Winchester Lake and Upper Lapwai Creek

Total Maximum Daily Load (TMDL)

prepared for

Winchester Lake Watershed Advisory Group

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1.0 EXECUTIVE SUMMARY

Background

Winchester Lake is located within the exterior boundaries of the Nez Perce Reservation as established by the 1863 Treaty with the Nez Perce. The lake sits approximately 30 miles southeast of Lewiston, Idaho, and one-half mile south of the town of Winchester in Lewis County. Winchester Lake is a manmade reservoir, created by the damming of Lapwai Creek in 1910, and is the focal point of 318-acre Winchester Lake State Park. The reservoir and its watershed lie entirely within the Nez Perce Reservation. The lake has a surface area of 100 acres, drains a watershed of 7,800 acres, and acts as a settling basin for the watershed.

Land coverage includes approximately 3,419 acres of forest and rangeland, 3,295 acres of dryland crops, and 697 acres of pasture. Land uses in the Winchester Lake watershed consist of dryland farming, grazing, timber harvesting and recreation.

Winchester Lake currently hosts populations of rainbow trout, largemouth bass, black crappie, black bullhead, yellow perch and tiger muskie. All these populations have been introduced to the lake and all are self-reproducing except tiger muskie, which are sterile. Naturally produced rainbow trout have been documented in recent years (1993-1996) in Winchester Lake and have probably occurred throughout the history of the lake.

Upper Lapwai Creek is the largest tributary to the lake, contributing about 70% of the average annual flow. The creek drains an area of 5,950 acres and has a stream length, including all tributaries, of approximately 27 miles. Fish species in the drainage include native redband and planted rainbow trout, sculpin, largemouth bass, and black bullhead.

Water Quality Problems

Citizen complaints of poor water clarity, odors and decline in angler success have led to several water quality studies at Winchester Lake since the mid-1980's. Blue-green algal blooms develop frequently, and periodic fish kills have occurred. All studies indicate Winchester Lake is severely eutrophic. A 1990 U.S. EPA Clean Lakes Program study identified the lake water quality problems as frequent nuisance algal blooms, poor water clarity, inadequate dissolved oxygen for fish, and concern over the potential for bacterial contamination.

Excessive sediment loading, degraded habitat and elevated temperatures are also having an adverse effect on redband trout and other native fish populations in Upper Lapwai Creek. Monitoring indicates that fine material is accumulating in pools and is clogging gravels which could be used for spawning. Low fish densities are believed to be a result of these impacts. Elevated concentrations of phosphorus and nitrogen compounds are also contributing to algae growth in certain areas of the creek, and Lapwai Creek is a major source of nutrients to the lake.

Actions to Date

The 1990 Clean Lakes Program Phase I study developed a lake restoration plan to address nutrient related problems. The restoration plan identified specific management activities for the watershed with the goal of reducing sediment and nutrient loading to the lake. A range of goals was provided because there was some uncertainty regarding the amount of phosphorous load reductions that will result from the combination of recommended watershed management and lake restoration techniques.

The Winchester Lake Phase II Implementation and Restoration Project began in June 1990 and concluded in 1995. Best Management Practices have been implemented throughout the watershed by private landowners, the Nez Perce Tribe, and the Idaho Department of Parks and Recreation with assistance from the Lewis Soil Conservation District, Natural Resources Conservation Service, and the State of Idaho.

Beneficial Uses Affected

Water quality problems in Winchester Lake and Upper Lapwai Creek are primarily impacting aquatic life such as cold and warm water fish species. Elevated bacteria levels in Upper Lapwai Creek are also impairing recreational uses. Designated beneficial uses for Winchester Lake include drinking water, agricultural water supply, cold water biota, primary and secondary contact recreation. Designated beneficial uses for Lapwai Creek include salmonid spawning drinking water, agricultural water supply, cold water biota, primary and secondary contact recreation. Since Winchester Lake is within a State Park, it is also designated as a special resource water.

Parameters of Concern

Parameters of concern listed in the Idaho 1994 §303(d) list for Winchester Lake are: nutrients, sediment, dissolved oxygen, temperature, flow, habitat alteration, pathogens, and pesticides. Upper Lapwai Creek is listed for six parameters: sediment, nutrients, temperature, pathogens, flow and habitat alteration. Pollutant sources in the Winchester Lake watershed include agriculture, silviculture, grazing, recreation, storm water, septic systems and the internal nutrient cycling from lake bottom sediments. These nutrients that cycle from lake bottom sediments originate from various sources within the watershed.

Total Maximum Daily Loads (TMDLs)

Total Maximum Daily Loads (TMDLs) are water quality management plans required under the Section 303(d) of the Clean Water Act for waters determined to not meet state water quality standards. The goal of a TMDL is to restore beneficial uses and achieve state water quality standards. Winchester Lake and Lapwai Creek were identified on Idaho's 1994 and 1996 303(d) lists as not meeting state water quality standards, and requiring TMDLs.

Since Winchester Lake and Lapwai Creek lie within the Nez Perce Reservation, a Memorandum of Agreement (MOA) was developed between the Nez Perce Tribe, the Environmental Protection Agency, and the State of Idaho Division of Environmental Quality to develop the TMDL, with the advice of the Winchester Lake Watershed Advisory Group. The MOA provides that all parties have agreed to use Idaho's Water Quality Standards in the TMDL development.

As additional information becomes available during implementation of the TMDL, the targets, loading capacity, and allocations may need to be changed. In the event that data show that changes are warranted, TMDL revisions will be made with the assistance of the Winchester Lake Advisory Group. Although specific targets and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether these targets and allocations are met, but whether beneficial uses and state water quality standards are achieved and maintained.

The following discussion explains how all the listed parameters were addressed by the TMDL, and the attached table summarizes pollutant loading and allocations.

Phosphorus

Past water quality studies of Winchester Lake have indicated that excessive levels of nutrient compounds in lake waters and lake bottom sediment cause nuisance algae growth that causes depleted oxygen in the lake's deeper waters during the summertime/early fall. This oxygen depletion, combined with warm water in the lake's upper layers, greatly reduces the volume of water in the lake that supports a cold water fishery to less than 16% of the total lake volume. This TMDL estimates reductions in phosphorus loading to Winchester Lake needed to ensure that increased dissolved oxygen levels meet dissolved oxygen criteria, and that a sufficient volume of the lake meets both the dissolved oxygen and temperature criteria to fully support a cold water fishery.

The estimated total phosphorus load to the lake based on averaging past studies is 1926 lbs/year. The estimated necessary load reduction is 62% or 1187 lbs/year. This estimated reduction is based on two models that determine a load capacity based on desired in-lake phosphorus and dissolved oxygen levels. To achieve this reduction, a reduction of 741 lbs/year in the estimated phosphorus coming into the lake from Upper Lapwai Creek is allocated in the TMDL, which is 74% of the Creek's estimated phosphorus load of 1001 lbs/year. The rest of the estimated reduction (446 lbs) is proposed to be accomplished from in-lake management techniques that reduce the release of phosphorus from lake bottom sediments. To maximize the effectiveness of implementation, reductions from Upper Lapwai Creek should be achieved before in-lake management methods are applied. Nutrients are best controlled at the source before reaching the lake.

Nutrient reductions necessary to support beneficial uses in Upper Lapwai Creek are also evaluated in the TMDL. This evaluation determined that a 57% reduction in the total phosphorus loading to Upper Lapwai Creek would be needed during the algal growth season. This reduction is less than the 74% reduction estimated to be needed in Upper Lapwai Creek to meet the lake target. Thus, the reduction needed to meet the lake target is expected to resolve nutrient problems in Upper Lapwai Creek as well.

Sediment

Sediment is degrading the water quality of Upper Lapwai Creek and Winchester Lake. The sediment analysis indicates that major sediment reductions are needed to improve water quality and the fisheries of both the stream and the reservoir.

Fine sediments are inhibiting the native redband trout's ability to reproduce and flourish in Upper Lapwai Creek. The amount of fine sediment accumulating in the low gradient areas of the stream channel needs to be reduced. Overall, about a 90% reduction of the existing sediment load is needed to improve the fishery. Sediment entering Winchester Lake also needs to be reduced in order to reduce the amount of nutrients that they carry. These nutrients are one of the major causes of low dissolved oxygen levels in the reservoir.

Reducing erosion and sediment delivery through implementation of Best Management Practices will help improve water quality in Winchester Lake and Upper Lapwai Creek. The major sources of sediment are surface and stream bank erosion. Agricultural lands are likely the largest contributor of sediment, and both surface and bank erosion occur on these lands. The second major source of sediment is stream bank erosion on pasture lands.

Temperature

Winchester Lake

During the summer, the surface of the lake heats up considerably and adversely affects cold water species such as trout. Water cool enough for coldwater species ($<19^{o}$ C daily average) only occurs at a depth of 1.5 meters or greater within the lake. However, water below 2.5 meters has inadequate dissolved oxygen levels. As a result, only a narrow 1 meter layer of water exists during the summer which has adequate temperature and dissolved oxygen; 84% of the water column is uninhabitable by trout and other coldwater species.

The temperature analysis has concluded that temperature in the lake is elevated primarily because of the shallow nature, large surface area, and relatively low flow through the lake. Little can be done to change these conditions, or reduce the surface temperature of the lake. Therefore, the goal of the temperature TMDL is to increase dissolved oxygen in the deeper water by decreasing nutrient input, thereby allowing trout and other species to utilize the cooler water which meets the temperature criteria year-round. Additional detail on the effects of nutrients and control measures are included in sections regarding Phosphorus and Implementation Plans.

Upper Lapwai Creek

A temperature TMDL for Upper Lapwai Creek was established to address impaired salmonid spawning and rearing uses in the watershed. Solar radiation currently raises water temperatures in Lapwai Creek above the prescribed state water quality standards for salmonid spawning (9°C daily average) and coldwater biota (19°C daily average). Management activities within a watershed, such as removing riparian shade trees, harvesting of conifer overstory, grazing in riparian areas, and introducing bedload sediment which results in increased stream surface area, can increase the amount of solar radiation entering a stream.

The amount of heat energy (*i.e loading capacity*) which would meet state water quality temperature standards in the creek was determined by applying a modeling technique. Model results indicate that a 38% - 87% increase in shade is necessary in order to attain and maintain state water quality standards, depending on the stream reach. In addition to stream shade, other factors such as narrowing and deepening of the channel, colder water temperature from improved segments upstream, or increases in flow, may also help to decrease temperatures.

Bacteria

Fecal contamination from animal and human sources can cause illness in people swimming or fishing in lakes and streams. In the past, bacteria concentrations in Winchester Lake were quite high, likely due to improper sewage disposal. These problems are believed to have been corrected by the construction of a sewage lagoon for Winchester in 1972 which discharged to Lapwai Creek below Winchester Lake. Although recent data are not available, >98% of samples collected in 1988 were below the applicable standards.

Sampling in 1988 and 1993 indicates that fecal coliform levels exceeded state water quality standards at several locations within the Lapwai Creek drainage, but samples from other tributaries to the lake met the standards. Lapwai Creek is the most significant tributary to the lake, contributing 70% of the annual flow. Since Lapwai Creek is such a significant contributor to the lake, and since it appears that Winchester Lake meets bacteria standards, it was concluded that a bacteria TMDL for Upper Lapwai Creek would be adequately protective of both the creek and lake.

The sources of bacteria in Lapwai Creek are largely unknown, but it is suspected that cattle grazing in the watershed are a significant source. Improperly operating septic systems and other methods of sewage disposal may also be contributing at times.

Although data are extremely limited, it appears that a 90% reduction in bacteria concentrations at the mouth of Lapwai Creek would be needed to ensure that state water quality standards are met at all times.

Due to the age and limited nature of the bacteria data, a sampling effort is being planned for 1999 to reassess bacteria concentrations in Lapwai Creek and Winchester Lake. These data will be used to revise the bacteria load allocations set for Upper Lapwai Creek.

Pesticides

In 1985 low levels of DDT, hexachlorobenzene and hexachlorocyclohexane were found in trout and bullheads in Winchester Lake, prompting the listing of pesticides on the 1994 303(d) list for Winchester Lake. The primary concern was that there may be a health threat to individuals who regularly consume fish from the lake over a long period of time. To better establish whether pesticides in fish posed a problem, the USEPA, IDEQ and IDFG collected five fish species (trout, bullheads, perch, muskie, and largemouth bass) in April 1998 from five locations within the lake, and analyzed tissue samples for pesticides.

DDT compounds, hexachlorobenzene, triallate, and DDMU were detected in tissues samples, with the highest concentrations in bullheads. Analysis of these data indicates that the risk of health effects from eating these fish is very low, and does not exceed risk levels used to establish state water quality standards. As a result, a TMDL for pesticides has not been developed, and it is planned to remove pesticides from the 303(d) list for Winchester Lake.

Flow and Habitat

Flow and habitat are identified in the 1994 303(d)list as impairing uses in Winchester Lake and Upper Lapwai Creek This TMDL does not address flow and habitat issues because it is unclear whether these parameters are required to be addressed under Section 303(d) of the Clean Water Act. If EPA determines that TMDLs are required for water quality problems caused by flow and habitat modification, TMDLs will be developed.

Implementation Plan

The next step after completing the TMDL is to develop an implementation plan which spells out the actions needed on the ground to meet the goals of the TMDL. Implementation of Best Management Practices within the watershed will be on a voluntary basis.

A restoration plan to reduce excessive nutrients in Winchester Lake was developed as part of the Clean Lakes Study. The plan recommended a combination of agricultural, forestry, riparian, and direct runoff Best Management Practices; sedimentation basins and gully plugs; community education; and in-lake management techniques. These suggestions can be a starting point for developing an implementation plan for phosphorus for this TMDL.
Suggested agricultural Best Management Practices included conservation tillage, divided slope, stripcropping, grassed waterways, livestock stream crossings, fencing , small sedimentation basins and improved fertilizer management. Riparian Best Management Practices suggested to stabilize banks included terracing, fencing, livestock access ramps, log drop structures,

development of alternative livestock water sources, and vegetative plantings. Techniques for reducing erosion will also reduce phosphorus loading since the majority of phosphorus is associated with sediment. However, further study will be necessary as part of the implementation plan to identify the source of and best methods to reduce dissolved phosphorus.

The Clean Lakes Study recommended aluminum sulfate treatment as an in-lake management technique.   Other options considered include hypolimnetic aeration, phosphorus inactivation through chemical treatment of surface in-flows, dredging, and full lake aeration.   As part of this phased TMDL, the necessity of in-lake management techniques can be evaluated once the effectiveness of external source reductions has been determined.

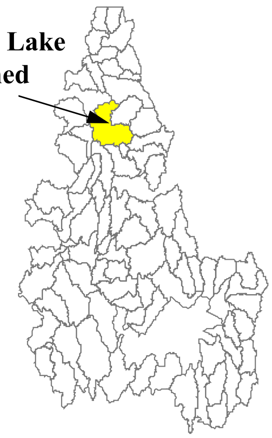
Implementation measures to address temperature concerns in Upper Lapwai Creek will likely be similar to measures needed to control sediment and phosphorus and include the following: 1) increasing riparian vegetative shade in various sub-watersheds, 2) reducing sediment input into Upper Lapwai Creek, 3) restoration of headwater reaches.

Techniques to reduce bacteria levels in Upper Lapwai Creek and its tributaries are less clear until the sources are further identified. In other Idaho watersheds with grazing activity, measures to control runoff from these operations has been a common practice to reduce bacteria levels.

Winchester Lake and Upper Lapwai Creek Loading and Allocation Summary

Pollutant	Waterbody	Target (s)	Subwatershed	Load	Load allocation	Reduction needed
Nutrients/DO	Winchester L.	37 ug/l total phosphorus		1926 lb/yr	739 lb/yr	62%
	Lapwai Cr.	50 ug/l total phosphorus (May thru Oct.)		42 lbs/month	18 lbs/month	57%
Sediment	Winchester L.	total reductions in sediment to Winchester Lake are the same as cumulative reduction in Upper Lapwai tributaries (LP6)		571 tons/yr	43 ton/yr	93%
	Lapwai Cr.	Improving trend in average annual sediment load with natural background as interim target and full support of salmonid spawning and cold water biota uses as the ultimate measure of success.	LP-1	322 tons/yr	21 tons/yr	93%
			LP-2	122 tons/yr	13 tons/yr	89%
			LP-3	234 tons/yr	18 tons/yr	92%
			LP-4	526 tons/yr	36 tons/yr	93%
			LP-5	555 tons/yr	40 tons/yr	93%
			LP-6	571 tons/yr	43 tons/yr	93%
Pathogens	Winchester L.	TMDL determined to be unnecessary				
	Lapwai Cr.	< 500 cfu/100 ml - at all times > 200 cfu/100 ml - <10% of samples over 30 days < 50 cfu/100 ml - geo. mean in 5 samples over 30 days		1.9E10 cfu/day @ 0.37 cfs	1.8E09 cfu/day @ 0.37 cfs	90%
Temperature	Winchester L.	Phosphorus/dissolved oxygen TMDL established as a surrogate for the temperature TMDL				
	Lapwai Cr.			**(j/m2/sec)**	**(j/m2/sec)**	**Shade increase needed**
		78% shade	LP-1	225.6	68.9	50%
		92% shade	LP-2	297.6	25.1	87%
		79% shade	LP-3	3.3.9	65.8	76%
		78% shade	LP-4	283.1	68.9	54%
		79% shade	LP-5	244.4	65.8	57%
		95% shade	LP-6	134.7	15.7	38%
Pesticides	Winchester L.	TMDL determined to be unnecessary				
Flow	Winchester L.	TMDL not developed until it is determined that TMDL's are required for impairments due to flow alteration				
	Lapwai Cr.	" "				
Habitat	Winchester L.	TMDL not developed until it is determined that TMDL's are required for impairments due to habitat alteration				
	Lapwai Cr.	" "				

2.0 WATERSHED ASSESSMENT



TMDL AT A GLANCE

Sub-basin(s):	Lower Clearwater
Uses affected:	Coldwater biota, salmonid spawning and rearing, secondary and primary contact recreation
Water quality concerns:	Nutrients, sediment, dissolved oxygen, temperature,
pathogens,	pesticides
Sources considered:	Nonpoint sources - agriculture, livestock grazing, timber harvesting

2.1 WATERSHED CHARACTERIZATION

General Description

Winchester Lake is located within the exterior boundaries of the Nez Perce Reservation as established by the 1863 Treaty with the Nez Perce. The lake sits approximately 30 miles southeast of Lewiston, Idaho, and one-half mile south of the town of Winchester in Lewis County. It is the focal point of 318 acre-Winchester Lake State Park and is surrounded by conifer forest. In 1910, the headwaters of Lapwai Creek were dammed to produce Winchester Lake. Tributary creeks above the lake are Big Springs, Scoles and Johnson Creeks (Moeller,1986). The lake was formed to serve as a mill pond, but by 1963 most of the marketable large-diameter timber in the area was harvested and the lake ceased to be used as a mill pond. The Idaho Department of Fish and Game purchased Winchester Lake from Potlatch Forests Inc. in 1966. In 1969, the Idaho Department of Parks and Recreation assumed management of the land surrounding the lake and developed Winchester Lake State Park (Moeller,1986). The City of Winchester, located on the north shore of the lake, discharged its municipal wastes via septic systems until the new wastewater facility became operational in 1972. Wastewater from the City of Winchester is now discharges downstream from the Winchester Lake outlet.

Winchester Lake has a surface area of 100 acres and receives surface runoff and groundwater supply from a tributary watershed drainage area of 7,800 acres and approximately one-third of the storm water runoff from the city of Winchester. The lake serves as a settling basin for the watershed. Lands are covered by: approximately 3,419 acres of forest and rangeland; 3,295 acres of dryland crops; and 697 acres of pasture.

Climate

Climatic data collected near Winchester Lake has recorded monthly precipitation from 1964 to present. Typically, summers are mild with air temperatures ranging from 80 to 95 Fahrenheit. Winters can be extremely cold with air temperature averaging about -15 Fahrenheit.

Summary of climate since 1964:

- average annual temperature: 42 Fahrenheit
- maximum summer temperature: 98
- minimum winter temperature: -40
- minimum January temperature: -26
- average annual precipitation: 24.76 inches
- maximum annual precipitation: 38.29 (1975)
- minimum annual precipitation: 17.90(1992)
- average winter snowfall: 94 inches
- intensity (2-year 24-hour rainfall): 1.5 inches

The majority of precipitation falls as rain during March, April, and May (Figure 1). During November, December, and January snow is the dominate form of precipitation. Monthly snow water equivalent is less than spring rainfall. Maximum monthly precipitation and peak stream flows is illustrated in Figure 2.

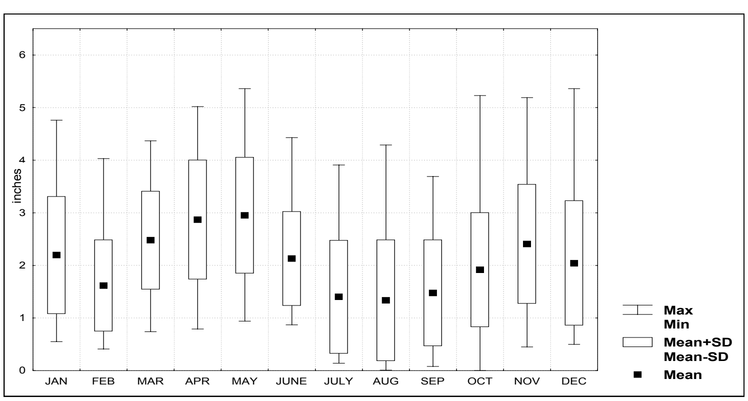


Figure 1. Duration Curve Illustrating Average, Maximum, and Minimum Precipitation by Month for the Period of Record (1995-1997)

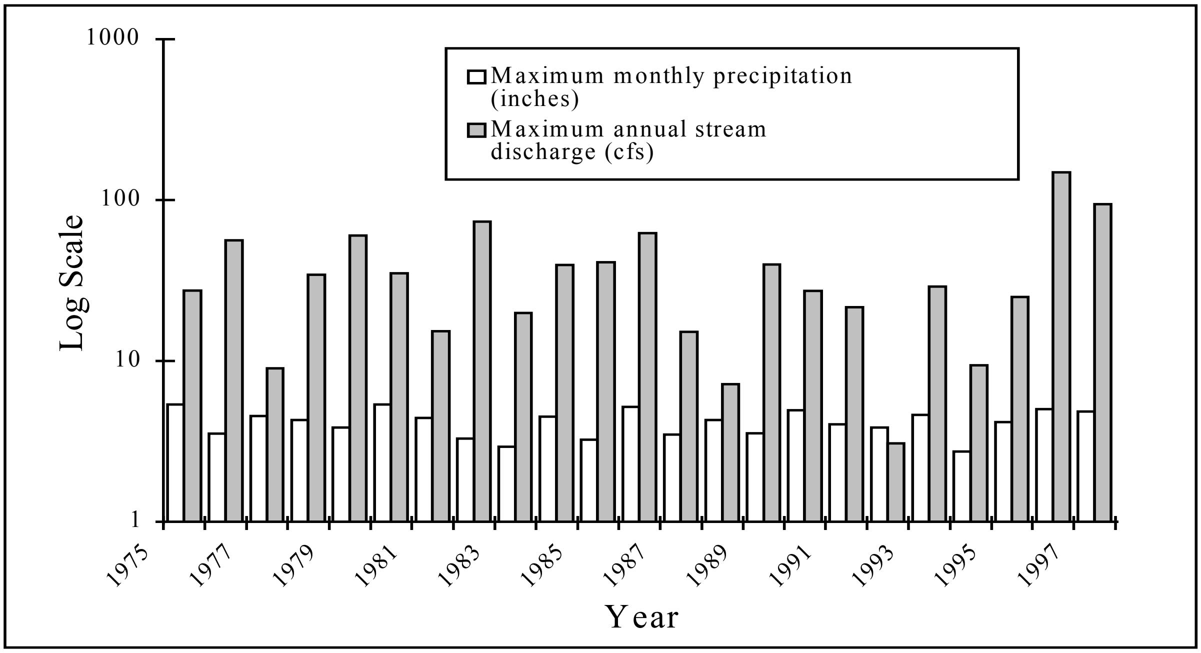


Figure 2. Winchester Lake Watershed Maximum Monthly Precipitation (1975-1997) and Annual Maximum Stream Discharge

Hydrology

Limited stream flow data exist for streams which drain into Winchester Lake. Latham (1986) measured Upper Lapwai Creek stream discharge 7 times during the 1985 water year. Entranco (1990) established a temporary stream gage on Upper Lapwai Creek and collected continuous stream stage from May 1988 to April 1989. Stream discharge was measured sixteen times and obtained high and low flow readings from 0.03 to 45.3 cfs. A smaller range of 0.08 to 20.2 cfs were measured by Wertz (1996) from October 1993 to May 1995.

According to Entranco (1990), the major source of inflow to Winchester Lake during 1988 and 1989 was surface runoff at 2,682 acre feet (79% of total). Total inflow to the reservoir, which includes stream inflow, groundwater inflow, precipitation, and direct runoff was 3,396 acre-feet. Total stream outflow in 1988 was 2,440 acre-feet (Associated Engineering Services, Inc., 1989). Total annual precipitation for these years was slightly above average (about 28 inches). Total annual precipitation when Wertz measured stream flow, was slightly below normal (Wertz, 1996).

A hydrograph was predicted for Upper Lapwai Creek to extend the flow record, characterize the extreme low and high flow regimes, and help validate flow estimates predicted using other models. The periodic stream flow data sets discussed above were regressed against data from a USGS stream gage, and a synthetic hydrograph was predicted for water years 1975 through 1997. For the details of this analysis refer to Appendix A.

This TMDL is concerned with two aspects of the hydrograph. First, the magnitude and frequency of flood events are important when trying to understand pollutant loading to the reservoir. Second, the magnitude and frequency of low flow events are needed to characterize the loading capacity of streams which drain to the reservoir.

Using the predicted hydrograph, the mean annual flood event or bankfull discharge is about 31 cfs. This flood event is defined as the channel maintaining flow and is used in the temperature TMDL to characterize average annual loading to the reservoir. The flood of record occurred in 1996 with a magnitude of about 150 cfs. This type of flooding is typically caused by either rain-on-snow or rain-on-frozen soil precipitation events. The 1996 flood was a result of a rain-on-snow event. Annual snow melt also generates higher flows, however, these events are small in comparison to rain-on-snow events. This point is illustrated in the data where the magnitude of annual peak stream flows do not correlate well with annual or monthly maximum precipitation (Figure 2).

Using the predicted hydrograph data, the minimum seven-day stream flow with a ten-year recurrence interval (7Q10) is about 0.48 cfs. For the temperature TMDL, this flow event is used to characterize the maximum amount of a pollutant a stream can assimilate and still meet state water quality standards. Low flows typically occur toward the latter part of the summer and continue through to at least November.

Winchester Lake and Upper Lapwai Creek were subdivided into fourteen subwatersheds (Figure 3 and Table 1). Upper Lapwai Creek is the largest watershed (9.3 mi^2) and contains six subwatersheds. Three smaller watersheds drain into Winchester Lake and range in size from 1.3 to 0.4 mi^2. Additionally, there are three face drainages which are less than 0.4 mi^2. Subwatershed drainage density is about 3 miles of stream per square mile.

The dominant aspect of the watershed is north; however, subwatershed aspect ranges from north-east to north-west (Table 1). The watershed is slightly dissected with a dendritic drainage texture. Elevation ranges from about 3900 feet (1189 meters) at Winchester Lake to 4639 feet (1414 meters) at Mason Butte. Physical and hydrological characteristics of the Winchester Lake subwatersheds are summarized in Table 1.

Lake Morphometry

The shape and depth of a lake basin greatly influence the response of a lake to pollutants entering the lake, particularly nutrients. Shallow lakes are more susceptible to eutrophication as a result of nutrient loading than deeper lakes. The ratio of watershed area to Winchester Lake surface area is large (88:1). Winchester Lake is a small, shallow lake with a flushing rate of 1.95 per year (Entranco, 1990). Physical and hydrological characteristics of Winchester Lake are summarized in Table 2.

Table 1. Summary of Winchester Lake subwatershed characteristics.

Subwatershed Code	Area (mi^2)	Stream Density (mi/mi^2)	Maximum Elevation (ft)	Minimum Elevation (ft)	Bankfull Discharge	Watershed Aspect
LP	9.3	2.9	4603	3902	31.0	NW
LP-1	2.8	3.3	4492	4008	9.4	N
LP-2	1.3	2.6	4603	3993	4.2	NW
LP-3	1.3	2.8	4390	3993	4.5	N
LP-4	2.0	2.5	4403	3997	6.7	NE
LP-5	1.3	3.2	4265	3902	4.2	NW
LP-6	0.6	2.3	4305	3902	1.9	NE
WW-1	1.3	2.1	4383	3910	4.4	NE
WW-2	0.4	1.9	4242	3918	1.4	E
WW-3	0.4	2.4	4167	3902	1.4	W
FD-1	0.1	0.2	4026	3902	0.4	S
FD-2	0.1	0	4026	3902	0.4	
FD-3	0.2	1.2	4059	3902	0.6	N
FD-4	0.04	0	4059	3902	0.2	
FD-5	0.1	0.9	4059	3902	0.2	

Table 2. Physical and Hydrological Characteristics of Winchester Lake (after Entranco,1990 with Update Based on IDL Mapping Effort)

Lake Surface Area	100 acres
Maximum Depth	35 ft
Mean Depth*	23 ft
Lake Volume	1,960 acre-ft
Drainage Basin Area	7,800 acres
Surface Lake Elevation	3,902 ft
Flushing Rate	1.95 $year^{-1}$

*Moeller, 1985

Geology

Bedrock geology consists primarily of basalt in the southern and western portions of the Winchester Lake watershed and granitic rocks in the northern and eastern portions (Figure 4). Overburden geology consists of basalt and granitic colluvium blanketed by loess, particularly in the immediate vicinity of the lake. A northwest-trending dip-slip fault has been mapped in the southeastern portion of the watershed.

Topography/Soils

Elevation of the Winchester Lake watershed ranges from 4,639 ft at Mason Butte to 3,902 ft at the lake surface. The slopes vary from 1% to 50% on forest land, and 1% to 20% on cropland. Soils in the watershed are primarily of forest origin (Boles-Joel complex, Johnson-Kruse complex and Johnson-Labuck complex) and can be classified as well-drained sandy to silt loams. The latter 2 soil types are classified as highly erodible. They are prone to erosion if left unvegetated by conventional tillage practices. Soils commonly associated with riparian areas are generally poorly-drained with a seasonally high water table, but not highly erodible. Soils distribution for the watershed is shown in Figure 5.

Fisheries

Winchester Lake was acquired in 1964 by Idaho Department of Fish and Game to provide sport fishing opportunity to the public. The lake was subsequently drained and cleaned of logs and debris remaining from its' operation as a mill pond. Since then, Winchester Lake has been host to many species of fish and has been chemically rehabilitated at least once to remove undesirable species.

Winchester Lake currently hosts populations of rainbow trout, largemouth bass, black crappie, black bullhead, yellow perch and tiger muskie. All these populations have been introduced to the lake and all are self-reproducing except tiger muskie, which are sterile. Naturally produced rainbow trout have been documented in recent years (1993-1996) in Winchester Lake and have probably occurred throughout the recent history of the lake. Fish species in Upper Lapwai Creek include native redband and planted rainbow trout, sculpin, largemouth bass, and black bullhead.

The majority of anglers at Winchester Lake fish for trout. The other species in the lake have either been illegally introduced or planted to diversify the fishery or control other species. For example black bullheads were illegally introduced to Winchester Lake. Bullheads quickly became well established, very numerous and relatively small. Bullhead numbers are currently controlled by predation from introduced largemouth bass. Winchester Lake now produces the largest black bullheads in the region because their numbers are relatively low.

According to Wertz (1996), Winchester Lake is the most intensively fished lake in North Central Idaho. An Idaho Department of Fish and Game study estimated that anglers spent over 43,000 hours fishing in Winchester Lake from January 15 to October 15, 1993. This represents approximately 430 hours of effort per acre annually, compared to Dworshak Reservoir that receives, on average, approximately 15 hours of effort per acre annually. Natural production of trout in Winchester Lake cannot provide for this level of use. To satisfy angler demand and meet IDFG fishery management objectives of 0.75 fish per hour in Winchester Lake, a stocking program is necessary. From 1990 to 1995 IDFG stocked an average of 46,538 fingerling and 30,594 catchable size trout per year. Current stocking level is 30,000 fingerling and 45,000 catchable size trout annually.

Trout are opportunistic feeders; their preferred food in Winchester Lake is zooplankton. During 1991-1993 IDFG studies showed 3-inch fingerling rainbow stocked in late May grew well through the summer and started contributing to the fishery in September as approximately 8-inch long fish. These fish continued to be caught throughout the ice fishery and into the spring months as 10- to 12-inch fish. Total estimated return was 10% numerically and 800% by weight. Estimated return of catchable size trout ranges from 60% to 80%.

Yellow perch were illegally introduced into Winchester Lake in 1993. The perch population may now exceed the trout population. Yellow perch will negatively affect the trout population by competing with trout for zooplankton, resulting in lower trout growth rates. Increased predation on zooplankton may also lead to larger phytoplankton blooms, due to decreased consumption by zooplankton which feed on phytoplankton.

The fact that the fishery in Winchester Lake has been relatively consistent over the past decades cannot be used as a relative judge of the water quality or environmental conditions in the lake. Favorable catch rates and successful trout fisheries are artificially created by stocking trout in Winchester Lake. Trout management in Winchester Lake exploits the productivity benefits of a eutrophic environment and gambles that the same eutrophic environment doesn't get pushed beyond the survival tolerances of trout.

Low dissolved oxygen levels in the hypolimnion during stratification periods and under ice cover can pose a significant problem for trout in Winchester Lake. Inadequate levels of dissolved oxygen has led to two fish kills, primarily trout, in Winchester Lake in winter 1992 and October 1994. The 1992 fish kill occurred when a thin layer of snow covered the ice. The 1994 fish kill occurred when the lake mixed. Several days before that mixing, IDFG had stocked the lake with 10,000 catchable trout.

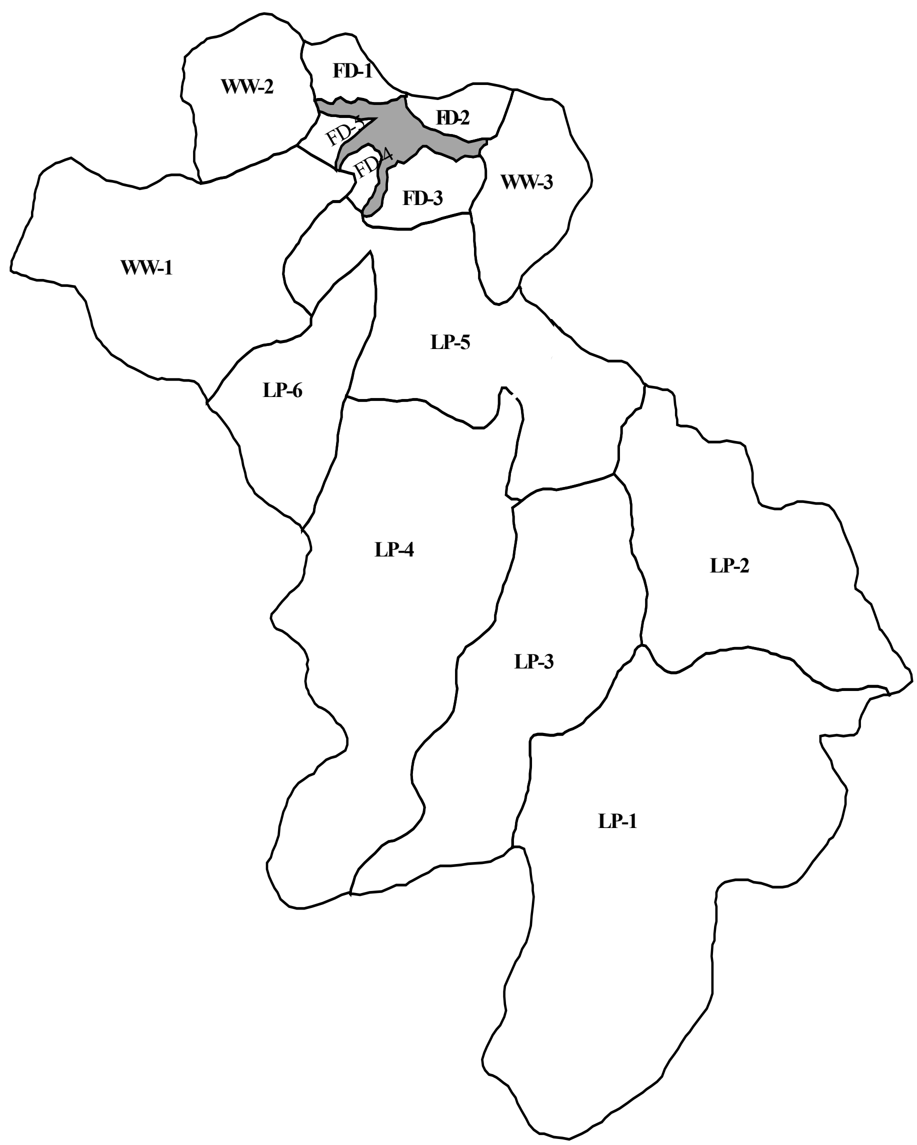


Figure 3. Winchester Lake Subwatershed Location Map

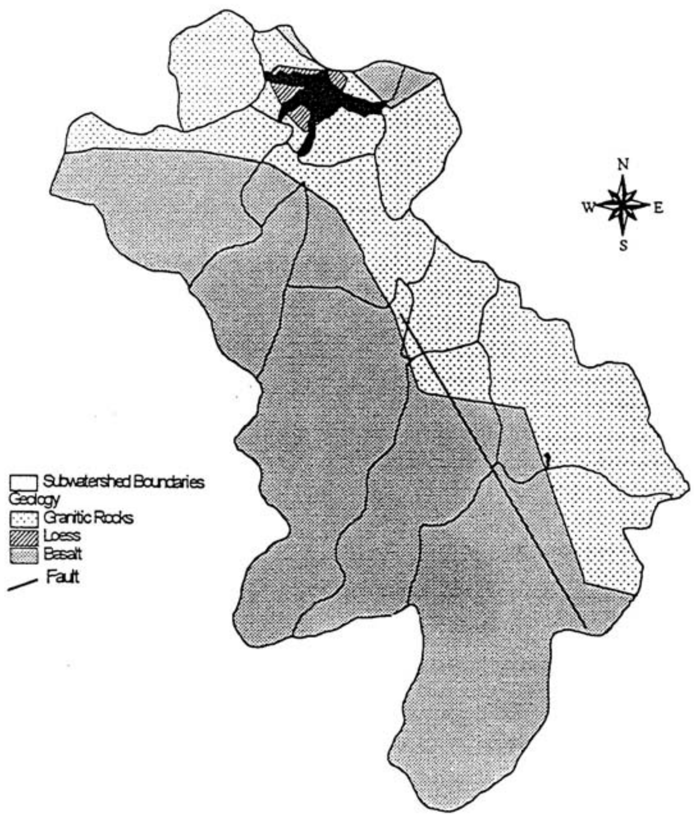


Figure 4. Winchester Lake Geology Map

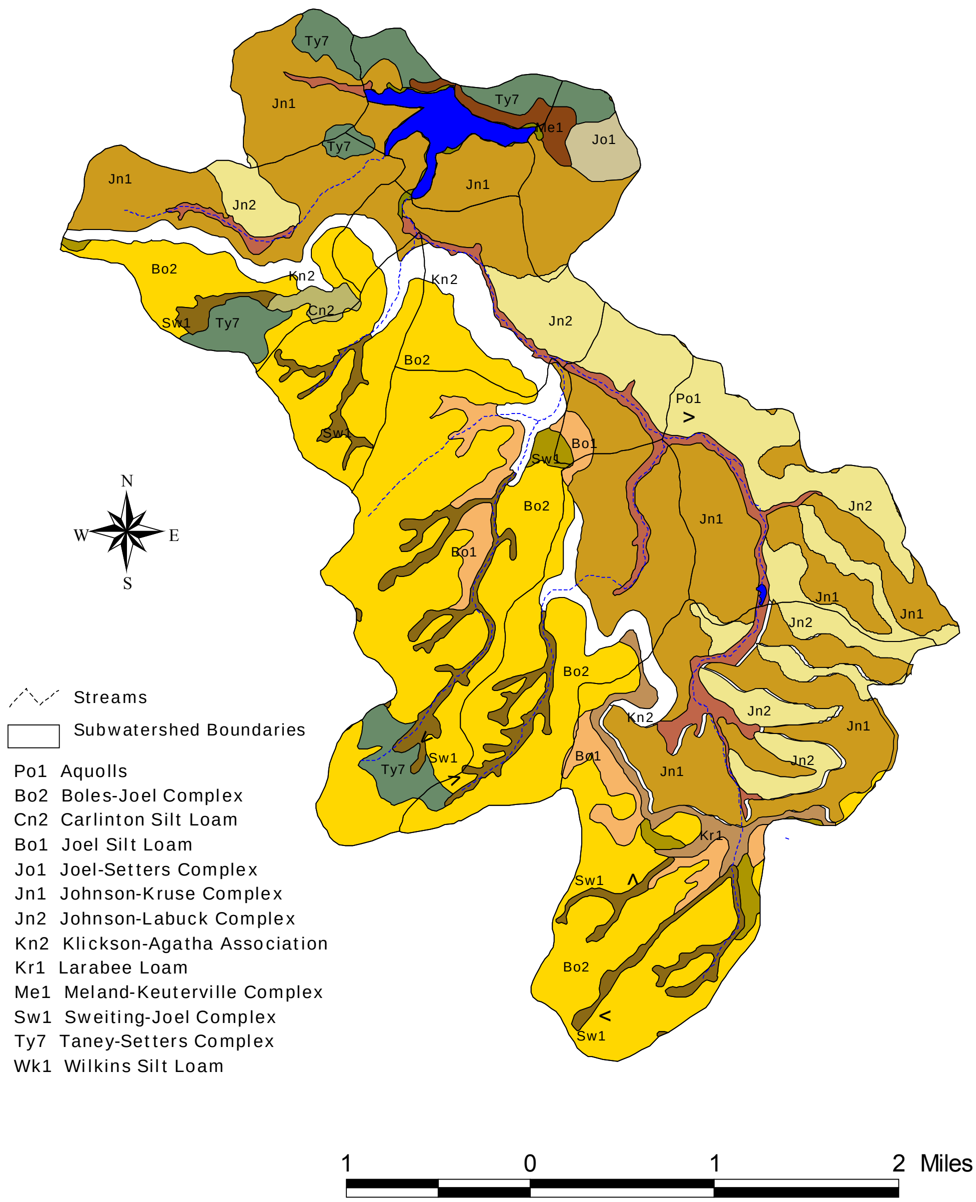


Figure 5. Winchester Lake Soils Distribution Map

Land Uses

Land uses in the Winchester Lake watershed are shown in Figure 6. Uses consist of: 1) cropland, 2) pastureland, 3) timber harvesting, 4) recreation. Land management, including past and present ranching, farming, and timber harvest, have converted range and forest land to agriculture causing patterned, persistent landscape disturbance. Fifty-two percent (3,992 acres) of the land in the watershed is comprised of crop and pastureland; 44% (about 3,419 acres) is used as forest and rangelands; and 2% (160 acres) is used for residential purposes (Table 3). Figure 7 shows land ownership in the Winchester Lake watershed. Five jurisdictions share the watershed: the State of Idaho Parks and Recreation, Idaho Fish and Game, Lewis County, the City of Winchester, and the Nez Perce Tribe.

The state park is open year-round for a variety of uses and has approximately 50,000 visitors per year. Boating (no gas motors), fishing, camping, picnicking and hiking are the primary summer activities. Ice fishing, ice skating and cross-country skiing are the main winter activities. The major park facilities are shown in Figure 8. Fishing is the major attraction at Winchester Lake (over 40,000 fishing hours per year). A wolf enclosure operated by the Wolf Education Research Center (WERC), under an agreement with the Nez Perce Tribe on tribal land, is expected to draw a significant number of visitors and subsequently increase visitation at Winchester Lake State Park.

2.2 WATER QUALITY CONCERNS AND STATUS

Federal Requirements for Water Quality Limited Waters

The Federal Clean Water Act (CWA) requires restoration and maintenance of the chemical, physical, and biological integrity of the nation's waters (Public Law 92-500 Federal Water Pollution Control Act Amendments of 1972). Each state is required to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the water whenever attainable.

Section 303(d) of CWA establishes requirements for states to identify and prioritize waterbodies that are water quality limited (i.e. waterbodies that do not meet state water quality standards). Current regulations require states to publish a priority list of impaired waters every 2 years.

For waters identified on this list, states must develop Total Maximum Daily Loads (TMDLs) set at a level to achieve state water quality standards. TMDLs are defined in 40 CFR Part 130 as the sum of the individual Waste Load Allocations (WLA) for point sources and Load Allocations (LA) for nonpoint sources, including a margin of safety and natural background conditions. In essence, TMDLs are water quality management plans that allocate responsibility for pollution reduction with a goal of achieving state water quality standards within a specified period of time.

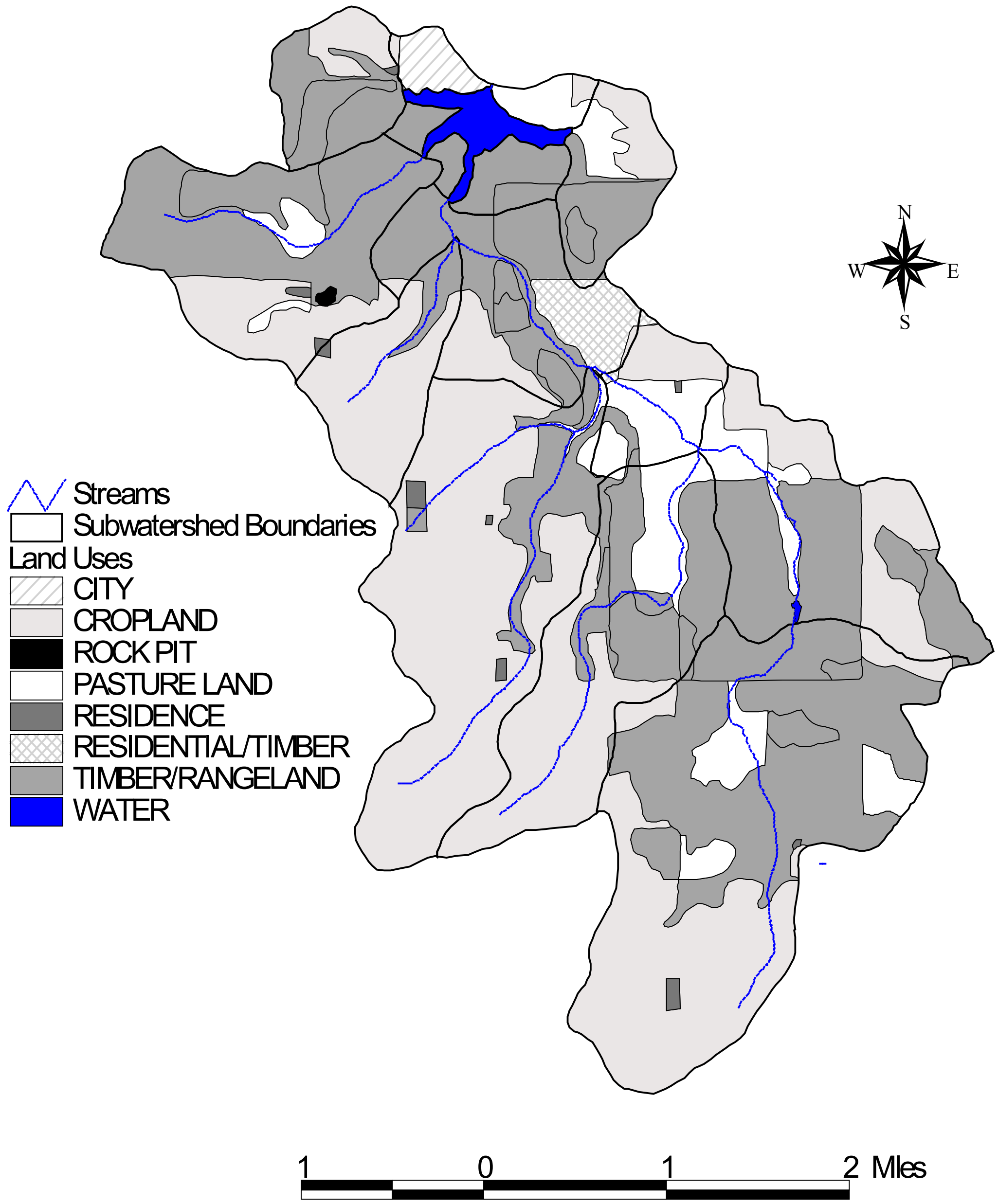


Figure 6. Winchester Lake Land Use Map

Table 3. Winchester Lake subwatershed land uses.

Land Uses	WW-1	WW-2	WW-3	LP-1	LP-2	LP-3	LP-4	LP-5	LP-6	FD-1	FD-2	FD-3	FD-4	FD-5	Total Acres
Cropland	204	72	76	710	264	396	1064	179	315	5	10				3295
Pastureland	52		46	156	103	121	20	139			60				697
Residential	6	2		8			14	2	2						34
Residential/ Timber			3					123							126
Rock Pit	5														5
Timber/ Rangeland	571	201	147	939	441	344	198	360	50			108	27	33	3419
Urban										70					70
Water					2										102*
Total Acres	**839**	**275**	**272**	**1813**	**810**	**861**	**1296**	**803**	**367**	**75**	**70**	**108**	**27**	**33**	**7748**

* This total includes 100 acre surface of Winchester Lake.

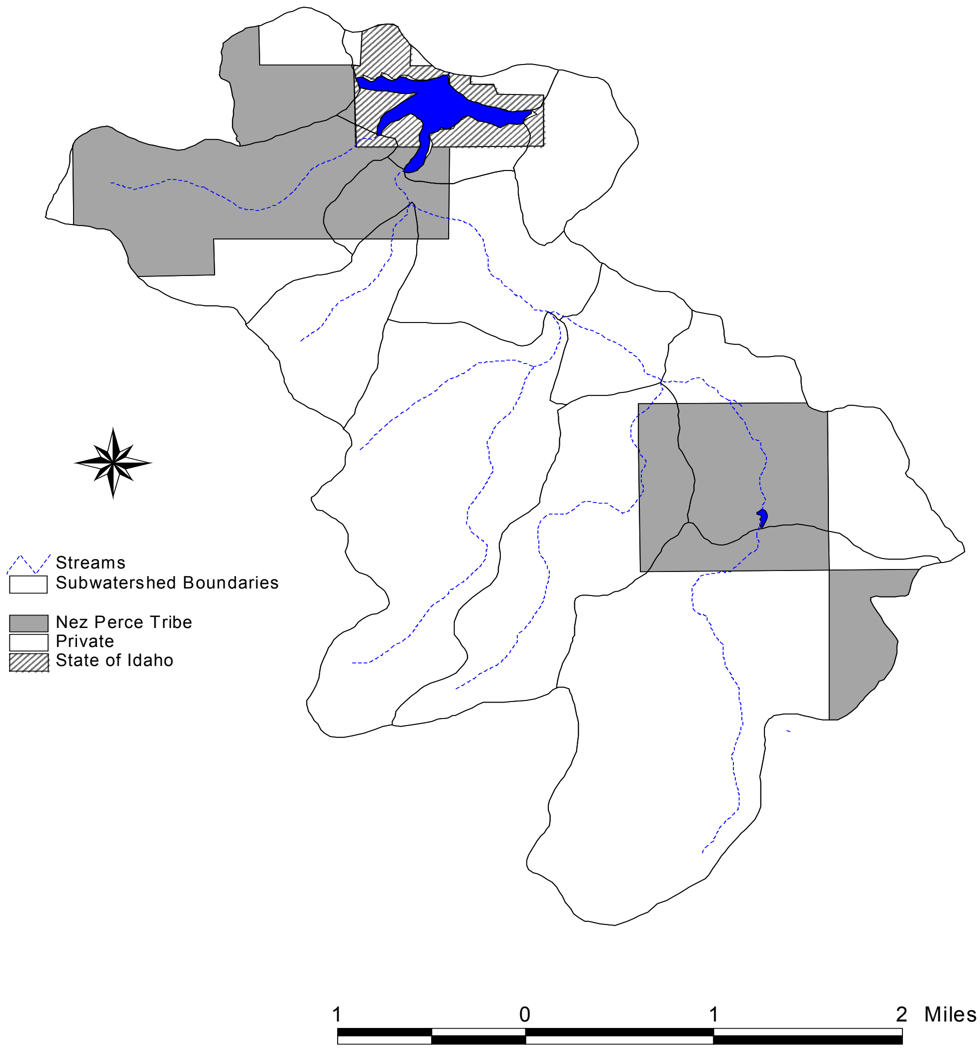


Figure 7. Winchester Lake Land Ownership Map

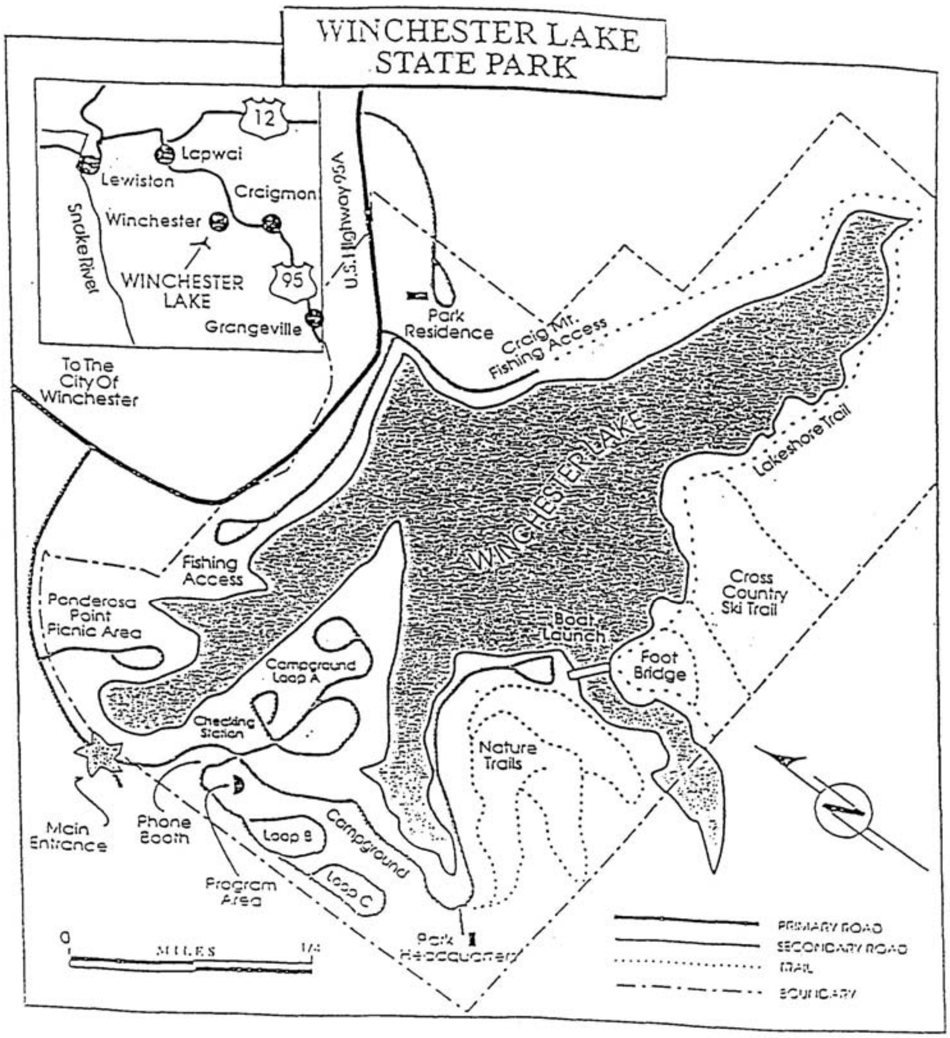


Figure 8. Winchester Lake State Park Facilities

Surface Water Beneficial Use Classification

Surface water beneficial use classifications are intended to protect the various uses of the state's surface water. Idaho waterbodies that have designated beneficial uses are listed in Idaho's Water Quality Standards and Wastewater Treatment Requirements (IDHW 1996). They are comprised of 5 categories: aquatic life; recreation; water supply; wildlife habitat; and aesthetics.

Aquatic life classifications are for waterbodies that are suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species. Aquatic life uses include cold water biota, warm water biota, and salmonid spawning.

Recreation classifications are for waterbodies that are suitable or intended to be made suitable for primary contact recreation and secondary contact recreation. Primary contact recreation (swimming, wading, etc.) depicts prolonged and intimate contact by humans where ingestion is likely to occur. Secondary contact recreation (fishing, boating, etc.) depicts recreational uses where ingestion of raw water is not probable.

Water supply classifications are for waterbodies which are suitable or intended to be made suitable for agriculture, domestic, and industrial uses. Wildlife habitat waters are those which are suitable or intended to be made suitable for wildlife habitat. Aesthetics are applied to all waters.

Designated Beneficial Uses of Winchester Lake and Upper Lapwai Creek

Beneficial uses identified for Winchester Lake in the *Idaho Water Quality Standards and Wastewater Treatment Requirements* are: domestic water supply, agricultural water supply, cold water biota, primary and secondary contact recreation (IDAPA 16.01.02). Beneficial uses identified for Upper Lapwai Creek are: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary and secondary contact recreation (IDAPA 16.01.02). Because it is in a state park, Winchester Lake is also designated as a special resource water.

Water Quality Criteria

Since Winchester Lake and Lapwai Creek lie within the Nez Perce Reservation, a Memorandum of Agreement (MOA) was developed between the Nez Perce Tribe, the Environmental Protection Agency, and the State of Idaho Division of Environmental Quality, stating that Idaho's Water Quality Standards will be used in developing the TMDL.

Idaho water quality standards include criteria necessary to protect designated beneficial uses. The standards are divided into 3 sections: General Surface Water Criteria, Surface Water Quality Criteria for Use Classifications, and Site-Specific Surface Water Quality Criteria (IDHW, 1996).

The following water quality criteria are applicable to pollutants of concern as listed on the 1994 303(d) list and uses designated for Winchester Lake and Upper Lapwai Creek.

IDAPA 16.01.02.200.01
Hazardous Materials. Surface waters of the state shall be free from hazardous materials in concentrations found to be of public health significance or to impair designated beneficial uses. These materials do not include suspended sediment produced as a result of nonpoint source activities.

IDAPA 16.01.02.200.02
Toxic substances. Surface waters of the state shall be free from toxic substances in concentrations that may impair designated beneficial uses. These substances do not include suspended sediment produced as a result of nonpoint source activities.

IDAPA 16.01.02.200.03
Deleterious materials. Surface waters of the state shall be free from deleterious materials in concentrations that may impair designated beneficial uses. These materials do not include suspended sediment produced as a result of nonpoint source activities.

IDAPA 16.01.02.200.05
Floating, Suspended, or Submerged Matter. Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities.

IDAPA 16.01.02.200.06
Excess Nutrients. Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.

IDAPA 16.01.02.200.07
Oxygen-Demanding Materials. Surface waters of the state shall be free from oxygen demanding materials in concentrations that would result in an anaerobic water condition.

IDAPA 16.01.02.200.08
Sediment. Sediment shall not exceed quantities specified in Section 250, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350.02.b. Subsection 350.02.b generally describes the BMP feedback loop for nonpoint source activities.

IDAPA 16.01.01.250.01.a
Primary Contact Recreation: between May 1 and September 30 of each calendar year, waters designated for primary contact recreation are not to contain fecal coliform bacteria significant to the public health in concentrations exceeding:

i. 500/100ml at any time; and

ii. 200/100 ml in more than 10% of the total samples taken over a 30-day period; and

iii. A geometric mean of 50/100 ml based on a minimum of 5 samples taken over a 30-day period.

IDAPA 16.01.01.250.01.b
Secondary Contact Recreation: waters designated for secondary contact recreation are not to contain fecal coliform bacteria significant to the public health in concentrations exceeding:

i. 800/100 ml at any time; and

ii. 400/100 ml in more than 10% of the total samples taken over a 30-day period; and

iii. A geometric mean of 200/100 ml based on a minimum of 5 samples taken over a 30-day period.

IDAPA 16.01.01.250.02.a.iv
iv. All toxic substance criteria set forth in 40 CFR 131.36(b)(1), Columns B1, B2 and D2, revised as of December 22, 1992, effective February 5, 1993 (57 FR 608-48, December 22, 1992) provided, however, the standard for arsenic shall be fifty (50) ug/L for Column D2. 40 CFR 131.36(b)(1) is hereby incorporated by reference in the manner provided in subsection 250.07.

IDAPA 16.01.01.250.02.c
Cold Water Biota: water designated for cold water biota are to exhibit the following characteristics:

i. Dissolved Oxygen Concentrations exceeding 6 mg/l at all times. In lakes and reservoirs this standard does not apply to:

(1) The bottom twenty percent (20%) of water depth in natural lakes and reservoirs where depths are 35 m or less.

(2) The bottom seven (7) m of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) m.

(3) Those waters of the hypolimnion in stratified lakes and reservoirs.

ii. Water temperatures of 22 ^{o}C or less with a maximum daily average of no greater than 19 ^{o}C.

iv. Turbidity below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than 50 NTU instantaneously or more than 25 NTU for more than ten (10) consecutive days.

IDAPA 16.01.01.250.02.d
Salmonid spawning: waters designated for salmonid spawning are to exhibit the following characteristics during the spawning period and incubation for the particularspecies inhabiting those water:

i. Dissolved Oxygen.

(1) Intergravel Dissolved Oxygen.

(a) One (1) day minimum of not less than five point zero (5.0) mg/l.

(b) Seven (7) day average mean of not less than six point zero (6.0) mg/l.

(2) Water-Column Dissolved Oxygen.

(a) One (1) day minimum of not less than six point zero (6.0) mg/l or ninety percent (90%) of saturation, whichever is greater.

ii. Water temperature of thirteen (13) degrees C or less with a maximum daily average no greater than nine (9) degrees C.

Past Water Quality Studies and Available Monitoring Data

Several evaluations of water quality conditions in the Winchester Lake watershed have been undertaken since the early 1980s. These studies document the eutrophic condition of the lake and the pollution impacts that come from the watershed.

1) <u>1972 IDHW Division of the Environment Study, Tulloch, 1972</u>. During August, Ed Tulloch and Mike McMasters conducted a limnological survey of Winchester Lake. A total of 6 stations were sampled on the lake for bacteriological and chemical analysis, dissolved oxygen and temperature. Secchi-disk transparency readings were determined as well as bottom depth soundings. Each station was also sampled with an Eckman dredge and a plankton net. Laboratory results for bacteriological quality indicated maximum concentrations to be located near the Winchester city side of the lake, probably due to domestic sewage discharge. The other

stations indicated lower coliform concentrations. Bottom dredge samples seemed to indicate bottom concentrations generally composed of bark and decaying wood along the eastern shore of the lake. The bottom samples of the western areas of the lake demonstrated no bark or decaying wood; mud, silt, and little aquatic life were present.

The August sampling showed that secchi-disk transparency ranged from 4 ft to 5.5 ft. Depth soundings at the several stations ranged from 13 ft to 32 ft. The dissolved oxygen, at a depth of 4 ft, ranged from 11.2 to 13.8 parts per million (ppm). Temperature, at a depth of 4 ft, ranged from 21.2 to 24°C. A dissolved oxygen and temperature reading were also noted on the bottom at stations 2 and 3, averaging 0.5 ppm and 13°C respectively.

2) Lapwai Creek Study, Idaho Department of Health and Welfare, 1980. A study done by IDHW-DEQ in 1979 indicated that water quality in Lapwai Creek was marginal with frequent bacteria violations and seasonally elevated turbidity and suspended sediment levels. However, the study focused on that portion of Lapwai Creek below Winchester Lake to the confluence with the Clearwater River, not the Winchester Lake watershed.

3) Idaho Department of Health and Welfare. Water Quality Status Report #61. Moeller (1986). Sampling was conducted by the Bureau of Water Quality in cooperation with the Idaho Department of Fish and Game over a 6-month period from May through October 1985. Measured parameters were selected to address the decline in water quality and fisheries.

Samples were collected every 2 weeks between May 7 and October 24, 1985, resulting in a total of 13 sample sets. Temperature, conductivity, and dissolved oxygen concentration profiles were determined at 1-m intervals from the surface to lake bottom on each sample date. Secchi disk transparency was measured in order to determine the euphotic zone, i.e. the area of effective light penetration, and the major region of primary production.

All water samples were immediately analyzed for pH. Water samples were analyzed for physical, chemical, and biological parameters at various frequencies within the general time frame of May through October. Euphotic zone samples were analyzed for chlorophyll *a*. Phytoplankton were collected 3 times: preceeding, during, and after the suspected period of maximum growth. Fish were collected with electroshocking methods on one occasion. Fish flesh from 2 species was analyzed for heavy metals and a wide spectrum of pesticides and herbicides. Sediments were collected every other month at the 6 sites with an Eckman dredge.

Moeller (1986) determined that Winchester Lake exhibited severe eutrophic symptoms. Anaerobic conditions and high temperatures were prevalent during summer. Secchi depths ranged from 0.4 to 1.5 m. Mean total phosphate concentrations in the euphotic zones were 6 times the recommended limits for reservoirs. The phosphorus loading rate of 1.1 $g/m^2/yr$ was 2.5 times the suggested critical rate of 0.45 $g/m^2/yr$ for eutrophic loading in lakes where the lake depth to hydraulic retention time ratio equals 5.0 m/yr (Vollenweider, 1973). The ratio of lake depth to hydraulic retention time in Winchester Lake is estimated to be 4.7 m/yr. Influent inorganic nitrogen concentrations were over twice critical values (0.3 mg/l). Mean chlorophyll *a* concentration was more than 6 times that considered eutrophic (10 ug/l).

Of the pesticides that were sampled, neither inorganic metals nor organic compounds (herbicides and pesticides) exceeded water quality criteria for fish flesh. However, values for DDT in one bullhead catfish indicate that DDT was present in 1984. Due to the small sample size of fish (n=4) and the unknown methods deployed for evaluating toxics, there was uncertainty as to whether pesticides are a problem in Winchester Lake. None of the toxics listed in Moeller (1986) are consistent with what is believed to be currently used by the agriculture industry on the upper Lapwai Creek watershed above Winchester Lake (see for example comparable chemicals listed as being used on the Big Canyon Creek Watershed in the Nez Perce Soil & Water Conservation District, 1995).

4) Lapwai/Mission Creek Status Report. No.65.Idaho Department of Health and Welfare, 1986. A study was done by IDHW-DOE in 1985 to determine baseline water quality and to document the effects of storm runoff on water quality in Mission/Lapwai Creeks. An estimated 53,000 lbs. of nitrite+nitrate as N and 6,000 lbs. of phosphorus were discharged from the Lapwai Creek drainage to the Clearwater River during storm events.

5) Phase I Diagnostic and Feasibility Analysis for Winchester Lake , Lewis County, Idaho. Entranco Engineers, Inc., 1990. Monthly samples were collected from a station in Winchester Lake from May 1988 to April 1989. Samples at this location were collected at 0.5 m below surface, mid-depth, and 0.5 m off the bottom. Parameters analyzed are: soluble reactive phosphorous (SRP), total phosphorous (TP), nitrite (NO_2), nitrate (NO_3), ammonia (NH_3), total Kjeldahl nitrogen (TKN), temperature, DO, pH, alkalinity, conductivity, secchi depth, turbidity, and chlorophyll-*a*. A total of 36 samples were collected.

Continuous flow recording (Stevens Gage) and sampling was conducted at the lake inlet and outlet on Lapwai Creek. Samples were also collected at 6 non-recording stations on Lapwai Creek upstream of Winchester Lake. A total of 126 samples were collected.

The 12-month lake study documented that water clarity at Winchester Lake was poor, generally restricted to 3 ft or less during summer months. Poor visibility is associated with the presence of visible blue-green algae blooms during the same period. About half the lake volume is unusable by trout between June and October due to a lack of dissolved oxygen. The study indicated that annual phosphorus loading to Winchester Lake is about 952 kg P/yr, and estimated that a load reduction of 534 kg P/yr would be needed to achieve an annual in-lake concentration (48 mg P/m^3) characteristic of the mesotrophic/eutrophic threshold. The study indicated about 71% of the phosphorus input to Winchester lake comes from external or watershed sources. The remainder is primarily released from sediments within the lake during anoxic conditions.

Bacteriological samples collected in Winchester Lake did not exceed State of Idaho criteria for primary contact recreation. However, the inlet to Winchester Lake did exceed the State of Idaho water quality standards for fecal coliform at least one time during the summer of 1988.

The study concluded that Winchester Lake was sufficiently degraded that an intensive and aggressive lake restoration and watershed management program was recommended.

6) Winchester Lake Fishery Monitoring Summary 1990,1991,1992. Idaho Department of Fish and Game, Lewiston , Idaho. The 1990 study concluded that growth rates of largemouth bass in Winchester Lake were the fastest of any largemouth bass populations in Clearwater Region lowland lakes. Larger bass forage on black bullheads and trout fingerlings. Spokane strain rainbow fingerlings (90 mm) stocked in May had all achieved 180 mm in size before fall gill net sampling.

The 1991 Fishery Monitoring Summary stated that Winchester Lake represented the most successful stocking program of the Clearwater Region lowland lakes.

The 1992 Fishery Monitoring Summary listed Winchester Lake as having the highest growth rates for trout of any Clearwater Region lowland lake.

7) Winchester Lake Restoration Project. Entranco Engineers, Inc., 1992. This document includes 3 separate reports pertaining to water quality management at Winchester Lake. This report reviewed and reevaluated water quality controls and phosphorus control strategies discussed in their 1990 report. It evaluated agricultural and riparian Best Managment Practices, compared the costs and benefits of dredging vs. aluminum sulfate (i.e. alum) treatment in the lake, and provided information on shoreline erosion control measures.

8) Mud Springs Reservoir: Phase I Diagnostic and Feasibility Water Quality Study. Nez Perce Tribe, Water Resources Division, 1995. This study included water quality monitoring of Mud Springs Reservoir, an 8.7 acre impoundment of Lapwai Creek above Winchester Lake. Algal blooms, low water clarity, low dissolved oxygen are symptomatic of eutrophic conditions; bacterial contamination potential was also identified by the study. Water quality was determined to be severely degraded and a restoration evaluation was conducted.

9) Clean Lakes Phase II Implementation and Restoration Project Report. Wertz, L., 1996. This report summarized the Winchester Lake Phase II Clean Lakes Project which included implementation of many of the components of the Lake Restoration Plan (Entranco, 1992). Water quality monitoring conducted from July 1992 through October 1995 showed mixed results with the lake meeting water quality goals during certain periods and not meeting them in others. Wertz speculated that this may be a product of Best Management Practice implementation or precipitation patterns.

10) DEQ monitoring, 1996. DEQ also collected water quality samples at Winchester Lake just prior to lake turnover during October, 1996. Data collected at 5 sites confirmed water quality concerns relative to dissolved oxygen and total phosphorous.

Summary of Existing Sediment Data

Wertz (1996) reports total suspended solids (TSS) data for upper Lapwai Creek from late-1993 to mid-1995. This data set represents the most comprehensive monitoring effort to date where continuous flow and composite TSS samples were taken using a Sigma sampler. Daily minimum, maximum and average flows were measured. Composite TSS samples were collected, producing an average weekly TSS concentration. Unfortunately, without knowing daily TSS concentrations, these TSS data have very limited application since TSS varies significantly with flow (Ketcheson, 1986).

Review of these assessments indicates the need to further quantify flow alteration and sediment loads. The following is a summary of problems identified that require further analysis.

- The Entranco (1990) water budget is only for water years 1988 and 1989. Additionally, new flow data exist (i.e., IDEQ, 1996) and need to be incorporated to estimate a long-term water budget for Winchester Lake.

- The sediment loads calculated by Entranco (1990) and IDEQ (1996) primarily account for suspended load. Like most systems in this region, bedload may represent a substantial portion of the total load (e.g., 5 to 20%). Additionally, the measured TSS concentrations are extremely low given the parent lithology (i.e., Palouse Loess). Commonly, TSS values in the Palouse exceed 100 to 2000 mg/l (Boucher, 1970). The median concentration measured in these assessments is 12 mg/l and the maximum is 200 mg/l.

- Entranco (1990) collected 15 TSS grab samples, which included only three storm events. Initial analysis of these data indicates no significant relationship between flow and TSS concentrations, meaning sediment load calculations might underestimate suspended load. A similar problem is present in the IDEQ (1996) data, where composite samples were collected using a Sigma Sampler. Less of a relationship exists in these data, meaning the majority of the load may not have been measured.

Water Quality Problem Summary

To summarize all the past water quality studies in Winchester Lake, the following water quality problems were identified: poor water clarity, nuisance algal blooms, low dissolved oxygen, high summertime temperatures, excess nutrients. The studies also indicated potential bacteria and pesticides contamination problems.

In 1994, Winchester Lake was listed by EPA as a water quality limited waterbody and Upper Lapwai Creek was listed as a water quality limited stream (US EPA, 1994). Section 303(d) of the Clean Water Act requires states to inventory all waters within their jurisdiction that exceed criteria for 1 or more parameters covered by state water quality standards. The 1994 303(d) list for the state of Idaho reports nutrients, sediment, dissolved oxygen, thermal modification, flow, habitat alteration, pathogens, and pesticides as pollutants of concern at Winchester Lake. This list reports nutrients, thermal modification, flow, habitat alteration, and pathogens as pollutants of concern for Upper Lapwai Creek.

Regarding flow limitations, there are no known irrigation diversions from Lapwai Creek above Winchester Lake. Thermal modification and habitat alteration concerns are likely related to the lack of shade in riparian areas along Lapwai Creek due to a combination of several cultural practices that denude and contribute to bank destabilization. One of the most obvious cultural practices is grazing in and along streams because few remedial Best Management Practices are currently in place. Nutrient and sediment problems have common sources. Dissolved oxygen problems likely result from excessive algal growth associated with the nutrient problem and the subsequent rise in biochemical oxygen demand (BOD) from organic decomposition.

Data Gaps

The assessments described above looked at water yield and sediment loads from Lapwai Creek and other minor tributaries to the reservoir. Review of these studies and available data indicates several substantial data gaps. The following is a list of identified data gaps:

- stream flow data, to characterize trends as well as peak flow conditions;
- more current and adequate suspended sediment data that characterizes trends as well as peak flow conditions;
- bedload data;
- assessment of the effectiveness of existing BMPs;
- more current water quality analyses for all pollutants of concern with pathogen data collection and analysis the most immediate priority;
- McNeil core samples and residual pool volume data in Upper Lapwai Creek;
- monitoring and/or modelling to assess the effect of reduced phosphorus loads and increased dissolved oxygen levels on water clarity and macrophytic plant growth;
- data to determine phosphorus loading attributable to background conditions;
- current data and analyses of the relationship between dissolved and particulate forms of phosphorus in Upper Lapwai Creek to help identify likely sources and background conditions;
- analysis of nutrient storage and release in Upper Lapwai Creek sediments; and
- dissolved oxygen trends in Upper Lapwai Creek.

2.3 POLLUTANT SOURCE INVENTORY

Pollutants and Sources

Parameters listed in Appendix "C" of the 1994 303(d) list for Winchester Lake are: nutrients; sediment; dissolved oxygen; thermal modification; pathogens; pesticides; flow and habitat alteration. Section 2.2 summarizes water quality monitoring results. Pollutants listed in this Appendix for Upper Lapwai Creek are: sediment; nutrients; thermal modification; pathogens; flow and habitat alteration.

Pollutant sources in the Winchester Lake watershed include: 1) agricultural and silvicultural runoff; 2) bank erosion due to grazing and other agricultural activities, silviculture, and recreation; 3) recreation; 4) atmospheric deposition (wind, rain or snow); and 5) storm water discharge. In addition to these external pollution sources, a release periodically occurs from nutrients that have accumulated in the lake bottom sediments.

Point Source Pollution

There are no point sources of pollution identified at Winchester Lake. Prior to 1972 the town of Winchester did not have a sewage collection system but discharged sewage to drainfields. The town now has a wastewater treatment facility that discharges treated effluent to Lapwai Creek 100 yards downstream from the lake outlet. In March of 1998, the city drained the sewage lagoon and pumped out all sludge to perform maintenance on the aerator system and to inspect the liner; the liner was in good condition so subsurface leakage from the lagoon should not be a source (M. Haight, 1998).

Nonpoint Source Pollution

Soils in the watershed are primarily of forest origin, derived from windblown silt (loess), decomposed granite and basalt. Soil types present are prone to erosion and sediment production if left unvegetated by conventional tillage, grazing or silvicultural activities.

Agricultural and silvicultural activities in the upper watershed degrade the water quality and beneficial uses of Lapwai Creek, the major tributary to Winchester Lake (Moeller, 1986). The primary pollutants entering the watershed tributaries and eventually Winchester Lake are excessive sediments and nutrients. The 1992 Entranco report estimated that 15 miles of critical stream bank reaches exist in the watershed, with 6.6 miles in the dryland agriculture area, 5.2 miles in rangeland, and 3.2 miles in forest lands. The report provides a map indicating the location of these critical stream bank reaches.

The large number of people fishing at Winchester Lake has resulted in large exposed shoreline areas. In 1992, Entranco inventoried the 7 miles of shoreline and classified areas into the following impact zones: high erosion (19%); low erosion (22%); potential future erosion (11%);

and minimal or no erosion (48%). These highly-impacted areas distracted from the beauty of the park and were a continual source of sediment and phosphorus to the lake. In 1990, Entranco identified direct runoff as contributing 54 kg P/year or 6% of the total phosphorus budget.

Septic Drain Fields

There are 2 septic drainfields in Winchester Lake State Park and an unknown number of individual drainfields dispersed throughout the watershed.

Urban Stormwater Runoff

Examination of topographic and land use maps indicates that approximately 70% of the town of Winchester drains toward Winchester Lake. There are several city streets that drain past the city sewage lagoon and into Winchester Lake.

2.4 POLLUTION CONTROL EFFORTS

Winchester Lake has been involved in the U.S. EPA Clean Lakes Program (Clean Water Act 314) since 1988. The Phase I Diagnostic and Feasibility Study was completed by Entranco Engineers in February 1990. The Phase I study also developed a lake restoration plan (Entranco, 1992) to address water quality problems. The restoration plan identified specific management activities to implement in the watershed with the goal of reducing sediment and nutrient loading to the lake. These management activities include agricultural, riparian, and forestry best management practices (BMPs) and direct runoff controls. If the water quality did not improve as a result of watershed loading reductions, the restoration plan suggested an aluminum sulfate treatment to reduce the contribution of phosphorus from lake bottom sediments.

The Winchester Lake Phase II Implementation and Restoration Project began in June 1990. The goals of this project were to:

1) implement the BMPs outlined in the lake restoration plan;
2) develop an information and education program; and
3) continue water quality monitoring to evaluate the effectiveness of BMPs.

Implementation and Restoration Activities

●Forestry BMPs--Timber harvest activities by private landowners occurred on approximately 850 acres in the watershed between January 1990 and June 1995. An estimated 8 miles of road were built as a result of this activity. The forestry BMPs were implemented under the Idaho Forest Practices Act and included proper road design and maintenance, stream protection zones, and replanting. The Nez Perce Tribe conducts Environmental Assessments (EA) on their timber lands before any harvest takes place. The implementation of the recommendations developed through EAs result in application of BMPs that are at least as stringent as those required under the Idaho Forest Practices Act. Clean Lakes Project money was not used to implement these BMPs.

●Direct Runoff BMPs--The large number of people fishing at Winchester Lake has created large exposed shoreline areas requiring erosion controls. The Winchester Lake State Park was responsible for implementing the shoreline erosion controls. The park reseeded areas that were the least damaged. On the areas that were severely damaged, the park constructed rock-filled baskets utilized as fishing platforms and additional docks for public access to the lake. Twenty rock-filled fishing platforms totaling 1100 linear ft were installed in the most damaged areas. The rock-filled baskets are not properly constructed gabions and currently require repair. Five docks were constructed into a T-shape design providing 32 linear ft of fishing area for every 8 ft of shoreline used. The public response to these improvements has been very positive. Implementation of these BMPs cost approximately $26,825. Estimated cost to repair the rock-filled fishing platforms is $2500 each or $50,000 (Silvers, 1998).

●Agricultural BMPs--The Lewis Soil Conservation District was contracted by the Idaho Division of Environmental Quality to administer the installation of the nutrient and sediment control structures within the Winchester Lake watershed. Since 1990, within the Winchester Lake watershed, 11 contracts treating 2880 cropland and pastureland critical acres have been initiated (ongoing projects). Conservation tillage is the most common treatment practice. The Clean Lakes project funded the installation of sediment basins and gully plugs on acres through District contracts with landowners. As of January 1998, 7 sediment basins, 20 gully plugs, and 7 grade stabilizations had been constructed. The District had $68,000 to implement these structural BMPs and as of January 1998, $7,000 is unspent but obligated for BMP installation. A complete list of BMPs installed is shown in Table 4. Locations are shown in Figure 9.

●Riparian BMPs--The Lewis Soil Conservation District administered the installation of the riparian BMPs. Due to limited funding that did not allow for treatment of all the high priority areas, the District chose to develop a riparian demonstration area. The demonstration area is located in the upper portion of the watershed above Mud Springs Reservoir and is used to educate landowners in the watershed about riparian BMPs. This area had extensive bank erosion and little woody vegetation. Seven log drop structures were constructed in 900 feet of the stream. These structures are designed to raise the water table near the stream so that vegetation can be reestablished. Additionally, 2800 ft of fencing and a livestock access ramp were installed so that the cattle could only cross the creek in one location. A livestock water supply was built away from the creek to give the cattle an alternate water supply. In the spring of 1995, the District and the Nez Perce Tribe planted several hundred willow cuttings along the creek in an effort to restore the riparian area. The District spent $6,000 to implement the riparian BMPs. In addition, 4021 feet of fence have been built and a rotational grazing plan has been implemented on a landowner's property along Lapwai Creek between Winchester Lake and Mud Springs reservoir. In addition, 2 log drop structures and 4 spring developments are planned for implementation on the same property.

The Nez Perce Tribe has worked to restore Lapwai Creek above and below Mud Springs Reservoir within the Nez Perce Reservation. The upper stream was fenced off, willows were planted, and transects were established to evaluate aggradation and degradation. The reservoir was deepened by the Nez Perce Tribe in the fall of 1998 and will be restocked with trout and bass.

Information and Education

The information and education component of the Phase II project consisted of several different activities designed to increase awareness of the lake's condition and the efforts needed to restore the lake's water quality. In the summer of 1994, approximately 300 people at Winchester Lake State Park participated in a survey that determined the demography of the park and lake users, the activities they participated in while at the park, their preferred fishing locations, their views on water quality, and their knowledge of BMPs. After the survey the participants were given information regarding the lake project and the BMPs in the watershed.

Table 4. Summary of BMPs (Lewis Soil Conservation District).

Winchester Lake Clean Lakes Project Summary of BMPs Installed (as of 1/26/98)			
NUMBER INSTALLED	**BMP**	**AMOUNT SPENT**	**COST PER UNIT**
7 ea	Sediment basins	$3,598.50	$514.07/unit
20 ea	Gully plugs	$7,674.00	$383.70/unit
7 ea	Grade stabilization structures	$4,048.00	$578.29/unit
36 ea	Standpipes	$3,361.00	$93.36/unit
18,012 ft	4" underground outlet	$14,221.00	$0.79/ft
12,593 ft	6" underground outlet	$19,128.00	$1.52/ft
6 ea	Log drop stabilization structure	$2,339.00	$389.83/unit
1 ea	Livestock access ramp	$390.00	$390.00/unit
419 rods or 6915 ft	Fence	$5,825.00	$13.90/rod $0.84/ft
TOTAL AMOUNT SPENT FOR BMP=S = $60,584.50			

PRACTICES INSTALLED ON PRIVATELY OWNED PROPERTY THROUGH OTHER PROGRAMS	
Lapwai State Ag Water Quality Project	11 contracts providing financial incentives installing ag-related BMP's on 2880 privately-owned critical acres.
Public Law 566	3 basins Contract signed with Nez Perce Tribe on Mud Springs
Annual Conservation Practices	Spring developments
Idaho Department of Lands	Timber management/ thinning/ reforestation
Privately-installed	2 additional log drop structures

1996 PHASE II REPORT LISTS 5 JURISDICTIONAL ENTITIES ABOVE THE LAKE
IDFG ● IDPR ● Lewis County ● City of Winchester ● Nez Perce Tribe

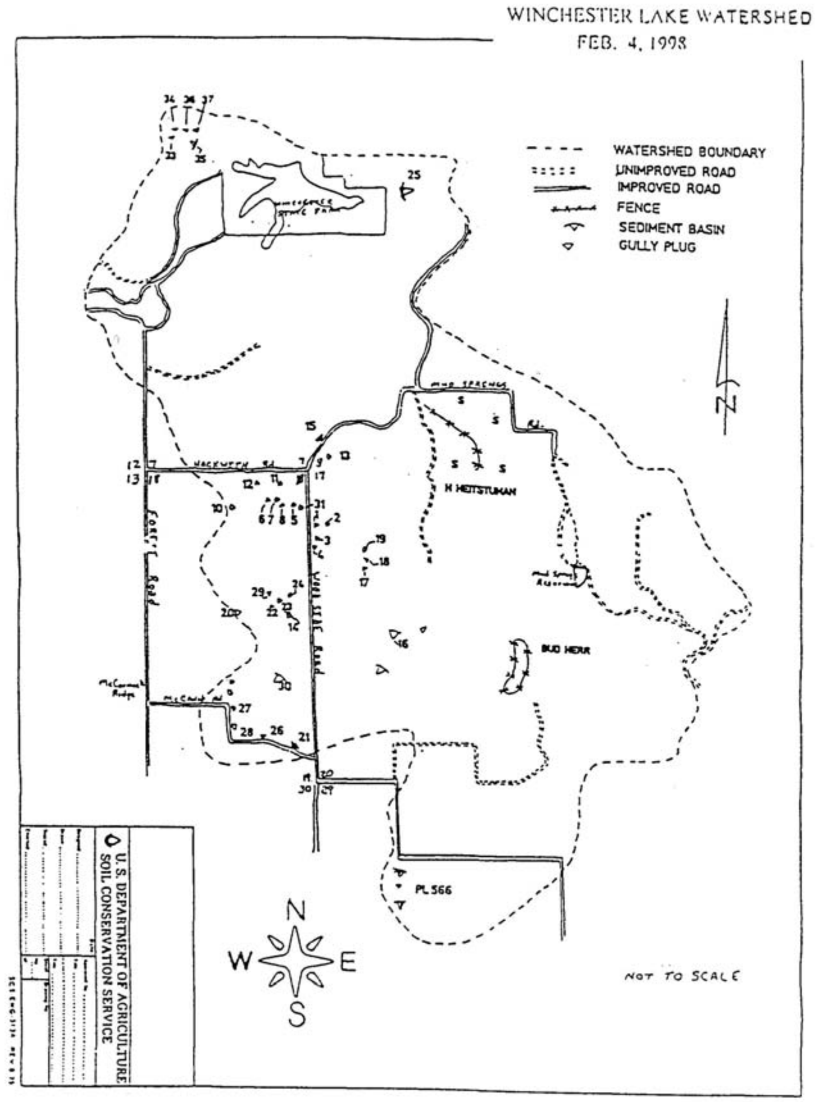


Figure 9. Improvement Location Map

Two brochures were developed for the project and distributed to the public. The first brochure described the Clean Lakes Project, water quality in the lake, watershed sources of pollution, and the lake management plan. The second brochure was targeted at landowners in the watershed and explained various types of recommended BMPs. Informational display boards were constructed. The displays contained 3 informational panels about the lake project. These panels were displayed at several locations within the park, placed at the Lewis Soil Conservation District Office and used by DEQ when addressing various groups. A traveling display was developed and used for an exhibit at the Lewis County Fair and other locations.

Mechanisms for Implementation of Nonpoint Source Reductions

Nonpoint source reductions listed in the Winchester Lake TMDL will be achieved through the combination of authorities the state possesses within the Idaho Nonpoint Source Management Program, Nez Perce Tribal authorities, and commitments the community makes in the future Winchester Lake Watershed Implementation Plan. Section 319 of the Federal Clean Water Act requires each state to submit to EPA a management plan for controlling pollution from nonpoint sources to waters of the state. The plan must do the following: identify programs to achieve implementation of the best management practices (BMPs), outline a schedule containing annual milestones for utilization of the program implementation methods and for implementation of best management practices, obtain certification by the attorney general of the state which states that adequate authorities exist to implement the plan, and provide a listing of available funding sources for these programs.

Existing authorities and programs for assuring implementation of BMPs to control nonpoint sources of pollution in Idaho include:

- State Agricultural Water Quality Program
- Wetlands Reserve Program
- Environmental Quality Improvement Program
- Idaho Forest Practices Act
- Water Quality Certification For Dredge and Fill
- Stewardship Incentive Program
- Wildlife Habitat Incentive Program
- Nonpoint Source 319 Grant Program
- Conservation Reserve Program
- Resource Conservation and Development
- Agricultural Pollution Abatement Plan
- Stream Channel Protection Act
- Forestry Incentive Program
- Environmental Quality Incentive Program

The Winchester Lake Restoration Plan pre-dates the Winchester Lake and Upper Lapwai Creek TMDL and was conceived and developed as the most appropriate plan for community-implemented nonpoint source water quality pollution controls. The Plan lists activities that can be implemented by the community to enhance water quality in the entire Winchester Lake watershed. The Plan includes costs and a schedule for implementation of each activity. Activities include but are not limited to: riparian tree plantings; agricultural best management practices; bioengineering structures; and education and information programs to increase community awareness of the water quality conditions and the activities to be undertaken to restore water quality in the Winchester Lake watershed.

3.0 LOADING ANALYSES

Winchester Lake is listed on Idaho's 1994 303(d) list for seven parameters: sediment, dissolved oxygen, temperature, pathogens, nutrients, pesticides, and flow and habitat alterations. Total Maximum Daily Loads (TMDL) have been developed for sediment, pathogens, temperature, and nutrients, the latter of which is expected to also address dissolved oxygen impairments.

Upper Lapwai Creek is listed on Idaho's 1994 303(d) list for six parameters: sediment, temperature, pathogens, nutrients and flow and habitat alterations. TMDLs have been developed for sediment, pathogens, temperature, and nutrients. As discussed further below, TMDLs are not being developed for flow and habitat at this time.

Flow and habitat are identified in the 1994 303(d) list as impairing uses in Winchester Lake and Upper Lapwai Creek. This TMDL does not address flow and habitat issues because it is unclear whether these parameters are required to be addressed under section 303(d) of the Clean Water Act. In addition, flow and habitat do not lend themselves to mass/time pollutant loading as defined by EPA guidance on TMDL development. Because of these regulatory and practical limitations, a TMDL for habitat modification and flow alteration are not being developed at this time. If EPA determines that TMDLs are required for water quality problems caused by flow and habitat modification, TMDLs will be developed. Flow and habitat modifications may be addressed through activities needed to implement TMDLs for other listed parameters.

Loading capacity (LC) is effectively synonymous with the total maximum daily load (TMDL) for a waterbody. TMDL is defined as mass per unit time (ex. pounds per day) of pollutant allowed. The TMDL is the amount of pollutant that can enter the creek without exceeding water quality standards. Although the TMDL is defined in pounds per day or equivalent measurement, in practice compliance is measured as a concentration of pollutant in the creek (the water quality target) usually expressed in mg/l.

Wasteload allocations (WLA) are established for point sources and load allocations (LA) are determined for other sources. There are no point sources within the Winchester Lake and Lapwai Creek watershed, therefore no WLA has been established in the TMDL. Load allocations are best estimates of the portion of the total load that can be contributed by nonpoint sources or by natural sources. When uncertainty exists (this is almost always the case) about the pollutant to water quality relationship, federal law requires a margin of safety (MOS) be included in the calculations. The MOS may be explicitly incorporated into the TMDL or may be incorporated in conservative assumptions used to establish the TMDL. The MOS is intended to insure that water quality goals will be met even though uncertainty in the loading capacity exists. The TMDL=WLA+LA+MOS.

In the TMDLs developed for Winchester Lake and Upper Lapwai Creek, pollutant targets are based on numeric water quality standards where they exist, or interpretation of narrative water quality standards in the case of nutrients and sediment. Pollutant load allocations are presented as a function of available flow and allowable pollutant concentration based on the pollutant targets. Since there are no point sources identified within this watershed, the estimated load capacity is divided among the nonpoint sources.

An implementation plan will be developed by the Winchester Lake Watershed Advisory Group and supporting agencies to specify controls designed to improve Winchester Lake and Upper Lapwai Creek water quality by meeting the load allocations contained in this TMDL document. During implementation, additional water quality information is expected to be generated. This information may indicate that targets, load capacities, and load allocations may need to be changed. In the event that data show changes are warranted, TMDL revisions will be made with assistance from the Winchester Lake Watershed Advisory Group. Because the targets, load capacity, and allocations will be re-examined and potentially revised in the future, the Winchester Lake and Upper Lapwai TMDL is considered to be a phased TMDL.

3.1 NUTRIENTS/DISSOLVED OXYGEN

Nutrients

The Idaho general surface water quality criteria states that "Surface waters must be free of excess nutrients that cause visible slime growth, or nuisance aquatic growth, which impairs beneficial uses." Under favorable light and temperature conditions, nitrogen and phosphorus compounds are considered the major nutrients that control the development of aquatic blooms and growth of rooted or floating aquatic plants called macrophytes. Algae blooms have been identified as a significant problem in Winchester Lake during the summer/early fall months; however, the lake has not experienced problems with excessive growth of macrophytes (Entranco, 1990).

Excessive algae growth has resulted in poor water clarity near the lake surface and a lack of dissolved oxygen in the deeper waters during the summer, thus greatly reducing the volume of water in the lake where fish can reside. This problem is compounded by the fact that the upper layers that typically have sufficient oxygen in the summertime are generally too warm for cold water fish species. Algae blooms have also reduced recreational use of the lake because of undesirable odors produced during decay and decomposition. Although beneficial uses are impaired when such growths are present and active typically during the summer and early fall months, nutrient loading to the lake during other times contributes to increased aquatic growth because significant quantities of phosphorus can be stored in lake bottom sediments. In eutrophic lakes such as Winchester, this stored phosphorus is released under depleted oxygen conditions that exist in deeper waters during summer stratification.

Nitrogen occurs as nitrate, nitrite, ammonia, and organic nitrogen in surface waters. Ammonia is released from organic matter and urea, or is synthesized in an industrial process involving atmospheric nitrogen fixation. Nitrite is formed by micro-organisms found in soil, water, sewage, and animal digestive tracts from ammonia and nitrate. In oxygenated water, nitrite rapidly oxidizes to nitrate. Nitrate is formed by the complete oxidation of ammonium ions by micro-organisms found in soil and water. Growing plants assimilate nitrate and/or ammonium ions and convert them to protein. Nitrate and nitrite comprise the majority of available nitrogen in surface water.

Phosphorus in surface waters exists in two basic forms, particulate and dissolved. Particulate phosphorus is often associated with sediment or organic matter, while the dissolved is mostly in the form of orthophosphate ($P0_4^{-3}$). Dissolved phosphorus can also consist of polyphosphates which originate from synthetic detergents (Wetzel, 1983). Typically, greater than 90% of the total phosphorus present in freshwater occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel, 1983). The small remaining fraction is inorganic, largely orthophosphate and in soluble forms that are rapidly assimilated by plants.

Nitrogen and phosphorus are the major nutrients controlling algae growth in lakes. Comparing the nitrogen concentrations to phosphorus concentrations (the nitrogen/phosphorus ratio) within a flowing water can indicate which of these nutrients is in shorter supply relative to a plant's growth needs and thus drives the algae growth (often referred to as the limiting factor). Based on the natural ratio of nitrogen and phosphorus in algae tissue, it is generally accepted that when the total nitrogen: total phosphorus (N:P) ratio falls below 15:1, algae will have less nitrogen available per unit of phosphorus, and thus experience reduced growth due to a nitrogen limitation. On the flip side, ratios above 15N:1P indicate that phosphorus is the limiting factor in algae growth (Krenkel and Novotny, 1980).

The past studies of Winchester Lake indicate phosphorus to be limiting factor as the N:P ratio exceeded 15:1. Moeller (1986) found relative N:P concentrations of 16:1. Entranco (1990) found the annual N:P mean epilimnetic ratio of 20:1 and 34:1 for 1988 and 1989, respectively. Wertz (1996) determined a N:P ratio of 18:1 based on load from Lapwai Creek in 1995. Since past studies have indicated phosphorus to be the limiting nutrient in Winchester Lake, total phosphorus levels will be used as the target nutrient parameter in this TMDL to decrease nuisance aquatic growth. It should be recognized the response to reductions in phosphorus inputs will not be immediate; recovery to a less eutrophic state will take many years as related to the lake's current eutrophic condition, phosphorus storage in lake sediments, and the hydrologic retention time.

Dissolved Oxygen

Winchester Lake is also listed on the 303(d) for dissolved oxygen. Increased nutrient levels lead to increases in aquatic growth that lead to increases in aquatic plant decomposition. Chemical and microbial decomposition use up oxygen from the surrounding water. During summer months, substantial oxygen depletion occurs in the lower depths of the lake as the algae settle within the water column. In lakes with low biological activity, the oxygen in the hypolimnion isn't completely consumed during the stratification period. In eutrophic lakes with high biological activity such as Winchester, the oxygen in the hypolimnion is rapidly utilized, and low

/no dissolved oxygen conditions develop before the stratification period ends. Past studies of Winchester Lake have consistently indicated oxygen depletion in the hypolimnion during summer months continued into the fall, as described more fully in section 3.3.

Depressed dissolved oxygen levels (anaerobic conditions) have multiple effects on lake systems. Low dissolved oxygen levels make conditions inhospitable to most species of fish. Anaerobic conditions also result in chemical conditions in the lake sediment which results in the release of inorganic phosphorus and ammonia. After a season of thermal stratification in a eutrophic lake, anaerobic conditions have typically resulted in extraordinarily high levels of inorganic phosphorus and ammonia. The inorganic phosphorus can be utilized in a matter of minutes by the phytoplankton, triggering the fall "algae blooms often observed in Winchester Lake. Ammonia levels can also be high enough to stress or even kill fish. Data for Winchester lake has not indicated ammonia is a problem, although conditions in 1985 indicated a potential for ammonia toxicity (Entranco, 1990).

Studies of many eutrophic lakes have shown a consistent cause-and-effect relationship between high nutrient levels and low dissolved oxygen. Water quality studies of Winchester lake confirm this relationship. Because of the cause-and-effect relationship between nutrients and dissolved oxygen within Winchester Lake and because phosphorus is the nutrient in shortest supply, the reduction of total phosphorus input to the lake is being specifically targeted in this TMDL as the mechanism to improve nuisance algae and dissolved oxygen conditions.

Winchester Lake

Phosphorus Target

Total phosphorus (P) concentrations in uncontaminated surface waters range from 10 to 50 ug/l, with soluble phosphorus comprising only a few percent of that value (Wetzel, 1983). EPA's Gold Book (EPA, 1986) indicates total phosphates as phosphorus should not exceed 25 ug/l within a lake or reservoir to prevent the development of biological nuisances and to control accelerated or cultural eutrophication. Entranco (1990) used Carlson's trophic state index (1977) to propose a target level of 48 ug/l to achieve conditions at the boundary between eutrophic conditions (high nutrient availability and biological activity) and mesotrophic conditions (intermediate nutrient availability and biological productivity).

Margin of Safety: In addressing uncertainties in this phased TMDL analyses, an explicit margin of safety of 20% as proposed by Entranco (1990) was applied to the load capacity and resulted in a modeled target concentration of 37 ug/l (refer to section on phosphorus load capacity for more details). Load capacity and needed load reductions in this TMDL are based on a 37 ug/l target.

Dissolved Oxygen Target

Minimum concentrations of dissolved oxygen set forth in current State of Idaho Water Quality Standards for waters designated for cold water biota are 6.0 mg/l at all times. However, this standard does not apply to (1) the bottom 20% of water depth in lakes and reservoirs where depths are 35 meters or less; and (2) those waters of the hypolimnion in stratified lakes and reservoirs (ID Code 16.01.02). Winchester Lake is a stratified with a mean depth of 23 feet and a maximum depth of 35 feet (11 meters).

The goal of this TMDL is to reduce nutrients so that dissolved oxygen levels increase enough to meet water quality standards and provide an adequate habitat to fully support a cold water fishery in Winchester Lake. As part of the phosphorus TMDL, an evaluation is provided as how targeted phosphorus reductions will improve dissolved oxygen conditions in Winchester Lake.

Estimates of Existing Pollutant Loads

Three methods were developed to estimate the total phosphorus load to Winchester Lake and are summarized in the following section. The first estimate was derived through the Clean Lakes Study (Entranco, 1990). The second estimate was derived by averaging results from three past studies. The third estimate was derived by using predicted flows based on a 15-year hydrograph and applying the demonstrated relationship between flow and phosphorus concentrations from past data. These three methods used to estimate phosphorus loads resulted in estimates of 2100, 1786, and 1892 lbs P/year, respectively. Although limitations have been identified with each approach, these results are within 20 percent of each other and therefore considered reasonable estimates. The average load estimate from the three approaches is 1926 pounds of phosphorus per year with a standard deviation of 160 lbs. This average of 1926 lbs P/year is the loading estimate used to compare to the load capacity in this TMDL.

<u>1) Clean Lakes Study Load Estimates.</u> Entranco (1990) developed a phosphorus budget for all sources based on samples collected from the lake and influent creeks between May 1988 and October 1988. For stream samples, grab samples were taken at seven sites monthly and during three storm events. Monthly flow measurements were made at grab sampling sites. This study developed loading estimates for all sources to the lake; other studies did not. The limitations associated with estimates based on this study are the use of 10 year old data and some peak flow events were not sampled.

Table 5 presents the results of Entranco's phosphorus budget. Estimates of external phosphorus loading were developed by multiplying the monthly inflow volumes by the concentration of P for the corresponding monitoring period and then taking the sum of the monthly loads. The concentration of P in direct runoff was taken as the average measured in the various tributary streams. An assumed value of 100 µg/l P was used for groundwater due to lack of groundwater data. The value is within the range observed within the Palouse and Clearwater Hydrogeologic Subareas (Crockett, 1995). Precipitation data was multiplied by a P concentration of 38 ug/l;

this concentration was derived from data collected at Hauser Lake due to lack of reliable applicable data for Winchester Lake.

Entranco estimated the contribution from aerobic sediment release above the thermocline during the growing season and from the hypolimnetic turnover contribution which occurs during fall lake turnover when the high phosphorus waters from the hypolimnion are mixed throughout the entire lake. An estimate of summer sediment release was developed using a mass balance approach where the monthly inflow P, change in the epilimnetic P, and outflow P were used to estimate net internal load contribution. The turnover contribution was calculated as the quantity of phosphorus needed to increase lake P concentration by 69 ug/l, the amount of increase observed in lake waters following turnover. The sum of the internal loads was 602 lbs P/yr or 29% of the total annual load of 2099 lbs P/year.

Table 5. Winchester Lake phosphorus budget (Entranco, 1990).

	lbs P/yr	% contribution to total load
EXTERNAL LOAD		
Surface Drainage		
Lapwai Creek	1096 lbs P/yr	52%
Other Drainages	182 lbs P/yr	8%
Direct Runoff	119 lbs P/yr	6%
Precipitation	18 lbs P/yr	1%
Groundwater	82 lbs P/yr	4%
Total External Load	1497 lbs P/yr	71%
INTERNAL LOAD		
Aerobic Sediment Release	179 lbs P/yr	9%
Hypolimnetic Turnover	423 lbs P/yr	20%
Total Internal Load	602 lbs P/yr	29%
TOTAL LAKE LOAD	2099 lbs P/yr	100%

2) Average load estimate based on all past studies. Although Entranco is the only past study with a complete phosphorus budget, two other studies estimated the load from Lapwai Creek to the lake. Using the same proportionate relationship among all sources determined in the Entranco (1990) study (i.e. load from Upper Lapwai was 52% of total load), total loads can be estimated for the Moeller (1986) and Wertz (1996) studies. A limitation associated with this estimation approach is the reliance on the same source proportions from the Entranco study when these proportions (e.g. that attributable to internal sources) will vary based on different land use, climatological, and limnological conditions over time.

Moeller (1986) estimated the phosphorus loading from Upper Lapwai Creek based on five grab samples collected upstream of the mouth of Lapwai Creek taken between March and June 1985. Stream discharges and concentrations were used to determine loading rates; those figures were extrapolated to provide estimates for the year through the use of weighted averages. The estimate of loading from Upper Lapwai Creek to Winchester Lake during that time period was 842 lbs P/yr.

The Wertz (1996) study involved collecting samples from Winchester Lake in the summers of 1992 - 1995 and collecting samples from Lapwai Creek approximately one mile upstream of the lake from March 1993 through October 1994 and from February 1995 through May 1995. Unlike the previous two studies that used grab samples, samples on Lapwai Creek were taken using a continuous Sigma sampler programmed on a flow-dependent basis with a sample collected a minimum of once every 5 hours. Samples were composited weekly. The estimated P loading from Upper Lapwai Creek to Winchester Lake was 816 lbs and 968 lbs P/year in 1994 and 1995, respectively.

The estimated loads for Lapwai Creek generated by these three studies were: 842 lbs P/year in 1985; 1096 lbs P/year in 1988-1989; 816 lbs P/year in 1994 and 968 lbs P/year in 1995. The mean is 930 lbs P/year with a standard deviation of 128 lbs P/year. Using the proportions determined by Entranco for Upper Lapwai Creek (52%) and other sources (48%), the mean total load to the Winchester Lake would be 1786 lbs P/year with a standard deviation of 245 lbs.

3) Loads based on 15-year predicted hydrograph. EPA has calculated a predicted hydrograph for Upper Lapwai Creek based on 15 years of daily flow measured data from Lower Lapwai and a strong correlation between Upper Lapwai and Lower Lapwai flows. The average daily predicted flow for the entire 15-year period for Upper Lapwai Creek is 3.8 cfs. Using this flow and applying it to the predictive relationship based between flow and P concentrations found in the Moeller and Entranco studies, (P mg/l = 0.0065*flow + .1048; $r^2 = .62$, $p \leq .05$), results in an estimated annual load of 983 lbs P/year for Upper Lapwai Creek. Using the same proportionate contributions for various sources to Winchester Lake as determined by Entranco, the total loading to the lake is 1892 lbs P/year. A limitation of this method is the reliance on a correlation between flow and phosphorus concentrations using a small data set (22 samples).

Because the results of the three above methods used to estimate loads are within 20% of each other, the average of these three estimates, 1926 lbs/year, is the loading estimate used in this TMDL. In Table 6, the proportions established by Entranco (1990) have been applied to the estimated load of 1926 lbs/year to determine contributions from external and internal sources.

Table 6. Winchester Lake phosphorus budget with TMDL loads.

	lbs P/yr	% contribution to total load
EXTERNAL LOAD		
Surface Drainage		
Lapwai Creek	1002 lbs P/yr	52%
Other Drainages	154 lbs P/yr	8%
Direct Runoff	116 lbs P/yr	6%
Precipitation	19 lbs P/yr	1%
Groundwater	77 lbs P/yr	4%
Total External Load	1368 lbs P/yr	71%
INTERNAL LOAD		
Aerobic Sediment Release	173 lbs P/yr	9%
Hypolimnetic Turnover	385 lbs P/yr	20%
Total Internal Load	558 lbs P/yr	29%
TOTAL LAKE LOAD	1926 lbs P/yr	100%

Proportioning of Nonpoint Source Load

Entranco's phosphorus budget identified the percentage contribution by particular source types; however, none of the past studies for Winchester Lake have analyzed the proportional contribution to the external phosphorus load by land use in the watershed. This analysis has been conducted for the sediment TMDL in Section 3.2. Because phosphorus has a tendency to attach to soil particles and organic matter and be transported in surface runoff with eroded sediments, the percentages of sediment contributed by land use provided in table 9 are reasonable estimates of the proportional contribution of phosphorus by sub-tributary by land use. Data from Lapwai Creek confirms the majority of the phosphorus entering the lake from streams is in the particulate phase (63% on average based on data from Upper Lapwai Creek) (Moeller, 1986; Entranco, 1990); however, further study of the forms of phosphorus loading to the lake is needed for implementation planning. Results from the sediment budget analyses indicate 7% to 27% of the existing sediment load to the reservoir is attributable to background.

Using the Simple Method for urban runoff concentrations as provided for in Idaho's stormwater guidance (DEQ, 1998), the predicted contribution from runoff in the Winchester area that drains into the lake is 57 lbs P/year or approximately 3% of the total annual load to the lake.

Load Capacity

To define the relationship between annual phosphorus loading and desired in-lake phosphorus concentrations, Entranco (1990) used a mathematical model originally developed by Vollenweider (Gilliom, 1980). It is a simple mass-balance accounting model that assumes complete mixing of the water column and produces a steady state in-lake phosphorus concentration estimate. The model states that the average P concentration in a lake is determined by the amount of P loading to the lake, less those amounts of loading lost by sedimentation and lake outflow, diluted by the volume of water in the lake.

P = L(1-R)/zAp where

P	=	Mean annual P concentration (ug/l)	48 ug/l
L	=	Annual P loading (kg P/year)	Unknown
R	=	Retention coefficient (percent to sediment)	0.61
z	=	mean lake depth (m)	5.2 m
A	=	lake surface area (km^2)	0.344 km^2
p	=	Lake flushing rate (lake volumes/year)	1.95 vol/year (total inflow/lake volume)

The load capacity relies on a model which predicts that there is a linear relationship between loading to the lake and mean phosphorus concentrations in the lake. Water quality monitoring data from past studies do not consistently fit this pattern; years with the highest loads from Upper Lapwai did not have the highest in-lake phosphorus concentrations. However, when Entranco used this model and solved for the retention coefficient using observed loading and lake concentration data, the coefficient obtained from the model of 0.60 fell within the range of values that can be computed using various methods from the literature as well as very close to that derived using a formula derived by Chapra (1975) of 0.61. It was slightly lower than that generated by the actual data during Entranco's study of 0.71. These comparable results, combined with other validated uses of the model (Gilliom, 1980), would support use of this model to determine load capacity.

Using the retention coefficient calculated by the 1988-89 loading calculations, the target loading capacity to achieve Entranco's (1990) proposed target concentration of 48 ug/l is 924 lbs P/year. Since considerable potential variability can occur in the annual water budget, the phosphorus budget, and retention coefficient, Entranco (1990) recommended that the total loading value reflecting the eutrophic/mesotrophic threshold be considered as ± 20%, or 739 to 1109 lbs P/year. To allow a margin of safety, the lower load capacity of 739 lbs P/year will be the initial load capacity in this phased TMDL. Variation will occur seasonally and year to year in the amount of phosphorus entering the lake from drainages, sinking to the sediment, and releasing from lake bottom sediments during anoxic conditions; therefore, the simplistic assumptions used in estimating this load capacity should be evaluated and refined as part of the phased TMDL process. Comparing the conservative load capacity of 739 lbs P/year to the estimated load of

1926 lbs P/year indicates the overall phosphorus load to Winchester Lake needs to be reduced by 1187 pounds per year, or 62%.

Although a specific load capacity and allocation have not been determined for dissolved oxygen, EPA used a dynamic mass balance model of primary productivity for Winchester Lake to predict dissolved oxygen conditions under certain loading assumptions (Appendix C). Figure 10 shows the predicted average concentrations in the hypolimnion using the target load capacity of 739 lbs compared to the modeled average concentration based on the Entranco 1988-89 data. These results indicate that concentrations of dissolved oxygen would average above 6 mg/l from January through July, decrease to between 6 and 4 mg/l between July and October, and then average above 6 mg/l from October through January. This model indicates a substantial decrease in the amount of time the hypolimnion has average dissolved oxygen levels below 6 mg/l. It also predicts average dissolved oxygen levels in the hypolimnion would not drop below 4 mg/l during the summertime. This is a significant improvement over the anoxic summertime condition. For the proposed TMDL reductions, the model simulates an increase in the volume of lake water with sufficient temperature and dissolved oxygen level during the summer from the current 16% to 35-48%, as further described in section 3.3 and Appendix C.

Although the dynamic mass balance model incorporates a fall overturn, it does not incorporate an algal bloom that may be caused by that overturn and the resulting decrease in dissolved oxygen it could cause. Fall algae blooms have been documented in past studies of Winchester Lake and are believed to be a contributing factor to lower wintertime dissolved oxygen levels. Consequently, the simulated dissolved oxygen levels for fall/winter months may be higher than observed levels. However, with the targeted reduction in phosphorus, the frequency and magnitude of algae blooms in the fall are expected to decrease and thus both summertime and wintertime dissolved oxygen conditions are predicted to improve.

The dynamic model of primary productivity and Vollenweider mass balance model both use mass balance methods to estimate the impact of phosphorus loading on Winchester Lake. The dynamic model of primary productivity assumes the lake can be divided into two well-mixed compartments, a hypolimnion and epilimnion, and predicts daily average conditions in each compartment for temperature, dissolved oxygen, phosphorus and phytoplankton. The Vollenweider model assumes the lake is completely mixed and predicts annual average conditions for total phosphorus in the lake. An important difference in the way the two models were applied is a result of the way in which internal recycling of phosphorus from the sediments was treated. In the case of the dynamic model of primary productivity, only the release of orthophosphorus from sediments under aerobic conditions was included in the analysis. For the Vollenweider model, internal recycling of phosphorus resulting from anaerobic conditions in the sediment was included, in addition to the contribution from sediments under aerobic conditions.

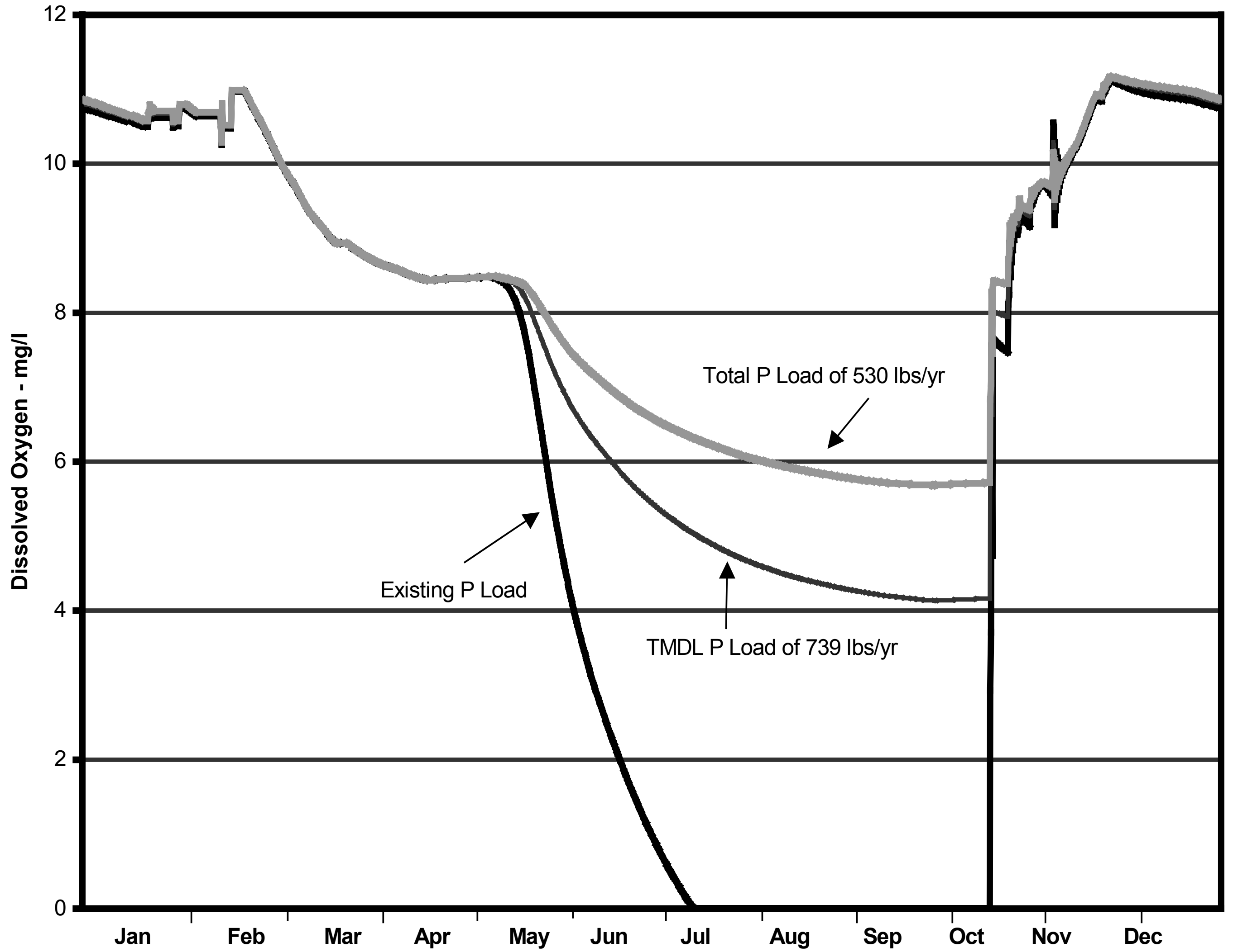


Figure 10. Simulated Average Dissolved Oxygen in the Hypolimnion of Winchester Lake for (1) Existing Conditions, (2) TMDL, (3) 530 lbs/year

For the phosphorus TMDL, Vollenweider's equation was used to determine the load capacity at a desired 37 ppb annual in-lake concentration. This resulted in an overall needed reduction of 62% in total phosphorus loading to the lake; improved dissolved oxygen concentrations were not determined as part of the analysis. Using the dynamic model of primary productivity and data from Entranco (1990), EPA determined an external load of 530 lb/yr, representing a reduction of 68% and annual in-lake concentration of 32 ppb would be necessary to achieve an average concentration in the hypolimnion above 6.0 mg/l year-round (refer to figure 10 and Appendix C). The difference in results between the two analyses is within the uncertainty of the two methods. Therefore, an initial 62% targeted reduction of total phosphorus load to Winchester Lake will be used in this TMDL to achieve sufficient improvement in dissolved oxygen concentrations in the hypolimnion. As part of this phased TMDL, further monitoring and modeling efforts will be conducted as reductions in phosphorus loading are achieved to assess the relationship between dissolved oxygen and phosphorus loading and determine what adjustments, if any, are necessary to the targeted load reductions.

Load Allocations

Achieving the targeted reduction of 62% or 1187 lbs/year of phosphorus to the lake will require the application of both internal and external control technologies (Entranco, 1990). Based on an assumption that in-lake management efforts could reduce the internal loading by a maximum of 80%, a reduction of 446 lbs P/year would be achieved. The additional needed reduction from external sources would then be 741 lbs P/year. For maximum effectiveness, external reductions should be achieved before in-lake management methods are applied. As part of the phased TMDL, once targeted reductions in external loading are achieved, the necessity of any in-lake management efforts can be evaluated.

Given that the precipitation and groundwater loads cannot be managed, options remain for controlling the other external loads (surface drainage and direct runoff). Since Upper Lapwai Creek contributes an estimated 52% of the phosphorus load to the lake compared to a total 9% contribution from other drainages (Table 6), pollution control efforts should focus first on Upper Lapwai Creek. A reduction of 741 lbs in Upper Lapwai Creek would be a 74% reduction based on the estimated average phosphorus load from Upper Lapwai Creek to Winchester Lake of 1002 lbs/year. The Winchester Watershed Advisory Group decided to allocate an overall reduction of 741 lbs or 74% in Upper Lapwai Creek for this phased TMDL. The TMDL implementation plan will evaluate and further specify the basis upon which load reductions within the Upper Lapwai Creek will be accomplished.

Seasonal Variation

Section 303(d)(1) requires TMDLs to be "established at a level necessary to implement the applicable water quality standards with seasonal variations." The highest loading of phosphorus to the lake seasonally occurs during the spring runoff periods (Entranco, 1990; Wertz, 1996; Moeller, 1986). The three methods used to estimate the total phosphorus load to the lake used data from all these three studies, which included data during the runoff seasons and some limited storm events. The third method relied on average annual flow over a 15 year period and not on the high flow season but took advantage of a relationship that existed between flow and total phosphorus concentrations over variable flows. The estimates from these three methods were within 20% of each other and are believed to adequately consider seasonal variation based on the seasonality of the data used to generate the estimates.

Margin of Safety

Implicit and explicit margins of safety (MOS) have been factored into this TMDL. The implicit MOS is the reliance on water quality monitoring data collected 1985, 1988, 1989, 1994, and 1995 that do not reflect the positive impact of more recent nonpoint source pollution control efforts (described in section 2.4). However, this implicit MOS is somewhat countered by the observation that past sampling efforts had limited samples during peak flow events. Therefore, an explicit MOS has been added in using a target load capacity 20% lower than the model-predicted load capacity. Adding this explicit margin of safety resulted in total target load reductions of phosphorus to the lake increasing from 52% to 62%.

Upper Lapwai Creek

Upper Lapwai Creek was listed for nutrients on the 1994 303(d) list. Although algal growths do occur in the Creek, it is unclear what impairment of beneficial uses has resulted from nuisance aquatic growths. Since the Creek is listed for nutrients, a TMDL analyses has been conducted. Dissolved oxygen was not listed as a pollutant of concern on the 303(d) list for Upper Lapwai Creek and consequently is not addressed further in the Creek TMDL.

Phosphorus Target

EPA's Gold Book (EPA, 1986) indicates total phosphates as phosphorus should not exceed 50 ug/l in any stream at the point where it enters any lake or reservoir to prevent the development of biological nuisances and to control accelerated or cultural eutrophication. This target will be used as an initial target for the upper Lapwai Creek phased TMDL. It is assumed that nuisance aquatic growth in Upper Lapwai Creek is attributable to nutrient concentrations in the stream during the summer and early fall when other conditions such as light, temperature, and flow are conducive to these growths and not attributable to storage of nutrient compound materials in Upper Lapwai Creek during other times of the year. Therefore, this target of 50 ug/l will be applied only to the growing season months (May to October) for the Upper Lapwai load analysis. This assumption needs to be verified in future data collection efforts.

Because year-round nutrient contributions from Upper Lapwai affect nuisance aquatic growth in Winchester Lake, the necessary load reductions to Upper Lapwai Creek based on the seasonal stream target versus the annual lake targets are compared below.

Estimates of Existing Pollutant Loads

Since the algae growth season is typically May through October, the load analyses for the stream will cover this season only. Three methods were used to estimated phosphorus loading to Upper Lapwai Creek. Method one based loads on estimates provided by Wertz (1996). Method two based loads on 1988-89 data (Entranco, 1990). Method three based loads on the 15 year hydrograph and the relationship between flow and total phosphorus demonstrated by Entranco (1990) and Moeller (1986). Given the same result of 42 lbs P/month for methods one and three, 42 lbs P/month will be used in this TMDL as the estimated load for Upper Lapwai Creek between May and October. The same data limitations identified in the lake loading analysis regarding use of past data for estimates apply to the stream loading estimates.

1) Estimated Loads based on Wertz (1996). Using Wertz's monthly grab samples between May and October as indicative of daily flow and concentration data for the month, the estimated load is 42 lbs P/month.

2) Estimated Loads based on Entranco (1990). Using Entranco's monthly grab samples between May and October as indicative of daily flow and concentration data for the month, the estimated average monthly load is 26 lbs P/month.

3) Estimated loads based on 15-year hydrograph. Using the 15-year Upper Lapwai predicted hydrograph, the average daily flow between May and October is 2.2 cfs. Using this flow and applying the relationship between P and flow demonstrated in grab sample data from the Moeller (1986) and Entranco (1990) studies, the average monthly predicted load is 42 lbs P/month.

Proportioning of Nonpoint Source Load

As part of the analysis to determine proportional source contribution to the lake, the proportional source contribution to Upper Lapwai Creek is also addressed.

Load Capacity

Using the average seasonal predicted flow of 2.2 cfs between May and October based on the 15-year hydrograph and a target concentration of 50 ug/l, the seasonal target load capacity is 18 lbs P/month.

Load Allocations

In comparing the seasonal load estimate of 42 lbs P/month to the seasonal load capacity of 18 lbs P/month, the needed reduction of phosphorus loading in Upper Lapwai Creek during the algae growing season is 57%. This reduction is less than the 74% reduction estimated to be needed in Upper Lapwai Creek to meet the lake target. Thus, the reduction needed to meet the lake target is expected to resolve nutrient problems in Upper Lapwai Creek as well.

Margin of Safety

An implicit margin of safety has been provided in selecting an initial target of 50 ug/l based on EPA's Gold Book. In addition, the targeted reduction in Upper Lapwai has an implicit margin of safety because this reduction is based on meeting the lake target and is greater than the estimated reduction needed to meet the stream target.

3.2 SEDIMENT

Applicable Criteria

Idaho water quality standards include two criteria which relate to sediment. A narrative sediment standard is established (IDAPA 16,01.02.200.08) which states that *"Sediment shall not exceed quantities specified in Section 250, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses...".* In addition, a numeric turbidity criteria (IDAPA 16.01.01.250.02.b) is established to control water clarity. This standard states that turbidity shall not exceed background by more than 50 NTU instantaneously or more than 25 NTU for more than ten consecutive days.

Load Capacities and Targets

The current state of the science does not allow specification of a sediment load or load capacity that is known in advance to meet the narrative criteria and to fully support beneficial uses. All that can be said is that the load capacity lies somewhere between the current loading and natural background. We presume that beneficial uses were or would be fully supported at natural background sediment loading rates; therefore, until the relationship between beneficial use support and sediment loading is better understood, the loading capacity for sediment for Winchester Lake and Upper Lapwai Creek will be the natural background sediment load rate.

Beneficial uses may be fully supported at higher rates of sediment loading. The strategy is to establish a target of a declining trend in sediment loads, and to regularly monitor water quality and beneficial use support status. It is our intent to re-interpret the sediment standards and revise the TMDL accordingly if it is established that full support of beneficial uses is achieved at sediment loads above natural background.

Winchester Lake

The designated beneficial uses of Winchester Lake are thought to be, in part, impaired as a result of excess sedimentation, but high turbidity levels caused by fine sediment in the lake are not known to exceed the turbidity criteria. It is generally agreed that the sediment load to the reservoir from upland sources needs to be reduced for two reasons: 1) sediment is a primary carrier of inorganic phosphorous (see Section 3.1); and 2) sediment deposition in the reservoir reduces water depth, compounding dissolved oxygen problems. Consequently, sediment load reductions to decrease the rate of sediment accumulation in the reservoir are established in this TMDL.

Results from the sediment budget analysis (discussed below) indicate 7 to 27% of the existing sediment load to the reservoir is attributable to natural background. Since sediment is a major source of phosphorus to the lake, achieving these load targets coincides with needed phosphorous load reductions as well as sediment reductions needed for Upper Lapwai Creek.

Upper Lapwai Creek

Cold water biota and salmonid spawning are currently impaired in Upper Lapwai Creek as a result of excess sedimentation and elevated turbidity levels. Coarse and fine sediments have degraded the fish habitat of Upper Lapwai Creek. Sediment is significantly affecting salmonid spawning and rearing by filling in pools and other rearing habitat and clogging spawning gravels. To be considered "full support," this stream needs to provide adequate living space for feeding and rearing, and spawning gravels free from excess fine material for the most sensitive species within the stream, which is believed to be the native interior redband rainbow trout *(Oncorynchus mykiss).*

Turbidity data collected in 1998 indicate Upper Lapwai Creek exceeds the Idaho turbidity criteria, and reductions are needed to meet the criteria and fully support beneficial uses. However, because of the lack of flow, suspended sediment and turbidity data, it is currently not possible to establish a specific target at which the turbidity criteria will be met. Turbidity data have only been collected at low flow and suggest that high turbidity is a function of suspended sediment concentration. Suspended sediment and turbidity levels are expected to increase with additional stream flow. For example, Entranco (1990) measured TSS concentration of 216 mg/l at 41 cfs which is near average annual peak flow (i.e., 29 cfs). Ongoing data collection efforts will provide the data to establish this target. However, it is expected that achieving a sediment load reduction that will fully support salmonid spawning and cold water biota beneficial uses will achieve the turbidity criteria.

Two types of sediment targets are established for Upper Lapwai Creek: 1) compliance with the turbidity criteria, although the specific turbidity level cannot be established at this time; and 2) an average annual sediment load reduction of up to 90% using natural background conditions as the load reduction target until it is determined that some other load will fully support the beneficial uses.

Estimates of Existing Sediment Loads

The rock types and soils of Winchester Lake and Upper Lapwai Creek watersheds contribute a wide range of sediment size classes and loads. Generally, in this watershed granite and basalt underlie silt loam soils (see geology and soil maps). The mainstem of Upper Lapwai Creek is underlain by granite, and this type of rock contributes boulders to fine sands to the stream channel. Basalt crops out along the western margin of Upper Lapwai Creek, underlies the headwater channels, and contributes boulders to clay size material to the stream channel. Silt loam soils are uniformly distributed across the watershed and tend to have low to moderate permeability and are highly erodible. In effect, these soils are the major source of fine material to the stream channel.

The three processes which erode and deliver fine sediment to the stream channel and reservoir are: 1) surface erosion (sheet); 2) fluvial erosion (gully and rill); and 3) bank erosion. The occurrence of mass wasting is limited and is likely not a substantial sediment source relative to runoff-driven erosion. Surface and fluvial erosion is common in the headwaters where overland flow occurs. Some of the soils have inherently low effective hydraulic conductivity (e.g., Johnson-Kruse Complex); however, the majority of overland flow occurs in areas where the soils have been compacted. Stream banks commonly consist of silt to clay loam material; consequently, bank erosion is also a contributor of fine grain sediment.

The four dominant uses of land within the watershed are agriculture, range, forestry, and urban development. The type of sediment source is generally related to the type of land use: for example, most surface and gully erosion of the silt loam soils tends to occur in areas used for dryland agriculture, whereas bank erosion is prevalent in areas used for grazing or pasture land. In forested areas where timber extraction occurs, roads tend to be a source of sediment. Urban development of Winchester Lake and Upper Lapwai Creek watersheds is limited. Small rural developments exist and contribute some sediment to the reservoir and stream channel.

Data Gaps

A sediment budget was developed for the TMDL using a combination of field surveys and predictive models. Because of the sediment data limitations, this sediment budget analysis relies heavily on predictive models to estimate background and present sediment load. A review of existing flow and sediment data for this watershed (provided in the Watershed Assessment) revealed several data gaps. Some of these data gaps were met during the 1998 field season: for example, reservoir bathymetry was resurveyed and is presently being analyzed. However, data gaps related directly to sediment load estimates remain, and the TAG concludes the existing load estimates presented in Entranco (1990) and Wertz (1996) are under-estimates of actual load.

The existing sediment data are problematic for five reasons: 1) samples were analyzed for total suspended solids (TSS) not suspended sediment. The USGS has shown that the TSS analysis method underestimates suspended sediment concentration for water samples that contain sand size material (Clark, 1997 written communication); 2) limited number of samples taken during high flow events; 3) Wertz (1996) TSS samples were composited weekly; 4) no bedload data; and 5) no samples taken during the 1996 and 1997 floods.

Estimating sediment load with the above data is not possible using traditional techniques. For example, a sediment rating curve was developed from these data and the best possible curve fit has no statistical significance ($p < 0.05$) [data sets from Entranco (1990) and Wertz (1996)]. TSS data does not correlate well with stream discharge because high TSS concentrations occur at low flow as well as high flow. To address these concerns, an alternative sediment budget methodology was used, as described below. Presently, the Nez Perce Tribe and EPA are monitoring stream flow and sediment load of Upper Lapwai Creek. Data generated from this effort will help confirm sediment load estimates predicted using the following methods.

Sediment Budget Methodology

A sediment budget is an accounting of the sources and deposition of sediment as it travels from its point of origin to its delivery from a watershed (Reid and Dunne, 1996). Four steps are used to develop the sediment budget for Winchester Lake and Upper Lapwai Creek (Figure 11). As stated above this analysis only considers surface erosion (sheet), fluvial erosion (gully and rill), and stream bank erosion. First, total erosion from the four process categories are estimated. Second, using the total erosion values, sediment delivery from the hillslope to the stream channel is estimated. Third, sediment transport and delivery from individual subwatersheds is calculated and used to estimate the cumulative sediment load delivered to the reservoir. Finally, available sediment data and instream sediment models are used to help verify sediment budget estimates. For an expanded description of the sediment budget analysis, including input data and results, refer to Appendix A. Additionally, a discussion of seasonal variation and method uncertainty is provided in Appendix A.

Winchester Lake Existing Sediment Load

Six subwatersheds are delineated to characterize the existing sediment load estimates for the Winchester Lake TMDL (Table 7): for example, Upper Lapwai Creek is considered one watershed in this portion of the analysis. The sediment budget quantifies the types and sources of sediment to Winchester Lake. Using these estimates, load reduction strategies can target substantial sediment source areas in subwatersheds. Table 7 lists the estimated background and existing sediment load by sediment source category for these subwatersheds. The total estimated sediment to Winchester Lake is 650 tons per year, and the estimated background delivery is 50 tons per year.

From the results presented in Table 7, it is apparent that Upper Lapwai Creek is likely the major source of sediment to Winchester Lake. The Upper Lapwai Creek (LP) subwatershed contributes about 90% of the total sediment load to the reservoir, of which, about 10% is attributable to background. Within the LP subwatershed, surface erosion from agricultural lands represents about 87% of the current sediment load, stream bank erosion represents about 10%, and surface erosion from roads represents about 2% (Table 7).

The Johnson Creek watershed (WW-1) contributes about 53 tons per year to the reservoir, of which, about 5% is background. WW-1, which is the second largest subwatershed, contributes 8% of the total sediment load to the reservoir. Within WW-1, the major sources of sediment are surface and bank erosion (Table 7). The unnamed tributary (WW-2) and Skoal Creek (WW-3) contribute 5 and 21 tons per year, respectively. WW-2 has slightly more bank erosion than surface erosion, and 27% of the load is attributable to background. In WW-3 surface erosion is the dominant source of sediment and only 6% is attributable to background.

Table 7. Existing sediment load of subwatersheds to Winchester Lake.

	WW-1	WW-2	WW-3	LP	FD-1	FD-2	FD-3	FD-4	FD-5
Drainage Area (mi2)	1.3	0.4	0.4	9.3	0.1	0.1	0.2	0.0	0.1
Potential Sediment Transport Coeff.*	0.13	0.08	0.07	0.34	0.02	0.00	0.06	0.00	0.02
Hillslope Surface Erosion (t/y)	333	26	251	5763	2	33	0	0	0
Background Hillslope Surface Erosion (t/y)	37	13	14	405	1	2	0	0	0
% Load Attributable to Background	11	50	5	7	45	6	0	0	0
Bank Erosion (t/y)	56	28	25	684	1	0	0	0	0
Background Bank Erosion (t/y)	5	2	2	50	0	0	0	0	0
% Load Attributable to Background	9	7	9	7	7	0	0	0	0
Road Surface Erosion (t/y)	24	1	1	103	0	0	0	0	0
Urban Surface Erosion (t/y)	0	0	0	11	6	0	0	0	0
Total Erosion Est. (t/y)	**413**	**55**	**277**	**6560**	**8**	**33**	**0**	**0**	**0**
Total BG Erosion Est. (t/y)	**42**	**15**	**16**	**456**	**1**	**2**	**0**	**0**	**0**
% Load Attributable to Background	10	27	6	7	10	6	0	0	0
Potential Sediment Delivery	53	5	21	571	0	0	0	0	0
Background Potential Sediment Delivery	5	1	1	43	0	0	0	0	0

* = the Potentail Sediment Delivery (PSD) coefficient is explained in Appendix A.

(t/y) = tons per year

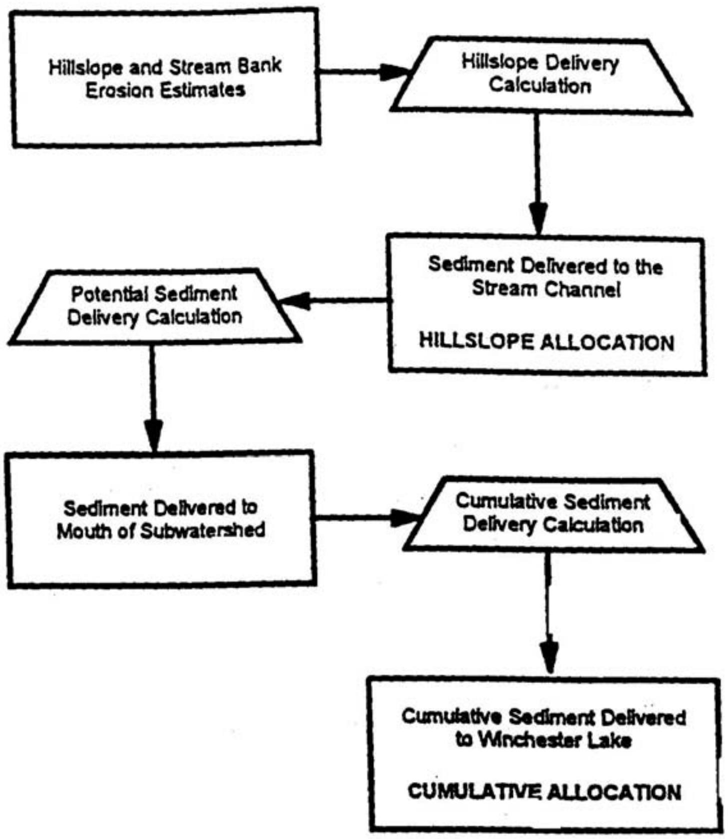


Figure 11. Chart illustrating flow of sediment budget analysis and sediment load allocations.

Erosion is occurring in the remaining small subwatersheds; however, there is limited hydrologic connection between these subwatersheds and Winchester Lake. For example, stream bank inventories in FD-5 found no active channels meaning the occurrence of channel forming flows is limited. Limited erosion is present around the lake from State Park roads, the boat ramp, and the shoreline. Fishing structures, described in Entranco (1990), have substantially reduced shoreline erosion. Sediment sources directly above and adjacent to the reservoir are likely inconsequential relative to sediment inputs from Upper Lapwai Creek.

Upper Lapwai Creek Existing Sediment Load

Six subwatersheds contribute sediment to the mainstem of Upper Lapwai Creek. Table 8 lists the estimated background and existing sediment load by sediment source category for these subwatersheds. Figure 12 illustrates sediment delivery estimates for Upper Lapwai Creek which shows the cumulative disposition of sediment downstream. The total estimated erosion and sediment delivery from subwatersheds which contribute to Upper Lapwai Creek is 571 tons per year, the estimated background erosion is 43 tons per year or 7% is attributable to background. As stated above, Upper Lapwai Creek contributes about 87% of the total sediment load to the reservoir.

Table 8. Existing sediment load of subwatersheds to Up|

	LP-1	LP-2	LP-3	LP-4	LP-5	LP-6
Drainage Area (mi2)	2.8	1.3	1.3	2.0	1.3	0.6
Potential Sediment Delivery Coeff.*	0.14	0.22	0.06	0.09	0.09	0.05
Hillslope Surface Erosion (t/y)	1879	364	1763	3201	126	215
Background Hillslope Surface Erosion (t/y)	128	47	71	191	32	57
% Load Attributable to Background	7	13	4	6	26	26
Bank Erosion (t/y)	344	108	169	200	147	43
Background Bank Erosion (t/y)	26	8	12	14	11	3
% Load Attributable to Background	7	8	7	7	8	8
Road Surface Erosion (t/y)	79	15	5	2	18	59
Urban Surface Erosion (t/y)	1	0	0	1	10	0
Total Erosion Est. (t/y)	**2302**	**487**	**1937**	**3404**	**301**	**317**
Total BG Erosion Est. (t/y)	**154**	**56**	**83**	**206**	**43**	**60**
% Load Attributable to Background	7	11	4	6	14	19
Potential Sediment Delivery	322	106	112	292	28	16
Background Potential Sediment Delivery	21	12	5	18	4	3

* = the Potentail Sediment Delivery (PSD) coefficient is explained in Appendix A.
(t/y) = tons per year

The following discussion outlines the cumulative disposition of sediment in Upper Lapwai Creek and describes the contents of Figure 12. Mud Springs Reservoir (LP-1) captures about 1/3 of the incoming stream flow and sediment to Upper Lapwai Creek. Available data suggest that the reservoir has a sediment trap efficiency of about 90%. The total erosion estimate for LP-1 is 2281 tons per year, the background estimate is 153 tons per year which is 7% of the total erosion. Multiplying the total sediment input by the potential sediment delivery coefficient indicates that about 322 tons per year is delivered to the Mud Springs Reservoir, of which about 16 tons per year is discharged from the outlet. The LP-2 stream channel receives the incoming load from Mud Springs Reservoir (16 tons/year) and an additional 106 tons per year is accumulated through this reach to total 122 tons per year delivered to LP-5 (Figure 12).

LP-3 delivers about 112 tons per year of which 4% is background which combined with LP-2 delivers about 234 tons per year to the lower reach of LP-5. As shown in Figure 12, subwatershed LP-4 delivers 292 tons per year to LP-5 and represents the largest single contributor of sediment to the mainstem of Upper Lapwai Creek. Cumulatively, LP-5 delivers about 571 tons per year to Winchester Lake, of which 7% is attributable to background (Figure 12).

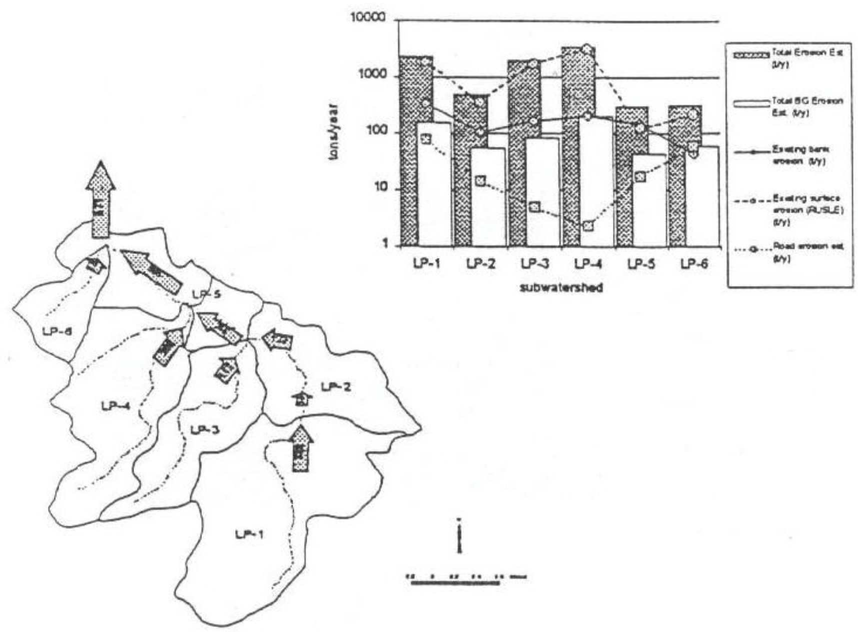


Figure 12. Upper Lapwai Creek Sediment Budget - Estimated Cumulative Sediment Delivery for Each Subwatershed (tons per year shown in arrows). Histogram Illustrating Total Erosion by Subwatershed and Erosion Process Category

Load Allocations

Winchester Lake and Upper Lapwai Creek sediment load reductions are allocated by subwatershed and land use category (Table 9 and Figure 12). Load allocations are established for the subwatersheds of Upper Lapwai Creek since they are the significant contributors of sediment and phosphorous to the stream channel and Winchester Lake. Each subwatershed has a *hillslope* and *cumulative* sediment load allocation by land use category and a percent sediment load reduction (Table 9 and Figure 11). The load allocation quantifies the maximum amount of sediment the stream and reservoir can assimilate and still meet the interim sediment targets set as part of the TMDL.

Generally, the land use category coincides with the erosion process category; for example, road erosion is associated with forest practices. The only exception is stream bank erosion which occurs on forested, agriculture, and pasture lands. A percent reduction by land use and subwatershed is provided to illustrate those areas which are contributing the majority of sediment; for example, LP-1 (i.e., area above Mud Springs Reservoir) is presently contributing 322 tons per year to Upper Lapwai Creek, and the estimated background contribution is about 21 tons per year, therefore a 93% reduction is allocated to this subwatershed (Table 9 and Figure 12).

Based on the results of the sediment budget, LP-3 and LP-4 are the largest contributors of sediment to the stream and reservoir (Table 9). LP-1 also has a high total erosion estimate (Table 9); however, as stated above Mud Springs Reservoir is, in effect, a sediment trap. Agricultural surface and stream bank erosion are the most significant sources of sediment within all of the subwatersheds (Table 9). Stream bank erosion within pasture lands is also a substantial source of sediment. LP-1 and LP-6 contribute the largest amount of road-related surface erosion which coincides with forest practices within these subwatersheds.

Margin of Safety

Implicit and explicit margins of safety are factored into this TMDL. The implicit margin of safety (MOS) is the conservative assumptions used to develop background and existing sediment loads. Four conservative assumptions were made as part of the sediment budget analysis and include: 1) 0.3 tons/acre/year is the background surface erosion rate; 2) 60% of the surface erosion predicted using RUSLE reaches the stream channel; 3) 85% bank stability is representative of background conditions; 4) 10% is added to road erosion estimates to account for un-inventoried forest roads and skid trails.

The explicit MOS is equated into the sediment allocations. This analysis is unable to quantify the level of sedimentation that will provide conditions characteristic of fully supporting beneficial uses. Consequently, the reservoir and instream sediment load reductions are established relative to background. The load reductions and the allocation strategy use background conditions as a benchmark or baseline.

Table 9. Load allocation summary for Upper Lapwai Creek by subwatershed and land use category.

		LP-1	LP-2	LP-3	LP-4	LP-5	LP-6
HILLSOPE ALLOCATION	**Agricutural Erosion (t/y)**	1879	364	1763	3201	126	215
	Load Allocation (t/y)	128	47	71	191	32	57
	Percent Reduction	93	87	96	94	74	74
	Bank Erosion (t/y)	344	108	169	200	-132	43
	Load Allocation (t/y)	26	8	12	14	277	3
	Percent Reduction	93	92	93	93	310	92
	Road Erosion (t/y)	79	15	5	2	-12	59
	Urban Erosion (t/y)	1	0	0	1	104	0
	Total Sediment Delivered (t/y)	**2302**	**487**	**1937**	**3404**	965	**317**
	Total Delivered Allocation (t/y)	**154**	**56**	**83**	**206**	-829	**60**
	Percent Reduction	93	89	96	94	186	81
CUMULATIVE ALLOCATION	**Cumulative Sediment Delivery* (t/y)**	322	122	234	526	122	571
	Allocation (t/y)	21	13	18	36	34	43
	Percent Reduction	93	89	92	93	72	93

* = the Potentail Sediment Delivery (PSD) coefficient is explained in Appendix A.

(t/y) = tons per year

3.3 TEMPERATURE

Winchester Lake

Thermal Characteristics

The storage of heat in a lake depends on solar radiation, cloud cover, surface and air temperatures, humidity, and wind speed as well as the amount of heat entering the lake.

$$S = R\,(net) - E - H - Q$$

S = storage rate of heat in lake
R (net)= net radiation
E = evaporation
H = conduction
Q = heat input or output due to water currents or inflow and outflow of streams

Lake temperature increases slowly because water has an enormous capacity for heat storage. Major heat losses occur by evaporation and conduction to the air, and to a lesser extent to the sediments. The natural heat buffering capacity of lakes prevents large or rapid changes in temperature on unusually sunny or cloudy days.

Due to the capacity for heat storage in lakes, it is unlikely the volume of water flowing into Winchester Lake from Upper Lapwai Creek is sufficient to alter the lake's temperature. The annual heat budget or total amount of heat entering Winchester Lake from lowest mean temperature to highest mean temperature is approximately 61,877,289 cal/m^2 (based on 1995 mean weighted temperature). The average daily temperature recorded by thermograph (July 18-August 31, 1998) for Upper Lapwai Creek, 1/4 mile upstream from the mouth, was 15.5° C. Thus, overall, Upper Lapwai Creek does not contribute water with temperatures above the cold water biota standard during the hottest months.

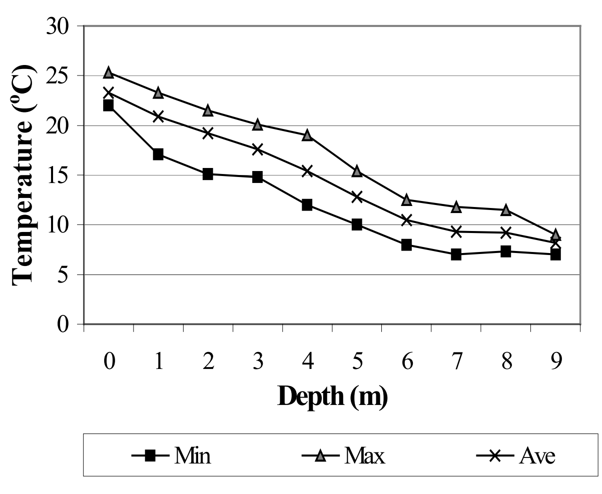
Temperature and Dissolved Oxygen Characteristics

Winchester Lake stratifies into layers of different temperatures and densities in the early spring and summer, and remains stratified through mid-October. Decomposition of organic material rapidly depletes the dissolved oxygen in the lower layer of water (hypolimnion) as early as May (Entranco, 1990; Moeller, 1986; and Wertz, 1996). The Winchester Lake hypolimnion (approximately 50% of the water volume) only contains adequate (5-6 mg/l) dissolved oxygen for aquatic species in November, December, and April (Entranco, 1990). Levels of dissolved oxygen were below acceptable levels for aquatic species at depths of 2 to 3 m, approaching 0 mg/l at 4 m depth for the other months of the year (Entranco, 1990; Moeller, 1986; Wertz, 1996; IDFG, 1997). Fresh water salmonids exhibit distress at dissolved oxygen levels of 6 mg/l (Bjornn and Reiser, 1991).

Average temperatures in the upper layer of water (epilimnion) commonly exceed desirable levels for cold water species (>19°C) beginning in June and persisting through August (Entranco, 1990; Moeller, 1986; Wertz, 1996; IDFG, 1997). State of Idaho criteria for cold water biota are for maximum instantaneous temperatures not exceeding 22°C with maximum daily average no greater than 19°C. The preferred temperature for rainbow trout is 14-16°C with an upper lethal level of 25-29.4°C (Bjornn and Reiser, 1991).

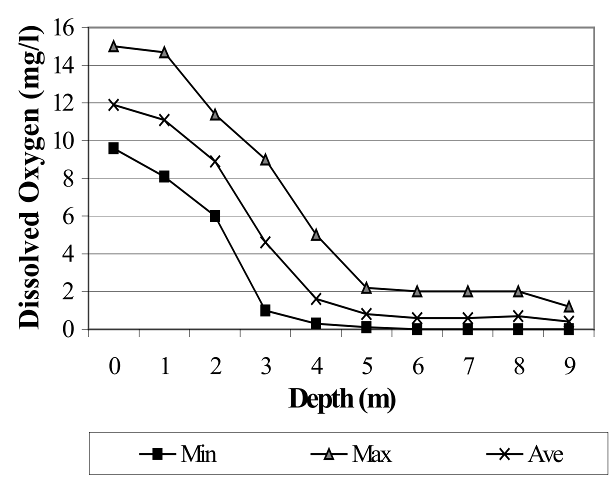
The result of this temperature-oxygen squeeze is the forcing of aquatic species into the warmer, upper layers of the lake. Moeller (1986) found that by July 17,1985, dissolved oxygen concentrations for salmonid fish were available only in the uppermost 2 m of surface water where temperatures approached 24° C. Other studies (Entranco, 1990; Wertz, 1996; and IDFG, 1997) found similar results. In addition, Moeller found this layer to have a pH (9.0-12.0) that may be limiting to fish. Generally most fish species tolerate a pH from 6.2-9.2 without adverse effects (Post, 1987). Figures 13 and 14 show the minimum, maximum, and average temperature and corresponding dissolved oxygen levels for the warmest summer temperatures of the indicated years covered in these past studies.

Figure 13. Winchester Lake Data Set for Warmest Temperature of Summer Season,



Years 1986, 88-89, 91-95, and 97

Figure 14. Winchester Lake DO Levels Corresponding to Warmest



Temperatures of Summer Season, Years 1986, 88, 91-95, and 97

Fish kills have occurred on 2 occasions in Winchester Lake as a result of oxygen depletion. One fish kill occurred in the winter of 1992, when a thick layer of snow covered the ice. The low dissolved oxygen levels could have resulted from biochemical oxygen demand from decomposition of organic materials, reduced photosynthetic activity, insufficient re-aeration before ice cover, or a combination of all these factors. Another large fish kill resulted in October 1994, when IDFG stocked 10,000 trout following fall destratification, immediately after redistribution of oxygen poor waters from depth (Wertz, 1996).

Although some salmonids have been shown to survive at relatively high temperatures, most are placed in life-threatening conditions when temperatures exceed 23-25°C, and will usually move to other areas to avoid such temperatures (Bjornn and Reiser, 1991). The maximum instantaneous temperature of the Winchester Lake epilimnion reached 24.2°C in July 1994 (Wertz, 1996). Other available temperature profiles show the maximum temperature generally ranging from 20 to 22°C in the summer months (Entranco, 1990; Moeller, 1986; Wertz, 1996).

In summary, suitable aquatic habitat in Winchester Lake is limited in the summer months due to high surface water temperatures and low dissolved oxygen at greater depths. A temperature-oxygen profile for warmest average temperatures (1986,1988, 1991-1995, 1997) portrays available suitable habitat as a 1-m stratum between 1.5 and 2.5 m in depth (Figure 15). The estimated volume of this layer is 281,850 m^3 or 15.8 % of the total volume. Above approximately 1.5 m average temperatures generally exceed 19°C during summer months, and below approximately 2.5 m anoxic conditions persist. Thus an estimated 84% of the water volume is uninhabitable by fish species during these months.

Targets

The temperature target set for Winchester Lake is for cold water biota: maximum instantaneous temperatures not to exceed 22°C with a maximum daily average no greater than 19°C. With the exception of approximately the top 2 m of surface water during June, July, and August, temperatures in Winchester Lake support cold water biota. The water column during summer stratification (epilimnion through hypolimnion) has a maximum daily average less than 19°C (Entranco, 1990; Moeller, 1986; Wertz, 1996; IDFG, 1997). Habitat available for cold water biota is limited to a 1-m stratum with a 281,850 m^3 or 16% of the lake volume due to a combination of temperature and dissolved oxygen requirements. The goal of the temperature TMDL is to increase dissolved oxygen in deeper water by decreasing nutrient input, thereby allowing trout and other species to utilize deeper water which meets the temperature standards year-round. Phosphorus and dissolved oxygen are in essence surrogates for the temperature TMDL, and as indicated in section 3.1, one of the goals of the phosphorus TMDL is to provide an adequate volume of water with sufficient dissolved oxygen that meets that temperature criteria in order to fully support a cold water fishery.

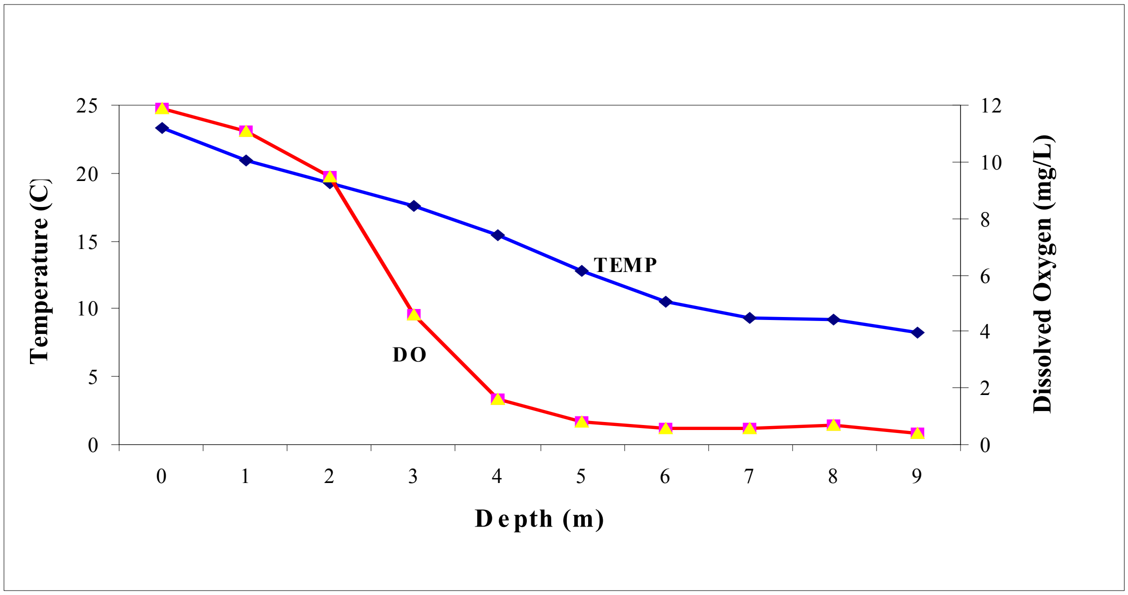


Figure 15. Winchester Lake Temperature and Dissolved Oxygen Profiles. Values are Averages of Warmest Temperatures and Corresponding Dissolved Oxygen Levels for Years 1986, 1988, 1991-95, and 1997

Using bathymetry information to estimate lake volume, combined with the expected change in the dissolved oxygen depth profile, the increase in lake volume which meets both dissolved oxygen and temperature criteria during the summer is estimated to increase from the current 16% to a range of 35% to 46% (refer to Appendix C). This increase in suitable habitat expected as a result of the phosphorus TMDL appears to provide adequate habitat to fully support a cold water fishery in Winchester Lake (Schriever, 1999). Follow-up monitoring to verify dissolved oxygen improvements and make further adjustments to the TMDL as appropriate are essential to the success of the TMDL.

Upper Lapwai Creek

The Upper Lapwai Creek Total Maximum Daily Load (TMDL) is established to address thermal loading (heat) during the salmonid spawning period (January 15 - July 15) for the entire watershed inclusive of all land uses. This TMDL establishes "P*ercent Increase In Shade"* and "*Target Solar Radiation Load*" targets for each sub-watershed which would allow Upper Lapwai Creek to attain and maintain a mean temperature criteria of 9°C. The Upper Lapwai Creek TMDL has been developed for heat. Heat, generated by the amount of solar radiation from sunlight reaching the stream, provides energy to raise water temperatures. The amount of surface area exposed to heat transfer from solar radiation is increased as channels are widened.

Targets

Idaho Water Quality Standards (IDAPA 16.01.02.120 (cc. CB-156)) protect Upper Lapwai Creek for both cold water biota and salmonid spawning. This TMDL addresses fisheries concerns resulting from impairments due to water temperature increases. The State of Idaho temperature criteria protects rainbow trout during the spawning period from January 15 to July 15. The remaining time period is protected by the cold water biota criteria.

Temperature criteria that apply.

Beneficial Use	Criteria
Salmonid Spawning	Water temperatures of thirteen (13□C) or less with a maximum daily average no greater than nine (9□C). IDAPA 16.01.02.250.02(d)(a)(ii)
Cold Water Biota	Water temperatures of twenty-two (22□C) or less with a maximum daily average no greater than nineteen (19□C). IDAPA 16.01.02.250.02(d)(a)(ii)

Condition Assessment

Stream temperature is driven by the interaction of many instream variables. Energy exchange may involve solar radiation, longwave radiation, evaporative heat transfer, convective heat transfer, conduction, and advection (Figure 16). With the many variables which affect instream temperature, solar radiation is one of most critical in small low flow streams.

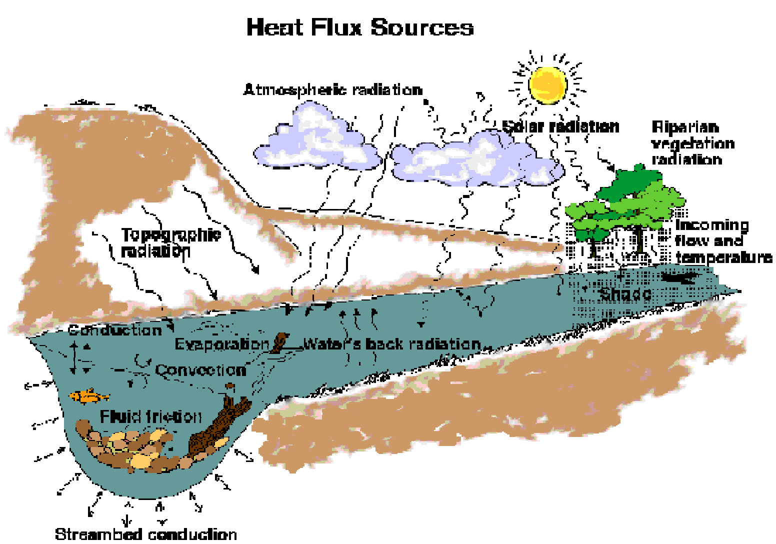


Figure 16. Variables Which Affect Instream Temperature

Management activities within a watershed can increase the amount of solar radiation entering a stream by removing riparian shade trees, harvesting of conifer overstory, grazing in riparian areas, and through the introduction of bedload sediment resulting in increases in the stream's surface area (Figure 17). The Upper Lapwai Creek TMDL was developed to address the lack of adequate stream shade contributing to instream temperature problems.

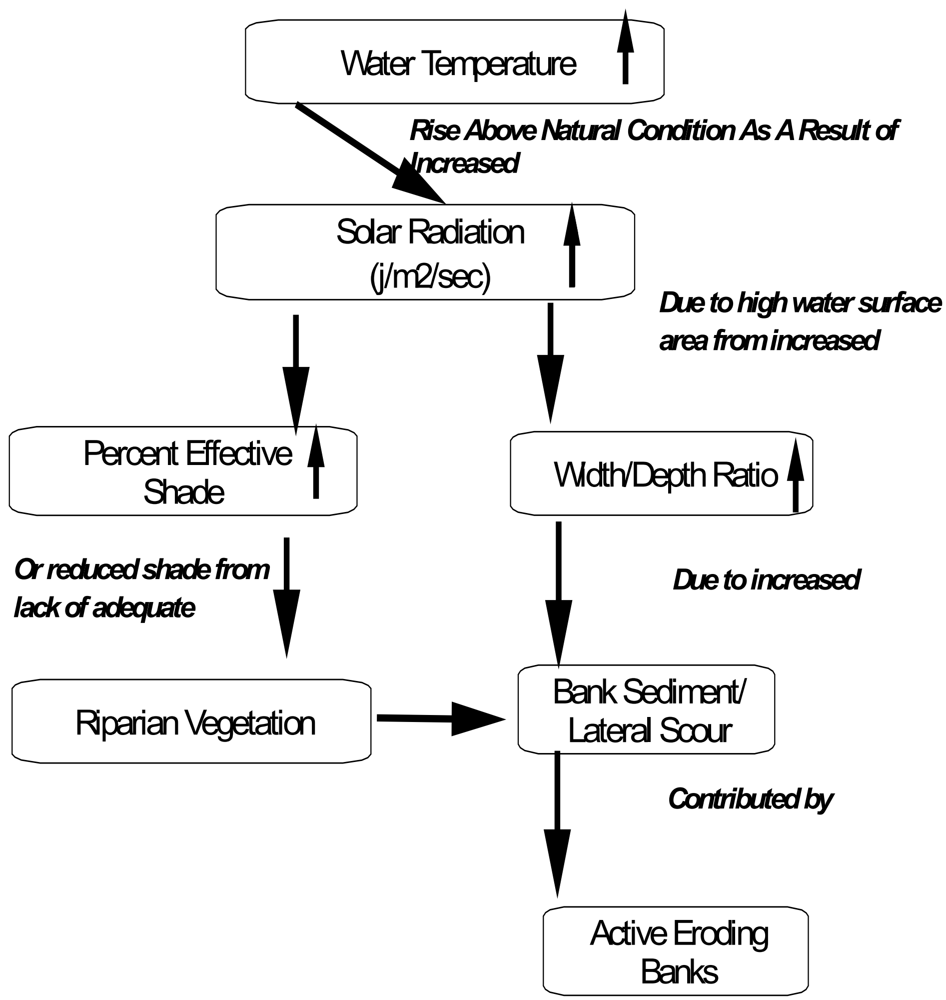


Figure 17. Relationship Between Water Temperature and Shade

Without riparian shade trees, most incoming solar radiation energy would be available to heat the stream. Riparian vegetation effectively reduces the amount of daily solar radiation load. Stream shade data collected by the Nez Perce Tribe identified areas where existing shade has been reduced due to grazing, agricultural and timber harvesting activities and calculates the resulting increase in total daily solar heating. To determine where shading problems exist and the magnitude of the problem, Upper Lapwai Creek was broken into six (6) sub-watersheds.

Target shade values were calculated using the Stream Segment Temperature Model (SSTEMP) and the Stream Segment Solar Temperature Model developed by the US Geological Survey (USGS, 1987).

Target shade values for Upper Lapwai Creek represent the *Percent Increase in Shade* needed by each sub-watershed to attain Idaho's daily mean temperature criteria of 9°C during the salmonid spawning period and 19°C during the salmonid rearing period. Table 10 displays the existing shade condition and the corresponding existing solar radiation load for each sub-watershed.

Table 10. Upper Lapwai Creek current shade conditions by subwatershed.

Watershed	% Existing Shade	Existing Solar Radiation Load ($j/m^2/sec$)
Lapwai Creek 1	28	225.6
Lapwai Creek 2	5	297.6
Lapwai Creek 3	3	303.9
Lapwai Creek 4	24	283.1
Lapwai Creek 5	22	244.4
Lapwai Creek 6	57	134.7

The determination of a critical time period for Upper Lapwai Creek was based on two factors, the availability of stream temperature data for Upper Lapwai Creek and the beneficial use being protected. Hobo temperature data loggers were placed in the lower portion of Upper Lapwai Creek from April 28 - August 31, 1998.

Analysis of the Hobo temperature data revealed April 29 - May 13 as the critical time period where the daily mean temperatures consistently exceeded 9°C (Figure 18). Observed stream temperature data from July 18 - August 31 showed that the daily average stream temperature exceeded 19°C only one day (Figure 19). Because salmonid spawning is the use at risk, the time period from April 29 - May 13 was identified as the critical time period.

Calibration of the SSTEMP Model and Assumptions

The SSTEMP model was calibrated using existing stream temperature, estimated streamflow and climatic data. Parameters which feed into SSSOLAR and SSTEMP relied on information such as streamflow, relative humidity, wind speed, cloud cover and air temperature. Air temperature data from the Grangeville, Idaho weather station was used for both the calibration and modeling

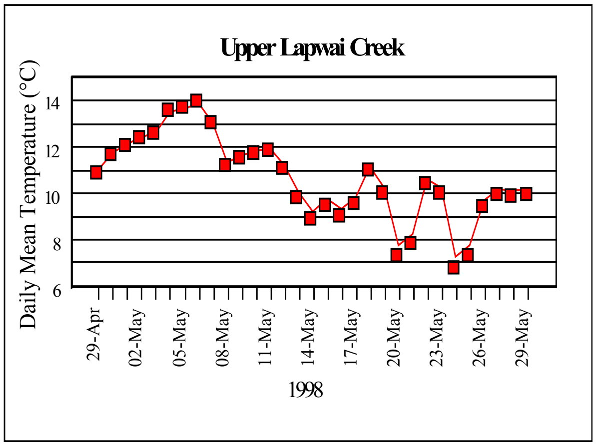


Figure 18. Mean Daily Temperature April 29 through May 30.

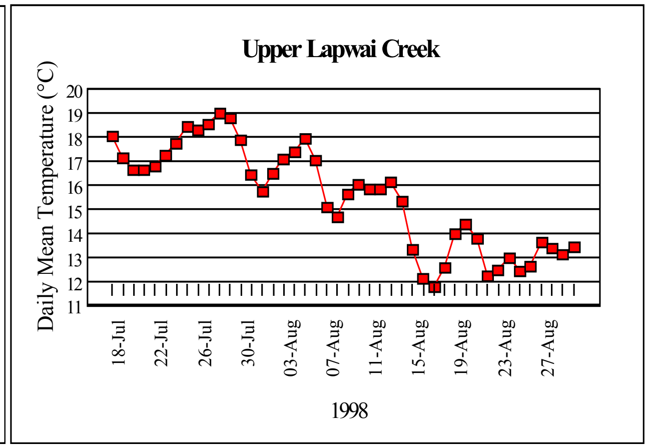


Figure 19. Mean Daily Temperature July 18-August 30.

exercise. The maximum and minimum air temperature was averaged over the eight-year period of record to obtain the average air temperature for the critical time period of interest. Because the Grangeville, Idaho weather station did not collect relative humidity, wind speed or cloud cover data, conservative assumptions were made with the aid of a NOAA Climatic Atlas.

The site/thermograph used to calibrate the SSTEMP model is located approximately ½ mile upstream from mouth in open meadow (Figure 22). The thermograph's location allowed it to serve as an integrator point in the watershed before discharging into Winchester Lake. This site reflects upstream activities which can have an impact on stream temperature. Figure 22 also shows the range of shade conditions throughout Upper Lapwai Creek. Using the readily available information described above, the calibration showed that the difference between the modeled stream temperature and the observed stream temperature was 1°C (Figure 20). This calibration exercise demonstrates that the model can predict mean daily stream temperature within a reasonable range (Figure 21).

Loading Capacity and TMDL Allocations

The loading capacity for Upper Lapwai Creek is heat from incoming solar radiation expressed in j/m2/sec based on the critical time period of April 29 through May 13. Analysis of heat transfer processes indicates that water temperatures increase when the heat load from solar radiation is above 244 $j/m^2/sec$. The current cumulative solar radiation load for Upper Lapwai Creek is 1489.3 $j/m^2/sec$. Because of the lack of streamflow information for each tributary to Upper Lapwai Creek, one loading capacity has been developed for Upper Lapwai Creek. The percent increase in shade developed for each sub-watershed will ensure that the loading capacity is met. Also the percent increase in shade needed for each sub-watershed was designed so that each

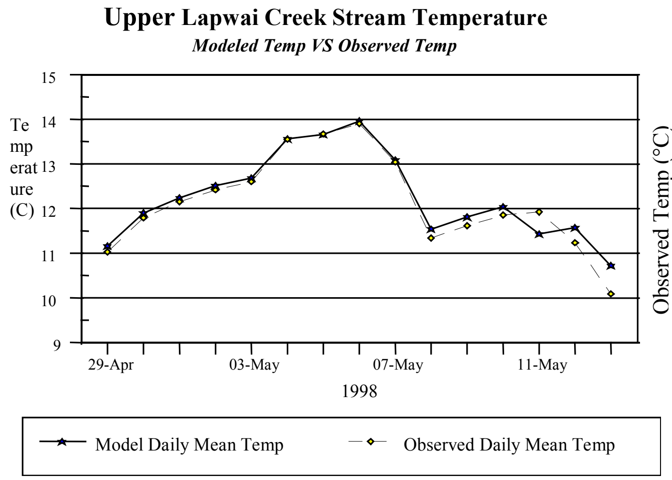


Figure 20. Modeled and Observed Daily Mean Temperatures

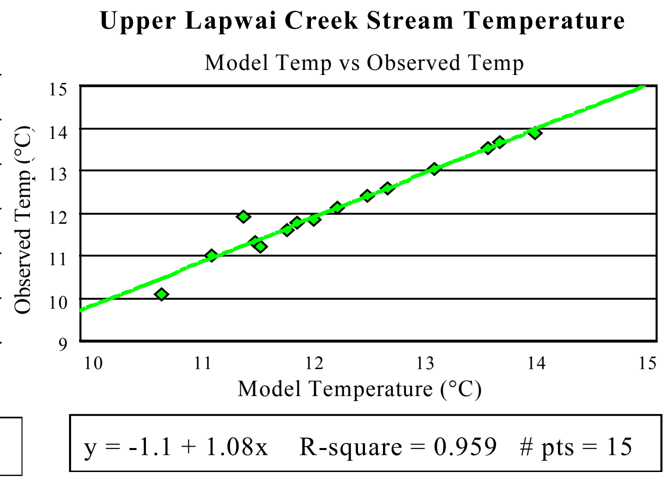


Figure 21. Regression Analysis Between Observed and Modeled Temperatures

sub-watershed would meet the instream temperature standard during salmonid spawning and rearing period respectively.

Allocations in the TMDL are derived using the percent shade target. These surrogate measures can be linked to source areas and to management actions needed to solve land management problems which cause water temperature to increase. The TMDL allocations described in Table 11 identifies the estimated shade targets needed for each sub-watershed needed to attain and maintain Idaho's daily mean temperature criteria of 9°C during the salmonid spawning period and 19°C during the salmonid rearing period. By meeting the proposed shade targets for each sub-watershed, Upper Lapwai Creek should attain the 9°C and 19°C criteria at the mouth of Lapwai Creek.

Although shade values may be higher in certain land use types, the *Existing Shade Condition* as described in Table 11 is the average of shade value for an entire watershed. For example, if a stream reach within a sub-watershed contained shade values of 0%, 0%, 0%, and 75% , the average shade value for that sub-watershed would be 18.75%. This allocation approach provides the Watershed Advisory Group with a planning tool which can be used to set priorities and target watersheds for restoration.

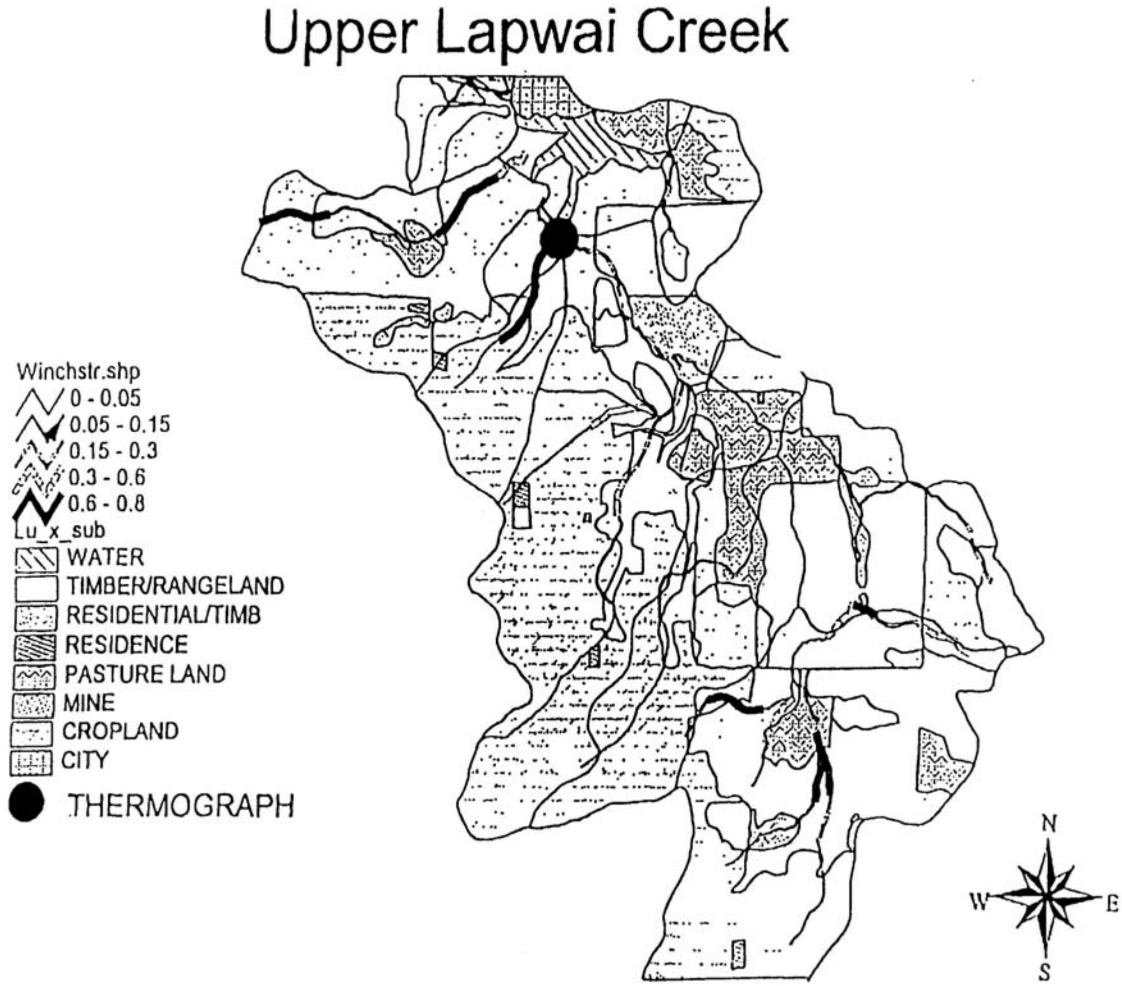


Figure 22. Location of Calibration Point and Thermograph. Percent Shade Values Across the Watershed

Table 11. TMDL allocation and target solar radiation load summary for upper Lapwai Creek subwatershed.

Watershed Name (length in mi.)	TMDL / Allocations				
	Existing Shade Condition (average)	Existing Solar Load (j/m^2 /sec)	Percent Increase in Shade	Total Shade	Target Solar Load (j/m^2 /sec)
Lapwai(1).....2.5	28%	225.6 j/m^2 /sec	50%	78%	51.7 j/m^2 /sec
Lapwai(2)...1.36	5%	297.6 j/m^2 /sec	87%	92%	18.82 j/m^2 /sec
Lapwai(3).....2.7	3%	303.9 j/m^2 /sec	76%	79%	49.35 j/m^2 /sec
Lapwai(4)...4.01	24%	283.1 j/m^2 /sec	54%	78%	51.7 j/m^2 /sec
Lapwai(5)...2.19	22%	244.4 j/m^2 /sec	57%	79%	49.35 j/m^2 /sec
Lapwai(6)...1.08	57%	134.7 j/m^2 /sec	38%	95%	11.7 j/m^2 /sec

Margin of Safety

Adaptative Management

Implementation of the Upper Lapwai Creek TMDL is intended to be an adaptive management process. This TMDL allows for future changes to the loading capacity and surrogate measures (allocations) in the event that scientifically valid reasons warrant changes. In the event that data show changes are warranted, changes to the TMDL will be made in consultation with the Winchester Lake Advisory Group.

Assumptions

The margin of safety is inherent in the temperature simulation methodology. A margin of safety of 25% was incorporated into each sub-watershed target to account for the conservative estimates of wind speed, relative humidity, and cloud cover. The following is a list of assumptions and documented data sources used in calibrating and running SSTEMP Model for Upper Lapwai Creek.

Parameter	Assumptions/Data Source
Relative Humidity	40% NOAA Climatic Atlas
Wind Speed	6.7 mph NOAA Climatic Atlas
Percent Possible Sun (Cloud Cover)	70% NOAA Climatic Atlas

Seasonal Variation

Section 303(d)(1) requires TMDLs to be "established at a level necessary to implement the applicable water quality standards with seasonal variations." Both stream temperature and streamflow vary seasonally from year to year. Water temperatures are coolest in the winter and early spring months. Stream temperature exceeds the Idaho water quality standards in late spring though mid summer (May - mid-July). Warmest stream temperatures correspond to areas with prolonged solar radiation exposure, warm air temperature and low flow conditions. These conditions occur during late spring and early summer and promote the warmest seasonal instream temperatures. The analysis presented in the TMDL is performed during late spring and early summer where the controlling factors for stream temperature are most critical.

3.4 BACTERIA

Upper Lapwai Creek and Winchester Lake are included in the 1994 303(d) list for pathogens. Pathogens are a small subset of microorganisms (e.g. certain bacteria, viruses, and protozoa) which if taken into the body through contaminated water or food can cause sickness or even death. Some pathogens are also able to cause illness by entering the body through abrasions in the skin.

Direct measurement of pathogen levels in surface water is difficult because they usually occur in low numbers, analysis methods are expensive, etc. Consequently, non-pathogenic bacteria which are often associated with pathogens, but which typically occur in higher concentrations, are usually measured. Fecal coliform bacteria are a commonly used indicator organism, although they are not pathogenic themselves in most instances. Fecal coliforms grow in the intestinal tract of warm blooded animals and man, so their presence indicates recent fecal contamination either from animals or man.

Winchester Lake

A fecal coliform TMDL specifically for Winchester Lake has been determined to be unnecessary for the following reasons.

First, Lapwai Creek is the single largest tributary to Winchester Lake, contributing approximately 70 % of the annual surface flow (Appendix A). The limited fecal coliform data available from Entranco (1990) also indicate that Lapwai Creek has the highest concentration of bacteria of the tributaries entering the lake. The mean fecal coliform concentration from lower Lapwai Creek (Station S-1) is 488 cfu/100ml, with a maximum of 2,100 cfu/100 ml. Mean concentrations for the other 3 tributaries sampled (S-5, S-6, S-7) are 1 cfu/100 ml, 2 cfu/100 ml, and 124 cfu/100 ml respectively, with the highest concentration being 340 cfu/100 ml.

Although these data are admittedly sparse, considering that Lapwai Creek contributes a high percentage of flow to Winchester Lake, the much lower fecal coliform concentrations from other tributaries, and the relative lack of significant fecal coliform sources draining directly into Winchester Lake, it is expected that implementation of the Lapwai Creek fecal coliform TMDL will address all significant sources of fecal coliforms to Winchester Lake.

Second, the basis for the listing of pathogens for Winchester Lake in 1994 is unclear. Early reports (Tulloch, 1972) indicate elevated bacteria levels in the lake in the vicinity of Winchester are apparently from domestic sewage. No data are included in this report, and no other data from that time period have been found.

In 1972 the City of Winchester constructed a single cell lagoon sewage disposal system which discharges to Lapwai Creek below Winchester Lake. Subsequently, the Idaho Department of Health and Welfare sampled the lake during the summer and early fall of 1985 at 5 locations (Moeller, 1986). Results are presented in Table 12.

Table 12. 1985 Winchester Lake fecal coliform data (Moeller, 1986).

	Station					
	1A	1B	3A	3B	5A	5B
Date	Fecal coliforms (#/100ml)	Fecal coliforms (#/100ml)	Fecal coliforms (#/100ml)	Fecal coliforms (#/100ml)	Fecal coliforms (#/100ml)	Fecal coliforms (#/100ml)
5/7/85	NR	NR				
5/23/85	NR	NR				
6/5/85	4	29	1	12	3	10
6/19/85	<1	25	<1	16	<1	5
7/2/85	1	8	1	26	7	8
7/17/85	<10	<10	<10	10	<10	<10
8/1/85	<1	<1	14	6	<1	<1
8/15/85	<2	4	<2	<2	<2	<2
8/29/85	<1	<1	TNCT	<1	<1	<1
9/12/85	<1	<1	1	<1	<1	<1
9/26/85	<1	<1	<1	<1	1	<1
10/9/85	<1	<1	<1	<1	<1	<1
10/24/85	1	3	4	1	1	<1

NR = data not reported
TNTC = too numerous to count

Primary and secondary contact recreation were designated uses for Winchester Lake in 1985. Fecal coliform criteria were also the same as they are today, as follows:

Table 13. 1985 Winchester Lake designated uses and fecal coliform criteria.

Designated Use	Fecal coliform criteria
Primary Contact Recreation (applicable May 1 - Sept. 30)	≤500 cfu/100 ml - at all times 200/100 ml - ≤ 10% of samples over 30 days ≤50 cfu/100 ml – geo mean in 5 samples over 30 days
Secondary Contact Recreation	≤800 cfu/100 ml - at all times 400/100 ml - ≤ 10% of samples over 30 days ≤200 cfu/100 ml - geo mean in 5 samples over 30 days

Data from the 1985 monitoring indicate that of the 66 samples analyzed, only a single sample may have exceeded the applicable criteria. Reevaluation of this data has lead us to conclude that Winchester Lake should not be listed for pathogens since the only available information indicates that the lake meets applicable criteria in > 98% of samples.

Since it is expected that the Lapwai Creek TMDL will be adequately protective of Winchester Lake, and since reevaluation of existing data indicates that Winchester Lake should not be listed for pathogens, pathogens will be removed from the 303(d) list for Winchester Lake during the next listing cycle in lieu of developing a fecal coliform TMDL for Winchester Lake at this time.

Upper Lapwai Creek

Beneficial Uses and Applicable Criteria

Relevant beneficial uses designated for Lapwai Creek include both primary and secondary contact recreation (IDAPA 16.01.02.120.01.aa). Fecal coliform criteria established to protect these uses are as listed in Table 13.

Targets

The goal of the TMDL is to achieve the fecal coliform criteria established for primary and secondary contact recreation. Since criteria to protect primary contact recreation are more stringent than for secondary contact recreation, they will be used as the goals of the Lapwai Creek TMDL. Consequently, the targets of the TMDL which are applicable May 1 - Sept. 30 are:

≤ 500 cfu/100 ml - at any time
\> 200 cfu/100 ml - <10% of samples over 30 days
≤ 50cfu/100 ml - geo. mean in 5 samples over 30 days

Fecal Coliform Loads

To estimate the load of fecal coliforms, both concentration and flow data are needed, as follows:

Loading = (concentration)(flow)
= (cfu/100ml)(1L/1000 ml)(cfs)(28.32 L/cfs)(86,400 sec/day) = cfu/day

where:
cfu = colony forming units
cfs = cubic feet per second

Fecal coliform data are available for Lapwai Creek (Table 14), Mud Springs Reservoir (Table 15) and Winchester Lake (Table 16). These data are very limited in nature, for example they only represent conditions in 1985, 1988, and 1995, and samples were only collected monthly.

The only fecal coliform data available for Upper Lapwai Creek are reported in Entranco (1990) as listed in Table 14. Between May 1 and September 30 when the criteria apply, concentrations ranged from 4 cfu/100ml to 2,100 cfu/100 ml. A minimum of five samples collected over 30 days are needed to evaluate compliance with the 30 day criteria, ie. 200 cfu/100 ml and 50 cfu/100 ml. In most instances samples were collected only once monthly, or at most, twice monthly. Therefore, the data are insufficient to allow a comparison to the monthly criteria. As a result, an estimate of a peak instantaneous load is calculated rather than an average load. Since a limited amount of data is available, the maximum concentration measured (2,100 cfu/100 ml) will be used to estimate the peak load. The goal of the TMDL is to reduce this load so that instream concentrations would meet the instantaneous criteria of 500 cfu/100 ml at all times.

Flow data were obtained from USGS records at the Lapwai Creek gage below Winchester Lake. Using the relationship between gage data and Upper Lapwai Creek developed in Appendix A, flow in Upper Lapwai Creek was estimated for the date of the highest measured fecal coliform concentration (7/11/88) as follows:

Flow = (gage flow)(0.0481)
= (7.7 cfs)(0.0481) = 0.37 cfs

Peak loading is therefore estimated as:

Load = (2,100 cfu/100 ml)(1000 ml/1L)(0.37 cfs)(28.32 L/cfs)(86,400 sec/day)
= 1.9×10^{10} cfu/day

Table 14. 1988 Winchester Lake and Upper Lapwai Creek bacteria data.

Site	Date	Fecal C. (cts/100ml)	Fecal S. (cts/100ml)	Ratio (FC/FS)	Data Source
S1	5/9/88	38	72	0.5	(Entranco, 1990)
S1	6/6/88	89	20	4.5	(Entranco, 1990)
S1	7/11/88	2100	49	42.9	(Entranco, 1990)
S1	8/15/88	136	360	0.4	(Entranco, 1990)
S1	9/12/88	26	83	0.3	(Entranco, 1990)
S2	5/9/88	4	18	0.2	(Entranco, 1990)
S2	6/6/88	66	10	6.6	(Entranco, 1990)
S2	7/11/88	20	16	1.3	(Entranco, 1990)
S3	5/9/88	135	92	1.5	(Entranco, 1990)
S3	6/6/88	38	49	0.8	(Entranco, 1990)
S3	7/11/88	280	260	1.1	(Entranco, 1990)
S3	8/15/88	520	1150	0.5	(Entranco, 1990)
S3	9/12/88	380	430	0.9	(Entranco, 1990)
S4	5/9/88	9	25	0.4	(Entranco, 1990)
S4	6/6/88	52	66	0.8	(Entranco, 1990)
S4	7/11/88	190	940	0.2	(Entranco, 1990)
S4	8/15/88	570	520	1.1	(Entranco, 1990)
S4	9/12/88	630	320	2.0	(Entranco, 1990)
S4	10/11/88	10	50	0.2	(Entranco, 1990)
S5	5/9/88	1	33	0.0	(Entranco, 1990)
S5	6/6/88	1	22	0.0	(Entranco, 1990)
S6	5/9/88	1	7	0.1	(Entranco, 1990)
S6	6/6/88	3	12	0.3	(Entranco, 1990)
S7	5/9/88	70	52	1.3	(Entranco, 1990)
S7	6/6/88	41	73	0.6	(Entranco, 1990)
S7	7/11/88	127	57	2.2	(Entranco, 1990)
S7	8/15/88	40	440	0.1	(Entranco, 1990)
S7	9/12/88	340	1100	0.3	(Entranco, 1990)

Table 15. Mud Springs Reservoir bacteria data.

Site	Date	Fecal C. (cts/100ml)	Fecal S. (cts/100ml)	Ratio (FC/FS)	Data Source
MS1A	7/19/93	1400	285	4.9	(Nez Perce, 1995)
MS1A	6/3/93	203	37	5.5	(Nez Perce, 1995)
MS1A	7/1/93	153	116	1.3	(Nez Perce, 1995)
MS1A	5/20/93	13	16	0.8	(Nez Perce, 1995)
MS1B	7/19/93	1506	321	4.7	(Nez Perce, 1995)
MS1C	7/1/93	147	223	0.7	(Nez Perce, 1995)
MS1C	6/3/93	72	51	1.4	(Nez Perce, 1995)
MS1C	4/29/93	63	74	0.9	(Nez Perce, 1995)
MS1C	5/20/93	36	83	0.4	(Nez Perce, 1995)
MS2C	7/1/93	82	5	16.4	(Nez Perce, 1995)
MS2C	10/28/9	14	180	0.1	(Nez Perce, 1995)
MS2C	4/29/93	7	17	0.4	(Nez Perce, 1995)
MS2C	6/3/93	3	1	3.0	(Nez Perce, 1995)
MS2C	5/21/93	2	24	0.1	(Nez Perce, 1995)
MS2C	8/27/93	2	4	0.5	(Nez Perce, 1995)
MS2C	8/27/93	2	4	0.5	(Nez Perce, 1995)
MS2C	8/5/93	1	101	0.0	(Nez Perce, 1995)
MS2C	9/17/93	0	0		(Nez Perce, 1995)
MS2C	10/8/93	0	24	0.0	(Nez Perce, 1995)
MS3	7/1/93	432	176	2.5	(Nez Perce, 1995)
MS3	8/5/93	275	1086	0.3	(Nez Perce, 1995)
MS3	4/29/93	55	3	18.3	(Nez Perce, 1995)
MS3	7/19/93	37	118	0.3	(Nez Perce, 1995)
MS3	6/3/93	8	25	0.3	(Nez Perce, 1995)
MS3	5/20/93	3	3	1.0	(Nez Perce, 1995)

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Table 16. 1985 Winchester Lake bacteria data.

Site	Date	Fecal C. (cts/100ml)	Fecal S. (cts/100ml)	Ratio (FC/FS)	Data Source
Station-1	3/18/85	18	34	0.5	(Latham, 1986)
Station-1	3/28/85	13	5	2.6	(Latham, 1986)
Station-1	4/2/85	80	120	0.7	(Latham, 1986)
Station-1	4/18/85	10	80	0.1	(Latham, 1986)
Station-1	6/18/85	169	175	1.0	(Latham, 1986)
Station-1	3/11/86	100	10	10.0	(Latham, 1986)
Station-1	4/8/86	4	24	0.2	(Latham, 1986)
Station-2	3/28/85	4	2	2.0	(Latham, 1986)
Station-2	4/2/85	10	10	1.0	(Latham, 1986)
Station-2	4/18/85	7	2	3.5	(Latham, 1986)
Station-2	2/18/86	1	10	0.1	(Latham, 1986)
Station-2	2/25/86	3	28	0.1	(Latham, 1986)
Station-2	3/11/86	10	10	1.0	(Latham, 1986)
Station-2	4/8/86	1	1	1.0	(Latham, 1986)

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Load Capacity

The load capacity is the greatest amount of a pollutant that can be added to a waterbody and still meet the water quality standards. Since the fecal coliform criteria are expressed as a concentration, the loading capacity will vary with flow. In other words, as flow increases the loading capacity does as well.

Load capacity could be estimated for each of the three fecal coliform criteria. However, since there are inadequate data to estimate 30 day mean concentrations, only an instantaneous (ie. single sample) loading capacity is estimated.

As indicated above, monitoring data from which to estimate geometric mean and peak instantaneous concentrations are limited. As a result, rather than estimating load capacity using the 500 cfu/100 ml criteria, the next lower standard, 200 cfu/100 ml, is used as an instantaneous target in order to provide an additional margin of safety.

Flow (cfs)	Instantaneous Target Conc.	Load Capacity (cfu/day)
0.1	200 cfu/100 ml	4.9×10^{8}
0.5	200 cfu/100 ml	2.5×10^{9}
1	200 cfu/100 ml	4.9×10^{9}
5	200 cfu/100 ml	2.5×10^{10}
10	200 cfu/100 ml	4.9×10^{10}
20	200 cfu/100 ml	9.8×10^{10}

The estimated percentage reduction in fecal coliform loading necessary to achieve the above load capacity is:

[1 - (200/2,100 cfu/100 ml)] x 100 = 90% reduction in bacteria loading

Allocations

Since there are no point sources in the upper Lapwai Creek watershed, establishing wasteload allocations for point sources is not relevant. Only a load allocation for nonpoint sources and background will be established.

Options for distributing bacteria allocations were presented to the WAG on October 29, 1998. These included allocating load reductions by subwatershed draining into Lapwai Creek, or by allocating load reductions by subwatershed and land use. The latter has difficulties since we currently do not have a method to estimate what fraction of the bacteria loading is originating from various land use categories.

The WAG was concerned that allocation decisions were being made based on data which is not current; 1988 for most of the watershed, 1993 for Mud Springs Reservoir. Their recommendation was to establish the nonpoint source allocation for bacteria at the mouth of Lapwai Creek in this TMDL, conduct additional monitoring during 1999, then revise the TMDL allocations as appropriate, including specific allocations for tributaries to Upper Lapwai Creek.

A number of factors were considered in addition to the WAG's recommendations in establishing the final allocation. First, it is acknowledged that recent land use practices may have lowered bacteria concentrations in Lapwai Creek and tributaries. For example, in 1994 a Clean Lakes Phase II grant funded the installation of 6,900 feet of riparian fencing, several offstream watering locations and the landowner changed to an alternative rotational grazing method, all of which are expected to greatly reduce cattle access to Lapwai Creek above and below Mud Springs Reservoir. In addition, approximately three years ago, a pig feeding operation located directly in a drainage-way in LP-3 was elimated and moved to a more suitable location in another subwatershed. Land owners are understandably concerned that bacteria levels have improved as a result of such practices, and that these be accounted for in setting specific bacteria allocations which will directly affect them.

Second, the age of the data raises questions regarding its validity, particularly in light of the land use changes mentioned above. Data were collected in 1988 for three of the four tributaries to Lapwai Creek, data in the fourth tributary was collected in 1993. Since changes in land use practices such as fencing to prevent livestock access to the stream are expected to have a relatively rapid impact on bacteria levels, concern was raised that using historic data may inaccurately represent current conditions.

Third, the scale of the Upper Lapwai Creek watershed is small. The listed stream segment is only approximately three miles in length, and drains a watershed of 7,800 acres. Because the size of the watershed is small and there are a limited number of source types, it is reasonable to establish a gross allocation for fecal coliforms at the mouth of Lapwai Creek until additional data is available to further refine these allocations by subwatershed or land use.

Finally, EPA and the Nez Perce Tribe have committed to conduct follow up monitoring in 1999 to better characterize bacteria concentrations in Upper Lapwai Creek and Winchester Lake. Based on results of these data, the TMDL will be revised as appropriate, including specific allocations for tributaries to Upper Lapwai Creek.

In consideration of all the factors listed above, it was concluded that it is reasonable to establish a gross allocation for all nonpoint sources and background at the mouth of Lapwai Creek. The allocation is as follows:

$$\text{load capacity} = \text{load allocation} = (4.9 \times 10^9 \text{ cfu/day}) \times \text{streamflow (cfs)}$$

The table below identifies specific fecal coliform load allocations established for various flows expected to occur during the critical period of May 1 to Sept. 30. To determine the load capacity and load allocations at other flows, the above equation applies.

Flow (cfs)	Load Allocation (cfu/day)	% reduction needed at mouth of Lapwai Creek
0.1	4.90E+08	90%
0.5	2.50E+09	90%
1	4.90E+09	90%
5	2.50E+10	90%
10	4.90E+10	90%
20	9.80E+10	90%

Seasonal Variations

Two approaches have been used in this TMDL to account for seasonal variations. First, load capacity, needed reductions and allocations in the TMDL focus on the May through September time period when the most stringent criteria (primary contact recreation) apply. Second, the highest concentrations measured during the critical time period were used in deriving allocations and needed reductions. This is a relatively conservative approach and is believed to result in protective allocations which account for seasonal peaks in bacteria concentrations, to the extent they are known given the data available.

Margin of Safety

Uncertainties inherent in developing the bacteria TMDL include:

- lack of land use specific estimates of coliform loading
- lack of detailed monitoring data
- age of monitoring data (1988, 1995)
- unknown rate of pathogen die-off

To account for these uncertainties, a margin of safety has been incorporated into the TMDL by using the following conservative assumptions.

> *The maximum concentration reported for all samples collected in Lapwai Creek was used to estimate peak loading.* Data for the creek are rather limited. Using the highest recorded concentration to estimate peak concentrations may result in conservatively high estimates of peak concentrations and loads, particularly since land use changes such as the fencing of certain stream reaches, may have subsequently lowered fecal coliform concentrations.
>
> *An instantaneous target of 200 cfu/100 ml was used to derive needed load reductions, rather than using the 500 cfu/100 ml criteria in Idaho water quality standards.* Again due to the limited nature of the available data, this conservative assumption was made in order to err on the side of safety. Using a 200 cfu/100 ml target results in a needed reduction of 90%, whereas use of a 500 cfu/100 ml target would result in a needed reduction of only 76%.

3.5 PESTICIDES

Winchester Lake was listed in 1994 and in subsequent 303(d) lists for pesticides as a result of pesticides residues found in fish in 1985 by Moeller (1986). Low levels of DDT and related compounds, and hexachlorobenzene and hexachlorocyclohexane were detected in two brown bullheads and two trout (Table 17).

This data was insufficient to determine whether pesticides in Winchester Lake fish presented a human health risk which violated Idaho water quality standards. Additional data was collected to determine whether a TMDL for pesticides was necessary.

Table 17. Pesticides in Winchester lake fish 1985.

Compound	Trout #1	Trout #2	Brown Bullhead #1	Brown Bullhead #2	Units
Total DDT	0.002	0.004	0.002	0.017	mg/kg
o,p DDE	<0.001	<0.001	<0.001	<0.001	mg/kg
p,p DDE	0.002	0.004	0.002	0.012	mg/kg
o,p DDD	<0.001	<0.001	<0.001	<0.001	mg/kg
p,p DDD	<0.001	<0.001	<0.001	0.004	mg/kg
o,p DDT	<0.001	<0.001	<0.001	<0.001	mg/kg
p,p DDT	<0.001	<0.001	<0.001	<0.001	mg/kg
Hexachlorobenzene	<0.001	<0.001	<0.001	0.002	mg/kg
Hexachlorocyclohexane (alpha BHC isomer)	<0.001	<0.001	<0.001	0.003	mg/kg

Water quality criteria for pesticides are defined as water column concentrations. For pesticides and other chemicals, criteria are established to protect organisms which live in the water and separate criteria are established to protect the health of humans who eat fish and other aquatic organisms. Human health criteria are established to ensure that the additional cancer risk as a result of eating aquatic organisms does not exceed 10^{-6} and that there is not an appreciable risk of noncancer effects such as liver or kidney damage. These criteria are established using national exposure factors including the assumption that a person eats 6.5 grams/day (about one 1/4 lb meal every 2 ½ weeks) of fish for 70 years (U.S. EPA, 1980).

For all chemicals found in the 1985 sampling, applicable criteria (40 CFR 131.36(b)(1) column D2) to protect human health are either much lower than criteria to protect the aquatic organisms themselves, or aquatic life criteria have not been established:

Chemical	Human health criteria	Aquatic Life Criteria Acute	Chronic
DDT	0.00059 ug/l	1.1 ug/l	0.001 ug/l
DDE	0.00059 ug/l	*	*
DDD	0.00084 ug/l	*	*
Hexachlorobenzene	0.00077 ug/l	*	*
Hexachlorocyclohexane (α-BHC)	0.013ug/l	*	*

* - criteria not established

Detection limits for these compounds in water samples normally range from 0.5 - 1.5 ug/l using EPA Method 8081 (Woods, 1998). Since these detection limits are much higher than the human health water quality criteria, it is conceivable that water column concentrations could exceed the criteria, but the compounds would not be detected in water samples. Since human health criteria are much lower than the aquatic life criteria and since water column sampling might not detect pesticides at levels exceeding criteria, it was decided to sample fish tissue, as done by Moeller in 1985. Fish tissue analysis would be used to determine whether the risk of fish consumption exceeds risk levels used to establish the federal criteria, using exposure assumptions which form the basis of the federal criteria which are adopted by reference in Idaho water quality standards (IDAPA 16.01.02.250.07).

Details of the abbreviated risk assessment follow. For a more complete discussion of risk assessment methods and procedures, the reader is referred to the Risk Assessment Guidelines of 1986 (USEPA, 1987).

Sampling

In April 1998, EPA and Idaho Department of Fish and Game personell collected five fish species at five sites in the lake. Tissue samples were processed in the field by EPA and IDFG personnel, and submitted to the U.S. EPA laboratory in Manchester for further processing and pesticides analysis. Sampling, processing, analysis and protocol are listed in the 1998 USEPA QAPP for the project.

Fish were collected from five locations in the lake believed to range from the most (ST-2) to least (ST-4) impacted from pesticides (Figure 23). At each of these locations fish were collected by electrofishing, gill nets, and fyke nets. The intent was to collect fish species normally caught and consumed by fisherman, particularly larger adult fish which are likely to contain higher pesticide residues. Target species included rainbow trout, bass, bullheads and perch.

Rainbow trout are planted in the lake annually by IDFG. An effort was made to sample only larger rainbow trout which were believed to overwinter in the lake and would be more likely to accumulate higher levels of pesticides.

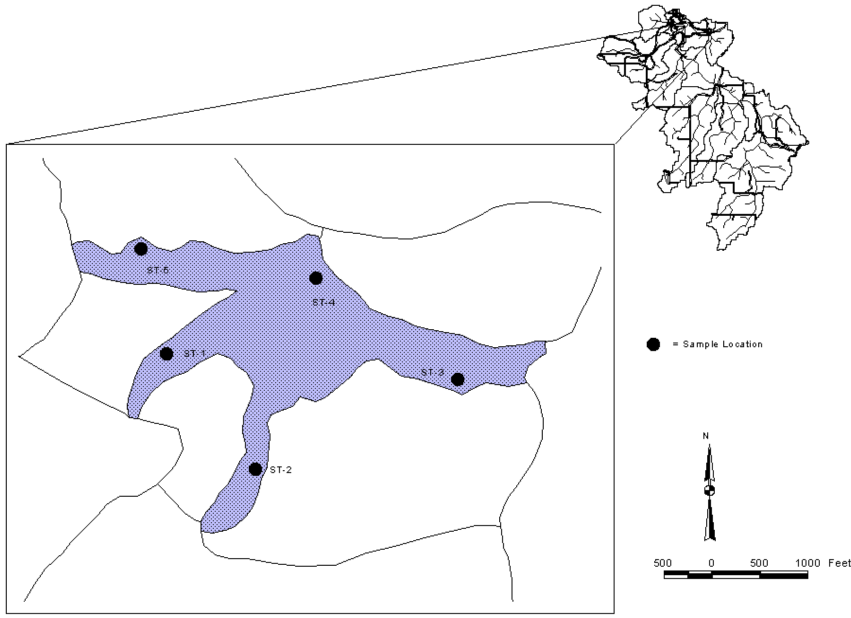

Figure 23. Winchester Lake Fish Tissue Sampling Locations

Bullheads were considered to be a particularly critical species since 1986 sample results found higher levels of DDT in bullheads than in trout. DDT and related compounds are relatively insoluble in water, and when transported are usually bound to sediments. Bullheads tend to be bottom dwellers and are more likely to be in contact with or ingest pesticides laden sediments than other target species.

Sample Preparation

Fish were inventoried, weighed, measured and fileted in the field, using standard EPA procedures. Most fish were fileted leaving the skin on to represent typical home preparation techniques. Filets from one of the bullheads were also skinned to evaluate the effect this would have on pesticides concentrations. The whole body of perch were analyzed rather than fileting, due to their small size and time constraints. As a result, comparison of perch results with other fish species should be done with caution, since these analysis likely do not represent how fisherman normally prepare perch for consumption. It is expected that pesticides would accumulate in higher concentrations in internal organs, therefore pesticides concentrations in whole body samples are likely higher than in filets.

In most instances, several specimens of each species were collected at each station. At the EPA Manchester Laboratory each species was separately homogenized into a single sample for each station.

Based on review of pesticides previously detected, and pesticides use information for the Winchester Lake watershed provided by NRCS, all samples were analyzed using EPA Method

8081 for chlorinated pesticides and PCBs, and EPA Method 8085 Atomic Emission Detector Pesticides Screen. Quality assurance review by USEPA chemists determined that analytical results were acceptable (USEPA, 1998a; USEPA, 1998b).

Table 18 summarizes fish tissue concentrations by sample station and fish species. If a pesticide was not detected in a sample but it was detected in other samples, ½ the detection limit for that sample is listed in this table in bold. DDT, DDD, DDE, hexachlorobenzene and triallate were found in most fish collected. DDMU was only found in bullheads at ST-5.

Exposure Assessment

An estimate of a person's long term exposure to a chemical is needed to establish the likelihood of cancer and noncancer effects. A consistent methodology for estimating exposure has been established by EPA (EPA, 1987). The degree of individual exposure will vary depending on the concentration of the compound, the amount of fish consumed, the frequency of fish consumption, and other factors. Exposure is usually normallized to an amount per body weight per time, e.g. chronic daily intake (mg/kg/day). The equation used to estimate exposure is as follows:

$$\text{Chronic Daily Intake (mg/kg/day)} = \frac{\text{(tissue conc.)(ingestion rate)(exposure frequency)(exposure duration)}}{\text{(body weight)(averaging time)}}$$

Parameters used to calculate the Chronic Daily Intake are listed in Table 19.

It is important to note that the use of a fish ingestion rate of 6.5 gm/day is based solely on the fact that this is the rate used to establish federal water quality criteria adopted by reference in Idaho water quality standards, which were agreed upon as the basis for this TMDL. This is in no way intended to indicate that this ingestion rate is representative of subsistence fishers. Tribal members in particular are known to consume on average much higher quantities of fish, though a high percentage of their diet are anadromous species rather than the resident species found in Winchester Lake (CRITFC, 1994).

Sample Number	Station #	Fish species	Sample Preparation	# Fish	Duplicate Sample #	Hexachlorobenzene (ug/kg)	DDMU (ug/kg)	P,P' - DDE (ug/kg)	o,p' - DDE (ug/kg)	DDD, o,p (ug/kg)	o,p' - DDT (ug/kg)	PP' - DDD (ug/kg)	PP' - DDT (ug/kg)	Triallate (ug/kg)
98184564	ST-1	bass	F	1		1.8		18	1.1	1.1	**0.9**	2.4	1.8	1.4
98184565	ST-1	bass	F	1		2.9		27	1.5	1	**0.95**	3.8	3.4	2.7
98184568	ST-1	bullhead	F	7		5.2		50	**0.95**	1.1	**0.95**	5.7	11	2.7
98184569	ST-1	bullhead	S	5		4.7		23	0.89	0.89	**0.9**	3.8	1.3	2.5
98184560	ST-1	perch	WB	10		2.2		27	**1**	1.2	**1**	2.6	2.2	7.1
98184566	ST-1	rainbow	F	13	567	1		10	1.3	1.2	**1.05**	1.6	1.3	**2**
98184567	ST-1	rainbow	F	13	566	**0.95**		15	**0.95**	0.95	**0.95**	1.4	1.2	**2**
98184551	ST-2	bass	F	2		1.9		19	**1.5**	**1.9**	**0.95**	2.3	2	3.7
98184555	ST-2	bass	F	3		**1.05**		8.2	**1.05**	1.6	**1.05**	1	1	**2**
98184550	ST-2	perch	WB	16	575	2.6		29	**0.9**	**0.9**	**0.9**	2.9	**1**	6.4
98184575	ST-2	perch	WB	16	550	2.9		25	0.96	0.77	**0.95**	3.5	3.7	8.1
98184562	ST-3	bass	F	2	572	2.1		17	1.3	1.3	**0.95**	2.5	2.4	2.3
98184563	ST-3	bass	F	4		**1**		12	0.99	1.2	**1**	1.4	1.5	**2**
98184572	ST-3	bass	F	2	562	2.1		23	1.7	1.3	**0.95**	3	2.4	3.1
98184570	ST-3	bullhead	F	7	571	3.9		43	**0.9**	1.4	**0.9**	8.3	1.6	3.4
98184571	ST-3	bullhead	F	7	570	4		47	**1**	1	**1**	7.9	1.6	**2**
98184557	ST-3	perch	WB	15		1.8		36	**1**	1.2	**1**	3.6	3.4	6.9
98184561	ST-3	rainbow	F	9		**0.95**		11	0.76	0.76	**0.95**	1.4	0.76	**2**
98184558	ST-4	bullhead	F	7	574	3.4		32	**0.95**	1.1	**0.95**	4.5	2.3	3.8
98184574	ST-4	bullhead	F	7	558	4.2		28	0.79	1.2	**1**	4.7	1.8	**2**
98184556	ST-4	muskie	F	1		1		8	**1**	0.8	**1**	1	0.7	**2**
98184559	ST-4	rainbow	F	12	573	**1**		9.9	0.79	0.79	**1**	1.5	0.99	2.4
98184573	ST-4	rainbow	F	12	559	**1**		7.8	0.98	0.78	**1**	1.4	1.2	7
98184552	ST-5	bullhead	F	4		2.9	3.9	21	1	2.7	**1.05**	3.2	1	3.7
98184554	ST-5	perch	WB	15		2.7		34	0.76	**0.95**	**0.95**	3.2	2.6	9.9
98184554	ST-5	perch	WB	15	internal dup #1	2.8		42	**1**	**1**	**1**	3.6	2.7	**2**
98184554	ST-5	perch	WB	15	internal dup #2	**2.1**		39	**0.95**	**0.95**	**0.95**	2.6	2.2	**2**
98184553	ST-5	rainbow	F	8		**0.95**		11	0.93	1.7	**0.95**	1.3	1	**2**
average bass dups @ station 3						3.075		32.5	0.95	1.025	0.95	3.55	6.1	2.35

NOTES: **Bold** values are 1/2 the detection limit for chemicals not detected. F = filet with skin on S = filet without skin WB = whole body

Table 18. Raw Data including QA/QC samples.

Table 19. Exposure parameters.

Variable		Reference
Tissue concentration	arithmetic average	U.S. EPA, 1997
Ingestion rate	6.5 gm/day	IDAPA 16.01.02; U.S. EPA 1980
Exposure frequency	365 d/yr	U.S. EPA, 1980
Exposure duration	70 years	IDAPA 16.01.02; U.S. EPA 1980
Body weight	70 kg	U.S. EPA, 1980
Averaging time	70 years	IDAPA 16.01.02; U.S. EPA 1980

Dose-Response Assessment

The dose-response assessment for noncarcinogenic effects is a process of establishing the lowest dose of a chemical at which a critical effect occurs. The dose-response assessment typically establishes a reference dose (Rfd). An Rfd is an estimate of human daily exposure that is likely to be without an appreciable risk of adverse effects over a lifetime (IRIS, 1998). An Rfd is usually based on human or animal data which identifies a No Observed Adverse Effects Level or Lowest Observed Adverse Effects Level (experimental data) and a Modifying Factor to account for species differences and inter-individual variability (some people are more sensitive than others). The experimental data, together with modifying factors, are used to estimate a threshold dose below which adverse health effects are considered to be unlikely.

Table 20 lists the chronic oral Rfd's for chemicals of concern. The Rfd for DDT has been used for DDT metabolites for which Rfds have not yet been established (o,p'-DDD; p,p'-DDD; o,p'-DDE; and p,p'-DDE). Using surrogate Rfd's adds to the uncertainty of the risk estimate, but this uncertainty is expected to be protective.

The relationship between the dose of an agent and the likelihood of a carcinogenic effect is established for chemicals known to cause cancer based on human or animal studies, or both. A slope factor is derived from these studies, which can be used in combination with exposure information (ie. chronic daily intake) to estimate the lifetime risk of cancer. Table 20 lists the slope factors for chemicals of concern.

Risk Characterization

The predicted cancer risks represent upper bound estimates of additional risk occurring above anticipated background rates of cancer occurrence, which range from 20% (1 in 5) to 40% (1 in 2.5). Water quality standards are established at a level to ensure that the increased lifetime risk from any chemical does not exceed 1×10^{-6} (ie. 1 in 1,000,000). Cancer risk is calculated as follows:

Cancer risk = (chronic daily intake)(oral slope factor)

Table 21 lists cancer risks by fish species and chemical. Compared to the other species, bullheads pose the highest excess cancer risk when summing risk across all chemicals (2×10^{-6}), followed by perch, bass and muskie.

Table 20. Slope factors and chronic oral reference doses for chemicals of concern.

Chemical	Slope factor (1/mg/kg/day)	Chronic Oral Rfd (mg/kg/day)	Reference
o,p= - DDT	0.34	5.00E-04	IRIS, 1998
p,p= - DDT	0.34	5.00E-04	IRIS, 1998
o,p= - DDD	0.24	5.00E-04[1]	IRIS, 1998
p,p= - DDD	0.24	5.00E-04[1]	IRIS, 1998
o,p= - DDE	0.34	5.00E-04[1]	IRIS, 1998
p,p= - DDE	0.34	5.00E-04[1]	IRIS, 1998
Hexachlorobenzene	1.6	8.00E-04	IRIS, 1998
Triallate	[2]	1.30E-02	IRIS, 1998
DDMU	[2]	[2]	

[1] - the Rfd for DDT was used for its metabolites if the Rfd was unavailable for a particular metabolite
[2] - slope factor and Rfd's not currently established

Table 21. Estimated cancer risks from consumption of Winchester Lake fish.

Compound	Slope Factor	Exposure Duration (years)	Bass	Bullhead	Muskie	Perch	RB trout	Average for Bass, Bullhead, Perch, and RB
Hexachlorobenzene	1.6	70	2.7E-07	5.9E-07	1.5E-07	3.4E-07	1.4E-07	3.4E-07
p,p' - DDE	0.34	70	5.5E-07	1.2E-06	2.5E-07	1.0E-06	3.4E-07	7.6E-07
o,p' - DDE	0.34	70	4.0E-08	3.0E-08	3.2E-08	3.0E-08	2.9E-08	3.2E-08
o,p' - DDD	0.24	70	3.0E-08	3.4E-08	1.8E-08	2.3E-08	2.4E-08	2.8E-08
o,p' - DDT	0.34	70	3.1E-08	3.1E-08	3.2E-08	3.1E-08	3.1E-08	3.1E-08
p,p' - DDD	0.24	70	5.1E-08	1.2E-07	2.2E-08	7.0E-08	3.1E-08	6.8E-08
p,p' - DDT	0.34	70	6.4E-08	1.2E-07	2.2E-08	8.2E-08	3.2E-08	7.6E-08
Combined Risk for all Compounds		70	1.0E-06	2.1E-06	5.3E-07	1.6E-06	6.3E-07	1.3E-06

Muskie are a recently introduced species which are in low numbers in Winchester Lake, and are generally below the legal size limit (20"). As a result, it is unlikley that they currently represent a significant portion of fish consumed from the lake, although their future contribution to the fishery is unknown. Generally pesticides concentrations in muskie were lower than in other species, and they are not considered further in the assessment.

Since the relative consumption pattern for different species was unknown, for this analysis it was assumed that a person eats an equal amount of bullheads, perch, bass and trout from Winchester Lake over their lifetime (70 years). Using this assumption, the excess risk for each chemical ranges from 1×10^{-8} to 8×10^{-7}. These risks fall below the risk level of 10^{-6} identified as the basis for human health criteria in Idaho water quality standards. If you sum the risk from exposure to all chemicals found in these four fish species, the combined risk over a lifetime exposure is 1.3×10^{-6}. Although marginally above a 10^{-6} risk level, this is not viewed as an exceedance of water quality standards, because water quality standards are chemical specific and are not based on summing risks across chemicals. Eating fish from Winchester Lake is highly unlikely to contribute to an individual's risk of contracting cancer.

Noncarcinogenic Health Effects

The likelihood that noncancer effects would occur as a result of exposure to a contaminant is often presented as a ratio of the exposure to the reference dose (chronic daily intake/Rfd) . This ratio is known as the hazard index. If the hazard index is < 1 there is little likelihood of noncancer effects. As the hazard index increases above 1, the likelihood of noncancer effects become more probable.

If a person is exposed to multiple chemicals, it may be appropriate to sum the hazard indices for the different chemicals if it is known that the chemicals effect the same target organ. The resulting sum is known as a hazard quotient, and as with hazard indices, there is little likelihood of noncancer effects if a hazard quotient is less than 1. Hazard indices were summed in this analysis because they describe health effects from a group of chemically related compounds, DDT and its metabolites or decomposition products, which are anticipated to exert their toxic effect on the liver.

Noncancer health effects calculations are as follows:

Hazard index = (chronic daily intake)/(chronic oral Rfd)
Hazard quotient = ∑ hazard indices across chemicals with similar target organs

Results in Table 22 illustrate that for all chemicals individually, and when exposure is summed across chemicals, the hazard indices and hazard quotients are far below 1.

Conclusions

Results indicate that the human health risks from consumption of Winchester Lake fish are below human health risk levels used to derive federal ambient water quality criteria, which are adopted by reference into Idaho water quality standards. As a result, it is concluded that water quality criteria for pesticides in Winchester Lake are not being exceeded, a TMDL for pesticides is not needed at this time, and pesticides should be removed from the Idaho 303(d) list for Winchester Lake.

Table 22. Hazard quotients assuming 6.5 gm/day ingestion rate.

EF	ED years	Hazard	Ingestion	RfD	Chronic Intake	Fish	Compoun	Conc. ug/kg	mg/kg	Body
365	70	1.8E-04	6.5E+00	5.0E-04	8.9E-08	Bass	op DDT	1.0	9.58E-04	70
365	70	5.0E-04	6.5E+00	5.0E-04	2.5E-07	Bass	pp DDT	2.6833	2.68E-03	70
365	70	2.1E-04	6.5E+00	5.0E-04	1.0E-07	Bass	op DDE	1.1233	1.12E-03	70
365	70	4.3E-03	6.5E+00	5.0E-04	2.1E-06	Bass	pp DDE	22.9167	2.29E-02	70
365	70	2.0E-04	6.5E+00	5.0E-04	9.9E-08	Bass	op DDD	1.0692	1.07E-03	70
365	70	5.5E-04	6.5E+00	5.0E-04	2.7E-07	Bass	pp DDD	2.9583	2.96E-03	70
365	70	3.0E-04	6.5E+00	8.0E-04	2.4E-07	Bass	HexClBer	2.6125	2.61E-03	70
365	70	2.1E-05	6.5E+00	1.3E-02	2.8E-07	Bass	Triallate	3.0083	3.01E-03	70
365	70	0.0E+00	6.5E+00	5.0E-04	0.0E+00	Bass	DDMU	0.0000	0.00E+0	70
Haz.		**6.2E-03**								
365	70	1.8E-04	6.5E+00	5.0E-04	8.9E-08	Bullhead	op DDT	0.9563	9.56E-04	70
365	70	3.1E-04	6.5E+00	5.0E-04	1.5E-07	Bullhead	pp DDT	1.6625	1.66E-03	70
365	70	2.3E-04	6.5E+00	5.0E-04	1.1E-07	Bullhead	op DDE	1.2300	1.23E-03	70
365	70	3.6E-03	6.5E+00	5.0E-04	1.8E-06	Bullhead	pp DDE	19.5250	1.95E-02	70
365	70	2.6E-04	6.5E+00	5.0E-04	1.3E-07	Bullhead	op DDD	1.3750	1.38E-03	70
365	70	4.2E-04	6.5E+00	5.0E-04	2.1E-07	Bullhead	pp DDD	2.2875	2.29E-03	70
365	70	2.2E-04	6.5E+00	8.0E-04	1.8E-07	Bullhead	HexClBer	1.9063	1.91E-03	70
365	70	2.6E-05	6.5E+00	1.3E-02	3.4E-07	Bullhead	Triallate	3.7000	3.70E-03	70
365	70	7.2E-04	6.5E+00	5.0E-04	3.6E-07	Bullhead	DDMU	3.9000	3.90E-03	70
Haz.		**5.2E-03**								
365	70	1.9E-04	6.5E+00	5.0E-04	9.3E-08	muskie	op DDT	1.0000	1.00E-03	70
365	70	1.3E-04	6.5E+00	5.0E-04	6.5E-08	muskie	pp DDT	0.7000	7.00E-04	70
365	70	1.9E-04	6.5E+00	5.0E-04	9.3E-08	muskie	op DDE	1.0000	1.00E-03	70
365	70	1.5E-03	6.5E+00	5.0E-04	7.4E-07	muskie	pp DDE	8.0000	8.00E-03	70
365	70	1.5E-04	6.5E+00	5.0E-04	7.4E-08	muskie	op DDD	0.8000	8.00E-04	70
365	70	1.9E-04	6.5E+00	5.0E-04	9.3E-08	muskie	pp DDD	1.0000	1.00E-03	70
365	70	1.2E-04	6.5E+00	8.0E-04	9.3E-08	muskie	HexClBer	1.0000	1.00E-03	70
365	70	1.4E-05	6.5E+00	1.3E-02	1.9E-07	muskie	Triallate	2.0000	2.00E-03	70
365	70	0.0E+00	6.5E+00	5.0E-04	0.0E+00	muskie	DDMU	0.0000	0.00E+0	70
Haz.		**2.4E-03**								
365	70	1.8E-04	6.5E+00	5.0E-04	9.0E-08	perch	op DDT	0.9729	9.73E-04	70
365	70	4.9E-04	6.5E+00	5.0E-04	2.4E-07	perch	pp DDT	2.6125	2.61E-03	70
365	70	1.8E-04	6.5E+00	5.0E-04	8.9E-08	perch	op DDE	0.9583	9.58E-04	70
365	70	6.0E-03	6.5E+00	5.0E-04	3.0E-06	perch	pp DDE	32.0833	3.21E-02	70
365	70	2.0E-04	6.5E+00	5.0E-04	9.8E-08	perch	op DDD	1.0504	1.05E-03	70
365	70	5.8E-04	6.5E+00	5.0E-04	2.9E-07	perch	pp DDD	3.1333	3.13E-03	70
365	70	2.7E-04	6.5E+00	8.0E-04	2.2E-07	perch	HexClBer	2.3208	2.32E-03	70
365	70	3.6E-05	6.5E+00	1.3E-02	4.7E-07	perch	Triallate	5.1083	5.11E-03	70
365	70	0.0E+00	6.5E+00	5.0E-04	0.0E+00	perch	DDMU	0.0000	0.00E+0	70
Haz.		**7.8E-03**								
365	70	1.8E-04	6.5E+00	5.0E-04	9.1E-08	rainbow	op DDT	0.9750	9.75E-04	70
365	70	1.9E-04	6.5E+00	5.0E-04	9.5E-08	rainbow	pp DDT	1.0263	1.03E-03	70
365	70	1.7E-04	6.5E+00	5.0E-04	8.6E-08	rainbow	op DDE	0.9250	9.25E-04	70
365	70	2.0E-03	6.5E+00	5.0E-04	1.0E-06	rainbow	pp DDE	10.8375	1.08E-02	70
365	70	2.0E-04	6.5E+00	5.0E-04	1.0E-07	rainbow	op DDD	1.0800	1.08E-03	70
365	70	2.6E-04	6.5E+00	5.0E-04	1.3E-07	rainbow	pp DDD	1.4125	1.41E-03	70
365	70	1.1E-04	6.5E+00	8.0E-04	9.0E-08	rainbow	HexClBer	0.9688	9.69E-04	70
365	70	1.6E-05	6.5E+00	1.3E-02	2.1E-07	rainbow	Triallate	2.2125	2.21E-03	70
365	70	0.0E+00	6.5E+00	5.0E-04	0.0E+00	rainbow	DDMU	0.0000	0.00E+0	70
Haz.		**3.1E-03**								

Ave. hazard quotient for Bullhead, Perch, and Rainbow **5.0E-03**

4.0 LOADING SUMMARY

Table 23 summarizes the Winchester Lake and Upper Lapwai Creek TMDL water quality targets, pollutant load capacities, load allocations and margins of safety. As discussed in Section 3.0, no dissolved oxygen, temperature, or pesticide load allocations are required for the Winchester Lake watershed. Therefore, no load targets, capacities, or reductions are needed for those parameters.

Table 23. Winchester Lake and Upper Lapwai Creek pollutant loading and allocation summary.

Pollutant	Waterbody	Target (s)	Subwatershed	Load	Load allocation	Reduction needed
Nutrients/DO	Winchester L.	37 ug/l total phosphorus		1926 lb/yr	739 lb/yr	62%
	Lapwai Cr.	50 ug/l total phosphorus (May thru Oct.)		42 lbs/month	18 lbs/month	57%
Sediment	Winchester L.	total reductions in sediment to Winchester Lake are the same as cumulative reduction in Upper Lapwai tributaries (LP6)		571 tons/yr	43 ton/yr	93%
	Lapwai Cr.	Improving trend in average annual sediment load with natural background as interim target and full support of salmonid spawning and cold water biota uses as the ultimate measure of success.	LP-1	322 tons/yr	21 tons/yr	93%
			LP-2	122 tons/yr	13 tons/yr	89%
			LP-3	234 tons/yr	18 tons/yr	92%
			LP-4	526 tons/yr	36 tons/yr	93%
			LP-5	555 tons/yr	40 tons/yr	93%
			LP-6	571 tons/yr	43 tons/yr	93%
Pathogens	Winchester L.	TMDL determined to be unnecessary				
	Lapwai Cr.	< 500 cfu/100 ml - at all times > 200 cfu/100 ml - <10% of samples over 30 days < 50 cfu/100 ml - geo. mean in 5 samples over 30 days		1.9E10 cfu/day @ 0.37 cfs	1.8E09 cfu/day @ 0.37 cfs	90%
Temperature	Winchester L.	Phosphorus/dissolved oxygen TMDL established as a surrogate for the temperature TMDL				
	Lapwai Cr.			**(j/m2/sec)**	**(j/m2/sec)**	**Shade increase needed**
		78% shade	LP-1	225.6	68.9	50%
		92% shade	LP-2	297.6	25.1	87%
		79% shade	LP-3	3.3.9	65.8	76%
		78% shade	LP-4	283.1	68.9	54%
		79% shade	LP-5	244.4	65.8	57%
		95% shade	LP-6	134.7	15.7	38%
Pesticides	Winchester L.	TMDL determined to be unnecessary				
Flow	Winchester L.	TMDL not developed until it is determined that TMDL's are required for impairments due to flow alteration				
	Lapwai Cr.	" "				
Habitat	Winchester L.	TMDL not developed until it is determined that TMDL's are required for impairments due to habitat alteration				
	Lapwai Cr.	" "				

5.0 PUBLIC PARTICIPATION

Winchester Lake WAG

The Winchester Lake WAG was jointly appointed by the Nez Perce Tribe, Idaho Division of Environmental Quality, and USEPA. Pursuant to the three party Memorandum of Agreement, the WAG represented key stakeholders in the watershed. The WAG met periodically beginning on February 4, 1998 and provided input and advice to the three parties throughout the development of the TMDL. We are indebted to the commitment and sound advice provided by the WAG, and wish to offer our sincere thanks for their efforts.

Public Comments

The Winchester Lake and Upper Lapwai Creek TMDL was made available for public review from November 24 through December 24, 1998. Notification to the general public of the opportunity to comment on the draft TMDL was made in the Cottonwood Chronicle (December 3, 17), Lewiston County Herald (December 3, 17), Lewiston Tribune (November 28, December 15), and Idaho County Free Press (December 2, 16). Copies of the TMDL were sent to each of the Winchester Lake WAG members, members of the Clearwater Basin Advisory Group, and members of the Winchester Lake Technical Advisory Group. In addition, copies of the TMDL were available for review at the following locations: DEQ Lewiston Regional Office, Department of Fish and Game's Lewiston Office, Nez Perce Tribe Water Resources Division Lapwai Office, USEPA Boise Office, Winchester City Library, Lewis County Soil Conservation District, Craigmont City Library, and Winchester Lake State Park Office.

On December 3, 1998 the Clearwater Basin Advisory Group discussed the Winchester Lake TMDL during a regularly scheduled Basin Advisory Group meeting held in Winchester. During this meeting, members of the Winchester Lake WAG provided verbal comments that a better executive summary would help members of the public understand the TMDL. Subsequently a revised executive summary was produced and distributed to WAG members and members of the Clearwater Basin Advisory Group, and the deadline for final comments was extended until December 31, 1998. These revisions did not change the content or substance of the TMDL.

No other written or verbal public comments were received by the three parties during the public comment period. However, numerous internal comments were received from the State of Idaho, the Nez Perce Tribe, and USEPA regarding clarifications, typographical errors, etc. These comments were incorporated in order to improve the accuracy and readability of the document, but they do not change the technical basis, allocations or conclusions of the TMDL.

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GLOSSARY

Alevin: Newly hatched salmonid still dependent on yolk sac; remains in stream bed gravel until yolk sac is absorbed.

Aerobic: Describes life or processes that require the presence of molecular oxygen.

Algae: Small aquatic plants that occur as single cells, colonies, or filaments.

Anaerobic: Describes processes that occur in the absence of molecular oxygen.

Aquatic: Growing, living, or frequenting water.

Assimilative capacity: An estimate of the amount of pollutants that can be discharged to and processed by a waterbody and still meet the state water quality standards. It is the equivalent of the Loading Capacity which is the equivalent of the TMDL for the waterbody.

Basalt: A fine-grained, dark-colored extrusive igneous rock**.**

Bedload: Material, generally of sand size or larger, carried by a stream on or immediately above (3") its bed.

Beneficial uses: Any of the various uses which may be made of the water of an area, including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, navigation, recreation in and on the water, wildlife habitat, and aesthetics.

Benthic organic matter: The organic matter on the bottom of the river.

Benthic: Pertaining to or living on the bottom or at the greatest depths of a body of water.

Benthos: Macroscopic (seen without aid of a microscope) organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the substrate.

Best management practice (BMP): A measure determined to be the most effective, practical means of preventing or reducing pollution inputs from point or nonpoint sources in order to achieve water quality goals.

Bioaccumulation: Accumulation of substances over time, such as pesticides, in an organism.

Biochemical oxygen demand (BOD): The rate of oxygen consumption by organisms during the decomposition (= respiration) of organic matter, expressed as grams oxygen per cubic meter of water per hour.

Biomass: The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.

Biomass accumulation: A measure of the density and lateral and downstream extent of plant growth across a waterbody.

Biota: All plant and animal species occurring in a specified area.

Cfs: Cubic feet per second, a unit of measure for the rate of discharge of water. One cubic foot per second is the rate of flow of a stream with a cross section of one square foot which is flowing at a mean velocity of one foot per second. It is equal to 448.8 gallons per minute, 0.646 million gallons per day, or 1.98 acre-foot per day.

Coliform bacteria: A group of bacteria predominantly inhabiting the intestines of man and animal but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms.

Colluvium: Material transported to a site by gravity.

Decomposition: The transformation of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and non-biological processes.

Dissolved oxygen: Commonly abbreviated D.O., it is the amount of oxygen dispersed in water and is usually expressed as mg/L (ppm). The amount of oxygen dissolved in water is affected by temperature, elevation, and total dissolved solids.

Effluent: A discharge into the environment; often used to refer to discharge of untreated , partially treated, or treated pollutants into a receiving waterbody.

Environment: Collectively, the surrounding conditions, influences, and living and inert matter that affect a particular organism or biological community.

Epilimnion: The upper, well-mixed, well-illuminated, nearly isothermal region of a stratified lake

Erosion: The wearing away of areas of the earth's surface by water, wind, ice, and other forces.

Culturally-induced erosion is that caused by increased runoff or wind action due to the work of man in deforestation, cultivation of the land, overgrazing, and disturbance of the natural drainage; the excess of erosion over that normal for the area.

Eutrophic: From Greek for "well-nourished," describes a body of water of high photosynthetic activity and low transparency.

Eutrophication: The process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment and sedimentation of a body of water. If the process is accelerated by man-made influences, it is termed cultural eutrophication. Eutrophication refers to natural addition of nutrients to waterbodies and to the effects of artficially added nutrients.

Existing beneficial use or existing use: Those beneficial uses actually attained in waters on or after November 28, 1975, whether or not they are designated for those waters in Idaho Department of Health and Welfare Rules, Title 1, Chapter 2, "Water Quality Standards ad Wastewater Treatment Requirements."

Fecal Streptococci: A species of spherical bacteria including pathogenic strains found in the intestines of warm blooded animals.

Feedback loop: A component of a watershed management plan strategy that provides for accountability on targeted watershed goals.

Flow: The quantity of water that passes a given point in some time increment.

Flushing Rate: The rate at which water entersand leaves a lake relative to lake volume, usually expressed as time needed to replace the lake volume with inflowing water.

Granitic: Derived from granite; coarse to medium grained intrusive igneous rock

Groundwater: Water found beneath the soil's surface; saturates the stratum at which it is located; often connected to surface water.

Growth rate: The amount of new plant tissue produced per a given time unit of time. It is also a measure of how quickly a plant will develop and grow.

Habitat: A specific type of place that is occupied by an organism, a population or a community.

Headwater: The origin or beginning of a stream.

Hydrologic basin: The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area. There are 6 basins described in the Nutrient management Act (NMA) for Idaho -- Panhandle, Clearwater, Salmon, Southwest, Upper Snake, and the Bear Basins.

Hypolimnion: The poorly illuminated, dense, colder lower region of a stratified lake that is protected from wind action.

Influent: The flow into a process, facility, or larger body of water

Inorganic: Materials not containing carbon and hydrogen, and not of biologic origin.

Limiting factor: A chemical or physical condition that determines the growth potential of an organism, can result in less than maximum or complete inhibition of growth, typically results in less than maximum growth rates.

Load allocation: The amount of pollutant that nonpoint sources can release to a waterbody.

Loading: The quantity of a substance entering a receiving stream, usually expressed in pounds (kilograms) per day or tons per month. Loading is calculated from flow (discharge) and concentration.

Loading Capacity: The maximum amount of pollutant a waterbody can safely assimilate without violating state water quality standards. It is also the equivalent of a TMDL.

Loam: Moderately coarse, medium and moderately fine-textured soils that include such textural classes as sandy loam, fine sandy loam, very fine sandy loam, silt loam, silt, clay loam, sandy clay loam and silty clay loam.

Loess: Is defined as a uniform eolian (wind-blown) deposit of silty material having an open structure and relatively high cohesion due to cementation by clay or calcareous material at the grain contacts. A characteristic of loess deposits is that they can stand with nearly vertical slopes (ASCE P1826). Erosion potential is highly dependent on topography; ranges from low to very high within the Paradise Creek watershed.

Macrophytes: Rooted and floating aquatic plants, commonly referred to as water weeds. These plants may flower and bear seed. Some forms, such as duckweed and coontail (*Ceratophyllum*), are free-floating forms without roots in the sediment.

Margin of safety: An implicit or explicit component of water quality modeling that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody.

Mean: The **arithmetic mean** is the most common statistic familiar to most people. The mean is calculated by summing all the individual observations or items of a sample and dividing this sum by the number of items in the sample. The geometric mean is used to calculate bacterial numbers. The **geometric mean** is a back-transformed mean of the logarithmically transformed variables.

Meter: The basic metric unit of length; 1 meter = 39.37 inches or 3.28 feet.

Milligrams per liter (mg/L): See parts per million. Concentration equal to .001 grams in substance weight per liter (0.9 quart) capacity.

Million gallons per day (MGD): A unit of measure for the rate of discharge of water**,** often used to measure flow at WWTPs. It is equal to 1.55 cubic feet per second.

Monitoring: The process of watching, observing, or checking (in this case water). The entire process of a water quality study including: planning, sampling, sample analyses, data analyses, and report writing and distribution.

Mouth: The location where a waterbody flows into a larger waterbody.

Nitrogen: A nutrient essential to plant growth, often in more demand than available supply.

Nonpoint source: A dispersed source of pollutants such as a geographical area on which pollutants are deposited or dissolved or suspended in water applied to or incident on that area, the resultant mixture being carried by runoff into the waters of the state. Nonpoint source activities include, but are not limited to irrigated and non-irrigated lands used for grazing, crop production and silviculture; log storage or rafting; urban areas; construction sites; recreation sites; and septic tank disposal fields.

Nuisance: Anything which is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient: An element or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus.

Organic matter: Molecules manufactured by plants and animals and containing linked carbon atoms and elements such as hydrogen, oxygen, nitrogen, sulfur, and phosphorus.

Orthophosphate: A form of soluble inorganic phosphorus which is directly utilizable for algal growth.

Oxygen-demanding materials: Those materials, usually organic, in a waterbody which consume oxygen during decomposition or transformation. Sediment can be an oxygen-demanding material.

Parameter: A variable quantity such as temperature, dissolved oxygen, or fish population, that is the subject of a survey or sampling routine.

Pathogen: Any disease-producing organism.

pH: A measure of the concentration of hydrogen ions of a substance, which ranges from very acid (pH = 1) to very alkaline (pH = 14). pH 7 is neutral, and most lake waters range between 6 and 9. pH values less than 7 are considered acidic, and most life forms cannot survive at pH of 4.0 or lower.

Phased TMDL: A TMDL which identifies interim load allocations with further monitoring to gauge success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a waterbody. Under a phased TMDL, the TMDL has load allocations and wasteload allocations calculated with margins of safety to meet water quality standards.

Phosphorus: A nutrient essential to plant growth, typically in more demand than the available supply.

Phytoplankton: Microscopic algae and microbes that float freely in open water of lakes and oceans.

Point source pollution: The type of water quality degradation resulting from the discharges into receiving waters from sewers and other identifiable "points." Common point sources of pollution are the discharges from industrial and municipal sewage plants.

Reach: A stream section with fairly homogenous characteristics.

Respiration: Process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water.

Riparian: Associated with aquatic (streams, rivers, lakes) habitats. Living or located on the bank of a waterbody.

Runoff: The portion of rainfall, melted snow, or irrigation water that flows across the surface or through underground zones and eventually runs into streams.

Sediment: Bottom material in a body of water that has been deposited after the formation of the basin. It originates from remains of aquatic organism, chemical precipitation of dissolved minerals, and erosion of surrounding lands.

Stream segments of concern (SSOCs): Stream segments nominated by the public and designated by a committee whose members are appointed by the Governor.

Sub-basin: Smaller geographic management areas within a hydrologic basin delineated for purposes of addressing site specific situations.

Suspended solids: Fine mineral or soil particles that remain suspended by the current until deposited in areas of weaker current. They create turbidity and, when deposited, can cover fish eggs or alevins.

Thermocline: Zone in stratified lake where temperature changes rapidly with depth

Total Maximum Daily Load (TMDL): TMDL = LA + WLA + MOS. A TMDL is the equivalent of the Loading Capacity which is the equivalent of the assimilative capacity of a waterbody.

Total suspended solids (TSS): The material retained on a 2.0 micron filter after filtration.

Tributary: A stream feeding into a larger stream or lake.

Trophic state: Level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount of aquatic vegetation, algal abundance, and water clarity.

Turbidity: A measure of the extent to which light passing through water is scattered due to suspended materials. Excessive turbidity may interfere with light penetration and minimize photosynthesis, thereby causing a decrease in primary productivity. It may alter water temperature and interfere directly with essential physiological functions of fish and other aquatic organisms, making it difficult for fish to locate a food source.

Waste load allocation: A portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. It specifies how much pollutant each point source can release to a waterbody.

Water column: Water between the interface with the atmosphere at the surface and the interface with the sediment layer at the bottom. Idea derives from vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water pollution: Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to fish and wildlife, or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water quality limited segment (WQLS): Any waterbody, or definable portion of waterbody, where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards.

Water quality management plan: A state or areawide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.

Water quality modeling: The input of variable sets of water quality data to predict the response of a lake or stream.

Water table: The upper surface of groundwater; below this surface the ground is saturated with water.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation. The whole geographic region contributing to a waterbody.

Wetlands: Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have the following 3 attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominately undrained hydric soil; and (3) the substrate is on soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Zooplankton: Microscopic animals that float freely in lake water, graze on detritus particles, bacteria, and algae, and may be consumed by fish.

ACRONYMS/ABBREVIATIONS

ACRONYM OR ABBREVIATION	FULL NAME
ARS	Agricultural Research Station
ASCE	American Society of Civil Engineers
BAG	Basin Advisory Group
BMP or BMPs	Best Management Practice or Best Management Practices
BOD or BOD5	Biological Oxygen Demand or 5-day Biological Oxygen Demand
BURP	Beneficial Use Reconnaissance Project
^{o}C	degrees Celsius
CAFO	Confined Animal Feeding Operations
CBOD	Carbonaceous Biological Oxygen Demand
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
CFO	Confined Feeding Operations
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfu	colony forming units
CSO	Combined Sewer Overflow
CWA	Clean Water Act
CWE	Cumumlative Watershed Effects
DEQ	Division of Environmental Quality
DO	Dissolved Oxygen
DMR or DMRs	Discharge Monitoring Report or Discharge Monitoring Reports
EHS	Extremely Hazardous Substances
EPA	United States Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPT	Ephemeroptera, Plecoptera, Trichoptera Insect Orders
ESA	Endangered Species Act
ft	feet
FY	Fiscal Year
GIS	Geographic Information System
ha	hectare

ACRONYM OR ABBREVIATION	**FULL NAME**
HI	Habitat Index
HUC or HUCs	Hydrologic Unit Code or Hydrologic Unit Codes
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Division of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDHW	Idaho Department of Health and Welfare
IDL	Idaho Department of Lands
IDPR	Idaho Department of Parks and Recreation
IDWR	Idaho Department of Water Resources
$j/m^2/sec$	joule per meter squared per second
kg	kilogram
l	liter
LA	Load Allocation
lbs	pounds
LC	Loading Capacity (which = TMDL = Assimilative Capacity)
LUST	Leaking Underground Storage Tank
MBI	Macroinvertebrate Biotic Index
MGD	million gallons per day
m	meter
mg	milligrams
mg/l	milligrams per liter
ml	milliliter
MOS	Margin of Safety
µg	microgram
µg/l	micrograms per liter
MWWTP	Moscow Waste Water Treatment Plant
NAWQA	National Agriculture Water Quality Assessment
NMP	Nutrient Management Plan
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source

ACRONYM OR ABBREVIATION	FULL NAME
NRCS	Natural Resource Conservation Service
NTU	nephelometric turbidity unit
PCEI	Palouse Clearwater Environmental Institute
PNRS	Pacific Northwest River System (EPA Numbering System)
RCWP	Rural Clean Water Project
RM or R.M.	USGS River Mile
SARA	Superfund Amendments and Reauthorization Act of 1986
SAWQP	State Agricultural Water Quality Program
SCC	Soil Conservation Commission
SCD or SCDs	Soil Conservation District or Soil Conservation Districts
SCS	Soil Conservation Service
SFPR	South Fork of the Palouse River
SSOCs	Stream Segments of Concern
SWCD	Soil Water Conservation District
SWWRC	State of Washington Water Research Center
T/yr	Tons per year
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TPQ	Threshold Planning Quantity
TSS	Total Suspended Solids
UAA	Use Attainability Assessment
U of I	University of Idaho
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
WAC	Washington Administrative Code

ACRONYM OR ABBREVIATION	**FULL NAME**
WAG	Watershed Advisory Group
WBAG	Waterbody Assessment Guidance
WLA	Waste Load Allocation
WMP	Watershed Management Plan
WQLS	Water Quality Limited Segment
WSU	Washington State University
WWTP	Wastewater Treatment Plant
yr	year

Appendix A

Documentation of hydrologic and sediment budget analyses

Prepared by

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Introduction

This appendix documents the data and analytical techniques used to develop the hydrologic and sediment portions of the TMDL. It describes the methods, data, and results for the following analyses: 1) upper Lapwai Creek extended hydrograph; 2) Upper Lapwai Creek predicted stream network; and 3) Winchester Lake and Upper Lapwai Creek sediment budget.

Upper Lapwai Creek Extended Hydrograph

This narrative is intended to document the data and analysis used to extend the gage record for Upper Lapwai Creek. The purpose of this analysis is to characterize the extreme low and high flow regimes of the stream. Stream discharge measurements were taken periodically from 1985 to 1986 and from 1988 to 1989, and continuously from 1993 to 1995. The periodic stream flow data sets (*ungaged site*) were regressed against continuous data from a USGS stream gage (*gaged site*), and a synthetic hydrograph was predicted for water years 1975 through 1997 using the MOVE.1 technique.

Latham (1986) measured the stream flow of Upper Lapwai Creek 7 times during the 1985 water year. Entranco (1990) established a temporary stream gage on the stream and collected continuous stream stage from May 1988 to April 1989. The latter effort measured stream discharge sixteen different times and obtained both high and low flow readings (from 0.03 to 45.3 cfs). Wertz (1996) also measured stream flow continuously from October 1993 to May 1995. These data represent the most complete stream flow record available for Upper Lapwai Creek, however, a small range of flows were measured (from 0.08 to 20.2 cfs).

Stream flow data from the USGS stream gage on Lapwai Creek near Lapwai, Idaho (13342450), was used in this analysis. The period of record for this gage is from 1974 to present. There are substantial physiographic differences between the gaged and ungaged sites. The most obvious difference is drainage area, Lapwai Creek at the USGS gage drains 235 mi^2, whereas Upper Lapwai Creek drains 9.3 mi^2. Additionally, the USGS gage is at an elevation of 865 feet, and the ungaged watershed is at an elevation of 3902 feet. This gage was used in this analysis for four reasons: 1) linear relationship between average daily stream flow data; 2) nearest gage with long period of record; 3); base and peak flows driven by same processes; and 4) similar climatic conditions during the flood of 1996 and other peak flow events.

The hydrograph of Upper Lapwai Creek was extended using the Maintenance of Variance Extension, Type 1 (MOVE.1) technique (Hirsch, 1982). A statistically significant linear relationship exists between the USGS gage stream flow data and the periodic flow data set (Latham, 1986 and Entranco, 1990 data sets). This curve is statistically significant at the 0.05 probability level, however, it tends to over-predict low flows and under predict high flows. As a result, the MOVE.1 technique is applied which has been shown to reduce model bias and improve accuracy (Hirsch, 1982). The MOVE.1 equation is defined as follows:

$Yi = m(y) + ((S(y)/S(x))*(Xi - m(x)))$

where:

Yi = predicted stream flow of ungaged site
Xi = measured stream flow of gaged site
m(y) = mean of ungaged site data
m(x) = mean of gaged site data
S(y) = standard deviation of ungaged site
S(x) = standard deviation of gaged site

The extended hydrograph was predicted using the following values:

m(y) = 3
m(x) = 71
S(y) = 4
S(x) = 101

To help verify the accuracy of the MOVE.1 model a random set of measured data (n = 45) was extracted from the main data set prior to deriving the model. The model was then used to predict these 45 stream flow values and the predicted values were compared to measured values. The results from a student t-test indicate no significant difference between measured and predicted stream flow at the ungaged site ($p < 0.05$). Stream flow of Upper Lapwai Creek will be gaged for at least two water years to further verify this analysis.

As stated above, the purpose of this analysis is to extend the stream flow record of Upper Lapwai Creek to better understand the hydrology. This analysis relies on a limited stream flow data set and a gaged site which is substantially different from the ungaged site. These two factors reduce the robustness of the predictive model. However, given the lack of long-term stream flow data and the reasonable statistical results, this extended hydrograph is used in the TMDL to help set instream targets, estimate existing pollutant loads, and estimate load reductions.

The stream data generated through hydrograph extension was used to calculate the bankfull discharge and maximum peaks of record. Bankfull discharge is often defined as the 2 year flood event and is estimated to be 29 cfs for Upper Lapwai Creek. According to the USGS gage the peak of record occurred in 1996, and the model estimate is at a flow of 158 cfs.

Bankfull discharge was estimated for all the subwatersheds which drain to Winchester Lake. This analysis used the unit discharge method to estimate bankfull flow at the mouth of each subwatershed. The bankfull discharge of Upper Lapwai Creek, generated from the hydrograph data, was divided by drainage area to produce a bankfull discharge coefficient of 3.1 cfs/mi^2.

Upper Lapwai Creek Predicted Stream Network

This narrative is intended to document the analysis used to predict the stream network of Upper Lapwai Creek as part of the TMDL. The purpose of this analysis is to better define the drainage network of Upper Lapwai Creek and other watersheds which drain to the reservoir. Geographic Information Systems and 30 meter digital elevation models (DEM) were used to predict the channel network**.** This method predicts the location, length, and slope of perennial and intermittent channels. The accuracy of channel delineation was verified using field data.

The available stream coverage of Winchester Lake watershed is mapped at a coarse scale. To better understand the hydrology of this watershed, a finer scale stream layer was predicted. The location, length, and slope variables produced by this analysis were validated in the field by randomly selecting sites along the drainage network and measuring stream characteristics. Good agreement was found between predicted and actual stream channel network (Table 1). There is 18% error between predicted and actual channel locations where the DEMs under predicted the length and location of intermittent channels.

Table 1. Field validation results for predicted stream network.

Site	Watershed	GIS Predicted Channel	Channel Present in Field	Type*
1	LP-1	Y	Y	P
2	LP-1	Y	Y	I
3	LP-1	N	Y	I
4	LP-3	Y	Y	I
5	LP-3	Y	Y	I
6	LP-4	Y	Y	I
7	LP-4	Y	Y	I
8	LP-4	Y	Y	I
9	LP-4	Y	Y	I
10	LP-6	N	Y	I
11	WW-1	Y	Y	P

* P = perennial and I = intermittent

Winchester Lake and Upper Lapwai Creek Sediment Budget

Sediment Budget Methodology

A sediment budget is an accounting of the sources and disposition of sediment as it travels from its point of origin to its delivery from a watershed (Reid and Dunne, 1996). Five steps are used to develop the sediment budget for Winchester Lake and Upper Lapwai Creek. This analysis considers surface erosion (sheet), fluvial erosion (gully and rill), and stream bank erosion. First, total erosion from the four process categories are estimated. Second, using the total erosion values, sediment delivery from the hillslope to the stream channel is estimated. Third, sediment transport and delivery from individual subwatersheds is calculated and used to estimate the cumulative sediment load delivered to the reservoir. Fourth, the seasonal variation and critical timing of sediment loading are considered. Finally, the uncertainty of the sediment load estimates is qualified.

Many of the methods and models used in this analysis produce rough estimates of actual soil erosion and sediment transport which is compounded by the fact that average annual sediment yield is highly variable. As a result, the accuracy of the erosion and sediment yield estimates is considered to be within an order of magnitude of actual loads. However, these methods and models produce precise estimates of sediment production and are important when trying to understand the relative contribution of sediments from the different erosion process categories, land uses, and subwatersheds.

Total Erosion Estimates

RUSLE Surface Erosion Estimates

Total surface erosion is estimated using the Revised Universal Soil Loss Equation (RUSLE). RUSLE is the Revised form of the “Universal Soil Loss Equation” that was originally developed in the late 1950’s, and has been refined with the objective of predicting sheet and rill erosion amounts off of cropland and pastureland. It is intended to be used as a guide in Conservation Planning and evaluation, which the Natural Resources Conservation Service and other land use managers use as the basis for sheet & rill erosion prediction. The RUSLE is an empirical equation and uses modern theories on erosion processes of soil detachment, transport, and deposition of soil particles by rain drop impact, surface runoff and snowmelt runoff on thawing soil. RUSLE uses the following parameters in the equation: rainfall; erodibility of the soil type; combined effect of slope length & steepness; cover management; and land use support practices.

The T value represents a soil loss limit expressed as “Tolerable Soil Loss” which is intended to prevent long term soil degradation and to economically sustain the potential level of productivity. However, this value does not consider the impacts of sediment on water quality.

The soil loss computed by RUSLE estimates the amount of sediment lost from the landscape profile as represented by each RUSLE computation; it is not the amount of sediment leaving a field or watershed. In addition, erosion in concentrated flow areas (ephemeral gullies), stream channels, etc. are not included in the RUSLE calculations. Erosion rates were estimated for background and existing crop rotations (Plate 1) and were multiplied by a hillslope delivery factor. The computations provided in Plate 1 assume that 60% of the eroded sediment is delivered from the hillslope to an active channel. The amount of gully and bank erosion, which also occur on agricultural lands, were estimated as part of the bank erosion calculations described below.

The background surface erosion rate on agricultural lands is assumed to be 0.3 tons/acre/year. Because most of the landscape above the reservoir was forested prior to substantial land use very little, if any, surface erosion would have occurred. Most natural erosion likely resulted from bank erosion and small upper bank mass failures. Instead of assuming zero natural erosion, this analysis considers the crop rotation which provides the most unerodible soil mantle to be background. Empirical evidence suggests this value is about 0.3 tons/acre/year.

The cropland acreage by subwatershed was subdivided into crop rotation categories. The Idaho Soil Conservation Commission estimated, for each subwatershed, the percentage of cropland which is presently in a given crop rotation. The crop rotation acreage is multiplied by the erosion rate and then summed for each subwatershed which produces a total erosion estimate in tons per year. The acreage of each crop rotation and background and existing erosion estimates by subwatershed are summarized in Plate 1.

Steam Bank Erosion Estimates

This narrative is intended to document the data and methodology used to quantify bank erosion. Stream banks were inventoried in the field to estimate bank erosion rate and annual average erosion. These data are used to develop a quantitative estimate of background and existing stream bank erosion. This inventory followed methods outlined in the proceedings from a Natural Resource Conservation Service Channel Evaluation Workshop (1983). Using the information from previous studies (Entranco, 1990) and the direct volume method, sub-sections of the stream network were surveyed to determine the extent of chronic bank erosion. Bank erosion rates were estimated for each land use category (Table 2) and used to estimate total bank erosion for each subwatershed. A description of the field methods and erosion calculations is provided below, and the results are attached as Plates 2 through 6.

Bank erosion and channel stability inventory methods were originally developed by the USDA Forest Service (e.g., Pfankuch, 1975). Further development of bank stability inventory methods are outlined in Lohrey (1989) and NRCS (1983). The NRCS (1983) document describes the field methods used in this inventory, however, slight modifications to these methods were made and are documented below.

Table 2. Upper Lapwai Creek bank erosion inventory results.

Reach	Lnd Use	Existing Erosion Rate (t/mLy	Background Erosion Rate (t/mLy)
T-1	Forestry	1	1
T-2	Pasture	48	3
T-3	Pasture	55	4
T-4	Pasture/Forestry	32	4
T-5	Cropland	71	4

field methods

The inventoried stream reaches are subdivided into *sites* with similar channel and bank characteristics. Breaks between sites are made where channel type and/or dominate bank characteristics change dramatically. In a stream with uniform channel geometry there may be only one site per stream reach, whereas in an area with variable channel conditions there may be several sites.

Field crews typically consist of two to four people and are trained as a group to ensure quality control or consistent data collection. Field crews survey stream reaches measuring bank length, slope height, bank recession rate, bankfull width and depth, and bank soil content. In most cases, a Global Positioning System (GPS) is used to locate the upper and lower boundaries of inventoried stream reaches. Additionally, while surveying, field crews photographed the reach and key problem areas. The members of the bank inventory crew include: Jon Matthews (NPT); Doug Fitting (IDL); Joe Dupont (IDL); Bill Dansart (SCC); and Jim Fitzgerald (EPA).

bank erosion calculations

The direct volume method uses the bank erosion inventories to calculate average annual bank erosion rate (NRCS, 1983). Because not every reach of a given stream can be sampled, the sample bank erosion rate is extrapolated over a larger stream segment. This analysis inventoried 9% of perennial stream channels which drain to Winchester Lake. The direct volume method is summarized in the following equations:

$E = [A_E * R_{LR} * \_{B}]/2000$ (lbs/ton)

where:
E = bank erosion over sampled stream reach (tons/yr/sample reach)
A_E = eroding area (ft^2)
R_{LR} = lateral recession rate (ft/yr)
$\_{B}$ = bulk density of bank material (lbs/ft^3)

The bank erosion rate (E_R) is calculated by dividing the sampled bank erosion (E) by the total stream length sampled:

$E_R = E/L_{BB}$

where:
E_R = bank erosion rate (tons/mile/year)
E = bank erosion over sampled stream reach (tons/yr/sample reach)
L_{BB} = bank to bank stream length over sampled reach

The lateral recession rate (R_{LR}) is one of the most critical variables in the above equation (NRCS, 1983). Several techniques are available to quantify the lateral recession rate: for example, NRCS (1983) method, aerial photo interpretation, anectodal data, bank pins, and channel cross-sections. This analysis uses the NRCS (1983) method to determine the lateral recession rate. Similar to methods developed by Pfankuch (1975), the NRCS method measures channel and bank stability and then uses the stability ratings as surrogates for the lateral recession rate.

The lateral recession rate was determined for the background and existing condition of the stream bank. It is difficult to determine what level of stream bank stability was present pre-historic conditions. Moreover, there is a lack of reference conditions within and adjacent to Upper Lapwai Creek. As a result, this analysis uses bank stability values cited in the literature to established the background lateral recession rate. Studies of salmonids and bank stability have shown that 80 to 100% bank stability is needed to protect sensitive species (Overton et al., 1995; Waters, 1995). As a relative measure of bank erosion, this analysis uses 85% bank stability as a reference condition (i.e., background). Because bank stability and lateral recession rate are measured using the same technique, 85% bank stability is proportional to a lateral recession rate of 0.025 feet/year.

The background and existing bank erosion rates are stratified by land use category and extrapolated over the entire stream network (Table 2): for example, the background and existing bank erosion rates for pasture lands are 4 and 52 tons/mile/year, respectively; LP-1 contains 3.1 miles of stream in pasture lands; therefore the amount of background and existing bank erosion on pasture land within LP-1 is about 26 and 344 tons/year, respectively.

The total bank erosion is expressed as an annual average, however, the frequency and magnitude of bank erosion events are greatly a function of bank soil moisture and stream discharge. Because major channel erosion events typically result from infrequent flow events when the banks are saturated, the annual average bank erosion rate should be considered a long term average: for example, a major flood event which occurs once in ten years might cause five feet of bank erosion accounting for the majority of bank erosion over the ten year period.

Surface Erosion from Roads

Surface and fluvial erosion from roads was estimated using the IDL CWE method (IDL, 1995) and an extension of the US Department of Agriculture model WEPP called X-Drain (Morfin et al., 1996). A detailed description of the CWE methodology and data is provided in Appendix B (Upper Lapwai Creek Cumulative Watershed Effects Assessment). This analysis used the CWE road score and a statistical model developed by McGreer (1998) to estimate the amount of sediment produced by road erosion. For the input data and results refer to Plate 7.

The CWE analysis did not inventory all of the roads within the watershed (see road map Appendix B). As a result, surface erosion off of roads which were not inventoried using CWE was estimated using X-Drain. This model was used in LP-6 where unmapped and new roads exist (Plate 7). Additionally, skid trails and other unmapped roads, which were not modeled and are known to exist within the watershed, were accounted for by adding 10% to the total road erosion modeled using CWE and WEPP.

To test the comparability of the model output, four road segments were modeled separately using CWE and WEPP. The results indicate reasonable agreement between the models where the percent difference ranges from -7 to 77 percent (Table 3). Considering the overall estimates produced by this sediment budget are likely within an order of magnitude of actual sediment yield (further discussion provided below), and the relative sediment contribution between erosion process categories is more important than actual contribution, this analysis considers these differences acceptable.

Delivery of sediment from the road surface to the stream channel is accounted for in the two models described above. The CWE analysis uses the probability of delivery as a modifier in the CWE road score (IDL, 1995), and the X-drain model allows the user to assign a vegetative buffer.

Surface Erosion from Urban Areas

Total surface erosion from urban areas was estimated using the SIMPLE model (USEPA, 1995). Erosion estimates from this model are summed for each subwatershed producing an approximation of total urban erosion. The model output is attached as Plate 8. This sediment budget infers that surface erosion from current urban development is likely inconsequential relative to other sediment sources (e.g., agriculture and pasture).

Table 3. Road erosion estimates from CWE and WEPP models on same road segments.

Watershed	Soil Type	Rock Type	Road Width (ft)	Road slope (%)	Distance between x-drains (ft)	Buffer Length (ft)	Road CWE Score	Buffer Slope (%)	CWE (t/ml/y)	WEPP ((t/ml/y)	Road (ml)	CWE tons delivered per year	WEPP tons delivered per	Percent Difference
LP-5	silt-loam	G	20	16	330	30	63	60	91	90	0.2	18	18	1
WW-1	silt-loam	G	30	4	330	30	51	60	47	26	0.2	9	5	77
LP-2	silt-loam	G	20	4	330	30	42	25	26	16	0.6	16	9	67
WW-1	silt-loam	G/B	20	4	330	30	34	25	14	16	0.3	4	5	-7

G = granite
B = basalt

Hillslope Sediment Delivery

Hillslope sediment delivery to the stream channel is estimated for each erosion process category described above. The hillslope delivery ratio expresses the amount of eroded sediments which reach an active stream channel. Delivery ratios vary based on erosion process and slope steepness, length, form, dissection and roughness (Ketcheson and Megahan, 1996). Typical delivery coefficients from RUSLE range from 0.3 to 0.6 where total sediment delivery is greater near the stream channel. A delivery coefficient of 0.6 is used in this TMDL. In other words, 60% of the total surface erosion is considered to be delivered to an active stream channel.

Surface erosion and sediment delivery from the road surface is greatest where roads are hydrologically connected to the stream channel: for example, where a road crosses a stream or where a road is constructed directly adjacent to a stream (typically within 300 feet). Bank erosion typically occurs directly in the active stream channel and often is a result of peak flow events. Consequently, 100% of the erosion from bank failure is assumed to be delivered to the stream channel.

Cumulative Sediment Yield

Sediment that is delivered from the hillslope or stream bank to the stream channel is either transported down-stream or stored in-stream in depositional areas. For this analysis, the Potential Sediment Delivery Coefficient (PSD) is used to account for in-stream sediment delivery and storage. Using the erosion estimates described above, the amount of hillslope sediment delivered to the stream channel is multiplied by the PSD producing a quantitative estimate of the average annual sediment delivery.

The PSD coefficient characterizes a stream's ability to transport, store, and deliver sediment. Use of this coefficient assumes that sediment transport and yield are a function of stream power (Geier and Loggy, 1995). The PSD method uses relief ratio, drainage density, bankfull discharge, and stream gradient as surrogates for potential sediment transport (Marston, 1978; Geier and Loggy, 1995; Fitzgerald et al., 1998). The equation is defined as follows:

$$P_S = (E_{mx}\text{-}E_{mn}/L_B * L_S/A_W * Q_{unit}/Q_{AA}) / (L_{RSP}+ (0.5*L_{TSP})/A_W) = \text{dimension-less}$$

where:
E_{mx} = maximum watershed elevation at the initial point of drainage (ft)
E_{mn} = minimum watershed elevation (ft)
L_B = basin length (ft)
L_S = total stream length (mi)
Q_{unit} = estimated bankfull discharge for a given unit (cfs)
Q_{AA}= estimated bankfull discharge for analysis area (cfs)
L_{RSP} = total response reach length (< 1.5% slope) (mi)
L_{TSP} = total transport reach length (1.5 to 3% slope) (mi)
A_W= drainage area (mi^2)

This equation assumes that steep high-energy streams will transport more sediment than low gradient streams, and that as the length of low gradient stream segments (i.e., depositional reaches) increases, the potential sediment transport decreases. In a steep watershed with high stream density, the PSD will be high relative to a watershed with moderate relief and many depositional channels. Using bankfull discharge as a variable in the PSD helps account for the long-term climatic trends present in a given basin which limits the effects of annual variability.

In addition to potential stream power, the ability of a stream to transport sediment is influenced by valley and channel slope and confinement, substrate characteristics, and volume of large woody debris. Generally, low gradient channels with high width to depth ratios will store sediment, whereas, high gradient confined channels will tend to transport sediment (Rosgen, 1996; Montgomery and Buffington, 1993). To account for instream sediment storage this method uses the depositional stream density, similar to drainage density, which is the quotient of a given watershed's length of response or depositional reaches to drainage area. This variable assumes that a high depositional stream density is proportional to high instream sediment storage.

Seasonal Variation and Critical Time Periods of Sediment Loading

To qualify the seasonal and annual variability and critical timing of sediment loading, climate and hydrology must be considered. This sediment budget analysis characterizes sediment loads using annual estimates averaged over about a 20-year time period. While deriving these estimates it is difficult to account for seasonal and annual variation. Annual erosion and sediment delivery are greatly a function of climate where wet water years typically produce the highest sediment loads, whereas dry water years produce below average sediment loads. Additionally, annual average sediment load is not distributed equally throughout the year. Erosion typically occurs during a few critical months: for example, in Upper Lapwai Creek most hillslope erosion occurs from August to November and February to June.

This sediment budget analysis uses empirically derived hydrologic concepts to help account for variation and critical time periods. First, climate and hydrology are variables in the predictive models so that erosion estimates factor in long term climatic trends (i.e., RUSLE and WEPP). Second, field-based methods consider critical hydrologic mechanisms: for example, bank erosion inventories account for the fact that most bank recession occurs during peak flow events when banks are saturated. Finally, the estimated annual average sediment delivery from a given watershed is a function of bankfull discharge or the average annual peak flow event. For example, bankfull discharge, which is a function of long-term climatic trends, is used to characterize the frequency of sediment transport and delivery from subwatersheds.

In an attempt to quantify seasonal and annual variation of sediment loads, the total load for wet and dry water years was estimated using measured suspended load and predicted bedload. A less than desirable sediment rating curve ($R^2 = 0.46$; $p < 0.05$) was used to predict the average annual suspended load. The measured channel cross-section and flow data, and the Meyer-Peter Muller bedload equation were used to predict the bedload transport rate. Subsequently, the total sediment load for four water years was estimated using the extended hydrograph. The results of this analysis are intended to illustrate the possible range of annual sediment load and are not used to derive loads in the TMDL.

Using suspended and bedload equations, the total sediment load ranges from about 2000 to 7000 tons per year (Table 4) where bedload constitutes about 25% of the total load. The critical factor influencing the amount of sediment transport is the frequency and magnitude of annual peak flow events where at flows less than about 15 cfs bedload transport is negligible. These estimates are greater than the average annual sediment delivery predicted from the sediment budget analysis: for example, the average annual sediment load from the sediment budget is 571 tons per year, meaning the average predicted instream load is greater by a factor of nine.

Extreme flood events are known to transport the greatest sediment load and cause significant channel changes: therefore, they are critical to understanding the actual sediment load. The flood of 1996 is used to illustrate this point. Using the extended hydrograph, the flood of 1996 peaked at about 158 cfs which has a 23-year recurrence interval. The predicted sediment load for this water year is about 22,000 tons, of which, about 50% was bedload.

Certainty of Sediment Budget

Because this sediment budget relies on predictive models and limited data, the total uncertainty is difficult to quantify. Many of the methods and models used in this analysis produce rough estimates of actual soil erosion and sediment transport which is compounded by the fact that average annual sediment yield is highly variable. As a result, the accuracy of the erosion and sediment yield estimates is considered to be within an order of magnitude of actual loads. However, these methods and models produce precise estimates of sediment production and are important when trying to understand the relative contribution of sediment from the different erosion process categories, land uses, and subwatersheds.

The total erosion and delivery estimates are relative to background, and regardless of the accuracy of a given model the proportions remain constant. This point is illustrated in the sediment budget results where current and background surface and bank erosion rates were estimated using separate methods (i.e., RUSLE and the Direct Volume Method): for example, in LP-1, which has elevated surface and bank erosion, the percent attributable to background is 7% for both processes. Conversely, in LP-5 26% of surface erosion and 8% of bank erosion is attributable to background. The same type of proportioning is used to compare the relative contribution between erosion process categories.

The sediment budget estimates are better measures of sedimentation because calculated suspended solids loads from previous studies are under-estimates of actual load. For example, in 1986 the lowest sediment load was measured, however, of these four water years 1986 had the highest peak flow. Moreover, in 1995 the second highest sediment load was measured when bankfull discharge did not occur (i.e., 29 cfs) (Table 4).

Table 4. Comparison of modeled to measured stream flow and sediment load of Upper Lapwai Creek

Water Year	TSS load (tons/year)	Peak Q. Measurement	Peak Q. Predicted	Measured TSS Load (tons/year)	Predicted Bedload (tons/year)	Total Load (tons/year)	Reference
1986	25	41	57	25	1774	1800	Latham (1986)
1989	77	45	36	77	1738	1815	Entranco (1990)
1994	27	14	9	27	0	27	Wertz (1996)
1995	55	20	23	55	0	55	Wertz (1996)

Plate 1. Summary of RUSLE gross erosion rates and crop rotation factors.

Watershed Code	Drainage Area (ac)	Win_subw#	Cropland Area (ac)	Rotation Factor 1	2	3	4	5	6	7	8	Total	Total erosion (tons/yr)*	Background Erosion (tons/yr)
WW-1	839	9	204	154	50							204	333	37
WW-2	275	2	72							72		72	26	13
WW-3	272	5	76					76				76	251	14
LP	5949		2926									0	5609	399
LP-1	1813	17	710		355				355			710	1879	128
LP-2	810	14	263								284	284	364	47
LP-3	861	16	396	189			207					396	1763	71
LP-4	1296	15	1064	558		331	175					1064	3201	191
LP-5	803	13/11	179		102						77	179	126	32
LP-6	367	12	314		252	63						315	215	57
FD-1	75	3	4							5		5	2	1
FD-2	70	4	11					10				10	33	2
FD-3	108	10	0											
FD-4	27	8	0											
FD-5	33	7	0											
			3293											

* = hillslope delivery factor of 60% used to compute total erosior

Rotation	Crop Rotation Description	Erosion Coeff. (t/ac/y)
1	wheat/barley/barley	3.5
2	BG (8)/oats(NT)(3)/wheat/barley	0.32
3	wheat/barley	4.4
4	wheat/barley/AWP/wheat	11
5	wheat/barley/sf/NT wheat	5.5
6	wheat/barley/barley/SF	8.5
7	H(8)/O(NT)/O/H(8)	0.6
8	WBW	2.3

Plate 2 Bank erosion inventory data summary sheet.

Stream Name: Johnson Creek
Site Number: 1-1
Date Sampled: 6/30/98 Time: 1230
Crew: Fitzgerald, Fitting, Dupont, and Matthews
Adjacent land uses: recreation and forestry

Data Reduced by: Fitzgerald

Stream Bank Erosion Calculations

Avg. Bank Height	1.3	feet
Inventoried Eroding Bank Length	1200	feet
Percent eroding bank	0.13	
Bank erosion over sampled reach (E)	1	tons/mile/sample reach
Erosion Rate (Ea)	1	tons/mile/year
Miles of Similar Stream Types	3.66	miles
Eroding bank extrapolation	0.93	
Total stream bank erosion	0.886	tons/year

Toe bank to bank length (LOB): 9482 feet

Stream Bank Erosion Reduction Calculations

Bank erosion over sampled reach (E)	1	tons/mile/sample reach
Erosion Rate (Ea)	1	tons/mile/year
Miles of Similar Stream Types	3.66	miles
Eroding bank extrapolation	0.93	
Total stream bank erosion	0.733	tons/year

Is stream flow a contributing factor? Not substantial, some longterm entrenchment

If yes, why?

any other contributing factors (animal access, return flows, etc.)?

Other notes: Abundant surface fines in channel bottom

Reach Description

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
650	1	2	0.5	1	0	CLY-SLT	G-Type Channel
	1.5	1	1	2	0		
	1	3	0.5	3	0		
	1			4	0		
				5	1		
				6	1		
650	1.125	2	0.7		2		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
3	731	0.02	73	0.53	3.0	731	0.025	73	0.67

Reach Description

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
550	1	3	1	1	1	CLY-SLT	C-type channel
	2	1	1	2	0		abundant fines in channel bottom
		2	1	3	0		some boulders
				4	0		
				5	0		
				6	1		
550	1.5	2	1		2		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
2	825	0.02	73	0.60	2.0	825	0.025	73	0.75

Summary Section

Total Length (ft)	Average Bank slope Height	Average Width	Average Depth	Average Rating Factor
1200	1.3	2.0	0.8	2.0

Average Width Depth Ratio	Average Eroding Area (ft2)	Average Recession Rate (ft/yr)	Average Bulk Density (psf)	Total reach erosion rate (tons/year)	Total reach erosion rate (tons/year)
2.5	778	0.02	73	1.14	1.42

Plate 3 Bank erosion inventory data summary sheet.

Stream Name: Upper Lapwai Creek
Site Number: 1-2
Date Sampled: 6/30/98 Time: 1430
Crew: Matthews and Fitzgerald
Adjacent land uses: range

Data Reduced by: Fitzgerald

Stream Bank Erosion Calculations

Ave. Bank Height	3 3	feet
Inv. bank to bank length (LBB)	3198	feet
Inventoried Eroding Bank Length	1550	feet
Percent eroding bank	0 48	
Bank erosion over sampled reach (E)	29	tons/mile/sample reach
Erosion Rate (Er)	48	tons/mile/year
Miles of Similar Stream Types	3 38	miles
Eroding bank extrapolation	3 27	
Total stream bank erosion	157	tons/year

Stream Bank Erosion Reduction Calculations

Bank erosion over sampled reach (E)	2	tons/mile/sample reach
Erosion Rate (Er)	3	tons/mile/year
Miles of Similar Stream Types	3.38	miles
Eroding bank extrapolation	3.27	
Total stream bank erosion	10	tons/year

Is stream flow a contributing factor? Yes

If yes, why? peak flow increases likely and lack of vegetation causing channel instability

any other contributing factors (animal access, return flows, etc.)? bank trampling

Other notes: Entrenched channel below Mudsprings Reservoir. Abundant bank erosion on outside bends, stream is cutting off meanders, decreasing sinuosity

Reach Description: Start at road crossing lower and moving u/s

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (pcf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (pcf)	Reach erosion rate (tons/year)
300	2	4 5	2	1	0	CLY-Loam	G-Type Channel	2.2	525	0 05	75	0 98	2.2	525	0 025	75	0 49
	1 5	3 3	1.5	2	0												
				3	0												
				4	2												
				5	1												
				6	1												
300	1 75	3 9	1.8		4												

Reach Description: Start at fence

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (pcf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (pcf)	Reach erosion rate (tons/year)
100	2 4	6 7	2.7	1	3	CLY-SS	G-Type Channel	5.7	1400	0.5	80	28	5.7	1400	0 025	80	1 40
250	8	7	2	2	3												
100	6	15	1.3	3	2												
200	8	10 7	2	4	3												
35'5	4	8 6	1 5	5	2												
250	5	9	2 7	8	1												
350	4	8	1 4														
1250	4 8	9 6	1 9		14												

Summary Section

Total Length (ft)	Average Bank slope Height	Average Width	Average Depth	Average Rating Factor	Average Width Depth Ratio	Average Eroding Area (ft2)	Average Recession Rate (ft/yr)	Average Bulk Density (pcf)	Total reach erosion rate (tons/year)	Total reach erosion rate (tons/year)
1550	3 3	6 7	1 8	9 0	4.0	962.5	0.3	77.5	26 96	1 89

Plate 4 Bank erosion inventory data summary sheet.

Stream Name: Upper Lapwai Creek at riparian enclosure
Site Number: 1-3
Date Sampled: 7/1/98
Time: 1140
Data Reduced by: Fitzgerald
Crew: Dupont and Fitzgerald
Adjacent land uses: range

Stream Bank Erosion Calculations

avg. Bank height	3.0	feet
Increment Eroding Bank Length	2875	feet
Percent eroding bank	0.29	
Bank erosion over sampled reach (E)	105	tons/mile/sample reach
Erosion Rate (En)	55	tons/mile/year
Miles of Similar Stream Types	2	miles
Eroding bank extrapolation	0.92	
Total stream bank erosion	81	tons/year

Inc. bank to bank length (LBB): 10012 feet

Stream Bank Erosion Reduction Calculations

Bank erosion over sampled reach (E)	7	tons/mile/sample reach
Erosion Rate (En)	4	tons/mile/year
Miles of Similar Stream Types	1.60	miles
Eroding bank extrapolation	0.92	
Total stream bank erosion	4	tons/year

Is stream flow a contributing factor? yes

If yes, why? Peak flow increases likely, causing downcutting and bank erosion

any other contributing factors (animal access, return flows, etc.)? bank trampling and vegetation removal

Other notes: D/S of riparian enclosure and grazed

Reach Description: Top of reach to last fence moving D/S

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
				1	1	CLY-SLT	
0	4	4.5	1.3	2	0		
100	2	11	1.4	3	1		
50	3.5	5.7	1	4	1		
150	3	4.5	1	5	1		
250	2.4	6	1	6	1		
630	3.0	6.24	1.1		5		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
5.6	1877	0.06	73	4.1	5.6	1877	0.025	73	1.71

Reach Description: Top of enclosure (end at top of main headcut)

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
75	1.7	3.5	1	1	1	CLY-SLT	
150	2.4	9	1.4	2	0		
150	2.7			3	1		
				4	1		
				5	1		
				6	1		
375	2.3	6.25	1.2		5		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
5.2	850	0.06	73	1.9	5.2	850	0.025	73	0.76

Reach Description: Top of upper instream structure near second fence

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
25	3	6	1	1	2	CLY	outcrop of modern soil
100	2.7	5.5	1.4	2	2		overlaying Palouse Loess
150	2.4	8	1.1	3	2		some sand present
115				4	2		
				5	2		
				6	1		
430	2.7	6.5	1.16666667		11		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
5.8	1161	0.5	70	20.3	5.6	1161	0.025	70	1.02

Plate 5 cont

Reach Description

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
0	2	10	1.6	1	3	CLY	
165	4.5	8	1.2	2	2		
175	6			3	2		
				4	3		
				5	1		
				6	1		
340	4.8	9	1.4		12		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
6.4	1643	0.5	70	28.4	6.4	1643	0.025	70	1.44

Reach Description — Top of abandon instream structure

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
50	3	13	1.5	1	2	CLY	sand lenses present, dom clay
100	3.4	10	1	2	2	GRVL-CRS SS (10%)	
175	3	7.5	0.8	3	2	CLY-SLT (90%)	
140				4	3		
				5	1		
				6	1		
465	3.3	10.1666667	1.1		11		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
8.2	1457	0.5	73	26.6	9.2	1457	0.025	73	1.33

Reach Description — Top of bottom enclosure

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
0	2.2	10	0.8	1	1	CLY	Clay overlays Palouse
100	2	7	0.9	2	3		
175	2.2	7	1.1	3	2		
125	2	13	1	4	3		
235				5	1		
				6	1		
635	2.1	9.25	0.94		10		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
9.5	1334	0.5	70	23.3	9.5	1334	0.025	70	1.17

Summary Section

Total Length (ft)	Average Bank slope Height	Average Width	Average Depth	Average Rating Factor	Average Width Depth Ratio	Average Eroding Area (ft2)	Average Recession Rate (ft/yr)	Average Bulk Density (psf)	Total reach erosion rate (tons/year)	Total reach erosion rate (tons/year)
2575	3.0	7.9	1.2	9.0	6.8	1387.0	0.4	71.5	105.0	7.4

Plate 5 Bank erosion inventory data summary sheet.

Stream Name: Upper Lapwai Creek at Winchester Lake
Site Number: I-4
Date Sampled: 7/1/98 Time: 1530
Crew: Matthews, Dansart and Fitzgerald
Adjacent land uses: range and forestry

Data Reduced by: Fitzgerald

Stream Bank Erosion Calculations

Avg. Bank height	2.6	feet
Inventoried Eroding Bank Length	1365	feet
Percent eroding bank	0.18	
Bank erosion over sampled reach (E)	32	tons/mile/sample reach
Erosion Rate (ER)	22	tons/mile/year
Miles of Similar Stream Types	9	miles
Eroding bank extrapolation	3.21	
Total stream bank erosion	71	tons/year

Bank to bank length (LBB): 7621 feet

Stream Bank Erosion Reduction Calculations

Bank erosion over sampled reach (E)	5	tons/mile/sample reach
Erosion Rate (Ea)	4	tons/mile/year
Miles of Similar Stream Types	8.98	miles
Eroding bank extrapolation	3.21	
Total stream bank erosion	11	tons/year

Is stream flow a contributing factor? Peak flow increases likely

If yes, why?

any other contributing factors (animal access, return flows, etc)? Recreation (motorized)

Other notes

Reach Description *Start below higher gradient forested reach (D/S)*

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
0	6.5	16	2.5	1	1	SS-SLT	some boulders	5.6	2448	0.15	90	18.5	5.6	2446	0.025	90	2.75
110	4.7	8.5	1.7	2	0												
175	3.4	11	2.3	3	2												
150	6	12	2	4	1												
				5	1												
				6	1												
675	5.15	11.9	2.1		6												

Reach Description Break reach where more vegetation (stop at old fence line)

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (psf)	Reach erosion rate (tons/year)
150	5	12	2	1	1	SLT-SS		5.3	2278	0.15	90	15.4	5.3	2274	0.025	90	2.56
125	2.2	14	1.6	2	0												
150	1	3.5	1.8	3	2												
155	2.6	13	2.5	4	1												
160	2	13	2.5	5	1												
150				6	1												
850	2.56	11.1	2.08		6												

Summary Section

Total Length (ft)	Average Bank slope Height	Average Width	Average Depth	Average Rating Factor		Average Width Depth Ratio	Average Eroding Area (ft2)	Average Recession Rate (ft/yr)	Average Bulk Density (psf)	Total reach erosion rate (tons/year)
1365	2.57	7.65833333	1.40166667			5.5	2362.3	0.2	90.0	31.9

Plate 6 Bank erosion inventory data summary sheet.

Stream Name Agricultural leads

Site Number

Date Sampled Time

Crew

Data Reduced by

Adjacent land uses

Stream Bank Erosion Calculations

Avg. Bank Height	1.5	feet	Tot. bank to bank length (LBB)	2000	feet
Inventoried Eroding Bank Length	1000	feet			
Percent eroding bank	0.50				
Bank erosion over sampled reach (E)	21	tons/mile/sample reach			
Erosion Rate (En)	71	tons/mile/year			
Miles of Similar Stream Types	12	miles			
Eroding bank extrapolation	12.03				
Total stream bank erosion	[illegible]	tons/year			

Stream Bank Erosion Reduction Calculations

Bank erosion over sampled reach (E)	2	tons/mile/sample reach
Erosion Rate (En)	4	tons/mile/year
Miles of Similar Stream Types	12.03	miles
Eroding bank extrapolation	12.03	
Total stream bank erosion	[illegible]	tons/year

Is stream flow a contributing factor?

If yes, why?

Any other contributing factors (animal access, return flows, etc.)?

Other notes

Reach Description

Length	Bank slope Height	Width	Depth	Rating Factor		Bank Material	Comments
1000	1	2	0.5	1	0	CLY-SLT	Q-Type Channel
	1.5	1	1	2	0		
	2	3	0.5	3	0		
	1.5			4	0		
				5	1		
				6	1		
1000	1.5	2	0.7		2		

Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (pcf)	Reach erosion rate (tons/year)	Width Depth Ratio	Eroding Area (ft2)	Recession Rate (ft/yr)	Bulk Density (pcf)	Reach erosion rate (tons/year)
3.0	1500	0.4	90	27	3.0	1500	0.025	90	1.69

Plate 7 Road erosion scores estimated using CWE and WEPP by subwatershed.

Watershed Code	Geologic Unit Code	CWE score	Road (mi)	Predicted Erosion rate	Total est. erosion	WEPP est. erosion	Total Timber Land Estimate (tons/year)*
FD-1	G			0	0		0
FD-1	B			0	0		0
FD-2	G			0	0		0
FD-2	B			0	0		0
FD-3	G			0	0		0
FD-3	B			0	0		0
FD-4	G	13	0.1	3	0		0
FD-4	B			0	0		0
FD-5	G			0	0		0
FD-5	B			0	0		0
LP-1	G	54	1.0	56	58		64
LP-1	B	19	3.1	4	14		15
LP-2	G	37	0.6	18	12		13
LP-2	B	18	0.4	4	2		2
LP-3	G	17	0.3	4	1		1
LP-3	B	16	0.9	4	3		4
LP-4	G	13	0.1	3	0		0
LP-4	B	13	0.6	3	2		2
LP-5	G	28	1.7	9	15		17
LP-5	B	13	0.3	3	1		1
LP-6	G					54	59
LP-6	B	13	0.0	3	0.042		0
WW-1	G	26	0.9	8	7		8
WW-1	B	23	2.5	6	15		16
WW-2	G	13	0.4	3	1		1
WW-2	B			0	0		0
WW-3	G	13	0.3	3	1		1
WW-3	B			0	0		0
		Total =	13		132		205

G = Lower Cretaceous to Upper Jurassic intrusives of west-central Idaho

B = Miocene basalt flows

* = road erosion estimates on timber lands are multiplied by 10% to account for skid trails.

Plate 8. Erosion estimates for urban land use by subwatershed.

Watershed Code	export coefficent (t/ac/y)	CITY (ac)	RESIDENCE (ac)	RESID/TIMB (ac)	CITY (t/y)	RESIDENCE (t/y)	RESID/TIMB (ac)
WW-1	0.08	0.0	2.4	0.0	0.0	0.2	0.0
WW-2	0.08	0.2	1.6	0.0	0.02	0.1	0.0
WW-3	0.08	0.0	0.0	2.6	0.0	0.0	0.2
LP-1	0.08	0.0	8.3	0.0	0.0	0.7	0.0
LP-2	0.08	0.0	0.0	0.0	0.0	0.0	0.0
LP-3	0.08	0.0	0.0	0.0	0.0	0.0	0.0
LP-4	0.08	0.0	14.2	0.0	0.0	1.2	0.0
LP-5	0.04	0.0	1.5	122.6	0.0	0.1	10.1
LP-6	0.08	0.0	2.4	0.0	0.0	0.2	0.0
FD-1	0.08	70.0	0.0	0.0	5.7	0.0	0.0
FD-2	0.08	0.0	0.0	0.0	0.0	0.0	0.0
FD-3	0.08	0.0	0.0	0.0	0.0	0.0	0.0
FD-4	0.08	0.0	0.0	0.0	0.0	0.0	0.0
FD-5	0.08	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX B:

UPPER LAPWAI CREEK
CUMULATIVE WATERSHED EFFECTS ASSESSMENT

January 1999

Assessment conducted under the auspices of the

Idaho Forest Practices Act

Report prepared by
Tom Dechert
Idaho Department of Lands
Coeur d'Alene, Idaho

Executive Summary

Upper Lapwai Creek is a third order stream draining into Winchester Lake in the Clearwater River drainage of north central Idaho. It had been identified as a Stream Segment of Concern and has been 303(d) listed by the U.S. Environmental Protection Agency (USEPA) for beneficial uses being threatened by sediment, nutrients, temperature, dissolved oxygen, pathogens, pesticides, and flow and habitat alteration. To address these and other concerns, the USEPA entered into a memorandum of agreement with the Nez Perce Tribe and the Idaho Division of Environmental Quality (DEQ), creating a Technical Advisory Group (TAG). The TAG asked the Idaho Department of Lands to complete a Cumulative Watershed Effects assessment of forested portions of the drainage in 1998. The results of the analyses, coupled with the results of a 1996 DEQ Beneficial Use Reconnaissance Survey of the stream, show that water quality and beneficial uses are being maintained in the forested portions of the watershed using current forest management practices as specified by the Idaho Forest Practices Act, and modified by the Site Specific Best Management Practices adopted in 1994 by the Idaho Department of Lands pursuant to the Idaho Antidegradation Agreement.

I. INTRODUCTION

A. Watershed Description

Upper Lapwai Creek and Winchester Lake are located immediately to the south of the town Winchester, Idaho, and approximately 30 miles southeast of Lewiston, Idaho (Figure 1). The Upper Lapwai Creek drainage contains 7,748 acres used primarily for agriculture and forestry, with some suburban development. Land ownership is distributed between the Nez Perce Tribe and small, private owners.

Two rock types underlie the Upper Lapwai Creek drainage. Mesozoic intrusive rocks support a hilly terrain in the eastern portion; the remainder of the basin in underlain by Tertiary (Miocene) basalt flows. In the basalt areas, the terrain is generally gently rolling with a few steeper stream dissections. Most of the gentle terrain and some of the hills have a surficial layer of wind deposited silt (loess). The broader valley bottoms are floored by retransported silt washed off the uplands. The Granitic hills are characterized by a thick surficial layer of sandy clay loam soil over highly weathered rock.

Upper Lapwai Creek is a third order tributary to Winchester Lake. The drainage is oriented in a northerly direction with Upper Lapwai Creek generally flowing from south to north-northwest. Elevation ranges from 3902 feet at the Upper Lapwai Creek and Winchester Lake confluence to near 4630 feet on Mason Butte. The drainage pattern is influenced by the contact between the granitics and volcanics, with the main Upper Lapwai Creek more-or-less following the contact. Stream profiles are relatively low gradient, and with the abundance of loess, fine sediment accumulates throughout most of the basin, creating graded conditions with notable lateral migration.

Warm, dry summers and cold winters, with an average annual precipitation of 25 inches characterize the area. The majority of precipitation occurs as winter snowfall and spring rain. High-volume runoff occurs during spring snowmelt and major rain-on-snow events.

Vegetation varies with elevation and aspect; however, the majority of the forested portion of the watershed supports semi-open stands of Ponderosa Pine and Douglas fir. These stands were likely maintained evolutionarily by frequent fire. Grand Fir is found on northerly aspects and at higher elevations. Agriculture and grazing have permanently removed a large portion of the conifer overstory, converting these areas to dryland agriculture and rangeland.

B. Stream Segment of Concern: Antidegradation

Winchester Lake including Upper Lapwai Creek was designated a Stream Segment of Concern (SSOC) on May 11, 1993, pursuant to Idaho's Antidegradation Agreement. No Local Working Committee (LWC) was required; however, on June 2, 1994 revisions pertaining to site specific best management practices (SSBMPs) were reached after consultation with other agency resource management personnel. The IDL Director approved the SSBMPs on December 14, 1994 (Appendix 1).

C. Beneficial Uses

The USEPA determined that sediment, nutrients, dissolved oxygen, pathogens, pesticides, temperature, and flow and habitat alterations threaten Upper Lapwai Creek's beneficial uses [U.S. Environmental Protection Agency, Region 10: 303(D) list for Idaho, Appendix C, October 7, 1994].

Based on an evaluation of 1996 Beneficial Use Reconnaissance Project (BURP) data for Upper Lapwai Creek using the associated 1996 Water Body Assessment Guidance, DEQ categorized Upper Lapwai Creek as having full support of beneficial uses (John Cardwell, DEQ, personal communication). The Nez Perce Tribe and EPA do not necessarily agree with this conclusion, and EPA is in the process of reviewing the Idaho WBAG process used to interpret this data (Leigh Woodruff, Region 10 EPA, personal communication).

D. Goals of this Assessment

A Cumulative Watershed Effects (CWE) assessment of the forested portions of Upper Lapwai Creek was conducted by IDL and other interested agencies, under the auspices of the TAG, to: 1) develop an understanding of the inherent hazards of the landscape within the Upper Lapwai Creek watershed, 2) document the current conditions within the watershed relevant to hydrologic processes and the disturbance history, and 3) develop a control process that will ensure that the watershed is managed to protect water quality so that beneficial uses are supported.

II. CUMULATIVE WATERSHED EFFECTS METHODOLOGY

Personnel from IDL, DEQ, the Idaho Soil Conservation Commission, the Nez Perce Tribe, and the USEPA conducted a CWE assessment of the Upper Lapwai Creek watershed in June 1998. The Upper Lapwai Creek CWE assessment followed the standard procedures of the Forest Practices Cumulative Watershed Effects Process for Idaho (Idaho Department of Lands, April 1995).

Idaho Code Section 38-1303 (17) defines cumulative watershed effects as "*...the impact on water quality and/or beneficial uses which result from the incremental impact of two (2) or more forest practices. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.*" The CWE methodology is designed first to examine conditions in the watershed surrounding a stream and in the stream itself. It then attempts to identify the causes of any adverse conditions. Finally, it helps identify actions that will correct any identified adverse conditions.

As described in the Forest Practices Cumulative Watershed Effects Process for Idaho (Idaho Department of Lands, April 1995), the CWE process consists of seven specific assessments: A) Erosion Hazard, B) Canopy Closure/Stream Temperature, C) Hydrologic, D) Sediment Delivery, E) Channel Stability, F) Nutrients, and G) Beneficial Uses/Fine

Sediment. Summaries of the results of each of these assessments in the Upper Lapwai Creek drainage are presented in Section III, respectively.

The CWE "Adverse Conditions Assessment" method was applied to analyze whether significant adverse effects occur in the forested portions of Upper Lapwai Creek drainage. Adverse condition assessments were conducted for stream temperature, hydrology, nutrients, and beneficial uses/fine sediment. The results of the adverse condition assessments are presented in Section IV.

Finally, the CWE process provides guidance to help forest landowners design management practices to alleviate any adverse conditions and prevent problems from future forest practices. These prescriptions and recommendations are presented in Section V.

The following individuals participated in the field data collection:

- Jim Fitzgerald (U.S. Environmental Protection Agency)
- Jonathan Matthews (Nez Perce Tribe)
- Bill Dansart (Idaho Division of Environmental Quality)
- Mitch Silvers (Idaho State Parks)
- John Campbell (Nez Perce Tribe)
- Chuck Pentzer (Idaho Soil Conservation Commission)
- Doug Fitting (Idaho Department of Lands)
- Joe Dupont (Idaho Department of Lands)
- Larry Morrison (Idaho Department of Lands)
- Tom Dechert (Idaho Department of Lands)
- Rich Talbott (Idaho Department of Lands)

III. CUMULATIVE WATERSHED EFFECTS ASSESSMENT RESULTS

A. Erosion and Mass Failure Hazard Assessment

The primary landtype associations (LTAs) mapped in the drainage are "Loess Dominated Plains" and "Old Volcanic Surfaces" (LTAs 17 and 82). Fieldwork in the drainage compared with the geology and soil maps identified a major section of "Old Granitic Surfaces (LTA 81). Figure 2 exhibits the revised LTA map of the watershed. The old surface LTAs have moderate inherent hazard for surface erosion and mass failures (Table 1). The "Loess Dominated Plains" LTAs have a high surface erosion hazard, and a low mass failure hazard. Overall, the forested portions of the Upper Lapwai Creek watershed have a **moderate surface erosion hazard** rating and a **moderate mass failure hazard** rating.

Table 1. Upper Lapwai Creek hazard ratings by landtype association.

Landtype Association	Forested Acres	Percent of Total Forested Acres	Mass Failure Hazard	Surface Erosion Hazard
17	378	11	Low	High
81	1648	46	Moderate	Moderate
82	1519	43	Moderate	Moderate

B. Canopy Closure/Stream Temperature Assessment

Class I streams were divided into 8 segments at intervals determined by land use and natural breaks (Figure 3). Percent shading over each segment was estimated from aerial photos and verified with field measurements. Table 2 presents the comparison of the measured results with target shade requirements. The Canopy Closure/Stream Temperature rating is determined only for those segments under forestry land use. The existing stream shade on all forested segments meets or exceeds the levels needed to predict that stream temperatures are likely within the temperature targets. Data for the non-forested segments are presented for comparison and other analyses.

Table 2. Canopy closure/stream temperature ratings by stream reach.

Stream Segment	In Forested Zone (?)	Existing Canopy Cover (%)	Target Canopy Cover (%)	Chinook Salmon Present	Other Salmonids Present	Canopy Closure/ Temperature Rating
1	Y	21-40	25	N	Y	Low
2	N	0-20	Min FPA	N	N	Non-FPA
3	Y	21-40	Min FPA	N	N	Low
4	N	0-20	Min FPA	N	N	Non-FPA
5	Y	41-70	Min FPA	N	N	Low
6	N	0-20	Min FPA	N	N	Non-FPA
7	Y	71-90	25	N	Y	Low
8	Y	41-70	Min FPA	N	N	Low

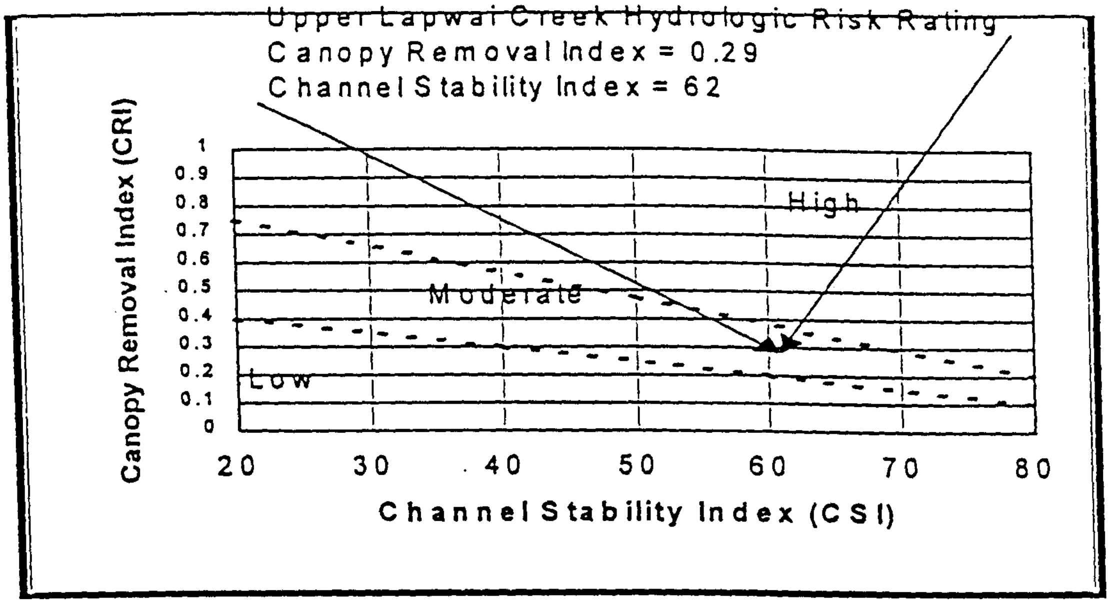
C. Hydrologic Risk Assessment

Forestry is currently being practiced on 3546 acres or about 46% of the Upper Lapwai Creek watershed. The effective area of canopy removed through timber harvest from forestry land is about 1028 acres. Figure 4 shows the current land use and canopy condition in the Upper Lapwai Creek watershed.

The calculated CWE Canopy Removal Index is 0.29. While it is probable that most of the Upper Lapwai Creek was timbered before 1850, the Canopy Removal Index is calculated only for those acres that are still being managed for forestry.

The canopy removal index is coupled with the channel stability index (from Section E below) to produce a hydrologic risk rating (HRR). The HRR rates the risk that the stream channel may be impacted by forest canopy removal by comparing the level of forest cover removal in the watershed with the stability of the stream channel. **The HRR for Upper Lapwai Creek is moderate** as shown in Chart 1.

Chart 1. Hydrologic Risk Rating of Upper Lapwai Creek.



D. Sediment Delivery Assessment

Sediment generated from roads, skid trails, and mass wasting was evaluated for delivery to streams. In order to provide more detailed data for analysis, the road and mass failure data were collected on a site-specific basis. Roads were divided into segments with more-or-less uniform cut and fill slope, road surface, road drainage, road type, and sediment delivery characteristics such that a single CWE "road sediment delivery score" could be calculated for each segment. From these segment scores, a single road sediment delivery score for the watershed was calculated using a weighted average based on segment lengths and total length of roads sampled. Similarly for mass failures, each mass failure was recorded for location, volume of material moved, and percent delivery to a waterway. The mass failure sediment delivery score was calculated based on the mass failure frequency, size, and delivery. Much of the data was recorded using GPS, and all of the data were entered into a GIS for the analyses.

1. Roads

The Upper Lapwai Creek drainage contains approximately 35.4 miles of roads, very few of which are closed with culverts removed (Figure 5). 18.2 miles of the roads were analyzed under this CWE assessment as roads used for forestry practices and the remaining 17.2 were considered non-forestry roads. Of the 18.2 miles of forestry roads, 13.5 miles were sampled, and of the 17.2 miles of non-forestry roads, 7.9 miles were sampled. (Generally, the CWE road assessment does not work well for paved and graveled county roads.) The road sample was skewed towards roads close to streams and those considered to have potential for impacting stream quality.

Road segment scores in the forestry portion of the watershed range from 13 to 87, with a weighted average of 24. Road segment scores in the non-forestry portion of the watershed range from 13 to 51, with a weighted average of 22. The various roads sampled and the associated road scores are presented in Figure 5. Road segments with scores > 56 are considered site specific problems needing management attention.

Based on the weighted average score for the forestry portion of the watershed, **the sediment delivery rating from roads is low**, reflecting mostly road surface and inside ditch erosion but little delivery to stream channels.

2. Skid Trails

Most historic harvest activity used ground-based tractor skidding; some of this occurred in stream protection zones. These skid trails have recovered substantially and will not be used in the future. New skid trails are outside stream protection zones, with sufficient vegetation and surface drainage to control erosion.

Sediment delivery rating from skid trails is low.

3. Mass Wasting

Only one instance of mass wasting was observed in the watershed. This cut slope failure was along the road west of Winchester. It was about 20 cubic yards in size, and some was delivered to a Class I stream.

The mass failure sediment delivery rating is low.

Since the sediment delivery ratings of roads, skid trails and mass wasting are all low, **the overall sediment delivery rating for the forestry portion of the watershed is also low.**

E. Channel Stability

Five similar reaches in the forested portion of Upper Lapwai Creek were evaluated (Figure 4) in June 1998 when stream flow was relatively low. All of the reaches have a Medium Channel Stability Index except stream reach no. 5, which has a High index. Stream reach no. 5 is the overflow channel to Mud Lake and is an artificial channel that is downcutting. In general, the poor channel stability ratings are the result of low bank rock content, and lack of large organic debris.

The overall channel stability rating is high, indicating a high risk stream channel.

F. Nutrient Assessment

Because Upper Lapwai Creek flows into Winchester Lake, a nutrient hazard rating and a nutrient current condition analysis were completed for the watershed. Since the watershed has a moderate erosion hazard rating and a moderate mass wasting hazard rating, it has a moderate nutrient hazard rating. The nutrient current condition analysis resulted in a moderate rating.

The overall nutrient rating couples the nutrient hazard rating and the nutrient current condition rating; for Upper Lapwai Creek, **the rating is moderate** (Table 4).

Table 4. Nutrient Rating Key (shaded areas apply to Upper Lapwai Creek).

	Low Nutrient Hazard	Moderate Nutrient Hazard	High Nutrient Hazard
Current Nutrient Condition – Low	Low	Low	Moderate
Current Nutrient Condition – Moderate	Moderate	Moderate	High
Current Nutrient Condition – High	High	High	High

G. Beneficial Use Attainability and Status

A Beneficial Use Attainability and Status Reconnaissance (BURP) survey was completed for Upper Lapwai Creek in July 1996 by DEQ. The macrobiotic index (MBI) of 4.42 and the habitat index (HI) of 97 indicate that Upper Lapwai Creek is not impaired and that **beneficial uses are fully supported** (John Cardwell, DEQ, personal communication).

IV. ADVERSE CONDITION ANALYSIS

Table 5 presents the summary results from all the assessments. These results are used to determine whether an adverse condition exists. If no adverse condition exists, then standard Best Management Practices (BMPs) as specified in the Idaho Forest Practices Act, and, as in the case with Upper Lapwai Creek which was previously an SSOC, Site-Specific BMPs to control degradation are considered adequate to protect stream quality. If an adverse condition exits, then Cumulative Watershed Effects Management Prescriptions (CWEMPs), that will ultimately be SSBMPs, must be developed.

Table 5. CWE Analysis Summary

CWE Assessment Category (with possible ratings)	CWE Assessment Report Section	Current Condition Rating
Surface Erosion Hazard (H, M, L)	A	Moderate
Mass Failure Hazard (H, M, L)	A	Moderate
Stream Temperature (H, L)	B	Low
Hydrologic Risk Rating (H, M, L)	C	Moderate
Sediment Delivery (H, M, L)	D	Low
Channel Stability Index (H, M, L)	E	High
Beneficial Use/Fine Sediment (S, NS)	G	Supported
Overall Nutrient Rating (H, M, L)	F	Moderate

A. Stream Temperature Adverse Condition – No adverse condition exists

All Canopy Cover/Stream Temperature ratings for the stream segments in the forested portions of the watershed are Low. Therefore, as shown in Table 6, no adverse condition exists and FPA standard BMPs should continue to be implemented.

Table 6: Stream Temperature Adverse Condition Key[1].

Temperature Rating	Adverse Condition?	Management Direction
High	Yes	CWEMPs
Low	No	Standard BMPs

[1] Shaded blocks show conditions for Upper Lapwai Creek.

B. Hydrology Adverse Condition – No adverse condition exists

The hydrological risk rating (HRR) derived from the hydrologic risk assessment and the channel stability assessment is moderate. Since the HRR is moderate, no adverse condition exists. FPA standard BMPs and Site-Specific BMPs to control degradation should continue to be implemented. It is noted that this watershed has a high channel stability index (high stability risk), indicating that forest managers need to exercise caution such that forest practices will not negatively impact the stream channel.

C: Nutrient Adverse Condition – No adverse condition exists

The Nutrient Current Condition Analysis resulted in a moderate hazard rating for nutrients related to water quality (Table 7). The moderate rating is not an adverse condition. Standard forestry BMPs and Site-Specific BMPs to control degradation should continue to be applied.

Table 7. Nutrient Adverse Condition Key[1].

Lake Present?	Overall Nutrient Rating	Adverse Condition?	Management Direction
Yes	H	Yes	CWEMPs
Yes	M, L	No	Standard BMPs
No	NA		

[1] Shaded blocks show conditions for Upper Lapwai Creek.

D. Beneficial Use/Fine Sediment Adverse Condition – No adverse condition exists

Based on an evaluation of 1996 Beneficial Use Reconnaissance Project (BURP) data for Upper Lapwai Creek using the associated 1996 Water Body Assessment Guidance, DEQ categorized Upper Lapwai Creek as having full support of beneficial uses (John Cardwell, DEQ, personal communication). The Nez Perce Tribe and EPA do not necessarily agree with this conclusion, and EPA is in the process of reviewing the Idaho WBAG process used to interpret this data (Leigh Woodruff, Region 10 EPA, personal communication). The CWE sediment delivery assessment resulted in a low rating. Therefore, an adverse condition does not exist (Table 8). Standard forestry BMPs and Site-Specific BMPs to control degradation should continue to be applied.

Table 8. Beneficial use/Fine sediment adverse condition key[1].

Sediment Delivery Rating	Beneficial Use Condition	Management Direction
Low	Supported	Standard BMPs
	Not Supported	Additional Analysis
Medium	Supported	CWEMPs
	Not Supported	CWEMPs Additional Analysis
High	Supported	CWEMPs
	Not Supported	CWEMPs Additional Analysis

[1] Shaded blocks show conditions for Upper Lapwai Creek.

V. MANAGEMENT PRESCRIPTIONS AND RECOMMENDATIONS

No adverse conditions for forestry were identified in Upper Lapwai Creek. The CWE analysis indicates that the standard BMPs of the Idaho Forest Practices Act applied before 1994 and modified by the Site Specific BMPs applied since 1994 have protected water quality and beneficial uses in Upper Lapwai Creek. Since Upper Lapwai Creek is a Stream Segment of Concern under Idaho's antidegradation policy, the Site Specific BMPs, which are more stringent than the minimum Idaho Forest Practice Rules and Regulations, should continue to be implemented in the drainage.

Even though no adverse conditions were identified, this CWE assessment does identify areas of concern for future forestry management. Under the current SSBMPs (Appendix 1), "pre-operational inspections are required on all forest practices when operation is near a Class I stream." Future pre-operational inspections should consider the following: 1) stream channels in this watershed have a moderate to high stability risk; 2) the nutrient current condition of the watershed is marginally acceptable; and 3) both the surface erosion hazard and mass failure hazard ratings are moderate. In addition, the CWE assessment identified particular problems needing attention. Current management should address the following specific problems: 1) the downcutting of the stream/overflow channel immediately below Mud Springs Reservoir; 2) the road in the southeast quarter of section 16 to the southeast of Mud Springs Reservoir identified on Figure 5 with the CWE sediment delivery score of 81; and 3) the road near the center of section 6 with the high score identified on Figure 5 with the CWE sediment delivery score of 63.

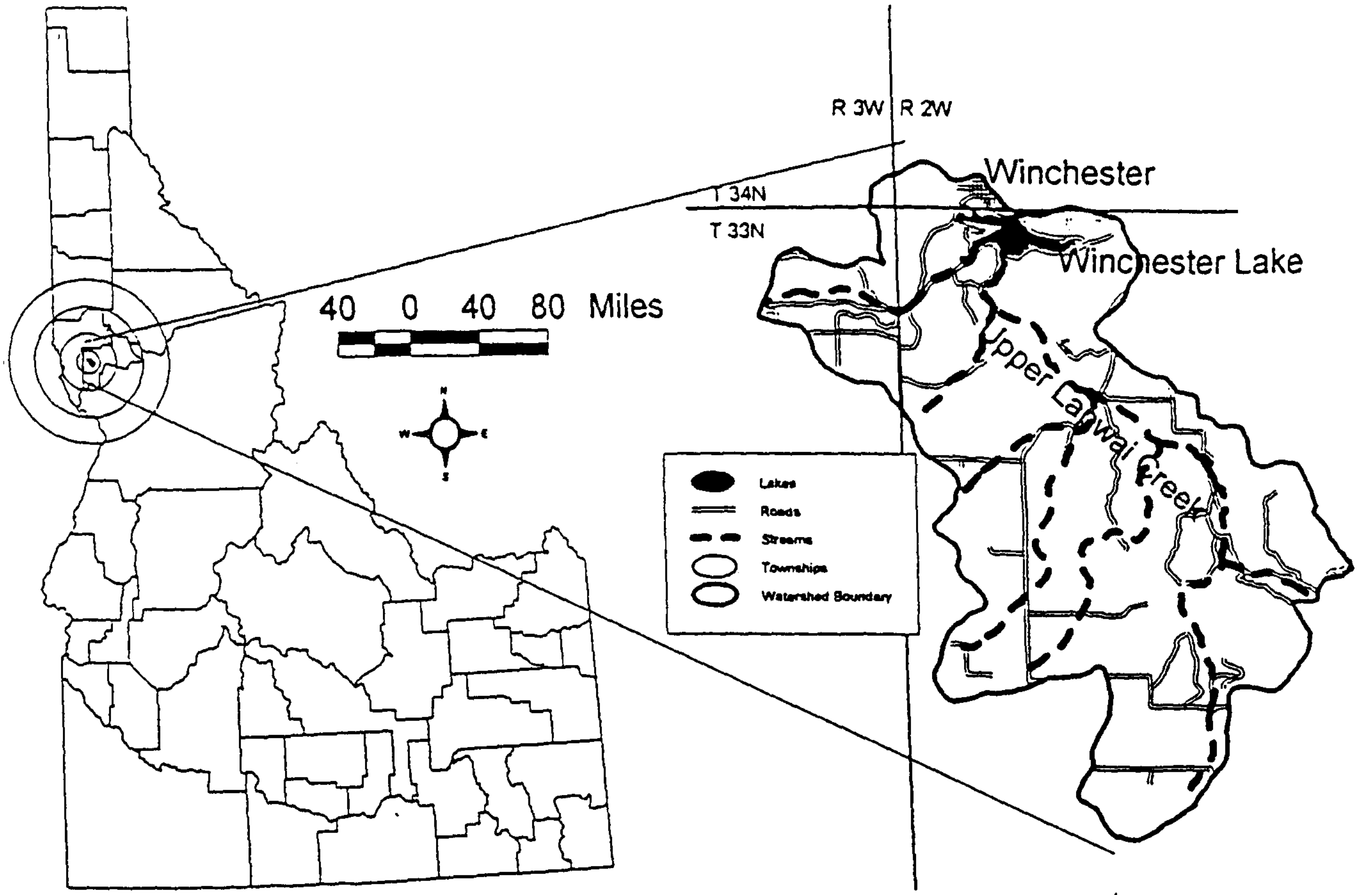


Figure 1. Location of the Upper Lapwai Creek Watershed.

January 1999

Figure 2a. Landtype associations.

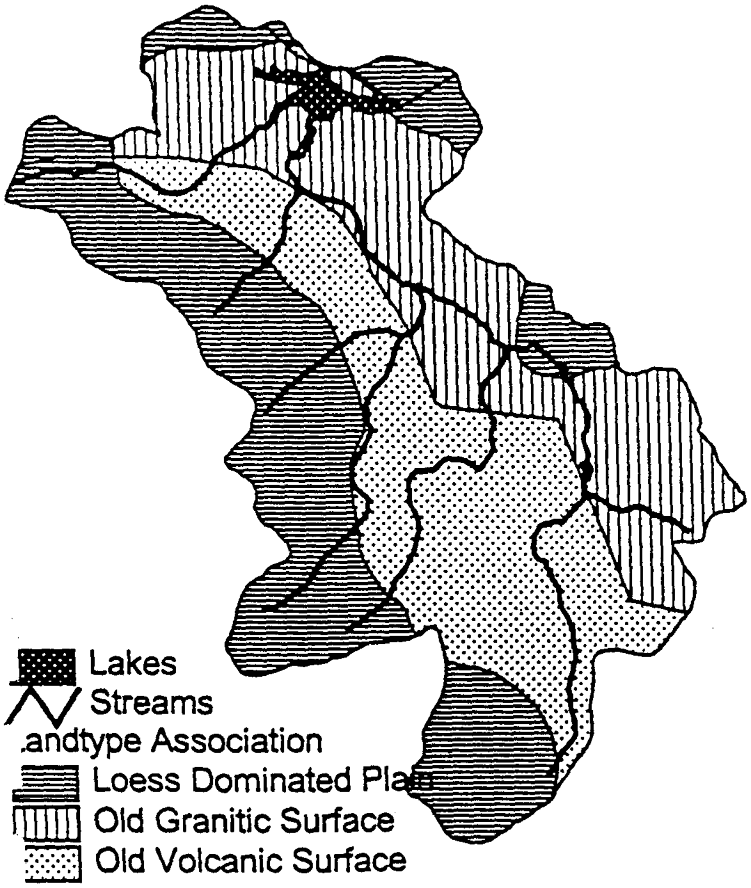


Figure 2b. Landtype associations of forested land.

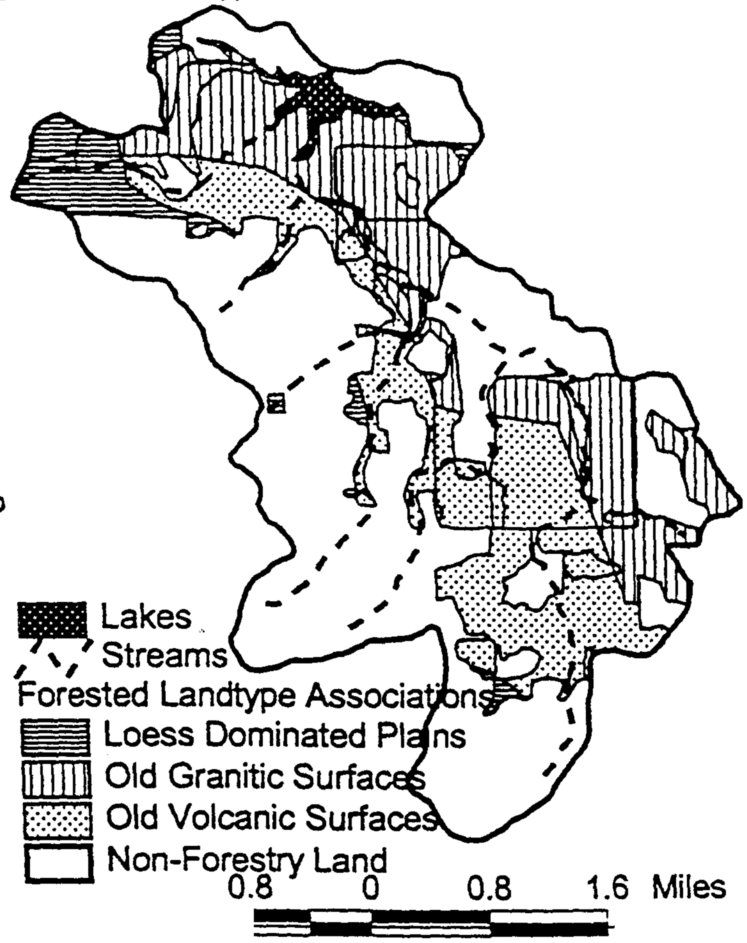


Figure 2c. Mass failure hazard ratings.

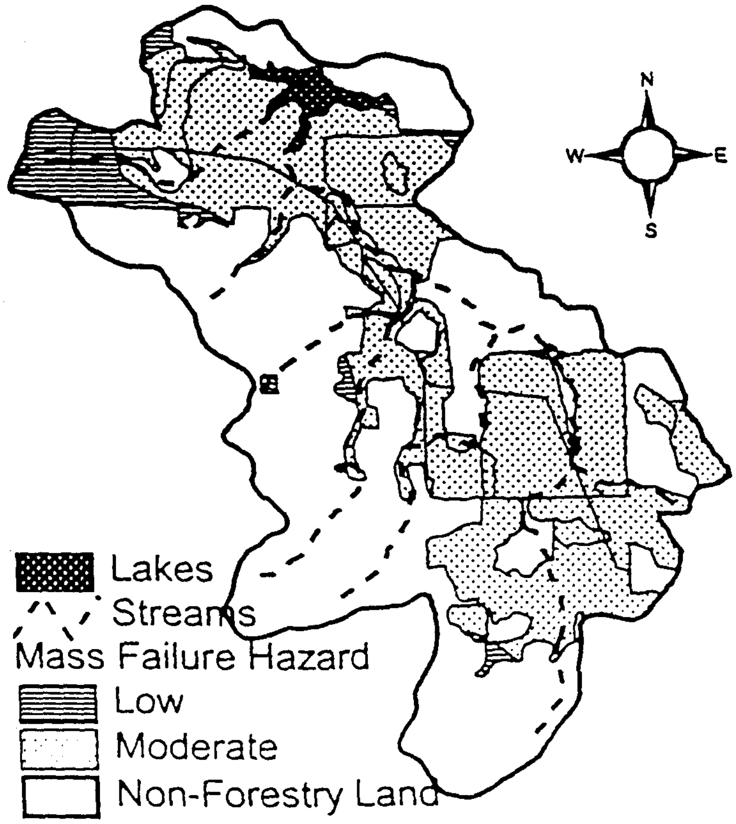


Figure 2d. Surface erosion hazard ratings.

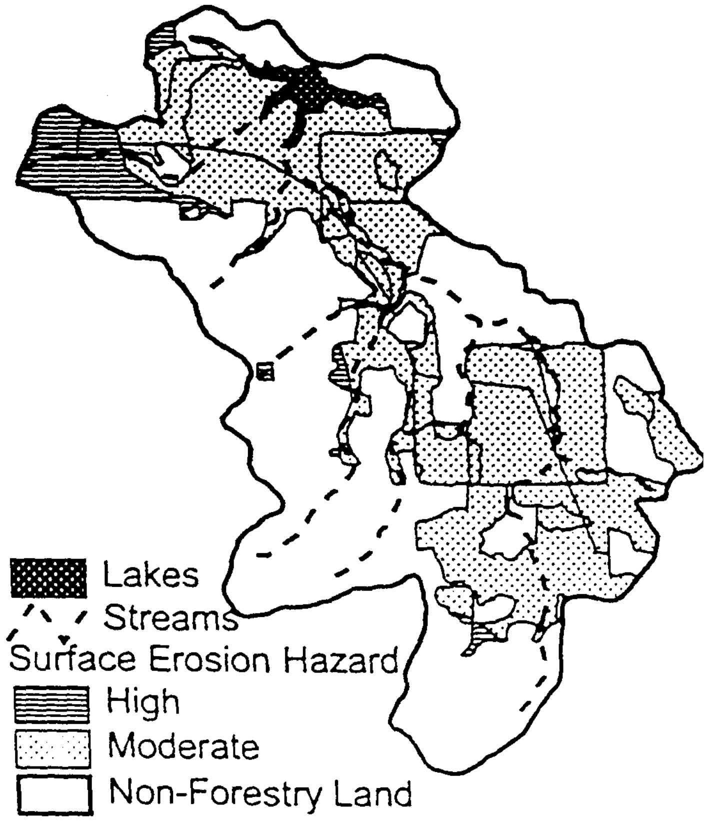


Figure 3. Canopy Cover/Stream Temperature and Channel Stability stream assessment segments.

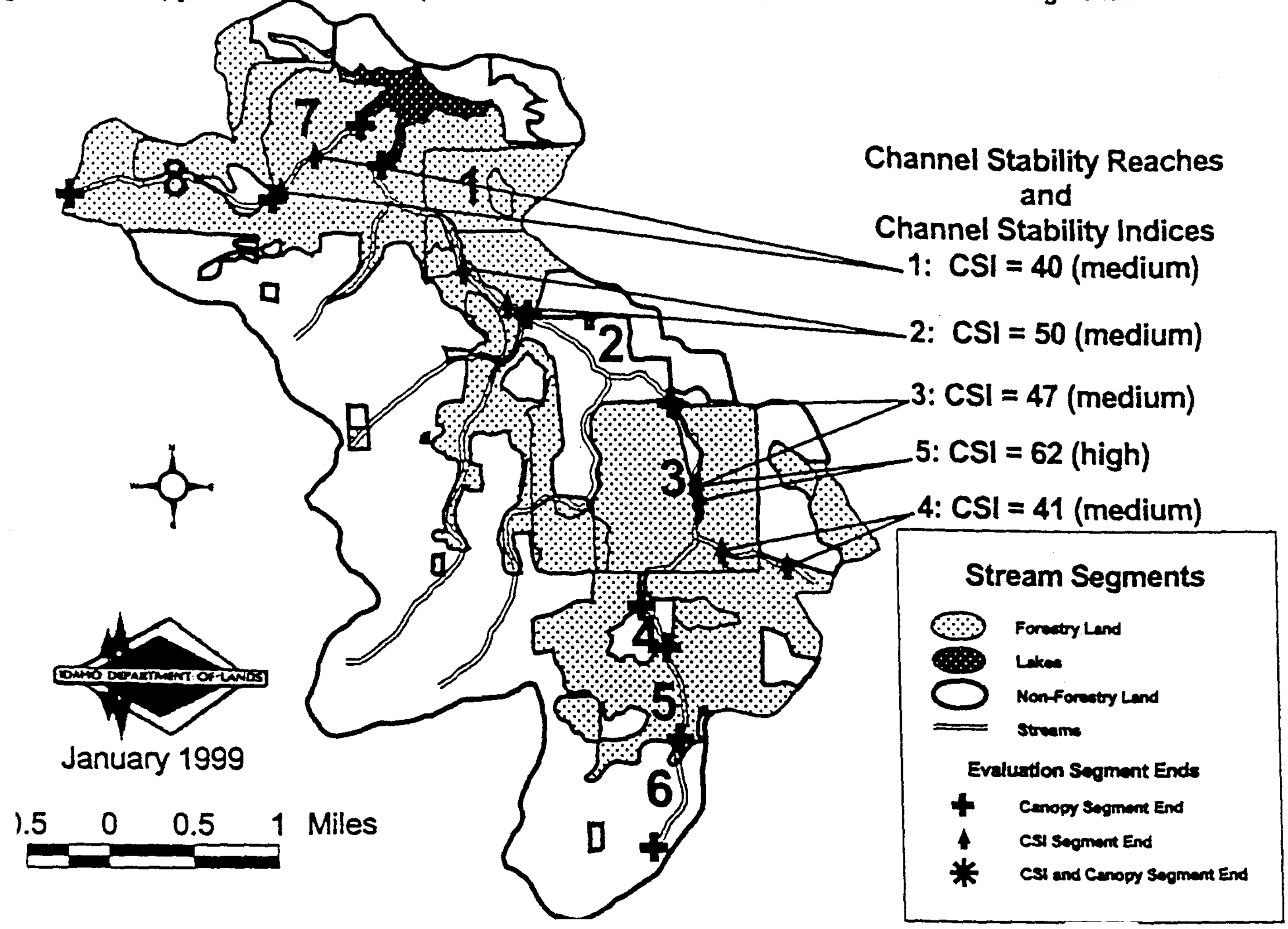


Figure 4. Percent canopy cover present on forestry land.

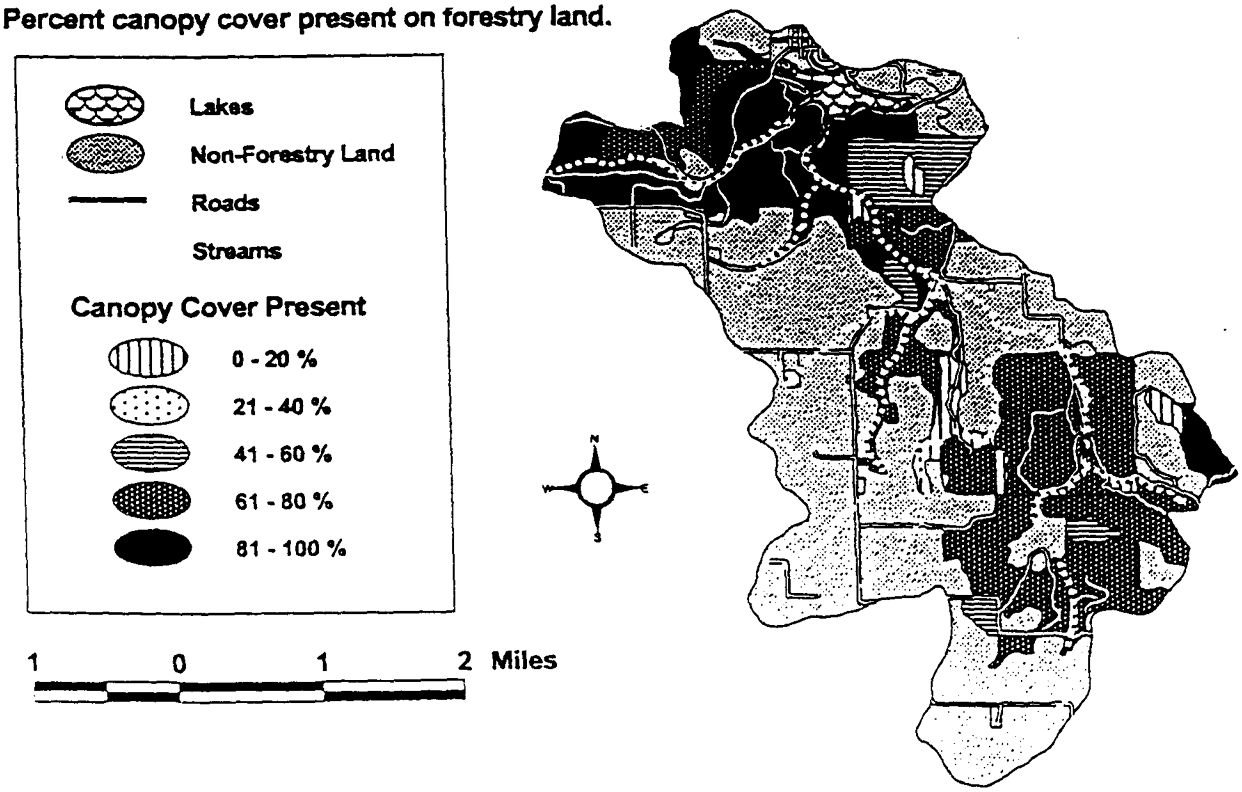
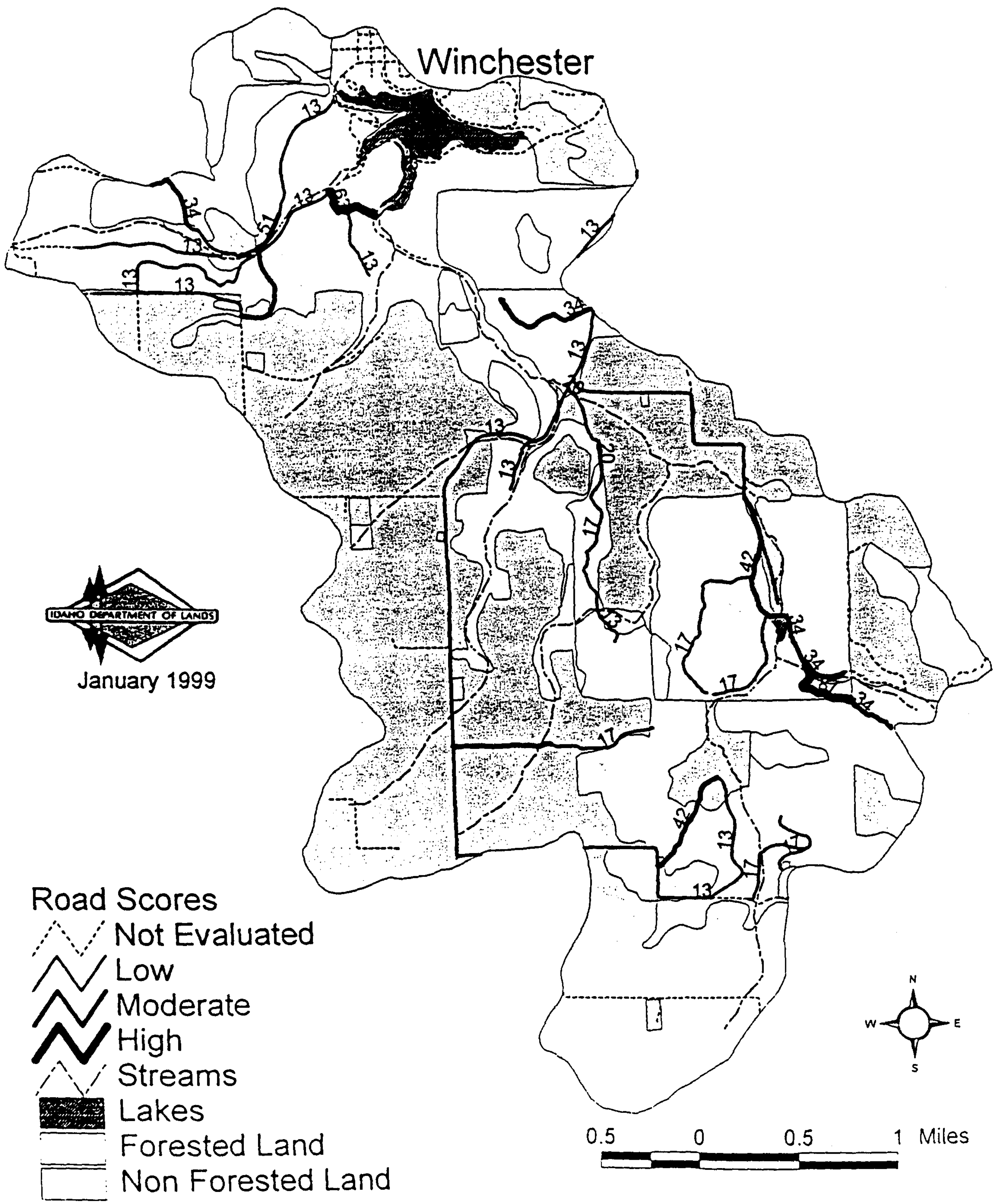


Figure 5. Upper Lapwai Creek CWE Road Segments and CWE Scores



FINAL REPORT

FOR

Nez Perce and Lewis County 1992 Stream Segments of Concern (SSOC) where no Local Working Committee is Required

PNRS	STREAM	DESIGNATION
1143.00	Lapwai Creek	Timber
1167.00	Lapwai Creek	Agriculture/Grazing/Timber
1143.10	Winchester Lake	Agriculture/Grazing/Timber
1143.11	Tom Beale Creek	Agriculture/Grazing
1147.00	Mission Creek	Agriculture/Grazing
1147.10	Mission Creek	Agriculture/Grazing/Timber
1164.00	Big Canyon Creek	Agriculture/Grazing
1164.10	Big Canyon Creek	Agriculture/Grazing
1180.00	Lawyers Creek	Agriculture/Grazing
1180.10	Lawyers Creek	Agriculture/Grazing
2004.00	Lake Waha	Agriculture/Grazing/Timber
2004.10	Lake Creek	Agriculture/Grazing/Timber

Prepared by:

Richard K. Talbott
Forest Practice Advisor
October 14, 1994

Approved by:

Stanley F. Hamilton

Stanley F. Hamilton, Director
Idaho Department of Lands

December 14, 1994
Date

WATER QUALITY OBJECTIVES

FOR

MISSION CREEK, LAPWAI CREEK, TOM BEALE CREEK, LAKE WAHA, LAKE CREEK, WINCHESTER LAKE, BIG CANYON CREEK AND LAWYERS CREEK

The objective is to maintain beneficial uses for the above drainages.

CHRONOLOGY OF EVENTS

DATE	EVENT
02/16/90	Mission Creek was designated as an agriculture and timber harvest activity stream segment of concern. No local working committee is required on this SSOC.
05/14/90	Reconnaissance of proposed logging operations on Upper Mission Creek with Idaho Department of Lands Forest Hydrologist.
10/09/90	Review of Mission-Lapwai Creek Watershed Protection Plan and Environmental Assessment drafted by the Soil Conservation Service.
02/15/91	After consultation with other agency personnel, the forest practice advisor determined site specific best management practices (SSBMP) will developed for individual forest practices during a preoperational instruction.
04/29/91	Mission Cr. SSBMP in effect.
05/11/93	Mission Creek is redesignated and Winchester Lake, Tom Beale Creek, Lake Waha, Lake Creek, Big Canyon Creel and Lawyers Creek are newly designated as stream segments of concern.
06/02/94	An agreement on revised site specific best management practices was reached after consultation with other agency resource management personnel.

SITE SPECIFIC BEST MANAGEMENT PRACTICES

In addition to the Rules and Regulations of the Idaho Forest Practices Act, the following site specific BMPs apply to Mission Creek, Lapwai Creek, Tom Beale Creek, Lake Waha, Lake Creek, Winchester Lake, Big Canyon Creek and Lawyers Creek stream segments of concern. These BMPs were developed in accordance with Rule 8.d. of the Idaho Forest Practices Act Rules and Regulations.

Rule 8.d. Requirements

SITE SPECIFIC BMPS DEVELOPED BY THE FOREST PRACTICES ADVISOR:

GENERAL RULES

1. Pre-operational inspections are required on all forest practices when operation is near a Class I stream.

2. The use of a ford in a Class I portion of a stream will not be permitted from February 15th to June 15th.

3. Additional site specific best management practices will be developed as needed to maintain water quality or mitigate for potential forest practice impacts for each operation.

OTHER SIGNIFICANT CONCERNS AND ISSUES OF THE ADVISOR

1. Number of agricultural/grazing stream segments should be limited to allow for thorough analysis and evaluation by the advisor.

2. The Soil Conservation Service and the Idaho Department of Lands should work together to jointly address cumulative effects in the watershed.

Field notes, supporting technical data and related correspondence are available for review upon request.

Appendix C

A Mathematical Model of Primary Productivity in Winchester Lake, Idaho

APPENDIX C

A Mathematical Model of Primary Productivity in Winchester Lake, Idaho

Prepared by JohnYearsley, EPA Region 10, Seattle WA

I. Management Objectives

Winchester Lake in central Idaho has been identified by the State of Idaho's Division of Environmental Quality as water-quality limited. Limnological studies of the lake by Moeller (1986) and ENTRANCO Engineers (1990) identified water-quality issues typical of eutrophic lake systems. These issues included nuisance algal blooms, poor water clarity, and low dissolved oxygen. To address these issues, the State of Idaho is developing a total maximum daily load (TMDL) for phosphorus, as required by Section 303 of the Clean Water Act. This report describes a mathematical model of primary productivity developed to estimate the impact of phosphorus loading from external sources (surface and groundwater) on the dissolved oxygen resources of Winchester Lake.

II. Technical Approach

The technical approach is based on mass and energy balance of variables in the lake which have important roles in determining the dissolved oxygen. These include:

(1) Dissolved oxygen
(2) Water temperature
(3) Organic matter in the form of phytoplankton and detritus
(4) Phosphorus in organic, inorganic and particulate forms

The approach is derived from previous models developed for the analysis of primary productivity as described in Bowie et al (1985). Major assumptions include:

(1) The lake can be divided into two well-mixed compartments, an epilimnion and a hypolimnion.
(2) Phosphorus is the limiting nutrient
(3) The phytoplankton community can be characterized by a single species
(4) Contribution of soluble reactive phosphorus (dissolved orthophosphorus) from the sediments is always approximately 10% of the surface loading
(5) Data from the 1988-1989 studies by ENTRANCO Engineers (1990) can be used as a typical or design condition

A realization of the conceptual model of primary productivity for Winchester Lake was accomplished using the object-oriented simulation software STELLA. The STELLA mass balance equations, with documentation of specific elements, are available from Idaho DEQ upon request.

III. Parameter Estimation

Primary productivity was simulated in Winchester Lake using the mass balance equations with a range of parameters. The parameter set chosen for the final analysis of dissolved oxygen produced the results for dissolved oxygen and water temperature in the epilimnion and hypolimnion shown in Figures 1-4 and for chlorophyll are shown in Figure 5. The actual values for this parameter set are given in the documentation. In some cases, parameters were estimated from Bowie et al (1985).

IV. Scenarios

Three following three scenarios of phosphorus loading to Winchester Lake were analyzed:

1. Existing conditions
2. TMDL loading of 334 kg/yr (739 lbs/yr)
3. Loading needed to achieve a volume-averaged DO in the hypolimnion of 6.0 grams/meter^3 or greater

V. Results

Simulation results for the three loading scenarios are given in Table C-1. Figure 10 in Section 3.1 of the TMDL document shows the simulated DO in the hypolimnion for each of the three scenarios.

Table C-1. Annual average loading of total phosphorus to Winchester Lake from surface and groundwater; average annual total phosphorus in the entire lake; average annual total phosphorus in the epilimnion and average annual total phosphorus in the hypolimnion for three scenarios.

	Existing Conditions (1988)	TMDL Condition (Idaho DEQ)	Target Condition (DO > 6.0 grams/meter^3)
Annual External Loading of Total P From Surface and Groundwater	750 kg/year	334 kg/yr	240 kg/year
Average Annual Total P in Winchester Lake	140 mg/meter^3	57 mg/meter^3	32 mg/meter^3
Average Annual Total P in the Epilimnion of Winchester Lake	100 mg/meter^3	45 mg/meter^3	28 mg/meter^3
Average Annual Total P in the Hypolimnion of Winchester Lake	180 mg/meter^3	70 mg/meter^3	48 mg/meter^3

VI. Simulated Vertical Variation of Dissolved Oxygen

An analysis was performed using the simulation results of the primary productivity model to estimate the vertical variation of dissolved oxygen under the TMDL loading scenario of 334 kg/yr (739 lbs/yr). The average DO measurements from IDFG's 1998 studies were used to estimate the vertical variation of DO in the hypolimnion of Winchester Lake, given the average DO of the hypolimnion. It was assumed that the incremental change in DO would be the same as that measured by IDFG such that the observed value in the hypolimnion could always be described as:

$$DO(z) = DO_{ref} + \Delta DO(\mathbf{z})$$

where,

$DO(z) =$ the observed value, mg/l

$DO_{ref} =$ a constant, reference value, mg/l,

$DO(z) =$ the average DO measured by IDFG in the hypolimnion, mg/l.

The average DO for the hypolimnion would then be

$$DO_{avg} = \Sigma \{DO(z) * DV(z)\}/V_{hypo}$$

where,

$\Delta V(z)$ = the incremental volume of the lake at some depth, z,

V_{hypo} = the total volume of the hypolimnion.

Given a simulated average value of the hypolimnetic DO, the DO_{ref} was adjusted until the DO_{avg} was equal to the simulated average. Results of the simulation are provided in table C-2. Using bathymetry information to estimate lake volume, combined with the expected change in the dissolved oxygen depth profile, the increase in lake volume which meets both the dissolved oxygen and temperature criteria during the critical summertime period is estimated to increase from the current estimated 16% to an estimated range between 35% to 46%.

VI. References

Bowie, G.L. W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopf, G.L. Rupp, K.M. Johnson, P.W.H. Chan, S.A. Gherini and C.E. Chamberlin. 1985. Rates, constants and kinetics formulations in surface water quality modeling. EPA/600/3-85/040. U.S. Environmental Protection Agency, Athens, Georgia.

ENTRANCO Engineers, Inc. 1990. Winchester Lake. Final Report. Phase I diagnostic and feasibility analysis. Prepared for Idaho Division of Environmental Quality and U.S. Environmental Protection Agency, Region 10, Kirkland, Washington

Moeller, J.R. 1986. Winchester Lake, Lewis County, Idaho, 1985, water quality status report. Report No. 61. Idaho Division of Environment, Boise, Idaho.

Table C 2 Analysis of vertical variation of DO under simulated existing and simulated conditions

Depth	Area (m2)	Area (ac.)	V(m3)	V(L)	%
0 - 0 5 m	375975 00	92 91	187987.5	187987500	0.11
0 5 - 1 m	338725 00	83 70	169362.5	169362500	0.10
1 - 1 5 m	315800 00	78 04	157900	157900000	0.09
1 5 - 2 m	294375 00	72.74	147187.5	147187500	0.08
2 - 2 5 m	269325 00	66 55	134662.5	134662500	0.08
2 5 - 3 m	248250 00	61.34	124125	124125000	0.07
3 - 3 5 m	231525 00	57.21	115762.5	115762500	0.06
3 5 - 4 m	215100 00	53 15	107550	107550000	0.06
4 - 4 5 m	202200 00	49 96	101100	101100000	0.06
4 5 - 5 m	190350 00	47.04	95175	95175000	0.05
5 - 5 5 m	176625 00	43 64	88312.5	88312500	0 05
5 5 - 6 m	160950 00	39 77	80475	80475000	0.05
6 - 6 5 m	140675 00	34.76	70337.5	70337500	0.04
6 5 - 7 m	109950 00	27.17	54975	54975000	0 03
7 - 7 5 m	91225 00	22.54	45612.5	45612500	0.03
7 5 - 8 m	76150 00	18.82	38075	38075000	0.02
8 - 8 5 m	45225 00	11.18	22612.5	22612500	0.01
8 5 - 9 m	36150 00	8 93	18075	18075000	0.01
9 - 9 5 m	24750 00	6 12	12375	12375000	0.01
9 5 - 10 m	11375 00	2 81	5687.5	5687500	0.00
10 - 10 5 m	4375 00	1 08	2187.5	2187500	0.00
10 5 - 11 m	2550 00	0 63	1275	1275000	0.00
11 - 11 5 m	1425 00	0.35	712.5	712500	0 00
11 5 - 11 6 m	300 00	0 07	30	30000	0.00
					1.00
			1781555	1781555000	

#	Depth	V(L)	%			
0	0 - 1 m	357350000	0 20	11.9	Adjust =	4
1	1 - 2 m	305087500	0.17	11.1		
2	2 - 3 m	258787500	0.15	8.9		DO est
3	3 - 4 m	223312500	0.13	4.6	1920487500	8 8
.4	4 - 5 m	198275000	0.11	1.6	1099140000	5 8
5	5 - 6 m	168787500	0 09	0.8	810180000	4 8
6	6 - 7 m	125312500	0 07	0.6	578437500	4 6
7	7 - 8 m	83687500	0 05	0.6	384962500	4 6
8	8 - 9 m	40687500	0 02	0.7	191231250	4 7
9	9 - 10 m	18062500	0.01	0.4	79475000	4 4
10	10 - 11 m	3462500	0 00	0.4	15235000	4 4
11	11 - 11.61 m	742500	0.00	0.4	3267000	4 4
				Volume Mean DO=	5.90519423	
		1781555000	1.00			
	Epilimnion	921225000				
	Hypolimnion	860330000				

Bottom 20%= 356311000

Figure 1. Simulated and observed dissolved oxygen in the epilimnion of Winchester Lake during 1988

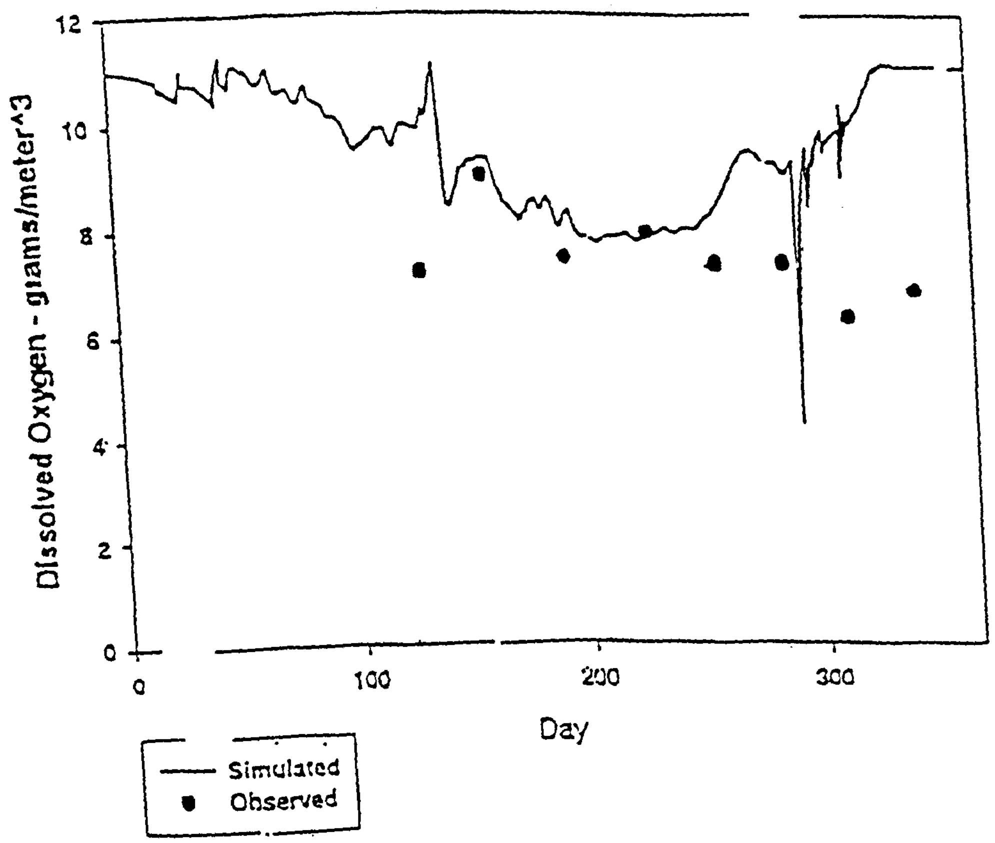


Figure 2. Simulated and observed dissolved oxygen in the hypolimnion of Winchester Lake during 1988

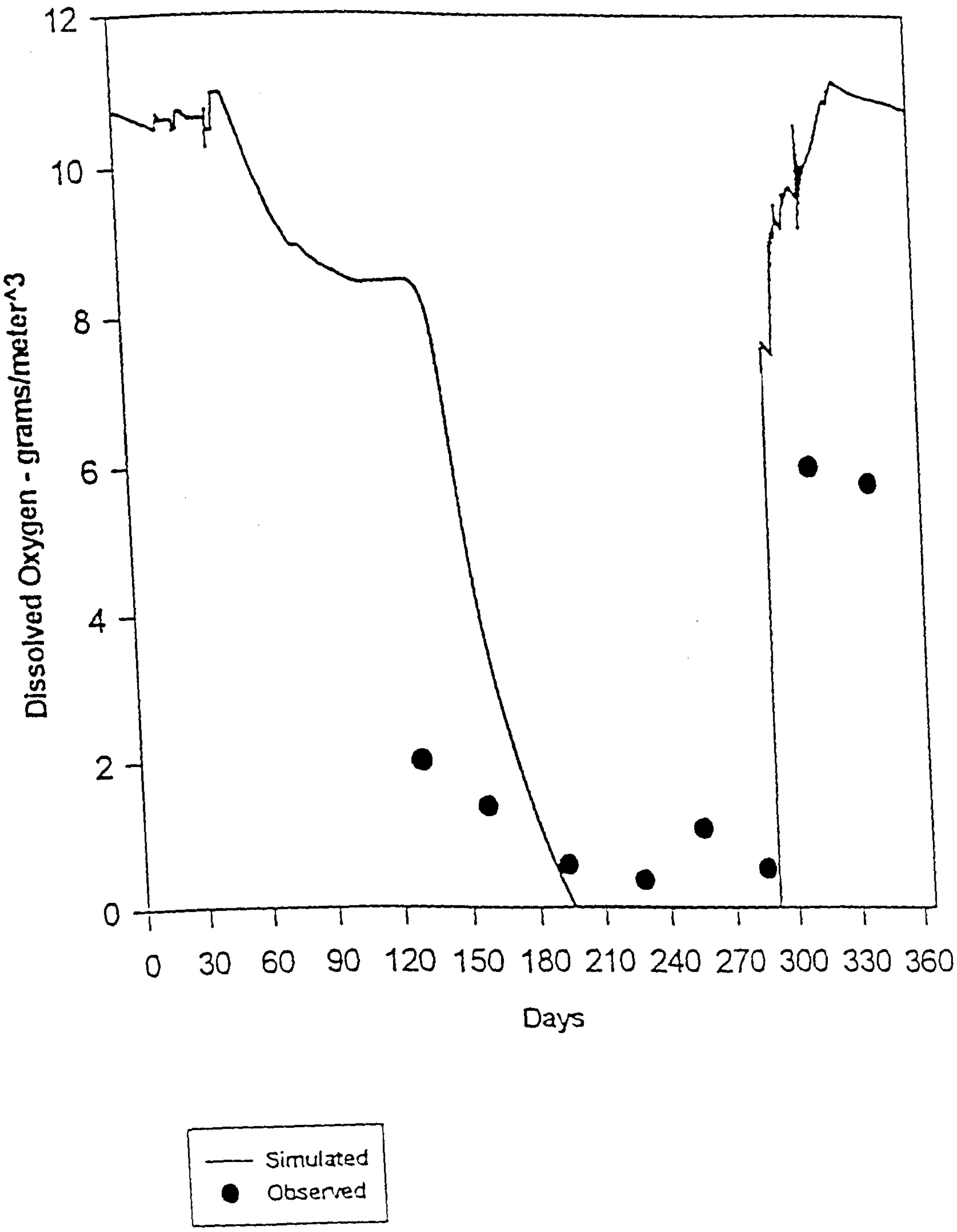


Figure 3. Simulated and observed water temperature in the epilimnion of Winchester Lake in 1988

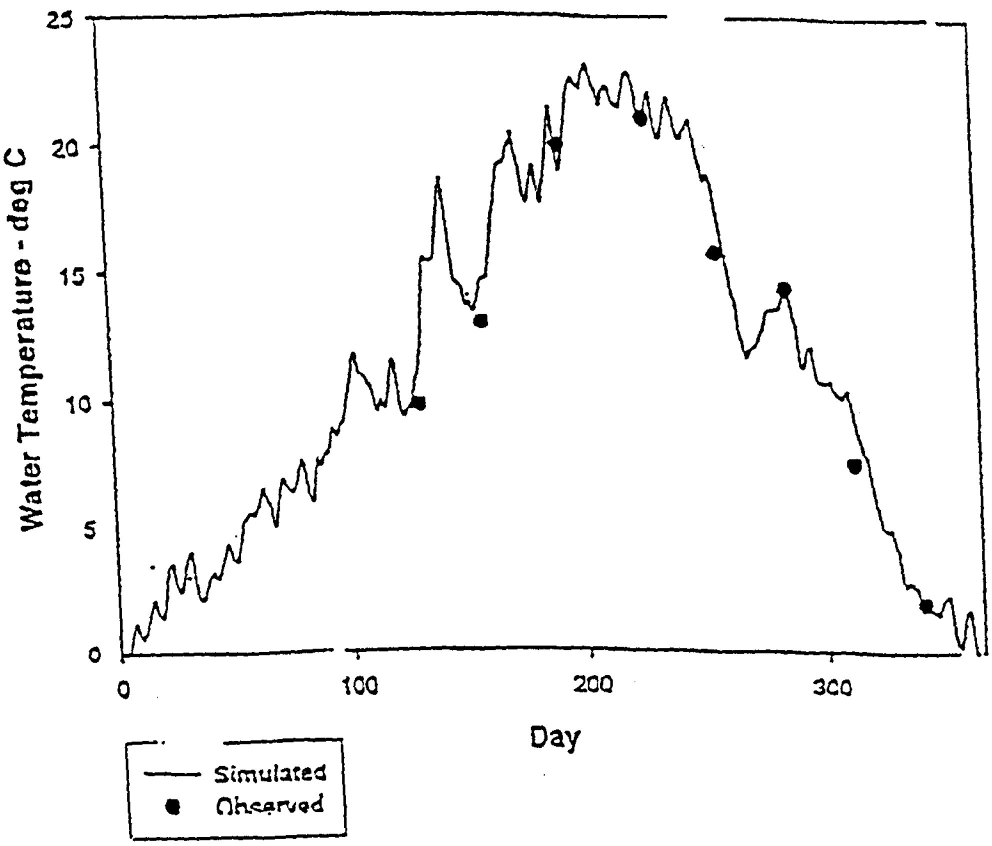


Figure 4. Simulated and observed water temperature in the hypolimnion of Winchester Lake in 1988

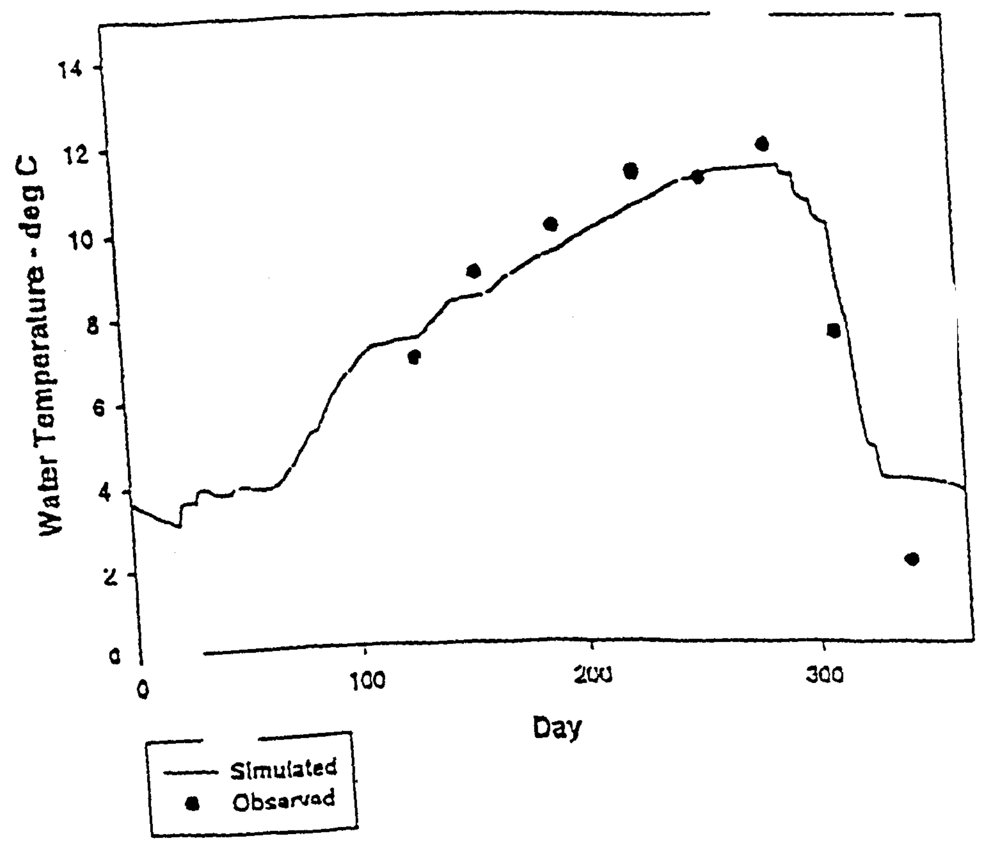
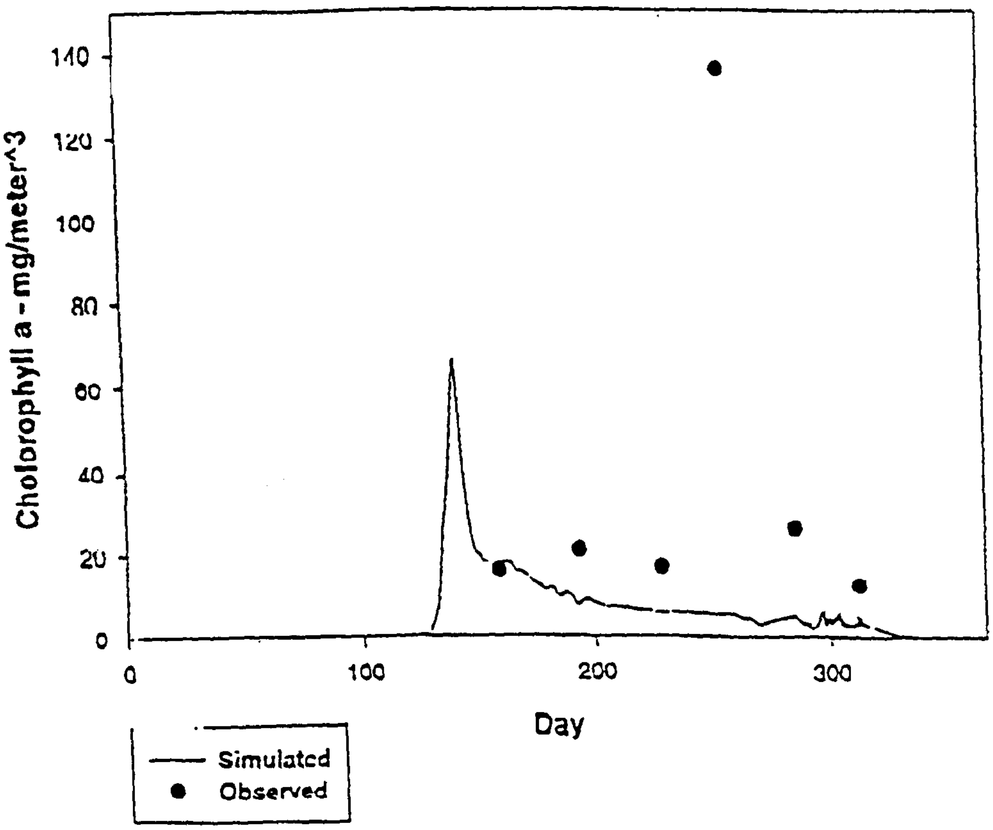


Figure 5. Simulated and observed chlorophyll a in the epilimnion of Winchester Lake in 1988



Appendix D

Thermal Loading Analysis

STREAM FLOW/STREAM CHANNEL

Upper Lapwai Creek (from Winchester Lake northward) is an ungaged segment. To determine streamflow in Upper Lapwai Creek, a synthetic hydrograph was developed using the hydrologic analysis described in Appendix A. Streamflow in Upper Lapwai Creek, based on the synthetic hydrograph, increases during spring snowmelt (March - Mid-April) and decreases in the summer. The temperature analysis used the 7Q10 flow of 0.56 cfs. The 7Q10 flow was because this flow is indicative of flows commonly seen in Upper Lapwai Creek during the time period of interest.

Stream channel cross-section information was also used in calibrating and running the SSTEMP model. The stream channel cross-sectional information used in the analysis included channel width, channel depth, elevation, and study area length. Table D-1 provides the channel information used for Upper Lapwai Creek.

Table D-1 - Stream Channel Cross-Section Information

	Mean wetted Width (ft)	Depth (ft)	Mean Elevation (ft)	Channel Length (miles)
Lapwai Creek (2)	6.7	1.8	4020	.761
Lapwai Creek (3)	7.9	1.2	4170	2.68
Lapwai Creek (4)	7.9	1.2	4153	4.01
Lapwai Creek (1)	7.9	1.2	4175	2.5
Lapwai Creek (5)	7.7	1.4	3995	2.20
Lapwai Creek (6)	2.5	0.8	4095	1.10

ATMOSPHERIC CONDITION

Climatic data used in calibrating and running SSSOLAR and SSTEMP included mean daily air temperature, wind speed, relative humidity and cloud cover Air temperature data was made available from the University of Idaho weather station in Grangeville, Idaho. The only long term climatic variable available at this weather station was maximum and minimum air temperature. The maximum and minimum air temperature were averaged over the eight-year period of record to obtain the mean air temperature for both the salmonid spawning period and the salmonid rearing period (Table D-2). The mean air temperature for the spawning period (Table D-2) was used in developing the loading capacity and shade targets for each sub-watershed.

The mean air temperature for the rearing period was used to determine if the shade targets developed using the spawning temperature would be effective in reducing summer temperatures.

Because wind speed, cloud cover and relative humidity data was not available at the Grangeville, Idaho weather station, conservative assumptions were made using the NOAA Climatic Atlas.

Table D-2 - Mean Air Temperature for Salmonid Spawning and Rearing Time Period

Spawning Period	
April	9.998EC
May	11.904EC
June	14.634EC
July 1 - 15	17.529EC
Mean Temperature	**12.496**EC
Rearing Period	
July 15 - 31	19.098EC
August	19.046EC
September	14.756EC
Mean Temperature	**17.767**EC

STREAM SHADE

Stream shade data was collected by the Nez Perce Tribe using a combination of both aerial photo interpretation and ground truthing. The analysis was completed independent of the Cumulative Watershed Effects (CWE) protocol adopted by the Idaho Department of Lands. The CWE analysis focuses only on forested lands, while the Winchester Lake/Upper Lapwai Creek TMDL focused on the entire watershed regardless of landownership. The shade data identified areas where existing shade has been reduced due to grazing, agricultural and timber harvesting activities and calculates the resulting increase in total daily solar heating. Upper Lapwai Creek was broken into six (6) sub-watersheds. For ach sub-watershed, the mean percent shade is the value that is reported for the "Existing Shade Condition". The sum of Target shade values were calculated using the Stream Segment Temperature Model (SSTEMP) and the Stream Segment Solar Temperature Model developed by the US Geological Survey.

Target shade values for Upper Lapwai Creek represent the *"Percent increase in Shade"* needed within each sub-watershed to attain the Idaho's daily mean temperature criteria of 9°C during the salmonid spawning period and 19°C during the salmonid rearing period.

SHADE DATA COLLECTION METHODOLOGY

Introduction:

Riparian habitat functions as an important component of stream health by stabilizing soils, providing shade, filtering surface runoff, and buffering surface flow. Low gradient streams devoid of riparian vegetation often develop sediment and nutrient problems from spring runoff, as well as high water temperatures and low dissolved oxygen concentrations during summer. The Nez Perce Tribe recognizes these water health connections to riparian vegetation, and so devised a low-budget methodology to create a GIS riparian habitat coverage for use in watershed health assessments.

The following describes this inventory methodology. There are four basic phases to the assessment methodology: aerial photo interpretation, field verification, data entry, and spatial connection of data to GIS stream coverage.

Aerial Photo Interpretation

Riparian habitat characteristics are readily distinguishable from aerial photos. The Nez Perce Tribe Water Resources office used 1992 color aerial photos to document presence of riparian habitat and other related characteristics by mapping stream shade, tree and shrub component of the vegetation, stream sinuosity, etc.

Printed maps of the GIS stream coverage were dissected into unique reaches by Rosgen classification and land use. The percent of available woody shade was estimated from the aerial photos for each unique reach. The purpose was to link the shade data to the stream GIS coverage. The shade data was collected on a 6th order HUC level. It was anticipated that future assessment and management would include 4th, 5th, and 6th order sub-basin evaluations.

Field Verification

Field verification has three purposes; 1) to calibrate one's eye to better interpret the photos, 2) to validate the photo interpretations and make necessary changes, and 3) to check if vegetation has changed from recent floods. Two floods have occurred since the aerial photos were taken in 1992, which could have altered the vegetation or the stream channel.

A stream classification was performed during the photo field verification. It was an opportunity to collect additional information on the streams and the Rosgen stream typing was recognized as the most important feature needing documentation.

The road system in this region follows many of the drainages, making field verification and stream typing a fairly efficient procedure. It was possible to drive and view many of the stream miles. Frequent stops were made to check photo interpretations and make stream measurements for Rosgen stream typing. Edits and the new Rosgen classifications were added in the field.

Data Entry

The data was collected on field forms then entered into a Microsoft Excel database that can be linked to the GIS 1:24,000 scale stream coverage.

Spatial Connection

The first four columns in the database correspond to a stream numbering systems that can identify a specific reach in any 6^{th} order HUC sub-basin. This repeatable numbering system recognizes the watershed, the sub-basin, the channel, and the specific reach along that channel. This repeatable numbering system can link any reach in any watershed to corresponding information in the database.

This technique will be valuable when restoration measures are implemented and need to be trackable for effectiveness monitoring.

DEVELOPMENT OF SHADE TARGETS

Stream shade affects stream temperature in three ways. First, shade screens the water's surface form direct solar radiation. Solar radiation may account for more than 95% of the heat input during the midday period during midsummer (Brown, 1970). Second, shade reduces the amount of the water's back radiation at night, tending to moderate the minimum stream temperatures. Third, shade produces its own long wave (thermal) radiation, while also tends to raise minimum temperatures at night. Shade removal allows increased light, which may result in increased algal production (Burton and Likens, 1973), and also may influence migration or other movement activity. Vegetative alteration also has the attendant problems of streambank stability and sedimentation.

Shade targets for Upper Lapwai Creek were developed using a combination of both existing shade data for each sub-watershed and existing climate data for the area. This data was fed into the SSTEMP model to determine the amount of effective shade needed, within each sub-watershed, to attain and maintain the 9°C and 13°C temperature standard during salmonid spawning and rearing period respectively.