DESCHUTES RIVER/ BUDD INLET WATERSHEDS

Thurston County
Washington

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USDA PUGET SOUND COOPERATIVE RIVER BASIN

DESCHUTES/BUDD INLET WATERSHED
THURSTON COUNTY
WASHINGTON

Prepared for

DESCHUTES/BUDD INLET
WATERSHED MANAGEMENT COMMITTEE

by

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INTRODUCTION

In March 1987, the U.S. Department of Agriculture, Soil Conservation Service approved funding of a three-year program to assist the State of Washington in the implementation of its Puget Sound Water Quality Management Plan. In 1989 the program received additional authorization until October, 1992. The program established a Puget Sound Cooperative River Basin Team (PSCRBT) of resource oriented personnel with a geographic information system. Its purpose was to work directly with local water quality planning agencies and watershed management committees. The PSCRBT is composed of representatives from the USDA Forest Service and Soil Conservation Service and the Washington Departments of Ecology and Fisheries.

Thurston County requested the assistance of the PSCRBT to inventory and evaluate the potential nonpoint sources of pollution within the Deschutes River/Budd Inlet Watersheds. This report discusses the forest, rural, and agricultural portions of these watersheds and their impacts on water quality. The report also includes a summary of findings with conclusions and recommendations for the improvement of water quality. A watershed base map is included within this report. Because of scale limitations, other kinds of watershed maps cited in the report are not, but are available under separate cover from Thurston County. Fieldwork for this report was conducted in the 1988-89 period.

Information was acquired from published and unpublished reports, field data, and from individuals living and working in the watershed. The Weyerhaeuser Company as well as agencies of state and local government, provided published and unpublished information. A windshield survey and interviews with residents provided the background for the rural source area discussion. In addition all commercial farmers were interviewed. The information was evaluated as to the potential sources of nonpoint pollution.

The cooperation and support of all the individuals, groups, agencies, and, business and industry were very much appreciated.

This report is submitted to the Deschutes/Budd Inlet Watershed Management Committee for its information and use.

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SUMMARY OF FINDINGS

NONPOINT WATER QUALITY PROBLEMS

Nonpoint sources of pollution in the Deschutes-Budd Inlet Watershed impact the beneficial use of its waters for shellfish, anadromous fish, recreation, and domestic water supply. The economic base of the region is dependent on its position as the center of state government and on its environmental quality. This promotes the area as a desirable center of urban growth and, of commercial fishery and recreation. Pollution of the waters of the Deschutes/Budd Inlet could have serious negatives impacts on major parts of its economy.

The streams and estuary of The Deschutes/Budd Inlet Watershed form a unique interrelated environment for spawning and rearing anadromous fish, and for shellfish that can be impaired by poor water quality. Day-to-day activities by individuals and by businesses in the forest, rural/agriculture, and urban areas of the watershed have contributed sediment, bacteria, nutrients, and other pollutants to its waters.

Source Areas Of Nonpoint Pollution

The nonpoint sources of pollution for the forest and rural/agricultural land uses are evaluated as suggested in the Washington Administrative Code (WAC 400-12).

A major source of fine sediment is the eroding streambanks in the lower Deschutes River Watershed. Sediment deposited into Capitol Lake and Budd Inlet is a major problem. The sediment acts as a transport mechanism for fecal coliforms as well as other pollutants which will attach to the finer particles. Fecal contaminates also can be tied up in the estuary sediments to be slowly released over time into the water column. Sediment and turbidity can reduce the productivity of shellfish by interfering with respiration and feeding.

-Sedimentation in Capitol Lake will continue, but at a slower rate than during the 1970's and early 1980's when heavy road construction was being done. Dredging will still be necessary. In recent years the Deschutes River has become heavily aggraded and is not likely to reach a stage of equilibrium in the near future.

-Forest harvest activities is a significant contributor of sediment. Maintenance, and use of forest roads, landslides, and increased streamflow are the major problems in the forested portion of the watershed.

-Material from past landslides (debris flows) exist in in-channel storage and will provide additional sediment to Capitol Lake.

-Land conversions from forestry to more intensive uses create conditions subject to higher runoffs and erosion.

A major source of fecal contamination is animal waste. A Thurston County Health Department water quality study revealed higher than normal levels of fecal coliform bacteria in areas with concentrations of livestock. These organisms are present in the intestinal tracts of all warm-blooded animals and are indicators of livestock or human wastes. Cattle produce approximately sixteen times as much waste per day as people.

-Commercial farms without a complete system of best management practices or those with improperly managed systems directly impact water quality of the Deschutes and its tributaries.

-Only one of the four dairy farms has adequate animal waste storage capacity.

-Unlimited livestock access to streams and waterways, increased levels of livestock on small parcels, overgrazed pastures, and inadequately managed animal waste are major problems.

Whether the contribution from septic systems is a major or minor source of nonpoint pollution is not known. However, septic systems may be a major contributor as there is a obvious lack of awareness by many residents as to their function and proper maintenance.

-Residential septic systems sited in soils with less than desirable drainage conditions may be contributors of fecal coliform bacteria to the waters of Budd Inlet. Systems in soils with excessive drainage (Spanaway-Nisqually Soil Areas) may contribute poorly treated waste to groundwaters in the areas of Chambers and Weir Prairies.

Forestland

Forest vegetation covers 94,473 acres, or about 75 percent of the Deschutes/Budd Inlet Watershed. As the population and growth pressures increase around the cities of Olympia, Tumwater, Lacey and Rainer and along the marine waters, it is expected that more forest cover will be removed as the land is converted to homesites and other urban uses. Some 63,970 acres are presently in commercial forest ownership and are expected to remain in this use in the future.

Conclusions

-Land managed for forestry will remain the dominate use in the upper half of the watershed.

-Forestland will continue to contribute both to the economy and to potential water quality problems in Thurston County.

-During the last 15 years about 44 percent of the commercial forestland has been cut and reforested in the upper third of the watershed.

-Forestland is a contributor of sediment to Capitol Lake and to marine waters.

-Presently most of the sediment originates from debris flows.

-New road construction in the next decade will be limited, therefore sedimentation from new roads should be minor.

-The accelerated streambank erosion in recent years is caused by excessive channel aggradation.

-The stream has changed below Road 1000 from a meandering to a braided stream. Increased riparian buffer zone width, and return of the stream to a meandering configuration (lower width/depth ratio), would reduce streambank erosion.

-Sedimentation resulting from timber harvest activities can be better controlled.

-Overall sedimentation to Capitol Lake will continue but probably at a lower rate than that of the 1970s and early 1980s.

-TFW riparian management zones (WAC 222-30-020) will help decrease sedimentation in the upper watershed.

-Timber and road management activities presently appear to meet state requirements and regulations (Washington Forest Practice Handbook -January 1, 1988).

-The forest road system currently in place is adequate to harvest most of the remaining old growth timber. Construction of a few spurs may be needed.

-Streambanks contribute some sediment in areas lacking vegetation as a result of timber harvest, but this will decrease due to the increased riparian buffer zone width required by WAC 222-30-020.

-Streamside buffers for type 2 and 3 waters, in most cases, meet TFW standards. Buffer strips have occasionally been left on type 4 waters and rarely on type 5 waters.

-Freshwater wetlands make up a small (less than 1 percent), but important percentage of the forestland.

RECOMMENDATIONS

- Develop and continue to implement plans for forest roads that reduce erosion and sedimentation.

  - Increase size and numbers of culverts (and downspouts) to move water from the roads more efficiently and help reduce mass waste potential. Use waterbars to remove water from surface of roads.

  - Maintain roads more often in the landslide prone areas of the watershed. Use storm patrols during heavy and sustained rainfall to reduce landslide potential.

- Space harvest patterns with forest buffers around units (maximum size 250 acres) over the watershed to reduce the potential increase in streamflow caused by large units and by rain on snow events in the transient snow zone.

- Continue to follow TFW recommendations for streamside buffers. Adequate buffers should always be left on type 1, 2, and 3 waters. Any additional buffers left on stream types 4 and 5 are always beneficial to water quality, fisheries, and wildlife.

- Retain buffers around all wetlands, Washington Department of Wildlife recommends a minimum of 100 feet.

- Continue to support the forest cumulative effects study.

- Continue to support the TFW advisory group on sedimentation, hydrology and mass wasting. Incorporate findings in any revisions of the Deschutes/Budd Inlet watershed plan.

- Put roads that are not needed for forest management activities in the next 5 or more years.

- Educate the general public in forest management to further their awareness of potential nonpoint problems.

- Educate the general public about changes needed to reduce downstream sedimentation problems.

- Attend the Weyerhaeuser Company annual forest management review, an open meeting where the public can learn and have input into Company forestry activities.

- Monitor sedimentation to show change over time as additional forest management practices are implemented ie. unit size, road maintenance, put roads to bed. Develop in conjunction with the Weyerhaeuser Company.

Rural/Agricultural

The Rural/Agricultural land, 44,449 acres or about 35 percent of the watershed, is covered by residential, small farm, commercial farm, woodlot and commercial/industrial uses.

Conclusions

-Pollutants from rural/agricultural sources can be better controlled.

-Small farms in the Spanaway-Nisqually Soil Association (Appendix A-Soils On Glacial Uplands) have minor impacts on nonpoint pollution.

-Farm units in proximity to streams and waterways are major factors to continuing bacterial, organic and sediment inputs.

-Nonpoint sources of pollution include field runoff of applied animal wastes, runoff from pastures and confinement areas and unlimited livestock access to streams and waterways.

-Most livestock operations employ inadequate animal-keeping and waste management practices.

-Small farm parcels with livestock have inadequate land base on which to apply animal waste.

-Residential units in proximity to shorelines and to perennial and intermittent streams may contribute household waste.

-Septic systems may contribute waste to the groundwaters in the Spanaway-Nisqually Soil Association (Map 1).

Recommendations

-Develop educational materials specifically for the Deschutes-Budd Inlet Watershed as to what are nonpoint sources of pollution and what are technically sound control practices.

-Develop and implement a water quality monitoring plan to better evaluate levels and sources of nonpoint pollution, to monitor the success of corrective actions and to determine if additional action is needed.

-Establish stream corridor zones within the Rural/Agricultural area to retain the productive capacities of these habitats for fisheries and wildlife, to reduce streambank erosion, and to retain their filtering and assimilative capacities to rid streams of sediment and other pollutants.

-Maintain and enhance water quality by eliminating further disturbance of stream corridors.

-Develop a program in the Rural/Agricultural area which encourages the retention or the reestablishment of vegetation especially native vegetation, within all stream corridors.

-Use a best management practice (BMP) or a system of BMPs to control bacterial, organic, and sediment pollutants on all farm units.

-Store animal waste in most cases, during the six-month rainy period (October-March) and apply the waste between April and September.

-Provide technical assistance to operators of small and commercial farm parcels to develop an action plan to control pollutants. (A conservation plan is an ideal way to implement this recommendation - Thurston Conservation District offers this service).

-Develop and implement a continuing educational program to increase the awareness of proper septic system maintenance and of those BMPs for other household wastes.

-Develop a watershed-wide program that requires preventive maintenance for septic systems.

-Examine the alternatives that would result in livestock density limitations for parcels less than 20 acres in size and for parcels less than 1.5 acres in size.

WATERSHED CHARACTERIZATION

General Setting

The study area (Figure 1) is located in south Puget Sound in Thurston and Lewis Counties in the State of Washington. Most of it lies in Thurston County. It makes up an area of 126,609 acres. The Nisqually watershed and Henderson Inlet border the area on the east and the Skookumchuck watershed , Black Lake, and Eld Inlet on the west. The Deschutes River flows 57 miles in a northwesterly direction and empties into Capitol Lake at Olympia (see base map). Black Lake flows in a northerly direction into Percival Creek to also empty into Capitol Lake and Budd Inlet. The highest point is Cougar Mountain at 3870 feet, and the lowest point is the Budd Inlet of Puget Sound.

The climate is mild, reflecting the moderating influence of the Pacific Ocean. Rainfall ranges from 52 inches in Olympia to over 90 inches in the upper watershed. The average daily temperature at Olympia is about 31 degrees F. in January and about 80 degrees F. in July. Snow is prevalent at higher elevations during the winter months. The transient snow zone is considered to be at an elevation of 1,100 to 3,600 feet.

The topography is steep in the upper third of the Deschutes watershed with slopes over 30 percent and some, exceeding 65 percent. The middle third is more rolling with slopes ranging from 5 to 30 percent. The lower portion of this watershed is relatively flat across the grassy prairies, and gently sloping across the peninsula with steep slopes to Budd Inlet.

Forest vegetation covers the upper third of the Deschutes River watershed. The middle third is mostly forest vegetation but includes a small number of large farms, many small farms, and the Fort Lewis Military Reservation. The lower part is mostly small landowners, or urban tracts with some forested areas.

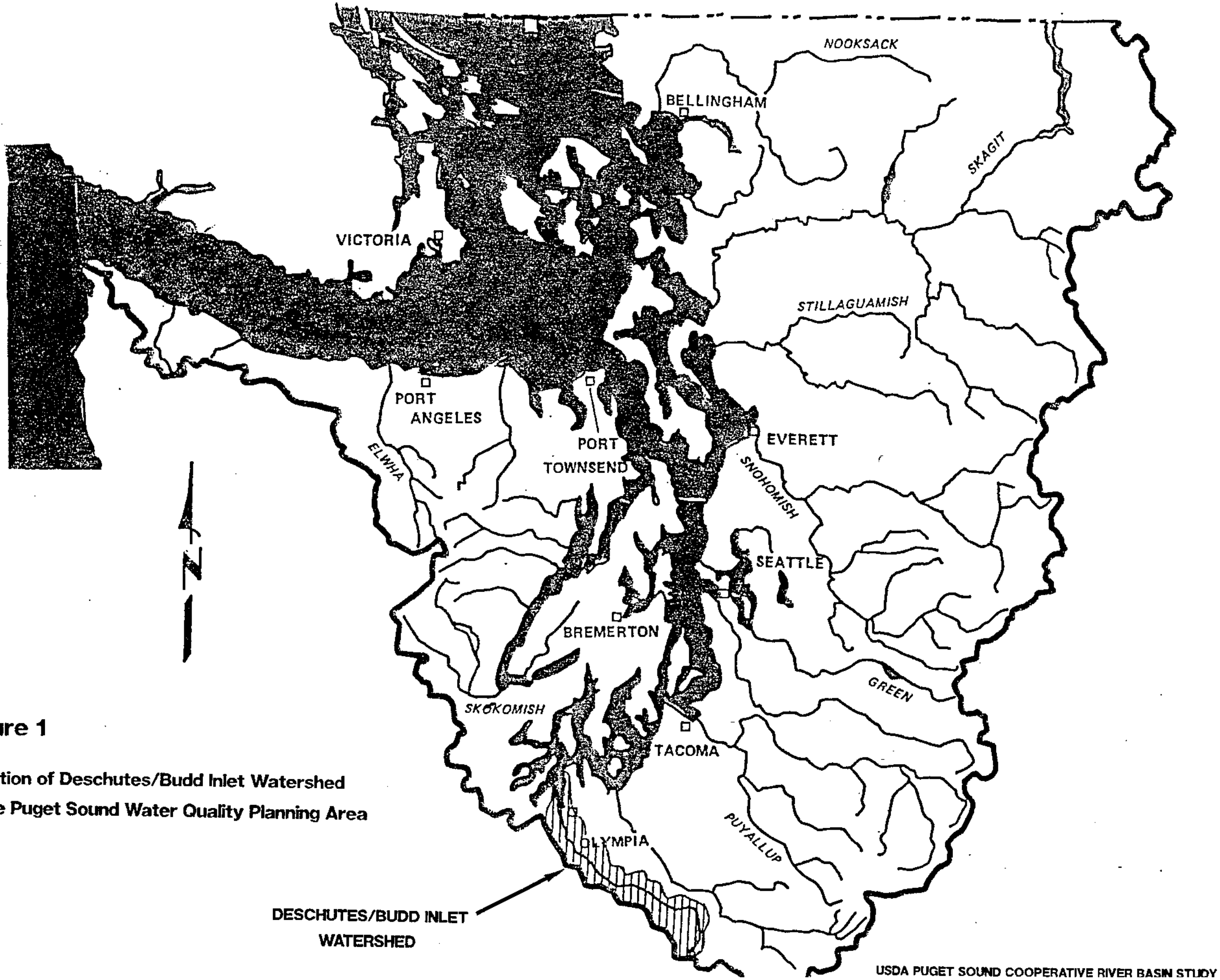


Figure 1

Location of Deschutes/Budd Inlet Watershed in the Puget Sound Water Quality Planning Area

Land Use

The Deschutes/Budd Inlet Watershed contains Olympia, the State Capitol, and the smaller cities of Lacey and Tumwater. It also contains residential development along Budd Inlet and the larger lakes; agricultural/rural development on the prairies and extensive forest holdings in the foothills of the Cascades. The largest lakes are Black, Chambers, Lawrence, Offutt, and McIntosh Lakes. Industrial forestry is the most extensive land use in the watershed occupying 57,984 acres or 46 percent of the land base. Most of it is contained in the headwaters of the Deschutes River. Forest cover not only includes the commercial forestlands but also woodlots and wooded residential areas. Over 59 percent (74,654 acres) of the watershed has forest cover.

Rural/agricultural land use makes up about 35 percent of the Deschutes-Budd Inlet Watershed (Table 1). It includes residential (about 36 percent), small livestock farms (18 percent), commercial farms (5 percent), woodlots (38 percent), and commercial/industrial (3 percent). Rural residential land use is divided into three levels of residential density: high (less than 1.5 acres per housing unit), medium (1.5 to 5 acres per housing unit), and low (5 to 20 acres per housing unit). The rural residential area includes over 90 percent of the nonurban population in the watershed. For the purposes of this study small farms is defined as those parcels containing livestock for recreational purposes or to supplement family income. Small farms (605) range in size from less than 1.5 to more than 80 acres. Many are concentrated along the east side of Budd Inlet and in the central prairie portion of the Deschutes watershed. A commercial farm is defined as those land parcels containing farm related activities which provide significant income to the operator. Commercial livestock farms (19) range in size from 65 to 1,080 acres. Most commercial operations are located on the more productive bottomlands that border the Deschutes River and its tributaries. Woodlots are defined as small forested parcels that are not intensively managed for wood production and are taxed at "highest and best use". A small amount of commercial and industrial activities is located outside the urban area but within the watershed.

The urban area includes a large portion of the urban area associated with Olympia, Tumwater and Lacy. Eleven percent of the watershed area was considered to be within the urban area boundary. The urban area has a population of 52,150 or 65 percent of the watershed's total population. This report will not address water quality problems related to the urban area. However, it is understood that most urban non point sources such as stormwater runoff and disposal of homeowner wastes, impact the Deschutes/Budd Inlet Watershed and will be reported later by Thurston County.

Other land uses includes lakes, wetlands, military land, parks, etc. and cover about 8 percent of the watershed. Ft. Lewis while used for military purposes is also managed for commercial production of timber. It will so be discussed under forest resources later in this report.

Table 1: Land Use and Population Summary- Deschutes/Budd Inlet Watershed

Land Use	Housing Units	Population (Est.)	Acres
Forestland			
Plantations (0-10 Yrs)	0	0	12,792
Second Growth (10-50 Yrs)	8	26	25,670
Commercial Timber (>50 Yrs)	5	16	19,522
Forestland- Subtotal	13	42	57,984
Rural/Agricultural			
Residential 5/			
High Density (<1.5 Ac/HU)	5,643	18,243	4,463
Med. Density (1.5-5 Ac/HU)	1,652	6,090	3,824
Low Density (5-20 Ac/HU)	908	3,613	7,520
Small Farm 2/			
High Density (<1.5 Ac/HU)	58	186	53
Med. Density (1.5-5 Ac/HU)	251	803	1,059
Low Density (5-20 Ac/HU)	221	707	2,542
Large Parcel (>20 AC/HU)	70	224	4,398
Commercial Farms 3/	19	61	2,296
Woodlots			
Plant., Xmas Trees (0-1 Yr)	1	3	553
Second Growth (10-50 Yr)	68	218	7,371
Commercial 1 Timber(>50 Yr)	88	282	8,738
Conversions	0	0	237
Commercial/Industrial	24	77	1,396
Rural/Ag- Subtotal	9,003	30,507	44,449
Urban 1/	24,447	52,150	13,862
Other			
Mines, Pits	2	6	132
Parks, Schools, Cemetery,	1	3	818
Utilities	0	0	399
Military Lands (Ft. Lewis	0	0	5,986
Lakes and Wetlands 4/	0	0	2,948
Other- Subtotal	3	9	10,312
Grand Total	33,466	82,708	126,609

1/ Urban Area includes residential, commercial and industrial property within the urban area boundary.
2/ Estimated from Puget Sound Cooperative River Basin Team's Survey of Rural Parcels.
3/ Only includes hay, pastureland areas of farms and any existing residence.
4/ Permenant Wetlands.
5/ Ac/Hu - Acres per Housing unit

The lakes and wetlands shown in the above land use table includes only the acreage of the freshwater lakes and permanent wetlands as identified through aerial photography. Potential wetlands (Table 2) as classified through identification of hydric soils would total some 8,178 as compared to 900 acres of permanent wetlands. Permanent wetlands have not been converted to other land uses, however, those identified as areas with hydric soils are in pasture or residential use. As such their capability to function as wetlands may be severely impaired or destroyed.

Table 2: Wetlands and Lakes

Type	Acres	%
Potential Wetlands 1/	8,178	6
Permanent Wetlands 2/	900	1
Freshwater Lakes	2,048	2
Total	11,126	9

1/ Wetlands identified by presence of hydric soils. May include areas currently used for grazing, development, etc.
2/ Identified through aerial photography.

The predominance of water upon the landscape of the Deschutes/Budd Inlet watershed emphasizes its importance to the economy, environment and overall quality of life enjoyed in the south Puget Sound area. There are 29.2 miles of saltwater frontage associated with Budd Inlet itself. Some 40 lakes with 40.8 miles of shoreline lie within the watershed (Table 3). In total there are over 221 miles of streams with 68 percent of the total stream miles classified as type 1-3 waters.

Table 3: Miles of Shorelines and Streams

	Miles	%
Saltwater Shohoreline	29.2	9.97
Lake Shorelines	40.8	13.99
Streams		
Type 1	50.6	17.35
Type 2	3.4	1.17
Type 3	64.4	22.06
Type 4	58.2	19.95
Type 5	45.3	15.51
Total Streams	221.9	76.04
Total Water Frontage	291.8	100.0

The Deschutes/Budd Inlet Watershed is on the Interstate 5 corridor. There are approximately 970 miles of roads in the watershed not counting streets within the urban area (Table 4). Improved (paved) state and local roads make up 30 percent of the total miles. Almost 50 percent of the roads (483 miles) are forest roads and another 20 percent (191 miles) are local unimproved (gravel or dirt) roads.

Table 4: Road Type and Miles

Type	Miles	%
State Roads		
I-5, St. Highways 101 & 5	31.8	3.3
Local Roads Improved	263.4	27.2
Local Roads Unimproved	191.2	19.2
Forest Roads		
Main Haul	(22.2)	(2.3)
Other	(460.9)	(47.5)
Subtotal Forest Roads	483.1	49.8
Total Roads	969.5	100.0

Socioeconomic

The economy of the watershed as well as for all of Thurston County revolves around governmental activities associated with Olympia being the State Capitol. Forty-two percent of all jobs within Thurston County are government related (Table 5). Forestry, agriculture and fisheries are major extractive industries in the watershed. Commercial forestry operations in the watershed has the potential to produce an gross annual income of $7,700,000 compared to $3,500,000 from commercial livestock farms. At the present with most of Budd Inlet closed to commercial or recreational shellfish harvesting, the fishery is limited to the wild and hatchery anadromous fish produced within the watershed.

Table 5: Average Employment by Industry, Thurston County ("State of Washington Data Book - 1987", Office of Financial Management).

Industry	Ave. No. of Employees	%
Agriculture (Forest Fishing)	1,294	2.5
Mining	42	0.1
Construction	1,956	3.8
Manufacturing	3,520	6.9
Trans. & Public Utility	1,224	2.4
Wholesale Trade	1,270	2.5
Retail Trade	9,361	18.4
Finance-Ins. & Real Estate	2,134	4.2
Services	8,716	17.1
Government	21,459	42.1
Total	49,682	100.0

The Deschutes River/Budd Inlet Watershed currently has a population of 82,708 living in 33,466 housing units (Thurston County Assessor Records, 1988 and Office of Financial Management, 1986). Of this population 30,558 person live outside the urban area boundaries and occupy 9,019 housing units. About 8 percent of the population are considered as minorities and some 11 percent are over 65 years of age compared to 13 and 12 percent respectively for the state as a whole. (Office of Financial Management, State of Washington-1986).

Of the non urban population 94 percent live on rural residential lots with most (82 percent) living on parcels of 5 acres or less in size. Small farms include rural residential parcels that also harbor livestock. These small farms account for 6 percent of the non urban population.

An annual growth rate of between 3 and 3.5 percent occurred from 1980 to 1986 in unincorporated parts of Thurston County. (Office of Financial Management, 1986). Projecting this rate of growth through the year 2000 would estimate a total population of 111,888 or 44,614 in the non urban portion of the watershed (see Table 6). It is assumed that most of the population growth and addition of housing units in the non urban area will occur in the form of rural residential or small farm parcels. This non urban growth will create a demand for 3,787 additional non urban housing units that will require approximately 6,450 acres of land for development. This additional land will have to come from land currently used for agriculture or forestry. Of this growth, assuming the same proportions of small farms to rural residences as currently exist, there will be an increase of over 40 percent in the total number of small farms by year 2000.

Table 6: Demand on Non urban Land from Growth in Population and Housing (1989 to year 2000) Deschutes/Budd Inlet Watershed 1/

	1989			2000		
Land Use	Population	Housing Units	Land (acres)	Population	Housing Units	Land (acres)
Residential						
(<1.5 Ac/HU)	18,243	5,643	4,463	26,635	8,013	6,330
(1.5-5 Ac/HU)	6,090	1,652	3,824	8,891	2,346	5,419
(5-20 Ac/HU)	3,163	908	7,520	5,275	1,289	10,673
Small Farm						
(<1.5 Ac/HU)	186	58	53	272	82	65
(1.5-5 Ac/HU)	803	251	1,059	1,172	356	822
(5-20 Ac/HU)	707	221	2,541	1,032	314	2,600
Subtotal	29,642	8,733	19,460	43,277	12,400	25,910
Other Rural 2	916	286	93,287	1,337	406	86,837
Subtotal Non urban	30,558	9,019	112,747	44,614	12,806	112,747
Urban 3/	52,150	24,447	13,862	67,274	33,248	13,862
Total	82,708	33,466	126,609	111,888	46,054	126,609

1/ Projected growth based on "1986 Population Trends for Washington State", Office of Financial Management.
Unincorporated Thurston County - 3.25% for residential units
- 3.5% for population
Incorporated Thurston County - 2.875% for residential units
- 2.3125% for population

2/ Other Rural Includes forestry, large farms, and other misc. land uses.

3/ Urban includes only those areas within the city limits of Olympia, Lacy and Tumwater.

GEOLOGY

The oldest rocks in the Deschutes-Budd Inlet watershed are of volcanic origin and were deposited toward the end of the Tertiary Period more than 2 million years ago. These andesitic and basaltic volcanics consist predominantly of explosively erupted volcaniclastics with a limited extent of massive flow deposits. These volcanic rocks are often interbedded with sedimentary siltstone, sandstone, and conglomerates. The massive andesite and basaltic flows are relatively dense and very resistant to erosion. The sedimentary and volcaniclastic rock formations have a tendency to weather more readily and are more subject to mass wasting and other forms of surface erosion.

Rock exposures are limited as most of these rocks are covered with a moderate to shallow depth of weathered and residual soil deposits. These deposits are located almost exclusively in the upper watershed at the higher elevations. The slopes are frequently steep, at times exceeding 60 percent. Surface drainages are well developed and stream densities are relatively high.

The deposits in the lower watershed consist of glacial deposits from the Fraiser Glaciation and a few older more compact glacial deposits of Pre-Fraser age. The erodibility of these glacial deposits depends mainly on the original depositional environment. Glacial till is relatively compact and fairly resistant to erosion. Outwash deposits mainly consist of sorted to unsorted sediments with particles sizes ranging from silt to boulders. Outwash deposits that contain large percentages of silt and sand erode easily. The more highly sorted outwash gravels that contain the large particles are much more erosion resistant.

The glacial deposits are located at the lower elevations. Surface drainage patterns are poorly developed and the uplands are characterized by pothole lakes ranging in size from less than one surface acre to Lake Lawrence with 320 acres.

Holocene non-glacial deposits include Recent Alluvium which was deposited as floodplain deposits along the Deschutes River, its tributaries and Percival Creek. Landslide debris with unstable slopes are commonly found scattered throughout the middle and upper portions of the watershed. Both of these geologic formations are unconsolidated and are usually very susceptible to erosion.

SOILS

The soils of the Deschutes-Budd Inlet Watershed are grouped into three general kinds of landscape for discussion purposes: *Soils on Floodplains*, *Soils on Glacial Uplands*, and *Soils Dominantly on Plains, Uplands, and Mountains*. Each of these broad groups contain subgroups which are discussed further in Appendix of this report and displayed on the Soils Map. For more detailed information the reader can consult The Soil Survey of Thurston County, Washington.

The *Soils on Floodplains* group makes up a relatively small portion, only 5 percent (6,300 acres), but a very important portion of the watershed. The soils are well to very poorly drained. Elevation ranges from 50 to 500 feet. Slopes are nearly level. The average annual precipitation is 45 to 55 inches.

The soils formed in very deep loamy or clayey alluvium. Some of the soils are artificially drained by ditches or tile. In places there are remnants of the native hardwoods and conifers not replaced by agriculture or homesites.

Soils in this group are subject to periodic flooding by the Deschutes River and its major tributaries. They are well suited for agricultural crops due to their high natural fertility and moisture holding capacity and poorly suited for homesites due to flooding and/or a seasonal high water table. A major soil and water management consideration is the land application of animal waste and the animal access to stream and/or ditches.

The *Soils on Glacial Uplands* the most prominent group, makes up about 54 percent (68,400 acres) of the watershed. The soils are on glacial terraces, till plains, and terminal moraines. Drainage is somewhat excessive to poor. Elevation ranges from 100 to 980 feet. Slopes range from nearly level to very steep. The average annual precipitation is 45 to 60 inches.

The soils formed in very deep to moderately deep, gravelly to extremely gravelly loams and sands, many of which are underlain by compact glacial till.

Soils in this group are used for agriculture and rural homesites, and as sources for sand and gravel. Much of the area is under forest management. The main limitation in areas of agriculture use is low natural fertility and droughtiness during the growing season. The main limitation for many of the soils in this group for homesites is wetness. A major water quality management consideration is that Almost one-third of the soils in this group present a severe potential for polluting groundwater when the conventional septic system is the principal waste disposal method.

The *Soils Dominantly on Plains, Uplands, an Mountains* group makes up about 41 percent (51,900 acres) of the watershed. The soils are on terminal moraines, glaciated uplands, and mountainsides. These soils are very deep to moderately deep and well to moderately well drained. Elevation ranges from 700 to 3400 feet. Slopes range from nearly level to very steep. Vegetation is dominantly conifers. The average annual precipitation is 45 to more than 90 inches.

The soils formed in stony glacial till and, in residuum and colluvium derived from basalt and andesite or andesitic volcanic breccia. Soils in this group are used for agriculture, principally forestry, and for recreation, homesites, and wildlife habitat. Soils of steep slopes have contributed sediment to the Deschutes River. The main limitation for many of these soils when managed for forest products is steepness of slope. There is a continual high potential for mass wasting and other forms of erosion. The limitation of soils on flatter slopes is seasonal wetness. Year-round logging roads require suitable surfacing to permit use and to reduce surface erosion.

BENEFICIAL USES

The purpose of the 1987 Puget Sound Water Quality Management Plan is to restore and protect the biological health and diversity of Puget Sound.

> "Puget Sound is recognized worldwide as an extraordinary natural resource. The region's 2.9 million residents enjoy boating, beachcombing, and other activities on the Sound's water and beaches. Its deep waterways support international commerce, abundant commercial and recreational fisheries, and varied wildlife habitats" (Puget Sound Water Quality Management Plan, 1987).

Beneficial uses as defined by the "Guidelines for Local Nonpoint Planning for Puget Sound" (PSWQA, 1987) include, but not limited to:

> ...domestic water supply; agricultural water supply; stock watering; salmonid migration, rearing, spawning, and harvesting; other fish rearing, spawning, and harvesting (commercial and recreational); crustacean and other shellfish rearing, spawning and harvesting (commercial and recreational); wildlife habitat; primary contact recreation (swimming, wading water skiing); secondary contact recreation (boating, fishing); commerce and navigation; mining; irrigation; hydroelectric power production; preservation of environmental and aesthetic values; and all other uses compatible with the enjoyment of public waters of the state."

National recognition of the beneficial values of the Puget Sound has lead to its recent formal designation as an "Estuary of National Significance" (EPA, April, 1988).

This section of the report will attempt to quantify the beneficial uses in the Deschutes-Budd Inlet watershed and the degree those uses may be impacted or threatened by nonpoint sources.

Fishery Resources

The Deschutes/Budd Inlet watershed supports important shellfish and anadromous fish populations. Five salmonid species use the Deschutes basin and other drainages into Budd Inlet for spawning and rearing; steelhead trout, searun and resident cutthroat trout, coho, chinook, and chum salmon. The distribution of chum salmon is restricted primarily to small, low gradient streams feeding directly into Budd Inlet. Chinook salmon use of the basin is limited mainly to the lower and middle mainstem of the Deschutes River and Percival Creek. The middle and upper reaches of most of the accessible drainages are used by coho salmon, steelhead trout and searun and resident cutthroat trout. Resident trout are common in the tributaries above barriers to anadromous salmonids.

Other fish species that occur within the drainages of Budd Inlet include the pacific lamprey, largescale suckers, speckled dace, longnose dace, redside shiners, torrent sculpin, and shorthead sculpin (Weyerhaeuser, 1987). The Olympic mudminnow, the only primary freshwater fish species in western Washington to be classified as "threatened" by the U.S. Fish and Wildlife Service, inhabits a few swamps in the lower Deschutes basin and occurs in some of the ponds in the Tumwater golf course. Smelt utilize Budd Inlet intertidal areas for spawning.

Species of shellfish known to occur within Budd Inlet important to recreational and commercial harvesters are geoducks, manila, native littleneck and butter clams, cockles, mussels, squid, red rock crabs and oysters. Shellfish occur throughout Budd Inlet, however the Department of Health (DOH) prohibits commercial harvest of any species of shellfish south of Gull Harbor. Budd Inlet has several public and private beaches open to recreational harvesting of shellfish. Recently, several bids were received by DNR for commercial harvest of geoducks outside the prohibited area in the north end of Budd Inlet.

Recreational Resources

The Deschutes River and Budd Inlet are important recreational areas with local residents. Recreational activities include boating, fishing, swimming, clamming, scuba diving, picnicking, and scenic enjoyment. Capitol Lake provides a scenic setting for the Washington State Capital. There are a number of marinas in Budd Inlet. Recreation stimulates additional economic activity through expenditures at local businesses. A large, yearly community event is centered on the shorelines of Capitol Lake and Budd Inlet.

The shoreline of Budd Inlet and freshwater lakes are in high demand for private beach front homesites. Research in other areas has shown that poor water quality can reduce property values by impairing the associated recreational and aesthetic resources (Epp, 1978 and Freeman, 1979).

NONPOINT SOURCES OF POLLUTION

Nonpoint source of pollution as defined by the "Guidelines for Local Nonpoint Planning for Puget Sound" (PSWQA, 1987) is:

> "...pollution that is not discharged through pipes. Nonpoint source pollution includes sediments, pathogens (as indicated by fecal coliform bacteria), and toxicants. Pollutants can be discharged directly into the water from boats or other water-based sources and indirectly from the land where they are picked up by rainwater and carried into streams and rivers and thence to Puget Sound. Because a bay can receive the drainage from a large land area ("watershed") as well as discharges from the water, the potential contributors to nonpoint pollution can be numerous and difficult to identify."

Sediment input into Capital Lake has been a major concern in this watershed since 1951. Legislative concern was first expressed in 1971 with respect to the origin and the removal of these sediments. Cost estimates were initially $2.2 million (Osborn et al, 1975) and a biennial cost of about $800,000 to remove approximately 38,250 cubic meters or 50,000 cubic yards (CH2M-Hill, 1976).

Where the sediment came from, what caused it, and who should pay for its removal from Capital Lake has had considerable study especially since the CH2M-Hill Capitol Lake restoration plan showed the biennial cost of such activity.

Other studies develop different sediment levels deposited in Capital Lake. The Entranco Engineers for the Washington Department of General Administration is considerably higher than the Moore and Anderson study. The annual sediment load to Capital Lake amounts to 54,800 cubic yards. This is about 70 percent of the total sediment load from the Deschutes River as 30 percent goes out into Budd Inlet. The annual removal cost for the dredged material at $6 cubic yard is $328,000. This does not include the cost of transporting and handling this material (Ardnt, 1983).

The cost of the 1987 dredging in Capitol Lake, completed in January and February, was $1,294,000 for 57,500 cubic yards (CY) or $22.50 per CY. This included dredging, storage, handling and park building. Future costs will increase as handling, storage and transportation will be an increasing problem as the material must be moved further from the lake.

As shown in the Entranco Engineers report, there are three basic options for in-lake sediment control that were identified.

a. No Action: allow current sedimentation to continue.
b. Dredge sediment traps: cost-$132,600 per year
c. Maintain the integrity of Capitol Lake: cost-$328,000 per year

The Washington Department of General Administration estimated the 1989-91 removal of annually deposited sediment into Capital Lake as 30,000 to 50,000 cubic yards and costing 1.8 million dollars. This amount, according to the Entranco study, is about 70 percent of the sediment transported from the Deschutes River. The remaining 30 percent is sediment that flushes out into Budd Inlet. That sediment has to be dredged from the Inlet at least every 10 years by the U.S. Army Corps of Engineers. The cost estimate includes a lake bottom survey to document the amount of silt deposited and the change in the lake bottom since the last survey, removal of the 1985-87 project dredge spoils from the spoil holding site, dredge as required, and conduct water quality monitoring as necessary. The budget also includes money for 260 CY of riprap (Ardnt 1989).

A summary report of the Deschutes River Basin (Weyerhaeuser Company Sullivan, et al 1987) discusses the source of the sediment and the forest management effects on sedimentation. It utilizes a number of studies in the development of its conclusion. Some important discussion is lacking, however, as to the effect of the slides on the watershed hydrology and sedimentation.

A study by the Thurston County Conservation District showed an annual sedimentation rate of 39,545 CY. This report identifies the major source of sediment as the mainstem of the Deschutes River rather than from its upper tributaries (McNicholas, 1984). However, the acceleration of streambank erosion occurs because of extensive aggradation in recent years, and conversion of the stream from a meandering to a braided pattern in the area below the Road 1000 bridge.

Using a model, Kilian, (1989) computed the volume of sediment from the Deschutes River at 57,000 CY. Thus, using Entranco's 70 percent trap efficiency for Capitol Lake, about 40,000 CY would be in Capitol Lake. These volumes exceed those described in the report by Sullivan et al. See Table 21 for a summary of sediment values from studies of the Deschutes River or Capitol Lake.

Sedimentation is also a concern in the saltwater bay below Capital Lake from the Olympic Yacht Club to the Port of Olympia.

Potential pollutants from rural/agricultural practices are pathogens, sediments, nutrients, pesticides, and organic materials. Pathogens as indicated by fecal coliform, nutrients, and organic materials result from failing septic systems, animal waste applied to land, and from poor animal-keeping and pasture management practices. Sediments, which transport pathogens and damage salmonid habitat, are generated by livestock grazing streamside vegetation and breaking down streambanks.

Increasing development of small, noncommercial farms and residences in rural areas leads to problems from animal keeping practices and on-site septic systems. Runoff from rural residential lawns and gardens and, roads and driveways carries nutrients, pesticides, and organic materials.

Forest practices which may adversely affect the water quality and biota of Puget Sound include logging, road building and maintenance, and post harvest activities such as slash burning reforestation, and herbicide applications. These activities can cause increased sediment loads, elevated water temperatures, chemical contamination, generation of organic debris, and loss of salmon habitat.

Urban areas are also significant sources of nonpoint pollution. Many residential areas along the Sound develop at urban densities without sanitary sewage systems. These areas near the shorelines of the Sound and its rivers and streams, increase the probability of pathogenic contamination from failing or improperly maintained on-site septic systems. The storm runoff from urban areas is characterized by metals, nutrients, bacteria/viruses, and organic toxicants. Washwater, spills, improper maintenance of industrial facilities, and illegal dumping of household and/or industrial waters contribute toxicants to runoff.

Motor vehicles and the associated runoff from highways contribute fuel combustion products, lubricants, hydrocarbons and other contaminated particles.

Recreational boating contributes fuel, sewage, and refuge spillage. Impacts are potentially greatest at popular overnight anchorages and "destination" marinas, particularly in shallow water bays with poor tidal flushing.

The following sections of the report discuss the potential of nonpoint pollution for forestland and rural/agricultural source areas in the Deschutes River/Budd Inlet Watershed.

FORESTLAND

General Characterization

The forestland source area includes federal, state, and private lands. It makes up about 57,984 acres. The Fort Lewis Military Reservation (5,986 acres-Other Land Use, see Table 1) is also included in this discussion as it contains substantial forest cover and forest management is a major secondary use. The total acreage, therefore, included in this discussion is 63,970, or about 51 percent of the Deschutes/Budd Inlet watershed. Most of this source area is located in the middle and upper portion of the watershed. The other federal land is the national forest, 533 acres, most (401 acres) of which are to be exchanged with the Weyerhaeuser Company. The state land is trust lands. There are 62,723 acres, of private lands included on the property tax rolls of Thurston County as designated (D) forest, classified (C) forest, or open space-timber (T). The private land includes some uses other than commercial forestry such as wetlands and meadows.

It is important to recognize the different objectives of forest land managers which are reflected in the use of the resource and in the potential impacts to water quality. Fort Lewis, although primarily used as a military training area, does have a forest management plan for the reservation and an annual allowable cut. For the entire installation that cut amounts to 10.5 million board feet. The national forest is managed by the U.S. Forest Service under the "multiple use" concept, with no one use to override other uses. A financial return is not always the purpose for management activities, i.e. a campground or an elk calving area could take precedence over a timber sale on a specific piece of land. The purpose of private forest lands is to generate the highest net income possible for its owner and still remain within current laws and regulations.

The major forestland owners within the watershed are listed in Table 7. There are 97 individual forestland owners in the watershed whose lands are being taxed for forestry purposes by the Thurston County Assessor. State and national forestland, of course, are not imcluded.

Table 7: Major Forestland Owners - 1989

Weyerhaeuser Timber Company	49,480 acres
Ft. Lewis Military Reservation	5,986
Port Blakely Mill Company	1,100
Three Rivers Timber Company	860
Hutson Tree Farm	540
U.S. Forest Land	533
Jess Thompson Inc.	460
Pendleton Miller Land and Timber	260

Use and Management

The number of forest practices applications has increased every year for the last three years according to the Department of Natural Resources (DNR). This trend is expected to continue as long as the export log market exists. If a restriction was to be placed on log exports, the number of applications would decrease. This is not expected to happen within the next ten-year period.

The Timber-Fish and Wildlife (TFW) process has had the effect of opening up the forest application process to the various groups which are interested in good land management. The TFW process has given the opportunity to private landowners to work with the interested parties and to make site-specific changes in their land management practices without those changes being precedence setting, but only pertaining to the specific site in question (Barrspul, 1989).

The summary of forest practice applications (Table 8) for the Deschutes/Budd Inlet watershed is a DNR computer run for a four county region. Thinning and partial cutting applications are not reviewed as there is little ground disturbance to affect water quality.

Table 8: Summary of Forest Practice Application
Deschutes/Budd Inlet Watershed- 1989

Open Sales---------	No. of Clearcuts	3,270
Completed Sales---	No. of Clearcuts	5,145
Planted Acres-----	No. of Clearcuts	2,655
Roads Under Construction-----	Miles	20
Roads Completed--------------	Miles	13
Road Maintanence-------------	Miles	19
Aerial Spray Open------------	Acres	6,024
Aerial Spray Closed----------	Acres	19,117
Aerial Fertilized------------	Acres	7,376

The above figures show that forest management in the watershed to be quite active. The owners of commercial forest land are operating at a high level and will continue as a viable industry into the future.

The six largest forestland owners were interviewed concerning present and future plans, marketing, timber volume, site classes, herbicide use, and roads. The interviews and sources are as follows:

Weyerhaeuser Company

Weyerhaeuser Company is the major landowner in the Deschutes watershed with 49,480 acres or 39 percent of the Deschutes/Budd Inlet watershed. Their Deschutes watershed holdings are about one quarter of the Company's Vail Tree Farm management unit. The timber from the Deschutes unit is hauled by truck to a sort yard at Reichel Lake and railed out to Tacoma. Some logs go by truck to Clear Lake or to the Camp Five road into the Skookumchuck drainage.

Roads in the unit are designed for off-highway size trucks. These are 14-foot wide roads with turnouts and the mainline (identified as the 1000 and the 3000 line) roads are 24-feet wide. Off-highway trucks have 10 foot wide bunks and haul wider than highway legal loads. Their road program is nearly complete with two to three percent of the area still needing roads to tap the remaining old growth timber.

The maximum clearcut unit size of the company is generally 250 acres. All units are buffered with the buffer left until the plantation units are 4.5 feet tall in about 8-10 years old and free to grow. The Company is still reviewing this standard.

Riparian Zones are as listed in the WAC based on TFW or greater. The riparian zones established prior to TFW were less than what is now required in some places.

Fertilizer is applied at a rate of 200 lbs/acre of actual nitrogen with a helicopter. The frequency period is every 5 years for the stand ages 18 to 35 years, or 4 applications.

Precommercial thinning is normally done between 18 and 20 years of age on a 12 by 12 spacing.

Planting was accomplished on 5,300 acres in 1987 on the Vail Tree Farm with 795 acres in the Deschutes watershed.

Burning was done on the high sites, but the trend is getting away from broadcast burning. Including burning, there is a strong commitment to reforest within 1 year of harvest. Reforestation is by planting; no seeding was done in the Deschutes watershed.

Herbicide spraying is regulated by the WAC 222-38. The 1988 vegetation management plan has an acreage of 1,110 acres to be done aerially and 600 acres by ground application in the Deschutes watershed. This plan is included with the appendix of this report.

The management planned for the watershed is to complete the logging of the old growth in Lewis county within the next five years. The logging will then shift to the Skookumchuck watershed then back to the lower portion of the Deschutes watershed.

Plantation establishment takes 5 years to slightly longer in the lower elevations and 5-10 years in the upper elevations. This means the trees are established and free to grow. The land is sufficiently covered with vegetation at this time to prevent erosion from the units.

Abandoned roads are not felt to be a large problem on Weyerhaeuser land. The abandonment is done in accordance with WAC 222-24-050. (Source: Dan Treat-Land Use Supervisor, Chehalis, 9/27/88.)

Fort Lewis Military Reservation

Fort Lewis is the second largest landowner in the Deschutes watershed, with about 6,000 acres or 5 percent of the watershed. It makes up about 7 percent of the 84,000 acre military reservation. A forest management plan covers 50,000 acres of commercial forest on the installation. The plan is based on area control- 50,000 acres of commercial timber on a 80 year rotation is 625 acres a year .

The 6,000 acres within the watershed is about 70 percent forested. The nonforested lands are wet meadows, grasslands, and pits. The lands are used by the army for maneuvers but contribute little to surface water quality pollution due to the flat terrain.

The annual allowable cut for the entire Fort Lewis Military Reservation is 10.5 million board feet per year. The average site index for Douglas-fir is a low site III or a high site IV (around 134 on 100-year index). Trees, particularly Douglas-fir, grow fairly well, but growth is slow in the more droughty and gravelly soils.

The harvest method is commercial thinning with tractor and mountain logger (skidder). Clearcutting is used on a limited basis. Timber stands are entered every 10 years with a regeneration cut at 80 years of age. The land is generally replanted after the regeneration cut if it is not naturally restocked after 10 years.

Soils are gravelly hence the skidder- tractor logging doesn't appear to compact or mud them up. Eighty percent of Ft. Lewis is on slopes less than 5 percent, 94 percent of the reservation is on slopes less than 15 percent. Therefore, the potential for timber harvesting activities to cause water quality problems are minimal. Buffers on the small streams are 50 feet on each side. Roads and boundaries are also buffered.

Roads are basically in place except for the short spurs needed to log the individual timber sales. The spurs are 8 to 10 feet wide. As all streams are roaded on each side, there is no falling or yarding across the streams.

Herbicides 2-4 D, and Garlon are used to control brush and Atrazine is used to control grass. The herbicides are applied by aerial contracts at the EPA recommended rates on the container labels and assumed to be safe. Herbicides are applied in two applications, one right after logging and one three years later if needed.

The cut by year for 1984 to 1987 is as follows:

1984-----13.0 million board feet
1985----- 9.0 million board feet
1986-----11.6 million board feet
1987----- 9.3 million board feet

(Source: Paul Carbaugh, Post Forester, 7/5/88)

Port Blakely Mill Company

The company owns six tracts totaling 1,100 acres in the watershed.

Rotation age varies from 60 to 90 years for an average of 75 years.

Tree site class for Douglas-fir (100 year tables) varies from a high of a site III to a high site IV where the soil is more gravelly.

Volume ranges from a low of 20,000 bd.ft./acre on tracts that are heavy to hardwoods to tracts in excess of 30,000 bd.ft./acre. Status by tract is as follows:

Tract #1 The largest tract covers over 470 acres and is located near the town of Rainier. Clearcuts are to cover 40 acres this decade with the rest of the tract thinned and left to grow. The roads are all in.

Tract #2 This 238 acre tract is near Black Lake. It will be thinned with about 60 acres in clearcuts. Work has started and will be completed in the next few years. The roads are in.

Tract #3 This 40 acre block is located near Tumwater, trees are about 14 feet tall and left to grow for the next decade.

Tract #4 This 80 acre tract was logged and planted in 1983 and left to grow. There is a wetland in this tract of over 10 acres (peat bog with pine trees).

Tract #5 This tract is near Vail and is over 202 acres in size. It is logged and replanted except for about 60 acres in small patches. The remainder is to be logged within the next decade. The roads are in.

Tract #6 This tract is near McIntosh Lake. About 12 acres are in the watershed. This tract is to be logged this decade.

The roads for all of the tracts are mostly in but may need some small spurs to finish logging. The WAC is to be followed for the reforestation and riparian zones. The TFW agreement may be used where it will benefit the company. The herbicides used are 2-4-D on alder, and Garlon on maple stumps. A limited amount of chemicals will be used in this watershed. Logging is done with a tower (hi-lead) or skidders if the ground is flat enough-less than 30 percent slope. Often a combination of logging systems is used.
(Source: Court Stanley and John Watjohn, Local Manager and Area Manager, Port Blakely Mill Company).

Three Rivers Timber Company

This company has 860 acres of land in the watershed. This company is a holding company for Scott Paper Co. All tracts are for sale. This entire holding is logged and planted. Spraying with Roundup was done in 1987 in the plantations of sections 10, and 11, and a portion of section 3. Reproduction ranges from 1-2 year old seedlings in sections 3 and 4 to 7 year old seedlings in section 11, and about 85 acres of young growth averaging about 20 feet tall in section 3. The management of this property for the next decade is to let it grow.
(Source: Dan Boon Scott Paper Company. Skookumchuck Office, Centralia-Chehalis, 1/12/89).

Norm Hutson Tree Farm

This tree farm consists of four tracts (540 acres). The largest is 341 acres. All tracts are managed for forest products ranging from Christmas trees to timber. The areas will stay in the present mix of uses for this decade except for a gravel pit near the Deschutes River in section 20, T17N., R1W. Land slope varies from flat to rolling and steep except for very steep slopes into the Deschutes. The pit will have state approval. The present pit which has a permit is located on the tree farm in section 6, T17N., R1W. The pit in section 6 produces 70,000 cubic yards of material a year. The new pit will be above the 100-year flood plain of the Deschutes River.

The tree farm varies from site V in the gravelly areas to a high of site III in the better areas. Stand age varies but the commercial timber has a rotation of about 75 years.

The roads are all ditched with many sumps along them. The slope is flat and the drainage appears adequate. Chemicals used are Atrazine, Roundup, and Velpar. Velpar is used on the Christmas trees in various strengths depending on timing. They are used on a very small area of the tree farm.

Slash and tops are used for firewood.

The tract in section 6 may have trailers on the north side near the existing subdivision within this decade.
(Source: Norm Hutson Jr. , 1/12/89)

U.S. Forest Service

Most of these National Forest lands are in the process of being exchanged with the Weyerhaeuser Company over the next decade. All cutting will be completed in the next two years. Lands that will remain as National Forest Land include:

T14N,R3E, Sec 24---Timber is cut and planted less than 10 years ago;

T14N,R4E Sec 5-----Timber cut and planted less than 10 years ago.

T14N,R4E,Sec 6, SE quarter---- 7 acres were cut in 1987 and planted in 1988. The remainder inside the watershed is commercial and is to be left for the rest of the decade;

T15N,R4E,Sec 32, E half----10 acres clearcut in 1989. The remaining commercial timber is to be retained for this decade.

Total National Forest acreage 533 ac.

Future National Forest acreage 132 ac. after the exchange.

Total National Forest Land exchanged in the watershed is 4,000 acres. Source: John Walker, Hydrologist, Randle District, Gifford Pinchot National Forest, 9/21/88).

Plantations

Plantations are shown on the forest cover map (see Map 2). The range of identified stand ages are: Plantation--1 to 10 years; Young Growth--10 to 50 years; and Commercial Timber--over 50 years. Timber harvest varies on the different ownerships as they respond to their different markets. Timber harvest occurs at age 50 years on Weyerhaeuser land in the second rotation timber, with the old growth being over 200 years old. Port Blakely harvests at an average age of 75 years, while Fort Lewis has a planned rotation of 80 years. The following table 9 summarizes the acreage of each forest class within the Deschutes River-Budd Inlet Watershed.

Table 9: Forest Stand--Deschutes/Budd Inlet Watershed (1989). 1/

Stand Age (years)	Commercial (acres)	(%)	Woodlots (Acres)	%	Watershed (acres)	(%)
less than 10	12,980	21	596	2	13,576	15
10 to 50	26,416	42	13,791	46	40,207	43
more than 50	23,327	37	15,660	52	38,987	42
total	62,723	100	30,047	100	92,770	100

1/ includes forests of Ft. Lewis within the watershed.

Economics

Tree harvest appears to be on the decline within the watershed for the next 10 years. Weyerhaeuser is shifting its operations from the Deschutes to the Skookumchuck watershed. The logging of the old growth in the upper Deschutes watershed in Lewis Co. is expected to be complete in the next 5 to 10 years.

While the forest production may be down during the next decade, the 62,723 acres of tax designated forestland has the potential to produce an average of 7.7 million dollars revenue annually. This value is conservative and is based on an average of 30,000 board feet (bd. ft.) per acre over a 50-year rotation at $205 per thousand bd.ft. which is the average price of Douglas-fir and hemlock-white fir saw-logs in the State of Washington (Sawlog Prices for Late July, 1988, Washington Agriculture Statistics Service, 1988).

The export market is expected to remain high, which will tend to reduce the rotation age (smaller logs are preferred) and increase the value so actual value from Budd Inlet-Deschutes will probably be considerably higher than the annual revenue stated above.

The Effects of Forest Management

Forest management can increase the export of sediment from portions of a basin where activities are located. Most of the increase in sedimentation associated directly with forest activities is attributed to forest roads. This ranges from erosion from the surfaces of in-use roads to debris flows attributable to roads because of increased water loading caused by changes in the natural downhill migration of water. Unit size will be reduced to 250 acres in the upper watershed and buffered. Harvesting can alter snow accumulation and melt rates which can increase channel and hillside erosion from greater runoff. The Deschutes watershed, like much of the Cascade mountains, is in the transient snow zone of 1100 feet to 3600 feet elevation. A further emerging concern is the cumulative effects of the past management practices in a watershed and the possible off-site effects as well as the on-site effects. These items will be discussed separately.

Roads

There are 970 miles of roads in the Deschutes Watershed, composed of state, federal, and local forest roads.

The majority of the roads that can cause sedimentation are on the steeper land in the upper watershed where forest activities are the dominant land use.

There are 407 miles of forest roads on Weyerhaeuser Company lands. These roads are built to handle off highway size loads, 10 foot wide bunks on the logging trucks. The mainline roads are 24 feet wide with the secondary roads being 14 feet wide with turnouts. The road system for the ownership is nearly completed, with 2 to 3 percent of the area still needing roads to tap the remaining old growth. Other than that, the road activity for the next decade will be use and maintenance but with some reconstruction.

Sedimentation from road use is generally the fine soil material being carried by surface runoff into the adjacent road ditches and streams. As a new road is completed, sediment will continually come from the road surface and from potentially new slides unless there is an active and effective road maintenance program. Debris plugged culverts, for example, can create ponding conditions which can lead to saturated roadbeds and landslides.

Road maintenance consists of many activities including pulling ditches, surface blading with a grader, fixing culvert catch basins and culvert downspouts, outsloping some roads, seeding cutslopes to erosion controlling plants and seeding surfaces of little-used roads, and waterbarring roads. Other considerations are: frequency of maintenance in spring and fall; based on heavy use: the use of storm patrols, and emergency repairs, surface rock replacement, and special equipment to replace culverts if they are washed out. During the winter rainy periods storm patrols unplugs culverts, ditches, rebuilds crossdrains, and whatever else is needed to get the water off the road as quickly as is possible. Storm patrols also remove blowdown and keep road open for quick repair. A storm patrol is expensive but by catching problems early it saves money in the long run and helps to prevent downstream problems.

Road fills should be protected from culvert discharge by extending downpipes beyond the fill and riprapping the outfall (Sidle, 1985). Such a practice reduces the potential water loading of roadfills that contribute to landslides.

The Department of Natural Resources was asked about road maintenance and use in the upper watershed. Road maintenance requirements are the same all over the upper watershed with no change for the landslide prone areas. The Weyerhaeuser Company has increased the number of culverts in the upper watershed. Storm patrols are done with two graders. Road cleanup is done faster to help prevent landslides. The Department is working with the Company to pull back some landings and landing debris. Roads are not closed since they are used by the company for burning, planting, fertilization, and herbicide spray programs.
(Source: Roger Ramsdell, Forest Practices Technician, Central Region, 2/1/89).

Road Maintenance Costs

The following is an example of the costs involved in putting a road to bed from a contract of an off-highway road system used by the Simpson Timber Company on the Olympic National Forest. The road has a 14 foot Running Surface. The road is insloped or outsloped and scarified with a grader. Waterbars are installed if the road has a grade of over 12 percent. All traffic is kept off the road by building a tank trap at the start of the road. Cost: $500-$600 per mile.

A contract to spread seed and fertilizer with a helicopter and bucket on cutslopes, fillslopes, and on the scarified road surface. Cost: $150-$200 per mile. The overall cost is $750-$800 per mile.

There are several advantages:

1. By using a helicopter the scarified road will not be compacted and result in a better seed catch.

2. A large contract provides a better per unit price. The example is for several miles and the cost is $750.00 per mile.

Putting-the-road-to-bed saves a landowner money if first preventive maintenance is carried out and the road is closed; rather than continue with an annual maintenance program and the road is open. Preventive maintenance includes storm patrol and slide removal. The advantage to this practice is the pay off with the road in non-use status for 5 years or greater. This is a holding pattern for a road that is not to be abandoned, but will not be needed for several years. It works well without removing the culverts. The road contract was on the off-highway road system on the Shelton Ranger District used by the Simpson Timber Company.
(Source: Art Tracy, District Engineer, Hood Canal Ranger District, Olympic National Forest, 1989).

Mass wasting

Mass wasting is a general term for any of the variety of processes by which large masses of earth material are moved downslope either slowly or rapidly, by gravitational forces. Some mass wasting results from natural occurrences, however much of it can be attributed to human activity on the landscape. Debris flows and rotary slumps are examples of mass wasting.

Several studies show most non-natural landslides in forested areas are associated with roads rather than harvesting. In part, these studies represent past practices because they are often based on landslide histories covering 10 to 30 years. Nevertheless, they demonstrate that by addressing road-related landslides, any accelerated landsliding associated with management practices can be dramatically reduced.

The Soil Task Force of the Oregon Forest Practices Regional Committee concluded that debris avalanches associated with roads and landings provide more opportunities for prevention than in-unit slides and that there are no proven techniques that are effective in preventing in-unit slides (Source: George Ice, NCASI). In another study, roads were the major cause of landslides in the 1950's and 1960's, but the number and total volume of road related slides have decreased dramatically. This appears to be due to a combination of factors: improved road building techniques, better enforcement of contract specifications, and a reduction in the number of miles of road built each year. (Source: Dwight D. Barnett, USDA Forest Service).

One of the sources of sediment coming from the upper Deschutes watershed is mass failures called debris flows. A 1987 study by Sullivan et al, discusses the seven major slides that occurred in the watershed. The study covered a twelve-year period. The estimated amount of material from these seven slides is equal to more than that produced from all sources during any given year. Sullivan et al, stated that because of their infrequent occurrence, landslide sediments are not considered as part of the annual sediment budget in their study. This sediment from landslides, then, is in addition to the amount annually reported, or over ten percent of the total sediment load entering Capitol Lake during the study period. These slides deposited a large amount of sediment directly into the upper reaches of the mainstem of the river. Although sediment export from the upper watershed was not unusually high in the years immediately following the landslides, the slow downstream movement of the sediment may have been the cause of the eight-fold increase in sediment observed in the river at the monitoring site in 1986. A large amount of sediment passing the monitoring site at 15km or 5.8 miles downstream from the original deposition site may represent the bulk of the sediment pulse as it moves through the river system. Sediment exported from the upper watershed, as measured at the monitoring site, declined to near preslide levels in 1987. Storm events which contributed to these flows have a seven year-return interval and new debris flows can be expected unless forest management is changed.

At this rate this sediment can be expected to be deposited in Capital Lake around the year 2002. If this pulse ends up with half of the original volume of 52,753 cubic yards (60,500 tons or 55,000 tonnes), and if this is felt to be very conservative, it would represent a removal cost of $181,500 at only the $6.00 per cubic yard (rate shown in the Entranco report). This cost is stated in 1983 dollars. The cost is $6.00 for dredging but an additional cost is incurred in the removal of the spoils and handling of this material which will in all likelihood double the cost shown, to $12.00 per cubic yard.

A review of the location of these seven slides using 1986 and 1987 aerial photography, as well as onsite visitations of these slides (Weyerhaeuser Company map in the Appendix) indicates that five of the seven slides are road related and the others are forest management related. The roads appear to be designed with insufficient waterhandling capabilities, i.e. not enough culverts, lack of ditch cleaning, waterbarring, outsloping of roads, insufficient means of removing the water from fill slopes, or the lack of road closures.

The increased water available after clearcutting may have overloaded the culvert system in heavy storm periods. In dense evergreen stands interception losses alone can evaporate 25 to 35 percent of gross rainfall even in wet winter months (Sidle 1985).

The geology in the area of the landslides consists of a broad band of weathered volcanic and sedimentary rocks. This band is associated with ancient landslides (Duncan-1978 map see Appendix). Special care is needed for forest management activities in this area. The band appears to start at the border of Lewis and Thurston Counties and to extend toward the south for about four miles. This then, is the area of greatest potential damage and the area where care (including road maintenance and possibly skyline logging) needs to be considered.

The soils in this band are located on the steep slopes near the southern boundary of the watershed and are part of the Baumgard-Mashel Soil Association (Appendix-Soils). Steep slopes and seasonal wetness increase the susceptibility of soils to landslides, slumps, and debris avalanches. Other soils of the very steep mountain sides in this association are deep and highly permeable, and less prone to landslides, but can contribute to debris flows in steep valleys (McNicholas,1984).

Other Effects

Forest management activities that can effect water quality, in addition to road construction, use, and maintenance are harvesting, fertilization, burning, spraying, and reforestation

In the upper watershed where slopes are over 70 percent the main harvest method is clearcutting with hi-lead cable systems. A skyline cable system could also be used and with its longer reach and ground clearing suspension would result in less ground disturbance.

In the middle and lower portions of the watershed the hi-lead and skidder yarding operations are used, with hi-lead on the slopes over 30 percent and skidders on the flatter ground if the soil can take the added compaction.

Large clearcuts have increased water availability. Since interception and, absorption and transpiration of moisture by trees is not a factor until regrowth occurs, and as evaporation from vegetative surfaces and the soil surface occurrs at a much reduced level, more water becomes available for surface and stream runoff. Smaller clearcuts, for example, up to 250 acres with buffers, should help reduce the amount of water and slow down its downhill migration. Unit size is of special concerned on the steeper portions of the watershed in the transient snow zone where the potential of runoff from rain on snow increases significantly.

Cummulative effects are one of the major current concerns. A discussion of how little is known at this time about cummulative effects and the broad considerations which required adequate research are included later in the text.

Transient Snow Zone

The transient snow zone is a zone where rain-on-snow precipitation events are relatively common. The rain-on-snow events presents a "wild card" to hydrologists in the estimation of runoff and infiltration on watersheds within the transient zone. Although our knowledge of snow hydrology in the transient snow zone is far from complete, we recognize that certain changes in the snow hydrologic system can occur. The physical basis for increased rate of snow melt after logging does exist in the components of snow melt that are dependent on wind speed and turbulence. Increased melt results in increased rate of water delivery to soil, and roads and ditches can route surface and subsurface water to streams faster than in undisturbed watersheds. Increased rate of delivery of water to soil can lead to more or larger landslides in areas susceptible to mass erosion (Christner and Harr, 1982).

In addition, surface erosion on disturbed soil can increase during periods of high runoff. Faster delivery of more water to streams can cause higher flows and stream velocities that erode banks and channels and move large organic debris. And, because the flow changes we have been discussing have been detected in streams draining relatively large areas, there is reason to believe that changes in peak flows in some smaller basins within the large watersheds could have been much greater. Smaller watersheds tend to have greater proportions of their areas in an altered condition, and harvesting tends to be concentrated in a shorter period of time. Increased size of peak flows appears related to cumulative effects of timber harvest activities, primarily clearcut logging in the transient snow zone. More rapid delivery of water to soil and to streams increases the probability of landslides and stream channel erosion in headwater areas as well as channel erosion processes downstream. Timber harvest scheduling should take into account both the possibility for changes in snow accumulation and melt resulting from logging in the transient snow zone and the time required for hydrologic recovery (Christner and Harr, 1982).

Snowpacks in large openings are known to develop more ice lenses due to lower nighttime temperatures than do packs under forest cover. During some melt conditions, meltwater may flow over ice lenses to watercourses without entering the soil and may contribute to higher rates of stream flow. The frequency of occurrence of ice lenses and their extent within the transient snow zone are not known (Smith, 1974).

The transient snow zone in Washington and Oregon appear to be similar in that they occur at about the same elevation. Most of the research has been done in Oregon although new research by Harr is now being done in both states.

Harr's summary from his review of "Effects of Clearcutting on Rain-on-Snow Runoff in Western Oregon. A new look at Old Studies" suggests that clearcut logging has altered snow accumulation and melt sufficiently to have affected size of peak flows resulting from snow melt during rainfall. Another updating suggests although less conclusively (Harr and McCorison 1979), that snow accumulation and melt both may have been altered by clearcut logging.

In a discussion of unit size, harvest timing, and spatial location of units as tied to rain on snow events Harr felt that while they are not far enough along to specifically tie unit size and spatial location, it would be appropriate to err on the conservative side (Harr, 1989).

As was pointed out by Moore and Anderson (DOE, 1979) the majority of the sedimentation in the Deschutes River appears to be coming from the streambanks of the mainstem from near the 1000 line bridge on down the river to the lower sections. There is a strong possibility that the increased stream flow from the transient snow zone and large clearcut units can increase the amount of water in the mainstem. As a result, the rate of bankcutting is increased, hence greater sedimentation at a faster rate into Capitol Lake.

In the area of the upper watershed where landslide activity occurred, special care in harvesting, unit size, and location needs to be considered in the future. Intensified road maintenance including storm patrol during rain-on-snow events in the transient snow zone (where possible) is helpful as rain on snow can, for example, load up the road shoulders, fill slopes, and increase the probability of landslides.

Further monitoring and research may tie together the transient snow zone and cumulative effects.

Cumulative Effects of Forest Management

The DNR definition of cumulative effects is "a change in the environment caused by the interaction ofnatural ecosystem processes with the effect of two or more forest practices (Geppert, Lorenz and Laser, 1984).

In papers presented at the American Geographical Union meeting on Cumulative Effects, Lawrence and Ice questioned if the control of site-specific forest practices is adequate to the task and whether these practices are effective. They did not define cumulative effects. Rice and Thomas had several definitions of cumulative effects: (1) "a whole that is greater than the sum of the parts", to (2) "the joint occurrence of two or more effects from different sources". The importance of their paper seemed to be that until better data are available it should be argued that the addressing of cumulative effects through elaborate harvesting schedules is not feasible. What is feasible and likely to be effective is a simple scheme of dispersing impacts in time and space coupled with vigorous application of professional skill in the construction of each road and the conducting of each logging operation.

To study cumulative effects, a threshold of acceptability approach needs to be established. The threshold could vary from before-logging to presently planned management with units of 250 acres which are spaced over the entire watershed.

There is no data to show stream flow, erosion, and sedimentation rates "prior to logging" nor is this a realistic or economically viable threshold, since the land is 95 percent in private ownership to be held and /or used by the owners to return a profit. Under present regulation, (WAC Chapter 222-08 through 222-50) there is no restriction on unit size, sale layout, or timing of timber removal. WAC chapter 222 gives good guidance on road design, construction, and abandonment, however, it is not possible to determine how much DNR involvement or review was done in the past in the existing road system. Public resource protection is mentioned in the WAC Chapter 222-24-024, road design (222-24-035) and, in landing location and culvert installation (222-24-040). Timber harvest (WAC Chapter 222-30) gives good direction on unit planning and design, riparian management zones, bucking of timber, yarding, and slash disposal. The rules and regulations are silent on unit size and length of time that the unit buffers need to remain. The Department of Natural Resources (DNR) in its management of state land imposes a maximum size unit of 100 acres; the USDA Forest Service has a 100-acre size limit and as do some private companies. The Weyerhaeuser Company has a 250-acre limit.

Fertilization

Fertilization other than for Christmas trees has generally been done by helicopter as shown in the DNR forest applications. The WAC (Chapter 222-38 Forest Chemicals) includes fertilizers when discussing width of riparian zone. There is no indication that forest fertilization is causing any water quality degradation in the watershed.

Slash Disposal

The Washington Administrative Code (WAC 222-30-010 [4][B]) provides that the Washington Department of Natural Resources may require removal of "slash" and "debris" from below the 50-year flood level Type 4 and 5 waters when there is potential for damage to public resources. There appears to have been a slide in Ware Creek in January, 1982 within a logged but uncleaned section of channel which might have been prevented by slash removal.

The normal method of disposal of clearcut slash is by broadcast burning. The DNR has jurisdiction through a required Smoke Management Plan. This applies to all federal, state, and private land. Slash disposal is done to reduce fire hazards according to state law and to establish a condition suitable for reforestation. There are other methods to use such as pile and windrow and burn, pile and windrow without burning, mechanically scatter and compaction, scarification, chip, lop and scatter, burying and physical removal. Under the State of Washington's Smoke Management Plan there are less and less opportunities to burn. As economics and harvesting methods change there is less need to burn. A concern of some foresters is that more chemicals may be used to replace burning, in order to remove or set back the competition for food and water so that trees will survive and out-grow their competition.

Spraying

Spraying, control, storage, and handling are covered by WAC Chapter 222-38-Forest Chemicals. The protection of streams from spraying appears to be adequate in the watershed. A overview of the 1988 Weyerhaeuser vegetation management plan is located in the appendix. It shows the types of chemicals used, application rates, and the planned acreage to be sprayed. In the Deschutes watershed about 1,710 acres of an ownership of over 49,000 acres or about 4 percent of the land area, is to be sprayed.

RURAL/AGRICULTURAL SOURCES

General Characterization

The rural/agricultural source area includes all lands located between commercial forestry and the urban centers of Olympia, Lacy, and Tumwater. It is about 44,000 acres or 35 percent of the watershed. This source area is made up of rural residential parcels, small and large farms, and woodlots. Woodlots and pasturelands or native grasslands interspersed with residential parcels characterize this nonpoint source area. Small-lot residential developments surround Sun Lakes, and Offutt and Lawrence Lakes. The small communities of East Olympia and Rainier along with other suburban development exist at the fringe of the urban areas.

A sample of the community was conducted within the rural/agricultural source area to assess its potential for supplying pollutants to the Deschutes River and to Budd Inlet. A complete invnetory was made of those sections of land most likely to have livestock and a high potential for nonpoint pollution. The chosen sections was based on the existence of pasturelands and their proximity to a stream or water body. Information was gathered on these sections and expanded to the entire watershed. Land use information and the Thurston County Assessor's records were used to assist in the selection. The size of land ownerships, number and types of animals, waste handling methods, distance to the river, stream or ditch, or other water body, and the condition of the stream corridor were some of the items surveyed. General questions related to use of water, pesticides and care of the home septic system were also surveyed. Interviews with 98 residents covering some 5,400 acres and "windshield surveys" of 223 parcels covering 4,000 acres provide the background for the discussion which follows. The "windshield surveys" provide as much information as possible without actually interviewing residents. Time was a factor which limited the number of interviews with residents. Operators of seventeen commercial farms were interviewed. The total survey reflects more than 50 percent of the estimated 605 small farms units within the rural/agricultural source area which are likely to have livestock. Most residents were very cooperative and willing to respond to the twenty-nine question survey. Their assistance was very much appreciated.

The rural/agricultural source area (see Table 1) is placed in five categories: rural residential, small farms, commercial farms, woodlots, and commercial/industrial. Rural residential includes all parcels less than 20 acres in size without livestock which are used for homesites. This category also includes residential lots with urban-type density adjacent to streams and lakes, and other minor land uses. Small livestock operations include parcels with a horse for recreational purposes to larger parcels with 30 to 50 livestock which supplement family income.

In the watershed the commercial farms average more than 275 acres and are considered to continually produce significant annual income. There are four dairy and thirteen beef cattle operations. Also included are two commercial horse stables. Typically nonpoint sources of pollution are associated with animal waste and animal access to a stream corridor. Dairy farms require an elaborate waste management system at the barn and an adequate land base for disposal and utilization of the waste. Beef farms require a more modified, less expensive waste management system.

The woodlots category contains large forested parcels with or without residences, but not specifically managed for timber production.

Rural Residential As A NonPoint Source

The rural residential area covers about 15,807 acres or about 36 percent of the rural/agricultural nonpoint source area. Its population is estimated at about 27,950 or about 1,131 persons per square mile. Most of these residents (87%) reside on land parcels of less than five acres in size (see table 1). These smaller parcels represent but a minor amount (7%) of the land within the rural/agricultural area. Individually such land parcels may not present a significant water quality problem. However, when considered from an accumulative aspect, these parcels may represent a significant water quality problem in this watershed. The wide dispersal, and obvious low density of the remaining group (5 to 20 acres), reduces the overall potential of nonpoint pollution.

Most homes have the conventional septic system as a method of disposing of graywater and sewage, and that scheduled maintenance is not a priority with most residents, one can only assume a greater potential failure rate with time and the subsequent polluting of surface water and/or groundwater. Only a small percentage (34%) of households have had the septic tank pumped out within the last five years. The practice of pumping at least once every five years is recommended by the Thurston County Health Department and the Washington State Department of Social and Health Services (Leaf, 1989).

The average age of most septic systems learned from the interviews with residents is 13.5 years. Most (78%) are over five years old. Tables 10 and 11 derived from the community survey, demonstrate there is a lack of awareness by many residents as to the function and proper maintenance of the septic system. More than sixty percent of septic systems over five years old have either never been pumped out or were pumped out more than five years ago. Most financial institutions in Thurston County, prior to a home loan approval or to closing, require a letter from the Health Department certifying the septic system is in working order. Some require a pump-out of the septic tank if not done in the last two years.

Table 10: Septic Tank Clean Out: Systems Over 5 years Of Age

Septic Tank Clean Out	Respondents (57) (%)
Less than 6 months	7
6 to 12 months	5
1 to 2 years	9
2 to 5 years	12
More than 5 years	16
Never	44
Unknown	7

Table 11: Septic Tank Clean Out: Systems Of All Ages

Septic Tank Clean Out	Respondents (83) (%)
Less than 6 months	6
6 to 12 months	4
1 to 2	8
2 to 5 years	16
More than 5 years	14
Never *	41
Unknown	11

* This includes new or young systems

Fifty-six percent of the septic systems over ten years of age (or 49% of households) were pumped either more than five years ago or never.

The Soil Survey Of Thurston County Area can be used to evaluate the limitations of soils for the conventional septic system. For example, based on the location of the rural residential housing units, nearly all systems (97%) in the rural/agricultural source area of this watershed are installed in soils with severe limitations. More than half of those (55%) are located on soils that are poor filters of septic tank effluent. Such soils generally do not pose a threat to surface water. However, that is not the case with regard to groundwater. Unless the drainfield is designed to slow down water movement through the subsoil, septic water will move very rapidly through the coarse soil material below a drainfield with the likelihood of very little treatment.

Tables 12 and 13 clearly show that development patterns in the watershed favored development on soils with poor filters for septic systems over soils with other limitations. It needs to be stated that with proper soil evaluation, and a good design and installation with periodic maintenance by the user, an on-site waste disposal system may function problem-free for a long period of time.

Table 12: Rural Residential -Soil Limitations For Septic Tank Absorption Fields.

Soil Limitation 1/	Housing Units (No.)	Percent
Slight	0	0.0
Moderate	232	2.5
Severe	9,037	97.5
(cemented pan)	(1,696)	(18.3)
(flooding)	(213)	(2.3)
(slope)	(223)	(2.4)
(percs slowly, wetness)	(1,789)	(19.3)
(poor filter)	(5,107)	(55.1)
(depth to bedrock)	(9)	(0.1)
Total Slight, Moderate, Severe	9,269	100.0

1/ Based on USDA Soil Conservation Service Soil Interpretations. and Soil Survey of Thurston County Area, Washington.

Table 13: Rural/Agricultural Source Area: Soil Limitations For Septic Tank Absorption Fields

Soil Limitation 1/	Within Rural Residential Area	Total Watershed 2/
	(%)	(%)
Slight	0.0	0.1
Moderate	2.5	2.6
Severe	97.5	97.3
(cemented pan)	(16.2)	(12.1)
(flooding)	(7.2)	(4.2)
(slope)	(4.3)	(18.1)
(percs slowly)	(19.2)	(19.5)
(poor filter)	(50.2)	(31.1)
(depth to bedrock)	(0.4)	(12.3)
Total Slight, Moderate, Severe	100.0	100.0

1/USDA Soil Conservation Service Soil Handbook
2/Total watershed means all source areas except urban.

Wells are the primary source of domestic water within the rural/agricultural area. The depth of the wells ranged from 20 to 360 feet, averaging about 95 feet. The majority of the residents (85%) rated the water quality as good. Others considered it fair (11%) or poor (4%). The latter group stated the water contained too much iron or sulfur. One respondent imported water.

Table 14: Resident's Opinion- Quality of Domestic Water

Rating of Water	Respondents (%)
Good	85
Fair	11
Poor	4

Other potential nonpoint sources of pollution associated with this rural residential group include chemicals from lawns and gardens, disposal of household cleaning products, paints, and automotive products, and runoff from roads and highways. The community survey results indicated that chemicals for pest and weed control, and for fertilizing lawns and gardens are not used extensively within the rural residential area. About six percent of the respondents apply pesticides. Most of the respondents apply herbicides. Several well-known weed control chemicals were cited. Diazinon was the most used insecticide. Commercial fertilizer is used by less than 15 percent of the small farm residents. Approximately half of those that do use it apply fertilizer once to their lawns. Those pastures receiving one application of commercial fertilizer generally receive the application in spring.

<u>Small Farm As A Nonpoint Source</u>

The small farm area (see Table 1) covers about 8,052 or about 18 percent of the rural/agricultural. Its population is estimated at about 1,920 or about 147 persons per square mile. Land units range in size from less than 1.5 to more than 20 acres. Most of these residents (78%) reside on land parcels between 1.5 to 20 acres in size. The estimated livestock density of small farms (see Table 15) depends on the size of the parcel. The total number of animals on small farms parcels is estimated at more than 3500. The overall livestock density within the small farm area is about 6.0 animals per farm (Table 15).

The extent of the water quality problem attributed to small livestock operations depends on whether animals are confined or unconfined, and overall management practices. Stocking rate in critical areas, pasture condition, level of waste management, and proximity of pathways which are able to transport pollutants to streams are some indicators used to evaluate potential problems for water quality. Within this watershed, pastures are typically in fair to poor condition. Soil compaction by

Table 15: Livestock Density of Small Farm Parcels-1989

Parcel Size	Residential Units (no.)	Livestock Beef (no.)	Dairy (no.)	Horse (no.)	Other (no.)	Total (no.)	Parcel Livestock Density
<1.5 ac	58	9	3	66	3	81	1.4
1.5-5 ac	251	201	0	413	73	687	2.7
5-20 ac	221	420	22	682	511	1,635	7.4
>20 ac	75	585	193	216	170	1,164	15.5
Total	605	1,215	218	1,377	757	3,567	6.0

Table 16: Condition and Livestock Densities of Small Farm Pasture-1989

Parcel Size	Pasture (ac.)	Good (%)	Fair (%)	Poor (%)	Livestock Density per acre
<1.5 ac	37	7	20	73	2.2
1.5-5 ac	753	30	42	28	0.9
5-20 ac	1,702	36	49	15	1.0
>20 ac	2,565	44	38	18	0.5
Total	5,057				0.7

animals is a common problem. As a result, rainfall is less likely to enter the soil and runoff becomes a problem. Such conditions increase the likelihood of surface water carrying waste to roadside ditches and nearby streams.

In Table 16 pasture condition and livestock densities are presented for the small farms. A good management guideline of one animal unit (AU) per acre of pasture for a seven-month growing season is used to evaluate levels of livestock density. An animal unit is defined as a 1000-pound cow with calf. Generally these small farms do not generate large quantities of manure.

--Less than 1.5 acres in size - total 58 housing units on 53 acres. The livestock population is estimated at 81 head, most are horses. More than sixty percent of the parcels in this group exceed the management guideline of 1 AU per acre. Generally animals housed on small parcels require supplemental feeding as the pasture grasses are rapidly overgrazed. The livestock density on pasture (see Table 16) is 2.2 animal units per acre. Based on the survey results, most pastures (73%) are overgrazed and in poor condition. Pastures generally become confinement areas and animal waste is concentrated in a small area. Perennial or intermittent streams occur on less than 10 percent of these parcels. In only twenty percent of these, do livestock have access to a stream.

--From 1.5 to 5 acres in size - total 251 housing units on 1,059 acres. The livestock population is estimated at 687 head, most (413) are horses. Based on the survey, these parcels predominately house 2 to 3 horses. Several of these also have an additional 2 or 3 beef animals presumably to supplement the family food budget. Landowner objectives appear to be similar to those of smaller parcels. Livestock have access to more pasture. The benefits of having more acreage is evident from the lower livestock density of pastures (0.9 AU per acre) and from the subsequently improved pasture condition, seventy-two percent fair or good (Table 16). However, 34 percent of the parcels have herd sizes that exceed a pasture guideline of 1 AU per acre. Few (12%) farms border streams (Table 17) and, in almost half of these, animal have access to the streams (Table 18).

--From 5 to 20 acres in size - occupy 2542 acres with 221 housing units. Their livestock population is estimated at 1,775 head, most (682) are horses. The rest is made up of beef cattle (420), dairy cattle (22), and other livestock, mostly sheep (651). One ten-acre cutover woodlot which contains 70 pigs, is included in this group. The average herd size is 7 to 8. While primarily for recreational or hobby purposes, some do produce income. The average livestock density is in agreement with the guideline (1.0 AUs per acre). Most pasture acreage (85%) is in at least fair or better condition. While the average livestock density level and pasture condition provide a picture of low potential impact to water quality, the extent of nonpoint pollution is directly related to the use of critical areas. Twenty percent of these small farms contain or border streams and animals have access to most of these critical areas (see Table 17).

Table 17: Small Farms with Streams - Streambank and Canopy Conditions

Parcel Size (ac)	Parcels With Livestock (%)	Streambank Condition Good (%)	Streambank Condition Fair (%)	Streambank Condition Poor (%)	Canopy Condition Good (%)	Canopy Condition Fair (%)	Canopy Condition Poor (%)
All	17	53	29	18	38	29	33
<1.5	9	23	77	0	60	20	20
1.5-5	12	50	35	15	31	31	38
5-20	20	32	44	24	34	37	29
>20	36	61	22	17	48	16	36

Table 18: Small Farms with Streams- Livestock Access, Streambank and Canopy Condition- 1989

Parcel Size (ac)	Parcels With Livestock & w/Streams (%)	Streambank Condition Good (%)	Streambank Condition Fair (%)	Streambank Condition Poor (%)	Canopy Condition Good (%)	Canopy Condition Fair (%)	Canopy Condition Poor (%)
All	62	52	28	20	34	29	37
< 1.5	20	0	100	0	0	0	100
1.5 - 5	48	43	46	11	36	36	28
5 - 20	63	24	43	33	28	36	36
> 20	82	61	21	18	41	18	41

--Over 20 acres in size - occupy 4812 acres with 75 housing units. These units are not considered commercial farms. Out of a total of 1,164 head of livestock there are 193 dairy animals, 585 beef, 216 horses and 170 other livestock (sheep, pigs, and goats). Average herd size is over 15 head (Table 15) with some units having up to 30 to 40 head of horses or cows. Few if any of these units are operated for only recreational purposes. Most would be considered part-time farms where revenue from the operation generates a substantial portion of the total family income. Livestock densities are low (.45 animals per acre) and over 82 percent of the pastureland is in at least fair condition (Table 16). The potential source of nonpoint pollution from these units is along the stream corridor. Thirty-six percent of these larger operations border or have streams flowing through them (Table 17). In most, livestock have access to the stream (Table 18). Generally these corridors are heavily utilized for pasture because the best soil for growing forage are located in bottomlands. Livestock operations of this size often confine livestock to a small area for at least part of the year because of weather conditions and for ease of feeding. During the confinement period the concentration of wastes can become a source of pollution if it not properly controlled and managed.

It is well documented that parcels with large concentrations of livestock are potential significant contributors of nutrients and bacteria to streams of Western Washington. Several studies have examined the effect of livestock grazing and of bacteria levels in water (Coltharp and Darling, 1973; Doran and Linn, 1979; Gary et al., 1983; Kunkle and Meiman, 1968; Skinner et al, 1974). These authors agree that livestock noticeably increase fecal coliform (FC) counts in runoff from grazed areas--some counts show up to 10-fold increases over background counts. Tiedemann found significant increases in streamwater FC counts with increase intensity of grazing and that FC levels remain elevated up to 9 months after livestock is removed from a watershed.

A livestock population density map attached to this report provides a general overall view of livestock levels and location by land section. A livestock waste hazard map also included with this report shows the relative potential of farms to provide pollutants to streams within the watershed. These maps can be useful tools to focus on potential problem areas and to prioritize follow-up water quality activities.

In the Deschutes River watershed it is interesting to note (Table 15) that as the small farms decrease in size, the livestock densities increase. The small livestock farms of less than 1.5 acres in size with the animal unit density greater than 1.5 deserves further evaluation. Such intense use of small parcels could be described as animal confinements or miniature feedlots. In some cases, a severely impacted pasture or confinement area needs BMPs similar to those applied to a feedlot. It is most difficult to apply best management practices (BMPs) to this size of small farm unit as space and economics determine to a great extent what BMPs may be practical for a landowner. There are other variables which may dictate levels of management of the small farm. A transitional group within the watershed appears to be within the 1.5 to 5 acre units where these larger parcels provide greater opportunities for grazing and for distribution of animal waste than the smaller unit.

Best management practices are considered essential parts of any livestock farm management plan. A BMP is an agronomic, management, or structural practice that, when used singly or in combination with other BMPs as a component of farm management plan, addresses the minimum essential treatment needed to solve site specific water quality problems (DOE, 1979). There are few instances where the installation of one BMP will solve a water quality problem.

Many if not all of the small livestock farms lack storage for barn waste. In a number of observed instances waste is stored alongside the barn waiting for disposal. Covered waste storage structures control runoff and eliminate any rainfall additions to animal manure during the winter months. The common practice in the watershed is for waste to be applied throughout the year to land on the farm or offered to residents for garden use. Rainy season application is not a desirable practice because surface runoff can collect manure and transport pollutants to a nearby stream. In addition, as soil temperatures are low during this period, there is little bacterial action to convert nutrients in the manure for use by plants. The Soil Conservation Service recommends BMPs for a waste storage structure that has a capacity of at least five to six-months and for application of the manure during the plants' active growth period.

Technical assistance that is available to large livestock farms is generally of limited availability to owners of small acreage. The Thurston Conservation District provides assistance to small livestock farms. Washington State University provides information on best methods of waste management.

<u>Woodlots As A Nonpoint Source</u>

The woodlots land use category is made up large forested parcels with and without residences. Woodlots is differentiated from commercial forest which has special tax designations. It is assumed that these forested parcels are not actively managed for commercial production. Many of the young trees however, are used for Christmas tree production. The older or more mature trees do not appear to be actively managed or harvested for timber. There is some use for firewood. Such lands cover 16,899 acres or 35 percent of the rural/agricultural source area. Woodlots is not considered a significant source area as most of these lands have gentle slopes and very good drainage. While much acreage of woodlots could be assumed to be held for conversion to more intensive uses since these lands are not in the open space taxation program, less than 1.5 percent has been recently converted.

Commercial/Industrial As a Nonpoint Source

The commercial/industrial covers about 1,396 acres or 3 percent of the rural/agricultural source area. The extent of a water quality problem attributed to this source was not evaluated. No discussion is included in this report.

Commercial Farm As A Nonpoint Source

The commercial farm area covers about 2,296 acres or 5.1 percent of the rural/agricultural. Its population is estimated at about 61 or about 17 per square mile. Most of these residents reside on large land parcels ranging in size from 65 to 1,080 acres. The livestock population of these farms is estimated at 2,213 head. One dairy farm also contains a chicken (over 97,000 chickens) and a sheep operation. Even though their acreage is small relative to other farms in this group, two horse stables are included in this group because each has a large number of livestock and a substantial quantity of animal waste. Most owners of these farms have worked previously with the Thurston Conservation District. An average dairy operation within the watershed occupies more than 250 acres and has more than 200 head of dairy cattle. A beef operation averages about 300 acres in size and about 75 head of beef cattle. Adjacent wooded areas are utilized for grazing.

The nonpoint sources of pollution within the commercial farm area are similar to those of the small farm but differ in magnitude. Any given dairy has the capacity to be a major nonpoint source of pollution. For example, a 200-cow dairy produces nearly 3000 gallons of waste a day or 1.1 million gallons a year. Such large quantities of dairy waste demand an adequate land base and a number of BMPs at the barn and on the land. A beef cattle operation of 75 head is less likely to be a major nonpoint source. It does not require the elaborate waste management system of a dairy but as beef cattle are often confined for short periods during the winter months, it does require adequate dry-stack storage until the waste can be applied to pastureland in the spring. Most beef operations in the watershed do not have any storage (see Table 19). The horse stables lack any means of controlling or storing waste and rely on trucking it to other land for disposal.

A monitoring study in a large dairy dominated watershed of Whatcom County, Washington showed that high fecal coliform counts, and high concentrations of nitrate and phosphate in the waters of Kamm Creek were directly linked to agricultural activities (Tera Tech, 1989). Good management is the key to eliminate water quality problems and to best utilize the nutrients in waste for increased forage production. A substantial amount of land, capital, and labor is required to implement a system of BMPs which collects, stores, and utilizes this byproduct.

In the Deschutes River watershed many streams and ditches have cattle entry (see Table 18). Such activity adds sediment to the stream as cattle break down stream banks. Higher temperatures and higher levels of fecal coliform in the shallow waters of tributaries and ditches are to be expected as cattle graze the protective vegetation and discharge waste. Cattle require access to water. A watering facility is included as an essential part of any pasture management system (a BMP).

The lack of best management practices or a system of BMPs can be cited as contributing to high fecal coliform (FC) levels in the Deschutes River. A study of land use activities along the upper Deschutes River by the Thurston County Health Department in 1986 identified some farm practices as contributing to high FC levels. Those practices included the year-around land application of animal waste and direct access to the river by cattle. Animal waste is best utilized by pasture plants during in its active growing stage rather than during the winter dormant stage. Unless properly managed, waste may flow into a field ditch when too much is applied to part of a field. Nutrients which are not utilized by the plants or do not runoff, probably leach into the groundwater. Poor quality water was observed along a major ditch/stream tributary in the upper watershed as a result of animal access. Water flow was reduced by excessive soil input from damaged channel sideslopes. In addition, a fence placed on the wrong side of this ditch/stream, did little to protect and maintain the capacity of the ditch/stream to dispose of excess surface water. The fence needs to be moved to the opposite side of the ditch/stream and access by cattle to drinking water made available.

The Thurston Conservation District has worked with most of the commercial livestock farms in the application of BMPs. Most of these farms have applied one or several BMPs. One can assess the potential nonpoint source problems of commercial farms by assessing certain factors (See Table 19).

In summary, the intensity of livestock grazing, stocking rate, and proximity to surface water determine to a large extent the level of water quality impacts. High animal unit densities do not necessarily result in water quality problems for nearby streams if a system of best management practices are in place, and there is an adequate land base to utilize the animal waste. Livestock waste- its collection, storage and its disposal- is best handled by a waste management system. The major activities on many commercial farms in the watershed which lead to lower water quality are associated with inadequate manure storage facilities, with animal waste applied throughout the year, with inadequate pasture management, and with animal access to the stream corridor.

TABLE 19: Commerical Farms Evaluation
Deschutes-Budd Inlet Watersheds, 1989

Evaluating Factor	Farm Units Dairy	Farm Units Beef
Commercial farms (no.)	4	15
Average farm size (acres)	265	295
Average AUs per farm (no.)	490	74
Available waste storage		
6 months or more	1	0
3 to 6 months	0	0
1 to 3 months	0	0
2 weeks to 1 month	1	1
less than 2 weeks	2	1
No storage	0	14
Waste application period		
all year	3	0
spring through fall	1	15
Distance to waterways from holding areas		
0-250 feet	1	3
250-1000 feet	2	5
1000-3000 feet	1	7
Distance to Capitol Lake/Budd Inlet		
0-3 miles	0	0
3-6 miles	2	1
6-9 miles	0	3
greater than 9 miles	2	11
Animal access to waterways		
fence, water available	2	4
fence-controlled access	0	2
partial fence-seasonal	1	2
no exclusion-continuous grazing	1	7

*includes horse operations

ONE POLLUTANT, ITS CAUSE AND EFFECT

Sediment is a pollutant. A pollutant is a contaminant that adversely alters the physical, chemical, or biological properties of the environment (PSWQ Management Plan, 1987). Sediment is the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level. It is also defined as any substance of such character and in such quantities that when it reaches a body of water, soil, or air, it is degrading in effect so as to impair its usefulness or render it offensive (Water Quality Field Guide USDA, 1983).

Sediment, the result of erosion, has a number of adverse effects as a pollutant. In suspension it reduces the amount of sunlight available to aquatic plants, covers fish spawning areas and food supplies, and clogs gills of fish. It fills drainage ditches, road ditches, and stream channels reducing channel capacity which can cause flooding. Sediment can result in shortening the life of lakes. Sediment which originates from surface soils will have a higher pollution potential than that from subsurface soils. The topsoil of a field is usually richer in nutrients and other chemicals from past fertilizer and pesticide applications, as well as nutrient cycling and biological activity. Sediment from gullies and streambanks usually carries less adsorbed pollutants than sediment from surface soils.

Within the Deschutes River/Budd Inlet watershed there are two main land use changes taking place, one permanent, the other cyclic. Urbanization of the lower watershed increases the discharge and volume of storm runoff which in turn can increase erosion in the watershed. Although the urbanized area in most watersheds is generally a small percentage of the total watershed, the disruption in natural drainage patterns can be of major significance (Puget Sound and Adjacent Waters Study Pacific Northwest River Basins Commission, 1970). Major timber removal, a more short-term event in the upper and middle reaches of the Deschutes River watershed, has initially contributed to a greater discharge and volume of runoff. When the land is replanted and trees begin to dominate the landscape over the following ten-year period, runoff will gradually decrease. The break point where streamflow approaches that of a mature forest condition, is considered to be between plantation age (0 to 10 years) and young growth (10 to 50 years).

Land use activities such as logging, road building, or the creation of impervious surfaces can be expected to increase peak flow. These activities tend to decrease the infiltration of water into the ground and to concentrate surface waters. In general, peak flows increased during periods when extensive harvesting occurred in the upper watersheds of the Deschutes River. One factor, the removal of vegetation, contributes to the land's inability to handle storm events. Vegetation intercepts rainfall, absorbs energy, and reduces the erosive effects of raindrops. It returns moisture to the atmosphere through transpiration and evaporation, and acts as a sponge to absorb water through roots thereby providing space in the soil profile for additional water. As vegetation is removed, moisture slowly begins to accumulate in the soil profile until the profile is saturated and runoff occurs. The harvest of trees may result in increased base flows and increases during the period of snow melt. Troendle (1987) reported that peak water equivalent in subalpine snowpack, total flow, and peak discharge rate increased during the first year after harvest. The overall energy in the river increases with larger peak flows which can create problems such as flooding, streambank erosion, and higher sediment loading.

Road building activities associated with logging tend to change natural flow and to concentrate surface runoff which decreases the time for runoff to reach streams. In the upper Deschutes watershed as timber was harvested, there was an associated increase in the miles of forest roads. Presently there are between 5 and 6 miles of forest roads per square mile in these subwatersheds which is considered to be a moderately high density. Even after the regrowth of forest stands, much of the impact of forest road use on runoff remains unless they are put to bed or abandoned.

In the Deschutes River watershed most of the runoff is generated in its steep upper portion as the lower portion lies on more gently sloping glacial outwash soils with high infiltration rates. McNicholas (1984) provided estimates of peak flows which are based on 1966 and 1981 land use conditions within the watershed. Weller, (1989) provided updated peak flows using three land use conditions (Table 20). The subwatersheds of the upper Deschutes have experienced extensive harvesting and road building during the last decade. To demonstrate the effect of forest land use activities on peak flows, a hydrologic model (USDA, 1982) was run for the upper watershed using three stand conditions: the present, optimum, and mature (see table below). The forest stand age for the present condition was established from the Landuse/Landcover Map data. The other two conditions are hypothetical. The following matrix shows the percentage of each age group that makes up the forest in the three modeled conditions.

	Plantation Age (LT 10 yrs.)	Second Growth (10-50 yrs)	Commercial Timber (GT 50 years)
Present Condition	20%	49%	31%
Optimum Condition	10%	45%	45%
Mature Condition	0%	0%	100%

During the 1959-1970 period this modeled portion of the upper Deschutes River Watershed reflected increasing peak flow values as the mature forest was harvested and replaced by plantations. This forest has now undergone a complete rotation and as the present second growth approaches maturity, peak flow values should decrease. As you can see from Table 20, peak flows for the present condition are estimated to be 60% greater than those occurring prior to logging in the watershed. Directing forest management plans towards a more optimum harvest cycle could reduce peak flow values over present levels by 15%. However, it would still represent a 37% increase over mature conditions.

Table 20: Results of a Hydrological Model of the Upper Deschutes River Watershed (Weller, 1989)

Subwatershed	Present (cfs)	Optimum (cfs)	Mature (cfs)
West Fork	1889	1518	1187
Lincoln Creek	730	616	381
Green Hill	1552	1268	845
Little Deschutes	965	689	462
Thurston Creek	619	473	308
Johnson Creek	716	717	536
Mitchel Creek	1090	1162	815
Bald Hill	239	314	217
Falls Creek	364	420	288
Hull Creek	1199	965	615
Lake Lawrence	88	88	88
Rainier	349	349	226
Reichel Lake	552	394	247
S. Vail At	82	152	82
Stream Guage Station	6852	5870	4274

Sources of Sediment

The rapid rate of siltation within Capital Lake has been a concern for several years. Numerous studies by a wide variety of interested agencies, organizations, and companies are available on the subject. The various methods used to quantify erosion and sedimentation rates include the following: streambank erosion inventories, suspended sediment load measurements, precipitation and runoff relationships, and change in lake volume. Just as the methods of evaluating vary with each report, so do the amounts and rates of sediment deposition. These reports contain estimates of average annual rates of sediment being deposited in Capital Lake that range from 20,100 cubic yards (Moore and Anderson, 1979) to 85,600 cubic yards (Entranco Engineers, 1984). Table 21 summarizes sediment loading values from the Deschutes River from a number of studies.

Table 21: Summary of Various Studies Relating to Sediment from the Deschutes River

Reference Studies	Annual Sediment Loading (CY)
1970- Puget Sound Task Force	25,900
1970- Nelson	20,900
1973- Walker and Bryne	28,300
1975- Orsborn, et al	41,000
1979- Moore and Anderson	20,100
1983- Entranco Engineers	56,500-85,600
1983- Thurston Conservation District	39,500
1989- Kilian	56,700

1989 and 1990 Field Investigation

A general reconnaissance of the Deschutes River watershed was completed during the fall of 1988 and the spring of 1989. Most known potential sources of erosion were inventoried and evaluated. The erosion sources fall into the following categories: streambanks, agricultural land use, forest land use, and urban.

Streambanks:
Twenty-one percent of the streambank erosion locations identified in the 1981-82 inventory (Thurston County Conservation District, 1984) were revisited. Although it may have originally been overestimated, it appears that the overall average annual rate of recession has remained constant.

The Deschutes River is a dynamic, actively meandering river not in equilibrium with its watershed. There are several areas where the river has noticeably changed course, abandoning its former channel within the past eight years. The channel also has become braided below Road 1000 bridge as the river deposited a portion of its large sediment load. When a stream is in equilibrium, the normal stream configuration will be a meandering stream. When excessive sediment is added to a stream, to carry the sediment plus the volume of water something must change, i.e.; the stream must go wider or deeper or both (Reckendorf, 1989). The Deschutes River is now much wider. The high ratio of channel width to bank height indicates the river is unable to carry the large sediment load it is receiving.

As the sediment load increases, the ability of the river to "cleanse" itself decreases and the riverbed aggrades. As the channel becomes more shallow it must then also become wider to accommodate the same volume of water. Most of the banks of the Deschutes River are composed of unconsolidated, easily erodible alluvial and glacial deposits. Due to the drastic change in landuse over the last fifty years, not only has the sediment load increased, the amount of discharge of the Deschutes River has also increased (Weller 1989). In summary, with the aggradation of the river bed and the increase in flow, the Deschutes River attempts to come into equilibrium by establishing a shallower, wider channel and by so doing, accelerates the streambank erosion above what is normally expected of the river.

Agricultural Land:
Most of the agricultural land is in the middle to lower watershed where slopes are less than 20 percent and surface drainage is not well developed. Much of the erosion in these areas is along the streambanks, where animals have access to the stream and/or where stream banks are eroded into cropped areas. Some of the pasture land apparently is intensively grazed. However, with the fairly level land and lack of surface drainage, surface erosion is minimal.

Forest Land:
A reconnaissance was made of several of the major forested areas. The forest lands are mainly in the upper watershed, at the higher elevations where there is a greater amount of precipitation and the slope of the land is steeper. Logging has been active in the watershed for the last forty years. There are very few old growth stands left in the drainage, with the majority of the trees between 5 and 50 years old. The recently logged areas exhibited several forms of surface erosion.

At least six individual debris flows (mass wasting) directly associated with logging road construction and forest management are identified. The use of 1981 and 1986 aerial photos show that these slides are less than 10 years old. One of the larger slope failures occurred as recently as 1986. The surface area of these slides are still void of vegetation, indicating erosion is still active. The slides apparently occurred due to a combination of conditions which lead to slope instability. When surface cover is removed (tree harvesting) more of the precipitation is available for infiltration, therefore the soil can quickly become supersaturated. Roads tend to concentrate surface and subsurface flow compounding the situation. In addition, the construction of a road on a slope requires a "cut and fill". The "cut" removes material from one portion of the slope creating a point of weakness, and the "fill" adds weight to another point on the slope further adding to the instability. All of the slides are near creeks (Ware, Buck, Lincoln) increasing the likelihood that the eroded material will enter the surface water transportation system.

Forest roads also contribute a significant amount of erosion and off-site sedimentation. A majority of the forest harvesting activities occur within the elevations subject to freeze and thaw conditions. During March 1989 an abundant amount of soil and rock particles were observed falling from the cut slopes of most traversed forest roads. As the frozen soil surface warmed, soil particles and rock fragments fell and accumulated in the road ditches, often completely filling the ditch.

When the heavy spring rains hit, the road ditches will undoubtedly be washed "clean", as the sediment is transported into the river system. The surfaces of the main haul roads and most of the other roads appeared to be well maintained with crushed rock, so there is little surface erosion. Eroded areas directly below the road culvert outlets are numerous and as buffer zones are nearly non-existent on smaller streams, most of the eroded material could easily be transported down the watershed.

Other than the above noted known sources of erosion associated with forest management activities, there is little observed erosion occurring on the recently logged land. The areas had not been burned and the remaining litter appears to have helped in preventing the formation of extensive rills and gullies.

Urban Land:
Much of the lower watershed land use is urban and industrial. In the older well established areas, erosion is almost nonexistent. The slopes are nearly flat and very little soil is bare and susceptible to erosion. A few large areas however, are in some stage of development and/or construction. During land conversion and at construction sites the potential for erosion is significant. Surface drainage in most of these areas is not well developed so off site transport of the eroded material is limited. Significant urban erosion is from those few locations where slopes are steeper and surface water is in close proximity to construction activities.

Evaluation of Major Sediment Sources

As noted earlier several studies over the past 20 years are available to quantify the amounts and sources of the sediment entering Capitol Lake. Each study appears to focus on one or two sources and arrives at very different quantities of sediment for the entire watershed. The following is an explanation of the results of a recent field investigation (Kilian 1989). It combines previous data collection and reports.

Each of the major sources of erosion was evaluated separately using a variety of methods, as each type of erosion has a different cause or driving force. The total sediment contributed from each major source in the Deschutes River Watershed to Capitol Lakemis computed at 56,730 cubic yards.

Streambank Erosion:
The values for streambank erosion were obtained from a 1981/82 field inventory (Thurston Conservation District, 1984). From recent field observations some of the recession rates for streambank erosion appeared to be too high for current conditions and were lowered. The volume (cubic yards) of fine and coarse size material is separated, as the delivery ratio for fine sediment originating from streambank erosion in

the Deschutes River is 90 to 95 percent, and the delivery ratio for the coarse sediment is only 20 to 30 percent. For the purpose of this discussion the delivery ratios are computed to Capitol Lake. Most of the coarse (gravel size and larger) sediment being eroded from the stream banks remains as bedload within the river. This coarse fraction forms large bars and builds up the streambed, further accelerating streambank erosion and the aggradation of the river channel. The total annual volume of fine material is estimated from the 1982 inventory at 20,234 cubic yards(CY) or 23,219 tons per year (as a majority of this material is silt and sand size, a value of 85 lbs/cubic feet (CF) is placed on fines). The estimated volume of coarse material is 6,297 CY (a value of 110 lbs/CF is used for coarse material). At a 25 percent delivery rate it equals 1,574 CY per year. This results in 21,808 CY per year of sediment from the streambanks which were inventoried.

The Deschutes River is 57 miles in length and 37.2 miles were inventoried for stream bank erosion. In addition, there are more than 56 miles of class 3 streams and 97 miles of class 4 and 5 streams in the watershed that were not inventoried. Therefore, it is estimated that the above total sedimentation derived from inventoried streambank erosion is only representative of 50 percent of the total streambank erosion in the Deschutes River watershed. As a result, the total annual sediment loading from all streambanks that is delivered to Capitol Lake is 43,616 CY.

Road Erosion:
A procedure developed by the USDA Forest Service on the Olympic National Forest was used to calculate road erosion (Stephens, 1984). Five erosion classes based on slope and erodibility of the soil are identified. Most of the forest roads are constructed on moderately erodible material and on slopes up to 40 percent. The roads within each subwatershed are placed into an erosion classification A through C . Based on the land use categories, it is estimated that the average age of all roads within the forest lands is 20 years, recognizing that the older roads still in service receive occasional repair and maintenance. There are 480 miles of identifiable forest roads within the Deschutes watershed. Of these, 146 are within the water influence zone (WIZ) which is defined as "approximately 200 feet on either side of Class I through IV streams". The remainder (336 miles) are not within this zone, and a lower rate of delivered sediment was used. The miles of road estimated to be within the WIZ were determined by reviewing the USGS maps and from evaluating both the stream and road densities for each subwatershed. The rates for A, B, and C classes are averaged over the first 20 years following construction. Although conditions in the Olympic National Forest differ from the Deschutes area, the estimates are representative. The estimated average annual rate of delivered sediment from road erosion ranges from 2.4 tons per mile per year (Class A, Non-WIZ) to 41.2 tons per mile per year (Class C, WIZ). The total estimated sediment from forest roads is 6,194 CY per year. In addition to the forest roads, there are more than 500 miles of state and local roads, which undoubtedly contribute a small amount of sediment to Capital Lake.

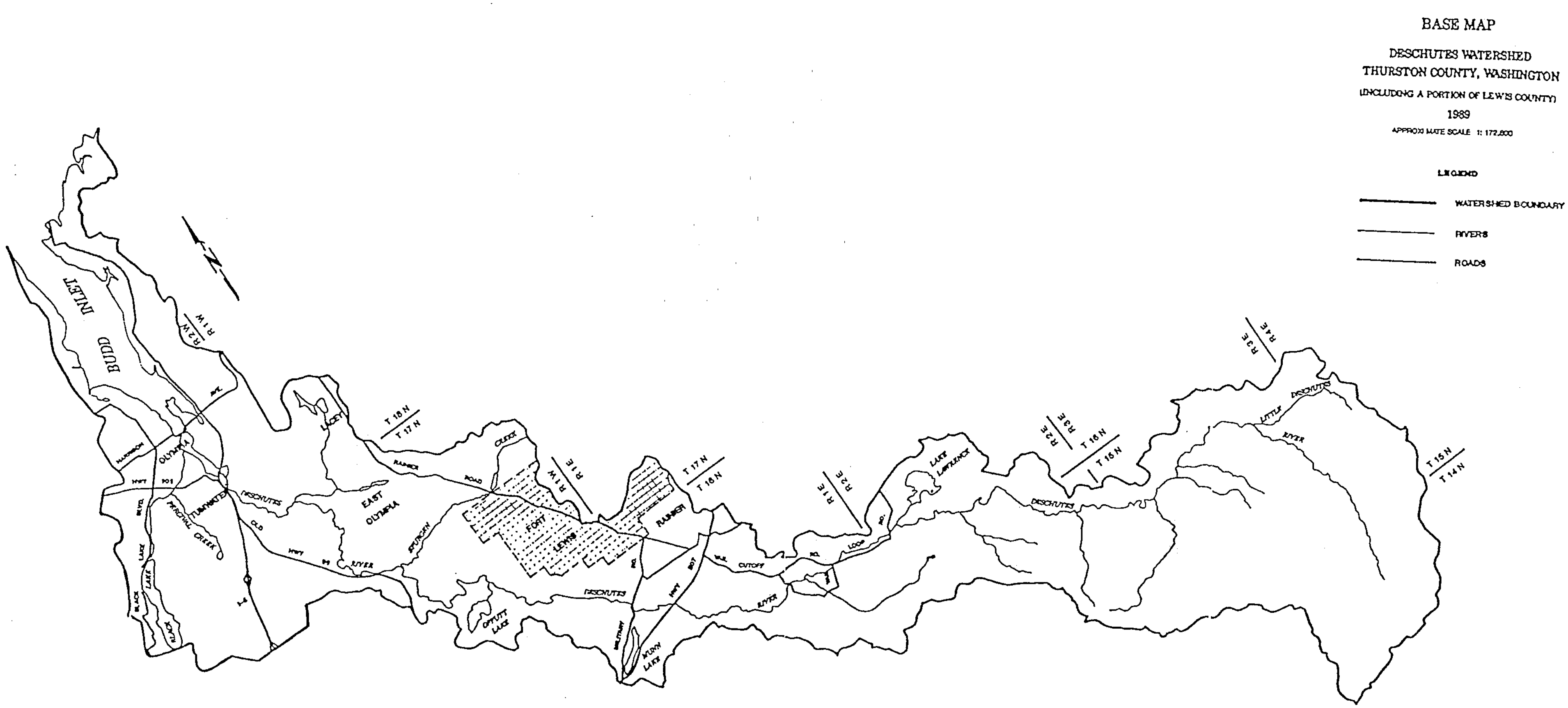
Recently Logged Forest Land Erosion (other than mass wasting):
There are about 13,274 acres of forest land within the Deschutes watershed that were logged within the past ten years. Approximately 1,578 acres are within the WIZ, and the remaining 11,696 acres are classified as NON-WIZ. As for the forest roads, the Olympic National Forest procedure was used to estimate the average annual amount of delivered sediment originating from the recently logged forest land . The subwatersheds are placed in slope-erosion classes A,B, and C depending on the average slope and soil erodibility. The delivered sediment for each category for time periods since logging of 0-5 years and 5-10 years is calculated. These values are combined to obtain a 0 to 10 year average. The resulting average annual erosion rates ranges from 0.008 tons per acre per year for NON-WIZ class A up to 0.1 tons per acre per year for WIZ class C. The total estimated delivered sediment originating from recently logged forest land is 386 CY per year.

Mass Wasting Erosion:
Several forms of mass wasting are evident within the forested portions of the Deschutes watershed. Typical rotation landslides, debris flows, and soil slumps are the most prevalent in a range of sizes. The failures, both recent and historic, are mainly limited to the steeper slopes of the watershed.

The natural factors contributing to slope failures include: increased precipitation; freeze-thaw conditions; relatively thin soil over bedrock; bedrock that is subject to rapid weathering; steep slopes; fire (destroys vegetation); and earthquake activity (Sidle, Pearce and O'Loughlin).

Land management contributing factors: 1. road construction; increase weight to fill slope, steepening both cut and fill slopes, removing support of the cut slope, and rerouting and concentrating road water. 2. timber harvesting; reduces root reinforcement, increases soil moisture by decreasing evapotranspiration (Sidle, Pearce and O'Loughlin).

Five major debris flows have occurred since 1982, as determined by air photo interpretation and field reconnaissance, and displaced more than 18,500 tons of material. At least three of these are directly road related, and possibly accelerated due to removal of vegetation. The areas are identified as slide prone due to the nature of the shallow soils over fractured bedrock. There is evidence of larger naturally occurring slides within the upper watershed. It has been noted that timber harvesting activities increase the occurrence of slope failures as much as twenty-four times that of natural non-logged forests during the first twenty years following harvest. (Sidle, et.al.) All of the measured slides occurred and/or deposited material near a stream capable of efficiently transporting the material. The delivery ratio for the erosion from mass wasting is estimated at 80 percent. The entire watershed is not inventoried for slope failures, so it is estimated that the known quantities represent only 75 percent of the total and an annual delivered sediment rate of 6,535 CY per year.



BASE MAP
DESCHUTES WATERSHED
THURSTON COUNTY, WASHINGTON
(INCLUDING A PORTION OF LEWIS COUNTY)
1989
APPROXIMATE SCALE 1: 172,800
LEGEND
WATERSHED BOUNDARY
RIVERS
ROADS
BUDD INLET
N
R 2 W
R 1 W
T 18 N
T 17 N
OLYMPIA
LACEY
EAST OLYMPIA
TUMWATER
PERCIVAL CREEK
BLACK LAKE
DESCHUTES
FORT LEWIS
R 1 W
R 1 E
RAINIER
T 17 N
T 16 N
R 1 E
R 2 E
LAKE LAWRENCE
R 2 E
R 3 E
T 16 N
T 15 N
R 3 E
R 4 E
LITTLE DESCHUTES RIVER
T 15 N
T 14 N
OFFUTT LAKE
MCINTOSH LAKE

Appendix A

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Appendix B

SOILS

The general soil map for the Deschutes Watershed (map 1) shows broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, a map unit consists of one or more major soils or miscellaneous areas and some minor soils or miscellaneous areas. The soils making up one unit can occur in other units but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Such a map is a useful general guide in managing a watershed. Likewise, areas that are not suitable can be identified. Because of its small scale, the map is not useful for planning management of a farm or small field, or for selecting the exact location of a road or building. The soils in any one map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The general soil map units are grouped into three general kinds of landscape for broad interpretive purposes. Each of the broad groups and the map units in each group are described in the following paragraphs.

SOILS ON FlOOD PLAINS

1. Chehalis-Godfrey

Very deep, well drained to very poorly drained, nearly level soils on flood plains.

This map unit occurs along the Deschutes River and its major tributaries. Slope is 0 to 3 percent. The native vegetation is mainly grasses and sedges and an overstory of conifers and hardwoods. Elevation is 100 to 650 feet. The average annual precipitation is 45 to 55 inches, the average annual air temperature is about 50 degrees F., and the average frost-free period is 150 to 210 days.

This unit makes up about 5 percent of the watershed. The map unit is about 29 percent Chehalis soils, 16 percent Godfrey soils, and 11 percent Newberg soils. The remaining 44 percent is components of minor extent.

The Chehalis soils are on flood plains. These soils are very deep and well drained. They formed in alluvium. The surface layer is silt loam. The subsoil to a depth of 60 inches is silty clay loam and loam.

The Godfrey soils are on flood plains. These soils are very deep and very poorly drained. They formed in alluvium. The surface layer is silty clay loam. The subsoil to a depth of 60 inches is silty clay loam, clay loam, and silty clay.

The Newberg soils are on flood plains. These are very deep and well drained. They formed in alluvium. The surface layer is loam and fine sandy loam. Below this layer to a depth of 60 inches, the underlying material is fine sandy loam.

Of minor extent in this map unit are the very poorly drained Semiahmoo and Shalcar soils, the well drained Puyallup soils, and the moderately well drained Sultan soils.

This map unit is used as hayland, pasture, cropland, woodland, or homesites. It is well suited to hayland, pasture, and cropland. Flooding and soil wetness is a hazard on sites for homes.

SOILS ON GLACIAL UPLANDS

2. Spanaway-Nisqually

Very deep and deep, somewhat excessively drained and moderately well drained, nearly level to sloping soils on glacial terraces.

The Spanaway-Nisqually soils are on the terraces and plains in the middle portion of the watershed. Chambers and Weir Prairies are located within this unit. Slope is 0 to 30 percent. The native vegetation is grass, conifers, and hardwoods. Elevation is 130 TO 640 feet. The average annual precipitation is 45 to 55 inches, the average annual air temperature is about 51 degrees F., and the average frost-free period is 150 to 200 days.

This unit makes up about 16 percent of the watershed. The map unit is about 37 percent Spanaway soils and 25 percent Nisqually soils. The remaining 38 percent is components of minor extent.

The Spanaway soils are on glacial terraces. These soils are very deep and somewhat excessively drained. They formed in glacial outwash. The surface layer is gravelly sandy loam. The subsoil to a depth of 60 inches is extremely gravelly sand.

The Nisqually soils are on glacial terraces. These soils are very deep and somewhat excessively drained. They formed in sandy glacial outwash. The surface layer is loamy sand. The subsoil to a depth of 60 inches is a loamy sand.

Of minor extent in this map unit are the moderately well drained Cagey soil, the poorly drained Everson soils, and the well drained Yelm soil.

This map unit is used as hayland, pasture, cropland, and homesites or as a source of gravel. Some small areas are used as woodland. In the areas of hayland, pasture, or cropland the main limitation is a low available water capacity during the growing season. The main problem on sites for septic tank absorption fields is ground water contamination caused by poor filtering capacity.

3. Alderwood-Everett

Moderately deep and very deep, moderately well drained and somewhat excessively drained, nearly level to steep soils on glacial till plains.

The Alderwood-Everett soils appear on the broad uplands and terraces of the middle to lower reaches of the watershed. The City of Olympia and much of the urban population is located within this unit. Slope is 0 to 50 percent. The native vegetation is mainly conifers and hardwoods. Elevation is 210 to 600 feet. The average annual precipitation is 45 to 55 inches, The average annual air temperature is about 50 degrees F., and the average frost-free period is 150 to 200 days.

This unit makes up about 33 percent of the watershed. The map unit is about 22 percent Alderwood soils, 19 percent Everett soils, and 12 percent Indianola soil. The remaining 47 percent is components of minor extent.

The Alderwood soils are on broad glacial till plains. These soils are moderately deep and moderately well drained. They formed in ablation till over basal till. The surface layer is gravelly sandy loam. The subsoil is very gravelly sandy loam over compact glacial till.

The Everett soils are on terrace moraines and terrace escarpments. These soils are very deep and somewhat excessively drained. They formed in glacial outwash. The surface layer is very gravelly sandy loam. The subsoil to a depth of 60 inches is extremely gravelly loamy sand and extremely gravelly sandy loam.

The Indianola soils are on terraces. These soils are very deep and somewhat excessively drained. They formed in glacial outwash. The surface layer is loamy sand. The subsoil to a depth of 60 inches, is sand. Of minor extent in this map unit are the very poorly drained Mukilteo soil, and the well drained Giles soils.

This map unit is used as hayland, pasture, woodland, or homesites. In the areas of hayland and pasture, the main limitation is low precipitation during the growing season. The main limitation on sites for homes is the seasonal wetness of the Alderwood soils.

4. Kapowsin-McKenna

Moderately deep, moderately well drained and poorly drained, nearly level to steep soils on till plains.

This map unit occurs on till plains in several small areas within the watershed. Slope is 0 to 30 percent. The native vegetation is conifers and hardwoods. Elevation is 100 to 640 feet. The average annual precipitation is 45 to 55 inches, the average annual air temperature is about 50 degrees F., and the average frost-free period is 150 to 200 days.

This unit makes up about 2 percent of the watershed. The map unit is about 67 percent Kapowsin soils and 5 percent McKenna soils. The remaining 28 percent is components of minor extent.

The Kapowsin soils are on till plains. These soils are moderately deep and moderately well drained. They formed in compact glacial till. The surface layer is silt loam. The subsoil is silt loam, loam, and gravelly loam over compact glacial till.

The McKenna soils are in depressions and drainageways. These soils are moderately deep and poorly drained. They formed in glacial drift. The surface layer is gravelly silt loam. The subsoil is gravelly silt loam, very gravelly silt loam, and very gravelly loam over compact glacial till.

Of minor extent in this map unit are the very poorly drained Tisch soils and the poorly drained McKenna soils in depressions and drainageways, and the moderately well drained Kapowsin soils with a stony surface layer.

This map unit is used as hayland, pasture, woodland, or homesites. Seasonal soil wetness is a limitation for all uses.

5. Cathcart-Tenino

Deep and moderately deep, well drained, nearly level to steep soils on glacial uplands and terminal moraines.

This map unit occurs within a small area in the middle of the watershed. McIntosh Lake is located in this unit. Slope is 3 to 65 percent. The vegetation is mainly conifers and hardwoods. Elevation is 340 to 980 feet. The average annual precipitation is 45 to 60 inches, the average annual air temperature is about 49 degrees F., and the average frost-free period is 150 to 200 days.

This map unit makes up about 3 percent of the watershed. The map unit is about 39 percent Cathcart soils and 25 percent Tenino soils. The remaining 36 percent is soils of minor extent.

Cathcart soils are on uplands. These deep soils formed in glacial drift and volcanic ash over sandstone and siltstone. The surface layer is gravelly loam. The subsoil is silt loam and clay loam over weathered sandstone or siltstone.

Tenino soils are on terminal moraines. These moderately deep soils formed in glacial till over glacial outwash. The surface layer is gravelly loam. The subsoil is gravelly loam and gravelly sandy loam. The upper part of the substratum is weakly cemented very gravelly loam. The lower part is extremely gravelly sandy loam.

Of minor extent in this map unit are the moderately well drained Alderwood soils, the somewhat excessively drained Everett and Indianola soils, and the poorly drained McKenna and Norma soils.

This map unit is used mostly as woodland, a few small areas are used as hayland, pasture, or homesites. In areas of hayland or pasture, the main limitation is a low available water capacity during the growing season. Slope is a limitation on sites for homes.

SOILS DOMINANTLY ON PLAINS, UPLANDS AND MOUNTAINS

6. Baldhill

Deep, well drained nearly level to steep soils on terminal moraines.

This map unit occurs in several units in the upper reaches of trhe watershed. Slope is 0 to 90 percent. The native vegetation is conifers. Elevation is 700 to 1800 feet. The average annual precipitation is 45 to 60 inches, the average annual air temperature is about 50 degrees F., and the average frost-free period is 160 to 210 days.

This unit makes up about 4 percent of the watershed. The map unit is about 51 percent Baldhill soils. The remaining 49 percent is components of minor extent.

The Baldhill soils are on terminal moraines. These soils are deep and well drained. They formed in stony ablation till. The surface layer is very stony sandy loam. The subsoil is very stony sandy loam, very gravelly sandy loam, extremely gravelly sandy loam, and very gravelly loamy sand.

Of minor extent in this map unit are the moderately well drained Alderwood and Kapowsin soils, the somewhat excessively drained Everett soils, the poorly drained Norma soils, and the very poorly drained Mukilteo soils.

This map unit is used for woodland and homesites.

7. Baumgard-Mashel

Very deep and deep, well drained and moderately well drained, sloping to steep soils on glaciated plains, uplands, and mountains.

This map unit occurs in the upper reaches of the watershed. A large area is located downslope from Porcupine Ridge. Slope is 5 to 65 percent. The native vegetation is conifers. Elevation is 700 to 2250 feet. The average annual precipitation is 50 to 75 inches, the average annual air temperature is about 48 degrees F., and the average frost-free period is 125 to 175 days.

This unit makes up about 18 percent of the watershed. The map unit is about 25 percent Baumgard soils and 18 percent Mashel soils. The remaining 57 percent is components of minor extent.

The Baumgard soils are on uplands. These soils are deep and well drained. They formed in residium and colluvium derived dominantly from andesite. The surface layer is loam. The subsoil is clay loam and very gravelly clay loam over fractured andesite.

The Mashel soils are on glaciated plains and the adjacent uplands. These soils are deep and moderately well drained. The formed in highly weathered glacial till. The surface layer is loam. The subsoil is loam, silty clay, and clay loam.

Of minor extent in this map unit are the well drained Pheeney and Wilkeson soils, the moderately well drained Rainier soils, and the somewhat poorly drained Scamman soils.

This map unit is used as woodland, recreational development and wildlife habitat.

8. Pheeney-Schneider-Jones

Moderately deep and deep, well drained, moderately sloping to very steep soils on benches, mountainsides, and ridgetops.

This map unit occurs in the upper forested portion of the watershed. Slope is 8 to 90 percent. The native vegetation is mainly conifers. Elevation is 1500 to 3400 feet. The average annual precipitation is 65 to 90 inches, the average annual air temperature is about 43 degrees F., and the average frost-free period is 120 to 170 days.

This unit makes up about 19 percent of the watershed. The map unit is about 48 percent Pheeney soils, 12 percent Schneider soils and 10 percent Jonas soils. The remaining 30 percent is components of minor extent.

The Pheeney soils are on mountainsides. These soils are moderately deep and well drained. They formed in residuum and colluvium derived from andesite mixed with volcanic ash. The surface layer is gravelly loam or gravelly silt loam. The subsoil is very gravelly silt loam over slightly weathered, fractured andesite. These coarser soils are highly permeable and less prone to landslides, but can contribute to debris torrents in steep valleys. The coarse angular nature of the debris torrent material does not create a problem of sedimentation directly into Capital Lake. It does, however, increase a stream channel's supply of bedload material which ultimately contributes to its instability.

The Schneider soils are on mountainsides. These soils are deep and well drained. They formed in colluvium derived from basalt. The surface layer is very gravelly loam. The subsoil is very gravelly silt loam and extremely gravelly gravelly silt loam over fractured basalt.

The Jonas soils are on mountainsides. These soils are deep and well drained. They formed in colluvium and residuum derived dominantly from andesite mixed with volcanic ash in the upper part. The surface layer is silt loam. The subsoil is very cobbly silt loam, cobbly loam, and cobbly clay loam.

Of minor extent in this map unit are the moderately well drained Mal soils and the well drained Stahl soils.

This map unit is used as forest and wildlife habitat.

Appendix C

WATER TYPING SYSTEM

The following water typing system was developed and agreed to by the Washington State Departments of Fisheries, Wildlife and Ecology and in consultation with affected Indian Tribes to classify streams, lakes, and ponds. These definitions are found in WAC 222-16-20.

Type 1 Water- All waters, within their ordinary high water mark, as inventoried as "shoreline of the state" under chapter 90.58 RCW.

Type 2 Water- Segments of natural waters which are not classified as Type 1 water and have a high use and are important from a water quality standpoint for:

a. Domestic water supply
b. Public recreation
c. Fish spawning, rearing or migration or wildlife uses; or
d. are highly significant to protect water quality

Type 3 Water- Segments of natural waters which waters are not classified as Type 1 or 2 and have a moderate to slight use and are moderately important from a water quality standpoint for:

a. Domestic use
b. Public recreation
c. Fish spawning, rearing or migration or wildlife uses; or
d. Have moderate value to protect water quality

Type 4 Water- Segments of natural waters which are not classified as Type 1, 2 or 3. Their significance lies in their influence on water quality downstream in Type 1, 2 or 3 waters. These may be perennial or intermittent.

Type 5 Water- 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. Drainage ways having short periods of spring runoff are considered to be Type 5 waters.

Appendix D

WATER QUALITY STANDARDS FOR STATE OF WASHINGTON

Parameter	Water Classification				
	AA	A	B	C	Lake
Bacteria (org/100ml)					
Freshwater (Max)	50	100	200	N/A	50
Marine (Max)	14	14	100	200	N/A
Dissolved Oxygen (mg/ml)					
Freshwater (Min)	9.5	8.0	6.5	N/A	**
Marine (Min)	7.0	6.0	5.0	4.0	N/A
Temperature (degrees C)					
Freshwater (Max)	16	18	21	N/A	**
Marine (Max)	13	16	19	22	N/A
pH (Within Range)					
Freshwater	6.5-8.5	6.5-8.5	6.5-8.5	N/A	**
Marine	7.0-8.5	7.0-8.5	7.0-8.5	6.5-9.0	N/A
Turbidity (NTU-Max.)	5	5	10	10	5
Toxicity*	*	*	*	*	*

* See Chapter 173-201 WAC for specific numeric and narrative criteria.
**No change from background.

Appendix E

CHARACTERISTIC USES BY WATERBODY CLASSIFICVATION

Characteristic Use	Waterbody Classification				
	AA	A	B	C	Lake
Water Supply					
Domestic	X	X			X
Industrial	X	X	X	X	X
Agricultural	X	X	X		X
Stock Watering	X	X	X		X
Fish and Shellfish					
Salmonids					
Spawning	X	X			X
Rearing	X	X	X		X
Migration	X	X	X	X	X
Harvesting	X	X	X		X
Other Fish					
Spawning	X	X	X		X
Rearing	X	X	X		X
Migration	X	X	X	X	X
Harvesting	X	X	X		X
Clams, oysters, mussels					
Spawning	X	X	X		X
Rearing	X	X	X		X
Harvesting	X	X			X
Crabs, shrimp, etc.					
Spawning	X	X	X		X
Rearing	X	X	X		X
Harvesting	X	X	X		X
Wildlife Habitat	X	X	X	X	X
Recreation					
Primary Contact	X	X			X
Secondary Contact	X	X	X	X	X
Navigation	X	X	X	X	X

Appendix F

TOTAL SUSPENDED SOLIDS SAMPLING

Reason for measurement:

Total suspended solids (TSS) is a direct measurement of the concentration of suspended particulates in water and is a good indicator of mass movement of materials in the water column. TSS measures both inorganic and organic materials. Results are used to calculate suspended solids loadings which can be used to compare different stream sections.

Considerations:

TSS responds to physical factors, such as the amount of runoff, the proximity to exposed erodible soils, and the energy in the stream (stream flow). These values change hourly, daily, or seasonally, and between sites; consequently, timing and location of sampling will affect results.

Sampling and analysis:

Use pre-cleaned polyethylene bottless with no preservative. Rinse the bottle with sample before filling. Cool to 4 degrees C immediately and analysze as soon as possible according to Standard Methods (APHA, 1985). Maximum holding time is seven days.

Appendix G

RHAEUSER VAIL TREE FARM
VEGETATION MANAGEMENT -PLAN OVERVIEW

SPRAY TYPE	TARGET SPP.	HERBICIDE	FORMULATION	MONTH	ESTIMATED WITHIN: PROJECT ACRES	NISQUALLY R. DRAINAGE (454,000 AC)	DESCHUTES R. DRAINAGE (106,000 AC)
AERIAL APPLICATIONS							
A. DORMANT	V.Maple P.Madrone Ceonothus	GARLON4	THIN INVERT (0.25gal GARLON4+ 0.07gal BIVERT +4.0 gal diesel+ 7.5 gal water carrier) TOTAL SOLUTION 12.0 GAL/ AC	MAR	350	105	70
B. FOLIAR	R.Alder B.Cottonwood Hazel	LV4 (or GARLON4/ LV4 MIX)	5% in water (0.5 gal LV4+ 9.5 gal water) TOTAL SOLUTION 10.0 GAL/ AC	APR/MAY	3000	900	900
	Tansy ragwort	WEEDMASTER/BANVEL	1.5% in water				
C.PRE-BURN BROWNUP	V.Maple Elderberry Grasses	GARLON4 (GARLON4+ROUNDUP)	THIN INVERT (0.375gal GARLON4+ 0.11gal BIVERT +6.0 gal diesel+ 11.5 gal water carrier) TOTAL SOLUTION 18.0 GAL/ AC	MAY	200	40	40
D. SUMMER FOLIAR	Salmonberry Elderberry Grasses	AMITROL T	5% IN H20 1 gal amitrol T +19 gal water TOTAL SOLUTION 20 GAL/ AC	JUNE	400	100	60
E. GRASS SPRAYING	Grasses Scotchbroom	AATREX 9-0 ROUNDUP	(40 AATREX 9-0 + 10 gal water) TOTAL SOLUTION 10 GAL/ AC	JUNE	0		
F. FALL FOLIAR	Salmonberry Elderberry	ROUNDUP	2% IN H20 0.325 in 12 gal water TOTAL SOLUTION 12.5 GAL/ AC	AUG/SEP	50	7.5	10
G. SITE PREP SPRAY	Vine maple	GARLON4	THIN INVERT (0.375gal garlon4+ 0.11gal Bivert +6.0 gal diesel+ 11.5 gal water carrier) TOTAL SOLUTION 18.0 GAL/ AC	SEP/OCT	150	45	30
GROUND APPLICATIONS							
.. THINLINE	Bigleaf maple	GARLON4	1-2 oz / clump 0.25- 0.75 GAL /AC applied directly to stem	DEC-MAR	3000	1200	600

Appendix I

Figure 5. Geologic map of the upper Deschutes basin.