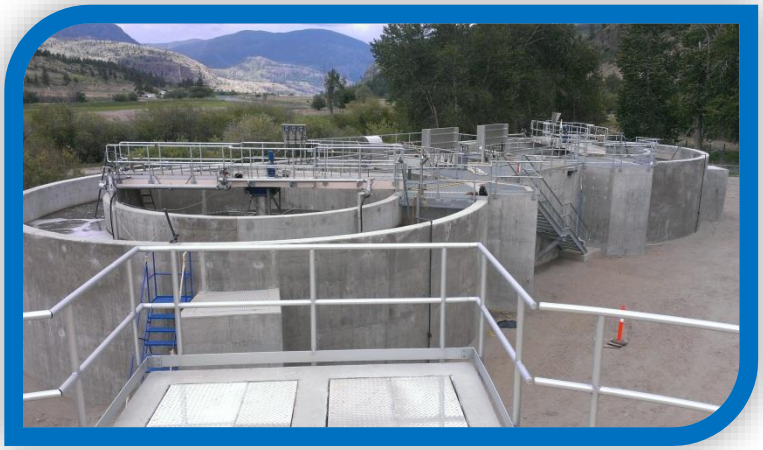
2022 Operations and Monitoring Report
Okanagan Falls Wastewater Treatment Facility and Polishing Wetland
Okanagan Falls B.C.



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EXECUTIVE SUMMARY

The Regional District of Okanagan-Similkameen is pleased to provide this report in conjunction with Larratt Aquatic for the Okanagan Falls Wastewater Treatment Facility (WWTF) located on Rail Road. All 2022 monitoring data and related data analysis by associated qualified professionals have been included in this report.

The Biological Nutrient Removal wastewater treatment facility and polishing wetland is located on Rail Road south of the community of Okanagan Falls. The Wastewater Treatment Facility has been in operation since 2013, while the polishing wetland began receiving effluent in the spring of 2021. Amendments made to Operational Permit OC106555 by Ministry of Environment to include the polishing wetland were received May 10, 2021. As per section 4.4b, no non-compliances occurred during the reporting period.

This facility produces highly treated effluent that is discharged directly into the Okanagan River adjacent to the treatment plant site, and/or discharged to a constructed polishing wetland that then discharges into Okanagan River. In 2022, 188,882.6 m^3 of treated effluent was discharged, with 79% (149,745.2 m^3) being discharged to Okanagan River and 21% (39,137.4 m^3) being discharged to the polishing wetland. Total flow into Okanagan River was 184,487.5 m^3 with 81% (149,745.2 m^3) discharged directly from the WWTF and 19% (34,742.3 m^3) discharged directly from the polishing wetland. Overall flow to Okanagan River was reduced by 4,395 m^3 or 2% in 2022 due to usage of the polishing wetland. The daily average flow rate of the Okanagan River was 1,750,440.4 m^3/day and average dilution factor was 4,196.

The effluent monthly 5-day carbonaceous biochemical oxygen demand (cBOD) and monthly total suspended solids (TSS) were consistently less than the maximum allowable concentrations of 10 mg/L in 2022.

Total phosphorus loadings released from the WWTF in 2022 were 38 kg/year. This is a 19% increase compared to 31 kg/year in 2021. Diversion of effluent through the wetland reduced the amount of total phosphorus discharged to Okanagan River to 34 kg/year; a 12% decrease. The maximum total phosphorus of the effluent grab sample was 0.443 mg/L P on March 1, 2022 and the maximum total phosphorus of the wetland outlet grab sample was 0.237 mg/L P on June 14, 2022. The annual average concentration for total phosphorus of the weekly effluent compliance grab samples was 0.204 mg/L P, which is at the allowable limit of 0.20 mg/L P. For the 257 effluent composite samples analyzed in-house for total phosphorus, the average was 0.206 mg/L P with a maximum of 0.739 mg/L P on June 13, 2022.

Total nitrogen loadings released from the WWTF in 2022 was 783 kg/year. This is an 8% increase compared to 725 kg/year in 2021. Diversion of effluent through the wetland reduced the amount of total nitrogen discharged to Okanagan River to 663 kg/year; a 15% decrease. The average total nitrogen was 4.15 mg/L N from the monthly effluent compliance samples, well below the average annual limit of 6.0 mg/L N. There were no exceedances of Total Daily Nitrogen limit of 10 mg/L in either the accredited laboratory data (maximum 6.36 mg/L N on October 4, 2022) or the in-house data for grab effluent samples (maximum 8.08 mg/L N on Dec 28, 2022). For in-house composite effluent samples, a maximum of 12.3 mg/L N was

measured on September 12, 2022. Total nitrogen concentrations were reduced in the polishing wetland to an average of 1.20 mg/L N.

The OC106555 maximum allowable concentration in the effluent for *E. coli* is 2.2 CFU/100 mL from April 15th to October 15th and 50 CFU/100 mL from October 16th to April 14th annually. All results from the outside laboratory for *E. coli* in the effluent for 2022 met the compliance limits for the entire year. Of the 54 effluent compliance samples, *E. coli* were detected nine times, with a maximum of 2 MPN/100mL on July 26 and August 16, 2022. This was not the case for *E. coli* in wetland outlet discharge samples; 8 of the 10 samples were positive for *E. coli* ranging from 192 MPN/100mL on August 24 to 5 MPN/100mL on September 26, 2022. These high values were attributed to plugging of the wetland sand filter that trapped and concentrated the *E. coli* from wildlife use within the wetland.

Effluent was discharged from the WWTF to the constructed wetland from May 17 until June 14th and then August 8th to September 26, 2022. Polished effluent was periodically discharged from the wetland between May 17 and October 8 by flowing through a sand filter to remove course organic material and fine silt prior to being discharged into the Okanagan River via one of the two existing outfall diffusers which was part of the original Okanagan Falls BNR WWTF construction. Since flow from the wetland is gravity flow, the height of the Okanagan River and sand filter plugging, reduced the number of days there was flow into and out of the wetland. Water quality data from three offsite domestic wells and one irrigation well located southeast and south of the constructed wetland were collected in 2022.

Since operation began in 2013, samples have been collected from Okanagan River 100 m upstream as well as 100 m and 500 m downstream of the WWTF to evaluate possible impacts of the treated effluent on Okanagan River. Similarly, water quality in Vaseux Lake was monitored by Larratt Aquatic Consulting, on the behalf of the Regional District of Okanagan Similkameen. Larratt Aquatic Consulting also provided statistical analysis of water quality and biota data to evaluate possible impacts on Okanagan River and Vaseux Lake from the treated effluent on either of these two water bodies.

In 2022, the WWTP effluent made up only 0.04% of the total flow, 0.39% of total nitrogen load and 0.32% total phosphorus load in Okanagan River at Okanagan Falls. Consequently, most of the annual nutrient loading into Vaseux Lake came from Okanagan River and internal nutrient recycling within the anoxic zone of Vaseux Lake. No statistical differences were detected for either total nitrogen or total phosphorus between upstream and downstream Okanagan River samples from 2013-2022. For Vaseux Lake (2013 to 2022) there were also no observed impacts from the WWTP operation on lake chemistry and biology.

As noted by Larratt Aquatics Consulting, there appears to be subtle increases in chloride and conductivity in Okanagan River downstream of the WWTP, but the differences were not statistically significant. Similarly, chloride concentration increased in Vaseux Lake from 2013 to 2022, but the largest source of anthropogenic chloride is typically road-salt. The maximum 2022 chloride concentrations in these freshwater bodies (7.56 mg/L 100 m downstream Okanagan River and 7.08 mg/L Vaseux hypoliminion) were far below aquatic life guideline of 600 mg/L chloride.

Sites downstream of the WWTP had higher abundance of pollution sensitive taxa than upstream of the WWTP during all sampled years. During half the sampled years (2014 to 2022, except 2015), benthic

invertebrates had greater species richness upstream than downstream of the WWTP. The WWTP may be impacting benthic invertebrates in some years, although the results contain high interannual variability that prevents strong conclusions on potential effects from the WWTP on the receiving environment.

Installation of a centrifuge purchased in 2020 was completed early 2022 and commissioning began in March. The two types of thickened sludge produced – Thickened Waste Activated Sludge (TWAS) and Fermented Primary Sludge (FPS) - were centrifuged to increase the average solids concentrations from 2.1% and 4.8% respectively to 17% average solids concentration of the centrifuged cake. The thickened sludges hauled to Penticton AWWTP for further dewatering in 2022 was estimated at 10,252 kilograms (dry weight). Centrifuged biosolids cake, 36,323 kg dry weight, were transported from WWTF to the Compost Facility at the Campbell Mountain Landfill in Penticton for further processing. In 2022, all sludge and biosolid samples met the requirements for Class B compost and biosolids as specified in Provincial Organic Material Recycling Regulations.

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1. INTRODUCTION AND SITE BACKGROUND

In March of 2013, the Biological Nutrient Removal (BNR) Wastewater Treatment Facility (WWTF) at 300 Rail Road began operation (Lot A, Plan EPP42355 District Lot 10 Similkameen Division of Yale District). The Okanagan Falls BNR WWTF is located 2 km downstream of the old de-activated extended aeration activated sludge wastewater treatment facility at Cedar Street. The sewage collection system consists of three lift pump stations, pressurized forcemains and gravity sewer mains that deliver sewage to a lift pump station at the old Facility at 1440 Cedar Street (Crown Reserve 11, Sub Lot 37, Similkameen Division of Yale District (S.D.Y.D.). The Cedar Street lift pump station pumps the sewage into a forcemain, which travels to the BNR Facility along Rail Road.

The old extended aeration activated sludge wastewater treatment plant, located on Cedar Street, ceased producing effluent in March 2013. Monitoring of well static levels at the rapid infiltration basins was discontinued in 2017 as the requirement of monitoring of these wells was for a minimum of 3 years after flow ceases. With no water present in 2014, 2015, and 2016, a notification was sent to MOE that the RDOS would no longer monitor the rapid infiltration basins. Acknowledgement of this notification was received December 31, 2017 from the Ministry of Environment BC.

The Okanagan Falls sewer system, facility and polishing wetland is owned and operated by the RDOS and serves approximately 1424 properties, including single-family, multi-family, commercial, recreational, and institutional uses. The BNR Wastewater Treatment Facility consists of screening, primary clarifier/fermenter, biosolids dewatering centrifuge, bioreactors, secondary clarifiers, filtration units, ultraviolet disinfection and discharge outlets to either the polishing wetland and/or the Okanagan River channel. The constructed polishing wetland is located across from the WWTF with a civic address of 2026 Hwy 97 (Plan KAP1738B District Lot 10 Land District 54 Similkameen Division of Yale District).

Figure 1 shows an aerial view of site locations of Cedar Street Pump Station (old extended aeration wastewater treatment facility), of the old associated rapid infiltration basin, of the BNR WWTF and associated constructed polishing wetland (aerial and parcel view) Okanagan River and of Vaseux Lake.

Okanagan Falls BNR Wastewater Treatment Facility, constructed polishing wetland and river outfall are operated under the Operational Certificate (OC) No 106555, issued in 2013 and amended in 2021 by the BC MOE under the provisions of the Environmental Management Act (EMA). Figure 2 shows the three Okanagan River monitoring locations and the four groundwater offsite private well locations. Figure 3 shows the Vaseux Lake surface monitoring location. This report was prepared in accordance with the Annual Reporting requirements outlined in Section 4.4 of OC 106555. Appendix A provides a copy of this Operational Certificate. This report presents the monitoring activities from January 1 to December 31, 2022.

Analysis of our environmental monitoring data has been carried out by qualified environmental professionals through Larratt Aquatic and is included within this report. The full report prepared by Larratt Aquatic is available in Appendix U.

Aerial view of Okanagan Falls Biological Nutrient Removal Wastewater Treatment Facility showing centrifuge dewatering facility under construction in 2021 and polishing wetland located on the right side of Rail Rd.

2. FACILITY AND REGULATORY SETTING

2.1 FACILITY DESCRIPTION

Highly treated effluent from the Okanagan Falls Biological Nutrient Removal WWTF is discharged directly into the Okanagan River immediately southwest of the treatment plant and/or into a constructed polishing wetland on the south side of Rail Road just across the road from the WWTF. The polishing wetland discharges directly into the Okanagan River also via one of the two outfall diffusers located on the WWTF site. The outfall diffusers consists of two laterals with duck billed diffuser ports that open only when flow is being discharged. Biosolid sludges are thickened first before being dewatered by a centrifuge onsite. Centrifuged cake is hauled offsite to be further processed into compost.

2.2 TOPOGRAPHY AND DRAINAGE

The regional topography is described as slightly hummocky and kettled. The general topography slopes to the southwest, towards the Okanagan River.

The Okanagan Falls BNR Wastewater Treatment Facility is located directly beside Okanagan River. At the beginning of construction, the top layer was determined to be loose silty sand and peat deposits for

approximately 4 meters. These layers were removed and replaced with 150mm minus well-graded pit run sand and gravel that was left to preload and naturally compact on site. The material below the added sand and gravel is soft compressible fine-grained soils up to a depth of 15 m.

2.3 REGULATORY SETTING

The Operational Certificate (OC) 106555 was issued to the RDOS by the BC MOE in 2013, under the provisions of the Environmental Management Act. Amendments were made to this OC in 2021 to include a seasonal polishing wetland (optionally operated between March 1st to November 30th) as authorized works of the wastewater treatment processes. A finalized amended Operational Certificate was received on May 10, 2021 from the BC MOE for OC 106555. According to Section 1.1.1 of the OC, the Facility is authorized to discharge effluent to the River Channel at a maximum rate of 2307 m^3/day in 2022. Appendix A contains OC 106555

The existing monitoring and reporting requirements outlined in the amended OC, include the following:

- Influent monitoring (E292549) – quarterly sampling and analysis.
- Sludge monitoring (E292609) – bi-annually sampling and analysis of biosolids, in addition to biosolids disposal quantities and locations.
- Effluent flow and monitoring after disinfection (E292449) – sampling and analysis of the effluent after disinfection, in addition to daily records of effluent volume discharged to the wetland and/or Okanagan River.
- Wetland flow and monitoring (E319911) – measurement, sampling and analysis of wetland water quality and flow to Okanagan River.
- Annual groundwater monitoring of four private wells (E324131, E324132, E324133 and E324134) located southeast and south of the wetland along HWY 97
- Surface water monitoring – measurement, sampling, and analysis of surface water in sites along Okanagan River at 100m Upstream (E295990), 100m Downstream (E295991), and 500m Downstream (E295992) and in Vaseux Lake (E220331)

3. WASTEWATER TREATMENT MONITORING AND RESULTS

Regional District of Okanagan Similkameen staff collected the following samples:

- Compliance influent, biosolids, effluent and wetland samples.
- Influent, effluent and wetland in-house samples for process control, both grab and composites.
- Groundwater samples from private wells southeast and south of wetland.
- Surface water samples from Okanagan River Channel upstream and downstream sites.

Larratt Aquatic Consulting staff collected the following samples

- Benthic samples from Okanagan River Channel upstream and downstream sites.
- Water chemistry and microflora samples from Vaseux Lake.

Collected samples were sent to independent accredited laboratories in accordance with the Operational Certificate. Wastewater, wetland, groundwater, surface water, biosolids and bioassay samples were sent to CARO Analytical Services. Benthic samples were sent to Cordillera Consulting for taxonomy identification and numeration and these results are included in the Appendices of Larratt Aquatics Consulting Report in Appendix U.

In accordance with the terms and conditions of the Environmental Data Quality Assurance Regulation (EDQA), Certificates of Analysis for analytical results are provided in the relevant appendices containing the laboratory data. Quality control samples collected in 2022 consisted of triplicate and field blank samples at the following locations: influent, effluent, wetland outlet, an offsite well and Okanagan River 100m Downstream. Triplicate samples were collected for each sludge or biosolids type (FPS, TWAS and Centrifuged Cake) and for both Vaseux Lake composite samples.

3.1 INFLUENT MONITORING AND RESULTS

In 2022, the Okanagan Falls BNR Wastewater Treatment Facility influent (E292549) was sampled quarterly for chemical analysis consisting of carbonaceous biochemical oxygen demand (cBOD), phosphorus and nitrogen parameters. Appendices B and C provides the database summary and laboratory data for 2022 influent samples respectively. Table 1 provides a summary of 2022, 2021 and 2020 influent data showing the averages, number of samples (n) and the standard deviation (Std. Dev.).

Table 1 Summary of Influent Samples

Parameter	Average	n	Std. Dev.
2022			
cBOD (mg/L)	248	6	54
Total Phosphorus (mg/L)	10.9	6	2.3
Ortho Phosphorus (mg/L)	4.37	6	1.40
Total Nitrogen (mg/L)	69.0	6	11.3
2021			
BOD (mg/L)	228	5	43
cBOD (mg/L)	275	1	
Total Phosphorus (mg/L)	7.77	7	1.93
Ortho Phosphorus (mg/L)	3.84	7	0.68
Total Nitrogen (mg/L)	63.4	7	14.1
2020			
BOD (mg/L)	227	6	34
Total Phosphorus (mg/L)	7.25	6	0.83
Ortho Phosphorus (mg/L)	4.27	6	0.45
Total Nitrogen (mg/L)	62.7	6	7.6

In 2022, quality control triplicate samples were collected in December by filling three 1-litre bottles in succession with influent using a 500 mL cup on a sampling pole. The triplicate data is included in the number of samples, n, in Table 1 above (i.e. quarterly samples, plus two replicates). A field blank was collected in April 2022 by exposing the field blank bottle and water to the influent sampling site. Deionized water supplied by the accredited laboratory was used as the field blank and all influent analytes were less than detection limit in the field blank. Quality Control data can be found in Appendix J.

3.2 BIOSOLIDS MONITORING AND RESULTS

Okanagan Fall BNR WWTF produces two thickened sludges; TWAS (thickened waste activated sludge) and FPS (fermented primary sludge). Samples were analyzed in 2022 for total solids and leachable metals as listed in OC 10655. As of March 2022, these thickened sludges were dewatered onsite via a centrifuge to produce a cake. The centrifuged cake was only sampled once in 2022 in triplicate. All of the sludge and biosolid samples met the requirements for Class B compost and biosolids from Organic Material Recycling Regulations, Schedule 4. Appendices D and E provides the database summary and laboratory data for these three biosolids (E292609). Table 2 is summary of 2022 leachable metal analyses from the FPS, TWAS and cake biosolids.

Quality control samples in 2022 consisted of triplicate samples collected in July for both the FPS and TWAS sludges by filling six sample containers per sample location in succession using a 500 mL cup on a sampling pole. A centrifuged cake triplicate sample was collected in December by collecting sludge cake from the auger using the extendable sample pole to collect three x 125 ml samples in glass jars. The triplicate data is included in the number of samples, n, in Table 2 below. Relative standard deviation of the replicate quality control samples can be found in Appendix J.

Table 2 Summary of Sludge (FPS and TWAS) and Centrifuged Biosolids Cake Samples

	2022			2022			2022		
	Fermented Primary Sludge (FPS)			Thickened Waste Activated Sludge (TWAS)			Centrifuged Biosolids Cake		
	Average	n	Std. Dev.	Average	n	Std. Dev.	Average	n	Std. Dev.
Total solids, %	4.8	6	2.6	2.1	6	0.2	19.9	3	0.5
Arsenic, ug/g	2.62	6	0.32	2.78	6	0.35	2.21	3	0.05
Cadmium, ug/g	0.838	6	0.101	0.747	6	0.050	0.667	3	0.029
Chromium, ug/g	16.6	6	1.7	8.4	6	1.7	15.0	3	0.6
Cobalt, ug/g	0.97	6	0.06	1.12	6	0.13	1.28	3	0.09
Copper, ug/g	221	6	19	209	6	15	204	3	11
Lead, ug/g	21.0	6	23.5	7.23	6	1.59	11.1	3	1.6
Mercury, ug/g	0.579	6	0.118	0.282	6	0.096	0.525	3	0.044
Molybdenum, ug/g	6.95	6	0.571	6.44	6	0.30	5.85	3	0.22
Nickel, ug/g	10.7	6	1.3	8.88	6	1.01	10.9	3	0.2
Selenium, ug/g	3.88	6	0.45	5.26	6	0.323	3.89	3	0.24
Zinc, ug/g	690	6	83	526	6	72	549	3	19

3.3 FLOWS: EFFLUENT, WETLAND AND OKANAGAN RIVER

In 2022, the average effluent discharged after disinfection was 513 m^3/day. The maximum rate of discharge from the WWTP after disinfection was recorded on August 7 at 771 m^3/day. However, the maximum combined rate of discharge from both the WWTP and the wetland to the Okanagan River was recorded on September 29, 2022 at 1081 m^3/day. Both of these maximums are below the maximum authorized effluent discharge rate of 2,307 m^3/day stipulated in Section 1.1.1 of the OC for the year 2022. The minimum flow from the WWTP after disinfection was recorded on April 26 at 250 m^3/day when Bioreactor 2 was being brought online (April 26 – 28) for the summer. During this process, flow was diverted to Bioreactor 2 instead of to the effluent channel, thereby reducing the discharge to Okanagan River. Bioreactor 2 was fully operational by May 7, 2022.

Operation of the polishing wetland commenced on May 17, 2022 by installing the stop logs at the sand filter and opening both inlet and outlet valves. With the wetland inlet valve open, effluent leaving the WWTP after disinfection will discharge into the polishing wetland before being discharged into the River via one of the two existing outfall diffusers which was part of the original Okanagan Falls WWTF construction. Flows from the wetland decreased around the middle of June and eventually stopped as Okanagan River flows at Station 08NM002 reached approximately 71 m^3/sec (6,132,882 m^3/day) around June 20th. As noted in the Polishing Wetland Operations and Maintenance Manual provided by Ducks Unlimited and Native Plant Solutions, high River levels greater than approximately 74 m^3/sec will prevent gravity drainage from the wetland. Okanagan River flows did not drop below 71 m^3/sec (6,132,882 m^3/day) until about a month later

in July (see Appendix G for flow data and graphs). During this period of high River flows, the wetland inlet valve was closed (June 14th) to prevent wetland levels from exceeding normal operational levels. Operations staff did not re-open the wetland inlet valve until August 8th for a few days before closing it again. On August 18th the inlet valve was opened again until it was closed on September 26th. In total 39,137.4 m^3 of effluent was discharged to the wetland between May 17th and September 26th and 34,742.3 m^3 was discharged from the wetland to Okanagan River from May 17th to October 8th, 2022. Approximately 4,395 m^3 or 2% of effluent was diverted from discharging into Okanagan River in 2022 by polishing wetland usage (Appendix G). Flow to Okanagan River ranged from 6 m^3/day when the constructed wetland was not discharging, but receiving almost all of the flow from the WWTF to 1081 m^3/day when the wetland was not receiving any flow but still discharging and all of the WWTF flows were both being discharged to Okanagan River.

A summary of the total, average, minimum and maximum flows from the WWTP to wetland and/or Okanagan River and from wetland to Okanagan River has been summarized in Table 3 below. Figure 4 graphs 2022 monthly effluent and wetland flows, while daily flow data and graphs are in Appendix G.

Table 3 Summary of Effluent and Polishing Wetland Flows

	From WWTP to Wetland	From WWTP to Okanagan River	From Wetland to Okanagan River	Total WWTP Effluent	Total Effluent and Wetland flows to Okanagan River
Average, m^3/day	466	415	255	513	505
Minimum, m^3/day	0	0	0	250	6
Maximum, m^3/day	695	771	672	771	1,081
Total, m^3/year	39,137.4	149,745.2	34,742.3	188,882.6	184,487.5
Number of days	84	363	136	365	365

From data supplied by Environment Canada, Water Office,[1] the average daily flow in Okanagan River at Station 08NM002 was 1,750,440 m^3/day, with maximum flow 6,417,796 m^3/day occurring on June 22nd and minimum flow 488,931 m^3/day occurring on January 4th, 2022. Dilution factors in 2022 ranged from a maximum of 252,765 on May 19th to a minimum of 745 occurring September 29th, with an average dilution factor of 4,196. Table 4 provides a summary of 2022 to 2020 WWTP effluent flows after disinfection and Okanagan River flows. Daily 2022 flows are in Appendix G. Figure 5 graphs monthly effluent flows after disinfection for 2020 to 2022.

Table 4 Summary of Effluent and Okanagan River Flows (Station 08NM002)

	Flow to Okanagan River From Effluent and/or Wetland	Okanagan River Flow (Station 08NM002)	Dilution Factor = (OK River + WWTP) / WWTP
2022			
Average, m^3/day	505	1,750,440	4196
Minimum, m^3/day	6	488,931	745
Maximum, m^3/day	1,081	6,417,796	252,765
Total, m^3/year	188,488	638,910,739	
2021			
Average, m^3/day	498	1,264,217	27,261
Minimum, m^3/day	0.5	458,371	839
Maximum, m^3/day	1562	3,100,496	6,077,248
Total, m^3/year	181,707	461,439,419	
2020			
Average, m^3/day	542	2,938,440	10,531
Minimum, m^3/day	9	897,325	1,124
Maximum, m^3/day	1,113	6,894,176	315,877
Total, m^3/year	198,497	1,075,469,017	

3.4 EFFLUENT AND WETLAND MONITORING AND RESULTS

Effluent pH and temperature were measured continuously via an online HACH Digital PEEK pH/Temperature probe located in the treated effluent channel. Effluent (E292449) samples for analysis by an independent accredited laboratory were collected in appropriate laboratory-supplied sample containers and preserved as required by RDOS staff. Samples were submitted under chain-of-custody protocol to Caro Analytical Services for analysis as follows:

- weekly for chemical oxygen demand (COD), ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen, total phosphorus, orthophosphorus, UV transmittance at 254 nm, Fecal Coliforms and E. Coli.;
- monthly for carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids, organic nitrogen, total kjeldahl nitrogen, total nitrogen, dissolved total phosphorus and pH;
- quarterly for alkalinity, conductivity, hardness, total metals and common anions.
- annually for toxicity testing, 96-hour RBT single concentration

The summary statistics provided in Table 5 are from the weekly and/or monthly samples submitted to an independent laboratory with the exception of pH and temperature, which are based on daily 24-hour average online results. Complete effluent database summaries and laboratory reports are presented in Appendices H and I respectively. Annual toxicity bioassay was completed on July 11, 2022 and results are presented in Appendix K. There was a ten percent mortality rate (i.e. one fish out of ten fish died) in effluent concentration of 100%.

Table 5 Effluent Water Quality Summary Statistics

Parameter	Average	n	Std. Dev.	Minimum	Maximum
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$) (mg/L)	4.0	14	1.6	2.3	7.8
Total Suspended Solids (mg/L)	2.1	17	1.1	<2.0	4.6
pH, daily online measurement	6.92	365	0.17	6.37	7.24
Temperature, (°C) daily online measurement	15.6	365	4.5	8.4	22.9
Ammonia-Nitrogen as N (mg/L)	0.919	54	1.15	0.096	4.79
Nitrate-Nitrogen as N (mg/L)	2.11	54	1.96	<0.010	7.51
Nitrite-Nitrogen as N (mg/L)	0.104	54	0.095	<0.010	0.442
Total Kjeldahl Nitrogen, (mg/L)	1.92	14	0.66	1.13	3.51
Organic N, (mg/L)	1.25	14	0.41	0.64	1.90
Total Nitrogen, (mg/L)	4.15	14	1.62	1.87	6.36
Orthophosphate as P (mg/L)	0.0351	54	0.0443	<0.0050	0.199
Total Phosphorus, (mg/L)*	0.204	68	0.083	0.0811	0.443
E. Coli, (MPN/100mL)	<1	54	0	<1	2

* Includes total phosphorus data from both APHA 4500 and ICPMS/ICPOES analytical methods

Table 6 provides comparison of the OC 106555 nutrient limits with the effluent compliance samples collected after disinfection and sent to the independent laboratory for analyses.

Table 6 Effluent Compliance Samples 2022 Summary Compared to OC Requirements

Parameter	OC limit	WWTP (average)	WWTP (maximum)
Carbonaceous Biochemical Oxygen Demand ($cBOD_{5)}$ (mg/L)	10 mg/L Maximum	4.0	7.8
Total Suspended Solids (mg/L)	10 mg/L Maximum	2.1	4.6
Total Phosphorus, Maximum Annual Average	0.20 mg/L	0.204	
Total Phosphorus, Maximum Daily Concentration	2.0 mg/L		0.443
Total Phosphorus, Total Annual Discharge	300 kg/yr.		38.3
Total Nitrogen, Maximum Daily Concentration	Less than 10 mg/L		6.36
Total Nitrogen, Annual Average	6.0 mg/L	4.15	
E. Coli, April 15 to October 15	2.2 CFU/100 mL	<1	2
E. Coli, October 16 to April 14	50 CFU/100 mL	<1	1

Effluent quality control samples in 2022 consisted of a set of triplicate effluent samples and a field blank sample analyzed for weekly, monthly and quarterly parameters as defined above. The field blank was collected on April 19, 2022 by attaching the required bottles to the sampling pole, removing the lids, and lowering the sample pole with bottles attached into the effluent channel just after disinfection, but not letting the bottles touch the water. The bottles were then removed from the sample pole and filled with de-ionized water supplied by an independent laboratory and preserved as required immediately in the field. Triplicate samples were collected on December 6, 2022. The following protocol was used to collect the triplicate effluent samples.

- Disinfect sampling pole with a 500 mL cup with 70% to 90% ethanol,
- Sample pole was dipped into the effluent channel after the UV system, rinsed once with the effluent, dipped again to collect the sample and quickly poured the sample into the bacteriological bottles and replace caps.
- Repeated the above with the 1 L bottles
- Repeated the above with the 125 mL sample bottles
- Add required preservatives to sample bottles, once back in the WWTP in-house laboratory.

The field blank sample was below detection limit for all nutrients and total metals, except for total sodium that was detected at 0.12 mg/L Na. The detection limit for total sodium is <0.10 mg/L Na. The average sodium in the effluent was 93.6 mg/L; two orders of magnitude above the sodium detected in the field blank sample. Database summary of quality control effluent and field blank samples are in Appendix J.

In-house effluent (E292499) sampling consisted of grab and composite samples monitored for total phosphorus, reactive orthophosphate, ammonia, nitrate, nitrite, total nitrogen, pH and temperature. A HACH Sigma SD900 composite sampler with a 4-bottle swing arm configuration programmed to collect 48 samples per bottle was used to collect approximately 100 mL of effluent sample every 30 minutes from the effluent channel. The use of a swing arm with multiple bottle configuration minimizes the chance of missed composite samples. Grab samples were taken from the effluent channel by dipping sample bottles or a sample cup secured onto the end of a sample pole into the effluent channel. With the exception of pH and temperature, nutrient analyses were performed on a HACH DR3900 Spectrophotometer using associated Test-N-tube or powder pillow methodologies for ammonia, nitrate, nitrite, total nitrogen, orthophosphate and total phosphorus. pH and temperature were recorded using online HACH Digital PEEK pH/temperature probe in the effluent channel for continuous monitoring via SCADA output. Continuous effluent monitoring for ammonia, reactive orthophosphate, and nitrate plus nitrite was performed using a ChemScan online analyzer with output to SCADA. Appendix L contains 2022 raw data, graphs and summary statistics for in-house grab and composite effluent samples, online nutrient monitoring data and independent accredited laboratory effluent data. Data reported as less than detection limit were treated as a zero for the purpose of graphical representation.

Monitoring requirements and frequencies from the wetland outlet (E319911) when discharging to the Okanagan River during the commissioning phase April 30, 2021 to November 20, 2022 are listed in Section 3.5.2.2 of the amended OC 10655 and have been summarized below.

- weekly for temperature and pH using a meter and a grab sample for total phosphorus
- bi-weekly grab sample for *E. coli*.;
- monthly grab sample for carbonaceous biochemical oxygen demand ($cBOD_5$) ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen organic nitrogen, total kjeldahl nitrogen, total nitrogen, and total suspended solids;
- annual grab sample for total metals, and common cation and anions.

A portable peristaltic pump was used to draw water through the wetland outlet sample port into a container where temperature and pH were measured continuously using a portable temperature/pH meter. Once temperature had stabilized, wetland outlet (E319911) samples for analysis by an independent accredited laboratory were collected in appropriate laboratory-supplied sample containers and preserved as required by RDOS staff. Samples were submitted under chain-of-custody protocol to Caro Analytical Services for analysis.

In 2022, wetland outlet triplicate samples were collected August 24 and analyzed for *E. Coli.*, carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids, nutrients, total metals, and common anions. For the field blank sample, collected October 18, all parameters analyzed for, *E. Coli.*, carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids, and nutrients, were below the laboratory detection limits. Quality control data of triplicates and field blanks for wetland outlet samples has been summarized in Appendix J.

Data in Appendix M to Appendix O contains field parameters and independent accredited laboratory data and reports for wetland outlet samples collected in 2022. Table 7 below provides a summary of the water quality data from samples collected from the wetland outlet sampling port when the wetland was discharging to Okanagan River.

Table 7 Polishing Wetland Water Quality Summary Statistics

Parameter	Average	n	Std. Dev.	Minimum	Maximum
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$) (mg/L)	4.0	7	0.5	<5.3	6.3
Total Suspended Solids (mg/L)	3.9	7	2.8	<2.0	7.2
pH, field measured parameter	7.27	11	0.21	6.72	7.61
Temperature, (°C) field measured parameter	15.9	11	2.4	11.9	19.9
Ammonia-Nitrogen as N (mg/L)	0.084	7	0.034	<0.050	0.131
Nitrate-Nitrogen as N (mg/L)	0.059	7	0.103	<0.010	0.274
Nitrite-Nitrogen as N (mg/L)	0.008	7	0.008	<0.010	0.027
Total Kjeldahl Nitrogen, (mg/L)	1.14	7	0.303	0.687	1.40
Organic N, (mg/L)	1.06	7	0.324	0.556	1.34
Total Nitrogen, (mg/L)	1.20	7	0.246	0.755	1.40
Total Phosphorus, (mg/L)	0.097	13	0.0645	0.0244	0.237
E. coli, (MPN/100mL)	73	10	83	<1	192

In addition to the samples sent to an independent accredited laboratory, field parameters and in-house samples were collected by RDOS staff from the wetland outlet port when wetland was discharging to the Okanagan River. Field parameters were measured using a HACH HQ40d portable temperature and pH meter. In-house wetland outlet grab samples were analyzed for total phosphorus, ammonia, nitrate, nitrite,

total nitrogen on a HACH DR3900 Spectrophotometer using associated Test-N-tube. Total suspended solids were measured using gravimetric method with AH934 glass fiber filter discs dried at 103 °C to 105 °C as per Standard Methods 2540 D, 22nd Edition. Field parameters and in-house data can be found in Appendix M along with the independent accredited laboratory data.

Figures 6 to 12 show 2020 to 2022 time series plots for compliance parameters listed in Table 6, plus the total phosphorus and total nitrogen in-house analysis on effluent composite samples. Data that was reported as below the detection limit are plotted as zero on the time series plot.

Since operation began in 2013, there have been no exceedances of the maximum daily concentration (10 mg/L) of Biological Oxygen Demand (BOD_5) (2013 to 2021) or of carbonaceous Biochemical Oxygen Demand ($cBOD_5$) (2021 and 2022) of the effluent sampled monthly. The May 2021 OC 106555 amendment resulted in a change from Biological Oxygen Demand (BOD_5) to carbonaceous Biochemical Oxygen Demand ($cBOD_5$), with the maximum remaining unchanged at 10 mg/L for $cBOD_5$. Since 2020, we have requested the independent accredited laboratory use the lowest detection limit for BOD and cBOD on effluent to provide data that are more meaningful. Depending on the dilution ratio used by the independent accredited laboratory when performing this test, detection limits ranged from <4.6 mg/L to <7.6 mg/L and results ranged from 2.3 mg/L to 7.8 mg/L for effluent in 2022. The BOD_5 and $cBOD_5$ values from 2020 to 2022 are plotted in Figure 6. As expected in low ammonia samples, the difference between BOD_5 and $cBOD_5$ values is small.

Similarly, since operation began in 2013, there have been no exceedances for the maximum daily concentration, 10 mg/L, of Total Suspended Solids (TSS) of the effluent samples. The effluent TSS results from the independent accredited laboratory ranged from <2 mg/L to a maximum of 4.6 mg/L with an average of 2.1 mg/L. in 2022. Monthly wetland TSS concentrations while discharging to Okanagan River when initially sampled in May were low, but August monthly sample averaged 6.9 mg/L. The TSS results for the treated effluent from 2020 to 2022 and for the wetland outlet for 2021and 2022 are presented in Figure 7.

In 2022, the annual average total phosphorus from effluent grab samples sent to independent laboratory was 0.204 mg/L P, which is at the maximum allowable annual average for total phosphorus of 0.20 mg/L. There were no exceedances of the maximum daily allowable concentration of 2.0 mg/L P in 2022. The total phosphorus discharged from WWTP samples collected after disinfection was 38 kg/yr; almost 8 times lower than the allowable annual discharge of 300 kg/yr. The total phosphorus in wetland outlet samples averaged 0.097 mg/L P; approximately 2.1 times lower than the average 2022 total phosphorus concentration in WWTP effluent. Figure 8 shows the trend of total phosphorus levels in effluent and wetland outlet grab samples analyzed by CARO Analytical Services

As shown in Figure 9, total phosphorus levels in the effluent composite samples were often elevated since November 2021 compared to the previous 2020 and 2021 data. This is reflected in the increase in the rolling average total phosphorus in the daily effluent composite increasing from a low of 0.13 mg/L P in

summer of 2020 to 0.19 mg/L P as of October 9, 2022. Daily effluent composite total phosphorus analyzed in-house ranged from 0.070 to 0.739 mg/L P, with an average of 0.206 mg/L P for the 257 samples analyzed in-house from January 1st until October 10th, 2022. The daily effluent composite samples were analyzed in-house using HACH TNT 843 method on a HACH DR3900 spectrophotometer. The in-house composite effluent data is in Appendix L.

Figure 10 plots the effluent total nitrogen data from 2020 to 2022 and the wetland outlet from 2021 to 2022. This graph illustrates the effluent total nitrogen monthly or weekly data, while variable, shows an overall trend of remaining below the 6 mg/L annual average since 2020. In 2022, the plant achieved an annual average of 4.15 mg/L N for the compliance samples analyzed by independent accredited laboratory. None of the accredited laboratory results, nor any of the in-house effluent grab samples exceeded the maximum allowable daily concentration of 10.0 mg/L N in 2022. Monthly total nitrogen concentrations discharged from the wetland averaged 1.2 mg/L N; approximately 3.5 times lower that the average 2022 total nitrogen concentrations in WWTP effluent.

The rolling average total nitrogen has shown a slight increase in the daily effluent composite samples analyzed in-house since the spring of 2022 compared to previous data in 2020 and 2021. There has been a large range in 2020 to 2022 values (1.76 to 12.3 mg/L N) as shown in Figure 11. In 2022, daily effluent composite in-house total nitrogen exceeded the total nitrogen OC maximum of 10 mg/L N on four occasions - once April 30th and for four days in September 7 to 10, 2022, with a maximum of 12.3 mg/L N in September 9th effluent composite sample. A minimum of 2.3 mg/L N was measured March 4th, 2022. The average total nitrogen was 5.39 mg/L N for the 241 effluent composite samples analyzed from January 1st to September 22nd, 2022. Total nitrogen in-house samples (grab and composite) were analyzed using HACH TNT 826 method on a HACH DR3900 spectrophotometer. The in-house composite effluent data is in Appendix L.

Figure 12 is a 2020 to 2022 time series plot of weekly effluent *E. coli* data and 2021 to 2022 *E. Coli* wetland discharge data. Please note the two different y-axis scales on this graph; left-side for effluent *E. Coli* 0 to 50 scale and right-side for wetland *E. Coli* 0 to 1500 scale. The two different scales on this graph were required due to the large difference in *E. Coli* MPNs between the effluent after UV disinfection (<1 to 2 MPN/100mL) and the wetland outlet *E. Coli* MPNs (<1 to 1410 MPN/100mL). In 2022, there were no exceedances of *E. Coli* in effluent results; a maximum of 2 MPN/100 mL was recorded on July 26th and August 16th, 2022. In 2022, wetland outlet *E. Coli.* maximum of 192 MPN/100mL was recorded on August 24th. Again this year, drainage problems were experienced in the sand filter, resulting in pooling water on the sand filter surface.

The water quality of the treated effluent from the Okanagan Falls WWTF has not exceeded the OC maximums and/or annual averages for biochemical or carbonaceous biochemical oxygen demand, total suspended solids, total phosphorus, total nitrogen and *E. coli* concentrations. However, the increasing annual average 2022 trends and loadings for both total phosphorus and total nitrogen indicates nutrient removal this year were below levels achieved in 2021.

In 2022, the use of the constructed polishing wetland was limited by its gravity drainage design when River flows were above approximately 71 m^3/sec and by sand filter drainage problems. Effluent was discharged to the wetland for 76 days between May 17 and September 26 (Appendix G); half the number of days in 2021 of 158 days. As noted above, average concentrations for total phosphorus was approximately 2.1 times lower in the wetland outlet than the effluent discharge. For total nitrogen, the wetland outlet average concentration was approximately 3.5 times less than the average effluent total nitrogen concentration. This reduction in nutrient concentrations by the polishing wetland, in conjunction with reduced flows to Okanagan River, lowered nutrients loads to Okanagan River as discussed below.

Nutrients loading to Okanagan River were reduced by 11% for total phosphorus and by 15% for total nitrogen by the polishing wetland in 2022 due to both a reduction in phosphorus and nitrogen concentrations and flows into Okanagan River. However, carbonaceous biochemical oxygen demand (cBOD) loadings were only reduced by approximately 2%, while total suspended solids loadings to Okanagan River were increased by the wetland discharges by 13%, as tabulated in Table 8 below.

Table 8 Nutrient Loadings from WWTP and Polishing Wetland (kg/yr.)

Parameter (kg/yr.)	Total Loadings from WWTP after disinfection	Loadings from WWTP to Okanagan River	Loadings from Polishing Wetland to Okanagan River	Total Loadings to Okanagan River	Reduction in Loadings to Okanagan River	Reduction in Loadings to Okanagan River, %
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	756	599	139	738	18	2
Ammonia-Nitrogen as N	173	138	4	142	31	18
Nitrate-Nitrogen as N	399	316	2	318	81	20
Nitrite-Nitrogen as N	20	16	0.4	16	4	19
Total Kjeldahl Nitrogen	362	287	40	327	35	10
Organic Nitrogen	237	188	37	225	12	5
Total Nitrogen	783	621	42	663	120	15
Total Phosphorus	38	30	3.4	34	4.6	12
Total Suspended Solids	397	314	135	450	-53	-13

4. GROUNDWATER AND SURFACE WATER MONITORING AND RESULTS

In 2020, an independent hydrogeologist identified four groundwater wells to be sampled to provide background data of groundwater southeast and south of the constructed wetland across from Okanagan Falls BNR WWTF. The BC Ministry of Environment subsequently incorporated these four wells to be sampled annually into the amended OC106555. The location of the four properties and constructed wetland are shown in Figures 1 and 2. There were civic address errors for the wells with Plate ID17895 and Plate ID 37318 that were not identified until the fall of 2021, after the amended OC 106555 had been issued May 2021. The correct civic address for well with Plate ID 17895 (EMS ID E324132) is 2050 Hwy 97 and the correct civic address for well with Plate ID 37318 (EMS ID E324133) is 2100 Hwy 97.

Surface water monitoring required under OC 10655 includes four sites - three on Okanagan River and one in Vaseux Lake. Table 9 summarizes the groundwater well and surface water monitoring sites, while Figures 1 to 3 show the location of the Ok Falls WWTF, the constructed polishing wetland, groundwater well locations and the surface water sampling locations.

Table 9 Groundwater Wells and Surface Water Monitored Locations

Monitored Location	EMS #	Description	2022 Sampling Frequency
1998 Hwy97	E324131	Domestic well southeast of constructed wetland.	Annually (Fall 2022)
2050 Hwy 97 (2126 Hwy 97 civic address was incorrect in 2020)	E324132	Domestic well southeast of constructed wetland. Well Plate ID 17895	Annually (Fall 2022)
2100 (2150A Hwy 97 civic address was incorrect in 2020).	E324133	Irrigation well in vineyard south of constructed wetland. Well Plate ID 37318	Annually (Fall 2022)
2150 Hwy 97	E324134	Domestic well south of constructed wetland.	Annually (Fall 2022)
Ok River 100m Upstream	E295990	Northwest of BNR WWTP	Monthly*
OK River Downstream 100m of diffuser	E295991	South of diffuser at BNR WWTP	Monthly*
OK River Downstream 500m of diffuser	E295992	South of diffuser at BNR WWTP	Monthly*
Vaseux Lake	E220331	Central deep location (ice off to November)	Monthly

*In addition to the monthly samples, microbiological samples are required weekly for these three sites from May to September.

4.1 GROUNDWATER AND SURFACE WATER MONITORING METHODS

For groundwater well sampling, field parameters were continuously monitored during a sampling event using an YSI Pro Plus multi-meter with a flow-through cell allowing a steady flow of groundwater from the well over the probes. Field parameters for conductivity, temperature and pH were allowed to stabilize before any samples were collected to ensure samples were representative of the groundwater and all piping has been adequately flushed. RDOS staff followed the sampling protocol outlined below.

- Disinfect yard hydrant by well or outside hose bib prior to attaching a splitter to hose bib. A hose was attached to one side of the splitter to allow groundwater to be flushed from the well away

from the well head, while also allowing control of flow out of the other side of the splitter when sample were collected.
- Field measurements of temperature, dissolved oxygen [DO], conductivity [EC], total dissolved solids [TDS], pH and oxidation reduction potential [ORP] were recorded every 5 minutes.
- Samples were collected once conductivity, temperature and pH readings from the multi-meter had stabilized.
- Groundwater samples were collected in the appropriate laboratory-supplied sample containers and preserved as required.
- Groundwater samples were submitted under chain-of-custody protocol to Caro Analytical Services for analysis of general chemistry parameters, anions, nutrients, microbiology, dissolved metals and total metals.

In order to ensure that representative surface water quality samples were obtained from Okanagan River upstream and downstream of the WWTF, and that no contamination of the recovered samples occurred, the following sampling protocols were adhered to during the monitoring events by RDOS staff:
- Disinfect, with 70% to 90% ethanol, the sampling pole prior to attaching coliform sample bottle(s).
- Collect Okanagan River samples in areas of the surface water body that were representative of the surface water body conditions.
- Collect samples approximately 15 centimeters below the surface with the coliform sample bottle completely submerged to prevent floating debris from entering the sample bottles.
- Collect all other water quality parameters using a 2 L beaker attached to sampling pole rinsed three times in the River before a sample was drawn to pour into the appropriate laboratory-supplied sample containers and preserved as required.
- Submit samples, under chain-of-custody protocol, to Caro Analytical Services for analysis of general chemistry parameters, anions, nutrients, microbiology and total metals.

During each monthly Okanagan River monitoring event, field parameters for temperature, pH, dissolved oxygen [DO], oxidation-reduction potential [ORP], conductivity [EC] and total dissolved solids [TDS] were measured using an YSI Pro Plus multi-meter submersed in River water collected in a 2L beaker attached to a sampling pole at each sampling location. As defined in OC106555, water quality samples were collected monthly for chemical parameters and coliforms, with additional weekly coliform sampling from May to September. A summary of 2022 water quality for Okanagan River samples can be found in Appendix Q, while Appendix R contains the independent laboratory reports for each sampling event.

Sampling at Vaseux Lake was carried out by Larratt Aquatic on behalf of the Regional District for the collection of water chemistry, microflora and field parameters (Secchi depth, conductivity, density, dissolved oxygen, pH, salinity, temperature and total dissolved solids) for the identified sampling location on Vaseux Lake. In 2022, sampling started in March and continued monthly until November.

- Lake water samples were collected at the central deep sampling location is identified as EMS#220331 and has site coordinates of Lat 49.287684, Long -119.529662.
- Sample were collected in the appropriate laboratory-supplied sample containers and preserved as required.
- Water chemistry samples were collected within the epilimnion and hypolimnion of the lake. Two composite samples were collected – one at 1, 5 and 10m representing the epilimnion and the other at 20, 22 and 24m representing the hypolimnion.
- Water chemistry samples were submitted under chain-of-custody protocol, to Caro Analytical Services for analysis of general chemistry parameters, nutrients, total metals, and chlorophyll A.
- Field parameters (Temperature, Salinity, Density, Dissolved Oxygen, pH, Total Dissolved Solids and Conductivity) were taken using a multi-meter probe at one-meter intervals from the water surface to the bottom sediments.
- Algae samples were collected at 0, 10 and 20 m depths and their algae contents (Diatoms, Yellow-Brown Algae, Green Algae, Cyanobacteria, and Flagellates) were identified and enumerated by Larratt Aquatics.
- Phytoplankton and zooplankton were sampled qualitatively for type and abundance by towing an 80 *u*m net at 1m below the water surface. Larratt Aquatics analyzed the samples using light microscopy.

In addition to Vaseux Lake sampling, Larratt Aquatics conducted annual benthic invertebrate sampling at the three sites in Okanagan River in October 2022. Benthic samples were submitted by Larratt Aquatics to Cordillera Consulting for taxonomic sorting and identification.

4.2 GROUNDWATER AND SURFACE WATER MONITORING RESULTS

All four wells, three domestic wells at 1998 Hwy 97, 2050 Hwy 97 and 2150 Hwy 97 and an irrigation well located at 2100 Hwy 97 were sampled once in the fall, September 20, 2022. Appendix O contains the water quality database summaries for each of these four wells, while Appendix P contains the independent laboratory reports. Comparisons were made to federal Guidelines for Canadian Drinking Water Quality (GCDWQ), BC Approved and Working Water Quality Guidelines (BCAWQG and BCWWQG), BC Source Drinking Water Quality Guidelines (BC SDWQG), and BC Contaminated Site Regulations Generic Numerical Water Standards (CSR). Drinking water quality exceedances for these four wells are summarized in Table 10 below.

Quality control samples were collected at one of the four offsite groundwater wells listed in Table 9. In 2022, a triplicate and field blank was collected from well located at 2050 Hwy 97 on September 20, 2022. Database summary of quality control triplicates and field blank samples are in Appendix J.

Table 10 Summary of 2022 Water Quality Exceedances in Groundwater Wells South-east and South of Polishing Wetland

Sampling Location	Guideline[1]	Exceedances[2]
1998 Hwy 97	GCDWQ MAC	Arsenic (dissolved), Arsenic (total), Fluoride
	GCDWQ AO	Total dissolved solids [F]
	BCAWQG L	Arsenic (dissolved), Arsenic (total), Fluoride
	BCAWQG I	Chloride, Fluoride
	BCWWQG I	Conductivity [F], Conductivity, Total dissolved solids [F]
	BC SDWQG MAC	Arsenic (dissolved), Arsenic (total), Fluoride
	CSR IW	Chloride, Fluoride
	CSR LW	Arsenic (dissolved), Fluoride
	CSR DW	Arsenic (dissolved), Arsenic (total), Fluoride, Lithium (dissolved), Lithium (total)
2050 Hwy 97	GCDWQ MAC	Fluoride
	GCDWQ AO	Manganese (dissolved), Manganese (total), Total dissolved
	BCAWQG L	Fluoride, Molybdenum (dissolved)
	BCAWQG I	Chloride, Fluoride, Molybdenum (dissolved), Molybdenum (total), Selenium (dissolved), Selenium (total)
	BCWWQG I	Conductivity [F], Conductivity, Total dissolved solids [F]
	BC SDWQG MAC	Fluoride, Selenium (dissolved), Selenium (total)
	BC SDWQG AO	Manganese (dissolved), Manganese (total)
	CSR IW	Chloride, Fluoride, Molybdenum (dissolved)
	CSR LW	Fluoride
	CSR DW	Fluoride, Lithium (dissolved), Lithium (total), Selenium (dissolved), Selenium (total)
2100 Hwy 97	GCDWQ AO	Manganese (dissolved), Manganese (total)
	BC SDWQG AO	Manganese (dissolved), Manganese (total)
2150 Hwy 97	BCWWQG I	Conductivity [F]

1. GCDWQ MAC = Guidelines for Canadian Drinking Water Quality Maximum Acceptable Concentrations
   GCDWQ AO = Guidelines for Canadian Drinking Water Quality Aesthetic Objectives
   BCAWQG L = BC Approved Water Quality Guidelines for Livestock
   BCAWQG I = BC Approved Water Quality Guidelines for Irrigation
   BCWWQG I = BC Working Water Quality Guidelines for Irrigation
   BC SDWQG MAC = BC Source Drinking Water Quality Guidelines Maximum Acceptable Concentrations
   BC SDWQG AO = BC Source Drinking Water Quality Guidelines Aesthetic Objectives
   CSR IW BC CSR Generic Numerical Water Standards for Irrigation
   CSR LW BC CSR Generic Numerical Water Standards for Livestock
   CSR DW BC CSR Generic Numerical Water Standards for Drinking Water

2. [F] = Field Result(s)

Groundwater well triplicates were collected by grouping together the same sample bottle type and then filling each bottle in the triplicate set with approximately equal aliquots until all three bottles were filled, as noted below.

- Fill 60 mL syringe fitted with 0.45 um filter with well water and dispense equal aliquots into each of the three dissolved metals, 125 mL plastic bottles with nitric acid preservative inside. Repeat until all three bottles are filled.
- Fill 60 mL syringe fitted with 0.45 um filter with well water and dispense equal aliquots into each of the three dissolved mercury, 50 mL glass vials with hydrochloric acid preservative inside. Repeat until all three vials are filled.
- Fill 3 x 125 mL plastic bottles for total metals with nitric acid preservative inside with equal aliquots of well water until all three bottles are filled.
- Fill 3 x 125 mL glass vials for total mercury with hydrochloric acid preservative inside with equal aliquots of well water until all three vials are filled.
- Fill 3 x 125 mL plastic bottles for nutrients with sulphuric acid preservative inside with equal aliquots of well water until all three bottles are filled.
- Fill 3 x 200 bacteriological bottles with equal aliquots of well water until all three bottles are filled.
- Fill 3 x 250 mL plastic bottles for general parameters and anions with equal aliquots of well water until all three bottles are filled.

The field blank sample bottles were exposed to atmosphere at the sampling location by removing the lids and filling the sample bottles with de-ionized water supplied by an independent laboratory and preserved as required immediately in the field.

The field blank sample showed bacteriological contamination as the media plates were overgrown, and the presence or absence of coliforms could not be determined by the laboratory, but there were no visible total coliforms or *E. Coli* noted. It is unknown where the bacteriological contamination in the field blank came from as the groundwater well triplicates collected on the same day as the field blank at the same location of 2050 Hy97 were non-detect for both total coliforms and E. Coli. This private well is located on a farm with different types of livestock and pets. All of the other parameters in the field blank were below detection limit, except for dissolved zirconium and total copper that was detected at 0.00084 mg/L Zr and 0.00056 mg/L Cu respectively. The detection limit for zirconium is <0.00010 mg/L Zr and for total copper is <0.00040 mg/L Cu. However, the total zirconium in this field blank sample was <0.00010 mg/L Zr; since a dissolved metal concentration should not be greater than a total metal concentration, it is suspected the dissolved zirconium detected in the field blank sample was a laboratory analytical error and not a sampling error. The total copper in the groundwater from 2050 Hwy 97 well averaged 0.00213 mg/L Cu an order of magnitude higher than that reported in the 2022 field blank sample.

Quality control sampling of the Okanagan River in 2022 consisted of one set of triplicates and a field blank sample taken at the 100m downstream monitoring site. The field blank was collected on April 20, 2022 by exposing the required bottles to atmosphere at the sampling location by removing the lids, and swinging the sample pole with bottles attached over the surface water and back again, but not letting the bottles touch the water. The bottles were then removed from the sample pole and filled with de-ionized water supplied by an independent laboratory and preserved as required immediately in the field.

Triplicate samples were collected on July 26, 2022 at the 100m downstream sampling location and the same sampling method described in Section 4.1 was used. Additional sampling methodology for triplicate sample collection was as follows.

- Attach in triplicate bacteriological sample bottles to sampling pole, remove cap and collect samples from Okanagan River.
- As quickly as possible remove the bacteriological bottles from the sampling pole and replace caps.
- Using a 2L beaker attached to a sampling pole triple rinsed with River water, pour collected River water from the 2L beaker into each of the laboratory supplied sample bottles. Repeat filling the 2L beaker with River water and pouring into the sample bottles until all triplicate bottle sets have been filled.
- Preserve samples bottles as required in the field.

The Okanagan River field blank sample was below detection limit for all nutrients and total metals, except for total copper that was detected at 0.00072 mg/L Cu. The detection limit for total copper is <0.00040 mg/L Cu. The average total copper at the Okanagan River 100m downstream site was 0.00076 mg/L Cu, similar to the average copper levels at the 100m upstream and 500m downstream sampling sites. Since 2015, total copper has been detected three times in the field blank sample; it is unclear why total copper is periodically detected in the field blank at the 100m downstream sampling location. Database summary of quality control Okanagan River triplicates and field blank samples are in Appendix J.

A set of triplicate samples for Vaseux Lake were collected by Larratt Aquatic on behalf of the Regional District for the 1, 5, and 10 m composite and for the 20, 22 and 24 m composite on July 7, 2022 as seen in Appendix J.

The results of the surface water monitoring program for the 2022 reporting period are presented in Appendices Q to T. The database summaries for the three Okanagan River monitoring sites (Appendix Q) and the Vaseux Lake monitoring (Appendix S) highlight if a guideline was exceeded. Comparisons were made to federal Guidelines for Canadian Drinking Water Quality (GCDWQ), BC Approved and Working Water Quality Guidelines (BCAWQG and BCWWQG), BC Source Drinking Water Quality Guidelines (BC SDWQG), and BC Contaminated Site Regulations Generic Numerical Water Standards (CSR). The water quality exceedances for both Okanagan River and Vaseux Lake are summarized in Table 11.

Table 11 Summary of 2022 Water Quality Exceedances in Okanagan River and Vaseux Lake

Sampling Location	Guideline[1]	Exceedances[2]
Okanagan River Channel 100m Upstream	BCAWQG AL (LT)	Dissolved oxygen [F], Zinc (total)
	BCAWQG AL (ST)	Temperature [F]
	GCDWQ MAC	E. coli (MPN), Fecal coliforms (MPN)
	GCDWQ AO	pH, Temperature [F]
	BC SDWQG MAC	E. coli (MPN)
	BC SDWQG AO	Temperature [F]
Okanagan River Channel 100m Downstream	BCAWQG AL (LT)	Dissolved oxygen [F]
	BCAWQG AL (ST)	Temperature [F]
	GCDWQ MAC	E. coli (MPN), Fecal coliforms (MPN)
	GCDWQ AO	pH, Temperature [F]
	BC SDWQG MAC	E. coli (MPN)
	BC SDWQG AO	Temperature [F]
Okanagan River Channel 500m Downstream	BCAWQG AL (LT)	Dissolved oxygen [F], Zinc (total)
	BCAWQG AL (ST)	Temperature [F], Zinc (total)
	GCDWQ MAC	E. coli (MPN), Fecal coliforms (MPN)
	GCDWQ AO	Temperature [F]
	BC SDWQG MAC	E. coli (MPN)
	BC SDWQG AO	Temperature [F]
Vaseux Lake 1, 5, 10 m composite	BCAWQG AL (LT)	Dissolved oxygen [F]
	BCAWQG AL (ST)	Temperature [F]
	GCDWQ AO	Temperature [F]
	BC SDWQG AO	Temperature [F]
Vaseux Lake 20, 22, 24 m composite	BCAWQG AL (LT)	Dissolved oxygen [F]
	BCAWQG AL (ST)	Dissolved oxygen [F]
	GCDWQ MAC	Manganese (total)
	GCDWQ AO	Iron (total), Manganese (total)
	BCWWQG I	Manganese (total)
	BC SDWQG MAC	Manganese (total)
	BC SDWQG AO	Iron (total), Manganese (total)
	CSR IW	Manganese (total)

1. BCAWQG AL (ST) = BC Approved Water Quality Guidelines for freshwater aquatic life (Short-term acute)
   BCAWQG AL (LT) = BC Approved Water Quality Guidelines for freshwater aquatic life (Long-term chronic)
   BC CSR IW = BC CSR, Schedule 3.2, Generic Numerical Water Standards for Irrigation (2017 and updates)
   BC SDWQG MAC = BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations (2017 and updates)
   BC SDWQG AO = BC Source Drinking Water Quality Guidelines - Aesthetic Objectives (2017 and updates)
   BCWWQG AL = Working Water Quality Guidelines for British Columbia for freshwater aquatic life
   BCWWQG I = Working Water Quality Guidelines for British Columbia for irrigation
   GCDWQ MAC = Guidelines for Canadian Drinking Water Quality Maximum Acceptable Concentrations
   GCDWQ AO = Guidelines for Canadian Drinking Water Quality Aesthetic Objectives

2. [F] = Field Result(s)

Details regarding the analysis of the Okanagan River samples and the Vaseux Lake samples in relation to the treated effluent discharged from the treatment plant are found in the complete report from Larratt Aquatic Consulting available in Appendix U. This report provides a summary of monthly nutrient loading

for total phosphorus, nitrate and total nitrogen from the discharged effluent. It also trends water quality parameters measured in Okanagan River at all three sites and at Vaseux Lake since 2013 and notes any significant trends over this ten-year period. The taxonomy results from the benthic samples collected from the three Okanagan River sites in October are included in Larratt Aquatics Consulting report as an appendix. A brief overview of Larratt's Report in Appendix U with regards to WWTP effluent and Okanagan River sampling sites are;

- Flow from WWTP effluent and polishing wetland into Okanagan River was only 0.04% of the total flow in Okanagan River measured at Okanagan Falls during 2022.
- A very small fraction of nutrient loadings in Okanagan River and subsequently Vaseux Lake comes from the WWTP; 0.39% total nitrogen and 0.32% total phosphorus in 2022.
- The total effluent nitrogen concentrations appears to have slightly increased from 2021 to 2022, after showing a declining trend since 2013.
- The WWTP has supplied up to 10% of the nitrate load and 3.4% of the total phosphorus load to Vaseux Lake during Okanagan River low flow periods.
- Effluent total phosphorus has averaged 0.182 ± 0.163 mg/L P from 2013 to 2022.
- Fecal and *E. coli* in effluent samples contained very low counts, with 83% of samples having >1 MPN/mL *E. coli* in 2022.
- While the wetland was effective at removing nutrients, it was a net source of *E. Coli* into Okanagan River, averaging 73 ± 83 MPN in 2022.
- There were no statistically significant differences between samples taken upstream and downstream of the WWTP for any forms of nitrogen and phosphorus from 2013 to 2022.
- Both chloride and conductivity show subtle increases in downstream samples compared to upstream samples. Even though differences were not statistically significant, these two parameters may be a subtle marker of the effluent plume.
- Aluminum exceeded the BC guidelines for the protection of aquatic life during freshet 2022 at all three Okanagan River sampling sites. Aluminum is associated with sediment and routinely exceeds guidelines during freshet when water has high sediment loads.
- The benthic invertebrate data indicate Okanagan River is not a healthy water body and the WWTP may be impacting benthic invertebrates in some years with regards to species richness. However, the results contain high interannual variability that prevents strong conclusion from being drawn.

Trends in Vaseux Lake in relationship to the WWTP effluent as noted in Larratt's Report in Appendix U are as follows:

- Sampling of Vaseux Lake since 2013 has not detected a significant WWTP impact on Vaseux Lake water chemistry.
- Seasonal variation in Vaseux Lake water chemistry is far greater than the impact of the WWTP, since the contribution from the WWTP is very small compared to base Okanagan River loadings.
- Internal loading from the anoxic zone is a significant source of nutrients to Vaseux Lake.

- Chloride has increased significantly from 2013 to 2022. The largest source of anthropogenic chloride is typically road-salt, followed by sewage effluents. However, the chloride concentrations in Vaseux Lake were far below aquatic life guidelines.
- There were not exceedances of aquatic life maximum allowable concentrations (MAC) for any metals in Vaseux Lake 2022 samples.
- Diatoms and cyanobacteria dominated the phytoplankton at all depths in Vaseux Lake in 2022.
- Total cell counts were relatively high at all depths compared to historic averages and record high algae densities were recorded in 2022.
- Cyanobacteria trends declined from 2013 to 2017, increased from 2018 to 2020, and declined from 2020 to 2022.
- Trends identified to date appear to be climate-driven and there were no indications of nutrient enrichment or other impacts by the WWTP on Vaseux Lake's algae population from the 2013 to 2022 data.

Recommendations are to continue with the monitoring program in 2023. More years of study will be required to determine conclusively if there are impacts on Okanagan River benthic invertebrate community from the WWTP.

5. FACILITY OPERATIONS AND MAINTENANCE

The Okanagan Falls Wastewater Treatment Facility consists of four lift stations, forcemains, gravity mains, and Level IV biological nutrient removal plant with an outfall diffuser into Okanagan River.

Operations staff continued to implement process changes to facilitate more stable effluent throughout the year. The 2022 results are again within the Total Nitrogen and Total Phosphorus annual averages. The new dewatering building was completed early 2022 and the centrifuge to process solids, underwent commission beginning in February. Delays during commissioning saw sludge processing in-house as well as transfer of sludge to the Penticton AWWTP. The introduction of centrate to the OK Falls WWTP would increase the overall phosphorous loading to the plant resulting in adjustments to the biological process as well as the potential to rely more on chemical phosphorous removal.

This year again saw the utilization of two bioreactors for the summer season that allowed for the process to better adjust to higher flows in peak summer vacation residents. The effluent quality in the summer was extremely good due to the extended aeration with ammonia and nitrate greatly reduced.

Preventative maintenance program continues with emphasis on equipment replacement. Several quotes were obtained in 2022 for an asset management plan for the RDOS. Implementation of this program is awaiting integration of all RDOS assets. One of the aspects of asset management is the hiring of energy specialists that initiated an energy study of the Wastewater Treatment plant in alignment with Fortis rebate initiatives. Over $40, 000 worth of rebates became available to the Wastewater system as set out in the

study. A key part of this was the rebate for an energy efficient pump to replace the entire Dissolved Air Floatation pump. Both Kelowna WWTP and Penticton WWTP implemented this new technology resulting in significant energy savings. The RDOS purchased the Nikuni pump technology and the pump was installed and commissioned in March 2022. More projects from this rebate initiative will be reflected in budgetary requirements for 2023.

With age, equipment is being replaced within the collection system and the treatment plant. The RDOS has service level agreements with several outside contractors to maintain equipment for HVAC, electrical, and instrumentation. The HVAC system is showing age – both heat pumps required extensive maintenance. Falcon Engineering was commissioned to complete a study on the heat pump system. The report indicated that replacement of the heat pumps with newer technology will greatly improve the overall performance and as this is linked to the energy study some monies could be available from Fortis. Budgets are being forecast over the next few years to allocate monies for these such asset management projects.

The summer of 2022 saw use of the polishing wetland from mid-May until late June and from early August until late September. High Okanagan River flows from late June until early August prevented gravity drainage from the wetland and no effluent was discharged to/from the wetland during this time for over 50 days. (See graph in Appendix G of daily flows for wetland inlet and outlet and River). Ducks Unlimited Canada, operating as Native Plant Solutions, designed the constructed wetland to receive treated effluent for additional polishing prior to discharge to the Okanagan River. Following direction provided by Native Plant Solutions to RDOS staff, the wetland commissioning was completed in the fall of 2022. The wetland is located within species habitat that are red and blue listed including the western painted turtle, yellow breasted chat, tiger salamander and great basin spadefoot. With the wetland fully operational, there was a reduction in nutrient levels and loadings being discharged into the Okanagan river system (see Table 8 in Section 3.4). Appendix M and N provides tabulated data and individual laboratory reports respectively.

Staffing changes in 2022 were as follows.

- Retirement of a long serving operator
- Two operators hired - one to replace the retired operator and the other to increase operator staff to accommodate operation of the centrifuge
- Laboratory technician position eliminated and staff re-assigned to a different department

Operational staff during 2022 and their Environmental Operators Certification Program (EOCP) of BC certification, as required by Section 2.8.2 of OC 10655 are summarized in Table 12 below.

Table 12 Operational Staff during 2022

Name	RDOS Position Title	EOCP Certification
Rina Seppen	Utilities Foreman	Municipal Wastewater Treatment Level IV Municipal Wastewater Collection Level II
Steve Anderson	Systems Operator IV	Municipal Wastewater Treatment Level IV Municipal Wastewater Collection Level I
Kristi Betts	Systems Operator III	Municipal Wastewater Treatment Level III Municipal Water Treatment Level II
Rodney Yurick	Systems Operator II	Municipal Wastewater Treatment Level II Municipal Wastewater Collections Level I Municipal Water Treatment Level I Municipal Water Distribution Level I
Karen Moore	Lab Technician	Municipal Wastewater Treatment Level III

5.1 BIOSOLIDS MANAGEMENT PLAN

With the assistance of grant money from the Province, the RDOS purchased a centrifuge in 2020 and construction began on a dewatering system in 2021 to eliminate the costs associated with hauling and disposing of liquid sludge to the AWWTP in Penticton. Delays in supply chain and manufacturing pushed back the start date for the centrifuge commissioning from fall 2021 to spring 2022. Commissioning of the centrifuge was problematic taking over the first 3 months as there were delays with the piping system leaking. Centrifuge operation became steady by summer. Polymer for this new system is an expense that added to the overall chemical budget.

Centrifuged cake was produced at Okanagan Falls WWTF starting in March of 2022 from the two sludge types: Fermented Primary Sludge (FPS) and Thickened Waste Activated Sludge (TWAS). The FPS is thickened as it ferments and settles in the primary clarifier. Dissolved Air Floatation (DAF) thickens Waste Activated Sludge (TWAS) from the bioreactor. Both thickened sludges are held in storage vaults until they are pumped to the centrifuge. The biosolids cake produced by the centrifuge is hauled to the City of Penticton Composting facility where it is composted with other biosolids from the region.

In the event the centrifuge is down, these sludges can be pumped out of their respective storage vaults and hauled to the Penticton Advanced Wastewater Treatment Plant for further processing. The FPS sludge would be received at Penticton's Septic Waste Receiving Facility and the TWAS sludge would be deposited into a holding tank for processing by their dewatering equipment. The volume of sludge delivered and the density of each delivery is measured at City of Penticton's AWWTP and this data is provided monthly to RDOS for billing purposes.

In 2022, the total dry weight of biosolids hauled offsite was 46,574.5 kg with centrifuged cake making up 78% (36,322.9 kg) and FPS plus TWAS sludges, making up the remaining 22% (10,251.6 kg). This is an

increase of 6% by dry weight compared to the total biosolids disposed of in 2021 (43,675.3 kg). A monthly summary of sludge and centrifuged cake disposed of at City of Penticton's AWWTP or Compositing Facility respectively is presented in Appendix F.

5.2 SEWERAGE REGULATION BYLAW

In 2022, the Sewerage Regulation Bylaw No. 1707, 1996 has not been amended. The Sewer Bylaw is planned to be reviewed again in 2023. Urban Systems was hired in 2022 to complete a Sewer Master Plan to identify issues within the OK Falls Sewer system and give a framework for the RDOS to update the Sewerage Regulation Bylaw in 2023.

5.3 CONTINGENCY PLAN

In 2022, revisions were made to the Emergency Response and Contingency Plan for the Okanagan Falls Wastewater Collection and Treatment System (Appendix V) to include the dewatering building and appurtenances.

5.4 OPERATION AND MAINTENANCE EXPENDITURES

The annual operation costs for the Facility during the reporting period was $961, 206 (Total expenses less Depreciation, Debt Interest, Debt Principal, Transfer to Reserve and Transfer Interest to Reserves). The 2022 annual budget was $823, 983 (Total expenses less Depreciation, Debt Interest, Debt Principal, Transfer to Reserve and Transfer Interest to Reserves). These costs include the site operations labour, and other ancillary expenses. The new Solids Processing Facility (dewatering project) was a major project completed in 2022. It was funded with Provincial Grant money to purchase the new centrifuge and cover construction costs.

As mentioned above in Facility Maintenance and Operations, the RDOS completed an energy efficiency study for the WWTP in co-operation with Fortis BC. This energy study, at the cost of $31,900, was completed by Prism Engineering that would identify aspects of the wastewater treatment plant equipment that could be eligible for Fortis rebates with optimization. Of the total $40,484 incentives available, the RDOS received a rebate of $26, 755 with the purchase and installation of the Nikuni recirculation pump in spring 2022 replacing the older Dissolved Air Flotation pump; an incentive identified in the energy savings study.

Supply chain issues and rapid rising costs from suppliers toward the end of the year has created an inflationary increase in the cost of consumables and parts (noted mostly in the cost of chemicals, consumables and environmental monitoring) and will continue into 2023. A summary of the budgetary information for the Okanagan Falls BNR WWTF during the reporting period is presented in Table 13.

Table 13 Summary of 2022 OKFWWTP Budget

Financial Summary		2022 Year Actual	2022 Annual Budget	2022 Variance	2021 Year Actual
Revenue:					
4-1-3800-2955	GAS TAX				1,268,609
4-1-3800-2915	COMMUNITY WORKS GAS TAX		142,955	(142,955)	
4-1-3800-4500	USER FEES	1,155,298	940,341	249,957	1,162,875
4-1-3800-4510	CONNECTION & EXTENSION FEES	2,100	3,535	(1,435)	3,500
4-1-3800-4520	NEW SERVICES INSTALLATION FEES		253	(253)	
4-1-3800-4570	USER FEES - CAPITAL		241,760	(241,760)	
4-1-3800-6000	TRANSFER FROM RESERVE				
4-1-3800-6290	TRANSFER FROM OPERATING RESERVE				
4-1-3800-8510	OBWB GRANT - DEBENTURE	80,227	80,227	0	80,227
4-1-3800-9000	MISCELLANEOUS REVENUE		1,200	(1,200)	23,925
4-1-3800-9001	FORTIS CUSTOM EFFICIENCY PROGRAM	26,755		26,755	
4-1-3800-9990	PRIOR YEARS SURPLUS	(50,755)	(34,828)	(15,927)	(34,828)
	Total Revenue	1,213,625	1,197,488	16,137	2,539,136
Expenses:					
4-2-3800-1000	SALARIES & WAGES	434,193	375,593	(58,600)	357,973
4-2-3800-1400	ADMINISTRATION CHARGES	43,807	43,807	0	41,801
4-2-3800-1500	IS	0	0	0	0
4-2-3800-2500	OPERATIONS	37,741	35,000	2,741	21,560
4-2-3800-2501	SEWER FLUSHING	0	30,450	(30,450)	20,745
4-2-3800-2502	MAINTENANCE AND PARTS	101,672	80,000	21,672	91,714
4-2-3800-2503	CHEMICALS	39,787	7,160	32,627	8,438
4-2-3800-2505	OPS – SLUDGE HAULING	24,959	20,000	4,959	64,833
4-2-3800-2506	OPS – SLUDGE DISPOSAL	28,101	30,000	(1,899)	90,648
4-2-3800-2595	OP - ENVIRONMENTAL MONITORING	23,607	11,165	12,442	20,879
4-2-3800-2596	OUTSIDE LAB	20,910	26,136	(5,226)	26,031
4-2-3800-2597	INHOUSE LAB	17,069	17,255	(186)	15,465
4-2-3800-2640	OPERATIONS - HEALTH & SAFETY	4,206	4,060	146	1,822
4-2-3800-2960	OK WWTP SOLIDS PROCESSING				1,268,609
4-2-3800-2961	OK FALLS WETLAND ENHANCEMENT				44,299
4-2-3800-3000	CONSULTANTS	6,760	5,075	1,185	39,106
4-2-3800-4000	EDUCATION & TRAINING	2,185	3,045	(860)	2,202
4-2-3800-5400	DEPRECIATION		3045	(3045)	0
4-2-3800-5500	CAPITAL EXPENDITURES				22,830
4-2-3800-6000	INSURANCE - PROPERTY	18,585	7,896	10,689	13,335
4-2-3800-6050	INSURANCE - LIABILITY	15,219	21,624	(6,405)	16,864
4-2-3800-6150	INSURANCE - ENVIRONMENTAL	12,998	0	12,998	14,475
4-2-3800-6200	LEGAL FEES	210	508	(298)	1,782
4-2-3800-7000	SUPPLIES	310	140	(298)	117
4-2-3800-8200	TRAVEL/LEASING	28,364	10,674	17,690	15,937
4-2-3800-8500	UTILITIES	91,249	81,200	10,049	82,226
4-2-3800-9010	DEBT INTEREST	158,400	158,400	0	158,400
4-2-3800-9020	DEBT PRINCIPAL	161,192	161,192	0	161,192
4-2-3800-9200	TRANSFER TO OPERATING RESERVE		53,913	(53,913)	5000
4-2-3800-9202	TRANSFER VEHICLE REPLACEMENT	3,045	0	3045	
	Total Expenses	1,280,798	1,197,488	(83,310)	2,603,283

6. CONCLUSIONS

The tenth year of operation of the Okanagan Falls Biological Nutrient Removal Wastewater Treatment Facility saw an increase in nutrients discharged to the Okanagan River compared to 2021, due to both an increase in flow and concentrations of total phosphorus and total nitrogen. The use of the polishing wetland reduced loadings by 12% for total phosphorus and 15% for total nitrogen, but increased loadings by 13% for total suspended solids.

In 2022, the annual average total phosphorus from grab samples sent to independent laboratory was 0.204 mg/L P, which is at the maximum allowable annual average of 0.20 mg/L. The total nitrogen annual average from grab samples sent to independent laboratory was 4.15 mg/L N, which is below the maximum allowable annual average for of 6.0 mg/L. There were no exceedances of the permitted effluent parameters in 2022 for the OK Falls WWTF.

There are continuous maintenance issues that arise as is indicative of the age of the treatment plant and the sewer collection system. Adjustments to the maintenance budget and preventative maintenance program will be made for 2023 to reflect the need to upgrade the system.

Installation of a centrifuge purchased in 2020 was completed early 2022 and commissioning began in March. Commissioning of the centrifuge was problematic taking over the first 3 months as there were delays with the piping system leaking. Centrifuge operation became steady by summer. Polymer for this new system is an expense that added to the overall chemical budget.

The two types of thickened sludge produced – Thickened Waste Activated Sludge (TWAS) and Fermented Primary Sludge (FPS) - were centrifuged to increase the average solids concentrations from 2.1% and 4.8% respectively to 17% average solids concentration of the centrifuged cake. The thickened sludges hauled to Penticton AWWTP for further dewatering in 2022 was estimated at 10,252 kilograms (dry weight). Centrifuged cake biosolids, 36,323 kg dry weight were transported from WWTF to the Compost facility at the Campbell Mountain landfill in Penticton for further processing. In 2022, all sludge samples met the requirements for Class B compost and biosolids as specified in Provincial Organic Material Recycling Regulations

The report from Larratt Aquatic Consulting has indicated from 2013-2022 there were no statistical differences between upstream and downstream nutrients levels in Okanagan River. However, there appears to be subtle increases in chloride and conductivity in Okanagan River downstream of the WWTP, and even though not at a statistically significant level, both parameters were consistently higher downstream than upstream on any give sample date. The benthic invertebrate data indicate Okanagan River is not a healthy water body and the WWTP may be impacting benthic invertebrates in some years with regards to species richness. No observed impacts from the WWTP operation on Vaseux Lake water quality or microflora. Algae trends in Vaseux Lake identified to date appear to be climate-driven and there were no indications

of nutrient enrichment or other impacts by the WWTP on Vaseux Lake's algae population from 2013 to 2022 data.

7. RECOMMENDATIONS

Based on the results of the 2022 monitoring program, the following recommendations are provided:

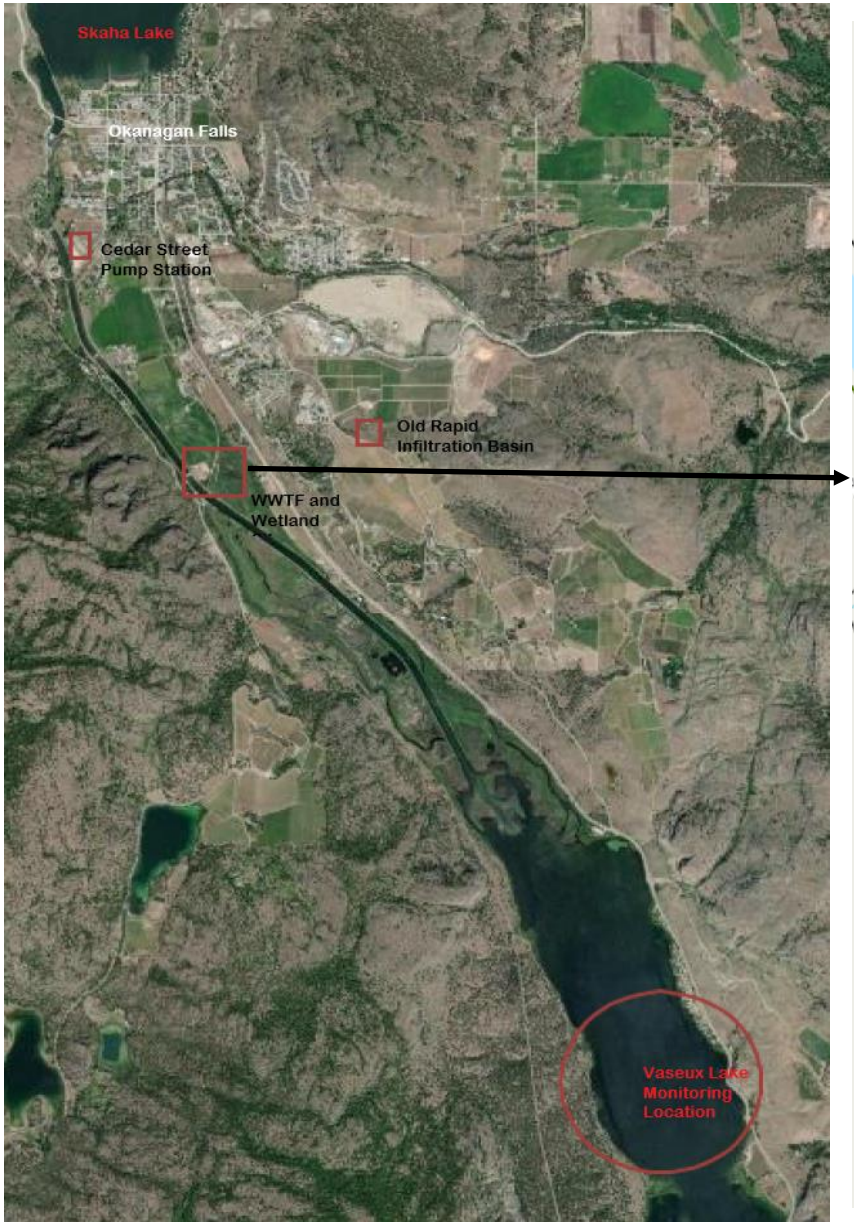
1. Review the monitoring program on an annual basis to accommodate changes in Facility conditions and monitoring program results.

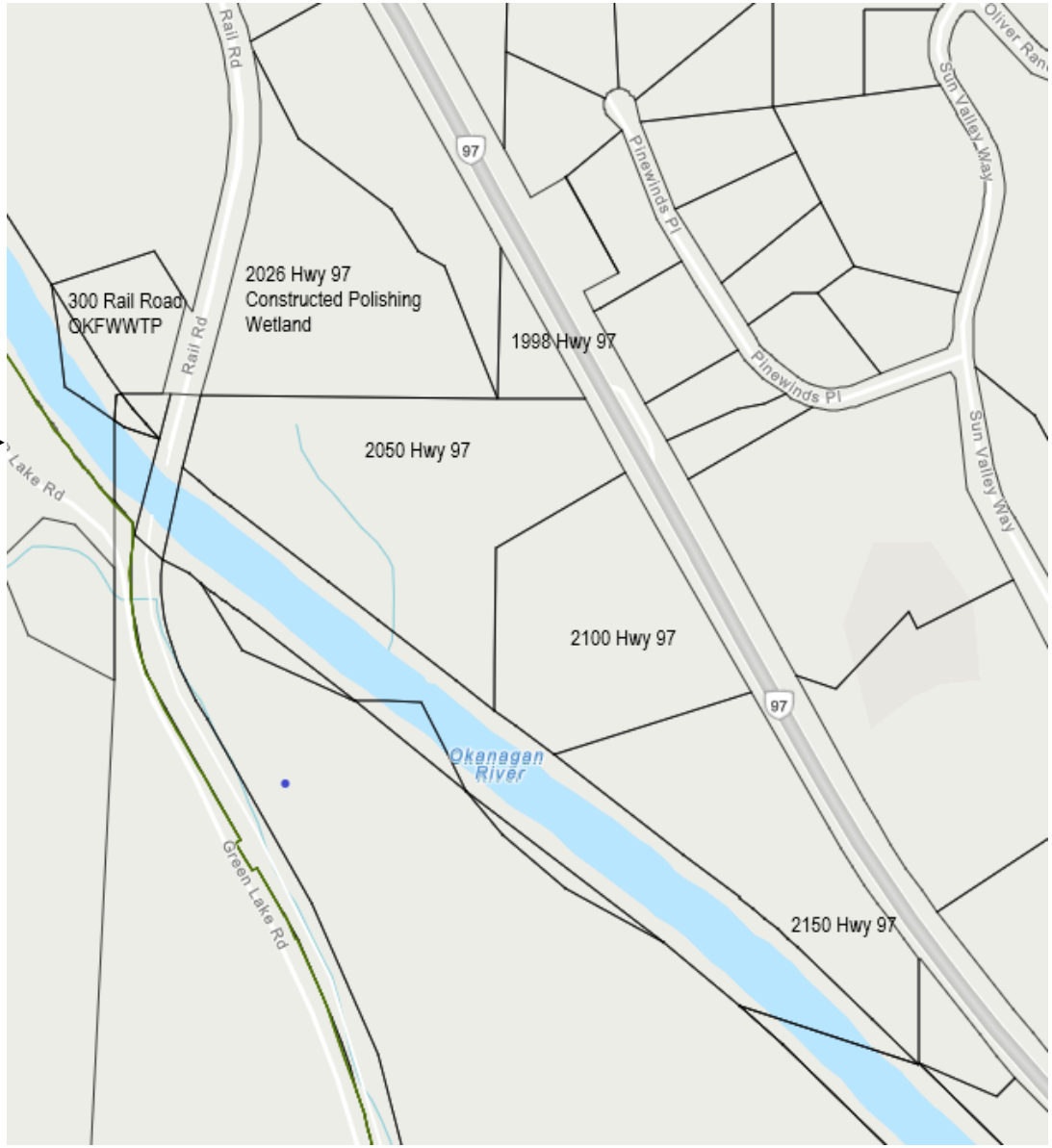
8. REFERENCES

1. Environment Canada, Water Office – 2022 daily mean discharge for Station 08NM002 was received January 5, 2023 via email from National Hydrological Services Meteorological Service of Canada Branch Environment and Climate Change Canada/Government of Canada.

2. Ernst, T. (2008) *Fishing Mapbook Southeastern BC Region 4: Kootenay, Region 8: Okanagan*, 1St Edition. Backroad Mapbooks, Mussio Ventures Ltd

FIGURES



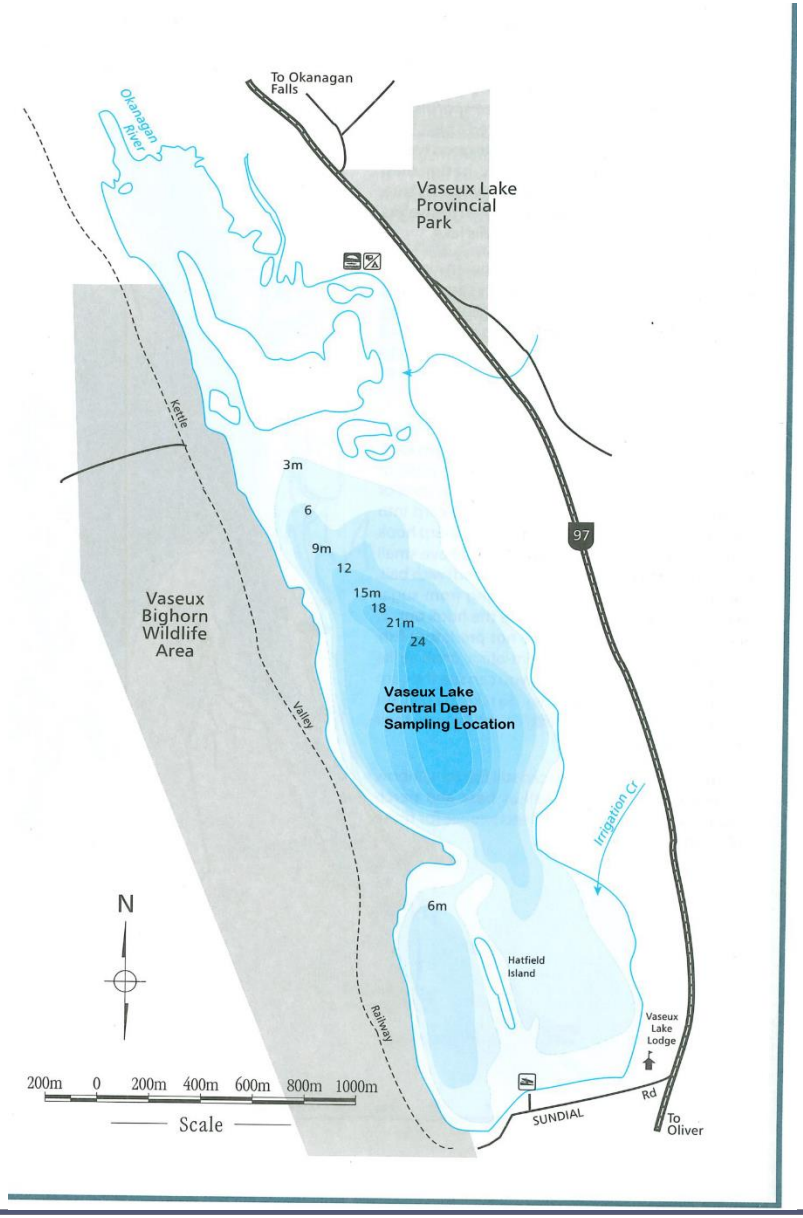


REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 1: SITE LOCATIONS AND PARCEL MAP

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

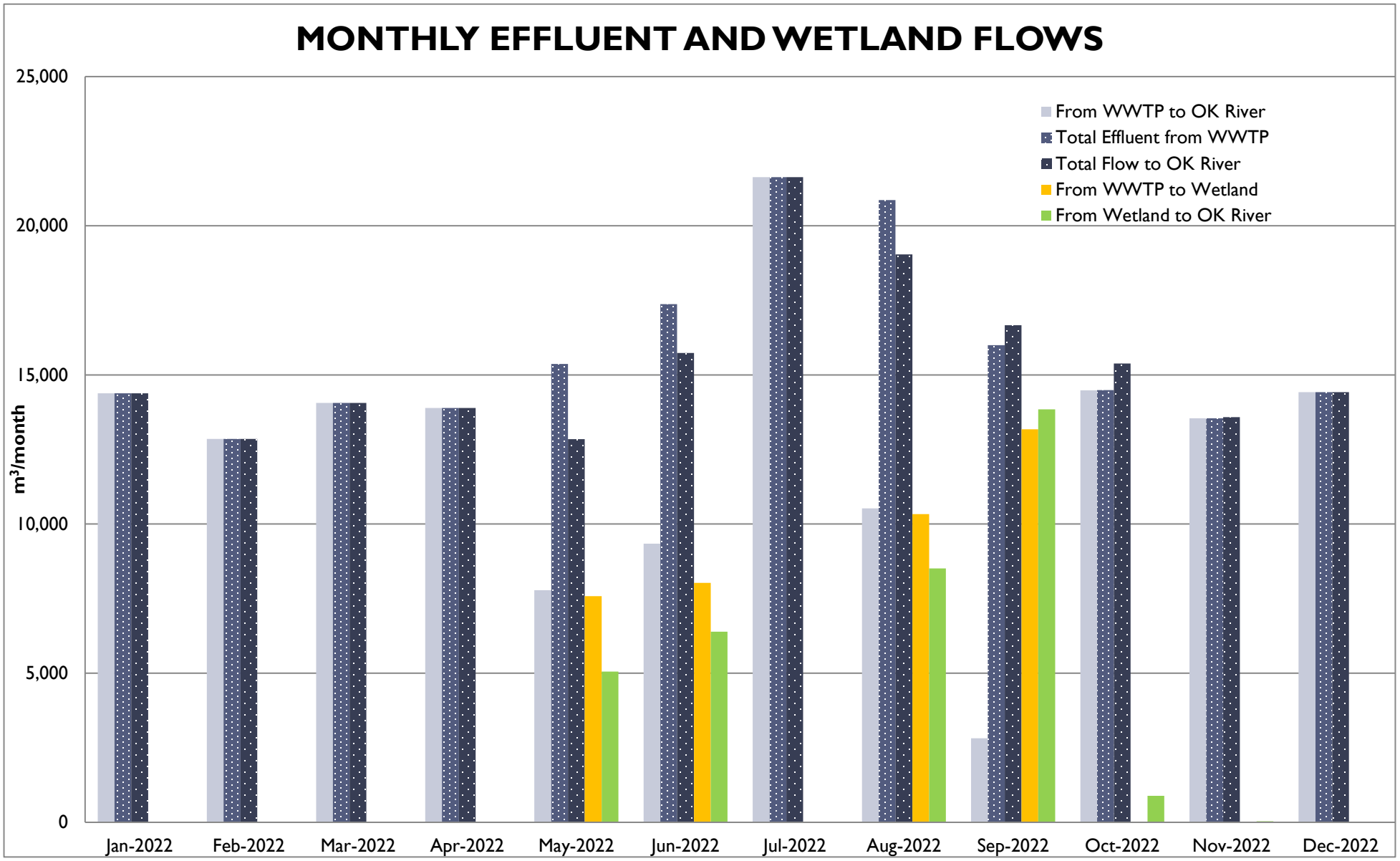
FIGURE 2: OKANAGAN RIVER AND GROUNDWATER WELLS SAMPLING LOCATIONS



REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

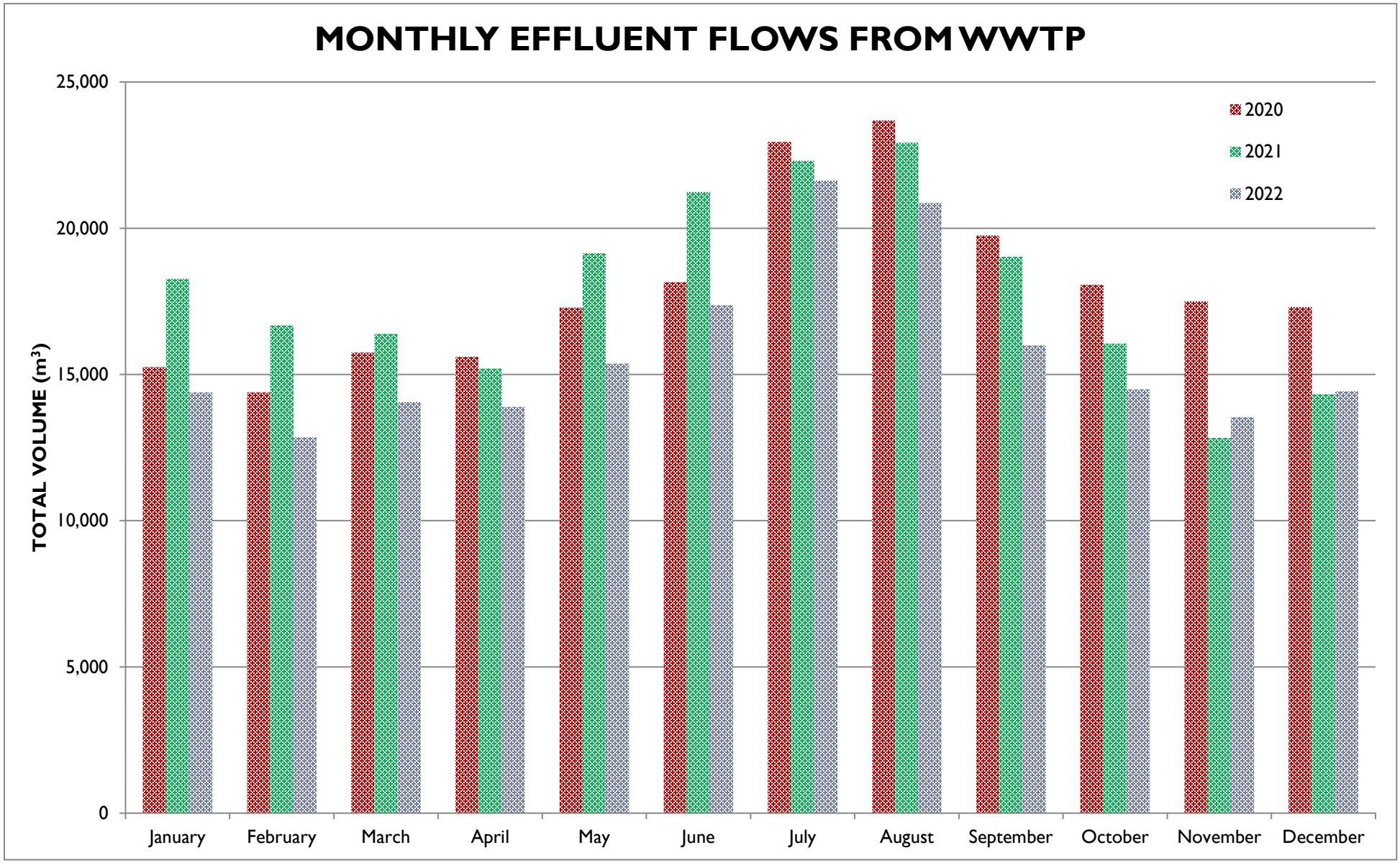
FIGURE 3: VASEUX LAKE SAMPLING LOCATION

Bathymetry Map from: Ernst, T. (2008), *Fishing Mapbook Southeastern BC Region 4: Kootenay, Region 8: Okanagan*, 1St Edition. (p. 164) Backroad Mapbooks, Mussio Ventures Ltd.



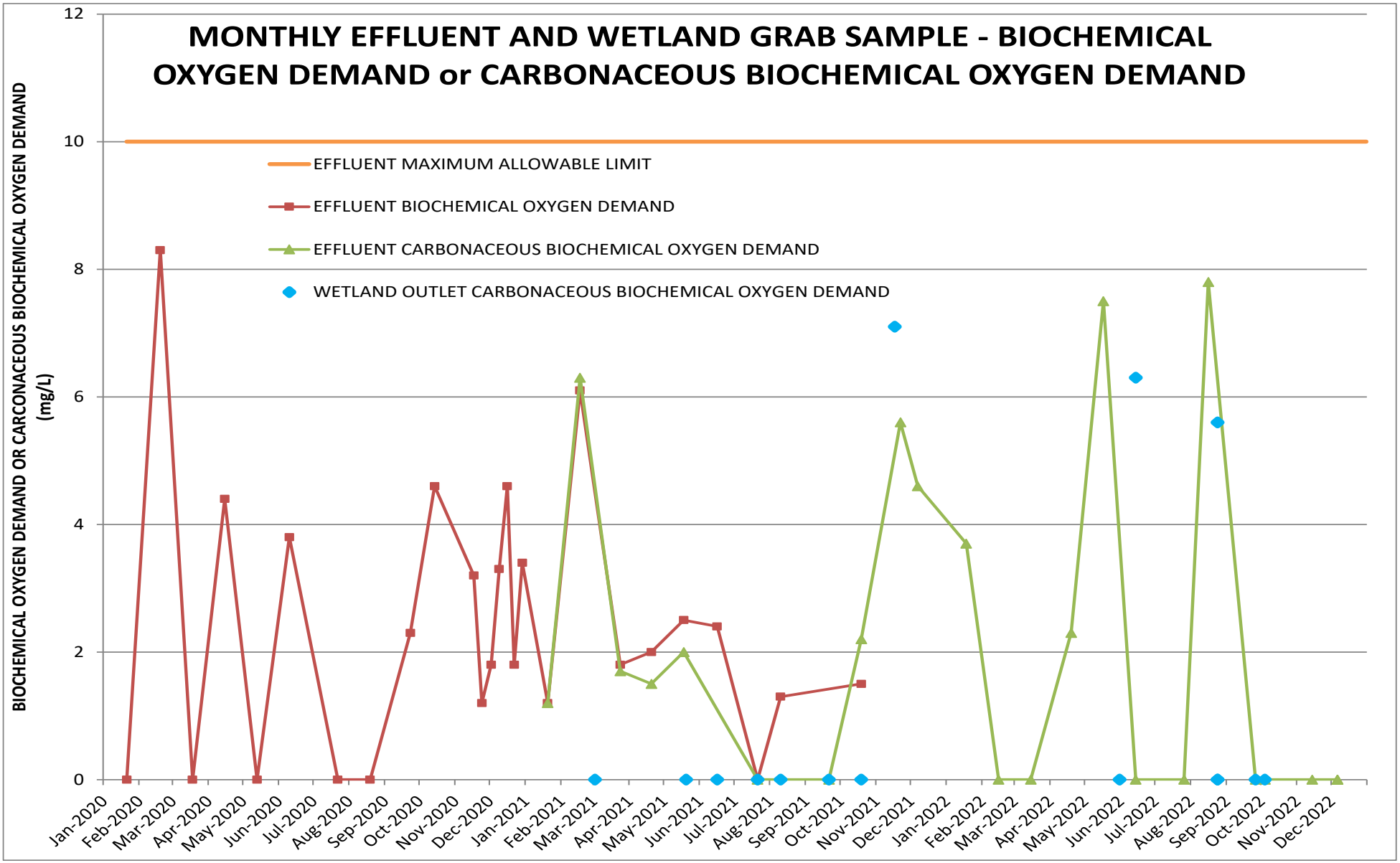
REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 4: MONTHLY EFFLUENT AND WETLAND FLOWS 2022



REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

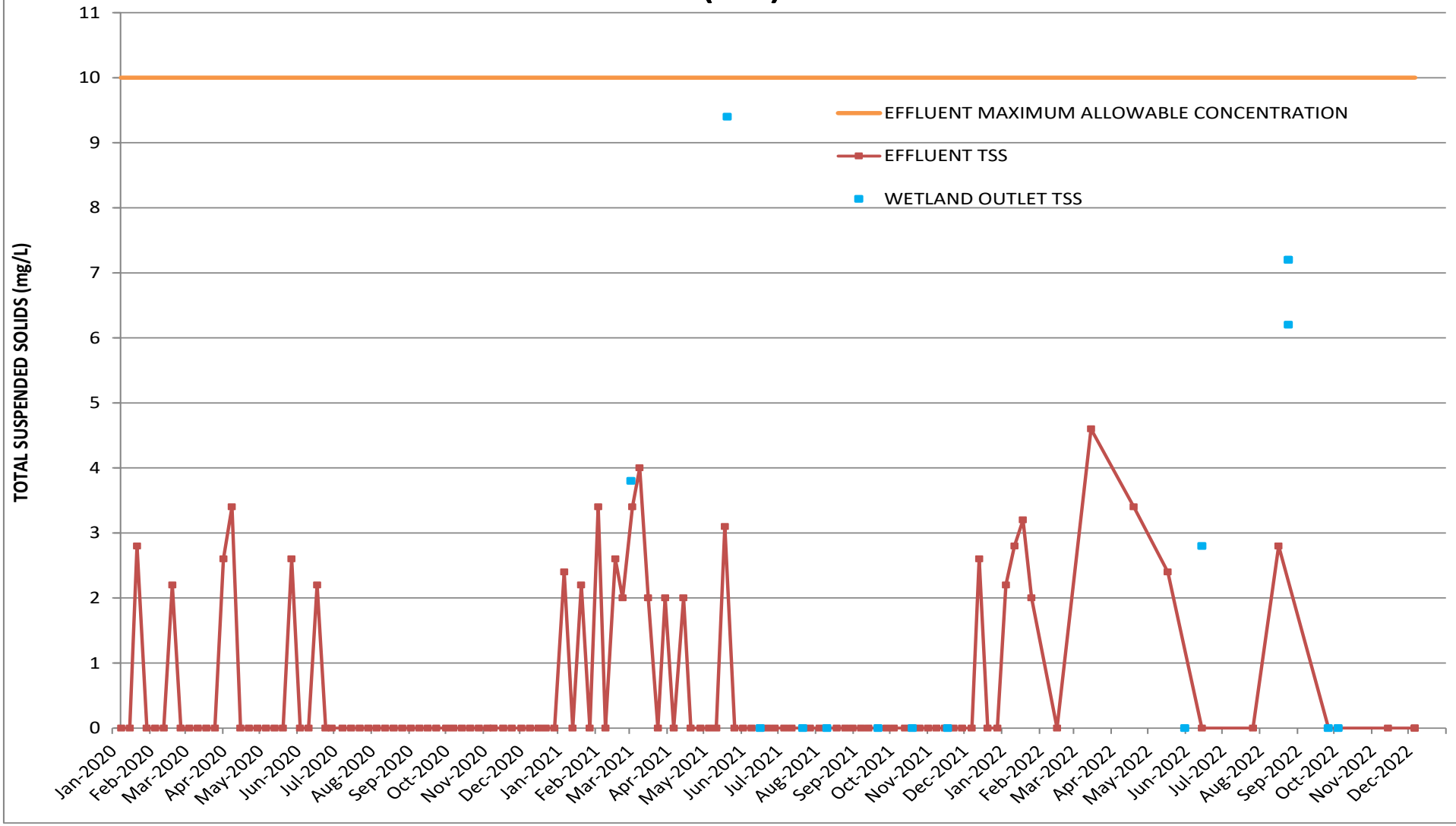
FIGURE 5: MONTHLY EFFLUENT FLOWS AFTER DISINFECTION 2020 TO 2022



REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

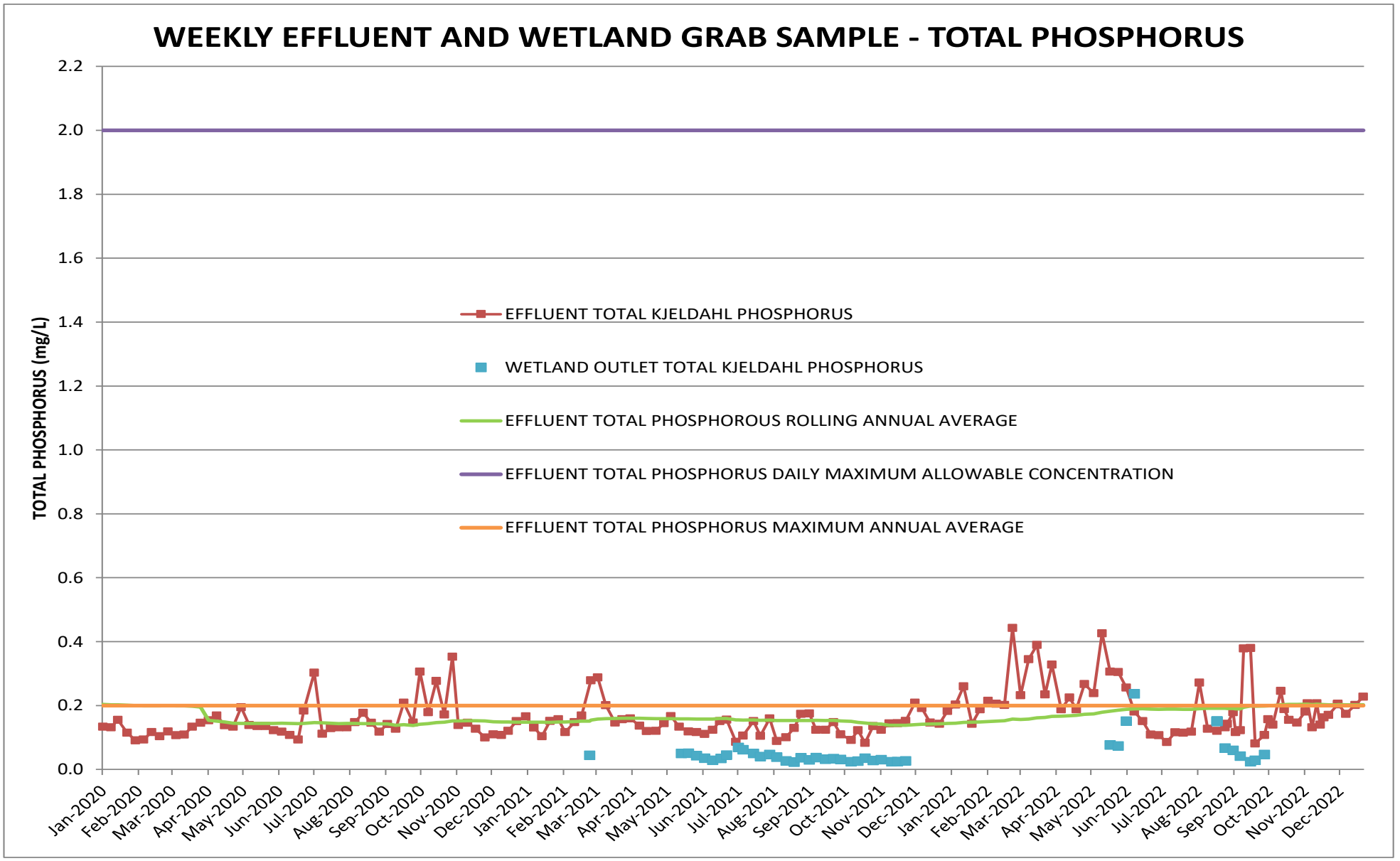
FIGURE 6: MONTHLY EFFLUENT AND WETLAND BIOCHEMICAL OXYGEN DEMAND OR CARBONACEOUS OXYGEN DEMAND TIME SERIES PLOT

EFFLUENT AND WETLAND GRAB SAMPLE TOTAL SUSPENDED SOLIDS (TSS)



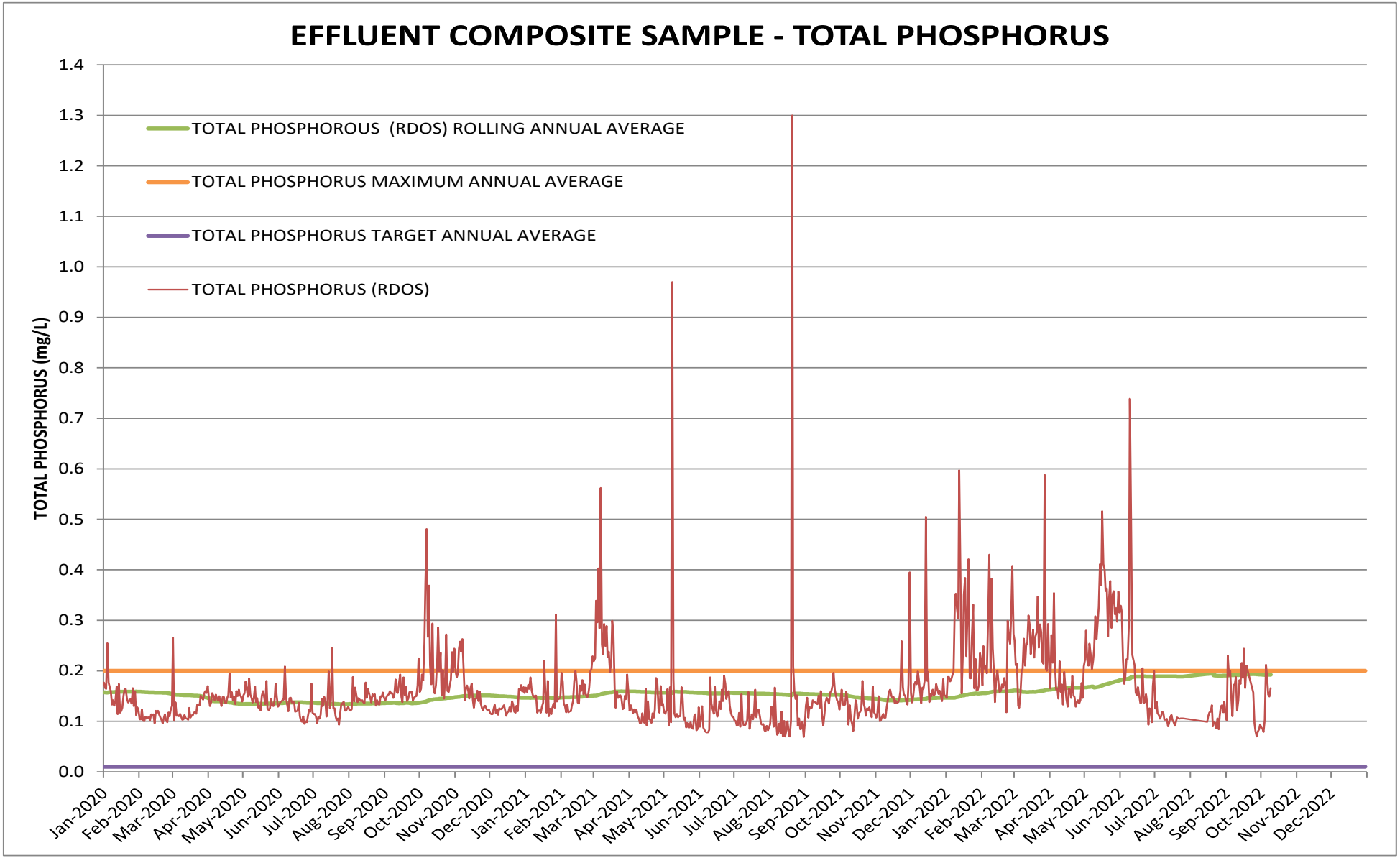
REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 7: EFFLUENT AND WETLAND TOTAL SUSPENDED SOLIDS TIME SERIES PLOT



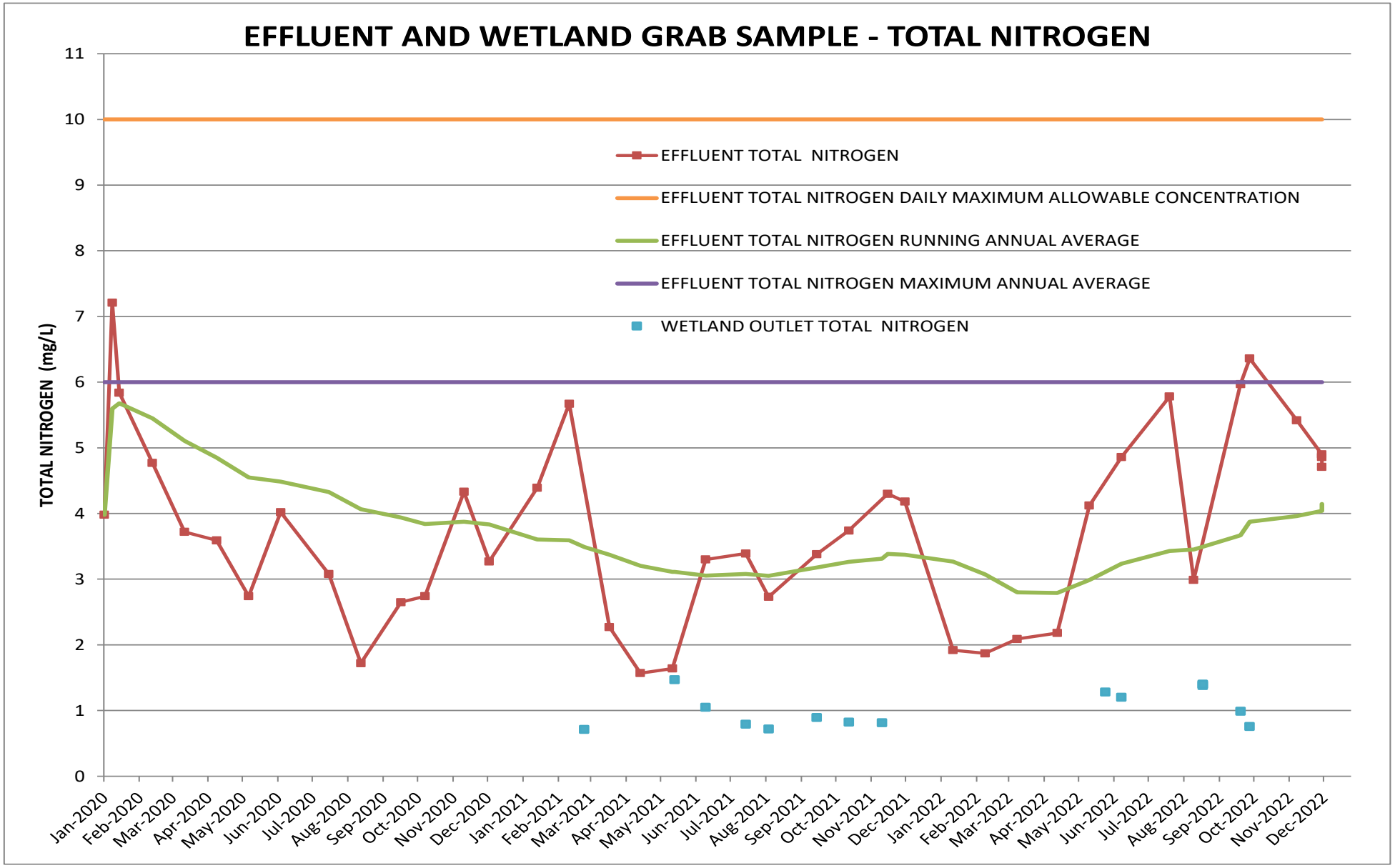
REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 8: WEEKLY EFFLUENT AND WETLAND TOTAL PHOSPHORUS TIME SERIES PLOT



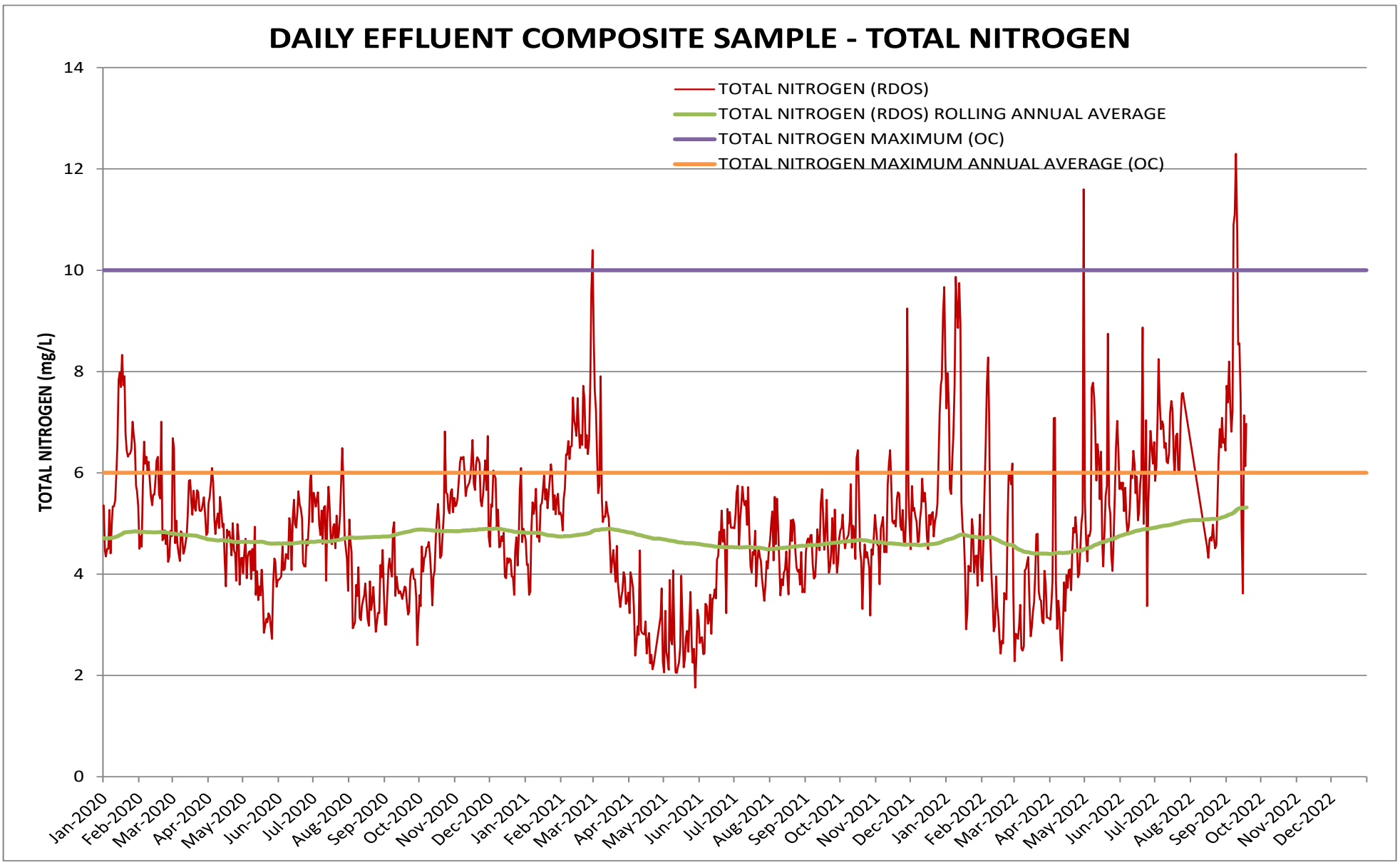
REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 9: EFFLUENT COMPOSITE TOTAL PHOSPHORUS TIME SERIES PLOT



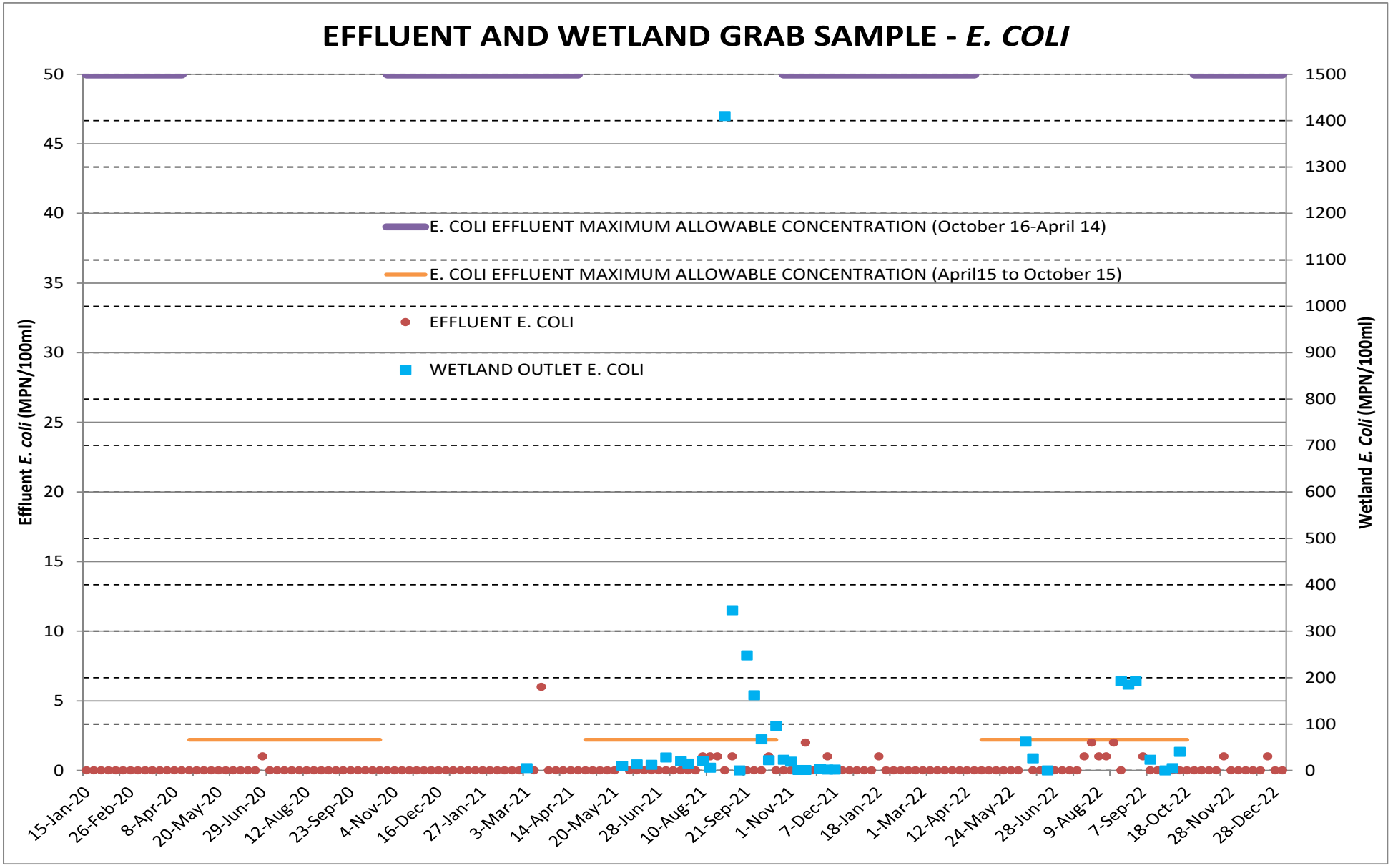
REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 10: EFFLUENT AND WETLAND TOTAL NITROGEN TIME SERIES PLOT



REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 11: EFFLUENT COMPOSITE TOTAL NITROGEN TIME SERIES PLOT



REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN

FIGURE 12: WEEKLY EFFLUENT AND WETLAND *E. COLI* TIME SERIES PLOT