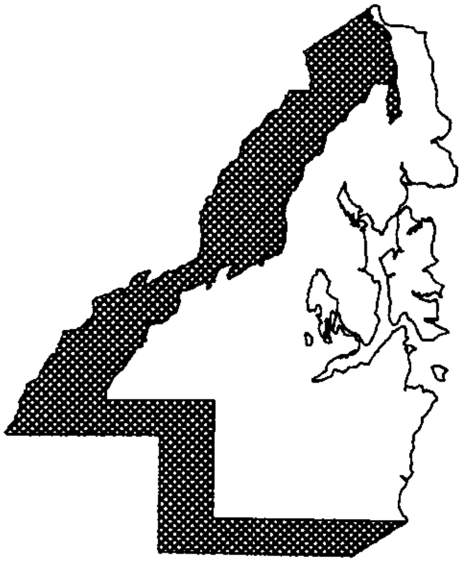
KITSAP COUNTY

GROUND WATER MANAGEMENT PLAN

GRANT NO. 1

BACKGROUND DATA COLLECTION AND MANAGEMENT ISSUES

VOLUME I



April 1991

Prepared By

Kitsap County Ground Water Advisory Committee
Economic and Engineering Services, Inc.
Hart–Crowser, Inc.
Pacific Groundwater Group
Robinson & Noble, Inc.

A Project Funded In Part
Through The
Centennial Clean Water Fund

WASHINGTON STATE DEPARTMENT OF ECOLOGY

90162491

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April 28, 1991

File # 41660.0

Ms. Clair Burwell
5028 N.W. El Dorado Blvd.
Bremerton, WA 98312

Subject: Kitsap County Ground Water Management Plan
Grant No. 1 - Volume I & Volume II Report

Dear Ms. Burwell:

Economic and Engineering Services, Inc., in association with Hart-Crowser, Inc., Pacific Groundwater Group, and Robinson & Noble, Inc., is pleased to submit documentation for the Kitsap County Ground Water Management Plan (GWMP), Grant No. 1 activities.

Grant No. 1 activities focused upon the collection and analysis of data used to characterize the groundwater of Kitsap County. Where data was insufficient to accurately characterize conditions of particular interest, a specific program was recommended to collect and analyze additional information during Grant No. 2 activities and in later years. In addition, resource issues and management strategies were identified which require further refinement in Grant No. 2.

This information is presented in two volumes. This letter transmits Volume I. Volume I provides a summary of the approach, major findings, and recommendations of this effort. Volume II presents several appendices of supporting information for the study and each Subarea. The information in this final version of Volumes I and II incorporates appropriate changes and suggestions to the original draft document.

We have enjoyed working with the Ground Water Advisory Committee on this important and challenging portion of the GWMP. We look forward to continued activity during Grant No.2 as refinement and implementation of many of the enclosed recommendations are pursued.

Sincerely,

John M. Maxwell

John M. Maxwell, P.E.
Vice President

JMM:aa:9

Enclosure

KITSAP COUNTY

GROUND WATER MANAGEMENT PLAN

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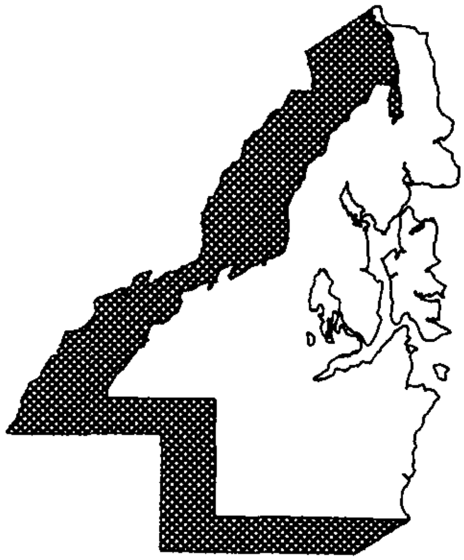

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ACKNOWLEDGEMENTS

The authors of the Kitsap County Ground Water Management Plan, Grant No. 1 Background Data Collection and Management Issues, Volumes I and II, would like to acknowledge the extensive assistance by all those contributing to the technical and administrative issues presented in this report.

A Bibliography is enclosed at the back of Volume I to cite the major published and unpublished sources of information used in preparation of the text and exhibits in this document.

Special recognition is provided to the entire Kitsap County Ground Water Advisory Committee and the agencies and individuals listed below who assisted throughout this phase of the project.

Bremerton Kitsap County Health Department

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Department of Ecology

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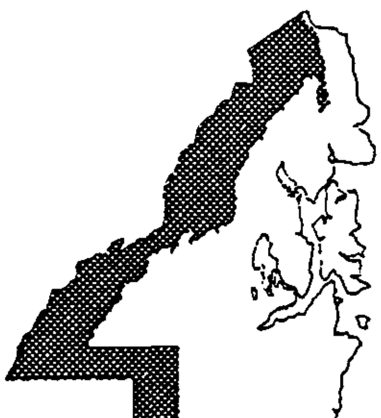
SECTION I



SECTION I

SUMMARY

1. INTRODUCTION

Kitsap County is a rapidly growing area which is heavily reliant upon groundwater resources. The issue of water resource management, both in quantitative and qualitative terms, is a concern shared by the citizens, municipalities, utilities, and County agencies who live in and serve the Kitsap County area. The ever increasing demands for municipal, industrial, domestic, recreational, and aesthetic enjoyment and, to a lesser degree, agriculture and irrigation, have raised questions regarding the adequacy of existing resources to meet the combined demands of all groundwater resource users. In addition, examples of water quality contamination at specific sites within Kitsap County and elsewhere throughout the State and nation have increased the importance in evaluating the quality of the groundwater resources throughout the area.

This document culminates activities for the first of two grants provided by the Department of Ecology (Ecology). The grants, in part, are funding the preparation of a Ground Water Management Plan (GWMP) for Kitsap County. This document has been prepared under a program initiated by the Washington State Legislature in 1985. It directed Ecology to establish a process of designating groundwater areas for development of groundwater management programs. Preparation of the GWMP has been done in accordance with the requirements of Chapter 173-100 WAC, Ground Water Management Areas and Programs. These regulations led to the designation of Kitsap County as a Ground Water Management Area (GWMA) on October 7, 1986. An Interlocal Agreement was entered between the Kitsap County Public Utility District No. 1 of Kitsap County (District) and the Kitsap County Board of Commissioners (County) on December 15, 1986. This Agreement established both entities as co-lead agencies for the evaluation and preparation of the GWMP.

The District is responsible for water resource development and management throughout Kitsap County, whereas the County is responsible for wastewater management. Therefore, the District worked cooperatively with the County to initiate the GWMP process. The District and County have also jointly sponsored the preparation of a Coordinated Water System Plan (CWSP) for Kitsap County. In addition, both entities joined Ecology and the U.S. Geological Survey (USGS) in an earlier groundwater study on Bainbridge Island.

A Ground Water Advisory Committee (GWAC) was formed in accordance with WAC 173-100-050, to guide development of the GWMP. The GWAC is composed of a variety of public and private interest groups. The GWAC submitted a grant request to Ecology on January 30, 1987, for assistance in preparing this document. Notice to proceed on the GWMP was provided by Ecology on December 10, 1987. In view of limited grant funding, preparation of the GWMP was segregated into two grants. Activities of the first grant have focused on collecting and evaluating background data regarding the quantitative and qualitative aspects of the groundwater resource, along with identifying resource management and strategy issues which need to be addressed in Grant No. 2.

This document is presented in two volumes. Volume I provides a summary of the major findings, conclusions, and recommended implementation efforts needed to continue development of the GWMP in the second grant activities. Volume II provides technical supporting data and additional information developed for the study and each of the study's five individual subareas. This first grant effort has initiated action on a variety of management issues and policies deemed appropriate by the GWAC in order to provide a comprehensive management strategy for groundwater resources throughout Kitsap County.

A completed GWMP will be submitted at the conclusion of Grant No. 2 activities. This Grant No. 1 report, and results of Grant No. 2 activities, will be reviewed and accepted by the GWAC and its policy, technical, and public involvement subcommittees. The eventual adoption of the completed GWMP under both grant activities will lead to certification of the GWMP by the GWAC. Certification will be required of all participating GWAC members and State agencies. Affected local governments will eventually need to adopt or amend regulations or ordinances implementing the provisions and recommendations of the GWMP. The document prepared for Grant No. 1 activities does not require certification now but summarizes the basic findings and recommendations to-date.

2. AUTHORIZATION

This GWMP Grant No. 1 report was developed jointly by Economic and Engineering Services, Inc. (EES), Hart-Crowser and Associates, Inc. (HC), Pacific Groundwater Group (PGG), and Robinson and Noble, Inc. (RN). The Consultant team prepared this document under the direction of the co-lead agencies and the GWAC.

3. GOALS AND OBJECTIVES

One of the first activities of the GWAC was to establish goals and objectives to be used as guidelines in development of the GWMP. A general program goal and several specific program objectives were identified by the GWAC. The general program goal for the GWMP was the following:

To ensure an adequate quantity of high quality groundwater through conservation and by adopting and enforcing a sensible Groundwater Resource Plan.

Exhibit I-1 provides a complete listing of the 14 specific program objectives developed by the GWAC and adopted at their January 20, 1988, meeting for preparation of this document.

It is the intent of the GWAC to review and compare the findings and recommendations contained within this document with the original program goals and objectives before initiating work on Grant No. 2. Confirmation or modification of these goals and objectives will be instrumental in developing management strategies during Grant No. 2.

4. STUDY AREA AND APPROACH

The GWMA used for the study includes the entire County and ends at the County border on the south. The GWMP was segregated to provide a more detailed evaluation of five subareas within Kitsap County. These five subareas include: Hansville-Indianola; Bainbridge Island; Poulsbo-Bremerton; West Kitsap; and South Kitsap.

Development of the complete GWMP, as required by Ecology, includes five major phases of work:

Phase 1 - Program Development/Grant Application;
Phase 2 - Public Involvement/Administration;
Phase 3 - Data Collection/Analysis;
Phase 4 - Management Alternatives and Implementation Plan; and,
Phase 5 - Public Review and Adoption.

As mentioned above, Grant No. 1 activities focused primarily on work elements in Phase 3, with initial efforts in Phase 4. The essence of Grant No. 1 was to analyze and trend existing information characterizing the topography/geology, climate, water quality, and water resource requirements of the GWMP. Further, it evaluated land use patterns in comparison to quantitative and qualitative issues. This led to a definition of problems perceived to exist throughout the area based upon existing information. In addition, resource management issues have been identified which may result in the implementation of new or revised local policies, ordinances, or State guidelines and statutes.

Throughout preparation of the document, close coordination was maintained with other State and local agencies, USGS, and the U.S. Environmental Protection Agency (EPA). A master database of hydrogeologic information was developed for Kitsap County. This database relied upon data provided by USGS for approximately 3,350 wells. Data was extracted for approximately 350 reliable wells with suitable locations. Data for an additional 450 wells was added from reliable data obtained from records maintained by the hydrogeological consultants on the project. Geologic logs for approximately 700 wells were also computerized. This information was entered on a database, in accordance with the Data Management Program established to meet Ecology requirements. Some new information was also collected during drilling of test wells throughout the course of the study. This information was entered into the database only if it conformed to provisions of the Quality Assurance/Quality Control criteria established by Ecology. The information on the database has also been digitized to facilitate computer mapping as generated from information within the database.

Information on water rights and water quality was also entered in the database. Correlation of this information to individual wells was not always possible due to insufficient location information. One major detriment in effectively analyzing water resource/water quality conditions throughout Kitsap County and the State, is the lack of a common identification system. An improved locating system would allow the correlation of water resource data to specific wells and the aquifer they withdraw from. Water quality analyses were evaluated for over 550 wells reported for public and private uses by the Bremerton-Kitsap Health Department (BKHD), Ecology, Department of Health (DOH), EPA, or other entities. Statistical analyses were conducted on over 535 of these wells. The results of key indicator parameters tested since 1970 were analyzed to evaluate regional trends in water quality. Where possible, excessive concentrations of specific test results were evaluated to determine if contamination presence was occurring at a specific location. Results from known contamination sites were not included in the statistical trend analysis in order to not skew the trend results. It was determined by the GWAC that known contamination sites frequently have an abundance of information and did not merit further evaluation. Whereas, these contamination sites are of concern, the GWAC focused on background concentrations and any increasing regional trends in water quality.

Key activities in development of the GWMP document were guided by the GWAC and its three subcommittees. The GWAC met approximately 15 times during preparation of the GWMP and several times previously during development of the Scope of Work and grant application. The Technical Subcommittee met approximately 8 times to review the technical approach, findings, and recommendations within this document. In addition, the Policy Subcommittee met approximately 2 times to address potential management issues, strategies, and policy requirements that will require further refinement in Grant No. 2. The Public Involvement Subcommittee met approximately 15 times to establish a means of advising the community of the ongoing effort, its findings, and generally creating a public awareness of groundwater management goals and responsibilities. During Grant No. 1, the Public Involvement Subcommittee prepared a

Public Involvement Plan. This Plan incorporates a variety of media and public education activities including newspaper articles, speakers bureau at local civic groups, releases for radio and television, and a public workshop during Grant No. 1 activities. All of the above actions were pursued, including presentation of a groundwater fair on April 4, 1989, at Olympic College in Bremerton.

5. RELATED STUDIES

Simultaneous to the development of the GWMP, several other ongoing local activities have complimented the GWMP effort. Listed below are some of these major activities.

A. U.S. Geological Survey

In 1984, the USGS initiated efforts related to an evaluation of groundwater resources on Bainbridge Island. The Island is almost solely dependent on groundwater, as there are no significant surface water supplies. USGS study activities preceded that of the GWMP. However, development of technical information in the GWMP was coordinated between both study efforts.

The objectives of the study are listed below:

- Define, to the extent available data allow, the general lithology of the unconsolidated deposits on the Island and the groundwater flow system within those deposits.
- Define the present quality of groundwater beneath the Island based on data collected during the study.
- Identify groundwater quality problems where they exist.
- Design a monitoring network of wells for determining changes in groundwater levels and quality with time.
- Determine whether the groundwater resources of the Island can be assessed adequately using existing data and data collected as part of this study and, if not, what additional data would be required to do so.

Approximately 250 of 600 recorded wells were selected for field visits, beginning in October, 1984. Selection of wells for field visits was based on several criteria: (1) existence of water level and (or) water quality data; (2) existence of drillers' lithologic logs; (3) geographic location; (4) depth; (5) geologic framework; (6) well use; and (7) permission from owner or tenant to include the well in this study.

The available data allowed a detailed study of the stratigraphy of the upper 200 feet of unconsolidated deposits that underlie Bainbridge Island, based on surface geology, geophysical data, and drillers' well logs. Well yield and specific capacity data were based on reports submitted by drillers to Ecology.

About 210 wells were visited in the spring and fall of 1985 to measure depth to water and to collect a water sample for analyses of specific conductance and chloride concentration. Forty-eight of the samples collected in April were analyzed for major cations and anions, nitrate, iron, manganese, and fecal-coliform bacteria; nine of the 48 samples were also analyzed for trace metals. Water levels and (or) chloride concentrations were measured monthly in 24 selected observation wells to document the magnitude of seasonal fluctuations in those constituents. Water quality data were compared with historical data in an attempt to identify areas where deterioration, especially seawater intrusion, has occurred with time.

The study concluded that Bainbridge Island is underlain by as much as 1,600 feet of unconsolidated glacial and nonglacial deposits of Quanternary age, and that most stratigraphic units have limited vertical and lateral extent. The upper 200 feet of deposits are divided into three permeable, water-bearing geohydrologic units (aquifers) and three semiconfining geohydrologic units. None of the aquifers are laterally continuous across the Island, although water level and water quality data suggest that the stratigraphic units are hydraulically interconnected.

Recharge to the groundwater system occurs throughout most of the Island. Potentially greater recharge occurs, for the most part, near the periphery of the Island. The Island's aquifers are recharged chiefly by direct precipitation and, in part, by leakage through the overlying stratigraphic unit.

Drillers' reports indicate that more than two-thirds of the study wells, as constructed, are capable of yielding from 6 to 20 gallons per minute.

Groundwater on Bainbridge Island generally is suitable for most purposes. However, 3 of 48 samples exceeded the criterion for iron and 19 exceeded the criterion for manganese. However, the criteria exceeded pertain only to aesthetics and not to human health, so the situation is not seen as a major water quality problem.

Water samples for analysis of chloride concentration were collected in April, when groundwater levels are usually highest, and in September, when levels are usually lowest. Median chloride concentrations in September were essentially the same as in April, and wells finished below sea level contained water with slightly smaller chloride concentrations than water from wells finished above sea level. Because of the physiography of the study area, seawater intrusion constitutes a serious potential threat to the groundwater resources of Bainbridge Island. Seawater intrusion currently is not a problem on Bainbridge Island. Groundwater development on the Island to-date has not been sufficient to induce the movement of seawater into the freshwater aquifers. In order to detect the onset of seawater intrusion, the study recommended development of a network of potential observation wells used to monitor groundwater levels and chloride concentrations. This monitoring network has been initiated.

A comparison of chloride concentrations observed in 1985 with those observed in similar studies in 1967 and 1978 indicates that, of 26 wells, only one showed an increase in chloride concentration with time.

The study concluded that available data are adequate to permit an assessment of the groundwater resources of the Island, but only in a qualitative manner and only for the uppermost part of the thick unconsolidated deposits. The data are inadequate to permit the calculation of a detailed water budget, to delineate the position of the freshwater-seawater interface, to determine the potential for additional groundwater development from known or unknown aquifers, or to assess the effects of such additional development.

The report is available for review and is entitled Preliminary Evaluation of the Groundwater Resources of Bainbridge Island, Kitsap, County, Washington, Report #87-4237.

B. Coordinated Water System Plan

The District has also worked cooperatively with Kitsap County Department of Community Development in preparation of a CWSP for the entire County. The CWSP presents an assessment of municipal and industrial water supply needs in Kitsap County and a program to effectively provide supply and service to customers throughout the area. The CWSP is enacted through Chapter 70.116 RCW. These procedures are outlined in Chapter 248-56 WAC. The Public Water System Coordination Act provides for water utilities throughout the State to coordinate through planning and construction programs with other water utilities and local governments in the same geographic area.

A preliminary assessment was conducted in 1986 for Kitsap County and other areas. The preliminary assessment identified several issues of concern throughout the County that may preclude the delivery of safe, efficient, and reliable water service to its customers. The preliminary assessment made the following conclusions:

- o Preventive action for the provision of reliable service and the protection of water supplies serving current customers is prudent and cost-effective.
- o The County's Comprehensive Plan projects a continued growth in population and water demand that will most effectively be met primarily by existing water utilities.
- o The County currently has more than 800 public water systems, with coordination of utility services only occurring between the major purveyors.
- o Preliminary estimates on growth, population, and water demand exceed the anticipated available groundwater resources.
- o Ecology has released draft regulations for the Instream Resources Protection Program which severely limit the possibility of developing an Olympic Peninsula surface supply for public water use within Kitsap County. It is necessary to coordinate the water supply development, protection, and transmission, particularly if a new surface water supply is required to meet future needs.
- o The existing County Water Plan was completed in 1970, and its findings may no longer be valid.
- o With the continued growth anticipated within Kitsap County, the responsibilities for protecting and managing the available groundwater resources consistent with County policies, must be established both for existing and future customers.

The CWSP was prepared under the direction of a Water Utility Coordinating Committee (WUCC). The WUCC is composed of public water systems throughout the area having 50 or more service connections. In combination, it is anticipated that the GWMP study will characterize the groundwater supplies and establish methods to properly monitor and manage the resource. The CWSP provides administrative procedures to ensure the coordinated utilization of the resource and a regional strategy to ensure the public water supplies can meet future demands created by adopting Kitsap County land use policies.

CWSP efforts relating to water resource issues, principally focus upon demand forecasts and comparison to existing water rights and water supply capacities. Water demand forecasts were conducted under four varying assumptions. These evaluated, respectively, the impact of continued consumption at the current rates, reduced per capita consumption created by conservation, reduced consumption created by increased multi-family densities, and reduced consumption created by the combined effect of conservation and multi-family living units. Conservation impacts were assumed to result in a 10 percent reduction in water demands by the year 2000. A similar level of reduced consumption was forecast through the year 2040. The conclusion of this analysis indicated that peak daily water demands would increase throughout the area from approximately 68 MGD in 1990 to between 115 and 133 MGD in 2040 based on the range of demand scenarios.

The CWSP also noted very few systems within Kitsap County having adequate groundwater monitoring programs in place to properly manage groundwater resources. Such a monitoring program should be initiated cooperatively with all water purveyors and local governments.

An evaluation of source alternatives for the Kitsap County are currently being developed and evaluated. Source availability, development problems, water right conflicts, and treatment costs indicate that significant surface supplies within the County will be limited to the 15 MGD current and 20 MGD proposed supply capacity for the City of Bremerton's Cascade Dam Supply System. Further, reliance upon imported surface water from the Olympic Peninsula is considered a potential option if groundwater supplies appear insufficient to meet the high growth rate anticipated in Kitsap County. The City of Bremerton and the District both have 100 cubic feet per second (cfs) water right applications on surface water withdrawals, respectively, from the Hamma Hamma and Duckabush Rivers. Alignments from the transmission facilities are either a submerged crossing of Hood Canal or following the City of Tacoma's powerline right-of-way from Lake Cushman around the southern leg of Hood Canal into Pierce County. This latter alignment provides an opportunity to work with the Gig Harbor GWMP to meet their future supply requirements. The transmission network also facilitates an option for artificial recharge of aquifers in Kitsap County.

C. Local Authorities

A variety of drilling activities occurred during the development of the GWMP which provided useful data to the study. These drilling activities were sponsored primarily by individual utilities throughout the study area.

The majority of these wells were predominantly for test purposes. A total of seventeen wells were drilled which provide useful information for the database:

- PUD - 4 wells at Keyport, Kingston, and Bainbridge Island which ranged in depth from 805 feet to 1,040 feet. The Bainbridge Island well was drilled near Wardwell Road to a depth of 1,040 feet where data on deep wells is limited.

- City of Bremerton - 6 wells at Twin Lakes, Gorst, Alder Bottom, Central Valley, and Anderson Creek. These Wells ranged in depth from 55 feet to 327 feet. Some of the wells are intended for increased production with yields up to 1,000 gpm.

- Manchester Water District - 2 wells were drilled by the District with depths of 269 feet and 356 feet. Yields ranged from 80 to 310 gpm.

- City of Poulsbo - 1 well to 310 feet deep with a yield of 758 gpm.

- City of Winslow - 1 well at Sands Road to a depth of 1,053 feet and yields of 288 gpm. This well also helped characterize deeper aquifers on Bainbridge Island.

- Other Owners - Wells were also drilled by Port Blakely Lumber Company, McCormick Woods Development, and Suquamish Tribe Fisheries at key locations. These wells ranged, respectively, from 958 feet to 270 feet in depth.

These wells were drilled and tested in conformance with the Quality Assurance/Quality Control criteria specified by Ecology for new information collected by the GWMP.

All of the above documents have assisted in building upon information provided in Washington State Water Supply Bulletin No. 28 prepared in 1969, which had previously been the primary document in describing the groundwater system for Kitsap County. All of these major documents have been incorporated into the Bibliography for this report.

6. CONCLUSIONS AND RECOMMENDATIONS

The major conclusions and recommendations of Grant No. 1 activities for the GWMP are summarized below. These statements are based on the information presented within Volumes I and II.

A. Technical

(1) General Issues

Conclusions

Twenty-seven principal aquifer areas have been identified within Kitsap County. These aquifer areas are mainly contained within five stratigraphic units. From shallowest to deepest, the units include:

- Qg1a
- Qg2
- Qg3
- Qg4
- Qg5

The units Qg1a, Qg2, and locally, Qg3 are found above sea level. The units Qg4 and Qg5 are exclusively below sea level. Units Qg1a, Qg2, and Qg3 are the most susceptible to land use impacts given their shallow occurrence.

The productivity within the stratigraphic units is highly variable. The Qg1a, Qg2, Qg3, and rarely, Qg4 are used extensively for domestic and small community supplies. These units, as well as the deeper layer Qg5, serve major water purveyors within localized areas.

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.

The extent and character of each of the stratigraphic layers are generally well defined in areas of high concentration of well data and poorly defined in areas lacking in data, particularly in the West Kitsap Subarea.

The following is a list of the identified aquifer systems of Kitsap County grouped by the stratigraphic unit in which they are completed.

Qg1a

Hansville
Meadowmere
North Lake-Bremerton South (upper)

Qn2

Bangor (upper)

Qg2

Port Gamble
Poulsbo
Wilson Creek

Qg3

Kingston (upper)
Suquamish-Miller
Wardwell (upper)
Bayhead
Lynwood Center
Edgewater
Bangor (upper)
Island Lake
Clam Bay
Manette-Bremerton North
Yukon
Gorst

Qg4

Big Beef
Silverdale
Salmonberry
North Lake-Bremerton South (middle)
Bangor (lower)
Gilberton-Fletcher (upper)

Qn5

Creosote

Qg5

Kingston (lower)
Wardwell (lower)
Gilberton-Fletcher
Keyport
Bucklin Hill
Port Orchard Deep
North Lake-Bremerton South (lower)

Qn6

Keyport

There are large areas which have no presently identified aquifers, especially in the western and southern portions of the County.

- o An analysis of recharge and water balance relationships suggest that the western and southern portions of the County may be the most promising areas for additional groundwater supply. The productivity of the various aquifer zones which occur within these areas is poorly defined at this time.

- o A relatively extensive network of gaging stations was operated by the USGS in the 1940s and 1950s to assess surface water supply potential within the County. Only one gaging station is currently being operated.

- o Precipitation varies considerably throughout the County. Long-term average annual precipitation varies from a low of approximately 20 inches/year in the north portions of the County to as high as 80 inches/year in the west portions of the County. Very little precipitation data is currently being collected within the County. The only long-term precipitation recording station is located within Bremerton.

- o In general, water quality conditions evaluated since 1970 throughout the GWMP study area were found to be satisfactory. With the exception of some site specific occurrences of contamination, the available data does not indicate a trend of water quality degradation.

- o Naturally occurring concentrations of iron and manganese above the maximum contaminant levels promulgated by State and federal regulations were found occasionally. However, those are an aesthetic concern without health-related impacts. Information regarding organic concentrations within the groundwater was limited. A wider sample base is needed to more thoroughly assess this situation.

- o No evidence of saltwater intrusion was noted along coastal wells during the study.

- o Expanded water quality monitoring is needed to establish ongoing analysis of background indicator parameters.

- o Insufficient data was generally found for accurately correlating pumpage, weather, and water level trends.

- Projected population and total water resource demands within Kitsap County were estimated through the year 2040. Population forecasts were based on 1988 Puget Sound Council of Governments forecasts, with straight-line extrapolation from 2020 to 2040. The population within the GWMP is anticipated to increase from a 1989 population total of 183,400, to approximately 258,600 in 2010, and 366,400 in 2040.

- Total water resource demands are expected to experience similar growth for the combined requirements of municipal/domestic supply, commercial/industrial demands, irrigation, fish propagation, heat exchange, and stock watering.

- Approximately 76 percent of water demands throughout the area are utilized to meet municipal/domestic supplies.

- The combined peak daily water resource requirements for the GWMP study area increase from approximately 74 MGD in 1989 to a range of 123 MGD to 141 MGD in 2040, based on reduced demands created by conservation and multi-family structures. Average daily water resource requirements fluctuate from 32 MGD in 1989 to 48 MGD to 55 MGD in 2040 under the same scenarios.

- An evaluation of water rights issued within the study area indicate that many unused groundwater wells still carry their water rights. This leads to an inflated total of groundwater rights when compared to consumption requirements.

Recommendations

- Additional and continued hydrogeologic data including well construction, geologic logs, water levels, pumpage, and water use should be systematically collected and entered into the GWMP database to provide a basis for ongoing analysis and management of the project area resource.

- Additional well drilling and testing programs are needed and should be coordinated with the water purveyors and the GWMP database to provide a basis for ongoing analysis and management of the project area resource.

- o Additional groundwater quality testing data should be routinely collected throughout the area for inorganic, organic, and bacteriological parameters.

- o Streamflow monitoring is needed throughout the County to establish baseline trends and possible impacts related to groundwater development.

- o Ongoing precipitation monitoring is needed throughout the County to establish a database from which to better assess the spatial and temporal variations of precipitation and other water balance components.

- o A comprehensive ongoing monitoring program including well water levels, pumpage, stream flow, lake levels, and water quality should be implemented throughout the study area.

- o Relinquishment of many existing water rights should be pursued to clean up existing records and establish an accurate assessment of future water right requirements.

(2) Hansville/Indianola Subarea

<u>Conclusions</u>

Principal aquifer systems:

- Hansville
- Port Gamble-South
- Kingston
- Suquamish-Miller Bay
- Poulsbo

- o Hansville - Encountered between +200 and +100 feet Mean Sea Level (MSL) within Unit Qg1a. This sand aquifer is the source for the Hansville area water supply. There are no recorded deep wells in this area which penetrate Qg4, i.e., -300 feet MSL.

- o Port Gamble-South - Encountered between -50 and -175 feet MSL within Unit Qg2. The extent of this aquifer is poorly defined due to lack of wells.

- Kingston - This is a two-aquifer system. The upper aquifer is encountered between -25 and -150 feet MSL within Unit Qg3. The lower aquifer is encountered between -600 and -725 feet MSL in Unit Qg5. These aquifers are inconsistent and localized in nature.

- Suquamish-Miller Bay - Encountered between 0 to -300 feet MSL within Unit Qg3. Aquifer characteristics are fairly well defined. It is unknown if there is any continuity between the Qg3 aquifer in this area and Kingston.

- Poulsbo - Encountered between +170 and 0 feet MSL within Unit Qg2. The extent of this above sea level aquifer is generally not present at sites where ground surface elevation is less than +50 feet MSL.

- Areas of exploration for new water resources are limited in the Hansville-Indianola subarea, due to the close proximity of Puget Sound on three sides, the related possibilities of sea water intrusion and because of limited recharge area available on the upper peninsula.

Recommendations:

- Deep test wells are needed in the Hansville and Poulsbo areas to explore the presence of Qg4 and Qg5 aquifers, i.e., -300 to -800 MSL.

- A test well is recommended between Suquamish-Indianola and Kingston to verify the continuity of the Qg3 aquifer and the presence of Qg4 and Qg5 aquifers.o Wells should be drilled immediately north of Gamblewood to evaluate the Qg2 and Qg3 aquifers in this area.

- In view of the limited data regarding the availability of the deeper aquifers for the Hansville area, land surface activities should be closely scrutinized to ensure the water quality and quantity of the shallow aquifers are not impacted.

(3) Bainbridge Island Subarea

<u>Conclusions</u>:

Principal aquifer systems:

- Meadowmere
- Wardwell
- Bayhead
- Creosote
- Lynwood Center
- Gilberton-Fletcher

o Meadowmere - Encountered between +100 and 0 feet MSL within Unit Qg1a. Characterized by large variation in transmissivity values (4,000 to 190,000 gpd/ft). The extent of this above sea level aquifer is generally not present at sites where ground surface elevation is less than +50 feet MSL.

o Wardwell - This is a two-aquifer system. The upper aquifer is encountered between -75 and -175 feet MSL within Unit Qg3. The lower aquifer is encountered between -650 to -975 feet MSL. The lower aquifer has major groundwater potential. The extent of the upper aquifer is poorly defined. The extent of the lower aquifer is poorly defined in all directions except to the southwest where the Island Center well has not encountered this aquifer.

o Bayhead - Encountered between 0 and -150 feet MSL within Unit Qg3. The extent of this aquifer is fairly well defined to the north and east, but poorly defined to the south and west. Based on existing information, it appears that the Qg3 is extensively utilized and may be reaching its potential supply capacity.

o Creosote - Encountered between -600 to -800 feet MSL within Unit Qg5 or Qn5. The aquifer's extent is well defined in all directions except to the west.

o Lynwood Center - Encountered between -25 to -125 feet MSL within Unit Qg3. In spite of the presence of several wells within the aquifer, the extent of this aquifer is poorly defined. It is anticipated that this aquifer encompasses a greater area except toward the southeast where bedrock is encountered.

- o Gilberton-Fletcher - On Bainbridge Island this aquifer is encountered between -850 and -900 feet MSL within Qg5. The boundaries are extended to the Manette Peninsula. The aquifer's extent on Bainbridge Island is poorly defined.

Recommendations:

- o A water level monitoring program for all of the designated aquifers should be developed and implemented along with Fletcher Bay which is already sufficiently monitored.
- o Exploration for new aquifers should be conducted in the northern portion of the Island where there is paucity of data, especially regarding the deeper systems, i.e., Qg4 and Qg5 aquifers.
- o Shallow test wells in the area of the Lynwood aquifer system are needed to allow a proper definition of the hydrology and to provide an appropriate water level monitoring network.

(4) Poulsbo/Bremerton Subarea

Conclusions:

Principal aquifer systems:

- Edgewater
- Bangor
- Keyport
- Island Lake
- Silverdale
- Bucklin Hill
- Gilberton-Fletcher
- Manette

- o Edgewater - Encountered between +200 to -150 feet MSL within Unit Qg3. Aquifer characteristics are highly variable. The extent of the aquifer is poorly defined. It is suspected that the Qg3 aquifer may extend south to Bangor, but needs further exploration to confirm this.
- o Bangor - This is a two-aquifer system. The upper aquifer is encountered between +25 to -25 feet MSL within Units

Qg3 and Qn2. The lower aquifer is encountered between -50 to -250 feet MSL within Unit Qg4. The eastern boundary of the aquifer system is well defined. The extent to the north and south of those aquifers is poorly defined.

- Keyport - Encountered between -675 to -800 feet MSL within Units Qg5 and Qn6. The lateral extent of this productive aquifer is poorly defined due to lack of deep wells in the immediate area.

- Island Lake - Encountered between +150 to 0 feet MSL within Unit Qg3. The lateral extent of this productive, above sea level aquifer is generally not present at sites where ground surface elevation is less than +50 feet MSL.

- Silverdale - Encountered between MSL to -250 feet MSL within Unit Qg4. The extent of this moderately productive aquifer is poorly defined. The Qg4 aquifer overlaps the deeper Bucklin Hill Qg5 aquifer at the western edge of Bucklin Hill.

- Bucklin Hill - Encountered between -400 to -700 feet MSL within Unit Qg5. The northeastern boundary of the aquifer is well defined, but the extent in other directions is poorly defined.

- Gilberton-Fletcher - This is a two-aquifer system. The upper aquifer is encountered between -300 to -475 feet MSL within Unit Qg4. The lower aquifer is encountered between -575 to -650 feet MSL within Unit Qg5. the extent of the aquifer system is limited by the lack of deep-well data in the vicinity.

- Manette-Bremerton North - Encountered between 0 to -250 feet MSL within Unit Qg3. Although numerous wells are completed in this aquifer, the boundaries are not well defined though they are assumed not to encompass much greater of an area than drawn.

Recommendations:

- Exploratory drilling is needed between the Edgewater and Bangor areas to confirm continuity of the Qg3 aquifer.

- Deep test wells are needed in the Island Lake area into the Qg4 and Qg5 aquifers.

- o Additional deep test wells are also needed in the Keyport and Silverdale areas to confirm the presence of the Qg5 aquifer.

- o Test wells are needed south of Bangor to penetrate and locate the extent of the Qg3 aquifer in this area.

- o A thorough monitoring system must be developed to assess the results of heavy use in the Gilberton and Manette-Bremerton North aquifer systems.

(5) West Kitsap Subarea:

Conclusions:

Principal aquifer systems:

- Big Beef

- o Big Beef - Encountered between -100 to -250 feet MSL within Qg4. The extent of this highly productive aquifer is poorly defined and probably extends a great distance to the south.

- o It is highly probable that the groundwater production potential far exceeds the demand suggested for projected future population trends for this subarea.

- o The Big Beef aquifer system may provide adequate groundwater supplies for transmission to meet regional demands throughout the County. However, additional groundwater data is needed to fully evaluate this option.

Recommendations:

- o Extensive test drilling of the Qg3 and deeper aquifers is required in this area to define the stratigraphic and hydrologic conditions.

- o The University of Washington's Big Beef Fish Farm and Laks Trout Farm artesian wells should be monitored to measure aquifer stress.

(6) South Kitsap Subarea:

Conclusions:

Principal aquifer systems:

- Clam Bay
- Yukon
- Wilson Creek
- Port Orchard Deep
- Salmonberry
- Northlake-Bremerton
- Gorst

o Clam Bay - Encountered between 0 to -150 feet MSL within Qg3. The extent of this aquifer is limited by the occurrence of the surrounding bedrock Unit Tb.

o Yukon - Encountered between 0 to -150 feet MSL within Unit Qg3. The extent of this aquifer is poorly defined due to a lack of wells with reliable data.

o Wilson Creek - Encountered between +150 to +50 feet MSL within Unit Qg2. The extent of this aquifer is poorly defined, but is suspected to extend appreciably beyond the boundaries as drawn.

o Port Orchard Deep - Encountered between -650 to -1,100 feet MSL within Qg5. The extent of this aquifer is poorly defined due to the lack of deep-well data.

o Salmonberry - Encountered between -150 to -250 feet MSL within Unit Qg4. The extent of this aquifer is poorly defined, again due to the lack of deep wells.

o Northlake-Bremerton South - This system is comprised of three aquifers. The upper aquifer is encountered between +250 to +200 feet MSL within Qg1a. The middle aquifer is encountered between -150 to -200 within Qg4. The lower aquifer is -450 to -525 feet MSL within Qg5. The upper aquifer is found in the southern area of the system and could possibly be extended further south.

o Gorst - Encountered between +50 to -100 feet MSL within Qg3. The extent of this very productive aquifer is limited to north by bedrock and is poorly defined in other directions. There is the likelihood for a large amount of recharge from the Gold Mountain area.

- The principal aquifer systems are all located to the north, principally along the more densely populated areas. The southern portion presently has no defined principal aquifer systems.

- The available hydrogeologic data from the southern portion of the subarea is dominated by shallow domestic wells with occasional wells drilled to moderate depths.

Recommendations:

- Several dedicated monitoring wells should be established for the Gorst aquifer system and at least one dedicated water level monitoring well is recommended in each of the other defined aquifers.

- Future test drilling in the southern portion of this subarea should focus on the stratigraphy and aquifer parameters of the deeper aquifer systems below Qg2.

B. Institutional/Management Issues

Conclusions

- There are numerous agencies at the local, State, and federal level which operate programs with the potential to affect groundwater quality and quantity.

- In general, these ongoing programs are diligently pursued, but occasionally result in overlapping or uncoordinated efforts.

- Existing resource management concerns which merit further evaluation include:

    - Data limitations
    - Data management responsibilities
    - Improved inter-agency coordination
        Uniform Well Identification Numbering System
        Abandoned Wells

- Water rights
- Aquifer overdrafts and limitation of new wells
- Conjunctive use/artificial recharge
- Public education/awareness

o The County has authority under SEPA (Chapter 43.20C RCW) and the Planning Enabling Act (Chapter 36.70 RCW), to control development so as to protect groundwater. However, conditioning or denial of permits must be based on specific adverse impacts. Furthermore, reasonable mitigation measures must be set forth, or, if no mitigation exists, reasons why impacts are unavoidable must be stated.

o The GWMP Grant No. 1 activities did not establish a basis to render site specific land use decisions based on impacts to either groundwater quality or quantity. However, sensitive areas were established within subareas where land surface practices should be reviewed more closely to assess their impacts.

o Many of the management issues identified by existing technical data require coordinated efforts between various local, State, and federal agencies.

o Coordination and development of some major policy changes and procedures to address the above issues and others established in Grant No. 2 may not be accomplished within a short period.

Recommendations

o Continue during Grant No. 2 to identify local resource management issues and their solutions.

o Encourage a broad base of public and political support for change regarding key management issues.

o Develop regional and State-wide support for legislative change where necessary, to address issues common to areas outside Kitsap County.

o Pursue development of policies by the GWAC and its Policy Subcommittee.

C. Implementation

Conclusions

- The most immediate action items once Grant No. 2 is initiated is implementation of the comprehensive hydrogeologic and water quality monitoring network recommended herein.
- Financial and political support for continued groundwater management activities are required to implement effective management strategies.

Recommendations

- Refine and implement a hydrogeologic and water quality monitoring network to develop comprehensive and sustained background data.

EXHIBIT I-1

KITSAP COUNTY
GROUND WATER MANAGEMENT PROGRAM

PROGRAM GOALS AND OBJECTIVES

WHEREAS, Kitsap County is primarily dependent upon groundwater for the continued viability of water supply to its existing and future citizens, and

WHEREAS, Several existing and potential impacts on the quality and quantity of groundwater resources in Kitsap County have been identified; and

WHEREAS, it is desirable to identify groundwater management procedures that are consistent with both local needs and state water resource policies and management objectives including the protection of water quality, assurance of quantity, and efficient management of water resources to meet future needs; and

WHEREAS, the Department of Ecology pursuant to RCW 90.44.00 and its implementing rules, Chapter 173-100 WAC have designated Kitsap County as a Ground Water Management Area; and

WHEREAS, a Ground Water Advisory Committee has been formed to oversee the development of the Ground Water Management Program, review the work plan, budget, and assure that the program is technically and functionally sound;

NOW THEREFORE, the Ground Water Advisory Committee endorse the general goal and specific objectives listed below to be used in the development of the Ground Water Management Program:

General Program Goal

To ensure an adequate quantity of high quality groundwater through conservation and by adopting and enforcing a sensible Groundwater Resource Plan.

Specific Program Objectives

Evaluate Existing Conditions and Concerns

1. To the extent that available funding permits, define/delineate hydrogeology of the County's aquifers.

2. Establish existing water quality conditions and areas of existing or potential water quality degradation trends.

3. Identify recharge areas and measures to protect them from contamination by surface water runoff and other pollutant sources.

4. Project the current and future water demands and identify pumpage impacts upon groundwater quantity and quality.

5. Evaluate the benefits, advantages, and viability of regional resource utilization.

6. Identify area-wide and subarea groundwater resource issues.

<u>Identify Management Procedures and Responsibilities</u>

7. Identify land use and water use policies which are inconsistent with these goals and objectives and recommend needed changes.

8. Identify management policies and practices which encourage conservation at all levels.

9. Recommend land use policies to protect aquifers and recharge areas.

10. Evaluate the proliferation of individual and small public water supplies and their impact on groundwater resources.

11. Define the long-term priority of use for groundwater.

12. Recommend a procedure for and the responsible entities to continually update and manage groundwater resource data.

13. Review existing laws, ordinances, procedures, responsibilities, and their efficacy with respect to groundwater resource management and protection and recommend such revisions as are appropriate. Identify the proper agency or entity with responsibility for implementation and enforcement.

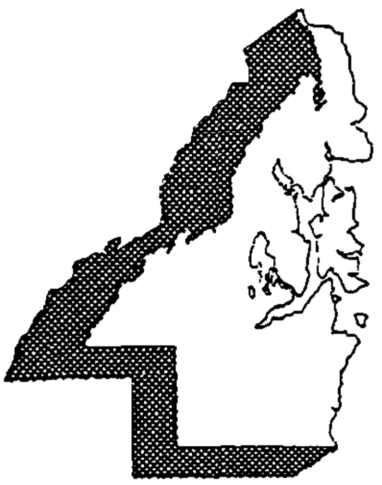
14. Utilize a citizen participation process in meeting the above objectives.

The above Ground Water Management Program Goals and Objectives are hereby formally reviewed and adopted by the Kitsap County Ground Water Advisory Committee on January 20,1987.

Clair H. Burwell

Chairperson, Kitsap County
Ground Water Advisory Committee

SECTION II



SECTION II

APPROACH AND FINDINGS

1. PLANNING CRITERIA

A. Regional and Subarea Boundaries

The Kitsap County project area, shown in Exhibit II-1, encompasses approximately 402 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 characteristics of the project area are similar to much of the surrounding Puget Sound area, consisting of remnants of an upland plateau modified by glaciation. The surface is composed of generally flat-topped rolling hills and ridges which rise to approximately 400 to 600 feet above mean sea level, and are separated by valleys and marine embayments. The Blue Hills are a prominent group of rugged volcanic rock hills in the west-central portion of the study area which rise to an elevation of approximately 1,700 feet above mean sea level. Much of the upland areas terminate along the coast in steep bluffs created by wave action.

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 groundwater 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 percolation that originates within the uplands.

The County was divided into five subareas based on the major surface water drainage features and watershed boundaries. The five project subareas include the following:

- Hansville-Indianola Subarea is the northern-most subarea. It is bounded on the north and east by Admiralty Inlet and Puget Sound, on the south by Port Madison and Agate Pass, and on the west by a northerly transect located just east of the Big Valley

Drainage and passing through Lemolo. These boundaries are major discharge areas for this subarea.

- o Bainbridge Island Subarea is located on the eastern portion of the County. It is bounded on the east by Puget Sound, on the north by Port Madison, on the west by Agate Pass and Fletcher Bay, and on the south by Rich Passage. This subarea also includes Blake Island which is located south of Bainbridge and is bounded by Puget Sound. Blake Island is currently a State Park.

- o Poulsbo-Bremerton Subarea incorporates much of the northwestern portion of the County, including Bangor, Poulsbo, and Bremerton. It is bounded on the north and west by Hood Canal, on the south by Sinclair Inlet and the Green and Gold Mountains, and on the east by Port Orchard. This subarea includes the Big Valley Drainage.

- o West Kitsap Subarea encompasses the western-most portion of the County. It is bounded on the north and west by Hood Canal, on the south by Mason County, and on the east by upland drainages and the Green and Gold Mountains. This subarea is characterized by extensive volcanic bedrock deposits which form the Blue Hills.

- o South Kitsap Subarea includes the southern portion of the county. Due to the large size of the subarea, it was divided into a west and an east section for presentation purposes. It is bounded on the south by Pierce County, on the west by Mason County, on the east by Colvos Passage, and on the north by Sinclair Inlet. This subarea includes the Gorst Creek Drainage.

A series of six base maps are used to characterize the study area within this report. This includes one map for each subarea except South Kitsap where two base maps (east and west) are used. All the base maps and accompanying figures in Volume II are presented at a scale of 1:48000 (1 inch = 4,000 feet).

B. Land Use Factors

The quality of both surface and groundwaters are known to be impacted by the type and intensity of land use activities that occur in a watershed or recharge area. To assess the impact which various types of land use may have on groundwater resources, these activities must first be characterized and located with respect to the hydrogeology within the area. The project approach for determining the potential for aquifer contamination can be seen in Exhibit II-2. This approach involves correlating land use evaluation with corresponding water quality assessments to arrive at a determination on contamination potential. Existing regulatory requirements and national groundwater quality surveys on occurrence of contamination are used as guidelines for gathering local land use and water quality data. Review and documentation of this data leads to identification of key indicator parameters used to assess the potential impact of land use activities on groundwater quality.

(1) Land Use Evaluations

A survey of existing and historical land use activities was completed throughout the Kitsap County Ground Water Management area. Land use categories were patterned after the U.S. Office of Technology Assessment's (OTA) system for categorizing various sources of groundwater contamination and these categories are depicted in Exhibit II-3. These source classifications were used as a guide in researching activities within Kitsap County. The results of the investigation were then graphically displayed to correlate the location of potential contamination sites with quality of the groundwater. These overlays of land use activity along with more specific descriptions of potential impact on groundwater are contained in the discussions for each subarea (Volume II, Appendix A through E).

From a regional viewpoint, Kitsap County contains numerous agricultural and forestry areas as well as many government owned and operated facilities, including the Bangor Submarine Base, Keyport Naval Undersea Warfare Engineering Station, and the Puget Sound Naval Shipyard. Outside of the urbanized centers of Bremerton, Port Orchard, Silverdale, Poulsbo, Manchester, and Winslow, the county is generally characterized by large parcels of undeveloped land and open space. Low density, single-family dwellings and small farms are scattered throughout the County, and there are large areas of pasture and forest land. The major urbanized areas are sewered, as well as portions of unincorporated Kitsap County which is served by the Central Kitsap Sewer District near the Trident Base, Keyport, Poulsbo, Silverdale, and East Bremerton. There are 10 documented historical landfills throughout the county and two currently operating municipal landfills at Hansville and Olympic View Industrial Park. In addition, there are three auto demolition sites in use. There are over 1,000 underground storage tanks located at approximately 280 sites throughout the Ground Water Management Area (GWMA). The majority of the underground tanks are for storage of gasoline, diesel and used oil. However, there are also materials such as aviation fuel, undefined hazardous waste, and kerosene. A number of facilities (48 currently) are regulated under the Resource Conservation and Recovery Act (RCRA) and three Superfund sites are located in Kitsap County; Strandley Scrap Metal in the southern part of the County, the Wycoff site near Eagle Harbor on Bainbridge Island, and an ordinance disposal site at the Bangor Submarine Base.

(2) Water Quality Assessments

In addition to providing a guide for characterization of potential contamination sources, the OTA categories were also used to develop a list of parameters whose presence might indicate an impact to groundwater quality. Indicator parameters were developed for each of the potential contaminant sources and are presented in Table II-1.

Criteria for selection of the indicator water quality parameters included:

- o Type and intensity of land use activity
- o Human health considerations
- o Frequency of occurrence in groundwater

The type of land use activity can have a direct impact on the water quality parameters found in groundwater. For example, measuring a trend of increasing nitrate levels may indicate the presence of on-site sewage facilities. Likewise, detecting a pesticide in groundwater quality samples would imply the possibility of nearby agricultural activity.

To evaluate human health concerns, primary and secondary contaminants, as defined by the Rules and Regulations of the State Board of Health Regarding Public Water Systems, February, 1988, and the U.S. Safe Drinking Water Act, were used as indicator parameters. Maximum contaminant levels (MCLs) for primary contaminants are based on chronic and/or acute human health effects. Secondary contaminants have MCLs based on non-health issues such as aesthetics. These parameters and their MCL values for both existing and proposed regulations can be seen in Tables II-2 and II-3.

Frequency of occurrence of organic substances was based on national surveys of groundwater quality and regional and site specific studies of Kitsap County. Nationally, there have been several surveys completed which addressed the quality of groundwater. They include the National Organics Monitoring Survey

(NOMS), the National Screening Program (NSP), the Ground Water Supply Survey (GWSS), and the Community Water Supply Survey (CWSS). These surveys found the following volatile organic chemicals (VOCs) to be fairly prevalent in groundwater: trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane. For this reason, these VOCs were included in the list of indicator parameters. In addition, review of the hazardous materials transporters, and disposal and storage facilities within Kitsap County indicated that methylene chloride, polychlorinated biphenyls (PCBs), chromium, lead, mercury, creosote, phenols, acetone, ketone and cyanide were prevalent. These parameters were also included in the list.

Parameters chosen as indicative of pesticide use were based on a study titled "Survey of Pesticides Used in Selected Areas Having Vulnerable Groundwaters in Washington State," July 1987, by the Environmental Protection Agency (EPA) in association with the Department of Agriculture. This study evaluated crop use and associated pesticide use throughout Washington State. Table II-4 presents the crops and pesticides/herbicides potentially used in Kitsap County. These pesticides were included in the list of indicator parameters.

Conductivity and pH were chosen as indicator parameters because increasing conductivity and/or extreme pH levels can signal the presence of contaminant streams. For example, a highly concentrated acidic chemical could cause the conductivity of a groundwater sample to be elevated above background conditions, and the acidity would drive the pH measurement below pH 7.0.

Historical records on the occurrence of these indicator parameters in wells within the GWMA were collected. A statistical trending analysis was performed for each parameter. The measurement of these parameters at levels above the MCL or the presence of a significant upward trend, could identify a groundwater contamination source. The methodology for the trending analysis is described more fully in Section II, 5.B., Water Quality Trends.

In addition to the trend analysis, the presence of indicator parameters at levels above the MCL were evaluated to locate potentially sensitive water quality areas. Generally, MCLs were not exceeded throughout the study area except for some iron and manganese concentrations which are an aesthetic and not a water quality concern. Some site-specific contamination has occurred within Kitsap County, but overall background degradation trends were not found. These evaluations are discussed in the Volume II, Appendices, for each subarea.

(3) Infiltration Potential

In addition to categorizing land use as it relates to contamination potential, land use evaluations were also used in developing a relative infiltration potential map for the GWMA. This map combined information on soils, slope, and impervious cover to arrive at a relative potential for infiltration. Land use categories were used to evaluate the percentage of impervious area. The methodology and results from the infiltration potential analysis are presented in more detail in Section II, 4. E.

Future land use categories were derived from Kitsap County's Subarea Plans. Total future impervious area percentages were developed based on aerial photographs of 100 percent build up conditions for the various land use categories. Existing impervious percentages were calculated based on population and dwelling units per acre. Assumptions in the analysis for existing impervious cover were as follows:

- o Dwelling units contain 3,500 square feet of impervious surface.
- o *Imprevious percentages for urban and industrial zones are the same as future conditions.
- o Roadways are distributed proportionally throughout the County.
- o Bangor is assumed to be 15 percent impervious.

Table II-5 displays these land use categories with the calculated impervious percentages for both future and existing conditions.

C. Population Projection

(1) Methodology

Population projections were initially developed based on discussions and meetings with representatives from the Puget Sound Council of Governments (PSCOG), and PSCOG's Population and Employment Report, 1984. These projections were then refined based upon the PSCOG's Draft 1987 Report. They were finally revised based on final PSCOG data made available in June 1988.

PSCOG forecasts are developed using a four-county regional econometric model. The expected growth in population, employment, income, and other components is based on economic and demographic forecasts of the United States as a whole. The PSCOG model also uses the county-wide figures to project trends in smaller areas. These are called Forecast and Analysis Zones (FAZs). The FAZs include groupings of census tracts which give a more accurate referenced population, using the most recent census data. The FAZ breakdown provides a convenient basis for locating areas within Kitsap County which may be expected to show relatively higher or lower growth rates than the County average. FAZs are identified on Exhibit II-4.

Population figures through 2020 were taken directly from the June, 1988, PSCOG report. Straight-line projections were used to forecast the population between 2020 and 2040. A summary of the assumptions used to prepare the population projections including percent of subareas within FAZs is presented in Table II-6.

(2) Summary of Results

Population estimates are shown on Table II-7. The total population within the GWMP study area is estimated to increase from its current level of approximately 181,400 people (1989), to 258,600 in 2010, and 366,400 in 2040. Exhibit II-5 is a graph of historical and future population growth from 1970 to 2040.

D. Water Resource Requirements

(1) Municipal and Domestic Water Demand

Municipal and domestic water demand includes all public water supply systems and individual single resident water systems. The municipal and domestic water demand projections reflect population forecasts and per capita consumption rates for urban, semi-urban/rural, and rural areas of the study area. It includes water demands estimated to be met by the City of Bremerton's surface water supply. Total demand is influenced by the economic factors considered by PSCOG in its population model. It is estimated only as a function of population growth, as described in the previous section. Water demand impacts from unknown closures or construction of large industrial water use facilities was not assumed. Water conservation was addressed as described below.

Water usage values were selected for three categories of water consumption patterns that reflect varying mixes of residential, commercial, and industrial customers. Per capita average day demands of either 100 gallons per capita per day (gpcd) for rural areas, 140 gpcd for semi-urban/rural areas, or 175 gpcd for urban areas were selected based upon available historical water use records of several utilities throughout Kitsap County collected by the Kitsap County Health Department. The designations of urban, semi-urban/rural, and rural FAZs are based on the Kitsap County Land Use Plan. The demands were assigned to FAZs to reflect increasing influence of commercial/industrial activities representing existing conditions in Kitsap County. Peaking factors of 2.3 for urban areas was selected based upon the City of Bremerton's water use records. Peaking factors of 3.0 for rural and semi-urban/rural areas was selected based on prior work in similar areas of the State and recommended guidelines for average to peak day demand estimates. These demands and factors are summarized by FAZ on Table II-6.

Available surface water supply was estimated from existing water supply records from the City of Bremerton. Water use was projected for the City of Bremerton based on overall projected increase in water demand for the Poulsbo-Bremerton Subarea. Proportion of surface water used annually was based on current utilization of 65 percent surface to 35 percent groundwater. The City of Bremerton's current maximum surface water supply capacity of 15 MGD and planned expansion to 20 MGD will be used to offset peak day groundwater demands in the Poulsbo-Bremerton Subarea, as footnoted in Table II-8.

(a) Scenarios

Demand scenarios were developed for existing conditions and three other scenarios of varying consumption regarding conservation and multi-family impacts. Scenario 1 represents demand under existing conditions, as described above. The other three scenarios considered were: increase in multi-family housing in the semi-urban/ rural and urban areas; water demands with water conservation for all areas; and, a combination of both. Scenario 2, with increase in multi-family units, assumes a gradual reduction in per capita consumption of 1.5 percent in the urban areas and 3.5 percent in the semi-urban/rural areas for the year 1995, up to 3 percent and 7 percent, respectively, after the year 2000. Scenario 3, with water conservation, assumes savings in per capita consumption of 5 percent in 1995, up to 10 percent in 2000, and thereafter, for all urban, semi-urban/

rural, and rural areas. Scenario 4 is a combination of Scenarios 2 and 3.

(b) Subareas

Population and average and peak day water demand is summarized by the six subareas. The subareas correspond with planning areas used to describe hydrogeology and groundwater quality. These subareas are:

Subarea 1	- Hansville-Indianola
Subarea 2	- Bainbridge
Subarea 3	- Poulsbo-Bremerton
Subarea 4	- West Kitsap
Subarea 5A	- South Kitsap West
Subarea 5B	- South Kitsap East

For individual summaries by subarea, refer to Volume II of this Report.

(c) Average Day Demand

Table II-6 shows the consumption values assigned to each FAZ. Table II-8 summarizes the resultant average demands for the GWMP study area for the four different scenarios by subarea. Average day demands for the GWMP study area are estimated to range from current levels of approximately 24 MGD, in 1989, to the following:

- Scenario 1, Existing - 34 MGD in 2010 and 47 MGD in 2040.
- Scenario 2, Multi-Family - 32 MGD in 2010 and 45 MGD in 2040.
- Scenario 3, Conservation - 30 MGD in 2010 and 42 MGD in 2040.
- Scenario 4, Conservation and Multi-Family - 29 MGD in 2010 and 41 MGD in 2040.

(d) Peak Day Demand

Peak day demand is also shown for the GWMP study area by subarea on Table II-8. Based upon the analysis, the potential peak day demand within the study area could increase from current levels of approximately 66 MGD in 1989 to the following:

- o Scenario 1-Existing - 94 MGD in 2010 and 133 MGD in 2040;
- o Scenario 2-Multi-Family - 91 MGD in 2010 and 128 MGD in 2040;
- o Scenario 3-Conservation - 86 MGD in 2010 and 120 MGD in 2040; and,
- o Scenario 4-Conservation and Multi-Family - 81 MGD in 2010 and 115 MGD in 2040.

(e) Segregation of Municipal and Domestic Water Demand

A methodology to segregate municipal and domestic water demand was evaluated using 1980 census data summarized by the National Water Well Association. The database is a listing of wells by zip code for all of Washington State. However, the listing was found to be incomplete for some areas of Kitsap County, and therefore, could not be utilized. In addition, this listing assumed water utilities consisted of five or more connections which excludes some Class 4 public water systems. Class 4 systems are defined as serving two to nine connections.

The method used was based on a comparison of estimated population served by public water systems with total population of the County. Population served by Class 1, 2, 3, and 4 water systems was taken from the 1986 report, "Preliminary Assessment of Water Resource and Public Water Services Issues in Kitsap County," by the Department of Community Development and PUD No. 1 of Kitsap County. The estimated population served by all public water systems was approximately 132,850. The total population of the County, based on PSCOG forecast data for 1985, was approximately 166,160. Given these population estimates, approximately 80 percent of the population is served by municipal systems and the remaining 20 percent is served by domestic systems.

(f) Seasonal Water Demand

Due to the limited availability of data, it is not possible now to accurately estimate seasonal water demand changes. Irrigation use is seasonal (i.e., it occurs during the spring and summer months). The seasonal variability of irrigation has been accounted for in the water use projection tables. Irrigation use is based on a 5-month period rather than assuming it occurs year long. Municipal and domestic water use tends to fluctuate during the year because residential demand is lowest during the winter months and highest during the summer months. Average day represents a leveling of demand, and peak day represents the highest estimate of water use that will occur during a given day in the summer. Generally, winter residential use is approximately 80 percent of annual daily average, and summer is approximately 25 percent greater than average annual daily demand. Spring and fall tend to reflect the average day demand estimate.

(2) Commercial and Industrial Water Demand

Most of the commercial and industrial water use is accounted for in the municipal and domestic water use category. For those business establishments and industries not connected to a municipal water system, water use was estimated based on existing annual water right records for the Department of Ecology (Ecology). Commercial and industrial water use by this method accounts for approximately 0.27 MGD for all of Kitsap County. The breakdown by subarea is shown on Table II-9. Private commercial and industrial use accounts for less than 1 percent of the projected annual demand. Non-municipal sources of supply for commercial establishments and industrial facilities are not expected to increase significantly. Most of this category of water use is anticipated to be met by surrounding utilities.

(3) Irrigation

Existing irrigation use is based on 1982 Bureau of the Census agricultural statistics data for number of acres irrigated. In 1982, 677 acres of land in irrigated farms were irrigated. Total land in irrigated farms was reported to be 3,147 acres, up from 2,462 acres in 1978. An estimated 603 acres of land was irrigated in 1978. Lower estimates of farmland irrigated have been reported by the

Bureau of Census. However, these lower figures are only based on farms with sales of $2,500 or more.

Irrigation estimates for the GWMP study area by subarea, as shown on Table II-9, were apportioned based on existing water right records from Ecology. The number of acres under irrigation was originally assumed to be irrigated at an average rate of 1.5 acre-feet per acre per year. Irrigation use was revised to 0.8 acre-feet per acre per year as recommended. Although this figure is low in comparison with values reported for similar areas, it has been reported as low as this by the Bureau of Census. In addition, it is assumed that the irrigation occurs during a 150-day irrigation season.

Because of the overall historical decline in agriculture, it is not anticipated that irrigation will increase. In fact, overall irrigation demand may decline. For purposes of this study, irrigation use was assumed to remain constant.

The existing total average day demand for irrigation during the irrigation season was estimated to be 2.21 MGD based on 1.5 acre-feet per acre per year. Based on 0.8 acre-feet per acre per year, the total average day demand for irrigation is 1.18 MGD. Irrigation accounts for approximately 4 percent of the total annual water use in Kitsap County.

(4) Fish Propagation

Water demand for fish propagation was based on existing annual water right records obtained from Ecology and is summarized by subarea in Table II-9.

Water use based on groundwater rights for fish propagation account for approximately 16 percent of the total annual water use in Kitsap County. In discussions with the Department of Fisheries (Fisheries), no methodology for estimating future groundwater development for aquacultural purposes was recommended. The average water use for a facility ranges from approximately 1,500 to 4,000 gpm. Based on discussions with Fisheries, because of disposal restrictions of water, new industry is not as likely to develop in populated areas. The primary consideration in locating an aquaculture farm is: (1) adequate and reliable supply of water, and (2) ease in disposal of wastewater. Hence, no significant increase in groundwater demand from aquaculture farms is anticipated at this time. Water demand for fish propagation is shown to occur in all subareas except 2, Bainbridge Island, and 3, Poulsbo-

Bremerton. The combined total average day requirement for fish propagation was estimated to be 5.20 MGD.

(5) Stock Watering

The only other category of water demand considered was stock watering. Again, annual water right records from Ecology were used here, as well, to allocate water use between subareas. As with irrigation, no increase or decrease in water use for stock watering was anticipated. From 1978 to 1988, with the exception of poultry, there has been an increase in the number of stock animals, including cattle, sheep, horses, and swine in Kitsap County. This is based on data provided during review of this document from the Washington State and County Census agricultural statistics performed by key informants every 4 years, and separate of the regular census reporting. Excluding poultry, there were approximately 2,018 stock animals in 1978 as compared to 4,910 stock animals in 1988. Poultry, on the other hand, was reduced from 14,491 in 1978 to 2,000 in 1988.

The overall water use for the County is not significantly impacted by water used for stock, and since it is difficult to project future growth trends in this area, no new groundwater development is anticipated at this time. The total projected average day requirement for stock watering was estimated to be 0.02 MGD based on water rights alone.

Based on data provided from Washington State and County Census agricultural statistics, the number of beef and dairy cattle, sheep, horses, swine, and poultry, with an estimate of water use per category of animals, was used to determine annual water use for stock watering. Given 1,328 cattle, 847 sheep, 1,153 swine, and 2,000 poultry, an annual water use of 14 million gallons or 0.04 MGD was estimated. Although, this figure is twice the previous estimate, and exceeds the amount strictly allocated by water rights for stock, the amount is relatively insignificant given total water use in the County. This revised figure is reflected in Table II-9.

(6) Total Water Resource Requirement

A summary of average and peak day water demand for the Kitsap County GWMP study area by subarea is provided in Table II-10 and graphically depicted in Exhibit II-6. The water demand projections shown include all of the above referenced demands, i.e. municipal and domestic, commercial/industrial, irrigation, fish propagation, and heat exchange. All total, municipal and domestic water demand accounts for approximately 75 percent of the existing average day water demand during the irrigation season. During the non-irrigation season, municipal and domestic water demand accounts for about 80 percent of the existing average day water demand. Monthly, quarterly, and seasonal fluctuations in water demand beyond average and peak daily usage patterns were considered but found to be of small impact. This is particularly true where irrigation and commercial/industrial process activities are small outside the summer period.

The total average day existing water resource requirement is about 31 MGD for 1989. It is projected to increase to approximately 54 MGD in 2040, 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 semi-urban/rural and urban areas of Kitsap County, and a municipal and domestic water conservation program is initiated at the County and local utility levels, then the anticipated average day demand in 2040 is projected to be about 47 MGD. Hence, an additional average day water resource requirement of 16 to 23 MGD would be necessary by the year 2040.

Total peak day demand is estimated to be about 74 MGD for 1989. By 2040 this demand is anticipated to range from 122 to 140 MGD depending on the scenario assumed. Hence, the additional water resource requirement during a peak day event would be about 48 to 66 MGD by 2040.

E. Groundwater Rights

(1) General

The groundwater right information for each subarea is presented in Volume II, Appendices A through E. The summary Table II-11 has been derived from water right printout records of Ecology, dated July 11, 1988, and from data previously compiled during development of the Kitsap County Coordinated Water System Plan (CWSP). These water rights were established under the State ground-water code, Chapter 90.44 RCW.

The tables include all groundwater rights that were in the computer system on the date of the water right printout. The entries under the Source I.D. column on the tables are variable. They are intended only to portray the best apparent identifier for a particular water right. Water right ownership changes are not usually reflected in the water right records. Therefore, in many cases, the entry under the Source I.D. may have no relationship to the present ownership of the water right.

In preparing the summary table, it was necessary to make some estimates on the annual quantities authorized where the right was granted for more than one use, but did not specifically break down the annual authorization for each use.

The groundwater rights for the GWMA have been compiled for each of the subareas. Because of the nature of boundary lines between subareas and the lack of preciseness in the water right printout concerning location, it is possible that a few rights may be erroneously identified as being in the wrong subarea. This should not, however, materially affect the totals.

(2) Water Rights and Claims

It is important to note that the above-referenced tables include only recorded rights established under the permit system or through a declaration of prior right, as provided in the groundwater code of 1945. There are at least two other types of groundwater rights in the Kitsap County GWMA. One type is generally referred to as a claim to vested right established through actual development and use of groundwater prior to June 7, 1945. In order to retain such a right, the owner or right holder was required to file a claim under the "Registration Claims Act" of 1969. Such claims are recorded in Ecology's water right claims registry.

The second type of other groundwater right is the right that is established under a permit exemption provision of the groundwater code where not more than 5,000 gallons a day have been developed and used (e.g., domestic use). If such a right were not claimed under the "Registration Claims Act" or was established subsequent to June 30, 1974, the right still exists, but is unrecorded.

Claims and unrecorded small quantity wells are very large in numbers of claimants or right holders, but generally would not constitute a very high percentage of the total authorized use of groundwater within a given geographic area. Unfortunately, the actual validity and amount of water right that exists under these two types of other rights are unknown. Quantification of such rights can only be determined with certainty through a general adjudication of water rights (see RCW 90.03.110 through RCW 90.03.245, and RCW 90.44.220 and 90.44.230).

The multitude of wells being used under claims or the exemption provision of the groundwater code must be considered in the groundwater management planning process. Impacts on existing water rights can be a constraint to future groundwater development.

(3) Summary of Groundwater Right Information

It is important that the data in the water right tables in Volume II, and in particular Table II-11, be understood to minimize the risk of misuse. Unfortunately, the water rights do not reflect actual current usage of the groundwater resource. They only identify the possible maximum legal appropriations that can be made under the water rights. Some of the uncertainties are as follows:

(a) Certificates of water rights have often been issued in amounts greater than actually developed and used.

(b) Numerous rights are still recorded and considered active although they are currently unused or totally abandoned and have never been formally relinquished.

(c) Originally developed well capacities have permanently diminished to a point below the water right amounts due to system deficiencies or source deterioration.

(d) New permits have been processed instead of changing ownership or point of withdrawal for an existing water right.

(e) Permit listings reflect authorization to develop and use certain amounts of water, but the status of development is not reflected on the water right printout (e.g. the well may not even be drilled yet).

Additionally, care should be exercised in the use of the MGD conversion figures from either the instantaneous amounts (gpm) or the annual quantities (acre-feet per year). For example, in the case of instantaneous withdrawal rates, the conversion from gpm to MGD makes an assumption that all wells can be and are operated continuously for 24 hours. In the case of converting annual acre-feet to an average daily withdrawal rate in MGD, it should be recognized that some uses (e.g., irrigation) have highly variable water requirements throughout the year.

Even with the above limitations, the Summary of Groundwater Right Information is useful in showing some general groundwater right relationships.

Water rights listed under domestic multiple or domestic municipal authorize the withdrawal of 52,184 gpm (116 cfs) which would equal 75.15 MGD if all rights could be continuously utilized for a full day; annual withdrawal is limited to 35,354 acre-feet per year (average of 31.57 MGD).

Groundwater rights for all other uses amount to 7,972 acre-feet annually (9.01 MGD), or approximately 18 percent of the total groundwater authorizations. Of note, is the fact that fish propagation accounts for 5,828 acre-feet per year o the "other use" authorization. Surface water rights and Ecology's water right claims registry have been scan reviewed for general relationships. There are over 7,500 claims to groundwater rights in Kitsap County and over 1,250 surface water claims.

(4) Comparison of Water Demands with Groundwater Rights

For most of the water use categories, water rights exceed existing and projected demand at least through the year 2000. The most notable deficit in water rights is in the Poulsbo-Bremerton Subarea. Both average and peak municipal and domestic water demand estimates exceed instantaneous and annual water rights. The estimate for irrigation water use is approximately 70 percent of existing annual water rights. The assumption of 1.5 acre-feet per year may not adequately reflect actual usage or there may be water rights not being currently utilized. All other uses were based on existing water rights. Therefore, no comparison can be made.

(5) Summary

In reviewing water right claims listings and the recorded water right printout, the following areas warrant special note:

(a) Some individuals or entities may think they have established a new water right by filing a claim under the "Registration Claims Act" of 1969. In the case of groundwater, uses of water initiated after June 6, 1945, in amounts greater than 5,000 gallons per day, require a State permit or certificate of water right, not a filed claim.

(b) Water right records could be a much better tool in groundwater management if the individual water right more clearly reflected actual use and if unused rights were voluntarily or involuntarily relinquished to be eliminated from the records.

2. DATABASE MANAGEMENT SYSTEM AND PROJECT DATABASE

A water resource database management system and a project database were developed for the study. The database management system is a customized program that allows the user to conveniently manipulate data. The system was developed to assist the County and other water resource planners in future data management.

The project database includes a wide variety of information such as well construction data, geologic logs, water level data, owner and water rights information, and water quality data. The database provided that basic information necessary to assess hydrostratigraphy, groundwater flow systems, water quality conditions, and quantity and quality trends.

A. Database Management System

A computerized database management system was developed for the project to provide the project consultants and local agencies a tool for management of groundwater resource information. The system incorporates the following features:

- o Operates on a standard desktop PC computer system;
- o Compatible with Ecology data management requirements as well as U.S. Geological Survey (USGS) and EPA database systems;
- o Provides a user friendly menu interface that allows water resource planners access to information without having to understand complicated programming commands;
- o Accepts both site-based and time series data; and
- o Provides an optional graphics interface which allows presentation of data within an AutoCAD mapping environment.

The database procedures which are used to manipulate the data were developed with Dbase III (R) software. Dbase III is a relational database manager that provides a programing environment for development of specific procedures for data manipulation. The programing environment was used to develop procedures that run behind a menu interface. The menu interface prompts the user to make selections and to key in data. Consequently, the user does not need to have a programing background to use the system. The procedures serve five basic functions including data input, editing, retrieval, transfer, and backup.

The data input procedures are designed to prompt the user for required data fields and to do limited error checking to confirm that the data was properly entered.

The data editing procedures allow the user to modify or update existing information that is already contained in the database.

Data retrieval routines allow the user to prepare data reports for use in water resource planning studies. Standardized report forms can be used (e.g. water levels, pumpage, well logs, etc.). Data retrieval can be accommodated by the following:

- o Retrieve by Site ID,
- o Retrieve by an Owner ID (e.g. Department of Health (DOH) number),
- o Retrieve by Township-Range-Section, and
- o Retrieve by Latitude-Longitude or State Plane Coordinate windows.

The data transfer routine allows the user to periodically extract all new or modified data and automatically build appropriately structured files for transfer to Ecology.

The data backup routine allows the user to periodically save the contents of the entire database management system to a set of floppy disks.

The structure and organization of the data management system conforms to the requirements defined in Ecology's Data Reporting Manual for the Groundwater Management Program (revised February 1988). All database information is organized and indexed using a site identification number (SITEID) based on the USGS protocol.

B. Project Database

One of the principal goals of the study is the compilation and assessment of the existing hydrogeologic data within the county. This effort created a reliable set of baseline data from which we have defined what could be realistically studied. It also served to demonstrate gaps in the available data which should be closed by collection of additional data. This data is the foundation upon which development of the recommended management practices is based. To systematically process the vast amount of available data, it was determined that the construction of a computerized database was essential. This makes application, editing, and maintenance of the data appreciably more efficient.

At the beginning of the study, well construction and water level data for approximately 2,900 wells were transferred from the USGS WATSTOR computer system through a PC computer system. A preliminary assessment of the available hydrogeologic data demonstrated that far more data existed than could be processed under the scope of this project. It was, therefore, necessary to establish a selection process by which the best and most appropriate data was incorporated into the working database. The goal was to create a database which contained approximately 800 high quality data points which provided reasonable areal distribution over the study area. Approximately 350 of the 3,350 wells in the USGS WATSTOR database were extracted and, when necessary, modified and 450 new wells were added to create the new database. The intent was to choose the two best data source wells per section and thereby acquire two valid data sets for each square mile of the study area. Where additional high quality data was determined to have sufficient value to the study it was included. Where no data of acceptable quality existed for a given section, the deficiency was noted and no data was entered. The development of the database was designed to create a computerized database compatible with the hardware and software employed by Ecology. Selected parameters for wells contained in the USGS WATSTOR and project databases are presented in Appendix F.

The criteria for selecting data-base wells were: (a) confidence in well location, (b) availability of a geologic description, and (c) construction details. Data reliability was also of critical importance. Data generated as part of a professional study or involving the input of a hydrogeologist was assigned a high priority where available.

Data sources for the selected wells included: reports from hydrogeologic consultants, purveyor files of the Kitsap County Environmental Health Department, files maintained by Nicholson Well Drilling, USGS publications and unpublished data, and various purveyor's well files. Ecology water well reports are included in the information acquired from Kitsap County Environmental Health Department and Nicholson Well Drilling.

The confidence in the well location was perhaps the most important factor in determining if the data from a well would be included in the file. If, and only if, a well could be located with reasonable accuracy, was the information from the well incorporated into the database. The location of each of the 800 wells was determined by a field check, legal description, detailed site map or engineering plan. The location of the well was indicated on the appropriate USGS topographic quadrangle, the base maps for the study, and entered into the database file.

Geologic description of materials encountered in the drilling of each well was an essential component of the database. Geologic logs were acquired either from Ecology Water Well Reports completed by the driller, or hydrogeologic reports provided by consultants for a particular project. A listing of geologic logs contained within the database is presented in Appendix G.

At a minimum, construction details of the wells such as depth drilled, casing diameter, and screened zone were required. In addition, water levels, pumping data, owner identification and other detailed information were included where available. The lack of the latter information was not considered as justification for exclusion of wells from the database.

Reports completed by consulting geologists regarding individual wells were used as primary sources of reliable information. These reports generally include details on construction, pump tests, and aquifer characteristics not found in most other sources. The bulk of the well information provided by consultant files, about 240 wells, originated from project reports and files of Robinson and Noble, Inc. of Tacoma. Other reports from Carr and Associates, Hart-Crowser, Inc., and Applied Geotechnology, Inc. were also utilized.

The extensive files of Kitsap County Environmental Health Department were important sources of information on the wells used by public water purveyors. These files included high quality information on well location, Ecology water well reports, engineering reports, and water quality. The files of all Class 1, 2, 3, and occasionally Class 4 water purveyors were reviewed for accurately located wells with significant well information. Approximately 185 data-wells came from this source.

Nicholson Drilling of Port Orchard has on file information on numerous wells drilled in Kitsap County. These wells have been field checked by them and their locations are considered as verified. About 280 wells were added to the database from the Nicholson files.

The USGS Water-Supply Paper 1413 was used as a source for selected wells in specific areas of Kitsap County where other data sources were unavailable. The paper contains concise data on 1,146 wells completed before 1951. Forty-one database wells originated from this source.

The data for about 40 wells on Bainbridge Island were provided by USGS office in Tacoma. This information was developed for a recently completed USGS study effort on the island.

Various Class 1 purveyors of Kitsap County were contacted directly in order to search their files for wells not included in the above-mentioned sources. Some valuable information for the most part on deep, older wells was found in these files.

As the data was collected, each data point was located on USGS quadrangle maps. The data was then transcribed onto a pre-printed, standardized form number ECY 030-29 ("green sheets") provided by Ecology. The following discussion describes the data recording process for selected data categories.

(1) Location

The location of each well was transferred to USGS quadrangles from the best available description. When practical, the AutoCad computer system was used to digitize the location from the base map and to convert the location to latitude/longitude coordinates. For the remainder of the wells, the latitude/longitude coordinates were determined using a scaled overlay designed to fit the particular base map.

For newly added wells, the latitude/longitude of the site location is used to form the site identification number. In the case of wells imported from the WATSTOR database, the existing WATSTOR identification number was retained and if necessary only the latitude/longitude coordinates were changed. The site identification number is a unique identifier developed by the USGS and is a concatenation of "lat-long" and a sequential well number (i.e., 01, 02, etc.). In cases where WATSTOR well locations were corrected the new "lat-long" was assigned and the original site identification number was retained.

The "local number" of the well is assigned using the standard Township/ Range/Section scheme of the USGS. In this scheme the 40 acre section divisions are assigned letters from A to R. Therefore for the second well entered in Township 25N, Range 2E, Section 10 and subsection B (NW1/4, of NE1/4) the local number is 25N/02E-10B02.

(2) Remarks

The remarks field was used to give the source of the well data and, in some cases, the owner`s well name. This field is helpful for quick identification and cross-referencing of the wells.

(3) Construction Details

Included in the database are construction details such as the hole diameter and depth, casing and completion record, drilling company and the drilling method used.

(4) Geologic Log

This field provides the written description of the geologic material encountered as the well was drilled. These descriptions came from hydrogeologic reports and State Water Well Reports that include the geologic description and depths.

The availability of additional logs such as geophysical logs (electrical, natural gamma, caliper, etc.) is indicated in the database in the Geophysical-log field, although the actual logs are not included.

(5) Pump Test Data

Additional fields added to the "green sheet" data form contain the data acquired during pumping tests. These include type of test, drawdown, and test duration. In most wells where hydrogeological consultants conducted the well test, an aquifer transmissivity was calculated and when one or more monitoring wells were available, storativity was also calculated. Fields are included for these parameters but are only filled where sufficient work was done to provide reasonable values.

3. MAPPING PROCEDURES

Most all of the major work products (maps) that were developed during the study were prepared using AutoCAD (R) computer aided drafting software. The AutoCAD work products provide a convenient medium for manipulation and presentation of the data within public forums and reports and facilitates future updating of maps as new information becomes available.

The AutoCAD mapping is based on the Washington State Plane Coordinate System, Lambert Projection (north zone). An AutoCAD base map was initially digitized using USGS topographic quadrangle maps. The base map includes data such as township-range-section grid and major surface water features. Report figures and other information were digitized as overlays that register to the base map data.

All information contained within the database is also stored by State Plane Coordinates which allows extraction and presentation of water resource information as AutoCAD overlays.

A number of utility procedures were developed to facilitate extraction of data from the database and presentation within the AutoCAD mapping environment. The routines allow the user to perform the following functions:

- o Query the database for information such as well yield, well depth, water level, water use, etc., and to plot the data onto an AutoCAD base map.
- o Extract well data and to prepare diagrams that illustrate well construction features, water levels, and subsurface geologic data.
- o Build cross section profiles through an arbitrary alignment and set of wells.

4. HYDROGEOLOGY

To assure that the management recommendations subsequently developed in this study are based on sound hydrogeologic information, a program was designed to collect, organize, and assess the available information. This data collection program was designed to treat all areas of the County with equal emphasis. Since the scope of the study covers the entire County, an area of approximately 402 square miles, the description and interpretation of the hydrogeology are necessarily regional in scope. However, where possible, the regional interpretations have incorporated information developed by studies with more site-specific focus. This has helped to verify the accuracy of the regional description.

The hydrogeologic interpretation was developed after a systematic collection and compilation of verifiable data. This data is the basis for various interpretive maps and cross sections. The explicit products include maps showing surface geologic characteristics, data location, drainage basins, slope/topography, and groundwater contour maps, as well as geologic cross sections. The goals of this interpretive process were the preliminary evaluation of groundwater infiltration and surface drainage patterns, the identification and description of known and suspected principal aquifers within the county, and the description of the flow dynamics of those aquifers where possible. The following sections detail the data collection efforts and interpretations which were applied to develop each of these products.

A. Drainage and Topography

There are hundreds of drainage basins in Kitsap County ranging in size from several acres to 16 square miles as shown on Exhibit II-7. In that exhibit the principal drainage basins have been identified by the name of the stream which discharges from the basin.

The drainage basin map was prepared to identify the relative discharge quantity and direction of surface water flow and to provide a preliminary estimate of the volume of surface water discharging from each basin. The quantification of these values is important in developing the overall water budget for the study area, to give some insight as to the volume and pattern of groundwater flow, and to develop evidence of groundwater transfer between basins. The basic relationship which is evaluated here is the concept that water originating as precipitation falling within each basin contributes to the stream that drains that basin.

For each stream with a surface drainage area equal to or greater than one square mile, the individual drainage basin divide was outlined based upon the topography data provided on USGS 7.5 minute quadrangle maps. The name and number assigned to the drainage basins are from Garling and others (1965). If a stream was unnamed, a name was assigned by Robinson & Noble, Inc., based on a local geographic name or feature shown on the USGS quadrangles.

Data for each basin is listed in tables on Appendix I. An index number which relates discharge per unit area was created by dividing the low flow value by the drainage basin area (discharge measured during low-flow periods and believed to be representative of groundwater input). This index allows comparison of basins of various sizes. Low index values may indicate that groundwater in the basin may be discharging somewhere other that the stream. High values may indicate that the basin's groundwater is discharging to the stream or even that groundwater is being imported from outside the basin boundary.

The topographic texture of Kitsap County is primarily that of low drumlinal hills which have been sculpted by the most recent glacial advance. The hills are separated by long valleys, such as Big Beef and Gorst Creeks and marine embayments, such as Liberty Bay and Dyes Inlet. Since the retreat of the Vashon Glacier the landscape has been slightly modified by stream erosion, landslides and wave action. Upland areas tend to be at elevations of 300 to 500 feet above sea level and occupy approximately 75 percent of the study area. The flat valley floors occupy about 5 percent of the county area with the remaining 20 percent occupied by transitional valley slopes, sea cliffs and the Green and Gold Mountain area.

B. Geology

Kitsap County lies in the center of the Puget Sound Lowland. The lowland lies between the Olympic Mountains to the west and the Cascade Range to the east. The Puget Sound 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 study area. This sediment blanket ranges in thickness from 0 to over 3,600 feet. It overlays an irregular bedrock surface which is exposed in the central and eastern portions of the study area on south Bainbridge Island and the Green and Gold Mountain highlands.

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 Kitsap County. The oldest is the unnamed igneous rocks that compose the Gold and Green Mountains located west of Bremerton (West Kitsap Subarea). These rocks have been age dated between 50 and 55 million years old (Duncan, 1982) and may be equivalent to 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 (Bainbridge Island Subarea) and across Rich Passage around Point Glover (South Kitsap Subarea) and north of Bremerton at Rocky Point and Sulfur Spring (Poulsbo-Bremerton Subarea). Bedrock units are not major sources for groundwater in Kitsap County.

The Tertiary rock units are overlain by a thick layer 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 groundwater is produced from these Quaternary (Recent and Pleistocene) sediments.

In the Pleistocene Epoch of the last 1.5 million years, the Puget 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

The geologic units presented in Table II-12 are primarily based on the interpretation of the county's deeper well logs. These interpretations have identified a superpositioned sequence of 13 units. In the study, these units have been assigned stratigraphic symbols which are used in maps, tables and cross sections. The lowest or oldest (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.

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. Further, the implication of correlation with units outside the study area is not sufficiently justified. A tentative correlation with published nomenclature is presented in Table II-12.

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 Kitsap County. Although several wells have been drilled in Unit Tv, none are known to be major producers of groundwater.

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 Tv this unit is not a significant source of groundwater.

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 areal extent and thickness. It is not a groundwater source and is not correlative with any unit identified in other groundwater studies located outside the Kitsap County area. This unit has been informally termed the Fletcher Bay formation by John B. Noble in several unpublished studies.

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 PUD well located at Fletcher Bay (Well 20K01). The unit has been tentatively identified in approximately 12 other locations throughout the county. It is located quite deep, being 600 to 800 feet below sea level.

Unit Qn5, the forth 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 groundwater potential.

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. The unit is best recognized in the Port Orchard area and is represented in Annapolis Water District Well No. 1 (Well 01K01). In this area it is capable of producing groundwater yields ranging from 25 to 700. 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 third interglacial episode. This fine grained deposit, up to 200 feet thick, is laterally extensive and is found throughout the central and southern Puget Lowland. It is probably correlative to the Clover Park formation (Noble, 1989, in preparation) of the southern Puget Sound area. Because of its fine grained nature, unit Qn4 is generally an aquitard which hydraulically separates the Qg4 and Qg3 aquifers. Qn4 does not yield substantial amounts of groundwater.

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. Very rarely are wells 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 Kitsap 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 100 to 300 feet above sea level, is up to 150 feet thick, and is not areally extensive. 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 (1989, in preparation).

Unit Qg1a 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 prodigious aquifer. This unit can be correlated with confidence to the Colvos and Esperance sands.

Unit Qg1 is Vashon glacial drift. This unit was deposited as a veneer of till over the entire county as the ice flowed south. Qg1 yields minor amounts of groundwater 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 Qn1, but are too thin to be shown on the cross-sections at the scale used. 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 Qn1. These consist of peat and recent alluvium both of which are generally thin. The recent alluvium can be a source of groundwater in some valley floors, particularly if in hydraulic continuity with surface water.

In an effort to better understand the stratigraphic relationships of these units, and assist in the delineation of the hydrogeology of the county, a series of 22 cross sections were developed. The locations of the cross sections were chosen to give the best areal coverage of Kitsap County geology. The cross sections were drawn as straight lines through the areas with the most reliable and abundant geological information. The areas with a paucity of well data were avoided. The cross sections are arranged so that wherever possible they could be matched or continued by another section with minimal extrapolation between them, i.e. nearby east-west cross sections can be lined up to give coverage of the entire county on an east to west line. Once the location of the cross-section traces were chosen and the topography plotted, all wells with geologic logs that lie within approximately one-half mile of the cross section were projected onto the section.

In addition to the stratigraphic unit symbols described above, the cross sections, which are displayed as exhibits in Volume II, show the data-source wells and a coded breakdown of the materials penetrated. These lithologic codes are explained on the individual sections. Special indicators (i.e. clam shells) are also shown. Wherever available, the tested aquifer transmissivity and/or the well's specific capacity are also noted adjacent to the tested interval for that well.

In general the cross sections show a high degree of variability in lithologic and hydrologic characteristics, as well as thickness and extent of each stratigraphic layer. Formations swell and pinch out in an unpredictable manner, which makes interpolation between widely spaced wells tenuous.

The geologic characteristics maps for each subarea provide surficial geologic information and are based on information presented in the geologic map of the county created by Deeter (1979b), and a compilation of mapping done by Sceva (1957), Molenaar, Garling and others (1965) and Deeter (1979a). The geologic units shown on Deeter's map were grouped into eight units of differing hydrogeologic characteristics. This was done on the basis of the type of geologic materials, grain size and slope as they affect the surface hydrology. The maps are included in the discussion of each subarea in Volume II.

The various map units for the geologic characteristics maps were defined recognizing that their primary function was to convey concepts pertinent to the hydrogeologic aspects of the study area. In some cases complex exposures were simplified where the detail tended to mask hydrologic characteristics or where the details added no significant information to the hydrologic interpretation. This was particularly true of high slope areas along the shoreline bluffs.

Unit 1 includes all lithified bedrock that crops out within the county. Two distinct formations are found within the study area. These are the Tertiary volcanics, found east of Bremerton, and the Blakeley Formation, found west of Bremerton and on Bainbridge Island. The physical nature of these units has been presented above. The units are characterized by high runoff rates, low permeability and are not generally considered to contain significant groundwater resources. Their implication in the resource analysis is important in that catchment areas dominated by this map unit tend to have high runoff/low recharge characteristics. However, the runoff can be very important to adjacent areas where runoff can be more easily infiltrated.

Unit 2 delineates areas with high slope and/or complex geology. Based on USGS topographic maps, areas with a slope of greater than 30 percent were assigned to this unit. Areas of complex geology were defined generally as areas where multiple units crop out in a small area, such as in valley walls and sea bluffs. Since the slope is the dominant hydrologic characteristic, and the geologic detail is not significant in the hydrogeologic response of these areas, the geology was simplified for these areas to make map reading and interpretation simpler. Areas dominated by Unit 2 are characterized by high runoff rates and variable, but generally low, infiltration. Unit 2 areas are not significant as recharge zones in the county. However, they may locally contain discharge points, particularly in the form of springs.

Unit 3 describes areas of lacustrine and flood plain deposits and includes the geologic unit "Vashon lacustrine", identified on Deeter's map as Ql, as well as other lacustrine deposits defined in the county. The deposits are thinly bedded gray to tan silt and clay. The unit is mapped as sporadic deposits spread throughout the study area with occasional deposits of relatively large areal extent. Unit 3 is characterized by high runoff and low permeability. Percolation to deeper zones is inhibited by this deposit. In addition, where this unit is present, any contaminant introduced would be expected to migrate laterally more quickly than vertically.

Unit 4 shows areas of organic sediments such as peat bogs and swamps and are generally water saturated. This unit generally occurs as sporadic deposits in valleys and as swamps which form in depressions in the upland areas. The unit is characterized by low permeability such that percolation to deeper zones is inhibited. Since these features are usually in local low areas, they tend to accept runoff from adjacent areas. For this reason, in some cases these areas can be significant as recharge zones in spite of their relatively low permeability.

Unit 5 includes areas of poorly sorted glacial deposits. This unit consists primarily of the geologic unit Vashon till which has the greatest areal extent of all the surficial geologic units. In Kitsap County the till has generally been deposited as a veneer which mantles older deposits. This unit, particularly where it represents glacial till, is highly variable in it's hydrologic character. Till is generally considered as producing high rates of runoff and generally low permeability. However, our findings in Kitsap County have demonstrated that significant groundwater recharge can occur through till-covered areas. Areas mapped as Unit 5, therefore, probably serve as the County's primary recharge area, though in a very non-uniform manner.

Unit 6 delineates areas of stratified sand generally found as Vashon advance outwash deposits. Though these deposits are extensive in the county they are usually found below Unit 5 (Vashon Till). Surface exposure is generally limited to areas where the till is missing. The deposits are exposed for the most part in valley walls and sea bluffs. Since many of these areas have been incorporated into Unit 2 there are only minor areas mapped as Unit 6. This unit is characterized by low runoff rates and high permeability. As such, when present it is a significant recharge area. Where this unit is water saturated these deposits can serve as a shallow aquifer.

Unit 7 represents gravel and coarse sand and gravel. It is generally found as Recent valley alluvium or older recessional outwash channels of the Vashon glaciation. This unit exhibits low runoff and high permeability. It has hydrologic properties similar to Unit 6. However, inasmuch as the unit is commonly underlain by till or other relatively low permeability deposits it does not usually offer as direct a route to the deeper aquifer systems as occurs in Unit 6. Some shallow domestic wells are completed in areas dominated by Unit 7.

Unit 8 shows areas of undifferentiated glacial deposits where geologic or hydrologic properties have not been adequately classified to define their hydrogeologic significance. For the purpose of this study we have assumed that Unit 8 material promotes moderate amounts of runoff and has medium permeability.

C. Principal Aquifers

Assessment of the geologic and hydrologic data allowed the identification of 27 areas which have been designated to contain the principal aquifers of Kitsap County (See Exhibit II-8). The North Lake and Bremerton South aquifers are shown separately in the exhibits but are discussed collectively in the text because of suspected continuity. Multiple aquifers have been identified and named as a result of this study. These delineated aquifers are the major areas of groundwater development at this time. Each of the aquifer areas are detailed in the appropriate subarea description in Volume II.

For a lithologic unit to be identified as a principal aquifer it was necessary for it to have the following characteristics: several proven major water supply wells or springs, sufficient test data to evaluate aquifer characteristics, and sufficient correlation of geologic characteristics to justify assumption of continuity between wells. In several locations the named aquifer area comprises two or more vertically separated aquifers. Due to the preliminary nature of the definition, the level of understanding varies for each aquifer. For the most part, these aquifers are near or below sea level and are comprised of pre-Vashon geologic units.

The definition of aquifer boundaries was accomplished by interpretation of the geologic data available in the database 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, a best guess interpretation was made and the boundary represented by a dashed line. As can be seen in Exhibit II-8, in many cases the aquifers are bounded by dashed lines.

It is expected that as additional hydrogeologic data are generated, the shape of the delineated aquifers will be altered and additional aquifer areas will be identified. In a few instances single wells which may represent a large aquifer were identified, but there was insufficient evidence to qualify the area for designation as a principal aquifer.

D. Groundwater Flow System

Groundwater flow within the system is controlled by a large number of factors including water level elevation, topography, geology, soil properties, recharge rates, and position of recharge and discharge features. In general, groundwater flow is from areas of high hydraulic head, or water levels, to areas of low hydraulic head. Water level contours or equipotential lines provide definition of areas where the hydraulic head is equal. Flowlines define the direction of groundwater movement within the system. For idealized systems, flow lines are oriented perpendicular to contour lines. The flowlines show the direction of groundwater movement from recharge areas to discharge areas.

A recharge area includes that portion of the drainage basin where the net direction of groundwater movement is downward and away from the water table. A discharge area includes that portion of the drainage basin where the net direction of the groundwater movement is upward towards the water table.

A regional groundwater system is usually composed of several flow cells. Localized flow cells often exist in shallow groundwater 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 groundwater 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 groundwater movement. Where local relief is negligible and soil properties are uniform, only regional flow systems will develop. 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. Geologic heterogeneity can affect the interrelationship between local and regional flow cells, it can affect the surficial pattern of recharge and discharge areas, and it can affect the quantities of flow that are discharged through the system.

Groundwater movement within the flow system is three dimensional in nature. In regional systems where significant contrasts between vertical and horizontal permeability occur, flow patterns become almost rectilinear with horizontal flow in the aquifers and vertical flow across the aquitards.

Rates of flow within the system are controlled primarily by aquifer permeability and hydraulic gradients. For steady-state systems, rates of flow can be quantified by Darcy's Law:

$$Q = K \bullet I \bullet A$$

where:

- Q = Flow rate
- K = Hydraulic conductivity or permeability
- I = Hydraulic gradient
- A = Cross section area perpendicular to flow

Shallow aquifer groundwater elevation contour and flow direction maps were prepared for each of the project subareas and are presented within Appendices A through E. The shallow aquifer is comprised of Vashon glacial drift (Qg1) and Vashon advance deposits (Qg1a), 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 the shallow aquifer system. Sufficient data was not available to assess flow within deeper water bearing zones over the majority of the county.

The methodology used for generating these maps consisted of examining the cross sections for each of the subareas to determine the approximate lowest elevation of the shallow aquifers (Qg1 and Qg1a) in each subarea. The chosen elevations were 0 feet above sea level in the Hansville-Indianola and Bainbridge Island Subareas, and 100 feet above sea level in the Poulsbo-Bremerton, West Kitsap, and South Kitsap Subareas. In some areas, this selected elevation resulted in incorporation of locally occurring deeper stratigraphic units.

The database was then queried for all wells completed at or above the chosen elevations within each subarea. The result was a Dbase file for each subarea which included well location (Lambert coordinates), local well number, and water level elevation. A computer routine was then used in conjunction with Autocad to convert each Dbase file into a 1:48,000 Autocad map showing well location, local well number, and water level elevation. The shallow aquifer groundwater contour and flow direction maps were developed by contouring the water level elevation data. The Autocad map for each subarea was overlain on the corresponding USGS 7.5 minute topographic maps to assist in the contouring interpretations. The data were contoured using 50-foot contour intervals, although 100-foot intervals are presented on the maps for clarity and to account for confidence level of the available data.

In constructing the contour/flow direction maps, many water level elevations were disregarded because they were suspected to be from a deeper aquifer. Additionally, where well data were lacking, the contours were inferred based on the assumption that the water level contours are correlated with topographic contours. Inferred water level contours are presented as dashed lines on the maps.

E. Infiltration Potential

Infiltration potential is a measure of an area's ability to absorb and percolate precipitation. Once water has entered the soil to a depth below the rooting zone (recharge), it flows downward to the water table (perched, local, or regional) and becomes groundwater. Areas with high infiltration potential are more likely to contribute to groundwater recharge than areas of low infiltration potential. Consequently, an infiltration potential map provides a qualitative definition of areas that may require special management practices.

The infiltration potential for any given area is a function of many variables. For this study, infiltration potential maps were developed based on an analysis of soil permeability, topography, and land use.

Soil permeability will influence the rate at which incident precipitation infiltrates into the subsurface. Clean coarse grained soils such as glacial outwash will tend to promote much higher rates of infiltration than soils with high percentages of fine-grained material such as glacial till or areas with bedrock. The distribution of soil permeability as interpreted from the geologic characteristic maps (see Exhibits A-1, B-1, C-1, D-1, E-1, and E-2) is presented on Exhibit II-9. The relationship between soil permeability categories and geologic units are presented in Table II-13.

Topography or degree of slope will influence the degree to which water runs off or infiltrates. Topography can also indirectly influence the amount of drainage within an area. High slope areas will tend to be better drained (i.e. lower net recharge) than low slope areas. The distribution of slope as interpreted from the USGS topography maps is shown on Exhibit II-10.

Land use (as it relates to impervious cover) will also influence infiltration potential. Areas that are zoned and developed for commercial, industrial, and high density residential purposes will have a high percentage of impervious surface, which will serve to promote runoff and limit infiltration. On the other hand, areas zoned and developed for agriculture, natural resources, and parks and open spaces will have a low percentage of impervious surface which will serve to limit runoff and promote infiltration. The distribution of existing land use is shown on Exhibit II-11.

Future land use in accordance with currently adopted land use documents for the County are shown in Exhibit II-12.

An empirical approach was used to develop infiltration potential maps. Each of the parameters that influence infiltration were given weights and rankings (see Table II-13). Each parameter was evaluated with respect to the other parameters to determine its relative importance. Weighting factors were assigned accordingly. Parameters judged to have a greater influence on infiltration potential were assigned higher weighting factors. Each parameter was then assigned a ranking factor that reflects the relative importance of the parameter on infiltration potential. High ranking values will produce a higher infiltration potential rating. An overall infiltration potential rating score was then computed as the sum of the products of the ranking and weighting factors (see notes on Table II-13).

The weighting and ranking factors used in the analysis are presented in Table II-13. The soil permeability and land use overlays were given a weighting factor of 2.0 and the slope overlay was assigned a weighting factor of 1.0. Thus, our analysis assumed that soil and land use factors were considerably more important than slope in enhancing infiltration potential. Ranking factors for all three parameters ranged between 1.0 and 10.0.

A special AutoCAD mapping procedure was used to develop the infiltration potential maps. A separate overlay was created for each of the parameters. On each overlay, the parameters were broken into hatched polygon areas and were assigned ranking values. Each overlay was given a single weighting value. The infiltration potential maps were produced by superimposing a gridded mesh over all of the overlays. At each grid point, a resultant infiltration potential composite score was computed by adding the product of all ranking and weighting values.

Two infiltration maps were prepared: a map based on existing land use conditions as well as a map based on future land use conditions. The objective of developing infiltration maps for both land use scenarios was to assess areas where proposed land use changes may adversely impact infiltration of recharge.

The results of the infiltration potential analysis for existing land use conditions is presented in Exhibit II-13. The infiltration map for future land use conditions is very similar to the map for existing conditions and is not presented (i.e. the future land use scenario is approximately the same as existing conditions as is shown on Exhibit II-11 and Exhibit II-12, consequently the infiltration potential is approximately the same).

High infiltration potential areas occur extensively within the north, west, and south portions of the study area. These areas tend to have medium to high soil permeability, moderate to low slope, and land use patterns with a low percentage of impervious cover. Low infiltration potential areas occur extensively along the margins of the upland where slopes are high, in urbanized areas (i.e. Bremerton, Winslow, Poulsbo, etc.) where there is a high percentage of impervious cover, and in areas such as the Green and Gold Mountains and the southern portion of Bainbridge Island where soil permeability is quite low (bedrock areas).

The infiltration potential map provides only a relative evaluation tool for assessing factors which effect recharge. Extreme care should be exercised when interpreting and applying the results of the analysis, particularly to localized areas.

F. Recharge/Aquifer Vulnerability Potential

Recharge to the groundwater system is largely dependant upon the infiltration potential of the soil and precipitation rates. In addition, areas with a high recharge potential also tend to be areas that are more vulnerable to water quality impacts associated with land use activity. High recharge areas are generally at greater risk to water quality impacts because contaminants can be rapidly transferred to underlying aquifers.

A recharge potential/aquifer vulnerability map was developed based upon an analysis of soil permeability, slope, and precipitation. The map provides a qualitative definition of areas where the highest rates of recharge are anticipated within the study area as well as areas where underlying aquifer systems may be at greater risk to land use activity.

The approach to generating the recharge potential/aquifer vulnerability map was similar to the procedures used in generating the infiltration potential maps. The variables of soil permeability, slope, and precipitation were assigned weighting and ranking factors that reflects their relative importance upon recharge potential (note, land use was not factored into this analysis because it biases the recharge/aquifer vulnerability potential within urbanized areas). High ranking values will produce a higher recharge potential rating. An overall recharge potential rating score was then computed as the sum of the products of the ranking and weighting factors (see notes on Table II-13).

The weighting and ranking factors used in the analysis are presented in Table II-13. Soil permeability and slope were assigned the same weightings and rankings as were used in the infiltration potential analysis. Precipitation rankings were assigned based on the distribution of precipitation rates with the highest ranking (9) associated with the highest precipitation rate (> 80 in/yr) and the lowest ranking (2) associated with the lowest precipitation rate (< 20 in/yr). The distribution of precipitation within the study area is shown on Exhibit II-15. Precipitation was assigned a weighting factor of 2. Thus, our analysis assumed that soil and precipitation factors were considerably more important than slope in enhancing recharge potential.

The result of the recharge potential/aquifer vulnerability analysis is shown on Exhibit II-14. The location of the principal aquifer zones are also superimposed upon the map to illustrate areas with relatively greater aquifer vulnerability. Most of the principal aquifers occur at relatively deep depths and are well protected from near surface contaminant sources by overlying low permeability strata. Exceptions to this include the Hansville, Meadowmere, Lynwood Center, and Poulsbo aquifers which lie at relatively shallow depths (i.e. generally less than 150 feet). The highest recharge potential areas occur within the western and southern portions of the study area where precipitation rates are the highest. High recharge areas also locally occur within other areas where permeable soils occur at the surface. The lowest recharge potential areas occur within the northern portion of the County where precipitation rates are relatively low as well as in vicinity of the Green and Gold Mountains where soil permeability is relatively low.

G. Water Balance and Recharge

The water balance serves as the basis for initial planning of groundwater use. It provides a general understanding of the components of recharge and discharge and provides a basis for assessing the potential amount of groundwater that can be developed for human use. This general understanding helps to manage groundwater resources by indicating the relative magnitude of each component of the flow system. It cannot be used by itself as a tool for accurate long-term management of groundwater resources. The variability of the natural earth system is too great to allow precise knowledge of the individual components of the balance to the degree required for management of the resource by water balance analysis alone. Additional information obtained through monitoring the system is needed for proper management. The water balance helps to better understand the system and provides input to the design of monitoring plans that yield the information needed for management.

The water balance is based on the mass-balance principal: water going into the system is equal to water flowing out of the system plus or minus the change in storage of the water within the system. In our analysis we have assumed that long-term (many year) change in water amounts within the system will be accounted for in the trend analysis, as discussed later in this section. Change in storage over the average year (typical period of a water balance analysis) is assumed to be self canceling for a net effect of 0. With this assumption, the mass balance equation becomes:

Recharge = Discharge

where: Recharge = Precipitation - Evapotranspiration - Storm Runoff

and: Discharge = Human Use + Natural Discharge

Long-term estimates of recharge and other water balance components were developed for each of the subareas based on a climatic water balance assessment. These water balance estimates are summarized in Table II-14. All water balance components are presented as a range to emphasize the fact that inherent errors exist with all the estimates. The following provides a brief discussion of each of the water budget components:

(1) Recharge

Recharge within this study includes all water that infiltrates the soil beyond the root zone and becomes groundwater. The downward movement of recharge is often impeded by low permeability strata which forces a fraction of the recharge laterally towards points of discharge such as springs, seeps, streams, and wetlands where it is lost from the groundwater system. The remaining fraction of recharge continues its downward migration where it recharges deeper aquifer systems and is ultimately discharged to the surface water system. Depending upon its potential travel path within the subsurface, soil permeability, and hydraulic gradients, groundwater may be resident within the system for as little as several days or for as long as several hundred years.

Actual recharge to the underlying aquifers is a function of many complex variables such as the infiltration potential of the near surface soils; the climatic balance of precipitation, runoff, and evapotranspiration; hydraulic gradients that move water downward; and the presence of low permeability units that can restrict the downward movement of groundwater. The infiltration and recharge/aquifer vulnerability potential (discussed above) provides a general indication of the areas that are better at allowing precipitation to enter the soil and move downward as recharge. The climatic balance provides an approximate estimate of the average amounts of water that infiltrate beyond the root zone and has potential for recharging underlying aquifers. Hydraulic gradients and the permeability of deeper strata will control the rates and direction of groundwater movement within the subsurface. These factors are, in general, not easily quantified.

For this study, direct recharge was computed as the residual of average precipitation minus average evapotranspiration and runoff using a climatic water balance assessment. A "middle of the road" approach was used to estimate resultant long-term recharge rates. The approach uses the values that fall to the center of the range of water balance components when computing resultant recharge.

(2) Precipitation

Precipitation is the principal input to the hydrologic system. The general distribution of precipitation within the project vicinity is shown on Exhibit II-15. The precipitation isoheytals (contour lines of equal annual average precipitation) are based on an analysis of U.S. Weather Bureau statistics for ten stations within the Kitsap Peninsula area. The precipitation stations include Port Townsend, Chimacum, Quilcene, Brinnon, Bremerton, Keyport, Vashon, Wauna, Grapeview, and Union (note, the Port Townsend and Union stations are not shown on the Exhibit). Long-term average annual precipitation and the period of record for each of the reporting stations is also shown on the Exhibit. The precipitation isohyetals are primarily based on weather stations data for the 30 year period 1950 - 1980. Weather stations with more limited data were only given partial weighting in the analysis (i.e. Brinnon and Vashon). Bremerton has the only active U.S. Weather Bureau Station within the County.

Precipitation data are also collected at the U.S. Naval Facility at Bangor and at the Casad Dam in the Union River watershed west of Bremerton. Data are not currently being collected at the Bangor Station and equipment would need to be serviced. Ongoing data collection is occurring at the Casad Dam Station by the City of Bremerton. The data for these Stations has not been included in the present analysis. However, these Stations could be included in a regional precipitation data gathering network.

The areal pattern of precipitation within the County is largely influenced by the rain shadow effects of the Olympic Mountains. Average annual precipitation ranges from a low of approximately 20 inches/year in the extreme northern portion of the County where the rain shadow effects are most pronounced to a high of approximately 80 inches/year in the western portion of the

County. Average annual precipitation may locally exceed 80 inches/year within the Green and Gold Mountains where orographic effects contribute to an anomalous precipitation high (Garling, et.al, 1965).

(3) Evapotranspiration

Evapotranspiration includes water lost to the atmosphere through the processes of evaporation, sublimation, and plant transpiration. Long-term average annual evapotranspiration rates were estimated using a Thornthwaite analysis and assuming a 3- to 5-inch soil moisture holding capacity (assumed typical for glacial soils).

The Thornthwaite method uses latitude and temperature to calculate potential evapotranspiration and a simple water balance within the soil to relate potential to actual evapotranspiration. In this balance, actual evapotranspiration equals potential as long as the soil has sufficient moisture. When the soil is drier, the actual rate decreases. In our analysis, we have computerized the soil mass balance procedure to calculate the actual evapotranspiration rate on a quarter-month basis In this analysis, monthly data (rainfall and temperature) are distributed evenly over each week of the month and actual evapotranspiration is calculated by:

$$ET = PET * (SM/SMC)$$

where:

ET = Actual evapotranspiration (in/yr)
PET = Potential evapotranspiration (in/yr)
SM = Soil moisture content for the previous week (in)
SMC = Soil moisture holding capacity (in)

This linear function of the ratio of actual water content to soil moisture holding capacity was used to relate actual to potential evapotranspiration (Dunne and Leopold, 1978).

(4) Runoff

Runoff within this analysis is assumed to be the stormflow portion of the streamflow hydrograph. It does not include that portion of the hydrograph that is derived from groundwater return flow (considered to be recharge). Storm runoff is generally assumed to be residual portion of the streamflow hydrograph after accounting for the groundwater inputs.

Various methods can be used to estimate storm runoff. Within this study, storm runoff was estimated as a percentage of average annual precipitation. Recent modeling of streamflow by the USGS has indicated that runoff percentages for Puget Lowland basins typically range between 15 and 25 percent of total average annual precipitation (USGS, Recharge modeling analysis for South King County, in progress). Similar runoff percentages were applied to each of the project subareas with consideration given to variations in soils, slope, degree of urbanization and other controlling factors influencing infiltration potential and runoff. The assumed runoff percentage for each of the subareas is presented within Table II-14. The percentages range from a low of between 10 and 15 percent of total precipitation in the Hansville-Indianola subarea to a high of between 25 and 30 percent in the West Kitsap subarea.

The location of stream gaging sites within the project area as well as the period of record for each of the sites are shown on Exhibit II-15. Presently, there is only one active gaging station within the County that is being maintained by the USGS. The site is located on Big Beef Creek near Seabeck (Exhibit II-15). Many of the other sites, particularly those east of Bremerton, were operated for short-term periods during the 1940s and 1950s in order to evaluate surface water supply potential.

H. Hypothetical Groundwater Yield

Effective groundwater planning and management requires that one know the limits to which water can be withdrawn creating unacceptable impacts. By definition, any groundwater that is artificially withdrawn from the system will result in some net impact such as reduction in aquifer storage, reduction in natural discharge to surface water features, and/or increases in recharge from surface water features. There is for the most part insufficient data for providing a reliable assessment of the relationship between groundwater development and the degree of impact to the system. However, efforts must be made to provide some basic framework in which to quantify the potential yield of the system in order to evaluate present development patterns, to plan future development, and to direct long-term efforts.

Groundwater yield is often defined in terms of either the sustained yield or optimal yield of the system. U.S. Water Resources Council, Hydrology

Committee, Bulletin 16 (revised), circa 1980, presents the most widely accepted definition of these terms:

Sustained Yield - Continuous long-term groundwater production without progressive storage depletion. Often interchangeably used with safe yield which is the magnitude of yield that can be relied upon over a long period.

Optimal Yield - The best use of groundwater that can be made under the circumstances; a use dependent not only upon hydrologic factors, but also upon legal, social, and economic factors.

A determination of the sustained yield generally requires a comprehensive analysis of the hydrogeologic system which can be provided through a rigorous program of exploratory drilling, aquifer testing, and monitoring of water levels, streamflow and climatic data. Data collected through such a program can be incorporated into conceptual, analytical, and numerical models of the system that evaluate the amount of groundwater that can be withdrawn from the system without producing long-term water level declines and reduction in storage. An alternative approach to evaluating sustained yield is to monitor water level data as groundwater development proceeds and make appropriate adjustments in development rates and patterns so as to avoid water level impacts. The disadvantage of this approach is that it does not provide a prediction of groundwater yield which may be required for long-term planning of source development.

Optimal yield requires that one not only consider hydrologic factors when estimating groundwater yield, but also any associated legal, social, and economic factors. It is usually relatively easy to place a value an cost for water pumped by a well. The value of natural discharge is significantly more difficult to quantify. For example, natural discharge may be maintaining a stream or a wetland, or the proper salinity balance in an estuary. Changes in natural discharge to these environments may affect plant and animal life, scenic beauty, fisheries, etc. Assessment of the value of these situations are difficult to make. In general, the regulatory community which represents the interests of society must ultimately define what level of impact is unacceptable and what the optimal yield may be for any particular system.

Determination of the groundwater yield of the system by either a sustained yield or optimal yield approach is generally beyond the scope of the present study. For the purposes of providing yield estimates for planning needs, a simplistic analysis was used. In this analysis, the "hypothetical groundwater yield" of the system was assessed as a percentage of the direct recharge which was computed from the water balance analysis. The hypothetical groundwater yield was estimated with the following relationship:

Hypothetical Groundwater Yield = C_1 * Recharge Rate * Recharge Area

The coefficient C_1 is assumed to be a best estimate of the fractional percent of recharge that can be developed without imposing unacceptable impacts on the system. For the most part, impacts can only be adequately addressed through comprehensive long-term monitoring efforts. Long-term monitoring data are available for only limited areas within the project area. For this study we have assumed that an acceptable range in C_1 may lie between 0.3 and 0.5.

Hypothetical groundwater yield estimates were prepared for each subarea based on consideration of two recharge areas. The first set of hypothetical groundwater yield estimates only considers the recharge that is contributed to the major aquifer systems that have been identified within the County (see Section II.4.C). These estimates reflect a lower bound for groundwater development potential. The second set of hypothetical groundwater yield estimates consider the entire subarea as a recharge area for water supply (with the exceptions of bedrock and high relief areas adjacent to Puget Sound). These estimates reflect an upper bound for groundwater development potential.

The above methods for assessing contributing recharge area leads to significantly different estimates of hypothetical groundwater yield. The large range in the estimates can be attributed to the fact that the extent of the major aquifer system is somewhat poorly defined at this time. As more subsurface information becomes available, the extent of the principal aquifer will be refined, and consequently the estimates of hypothetical groundwater yield.

A summary of hypothetical groundwater yield estimates for all subareas is presented in Table II-15. Estimates of average day and peak day groundwater usage for the years 1985, 2010, and 2040 are presented for comparison. In addition, annual and instantaneous existing groundwater rights are also presented for comparison.

Existing groundwater development within the Kingston-Indianola subarea and the Bainbridge Island subarea fall within the midrange of the estimates of hypothetical groundwater yield. Existing groundwater development for the other three subareas generally falls near or well below the lower limits of the estimates of hypothetical groundwater yield. The hypothetical groundwater yield analysis suggests that additional water supply could likely be developed from the West Kitsap and South Kitsap subareas if productive aquifers can be located.

5. TREND ANALYSIS

A. Precipitation, Pumpage, and Water Level Trends

(1) Purpose

The purpose of compiling precipitation, pumpage and water level trend data is to:

- o Establish baseline trends and seasonal variations;
- o Evaluate the effects of pumping and climate on water level trends;
- o Identify areas of possible groundwater overdraft; and
- o Assess long-term monitoring system requirements.

(2) Approach

Precipitation: Data from the U.S. Weather Bureau's climatological station in Bremerton were used to assess precipitation trends from 1976 to 1988.

Water Level and Pumpage: Water level and pumpage trend data were compiled from the project database, consultant reports, and direct contact with water purveyors by the Bremerton-Kitsap County Health Department.

The project database was queried to identify and produce water level plots of all wells for which there were data from six or more water level measurements.

Available reports concerning water level and pumpage fluctuations, for individual or groups of wells, over a period of years were identified and reviewed.

In the summer of 1988, the Bremerton-Kitsap County Health Department contacted the Class 1 and Class 2 Water Systems in Kitsap County and requested information on:

- o Historic pumpage data from metered wells;

- o Historic static water level data obtained under non-pumping conditions;
- o Historic water quality data and the frequency of data collection; and
- o Information on abandoned wells.

Approximately 23 purveyors responded. Their responses were compiled by the Bremerton-Kitsap County Health Department (BKCHD) in "Pumpage Trends, Static Water Levels, Water Quality and Abandoned Well Data from Participating Class 1 and 2 Water Systems" (October 1988). However, because the data received was incomplete, selected purveyors were contacted again by letter in December 1988 and by phone in January 1989, and asked to provide the aforementioned data.

(3) Results

Precipitation: The monthly precipitation data for the last 12 years was plotted on a graph as shown in Exhibit II-16. As expected, the peaks, or periods of the most rain, coincide with the winter months, and the troughs with the drier summer months. The wettest period during this time span occurred in late 1984 when almost 20 inches of rain fell in one month.

Exhibit II-16 also shows a 12-month running average plot using the same data from the Bremerton station. In this instance, the monthly precipitation amount was averaged with the amounts from the previous 11 months to obtain the data point. This method provides a better view of precipitation trends over the years, by smoothing out the peaks and troughs created by the seasonal patterns. This plot shows that the mid-part of the time period 1976 to 1988, roughly 1983, was wetter than the earlier and later parts of the span.

Water Level and Pumpage: Forty-four (44) wells with six or more water level measurement entries were identified in the database and plotted in time series. Unfortunately, the data recovered for these individual wells were generally inconclusive, and in some instances appeared to be unreliable. Often, all of the water level readings were from a one or two year period, so that trends could not be perceived. In other cases, there were very large discrepancies among the water level readings over a short time span, possibly indicating that some of the readings were taken while the well was being pumped. In general, there were too many anomalies in the data to discern any trends.

Two (2) consultant reports concerning water levels and pumpage trends in Kitsap County were identified and reviewed. The following is a summary of the conclusions of the reports:

- North Perry Avenue Water District Pumpage and Water Level Summary (Robinson and Noble, 1984): Among other issues, this report considered the non-pumping water levels for 8 wells in the North Perry Avenue Water District from 1977 to 1983. Three (3) of the wells showed a decline in water levels, while 3 other wells showed a rise in water levels over the study period. The remaining 2 wells showed no apparent trend. The study concludes that the consistent on-going collection of hydrologic data is necessary for proper groundwater resource management.

- Monitoring of a 4-Inch Observation Well at Fletcher Bay (Robinson and Noble, 1988): Water levels in an observation well located near the Kitsap County PUD No. 1 production well at Fletcher Bay and pumpage were considered over the 1980 to 1987 time period. As the withdrawal rates from the production well increased over the time period, a slight decline was seen in the water level in the observation well. However, the report concludes that at the current and past rates of withdrawal, the aquifer supplying the production well does not show any signs of depletion.

Despite the efforts by the BKCHD, the attempt to collect trend data directly from the purveyors was generally unsuccessful. Trend data provided by the purveyors was often sporadic in nature, indicating inconsistent data collection over the years. In other cases, the pumpage and water level data only covered a short time span - insufficient for trend analysis. A number of water systems did not respond to the request for information.

B. Water Quality Trends

(1) Background

Water quality trends were performed for the key indicator parameters within the study area. A description of these parameters, and the criteria for their selection were described previously in paragraph 1, Planning Criteria of this Section. Historical and current information relating to the presence of these groundwater quality indicator parameters in Kitsap County was gathered from several sources including Ecology, the BKCHD, and USGS. Trends in each parameter over time were plotted and evaluated statistically.

Statistical analyses were conducted on results of key indicator parameters tested since 1970 to evaluate regional trends in water quality. Where possible, excessive concentrations of specific test results were evaluated to determine if contamination was occurring at a specific location. Results from known contamination sites were not included in the statistical trend analyses in order to not skew the trend results. It was determined by the Ground Water Advisory Committee (GWAC) that known contamination sites frequently have an abundance of information and did not merit further evaluation. Whereas, these contamination sites are of concern, the GWAC focused on background concentrations and any increasing regional trends in water quality.

Water quality data from each of the six subareas was evaluated separately. The wells used in this evaluation were categorized as "shallow" or "deep". It was conjectured that segregating wells by depth might indicate the impact of surface activities on shallow wells, keeping in mind that several factors contribute to contamination potential including surficial geology, presence of aquitards, hydraulic continuity with other aquifers, and mobility of specific chemical parameters.

The preferable method for analyzing water quality data would be to tie each well into a specific aquifer zone. Unfortunately, the format of reporting groundwater quality test results did not correlate with databases of construction and well log information. Specifically, well location and wellhead elevation data was commonly unavailable. In addition, water quality results are normally submitted with only an owner name or DOH water facility identification (WFI) number attached. Therefore, correlation to specific sites was impossible where an owner had multiple wells. The alternative was to break the wells into depth categories which would roughly correlate to aquifer zones and potential impacts from land surfaces. The definition of "shallow" or "deep" for each subarea was identified in the following manner:

Subarea	Depth Zone (Depth from surface) Shallow	Deep
Hansville/Indianola	<100'	>100'
Bainbridge Island	<100'	>100'
Poulsbo/Bremerton	<100'	>100'
West Kitsap	<250'	>250'
South Kitsap - West	<100'	>100'
South Kitsap - East	<100'	>100'

These zones depict depth from ground surface rather than elevation.

(2) Data Sources and Procedures

Several data sources were used to gather information for groundwater quality trending. EPA provided historical data on wells in Kitsap County monitored by USGS, as well as Class 1 and Class 2 public water supply wells. Ecology provided historical and current data on the Class 1 and Class 2 wells within the study area. Water quality data from Class 3 and Class 4 wells were obtained from DOH. The DOH data was limited to only those systems which contain one source. The current system for storing water quality data at DOH ties the data into a water system through the system's WFI rather than a specific source. In addition, data received from DOH, could only locate wells to a quarter section accuracy.

Data was also received from specific investigations on potential contamination from the following specific sites:

- o Strandley Scrap Metal Site
- o Wycoff Wood Preservation Facility
- o Bangor Submarine Base Ordinance Disposal Site
- o Activities at the Keyport Naval Undersea Warfare Engineering Station

The specific on-site data was excluded from the trending analysis because this information would tend to skew the trending results to very discrete areas rather than explain general groundwater conditions throughout each subarea. Specific information of this nature was used to evaluate potentially sensitive water quality areas.

The data from EPA, Ecology, and DOH was received in STORET format. STORET is EPA's mainframe water quality database system. The data consisted of files containing information on individual station location and files containing parametric information. A personal computer version, PCSTORET, was used to take the separate data retrievals and combine them into a master file. This master file is then accessed using PCSTORET to retrieve the water quality data of interest. Exhibit II-17 displays the locations of wells from which water quality data was evaluated.

(3) Statistical Method

To evaluate the significance of water quality trends in the data, regression analyses were performed for each parameter. Parameter measurements versus time were plotted. Both a linear and non-linear regression analysis of measurement against time was performed, where time was quantified in quarters. Wells with more than one observation within the same quarter were averaged. In this way, no single well could skew the results either upwards or downwards over time. Several statistics were calculated to assess the appropriateness of the regression. These statistics and the regression methods are described below.

The best fitting of either a linear or non-linear form of the two models was chosen. Statistics on the goodness of fit of the regression were calculated to evaluate the significance of the regression. Goodness of fit refers to how well the regression equation explains the variation in the data. These goodness of fit statistics include the R-squared (R^2) of the equation, the F-Statistic of the regression and the T-statistic of the coefficients. The R^2 statistic measures the amount of explained variation in the regression. The F-statistic for the regression can be used to test the significance of all coefficients in the model. The T-statistic measures the significance of individual coefficients. Values for these statistics, and their meanings, are identified below:

Statistic	Value	Meaning
R-squared	>0.5	Indicates that the equation moderately explains the data for regressions of time series data with over 20 observations.
F-statistic	>10	Indicates a significant regression at the 5 percent level.
T-statistic	[2.00]	Significant at the 5 percent level.

(4) Trends

A summary of the trending analysis for each of the indicator parameters can be found in the discussions of each subarea in Volume II, and the water quality trend plots for all subareas can be seen in Appendix H. In general, no significant trends in any of the indicator parameters were found. Very few observations of parameters measured above the MCL were found with the exception of naturally occurring iron and manganese. These two parameters were found at high levels in all of the subareas. Historical information on pesticides and on the volatile organic indicator parameters was virtually non-existent in the database. The low r-squared valves seen on the majority of trend plots in Appendix H indicate poor agreement between the data and the calculated trend line equations.

(5) Summary

Overall, the number of wells with water quality information in a form usable for this type of trend analysis was not extensive. Beyond compliance monitoring for public water supplies, and shallow monitoring wells for specific contamination investigations, there is little time series data for groundwater in Kitsap County. A total of 554 wells were found to have documented water quality data for discrete wells through computerized databases, and many of these wells have only one or two sampling observations. Lack of a common identifier for each well between the various local, state and federal agencies charged with maintaining these records complicated the effort to gather and correlate water quality data with specific wells and the aquifer they withdraw from. EPA, Ecology, and DOH each have separate interagency identification schemes for their respective databases. In addition, the DOH system identifies water systems rather than discrete wells. For this reason, only the Class 3 and Class 4 wells in the water quality database which contain a single source and were located down to quarter section could be used in the trending to insure that the parameter was measured from the well rather than the distribution system.

Bacteriological data is documented by water system so this information reflected distribution sampling as well as groundwater source sampling. BKCHD personnel were interviewed to establish areas where repeated bacteriological or inorganic/organic contamination problems exist. No significant or chronic problem areas were identified.

The majority of the wells with water quality information were from public water supplies which are subject to compliance monitoring for primary and secondary parameters. These parameters have compliance schedules which typically do not exceed 3-year intervals. The majority of observations for these parameters were at detection or reporting limits. Water quality trend plots for all Subareas can be seen in Appendix H.

TABLE II-1
Kitsap County
Groundwater Management Plan
Land Use and Water Quality Indicator Parameters

OTA Categories	Water Quality Indicator Parameters
I. Category 1	
A. Subsurface percolation	
	TC, FC, FS
	Nitrate-Nitrite, Chloride, Sulfate
	Conductivity, pH
B. Injection Wells	Boron
1. Hazardous Waste	
2. Non-Hazardous waste	
C. Land Application	
1. Waste Water	
2. Wastewater byproducts:	TC, FC, FS
sludge	Nitrate-Nitrite, Chloride, Sulfate
	Conductivity, pH
	Arsenic, Chromium, Tin
	Heavy Metals
3. Hazardous waste	HAZARDOUS WASTE LIST:
	Trichloroethylene
	Tetrachloroethylene
	1,1,1-Trichloroethane
	Methylene Chloride
	TOX, TOC
	Chromium, Lead, Cyanide
	Phenols, PCB, PNA
	Conductivity, pH
4. Non-hazardous waste	Conductivity, pH
II. Category 2	
A. Landfills	
1. Industrial Haz. waste	
	HAZARDOUS WASTE LIST
	Copper, Zinc, Cadmium
	Acetone, Ketone
	Phthalate ester
	Conductivity, pH
	Hardness
2. Industrial Non-Haz. waste	Iron, Chloride, Sulfate
	Conductivity, pH
3. Municipal sanitary	Nitrate-Nitrite
	Conductivity, pH
B. Open dumps	
C. Residential disposal	

TABLE II-1 continued

OTA Categories	Water Quality Indicator Parameters
D. Surface Impoundments	
1. Hazardous waste	HAZARDOUS WASTE LIST Mercury Conductivity, pH
2. Non-hazardous waste	Iron, Chloride, Sulfate Nitrate-Nitrite Conductivity, pH
E. Waste tailings	
F. Waste piles	
1. Hazardous waste	HAZARDOUS WASTE LIST Mercury Conductivity, pH
2. Non-hazardous waste	Iron, Chloride, Sulfate Nitrate-Nitrite Conductivity, pH
G. Materials stockpiles (non-waste)	
H. Graveyards	Formaldehyde, Diss. Organic Carbon NH3, Nitrate-Nitrite Conductivity, pH
I. Animal burial	Formaldehyde, Diss. Organic Carbon NH3, Nitrate-Nitrite Conductivity, pH
J. Aboveground storage tanks	
1. Hazardous waste	HAZARDOUS WASTE LIST Mercury Conductivity, pH
2. Non-hazardous waste	Iron, Chloride, Sulfate Nitrate-Nitrite Conductivity, pH
K. Underground storage tanks	
1. Hazardous waste	HAZARDOUS WASTE LIST Conductivity, pH
2. Non-hazardous waste	BTX, PNA Conductivity, pH
L. Containers	
1. Hazardous waste	HAZARDOUS WASTE LIST Conductivity, pH
2. Non-hazardous waste	BTX, PNA
M. Open burning/detonation	PNA, Nitrate, Phenol
N. Radioactive disposal sites	

TABLE II-1 continued

OTA Categories	Water Quality Indicator Parameters
III. Category 3	
A. Pipeline	
1. Hazardous waste	HAZARDOUS WASTE LIST Mercury
2. Non-hazardous waste	BTX, PNA
3. Non-waste	
B. Materials transport/transfer	
1. Hazardous waste	HAZARDOUS WASTE LIST
IV. Category 4	
A. Irrigation practices	
B. Pesticide/Herbicide applications	Methomyl, Picloram, Simazine, Atrazine, Hexazinone, Dicamba, Triclopyr (Garlon), 2,4-D, Glyphosate
C. Fertilizer Applications	Nitrate-Nitrite
D. Animal feeding operations	TC, FC, Chloride, Sulfate Nitrate-Nitrite, NH3 Conductivity, pH
E. De-icing salts applications	Chloride, Calcium, Ammonium Sulfate Conductivity, pH
F. Urban runoff	TC, FC Copper, Lead, Zinc Mercury, Chromium Conductivity, pH
G. Percolation of air pollutants	Arsenic
H. Mining and mine drainage	Conductivity, pH
1. Surface mine-related	
2. Underground mine-related	
V. Category 5	
A. Production wells	
1. Oil/gas wells	BTX, PNA, Sulfide
2. Geothermal/heat recovery wells	
3. Water supply wells	TC, FC
B. Other wells (non-waste)	
1. Monitoring wells	
2. Exploration wells	

TABLE II-1 continued

OTA Categories	Water Quality Indicator Parameters
C. Construction excavation	TC, FC Copper, Lead, Zinc Mercury, Chromium Conductivity, pH
D. Other: Abandoned wells	
VI. Category 6	
A. GW - SW interactions	
B. Natural leaching	Chloride, Conductivity
C. Salt-water intrusion	Chloride, Conductivity
D. Other	
1. Fe, Mn	Fe, Mn
2. CO2, Na	CO2, Na
3. Hardness	Hardness
4. H2S	H2S

TABLE II-2

CURRENT (1986) NATIONAL PRIMARY DRINKING WATER REGULATIONS
U.S. ENVIRONMENTAL PROTECTION AGENCY

Constituent	Maximum Contaminant Level
Arsenic	0.05 mg/L
Barium	1 mg/L
Cadmium	0.010 mg/L
Chromium	0.05 mg/L
Fluoride	Varies with temperature
Lead	0.05 mg/L
Mercury	0.002 mg/L
Nitrate as N	10 mg/L
Selenium	0.01 mg/L
Silver	0.05 mg/L
Sodium	Analyze 1 sample per year per plant at entry to distribution system for surface waters and once every 3 years for groundwater systems
Radium^{226} and ^{228}	5 pCi/L
Gross alpha activity (Including radium^{226} but excluding radon and uranium)	15 pCi/L
Beta and photon radioactivity (Detailed studies must be made if the gross beta activity exceeds 50 pCi/L)	4 mrem/yr
Endrin	0.0002 mg/L
Lindane	0.004 mg/L
Methoxychlor	0.1 mg/L
Toxaphene	0.005 mg/L
2,4-D	0.1 mg/L
2,4,5-TP (Silvex)	0.01 mg/L

TABLE II-3

PROPOSED DRINKING WATER REGULATIONS

PROPOSED RMCLs (MCLGs) FOR INORGANIC COMPOUNDS

Constituent	Proposed RMCL (MCLG) mg/L
Arsenic	0.050
Barium	1.5
Cadmium	0.005
Chromium	0.12
Copper	1.3
Lead	0.020
Mercury	0.003
Nitrate-N	10.0
~~Nitrate-N~~ NITRITE-N	1.0
Selenium	0.045

PROMULGATED RMCLs (MCLGs) AND PROPOSED MCLs FOR ORGANIC SOLVENTS

Constituent	Final RMCL (MCLG)	Proposed MCL
Trichlorethylene	Zero	0.005 mg/L
Carbon Tetrachloride	Zero	0.005 mg/L
Vinyl Chloride	Zero	0.001 mg/L
1,2-Dichloroethane	Zero	0.005 mg/L
Benzene	Zero	0.005 mg/L
1,1-Dichloroethylene	0.007 mg/L	0.007 mg/L
1,1,1-Trichlorethane	0.20 mg/L	0.20 mg/L
1,4-Dichlorobenzene	0.75 mg/L	0.75 mg/L

PROPOSED RMCLs (MCLGs) FOR ORGANIC COMPOUNDS

Constituent	Proposed RMCL (MCLG) mg/L
Acrylamide	Zero
Alachlor	Zero
Aldicarb, aldicarb sulfoxide, aldicarb sulfone	0.009
Carbofuran	0.036
Chlordane	Zero
cis-1,2-Dichloroethylene	0.07
Dibromochloropropane (DBCP)	Zero
1,2-Dichloropropane	0.006
o-Dichlorobenzene	0.62
2,4-D	0.07
Ethylene Dibromide (EBD)	Zero
Epichlorohydrin	Zero
Ethylbenzene	0.68
Heptachlor	Zero
Heptachlor epoxide	Zero
Lindane	0.0002
Methoxychlor	0.34
Monochlorobenzene	0.06
Polychlorinated Biphenals (PCBs)	Zero
Pentachlorophenol	0.22
Styrene	0.14
Toluene	2.0
2,4,5-TP	0.052
Toxaphene	Zero
trans-1,2-Dichloroethylene	0.07
Xylene	0.44

TABLE II-4

PESTICIDE/HERBICIDE USE IN KITSAP COUNTY

Crop	Pesticide Use
Grass	Dicamba, Picloram
Raspberries	Methomyl,Simazine
Strawberries	Simazine
Trees, Shrubs	Dicamba, Picloram, Triclopyr (Garlon) 2, 4-D Glyphosate
Christmas Trees	Atrazine*, Hexazinone*, Simazine Triclopyr (Garlon) 2, 4-D Glyphosate

* Includes annual.

TABLE II-5

LAND USE CATEGORIES

Category	Percent Impervious Future	Percent Impervious Existing
Urban	70	70
Semi-Urban	50	3-15
Semi-Rural	30	3-15
Rural (1 acre)	15	3-15
Rural (2.5 acre)	10	3-15
Parks	0	0
Industrial/Commercial	90	90

TABLE II-6

KITSAP COUNTY
SUMMARY OF ASSUMPTIONS

SUB-AREA (1)	FAZ NO.(2)	% IN SUB-AREA	WATER USE CATEGORY	AVERAGE GPCD (3)	PEAK/AVG FACTOR (4)
SUBAREA 1 - Hansville-Indianola					
	9011	67%	Semi-Urban/Rural	140	3.0
	9012	87%	Rural	100	3.0
SUBAREA 2 - Bainbridge					
	9913	100%	Semi-Urban/Rural	140	3.0
	9914	100%	Rural	100	3.0
SUBAREA 3 - Poulsbo-Bremerton					
	9005	10%	Rural	100	3.0
	9006	31%	Rural	100	3.0
	9007	100%	Semi-Urban/Rural	140	3.0
	9009	100%	Rural	100	3.0
	9011	33%	Semi-Urban/Rural	140	3.0
	9012	13%	Rural	100	3.0
	9900	100%	Urban	175	2.3
	9901	78%	Urban	175	2.3
	9902	100%	Urban	175	2.3
	9904	100%	Urban	175	2.3
	9908	100%	Rural	100	3.0
	9909	100%	Rural	100	3.0
	9915	100%	Semi-Urban/Rural	140	3.0
	9916	100%	Semi-Urban/Rural	140	3.0
SUBAREA 4 - West Kitsap					
	9005	76%	Rural	100	3.0
	9006	69%	Rural	100	3.0
SUBAREA 5A - South Kitsap West					
	9002	10%	Semi-Urban/Rural	140	3.0
	9004	89%	Rural	100	3.0
	9005	14%	Rural	100	3.0
	9901	22%	Rural	100	3.0
SUBAREA 5B - South Kitsap East					
	9002	90%	Semi-Urban/Rural	140	3.0
	9003	100%	Rural	100	3.0
	9004	11%	Rural	100	3.0

See footnotes on next page.

Footnotes (Table II-6):

(1) These subareas correpsond with planning areas used to describe aquifer recharge areas and groundwater quality. See Exhibit II-1.

(2) Forecast and Analysis Zone (FAZ) as shown in Exhibit II-4.

(3) Assumes 175, 140 and 100 gallons pwer capita per day (gpcd) for existing conditions for urban, semi-urban/rural and rural areas, respectively. These numbers are consistent with figures used for Kitsap County CWSP.

(4) Assumes peak to average day factors of 2.3, 3.0 and 3.0 for urban, semi-urban/rural, and rural areas, respectively. These figures are consistent with figures used for Kitsap County CWSP.

TABLE II-7

KITSAP COUNTY
POPULATION PROJECTION

SUB-AREA	FAZ NOS.	% IN SUB-AREA	1970	1980	1985 (1)	1990	1995 (1)	2000	2010 (1)	2020	2030 (2)	2040 (2)
SUBAREA 1 - Hansville-Indianola												
	9011	67%	1,693	2,801	3,216	3,631	4,145	4,660	6,052	7,445	8,837	10,230
	9012	87%	5,540	11,260	13,576	15,892	17,989	20,087	24,985	29,882	34,780	39,677
TOTAL Subarea 1			7,234	14,061	16,792	19,523	22,135	24,747	31,037	37,327	43,617	49,907
SUBAREA 2 - Bainbridge												
	9913	100%	2,158	3,055	3,287	3,519	3,827	4,135	4,646	5,157	5,668	6,179
	9914	100%	6,336	9,259	10,239	11,218	12,158	13,098	13,821	14,544	15,267	15,990
TOTAL Subarea 2			8,494	12,314	13,526	14,737	15,985	17,233	18,467	19,701	20,935	22,169
SUBAREA 3 - Poulsbo-Bremerton												
	9005	10%	114	210	275	341	383	426	517	608	699	791
	9006	31%	561	1,062	1,431	1,799	1,985	2,171	2,667	3,162	3,658	4,154
	9007	100%	4,171	5,277	7,076	8,874	11,670	14,466	19,749	25,032	30,315	35,598
	9009	100%	2,247	2,926	3,350	3,774	4,478	5,182	6,648	8,114	9,580	11,046
	9011	33%	849	1,404	1,612	1,820	2,078	2,335	3,033	3,731	4,429	5,127
	9012	13%	855	1,737	2,094	2,451	2,775	3,099	3,854	4,610	5,365	6,121
	9900	100%	4,152	5,026	5,465	5,904	6,240	6,575	6,959	7,343	7,727	8,111
	9901	78%	3,297	4,546	4,738	4,931	5,520	6,109	6,867	7,625	8,383	9,141
	9902	100%	26,151	23,723	23,837	23,950	24,589	25,227	26,167	27,106	28,046	28,985
	9904	100%	10,530	11,076	11,337	11,598	11,909	12,219	12,840	13,461	14,082	14,703
	9908	100%	398	2,966	2,920	2,873	2,936	2,998	3,082	3,166	3,250	3,334
	9909	100%	2,127	2,475	2,706	2,937	3,221	3,504	3,929	4,354	4,779	5,204
	9915	100%	2,796	6,929	8,780	10,631	11,876	13,121	15,398	17,674	19,951	22,227
	9916	100%	2,750	8,345	9,142	9,939	10,991	12,043	14,078	16,112	18,147	20,181
TOTAL Subarea 3			60,997	77,702	84,762	91,822	100,649	109,475	125,787	142,098	158,410	174,722
SUBAREA 4 - West Kitsap												
	9005	76%	873	1,613	2,113	2,612	2,939	3,265	3,965	4,665	5,364	6,064
	9006	69%	1,276	2,416	3,256	4,096	4,519	4,942	6,070	7,198	8,325	9,453
TOTAL Subarea 4			2,149	4,030	5,369	6,708	7,457	8,207	10,035	11,862	13,690	15,517
SUBAREA 5A - South Kitsap West												
	9002	10%	1,067	1,738	1,992	2,246	2,448	2,650	3,064	3,478	3,893	4,307
	9004	89%	3,904	7,225	8,688	10,150	11,361	12,571	14,640	16,708	18,776	20,844
	9005	14%	164	302	396	489	551	612	743	874	1,005	1,136
	9901	22%	905	1,248	1,301	1,354	1,516	1,678	1,886	2,094	2,302	2,510
TOTAL Subarea 5A			6,040	10,514	12,377	14,240	15,876	17,511	20,333	23,154	25,976	28,798
SUBAREA 5B - South Kitsap East												
	9002	90%	9,739	15,866	18,185	20,505	22,349	24,194	27,975	31,756	35,536	39,317
	9003	100%	6,594	11,767	14,069	16,370	18,073	19,776	23,180	26,583	29,987	33,390
	9004	11%	486	899	1,081	1,263	1,413	1,564	1,821	2,078	2,335	2,593
TOTAL Subarea 5B			16,819	28,532	33,335	38,137	41,835	45,534	52,975	60,417	67,858	75,300
TOTAL Kitsap County			101,732	147,152	166,160	185,167	203,937	222,707	258,634	294,560	330,487	366,413

(1) Linearly extrapolated.

(2) Straight line projection.

Source: Puget Sound Council of Governments (PSCOG) June 1988 Population and Employment Forecasts

TABLE II-8

KITSAP COUNTY
SUMMARY OF MUNCIPAL AND DOMESTIC WATER DEMAND PROJECTIONS (1)

AVERAGE DAY DEMAND (MGD)

SCENARIO / SUBAREA	YEAR 1985	1990	1995	2000	2010	2020	STRAIGHT-LINE 2030	2040
SCENARIO 1 - EXISTING CONDITION (2)								
Subarea 1 - Hansville-Indianola	1.81	2.10	2.38	2.66	3.35	4.03	4.72	5.40
Subarea 2 - Bainbridge Island	1.48	1.61	1.75	1.89	2.03	2.18	2.32	2.46
Subarea 3 - Poulsbo-Bremerton	12.94	13.91	15.15	16.39	18.63	20.88	23.12	25.37
Subarea 4 - West Kitsap	0.54	0.67	0.75	0.82	1.00	1.19	1.37	1.55
Subarea 5a - South Kitsap West	1.32	1.51	1.69	1.86	2.16	2.45	2.75	3.05
Subarea 5b - South Kitsap East	4.06	4.63	5.08	5.52	6.42	7.31	8.21	9.10
TOTAL Existing Condition	22.15	24.44	26.79	29.13	33.59	38.04	42.49	46.94
SCENARIO 2 - WITH MULTI-FAMILY INCREASE (3)								
Subarea 1 - Hansville-Indianola	1.81	2.10	2.36	2.62	3.29	3.96	4.63	5.30
Subarea 2 - Bainbridge Island	1.48	1.61	1.73	1.85	1.99	2.13	2.26	2.40
Subarea 3 - Poulsbo-Bremerton	12.94	13.91	14.84	15.71	17.84	19.97	22.10	24.23
Subarea 4 - West Kitsap	0.54	0.67	0.75	0.82	1.00	1.19	1.37	1.55
Subarea 5a - South Kitsap West	1.32	1.51	1.67	1.83	2.13	2.42	2.72	3.01
Subarea 5b - South Kitsap East	4.06	4.63	4.97	5.28	6.14	7.00	7.86	8.72
TOTAL Multi-Family Increase	22.15	24.44	26.32	28.11	32.39	36.66	40.94	45.22
SCENARIO 3 - WITH WATER CONSERVATION (4)								
Subarea 1 - Hansville-Indianola	1.81	2.10	2.26	2.39	3.01	3.63	4.24	4.86
Subarea 2 - Bainbridge Island	1.48	1.61	1.66	1.70	1.83	1.96	2.09	2.22
Subarea 3 - Poulsbo-Bremerton	12.94	13.91	14.39	14.75	16.77	18.79	20.81	22.83
Subarea 4 - West Kitsap	0.54	0.67	0.71	0.74	0.90	1.07	1.23	1.40
Subarea 5a - South Kitsap West	1.32	1.51	1.60	1.67	1.94	2.21	2.48	2.75
Subarea 5b - South Kitsap East	4.06	4.63	4.82	4.97	5.77	6.58	7.39	8.19
TOTAL Water Conservation	22.15	24.44	25.45	26.22	30.23	34.23	38.24	42.24
SCENARIO 4 - MULTI-FAMILY INCREASE AND CONSERVATION (5)								
Subarea 1 - Hansville-Indianola	1.81	2.10	2.24	2.35	2.95	3.55	4.16	4.76
Subarea 2 - Bainbridge Island	1.48	1.61	1.65	1.66	1.78	1.91	2.03	2.16
Subarea 3 - Poulsbo-Bremerton	12.94	13.91	14.09	14.07	15.98	17.88	19.79	21.70
Subarea 4 - West Kitsap	0.54	0.67	0.71	0.74	0.90	1.07	1.23	1.40
Subarea 5a - South Kitsap West	1.32	1.51	1.59	1.65	1.91	2.18	2.44	2.70
Subarea 5b - South Kitsap East	4.06	4.63	4.71	4.73	5.50	6.27	7.04	7.81
TOTAL Multi-Family & Conservation	22.15	24.44	24.98	25.20	29.03	32.86	36.69	40.52

PEAK DAY DEMAND (MGD)

SCENARIO / SUBAREA	1985	1990	1995	2000	2010	2020	2030	2040
SCENARIO 1 - EXISTING CONDITION (2)								
Subarea 1 - Hansville-Indianola	5.42	6.29	7.14	7.98	10.04	12.09	14.15	16.20
Subarea 2 - Bainbridge Island	4.45	4.84	5.25	5.67	6.10	6.53	6.96	7.39
Subarea 3 - Poulsbo-Bremerton	33.27	36.05	39.53	43.02	49.42	55.83	62.23	68.64
Subarea 4 - West Kitsap	1.61	2.01	2.24	2.46	3.01	3.56	4.11	4.66
Subarea 5a - South Kitsap West	3.95	4.54	5.06	5.57	6.47	7.36	8.26	9.16
Subarea 5b - South Kitsap East	12.18	13.90	15.23	16.56	19.25	21.94	24.62	27.31
TOTAL Existing Condition	60.89	67.64	74.45	81.26	94.28	107.31	120.33	133.35
SCENARIO 2 - WITH MULTI-FAMILY INCREASE (3)								
Subarea 1 - Hansville-Indianola	5.42	6.29	7.08	7.85	9.86	11.87	13.89	15.90
Subarea 2 - Bainbridge Island	4.45	4.84	5.20	5.54	5.96	6.38	6.79	7.21
Subarea 3 - Poulsbo-Bremerton	33.27	36.05	38.71	41.18	47.25	53.32	59.39	65.46
Subarea 4 - West Kitsap	1.61	2.01	2.24	2.46	3.01	3.56	4.11	4.66
Subarea 5a - South Kitsap West	3.95	4.54	5.02	5.49	6.38	7.26	8.15	9.03
Subarea 5b - South Kitsap East	12.18	13.90	14.90	15.85	18.43	21.00	23.58	26.15
TOTAL Multi-Family Increase	60.89	67.64	73.14	78.38	90.88	103.39	115.90	128.41
SCENARIO 3 - WITH WATER CONSERVATION (4)								
Subarea 1 - Hansville-Indianola	5.42	6.29	6.78	7.18	9.03	10.88	12.73	14.58
Subarea 2 - Bainbridge Island	4.45	4.84	4.99	5.10	5.49	5.88	6.26	6.65
Subarea 3 - Poulsbo-Bremerton	33.27	36.05	37.56	38.72	44.48	50.24	56.01	61.77
Subarea 4 - West Kitsap	1.61	2.01	2.13	2.22	2.71	3.20	3.70	4.19
Subarea 5a - South Kitsap West	3.95	4.54	4.80	5.01	5.82	6.63	7.43	8.24
Subarea 5b - South Kitsap East	12.18	13.90	14.47	14.91	17.32	19.74	22.16	24.58
TOTAL Water Conservation	60.89	67.64	70.73	73.14	84.86	96.58	108.30	120.02
SCENARIO 4 - MULTI-FAMILY INCREASE AND CONSERVATION (5)								
Subarea 1 - Hansville-Indianola	5.42	6.29	6.72	7.05	8.86	10.66	12.47	14.28
Subarea 2 - Bainbridge Island	4.45	4.84	4.94	4.98	5.35	5.72	6.10	6.47
Subarea 3 - Poulsbo-Bremerton	33.27	36.05	36.73	36.88	42.31	47.74	53.17	58.59
Subarea 4 - West Kitsap	1.61	2.01	2.13	2.22	2.71	3.20	3.70	4.19
Subarea 5a - South Kitsap West	3.95	4.54	4.77	4.94	5.73	6.53	7.32	8.11
Subarea 5b - South Kitsap East	12.18	13.90	14.14	14.20	16.50	18.81	21.11	23.42
TOTAL Multi-Family & Conservation	60.89	67.64	69.42	70.25	81.45	92.66	103.87	115.07

See next page for footnotes.

FOOTNOTES (Table II-8):

(1) Includes only municipal and domestic water use. Also includes City of Bremerton surface water demand. City of Bremerton's surface and ground water average day requirements have been estimated to be:

Average Day	1985 *	1990 **	1995 **	2000 **	2010 **	2020 **	2030 ***	2040 ***
Groundwater	3.0	3.1	3.3	3.6	4.1	4.6	5.1	5.6
Surface Water	5.5	5.7	6.2	6.7	7.6	8.5	9.5	10.4
Total	8.5	8.7	9.5	10.3	11.7	13.1	14.5	16.0

* No accurate records available for 1985. Based on actual water records for 1986 through 1988.
** Based on projected growth in water demand for Subarea 3.
*** Straight-line projection from 2020 to 2040.

Maximum current surface water supply capacity for Bremerton is 15 MGD and with proposed improvements will be 20 MGD. This capacity offset peak day demands. See Table II-9 for other water uses.

(2) Assumes the following average and peak gallons per capita per day (gpcd) demand for existing conditions for each area:

Water Use Category	Average GPCD	Peak GPCD
Rural	100	300
Semi-Urban/Rural .	140	420
Urban	175	402.5

(3) Assumes increase in multi-family units in both the urban, semi-urban and semi-rural areas resulting in gradual reduction in per capita water consumption of 1.5% in the urban area and 3.5% in the semi-urban/rural areas for the year 1995, up to 3% and 7%, respectively, for the year 2000 and thereafter.

(4) Assumes conservation savings in gallons per capita per day (gpcd) of 5% in 1995 up to 10% in 2000 and thereafter for all urban, semi-urban/rural, and rural areas.

(5) Combination of (3) and (4).

TABLE II-9

KITSAP COUNTY
WATER DEMAND PROJECTIONS - EXISTING CONDITION
AVERAGE DAY DURING IRRIGATION SEASON

SUB-AREA : WATER USE CATEGORY		1985	1990	1995	2000	2010	2020	STRAIGHT-LINE 2030	STRAIGHT-LINE 2040
SUBAREA 1 - Hansville-Indianola									
Municipal	(1)	1.45	1.68	1.90	2.13	2.68	3.22	3.77	4.32
Domestic/Single Family	(2)	0.36	0.42	0.48	0.53	0.67	0.81	0.94	1.08
Commerical/Industrial	(3)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Irrigation	(4)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Fish Propagation	(5)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Stock Watering	(6)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SUBTOTAL Subarea 1		2.80	3.09	3.37	3.65	4.34	5.02	5.70	6.39
SUBAREA 2 - Bainbridge									
Municipal	(1)	1.19	1.29	1.40	1.51	1.63	1.74	1.86	1.97
Domestic/Single Family	(2)	0.30	0.32	0.35	0.38	0.41	0.44	0.46	0.49
Commerical/Industrial	(3)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Irrigation	(4)	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Fish Propagation	(5)	0	0	0	0	0	0	0	0
Stock Watering	(6)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUBTOTAL Subarea 2		1.74	1.87	2.00	2.14	2.29	2.43	2.57	2.72
SUBAREA 3 - Poulsbo-Bremerton									
Municipal	(1,7)	10.36	11.13	12.12	13.11	14.91	16.70	18.50	20.29
Domestic/Single Family	(2)	2.59	2.78	3.03	3.28	3.73	4.18	4.62	5.07
Commerical/Industrial	(3)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Irrigation	(4)	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Fish Propagation	(5)	0	0	0	0	0	0	0	0
Stock Watering	(6)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SUBTOTAL Subarea 3		13.41	14.38	15.62	16.85	19.10	21.34	23.59	25.84
SUBAREA 4 - West Kitsap									
Municipal	(1)	0.43	0.54	0.60	0.66	0.80	0.95	1.10	1.24
Domestic/Single Family	(2)	0.11	0.13	0.15	0.16	0.20	0.24	0.27	0.31
Commerical/Industrial	(3)	0	0	0	0	0	0	0	0
Irrigation	(4)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Fish Propagation	(5)	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
Stock Watering	(6)	0	0	0	0	0	0	0	0
SUBTOTAL Subarea 4		3.08	3.21	3.28	3.36	3.54	3.73	3.91	4.09
SUBAREA 5A - South Kitsap West									
Municipal	(1)	1.05	1.21	1.35	1.49	1.72	1.96	2.20	2.44
Domestic/Single Family	(2)	0.26	0.30	0.34	0.37	0.43	0.49	0.55	0.61
Commerical/Industrial	(3)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Irrigation	(4)	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Fish Propagation	(5)	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93
Stock Watering	(6)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SUBTOTAL Subarea 5A		3.59	3.79	3.96	4.13	4.43	4.73	5.03	5.32
SUBAREA 5B - South Kitsap East									
Municipal	(1)	3.25	3.71	4.06	4.42	5.13	5.85	6.57	7.28
Domestic/Single Family	(2)	0.81	0.93	1.02	1.10	1.28	1.46	1.64	1.82
Commerical/Industrial	(3)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Irrigation	(4)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Fish Propagation	(5)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Stock Watering	(6)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SUBTOTAL Subarea 5B		4.24	4.81	5.25	5.70	6.59	7.49	8.38	9.28
KITSAP COUNTY									
Municipal	(1)	17.72	19.55	21.43	23.31	26.87	30.43	33.99	37.55
Domestic/Single Family	(2)	4.43	4.89	5.36	5.83	6.72	7.61	8.50	9.39
Commerical/Industrial	(3)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Irrigation	(4)	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18
Fish Propagation	(5)	5.20	5.20	5.20	5.20	5.20	5.20	5.20	5.20
Stock Watering	(6)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL KITSAP COUNTY		28.85	31.14	33.49	35.83	40.28	44.73	49.18	53.64

(1) Includes all water supplied by public water systems based on estimate of number of persons served by Class 1 - 4 water systems. Approximately 80 percent of population is presently served by public supply.
(2) Assumes remaining population (approximately 20 percent of the County) is served by individual wells.
(3) Based on existing annual water right records from Department of Ecology.
(4) Total for 1985 through 2040 based on 1982 Bureau of the Census agriculture statistics. Proportioned to subareas based on water right records from Department of Ecology. Number of acres assumed to be irrigated at 0.8 acre-feet per acre per year. Also, water use based on a 5 month irrigation period.
(5) Based on existing annual water right records from Department of Ecology.
(6) Estimated from number of animals in County based on agricultural statitics and typical daily water use. Proportioned between subareas based on existing annual water right records from Department of Ecology.
(7) Includes portion of demand estimated to be met by surface water from the City of Bremerton. See Footnote (1) for Table II-8.

TABLE II-10

KITSAP COUNTY
SUMMARY OF WATER USE PROJECTIONS (1)

AVERAGE DAY DEMAND (MGD)

SCENARIO / SUBAREA	YEAR 1985	1990	1995	2000	2010	2020	STRAIGHT-LINE 2030	2040
SCENARIO 1 - EXISTING CONDITION (2)								
Subarea 1 - Hansville-Indianola	2.80	3.09	3.37	3.65	4.34	5.02	5.70	6.39
Subarea 2 - Bainbridge Island	1.74	1.87	2.00	2.14	2.29	2.43	2.57	2.72
Subarea 3 - Poulsbo-Bremerton	13.41	14.38	15.62	16.85	19.10	21.34	23.59	25.84
Subarea 4 - West Kitsap	3.08	3.21	3.28	3.36	3.54	3.73	3.91	4.09
Subarea 5a - South Kitsap West	3.59	3.79	3.96	4.13	4.43	4.73	5.03	5.32
Subarea 5b - South Kitsap East	4.24	4.81	5.25	5.70	6.59	7.49	8.38	9.28
TOTAL Existing Condition	28.85	31.14	33.49	35.83	40.28	44.73	49.18	53.64
SCENARIO 2 - WITH MULTI-FAMILY INCREASE (3)								
Subarea 1 - Hansville-Indianola	2.80	3.09	3.35	3.60	4.28	4.95	5.62	6.29
Subarea 2 - Bainbridge Island	1.74	1.87	1.99	2.10	2.24	2.38	2.52	2.66
Subarea 3 - Poulsbo-Bremerton	13.41	14.38	15.31	16.18	18.31	20.44	22.57	24.70
Subarea 4 - West Kitsap	3.08	3.21	3.28	3.36	3.54	3.73	3.91	4.09
Subarea 5a - South Kitsap West	3.59	3.79	3.95	4.10	4.40	4.69	4.99	5.28
Subarea 5b - South Kitsap East	4.24	4.81	5.14	5.46	6.32	7.18	8.03	8.89
TOTAL Multi-Family Increase	28.85	31.14	33.02	34.81	39.08	43.36	47.64	51.91
SCENARIO 3 - WITH WATER CONSERVATION (4)								
Subarea 1 - Hansville-Indianola	2.80	3.09	3.25	3.38	4.00	4.62	5.23	5.85
Subarea 2 - Bainbridge Island	1.74	1.87	1.92	1.95	2.08	2.21	2.34	2.47
Subarea 3 - Poulsbo-Bremerton	13.41	14.38	14.86	15.22	17.24	19.26	21.28	23.30
Subarea 4 - West Kitsap	3.08	3.21	3.25	3.28	3.44	3.61	3.77	3.94
Subarea 5a - South Kitsap West	3.59	3.79	3.87	3.94	4.21	4.48	4.75	5.02
Subarea 5b - South Kitsap East	4.24	4.81	5.00	5.14	5.95	6.76	7.56	8.37
TOTAL Water Conservation	28.85	31.14	32.15	32.92	36.92	40.93	44.94	48.94
SCENARIO 4 - MULTI-FAMILY INCREASE AND CONSERVATION (5)								
Subarea 1 - Hansville-Indianola	2.80	3.09	3.23	3.34	3.94	4.54	5.15	5.75
Subarea 2 - Bainbridge Island	1.74	1.87	1.90	1.91	2.04	2.16	2.29	2.41
Subarea 3 - Poulsbo-Bremerton	13.41	14.38	14.55	14.54	16.45	18.35	20.26	22.16
Subarea 4 - West Kitsap	3.08	3.21	3.25	3.28	3.44	3.61	3.77	3.94
Subarea 5a - South Kitsap West	3.59	3.79	3.86	3.92	4.18	4.45	4.71	4.98
Subarea 5b - South Kitsap East	4.24	4.81	4.89	4.91	5.68	6.44	7.21	7.98
TOTAL Multi-Family & Conservation	28.85	31.14	31.68	31.89	35.73	39.56	43.39	47.22

PEAK DAY DEMAND (MGD)

SCENARIO / SUBAREA	1985	1990	1995	2000	2010	2020	2030	2040
SCENARIO 1 - EXISTING CONDITION (2)								
Subarea 1 - Hansville-Indianola	6.41	7.28	8.13	8.97	11.03	13.08	15.14	17.19
Subarea 2 - Bainbridge Island	4.70	5.10	5.51	5.92	6.35	6.78	7.21	7.64
Subarea 3 - Poulsbo-Bremerton	33.74	36.52	40.00	43.48	49.89	56.30	62.70	69.11
Subarea 4 - West Kitsap	4.15	4.55	4.78	5.00	5.55	6.10	6.65	7.19
Subarea 5a - South Kitsap West	6.22	6.81	7.33	7.84	8.74	9.64	10.53	11.43
Subarea 5b - South Kitsap East	12.36	14.08	15.41	16.74	19.42	22.11	24.80	27.48
TOTAL Existing Condition	67.59	74.34	81.15	87.96	100.98	114.00	127.03	140.05
SCENARIO 2 - WITH MULTI-FAMILY INCREASE (3)								
Subarea 1 - Hansville-Indianola	6.41	7.28	8.07	8.84	10.85	12.86	14.88	16.89
Subarea 2 - Bainbridge Island	4.70	5.10	5.45	5.80	6.21	6.63	7.05	7.46
Subarea 3 - Poulsbo-Bremerton	33.74	36.52	39.17	41.65	47.72	53.79	59.86	65.93
Subarea 4 - West Kitsap	4.15	4.55	4.78	5.00	5.55	6.10	6.65	7.19
Subarea 5a - South Kitsap West	6.22	6.81	7.29	7.77	8.65	9.53	10.42	11.30
Subarea 5b - South Kitsap East	12.36	14.08	15.08	16.03	18.60	21.18	23.75	26.33
TOTAL Multi-Family Increase	67.59	74.34	79.84	85.07	97.58	110.09	122.60	135.10
SCENARIO 3 - WITH WATER CONSERVATION (4)								
Subarea 1 - Hansville-Indianola	6.41	7.28	7.77	8.17	10.02	11.87	13.72	15.57
Subarea 2 - Bainbridge Island	4.70	5.10	5.24	5.35	5.74	6.13	6.52	6.91
Subarea 3 - Poulsbo-Bremerton	33.74	36.52	38.03	39.18	44.95	50.71	56.48	62.24
Subarea 4 - West Kitsap	4.15	4.55	4.66	4.75	5.25	5.74	6.24	6.73
Subarea 5a - South Kitsap West	6.22	6.81	7.08	7.29	8.09	8.90	9.71	10.51
Subarea 5b - South Kitsap East	12.36	14.08	14.65	15.08	17.50	19.92	22.34	24.75
TOTAL Water Conservation	67.59	74.34	77.43	79.83	91.55	103.27	114.99	126.71
SCENARIO 4 - MULTI-FAMILY INCREASE AND CONSERVATION (5)								
Subarea 1 - Hansville-Indianola	6.41	7.28	7.71	8.04	9.85	11.65	13.46	15.27
Subarea 2 - Bainbridge Island	4.70	5.10	5.19	5.23	5.60	5.98	6.35	6.72
Subarea 3 - Poulsbo-Bremerton	33.74	36.52	37.20	37.34	42.77	48.20	53.63	59.06
Subarea 4 - West Kitsap	4.15	4.55	4.66	4.75	5.25	5.74	6.24	6.73
Subarea 5a - South Kitsap West	6.22	6.81	7.04	7.21	8.00	8.80	9.59	10.39
Subarea 5b - South Kitsap East	12.36	14.08	14.32	14.37	16.68	18.98	21.29	23.60
TOTAL Multi-Family & Conservation	67.59	74.34	76.12	76.95	88.15	99.36	110.56	121.77

See next page for footnotes.

FOOTNOTES (Table II-10):

(1) All scenarios include municipal and domestic groundwater use, as well as private commerical/industrial, irrigation, fish propagation and stock watering. Municipal and domestic use are only variables in groundwater use projection. Irrigation based on Bureau of the Census agricultural statistics. Other uses estimated from water right records. City of Bremerton surface water demand is included. City of Bremerton's surface and ground water average day requirements have been estimated to be:

Average Day	1985 *	1990 **	1995 **	2000 **	2010 **	2020 **	2030 ***	2040 ***
Groundwater	3.0	3.1	3.3	3.6	4.1	4.6	5.1	5.6
Surface Water	5.5	5.7	6.2	6.7	7.6	8.5	9.5	10.4
	=====	=====	=====	=====	=====	=====	=====	=====
Total	8.5	8.7	9.5	10.3	11.7	13.1	14.5	16.0

* No accurate records available for 1985. Based on actual water records for 1986 through 1988.
** Based on projected growth in water demand for Subarea 3.
*** Straight-line projection from 2020 to 2040.

Maximum current surface water supply capacity for Bremerton is 15 MGD and with proposed improvements will be 20 MGD. This capacity offsets peak day water demands.

(2) Assumes the following average and peak gallons per capita per day (gpcd) demand for existing conditions for each area:

Water Use Category	Average GPCD	Peak GPCD
Rural	100	300
Semi-Urban/Rural	140	420
Urban	175	402.5

(3) Assumes increase in multi-family units in both the urban, semi-urban and semi-rural areas resulting in gradual reduction in per capita water consumption of 1.5% in the urban area and 3.5% in the semi-urban/rural areas for the year 1995, up to 3% and 7%, respectively, for the year 2000 and thereafter.

(4) Assumes conservation savings in gallons per capita per day (gpcd) of 5% in 1995 up to 10% in 2000 and thereafter for all urban, semi-urban/rural, and rural areas.

(5) Combination of (3) and (4).

TABLE II-11

KITSAP COUNTY GROUND WATER MANAGEMENT AREA

SUMMARY OF GROUNDWATER RIGHT INFORMATION

	Hansville Indianola	Bainbridge Island	Poulsbo Bremerton	West Kitsap	S. Kitsap West	S. Kitsap East	Totals
PUBLIC WATER SUPPLY							
Instantaneous							
GPM	7,182.5	4,810	17,311.3	2,552	5,863	14,465.1	52,184.4
MGD (1)	10.34	6.93	24.93	3.68	8.44	20.83	75.15
Annual							
AF/YR	3,284.7	3,657.5	13,229.4	1,042.9	3,042.4	11,097.3	35,354.2
MGD	2.93	3.27	11.81	0.93	2.72	9.91	31.57
OTHER USES: (2)							
Annual Only							
Irrigation							
No. of Acres	209	53.25	356.5	17	158	75.7	869
AF/YR	417.4	98	628	34	175.3	134.5	1,487.2
MGD (3)	.91	.21	1.37	.07	.38	0.29	3.23
Domestic, Single							
AF/YR	46.6	48.85	132.95	14.8	33.3	53	329.5
MGD	.04	.04	.12	.01	.03	0.05	0.29
Commercial/Industrial							
AF/YR	20	183	53		26	20.04	302.04
MGD	.02	.16	.05		.02	0.02	0.27
Stock Watering							
AF/YR	4	0.50	5.95		2	2.5	14.95
MGD	-	-	.01		-	-	0.01
Recreation and Beautification							
AF/YR			4				4
MGD			-				-
Wildlife Propagation							
AF/YR				6.2			6.2
MGD				.01			.01
Fish Propagation							
AF/YR	800			2,815	2,167	46	5,828
MGD	.71			2.51	1.93	.04	5.20
Subtotal: Other Uses							
AF/YR	1,288	330.35	823.9	2,870	2,403.6	256.04	7,971.89
MGD	1.68	0.41	1.55	2.60	2.36	0.40	9.01
TOTAL GWMP Study Area							
AF/YR	4,572.7	3,987.85	14,053.3	3,912.9	5,446	11,353.34	43,326.09
MGD - Annual	4.61	3.68	13.36	3.53	5.08	10.31	40.58

(1) Conversion of water right quantities to MGD is for descriptive purposes only; caution should be used in using MGD figures for supply analysis.

(2) Estimates were made on AF/YR figures on those water rights where annual quantities were not specifically identified by use category.

(3) Irrigation average day water use based on 5 month period rather than average over 12 month period.

TABLE II-12

NOMENCLATURE AND REGIONAL CORRELATION OF STRATIGRAPHY

UNIT	THIS STUDY	SUGGESTED REGIONAL CORRELATION
Qn1.	Recent alluvium and peat deposits younger than Vashon and peat glacial till-unit is too thin to be shown on these sections	Quaternary alluvium
Qg1.	Vashon glacial till	Vashon till
Qg1a.	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 deposits (Mid-cliff drift)	Possession Drift (Easterbrook, 1968)
Qn3.	Second interglacial deposits	Whidbey Formation (Easterbrook, 1968) Kitsap Formation (Garling & 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(?)

Table II-13 Ranking Factors for Infiltration and Recharge/Aquifer Vulnerability Analysis

PARAMETER: LAND USE

LAND USE CATAGORIES	PERCENT IMPERVIOUS	NUMERICAL RANKING
Parks/ Watersheds	0	10
Rural/ 2.5 Acre	3	9
Rural/ 1 Acre	3 - 7	8
Rural/ High Impervious	3 -15	7
Semi-Rural	7 - 15	7
Semi-Urban	15	5
Urban	70	3
Industrial/ Light Manufacturing	90	1

PARAMETER: SLOPE

SLOPE CATAGORIES	PERCENTAGE SLOPE	NUMERICAL RANKING
Low Slope	0 - 6 Percent	10
Moderate Slope	6 - 20 Percent	6
High Slope	> 20 Percent	3

PARAMETER: PRECIPITATION

PRECIPITATION RANGES (in/yr)	NUMERICAL RANKING
> 80	9
70 - 80	8
60 - 70	7
50 - 60	6
40 - 50	5
30 - 40	4
20 - 30	3
< 20	2

PARAMETER: SOIL PERMEABILITY

GEOLOGIC UNITS	QUALITATIVE RANKING	NUMERICAL RANKING
Gravels	High	10
Glacial Till, Peat, Advance Outwash, and Undiff. Deposits	Medium	6
Bedrock, High Slope, and Lacustrine	Low	3

Notes:

Infiltration Potential (IP):

$IP = NRLU*WLU + NRSO*WSO + NRSL*WSL$

Recharge/Aquifer Vulnerability Potential (RP):

$RP = NRPR*WPR + NRSO*WSO + NRSL*WSL$

where:

- o NRLU, NRSO, NRSL, NRPR are the numerical ranking values for land use, soils, slope, and precipitation, respectively.
- o WLU, WSO, WSL, WPR are the weighting factors for land use (2), soils (2), slope (1), and precipitation (2), respectively.

See Geologic Characteristics Maps within the Appendices for distribution of Geologic Units.

Table II-14 Long-Term Average Water Balance Components
Kitsap County

SUBAREA	AVERAGE PRECIP. (P)	AVERAGE EVAPOTRAN. (ET)	AVERAGE RUNOFF (RO)	ASSUMED RUNOFF PERCENTAGE	DIRECT RECHARGE (R)
Hansville-Indianola	20-30	13-15	2-4	10-15	6-10
Bainbridge Island	35-40	14-16	6-7	15-20	15-17
Poulsbo-Bremerton	40-50	15-18	7-10	15-20	18-22
West Kitsap	65-75	20-22	18-21	25-30	27-32
South Kitsap	45-55	17-19	7-10	15-20	21-26

Notes:

1) All values except runoff percentages are in inches/year.
2) Water balance formula is as follows:
   R = P - ET - RO
3) Precipitation estimated from isohyetal map (Exhibit II-15).
4) Evapotranspiration was extimated using Thorthwaite method assuming a 3- to 5-inch soil moisture holding capacity.
5) Runoff was estimated as a percentage of precipitation (percentages are provided). Runoff percentages are based in part on values extrapolated from USGS recharge modeling analysis of South King County (Steve Sumioka, USGS, Personal Comm.).
6) Changes in storage were neglected for long-term analysis.
7) Recharge is the amount of water calculated to pass beyond the root zone. The hydrogeologic characteristics of localized areas will have a profound effect on actual recharge to underlying aquifer zones.

Table II-15 Summary of Hypothetical Groundwater Yield Estimates
Kitsap County

SUBAREA/ AQUIFER SYSTEM	YIELD FOR MAJOR AQUIFER SYSTEMS: RECHARGE AREA (sq. mi.)	RECHARGE RATE (in/yr)	HYPOTHETICAL YIELD C=0.3 (mgd)	HYPOTHETICAL YIELD C=0.5 (mgd)	YIELD FOR ALL AQUIFER SYSTEMS: RECHARGE AREA (sq. mi.)	RECHARGE RATE (in/yr)	HYPOTHETICAL YIELD C=0.3 (mgd)	HYPOTHETICAL YIELD C=0.5 (mgd)	AVERAGE GROUNDWATER USE FOR EXISTING CONDITIONS 1985 (mgd)	2010 (mgd)	2040 (mgd)	PEAK GROUNDWATER USE FOR EXISTING CONDITIONS 1985 (mgd)	2010 (mgd)	2040 (mgd)	GROUNDWATER RIGHTS ANNUAL (mgd)	INSTANT. (mgd)
Hansville-Indianola																
Hansville	3.5	6	0.3	0.5												
Port Gamble South	3.6	8	0.4	0.7												
Kingston	2.8	8	0.3	0.5												
Suquamish-Miller Bay	7.8	11	1.2	2.0												
Poulsbo	4.1	13	0.8	1.3												
SUBTOTAL	21.8		3.0	5.0	62	8	7.1	11.8	1.81	3.35	5.40	5.42	10.04	16.20	4.61	10.34
Bainbridge Island	9	16	2.1	3.4												
Meadowmere	-	-	-	-												
Wardwell	-	-	-	-												
Bayhead	-	-	-	-												
Coosante	-	-	-	-												
Lynnwood Center	-	-	-	-												
Gilbert Fletcher (east)	-	-	-	-												
SUBTOTAL	9		2.1	3.4	21	16	4.8	8.0	1.48	2.03	2.46	4.93	6.10	7.39	3.68	6.93
Poulsbo-Bremerton																
Edgewater	2.2	13	0.4	0.7												
Bangor	16.5	17	4.0	6.7												
Keyport	5.4	15	1.2	1.9												
Island Lake	-	-	-	-												
Silverdale	17.5	18	4.5	7.5												
Bucklin Hill	-	-	-	-												
Manette-Bremerton North	-	-	-	-												
Gilbert-Fletcher (west)	-	-	-	-												
SUBTOTAL	41.6		10.1	16.8	79	17	19.2	32.0	7.42	11.02	14.99	18.27	29.42	48.64	13.36	24.93
West Kitsap																
Big Beef	2.5	26	0.9	1.5												
SUBTOTAL	2.5		0.9	1.5	64	30	27.4	45.7	0.54	1.00	1.55	1.61	3.01	4.66	3.33	3.68
South Kitsap																
Gorst	5.5	24	1.9	3.1												
Port Orchard	14	22	4.4	7.3												
Bremerton South	-	-	-	-												
North Lake	-	-	-	-												
Salmonberry	-	-	-	-												
Clam Bay	4.8	20	1.4	2.3												
Yukon	-	-	-	-												
Wilson Creek	-	-	-	-												
SUBTOTAL	24.3		7.7	12.8	119	22	37.4	62.3	5.38	8.58	12.15	16.13	25.72	36.47	13.39	29.23
TOTALS	99.2		23.7	39.6	345.0		95.9	159.8	16.63	25.98	36.55	46.38	74.29	113.36	38.57	75.15

Notes:

(1) Hypothetical Groundwater Yield = C * Recharge Rate * Recharge Area

(2) Location of major aquifer systems identified from hydrogeologic analysis are shown in Exhibit II-8.

(3) Recharge area for major aquifer systems include approx. 1/2 mile buffer zone around perimeter of aquifer (excluding areas that border on Puget Sound). Recharge area for all aquifer systems do not include bedrock or high relief areas adjacent to Puget Sound.

(4) Results for some of the major aquifer systems are lumped together (i.e. "-"). See the overlying entry for combined results.

(5) Recharge rates are based on values presented in water balance summary table (Table II-14).

(6) Hypothetical groundwater yield estimates are very approximate in nature. Caution should be exercised in applying the results of this analysis.

(7) Annual water rights estimates include public water supply and other uses.

(8) Instantaneous water rights estimates are only for public water supply system.

Kitsap County
Ground Water Management Plan

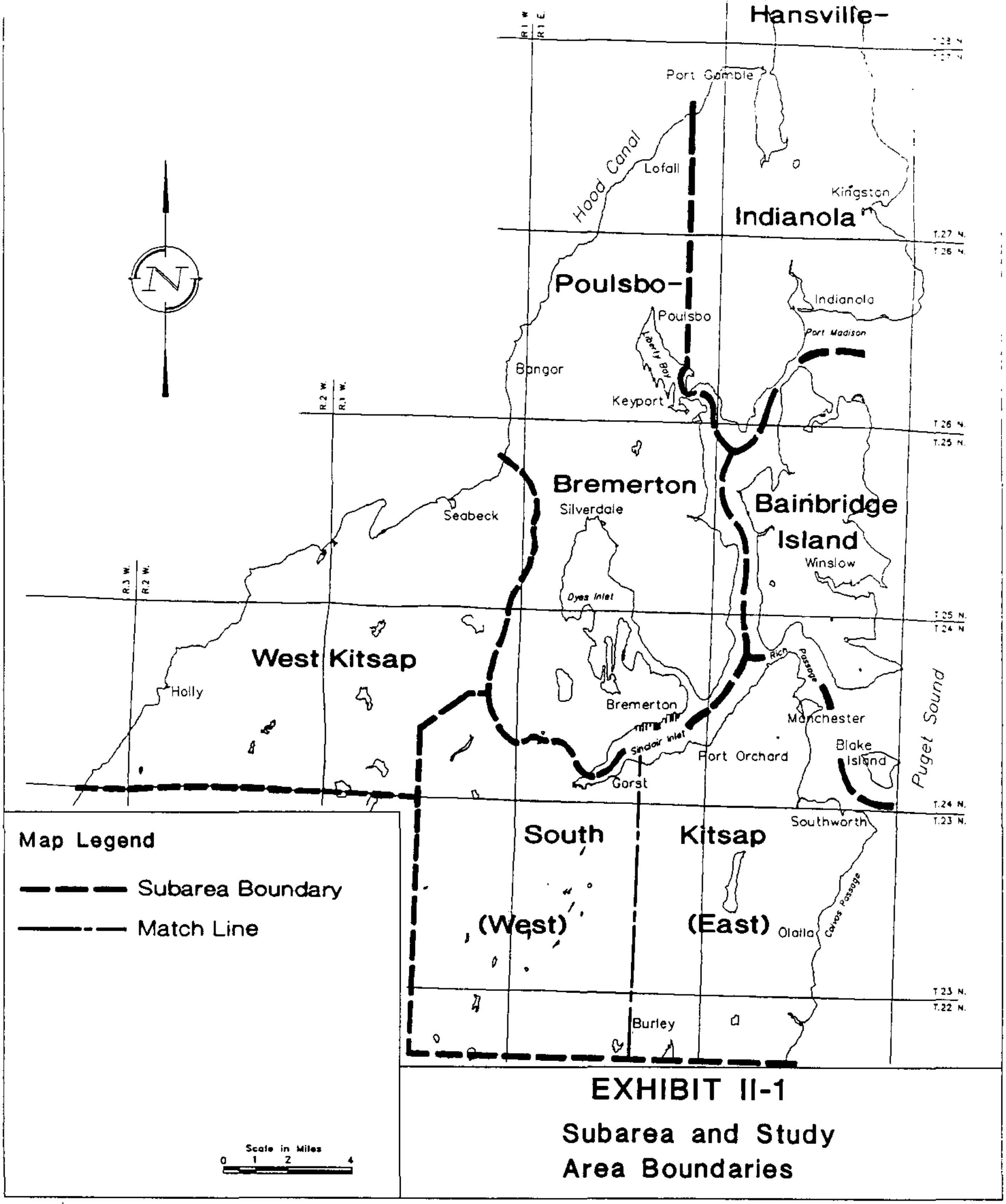


EXHIBIT II-1

Subarea and Study Area Boundaries

Exhibit II-2

KITSAP COUNTY GROUND WATER MANAGEMENT PROGRAM
AQUIFER CONTAMINATION POTENTIAL
LAND USE AND WATER QUALITY DATA APPROACH

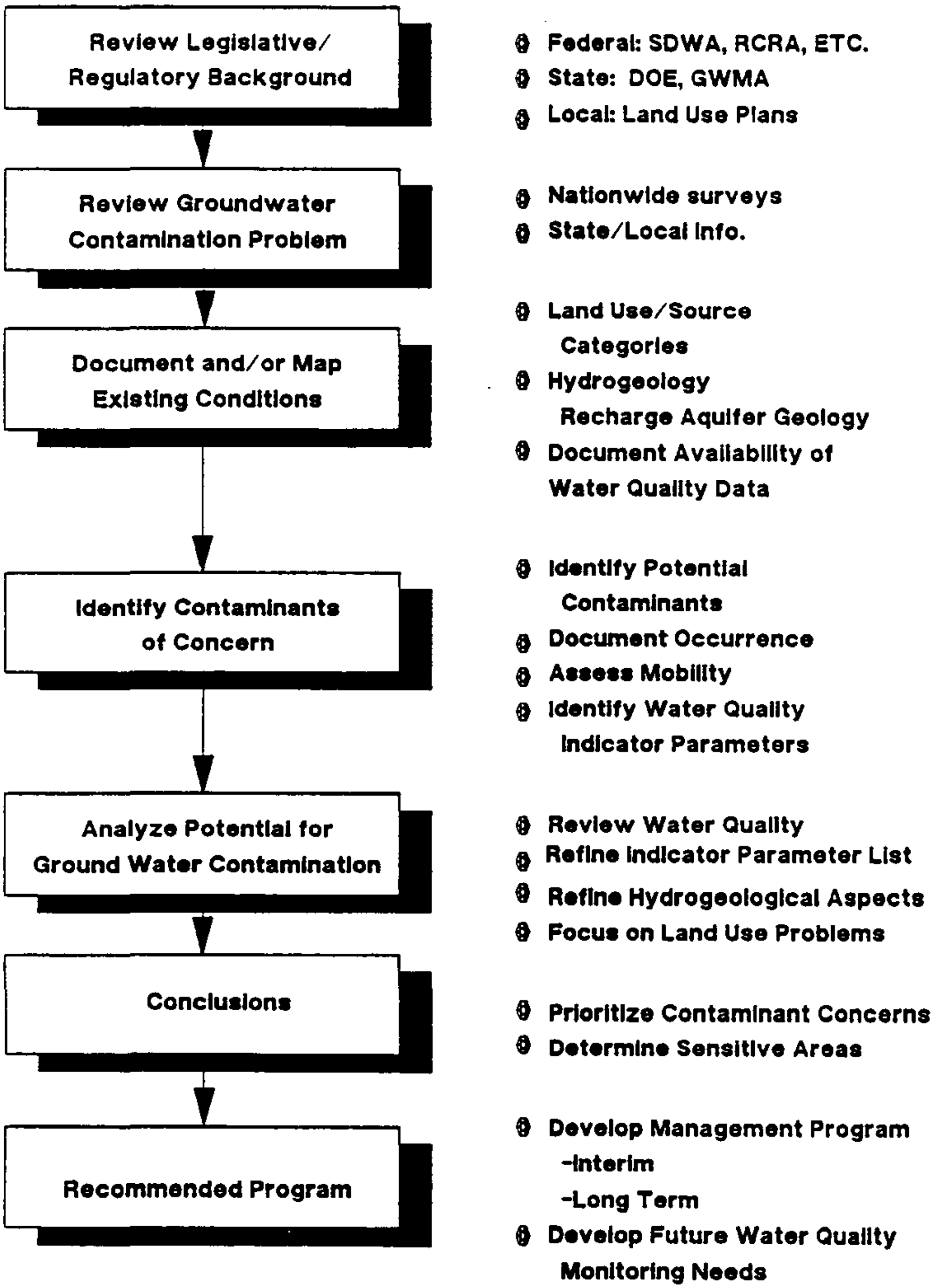


EXHIBIT II-3

SOURCES OF GROUND-WATER CONTAMINATION

CATEGORY I - Sources designed to discharge substances
Subsurface percolation (e.g., septic tanks and cesspools)
Injection wells
- Hazardous waste
- Non-hazardous waste (e.g., brine disposal and drainage)
- Non-waste (e.g., enhanced recovery, artificial recharge solution mining, and in-situ mining)

Land application
- Waste water (e.g., spray irrigation)
- Wastewater byproducts (e.g., sludge)
- Hazardous waste
- Non-hazardous waste

CATEGORY II - Sources designed to store, treat, and/or dispose of substances; discharge through unplanned release
Landfills
- Industrial hazardous waste
- Industrial non-hazardous waste
- Municipal sanitary

Open dumps, including illegal dumping (waste)
Residential (or local) disposal (waste)
Surface impoundments
- Hazardous waste
- Non-hazardous waste

Waste tailings
Waste piles
- Hazardous waste
- Non-hazardous waste

Materials stockpiles (non-waste)
Graveyards
Animal burial
Aboveground storage tanks
- Hazardous waste
- Non-hazardous waste
- Non-waste

Underground storage tanks
- Hazardous waste
- Non-hazardous waste
- Non-waste

Containers
- Hazardous waste
- Non-hazardous waste
- Non-waste

Open burning and detonation sites
Radioactive disposal sites

CATEGORY III-Sources designed to retain substances during transport or transmission
Pipelines
- Hazardous waste
- Non-hazardous waste
- Non-waste

Materials transport and transfer operations
- Hazardous waste
- Non-hazardous waste
- Non-waste

CATEGORY IV - Sources discharging substances as a consequence of other planned activities
Irrigation practices (e.g., return flow)
Pesticide applications
Fertilizer applications
Animal feeding operations
De-icing salts applications
Urban runoff
Percolation of atmospheric pollutants
Mining and mine drainage
- Surface mine-related
- Underground mine-related

CATEGORY V - Sources providing conduit or inducing discharge through altered flow patterns
Production wells
- Oil (and gas) wells
- Geothermal and heat recovery wells
- Water supply wells

Other wells (non-waste)
- Monitoring wells
- Exploration wells

Construction excavation

CATEGORY VI - Naturally occurring sources whose discharge is created and/or exacerbated by human activity
Groundwater - surface water interactions
Natural leaching
Salt-water intrusion/brackish water upconing (or intrusion of other poor-quality natural water)

Source: Office of Technology Assessment, Protecting The Nation's Groundwater From Contamination, October 1984.

Kitsap County Ground Water Management Plan

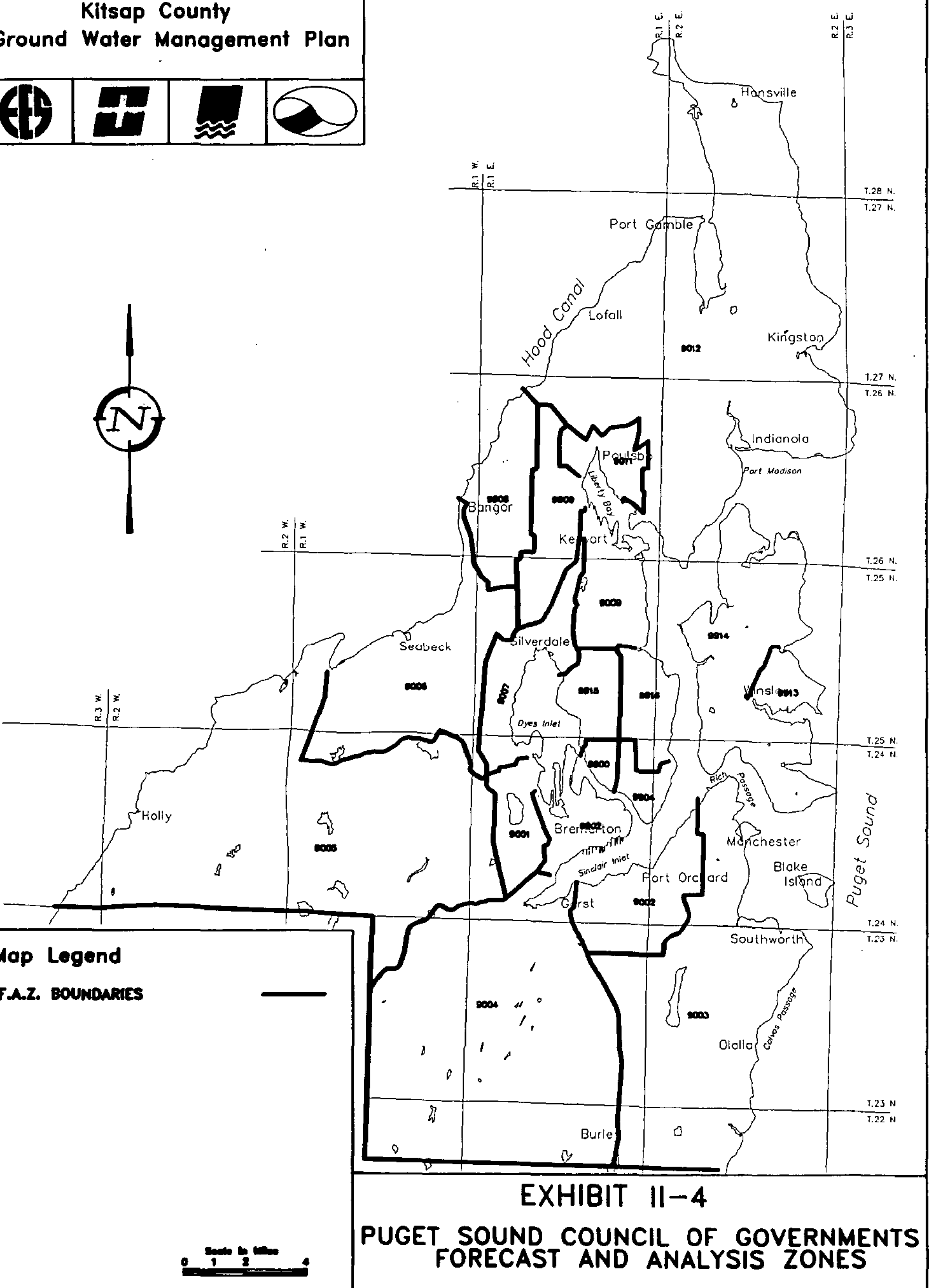
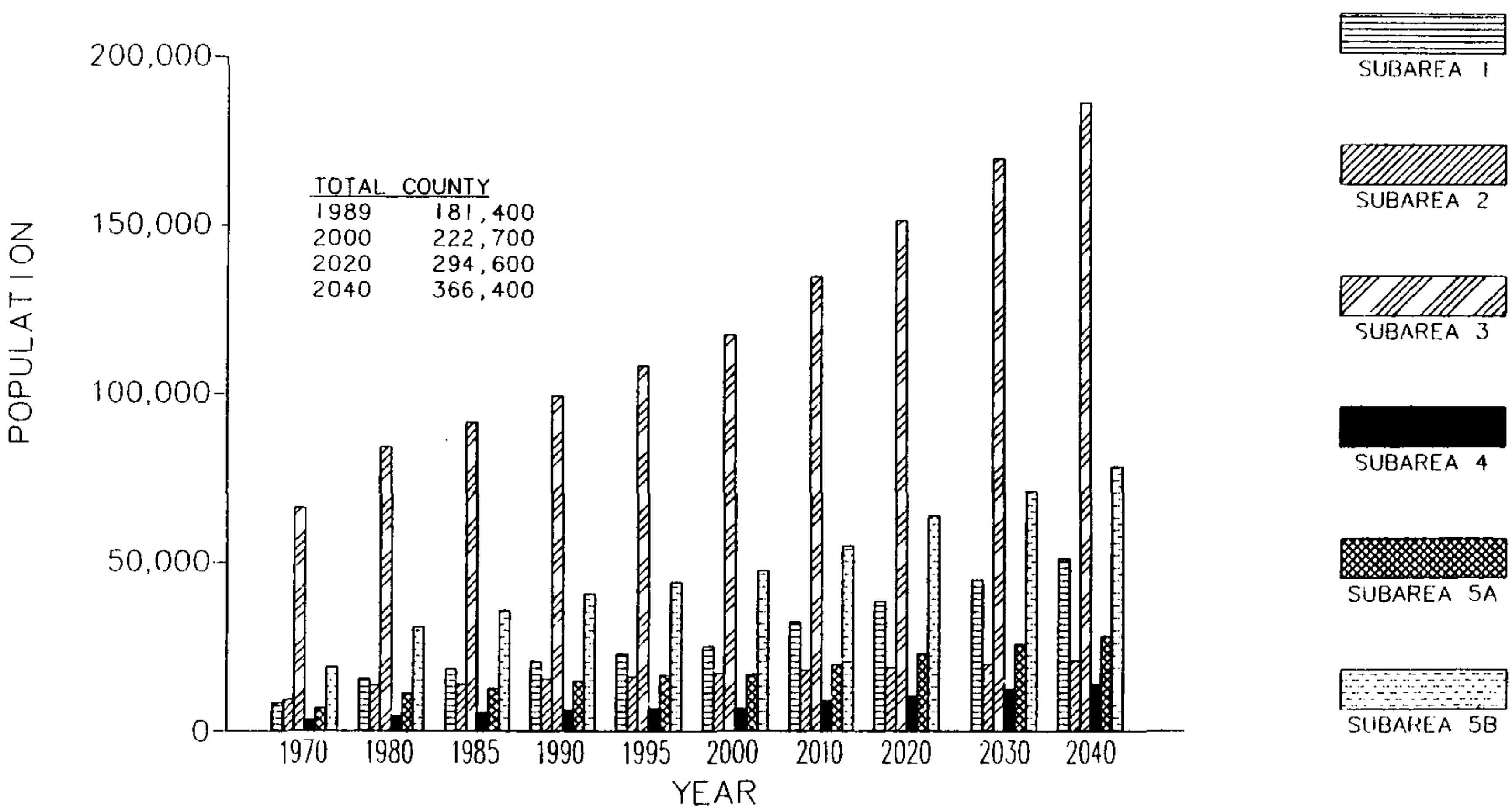


EXHIBIT II-4

PUGET SOUND COUNCIL OF GOVERNMENTS FORECAST AND ANALYSIS ZONES

EXHIBIT II-5

KITSAP COUNTY POPULATION PROJECTION[1,2]
BY SUBAREA

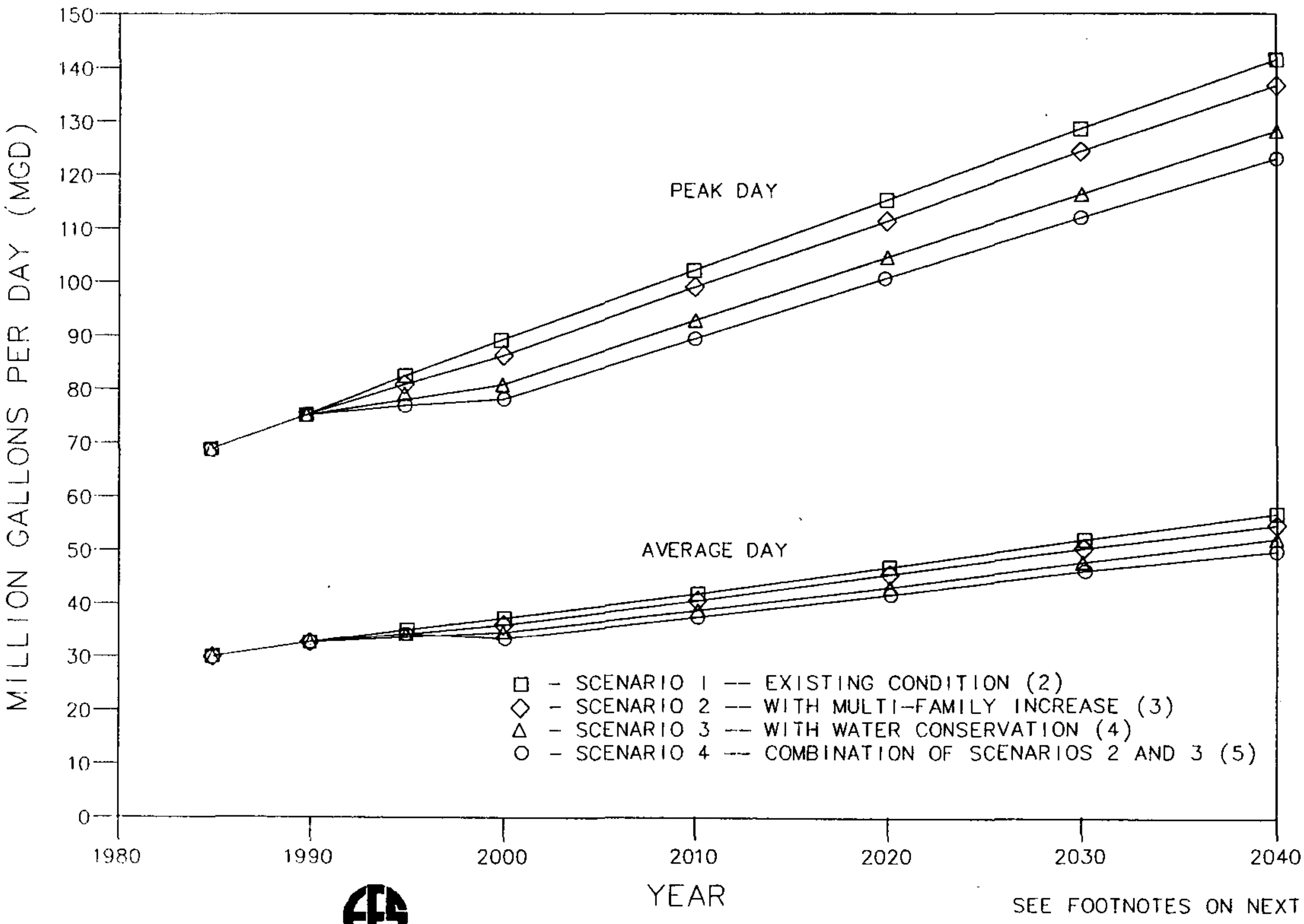


(1) BASED ON POPULATION PROJECTIONS FOR MODERATE GROWTH AS ESTIMATED BY PUGET SOUND COUNCIL OF GOVERNMENTS (PSCOG) FOR 1970 THROUGH 2020 IN "JUNE 1988 POPULATION AND EMPLOYMENT FORECAST" REPORT

(2) STRAIGHT-LINE PROJECTION FORM 2020 TO 2040.

EXHIBIT II-6

KITSAP COUNTY
AVERAGE AND PEAK DAY WATER DEMAND PROJECTIONS [1]
(ALL WATER USES)



SEE FOOTNOTES ON NEXT PAGE

ECONOMIC AND ENGINEERING SERVICES, INC.

FOOTNOTES (Exhibit II-6):

(1) All scenarios include municipal and domestic groundwater use, as well as private commercial/industrial, irrigation, fish propagation, and stock watering. Municipal and domestic use are only variables in groundwater use projection. Irrigation based on Bureau of the Census agricultural statistics. Other uses estimated from water right records. City of Bremerton surface water demand is included. City of Bremerton's surface and groundwater average day requirements have been estimated to be:

Average Day	1985*	1990**	1995**	2000**	2010**	2020**	2030***	2040***
Groundwater	3.0	3.1	3.3	3.6	4.1	4.6	5.1	5.6
Surface Water	5.5	5.7	6.2	6.7	7.6	8.5	9.5	10.4
Total	8.5	8.7	9.5	10.3	11.7	13.1	14.5	16.0

* No accurate records available for 1985. Based on actual water records for 1986 through 1988.
** Based on projected growth in water demand for Subarea 3.
*** Straight-line projection from 2020 to 2040.

Maximum current surface water supply capacity for Bremerton is 15 MGD and with proposed improvements will be 20 MGD. This capacity offsets peak day water demands.

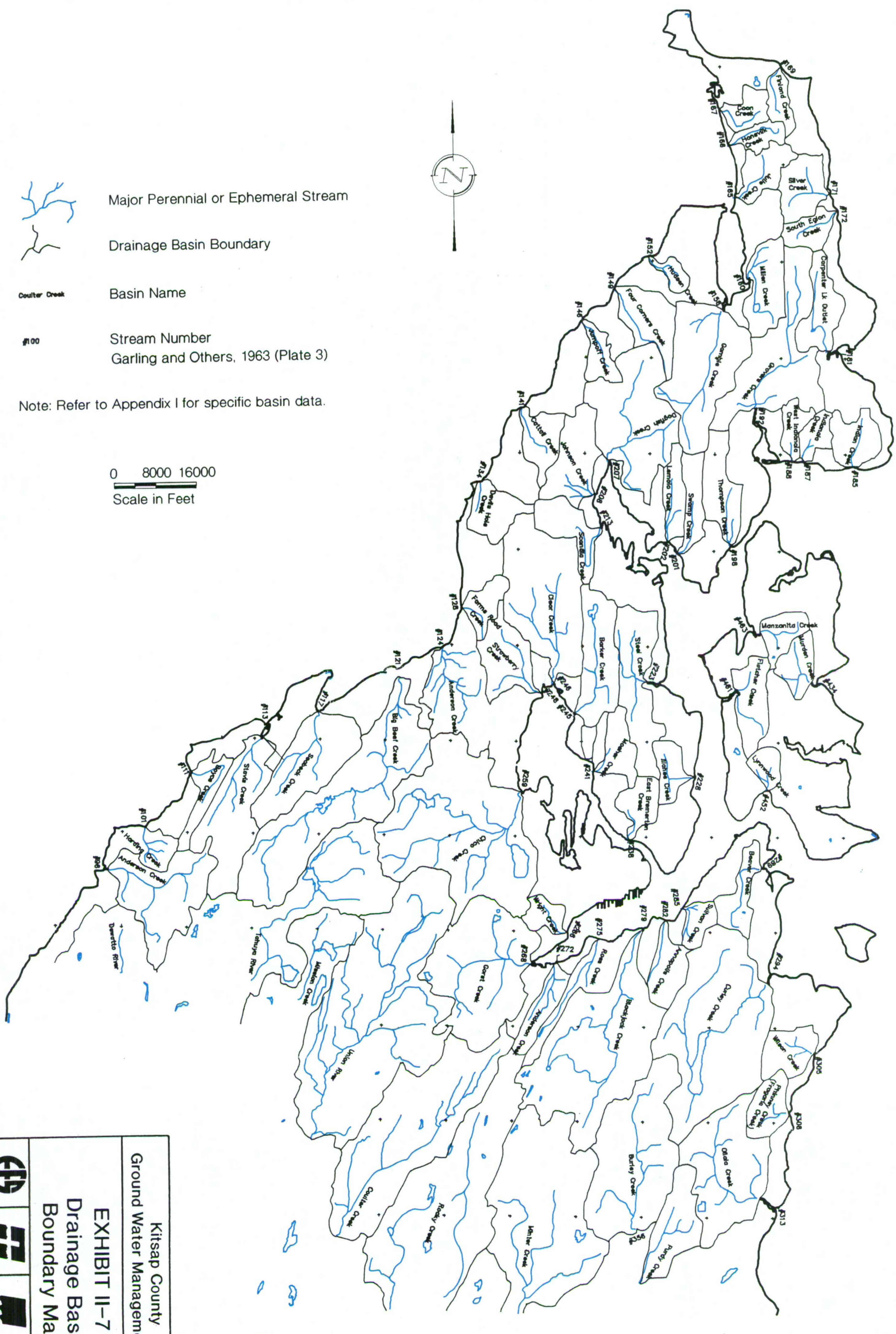
(2) Assumes the following average and peak gallons per capita per day (gpcd) demand for existing conditions for each area:

Water Use Category	Average GPCD	Peak GPCD
Rural	100	100
Semi-Urban/Rural	140	420
Urban	175	402.5

(3) Assumes increase in multi-family units in both the urban, semi-urban, and semi-rural areas resulting in gradual reduction in per capita water consumption of 1.5% in the urban area and 3.5% in the semi-urban/rural areas for the year 1995, up to 3% and 7%, respectively, for the year 2000 and thereafter.

(4) Assumes conservation savings in gallons per capita per day (gpcd) of 5% in 1995 up to 10% in 2000 and thereafter for all urban, semi-urban/rural, and rural areas.

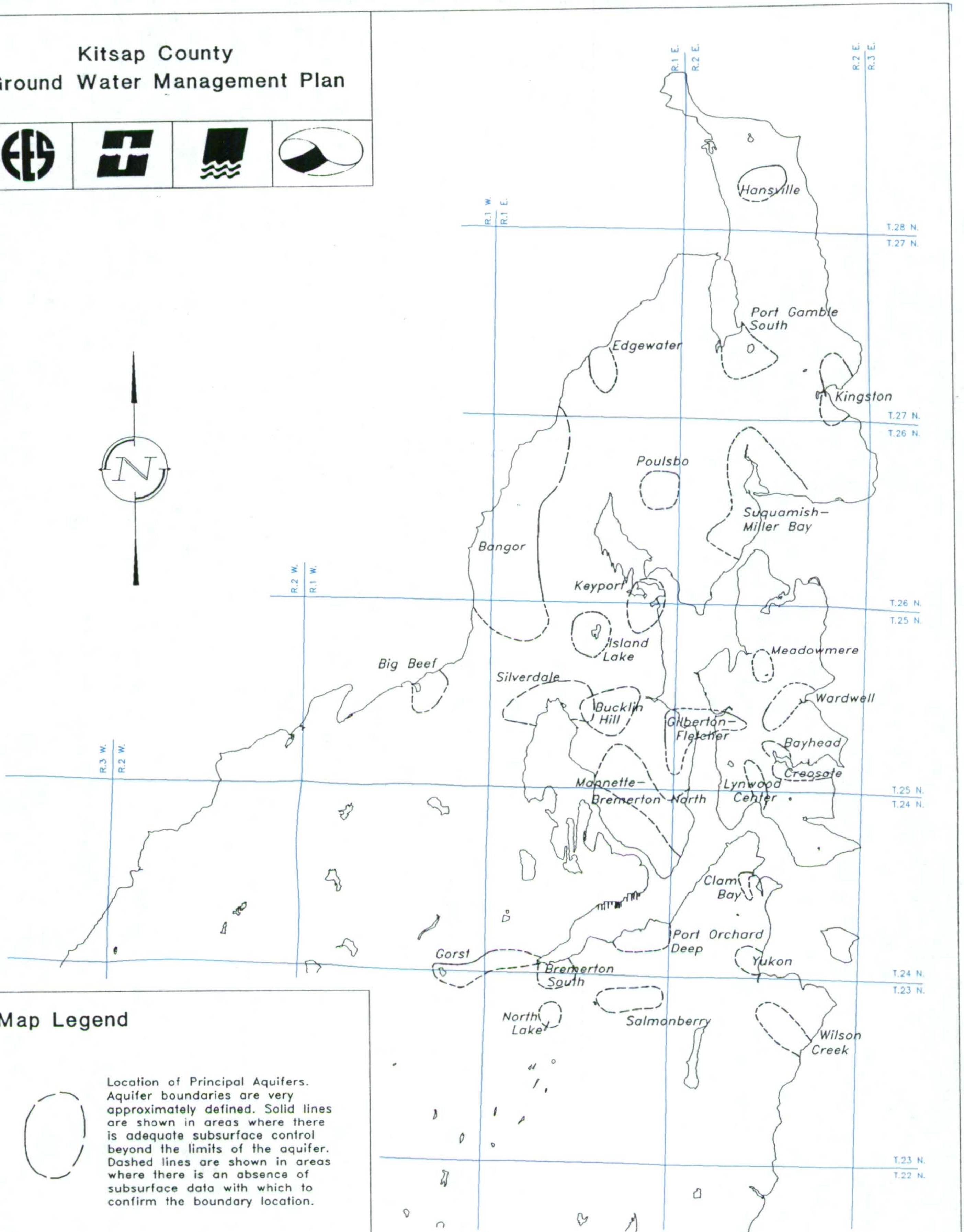
(5) Combination of (3) and (4).



Kitsap County
Ground Water Management Plan

EXHIBIT II-7
Drainage Basin
Boundary Map

Kitsap County
Ground Water Management Plan



Map Legend

Location of Principal Aquifers. Aquifer boundaries are very approximately defined. Solid lines are shown in areas where there is adequate subsurface control beyond the limits of the aquifer. Dashed lines are shown in areas where there is an absence of subsurface data with which to confirm the boundary location.

Scale in Miles
0 1 2 4

EXHIBIT II–8

Location of Principal Aquifers

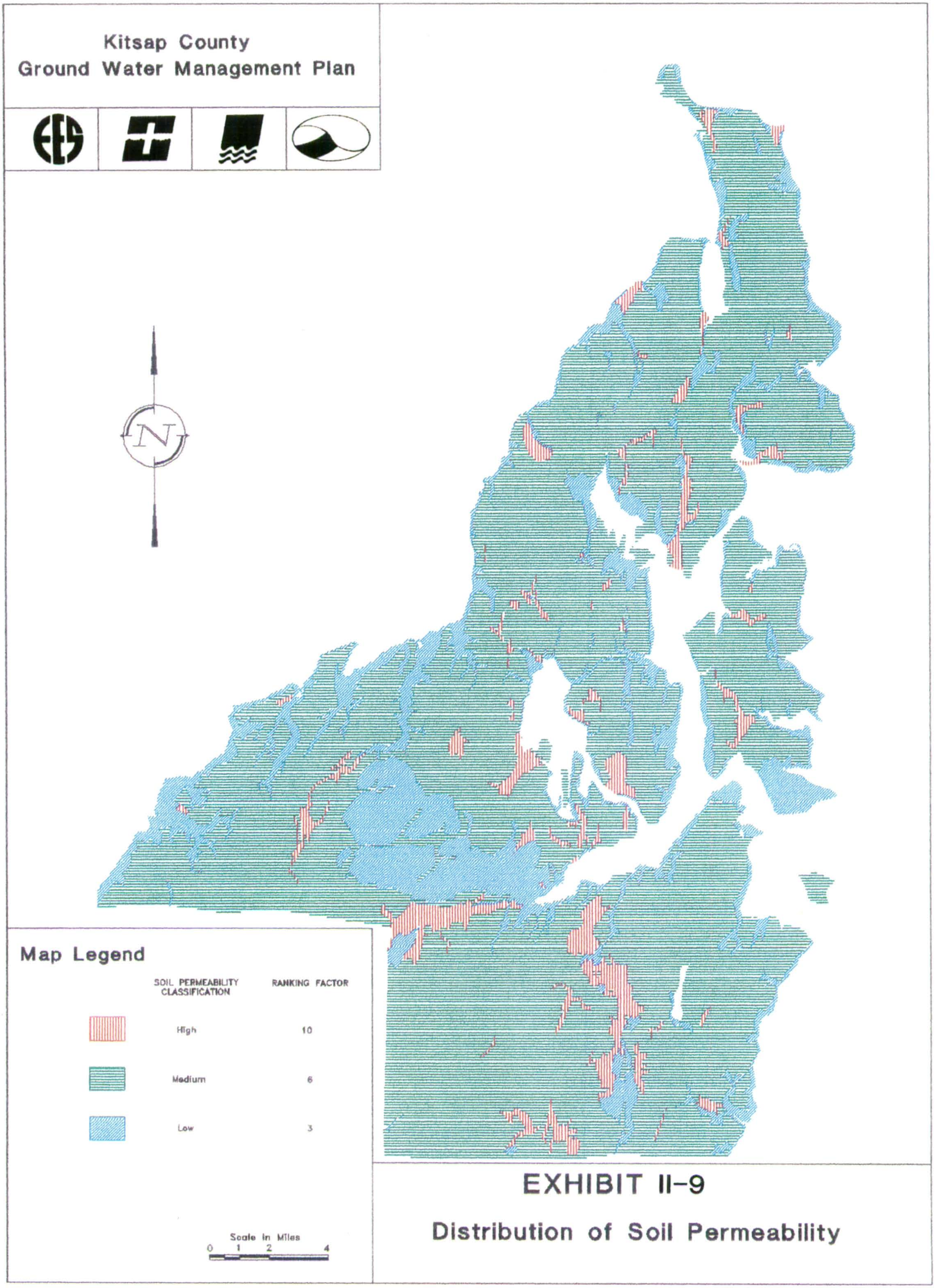
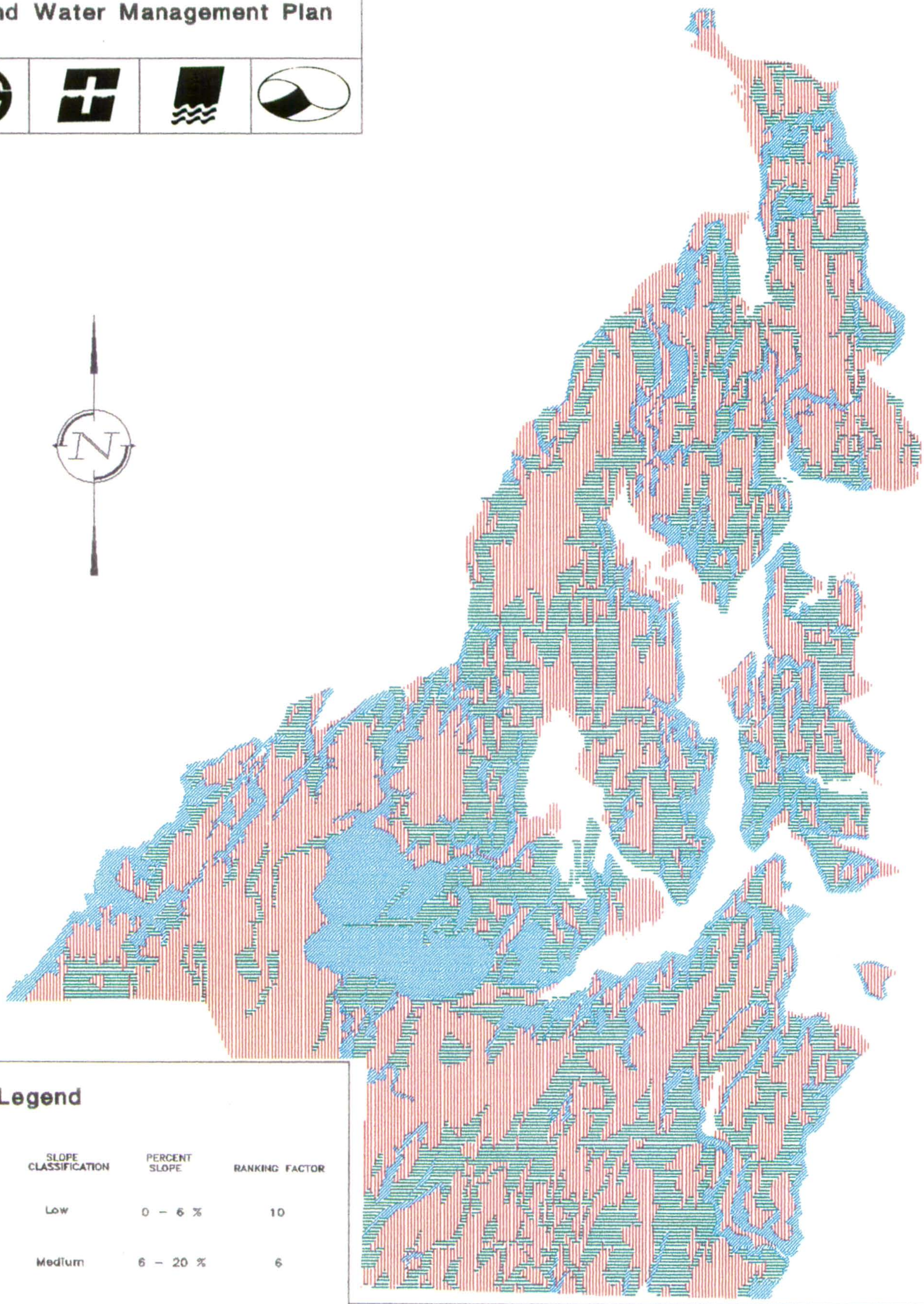


EXHIBIT II-9

Distribution of Soil Permeability

Kitsap County
Ground Water Management Plan



Map Legend

SLOPE CLASSIFICATION	PERCENT SLOPE	RANKING FACTOR
Low	0 – 6 %	10
Medium	6 – 20 %	6
High	> 20 %	3

Scale in Miles
0 1 2 4

EXHIBIT II-10

Distribution of Slope

Kitsap County Ground Water Management Plan

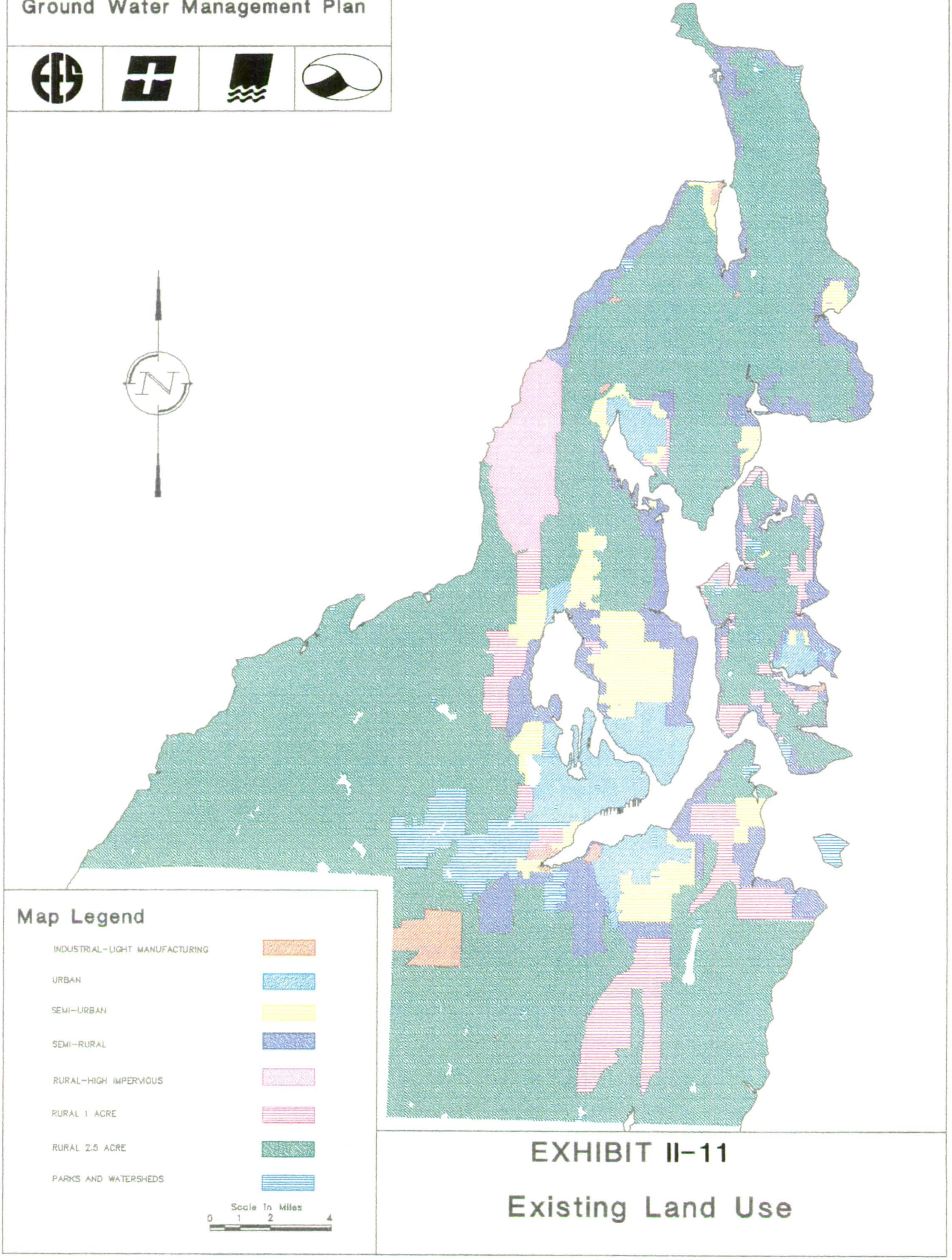


EXHIBIT II-11

Existing Land Use

Kitsap County
Ground Water Management Plan

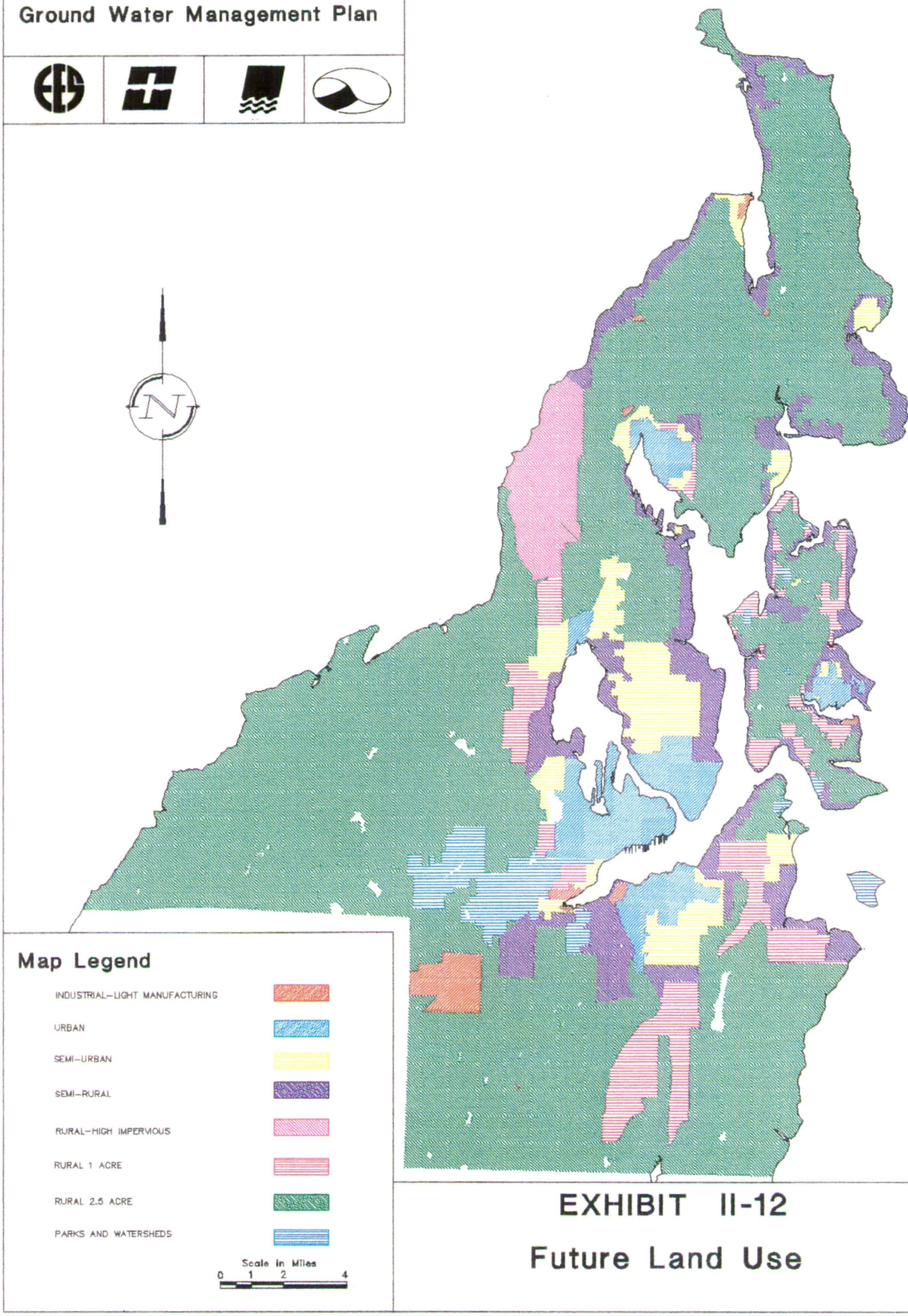
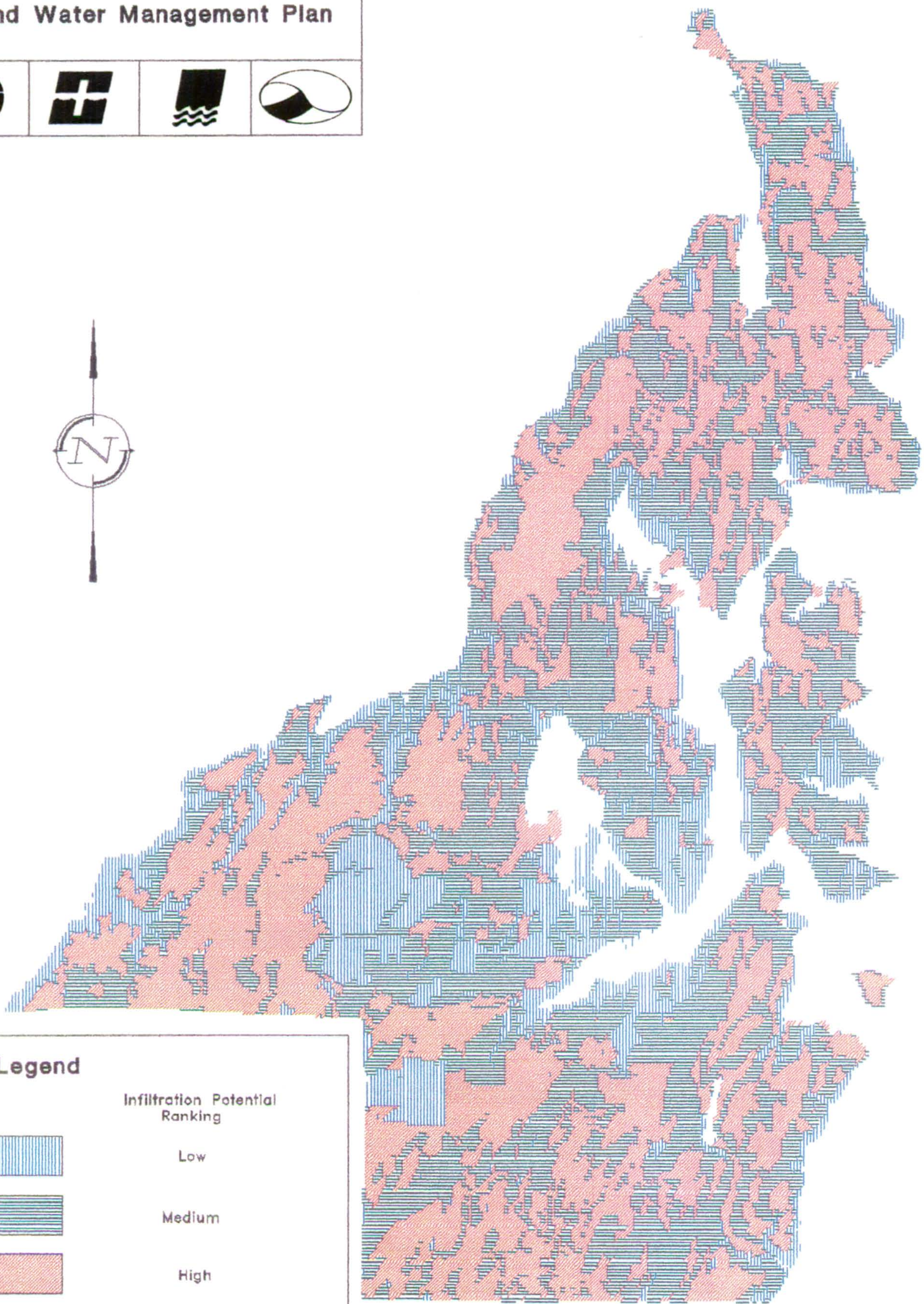


EXHIBIT II-12

Future Land Use

Kitsap County
Ground Water Management Plan



Notes:
See text for discussion of assumptions and methodology. Map provides a general definition of infiltration potential in a regional context. Care should be exercised when evaluating the results within localized areas. Actual infiltration to the groundwater system is a function of many complex variables which are not accounted for in this analysis.

Scale in Miles
0 1 2 4

EXHIBIT II-13
Infiltration Potential Based on Existing Land Use

Kitsap County
Ground Water Management Plan

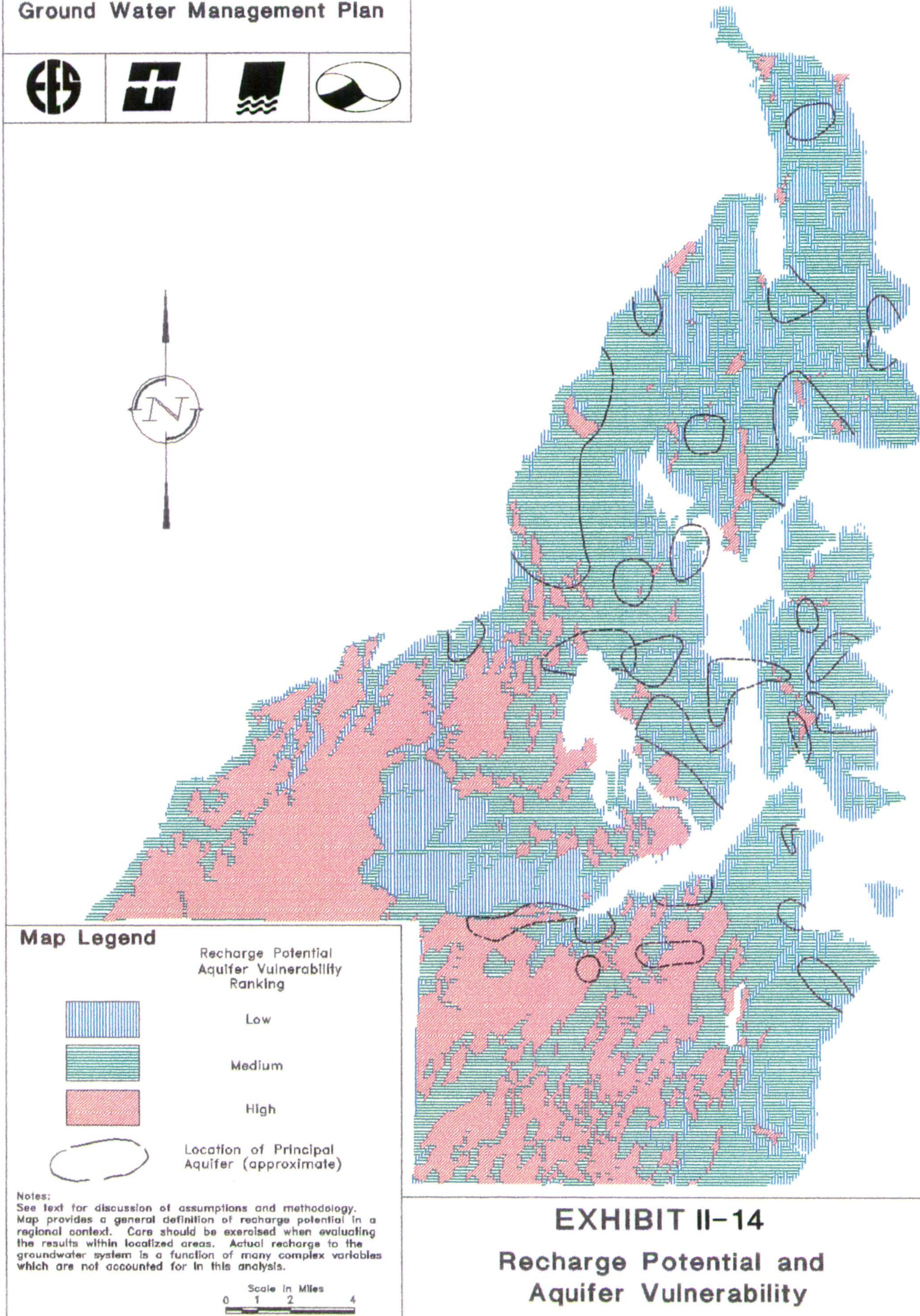


EXHIBIT II-14

Recharge Potential and
Aquifer Vulnerability

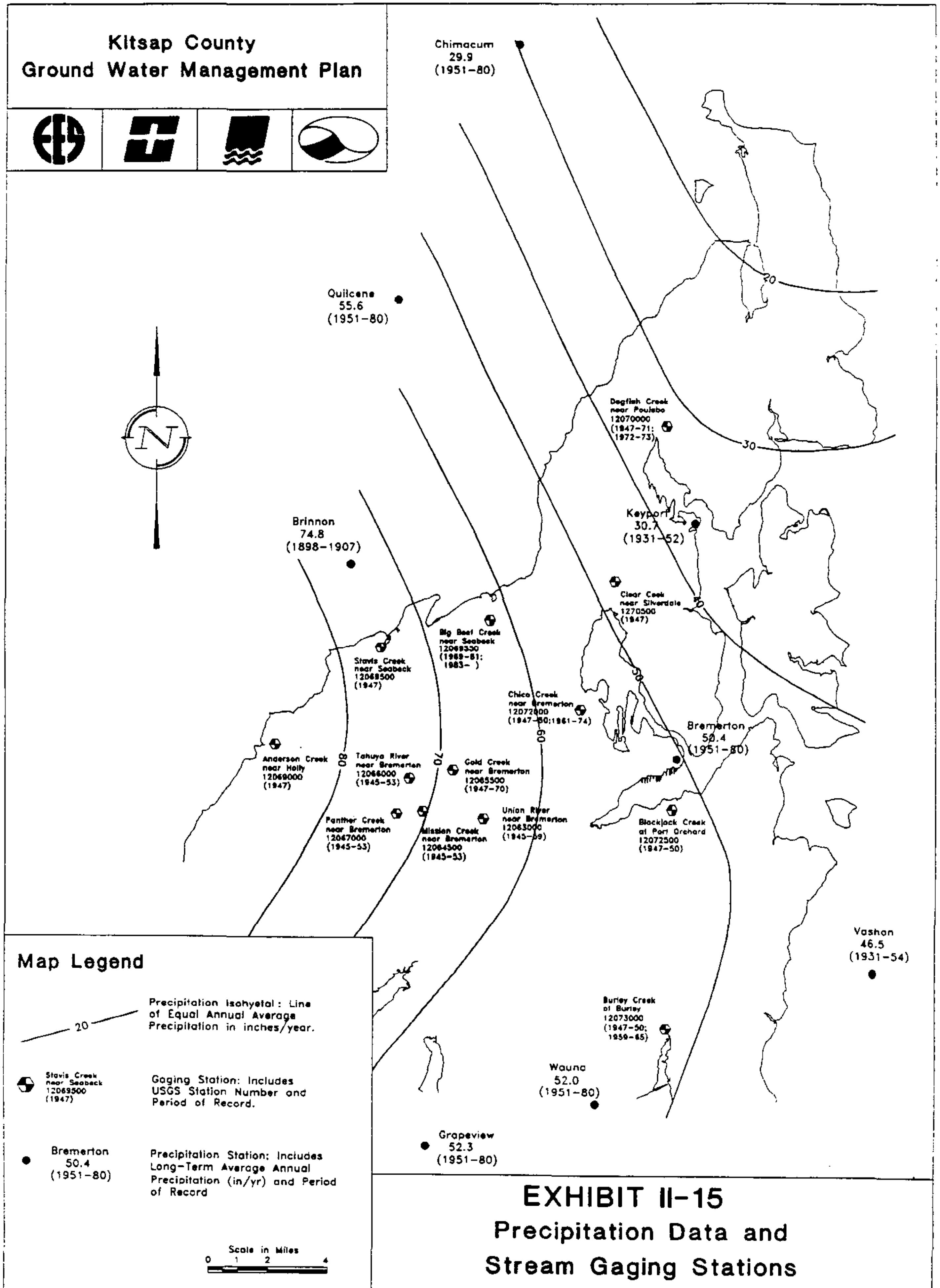
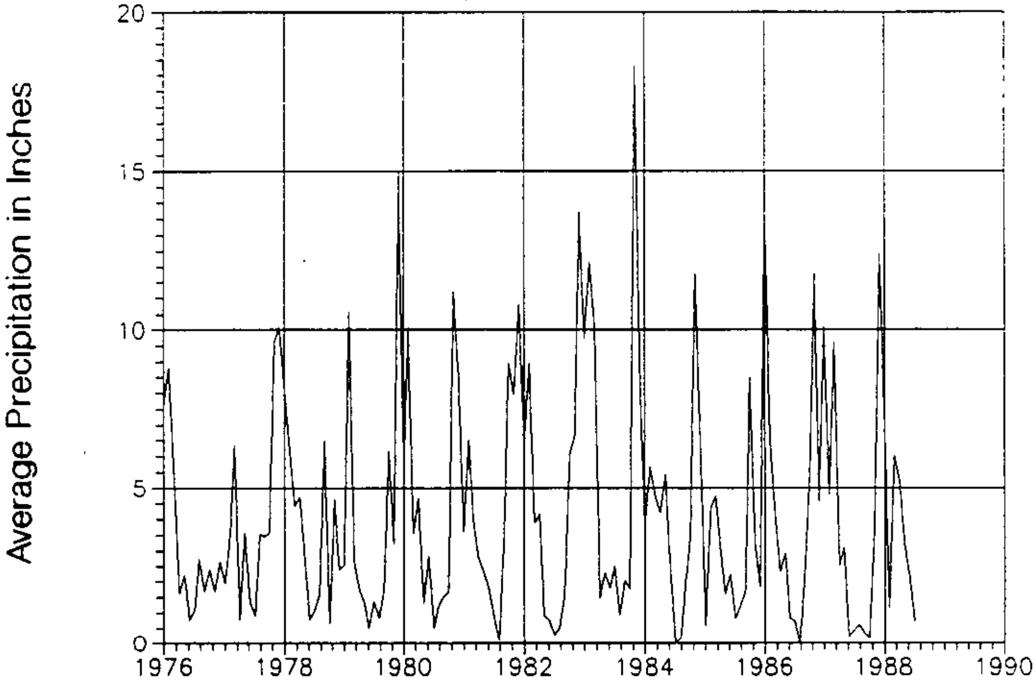


EXHIBIT II-15
Precipitation Data and Stream Gaging Stations

Kitsap County
Ground Water Management Plan

Monthly Precipitation Data



Precipitation Data - 12-month Running Average

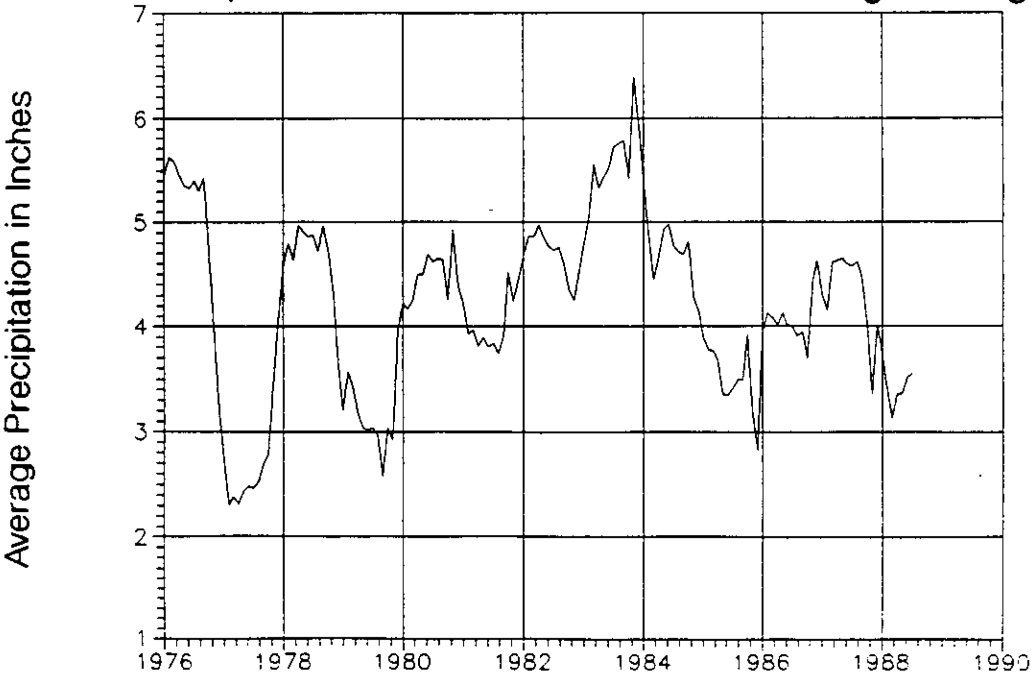
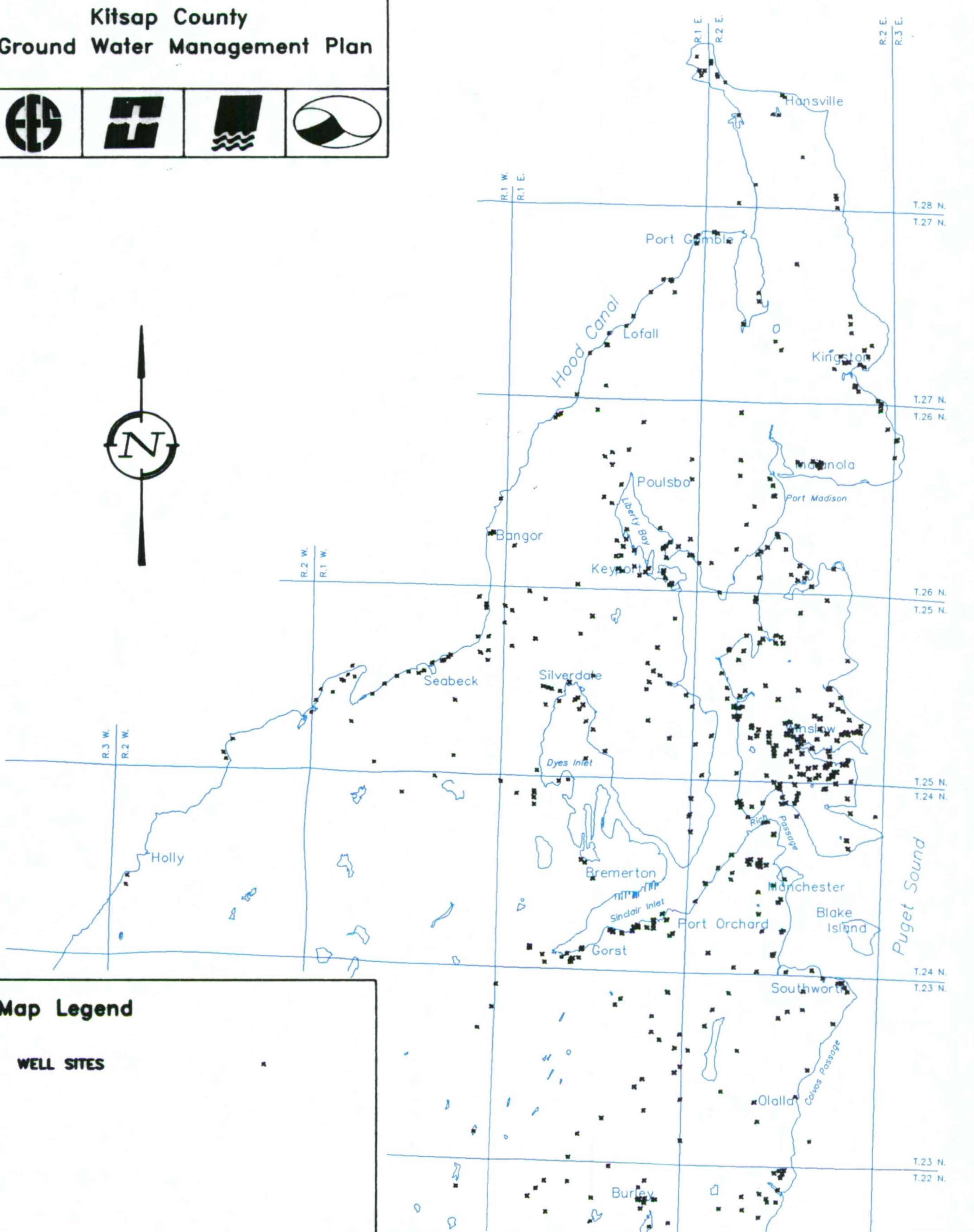


EXHIBIT II-16

Precipitation Trends

Bremerton Climatological Station - Kitsap County

Kitsap County
Ground Water Management Plan



Map Legend

WELL SITES ×

Scale in Miles
0 1 2 4

EXHIBIT II–17
WATER QUALITY DATABASE WELLS

SECTION III

SECTION III

FUTURE DATA COLLECTION

The Ground Water Management Plan (GWMP) Grant No. 1 activities have identified an abundance of hydrogeologic data with which to define aquifer systems, production potential, and resource vulnerability. However, there are still deficiencies in the ability of existing data to resolve all specific hydrogeologic issues. Therefore, one of the benefits of the assessment of existing hydrogeologic data is the definition of areas where insufficient information exists to confidently make regional interpretations. Several types of data are required in defining and managing groundwater resources. These include: (1) groundwater level monitoring; (2) additional evaluation of aquifer characteristics for identified aquifers; (3) generation of preliminary hydrogeologic information in data-poor areas by test drilling, aquifer testing and sampling; (4) collection of pumpage information; (5) background water quality sampling and monitoring with time; (6) collection of stream flow and precipitation data; and (7) monitoring of lake surface elevations. In some areas the available data needed for characterizing groundwater resources and establishing management alternatives is satisfactory. There are, however, some areas which require additional data to monitor and manage the groundwater resources.

This report recommends the collection of additional hydrogeologic, hydrologic, and water quality data to more accurately assess the areas' aquifer characteristics and their relationship with surface water and land surface activities. The intent is that Grant No. 2 efforts will prioritize these activities and develop a long-term comprehensive monitoring program. Since each subarea has it's own specific needs, data collection efforts will be discussed on a subarea basis. Where possible specific locations for data collection are suggested, as shown in Exhibit III-1. It must be noted, however, that these suggestions should not preclude data collection opportunities which may arise nearby. Where offered, explicit data collection efforts are presented to provide conceptual clarity as to how the data needs may be met. In no case are they presented as the only solution to the problem of data paucity.

The recommendations presented within this Section recognize that additional information and a comprehensive monitoring program are warranted throughout all areas, not just those of known or existing major supplies or suppliers. This list of activities was also developed with the knowledge that sources of funding for implementing these recommendations are unresolved, as yet. These will be addressed during Grant No. 2. However, exploratory drillings or other data collection activities by State and local agencies, private interests, or public purveyors, during the interim, should be influenced by this list of recommended actions.

It is possible that many existing wells will adequately aid in this effort. Many wells of record have not been computerized given the limitations on project resources. Field survey of wells would provide accurate definition of well location, elevation, construction details, water levels, and ownership. At a minimum, all public water system wells should be field checked to incorporate into the database.

It is also recommended that collection of information cited in subsequent paragraphs be done in a manner consistent with the GWMP's Quality Assurance Project Plan (QAPP) and reported in accordance with the GWMP's Data Management Plan.

The first part of this section discusses hydrogeologic data collection. It is followed by a discussion of hydrologic data collection needs. The third and final part of this section considers future water quality data collection.

1. HYDROGEOLOGIC DATA COLLECTION

Many of the test drilling and well monitoring suggestions were developed by analysis of the information presented in Exhibit II-8, which displays the principal aquifers of Kitsap County. This analysis defined numerous data needs for proper definition and management of the groundwater resources of the county. The relative unknown lateral extent and the incomplete understanding of aquifer parameters for most of the delineated aquifers clearly indicates that extensive test drilling and aquifer evaluation testing should be considered in long range planning. Also apparent are the large areas which have no presently identified aquifers, especially in the western and southern portions of the county. This lack of identified aquifers most likely reflects a lack of data rather than a lack of aquifers. In addition, a system for standardizing data gathering and recording during pumping and non-pumping periods should be established throughout the County.

Another critical data need is the collection of information which will allow refinement of the water budget calculations for the county. A particular need for water level and runoff data exists. This means regular measurement of key wells to create hydrographs and gauging of streams and lakes and wetland areas to provide definition of the surface/groundwater interaction. The following data collection plans are designed to supply that supplemental data that can reasonably be generated at this time. (In the water quality data collection part of this section a number of wells are proposed for background water quality monitoring in the shallow aquifer. These same wells could be used for obtaining water level data in the shallow aquifer.)

A. Hansville-Indianola Subarea

A water level monitoring program for each of the five designated aquifers should be developed and implemented as soon as possible, with at least one dedicated monitor well in the Hansville, Poulsbo and Port Gamble

South aquifers and two in the Kingston and Suquamish-Miller Bay aquifers. A suggested monitor well location for the Hansville aquifer is T28N R02E Sec 28G. Several test wells are known to exist in the Hansville aquifer which may qualify as monitoring sites, such as well 22N01. The first effort in this area should be to determine the status of these wells and select the most appropriate as a monitoring site. In the Port Gamble South aquifer, Well 28C02, known as the old Wolfe Elementary School Well, is recommended as a possible monitoring site. Two areas are recommended in the Kingston aquifer, one in T27N R02E Sec 25 (Well 25E03) and a second in T27N R02E Sec 35 (Well 35K01). The Suquamish-Miller Bay aquifer should be monitored in T26N R02E Sec 9 and T26N R02E Sec 20, suggested specific wells within this area are 20L01 and 09H01. A new well in T26N R02E Sec 13G is suggested for the Poulsbo aquifer. Monitoring wells should be set up such that the water levels are measured at least on a monthly basis. The data should be verified and placed in the database every 6 months.

The principal resource management need for the Hansville aquifer is for the identification of an innovative method of efficiently extracting the water from the aquifer. This may be through a periphery collection system, by numerous low-yield wells within the aquifer, or by a method as yet not considered. Monitoring of fluctuation of water levels in this aquifer is critical to proper management of its production and to the recognition of the point where production limits of the aquifer are reached.

Recent drilling efforts in the Port Gamble South aquifer at the Wolfe Elementary School have demonstrated the limits of the aquifer to the southeast. Due to the limited number of successful wells in this unit (4), the principal need here is for additional test drilling to define the lateral extent of the aquifer and to establish better understanding of aquifer parameters. A site between Wolfe School and the PUD well at Gamblewood, probably within T27N R02E Sec 21N, is recommended for test drilling to a level of about 200 feet below sea level. Additional options for deep exploration should also be considered. Following completion of this well a second similar test well should be considered in T27N R02E, in the east half of Section 19 or along the western edge of Section 20.

The Kingston aquifer could possibly have a greater potential pumping capacity with its existing wells than the aquifer can supply. Prior to installing more production wells a thorough monitoring system should be installed to evaluate both the shallow and deep systems. Suggested monitoring well locations are T27N R02E Sec 25 (Well 25E03) and T27N R02E Sec 35 (Well 35K01). Should the monitoring data show that the capacity of the aquifer has not been exceeded then deep exploration to evaluate the southwestern extension of the aquifer (T26N R02E Sec 2J) should be considered.

The Suquamish-Miller Bay aquifer contains several potentially high yielding wells which have been completed at varying depths. One of the major users at this time is the Suquamish Tribal Hatchery, who may possess the paramount right to the water. The PUD has drilled several test wells in the area which showed good potential. One of these wells should be dedicated as a permanent water level monitoring site, i.e., Well 09H01. At least one other well on the east side of Miller Bay should also be dedicated to long term water level monitoring for this portion of the aquifer (Well 20L01).

The Poulsbo aquifer is identified by several good wells completed in a stratigraphic horizon between 175 feet above sea level down to sea level. This aquifer should have a dedicated monitor well placed in T26N R01E Sec 13G. Should expansion of the production from this aquifer be desired, it is suggested that the test drilling pattern be designed to evaluate the lateral extent of the shallow system and to provide stratigraphic information of any deeper systems. No information is available regarding the possible presence of deep aquifers beneath the Poulsbo aquifer. However, the area appears promising for deep well sources, principally because of its relative distance from deep salt water bodies.

Areas of exploration for new water sources are somewhat limited in the Hansville-Indianola Subarea, due to the close proximity of Puget Sound on three sides, the related possibilities of sea water intrusion and because of the limited recharge area available on the upper peninsula. Deep test wells may be justified to evaluate the local stratigraphy in T27N R02E Sec 9G, T26N R02E Sec 6J, T27N R02E Sec 18L and T26N R02E Sec 3F. A summary of the recommended monitoring and exploration locations for the Hansville-Indianola Subarea can be seen in Table III-1.

B. Bainbridge Island Subarea

Bainbridge Island has recently undergone a significant amount of test drilling, which has identified several new and potentially prolific aquifer zones. At this time it appears that the subarea is more in need of aquifer evaluation than identification of additional aquifers. A water level monitoring program for five of the six designated aquifers should be developed and implemented as soon as possible with at least one dedicated monitoring well for each aquifer. The Gilberton-Fletcher aquifer contains the PUD's Fletcher Bay Well (Well No. 20K01), which presently is being regularly monitored.

The Meadowmere aquifer is heavily utilized in the local area and as such is in serious need of a dedicated monitoring well, probably located at some distance from the present pumping centers, possibly in T25N R02E Sec 9Q. This would more accurately reflect the regional water level response of the aquifer. In addition to water level monitoring the amount of water pumped by the current users needs to be measured, reported and evaluated in light of the water level record from the monitored wells.

The impending production from the Wardwell aquifer by the City of Winslow at the recently completed Sands Road Well (Well No. 22J02) makes the monitoring of that well and the PUD's Wardwell Road well (Well No. 15J01) critical. The long-term production capacity of this aquifer is unknown. Assessment of the information collected over the next few years will provide insight into the ultimate production capacity of this system.

The Bayhead aquifer, which represents the primary source of water for the City of Winslow, appears to have somewhat more capability than is presently being pumped. A water level and total pumpage monitoring program should be developed to establish base line data for this aquifer. Well 27E03 could be dedicated to monitor these conditions. It may be found that additional yield can be obtained from the City of Winslow's existing well field through a designed program of efficient operation of existing wells. Further drilling is not advised at this time due to the limited area available for additional well sites.

For the Creosote aquifer, the planned monitoring program at the Port Blakely Well No. 1 (Well No. 35G01) should provide much needed data on the aquifer characteristics. No additional yield should be planned until the evaluation of the monitoring data assures that increased production is feasible. New production will likely be developed within the presently identified boundaries, due to the geographic limits to the north and east (Eagle Harbor and Puget Sound) and the known bedrock high to the south.

There is some evidence that the Lynwood aquifer can yield more water than is presently being produced. This may be possible by placement of optimally spaced wells. Test drilling would be required to provide several observation wells and to better define the local aquifer geometry and other aquifer characteristics. Several shallow test wells in T24N R02E Sec 4B and T25N R02E Sec 33L would allow a proper definition of the hydrogeology and provide an appropriate water level monitoring network. The cost effectiveness of maximizing production of the aquifer should be considered.

Exploration for new aquifers should be contemplated in the northern portion of the island where there is a paucity of data, especially regarding the deeper systems. The first deep test well should be contemplated in T25N

R02E Sec 10A. A summary of the recommended monitoring and exploration locations for Bainbridge Island can be seen in Table III-2.

C. Poulsbo-Bremerton Subarea

This subarea contains the greatest number of aquifers identified in the study and also possesses the greatest number of major producing wells. A water level monitoring program for each of the principal aquifers in the subarea should be developed and implemented as soon as possible. It is suggested that at least one dedicated monitoring well be placed in the Edgewater, Keyport and Island Lake aquifers. Multiple monitoring wells should be set up in the Bangor, Silverdale, Bucklin Hill, Gilberton-Fletcher, and Manette-Bremerton North aquifers.

The Edgewater aquifer, which contains two production zones, requires testing and water level monitoring in order to clarify aquifer response to pumping and to evaluate the production capacity of the system. An existing well (27F02) could be set up to provide aquifer characteristics, as an observation well for production well testing, and to monitor regional water levels. Unless this information demonstrates that the aquifer cannot support additional expansion, test wells should be drilled to the south in T27N R01E Sec 34R and 35Q.

The aquifer characteristics of the Keyport aquifer have been fairly well defined by the five deep wells on the U.S. Navy torpedo station. Reportedly these wells produced about 600 gpm on a nearly continuous basis from two of the five wells for cooling water. The long-term withdrawal effectively demonstrates that a major water supply exists within this aquifer.

The PUD presently has a possible monitoring well at their Keyport No. 2 site (Well No. 36M01). Records from that well, combined with pumping use in the area, may demonstrate that additional production is possible from this aquifer. Should the assessment of this data demonstrate the possibility of expanding production from the aquifer, deep test drilling should be contemplated along Liberty Bay to the northwest and southeast and may be possible across the bay near Lamolo. Test drilling sites would depend primarily on property availability but may be suggested in T26N R01E Sec 27P, T26N R01E Sec 01E, and T26N R01E Sec 30R.

The Bangor aquifer is a major system which, except for Vineland, is essentially confined to Navy property and almost exclusively used by the Subbase Bangor facility. Historical records, including records prior to extensive pumping in this area are very good for this aquifer. Evaluation and monitoring of this aquifer was performed by Robinson & Noble, Inc. over a 7-year period, from 1975 to 1982, while the base was being constructed. Later records of water use and water levels need to be assessed. Major surpluses of water beyond the Navy's requirements may be available from this aquifer. Estimated natural subsurface flow for the aquifer system is at least 2,000 gpm. During dry-dock construction, a withdrawal of 3,500 gpm induced moderate saltwater intrusion. Development of these sources would most likely require access to Navy property. Refinement of the aquifer characteristics could be accomplished by developing a dedicated monitoring program for Wells 31B02 and 19P01.

The Island Lake aquifer is defined by three major Silverdale Water District wells with a potential pumping capacity of over 2000 gpm. The base of the aquifer is above sea level and the aquifer may have continuity to the north. The principal data need for this aquifer is a thorough monitoring program which documents pumping and non-pumping water levels and production rates for each well. By 1988 the aquifer was undergoing its first major stress. A dedicated monitoring well located near the center of the area in T25N R01E Sec 03G would be useful. Such a well would measure general aquifer water level response and be less influenced by a pumping well in close proximity. If this monitoring program does not demonstrate that the aquifer capacity has been reached the expansion of production may be reasonable. Any expansion of production should be from within the defined aquifer boundaries or very near the east and west edges of the delineated area.

A secure staff gauge should be set in Island Lake to measure water level changes. The lake may be hydraulically connected to the Island Lake aquifer system.

The Silverdale aquifer is found between sea level and 250 feet below sea level. This aquifer served all of Silverdale's needs for more than 30 years until the Island Lake wells came on line. Although no aquifer depletion is evident at the present time, dedicated monitoring wells should be set up in wells 16J01 and 20C01.

A new well is presently planned to be drilled at T25N, R01E, Sec 19P to test for a western extension of the Silverdale aquifer. A redeveloped well ("Newberry Hill Interchange", Well 29D01) has shown a deep aquifer zone that had not been previously recognized. Monitoring of these new wells is important prior to increasing the production stress on the aquifer.

The Bucklin Hill aquifer system is shared by North Perry Avenue District, Bremerton and Silverdale. It is a relatively deep system which has not to date been subjected to major pumping. Monitoring of pumping and of water levels is essential to determine the response of this system to current pumping and to evaluate it's potential for increased withdrawal. Dedicated monitoring wells are suggested at the Parkwood East well (Well No. 23N02), which is reportedly unused and may be available for monitoring access, and at Silverdale's Selbo Road well (Well No. 22F03).

The Gilberton-Fletcher aquifer is represented by deep wells at Gilberton on the Manette peninsula and near Fletcher Bay on Bainbridge Island. These areas are separated by Port Orchard Bay which is a relatively shallow arm of the Puget Sound. The bottom of the Bay is appreciably higher in elevation than the aquifer. There is reason to speculate continuity between the Gilberton and Fletcher Bay Areas, with the bay perched well above the aquifer. The continuity between the two areas is implied and the aquifer configuration as presented on Exhibit II-9 probable, but not proven. An extensive amount of water level monitor information is available on the Fletcher Bay side from the PUD's Fletcher Bay Monitor Well (Well No. 20K01). These records show response to pumping and apparent aquifer pressure equilibrium during pumping. The well exhibits a high amplitude tidal fluctuation suggestive of elastic loading as opposed to an actual influx and egress of salt water from within the aquifer. Water levels remain above sea level. At Gilberton, a more sporadic set of records shows major declines in water levels due to pumping. These levels appear to be at least 50 feet below sea level which may provide a long-term potential for saltwater intrusion. A monitoring program similar to the Fletcher Bay Well is needed. A possible site for this monitoring well is near the Gilberton No. 1 Well (Well No. 19M01).

Numerous wells owned by North Perry Avenue Water District and the City of Bremerton have been producing from the Manette-Bremerton North aquifer system for many years. A thorough monitoring system must be developed to assess the results of this heavy use. Suggested new monitoring well sites are in T25N R01E Sec 35R and T24N R01E Sec 01P. Existing Well 07M02 could be converted to serve as a dedicated monitoring well. Close comparison of current levels with historic water level patterns is necessary to establish trend evaluations. Suspicions of an overdraft situation in this aquifer should be evaluated. More water may be available but should only be considered after a monitoring plan is operational and sufficient data has been generated. Expansion of this aquifer's production, if warranted, would likely come from within or very near the presently identified boundaries, due primarily to geographical constraints. A summary of the recommended monitoring and exploration locations for the Poulsbo-Bremerton subarea can be seen in Table III-3.

D. West Kitsap Subarea

This subarea contains only one defined aquifer, the Big Beef aquifer, although other major aquifers almost certainly exist. The Big Beef aquifer is likely to be among the best in Kitsap County, possibly better than the Bangor aquifer. It has been demonstrated to have high transmissivity and presumably is recharged from a large catchment area to the south including the northern slopes of Green Mountain.

The principal hydrogeologic data needs in this subarea are the definition of stratigraphic and hydrologic conditions necessary to define aquifers. This will require extensive test drilling. There is ample justification to speculate that major aquifers exist elsewhere in the subarea.

Although the Big Beef aquifer is mapped as a small area east of Seabeck where a major aquifer has been developed, the actual aquifer area may be much larger. Current use is primarily for fish propagation by the University of Washington Big Beef Station and by the nearby Lakes Trout Farm. These wells may have a combined and continuous yield of about 1,500 gpm. In that the University of Washington facility depends solely upon artesian flow and the facility has not expressed a problem with diminished flow, aquifer depletion does not appear to have occurred. This fact does not constitute a complete evaluation of trends. Some procedure for monitoring and recording water use and water level (or in the case of flowing artesian wells, the shut-in pressure) data at the facilities should be implemented at wells 14E01, 22A02, 22A03 and 22A04.

Although distant from population centers, the aquifer would be a candidate for a regional groundwater supply to be transported to more distant areas of demand within the county. If such plans were to be considered, extensive test drilling to depths of at least 300 feet below sea level would be required to determine aquifer geometry and to properly define transmissivity and storativity. Suggested locations for these test wells are in T25N R01W Sec 22N, 23P, 27H, 28Q, 33L, and 34H and T24N R01W Sec 3A, 4D, and 5D.

Other exploration targets should be developed along the Seabeck and Stavis Creek drainages possibly in T25N R01W Sec 01F, T24N R01W Sec 06M, T24N R02W Sec 01E, T24N R02W Sec 11F, T24N R02W Sec 14F, and T24N R02W Sec 30A. In addition, the well recently completed for the community of Holly (Well No. 19K01), which has one of the highest specific capacity values in the entire county, may be indicative of another major aquifer.

It is highly probable that the groundwater production potential far exceeds the demand suggested for projected future population trends for this subarea. The data collection for this area may be best oriented toward the identification of major aquifers which can be developed for future export of the resource to other sections of the County. Monitoring of the response to withdrawal at the University of Washington Big Beef facility will give some insight as to aquifer response to stress. A summary of the recommended monitoring and exploration locations for the West Kitsap subarea can be seen in Table III-4.

E. South Kitsap Subarea

The data collection needs of this subarea tend to fall into two distinct categories. These are divided rather neatly between the needs of the northern and those of the southern portions. The northern portions contain seven defined aquifers located principally along the more densely populated areas of Gorst, Port Orchard and Manchester. The southern portion presently has no defined principal aquifer units. As a result the future data collection needs of the southern portion of the subarea are quite different.

Several dedicated monitoring wells are suggested for the Gorst Creek aquifer and at least one dedicated water level monitoring well is recommended in each of the other defined aquifers.

The Clam Bay aquifer is an aquifer with a very small areal extent, yet is utilized by Manchester, the Navy, and the Wautauga Beach community. It is bounded by bedrock and by relatively impermeable glacial deposits; as such it has the geometric conditions that make aquifer overdraft likely. Water quality is variable within the aquifer particularly with respect to iron content which is very high at Wautauga Beach. Two new wells have been recently drilled by Manchester Water District. Since there are no plans to place these in service in the immediate future, one of these wells (Well 21B01) is suggested as a key well in monitoring of the aquifer.

The Yukon Harbor aquifer is presently used exclusively by Manchester Water District. Production is principally from two adjacent wells off Garfield Road. The original well (Colby), near the Yukon Harbor shoreline is in limited use. The older well (33J01) should be dedicated as a monitoring well for this relatively small aquifer system. The lateral extent of the aquifer is poorly defined by existing data. This should be rectified by a test drilling program. The first effort should consider drilling to the southwest in T24N, R02E, Sec 33P.

The Wilson Creek aquifer has recently been put to use by Manchester Water District where there are three wells in the same field. Pumping tests have indicated the presence of confining boundaries which will ultimately limit withdrawal. One of the shallower wells in the field, perhaps

Well 10G03, should be considered as a candidate for conversion to a dedicated monitoring point to record seasonal and long-term changes. Wilson Creek itself appears to have a strong baseflow which may indicate capture of groundwater from beyond its topographic basin boundary. Wilson Creek should be gauged to define seasonal variation in stream flow.

Numerous very deep wells which are completed in the Port Orchard Deep aquifer, have been used in and near Port Orchard for over 50 years. Past water level monitoring has been sporadic at best. Recent reviews of this data suggest no major declines in artesian pressure in these wells. A more systematic monitoring program is required to draw definitive conclusions. When proper monitoring is accomplished, it may be found that additional groundwater is available from this aquifer. Several unused wells exist in the area. Some of these may be available for monitoring by both the Annapolis (Well 25Q02) and Port Orchard Water Districts (Well 26K05).

The North Lake-Bremerton South aquifer actually contains three aquifer zones. The shallowest is tapped by McCormick Woods Water Co. This zone has recently been put to heavy use and has experienced subtle water level declines, which may be indicative of either aquifer depletion or recent relative drought conditions. Overflow from this shallow system ultimately feeds Anderson Creek which should be considered for stream gauging to evaluate seasonal variations in flow volumes.

Bremerton's Anderson Creek well field taps the deeper systems. The shallower of these extends to about 200 feet below sea level; the deeper extends to about 500 feet below sea level. Pumping of each has minor influence on the other, but there is considerable interference between wells within the same system. Bremerton has several old wells that could be scheduled for abandonment. Prior to this, efforts should be made to equip such wells as monitoring wells to better assess the seasonal and long-term water level changes in Wells 33L02, 33K02, and 09C02.

The shallower component of this aquifer tapped by the McCormick Woods wells may extend a considerable distance to the south and is believed to be a possible source of groundwater flow into Coulter Creek. Test drilling is recommended south of North Lake in T23N, R02E, Sec 9. In addition, stream gauging of Coulter Creek should be implemented to define water flow volumes.

The Gorst Creek valley, from near its mouth west to Twin Lakes, has been recently studied and several test wells have been drilled. Based upon this program the fairly shallow, highly transmissive Gorst Creek aquifer has been identified. To-date, there has been no major production. This aquifer system could become very important to Bremerton as a groundwater supplement to the City's surface water supply. Monitoring plans should be developed immediately to establish baseline water level conditions prior to initiation of additional production from this aquifer in Wells 31F01, 35R01 and 36R02.

The Salmonberry aquifer system, which is roughly 150 to 200 feet below sea level, is used by both Annapolis and Port Orchard Water Districts. The aquifer may be an eastern continuation of the shallower zone at Bremerton's Anderson Creek well field. The system has been in use for at least 15 years. A monitoring system should be initiated to facilitate evaluation of the aquifer response characteristics in Wells 02M03 and 01K01. The aquifer is thought be extensive to the south. Test drilling about a mile south of the Salmonberry well field in T23N, R01E, Sec 1K is advisable to delineate the southern boundary of the aquifer.

The available hydrogeologic data from the southern portion of the subarea is dominated by shallow domestic wells with occasional wells drilled to moderate depths. Future test drilling in this area should focus on definition of deeper stratigraphy and evaluation of aquifer parameters. Test wells can only be realistically considered where population growth supports the development of larger water production facilities. At the present time these areas appear to be to the south of McCormick Woods and along the State Highway 16 corridor. Deep test wells could be considered in T23N R02E Sec 32L, T22N R02E Sec 07J, T23N R02E Sec 21R, T23N R01E Sec 24G, T23N R01E Sec 35F, T22N R01E Sec 09L, T23N R 01E Sec 28M, T22N R01E Sec 06H, T23N R01W Sec 24R, and T23N R01W Sec 35G. A summary of the recommended monitoring and exploration locations for the South Kitsap subarea can be seen in Table III-5.

2. HYDROLOGIC DATA COLLECTION

A. Stream Gaging

Streamflow data is a critical element in evaluating water balance relationships within any given drainage basin. Streamflow data can also provide insight into possible hydrogeologic impacts related to groundwater development. Currently, there is only one active stream gaging station within the County. The site is located on Big Beef Creek near Seabeck. Previously however, in the 1940s and 1950s many other stations were operated within the County. Additional streamflow data should be collected throughout the County.

Criteria for selecting stream gaging sites would be as follows:

- o Locate sites in proximity to major groundwater pumping centers;
- o Locate sites where historical streamflow data are available;
- o Locate some sites within urbanized areas to evaluate effects of urbanization on runoff; and
- o Accessibility, channel geometry, and other siting factors.

See Table III-6 for potential stream gaging sites listed by subarea.

Implementation of streamflow measurements could be coordinated with the surface water data collection recommendations for Kitsap County's Basin Planning effort. These recommendations have been reported by the Kitsap County Watershed Ranking Committee.

B. Precipitation Monitoring

Precipitation information is a major component in water balance calculations. Accurate and extensive data can help to refine recharge/discharge relationships and provide a more detailed assessment of groundwater resources.

Currently, there is only one active U.S. Weather Bureau site in Kitsap County which is located in Bremerton. Precipitation rates vary widely throughout the County from as little as 20 inches/year in the Hansville area to as much as 80 inches/year in the western portion of the County. Additional precipitation data sites are needed to evaluate this wide range. The orographic influence of the Green and Gold Mountains is poorly understood. Additional data is required to evaluate the distribution of precipitation within this area.

See Table III-6 for potential precipitation monitoring sites.

C. Lakes and Wetland Habitat Gaging

Staff gaging data from lakes and wetlands can provide valuable information on potential hydraulic continuity between surface and groundwaters. Several representative lakes and wetland areas have been recommended for staff gaging data collection, and are listed by Subarea in Table III-6.

3. WATER QUALITY DATA COLLECTION

It is recommended that a water quality monitoring network be developed which acknowledges the impact of land use activities in relation to the hydrogeology of the area. The network should provide adequate background data and continuing water quality information for the aquifers in each subarea. It should incorporate existing monitoring networks where they exist. Indicator water quality parameters have been recommended based on major land use categories found in the subarea, parameters of health concern, frequency of occurrence in the groundwater, and aesthetic parameters which help to assess the hydrogeologic characteristics of the aquifer. Specifically, the parameters have been sorted to reflect potential contamination from land uses associated with urbanization, industrial/ commercial, or agricultural activities.

Specific subarea monitoring needs are listed below. These monitoring needs discuss well location, parameters to be measured and the frequency of measurement. In addition to wells located in specific aquifers, an overall network of wells representing the shallow groundwater system have been identified. Evaluation of water quality data from this shallow system will provide overall areal coverage of the County, while wells in specific aquifers will help to assess any impacts on major groundwater resources. A specific network will be prepared during Grant No. 2 activities. Where selected well locations are not yet known, it is noted that well locations are "to be identified." In most cases, the wells recommended for water quality data collection have also been slated for water level monitoring.

A. Hansville-Indianola Subarea

(1) Monitoring Locations

Specific groundwater quality monitoring locations are presented in Table III-7.

(2) Parameters

Parameters should include indicators of agricultural activity and urbanization. Specifically:

<u>Agricultural Indicators</u>

Nitrate
Ammonia
Atrazine
Dicamba
Hexazinone
Methomyl
Picloram
Conductivity, pH
EDB
Garlon
2, 4-D

<u>Urbanization Indicators</u>

Total and Fecal Coliforms
Nitrate
Chloride
Sulfate
Conductivity, pH

<u>Other</u>

Primary/Secondary Contaminants for public water supplies
Volatile Organics

(3) Frequency

Indicator parameters for urban and agricultural land uses should be taken quarterly or twice/year. Background data on volatile organic chemicals should be taken quarterly the first year then twice per year for following years. Primary and secondary drinking water contaminants from public water supplies should be incorporated into the database. These parameters are monitored according to compliance schedules.

B. Bainbridge Island Subarea

(1) Monitoring Locations

Specific monitoring locations are presented in Table III-8.

(2) Parameters

Parameters should include indicators of urban and industrial/commercial activity, as well as agricultural activity. Specifically:

Urbanization Indicators

Total and Fecal Coliforms
Nitrate
Chloride
Sulfate
Conductivity, pH

Industrial/Commercial

Conductivity
pH
Trichloroethylene
Tetrachloroethylene
1,1,1-trichloroethane
Methylene Chloride
Vinyl Chloride
Cyanide
Chromium
Cadmium
Phenols

Agricultural Indicators

Nitrate
Ammonia
Atrazine
Dicamba
Hexazinone
Methomyl
Picloram
EDB
Garlon
2, 4-D
Conductivity, pH

Other

Primary/Secondary Contaminants for public water supplies
Volatile Organics

(3) Frequency

Indicator parameters for industrial and urban land uses should be taken quarterly or twice/year. Background data on volatile organic chemicals should be taken quarterly the first year then twice per year for following years. Primary and secondary drinking water contaminants from public water supplies should be incorporated into the database. These parameters are monitored according to compliance schedules.

C. Poulsbo-Bremerton Subarea

(1) Monitoring Locations

Specific monitoring locations are presented in Table III-9.

(2) Parameters

Parameters should include indicators of urban and industrial/commercial activity, agricultural activity, and saltwater intrusion in the Gilberton-Fletcher aquifer. Specifically:

Urbanization Indicators

Total and Fecal Coliforms
Nitrate
Chloride
Sulfate
Conductivity, pH

Industrial/Commercial

Conductivity
pH
Trichloroethylene
Tetrachloroethylene
1,1,1-trichloroethane
Methylene Chloride
Vinyl Chloride
Cyanide
Chromium
Cadmium
Phenols

Agricultural Indicators

Nitrate
Ammonia
Atrazine
Dicamba
Hexazinone
Methomyl

Picloram
EDB
Garlon
2, 4-D
Conductivity, pH

<u>Saltwater Intrusion</u>

Chloride
Sodium
TDS, Conductivity

<u>Other</u>

Primary/Secondary Contaminants for public water supplies
Volatile Organics

(3) Frequency

Indicator parameters for industrial and urban land uses should be taken quarterly or twice/year. Background data on volatile organic chemicals should be taken quarterly the first year then twice per year for following years. Primary and secondary drinking water contaminants from public water supplies should be incorporated into the database. These parameters are monitored according to compliance schedules.

D. West Kitsap Subarea

(1) Monitoring Locations

Specific monitoring locations are presented in Table III-10.

(2) Parameters

Parameters should include indicators of agricultural and forestry activity. Specifically:

<u>Agricultural Indicators</u>

Nitrate
Ammonia
Atrazine
Dicamba
Hexazinone
Methomyl
Picloram

2, 4-D
EDB
Garlon
Conductivity, pH

Other

Primary/Secondary Contaminants for public water supplies
Volatile Organics

(3) Frequency

Indicator parameters for industrial and urban land uses should be taken quarterly or twice/year. Background data on volatile organic chemicals should be taken quarterly the first year then twice per year for following years. Primary and secondary drinking water contaminants from public water supplies should be incorporated into the database. These parameters are monitored according to compliance schedules.

E. South Kitsap Subarea

(1) Monitoring Locations

Specific monitoring locations are presented in Table III-11.

(2) Parameters

Parameters should include indicators of urban and industrial/commercial activity, as well as agricultural activity. Specifically:

Urbanization Indicators

Total and Fecal Coliforms
Nitrate
Chloride
Sulfate
Conductivity, pH

Industrial/Commercial

Conductivity
pH
Trichloroethylene
Tetrachloroethylene

1,1,1-trichloroethane
Methylene Chloride
Vinyl Chloride
Cyanide
Chromium
Cadmium
Phenols

Agricultural Indicators

Nitrate
Ammonia
Atrazine
Dicamba
Hexazinone
Methomyl
Picloram
EDB
Garlon
Conductivity, pH
2, 4-D

Other

Primary/Secondary Contaminants for public water supplies
Volatile Organics

(3) Frequency

Indicator parameters for industrial and urban land uses should be taken quarterly or twice/year. Background data on volatile organic chemicals should be taken quarterly the first year then twice per year for following years. Primary and secondary drinking water contaminants from public water supplies should be incorporated into the database. These parameters are monitored according the compliance schedules.

TABLE III-1

HANSVILLE-INDIANOLA SUBAREA

POTENTIAL HYDROGEOLOGIC MONITORING AND EXPLORATION LOCATIONS

STR	Well ID	Aquifer
T28N R02E S22	22N01	Hansville
T27N R02C S28	28C02	Port Gamble South
T27N R02E S25	25E03	Kingston
T27N R02E S35	35K01	Kingston
T26N R02E S09	09H01	Suquamish/Miller Bay
T26N R02E S20	20L01	Suquamish/Miller Bay
T26N R02E S13G	New Well	Poulsbo
T27N R02E S21N	New Well	Port Gamble South
T27N R02E S19E or	New Well	Port Gamble South
S20W	New Well	Port Gamble South
T26N R02E S2J	New Well	Kingston
T27N R02E S09G	New Well	
T26N R02E S06J	New Well	
T27N R02E S18L	New Well	
T26N R02E S03F	New Well	

TABLE III-2

BAINBRIDGE ISLAND SUBAREA

POTENTIAL HYDROGEOLOGIC MONITORING AND EXPLORATION LOCATIONS

STR	Well ID	Aquifer
T25N R02E	20K01	Gilberton-Fletcher
T25N R02E S09Q	New Well	Meadowmere
T25N R02E	22J02	Wardwell
T25N R02E	15J01	Wardwell
T25N R02E	27E03	Bayhead
	35G01	Creosote
T24N R02E S04B	New Well	Lynwood
T25N R02E S33L	New Well	Lynwood
T25N R02E S10A	New Well	--

TABLE III-3

POULSBO-BREMERTON SUBAREA

POTENTIAL HYDROGEOLOGIC MONITORING AND EXPLORATION LOCATIONS

STR	Well ID	Aquifer
T27N R01E	27F02	Edgewater
T27N R01E S34R	New Well	Edgewater
T27N R01E S35Q	New Well	Edgewater
T26N R01E	36M01	Keyport
T26N R01E S27P	New Well	Keyport
T26N R01E S01E	New Well	Keyport
T26N R01E S30R	New Well	Keyport
T26N R01E	31B02	Bangor
T26N R01E	19P01	
T25N R01E S03G	New Well	Island Lake
T25N R01E	16J01	Silverdale
T25N R01E	20C01	Silverdale
T25N R01E	29D01	Silverdale
T25N R01E S19P	New Well	Silverdale
T25N R01E	23N02	Bucklin Hill
T25N R01E	22F03	
T25R R02E	19M01	Gilberton-Fletcher
T25N R01E S35R	New Well	Manette-Bremerton
T24N R01E S01P	New Well	
	07M02	

TABLE III-4

WEST KITSAP SUBAREA

POTENTIAL HYDROGEOLOGIC MONITORING
AND EXPLORATION LOCATIONS

STR	Well ID	Aquifer
T25N R01W	14E01	Big Beef
T25N R01W	22A02	Big Beef
T25N R01W	22A03	Big Beef
T25N R01W	22A04	Big Beef
T25N R01W S22N	New Test Well	Big Beef
T25N R01W S23P	New Test Well	Big Beef
T25N R01W S27H	New Test Well	Big Beef
T25N R01W S28Q	New Test Well	Big Beef
T25N R01W S33L	New Test Well	Big Beef
T25N R01W S34H	New Test Well	Big Beef
T24N R01W S03A	New Test Well	Big Beef
T24N R01W S04B	New Test Well	Big Beef
T24N R01W S05D	New Test Well	Big Beef

Other Exploration Locations

T25N R01W S01F	New Test Well
T24N R01W S06M	New Test Well
T24N R02W S01E	New Test Well
T24N R02W S11F	New Test Well
T24N R02W S14F	New Test Well
T24N R02W S30A	New Test Well

TABLE III-5

SOUTH KITSAP SUBAREA

POTENTIAL HYDROGEOLOGIC MONITORING AND EXPLORATION LOCATIONS

STR	Well ID	Aquifer
T24N R02E	21B01	Clam Bay
T24N R02E	33J01	Yukon Harbor
T24N R02E S33P	New Test Well	
T23N R02E	10G03	Wilson Creek
T24N R01E	25Q02	Port Orchard-Deep
T24N R01E	26K05	
T24N R01E	33L02	N. Lake Bremerton-South
T24N R01E	33K02	N. Lake Bremerton-South
T24N R01E	09C02	N. Lake Bremerton-South
T23N R02E S09	New Test Well	N. Lake Bremerton-South
T24N R01E	31F01	Gorst Creek
T24N R01W	35R01	Gorst Creek
T24N R01W	36R02	Gorst Creek
T23N R01E	02M03	Salmonberry
T23N R01E	01K01	Salmonberry
T23N R01E S01K	New Test Well	Salmonberry

Other Exploratory Deep Test Wells

T23N R02E S32L
T23N R02E S07J
T23N R02E S21R
T23N R01E S24G
T23N R01E S35F
T23N R01E S09L
T23N R01E S28M
T22N R01E S06H
T23N R01W S24R
T23N R01W S35G

Table III-6 Potential Stream, Precipitation, and Lake Gaging Sites
Kitsap County

SUBAREA	STREAM GAGING SITES	PRECIPITATION GAGING SITES	LAKE GAGING SITES
Hansville-Indianola	Gamble Creek Grovers Creek	Hansville	Miller Lake
Bainbridge Island	Unknown Stream Tributary to Manzanita Bay Unknown Stream Tributary to Fletcher Bay	Winslow	
Poulsbo-Bremerton	Dogfish Creek Clear Creek Steel Creek Barker Creek Steel Creek Chico Creek	Bremerton (exist.) Poulsbo Bangor	Island Lake Kitsap Lake
West Kitsap	Big Beef Creek (exist.) DeWatto Creek	Union River Reservoir/ Gold Mountain Area DeWatto	
South Kitsap	Gorst Creek Blackjack Creek Burley Creek Salmonberry Creek Anderson Creek Wilson Creek Coulter Creek	Burley	Long Lake

TABLE III-7

HANSVILLE-INDIANOLA SUBAREA

GROUNDWATER QUALITY MONITORING LOCATIONS

STR	Well ID	Aquifer
T28N R02E S33	33A01	Shallow System
T28N R02E S21	21C02	Shallow System
T28N R02E S28G	New Well	Hansville
T28N R02E S22	22N01	Hansville
T27N R02E S28	28C02	Port Gamble South
T27N R02E S25	25E03	Kingston
T27N R02E S03	03A01	Shallow System
T27N R02E S14	14L01	Shallow System
T27N R02E S16	16Q01	Shallow System
T27N R02E S07	07A01	Shallow System
T27N R02E S27	27N01	Shallow System
T27N R02E S36	36N01	Shallow System
T26N R02E S09	09H01	Suquamish/Miller Bay
T26N R02E S29	29M02	Shallow System
T26N R02E S12	12P01	Shallow System
T26N R02E S13G	New Well	Poulsbo
Additional Wells in the Hansville Aquifer	To Be Identified	Hansville
Additional Wells in the Poulsbo Aquifer	To Be Identified	Poulsbo

TABLE III-8

BAINBRIDGE ISLAND SUBAREA

GROUNDWATER QUALITY MONITORING LOCATIONS

STR	Well ID	Aquifer
T24N R02E S11	11G02	Shallow System
T24N R02E S04B	New Well	Lynwood
T25N R02E S33L	New Well	Lynwood
T25N R02E S09Q	New Well	Meadowmere
T25N R02E S28	28O05	Shallow System
T25N R02E S29	29J01	Shallow System
T25N R02E S17	17L01	Shallow System
T25N R02E S09	09H02	Shallow System
T26N R02E S34	34P04	Shallow System
T26N R02E S33	33G01	Shallow System
	22J02	Wardwell
	20K01	Gilberton-Fletcher
T25N R02E S03	27E03	Bayhead
T25N R02E S35	35G01	Creasote
Additional Wells in the Lynwood Aquifer	To Be Identified	Lynwood
Additional Wells in the Meadowmere Aquifer	To Be Identified	Meadowmere
Wycoff Facility	To Be Identified	--
Eagle Harbor	To Be Identified	--
Monitoring Wells	To Be Identified	--

TABLE III-9

POULSBO-BREMERTON SUBAREA

GROUNDWATER QUALITY MONITORING LOCATIONS

STR	Well ID	Aquifer
T24N R01F S31	31G01	Shallow System
T24N R01E S06	06K01	Shallow System
T25N R01E S12	12C01	Shallow System
T25N R01E S11	11N01	Shallow System
T25N R01E S25	25J01	Shallow System
T25N R01E S03G	New Well	Island Lake
T25N R01W S01	01A01	Shallow System
T26N R01E S17	17K02	Shallow System
T26N R01E S21	21R01	Shallow System
T26N R01E S09	09R01	Shallow System
T27N R01E S27	27J01	Shallow System
T27N R01E S27	27F02	Edgewater
	36M01	Keyport
T26N R01E S31	31B02	Bangor
T26N R01E S19	19P01	Bangor
T25N R01E S16	16J01	Silverdale
T25N R01E S20	20C01	Silverdale
T25N R01E S23	23N02	Bucklin Hill
	29K01	Gilberton-Fletcher
T24N R02E S07	07M02	Manette-Bremerton
Bangor Sub-base Monitoring Wells	To Be Identified	--
Additional Wells in the Silverdale Area	To Be Identified	--

TABLE III-10

WEST KITSAP SUBAREA

GROUNDWATER QUALITY MONITORING LOCATIONS

STR	Well ID	Aquifer
T24N R01W S11	11C01	Shallow System
T24N R01W S05	05P02	Shallow System
T24N R01W S31	31P01	Shallow System
T24N R02W S24	24A01	Shallow System
T24N R02W S23	23F01	Shallow System
T24N R02W S10	10B01	Shallow System
T25N R01W S23	23H01	Shallow System
T25N R01W S26	26E01	Shallow System
T25N R01W S31	31A01	Shallow System
T25N R01W S33	33F01	Shallow System
T25N R01W S14	14E01	Big Beef
T25N R01W S22	22A02	Big Beef
T25N R01W S22	22A03	Big Beef
T25N R01W S22	22A04	Big Beef

TABLE III-11

SOUTH KITSAP SUBAREA

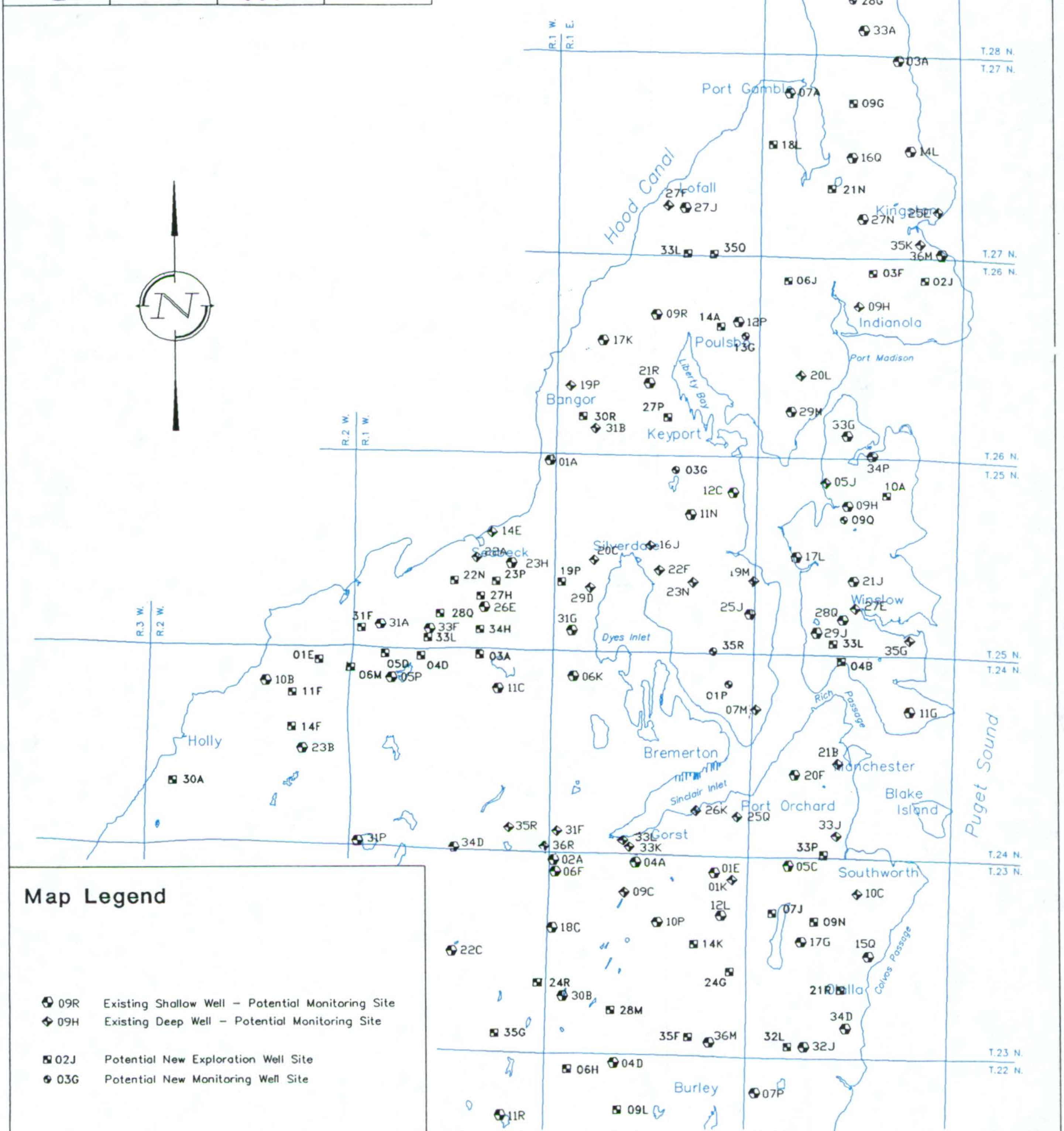
GROUNDWATER QUALITY MONITORING LOCATIONS

STR	Well ID	Aquifer
T22N R01E S04	04O01	Shallow System
T22N R01W S11	11R01	Shallow System
T22N R02E S07	07P01	Shallow System
T23N R01E S10	10P01	Shallow System
S30	30B01	Shallow System
S18	18C01	Shallow System
S06	06F01	Shallow System
S04	04A01	Shallow System
S01	01E01	Shallow System
S12	12L02	Shallow System
S36	36M01	Shallow System
T23N R01W S22	22C01	Shallow System
T23N R01W S02	02A01	Shallow System
T23N R02E S15	15Q01	Shallow System
T23N R02E S32	32J01	Shallow System
T23N R02E S17	17G01	Shallow System
T23N R02E S34	34D01	Shallow System
T24N R01W S34	34O01	Shallow System
T24N R02E S05	05C01	Shallow System
T24N R02E S20	20F02	Shallow System
T24N R02E S21	21B01	Clam Bay
T24N R02E S33	33J01	Yukon Harbor
T23N R02E S10	10G03	Wilson Creek
T24N R01E S26	26K05	Port Orchard-Deep

TABLE III-11 continued

STR	Well ID	Aquifer
T23N R01E S9	09C02	N. Lake Bremerton-South
T23N R02E S9	New Well	N. Lake Bremerton-South
T24N R01E S31	31F01	Gorst Creek
T23N R01E S02	02M03	Salmonberry
Strandley Scrap Metal Site - Monitoring Wells	To Be Identified	--

Kitsap County
Ground Water Management Plan



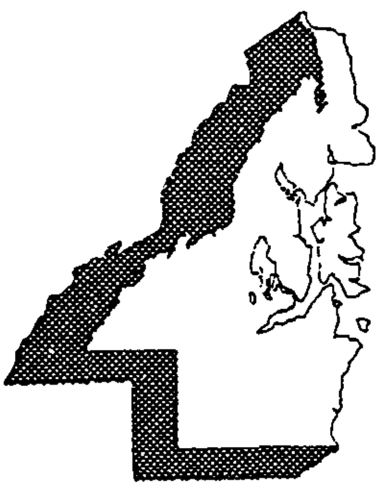
Map Legend

- 09R Existing Shallow Well – Potential Monitoring Site
- 09H Existing Deep Well – Potential Monitoring Site
- 02J Potential New Exploration Well Site
- 03G Potential New Monitoring Well Site

Scale in Miles
0 1 2 4

EXHIBIT III-1
Location of Potential Monitoring Sites

SECTION IV



SECTION IV

GROUND WATER RESOURCE MANAGEMENT

1. STATE FEDERAL AND LOCAL RESOURCE ORGANIZATIONS

There are numerous agencies at the local, State, and federal level which operate programs with the potential to effect groundwater quality and quantity. A listing of these agencies, with a description of their jurisdictions and programs can be found in Table IV-1 through Table IV-3. On the local level, these jurisdictions are divided mainly among Kitsap County, municipalities, and local utility, water, and sewer districts. The primary state agencies with programs affecting groundwater are the Department of Ecology (Ecology) and the Department of Health (DOH). The Departments of Agriculture, Natural Resources (DNR), Fisheries, and Wildlife play supporting roles in protecting groundwater quality. On a Federal level, the U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), and the Department of Agriculture (WSDA) are the key agencies in groundwater protection. These agencies support a wide variety of programs which deal with groundwater quality and quantity. A summary of their jurisdictional areas can be seen in Exhibit IV-1.

A. Local Agencies

A summary of local agencies can be found in Table IV-1 and a matrix of responsibilities at the local level for various land use activities which could potentially affect groundwater is summarized in Table IV-4. Table IV-5 contains a summary of these groundwater management responsibilities. There are several departments within Kitsap County which provide primary and secondary support of groundwater related programs.

(1) Bremerton/Kitsap County Health Department

The Bremerton/Kitsap County Health Department (BKCHD) is responsible for Class 3 and 4 drinking water supplies and serves as an advisory agency for larger public water supply wells. The BKCHD is also involved in assessing health impacts of landfills by conducting ground and surface water quality monitoring to determine potential contamination from leachate, permitting of on-site sewage disposal facilities, design approval of liquid waste facilities (lagoons and holding ponds), and small quantity hazardous waste management. In general, the BKCHD provides technical support and assessment on issues pertaining to public health. Jurisdictional boundaries include all of Kitsap County.

(2) Kitsap County Department of Community Development

Numerous programs within the Kitsap County Department of Community Development (DCD) support and/or directly implement protection of groundwater resources. They develop land use plans throughout unincorporated Kitsap County, implement the various subarea plans, and create and classify land use and zoning categories. Commercial and residential building permits are issued, the State Environmental Policy Act (SEPA) enforced, and sensitive area reviews are initiated. The DCD is also involved in water and sewer utility planning and watershed and basin planning for control of non-point pollution sources.

(3) Kitsap County Department of Public Works

Kitsap County Department of Public Works (KCPW) is responsible for control of stormwater runoff and enforcement of drainage regulations and operation and maintenance of sewerage facilities throughout the County. In addition, they control herbicide and pesticide application on County roads and rights-of-way and operate and maintain county landfills.

(4) Other Kitsap County Agencies

The Kitsap County Soil Conservation District is charged with promoting and implementing local conservation programs. They play a lead role in agricultural and soil erosion measures to minimize adverse water quality impacts. Kitsap County Fire District's primary responsibility is fire protection. However, they do contain local hazardous materials response units which respond to hazardous materials spills.

(5) Municipalities

Incorporated cities within the Kitsap County Ground Water Management Plan (GWMP) boundary include Bremerton, Poulsbo, Port Orchard, and Winslow. They provide land use planning, implement their respective zoning regulations within city boundaries, and in some cases provide water and sewer service. Municipalities also have the authority to issue construction permits and initiate planning and policy related to surface and groundwater quality concerns within their boundaries.

(6) Districts

The water and sewer districts located within Kitsap County, and their jurisdictional boundaries, can be seen in Exhibit IV-1. The water districts provide potable water to customers within their jurisdiction. They are primarily responsible for groundwater development, protection of source waters, and must insure that the supply meets current state and federal drinking water regulations. They are also involved in maintaining records on status of supply, i.e. water level and pumpage, and control use of herbicides or pesticides on their property. The sewer districts provide collection and in some cases treatment of sewage within their service area boundaries

B. State Agencies

The primary state agencies involved in groundwater management are DOH and Ecology. The WSDA, DNR, and the Puget Sound Water Quality Authority provide secondary and supporting roles. A summary of state agencies which have programs connected to groundwater management can be found in Table IV-2. A matrix of responsibilities at the state level for various land use activities which could potentially affect groundwater is summarized in Table IV-6.

The DOH regulates drinking water quality, conducts water system plan reviews, and approves well site applications. They are also charged with investigation of public health concerns related to drinking water contaminants and provide support to local health agencies in public health matters. They review alternative on-site system applications and provide technical information on on-site septic systems' design and installation. Ecology is directly responsible for developing groundwater quality standards and implementation of state activities regarding groundwater quality and resources, including water rights. Ecology programs which secondarily impact groundwater resources include the solid and hazardous waste program, underground storage tank program, and point and nonpoint source pollution programs. The WSDA issues permits for pesticide application on agricultural lands and also provides technical expertise in the area of pesticide contamination of groundwaters. The WSDA has entered into an agreement with DOH and Ecology. This agreement states that the WSDA will provide information on pesticide practices, identify problem groundwater areas, and investigate complaints of well contamination in agricultural areas. DNR manages state lands and maintains programs controlling surface mining activities, chemical vegetation control, and regulates state forest practices. The Washington Department of Transportation (WSDOT) provides technical assistance on water quantity and quality issues pertaining to stormwater runoff from highways. WSDOT also controls use of pesticides and herbicides on State roads and rights-of-way. The Puget Sound Water Quality Authority has developed and is implementing a comprehensive management plan for Puget Sound and its related waterways. This involves control and management of both point and non-point sources of pollution.

C. Federal Agencies

The EPA and USGS are the primary federal agencies responsible for groundwater management. A summary of federal agencies can be found in Table IV-3. A matrix of responsibilities at the federal level for various land use activities which could potentially affect groundwater is summarized in Table IV-7.

The EPA provides technical assistance to the State in the areas of groundwater quality and distributes federal funds for groundwater programs. They oversee the Safe Drinking Water and Clean Water Acts and their Office of Groundwater contains both a wellhead protection program and sole source aquifer program. They are also involved in review and approval of groundwater quality standards, underground storage tank programs, and hazardous waste and superfund activities.

The USGS provides technical information on groundwater resources, aquifer depletion, seawater intrusion, and groundwater quality data.

The Corps of Engineers is responsible for activities on or near shore lines of all navigable waters and wetlands. They permit construction activity and disposal of dredged materials in these areas. The U.S. Department of Agriculture provides technical information on non-point source pollution from agricultural activity and the Agriculture/Stabilization and Soil Conservation agency administers federal funds for agricultural projects, i.e. waste storage facilities and erosion control.

In addition, the Suquamish and Klallam Indian tribes have jurisdiction over activities on the Port Gamble and Port Madison Indian Reservations and had actively participated in the Groundwater Advisory Committee for Kitsap County. The locations of the reservations are shown on Exhibit IV-1. The Tribes have conducted reservation-wide groundwater studies, conducted streamflow measurements, and monitored specific wells within their jurisdiction.

2. EXISTING RESOURCE MANAGEMENT CONCERNS

The Ground Water Advisory Committee (GWAC) and its Technical Subcommittee worked with the Consultants in a joint review of the technical issues discussed in Section II of this report. Based on this information, potential problems and concerns of existing groundwater management practices currently affecting Kitsap County were identified. Some of these concerns relate to technical, institutional, and financial issues.

Paragraph 1 of this Section summarized the existing groundwater management programs and responsibilities of various local, State, and federal entities/ agencies. In general, these programs are being diligently pursued although there occasionally is some overlapping or uncoordinated effort. During the review of these responsibilities with the GWAC, several categories of concern were identified that bear further evaluation. The complexities of many of the issues listed below suggest that political, institutional, technical, and financial solutions are not easily, nor readily, attainable. Much of Grant No. 2 activities will be devoted to further evaluation of these issues.

The major categories of concern regarding improved groundwater management activities are summarized below:

A. Data Limitations

The collection of technical information used in preparation of the GWMP revealed several shortfalls in the sufficiency of data needed to accurately establish aquifer characteristics and water quality. Specifically, existing records available through County agencies, major purveyors, and other private water well owners revealed a lack of historical information necessary to accurately determine trends for several important items including water levels, pumpage, stream gaging, and water quality. Part of this problem stems from the lack of wells desired to monitor the aquifer found at various geographic locations and depths throughout the area. As a result, the GWMP Grant No. 1 activities had partial success in determining levels of background information.

Therefore, it is recommended that a comprehensive data collection strategy and network of specific groundwater wells be established. Section III provides a recommended monitoring network. The network eventually implemented should also be structured to collect data useful for future groundwater modeling efforts throughout Kitsap County. Notwithstanding the need to obtain financing for the startup and maintenance of the activities, implementation of this program must be accomplished at the local level. However, State and federal agency support is critical to ensuring that uniform and consistent procedures and reporting formats are created and interpreted.

B. Data Management Responsibilities

With improved levels of water resource information comes a complex problem of reporting, recording, and managing this information. This responsibility is one that has been shared primarily by federal and State agencies. Their priorities and focus are, therefore, logically at a larger scale.

A computerized database and database management system were developed as part of GWMP Grant No. 1 efforts. The database management system was designed to accommodate well construction, water level, geologic, owner, and water quality data that is commonly collected from wells during installation or subsequent sampling. The system in its present form provides a useful tool for long-term groundwater management. However, the database will need to be maintained over time and its data handling capabilities expanded.

A long-term program for data gathering, reporting, and processing needs to be established. The Public Utility District No. 1 of Kitsap County (District) has the responsibility for water resource management throughout the County. As such, the District is assuming responsibility for data management and AutoCAD support activities at the local level to facilitate the orderly accumulation and management of accurate data. The District is pursuing the establishment of computerized data centers with utilities and agencies within the County. This approach will be pursued during Grant No. 2 and may lead to the placement of computers with entities who will routinely report data useful to the monitoring program.

Other agency responsibilities need to be identified, including who will be responsible for data collection and verification. In addition, data exchange protocols need to be established so that all agencies responsible for groundwater management have adequate access to the information gathered.

The computerized database management system should be expanded in the following areas:

- Integrated with Kitsap County databases through the Assessor parcel numbering system.
- Develop procedures for processing water use information.
- Expand the data reporting capability to provide better access to the data that is stored in the system.
- Develop procedures to facilitate linkage between water quality data stored within PCSTORET with the physical data contained within the database management system.

- o Develop procedures for storing and manipulating streamflow and precipitation data.

C. Improved Inter-agency Coordination

In spite of the fact that this Section has identified several agencies taking active roles in groundwater management activities, there is still a lack of several important areas of coordinated responsibilities. Some major issues addressed by the GWAC are as follows:

(1) Uniform Well Identification Numbering System (UWIN).

Presently, there is a lack of correlation between well site location information and specific wells. This problem applies to wells drilled within Kitsap County and throughout the State. It is currently impossible to correlate a variety of important reporting forms related to water well logs, water quality results, etc. This inadequacy also limits the effectiveness of a database system that is linked to digitized computer mapping.

One proposed solution is to tag the well casing within a UWIN. Implementation of a UWIN system would require interagency cooperation at the state and federal level in adopting a new well numbering standard, as well as a commitment by local government to provide enforcement of the program. If possible, UWIN should be tagged to all the existing wells through a prioritized schedule that may be tied to a condition of property sales, etc.

Examples of effective programs being conducted in the States of Kansas, Wisconsin, and Minnesota, lend support to the recommendation that a UWIN program be instituted in this locality and throughout the State of Washington. It is an issue that has been jointly evaluated by other groundwater management areas throughout the State. No doubt, such an effort will require State legislative support and funding.

(2) Abandoned Wells

The issue regarding abandoned wells is one of significant concern. The magnitude of the problem within Kitsap County is not well-defined. Discussions with representatives from State and County agencies, GWAC members, and public and private purveyors indicate that the existence of unabandoned wells is prolific throughout this and other areas of the State. One estimate cited over 250,000 unused but unabandoned wells within the State. Improperly abandoned or unabandoned wells provide an open conduit for surface contaminants to pollute groundwater aquifers. Current legislation within the State provides procedures on how to properly abandon wells, but does not require the mandatory abandonment of wells without documented evidence of health impacts.

State programs in Kansas and elsewhere have been reviewed. The effectiveness of these programs hinges on local enforcement. However, program funding is provided by state property tax monies or other sources. These funds pay for abandonment costs of the well owner. Some states have opted to provide monies under a "sunset" clause to well owners. Those who abandon their wells prior to a specified deadline are compensated by the state. After the deadline, well owners may be penalized and are individually responsible for the abandonment costs.

Specific statutes regarding proper abandonment, procedures, liability, and funding are needed at the state level to uniformly address this issue. It is recommended the GWAC work with other committees throughout the State in educating the public as to the magnitude of this problem, and building support throughout special interest groups and State legislators to correct this inadequacy.

D. Water Rights

The review of existing water rights within Kitsap County revealed that water rights have been issued to well owners for facilities that may not be still actively operating. The problems associated with this are significant. The implication is that over appropriation of water rights will skew knowledge regarding the utilization and availability of groundwater supplies needed to meet the future needs of all users. Water right conflicts may be further complicated by minimum instream flow requirements proposed for surface waters on the Olympic Peninsula which are included in potential conjunctive use supply programs for the County. Conjunctive groundwater/surface water supplies are already relied upon through the 15 MGD of current surface supply from the City of Bremerton's Casad Dam. Ecology has procedures for the relinquishment of unused water rights. The review and relinquishment of unused rights needs to be enforced by Ecology and locally supported.

E. Aquifer Overdrafts and Limitations of New Wells

A major issue requiring attention in the near future relates to the necessity for placing limits on overdevelopment of aquifers. The study has concluded that aquifers within the Gilberton, Manette, and Bayhead areas may be approaching their supply limits. The implication of aquifer overdrafts has a corresponding impact upon surface waters and wetlands. Whereas, this does not currently appear to be a regional problem, the absence of more detailed information may yield different conclusions once more fully evaluated. It will be important to establish what is an acceptable limit of aquifer drawdown and during what conditions should overdrafting occur, if at all. Decisions need to be rendered regarding acceptability of aquifer overdrafts for peaking purposes, or extreme droughts, as opposed to sustained and continuous water level drawdowns.

F. Conjunctive Use/Artificial Recharge

Demand forecasts prepared by the GWMP indicate that groundwater supplies may be sufficient to meet future requirements of Kitsap County if large quantities of groundwater can be developed in the West and South Kitsap areas. If these supplies are not available, a conjunctive supply program will be needed to effectively meet future supply requirements.

The District and City of Bremerton have filed water right applications on the Olympic Peninsula's Duckabush and Hamma Hamma Rivers, respectively, for 100 cfs (65.6 MGD), with Bremerton having another 10,000 acre feet for storage on Jefferson Creek. Minimum instream flow regulations previously proposed by Ecology in WAC 173-516, Instream Resources Protection Program - Skokomish-Dosewallips Water Resource Inventory Area (WRIA 16), would eliminate the ability for either the District or the City to utilize these water rights. The domestic supply capacity from the Hamma Hamma River has been estimated to be approximately 70 MGD for average flows of 100 MGD for peaking purposes. Capacity estimates for a similar facility constructed on the Duckabush River are approximately 65 MGD.

Aiding in the conjunctive use strategy is the possibility of artificial recharge. Artificial recharge would be accomplished by injecting surface water supplies into groundwater aquifer systems during winter months when surplus stream flows exist. Stored waters could be withdrawn during peak demand periods to meet short-term instantaneous requirements. These instantaneous requirements generally occur in summer months when surface supplies are at their minimum. Whereas the combined conjunctive use/artificial recharge concept appears to pose benefits to both instream and out-of-stream users it poses several significant questions regarding technical and administrative issues.

The hydrostratigraphy and groundwater geology of a selected artificial recharge site must provide the proper qualities to allow the injection, storage, and withdrawal of water in an efficient manner. Grant No. 1

activities of the GWMP did not establish sufficient information to recommend specific artificial recharge sites. However, site-specific investigations are required before the suitability of any site is established.

The co-mingled condition of surface and groundwaters also presents potential water right questions regarding point of withdrawal and point of use disputes. In addition to the quantitative issues, qualitative issues must be addressed regarding the co-mingled water chemistry of surface and groundwaters. Aggravated iron and manganese concerns, oxygen content, organic concentrations, pH adjustments, and several other chemical parameters of interest need to be specifically evaluated at each site. Further detailed studies are required in order to fully analyze artificial recharge as a viable supply option.

G. Public Education/Awareness

The lack of attendance at GWMP public workshops, as well as other public meetings for regional resource activities in Kitsap County emphasize a lack of information or interest by the public on water resource issues. Recent drought conditions in 1977 did help to draw attention to this matter. However, the lack of severe contamination or resource limitations make it difficult to obtain active participation by wide-spread groups of citizens in a preventive program.

The GWAC feels that education and public awareness is vital for several obvious factors, including support for proper funding and administrative controls, where needed, to protect aquifer recharge. Intensive programs in conservation, stormwater management, land use controls, household waste management, and other examples of resource protection will require support by local citizens, as well as legislative and economic incentives to see that implementation occurs. Financially, an educated and supportive populace is critical in developing and maintaining proper levels of funding at the local, State, and federal level to implement and maintain water resource protection and management programs.

3. <u>RESOURCE MANAGEMENT ISSUES AND STRATEGIES</u>

During Grant No. 1, the GWAC obtained additional citizen input regarding resource management issues at a Groundwater Fair and at GWAC Committee meetings conducted throughout the County. This input has been used to prepare a list of issues shown in Table IV-8 which supplements the items discussed in paragraph 2. The Policy Subcommittee has met once to review the citizen input. The list is dynamic and subject to further modification by the GWAC. Eventually, policies will be developed, adopted, and certified by the GWAC during

Grant No. 2 activities. The intent of these policies will be to provide procedures and guidelines for local, County, and State agencies regarding groundwater resource management programs.

The County has authority, under SEPA (Chapter 43.20C RCW) and the Planning Enabling Act (Chapter 36.70 RCW), to control development so as to protect groundwater. However, conditioning or denial of permits must be based on specific adverse impacts. Furthermore, reasonable mitigation measures must be set forth, or, if no mitigation exists, reasons why impacts are unavoidable must be stated.

In general, the data collected from the GWMP Grant No. 1 activities is not sufficient to address site-specific issues. A much more extensive site specific evaluation should be expected in order to provide detailed policy decisions which could significantly alter previously approved site-specific land use decisions. Nonetheless, Grant No. 1 activities of the GWMP does provide a good indication of where key sensitive areas are located. These vicinities are described in Section III. Therefore, in these areas, it may be appropriate to require more detailed investigation of groundwater aquifer impacts prior to approving a proposed activity. Continued data refinement is needed in many of these areas to render these decisions.

Solutions for Resource Management Concerns, identified previously for Data Limitations, 2A, and Data Management, 2B, need immediate attention. The need to collect additional data was well documented in Grant No. 1 activities. This led to the monitoring and data collection recommendations presented in Section III. Continued data collection should not be deferred until completion of the GWMP.

TABLE IV-1

KITSAP COUNTY AGENCIES/CITY GROUNDWATER PROGRAMS

Name of Agency	Description of Agency's Area(s) of Jurisdiction	Controlling Documents, Statutes or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs or Projects in Kitsap County
LOCAL				
Kitsap County Commission	Kitsap County	WAC 173-100-090, RCW 90.44.410 Washington State Constitution RCW 36.70	Enactment of ordinances and regulations governing protection of ground water resources	Subarea Plan review
Kitsap County Public Works Department	Kitsap County	RCW 36 RCW 70.95	Road Construction/Maintenance Herbicide Application Drainage system construction and maintenance Sanitary Sewer Construction Stream Gaging Landfill Operation/Maintenance	
Bremerton/Kitsap Health Department	Kitsap County	RCW 70.05, 70.12, 70.118 WAC 173-303, 304, 160 WAC 248-50, 54, 84, 96, 98	Regulatory and Advisory Water System/Well Sites Sewage Disposal Solid Waste Permits Sludge Application sites Conduct ground & surface water monitoring at landfill sites	Drinking Water Program (Primacy for systems with less than 25 connections) Liquid Waste Program Solid Waste Program Hazardous Waste Program
Kitsap County Department of Community Development	Kitsap County	Zoning Codes, Subarea Plans Land Development Standards Comprehensive Land Use Plan SEPA	Implementation of Kitsap County Subarea Plans Develop land use policy plans Develop zoning plans Basin planning; including data analyses, recommendations for projects, land use changes, regulations, and water quality programs.	Central Kitsap Subarea Plan South Kitsap Subarea Plan Bainbridge Island Subarea Plan North Kitsap Subarea Plan Zoning Plan for Kitsap County Basin Planning Program

TABLE IV-1 continued

Name of Agency	Description of Agency's Area(s) of Jurisdiction	Controlling Documents, Statutes or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs or Projects in Kitsap County
Kitsap County Public Utility District #1	Service areas in North Kitsap	RCW 57.08.010	Source Development Herbicide/Pesticide use	
Water Districts	Service Area boundaries	RCW 57.08.010	Source development Herbicide/Pesticide use	
Sewer Districts	Service Area boundaries	RCW 56.08.010	Sanitary sewer construction and maintenance Wastewater treatment plant operation and maintenance Herbicide/Pesticide use	
Cities	City Limits	SDWA (PL 93-523) Rules & Regulations of State Board of Health/Water Supplies Municipal Ordinances RCW 56, RCW 35.67.010 RCW 35.67.020 Water System Comprehensive Water and Sewer Comprehensive Plans (where applicable) Zoning Plans	Water Source development Herbicide/Pesticide application on city properties Zoning	
Kitsap Soil Conservation District		RCW 89.08.005, .010, .200, .210, .220 (enclosed w/ survey) USDA Soil Conservation Service	Commerical farm and small landowner services in field and home drainage, animal waste control, pasture grass improvements, manure application, fencing and erosion control. Assists landowner, local organizations and agencies	Information/Education Long Term Agreements/Conservation
Puget Power	Throughout Kitsap County		Electric Util.-Investor Owned Fuel Storage Tanks @ Service Center and SW Generation Station, Substation Transformers Herbicide/Pesticide application on right-of-way	N/A

TABLE IV-1 continued

Name of Agency	Description of Agency's Area(s) of Jurisdiction	Controlling Documents, Statutes or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs or Projects in Kitsap County
Fire Districts	Throughout Kitsap County	RCW 52, 9A.48, 39.96, 46.16 and 70.105	Response to and reporting of hazardous materials spills	Emergency response program for Hazardous materials spills

TABLE IV-2
STATE AGENCIES
GROUNDWATER PROGRAMS

Name of Agency	Completed By	Description of Agency's Area's of Jurisdiction	Controlling Documents Statutes or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs of Projects in Kitsap County	Responsible Office/Individual	Phone No.
STATE							
Department of Agriculture C. Alan Pettibone, Director	Art Scheunemann, Asst. Dir. Agri. Dev Don Alexander, Noxious Weeds/ Art Losey, Chemical & Plant Div		RCW 17.21 RCW 15.58 Various WAC's	Liscening and permitting of pesticide applications on agricultural lands of both farmer and seller.	Dairy Livestock Services Agriculture Development Chemical and Plant Services (Noxious Weeds) Statistical Division		753-5063
Washington State Conservation Commission	Robert P. Bottman, Admin. Officer/ Same	Responsible for guiding and assisting state's 48 local conservation districts.	RCW 89.08	No direct activities, except Awarded grant to WICD to do work relating to non-point source pollution.	Nonpoint Water Quality Information, Education, and Technical Assistance Program	Martin Boon, Chairman WICD	675-2318
Environmental Hearings Office	Not Returned	Appeals from Ecology and Shorelines actions			Pollution Control Hearings Board Shoreline Hearings Board Forest Practice Appeals Board Hydraulic Hearings Board		459-6327
Department of Ecology (3 surveys completed)	Carol Jolly, WQ Nedia Adelson, Water Rod Mack, Shorelines Stu Clark, Air Thom Lufkin, UST's Dave Saunders, Hazardous Waste	Water Quality Protection thru waste discharge permits, enforcement of discharge regulations, and spill response activities. Water Resource Management thru water right permits, regulation of water well construction. Underground Storage Tanks Hazardous Waste Management	RCW 90.48 - Water Pollution Control RCW 90.03 - Water Code, 90.44 - Reg. of Public GW, 90.54 - Water Resource Act 90.14 - Water Rights 18.104 - Well Construction 43.21C - SEPA RCW 70.105 - Harzardous Waste WAC 173-303 - Dangerous Waste SB 6085 - Pending Laws of 1987	Regional Office: issues waste discharge permits, enforces permit conditions, inspects municipal and industrial, responds to pollution incidents and spills to monitor clean-up activities Regional Office: issues water right permits, regulates against illegal water users and regulates water well construction.	Northwest Regional Operations and Enforcement Water Resources Program Point, Non-Point Source Program Lake Protection, stormwater mngment Solids and Hazardous Wate Program Underground Storage Tank Program Well Drilling	Nancy Ellison Nedia Adelman Carol Jolly Carol Jolly Chris Haynes Thom Lufkin Bill Miller	867-7000 459-6000

TABLE IV-2
STATE AGENCIES
GROUNDWATER PROGRAMS

Name of Agency	Completed By	Description of Agency's Area's of Jurisdiction	Controlling Documents Statutes or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs of Projects in Kitsap County	Responsible Office/Individual	Phone No.
STATE							
Department of Fisheries	Joe Robel Regional Habitat Joseph R. Blum, Director	Preserves, protects, perpetuates and manages the food fish and shellfish in state waters and off shore waters. Wetted Perimeter	RCW 75 RCW 74.20.100 - Hydraulic Code (Fisheries and Hydraulic Codes enclosed with survey)	Regulatory authority under the Hydraulics Code	Regional Habitat Manager-Marine Regional Habitat Manager-Freshwater	 Joe Robel	753-5732 339-1718
Department of Parks and Recreation	Not Returned						753-5755
Department of Natural Resources (DNR)	Mike Griggs Regional Manager Brian Boyle, Commissioner of Public Lands/ Don Theoe Forester	Statewide Natural Resource Administration of Non Federal Lands.	Revised Code of Washington Washington Administration Code	Surface Mining Logging Wildfire Slash Burning Chemical Vegetation Control	State Land Management Forest Practices Private Lands Wildfire Control Surface Mining		753-5327
Department of Health (DOH)	Eric Slagle, Chief Environmental Health /Not Returned	Public Health Protection Drinking Water Quality On-Site Sewage	Revised Code of Washington Washington Administrative Code Rules and Regulations adopted by the State Board of Health RCW 43.20A - Public Health Protection Safe Drinking Water Act RCW 70.119 - Public Water System Certification	conducts or coordinates: water system plan review well site approval on-site sewage disposal water qualitly monitoring and analysis for drinking water constituents Enforces drinking water standards Investigates public health risks due to drinking water	Liquid Waste Program Drinking Water Program Well Site Approval		753-7039

TABLE IV-2
STATE AGENCIES
GROUNDWATER PROGRAMS

Name of Agency	Completed By	Description of Agency's Area's of Jurisdiction	Controlling Documents Statutes or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs of Projects in Kitsap County	Responsible Office/Individual	Phone No.
STATE							
Department of Health (continued)			WAC-248-96: On-Site Sewage Disposal	contamination			
Department of Transportation (DOT)		All the state highway routes and right-of-way located in King County, including	RCW's for DOT right-of-way. Within cities modified. For non-limited access vested in the City as specified in RCW 47.24.	State Highway planning, location-design, construction and activities assoc. with roadway maintenance incl.: resurfacing; shoulder and ditch maint.; brush, tree and noxious weed control.	State Highway Maintenance State Highway Construction State Highway Plans Preparation State Highway Accident Report DOT Marine Division	Pat Foley	753-6005
Department of Wildlife	Joan Keller, Regional Manager/Not Returned						753-5700
Northwest Air Pollution Control Authority (NWAPCA)		Air pollution control	Washington Clean Air Act Federal Clean Air Act Ecology Admin. Codes - WAC 173 NWAPA Regulation	Regulatory agency, conducts air quality monitoring, new source permitting, handles citizen complaint, inspects industrial sources, and enforces air pollution regs	None listed.		428-1617
Puget Sound Water Quality Authority (PSWQA)	Joanne Richter "State of the Sound Report"	Puget Sound	Identical to the Department of Ecology	Water Quality Protection of Puget Sound	Assist in development of non-point source pollution action plan for Kitsap County - Surface water monitoring - Water quality protection recommendations		464-7320

TABLE IV-3
FEDERAL AGENCIES
GOVERNMENT PROGRAMS

Name of Agency	Completed By	Description of Agency's Area(s) of Jurisdiction	Controlling Documents, Statutes, or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs or Projects in Kitsap County	Responsible Office/Individual	Phone No.
FEDERAL							
Environmental Protection Agency (EPA)	Robert Burd, Dir. of Water Division	Hazardous Waste - Superfund and Generators	CERCLA/SARA, Section 120	Provide technical assistance to the State. Regulatory Agency, as well as research and monitoring programs.	Oversite for Remedial Investigation /Feasibility Studies (RI/FS)	Bub Leiselle	442-1847
Region 10	Chuck Findley, Dir. Waste Division		Navy's WI Current Situation Report and Pending Workplan Development & Pending RI/FS		Sludge Disposal, Treatment and Land Spreading	Dick Hetherington	442-1941
	Gary O'Neal, Dir Toxics Division/	Municipal Facilities	Clean Water Act as amended.				
(5 surveys completed)	Robert Burd	Pesticides	Fed. Insecticide, Fungicide, and Rodenticide Act	EPA is responsible for overseeing the Safe Drinking Water Act and the Clean Water Act. The Underground Storage Tank program is for the entire Pacific Northwest. Hazardous waste is divided into Superfund and hazardous waste.	Pesticide Registration	Chuck Shenk	442-8576
					Pesticides in Ground Water Survey	Steve Bubnick	442-1369
		Underground Storage Tanks	CERCLA		Agricultural Chemicals in Ground Water Strategy	Gary O'Neal	442-4152
		Sole Source Aquifer Program	Section 1424(e) of the Safe Drinking Water Act		Underground Storage Tanks		
		Region 10 includes: Washington Oregon Idaho Alaska			Sole Source Aquifer Program	Jonathan W. Vierns	442-1541
				Wellhead and Sole Source Aquifer programs are both under the Office of Groundwater.	Water Division Ground Water Coord.	Steven Roy	442-2118
Farmer's Home Administration (FmHA)		Single & Multi- Family Housing Water & waste systems, community facilities, and rural business projects financed by FmHA.	U.S.D.A. rules and regulations drafted as a result of congressional proceedings.	Construction of multi-family housing projects w/ parking lots and single-family w/ on-site sewage disposal.			876-5811
US Geological Survey (USGS)		Collection, analysis, management of water resources data		- Groundwater quantity and quality monitoring data - Numerous hydrogeologic studies			593-6510
Suquamish and Klallam Indian Tribes		Indian Reservation Lands		- Reservation-wide groundwater studies	- Grovers Creek Hatchery Well Monitoring Program		598-3311
				- Well monitoring	- Streamflow data collection		297-2646

TABLE IV-3
FEDERAL AGENCIES
GOVERNMENT PROGRAMS

Name of Agency	Completed By	Description of Agency's Area(s) of Jurisdiction	Controlling Documents, Statutes, or Ordinances	Description of Activities Potentially Affecting GW	Names of Programs or Projects in Kitsap County	Responsible Office/Individual	Phone No.
FEDERAL							
Dept of Agriculture-USDA	Ken Shanblin, State Director of Agri Gary Oldenburg, State Director of Animal Damage	Provide assistance to land-owner and communities in municipal sludge application livestock, crops, irrigation design and certify wildlife and animal waste ponds as shared with ASCS. Woodland assistance, too.	SCS/non-regulatory agency of the USDA. PL 46, 74th Congress 16 USC 590 a-f, i-l, q, q-1; 42 USC 3271-3274; 7 USC 2201		Technical Assistance Soil Surveys Plant Materials Watershed Projects River Basin Surveys Resource Construction & Development Emergency Watershed Protection	Dept. of Agriculture Olympia, WA	753-5063
Soil Conservation Service (SCS)	Lyle Fitz			Federal cost sharing for construction of animal waste storage facilities, ponds, underground drains, shallow wildlife ponds on farms, thinning forestry strands, tree plantings, and erosion control.	Resources Conservation Act Fish & Wildlife Conservation Woodland Conservation		753-9454
Agriculture/Stabilization and Soil Conservation (ASCS)		Administration of Federal farm and agriculture programs	Numerous Federal Register regulations and Executive Orders		Agriculture Conservation Program ASCS Committee		753-9453
Corp of Engineers	R.P. Sellevold, Chief Engineering Div. Ray Fause, Chief of Construction Div. Vernon Cook, Chief Operations Div. Warren Baxter, Regulatory Branch	All activities in, under or over navigable waters of the US (Section 10) Discharge of dredge or fill materials in waters of US, including wetlands.	Section 10 of Rivers and Harbors Act of 1909. Section 404 of the Clean Water Act.	Regulatory jurisdiction over wetlands.	Regulatory Program Maintenance Dredging The Corps is responsible for all navigable waters including shorelines, as well as wetlands. The Corps handles construction and disposal of dredge material permits. Permits area handled through the regulatory branch.	Corps of Engineers Department of the Army Seattle District	764-6710

TABLE IV-4

KITSAP COUNTY AGENCIES/CITY

GROUNDWATER RESPONSIBILITY MATRIX

CATEGORIES	LOCAL										
L = Lead Agency S = Support Agency	Commis-sioners	Kitsap County Public Works	Brem-Kitsap Health Dept.	Kitsap Co. DCD	Cities	Kitsap Co. Cons. Dist.	Fire Districts	Sewer Districts	Water Districts	Kitsap P.U.D.	Puget Power
Air Pollution											
Agriculture (see Irrigation)						L					
Aquifer Depletion/Overdraft			S	S	S				S	S	
Commercial/Industrial Sites	S		S	L	L						
Diking and Drainage		L	S	S	L/S						
Drinking Water Program			L		S				S	S	
Dredge Spoil Disposal		S									
Energy Generation/Transmission										L	L
Fire Protection							L				
Forestry Managament/Practices				S		S					S
Gravel Pits			S	L							
Hazardous Waste Management			L	S	S		S				
Irrigation						S					
Lagoons/Holding Ponds		L\S	L\S			S					
Landfills		L\S	L\S								
Land Use Classification		S		L	L						
Liquid Waste (see Lagoons)			L					L\S			

TABLE IV-4 continued

CATEGORIES	LOCAL									
L = Lead Agency S = Support Agency	Commis-sioners	Kitsap County Public Works	Brem-Kitsap Health Dept.	Kitsap Co. DCD	Cities	Kitsap Co. Cons. Dist.	Fire Districts	Sewer Districts	Water Districts	Kitsap P.U.D.	Puget Power
Mining Operations		S	S	L\S							
Seawater Intrusion			L								
Septic Tanks			L								
Shorelands		S	S	L	L						
Sludge Application		S	L								
Spill Control/Prevention		S	L				L\S				
Solid Waste Handling		L	L								
Stormwater/Surface Runoff		L	S	S	L						
Transportation Cooridors		L		S	S						
Underground Pipelines											
Underground Storage Tanks			L\S		S		S				
Wastewater Treatment/Disposal		L	L\S		L			L			
Wells\Water Rights			L		L\S				L\S		
Other (Not Listed Above)											

TABLE IV-5
LOCAL/STATE/FEDERAL
GROUNDWATER MANAGEMENT RESPONSIBILITIES

Category	Activity	Lead Agency	Support Agency	Controlling Documents Statutes, or Ordinances	Projects or Programs
Air Pollution	Standards	EPA		General Regulations for Air Pollution	
	Standards	NWAPCA		Source WAC 173-400	
	Monitoring	NWAPCA		Federal Clean Air Act	
	Permitting	NWAPCA		Washington Clean Air Act	
				Emission Standards WAC 173-490	
				Open Burning WAC 173-425	
Agriculture (see		Dept of Agriculture/	U.S. Department of	ASCS funding	
Irrigation)		Agricultural Stabi-	Agricuture/SCS		
		lization Service	PSWQA		
Aquifer Depletion/	Designation	Ecology and EPA	DOH	Section 1424(e) of SDWA	Sole Source Aquifer Program
Overdraft (see	Permitting	Ecology	KCDCD	Water Rights - Ch. 90.14 RCW	
Groundwater)	Permitting	BKCHD		Ground Water Management Areas and	Ground Water Management Plan
				Programs - Ch 173-100 WAC	
Commercial/Industrial	Site Plan Review	KCDCD	KCPW	Kitsap County Comprehensive Plan	Commercial Permits
Sites	Fire Protection	Cities	Fire Marshall	Subarea Plans	SEPA
				Municipal Codes	
Diking and Drainage	Dredge and Fill	Corp of Engineers	KCDCD, KCPW		
Drinking Water Program	Approval of Systems	DOH	EPA	Safe Drinking Water Act and 1986	Drinking Water Program
	Monitoring	BKCHD		Amendments	
				Rules and Regulations of State Board	
				of Health Regarding Public Water	
				Supplies Ch 248-54 WAC	
				Public Water Systems - Cert. and	
				Regulation of Operators Ch 70.119 RCW	
				Water System Coordination Act -	
				248-56 WAC	
Dredge Spoil Disposal	Permitting	Corp of Engineers	Environmental Hearings	(see Diking and Drainage above)	
			Office		

TABLE IV-5 continued

Category	Activity	Lead Agency	Support Agency	Controlling Documents Statutes, or Ordinances	Projects or Programs
Fire Protection		Fire Districts		ISO Standards, Uniform Fire Code	
		Fire Marshall		NFFA Standards, Water System	
				Coordination Act, Fire Flow Regulation	
				Ch 248-57 WAC	
Forestry Management Practices	Mitigation	DNR	Soil Conservation District	RCW's and WAC's	
			Environmental Hearings Office	Environmental Hearings Office	
			PSWQA, Dept. of Wildlife	Ch 43-21B RCW	
			Suquamish and Klallam Indian Tribes		
Hazardous Waste Management	Monitoring	EPA and Ecology	BKCHD	CERCLA/SARA Section 120	Superfund
	Clean-Up	EPA and Ecology		Hazardous Waste Management -	Hazardous Waste Management
	Permitting	Ecology	Env. Hearings Office	Ch 70.105 RCW	Regional District
	Transporting	Ecology	DOT	Dangerous Waste Regulations -	
				Ch 173-303 WAC	
				FIFRA	
				TOSCA	
				Minimum Functional Standards	
				for Solid Waste Handling WAC 173-304	
Irrigation (see Water Rights)	Permitting	Ecology			
Lagoons/Holding Ponds	Design Approval	BKCHD	Soil Conservation Districts	Soil Conservation Districts	SCD Manure Ponds/Wildlife Ponds
		DOH, Ecology		Ch. 89.08 RCW	
Landfills (see Solid Waste)	Permitting	KCPW	BKCHD	Minimum Functional Standards for	
	Monitoring	Ecology	Env. Hearings Office	Solid Waste Handling WAC 173-304	
				Hazardous Waste Management -	
				Ch 70.105 RCW	
				Dangerous Waste Regulations -	
				Ch 173-303 WAC	
				State Waste Discharge Permits -	
				WAC 173-216	
				NPDES - WAC 173-220	

TABLE IV-5 continued

Category	Activity	Lead Agency	Support Agency	Controlling Documents Statutes, or Ordinances	Projects or Programs
Land Use Classification	Zoning Changes Plan Amendments	KCDCD Cities		Kitsap County Comprehensive Plan Subarea Plans Zoning Codes Municipal Codes	
Liquid Waste (see Lagoons and Sewage)	Permitting Monitoring	BKCHD Ecology DOH		On-Site Sewage Disposal - WAC 248-95	Liquid Waste Program
Mining Operations (Gravel Pits)	Site Approval	DNR KCDCD			State Land Management Surface Mining
Pesticides/Herbicides	Standards Monitoring Application Disposal	EPA/Ecology DNR Dept. of Agriculture	WSU Extension BKCHD	Dangerous Waste Regulations WAC 173-303	Pesticide Registration Pesticides in Groundwater Survey Agricultural Chemicals in Groundwater Survey Agricultural Chemicals and Plant Services Chemical Vegetation Control
Saltwater Intrusion		Ecology BKCHD DOH	USGS	Protection of Withdrawal Facilities Associated with Groundwater Rights - WAC 173-150	
On-Site Sewage Disposal	Standards Permitting	Ecology, DOH BKCHD	EPA	On-Site Sewage Disposal - WAC 248-96	Liquid Waste Program
Shorelands	Substantial Dev. Permit Mitigation	County Council Ecology KCDCD	Env. Hearings Office DNR, Dept. of Wildlife	Shoreline Management Ch. 90.58 RCW	
Sludge Application	Permitting Monitoring	BKCHD Ecology	EPA	Solid Waste Management RCW 70.95 Minimum Functional Standards for Solid Waste Handling WAC 173-304 Federal Clean Water Act Water Pollution Control Act - Ch 90.48 RCW	Solid Waste Program NPDES Program

TABLE IV-5 continued

Category	Activity	Lead Agency	Support Agency	Controlling Documents Statutes, or Ordinances	Projects or Programs
Soil Erosion Control	Permits	DNR	Dept. of Ag./ASCS Conservation District Ecology, DOT, PSWQA KCDCD KCPW		
Solid Waste Handling	Permits Operation Monitoring	KCPW	EPA, Ecology	State Waste Disposal Act of 1970 Resource Conservation and Recovery Act Minimum Functional Standards for Solid Waste Handling - WAC 248-54	
Spill Control/Prevention		Ecology	EPA BKCHD		
Stormwater/Surface Runoff	Permit	KCPW Ecology	EPA, Dept. of Agric., Corp of Engineers, PSWQA, DOT, Fisheries Env. Hearings Office Dept. of Ag/ASCS	Water Pollution Control Act - Ch. 90.48 RCW Pollution Disclosure Act - Ch 90.52 RCW King County Ordinance 7590 King Count Code 9.8	
Transportation Corridors		DOT KCDCD KCPW		King County Code - Chs. 12, 14, 17, 19 RCW 70.95 RCW 36	
Underground Pipelines	Franchise Permits	Ecology	EFSEC		
Underground Storage Tanks	Permitting Monitoring	Ecology, EPA	Env. Hearings Office BKCHD	RCRA Water Pollution Control Act - Ch. 90.48 RCW Hazardous Waste Management - Ch 70.105 RCW	
Water Pollution	NPDES Permitting Monitoring	Ecology BKCHD	EPA DOH	Water Pollution Control Act - Ch. 90.48 RCW Safe Drinking Water Act Clean Water Act State Toxic Substances Act	

TABLE IV-5 continued

Category	Activity	Lead Agency	Support Agency	Controlling Documents Statutes, or Ordinances	Projects or Programs
Wastewater Treatment/Disposal	Approvals	BKCHD	EPA	Dangerous Waste Regulations - WAC 173-303	
	Monitoring	Ecology	Env. Hearings Office	National Pollutant Discharge Elimination System Permit Program - WAC 173-220	
				Minimum Functional Standards for Solid Waste Handling - WAC 173-304	
Water Resources	Groundwater	Ecology, BKCHD	USGS, KCDCD, KCPW	Regulation of Public Ground Water - Ch 90.44 RCW	
	Surface Water/ Streams/Lakes	Ecology, KCDCD	Fisheries, DNR, PSWQA, EPA, Wildlife, USDA/SCS	Water Resources Act Ch 90.54 RCW	
	Wetlands	Ecology, KCDCD	Suquamish and Klallam Indian Tribes		
Water Rights	Application	Ecology	DOH, BKCHD	Water Rights Ch 90.14 RCW	
	Permits			Protection of Withdrawal Facilities Associated with Groundwater Rights WAC 173-150	
	Certificates				
Wells	Abandoned Wells	Ecology	EPA, BKCHD	Water Well Construction Ch 18.104 RCW	
	Construction Stds.	Ecology	EPA, BKCHD	Protection of Upper Aquifer Zones - Ch. 173-154 WAC	
	Injection Wells	Ecology	EPA, BKCHD	Minimum Standards for Construction and Maintenance of Wells - Ch 173-160 WAC	
	Permits/Siting	DOH, BKCHD	Ecology	Regulation and Licensing of Water Well Contractors and Operators Ch 173-162 WAC	

TABLE IV-6
STATE AGENCIES
GROUNDWATER RESPONSIBILITY MATRIX

CATEGORIES (1)	STATE												
L = Lead Agency (3) S = Support Agency (4)	Dept of Agril/ASCS	Conserva Commissio	Energy (EFSEC)	Environ Hearings	Dept of ECOLOGY	Dept of Fisheries	Dept of Park&Rec	DNR	DOH	Dept of Transport	Dept of Wildlife	NWAPCA	PSWQA
Air Pollution			S		S							L	
Agriculture (see Irrigation)	L												S
Aquifer Depletion/Overdraft					L				S				
Commercial/Industrial Sites					S								
Diking and Drainage					S								S
Drinking Water Program					S				L				
Dredge Spoil Disposal				S	S			L					
Energy Generation/Transmission			L										
Fire Protection									S				
Forestry Management/Practices	S			S		S		L			S		S
Gravel Pits					S			L					
Hazardous Waste Management				S	L								
Irrigation					L								
Lagoons/Holding Ponds	S			S	L								

TABLE IV-6
STATE AGENCIES
GROUNDWATER RESPONSIBILITY MATRIX

CATEGORIES (1)	STATE												
L = Lead Agency (3) S = Support Agency (4)	Dept of Agril/ASCS	Conserva Commissio	Energy (EFSEC)	Environ Hearings	Dept of ECOLOGY	Dept of Fisheries	Dept of Park&Rec	DNR	DOH	Dept of Transport	Dept of Wildlife	NWAPCA	PSWQA
Landfills (see Solid Waste)				S	L								
Land Use Classification													
Liquid Waste (see Lagoons)				S	L								
Mining Operations								L					
Pesticides/Herbicides	L				S			S		S			
Seawater Intrusion					L				S				
Sewage Waste Disposal					L				L				
Shorelands				S	L	S	S				S		
Sludge Application					S\L								
Soil Erosion Control	S				S			S		S			S
Spill Control/Prevention					L								
Solid Waste Handling				S	L								
Stormwater/Surface Runoff	S			S	L	S			S				S
Transportation Cooridors										L			

TABLE IV-6

STATE AGENCIES

GROUNDWATER RESPONSIBILITY MATRIX

CATEGORIES (1)	STATE												
L = Lead Agency (3) S = Support Agency (4)	Dept of Agri/ASCS	Conserva Commissio	Energy (EFSEC)	Environ Hearings	Dept of ECOLOGY	Dept of Fisheries	Dept of Park&Rec	DNR	DOH	Dept of Transport	Dept of Wildlife	NWAPCA	PSWQA
Underground Pipelines			S		L								
Underground Storage Tanks				S	L								
Wastewater Treatment/Disposal				S	L								
Water Pollution					L				S				S
Water Resources													
Groundwater					L				S				
Surface Water/Streams/Lakes					L	S		S		S			S
Wetlands					L	S		S		S	S		
Wells/Water Rights					L				L				
Other (Not Listed Above)													

TABLE IV-7

FEDERAL AGENCIES

GROUNDWATER RESPONSIBILITY MATRIX

CATEGORIES (1)	FEDERAL						
L = Lead Agency (3) S = Support Agency (4)	Dept of Agril	Corp of Engineers	EPA	FmHA	SCS	USGS	Suquamish and Klallam Indian Tribes
Air Pollution			L				
Agriculture (see Irrigation)	S			S	S		
Aquifer Depletion/Overdraft			S			S	
Commercial/Industrial Sites							
Diking and Drainage		L			S		
Drinking Water Program			L\S				
Dredge Spoil Disposal		L					
Energy Generation/Transmission							
Fire Protection							
Forestry Management/Practices					S		S
Gravel Pits							
Hazardous Waste Management			L\S				
Irrigation							
Lagoons/Holding Ponds			S		S		

TABLE IV-7

FEDERAL AGENCIES

GROUNDWATER RESPONSIBILITY MATRIX

CATEGORIES (1)	FEDERAL						
L = Lead Agency (3) S = Support Agency (4)	Dept of Agril	Corp of Engineers	EPA	FmHA	SCS	USGS	Suquamish and Klallam Indian Tribes
Landfills (see Solid Waste)			L\S				
Land Use Classification							
Liquid Waste (see Lagoons)			L\S				
Mining Operations							
Pesticides/Herbicides	L\S		L\S		L\S		
Seawater Intrusion						S	
Sewage Waste Disposal			S/L				
Shorelands							S
Sludge Application			S				
Soil Erosion Control					L\S		
Spill Control/Prevention			S				
Solid Waste Handling			S				
Stormwater/Surface Runoff		S	S				S
Transportation Cooridors							

TABLE IV-7

FEDERAL AGENCIES

GROUNDWATER RESPONSIBILITY MATRIX

CATEGORIES (1)	FEDERAL						
L = Lead Agency (3) S = Support Agency (4)	Dept of Agril	Corp of Engineers	EPA	FmHA	SCS	USGS	Suquamish and Klallam Indian Tribes
Underground Pipelines							
Underground Storage Tanks			L				
Wastewater Treatment/Disposal			S/L				
Water Pollution			L				
Water Resources							
Groundwater			S			S	S
Surface Water/Streams/Lakes			S		S	S	S
Wetlands		L	S		S	S	S
Wells/Water Rights			S				
Other (Not Listed Above)							

TABLE IV-8

KITSAP COUNTY
GROUND WATER MANAGEMENT PLAN

GROUNDWATER MANAGEMENT ISSUES (1)

- Education Programs in Schools
- Landfills and Hazardous Waste Dumping Practices
- Fertilization and Herbicide/Pesticide Practices
- Salt Water Intrusion
- Wetlands Preservation
- Water Use and Conservation Practices
- Stormwater Runoff and Improved Erosion Control
- Wastewater Irrigation
- Reduced Recharge from Development
- Well Drilling Activities in Recharge Areas
- Well Abandonment Procedures
- Inadequate Aquifer Recharge Protection Measures
- Adequate Protection for Shallow Aquifers
- Protection of Existing Wells From New Well Development
- "Mining" Aquifers
- Overdevelopment of Aquifers
- Water System Expansion without Adequate Resources
- Coordinated Water Resource Management

Note:

(1) Issues provided by citizen input at GWAC Groundwater Fair and Committee meetings.

Kitsap County
Ground Water Management Plan

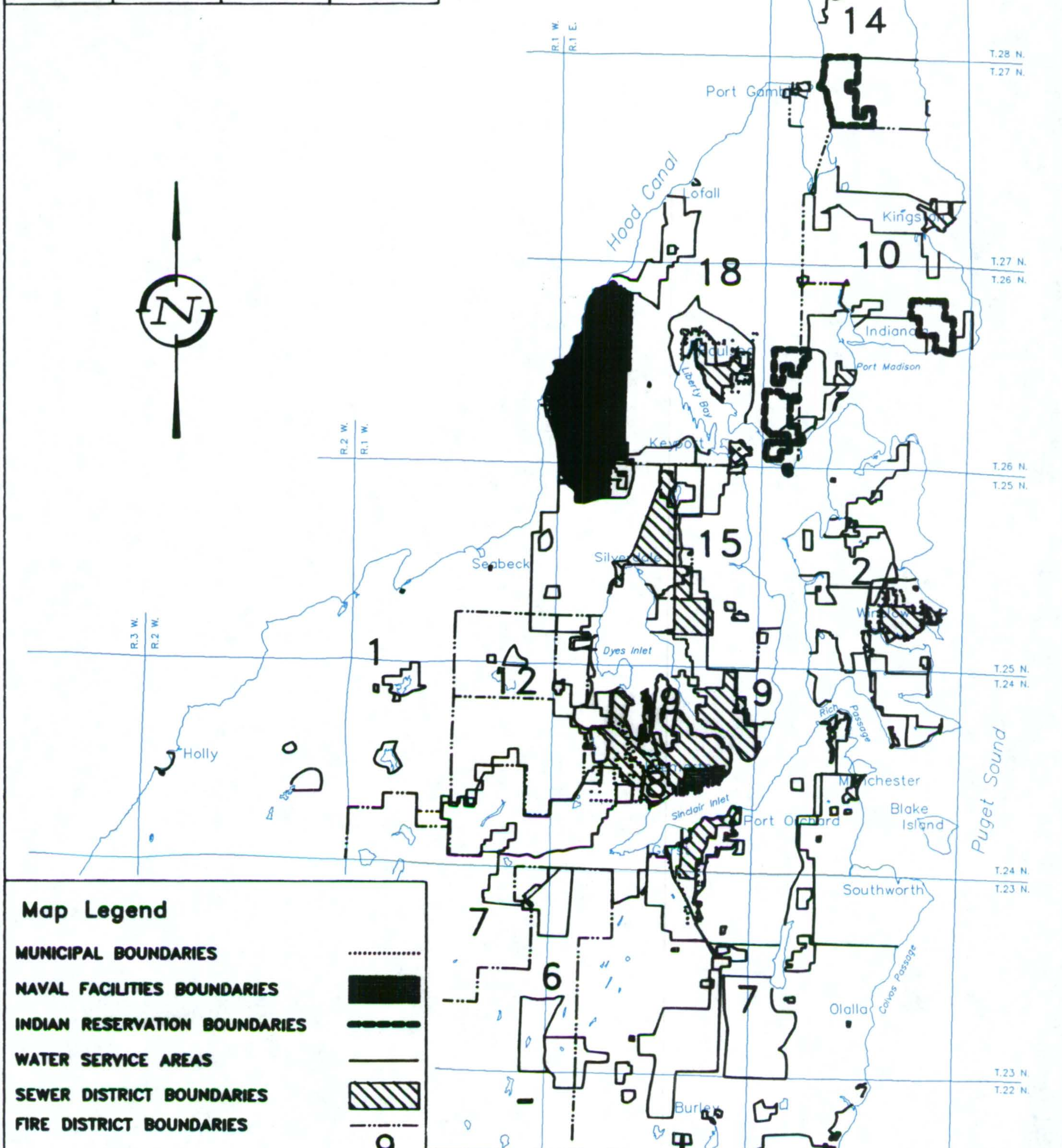
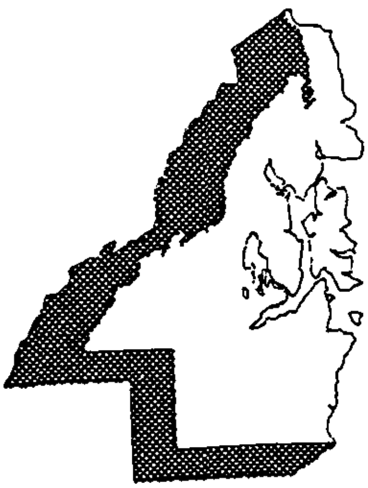


EXHIBIT IV-1

JURISTDICTIONAL BOUNDARIES FOR KITSAP COUNTY GWMP

BIBLIOGRAPHY



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DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
GEOLOGY				
Published Report	Washington State University, Publications in Geology.	C. E. Weaver	Tertiary stratigraphy of Western Washington and Northwestern Oregon.	1937
Published Report	Geological Society of America Bulletin, v. 65, p. 1341	C.V. Fulmer	Stratigraphy and paleontology of the type Blakeley Formation of Washington	1954
Published Report	USGS	Jack E. Sceva, for USGS	Geology and groundwater resources of Kitsap County Washington, Water Supply Paper 1413	1957
Published Report	Washington Department of Water Resources.	D. J. Easterbrook Washington.	Pleistocene stratigraphy of Island County,	1963
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Published Report	State of Washington, Division of Water Resources.	M. E. Garling, and Dee Molenaar.	Water Resources and geology of the Kitsap Peninsula and certain adjacent islands.	1965
Published Report	U.S. Geological Survey Professional Paper, 1033	R.W. Tabor and W.M. Cady	The structure of the Olympic Mountains, Washington - analysis of a subduction zone	1978
Unpublished Thesis	Western Washington University.	Jerald Deeter	Quaternary geology and stratigraphy of Kitsap County Washington.	1979
Geologic Map	Kitsap County Department of Health	Jerald Deeter	Quaternary Geology and On Site Sewage Feasibility, Kitsap County Washington.	1979
Published Report	Soil Conservation Ser.	Soil Conservation Ser.	Soil Survey of Kitsap County Area, WA	1980
Published Report	Journal of Geophysical Research v. 87, p. 10827-10837	R.A. Duncan	A captured island chain in the Coast Range of Oregon and Washington	1982
Open File Report	Robinson & Noble, Inc.	Robinson, for the WA State Division of Geology and Earth Resources.	Proposed Revisions of nomenclature for the Pleistocene stratigraphy of coastal Pierce County, WA (in preparation).	1989
HYDROGEOLOGY				
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for the Town of Winslow.	Construction of a well at the site of test hole No. 2, Winslow, WA.	1952

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for the Town of Winslow.	Report to the Town of Winslow on test hole No. 2.	1952
Private Letter	Robinson & Noble, Inc.	Robinson & Roberts, letter to Parker, Hill and Ingman.	Letter concerning a pump test of a Sunnyslope Water Development Association well near Port Orchard.	1952
Private Letter	Robinson & Noble, Inc.	Robinson & Roberts, for Branch & Branch Architects	Construction of Well No. 2 for J.G. Shakman residence at Eglon.	1953
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for North Perry Water District.	Construction and testing of test well No. 2, Pickering Site.	1956
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Private Report	Robinson & Noble, Inc.	Robinson & Roberts prepared for North Perry Avenue Water District.	Construction and testing of the North Perry Avenue Well, formerly Test Well No. 5.	1959
Private Letter	Robinson & Noble, Inc.	Robinson & Roberts letter to the First Methodist Church of Seattle.	Drilling of a test well for the First Methodist Church of Seattle near Indianola, Washington.	1960
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Private Report	Robinson & Noble, Inc.	Robinson & Roberts prepared for the Washington State Parks and Recreation Commission.	Drilling a series of test wells on Blake Island.	1961
Private Letter	Robinson & Noble, Inc.	Robinson & Roberts letter report to Dr. R. E. Boehme.	Groundwater supply for Mission View Plat.	1962
Private Report	Robinson & Noble, Inc.	Robinson & Roberts prepared for the Hansville Water District.	Report on groundwater sources for the Hansville Water District.	1962
Private Report	Robinson & Noble, Inc.	Robinson & Roberts prepared for Mr. Horace Whitacre.	Hydrogeologic report on a slide at the Hall property in Port Orchard, WA.	1962

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Robinson & Noble, Inc.	Robinson, Roberts & Associates, prepared for Silverdale Water District.	Construction of Well No. 1 and Well No. 2.	1963
Private Report	Robinson & Noble, Inc.	Robinson, Roberts & Associates, prepared for the Hansville Water District.	Report of results of initial test drilling for the Hansville Water District.	1963
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Private Report	Robinson & Noble, Inc.	Robinson, Roberts & Associates, prepared for the Town of Winslow.	Report concerning additional groundwater supplies for the Town of Winslow.	1964
Private Report	Robinson & Noble, Inc.	Robinson, Roberts & Associates, prepared for the town of Poulsbo.	Development of water supplies, Town of Poulsbo.	1964
Private Letter	Robinson & Noble, Inc.	Robinson, Roberts & Associates, letter to the Seattle Yacht Club.	Letter to the Seattle Yacht Club concerning the Port Madison Well.	1964
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Private Letter	Robinson & Noble, Inc.	Robinson, Roberts & Associates, letter to the Town of Winslow.	Letter concerning the drilling of production well 25/2E-27E2.	1966
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for the Annapolis Water District.	Construction of Well 1-B for Annapolis Water District.	1966
Published Report	Hill & Ingman and Robinson & Noble.	Hill & Ingman, with Robinson & Roberts for PUD No. 1 of Kitsap County.	Comprehensive water study of Kitsap County for PUD No. 1 of Kitsap County.	1966
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for the City of Winslow.	Construction report for the City of Winslow Bayhead Well 1A.	1967

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
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Private Letter	Robinson & Noble, Inc.	Robinson & Roberts, letter to the Annapolis Water District.	Letter to Annapolis Water District describing the redevelopment of Well 6.	1968
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for Annapolis - Manchester Water District.	Ground Water Study for Annapolis - Manchester Water Districts.	1969
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for Kitsap County Public Utility District No. 1.	Report to Kitsap Public Utility District No. 1 on the Gilberton Well No. 1.	1969
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for Kitsap County Public Utility District No. 1.	Report to Kitsap Public Utility District No. 1 on ground water potential in the Indianola Area.	1969
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Private Letter	Robinson & Noble, Inc.	Robinson & Roberts, letter to Seattle - King County Council of the Camp Fire Girls.	Letter to the Camp Fire Girls concerning the existing Dupar Camp well.	1971
Private Report	Robinson & Noble, Inc.	Robinson & Roberts, prepared for the Annapolis Water District.	Construction and testing of Well No. 11.	1971
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DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
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Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Kitsap Public Utility District No. 1.	Letter concerning results of test drilling of Kingston #2 and Island Center #1.	1973
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Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Greco Utilities Inc.	Letter to Greco Utilities describing tests on Wells 1 and 2.	1973
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Manchester Water District.	Construction Report of Well 4, Manchester Water District, Kitsap County Washington.	1973
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Washington State Parks and Recreation Commission.	Construction and testing of Scenic Beach State Park Well No. 2.	1973
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to PUD No. 1 of Kitsap County.	Letter to PUD No. 1 of Kitsap County concerning test drilling results of the the Fletcher Bay Well No. 1.	1973
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Olson, Richert, Bignold Engineers.	Ground water investigation for proposed county park supply at Buck Lake near Hansville, WA.	1973
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Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Alexander Enterprises.	Letter to Alexander Enterprises concerning additional water supplies at Lake Tahuyeh.	1974
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DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Construction Report on Selbo Road Production Well No. 1.	1975
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Manchester Water District.	Letter to Manchester Water District concerning the evaluation of Sedgwick Well #5.	1975
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for McGinnes, Olson and Rowland Engineers.	Results of test drilling at Parkwood East, Kitsap County.	1975
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, for Watauga Beach Community Water Company.	Evaluation of a water well owned by the Watauga Beach Community.	1975
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Manchester Water District.	Letter concerning the effects of Well #4 on neighboring Leonard Well.	1975
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Town of Kingston.	Construction and testing of Well #2.	1975
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Construction and testing of Indianola Well #6.	1975
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to PUD No. 1 of Kitsap County.	Letter to PUD No. 1 of Kitsap County concerning Edgewater Replacement Well #2.	1976
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Results of drilling Gamblewood Well No. 2.	1976
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, prepared for the City of Winslow.	Construction of a replacement well at Weaver Road.	1976
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Construction Report of Silverdale's Well #1, Zone 2E.	1976
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Olson, Richert and Bignold.	Letter concerning the ground water supply in Point No Point County Park.	1976
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Mr. Jack Youngblood.	Letter concerning the evaluation and testing of Mr. Youngblood's domestic Well near Bangor.	1976

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Published Report	USGS	A. J. Hansen Jr. and Dee Molenaar.	Availability of Ground Water in the area surrounding the Trident Submarine Construction Facility, Kitsap County.	1976
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to North Perry Avenue Water District.	Letter concerning proposed new drilling sites.	1977
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Silverdale Water District.	Construction report for Spirit Ridge Well 3, Silverdale Water District.	1977
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Jefferson Beach Estates.	Letter to Jefferson Beach Estates concerning the evaluation of Well No. 2	1977
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Silverdale Water District.	Letter to Silverdale Water District concerning a pump test on the Chena Road Well.	1977
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Department of Ecology.	Letter concerning aquifer evaluations using the Royalwood and Regency Wells.	1977
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Bridleridge test drilling and well construction for PUD No. 1 of Kitsap County.	1977
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Perry Avenue Water District.	Construction of Gilberton Well #2 for North Perry Avenue Water District.	1977
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Smith, Redman and O'Hare.	Letter concerning the Claire Marsh development site in Bremerton.	1977
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Apex Water System.	Letter concerning a pump test on the Apex Airport Well.	1977
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Mr. Harvey Olson.	Letter concerning interference caused by Annapolis Water District wells on Mr. Olson's well.	1978
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Mr. Alan Corner.	Letter concerning a pump test on Mr. Corner's well.	1978
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the City of Bremerton.	Letter concerning a test of the Parkwood East Well.	1978
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Manchester Water District.	Report on test drilling at the California Tank Site, Manchester Water District.	1978

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No.1 of Kitsap County.	Construction Report of the Fletcher Bay Well for PUD No. 1 of Kitsap County.	1978
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Silverdale Water District and Central Kitsap School District.	Construction and testing of Test Wells 29D and 19H	1978
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Knapp Brothers Realty Inc.	Letter concerning the Danford Water System.	1978
Published Report	U.S.G.S.	U.S.G.S.	USGS WR 78-112, Water Resources of Port Madison Indian Reservation, WE Rum II	1978
Published Report	Univ. of Washington	Dunne, Thomas, & Leopold, L.B.	Water in Environmental Planning	1978
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Wyckoff company.	Letter to the Wykoff Company concerning recommendations on improving well yields of the two deep wells at Creosote.	1979
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Wyckoff company.	Letter to the Wyckoff Company concerning the pump test of the two artesian wells at Creosote.	1979
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Pazooki and McMenamin.	Letter describing further test drilling near the "Freeway Well".	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Kramer, Chin & Mayo.	Ground Water Resources of the Clam Bay Area, Manchester, WA.	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Peter Overton.	Preliminary report on the hydrogeology of the Coulter Creek Basin, Kitsap and Mason Counties.	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Manchester Water District.	Report on test drilling and construction of Well 6, Manchester Water District.	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Bainbridge Water Company.	Well field evaluation of the North Bainbridge Water Company.	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Domsea Farms, Gorst.	Well study for Domsea Farms, Gorst.	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Pan American Airways Inc., Trident Support Group.	Investigation of water supply wells at the Naval Undersea Warfare Engineering Station, Keyport, WA.	1979

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Test drilling and well construction at the Sunset Tank Site.	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Test drilling and well construction at Edgewater #3.	1979
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Construction report for Kingston Well 3.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Perry Avenue Water District.	Bucklin Hill Road Well for North Perry Avenue Water District.	1980
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to North Perry Avenue Water District.	Letter to North Perry Avenue Water District concerning the Bucklin Hill Road Well.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Pan American Airways Inc., Trident Support Group.	Rehabilitation of the Keyport Nuwes Well #5.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Peter Overton.	The hydrogeology of the Peter Overton property within the Coulter Creek basin in Kitsap and Mason Counties.	1980
Published Report	USGS	A. J. Hansen Jr. and E. L. Bolke.	Ground water availability on the Kitsap Peninsula, Washington.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Pope & Talbot Development, Inc.	Construction report of the test well on the Homestead Property.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Suquamish Tribal Fisheries.	Construction of water Well #1 for the Suquamish Tribal Fisheries.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Bainbridge Island School District No. 303.	Construction of Well No. 2 for Bainbridge Island School District, No. 303.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Community of Meadowmere.	Design and testing of Meadowmere Well No. 2, Bainbridge Island.	1980
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Perry Avenue Water District.	Background and testing of the Sunset Tank Test Well.	1980

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Silverdale Water District.	Results of testing Selbo Road Well # 1 and monitoring of neighboring wells.	1981
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the University of Washington.	Groundwater exploration at Big Beef Creek Fisheries Research Center.	1981
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to PUD No. 1 of Kitsap County.	Letter to PUD No. 1 of Kitsap County concerning the Gazzam Lake Test Well.	1981
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to PUD No. 1 of Kitsap County.	Letter to PUD No.1 of Kitsap County concerning the results of drilling a deep rotary test well near Keyport.	1981
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Construction report on Suquamish Well #5.	1981
Private Report	Robinson & Noble, Inc.	Robinson, Noble & Carr, prepared for the Naval Submarine Base at Bangor.	Report and appendix on groundwater hydrology for the naval base at Bangor.	1981
Published Report	Suquamish Indian Tribe	Nina Kocourek	Port Madison Reservation Water Consumption Demands Study, Phase II	1981
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Pazooki & McMenamin.	Letter to Pazooki & McMenamin concerning the Hoem Well test.	1982
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, Letter to Blossom Const.	Letter to Blossom Construction evaluating groundwater quality.	1982
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, Letter to PUD No. 1 of Kitsap County.	Letter concerning results of drilling the Kingston test well at the Barber - Cutoff road site.	1982
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Construction of Indianola Well # 5 for Kitsap County PUD No. 1.	1982
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Gerald Peterson.	Letter concerning the results of a hydrogeologic study on Mr. Peterson's property.	1982
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the City of Winslow	Letter concerning the redevelopment of Bayhead Wells 1 and 2.	1982
Private Report	Hart Crowser, Inc.	Hart Crowser, prepared for Gray & Osborne	Groundwater Supply Evaluation, Bremerton Comprehensive Plan	1983

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Hart Crowser, Inc.	Hart Crowser, prepared for U.S. Navy	Report on construction and testing of Well No. 4, Naval Supply Center, Manchester	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No. 1 of Kitsap County.	Construction report for Suquamish Well #5 (Replacement).	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Port Blakely Mill Co.	Ground water feasibility study for the Port Blakely Mill Company on Bainbridge Island.	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Dave Symington.	Report on construction and testing of Well #4	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No.1 of Kitsap County.	Construction and testing of Indianola Well #6.	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Manchester Water District.	Construction of Well 7 for Manchester Water District.	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Suquamish Tribal Fisheries.	Construction of Well 2 at Grovers Creek Hatchery for Suquamish Tribal Fisheries.	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the City of Winslow.	Construction of Bayhead Wells 4 and 5 for the City of Winslow.	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Naval Submarine Base at Bangor.	An evaluation of selected artesian relief wells.	1983
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Kitsap County PUD #1.	Construction of Kingston Well 4, Kitsap County PUD No. 1.	1984
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Kitsap County PUD #1.	Construction report for Indianola Well 1-A.	1984
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Perry Avenue Water District.	Construction of Center Street Well #2.	1984
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the City of Bremerton.	Hydrologic analysis of the Andersen Creek well field.	1984

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for McCormick Land Company.	Construction report for Wells 1 and 2 in the North Lake area.	1984
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Perry Avenue Water District.	A summary of pumpage and water level data.	1984
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Anderson Hill Community Association.	Comments on ground water conditions related to EIS for Dickey Pit expansion.	1984
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Pazooki & McMenamin.	Marjelane EIS expanded comments.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Silverdale Water District.	Construction report for Spirit Ridge Well #4, Silverdale Water District.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for PUD No.1 of Kitsap County.	Construction report for Vinland View Well #2.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the City of Winslow.	Construction report for Bayhead Well #6, City of Winslow.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Silverdale Water District.	Construction report for Island Lake 12-inch Well, Silverdale Water District.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Silverdale Water District.	Construction report for the Chena Road Well 2, Silverdale Water District.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Silverdale Water District.	Construction report for Spirit Ridge Well 4, Silverdale Water District.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Perry Avenue Water District.	Construction of Meadowdale Well #2.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for North Perry Avenue Water District.	Construction report of Riddell Road Well #1.	1985
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Kitsap PUD No. 1.	Letter concerning the Suquamish Pine Street Well.	1985

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Manchester Water District.	Letter to Manchester Water District concerning an aquifer test on Sedgwick Well #5.	1985
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Manchester Water District.	Construction report for Sedgwick Well 8.	1985
Private Report	Kitsap County PUD #1.	Applied Geotechnology, prepared for Kitsap PUD #1.	Pine Street Well No. 2, installation and testing, Suquamish WA.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble letter to the Bloedel Reserve.	Letter concerning the Bloedel Reserve's groundwater source study.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Bloedel Reserve.	Letter concerning results of pumping tests on the Farm and Berg wells.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Summit Technology.	Letter describing the drilling log of the Nellita Well.	1986
Private Report	Kitsap County PUD #1	Applied Geotechnology, prepared for Kitsap PUD #1.	Agusta Road Well No. 3, installation and testing, Suquamish, WA.	1986
Private Report	Kitsap County PUD #1	Applied Geotechnology, prepared for Kitsap PUD #1.	Waggoner Well, installation and testing, Suquamish, WA.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Port Blakely Tree Farm.	Letter describing the results of drilling at the Wykoff Tank Site.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Port Blakely Tree Farm.	Summary of test drilling at Wyckoff.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to North Perry Water District.	Results of the Gilberton West Test Well.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Bremerton Water Department.	Summary of the Well 9 (redrill) drilling project.	1986
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Suquamish Tribal Fisheries.	Letter concerning surge redevelopment of Well 1 and air redevelopment of Well 6.	1986
Published Report	Suquamish Indian Tribe	Mark Schaffer	Groundwater Data for Port Madison Indian Reservation	1986

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
HYDROGEOLOGY (continued)				
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter for Andersen, Bjornstad, Kane & Jacobs Inc.	Results & recommendations from Sub-Base well testing.	1987
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Hansville Water District.	Letter to the commissioners concerning spring sites 1 and 2.	1987
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Kitsap PUD No. 1.	Construction of Edgewater Well #3B for Kitsap County PUD No. 1.	1987
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Manchester Water District.	Report to Manchester Water District on the construction of the Sedgwick Well 9.	1987
Private Report	Hart Crowser, Inc.	Hart Crowser, prepared for Seifert & Forbes	Reconditioning and Testing of Well No. 3, U.S. Navy-Manchester Fuel Depot	1988
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Economic and Engineering Services, Inc.	Letter concerning a pumping test at the Port Gamble Well.	1988
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the Suquamish Tribal Fisheries.	Letter concerning redevelopment of Wells 1 and 2 at the Grovers Creek Hatchery.	1988
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Meadowmeer Golf & Country Club.	Letter concerning a pump test on the new irrigation well.	1988
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Manchester Water District.	Construction and testing of Well 10.	1988
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Port Blakely Tree Farm.	Letter concerning the new deep well at Old Mill Road.	1988
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Kitsap PUD #1.	Construction and testing of the South Kingston Test Well.	1988
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Kitsap PUD #1.	Wardwell Road Test Well, Kitsap County PUD #1.	1988
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Suquamish Tribal Fisheries.	Construction of Well 3 at the Grovers Creek Hatchery.	1988
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for Kitsap PUD #1.	Construction of Keyport Well #2 for Kitsap PUD #1.	1988

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
SURFACE WATER/CLIMATALOGICAL				
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Bremerton Water Utility.	Construction of Test Well 3 as part of the Gorst Creek test drilling program.	1988
Private Report	Robinson & Noble, Inc.	Robinson & Noble, prepared for the Bremerton Water Utility.	New water source survey.	1988
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Kitsap PUD #1.	Letter to Kitsap PUD #1 concerning the new Holly Water System well.	1988
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to the City of Winslow.	Letter to City of Winslow concerning the Sands Road Test Well.	1988
Private Letter	Robinson & Noble, Inc.	Robinson & Noble, letter to Meadowmeer Golf & Country Club.	Letter concerning the analysis of air entrainment and related well problems on the three wells owned by Meadowmeer.	1988
Computer Printout	Ecology	Ecology	Water Rights Records Printout	1988
Published Report	Suquamish Indian Tribe	Applied Geotech, Inc.	Groundwater Resources Study of Port Madison Indian Reservation	1989
SURFACE WATER/CLIMATALOGICAL				
Published Report	Washington State U.	Earl L. Phillips	Washington Climate for these counties: King, Kitsap, Mason, and Pierce.	1968
Published Report	Soil Conservation Ser.	Soil Conservation Ser.	Soil Survey of Kitsap County Area, WA	1980
WATER QUALITY				
Published Federal Register	Federal Register Vol. 49, No. 114	U.S. EPA	National Primary Drinking Water Regulations; Volatile Synthetic Organic Chemicals	1984
Published Report	WDOE	Office of Technology Assessment	Protecting the Nation's Groundwater from Contamination	1984
Published Federal Register	Federal Register	U.S. EPA	Amendments to the Safe Drinking Water Act	1986
Summary	EPA	EPA	Summary of Field Investigation Wykoff Facility. Bainbridge Island	1987
Fact Sheet	WDOE	WDOE	Fact Sheet on Eagle Harbor, Bainbridge Island	1987

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
WATER QUALITY (continued)				
Water Quality Data	U.S. EPA	U.S. EPA	STORET Retrieval for Ground-water Quality Data	1988
Water Quality Data	WDOE	WDOE U.S. EPA	STORET Retrieval for Ground-water Quality Data	1988
Water Quality Data	DSHS	DSHS	Water quality data from DSHS for Class 3 and 4 wells	1988
LAND USE				
Published Report	KCDCD	Jim Ach	Bainbridge Island Subarea Plan	1980
Published Report	KCDCD	Jim Ach	South Kitsap Subarea Plan	1982
Published Report	KCDCD	Jim Ach	Central Kitsap Subarea Plan	1983
Published Report	KCDCD	Jim Ach	North Kitsap Subarea Plan	1984
Published Report	PSCOG	PSCOG	Population and Employment Forecasts	1984
Published Report	US Dept. of Commerce	US Dept. of Commerce Bureau of Census	1982 Census of Agriculture - Volume 1 Geographic Area Series, Part 47 - Washington	1984
Published Report	WDOE	WDOE	1985 Hazardous Waste Annual Report Summary, Report No. 87-14	1985
Published Report	BKCHD	Tetra Tech	Strandly Scrap Metal/Mining Property focused remedial investigation	1985
Published Report	Kitsap County PUD No. 1	Kitsap	Preliminary Assessment of Water Resources and Public Water Service Issues in Kitsap County	1986
Computer Printout	U.S. EPA	U.S. EPA	Printout of Facilities Index List (Finds) for Kitsap County, WA. FOI request #640	1987
Computer Printout	U.S. EPA	U.S. EPA	Printout from Waste Handlers Data Management System (WHDMS) on hazardous waste treatment, storage, and disposal facilities for Kitsap County, WA, FOI Request No. 640	1987

DOCUMENT/ DATA TYPE	SOURCE	AUTHOR/AGENCY	TITLE/DESCRIPTION	YEAR
LAND USE (continued)				
Computer Printout	U.S. EPA	U.S. EPA	Printout from Waste Handlers Data Management System (WHDMS) for hazardous waste generators and transporters in Kitsap County WA. FOI No. 640	1987
Published Report	WSDOT	WSDOT	1986 Highway Traffic Accident Report	1987
Listing	DNR	DNR	Listing of surface mining activities in Kitsap County	1987
Published Report	BKCHD	Hart-Crowser	Draft, Volume I, Current Situation Report - Site A; Subbase Bangor, Bangor, WA	1987
Unpublished Tables	PSCOG	PSCOG	Population and Employment Forecasts	1987
Published Report	PSCOG	PSCOG	Population and Employment Forecasts	1988
Personal Communication	Phil Stuck Jerry Deeter	BKCHD	Information pertaining to historical and current landfills in Kitsap County	1988
Computer Listing	Thom Lufkin	WDOE	Listing of underground storage tanks in Kitsap County	1988
Published WAC	DSHS	WA State Board of Health	Rules and Regulations of the State Board of Health Regarding Public Water Systems	1988
Personal Communication	Dave Siburg	Dave Siburg/Kitsap PUD No. 1	Impervious area percentages for land use categoreis within Kitsap County	1989