Water Quality: 2014 pumping event from Horseshoe Lake to a gravel pit located in The Villages proposed development

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King County

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1.0 INTRODUCTION

In 2014, the water levels of Horseshoe Lake increased to near-flood levels after large amounts of rain fell in March, increasing the ground water that controls the lake level in the winter.

King County Water and Land Resources (WLRD) made a decision to apply to the City of Black Diamond to allow pumping of the water from the lake to an unused gravel pit in the middle of property owned by Yarrow Bay Holdings, located to the south and east of the lake. Data from the company's drainage subcontractor Golder Associates indicated that flow from the site would be in a direction away from Horseshoe Lake and that sufficient capacity existed to accept infiltrating water in the shallow glacial outwash morphology with little or no resulting increase in surface flows nearby.

Representatives from the Muckleshoot Nation expressed concern because of the sensitivity of their hatchery operation downstream to changes in the quality of the water from Crisp Creek, which they were using exclusively for hatchery operations during this time. King County WLRD science staff discussed the situation with Muckleshoot environmental personnel and determined that water quality monitoring should be carried out, with the ability to stop pumping water from the lake if potentially harmful levels of pollutants were found during the operation that could be tied to the pumping project.

Pumping was performed during a 25-day period from April 7 to May 1, 2014. A total of 46 acre-ft was pumped from Horseshoe Lake. The pump was operated for 7 to 10 hours per day on 15 of the 25 days.

Water quality parameters chosen were similar to those in 2011, based on information provided by Muckleshoot staff about potential changes in water quality that could affect their salmon rearing ponds, which use unfiltered Crisp Creek water (King County 2012). The Muckleshoots have followed a chart of concentration recommendations and thresholds for aquatic parameters that has been published for hatchery managers (Timmons et al. 2002).

The tribe had already collected a body of data from the creek at a site just above their hatchery. In particular, they were concerned about changes in total iron content and total suspended solids. There were several other parameters that also appeared to be important for King County to track (see Table 1 for list of parameters), based on the minimum detection levels for some of the previously collected data, as well as some metals of potential concern that were not listed in the table provided.

Table 1. Ranges of previous values for parameters of concern compared to recommended ranges

Parameter	Recommendation	Keta Spring	Crisp Ck	Crisp at Hatchery	Crisp at Auburn-BD Road	Woodlands infiltration pond
Aluminum, dissolved (ug/L)	< 10	< 20	< 20	15.1 - 49.9	140 - 221	8.5 - 21.8
Alkalinity, total (mg/L)	50 - 300	54.9 - 58.8	32.3 - 53.1			
Alkalinity, bicarbonate (mg/L)	NA	54.9 - 58.4	32.3 - 53.1	33.8 - 40.1	6.3 - 9.7	22.6 - 24.8
Alkalinity, hydroxide (mg/L)	< 0.005	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Arsenic, dissolved (ug/)L				0.38 - 0.45	0.27 - 0.41	0.37 - 0.50
Cadmium, dissolved (ug/L)	< 0.5	< 0.2	< 0.2	< 0.05	< 0.05	< 0.05
Calcium, dissolved (mg/L)	4.0 - 160	15.4 - 17.0	9.8 - 14.8	8.3 - 10.9	2.3 - 2.6	5.6 - 6.6
Conductivity, specific (us/cm)				78 - 96	27 - 30	61 - 73
Copper, dissolved (ug/L)				< 0.4	0.4 - 0.6	0.7 - 0.9
Hardness (mg/L)	> 100	66 - 73	37 - 53	31.1 - 40.6	8.7 - 11.1	21.8 - 26.3
Iron, dissolved (ug/L)				22 - 45	120 - 169	182 - 523
Iron, total (ug/L)	< 150	50 - 210	50 - 380	68 - 218	158 - 330	453 - 889
Lead, dissolved (ug/L)	< 20	< 1	< 1	< 0.1	< 0.1 - 0.19	< 0.1 - 0.12
Oxygen, dissolved (mg/L)				11.7 - 12.9	11.5 - 12.7	7.1 - 14.8
Magnesium, dissolved (mg/L)	15	6.8 - 7.4	2.9 - 4.0	2.5 - 3.0	0.75 - 0.83	1.6 - 1.9
Manganese, dissolved (ug/L)	< 10	0.5 - 1.1	0.6 - 4.6	1.0 - 1.4	2.4 - 3.2	10.0 - 43.5
Nickel, dissolved (ug/L)				< 0.1 - 0.13	0.21 - 0.35	0.31 - 0.50
pH				7.1 - 7.5	5.8 - 6.8	5.8 - 7.5
Sulfide (mg/L)	< 0.002	< 0.050	< 0.050	<0.010	<0.010	<0.010
Total Suspended Solids mg/L	< 80	1.5 - 6.7	1.6 - 10.0	1.6 - 5.1	1.5 - 4.0	1.4 - 9.8
Zinc ug/L	< 5	< 4	< 4	< 0.5 - 0.6	0.9 - 1.4	2.0 - 40.4

2.0 SAMPLING LOCATIONS AND METHODS

Sites were chosen to check for changes in water quality at places upstream from the hatchery along Crisp Creek, at points where affected ground water might have an impact (Figure 1).

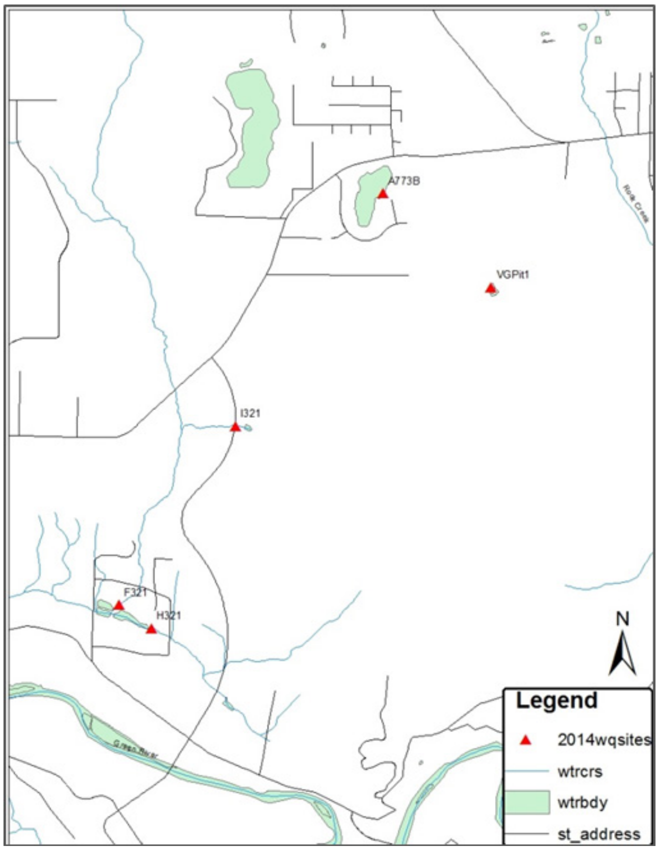

Figure 1. Map of sampling locations in 2014. Horseshoe Lake is the water body with sample site A773B.

The specific locations that were sampled in 2014 included:

- VGPIT1: at the gravel pit infiltration site, characterizing the water pumped from the lake (see Figure 2 for photo);
- I321: at the outflow from the wetland outlet that flows to upper Crisp Creek, as it enters the culvert under 218th Ave SE (Figure 3);

- H321: at 216th Ave SE water was taken from a small tributary that flows along the valley bottom, draining the hillside as well as private property along the Green Valley Road before it enters Muckleshoot property (Figure 4).;
- F321: just above the hatchery intake. This location was also sampled in 2011 (Figure 5).
- A773B: eastern shoreline of Horseshoe Lake near the site of the pump intake. This was sampled once, at the same time as baseline sampling before the pump was turned on. Subsequent samples were taken at the VGPIT1 site where outflow from the lake came through the pipe.

Figure 2. Site VGPIT1: The gravel pit infiltration pond, including the Horseshoe Lake pipe outlet in the distance. The sample site was approximately halfway between the standing pipe and shoreline.

Figure 3. **I321, wetland east of 218th Ave SE. near outlet. Taken from the sample site looking east.**

Figure 4. **H321, valley tributary of Crisp Creek, east of 216th Ave SE. photo taken looking west towards 216th Ave SW.**

Figure 5. F321, Crisp Creek at hatchery intake. Picture taken looking north, with hatchery ponds to the left of the photo.

In the field, specific conductivity, temperature, pH and dissolved oxygen were measured in-situ using a Hydrolab MS5 field probe. Grab samples were taken for metals and alkalinity analyses by the King County Environmental Laboratory (KCEL) using ICP-MS technology. Samples for dissolved metals were filtered on-site immediately. Operating procedures, precision, and accuracy for these tests can be obtained upon request to the KCEL quality control officer.

3.0 RESULTS AND DISCUSSION

Table 1 contains the range of values recommended for optimal hatchery operations (Timmons et al. 2002), as well as measurements obtained in 2011 by King County during a similar project and data previously collected by the Muckleshoot staff.

Parameters with previously collected data include dissolved aluminum; alkalinity; dissolved cadmium; dissolved calcium; hardness; total iron; dissolved lead; dissolved magnesium; dissolved manganese; sulfides, total suspended solids, and dissolved zinc.

Additional parameters of interest that were measured include pH, dissolved arsenic, dissolved copper, specific conductivity, dissolved iron, dissolved oxygen, and dissolved nickel.

Parameters with previously collected data that fell within the recommended ranges by Timmons include cadmium, lead, manganese, and zinc.

The soft nature of the water in the Pacific Northwest likely explains why values for hardness, alkalinity, calcium and magnesium were all on the low side compared to the values recommended by Timmons et al. This probably reflects the water quality in the regions in which the authors work more than it signals specific problems for fish living in hatchery water provided by Crisp Creek.

Metals with defined acute and chronic toxicities for humans listed in the Washington Administrative Code (WAC) include arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. Calculations of toxicity thresholds include a term for water hardness and were carried out for the maximum concentration found during the sample period for each metal on the defined list. None of the maximum metal concentrations at the creek site above the hatchery exceeded either the acute or chronic thresholds. However, these thresholds are defined for human risk and may not be directly applicable to salmonids.

Total iron was identified as a parameter of particular concern because of potential problems for the gills of very young fish. Timmons et al. recommended a concentration of less than 150 µg/L, and the Muckleshoots had some data to show that Crisp Creek concentrations sometimes exceeded that value. Therefore, they were concerned that the addition of Horseshoe Lake water to the gravel pit might have the effect of elevating already high concentrations if it moved into the creeks from the groundwater.

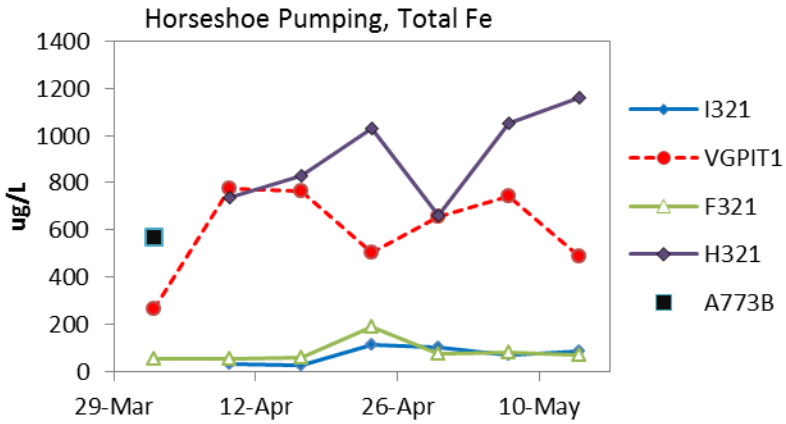

Figure 6. Total iron concentrations before and during Horseshoe Lake pumping.

Values measured by King County (Figure 6) showed that, while the water in the gravel pit from Horseshoe Lake (VGPIT1) was indeed quite high in total iron, this was not reflected in the concentrations found in the Crisp Creek water at the hatchery uptake (F321).

The highest values in Crisp Creek were found in the small tributary to the east of the Hatchery ponds. Site H321 was consistently very high in total iron, and it was noted that a well head next to the sampling site had a large amount of precipitated iron on the structure (Figure 7). Talking with the property owners elicited the information that this well site had a commercial history of producing highly mineralized water for human consumption and that the well is very deep, originally drilled for locating coal seams viable for mining activities.

Figure 7. Ornamental well head with iron precipitation by sampling site H321 on the valley floor tributary to Crisp Creek.

Another parameter of concern was total suspended solids (Figure 8). The values obtained from all sites during pumping remained similar to previously collected data and were all well below the recommended threshold of 80 mg/L.

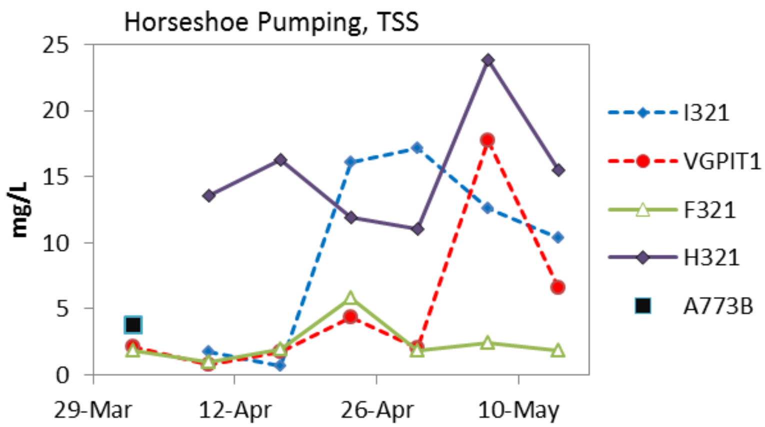

Figure 8. Total suspended solids concentrations before and during Horseshoe Lake pumping.

While the test used for total sulfides by King County in 2011 produced a minimum detection level 5 times lower than that used by previous data collection effort (0.01 vs 0.05 mg/L), it still was 5 times higher than the recommended threshold for hatchery water (0.002). This means that we still do not know how the levels of sulfide in crisp Creek compare with the recommendation, but we do know that it was at least 5 times lower than the minimum measured previously. A similar outcome was also true for hydroxides, in which the KCEL minimum detection level was the same as that of previous data and both were below the minimum. However, the maximum threshold recommended was very much lower at 0.005 mg/L vs 1.0 mg/L.

In 2014, sulfate was measured, but not sulfide. This was because no advances have been made in lowering the detection level since 2011, and the oxygen data produced by the field probe (Figure 9) indicated that levels were high enough to convert most sulfide to sulphate in surface flowing water in any case.

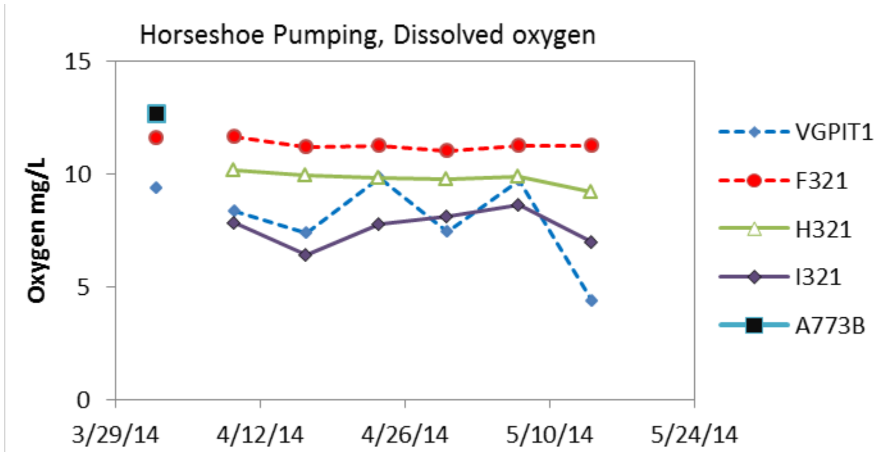

Figure 9. Oxygen levels in water at sites before and during Horseshoe Lake pumping.

Sulphate levels remained very stable during the period before and during pumping, suggesting no great changes in ground water quality (Figure 10). The low value in the gravel pit came from the very small amount of water present at the site before pumping began, which illustrates that the preponderance of the water at the site was pumped from Horseshoe Lake.

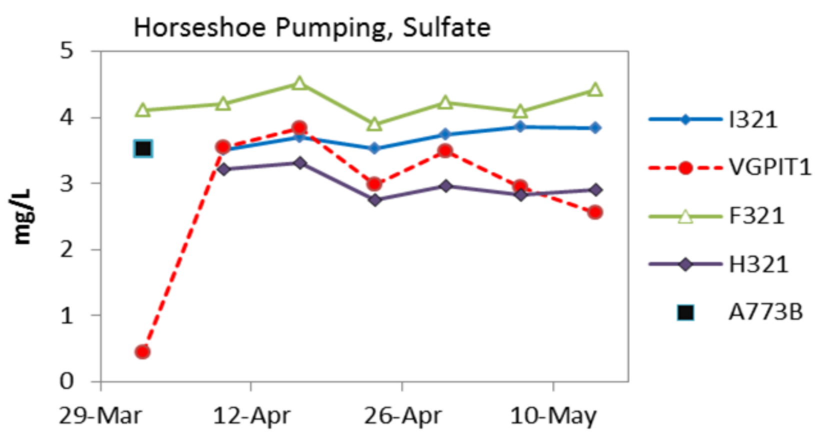

Figure 10. Sulphate levels in water at sites before and during Horseshoe Lake pumping.

Dissolved aluminum was recommended to remain below 10 µg/L. King County 2014 samples produced a range of 4.8 to 58.8 µg/L, showing that aluminum levels do exceed the recommended value (Figure 11). The water taken at the hatchery uptake (F321) averaged 16.3 µg/L, while the east tributary on the valley floor (H321) averaged 17.8 µg/L The gravel pit water average was higher, at 27.2 µg/L

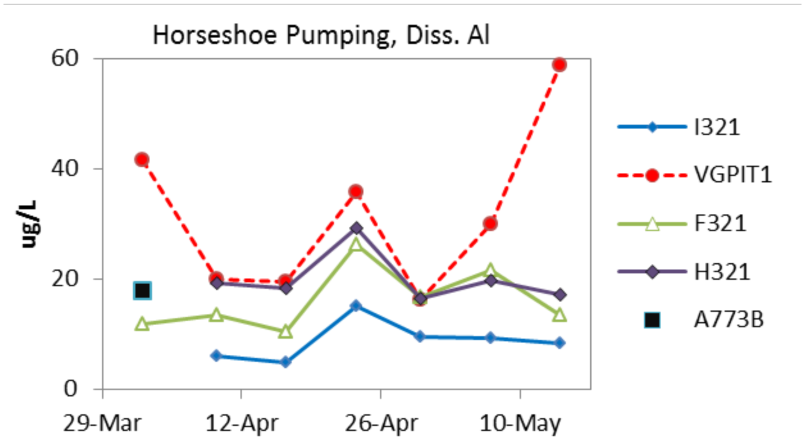

Figure 11. Dissolved aluminum levels in water at sites before and during Horseshoe Lake pumping.

The slightly higher aluminum values in F321 and H321 may not be a major problem, depending on the pH of the water in the hatchery ponds. In general, pH values around neutral (6.5 – 7.5) should be better than more acidic pH values in terms of aluminum availability and toxicity. The pH was measured in situ each time samples were taken (Figure 12), and are representative of conditions at that time, but pH can change readily in soft water with low total alkalinities, so these values should be taken only as general indicators of conditions in the system. Only one sample was low enough to impact toxicity of aluminum, which was the last sample at I321, the outlet of the wetland flowing to Crisp Creek. However, this water flows into the creek well above the hatchery intake, so it is unlikely to have a direct impact on the water at the fish hatchery uptake.

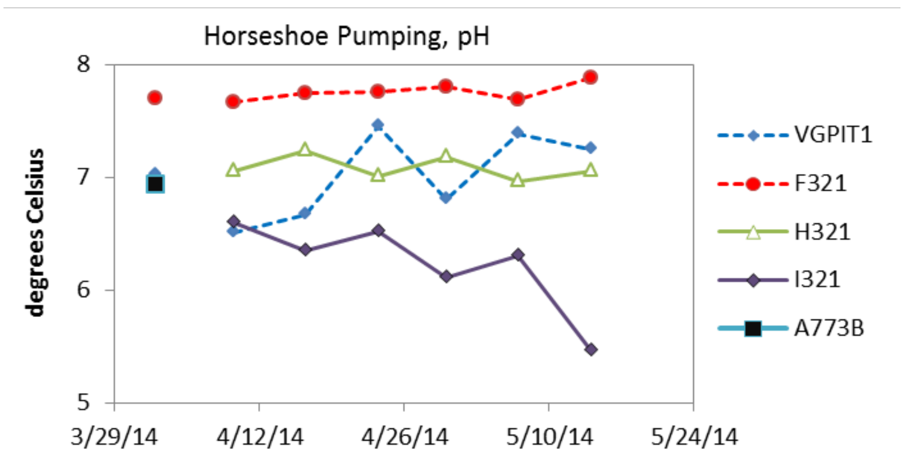

Figure 12. pH of water at sites before and during Horseshoe Lake pumping.

Because the water in this area is relatively soft, both calcium and magnesium concentrations were well within the Timmons et al. recommendations, although towards the low end of the ranges. Calcium ranged from 5.3 to 11.5 mg/L, with an initial measurement at the gravel pit of 1.1 mg/L before pumping commenced. Magnesium ranged from 1.6 to 3.2 mg/L, with the gravel pit initial measurement of 0.3 mg/L.

4.0 SUMMARY

The water quality testing of the Horseshoe Lake water pumped into the gravel pit and at three sites on Crisp Creek and its tributaries did not turn up any water quality issues with respect to increases in either total iron or total suspended solids that could be associated with the pumping event.

Comparison of other parameters to the recommended levels for hatchery water published by Timmons et al. (2002) showed only aluminum exceeded the recommendations, while calcium and magnesium were within the recommended concentrations, although at the low end of the ranges.

Comparison of maximum values for metals to the toxicity standards based on ambient hardness set in Washington State Administrative Code 173-201A-240 showed that metals concentrations were below thresholds for both acute and chronic toxicity for humans.

There were some significant differences in some parameters between the site at the hatchery diversion and the site at the valley floor tributary that flows to the third pond in the hatchery upstream from the second fish-rearing pond, which had not previously been measured. Some difference, in particular the amount of total iron present, could be due to flows from the nearby mineral water well at the valley floor site or to localized surficial geology.

A new monitoring site was added in 2014. It is at the outlet of a wetland to the east of 218th Ave SE that contributes significant flow to Crisp Creek upstream of the hatchery uptake. Samples from this site (I321) were very close in value to the samples at the hatchery site (F321), suggesting that there is little difference in the source water from the wetland from the upstream flow in Crisp Creek.

5.0 REFERENCES:

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