WATER QUALITY STATUS REPORT ● REPORT NO. 76

LITTLE POTLATCH CREEK
Latah County, Idaho
1987

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Little Potlatch Creek is a second order tributary to the Potlatch River (CB-154) in north-central Idaho. The benefical uses of the stream are as an agricultural water supply, contact recreation, anadromous fish habitat, and for cold water biota. Seventy-eight percent of the watershed is under cultivation. Timber and rangeland cover the steeper canyon walls. The main crop rotation utilized is wheat/pea with conventional tillage.

Little Potlatch Creek is identified in the Idaho Agricultural Pollution Abatement Plan (1983) as a stream segment that has been heavily impacted by non-point sources. The Latah Soil Conservation District (SCD) applied for and received a planning grant to study the watershed through the Idaho Agricultural Pollution Abatement Plan. Part of this study was an assessment of the water quality. With the assistance of the Latah SCD and the Latah Soil Conservation Service the Idaho Division of Environment has completed a two year study at five sample sites on the stream. Samples were taken during the springs of 1986-1987 to characterize the stream during the period of the major influx of sediments and nutrients.

On the basis of the completed study, it was determined that the water quality of the stream has been heavily impacted by nonpoint sources. Suspended sediments and inorganic nitrogen, in the form of $NO_2 + NO_3$, pose the greatest threat to the beneficial uses. Bacterial contamination by livestock, phosphorus, and organic nitrogen loading are of lesser concern, but may lead to the degradation and cultural eutrophication of the stream and its receiving waters, the Potlatch River.

The major sediment and nutrient loadings occurred during rains on snow or frozen ground, and with runoff from rains on bare fields in the spring. An intense thunderstorm that approached the magnitude of a "50-year" event occurred on April 30, 1987. This storm exceeded the combined loads for two previous years. An estimated 1,360 tons of sediment a minute were discharged during the peak of the storm. Within one hour the sediment load being discharged was reduced to 140 tons/minute. Prior to the 50-year event, 83% of the calculated load came during two storm events.

The Idaho Agricultural Pollution Abatement Plan, if implemented, calls for the use of Best Management Practices (BMP) on the "critical" or highly erodable acres. A reduction of sediment and nutrient loads delivered to the stream is necessary to improve the water quality and protect the present beneficial uses. Failure to address these impacts will result in further degradation of water quality.

INTRODUCTION

The Little Potlatch Creek has been identified by the Division of Environment (DOE) as a "1st priority" stream segment in the Idaho Agricultural Pollution Abatement Plan (1983). This classification is reserved for streams with poor water quality which may be attributable to agricultural practices, or streams with water quality and designated uses that need protection from degradation. The Abatement Plan, if implemented, will provide cost share money for the installation of Best Management Plans (BMP's) on "critical" or highly erodable acres,(Latah, 1987), and on agricultural activities that may contribute to the degradation of a stream's quality.

The Latah Soil Conservation District (SCD) signed a planning grant with the DOE on June 20, 1986. The planning grant process includes an assessment of the stream's quality, identification of the "critical" acres, and other nonpoint source activities on the watershed. An Information and Education (I&E) program is included within the grant to acquaint the land owners and managers in the watershed with the project goals and accomplishments.

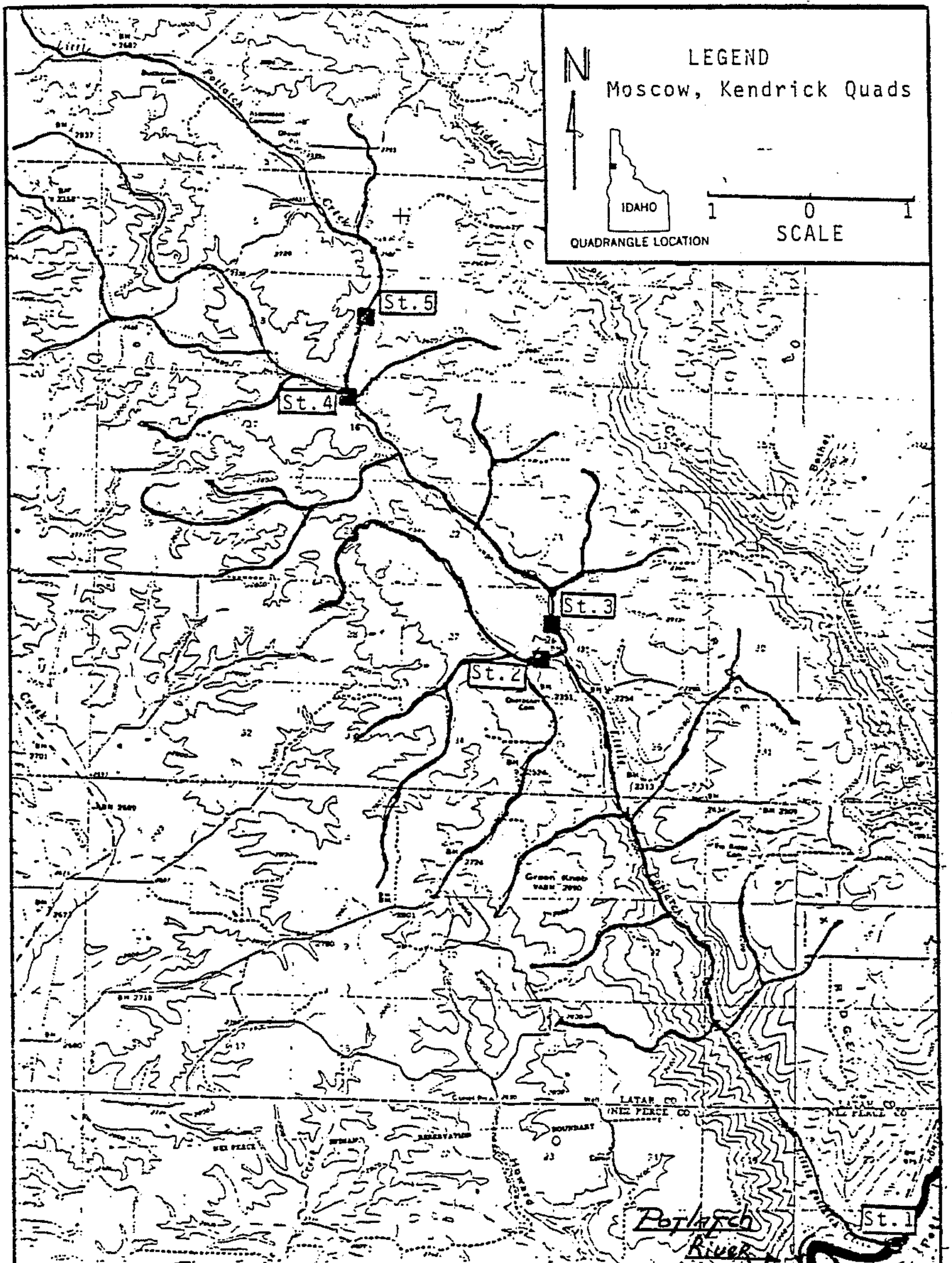
This study was undertaken to: 1) provide water quality information about this system, 2) document the effects of storm-event runoff on water quality, 3) determine the impact of agricultural activities on the water quality of Little Potlatch Creek.

PROJECT AREA DESCRIPTION

Little Potlatch Creek is a second order tributary to the Potlatch River (CB-154) in north-central Idaho (Figure 1). The stream originates on the southern slopes of Tomer Butte, five miles east of Moscow, Idaho. The main stem is 16 miles long with over a dozen tributaries. The stream is intermittent on the upper end of the watershed, but is perennial at approximately river mile 7; where it enters the canyon.

The current uses of the stream are for cold water biota, salmonid spawning, secondary contact recreation and as an agricultural water supply. The Idaho Department of Fish and Game has planted anadromous fish in the lower end of the Potlatch River to re-establish a diminished natural population (Bowler, pers. comm.).

Figure 1. Map of Little Potlatch Creek Watershed



There are 32,985 total acres in the watershed. Ninety-nine percent of the property is privately owned by 58 landholders. Seventy-eight percent (25,630 acres) of the land is cultivated. Most of the cropland is on the rolling ridgetops of the upper watershed. The steeper canyon walls contain the remaining 7,355 acres which is typically range and timberland. The elevation of the watershed ranges from 3,702 feet to 948 feet.

The topography of the area can be characterized by two major soil types. The Palouse - Naff soil series, formed in loess, which produces winter wheat, spring peas, lentils, and spring barley is on the ridgetops. Slopes vary from 7-35%. The natural vegetation is predominately grasses. The canyon walls are covered with Southwick/Keuterville/Bluesprin soil series, and have slopes from 35-65%. Coniferous forests and range species are native to these areas (SCS, 1987).

Precipitation varies from 24 inches annually on the upper watershed to 19 inches per year at the mouth of Little Potlatch Creek (NOAA, 1987). Snow depths range from 1 to 3 feet on the upper watershed during the winter months. Chinook winds and spring rains quickly melt the snowpack creating flooding conditions. High intensity, short duration thunderstorms are common to the region.

CLIMATE

Annual precipitation in the vicinity of the upper watershed of Little Potlatch Creek averages 24 inches a year (Table 1). The lower watershed receives approximately 19 inches annually (N.O.A.A., 1987). Two to three inches of precipitation may be expected to fall monthly from October through May. Slightly lesser amounts, 0.7 inches to 1.6 inches, can be anticipated monthly during the summer.

The winters are relatively mild with a mean monthly temperature for November through March ranging from 28° F to 38° F (-2° C to 3° C). Snow pack usually covers the ground from December through February with the average depths being 1.5 feet.

Spring comes early on the Palouse, usually by mid-March. Spring "chinook" rains melt the snowpack rapidly, creating flood conditions on the frozen soils. Spring storms continue through June with occasional heavy thunderstorms that may amount to 1-2 inches of rain over a 1-2 day period.

Table 1. Summary of Climatological Data for Moscow, Idaho Region*

Month	Temperature (°F)							Mean degree days**	Precipitation Totals (Inches)								Mean Number of Days					
	Means			Extremes								Snow, Ice Pellets							Temperatures			
																			Max.		Min.	
	Daily maximum	Daily minimum	Monthly	Record highest	Day/Year	Record lowest	Day/Year		Mean	Greatest daily	Day/Year	Mean	Maximum monthly	Year	Maximum depth	Day/Year	Precip. .10 inch or more	Precip. .50 inch or more	90° and above	32° and below	32° and below	0° and below
(a)	30	30	30					30	30	30							30	30	30	30	30	30
Jan.	34.6	22.0	28.3	58	31/1971	-22	1/1979	1131	3.21	1.37	20/1972	16.9	55.5	1969	35	31/1969	10	2	0	11	25	2
Feb.	41.2	27.4	34.3	63	19/1958	-16	1/1956	860	2.12	1.71	19/1968	7.4	27.8	1975	36	2/1969	7	1	0	3	21	0
Mar.	46.8	29.8	38.3	73	29/1978	-5	4/1955	821	2.04	.94	18/1976	5.0	17.4	1955	16	1/1969	7	1	0	1	20	0
Apr.	56.6	34.6	45.6	88	24/1977	12	19/1966	575	1.98	1.22	19/1965	1.1	8.0	1967	3	2/1965	6	1	0	0	12	0
May	65.9	40.5	53.2	90	5/1966+	19	1/1954	364	1.99	1.67	8/1972	0.0	0.0	--	0	--	6	1	0	0	3	0
June	73.7	45.6	59.7	96	17/1961	28	10/1973	182	1.65	1.84	2/1971	0.0	0.0	--	0	--	5	0	1	0	0	0
July	83.9	48.8	66.4	103	12/1967+	32	3/1962	57	.71	.89	10/1971	0.0	0.0	--	0	--	2	0	8	0	0	0
Aug.	82.7	48.5	65.6	109	4/1961	30	25/1980	69	1.07	1.19	23/1975	0.0	0.0	--	0	--	3	1	8	0	0	0
Sep.	74.2	43.7	59.0	100	5/1973	22	14/1970	199	1.10	1.34	14/1956	0.0	0.0	--	0	--	4	1	1	0	2	0
Oct.	60.7	36.9	48.8	86	7/1980	14	21/1971	495	1.83	1.64	25/1976	0.2	2.1	1966	1	31/1971	5	1	0	0	8	0
Nov.	44.5	30.1	37.3	67	3/1975	-14	15/1955	824	2.95	2.10	26/1964	5.1	29.0	1973	13	30/1975	9	2	0	2	18	0
Dec.	37.2	25.6	31.4	59	26/1980	-42	30/1968	1035	3.31	1.59	20/1974	12.5	46.8	1971	29	16/1971	10	2	0	8	24	1
Year	58.5	36.1	47.3	109	Aug. 4/1961	-42	Dec. 30/1968	6612	23.96	2.10	Nov. 26/1964	48.2	55.5	Jan. 1969	36	Feb. 2/1969	74	13	18	25	133	3

(a) Average length of record, years

** Base 65 F

+ Also on earlier dates, months, or years

* NOAA Weather St.# 10-6152-2

METHODS AND MATERIALS

MONITORING SITES

Five sampling sites were located in the watershed to assess the water quality of various stream segments and drainage areas (Table 2, Figure 2).

a) Station *1 (St.*1) is 150 yards from the mouth of Little Potlatch Creek, at a railroad bridge. The cumulative impact of all 32,985 acres in the watershed were monitored here.

b) Station *2 (St.*2) is at a culvert outlet on a first order tributary of Little Potlatch Creek, 7.5 miles from the mouth. There are 4,227 acres in the drainage.

c) Station *3 (St.*3) is near a bridge at stream mile 8.2. There are four first order tributaries with a total surface area of 5,199 acres between this station and Station *4, three miles upstream.

d) Station *4 (St. *4) is below a bridge at stream mile 11.5 on Little Potlatch Creek. It is 100 yards below the confluence of a 8,064 acre subdrainage and the stream. There are a total of 14,739 Ac. that drain to this site.

e) Station *5A (St.*5A) was on the mainstream of Little Potlatch Creek at stream mile 13.2, approximately 6 miles southeast of Tomer Butte. There are 5,186 acres in the drainage. Station *5A was relocated to a bridge, St.*5B, 1/2 mile south in January, 1987, to accommodate a volunteer sampler. The move encompassed another 574 acres.

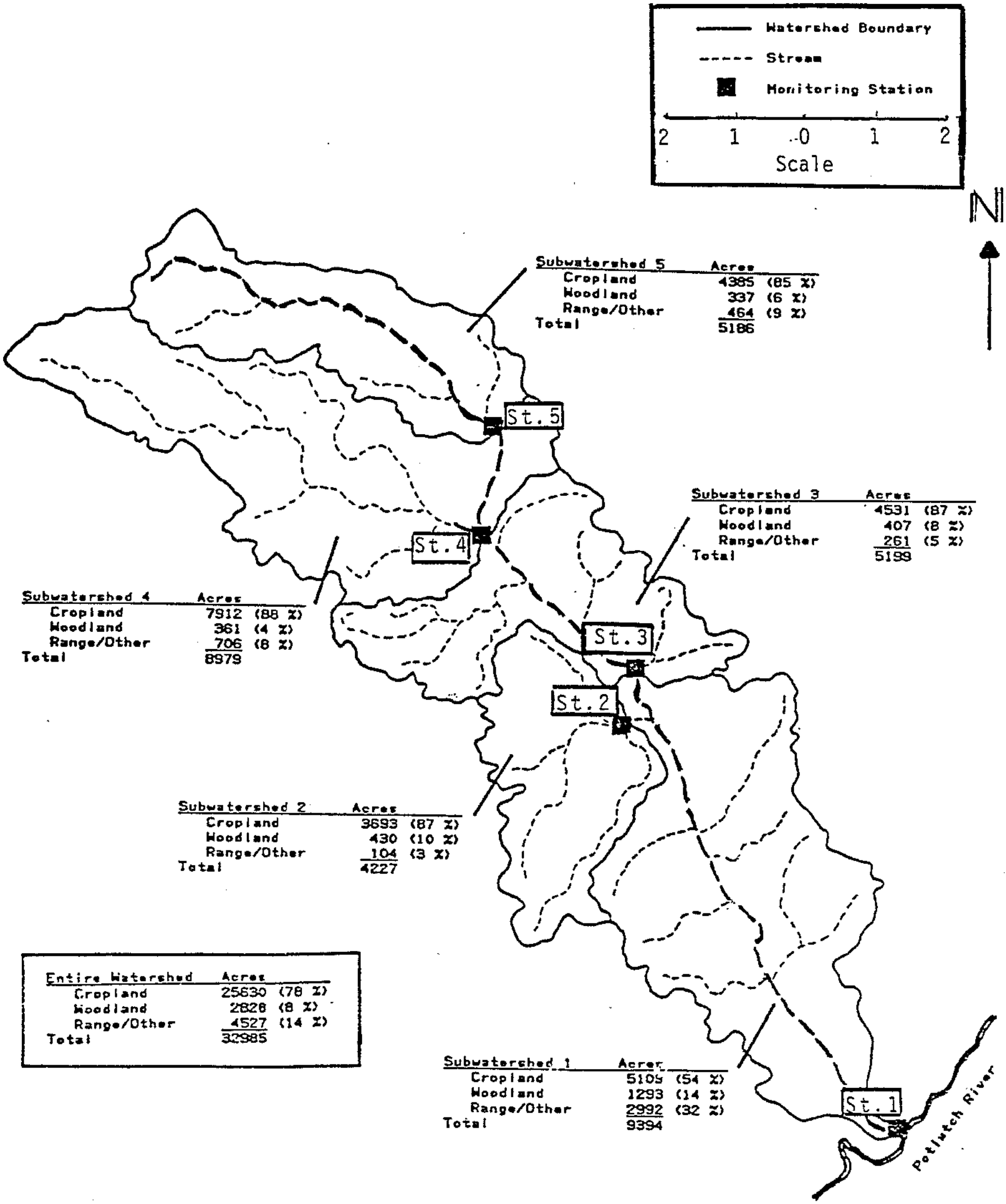
A sampling schedule was established that would provide the flexibility to respond to the snow runoff and storm events when they occurred. Thunderstorms on the Palouse may be of short duration, but are often very intense, creating flash floods. Volunteers from the watershed were recruited to respond to the runoffs and storm events as they occurred. Each volunteer was provided with sampling containers, preservatives, a data recording sheet, and instructions on sampling techniques.

Table 2. Water Quality Monitoring Stations on the Little Potlatch Creek

St#	STORET#	LEGAL DESCRIPTION	ELEV. (FT.)	TOTAL ACRES
1.	2020065	T37N, R3W,SEC29, SE1/4 NE1/4	960	32,985*
2.	2020302	T38N,R3W,SEC26, NE1/4 SW1/4	2200	4,227
3.	2020303	T38N,R3W,SEC26, NW1/4 SE1/4	2200	19,364*
4.	2020304	T38N,R3W,SEC16, NE1/4 SE1/4	2400	14,739*
5A.	2020305	T38N,R3W,SEC 4, NW1/4 SE1/4	2520	5,186
5B.	2020305	T38N,R3W,SEC 9, SW1/4 NE1/4	2440	5,760

* Cumulative acres of watershed

Figure 2. Land Uses on Little Potlatch Creek Watershed



PARAMETERS

Agricultural practices contribute substantially to sedimentation and nutrient loadings on Little Potlatch Creek which subseqently enters the Potlatch River. Some of the sample parameters were included to provide an indication of the nutrients that are leached from agricultural lands. Additional parameters were used as indicators for assessing the effects of the water quality on the designated beneficial uses of a particular stream segment (Table 3). Sample collection and preservation followed the guidelines for water data acquisition (U.S.G.S.,1977).

Discharge

Direct measurements of velocity, depth and width were used to calculate the instantaneous discharges at a given point. The methodology used followed the techniques outlined by the U. S. Geological Survey (U.S.G.S., 1977).

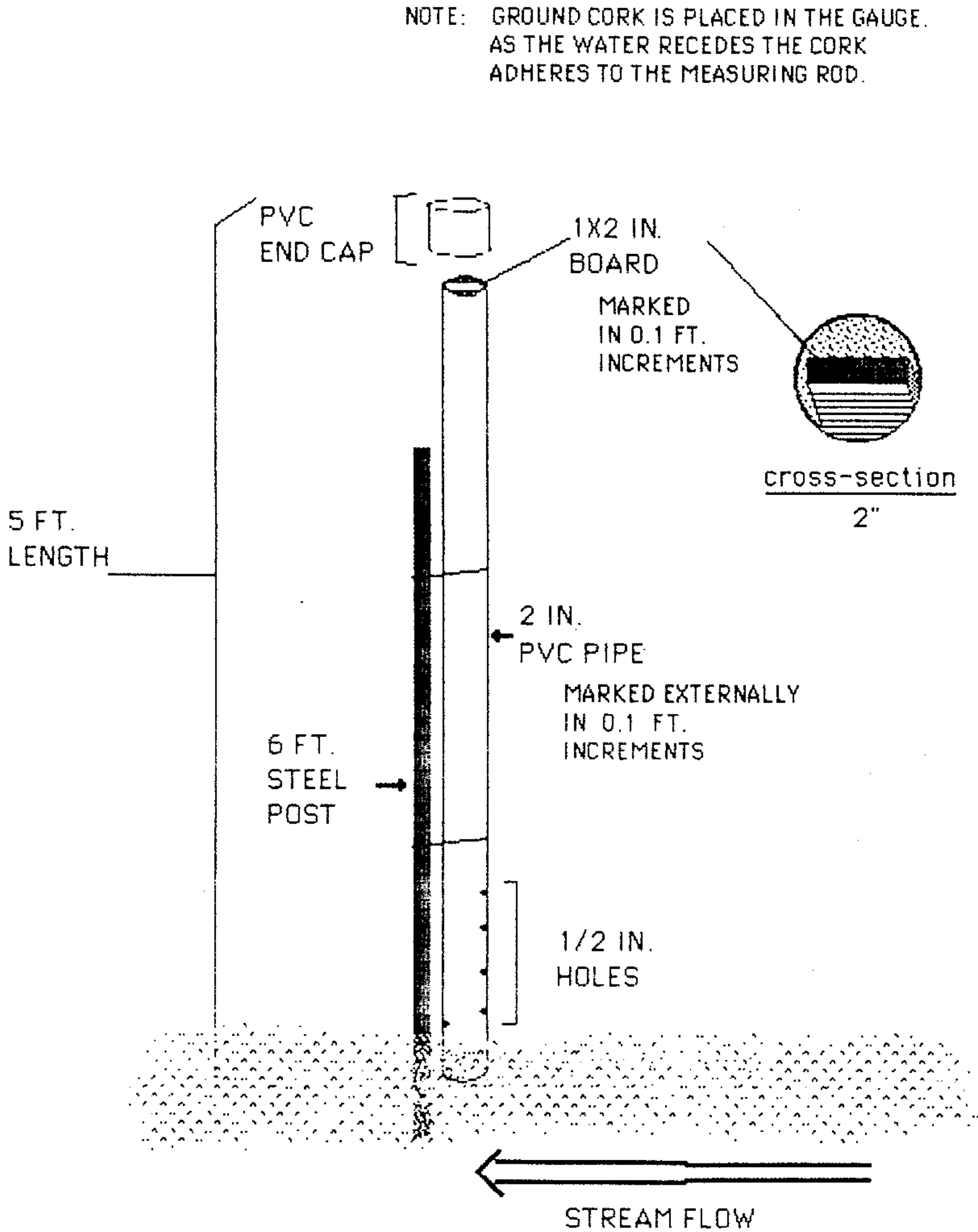
Measurements of velocity and depth were made by DOE personnel with a Marsh McBirney #201 current meter and wading rod. Roy Breckenridge, a SCD volunteer, used a Price "A" current meter to measure water velocity at St. #5 B. Evidence of the peak stream stages were gathered by use of crest-gauges installed at each sampling site (Figure 3). Crest gauges had seven grams of ground cork poured inside the pvc pipe. Increasing water levels deposited the cork on the internal graduate board. The cork deposition corresponded to highest stream level.

Estimates of the peak discharges were calculated utilizing the R4 Cross computer program provided by the Clearwater National Forest (Burton, 1987). This program utilized known stream stage vs. discharge relationships, through the Manning equation, for estimating flows from crest gauge readings. The cross-sectional area and channel slope of the various stream gauging sites were calculated from levels shot with a Lietz/Sokkisha B-2A level and stadia rod. Readings were taken along the channel bottom, at the gauging site, and at salient morphological features. The wetted perimeter was calculated from this data along with a stage to cross-sectional area ratio. The hydraulic grade line was assumed to be equivalent to the channel slope. The roughness coefficients at each station were calculated from measured stage-vs-discharge information.

Table 3. Sample Parameters for Little Potlatch Creek Study

Parameter	**Units**	**STORET #**
Stream Discharge	cfs	00061
Crest gauge	ft	None
Water Temperature	°C	00010
pH	S.U.	00400
Specific Conductivity	µmhos/cm	00094
Suspended Sediments (S.S.)	mg/l	80154
Total Phosphorus (T.P.)	mg/l	00665
Ortho phosphate (O' PO4)	mg/l	00671
Total Kjeldahl Nitrogen (TKN)	mg/l	00625
Total Amonnia (NH3)	mg/l	00610
Nitrate+Nitrite (NO2+NO3)	mg/l	00630
Fecal Coliform (FC)	#/100 ml	31616
Fecal Streptococcus (FS)	#/100 ml	31679

FIGURE 3. STREAM CREST GAUGE



pH

The pH of water is a measure of its hydrogen ion concentration. Many chemical reactions are affected by the pH. On-site pH measurements were obtained with a Corning, Model #103, pH meter.

Conductivity and Temperature

Conductivity is a numerical expression of the ability of a water sample to carry an electrical current. It is dependent on the concentrations of the total dissolved solids and salts in the water and temperature (APHA, 1985). Conductance is reported in units of µmhos/cm. Conductivity and temperature measurements were taken with a YSI, Model 33, S-C-T meter.

Suspended Sediment

Suspended sediment concentrations are one of the prime indicators of nonpoint source pollution. Suspended sediment consists of soil particles that are entrained in the water column from three inches above the stream bottom to the surface (Clark, 1985). The unit of measurement for suspended sediment samples is mg/l.

Nitrogen

The organic nitrogen concentrations were determined by the Total Kjeldahl Nitrogen (TKN) process, which does not distinguish between the organic and ammonia nitrogen compounds. The organic fraction may be estimated by subtracting the ammonia concentration from the TKN concentration. The inorganic nitrogen fraction includes the ammonia and nitrite + nitrate concentrations. All samples analyzed for the nitrogen fractions were preserved with 2 milliliter (ml.) of sulfuric acid and shipped on ice to the State of Idaho Bureau of Labs in Boise for analysis. Results were reported in mg/l.

Phosphorus

The two major forms of phosphorus that were monitored during this study were total phosphorus (T.P.), and dissolved orthophosphate ($O'PO_4$).

Total phosphorus includes all the forms of phosphorus present in the sample. Orthophosphate is the dissolved fraction, and is the form most readily available for plant uptake.

Total phosphorus samples were preserved with 2 ml. of concentrated sulfuric acid. The samples to be analyzed for dissolved orthophosphate were filtered on site through a 0.45 µm prewashed membrane filter and sent on ice to the State of Idaho Bureau of Labs in Boise or for analysis. Results were reported in mg/l.

Bacteria

Samples for bacterial analysis were collected in sterile, 250 ml. bottles. The samples were refrigerated until analysis by the State of Idaho Bureau of Labs in Lewiston. The results are reported in units of colonies/100ml.

QUALITY ASSURANCE

This project served as part of a series of quality assurance checks by the DOE on precision and accuracy of sampling procedures. Duplicate and spiked samples were collected from various stations and on different dates. Data from duplicate samples collected the same day were averaged together. The methods used to estimate the average relative range and percent recovery followed the procedures outlined by Bauer (Bauer, 1985).

RESULTS AND DISCUSSION

A storm corridor 2-3 miles wide seems to exist across the middle of the upper watershed (Roy Patten, pers. comm.). Storms seem to travel on a west to east path around Paradise Ridge between Moscow and Genesee. They then sweep north and east towards Troy, entering the sub-watershed of Little Potlatch Creek which drains into St. *4. This corridor appears to receive more intense rainfall than areas a mile to the north or south. An example of such an event occurred on April 30, 1987. Unofficial reports of 1.6 inches of rain fell within 15 minutes over a two mile wide strip, Locations 1/2 mile away received only 0.5 inches. Coincidentally, a similar storm occurred at the same location on April 30, 1981 (SCS, pers. comm.).

Precipitation amounts for all of 1986 were near normal (118% of average), but individual months differed dramatically from the norm (Table 4). An inch of rain in late January melted the last of the snowpack and created the first heavy runoff of the year (Figure 4). Most of February was cloudy, with rain and snow. Around the 23rd and 24th, 3/4 of an inch of rain melted the 5 inches of accumulated snow. March, April, and May had near normal precipitation. On May 21st strong winds brought 1.2 inches of rain, but good ground cover minimized the runoff.

The winter of 1986-1987 started with lower than normal snowpack. The precipitation that did fall in November and December was in the form of rain. Only 1.8 inches of precipitation fell in January. This is 56% of the 30-year norm. A rain on snow event started the spring runoff season on January 24th. February and March were fairly typical spring months with periods of rain.

April was warm and dry for most of the month. Rainfall amounts were 67% of the norm until April 30th. On that day a storm approaching the "50-year" event occurred in the Little Potlatch drainage. The official gage at the University of Idaho agriculture research farm outside Moscow registered 0.42 inches of rain. In the path of the storm there were reports of 1.5-1.6 inches of rain falling in less than 15 minutes.

DISCHARGE

Little Potlatch Creek is typical of many of the watersheds that drain the Palouse region of north-central Idaho and eastern Washington. The native vegetation which helps retain the winter moisture has been removed. The result has been a shortened hydraulic retention time and greater extremes in discharge throughout the year (Boucher,1970). The extremes in discharge may be seen in the data of the Little Potlatch Creek Study (Appendix).

The discharge runoff from the two major storm events of 1986 were monitored. The first recorded discharge of 168 cubic feet per second (cfs) occurred on January 30th. The combined crest gauge estimates from the upper watershed indicate that the peak may have been as high as 350 cfs. The second rain event on February 23rd and 24th followed a seven inch snowfall accumulation. The rains started with a warming trend on

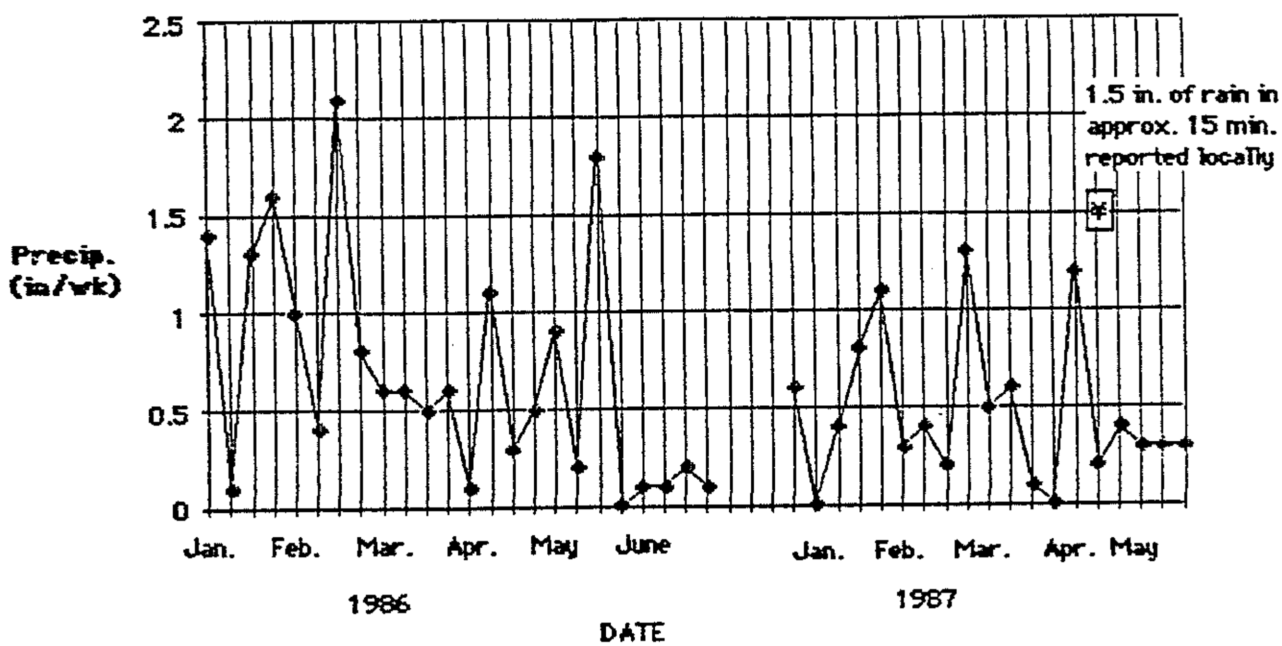
Table 4. Summary of Monthly Precipitation at Moscow Id.*

MONTH	1986 PRECIP.Δ	% NORM	1987 PRECIP.Δ	% NORM	30 YR. MEANΔ
JANUARY	4.40	137	1.80	56	3.21
FEBRUARY	4.26	201	1.92	91	2.12
MARCH	2.28	112	2.51	123	2.04
APRIL	2.05	104	1.75	88	1.98
MAY	2.08	105	2.42	122	1.99
JUNE	0.53	32	----	----	1.65
JULY	1.31	185	----	----	0.71
AUGUST	1.81	169	----	----	1.07
SEPTEMBER	3.43	312	----	----	1.10
OCTOBER	1.07	58	----	----	1.83
NOVEMBER	4.45	151	----	----	2.95
DECEMBER	0.71	21	----	----	3.31
CUMULATIVE TOTALS	28.38	118%	10.4	92%	23.96

* NOAA Weather Data for ST.# 10-6152-2, Moscow, Id.

Δ Inches/month

Figure 4. Weekly Summary of 1986 and 1987 Spring Precipitation Data for U of I Ag. Research Center, NOAA St.# 10-615-2, Moscow, Id.*



February 23rd and, according to the local volunteer observer at St.#2, the stream peaked about 10:00 p.m. Crest gauge readings indicated the peak at St.#2 was 140 cfs, and a peak of 630 cfs at St.#3 (Table 5). The rains continued on February 24th allowing time to make more direct measurements of discharge. An instantaneous discharge of 840 cfs was estimated at St.#1 by timing floating objects over a known stream length, and confirmed by utilizing the Manning equation (USDI, 1967). Direct flow measurements were possible on the upper watershed. On this event 54% of the runoff came from above St. #4. The watershed on the south of Tomer Butte, St #5, contributed 13%, and the S.E. Paradise Ridge, St.#4 watershed contributed 41%. The drainage west of St. #2 yielded 13% of the total.

A late spring thunderstorm on May 22 provided the next opportunity to monitor stream flows. Rains totaling 1.25 inches during a two day period responded with 5 cfs stream flow at St.#3 before the canyon. St. #2 flowed at 0.5 cfs while the two upper stations, #4 and #5, had measured discharges of 4 cfs and 1 cfs respectively. By June 16th the stream flowed at 0.1 to 0.2 cfs following 0.25 inches of rain over 2 days. Periods of intermittent flows occur during the late spring and summer.

The 1987 sampling season began on January 27th following 2 days of light rain on the snowpack and frozen soils. The streambeds on the tributaries at St.#2 and St.#5 were still frozen. Minimal flows estimated at <0.1 cfs were flowing under the ice. The flows at that time represented pre-runoff condition. On February 1st, following a chinook rain, the first spring runoff began. A recorded flow of 760 cfs was measured at the mouth. Crest gauge readings at St.#5 at the top of the watershed indicated a peak flow of 180 cfs for that day. The mid-point crest gauge at St.#3 registered an estimated 430 cfs. The majority of the 250 cfs difference in the flows that occurred between St.#5 and St.#3 may be assumed to come from the 8,064 acre subwatershed northwest of St.#4. An estimate of the contribution to the discharge from the watershed above St.#2 for that runoff peak was 150 cfs.

Two more rainy periods occurred in February at 10 to 12 day intervals. On February 13 the runoff was measured at 155 cfs at St.#1, near the mouth. Crest gauge readings of February 14 at St.#3 indicate that the peak discharge was approximately 290 cfs or twice the recorded instantaneous discharge of the 13th. The stream was monitored once again

Table 5. Discharge in cfs for Selected Dates of the Little Potlatch Creek Study

Date	Station 1	Station 2	Station 3	Station 4	Station 5
1986					
01/30	168	110*	240*	190*	130*
02/23	----	140*	630*	580*	215*
02/24	840	110	720	460	110
05/22	----	0.5	4.8	3.7	1.1
06/16	<0.1	< 0.1	0.2	0.1	< 0.1
1987					
01/27	16	2.0	7.0	3.0	1.0
02/01	760	150*	430*	350*	180*
02/13-14	155	----	290*	270*	120*
02/23-24	10	1.4	7.0	7.2	0.3
03/03-04	100	----	200*	150*	90*
04/30	2100*	90*	2000*	1600*	900*

---- Data Unavailable
* Estimated Peak of Discharges

on Feb. 24th. Flows at that time were 10 cfs at the mouth. Most of the flow (7.0 cfs) was provided by the melting snow from the south side of Paradise Ridge as monitored at St. #4.

A half inch of rain fell in the late afternoon of March 3rd. This typical spring rain brought a measured discharge of 100 cfs to the mouth. On March 4th the peak at the head of the drainage occurred during the night. An estimate of 90 cfs at St.#5 came from the northernmost drainage. Approximately 60 cfs came from South Paradise Ridge above St. #4.

A devastasting thunderstorm swept across the storm corridor of Little Potlatch Creek on April 30th. Reports of 1.5-1.6 inches of rain fell in 10 to 15 minutes causing flash floods. The hardest hit area was the drainages above St. #3. Rainfall amounts of about 1/2 inch were reported across the rest of the watershed.

The maximum depth of the flash flood was estimated from observation of debris left behind on the banks. At St.#5 the peak discharge was estimated at 900 cfs. The watershed on the south side of Paradise Ridge contributed approximately 700 cfs for a total of 1600 cfs at St.#4. The estimated peak discharge at St.#3 was 2000 cfs. A peak discharge of 90 cfs came from above St.#2.

A regression flow equation for estimating peak discharges was used to estimate a 10, 25, and 50-year frequency flood (Thomas, 1973). A 10-year frequency flood may be expected to discharge approximately 1,490 cfs; 25-year 1,940 cfs; and a 50-year 2,230 cfs. The estimates of channel capacity discharges taken at the various points indicate that the April 30, 1987 storm approached a "50 year" event. A storm of a similar magnitude occurred six years earlier on April 30, 1981.

SUSPENDED SEDIMENT

Prior to the development of an agricultural economy on the Palouse the streams ran almost free of sediment (Victor, 1935). The result of "sod-busting" has been an increase in the erosion rates from the cropland acres (Boucher 1970). In the Little Potlatch Creek watershed nearly 80% (Figure 2) of the land is now cultivated. Consequently there has been an increase in the sediment load delivered to Little Potlatch Creek and the river systems downstream.

The sediment delivery rates used by the Soil Conservation Service (SCS) are based on a "normal" years precipitation, and "average" field conditions (Table 6). Individual storm events may have more influence on these delivery rates, depending upon storm intensity, and field conditions.

As previously mentioned, one such event occurred on April 30th, 1987. Several fields in the path of the storm were bare or fallow, or newly seeded with peas. The erosion rate for these fields was estimated at greater than 200 tons/acre during the storm, compared with an "average" annual erosion rate of 8.7 tons/acre from cropland in the watershed (Glenn Shea pers. comm.).

The Soil Conservation Service estimates that 225,110 tons of sediment are transported down Little Potlatch Creek annually. The instream impact of the sediment loads has been a loss or impairment of the designated beneficial uses. In Little Potlatch Creek the quality of the agricultural water supply has diminished and contact recreation opportunities are impaired due to the excess suspended sediment. Sediment deposits have covered the cold water biota habitat and the anadromous fish habitat. Field observations indicated spawning gravels to be 75-100% embedded.

These impacts are not confined to Little Potlatch Creek. Efforts to protect the beneficial uses and reestablish an anadromous fishery in the Potlatch River are impaired by sediment, not only of Little Potlatch Creek but the other tributaries of the Potlatch river system.

The Potlatch River enters the Clearwater River approximately 10 miles east of the confluence of the Clearwater and Snake rivers. The confluence of these two rivers are the backwaters of the Lower Granite dam pool. The slower velocities in the pool allows the settling of sediments. This has resulted in the annual dredging and removal of over 400,000 tons of sediment to maintain a navigational channel and provide flood protection for the City of Lewiston.

A variety of climatic conditions existed on each sub-watershed during each sampled event, but some general trends in the data were observed.

Table 6. Sediment Delivery Rates for Land Uses on Little Potlatch Creek (T/Ac.)*

Land Use	Acres	Rate (T/ Ac.)	Tons/Year
Cropland	25,630	8.7**	224,000
Hay/ Pasture	294	1.0	290
Forest	2,828	0.5	1,400
Rangeland	4,233	0.1	420
Totals	-32,985		225,110

** Weighted average for various croplands. (Dave Brown, pers. comm.)
* S.C.S., 1985.

Concentrations of suspended sediment at the mouth of Little Potlatch Creek (St.*1) ranged from 7 mg/l to 311,500 mg/l for the samples taken during the study (Table 7). Flows of less than 20 cfs for this system carried sediment concentrations ranging from 7-128 mg/l (Appendix). Flows of 20 cfs usually associated with rain on snow runoff, transported most of the sediment loads. The concentrations for these events varied from 1,080 to 5510 mg/l. Spring thunderstorms brought concentrations ranging up to 345,000 mg/l.

Overall, an estimated 33,700 tons of sediment were discharged on the sampled days excluding the April 30, 1987 data. This was not included because of lack of sufficient data to quantify the load of the flash flood, and the anticipated infrequency of such a storm.

Two storms, January 30, and February 24, were the main runoff events of 1986. Approximately 600 tons of sediment were discharged from Little Potlatch Creek on January 30th. The heaviest concentration and largest flows came from the drainage above St.*2 (Appendix). Sixty-six percent of the load for the watershed can be accounted for from this drainage.

The February 24th storm carried over 7,000 tons of sediment from the drainage. Once again the highest suspended sediment concentrations were from above St.*2, but greater runoff flows, and consequently greater loads, were coming off the upper watershed.

The 1987 runoff started on February 1st. An estimated 23,900 tons of sediment were transported off the drainage. Only 1,420 tons came from above St.*5. The next monitored storm came on March 3rd and 4th. The sediment loss at the mouth was estimated to be 290 tons/day. St.*3, which was monitored during a different part of the hydrograph, indicated a loss of 500 tons/day of sediment.

At the time of the first sampling on April 30th, 140 tons/minute of sediment were transported out of the watershed. Forty minutes later the load had been reduced to 91 tons/minute. Observations lead to the conclusion that the estimated peak of 2,100 cfs had occurred within one hour of the first sampling. Assuming that the concentration was at least 345,000 mg/l during the peak, the load would have been over 1,350 tons/minute.

Table 7. Suspended Sediment Concentrations (mg/l) for Selected Dates of the Little Potlatch Creek Study, 1986-1987.

	Station				
Date	1	2	3	4	5
1986					
01/30	1330	1350	232	128	196
02/24	3080	5510	1346	960	788
06/16	7	16	12	12	14
1987					
01/27	128	57	94	32	9
02/24	48	66	104	114	112
03/04	1080	532	932	690	476
04/30	311,500	76,200	111,500	202,000	------
N*	6	6	6	6	6
Mean	946	1255	453	323	266
Min.	7	16	12	12	9
Max.	3080	5510	1346	960	788
S.D.	1190	2146	552	400	308

* Excludes April 30, 1987 storm data
S.D. Standard Deviation
--- Not Sampled

The variation in the suspended sediment concentration of the different stations is attributed to several factors: 1) The flashy streams tended to change in concentration and flows very rapidly. For example; two samples were taken 40 minutes apart after the April 30th, 1987 storm. The stream had dropped 0.5 feet and the suspended concentration was reduced twenty percent. 2) Sample collection by volunteers were not always completed in a sequential manner. This lead to monitoring different parts of the streams hydrograph. 3) The stream has several slow velocity areas which allow some settling of the sediment.

In the Palouse River Basin Study 81% of the delivered suspended sediment loads were the result of storms (Boucher, 1970). The Little Potlatch Creek study results indicate similar findings. Eighty-three percent of the total daily loads for the study were delivered during two storm events, February 24, 1986 and February 1, 1987.

BACTERIA

Monitoring for fecal coliform (FC) and fecal streptococcus (FS) are standard water quality procedures. These species are used as indicators of potential contamination, possible presence of other pathogenic organisms, and to indicate a probable origin of the contamination (APHA, 1985).

The IDHW/DOE (1985) criteria to protect waters for primary and secondary contact recreation are not to exceed 500 FC colonies/100 ml, and 800 FC/100 ml respectively. These criteria were exceeded in the sample taken on June 16,1986 at the mouth (Table 8).

Lesser counts of 60-216 colonies/100 ml on the upper watershed for that day led to the conclusion that the source of contamination was a feedlot above Station #1. No other samples exceeded the single day coliform criterion for contact recreation.

The ratio of fecal coliform/fecal strep (FC/FS) colonies are used to indicate the source of fecal bacteria contamination (APHA, 1985). A ratio greater than 4 usually indicates human sources, while ratios of less than 1 indicates livestock as a source.

Table 8. Bacteriological Counts (Colonies/100 ml) of the Little Potlatch Creek Study.

	Station 1		2		3		4		5	
	FC	FS	FC	FS	FC	FS	FC	FS	FC	FS
DATE										
1986										
01/30	200	1800	---	---	---	---	---	---	---	---
FC/FS	0.11		----		----		----		----	
02/24	100	200	<100	300	<100	200	100	200	100	200
FC/FS	0.5		0.33		0.5		0.5		0.5	
06/16	2130	2350	216	630	65	410	60	720	60	160
FC/FS	0.91		0.34		0.16		0.08		0.38	
1987										
01/27	180	800	250	720	80	1130	150	720	390	400
FC/FS	0.22		0.35		0.07		0.21		0.98	
02/01	100	<100	---	---	---	---	---	---	---	---
FC/FS	1		----		----		----		----	
02/24	10	40	20	30	30	20	50	80	350	160
FC/FS	0.25		0.66		1.5		0.6		2.2	
03/04	100	200	---	---	---	---	---	---	---	---
FC/FS	0.5		----		----		----		----	
Geometric Mean	134	341	102	252	63	207	82	302	169	213

FC Fecal Coliform
FS Fecal Streptococcus
---- Not Sampled
FC/FS Ratio of Fecal Coliform to Fecal Streptococcus
< Mean calculated with "less than" number

The ratio of the geometric means at St.*5 were the highest of all the monitoring sites (0.79). This ratio indicates livestock as the predominate source of fecal contamination. Several pastures exist on the flood plains of the upper watershed. These, coupled with run-off from barn lots, are the probable sources of bacterial contamination. One feedlot exists approximately one-half mile above St.*1 at the mouth. Runoff from this source will carry the fecal contamination to the stream.

Bacterial contamination is not considered to be a chronic problem to the stream's water quality. Little contact recreation occurs in Little Potlatch Creek, due to minimal flows, but the Potlatch River does receive some recreational use. A reduction of the runoff from the barnyards and feedlots would help protect the users of Little Potlatch Creek and the Potlatch River from exposure to fecal bacteria contamination.

NITROGEN

Nitrogen in surface waters may be characterized as either organic or inorganic. Organic nitrogens, as detected by the Kjeldahl process (TKN) includes decomposing plant materials, animal wastes, algae, and a variety of farm chemicals. Inorganic nitrogens are in the form of nitrite, nitrate, and ammonia. Sources of inorganic nitrogen include the byproducts of nitrifying bacteria, animal wastes, and applied nitrogen fertilizers.

No criteria limits are set for TKN concentrations in water but it is indicative of pollution (Hem,1985). Clark has associated TKN concentrations with sediments, due to the organic matter in the sediments (Clark, 1985). This relationship is evident in a graph of suspended sediments and TKN concentrations of Little Potlatch Creek (Figure 5).

Concentrations of TKN in the Little Potlatch Creek study varied from 0.12 mg/l during minimal flows of June 16, 1986 to 449.8 mg/l from the April 30, 1987 flash flood (Table 9). Most of the TKN concentration is considered to be organic matter. Ammonia, which is detected in the TKN process, averaged between 2-8% of the TKN.

The chemically interconvertible inorganic nitrogen forms of ammonia (NH_3), nitrite (NO_2) and nitrate (NO_3) are available for biological uptake.

FIGURE 5. Relationship of Suspended Sediment Concentrations to Total Kjeldahl Nitrogen Concentrations

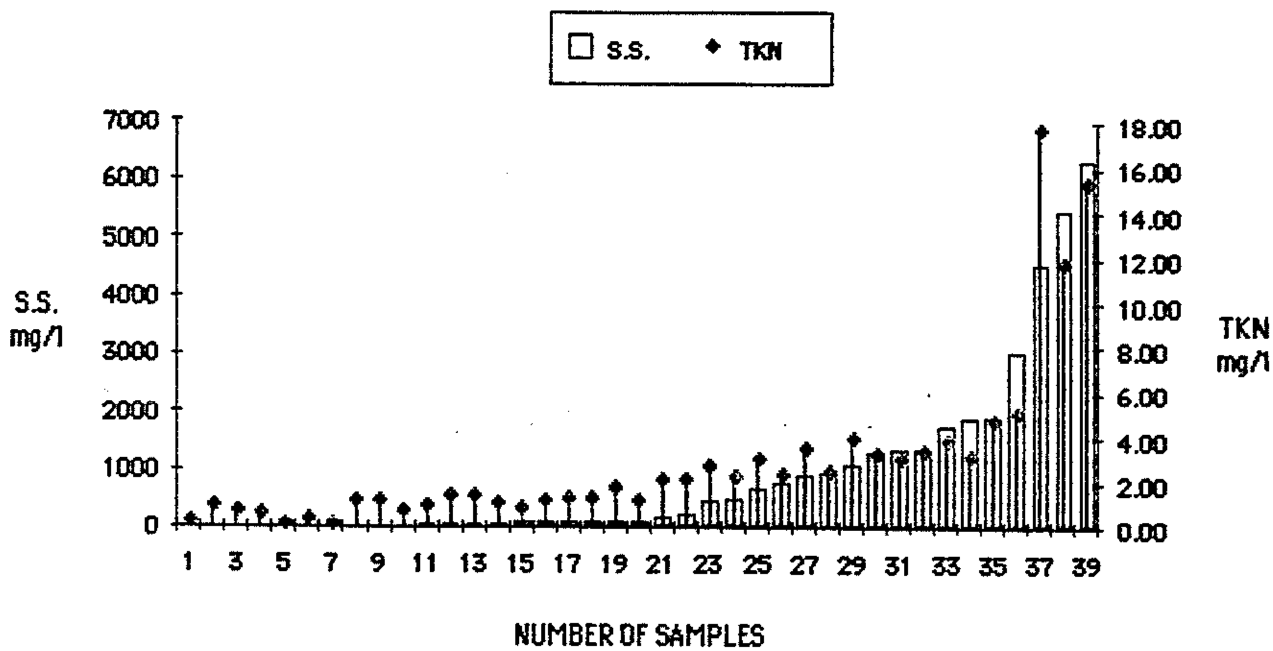


Table 9. Total Kjeldahl Nitrogen (TKN) Concentrations (mg/l) for Selected Dates of the Little Potlatch Creek Study 1986-1987.

	Station				
Date	1	2	3	4	5
1986					
01/30	3.30	3.40	2.07	1.73	2.16
02/24	5.16	11.8	2.99	2.48	2.34
06/16	0.30	0.16	0.60	0.12	0.35
1987					
01/27	1.2	1.4	0.90	0.75	0.95
02/24	0.99	1.12	1.22	1.28	1.28
03/04	4.02	2.22	3.46	3.02	2.65
04/30	449.8	109.2	190.8	234.0	---
*N	6	6	6	6	6
Mean	2.50	3.4	1.87	1.56	1.62
Min.	0.30	0.16	0.60	0.12	0.35
Max.	5.16	11.8	3.46	3.02	2.65
S.D.	1.94	4.28	1.17	1.08	0.90

--- Not Sampled

* Summary data excludes April 30, 1987 storm data

S.D. Standard Deviation

Concentrations of total inorganic nitrogen in excess of 0.3 mg/l have been shown to accelerate the eutrophication of water and create biological nuisances (Mackenthun,1973). Only under the low flow conditions late in the spring was this criterion met.

Ammonia concentrations at each of the Little Potlatch Creek monitoring sites were between 0.033 mg/l and 4.32 mg/l (Table 10). The means, excluding the April 30th storm, ranged from 0.133 mg/l at St.#5 to 0.210 mg/l at the mouth, St.#1.

A criterion limit of 10 mg/l of nitrate as N has been established for waters protected as a drinking water supply (IDHW/DOE,1985). This criterion may have been exceeded numerous times during the study, particularly during high flows. Little Potlatch Creek is not a domestic water supply. Some residents in the watershed do use private wells that exist near the stream and near the Potlatch River.

The highest $NO_2 + NO_3$ concentrations were recorded from samples taken when the ground was not frozen. Groundwater leaching and increased microbial activity may play a part in this observation. Lower concentration values, probably due to dilution, were reported from the snowmelt runoff over frozen soils. Seasonally, concentrations declined as the available nitrogen was utilized by the growing crops and/or leached from the soil.

A major source of inorganic nitrogen on irrigated fields has been identified as the plow-out of leguminous crops (Robbins and Carter, 1980). An estimated 30% of the planted cropland of Little Potlatch are in legumes, (SCS, pers. comm.). The nitrogenous fixation by these crops may contribute substantially to the inorganic nitrogen loads of the stream. Another source of inorganic nitrogen is from the application of ammonia and nitrates as fertilizers.

PHOSPHORUS

Phosphorus is an essential element to plant growth, and if not present in sufficient quantities, is a limiting factor to maximum plant production. Sources of phosphorus are natural deposits, fertilizers, animal wastes domestic wastewater, and decomposing organic material. An instream limit of 0.1 mg/l total phosphorus has been suggested to prevent nuisance

Table 10. Inorganic Nitrogen Concentrations (mg/l) for Selected Dates of the Little Potlatch Creek Study.

	Station 1		Station 2		Station 3		Station 4		Station 5	
	NO_2+ NO_3	NH_3	NO_2+ NO_3	NH_3	NO_2+ NO_3	NH_3	NO_2+ NO_3	NH_3	NO_2+ NO_3	NH_3
DATE										
1986										
01/30	12.2	0.162	13.1	---	11.9	---	12.6	---	15.3	---
02/24	11.1	0.178	9.88	0.284	11.75	0.147	11.35	0.199	11.95	0.123
06/16	0.66	----	1.28	----	1.34	----	0.03	----	0.42	----
1987										
01/27	3.97	----	4.48	----	3.06	----	2.46	----	2.04	----
02/24	8.57	0.055	11.4	0.085	9.72	0.033	9.54	0.072	9.76	0.081
03/04	8.87	0.158	12.0	0.114	10.1	0.119	9.64	0.108	10.3	0.150
04/30	4.32	1.16	4.02	0.567	3.32	0.856	2.91	0.915	----	----
*N	6	4	6	3	6	3	6	3	6	3
Mean	7.6	0.138	8.7	0.161	8.0	0.100	7.6	0.100	8.3	0.118
Min.	0.66	0.055	1.28	0.085	1.34	0.033	0.03	0.072	0.42	0.081
Max.	12.2	0.178	13.1	0.114	11.9	0.147	12.6	0.199	15.3	0.150
S.D.	4.41	0.056	4.72	0.108	4.59	0.059	5.11	0.025	5.83	0.035

--- Not sampled
* Summary data excludes April 30, 1987 storm data
S.D. Standard Deviation

growth in flowing waters not discharging directly to lakes or impoundments (Mackenthun, 1973).

Analysis for total phosphorus includes all the phosphorus present in the sample regardless of form. Included are organically bound phosphates, condensed phosphates, and orthophosphates. Dissolved orthophosphate refers to a water soluble form of phosphate available for biological uptake.

Total phosphorus concentration during the Little Potlatch Creek study ranged from a low of 0.1 mg/l to 68.7 mg/l (Appendix). Table 11 is a comparison of data from six occasions representing a variety of runoff events. St.#2, monitoring a sub-drainage, had the greatest mean concentration influenced primarily by the February 24, 1986 sample. On that day the total phosphorus concentration was 4.8 mg/l. The cumulative impact of each additional watershed may be seen as a steady downstream increase in the mean total phosphorus content.

The variation in the phosphorus concentrations and loadings are typically event related. The erosion of the soil then transports the phosphorus to the stream. Therefore an increase in suspended sediment concentrations was associated with increased total phosphorus concentrations (Figure 6). This is also evident in the April 30, 1987 data (Appendix). The peak concentration of 68.7 mg/l of total phosphorus coincided with the highest suspended sediment concentration of 311,500 mg/l.

Dissolved orthophosphate is a phosphate form available for biological uptake. The samples must be filtered at the time of collection to prevent further biological and/or chemical changes. This methodology prevented the volunteers from taking samples for dissolved orthophosphate.

Overall, concentrations of orthophosphate ranged from 0.019 mg/l during the lowest flows at St. #4, to a peak of 0.259 mg/l on February 24, 1986 at St. #2 (Table 12). The highest mean concentration was recorded at St.#2, while the uppermost station, #5, recorded the lowest average. No discernible trend existed in the orthophosphate concentration data. A variety of values existed at differing runoff regimes, suspended sediment, and total phosphorus concentrations.

Table 11. Total Phosphorus Concentrations (mg/l) for Selected Dates of the Little Potlatch Creek Study.

	Station				
	1	2	3	4	5
DATE					
1986					
01/30	1.5	1.7	0.6	0.5	0.6
02/24	3.15	4.8	1.6	1.2	1.0
06/16	0.3	0.3	0.2	0.1	0.1
1987					
01/27	0.44	0.49	0.34	0.30	0.22
02/24	0.36	0.38	0.39	0.39	0.38
03/04	1.68	0.82	1.21	1.05	0.89
04/30	68.7	40.4	57.9	64.5	----
N*	6	6	6	6	6
Mean	1.2	1.4	0.7	0.6	0.5
Min.	0.3	0.2	0.2	0.1	0.1
Max.	3.15	4.8	1.6	1.2	1.0
S.D.	1.11	1.74	0.56	0.44	0.36

--- Not Sampled
* Summary data excludes April 30, 1987 storm data
S.D. Standard Deviation

FIGURE 6. Relationship of Concentrations of Total Phosphorus to Suspended Sediment Concentrations

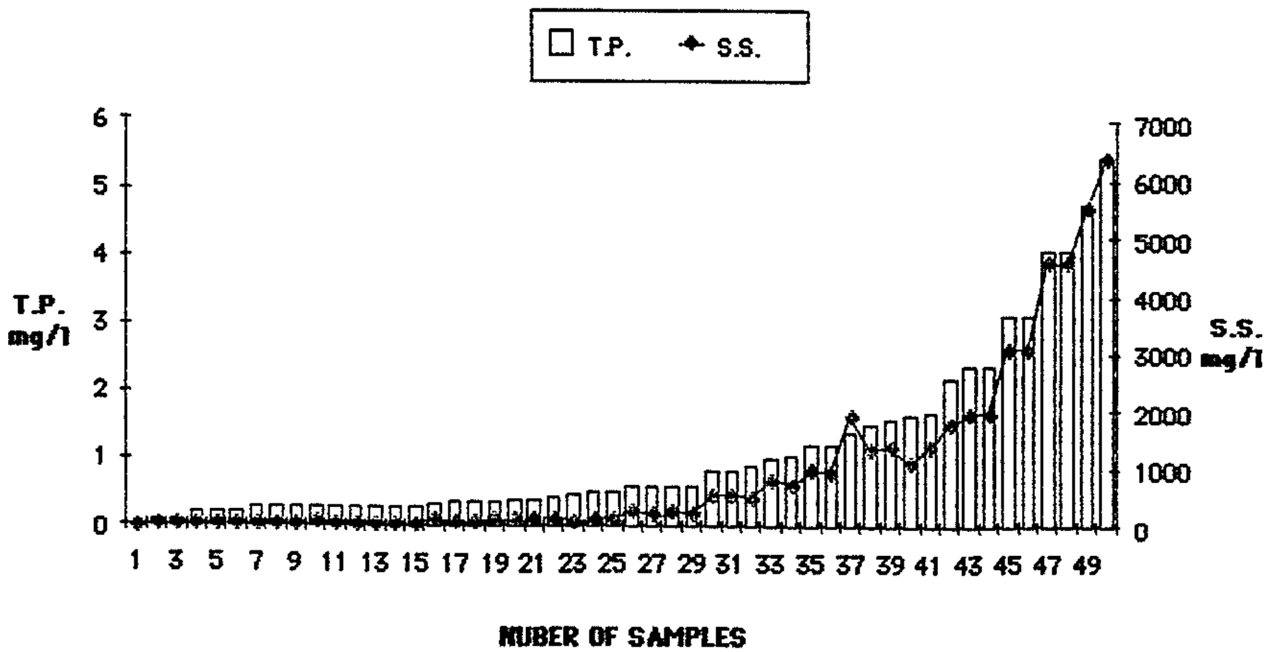


Table 12. Orthophosphate Concentrations (mg/l) for Selected Dates of the Little Potlatch Creek Study.

	Station				
Date	1	2	3	4	5
1986					
01/30	0.236	----	----	----	----
02/24	----	0.259	0.157	0.154	0.151
06/16	0.201	0.175	0.097	0.019	0.026
1987					
01/27	0.178	0.252	0.094	0.104	0.072
02/24	0.075	0.125	0.058	0.043	0.032
03/04	0.081	----	----	----	----
N*	5	4	4	4	4
Mean	0.154	0.203	0.102	0.080	0.070
Min.	0.075	0.125	0.058	0.019	0.026
Max.	0.236	0.259	0.157	0.154	0.151
S.D.	0.073	0.064	0.041	0.061	0.058

N* Number of Samples
--- Not Sampled
S.D. Standard Deviation

Over 1,000 lbs. of orthophosphate were estimated as being discharged from the drainage during the six representative sample days. The greatest single day contribution was at least 800 lbs. on February 24, 1986. This estimate was derived by adding the total loads of St.#2 and St.#3. Because of the varying climatic, or other conditions, that may affect concentrations and loads no conclusions were made from the relative load contributions by the various watersheds.

QUALITY ASSURANCE

A data point is a value assumed to be within certain limits. These limits are defined in terms of accuracy and precision. Accuracy, expressed as "Mean Percent Recovery", is a degree of the agreement of a measured value with an accepted reference or "true" value. Precision, in terms of average relative range, is a measure of the mutual agreement or dispersion among individual analysis of the same property. The procedures for determining precision and accuracy followed the DOE guidelines for quality assurance (Bauer, 1986).

The accuracy of the Little Potlatch Creek data was evaluated in terms of a series of spiked samples submitted during the 1986 field season. This approach allowed for a broader set of sample conditions than would be provided by a single sample. Two to five samples were submitted to the IDHW lab in Boise for analysis of accuracy of the monitored parameters (Table 13). This low number of samples affected the confidence interval.

A comparison of the mean percent recoveries for the 1986 survey and a previous survey, as presented in Bauer's Pilot Study of Quality Assurance, shows less than a 3% difference between the respective values for suspended sediment, total phosphorus, and $NO_2 + NO_3$ (Bauer, 1986). TKN recoveries had the greatest downward shift of 13.1%. TKN concentrations tended to be underestimated by 9.1% and suspended sediments by 7.2%. The nitrite and nitrate complex and the total phosphorus were overestimated by 5.1% and 11.3% respectively.

The average relative range for total ammonia 22.3% indicates an ongoing problem with replicating results (Table 14). Contributing to this problem may be sampling techniques, the unstable nature of the ion

Table 13. Accuracy Results of the 1986 Lewiston Field Office Water Quality Surveys

STORET*	PARAMETER	N	MEAN % RECOVERY	95% C.I.*
00630	Nitrite+Nitrate (NO_2+NO_3)	2	105.1	± 5.4
00625	Total Kjeldahl Nitrogen (TKN)	4	90.9	±17.5
00665	Total Phosphorus (T.P.)	5	111.3	±11.1
80154	Suspended Sediment (S.S.)	5	92.8	± 8.3

N Number of Samples
CI Confidence Interval

Table 14. Precision Results of Duplicate Samples Collected During the Little Potlatch Creek Study

STORET*	PARAMETER	N	AVERAGE RELATIVE RANGE (%)
00610	Total Ammonia (NH_3)	3	22.3
00630	Nitrite + Nitrate (NO_2+NO_3)	11	3.5
00625	Total Kjeldahl Nitrogen (TKN)	13	6.9
00665	Total Phosphorus (T.P.)	13	1.4
00671	Orthophosphate (O'PO_4)	2	6.4
80154	Suspended Sediment (S.S.)	14	7.5

N Number of Samples

and laboratory accuracy. Precision estimates for the other parameters remained similar to the 1985 summary estimates of precision, with the relative range of 5.2% for total phosphorus, 10.2% for orthophosphate, 6.2% for nitrite and nitrate, and 1.6% for TKN. A slight decrease in precision, when compared with other similar studies, was experienced with the suspended sediments.

CONCLUSIONS

1. Little Potlatch Creek is currently used for salmonid spawning, agricultural water supply, secondary contact recreation and by cold water biota. The beneficial uses of the stream are threatened most by excessive sediment loads, nutrient concentrations, and the extremes of variation in flows.

2. The water quality of Little Potlatch Creek is heavily impacted by sediments from nonpoint sources. These impacts include; siltation of anadromous fish spawning gravels, and benthic substrates, decreased quality as an agricultural water supply, and decreased aesthetic value for secondary contact recreation.

3. The IDHW/DOE fecal coliform criteria for contact recreation was exceeded once at St. #1 on 6/16/87. The suspected source of fecal contamination is the runoff from feedlots, barnlots and pasture lands.

4. Organic nitrogen, as detected by the Kjeldahl process (TKN), corresponded to increases in suspended sediment concentrations. This indicates the organic content of the soil is the source of TKN.

5. Nitrogen criterion was exceeded under all conditions except extreme low flows in late spring. The largest concentrations of $NO_2 + NO_3$ occurred with runoff from unfrozen ground. The source of inorganic nitrogen is suspected to be from leguminous crops grown in the region, microbial action and fertilizers.

6. Increases in total phosphorous concentrations were associated with increases in suspended sediment concentrations. Concentrations of phosphorus were over the 0.1 mg/l instream suggested limit to prevent nuisance growths in natural waters.

7. Sediment and nutrient influxes are the products of snowmelt runoff and thunderstorm events. The heaviest sediment and phosphorus loads were noted during rains on frozen soils, and heavy rains on fields with reduced vegetative cover.

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LITERATURE CITED

APHA, 1985. Standard Methods for the Examination of Water and Wastewater, American Public Health Assoc., American Water Works Assn., Water Pollution Control Federation, 16th edition.

Bauer, S. B., 1986. Pilot Study of Quality Assurance Sample Procedures for Div. of Environment, Water Quality Studies. IDHW-DOE, Boise,Id.

Boucher, P.R., 1970, Sediment Transport by Streams in the Palouse River Basin, Washington & Idaho, July 1961 - June 1965. U.S.G.S. Water Supply Paper 1899-C, Washington D. C.

Burton, T., 1987. R4. Cross, Hydrologic Fortran Program, Carribou National Forest, U.S.F.S.

Clark, W.H., 1986. Rock Creek Comprehensive Water Quality Monitoring Report. IDHW-DOE, Boise, Id.

E.P.A., 1979, Environmental Assessment Idaho Agriculture & Grazing Practices. EPA - 910/9-79-061, Seattle, Wa.

E.P.A., 1979. Methods for Chemical Analysis of Water and Wastes. EPA-0600, 14-79-020.

Hem, J. D., 1985. Study & Interpretation of Chemical Characteristics of Natural Waters. U. S. G. S. Water Supply Paper 2254.

IDHW-DOE, 1983. Idaho Agricultural Pollution Abatement Plan. Unpublished. IDHW-DOE, Boise, Id.

IDHW-DOE, 1985. Idaho Water Quality Standards. IDHW-DOE, Boise, Id.

IDHW-DOE, 1985. Idaho Water Quality Standards & Wastewater Treatment Requirements. January 1985, IDHW-DOE, Boise, Id.

Latah Soil Conservation District, 1987. Little Potlatch Creek Water Quality Project Final Report. Unpublished. Craigmont, Id.

Mackenthun, K.M., 1973. Toward a Cleaner Aquatic Environment. U.S. Environmental Protection Agency, Washington, D.C.

N.O.A.A., 1987. Record of Climatological Observations. Station #10-6152-2 Moscow, ID.

Robbins, C. W. & Carter, D. L., 1975. Conservation of Sediment in Irrigation Runoff. Soil & Water Cons. 30:134-135.

S.C.S., 1985. Mission-Lapwai Erosion/Sedimentation Analysis. U.S.D.A., Soil Conservation Service, Boise, ID.

Thomas, C. A., 1973. Magnitude & Frequency of Floods in Small Drainage Basins in Idaho. Geological Survey, Boise, Id.

U.S.D.A., 1986. Lower Granite Sedimentation Study (Amended). Soil Conservation Service, Portland, OR.

U.S.G.S., 1977. National Handbook of Recommended Methods for Water Data Acquisition. Office of Water Data Coordination, U.S.D.I. Reston,Va.

U.S.G.S., 1980. Sediment Transport in the Snake and Clearwater Rivers in the Vicinity of Lewiston, Idaho. Open-file Report 80-690, U.S.G.S., Water Resources Division, Boise, Id.

U.S.D.I., 1967. Water Measurement Manual. Bureau of Reclamation Water Resources Technical Publication, Washington, D. C.

Victor, Earl, 1935. Some Effects of Cultivation upon Stream History & Upon the Topography of the Palouse Region. Northwest Sci., V.9, No.3, p.18-19.

APPENDIX: LITTLE POTLATCH CREEK WATER QUALITY STUDY DATA

ST. #	STORET #	DATE	FLOW (CFS)	TEMP. (°C)	COND. (µmhos/cm)	pH (S.U.)	T. NH3 (mg/l)	NO2+NO3 (mg/l)	TKN (mg/l)	T.P. (mg/l)	O' PO4 (mg/l)	S.S. (mg/l)	F.C. (colonies/100ml)	F.S. (colonies/100ml)
1	2020065	1/30/86	168	1.8	130	7.3	0.162	12.2	3.30	1.5	0.236	1330	200	1800
2	2020302	1/30/86	*110	---	---	---	---	13.1	3.40	1.7	---	1350	---	---
3	2020303	1/30/86	*240	---	---	---	---	11.9	2.07	0.6	---	232	---	---
4	2020304	1/30/86	*190	---	---	---	---	12.6	1.73	0.5	---	128	---	---
5	2020305	1/30/86	*130	---	---	---	---	15.3	2.16	0.6	---	196	---	---
1	2020065	2/23/86	---	---	---	---	---	---	---	---	----	---	---	---
2	2020302	2/23/86	140	---	149	6.6	---	10.5	4.80	2.4	----	1960	---	---
3	2020303	2/23/86	*630	---	141	5.4	---	10.5	3.90	2.2	----	1760	---	---
4	2020304	2/23/86	*580	---	---	---	---	---	---	---	----	---	---	---
5	2020305	2/23/86	*215	---	---	---	---	---	---	---	----	---	---	---
1	2020065	2/24/86	840	10	98	5.9	0.178	11.1	5.16	3.15	---	3080	100	200
2Δ	2020302	2/24/86	110	5.2	98	7.0	0.284	9.88	11.75	4.8	0.259	5510	<100	300
3Δ	2020303	2/24/86	720	2.9	99	6.1	0.147	11.75	2.99	1.6	0.157	1346	<100	200
4Δ	2020304	2/24/86	460	1.6	92	6.2	0.199	11.35	2.48	1.2	0.154	960	100	200
5Δ	2020305	2/24/86	110	1.2	82	6.2	0.123	11.95	2.34	1.0	0.151	788	100	200
1	2020065	5/22/86	---	---	---	---	---	---	---	---	---	---	---	---
2	2020302	5/22/86	0.5	10	198	6.5	0.035	3.41	0.71	0.2	---	10	---	---
3	2020303	5/22/86	4.8	11.8	156	6.8	0.042	1.15	1.42	0.3	---	50	---	---
4	2020304	5/22/86	3.7	11.8	152	6.8	0.045	1.01	1.20	0.3	---	32	---	---
5	2020305	5/22/86	1.1	13.2	148	6.5	0.043	0.841	1.25	0.3	---	32	---	---

* Estimated Peak Discharge
--- Not Sampled
Δ Mean of Duplicated Samples

ST. #	STORET #	DATE	FLOW (CFS)	TEMP. (°C)	COND. (µmhos/cm)	pH (S.U.)	T. NH3 (mg/l)	NO2+NO3 (mg/l)	TKN (mg/l)	T.P. (mg/l)	O'PO4 (mg/l)	S.S. (mg/l)	F.C. (colonies/100ml)	F.S. (colonies/100ml)
1Δ	2020065	6/16/86	0.1	19.8	259	7.0	---	0.662	0.30	0.3	0.201	7	2130	2350
2	2020302	6/16/86	<0.1	19	230	7.8	---	1.28	0.16	0.3	0.175	16	216	630
3	2020303	6/16/86	0.2	24.8	260	9.0	---	1.34	0.60	0.2	0.097	12	65	410
4	2020304	6/16/86	0.1	17.1	259	7.4	---	0.034	0.12	0.1	0.019	12	60	720
5	2020305	6/16/86	<0.1	15.8	193	7.2	---	0.417	0.35	0.1	0.026	14	60	160
1Δ	2020065	1/27/87	16	1	130	7.5	---	3.97	1.20	0.44	0.178	128	180	800
2Δ	2020302	1/27/87	2	1	152	7.5	---	4.48	1.40	0.49	0.252	57	250	720
3Δ	2020303	1/27/87	7	1	130	7.7	---	3.06	0.90	0.34	0.094	94	80	1130
4Δ	2020304	1/27/87	3	1	98	7.3	---	2.46	0.75	0.30	0.104	32	150	720
5Δ	2020305	1/27/87	1	1	148	7.4	---	2.04	0.95	0.22	0.072	9	390	400
1Δ	2020065	2/1/87	760	1	20	7.2	---	1.45	16.30	7.82	0.03	11635	100	<100
2	2020302	2/1/87	*150	---	64	---	0.302	2.67	---	---	---	---	---	---
3	2020303	2/1/87	*430	---	43	---	0.285	1.07	---	---	---	---	---	---
4	2020304	2/1/87	*350	---	---	---	---	---	---	---	---	---	---	---
5	2020305	2/1/87	*180	---	---	---	---	1.1	3.21	1.41	---	1880	---	---
1Δ	2020065	2/13/87	155	4	118	6.9	0.495	9.82	17.80	4.1	---	4570	---	---
2	2020302	2/13/87	---	---	---	---	---	---	---	---	---	---	---	---
3	2020303	2/13/87	---	---	---	---	---	---	---	---	---	---	---	---
4	2020304	2/13/87	---	---	---	---	---	---	---	---	---	---	---	---
5	2020305	2/13/87	---	---	---	---	---	---	---	---	---	---	---	---
1	2020065	2/14/87	---	---	---	---	---	---	---	---	---	---	---	---
2	2020302	2/14/87	---	---	244	---	0.667	11.1	2.22	0.78	---	---	---	---
3	2020303	2/14/87	*290	---	143	---	0.167	7.34	4.77	2.28	---	---	---	---
4	2020304	2/14/87	*270	---	135	---	0.151	7.06	5.04	2.32	---	---	---	---
5	2020305	2/14/87	*120	---	129	---	0.167	6.89	3.74	1.61	---	---	---	---

* Estimated Peak Discharge
--- Not Sampled
Δ Mean of Duplicated Samples

ST. #	STORET #	DATE	FLOW (CFS)	TEMP. (°C)	COND. (µmhos/cm)	pH (S.U.)	T. NH3 (mg/l)	NO2+NO3 (mg/l)	TKN (mg/l)	T.P. (mg/l)	O' PO4 (mg/l)	S.S. (mg/l)	F.C. (colonies/100ml)	F.S. (colonies/100ml)
1	2020065	2/24/87	10	11	158	7.6	0.055	8.57	0.99	0.36	0.075	48	10	40
2	2020302	2/24/87	1.0	9	188	7.5	0.085	11.4	1.12	0.38	0.125	66	20	30
3	2020303	2/24/87	7.0	8	168	7.5	0.033	9.72	1.22	0.39	0.058	104	30	20
4	2020304	2/24/87	7.0	8	158	7.3	0.072	9.54	1.28	0.39	0.043	114	50	80
5	2020305	2/24/87	0.3	8	154	7.3	0.081	9.76	1.28	0.38	0.032	112	350	160
1	2020065	3/3/87	---	---	---	---	---	---	---	---	---	---	---	---
2	2020302	3/3/87	---	---	---	---	---	---	---	---	---	---	---	---
3	2020303	3/3/87	---	---	---	---	---	---	---	---	---	---	---	---
4	2020304	3/3/87	*150	13	128	---	0.293	0.935	15.40	5.5	---	6360	---	---
5	2020305	3/3/87	*120	---	---	---	---	---	---	---	---	---	---	---
1Δ	2020065	3/4/87	100	5	118	7.4	0.158	8.87	4.02	1.68	0.081	1080	100	200
2	2020302	3/4/87	---	14	210	---	0.114	12	2.22	0.82	---	532	---	---
3	2020303	3/4/87	*200	12	158	---	0.119	10.1	3.46	1.21	---	932	---	---
4	2020304	3/4/87	*150	9.2	138	---	0.108	9.64	3.02	1.05	---	690	---	---
5	2020305	3/4/87	*90	13	144	---	0.150	10.3	2.65	0.89	---	476	---	---
1	2020065	4/30/87	216	4.6	58	7.5	1.440	3.99	504.9	70.5	---	345000	---	---
1	2020065	4/30/87	175	4.6	58	7.5	0.899	4.66	394.8	66.9	---	278000	---	---
1Δ	2020065	4/30/87	*2100	---	---	---	---	---	---	---	---	---	---	---
2	2020302	4/30/87	*90	14.2*	100	---	0.567	4.02	109.2	40.4	---	76200	---	---
3	2020303	4/30/87	*2000	11.4*	66	---	0.856	3.32	190.8	57.9	---	111500	---	---
4	2020304	4/30/87	*1600	14.0*	---	---	0.915	2.91	234.0	64.5	---	202000	---	---
5	2020305	4/30/87	*900		---	---	---	---	---	---	---	---	---	---

* Estimated Peak Discharge

--- Not Sampled.

Δ Mean of Duplicated Samples