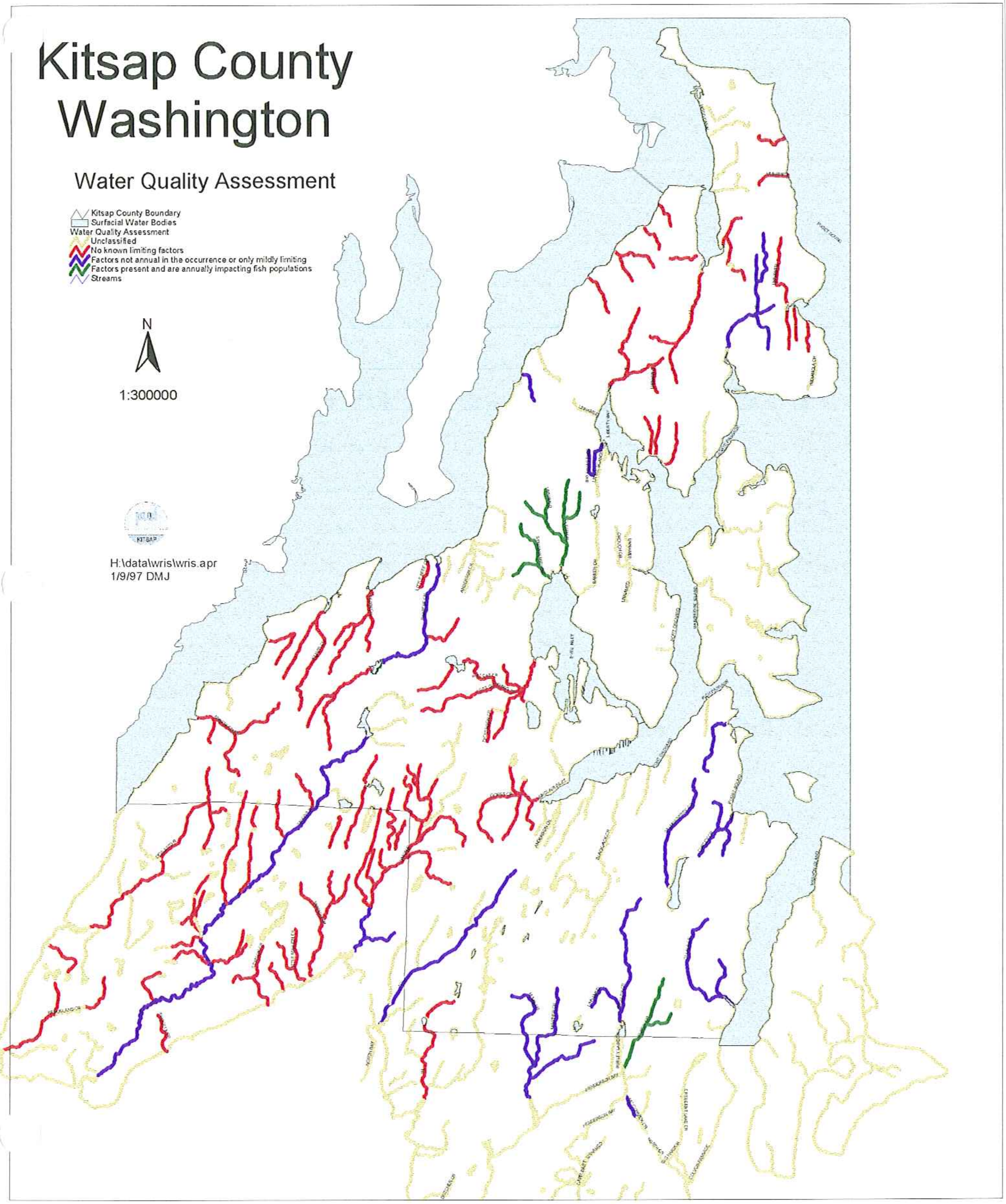




Kitsap County
Washington
Stream Blockages
Kitsap County Boundary
Surfacial Water Bodies
Blockages in Streams
Passable Weirs
Passable Culverts
Passable Screens
Passable Logjams
Passable Dam
Passable Cascades
Passable Beaver Dam
Impassable Culvert
Impassable Falls
Impassable Dam
Impassable Cascades
Impassable Beaver Dam
Dam
Streams
N
1:300000
KITSAP
H:\data\wris\wris.apr
1/9/97 DMJ


Kitsap County
Washington
Riparian Cover
Kitsap County Boundary
Surfacial Water Bodies
Riparian Cover
unclassified
> 50% of stream bank with little or no erosion
25 - 50% of stream bank and limited active erosion
< 25% of stream bank and active erosion
Streams
N
1:300000
KITSAP
H:\data\wris\wris.apr
1/9/97 DMJ


Kitsap County
Washington
Instream Cover
Kitsap County Boundary
Surfacial Water Bodies
In-stream Cover
Unclassified
> 50% of wetted area
25 - 50% of wetted area
< 25% of wetted area
Streams
N
1:300000
H:\data\wris\wris.apr
1/9/97 DMJ


Kitsap County
Washington
Water Quality Assessment
Kitsap County Boundary
Surfacial Water Bodies
Water Quality Assessment
Unclassified
No known limiting factors
Factors not annual in the occurrence or only mildly limiting
Factors present and are annually impacting fish populations
Streams
N
1:300000
KITSAP
H:\data\wris\wris.apr
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Kitsap County Washington

Game Fish Abundance

- Kitsap County Boundary
- Surfacial Water Bodies
- Game Fish Abundance
  - Unclassified
  - High Abundance
  - Intermediate Abundance
  - Low Abundance
- Streams

N

1:300000

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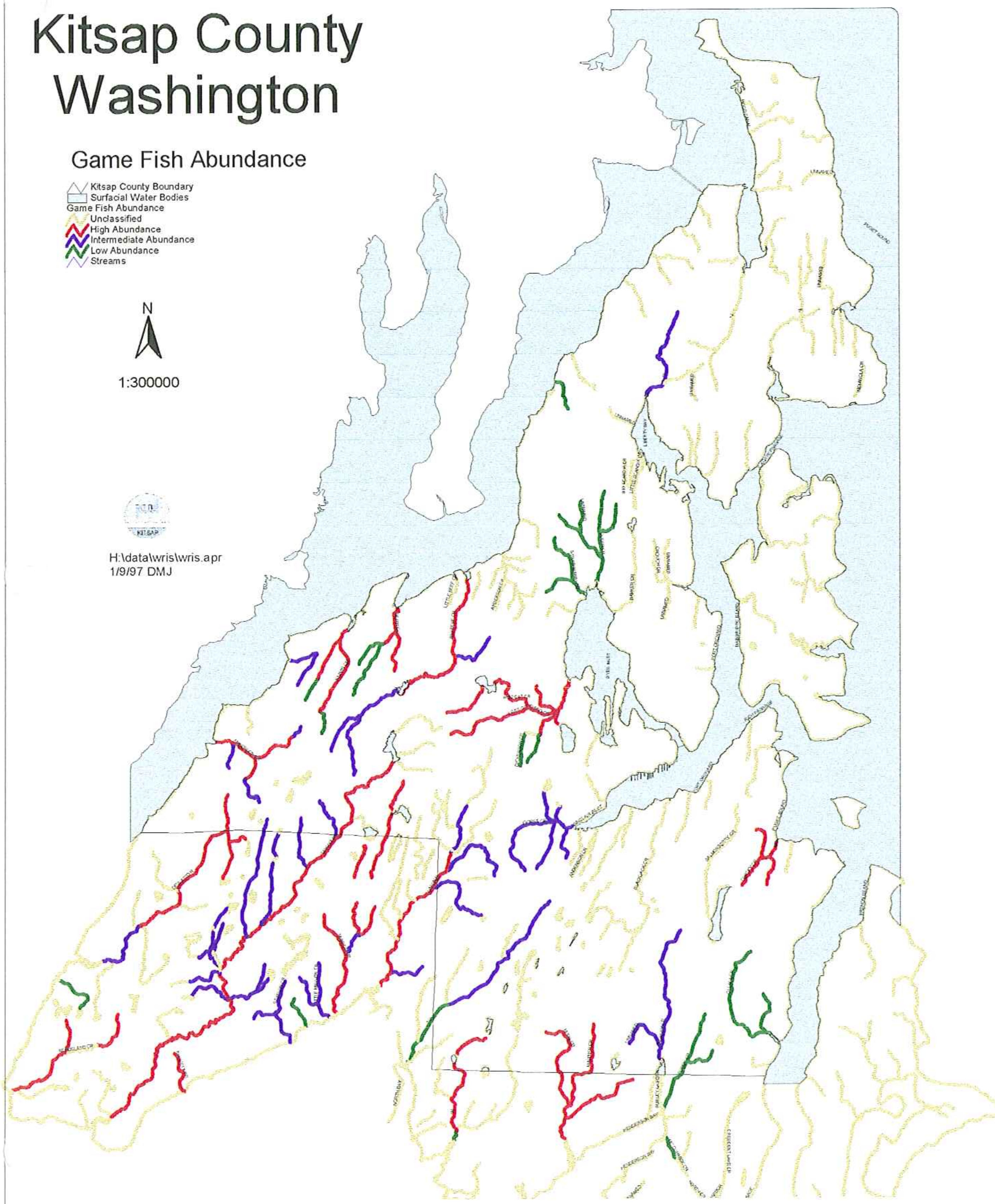

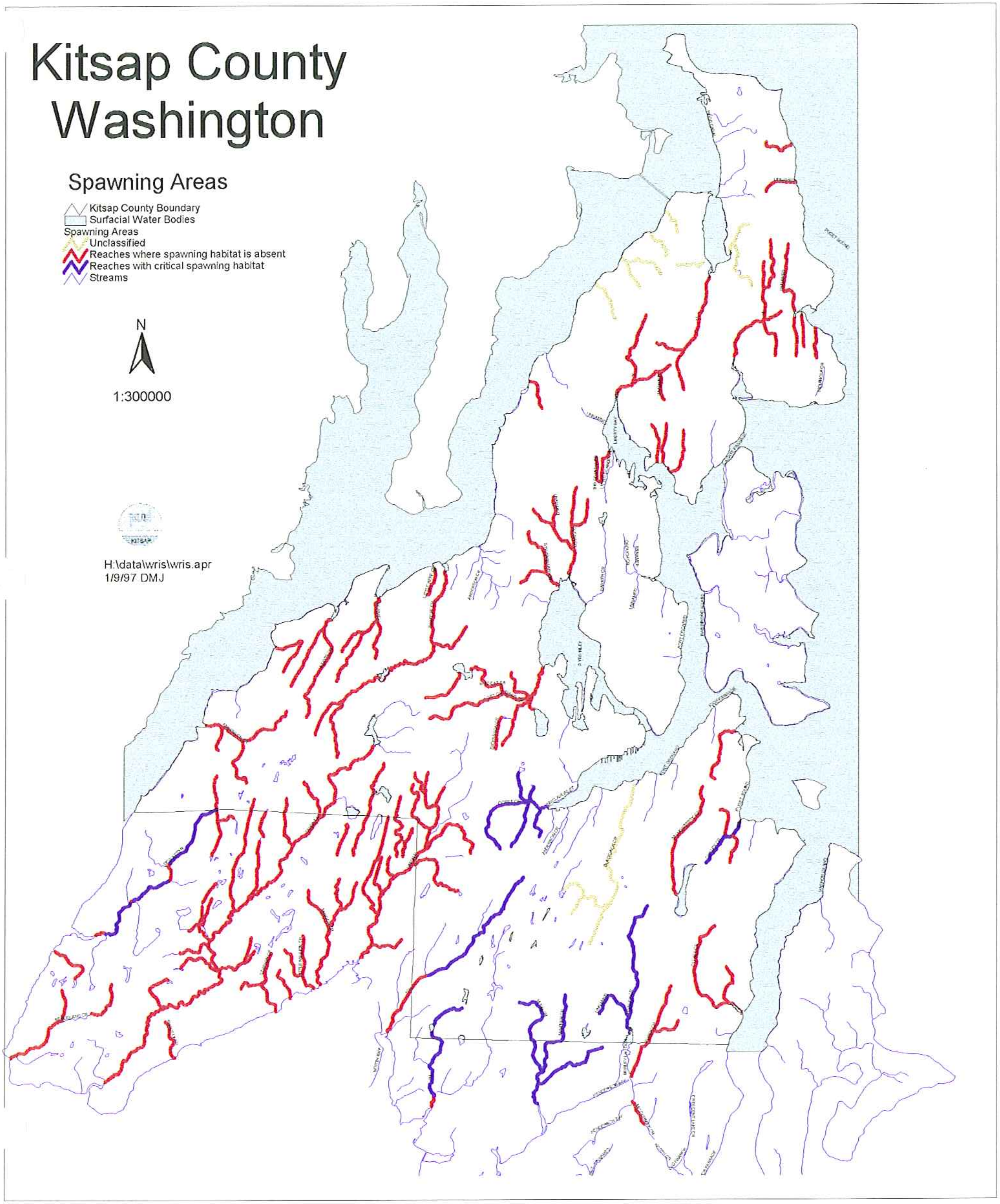
Kitsap County
Washington
Spawning Areas
Kitsap County Boundary
Surfacial Water Bodies
Spawning Areas
Unclassified
Reaches where spawning habitat is absent
Reaches with critical spawning habitat
Streams
N
1:300000
H:\data\wris\wris.apr
1/9/97 DMJ

Kitsap County Washington

Summary Ranking of Streams