CRWC

CROOKED RIVER WATERSHED COUNCIL

2022 Annual Baseline Monitoring

Summary Report

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for

The Crooked River Watershed Council

1.0 Introduction & Background

1.1 Background

This water quality sampling project is located within the Lower Crooked River watershed (HUC8 17070305), a 105-kilometer river segment spanning from Bowman Dam to the mouth of the Crooked River as it enters Lake Billy Chinook, located in Central Oregon. The Crooked River has been assumed to contribute high amounts of nutrients to Lake Billy Chinook compared to other major tributaries to the Deschutes River, the largest in the region. While there is evidence that the Crooked River is a eutrophic environment, there are uncertainties surrounding the origin of nitrogen and phosphorus inputs, whether they be from geomorphologic characteristics of the basin, from agriculture, or from other origination sources, or some combination of all of these. Water temperatures in several locations within the lower Crooked River are higher than state standards set for cold-water fish species such as steelhead and Chinook salmon.

1.2 Introduction to the Project

The baseline monitoring project is designed to establish current water quality conditions in the Lower Crooked River watershed, a subset area of the larger Crooked River watershed. The lower watershed hosts the majority of the human population in the watershed and contains a large portion of the most productive soil types. These highly productive soil resources tend to be associated with floodplains along the Crooked River, its major tributaries, and smaller drainage areas.

The data results from the project set water quality parameter reference points that can be used for comparative purposes in the future following a large investment in active restoration in the project area. Over 6,000 acres and over 17 river miles are expected to have some level of habitat restoration and water quality improvement actions completed over the next 10 to 15 years.

1.3 Need & Purpose

For future comparative purposes, this assessment will be utilized to provide a picture of water quality data pre-restoration. The data collected from this assessment allows us to make inferences on the quantity of nutrients as well as their possible origins, whether it be from agriculture, industry, rural septic systems, geomorphic characteristics of the basin, or other non-point sources. Having this baseline data available for future comparison to assess the impact of future restoration efforts will be invaluable. Evaluating current conditions in a baseline data collection effort will represent the necessary reference point for measuring and evaluating changes occurring over the next decade. The baseline data captured in this monitoring report is important to support adaptive management over time.

1.4 Goals & Objectives

Monitor and Quantify Improvements in Water Quality

The CRWC will deploy temperature loggers, collect nutrient samples, and collect multi-parameter water quality data at all known and accessible irrigation returns within the project area to quantify water quality impacts to the Crooked River from these returns. This data collection will be duplicated following completion of restoration projects to quantify reductions in nutrients and other potential water quality impairments. The primary nutrients of interest will be nitrates, total nitrogen, and phosphorus.

CRWC will monitor and quantify improvements in water quality by tracking changes at two major tributary sites, McKay and Ochoco Creek confluences with the Crooked River, and three suspected, discrete irrigation return locations associated with either natural drainage ways (Lytle Creek and Dry River) or artificial returns (Crooked River Central and Low Line Irrigation District ditches; combined load). To understand nitrogen and phosphoric inputs from springs into the system, three sites at Opal Springs were analyzed via grab samples. Eight sites out of 10 will be sampled for selected water quality parameters conducted by grab samples analyzed in the USBR laboratory in Boise, Idaho. Two sites in this project are only sampled with a handheld In Situ AquaTroll 600, as are the other eight, for dissolved oxygen, pH, conductivity, and total dissolved solids. The over-arching objective of this monitoring report is to provide nutrient and other key water quality data for future reference.

2.0 Sampling & Laboratory Methods

Sampling Methods

Water quality was sampled at 8 sites in the Lower Crooked River watershed: 3 groundwater input sites at Opal Springs, and 5 sites in tributary streams. Monthly grab samples were collected starting in June 2022 and concluding in December 2022. Samples were not collected during October 2022. Surface water grab samples were collected by dipping clean 125-, 250-, or 500-mL HDPE bottles into flow facing upstream and triple rinsed before collection. These samples were collected as close to mid-channel as wading would safely permit and care was taken not to disturb the stream substrate upstream and in the proximity of the sampling site. Samples were then labeled and temporarily stored in a cooler with ice before later being overnight shipped to be tested at the Bureau of Reclamation Soil & Water Laboratory in Boise, Idaho. Samples are tested within 48 hours of collection Grab samples were tested for total Kjeldahl nitrogen (TKN), total nitrogen, orthophosphate, total phosphorus, and nitrate + nitrite as nitrogen. See Table 1 for reference methods.

Quality Controls

Precision and accuracy for water nutrient data are determined through the use of duplicate grab samples and by the laboratory that analyzes samples. Duplicate grab samples are collected at a 10% rate of total samples collected, which for this study design means one duplicate for each sample run of 10 samples. Comparison between these duplicate samples provides an estimate of precision, with precision demonstrated if results are within 20 percent of each other for each nutrient analyzed. Analysis of grab samples is conducted at a certified laboratory that performs quality assurance and quality control checks throughout the analysis. Accuracy is estimated with the use of unidentified blank samples throughout the analysis period. Sample blanks are included in each monthly sample run as well as created at the laboratory as part of their internal quality control systems. Blanks are used to verify the accuracy of lab results. Blank samples contain distilled water only. Other quality checks performed during analyses may include detection limit standards run once for each analysis.

Additional data is collected at all ten sample locations using an *In Situ* AquaTroll 600 to collect specific conductivity, TDS, DO, and pH. The objectives of collecting this information are to increase our understanding any relationships and interlinkages with nutrient and temperature information for each site. The instrument readings are taken at the same time bottle samples are collected for laboratory analyses.

Laboratory Methods

Laboratory analysis of the surface water grab samples is conducted by the USBR Regional Soil & Water Laboratory in Boise, Idaho (see Table 1, for reference methods). After a water grab sample has been collected and shipped to Boise, USBR Lab will analyze and provide results for grab samples for ortho-phosphate, total phosphorus, total nitrogen, total Kjeldal nitrogen, and nitrate nitrogen. The laboratory transfers results to CRWC staff, who then review the data for quality and enter it into an Excel file formatted to match the ODEQ template for grab water quality data.

Table 1. Summary of analytical parameters and methods.

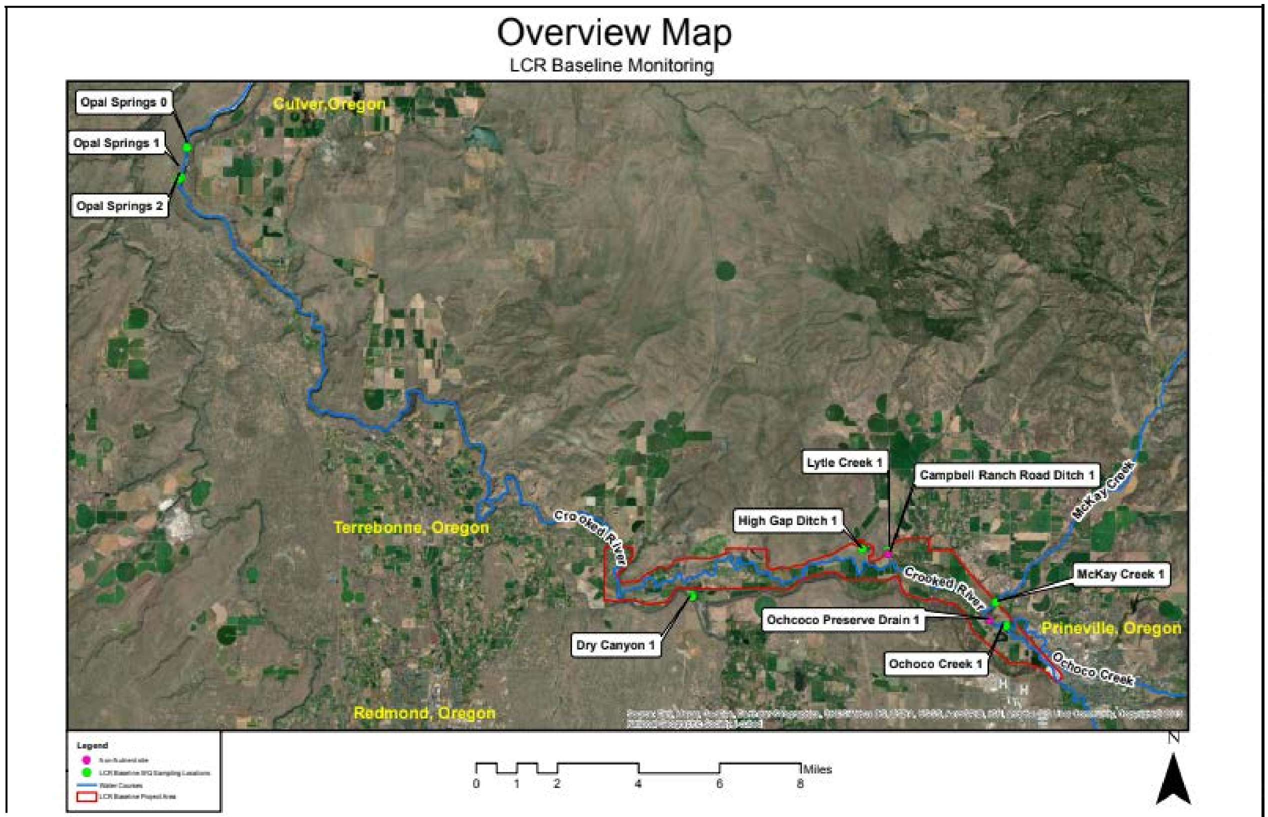
Parameter	Method[1]	Units	Equipment
Orthophosphate	EPA 365.2	mg/L	All forms of phosphorus, including organic phosphorus, are converted to orthophosphate by an acid-persulfate digestion. The persulfate digestion procedure and phosphate determination follow EPA 365.2, with the size of the sample reduced.
Total Phosphorus	APHA 4500-P F; EPA 365.1	mg/L	EPA method 365.1 Uses antimony potassium tartrate as a catalyst, to react ammonium molybdate and ascorbic acid with ortho-phosphate to form a blue color measurable at 660 nm or 880nm. Organic phosphorous compounds must be converted to ortho-phosphate using a persulfate digestion, as only orthophosphate will form a blue color.
Total Nitrogen	EPA 351.2	mg/L	EPA method 351.2 converts nitrogen components of a sample into ammonia for analysis through the use of a heated H_2SO_4 digestion. The samples are heated for 1 hour, diluted and cooled, then analyzed.
Nitrate/Nitrite	APHA 4500-NO3 F; EPA 353.2	mg/L	EPA method 353.2 uses a copper-cadmium reduction column to reduce nitrate to nitrite in filtered samples. The resulting total nitrite is then reacted with the color reagent to form a bright pink azo dye which is then measured colorimetrically. Should separate values for nitrate and nitrite be desired, the sample is run first with the Cu-Cd column and then without.

3.0 Sampling Sites

3.1 Site Map of Sampling Sites

Sampling sites occur within a subset of the total river kilometers from Bowman Dam and Lake Billy Chinook. The active sampling sites begin near the confluence of the Crooked River and the lake and end at the confluence of the Crooked River and Ochoco Creek.

Figure 1. Map of 2022 sampling locations in the Lower Crooked River



3.2 Site Descriptions

Site I.D. label	***Site Name***	***Latitude***	***Longitude***
OCH1	Ochoco Creek downstream of irrigation ditch return	44.32201	-120.88815
MCK1	McKay Creek above the confluence with the Crooked River	44.33033	-120.89321
DC1	Dry Creek above confluence with Crooked River	44.33435	-121.04787
LTLK1	Lytle Creek downstream of Rye Grass return	44.34922	-120.95986
HG1	High Gap irrigation return to the Crooked River	44.34843	-120.94714
OS-01	Opal Springs, main spring of approximately 240 cfs	44.49058	-121.29809
OS-02	Unnamed spring near Opal Springs, approx. 1-2 cfs	44.47981	-121.30074
OS-03	Unnamed spring near Opal Springs, approx. 4-5 cfs	44.47857	-121.30206

3.3 Challenges Associated with Sites

Inclement Weather

Extreme low and high temperatures can pose challenges during sample collection. In winter months, snowy and icy road conditions make travel more difficult between sites. Opal Springs especially becomes more difficult to traverse in icy conditions with the steep grade. 4x4 vehicles and adequate driving skills are necessary to safely navigate to the bottom of the gorge where Opal Springs sites are located. Icy conditions can also make slippery surfaces and pose hazards to personnel, falling into waterbodies are also a risk during cold conditions. During hotter months, high temperatures and sun exposure for long periods of time must also be considered for field collection. Instruments must be protected from heat, as well as bottled samples and personnel collecting data.

Low Flow Challenges

Sampling sites on smaller tributaries such as Lytle Creek and Dry Canyon have experienced low flows during months before major snowmelt has replenished them. To collect grab samples free of suspended sediments and organic matter, some moderate flow is required to adequately submerge sample bottles. Low flows make this process difficult, increasing the amount of sediment and organic matter that can enter the sample bottle, skewing results, and providing suboptimal grab samples. With lower flows, it is more difficult to fill bottles completely and, in some cases, forces personnel to collect grab samples a few meters upstream or downstream of the typical sample area where flow is more desirable.

Wildlife and Livestock Interactions

Drier months mean more activity from warmer weather species such as rattlesnakes and wasps. With some sample sites being in dry, grassy areas, there is a higher possibility of a rattlesnake encounter during sample collection. Wasps have also been seen to build nests on gate latches and locks that must be opened to access sample sites. Personnel must exercise caution and use their best judgment to avoid harm from the wildlife they may encounter at sample sites. Livestock, while not posing immediate harm to personnel, must still be considered when in the field. With their investigative nature, they can pose a threat to equipment left unattended or damage sensors placed in waterways.

4.0 Data Results & Analysis

4.1 Data Summaries by Site

Using the lab results from USBR, below are graphical analyses that visually display results to help draw conclusions and identify trends in nutrient concentrations at the eight grab sample sites (Figures 2-6.). Tables including site data for each test parameter are also displayed to guide inferences on sites (Tables 2-6). Standard deviations from the mean for each site for their respective nutrient test will provide statistical evidence for differences between sites and assist in interpretation. The Coefficient of Variation (CV) formula will be used to standardize deviations to help identify which sites vary the most when compared to their mean. This way, deviations at smaller concentrations aren't overshadowed by deviations at larger concentrations.

$$CV = \frac{Standard\ deviation}{Mean}$$

Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen (which tests for both organic and inorganic forms of nitrogen) had the highest concentrations in Lytle Creek (LTLK1) during July and December (Figure 2.). Lytle Creek had the highest average above all sites with the lowest being Opal Springs sites (Table 2.) With the highest CV, Lytle Creek also displays the highest degree of variance from the site mean with the standard deviation being 53% of the mean.

Total Kjeldahl Nitrogen Standard Deviation Across Sites (mg/L)									
Site	Jun	Jul	Aug	Sep	Nov	Dec	Standard Deviation	Mean	CV
OCH1	0.54	0.34	0.45	0.43	0.37	0.28	0.091524132	0.401667	23%
MCK1	0.32	0.35	0.32	0.23	0.22	0.31	0.053447794	0.291667	18%
DC1	0.67	0.47	0.32	0.3675	0.43875	0.51	0.122689692	0.462708	27%
LTLK1	0.54	1.72	0.42	1.01	0.85	1.62	0.542057807	1.026667	53%
HG1	0.51	0.51	0.17	0.45	0.42	0.65	0.159049259	0.451667	35%
OS0	0.1	0.04	0.04	0.04	0.04	0.04	0.024494897	0.05	49%
OS1	0.04	0.07	0.06	0.05	0.04	0.04	0.012649111	0.05	25%
OS2	0.04	0.04	0.04	0.04	0.04	0.04	0	0.04	0%

Table 2. Total Kjeldahl Nitrogen standard deviation comparison

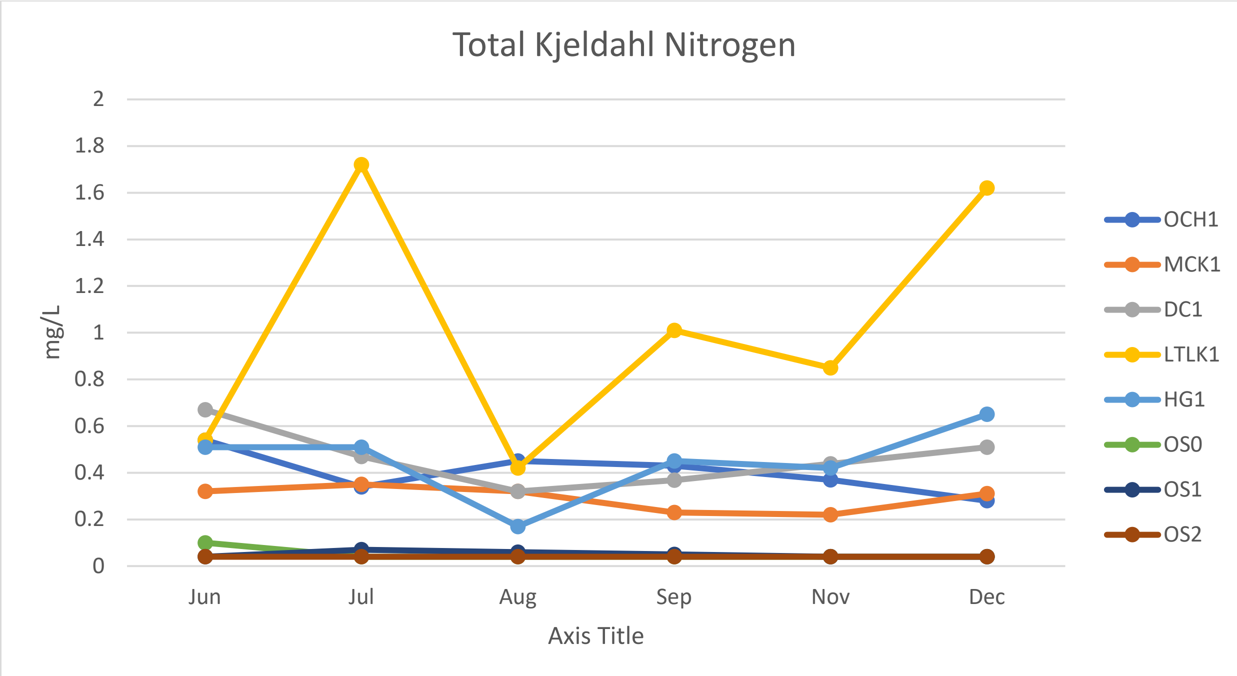


Figure 2. Total Kjeldahl Nitrogen across sites

Total Nitrogen

Lytle Creek displayed the highest mean concentration across all sites with McKay Creek following in second (Table 3). Opal Springs sites were observed to have the lowest concentraitons and displayed the most consistensy at 22%-4% in CV. Lytle Creek holds the highest degree of variance with the standard deviation 64% of the mean.

Total Nitrogen Standard Deviation Across Sites (mg/L)									
Site	Jun	Jul	Aug	Sep	Nov	Dec	Standard Deviation	Mean	CV
OCH1	0.82	1.28	1.05	2.42	2.47	2.29	0.752314207	1.721667	44%
MCK1	3.21	1.32	2.14	2.36	2.8	3.82	0.872660682	2.608333	33%
DC1	1.03	0.569	0.399	0.461	0.554	0.647	0.223297111	0.61	37%
LTLK1	1.99	2.3	1.13	4.1	6.11	7.1	2.407084682	3.788333	64%
HG1	0.525	0.553	2.76	0.717	1.11	1.82	0.885447401	1.2475	71%
OS0	0.277	0.198	0.175	0.172	0.173	0.17	0.041873221	0.194167	22%
OS1	0.447	0.559	0.512	0.4255	0.339	0.318	0.094264742	0.433417	22%
OS2	0.185	0.178	0.181	0.174	0.194	0.181	0.006853223	0.182167	4%

Table 3. Total Nitrogen standard deviation comparison

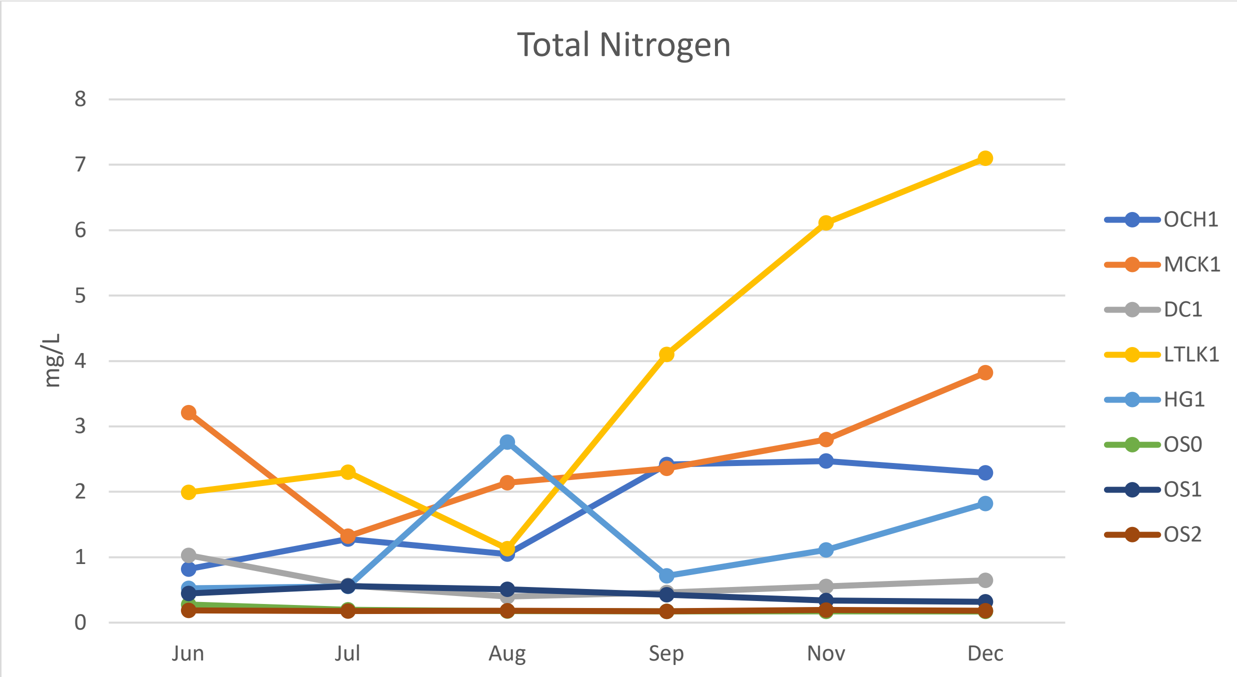


Figure 3. Total Nitrogen across sites

<u>Orthophosphates</u>

In Orthophosphate concentrations, Dry Canyon scores the highest across sites with the greatest mean (Table 4). Opal Springs continues to score the lowest in mean concentration across sites and displays the lowest degrees of variance between 3%-5%. However, Dry Canyon also displays very low variance with 7%, showing consistency in concentration over time, similarly to Opal Springs sites.

Orthophosphate Standard Deviation Across Sites									
Site	Jun	Jul	Aug	Sep	Nov	Dec	Standard Deviation	Mean	CV
OCH1	0.089	0.093	0.074	0.13	0.137	0.137	0.027871132	0.11	25%
MCK1	0.11	0.07	0.08	0.078	0.063	0.087	0.01631768	0.081333	20%
DC1	0.279	0.227	0.24	0.253	0.2595	0.266	0.018575297	0.254083	7%
LTLK1	0.066	0.062	0.098	0.082	0.147	0.18	0.047608473	0.105833	45%
HG1	0.068	0.057	0.081	0.111	0.102	0.146	0.032467933	0.094167	34%
OS0	0.086	0.087	0.084	0.083	0.087	0.091	0.002804758	0.086333	3%
OS1	0.081	0.084	0.08	0.0835	0.087	0.091	0.004054833	0.084417	5%
OS2	0.089	0.086	0.085	0.081	0.086	0.089	0.002966479	0.086	3%

Table 4. Orthophosphate standard deviation comparison

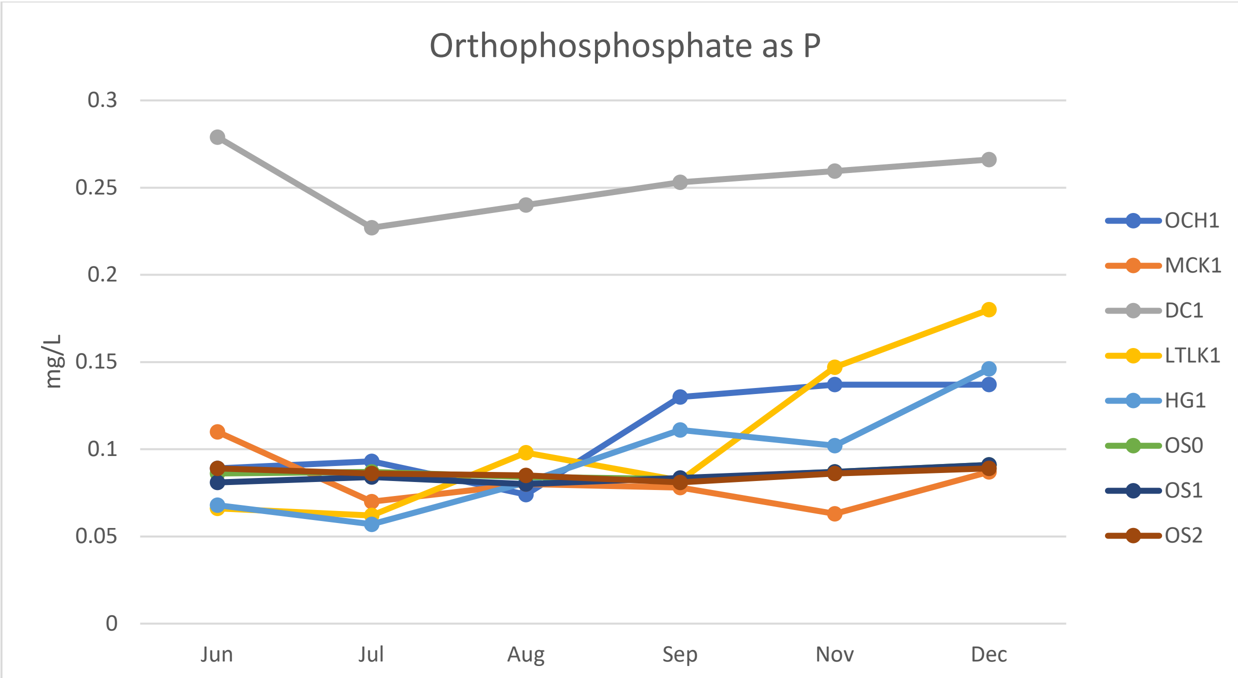


Figure 4. Orthophosphates as P across sites

<u>Total Phosphorus</u>

Dry Canyon is observed to have the highest mean in total phosphorus concentration across sites with the lowest being OS0 (Table 4). Lytle Creek displays the highest variance with 57% CV with Opal Springs sites lying between 2%-3%, continuing their trend of highly consistent nutrient concentrations.

Total Phosphorus Standard Deviation Across Sites									
Site	Jun	Jul	Aug	Sep	Nov	Dec	Standard Deviation	Mean	CV
OCH1	0.144	0.118	0.118	0.151	0.181	0.164	0.025083859	0.146	17%
MCK1	0.128	0.111	0.102	0.088	0.075	0.101	0.018302095	0.100833	18%
DC1	0.331	0.274	0.254	0.3355	0.37625	0.417	0.061059483	0.331292	18%
LTLK1	0.096	0.108	0.117	0.268	0.26	0.389	0.118214494	0.206333	57%
HG1	0.113	0.095	0.106	0.145	0.12	0.192	0.035342609	0.1285	28%
OS0	0.095	0.089	0.091	0.095	0.089	0.093	0.00275681	0.092	3%
OS1	0.085	0.089	0.087	0.0875	0.088	0.088	0.327784444	0.220917	2%
OS2	0.093	0.089	0.084	0.089	0.087	0.088	0.327346554	0.221833	3%

Table 4. Total Phosphorus standard deviation comparison.

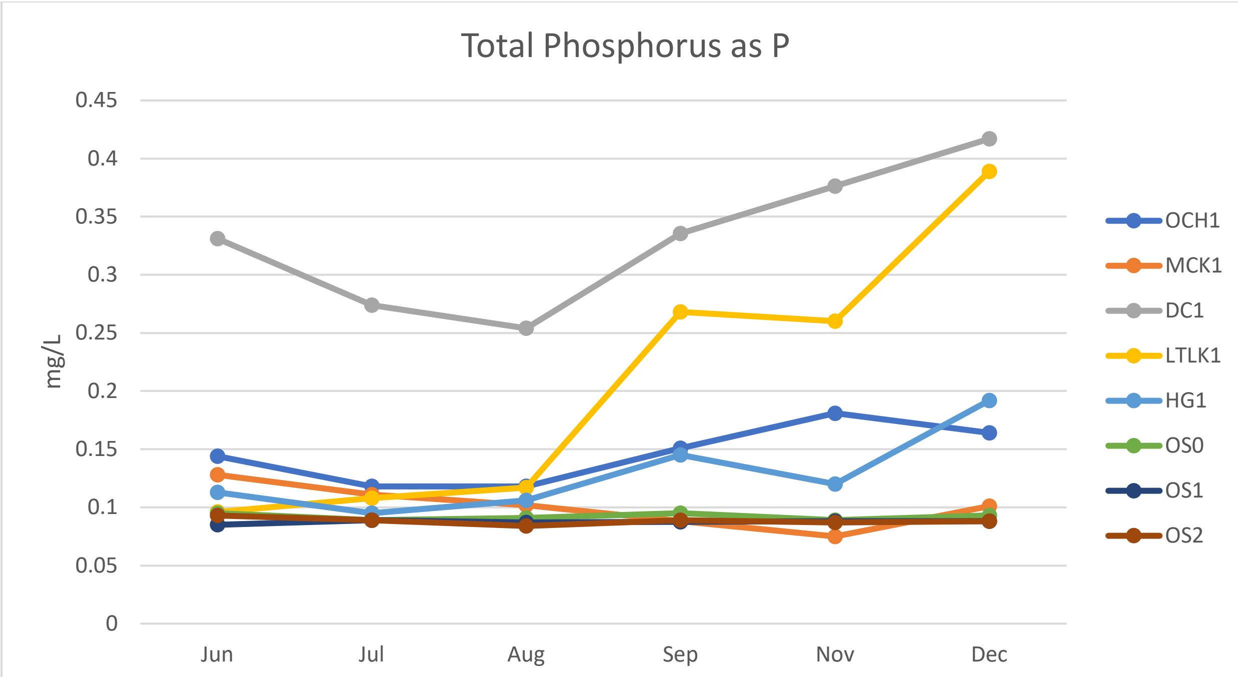


Figure 5. Total Phosphorus as P across sites

Nitrate + Nitrite

Lytle Creek is observed to have the highest mean across sites with McKay Creek relatively close behind (Table 5.) While means are somewhat close between the two, Lytle Creek displays higher variance with 68% CV. This test saw the highest variance across sites with High Gap having a standard deviation 123% of the site mean. OS1 also sees the highest degree of variance at the Opal Springs site with 16% CV. A large spike in August on High Gap is certainly affecting the variance for the site (Figure 5). It could be possible that the abnormality is the result of improper sampling or testing in the lab due to the trend continuing at a much lower value in September.

Nitrate + Nitrite as N Standard Deviation Across Sites									
Site	Jun	Jul	Aug	Sep	Nov	Dec	Standard Deviation	Mean	CV
OCH1	0.28	0.95	0.61	1.99	2.1	2	0.805268071	1.32166667	61%
MCK1	2.89	0.97	1.83	2.13	2.58	3.51	0.884000377	2.31833333	38%
DC1	0.36	0.1	0.08	0.11	0.125	0.14	0.103718369	0.1525	68%
LTLK1	1.45	0.57	0.72	3.09	5.27	5.48	2.212741889	2.76333333	80%
HG1	0.02	0.04	2.59	0.27	0.68	1.18	0.982825858	0.79666667	123%
OS0	0.18	0.2	0.18	0.17	0.17	0.17	0.011690452	0.17833333	7%
OS1	0.45	0.48	0.45	0.395	0.34	0.32	0.065147269	0.40583333	16%
OS2	0.18	0.18	0.18	0.17	0.19	0.18	0.006324555	0.18	4%

Table 5. Nitrate + Nitrite standard deviation comparison

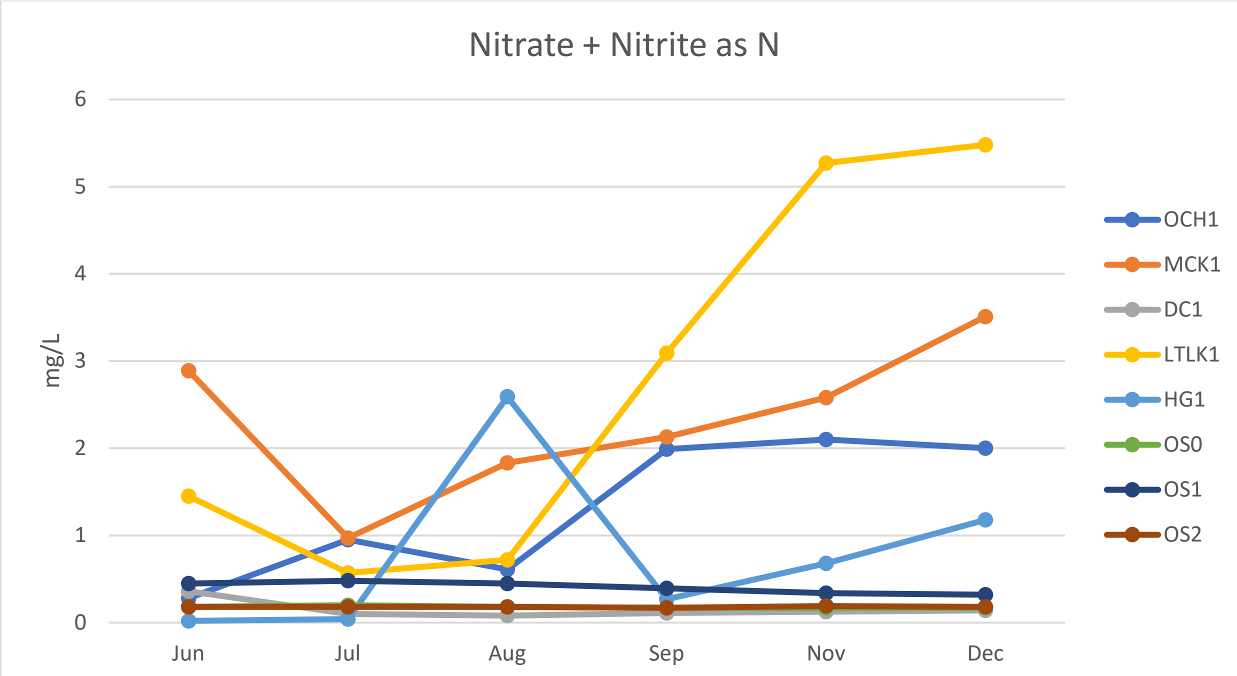


Figure 6. Nitrate + Nitrite as N across sites

5.0 Conclusions

5.1 Data Inferences & Interpretations

There is an increasing trend observed in phosphorus and nitrogen concentrations at the start of fall months, this could most likely be attributed to plant activity beginning to wind down for dormancy. Less uptake of nitrogen and phosphorus, two of the three macronutrients for plants (Nitrogen, Phosphorus, and Potassium), could result in more nutrients entering the waterways. These trends, however, are not present at Opal Springs sites, which is to be expected. Opal Springs is consistently supplied with water that has long residence times, it is anticipated that any recent or short-term nutrient inputs would have little to no effect on water quality in Opal Springs.

5.2 Discussion

Nutrient concentrations in the sampling run varied seasonally. Nitrate concentrations were highest during the fall and winter and lowest in the spring and summer, likely due to increased uptake rates associated with increased water temperature, aquatic vegetation, and algae densities. The most dramatic change in total nitrogen concentrations across all input streams was Lytle Creek, where a roughly six-fold increase from 1.13 mg/L in August to 7.1 mg/L in December was observed. A similar trend was observed in total phosphates as well at Lytle Creek, increasing from 0.1 mg/L in August to 0.4 mg/L, though at a lesser degree than total nitrogen.