NATURAL SYSTEMS APPENDIX

I. INTRODUCTION

This Appendix examines the natural environment in Kitsap County and provides a framework for understanding natural systems during the land use planning and regulatory process. The inventory is compiled from a variety of federal, state and local resource documents, as well as from notes taken from technical experts who presented information to the Kitsap County Planning Commission. Information from the inventory is displayed on a series of maps produced by the County's Geographic Information System.

The inventory begins with an overview of the county's location, topography, climate, vegetation and drainage patterns. This leads into a more detailed survey of natural systems and environmental factors. The inventory notes where complete information does not exist and will be revised as more information about natural systems becomes available. (Note: An inventory of the county's natural resource lands -- agricultural, forest and mineral -- is found in the Land Use Appendix)

Location

Kitsap County is centrally located in the Puget Sound region, on the northern Kitsap Peninsula. The Puget Sound borders Kitsap County on the north and east, while the shoreline of Hood Canal stretches along the western border. The county's political boundaries include both Blake and Bainbridge Islands on the east and adjoin the boundaries of Mason and Pierce counties to the south. Due in part to its close proximity to Seattle and Tacoma, and in part to the natural beauty of the peninsula, population growth trends in Kitsap County reflect the rapid growth characterizing most of the Puget Sound region.

Geology and Topography

In geological terms, the Kitsap Peninsula lies within a structural downfold, between the Olympic and Cascade mountain ranges. The principal rock formations underlying the county include basalt and sandstone formed millions of years ago and silt, sand, clay and gravel deposits left by ice flow and streams during glaciation about 13,000 years ago.

Meltwater streams emerging from the glacier deposited layers of gravel, sand and silt, while fine silts and clays were deposited in extensive lakes and ponds where drainages from the Cascade and Olympic mountain ranges were blocked. The ice sheet itself laid down till, an unsorted and unlayered, concrete-like mixture of silt, sand and cobbles. The ice, stream and lake deposits are known as glacial drift, which forms a broad plain across the county's lowlands. These broad formations are shown in **Figure A-NS-1,** Generalized Surficial Geology of Kitsap County (Molenaar, 1993).

FIGURE A-NS-1

Generalized Surficial Geology of Kitsap County

Much of the county is characterized by broad glacial-drift plain, with gently rolling hills. The area's topography was formed by the most recent glacier, a 3,000-foot-thick ice flow which molded long north/south trending terraces, valleys and troughs as it moved south. Elevation typically ranges between 100 to 400 feet, with the exception of the Green Mountain-Gold Mountain area a few miles west of Bremerton, where the highest peak reaches 1,761 feet. This greater relief is due to a 40- to 50-million-year-old basalt bedrock formation that withstood glaciation.

Throughout the county, kettle lakes can be found, i.e. lakes and ponds with no surface inlets or outlets. These water bodies, like Island Lake, formed where large chunks of ice were stranded as the glacier receded north.

Kitsap County's saltwater shorelines stretch over 228 miles, extending along bays and inlets. The coastline is interspersed with steep sea cliffs and gently rolling lands and is dotted with small estuaries where streams empty their freshwater loads.

Cimate

The climate in Kitsap County reflects the moderating influence of Puget Sound and the Pacific Ocean. During the county''s mild, wet winters, the average temperature is 40-50E F during the day and 30-40E F at night. During the fairly warm summer, the temperature ranges between 70-80E F during the day and 50-60E F at night.

The county receives an annual average of 50 inches of precipitation, 80% of which typically falls in October through March. The prevailing winds blow from the south-southwest, and the amount of moisture they carry is affected by the presence of the Olympic Mountains. Because of the "rain shadow" effect, precipitation volumes vary greatly throughout the county. Per **Figure A-NS-2,** precipitation in the northern end averages 26 inches annually, while precipitation may total over 70 inches annually in some areas in the south. This variation in rainfall causes different areas of the county to experience dissimilar aquifer recharge rates, stream flows and suitability for forestry and agriculture.

The average seasonal snowfall is nine inches. In most winters, one or two storms bring strong winds and sometimes heavy rains, which may damage trees, buildings and utility lines and may cause flooding. During the normally dry summer, thunderstorms typically occur about seven times.

Vegetation

Before the arrival of non-native settlers, old-growth Douglas fir and red cedar forest blanketed much of Kitsap County. The remnants of this forest, cleared at the turn of the century, can be seen only in the enormous stumps which dot the county's second-growth forest lands. Most of the county's mature forests are dominated by Douglas fir, a species well adapted to the local climate. Other common coniferous species include Western hemlock, Western red cedar and Western white pine. Ocean spray, Evergreen huckleberry and ferns are among the shrubs and plants found in the understory.

Throughout the county, human activities have increased the range of deciduous vegetation, which successfully competes with conifers in cleared and urban areas. Red alder and big-leaf maple are the

most familiar components of broadleaf forests, but Pacific willow, Madrona and Cascara are also commonly found. Understory species include salmonberry, blackcap, red elderberry and sword fern. Pastures and meadows typify the county's valleys and low-lying areas. These places may support agricultural crops or may host woody vegetation, grasses, salmonberry, blackcap, ox-eye daisy, sword fern, rushes and wildflowers. A variety of wetland types exist in these pastures as well as other environments and sustain vegetation such as alder, willow and reedgrass adapted to the hydric soils and wet surroundings.

Drainage Patterns

Most of Kitsap County's surface drainage is influenced by glacially formed topography or by large channels that were the sites of glacial meltwater streams. The county's permeable upper soils (a product of glaciation) combine with cool, wet winters to produce relatively low surface water runoff and saturation of the lower part of the soil profile. This leads to a high potential for groundwater recharge and low runoff to streams.

The low runoff levels and short distances to marine waters contribute to a dearth of large river or stream systems. More than 80 drainage basins have been identified throughout the county, most of which are characterized by small streams that empty directly into Hood Canal or Puget Sound, with intermittent tributaries fed by springs. Two small river systems, the Union and Tahuya Rivers, drain the Green and Gold mountains area.

Due to the small sizes of streams, most floodplains in Kitsap County are narrow and the probability of catastrophic flooding is low. Many of the streams provide critical fish and wildlife habitat, with small salmon populations scattered throughout the county combining to total a significant countywide fish resource.

II. GEOLOGICALLY CRITICAL AREAS

Geologically critical areas are places highly susceptible to erosion, landslides, earthquakes or other geologic events. In Kitsap County, the most hazardous of these areas are typically found along the marine shoreline, stream ravines and the steep slopes of Gold and Green mountains. In many cases, these areas may be extremely desirable for development because of their scenic views or water and beach access, but their development may endanger people, property and surface water resources.

Because of the potential threats associated with land use activities in geologically critical areas, hazardous conditions must be identified in the land use planning process and addressed in associated regulations. This inventory summarizes the characteristics of geologically critical areas and concludes with a designation of those areas which, given existing information, should be considered hazardous for public health and safety reasons.

Information for this inventory is derived from a number of federal, state and local sources, most notably the U.S. Natural Resources Conservation Service, the Coastal Zone Atlas of Washington State and a study known as the Quaternary Geology and Stratigraphy of Kitsap County, Washington. Despite these sources, countywide information about geologically critical areas is incomplete and as more data about geologic conditions in Kitsap County becomes known, designations and regulations will be subject to change.

Characteristics of Geologically Critical Areas

In Kitsap County, three types of geologically critical areas exist: landslide hazard areas, erosion hazard areas, and seismic hazard areas. (In other regions, volcanic hazards and mine hazards may be considered geologically critical, but these two types of hazards are not known to exist in Kitsap County.) This section reviews the causes of these hazardous areas and describes criteria suitable for identifying them.

Landslide Hazard Areas

Causes: The geology and climate of Kitsap County contribute to its potential for landslides. Thousands of years ago, glaciation deposited unconsolidated materials over the bedrock of much of the area. Subsequent glacial meltwater, streams and wave actions sculpted these unconsolidated materials into steep ravines and bluffs. When rain or groundwater permeate the unconsolidated materials on or at the top of slopes, landslides can occur. Almost all landslides in the Puget Sound region are triggered by excessive groundwater.

A common type of landslide, occurring on bluffs, is a slump. A slump occurs when the upper bluff is pervious sand and the lower bluff is compact silt or clay. Rainwater saturates the ground, moves down through the sand, concentrates at the sand/silt contact and moves laterally to the nearest bluff, causing the ground above it to slump. The slumped and saturated upper bank material turns into mud and flows down and over the steep but still intact lower bluff, carrying trees and rocks with it.

Debris avalanches, or shallow slides, can occur when the soils underlying the uppermost sediments become saturated. Where the slope is steep enough, the smooth surface of the underlying clay or silt may become a slide plane. A single storm, or even storm drainage from a single lot, may trigger these shallow slides.

A landslide can also occur when a slope composed of unconsolidated materials is undercut or steepened by human or erosional activities and the slope fails. This situation is occasionally seen where roads cut through steep slopes and can also occur when waves undercut shoreline slopes during winter storms.

Because many of the landslides in Kitsap County are induced by excessive groundwater, most landslides become mudflow during some or all of their travel. Due to their viscosity and weight, mudflows are capable of great destruction, and can move logs, roadbeds and even houses. Notoriously destructive mudflows in Kitsap County have occurred in recent years at Fragaria, Applecove Point and along Highway 160 (Beach Dr.) in Port Orchard.

Landslides, while also occurring naturally, can be exacerbated by human activities like removal of vegetation, increase in stormwater runoff, undercutting of slopes, on-site sewage system discharge and increased burden at the top and base of slopes caused by buildings.

Criteria for Identification: Potential landslide hazard areas can be identified based upon geology, hydrology, slope or the evidence of historical slide activity. More specifically, these landslide hazard areas may include the following characteristics:

1. An area characterized by all three of the following characteristics: slopes greater than 15%; hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; springs or groundwater seepage; or

2. Areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of that epoch.

3. Slopes that are parallel or sub-parallel to planes of weakness (such as bedding planes, joint systems and fault planes) in subsurface materials; or

4. Slopes with gradients steeper than 80% subject to rockfall during seismic shaking; or

5. Slopes potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action.

6. Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding.

7. Any area with a slope of 40% or greater and with a vertical relief of 10 or more feet except areas composed of consolidated rock.

8. Areas classified by the Coastal Zone Atlas of Washington or by the Quaternary Geology and Stratigraphy of Kitsap County as unstable, unstable recent slide or unstable old slide (See **Table A-NS-1**).

Areas identified by any of these characteristics may be unsuitable for building or development. Property located at both the top and toe of hazardous slopes may contribute to and be damaged by slide activities. Roads through slide areas are also susceptible and may represent potential threats to vehicle safety and traffic patterns. Development along hazardous marine bluffs may increase the potential for slides to occur, resulting in harm to beach habitat and shellfish beds. Land use activities at the top of stream ravines may provoke landslides, leading to stream habitat destruction and flooding.

TABLE A-NS-1 Classifications of Unstable Slide Areas

CATEGORY (MAP SYMBOL)	CRITERIA
Intermediate$_1$	Slopes between 15% and 30%, including slopes in sand, gravel, till and thin soil over bedrock, without known failures.
Intermediate$_2$	Slopes greater than 30%, including slopes in sand, gravel, till and thin soil over bedrock, without known failures.
Unstable (U)	Slopes considered unstable due to geologic, groundwater, slope or erosional factors. Includes areas of talus and landslides too small to be individually categorized.
Unstable Recent Slide (URS)	Recent or historically active landslide.
Unstable Old Slide (UOS)	Old, post-glacial but prehistoric slides.
Modified Slopes (M)	Slopes highly modified by man, including areas of significant excavation and filling.

Erosion Hazard Areas

Causes: The term "erosion" encompasses all natural processes by which soil and rock are moved by wind, water and gravity on the earth's surface. Erosion hazard areas are places susceptible to mass erosion due to soil conditions or wind and water actions. Mass erosion can pose threats to property by instigating landslides, as when slopes and bluffs are undermined by stream or wave erosion; and can affect water quality and quantity, as when sediment from hillsides are deposited in streams or marine waters.

Some soils are highly susceptible to erosion by rain, wind, stream flow or frost action. These soils may not bind well to themselves or may not have the chemical or physical properties to absorb excess amounts of water. In some cases, soil may not be susceptible to erosion until vegetative cover is removed. When vegetative cover is absent from certain types of soils, sheet erosion (when soils slide off the land as a sheet) and rill erosion (the creation of a steep-sided channel several inches deep) may occur.

Along marine shorelines, winter storm waves wear away at exposed banks. This may lead to the undercutting and steepening of shoreline slopes and may result in slope instability and landslides.

Criteria for Identification: Potential erosion hazard areas can be identified using the following:

1. The Natural Resources Conservation Service's classification of highly erodible and potentially highly erodible soils with slopes greater than 15%, as listed in **Table A-NS_2.** All soils considered highly erodible have slopes greater than 15%. The general locations of these soils in Kitsap County have been determined by the U.S. Natural Resources Conservation Service.

TABLE A-NS-2 Soils And Potentially Highly Erodible Soils With Slopes Greater Than 15%

SYMBOL	SOIL TYPE (Slope)	ACRES
10	Dystric Xerortnents (45 - 70%)	12,300
17	Harstine (30 - 45%)	1,900
21	Indianola-Kitsap Complex (45 - 70%)	7,550
26	Kilchis (30 - 70%)	5,100
27	Kilchis, Shelton Complex (30 - 50%)	2,390
31	Kitsap (30 - 45%)	540
48	Schneider (45 - 70%)	1,490
54	Shelton (30 - 45%)	1,440
3	Alderwood (15 - 30%)	8,080
25	Kilchis (15 - 30%)	1,890
46	Ragnar (15 - 30%)	3,490
53	Shelton (15 - 30%)	3,290
9	Cathcart (15 - 30%)	370
13	Grove (15 - 30%)	570
16	Harstine (15 - 30%)	6,600
20	Indianola (15 - 30%)	1,640
30	Kitsap (15 - 30%)	1,670
36	Neilton (15 - 30%)	1,470
41	Poulsbo (15 - 30%)	2,170
47	Ragnar-Poulsbo (15 - 30%)	3,170
57	Shelton (15 - 30%)	930
61	Sinclair (15 - 30%)	590
	TOTAL ACRES	**68,640**

Source: U.S. Natural Resources Conservation Service, Soil Survey of Kitsap County Area, Washington, September 1980

2. Areas subject to intense erosion may also be identified as landslide hazard areas by the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County.

Because soil erosion problems are frequently caused by land use activities, site-specific topography and drainage are often as important as the natural erodibility of the soil in determining susceptibility to erosion. Standard construction techniques and appropriate permanent stormwater drainage designs can be used to greatly reduce the risk of erosion damage.

Seismic Hazard Areas

Causes: Regional forces related to temperature differences inside the earth produce slow movements of continent-sized slabs of rock called plates. Off the Washington coast, three plates converge and the forces created by this movement cause rocks to suddenly break and slip. The ground shaking from the sudden slip is called an earthquake. In the Puget Sound area, damaging earthquakes appear to occur about every 30 years.

While the likelihood of a serious earthquake is unknown, precautions can be taken to lessen the amount of damage incurred as a result of earthquake-induced ground shaking, slope failure, settlement, soil liquification, or surface faulting. Some areas are more prone to damage than others, and are known as seismic hazard areas. They include places prone to landslides, areas with hydric soils and fill areas. Hydric soils and fill areas may undergo liquification when vibrated and thus may not provide sufficient support for structures or equipment.

Criteria for Identification: the following areas may be at higher risk of damage caused by seismic activity:

1. Places with historic earthquake damage. While no historical evidence exists of a massive earthquake in Puget Sound during the past 200 years, geologic evidence indicates that massive earthquakes have occurred in the region.

2. Areas along fault lines. The only known fault in Kitsap County extends from Restoration Point on the southern tip of Bainbridge Island through downtown Seattle.

3. Areas with hydric soils. Hydric soils occur throughout Kitsap County and have been identified by the Natural Resources Conservation Service. Their location is discussed in more detail in the wetlands section of the natural systems inventory.

4. Areas that have been filled with additional soil materials to enhance buildability. In many cases these are former wetland areas or areas with small slopes.

5. Slopes subject to landslides. The criteria to determine these areas are listed above in the discussion of landslide hazard areas.

While earthquake damage can be minimized by avoiding high-density development in areas highly susceptible to seismic activity, the threat of damage can also be avoided through proper engineering and construction practices.

Designations of Geologically Critical Areas

For comprehensive planning purposes, areas that may be geologically unstable must be designated as critical areas. In some areas, incompatible residential, commercial or industrial development in these areas should be avoided for the protection of public health and safety. In some cases, geological hazards can be reduced or mitigated by engineering, design or modified construction practices, so that risks are diminished.

While detailed geological data about Kitsap County is not available, three sources of information exist that can be used to estimate the location of geologically critical areas: the Coastal Zone Atlas of Washington (Department of Ecology) and the Soil Survey of Kitsap County (US Natural Resources Conservation Service). These sources provide information on slope stability, erodible soils and hydric soils.

Because of the amount of overlap that exists between landslide, erosion and seismic hazard areas, this section separtes geologically sensitive areas into two broad categories based on potential threats. These two categories and the criteria that comprise them are listed below and are mapped in **Figure A-NS-3**. As more information about the geology of Kitsap County becomes available, these designations may be revisited.

Geologically Hazardous Areas

1. Areas with slopes greater than 30% (see **Table A- NS-2**) and mapped by the Coastal Zone Atlas or the Quaternary Geology and Stratigraphy of Kitsap County as U (Unstable), UOS (Unstable Old Slides) or URS (Unstable Recent Slides) as defined in **Table A-NS-1**. (These places could be extremely hazardous due to landslide, erosion or seismic activities); or

2. Areas deemed, by a qualified Geologist, to meet the criteria of U, UOS, or the URS.

Because of the high hazardous potential associated with these areas, they should generally be considered unsafe for construction and the development in these areas should be avoided.

Areas of Geologic Concern

1. Areas designated Unstable in the Coastal Zone Atlas or Quaternary Geology and Stratigraphy of Kitsap County, with slopes less than 30%; or areas found by a qualified geologist to meet the criteria; or

2. Slopes identified as Intermediate (I) on the Coastal Zone Atlas or the Quaternary Geology and Stratigraphy of Kitsap County as defined in **Table A-NS-1**; or areas found by a qualified geologist to meet the criteria of I; or

3. Slopes 15% or greater, with soils classified as “high” or “potentially highly erodible;” or

4. Hydric soils as identified by the U.S. Natural Resources Conservation Service; or

5. Areas that have been filled with additional soil materials to enhance buildability. In many cases these are former wetland areas or areas with small slopes.

Areas of geologic concern are likely to present geological risks for development and construction. Land Use activities within and adjacent to these areas will be carefully reviewed and mitigative measures may be required.

III. SOIL SUITABILITY

Soil is a loose mass of chemically weathered rock fragments mixed with organic matter. It plays a vital role in supporting vegetation and filtering water and is thus a key component of Kitsap County's natural systems. There are 63 kinds of soils in Kitsap County, which differ in depth, structure, moisture, organic content, steepness of slopes and other chemical and physical properties.

Soils can vary greatly within short distances and lay in patterns that reflect the county' topography and geological history. The parent rock material from which soil weathers has the greatest influence on its characteristics. Throughout most of the county, the parent rock is glacial, deposited by an ice flow over 13,000 years ago. However, the sedimentary bedrock found at Bremerton, Bainbridge Island and Waterman Point yields a distinct family of soils, as does the basalt bedrock of Gold and Green mountains.
The unique characteristics of each soil type make some soils more suitable for different land uses than others. This section on suitable soils discusses the relationships between soils and agriculture, forestry and on-site sewage systems and identifies the location of soil types compatible with these activities.

The 1977 Soil Survey of Kitsap County, provides much of the information discussed below. The U.S. Department of Agriculture's Natural Resources Conservation Service compiled this information and it represents the most comprehensive evaluation of soils available. As more precise information about Kitsap County's soils becomes known, this section of the natural systems inventory will be reevaluated.

Agriculture

Prime Soil Characteristics

The Natural Resources Conservation Service lists seven Kitsap County soils as "prime" for agriculture due to their temperature, salinity, erodibility, permeability, texture, ability to hold water and acidity/alkalinity. These characteristics are influenced mostly by parent material, organic content, slope and climate. When combined with an adequate growing season and moisture supply, soils identified as "prime" can economically support sustained yields of crops with minimal treatment.

Prime agricultural soils comprise about 15,020 acres of Kitsap County, less than 4% of the county's total area (**Table A-NS-3**). As shown in **Figure A-NS-4**, these soils are scattered throughout the county, predominantly in flat areas adjacent to streams or rivers. Five of the seven "prime" soil types are considered hydric, and must be drained to be productive farmland.

Not all prime soils are currently used for agriculture, nor are they all available for agricultural use. In some prime farm soil areas, such as Big Valley and upper Clear Creek, farms dot the landscape. In other places, prime agricultural soils may instead host stands of trees or may be covered by commercial or residential development.

TABLE A-NS-3
Prime Farmland Soils in Kitsap County

Soil	Acres
Belfast Loam	530
Bellingham	880
Kitsap	2,310
Mukilteo	1,320
Norma	7,700
Semiahmoo	1,320
Shalcar	960
TOTAL	15,020

Land Use Implications

Prime soils are only one indicator of the land's suitability for farming. Commercially successful agriculture may also require large tracts of land in which to grow crops or graze animals. The relative scarcity of prime soils in sizeable, contiguous parcels inhibits large-scale commercial agriculture in Kitsap County. Smaller ventures located in areas with prime soils may successfully yield crops and provide supplementary income to the landowner. Farms with poorer soils can also successfully produce commercial farm goods if existing soils are improved (i.e., fertilizer, grading or rock removal), or if the enterprise is not soil-dependent (like poultry raising, egg production and animal breeding).

The presence of prime agricultural soils indicates that an area may have the capacity to efficiently and economically provide a source of food. This opportunity may be permanently lost when prime farm soils undergo excessive erosion or are otherwise modified or used by development. To maintain an agricultural base in Kitsap County, therefore, it is important to identify where these soils exist and to encourage their use for agricultural production.

Forestry

Prime Forest Soil Characteristics

Soils capable of growing trees for commercial forest production generally are located in climates with enough moisture to sustain tree growth and have a moderate soil temperature regime and an adequate supply of nutrients. Two means of measuring soil productivity for timber exist, both of which are based upon the quantity of tree growth that can occur in a soil. These rating systems are discussed below.

Culmination Mean Annual Increment: The U.S. Natural Resources Conservation Service identifies prime timberland soils nationwide as those not presently in urban or built-up land uses and capable of producing wood fiber at a culmination of mean annual increment (CMAI) of 85 cubic feet per acre. Approximately 34% of the commercial timberland in the United States, representing 48% of the productive capacity of forestlands, has a CMAI or 85 or higher. Most Kitsap County soils, and indeed most soils in western Washington, meet this national standard for prime timberland.

Soil Site Index: Both the Natural Resources Conservation Service and the Department of Natural Resources rate the soils of Kitsap County for commercial timber productivity based upon the 50-year "site index" for each soil unit. The site index of a soil type refers to the potential productivity of merchantable or "common" trees (those trees generally favored by foresters based on growth rate, quality and value) by measuring the average height in feet that dominant and co-dominant trees of commercial species attain in 50 years. Soil site indexes in western Washington are typically based upon the Douglas fir. The higher the site index, the taller the tree, indicating a more productive soil.

The site index applies to fully stocked, even-aged unmanaged stands. It is just one measurement of an area's productivity -- it does not take into consideration ease of mechanical harvesting due to slope, erodibility, urban or rural development influences or other factors important to commercial timber production.

Inventory of Prime Forest Soils in Kitsap County

Figure A-NS-5 shows four categories of site indices based upon the soil survey's data: site index greater than 110; site index 100-109; site index 90-99; site index 84-89. **Table A-NS-4** lists the most productive soil types, those with a site index greater than 100. Soils in Kitsap County are comparatively lower site index than other areas of Western Washington, where site indices may be as high as 140, and are frequently greater than 120. The 180,000 acres of productive soils listed in the table includes lands not available to forestry due to development or other conflicting uses.

According to **Figure A-NS-5**, the most productive timberlands lie in the northern part of the county and the least productive soils are found in the southwestern corner of the county. Despite the lower site index, this area is presently actively managed for timber production.

The numbers used for soil site indices vary among sources and studies, based upon the number of soil plots sampled. However, whether using the numbers produced by the Soil Survey or by other Natural Resources Conservation Service Department of Natural Resources reports, the soil type and characteristics do not vary.

Land Use Implications

Some soils are more conducive to growing trees than others. To maintain a productive forest base, soils prime for forestry should be encouraged to be used for timber production where feasible. Kitsap County site indexes are comparatively lower than other areas in Western Washington, although they would be considered highly productive when compared to other forestry soils in the arid west or the southern United States.

On-Site Sewage Systems

Soil Characteristics

A conventional, on-site sewage system consists of the septic tank, absorption trenches and surrounding soil which serves as an absorption field. Final treatment and disposal of the wastewater occurs in the soil, thus the type of soil available plays an important role in the functioning of the system.

Soil contains roughly 50% pore (air) space. Many chemical and biological reactions in soil occur on surfaces adjacent to the pore space. The ability of a soil to treat wastewater depends in part upon the amount of accessible soil particle surface area (smaller particles have greater surface area per unit volume); the chemical properties of the surfaces and temperature, moisture and oxygen levels. Depth of soil before encountering hardpan (a restrictive layer that doesn't allow water to pass through) and depth to the water table also play significant roles in soil treatment.

TABLE A-NS-4 Soil Site Index
Based on a 50 Year Site Curve

Soil	Site Index	Acreage
Ragnar	125	8,650
Kitsap	123	6,510
Poulsbo-Ragnar	123	7,280
Poulsbo	121	15,090
Cathcart	120	1,690
Belfast Loam	120	530
Kapowsin	119	16,730
Schneider	115	1,490
Ragnar-Poulsbo	112	3,170
Indianola-Kitsap	110	7,550
Kapowsin Variant	109	1,090
Shelton	107	12,430
Grove	106	3,060
Harstine	105	33,160
Ragnar (15-30% slope)	105	3,490
Alderwood	104	43,720
Sinclair	103	2,880
Kilchis-Shelton	103	2,390
Kilchis	101	6,990
TOTAL ACRES		**177,900**

Note: Information is not available concerning forest soil land devoted to other land uses.
Source: SCS Kitsap County Soil Survey

Although the Bremerton-Kitsap County Health District has ultimate authority regarding whether soils are suitable for on-site sewage systems, the U.S. Natural Resources Conservation Service has determined a rating system for soil suitability. This system evaluates the part of the soil between depths of 24 and 72 inches. Most soils in Kitsap County are rated severe for conventionally designed on-site sewage disposal fields due to cemented pan, soil saturation, flooding, ponding, slow percolation, poor filtering and slope. Cathcart soils, which comprise about 1,690 acres of Kitsap County, are the only soil not rated severe for conventional septic design.

Land Use Implications

According to the Bremerton-Kitsap County Health District, an on-site sewage system, properly designed, installed and maintained, is as effective as a sophisticated sewage treatment plant. Unsatisfactory performance of on-site sewage systems, including excessively slow absorption of effluent, saturated soil from water table or surface discharge of effluent can cause public health and environmental impacts. Groundwater can be polluted if the distance between the absorption field and groundwater is less than two feet.

The severe rating for most Kitsap County soils indicates that soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs and possibly increased maintenance are required. In some cases, a drainfield may not be possible or may require obtaining additional land beyond the initial site. Some areas of the county, particularly along the shoreline, may need to be sewered in order to adequately protect public health and water quality.

IV. WATER RESOURCES

The waters of Puget Sound and Hood Canal surround Kitsap County on the north, east and west. The estuaries and embayments and the open waters of the Sound define a county rich in scenic beauty and water-based resources. The streams, lakes, ponds and wetlands that form the county's freshwater landscape support significant numbers of fish and wildlife and provide a variety of recreational, economic and aesthetic opportunities for county residents and visitors.

As the population of the county grows, these water resources become increasingly threatened by land use activities and development patterns. This section explores the hydrology of Kitsap County, describes the necessity of protecting both surface and groundwater quality and examines the water quality and quantity threats caused by development, commercial activities and other land uses.

As efforts such as the Draft Kitsap County Groundwater Management Plan (GWMP) are completed and a better understanding of the complex hydrology of the county is refined, it is understood that this Comprehensive Plan and the appropriate subsections will be amended accordingly. The GWMP will require State Environmental Policy Act (SEPA) review , , and concurrence from local jurisdictions with the recommendations.

Hydrology

Hydrology is the science concerned with the distribution, movement and effects of the earth's water. The hydrological cycle is described in **Figure A-NS-6.**

A basic hydrological component is a watershed, or drainage basin. A watershed is an area of land that has one common denominator -- precipitation that falls within its boundaries and becomes surface water eventually drains to a common stream, river, bay or other water body. As water from rainfall (stormwater) flows over the land, it collects pollutants and sediments from the land. The runoff will eventually flow into a stream or other common body of water. Thus, every activity that occurs within a watershed has the potential to impact the body of water into which the watershed drains.

Some rainwater filters into the soil, and is absorbed by vegetation or recharged to underlying aquifers. Surface water flow, as well as groundwater movement and aquifer recharge can be affected by factors such as rainfall amount and intensity; soils or land cover; slope of land and stream channels; and evapotranspiration (water returning to the atmosphere through evaporation from the land and transpiration from plants).

The condition of the land's surface also has a major influence on surface water hydrology. When development occurs, the increase in impervious surfaces (such as roads and roofs), the loss of wetlands and vegetated areas and the concentration of stormwater runoff into ditches and pipes all lead to increases in total surface runoff and higher peak flows in streams and ditches. The immediate impact may be increased occurrences of flooding, increased erosion of stream beds and stream habitat loss. Increases in stormwater runoff can also lead to higher pollutant loads in the runoff and declines in water quality. Increased runoff in the longer term will decrease the amount of recharge to groundwater.

Aquifer Recharge Areas

Groundwater constitutes more than 80% of the water used by Kitsap County residents. It originates in aquifers -- saturated geologic formations located beneath the ground's surface. Aquifers are recharged from precipitation that slowly infiltrates the ground and eventually reaches the aquifer. Places where water passes through the ground to replenish aquifers are known as "aquifer recharge areas."

The quality and quantity of groundwater in an aquifer is inextricably linked to the aquifer's recharge area. In order to protect groundwater from contamination, aquifer recharge areas and the waters that flow through them must be protected from degradation and contamination.

Groundwater is available on most areas of the county and almost all of the county contributes to groundwater recharge. This inventory briefly identifies the known principal aquifers in Kitsap County that provide potable water and describes the characteristics of aquifer recharge areas. It summarizes land use threats to groundwater supplies and provides a preliminary designation of aquifer recharge areas in Kitsap County.

FIGURE A-NS-6

The Water Cycle

A more complete inventory and designation of aquifer recharge areas will be provided upon completion of the Groundwater Management Plan for Kitsap County. This plan is being developed by the Groundwater Advisory Committee (GWAC), a committee composed of citizens; groundwater-related businesses; tribal, state and local government agencies; and Kitsap Public Utility District (KPUD). The information and data produced during this planning process will be incorporated into the County's Comprehensive Plan.

Even with this additional information, much remains to be learned about the complex functioning of aquifer recharge areas. Strategies for protecting these areas and the county's groundwater supply will evolve over time as more data becomes available and the plan is subsequently amended.

Aquifer Characteristics

There have been 27 principal aquifers identified in Kitsap County. The aquifers are typically composed of glacially derived deposits of sand and gravel which are encountered from about 100 feet above to 800 feet below sea level. The aquifers are often capped or vertically separated by aquitards (materials which impede the flow of water). **Figure A-NS-7** shows the approximate location of these principal aquifers. Most major production wells in the county tap water from the principal aquifers, which are relatively deep. Some production wells and numerous private domestic wells withdraw water from principal aquifers which are relatively shallow, or from localized perched water tables. KPUD anticipates that additional aquifer systems will be identified in the future and continues to refine aquifer boundaries as more information becomes available. Refining the understanding of aquifers characteristics is a costly and time consuming process.

The water quality of these aquifers is generally good, and known water sources for most of these aquifers are expected to be adequate for projected water demand until 2010 (according to the Kitsap County Coordinated Water System Plan that was based on Puget Sound Council of Governments population figures of 258,600).There are some areas with saltwater intrusion, water with excessive iron or manganese concentrations, or groundwater contamination from man-made chemicals. The GWAC has initially identified four aquifers where groundwater contamination maybe a concern. These are the Hansville, Lynwood Center, Poulsbo and Meadowmere aquifers, in North Kitsap. Additionally, overdrafting may have occurred in the Island Lake Aquifer, and as a result of low lake level, the State Department of Ecology has imposed a moratorium on well completion in that aquifer.

As the county becomes more urbanized, the changing quality and quantity of the water recharging aquifers will play a greater role in determining the quality, quantity and cost of the water source available to county residents and businesses.

Aquifer Recharge Area Characteristics

Recharge of an aquifer occurs naturally by the percolation of surface water or precipitation through the ground's surface to a depth where the earth's material is saturated with water. Recharge can also occur from lakes, streams, stormwater from drainage ditches and retention ponds and wastewater from septic systems. Generally, aquifers are recharged sequentially from shallowest to deepest. Therefore, deep aquifers are recharged more slowly than shallower ones.

The majority of Kitsap County is considered a potential aquifer recharge area. Because of varying surficial geology, some areas are considered more effective or critical for aquifer recharge. Groundwater pollution may be a greater threat to recharge areas that contain shallow aquifers below porous soils because contaminants can rapidly infiltrate to the aquifer.

While it is difficult to determine exactly which areas of Kitsap County are responsible for the recharge of the county's principal aquifers, three characteristics of aquifer recharge areas can be identified at ground surface. These three factors, which influence the infiltration potential of an area, are discussed below.

Soil: Soil conditions such as composition, moisture and compaction influence the amount of infiltration that occurs. Soils composed of coarse-grained materials (i.e., sand and gravel) are generally more permeable than those composed of finer-grained particles such as clay and allow infiltration of surface waters. Surface waters that flow over soils that are already saturated will not be able to easily infiltrate those soils. Soil compaction inhibits infiltration because it decreases soil permeability (the size and number of passageways between soil particles).

Vegetation: The presence of vegetation encourages infiltration of rainfall in several ways: Vegetation decreases the velocity of runoff as water is diverted around plant stems and roots; slowing the runoff increases the time available for infiltration. Plant roots and live organisms (like earthworms) increase the porosity of the soil, thus facilitating infiltration. Plant cover absorbs some of the energy of raindrop impacts, reducing the amount of soil that is splashed into the air and thus reducing the amount of soil that fills the pores between soil particles. Plants also absorb water and return a portion of the water to the air through transpiration. Because vegetation is a key component of an area's recharge potential, the land use characterizing an area is an important component.

Topography: Rain tends to flow off of steep slopes, thus less moisture is available for infiltration. On uneven surfaces, runoff may be detained in pools for periods long enough for infiltration to occur.

Critical aquifer recharge areas in Kitsap County are being identified by the Groundwater Advisory Committee, as part of the Groundwater Management Plan. Preliminary discussion of critical aquifer recharge area identification focuses on soils, depth of aquifer, number of wells present and wellhead protection areas.

Land Use Implications

The quality and quantity of water being recharged into an aquifer can be affected by a number of activities occurring within an aquifer recharge area. These activities are summarized below and are described in more detail in the Issue Papers prepared as part of the GWAC Groundwater Management Plan and available from the Kitsap County Public Utility District No. 1.

The GWAC preliminary procedure for designation of critical recharge areas proposes that areas of the county be designated as Critical Areas of Concern, based upon the potential for water to be contaminated from land use activities which involve hazardous materials.

Urbanization and Stormwater Runoff. Water runoff increases and natural recharge decreases as an area becomes more urban. Impervious surfaces such as pavement, roofs and compacted soils can increase runoff of rainwater during and after storms. Removal of vegetation can also turn potential recharge into runoff. Overdrafting of an aquifer can occur during urbanization when lower recharge rates combine with higher demand for groundwater.

Leaking Underground Storage Tanks. Underground storage tanks typically contain motor fuels, heating oils or other compounds. Leaking underground storage tanks and associated piping can cause serious groundwater contamination.

Solid Waste Disposal. Leachate is water or liquid contaminated with dissolved or suspended materials due to contact with solid waste or associated gases. In some older landfills, leachate may be able to infiltrate the soils that lay below the waste.

Erosion. Clays and silts derived from erosion can plug the porous native soils where they are deposited and can decrease infiltration in streambeds by covering sand or gravel surfaces. Erosion of an area can also expose new layers of soil, which can enhance or diminish infiltration.

On-Site Sewage Systems. On-site wastewater treatment systems can replenish groundwater supply by returning used water back to the aquifer system. Improperly installed and/or maintained systems may provide a source of contamination by releasing untreated wastes and chemicals into the soil.

Sand and Gravel Mining. Sand and gravel operations decrease the distance between the groundwater table and land surface. Wastewater collected on the mine site can infiltrate more easily into the groundwater, increasing the potential for contaminants to enter the groundwater supply.

Fertilizers, Pesticides and Herbicides. Misuse of pesticides, fertilizers and herbicides can lead to excess chemicals or nutrients infiltrating the ground during rain or through stormwater runoff.

Hazardous Materials. The presence of hazardous materials within an aquifer recharge area can lead to the serious contamination of groundwater if the materials are exposed to surface waters or are contained in soils through which water infiltrates.

Surface Water

The county's marine and fresh surface waters provide more than aesthetic amenities to Kitsap County residents and businesses. Twenty percent of the people who live in the county depend upon surface water from streams, springs and freshwater reservoirs for their drinking water supply. Both fresh and salt water bodies provide habitat for fish, wildlife and plant life and provide unique recreational opportunities like fishing, beach combing, swimming, boating and shellfish gathering.

The regional economy also depends in part upon the health of Kitsap County's waters. Locally, some small farms rely upon clean water and adequate water quantity for animal and crop watering. Shellfish harvests in marine embayments and Hood Canal depend upon clean water supplies, while the Puget Sound salmon fishery depends upon healthy fresh-water habitats in local streams for survival. Indeed, the condition of Kitsap County's salmon streams has international implications. Coastwide fisheries are affected by the status of Washington's salmon stocks.

The health of salt and fresh water systems are inextricably linked through a stream network which carries water and pollutants from the county's uplands to the marine environment. A system of freshwater and saltwater wetlands which stretch throughout the county also play a vital role in filtering and transferring water. This section will inventory the county's fresh water and marine environments, discuss threats to water quality and survey existing problem areas.

Streams

Characteristics. According to the Department of Fish and Wildlife's Water Resources Information Area (WRIA) stream catalog, the Kitsap Peninsula is marked by hundreds of miles of small streams and creeks, which flow only short distances before meeting other streams, Puget Sound or the Hood Canal. River systems in Kitsap County (Tahuya River, Dewatto River, and Union River) originate in the semi-mountainous, south-central part of the county, while numerous creeks and streams drain the county's predominantly low lying lands.

Most Kitsap County streams originate from lakes, groundwater or spring-fed marsh basins. Streams supplemented by groundwater or springs usually flow throughout the year with water supplied by rainfall. Hundreds of intermittent streams flow only during certain seasons of the year with water supplied by rainfall. The County's streams used to provide excellent habitat for anadromous fish (salmon and trout) due to good water quality and insect supply. Degradation of streams has resulted in few streams having a viable fish run. Local groups are working to restore the damaged habitat of the streams to bring back the fish.

Throughout the state, water bodies, including streams, have been classified by the Department of Natural Resources based on flow volume and importance to fish and wildlife, domestic use or public recreation. Type 1 streams have the largest flow volumes and important fish and wildlife habitat, while Type 2 and 3 typically provide smaller flows but important fish and wildlife habitat. These classifications are defined in **Table A-NS-5.**

Stream types and locations of streams in Kitsap County are shown in **Figure A-NS-8** produced by the Kitsap County Geographical Information System. Type 1 streams in Kitsap County include portions of Big Beef Creek, Blackjack Creek, Burley Creek, Chico Creek, Minter Creek, Curley Creek, Tahuya River and the Union River.

TABLE A-NS-5 Department of Natural Resources Waters of the State Definitions (in accordance with WAC 222-16-030)

Type 1:	All waters within their ordinary high-water mark, inventoried as "shorelines of the state," but not including those waters associated with wetlands. (Under the State Shoreline Management Act of 1971 Chapter 90.58, shorelines of the state are those associated with water bodies of 20 acres or more and stream segments where the mean annual flow is 20 cubic feet per second or more).
Type 2:	Segments of natural waters that are not classified as Type 1 water and have a high use and are important from a water quality standpoint for: domestic water supplies; public recreation; fish spawning, rearing or migration or wildlife uses; or are highly significant to protect water quality.
Type 3:	Segments of natural waters that are not classified as Type 1 or 2 waters and have a moderate to slight use and are moderately important from a water quality standpoint for: domestic use; public recreation; fish spawning, rearing or migration or wildlife uses; or have moderate value to protect water quality.
Type 4:	Segments of natural waters not classified as Type 1, 2 or 3. The significance of Type 4 waters lies in their influence on water quality downstream in Type 1, 2, 3 waters. They are classified Type 4 until the channel width becomes less than two feet between the ordinary high-water marks, and may be perennial or intermittent.
Type 5:	All other waters, in natural water courses, including streams with or without a well-defined channel, areas of perennial or intermittent seepage, ponds and natural sinks. This type also includes drainage ways having short periods of spring runoff.
Type 9:	Those streams that have not been previously classified as one of the above types.

Functions and Values. Kitsap County's streams and creeks play a major role in the hydrologic cycle. They are the drainage systems of the county's surface, carrying runoff water and sediments from upper watersheds to low-lying land or water bodies. Some stream water may enter shallow aquifers as recharge. Through their influence on reservoirs, their role in groundwater recharge, and as suppliers of surface water, streams play a major role in drinking water quantity and quality. In addition, in-stream and stream-side vegetation provides food and habitat for insects, fish and other wildlife. The streams themselves provide necessary water for fish and water-dependent wildlife. Finally, stream corridors serve as passageways for wildlife and provide scenic open spaces.

Land Use Implications. If stream habitat and water quality are degraded by development and increased runoff, the county's stream systems lose some of their significant values and functions. Studies indicate that, without mitigation, when 12% of a watershed becomes impervious, the hydraulic properties of streams are affected due to changes in

stream flow, increased erosion of stream banks and changes in the physical or chemical properties of the water.

Increased stormwater runoff from development can lead to increased flooding. The sedimentation affiliated with the runoff can raise streambeds, exacerbating flooding and destroying stream corridor vegetation and habitat. With increased sedimentation and increased flow velocity, the erosive power of the stream also increases. An unnaturally fast flowing stream will more rapidly cut its own stream banks, scour its bed and further increase sedimentation in the stream bed.

Increases in sedimentation lead to increases in stream turbidity -- the cloudiness of water caused by suspended particles. This reduces the amount of light reaching lower depths of the stream, and can affect the health of many species of plants and animals. The decomposing bacteria which feed on the organic debris use up the available oxygen in the water, contributing further to stream pollution, and resulting in an algae-choked, ecologically barren stream. Chemical and organic pollution from land use activities in a watershed can also create stressful, toxic stream environments.

Finally, development in stream corridors can alter stream systems by removing vegetation along stream banks and exacerbating flood conditions. In a natural condition, the soil and organic litter help to filter and purify the water. As stream-side vegetation and stream channels become altered, the stream system loses it filtering capacity and the ecological integrity of the stream becomes threatened.

Stream Problem Areas. Streams that empty into the county's eastern marine waters and embayments typically drain mostly rural upper watersheds and more densely populated lower watersheds. Most of these streams experience some water quality problems, tending toward increased stream flows and sedimentation due to urbanization, and sewage and animal waste contamination caused by poor farming practices and improperly installed and/or maintained on-site sewage systems. Watershed planning studies identify notably high bacterial levels in Burley, Minter, Gorst, Blackjack, Beaver, Clear and Dogfish creeks, as well as excessive sedimentation in Blackjack Creek.

Streams that drain into Hood Canal and Port Gamble Bay generally flow mostly through forest and rural lands to the more developed shoreline. For the most part, the water quality of these streams is good. Elevated bacterial levels from farm animals and leaking on-site sewage systems exist at Gamble, Little Anderson, Seabeck and Upper Big Beef creeks.

Lakes

Characteristics. More than 100 lakes and ponds exceeding one acre in size adorn Kitsap County, many of which are shown in **Figure A-NS-8.** Eighteen of these lakes are greater than 20 acres in size and are regulated under the Shoreline Management Master Program. These lakes, and their size, are listed in **Table A-NS-6.** Smaller lakes are generally considered wetlands or ponds and are later discussed in more detail as wetlands and fish and wildlife habitat.

Kitsap County's lakes originate from the glacial activity that characterized the area thousands of years ago. In some places, outwash materials from the ice sheet accumulated, and as the ice moved south it cut into these deposits, carving linear, north-south depressions in the land. Those depressed areas which later filled with water are now known geologically as glacial drift-plain lakes; Long Lake in South Kitsap is one example of this type of lake.

Other lakes, known geologically as kettle lakes, formed where the receding glacier stranded large isolated ice blocks. As the ice fragments melted away, they left depressions which eventually filled with precipitation. Lakes and ponds that formed in this way typically have no surface inlet, and may have no outlet, like Hansville's Buck Lake and South Kitsap's Horseshoe Lake. Water levels in these lakes depend highly upon the water table beneath the land, and as water tables fluctuate due to precipitation and groundwater withdrawal, the water levels of the kettle lakes also fluctuate.

Three Kitsap County lakes are man-made, all of which are found in the central part of the county. Lake Symington and Lake Tahuya were formed for residential development, while the Union River Reservoir provides the water supply for the city of Bremerton. Along most Kitsap County lakes, residential development dominates the shorelines. In some cases, development along the shorelines originally provided summer residences, most of which are now converted to year-round use. Less developed shorelines encircle Miller Lake, Buck Lake and Morgan Marsh.

Functions and Values. Kitsap County's lakes provide the highly desirable residential amenities of water access and views. In some lakes, like Wildcat Lake and Long Lake, residents can water ski, while most other lakes provide boating, swimming, fishing and wildlife viewing opportunities. In some places, the Department of Fish and Wildlife stocks lakes with game fish to enhance sport fishing.

Fish and wildlife also depend upon lakes for habitat. Osprey, bald eagle, waterfowl and other types of wildlife are common sights along lake shorelines. Most species depend upon the trees and non-bulkheaded waterfront that characterize natural shoreline areas. Fish and aquatic vegetation depend primarily upon clean, unclouded waters for their survival.

TABLE A-NS-6 Kitsap County Lakes greater than 20 Acres

LAKE	(Acres)
Buck Lake	(22.0)
Carney Lake	(39.2)
Kitsap Lake	(238.4)
Union River Res.	(93.0)
Panther Lake	(104.1)
Wye Lake	(37.9)
Wildcat Lake	(111.6)
Twin Lakes Res.	(21.7)
Mission Lake	(87.7)
Horseshoe Lake	(40.3)
Tiger Lake	(N/A)
Long Lake	(314.0)
Island Lake	(42.7)
Lake William Symington	(N/A)
Tahuya Lake	(N/A)
Three Fingers Pond & Holland Ponds	(30.8)
Morgan Marsh	(95.0)
Miller Lake	(25.7)

Land Use Implications. Residential and commercial development along Kitsap County's lakes represent the largest threats to this surface water resource. Disturbance of native vegetation and construction of impervious surfaces near the waterfront disrupt the shoreline's natural systems, reducing the shoreline's ability to filter pollutants out of surface water runoff and stem the flow of stormwater. Development along shorelines in non-urban areas can also lead to bacterial contamination of the waters due to improperly installed and/or maintained on-site sewage systems -- a condition prevalent in many rural areas of the county.

Construction of bulkheads to enhance landscaped properties may alter the natural erosion pattern of the shoreline and destroy habitat by blocking sunlight, replacing native lakebed vegetation and altering feeding, nesting and breeding areas. Removal of trees along the shoreline can also disrupt roosting and nesting areas for waterfowl and birds of prey.

Problem Areas. As shorelines are developed, water quality in the county's lakes deteriorates. Causes are stormwater runoff, failure of older on-site sewage systems, and other sources of non-point pollution, such as waterfowl, fertilizers, etc. Eutrophication (the excessive build-up of nutrients causing elevated plant growth and the depletions in dissolved oxygen) threatens recreational opportunities and degrades fish and wildlife habitat. Long Lake has experienced significant rates of organic pollution in recent years. A sewer line was recently extended to Kitsap Lake because of water quality problems. The County's Draft Comprehensive Sewer Plan also identifies Lake William Symington, Wildcat Lake and Tahuya lake as "hot spots" for water quality reasons.

In addition to water quality problems, kettle lakes must also weather low water levels caused by deficit precipitation or groundwater withdrawal. Water level fluctuations and declines in Horseshoe and Island Lakes are most likely due to a combination of groundwater withdrawals, large community wells, variable precipitation and increase in urban density.

Wetlands

Characteristics. Areas designated as wetlands exhibit three distinct characteristics: Hydric soils (soils saturated with water), high water table (the presence of standing water at least part of the year) and water-tolerant or water-dependent plant species. If water-tolerant vegetation has been removed from the site but the area still has hydric soils and high water table, the site may remain part of an aquatic system and may be classified as a wetland.

One general pattern of freshwater wetlands occurs in isolated, glacially carved depressions that have filled with silt, organic materials and rainwater. These wetlands are typically north-south, tending to be elongated figures. Another pattern of wetlands is associated with stream or other large hydrological systems, like lakes and marine waters. In low-lying areas, such as along streams or shorelines where water-velocity is slow, silt and organic materials are deposited. In these areas, water-tolerant vegetation has a chance to take root, which further slows the flow of water and eventually leads to the formation of a wetland.

Kitsap County relies primarily on the USDA Natural Resources Conservation Service (SCS) Soils Maps and the US Fish and Wildlife Service's National Wetlands Inventory (NWI) Map for identifying and regulating wetlands. These two sources have been compiled into **Figure A-NS-8**. Neither the NWI nor the SCS maps identify all the wetlands in the county, due in part to their scale. Additional wetlands information can also be derived from the Coastal Zone Atlas, from the

Department of Natural Resource stream types maps and from local wetlands inventories. In the future, the county's Geographic Information System will map the site-specific wetlands identified during the building and development process as well as the information provided in local wetland inventories.

Classification. The Natural Resources Conservation Service considers nine Kitsap County soil types to be hydric, totaling an estimated 20,140 acres (approximately 8%) of the county. The wetlands identified by the National Wetlands Inventory through aerial photography do not always coincide with the hydric soils survey. One Department of Ecology inventory completed in 1983 estimates that three major wetlands types exist throughout the county, totaling more than 17,700 acres:

Estuarine wetlands (13,614 acres): Located where fresh and salt waters meet. Estuarine wetlands extend upstream and adjacent and landward to where ocean-derived salinity measures less than 0.5 parts per thousand. Examples of this type of wetland include vegetated salt marshes, kelp beds or eelgrass beds and unvegetated areas such as sandy beaches or mudflats.

Lacustrine wetlands (1,154 acres): Essentially open water lakes, with a minimum of vegetated wetlands adjacent to them. These wetlands generally exceed 20 acres in size or have standing water that reaches a minimum depth of 6.6 feet.

Palustrine wetlands (2,971 acres): Inland freshwater habitats fed by groundwater as well as surface runoff. They include freshwater marshes and swamps, bogs, ponds and wet meadows.

When wetlands are identified, they are typically identified by one of the above types and categorized according to the Washington State Four-Tiered Wetlands Rating System. These categories are used to determine setbacks and buffers during the State Environmental Policy Act review process. The rating system is summarized in **Table A-NS-7.**

Wetlands containing sphagnum moss are one of the most sensitive types of wetlands -- one inch of organic soils in these wetlands can take 40 or more years to form. These wetlands are especially vulnerable to nonpoint source pollution and alterations to water regimes. While uncommon, examples of this type of wetland include those on the peninsulas east of Gamble and Seabeck Bays, near Newberry Road and near the intersection of Nellita and Albert Pfundt Roads. Other noteworthy wetlands are identified by the state's Natural Heritage Program and include Miller Lake, Foulweather Bluff and Stavis Bay.

Functions and Values. Wetlands represent a significant part of the local and regional hydrologic cycles. Some wetlands serve as groundwater recharge areas, and all wetlands serve in some capacity to store stormwater runoff, thus reducing flood damage. As timber harvesting, agriculture or development occurs in a drainage basin, stormwater flow in the drainage basin increases. The flood control capability of a wetlands is reduced when it receives these greater amounts of overland flow, and incidences of localized flooding increase. Likewise, the capacity to control wave and current erosion and prevent shoreline flooding is removed when coastal wetlands are seriously degraded, filled or dredged.

In addition to their water quantity roles, wetlands protect water quality by trapping and storing the nutrients from upland runoff in plant tissue and serving as a settling basin for silt from upland erosion. As a highly productive ecosystem, wetlands play a major role in providing habitat for the county's fish and wildlife. Many fish species, including some salmon, depend upon wetlands for one cycle of their lives. Coastal wetlands are particularly important to productive marine fisheries and healthy waterfowl populations. Wetlands are also important to the survival of many species of insects, amphibians, reptiles, birds and mammals. The presence of diverse species in these ecosystems contributes to their value for recreation and education.

Land Use Implications. Development around a wetland can destroy its ecological health by overloading the wetland with silt and nutrients. This may destroy the wetland's filtering abilities and affect plant, amphibian and fish life by reducing the amount of oxygen or sunlight available for life. Even a one-time silting from construction can have a long-term impact on marsh ecology: silt is slowly flushed out of wetlands and is constantly stirred up by wind and scavenger fish.

TABLE A-NS-7 Washington State Four-Tier Wetlands Rating System

Category	Criteria
Category I	(i) Documented habitat for endangered or threatened plant, fish or animal species or for potentially extirpated plant species recognized by state or federal agencies; or (ii) High quality native wetland communities, including documented Category I or Ii quality natural heritage wetland sites and sites which qualify as a Category I or Ii quality natural heritage wetland; or (iii) High quality, regionally rare wetland communities with irreplaceable ecological functions including sphagnum bogs and fens, kelp and eelgrass beds, estuarine wetlands or mature forested swamps; or (iv) Wetlands of exceptional local significance (i.e., rarity, groundwater recharge areas, significant habitats, unique educational sites or other specific functional values within a watershed or other regional boundary).
Category II	(i) Regulated wetlands that do not contain features outlined in Category I; and (ii) Documented habitat for sensitive plant, fish or animal species recognized by federal or state agencies; or (iii) Rare wetland communities listed in subsection Category I, iii, which are not high quality; or (iv) Wetland types with significant functions which may not be adequately replicated through creation or restoration; or (v) Wetlands with significant habitat value based on diversity and size; or (vi) Wetlands which provide exceptionally high habitat, or represent regionally rare habitat to anadromous fish or priority fish species; or
	(vii) Wetlands with significant use by fish and wildlife.

TABLE A-NS-7 Washington State Four-Tier Wetlands Rating System	
Category III	(i) Wetlands that do not contain features outlined in Category I, II, or IV.
Category IV	(i) Wetlands that do not meet the criteria of a Category I or II wetland; and (ii) Wetlands that are less than or equal to one acre in size, and have only one wetland class or only one dominant plan species (monotypic vegetation); or (iii) Isolated wetlands that are less than or equal to two acres in size, and have only one wetland class and a predominance of exotic species.

Land use activities in the uplands of a wetland's drainage basin can affect the wetland's role in the hydrologic cycle. Some wetlands serve as groundwater recharge areas, and all wetlands serve in some capacity to store overland flows of water. As timber harvesting, agriculture or development occurs in a drainage basin, overland flow of water in the drainage basin increases and groundwater recharge decreases.

The storage capacity of a wetland is reduced when it receives these greater amounts of overland flow. During the dry season, the demands on wetlands for groundwater recharge are increasingly high, creating seasonal fluctuations in the amount of water present. These fluctuations create disturbances in the ecological system of the wetlands, further threatening the wetland's ability to perform its hydrological role.

Coastal wetlands are sensitive to alterations in freshwater flows due to adjacent or upland development. Loss of coastal wetland ecosystems through filling, dredging, channelizing and adjacent development can exacerbate coastal flooding and erosion, reduce pollutant filtering and negatively impact fisheries resources.

Problem Areas. Historical losses of wetlands in Kitsap County are difficult to estimate for a number of reasons, including lack of historical wetlands inventories. The Puget Sound Water Quality Authority estimates that throughout Puget Sound an estimated 70% of the original tidal wetlands have been lost to diking, dredging and filling. Immeasurable acres of freshwater wetlands have also been lost in this manner.

In addition to direct losses caused by dredging, diking and filling, numerous wetlands have been degraded by land use activities which alter the quantity or quality of water entering the wetland or which disturb the wetlands ecosystem through encroachment or removal of perimeter vegetation.

Closed Depressions

Closed depressions are low-lying areas which have no, or such a limited, surface water outlet that in most storm events the area acts as a retention basin. Typically, closed depressions have no surface water outlet except for infiltration or evapotranspiration (water returning to the atmosphere through evaporation from the land and transpiration from plants). By their nature, closed depressions may contain wetlands regulated under Kitsap County's Critical Areas Ordinance.

In those cases where a surface water outlet does not exist, and the underlying geology precludes infiltration, closed depressions should be given important consideration during the land use process.

Failure to consider potential increases in water level resulting from land development activities may result in flooding problems or degradation of valuable wetland resources. Because depressions are geographically widespread and discreet in configuration, they are not feasibly inventoried or classified as to individual value.

In those cases where a closed depression is underlaid by pervious soils, there may be significant aquifer recharge considerations.

Whether or not a depression has a surface water outlet, they act to attenuate stormwater runoff rates and volumes. In those cases where a depression has a surface water outlet, detention of peak runoff rates is provided. Where depressions retain significant volumes of runoff, shallow groundwater movement can be important in maintaining valuable fish habitat by providing dry period stream flows.

Land development activities contributing runoff to a depression require a specialized analysis to evaluate potential impacts to adjacent lands and downstream drainage courses. Kitsap County's "Stormwater Management Ordinance" Section 7.20(3) requires that major development activities contributing runoff to closed depressions with greater than 5,000-sf of water surface area at the overflow elevation, meet the following requirements:

1. **CASE 1:** The pre-development 100-year, 7-day and 24-hour duration design storms from the drainage basin tributary to the closed depression are routed into the closed depression using only infiltration as outflow. If the design storms do not overflow the closed depression, no runoff may leave the site for the same storm events following development of a proposed project. This may be accomplished by excavating additional volume in the closed depression subject to all applicable requirements. If a portion of the depression is located off of the project site, impacts to adjacent properties shall be evaluated.

2. **CASE 2:** The pre-development 100-year, 7-day 24-hour duration design storm events from the drainage basin tributary to the closed depression are routed to the closed depression using only infiltration as outflow, and overflow occurs. The closed depression shall then be analyzed as a detention/infiltration pond. The required performance, therefore, shall not exceed the pre-development runoff rates for 50% of the 2-year and 100% of the 10-year and 100-year, 24-hour duration and 100-year, 7-day duration design storms. This will require that a control structure, emergency overflow spillway, access road, and other applicable design criteria be met. If the facility will be maintained by Kitsap County, the closed depression shall be placed in a dedicated tract. If the facility will be privately maintained, the tract shall be located within a drainage easement. If a portion of the depression is located off of the project site, impacts to adjacent properties shall be evaluated.

3. **CASE 3:** When a proposed project is contributory to a closed depression located off-site, the volume of runoff discharged may not be increased for the 2-, 10- and 100-year, 24-hour duration, and the 100-year, 7-day duration storm events. The exception to this requirement is in the case where discharge would not result in an increase in water surface elevation of greater than 0.01-foot for the 100-year storm events.

The method of analysis conforms to the technical requirements of the WSDOE "Stormwater Management Manual for the Puget Sound Basin."

Marine Environment

Characteristics. The marine waters along the shorelines and borders of the eastern part of the county contain a highly diversified salt water environment that can be greatly influenced by activities which occur on land. Three major types of water bodies exist off of Kitsap County's 228 miles of saltwater shoreline: embayments, Hood Canal and open water.

Embayments: Prominent embayments, like Gamble Bay, Liberty Bay, Miller Bay, Sinclair Inlet and Dyes Inlet, contain tidally influenced waters that mix slowly with the more open waters of Puget Sound or Hood Canal. Because of their slow mixing rates, their shallow depths and their proximity to land Use activities along the shoreline, marine embayments are extremely susceptible to both upland and offshore pollution.

Hood Canal: Hood Canal can be considered a narrow and deep extension of Puget Sound, with a marine ecosystem unique to the region. The Canal's depth reaches 600 feet in some places and averages 1.5 miles in width. In general, strongest tidal flow and greatest mixing with the waters of Puget Sound occur in the northern canal, with slow exchange and movement of water in the central and southern canal, particularly in the deeper waters.

From the surface to about 60 feet in depth, temperatures and salinities are largely influenced by freshwater runoff and tidal currents. Waters at these shallow depths are warm and rich in nutrients and susceptible to environmental changes caused by freshwater runoff.

Puget Sound: Colvos Passage, Port Orchard Narrows, Rich Passage, Agate Passage and the open waters of Puget Sound north of Bainbridge Island represent well-mixed, deeper marine waters where freshwater loads are mostly diluted. Pollution and excess sedimentation from land Use activities has the greatest influence on near shore habitats like shellfish beds and kelp and eelgrass beds.

Functions and Values. The waters off the shoreline of Kitsap County are vital to fish and shellfish resources because they provide mixing and transition zones from the cool, dense saline waters of Puget Sound to the warmer, less saline water layers of the peninsula's shallow shelves, bays and channels. Within prominent protected waters, such as Dyes and Sinclair Inlets and Liberty Bay, rich feeding areas for anadromous fish and birdlife exist, and the sheltered waters of these inlets provide important wintering habitat for migratory waterfowl. The strongly mixed currents within Colvos, Agate and Rich Passages also create prime feeding areas by collecting a great diversity of marine organisms within the tide rips.

A healthy marine environment is important to the survival of birds and marine mammals that depend upon fish and plant life for food. Near shore habitats, including mud flats, vegetation, cobble and sand provide critical spawning, rearing and feeding areas, protect the shoreline from erosion and filter pollutants from the water. In addition, Puget Sound's open waters, embayments and Hood Canal provide aesthetic benefits to county residents, benefits which are greatly reduced when waters and beaches are clouded with excessive nutrient growth or pollutants.

Land Use Implications. The marine waters surrounding Kitsap County can be greatly influenced by land use activities. Upland streams carry freshwater, nutrients and pollutants directly to the offshore salty waters. Runoff from areas adjacent to the shoreline also flows directly into embayments, Puget Sound and Hood Canal, while development-influenced changes in natural shoreline vegetation and beaches can directly impact marine ecosystems and near shore habitat.

In Kitsap County the marine environment is impacted by point source and nonpoint source water pollution related to land use activities. Point sources of pollution originate from single, readily identifiable locations, such as sewer pipes or industrial discharges, and are discharged to water at a specified point such as the mouth of a pipe or ditch.

Municipal and industrial discharges are forms of point source pollution and contribute to nearly half of the toxins loading in Puget Sound. Some industrial facilities or commercial businesses discharge wastes directly into Puget Sound. Others utilize municipal treatment plants that treat and then discharge the waste. However, even when the waste undergoes treatment, toxicants still enter the region's marine waters. Point sources of pollution are regulated through both state and federal legislation. Locations of point source discharges in Kitsap County are listed in **Table A-NS_8.**

TABLE A-NS-8 Locations of Point Source Discharges with State or Federal Permits

Type of Industry	Location of Source
Wastewater Treatment:	
	Bremerton
	Manchester
	Central Kitsap
	Port Orchard
	Fort Ward
	Suquamish
	Kingston
	Winslow
Hatcheries:	
	Global Aqua (net pens in Gorst Creek Clam Bay and Fort Ward)
	Grovers Creek
Boat Yards:	
	Eagle Harbor
	Sinclair
	Kingston
General Industrial:	
	Fred Hill Concrete
	Navy City Metals
	Pope and Talbot
	Olympic View Sanitary Landfill
Construction Sites:	Greater than 5 acres, stormwater control
Federal Installments:	All Navy facilities

Source: Department of Ecology, Water Quality Division, 1993

Nonpoint sources of pollution enter streams, wetlands, lakes and marine waters from dispersed land-based or water-based activities, and include: surface water runoff from agricultural lands, urban areas or forest lands; failing on-site sewage systems; atmospheric deposition; leaking landfills and underground storage tanks; and sewage discharge and litter from boats and marinas. Sources of nonpoint pollution increase as an area becomes more developed and more human activity occurs.

The diffused nature of nonpoint source pollution makes it difficult to control, monitor or regulate. Requirements contained in clearing, grading and drainage ordinances help to control erosion and stormwater runoff, while some health regulations address improperly installed and/or maintained on-site sewage systems, farm practices and boater waste.

In Kitsap County, local jurisdictions, agencies and citizens have worked together to draft coordinated watershed management plans for the Burley Lagoon/Minter Bay, Dyes Inlet and Sinclair Inlet watersheds (plans are also currently being developed for the Hood Canal and Liberty Bay/Miller Bay watersheds). These watershed management plans are designed to improve the protection of both salt and freshwater resources through stronger control of nonpoint source pollution. They identify watershed-specific pollution sources and recommend voluntary and governmental actions to watershed residents, businesses, organizations and governments that reduce the occurrence of harmful pollutants.

Problem Areas. Most of the water quality problems identified in the county by the Puget Sound Ambient Monitoring Program occur in the county's embayments. In embayments, contaminants tend to settle rapidly, accumulating in sediments close to their source. Contamination can be severe and long-lasting in these areas because the toxic chemicals, for the most part, do not dissipate. Because contaminants diminish rapidly with distance from their source, the effects of toxic chemicals on the overall health of open waters are not as severe.

Sinclair Inlet is considered one of the most polluted embayments in Puget Sound. In 1993, the U.S. Environmental Protection Agency identified the area near the Puget Sound Naval Shipyard as a Superfund site. According to the Puget Sound Water Quality Authority, in 1992 both Sinclair and Dyes Inlets had chronic mercury problems, and Sinclair Inlet was one of the few places in Puget Sound that violated state fecal coliform standards.

Along Kitsap County's shorelines, shellfish beds have been restricted or closed to harvest in the following areas due to water quality problems: Liberty Bay, Dyes Inlet, Sinclair Inlet, inner Seabeck Bay; and at Port Orchard, Suquamish, Port Gamble and Kingston sewage treatment outfalls. Restrictions on shellfish beds translate into a loss of revenue for private industry -- in Liberty Bay alone, the total value of the shellfish resource unable to be harvested due to closure is estimated to be $6 million.

The overall water quality of Kitsap County's portion of the Hood Canal is considered excellent. Localized problems exist with leaking on-site sewage systems at Olympic View and Driftwood Keys. Hood Canal's headwaters at Belfair (in Mason County) are experiencing pollution from nonpoint source pollution and shellfish beds have been closed to commercial harvest.

V. FREQUENTLY FLOODED AREAS

Frequently flooded areas are lands inundated with water during periods of high rainfall or strong coastal winds. They typically lie adjacent to streams, rivers, lakes and coastlines and include wetlands associated with these areas. During intense storms, properties located in frequently flooded areas are prone to severe damage. Development in these areas may be hazardous not only to the property owner, but may also aggravate flood conditions on neighboring lands and compound damage to the natural environment.

Kitsap County is not as prone to catastrophic flooding as other counties in the Puget Sound region, due to a lack of major river systems, a preponderance of embayments which soften wave velocities and the presence of steep bluffs along much of the shoreline. Despite this fact, some flooding has historically created minor damage in some areas of the county and should be addressed in the land use planning process and associated regulations. This section describes the characteristics of frequently flooded areas and summarizes the causes of flooding and the implications to land use.

Characteristics

Figure A-NS-9 illustrates the concept of a floodway and 100-year floodplain along stream and river corridors. It also depicts the changes to the floodplain when development occurs within frequently flooded areas. Along the shoreline, frequently flooded areas are typically low bank, or at the base of steep bluffs (which have typically been eroded by past wave action). Strong wave action, flood levels in stream outflows, high wind velocity and high tides may combine to make these coastal areas hazardous during storms.

The floodplain designations of the Federal Emergency Management Agency (FEMA) National Flood Insurance Program present the most complete information available about frequently flooded areas in Kitsap County. These maps were produced in 1980, mostly from aerial photography, and delineate different flood zone areas based upon flooding potential. Areas of 100- and 500- year floods are depicted in **Figure A-NS-10**, and lie mostly along coastal and lake shorelines and major streams.

Although a 100-year flood event theoretically has a 1% chance of occurring in a given year, this type of storm may actually occur more frequently than every 100 years; King County experienced two 100-year storm events between 1986 and 1990. Because the FEMA maps were designed only from aerial photos and topographic maps, in some areas they may not accurately portray the real flood risks. For example, no areas in Kitsap County are designated as V-Zones, points along coastal areas where the 100-year flood will be accompanied by high velocity waves. Despite this, Point Jefferson has incurred significant wave and wind damage in recent years.

Throughout the county, localized flooding occurs in areas that have not been identified on the FEMA maps. These flood occurrences can be described as “drainage problems” which have resulted from disturbance of natural hydrological patterns caused by development, vegetation removal and filling and damage to wetlands. Drainage control mechanisms, such as stormwater retention ponds and ditches, occasionally overflow and damage neighboring properties.

Flooding can result in loss of stream or shoreline habitat and can cause water quality problems through increased sedimentation, increased contamination from urban runoff or saturation of on-site sewage system drainfields. Along some stream corridors, floods have deposited fertile agricultural soils in the floodplain. Due to the danger inherent in building in frequently flooded areas, these places are often better suited for farmland, parks, trails and fish and wildlife habitat.

Causes

The county's FIRM (Flood Insurance Rate Map) maps delineate areas that would flood during a 100- or 500-year storm that bring unusually heavy rains and winds. These maps do not reflect recent hydrological changes in drainage basins, or changing environmental conditions along coastal areas. These additional causes of potential flooding in Kitsap County are discussed below.

Figure A-NS-9

The Concept of the Floodplain
(From Ecology's Floodplain Management Handbook)

High Tides/Strong Winds. High tides and strong winds may increase the risk of flood damage along the shoreline. According to the National Weather Service, the highest storm tide recorded in Puget Sound occurred in Seattle in December of 1977 and measured 14.6 feet above zero tide level. This storm tide caused significant flooding. Historical records of storm events do not exist for the Kitsap Peninsula.

Tsunami. A tsunami is a series of traveling ocean waves of great length and long period, generated by disturbances associated with earthquakes in oceanic and coastal regions. These enormous waves can cause great destruction along shorelines but are not likely to occur in the protected waters of Puget Sound.

Sea Level Rise. Global climate change and land subsidence may increase sea level rise between 0.75 feet and 5.7 feet over the next 100 years, according to the Department of Ecology. At its most extreme, this rise in the level of Puget Sound could inundate some low-lying shorelines, disrupt storm drain flow, increase coastal erosion and aggravate coastal flooding during storms.

Increased Runoff From Impermeable Surfaces. Roofs, roads, and parking lots in a developed area causes the volume of surface runoff and the peak rate of flow to increase and decreases ground water recharge. Runoff runs quickly off the surface directly into the streams. This increases both the velocity and total quantity of flow and leads to localized flooding along the stream corridor. In addition, sediment from increasingly eroded and unstable stream banks and cleared areas amasses downstream and fills ponds, streambeds and stormwater facilities. This filling can also result in flooding, as water catchments become incapable of holding high volumes of water.

Other Hydrological Changes. Other hydrological changes in drainage areas occur due to vegetation removal and land grading from timber harvest and development. These activities lead to higher volumes of stormwater runoff by reducing the amount of vegetation present to slow water movement as well as by increasing impervious surfaces. Increased runoff and erosion from these sites can obstruct flood channels, causing streams to overflow. Filling and degrading of wetlands impacts their water storage capacity and can lead to increased flooding in the wetlands' vicinity or lead to increases in water volumes released to streams.

Floodplain Development. Development In The Floodplains can also lead to hazardous flood conditions. Any structure that exists in a floodplain contributes to a rise in flood levels. Structures or debris swept away by floods create additional damage as they are carried downstream. In Kitsap County, development is not permitted in a floodplain unless stringent building and setback guidelines are met.

Land Use Implications

Because of the environmental, health and physical hazards to landowners and neighboring properties, alternatives to development should be encouraged in areas recognized by FEMA as floodplain. A floodplain maintained in its natural state can provide recreational land and can protect critical fish and wildlife habitat and stream water quality. Alternative uses for floodplain include agricultural lands (soils are typically prime in these areas), parks, trails and private or public open space. Other land use implications include the impacts of flood damage restoration and prevention, such as dredging, installation of bank protection, channel relocation and wood debris removal.

FEMA requires local jurisdictions to regulate development in areas designated by FEMA as floodplain. The Kitsap County Flood Damage Prevention Ordinance includes methods and provisions for restricting activities within floodplains that may be vulnerable to flooding and activities that might increase flood damage.

In areas not designated as floodplain, the threat of flooding from drainage problems can be partially alleviated through actions which reduce the amount of change in an area's hydrology. Protection of wetlands and stream buffers, reduction of soil erosion at development project sites, maintenance of stormwater ponds and ditches and minimization of impervious surfaces can help to reduce drainage problems and the occurrence of damaging flooding.

VI. PLANT, FISH AND WILDLIFE HABITAT CONSERVATION AREAS

Habitat conservation areas are places critical to the survival of Kitsap County's diverse plant and wildlife communities. These areas encompass a variety of habitat types, including large parcels of contiguous undeveloped land, special areas like streams or wetlands and structural elements like rocky shorelines or standing dead trees. The ecological value of an area depends on the quantity, quality, diversity and seasonality of the food, water and cover that it offers. A site''s value is also a function of proximity to other usable habitats, the presence of rare species and the rarity of the habitat type. Habitat conditions are the prime determinant of wildlife abundance both in the number of species present and the number of individuals.

Protection and restoration of habitat conservation areas are key to maintaining the biological diversity of Kitsap County and the Puget Sound region. As development changes the face of the landscape, habitat conservation areas are lost or degraded. These losses can be minimized or reduced through land use policies and regulations which address important habitat issues. In some instances, the most valuable habitat conservation areas may undergo restoration or may be acquired for permanent protection.

This section summarizes the values of healthy habitat, provides an overview of terrestrial, freshwater and marine habitats in Kitsap County and discusses habitat needs and land use threats to significant species. It must be noted that the broad categorization of habitat in terms of terrestrial, freshwater and marine is for ease of discussion -- the health of these habitats is interdependent, and many species rely upon all three of these habitat categories for survival. Information for this discussion is drawn from a variety of sources. No complete countywide inventory of historic or current habitat exists.

Functions and Values

The variety of terrestrial, freshwater and marine habitat in Kitsap County supports a diversity of plant and wildlife types. In addition to providing food, cover and water for these species, habitat areas provide a number of other vital functions.

Biological Diversity

The biological diversity of the Puget Sound region is enhanced when habitat and intact ecosystems are protected in Kitsap County. Populations of some species, such as many types of birds, can colonize or enhance gene pools of surrounding areas. Healthy fish populations can contribute to the overall status of the Puget Sound food chain, as evidenced by the significant contribution of Hood Canal Coho salmon runs to the overall Puget Sound Coho salmon fishery.

Water Quality Protection

Water quality protection can also be enhanced when important habitat and vegetation is left undisturbed. Vegetation and groundcover help retain soil during a rain event, reducing the effects of erosion and sedimentation to lakes, streams, wetlands and marine waters. Vegetation along riparian corridors, wetlands and shorelines also plays an important role in reducing turbidity and siltation by trapping sediment and provides thermal cover to prevent water temperature extremes.

Groundwater Recharge

Groundwater recharge is maintained when woodlands and forests remain intact. In these vegetated areas, rainwater can slowly percolate into the soil, recharging groundwater and reducing stormwater runoff.

Flood Control

Flood control can be enhanced by the presence of marine and riparian vegetation. Marine vegetation such as kelp and eelgrass absorb wave energy and thus minimize the impact to the shoreline from stormwaves. The preservation of floodplains for wildlife habitat reduces the amount of impervious surface present in the floodplain, thus reducing stormwater runoff and minimizing the height and velocity of floodwaters.

Erosion Control

Erosion control can also be enhanced by vegetation in the watershed and along the shoreline. Plant roots prevent soil from being readily carried through a watershed by rainwater and prevent excessive erosion of streambanks and shorelines. Eelgrass and kelp beds slow shoreline erosion caused by waves. Eelgrass beds are the first step in the conversion of a marine environment to a wet meadowland and, ultimately into land.

Recreational/Cultural Activities

Recreational and cultural activities are afforded by wildlife habitat protection. Kitsap County's shorelines and tidelands provide recreational and subsistence shellfish harvesting opportunities for Suquamish and S'Klallam tribal members, county residents and visitors. Throughout the county's inlets, streams, lakes and ponds, opportunities exist to sport fish for trout, salmon and bass. For many people, the presence of healthy populations of fish and wildlife contributes to the quality of life in Kitsap County and birdwatching, nature walks and beachcombing provide popular nonconsumptive forms of recreation.

Commercia/Economic Vitality

Commercial and economic vitality from forestry, commercial fisheries, shellfish harvesting and tourism all depend upon healthy habitat areas which contribute to the local and tribal economies and provide economic diversification in a region heavily reliant on the defense industry.

Terrestrial

Characteristics

Before the turn of the century, old-growth Douglas fir and red cedar forest blanketed much of Kitsap County. The remnants of this forest can be seen as isolated, single, old-growth trees and as enormous stumps which lie throughout the county's second growth wooded lands. With the disappearance of the old-growth forest and the added human activity in the area, the Kitsap Peninsula lost the plant and wildlife communities associated with the Northwest's mature old-growth ecosystem, including various fungi, the fisher, the marbled murrelet and the spotted owl.

Today, the county’s 396 square miles of land greatly reflect human presence. Mature second-growth forests stand in place of the old growth forest ecosystem and are dominated by Douglas fir, with some Western hemlock, Western red cedar and Western white pine also present. In cleared and urban areas, deciduous vegetation successfully competes with conifers. Red alder and big-leaf maple are the most familiar components of broadleaf forests, but Pacific willow, Madrona and Cascara are also commonly found. Large areas of forested or recently logged lands are found in the southwestern and northern parts of the county, while smaller forests or woodlots lie scattered throughout. Many plant and wildlife species rely on wooded areas, old trees or mature forests for habitat.

The county’s topography is gently rolling, with the exception of Gold and Green mountains which reach 1,700 feet in elevation. Pastures and meadows are familiar components of valleys and low-lying areas. These places may support agricultural crops, or may host woody vegetation, grasses and wild flowers. They provide food for animals like migratory waterfowl and deer, enhance the habitat for rodents and other small mammals and support predators like barn owls, fox, garter snakes and red-tailed hawk.

The county’s most rural areas provide habitat for large mammals like bear, deer and bobcat that depend for survival primarily upon contiguous parcels of undeveloped land, with minimal road or human intrusions. Large contiguous parcels of mature forest land also provide important habitat for wildlife, particularly birds, that compete successfully with other species only in deep forests.

Important Habitats and Habitat Elements

Available information about important terrestrial habitats and habitat elements in Kitsap County is generally specific to certain species. In some cases, state agencies have identified and mapped areas which provide unique habitat values, and these areas are shown in **Figure A-NS-11.**

Unique Plant Species and Plant Communities. The Department of Natural Resources Natural Heritage Program has identified six "sensitive plant species" which are in danger of becoming extinct within the county. The Kitsap Audubon Society has identified an additional eight rare plant species which they believe should also be protected where they exist. These plants and their habitat needs are listed in **Table A-NS-9.** Most of these species depend upon undisturbed wetlands, shorelines, or mature forests for habitat.

The Natural Heritage Program has also identified at least 10 areas throughout the county which contain plant communities of statewide significance. One Douglas Fir-Western hemlock forest has been identified as outstanding representatives of plant communities in central Puget Sound. These were once dominant woodland types across the Kitsap Peninsula and are now only found in remnant patches. Other natural heritage sites are associated with fresh and saltwater wetlands.

Department of Fish and Wildlife Priority Habitat. The Department of Fish and Wildlife (DFW) defines "priority species" as those species that are of concern due to their population status and their sensitivity to habitat alteration. Priority species in Kitsap County and their habitat requirements are listed in **Table A-NS-10.** The bald eagle is the only species still found in Kitsap County listed as threatened or endangered by state or federal agencies. The purple martin and pileated woodpecker are listed as candidate species, indicating that without substantial population recovery, these species may warrant the extra protection afforded by threatened or endangered status.

Priority terrestrial habitats mapped by the DFW include areas known to provide nesting or roosting sites for bald eagles, heron rookeries (where colonies of heron nest) and known nesting sites for purple martin and pileated woodpecker. Priority habitats are mapped in **Figure A-NS-11.** Other priority habitats listed by the DFW but not mapped include caves, cliffs, urban natural open space and snag-rich areas.

In reviewing the habitat needs of priority species listed in **Table A-NS-10**, certain important habitat requirements become evident. Important terrestrial habitat elements in Kitsap County include tall trees along the shoreline, mature forest with snags and fallen trees and undisturbed mature forest near or surrounding wetlands. These habitat elements are primarily important to bird species which use the trees for nesting and perching, and to small mammals like beaver and river otter which rely upon an interface between undisturbed terrestrial and aquatic areas. Some areas of the county may provide an abundance of important habitat elements, but these areas have not yet been mapped.

Other Important Habitats. Kitsap County's rural areas are home to small populations of black bear and bobcat. Black bear have ranges that often reach 10 miles in radius, and both bear and bobcats rely on large areas of contiguous, undeveloped land that provide minimal contact with humans and roads. Many other animals rely on the habitat provided by large wooded areas. These species, most notably migratory songbirds, are known as area-sensitive, and do not adapt well to fragmentation of forest habitat. Further research on the habitat needs of these birds would help to determine ideal sizes for natural preserves. In general, there is a strong correlation between forest size and number of bird and mammal species present.

TABLE A- NS-9 State-Sensitive and Locally Unique Plants

SPECIES	KITSAP COUNTY HABITAT
1. Bog clubmoss (sensitive)	Wetlands adjacent to low elevation lakes
2. Western yellow oxalis (sensitive)	Moist coastal woods, dry open slopes
3. Alaska alkaligrass (sensitive)	Salt marshes, mudflats, gravelly areas near beaches, rock outcrops in sea spray
4. Chain-fern (sensitive)	Stream banks, moist "seep" areas, mostly near salt water
5. Pink sandverbena (sensitive)	Sandy beaches along saltwater
6. Fringed pinesap (sensitive)	Duff and humus of shaded, low-elevation coniferous forest
7. Bristly sedge	Marshes and wet meadows
8. Gnome plant	Deep humus in coniferous forest
9. Water lobelia (lobellia dortmania)	Emergent freshwater wetlands
10. Chick lupine (lupinus micipcarpus)	Dry to moist soils
11. White meconella (meconella oregana)	Open ground where wet in the spring
12. Branch montia (montia diffusa)	Moist places, mostly in the west Cascades
13. Great pole monium (pole monium corneum)	Thickets, woodlands and forest openings
14. Woolgrass (scirpus cyperinus)	Wet, low ground

Source: Flora of the Pacific NW, Hitchcock - Cronquist, University of Washington Press, 1973 Seattle, 1991

Smaller tracts of natural habitat are suitable for many plant and animal communities and are temporarily used by other species as they forage for food or move from one large natural area to another. Even in urban areas, parks or open space can serve as wildlife refuges, but species diversity is less in smaller preserves and in refuges that are relatively isolated from other natural areas.

Natural corridors that connect small tracts and large reserves facilitate wildlife movement and thus help to maintain healthy populations of plant and animals by enabling species to colonize new areas, forage for food, find mates and exchange genes with neighboring populations. Studies performed in King County indicate that 100-foot buffers along streams provide adequate wildlife corridors, with variations for severe slopes or extensive wetland areas.

These important habitats thus include large tracts of undeveloped rural lands, small natural habitats (even in urban areas) and corridors that connect preserves with one another. These habitats have not yet been inventoried in Kitsap County, and optimal sizes for these habitat areas have not been determined.

Land Use Implications

When undeveloped land is converted to residential or commercial uses, existing habitat is permanently lost or greatly modified. Many species which lived on the property either die or move to adjacent parcels, where they compete with existing populations for space. When the habitat is modified, it may become more suitable for some species, like raccoons and crows. Small-scale opportunities for habitat enhancement, such as replanting of native vegetation, or cultivating berry or fruit-producing plants, may encourage colonization by others. In some cases, loss of important habitat elements such as mature trees along shorelines, snags and downed logs can cause the decline of different types of wildlife which might otherwise be able to adapt to urban or suburban development patterns.

As the landscape in rural areas becomes more fragmented by human development, less habitat remains for species like black bear and bobcat that avoid human contact. Wildlife deaths from automobiles, hunting or trapping also increase. As roads and residential developments fragment habitats, some plant and wildlife populations become isolated from neighboring populations. This isolation decreases genetic diversity and can lead to the eventual extinction of that population. In addition, habitat fragmentation increases the "edge effect" on remaining intact habitats. This enables urban tolerant species to invade the habitat from its edges and leads to localized extirpation of more specialized species.

Terrestrial habitat areas can best be preserved through land use policies which direct human population growth to concentrate in certain areas and encourage preservation of large, minimally developed parcels for rural uses. Sensitive development designs that minimize roads, optimize preservation of contiguous open space and maintain undisturbed native vegetation and critical habitat elements can also contribute to habitat preservation. Forestry operations that minimize roads, preserve critical wildlife habitat and replant quickly can also help to maintain habitat areas. Permanent protection of terrestrial habitat can be ensured through private or public efforts to acquire natural open space areas. A system of open spaces can help to address wildlife habitat areas in conjunction with preserving rural character, environmental quality and recreation lands.

Freshwater Habitat

Characteristics

Kitsap County's freshwater habitat include streams and riparian areas, wetlands and lakes. Water is the primary habitat for many life forms and provides critical habitat during the life cycles of many others One U.S. Forest Service report estimated that 87% of the wildlife and fish species found in forested areas of western Washington depend upon streams or wetlands during at least one part of their life cycle. Terrestrial species depend upon freshwater areas for drinking water, movement corridors or feeding, and a variety of plant species depend solely upon the moist soils or open freshwater associated with these habitats. The locations of freshwater bodies in Kitsap County are mapped in **Figure A-NS-8**, Surface Water and Wetlands.

TABLE A-NS-10 Habitat Needs of Priority Species

SPECIES SPECIES	SIGNIFICANT KITSAP COUNTY HABITAT KITSAP COUNTY HABITAT	LAND USE THREATS LAND USE THREATS
Bald Eagle	Coniferous, uneven-aged forests near water. Large trees along river, lake and marine shorelines.	Loss of large shoreline trees; highly sensitive to human activity near perch, roost and nest sites.
Purple Martin	Tree cavities in low-lying forests.	Conversion of forest lands to non-forest uses.
Pileated Woodpecker	Mature 2nd growth coniferous forests with snags and fallen trees.	Conversion of forest lands; clear-cutting and removal of snags and fallen trees.
Great Blue Heron	Undisturbed stands of tall trees near wetlands or water bodies; fresh and saltwater wetlands, streams and shorelines.	Highly sensitive to human activity near nest sites; loss of wetlands; shoreline development.
Osprey	Tall trees or dead snags near large bodies of water.	Loss of shoreline habitat; highly sensitive to human activity near nest, perch sties.
Columbian Black-Tailed Deer	Forest.	Conversion of forest lands.
Harlequin Duck	Tree/shrub stream, banks, boulder/gravel shoreline, kelp beds.	Shoreline development; loss of riparian habitat; siltation of kelp beds.
Cavity Nesting Ducks (Barrow's Goldeneye, Bufflehead, Wood Duck, Hooded Merganser)	Tree cavities in trees adjacent to sloughs, lakes, beaver ponds; shallow open water wetlands.	Loss of tree cavities near water, loss of undisturbed wetlands.
Blue Goose	Open foothills (created by fire or small clearcuts) with streams, springs and meadows.	Conversion of foothills to farms and houses.
Band-Tailed Pigeon	Coastal forests with diverse tree ages, and farmland, mineral springs, streams with gravel deposits.	Conversion of forests and farmland.
Sea run and Coastal Cutthroat	Wetlands and riparian corridors.	Loss of wetlands and undisturbed riparian corridors.
Steel head	Wetlands and riparian corridors.	Loss of wetlands and undisturbed riparian corridors.
Green backed Heron	Wooded ponds.	Development adjacent to ponds.
Red-Tailed Hawk	Mature 2nd growth, urban open space.	Loss of wood lots and urban open space.
Black Brant	Eelgrass beds.	Shoreline development; siltation of eelgrass beds.
Beaver	Wetlands, streams.	Loss of wetlands and undisturbed riparian habitat.
Rover Otter	Wooded streams and estuaries.	Loss of undisturbed riparian habitat, shoreline development.

TABLE A-NS-10 Habitat Needs of Priority Species

Harbor Seal		

Source: Washington Department of Wildlife, Management Recommendations for Washington's Priority Habitats and Species, May 1991.

Streams. Hundreds of streams and two rivers flow through the county, ranging in size from seasonal drainages to the Tahuya and Union rivers. Even the smallest of these creeks may provide important habitat for anadromous fish (salmon and sea-run trout that return to freshwater to spawn), and the county's anadromous fish populations contribute significant numbers to the overall Puget Sound fishery. Streams are "typed" by the Department of Natural Resources according to water volume and the importance of the stream for fish and wildlife habitat, drinking or recreation. Streams classified as Type 1, Type 2 or Type 3 typically contain anadromous fish habitat or have high value for fish and wildlife populations. Type 4 streams have habitat significance primarily for their impact as tributaries to other streams, while Type 5 streams generally have low habitat value. See **Table A-NS-6** in Water Resources for a more thorough description of stream types.

Riparian Areas. Riparian areas lie along rivers, streams and springs. They have high water tables, certain soil characteristics and vegetation that requires free water or moist conditions. These zones are transitional between freshwater and terrestrial lands, and the edge between the upland zone is usually identified by a change in plant composition, relative plant abundance or end of high soil moisture. Riparian corridors and streams serve as effective transport systems for water, soil, plant seeds and nutrients to downstream areas, and serve as important travel routes for the movement and dispersal of many wildlife species. Although they occupy only a small part of an overall landscape, riparian areas are an important source of biodiversity within the landscape.

Freshwater Wetland Habitats. Freshwater wetland habitats include marshes, swamps, bogs, seeps, wet meadows, shallow ponds and lakes less than 20 acres in area or less than six feet in depth. Like riparian areas, wetlands are characterized by high species diversity, species density and productivity of both plant and animal species. In many cases, wooded areas adjacent to wetlands provide a key habitat for wetland-dependent species by providing nesting areas for waterfowl or food and cover for small mammals like beaver. Studies of migratory waterfowl in Maryland have shown that migratory waterfowl greatly prefer shallow ponds to lakes.

As they are identified during the development process or by community wetlands inventories, wetlands in Kitsap County are categorized according to the Washington State Four-Tiered Wetlands Rating System. Category I wetlands are typically the most exceptional in terms of habitat and plant communities, while Category IV wetlands are generally small, less diverse habitat areas. Wetlands in Kitsap County have been mapped by the Department of Natural Resources, the U.S. Fish and Wildlife Service and the U.S. Natural Resources Conservation Service, and are depicted in **Figures A-NS-8** and **11**.

Lakes. Lakes greater than 20 acres in size or greater than six feet in depth also provide important fish and wildlife habitat. Eighteen lakes in Kitsap County are this size. The shorelines of these lakes are typified by waterfront residential development, with the exception of Buck Lake, Miller Lake and Morgan Marsh. Although most species generally prefer shallow ponds to lakes, the deeper waters and larger area of a lake support fish and wildlife, and wetlands associated with these lakes are particularly important habitat areas. The Department of Fish and Wildlife stocks many of these, and smaller lakes, with game fish for sport fishing.

Important Habitat and Habitat Elements.

Anadromous Fish Streams. Kitsap County's streams provide freshwater habitat for six species of anadromous fish (fish like salmon and sea-run trout that live part or the majority of their lives in salt water but return to freshwater to spawn.) These fish have evolved to return to the stream in which they were born, and thus each stream provides habitat for fish uniquely adapted to it. While many of the county's streams produce runs of fish numbering several hundred fish or less, the overall impact of these fish populations results in a significant resource countywide. Chico Creek, which empties into the west shoreline of Dyes Inlet, currently produces the largest run of wild salmon in the county.

Table A-NS-11 lists Kitsap County's salmonids, their habitat needs and the streams upon which they rely. **Table A-NS-12** highlights streams currently providing anadromous fish habitat based upon information provided by the Washington State Department of Fish and Wildlife.

A natural anadromous fish run is an indicator of a stream's health because salmon require cool, uncontaminated water with healthy stream beds and insect populations. Vegetated riparian areas are important to maintaining stream habitat because they stabilize water temperature through shade, produce an adequate insect supply, protect streams from excessive erosion and provide woody debris to the streams.

Streams Planted with Game Fish. Streams that provide habitat for steelhead trout and cutthroat and streams planted with game fish by the Department of Fisheries or various tribal governments are listed in **Table A-NS-13.** Tribal and state fish rearing facilities provide the fish for planting and are present on Cowling Creek, Grovers Creek, Dogfish Creek, Big Scandia Creek, Little Scandia Creek, Clear Creek, Steele Creek, Dickerson Creek, Gorst Creek and Blackjack Creek. Water quality and habitat conditions in these creeks are important for fish survival.

Other Streams and Riparian Areas. As described above, the Department of Natural Resources inventories and maps streams and categorizes them according to beneficial uses. Although stream Types 4 and 5, and unclassified streams (Type 9) generally do not provide habitat for game or anadromous fish and may flow only part of the year, they can still support populations of fish, amphibians or other animals. The riparian areas adjacent to these streams also provide important wildlife habitat and can serve as wildlife corridors. All streams identified by the Department of Natural Resources are mapped in **Figure A-NS-8.**

Lakes and Ponds Plantable with Game Fish. Lakes and ponds planted with game fish by the DFW are listed in **Table A-NS-13** and mapped in **Figure A-NS-11**. Game fish are those which may only be taken recreationally by non-Indian fishers. Foodfish are those species which may be taken commercially and/or recreationally. In order to support populations of game fish, open water must be maintained, and good water quality and healthy aquatic vegetation are necessary. These lakes and ponds provide recreational opportunities and can also support enhanced wildlife communities which feed on the fish.

Endangered Species Act. The National Marine Fisheries Services has recently proposed listing of the chinook and summer chum salmon under the Federal Endangered Species Act. Proposed listing of additional species is anticipated. Work with Federal and State agencies and area tribes, cities and counties will be needed to review local and regional programs and regulations in a coordinated effort to develop a recovery plan if final listing is to be avoided.

TABLE A-NS-11 Kitsap County Anadromous Fish and Habitat

FISH	SPAWNING HABITAT/ REARING HABITAT	STREAMS OR RIVERS
Chinook Salmon (King)	Lower stream reaches with gravel and greater water flows/river mouth estuaries	Coulter, Rocky, Minter, Burley, Gorst, Chico, Dogfish, Dewatto, Tahuya, Union
* Chum Salmon (Dogs)	Coastal sloughs, blind channels, upstream as far as good gravel extends/coastal estuaries	Coulter, Rocky, Lackey, Burley, Purdy, Crescent, Curley, Blackjack, Dogfish, Chico, Big Beef, Anderson, Big Mission, Rendsland, Dewatto, Tahuya, Union
Pink Salmon (Humpies)	Coastal streams, high velocities of water, may travel further upstream than Chum/coastal estuaries	Minter Creek and sometimes Dewatto, Tahuya, Union
Coho (Silvers)	Small streams with medium size gravel, medium flow velocity, springs, swamps, marshes, seasonal streams/streams and estuaries	Many creeks, independent streams and tributaries with suitable conditions
* Steelhead (Rainbow Trout)	Smaller streams with medium size gravel and medium flow velocity; seasonal streams/ripples and pools in streams; in winter, deeper, slower waters	Not listed by Fisheries
Searun Cutthroat (Trout)	Small, low gradient streams, near estuary mouth of streams	Not listed by Fisheries

Source: Department of Fish and Wildlife Washington Rivers Inventory ,and Yates, Adopting A Stream Handbook.

* Summer Chum Salmon in Hood Canal were identified by State Department of Fisheries as a critical stock in 1992. This means that population of the stock may be in jeopardy of extinction.

* Winter Steelhead runs in the Tahuya River have been identified by State Department of Fisheries as a depressed stock - production is below expected levels.

* Several Hood Canal Coho stocks have been identified by State Department of Fisheries as a depressed stock - production is below expected levels.

* Searun Cutthroat (Trout) throughout the county have been identified by State Department of Fisheries as a depressed stock - production is below expected levels.

TABLE A-NS-12 Streams with Salmon Releases in 1991 (Department of Fisheries, 1993) .

WATER BODY	SPECIES
Clear Creek	Coho, Fall Chinook, Chum
Burley Creek	Fall Chinook, Coho
Minter Creek	Fall Chinook, Chum, Coho
Barker Creek	Coho, Chum
Steele Creek	Coho, Chum
Big Scandia Creek	Coho, Chum
Johnson	Coho
Dogfish Creek	Coho, Chum, Fall Chinook
Salmonberry Creek	Coho
Olalla Creek	Coho, Chum
Beaver Creek	Coho
Little Boston Creek	Chum
Dickerson Creek	Chum
Cowling Creek	Chum
Gorst Creek	Fall Chinook
Steele Creek	Coho
Purdy Creek	Coho
Crescent Creek	Coho
Huge Creek	Coho
Coulter Creek	Fall Chinook, Chum
Hupp Springs	Spring Chinook
Mosher Creek	Coho
Grovers Creek	Fall Chinook, Coho
Hood Canal	Fall Chinook
Port Gamble	Chum, Coho
Agate Pass	Coho, Chum
Union River	Coho

TABLE A-NS-13 Lakes and Ponds with Game Fish

LAKE	CURRENTLY MANAGED SPECIES	NATURALLY OCCURRING OR ESTABLISHED SPECIES
Big Beef Ponds		Cutthroat Trout
Buck Lake	Rainbow Trout	
Carney Lake	Rainbow Trout	
Crescent Lake	Rainbow Trout	
Fairview Lake		Largemouth Bass, Brown Bullhead
Flora Lake		Largemouth Bass, Brown Bullhead
Gluds Ponds	Rainbow Trout	
Hintzville Beaver Pond	Cutthroat Trout	
Holland Lake	Cutthroat Trout	
Horseshoe Lake	Rainbow Trout	Brown Bullhead
Island Lake	Rainbow Trout	Brown Bullhead
Kitsap Lake	Rainbow Trout	Searun Cutthroat Trout, Largemouth Bass, Brown Bullhead, Bluegill
Koeneman Lake	Rainbow Trout	Largemouth Bass
Long Lake	Rainbow Trout	Searun Cutthroat Trout, Largemouth Bass, Black Crappie, Bluegill
Ludvick Lake	Cutthroat Trout	Largemouth Bass
McCaslin Marsh		Cutthroat Trout
Mission Lake	Rainbow Trout	Brown Bullhead
Mission Pond	Cutthroat Trout	
Mission Ridge	Cutthroat Trout	
Panther Lake	Rainbow Trout	Brown Bullhead
Scout Lake		Largemouth Bass
Spur 3 Pond	Cutthroat Trout	
Square Lake		Largemouth Bass
Tahuya Lake		Searun Cutthroat Trout, Largemouth Bass
Wildcat Lake	Rainbow Trout	Cutthroat Trout, Brown Bullhead
Wye Lake	Rainbow Trout	Largemouth Bass

Source: Washington Department of Wildlife, Lakes of Washington Fish Data, 1991.

Land Use Implications

Land use activities can both directly and indirectly damage the quality of freshwater habitat. Loss of vegetation in riparian areas, adjacent to lakes and wetlands reduces the suitability of these areas as wildlife corridors and as nesting and feeding areas for many water-dependent species. Vegetative loss can also affect the habitat quality of fresh water bodies by reducing both water quality and the amount of organic debris present. It may also increase the amount of siltation that chokes waters or covers spawning gravel beds.

Fish habitat in streams, lakes and wetlands can be ruined when drainage patterns are disturbed by land use activities. Increased flow of water over land can cause excessive erosion of stream banks and can change the hydrologic balance of wetlands. Increased sediments in runoff can cover important salmon spawning gravel and choke aquatic plant, animal and fish life. Increases in contaminants carried by stormwater can also destroy the ecological balance of lakes, wetlands and streams by increasing nutrient loads or killing aquatic life. Drainage studies completed by the DFW for Kitsap County indicate that when 12% of a watershed becomes impervious, the hydrological balance of a stream begins to change.

Aquatic habitat can also be directly destroyed by filling or dredging of a wetlands. Changes in wetland functions can alter the natural hydrologic balance of a drainage basin and lead to water quantity or quality changes in related streams. Culverts and dams can change stream habitat as well as directly block fish migration. Roads which follow streams corridors can fragment critical wildlife habitat, disturb wildlife and create water quality and quantity problems. Invasive plant species introduced from nearby lawns and gardens can also enter a wetland area and successfully outcompete native vegetation.

Marine Habitat

Characteristics

The marine environment includes estuaries and the deep waters of Puget Sound and Hood Canal. These environments provide critical plant, fish and wildlife habitat, which can be greatly affected by activities on land as well as in the water. Estuaries are semi-enclosed bodies of water with free connection with the open sea and within which salt water is measurably diluted with fresh water from land drainage. They form transitions between freshwater, terrestrial and marine environments and support a rich and diverse biota. Anadromous fish migrate through estuaries to spawn upstream in freshwater, and juveniles of these species also spend time rearing in the estuaries prior to emigration to the ocean. Commercially important marine species like herring spawn, feed and rear in extensive areas of estuaries, and shellfish are found throughout the county's estuaries and off most of the shoreline. Birds of prey and many mammals use the fish, shellfish and other species found in embayments as their forage base, and many bird and mammal species use estuaries as primary habitat.

Both estuaries and the waters of Puget Sound and Hood Canal depend upon the health of tideflats and the water column for primary production. Eelgrass, kelp and phytoplankton which float within the water column serve as the cornerstone of the grazing food chain and provide shelter for both invertebrate and vertebrate animal species. The deeper waters and narrow channel of the Hood Canal

embayment produce a unique marine environment rich in nutrients and host a remarkable diversity of fish and animal life, including octopus, ling cod and wolf eels.

While the entire marine environment can be classified as important plant, fish and wildlife habitat, some marine habitat areas contain greater species diversity or are more commercially productive than others. Existing information about the marine waters off Kitsap County's shoreline is more extensive than that available for terrestrial and freshwater habitats. Specific marine habitats and habitat areas are described below.

Important Habitat and Habitat Areas

Unique Wetland Plants and Plant Communities. The Department of Natural Resources identifies two sensitive plant species (listed in **Table A-NS-9**) that are dependent upon Kitsap County's shoreline habitat. The DNR also declares the Nature Conservancy's Foulweather Bluff Preserve, Stavis Bay and Doe-Kag-Wats (on the Port Madison Indian Reservation) to be significant statewide. These areas are depicted in **Figure A-NS-10**.

Department of Fish and Wildlife Priority Habitats. The DFW has mapped a number of shorelines and estuaries as priority habitat due to their importance to populations of black brant, harlequin duck, cavity nesting ducks, sea lion and river otter, or for their significance as bald eagle and great blue heron feeding areas. These areas are mapped in **Figure A-NS-10**.

Kelp and Eelgrass Beds. Kelp and eelgrass beds provide habitat, feeding and rearing ground for a large number of marine organisms including fish, crabs and birds. The term "kelp" refers to any of the large brown seaweeds in the order Laminariales, typically found in rocky intertidal areas. Eelgrass is a vascular plant which grows most commonly in intertidal and shallow subtidal areas.

Kelp beds provide a surface upon which other plants and animals grow. They are used as resting areas by birds and mammals including gulls, herons, waterfowl, shorebirds and otters. Kelp beds help create protected environments for intertidal plants and animals and reduce inshore erosion on sand and gravel beaches. The reduced current and wave actions resulting from the presence of kelp beds creates habitat for organisms which would not be present in the absence of the beds.

Eelgrass is a highly productive plant and is important in the trophic functioning and nutrient cycling of the entire coastal zone. Eelgrass beds help make the shoreline an important stop-over and wintering ground along the Pacific flyway. Studies have shown that the diving birds use of eelgrass beds in the Hood Canal was three times greater than use of nonvegetated near shore areas.

In recent years, the overall number of kelp and eelgrass beds and their size has been decreasing throughout Puget Sound. These changes are believed to be due to changes in water quality and turbidity resulting from increased development and forest activities on land. However, kelp usually undergo natural fluctuations in abundance as a result of storms, unusually hot weather, or changes in the populations of grazers. The shorelines of Kitsap County that contain kelp and eelgrass beds are identified in **Figure A-NS-10**, based on information from the Coastal Zone Atlas of Washington State.

Shellfish Beds. Shellfish areas are those tidelands and intertidal lands supporting naturally occurring bivalve shellfish populations or commercial shellfish aquaculture facilities. A variety of shellfish inhabit the muds, sands and rocky substrate of Kitsap County. Hardshell clams are found in intertidal areas and include butter clams, native littleneck, manila clams, cockles and horseclams. Geoducks typically burrow offshore, buried in subtidal areas two to three feet deep in the mud or soft sand. Other shellfish found along the county's shoreline include shrimp, crab and oysters. Dungeness crab frequently associate with eelgrass beds, but red rock crab prefer areas with rocky terrain and less silt.

As shown in **Figure A-NS-11**, most of Kitsap County's shoreline provides shellfish habitat. Significant commercial and recreational shellfish harvest areas are listed in **Table A-NS-14.** Commercial and recreational shellfish harvesting is restricted or prohibited in Dyes Inlet, Sinclair Inlet and parts of Liberty Bay, Burley Lagoon and at the mouths of sewage treatment outfalls.

TABLE A-NS-14 Commercial and Recreational Shellfish Beaches in Kitsap County

COMMERCIAL AREAS	RECREATIONAL BEACHES
Agate Pass, Big Beef Harbor, Liberty Bay, Misery Point, Nellita, Port Blakely, Port Gamble/Klallam Bay, Port Madison/Suquamish Reservation, Port Orchard Passage, Raft Island, Seabeck	Agate Pass, Anderson Cove, Fay Bainbridge State Park, Illahee State Park, Kitsap Memorial State Park, Miller Bay, Old Man House State Park, Point-No-Point, Point Southworth, Scenic Beach State Park

Source: Washington State Department of Ecology, Shellfish Protection Through Land Use Management. 1993

Herring and Smelt Spawning Areas. Herring and smelt are important to the survival of commercial and recreational fish species in Washington waters. According to the Department of Fish and Wildlife, herring spawn during the winter and early spring in low intertidal areas along Hood Canal, Dyes Inlet, Agate Passage, near Liberty Bay and around Port Gamble. Spawning occurs in eelgrass and seaweed in the low intertidal zone, and in some cases, in gravelly areas. Surf smelt spawn during the winter in sandy gravel beaches along Dyes Inlet, Sinclair Inlet and Liberty Bay. These areas are depicted in **Figure A-NS-11**.

Land Use Implications

Land use activities that influence marine water habitat can occur within the watershed or along the shoreline. Because of the elongated, narrow shape of Kitsap County and its 228 miles of saltwater shoreline, land use activities can seriously impact the marine environment. Watershed activities such as increased development or forest practices may increase the amount of suspended solids, pollutants or fresh water entering marine waters. Suspended solids reduce light penetration, increase sediment deposition, induce changes in water temperature and may affect dissolved oxygen and pH balance, thus affecting all forms of marine habitat.

Activities that cause slight increases in turbidity decrease light penetration and may result in a loss of kelp and eelgrass beds, while increased sedimentation can smother eelgrass beds at the shallow limits of their distribution.

Increased sedimentation from erosion or from the collapse of coastal bluffs can cover shellfish beds and fish spawning gravel. Shellfish beds are also susceptible to chemical and bacterial/viral contamination from certain agricultural practices, improperly installed and/or maintained septic drainfield systems, and stormwater runoff. USFDA rules require WDOH to maintain prohibited shell fishing areas around wastewater treatment plant outfalls as a precaution against failure of disinfection systems. Such contamination may not harm the shellfish. It does increase the risk of disease for the human and bird populations that feed off of the shellfish. Toxic contaminants from urban runoff or industrial discharges can poison the marine water column and sediments, resulting in tumors and concentrations of poisons in fish and invertebrate species.

Land use in the watershed can also impact wildlife species that play a critical role in the ecological balance of marine habitat, such as the great-blue heron or bald eagle. Construction of bulkheads or other shoreline activities can affect the rate of natural beach deposition or result in a loss of vegetation, thus contributing to a loss of herring and smelt spawning areas or other shoreline and intertidal habitat. Fish and wildlife habitat can be directly impacted by untreated sewage discharge, oil or toxic spills or litter from boats and marinas.

Terrestrial, freshwater and marine habitats in Kitsap County contribute to the overall biological diversity of the Puget Sound region and provide a number of additional functions and values. While some information exists about the needs of specific plant, animal and fish species, little research has been done on the location of critical habitat areas in Kitsap County and on the optimal sizes and locations of habitat areas.

Terrestrial and freshwater habitats can be directly affected by development and land use activities that remove vegetation and replace naturally functioning systems with impervious surfaces and invasive species. Land use activities can also indirectly impact freshwater and marine habitat by changing the quantity and quality of water entering these environments. There is constant interaction between the terrestrial, freshwater and marine environments, and many species depend upon the health of all three categories to survive.

As the county's human population grows, development will inevitably lead to loss of plant, fish and wildlife habitat. These impacts can be minimized by sensitive land use patterns, development design criteria, water quantity and quality controls and habitat restoration efforts.

VII. AIR QUALITY

Characteristics

Air pollution consists of a complex mixture of compounds that are often difficult to quantify. National and state standards have been established for six common pollutants that affect Washington state. These pollutants are carbon monoxide, particulate matter, ozone, sulfur dioxide, lead and nitrogen dioxide. The U.S. Environmental Protection Agency designates areas where violations of these standards occur as "nonattainment" areas. Kitsap County is currently outside of all such designated areas in the Puget Sound region.

The Puget Sound Air Pollution Control Agency enforces federal, state and local air quality regulations and oversees the monitoring and regulation of air pollution emissions from stationary (point) sources such as business and industry; area-wide sources such as wood stoves, fireplaces and outdoor fires; and trains and ships. The Department of Ecology retains primary responsibility for regulating on-road mobile sources like automobiles and trucks.

In Kitsap County, one permanent station at Fairgrounds Road monitors air quality. This station monitors particulate matter (lung-obstructing particles discharged into the air by traffic, industry and wood burning). The Washington State Department of Ecology does not monitor or enforce air quality regulations in the county, but the Puget Sound Air Pollution Control Agency oversees station maintenance and regularly collects data.

Local regulations in Puget Sound address a variety of contaminant sources including new construction permits, outdoor fire regulations, emission standards for opacity, sulfur dioxide, odors and fugitive dust, woodstove regulations and spray coating operations. Regulations also pertain to ozone emitting activities from gasoline stations, petroleum refineries, gasoline terminals, bulk plants, fiberglass/gelcoat, graphic arts, surface coaters and aerospace and auto body spray booths. Toxic contaminants from dry cleaners, asbestos renovation/demolition and other new or existing sources that exceed the allowable source impact levels for a toxic air contaminant are also regulated.Air pollutants in Kitsap County typically originate from one of three sources: industry, wood smoke or outdoor burning and traffic. These sources are discussed in more detail below.

Industrial Air Pollution

All air contaminating operations and equipment (sources other than on-road motor vehicles) are registered with and regularly inspected by the Puget Sound Air Pollution Control Agency (PSAPCA). These requirements are more stringent in areas that have been designated "nonattainment." In a nonattainment area, new major polluters must provide a pollution offset of 1.1 times their proposed allowable emissions. They must work to reduce the pollution of another industry or purchase pollution credits from the PSAPCA.

The PSAPCA considers "major polluters" to be those sources emitting 10 tons or more of volatile organic compounds (VOC) or toxic air contaminants (TAC) per annum and sources emitting 25 tons or more of particulate matter (PM10), oxides of sulfur (SOX), oxides of nitrogen (NOX), or carbon monoxide (CO) per annum. At this time, the "major" sources for Kitsap County include the Naval

Submarine Base, Puget Sound Naval Shipyard, Navy Supply Center and the Navy Undersea Warfare Engineering facility. These sites are inspected at least once annually.

Wood Smoke and Outdoor Burning

Under the Puget Sound Air Pollution Control Agency's residential wood smoke control program, burning in woodstoves and fireplaces is allowed throughout Kitsap County, but excessive wood smoke is illegal and subject to fines. During the winter months, PSAPCA implements a state-mandated, two-stage wood smoke curtailment program that goes into effect when a burn ban is called. This curtailment program applies to areas delineated in **Figure A-NS-12.** In a Stage I impairment, PSAPCA prohibits the use of uncertified wood stoves, fireplaces and outdoor burning when locally monitored 24-hour particulate pollution levels reach 75 micrograms per cubic meter of air. In a Stage II impairment, PSAPCA extends the ban to all stoves, including pellet types, when 24-hour particulate levels reach 105 micrograms per cubic meter of air. Households with no other source of adequate heat are exempt from local bans.
Outdoor residential and commercial burning permits are administered through local fire departments. In Kitsap County, only natural vegetation can be burned outdoors. Burn barrels and burning of trash are prohibited. The Washington State Clean Air Act mandates that by the year 2001, all outdoor burning in designated urban growth areas shall be prohibited. To meet this requirement, local governments or private entrepreneurs will need to consider a variety of options, including curbside yard waste pick-up, yard waste recycling stations and portable wood waste chippers.

Transportation

At the present time, the County's attainment status excludes it from state carbon monoxide and ozone monitoring programs as well as from state vehicle inspection and maintenance programs. To demonstrate and assure air quality conformity of transportation plans, programs and projects, state or federally funded projects must **not**:

- Cause or contribute to any new violation of federal air quality standards,
- Increase the frequency or severity of any existing violation of these standards,
- Delay the timely attainment of the standards.

The county's transportation plan, to be adopted as part of the countywide comprehensive plan, will be evaluated based on conformity with air quality regulations.

Land Use Implications and Conclusion

According to state and federal air quality regulations, Kitsap County is not currently considered a "non-attainment area." If increased population growth and development result in significant increases in traffic, outdoor burning, wood burning stoves and fireplaces, the county may eventually violate these regulations and become subject to the more stringent monitoring and control requirements of nonattainment areas.

Beyond the effect of poor air quality on human health and the environment, the implications of nonattainment area designation has economic implications. Local jurisdictions in nonattainment areas

must work with the state to develop an implementation plan illustrating how the area will meet state standards within a given time frame. These plans might identify existing industrial sources, future industrial sources, domestic smoke emissions or transportation and vehicle emissions as targets of stricter air quality requirements. The implementation of these plans can thus impact economic development strategies, require changes in business practices and the lifestyles of local residents and/or have financial impact on transportation agencies and local governments.

Nonattainment areas in Puget Sound include urbanized portions of Snohomish, King and Pierce counties. The PSAPCA has identified wood smoke from chimneys, fireplaces and outdoor burning as one of the biggest threats to Kitsap County's attainment status.

Careful land use and transportation planning can help to minimize air pollution hazards to local residents and minimize impacts on a regional and "global" scale. Higher-density development patterns in urban areas that are well served by public transportation, sidewalks and trails can contribute to a better jobs/housing balance and greater opportunities for alternative modes of transportation.
Alternative sources of fuel other than wood as a source of heat for residential developments can contribute to air quality preservation, as can wood waste recycling facilities that preclude the need to burn debris outside of no-burn zones. Land uses that create industrial pollution can harm the health of nearby neighborhoods and must be sited carefully. It is in the interest of Kitsap County residents and businesses to ensure that air quality is maintained.