WATER QUALITY STATUS REPORT NO. 98

AGRICULTURAL BEST MANAGEMENT PRACTICE EFFECTIVENESS: DRYLAND FARMING IN EASTERN IDAHO

Bonneville, Bannock, and Oneida Counties, Idaho

1988

Idaho Department of Health and Welfare

Division of Environmental Quality

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Prepared by
Blaine Drewes

Pocatello Field Office
224 South Arthur
Pocatello, Idaho 83204

Idaho Department of Health and Welfare
Division of Environmental Quality
1410 North Hilton Street
Boise, Idaho 83720-9000

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ABSTRACT

Little is known of the water quality effects resulting from the implementation of Best Management Practices (BMPs) on dryland farms in Idaho. Although it has been generally assumed that the pollution levels decrease as the land is treated, the only data which supports this concept comes from studies done on irrigated farms. The types of BMP systems and the conditions to which they are exposed vary greatly between irrigated and dryland farms. Data and suppositions which apply to irrigated farms may not apply to the dryland farm.

This survey examined three dryland farming areas in eastern Idaho which had large tracts of land treated with BMPs through the Idaho State Agricultural Water Quality Program (SAWQP). The purpose was to determine if pollution concentrations had been significantly reduced from pre-BMP treatment levels.

A major problem developed when the data was examined. The data sets for the before and after treatment analysis were too small for meaningful scientific appraisal. Although most of the parameters indicated some improvement in the pollution loading, the data sets were not significant at the 95% confidence level set in this study.

INTRODUCTION

From 1979 to 1982, three agricultural non-point source pollution studies were conducted in Southeastern Idaho. As a result of these studies, seven sub-watersheds have been treated to control agricultural pollution using the State Agricultural Water Quality Program (SAWQP). This study was conducted in an effort to determine the effectiveness of Best Management Practice (BMP) installation on water quality in six of the seven sub-watersheds.

Marsh Creek

Marsh Creek was the first agricultural area studied in southeastern Idaho. The Marsh Creek drainage is located in southern Bannock County and encompasses 261,415 acres (Figures 1, 2, and 3). The designated uses of Marsh Creek (USB-411) are for agricultural water supplies and secondary contact waters. Cold water biota, salmonid spawning, and primary contact recreation are protected for future use (Idaho Department of Health and Welfare 1987).

Two of the sub-drainages within the Marsh Creek area were funded for implementation of BMPs. The Arkansas Basin area was funded in December, 1981 and contracting for installation of BMPs was completed in March, 1988. The second area, Lone Pine, was funded in 1985 with farmer contracting completed in June, 1986. Due to a lack of data from the original planning portion of the project, the Arkansas Basin area was deleted from this study.

The Lone Pine SAWQP implementation project, located approximately four miles southeast of the City of Downey, included the Lone Pine and Sand Creek drainages as well as two forks of Marsh Creek. The project encompassed 22,484 acres. All 6,153 acres of cropland within the project area were determined to be critical erosion sites (Table 1). The watershed is ten miles long from Red Rock Pass to the Marsh Creek headwaters, and 5 miles wide at its widest point. The average width is 4 miles along its length. Elevations range from 8,050 at the headwaters to 4,800 ft. at Red Rock Pass.

The climate of the Lone Pine area is semi-arid with cool, moist winters and warm, dry summers. Annual precipitation ranges from 11 inches to more than 35 inches in the higher elevations. The frost-free growing season is less than 100 days, with higher elevations having less than 50 growing days. The average annual air temperature is 47 degrees F.

Topography of the area is characteristic of eastern Idaho with rolling hills and mountainous terrain. Agricultural slopes range from 1 to 30 percent, with woodland slopes in excess of 60 percent. All upper portions of the tributaries are used for range. The lower portions are used extensively to produce small grains, alfalfa, and for grass pastures.

Figure 1: Locations of Counties with Project Areas.

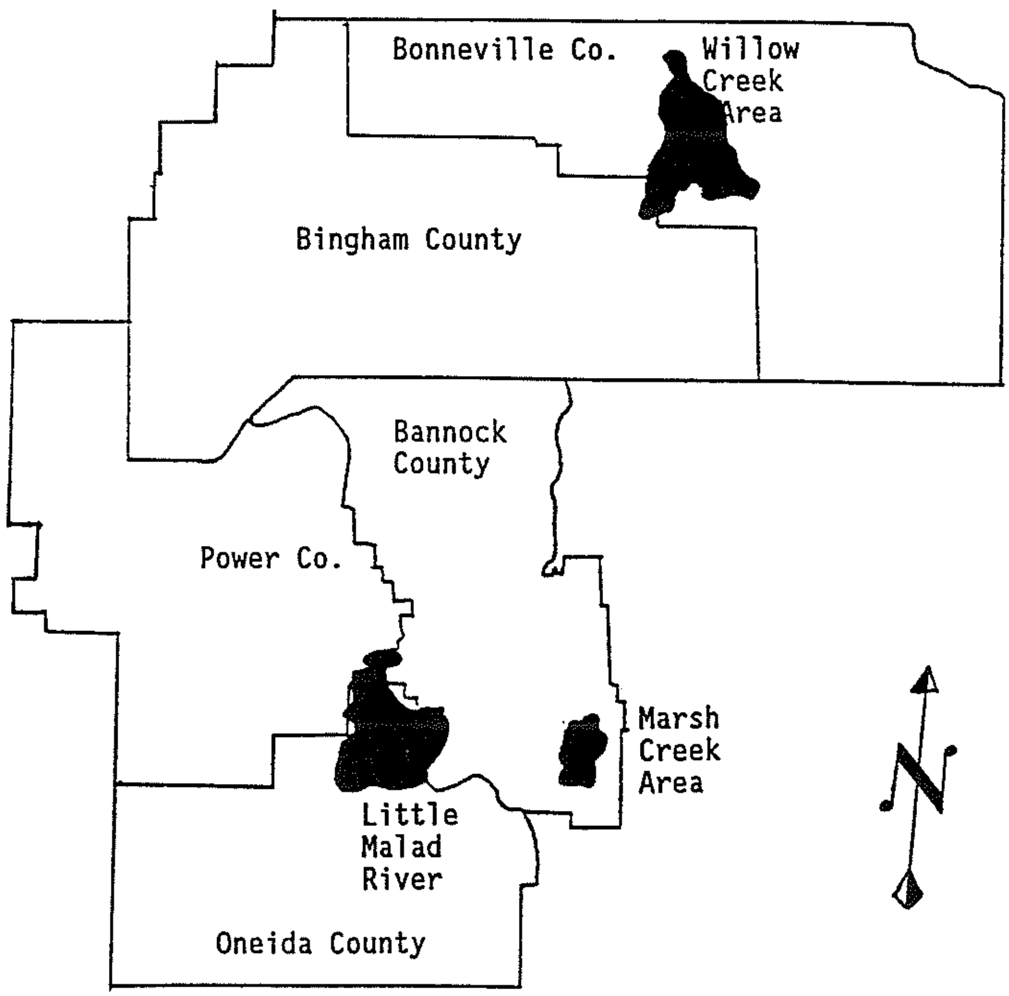

Figure 2: Location of Project Areas.

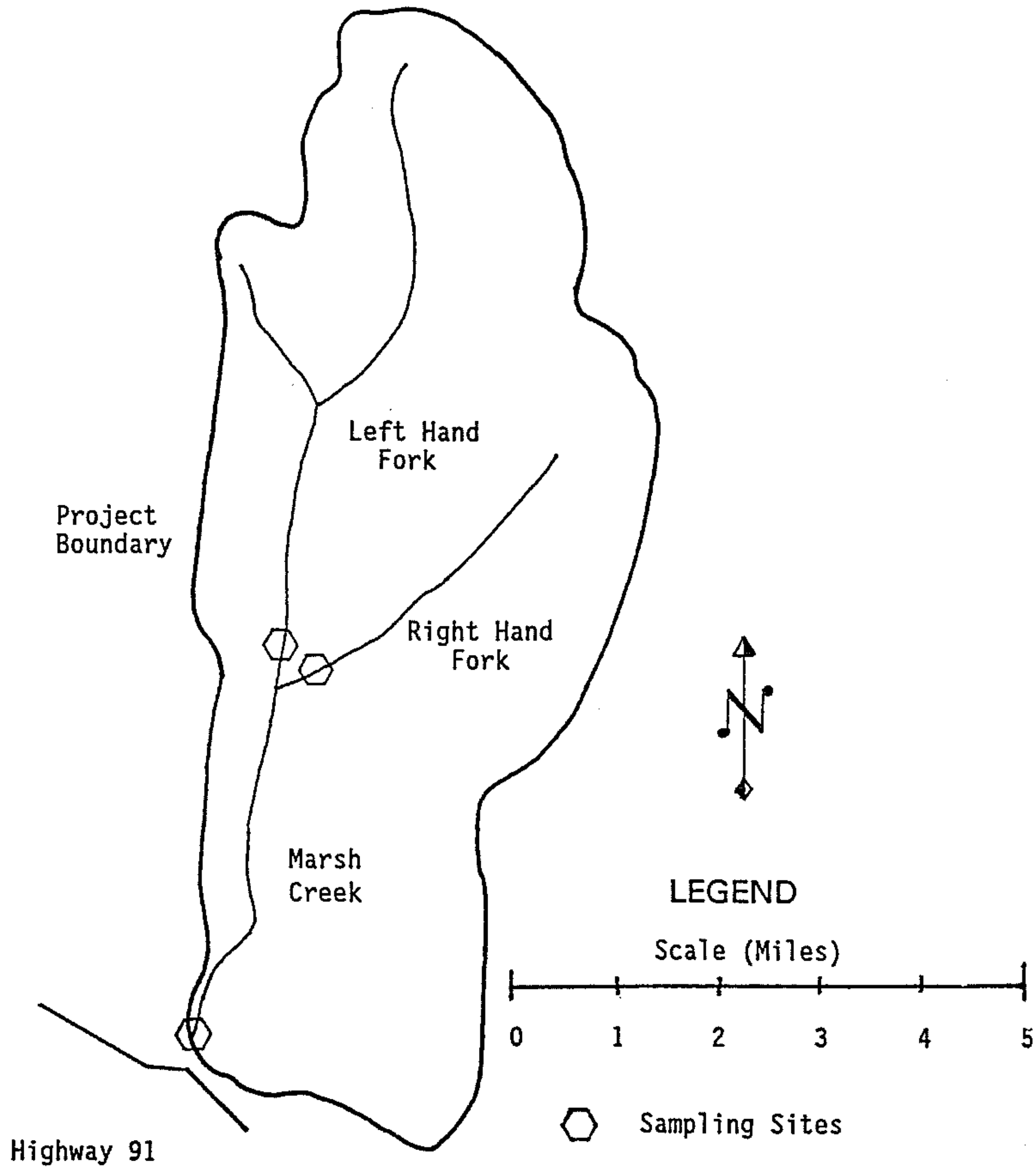

Figure 3: Marsh Creek Drainage.

Table 1: Marsh Creek Drainage Private Land Use.

Use	Number of Acres	% of Total
Dry Cropland	73,252	56.2
Irrigated Cropland	24,026	18.4
Pasture	11,456	8.8
Woodland	20,207	15.5
Other	1,444	1.1
Total	130,385	100.0

The main cropped soil types in the Lone Pine area are:

> Bancroft-Manila complex, 15 to 30 percent slopes. Elevation is 5,000 to 6,000 feet. This soil is mainly used for non-irrigated small grains. Surface runoff is very rapid and the potential for erosion is very high.
>
> Lanoak-Hades complex, 6 to 20 percent slopes. Elevation is 5,500 to 6,500 feet. The soil is used for dryland wheat, barley, and range. Surface runoff is very rapid, and the erosion potential is very high.
>
> Manila-Bancroft complex, 6 to 15 percent slopes. The description of this soil is similar to the Bancroft-Manila complex except runoff is moderate and the potential for erosion is high.
>
> Rexburg silt loam, 1 to 4 percent slopes. Elevation 5,000 to 6,000 feet. Most of these areas are used for non-irrigated small grains. A few areas are used as rangeland. This unit is very susceptible to the formation of a tillage pan. Runoff is medium and the potential of erosion is moderate.
>
> Ririe-Watercanyon complex, 12 to 20 percent. Elevation 4,800 to 6,000 feet. These soils are used for non-irrigated small grain production. Runoff is very rapid and the potential for erosion is very high (US Department of Agriculture 1987).

Agriculture is the major source of income for the residents.

<u>Willow Creek</u>

The Willow Creek area in Bonneville County was surveyed for agricultural water quality problems from April 1980 to April 1981. As a result of the findings, three of the sub-watersheds were funded for the BMP implementation program funded through the SAWQP.

Willow Creek is a tributary of the Snake River (USB-30), entering the river about 1 mile north of Idaho Falls (Figures 1, 2, and 4). The Willow Creek waters are impounded by the Ririe Dam approximately six miles south of the town of Ririe, Idaho, and are substantially diverted for agricultural irrigation. Willow Creek waters above Ririe Dam are protected for domestic and agricultural water supplies, cold water biota, salmonid spawning, primary and secondary contact recreation, and as a special resource water (Idaho Department of Health and Welfare 1987).

The Willow Creek drainage contains approximately 382,270 acres (Table 2). The project is bounded by the Blackfoot Mountains on the west, Grays Lake National Wildlife Refuge on the south, Caribou National Forest on the east, and Ririe Dam on the north.

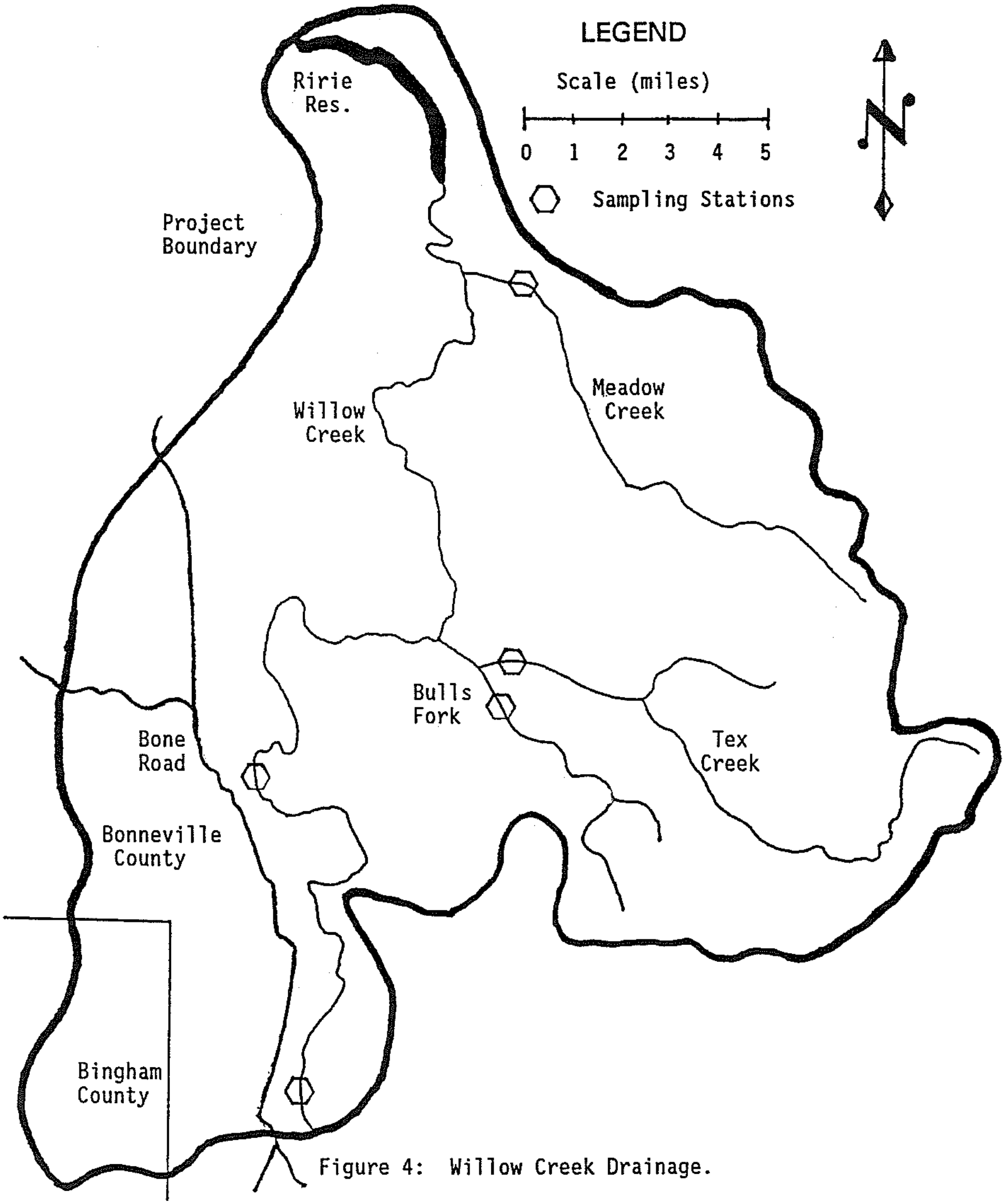

Figure 4: Willow Creek Drainage.

Elevations range from 7,700 feet at the headwaters to about 4,900 feet near the Ririe Reservoir. Topography consists of rolling hills in the lower reaches to steep mountainous terrain in the upper watershed areas. The gradient of the main stream channel averages about 38 feet per mile. Cropland is generally restricted to the northern portion of the watershed with the remainder used for range, recreation, and logging.

Cropland slopes range from 4 to 35 percent, with woodland slopes frequently exceeding 60 percent. The lower portions of the watershed are used extensively in a grain fallow rotation with winter wheat and spring barley being the main crops. There are small areas of irrigated potato crops and dryland alfalfa also present.

The climate of the Willow Creek watershed is semi-arid with cool, moist winters and warm dry summers. Annual precipitation ranges from 10 inches at the lower elevations to over 26 inches at the higher elevations. Winter precipitation occurs mainly in the form of snow, with a snowpack of over 80 inches common in the higher elevations. The frost free growing season ranges from 110 days to about 40 days at high elevations. The average annual air temperature varies from 36 to 43 degrees F.

The main farmed soil type is the Ririe silt loam with slopes of 0 to 20 percent. This soil is found at elevations of 5,200 feet to 6,200 feet. The runoff rate ranges from slow to rapid, and the hazard of erosion is from slight to very high depending upon slope (US Department of Agriculture 1981).

There have been three SAWQP implementation projects in the Willow Creek watershed. The first, Badger Creek was initiated in October, 1982 and achieved the goal of contracting 75% of the critically eroding farmland in December, 1984. A total of 5,360 acres have been treated in the Badger Creek project. Meadow Creek, the second, was started in October, 1983 and has contracted a total of 5,844 critical acres into the SAWQP through September, 1989. The Tex Creek SAWQP began in August, 1985 and has contracted 5,820 acres through September,1989. Agriculture provides the bulk of the income for residents of the Willow Creek watershed.

Little Malad River

The third area covered by this report is the Little Malad River drainage located above the Daniel's Reservoir in Oneida County. The original study was conducted by the Idaho Division of Environment from July, 1981 to June, 1982. As a result, there have been two SAWQP implementation projects in the area.

The Little Malad River (BB-460) study area is located approximately 13 miles northwest of Malad City, Idaho. The headwaters originate in northern Oneida, southern Bannock and southeastern Power Counties (Figures 1, 2, and 5). The Little Malad River waters are impounded for agricultural uses by the Daniel's Reservoir, located approximately 12 miles northwest of Malad City. Little Malad River waters are protected for agricultural water supplies, cold water biota, and primary and

Table 2: Willow Creek Drainage Land Ownership.

Use	Number of Acres	% of Total
Private Ownership	270,119	70.7
State of Idaho	66,640	17.4
Bureau of Land Management	14,980	3.9
U.S. Forest Service	17,970	4.7
Bureau of Reclamation	640	0.2
Tex Creek Big Game Wildlife Refuge	11,421	3.0
Army Corps of Engineers	500	0.1
Total	382,270	100.0

secondary contact recreation (Idaho Department of Health and Welfare 1987).

There are approximately 108,357 acres in the watershed of which 62,198 are privately owned (Table 3). The watershed is 16 miles long and averages 10 miles wide along its length. Elevations range from 6,500 feet at the headwaters to 5,162 feet at the Daniel's Reservoir.

Topography of the area is typical of eastern Idaho with rolling hills and mountainous terrain. Agricultural slopes range from 0 to 35% with woodland slopes in excess of 60%. The upper portions of the tributaries are used for range and recreation. The lower portions are used extensively in a wheat-barley- fallow rotation or annual cropped. There are some areas of alfalfa and grass-alfalfa cropping. There are two active mines in the watershed, both which are suspected of contributing to the pollution load in Wright Creek.

The climate of the Little Malad River drainage is representative of eastern Idaho with cool, moist winters and warm dry summers. Annual precipitation is mostly in the form of winter snows. Total yearly precipitation ranges from an average of 14 inches to 25 inches in the highlands. The frost free growing season lasts from 85 to 100 days.

The major farmed soils are:

Arbone silt loam, 0 to 12 percent slopes. Non-irrigated winter wheat and barley are the predominant crops. Runoff is rapid and erosion is high.

Honhodo very gravelly silt loam, 4 to 25 percent slopes. This soil is used for non-irrigated winter wheat and barley. Surface runoff is rapid and the erosion potential is very high.

Rexburg silt loam, 0 to 12 percent slopes. This soil is used for non-irrigated winter wheat and barley. Surface runoff is slow to medium and the erosion potential is slight to moderate depending upon the slope.

Ririe silt loam, 0 to 12 percent slopes. The runoff rate ranges from low to rapid, and the hazard of erosion is from slight to very high depending upon slope. Non-irrigated winter wheat and barley are the predominant crops (Oneida Soil and Water Conservation District, 1988).

The Little Daniel's River basin has two implementation projects funded through the SAWQP. The Wide Hollow implementation project was funded in October, 1982. In June, 1987, the project goal was reached. 6,360 acres of critically eroding farmland was treated by the SAWQP in Wide Hollow.

The Dairy Creek implementation project was funded in January, 1985. Through September, 1989 this project has treated 3,221 acres of highly

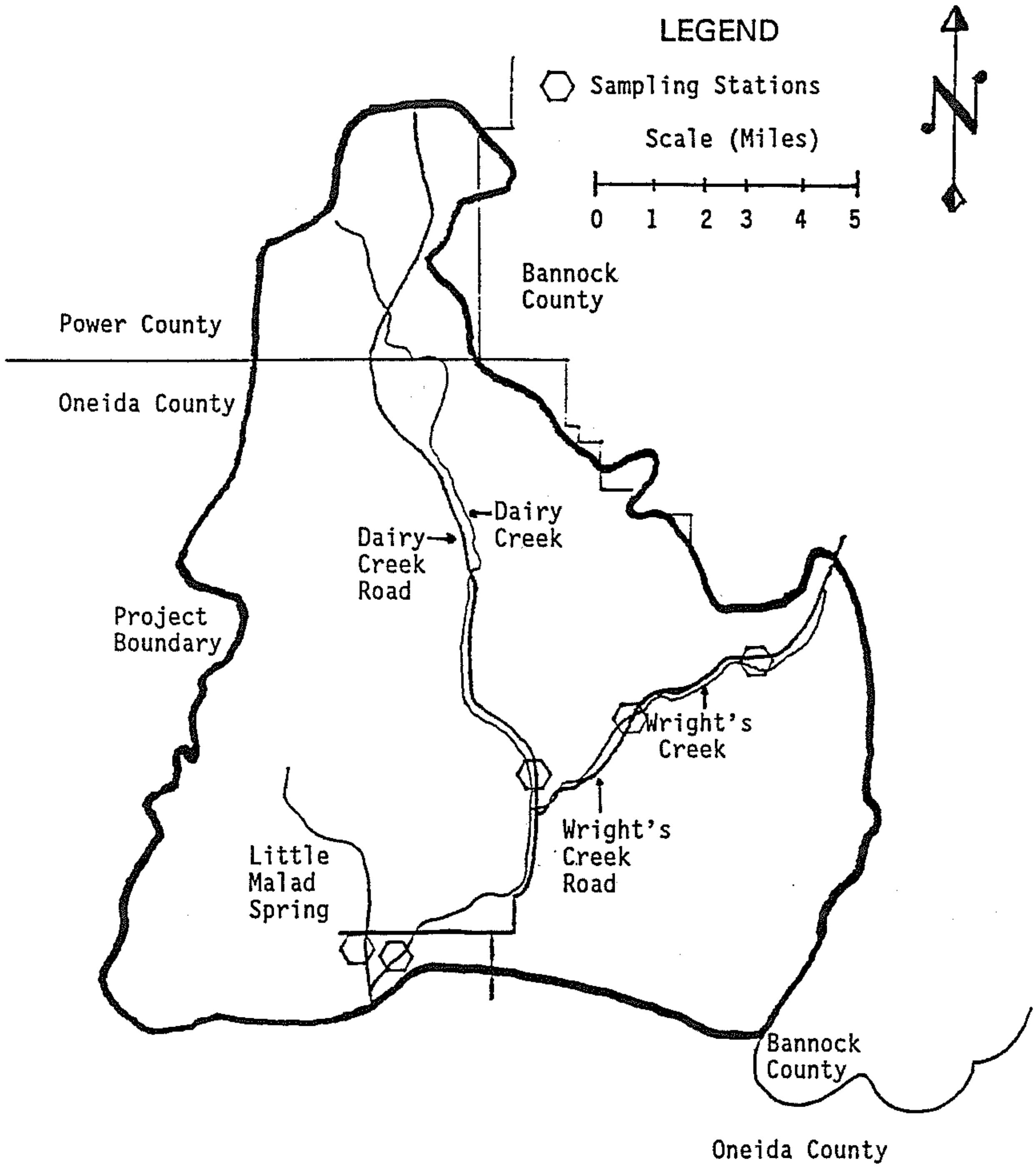

Figure 5: Wright's Creek Drainage.

Table 3: Wright's Creek Drainage Private Land Use.

Use	Number of Acres	% of Total
Dry Cropland	23,309	44.8
Irrigated Cropland	338	0.6
Mining	500	1.0
Rangeland	27,858	53.6
Total	52,005	100.0

75% program goal. Agriculture is the main source of income for residents of the Little Malad River drainage.

MATERIALS AND METHODS

During this study, methods of sample collection, preservation, and analysis followed Standard Methods (American Public Health Association 1985), EPA guidelines (US Environmental Protection Agency 1979), and the National Handbook of Recommended Methods for Water Data Acquisition (US Geologic Survey 1977). All samples, except bacterial, were collected using a Bel-Art Products churn splitter from which separate samples were drawn. Samples were collected from the center of the stream or from an area of complete mixing. Bacterial samples were hand dipped directly into the sample containers.

SAMPLE STATIONS

The sample stations for this project were placed in the same locations as those stations used during the original studies (US Geologic Survey 1985; Idaho Department of Health and Welfare 1980; and Idaho Department of Health and Welfare 1983). This was done in an effort to make the results of this study as comparable as possible to the earlier study data. The sample sites, STORET numbers, and reasons for their placement are given below.

Marsh Creek

Station 1. Left Hand Fork of Marsh Creek near Downey. STORET # 2080156. This was one of the two stations located above the farming areas in the Lone Pine project. The data collected here was used in the 1980-81 study as baseline data. Comparison of the 1980-81 data to the 1987-88 data would show any changes which may have occurred in the quality of the water above the farming region. This site was also used as one of the baseline data stations for the 1987-88 study.

Station 2. Right Hand Fork of Marsh Creek near Downey. STORET # 2080157. This was the second baseline data station located in the Lone Pine area. The data was used in the same manner as that acquired from the station on the Left Hand Fork of Marsh Creek.

Station 3. Marsh Creek at Red Rock Pass near Downey. STORET # 2080158. This was the lowest station in the Lone Pine implementation project area. As such, it indicated the pollution loading from the farms in the Lone Pine sub-watershed.

Willow Creek

Station 4. Willow Creek at High Road Bridge. STORET # 2080300. This was the upper station in the Willow Creek drainage, and is located above the majority of the farms. As such, it is the baseline data station. Comparison of the data collected here with the data collected in 1980 would show any changes which may have occurred in the ambient water quality.

Station 5. Willow Creek at Kepps Crossing Road. STORET # 2080301. This site is located about 0.25 miles below the mouth of Badger Creek. Data collected at this station, when compared to Station 4, is loosely indicative of the success of treating the Badger Creek SAWQP. There is, however, farmland outside of the project area which has been treated to varying degrees, so data from this station cannot be used to display project success or failure.

Station 6. Bulls Fork at Road. STORET # 2080335. Bulls Fork is a major tributary of Tex Creek and is located within the Tex Creek SAWQP implementation project area. Data collected here is indicative of the pollution loading in the southern half of the Tex Creek SAWQP.
Station 7. Tex Creek below Indian Fork. STORET # 2080333. Tex Creek runs through the norther half of the Tex Creek SAWQP implementation project. Comparison of the 1980 data to the 1988 data was used to define the progress made in reducing agricultural pollution through BMP installation in the northern half of the Tex Creek project.

Station 8. Meadow Creek at Mouth. STORET # 2080302. The Meadow Creek station is located at the bottom of the Meadow Creek SAWQP implementation project. Comparison of the 1980 data to the 1988 data was used to show the impact of agricultural land treatment on the waters of Meadow Creek.

Little Malad River

Station 9. Wright Creek above the confluence with Dairy Creek and above the Pumice Mine. STORET # 2080352. This was the baseline data station for the Little Malad River study. The station is located above any mining or agricultural pollution source.

Station 10. Wright Creek below the Perlite Mine. STORET # 2080347. The impact of the two mines in the watershed was measured at this site. There is little agriculture located above this station.

Station 11. Dairy Creek above the confluence with Wright Creek. STORET # 2080353. The area above this station is contained within the Dairy Creek SAWQP implementation project. Comparison of the 1981-82 data to the 1988 data was used to show the impact of agricultural land treatment on the waters of Dairy Creek.

Station 12. Wright Creek at Daniel's Road. STORET # 2080344. This is the lowest station on the watershed. It is indicative of the total pollution loading within the watershed.

Station 13. Little Malad Spring at the Mouth. STORET # 2080212. Agricultural impacts from the northern portion of the watershed was measured here. The station is located at the bottom of the Wide Hollow SAWQP implementation project.

This study was designed to monitor water quality during spring and storm runoff events when the maximum influx of nutrients and suspended solids was expected. It has been demonstrated that the greatest amounts of pollutants is delivered at these times. Therefore, the sample schedule was established with the flexibility to respond to storm events. Data was gathered twice monthly from mid-February to early July to provide information on water quality during spring thaw.

The determination of total solutes contributed during a one day period was based on the assumption that an individual sample was representative of the whole day.

For ease of comparison, the parameters which were sampled were the same as those taken during the earlier studies. These parameters are:

Parameter	Units	STORET No.
Flow	cfs	00061
Suspended Solids	mg/l	00530
Nutrients		
Total Ammonia as N (NH_3)	mg/l	00610
Total Nitrate+ Nitrite as N (NO_2+NO_3)	mg/l	00630
Total Kjeldahl Nitrogen as N (TKN)	mg/l	00625
Total Phosphorus as P (P)	mg/l	00665
Dissolved ortho-Phosphate as P (o-P)	mg/l	70507
Bacteria		
Fecal Coliform (FC)	colonies/ 100ml	31616
Fecal Streptococcus (FS)	colonies/ 100ml	31679

Flow

Direct measurement of stream velocity was made with a Marsh McBirney Model 201 or 201D flow meter. Cross sections of the creeks were made by measuring the stream width to the nearest tenth of a foot, and measuring the water depth to the nearest tenth of a foot. Velocities were measured each foot at 0.6 depth from the water surface.

Suspended solids

Suspended solids are one of the prime indicators of non-point agricultural pollution. Suspended solids consist of soil particles that are entrained in the water column from three inches above stream bottom to the top of the column (Clark, 1985).

Nitrogen

Nitrogen is a primary plant nutrient and is applied in various forms to agricultural lands. This study looked at the four most common nitrogen compounds: Nitrate, Nitrite, Ammonia, and Total Kjeldahl Nitrogen. The

Total Kjeldahl Nitrogen (TKN) method was used to determine the amount of organic nitrogen in the sample. Because of the rapid interchangability of nitrate and nitrite, these compounds were analyzed together as nitrate+ nitrite.

The TKN method does not distinguish between organic and ammonia nitrogen compounds. An estimate of the amount of organic material present in a sample can be made by subtracting the ammonia concentration from the TKN concentration.

Phosphorus

Phosphorus is another of the primary plant nutrients. The most common use is as a fertilizer, although some pesticides are phosphorus based. Most phosphorus is tightly bound to the soil particles with only a small portion (ortho-phosphate) dissolving in water. When erosion takes place on farms, the bound phosphorus molecules are washed away with the soils. It is not uncommon to note an increase in phosphorus concentrations when the suspended solid concentrations increase.

Two forms of phosphorus were monitored during the study. These were total phosphorus and dissolved ortho-phosphate. Dissolved ortho-phosphate is that form of phosphorus which is available for plant uptake.

Bacteria

Two bacterial parameters were sampled during the study. Fecal coliform and fecal streptococcus are monitored as part of standard water quality procedures. Both analyses are reported in terms of number of colonies per 100 ml of sample. A ratio of the fecal coliform to streptococcus colonies can be used to determine the source of the contamination (American Public Health Association 1985). Samples were collected in sterile 250 ml nalgene bottles.

QUALITY ASSURANCE

Duplicate samples were collected each sampling date from Marsh Creek at Red Rock Pass to measure sampling precision. The chemical samples were divided with the churn splitter. Average relative ranges were calculated according to Bauer (1986).

Spiked field samples were used to determine accuracy. IDHW Laboratory supplied spikes were added to 900ml of sample water. Spiked samples were analyzed for suspended solids, nitrite + nitrite, TKN, ammonia, total phosphorus, and dissolved ortho-phosphate. A different sampling site was selected for spiking each sampling run. Percent recovery is determined by subtracting the values of the unspiked samples from the spiked samples and comparing this figure with the known amount in the spike.

The Bureau of Laboratories in Boise also ran a blank composed of distilled water to check for contamination in the laboratory instrumentation.

Data analysis and statistical considerations

The main objective of this study is to determine the validity of the null hypothesis (Ho). When testing a hypothesis, it is usually easier and better to reject a hypothesis than to accept one because rejection can be stated with greater certainty. Should the Ho be statically disproved, the alternate hypothesis (Ha) would be accepted as true. The Ho and Ha are:

Ho: Mean annual pollutant concentrations will not decrease over time when corrected for flows.

Ha: Mean annual pollutant concentrations will decrease over time when corrected for stream flows.

Water quality monitoring data usually do not fit a "normal" distribution with a normal variance over the data range. This means the data has a low variance at low values and high variance at high values. To determine whether the data were normally distributed, the pre-BMP and post-BMP data was analyzed using D'Agostino's (1972) D-test at a 95% confidence level (CL) for all parameters except ortho-phosphate and bacteria. 44 of the data sets were non-normal with 60 data sets proving to be normally distributed.

Because 42% of the data was non-normally distributed and 58% of the data was normally distributed, and since there was no apparent pattern to the distribution it was decided all of the data would be subjected to parametric and non-parametric testing.

Parametric testing is based upon the assumptions the data is normally distributed and the samples are random and independent. The test statistic selected for our analysis is the Students t-test in which the means of the pre- and post-BMP data were compared (Zar, 1974). The data was first converted from concentrations to loads using the formula:

Pounds/Day= Flow (cfs) * Concentration (mg/L) * 5.4

The converted data was then analyzed using the F-test at 95% CL to find out if the ratio of the variances of the pre- and post-BMP periods are from the same populations (Zar, 1974). This determines whether the data sets are actually independent, random samples. If it was determined the data was not independent and random, the t-test could not be run on those data sets.

The data sets which proved to be independent and random were subjected to a 95% CL, lower one-sided t-test. The lower one-sided test was chosen since only decreases in pollution loading were of interest to the study. Under the above assumptions, the t-test statistic has the following formulation (Remington & Schork 1970):

$$t = \frac{\Sigma(x_1 - x_2)}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where

x_1= pre-BMP loading
x_2= post-BMP loading
s_1= pre-BMP sample standard deviation
s_2= post-BMP sample standard deviation
s_p= pooled standard deviation
n_1= pre-BMP number of samples
n_2= post- BMP number of samples

The pooled standard deviation was determined by the following formulation:

$$s_p = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}$$

The data which was below the detection limits of the laboratory were coded in as 1/2 the detection value. The results for the testing will be discussed under the various parameter categories.

The non-parametric tests used involved regression analysis. Regression analysis is based on the assumption that a result is dependant upon a cause. In this case, pollution loading is dependant upon the amount of runoff (stream flow) present.

The data were logarithmic transformed to equalize the variance over the data range. The data was coded by multiplying it by 100 for the suspended solids and 1000 for the other parameters in order to cause the data to be positive after the transformation. The transformed data was statistically plotted on log-log paper with flow on the x-axis and the parameter in question on the y-axis. Using standard regression analysis, the slope,

Y-intercept, Σx^2, Σxy, Σy^2, and the correlation coefficient (r) were obtained for each data set.

The pre- and post-BMP regression coefficients for each parameter and station were then compared for equality. The test statistic is:

$$t = \frac{b_1 - b_2}{{}^{s}b_1 - b_2}$$

where

$$b_1 = \frac{xy}{x^2} \text{ for the pre-BMP data}$$

$$b_2 = \frac{xy}{x^2} \text{ for the post-BMP data}$$

$$^{*}b_1 = \frac{(s_y^2 * x)}{(\Sigma x^2)_1} + \frac{(s_y^2 * x)}{(\Sigma x^2)_2}$$

and the pooled residual mean square ($s_y^2 * x$) is calculated as the residual sum of squares from the post-BMP regression line plus the residual sum of the squares from the pre-BMP regression line divided by the degrees of freedom from the pre- plus the post BMP samples (Zar, 1974).

The results of the test were compared to one-sided, t-tables at 95% CL to determine equality. Those sample sets which were rejected by this test were assumed to represent areas where the implementation of BMPs has caused the reduction of pollution loading to the study streams. The results of these tests shall be discussed under the appropriate heading.

A third, non-statistical, test was also conducted on the data. The mean Post-BMP flows were divided by the mean pre-BMP flows for each station. This resulted in a percent reduction or increase in flows between the two study periods. The same data reduction was done for each of the parameters at each of the stations. The parameter percentage was divided by the flow percentage to give the pollutant decrease or increase per unit flow. Any decrease or increase in this final figure was assumed to be attributable to the installation of BMP's unless field examination proved otherwise.

RESULTS AND DISCUSSION

FLOW

Flows at all but one station were representative of the regime experienced by uncontrolled waterways in Idaho. The flows are lowest in the summer, fall, and winter with a large flow in the spring. Occasional flow pulses do occur in response to summer thunderstorms. Discharges from the Little Malad Springs were stable throughout the study however. This stability is due to groundwater recharge since surface water inputs are minor.

Drought conditions during the 1988 study reduced the flows at most stations. A comparison of flow data gathered in 1988 to the flow data collected during the earlier studies demonstrates the effect of the drought on the streams. Stations which were lower in the watershed did not show as much effect from the drought as did the higher stations. This may be due to input from springs, seeps, and groundwater recharge.

All flows recorded in the 1988 study season are considered baseline flows. The low snowpack combined with dry soils and a long, cool runoff period caused much lower flows than normal. Most of the runoff was retained in the soil.

D'Agostino's D-test determined 7 of the 26 data sets were non-normal (Table 4). No other statistical tests were conducted on the flows since the flows were included in the loading portion of the parametric tests and as the x-axis in the regression analysis.

SUSPENDED SOLIDS

There are no accepted in-stream water quality standards to compare suspended solids with, but for the purpose of comparison the EPA Water Quality Index will be used (1983). The index uses the following scale to rate the effects of suspended sediment (solids) in streams:

0-80 mg/l	No Pollution
81-500 mg/l	Moderately Polluted
Over 500 mg/l	Severely Polluted

MARSH CREEK

Data collected in 1988 showed continuing problems in the Left Hand Fork of Marsh Creek and at Marsh Creek at Red Rock Pass. Solids concentrations in the Left Hand Fork were in the moderately polluted category on 3 dates and in the severely polluted category on one occasion (n=8). Marsh Creek at Red Rock Pass was in the moderate category on 7 sampling dates (n=10). The highest suspended solids readings coincided with the early spring snow melt, rapidly dropping as the season progressed.

Regression analysis showed no statistically significant difference in the pre-treatment when compared with the post-treatment data (Table 5). Using this analysis, there is no significant reduction in suspended solids caused by the installation of BMP's at these stations.

The Students t-test could not be run because the F-test showed the data was not random and independent for suspended solids at these three stations.

A comparison of the pre- and post-BMP flow data to the pre- and post-BMP suspended solids data indicated a decrease in the amount of suspended solids per unit of water of 21% in the Left Hand Fork of Marsh Creek, 50% in the Right Hand Fork, and 34% at Marsh Creek at Red Rock Pass.

WILLOW CREEK

Data comparisons of the pre- and post-BMP suspended solids concentration was not conducted for the Willow Creek Drainage. Although the 1980 Water Quality Status Report (IDHW) discusses suspended solids and sediments, we were unable to find any data for this parameter.

The 1988 survey indicated the relative purity of the water entering the study area. The high suspended solids reading on Willow Creek at the High Bridge was 24 mg/l (n=6). As the water traveled through areas of untreated farmlands, the suspended solids concentration and load increased. Comparison of the data from Willow Creek at the High Bridge to Willow Creek at Kepps Crossing shows heavy loading during spring runoff. Although there was no suspended solids pollution noted in Willow Creek at the High Bridge, Willow Creek at Kepps Crossing was rated as moderately polluted on two dates, both in early spring.

Tex Creek and Bulls Fork lie within a large game feeding area so were not sampled until May. A small rainstorm on June 14 and a storm event on June 20 provided the only non-baseline data collected on Bulls Fork in 1988. Bulls Fork suspended solids concentrations increased during both storms reaching the moderately polluted category on June 14, and the severely polluted category when sampled on June 21 with a reading of 6400 mg/l. The other samples were in the not polluted category.

Tex Creek was sampled 5 times in 1988. Two suspended solids samples had concentrations greater than 80 mg/l. The first (May 10) caught the end of the spring runoff, and the second was taken the day after the June 20 storm event. Both readings were in the moderately polluted category.

Suspended solids readings were consistently higher in Meadow Creek than any of the other streams in the area. Of the 7 samples, 4 had readings in the moderately polluted category.

LITTLE MALAD RIVER

Suspended solids concentrations in Wrights Creek above the perlite mine did not exceed 22 mg/l in 1988 (n=10). Of the 5 samples taken in 1981 and 1982 only one was in the moderately polluted category with a reading of 82mg/l. Over all, the water contained little suspended solids.

Wrights Creek below the perlite mine had readings above the not polluted level on 5 of the 10 sample dates in 1988. Field notes indicate the pollution sources varied by sample date. Notes made February 22 stated the majority of the sediment came from poorly maintained roads. March 7 notes showed the solids loading came from the mines, and notes taken March 28 stated a large untreated dryland farm was the major source of the suspended solids. It is interesting to note that the sediment which was loaded into Wright's Creek through March 28 did not flush past this station for over a month.

Table 4: Results of D'Agostino's D-test for Flows

Pre-BMP data

Location	# of Samples	D-value	Critical Values	Reject (X)
Left Hand Fork of Marsh Creek	4	0.2661	0.2513 0.2849	X
Right Hand Fork of Marsh Creek	4	0.2499	0.2513 0.2849	
Marsh Creek at Red Rock Pass	18	0.2235	0.2603 0.2862	X
Little Malad Spring	10	0.2761	0.2513 0.2849	
Wright's Creek at the Mouth	5	0.2735	0.2513 0.2849	
Wright's Creek above the Mine	3	0.0199	0.2513 0.2849	X
Wright's Creek below the Mine	8	0.1801	0.2513 0.2849	X
Dairy Creek	3	0.2667	0.2513 0.2849	
Willow Creek at High Bridge	3	0.2703	0.2513 0.2849	
Willow Creek at Kepps X-ing	6	0.2414	0.2513 0.2849	
Meadow Creek	6	0.2769	0.2513 0.2849	
Tex Creek	5	0.2204	0.2513 0.2849	
Bulls Fork	6	0.2592	0.2513 0.2849	

Post-BMP Data

Location	# of Samples	D-value	Critical Values	Reject (X)
Left Hand Fork of Marsh Creek	8	0.2794	0.2513 0.2849	
Right Hand Fork of Marsh Creek	8	0.2812	0.2513 0.2849	
Marsh Creek at Red Rock Pass	10	0.1957	0.2513 0.2849	X
Little Malad Spring	10	0.2819	0.2513 0.2849	
Wright's Creek at the Mouth	10	0.2736	0.2513 0.2849	
Wright's Creek above the Mine	10	0.2814	0.2513 0.2849	

Table 4: Results of D'Agostino's D-test for Flows (cont.)

Post-BMP Data (Cont.)

Location	# of Samples	D-value	Critical Values	Reject (X)
Wright's Creek below the Mine	10	0.3178	0.2513 0.2849	X
Dairy Creek	8	0.2729	0.2513 0.2849	
Willow Creek at High Bridge	7	0.2813	0.2513 0.2849	
Willow Creek at Kepps X-ing	9	0.2722	0.2513 0.2849	
Meadow Creek	7	0.2844	0.2513 0.2849	
Tex Creek	5	0.2741	0.2513 0.2849	
Bulls Fork	5	0.2767	0.2513 0.2849	

Table 5: Regression Analysis Results for Suspended Solids.

Pre-BMP Data

Location	Y- Intercept	Slope	Correlation Coefficient
Left Hand Fork of Marsh Creek	0.94	0.86	0.577
Right Hand Fork of Marsh Creek	0.67	0.88	0.947
Marsh Creek at Red Rock Pass	-0.14	3.27	0.501
Little Malad Spring	0.97	0.05	0.093
Wright's Creek at the Mouth	0.89	0.50	0.885
Wright's Creek above the Mine	1.25	0.41	0.877
Wright's Creek below the Mine	1.37	0.32	0.692
Dairy Creek	0.02	1.14	0.980

Post-BMP Data

Location	Y- Intercept	Slope	Correlation Coefficient
Left Hand Fork of Marsh Creek	1.17	1.29	0.885
Right Hand Fork of Marsh Creek	1.13	0.38	0.629
Marsh Creek at Red Rock Pass	1.67	0.42	0.648
Little Malad Spring	-3.59	1.55	0.480
Wright's Creek at the Mouth	0.63	0.57	0.454
Wright's Creek above the Mine	1.21	0.13	0.417
Wright's Creek below the Mine	1.97	0.22	0.265
Dairy Creek	2.32	-0.24	0.122

Location	T- value	Critical Value	Reject (X)
Left Hand Fork of Marsh Creek	1.94	1.64	X
Right Hand Fork of Marsh Creek	1.41	1.64	

Table 5: Regression Analysis Results for Suspended Solids. (cont.)

Location	T- value	Critical Value	Reject (X)
Marsh Creek at Red Rock Pass	0.36	1.64	
Little Malad Spring	0	1.64	
Wright's Creek at the Mouth	0	1.64	
Wright's Creek above the Mine	3.00	1.64	X
Wright's Creek below the Mine	2.06	1.64	X
Dairy Creek	0	1.64	

Wright's Creek at the mouth had two periods in 1988 where the suspended solids were greater than 80 mg/L. The first period started in February and lasted until mid-April. This was due to normal spring runoff. The second sediment flux was due to the introduction of cattle into the pasture located immediately upstream of the sampling station and on Dairy Creek in mid-June. This increase in suspended solids lasted through the remainder of the study.

Dairy Creek also had two periods in which the suspended solids were in the moderately and severely polluted categories. The first period was caused by the normal spring runoff, and the second, more severe situation was due to the introduction of cattle into the Dairy Creek pastures.

Samples taken during 1981 for the above stations did not contain suspended solids concentrations over 30 mg/L. This was due to the timing of the samples as they were all taken after spring runoff had occurred. The 1982 samples had two dates when the suspended solids concentrations were elevated. The April 14 sample was taken during spring runoff and the May 23 sample was taken shortly after a storm event.

The Little Malad Springs did not exceed the 80 mg/L EPA-WQI minimum sediment criteria at any time.

The Student's T-test did not indicate there was any statistical improvement in the suspended solids loading from 1981-1982 to 1988. Regression calculations also showed no significant improvement on Wright's Creek at the mouth, Dairy Creek, or Spring Creek (Table 5). However, they did indicate Wright's Creek just above and below the perlite mine had a reduction in the suspended solids loading.

The results obtained from the regression analysis of the suspended solids at Wright's Creek below the perlite mine appear to a mathematical anomaly. This supposition is supported by higher concentrations, mean loading, and slope and Y-intercept recorded in 1988 as compared to 1981 and 1982. An anomaly such as this is expected in about 1 in 20 analysis at 95% CL.

Flow-concentration ratios indicated the suspended solids concentrations increased at every station except Spring Creek and Wright's Creek above the perlite mine.

NUTRIENTS

Nitrogen

Nitrogen is an essential element in healthy plant growth. The most common agricultural use is as a fertilizer. There are three major interconvertable types of nitrogen found in soil and water: organic nitrogen, ammonia, and the nitrate and nitrite complex. Nitrate nitrogen is soluble in water making it very mobile in damp soils.

Nitrates, nitrites, and ammonia are considered inorganic nitrogen compounds. A concentration of total inorganic nitrogen of 0.3 mg/L is considered the limit for the prevention of the growth of nuisance aquatic plants (Mackenthun, 1973).

Organic nitrates were measured using the Total Kjeldahl Nitrogen (TKN) method. This method does not distinguish between the ammonia and the organic constituents in water. Therefore, the TKN concentrations are actually the TKN values minus the ammonia concentrations. Natural waters exhibit TKN values between 0.05 and 2.0 mg\L (US Geologic Survey 1977).

MARSH CREEK

Inorganic nitrogen concentrations in the Left Hand Fork of Marsh Creek and Marsh Creek at Red Rock Pass exceeded the recommended limit on every sampling date (n=40). Concentration ranges for 1988 in the Left Hand Fork were from 3.42 mg/L to 0.775 mg/L with a mean of 1.64 mg/L. For the 1980-81 sampling season, the values were 1.27, 0.67 and 0.95 mg/L respectively.

The Right Hand Fork of Marsh Creek did not exceed recommendations on two sampling dates (May 9, 1988 and July 12, 1980). All other dates had inorganic nitrogen levels above 0.3 mg/L. The maximum, minimum and mean levels were 0.51, 0.163, and 0.41 mg/L in 1988 and 0.88, 0.30, and 0.55 mg/L in 1980-81.

Mathematical calculations showed a difference in the pollution levels between pre and post treatment nitrate and nitrite samples in the Left Hand Fork (Table 6). However, flow/concentration ratios indicated a general reduction of nitrates and nitrites at all stations and a reduction of ammonia at the Right Hand Fork of Marsh Creek and Marsh Creek at Red Rock Pass.

TKN values indicate organic nitrogen loading into the drainage is not a major problem. Of the 52 TKN samples taken, only 5 had readings over 2 mg/L. Four of the high readings are associated with spring runoff and may be due to winter detritus accumulations being flushed out of the streams.

Data calculations showed no significant change between the 1980-81 and 1988 TKN levels, although flow/concentration ratios indicated a general reduction in each drainage.

WILLOW CREEK

Inorganic nitrogen continues to be a problem in all of the Willow Creek drainages except Tex Creek (Table 6). With the exception of Tex Creek, 46% of all samples taken in 1988 were higher than 0.3 mg/L. Samples taken in 1980-81 exceeded the recommended value 51% of the time (excluding Tex Creek).

Tex Creek showed, on the surface, a dramatic reduction in inorganic nitrogen. During the 1980-81 sampling season all of the samples had excessive concentrations of inorganic nitrogen (n=7). In 1988, not one of the 5 samples had readings above 0.25 mg/L, yet data computations did not show any improvement at the 95% CL.

Table 6: Regression Analysis Results for Nitrates and Nitrites.

Pre-BMP Data

Location	Y- Intercept	Slope	Correlation Coefficient
Left Hand Fork of Marsh Creek	1.96	-0.01	0.049
Right Hand Fork of Marsh Creek	1.39	0.21	0.960
Marsh Creek at Red Rock Pass	2.04	0.00	0.021
Little Malad Spring	1.64	0.03	0.462
Wright's Creek at the Mouth	0.93	0.31	0.486
Wright's Creek below the Mine	1.41	0.21	0.609
Willow Creek at High Bridge	0.25	0.46	0.487
Willow Creek at Kepps X-ing	1.39	0.22	0.580
Meadow Creek	2.87	-0.07	0.261
Tex Creek	3.08	-0.19	0.729
Bulls Fork	2.83	-0.31	0.709

Post-BMP Data

Location	Y- Intercept	Slope	Correlation Coefficient
Left Hand Fork of Marsh Creek	2.20	-0.08	0.283
Right Hand Fork of Marsh Creek	1.64	-0.11	0.255
Marsh Creek at Red Rock Pass	1.84	0.09	0.566
Little Malad Spring	0.64	0.39	0.423
Wright's Creek at the Mouth	0.95	0.18	0.107
Wright's Creek below the Mine	1.09	0.17	0.206
Willow Creek at High Bridge	-2.37	1.06	0.542
Willow Creek at Kepps X-ing	-2.67	1.09	0.818
Meadow Creek	3.70	-1.27	0.477
Tex Creek	1.59	0.12	0.197
Bulls Fork	2.18	-0.99	0.535

Table 6: Regression Analysis Results for Nitrates and Nitrites. (cont.)

Location	T- value	Critical Value	Reject (X)
Left Hand Fork of Marsh Creek	1.81	1.64	X
Right Hand Fork of Marsh Creek	1.32	1.64	
Marsh Creek at Red Rock Pass	0.29	1.64	
Little Malad Spring	3.38	1.64	X
Wright's Creek at the Mouth	0	1.64	
Wright's Creek below the Mine	0.35	1.64	
Willow Creek at the High Bridge	0	1.64	
Willow Creek at Kepps X-ing	0.20	1.64	
Meadow Creek	0	1.64	
Tex Creek	0.38	1.64	
Bulls Fork	1.12	1.64	

Data reduction using Student's T-test indicated a significant reduction in the nitrate + nitrite concentrations on Meadow Creek and on Willow Creek at the High Bridge. There was no mathematically demonstrated improvement at any other station, however, the flow-concentration ratio indicated a decrease in the nitrate + nitrite and ammonia concentrations at every station.

Organic (TKN) nitrogen is not a problem at any of the stations. Only 3 samples had a concentration above 2.0 mg/L (N=71). Statistically, using the Student's T-test, only Willow Creek at the High Bridge showed any improvement. No improvements were demonstrated using regression analysis. The flow-concentration ratio indicated a reduction in TKN at all stations.

LITTLE MALAD RIVER

Nitrogen compounds were not sampled on Wright's Creek above the Mine or on Dairy Creek during the pre-BMP study. Therefore, they will be deleted from the comparison discussion.

Ammonia concentrations did not exceed the recommended limits at any station (N=72). However, inorganic levels remained a problem at all of the stations except Wright's Creek above the mine. The increase in inorganic concentrations can be seen in comparing the means of the 1988 sampling concentrations. Wright's Creek above the mine had a mean concentration of 0.231 mg/L, Wright's Creek below the mine was 0.286 mg/L, and the mean concentration at the mouth was 0.509 mg/L. Dairy Creek, a tributary of Wright's Creek had a mean concentration of 0.643 mg/L. The inorganic nitrogen increase may not be directly due to runoff from agricultural lands.

The Little Malad Spring is not located on farmed lands, yet the inorganic nitrogen concentrations were higher than the recommended levels on 18 of the 19 sampling dates. This is directly due to the elevated levels of nitrates + nitrites found in the ground water. Sources of contamination may include nitrate leaching from farms in the watershed, or natural nitrogen deposits in the soil profile through which the groundwater flows.

Statistical analysis showed an improvement in the nitrate + nitrite concentrations in the Little Malad Spring using regression analysis, and in Wright's Creek at the mouth for ammonia using Student's T-test. No other station demonstrated a statistical improvement. The flow-concentration ratio indicated an improvement at all of the stations for nitrates + nitrites, and all of the stations except Wright's Creek below the mine for ammonia.

Organic nitrogen concentrations (TKN) showed there was little problem with this pollutant. Of the 72 samples tested for TKN, only 2 had concentrations over 2.0 mg/L. Both samples were taken on Wright's Creek below the mine, one on September 1, 1981 with a reading of 2.08 mg/L and the other on March 28, 1988 had a reading of 3.53.

Phosphorus

Phosphorus is another of the primary plant nutrients. The most common use of phosphorus is as a fertilizer, although some pest control sprays are phosphorus bases. Most phosphorus becomes tightly bound to the soil particles with only a small amount (ortho-phosphate) dissolving in water. When high erosion occurs on farms, the bound soil particles are washed away with the soil. It is not uncommon to note an increase in the phosphorus concentration when the suspended solids concentrations increase. Recommended concentrations are 0.1 mg/L or less for total phosphorus and 0.025 mg/L or less for ortho-phosphate (Mackenthun, 1973).

The 1988 study measured the concentration of both total phosphorus and ortho-phosphate. However, the pre-BMP study did not sample for ortho-phosphate so no pre- versus post-BMP comparison can be made.

MARSH CREEK

Total phosphorus concentrations remained elevated in the Left Hand Fork of Marsh Creek and in Marsh Creek at Red Rock Pass. Mean concentrations for 1988 were 0.55 mg/L and 0.25 mg/L respectfully. Readings for the Left Hand Fork of Marsh Creek were higher than 0.1 mg/L on 4 of 8 sampling dates in 1988 and on 7 of 10 dates in Marsh Creek at Red Rock Pass.

The Right Hand Fork of Marsh Creek had a lesser problem than the other two stations. Of the 8 samples taken in 1988, one had total phosphorus readings greater than the recommended 0.1 mg/L. The 1988 mean reading was 0.07 mg/L.

The 1980-81 total phosphorus means were 0.27 mg/L on the Left Hand Fork, 0.19 mg/L on the Right Hand Fork, and 0.24 mg/L on Marsh Creek at Red Rock Pass.

Dissolved ortho-phosphate was a much lesser problem in the drainage. Of the 26 samples taken, 3 exceeded the recommended 0.025 mg/L limit. All three occasions were during spring runoff with the highest reading being 0.033 mg/L.

Regression analysis indicated a reduction in the concentration of phosphorus in the Left Hand Fork of Marsh Creek. This result is probably a mathematical anomaly. The Student's T-test indicated the concentration had increased above the 95% CL on the high side, the mean was higher in 1988 than in 1980-81, and the flow-concentration ratio indicated an increase in the phosphorus concentration versus the flow in 1988.

No other station showed a significant decrease in total phosphorus, although the flow-concentration ratio indicated a reduction in the Right Hand Fork of Marsh Creek and in Marsh Creek at Red Rock Pass.

WILLOW CREEK

Mean phosphorus concentrations changed little in Willow Creek between

1979-81 and 1988. The mean total phosphorus concentration at the High Bridge was 0.099 mg/L in 1979-81, and 0.088 mg/L in 1988, and 0.255 mg/L and 0.134 mg/ L respectively at Kepps Crossing. This was expected since the creek has a well developed riparian area, and there is little stream erosion in the stream segment.

Elevated concentrations of phosphorus are expected in streams where there is little filtering of sediment due to a lack of riparian zone, or where there is the addition of sediment through stream erosion. This was the case in Meadow Creek, Tex Creek, and Bulls Fork.

Total phosphorus concentrations exceeded 0.1 mg/L in Tex Creek, Meadow Creek, and Bulls Fork on 34 of 39 dates sampled. The mean concentrations in Meadow Creek were 1.153 mg/L in 1980-81 and 0.279 mg/L in 1988. Tex Creek means were 0.376 mg/L in 1980-81, and 0.234 mg/L in 1988. Bulls Fork means were 0.591 mg/L and 0.330 mg/L respectively.

Although the mean total phosphorus concentrations and the concentration-flow comparisons indicate an improvement in the phosphorus loading between 1980-81 and 1988, the statistical regression analysis and Student's T- test showed no significant improvement at any station.

Dissolved ortho-phosphate readings exceeded the recommended criteria of 0.025 mg/L in 12 of the 31 samples taken. The highest reading recorded was 0.06 mg/L in Meadow Creek on March 29, 1988.

LITTLE MALAD RIVER

Total phosphorus and dissolved ortho-phosphate are a major pollutant in Wright's Creek. Total phosphorus concentrations were higher than the recommended 0.1 mg/L criteria at the three Wright's Creek stations on all but 2 occasions (n=43). Only Wright's Creek at the mouth had total phosphorus readings below or at 0.1 mg/L (May 9, 1988 and October 8, 1981).

Of the dissolved ortho-phosphate samples taken from Wright's Creek (n=30), 26 were higher than 0.025 mg/L. Again, the 4 samples which were below recommended limits were taken from Wright's Creek at the mouth.

Dairy Creek was only sampled for phosphorus in 1988. Of the 8 total phosphorus samples taken, 5 were in excess of the recommended values. Half of the dissolved ortho-phosphate samples taken were in excess of the recommended limit.

The Little Malad Spring waters are indicative of groundwater around the state. There were no readings of total phosphorus or dissolved ortho-phosphate above the recommended levels in 1988. Three total phosphorus

readings taken in 1980-81 were over the recommended criteria, but this may have been due to the pasturing of cattle and horses in the spring bottoms.

readings taken in 1980-81 were over the recommended criteria, but this may have been due to the pasturing of cattle and horses in the spring bottoms.

Regression analysis of the total phosphorus concentrations in the Little Malad Spring showed an improvement from 1981 to 1988. No other improvement could be demonstrated at any other station.

BACTERIA

Fecal coliform and fecal streptococcus were the only living constituents sampled during the study. The bacteria are indicators of animal and/or human fecal pollution. Ratios of the fecal coliform to the fecal streptococcus counts can indicate whether the source is animal, human, or animal-human mix. Fecal coliform /Fecal streptococcus ratios <0.7 indicate the source is animal. Ratios between 0.7 and 4.1 indicate animal-human mix and ratios >4.1 indicate human sources.

The fecal coliform /fecal streptococcus ratios presented in the appendix are based primarily upon the fecal coliform counts. Fecal coliform counts of less than 50 colonies were determined to be insignificant when computing the ratio.

Other than the ratios mentioned above, the data was not subjected to analytical computations. Since the BMP's were designed to reduce the pollution loads from the farm lands and not the range lands, results obtained from the data could not be applied to our hypothesis.

MARSH CREEK

Marsh Creek is protected as a secondary contact recreation water with primary contact recreation protected for future use (Idaho Water Quality Standards, 1987). As such the waters are not to contain fecal coliform bacteria in concentrations exceeding 800 colonies per 100 mL of water. The secondary standards were not exceeded at any station at any time (Appendix, pgs. 40-42). Primary standards (500 colonies /100 mL) were exceeded June 3, 1980 and June 18, 1981. The Fecal Coliform /Fecal Streptococcus ratios indicate the major bacterial source is livestock.

WILLOW CREEK

Willow Creek is protected a primary contact recreation water. As such, the waters are not to contain more than 500 fecal coliform colonies per 100 mL water. Of the 71 samples taken in the Willow Creek drainage, 3 had counts over primary standards. Only one of these readings exceeded secondary standards. The coliform /streptococcus ratio indicates the source is primarily livestock.

LITTLE MALAD RIVER

Wright's Creek is protected as a primary contact recreation water. Bacterial samples show the primary and secondary contact standards are increase in the coliform counts as the flows decrease. Field notes indicate this is due to cattle congregating in the stream bottoms during the late spring and summer.

The fecal coliform/fecal streptococcus ratios indicate the source is predominately livestock, although there is an indication human wastes may also be present.

QUALITY ASSURANCE

The precision of all the duplicate samples except ammonia was excellent. The average relative ranges, excluding ammonia, were between 3.5% and 7.0% (Table 7). Ammonia precision was poor with a relative range of 29.2%.

Accuracy data (Table 8), showed a good to excellent recovery for all parameters. The range of recoveries went from a high of 111.6% for nitrates and nitrites to a low of 93.8% for suspended solids.

PROBLEMS ENCOUNTERED

The greatest problem with conducting a before-after study of this type is the lack of both before and after data. Spooner, et al. (1987), using Rock Creek, Idaho data, stated that using data from 20 samples per year, it would take a 45% reduction in the pollutant concentration to statistically show an improvement between any two yearly means using the T-test.

A detailed look at our before data shows that only one of the eleven stations sampled had more than 10 samples, and only 6 had more than 5 samples. The post-BMP data was somewhat better with 5 of the stations having 10 samples and all of the stations having more than 5 samples. Both sample sets are lacking the long term, intense sampling required to come to a statistical conclusion.

Access to the collection sites, especially, in the Willow Creek drainage, also proved troublesome. The Bulls Fork and Tex Creek stations are located in a Fish and Game wildlife feeding area. Access to these stations was prohibited until May. This was too late to measure spring runoff events which may have occurred.

CONCLUSIONS AND RECOMMENDATIONS

The objective of this study was to determine if the implementation of BMPs would result in a reduction in pollution levels in the receiving streams. The lack of significant before and after data severely limited the scope of this study.

The data sets were subjected to the Student's T-test, regression analysis, and a non-statistical comparison of flows versus concentrations. T-test results showed a reduction in nitrate and nitrite and total Kjeldahl nitrogen concentrations in Willow Creek at the High Bridge, nitrate concentrations in Meadow Creek, and ammonia and total Kjeldahl

Table 7: Precision of Split Samples.

PARAMETER	N	RANGE (%)
Suspended Solids	10	5.6
Nitrate + Nitrite	10	3.5
Ammonia	10	29.2
Total Kjeldahl Nitrogen	10	7.0
Total Phosphorus	9	4.6
Dissolved ortho-Phosphate	9	6.8

Table 8: Accuracy (% average recovery) and the 95% Confidence Interval for Spiked Samples.

PARAMETER	N	AVE. % RECOVERY	95% CL
Suspended Solids	9	93.78	± 6.0
Nitrate + Nitrite	10	111.64	± 6.1
Ammonia	9	99.90	± 11.0
Total Kjeldahl Nitrogen	10	105.70	± 4.3
Total Phosphorus	10	100.50	± 1.8
Dissolved ortho-Phosphate	11	100.00	± 5.3

nitrogen concentrations in Wright's Creek at the mouth.

Regression analysis demonstrated an improvement in the suspended solids and total phosphorus concentrations in the Left Hand Fork of Marsh Creek; the total phosphorus, ammonia, and nitrate and nitrite concentrations in the Little Malad Spring; and the suspended solids concentrations in Wright's Creek both above and below the mines. However, the analysis reports of the phosphorus concentrations in the Left Hand Fork of Marsh Creek and the suspended solids concentrations in Wright's Creek below the mine appear to be mathematical anomalies.

Probably the best indication that BMP implementation is succeeding is the non-statistical comparison of flow and pollution concentration. The comparisons indicated a decrease in the pollution levels which were not reveled through the use of statistical analysis.

The flow/concentration relationship showed an improvement in suspended solids at 5 of the 8 stations; ammonia reductions at 10 of 11 stations; nitrate and nitrite reductions at 10 of the 11 stations; total Kjeldahl nitrogen reductions at all 11 stations; and total phosphorus reductions at 10 of 11 stations.

It is recommended that a study of this type be conducted at another dryland farming site where the pre-BMP data is complete enough to form the basis of a statistically accurate study. It is further recommended that, should a study of this sort be funded, the post-BMP study be conducted for a minimum of 5 years. This would ensure a large enough data base to conduct a statistically meaningful analysis.

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APPENDIX

1988 DATA

Left Hand Fork of Marsh Creek STORET # 2080156

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
March 28	1.9	5000	0.029	3.46
April 11	3.3	48	0.054	0.59
April 25	1.9	28	0.023	0.47
May 9	2.4	15	<0.010	0.28
May 23	2.3	21	0.018	0.26
June 6	1.4	5.2	0.002	0.29
June 20	0.4	1.1	0.018	0.26
July 5	0.7	0.7	0.018	0.20

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
March 28	3.400	3.51	0.027	687
April 11	1.580	0.39	0.003	370
April 25	1.050	0.17	0.006	176
May 9	0.775	0.08	0.002	76
May 23	1.120	0.15	0.008	114
June 6	1.270	0.05	<0.001	44
June 20	1.600	<0.05	0.002	2
July 5	2.18	<0.05	0.003	2

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
March 28	<10	160	-
April 11	<10	20	-
April 25	<10	<10	-
May 9	<10	<10	-
May 23	60	130	0.46
June 6	100	160	0.63
June 20	20	290	0.07
July 5	110	650	0.17

All readings are in mg/L unless otherwise noted.

Right Hand Fork of Marsh Creek STORET # 2080157

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
March 28	2.8	20	0.011	0.50
April 11	3.4	11	0.054	0.30
April 25	2.4	16	0.030	0.42
May 9	3.5	6	0.006	0.05
May 23	1.7	5.7	0.036	0.21
June 6	1.8	5.5	0.010	0.34
June 20	1.6	1.8	0.013	0.33
July 5	1.1	1.1	0.038	0.24

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
March 28	0.486	0.12	0.006	54
April 11	0.537	0.07	0.006	26
April 25	0.364	0.09	0.008	58
May 9	0.157	0.05	0.002	24
May 23	0.293	0.06	0.005	24
June 6	0.416	0.06	0.002	26
June 20	0.385	0.07	0.006	18
July 5	0.446	0.05	0.003	10

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
March 28	<10	40	-
April 11	<10	<10	-
April 25	20	10	2.00
May 9	30	20	1.50
May 23	40	220	0.18
June 6	100	290	0.35
June 20	240	1400	0.17
July 5	490	1400	0.35

All readings are in mg/L unless otherwise noted.

Marsh Creek at Red Rock Pass STORET # 2080158

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
February 22	0.7	6.6	0.025	0.27
March 7	2.0	430	0.385	0.76
March 28	31.9	63.5	0.030	0.66
April 11	6.8	65	0.054	0.78
April 25	3.3	68	0.058	0.76
May 9	4.6	22	0.013	0.47
May 23	3.1	20	0.029	0.45
June 6	1.3	12	0.025	0.39
June 20	2.8	27	0.014	0.47
July 5	0.1	15	0.035	0.27

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
February 22	0.669	0.10	0.006	70
March 7	1.390	0.39	0.024	305
March 28	1.220	0.44	0.026	415
April 11	1.170	0.48	0.011	476
April 25	1.060	0.33	0.020	322
May 9	0.679	0.19	0.008	130
May 23	0.677	0.13	0.004	97
June 6	0.669	0.10	0.006	70
June 20	0.528	0.24	0.004	167
July 5	0.272	0.06	0.006	2

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
February 22	10	60	0.17
March 7	<10	160	-
March 28	<10	30	-
April 11	<10	60	-
April 25	40	40	1.00
May 9	20	90	0.22
May 23	100	120	0.83
June 6	80	230	0.35
June 20	310	260	1.19
July 5	360	760	0.47

All readings are in mg/L unless otherwise noted.

Willow Creek at High Road Bridge STORET #2080300

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
April 12	51.6	8	0.074	0.63
April 26	54.7	3.7	0.021	0.43
May 10	32.9	28	0.010	0.36
May 24	43.0	-	-	-
June 14	32.0	1.1	0.018	0.34
June 21	17.0	1.0	0.029	0.40
July 12	18.7	0.7	0.032	0.38

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
April 12	0.280	0.13	0.026	24
April 26	0.208	0.07	0.034	12
May 10	<0.001	0.07	0.020	6
May 24	-	-	-	-
June 14	0.005	0.09	0.022	6
June 21	0.021	0.11	0.040	4
July 12	0.008	0.06	0.019	2

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
April 12	<10	40	-
April 25	<10	40	-
May 10	<10	<10	-
May 24	<10	10	-
June 14	10	10	1.00
June 21	60	100	0.60
July 12	<10	20	-

All readings are in mg/L unless otherwise noted.

Willow Creek at Kepps Crossing STORET #2080301

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
March 8	70.5	3.1	0.016	0.26
March 29	70.8	18	0.030	0.37
April 12	99.5	64	0.062	1.16
April 26	88.4	9.1	0.013	0.47
May 10	71.0	6	0.003	0.37
May 24	68.8	-	-	-
June 14	34.0	1.8	0.015	0.45
June 21	48.0	1.3	0.039	0.40
July 12	14.0	0.8	0.026	0.46

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
March 8	0.410	0.12	0.024	22
March 29	0.302	0.13	0.028	194
April 12	0.229	0.45	0.035	232
April 26	0.131	0.08	0.025	24
May 10	0.047	0.09	0.012	26
May 24	-	-	-	-
June 14	0.004	0.08	0.017	8
June 21	0.008	0.07	0.015	4
July 12	0.004	<0.05	0.003	2

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
March 8	<1	32	-
March 29	<10	10	-
April 12	<10	60	-
April 26	<10	40	-
May 10	<10	<10	-
May 24	30	50	0.60
June 14	<10	<10	-
June 21	130	140	0.93
July 12	40	20	2.00

All readings are in mg/L unless otherwise noted.

Bulls Fork at Road STORET #2080335

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
May 10	1.8	8.8	<0.001	0.41
May 24	0.9	0.5	0.063	0.39
June 14	1.1	37	0.073	0.67
June 21	1.3	260	0.086	2.30
July 12	0.3	11	0.040	0.41

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
May 10	<0.001	0.10	0.017	36
May 24	0.063	0.39	0.451	42
June 14	0.707	0.23	0.044	138
June 21	0.839	1.06	0.024	6400
July 12	0.694	0.11	0.003	34

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
May 10	<10	10	-
May 24	70	70	1.00
June 14	70	60	1.17
June 21	4800	6600	0.73
July 12	40	250	0.16

All readings are in mg/L unless otherwise noted.

Tex Creek below Indian Fork STORET #2080333

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
May 10	8.7	55	0.001	0.67
May 24	7.2	26	0.008	0.35
June 14	4.5	28	0.081	0.63
June 21	4.7	84	0.042	1.00
July 12	0.7	16	0.039	0.45

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
May 10	0.242	0.28	0.028	144
May 24	0.090	0.17	0.024	48
June 14	0.036	0.17	0.032	58
June 21	0.206	0.42	0.023	200
July 12	0.034	0.13	0.012	32

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
May 10	<10	10	-
May 24	20	10	2.00
June 14	50	10	5.00
June 21	260	470	0.55
July 12	50	230	0.22

All readings are in mg/L unless otherwise noted.

Meadow Creek at Mouth STORET #2080302

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
February 16	4.2	5.2	0.016	<0.01
March 29	3.1	34	0.043	0.45
April 12	4.4	70	0.056	0.79
May 10	4.7	75	0.007	0.82
May 24	3.8	25	0.035	0.44
June 14	2.3	17	0.015	0.49
June 21	2.8	37	0.057	0.67
July 12	1.6	4.1	0.019	0.23

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
February 16	2.130	0.05	0.021	18
March 29	0.851	0.25	0.060	112
April 12	0.594	0.43	0.048	50
May 10	<0.001	0.46	0.024	372
May 24	0.258	0.24	0.026	154
June 14	0.325	0.19	0.035	74
June 21	0.419	0.30	0.018	164
July 12	0.467	0.80	0.002	16

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
February 16	<10	20	-
March 29	<10	70	-
April 12	<10	10	-
May 10	<10	30	-
May 24	80	10	8.00
June 14	210	60	3.50
June 21	570	230	2.48
July 12	200	140	1.43

All readings are in mg/L unless otherwise noted.

Wright's Creek above the Pumice Mine STORET #2080352

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
February 22	1.1	4	0.049	0.40
March 7	1.0	2.7	0.039	0.36
March 28	0.8	14.5	0.059	0.62
April 11	0.8	11	0.081	0.45
April 25	1.0	2.7	0.159	0.33
May 9	0.6	2.2	0.032	0.32
May 23	0.3	2.8	0.024	0.20
June 6	0.6	2.1	0.003	0.37
June 20	0.3	0.7	0.024	0.27
July 5	0.1	3.5	0.032	0.45

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
February 22	0.266	0.11	0.098	22
March 7	0.248	0.12	0.061	20
March 28	0.199	0.26	0.081	22
April 11	0.077	0.14	0.062	20
April 25	0.071	0.12	0.058	8
May 9	1.060	0.12	0.058	8
May 23	0.035	0.13	0.055	6
June 6	<0.001	0.12	0.071	20
June 20	0.015	0.13	0.063	6
July 5	0.043	0.16	0.043	16

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
February 22	<10	70	-
March 7	<1	11	-
March 28	<10	80	-
April 11	<10	10	-
April 25	<10	<10	-
May 9	<10	60	-
May 23	<10	110	-
June 6	120	40	3.00
June 20	40	410	0.10
July 5	990	-	-

All readings are in mg/L unless otherwise noted.

Wright's Creek below the Pumice Mine STORET #2080347

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
February 22	5.9	15	0.027	0.32
March 7	3.0	36	0.046	0.99
March 28	2.2	370	0.079	3.53
April 11	5.3	50	0.070	1.06
April 25	3.7	40	0.041	0.78
May 9	2.8	17	0.010	0.48
May 23	1.4	12	0.046	0.25
June 6	2.2	13	0.045	0.70
June 20	2.3	6.5	0.024	0.61
July 5	0.8	12	0.078	0.72

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
February 22	0.301	0.12	0.089	48
March 7	0.387	0.39	0.069	252
March 28	0.505	1.74	0.145	1470
April 11	0.389	0.64	0.094	558
April 25	0.258	0.43	0.093	298
May 9	<0.001	0.25	0.032	126
May 23	0.134	0.36	0.088	70
June 6	0.158	0.23	0.088	62
June 20	0.158	0.28	0.096	64
July 5	0.154	0.28	0.080	66

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
February 22	<10	<10	-
March 7	22	34	0.65
March 28	10	210	0.05
April 11	<10	20	-
April 25	<10	10	-
May 9	<10	130	-
May 23	180	40	4.50
June 6	1400	430	3.26
June 20	250	90	2.78
July 5	680	240	2.83

All readings are in mg/L unless otherwise noted.

Dairy Creek above the Confluence with Wright's Creek STORET #2080353

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
March 28	6.4	71	0.021	1.13
April 11	4.8	44	0.105	0.72
April 25	5.4	8.8	0.020	0.39
May 9	3.5	4.2	0.005	0.40
May 23	2.8	6	0.052	0.39
June 6	2.6	25	0.024	0.64
June 20	3.0	60	0.138	1.60
July 5	2.4	52	0.033	0.91

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
March 28	1.140	0.50	0.090	208
April 11	1.230	0.29	0.056	116
April 25	0.558	0.80	0.032	26
May 9	0.450	0.05	0.004	16
May 23	0.095	0.07	0.012	24
June 6	0.084	0.17	0.013	84
June 20	0.602	0.60	0.029	2700
July 5	0.588	0.41	0.028	212

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
March 28	<10	210	-
April 11	<10	630	-
April 25	20	200	0.10
May 9	<10	60	-
May 23	60	230	0.26
June 6	1400	330	4.24
June 20	3100	1500	2.07
July 5	1500	1100	1.36

All readings are in mg/L unless otherwise noted.

Wright's Creek at Daniels Road STORET #2080353

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
February 22	13.4	45	0.027	0.59
March 7	13.3	66	0.016	1.33
March 28	13.2	82	0.101	1.18
April 11	11.7	42	0.050	0.63
April 25	11.3	17	0.025	0.54
May 9	8.7	1.5	0.052	0.43
May 23	5.3	4.7	0.046	0.40
June 6	12.8	8.5	0.030	0.62
June 20	5.2	33	0.097	0.88
July 5	7.7	24	0.068	0.69

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
February 22	0.987	0.49	0.049	140
March 7	0.802	0.67	0.090	412
March 28	1.11	0.58	0.091	292
April 11	0.912	0.31	0.070	116
April 25	0.330	0.16	0.025	56
May 9	0.117	0.05	0.004	120
May 23	0.041	0.11	0.008	28
June 6	0.072	0.14	0.035	60
June 20	0.544	0.32	0.065	114
July 5	0.446	0.26	0.023	88

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
February 22	<10	210	-
March 7	<10	530	-
March 28	-	-	-
April 11	<10	30	-
April 25	<10	110	-
May 9	<10	120	-
May 23	110	50	2.20
June 6	400	130	3.08
June 20	300	290	1.03
July 5	290	360	0.81

All readings are in mg/L unless otherwise noted.

Little Malad Springs at Mouth STORET #2080212

Date	Flow (cfs)	TURB. (FTU)	NH_3	TKN.
February 22	14.2	0.6	0.011	0.09
March 7	17.1	13	0.054	0.25
March 28	15.6	2.4	0.011	0.09
April 11	17.7	0.8	0.025	0.06
April 25	13.8	0.7	0.073	<0.05
May 9	12.9	0.5	0.001	0.05
May 23	12.1	0.5	0.014	0.07
June 6	11.8	0.4	<0.001	0.11
June 20	13.3	0.2	0.058	0.07
July 5	18.2	0.7	0.022	0.13

Date	NO_2&NO_3	Tot. Phos.	D.O.P.	Susp. Sol.
February 22	0.543	<0.01	0.015	4
March 7	0.572	0.07	0.008	26
March 28	0.616	0.07	0.009	20
April 11	0.536	<0.05	0.003	<2
April 25	0.533	<0.05	0.007	4
May 9	0.193	<0.05	0.002	<2
May 23	0.448	0.07	0.004	<2
June 6	0.450	<0.05	0.001	2
June 20	0.551	<0.05	0.003	4
July 5	0.515	<0.05	0.003	6

Date	Fec. Coli. / 100 mL	Fec. Strep. / 100 mL	Coli./Strep. Ratio
February 22	<10	70	-
March 7	12	63	0.19
March 28	<10	<10	-
April 11	<10	40	-
April 25	10	10	1.00
May 9	90	210	0.43
May 23	10	30	0.33
June 6	40	40	1.00
June 20	70	170	0.41
July 5	40	420	0.10

All readings are in mg/L unless otherwise noted.