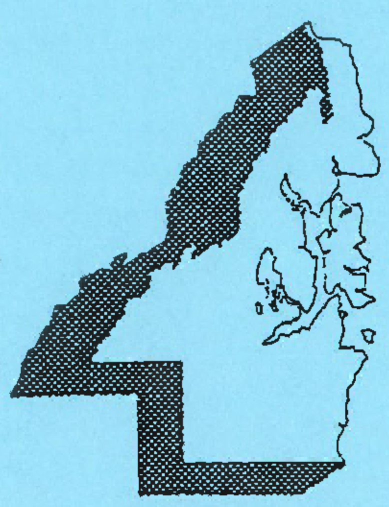
SECTION II



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:

o 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 multifamily 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:

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

- Retrieve by Site ID,
- Retrieve by an Owner ID (e.g. Department of Health (DOH) number),
- Retrieve by Township-Range-Section, and
- 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:

- 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.
- Extract well data and to prepare diagrams that illustrate well construction features, water levels, and subsurface geologic data.
- 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:

$$Q = K * I * A$$

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:

- o 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.

- o 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: sludge	TC, FC, FS 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. CO_2, Na	CO_2, Na
3. Hardness	Hardness
4. H_2S	H_2S

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)

SCENARIO / SUBAREA	YEAR 1985	1990	1995	2000	2010	2020	STRAIGHT-LINE 2030	2040
AVERAGE DAY DEMAND (MGD)								
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 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		YEAR						STRAIGHT-LINE	
		1985	1990	1995	2000	2010	2020	2030	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				YIELD FOR ALL AQUIFER SYSTEMS				AVERAGE GROUNDWATER USE FOR EXISTING CONDITIONS			PEAK GROUNDWATER USE FOR EXISTING CONDITIONS			GROUNDWATER RIGHTS	
	RECHARGE AREA (sq. mi.)	RECHARGE RATE (in/yr)	HYPOTHETICAL YIELD C=0.3 (mgd)	HYPOTHETICAL YIELD C=0.5 (mgd)	RECHARGE AREA (sq. mi.)	RECHARGE RATE (in/yr)	HYPOTHETICAL YIELD C=0.3 (mgd)	HYPOTHETICAL YIELD C=0.5 (mgd)	1985 (mgd)	2010 (mgd)	2040 (mgd)	1985 (mgd)	2010 (mgd)	2040 (mgd)	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	-	-	-	-												
Creosote	-	-	-	-												
Lynnwood Center	-	-	-	-												
Gilbert Fletcher (east)	-	-	-	-												
SUBTOTAL	9		2.1	3.4	21	16	4.8	8.0	1.48	2.03	2.46	4.95	6.10	7.39	3.68	6.95
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	24	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	29.27
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	38.37	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

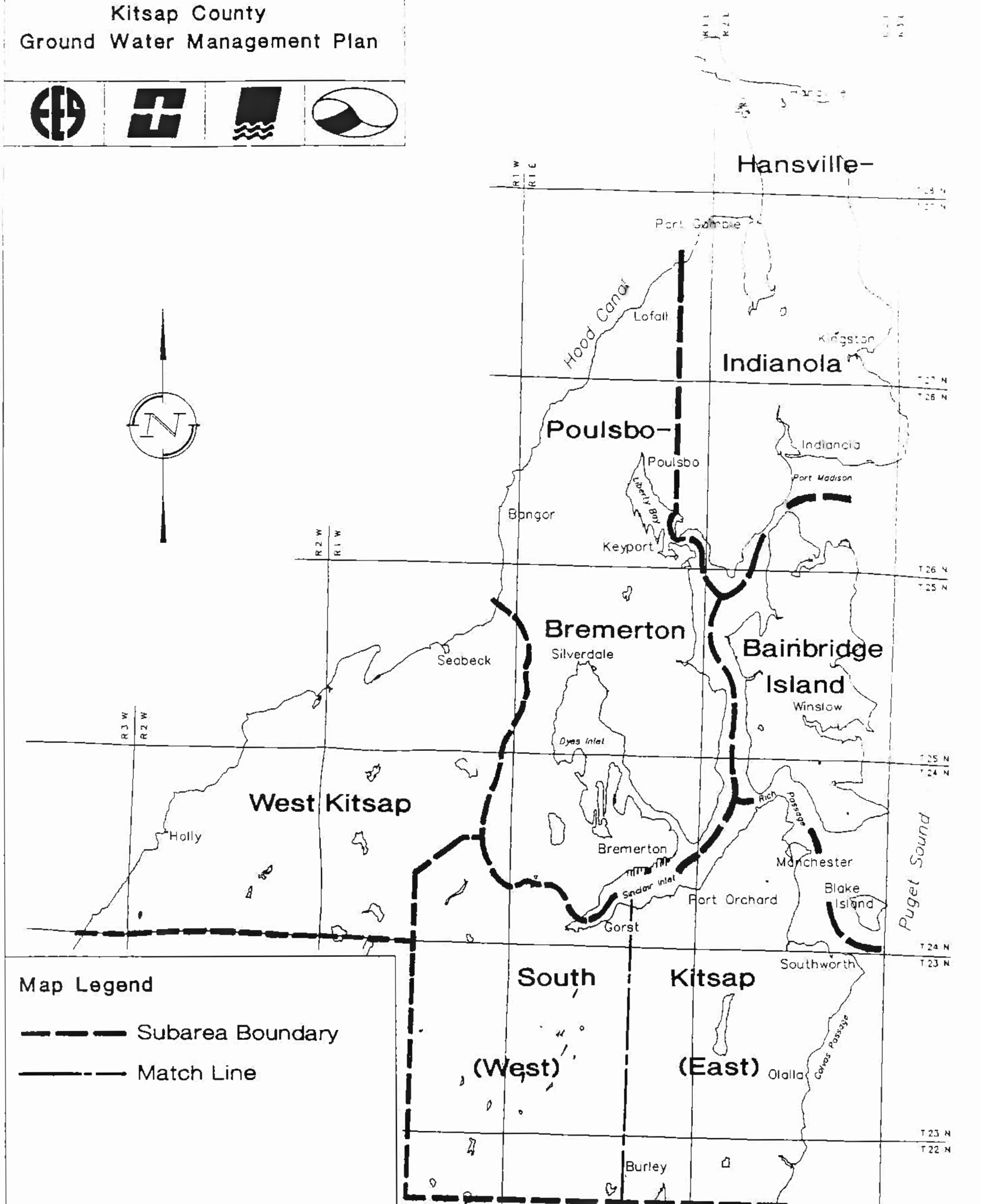


EXHIBIT II-1
Subarea and Study
Area Boundaries

Exhibit II-2

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

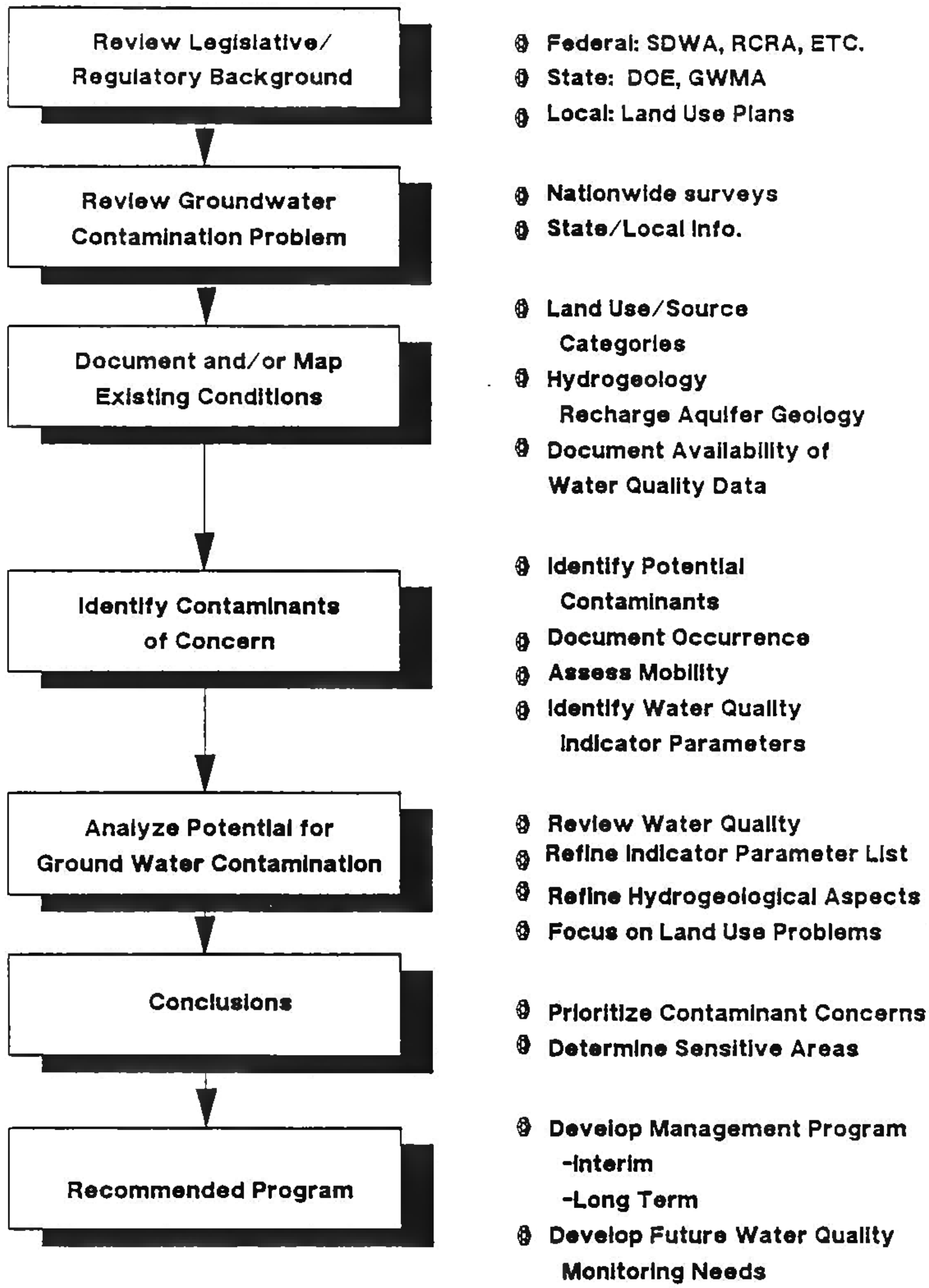


EXHIBIT II-3

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

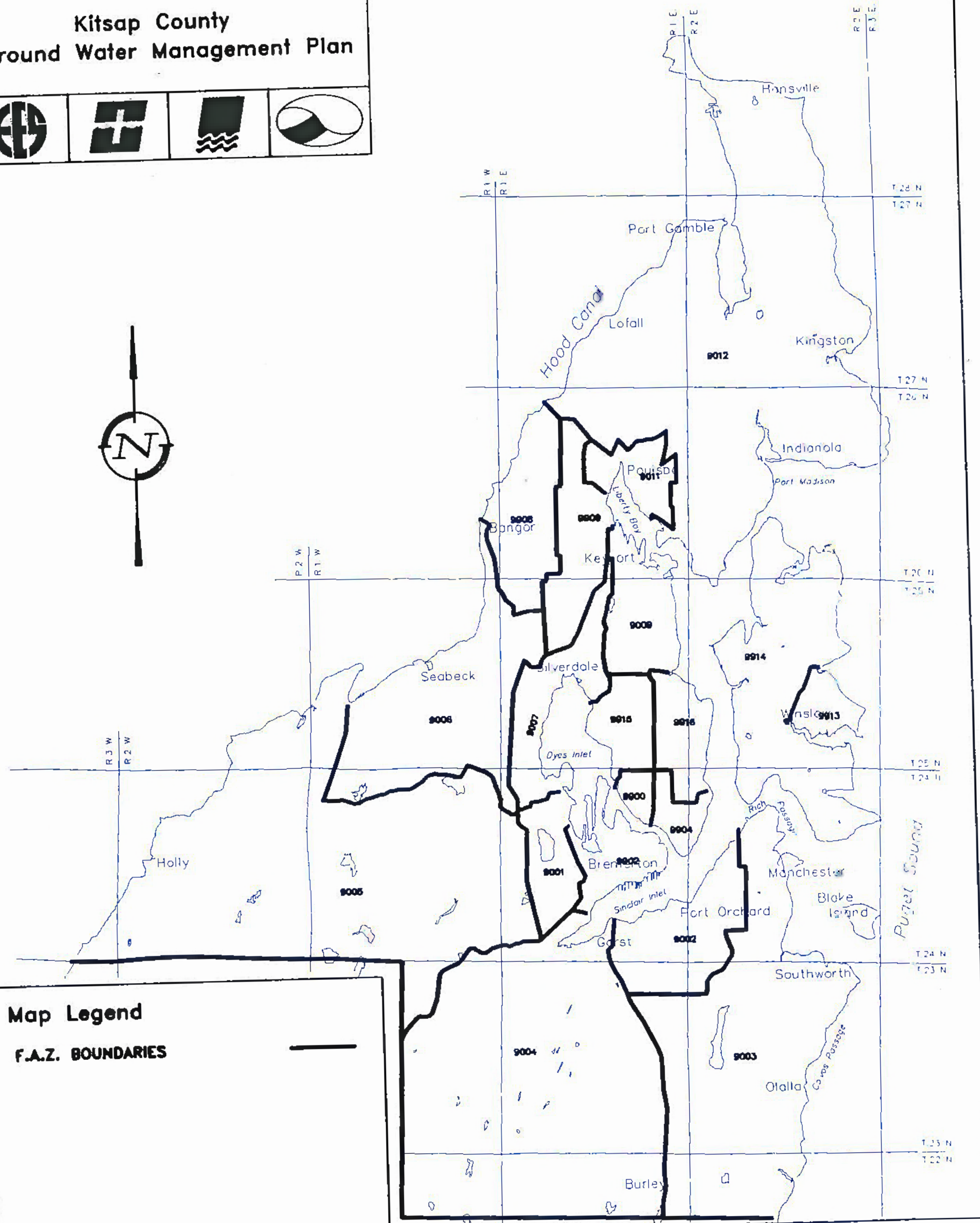
Other wells (non-waste)
- Monitoring wells
- Exploration wells

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



Map Legend

F.A.Z. BOUNDARIES

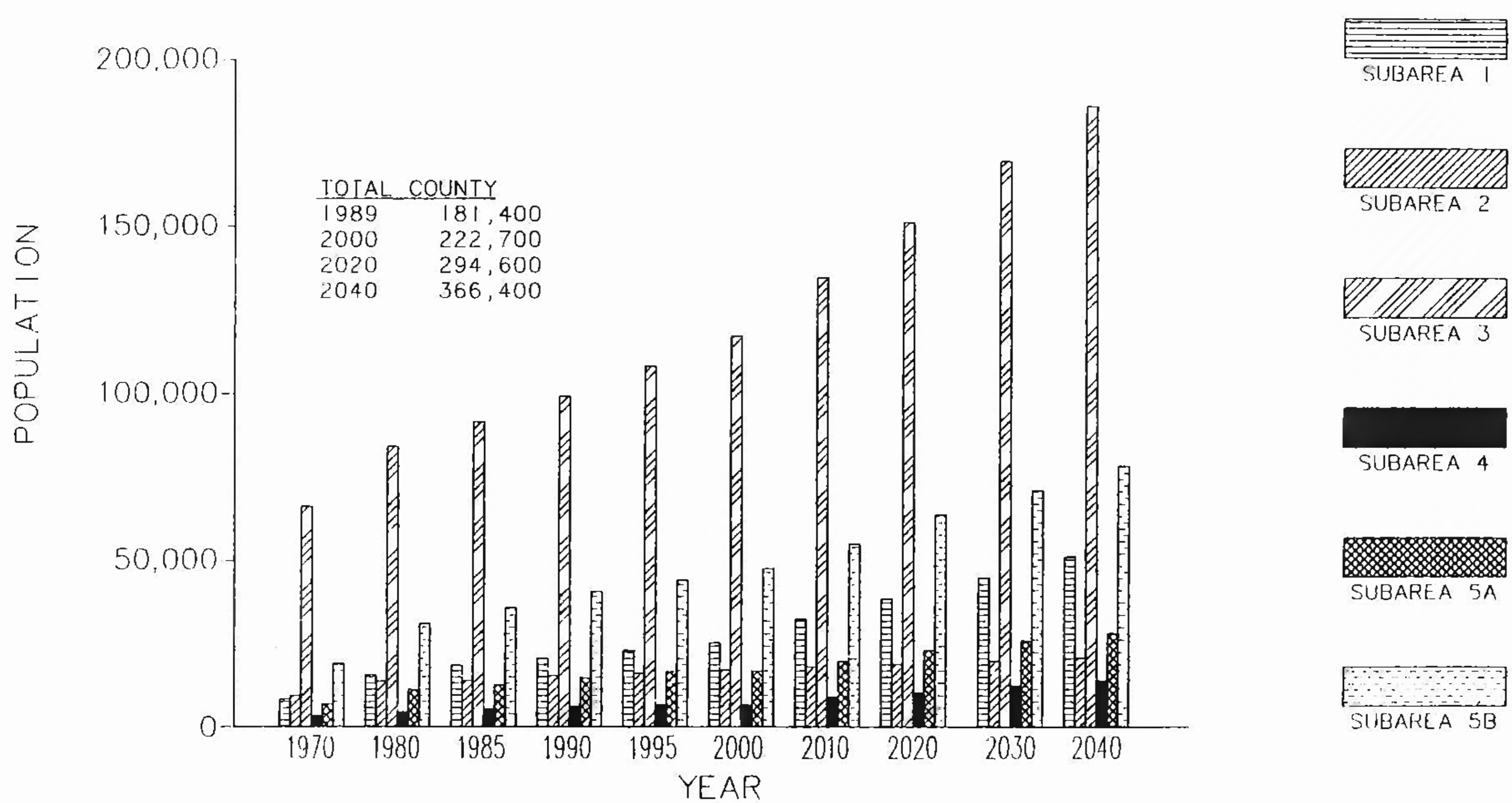
Scale in Miles 0 1 2 4

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

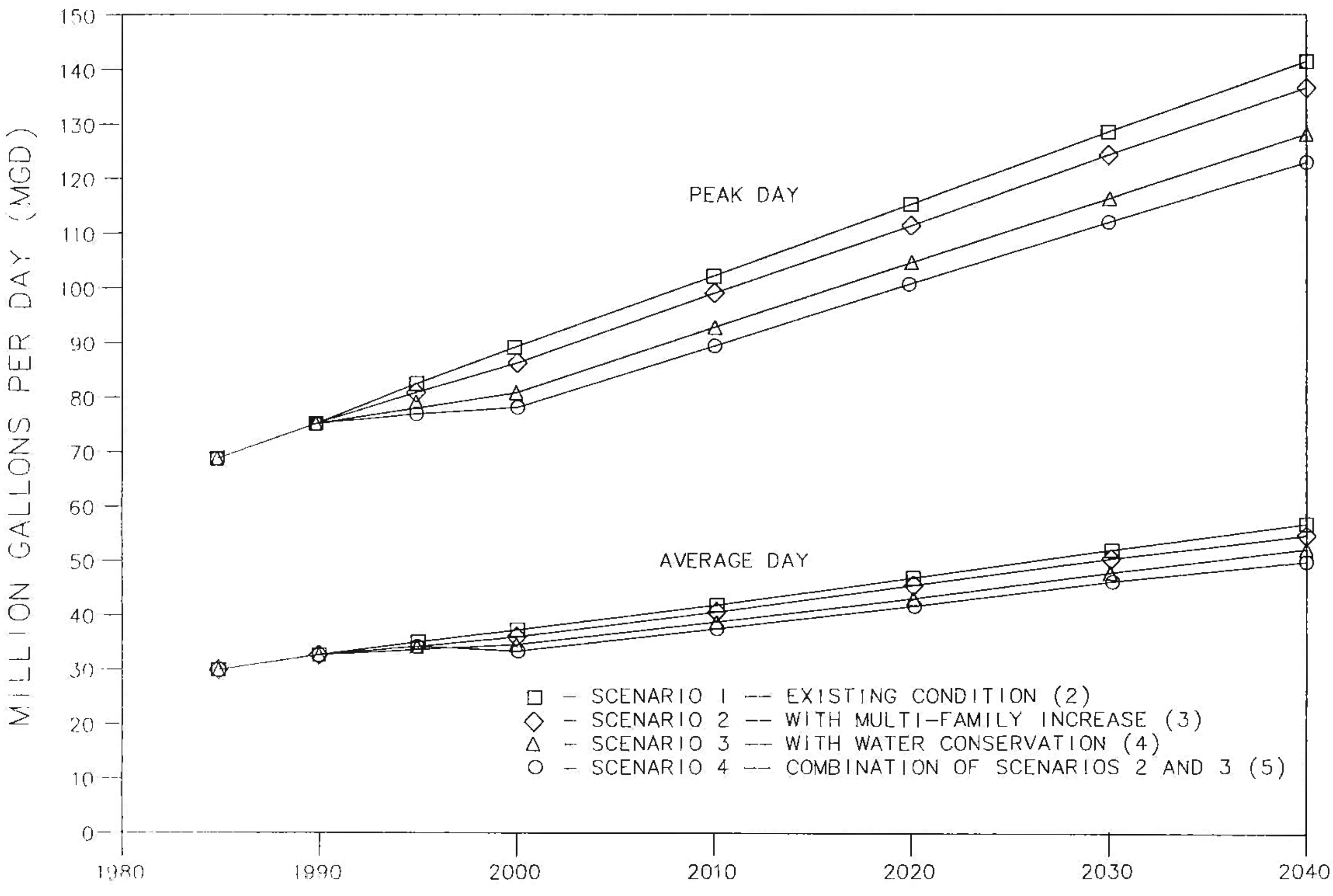
(2) STRAIGHT-LINE PROJECTION FORM 2020 TO 2040.

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.

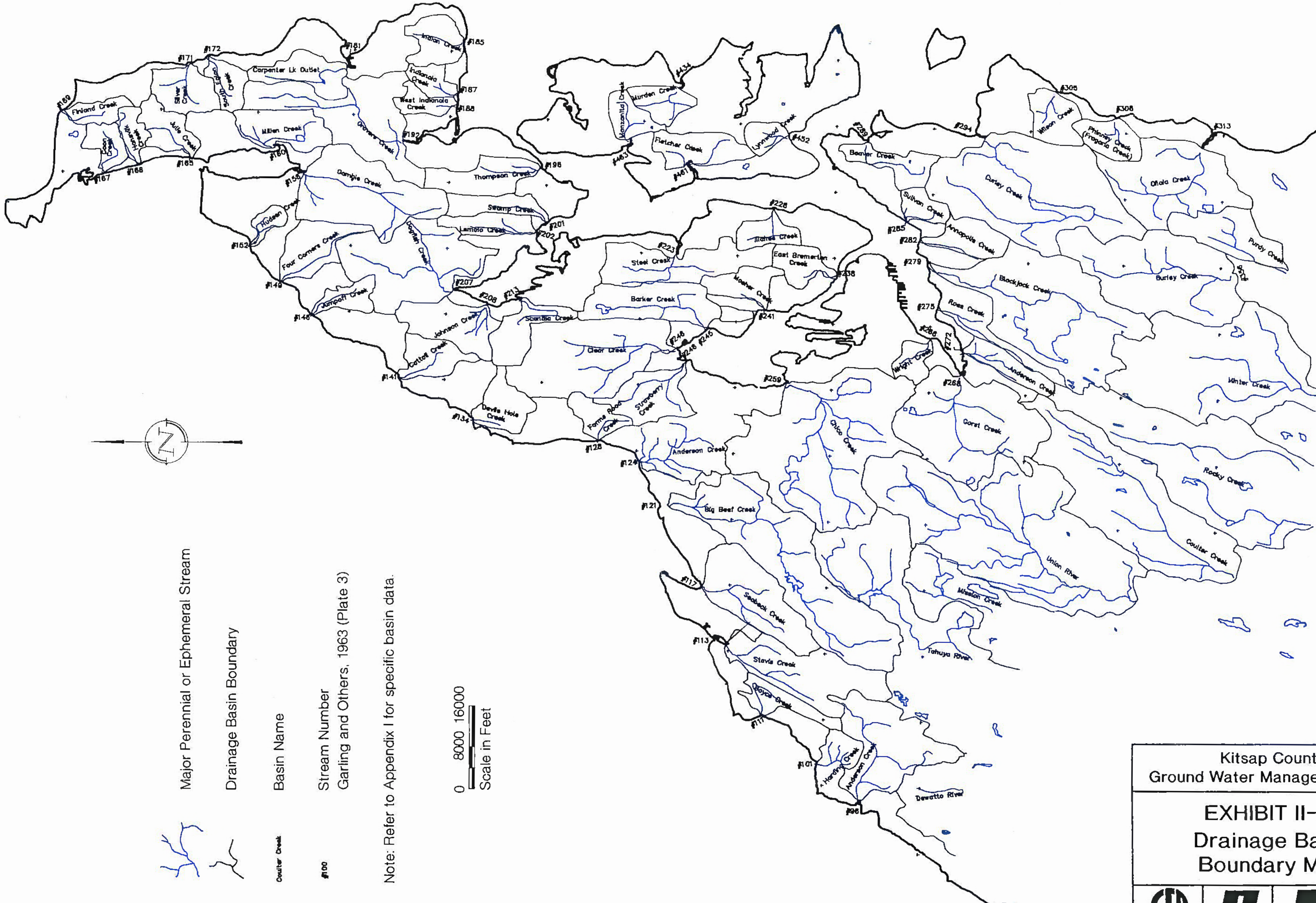
(2) Assumes the following average and peak gallons per capita per day (gpcd) demand for existing conditions for each area:

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.

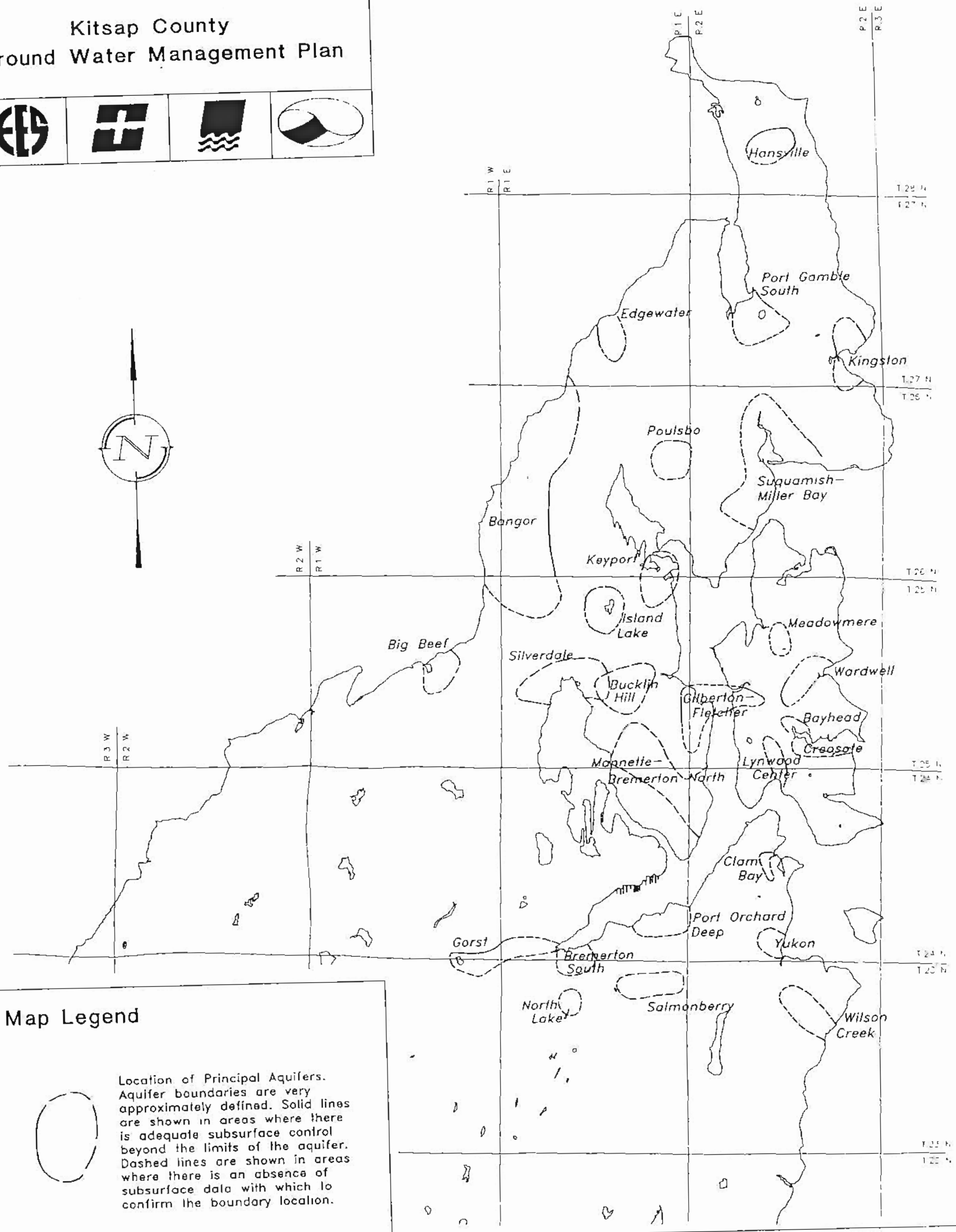
(5) Combination of (3) and (4).



Kitsap County
Ground Water Management Plan

EXHIBIT II-7
Drainage Basin Boundary Map

Kitsap County
Ground Water Management Plan



Map Legend

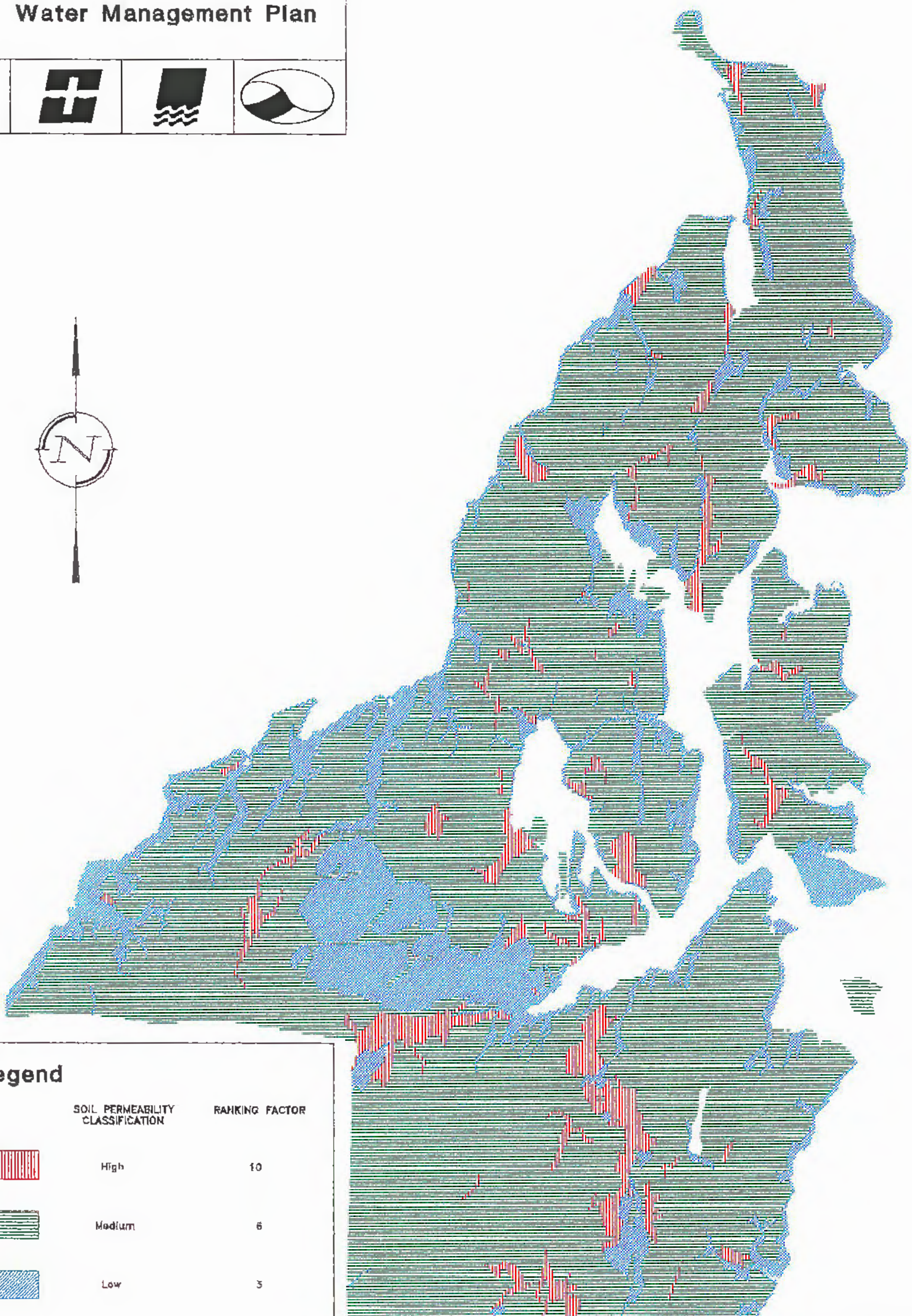
Location of Principal Aquifers. Aquifer boundaries are very approximately defined. Solid lines are shown in areas where there is adequate subsurface control beyond the limits of the aquifer. Dashed lines are shown in areas where there is an absence of subsurface data with which to confirm the boundary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

Scale in Miles
0 1 2 4

EXHIBIT II-8

Location of Principal Aquifers

Kitsap County
Ground Water Management Plan



Map Legend

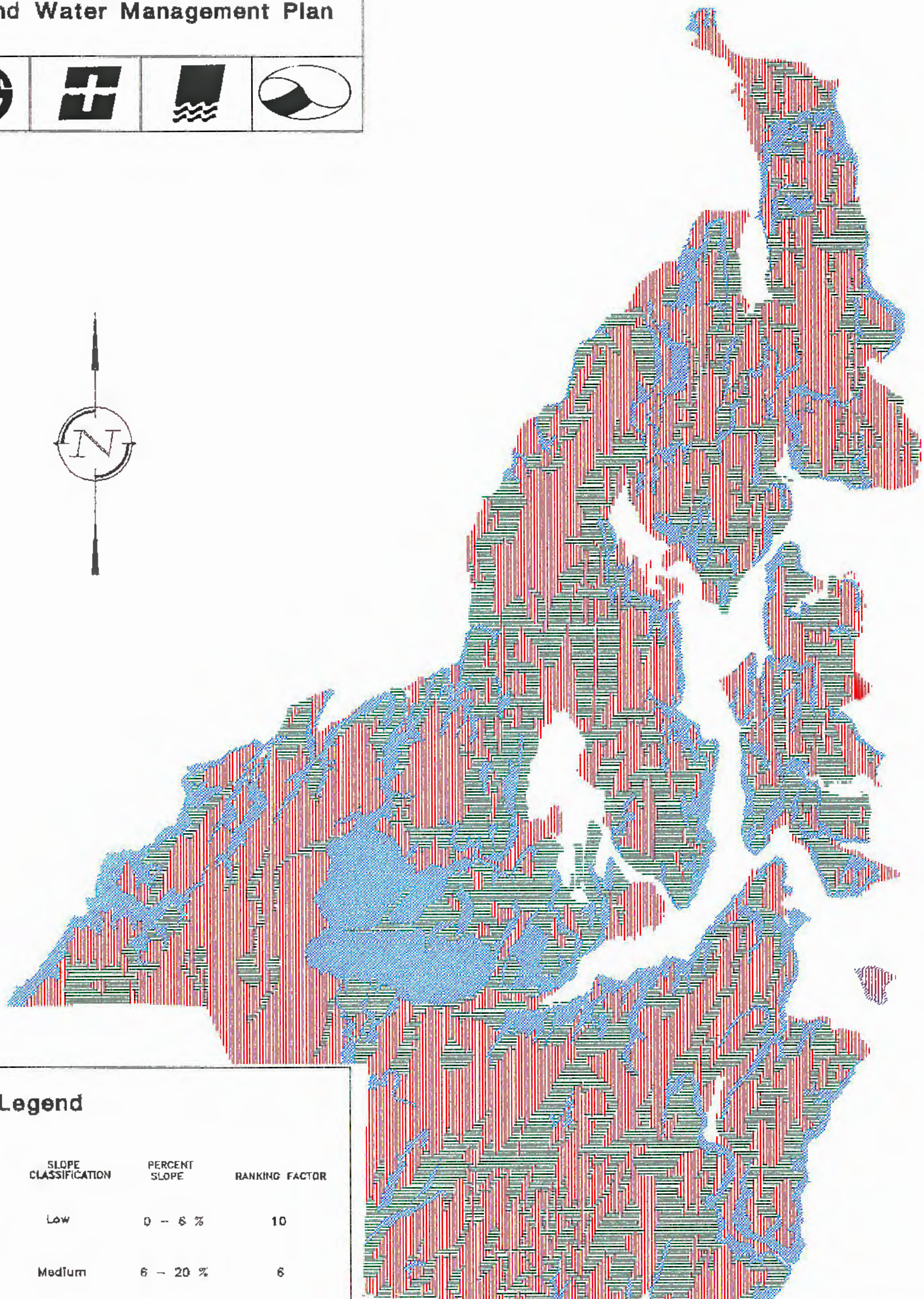
SOIL PERMEABILITY CLASSIFICATION	RANKING FACTOR
High	10
Medium	6
Low	3

Scale in Miles
0 1 2 4

EXHIBIT II-9

Distribution of Soil Permeability

Kitsap County
Ground Water Management Plan



Map Legend

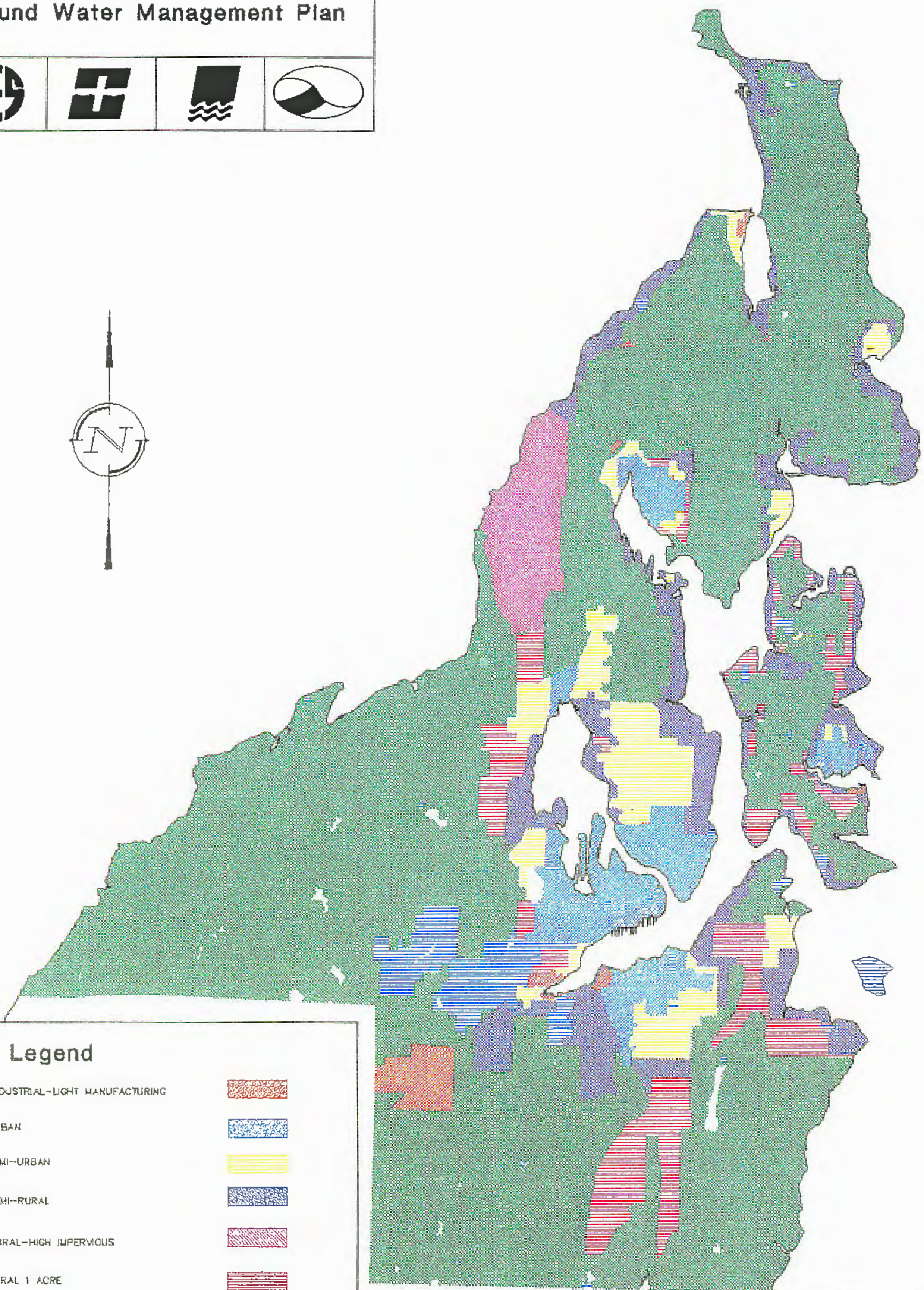
	SLOPE CLASSIFICATION	PERCENT SLOPE	RANKING FACTOR
(vertical red hatch)	Low	0 – 6 %	10
(horizontal green hatch)	Medium	6 – 20 %	6
(blue diagonal hatch)	High	> 20 %	3

Scale In Miles
0 1 2 4

EXHIBIT II–10

Distribution of Slope

Kitsap County
Ground Water Management Plan



Map Legend

- INDUSTRIAL–LIGHT MANUFACTURING
- URBAN
- SEMI–URBAN
- SEMI–RURAL
- RURAL–HIGH IMPERVIOUS
- RURAL 1 ACRE
- RURAL 2.5 ACRE
- PARKS AND WATERSHEDS

Scale In Miles
0 1 2 4

EXHIBIT II–11

Existing Land Use

Kitsap County
Ground Water Management Plan

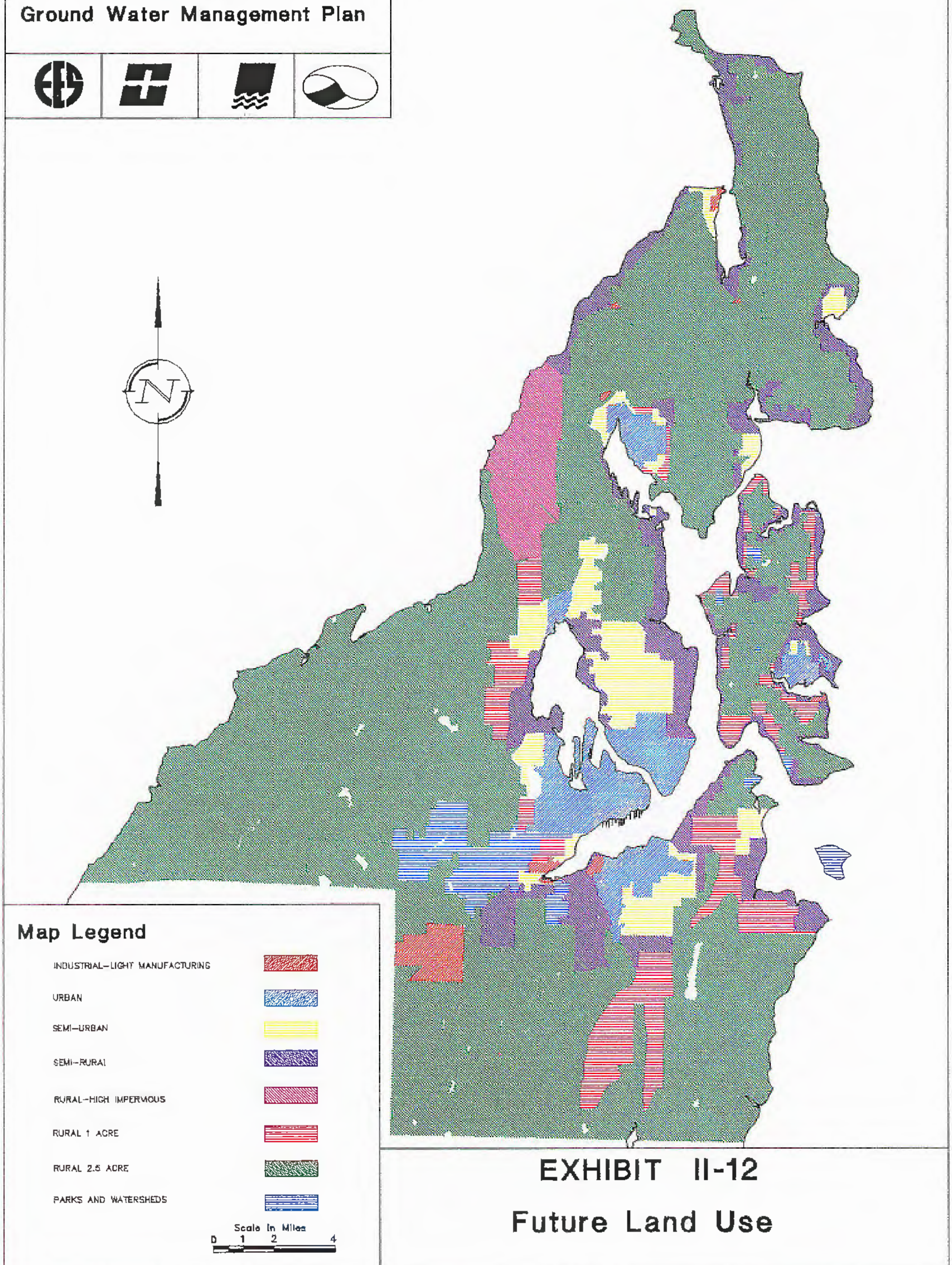
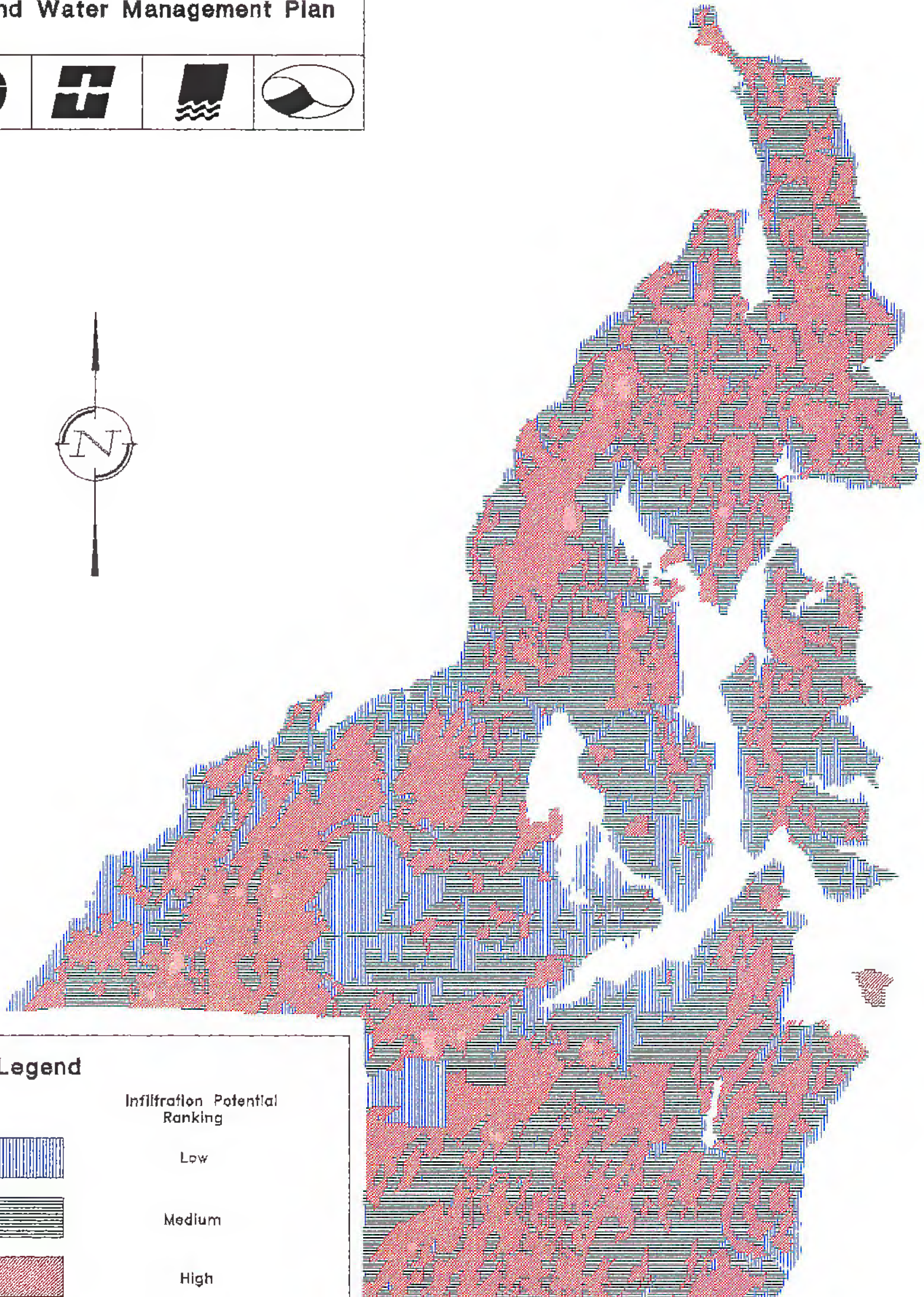


EXHIBIT II-12

Future Land Use

Kitsap County
Ground Water Management Plan



Map Legend

Infiltration Potential Ranking

- Low
- Medium
- High

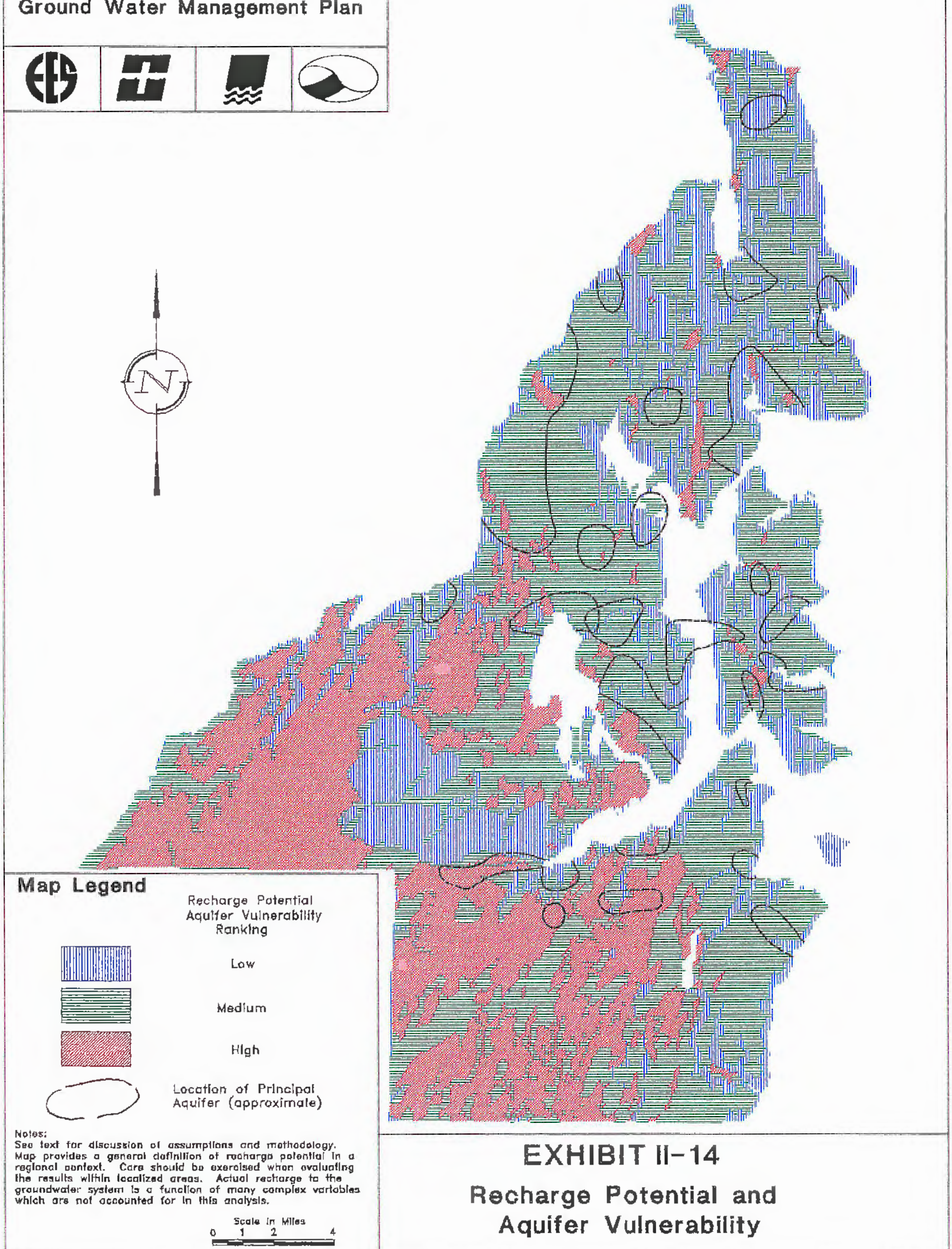
Notes:
See text for discussion of assumptions and methodology. Map provides a general definition of infiltration potential in a regional context. Care should be exercised when evaluating the results within localized areas. Actual infiltration to the groundwater system is a function of many complex variables 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



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

EXHIBIT II-14

Recharge Potential and Aquifer Vulnerability

Kitsap County Ground Water Management Plan

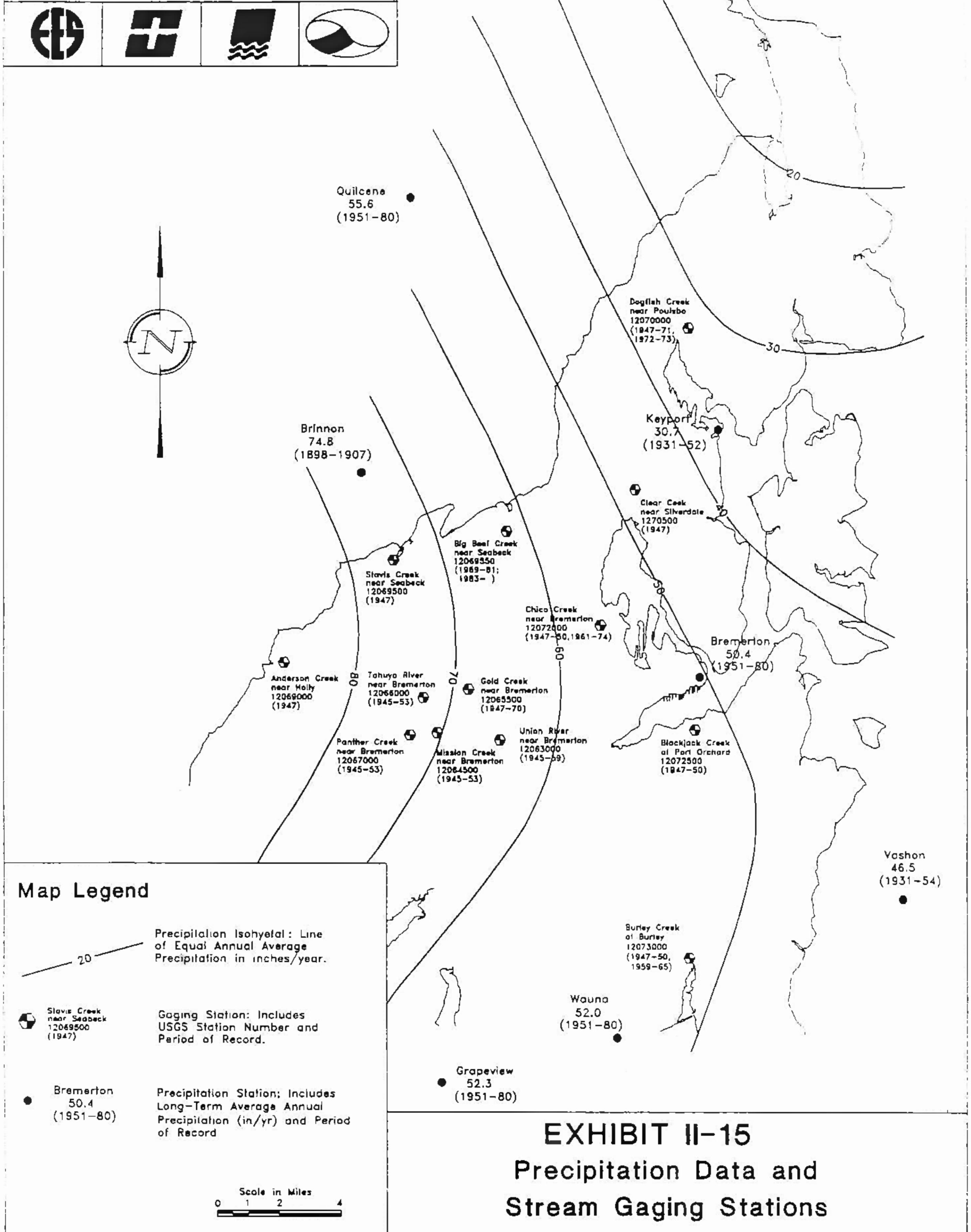
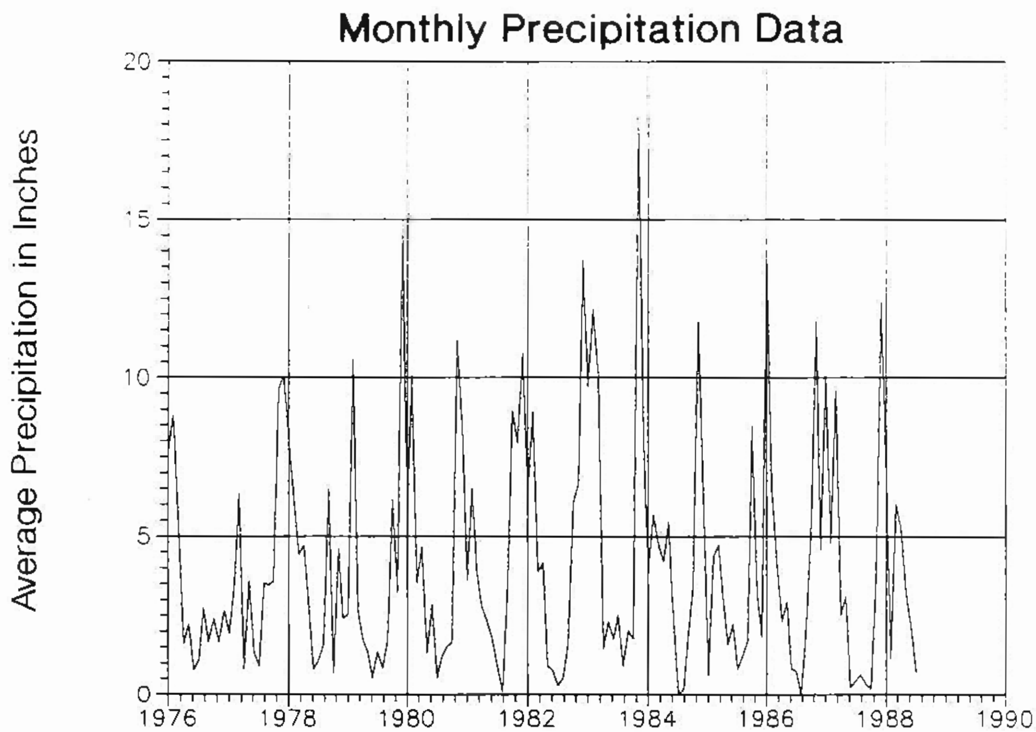


EXHIBIT II-15
Precipitation Data and Stream Gaging Stations

Kitsap County
Ground Water Management Plan



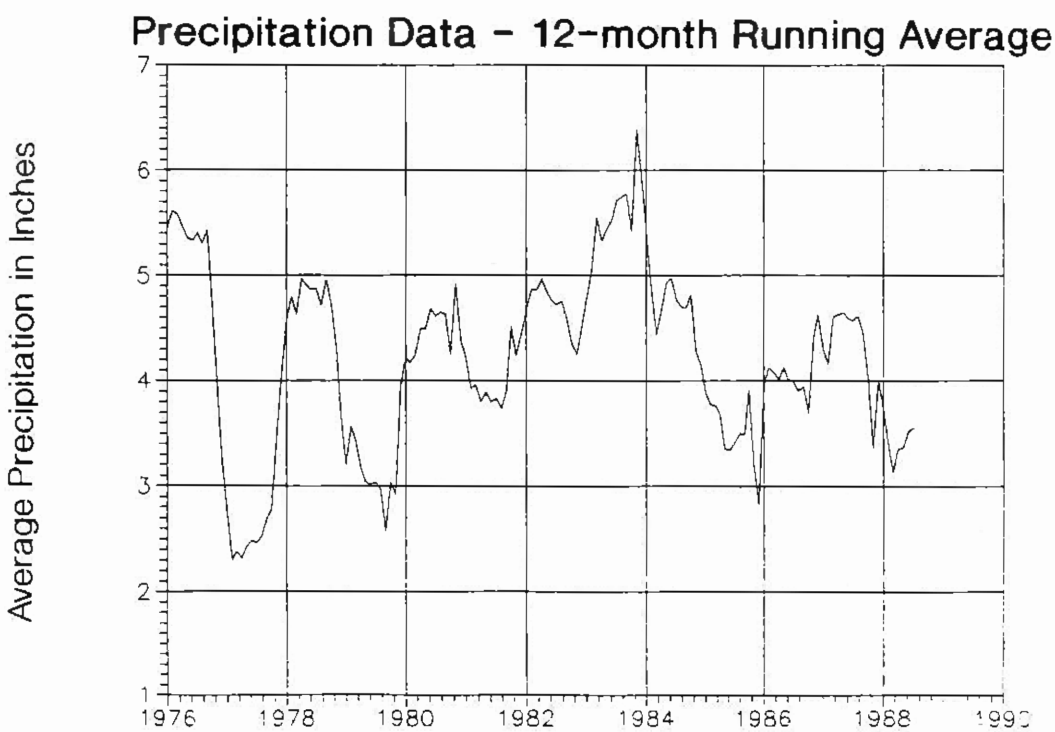
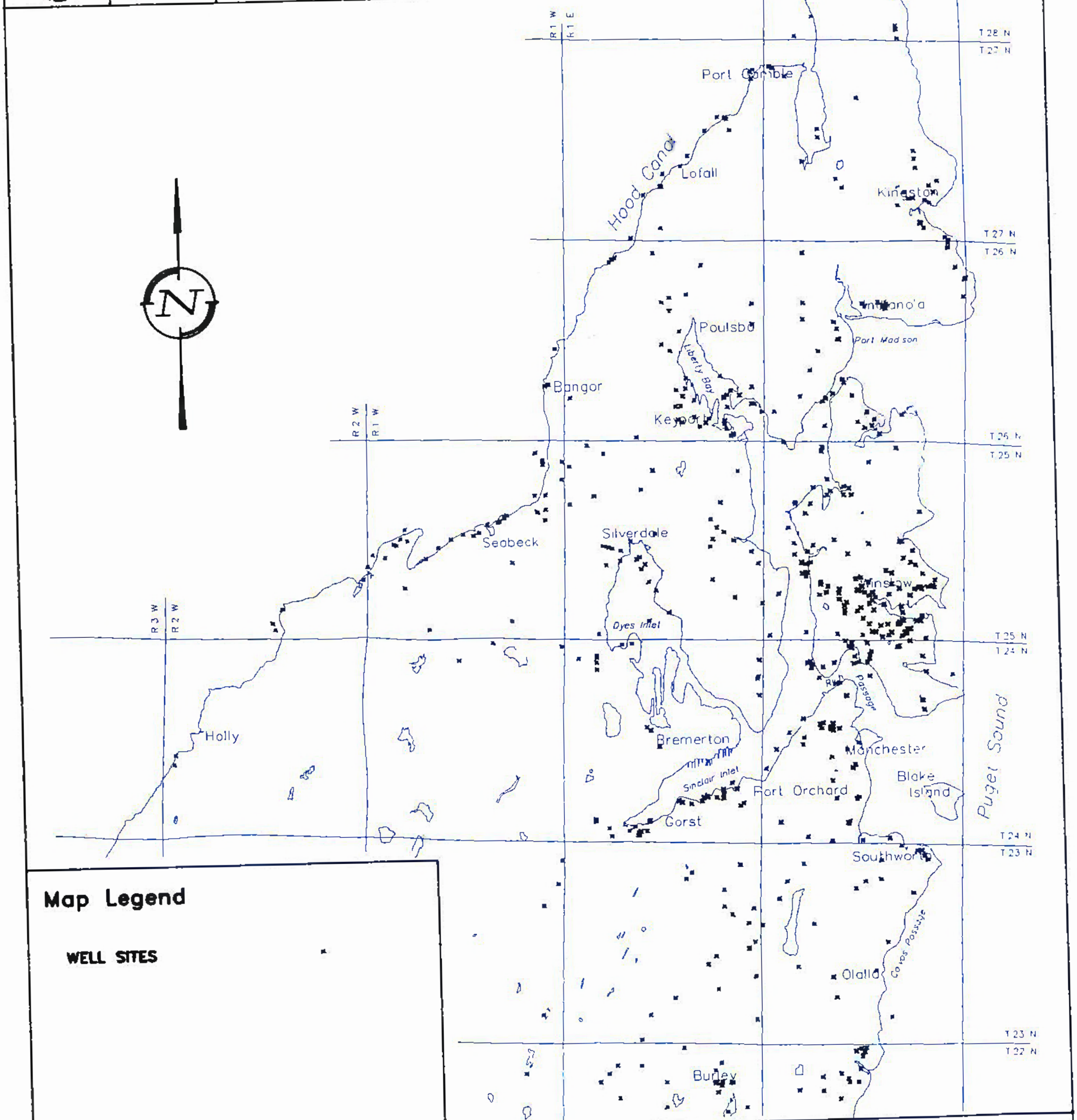


EXHIBIT II-16
Precipitation Trends
Bremerton Climatological Station - Kitsap County

Kitsap County
Ground Water Management Plan



Map Legend

WELL SITES

Scale in Miles
0 1 2 4

EXHIBIT II-17
WATER QUALITY DATABASE WELLS