Technical Analysis Report for Prairie Creek, Oregon

Report generated through the Conservation Effectiveness Partnership by Oregon Department of Environmental Quality Staff:

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Introduction

Located in Eastern Oregon, Prairie Creek watershed was an alkali flat that has been converted to agricultural land through the construction of Wallowa Dam in ~1917. The dam added irrigation ditches for crops and livestock, turning a once dry valley into agricultural land. Spur ditches off main canals provide water to irrigation pumps, yet also flow through numerous properties and pumps, collecting sediment and animal waste along the way. In an effort to reduce contamination, many spur ditches are being piped. This analysis aims at quantifying the conservation work along Prairie Creek by comparing data from before restoration efforts to after.

The Wallowa SWCD collected water quality data (Orthophosphate, Inorganic Nitrogen, Bacteria, Total Phosphorus, and Turbidity) from 1991-1993 and again from 2012-2015 at six locations along Prairie Creek. See the appendix for site descriptions and site map.

Objective:

The objective of this report is to provide a quantitative assessment of water quality improvements at the six locations with pre-and post-restoration by answering the following questions:

1. Is the data queried by DEQ staff consistent with that of the Wallowa SWCD report?
2. Do any sites have statistically significant decreases in pollutant concentrations pre- and post-piping of the spur ditches?

Methods

Data Query

Data from 1991-1993 was provided to the Oregon DEQ by the Wallowa SWCD in a single tabbed excel spreadsheet. The data from 2012-2015 was downloaded by DEQ analysts from the Water Quality Portal. The data was analyzed by the Bureau of Reclamation and collected by the Wallowa SWCD. Analyte names were reconciled in order to compare data across the two time periods (Table 1). Analysts used the EPA conversion to convert fecal coliform values to *E. coli* and therefore all bacteria and *E. coli* tables and plots include fecal coliform[1].

[1] https://www.epa.state.oh.us/portals/35/tmdl/YellowCreekTMDL_final_nov09_appD.pdf

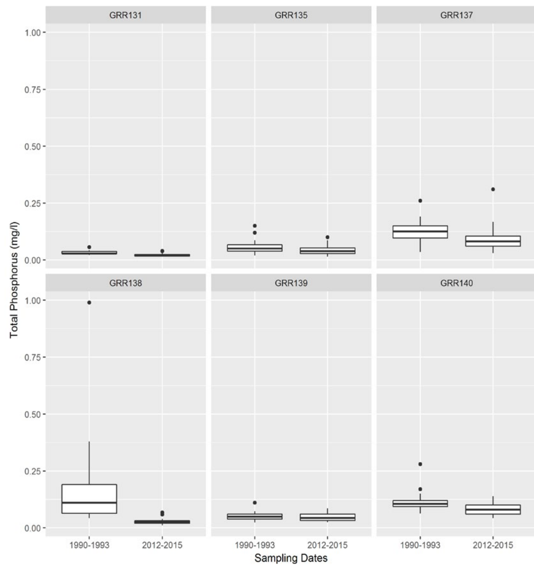
Table 1- Analyte names versus the names in the Water Quality Portal (WQP) or the Wallowa SWCD (WSWCD) provided excel spreadsheet.

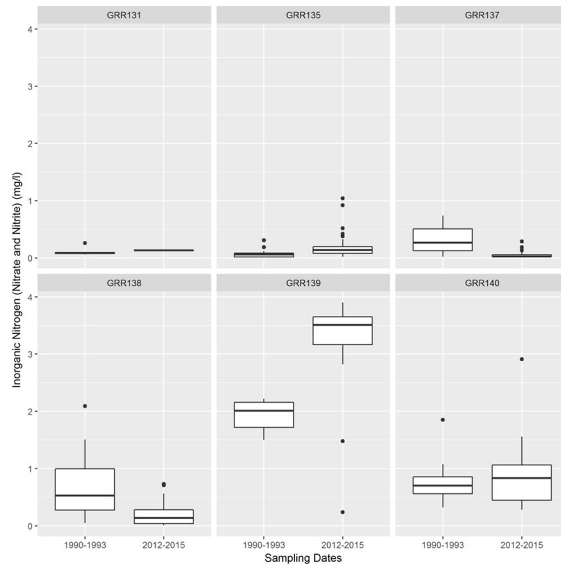
Analyte	Original Analyte Name	Source*
Bacteria	Escherichia coli	WQP
	Fecal	WSWCD
	Fecal Coliform	WQP
	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH,44.5 C	WSWCD
Inorganic nitrogen (nitrate and nitrite)	Inorganic nitrogen (nitrate and nitrite)	WQP
	NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	WSWCD
	NO3/ NO2	WSWCD
pH	pH	WQP
	PH, LAB, STANDARD UNITS SU	WSWCD
Total Phosphorus	Phosphorus	WQP
	PHOSPHORUS, TOTAL (MG/L AS P)	WSWCD
	T-Phos	WSWCD
Temperature	Temp	WSWCD
	Temperature, water	WQP
	TEMPERATURE, WATER (DEGREES CENTIGRADE)	WSWCD
Turbidity	TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	WSWCD
	Turbidity	WSWCD
Orthophosphate	PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	WSWCD
	Orthophosphate	WQP
	OrthoP	WSWCD

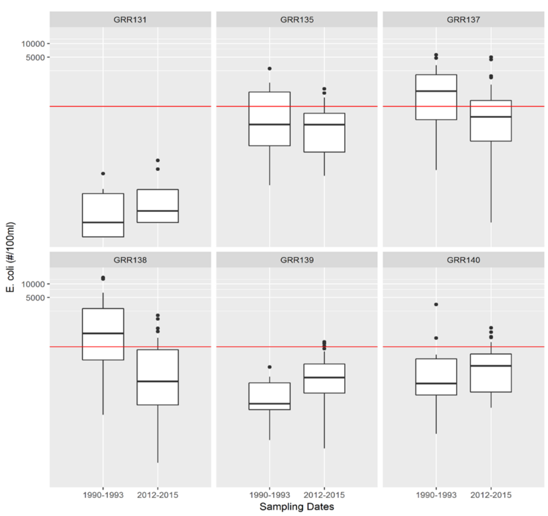
*WSWCD: Wallowa SWCD data, provided in a multi-tabbed excel spreadsheet
WQP: Data queried using the Water Quality Portal

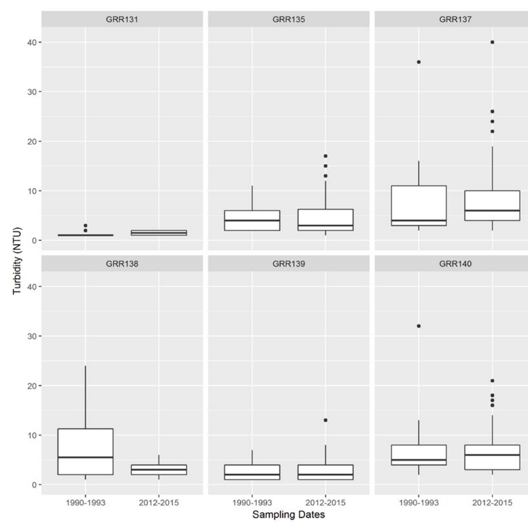
Analysis

Statistical analysis was performed to compare the pollutant levels before and after restoration period. Available data was divided into two time spans: before restoration (1991-1993) and after restoration (2012-2015). The parameters under consideration were turbidity, total phosphorus, orthophosphate, inorganic nitrogen and bacteria. Data was available at fifteen locations in the Prairie Creek Watershed, yet only six contain pre- and post- restoration data. This analysis is focused on those six stations which are also included in the SWCD Prairie Creek Report. The following monitoring stations were used for analysis: GRR131, GRR135, GRR137, GRR138, GRR139, and GRR140.









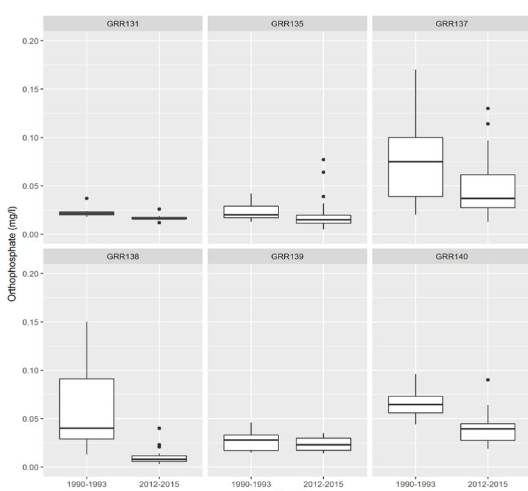


Figure 1 (a-e): concentrations of pollutants before and after restoration activities occurred along Prairie Creek. Note red line in figure d represents the 406 maximum Oregon water quality standard *E. coli* concentration limit for a single sample.

Exploratory Analysis and Check for Outliers

Boxplots were used to identify the distribution and presence of outliers in the data. Figure 1 shows boxplots for inorganic nitrogen,turbidity, total phosphorus, orthophosphate, and bacteria. Pollutant concentrations were compared to the Wallowa SWCD report to verify the use of the same data in this analysis.

Check for normality

Histograms were used to qualitatively assess the distribution represented by the data (see appendix Figure A-2 and A-3). Total phosphorus and turbidity show near normal distribution, with data right-skewed at monitoring station GRR137 for turbidity. Histograms for inorganic nitrogen exhibit highly right-skewed distributions (GRR 135, GRR137, GRR 138 and GRR140). GRR 139 shows two peaks in inorganic nitrogen histogram within a range of 1.5-2.5 mg/L and 3-4mg/L. Considering robustness of t-test against non-normality, total phosphorus and turbidity were analyzed without transformation. Log-transformation was peformed on bacteria since it was highly skewed, it now shows a near-normal distribution. Orthophosphate is right-skewed for stations GRR131, GRR135, GRR139 and close to normal distribution for the rest of the monitoring stations.

F Test to Compare Variances

Two F tests for comparing variances were performed. The first F test (I) checked for unequal variances and the second (II) checked for changing variability within the datasets before and after restoration. The first test for unequal variances was a diagnostic check for meeting the assumptions of Welch's t-test (Table 2). A significant p-value ($p<0.05$) means that the variance in the data is unequal and meets the assumption of the t-test.

The second test of variance provided a quantitative assessment of a changing variability when comparing the before restoration data to the data collected after restoration (Table 3). A significant p-value ($p<0.05$) represents a decrease in the data variability in the data collected in 2012-2015 compared to the data collected in 1991-1993.

(I) Null and alternative hypotheses for F Test for unequal variances:

H_o= True ratio of variances is equal to 1

H_A= True ratio of variances is not equal to 1

(II) Null and alternative hypotheses for F Test for changing variances:

H_o= True ratio of variances is less than 1

H_A= True ratio of variances is greater than 1

Welch's t-test

Statistical tests were used to compare the before and after restoration levels of the pollutants. Analysts used Welch's t-tests to perform the statistical comparison (Table 4), since it is ideal for data that has unequal variance and is more robust than Student's t-test. Though Welch's test assumes data is normally distributed and has unequal variance, it remains robust if the variances are equal or if the data is skewed.

The following are the null and alternate hypotheses for Welch's t-test:

H_o= the difference in mean concentration (before and after restoration) is 0

H_A = the difference in mean concentration (before and after restoration) is greater than 0

If the p-value is less than 0.05 we can reject the null hypothesis implying that the recent data (2012-2015) is significantly improving (decreasing in concentration).

Results

Most monitoring stations exhibited unequal variance, indicating the use of the more robust Welch's t-test (Table 2). Many stations exhibited a decreased variability post-restoration (Table 3, Figure 1). GRR131 exhibits a significant improvement in total phosphorus and orthophosphate concentration and has low levels of all parameters when compared with other montioring stations (Table 4, Figure 1). Station GRR 135 has signficant improvements in total phosphorus and bacteria concentrations and GRR 137 has significant improvements in total phosphorus, inorganic nitrogen, bacteria, and orthophosphate concentrations. GRR138 exhibits significant improvements in all parameters. GRR139 has a significant improvement in orthophosphate and GRR140 exhibits a significant improvement in total phosphorus (Table 4). Stations GRR137 and GRR138 confirm (higher probability) reduced inorganic nitrogen levels post restoration. Log-transformation did not change the outcome of the test, which confirms robustness of t-test against non-normality (assumption) for the data.

Table 2- F-Test for unequal variances, a significant p-value (p<0.05) represents data with unequal variances meaning it meets one of the assumptions of Welch's t-test. Note: * denotes a significant p-value

Station ID	**Turbidity**		**Total Phosphorus**		**Inorganic nitrogen (nitrate and nitrite)**		**Log(Bacteria + 1)**		**Orthophosphate**	
	f-stat	p-value	f-stat	p-value	f-stat	p-value	f-stat	p-value	f-stat	p-value
GRR131	1.09	0.887	1.57	0.368	56.25	0.000*	0.55	0.233	2.51	0.068
GRR135	9E+11	0.000*	2.00	0.031*	0.09	0.000*	1.66	0.047*	0.26	0.000*
GRR137	1.40	0.187	0.92	0.753	11.41	0.000*	1.50	0.116	1.99	0.032*
GRR138	361.68	0.000*	295.38	0.000*	5.90	0.000*	1.02	0.937	23.28	0.000*
GRR139	0.59	0.093	2.10	0.033*	0.14	0.000*	0.81	0.503	2.42	0.011*
GRR140	1.98	0.008*	2.86	0.001*	0.37	0.001*	1.76	0.027*	5E+16	0.000*

Table 3- F-Test for changing variances when comparing 1991-1993 and 2012-2015 data; a significant p-value ($p<0.05$) means that the variance in the recent data (2012-2015) is significantly lower than the older data (1991-1993).

Station ID	Turbidity		Total Phosphorus		Inorganic nitrogen (nitrate and nitrite)		Log(Bacteria + 1)		Orthophosphate	
	f-stat	p-value	f-stat	p-value	f-stat	p-value	f-stat	p-value	f-stat	p-value
GRR131	1.09	0.56	1.57	0.18	56.25	0.00*	0.55	0.88	2.51	0.03*
GRR135	9.5E+11	0.00*	2.00	0.02*	0.09	1.00	1.66	0.02*	0.26	1.00
GRR137	1.40	0.09	0.92	0.62	11.41	0.00*	1.50	0.06*	1.99	0.02*
GRR138	361.68	0.00*	295.38	0.00*	5.90	0.00*	1.02	0.47	23.28	0.00*
GRR139	0.59	0.95	2.10	0.02*	0.14	1.00	0.81	0.75	2.42	0.01*
GRR140	1.98	0.00*	2.86	0.00*	0.37	1.00	1.76	0.01*	5.9E+16	0.00*

Table 4- Welch's t-test was used to compare the before (1991-1993) and after (2012-2015) datasets for turbidity, total phosphorus, and inorganic nitrogen. A significant p-value ($p<0.05$) represents a significant decrease in mean concentrations in the most recent dataset (Ha: $u1 - u2 > 0$). * denotes significance.

Station ID	Turbidity		Total Phosphorus		Inorganic nitrogen (nitrate and nitrite)		Log(Bacteria + 1)		Orthophosphate	
	t-stat	p-value	t-stat	p-value	t-stat	p-value	t-stat	p-value	t-stat	p-value
GRR131	-0.818	0.769	4.122	0.000*	-3.708	1.000	-1.136	0.857	5.166	0.000*
GRR135	1.000	0.161	2.738	0.004*	-3.388	0.999	1.633	0.053*	1.644	0.054
GRR137	-0.087	0.535	2.906	0.003*	8.472	0.000*	2.896	0.002*	4.441	0.000*
GRR138	3.030	0.002*	5.619	0.000*	6.562	0.000*	6.432	0.000*	9.353	0.000*
GRR139	-0.353	0.637	0.905	0.184	-11.13	1.000	-4.261	1.000	1.992	0.025*
GRR140	0.312	0.378	4.562	0.000*	-1.385	0.914	-1.669	0.951	1.000	0.160

Discussion and Conclusion

Due to low concentrations of all parameters, and its location in a forested area upstream of spur ditches, GRR131 can be considered a reference site. The mainstem of Upper Prairie Creek (GRR138) is downstream of the highest concentration of restoration projects and shows statistically signifcant reductions in all parameters analzyed in this report (turbidity, total phosphorus, orthophosphate, inorganic nitrogen, and bacteria). The North Fork of Prairie Creek (GRR137) shows improvements in total phosphorus, orthophosphate, inorganic nitrogen, and bacteria. However, since the SWCD report indicates that ditching improvements were concurrent with sampling, it is not possible to draw concrete conclusions on the reason for improvement in water quality. Mainstem Prairie Creek downstream of confluence with North Fork Prairie Creek and other spur ditches (GRR140) does not show significant changes in means between 1991-93 and 2012-15. This is potentially due to influences from un-implemented areas but we are unable to make this determination due to lack of flow data. Though

GRR140 did not display significant decreases in all parameters (bacteria, inorganic nitrogen, orthophosphate, and turbidity), there was a significant decrease in variability between 1991-1993 and 2012-15 data for bacteria, orthophosphate, and turbidity. It is difficult to draw firm conclusions on reasons for decreased variability, but a less flashy system or cumulative effects of upstream restoration are potential factors.

Stations GRR139 and GRR140 are not showing many improvements in water quality. GRR139 is dominated by agricultural lands and is located on a large ditch that begins in the central to upper portion of the watershed, draining into Prairie Creek just below the sampling site. GRR139 exhibits increased concentrations of bacteria, turbidity, total phosphorus, and inorganic nitrogen but has significant improvements in orthphosphate. The location of GRR140 should show the combined effects of North Prairie Creek, Prairie Creek, and the first major spur ditch, before the second major ditch enters the Creek. GRR140 has significant improvements in total phosphorus, but does not show improvents in any of the other parameters (with some parameters slighly increasing in concentrations).

All stations have concentrations higher than the reference station (GRR131), however where implementation practices are concentrated we are seeing improvements in water quality. Potential reasons for outliers in the data can be attributed to seasonal fluctuations or flashiness within the Prairie Creek system.

Appendix

Site Descriptions:

- GRR131: This site is at the upper end of the Prairie Creek Watershed above any agricultural land
- GRR135: This site is in the Middle Prairie Creek Watershed, which is dominated by agricultural lands. The site was chosen to evaluate water quality trends as a result of projects.
- GRR113: This site was selected because it is in the middle of the watershed amongst the agricultural lands.
- GRR114: This site was selected because this will allow baseline data for the water quality of a branch of Prairie Creek before entering agriculture land and after it comes out of the highly dominated rangeland of the northern portion of the Prairie Creek Watershed.
- GRR137: This site was selected because there is a large three mile ditch elimination project in the development stages that enters Prairie Creek above this point. The project will be implemented between year one and year 2 of the monitoring project. There also are some side creeks that enter the stream from the northern portion of the watershed that would influence water quality in Prairie Creek.
- GRR115: This area is dominated by agricultural land and has had a number of projects implemented and one in progress (during 2012-2015). The site is located just above where this branch enters into the mainstem of Prairie Creek.
- GRR138: This area is dominated by agricultural land. This site was chosen because it will test Prairie Creek before its confluence with the North Prairie Creek Branch.
- GRR140: This site will show the combined effects of North Prairie Creek, Prairie Creek, and the first major spur ditch, before the second major ditch enters the Creek.
- GRR139: This area continues to be dominated by agricultural lands. This is a large ditch that begins in the central to upper portion of the watershed and drains into Prairie Creek just below the sampling site.
- GRR311: This ditch runs through agricultural land, follows the highway, and receives water from the Joseph waste water treatment.
- GRR116: This is the last sample before the creek goes into town. This extra site will allow us to see if there are impacts in town to Prairie Creek.

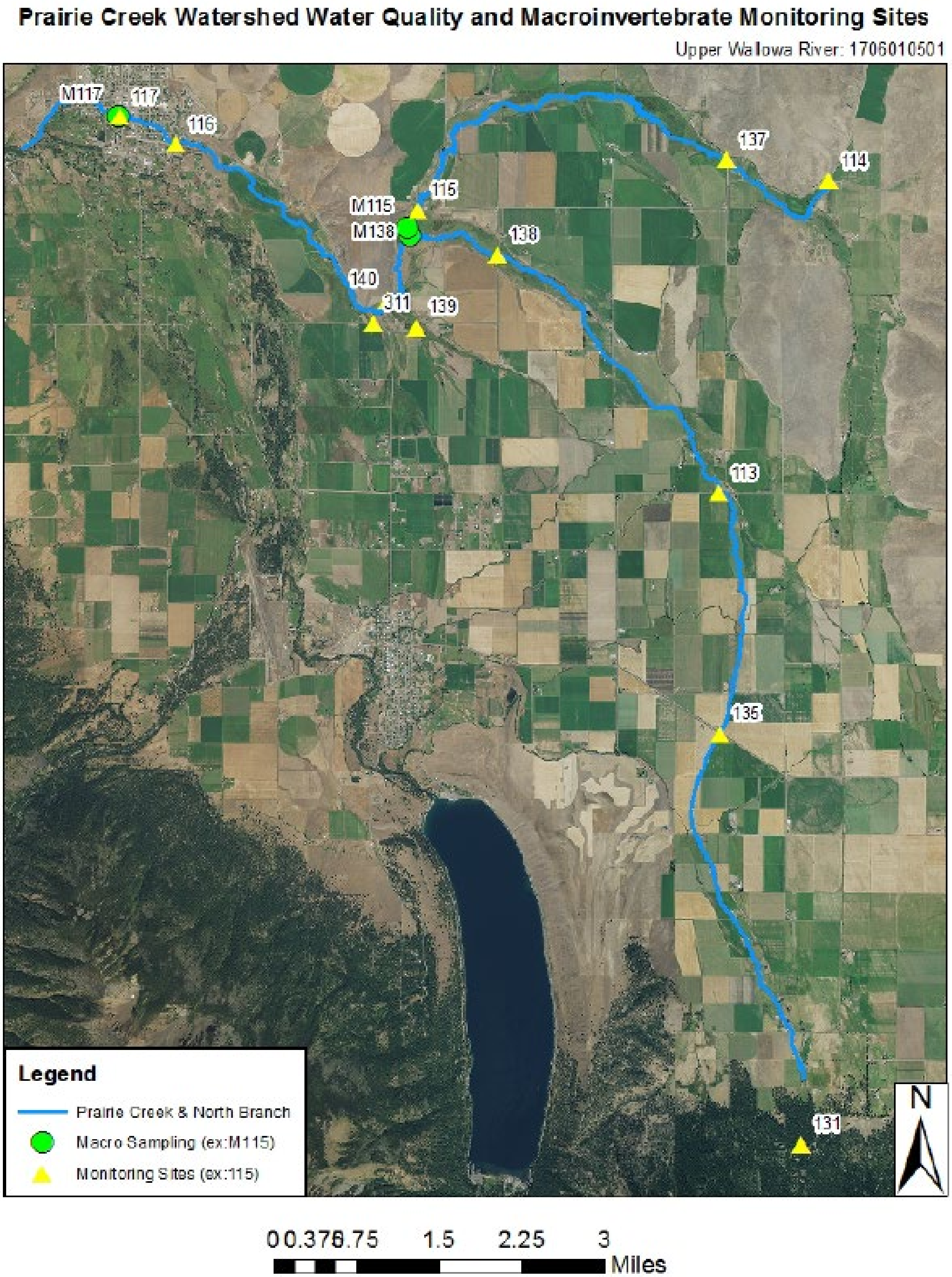


Figure A- 1: monitoring site locations, map created by the Wallowa SWCD as part of their Prairie Creek Final Report

Figure A- 2- Histograms for turbidity, total phosphorus, and inorganic nitrogen of all before and after restoration data. The histograms were used to check for normality prior to performing statistical tests.

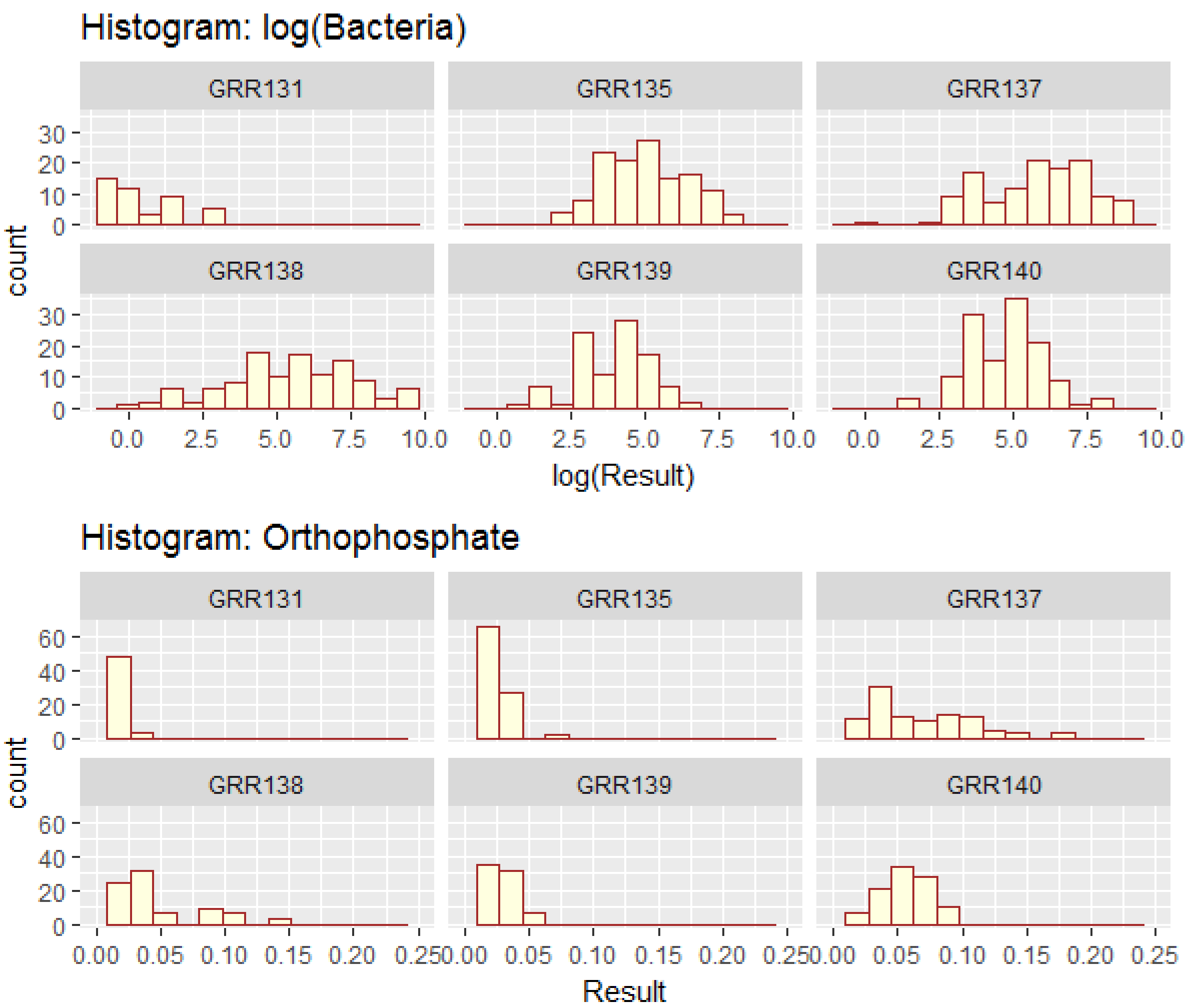


Figure A- 3- Histograms for bacteria and orthophosphate of all before and after restoration data. The histograms were used to check for normality prior to performing statistical tests. Note that bacteria was log-transformed to provide a more normal distribution of data.