Analysis of a Future Salmon Spawning Habitat in Bowker Creek

Oak Bay High School

Canada

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Abstract

Bowker Creek is an urban waterway flowing by our school, Oak Bay High. The creek runs for eight kilometers through Victoria, though only 2.5 kilometers of it are daylighted. A group of community members recently have been able to begin to repopulate a downstream site of Bowker Creek with salmon eggs, through a combination of restoration efforts and environmental monitoring. Our goal is to conduct an analysis comparing the new salmon egg placement site with a site upstream at the high school. There are some differences between the two locations, foremost among them is that the school site is a newer restoration site and still has a running track on one side. To compare the two sites we will use the Streamkeepers protocol, developed by the Pacific Streamkeepers Federation. The protocol will be divided into four units, an introductory creek analysis, habitat assessment, water quality survey and invertebrates survey. Based on the results of our analysis, we expect to be able to set up a plan for future groups to improve the riparian ecosystem at Oak Bay High School, resulting in a better salmon spawning habitat. Ideally, this plan will allow for a salmon run in Bowker creek at Oak Bay High School, something that hasn't been seen in over 100 years.

1 Introduction

Bowker Creek is a 7.9 km urban waterway that traces its way through the municipalities of Saanich, Victoria, and Oak Bay. However due to city urbanization, the majority of the creek has been diverted to underground pipes and narrow pathways. Currently, only 2.9 km of the 7.9 km creek is above ground. Though Bowker is fed by over 1,000 hectares of land, more than half of it is impermeable.

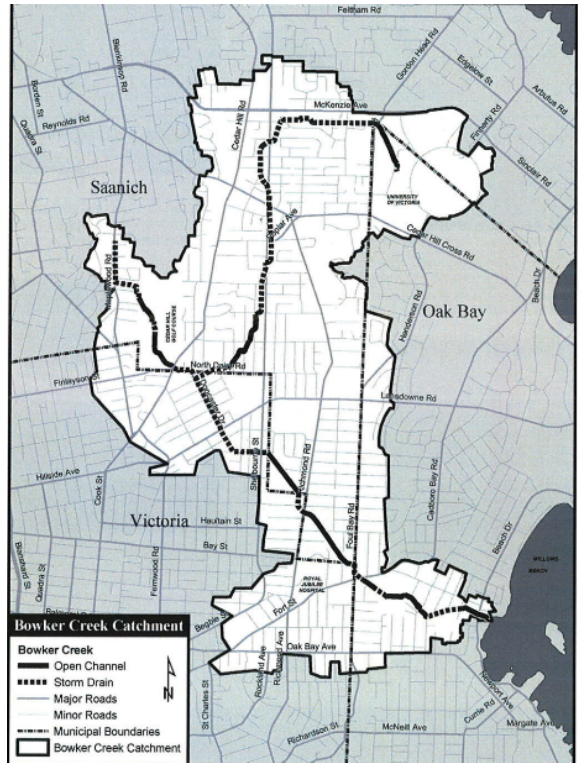

Figure 1 - Watershed Map of Bowker Creek

Historically, local First Nations thrived off the abundance of wildlife and salmon species, such as coho and chum, that the creek had to offer. The salmon ran from the creek's mouth located at what is now known as Willows Beach. Here, approximately 2500 years ago, a Native village occupied and prospered off this land. We see their presence in the layers of broken shells and charcoal, called a midden. The fresh waterway also plays a crucial role in feeding marine biodiversity. Minerals and nutrients are carried downstream to its mouth, benefiting the marine ecosystems as freshwater mixes with the salt. This enrichment of Bowker Creek would have played an integral part of the Indiginous people's lives at the pre-existing village site. Because of the rich history of Bowker Creek and the area around it, it is important that we acknowledge the Esquimalt and Songhees Nations through who's land Bowker Creek flows.

Within the past 200 years, the watershed has been altered from a natural state, to agricultural use, to its present condition of accommodating industrial, commercial and institutional uses. The first modifications were in its agricultural phase, where ditches channelized the water flow. This eventually gave way to industrial and stormwater management for runoff. The devastating loss of wildlife over this time period showed a reduction in the value placed upon the natural ecosystems like Bowker Creek. However, as environmental values shifted, initiation for the Capital Regional District Environment Committee to adopt a regional watershed management strategy in 1997 was created. In 2004, a 100-year plan to restore the Bowker Creek Watershed was approved. The initiative reflects a change in the community's values from viewing urban waterways as a storm water drain, to appreciating and respecting the creek as a natural ecosystem.

In 2005, some of the first restoration efforts were made on a stretch of Bowker Creek further upstream by St Patrick's Elementary School. The attempt focused on replacing elements of the stream bed to give a more natural look, however it was not done to provide a community connection to the creek. Nevertheless, these efforts were an important first step in reviving the creek.

As part of the reconstruction of Oak Bay High School in 2015, aspects of the 100-year watershed restoration plan were used in designing a riparian ecosystem that would foster public connection to Bowker Creek. To improve stream flow for aquatic life the meandering flow design slowed the flow rate of the Creek, especially during the fall and winter months, as Oak Bay receives the majority of its rainfall. To help connect students and the community to the creek, an outdoor education area was added along the edge of the water way. Along with the construction of the outdoor education facility, work was completed to stabilize the bank, stream bed, and the riparian zone. Native species Indigenous to southern Vancouver Island were planted not only to emulate what would have once grown wildly, but to educate students and community members on a wide variety of native plant species. Because of the outdoor learning space's proximity to the creek, students are also able to view and study terrestrial insects and aquatic invertebrates. Although it is acknowledged that Bowker Creek will never fully recover the stresses of urbanization, it is spaces like the education facility that bring awareness and knowledge to the community.

In August of 2021, The Friends of Bowker Creek Society were granted permission to release 30,000 salmon eggs into the creek. The specific site is referred to as the "Monteith site", deemed to be most suitable for spawning salmon because of its closer resemblance to an organic waterway. With the society's efforts, salmon could possibly return to Bowker Creek for the first time since 1914. The ideal outcome envisions salmon eggs being placed in Bowker Creek at Oak Bay High School. This project endeavors to compare the two sites and evaluate their suitability for hosting salmon eggs.

2 Methods

2.1 Water Quality Survey

Multiple tests to determine water quality were conducted in two locations along the Bowker creek waterway. The tests conducted included a pH test, temperature reading, a D.O test (dissolved oxygen), and a turbidity test. One survey was conducted at Oak Bay high school, the other at the Monteith site. The samples from each site helped determine some of the many differences between a more sheltered, protected site at Monteith, and a more developed, newer site at the school. The tests were conducted in late spring of 2022. The results were gathered using a turbidity tube, a DO (dissolved oxygen) test kit, a thermometer, and ph strips. Using all three of these tests the group was able to determine the water quality of both locations.

For the turbidity test a turbidity tube was used. To effectively use the turbidity tube water must be filled to the top of the scale, with the exit tube pinched close. Slowly water is released until the secchi disk can be seen; once the disk can be seen, the exit tube is closed, and measurements of the scale are taken.

To determine the saturation levels in the oxygen, a D.O test was conducted. In a D.O test water is tightly sealed into a small glass bottle. Once the water settles clippers are used to open and add the Dissolved Oxygen 1 Reagent Pillow and one Dissolved Oxygen 2 Reagent Powder Pillow into the bottle. After adding both powders, the stopper is inserted to ensure there are no air bubbles. Shake the bottle vigorously, following the bottle being shook a flocculant (floc) precipitate will form. If oxygen is present the floc will be brownish orange in color. Let the bottle settle until the floc has settled halfway in the bottle, leaving the upper half of the sample clear. Use the clippers to open one Dissolved Oxygen 3 Reagent Powder Pillow. Remove the stopper from the bottle and add the contents of the pillow. Carefully reapply the stopper and then shake to mix. The Floc will dissolve and the color yellow will develop. Once this step is completed pour the solution into a plastic measuring tune and pour the sample into a square mixing bottle. Drop by drop add Sodium Thiosulfate Standard Solution into the mixing bottle, while swirling the bottle following each drop. Continue to add drops until the solution loses its color and becomes clear. Each drop used is equivalent to 1 mg/l of dissolved oxygen.

When determining the water quality of a stream a pH test is required. Using universal pH strips the group determined the pH level of each location. The strips were dipped in the stream for 2 seconds and waited for 10 seconds before recording the result. The pH level were determined using a pH indicator scale.

2.2 Stream bed

When looking at a stream to determine whether the habitat is suitable for salmon or not, the quality of the stream bed is one of the most important factors. Not only is a stream bed important for the laying of eggs, but also the survival of the eggs and alevin. Gravel helps oxidize the water along with providing protection for eggs and alevin. A survey was done at both locations to analyze the material each streambed consists of. By conducting these surveys the group will be able to tell what is needed to analyze and create a healthy streambed. An ideal size for stream bed material would be about 10% of the salmon's size. If the stream bed material is too small it could potentially suffocate the eggs. The surveys were done by randomly selecting 24 particles in the stream bed. Once the particles were selected the length and width of the particles were recorded. Using the length and width of each particle the average diameter was found, along with the type of particle.

2.3 Pool habitat

Streams are generally divided into shallow, fast moving ripples, and slower moving, deeper pools. Pool Habitat is essential for salmon to be able to successfully spawn.

Salmon require deep pools with overhang and moderate shade.

Measurements were taken at both sites' pool habitat to determine whether or not the area is suitable for salmon or not. Starting with taking the total length of the reference site, the group then measured the length of each pool area and added them together to find the total length of the pool habitat. By dividing the total length of the pool habitat by the total length of the reference site, then multiplying by 100 the percentage of the pool habitat can be found. Using the measurements the group was able to determine the percentage of pool habitat that the stream possesses and if it is suitable for salmon or not.

2.4 Bank Stability

Bank Stability is a vital contributor towards keeping a stream suitable for salmon spawning. Oxygen is essential for the survival of salmon eggs, sediment that enters the creek from the banks, filling space and suffocating the eggs.

A survey was done at both sites to determine the stability of the banks. Signs of erosion, artificial bank stabilization, and landslides were looked for at each reference site. The length of erosion along each bank was taken at both sites, identifying what has to be done to improve the stability of each reference site.

2.5 Off Channel Habitat

Off channel habitat in streams can influence the success of a salmon spawn. Off channel habitat is when the stream breaks off, creating an extra channel. Having more than one main channel can help disrupt the flow of water, making it easier for salmon to spawn.

The off channel habitat at both reference sites were found and analyzed. The size of each off channel was recorded, along with the amount of off channels the reference sites possess.

2.6 Bank Vegetation

To calculate bank vegetation, the total length of the reference area is first measured with a long tape measure with one group member on ea. Next, find the percentage of the habitat without vegetation by measuring the length of each part of the site without vegetation, then divide by 100, resulting in the percentage of banks without vegetation for the left and right bank. To find the total percentage, add the left and right bank percentages and then divide by two for the overall percentage of the bank without vegetation.

2.7 Overhead Canopy

The next step was to calculate the overhead canopy by measuring all the separate branches that go over the stretch of the steam. Then adding together all the lengths divided by the number of branches, giving the average length. After, divide the average length of overhanging branches by the channel width, multiplying that by 100 to get the percentage of the channel shaded. Even though the percentage of channel shaded would change in the real world depending on the time of day and season, this gives a good approximation of the average. The percentage of a channel shaded is key to the overall habitability of a creek. If a channel has no shade, the water would be too hot for salmon to spawn there.

2.8 Riparian Zone

One of the most important statistics when considering how

relatively healthy a steam is is measuring its riparian zone. The riparian zone refers to the area of natural vegetation beside the given stream. A long measuring tape was used to measure the riparian area along each stream. Next, record the riparian zone in measurements of how many channel widths of vegetation there is, so divide the width of the channel by the width of the riparian zone. Not only is the size of the riparian zone important but also is its makeup, with lots of plants in general as well as diversity being important.The plants and trees were broken up into four categories, coniferous, deciduous, shrubs and grasses.
Take these two data points and again, and give the streams a score in its respective riparian zone, overhead canopy and bank vegetation.

2.9 Overall Comparison

Using the graphs provided by the Streamkeepers federation, the stream is given a score out of 100 based on the sections above to determine its suitability as salmon habitat.

3 Results & Discussion

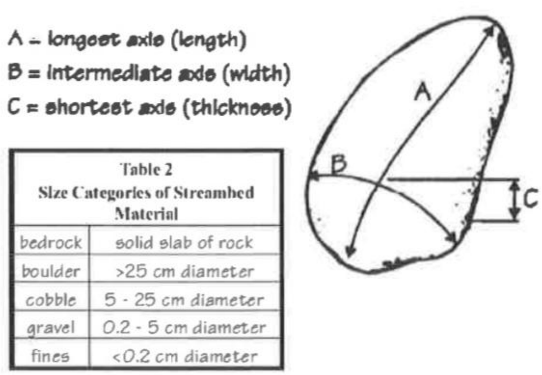

Table 2
Size Categories of Streambed Material

bedrock	solid slab of rock
boulder	>25 cm diameter
cobble	5 - 25 cm diameter
gravel	0.2 - 5 cm diameter
fines	<0.2 cm diameter

Figure 2 - Size Categories of Streambed Materials

3.1 Boulder and Cobble (Streambed)

Depending on the diameter of any individual rock, it was placed in one of five categories: bedrock, boulder, cobble, gravel or fines. After measuring all 24 rocks none of them were fines, boulder or bedrock. Only 16.6 percent of them were gravel and 83.3 percent of them were cobble. In general, a stream does better if there are greater amounts of boulders and cobble. This is because the larger the rock is, the more it breaks up the stream, making it easier for salmon to climb the creek back to their spawning bench. Bedrock is not as helpful as boulders or cobble because it is located on the stream's floor, making it flat and relatively smooth. Thus it does not slow down the water flow.

3.2 Pool Habitats and Off-Channel Habitats

Pool and off-channel habitats serve primarily as refuge sites for salmon.
Pool habitats can be described as deeper 'pools' or segments of a waterway. They provide refuge during dry conditions and protection/shelter from predators. Meanwhile, off-channel habitats are adjacent to the main stream body and serve similarly as areas of refuge for salmon. Both habitats slow water velocity. The depth of pool habitats allow organic debris to settle out and for food sources to accumulate, while the diverted off-channel habitats are often shallow, further providing better refuge for juvenile salmon under eroded banks. Food and debris accumulation is also beneficial in off-leading channels.

Unfortunately, the Oak Bay site has neither pool or off-channel habitats. This poses one of the more serious obstacles in preventing the ability for salmon spawning at the school, as it is more difficult to add deep pools or divert water into side channels, especially with limited space. Although Monteith has few of these habitats, they nevertheless give site 2 the cutting edge when compared to site 1 for salmon suitability.

3.3 Bank Stability

'Bank Stability' refers to the ability of a streambank to resist erosion from water flow and gravity. Soils and vegetation are great determining factors on whether a streambank will have good 'stability' or not. While both sites 1 and 2 fall within the 'acceptable' range for erosion resistance, site 2 (Monteith) is ranked slightly higher. This is in direct correlation to its bank vegetation (see below) and soil. Although Oak Bay High's site has more added artificial stabilizers (such as natural-like rock walls), the recent restoration activity means the soil is not held as well by the relatively new vegetation. On the contrary, Monteith site's soil has been left alone for a number of years allowing it to be more strongly held by the adapted vegetation.

3.4 Bank Vegetation

Both sites are plentiful with bank vegetation. Only 16 percent of Oak Bay's banks have no vegetation, most of which is caused by erosion. In the Monteith site, 100% of the bank is covered in vegetation. Bank vegetation is important because it slows erosion, makes it harder for people to damage the creek because it creates more of an obstacle. Furthermore,

3.5 Overhead Canopy

In a climate like Victoria, overhead canopy is an important factor that regulates the average temperature by the creek. It does this by giving the stream shade during the hot summer months and also insulating it during the winter. Although the creek's temperature will still fluctuate, a good overhead tree canopy will moderate the effects of more extreme weather. The fact that Monteith has an 80% overhead canopy coverage compared to Oak Bay High's 93.8 percent coverage shows that Oak Bay High's site has impeccable tree coverage and will be well suited for the changing seasons.

3.6 Riparian Zone

The riparian zone is one of the most important factors when it comes to a stream's health. However, certain factors differentiate riparian zones and depict why one might be better than another. It comes down to how wide the riparian zone is in relation to the width of the stream along with the biodiversity of the plants. The Oak Bay High site has a decently sized riparian zone and has some biodiversity. The Monteith side, on the other hand, has a very large riparian zone and an abundance of biodiversity. The riparian zone creates a buffer between the urban environment around it and the creek. This protects the creek and supports the surrounding ecosystem.

3.7 Habitat Survey Site Score

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Stream Assessment: Habitat Survey
Data Analysis

Use your data from each of the sites surveyed to summarize the habitat characteristics in the table below. For each characteristic the range of scores is shown in bold. You have already assigned a score to each characteristic within those ranges.

Habitat Characteristic	Good	Acceptable	Marginal	Poor	Site 1 OB	Site 2 Mt
% Boulder & Cobble	**15-20** 50%	**10-15** 30-50%	**5-10** 10-30%	**0-5** 0-5%	20	16.5
% Pool Habitat	**11-15** >50%	**7-11** 40-50%	**3-7** 30-40%	**0-3** <30%	0	7
Off-channel habitat description	**11-15** year round, good protection	**7-11** seasonal, good protection	**3-7** seasonal, minimal protection	**0-3** little or none, no protection	0	3
Bank stability Bank erosion	**11-15** Stable Intact banks	**7-11** Moderately stable Healed or stabilized banks	**3-7** Moderately unstable Active erosion	**0-3** Unstable Active erosion or slides	8	10
% of banks without vegetation	**8-10** <10%	**5-8** 10-30%	**2-5** 30-50%	**0-2** >50%	1	10
% channel shaded by overhanging vegetation	**8-10** >30%	**5-8** 20-30%	**2-5** 10-20%	**0-2** 0-10%	8	10
Riparian area width (# of channels) Abundance of trees and shrubs	**8-10** 2 or more Abundant over area	**5-8** 1-2 Good, mix of species	**2-5** <1 Common, few species	**0-2** 0 Absent or sparse	6	8
TOTAL SCORE	**72-95**	**46-72**	**20-46**	**0-20**	43	65 (64.5)

3.8 Water Quality

The water quality of a steam is integral to how healthy the salmon living in the stream would be. Many factors contribute to the overall quality of the water but among them the group looked at both air and water temperatures, pH, turbidity and DO.

3.8.1 Temperature

TABLE 1
Optimal Stream Life At Various Temperatures

TEMPERATURE RANGE	TYPES OF STREAM LIFE
20 - 25° C (warm)	lots of plant life; high fish disease risk; warm water fish (bass, carp, crappie, catfish, bluegill); caddisflies, dragonflies
13 - 20° C (cool)	plant life; moderate fish disease risk; trout, salmon, sculpins; stoneflies, mayflies, caddisflies, water beetles, water striders
5 - 13° C (cold)	plant life; low fish disease risk;trout, salmon, sculpins; stoneflies,mayflies, caddisflies

Figure 3 - Temperature Ranges in Freshwater Streams

At the Monteith site, on June seventh 2022 the air temperature was 18.5 degrees celsius and the water temperature was thirteen degrees celsius. On May 24th, 2022 the group got an air temperature of 17 degrees celsius and a water temperature of 20 degrees celsius. When a creek has a high temperature, up to 25 degrees celsius, the chances of fish diseases goes up, the colder a stream gets, down to 5 degrees celsius, there is a lower chance of fish diseases. As air temperature rises you also get more plant life and more biodiversity.

3.8.2 pH

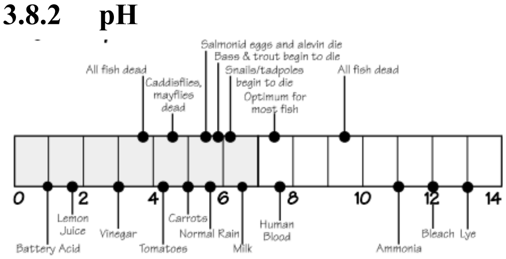

Figure 4 - pH Scale

At the Monteith site on June 7th, 2022 the pH was 7, only slightly below the optimal pH for salmon to spawn. On May 24th the pH was measured to also be 7, which makes sense because both sites are located on the same creek. While the pH for both sites is slightly below what is considered perfect, the difference is so negligible that it would make almost no noticeable difference.

3.8.3 Turbidity

On the same day that the temperature and the pH were measured at Montieth the turbidity was also measured, giving a reading of 1.15m. While at Oak Bay the turbidity was measured to be 1.2m. The turbidity of the water is a good indication of how clean the water is, or how many particles are in the water. In this case both streams the turbidity is low and will not cause a problem for salmon spawning.

3.8.4 Dissolved Oxygen

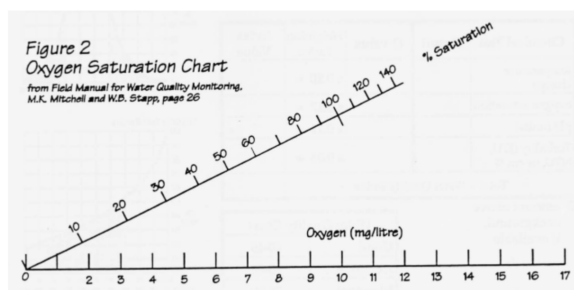

Figure 5 - Oxygen Saturation Chart

Dissolved oxygen is measured in oxygen saturation, or how much of the water has oxygen present in it. A higher level is beneficial for active species such as salmonids. In the tests the Oak Bay site measured at 70% oxygen saturation and Monteith had 45% oxygen Saturation. There is a high chance that this is some error on the group's end, as Monteith's DO would have had to have been very high for DFO to approve salmon eggs implantation. The error could be because of a human error or some error in the equipment's side. Even though the higher the oxygen saturation the better, the lowest oxygen saturation that is considered healthy is 5 ml/g or 35% saturation.

3.8.5 Water Quality Chart Scores

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Stream Assessment: Water Quality Data Analysis

Use the graphs on the facing page to determine the quality (Q-value) for each of the four water quality variables.

Fill in the table below to generate an index of water quality.

Site 1:

Test	Results	Q-value	Weighting Factor	Index Value
Δ Temperature	3°C	81	x 0.10 =	8.1
DO (% saturation)	45%	35	x 0.17 =	5.95
pH (0-14)	7	88	x 0.11 =	9.68
Turbidity	120	80	x 0.08 =	6.4
			Total Index Value =	30.13

Site 2:

Test	Results	Q-value	Weighting Factor	Index Value
Δ Temperature	5.5	65	x 0.10 =	6.5
DO (% saturation)	90%	98	x 0.17 =	16.66
pH (0-14)	7	88	x 0.11 =	9.68
Turbidity	115	78	x 0.08 =	6.24
			Total Index Value =	39.08

Water Quality Chart	
Good	40-45
Acceptable	30-40
Marginal	20-30
Poor	<20

Overall, Oak Bay High's site (site 2) is seen to have a higher water quality than Monteith's site (site 1), reaching a final score of 39.08 in comparison to Monteith's 30.13. While Oak Bay's water quality is considered highly 'acceptable', Monteith's nearly falls into the 'marginal' category. This is unexpected, as the Monteith site is our 'model site' for how Oak Bay High's site can improve.

These surprising results could be the effect of certain discrepancies between the survey periods. The two outliers in the data are most likely Oak Bay High's temperature delta and the dissolved oxygen at Monteith.

Temperature delta can vary depending on the time of day and present weather conditions when the tests were taken. Although the weather was consistent between the two sites, the temperatures were taken at different times throughout the day. Site 2 was recorded around 12pm, so it is likely that the water had not been exposed to much sunlight and therefore had not had the chance to heat up, whereas site 1 was recorded in the late afternoon.

The other outlier is the DO at Monteith which is a bit harder to explain because the discrepancy is so large, Oak Bay High's oxygen saturation at 90% to Monteith's 45%. To get salmon eggs in Monteith, you would need to obtain permission from DFO who would have seen such a low number and would never have approved if this number was correct. That leaves two options, either this was caused by human error or equipment failure. If Monteith had gotten an index score in DO more similar to Oak Bay High, its final score would have been above 40, inside of being called 'good'.

4 Conclusion

Overall, Oak Bay High scored 43 on the habitat survey, reaching a rating of marginal, while Monteith scored a 65 which is considered acceptable. These scores make sense as Monteith was approved as the area where salmon eggs have been put in; it gives a benchmark for where Oak Bay High should be aiming for. The biggest restoration effort this year was a major push to increase the riparian zone around the Oak Bay site. With these changes to the site it puts the Oak Bay High site even closer to Monteith and getting salmon at Oak Bay High.

Regarding water quality, both Oak Bay High and Montieth were given an acceptable score, with 39.08 and 30.13 respectively (* see 3.8.5) Because it is difficult to improve these scores, it's reassuring that both of these scores are well within respectable ranges. These water quality numbers can go down, though, many storm drains drain into Bowker Creek. One way to make the water quality better or stop it from getting worse is to educate people of the consequences caused by putting things like dangerous chemicals down these storm drains and how it affects the aquatic life in the creek.

On a positive note, Friends of Bowker Creek have permission to put salmon eggs into the creek until 2023 when they will have to renew the application to continue to put eggs in at Monteith. The hope is that this movement will bring attention to the fact that the goal to have the whole of Bowker Creek be a thriving salmon run is possible. This is encouraging because it took 13 years from the start of restoration at Monteith, and with the numbers being so similar even though restoration only began in 2018, only four years ago.

This goal is only possible with the help of DFO who are in charge of the protection of salmon and are also responsible for the distribution of salmon eggs for repopulation. It's only with their permission will we ever be able to put salmon eggs into the Oak Bay High site, which is why comparisons like this are so important.

With increasing attention surrounding Bowker Creek and its 100 year long stint without salmon, it's likely the restoration efforts will continue.

While on paper Oak Bay High is within range of being salmon compatible, there are factors downstream of the selected site that make it impossible at the moment for salmon to travel down the stream to the ocean. If these issues are fixed then the chances of salmon returning to Bowker Creek after over 100 years is very good!

5 References

CRD. (n.d.). Bowker Creek Blueprint: A 100 Year Plan. Last updated March 12, 2018. Retrieved November 6, 2022. https://www.crd.bc.ca/bowker-creek-initiative/about-bci/plans-and-strategies/bowker-creek-blueprint-a-100-year-plan

CRD. (n.d). Bowker Creek Initiative. Watershed info. Retrieved November 6, 2022. https://www.crd.bc.ca/bowker-creek-initiative/creek-info/watershed-info

Ephem. (n.d). Burnt Embers. Retrieved November 6, 2022. https://burntembers.com/2011/10/03/thaywun-bowker-creek/

Friends of Bowker Creek Society (2022). Friends of Bowker Creek. Retrieved November 6, 2022. https://bowkercreek.org

Pacific Streamkeepers Federation. (n.d). Streamkeepers modules 1-4. Retrieved November 6, 2022. https://www.pskf.ca/modules.html

Appendix - Raw Data Tables for Bowker Creek Sample Sites (Monteith & Oak Bay High)

LOCATION	TEMPERATURE (°C)
Air Temperature	17°C
Water Temperature	20 °C

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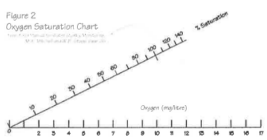
	Measurement #1	Measurement #2	Average
pH (0-14)	7	7	7

	Measurement #1	Measurement #2	Average
TURBIDITY			



	Measurement #1	Measurement #2	Average	% Saturation
DISSOLVED OXYGEN (mg/L)	4	8	6	

Data Table: Streambed Material
A = longest axis (length), B = intermediate axis (width), C = shortest axis (depth).
Type = Bedrock (B), Boulder (Bo), Cobble (C), Gravel (G) or Fine (F)

	A	B	C	Avg.	Type		A	B	C	Avg.	Type
1	3cm	2.5cm	4cm	3.16	G	6	20cm	12cm	9cm	13.3	C
2	4cm	7cm	2cm	2.6	G	7	12cm	28cm	9cm	16.3	C
3	9cm	6cm	4cm	7.3	C	8	20cm	12cm	8cm	13.3	C
4	13cm	19cm	8cm	13.3	C	9	14cm	10cm	7cm	10.3	C
5	15cm	8cm	9cm	10.6	C	10	12cm	6cm	5cm	7.6	C

	A	B	C	Avg.	Type		A	B	C	Avg.	Type
11	8cm	4cm	6cm	6	C	18	13cm	11cm	6cm	10	C
12	4cm	8cm	7cm	6.3	C	19	20cm	16cm	1cm	12.3	C
13	12cm	10cm	6cm	9.3	C	20	11cm	1km	4cm	8.6	C
14	20cm	14cm	5cm	13	C	21	2cm	3cm	.5cm	1.5	G
15	9cm	5cm	5cm	6.3	C	22	7cm	8cm	4cm	6.3	C
16	8cm	9cm	6cm	7.6	C	23	6cm	5cm	3cm	4.6	G
17	11cm	6cm	6cm	7.6	C	24	11cm	8cm	4cm	7.6	C

Material Type	Total Number	Percentage
Fines	0	0 %
Gravel	4	16.6 %
Cobble	20	83.3 %
Boulder	0	0 %
Bedrock	0	0 %
Cobble + Boulder	20	83.3 %

7. Based on the percentage of the streambed material that is boulder and cobble, give the stream a quality score. (*The score is in bold, estimate a value in the range listed*)

	Your Result	Good **15-20**	Acceptable **10-15**	Marginal **5-10**	Poor **0-5**	Your Score
% Boulder & Cobble	83.3	50%	30-50%	10-30%	0-5%	20+

Table 2 Size Categories of Streambed Material	
bedrock	solid slab of rock
boulder	>25 cm diameter
cobble	5 - 25 cm diameter
gravel	0.2 - 5 cm diameter
fines	<0.2 cm diameter

Length of Reference site	Total Length of Pool Habitat	Percentage Pool Habitat
15.0 m	m	%

Bank stability impacts	LEFT BANK		RIGHT BANK	
	# of sites	Length affected (m)	# of sites	Length affected (m)
Active bank erosion	II	3.45 2.8 } $\boxed{6.25}$	I	$\boxed{1.76}$
Slides into channel	II	0.7 2.4 } $\boxed{3.1}$	III	0.5 0.7 6.6 = $\boxed{7.8}$
Artificial stabilization	III	1.9 3.4 9.7 = $\boxed{15}$	II	4.8 2.1 = $\boxed{6.9}$

15 m	Total length of reference site (m)	Total length without vegetation (m)	Percentage without vegetation
LEFT BANK	3.41 m	2.95 m m	87% %
RIGHT BANK	3.30 m	3.00 m	91% %
		Total percentage without vegetation	89% %

Lengths of any overhanging branches (left and right banks)	Average length of overhanging branches	Channel width (m)	Percentage of channel shaded
3 m, 3.6 m, 3.1 m	3.20 m	3.41 m	93.8 %

Riparian zone	# of channel widths:			
Type/amount of vegetation (circle the appropriate amount)	Coniferous trees	None	Few	Many
	Deciduous trees	None	Few	Many
	Shrubs	None	Few	Many
	Grasses	None	Few	Many

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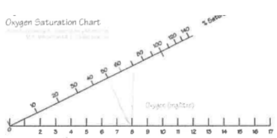
	Measurement #1	Measurement #2	Average
pH (0-14)	7.0	7.0	7.0

	Measurement #1	Measurement #2	Average
TURBIDITY	1.15m	1.15 m	1.15m



	Measurement #1	Measurement #2	Average	% Saturation
DISSOLVED OXYGEN (mg/L)	8mg per/L	8mg per/L	8mg per/L	90%

Data Table: Streambed Material
A = longest axis (length), B = intermediate axis (width), C = shortest axis (depth).
Type = Bedrock (B), Boulder (Bo), Cobble (C), Gravel (G) or Fine (F)

cm	A	B	C	Avg.	Type		A	B	C	Avg.	Type
1	4.5	9cm	4cm	5.1	C	6	3	5	3	3.6	G
2	5cm	3cm	3cm	3.6	G	7	11	5	5	7	C
3	5cm	4cm	3cm	4	G	8	30	27	20	25.6	B
4	3cm	3cm	1cm	2.3	G	9	22	7	6	11.6	C
5	30	25	17	24	C	10	7	6	3	5.3	C

Data Table: Streambed Material Continued
A = longest axis (length), B = intermediate axis (width), C = shortest axis (depth).
Type = Bedrock (B), Boulder (Bo), Cobble (C), Gravel (G) or Fine (F)

	A	B	C	Avg.	Type		A	B	C	Avg.	Type
11	13	9	6	8.6	C	18	14	11	7	10.6	C
12	14	11	6	10.3	C	19	12	7	4	7.6	C
13	6	7	2	5	C	20	4	4	4	4	G
14	4	7	5	5.3	C	21	7	6	1	4.6	G
15	5	3	2	3.3	G	22	4	6	5	5	C
16	3	3	3	3	G	23	5	5	5	5	C
17	4	2	1	2.3	G	24	8	6	4	6	C

Material Type	Total Number	Percentage
Fines	0	0 %
Gravel	9	37.5 %
Cobble	14	58.3 %
Boulder	1	4.2 %
Bedrock	0	0 %
Cobble + Boulder	15	62.5 %

Based on the percentage of the streambed material that is boulder and cobble, give the stream a quality score. (*The score is in bold, estimate a value in the range listed*)

	Your Result	Good **15-20**	Acceptable **10-15**	Marginal **5-10**	Poor **0-5**	Your Score
% Boulder & Cobble	62.5	50%	30-50%	10-30%	0-5%	16.5

Length of Reference site	Total Length of Pool Habitat	Percentage Pool Habitat
15 m	6.5 m	≈40 %

Bank stability impacts	LEFT BANK		RIGHT BANK	
	# of sites	Length affected (m)	# of sites	Length affected (m)
Active bank erosion	II	9.6	I	6.2m
Slides into channel				
Artificial stabilization	I	1.7		

	Total length of reference site (m)	Total length without vegetation (m)	Percentage without vegetation
LEFT BANK	15 m	0 m	0 %
RIGHT BANK	15 m	0 m	0 %
		Total percentage without vegetation	0 %

Lengths of any overhanging branches (left and right banks)	Average length of overhanging branches	Channel width (m)	Percentage of channel shaded
	4 m	5 m	60 %

Riparian zone	# of channel widths:			
Type/amount of vegetation (circle the appropriate amount)	Coniferous trees	None	Few	Many
	Deciduous trees	None	Few	Many
	Shrubs	None	Few	Many
	Grasses	None	Few	Many

	Total length of reference site (L/R)	Total length without vegetation (L/R)	Percentage without vegetation (L/R)	Total percentage without vegetation
OBH	3.41m/3.30m	2.95m/3m	87%/91%	89%
Monteith	15m	0m	0%	0%

	% without vegetation
OBH	89%
Montieth	0%

Sites	Lengths of any overhanging branches	Average length of overhanging branches	Channel width	Percentage of channel shaded
OBH	3m, 3.6m, 3.1m	3.2m	3.41m	93.8%
Monte	4m	4m	5m	80%

ith				

	% channel shaded
OBH	94%
Montieth	80%

	# of channel widths
OBH	3
Monteith	1

	Coniferous Trees	Deciduous Trees	Shrubs	Grasses
OBH	Few	Many	Few	Many
Monteith	None	Many	Many	Many

	Result (OBH/ Monteith)	Good (8-10)	Acceptable (5-8)	Marginal (2-5)	Poor (0-2)	Score (OBH/ Monteith)
Width (# of channels) Trees, shrubs and grasses	3/1 Good mix of Species	2 or more Abundant over area	1-2 Good mix of species	<1 Common, few species	0 Absent or sparse	7/8

Bank Stability:

Oak Bay High:	**Bank Stability Impacts**	**Left Bank** Number of sites	Length affected (m)	Number of sites	**Right Bank** Length affected (m)
	Active bank erosion	2	6.25	1	1.76
	Slides into channel	2	3.10	3	7.80
	Artificial stabilization	3	1.50	2	6.90

Monteith:	**Bank Stability Impacts**	**Left Bank** Number of sites	Length affected (m)	Number of sites	**Right Bank** Length affected (m)
	Active bank erosion	2	9.6	1	6.2
	Slides into channel				
	Artificial stabilization	1	1.7		

Pool Habitat Chart:

Bowker Creek:	Length of reference site	Length of pool habitat	Percentage of pool habitat
	15 m		

Monteith:	Length of reference site	Length of pool habitat	Percentage of pool habitat
	15 m	6.5 m	40%

Quality Score Of Pool Habitat:

Result Of Bowker Creek	Good (11-15)	Acceptable (7-11)	Marginal (3-7)	Poor (0-3)	Score
49.3%	>50%	40-50%	30-40%	<30%	10

Result of Monteith	Good (11-15)	Acceptable (7-11)	Marginal (3-7)	Poor (0-3)	Score
40%	>50%	40-50%	30-40%	<30%	7

https://www.pskf.ca/modules.html

https://www.crd.bc.ca/bowker-creek-initiative/creek-info/watershed-info

https://burntembers.com/2011/10/03/thaywun-bowker-creek/

https://www.crd.bc.ca/bowker-creek-initiative/about-bci/plans-and-strategies/bowker-creek-blueprint-a-100-year-plan

https://bowkercreek.org