Request for Proposals

Biological Impact Assessment of Sheep Creek

Issued:
April 24, 2024

Closing Location:
Resource Recovery, Regional District of Central Kootenay
Box 590, 202 Lakeside Drive
Nelson, BC V1L 5R4

Closing Date and Time:
May 22, 2024 at 12:00pm PDT

Contact:
Heidi Bench
Resource Recovery Project Advisor
250-354-3044
hbench@rdck.bc.ca

TABLE OF CONTENTS

PART 1 – INVITATION & INSTRUCTIONS TO PROPONENTS 3
1.1 Executive Summary 3
1.2 Request for Proposal Terminology 3
1.3 Proposal Documents 3
1.4 Inquiries and Clarifications 4
1.5 Examination of Sites and Local Conditions 4
1.6 Mandatory Site Visit 4
1.7 Proposal Closing Date, Time and Location 4
1.8 Proposal Submissions 4
1.9 Ownership of Proposals and Freedom of Information 5
1.10 RDCK's Right to Accept or Reject Proposal 5
1.11 No Claim for Compensation 5
1.12 Conflict of Interest 5
1.13 Anti-Collusion, Fraud & Corruption 5
1.14 Confidentiality 6
1.15 Irrevocability and Acceptance of Proposal 6
1.16 Irregularities and Informalities 6
1.17 Discrepancies or Omissions 6
1.18 Modification of Terms/Addenda 6
1.19 Liability for Errors 7
1.20 Basis of Contract Award 7
1.21 Definition of Contract 8
1.22 Form of Contract 8

PART 2 – SPECIFICATIONS 9

PART 3 – PROPOSAL SUBMISSION 9
3.1 Proposal Format 11
3.2 Proposal Content 11

SCHEDULE A – CONSULTING SERVICES AGREEMENT 13

SCHEDULE B – SUPPORTING DOCUMENTATION 14

PART 1 – INVITATION & INSTRUCTIONS TO PROPONENTS

1.1 EXECUTIVE SUMMARY

The Regional District of Central Kootenay (RDCK) is requesting proposals from qualified agencies for a Biological Impact Assessment of Sheep Creek.

Timeline of milestones and deliverables:

April 24, 2024	-	Issue Request for Proposals
May 15, 2024	-	Deadline for inquiries
May 22, 2024	-	Deadline for submissions
June 7, 2024	-	Award contract
September 2024	-	Conduct field program

Draft report due 6 weeks after receipt of final laboratory results
Final report due 3 weeks after receipt of RDCK comments on the Draft

1.2 REQUEST FOR PROPOSAL TERMINOLOGY

The following terms will apply to this Request for Proposal and to any subsequent Contract. Submission of a proposal in response to this Request for Proposal indicates acceptance of all the following terms.

Throughout this Request for Proposal, terminology is used as follows:

(a) "**CONTRACT**" means the written agreement resulting from this Request for Proposal executed by the RDCK and the Consultant;

(b) "**CONSULTANT**" means the successful Proponent to this Request for Proposal who enters into a written Contract with the RDCK;

(c) "**MUST**" or "mandatory" means a requirement that must be met in order for a proposal to receive consideration;

(d) "**PROPONENT**" means an individual or a company that submits, or intends to submit, a proposal in response to this Request for Proposal;

(e) "**REGIONAL DISTRICT**" means the Regional District of Central Kootenay (RDCK);

(f) "**SHOULD**" or "**DESIRABLE**" means a requirement having a significant degree of importance to the objectives of the Request for Proposal.

1.3 PROPOSAL DOCUMENTS

It is the responsibility of the Proponent to ascertain that they have received a full set of Proposal documents. Upon submission of their Proposal, the Proponent shall be deemed conclusively to have been in full possession of a full set of Proposal Documents.

1.4 INQUIRIES AND CLARIFICATIONS

It is the responsibility of the Proponent to thoroughly examine the documents and ensure that the requirements contained are fully understood.

Requests for clarifications or additional information related to this Request for Proposal must be directed, **in writing**, to the following person:

Heidi Bench
Resource Recovery Project Advisor
250-354-3044
hbench@rdck.bc.ca

Information obtained from any other source is not official and should not be relied upon. Enquiries and responses will be recorded and may be distributed to all Proponents at the Regional District's option.

1.5 EXAMINATION OF SITES AND LOCAL CONDITIONS

The Proponent must satisfy themselves as to the practicability of executing the work in accordance with the Contract, and shall be held to have satisfied themselves in every particular before making up a Proposal, by inquiry and by attending the site visit if it is a requirement.

The Proponent should examine the site and surroundings and, before submitting a Proposal shall satisfy themselves as to the nature of the site, the quantities and nature of the work and equipment necessary for the completion of the work, the means of access to the site, the accommodation they may require, and in general, shall obtain all relevant information as to risks, contingencies and other circumstances which may influence their Proposal.

~~1.6 MANDATORY SITE VISIT~~

~~A mandatory site visit is scheduled are for.~~

1.7 PROPOSAL CLOSING DATE, TIME AND LOCATION

Proposals must be submitted by the Closing Date and Time to the Closing Location identified on the cover page of this Request for Proposal.

1.8 PROPOSAL SUBMISSIONS

A digital PDF format of the Proposal submission must be sent by e-mail to: hbench@rdck.bc.ca.

The RDCK email server has about a 10mb file size limit. Proponents are to ensure that they have gotten a confirmation of receipt of email prior to the closing time. Larger submissions should be broken down into 2 or more emails or arrangements should be made ahead of time for file transfer by ftp.

1.9 OWNERSHIP OF PROPOSALS AND FREEDOM OF INFORMATION

All responses to this Request for Proposal become the property of the RDCK. By submitting a Proposal the Proponent agrees the RDCK has the right to copy the Proposal Documents. Proposals will be held in confidence by the RDCK, subject to the provisions of the *Freedom of Information and Protection of Privacy Act* and any requirement for disclosure of all or a part of a Proposal under that Act. The requirement for confidentiality shall not apply to any Proposal that is incorporated into a Contract for the Work. Further, the RDCK may disclose all or part of any Proposal to the RDCK Board at a public meeting of the Board, when making a recommendation for the award of the Contract.

1.10 RDCK'S RIGHT TO ACCEPT OR REJECT PROPOSAL

The lowest or any Proposal will not necessarily be accepted. The RDCK reserves the right in its absolute discretion to: accept the Proposal which it deems most advantageous and favourable in the interests of the RDCK; and waive informalities in, or reject any or all Proposals, in each case without giving any notice. If there is only one compliant Proposal received by the Closing Date, the RDCK reserves the right to accept the Proposal or cancel the Proposal process with no further consideration for the sole Proposal. This includes the right to cancel this Request for Proposal at any time prior to entering into a Contract with the Consultant. The RDCK reserves the right to cancel at any time before award of the Contract without being obliged to any Proponent – not just where there is only one compliant Proposal.

Proposals that contain qualifying conditions or otherwise fail to conform to these Instructions to Proponents may be disqualified or rejected. The RDCK, however, may at its sole discretion reject or retain for consideration Proposals which are non-conforming because they do not contain the content or form required by these Instructions to Proponents or because they have not complied with the process for submission set out herein.

1.11 NO CLAIM FOR COMPENSATION

Except as expressly and specifically permitted in these Instructions to Proponents, no Proponent shall have any claim for any compensation of any kind whatsoever, as a result of participating in the Request for Proposal, and by submitting a Proposal each Proponent shall be deemed to have agreed that it has no claim. In no event will the RDCK be responsible for the costs of preparation or submission of a Proposal.

1.12 CONFLICT OF INTEREST

By submitting a Proposal, the Proponent warrants that neither it nor any of its officers or directors, or any employee with authority to bind the Proponent has any financial or personal relationship or affiliation with any elected official or employee of the RDCK or their immediate families which might in any way be seen (in the RDCK's sole and unfettered discretion) to create a conflict.

1.13 ANTI-COLLUSION, FRAUD & CORRUPTION

The Proponent shall not communicate to any person prior to the opening of Proposals (other than to the RDCK through the delivery of a Proposal in the prescribed manner) the amount of any Proposal, or at any time adjust the amount of any Proposal by arrangement with any other persons, make any arrangement with any other person about whether or not he or that other person should or should not submit a Proposal or otherwise collude with any other person in any manner whatsoever in the Proposal process.

Any breach of this provision or non-compliance on the part of a Proponent shall, without affecting the Proponent's liability for such breach or non-compliance, result in the Proposal's disqualification.

1.14 CONFIDENTIALITY

Confidential information about the RDCK obtained by Proponents must not be disclosed unless authorized to do so, in writing, by the RDCK. The Proponent agrees that his obligation of confidentiality will survive the termination of any Contract awarded under this Proposal process.

1.15 IRREVOCABILITY AND ACCEPTANCE OF PROPOSAL

After the Closing Date and Time, all Proposals are irrevocable. By submission of a Proposal, the Proponent agrees that should its Proposal be successful the Proponent will enter into a Contract with the RDCK for the Work on the terms and conditions set out in the Proposal. Each Proposal will be irrevocable and open for acceptance by the RDCK for a period of ninety (90) calendar days from the day following the Proposal Closing Date and Time, even if the Proposal of another Proponent is accepted by the RDCK. By submission of a clear and detailed written notice the Proponent may amend or withdraw its Proposal PRIOR to the closing date and time.

1.16 IRREGULARITIES AND INFORMALITIES

The RDCK reserves the right, at its sole discretion to waive minor irregularities and informalities in any Proposal and to seek clarification or additional information on any area of any Proposal when it is in the best interest of the RDCK to do so.

1.17 DISCREPANCIES OR OMISSIONS

Proponents finding discrepancies or omissions in the specifications or other documents or having any doubts about the meaning or intent of any part thereof should immediately request, in writing, clarification from **Heidi Bench** by emailing hbench@rdck.bc.ca, who will send written instructions or explanations to all parties having a set of the Proposal Documents. Any work on a Proposal done by the Proponent after the discovery of discrepancies, errors or omissions, which the Proponent fails to seek clarification about, shall be done at the Proponent's risk.

1.18 MODIFICATION OF TERMS/ADDENDA

The RDCK reserves the right to modify the terms of this Request for Proposal at any time before the Closing Date and Time in its sole discretion. Written Addenda are the only means of amending or clarifying any of the information contained in the information package. The RDCK may amend or clarify the information package by issuing an Addendum. No employee or agent of the RDCK is authorized to amend or clarify the content of the information package or any Addenda except by issuing an Addendum. The RDCK makes no guarantee as to the timely delivery of any Addendum. Addenda issued prior to closing of this Invitation to Proposal shall become a part of the Proposal Documents.

1.19 LIABILITY FOR ERRORS

While the RDCK has used considerable efforts to ensure an accurate representation of information in this Request for Proposal, the information contained in this Request for Proposal is supplied solely as a guideline for Proponents. The information is not guaranteed or warranted to be accurate by the RDCK, nor is it necessarily comprehensive or exhaustive. Nothing in this Request for Proposal is intended to relieve the Proponents from forming their own opinions and conclusions with respect to the matters addressed in this Request for Proposal.

1.20 BASIS OF CONTRACT AWARD

Proponents are hereby notified that the RDCK intends to review and enter into a Contract for the Work based not only on the Proposal price, but the other factors considered essential by the RDCK to provide a service for the Work being requested. Proposal evaluation may include, but is not limited to:

Evaluation Criteria	**Points**
Experience and Qualifications	
Staff and corporate experience with projects similar to the Scope of Work, specifically biological impact assessments at aquatic sites	10
Professional qualification of managerial and technical personnel, including project lead with minimum of 10 years of experience and at least 3 projects of similar nature, size, and complexity to this Project	10
References provided by other clients of the Proponent	3
Experience of the Proponent on past RDCK projects	2
Project Comprehension and Approach	
Demonstrated understanding of Project requirements and expectations as reflected in the proposed approach, resources, priorities, sequences and critical tasks for meeting the Project deliverables while adhering to scope, cost, and schedule.	20
Demonstrated understanding of any challenges, special needs, risks, and/or concerns related to the Project as captured in the Proponent's response.	5
Availability and Ability to Meet Deliverables	
Confirmation of the Proponent's ability to complete the Project in accordance with the schedule, including confirmation of the availability of the proposed project team to complete the Work.	10
Pricing	
Breakdown of labour rates for key personnel as well as any other associated costs to perform the Work	10
Total project cost (includes optional site visit for all 3)	30
TOTAL SCORE	**100**

The evaluation process will be conducted solely at the discretion of the RDCK. The RDCK may decide to utilize other criteria in the review of Proposals other than those set forth above; in particular, the price to carry out the work will not be the only or primary criterion that will be utilized by the RDCK. The RDCK reserves the right to make inquiries regarding any or all Proposals and to verify all information submitted by Proponents. Proponents shall be competent and capable of performing the work. Proponents may be required to provide further evidence of previous experience and financial responsibility.

The RDCK reserves the right, at its discretion, to negotiate with any Proponent that the RDCK believes has the most advantageous Proposal or with any other Proponent or Proponents concurrently. In no event will the RDCK be required to offer any modified terms to any other Proponent prior to entering into a Contract with the successful Proponent, and the RDCK shall incur no liability to any other Proponent as a result of such negotiations or modifications.

Proponents are advised that, after receipt of Proposals and prior to award of Contract, Proponents may be required to provide the RDCK with additional information concerning the Proponent or their Proposal including, but not limited to, a further breakdown of relevant components of the proposed prices.

The RDCK reserves the right to reject any Proposals of a company that is, or whose principals are, at the time of submitting a Proposal, engaged in a lawsuit against the RDCK in relation to work similar to that being proposed.

The RDCK reserves the right to reject any Proposals of a company that owes, or whose principals owe, monies to the RDCK at the time of submitting a Proposal.

1.21 DEFINITION OF CONTRACT

This Request for Proposal should not be construed as an Agreement or Contract to purchase goods or services. The RDCK is not bound to enter into a Contract with the Proponent who submits the lowest priced Proposal or with any Proponent. The RDCK will be under no obligation to receive further information, whether written or oral, from a Proponent after the Proposal Closing Date and Time.

Neither the acceptance of a Proposal nor the execution of a Contract will constitute approval of any activity or development contemplated in any Proposal that requires any approval, permit or license pursuant to any federal, provincial, regional district or municipal statute, regulation or bylaw.

Notice in writing to a Proponent that it has been identified as the Consultant and the subsequent full execution of a written Agreement will constitute a Contract for the performance of the Work and no Proponent will acquire any legal or equitable rights or privileges relative to the Work until the occurrence of both such events.

1.22 FORM OF CONTRACT

By submission of a Proposal, the Proponent agrees that, should it be identified as the successful Proponent, it is willing to enter into a Consulting Services Agreement with the RDCK within fifteen (15) days of the date of the Notice of Award. A copy of the RDCK Consulting Services Agreement is attached in Schedule A.

By submission of a Proposal, the Proponent agrees that, should it be identified as the Consultant, it is willing provide to the RDCK the necessary Insurance Policies and WorkSafe BC Clearance Letter within fifteen (15) days of the date of the Notice of Award.

PART 2 – SPECIFICATIONS

2.1 BACKGROUND

Operational Certificate MR-16519 for the RDCK's Central landfill requires that a Biological Impact Assessment of Sheep Creek be completed by a Qualified Professional every 5 years. The purpose of the assessment is to characterize the aquatic community of Sheep Creek and determine if there are any landfill-related impacts on this community.

A series of groundwater seeps on the valley wall north of the Central landfill drain into Sheep Creek. While surface water samples collected from Sheep Creek have generally been below the applicable criteria, with the exception of a few total metals parameters in historic samples, annual environmental monitoring conducted at the site has identified that two of these seeps appear to be impacted by landfill leachate. Biological Impact Assessments have previously been completed at this site in 2003, 2008, 2013, and 2019. The most recent Biological Impact Assessment is included in Schedule B.

2.2 Scope of Work

The RDCK is requesting proposals from qualified firms for a Biological Impact Assessment of Sheep Creek that characterizes the aquatic community of Sheep Creek and determines if there are any landfill-related impacts on this community. The successful Proponent shall be responsible for developing a project timeline, methodology, and specific steps to meet the overall objectives, adhering to the Scope of Work requirements presented herein:

(a) Review available background information, data, and information pertinent to site conditions, such as annual environmental monitoring reports and local fish resource information, and integrate this into the Biological Impact Assessment of Sheep Creek.

(b) The Biological Impact Assessment shall include evaluation of benthic macroinvertebrates, periphyton, and fish populations, in accordance with the Canadian Aquatic Biomonitoring Network Field Manual, Guidelines for Sampling Benthic Invertebrates in British Columbia Streams, and other relevant industry standards. The field program shall include:

(i) Evaluation of habitat conditions and biological communities at the same three (3) locations as in previous assessments:

SAMPLE LOCATION ID	EMS ID	DESCRIPTION
SW-A	E242839	Downstream of seeps
SW-B	E242838	Adjacent to seeps
SW-C	E242837	Background (upstream of seeps)

A site plan showing sample locations is included in Schedule B.

(ii) Field measurements of at minimum, flow velocity, water pH, temperature, dissolved oxygen, turbidity, and conductivity at each sample location.

(iii) Collection of five (5) discrete replicates at each sampling location to be submitted for laboratory analysis for benthic macroinvertebrates and periphyton.

(c) Data analysis shall be consistent with historical analyses and shall include comparison of 2024 results to historical results to determine trends (if any).

(d) Develop DRAFT and FINAL reports for review. The DRAFT report is to be submitted to the RDCK for review and discussion prior to the issuance of the FINAL report.

PART 3 – PROPOSAL SUBMISSION

3.1 PROPOSAL FORMAT

The Proposal should clearly convey the Proponent's intent in a clear and concise manner. The Proposal should contain a covering letter, Table of Contents and a short executive summary of the key features of the proposal. All pages should be consecutively numbered.

3.2 PROPOSAL CONTENT

3.2.1 The Firm

(a) Firm Experience / Past Performance - The firm's past project experience with Biological Impact Assessments

(b) Project Team - The qualifications and experience of the personnel the Proponent intends to use for the Work. This must include any subcontractors proposed to be used in the Work

(c) Resources - The qualifications and experience of the Proponent's reserve personnel backing up the Project Team and the quality and quantity of resources available to the firm such as technical aids, IT resources, equipment etc.

3.2.2 The Proposal

(a) Methodology / Task Evaluation - The Proponent's approach to the services required as set out in Part 2 Specifications. Consideration is given to whether the Proponent has effectively addressed each aspect of the Request for Proposal, thoroughly understood the requirements of the Request for Proposal, chosen a suitable approach, and identified problem areas. The Proponent is expected to adhere as closely as possible to the project components outlined in Part 2; however, Proponents may suggest alternative approaches or propose modifications to the specifications.

(b) Scheduling / Work Plan - The completeness of the task items and rationale of the work plan which shows a clear indication of the anticipated work schedule along with any other supporting documents pertinent to the project. The RDCK requests that proponents agree to meet or better the following project deliverable milestones for completion of the project schedule:

Timeline of milestones and deliverables:

April 24, 2024	-	Issue Request for Proposals
May 15, 2024	-	Deadline for inquiries
May 22, 2024	-	Deadline for submissions
June 7, 2024	-	Award contract
September 2024	-	Conduct field program

Draft report due 6 weeks after receipt of final laboratory results
Final report due 3 weeks after receipt of RDCK comments on the Draft

(c) Detailed Cost Breakdown – the Proponent should provide a detailed cost breakdown of all work tasks which includes details of the team members assigned to those tasks, hours budgeted for each team member and hourly rates for each team member. Proposal should also include costs for laboratory analyses and details of Proponent's preferred arrangements for mileage, per diem and other disbursements.

SCHEDULE A – CONSULTING SERVICES AGREEMENT

Consulting Services
Agreement

Contract #: 2024-066-ENV
Project: Biological Impact Assessment of Sheep Creek
GL Code: Account 54040; Work Order OPR296-100

THIS AGREEMENT executed and dated for reference the:

day day of month, year
(Day) (Month) (Year)

BETWEEN

REGIONAL DISTRICT OF CENTRAL KOOTENAY		**CLICK HERE TO ADD CONSULTANT NAME**
(hereinafter called the "RDCK")	**AND**	(hereinafter called the "Consultant")
at the following address:		at the following address:
Box 590, 202 Lakeside Drive		Click here to add address
Nelson, BC V1L 5R4		City, Province, Postal Code
Agreement Administrator: Heidi Bench		Agreement Administrator: Add name
Telephone #: 250-354-3044		Telephone: Click here to add phone #
Email: hbench@rdck.bc.ca		Email: Click here to add email

FOR GOOD AND VALUABLE CONSIDERATION, THE RECEIPT OF WHICH IS CONFIRMED, THE REGIONAL DISTRICT OF CENTRAL KOOTENAY AND THE CONSULTANT AGREE AS FOLLOWS:

(a) **SERVICES:** The Consultant shall provide the services which are set out in the Consultant's proposal dated [Date] (the "Proposal") which forms part of this Agreement and as detailed in Schedule "A" of this Agreement (the "Services"). It is agreed that Services may also include any additional services authorized and agreed to by the Consultant and the RDCK by written agreement after the Agreement has commenced ("Additional Services").

(b) **CHANGES TO SERVICES:** The RDCK and the Consultant acknowledge that it may be necessary to modify the Services, the Project schedule and/or the Budget in order to complete the Project. In the event that the RDCK or the Consultant wishes to make a change or changes to the Services, the Project schedule and/or the Budget it shall notify the other of the proposed change and reason(s) therefore. The party receiving the notification shall review and consider the proposal for change and shall as soon as is reasonably possible and no longer than within five (5) working days, advise in writing the party proposing the change whether it agrees to the change. Where the parties agree to the change, such agreement will form part of this Agreement and be formalized by means of a Scope Change Letter.

Any RDCK authorized services required of the Consultant beyond those Services set out in the Proposal shall be considered Additional Services. The Consultant shall be compensated for all Additional Services on an hourly or per diem basis, as agreed upon by the RDCK and the Consultant in writing by means of a Scope Change Letter prior to the Consultant performing the Additional Services.

(c) **TERM:** Notwithstanding the date of execution of this Agreement the Consultant shall provide the Services described in Schedule A hereof commencing on **[Start Date]** (Start Date) and ending on **[End Date]** (End Date) (the "Term").

(d) **LOCATION:** The location for delivery of the Services shall be **Central Landfill**.

(e) **PAYMENT:** The total budget for the Services, as specified in the Proposal is **$[Contract Amount]** Choose GST Option and on the terms set out in Schedule B. The budget for the Services is broken into tasks in the Proposal. The Consultant agrees to complete all of the tasks specified in the Proposal at a cost that will not exceed the budget amount for each task. The Consultant shall submit an invoice to the RDCK for payment, together with supporting documents, in respect of the hours worked and disbursements made on or before the last day of each month, for the RDCK's approval and due processing.

(f) Schedules A and B are incorporated into, and form part of this Agreement.

(g) The following terms and conditions are incorporated into, and form part of this Agreement.

THE CONSULTANT' OBLIGATIONS

1 The Consultant shall:

(a) Undertake all work and supply all materials necessary to perform the Services, unless stipulated otherwise in Schedule A.

(b) In performing the Services, at all times, act in the best interests of the Regional District of Central Kootenay (herein after called the **"RDCK"**). Also, the Consultant shall exercise that degree of professional care, skill and diligence required according to generally accepted professional engineering standards and by the *Engineers and Geoscientists Act of British Columbia*, current as of the date that the Services are rendered.

(c) Engage the services of staff, sub-consultants and sub-contractors who have the education, training, skill and experience necessary to perform the Services, and shall cause them to perform the Services on behalf of the Consultant.

(d) Employ only those sub-consultants and sub-contractors identified in the Proposal to supply the Services. The Consultant agrees that it has the responsibility for the coordination of all professional Services rendered to the RDCK by the Consultant or by its sub-consultants or sub-contractors on the Project. The Consultant may, with the written approval of the RDCK, such approval not to be unreasonably withheld, replace any of the identified project team members described in the Proposal with other professional staff possessing equivalent knowledge, ability and skills.

(e) Ensure that all personnel hired by the Consultant to perform the Services will be the employees of the Consultant and not to the RDCK with the Consultant being solely responsible for the arrangement of reliefs and substitutions pay supervision, discipline, employment insurance, workers compensation, leave and all other matters arising out of the relationship of employer and employee.

(f) Upon the request of the RDCK fully inform the RDCK of the work done by the Consultant in connection with the provision of the Services and permit the RDCK at all reasonable times to inspect, review and copy all works, productions, buildings, accounting records, findings, data, specifications, drawings, working papers, reports, documents and materials, whether complete or otherwise, that have been produced, received or acquired by the Consultant as a result of this Agreement.

(g) Comply with all applicable municipal, provincial and federal legislation and regulations.

(h) At its own expense, obtain all permits and licenses necessary for the performance of the Services, and on request provide the RDCK with proof of having obtained such licenses or permits.

(i) Promptly pay all persons employed by it.

(j) Not assign this Agreement, not subcontract any of its obligations under this Agreement, to any person, firm or corporation without the prior written consent of the RDCK.

(k) At all times, exercise the standard of care, skill and diligence normally exercised and observed by persons engaged in the performance of services similar to the Services.

(l) Not perform any service for any other person, firm or corporation which, in the reasonable opinion of the RDCK, may give rise to a conflict of interest.

(m) Be an independent Consultant and not the servant, employee or agent of the RDCK. The Consultant and the RDCK acknowledge and agree that this Agreement does not create a partnership or joint venture between them.

(n) Accept instructions from the RDCK, provided that the Consultant shall not be subject to the control of the RDCK in respect of the manner in which such instructions are carried out.

(o) At its own expense, obtain Workers Compensation Board coverage for itself, all workers and any shareholders, directors, partners or other individuals employed or engaged in the execution of the Work. Upon request, the Consultant shall provide the RDCK with proof of such compliance.

(p) Be responsible for all fines, levies, penalties and assessments made or imposed under the *Worker's Compensation Act* and regulations relating in any way to the Services, and indemnify and save harmless fines, levies, penalties and assessments.

(q) Not in any manner whatsoever commit or purport to commit the RDCK to the payment of any money.

(r) Establish and maintain time records and books of account, invoices, receipts, and vouchers of all expenses incurred.

(s) Notwithstanding the provision of any insurance coverage by the RDCK, indemnify and save harmless the RDCK, its successor(s), assign(s) and authorized representative(s) and each of them from and against losses, claims, damages, actions, and causes of action (collectively referred to as "Claims"), that the RDCK may sustain, incur, suffer or be put to at any time either before or after the expiration or termination of this Agreement, that arise out of errors, omissions or negligent acts of the Consultant or its subconsultant(s), subcontractor(s), servant(s), agent(s) or employee(s) under this Agreement, excepting always that this indemnity does not apply to the extent, if any, to which the Claims are caused by errors, omissions or the negligent acts of the RDCK its other consultant(s), contractor(s), assign(s) and authorized representative(s) or any other persons.

(t) Use due care that no person or property is injured and no rights infringed in the performance of the Services, and shall be solely responsible for all losses, damages, costs and expenses in respect to any damage or injury, including death, to persons or property incurred in providing the Services or in any other respect whatsoever.

(u) The Contractor must provide the RDCK with a certificate of insurance upon execution of this Agreement in a form acceptable to the Chief Financial Officer of the Regional District and shall, during the Term of this Agreement, take out and maintain the following insurance coverage:

(i) Automobile liability (third party) insurance with a minimum limit of $5,000,000.

(ii) Comprehensive commercial general liability insurance against claims for bodily injury, death or property damage arising out of this Agreement or the provision of the Services in the amount of **$2,000,000 dollars per occurrence** with a **maximum deductible of $5,000**;

Such insurance will:

(A) name the Regional District, its elected officials, employees, officers, and agents as an additional insured;

(B) include the Contractor's Blanket contractual liability;

(C) include a Cross Liability clause;

(D) include occurrence property damage;

(E) include personal injury;

(F) include a Waiver of Subrogation clause in favor of the RDCK whereby the insurer, upon payment of any claim(s), waives its right to subrogate against the RDCK for any property loss or damage claim(s);

(G) be primary in respect to the operation of the named insured pursuant to the contract with the RDCK. Any insurance or self-insurance maintained by the RDCK will be in excess of such insurance policy (policies) and will not contribute to it;

(H) require the insurer not cancel or materially change the insurance without first giving the RDCK thirty days' prior written notice; provided that if the Contractor does not provide or maintain in force the insurance required by this Agreement, the Contractor agrees that the RDCK may take out the necessary insurance and the Contractor shall pay to the RDCK the amount of the premium immediately on demand.

(iii) Professional liability coverage in the amount of **$ 2,000,000 dollars per claim** and **$ 5,000,000 dollars aggregate,** with a **maximum deductible of $50,000;**

(v) Keep confidential for an unlimited period of time all communications, plans, specifications, reports or other information used in connection with the Project except:

(i) those requiring disclosure by operation of law; and
(ii) any disclosure authorized in writing by the RDCK.

CONSTRUCTION SUPERVISION

(w) Inspect the site where the Services are to be performed (the **"Site"**) and become familiar with all conditions pertaining thereto prior to commencement of the Services.

(x) Where materials and supplies are to be provided by the Consultant, use only the best quality available.

(y) Where samples of materials or supplies are requested by the RDCK, submit them to the RDCK for the RDCK's approval prior to their use.

(z) Not cover up any works without the prior approval or consent of the RDCK and, if so required by the RDCK, uncover such works at the Consultant's expense.

(aa) Keep the Site free of accumulated waste material and rubbish caused by it or the Services and, on the completion of the Services, leave the Site in a safe, clean and sanitary condition.

(bb) At all times, treat as confidential all information and material supplied to or obtained by the Consultant or subconsultant as a result of this Agreement and not permit the publication, release or disclosure of the same without the prior written consent of the RDCK.

STANDARD OF CARE

(cc) The RDCK recognizes that sub-surface conditions may vary from those encountered where samplings, borings, surveys or explorations are located by the Consultant and that the data, interpretations and recommendations of the Consultant are based solely on the information available to it.

UNDERGROUND UTILITIES

(dd) The Consultant shall be responsible for locating all underground utilities prior to commencing subterranean work and provide proof of such to the RDCK.

SAFETY

(ee) The Consultant shall be responsible for its activity and that of its employees on the job site. This shall not be construed to relieve the RDCK or any other contractor of their obligation to maintain a safe job site. Neither the presence of the Consultant nor of its employees, sub-consultants, sub-contractors and agents shall be understood to imply control of the operations of others, nor shall it be construed to be an acceptance of responsibility for job site safety.

THE REGIONAL DISTRICT OF CENTRAL KOOTENAY'S OBLIGATIONS

2 The RDCK shall:

(a) Retain the Consultant to provide the Services as set out in this Agreement.

(b) Subject to the provisions of this Agreement, pay the Consultant, in full payment for the Services which in the opinion of the RDCK at the times set out is Schedule "B" of this Agreement (herein called **"Agreement Price"**), and the Consultant shall accept such payment as full payment for the Services.

  (i) Notwithstanding Subsection 2(b), not be under any obligation to advance to the Consultant more than 90% of the Agreement Price for Services rendered in accordance with Schedule "A" to the satisfaction of the RDCK. The 10% holdback shall be retained and paid back in accordance with the *Builder Lien Act*.

  (ii) providing that it is not in breach of any of its obligations under this Agreement, holdback from the Agreement Price in addition to the 10% holdback contemplated in Subsection 2(b)(i), sufficient monies to indemnify the RDCK completely against any lien or claim of lien arising in connection with the provision of the Services.

(c) Provide the Consultant with all reports, data, studies, plans, specifications, documents and information available to the RDCK and relevant to the Project. The Consultant shall be entitled to rely on the reports, data studies, plans, specifications, documents and other information provided by the RDCK.

(d) Provide access to any site or adjacent properties as required to complete the Project. The Consultant shall be liable for any and all injury or damage which may occur to persons or to property due to any act, omission, neglect or default of the Consultant, or of his employees, sub-consultants, sub-contractors or agents.

(e) Give the Consultant reasonable notice of anything the RDCK considers likely to materially affect the provision of the Services.

(f) Examine all studies, reports, sketches, proposals and documents provided by the Consultant under this Agreement, and render decisions pertaining thereto within a reasonable time.

TERMINATION OF AGREEMENT

3 Should the Consultant neglect to complete the Services properly or fail to perform any of its obligations under this Agreement, the RDCK may notify the Consultant in writing that it is in default of its contractual obligations and instruct it to correct the default within fourteen (14) working days of receiving the notice. Failure to comply with the default request extends to the RDCK the option, without any other right or remedy, of suspending the Consultant's performance of the Services or immediately terminating this Agreement. The RDCK shall pay the Consultant for all Services performed and all disbursements incurred pursuant to this Agreement and remaining unpaid as of the effective date of such suspension or termination.

4 Other than for reasons set forth in section 3 the RDCK may suspend or terminate this Agreement for any reason by giving thirty (30) calendar days' prior written notice to the Consultant. Upon receipt of such written notice, the Consultant shall perform no further Services other than those reasonably necessary to close out the Project. In such an event, the Consultant will be paid by the RDCK pursuant to this Agreement, for the completed tasks according to the Project schedule of tasks remaining unpaid as of the effective date of such suspension or termination.

5 Should the RDCK fail to perform any of its obligations under this Agreement, the Consultant may notify the RDCK in writing that it is in default of its contractual obligations and instruct it to correct the default within fourteen (14) working days of receiving the notice. Failure to comply with the default request extends to the Consultant the option, without limiting any other right or remedy the Consultant may have, of immediately terminating this Agreement and requesting settlement for all Services performed and for all disbursements incurred pursuant to this Agreement and remaining unpaid as of the effective date of such termination.

6 Should the Consultant's Services be suspended by the RDCK at any time for more than thirty (30) calendar days in any calendar year through no fault of the Consultant, the Consultant shall have the right until such suspension is lifted by the RDCK, to terminate this Agreement upon giving seven (7) working days' written notice to the RDCK. In such an event, the Consultant will be paid by the RDCK pursuant to this Agreement, for the completed tasks as per the Schedule of Tasks that remain unpaid as of the effective date of such termination.

GENERAL TERMS

7 The RDCK shall be the sole judge of the work, material and the standards of workmanship in respect of both quality and quantity of the Services, and their decision on all questions in dispute with regard thereto, or as to the meaning and intentions of this Agreement, and as to the meaning or interpretation of the plans, drawings and specifications, shall be final, and no Services shall be deemed to have been performed as to entitle the Consultant to payment therefrom, until the RDCK is satisfied therewith.

8 The RDCK certifies that the Service purchased pursuant to this Agreement are for the use of and are being purchased by the RDCK and are therefore SUBJECT TO THE FEDERAL GOODS AND SERVICES TAX.

9 This Agreement shall be governed by and construed in accordance with the laws of the Province of British Columbia.

10 Time shall be of the essence of this Agreement.

11 Any notice required to be given hereunder shall be delivered or mailed by prepaid certified or registered mail to the addresses above (or at such other address as either party may from time to time designate by notice in writing to the other), and any such notice shall be deemed to be received 72 hours after mailing.

12 This Agreement shall be binding upon the parties and their respective successors, heirs and permitted assigns.

13 A waiver of any provision or breach by the Consultant of any provision of this Agreement shall be effective only if it is in writing and signed by the RDCK.

14 A waiver under Section 13 shall not be deemed to be a waiver of any subsequent breach of the same or any other provision of this Agreement.

15 Everything produced, received or acquired (the **"Material"**) by the Consultant or subcontractor as a result of this Agreement, including any property provided by the RDCK to the Consultant or sub-consultant, shall:

(a) be the exclusive property of the RDCK; and
(b) be delivered by the Consultant to the RDCK immediately upon the RDCK giving notice of such request to the Consultant.

16 The copyright in the Material belongs to the RDCK.

17 The RDCK may, at its discretion, notify the Consultant that the terms, amounts and types of insurance required to be obtained by the Consultant hereunder be changed.

18 Where the Consultant is a corporation, it does hereby covenant that the signatory hereto has been duly authorized by the requisite proceedings to enter into and execute this Agreement on behalf of the Consultant.

19 Where the Consultant is a partnership, all partners are to execute this Agreement.

20 Sections 1 f), l), m), s), and 18 of this Agreement will, notwithstanding the expiration or earlier termination of the Term, remain and continue in full force and effect.

21 The ideas, processes, or other information contained in the Consultant's Proposal is proprietary and, until the Consultant's Proposal is accepted, shall not be disclosed to any parties outside of the RDCK's staff or be duplicated by any means or used in whole or in part for any purpose. Should the Consultant's Proposal be accepted, the RDCK shall have the right to duplicate, use or disclose the information contained therein.

22 Neither the RDCK nor the Consultant will be considered in default of this Agreement for non-performance due to strikes, labour disputes, riots, civil insurrection, mechanical breakdowns, war, floods, or acts of God or for other reasons beyond the reasonable control of the RDCK or the Consultant.

23 Unbudgeted disbursements incurred by the Consultant due to delays caused by weather conditions and/or poor site access shall be for the RDCK's account.

24 The parties shall make all reasonable efforts to resolve a dispute by amicable negotiations and agree to provide, on a without prejudice basis, frank, candid and timely disclosure of relevant facts, information and documents to facilitate these negotiations.

25 All matters in dispute, which cannot be settled by the RDCK and the Consultant, may, with the concurrence of both the RDCK and the Consultant, be submitted to final and binding arbitration to a single arbitrator appointed jointly by them.

26 No person shall be nominated to act as arbitrator who is in any way financially interested in the Project or in the affairs of either the RDCK or the Consultant.

27 In the event that the RDCK and the Consultant cannot agree to an arbitrator, such arbitrator shall be chosen by reference to a Judge of the Supreme Court of British Columbia.

28 If any portion of this Agreement is held to be illegal or invalid by a court of competent jurisdiction, the illegal or invalid portion shall be severed and the decision that it is illegal or invalid does not affect the validity of this Agreement.

29 This Agreement constitutes the sole and entire Agreement between the RDCK and the Consultant relating to the Project and completely supersedes and abrogates any prior agreements existing between the RDCK and the Consultant, whether written or oral.

30 The headings in this Agreement are for convenience of reference only and shall not affect the interpretation or construction of this Agreement.

31 Parts 2, 3 and 4 of the Request for Proposals of the RDCK dated May 1, 2024 and the Contractor's Proposal provided in response are hereby incorporated into and forms part of this Agreement.

32 Except as expressly set out in this Agreement, nothing herein shall prejudice or affect the rights and powers of the RDCK in the exercise of its powers, duties or functions under the *Community Charter* or the *Local Government Act* or any of its bylaws, all of which may be fully and effectively exercised as if this Agreement had not been executed or delivered.

IN WITNESS WHEREOF the parties hereto have duly executed this Agreement as of the day and year first above written.

REGIONAL DISTRICT OF CENTRAL KOOTENAY	**CLICK HERE TO ADD CONSULTANT NAME**
(Signature of Authorized Signatory)	(Signature of Authorized Signatory)
(Name and Title of Authorized Signatory)	(Name and Title of Authorized Signatory)
(Signature of Authorized Signatory)	(Signature of Authorized Signatory)
(Name and Title of Authorized Signatory)	(Name and Title of Authorized Signatory)

Certificate of Insurance Form

Consulting Service Agreement

This certifies that policies of insurance as described below have been issued to the Insured named below and are in full force and effect at this time.

NOTE: PROOF OF INSURANCE WILL BE ACCEPTED ON THIS FORM ONLY. INSURANCE COMPANIES MUST BE LICENSED TO OPERATE IN CANADA AND HAVE A MINIMUM AM BEST RATING OF A- OR HIGHER.

This Certificate is issued to the Regional District of Central Kootenay

Insured Name: ____

Address: ____

Broker Name:__________________________ Agent's Name:________________________

Address:_________________________ Phone:________________________

Title, number and nature of contract, permit, lease, license or operation to which this Certificate applies:

____

____

____

Type of Insurance	Insurer Name and Policy Number	Policy Term dd/mm/yy	Limits of Liability/Amounts
Section 1 Commercial General Liability ☐ Occurrence Form ☐ Claims Made Form		From: To:	Bodily Injury, Death & Property Damage $ _________ Per Occurrence $ _________ Aggregate $ _________ Deductible
Section 2 ☐ Umbrella Liability ☐ Excess Liability		From: To:	$ _________ Umbrella Liability $ _________ Excess Gen. Liability
Section 3 Professional/Errors and Omissions Liability ☐ Occurrence Form ☐ Claims Made Form		From: To:	$ _________ Per Claim $ _________ Aggregate $ _________ Deductible Per Claim

Section 4 Environmental Impairment Liability ☐ Occurrence Form ☐ Claims Made Form		From: To:	$ __________ Per Occurrence $ __________ Aggregate $ __________ Deductible
Section 5 Automobile Liability (owned or leased vehicles)	If insured by ICBC, attach a copy of the ICBC form APV-47	From: To:	Personal Injury & Property Damage $ __________ Limit
Section 6 Other (Specify)		From: To:	$ __________ Limit $ __________ Aggregate $ __________ Deductible
Section 7 Other (Specify)		From: To:	$ __________ Limit $ __________ Aggregate $ __________ Deductible

Details of Coverage (Sections 1 & 2): ☒ indicates that the coverage is included.

☐ The Regional District of Central Kootenay, its officials, officers, employees, servants and agents added as Additional Insured	☐ Personal Injury	☐
	☐ Premises & operations	☐
	☐ Waiver of subrogation in favour of the RDCK	☐
☐ Blanket Contractual		
☐ Cross Liability/ Severability Interests	☐ Coverage is primary and not contributory	☐
☐ Occurrence Property Damage	☐ 30 days notice of cancellation	☐

Particulars of Environmental Impairment Liability Insurance (Section 4) ☒ indicates that the coverage is included.

☐ The Regional District of Central Kootenay, its officials, officers, employees, servants and agents added as Additional Insured	☐ Cross Liability/ Severability Interests	☐ Coverage is primary and not contributory
	☐ Waiver of subrogation in favour of the RDCK	☐ 30 days notice of cancellation
☐ Blanket Contractual	☐	☐

Details of Coverage (Sections 6): ☒ indicates that the coverage is included.

☐ ☐ ☐

Details of Coverage (Sections 7): ☒ indicates that the coverage is included.

☐ ☐ ☐

These policies comply with the insurance requirements of the governing contract, permit, lease, license or other requirements of the Regional District of Central Kootenay. It is understood and agreed any deductible or reimbursement clause contained in the policy shall be the sole responsibility of the Named Insured.

Signature and Broker's Stamp Authorized to Sign on Behalf of Insurers	Title	Date Signed

SCHEDULE B – CONTRACT PAYMENT TERMS

1 Total budget shall not exceed $[Amount] (excluding GST).

2 Invoices to be submitted Choose Billing Option.

The following contract number and GL code(s) **must** be quoted on the invoice(s):

Contract Number: **YYYY-##-DEPT_CONTRACTOR_NAME**

GL Code: **ACCOUNT # & WORK ORDER #**

Invoices should be emailed to ap@rdck.bc.ca, with the contract administrator identified on the first page of this contract in cc.

3 Invoices to be paid on net 30 day term.

4 GST (if applicable) shall be listed as a separate line item on all invoices.

SCHEDULE B – SUPPORTING DOCUMENTATION

SHEEP CREEK BIOLOGICAL IMPACT ASSESSMENT 2019

Version 1.2

Prepared for:

Regional District of Central Kootenay

202 Lakeside Drive

Nelson, BC V1L 5R4

Prepared by:

Allan Irvine, B.Sc., R.P.Bio

New Graph Environment

6 Regent St

Nelson, BC V1L 2P1

July 8, 2020

Executive Summary

A biological impact assessment was conducted in Sheep Creek adjacent to the Central landfill for the Regional District of Central Kootenay in 2019. As several groundwater seeps originating from the landfill enter Sheep Creek, the Central Landfill's operational certificate requires biological impact assessments every five years.

The periphyton and benthic macroinvertebrate communities were sampled at three sites in Sheep Creek in the fall of 2019. Consistent with past sampling conducted in 2003, 2008 and 2013, a control site was located upstream of where landfill influenced groundwater could potentially enter the stream, one site was located adjacent to the seeps, and one site was located a short distance (30 - 50m) downstream of the seeps (Lower Site). As in previous years, periphyton and benthic macro-invertebrate sampling in Sheep Creek in 2019 indicated diverse species assemblages at all sites with taxa present typical of cold interior mountain streams. Although often not discernible with statistical tests, and with no metrics implying severe stress, trends in multiple metrics (abundance, Shannon-Weiner diversity index, HBI and EPT%) were apparent within the 2019 dataset indicating that the landfill leachate entering Sheep Creek influences the benthic macro-invertebrate communities within a localized area adjacent to the seeps.

New to the biological impact assessment methodology in 2019, ordination and identification of indicator taxa were useful for exploring relationships between site invertebrate assemblages as well as between biological community structures and associated water quality data. For data acquired in 2003, 2013 and 2019, statistical analysis of the ordination models was able to differentiate sample assemblages based on site group. Additionally, with the exception of 2019 data, fitting of select water quality parameter results to ordination models provided visual representations of synergies between benthic community structure and water quality data. Overall, data indicates that community assemblages at sites sampled in Sheep Creek have been driven primarily by naturally occurring factors more consequential than water quality inputs from the landfill.

We recommend collecting annual Sheep Creek surface water samples in the fall, during low flows, and a return to a 5-year routine of collecting 5 water samples in 30 days to facilitate comparison of water quality results with British Columbia freshwater aquatic life long-term chronic water quality guidelines. We also recommend inclusion of testing for dissolved metals to discern if elevated total metal concentrations are related only to the presence of sediments in the samples or if dissolved metals are also sometimes elevated. Current and historic water quality data should be uploaded to the EMS database as soon as possible to facilitate efficient, consistent, reproducible review and analysis of current and historic analytical results. Finally, we recommend the temporary establishment of a fourth Sheep Creek water quality sampling site at a location approximately 350 m downstream from the Lower Site to confirm that impacts to water quality and ecological communities do not extend further downstream than assessed by sampling at the historic sample site locations.

Table of Contents

1 Introduction 1
2 Background 1
2.1 Sheep Creek 3
2.2 Hydrogeological Characterization 5
2.3 Sample Site Locations 5
3 Methodology 6
3.1 Water Quality 7
3.2 Habitat Characteristics 7
3.3 Periphyton 8
3.3.1 Chlorophyll a and Phaeophytin Biomass 8
3.3.2 Algal Taxonomy 8
3.4 Benthic Macro-Invertebrates 9
3.4.1 Abundance 9
3.4.2 Diversity 10
3.4.3 Hilsenhoff Biotic Index 10
3.4.4 EPT 10
3.4.5 Functional Feeding Group Composition 11
3.4.6 Ordination 11
3.4.7 Indicator Taxa 12
4 Results 13
4.1 Water Quality 13
4.2 Habitat Characteristics 15
4.3 Periphyton 16
4.3.1 Chlorophyll a and Phaeophytin Biomass 16
4.3.2 Algal Taxonomy 19
4.4 Benthic Macro-Invertebrates 20
4.4.1 Abundance 20
4.4.2 Diversity 22
4.4.3 Hilsenhoff Biotic Index 23
4.4.4 EPT Index 23
4.4.5 Functional Feeding Groups 26
4.4.6 Ordination 28

4.4.7 Indicator Taxa 32
5 Impact Assessment 32
6 Recommendations 34
7 References 36

Appendix 1 - Water Quality Boxplots for Parameters of Interest

Appendix 2 - Site Photos

Appendix 3 - Metric Summary and Statistical Result Tables

Digital Attachment 1 – Database (sheep_database_2020-06-13.xlsx. SQLite Version on file)

Digital Attachment 2 – 3D Ordinations (3D_ordination_models.html)

1 INTRODUCTION

New Graph Environment was retained by the Regional Regional District of Central Kootenay (RDCK) to conduct a biological impact assessment on Sheep Creek near the Village of Salmo, British Columbia. Following infiltration into groundwater, landfill leachate originating from the Central Landfill (formerly the Canex Landfill), enters Sheep Creek after emerging from a series of seeps located on the valley wall on the north side of the landfill. As a condition of the landfill's Operational Certificate (16519), authorized by the Ministry of Environment and Climate Change Strategy under provisions of the British Columbia *Environmental Management Act*, a biological impact assessment is required every 5 years to assess the impact of this groundwater discharging to the creek from the landfill property (MoE 2000). This is the fourth biological impact assessment conducted to determine the impact to the aquatic community of Sheep Creek. Impact assessments were also conducted in 2003 (Masse 2004), 2008 (Masse & Miller 2009) and 2013 (Irvine 2014).

2 BACKGROUND

Central landfill is located approximately 6.8 km south of Salmo, BC. The landfill borders Emerald Mine Road to the north with Sheep Creek located within a deeply incised valley approximately 50 m of elevation below and 200 - 250 m from the northern boundary. A gravel pit owned by the province of British Columbia is located adjacent to the north-eastern boundary of the landfill on the north side of Emerald Mine Road (Figure 1).

RDCK commenced Central Landfill operations in 1983. Daily land filling operations ceased in 2014, and the site now operates as a Transfer Station as well as a septage treatment facility. In 2018, 1555 tonnes of recyclable waste was diverted and approximately 1273 m^3 of septage was disposed of and processed at the site (RDCK 2019). According to annual operations and monitoring reports for the landfill facility, from 2016 to 2018 a combined total of 3819 m^3 of septage was placed at the site assuming a density of 1000 kg/m^3 (RDCK 2017, RDCK 2018, RDCK 2019). The septage is placed within designated drying beds within the western buffer of the site near Emerald Road. The drying beds drain into a constructed wetland area with flow from a pre-settling basin up slope of the beds. A site plan can be reference in annual operations and monitoring reports (RDCK 2017, RDCK 2018, RDCK 2019).

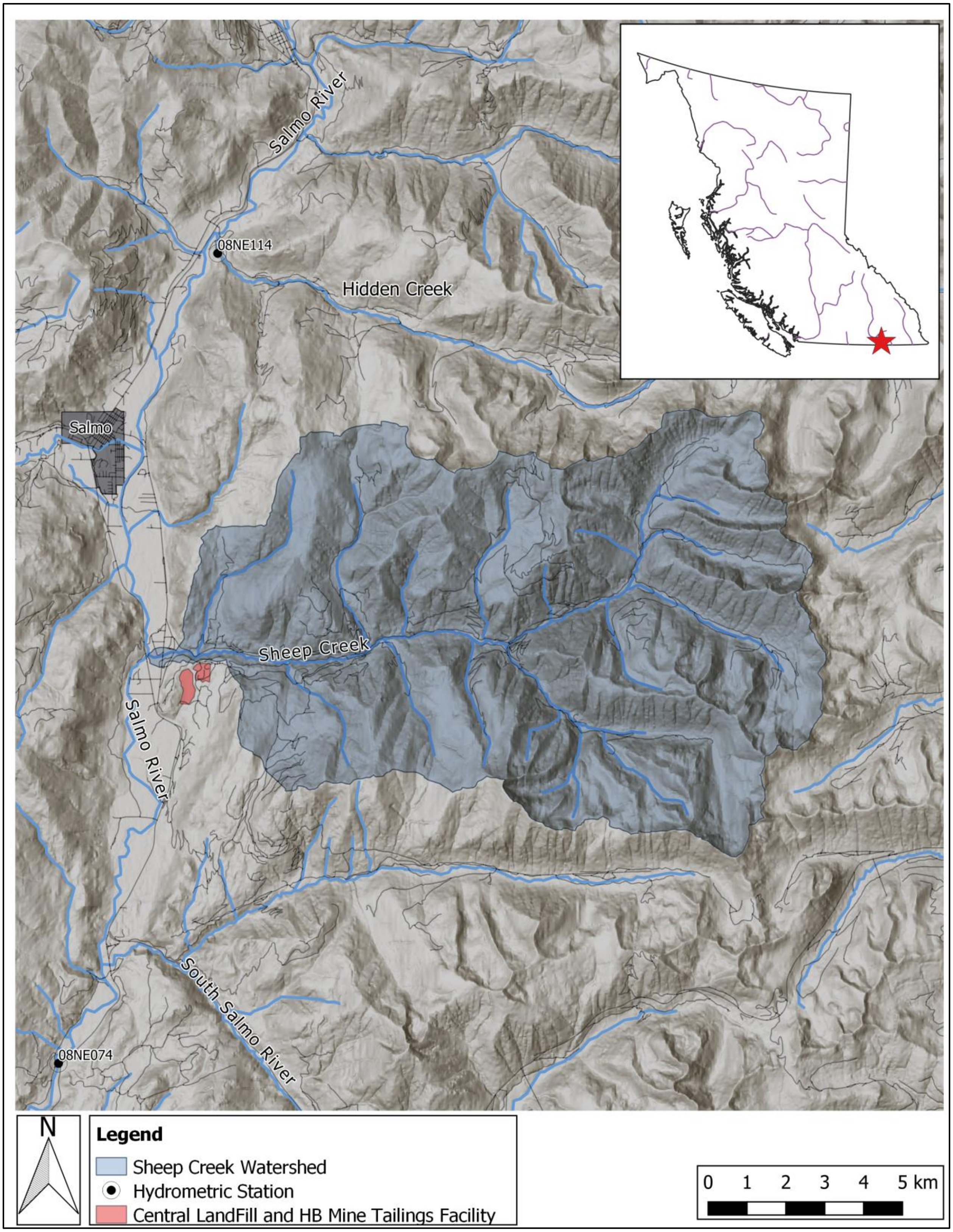

Figure 1: Overview Map

From 1912 to 1978, the HB Mine was active approximately 3.2 km north-east of the landfill site on the north side of Sheep Creek. It produced lead, zinc, silver, cadmium, copper, gold and talc which were mined from a lead-zinc sulphide ore deposit. A tailing flume line was used to transport tailings from the former HB Mine site to a 30 ha stockpile area and tailings pond (HB Mine Tailings Storage Facility) located down gradient and east of the landfill. Remnants of the flume are visible along the northern and western property boundaries. The tailing storage facility is scheduled to be decommissioned in 2020 (RDCK 2020).

2.1 Sheep Creek

Sheep Creek is a fifth order stream draining 135 km^2 of watershed in a western direction into the Salmo River. The height of land at the top of the watershed reaches approximately 2,300 m and the confluence with the Salmo River is at approximately 565 m. Stream flows in Sheep Creek are typical for high elevation watersheds in the Selkirk Mountains which receive large amounts of precipitation as snow leading to peak levels of discharge during snowmelt, typically from mid-April to mid-July. Environment Canada estimates a mean annual discharge in Sheep Creek of 3.4 m^3/s based on historical data from a hydrometric station operated in 1930 (BC Water Tool 2020). This estimate is consistent with results of extrapolation of discharge to watershed size from results of the active hydrometric monitoring station located on Hidden Creek (hydrometric station #08NE114) which has a mean annual discharge of 1.64 m^3/s and a watershed size of 56.7 km^2 (BC Water Tool). Hidden Creek enters the Salmo River from the east approximately 11 km upstream of the Sheep Creek confluence (Figure 1).

Fish species in the the Sheep Creek watershed are detailed in Table 1 and include Bull Trout and Westslope Cutthrout Trout. Both species are provincially listed as of special concern with Westslope Cutthroat Trout also listed federally as of special concern. Sheep Creek represents the most important Bull Trout spawning and juvenile rearing stream in the Salmo River watershed. Past radio telemetry work indicates that adult Bull Trout reside most of the year in the mainstem of the Salmo River then migrate into tributaries such as Sheep Creek during the summer or early fall. They return to the mainstem after spawning. Approximately 16km of Sheep Creek is accessible to Bull Trout migrating upstream from the Salmo River and spawning occurs primarily within the upper half of this area (Nellistijn 2019). Juvenile Bull Trout rear in Sheep Creek for 2-3 years before emigrating to the Salmo River mainstem.

Table 1: Fish species recorded as present within Sheep Creek watershed (MoE 2020, Nellistijn 2019).

Scientific name	**Species name**	**Species code**
Cottus cognatus	Slimy Sculpin	CCG
Oncorhynchus clarki lewisi	Westslope (Yellowstone) Cutthroat Trout	WCT
Oncorhynchus mykiss	Rainbow Trout	RB
Rhynichthys cataractae	Longnose Dace	LNC
Salvelinus confluentus	Bull Trout	BT
Salvelinus fontinalis	Brook Trout	EB
Prosopium williamsoni	Mountain Whitefish	MW

With support from BCHydro and the Columbia Region Fish and Wildlife Compensation Program, the Salmo Watershed Streamkeepers Society has operated an aquatic fertilization program on Sheep Creek since 2001. The program adds phosphorus and nitrogen to the water at a location approximately 11km upstream from the confluence with the Salmo River with the intent of supporting juvenile Bull Trout rearing in the stream. Since 2004, liquid agricultural fertilizers have been added to Sheep Creek flows with target application rates of 10 ug/L total dissolved phosphorus as ammonium polyphosphate drip (10-34-0) and 100 ug/L dissolved inorganic nitrogen as urea-ammonium nitrate drip (32-0-0). Application rates are set based on staff gauge heights taken every 5 to 8 days from the Sheep Creek bridge on Airport Road correlated to a stage discharge relationship established in the lower reach of the stream and flow data collected at hydrometric transects throughout the program operating months (PSlaney 2005). Typically, the program is underway from June - October. Nutrient additions have been conducted every year since 2004 with the exception of 2010 and 2011. Pre-addition monitoring conducted in 2001 - 2003. As part of the project, primary productivity has been assessed by the streamkeepers within Sheep Creek and the South Salmo River (control site) through monitoring of periphyton (Nellestijn *et al* 2019).

In addition to the HB Mine, throughout the 1900s, many other mines and mills operated in the Sheep Creek drainage. Some of the many historic mines and mills included the Queen, Yellowstone, Nugget, Kootenay Belle, Reno and Motherlode among many others. Considerable piles of waste rock and tailings are present throughout the valley and along adjacent mountain ridges and may contribute to water quality issues in Sheep Creek (Heinbuch 2000). Additionally, Wood (2020) note that the HB Mine Tailing Facility, Remediation and Closure Plan indicates that the northern ore body located in the vicinity of the original HB Mine upstream from the Sheep Creek Control may contribute metals to Sheep Creek surface water. Also of interest, an avalanche occurred in the watershed in 2014, approximately 15 km upstream from the landfill, resulting in a large debris flow and considerable bedload movement (Nellestijn 2019).

2.2 Hydrogeological Characterization

The operating certificate for the Central Landfill requires that every five years a detailed hydrogeological assessment of the site is conducted based on the previous five years monitoring data and other relevant information. The hydrogeological review must provide an update on the assimilative capacity of the site for contaminants of concern (MoE 2000).

Based on previous reports from Klohn-Crippen and Conestoga-Rovers and Associates drafted from 2000 - 2006 as well as the results of annual water quality and level monitoring, AMEC Environment & Infrastructure (now Wood) conducted a five year hydrogeology review of the Central Landfill site in 2013 (AMEC 2014) and again in 2019 (Wood 2020). The subsequent reports characterized the geology, hydrogeology, hydrology and current land use at and near the landfill site. The 2013 and 2019 investigations indicate that the site topography and the presence of a bedrock trough (oriented in a northwest to southeast direction) cause a groundwater flow divide beneath the landfill area with a component of the groundwater migrating towards Sheep Creek to the north and the other component flowing southwest through the mine tailings area to the valley bottom aquifer near the Salmo River (AMEC 2014, Wood 2020).

2.3 Sample Site Locations

To facilitate comparison with past impact assessments and analytical results from the ongoing water sampling program at the Central Landfill, biological communities at the three sites assessed in 2003, 2008 and 2013 (Control, Upper Site, Lower Site) were also assessed in 2019 with five samples taken within a 20 - 30 m long section of stream at each of the three sites. Details of the location of the three sites are included as Table 2 and shown in Figure 2. The location of the Lower Site coincides with surface water quality sampling location SW-A (RDCK ID) and is documented as EMS site E242839. However, the site location is documented within the EMS system as 350m downstream of the RDCK water quality sampling location and the periphyton/benthic macroinvertebrate “Lower Site” sampling location (UTM 11N 481781 5443349). The “Upper Site” location used for obtaining biological samples coincides with the RDCK surface water sampling site “SW-B”. Water quality and biological samples associated with this site are taken immediately adjacent to or slightly downstream of where Seep A enters Sheep Creek and approximately 135 m downstream of coordinates associated with the site in the EMS database (EMS ID E242838). Similarly, samples associated with the site location for RDCK water sampling (SW-C) and the “Control” biological sampling station are taken approximately 220 m downstream of coordinates identified in the EMS database (EMS ID E242837).

Table 2: Location of Sheep Creek Sample Sites and Surface Water Quality Monitoring Stations.

Site	EMS ID	RDCK ID	UTM	Description
Control	E242837	SW-C	11.483157.5443280	Upstream of area recieving groundwater potentially influenced by landfill
Upper Site	E242838	SW-B	11.482055.5443172	Adjacent to Seep A
Lower Site	E242839	SW-A	11.482028.5443157	30-50 m downstream of Seep A

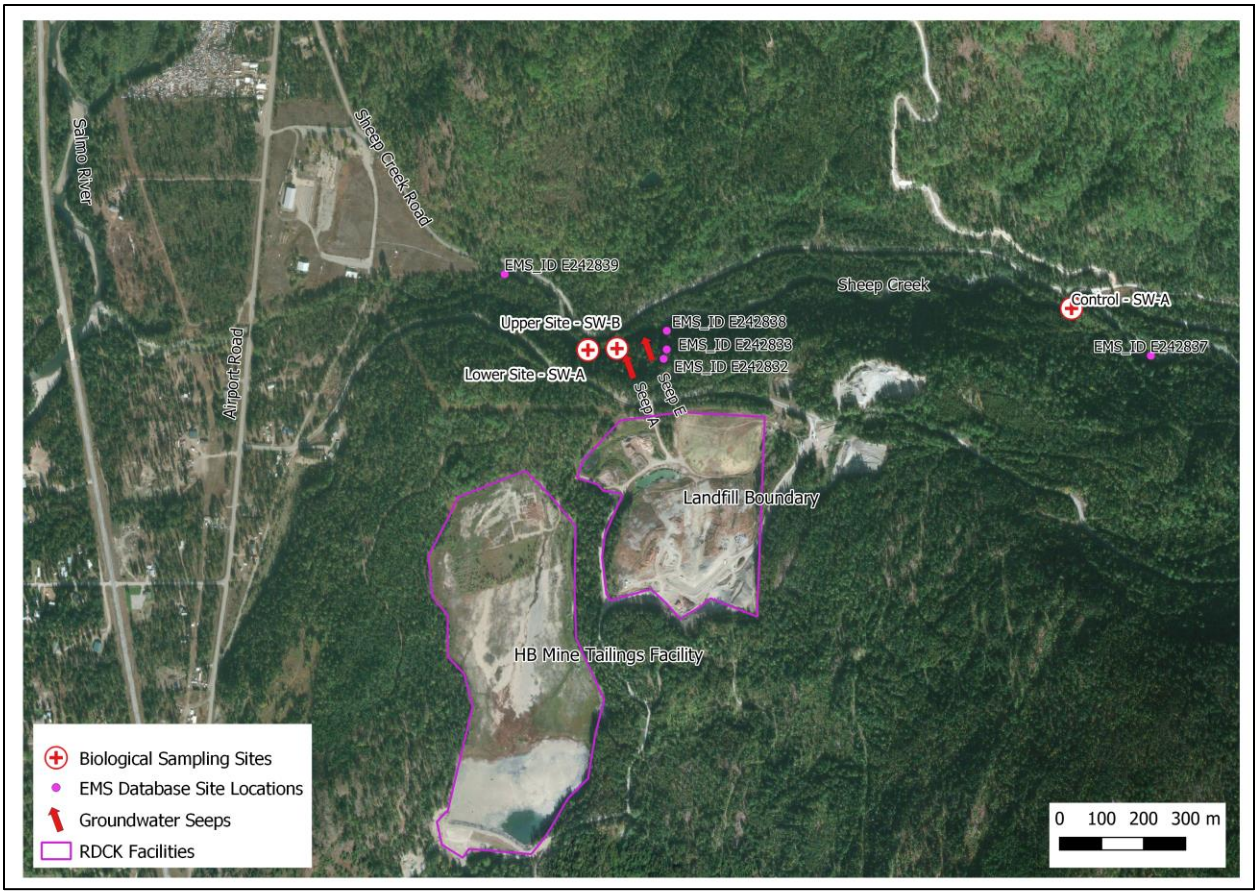

Figure 2: Map of Biological Sample Sites, EMS database site locations and other Key Features

3 Methodology

Benthic macro-invertebrates and periphyton are used as indicators of ecological health of aquatic systems. Shifts in organism abundance and species composition between sampling sites and over time can indicate the degree and extent of anthropogenic impacts.

To facilitate the analysis for this biological impact assessment, results from laboratory analysis of periphyton chlorophyll *a*/phaeophytin and benthic macro-invertebrate sampling from 2019 as well as all previous years of the study (2003, 2008 and 2013) were loaded to a database (sqlite format) from raw data files provided from either the laboratories (Cordillera Consulting, Algal Taxonomy and Ecology Inc. and Caro Analytical) or RDCK. To facilitate reproducibility and efficient future analysis, whenever possible, data loading, cleaning, analysis and reporting were scripted in R Language and Environment for Statistical Computing (R Core Team 2020) with script files stored in a private repository on the New Graph Environment Github site. Periphyton taxonomy results from 2019 were loaded to the database however past years' periphyton (algal) taxonomy data was not loaded due to year to year inconsistencies in laboratory analysis methodologies as well as project time constraints. The 'taxize' package (Chamberlain and Szocs 2013) was utilized to tidy and correct taxa names, match to Integrated Taxonomic Information System (ITIS) numeric identifiers and to source current taxonomic hierarchies from ITIS, the National Center for Biotechnology Information (NCBI) and other databases interfaced by taxize (ex. Encyclopedia of Life, Canada Species List). Field work was conducted on September 20, 2019 and October 6, 2019 by Allan Irvine, B.Sc., R.P.Bio. and Kyle Prince, B.Sc., P.Biol.

3.1 Water Quality

Available water quality data for select parameters from Sheep Creek surface water sampling sites were collated, reviewed and added to the project database (Digital Attachment 1). When possible, the data was obtained directly from the British Columbia Environmental Monitoring System. The R package "rems" (Teucher 2020) was used to query the government database for water quality parameters from sites of interest. A review of water quality data provided by RDCK indicated that analytical results from a number of sampling dates had not yet made it into the EMS system. For these dates, data was provided directly from RDCK. Available pre-2006 data consisted only of scanned tables within the 2003 Biological Impact Assessment document (Masse 2004) so average values from 5 in 30 day sampling for parameters of concern were transferred to an excel spreadsheet manually before being added to the project database. Water quality parameters of interest were chosen based on a review of background documentation including RDCK annual operations and monitoring reports, hydrogeological assessments and other documents relevant to water quality in the watershed (RDCK 2014, RDCK 2017, RDCK 2018, RDCK 2019, Amec 2014, Wood 2020, Nellestijn 2019).

3.2 Habitat Characteristics

Habitat characteristics were measured at all three sample site locations and included channel width, wetted width, type of stream cover, percent canopy coverage, periphyton coverage, dominant/subdominant substrate type, gradient, stream morphology, confinement and a pebble count survey. The pebble count survey was performed by walking along in a zigzag pattern across the creek and measuring the b-axis of pebbles randomly collected at regular intervals. A total of 50 rocks were measured at each site. Flow velocities and water depths were collected at all sites and for each invertebrate sample location using a Swoffer 2100 flow meter. Water and air temperature, pH, dissolved oxygen, turbidity, salinity and conductivity were measured in the field at each site with a handheld YSI ProDSS meter.

3.3 Periphyton

Five replicate samples were collected at each of the three sampling sites (Control, Upper Site and Lower Site) on October 6, 2019. A circular sampling frame with a diameter of 5.2 cm was used to scrape the periphyton from within an area of 21.24 cm^2 on randomly selected fully submerged rocks throughout the site. Periphyton was brushed from within the frame and rinsed from the scraped area into clean plastic containers (Barbour *et al.* 1999). A composite sub-sample for taxa identification was amalgamated from the five samples and preserved with Lugol's solution. The containers were then wrapped in aluminum foil, placed in a cooler on ice and immediately shipped to CARO Analytical in Kelowna for biomass analysis and to Algal Taxonomy and Ecology Inc. in Stony Mountain, Manitoba to determine community composition of dominant taxa based on plant density counts. The biomass samples were analyzed for Chlorophyll *a* and phaeophytin by Caro within 48 hours.

3.3.1 Chlorophyll a and Phaeophytin Biomass

Analysis of chlorophyll *a* biomass can be useful for detecting impacts from eutrophication or other disturbances. Study results were compared between sites and to the British Columbia water quality guideline for aquatic life with data presented in tables and boxplots for comparison. The ratio of phaeophytin to chlorophyll *a* was also calculated and compared for each site as it can provide insight into algal community integrity (Wetzel and Westlake 1974).

3.3.2 Algal Taxonomy

For each lugol's preserved periphyton sample, a 1 ml aliquot was diluted to 2 ml and settled in a Utermöhl settling chamber overnight. Microscopic analysis was conducted using a Leitz diavert inverted microscope at magnifications of between 125 and 625x. The small (< 3 um and < 20цm) or very numerous cells were enumerated on using 8-16 random fields on a 250 цm transect at the higher magnification, the entire transect was enumerated for less numerous cells and the larger (>20 цm cells) less numerous cells are enumerated at the lower magnification. At least 200 organisms were enumerated and classified to the lowest taxonomic entity possible given preservation and conditions of cells, to give a general composition following the standard inverted microscope method (Utermohl 1958 as modified by Nauwerck 1963) . Biomass conversions were based on measurements of 10 or more specimens in each sample and calculated using standard geometric shapes for algal protoplast and a density of 1 based on the methods of Rott, 1981 but not including flotation or vacuoles. Algal taxonomy density counts for each site were summarized as percent biomass at the *order* taxonomic level with the *class* taxonomic level also identified for context.

3.4 Benthic Macro-Invertebrates

Five replicate benthic macro-invertebrate samples were collected at each of the three sampling sites (Control, Upper Site and Lower Site) on September 20, 2019. Benthic macro-invertebrate samples were collected using a Surber sampler (220 um mesh) with a sampling area of 0.126 m^2. At each site, five samples were collected. The sampler was placed in the stream and positioned securely into the gravels to eliminate gaps between the bottom of the sampler and the stream-bed. Benthic invertebrates were collected by hand stirring the area within the sampler and the underlying streambed down to 10 cm below the initial streambed substrate surface. The invertebrates subsequently dislodged from the substrate drifted downstream into the Surber sampler net. Large rocks and debris captured in the Surber net were discarded after being rinsed and inspected to remove all clinging organisms. The entire content of the net was transferred to a clean plastic 500 ml sample jar. As mentioned, flow velocities and water depths were collected at each invertebrate sample location using a Swoffer 2100 flow meter.

Immediately after collection, all samples were preserved by adding 200 to 300 ml of formalin (10% buffered formaldehyde). The samples were then sent to Cordillera Consulting (Summerland, BC) for enumeration and identification. Each sample was elutriated to remove sand and gravel and then sieved through a brass screen (212 µm) to remove formalin and clay particles. The remaining organic material was transferred to an 80% ethanol solution. The sample was sub-sampled using a surface area based method when the number of organisms in the fraction was estimated to be significantly greater than 300. The goal of the sub-sampling was to achieve a sub-sample of at least 300 organisms. Material was carefully sorted and invertebrates were removed and sorted into individual categories. All debris was checked for organisms. The process of sorting was repeated until all organisms had been removed from the entire sample. The residue from each sample was resorted until acceptable accuracy of picking was achieved. Sorting efficiency was checked by a different technician on 10% of samples, with results documented at 97% and 99%. All data were tabulated and presented in Excel format then transferred to the database (Digital Attachment 1). Detailed methods and quality control from Cordillera are documented in a report on file at New Graph Environment.

3.4.1 Abundance

Total benthic macro invertebrate abundance (organisms/m^2) was compared between sites as it can be an indicator of site productivity and provide insight into ecosystem conditions. High abundances can be an indicator of aquatic health; however, significant variations in abundances from one location to the next within the same watershed can also indicate nutrient or other chemical inputs. Distribution of the data was assessed by comparing probability plots and by calculating the Shapiro-Wilk test (shapiro.test function) statistic. Statistical analysis was performed using the non-metric Kruskal-Wallis Rank Sum Test (kruskal.test function) in R.

3.4.2 Diversity

Habitat degradation and aquatic pollution can lead to losses in biological diversity. The Shannon-Weiner index is a measure of the number of taxa and the proportional abundances (evenness) of the taxa in a community. The higher the resulting output of the metric the greater the diversity and evenness of the community assemblages which can be an indicators of ecosystem integrity. The "diversity" function from the vegan package in R was used to calculate the Shannon-Weiner index for each of the samples taken at all sites in all years of the study (Oksanen et. al 2019, R Core Team 2020). All unique taxa recorded were considered separate for the calculation regardless of taxonomic rank. Statistical analysis was performed using the non-metric Kruskal-Wallis Rank Sum Test (kruskal.test function) in R.

3.4.3 Hilsenhoff Biotic Index

Helsenhoff's Biotic Index (HBI) was developed to evaluate the altering of invertebrate communities due to oxygen deprivation resulting from organic and nutrient pollution. Taxa are assigned a tolerance value from 0-10, with 0 assigned to taxa most intolerant of organic pollution and 10 assigned to the taxa most tolerant of pollution. The biotic index is an average of tolerance values for all individuals collected from a site (Hilsenhoff 1987). Tolerance values were sourced first from Barbour *et al.* (1999) for taxa with assigned tolerances for the northwest region and if not available then from the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) "Tolerance Values and Functional Feeding Groups" excel database (SAFIT 2020) which references Ode (2003). Both Barbour *et al.* (1999) and SAFIT (2020) reference values were obtained programmatically and processed through R, then saved as tables in the database for cross-referencing with the raw invertebrate data. Statistical analysis was performed using the non-metric Kruskal-Wallis Rank Sum Test (kruskal.test function) in R.

3.4.4 EPT

The EPT Index is a measure of the percent of the sample that are from the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) orders. As EPT species are generally intolerant to pollution and common in cold-water freshwater systems, this metric is predicted to decrease in response to increases in pollution (Balbour *et al.* 1999). Statistical analysis was performed using the non-metric Kruskal-Wallis Rank Sum Test (kruskal.test function) in R.

3.4.5 Functional Feeding Group Composition

Analysis of functional feeding group composition can provide insight into complex processes such as trophic interaction, food source availability and production. Stable food dynamics result in balanced feeding groups within benthic assemblages and unbalanced assemblages can be an indicator of stress (Barbour *et al* 1999). There are many metrics related to functional feeding groups that can inform assumptions regarding such things as predator-prey relationships, substrate stability and the presence of high amounts of suspended particulate organic matter. The percentage of predators below 15% indicates normal top down control of predators on prey and low proportions of collector filterers when compared to collector gatherers can indicate an absence of suspended particulate organic matter (Merrit et. al 2002). Proportions of shredders, scrapers, collector filterers and collector gatherers can indicate whether stable substrates are limiting and increases in the proportion of generalists, such as collector gatherers, and decreases in the proportion of more specialized feeders, such as scrapers and shredders can be interpreted as benthic community responses to disturbance (Barbour *et al.* 1999, Merrit et. al 2002). Functional feeding group was assigned to taxonomic data from all years' of the study based on values first sourced first from Barbour *et al.* (1999) and then subsequently from the SAFIT "Tolerance Values and Functional Feeding Groups" excel database (SAFIT 2020) if not assigned in Barbour *et al* (1999). SAFIT (2020) references Ode (2003). Both Both Barbour *et al.* (1999) and SAFIT (2020) were obtained programmatically and processed through R, then saved as tables in the database for cross-referencing with the raw invertebrate data.

3.4.6 Ordination

Species assemblages are commonly considered the best response variable to measure the impact of changes in ecosystems caused by anthropogenic and natural forces (Legendre and Gauthier 2014). Ordination is an exploratory analytical method of "ordering" taxa to discover patterns in abundance and distribution along actual or presumed ecological gradients. Non-metric Multidimensional Scaling (NMDS) is an ordination procedure that represents species assemblages as points within coordinate frames (most commonly two or three-dimensional plots) based on the rank order of among sample dissimilarities (Clarke 1993). In community ecology, NMDS is often regarded as the most robust ordination method as it does not rely on assumptions about distribution of sample data and because it's distance-preserving properties provide clarity in communicating results of impact studies to environmental managers (Minchin 1987, Clark 1993).

NMDS was performed on macro-invertebrate species assemblages collected within Sheep Creek from 2003 - 2019 using the "metaMDS" function from the vegan package within R (Oksanen et. al 2019). Before fitting assemblages to axis, community abundance data was transformed with Wisconsin double standardization and square root transformation to equalize emphasis among samples and species. The goodness of fit of the ordinations was assessed by reviewing stress plots and comparing stress versus number of dimensions. The stress value reflects how well the ordination summarizes the observed distances among the samples (Clarke 1993). Output NMDS results were processed and plotted on two axis with R package ggplot2 (Wickham 2016) and on three axis using the R package vegan3D (Oksanen et. al 2018). Select physical parameters and select water quality parameters for each site in 2019 were fit to the NMDS generated ordinations using the "env.fit" function from the vegan package with linear correlations between pararameters and the ordination axes considered significant and plotted when the p-value was <0.05. For 2003, 2008 and 2013 only select water quality parameters were fit. Physical parameters were excluded due to time constraints related to the loading of historic data to the database.

To facilitate statistical comparison between site taxa assemblages, distance matrices for each year were calculated using the Bray-Curtis dissimilarity index ("vegdist" function) and then variance among sites was compared for all study years utilizing permutational multivariate analysis of variance (permutational manova) with the "ADONIS" function in the vegan package. Models fitting effect of site to dissimilarity index were randomly permutated 999 times to determine p-values which when considered significant (<0.05) resulted in rejection of the null hypothesis of equal variances (i.e. evidence that the differences observed in community structure between sites are not likely attributable to random effects). As equal dispersion of variances (spread of the variance) between groups is an assumption of the ADONIS test, before analysis with permutational manova, dissimilarity matrices were assessed for equal variance using the "permutest.betadisper" function from the vegan package. A p-value <0.05 was considered significant to reject the null hypothesis of homogenous variance dispersion (i.e. spread of variance was not likely equivalent between sites and ADONIS test should not be used).

3.4.7 Indicator Taxa

It can be useful to describe conditions in site habitats grouped by location or treatments (ex. disturbed, undisturbed, etc.) using indicator taxa as they can be representative of many species with similar ecological requirements, reflect the state of the environment and provide evidence for the impacts of environmental change (Niemi and McDonald 2004, Landres et. al 1988). The "multipatt" function from the indicspecies R package (De Caceres and Legendre 2009) was used to statistically test the association between benthic macroinvertebrate taxa and there most strongly associated site group (or site group combination). Only taxa identified to the genus and species level were included in the analysis. Indicator value indices assess the predictive values of taxa as indicators of the conditions prevailing in site groups. The test statistic used for the analysis was the *Indicator Value* (IndVal) index detailed in Defrene and Legendre (1997) and is based on the product of *specificity* and *fidelity*. The *specificity* or *positive predictive value* of the taxa as an indicator of the site group is the sample estimate of the probability that a surveyed site belongs to the target group of sites based on the fact that the taxa was found there. The *fidelity* or *sensitivity* of a taxa as an indicator of a target site group is the sample estimate of the probability that the taxa occurs within a site given that the site belongs to the target group. The statistical significance (p-value) of the relationship represented by IndVal was tested by running 999 permutations of the multipatt analysis (De Caceres and Legendre 2009). P-values below 0.05 were considered significant to determine that the IndVal statistic was appropriately assigned for each indicator taxa identified.

4 RESULTS

4.1 Water Quality

Water quality monitoring is part of the ongoing environmental management program at Central Landfill with details of the annual sampling program available in RDCK (2019). Uphill from the landfill there are a series of drainage ditches that divert surface water around the Central Landfill and toward the tailing impoundment area. Onsite at the landfill, surface water is managed using a pre-settling basin, a constructed wetland and ditching systems (RDCK 2019). There are three primary sources of potential groundwater contamination (RDCK 2019):

- Tailings leachate originating from the HB Mine tailings impoundment area.
- Municipal solid waste leachate derived from the landfill waste cells onsite.
- Raw septage leachate from liquid septage disposal onsite.

Water quality chemistry results from sampling of tailings from the HB Mine tailings impoundment area confirms the presence of high concentrations of tailings-derived sulfate, cadmium, iron, and zinc (RDCK 2018, AMEC 2014).

Several groundwater seeps discharge into the steep southern embankment of Sheep Creek immediately north of the landfill (Figure 2). Water quality results indicate that Seep E and Seep A are located within the landfill leachate plume (RDCK 2019). Similiar trends of elevated levels of ammonia, arsenic, boron, cadmium and iron have been observed both at Seep E and up-gradient at groundwater monitoring well MW-99-7D (EMS ID# E240505) (RDCK 2019, Wood 2020). RDCK (2019) reports that estimated flow rates in Seep A are approximately 10 times those observed in Seep E in the fall (ex. 0.27L/s at Seep A vs. 0.021 L/s at Seep E on October 23, 2019) while they can be over 200 times as high at Seep A in the spring (ex. ~5 L/s in Seep A vs. ~0.03 L/s in Seep E on May 9, 2018). Somewhat similar to historical observations, surface water analytical results from Seep A and/or Seep E exceeded freshwater aquatic life chronic or acute criteria for cobalt, uranium, arsenic, iron, ammonia and manganese in both May and October of 2018 (RDCK 2019).

Sheep Creek surface water sampling sites for the ongoing environmental monitoring program at the landfill are aligned with the benthic invertebrate and periphyton monitoring site locations (see Section 2.2). In addition to the surface water sampling sites on Sheep Creek, there are ground water monitoring stations located adjacent to the "Control" (MW-03A-01 or EMS_ID E252592) as well as adjacent to the

"Upper Site" (MW-02A-01 or EMS_ID E252591). Review of available data from both EMS and RDCK indicates that Sheep Creek surface water sites were sampled bi-annually during low flows (September - early October) in the spring and fall from 2006 - 2013 with 5 samples in 30 days taken during fall sampling to facilitate comparison with BC freshwater aquatic life long-term chronic guidelines. In 2014 and 2015 Sheep Creek surface water sampling took place once in the spring and once in the fall. Since 2015, the sites have been sampled once a year in the spring only.

Leachate assessment parameters (ammonia, chloride, iron, manganese, sulfate and zinc) at the mixing zone in Sheep Creek (SW-B - Upper Site - EMS_ID E242838) have historically been elevated relative to the upstream (SW-C - Control - EMS_ID E242837) and downstream (SW-A - Lower Site - EMS_ID E242839) surface water monitoring sites (RDCK 2015a, RDCK 2015b, RDCK 2016, RDCK 2017, Amec 2014). However, since 2016, results from analysis of water samples taken at the three monitoring locations on Sheep Creek have been very similiar (Wood 2020, RDCK 2019). However, as previously mentioned, since 2014, water sampling at surface water monitoring stations in Sheep Creek have been conducted in the spring with higher flows than was typical of the pre-2014 monitoring program. Consequently, the lack of detection of water quality trends is likely at least partially attributable to seep water dilution from mixing with high Sheep Creek flows.

Water quality parameters from Sheep Creek surface water sampling locations that were chosen for a detailed review and fitting to ordination models include:

- Leachate characterization parameters (ammonia, chloride, iron, manganese, sulfate and zinc). Ammonia is also relevant for the biological impact assessment due to potential influences of the Salmo Watershed Streamkeepers Society nutrient addition program that has been adding phosphorus to the stream approximately 9 km upstream from the Control Site.
- Cadmium and arsenic due to ongoing exceedences noted at Seep E, Seep A and Sheep Creek surface water sampling sites in historic monitoring reports (RDCK 2014, RDCK 2017, RDCK 2018, RDCK 2019).
- Total organic carbon as this can be an indicator of impacts from waste management activities such as the disposal of septic waste (Moore 1998) and because exceedences of the long-term chronic guideline were noted at the Upper Site and Lower Site in Sheep Creek in 2013 (RDCK 2014).
- Total phosphorus. Phosphorus is often the limiting nutrient in aquatic systems and is actively added to the stream approximately 9km upstream of the Control from June – October by the Salmo Watershed Streamkeepers Society through the ongoing nutrient enrichment program.

Boxplots for water quality parameters of interest are included in Appendix 1. Comparison of water quality data for select parameters between project study periods (2003, 2004 - 2008, 2009 - 2013, 2014 - 2019) proved challenging due to the need to source data from multiple locations and the associated lack of consistency between formats. Additionally, there appears to be multiple errors potentially related to units reported in both EMS and the RDCK database that result in order of magnitude discrepancies between sample periods not likely attributable to conditions in Sheep Creek alone. However, in general, a pattern of highest median values at the Upper Site and lowest at the Control was apparent for total organic carbon, chloride, iron and manganese for all study periods. The same pattern was apparent for sulfate for pre-2014 but not 2015 - 2019 were no pattern was evident Phosphorus, zinc and cadmium showed no obvious patterns between sites over multiple study periods. Results for arsenic tended to have median or maximum values highest at the Upper Site in three of the four study periods with the exception of 2003 where a single result above the detection limit (from the 5 in 30 day sampling) at the Control put the average value above both the Upper Site and Lower Site.

With the exception of arsenic from 2003, site water quality data from the annual results associated with each of the biological impact assessment program sampling years (2003, 2008, 2013 and 2019) was fit to associated taxa ordination models to explore potential relationships between water quality results and ordination axes. Fitting water quality results to ordination models considers the ranks of the analytical results rather than the raw numeric data so although between-year data appears to be inconsistent and some results may contain errors, these errors appear to be consistent between sites within sample years rendering the data appropriate for fitting.

4.2 Habitat Characteristics

Site locations were adjacent to the Sheep Creek Forest Service Road (FSR) with a riparian buffer of 15 – 90 m separating the FSR from the creek. Representative photos from each site are included in Appendix 2. The habitat at each sample site was similiar at all sites (Table 3). However, streamside vegetation was dominated by mature deciduous forest at the Control and mature coniferous forest at the Upper Site and Lower Site. Also, the size of substrate (as indicated by the Wolman D50) was notably larger at the Control than the other two sites. Water quality parameters measured on site with a handheld meter were similiar between sites with a minor trend of slightly increasing conductivity, total dissolved solids and pH in a downstream direction. The channel width at the Lower Site was over double the measured width of both the Control and Lower Site due to a wider valley at this location and a partially wetted side channel area on the right bank.

Table 3: Summary of Habitat Characteristic and Field Measurements

Parameter	Control	Upper Site	Lower Site	Reference
Stream Gradient (%)	2	1	1	Environment Canada 2012
Channel Width (m)	15.0	32.0	15.5	Environment Canada 2012
Wetted Width (m)	12.5	16.0	13.0	Environment Canada 2012
Dominant Substrate	cobble	cobble	cobble	MoE 2008
Subdominant Substrate	boulder	boulder	boulder	MoE 2008
Temperature (C)	11.6	11.6	10.9	-
Dissolved Oxygen (% saturation)	94.5	96.2	96.1	-
Conductivity (mS/cm)	78.2	79.5	82.6	-
Total Dissolved Solids (mg/L)	68.3	69.5	73.6	-
pH	8.44	8.97	9.45	-
Turbidity (NTU)	0.1	0.2	0.1	-
Canopy Coverage (%)	1-25	1-25	1-25	Environment Canada 2012
Macrophyte Coverage (%)	1-25	1-25	1-25	Environment Canada 2012
Dominant Streamside Vegetation	deciduous trees	coniferous trees	coniferous trees	Environment Canada 2012
Periphyton Coverage	3	3	3	Environment Canada 2012
Wolman D50 (mm)[a]	154.5	130.0	134.5	-

[a]Wolman D50 = the particle size that 50 % of the samples are equal to or smaller than.

4.3 Periphyton

4.3.1 Chlorophyll a and Phaeophytin Biomass

Periphyton biomass as chlorophyll *a* was compared between sites as well as to the BC water quality guideline for freshwater aquatic life of 100 mg/m^2, which is designed to detect impacts from eutrophication (MoE 2019). Biomass of chlorophyll *a* is summarized in Figures 3 - 4 and Appendix 3 - Table 5. Levels at all sites were far below the provincial guideline. In 2019, the median biomass of chlorophyll *a* was highest at the Upper Site (19.7 mg/m^2), located adjacent to the leachate impacted seeps. Biomass was intermediate at the Control (19.7 mg/m^2) and lowest at the Lower Site (16.4 mg/m^2). Similiar to 2013, in 2019, a statistical comparison of the results failed to reject the null hypothesis that median biomass values were equivalent at the three sites (Table 6).

The ratio of phaeophytin to chlorophyll *a* can provide information on the physiological health of the algal community, with lower values present when periphyton are actively growing and higher values when there is a higher rate of senescence occurring. The ratio of phaeophytin to chlorophyll *a* was similar between the Upper Site and the Lower Site with median values of 0.15 and 0.22 respectively (Figure 5 and Table 7). The Control had a higher level of senescence (median = 0.43) as indicated by the statistical test results (p-value = 0.007, Appendix 3 - Table 6).

There has been a general pattern of highest chlorophyll *a* biomass at the Upper Site in three out of four sample periods with a difference between medians confirmed statistically in 2003 and 2008 (Appendix 3 - Tables 5 -6 and Figure 4). Additionally, the median value of the ratio of phaeophytin to chlorophyll *a* biomass samples has been highest at the Control in three out of the four study periods (2003, 2008 and 2019) but statistically confirmed as significant in 2019 only (Appendix 3 - Tables 5 - 6 and Figure 6) .

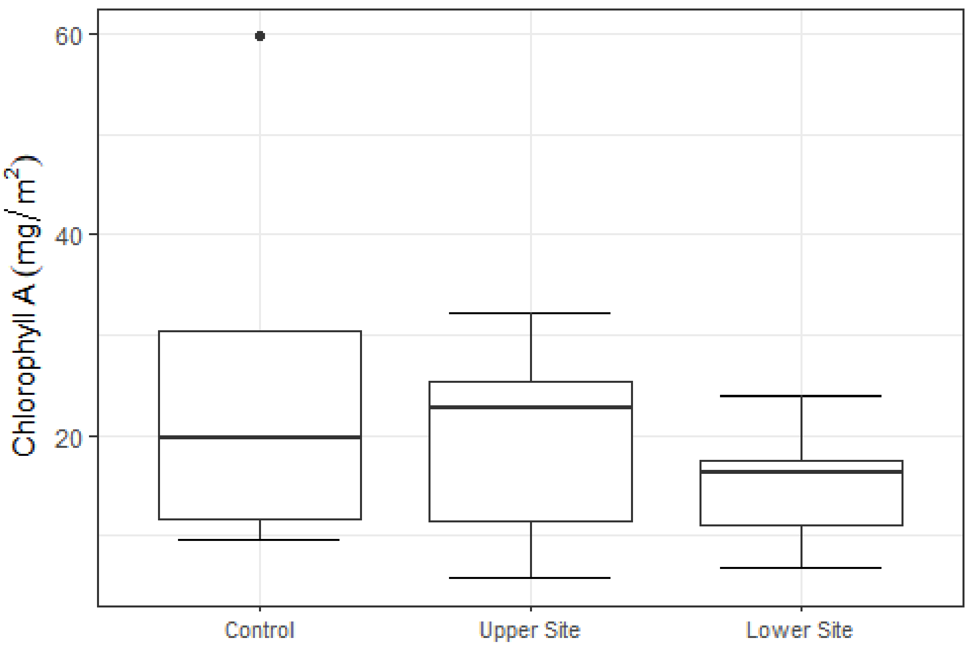

Figure 3: Boxplot of chlorophyll a biomass from samples collected in October 2019.

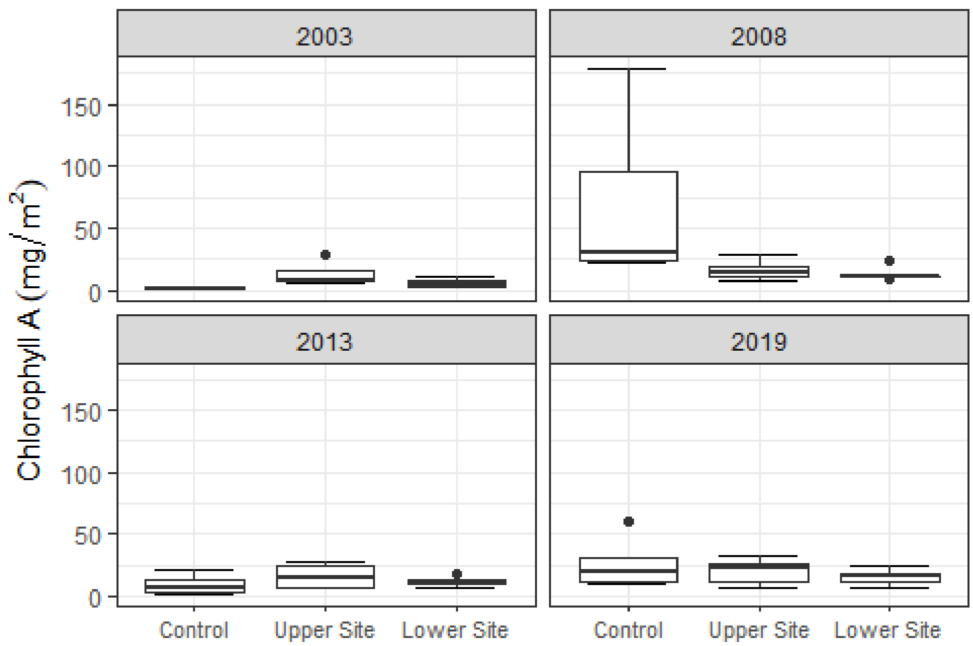

Figure 4: Boxplot of chlorophyll a biomass from samples collected in 2003 - 2019.

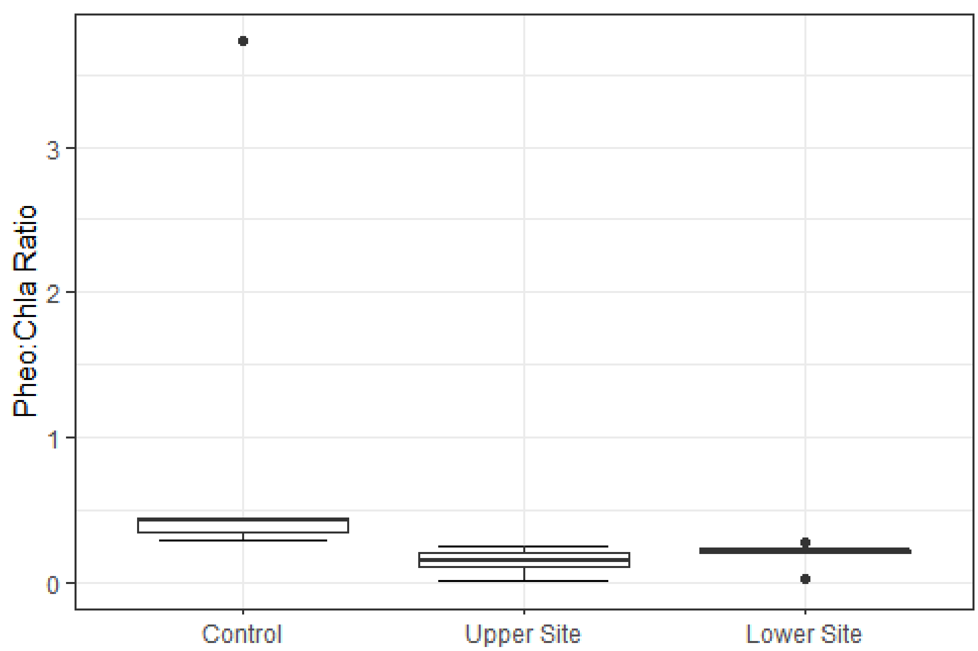

Figure 5: Boxplot of ratio of phaeophytin to chlorophyll a biomass from samples collected in 2019.

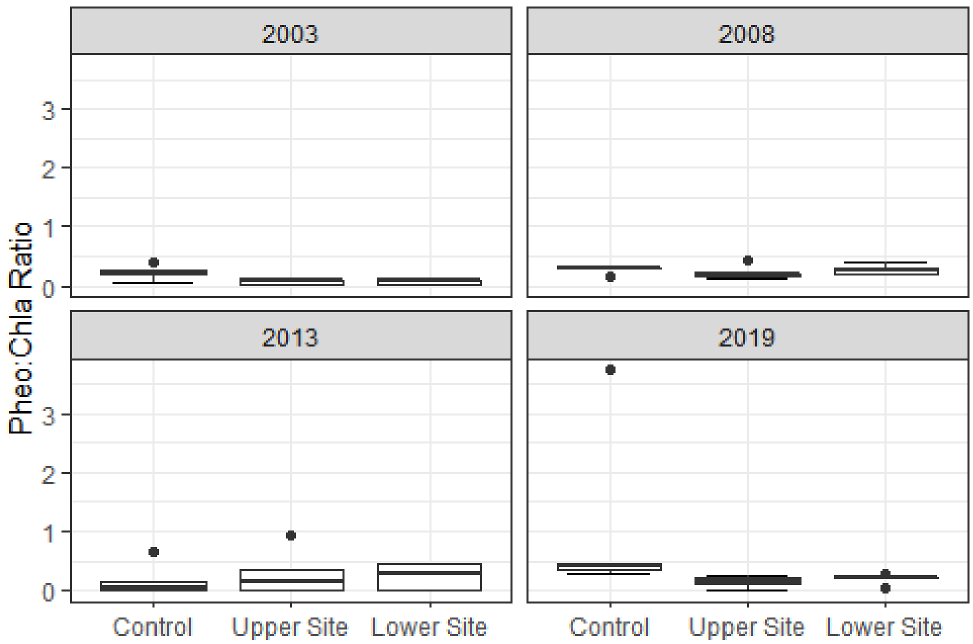

Figure 6: Boxplot of ratio of phaeophytin to chlorophyll a biomass from samples collected in 2003 - 2019 showing equal y-axis.

4.3.2 Algal Taxonomy

Algal taxonomy density counts for composite samples take from each site are summarized as percent biomass at the *order* taxonomic level in Table 4. Taxonomic orders comprising less than a total of 1% of composition at all three sites combined were not included in the summary table. In 2019, Bacillariophyceae was the dominant class at both the Control and Upper Site comprising 41.5% and 51.6% of taxa assemblage biomass composition repspectively. At the Lower Site, Cyanophyceae was the dominant class sampled comprising 30.5% of the composite sample. Chlorophyceae was subdominant at both the Control (34.2%) and Lower Site (25.8%) with Bacillariophyceae also subdominant at the Lower Site (28.6%). Ulvophyceae was subdominant at the Upper Site only (comprising 29.2% of the composite sample biomass) contrasting with the relatively low levels of composition at both the Control (7%) and Lower Sites (5.1%).

The dominant order differed between all three sites with *Chaetophorales* dominant at the Control, *Ulotrichales* dominant at the Upper Site and *Nostocales* dominant at the Lower Site (Table 4). The Control and Lower Site were both comprised of significant proportions of *Chaetophorales* and the Upper Site and Lower Site were both comprised of significant proportions of *Cymbellales*.

Table 4: Algal taxonomy results for 2019 as percent composition of biomass at the order taxonomic level.

Class	Order	Biomass (% Composition)		
		Control	Upper Site	Lower Site
Bacillariophyceae	Achnanthales	10	7.1	4.2
	Cymbellales	11.4	28.3	20
	Fragilariales	17.2	10.6	1.3
	Naviculales	2.9	4.7	-
	Bacillariales	-	0.1	3.1
Chlorophyceae	Chaetophorales	34.2	2.2	25.8
Cyanophyceae	Chroococcales	2.8	4.1	0.3
	Nostocales	10.1	8.6	30.2
	Synechococcales	3.5	1.8	5
Phaeophyceae	Sphacelariales	3.5	1.8	5
Ulvophyceae	Ulotrichales	4.2	29.2	5.1

4.4 Benthic Macro-Invertebrates

4.4.1 Abundance

Although high abundance of invertebrates can indicate a healthy aquatic environment large variations from one site to the next within a watershed can indicated nutrient or other chemical inputs. Invertebrate abundance at each of the three sites (thousands/m^2) is summarized in Figures 7 - 8 as well as Appendix 3 - Table 8. In 2019, site median abundance values were highest at Control (26300 invertebrates/m^2). Lowest median values were observed at the Lower Site (10500 invertebrates/m^2) with median abundance values intermediate at the Upper Site (18600 invertebrates/m^2). Statistical analysis indicated that the abundance values for 2019 were not equivalent between sites (p-value = 0.023, Appendix 3 - Table 10).

In three out of the four years of the sampling program (2003, 2013 and 2019) there has been a general pattern of higher maximum and median values of invertebrate abundance at the Upper Site and Lower Site when compared to the Control (Table 8 and Figure 8) although the differences between the site medians were decerned statistically in 2019 only (Appendix 3 - Table 10). Abundance values were notably higher in 2013 than all other sample years (Figure 8).

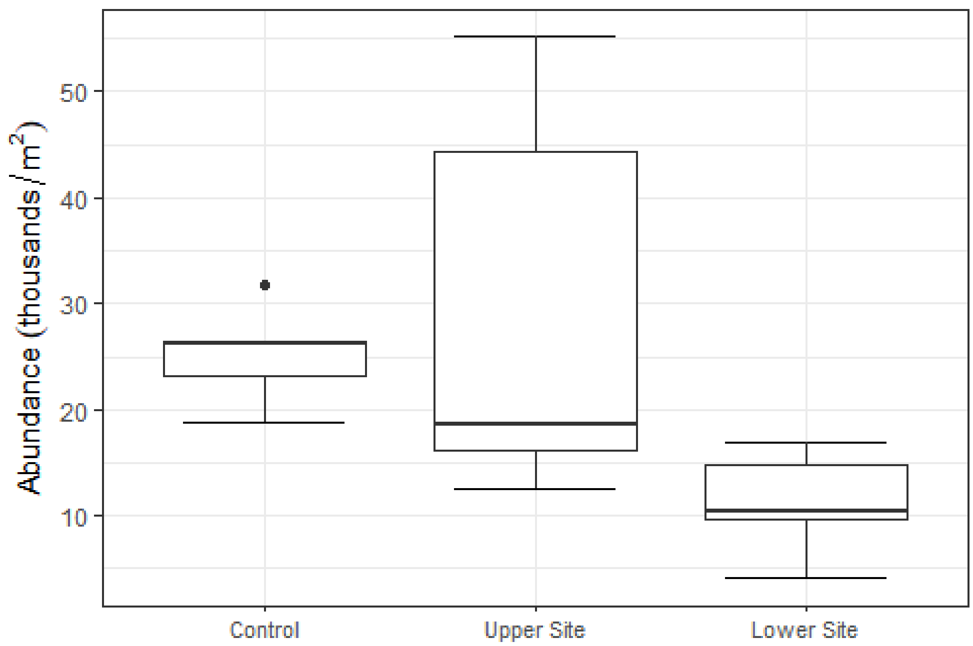

Figure 7: Boxplot of invertebrate abundance (thousands/m2) in 2019.

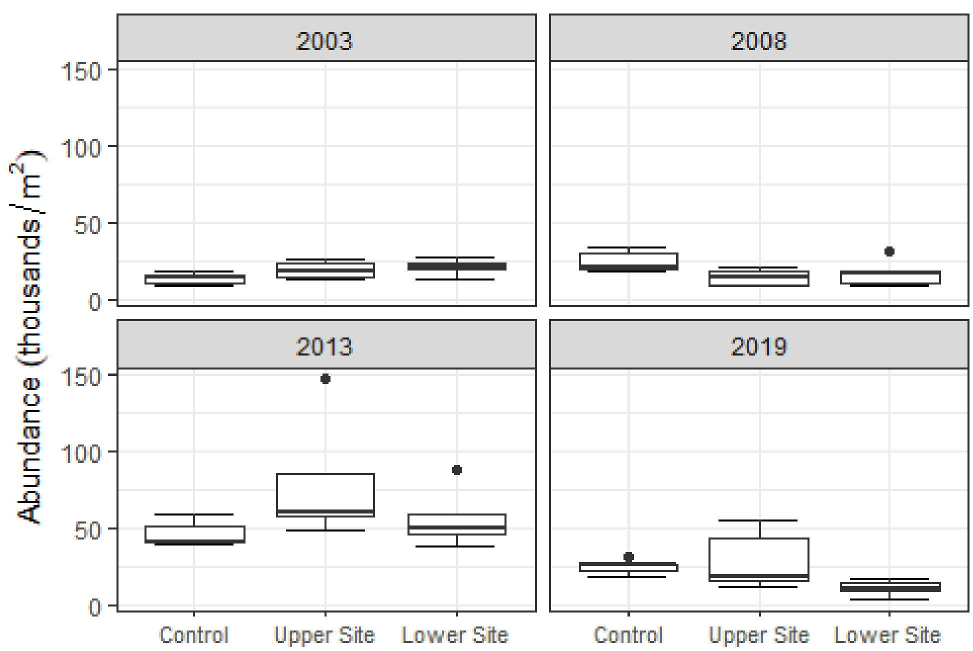

Figure 8: Boxplot of invertebrate abundance (thousands/m2) in 2003 - 2019.

4.4.2 Diversity

Results of Shannon-Weiner index values for diversity are summarized in Figures 9 - 10 as well as Appendix 3 - Table 8. In 2019, site median diversity values were highest at Control (3.3). Lowest median values were observed at the Lower Site (3.2) with median abundance values intermediate at the Upper Site (3). The Kruskal-Wallis rank sum test indicated that the median values for diversity were not discernible between sites in 2019 (p-value = 0.36, Appendix 3 - Table 10).

Although a difference between site median values for diversity was statistically describable only in 2013 (p-value = 0.011, Appendix 3 - Table 10), there has been a general pattern of lowest median values at the Upper Site in three (2008, 2013 and 2019) out of the four sampling program periods with highest median diversity values at the Control in 2008 and 2013 and at the Lower Site in 2003 and 2019 (Appendix 3 - Table 8 and Figure 10).

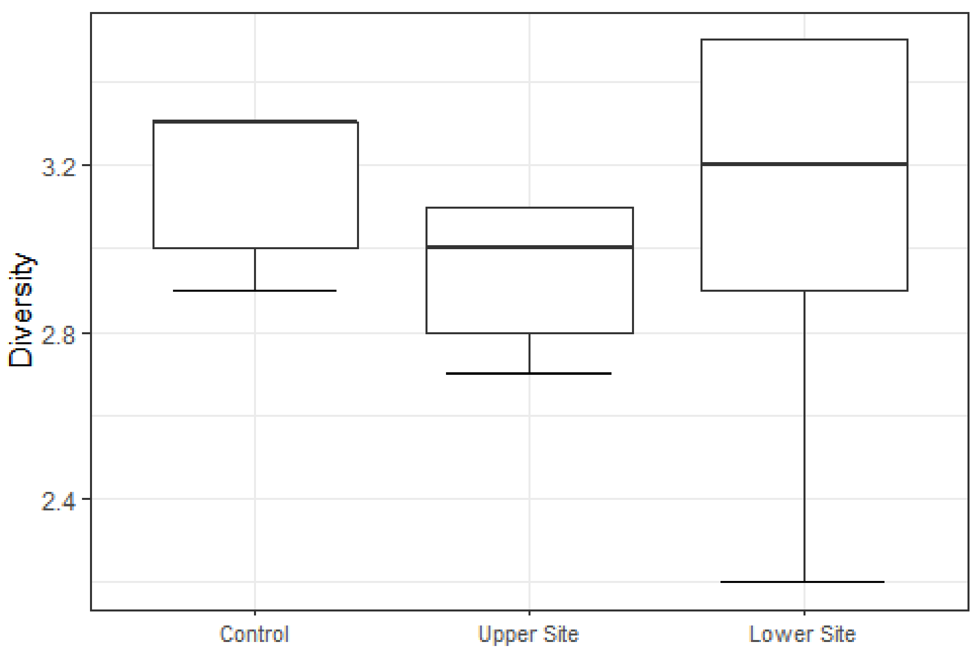

Figure 9: Boxplot of invertebrate diversity (Shannon-Weiner Index) in 2019.

Figure 10: Boxplot of invertebrate diversity (Shannon-Weiner Index) in 2003 - 2019.

4.4.3 Hilsenhoff Biotic Index

The Hilsenhoff biotic index is an average of tolerance values for all individuals collected from a site with increased values indicating the presence of higher numbers of more tolerant invertebrates. HBI values are summarized in Figures 11 - 12 as well as Appendix 3 - Table 9. In 2019, site median HBI values were highest at Upper Site (3.6), lowest at the Control (3.2) and intermediate at Lower Site (3.3). HBI values were not statistically discernible between sites in 2019 (p-value = 0.206, Appendix 3 - Table 10).

Although statistical analysis of the data did not discern differences between site medians for any of the sample years (Table 10), median HBI values have been highest at the Upper Site in three (2008, 2013 and 2019) out of the four years of program sampling (Figure 12 and (Appendix 3 - Table 8).

4.4.4 EPT Index

As EPT species are generally intolerant to pollution and common in cold-water freshwater systems, this metric is predicted to decrease in response to increases in pollution (Balbour *et al.* 1999). The percent of samples that were from the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) orders are summarized in Figures 13 - 14 as well as Appendix 3 - Table 9. In 2019, site median EPT values were highest at Control (67.9%), lowest at the Lower Site (53.8%) and intermediate at the Upper Site (55.8%). Median values were not statistically discerned between sites (p-value = 0.281, Appendix 3 - Table 10).

Review of results from all years of data indicated lowest EPT Index values (lower quartile range) at the Lower Site on three of the four (2008, 2013 and 2019) sampling years (Figure 14). Statistical analysis of the data did not reject the null hypothesis that site medians were equivalent in all four sample years (Appendix 3 - Table 10).

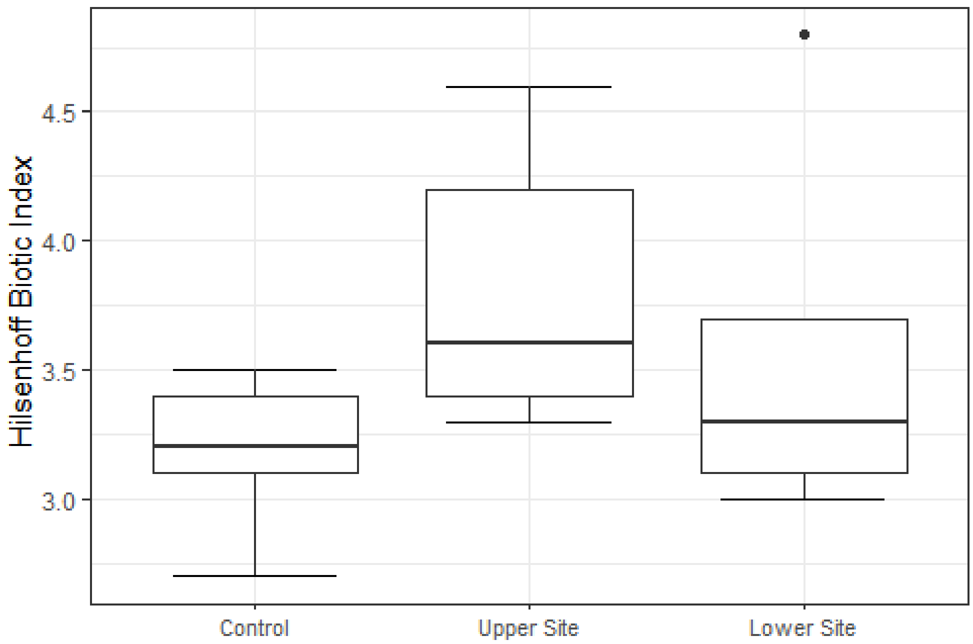

Figure 11: Boxplot of Hilsenhoff Biotic Index at study sites in 2019.

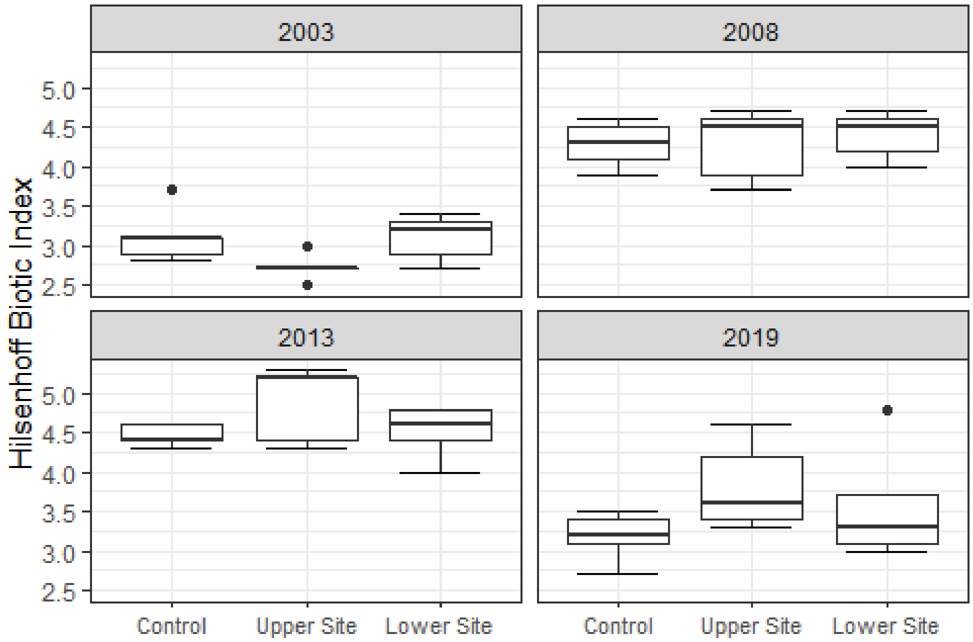

Figure 12: Boxplot of Hilsenhoff Biotic Index at study sites in 2003 - 2019.

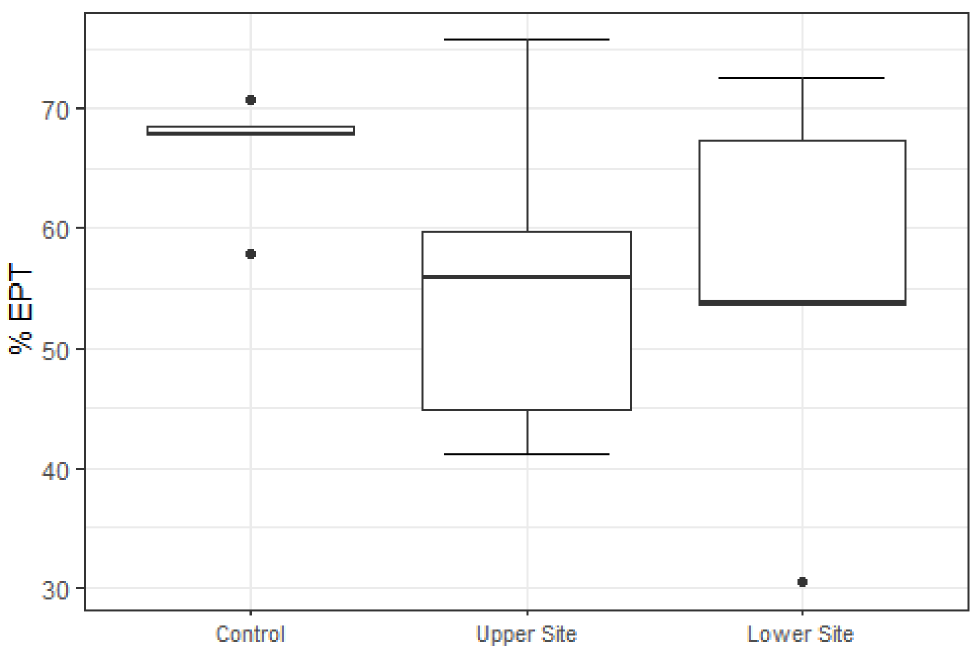

Figure 13: Boxplot of EPT Index at study sites in 2019.

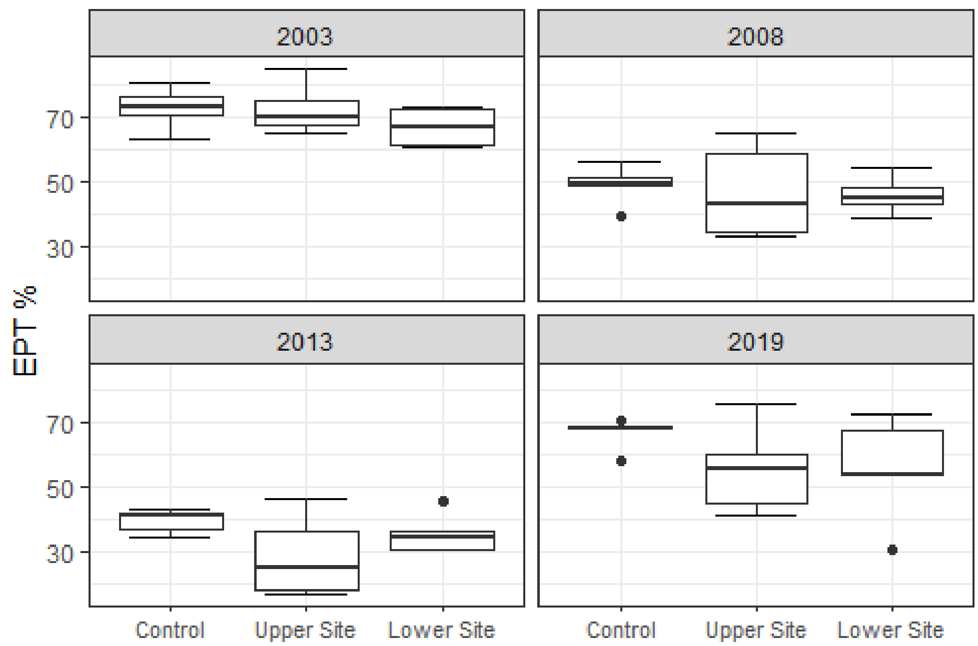

Figure 14: Boxplots of EPT Index at study sites in 2003 - 2019.

4.4.5 Functional Feeding Groups

The evaluation of functional feeding group is based on morphological attributes associated with feeding. Functional feeding group composition can provide insights into ecosystem functioning and assess the effect of anthropogenic impacts (ex. organic pollution, toxins and physical habitat alteration) on aquatic systems (Merrit *et. al* 2002). Functional feeding group analysis of samples taken at the three study sites are summarized in Appendix 3 - Table 11 as well as Figures 15 - 16. In 2019, collector gatherers and scrapers were the dominant feeding groups with combined site median values ranging from 65.8% at the Upper Site to 56.1% at the Control. The median values for functional feeding groups were not statistically discerned between sites (Appendix 3 - Table 12).

When the proportion of scrapers + collector filterers to total shredders + collector gatherers is less than 50% it can indicate that stable substrates are limiting invertebrate production potential (Merrit *et. al* 2002). Values of this metric ranged from 58% to 69% indicating that stable substrates were not limiting at any of the three sites .

Evaluation of functional feeding group composition at the three sites since 2003 indicates variation in composition between sample periods. For instance, higher proportions of collector gatherers were observed in 2013 when compared to 2019 and greater proportions of scrapers and collector filterers present at all sites in 2019 when compared to 2013. Also worthy of note, the proportion of collector filterers was much higher in 2019 than was observed in any of the previous sample periods.

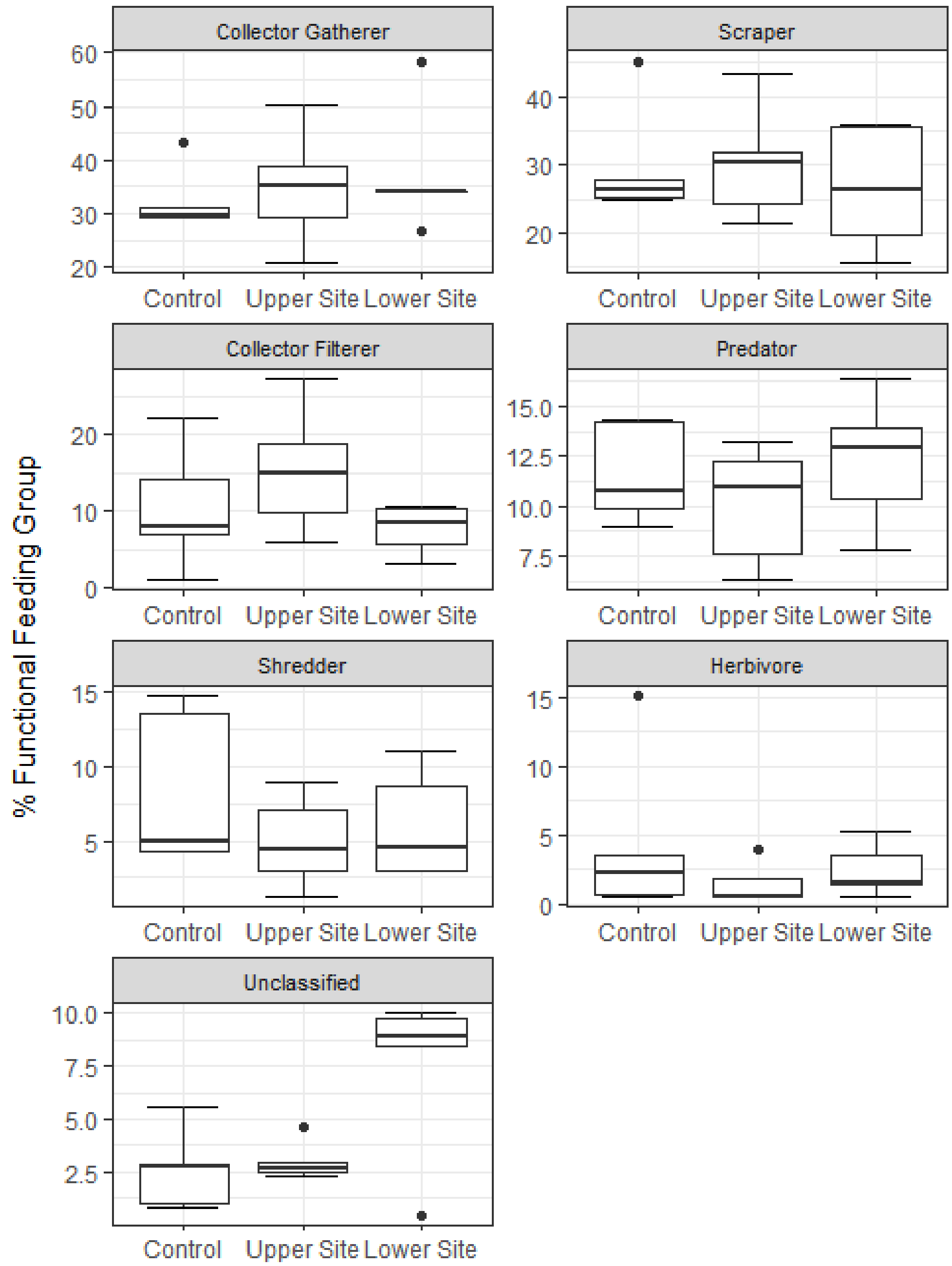

Figure 15: Boxplots of functional feeding groups at study sites in 2019.

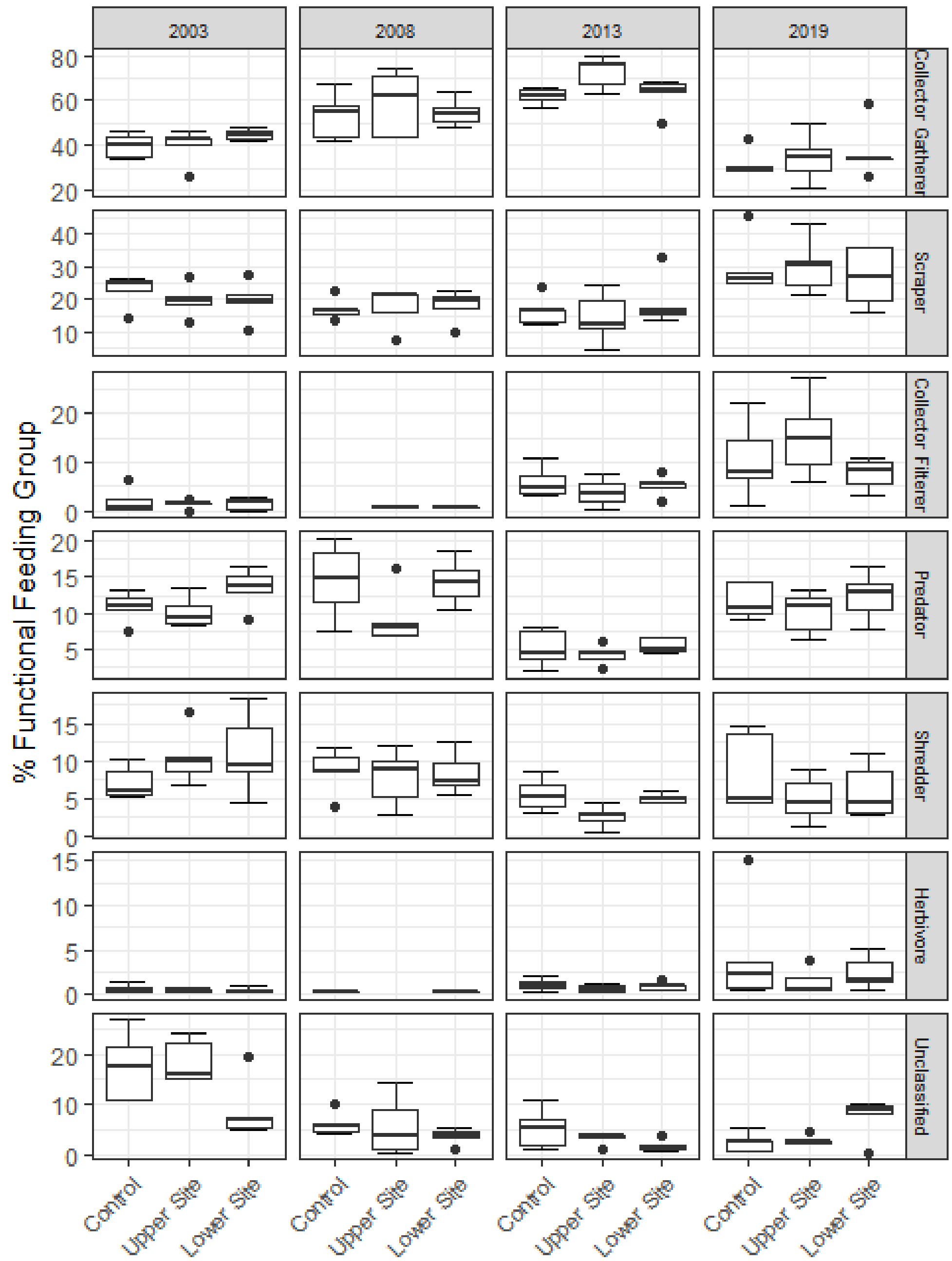

Figure 16: Boxplots of functional feeding groups at study sites in 2003 - 2019.

4.4.6 Ordination

Results of NMDS of 2019 data are shown in Figure 17 with two of three axis plotted for all samples. Interactive three-dimensional representations of the ordinations are attached in Digital Attachment 2 (3D_ordination_models.html). Stable configurations converged with 20 permutations and ordinations were fit to three axis with a stress value of 0.1 which is considered useable with very low risk for drawing false inferences (Clarke 1993).

Results indicated that in 2019, species assemblages differed between sites (p-value = 0.02) with site grouping accounting for 24% of the variation in distance between the positions of the sample assemblages (Appendix 3 - Tables 13 - 14). Review of the two and three-dimensional ordination plots indicates substantial overlap between the Upper Site and Lower Site assemblages with some community structure overlap apparent between the Upper Site and the Control (Figure 17, Digital Attachment 2). However, positions of modeled representations of taxa assemblages did not overlap between the Control and the Lower Site groups. In 2019, no physical or water quality parameters correlated to the NMDS axes. Physical parameters fit included conductivity, total dissolved solids, pH, dominant streamside vegetation and Wolman D50 (Table 3). Water quality parameters fit are detailed in Section 4.1.

NMDS results for 2003 - 2013 are included in Figures 18 - 20 and Digital Attachment 2. As with 2019 data, stable configurations converged with 20 permutations and ordinations were fit to three axis. Stress values for 2003, 2008 and 2013 were 0.11, 0.11 and 0.13 respectively. These stress values are considered usable with low potential to mislead (Clarke 1993). Permutational manova (ADONIS) indicated significantly different site structures for 2003 (p-values = 0.02) and 2013 (p-value = 0.03) with 23% and 27% of the variance between samples explained by site grouping (Appendix 3 - Table 14). In 2008, among site differences were not considered statistically significant (p-value = 0.06). Ordination plots for 2003 had fairly equivalent areas of overlap between representations of taxa assemblages all three sites. In 2013, the positions of Control and Upper Site models overlapped each other however the Lower Site group structure did not overlap with either the Upper Site group or the Control group.

Of the select water quality parameters fit to the ordination plots (total organic carbon, chloride, manganese, ammonia, phosphorus, sulfate and iron), only sulfate fit with NMDS axis in 2003 and only dissolved ammonia and total phosphorus fit reliably in 2013 (Appendix 3 - Table 15). In 2008, with the exception of phosphorus and iron all parameters fit the ordination axes with p-values < 0.05 (Appendix 3 - Table 15).

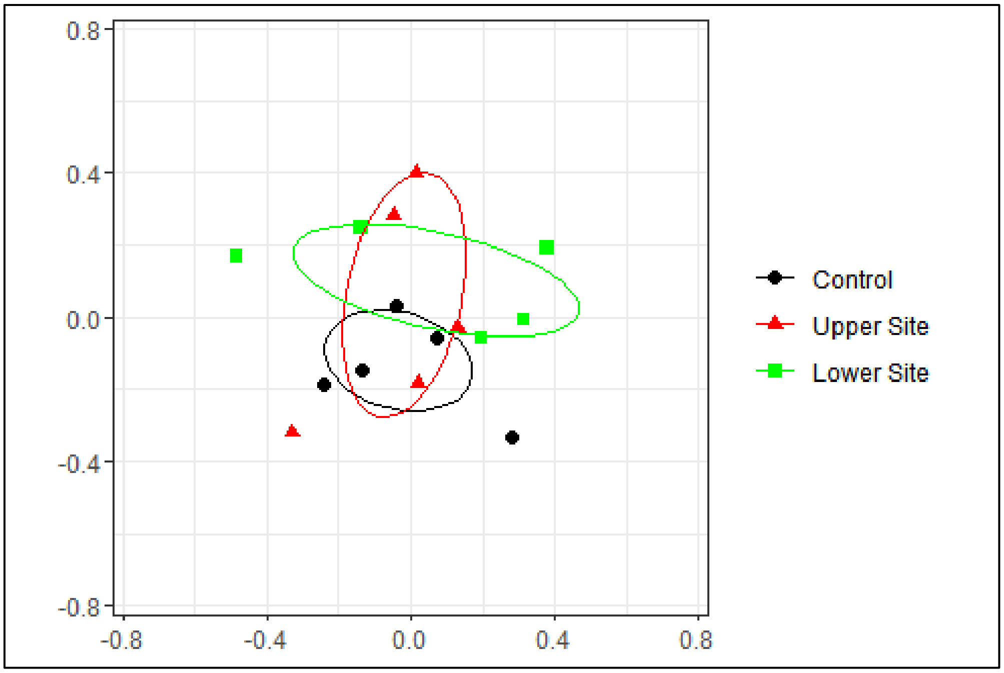

Figure 17: Results of Nonmetric Multidimensional Scaling for 2019. Arrows indicate water quality parameters with linear correlation (p-value < 0.05) to NMDS axes. Stress = 0.1

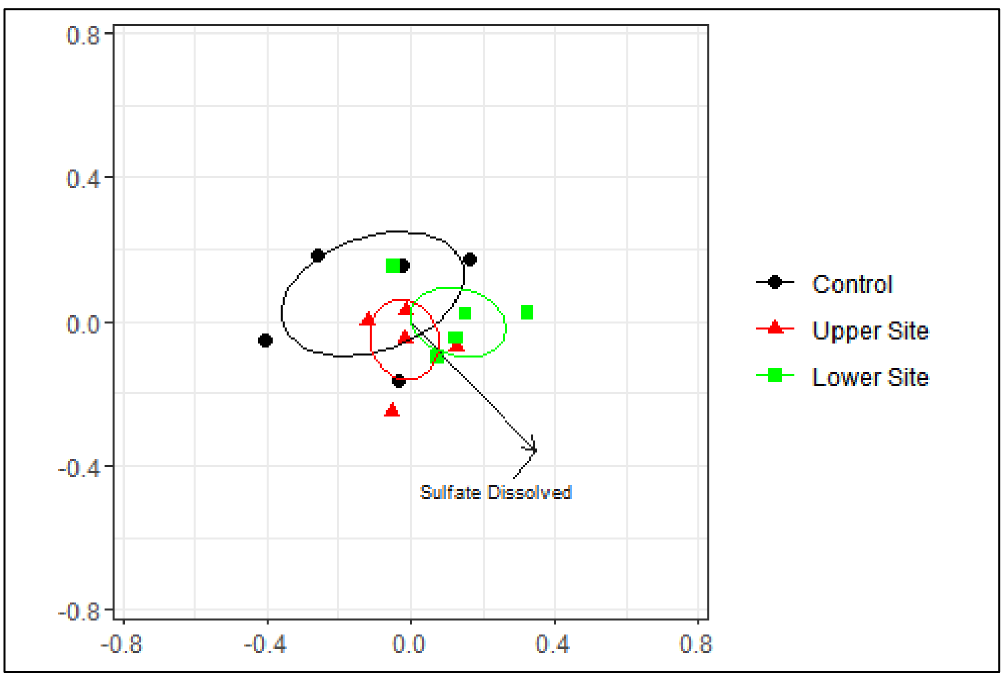

Figure 18: Results of Nonmetric Multidimensional Scaling for 2003. Arrows indicate water quality parameters with linear correlation (p-value < 0.05) to NMDS axes. Stress = 0.11

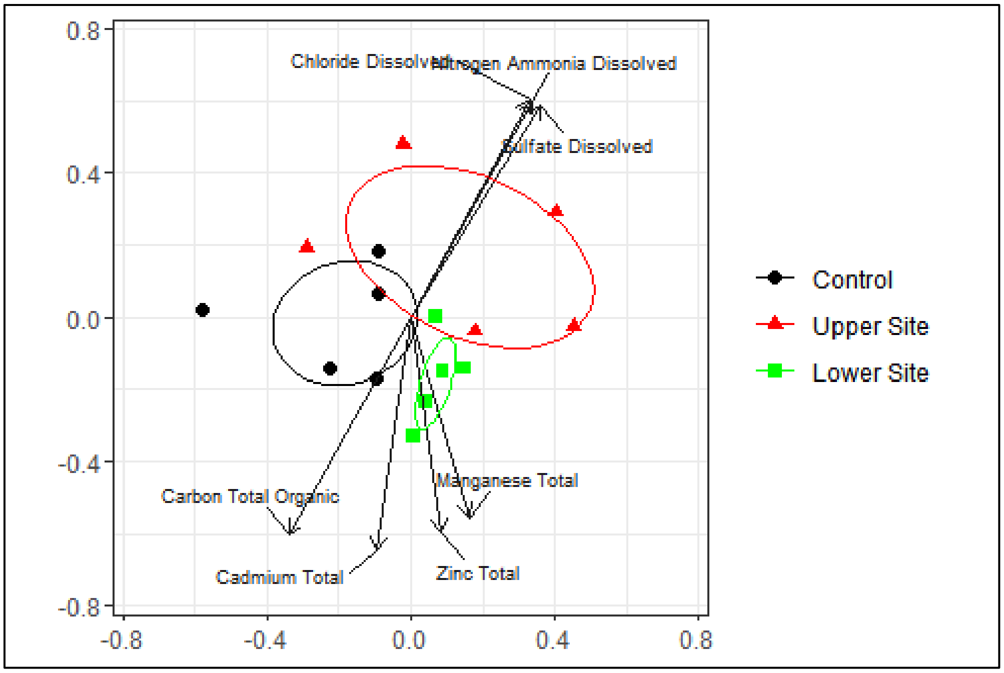

Figure 19: Results of Nonmetric Multidimensional Scaling for 2008. Arrows indicate water quality parameters with linear correlation (p-value < 0.05) to NMDS axes. Stress = 0.11

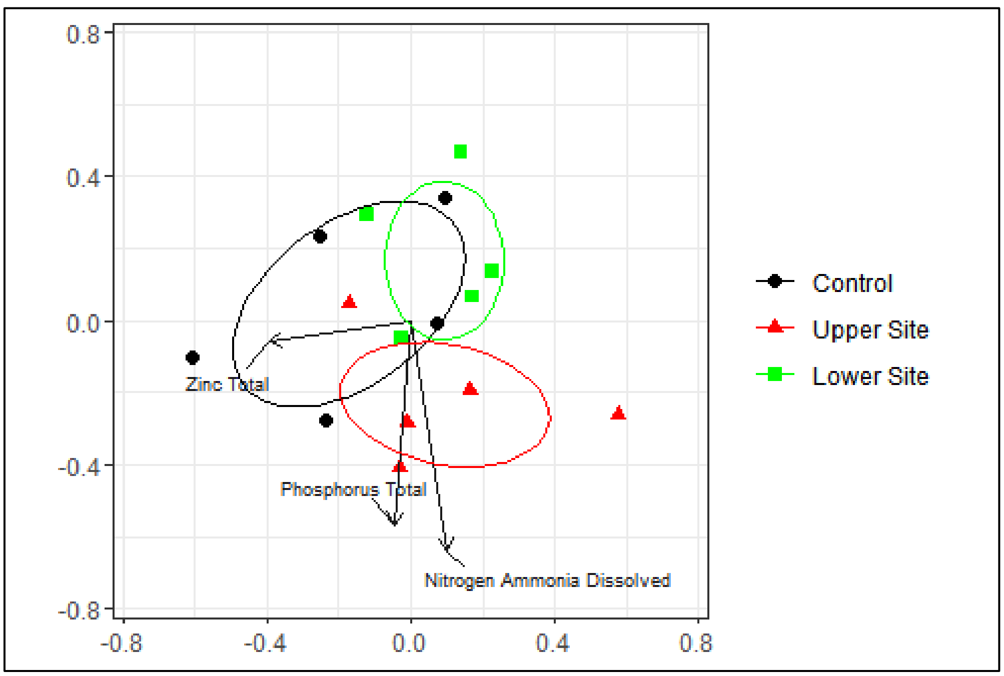

Figure 20: Results of Nonmetric Multidimensional Scaling for 2013. Arrows indicate water quality parameters with linear correlation (p-value < 0.05) to NMDS axes. Stress = 0.13

4.4.7 Indicator Taxa

Analysis of 2019 data identified the organic pollution sensitive *Glossosoma* sp. as strongly associated with both the Control and Upper Site and *Feltria* sp. was identified as an indicator taxa for both the Upper Site and Lower Site (Appendix 3 - Table 16). Indicator taxa identified with p-values <0.05 for 2003, 2008, 2013 and 2019 are summarized in Appendix 3 - Table 16.

Indicator taxa (*Epeorus* sp. and *Polycelis* sp.) with p-values <0.05 represented assemblages at the Lower Site only in 2003. In 2008, *Lebertia* sp. (mites tolerant to organic pollution) were identified as indicative of both the Upper Site and Lower Site while *Bezzia* (tolerance 6) and *Glossosoma* (tolerance 0) were associated with both the Control and Lower Site. In 2013, all three indicator taxa identified were of the generally more tolerant Diptera order (true flies) with *Microtendipes pedellus* representative of the Control, *Eukiefferiella* sp. indicative of both the Control and Upper Site and *Microtendipes* sp. indicative of the Lower Site only.

5 IMPACT ASSESSMENT

As in previous years, periphyton and benthic macro-invertebrate sampling in Sheep Creek in 2019 indicated diverse species assemblages at all sites with taxa present typical of cold interior mountain streams. Although often not discernible with statistical tests, trends in multiple metrics are apparent within the 2019 and all past datasets (2003, 2008 and 2013) indicating a small impact on the benthic invertebrate communities within a localized area adjacent to where seep water impacted by landfill leachate enters Sheep Creek.

Periphyton derived chlorophyll *a* biomass results showed a small and not statistically significant trend of increased productivity adjacent to where the seeps enter Sheep Creek however the levels at all sites are far below water quality guidelines and not of concern. The higher rate of periphyton senescence at the Control confirmed by statistical analysis that seems to be consistent with the general between-site trend in past years of sampling, is not likely a result of water quality impacts and is also not of concern. Results from algal taxonomy in 2019 indicated no consistent trends between sites in terms of proportional biomass of dominant/subdominant taxa.

Although often not discerned statistically, benthic invertebrate abundance, Shannon-Weiner diversity index, HBI and EPT% metrics all indicated that invertebrate communities may be negatively influenced at the Upper Site adjacent to the seeps when compared to Control conditions. However, none of the metrics imply severe stress and all metrics indicate that the condition of communities improves downstream at the Lower Site with results showing values near equal or less indicative of stress than upstream at the Control.

Functional feeding group composition at all sites in 2019 was diverse and indicative of healthy communities. The percentage of predators at all sites in 2019 was below 15% indicating normal top down control of predators on prey and low proportions of collector filterers when compared to collector gatherers implied low suspended particulate organic matter at all sites (Table 11, Figure 16). Within sample proportions of shredders, scrapers, collector filterers and collector gatherers indicated that stable substrates were not limiting at any of the sites. Comparison of the 2019 data to past years' of program sampling showed no major increases in the proportion of generalists, such as collector gatherers, or major decreases in the proportion of more specialized feeders, such as scrapers and shredders which can be a response of benthic communities to disturbance (Barbour *et al.* 1999).

NMDS was useful for exploring relationships between site invertebrate assemblages as well as between biological community structures and associated water quality data. For data acquired in 2003, 2013 and 2019, Statistical analysis of the ordination models was able to differentiate sample assemblages based on site group. Additionally, with the exception of 2019 data, fitting of select water quality parameter results to ordination models provided visual representations of synergies between benthic community structure and water quality data collected at associated locations on the stream. Although these correlations do not prove causal relationships, they highlight the importance of water quality data collection for identifying and documenting potential drivers of ecosystem function. Generally, in 2019, as in all past years' of biological sampling, community structural differences attributable to site group were low and indicator taxa were not consistently shared between site pairs either within sample years or between sampling years (particularly in 2013 and 2019 - Appendix 3 - Table 16). Overall, data indicates that community assemblages at sites sampled in Sheep Creek have been driven primarily by naturally occurring factors more consequential than water quality inputs from the landfill.

Surface water sampling site locations for the ongoing environmental monitoring program at the landfill are aligned with the benthic macro-invertebrate and periphyton monitoring sites on Sheep Creek with five water quality samples taken within 30 days during low flows (September - early October) annually from 2006 - 2013. In 2014 and 2015 Sheep Creek surface water sampling took place once in the spring and once in the fall. Since 2015, the surface water sites have been sampled only once annually in the spring and during significantly higher stream flows than was typical of the pre-2014 monitoring program. Figure 21 illustrates the difference between flow levels on water sampling dates pre vs. post 2014 by overlaying discharge levels on water sampling dates with historical Salmo River discharge ranges. Although Sheep Creek would have a slightly different discharge pattern due to elevation, watershed size and climatic factors, the hydrometric graph presented is likely representative of flow fluctuations relative to sampling dates in Sheep Creek. As apparent in Figure 21, the lack of detection of water quality trends in Sheep

Creek since 2014 and the inability to explore relationships between 2019 water quality parameter data and ordination models is likely at least partially attributable to dilution from mixing with high Sheep Creek flows during sampling events.

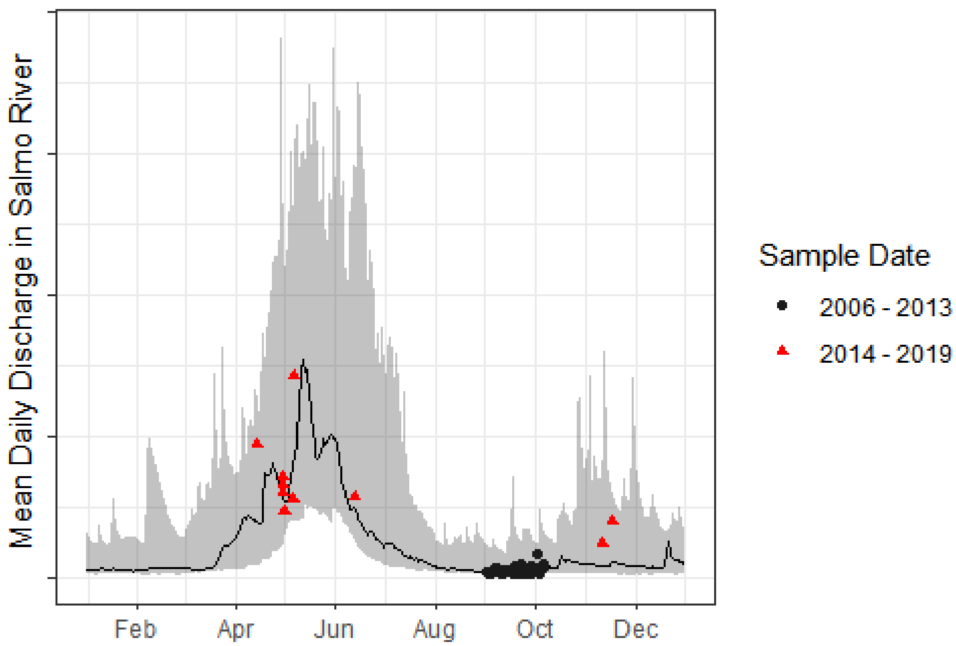

Figure 21: Sheep Creek surface water sample dates vs. Salmo River flow. Flow data from hydrometric station 08NE074 located approximately 10 km south of the Central Landfill. Grey area is max and min flows and black line is mean discharge for the period of record.

6 Recommendations

- As biogeochemistry at the landfill is complex due to the combination of municipal solid waste, liquid septage disposal and the presence of sulphide bearing mine tailings, groundwater chemistry is expected to change with time (Amec 2014). Due to the potential for these changes and the minor but detectable impacts to biological communities in Sheep Creek observed in 2019 and all past years of the biological monitoring program, we recommend collecting annual surface water samples at Sheep Creek surface water sampling stations in the fall, during low flows, to provide a conservative representation of seep impacts to Sheep Creek surface water quality.
- Collect 5 water samples in 30 days at Sheep Creek surface water sampling stations every five years timed to coincide with invertebrate sampling in the fall during low flows in Sheep Creek. This will facilitate comparison of water quality results with freshwater aquatic life long-term chronic water quality guidelines and align timing of water quality sampling with biological sampling. Water quality samples should be collected from all sites on the same days and

within as short a time period as possible to most accurately represent a snapshot of water quality conditions in Sheep Creek.

- Analyze surface water samples in Seep E and Seep A as well as within Sheep Creek for dissolved as well as total metals to help discern if exceedences of water quality guidelines for total metal concentrations are related only to the presence of sediments in the samples or if levels of dissolved metals are also elevated.
- Ensure that current and historic water quality data is uploaded to the EMS database as soon as possible to facilitate efficient, consistent, reproducible review and analysis of current and historic analytical results. Following upload to EMS, data management tools such as the "rems" (Teucher 2020) and "wqbc" (Thorley et. al 2020) R packages, which are currently available and under active development by the provincial government (Province of British Columbia 2020), can be used to retrieve water quality parameter data, evaluate trends and compare to relevant guidelines.
- Although significant impacts to water quality and biological communities are unlikely much further downstream than SW-C, ordination models for both 2013 and 2019 indicate that in general the invertebrate assemblages in samples taken at the Lower Site differ more in structure from the Control than from the communities sampled at the Upper Site located upstream only 30 - 50m (Figures 17 - 20, Digital Attachment 2). Additionally, Wood (2020) indicate groundwater flow direction orientated further west than the location of Seep A (Figure 22) highlighting the potential that leachate impacted groundwater may emerge into Sheep Creek further downstream than the location of the Lower Site (SW-C). We recommend a fourth Sheep Creek surface water quality sampling site be established in the vicinity of the location of EMS_ID E242839 as documented in the EMS database (UTM 11N 481781 5443349) which is downstream of SW-A approximately 350 m (Figure 2). Then, if leachate indicator parameters are detected in water quality samples collected at the newly established site between 2020 to 2024, sampling of biological communities could be conducted adjacent to the new site location during the 2025 biological impact assessment sampling to confirm that impacts to ecological communities do not extend further downstream than has historically been assessed.

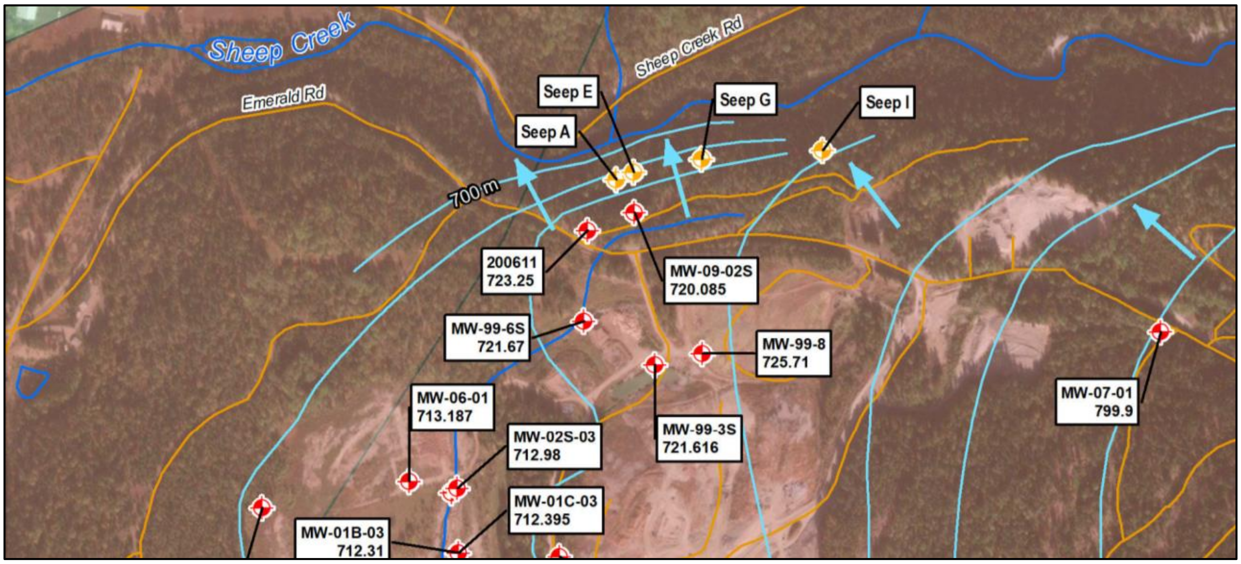

Figure 22: Screenshot of Figure 3 from Wood (2020) with blue lines indicating groundwater flow contours and blue arrows indicating direction of groundwater flow.

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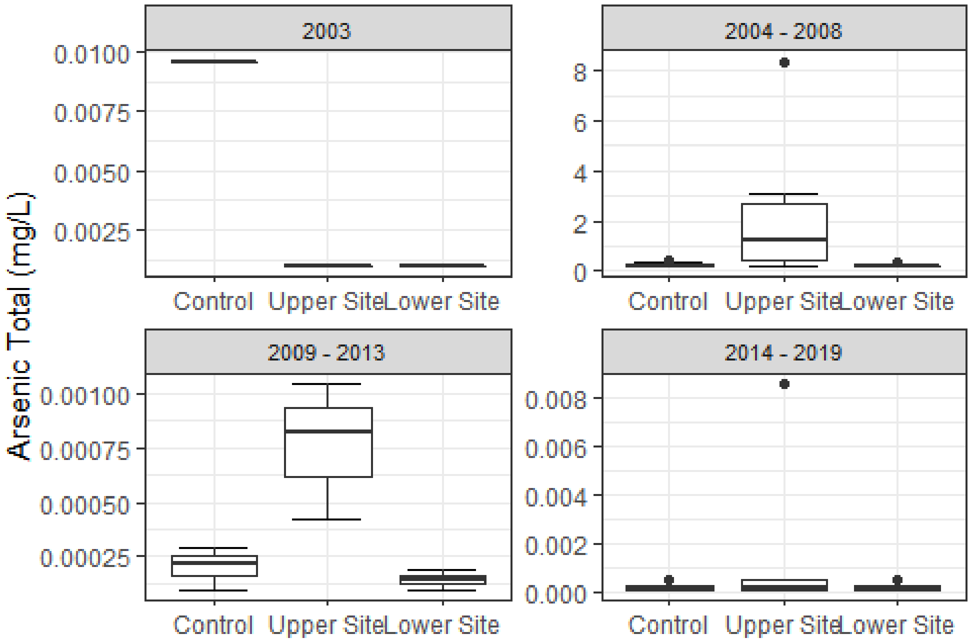
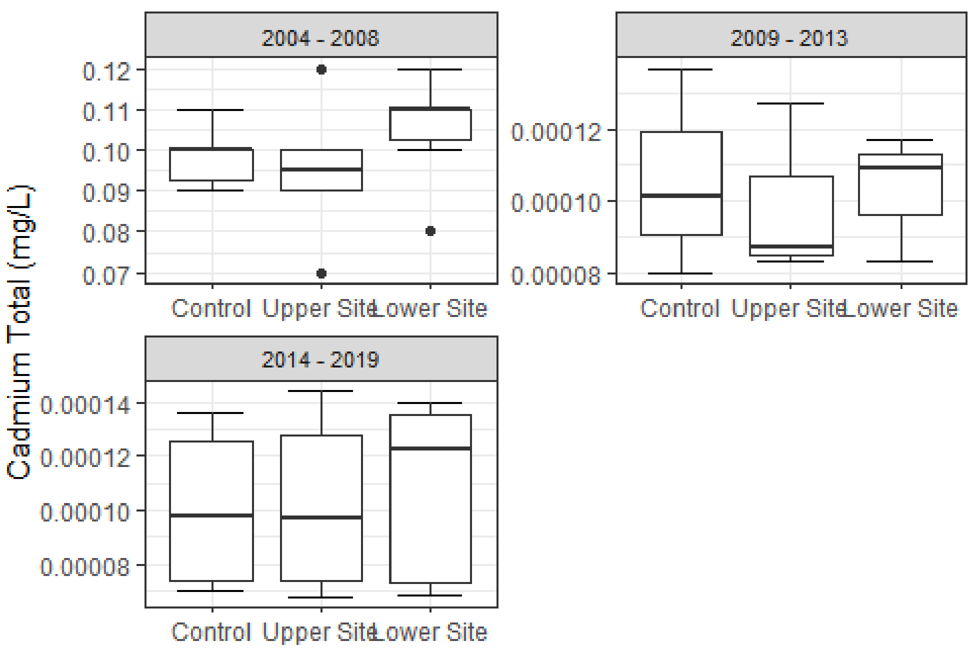
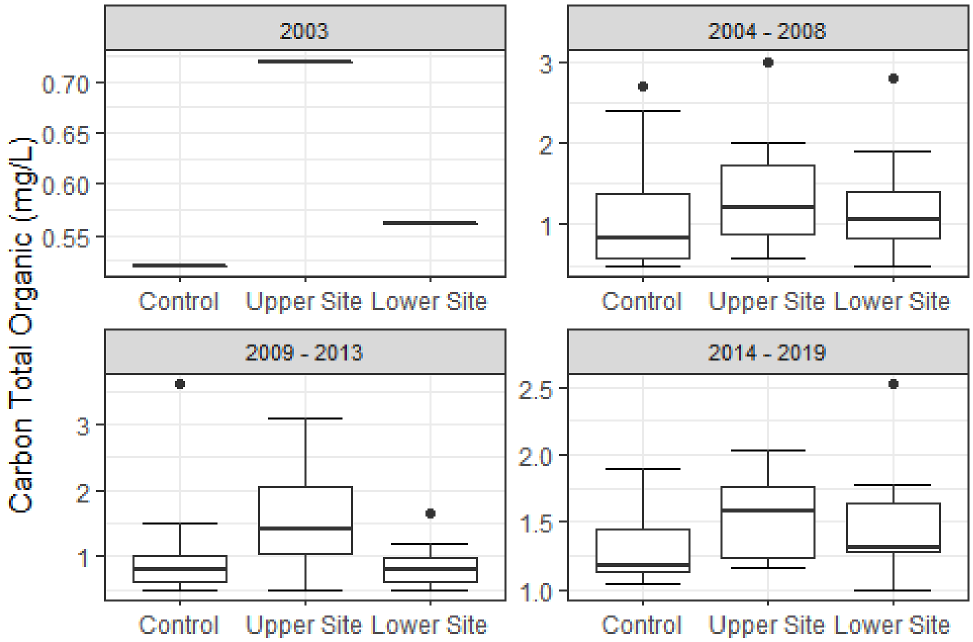
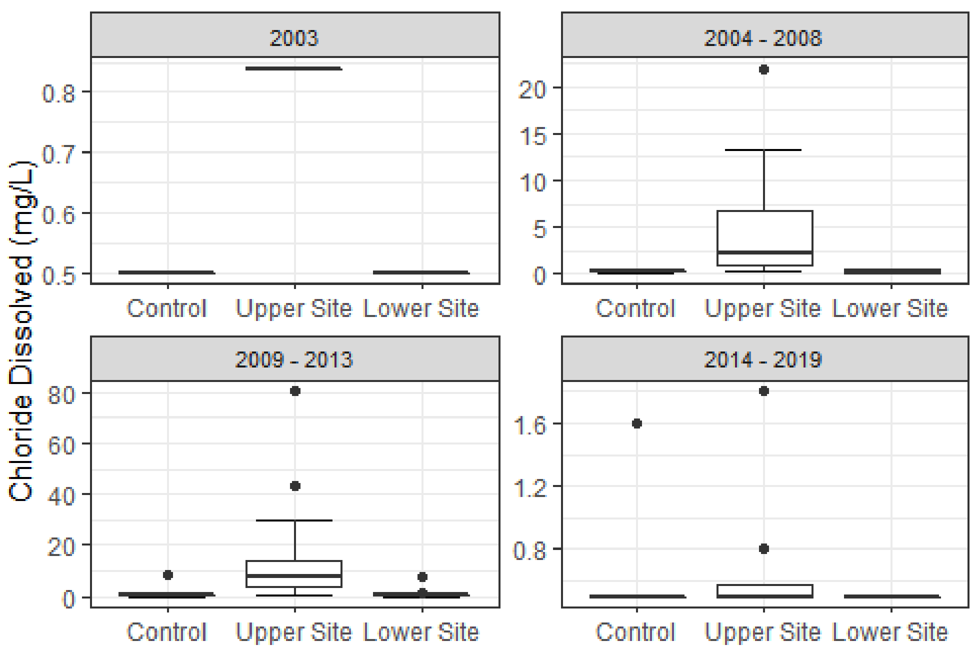
Appendix 1

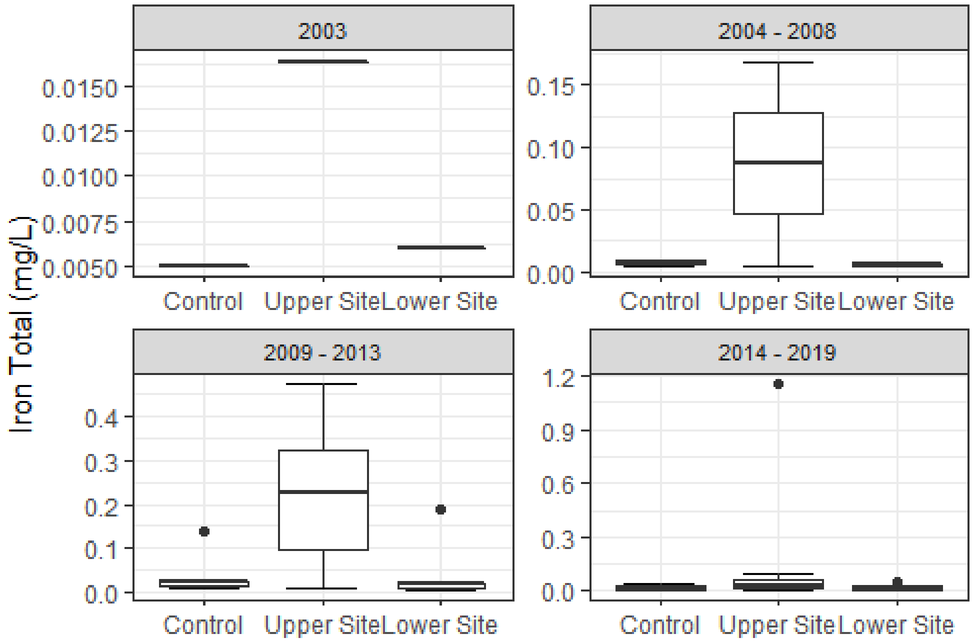
Water Quality Boxplots for Parameters of Interest

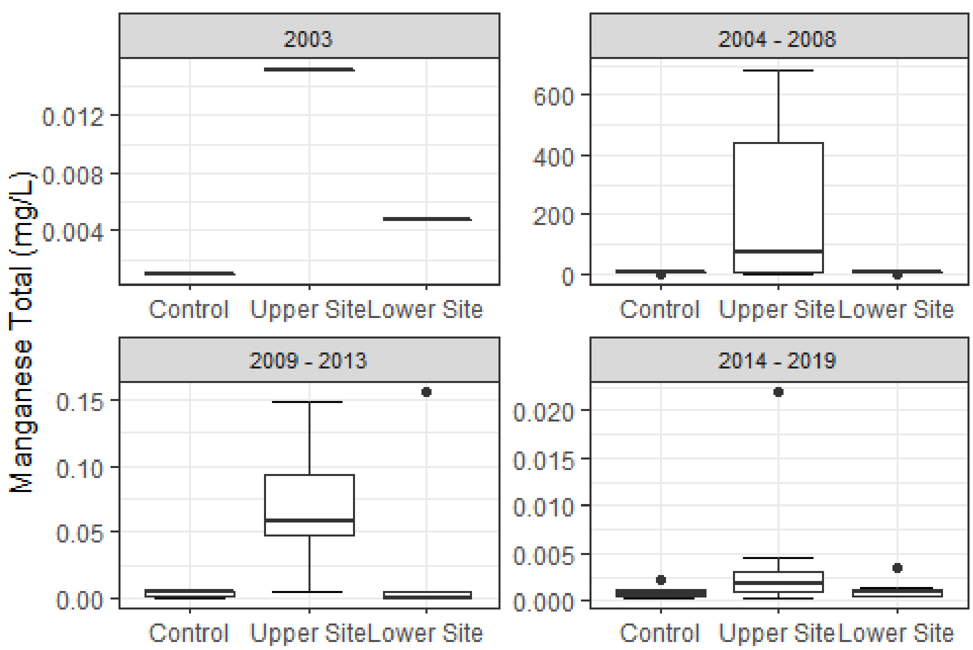

2003
2004 - 2008
2009 - 2013
2014 - 2019
Arsenic Total (mg/L)
0.0100
0.0075
0.0050
0.0025
8
6
4
2
0
0.00100
0.00075
0.00050
0.00025
0.008
0.006
0.004
0.002
0.000
Control
Upper Site
Lower Site

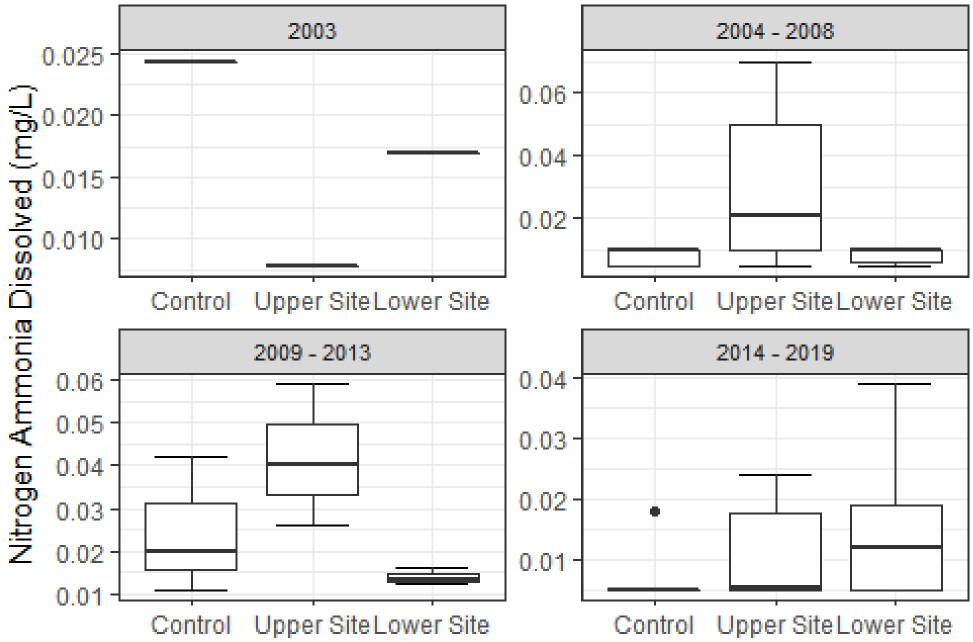

2004 - 2008
2009 - 2013
2014 - 2019
Cadmium Total (mg/L)
0.12
0.11
0.10
0.09
0.08
0.07
0.00012
0.00010
0.00008
0.00014
Control
Upper Site
Lower Site

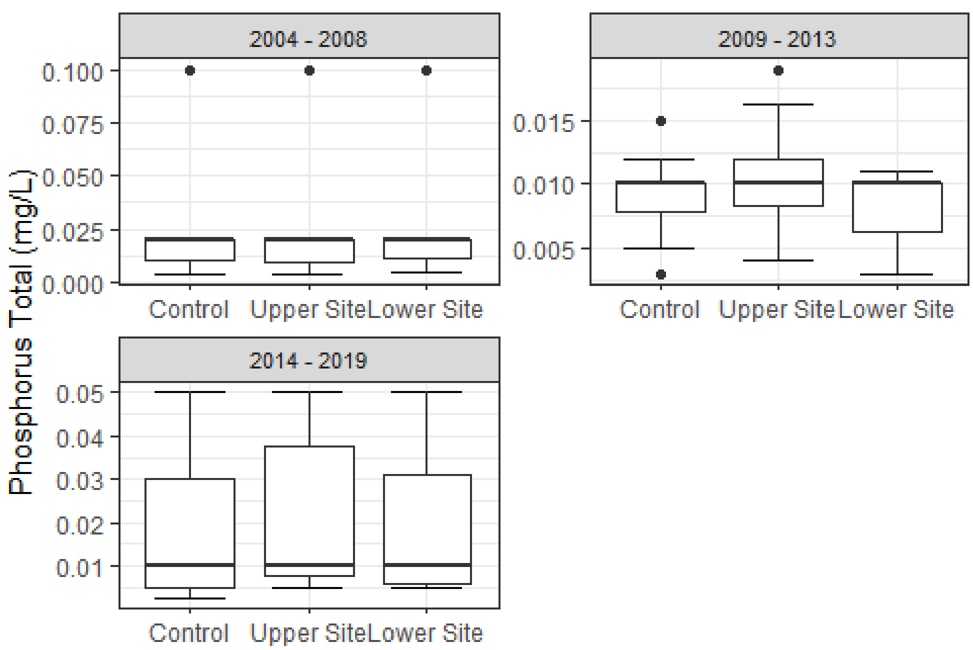

2003
2004 - 2008
2009 - 2013
2014 - 2019
Carbon Total Organic (mg/L)
0.70
0.65
0.60
0.55
3
2
1
2.5
2.0
1.5
1.0
Control
Upper Site
Lower Site

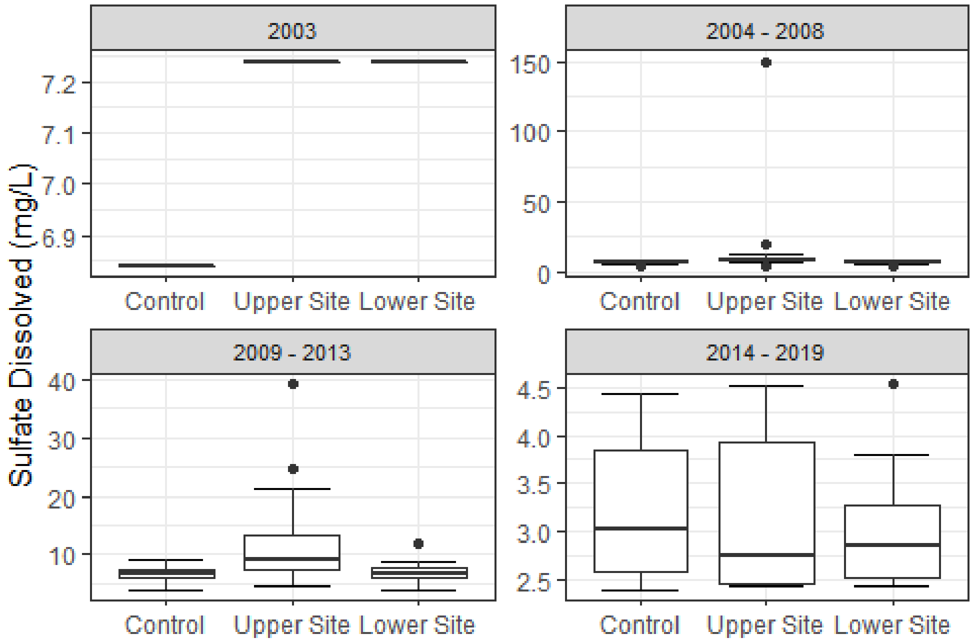

2003
2004 - 2008
2009 - 2013
2014 - 2019
Chloride Dissolved (mg/L)
0.8
0.7
0.6
0.5
20
15
10
5
0
80
60
40
1.6
1.2
0.8
Control
Upper Site
Lower Site

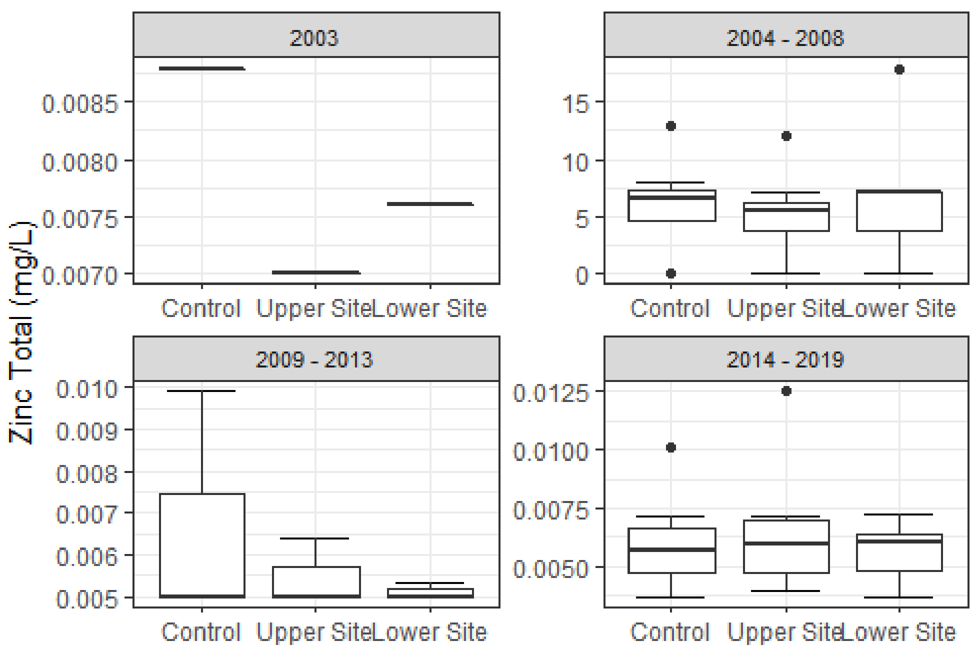

Iron Total (mg/L)
2003
2004 - 2008
2009 - 2013
2014 - 2019
0.0150
0.0125
0.0100
0.0075
0.0050
0.15
0.10
0.05
0.00
0.4
0.3
0.2
0.1
0.0
1.2
0.9
0.6
0.3
0.0
Control
Upper Site
Lower Site


Manganese Total (mg/L)
2003
2004 - 2008
2009 - 2013
2014 - 2019
0.012
0.008
0.004
600
400
200
0
0.15
0.10
0.05
0.00
0.020
0.015
0.010
0.005
0.000
Control
Upper Site
Lower Site


2003
2004 - 2008
2009 - 2013
2014 - 2019
Nitrogen Ammonia Dissolved (mg/L)
0.025
0.020
0.015
0.010
0.06
0.04
0.02
0.05
0.03
0.01
Control
Upper Site
Lower Site


2004 - 2008
2009 - 2013
2014 - 2019
Phosphorus Total (mg/L)
0.100
0.075
0.050
0.025
0.000
0.015
0.010
0.005
0.05
0.04
0.03
0.02
0.01
Control
Upper Site
Lower Site


2003
2004 - 2008
2009 - 2013
2014 - 2019
Sulfate Dissolved (mg/L)
Control
Upper Site
Lower Site


2003
2004 - 2008
2009 - 2013
2014 - 2019
Zinc Total (mg/L)
Control
Upper Site
Lower Site

Appendix 2

Site Photos

Site 1

Site 1

Site 2

Site 2

Site 3


Site 3

Appendix 3

Metric Summary and Statistical Result Tables

Table 5: Summary of Chlorophyll a biomass (mg/m2) in 2003 - 2019

Year	Site	Median (mg/m2)	Range (mg/m2)	MAD
2003	Control	1.5	1.1 - 2.5	0.6
2003	Upper Site	8.3	5.8 - 29.3	3.7
2003	Lower Site	4.8	2.1 - 11.7	4.0
2008	Control	31.0	22.7 - 179.1	12.3
2008	Upper Site	14.5	8.3 - 28.9	7.1
2008	Lower Site	11.0	9.6 - 23.4	1.0
2013	Control	7.0	1.4 - 20.5	7.7
2013	Upper Site	14.4	6.1 - 28.2	12.3
2013	Lower Site	11.0	6.9 - 17.9	2.8
2019	Control	19.7	9.7 - 59.8	14.8
2019	Upper Site	22.7	5.8 - 32.3	14.2
2019	Lower Site	16.4	6.9 - 24	7.9

Table 6: Results from statistical analysis of for chlorophyll a biomass and phaeophytin to chlorophyll a (P:C) ratios for 2003 - 2019.

Metric	Method	Statistic				P.Value			
		2003	2008	2013	2019	2003	2008	2013	2019
Chlr a Biomass	Shapiro-Wilk[a]	0.753	0.563	0.945	0.840	0.001	0.000	0.446	0.013
	Levene's[b]	1.660	2.132	1.650	1.068	0.231	0.161	0.233	0.374
	Kruskal-Wallis[c]	9.368	7.353	1.397	1.040	0.009	0.025	0.497	0.595
P:C Ratio	Shapiro-Wilk	0.831	0.946	0.820	0.412	0.009	0.460	0.007	0.000
	Levene's	1.932	0.207	0.230	0.996	0.187	0.816	0.798	0.398
	Kruskal-Wallis	5.670	1.820	0.256	9.980	0.059	0.403	0.880	0.007

[a]Shapiro-Wilk: Reject null hypothesis of normal distribution when P.Value <0.05.
[b]Levene's Test: Reject null hypothesis of equal variances when P.Value < 0.05.
[c]Kruskal-Wallis: Reject the null hypothesis that group medians are equal when P.Value < 0.05.

Table 7: Summary of ratio of phaeophytin to chlorophyll a biomass (mg/m2) in 2003 - 2019

Year	Site	Median (mg/m2)	Range (mg/m2)	MAD
2003	Control	0.24	0.07 - 0.4	0.08
2003	Upper Site	0.09	0.03 - 0.12	0.04
2003	Lower Site	0.08	0.03 - 0.1	0.02
2008	Control	0.29	0.15 - 0.32	0.02
2008	Upper Site	0.18	0.12 - 0.43	0.04
2008	Lower Site	0.25	0.19 - 0.41	0.07
2013	Control	0.06	0 - 0.65	0.09
2013	Upper Site	0.16	0 - 0.92	0.24
2013	Lower Site	0.27	0 - 0.44	0.25
2019	Control	0.43	0.28 - 3.73	0.12
2019	Upper Site	0.15	0.01 - 0.25	0.08
2019	Lower Site	0.22	0.03 - 0.27	0.02

Table 8: Summary of abundance (in thousands) and diversity (Shannon-Wiener Index) for 2003 - 2019.

Year	Site	Abundance[a]				Diversity[b]			
		Median	Min	Max	MAD[c]	Median	Min	Max	MAD[c]
2003	Control	14.3	9.3	18.3	5.93	2.9	2.6	3.1	0.15
	Upper Site	18.1	13.3	26.6	7.12	2.9	2.8	3.2	0.15
	Lower Site	20.8	13.1	27.4	5.34	3.0	2.9	3.3	0.15
2008	Control	21.6	19.3	34.3	3.41	2.7	2.1	3.0	0.15
	Upper Site	14.4	9.0	20.7	7.26	2.4	2.0	2.8	0.44
	Lower Site	17.1	9.1	31.6	9.04	2.5	2.4	2.7	0.15
2013	Control	41.3	39.9	59.1	2.08	2.5	2.3	2.6	0.15
	Upper Site	60.5	48.4	147.6	17.94	2.0	1.4	2.3	0.44
	Lower Site	50.5	37.9	88.4	12.45	2.1	2.0	2.2	0.15
2019	Control	26.3	18.9	31.7	4.45	3.3	2.9	3.3	0.00
	Upper Site	18.6	12.5	55.2	9.04	3.0	2.7	3.1	0.15
	Lower Site	10.5	4.1	17.0	6.38	3.2	2.2	3.5	0.44

[a]In thousands.
[b]Shannon–Wiener Index.
[c]Median Absolute Deviation.

Table 9: Summary of Hilsenhoff Biotic Index and percentage of invertebrates from Ephemeroptera, Plecoptera and Trichoptera orders for 2003 - 2019.

Year	Site	HBI[a]				EPT (%)[b]			
		Median	Min	Max	MAD	Median	Min	Max	MAD
2003	Control	3.1	2.8	3.7	0.30	72.9	63.0	80.7	5.04
	Upper Site	2.7	2.5	3.0	0.00	70.1	65.1	84.9	6.97
	Lower Site	3.2	2.7	3.4	0.30	66.7	60.7	73.1	8.45
2008	Control	4.3	3.9	4.6	0.30	49.0	39.0	55.9	3.56
	Upper Site	4.5	3.7	4.7	0.30	43.0	32.7	64.7	15.27
	Lower Site	4.5	4.0	4.7	0.30	45.0	38.9	54.2	4.30
2013	Control	4.4	4.3	4.6	0.15	41.2	34.2	42.9	2.52
	Upper Site	5.2	4.3	5.3	0.15	25.1	16.7	45.9	12.45
	Lower Site	4.6	4.0	4.8	0.30	34.4	30.5	45.7	5.78
2019	Control	3.2	2.7	3.5	0.30	67.9	57.9	70.8	1.04
	Upper Site	3.6	3.3	4.6	0.44	55.8	41.1	75.8	16.31
	Lower Site	3.3	3.0	4.8	0.44	53.8	30.4	72.7	20.02

[a]Hilsenhoff Biotic Index.
[b]Percentage of Invertebrates from Ephemeroptera, Plecoptera and Trichoptera Orders.

Table 10: Results from statistical analysis of abundance, diversity, HBI and EPT% metrics for 2003 - 2019.

Metric	Method	Statistic				P.Value			
		2003	2008	2013	2019	2003	2008	2013	2019
Abundance	Shapiro-Wilk[a]	0.953	0.914	0.728	0.898	0.581	0.154	0.001	0.089
	Levene's[b]	0.403	0.166	0.924	2.079	0.677	0.849	0.424	0.168
	Kruskal-Wallis[c]	3.780	5.540	3.780	7.580	0.151	0.063	0.151	0.023
Diversity	Shapiro-Wilk	0.957	0.960	0.923	0.928	0.644	0.689	0.214	0.257
	Levene's	0.042	1.457	2.638	1.532	0.959	0.271	0.112	0.256
	Kruskal-Wallis	1.635	1.603	9.063	2.044	0.442	0.449	0.011	0.360
HBI	Shapiro-Wilk	0.948	0.898	0.915	0.890	0.490	0.088	0.159	0.068
	Levene's	0.605	0.407	0.973	0.519	0.562	0.675	0.406	0.608
	Kruskal-Wallis	5.830	0.524	1.800	3.157	0.054	0.769	0.407	0.206
EPT	Shapiro-Wilk	0.969	0.983	0.924	0.926	0.842	0.985	0.219	0.238
	Levene's	0.043	2.732	2.240	1.572	0.958	0.105	0.149	0.247
	Kruskal-Wallis	2.240	0.780	2.665	2.540	0.326	0.677	0.264	0.281

[a]Shapiro-Wilk: Reject null hypothesis of normal distribution when P.Value <0.05.
[b]Levene's Test: Reject null hypothesis of equal variances when P.Value < 0.05.
[c]Kruskal-Wallis: Reject the null hypothesis that group medians are equal when P.Value < 0.05.

Table 11: Summary of functional feeding group composition (median %) of invertebrates at study sites from 2003 - 2019.

Year	Site	Median (%)						
		Collector Gatherer	Scraper	Collector Filterer	Predator	Shredder	Herbivore	Unclassified
2003	Control	40.2	25	0.75	10.9	6	0.2	17.6
	Upper Site	42.6	19.3	1.5	9.4	9.9	0.4	16
	Lower Site	44.4	19.5	2.1	13.6	9.5	0.3	7.1
2008	Control	55.2	16.8		14.8	8.6	0.3	5.8
	Upper Site	62.2	21.1	0.9	8	8.9		4
	Lower Site	54	19.4	0.7	14.4	7.4	0.3	3.9
2013	Control	61.8	16.7	4.6	4.3	5.3	1.05	5.6
	Upper Site	76.5	12.3	3.6	4.3	2.8	0.6	3.8
	Lower Site	64.8	15.7	5.7	5	5	0.9	1.4
2019	Control	29.8	26.3	8.1	10.8	5	2.2	2.8
	Upper Site	35.3	30.5	14.9	11	4.4	0.6	2.7
	Lower Site	34	26.5	8.6	12.9	4.5	1.5	8.9

Table 12: Results from statistical analysis for functional feeding group composition at study sites for 2003 - 2019.

Metric[a]	**Method**	**Statistic**				**P.Value**			
		2003	**2008**	**2013**	**2019**	**2003**	**2008**	**2013**	**2019**
Collector Gatherer	Shapiro-Wilk[b]	0.872	0.941	0.952	0.891	0.037	0.398	0.559	0.069
	Levene's[c]	0.521	1.850	0.373	0.443	0.607	0.199	0.696	0.652
	Kruskal-Wallis[d]	3.401	0.420	4.940	0.487	0.183	0.811	0.085	0.784
Scraper	Shapiro-Wilk	0.943	0.907	0.932	0.952	0.427	0.121	0.288	0.560
	Levene's	0.070	0.230	0.256	0.230	0.933	0.798	0.778	0.798
	Kruskal-Wallis	1.260	0.381	0.980	0.240	0.533	0.827	0.613	0.887
Collector Filterer	Shapiro-Wilk	0.791	0.833	0.972	0.938	0.004	0.113	0.933	0.355
	Levene's	0.661	0.000	0.353	1.011	0.536	1.000	0.712	0.393
	Kruskal-Wallis	0.081	0.051	0.420	2.340	0.960	0.822	0.810	0.310
Predator	Shapiro-Wilk	0.967	0.925	0.961	0.976	0.804	0.233	0.718	0.931
	Levene's	0.135	0.673	1.546	0.104	0.875	0.529	0.253	0.902
	Kruskal-Wallis	3.920	3.840	2.143	1.260	0.141	0.147	0.343	0.533
Shredder	Shapiro-Wilk	0.906	0.964	0.984	0.892	0.120	0.767	0.989	0.072
	Levene's	0.850	0.255	2.186	0.315	0.452	0.779	0.155	0.736
	Kruskal-Wallis	2.750	0.080	7.010	1.300	0.253	0.961	0.030	0.522
Unclassified	Shapiro-Wilk	0.947	0.905	0.851	0.862	0.484	0.112	0.023	0.026
	Levene's	0.408	2.430	2.889	0.665	0.674	0.130	0.098	0.532
	Kruskal-Wallis	5.470	2.710	3.467	3.420	0.065	0.258	0.177	0.181

[a]Herbivore feeding group removed due to small sample size.
[b]Shapiro-Wilk: Reject null hypothesis of normal distribution when P.Value <0.05.
[c]Levene's Test: Reject null hypothesis of equal variances when P.Value < 0.05.
[d]Kruskal-Wallis: Reject the null hypothesis that group medians are equal when P.Value < 0.05.

Table 13: Results of permutation test run on betadispersion to assess multivariate homogeneity of group dispersion for samples grouped by study site for 2003 - 2019.

Year	Df	Sumofsqs	Meanofsqs	Statistic	N.Perm	P.Val[a]
2003	2	0.003	0.002	0.325	999	0.709
	12	0.06	0.005	-	-	-
2008	2	0.016	0.008	1.115	999	0.364
	12	0.085	0.007	-	-	-
2013	2	0.041	0.021	4.003	999	0.058
	12	0.062	0.005	-	-	-
2019	2	0.014	0.007	0.841	999	0.438
	12	0.099	0.008	-	-	-

[a]permutest.betadisper: A p-value <0.05 considered significant to reject the null hypothesis of homogenous variance dispersion.

Table 14: Results from permutational multivariate analysis of variance using sample community assemblages transformed with the Bray-Curtis dissimilarity index for samples grouped by study sites for 2003 - 2019.

Year	Term	Df	Sumofsqs	R2	Statistic	P.Value[a]
2003	Site	2	0.3	0.23	1.83	0.03
	Residual	12	0.98	0.77	-	-
2008	Site	2	0.32	0.22	1.68	0.06
	Residual	12	1.16	0.78	-	-
2013	Site	2	0.35	0.27	2.21	0.02
	Residual	12	0.96	0.73	-	-
2019	Site	2	0.58	0.24	1.93	0.02
	Residual	12	1.81	0.76	-	-

[a]Permutational multivariate analysis of variance: when p-values <0.05 reject the null hypothesis of equal variances.

Table 15: Summary of water quality parameters correlated (P.Value < 0.05) with NMDS axes at study sites from 2003 - 2013.

Parameter	2003		2008		2013	
	R2	P.Val	R2	P.Val	R2	P.Val
Cadmium Total	-	-	0.725	0.003	-	-
Carbon Total Organic	-	-	0.737	0.005	-	-
Chloride Dissolved	-	-	0.739	0.005	-	-
Manganese Total	-	-	0.54	0.03	-	-
Nitrogen Ammonia Dissolved	-	-	0.737	0.005	0.527	0.046
Phosphorus Total	-	-	-	-	0.6	0.016
Sulfate Dissolved	0.518	0.033	0.726	0.004	-	-
Zinc Total	-	-	0.604	0.01	0.644	0.008

Table 16: Indicator taxa for sites and groups of sites in 2003 - 2019

Year	Order	Taxa	Control	Upper Site	Lower Site	IndVal[a]	P-value	Tol	FFG
2003	Ephemeroptera	Epeorus	-	-	X	0.85	0.016	0	Scraper
	Neoophora	Polycelis	-	-	X	1.00	0.003	6	Collector Gatherer
2008	Diptera	Bezzia	X	-	X	0.91	0.014	6	Predator
	Trichoptera	Glossosoma	X	-	X	0.95	0.001	0	Scraper
	Trombidiformes	Lebertia	-	X	X	0.80	0.032	8	Predator
2013	Diptera	Microtendipes pedellus	X	-	-	0.68	0.029	6	Collector Filterer
	Diptera	Eukiefferiella	X	X	-	0.80	0.023	8	Unclassified
	Diptera	Microtendipes	-	-	X	0.69	0.023	6	Collector Filterer
2019	Trichoptera	Glossosoma	X	X	-	0.88	0.031	0	Scraper
	Trombidiformes	Feltria	-	X	X	0.80	0.034	-	Predator

[a]Indicator Value index based on combination of taxa specificity and sensitivity (see details in Defrene and Legendre 1997).