CULVERT TYPE	QUANTITY*	AVERAGE DIAMETER*	DIAMETER RANGE*
Stream Crossing - Type 1	06	Bridges and 10-12' culv.	
Stream Crossing - Type 3	13	34"	12" to 96"
Stream Crossing - Type 4	70	24"	12" to 36"
Stream Crossing - Type 5	27	20"	12" to 36"
Stream Crossing - Untyped	21	21"	12" to 30"
Stream Crossing - Ephemeral	244	19"	8" to 48"
Drainage	213	18"	8" to 28"
Ditch Relief	186	13"	12" to 24"
TOTAL	780	13"	8" to 96"

*Table information does not include irregularly shaped culverts (ie. 2-pipe arches, 7-box culverts).

Five road segments were identified as areas where a culvert was needed but not found. This results in the need for 4 stream crossing culverts on ephemeral draws and 1 drainage culvert. Twenty-two drainage culverts were allowing water into the stream system. Flows from drainage culverts were found to reach a stream in several ways. Outlet discharge can create a rill or gully which migrates downslope eventually connecting with the drainage system or another road reach. Culvert inlets become blocked allowing ditch tlow to proceed toward a neighboring culvert.

An assessment of the culverts inventoried is provided by the type of culvert (stream crossing, relief, ...).

Stream Crossing Culverts

Reduced flow area of stream crossing culvert inlets result in numerous problems related to sediment production. Stream crossing culverts are designed to handle the discharge of a pre-determined frequency. For forested roads, the forest practices rules and regulations require that culverts be adequate to carry the discharge generated by the 50 year storm event. Reduced flow area greatly reduces a culverts capacity to carry the design discharge. Culvert blockage results in piping around the culvert, overtopping of the road, or the release of a flood wave should the blockage be freed during storm flows. Undermining of a culvert can result as pressure increases with increased depth of water at the inlet but is dependent on construction materials and specifications employed during installation. This results in water piping around the culvert and continued erosion of the culvert fill material. With time these culverts may fail (wash out). Overtopping of the road results in erosion of fill material as the water exits the road surface. The water will erode into the road surface and may result in the failure of the culvert installation.

Blockage at the inlet can alter the hydraulic characteristics of the culvert, primarily velocity. Increased velocity in the culvert can result in increased erosion at the culvert outlet. Should the blockage become freed during storm flow, stored water is released as a wall of water. This "flood wave" with the debris that caused the blockage can scour the receiving channel. Culvert blockage tends to compound itself if debris or brush growth act as strainers to collect additional material carried by the stream.

In this study, culverts with less than 75 % of their original flow area were considered a problem. This value was chosen because the effect approximates having a culvert one standard size smaller. Tables 7.9 and 7.10 identify the number of culvert inlets and outlets with a reduced flow area by cause of the reduction and by type of stream impacted.

Table 7.9 Stream crossing culvert inlet blockage

Cause of	Stream Type					
Reduction	Type 3	Type 4	Type 5	Untyped	Ephemeral	TOTAL
Brush	0	1	1	0	01	03
Debris	2	2	0	2	05	11
Physical damage	0	4	0	1	16	21
Sediment	0	1	1	0	04	06
TOTAL	2	8	2	3	26	41

These stream crossing culverts are identified and additional data is provided in appendix 19.

Table 7.10 Stream crossing culvert outlet blockage

Cause of			Stream	Type			
Reduction	Type 1	Type 3	Type 4	Type 5	Untyped	Ephemeral	TOTAL
Brush	0	1	0	2	0	02	05
Debris	1	0	2	2	1	21	27
Physical damage	0	0	1	0	0	09	10
Sediment	0	0	1	1	0	02	04

TOTAL	1	1	4	5	1	34	46

These stream crossing culverts are identified and additional data provided in appendix 20.

Forty-one (11%) stream crossing culverts were identified as having an inlet with less than 75% of its original flow area. Forty-six (12%) stream crossing culverts were identified as having an outlet with less than 75% of its original flow area. Sixteen (18%) of these culverts have reduced flow areas at both the inlet and the outlet. For culvert inlets with flow areas of less than 75%, flow area ranged from 0-70 with and average of 38%. For culvert outlets with flow areas less than 75%, flow area ranged from 0-70 with an average of 35%. Reduction in flow area was generally severe. Culvert problems occur predominantly on the small headwater stream types. Physical damage and blocking due to debris are the predominant problems identified. Physical damage refers to the crushing of the culvert resulting in a reduced flow area. This damage occurs during road maintenance activities or minor vehicle accidents. Debris blockage occurs during high runoff events when loose organic material (usually woody debris) can be carried to the culvert by stream flows.

The fill material used in culvert installations was inventoried for vegetative cover and erosion evidence. Erosion of the fill material can deliver soil directly to the stream channel. Seventeen percent of the culvert installations had erosion of the fill material at the inlet and seventeen percent had erosion of the fill material at the outlet. The erosion indicators were sloughing, gullies, or undercutting of the fill. Sloughing was the most predominant indicator and is prevalent on fills with less than 80% vegetative cover. Gullies were evident on 1.5% of the inlet and 6% of the outlet fill material. Gullies are a result of runoff from the road surface exiting the road at its low point. Much of the gullied fill material is 100% covered with vegetation. The gullies most likely formed prior to the establishment of vegetative cover. As with road cutbanks, good vegetative cover may take up to 5 years to establish naturally. Gully formation is also an indicator of the relative instability of the fill material.

Erosion data was collected for the area that received culvert discharge. This evidence included downcutting of the channel, sloughing of the channel banks, and undercutting of the culvert. Twenty- one percent of the stream crossing culverts exhibited evidence of increased erosion. Seventy-six percent of the problems were found on ephemeral draws. These draws may easily experience an one hundred percent increase in peakflows as a result of routing road runoff into them. Most ephemeral draws do not have a well defined channel. The bottom of the draw is typical of the surrounding soil (silt loams), and soil is easily eroded.

The outlet height of culverts is related to the occurrence of erosion in the receiving channel. As outlet height increased, the percent occurrence of erosion increased as well. All of the receiving channels with an culvert outlet higher than 4 feet showed increased erosion.

Three culverts on type 3 streams were identified as a problem for fish passage. One of these culverts had an outlet height of three feet and two had a height of four feet. No special design such as the placement of rip rap, splash basins or woody debris to reduce flow energy at the outlets was observed.

Drainage Culverts

Two hundred and thirteen drainage culverts were inventoried in the watershed. Drainage culverts are any culvert that provides flow relief to a ditch. These culverts are intended to outlet onto the forest floor and should not contribute flow directly to the stream system. However, flow from drainage culverts can reach a stream in several ways. Outlet discharge can create a rill or gully which migrates downslope eventually connecting with the drainage system or another road reach which directly impacts a stream. Culvert inlets can also become blocked allowing ditch flow to proceed toward a neighboring culvert which directly impacts a stream.

Twenty-two drainage culverts were found to be directly impacting the stream system. Occurrence of this condition is greatest for culverts draining into a field (38%) and harvested areas (16%). In both cases, the average length of the road segments contributing to these drainage culverts was greater than the average length for drainage culverts not contributing to the stream system. Increased runoff from the longer road segment and vegetative condition of the area receiving the discharge appears to determine the likelihood of a problem occurring. Culverts discharging into fields also drain paved road segments which increase runoff due to their impervious surface. Three drainage culverts were found to be contributing to the stream system because their road segments were receiving flow from another road segment. Two of these roads received increased runoff because logging slash had partially blocked a neighboring culvert. One drainage culvert was receiving runoff from two road segments **at** an intersection.

Tables 7.11 and 7.12 identify the number of culvert inlets and outlets with a reduced flow area by cause of the reduction.

Table 7.11 Drainage culvert inlet blockage

Cause of Reduction	Number of Culverts	Minimum Flow Area (percent)	Maximum Flow Area (percent)	Average Flow Area (percent)
Debris	03	0	50	20
Physical Damage	14	5	70	34
Sediment	09	5	70	37
TOTAL	26	0	70	34

These culverts are identified and additional data provided in appendix 21.

Table 7.12 Drainage culvert outlet blockage

Cause of Reduction	Number of Culverts	Minimum Flow Area (percent)	Maximum Flow Area (percent)	Average Flow Area (percent)
Debris	10	0	60	11
Physical Damage	08	0	70	35
Sediment	11	0	70	35
TOTAL	29	0	70	27

These culverts are identified and additional data provided in appendix 22.

Tables 7.11 and 7.12 indicate that all of the causes for flow reduction are important for drainage culverts. As with stream crossing culverts when the flow area of a culvert is found to be reduced it is generally by a significant amount. Thirteen of the culverts identified in the tables have a reduced flow area at both ends of the culvert.

The origin of sediment resulting in a flow reduction was found to be from many sources. Thirty-five percent of the problems were attributed to cutslope erosion and sediment generated from the road surface. Thirty-five percent was found to be a result of erosion of the culvert fill material and sediment generated from the road surface. This condition generally occurred at both ends of the culvert and was found in areas where run-off from the running surface exited the road at the culvert installation. Thirty percent of the culverts were installed incorrectly and were partially blocked by accumulation of sediment. These culverts were either placed on to flat a slope or were installed lower than the ditch.

Ditch Extension Culverts

One hundred seventy-eight ditch extension culverts were inventoried in the watershed. These culverts connect ditch flows at intersections, predominantly where driveways meet a road. Culvert sizes ranged from 12-24 inches in diameter. These culverts were found to be highly susceptible to physical damage, either by ditch maintenance activities or vehicles. The highest percent of reduced flow areas was found on the smaller culverts (12 inch diameter). Blockage included sediment, debris, and physical damage. The small culvert size tends to trap debris moving within the ditch. Sediment blockage was predominant on paved roads where ditch downcutting was occurring and on roads with poor to fair vegetative cover on the cutslopes. As with drainage culverts, installation practices are important to maintain adequate flow area. Culverts are identified and additional data provided in appendices 23 and 24.

Summary

Roads and culvert installations were inventoried to identify problem areas in the Silver Lake watershed. The problems identified were primarily those associated with the delivery of soil and therefore nutrients (Phosphorus) to the lake. The information was collected and mapped by road segments which deliver runoff to a common point, generally a culvert. The information is stored on maps and in a database for use in assisting landowners and Cowlitz County in locating problem sites. Information will be made available to citizens by Cowlitz County.

Inventory information indicates that 50% of the road system in the watershed contributes runoff and sediment directly to the stream system. The majority of this contribution occurs in the headwater streams of the watershed. The information collected confirms research findings about erosion and road contribution of sediment. Where bare soil exists it tends to erode. Length of the road segment, slope, and roughness or cover are the predominant factors governing the rate of surface erosion.

Problems that were found in the watershed include: 1) The amount of road contributing to the drainage system. All of the road segments generate sediment in some quantity. Individually, these impacts may seem minor. However, added together they can become significant. The additive effects of problems is termed cumulative effects. 2) Road surface erosion. The amount and type of surfacing material coupled with season of use on the road is the predominant concern. 3) Downcutting in ditches as a result of excess runoff being collected in the ditch or maintenance activities removing grasses and debris. Downcutting was observed as a result of excessive length or slope of the road and increased delivery of runoff to a ditch. During storm events, excessive length and slope can result in more runoff than a ditch can adequately handle. Additional runoff results from increased impervious surfaces such as new roof runoff or new driveways contributing to a ditch, from the failure of another culvert, or a change in vegetative cover above the road which can increase the amount of runoff intercepted by the road. 4) Cutslope erosion on areas with poor to fair vegetative cover. This includes approximately 35% of the roads in the watershed. 5) The contribution of ditch relief culverts to the drainage system. 6) Potential problems associated with the blocking of culvert inlets and outlets. 7) The delivery of additional runoff to the smaller streams following road construction. 8) Road maintenance does not necessarily equate to erosion control. Traditional road maintenance including grading and ditch scraping may expose soil increasing the potential for erosion.

Recommendations

1) Reducing the amount of contributing reaches through an active road closure plan. Closure should include permanent and temporary closures. Permanently closed roads should be ripped and returned to a productive condition (planted with trees or grasses). Temporarily closed roads should be properly drained to prevent erosion by installing waterbars and pulling culverts. Consideration should be given to the use of waterbars on spur roads. For an example a rocked over waterbar to direct runoff off the travelled surface and away from roadside ditches.

2) Minimize the use of the unimproved road system during wet weather months. Activities that can be scheduled during dry weather (ie. construction activities and road building) should be. Gain control over the access of the remaining roads in the watershed. Implement a plan to reduce road usage during hunting season (green-dot method).

3) Utilize the inventory information to identify at minimum the contributing road segments that

can be improved. This includes:

- Installing additional ditch relief culverts and energy dissipators of ditch relief flows.
- Minimizing the amount of contributing reaches through the installation ditch diversions and energy dissipators when possible. Ditch diversions should allow at minimum one hundred feet of stable forest floor between the outlet and the receiving channel to allow infiltration of the ditch flows.
- Maintaining adequate surfacing material on open roads.
- Establishment of vegetation on existing cutslopes in poor and fair vegetative condition particularly on segments contributing to the drainage system. Establishment of vegetation on cutslopes of newly built roads particularly on segments contributing to the drainage system. On forest access roads this may require monitoring to determine the effectiveness of establishing vegetative cover prior to yarding activities. Slopes over 75% should be considered for mulch treatment too.
- Cleaning and reshaping of culverts exhibiting blockage to reduce the potential for additional problems. Provide for routine inspection of culvert installations.
- Install energy dissipators at the outlets of ditch relief culverts contributing to the drainage system. Incorporate the monitoring of these culverts into a maintenance plan for areas that are to undergo a change in landuse or cover type. Provide for routine inspection of culvert installations.
- Explore new/innovative approaches to facilitate road surface drainage. For example, establish road drainage system in the subgrade during construction prior to surfacing.

4) Incorporate the above mitigation measures into management plan for new road construction and continued monitoring for maintenance of the road system.

5) Adhere to the Forest Practices rules and regulation for the placement of cross drains to avoid the build-up of erosive forces in ditches for new road construction. Incorporate forest practices recommended cross drain spacings for correcting problems with road reach lengths identified during the inventory.

6) Facilitate county road construction with adequate road conservation measures to allow for future growth. Initially the roads will be over built with regard to cross drains or ditch capacity but they'll be in place when growth occurs.

7) Explore the feasibility of routing residential runoff through sewage treatment facilities.

8) Develop county rules and regulations for the abatement of erosion and transport of sediment to surface waters.

Implementation to Date

1) The database information has been shared with Weyerhaeuser to begin implementation activities.

2) Weyerhaeuser has currently utilized the database information to;

- correct immediate priority culvert blockage problems.
- identify road reaches in need of additional cross drains resulting in the installation of 10 new cross drain culverts.
- identify road reaches with cutslope vegetation conditions of poor and fair ratings resulting in the seeding of 14 miles of road cutbanks.
- develop an internal maintenance plan for their road systems.

CHAPTER 8

STREAM INVENTORY

Stream channels are formed and change by the action of water and sediment. By examining physical characteristics of a channel, existing conditions can be noted and the potential for problems to occur as a result of increased peak flows or sediment delivery can be predicted. An inventory of the stream channels within the Silver Lake Watershed was conducted during the summer of 1992. Stream channel assessments were performed on Type 1 - 3 streams. Representative sample reaches were assessed to represent Type 4, 5, and untyped streams. Stream types were identified through the use of Department of Natural Resource (DNR.) stream type maps. Untyped streams are those streams that appear on a 7.5 minute USGS topographic map but are not typed on DNR maps. Appendix 25 provides the State of Washington Forest Practices Board (1993) definitions for stream types. Stream types are used to interpret the degree of riparian management required by various laws along streams. Management practices include the retention of buffer strips along type 1-3 streams, equipment use limitations, and road drainage requirements.

Stream assessments were conducted using the Field Assessment of Stream Channel Conditions developed by Jones & Stokes (1992). This procedure is a modification of the Stream Reach Inventory and Channel Stability Evaluation developed by Pfankuch (1978) for the United States Forest Service. The approach provides a means of estimating the current condition of a stream reach as related to peak flows and estimates its response (expected condition) if peak flows increase. A copy of the field form can be found in Appendix 26.

Stream Characterization

Table 8.1 depicts the stream types and lengths within the Silver Lake watershed. All measurements are in miles. Refer to the map in appendix 15 for subwatershed locations.

Table 8.1 Miles of Steam by steam type

Subwatershed	TYPE!	TYPE 2	TYPE 3	TYPE 4	TYPES	UNTYPED	TOTAL
Bl	0.00	0.00	0.00	1.33	1.14	0.00	2.47
B2	0.00	0.00	0.23	0.38	1.33	0.00	1.94
B3	2.23	0.00	1.02	1.29	1.78	0.34	6.66
B4	0.00	0.00	1.06	4.55	2.65	0.76	9.02
B5	0.00	0.00	0.38	2.39	1.29	0.00	4.06
HE1	1.25	0.00	0.15	1.82	1.52	1.06	5.80
HE2	0.00	0.00	3.22	9.85	1.48	0.83	15.38
HE3	0.00	0.00	2.31	4.05	3.37	1.17	10.90
N	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEI	0.00	0.00	0.00	0.68	0.00	0.83	1.51
SE2	0.00	0.00	0.00	0.83	0.00	0.00	0.83
SUI	0.00	0.00	0.76	2.77	0.11	0.95	4.59
SU2	0.00	0.64	2.84	6.63	2.35	0.45	12.91
SW	0.00	0.00	0.83	2.27	0.00	0.00	3.10
W54	0.00	0.00	0.30	0.08	0.49	0.00	0.87
TOTAL	3.48	0.64	13.10	38.92	17.51	6.39	80.04

Of the 80.04 miles of stream present in the Silver Lake Watershed 5.1 % (4.12 miles) is type 1 or 2 while 94.9% consists of smaller type 3, 4, 5, or untyped streams. The high percentage indicates the importance of smaller streams with regard to management activity impacts on water quality. These figures do not include the ephemeral draws within the watershed. These ephemeral draws are considered type 5 streams and can equal or greatly exceed the length of the streams that have been typed by DNR.

Stream reaches are the basic unit studied in a channel assessments. Reaches are segments of a stream that have similar characteristics including streambed materials and channel slope. Attempts were made to hold stream reaches with similar characteristics to a maximum length of 1000 feet for type 1-3 water. Representative reaches of type 4, 5, and untyped streams were sampled to obtain information for estimating stream condition. Fifty foot reaches of type 4, 5, and untyped streams were inventoried by taking one sample above and one below road crossings. These reaches were located at least 100 feet beyond the culvert to avoid immediate culvert influence (ie. scour in outlet pool/channel).

Table 8.2 summarizes the length of stream assessed by type and the length of stream represented by the sample inventory process. All measurements are in miles.

Table 8.2 Length of stream inventoried and length of stream represented

(miles)

Stream Type	Inventory Length	Represented Length	Total Length	Percent Represented
1	2.89	2.89	03.84	75.3
2	0.56	0.74	00.74	100.0
3	8.49	9.51	13.10	72.6
4	1.73	25.48	38.92	65.5
5	0.42	6.24	17.51	35.6
Untyped	0.08	1.04	6.39	16.3
TOTAL	14.17	45.90	80.50	57.0

The length of type 1 and 2 water not represented is due to the presence of wetland areas. The length of type 3 water not inventoried is due to wetland areas, beaver ponds, and the lack of access permission from landowners.

Nature Of Stream Problems

Streams serve as a conduit to carry water and sediment from a watershed. These conduits are constantly change as a result of inputs of water and sediment from the watershed. The amount and timing of water delivered to a forested stream is determined primarily by climate, geology, topography, soils, and vegetative cover (Brown, 1985). Water also represents the most important erosion agent for the delivery of sediment to a stream channel (Knighton, 1987). Therefore, these factors are the predominant factors controlling the formation and alteration of stream channels.

Stream channels continually change their form because of water and sediment. Channel forming processes are referred to as channel morphology. Channel form usually refers to the physical characteristics notably width, depth, and roughness of a channel. Stream channel form reflects long term adjustment to the hydrologic processes of water runoff and sediment movement or erosion and deposition at work in a watershed. Although simplified here, channel morphology is very complex and is often the result of interaction between both increased flows and sediment delivery and other factors including riparian vegetation, landuse and landform. Schumm (1977) identified several expected changes in stream channels experiencing changes in flow or sediment delivery. Stream discharge is the product of the width and depth of the channel and water velocity. An increase in streamflow (discharge) requires an increase in width, depth, velocity, or a combination of these factors. Usually the increase tends to be in channel width or depth. An increase in sediment delivery tends to increase width and decrease depth. In actively managed watersheds streams channels can become a significant source of sediment. Changing channel conditions can also result in the release of sediment that has been temporarily stored in the channel. The result is increased sediment discharge from the stream system.

Vegetative cover and the soil is impacted the greatest by landuse or management activities. In a forested environment these impacts include road building, harvesting, yarding, and site preparation activities. All of these activities can result in changes in sediment delivery or flow.

Road impacts on sediment delivery are presented in chapter 7. Harvest impacts depend on the intensity of disturbance, areal extent of the disturbance, and the proximity of the disturbance to the stream system. Impacts on sediment delivery associated with harvest center around yarding and site preparation activities. As table 1 suggests, concern for sediment delivery to the stream system should focus on the smaller streams which can comprise up to 90% of the stream system. Buffer strips along larger streams (type 1-3) have proven to be effective at removing sediment before it reaches the stream. The smaller streams (type 4, 5, and ephemeral) do not receive buffer filter strips increasing the opportunity for sediment delivery from hillslope erosion/processes. Once sediment is delivered to smaller streams it can be transported through the buffer strip directly to a larger stream.

An increase in water yield has been repeatedly documented following clearcutting (Bosch, 1982). Increases in peakflow can result from harvest activities (Rothacher, 1973; Harr et. al., 1975; Ziemer, 1981). Increases in peakflows as a result of harvesting occurred during fall storm events. This has been attributed to differences in soil moisture content between cut and uncut areas. Once soil moisture is recharged on both cut and uncut areas subsequent storm events tend to yield peakflows similar to pre-harvest levels. These increases appear to only effect the smaller peakflows associated with fall rainfall events and do not effect the larger peakflows associated with winter storm events. Harr (et al. 1979) also indicates that increases in peakflow are attributed to the amount of soil compaction during yarding and site preparation activities. Road building was found to have a significant impact on peakflows (Harr et al. 1975). According to Harr (1976) soil compaction and road building impacts appear to effect peakflows even during larger runoff events. Knighton (1987) suggests that increases in peakflow are more significant in smaller watersheds. Increases in peakflow from smaller watersheds may not be detectable in larger mainstem streams. This reflects the importance of scale in assessing impacts. For example, on a small headwater stream flowing 1 cubic foot per second an increase in flow to 2 cubic feet per second results in a peakflow increase of 100%. When this flow enters a mainstem stream flowing 50 cubic feet per second the addition of 1 cubic foot per second results in an increase of only 2%. Additionally, increases in peakflow may not be measurable in larger streams because the timing of the peakflow may not coincide with the peakflow of the larger stream (Harr, 1989).

The same factors discussed above apply to developed areas. In most cases the problems are significantly magnified. The amount of impervious surfaces leading to increased runoff is greater in a developed area and the impacts are essentially permanent. Knighton (1987) indicates that the creation of impervious surfaces and more efficient drainage systems increases both the magnitude and volume of runoff. Although the source is usually localized the effects may cause impacts downstream. Streams in developing areas may undergo two significant changes. During construction activities streams may be subjected to increased sediment yields as soil is disturbed. Secondly, as sediment sources stabilize increased runoff becomes the predominant concern. Hammer (1972) evaluated the influence of several land uses in promoting channel changes. The results indicate a correlation with the age and type of development. Table 8.3, reprinted from Hammer (1972), illustrates the influence that development can have on stream systems.

Table 8.3 Ratio of enlarged channel area to natural channel area assuming that all the basin is in the use specified (after hammer, 1972)

LAND USE	Enlarged Channel ArealNatural Channel Area
Wooded	0.75/1.00
Previous developed land	1.0811.00
Impervious areas less than 4 years old; unsewered streets and houses	1.08/1.00
Cultivation	1.29/1.00
Houses more than 4 years old fronted by sewered streets	2.19/1.00
Sewered streets more than 4 years old	5.95/1.00
Impervious areas more than 4 years old	6.79/1.00

Inventory Of Channel Conditions

Introduction

The Jones and Stokes (1992) process of stream channel condition assessment evaluates the potential response of the stream reach to increased peakflows, existing condition of the channel and banks related to peakflows, and the potential for damage from future increased peakflows. An evaluation of channel conditions is conducted to obtain a score for existing conditions based on 9 parameters. Although it will not be discussed in this section, a second evaluation is conducted to obtain a score that represents the potential condition of a stream should peak flows increase.

Existing Condition

The evaluation form is attached to the field form and can be found in appendix 26. Following is a brief description of the 9 parameters utilized to determine the existing condition of a stream reach using the Jones and Stokes methods.

<u>Channel Capacity</u>-

Conditions indicate that the active channel has downcut or widened.

<u>Bank Cutting</u>-

A. Indicates that the length of the inventoried reach is exhibiting bank cutting greater than 30%, and the cutting is unusual places such as straight stretches and on the inside of bends.

B. Indicates that the length of the inventoried reach is exhibiting bank cutting greater than 50% regardless of location.

Deposition-

A. Indicates that 20 - 50% of the channel bottom is covered with fresh deposits, and those deposits consist of mostly fine material (sand and smaller sizes).

B. Indicates that greater than 50% of the channel bottom is covered with fresh deposits.

Recent Bed Mobility-

Indicates that there is no staining, algae growth, or clinging vegetation in the channel and the majority of bed materials appear to be quite mobile during high flows.

Armoring-

Indicates that in the channel or on gravel bars, the surface particles are distinctly larger than the subsurface particles.

Particle Size Distribution-

Indicates that smaller particles are absent or present only in fresh deposits on bars.

Location of Woody Debris -

Indicates that logs have been transported into the reach.

A numerical score is generated from evaluating the above conditions. The following interpretations are then made from that numerical score.

< = 1 Channel conditions indicate little or no existing damage related to increased peak flows. (low)

2-3 Channel conditions indicate a moderate degree of existing damage, further investigation should (mod) be used to determine the specific cause of items scored above.

> = 4 Channel conditions indicate significant damage has occurred. (high)

Table 8.4 provides the existing condition by stream type for the Silver Lake Watershed. All measurements are in miles.

Table 8.4 Existing Condition by Steam Type

TOTAL WATERSHED:	WW « =1)		MODERATE (2-3)		IDGH (> =4)	
Stream Type	0	1	2	3	4	5
1	0.00	0.61	1.20	0.50	0.47	0.11
2	0.00	0.06	0.49	0.00	0.19	0.00
3	0.46	2.55	2.95	2.19	0.79	0.57
4	4.36	4.72	9.55	4.42	1.71	0.72
5	1.29	1.29	1.12	1.21	0.91	0.42
Untyped	0.03	0.38	0.08	0.21	0.34	0.00
TOTAL	6.14	9.61	15.39	8.53	4.41	1.82

Table 4 indicates that a majority of the streams are in moderate existing condition. All the type 1 and 2 streams rated as exhibiting either little/no damage or on the low end of moderate condition. The smaller streams existing condition scores indicate a shift to the right indicating that a majority of the stream concerns are associated with type 3 and smaller streams. The following is a short summary and explanation of the existing conditions within each subwatershed.

Hemlock Creek

Hemlock Creek traverses four subwatersheds B3, HEl, HE2, and HE3 (see maps in appendix 15). The creek flows through industrial forestland in HEl, HE2, and HE3. In B3, agriculture is the predominant landuse. The division between HEI and B3 closely corresponds between a break in geologic units. The HE watersheds are located in Basalt/Andesite flows and B3 is located on a Lahar (mudflow). The mainstem of Hemlock Creek is a type 1 stream through B3 and HEI and branches to type 3 into HE2 and HE3. The following provides the average existing condition of Hemlock Creek within each of the subwatersheds;

B3 3.4
HEI 1.9
HE2 2.3
HE3 1.6

Hemlock Creek enters subwatershed B3 at the Weyerhaeuser railroad crossing below the Weyerhaeuser bridge on the 1396 road. As indicated, there is a marked increase in assessed channel damage in B3. A review of the stream data indicate potential reasons for the different average conditions. The geologic break appears to be the predominant reason for the change in channel conditions. Hemlock Creek flows close to stable bedrock throughout a majority of its length. Into B3 it flows through the remnants of a mudflow which laid down a deep layer of unconsolidated material. Hemlock Creek has established itself as a meandering channel 10-20 feet deep in the upper reaches of this subwatershed. As a meandering stream, erosional processes along outside bends are expected. Attempts by local landowners to minimize meandering appears to be increasing the amount of erosion of the banks. The lower reaches have been impacted by the construction of the lake level control structure. By minimizing the fluctuation of the lake's level and maintaining an average elevation of 486.5 feet above mean sea level, the structure as raised the base level for the drainages feeding the lake. Raising the base level of the creek reduces the gradient of the stream. A reduced gradient reduces stream velocities resulting in a deposition of sediments carried by the stream. Photographs of Hemlock Creek taken during the summer of 1966, prior to the installation of the control structure, indicates the same channel geometry as today. However, the photographs also indicate a gravel bottomed stream flowing a few inches deep. Today, the water is approximately 20 feet deep during summer months. Wetland species have been encroaching on agriculture land as can be observed through a series of aerial photographs. During storm events, water over tops the banks and spreads across the floodplain. A concern voiced by landowners along this section of Hemlock Creek is the Weyerhaeuser railroad crossing. The trash rack effectively strains woody debris from the stream. During clean out activities a pulse of water through this section is not uncommon. This culvert represents a fisheries passage concern due to the length of the culvert. However, a natural barrier (20 foot falls) exists approximately 1 mile upstream. The type 1 water lacks large woody debris which assists to decrease stream energy and provide habitat for fisheries. In the type 3 streams the predominant concern is with woody debris that has formed unstable debris jams in several reaches.

Sucker Creek

Beaver activity is evident throughout the majority of type 1-3 streams. The resulting ponds serve to dissipate energy and store sediments delivered to the streams. In most instances the beaver dams were found to be stable and functioning well. Problems were encountered with beaver activity in one reach. The channel banks in this reach consist of silt loam with a high erosion hazard. Attempts to establish dams resulted in the stream eroding around the ends of the dam creating additional channels. As with Hemlock Creek, the lower reaches of Sucker Creek are influenced by the lake. The backwater effect of the lake results in deposition of stream carried sediments. During winter storm events, increasing discharge flushes the sediment from these reaches. Sediment flushed may appear as a sediment plume in the lake. Sediment movement has been observed following winter storm events by several residents in the watershed.

Riparian Areas / Buffer Zones

The riparian areas along the majority of the type 1-3 water are characterized by broad-flat-floodplains. Under these circumstances, flood flows are allowed to top the channel banks and spread across the floodplains reducing stream energy. During the stream inventory, buffer zones were assessed regarding their effectiveness as a filter strip. Buffers met or exceeded Forest Practices rules and regulations throughout the watershed. Buffers strips were retained along several type 4 streams (not required). Observations suggest that the buffer strips are very effective as a filter strip between the hillslope and the stream. Even during the limited occurrence of steep hill slopes down to the stream sediment movement was not observed. Logging practices around the turn of the century have resulted in riparian areas of type 1-3 water being comprised primarily of Red Alder. With woody debris being a critical component of retaining buffers, areas dominated by Red Alder are a concern. Compared with Douglas-fir or Western Red Cedar, Red Alder has much reduced effective life expectancy once it is incorporated into a stream.

A concern is type 4 and 5 streams. Regulations do not require buffer strips. They connect hillslope
erosion process directly to the type 1-3 streams. Type 4 and 5 streams are generally steep, but when they meet the floodplain of larger streams they are essentially flat. Reaches crossing floodplains are depositing and storing sediment. Bottoms of pools in type 1-3 water immediately below the confluence with smaller streams were frequently layered with sediment. During high flows the stored sediment from floodplain and pools is flushed through the stream system.

In additional concern observed in the upper reaches of Sucker Creek is the stability of the riparian buffer zone leave trees. In areas along type 3 steams, buffers meeting or exceeding Forest Practices regulations had been retained. These buffers have since blown down. Although woody debris recruitment is one reason for retaining trees along streams, in several cases windthrown trees have created channel changes and direct delivery of sediment to the stream system.

Potential Condition

An evaluation of channel conditions is conducted to obtain a score for potential condition if peak flows were increased from present levels. The evaluation is based on 10 parameters. Following is a brief description of the 10 parameters utilized to determine the existing condition of a stream reach using the Jones and Stokes methods.

The evaluation provides red flag conditions for 10 parameters indicating existing condition. These parameters are:

<u>Response Category Type</u> -

> Indicates channel is unconstrained or is slightly constrained with an unconsolidated bottom.

<u>Degree of Bank Protection</u> -

> Indicates that banks range from having no root protection to being protected by dense but shallow roots. Also indicates that banks are not predominantly bedrock.

<u>Resistance of Bank Material</u> -

> A. Indicates that bank rock content is less than 40% and the bank material ranges from cohesive but erodible to noncohesive assortments of material.

B. Indicates that bank rock content is 40-90 % but the bank is comprised of a noncohesive material.

Flow Deflection -

Indicates that there are numerous areas where flow is deflected into the channel banks by logs, boulders, or the channel pattern.

Dominant Particle Sizes -

Indicates that the dominant size of material in the channel ranges from mostly fine material to a cobble\gravel mixture.

Angularity -

Indicates that the substrate consists of mostly rounded rocks that have little resistance to rolling.

Particle Packing -

Indicates that the bottom material is very loose or there are larger particles surrounded by a loose matrix of smaller particles.

Woody Debris -

Indicates that one or more debris jams block the channel.

Culverts or Bridges -

Indicates that culverts or bridges appear inadequate.

A numerical score is generated from evaluating the above conditions. The following interpretations are then made from that numerical score.

< = 1 Channel conditions indicate the channel has low potential for damage if peak flows increase. (low)

2 - 3 Channel conditions indicate the channel has moderate potential for damage if peak flows increase. (mod)

> = 4 channel conditions indicate the channel has high potential for damage if peak flows increase. (high)

Table 8.5 provides the length of stream in miles by potential condition and stream type.

All measurements are in miles.

Table 8.5 Stream length in miles by potential condition and stream type

TOTAL WATERSHED:	LOW		MODERATE		HIGH				
Stream Type	0	1	2	3	4	5	6	7	8
1	0.00	0.00	0.98	0.00	0.68	0.00	0.00	0.00	0.00
2	0.27	0.08	0.91	0.79	0.91	0.23	0.00	0.00	0.00
3	0.00	0.00	0.00	1.48	2.73	1.97	4.77	0.15	0.91
4	0.02	0.00	0.00	0.38	0.58	1.17	2.79	1.02	0.00
5	0.34	0.00	0.00	0.18	0.91	1.29	2.80	0.31	0.00
UT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00
TOTAL	0.63	0.08	1.89	2.83	5.81	4.66	10.36	1.75	0.91

Table 8.5 indicates that a majority of the streams have a high potential for future damage should peak flows increase. Type 1 and 2 streams generally rated as having low to moderate potential for future damage. The smaller streams potential condition scores shift to the right indicating that a majority of the stream concerns are associated with type 3 and smaller streams. However, the survey method utilized appears to over estimate the condition of the stream. Modification should be conducted prior to utilizing the stream survey procedure on smaller headwater streams. Increased peakflow should not be a concern for the larger stream systems given the present forest cover characteristics and an established road systems. However, potential future damage is a concern for the type 4, 5, and ephemeral drainages. These concerns include the construction of roads, forest management, and development.

Influence Of Management Activities

Stream survey data was linked to the information collected for roads and forest stands. This provides the opportunity to explore relationships between some management factors such as road crossings and stand age vs. stream condition.

Of the 146.5 miles of road in the watershed, 74.3 (50.6%) miles contribute runoff directly to the stream system. Although not intended to include roads, DNR's definition for type 5 streams adequately (appendix 25) describes road behavior. Roads extend the length of the stream system within the watershed by 14.6 miles (26%). Roads increase the amount of runoff delivered to the stream and in the smaller headwater streams the change may be enough to initiate channel damage and erosion. Roads can also be a significant source of sediment.

The data gathered did not present a relationship between the presence of roads and the existing condition of the streams. This is probably because most roads in the watershed have been in place for several years and impacts to the stream have had time to adjust to the changes that occurred after road building.

Instead of utilizing existing condition scores, an assessment is being conducted utilizing individual data parameters collected on the field inventory form. Because channels tend to adjust to increases in sediment or flow, active channel width will be compared for stream reaches above and below road crossings.

Type 4 and 5 streams are currently being evaluated to determine if harvest activities above the stream reach have had any affect on the condition of the stream. Watersheds are delineated on topographic maps for the individual stream reaches. Stand age information was then overlaid onto the watershed boundaries to determine the percentage of the watershed in five age classes including recent harvest, 1-5 years old, 6-10 years old, 11-20 years old, and greater than 20 years old. Stands were considered to become "hydrologically mature", or behave as undisturbed, at 20 years of age to provide a starting point for assessing the data. The percentage of the watershed in agriculture use (fields/pastures) was also included in the assessment. Residential areas were found to directly impact the lake. Although data does not exist for impacts to streams due to development for the watershed, observations of road ditches in residential areas indicates a concern for increased runoff. Rural residential areas of greater than 5 acres were classified as either non-industrial forest land or agriculture for this assessment.

Summary

The streams of the Silver Lake watershed are generally in good condition at this time. Minor concerns exists on a few reaches of type 1-3 water including unstable debris jams and Beaver activity in a reach with readily erodible channel banks. Future woody debris recruitment is limited due to the dominance of the Red Alder in riparian zones. In-stream woody debris was found to be lacking throughout the type 1-3 water. A majority of the stream concern is associated with type 4 and 5 streams. Initial comparison of stream survey data with road and age class inventory information yielded weak relationships. Currently, the inventory data is being reviewed for further refinement to determine if conclusions can be drawn from these data comparisons.

Recommendations

1) Long term forest management objectives should be to strive for an uneven age distribution (both spatial and temporal) across the watershed.

2) Whenever possible, utilize cable yarding systems, one pass shovel logging, or designated skidtrails to minimize soil disturbance. By laying out skidtrails in advance and tailoring timber felling to the layout, the area of soil disturbed can be greatly reduced.

3) Avoid using ground-based equipment for harvesting during wet periods. The potential for soil compaction and displacement increases with increases in soil moisture. Operations should be suspended or mitigating practices used when soil displacement and compaction becomes evident (for example when rutting exceeds 4 inch depth). Techniques to reduce soil impacts

such as encouraging slash accumulations on skidtrails should be considered. For example; layers of slash can aid in supporting equipment, reduce the ground pressure exerted by machinery, and help reduce soil displacement.

4) Avoid soil disturbing activities in riparian zones of type 4, 5, and ephemeral draws. Design and plan harvest units to facilitate yarding material away from these channels instead of across. When crossing is unavoidable, strive for full suspension to minimize streambank disturbances. Techniques including directional felling, whole tree yarding, and establishment of equipment activity "use zones" outside riparian zones should be considered during planning stages.

5) The recommendations provided for roads should be adhered to.

6) Encourage the awareness and use of available technical and financial assistance for planning and implementing harvest activities (see appendix 27). Encourage local agencies to use cost share incentives for landowners to use these practices.

7) Ground cover plantings should be used on all disturbed soil areas that have the potential of eroding and being delivered to the stream system. Establish protective cover prior to the first winter.

8) Install waterbars on skidroads or corridors that do not have natural breaks to reduce delivery of water and sediment directly to the stream.

9) Encourage regulatory agencies to allow prescription planning for the management of riparian zones of influence.

10) Plan prescriptions for the management of buffer zones. The primary purpose of this part of planning is to avoid unnecessary stream damage as a result of windthrow. Prescription should consider retention of trees (current regulations), the felling and retention of sufficient woody debris in areas prone to windthrow, and management of riparian zones to encourage establishment of coniferous species (limited by Forest Practices and Shorelines of the State). Incorporating management capabilities for landowners may encourage the establishment and perpetuation of healthy riparian areas.

11) Provide assistance to the landowners along lower Hemlock Creek in slowing natural erosion processes that threaten property. Opportunities may exist through grants and agency cost share programs to assist in the implementation of such a project.

12) Encourage wetland development (ie. beaver activity or man-made structures) in the upper watershed to provide energy dissipation, sediment storage, and improved hydrologic conditions.

13) Emphasize hydrologic assessments for County zoning and permitting processes.

14) Educate landowners of the importance of functioning riparian zones. Encourage the establishment and <u>management</u> of riparian zones.

15) Establish a monitoring schedule for the trash rack under the railroad grade on Hemlock Creek. Cleanout activities should be planned to slowly release water stored by the debris.

CHAPTER 9

SOIL MONITORING

Introduction

Cowlitz conservation district submitted a proposal to Cowlitz County in November of 1992 to add a soil monitoring component to the workplan (proposal in appendix 28). The proposal was designed to assess the relative potential of particular soil types or geologic zones as phosphorus contributors through soil erosion.

The Silver Lake drainage can be divided into four geologic zones and contains thirty-two soil types as identified by the Soil Conservation Service. The geologic groups include volcanistic rocks in the Sucker Creek Area, Andesite/Basalt flows in the Upper Hemlock Creek area, continental sedimentary rock along the North side of the Lake, and Lahar (mudflow) in the Lower Hemlock Creek/Outlet Creek area (refer to geology map in appendix 2). Initially, soil sampling focused on the predominant soil types common to the four geologic zones. Since the predominant landuse in the watershed is forestry, samples were collected in forested stands greater than twenty (20) years of age. This resulted in samples being collected from all geologic areas except the lahar (predominantly agriculture). SCS soil maps were utilized to identify the soil and confirmation at each location was provide by the SCS Area I Soil Scientist. Samples were collected from the "A" (surface mineral soil) and "B" (subsurface) horizons. Three sites were sampled to a depth of 60 inches to allow for a vertical profile. The individual soil types and accessibility dictated the relative slope position of these sites. Samples were analyzed for total and extractable phosphorus by Oregon State University. Total phosphorus was determined by sulfuric acid digestion. Extractable phosphorus was analyzed using the Bray-p l method and serves as an index of plant available phosphorus. The pH for the samples was estimated using colorimetric field methods. This information provides insight to the nature and extent of the phosphorus pool in the watershed soils, but does not identify transport processes. A map, site descriptions and sample data for the sample locations can be found in appendix 29.

Soils in the watershed appear to be conducive to binding phosphorus. Clay size particles and humus are the principal soil constituents that interact with phosphorus. The soils in the watershed are generally high in their percentage of clay size particles. Volcanic activity that has deposited ash on the soils can increase the phosphorus binding capacity of the soils due to the input of additional clay sized particles. Soil Conservation Serve estimated soil properties for Olympic Silt Loam (predominant soil) is located in appendix 30.

Soil phosphorus is present in both inorganic and organic forms. Brady (1985), indicates that total phosphorus generally decreases with depth on grassland soils and the distribution of organic and inorganic forms changes. In surface soils a larger percent of the total phosphorus is in organic forms. With depth, there is shift from organic to inorganic forms. Data presented for Western Oregon soils indicate that hill soils are generally lower in total phosphorus than valley soils and the organic fraction is higher on hill soils than valley soils. In acid soils, phosphorus is bound in iron and aluminum compounds and are extremely insoluble. The degree to which phosphorus is bound is dependent on the pH of the soil. Phosphorus is most available at a pH of approximately 6.5. At lower pH phosphorus ecomes fixed by iron and aluminum. At higher pH phosphorus becomes fixed predominantly by Calcium. Brady (1985) presented total phosphorus content data for Western Oregon soils indicating that hill soils averaged 357 ppm. Old valley soils and recent valley soils averaged 1479 and 848 ppm respectively.

Initial Findings

Olympic Silt Loam, Godfrey Silt Loam, Miscellaneous Alluvial Soils not meeting soil type descriptions, and instream sediments are the soil types found on all the geologic settings. Olympic silt loam is the predominant soil type found in the watershed and is generally an upland soil (ridgetop and midslope sites). Godfrey silt loam is the predominant soil in valley bottoms. Several areas mapped as Godfrey did not meet the profile description and were lumped together as Alluvial Sediments. Instream sediments were collected from deposits accumulating behind Beaver dams. Figures 9.1 and 9.2 provide a comparison of the soil types common to the major geologic areas. Tabulated soil data for each of the sampling sites is located in appendix 29.

Figure 9.1. Average total phosphorus in the "a" horizon for similar soil types on different geologies

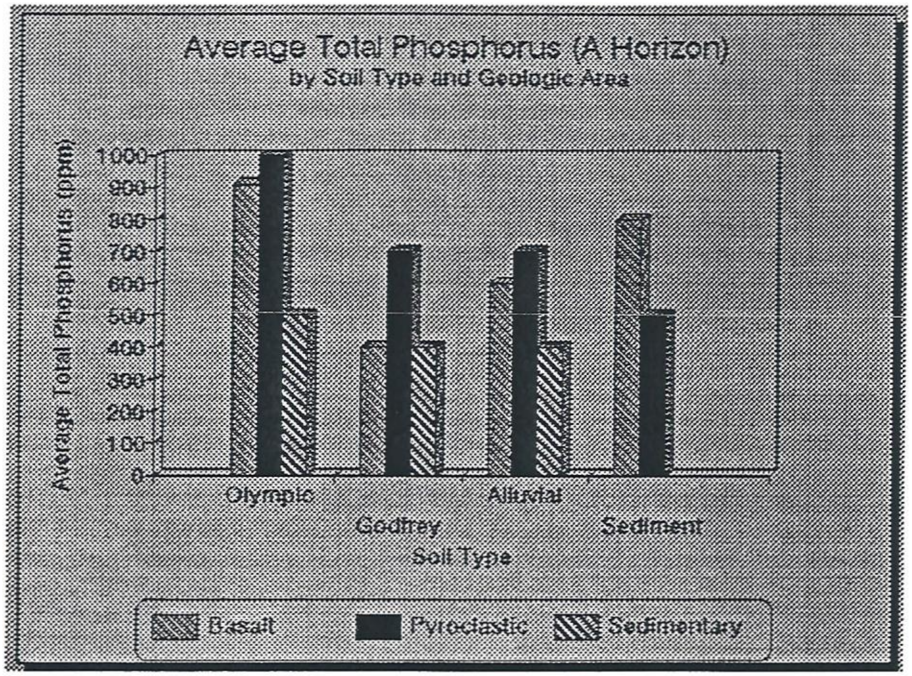


Figure 9.2 Average Extractable Phosphorus in the "A" Horizon for Similar Soil Types on Different Geologies

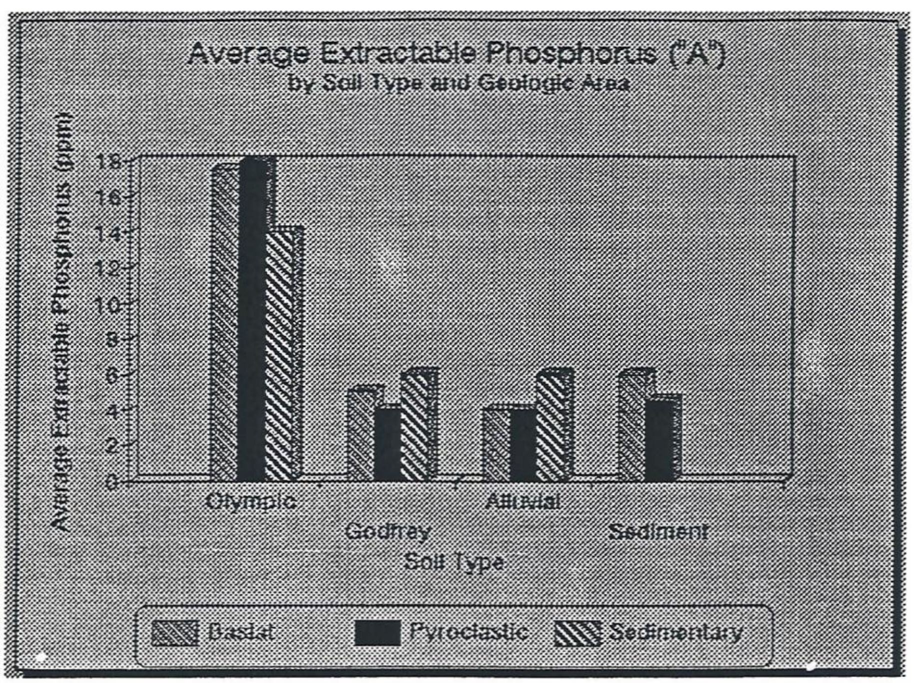


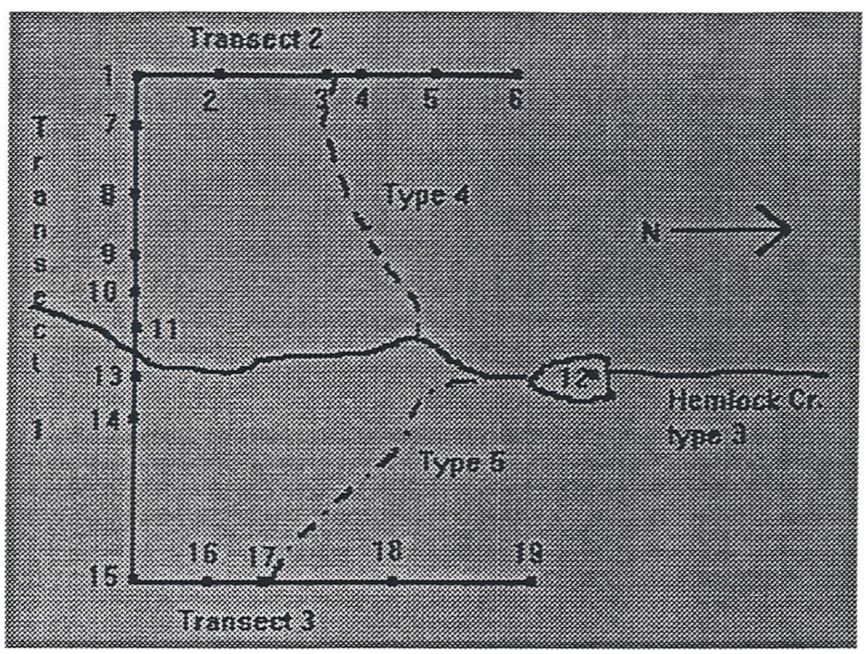
Figure 9.1 indicates similarities between valley bottom soils and instream sediments. Olympic Silt Loam is predominantly an upland soil. Although not significant, upland soils tend to be higher in total phosphorus than valley bottom soils. This conflicts with the information provided by Brady (1985). Although soils in the sedimentary geologic area appear to be lower in total

phosphorus natural variability and limited sample numbers yielded no significant differences. Extractable phosphorus appears to be 4 times greater on hillslopes when compared with valley bottom soils. Extractable phosphorus was found to be dependent on the total phosphorus in the soil. This information indicates highly variable levels of total phosphorus in the watershed soils. The charts indicate that total phosphorus may be a function of slope position. Slope position may be an indicator of the processes by which phosphorus is transported or retained by the soil.

Transect Sampling

Additional sampling was conducted to provide additional sample points and data for slope position. Three transects were established in the Hemlock 3 sub watershed (map in appendix 29). Figure 9.3 illustrates the layout of the three transects. Transect 1 traversed Hemlock Creek from ridge to ridge. The west end of the transect was located in a 1-5 year old stand of Douglas-fir. The East end of the transect was located in a mature, 50 + year old, mixed stand of Douglas-fir and Red Alder. Transect 2 was established at a right angle from the first sample point on transect 1 and traversed a type 4 stream in a 1-5 year old stand of Douglas-fir. Transect 3 was established at a right angle from the last sample point on transect 1 and traversed a type 5 stream in a mature mixed stand of Douglas-fir and Red Alder.

Figure 9.3 Transect layout in hemlock creek 3 (he3) subwatershed



Transect 1

The following provides the site descriptions for transect 1. Samples from site 1 and 7-9 were obtained on *9/24/93.* Samples from site 9-15 were obtained on *9/29/93.* The sketch of transect 1 (figure 9.4) provides an indication of the relative slope position of the various sites along transect 1 and the sampled horizon designation, total phosphorus (ppm), sampling depth, and estimated pH of the individual sampling sites.

Figure 9.4 < not available - displayed on typewritten copy version of SLWMP only >

SITE DESCRIPTIONS FOR TRANSECT 1

Sample	# Soil	# Location
1A	147	Transect 1, ridgetop site in 1-5 year old plantation of Douglas fir approximately 100 yards above the 1390C2 road segment in subwatershed HE3. Site appears to have been yarded and site prepped using ground based equipment. Sample was collected from 0-2”
1Eb	147	Sample was collected from 2-5 inches. This is horizon has leached the clay into the Bt1 horizon.
1B	147	Sample was collected from 5-11 inches.
7A	147	Olympic Silt Loam, midslope position between ridgetop and bench above Hemlock Creek (between 1391 and 1392 roads). Sample was collected from 0-5 inches.
7B	147	Sample was collected from 5-14 inches.

8A 147 Olympic Silt Loam, midslope but on bench above Hemlock Creek (representative of the soil description for Olympic's). Would expect this area to be similar to a ridgetop location in regards to phosphorus. Bench may be a remnant of a past failure. Sample was collected from 0-7 inches.

8B 147 Sample was collected from 7-14 inches.

9A 78 Hazeldell, midslope position between 1391 road and Hemlock Creek. Sample was collected from 0-4 inches.

9B 78 Sample was collected from 4-11 inches.

lOA 147/ Toe of slope before riparian management zone. Bull rush was evident along the slope 134 at this elevation (12-15 feet above creek). Subsoils are mottled and grade into a gleyed soil. Free water was encountered at 44 inches. Sample was collected from 0-3 inches.

lOBt1 147/ Sample was collected from 3-8 inches.

10Bt2 147/ Sample was collected from 12-18 inches. Horizon extended from 8-33”

lOBg 147/ Gleyed horizon from 33-52+ inches. Water table was located at 44”. Sample was collected from 46-52 inches.

11A RMZ Alluvial material, sample was located within the Riparian Management Zone of Hemlock Creek within 30 feet of the stream bank. Sample was collected from 0-5 inches (sandy ioam *wi* = 2 % day).

llCl RMZ Sample was collected from 5-8 inches (gravelly sands).

12A BP Sediments, collected from Beaver pond downstream of transect approximately 1000 feet. Sample was collected from upper u unconsolidated sediments, 0-2 inches.

13A RMZ Alluvial material, highly organic yet still considered a mineral soil. Histic Epipedon (Oa horizon). Sample was collected from 10-0 inches (ie. surface to 0 inches).

13B RMZ Sample was collected from 0-15 inches. This is two horizons combined a Cgl and a gleyed Cg2.

14A 34 Toe slope position 8-12 feet above RMZ from which sample 13 was collected. Slope is convex at this point. Soil is similar to Hazeldell but thinner horizons and larger and more rock. Sample was collected from 0-5 inches.

14B 34 Sample was collected from 5-11 inches.

15A	147	Olympic, ridgetop location. Soil was very dry at this location. Sample was collected from 0-5 inches.
15B	147	Sample was collected from 5-12 inches.

Ridgetop and depositional areas located in the uplands tend to be higher in total phosphorus (tp). Valley bottom soils and instream sediment are relatively lower in tp. An exception to this trend is sample site 13. This site is located in the riparian zone of Hemlock Creek. The soil was labeled as Alluvial sediments because it did not meet the description of the mapped soil type. The soil is highly organic yet still considered a mineral soil, indicating the importance of organic binding of phosphorus. In general, on upland sites tp tends to decrease with depth. Sample site 1 eludes to the importance of clay sized particles in phosphorus binding. The surface soil at this site is relatively high in tp (2100 ppm). The second horizon was identified as an Eb horizon, with a moderate level of tp (1300 ppm), meaning that clay is being leached to the next horizon. The B horizon receiving the leached clay particles increased in tp (1500 ppm). This indicates that movement of phosphorus can be by transport of clay sized particles. In the valley bottom soils along transect 1, total phosphorus tends to be similar or slightly increases with depth.

Transect 2

Transect 2 begins at the same site as transect 1. The transect cross a type 4 stream in a 1-5 year old plantation of Douglas-fir. The sketch of transect 2 in figure 9.5 provides an indication of the relative slope position of the various sites along transect 2 and the sampled horizon designation, total phosphorus, sampling depth, and pH of the individual sampling sites.

Figure 9.5 Transect 2 < not available - displayed on typewritten copy version of SLWMP only >

SITE DESCRIPTION FOR TRANSECT 2

Sample #	Soil	Location
1A	147	Transect 1, ridgetop site in 1-5 year old plantation of Douglas fir approximately 100 yards above the 1390C2 road segment in subwatershed HE3. Site appears to have been yarded and site prepped using ground based equipment. Sample was collected from 0-2 inches.
1Eb	147	Sample was collected from 2-5 inches. This is horizon has leached the clay into the Btl horizon.
1Bt1	147	Sample was collected from 5-11 inches.

2A	147	Midslope site on transect 2 (across type 4 in harvested area). Sample was collected from 0-1 inches.
2AB	147	Sample was collected from 1-10 inches.
3A	AS	Alluvial sediments collected from the valley bottom of transect 2. Sample was collected from 0-5 inches.
4A	78	Hazeldell, toe slope site on transect 2 approximately 5 vertical feet above floodplain of type 4 stream. Horse tail is prominent between the floodplain and approximately 7 vertical feet above the floodplain, indicating a moist site. Sample was collected from 0-2 inches.
4Bt	78	Sample was collected from 2-12 inches. Moisture level was observed to be significantly higher than the lower horizon at site 2.
5A	78v	Hazeldell variant, site had much coarser material than that found at site 4. Mid-slope position at same elevation as site 2 but much higher slope position. Sample was collected from 0-2 inches.
5Bt	78v	Sample was collected from 2-8 inches.
6A	78	Hazeldell ridgetop site. Ash layer was obvious at the surface. This site marks the end of transect 2. Sample was collected from 0-4 inches.
6Bt	78	Sample was collected from 4-10 inches.

Transect 2 data follows the same general trend as transect 1. Total phosphorus tends to be higher on upland soils than on valley bottom soils. Total phosphorus tends to decrease with depth.

Transect 3

Transect 3 begins at the end of transect 1. This transect crosses a type 5 stream under a 50 + year old stand of mixed Fir and Alder. The sketch in figure 9.6 provides an indication of the relative slope position of the various sites along transect and the total phosphorus, sampling depth, and pH of the individual sampling sites.

SITE DESCRIPTION FOR TRANSECT 3

Sample #	Soil	Location
15A	147	Olympic, ridgetop location. Soil was very dry at this location. Sample was collected from 0-5 inches.
15Bt	147	Sample was collected from 5-12 inches.
16A	34	This is the same soil as found at site 14. Midslope position, considerable more moisture than at site 15. Sample was collected from 0-6 inches.
16Bt	34	Sample was collected from 6-12 inches.
17A	Am	Alluvial material, valley bottom position located on the floodplain of a type 5 steam. Stream had well-defined channel but no water. Angular gavels were found at 34 inches. Sample was collected from 0-5 inches (silt loam).
17Bt	Am	Sample was collected from 5-21 inches (some sand layers evident).
18A	147	Midslope position 15 feet above type 5 channel. Sample was collected from 0-2 inches.
18Bt	147	Sample was collected from 2-11 inches.
19A	147	Ridgetop position. Sample was collected from 0-5 inches.
19Bt	147	Sample was collected from 5-10 inches.

Transect 3 data follows the same general trend as transects 1 and 2. Total phosphorus tends to be higher on upland soils than on valley bottom soils. Total phosphorus tends to decrease with depth, however total phosphorus is fairly similar with depth in valley bottom soils.

The data collected from the three transects supports the idea that slope position is a factor affecting the amount of total phosphorus. Figure 9.7 illustrates the relationship between slope position and total phosphorus in surface horizons for all the sample sites in the watershed. Figure 9.8 illustrates the relationship for subsurface soils (B Horizons).

Figure 9.7. Average total phosphorus by slope position

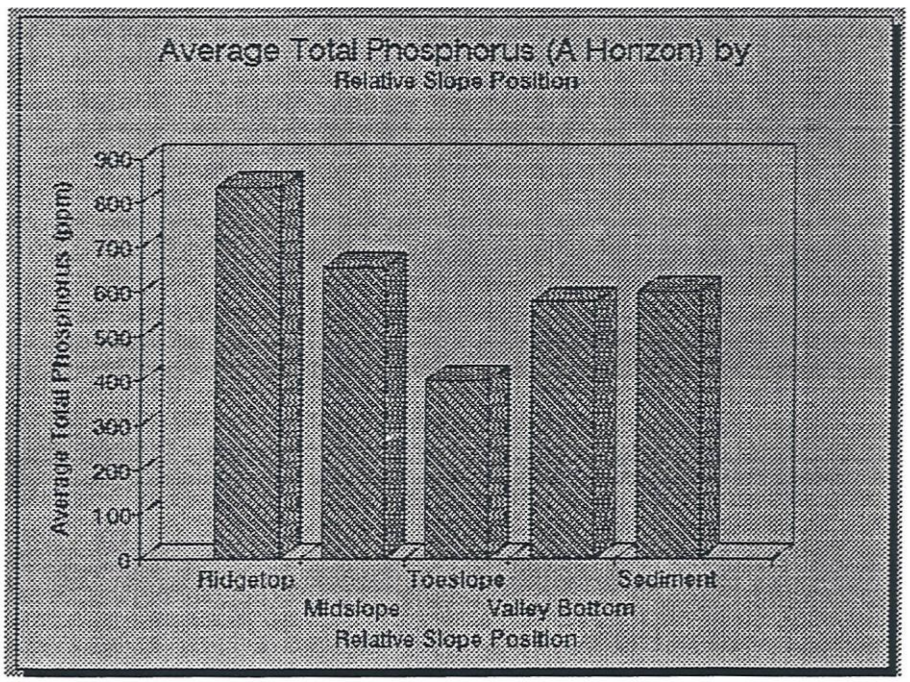


Figure 9.8 Average Total Phosphorus For Subsurface Horizons By Slope Position

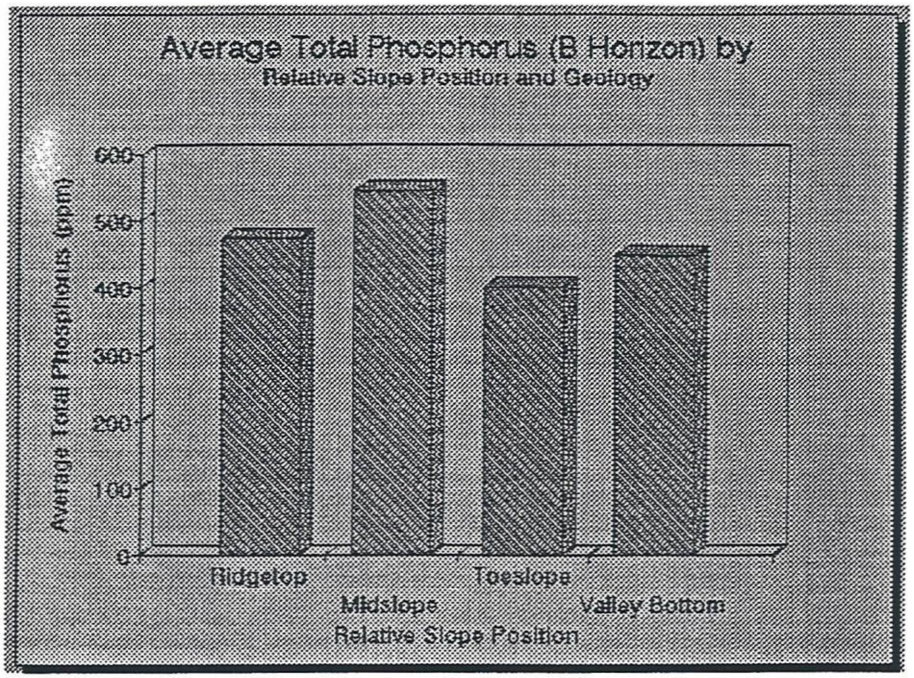
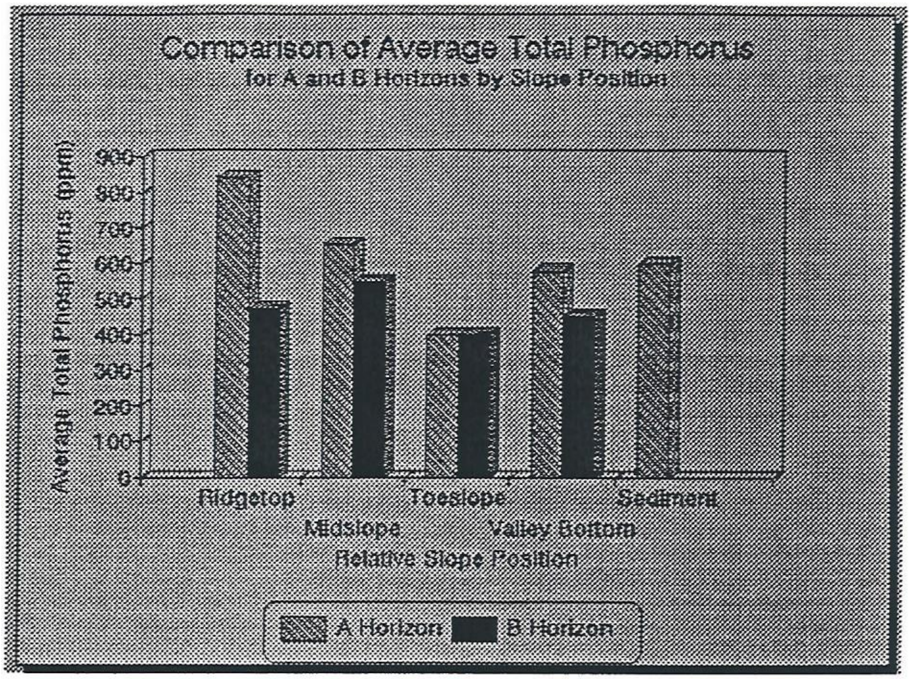


Figure 9.7 indicates that ridgetop soils tend to be slightly higher in total phosphorus than valley bottom soils. Figure 9.8 indicates that total phosphorus levels in subsurface soils tend to be fairly uniform amongst the slope positions. Comparing total phosphorus by soil horizon, figure 9.9, indicates that the largest stratification is at ridgetop sites. Valley bottom soils appear to have a more uniform distribution of total phosphorus with depth.

Figure 9.9 Comparison of a (surface) and b (subsurface) soil horizons by slope position.



Visual review of the transect data suggested that differences in total phosphorus may exist between the forested and recently harvested transect sites. Two sample analyses were conducted by slope position between harvested and forested sites. Figures 9.10 and 9. 11 compare the average total phosphorus and extractable phosphorus, respectively, in surface soils (A horizon) by slope position and vegetative cover.

Figure 9.10 Average total phosphorous by slope position and vegetative cover

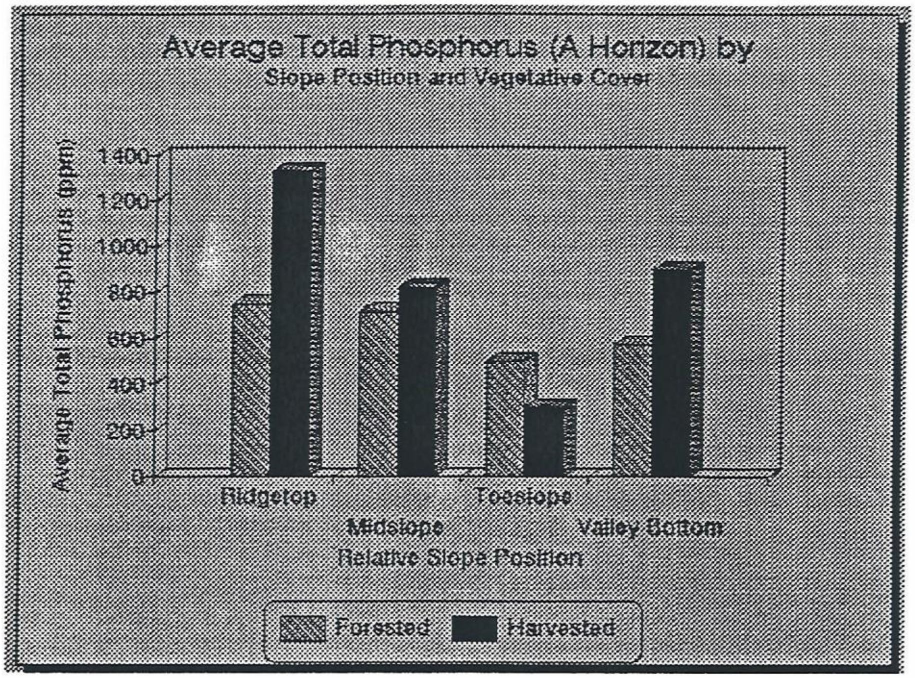


Figure 9.11 Average extractable phosphorous by slope position and vegetative cover

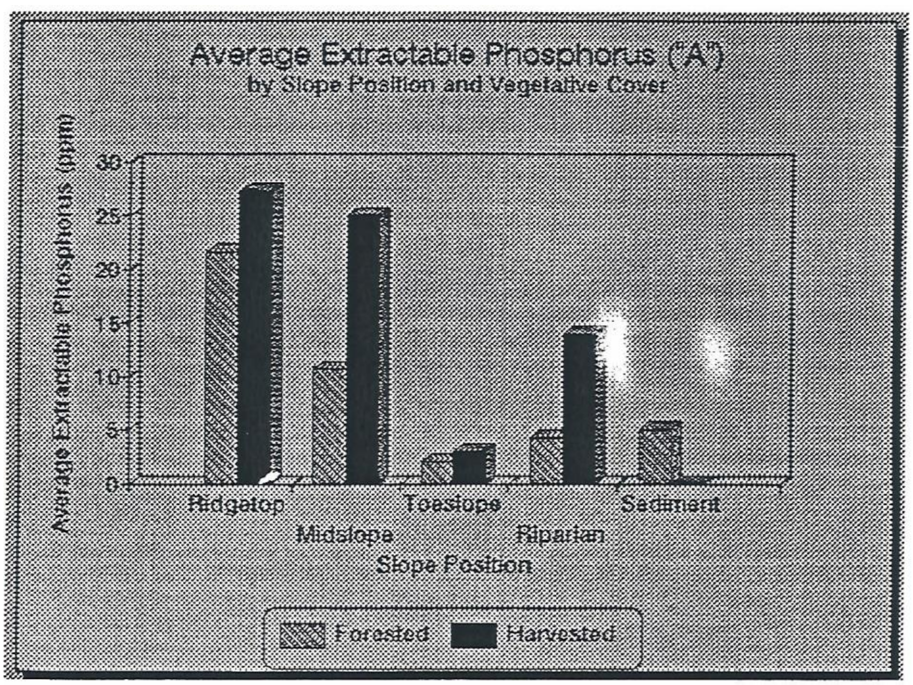


Figure 9.10 indicates that harvested sites tend to be slightly higher in total phosphorus than

forested sites, however differences are not statistically significant due to the natural variability of phosphorus in the soils. Figure 9.11 indicates the same trend for extractable phosphorus. Two sample analysis indicates that ridgetop and midslope sites on harvested sites may have greater total phosphorus levels in the surface soils than similar sites in a forested setting (p- .0342 and p= .00785 respectively). A lack of sample points did not allow for a comparison of sites located in valley bottoms.

Vertical transects were sampled at three locations to obtain an idea of changes in total phosphorus with depth. Two of these sites were ridgetop locations and one was a toeslope location. Figures 9.12 and 9.13 illustrate the results for total and extractable phosphorus respectively.

Figure 9.12 Vertical transects for total phosphorus

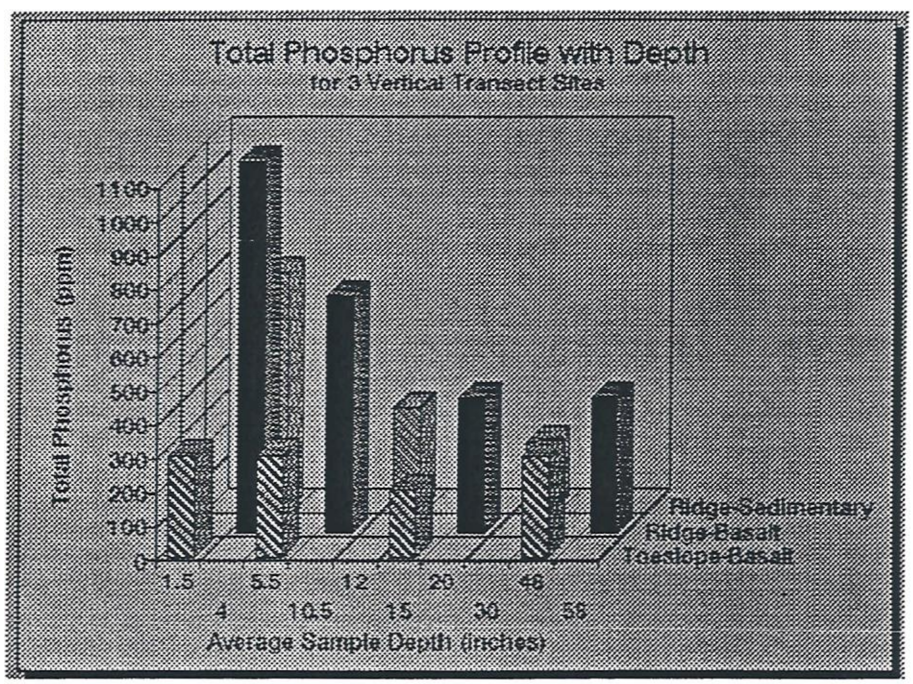
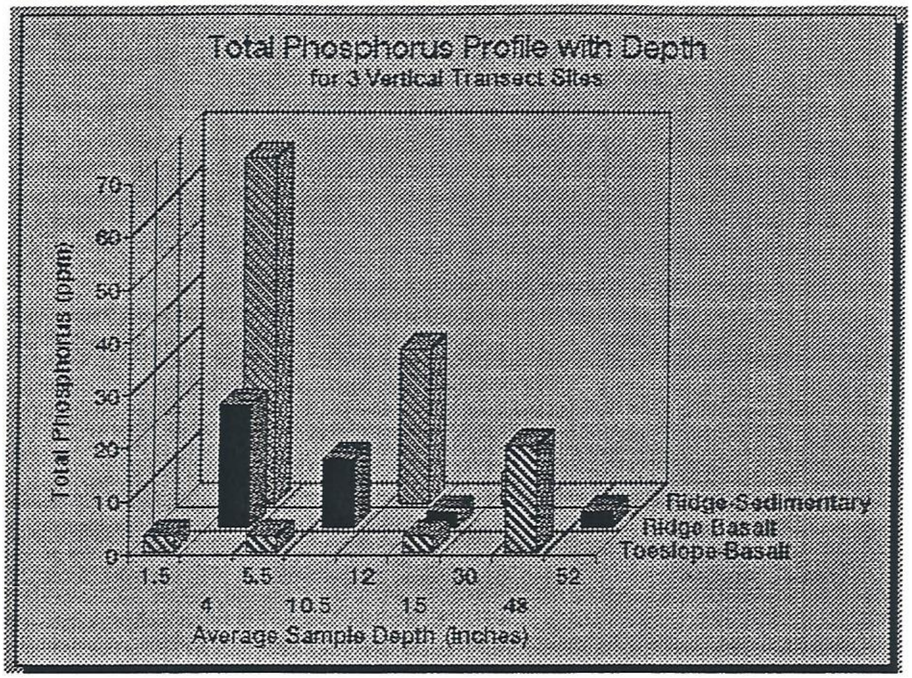


Figure 9.13 Vertical transects data for extractable phosphorus



Total phosphorus decreases with depth for ridge top sites. Total phosphorus remained fairly constant with depth at the toeslope site. Extractable phosphorus follows the same trend as tp for ridgetop sites. However, at the toeslope site total phosphorus increased greatly at the 48 inch depth. This depth corresponds closely with the depth at which the groundwater table was encountered (refer to transect description transect 1, site 10).

Discussion

Overall, the average total phosphorus content for the Silver Lake soils agrees closely with those presented by Brady (1985). However, discrepancies exist between total phosphorus on hill slopes. The soils in Silver Lake are considerably higher in total phosphorus than the hillslope soils presented for Western Oregon. The data also indicates that total phosphorus content is highly variable throughout the watershed.

In a natural environment there are essentially two sources of nutrients, these are the breakdown of parent material and inputs from the atmosphere. Man can increase the input of phosphorus by applying commercial fertilizer or through the application of human wastes (septic systems). In the forest environment fertilization programs have been entirely by urea (nitrogen) therefore it is assumed that sources of phosphorus are naturally occurring. This information provides insight that a source pool of natural phosphorus exists in the watershed and confirms the overall recommendation of minimizing accelerated erosion in the watershed.

Ridge top and depositional areas on hillslopes have soils which are fairly stationary or are accumulating soil. With the assumption that phosphorus moves attached to soils, these areas would be expected to have relatively high total phosphorus contents. Riparian areas are considered to be areas accumulating soils too. Thinking they are a depositional area, one would expect high *total* phosphorus contents. This was not evident from the sampling project. In general riparian areas and valley bottom soils were lower in total phosphorus than hillslope soils. Several processes may be at work in these areas. In general, the riparian soils were characterized by a coarser particle distribution. The lack of fines may greatly reduce these areas ability to fix and retain phosphorus. The lack of fines may also indicate the flushing action of streams. A large majority of the fines making their way into the riparian areas may be being flushed from the system during storm events. Brady (1985) indicates that availability of phosphorus increase as pH increases from acidic to more neutral conditions. Transects 1 and 2 indicate that pH tends to increase in the valley bottoms. pH conditions may result in some freeing of bound phosphorus making it available for leaching. An additional transport mechanism may be linked to the idea that phosphorus compounds itself with iron and aluminum. The to major forms of iron in soil are Fe(IJI) ferric and Fe(II) ferrous iron. In a aerobic (oxygen available) environment Ferric iron is the predominant form and is very insoluble. In an anaerobic environment ferrous iron is the predominant form and is more soluble than ferric iron. This is the condition identified for the lower horizon at site 10 on transect 1 (refer to site descriptions). Total phosphorus is relatively low at this site but extractable phosphorus is relatively high. As iron becomes more soluble, phosphorus may be released and become available for transport by leaching.

Recommended Alternatives

1) The sample results support the recommended alternatives for landuses. Reducing soil disturbance and subsequent soil erosion and transport to surface waters are primary objective to reduce nutrient delivery to Silver Lake.

2) Soil samples should be collected for the remaining land uses for comparison with forested sites.

CHAPTER 10

WATER QUALITY SAMPLING

Background Information

Washington State University (WSU) completed two investigations to identify sources of nutrients causing accelerated eutrophication. In both studies, hydrologic and nutrient budgets were constructed to identify nutrient sources.

In WSU's first report, Bhagat (1975) indicated that nitrogen and phosphorus loading are closely related to drainage area. The exception to this is Basin 1 on the North side of the lake which is relatively high in both nitrogen and phosphorus compared to similar drainage areas. Total contributions of nitrogen and phosphorus were highest for Hemlock Creek (36%-N, 45%-P). Septic systems from all subbasins were determined to contribute 23 % of the phosphorus entering the lake.

The nutrient budget in WSU's second report indicates a slight shift in total contribution of phosphorus. Moore (1990), reported that the most important sources of phosphorus, in order of relative contribution, are Basin! (North side of Lake), Hemlock Creek, Sucker Creek, Basin 5, and internal loading within the lake. Drainage area appears to be closely related with nutrient contributions with the exception of Basin 1. Relative contributions of nitrogen in order of magnitude was reported as Hemlock Creek, Basin 1, Sucker Creek, and Basin 5.

The 1990 WSU data shows the highest annual concentration of nitrogen to be associated with Basin 1 and the W54 inlet (Carnine Road Area). The highest annual concentration of phosphorus was associated with Basin 1 and Inlet A.

The Conservation District implemented an "Intensive Storm Survey" approach to water quality monitoring during spring of 1993. This involves monitoring during a storm event in an attempt to obtain samples along the rising and falling limb of the storm hydrograph. In addition, 3 days of monitoring are conducted following the event as the hydro graph recedes toward baseflow. Somers (1987) defined a storm event as any rain storm with an intensity and duration capable of delivering .8 inches of water within a 24 hour period. J.B. Baichtel (local resident who maintains a weather station) informed the District of the occurrence of a storm events in the watershed. The morning of March 23, 1993, J.B. Baichtel reported that a storm delivered 0.8 inches of rain during the night. Streams were sampled from March 23, 1993 to March 25, 1993 and again from March 29, 1993 to March 31, 1993. During the evening of March 29, 1994 the watershed received an additional .2 inches of rainfall.

Sample Sites

Fifteen sampling sites and one duplicate "control" sample per day resulted in sixteen sample sets (refer to appendix 31 for sample site location and description). Sites were selected to encompass the diverse land use, local geology, and to correlate with data gathered in previous studies by Washington State University (1975 & 1988). Additionally, sites were selected to evaluate cause and effect relationships by subwatersheds. Subwatershed size averages 1500 acres.

Sampling Parameters

The preliminary focus for the water quality monitoring phase was phosphorus. Since phosphorus is generally delivered to a stream bound to soil particles, samples were analyzed for suspended sediment, Orthophosphate as phosphorus, and Total Phosphorus as phosphorus. Nitrogen is also of interest due to the N:P ratio associated with vegetative growth, public concern for fertilization practices, and to allow correlation with WSU's work. Samples were analyzed for Nitrogen as Ammonia-N and Total Nitrogen-Kjeldahl. Discharge, temperature (tools: Taylor water temperature and pocket thermometers), pH (tools: Hanna HI-8424 meter), and specific conductivity (tools: Hanna HI-8633 meter0 were measured in the field.

Discussion

General water use criteria classes are used to establish water quality standards for surface waters in the state of Washington (Washington Administrative Code (WAC), Chapter 173-201). The streams in the Silver Lake watershed are classified as Class AA (extraordinary). According to WAC 173-201-045, "Water quality of this class shall marketly and uniformly exceed the requirements for all or substantially all uses." Uses include but are not limited to, water supply, stock watering, fish and shellfish, wildlife habitat, recreation, commerce and navigation. Water quality criteria has been developed for several water quality parameters. Criteria will be identified when available for each of the parameters analyzed during this project. Water quality data can be found in appendix 32.

Both total nutrient loading and nutrient concentrations are important in identifying alternatives for reducing nutrient input to the lake. Concentrations are indicative of landuse effect on nutrients, while total contribution may indicate the cumulative impact an area has on water quality. Both aspects need to be considered in the development of management recommendations to minimize nutrient delivery to Silver Lake.

Discharge

Discharge is the amount of water passing a point in a given period of time and is usually expressed in cubic feet per second or cubic meters per second. Discharge was measured or estimated at each sample site to assist in estimating total loads. Discharge was measured using a "Price" velocity meter where safe access to the stream was available. At several sites, depth of stream or velocity of the flow did not allow measuring discharge directly. At these sites, stream cross sections had been surveyed at low flow, and discharge was estimated using the rating curve developed by the Soil Conservation Service. The sample site at Canal road posed a problem for measuring or estimating discharge. During high steamflows water over tops the road in several locations. Discharge at Canal Road was estimated based on the discharges of 4 upsteam sample sites.

Sampling began at or slightly after the peak streamflow. Streamflows continued to decline throughout most of the sample period. The watershed received .2 inches or rainfall the evening of March 29, 1944. The additional rainfall resulted in increases in flow for two road ditch sample sites. Streamflows did not increase but remained the same on March 29 thru March 30. Discharge for the individual subwatersheds was found to be highly dependent on drainage area.

Temperature

Water temperature governs the rate at which chemical reactions occur and effects the lives of most aquatic organisms because their body temperature is usually near the water temperature.

State Standard for Temperature

Temperature shall not exceed 16.0 degrees C (60.8 degrees F) due to human activities. Temperature increases shall not, at any time, exceed t = 23 / (T +5), where "t" represents the maximum permissible temperature increase measured at a dilution zone boundary; and "T" represents the background temperatures measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge, provided that temperature increase resulting from nonpoint source activities shall not exceed 2.8 degrees C, and the maximum water temperature shall not exceed 16.3 degrees C (61.3 degrees F).

When conditions exceed 16.0 degrees C, no temperature increase will be allowed that will raise the receiving water temperature by greater than 0.3 degrees C.

Air and water temperature was measured at each of the water quality sampling stations during the March sampling period. Water temperature is collected to compare with state standards and is used in calculating standards for other water quality parameters. It was not anticipated that temperature problems would exist during the rainy season (October-March), therefore, air and water temperatures were also collected at the end of several stream reachers during stream inventories (July-September) for comparison with state standards.

During the sampling program the average temperature for the sites was 8.0 degrees C, the maximum was 13.3 degrees C, and the minimum was 5.3 degrees C. The maximum temperature was collected from a road ditch sample site. The maximum temperature for a free flowing stream was 9.4 degrees C.

Temperatures collected during stream inventories identified some concerns (refer to stream temperature map in appendix 33). Sites 3 and 4 on Hemlock Creek showed temperatures above standards on 7/21/92. Surveys were not conducted on reaches below the railroad crossing until late September. Give the lack of riparian vegetation along the stream through the lower reaches stream temperature is expected to continue to rise. The west tributary of Sucker Creek showed temperature well above state standards from the Weyerhaeuser railroad crossing to the 1310 road. Buffer strips retained along the stream experienced heavy blowdown and the stream flows in a east-west direction exposing the stream to solar radiation throughout most of the day. A large wetlands exists on the mainstream of Sucker Creek and was considered a concern for stream temperature due to its size and lack of effective shade. A temperature of 15.4 degrees C was recorded on 8/24/92 at the outer of the Beaver pond. Downstream temperatures quickly returned to an 11-12 degrees C range.

Total Suspended Solids (TSS)

Total suspended solids consist of both organic and inorganic particles able to be carried in the water column. The organic component includes vegetal and faunal matter. The inorganic component consists of sands, silts, clays and colloids (clay size and smaller) of various minerals which in time will settle out of water. The concentration of total suspended solids is usually greatest during early stormflow (before peak discharge). The laboratory analyzed the samples using EPA method 160.2. The method reporting limit is 5 parts per million (ppm).

Currently, state standards do not exist for total suspended solids.

Concentrations of TSS ranged from non detectable at or above the method reporting limit (5ppm) to 210 ppm.

The two road ditches sampled carried the highest concentrations of TSS and had concentrations above the reporting limit on each of the sampling dates. Concentration ranged from 8 ppm to 210 ppm. The highest concentrations were collected during a slight increase in ditch flow resulting from .2 inches of rainfall the night of March 29, 1993. The total daily load from these sites ranged from 8 to 125 pounds per day.

Total suspended solids concentration were similar for the upstream sites on Hemlock Creek. Near the mouth at Canal Road, TSS concentration dropped off significantly. The reduction in concentration is attributed to channel storage, deposition on the floodplain, and the wetland area that Hemlock Creek traverses above Canal Road. During the first day of sampling, TSS ranged from 18-22 ppm for the upstream sites on Hemlock Creek and 7 ppm at Canal Road. TSS concentrations dropped rapidly on subsequent days to below the detection limit of 5 ppm. Daily loads ranged from non detectable (ND) to 22,566 pounds per day at the upstream sites and from ND to 9045 (lbs/day) at Canal Road. This information indicates that 50-60 percent of TSS are removed from Hemlock Creek before it reaches Canal Road.

Sucker Creek and several unnamed streams along the South side of the lake exhibited similar concentrations of TSS. Concentration were slightly lower than those in Hemlock Creek.

Concentrations ranged from 6 to 16 ppm. These streams generally dropped off to a non detectable level on subsequent sample days. However Southeast Creek (Site SE2) concentrations continued to rise as discharge receded.

Total Phosphorus

Total phosphorus measures the amount of particulate and dissolved phosphorus in water. Particulate phosphorus can be either an inorganic or organic form; Inorganic particulate phosphorus is mineral in nature and is delivered to the stream primarily by soil erosion. Organic particulate phosphorus comes from a variety of sources and can be delivered to the stream by runoff or from direct deposit. Dissolved phosphorus is generally in the form of phosphate compounds as orthophosphate, condensed phosphates, or organically bound compounds (EPA, 1991). The laboratory analyzed total phosphorus using EPA method 365.3. The method reporting limit is 0.01 parts per million (ppm).

Currently, State standards do not exist for total phosphorus.

The highest concentrations of total phosphorus (fP) were found at the road ditch sample sites. TP ranged from 0.08 to 0.22 and averaged. 0.14 ppm. Peak concentrations at these sites corresponded. with the peak discharge and decreased. with discharge during the first three days of sampling. Concentrations increased during the second three days of sampling when the ditchflows had become minimal.

Total phosphorus concentrations were very similar for Hemlock Creek, Sucker Creek and the unnamed streams around the lake. Concentrations ranged from 0.02 to .12 and averaged. 0.06 ppm. Peak concentrations corresponded with the peak discharge, but remained fairly constant during subsequent sampling days.

Concentrations below the outlet structure ranged from 0.04 to 0.05 and averaged 0.043 ppm.

With similar concentrations, daily loads become very dependent on discharge. As mentioned earlier, discharge for the subwatersheds is highly dependent on drainage area. Therefore, daily nutrient loads are highly dependent on drainage area.

The sample data supports the idea that phosphorus is delivered to streams through erosional processes.

Figure 10.1 illustrates the relationship between total phosphorus and total suspended solids.

Figure 10.1 < Not available digitally - displayed on typewrite copy version of SLWMP only >

Orthophosphate

Orthophosphate refers to dissolved soluble and plant available phosphorus. Concentrations are expressed as phosphorus. Currently, no state standards exist for orthophosphate. The laboratory analyzed total phosphorus using EPA method 365.3. The method reporting limit is 0.01 parts per million (ppm).

The highest concentration of orthophosphate were found at the road ditch sample sites and corresponded with the highest ditch flow, At these sites orthophosphate ranged from 0.01 to 0.07 and averaged 0.05 ppm. Although concentrations were highest during peak ditchflow, concentration dropped and remained fairly consistent during subsequent sampling dates.

Streamflow concentrations remained fairly consistent throughout the sampling period. Concentrations ranged from 0.01 to 0.06 and averaged 0.022 ppm.

As with total phosphorus, orthophosphate daily loads are highly dependent on drainage area.

Total Nitrogen Kjeldahl

Kjeldahl nitrogen is a measure of organic nitrogen and total ammonia. Currently, no state standards exist for Kjeldahl nitrogen. The laboratory analyzed samples using EPA method 351.4. The method reporting limit is 0.1 parts per million (ppm).

Road ditch samples (map sites 13 and 14) and Southeast Creeks (map site 5 and 6) had the highest concentrations of Kjeldahl nitrogen. Concentrations at the road ditch sites remained fairly consistent or increased with decreasing discharge throughout the sampling period. Road ditch concentrations ranged from 0.70 to 1.4 and averaged 1.0 ppm. Southeast creeks concentrations were highest on the first day of sampling and tend to decrease rapidly with decreasing discharge. Southeast Creeks concentrations 0.3 to 1.3 and averaged 0.57 ppm.

The remaining streams exhibited fairly consistent concentrations and were comparably lower than the road ditches and Southeast Creeks. Concentrations tend to decrease with decreasing discharge. Concentrations ranged from 0.10 to 0.70 and averaged 0.36 ppm.

Ammonia

Ammonia is the product of mineralization of organic nitrogen. Ammonia does not persist in soils because it is oxidized by microbes into nitrite and nitrate forms of nitrogen. Ammonia can be toxic to fish and other aquatic organisms. Impacts can be immediate (acute) or occur over time (chronic) depending on the concentration. The laboratory analyzed the samples using EPA method 353.3. The method reporting limit is 0.05 parts per million. This limit is not sensitive enough to allow for comparisons of the data with the chronic concentrations provided by the state standard which are generally less than 0.02 ppm.

State Standard for Ammonia

Ammonia toxicity is dependent on pH and water temperature. State water quality standards provide formulas to calculate the acute and chronic concentrations. The formula for acute concentrations provides a l-hour concentration not to be exceeded more than once every three years. The formula for chronic concentrations provides a 4-day average not to be exceeded more than once every three years.

The small-unnamed-untyped stream at Vanhorn road (map code 12) exceeded the calculated acute and chronic toxicity concentration on all 6 sample days. Ditchflow on Hall road (map site 13) exceeded standards during the last 5 days of sampling.

Hemlock creek concentrations were non-detectable (< 0.05 ppm) for most of the sampling days. Detectable concentrations were observed during the first day of sampling at two sites but did not exceed state standards.

Sucker Creek and most of the unnamed streams sampled on the south and west side of the lake had concentrations less than the reporting limit (0.05 ppm) during the sampling period. However, Southeast Creeks (map codes 5 and 6) had concentrations above the state standards for acute toxicity during the first three days of sampling (highest runoff).

Summary

The sample period did not fulfill the intentions of the intensive storm survey approach employed. The intention was to sample a storm event to obtain water quality data as streamflows increased, peaked, and receded then by waiting a week obtain data when streamflow was relatively low. The nature and timing of the storm event resulted in a sampling period that began at peak streamflow. Therefore, data was not collected during increasing streamflows, the period when concentrations of total suspended solids are generally greatest.

Estimates of daily loads support the conclusion derived by Washington State University that nutrient loads are highly dependent on drainage area. Similarly the data supports the exception to this generalization. The basin on the North side of the lake delivers a disproportionately elevated load than suggested by its drainage area. Ditchflows repeatedly exhibited the highest concentrations with the exception of ammonia. Vanhorn Creek samples exceeded State Standards for ammonia during the entire sample period. Although the creek is not considered a fish bearing stream it may be indicative of small streams draining similar landuse. The data suggests that prolonged human activity tends to increase water quality problems. In an undisturbed environment, nutrient cycling is fairly consistent and nutrient loads being delivered to streams fairly constant. Human activities can result in additions to the nutrient cycle (fertilizers, septic systems, soil disturbances) that taxes natures ability to buffer waterways. Road ditches improve the efficiency by which sediment and nutrients can be delivered to streams. The data supports the emphasis placed on the road network as a critical problem in the watershed.

Temperature was not a concern during the winter sampling period. However, single point temperature data collected in the summer months during stream surveys indicate that problems may exist for Lower Hemlock Creek and the West Tributary of Sucker. The lower reaches of Hemlock Creek were also identified as a concern during the stream surveys from a channel stability perspective. Efforts to correct one concern would compliment efforts to correct the other.

Recommended Alternatives

1) Implement a program to improve shade along the lower reaches of Hemlock Creek. This alternative should be conducted in conjunction with efforts to reduce bank erosion.

2) The Conservation District should establish a temperature monitoring program on the Lower reaches of Hemlock Creek to determine the extent of temperature problems and provide background data to evaluate the effectiveness of any activities to improve shading.

3) Establish and maintain a long term water quality monitoring program to determine if implementation activities are achieving the desired effect. This should include above and below sampling of individual implementation activities to allow for cost/benefit comparisons and may require additions to the phase II project. The District should provide assistance when possible for a instream sampling component.

Implementation to Date

Phase II of the Silver Lake Restoration Project provides for long term monitoring of lake water quality. This phase has been contracted with KCM. The District has been assisting KCM with sample site information.

CHAPTER 11

Implementation Strategy

The Silver Lake Watershed Management Plan (Plan) recommendations are to be implemented on a voluntary basis. The ultimate goal of improving management of resources in the Silver Lake watershed is the responsibility of the community. The Watershed Advisory Committee (Committee) emphasized that community involvement is the key to maintaining or improving water quality in the Silver Lake watershed.

The Plan developed through the Committee and the Conservation District is designed to grow with the needs of the community. It provides a foundation for decisions and a means for facilitating action on resource management issues in the watershed. The Plan is only as strong as continued community involvement.

The Committee offers the following recommendations to encourage implementation:

- Encourage community awareness of the existence and contents of the Silver Lake Watershed Management Plan. Cowlitz County should schedule public meetings to introduce the plan to the community. Local media should be used to encourage participation in these public meetings. Cowlitz County should follow-up with a response to comments or questions asked at public meetings. This should be incorporated into the Plan as an addendum.

- The Silver Lake Watershed Management Planning Advisory Committee should evolve into an Implementation Committee and meet at least once a year. This committee should coordinate implementation of the Plan.

- A "lead" entity or individual should be identified by the Implementation Committee as a committee member to maintain continuity.

- The Cowlitz Conservation District and Cowlitz County should maintain an active role during implementation of the Plan

Implementation Guide

The following provides a suggested course of action for implementing the Plan recommendations:

I. Maintain a liaison between the watershed Community, Cowlitz County, and the Conservation District.

II. Explore and identify sources of funding to assist with implementation.

III. Share information and develop an education program that addresses concerns for:

A. Rural Residential Issues

1. Awareness of the Management Plan and recommended alternatives
2. The Growth Management Act
3. Sound septic system management
4. Awareness of existing codes/regulations
5. Information fact sheet concerning phosphorus in the environment
6. Lawn and garden management
7. Runoff management

B. Forest Lands / Roads Issues

1. Use of technical and financial assistance for planning and implementing harvest activities
2. Information concerning the opportunities and techniques for improving management of natural resources.
3. Current listing of sources of available technical and financial assistance
4. Information on how to use road inventory information and road maintenance

C. Streams

1. The importance of riparian zones of influence
2. Increase awareness of available technical and financial assistance for riparian management practices
3. Emphasize hydrologic assessments for County zoning and permitting processes with regard to new construction.
4. Encourage regulatory agencies to allow prescription management of riparian zones of influence

D. Agricultural Issues

1. Use of available technical and financial assistance for planning and implementing agricultural activities
2. Current listing of sources of available technical and financial assistance
3. Information concerning the opportunities and techniques for improving management of natural resources with regards to agricultural use.

IV. Action Items

A. Rural Residential Recommended Actions:

1. Form a Local Improvement District (LID) to provide for:
    a. Encourage County to conduct an analysis study of the existing sewage treatment plant and collection system directed at the feasibility of future expansion of the system to service the area from Hall Road to Carnine Road.
    b. Encourage the County to expand the sewer system to service residential areas from Hall Road to Carnine Road. Expansion should consider public acceptance, installation costs, and concerns for additional burden of expense on residences currently being serviced by the system.
    c. Explore additional funding sources for expanding the sewer system.
2. Develop a committee (or subcommittee of the implementation committee) to work with Cowlitz County during development of ordinances under the Growth Management Act.
    a. The committee should encourage local codes and construction standards for the abatement of erosion and transport of sediment to surface waters.
    b. The committee should encourage local codes and construction standards for the abatement of runoff and other changes of a hydrologic nature.

3. Obtain data for current soil nutrient levels to assist in providing lawn and garden information concerning fertilizer use/needs in residential areas.

    a. Encourage local vendors to stock a, "Silver Lake", low phosphorus fertilizer mix for lawn and gardens.

    b. Provide technical information to local fertilizer vendors so they can make proper recommendations.

4. Encourage pesticides recovery program for rural and urban landowners.

5. Encourage County to construct a hazardous waste/pesticides collection site on the Silver Lake watershed.

B. Roads Roads Recommended Action

1. Utilize the road inventory information to identify the sediment contributing road reaches with the highest priority for improvements.

    a. Specific items to be addressed are identified in the Plan.

    b. Monitor effectiveness and suitability of maintenance recommendations.

    c. Encourage landowners and the County to incorporate the above mitigation measures into management plan for new road construction and continued monitoring for maintenance of the road system.

2. Encourage the local codes and construction standards for the abatement of erosion and transport of sediment to surface waters.

3. Minimize the use of the unimproved road system during wet weather months. Activities such as construction and road building should be scheduled during dry weather. Gain control over the access of the remaining roads in the watershed. Implement a plan to reduce road usage during hunting season (ie. green-dot method).

4. Explore the feasibility of routing polluted residential runoff through sewage treatment facilities.

5. Reduce the amount of contributing reaches through an active road closure plan. Closure should include permanent and temporary closures. Permanently closed roads should be ripped and soil returned to a productive condition (planted with trees or grasses). Temporarily closed roads should be properly drained to prevent erosion by installing waterbars and pulling culverts. Consideration should be given to the use of waterbars on spur roads. For an example a rocked over waterbar could direct runoff from the travelled surface and away from roadside ditches.

6. Facilitate county road construction with adequate road conservation measures to allow for future growth. Initially the roads will be over built with regard to cross drains or ditch capacity but they'll be in place when growth occurs.

7. Adhere to the Forest Practices rules and regulation for the placement of cross drains to avoid the build-up of erosive forces in ditches for new road construction. Incorporate forest practices

recommended cross drain spacings for correcting problems with road reach lengths identified during the inventory.

C. Forest Land

1. Encourage the use of available technical and financial assistance for planning and implementing harvest activities. Encourage local agencies to provide cost share incentives for landowners to use these practices.

2. Avoid soil disturbing activities in riparian zones of type 4, 5, and ephemeral draws. Design and plan harvest units to yard material away from channels instead of across. When channel crossing is unavoidable, strive for full log suspension to minimize streambank disturbances. Minimizing the number of crossing locations for ground-based equipment. Use conservation measures including critical area seeding, bank shaping, and stream stabilization where soil disturbance is unavoidable. Consider directional felling, whole tree yarding, and establishment of equipment activity "use zones" outside riparian zones during harvest planning stages.
3. Avoid using ground-based equipment, including skidders and dozers, for harvesting during wet periods. The potential for soil compaction and displacement increases with soil moisture. Operations should be suspended or mitigating practices used when soil displacement and compaction becomes evident (for example when rutting exceeds 4 inch depth). Techniques to reduce soil impacts such as encouraging slash accumulations on skidtrails should be considered. Layers of slash can aid in supporting equipment, reduce the ground pressure exerted on soil by machinery, and help minimize soil displacement.
4. Whenever possible, utilize cable yarding systems, one pass shovel logging, or designated skidtrails to minimize soil disturbance. By laying out skidtrails in advance and tailoring timber felling to the layout, the area of soil disturbed can be greatly reduced.
5. Ground cover plantings should be used on all disturbed soil areas that have the potential of eroding and being delivered to the stream system. Establish protective cover prior to the first winter.
6. Install waterbars on skidroads or corridors that do not have natural breaks to reduce delivery of water and sediment directly to the stream.

D. Streams

1. Provide assistance to the landowners along lower Hemlock Creek in slowing natural erosion processes that threaten property. Opportunities

may exist through grants and agency cost share programs to assist in the implementation of such a project.

2. Encourage the establishment and wise use management of riparian zones rather than non-use set asides.
3. Establish a monitoring schedule for the trash rack under the railroad grade on Hemlock Creek. Cleanout activities should be planned to slowly release water stored by the debris and to totally remove stored debris from the system.
4. Plan prescriptions for the management of buffer zones. The primary purpose of this part of planning is to avoid unnecessary stream damage as a result of windthrow. Prescription should consider retention of trees (current regulations), the felling and retention of sufficient woody debris in areas prone to windthrow, and management of riparian zones to encourage establishment of coniferous species. (Forest Practices and Shorelines of the State). Incorporating management opportunities in the regulations for landowners, may encourage the establishment and perpetuation of healthy riparian areas.
5. Long term forest management objectives should strive for an uneven age distribution (both spatial and temporal) across the watershed.
6. Encourage wetland development (ie beaver activity or man-made structures) in the upper watershed to provide energy dissipation, sediment storage, and improved hydrologic conditions.

E. Agriculture Recommended Actions

1. Implement streambank protection including bio-engineered, revegetation, and rip- rap projects to minimize/reduce erosion problems associated with agricultural landuse.
2. Encourage the implementation of pasture management systems optimizing hydrologic values while meeting landowner objectives. Including but not limited to:
    a. Re-seeding, rotation grazing, deferred grazing, winter confinement, nutrient management...
    b. Maintain or upgrade existing facilities or management tools (ie fencing, water facilities)
    c. Encourage management for optimum pounds of livestock produced per acre rather than numbers of animals.
    d. Improve hay and pasture conditions on all fields to a "GC" good condition category. This is, the forage production meets landowner needs hydrologic needs, and water quality needs.

e. Encourage improved pasture maintenance
f. EXPLORE new technology that may decrease the cost of improving agricultural conditions.

3. Encourage the use of alternative livestock water source including pipelines and troughs and rocked/controlled stream access. (Recognize that this practice is site specific and will vary with individual farmers needs.)

4. Encourage use and application of pesticides and nutrients, WHEN USED*, according to plant needs and label instructions. *NOT INTENDED TO ENCOURAGE THE USE OF PESTICIDES AND FERTILIZERS.

5. Manage water table on low-lying pastures (eg, manipulate lake level as tool for vegetation management)

6. Encourage local agencies to provide cost share incentives for landowners to use these practices.

F. General

1. Explore and generate alternative means to achieve implementation.

2. Apply for grants to implement projects.

3. Establish demonstration projects or field trials.

4. Explore the economic and technological feasibility of implementing a dredging program (Morre, 1990).

Information and Education Strategy

Being a voluntary Plan, the Committee feels that a strong information and education (I&E) program is the cornerstone of implementation. The Implementation Committee with guidance from the Conservation District should be directly responsible for developing and implementing the program. A suggested course of action for an education and information program is provided above. The following provides the committees' suggestions for approaches to be considered in the development of the final strategy for each of the I&E recommended alternatives in the Plan.

I. Public Meetings - For sharing the Plan document and available information with the community. Meetings should be held in the community to encourage attendance (ie. Silver

Lake Grange, Toutle Lake High School, ...)

A. introductory meeting to share the completed Plan with the Community

B. Series of subsequent meetings to cover individual action items identified in the Plan.

1. Base emphasis or priority on public support for the action item.
2. Generate a means to target the attendance of appropriate audience.

C. Annual update meetings

D. Continued participation in Cowlitz County's Silver Lake Advisory Committee meetings

1. Designate subcommittee to report progress.
2. Solicit new ideas.

E. Technical Workshops to share ideas for better management

1. Coffee Clatches
2. Demonstration Areas
3. Field Trials
4. Guest speakers

II. Sharing information:

A. Mailings

1. Meeting notices
2. Informational Fact Sheets

B. Newspaper Articles

1. Meeting Notices
2. Meeting Summaries
3. Feature stories on plan implementation projects.

C. Community newsletter

1. Meeting notices
1. Meeting Summaries
2. Informational Fact Sheets
3. Technical updates and Implementation notes

D. Radio

1. Meeting notices

E. Flyers

1. Meeting notices
1. Informational Fact Sheets
2. Meeting highlights
3. Field Trips/workshops

F. Community Grange

III. Educational Programs

A. Work with local schools when possible for classroom and field projects (eg. streamside planting projects).

B. Establish volunteer groups (ie adopt-a-stream type program)

1. Streamside planting projects
1. Road maintenance demonstration groups

C. Workshops for natural resource management

IV. Update New Residents of Watershed Activities and Plan Recommendations

A. Welcoming committees

B. Attachments to Silver Lake building permit

Plan Progress and Evaluation

The Silver Lake Watershed Management Plan is intended to be a document that grows with the communities needs. The Plan needs to be continually evaluated to determine if goals and objectives are being met and whether the recommended alternatives are effective.

The goals and objectives for the Plan are:

GOAL:

Identifying and managing the sources of phosphorus in the Silver Lake watershed.

Since phosphorus tightly binds to soil particles and movement of phosphorus occurs when soil is displaced through erosion processes, this goal was translated to "find and correct" erosion problems in the watershed.

The objectives for reaching the goal include:

1) Preparing a watershed management plan for voluntary implementation.

2) Inventorying land uses and identify elements of each landuse that have potential to result in soil disturbance.

3) Establishing a watershed advisory committee both technical and functional to review the inventory data and generate the recommended management alternatives.

4) Involving the public whenever possible, both one-on-one and in groups, during the inventory process to encourage information sharing.

The objectives for the Plan will have been met when the final draft of the Plan has been completed and accepted by Cowlitz County. Half of the goal statement has been reached (Identifying sources of phosphorus). Managing sources of phosphorus is the portion of the goal statement that will continually need to be evaluated. The recommended alternatives are the mechanism by which sources of phosphorus are to be managed. By evaluating the effectiveness of implementation practices, Plan success can be evaluated.

Long term water quality monitoring is the most effective means to evaluate if the Plan is being effective. KCM consultants will be monitoring lake and stream water quality over the next 5 years. This data will be utilized to determine if there is a net improvement in lake water quality.

Individual recommended action items should be monitored to allow for adaptations and to identify details that have been effective. Evaluation should be the responsibility of the committee, landowner implementing the practice, and the resource agency or group providing technical assistance. Some guidelines for short term evaluations follows:

- Cooperation and communication among landowners and agencies helping to implement the recommendations is essential. Sharing experiences helps develop the most economical and effective method of implementation.

- Evaluations should be conducted at least annually.
- Evaluations should focus on the objective of the individual treatment. For example, if the objective is to establish ground cover on bare soil than the evaluation should focus on ground cover distribution, density, and quality characteristics.
- Photo documentation is a valuable tool to document effectiveness. Photos are useful in developing an information and education program based on the successes/failures of a practice. Photo documentation relies on a few key points including repeatability and clear definition of what is being shown. Repeatability refers to the ability of someone being able to photo the same before treatment location and take the exact same picture in the future. A clear statement, or caption, is needed to identify the photo and key viewers into the photos purpose.
- For individual implementation activities considered to have a major impact on a water quality parameter, collecting water quality samples above and below the project site would be appropriate means of evaluating the practice's effectiveness.
- Revisiting problem sites identified in the inventory after treatment of the problem, and re-evaluating the location using the same inventory process could be an excellent tool.

Projected Cost of Implementation

Assuming one hundred percent implementation of the recommended alternatives, the projected cost of implementation is $535,586. Table 10.1 provides a breakdown of components, costs, and assumptions used to arrive at this figure.

Overall Assumptions:

1) The Cowlitz Conservation District would be the entity with responsibility for developing and delivering information based on an Implementation Committee's guidance.

2) A majority of the technical assistance in planning, designing, and implementing projects would be through the District planning process in accordance with Soil Conservation Service standards.

3) Sewer system analysis and expansion would be accomplished through consultants.

Table 10.1 Breakdown of Implementation Costs

ITEM DESCRIPTION	STAFF DAYS	MISCELLANEOUS COSTS COST PER UNIT	UNIT	TOTAL COSTS
I. Exploring and Applying for Funding Assistance	20			
SUBTOTAL	20			
II. Information and Education Costs				
Meetings (Meeting notices, mailing, material preparation, attending)	24	$20	mtg.	$480
14 Informational Fact Sheets (development and delivery)	56	$300	sheet	$4200
4 Classroom Presentations (development and delivery)	8	$10	pres.	$40
24 Newspaper Articles (development and delivery)	12			
6 Group Presentations (arrange, develop. & delivery)	6	$10	pres.	$60
SUBTOTAL	106			$4780
III. Action Items Cost and Assumptions				
A. Rural Residential				
Maintain Liaison with County	3			
Collect Baseline Soils Data (Collect and analyze 15 samples)	7	$20	samp.	$300
Share Information with Fertilizer Vendors	1			
Coordinate with Implementation Committee	24			

B. Roads				
Landowner/County Technical Assistance	10			
C. Forest Land				
Landowner Technical Assistance (planning w/ 59 landowners)	180			
D. Streams				
Landowner Assistance	30			
fencing 6 miles (1 side)		$1	foot	$31680
Streambank protection 1 mile		$70	foot	$369600
riparian plantings 6 miles, 25' wide		$500	mile	$3000
E. Agriculture				
Landowner Technical Assistance (47)	141			
12 Alternative water sources		$1000	each	$12000
F. Monitoring				
Annual Monitoring of Plan Implementation	5			
Individual project monitoring	15			
SUBTOTAL	415			$404580
IV. Sewer System Analysis and Expansion(1)				
V. Miscellaneous Expenses (office supplies film, vehicles ...)				$10000
SUBTOTAL				$10000
TOTALS	542			$419360
OVERALL COST (@ $ 192.30/day)	$104,226			$431360

[1] Dollar figure is not available at this time. Cowlitz County is currently in the process of recieving statements of qualifications for generating a general sewer plan for the Toutle area in accordance with WAC 173-240-050. This process will identify costs and is expected to be completed by spring of 1995.