Capital Regional District

625 Fisgard St.,
Victoria, BC V8W 1R7

Notice of Meeting and Meeting Agenda
Environmental Services Committee

Wednesday, March 20, 2024 | **1:30 PM** | **6th Floor Boardroom, 625 Fisgard St., Victoria, BC V8W 1R7**

B. Desjardins (Chair), S. Tobias (Vice Chair), J. Brownoff, J. Caradonna, G. Holman,
D. Kobayashi, D. Murdock, M. Tait, D. Thompson, A. Wickheim, C. Plant (Board Chair, ex-officio)

The Capital Regional District strives to be a place where inclusion is paramount and all people are treated with dignity. We pledge to make our meetings a place where all feel welcome and respected.

1. Territorial Acknowledgement

2. Approval of Agenda

3. Adoption of Minutes

3.1. 24-125 Minutes of the January 17, 2024 Environmental Services Committee Meeting

Recommendation: That the minutes of the Environmental Services Committee meeting of January 17, 2024 be adopted as circulated.

Attachments: Minutes - January 17, 2024

4. Chair's Remarks

5. Presentations/Delegations

The public are welcome to attend CRD Board meetings in-person.

Delegations will have the option to participate electronically. Please complete the online application at www.crd.bc.ca/address no later than 4:30 pm two days before the meeting and staff will respond with details.

Alternatively, you may email your comments on an agenda item to the CRD Board at crdboard@crd.bc.ca.

5.1. 24-321 Delegation - Francois Brassard; Representing Esquimalt Climate Organizers: Re: Agenda Item 6.5.: Third-party Academic Review of the Scientific Literature on the Uses and Impacts of Biosolids - Verbal Update

5.2. 24-323 Delegation - Philippe Lucas; Representing Biosolids Free BC Re: Agenda Item 6.5.: Third-party Academic Review of the Scientific Literature on the Uses and Impacts of Biosolids - Verbal Update

6. Committee Business

6.1. 24-243 Curbside Collection of Packaging and Printed Products - 2024 Update

Recommendation: There is no recommendation. This report is for information only.

Attachments: Staff Report: Curbside Collection of Packaging & Printed Products - Update

6.2. 24-294 Material Stream Diversion - Award of Contract ERM2022-010

Recommendation: The Environmental Services Committee recommends to the Capital Regional District Board:
1. That staff be directed to finalize negotiations, and the Chief Administrative Officer be authorized to enter into a two-year operating and construction contract, for a combined value not to exceed $12,500,000 (excluding GST) with DL's Bins, for the construction and operation of a material diversion transfer station to begin processing of clean wood, treated wood and asphalt shingles on July 1, 2024;
2. That staff be directed to return to the Environmental Services Committee with proposed bylaw amendments to shift the ban on carpet and underlay and salvageable wood to Phase 3;
3. That staff be directed to return to the Environmental Services Committee with proposed bylaw amendments to shift the implementation of the $300/tonne unsorted load rate to Phase 3; and
4. That staff immediately begin consultation on policies to restrict the flow of general refuse waste outside of the capital region.

Attachments: Staff Report: Material Stream Diversion - Award of Contract ERM2022-010
Appendix A: Material Stream Diversion Request for Proposals Package
Presentation: Material Stream Diversion - Award of Contract ERM2022-010

6.3. 24-244 Extreme Heat Vulnerability Mapping and Information Portal Project

Recommendation: The Environmental Services Committee recommends to the Capital Regional District Board:
That the results of the Extreme Heat Vulnerability Mapping and Information Portal project for the capital region be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

Attachments: Staff Report: Extreme Heat Vulnerability Mapping & Info Portal Project
Appendix A: Heat Vulnerability & Analysis Project Final Report

6.4. 24-245 Climate Projections for the Capital Region

Recommendation: The Environmental Services Committee recommends to the Capital Regional District Board:
That the Climate Projections for the Capital Region (2024) report be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

Attachments: Staff Report: Climate Projections for the Capital Region
Appendix A: Climate Projections for the Capital Region Report - 2024 - PCIC
Presentation: Climate Projections for the Capital Region (2024)

6.5. 24-318 Third-party Academic Review of the Scientific Literature on the Uses and Impacts of Biosolids - Verbal Update

Recommendation: There is no recommendation. The verbal report is for information only.

6.6. 24-255 Previous Minutes of Other Committees and Commissions for Information

Recommendation: There is no recommendation. The following minutes are for information only.
a) Solid Waste Advisory Committee Meeting - March 1, 2024
b) Technical and Community Advisory Committee Meeting - October 27, 2023
c) Technical and Community Advisory Committee Meeting - November 24, 2023
d) Technical and Community Advisory Committee Meeting - January 19, 2024
e) Technical and Community Advisory Committee Meeting - February 13, 2024

Attachments: Minutes: Solid Waste Advisory Committee Meeting - March 1, 2024

Minutes: TCAC - October 27, 2023

Minutes: TCAC - November 24, 2023

Minutes: TCAC - January 19, 2024

Minutes: TCAC - February 13, 2024

7. Notice(s) of Motion

8. New Business

9. Adjournment

The next meeting is April 17, 2024.

To ensure quorum, please advise Jessica Dorman (jdorman@crd.bc.ca) if you or your alternate cannot attend.

Meeting Minutes

Environmental Services Committee

Wednesday, January 17, 2024 **1:30 PM** **6th Floor Boardroom 625 Fisgard St. Victoria, BC V8W 1R7**

B. Desjardins (Chair), S. Tobias (Vice Chair) (EP), J. Brownoff (EP), J. Caradonna, G. Holman (EP), D. Kobayashi (EP), D. Murdock (EP), M. Tait (EP), D. Thompson, A. Wickheim, C. Plant (Board Chair, ex-officio)

Staff: T. Robbins, Chief Administrative Officer; L. Hutcheson, General Manager, Parks and Environmental Services; G. Harris, Senior Manager, Environmental Protection; E. Sinclair, Senior Manager, Regional and Strategic Planning (EP); N. Elliott, Manager, Climate Action Programs; M. Lagoa, Deputy Corporate Officer; T. Pillipow, Committee Clerk (Recorder)

EP - Electronic Participation

The meeting was called to order at 1:32 pm.

1. Territorial Acknowledgement

Chair Desjardins provided a Territorial Acknowledgement.

2. Approval of Agenda

MOVED by Director Caradonna, SECONDED by Director Wickheim,
That the agenda for the January 17, 2024 Environmental Services Committee meeting be approved.
CARRIED

3. Adoption of Minutes

3.1. 24-083 Minutes of the November 15, 2023 Environmental Services Committee Meeting

MOVED by Director Wickheim, SECONDED by Director Caradonna,
That the minutes of the Environmental Services Committee meeting of November 15, 2023 be adopted as circulated.
CARRIED

4. Chair's Remarks

Chair Desjardins advised committee members they would be receiving an email from the Board Chair regarding information received via the Biosolids consultation process. Staff will bring forward a report at the January 31st special Board meeting.

The Chair shared an update of the motion put forward in August regarding a proposal for academic and legal review of Biosolids land application. The Province's review is to be completed at the end of January 2024.

5. Presentations/Delegations

There were no presentations or delegations.

6. Committee Business

6.1. 24-021 2024 Environmental Services Committee Terms of Reference

L. Hutcheson presented Item 6.1. for information.

6.2. 24-046 Climate Budgeting Update

N. Elliott spoke to Item 6.2.

Discussion ensued regarding:
- the value of focusing on the climate budget rather than the carbon budget
- contributions of the Climate Action Inter-Municipal Task Force
- consideration of a cost analysis

MOVED by Director Thompson, SECONDED by Director Caradonna,
That this item be postponed until after the City of Victoria staff have reported to Victoria City Council on this topic and the report is received at the CRD.
CARRIED

6.3. 24-057 Measures to Reduce Regional Greenhouse Gas Emissions

N. Elliott spoke to Item 6.3.

Discussion ensued regarding:
- clarification of the budget allotment for education and outreach
- GHG emissions resulting from buildings & transportation
- responsibilities and contribution of the auxiliary position

MOVED by Director Caradonna, SECONDED by Director Thompson,
The Environmental Services Committee recommends to the Capital Regional District Board:
That the Climate Action service initiate a 2024 budget amendment for $190,000 utilizing existing service budget reserves to accommodate:
1. a one-year auxiliary term position to develop a community mobilization program and undertake regional education activities; and
2. additional policy analysis, regulatory reviews, and greenhouse gas (GHG) modelling related to innovative policy approaches identified through the GHG policy mapping initiative.

MOVED by Director Caradonna, SECONDED by Director Thompson,
That the main motion be amended to include the following wording,
"3. to report back on modelling expanded mass transit in the CRD and its potential climate impacts."
CARRIED

MOVED by Director Thompson, SECONDED by Director Caradonna,
That the main motion be further amended to add the wording,
"to accelerate climate mitigation action in order to get on track to achieve our 2038 GHG targets, including", before the wording" existing service budget reserves".
CARRIED

The question was called on the main motion as amended:
The Environmental Services Committee recommends to the Capital Regional District Board:
That the Climate Action service initiate a 2024 budget amendment for $190,000 utilizing existing service budget reserves to accelerate climate mitigation action in order to get on track to achieve our 2038 GHG targets, including to accommodate:
1. a one-year auxiliary term position to develop a community mobilization program and undertake regional education activities; and
2. additional policy analysis, regulatory reviews, and greenhouse gas (GHG) modelling related to innovative policy approaches identified through the GHG policy mapping initiative.
3. to report back on modelling expanded mass transit in the CRD and its potential climate impacts.
CARRIED

Director Plant left the meeting at 2:48 pm.

6.4. 24-056 Boats Management Options in Regional Waters for Local Governments

G. Harris spoke to Item 6.4.

Discussion ensued regarding:
- clarification of stakeholders to be involved in the workshop
- the locations of dedicated moorage areas within the region

MOVED by Director Holman, SECONDED by Director Thompson,
The Environmental Services Committee recommends to the Capital Regional District Board:
That staff host a regional workshop regarding boats management options for local governments.
CARRIED

Motion Arising:
MOVED by Director Holman, SECONDED by Director Caradonna,
That Chair Plant contact appropriate provincial and federal ministers requesting their participation as well as their senior staff at the workshop.
CARRIED

6.5. 24-063 Previous Minutes of Other CRD Committees and Commissions for Information

The following minutes were received for information.
- Climate Action Inter-Municipal Task Force Meeting - December 1, 2023
- Solid Waste Advisory Committee Meeting - December 1, 2023

7. Notice(s) of Motion

There were no notices of motion.

8. New Business

There was no new business.

9. Adjournment

MOVED by Director Thompson, SECONDED by Director Wickheim,
That the January 17, 2024 Environmental Services Committee meeting be adjourned at 2:58 pm.
CARRIED

____
CHAIR

____
RECORDER

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ERM 24-11

REPORT TO ENVIRONMENTAL SERVICES COMMITTEE
MEETING OF WEDNESDAY, MARCH 20, 2024

SUBJECT **Curbside Collection of Packaging and Printed Products – 2024 Update**

ISSUE SUMMARY

To provide an update regarding the implementation of the new six-year contract with GFL Environmental Incorporated (GFL) for the provision of residential blue box curbside collection of packaging and printed products that began January 1, 2024.

BACKGROUND

At its October 12, 2022 meeting, the Capital Regional District Board approved a motion directing staff to enter into a six-year contract with GFL to provide residential curbside blue box collection from January 1, 2024 to December 31, 2029. GFL began service on January 2 but experienced roll-out challenges that have now largely been resolved. These challenges included:

- delayed delivery of the full fleet of specialized collection trucks due to a labour disruption
- changing collection days in some areas to optimize collection routes
- new collection crews learning collection routes
- increased volumes of recyclable materials following the Christmas holiday season
- a large snowfall event in early January that resulted in cancellation of collection for three days

The largest of these challenges was the delay in the delivery of the full fleet of 25 collection trucks, which meant that glass collection had to be suspended for the month of January because the back-up temporary replacement trucks were not configured to pick up three separate streams of materials. Glass collection resumed on February 1, but the large backlog of glass that then needed to be collected proved challenging, and there were days when not all materials were able to be collected on the scheduled collection day. Recovery collections were undertaken by GFL, including on weekends, and this backlog has now been cleared. Recyclable material volumes have now largely returned to normal levels and scheduled collections are now being fully completed.

As of the end of February, GFL has received 20 of the 25 trucks that were ordered in October 2022 for the program. The last three compressed natural gas fueled trucks are expected by mid-March and will continue to be replaced by the rental trucks until they are received. The remaining two trucks will be all-electric powered, but they are not expected to be delivered until the end of March due to manufacturing delays and will be put into service once they are received.

Understanding that its offices in Langford may not be convenient to many residents, GFL has been working to establish a distribution network for residents to obtain new and replacement blue boxes and bags throughout the region. There are now over 10 different distribution locations, including several municipal halls in the capital region.

CONCLUSION

The contract with GFL Environmental to provide curbside blue box collection began January 1, 2024, with a few roll-out challenges, including a delay in the delivery of collection trucks, resulting in the temporary suspension of glass collection, and there was inclement weather. These service delivery challenges have now largely been resolved, and service has normalized in the region. Two new all-electric collection trucks are expected to be received by the end of March and put into service as part of the program.

RECOMMENDATION

There is no recommendation. This report is for information only.

Submitted by:	Russ Smith, Senior Manager, Environmental Resource Management
Concurrence	Larisa Hutcheson, P.Eng., Acting General Manager, Parks & Environmental Services
Concurrence:	Ted Robbins, B. Sc., C. Tech., Chief Administrative Officer

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ERM 24-15

REPORT TO ENVIRONMENTAL SERVICES COMMITTEE
MEETING OF WEDNESDAY, MARCH 20, 2024

SUBJECT **Material Stream Diversion – Award of Contract ERM2022-010**

ISSUE SUMMARY

To provide an update on implementation of Hartland Landfill policy changes approved by the Capital Regional District (CRD) Board in December 2023, and to seek direction on next steps, including award of contract for construction and operation of a material diversion transfer station (MDTS).

BACKGROUND

In December 2023, the CRD Board passed a motion to adopt bylaw amendments, to come into effect in 2024, to divert materials from Hartland Landfill in alignment with the CRD's Solid Waste Management Plan.

Phase 1 of the Hartland policy changes were successfully implemented beginning January 1, 2024, including a ban on clean wood waste, changes to the tipping fee structure, introduction of a hauler waste stream collector incentive program, increases in fine rates, reductions for early payment of fines, and introduction of an education and warning program. To date, 22 Hartland commercial customers representing approximately 70% of Hartland's total general refuse tonnages have registered for the waste stream collector incentive. In the month of January, staff issued 30 warning tickets/MTIs to provide education around the clean wood ban, and 104.7 tonnes of clean wood was diverted from landfilling for recycling/energy recovery. Staff will continue to provide regular updates on implementation.

Phase 2 of the Hartland policy changes is planned to come into effect July 1, 2024, and includes further policy bans and tipping fee modifications. To support the execution of Phase 2 of the material diversion strategy, a Request for Proposals (RFP) for proponent to construct and operate a MDTS at Hartland to manage the processing, utilization, on-site operations and transportation of source-separated materials from Hartland Landfill was issued in September 2023, and closed January 2024.

Learnings through January's Phase 1 implementation have provided staff with valuable information about market response and participation. Phase 2 currently includes introduction of a new $300/tonne tipping fee for loads of unsorted renovation and demolition materials that contain banned items including wood waste. Market response to date suggests that under current market conditions, the $300/tonne rate will incent Hartland customers to seek lower cost landfill disposal options out of region, rather than divert banned materials, including wood waste. This is counter to the Solid Waste Management Plan objectives, and presents financial risk to the solid waste service, as these tipping fees would be paid out of region. To address this risk, staff recommend adding a Phase 3 of implementation in 2026 and shifting the implementation of $300/tonne rate to Phase 3, to allow the market time to develop processes to ensure removal of banned materials from refuse loads. To eliminate the risk of general refuse waste exiting the region during Phase 3, staff also recommend that the CRD immediately begin consultation on policies to restrict the flow of general refuse waste outside the capital region. These policies could be implemented as part of Phase 3 and would be subject to future consideration by the CRD Board. Additional material bans including rigid plastics could also be considered as part of Phase 3.

ALTERNATIVES

Alternative 1

The Environmental Services Committee recommends to the Capital Regional District Board:

1. That staff be directed to finalize negotiations, and the Chief Administrative Officer be authorized to enter into a two-year operating and construction contract, for a combined value not to exceed $12,500,000 (excluding GST) with DL's Bins, for the construction and operation of a material diversion transfer station to begin processing of clean wood, treated wood and asphalt shingles on July 1, 2024;
2. That staff be directed to return to the Environmental Services Committee with proposed bylaw amendments to shift the ban on carpet and underlay and salvageable wood to Phase 3;
3. That staff be directed to return to the Environmental Services Committee with proposed bylaw amendments to shift the implementation of the $300/tonne unsorted load rate to Phase 3; and
4. That staff immediately begin consultation on policies to restrict the flow of general refuse waste outside of the capital region.

Alternative 2

The Environmental Services Committee recommends to the Capital Regional District Board:

1. That staff be directed to finalize negotiations, and the Chief Administrative Officer be authorized to enter into a two-year operating and construction contract, for a combined value not to exceed $12,500,000 (excluding GST) with DL's Bins, for the construction and operation of a material diversion transfer station to begin processing of clean wood, treated wood and asphalt shingles on July 1, 2024;
2. That staff be directed to return to the Environmental Services Committee with proposed bylaw amendments to shift the ban on carpet and underlay and salvageable wood to Phase 3.

Alternative 3

That this report be referred back to staff for additional information.

IMPLICATIONS

Alignment with Board & Corporate Priorities

The proposed two-year contract under Alternative 1 aligns with the Board's desire to optimize the diversion of solid waste and maximize resource recovery from waste materials by executing new policies for diverting waste.

Service Delivery Implications

To support the execution of Phase 2 of the material diversion strategy, a RFP for proponent to construct and operate a MDTS at Hartland Landfill was issued in September 2023, and closed in January 2024. The RFP Package is included as Appendix A. Two submissions were received from Emterra Environmental and DL's Bins.

Staff have evaluated the MDTS proposals on technical and financial merit and conducted negotiations with the preferred proponent. Market feedback obtained through the procurement process identified that the costs to process and transport materials diverted from the landfill are higher than identified through the 2021 Market Sounding that was completed. A full financial evaluation is included in the financial implications section of this report.

Both proposals included options for processing clean and treated wood waste, asphalt shingles, and carpet and underlay. Neither proponent provided an option for salvageable wood, however negotiations with the preferred proponent have indicated that this could be considered as part of a Phase 3 alternative. Various options for staging were presented to allow for control of costs.

Staff recommend award of contract for the construction and operation of the MDTS to DL's Bins, enabling the start of Phase 2 policies July 1, 2024.

On the basis feedback obtained through procurement, staff recommend entering into a two-year 'pilot project' contract for the diversion and recycling/recovery of clean wood, treated wood and asphalt shingles. This two-year pilot will enable vendor learning on operational process and end-markets, allow the CRD to fully understand costs of material diversion, and minimize over all costs to the solid waste service.

At the end of the two-year pilot, and pending Board direction at that time, a new Phase 3 of implementation of the material diversion strategy would be implemented. Phase 3 could include a follow-on contract, terms of which are to be negotiated during the pilot period. This contract would extend the operation of the transfer station for a further 5 years, and expand accepted materials to include carpet and underlay, salvageable wood, books and rigid plastic. Additional capital investments at that time would be required to enable additional material streams, and a full financial evaluation would be brought forward at that time. Implementation of the ban on salvageable wood and carpet and underlay would be moved to Phase 3. Additional material bans on books and rigid plastics could also be considered at that time.

Alignment with Existing Plans & Strategies

Implementation of the proposed contract has the potential to divert up to 36,500 tonnes of waste per year from Hartland Landfill's active face, which would align with the Solid Waste Management Plan goal to target an annual disposal rate of 250kg per capita by 2031. Phase 3 could result in additional diverted tonnages.

Financial Implications

Alternative 1 (2-year contract) capital and operating expenditures over the 2-year contract are estimated to be $12.5 million ($3.5 million capital and $9 million operating), to be partially offset by diversion tipping fee revenue of $750,000 (20,000 tonnes). The shortfall will be funded within the 2024/25 Environmental Resource Management budget approvals and reserves.

Alternative 2 (2-year contract) capital and operating expenditures over the 2-year contract are estimated to be $12.5 million ($3.5 million capital and $9 million operating), to be partially offset by diversion tipping fee revenue of $750,000 (20,000 tonnes). The shortfall will be funded within the 2024/25 Environmental Resource Management budget approvals and reserves.

CRD Financial Services assisted in evaluating the long-term financial implications of the alternatives. The reserve balances have been projected to provide an indication of financial health and the need for tax requisition. Neither alternative is projected to require requisition support within the current 5-year planning horizon. Below is a summary of the proposed changes to tipping fees, and the implementation date:

Mandatory Recyclables		
Material Type	**Tipping Fee (per tonne)**	**Landfill Ban Implementation Date**
Clean Wood	segregated diversion $80	Phase 1
Treated Wood	segregated diversion $110	Phase 2
Asphalt Shingles	segregated diversion $110	Phase 2
Salvageable Wood	segregated diversion $0	Phase 3
Carpet and Underlay	segregated diversion $110	Phase 3
Renovation and Demolition Waste		
Clean	segregated diversion $150	Phase 2
Mixed	segregated diversion $150, with $500 fine in effect	Phase 2
Mixed	segregated diversion $300, with $500 fine in effect, potential flow control policies	Phase 3

Phase 1: January 1, 2024
Phase 2: July 1, 2024
Phase 3: 2026

CONCLUSION

The Capital Regional District (CRD) Board passed a motion to adopt the Hartland Landfill Tipping Fee and Regulation Bylaw and CRD Ticket Authorization Bylaw on December 13, 2023. The approval of these bylaws supports the goals and strategies of the CRD's Solid Waste Management Plan. Two proposals were received from the Request for Proposals issued in September 2023, one from Emterra Environmental and the other from DL's Bins. Upon review of the two proposals, staff recommend commencing a contract with DL's Bins for the processing, utilization, on-site operations and transportation of source-separated materials from Hartland Landfill.

RECOMMENDATION

The Environmental Services Committee recommends to the Capital Regional District Board:

1. That staff be directed to finalize negotiations, and the Chief Administrative Officer be authorized to enter into a two-year operating and construction contract, for a combined value not to exceed $12,500,000 (excluding GST) with DL's Bins, for the construction and operation of a material diversion transfer station to begin processing of clean wood, treated wood and asphalt shingles on July 1, 2024;

2. That staff be directed to return to the Environmental Services Committee with proposed bylaw amendments to shift the ban on carpet and underlay and salvageable wood to Phase 3;
3. That staff be directed to return to the Environmental Services Committee with proposed bylaw amendments to shift the implementation of the $300/tonne unsorted load rate to Phase 3; and
4. That staff immediately begin consultation on policies to restrict the flow of general refuse waste outside of the capital region.

Submitted by:	Russ Smith, Senior Manager, Environmental Resource Management
Concurrence	Larisa Hutcheson, P.Eng., Acting General Manager, Parks & Environmental Services
Concurrence:	Ted Robbins, B. Sc., C. Tech., Chief Administrative Officer

ATTACHMENT

Appendix A: Material Stream Diversion Request for Proposals Package

APPENDIX A

ProposalRequest

PARKS & ENVIRONMENTAL SERVICES | ENVIRONMENTAL RESOURCE MANAGEMENT

Request for Proposals

RFP No. ERM2022-010

Processing, Utilization, On-Site Operations and Transportation of Source-Separated Materials from Hartland Landfill

September 2023

CAPITAL REGIONAL DISTRICT

Request for Proposals

Contents

List of Appendices and Submittal Forms

CAPITAL REGIONAL DISTRICT

REQUEST FOR PROPOSALS
Processing and Utilization of Source-Separated Materials from Hartland Landfill

RFP NO. ERM2022-010

1. Instructions to Proponents

1.1. Invitation

The Capital Regional District ("CRD") invites detailed proposals from contractors (the "Proponents") in strict accordance with these Proposal Documents (CRD, RFP No. ERM2022-010). The proposals will be evaluated for the selection of a contractor (or contractors) with the intent to enter into a contract (the "Contract") to provide the services described in Appendix "A".

1.2. Closing Time and Date for Submission of Proposals

The CRD will accept physical copies of each proposal plus **one copy on a USB stick**, in accordance with the instructions contained herein, at the following specific physical location:

Attention: Allison Chambers
Senior Administrative Secretary
Environmental Resource Management

Address: Capital Regional District
625 Fisgard Street
Victoria, BC, V8W 2S6

On or before the following date and time (the "Closing Time"):

Time: **4:00 pm PST**
Date: **16 October 2023**

The CRD reserves the right to extend the Closing Time at its sole discretion.

Proposals must not be sent electronically.

1.3. Not a Tender

This is a Request for Proposal and not a tender call.

1.4. Proposal Documents

Each Proponent will ensure it provides its correct name, address, email address, telephone and number to the CRD at the time the Proponent receives a set of Proposal Documents.

Failure to return the attached Receipt Confirmation Form to the CRD Representative listed in section 1.5 within five (5) days of receiving the Proposal Documents may result in no further communication regarding this RFP.

Please use and reference the above RFP number on all correspondence.

Proponents are advised to read and respond appropriately to all sections of the RFP.

Incomplete proposals may be rejected at the sole discretion of the CRD.

1.5. Inquiries

All inquiries related to this RFP, including whether or not the Contract has been awarded, should be directed in writing to the person named below (the "CRD Representative"). Information obtained from any person or source other than the CRD Representative may not be relied upon.

Name: **Allison Chambers**
Address: **625 Fisgard Street, Victoria BC, V8W 2S6**
Telephone: **250.360.3084**
Email: **achambers@crd.bc.ca**

Inquiries should be made no less than seven (7) days prior to Closing Time. The CRD reserves the right not to respond to inquiries made less than seven (7) days prior to Closing Time. Inquiries and responses will be recorded and may be distributed to all Proponents at the discretion of the CRD.

Proponents finding discrepancies or omissions in the Contract or RFP or having doubts as to the meaning or intent of any provision, should immediately notify the CRD Representative. If the CRD determines that an amendment is required to this RFP, the CRD Representative will issue a written addendum to the Proponents. No oral conversation will affect or modify the terms of this RFP or may be relied upon by any Proponent.

1.6. Information Meeting and Site Visit

An information meeting will be hosted by the CRD Representative to discuss the CRD's requirements under this RFP, a site visit will also be hosted at this time. The information meeting and site visit are optional. **At the time of issuance of this RFP a meeting has been scheduled as follows:**

Date: 5 October 2023
Time: 2:00 pm to 4:00 pm PST
Location: In-person, Victoria, BC

To RSVP attendance, as well as receive the attachments for Appendix A, proponents must become a Proponent of record by submitting the Receipt Confirmation Form (Appendix E).

1.7. Addenda

If the CRD determines that an amendment is required to this RFP, the CRD will issue a written addendum to all Proponents of record that will be incorporated into and become a part of this RFP. Failure to acknowledge and address all addenda in a Proposal may render the Proposal invalid.

1.8. Late Proposals

Proposals received after the Closing Time will not be accepted or considered. Delays caused by any delivery, courier or mail service(s) will not be grounds for an extension of the Closing Time. Proposals received after the Closing Time will be returned unopened to the Proponent.

1.9. Amendments to Proposals

Proposals may be revised by written amendment, provided they are delivered to the location set out in section 1.2. An amendment must be signed by an authorized signatory of the Proponent in the same manner as provided by section 2.3.

1.10. CRD's Right to Modify Terms and Negotiate

The CRD, at its sole discretion, reserves the right to modify the terms of the RFP at any time before the Closing Time. The CRD also reserves the right following the Closing Time, and in accordance with the terms of this RFP, to negotiate with one or more Preferred Proponents any modification or variation of the terms of the RFP, including any of the documents referred to in the definition of "Contract" herein or any modification or variation of the terms of any Proposal, including price, that the CRD considers to be in its best interests. For certainty, and without limiting the foregoing, the CRD may, for the purpose of entering into a Contract with any Proponent, amend the description of the required work included in this RFP so that it accurately reflects the services to be provided by the Proponent.

1.11. Examination of Contract Documents and Site

Each Proponent will be deemed to have carefully examined and understood the requirements and limitations of the RFP, including all attached Appendices, the Contract and the Site (as applicable) prior to preparing and submitting a Proposal, with respect to any and all facts which may influence the decision to prepare and submit a Proposal.

2. Proposal Submission Form and Contents

2.1. Package

Each Proposal must be submitted using a two-envelope process. One envelope must contain the Proponent's price, fee schedule or cost of its Proposal and be clearly marked "Financial Proposal" and the other envelope must contain the balance of the Proposal and be clearly marked "Technical Proposal". Proposals must be in a sealed package and marked on the outside with the Proponent's name, title of the Project and RFP number.

2.2. Form of Proposal

Proponents must submit their Proposal in accordance with the instructions set out in Appendix "B" – Form of Proposal, including Submittal Forms A to F.

2.3. Signature

The Proposal should be signed by a person authorized to sign on behalf of the Proponent and include the following:

(a) If the Proponent is a corporation, then the full legal name of the corporation should be included, together with the names of the authorized signatories. The Proposal should be executed by all of the authorized signatories, or by one or more of them provided that a copy of the corporate resolution authorizing those persons to execute the Proposal on behalf of the corporation is submitted.

(b) If the Proponent is a partnership or joint venture, then the legal name of the partnership or joint venture and the name of each partner or joint venturer should be included and each partner or joint venturer should sign personally (or, if one or more person(s) having signing authority for the partnership or joint venture should provide evidence to the satisfaction of the CRD that the person(s) signing have signing authority for the partnership or joint venture). If a partner or joint venturer is a corporation then such corporation should sign as indicated in subsection (a) above.

(c) If the Proponent is an individual, including sole proprietorship, the name of the individual should be included.

3. Evaluation and Selection

3.1. Evaluation Team

The evaluation of Proposals will be undertaken on behalf of the CRD by the Evaluation Team. The Evaluation Team may consult with others including CRD staff members, third party contractors and references, as the Evaluation Team may in its discretion decide is required.

3.2. Evaluation Criteria

The Evaluation Team will compare and evaluate each Proposal to determine the Proponent's strength and ability to provide the Services in order to determine the Proposal which is most advantageous to the CRD. Specific criteria and their importance are outlined in the Evaluation Form attached as Appendix "C."

3.3. Litigation

In addition to any other provision of this RFP, the CRD may, in its absolute discretion, reject a Proposal if the Proponent, or any officer or director of the Proponent submitting the Proposal, is or has been engaged directly or indirectly in a legal action against the CRD, its elected or appointed officers, representatives or employees in relation to any matter.

In determining whether or not to reject a Proposal under this section, the CRD will consider whether the litigation is likely to affect the Proponent's ability to work with the CRD, its contractors and representatives and whether the CRD's experience with the Proponent indicates that there is a risk the CRD will incur increased staff and legal costs in the administration of the Contract if it is awarded to the Proponent.

3.4. Additional Information

The Evaluation Team may, at its discretion, request clarifications or additional information from any Proponent with respect to any Proposal. The Evaluation Team may consider such clarifications or additional information in evaluating a Proposal.

3.5. Interviews

The Evaluation Team may, at its discretion, invite some or all of the Proponents to appear before the Evaluation Team to provide clarifications of their Proposals. In such event, the Evaluation Team will be entitled to consider the answers received in evaluating Proposals.

3.6. Multiple Preferred Proposals

The CRD reserves the right and discretion to divide up the Services, either by scope, geographic area, or on any other basis as the CRD may decide, and to select one or more Preferred Proponents to enter into discussions and/or negotiations with the CRD for one or more Contracts to perform all or a portion or portions of the Services. In addition to any other provision of this RFP, Proposals may be evaluated on the basis of advantages and disadvantages to the CRD that might result or be achieved from the CRD dividing up the Services and entering into one or more Contracts with one or more Proponents.

3.7. Negotiation of Contract and Award

If the CRD selects one or more Preferred Proponents, then it may enter into a Contract with the Preferred Proponent(s), or enter into discussions with the Preferred Proponent(s) to attempt to negotiate the terms of the Contract(s), and such discussions may include but are not limited to negotiating amendments to the Scope of Services and the Preferred Proponent’s price(s).

If at any time the CRD reasonably forms the opinion that a mutually acceptable agreement is not likely to be reached within a reasonable time, the CRD may give the Preferred Proponent(s) written notice to terminate discussions, in which event the CRD may then either open discussions and/or negotiations with another Proponent or Proponents, or terminate the RFP and retain or obtain the Services in some other manner.

Proponents will be notified in writing when a Contract has been awarded.

4. General Conditions

4.1. No CRD Obligation

This RFP does not commit the CRD in any way to select a Preferred Proponent, or to proceed to discussions or negotiations for a Contract, or to award any Contract, and the CRD reserves the complete right to at any time reject all Proposals, and to terminate this RFP process for any reason.

4.2. Proponents Expenses

Proponents are solely responsible for their own expenses in preparing, submitting Proposals, and for any meetings, negotiations or discussions with the CRD or its representatives and contractors relating to or arising from this RFP.

4.3. No Contract

By submitting a Proposal and participating in the process as outlined in this RFP, Proponents expressly agree that no contract of any kind is formed under, or arises from, this RFP, prior to the signing of a formal written Contract.

4.4. Conflict of Interest

A Proponent shall disclose in its Proposal any actual or potential conflicts of interest and existing business relationships it may have with the CRD, its elected or appointed officials or employees. The CRD may rely upon such disclosure.

4.5. Solicitation of CRD Staff, Board Members and Contractors

Proponents and their agents will not contact any member of the CRD Board, CRD staff or CRD contractors with respect to this RFP, other than the CRD Representative named in section 1.5, at any time prior to entering into a Contract or the cancellation of this RFP.

4.6. Disclaimers/Limitations of Liability

Neither acceptance of a Proposal nor execution of a Contract constitute approval of any activity or development contemplated in any Proposal that requires any approval, permit or license pursuant to any federal, provincial, regional or municipal statute, regulation or bylaw. It is the responsibility of the Proponent to obtain such approval, permit or license prior to commencement of the work under the anticipated Contract.

The CRD, its elected officials, appointed officers, employees, agents, contractors and volunteers expressly disclaim any and all liability for representations or warranties expressed, implied or contained in, or for omissions from this RFP package or any written or oral information transmitted or made available at any time to a Proponent by or on behalf of the CRD. Nothing in this RFP is intended to relieve a Proponent from forming its own opinions and conclusions in respect of this RFP.

The CRD, its elected officials, appointed officers, employees, agents, contractors and volunteers will not be liable to any Proponent for any claims, whether for costs, expenses, losses, damages, or loss of anticipated profits, or for any other matter whatsoever, incurred by a Proponent in preparing and submitting a Proposal, or participating in negotiations for a Contract, or other activity related to or arising out of this RFP. By submitting a Proposal, each Proponent shall be deemed to have agreed that it has no right to make such claims.

4.7. Confidentiality

The RFP documents, or any portion thereof and any other confidential information to which a Proponent may have access as a result of this RFP process, may not be used by a Proponent for any purpose other than submission of Proposals.

By submitting a Proposal, every Proponent agrees not to divulge, release or otherwise use any information that has been given to it or acquired by it from the CRD on a confidential basis as a result of or during the course of the RFP process.

4.8. Ownership of Proposals and Freedom of Information

Each Proposal submitted, as well as any other documents received from a Proponent, become the property of the CRD, and as such are subject to the *Freedom of Information and Protection of Privacy Act* ("FIPPA"). FIPPA grants a general right of access to such records, but also includes grounds for refusing the disclosure of certain information.

Proponents are asked to specifically identify information contained in their Proposal that is submitted on a confidential basis. Subject to any requirement for access under FIPPA, the CRD will hold in confidence any such information received from a Proponent. However, the CRD specifically reserves the right to distribute information about any Proposal internally to its own directors, officers and employees, to its contractors and contractors where the distribution of that information is considered by the CRD to be necessary to its internal consultation process.

4.9. Time

The timing for the submission and receipt of Proposals and any amendments thereto shall be determined by reference to the CRD local area network time.

4.10. Acceptance of Terms

The submission of a Proposal constitutes the agreement of the Proponent that all the terms and conditions of this RFP are accepted by the Proponent and incorporated in its Proposal.

APPENDIX "A" – DESIGN, CONSTRUCTION AND OPERATION SPECIFICATIONS

1. Background

The Capital Regional District (CRD) governs 13 municipalities and 3 electoral areas located on the southern end of Vancouver Island. The Hartland Landfill (Landfill) is owned and operated by the CRD and is located approximately 14 kilometers (km) northwest of the City of Victoria, at 1 Hartland Ave, Victoria, BC, as shown in Figure 1 below.

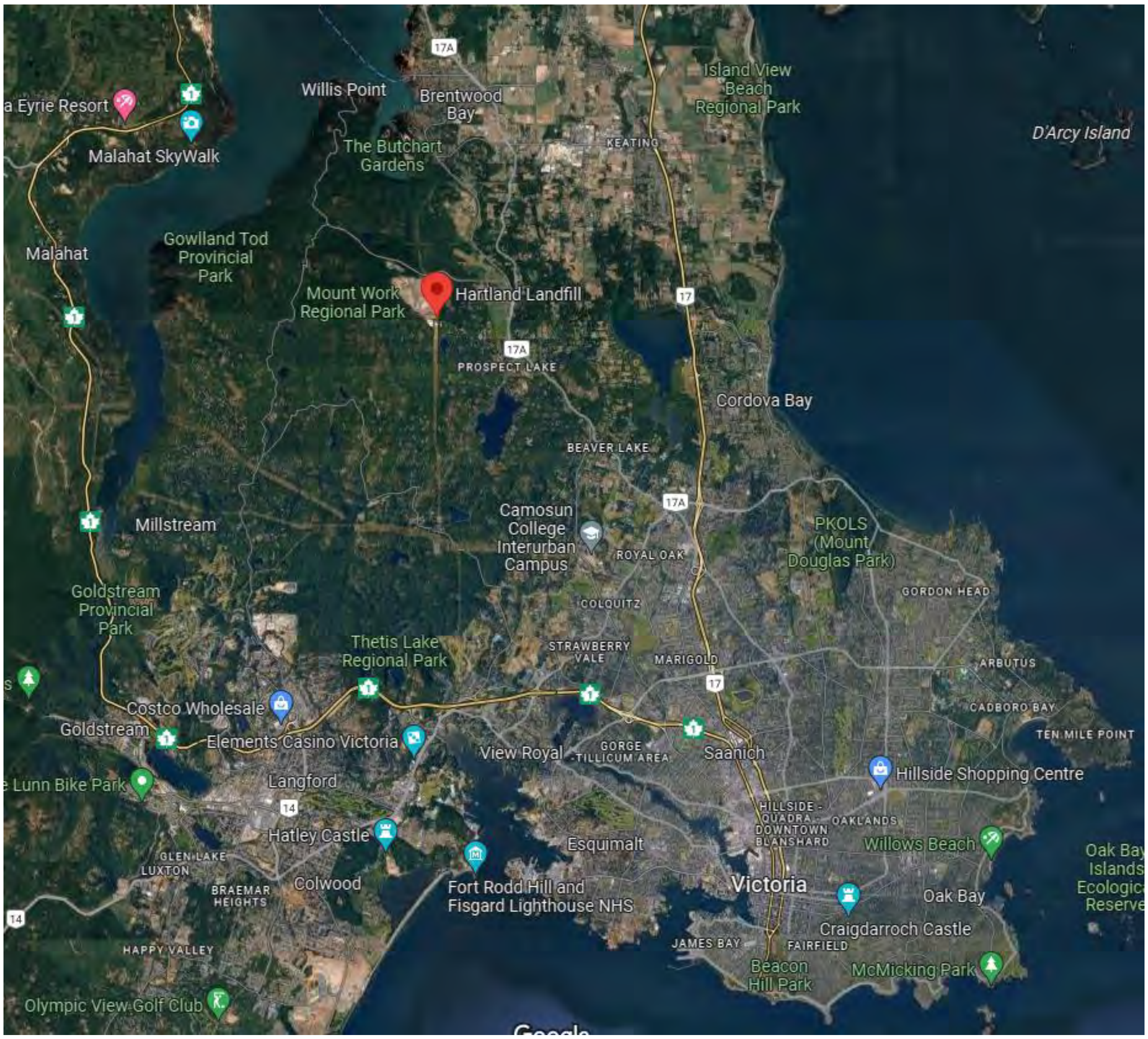


Figure 1 Landfill Location

The Landfill is a multi-purpose facility that provides the following waste management services and functions:

a) Landfill disposal of municipal solid waste for residential and commercial customers;
b) Landfill disposal of controlled waste;
c) Residential drop-off recycling depot for:
    - Household recyclable materials;
    - Extended Producer Responsibility (EPR) materials;
    - Household hazardous waste materials;
    - Reusable goods;
    - Food scraps, yard and garden material;

d) Residential and commercial food waste;
e) Leachate collection, treatment, and disposal;
f) Landfill gas collection, processing, conversion utilization and sale;
g) Administration and weigh scale facilities;
h) Learning Centre; and
i) Any other waste disposal and diversion initiatives as approved by the CRD Board.

In 2022, the Landfill accepted approximately 180,000 tonnes of solid waste for disposal and diverted over 16,640 tonnes of materials at the Hartland Public Drop-off Depot. In alignment with the CRD's Solid Waste Management Plan which follows the BC Ministry of Environment & Climate Change Strategy's (ENV) Pollution Prevention Hierarchy (Figure 2) to prioritize waste reduction, reuse and recycling as their first approach to waste management, the CRD intends to implement new policies in January 2024, to divert up to an additional 40,550 tonnes of material annually. This will be done through landfill bans on clean wood, treated wood, salvageable wood, asphalt roofing shingles, carpet and underlay, and optional materials such as books not accepted in the Recycle BC program and rigid plastics, all of which accounts for approximately 24% of the current mixed waste stream.

Figure 2 ENV Waste Reduction Hierarchy

With the landfill bans in place, surcharges will be applied to renovation and demolition loads containing these or other mandatory recyclable materials. The CRD currently operates a rental waste shredder at the Landfill's active face to improve their compaction rate.

In May 2022, the CRD Board endorsed the staff report titled *Meeting the Solid Waste Management Plan Targets through Material Stream Diversion*, which supports the procurement process for further material diversion (Attachment 1). In 2022, the CRD conducted a Waste Stream Composition Study (Attachment 2).

2. Definitions

Operations: refers to all on-site operations, including but not limited to transportation, loading, hauling, storage, reusing, recycling, repurposing, and pre-processing of material, parking, operation of equipment and management of the Material Diversion Transfer Station.

Works: refers to work required to design, construct, operate, and maintain the Material Diversion Transfer Station, including but not limited to equipment procurement, site and civil works, installation work, permitting and approvals and coordination with the CRD.

Material Diversion Transfer Station (MDTS): designated area where listed source-separated materials are consolidated, temporarily stored, processed, reused and repurposed for beneficial use off-site.

MDco: Material Diversion Transfer Station Contractor.

BUA: Beneficial Use Area: designated area encompassing both the Material Diversion Transfer Station and the Biosolids Mixing Area.

Biosolids Mixing Area: designated area where the CRD will be mixing and blending biosolids, adjacent to the Material Diversion Transfer Station.

End Users: refers to end use facilities where diverted and/or processed materials from the MDTS are transported to for beneficial use.

3. Partnership

The CRD encourages proponents to consider opportunities for indigenous employment, business involvement, and community opportunities for works at the Landfill, located in traditional territory of the W̱SÁNEĆ peoples. Proponents are encouraged to procure goods and services from W̱SÁNEĆ-affiliated businesses and to consider partnerships and joint ventures to benefit these communities. This is not a local preference, and each proponent will be evaluated on its merits at the time of submission.

4. Purpose

Through this Request for Proposals (RFP), the CRD invites submissions from Proponents with the capacity, ability and experience to design, build and operate (onsite operations, transportation/hauling as required and management of end use contracts) a MDTS to be located at the Landfill intended for the reuse, recycle, repurpose, or otherwise beneficially process the five source-separated waste streams listed below that will be diverted from the Landfill's active face through upcoming landfill bans. The scope additionally includes design and construction of the subgrade and final asphalt surface for the entire BUA (MDTS and Biosolids Mixing Area) however the CRD will operate the Biosolids Mixing Area. The CRD's preference is to enter into a single agreement with a single entity who has the capacity, ability and experience to complete the above scope of work.

This RFP relates solely to the MDTS operations, and reuse, recycle, repurpose, or recovery of the selected source-separated waste streams from the Landfill. Participation in this RFP will not restrict Proponents from participating in other CRD procurements.

Figure 3 below illustrates the scope of work discussed in this RFP and outlines interfaces with existing CRD operations.

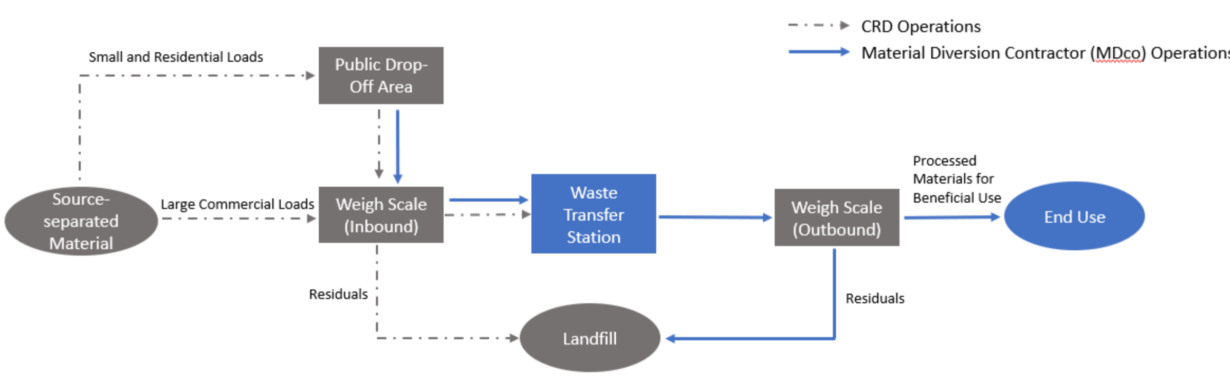


Figure 3 MDco Scope Design and Operations

The following materials will be collected at the Public Drop-Off Area or transported directly to the MDTS:

1. Clean Wood

2. Treated Wood
3. Asphalt roofing shingles
4. Carpet and underlay
5. Salvageable wood (in stacking racks)

Optional materials that will not be banned from the Landfill, but which the CRD would like to obtain pricing for pre-processing through the MDTS include:

6. Books (includes textbooks, novels, soft and hardcover books)
7. Rigid Plastics (non-EPR).

The following specifications present the minimum design considerations for the MDTS to be located at the Landfill. These specifications are broken into:

I. Design Specifications
II. Operations & Maintenance (O&M) specifications

5. Safety

MDco shall be solely and completely responsible for ensuring the safety of all employees. All contractors, where allowed by the Workers Compensation Act, must be registered with the Workers' Compensation Board (WorkSafeBC). The Contractor shall comply, at all times, with the WorkSafeBC Regulation. A current copy of the Contractor's Occupational Health and Safety Program, and site-specific safety plan as outlined in the WorkSafeBC OHS Regulation, must be made available to the CRD, upon request.

Health Hazards:

a) Oxygen deficiency
b) Build-up of highly toxic or flammable gases such as methane and hydrogen sulphide
c) Contact with refuse could cause skin irritations, cuts or abrasions
d) Handling of waste asbestos and controlled waste
e) Exposure to leachate
f) Exposure to septage and sewage sludge

5.1 Silica:

a) Dusty conditions (dust may contain silica)

5.2 Fire Hazards:

a) Ignition of pockets of methane gas may result in fire or explosion
b) Exposed decomposing waste may result in spontaneous combustion
c) The contents of some solid waste loads, such as lithium-ion batteries, may result in fires

5.3 Buried Refuse Stability Hazards:

a) Landfilled refuse may be unstable

5.4 Water Hazards:

a) Water hazards of varying depths exist on the landfill site

5.5 Slope Hazards:

a) Steep slopes of varying degrees exist on the landfill site

5.6 Traffic Hazards:

a) CRD staff, haulers, the general public, and various on-site contractors heavily utilize the Landfill roads

5.7 Power Lines:

a) BC Hydro power lines are situated throughout the landfill property

5.8 Personal Protective Equipment

a) Contractor personnel must wear personal protective equipment, including at a minimum, high visibility apparel and safety footwear.
b) Contractor personnel must utilize continuous air monitoring devices capable of measuring carbon monoxide, oxygen, hydrogen sulphide and the lower explosive limit for methane when working in potentially hazardous atmospheres.
c) Contractor personnel must be prepared to use respirators with appropriate filters, conduct respirator maintenance when required, and maintain fit-testing records on-site.
d) Unauthorized personnel shall not enter electrical switch rooms or controls rooms, including opening or closing of any switch, disconnect or circuit breaker on the property.
e) Due to the extreme fire hazard, contractors must obey the no smoking bylaw at Hartland Landfill.
f) All equipment must be well maintained.

6. Site and Operational Considerations

a) The CRD will provide approximately 1.3 hectares, denoted as MDTS Footprint in Drawing No. 24-W1067-1 – Location Plan, Vehicle Access Routing, Table of Contents and General Notes, for the purpose of this Work.
b) The MDTS Footprint currently consists of those features shown on Drawing No. 24-W1067-2 – Hartland Material Diversion Transfer Station Area Development Gravel Grading Plan, Detail and Coordinate Table.
c) The MDTS Footprint consists of a below grade smooth PVC membrane currently covered by 25 millimetres (mm) of sand, approximately 300mm of 25mm minus crush and varying depths of a topsoil, peat and compost mix. This is shown in Drawing No. 24-W1067-2 – Gravel Grading Plan, Detail and Coordinate Table.
d) A Waste Composition Study of Shredded Construction and Demolition Waste at the Hartland Landfill was conducted in February 2023 (Attachment 3).
e) The CRD has a program in place to identify asbestos containing materials and ensure they are properly disposed of. More information can be found in Attachment 4.
f) The CRD will make available a 100 feet (ft) x 110 ft sprung structure at no cost to MDco. Details of the sprung structure can be found in Attachment 5.
g) A paved area currently designated as the “Food Scraps Area” will be made available to the MDco on an as-needed basis, and with approval from the CRD, if additional footprint is required for MDTS operations. This is shown in Drawing No. 24-W1067-1.
h) The CRD has provided a Traffic Plan (Drawing No. 24-W1067, Section 14 Drawings) which outlines traffic flow requirements from the main Landfill gate to/from the MDTS boundary.
i) The CRD has provided a Fire Control Plan in Attachment 6.

j) MDco will not have access to any CRD services other than those explicitly mentioned within this Appendix A.
k) If required by MDco, the CRD can provide a location for a site trailer for MDco staff during operations at the current bird storage location indicated in Drawing No. 24-W1067-1. Two control buildings may also be available for MDco, pending decommissioning of the existing Gas Plant.
l) The footprint allocated for the MDTS is located on a closed portion of the Landfill; as a result, settlement of this area should be expected and accounted for during design and operation by MDco.
m) MDco will have priority access to the existing CRD weigh scales located at the entrance to the Landfill.
n) MDco will be able to dispose of waste at the active landfill face at no cost; however, MDco will be required to obtain a weigh scale ticket for any waste disposed of.
o) Potable water is not available near the MDTS.
p) Non-potable water is not available near the MDTS. Coordination with the CRD will be required to fill MDco holding tanks if non-potable water is required for operations.
q) Electrical service is not available near the MDTS.
r) The CRD will be stripping and cleaning up the MDTS footprint and a final survey will be provided to confirm the existing grade and fill requirements.
s) MDco will have access to CRD shot rock piles to crush aggregate needed for fill in the area.

7. Source-Separated Materials

Disposal bans on the source-separated materials listed below will be implemented at the Landfill as of January 2024, with the exception of rigid plastics and books which will not be banned from landfill disposal. Estimated annual tonnages provided for each material represent the maximum (100%) landfill diversion, based on the 2022 waste composition analysis. The CRD has no guaranteed minimums as these material tonnages are estimates and are expected to vary based on program participation.

a) **Clean Wood Waste**: Clean wood includes wood products that are untreated, unstained, unpainted and does not include any antisapstain, coatings, resins or glues, such as pallets, crating, wood fencing, wood shingles, wooden doors and clean renovation and demolition wood waste (up to 5,500 tonnes).
b) **Treated Wood Waste**: Treated wood includes engineered wood products or pressure treated, stained, or painted wood, and wooden furniture that may or may not contain nails or other metal fasteners (up to 22,000 tonnes).
c) **Salvageable Wood**: Painted or clean, minimum 4 ft in length. Nails are acceptable.
d) **Asphalt Roofing Shingles**: Asphalt roofing shingles includes shingles composed of a felt mat saturated with asphalt, with small rock granules added (up to 9,000 tonnes).
e) **Carpet and Underlay**: Carpet and underlay includes flooring material made of woven wool, silk, cotton or synthetic fibers and foam padding underlayment where tack stripping material has been removed (up to 4,000 tonnes).
f) **Books**: Books include textbooks, novels, softcover and hardcover books that are not currently accepted in the Recycle BC program (up to 60 tonnes). This does not include magazines, newspapers and phone directories.

g) **Rigid Plastics (non-EPR):** Hard plastic materials and products that are not included under EPR. This may include items such as plastic lawn chairs, kids toys, drums, etc. (up to 3,000 tonnes).

The CRD is currently in the process of completing a Shredded Waste Composition Analysis and will share the complete analysis results with proponents once it is available. The analysis is limited to mixed, unsorted construction and demolition waste only; however, the CRD is open to providing feedstock samples to proponents who would prefer to conduct their own testing.

If beneficial to MDco Operations, asphalt roofing shingles, carpet and underlay may be available from the Cowichan Valley Regional District (CVRD); however, minimum tonnages are not guaranteed. The CVRD received 525 tonnes of asphalt roofing shingles in 2022. Tonnages were not available for carpet and underlay. MDco may choose optionally to bid on transporting and accepting these materials. Refer to Appendix B, Submittal Form F- Other Services.

8. Design and Construction

The following section describes the scope of work and objectives related to the Design and Construction of the MDTS.

8.1 Design and Construction - Scope of Work

The CRD is seeking submissions from Proponents to design, permit, procure, supply, build, install, commission, operate and maintain a MDTS to be located at the Landfill. The MDTS shall be capable of reusing, recycling, repurposing, or otherwise pre-processing of the materials included in Section 7 above.

MDco's minimum scope of work shall include:

a) Detailed Engineering Designs (60%, draft Issued For Construction (IFC)) of the proposed MDTS. These shall include but are not limited to:
   i. Civil Drawings:
      1) Existing Conditions
      2) Site Layout
      3) Base Grades
      4) Final Grades
      5) Stormwater Management Plan

   ii. Structural Drawings:
      1) Foundations Drawings, if required
      2) Stockpile Loading Calculations (including the approximate anticipated height of stockpiles)

   iii. Utility Tie-in Drawings, if required.

b) Development of Plans including but not limited to:
   i. Schedule incl. Basis of Schedule
   ii. Project Execution Plan
   iii. Traffic Plan – this plan shall incorporate the CRD's Traffic Management Plan (Drawing No. 24-W1067, Section 14 Drawings).

iv. Permit List – this shall outline any permits required by MDco for construction and operation of the MDTS
v. Emergency Response Plan - this plan shall incorporate the CRD's Emergency Response Plan
vi. Environmental Plan
vii. Site Specific Health and Safety Plan (inclusive of plot plan)
   1) Fire suppression
   2) CRD Contractor Occupational, Health & Safety Project Checklist

viii. Stormwater Management and Erosions and Sediment Control Plan
ix. Operations and Maintenance (O&M) Plan
x. Monthly Report Template
xi. Closure Plan

c) Procurement of all equipment;
d) Temporary utilities and consumables required for Project Construction;
e) Site and civil works;
f) Structural installation work, if required;
g) Mechanical installation work, if required;
h) Electrical installation work, if required;
i) Permitting and approvals;
j) Coordination with the CRD throughout design, construction, and O&M;
k) Any other related work required to design, construct, operate and maintain the MDTS

MDco may propose alternative designs to those provided in this RFP. However all design and deliverables are subject to final approval by the CRD.

8.2 Design and Construction – Objectives

a) Throughout the design phase of the project, MDco shall consider and account for all health and safety design features, not limited to those mentioned within this document, that are required to construct, install, commission, test, operate and maintain the MDTS in a safe manner and in accordance with the BC Workers Compensation Act, BC Occupational Health and Safety Regulation, Policy, and Guidelines, including CRD protocols.

b) MDco shall design the MDTS such that all operations (storage, processing, hauling, parking, etc.) are completed on an asphalt binder surface with an aggregate base layer. Preference will be given to proposals which utilize recycled materials (such as recycled roadbase or concrete) for the asphalt surface and/or aggregate layer. Both the asphalt surface and aggregate layer shall be designed to adequately protect the below-grade PVC membrane. The CRD is open to alternative cost saving designs, such as modifications to the design surface and/or subgrade once the below grade PVC liner is adequately protected at all times and stormwater and leachate collection objectives are achieved. The gravel and road grading details (ref.: Drawing No. 24-W1067-2) provided are typical details; MDco may propose alternative materials for the asphalt and aggregate layer with approval from the CRD.

c) MDco shall design and operate the MDTS such that the maximum allowable load/stress on the below grade smooth PVC membrane is not exceeded. The technical specifications of the PVC membrane is available for reference as Attachment 8.

d) MDco may propose alternative traffic flows within the footprint of the MDTS for approval by the CRD.

e) An area located northeast of the MDTS shall be designated for biosolids mixing (~3,000 m^2) as indicated Drawing No. 24-W1067-1). This biosolids mixing area will remain available exclusively for the CRD's use.

f) MDco shall design and construct the subgrade and final asphalt surface for the entire BUA (MDTS and Biosolids Mixing Area).

g) Drawing No. 24-W1067-2 provides indicative site grading to manage stormwater. MDco may provide alternative site grading for approval by the CRD. However, all stormwater from the biosolids mixing area shall be routed towards the existing leachate collection system located on the eastern portion of the BUA as shown in Drawing No. 24-W1067-3.

h) MDco shall install effective treatment works for sediment control/solids reduction (e.g., catch basins, etc.) of all storm water run-off.

i) MDco shall design and construct the MDTS such that the quantity and type of materials coming in and out of the facility can be quantified. This can incorporate the use of CRD's weigh scales at the main gate.

j) The CRD would prefer to minimize teeing into existing utilities wherever possible.

9. Operations and Maintenance

The following section describes the scope of work and objectives related to the O&M of the MDTS.

9.1 Operations and Maintenance - Scope of Work

O&M of the MDTS shall include but is not limited to:

a) All loading and transportation of material from the MDTS, Kitchen Scrap Area, Public Drop Off Area and/or any other area which MDco may source material for the MDTS. (Commercial customers will be directed to offload source-separated materials directly at the MDTS).

b) Reusing, recycling, repurposing, or otherwise pre-processing of material at the MDTS in preparation for transfer to pre-approved End Use facilities.

c) All loading and transportation of material from the MDTS to pre-approved End Use facilities.

d) Loading and transportation of material not suitable for end-processing from the MDTS to the active face.

e) Supply and operate all necessary equipment for site operations and hauling.

f) Weighing of all material and material types processed and disposed. Loaded hauling/transportation equipment shall pass through the Landfill scale house for the CRD to accurately track material diversion. MDco will be provided with scale privileges to minimize standby time at the Landfill.

g) Maintain treatment works for sediment control/solids reduction in good working order. The CRD reserves the right to require additional treatment of SW if discharges result in a non-compliance of the landfill's Sewer Discharge Authorization under *Bylaw 2922, Capital Regional District Sewer Use Bylaw*, or other non-compliances under the Landfill's Operational Certificate. At no time, shall the contractor discharge *Hazardous Waste* as defined by the *BC Hazardous Waste Regulation*. The CRD will perform audit of stormwater discharges to confirm compliance.

h) Securing contracts with End Users, including negotiating, managing and holding any relevant contracts with End Users.

i) Maintaining records and providing the CRD with Monthly Reports.

j) Coordination with other contractors as required.

k) Utility/fuel consumption and recording.

l) Adhering to CRD Plans, local bylaws, standards and regulations.

m) Overall management of the MDTS including but not limited to:
   i. Educate users on material diversion locations,
   ii. Provide an Environmental, Health and Safety Plan,
   iii. Provide pre-processing capacity for materials on-site as required for End Use facilities
   iv. Coordinate with End Users to determine and conduct any necessary testing and pre-processing requirements of the End Use facility,
   v. Site Maintenance – including but not limited to:
      1) Maintain a clean Site by regularly removing source-separated materials,
      2) Ensuring the Site is free from loose or blowing garbage,
      3) Dust control as required,
      4) Snow removal,
      5) Fire Suppression,
      6) Asphalt/surface maintenance,
      7) Ensuring adequate protection at all times of the below grade smooth PVC membrane system
      8) Maintaining the CRD's Good Neighbour Policy.

9.2 Operations and Maintenance - Objectives

a) MDco shall operate and maintain the MDTS such that the quantity and type of material coming into and out of the facility can be quantified. This can incorporate the use of CRD's weigh scales at the main gate.

b) The MDco shall provide the CRD with a selection of available End Use options, associated costs per tonne and contamination tolerances for each option. These may include:
   i. Low volume options focused on innovative use of materials aligned with the waste hierarchy to reuse and recycle materials, supporting the development of a circular economy.
   ii. High volume options focused on maximizing diversion potential (e.g., wood waste to hog fuel).
   iii. Pilot projects with set timelines and objectives that could lead to innovation in the industry.

   The CRD is interested in End Use options which move waste higher up the waste hierarchy as per the ENV Waste Reduction Hierarchy. The CRD shall be able to select/prioritize End Use options available.

c) The CRD intends to evaluate Proponents on their methodology to continually seek out more cost effective or innovative material end-markets.

d) The consolidation and loading of materials shall be completed in a timely manner as there is limited ability for material stockpiling onsite.

9.3 Tolerances for Contamination

A maximum of 10-15% contamination threshold (by weight or volume, whichever is higher) for mandatory recyclables will be accepted at the start of the project. This will apply to the clean and treated wood, asphalt shingles, and carpet and underlay.

If contaminated/hazardous material is encountered at the MDTS, MDco shall notify the CRD and isolate the load to prevent material contamination. The MDco will be responsible for relocating mixed loads to the waste shredding stockpile at the Landfill's active face.

10. Operating Hours

The MDTS will not be accessible to the public; the public will only be permitted access to the Public Drop-Off for drop-off/pick-up. The MDTS will have the same operating hours as the Public Drop-off, which is currently open 9 am to 5 pm on weekdays and 7 am to 2 pm on Saturdays (closed Sunday and Holidays). In 2024, the CRD intends to pilot longer opening hours by extending the weekday hours by two hours to a total of 10 hours on weekdays and extending Saturday hours by 3 hours for a total of 8 hours. Exact opening hours will be confirmed with MDco.

11. Schedule

The CRD's tentative and non-binding schedule is provided below. This reflects an estimate of the process timelines at this stage and is provided solely for the convenience of the Proponent(s). The CRD will review proposal responses and request follow up interviews with shortlisted proponents. The following is the CRD's anticipated schedule:

Request for Proposals Steps	Date
RFP - Issued	September 18, 2023
Information Meeting (Optional)	October 5, 2023
Proponent's Site Visit (Optional)	October 5, 2023
Question Period Close	October 6, 2023
RFP - Closing	October 16, 2023
RFP - Award	November 10, 2023
In Service Target Date	January 31, 2024

The CRD's preference is for MDTS to be operational and in service starting in January 2024. The CRD understands that site prep and equipment lead time may make this target date challenging. Proponents are encouraged to consider project delivery options that can allow for some materials processing (e.g., limited streams or volumes) to begin in January 2024, even in advance of the full construction of the MDTS.

12. Length of Contract

The CRD is interested in contracting out operation of the MDTS for a 5-year term.

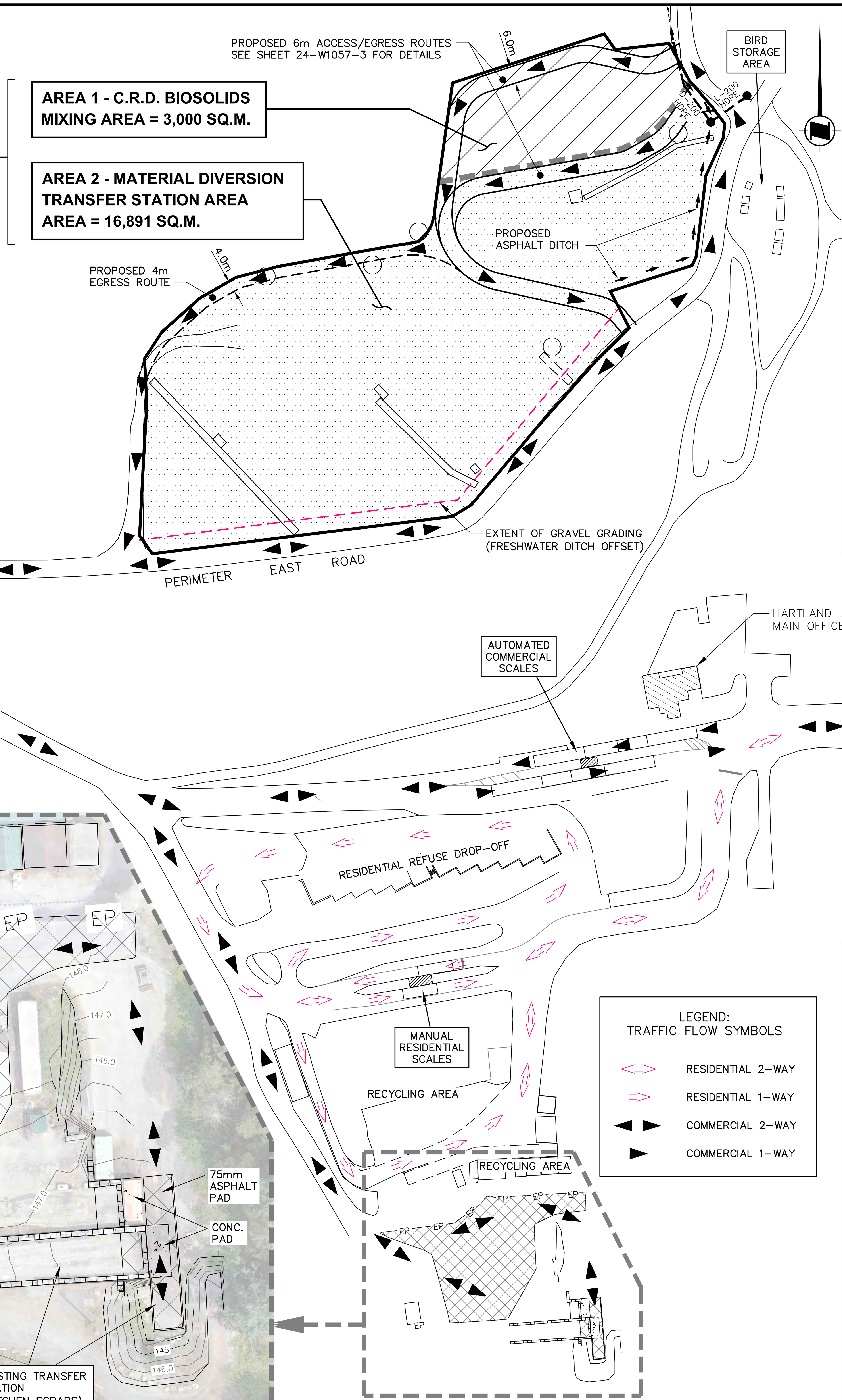
13. Attachments

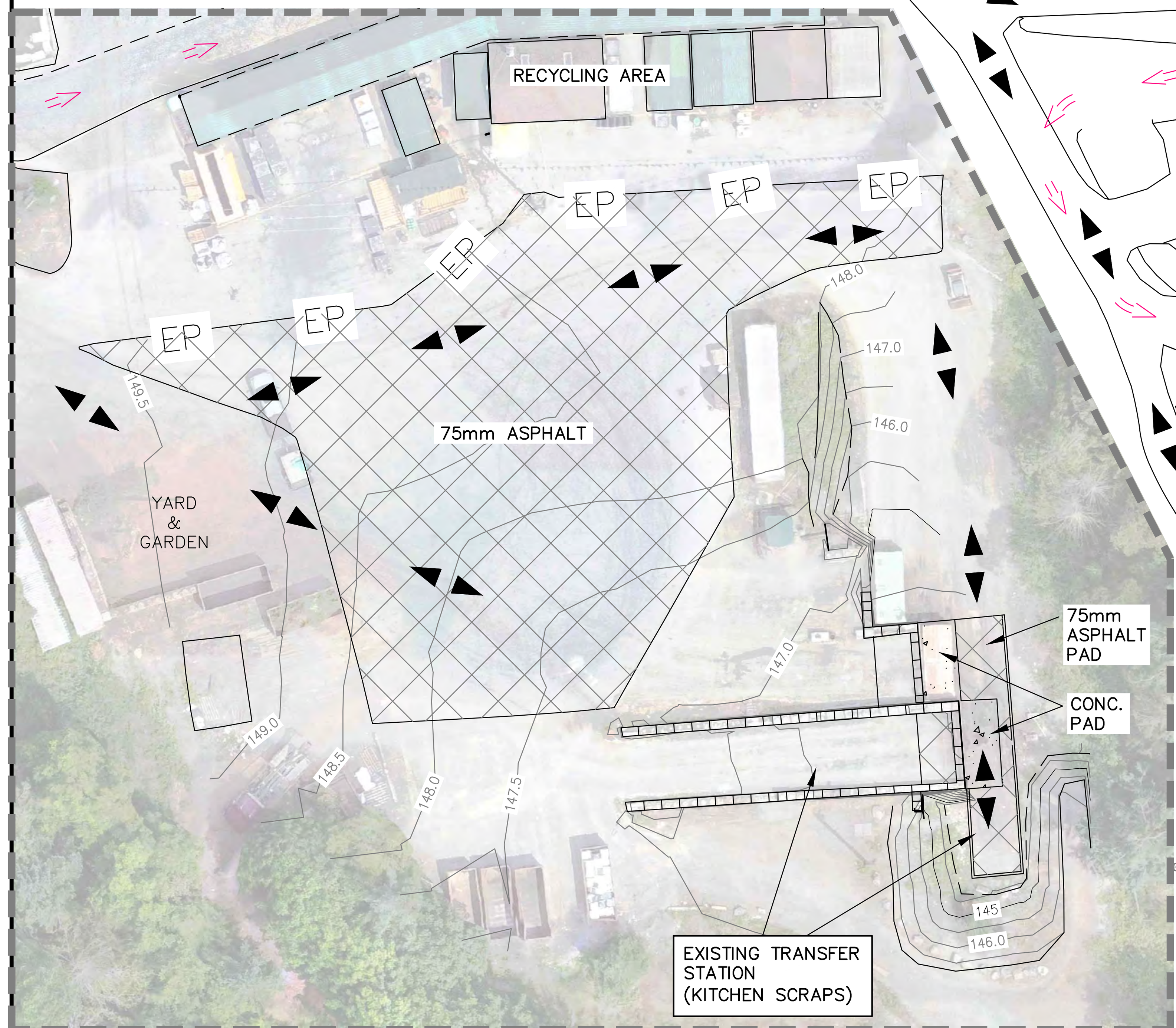
To receive the attachments for this Appendix A, proponents must become a Proponent of record by submitting the Receipt Confirmation Form (Appendix E).

- Attachment 1: Staff Report: Meeting the Solid Waste Management Plan Targets through Material Stream Diversion
- Attachment 2: 2022 Solid Waste Stream Composition Study
- Attachment 3: Shredded Composition & Demolition Waste at the Hartland Landfill
- Attachment 4: Pre-approval application for Renovation & Demolition Waste
- Attachment 5: Sprung Structure Drawings
- Attachment 6: Hartland Landfill Fire Safety Plan
- Attachment 7: Current Bird Storage Location
- Attachment 8: Technical specifications of the PVC membrane

14. Drawings

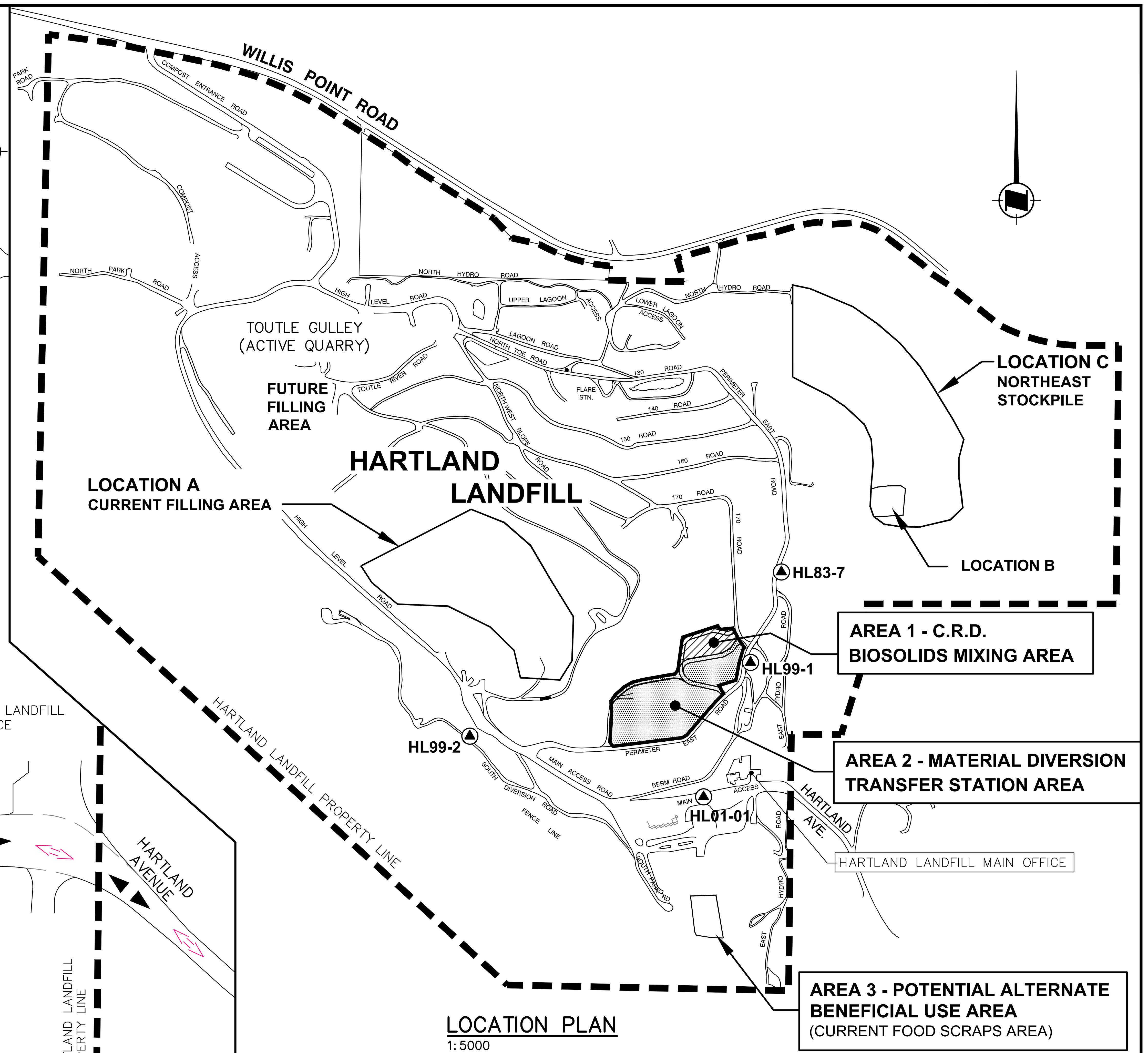
WORKSITE AREA SUMMARY TABLE	
DESCRIBED AREA:	AREA (m^2)
AREA 1 – C.R.D. BIOSOLIDS MIXING AREA	3,000
AREA 2 – MATERIAL DIVERSION TRANSFER STATION AREA	16,891
TOTAL AREA	19,891





INSET – AREA 3
1:400

VEHICLE ACCESS ROUTING
1:1000



LOCATION PLAN
1:5000

NOTES:

- CONTRACTOR TO COORDINATE WORKS WITH ENGINEER AT ALL PHASES OF CONSTRUCTION. ACTIVE LANDFILLING OCCURRING.
- ALL DETAIL SHOWN ON THESE DRAWINGS TO BE CONFIRMED IN THE FIELD.
- ANY ITEMS NOT SHOWN ON DRAWINGS TO BE REPORTED TO THE ENGINEER.
- ANY PORTION OF EXISTING LINER SYSTEM FOUND DAMAGED OR DAMAGED DURING CONSTRUCTION MUST BE REPORTED IMMEDIATELY TO THE ENGINEER.
- CONTRACTOR WILL REPAIR ANY DAMAGE TO EXISTING INFRASTRUCTURE.
- REMOVE DEBRIS AND VEGETATION WITHIN THE PROJECT AREA. DISPOSE OF WITHIN ACTIVE LANDFILLING AREA (CELL 3), OR AS DIRECTED BY THE ENGINEER.
- COORDINATES SHOWN ARE TO NAD83 UTM.
- ELEVATIONS ARE TO CANADIAN GEODETIC VERTICAL DATUM 28 (CGVD28) – METRES.
- EXISTING SURVEY MONUMENT COORDINATES AND ELEVATIONS (PER LOCATION PLAN):

MON. HL01–01	MON. HL83–7	MON. HL99–1	MON. HL99–2
N 5375706.614	N 5376053.443	N 5375913.974	N 5375800.291
E 466055.365	E 466175.318	E 466127.784	E 465694.922
ELEV. 150.032	ELEV. 162.585	ELEV. 171.022	ELEV. 186.376

LIST OF DRAWINGS

DWG. No.	TITLE
24–W1067–1	LOCATION PLAN, VEHICLE ACCESS ROUTING, TABLE OF CONTENTS AND GENERAL NOTES
24–W1067–2	DEDICATED BENEFICIAL USE AREA – GRAVEL GRADING PLAN, DETAIL AND COORDINATE TABLE
24–W1067–3	C.R.D. BIOSOLIDS MIXING AREA & MATERIAL DIVERSION TRANSFER STATION AREA – SITE PLAN, ACCESS ROAD PROFILE AND MANHOLE DETAIL
24–W1067–4	PROFILES AND DETAILS AND HEAT MAP

1:400 — 0, 8, 24m
1:1000 — 0, 20, 60m
1:5000 — 0, 100, 300m

ISSUE	DATE	BY	REVISION DESCRIPTION - COLUMN 1	ENG.	ISSUE	DATE	BY	REVISION DESCRIPTION - COLUMN 2	ENG.	SEAL	No.	DATE	ISSUE
											1	15/09/23	REQUEST FOR PROPOSAL

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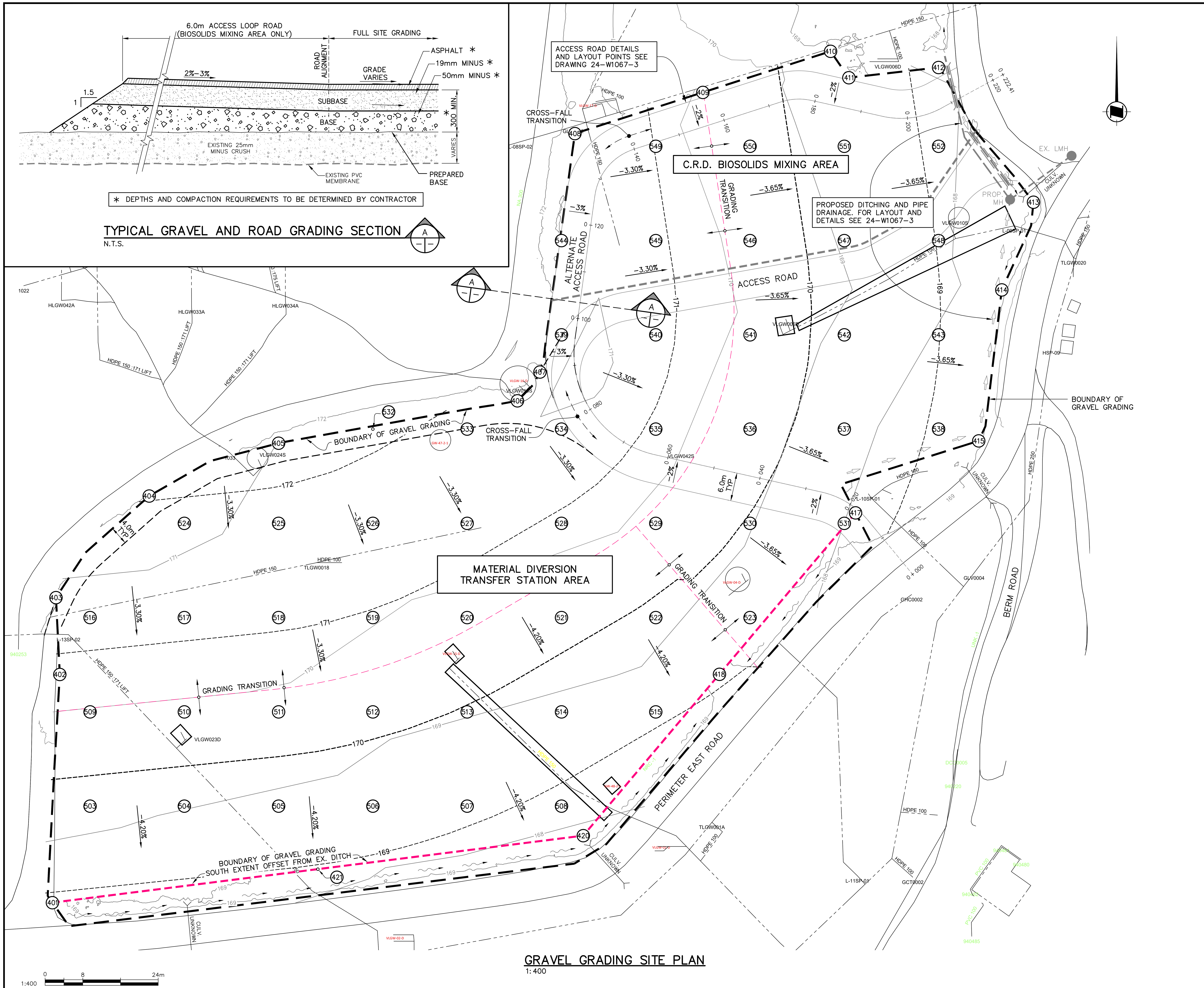
DRAWN	HL	START	11/07/23
SCALE HORIZONTAL	SHOWN	CHECKED	SR
SCALE VERTICAL		APPROVED	IW

HARTLAND LANDFILL
HARTLAND MATERIAL DIVERSION TRANSFER STATION AREA DEVELOPMENT
LOCATION PLAN, VEHICLE ACCESS ROUTING, TABLE OF CONTENTS AND GENERAL NOTES

PROJECT REFERENCE ERM2022–010 | DRAWING NUMBER 24–W1067–1 | ISSUE 1 | SHT. No. 1 OF 4



COORDINATE TABLE – TOP OF GRAVEL LAYOUT

Point #	Northing	Easting	Elevation	Description
401	5375789.515	465912.022	168.909	TOP OF GRAVELS – BOUNDARY
402	5375837.938	465913.593	170.855	TOP OF GRAVELS – BOUNDARY
403	5375854.239	465912.780	171.392	TOP OF GRAVELS – BOUNDARY
404	5375875.800	465932.559	172.033	TOP OF GRAVELS – BOUNDARY
405	5375887.000	465960.000	172.298	TOP OF GRAVELS – BOUNDARY
406	5375895.994	466010.666	171.801	TOP OF GRAVELS – BOUNDARY
407	5375902.104	466015.438	171.826	TOP OF GRAVELS – BOUNDARY
408	5375952.704	466022.857	171.531	TOP OF GRAVELS – BOUNDARY
409	5375961.436	466050.000	170.603	TOP OF GRAVELS – BOUNDARY
410	5375970.151	466077.088	169.578	TOP OF GRAVELS – BOUNDARY
411	5375964.559	466080.953	169.469	TOP OF GRAVELS – BOUNDARY
412	5375966.728	466100.000	168.770	TOP OF GRAVELS – BOUNDARY
413	5375938.133	466120.121	168.205	TOP OF GRAVELS – BOUNDARY
414	5375919.531	466113.399	168.521	TOP OF GRAVELS – BOUNDARY
415	5375887.492	466108.502	168.584	TOP OF GRAVELS – BOUNDARY
417	5375872.222	466082.387	169.293	TOP OF GRAVELS – BOUNDARY
418	5375837.975	466053.510	169.100	TOP OF GRAVELS – BOUNDARY
420	5375803.729	466024.632	168.495	TOP OF GRAVELS – BOUNDARY
421	5375796.622	465968.327	168.960	TOP OF GRAVELS – BOUNDARY
503	5375810.000	465920.000	169.731	TOP OF GRAVELS – GRID
504	5375810.000	465940.000	169.646	TOP OF GRAVELS – GRID
505	5375810.000	465960.000	169.562	TOP OF GRAVELS – GRID
506	5375810.000	465980.000	169.424	TOP OF GRAVELS – GRID
507	5375810.000	466000.000	169.170	TOP OF GRAVELS – GRID
508	5375810.000	466020.000	168.819	TOP OF GRAVELS – GRID
509	5375830.000	465920.000	170.567	TOP OF GRAVELS – GRID
510	5375830.000	465940.000	170.482	TOP OF GRAVELS – GRID
511	5375830.000	465960.000	170.397	TOP OF GRAVELS – GRID
512	5375830.000	465980.000	170.234	TOP OF GRAVELS – GRID
513	5375830.000	466000.000	169.944	TOP OF GRAVELS – GRID
514	5375830.000	466020.000	169.549	TOP OF GRAVELS – GRID
515	5375830.000	466040.000	169.125	TOP OF GRAVELS – GRID
516	5375850.000	465920.000	171.229	TOP OF GRAVELS – GRID
517	5375850.000	465940.000	171.163	TOP OF GRAVELS – GRID
518	5375850.000	465960.000	171.094	TOP OF GRAVELS – GRID
519	5375850.000	465980.000	170.944	TOP OF GRAVELS – GRID
520	5375850.000	466000.000	170.675	TOP OF GRAVELS – GRID
521	5375850.000	466020.000	170.274	TOP OF GRAVELS – GRID
522	5375850.000	466040.000	169.842	TOP OF GRAVELS – GRID
523	5375850.000	466060.000	169.478	TOP OF GRAVELS – GRID
524	5375870.000	465940.000	171.819	TOP OF GRAVELS – GRID
525	5375870.000	465960.000	171.747	TOP OF GRAVELS – GRID
526	5375870.000	465980.000	171.557	TOP OF GRAVELS – GRID
527	5375870.000	466000.000	171.246	TOP OF GRAVELS – GRID
528	5375870.000	466020.000	170.913	TOP OF GRAVELS – GRID
529	5375870.000	466040.000	170.508	TOP OF GRAVELS – GRID
530	5375870.000	466060.000	169.954	TOP OF GRAVELS – GRID
531	5375870.000	466080.000	169.428	TOP OF GRAVELS – GRID
532	5375890.000	465980.000	172.147	TOP OF GRAVELS – GRID
533	5375890.000	466000.000	171.815	TOP OF GRAVELS – GRID
534	5375890.000	466020.000	171.449	TOP OF GRAVELS – GRID
535	5375890.000	466040.000	170.926	TOP OF GRAVELS – GRID
536	5375890.000	466060.000	170.300	TOP OF GRAVELS – GRID
537	5375890.000	466080.000	169.613	TOP OF GRAVELS – GRID
538	5375890.000	466100.000	168.906	TOP OF GRAVELS – GRID
539	5375910.000	466020.000	171.786	TOP OF GRAVELS – GRID
540	5375910.000	466040.000	171.135	TOP OF GRAVELS – GRID
541	5375910.000	466060.000	170.464	TOP OF GRAVELS – GRID
542	5375910.000	466080.000	169.737	TOP OF GRAVELS – GRID
543	5375910.000	466100.000	169.009	TOP OF GRAVELS – GRID
544	5375930.000	466020.000	171.739	TOP OF GRAVELS – GRID
545	5375930.000	466040.000	171.088	TOP OF GRAVELS – GRID
546	5375930.000	466060.000	170.419	TOP OF GRAVELS – GRID
547	5375930.000	466080.000	169.698	TOP OF GRAVELS – GRID
548	5375930.000	466100.000	168.976	TOP OF GRAVELS – GRID
549	5375950.000	466040.000	170.986	TOP OF GRAVELS – GRID
550	5375950.000	466060.000	170.307	TOP OF GRAVELS – GRID
551	5375950.000	466080.000	169.585	TOP OF GRAVELS – GRID
552	5375950.000	466100.000	168.864	TOP OF GRAVELS – GRID

NOTES:

EXISTING GROUND SHOWN (TOP OF 25mm MINUS) IS NOT YET CONSTRUCTED AT TIME OF THIS GRADING DESIGN. POSITIONAL ACCURACY TO BE CONSIDERED AS SUCH. UPON COMPLETION OF PREPARATION OF THE 25mm EXISTING GROUND, A SURVEY WILL BE COMPLETED BY C.R.D. THEREFORE DESIGN SHOWN IS SUBJECT TO CHANGE.

INFERRED DEPTH OF EXISTING PVC LINER BELOW 'ASSUMED' EXISTING GRAVELS (DESIGN GRADING) IS 1.002m AVERAGE.

ISSUE	DATE	BY	REVISION DESCRIPTION - COLUMN 1	ENG.	ISSUE	DATE	BY	REVISION DESCRIPTION - COLUMN 2	ENG.	SEAL

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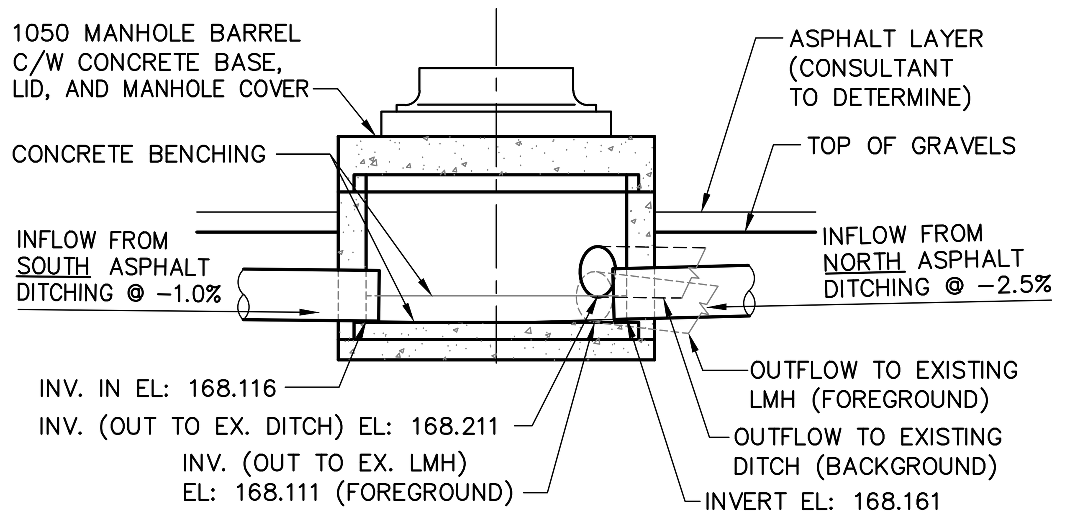
SCALE VERTICAL		APPROVED	IW

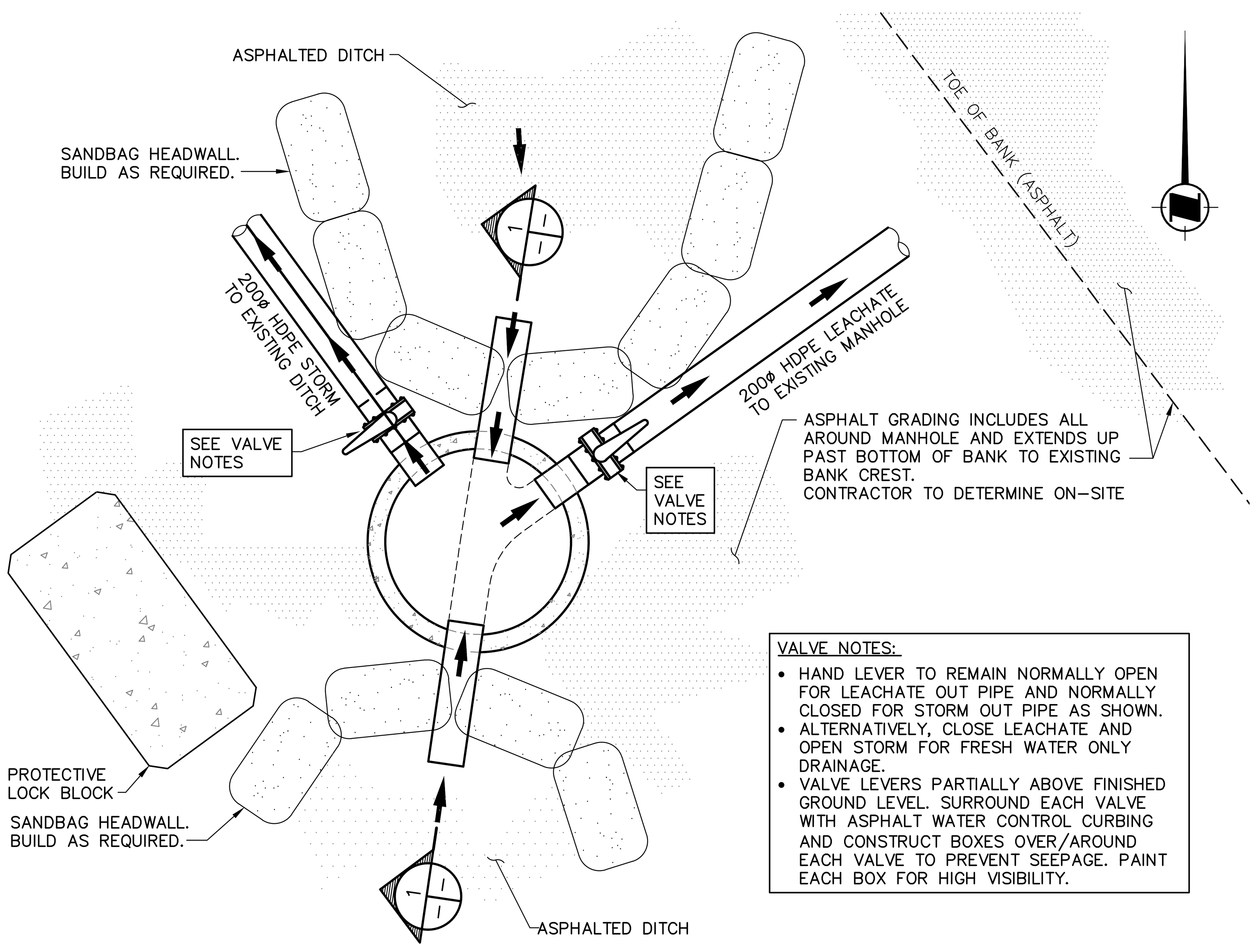
HARTLAND LANDFILL

HARTLAND MATERIAL DIVERSION TRANSFER STATION AREA DEVELOPMENT
GRAVEL GRADING PLAN, DETAIL AND COORDINATE TABLE

PROJECT REFERENCE ERM2022-010 | DRAWING NUMBER 24-W1067-2 | ISSUE 1 | SHT. No. 2 OF 4

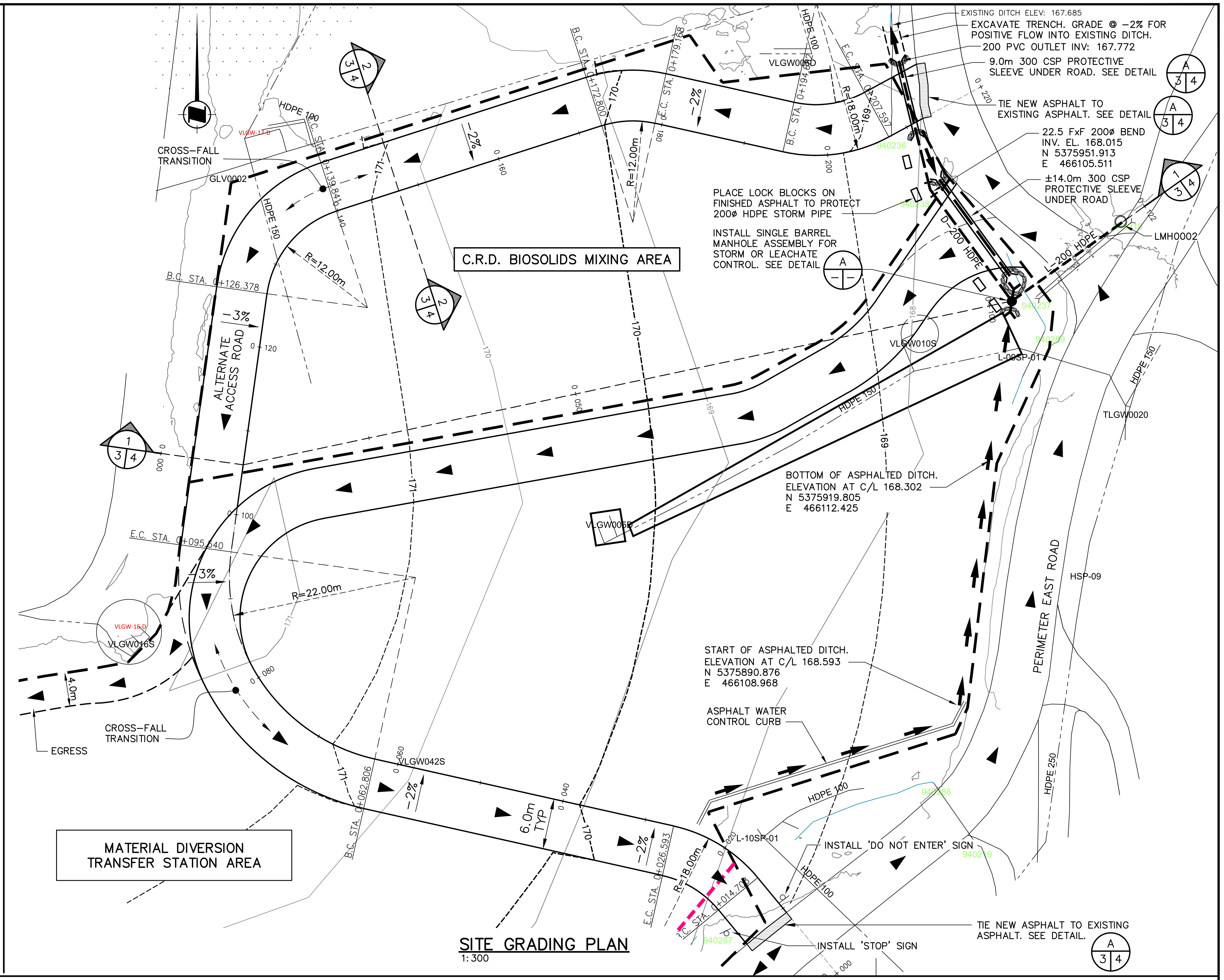


SECTION DETAIL 1 (1:25)

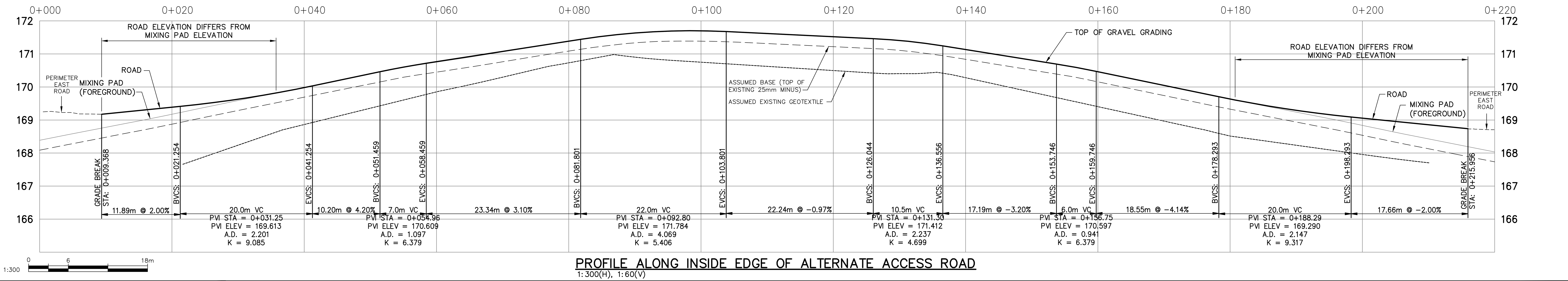


VALVE NOTES:
- HAND LEVER TO REMAIN NORMALLY OPEN FOR LEACHATE OUT PIPE AND NORMALLY CLOSED FOR STORM OUT PIPE AS SHOWN.
- ALTERNATIVELY, CLOSE LEACHATE AND OPEN STORM FOR FRESH WATER ONLY DRAINAGE.
- VALVE LEVERS PARTIALLY ABOVE FINISHED GROUND LEVEL. SURROUND EACH VALVE WITH ASPHALT WATER CONTROL CURBING AND CONSTRUCT BOXES OVER/AROUND EACH VALVE TO PREVENT SEEPAGE. PAINT EACH BOX FOR HIGH VISIBILITY.

MANHOLE DETAIL A (1:25)



SITE GRADING PLAN (1:300)



PROFILE ALONG INSIDE EDGE OF ALTERNATE ACCESS ROAD
1:300(H), 1:60(V)

No.	DATE	ISSUE
1	15/09/23	REQUEST FOR PROPOSAL

ISSUE | DATE | BY | REVISION DESCRIPTION - COLUMN 1 | ENG. | ISSUE | DATE | BY | REVISION DESCRIPTION - COLUMN 2 | ENG. | SEAL

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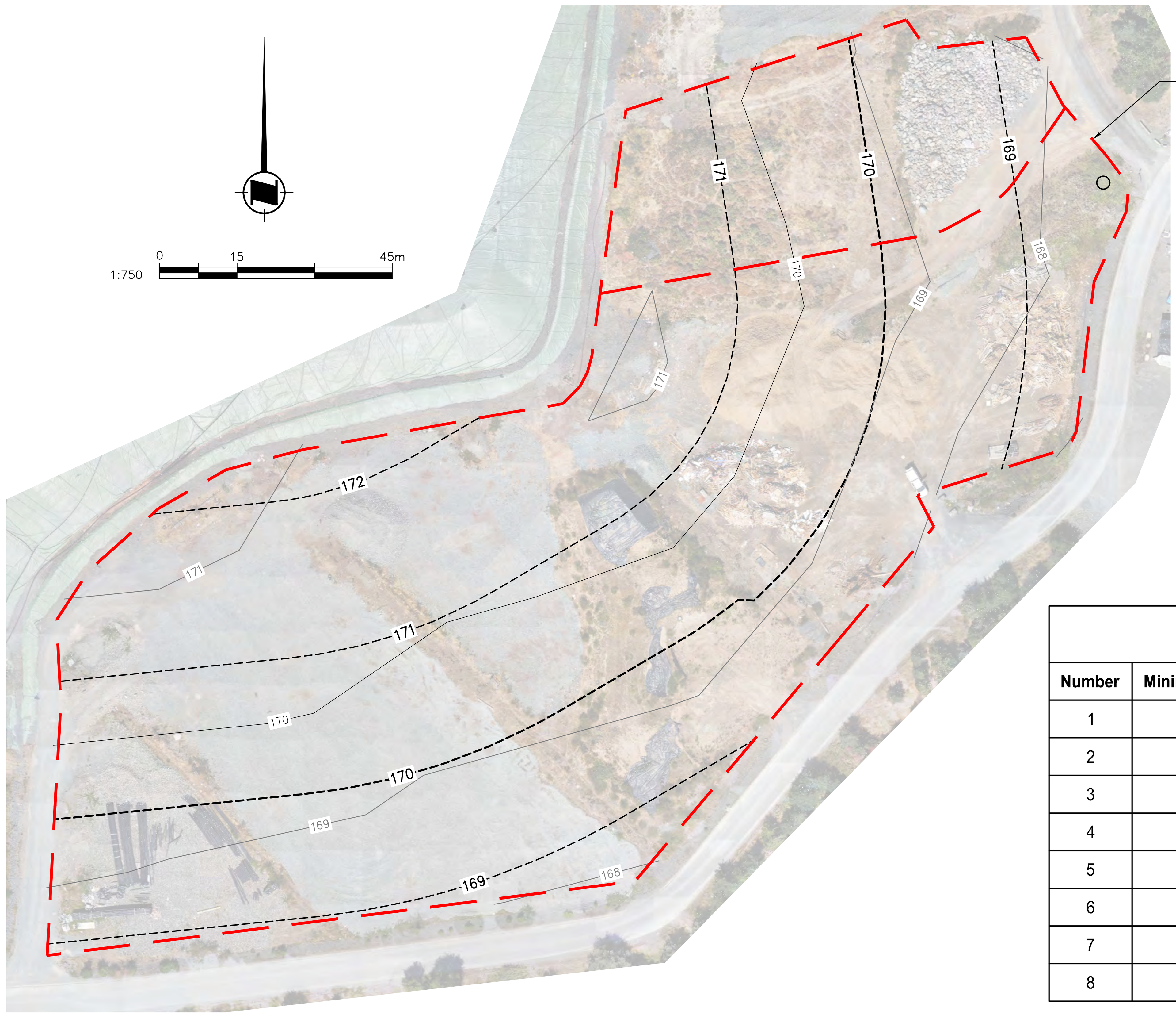
DRAWN	HL	START	11/07/23
SCALE HORIZONTAL	SHOWN	CHECKED	SR
SCALE VERTICAL		APPROVED	IW

HARTLAND LANDFILL

HARTLAND MATERIAL DIVERSION TRANSFER STATION AREA DEVELOPMENT
C.R.D. BIOSOLIDS MIXING AREA & MATERIAL DIVERSION TRANSFER STATION AREA – SITE PLAN, ACCESS ROAD PROFILE AND MANHOLE DETAIL

PROJECT REFERENCE ERM2022-010 | DRAWING NUMBER 24-W1067-3 | ISSUE 1 | SHT. No. 3 OF 4



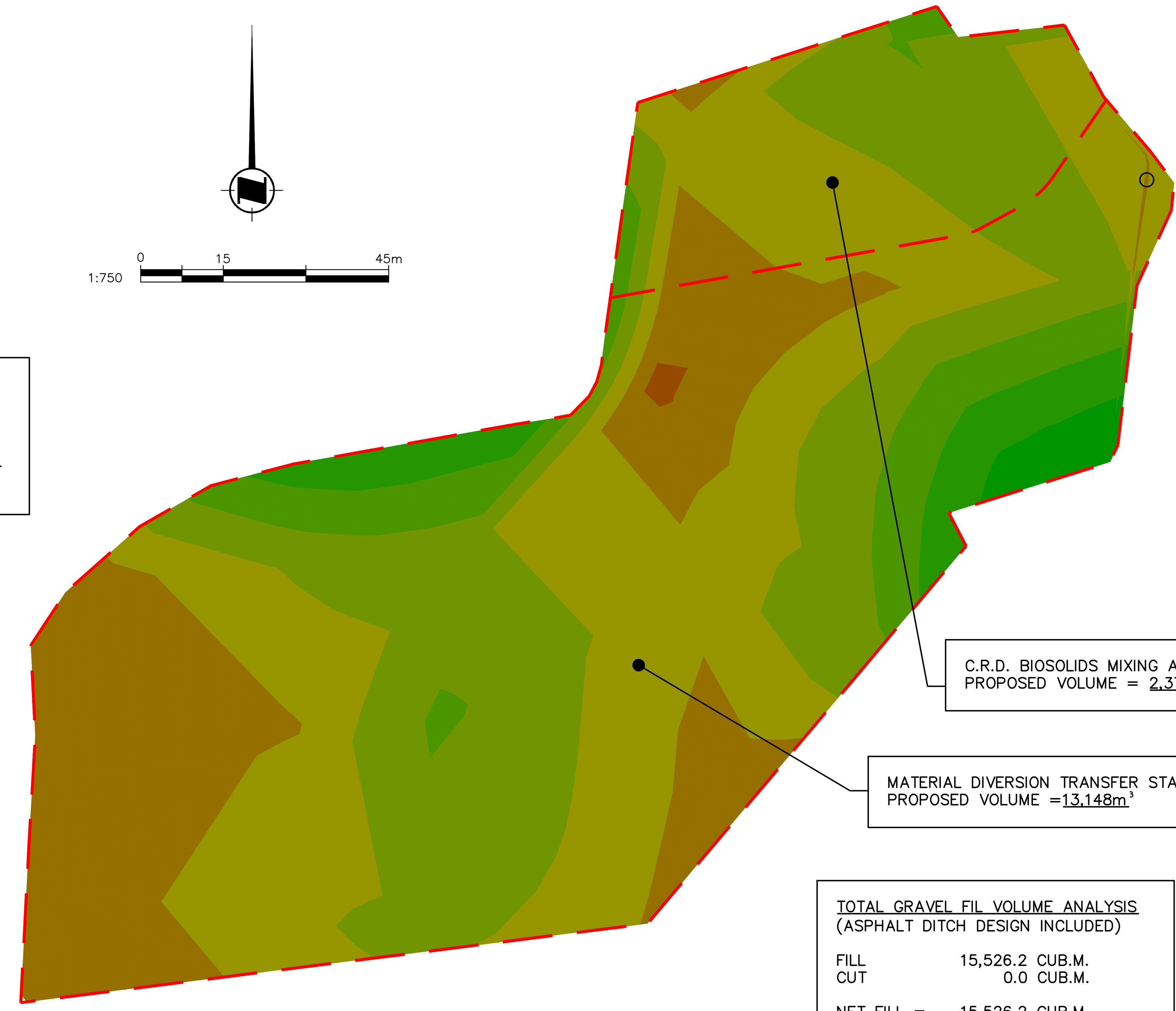
SITE PLAN – EXISTING TOPOGRAPHY
1:750

NOTE:
EXISTING GROUND SHOWN (TOP OF 25mm MINUS) IS NOT YET CONSTRUCTED AT TIME OF THIS GRADING DESIGN. POSITIONAL ACCURACY TO BE CONSIDERED AS SUCH. UPON COMPLETION OF PREPARATION OF THE 25mm EXISTING GROUND, A SURVEY WILL BE COMPLETED BY C.R.D. THEREFORE DESIGN SHOWN IS SUBJECT TO CHANGE.

Elevations Table

Number	Minimum Elevation	Maximum Elevation	Color
1	0.000	0.200	
2	0.200	0.400	
3	0.400	0.600	
4	0.600	0.800	
5	0.800	1.000	
6	1.000	1.200	
7	1.200	1.400	
8	1.400	1.630	

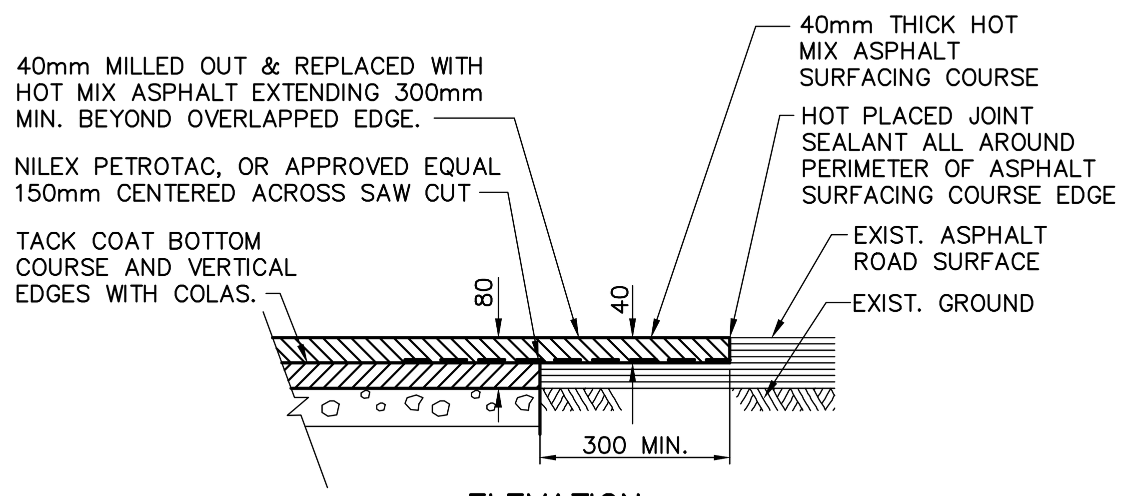
FILL REQUIRED TO MEET DESIGN



TOTAL GRAVEL FIL VOLUME ANALYSIS
(ASPHALT DITCH DESIGN INCLUDED)

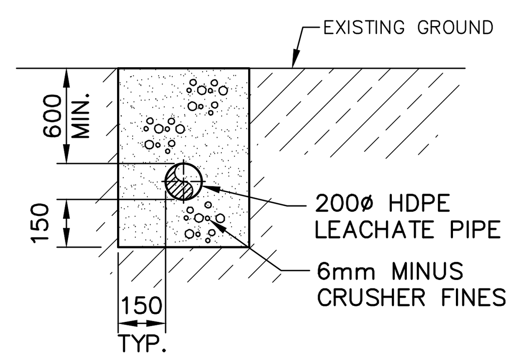
FILL	15,526.2 CUB.M.
CUT	0.0 CUB.M.
NET FILL =	15,526.2 CUB.M.

SITE PLAN – GRAVEL FILLING ANALYSIS
1:750



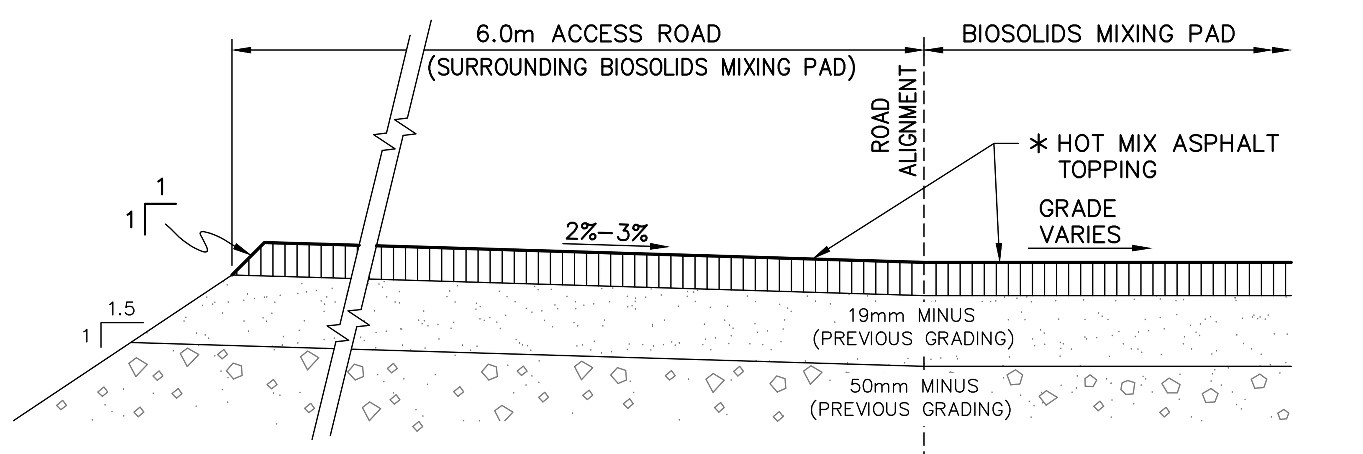
ELEVATION

TYPICAL NEW TO EXISTING ASPHALT CONNECTION DETAIL (A 3/4)
N.T.S.



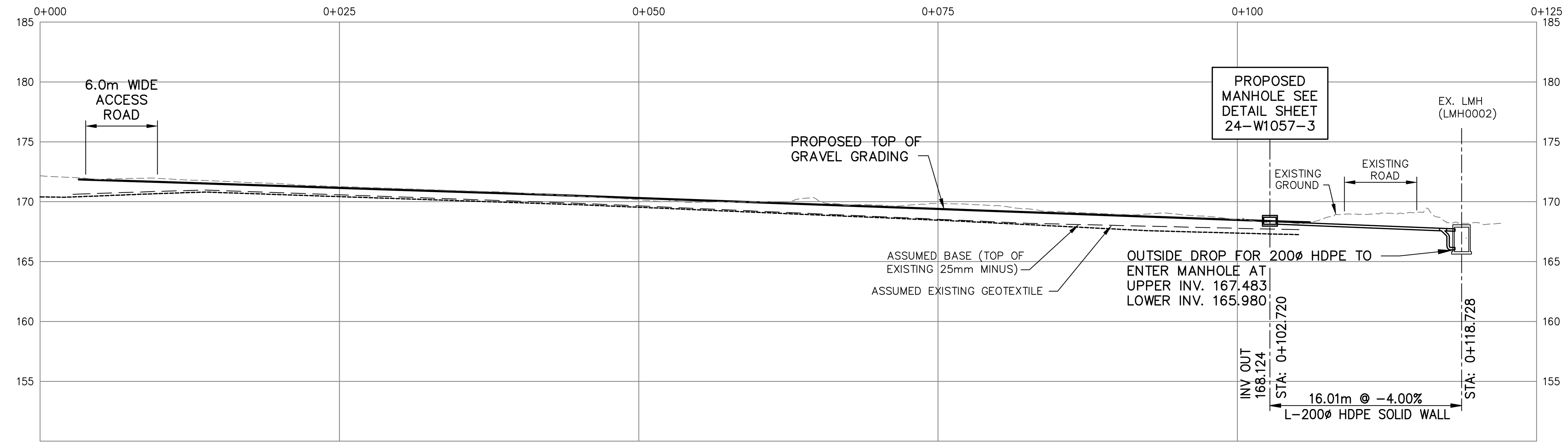
ELEVATION

TYPICAL LEACHATE TRENCH DETAIL
NTS



* CONTRACTOR TO DETERMINE ASPHALT THICKNESS, COMPACTION AND REQUIRED MATERIAL VOLUME

TYPICAL ASPHALT AND ROAD GRADING SECTION (2 3/4)
1:25



SECTION THRU C.R.D. BIOSOLIDS MIXING AREA (1 3/4)
1:300 (H&V)

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No.	DATE	ISSUE
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DRAWN	HL	START	08/09/23
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SCALE VERTICAL	SHOWN	APPROVED	IW

HARTLAND LANDFILL

HARTLAND MATERIAL DIVERSION TRANSFER STATION AREA DEVELOPMENT
PROFILES & DETAILS AND HEAT MAP

PROJECT REFERENCE ERM2022-010 DRAWING NUMBER 24-W1067-4 ISSUE 1 SHT. No. 4 OF 4

APPENDIX “B” – FORM OF PROPOSAL

Proposals must include the information outlined in this section. To facilitate evaluation, proposals should be organized as follows:

1. THE FIRM

1.1 Project Experience

Provide details of the firm’s experience with similar projects, including experience with:
- Material processing;
- Transportation/hauling coordination;
- Operations in waste facilities or similar.

1.2 Location of Firm

List the location(s) of the firm, both local and global if applicable.

1.3 Identify as First Nations

Confirm whether the Firm identify as First Nations and include:
- Experience working with First Nations
- Intention of including First Nations subcontractors for the proposed work.

2. THE PERSONNEL

Provide details of the proposed project team, including:
- Relevant experience.
- Provide a team organization chart, including any subcontractors. Outline each team member's role and their qualifications. Include resumes of key team members or subcontractor in an Appendix.
- Local knowledge.

3. THE METHOD

3.1 Project Understanding

In your own words, demonstrate your understanding of the project by summarizing the project requirements, identifying important aspects and needs.

3.2 Environment, Health and Safety

Provide details of your safety program and environmental management system. Describe how each will be implemented for this project both in construction and operations.

3.3 15% Design

Provide the following as part of a 15% preliminary design:
- Preliminary Site Layout (including usage of the Food Scraps area on an as needed basis if required)
- Preliminary Traffic Flow / Traffic Management Plan
- Preliminary Stormwater Management Plan

- Tie-in and Utility Requirements (if any)

3.4 Schedule

Provide a proposed progress schedule in the form of a bar graph indicating the start and completion times of the various project stages. Refer to "Submittal Form B- Schedule". The schedule should include:

- Key work activities and deliverables in terms of weeks after notification to award.
- Assumptions for review periods (i.e., documents submitted to the CRD for review and approval).
- Major Milestones

3.5 Operations and Maintenance Methodology

Provide a proposed operations and maintenance methodology, outlining your technical approach to address the projects 'Operations and Maintenance – Scope of Work' outlined in Schedule A. The methology should include but is not limited to:

- General description of material process flow (including usage of the Food Scraps area on an as needed basis if required)
- Onsite pre-processing equipment and requirements
- Approach to securing various End Use Options for pre-processed material
- A selection of current available End Use options. Include relevant experience with End Use options or End Users if available.
- Assumptions, issues, constraints, and other factors which may affect operations
- Any additional work that may be required to ensure success.

Preference may be given to responses that address additional items (requirements or approach) that were not specifically provided for in the scope of work but will add value to the project's overall success.

3. REFERENCES

Provide references for the firm and all key team members and subcontractors. Refer to "Submittal form C- References".

4. FINANCIAL PROPOSAL (ENVELOPE TWO)

Financial proposals shall be provided in a separate sealed envelope. The financial proposal envelopes will not be opened until after the technical evaluation of all proposals has been completed. The Financial Proposal will be evaluated based on the fee schedule and total upset prices submitted by the Proponent. Financial proposals shall include all commercial considerations including the following:

- State the legal name of the firm and authorized signature of individuals who will be responsible for the services:
  - Disbursements shall also be broken down and shown by work activity. Also provide subtotals by hours and by fees for each firm involved, if applicable. Refer to attached "Submittal Form A – Payment Terms".
  - Provide itemized costs of any services which will be varied or excluded from the present Scope of Services. Refer to attached "Submittal Form D – Excluded Services" and "Submittal Form E – Proposed Variation to the Scope of Services".

- Provide an itemized price for any other or additional services outside the present Scope of Services believed to be essential to completion of the project. Refer to attached “Submittal Form F – Other Services”.
- Pricing shall be in Canadian dollars, excluding 5% GST
- Rates shall be fixed for the duration of the contract except as explicitly noted in the contractor’s proposal.
- Travel disbursement for out-of-town personnel shall be quoted on the most economical travel methods.
- Fees are to be billed on an hourly basis. Fees and disbursements are to be billed to a maximum upset total price, except as provided for. State number of hours of work per day

6. SUBMITTAL FORMS

In addition to the information included within this Appendix B, Proposals must include the following submittal forms to be considered complete:

1. Submittal Form A: Payment Terms
2. Submittal Form B: Schedule
3. Submittal Form C: References
4. Submittal Form D: Excluded Services
5. Submittal Form E: Proposed Variation to the Scope of Services
6. Submittal Form F: Other Services

APPENDIX “C” – EVALUATION FORM

Capital Regional District
REQUEST FOR PROPOSALS

Processing, Utilization, On-Site Operations and Transportation of Source-Separated Materials from Hartland Landfill
RFP No. ERM2022-010

Evaluation of Technical Proposals
(Maximum 100 Points)

	POINTS	Proponents								
1. THE FIRM 1.1 Experience with similar projects:										
a) Material Processing	2									
b) Transportation/hauling coordination	2									
c) Onsite operations	2									
1.2 Location of firm	2									
1.3 Identify as First Nations	2									
TOTAL FIRM	**10**									
2. THE PERSONNEL 2.1 Project Team										
a) Experience	4									
b) Qualifications	4									
c) Local knowledge	2									
TOTAL PERSONNEL	**10**									

Evaluation Form, continued

	POINTS	Proponents								
Total Brought Forward										
3. THE METHOD										
3.1 Project understanding	2									
3.2 Health, Environment and Safety	2									
3.3 15% Design	6									
3.4 Schedule	2									
3.5 Operations & Maintenance Methodology	8									
TOTAL METHOD	**20**									
4. FINANCIAL PROPOSAL										
Capital Cost (CAPEX)	25									
Operating Cost (OPEX)	35									
TOTAL FINANCIAL	**60**									
TOTAL POINTS	**100**									

Capital Regional District Proponents Policy - Evaluation Procedures

Technical merit (the firm, the personnel and the method) is awarded a maximum of 40 points. Each technical presentation will be evaluated on the basis of the firm's experience, competence of its personnel and acceptability of the method proposed.

A firm's technical proposal shall be deemed qualified only if it complies with all requirements contained in the Request for Proposal.

Only proposals whose technical scores are within 15% of the proposal awarded the highest technical score will have their financial proposals opened and evaluated. All other financial proposals will be returned unopened upon appointment of the selected firm. The only exception to this policy is when the proposal of the second-ranked firm is more than 15% below the highest technical score and still technically qualified. In such a case, the second-ranked firm would have its financial proposal opened to avoid a non-competitive situation.

In all cases, the CRD reserves the right to cancel the competition and call for new proposals.

Financial proposals can be awarded a maximum of 60 points. The financial proposal with the lowest cost of fees will be awarded 60 points, which will be added to the technical score, resulting in the firm's total score. The percentage by which each of the remaining firms' proposed costs exceeds the cost of the lowest qualified proposal will be the percentage by which the 60 points is reduced, prior to adding it to the technical score resulting in each firm's total score.

For example, if the proposed cost of Firm A exceeds the lowest proposed cost (Firm B) by 10%, Firm A will add 60 minus (10% of 60), or 54 points to its technical score. The firm receiving the highest total score will be judged to have the best value to the Region.

COSTS INCLUDED IN PROPOSAL EVALUATION

All personnel fees, salaries, wages and reimbursable expenses will be taken into account in the proposal evaluation.

DEBRIEFING

Subsequent to final selection of a firm for contract award, all other proposing firms have the right to receive a debriefing on the strengths and weaknesses of their proposal. Points awarded by evaluation teams for both technical and financial proposals will remain confidential and may not be divulged to any proposing firm.

Minimum Technical Score

Technical proposals must achieve a score of at least 28 points (70%) to be considered “technically qualified”. Financial proposals for firms failing to achieve the minimum technical score will not be opened.

SCHEDULE “F”

VENDOR’S PROPOSAL

SCHEDULE "G"

VENDOR'S FEE PROPOSAL

APPENDIX "E" - RECEIPT CONFIRMATION FORM

Processing, Utilization, On-site Operations and Transportation of Source Separated Materials from Hartland Landfill

Request for Proposals No. ERM2022-010

Please complete this form and return it within five (5) working days from receipt to:

Allison Chambers
Parks & Environmental Services
Capital Regional District
625 Fisgard Street
Victoria, BC V8W 2S6
Telephone: 250.360.3084
Email: achambers@crd.bc.ca

Failure to return this form may result in no further communication regarding the Request for Proposals.

COMPANY: ______________________________

ADDRESS: ______________________________

CONTACT PERSON: ______________________________

CONTACT EMAIL: ______________________________

CONTACT PERSON: ______________________________

CONTACT EMAIL: ______________________________

PHONE: ______________________________

I have received a copy of the above-noted Request for Proposal, and (check one item)

☐ we will be submitting a proposal

☐ we will NOT be submitting a proposal

SIGNATURE: ______________________________

TITLE: ______________________________

DATE: ______________________________

SUBMITTAL FORM "A"
PAYMENT TERMS

CAPEX

The CRD will pay MDco for the Design and Construction of the MDTS through Milestone Payments. MDco shall provide the expected Milestone Payment amounts equal to the total CAPEX for the Project.

Table 1 – Design and Construction Payment Schedule

Milestone Payment	Amount	Estimated Payment Date
Approved Issued for Construction Design		
Asphalt Paving		
Equipment Delivery		
Construction Completion		
Total		

OPEX

The CRD will pay MDco for the Operation of the MDTS through a monthly Fixed Minimum and Variable Processing costs as outlined in the tables below.

Table 2 – Fixed Minimum Monthly Costs

Fixed Minimum Monthly Costs[1]	Unit Rate	Unit	Quantity	Total Costs ($)
Management Costs		$/month		$ -
Equipment Costs[2]		$/month		$ -
Staffing		$/month		$ -
Maintenance		$/month		$ -
Diesel		$/L		$ -
Electricity		NA		$ -
Potable Water		NA		$ -
Non-Potable Water		$/month		$ -
Total Fixed Minimum Monthly Costs				**$ -**

1. Fixed monthly costs assumes that end user contracts are secured. If end users are unavailable, the CRD retains the right to pause transfer service until end user contracts are in place.
2. MDco may recommend alternative delivery models for financing and owning equipment to maximize the value retention of equipment.

Table 3 – Variable Monthly Processing Costs

Variable Monthly Processing Costs	Unit Rate[1]	Unit	Quantity (tonnes)	Total Costs ($)
Clean Wood		$/tonne		$ -
Treated Wood		$/tonne		$ -
Asphalt Roofing Shingles		$/tonne		$ -
Carpet and Underlay		$/tonne		$ -
Books		$/tonne		$ -
Rigid Plastics (non-extended producer responsitility)		$/tonne		$ -
Waste to Active Area (Loading, Hauling/Transportation)		$/tonne		$ -
Total Variable Monthly Processing Costs				**$ -**

1. Includes Loading, Processing, Hauling/Transportation

Please note that the costs in Table 4 below is intended to provide indicative costing for the CRD, with the understanding that they are nonbinding to MDco for the purposes of this proposal.

Table 4 – Fixed Monthly End Use Costs

Fixed Monthly End Use Costs	End Use Options	End Use Option Unit Rate[1] ($/tonnes)	Range (tonnes)	Quantity (tonnes)	Total Costs ($)
Clean Wood			0 - 200		$ -
			> 200		$ -
			0 - 200		$ -
			> 200		$ -
Treated Wood			0 - 1000		$ -
			> 1000		$ -
			0 - 1000		$ -
			> 1000		$ -
Asphalt Roofing Shingles			0 - 300		$ -
			> 300		$ -
			0 - 300		$ -
			> 300		$ -
Carpet and Underlay			0 - 150		$ -
			> 150		$ -
			0 - 150		$ -
			> 150		$ -
Books			N/A		$ -
			N/A		$ -
Rigid Plastics (non-extended producer responsibility)			0 - 100		$ -
			> 100		$ -
			0 - 100		$ -
			> 100		$ -
Total Fixed Monthly End Use Costs					**$ -**

1. Includes End User Invoice and markup

Table 5 – Total Monthly Costs

Total Monthly Costs	Total Costs ($)
Total Fixed Minimum Monthly Costs	$ -
Total Variable Monthly Processing Costs	$ -
Total Fixed Monthly End Use Costs	$ -
Total Monthly Costs	**$ -**

Table 6 – Provisional Costs

Provisional Costs	Total Costs ($)
Rock Crushing ($/tonne) [1]	$ -

[1] Shot Rock will be available from the CRD at no cost to MDco for crushing and use on site. if beneficial to MDco.

SUBMITTAL FORM "B"
SCHEDULE

Provide a list of specific project activities and tasks in relation to the Scope of Services.

Provide a bar chart schedule which identities those project activities and tasks, and the duration of each activity and task.

The schedule shall include the key milestones noted in the RFP and should include:

- Key work activities and deliverables in terms of weeks after notification to award.
- Assumptions for review periods (i.e., documents submitted to the CRD for review and approval).
- Major Milestones

Identify submission of key project deliverables.

SUBMITTAL FORM "C"
REFERENCES

Provide at least five recent (within the last 10 years) references that show specific relevance to this project. Provide project name, project date/duration, project location, contract name, contact title/position, phone number and fax number.

Indicate names of key personnel (key team members and subcontractors) used on the referenced projects that will be involved on this project.

Sample Table

Project Name	Project Location	Project Date/Duration	Client Contract Name	Client Contract Title/Position	Client Contact Phone Number	Client Contact Email Address

SUBMITTAL FORM “D”
EXCLUDED SERVICES

Provide details of any services which will be excluded from the present Scope of Services and make reference to the sections mentioned. Provide itemized costs to be credited to the CRD.

Include time estimates of such excluded services.

The CRD reserves the right to accept any or all of the proposed exclusion of services.

SUBMITTAL FORM "E"
PROPOSED VARIATION TO THE SCOPE OF SERVICES

Summarize the proposed variations to the Scope of Services. Include benefits and/or capital cost savings from such variations. Provide cost or fee estimates of such variations to the Scope of Services.

The CRD reserves the right to accept any or all of the proposed variations.

SUBMITTAL FORM "F"
OTHER SERVICES

Provide details of any services which could be provided which are outside the current Scope of Services but are believed to be essential to the successful completion of the Project. Include time and costs estimates of such additional services.

The CRD reserves the right to accept any or all of the proposed other services.

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625 Fisgard Street, PO Box 1000
Victoria, BC, Canada V8W 2S6

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CAPITAL REGIONAL DISTRICT
PROCESSING AND UTILIZATION OF SOURCE-SEPARATED MATERIALS FROM HARTLAND LANDFILL
REQUEST FOR PROPOSALS ERM2022-010
ADDENDUM NO. 1

This letter shall serve as confirmation that the revisions included herein as Addendum No. 1 shall form part of the Request for Proposals (RFP) Documents for RFP No. ERM2022-010.

ADDENDUM NO. 1:

Revise the Request for Proposals as follows:

Instructions to Proponents

Delete: From Section 1.2 Closing Time and Date for Submission of Proposals

The CRD will accept physical copies of each proposal plus **one copy on a USB stick**, in accordance with the instructions contained herein, at the following specific physical location:

Attention: Allison Chambers
Senior Administrative Secretary
Environmental Resource Management

Address: Capital Regional District
625 Fisgard Street
Victoria, BC, V8W 2S6

On or before the following date and time (the "Closing Time"):

Time: 4:00 pm PST
Date: 16 October 2023

The CRD reserves the right to extend the Closing Time at its sole discretion.
Proposals must not be sent electronically.

Replace with:

The CRD will accept electronic copies emailed to achambers@crd.bc.ca or physical copies of each proposal plus **one copy on a USB stick**, in accordance with the instructions contained herein, at the following specific physical location:

Attention: Allison Chambers
Senior Administrative Secretary
Environmental Resource Management

Address: Capital Regional District

625 Fisgard Street
Victoria, BC, V8W 2S6

On or before the following date and time (the "Closing Time"):

Time: 10:00 am PST
Date: 31 October 2023

The CRD reserves the right to extend the Closing Time at its sole discretion.

Delete: From Section 1.6 Information Meeting and Site Visit

An information meeting will be hosted by the CRD Representative to discuss the CRD's requirements under this RFP, a site visit will also be hosted at this time. The information meeting and site visit are optional. **At the time of issuance of this RFP a meeting has been scheduled as follows:**

Date: 5 October 2023
Time: 2:00 pm to 4:00 pm PST
Location: In-person, Victoria, BC

To RSVP attendance, as well as receive the attachments for Appendix A, proponents must become a Proponent of record by submitting the Receipt Confirmation Form (Appendix E).

Replace with:

Section 1.6 Information Meeting, Site Visit and Collaborative Meetings

An information meeting will be hosted by the CRD Representative to discuss the CRD's requirements under this RFP, a site visit will also be hosted at this time. The information meeting and site visit are optional. **At the time of issuance of this RFP a meeting has been scheduled as follows:**

Date: 5 October 2023
Time: 2:00 pm to 4:00 pm PST
Location: In-person, Victoria, BC

To RSVP attendance, as well as receive the attachments for Appendix A, proponents must become a Proponent of record by submitting the Receipt Confirmation Form (Appendix E).

The CRD will make available certain personnel, consultants and advisors (the "***CRD Representatives***") to participate in collaborative discussions with the Proponents (the "***Collaborative Meetings***"). It is expected that Collaborative Meetings will be held via a virtual meeting platform with screen sharing capabilities, unless otherwise permitted at the discretion of the CRD. The CRD expects that Proponents will make available all necessary consultants to attend the Collaborative Meetings.

Unless otherwise agreed by the CRD, each Proponent will be granted a maximum of 2 hours of dedicated Collaborative Meeting time with the CRD. The purpose of the Collaborative Meetings is to provide a process that will assist the Proponents to develop optimal solutions for the Project while minimizing the risk that a Proponent's solution is unresponsive to this RFP, subject to ensuring equal access to relevant and significant information for all Proponents, and in particular:

1. to permit the Proponent to provide the CRD's Representatives with comments and feedback on material issues such as provisions of the Initial Agreement; and
2. to present potential solutions and approaches that the Proponent may be considering for various aspects of its Proposal.

Each Proponent should submit to the CRD a proposed Collaborative Meeting request (e.g., dates, duration and potential topics) by October 6, 2023 at 2:00 pm to permit the CRD to schedule its resources. The CRD will provide feedback on the proposed request and will schedule the agreed upon Collaborative Meetings with each Proponent.

At least three (3) Business Days in advance of each Collaborative Meeting, each Proponent should submit its proposed meeting agenda (including any consultants and advisors a Proponent would like in attendance from the CRD Representatives) and a list of prioritized issues the Proponent would like to discuss, and any materials relevant to such issues. The CRD may provide Proponents with comments on the agenda and a list of any prioritized issues the CRD would like to discuss.

If the CRD considers it desirable or necessary to offer more Collaborative Meeting hours to Proponents, the CRD may, in its discretion, amend the total hours allocated to each Proponent. The CRD expects the Collaborative Meetings to take place as follows:

a. the CRD will determine which CRD Representatives will be present at any Collaborative Meeting;

b. except as may be expressly stated otherwise in this RFP, including Section 4.8, the CRD will retain all information received from a Proponent during a Collaborative Meeting(s) as strictly confidential, and will not disclose such information to the other Proponents or any third party. The CRD may disclose such information to its consultants and advisors who are assisting or advising the CRD with respect to the Project;

c. at each Collaborative Meeting, a Proponent may have such officers, directors, employees, consultants and agents of the Proponent and the Proponent Team members present as the Proponent considers reasonably necessary for effective communication with the CRD and to fulfil the objectives of the Collaborative Meeting provided that the CRD may, in its discretion, limit the number of participants at any meeting.

d. to facilitate free and open discussion at the Collaborative Meetings, Proponents should note that any comments provided by or on behalf of the CRD during any Collaborative Meeting, including in respect of any particular matter raised by a Proponent or which is included in any documents or information provided by a Proponent prior to or during the Collaborative Meeting, and any positive or negative views, encouragement or endorsements expressed by or on behalf of the CRD during the Collaborative Meetings to anything said or provided by

Proponents, will not in any way bind the CRD and will not be deemed or considered to be an indication of a preference by the CRD even if adopted by the Proponent;

e. if for the purposes of the preparation of its Proposal a Proponent wishes to rely upon anything said or indicated at a Collaborative Meeting, then the Proponent must submit an inquiry describing the information it would like to have confirmed and request that the CRD provide that information to the Proponent in written form and, if such information relates to a clarification, explanation or change to a provision of this RFP or the Design-Build Agreement, request an Addendum to this RFP clarifying and amending the provision in question; and

f. by participating in the Collaborative Meetings, a Proponent confirms its agreement with these procedures and acknowledges that the meetings are an integral part of the Competitive Selection Process as described in this RFP and are in the interests of all parties.

Delete: From Section 2.1 Package

Each Proposal must be submitted using a two-envelope process. One envelope must contain the Proponent's price, fee schedule or cost of its Proposal and be clearly marked "Financial Proposal" and the other envelope must contain the balance of the Proposal and be clearly marked "Technical Proposal". Proposals must be in a sealed package and marked on the outside with the Proponent's name, title of the Project and RFP number.

Replace with:

Each Proposal must be submitted using a two-email or two-envelope process. One email or envelope must contain the Proponent's price, fee schedule or cost of its Proposal and be clearly marked "Financial Proposal" and the other email or envelope must contain the balance of the Proposal and be clearly marked "Technical Proposal". Physical proposals must be in a sealed package and marked on the outside with the Proponent's name, title of the Project and RFP number. Email subject line must be marked with the Proponent's name, title of the Project and RFP number.

Delete: From Appendix A Section 4. Purpose

Through this RFP, the CRD invites submissions from Proponents with the capacity, ability and experience to design, build and operate (onsite operations, transportation/hauling as required and management of end use contracts) a MDTS to be located at the Landfill intended for the reuse, recycle, repurpose, or otherwise beneficially process the five source-separated waste streams listed below that will be diverted from the Landfill's active face through upcoming landfill bans. The scope additionally includes design and construction of the subgrade and final asphalt surface for the entire BUA (MDTS and Biosolids Mixing Area) however the CRD will operate the Biosolids Mixing Area. The CRD's preference is to enter into a single agreement with a single entity who has the capacity, ability and experience to complete the above scope of work.

This RFP relates solely to the MDTS operations, and reuse, recycle, repurpose, or recovery of the selected source-separated waste streams from the Landfill. Participation in this RFP will not restrict Proponents from participating in other CRD procurements.

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625 Fisgard Street, PO Box 1000
Victoria, BC, Canada V8W 2S6

T: 250.360.3000
www.crd.bc.ca

Replace with:

Through this RFP, the CRD invites submissions from Proponents with the capacity, ability and experience to design, build and operate (onsite operations, transportation/hauling as required and management of end use contracts) a MDTS to be located at the Landfill intended for the reuse, recycle, repurpose, or otherwise beneficially process the five source-separated waste streams listed below that will be diverted from the Landfill's active face through upcoming landfill bans. The scope additionally includes design and construction of the subgrade and final asphalt surface for the entire BUA (MDTS and Biosolids Mixing Area) however the CRD will operate the Biosolids Mixing Area. The CRD's preference is to enter into a single agreement with a single entity who has the capacity, ability and experience to complete the above scope of work.

This RFP relates solely to the Specifications included in this Appendix A including MDTS design, build, operations, and reuse, recycle, repurpose, or recovery of the selected source-separated waste streams from the Landfill. Participation in this RFP will not restrict Proponents from participating in other CRD procurements.

Delete: From Appendix A Section 11: Schedule

The CRD's tentative and non-binding schedule is provided below. This reflects an estimate of the process timelines at this stage and is provided solely for the convenience of the Proponent(s). The CRD will review proposal responses and request follow up interviews with shortlisted proponents. The following is the CRD's anticipated schedule:

Request for Proposals Steps	Date
RFP - Issued	September 18, 2023
Information Meeting (Optional)	October 5, 2023
Proponent's Site Visit (Optional)	October 5, 2023
Question Period Close	October 6, 2023
RFP - Closing	October 16, 2023
RFP - Award	November 10, 2023
In Service Target Date	January 31, 2024

The CRD's preference is for MDTS to be operational and in service starting in January 2024. The CRD understands that site prep and equipment lead time may make this target date challenging. Proponents are encouraged to consider project delivery options that can allow for some materials processing (e.g., limited streams or volumes) to begin in January 2024, even in advance of the full construction of the MDTS.

Replace with:

The CRD's tentative and non-binding schedule is provided below. This reflects an estimate of the process timelines at this stage and is provided solely for the convenience of the Proponent(s). The CRD will review proposal responses and request follow up interviews with shortlisted proponents. The following is the CRD's anticipated schedule:

Request for Proposals Steps	Date
RFP - Issued	September 18, 2023
Information Meeting (Optional)	October 5, 2023
Proponent's Site Visit (Optional)	October 5, 2023
Deadline for Collaborative Meeting Request (Optional)	October 6, 2023 at 2:00 pm
Deadline for Collaborative Meeting	October 20, 2023
Question Period Close	October 20, 2023
Deadline for Issuing Addenda	October 24, 2023
RFP - Closing	October 31, 2023 at 10:00 am
RFP - Award	December, 2023
In Service Target Date	Quarter 1, 2024

The CRD's preference is for MDTS to be operational and in service starting in January 2024. The CRD understands that site prep and equipment lead time may make this target date challenging. Proponents are encouraged to consider project delivery options that can allow for some materials processing (e.g., limited streams or volumes) to begin in January 2024, even in advance of the full construction of the MDTS.

The CRD received the following questions regarding the RFP:

Question 1:
Please confirm that this RFP is for a design and build, as well as operations. The title of the RFP doesn't indicate design and build.

Response 1:
The RFP Design Construction and Operation Specifications are outlined in Appendix A. For clarity, this is a design, build and operate. Thanks for pointing out the inconsistency in the RFP title.

Question 2:
Can you extend the closing of this RFP to the end of October?

Response 2:
The closing date for the RFP has been extended per the above addendum.

Question 3:
We [Heritage Lumber adam@heritagelumber.ca] have interest in the Salvaged Wood component only, but I know proposals are preferred for all the materials. I anticipate the companies bidding on the other materials and full RFP don't know how to manage/handle the salvaged wood to sort what's of value, especially smaller dimensions that will be coming from Victoria's deconstruction policy. Is there room for two companies in the RFP due to this?

Response 3:
While RFP Section 3.6 allows for the services from this RFP to be divided amongst multiple vendors, the CRD's preference is to enter into a single agreement with a single entity with the

capacity, ability and experience to complete the full scope of work. This may require proponents to subcontract and/or develop partnerships with other vendors in responding to this RFP.

Question 4:
Can we arrange a commercially confidential/sensitive meeting with the CRD? Our bid team would greatly benefit from the opportunity to discuss the RFP with the CRD directly.

Response 4:
The CRD will meet with any proponent that requests a Collaboration meeting. See addendum to section 1.6 above.

All Proponents shall acknowledge receipt and acceptance of this Addendum No. 1 by signing and dating in the spaces provided below and submitting the signed Addendum with the Proposal. Proposals submitted without this Addendum may be considered incomplete.

September 27, 2023

____
PROPONENT - Please print name

________________________________ ________________________________
SIGNATURE DATE

RFP No. ERM2022-010

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CAPITAL REGIONAL DISTRICT
PROCESSING AND UTILIZATION OF SOURCE-SEPARATED MATERIALS FROM HARTLAND LANDFILL
REQUEST FOR PROPOSALS ERM2022-010
ADDENDUM NO. 2

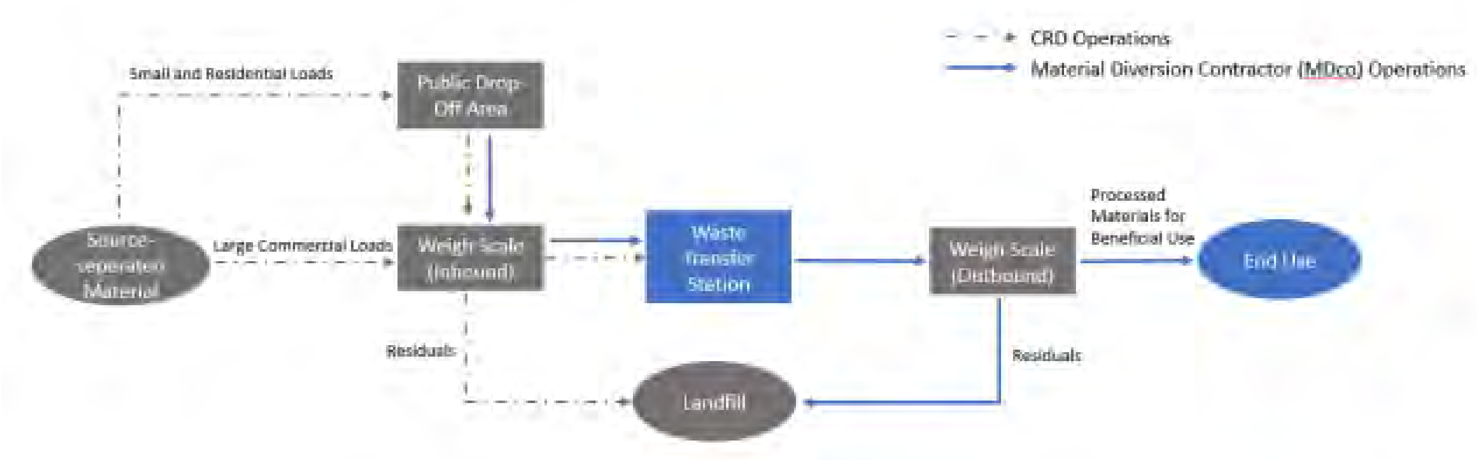
This letter shall serve as confirmation that the revisions included herein as Addendum No. 2 shall form part of the Request for Proposals (RFP) Documents for RFP No. ERM2022-010.

<u>ADDENDUM NO. 2:</u>

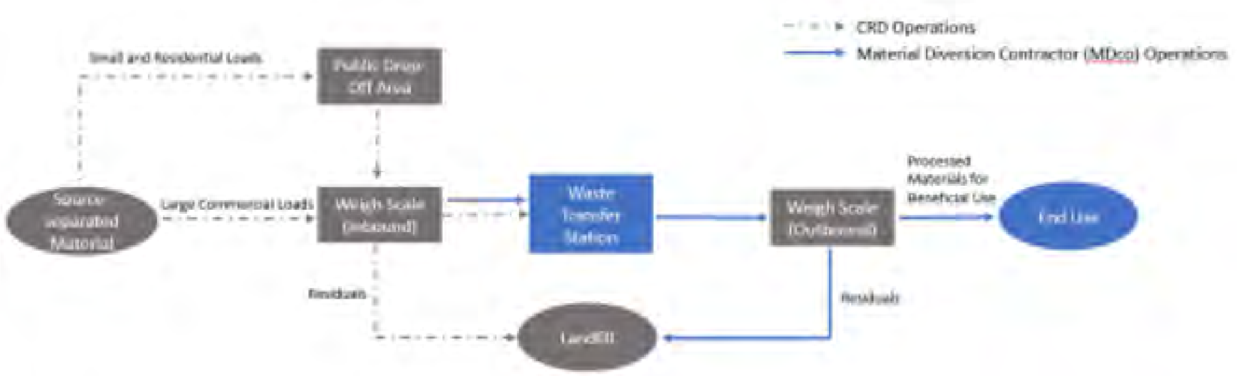
Revise the Request for Proposals as follows:

<u>Instructions to Proponents</u>

<u>Delete: from Appendix A Section 4 Purpose Figure 3</u>



<u>Replace with:</u>



<u>Delete: from Appendix A section 9. Operations and Maintenance</u>

a) All loading and transportation of material from the MDTS, Kitchen Scrap Area, Public Drop Off Area and/or any other area which MDco may source material for the MDTS. (Commercial customers will be directed to offload source-separated materials directly at the MDTS).

<u>Replace with</u>

a) All loading and transportation of material from the MDTS, Kitchen Scrap Area, and/or any other area which MDco may source material for the MDTS but excludes the transportation of source-separated materials from the Public Drop Off Area. (Commercial customers will be directed to offload source-separated materials directly at the MDTS).

<u>Delete: From Appendix A Section 13 Attachments</u>

13. Attachments

To receive the attachments for this Appendix A, proponents must become a Proponent of record by submitting the Receipt Confirmation Form (Appendix E).

- Attachment 1: Staff Report: Meeting the Solid Waste Management Plan Targets through Material Stream Diversion
- Attachment 2: 2022 Solid Waste Stream Composition Study
- Attachment 3: Shredded Composition & Demolition Waste at the Hartland Landfill
- Attachment 4: Pre-approval application for Renovation & Demolition Waste
- Attachment 5: Sprung Structure Drawings
- Attachment 6: Hartland Landfill Fire Safety Plan
- Attachment 7: Current Bird Storage Location
- Attachment 8: Technical specifications of the PVC membrane

Replace with:

13. Attachments

To receive the attachments for this Appendix A, proponents must become a Proponent of record by submitting the Receipt Confirmation Form (Appendix E).

- Attachment 1: Staff Report: Meeting the Solid Waste Management Plan Targets through Material Stream Diversion
- Attachment 2: 2022 Solid Waste Stream Composition Study
- Attachment 3: Shredded Composition & Demolition Waste at the Hartland Landfill
- Attachment 4: Pre-approval application for Renovation & Demolition Waste
- Attachment 5: Sprung Structure Drawings
- Attachment 6: Hartland Landfill Fire Safety Plan
- Attachment 7: Current Bird Storage Location
- Attachment 8: Technical specifications of the PVC membrane
- Attachment 9: Source-Separated Materials Available from the Cowichan Valley Regional Regional District
- Attachment 10: Technical Memorandum-Results of Waste Composition Study of Shredded Construction & Demolition Waste

Note: Attachment 9 is attached to this Addendum as Appendix A.

The CRD received the following questions regarding the RFP:

Question 1:
Referring to the biosolids mixing area, please confirm that surface water can go into the drainage ditch?

Response 1:
Yes, surface water from the biosolids portion of the Material Diversion Transfer Station (MDTS) can drain into a nearby ditch. Surface water can be toggled to leachate/stormwater and valves can be closed as needed to contain water within the footprint of the MDTS.

Question 2:
How long has the area been closed where the material diversion transfer station is to be located?

Response 2:
The area has been closed for approximately 30 years. The area has been used to store aggregate and settling of the ground has occurred.

Question 3:
Is there venting of landfill gas?

Response 3:
Active gas wells are present in the area of the MDTS and will be maintained by the CRD. There is no passive venting, the gas infrastructure is maintained under negative pressure.

Question 4:
Is there a measure of the subsidence in the area?

Response 4:
No there is no measure of settling, there are some constraints on loading and the integrity of the area must be maintained.

Question 5:
Can we be provided the lab sampling methods and dates for the shredded construction and demolition waste?

Response 5:
Please see Appendix B attachment 10, provided through this Addendum 2. Please let us know through the Inquiries process (Section 1.5 of this RFP) if you have further questions about the available data.

Question 6:
Can shot rock be processed where it is currently stored?

Response 6:
Yes, shot rock is currently stored just north of the area and can be crushed there and hauled to the MDTS for use.

Question 7:
How will the materials arrive on site and be processed?

Response 7:
The CRD expects that materials will arrive in dedicated loads to the landfill - see section 9.3 of the RFP for further information.

Question 8:
Will bylaw officers be present?

Response 8:
Yes, bylaw officers will be present at the MDTS site.

Question 9:
Will the contractor have access to CRD scales and scales staff?

Response 9:
Yes, the contractor can make use of the scales and CRD scales staff, in particular for internal hauling purposes. The contractor will have priority at the auto scales.

Question 10:
Can the contractor have access to CRD bins for the transportation of public loads?

Response 10:
The transportation of source-separated materials in CRD bins from the public drop of area is secured by another CRD contractor. As per this addendum, section 9a) from RFP Appendix A, the transportation of material from the Public Drop Off Area has been removed from the scope of this RFP.

Question 11:
We acknowledge that the RFP ERM2022-010 states in section 4.2 that proponents are solely responsible for their own expenses in preparing and submitting proposals, but we kindly request clarification regarding the possibility of reimbursement for proposal preparation costs. Given the complexity of the RFP, which includes a design, build and operation contract, this proposal necessitates not only proponent resources and staff time, but also the engagement of external experts, engineers, consultants and other professionals. Would the CRD be open to considering this reimbursement request?

Response 11:
As per section 4.2 of the RFP, proponents are solely responsible for their own expenses in preparing, submitting Proposals, and for any meetings, negotiations or discussions with the CRD or its representatives and contractors relating to or arising from this RFP.

Question 12:
Can I visit the site with my subcontractor?

Response 12:
Yes. To arrange for a site visit, please contact Allison following the Inquiries process (section 1.5) of the RFP.

All Proponents shall acknowledge receipt and acceptance of this Addendum No. 2 by signing and dating in the spaces provided below and submitting the signed Addendum with the Proposal. Proposals submitted without this Addendum may be considered incomplete.

October 12, 2023

____
PROPONENT - Please print name

____
SIGNATURE

____
DATE

RFP No. ERM2022-010

Source-Separated Materials Available from the Cowichan Valley Regional District

The Cowichan Valley Regional District (CVRD) operates three waste transfer stations but does not have a local landfill, solid waste is transported off-site to Washington State. The CVRD is continually looking to increase diversion rates and reduce solid waste volumes. However, due to the comparatively smaller population of the district, the volumes of potentially divertible material are more limited. By combining CVRD tonnages with those of the Capital Regional District (CRD), the CVRD hopes to gain more interest from prospective haulers and processors and potentially reduce costs to the CVRD.

CVRD recycling centres provide a one-stop-drop recycling collection point for residential materials related to all provincial Extended Producer Responsibility diversion programs including used oil and antifreeze, batteries, electronics, appliances, and outdoor power equipment. Outside of the provincial programs, the CVRD also provides collection of couches, mattresses, rubble, and clean and painted wood at the recycling centres. The CVRD would like to expand this already robust program to include carpet and underlay, asphalt shingles, and potentially books, and rigid plastics.

The CVRD landfilled 44,188 tonnes of material in 2022 and diverted 40,269 tonnes of material (including food organics). In addition to asphalt roofing shingles and carpet and underlay, the CVRD would like to consider the option to divert rigid plastics and books. While the CVRD does not have tonnages available for these streams, a waste composition study completed in 2017 identified that 4.7% of the residential garbage collected consisted of non-beverage rigid plastic packaging and durable plastic products.

The CVRD operates three recycling centres where garbage and recyclable materials are collected through public drop off:

Recycling Centre	Address	Hours
Bings Creek Recycling Centre	3900 Drinkwater Rd, Duncan.	Daily from 8 to 5 except Statutory holidays
Peerless Recycling Centre	10830 Westdowne Road, Ladysmith	April 1 to October 31 Wed to Sun 9 to 5 November 1 to March 31 Wed, Sat, Sun 9 to 5
Meade Creek Recycling Centre	8855 Youbou Rd, Lake Cowichan	April 1 to October 31 Tues, Wed, Sat, Sun 9 to 5 November 1 to March 31 Wed, Sat, Sun 9 to 5

Technical Memorandum

10 October 2023

To	Liz Ferris	**Contact No.**	250-360-3643
Copy to	Deacon Liddy	**Email**	lferris@crd.bc.ca
From	Laura Hnatiuk	**Project No.**	12590255
Project Name	Technical Advisor - Biosolids Beneficial Use and Resource Recovery Strategies		
Subject	Results of Waste Composition Study of Shredded Construction & Demolition Waste		

1. Introduction

The Capital Regional District (CRD) is undertaking a construction and demolition (C&D) waste shredding pilot at the Hartland Landfill. The purpose of the shredding trial is to understand the costs, impact on operations, and potential for preservation of Landfill airspace by reducing bulk. A waste composition study was undertaken to quantify and characterize the shredded C&D material. Understanding the composition and key specifications such as energy content, presence of chemicals, and particle size will be used to determine potential alternative end uses and support the development of the CRD's Resource Recovery Strategy.

Shredded C&D waste samples were collected at the Hartland Landfill and sent to GHD to undertake an asbestos test (performed by ALS Environmental), physical audit, waste characterization, and identification of three samples for further lab analysis. A total of seventeen (17) samples were obtained by CRD Landfill operators over a four-week period, from December 6th to December 31, 2022, which were included in the audit.

1.1 Purpose of this Memorandum

The primary objective of this Technical Memorandum is to summarize and present the results of the shredded C&D waste audit and characterization study, and results of the lab analysis based off of the Lafarge specifications for end use as low carbon fuel. The methodology and physical profile are discussed in the following sections. Data and field notes are provided in Attachment 1, and a photo log is provided in Attachment 2.

1.2 Scope and limitations

This technical memorandum has been prepared by GHD for Capital Regional District. It is not prepared as, and is not represented to be, a deliverable suitable for reliance by any person for any purpose. The matters discussed in this memorandum are limited to those specifically detailed in the memorandum and are subject to any limitations or assumptions specially set out.

2. Methodology

2.1 C&D Waste Sample Collection Methodology

Representative samples of shredded C&D materials were collected by CRD Landfill operators as follows:

1. CRD purchased 20 litre lidded buckets to store samples.
2. A designated CRD Landfill operator pulled contents from an area of the shredded C&D pile and placed the contents into one bucket.
3. The bucket was labelled with the date, lidded, and stored at secure location at the landfill.
4. One bucket of material was collected per day.
5. Steps 2 to 4 were repeated for a total of 17-days.

The buckets were stored until all 17 samples were collected. After collection, the CRD shipped the buckets to the GHD office in Vancouver. The buckets were received by GHD on January 1, 2023.

2.2 Asbestos Screening Methodology

The inbound C&D waste used in the shredding trial was prohibited to contain asbestos and was pre-screened by the CRD. However, an asbestos test was undertaken to confirm the materials were free of asbestos prior to undertaking the audit. A health and safety plan attached in Attachment 3 was developed to perform the asbestos test and waste audit. GHD reviewed WorkSafeBC's guidance documents in handling asbestos and donned the appropriate personal protective equipment (PPE) as a precautionary measure.

On January 23, 2023, a composite sample was obtained from the 17 buckets to test for asbestos as per the following:

1. One bucket was opened, and its contents were placed onto a tray.
2. The tray was agitated and tilted such that fines accumulated at the bottom edge of the tray.
3. A portion of the fines was obtained and transferred into a double-layered HDPE bag.
4. The contents on the tray were placed back into their respective bucket.
5. Steps 1-4 were repeated for each bucket until a composite sample was created.

The composite sample was sent to ALS Environmental for asbestos testing. The results were received on Jan 27^{th}, 2023. Asbestos was deemed non-detectable at the 0.25% (w/w) limit of reporting. A copy of the asbestos test results is included in Attachment 4.

2.3 Waste Audit Methodology

The waste audit was performed by GHD on February 1 and 2, 2023. The steps were completed in the following sequence:

1. A data collection sheet was created in Excel to record the composition results.
2. GHD purchased thirty sorting pails, two tables, three large trays, disinfectant, and one Starfrit electronic scale (model 93016). The scale was precise up to 1 gram (g) increments.
3. A workstation was setup by placing the sorting pails/trays, scale, and a laptop onto the tables.
4. The weight of one sorting pail was recorded and logged into the data sheet.
5. The contents of one sample bucket were then placed onto a tray, and a photo was captured of its mixed composition.
6. Materials from the mixed composition tray pile were separated into sorting pails.

7. Bulky contents were separated until the pile was reduced to 10 mm to 25 mm shreds.
8. The shreds were placed into a separate sorting pail. The fines remaining in the mixed composition tray were then placed into a separate sorting pail.
9. A photo was captured of the sorted sample bucket components in their respective sorting pails. Interesting miscellaneous material finds were photographed.
10. Each sorting pail and its components were weighed on the scale. The mass of the sorting pail was subtracted from the mass displayed on the scale via Excel, and the resulting mass was logged in the data sheet.
11. Steps 5 to 10 were repeated for 16 buckets. Field notes on certain bucket characteristics were noted in the data sheet.
12. A photolog was generated and is included in Attachment 2.

2.4 Lab Analysis Methodology

The CRD is seeking information on the energy and chemical content, and particle size within the C&D materials deposited at Hartland, based off of specifications for use as an alternative solid fuel in cement plants. Three buckets were sent for lab analysis based on the lowest (844 g in sample from December 29), closest to average (1,541 g in sample from December 13), and highest wood and plastic contents (3,105 g in sample from December 31). A copy of the lab results is attached as Attachment 5.

The specifications typically require chemistry criteria be met to qualify for potential use as alternative solid fuel. This criterion was provided by Geocycle, included in Attachment 6, and outlines the typical chemistry specifications for low carbon fuel use in cement plants. No generally agreed upon limit values exist, as different criteria are applied depending on the local context in regard to the receiving plant and their regulatory authorities.

The buckets were sent to ALS Environmental to test for the following parameters:

– Sieve screening: 4”, 3”, 2” sizes
– Proximate & Ultimate Analysis
– Calorific Analysis
– Chlorine Content
– Total Metals
– Mercury Content

3. Results & Discussion

The waste audit data and field notes are attached in Attachment 1. It is important to note the following limitations to the data. Sixteen out of seventeen bucket samples were sorted, as the sample dated December 19 was not audited due to heavy moisture. A photo of this sample and its sorted bulk contents is included for visual inspection in Attachment 2. Moreover, the accumulation of dust, dirt, mould, and water on the surface of wood contents and the small material sizes created challenges in identifying clean or treated wood. Consequently, wood content was separated into the following categories: non-painted wood, painted/finished wood, and plywood/particle board.

Table 1 in Attachment 1 depicts an overall summary of all the sample contents combined by mass and proportion. Minimum and maximum columns for each major material category are included to show the variance between bucket samples. For example, the minimum amount of wood observed within a sample was 569 g (15.1% of the sample) and the maximum was 2173 g (60.7% of the sample).

Table 2 in Attachment 1 presents the mass and proportion waste category results by each sample. Wood content was lowest (569 g) in the December 29 sample and highest (2173 g) in the December 7 sample. The average wood content based on all the samples combined was 1105 g per sample, with the December 23 sample containing wood content closest to the average (1080 g).

Figure 1 in Attachment 1 visually presents the summary table data. The C&D sample contents are mostly composed of wood (38.8%), plastic (14.5%), and shreds/fines (19.4%). Shreds were categorized as 10 mm to 25 mm pieces deemed too small to characterize. Figure 2 depicts the proportion of high heating value (HHV) materials (wood and plastic) within all the samples combined. Wood/plastic materials compose 65.5% of the sample contents, with the remaining 34.5% being non-wood/plastic materials. Figure 3 depicts the variance in composition and weight of each sample. As shown by Figure 3 and the photolog, the samples were not consistent in terms of composition and condition.

The lab results from the shredded C&D materials are compared for each criteria, and presented in Table 3.1 below.

Table 3.1 Lab Analysis and Alternative Fuel Criteria Comparison

Criteria[1]	Typical Limit(s)	Sample Lab Results		
		December 13	December 29	December 31
Heat Value	– Typical heat values in the range of 15-30 MJ/kg. – No less than 13 MJ/kg.	– 10.6 MJ/kg	– 17.5 MJ/kg	– 14.8 MJ/kg
Particle Size	– Maximum 5% passing 450 microns' screen – No larger than 1.5" for three dimensional pieces. – No larger than 2" for two dimensional pieces.	– 77% (wt./wt.) of contents are larger than 2"	– 97% (wt./wt.) of contents are larger than 2"	– 96% (wt./wt.) of contents are larger than 2"
Contamination[2]	– Should be as free of contamination as possible (i.e., rocks, dirt, metals, other non-combustible materials).	– 16% (wt./wt.) of contents are non-combustible	– 0% (wt./wt.) of contents are non-combustible	– 1.4% (wt./wt.) of contents are non-combustible
Moisture	– Maximum 20% (lower is better).	– 18.25%	– 15.66%	– 32.20%
Ash	– Maximum 20% (lower is better)	– 38.33% (as received) – 46.64% (moisture free)	– 47.78% (as received) – 55.38% (moisture free)	– 18.36% (as received) – 21.27% (moisture free)
Sulfur	– Maximum 1%	– 1.41%	– 0.52%	– 0.48%
Chlorine	– Maximum 0.10%	– 0.10%	– 0.15%	– 2.21%

[1] The chemistry requirements are a guideline only, and there may be additional flexibility or restrictions (e.g., volume, price, etc.).

[2] Contamination was not analysed by the lab. Resultant weight fractions of non-combustible materials were calculated from field data.

4. Key Findings & Conclusions

GHD concluded the following based on the lab analysis results:

– **Calorific Content:** Heat values were within range for two out of three lab samples. There is potential to use CRD's shredded C&D waste as an alternative fuel in cement manufacturing.
– **Chlorine Content:** Two out of three lab samples did not meet typical criteria for chlorine content.
– **Particle Size:** All three lab samples did not meet typical criteria for particle size. Additional shredding pre-treatment may be needed depending on the receiving plant's size specifications.
– **Moisture:** One out of three lab samples did not meet typical criteria for moisture content. Additional drying pre-treatment may be needed depending on the receiving plant's moisture specifications.
– **Ash:** All three lab samples did not meet the criteria for maximum ash content, with the exception of one moisture free sample.
– **Sulfur:** Two out of three lab samples met the criteria for maximum sulfur content.

Attachments

Attachment 1

Data, Figures and Field Notes

Date(s): **Feb 1st 2023, Feb 2nd 2023**

Auditor(s): **Abram Robiso, Anastassia Alexeeva, Jason Wilson**

Notes:

(1) General - Difficult to discern between treated and untreated wood due to moisture, dirt, and weathering.
(2) General - Shreds category refers to 10mm to 25mm pieces too small to characterize. Composed of mostly wood, plastic, and sand/dirt.
(3) Dec 7 - Painted wood included nails.
(4) Dec 8 - High water content.
(5) Dec 10 - Weight data for paper materials distorted due to water.
(6) Dec 17 - High water content. Fines dissolved in water.
(7) Dec 19 - Components not weighed. Picture of bulky sorted materials included in photolog for visual inspection.

Table 1 - Summary of All Samples

Major Category	Min. Grams Observed	Max. Grams Observed	Total Grams	Min. % Observed	Max. % Observed	% of Total
Flooring & Insulation	0	377	2,970	0	14.6%	6.5%
Wood	569	2173	17,728	15.1%	60.7%	38.8%
Masonry	0	327	1,661	0	8.1%	3.6%
Plastic	86	954	6,602	4.2%	24.4%	14.5%
Glass	0	9	16	0	0.2%	0.0%
Metals	0	393	1,624	0	9.8%	3.6%
Paper	0	573	2,645	0	15.9%	5.8%
Textiles	0	625	2,609	0	34.2%	5.7%
Misc./Other	0	279	932	0	8.8%	2.0%
Shreds/Fines	0	3564	8,847	0	71.4%	19.4%
Total Weight (g)	45,634					

Figure 1 - Composition of All Samples

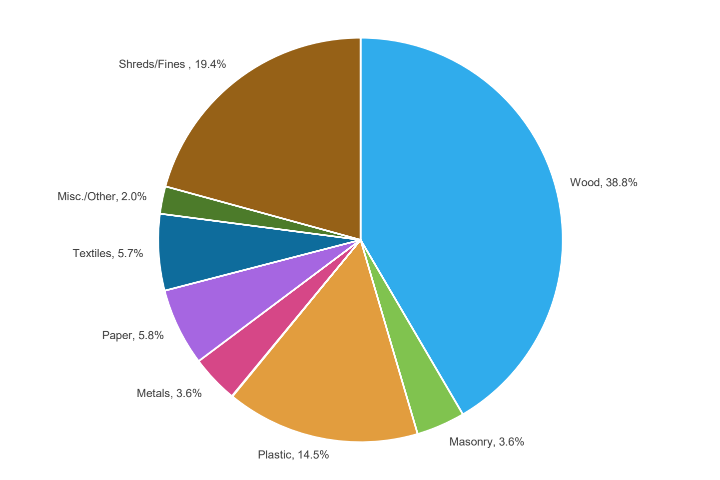


Figure 2 - Wood & Plastic in All Samples

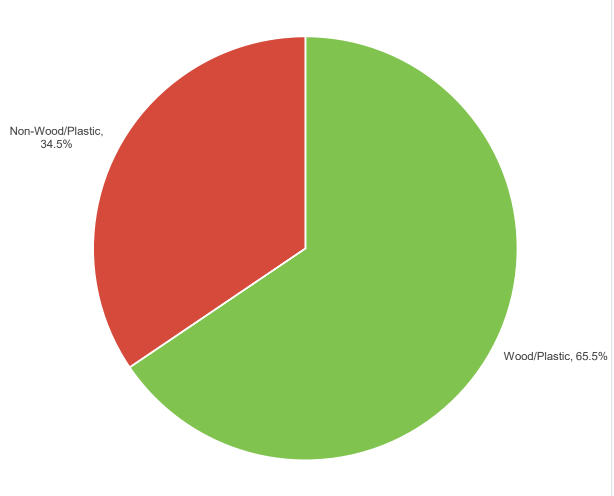


Figure 3 - Composition Per Sample

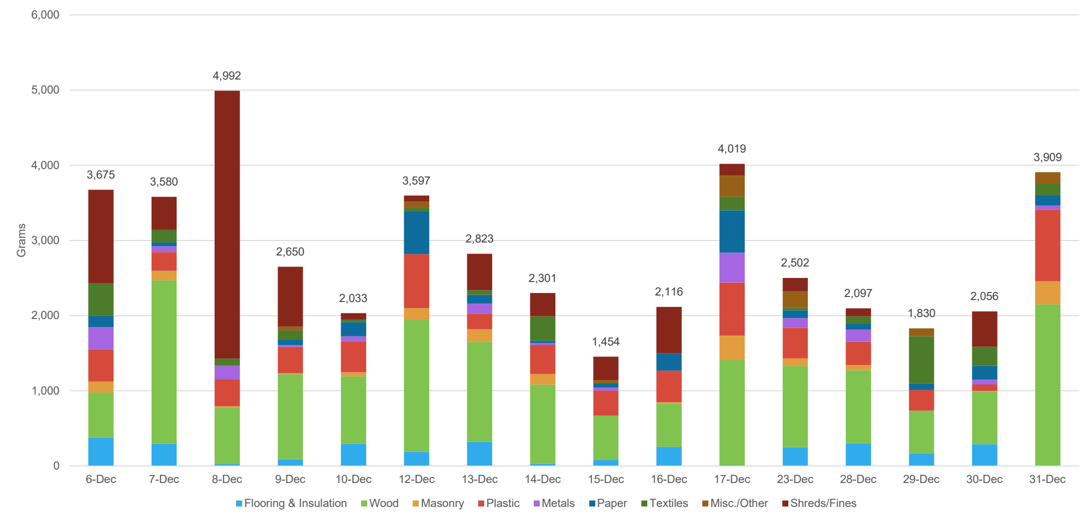


Table 2 - Composition Data by Mass and Proportion

Shredded C&D Waste Stream			6-Dec		7-Dec		8-Dec		9-Dec		10-Dec		12-Dec	
Major Category	#	Minor Category	g	%	g	%	g	%	g	%	g	%	g	%
Flooring & Insulation	1	Wood Flooring	24	0.7%	264	7.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	2	Linoleum	0	0.0%	10	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	3	Foam Insulation	0	0.0%	4	0.1%	0	0.0%	40	1.5%	14	0.7%	1	0.0%
	4	Paper/Wood Insulation	0	0.0%	19	0.5%	23	0.5%	20	0.8%	0	0.0%	0	0.0%
	5	Fiberglass Insulation	353	9.6%	0	0.0%	0	0.0%	0	0.0%	210	10.3%	0	0.0%
	6	Ceramic Tiles	0	0.0%	0	0.0%	0	0.0%	27	1.0%	72	3.5%	186	5.2%
Wood	7	Plywood/Particle Board	100	2.7%	241	6.7%	77	1.5%	385	14.5%	74	3.6%	355	9.9%
	8	Painted/Finished Wood	281	7.6%	189	5.3%	276	5.5%	93	3.5%	286	14.1%	773	21.5%
	9	Non-Painted Wood	220	6.0%	1,743	48.7%	399	8.0%	657	24.8%	536	26.4%	627	17.4%
Masonry	10	Asphalt (Non-Roofing)	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	11	Asphalt Roofing Shingles	146	4.0%	0	0.0%	20	0.4%	12	0.5%	55	2.7%	78	2.2%
	12	Stones/Rocks	0	0.0%	128	3.6%	0	0.0%	0	0.0%	0	0.0%	82	2.3%
Plastic	13	PET (#1) Plastic Food and Beverage Bottles	0	0.0%	0	0.0%	0	0.0%	34	1.3%	0	0.0%	28	0.8%
	14	HDPE (#2) Plastic Jugs, Crates, Totes and Drums	0	0.0%	0	0.0%	0	0.0%	15	0.6%	0	0.0%	0	0.0%
	15	LDPE (#4) Plastic Film, Milk Cartons	0	0.0%	12	0.3%	189	3.8%	46	1.7%	0	0.0%	0	0.0%
	16	PP (#5) Chip bags, Yogurt Containers	0	0.0%	26	0.7%	103	2.1%	8	0.3%	21	1.0%	1	0.0%
	17	PS (#6) Styrofoam	0	0.0%	8	0.2%	0	0.0%	6	0.2%	0	0.0%	61	1.7%
	18	Other Plastic (#7)	32	0.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	361	10.0%
	19	Hard/Rigid Plastic	135	3.7%	51	1.4%	15	0.3%	143	5.4%	42	2.1%	0	0.0%
	20	Thick Plastic Films	188	5.1%	14	0.4%	35	0.7%	76	2.9%	259	12.7%	132	3.7%
	21	Rubber	3	0.1%	0	0.0%	0	0.0%	10	0.4%	0	0.0%	0	0.0%
	22	Foam (Furniture Fill, Recycled Foam, Etc.)	70	1.9%	136	3.8%	20	0.4%	15	0.6%	89	4.4%	134	3.7%
Glass	23	Industrial Glass	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	24	Glass Food and Beverage Bottles or Jars	0	0.0%	7	0.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Metals	25	Aluminum or Steel Food and Beverage Cans	0	0.0%	0	0.0%	0	0.0%	20	0.8%	0	0.0%	0	0.0%
	26	Construction Wiring	110	3.0%	11	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	27	Industrial Metals	185	5.0%	59	1.6%	176	3.5%	0	0.0%	66	3.2%	0	0.0%
Paper	28	Fine Paper	0	0.0%	0	0.0%	0	0.0%	32	1.2%	0	0.0%	0	0.0%
	29	Non-Corrugated Cardboard (Boxboard Shoe Boxes, Cereal Boxes, etc.)	0	0.0%	41	1.1%	0	0.0%	20	0.8%	21	1.0%	534	14.8%
	30	Paper Cups	0	0.0%	0	0.0%	0	0.0%	0	0.0%	23	1.1%	0	0.0%
	31	Tissue	101	2.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	32	Other paper	49	1.3%	11	0.3%	0	0.0%	0	0.0%	147	7.2%	39	1.1%
	33	Corrugated Cardboard	0	0.0%	0	0.0%	0	0.0%	22	0.8%	0	0.0%	0	0.0%
Textiles	34	Clothing	0	0.0%	125	3.5%	77	1.5%	123	4.6%	0	0.0%	17	0.5%
	35	Carpet and Backing	433	11.8%	0	0.0%	18	0.4%	0	0.0%	33	1.6%	23	0.6%
	36	String/Yarn	0	0.0%	40	1.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other/Misc.	37	Wallpaper	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	38	Misc. Electronics	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	39	Diaper	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	40	Toys (Stuffed Animal, Balls)	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	41	Plastic Christmas Tree	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	83	2.3%
	42	Unknown (Dec 9 - Logged in Photos)	0	0.0%	0	0.0%	0	0.0%	49	1.8%	0	0.0%	0	0.0%
	43	Trophy	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	44	Shoes	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Shreds/Fines	45	10mm - 25mm Shreds	1,245	33.9%	335	9.4%	1,955	39.2%	592	22.3%	78	3.8%	0	0.0%
	46	Fines	0	0.0%	106	3.0%	1,609	32.2%	205	7.7%	7	0.3%	82	2.3%
Totals (g)			3,675		3,580		4,992		2,650		2,033		3,597	

Shredded C&D Waste Stream			13-Dec		14-Dec		15-Dec		16-Dec		17-Dec		23-Dec		28-Dec		29-Dec		30-Dec		31-Dec	
Major Category	#	Minor Category	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%	g	%
Flooring & Insulation	1	Wood Flooring	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	2	Linoleum	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9	0.4%	211	10.1%	0	0.0%	0	0.0%	0	0.0%
	3	Foam Insulation	0	0.0%	28	1.2%	0	0.0%	124	5.9%	11	0.3%	0	0.0%	0	0.0%	167	9.1%	290	14.1%	0	0.0%
	4	Paper/Wood Insulation	168	6.0%	0	0.0%	65	4.5%	130	6.1%	0	0.0%	21	0.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	5	Fiberglass Insulation	0	0.0%	0	0.0%	12	0.8%	0	0.0%	0	0.0%	204	8.2%	92	4.4%	0	0.0%	0	0.0%	0	0.0%
	6	Ceramic Tiles	155	5.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	16	0.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Wood	7	Plywood/Particle Board	0	0.0%	123	5.3%	182	12.5%	88	4.2%	194	4.8%	79	3.2%	0	0.0%	77	4.2%	303	14.7%	301	7.7%
	8	Painted/Finished Wood	394	14.0%	288	12.5%	27	1.9%	420	19.8%	183	4.6%	464	18.5%	288	13.7%	330	18.0%	243	11.8%	1,280	32.7%
	9	Non-Painted Wood	938	33.2%	643	27.9%	384	26.4%	65	3.1%	1,021	25.4%	537	21.5%	682	32.5%	162	8.9%	150	7.3%	570	14.6%
Masonry	10	Asphalt (Non-Roofing)	0	0.0%	0	0.0%	0	0.0%	0	0.0%	14	0.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	11	Asphalt Roofing Shingles	108	3.8%	142	6.2%	0	0.0%	21	1.0%	80	2.0%	36	1.4%	47	2.2%	0	0.0%	13	0.6%	305	7.8%
	12	Stones/Rocks	55	1.9%	0	0.0%	0	0.0%	0	0.0%	233	5.8%	65	2.6%	21	1.0%	0	0.0%	0	0.0%	0	0.0%
Plastic	13	PET (#1) Plastic Food and Beverage Bottles	0	0.0%	0	0.0%	0	0.0%	17	0.8%	0	0.0%	0	0.0%	0	0.0%	38	2.1%	0	0.0%	0	0.0%
	14	HDPE (#2) Plastic Jugs, Crates, Totes and Drums	0	0.0%	0	0.0%	7	0.5%	0	0.0%	3	0.1%	0	0.0%	0	0.0%	167	9.1%	0	0.0%	0	0.0%
	15	LDPE (#4) Plastic Film, Milk Cartons	96	3.4%	95	4.1%	31	2.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	81	2.1%
	16	PP (#5) Chip bags, Yogurt Containers	0	0.0%	15	0.7%	16	1.1%	17	0.8%	0	0.0%	0	0.0%	134	6.4%	31	1.7%	0	0.0%	0	0.0%
	17	PS (#6) Styrofoam	0	0.0%	0	0.0%	44	3.0%	0	0.0%	9	0.2%	15	0.6%	0	0.0%	1	0.1%	0	0.0%	15	0.4%
	18	Other Plastic (#7)	0	0.0%	127	5.5%	0	0.0%	0	0.0%	248	6.2%	237	9.5%	0	0.0%	1	0.1%	0	0.0%	141	3.6%
	19	Hard/Rigid Plastic	58	2.1%	0	0.0%	18	1.2%	105	5.0%	0	0.0%	0	0.0%	10	0.5%	0	0.0%	86	4.2%	304	7.8%
	20	Thick Plastic Films	0	0.0%	48	2.1%	149	10.2%	179	8.5%	305	7.6%	56	2.2%	0	0.0%	11	0.6%	0	0.0%	269	6.9%
	21	Rubber	0	0.0%	9	0.4%	0	0.0%	0	0.0%	60	1.5%	8	0.3%	0	0.0%	14	0.8%	0	0.0%	0	0.0%
	22	Foam (Furniture Fill, Recycled Foam, Etc.)	55	1.9%	91	4.0%	69	4.7%	104	4.9%	74	1.8%	92	3.7%	168	8.0%	12	0.7%	0	0.0%	144	3.7%
Glass	23	Industrial Glass	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9	0.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	24	Glass Food and Beverage Bottles or Jars	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Metals	25	Aluminum or Steel Food and Beverage Cans	0	0.0%	6	0.3%	37	2.5%	0	0.0%	33	0.8%	0	0.0%	0	0.0%	0	0.0%	11	0.5%	0	0.0%
	26	Construction Wiring	0	0.0%	10	0.4%	0	0.0%	0	0.0%	0	0.0%	129	5.2%	93	4.4%	0	0.0%	52	2.5%	56	1.4%
	27	Industrial Metals	131	4.6%	10	0.4%	0	0.0%	0	0.0%	360	9.0%	0	0.0%	69	3.3%	0	0.0%	0	0.0%	0	0.0%
Paper	28	Fine Paper	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	31	1.7%	0	0.0%	0	0.0%
	29	Non-Corrugated Cardboard (Boxboard Shoe Boxes, Cereal Boxes, etc.)	88	3.1%	14	0.6%	63	4.3%	96	4.5%	290	7.2%	72	2.9%	79	3.8%	42	2.3%	82	4.0%	0	0.0%
	30	Paper Cups	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	23	0.9%	0	0.0%	9	0.5%	0	0.0%	0	0.0%
	31	Tissue	0	0.0%	0	0.0%	0	0.0%	12	0.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	67	1.7%
	32	Other paper	31	1.1%	18	0.8%	0	0.0%	123	5.8%	271	6.7%	8	0.3%	0	0.0%	8	0.4%	48	2.3%	28	0.7%
	33	Corrugated Cardboard	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	0.1%	0	0.0%	0	0.0%	0	0.0%	55	2.7%	44	1.1%
Textiles	34	Clothing	34	1.2%	325	14.1%	0	0.0%	0	0.0%	32	0.8%	32	1.3%	96	4.6%	383	20.9%	255	12.4%	0	0.0%
	35	Carpet and Backing	27	1.0%	0	0.0%	0	0.0%	0	0.0%	149	3.7%	0	0.0%	0	0.0%	242	13.2%	0	0.0%	145	3.7%
	36	String/Yarn	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other/Misc.	37	Wallpaper	0	0.0%	0	0.0%	9	0.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	38	Misc. Electronics	0	0.0%	0	0.0%	0	0.0%	0	0.0%	22	0.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	39	Diaper	0	0.0%	0	0.0%	0	0.0%	0	0.0%	257	6.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	40	Toys (Stuffed Animal, Balls)	0	0.0%	0	0.0%	30	2.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	104	5.7%	0	0.0%	0	0.0%
	41	Plastic Christmas Tree	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	42	Unknown (Dec 9 - Logged in Photos)	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	43	Trophy	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	159	4.1%
	44	Shoes	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	219	8.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Shreds/Fines	45	10mm - 25mm Shreds	389	13.8%	0	0.0%	257	17.7%	30	1.4%	0	0.0%	149	6.0%	82	3.9%	0	0.0%	459	22.3%	0	0.0%
	46	Fines	96	3.4%	309	13.4%	54	3.7%	585	27.6%	158	3.9%	31	1.2%	25	1.2%	0	0.0%	9	0.4%	0	0.0%
Totals (g)			2,823		2,301		1,454		2,116		4,019		2,502		2,097		1,830		2,056		3,909	

Attachment 2

Photolog

Photo 1 Dec 6 - Mixed Composition

Photo 2 Dec 6 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 3 Dec 7 - Mixed Composition

Photo 4 Dec 7 – Paper/Wood Insulation

Photos 5/6 Dec 7 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 7 Dec 8 - Mixed Composition

Photos 8/9 Dec 8 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 10 Dec 9 - Mixed Composition

Photo 11 Dec 9 - Interesting Item - Unknown

Photo 12 Dec 9 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 13 Dec 10 - Mixed Composition

Photo 14 Dec 10 - Interesting Item - Charger Casing

Photo 15 Dec 10 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 16 Dec 12 - Mixed Composition

Photo 17 Dec 12 – Interesting Item- Christmas Tree Decor

Photos 18/19 Dec 12 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 20 Dec 13 - Mixed Composition

Photo 21 Dec 13 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 22 Dec 14 - Mixed Composition

Photo 23/24 Dec 14 - Sorted Composition

Photo 25 Dec 15 - Mixed Composition

Photo 26 Dec 15 – Interesting Item - Toy

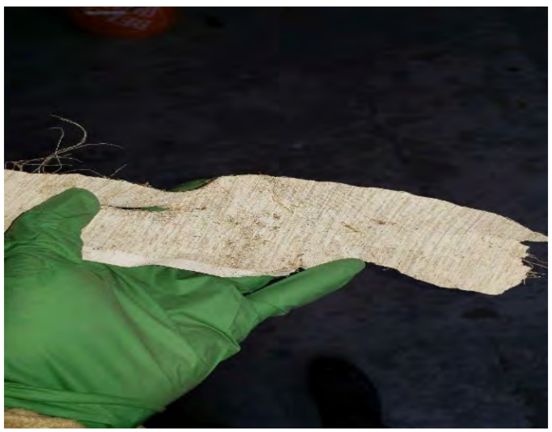


Photo 27 Dec 15 – Interesting Item - Wallpaper

Photos 28/29 Dec 15 – Sorted Composition

GHD

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 30 Dec 16 - Mixed Composition

Photo 31 Dec 16 - Sorted Composition

Photo 32 Dec 17- Mixed Composition

Photo 33 Dec 17 – Interesting Item - Unknown Foam

Photos 34/35/36 Dec 17 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 37 Dec 19 - Sorted Composition

Photo 38 Dec 23 - Mixed Composition

Photo 39 Dec 23 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 40 Dec 28 - Mixed Composition

Photo 41 Dec 28 - Sorted Composition

Photo 42 Dec 29 - Mixed Composition

Photo 43 Dec 29 - Sorted Composition

Site Photographs
TA - Biosolids and Resource Recovery
02/01/2023

Photo 44 Dec 30 - Mixed Composition

Photo 45 Dec 30 - Sorted Composition

Photo 46 Dec 31- Mixed Composition

Photo 47 Dec 31 - Sorted Composition

Attachment 3

Health and Safety Plan

HSE009 Job Safety and Environmental Analysis (JSEA)

Reference Documentation	HSE306 HSE Business Management SOP
Purpose of Form	JSEAs outline a safe and environmentally responsible method of work, identification of individual training needs, plant / machinery and equipment, inspection and legislative requirements for a specific activity taking into consideration the hazards and risks involved in completing the activity (during routine, non-routine and emergency working conditions).
Responsibility for Completion	Project Manager (or delegate) to complete in consultation with the GHD job team (includes identification and delivery of training).
Frequency of Completion and Review	JSEA to be developed prior to commencement of site work and reviewed at no more than 6 monthly intervals, or where there are significant changes to the job scope, equipment, environment, personnel or statutory framework. PD or qualified delegate responsible for review and approval.

Project Name & Description:	CRD - Shredded C&D Composition Analysis: Perform an confirmatory asbestos test on a consolidated sample of shredded C&D materials (pre-screened for asbestos) received from the CRD's Hartland Landfill. Once test is back, perform a full waste audit and characterization study on the 17 buckets. Send three buckets to the lab for energy and chemical analysis.	Activity Location:	GHD Office, Vancouver, BC
Project Number:	12590255	Activity: Waste Audit and Sampling	Activity Date: January 25, 2023 February 1, 2023 February 2, 2023

Sequential Task Step (Include a number to make for easy reference in Pre-Work Assessment)	Hazards What could cause injury or ill health, damage to property or damage to the environment (e.g. Water way, Refueling)	Event & Potential Outcome What could go wrong (e.g. fall in water / diesel spill) and what might happen as a result (e.g. person drowns / soil contamination)	Initial Risk Rating: Consequence	Initial Risk Rating: Likelihood	Initial Risk Rating: Risk Rating	Control Measures (Hazards are to be eliminated wherever possible or minimised where elimination is not reasonably practicable. Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, Personal and Environmental Protective Equipment).	Ref Guide (e.g. Hazard Guides, SOP's)	Residual Risk Rating: Consequence	Residual Risk Rating: Likelihood	Residual Risk Rating: Risk Rating	Person (s) Responsible (for implementing control measures)
Note: Consequence should be assessed first so that the likelihood rating is the likelihood of the selected consequence occurring.											
1.0 Setting up and taking down asbestos test site	Trip and fall hazards, lifting strain	Slippery conditions could cause a slip or fall accident. Lifting table and buckets could cause back strain and injury.	B	3	Low	Be aware of surroundings. Continuously inspect work areas for slip, trip and fall hazards. Never step onto obstacles unless you make sure you have a good foothold and are confident of their stability. Where possible walk around potential obstacles. Ensure propoer lifting procedures are followed when lifting heavy items. Seek immediate attention if injury from trip, fall or muscle strain occurs.	HSEG221 Slip and Trips	B	3	Low	GHD Staff
2.0 Performing asbestos test	Exposure to asbestos and other potentially harmful chemicals and sharp materials	Exposure to ACM may result in long term injury and increased risk of cancer. Exposure to other unknown harmful chemicals or sharps may cause immediate, short and long term	D	4	Significant	Review Worksafe BC's "Safe work Practices for Handling Asbestos" and " Safe work Practices for Asbestos Laboratories" guidance documents. Use of appropriate PPE. Seek immediate attention if injury from chemical or sharps occur.	Worksafe BC Safe work Practices for Handling Asbestos and Safe work Practices for Asbestos Laboratories	C	2	Low	GHD Staff
3.0 Setting up and taking down C&D audit site	Trip and fall hazards, lifting strain	Slippery conditions could cause a slip or fall accident. Lifting table and buckets could cause back strain and injury.	B	3	Low	Be aware of surroundings. Continuously inspect work areas for slip, trip and fall hazards. Never step onto obstacles unless you make sure you have a good foothold and are confident of their stability. Where possible walk around potential obstacles. Ensure proper lifting procedures are followed when lifting heavy items. Seek immediate attention if injury from trip, fall or muscle strain occurs.	HSEG221 Slip and Trips	B	3	Low	GHD Staff
4.0 Performing C&D waste audit	Exposure to potentially harmful chemicals and sharp materials	Exposure to unknown harmful chemicals or sharps may cause immediate, short and long term injury.	C	3	Moderate	Use of appropriate PPE.		C	2	Low	GHD Staff
4.1 Performing C&D waste audit	Risk of vehicle/pedestrian incident	Audit to be undertaken on active loading dock at GHD office. Incoming and outgoing vehicle may collide with auditor or audit set up and materials.	D	1	Moderate	Be aware of surroundings. Set up audit site in area of high visibility for incoming and outgoing vehicles. Locate audit site where vehicles do not enter. Do not use cell phones or perform other distracting activities while undertaking audit. Seek immediate attention if injury from vehicle contact occurs.		D	1	Moderate	GHD Staff
4.2 Audit Site Clean up	Inadequate clean up of audited materials and supplies may result in injury from residue.	Residue from audited C&D materials may remain on table, scale, buckets or other audit equipment causing injury to other users.	B	2	Negligible	Ensure the audited C&D materials are carefully placed back in buckets and sealed. Ensure audit equipment is thoroughly sanitized with alcohol spray to remove any chemical or sharp residues.		B	2	Negligible	GHD Staff

Inspection and maintenance required for this activity:	Relevant sections of Legislation, Codes of Practice or Standards applying to this activity:	Provide details of statutory and non-statutory certificates/ permits/approvals required for this activity & location if required:
N/A	GHD HSE Standard Operating procedures	N/A

Emergency Arrangements:		Plant/machinery and personal and/or environment protective equipment required:	Certifications / training and e-learning required to complete activity PM to confirm with project team:
Role	Name & Contact Number	Tyvex Suit Safety Glasses N95 Face Mask Gloves - puncture proof First Aid Kit Sanitizing Wipes	N/A
Project Manager	Deacon Liddy, 604-214-0510		
Client Contact	Andrea Panich , 250-360-3219		
HSE Manager	Justin Brusatore, 604-248-3973		
Emergency Services			
Nearest Hospital	Vancouver General Hospital, Jim Pattison Pavilion, 899 W 12th Ave, Vancouver, BC V5Z 1M9		
Information to provide in case of an emergency			
Assembly Point			
Nearest Rd / St and distance			
Local landmarks			

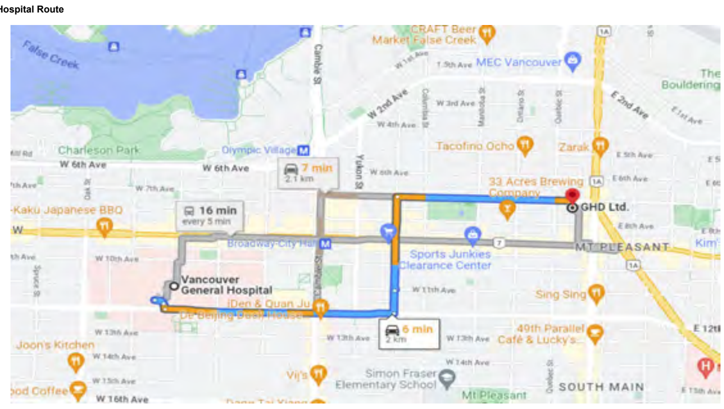
Created by PM Nam (or suitable delegate)	Signature	Date	Reviewed & Approved by PD Name(or suitably skilled and experienced delegate)	Signature	Date	PD Review in HSE Database?
Laura Hnatiuk			Justin Brusatore	Justin Brusatore	2/10/2023	Yes

By signing, I understand and agree to work to this JSEA, referenced procedures and have completed listed training. I am empowered to stop work if any person's safety or the environment are at risk.

GHD Project Team Name	Position	Qualification	Signature	Date
Abram Robiso	EIT			
Laura Hnatiuk	Zero Waste Coordinator			
Anastassia Alexeeva	EIT			
Jason Wilson	Waste Management Engineer			

Notes: Print a sufficient number of Pre-Work Assessment (single or multi-day) sheets for the number of days on site.

Map with Hospital Route



Attachment 4

Asbestos Test Results

ALS Canada Ltd.

right solutions.
right partner.

CERTIFICATE OF ANALYSIS

Work Order	: **VA23A1595**		Page	: 1 of 2
Client	: **GHD Limited**		Laboratory	: Vancouver - Environmental
Contact	: Laura Hnatiuk		Account Manager	: Amber Springer
Address	: 138 E 7th Ave Suite 100 Vancouver BC Canada V5T 1M6		Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----		Telephone	: +1 604 253 4188
Project	: 12590255		Date Samples Received	: 23-Jan-2023 16:15
PO	: ----		Date Analysis Commenced	: 27-Jan-2023
C-O-C number	: 17-866380		Issue Date	: 27-Jan-2023 15:19
Sampler	: ----			
Site	: C&D Waste			
Quote number	: ----			
No. of samples received	: 1			
No. of samples analysed	: 1			

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Trace Chometsky	Account Manager Assistant	Internal Subcontracting, Cincinnati, Ohio

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	Description
% (w/w)	% weight/weight

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Soil/Solid**
(Matrix: **Soil/Solid**)

				Client sample ID	**Sample 1**	----	----	----	----
				Client sampling date / time	23-Jan-2023 12:30	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA23A1595-001**	--------	--------	--------	--------
					Result	----	----	----	----
Asbestos/Other Fibres									
Asbestos, <2mm	1332-21-4	ASTM D7521	0.25	% (w/w)	See Attached	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: VA23A1595	Page	: 1 of 4
Client	: GHD Limited	Laboratory	: Vancouver - Environmental
Contact	: Laura Hnatiuk	Account Manager	: Amber Springer
Address	: 138 E 7th Ave Suite 100 Vancouver BC Canada V5T 1M6	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: 12590255	Date Samples Received	: 23-Jan-2023 16:15
PO	: ----	Issue Date	: 27-Jan-2023 15:19
C-O-C number	: 17-866380		
Sampler	: ----		
Site	: C&D Waste		
Quote number	: ----		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.

CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.

DQO: Data Quality Objective.

LOR: Limit of Reporting (detection limit).

RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Soil/Solid**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group	Method	Sampling Date	Extraction / Preparation				Analysis			
Container / Client Sample ID(s)			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Asbestos/Other Fibres : Asbestos by Sieving & PLM										
Double bagged HDPE Sample 1	ASTM D7521	23-Jan-2023	----	----	----		27-Jan-2023	----	----	

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

- **No Quality Control data available for this section.**

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by “mod”).

Analytical Methods	*Method / Lab*	*Matrix*	*Method Reference*	*Method Descriptions*
Asbestos by Sieving & PLM	ASTM D7521 Cincinnati - Environmental - 4388 Glendale-Milford Road Cincinnati Ohio United States 45242	Soil/Solid	ASTM D7521-16	Sample is dried and passed through nested sieves into a collection pan. The fine (<106um), medium (>106um <2mm) and coarse (>2mm <19mm) fraction are analyzed separately by stereomicroscopy and polarized light microscopy (PLM) using calibrated visual area estimation. If asbestos is identified in the fine fraction at a level below 1%, a point count approach is performed. If no asbestos is found in the fine fraction, TEM analysis can be conducted upon client request. If particle fraction (>19mm) is found, it can be analyzed by the regular PLM method EPA 600/R-93/116 as per client request and will be reported separately.

ALS Canada Ltd.

QUALITY CONTROL REPORT

Work Order	: **VA23A1595**	Page	: 1 of 2
Client	: GHD Limited	Laboratory	: Vancouver - Environmental
Contact	: Laura Hnatiuk	Account Manager	: Amber Springer
Address	: PO BOX 1000 625 Fisgard Street Victoria BC Canada V8W 2S6	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	:	Telephone	: +1 604 253 4188
Project	: 12590255	Date Samples Received	: 23-Jan-2023 16:15
PO	: ----	Date Analysis Commenced	: 27-Jan-2023
C-O-C number	: 17-866380	Issue Date	: 27-Jan-2023 15:19
Sampler	: ---- ----		
Site	: C&D Waste		
Quote number	: ----		
No. of samples received	: 1		
No. of samples analysed	: 1		

This Quality Control Report contains the following information:

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Trace Chometsky	Account Manager Assistant	USA - Cincinnati Internal Subcontracting, Cincinnati, Ohio

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

27-Jan-2023

Reporting
ALS Environmental
8081 Lougheed HWY
Suite 100
Burnaby, BC V5A 1W9

Re: **VA23A1595**   Work Order: **23010827**

Dear Reporting,

ALS Environmental received 1 sample on 26-Jan-2023 11:17 AM for the analyses presented in the following report.

The analytical data provided relates directly to the samples received by ALS Environmental and for only the analyses requested.

QC sample results for this data met laboratory specifications. Any exceptions are noted in the Case Narrative, or noted with qualifiers in the report or QC batch information. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Laboratory Group. Samples will be disposed in 30 days unless storage arrangements are made.

The total number of pages in this report is 8.

If you have any questions regarding this report, please feel free to contact me.

Sincerely,

Shawn Smythe

Electronically approved by: Hannah Ponder

Shawn Smythe
Project Manager

Report of Laboratory Analysis

ALS Environmental

Date: 27-Jan-23

Client: ALS Environmental
Project: VA23A1595
Work Order: **23010827**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
23010827-01	VA23A1595-001	Soil		1/23/2023 15:30	1/26/2023 11:17	☐

Client: ALS Environmental
Project: VA23A1595
Work Order: 23010827

Case Narrative

It is the responsibility of the client to notify the lab of any certification requirements in writing via the chain of custody as this may determine the preparation and analytical procedures employed.
Laboratory accreditation does not in any way constitute approval or endorsement by any accrediting body or agency of the federal government. Please contact ALS Cincinnati QA/QC Manager for accreditation identifications and certifications.
All sample collection is performed outside of ALS and is the sole responsibility of the client. Sample condition acceptable upon receipt except where noted. Estimates of concentration are semi-quantitative and are made on an area basis. Results apply only to portions of samples analyzed. Samples disposed after 60 days.
All analytical data (results) and technical content (comments) related to the preparation and analysis of the samples stated herein is the responsibility of the analyst. Raw data is reviewed and validated by a qualified peer analyst and imported into the Laboratory Information Management System (LIMS) where it is formatted by the cover letter signatory charged with compiling and sending the final LIMS generated report to the client.
The reporting limit (RL) for asbestos in bulk materials is 1% and is a function of the quantity of sample analyzed, the nature of any matrix interferences, sample preparation, and fiber size and distribution. Results reported as ND indicate that no asbestos was detected. Results reported as Trace indicate that asbestos was detected at some level confidently determined to be <1% which is considered inconclusive according to New York ELAP.
ALS performs variety of PLM methods for asbestos in bulk building materials including EPA 600/R-93/116, NIOSH 9002, ELAP 198.1, and ELAP 198.6. In addition, we perform a modified uncertified version of EPA 600/R-04/004 for asbestos in vermiculite which reports asbestos as present or absent only, an in-house developed uncertified method ALS SOP ENV 004 for asbestos in soil, and asbestos in soil by ASTM D7521.
Regardless of the method requested, all samples are examined according to mandatory method protocol. Any optional method protocol are eliminated from the initial analysis but may be performed upon client request. These may include; insufficient sample volume rejection*, phase separation of layered or heterogeneous samples, ashing to remove organic interferences, acid dissolution to remove mineral carbonate interferences, point counting**, and analysis by transmission electron microscopy (TEM) is recommended to verify all ND PLM results.
All samples are examined by stereomicroscope for the determination of homogeneity, texture, friability, color, and extent of fibrous components. Non-asbestos materials such as foil, paper, metal, plastic, pebbles, or organic debris are ignored and a subsample of the remaining material homogenized by some means for examination by polarized light microscope (PLM). Information obtained via both stereomicroscope and PLM are used in the final qualitative and quantitative analysis of fibrous components.
NOTE: Any visible building debris in soil samples such as pieces of drywall, roofing material,

insulation, concrete, etc., are not included in the soil analysis. If present, these are considered possible asbestos containing materials (ACM) and may be analyzed as separate samples upon client request.

*Sufficient sample volume is material dependent. For samples such as floor tiles, roofing felts, sheet insulation, etc., three to four square inches of the layered material is preferred. For materials such as ceiling tiles, loose fill insulation, pipe insulation, etc., one cubic inch (~15cc) is preferred. For samples of thin coating materials such as paints, mastics, spray plasters, etc., a smaller sample size may be suitable. For vermiculite analysis, a one gallon ziploc bag full of dry, loose material is acceptable. For ENV 004 soil samples, a 4oz jar is recommended. The ASTM D7521 Soil method requires a minimum of 8oz and a maximum of 16oz of homogeneous soil.

**PLM samples at or near the 1% detection limit may be analyzed by the 400 point count analysis which refers to method EPA 600/M4/82/020, or AHERA method EPA 40 CFR Part 763, Sub. E, App. E as these are synonymous

ALS Environmental

Date: *27-Jan-23*

Client: ALS Environmental
Project: VA23A1595

Work Order: 23010827

Lab ID: 23010827-01A
Client Sample ID: VA23A1595-001

Collection Date: 1/23/2023 3:30:00 PM
Matrix: SOIL

Analytical Results

Analyses	Result	Units		
Asbestos by PLM				Date Analyzed: **1/27/2023**
Macroscopic Examination	Prep Date: **1/27/2023**		**E600/R-93/116**	Analyst: **MRS**
Color	Brown			
Description	Debris			
Homogeneity	Heterogenous			
Texture	Fibrous			
Other Materials			**E600/R-93/116**	
Cellulose	>50<=60	%		
Fiberglass	>5<=10	%		
Non-fibrous	>20<=30	%		
Other fibers	ND	%		
Resin/binder	ND	%		
Asbestiform Minerals			**E600/R-93/116**	
Amosite	ND	%		
Anthophyllite	ND	%		
Chrysotile	ND	%		
Crocidolite	ND	%		
Tremolite - actinolite	ND	%		
Total asbestos	**ND**	**%**		

Note:

Client: ALS Environmental
Project: VA23A1595
WorkOrder: **23010827**

QUALIFIERS, ACRONYMS, UNITS

Qualifier	Description
*	Value exceeds Regulatory Limit
a	Not accredited
B	Analyte detected in the associated Method Blank above the Reporting Limit
E	Value above quantitation range
H	Analyzed outside of Holding Time
J	Analyte detected below quantitation limit
n	Not offered for accreditation
ND	Not Detected at the Reporting Limit
O	Sample amount is > 4 times amount spiked
P	Dual Column results percent difference > 40%
R	RPD above laboratory control limit
S	Spike Recovery outside laboratory control limits
U	Analyzed but not detected above the MDL

Acronym	Description
DUP	Method Duplicate
E	EPA Method
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MBLK	Method Blank
MDL	Method Detection Limit
MQL	Method Quantitation Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PDS	Post Digestion Spike
PQL	Practical Quantitaion Limit
SDL	Sample Detection Limit
SW	SW-846 Method

Units Reported	Description
%	

ALS Environmental

Sample Receipt Checklist

Client Name: **ALS-VANCOUVER** Date/Time Received: **26-Jan-23 11:17**

Work Order: **23010827** Received by: **AB**

Checklist completed by	Alec Bolender	26-Jan-23	Reviewed by:	Hannah Ponder	26-Jan-23
	eSignature	Date		eSignature	Date

Matrices: soil
Carrier name: DHL

	Yes	No	
Shipping container/cooler in good condition?	☑	☐	Not Present ☐
Custody seals intact on shipping container/cooler?	☐	☐	Not Present ☑
Custody seals intact on sample bottles?	☐	☐	Not Present ☑
Chain of custody present?	☑	☐	
Chain of custody signed when relinquished and received?	☑	☐	
Chain of custody agrees with sample labels?	☑	☐	
Samples in proper container/bottle?	☑	☐	
Sample containers intact?	☑	☐	
Sufficient sample volume for indicated test?	☑	☐	
All samples received within holding time?	☑	☐	
Container/Temp Blank temperature in compliance?	☑	☐	
Sample(s) received on ice?	☐	☑	

Temperature(s)/Thermometer(s): 11.4 119059

Cooler(s)/Kit(s):

Date/Time sample(s) sent to storage: 1/26/23 11.17

	Yes	No	
Water - VOA vials have zero headspace?	☐	☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	☐	☐	N/A ☑
pH adjusted?	☐	☐	N/A ☑

pH adjusted by: -

Login Notes:

Client Contacted: Date Contacted: Person Contacted:

Contacted By: Regarding:

Comments:

CorrectiveAction:

Chain of Custody

Vancouver - Environmental
8081 Lougheed Highway
Burnaby BC Canada V5A 1W9

97797

Destination Lab:	**USA - Cincinnati**
Address:	4388 Glendale-Milford Road Cincinnati OH United States 45242
Client:	Capital Regional District
Work Order Number:	**VA23A1595**
Original Receipt Date/Time	Instructions Received
23/01/2023 19:15	

23010827

Relinquished By	
Date/Time	
Received By	[signature] /ALS
Date/Time	1-26-23 1117
Receipt Temp	

Return as Indicated: Results: alsev.datasublet@alsglobal.com Invoice: alsev.datasublet@alsglobal.com Electronic Data: alsev.datasublet@alsglobal.com

Attention: Amber Springer

ALS Sample ID	Client ID	Matrix	Container Type	Test Codes	Method Description	Due Date	Sampling Date and Time	Remarks
VA23A1595-001	Sample 1	Soil/Solid	Double bagged HDPE	ASTM D7521	Asbestos by Sieving & PLM	07-02-2023	23/01/2023 15:30	

AB 1-26-23 / 8 11.4°C / 119059 DHC

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 17 - 866380

Page 1 of 1

Report To	Contact and company name below will appear on the final report
Company:	GHD Limited
Contact:	Laura Hnatiuk
Phone:	604-248-3658
	Company address below will appear on the final report
Street:	138 E 7th Ave
City/Province:	Vancouver, BC
Postal Code:	V5T 1M6
Invoice To	Same as Report To [ ] YES [✓] NO
	Copy of Invoice with Report [✓] YES [ ] NO
Company:	CRD
Contact:	Andrea Panich apanich@crd.bc.ca

Report Format / Distribution

Select Report Format: [✓] PDF [✓] EXCEL [ ] EDD (DIGITAL)

Quality Control (QC) Report with Report [✓] YES [ ] NO

[ ] Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: [✓] EMAIL [ ] MAIL [ ] FAX

Email 1 or Fax: laura.hnatiuk@ghd.com

Email 2: ~~Reference PO~~

Email 3: ~~apanich@crd.bc.ca~~

Invoice Distribution

Select Invoice Distribution: [✓] EMAIL [ ] MAIL [ ] FAX

Email 1 or Fax: apanich@crd.bc.ca

Email 2:

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] [ ] Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] [ ]; 3 day [P3-25%] [ ]; 2 day [P2-50%] [✓]

EMERGENCY: 1 Business day [E - 100%] [ ]; Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] [ ]

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #: 12590255

PO / AFE:

LSD: C&D waste

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only): 1595

ALS Contact:

Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Asbestos	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	Sample 1	23-01-23	12:30	Product	1	✓		

Environmental Division
Vancouver
Work Order Reference
VA23A1595
Telephone : +1 604 253 4188

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? [ ] YES [ ] NO

Are samples for human consumption/ use? [ ] YES [ ] NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ] SIF Observations Yes [ ] No [ ]

Ice Packs [ ] Ice Cubes [ ] Custody seal intact Yes [ ] No [ ]

Cooling Initiated [✓]

INITIAL COOLER TEMPERATURES °C:

FINAL COOLER TEMPERATURES °C: 18.8

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by: JH	Date: 01/23/23	Time: 4:15

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Attachment 5

CRD and C&D Shredding Lab Sample Analysis (ALS)

CERTIFICATE OF ANALYSIS

Work Order	: **VA23A5145**	Page	: 1 of 4
Client	: **Capital Regional District**	Laboratory	: Vancouver - Environmental
Contact	: Andrea Panich	Account Manager	: Amber Springer
Address	: PO BOX 1000 625 Fisgard Street Victoria BC Canada V8W 2S6	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 08-Mar-2023 11:00
PO	: ----	Date Analysis Commenced	: 01-May-2023
C-O-C number	: 20-1017661	Issue Date	: 01-May-2023 16:42
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Kaitlyn Gardner	Account Manager Assistant	Internal Subcontracting, Tucson, Arizona

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	no units
%	percent
mg/kg	milligrams per kilogram

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Soil/Solid**
(Matrix: **Soil/Solid**)

				Client sample ID	Dec 29	Dec 13	Dec 31	----	----
				Client sampling date / time	29-Dec-2022	13-Dec-2022	31-Dec-2022	----	----
Analyte	CAS Number	Method	LOR	Unit	VA23A5145-001	VA23A5145-002	VA23A5145-003	--------	--------
					Result	Result	Result	----	----
Sample Preparation									
Dry & grind	----	GRIND	-	-	See attached	See attached	See attached	----	----
Metals									
Aluminum	7429-90-5	EPA3052	12.5	mg/kg	See attached	See attached	See attached	----	----
Antimony	7440-36-0	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Arsenic	7440-38-2	EPA3052	5	mg/kg	See attached	See attached	See attached	----	----
Barium	7440-39-3	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Beryllium	7440-41-7	EPA3052	0.25	mg/kg	See attached	See attached	See attached	----	----
Cadmium	7440-43-9	EPA3052	0.25	mg/kg	See attached	See attached	See attached	----	----
Calcium	7440-70-2	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Chromium	7440-47-3	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Cobalt	7440-48-4	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Copper	7440-50-8	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Iron	7439-89-6	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Lead	7439-92-1	EPA3052	5	mg/kg	See attached	See attached	See attached	----	----
Lithium	7439-93-2	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Magnesium	7439-95-4	EPA3052	12.5	mg/kg	See attached	See attached	See attached	----	----
Manganese	7439-96-5	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Molybdenum	7439-98-7	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----

Analytical Results

Sub-Matrix: **Soil/Solid**

(Matrix: **Soil/Solid**)

				Client sample ID	Dec 29	Dec 13	Dec 31	----	----
				Client sampling date / time	29-Dec-2022	13-Dec-2022	31-Dec-2022	----	----
Analyte	CAS Number	Method	LOR	Unit	VA23A5145-001	VA23A5145-002	VA23A5145-003	--------	--------
					Result	Result	Result	----	----
Metals									
Nickel	7440-02-0	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Phosphorus	7723-14-0	EPA3052	12.5	mg/kg	See attached	See attached	See attached	----	----
Potassium	7440-09-7	EPA3052	12.5	mg/kg	See attached	See attached	See attached	----	----
Selenium	7782-49-2	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Silicon	7440-21-3	EPA3052	12.5	mg/kg	See attached	See attached	See attached	----	----
Silver	7440-22-4	EPA3052	12.5	mg/kg	See attached	See attached	See attached	----	----
Sodium	7440-23-5	EPA3052	12.5	mg/kg	See attached	See attached	See attached	----	----
Strontium	7440-24-6	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Tin	7440-31-5	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Titanium	7440-32-6	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Vanadium	7440-62-2	EPA3052	1.25	mg/kg	See attached	See attached	See attached	----	----
Zinc	7440-66-6	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Zirconium	7440-67-7	EPA3052	2.5	mg/kg	See attached	See attached	See attached	----	----
Elemental Composition									
Chloride, acid soluble	16887-00-6	CL(HNO3)	0.01	%	See attached	See attached	See attached	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

ALS Canada Ltd.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA23A5145**	Page	: 1 of 5
Client	: **Capital Regional District**	Laboratory	: Vancouver - Environmental
Contact	: Andrea Panich	Account Manager	: Amber Springer
Address	: PO BOX 1000 625 Fisgard Street Victoria BC Canada V8W 2S6	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 08-Mar-2023 11:00
PO	: ----	Issue Date	: 01-May-2023 16:40
C-O-C number	: 20-1017661		
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Soil/Solid**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Elemental Composition : Acid Soluble Chloride										
Compliant container Dec 13	CL(HNO3)	13-Dec-2022	----	----	----		01-May-2023	----	----	
Elemental Composition : Acid Soluble Chloride										
Compliant container Dec 29	CL(HNO3)	29-Dec-2022	----	----	----		01-May-2023	----	----	
Elemental Composition : Acid Soluble Chloride										
Compliant container Dec 31	CL(HNO3)	31-Dec-2022	----	----	----		01-May-2023	----	----	
Metals : Metals in Soil/Solid by HNO3,HCl and HF digestion										
Compliant container Dec 13	EPA3052	13-Dec-2022	----	----	----		01-May-2023	----	----	
Metals : Metals in Soil/Solid by HNO3,HCl and HF digestion										
Compliant container Dec 29	EPA3052	29-Dec-2022	----	----	----		01-May-2023	----	----	
Metals : Metals in Soil/Solid by HNO3,HCl and HF digestion										
Compliant container Dec 31	EPA3052	31-Dec-2022	----	----	----		01-May-2023	----	----	
Sample Preparation : Grinding of solid material										
Compliant container Dec 31	GRIND	31-Dec-2022	----	----	----		01-May-2023	180 days	121 days	✓

Matrix: **Soil/Solid**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Sample Preparation : Grinding of solid material										
Compliant container Dec 29	GRIND	29-Dec-2022	----	----	----		01-May-2023	180 days	123 days	✓
Sample Preparation : Grinding of solid material										
Compliant container Dec 13	GRIND	13-Dec-2022	----	----	----		01-May-2023	180 days	139 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

- **No Quality Control data available for this section.**

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by “mod”).

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Acid Soluble Chloride	CL(HNO3) Tucson - Environmental - 4208 S. Santa Rita Ave. Tucson Arizona United States 85714	Soil/Solid	ASTM C114	Samples are heated to boiling in dilute nitric acid to extract acid soluble chloride. Solids are then removed from the acid solution using a filter apparatus. An aliquot of NaCl is added to the filtrate and the solution is titrated with $AgNO_3$. The chlorine is quantified by using a chloride ISE to generate a calibration curve.
Metals in Soil/Solid by HNO3,HCl and HF digestion	EPA3052 Tucson - Environmental - 4208 S. Santa Rita Ave. Tucson Arizona United States 85714	Soil/Solid	EPA 3052/6010C	Sample is digested by HNO3,HCl and HF and analyzed by ICPOES.
Grinding of solid material	GRIND Tucson - Environmental - 4208 S. Santa Rita Ave. Tucson Arizona United States 85714	Soil/Solid	ALS Tucson In-house	Solids samples are ground using a grinder.

ALS Canada Ltd.

right solutions.
right partner.

QUALITY CONTROL REPORT

Work Order	: **VA23A5145**	Page	: 1 of 2
Client	: Capital Regional District	Laboratory	: Vancouver - Environmental
Contact	: Andrea Panich	Account Manager	: Amber Springer
Address	: PO BOX 1000 625 Fisgard Street Victoria BC Canada V8W 2S6	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	:	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 08-Mar-2023 11:00
PO	: ----	Date Analysis Commenced	: 01-May-2023
C-O-C number	: 20-1017661	Issue Date	: 01-May-2023 16:40
Sampler	: ---- ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Kaitlyn Gardner	Account Manager Assistant	USA - Tucson Internal Subcontracting, Tucson, Arizona

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

April 28, 2023

Service Request No:T2300517

Ms. Amber Springer
ALS Environmental - Canada
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9

Laboratory Results for:

Dear Ms.Springer,

Enclosed are the results of the sample(s) submitted to our laboratory March 21, 2023
For your reference, these analyses have been assigned our service request number **T2300517.**

All analyses were performed according to our laboratory's quality assurance program. All results are intended to be considered in their entirety, and ALS Environmental is not responsible for use of less than the complete report. Results
apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Respectfully submitted,

ALS Group USA, Corp. dba ALS Environmental

Wendy Hyatt
Laboratory Director

ADDRESS 4208 S Santa Rita Avenue, Tucson, AZ 85714
PHONE +1 520 573 1061 | FAX +1 520 623 9218
ALS Group USA, Corp.
dba ALS Environmental

Chain of Custody

Vancouver - Environmental
8081 Lougheed Highway
Burnaby BC Canada V5A 1W9

104438

Destination Lab:	**USA - Tucson**
Address:	4208 S. Santa Rita Ave. Tucson AZ United States 85714
Client:	Capital Regional District
Work Order Number:	**VA23A5145**
Original Receipt Date/Time	Instructions Received
08/03/2023 12:00	

T2300517 **5**
ALS Environmental - Canada

Relinquished By	
Date/Time	
Received By	Diego M.
Date/Time	3/21/23 1134
Receipt Temp	

Return as Indicated: Results: alsev.datasublet@alsglobal.com Invoice: alsev.datasublet@alsglobal.com Electronic Data: alsev.datasublet@alsglobal.com

Attention: Amber Springer

ALS Sample ID	Client ID	Matrix	Container Type	Test Codes	Method Description	Due Date	Sampling Date and Time	Remarks
VA23A5145-001	Dec 29	Soil/Solid	Compliant container	CL(HNO3), GRIND, EPA3052	Acid Soluble Chloride, Grinding of solid material, Metals in Soil/Solid by HNO3,HCl and HF digestion	14-03-2023	29/12/2022 01:00	
VA23A5145-002	Dec 13	Soil/Solid	Compliant container	CL(HNO3), GRIND, EPA3052	Acid Soluble Chloride, Grinding of solid material, Metals in Soil/Solid by HNO3,HCl and HF digestion	14-03-2023	13/12/2022 01:00	
VA23A5145-003	Dec 31	Soil/Solid	Compliant container	CL(HNO3), GRIND, EPA3052	Acid Soluble Chloride, Grinding of solid material, Metals in Soil/Solid by HNO3,HCl and HF digestion	14-03-2023	31/12/2022 01:00	

* Please refer to attached email for full list of analysis

4208 S.Santa Rita Ave.
Tucson, AZ 85714
T: +1 520 573 1061
www.alsglobal.com

ALS Canada

Sample Receipt Form

T2300517 5
ALS Environmental - Canada

Client/Project:	~~Captial Regional District~~	Work Order Number:	
Received by:	Diego Mendez	Date & Time:	3/21/2023 1134
Matrix:	Solid		
Samples were received via?:	DHL	Samples were received in:	Bucket
Were custody seals on containers?	(●) Yes ( ) No ( ) NA	If yes, how many and where?	1
If present were custody seals intact?	(●) Yes (●) No	If present, were they signed and dated?	( ) Yes (●) No

Arrival Temp C	Temp Blank C	Tracking Number
ambient	n/a	WAYBILL 23 5165 8400

Packing material used? | | | | |

Did all the bottles arrive in good condition (unbroken)?	(●) Yes ( ) No ( ) NA	If No, record comments below
Did all sample labels and tags agree with COC?	(●) Yes ( ) No ( ) NA	If No, record discrepancies below
Were all the appropriate containers and volumes received for the tests indicated?	(●) Yes ( ) No ( ) NA	
Are samples received deemed acceptable?	(●) Yes ( ) No	MSDS included with paperwork? No

Comments:

3 ~~10~~ 5 gallon buckets

As a part of ISO 17025 protocols, ALS occasionally discloses that the quoted analytical methods performed by ALS may have minor modifications from the methods as published. These modifications are written into our Standard Operating Procedures and do not impact the quality of the data. Receipt of this document will be considered as acceptance of the procedures used by the laboratory for analysis unless notified by the client.
Modifications may include, but are not limited to:

- The analysis of a sample matrix that differs from that stated in the published method (example - ASTM D5865 Standard Test Method for Gross Calorific Value of Coal and Coke is used for other matrices such as biomass, Tire Derived Fuel, etc.).
- Analyzing a sample mass that differs from those in the published method (example - to accommodate samples with high concentrations of analyte, samples of limited volume, or to comply with the instrument manufacturer's operating guidelines).
- Instruments used for the analysis may differ from those listed in the published method (example - using ICP- OES when the method references flame Atomic Absorption Spectroscopy)

Client: ALS Environmental - Canada
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9
Attn: Amber Springer

Project: VA23A5145 **Date Received:** March 21, 2023

Certificate of Analysis

Sample ID:	Sample Date:		Lab #:	Moisture, Total D3173 wt%		Chlorine, Total 5050/9056 Moist. Free mg/kg		Mercury, Total D6722 Moist. Free ppb		
VA23A5145-001 Dec 29	12/29/22	0100	T2300517-001	15.66		1,484		23		
VA23A5145-002 Dec 13	12/13/22	0100	T2300517-002	18.25		1,011		53		
VA23A5145-003 Dec 31	12/31/22	0100	T2300517-003	32.20		22,148		354		

Client: ALS Environmental - Canada
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9
Attn: Amber Springer

Project: VA23A5145 **Date Received:** March 21, 2023

Certificate of Analysis

Sample ID:	Sample Date:		Lab #:	Heating Value Wire Free D5865			Heating Value With Wire D5866			Wire Content D6700
				As Received BTU/lb	Moist. Free BTU/lb	Moist. Free MMBTU/Ton*	As Received BTU/lb	Moist. Free BTU/lb	Moist. Free MMBTU/Ton*	Air Dried wt%
VA23A5145-001 Dec 29	12/29/22	0100	T2300517-001	7,516	8,911	17.82	n/a	n/a	n/a	n/a
VA23A5145-002 Dec 13	12/13/22	0100	T2300517-002	4,571	5,592	11.18	4,354	5,326	10.65	4.7
VA23A5145-003 Dec 31	12/31/22	0100	T2300517-003	6,355	9,373	18.75	n/a	n/a	n/a	n/a

Notes:
TDF sample required freezing with liquid nitrogen prior to the coarse and fine grinding steps.

ALS Environmental - Tucson, AZ

Particle Size Analysis by Sieving

ASTM C117, C136, D421 & D422 - Sediment / Soil		Wet Sieve	
ASTM E828 - RDF and Biomass Fuels	X	Dry Seive	X

Analyst:	ALENA ESTRADA
Analysis Date:	4/18/2023
Analyst Review:	AE 4/18/23
Supervisor Review:	WH 4/28

Client: ALS Environmental - Canada
Project: VA23A5145

	Lab No.		T2300517-001		Lab No.		T2300517-002		Lab No.		T2300517-003		Lab No.			
	Client Sample ID		VA23A5145-001 Dec 29		Client Sample ID		VA23A5145-002 Dec 13		Client Sample ID		VA23A5145-003 Dec 31		Client Sample ID			
Starting Sample	Container Wt. g	Sx & Cont Wt. g	Sx (AR, AD or MF)	Begin Sx Wt. g	Container Wt. g	Sx & Cont Wt. g	Sx (AR, AD or MF)	Begin Sx Wt. g	Container Wt. g	Sx & Cont Wt. g	Sx (AR, AD or MF)	Begin Sx Wt. g	Container Wt. g	Sx & Cont Wt. g	Sx (AR, AD or MF)	Begin Sx Wt. g
	1853.24	3494.26	AR	1641.02	2028.27	5412.12	AR	3383.85	1975.84	4902.40	AR	2926.56				
Screen Sizes	Container Wt.	Sample + Cont. Wt.	Retained	Passing	Container Wt.	Sample + Cont. Wt.	Retained	Passing	Container Wt.	Sample + Cont. Wt.	Retained	Passing	Container Wt.	Sample + Cont. Wt.	Retained	Passing
	g	g	wt%	wt%	g	g	wt%	wt%	g	g	wt%	wt%	g	g	wt%	wt%
4"	332.40	1860.61	91.34	8.66	332.40	1664.03	39.74	60.26	332.40	2591.06	77.71	22.29				
3"	323.32	386.31	3.76	4.90	323.32	944.83	18.55	41.72	323.32	659.79	11.58	10.71				
2"	370.56	399.15	1.71	3.19	370.56	990.31	18.49	23.22	370.56	577.09	7.11	3.61				
Pan	332.58	385.97	3.19		332.58	1110.83	23.22		332.58	437.38	3.61					
	Finish Wt. g	1673.18	Recovered Sx %	102.0	Finish Wt. g	3351.14	Recovered Sx %	99.0	Finish Wt. g	2906.46	Recovered Sx %	99.3	Finish Wt. g	0.00	Recovered Sx %	

Remarks:

Particle Size Analysis by Sieving
ASTM D422
Rev 03.1 (removed calculation for residual moisture and corrected Retained % calculation to be based on Finish Wt. instead of Begin Sx Wt.)

Client: ALS Environmental - Canada
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9

Attn: Amber Springer

Project: VA23A5145 **Date Received:** March 21, 2023

Certificate of Analysis

Total Metals by ICP-OES	ID	VA23A5145-001 Dec 29	VA23A5145-002 Dec 13	VA23A5145-003 Dec 31		
	Units	T2300517-001	T2300517-002	T2300517-003		
Aluminum	mg/kg	3,945	19,067	29,729		
Antimony	mg/kg	< 79	< 87	< 65		
Arsenic	mg/kg	< 16	36	15		
Barium	mg/kg	131	132	283		
Beryllium	mg/kg	< 2	< 3	< 2		
Cadmium	mg/kg	< 8	< 9	< 7		
Calcium	mg/kg	22,510	49,670	13,634		
Chromium	mg/kg	10	56	37		
Cobalt	mg/kg	< 40	< 43	< 33		
Copper	mg/kg	12	34	16		
Iron	mg/kg	7,163	7,965	15,261		
Lead	mg/kg	< 16	< 17	28		
Lithium	mg/kg	< 24	< 26	20		
Magnesium	mg/kg	4,233	3,873	4,420		
Manganese	mg/kg	106	221	165		
Molybdenum	mg/kg	< 79	< 87	< 65		
Nickel	mg/kg	< 40	< 43	< 33		
Phosphorus	mg/kg	267	359	186		
Potassium	mg/kg	1,830	3,957	13,795		
Selenium	mg/kg	< 40	< 43	< 33		
Silicon	mg/kg	11,953	91,242	83,128		
Sodium	mg/kg	3,059	3,794	3,369		
Strontium	mg/kg	59	114	62		
Tin	mg/kg	17	22	24		
Titanium	mg/kg	936	1,433	2,641		
Vanadium	mg/kg	16	25	40		
Zinc	mg/kg	193	133	1,536		
Zirconium	mg/kg	< 16	41	54		

Note: Values reported on a dried basis.

Total Metals - Samples digested with HNO3, HCl & HF acids in microwave. Analysis was by ICP-OES.

Chain of Custody (COC) / Analytical Request Form

ALS www.alsglobal.com

Canada Toll Free: 1 800 668 9878

COC Number: 20 - 1017661

Page of

Report To	Contact and company name below will appear on the final report
Company:	Capital Regional District
Contact:	Andrea Panich
Phone:	250-360-3219
	Company address below will appear on the final report
Street:	625 Fisgard St
City/Province:	Victoria / BC
Postal Code:	V8W 1R7
Invoice To	Same as Report To ☐ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☐ NO
Company:	
Contact:	

Reports / Recipients

Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)

Merge QC/QCI Reports with COA ☐ YES ☐ NO ☐ N/A

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax

Email 2

Email 3

Invoice Recipients

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax

Email 2

Turnaround Time (TAT) Requested

☐ Routine [R] if received by 3pm M-F - no surcharges apply

☐ 4 day [P4] if received by 3pm M-F - 20% rush surcharge minimum

☐ 3 day [P3] if received by 3pm M-F - 25% rush surcharge minimum

☐ 2 day [P2] if received by 3pm M-F - 50% rush surcharge minimum

☐ 1 day [E] if received by 3pm M-F - 100% rush surcharge minimum

☐ Same day [E2] if received by 10am M-S - 200% rush surcharge. Additional fees may apply to rush requests on weekends, statutory holidays and non-routine tests

AFFIX ALS BARCODE LABEL HERE (ALS use only)

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm am/pm

For all tests with rush TATs requested, please contact your AM to confirm availability.

Project Information	
ALS Account # / Quote #:	CARD 100
Job #:	
PO / AFE:	
LSD:	
ALS Lab Work Order # (ALS use only):	

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	
ALS Contact:	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (ALS use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Grind	Heating value	Mercury EPA	Chlorine EPA	Total metals EPA	Sieve analysis 4" 1.3" 2"	SAMPLES ON HOLD	EXTENDED STORAGE REQUIRED	SUSPECTED HAZARD (see notes)
	December 29	29-12-22	—	C+D waste	1	✓	✓	✓	✓	✓	✓			N
	Dec 13	13-12-22	—	C+D waste	1	✓	✓	✓	✓	✓	✓			N
	Dec 31	31-12-22	—	C+D waste	1	✓	✓	✓	✓	✓	✓			N

Environmental Division
Vancouver
Work Order Reference
VA23A5145
Telephone : +1 604 253 4188

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

Notes / Specify Limits for resu[...]

SAMPLE RECEIPT DETAILS (ALS use only)

Cooling Method: ☐ NONE ☐ ICE ☐ ICE PACKS ☐ FROZEN ☐ COOLING INITIATED

Submission Comments identified on Sample Receipt Notification: ☐ YES ☐ NO

Cooler Custody Seals Intact: ☐ YES ☐ N/A Sample Custody Seals Intact: ☐ YES ☐ N/A

INITIAL COOLER TEMPERATURES °C | FINAL COOLER TEMPERATURES °C: 14 14 14

SHIPMENT RELEASE (client use)			[...] (ALS use only)			FINAL SHIPMENT RECEPTION (ALS use only)		
Released by: Andrea Panich	Date: March 07, 2023	Time: 14:30	Received by:	Date:	Time:	Received by: JC	Date: 8 Mar 23	Time: 11am

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

AUG 2020 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

ALS Canada Ltd.

CERTIFICATE OF ANALYSIS

Work Order	: **VA23B4478**	Page	: 1 of 3
Amendment	: **1**		
Client	: **Capital Regional District**	Laboratory	: ALS Environmental - Vancouver
Contact	: Andrea Panich	Account Manager	: Amber Springer
Address	: PO BOX 1000 625 Fisgard Street Victoria BC Canada V8W 2S6	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 23-Jun-2023 13:00
PO	: ----	Date Analysis Commenced	: 22-Sep-2023
C-O-C number	: ----	Issue Date	: 23-Sep-2023 09:42
Sampler	: Luke Novy		
Site	: ----		
Quote number	: VA22-CARD100-006		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Paolo Obillo	Account Manager Assistant	Internal Subcontracting, Tucson, Arizona

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances

LOR: Limit of Reporting (detection limit).

Unit	*Description*
%	percent

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Waste**

(Matrix: **Soil/Solid)**

Analyte	CAS Number	Method/Lab	LOR	Unit	March 9 1/3	March 10 2/3	March 18 3/3	----	----
				Client sampling date / time	09-Mar-2023 00:00	10-Mar-2023 00:00	18-Mar-2023 00:00	----	----
					VA23B4478-001	VA23B4478-002	VA23B4478-003	--------	--------
					Result	Result	Result	----	----
Physical Tests									
Ash	----	PROXIMATE/1J	0.01	%	see attached	see attached	see attached	----	----
Volatile matter	----	PROXIMATE/1J	0.01	%	see attached	see attached	see attached	----	----
Elemental Composition									
Carbon	----	ULTIMATE/1J	0.05	%	see attached	see attached	see attached	----	----
Hydrogen	1333-74-0	ULTIMATE/1J	0.05	%	see attached	see attached	see attached	----	----
Nitrogen	7727-37-9	ULTIMATE/1J	0.05	%	see attached	see attached	see attached	----	----
Oxygen, calculated	7782-44-7	ULTIMATE/1J	0.05	%	see attached	see attached	see attached	----	----
Sulfur	7704-34-9	ULTIMATE/1J	0.005	%	see attached	see attached	see attached	----	----

Please refer to the General Comments section for an explanation of any result qualifiers detected.

Please refer to the Accreditation section for an explanation of analyte accreditations.

ALS Canada Ltd.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA23B4478**	Page	:
Amendment	: **1**		
Client	: **Capital Regional District**	Laboratory	: ALS Environmental - Vancouver
Contact	: Andrea Panich	Account Manager	: Amber Springer
Address	: PO BOX 1000 625 Fisgard Street Victoria BC Canada V8W 2S6	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 23-Jun-2023 13:00
PO	: ----	Issue Date	: 23-Sep-2023 09:42
C-O-C number	: ----		
Sampler	: Luke Novy		
Site	: ----		
Quote number	: VA22-CARD100-006		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.

CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.

DQO: Data Quality Objective.

LOR: Limit of Reporting (detection limit).

RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Soil/Solid**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Elemental Composition : Ultimate										
HDPE Pail March 18 3/3	ULTIMATE	18-Mar-2023	----	----	----		22-Sep-2023	----	189 days	
Elemental Composition : Ultimate										
HDPE Pail March 10 2/3	ULTIMATE	10-Mar-2023	----	----	----		22-Sep-2023	----	197 days	
Elemental Composition : Ultimate										
HDPE Pail March 9 1/3	ULTIMATE	09-Mar-2023	----	----	----		22-Sep-2023	----	198 days	
Physical Tests : Proximate Analysis										
HDPE Pail March 18 3/3	PROXIMATE	18-Mar-2023	----	----	----		22-Sep-2023	----	189 days	
Physical Tests : Proximate Analysis										
HDPE Pail March 10 2/3	PROXIMATE	10-Mar-2023	----	----	----		22-Sep-2023	----	197 days	
Physical Tests : Proximate Analysis										
HDPE Pail March 9 1/3	PROXIMATE	09-Mar-2023	----	----	----		22-Sep-2023	----	198 days	

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

- **No Quality Control data available for this section.**

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by “mod”).

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Proximate Analysis	PROXIMATE Tucson - Environmental - 4208 S. Santa Rita Ave. Tucson Arizona United States 85714	Soil/Solid	ASTM D7582(D3173,D3174,D3175)	D7582: Proximate Analysis of Coal and Coke by Macro Thermogravimetric Analysis D3173: Moisture in the Analysis Sample of Coal and Coke D3174: Ash in the Analysis Sample of Coal and Coke from Coal D3175: Volatile Matter in the Analysis Sample of Coal and Coke
Ultimate	ULTIMATE Tucson - Environmental - 4208 S. Santa Rita Ave. Tucson Arizona United States 85714	Soil/Solid	ASTM D4239A/D5373	D4239: Sulfur in the Analysis Sample of Coal and Coke Using High-Temperature Tube Furnace Combustion. D5373: Determination of Carbon, Hydrogen and Nitrogen in Analysis Samples of Coal and Carbon in Analysis Samples of Coal and Coke.

ALS Canada Ltd.

QUALITY CONTROL REPORT

Work Order	: **VA23B4478**		Page	: 1 of 2
Amendment	: **1**			
Client	: Capital Regional District		Laboratory	: ALS Environmental - Vancouver
Contact	: Andrea Panich		Account Manager	: Amber Springer
Address	: PO BOX 1000 625 Fisgard Street Victoria BC Canada V8W 2S6		Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	:		Telephone	: +1 604 253 4188
Project	: ----		Date Samples Received	: 23-Jun-2023 13:00
PO	: ----		Date Analysis Commenced	: 22-Sep-2023
C-O-C number	: ----		Issue Date	: 23-Sep-2023 09:42
Sampler	: Luke Novy ----			
Site	: ----			
Quote number	: VA22-CARD100-006			
No. of samples received	: 3			
No. of samples analysed	: 3			

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Paolo Obillo	Account Manager Assistant	USA - Tucson Internal Subcontracting, Tucson, Arizona

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

September 22, 2023

Service Request No:T2301569

Ms. Amber Springer
ALS Environmental - Canada
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9

Laboratory Results for: VA23B4478

Dear Ms.Springer,

Enclosed are the results of the sample(s) submitted to our laboratory September 08, 2023
For your reference, these analyses have been assigned our service request number **T2301569.**

All analyses were performed according to our laboratory's quality assurance program. All results are intended to be considered in their entirety, and ALS Environmental is not responsible for use of less than the complete report. Results
apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Respectfully submitted,

ALS Group USA, Corp. dba ALS Environmental

Wendy Hyatt
Laboratory Director

ADDRESS 4208 S Santa Rita Avenue, Tucson, AZ 85714
PHONE +1 520 573 1061 | FAX +1 520 623 9218
ALS Group USA, Corp.
dba ALS Environmental

Chain of Custody

Vancouver - Environmental
8081 Lougheed Highway
Burnaby BC Canada V5A 1W9

T2301425 5
ALS Environmental - Canada
VA23B4478

DB 9/8/23

124165

Destination Lab:	USA - Tucson
Address:	4208 S. Santa Rita Ave. Tucson AZ United States 85714
Client:	Capital Regional District
Work Order Number:	VA23B4478
Original Receipt Date/Time	Instructions Received
23/08/2023 14:00	

T2301569 5
ALS Environmental - Canada
VA23B4478

Relinquished By

Date/Time

Received By: Chad

Date/Time: 8/15/23 1240

Receipt Temp

Return as Indicated: Results: alsev.datasublist@alsglobal.com | Invoice: alsev.datasublist@alsglobal.com | Electronic Data: alsev.datasublist@alsglobal.com

Attention: Amber Springer

ALS Sample ID	Client ID	Matrix	Container Type	Test Codes	Method Description	Due Date	Sampling Date and Time	Remarks
VA23B4478-001	March 9 1/3	Soil/Solid	HDPE Pail	see COC		17-07-2023	09/03/2023 01:00	
VA23B4478-002	March 10 2/3	Soil/Solid	HDPE Pail	"		17-07-2023	10/03/2023 01:00	
VA23B4478-003	March 16 3/3	Soil/Solid	HDPE Pail	"		17-07-2023	16/03/2023 01:00	

see attached CoC for analysis

Page 1 of 1

4208 S.Santa Rita Ave.
Tucson, AZ 85714
T: +1 520 573 1061
www.alsglobal.com

T2301569 5
ALS Environmental - Canada
VA23B4479

T2301425 5
ALS Environmental - Canada
VA23B4479

DB 9/18/23

Sample Receipt Form

Client/Project: ALS Canada

Work Order Number:

Received by: Cynthia Vroegh **Date & Time:** 9/15/2023 1240 **Matrix:** Solid

Samples were received via?: DHL **Samples were received in:** Bucket (3)

Were custody seals on containers? ○ Yes ● No ○ NA **If yes, how many and where?**

If present were custody seals intact? ○ Yes ● No **If present, were they signed and dated?** ○ Yes ● No

Arrival Temp C	Temp Blank C	Tracking Number
Ambient	NA	1439790074

Packing material used?

Did all the bottles arrive in good condition (unbroken)? ● Yes ○ No ○ NA **If No, record comments below**

Did all sample labels and tags agree with COC? ● Yes ○ No ○ NA **If No, record discrepancies below**

Were all the appropriate containers and volumes received for the tests indicated? ● Yes ○ No ○ NA

Are samples received deemed acceptable? ● Yes ○ No **MSDS included with paperwork?** No

3 - 5gl buckets

NOTES:

As a part of ISO 17025 protocols, ALS must notify clients that the quoted analytical methods performed by ALS may have minor modifications from the methods as published. These modifications are written into our Standard Operating Procedures and do not impact the quality of the data. Receipt of this document will be considered an acceptance of the procedures used by the laboratory for analysis unless notified by the client.
Modifications may include, but are not limited to:

- The analysis of a sample matrix that differs from that stated in the published method (example - ASTM D5865 Standard Test Method for Gross Calorific Value of Coal and Coke is used for other matrices such as biomass, Tire Derived Fuel, etc.)
- Analyzing a sample mass that differs from those in the published method (example - to accommodate samples with high concentrations of analyte, samples of limited volume, or to comply with the instrument manufacturer's operating guidelines).
- Instruments used for the analysis may differ from those listed in the published method (example - Spectroscopy)

Client: ALS Environmental - Canada
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9
Attn: Amber Springer

Project: VA23B4478 **Date Received:** September 8, 2023

Certificate of Analysis

Sample ID:	Sample Date and Time		Lab #:	Moisture, Total	Volatile Matter		Fixed Carbon		Ash	
					D7582 Proximate by Automated TGA System					
				wt%	As Received wt%	Moist. Free wt%	As Received wt%	Moist. Free wt%	As Received wt%	Moist. Free wt%
VA23B4478-001 March 9 1/3	3/9/23	0100	T2301569-001	17.82	38.51	46.86	5.34	6.50	38.33	46.64
VA23B4478-002 March 10 2/3	3/10/23	0100	T2301569-002	13.73	34.81	40.35	3.68	4.27	47.78	55.38
VA23B4478-003 March 18 3/3	3/18/23	0100	T2301569-003	13.67	54.92	63.61	13.05	15.12	18.36	21.27

Client: ALS Environmental - Canada
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9
Attn: Amber Springer

Project: VA23B4478 **Date Received:** September 8, 2023

Certificate of Analysis

Sample ID:	Sample Date and Time		Lab #:	Carbon, Total	Hydrogen, Total	Nitrogen, Total	Oxygen	Sulfur, Total		
					D5373		Calculated	D4239		
				Moist. Free wt%	Moist. Free wt%	Moist. Free wt%	Moist. Free wt%	Moist. Free wt%		
VA23B4478-001 March 9 1/3	3/9/23	0100	T2301569-001	24.29	2.45	1.05	24.15	1.41		
VA23B4478-002 March 10 2/3	3/10/23	0100	T2301569-002	24.13	2.59	0.88	16.50	0.52		
VA23B4478-003 March 18 3/3	3/18/23	0100	T2301569-003	41.59	5.82	1.64	29.20	0.48		

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

Affix ALS barcode label here (lab use only)

COC Number: 14 -

Page 1 of 1

Report To	Andrea Panich	Report Format / Distribution	Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Capital Regional District	Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)	R ☑ ~~Regular (Standard TAT if received by 3 pm - business days)~~
Contact:	Andrea Panich	Quality Control (QC) Report with Report ☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	625 Fisgard Street	☐ Criteria on Report - provide details below if box checked	E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
		Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	250-360-3219	Email 1 or Fax apanich@crd.bc.ca	Specify Date Required for E2,E or P:
		Email 2	Analysis Request
Invoice To	Same as Report To ☑ Yes ☐ No	Invoice Distribution	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:		Email 1 or Fax apanich@crd.bc.ca	
Contact:		Email 2	
Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Account # : CARD100	Approver ID: / Cost Center:	
Job #:		GL Account: / Routing Code:	
PO / AFE:		Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Selam Worku / Sampler: Luke Novy	

Environmental Division
Vancouver
Work Order Reference
VA23B4478

Telephone : +1 604 253 4188

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Sieve Analysis on 4", 3" and 2"	Sieve Analysis to report % material that passes through 0.5 mm	Number of Containers
	March 9 1/3	09-Mar-23	unknown	Shredded C&D waste	✓	✓	1
	March 10 2/3	10-Mar-23	unknown	Shredded C&D waste	✓	✓	1
	March 18 3/3	18-Mar-23	unknown	Shredded C&D waste	✓	✓	1

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

N/A

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C | FINAL COOLER TEMPERATURES °C: 22°C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: APanich	Date: June 21/23	Time: 3:00pm	Received by:	Date:	Time:	Received by: [illegible]	Date: Jun 23	Time: 13:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0326e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Attachment 6

Non-Haz Solid Spec Sheet

01 January, 2022

ALTERNATE NON-HAZARDOUS SOLID FUEL FOR USE IN RICHMOND KILN

General Description and Non-Technical Specification

Description:

Alternate Solid Fuel (ASF) is defined as: A fossil fuel substitute derived from non-hazardous materials that have been processed into a form for use as fuel. The non-hazardous materials used to produce ASF can be derived from either:

1) Post-consumer sources - material that has been recovered or diverted from the Municipal Solid Waste stream or from the residue of Material Recovery Facilities or,
2) Post-production sources - materials that have been recovered ***directly*** from manufacturing or industrial processes or activities.

These options represent the two most common sources of materials for the production of ASF. Cement kilns are also capable of utilizing hazardous materials however this document will not discuss use of those materials.

The following is a list of the more common materials used to produce ASF. This list is intended only to suggest possible materials that can be used as ASF in a cement kiln. It ***IS NOT*** a complete list of materials that cement kiln can utilize for fuel.

Plastics (no PVC)
Plastic films
Paper and paper products
Coated paper (plastic, wax ete)
Cardboard (waxed and plain)
Wood based materials
Biomass based products
Carpet & Carpet Backing
Foam
Textiles
Rubber
Roofing materials (shingles, tar paper etc.)
Containers, Packaging and Wrapping
Fiberglass
Other non-haz solid waste

Non-technical Specifications:

The following non-technical specifications ensure the responsible use of ASF as a supplemental fuel in the manufacture of cement, with the primary concerns being maintenance of high standards of environmental performance in cement manufacture, and maintenance of the high quality of cement products. Emissions to air, land and water will not be adversely affected by the use of ASF, and will be confirmed by environmental monitoring as required by the responsible environmental authority.

ASF shall meet the following specifications, which are similar to coal, and other fossil fuels. One element of concern for the cement plant is chlorine. This element can have an adverse affect on the cement manufacturing process and ultimately affect the quality of the cement product.

Heat Value:
ASF as used shall have a low heat value of no less than 13 GJ/Mt, without prior plant agreement, with typical heat values in the range of 15 GJ to 30 GJ/Mt.

Size:
It is understood that potential alternate fuel materials can originate in a large variety of shapes and sizes. Prior to use in a cement kiln as ASF, the material must be sized appropriately to match the requirements of the receiving kiln. Typical size specifications are no more than 5% passing 450 microns' screen (especially for combustible dusts like wood) and no larger than 1.5" for three-dimensional pieces and no larger than 2" for two dimensional pieces.

Contamination:
When sourcing materials for the production of ASF, the material should be as free of contamination as possible (i.e. rocks, dirt, metals, other non-combustible materials). Given the sources of materials used to produce ASF, it is recognized that it may not be possible to completely eliminate this contamination. Therefore, any processing facility set up to produce ASF will need to be able to reduce contamination to levels permissible by the receiving facility.

Typical ASF Chemistry Specification Guideline*:

Description	Maximum Percent
Moisture	20% (lower is better)
Ash	20% (lower is better)
Sulfur	1.0 %
Chlorine	0.10 %

Note: This table is intended as a guideline only as there may be additional flexibility or restrictions depending on situation (volume, price, deep evaluation)

Lab Analysis Required to Qualify (and Permit) an ASF:

Proximate Analysis and Ultimate Analysis
Net Calorific Values
Chlorine %
Total Metals – SALM (EPA 6020A)
Mercury total by CVAA (BCMOE/EPA)

Making a difference...together

Parks & Environmental Services
625 Fisgard Street, PO Box 1000
Victoria, BC, Canada V8W 2S6

T: 250.360.3000
www.crd.bc.ca

CAPITAL REGIONAL DISTRICT
PROCESSING AND UTILIZATION OF SOURCE-SEPARATED MATERIALS FROM HARTLAND LANDFILL
REQUEST FOR PROPOSALS ERM2022-010
ADDENDUM NO. 3

This letter shall serve as confirmation that the revisions included herein as Addendum No. 3 shall form part of the Request for Proposals (RFP) Documents for RFP No. ERM2022-010.

ADDENDUM NO. 3:

Revise the Request for Proposals as follows:

Instructions to Proponents

Delete: From Section 1.2 Closing Time and Date for Submission of Proposals

The CRD will accept electronic copies emailed to achambers@crd.bc.ca or physical copies of each proposal plus **one copy on a USB stick**, in accordance with the instructions contained herein, at the following specific physical location:

Attention: Allison Chambers
Senior Administrative Secretary
Environmental Resource Management

Address: Capital Regional District
625 Fisgard Street
Victoria, BC, V8W 2S6

On or before the following date and time (the “Closing Time”):

Time: 10:00 am PST
Date: 31 October 2023

The CRD reserves the right to extend the Closing Time at its sole discretion.

Replace with:

The CRD will accept electronic copies emailed to achambers@crd.bc.ca or physical copies of each proposal plus **one copy on a USB stick**, in accordance with the instructions contained herein, at the following specific physical location:

Attention: Allison Chambers
Senior Administrative Secretary
Environmental Resource Management

Making a difference...together

Parks & Environmental Services
625 Fisgard Street, PO Box 1000
Victoria, BC, Canada V8W 2S6

T: 250.360.3000
www.crd.bc.ca

Address: Capital Regional District
625 Fisgard Street
Victoria, BC, V8W 2S6

On or before the following date and time (the "Closing Time"):

Time: 10:00 am PST
Date: 3 January 2024

The CRD reserves the right to extend the Closing Time at its sole discretion.

Delete: from Appendix A Section 11: Schedule

Request for Proposals Steps	Date
RFP - Issued	September 18, 2023
Information Meeting (Optional)	October 5, 2023
Proponent's Site Visit (Optional)	October 5, 2023
Deadline for Collaborative Meeting Request (Optional)	October 6, 2023 at 2:00 pm
Deadline for Collaborative Meeting	October 20, 2023
Question Period Close	October 20, 2023
Deadline for Issuing Addenda	October 24, 2023
RFP - Closing	October 31, 2023 at 10:00 am
RFP - Award	December, 2023
In Service Target Date	Quarter 1, 2024

The CRD's preference is for MDTS to be operational and in service starting in January 2024. The CRD understands that site prep and equipment lead time may make this target date challenging. Proponents are encouraged to consider project delivery options that can allow for some materials processing (e.g., limited streams or volumes) to begin in January 2024, even in advance of the full construction of the MDTS.

Replace with:

Request for Proposals Steps	Date
RFP - Issued	September 18, 2023
Information Meeting (Optional)	October 5, 2023
Proponent's Site Visit (Optional)	October 5, 2023
Deadline for Collaborative Meeting Request (Optional)	December 13, 2023 at 2:00 pm
Question Period Close	December 13, 2023
Deadline for Issuing Addenda	December 18, 2023
RFP - Closing	January 3, 2024
RFP - Award	February 2024
In Service Target Date	July 1, 2024

~~The CRD's preference is for MDTS to be operational and in service starting in January 2024. The CRD understands that site prep and equipment lead time may make this target date challenging. Proponents are encouraged to consider project delivery options that can allow for some materials~~

~~processing (e.g., limited streams or volumes) to begin in January 2024, even in advance of the full construction of the MDTS.~~

All Proponents shall acknowledge receipt and acceptance of this Addendum No. 3 by signing and dating in the spaces provided below and submitting the signed Addendum with the Proposal. Proposals submitted without this Addendum may be considered incomplete.

October 17, 2023

____
PROPONENT - Please print name

____________________________________ ______________________________
SIGNATURE DATE

RFP No. ERM2022-010

Making a difference...together

Parks & Environmental Services
625 Fisgard Street, PO Box 1000
Victoria, BC, Canada V8W 2S6

T: 250.360.3000
www.crd.bc.ca

CAPITAL REGIONAL DISTRICT
PROCESSING AND UTILIZATION OF SOURCE-SEPARATED MATERIALS FROM HARTLAND LANDFILL
REQUEST FOR PROPOSALS ERM2022-010
ADDENDUM NO. 4

This letter shall serve as confirmation that the revisions included herein as Addendum No. 4 shall form part of the Request for Proposals (RFP) Documents for RFP No. ERM2022-010.

ADDENDUM NO. 4:

Revise the Request for Proposals as follows:

Instructions to Proponents

Delete: from Appendix A Section 9 Operations and Maintenance

g. Maintain treatment works for sediment control/solids reduction in good working order. The CRD reserves the right to require additional treatment of SW if discharges result in a non-compliance of the landfill's Sewer Discharge Authorization under Bylaw 2922, Capital Regional District Sewer Use Bylaw, or other non-compliances under the Landfill's Operational Certificate. At no time, shall the contractor discharge Hazardous Waste as defined by the BC Hazardous Waste Regulation. The CRD will perform audit of stormwater discharges to confirm compliance.

Replace with:

g. Maintain treatment works for sediment control/solids reduction in good working order. Stormwater run-off from the Biosolids Mixing Area must comply with the landfill's Sewer Discharge Authorization under Bylaw 2922, Capital Regional District Sewer Use Bylaw for discharge to leachate collection. All stormwater run-off from the MDTS, must comply with the BC Approved and Working Water Quality Guidelines for relevant parameters. At no time, shall the contractor discharge Hazardous Waste as defined by the BC Hazardous Waste Regulation.The CRD will perform audit of stormwater discharges to confirm compliance and reserves the right to require additional treatment of stormwater if discharges result in a non-compliance of the applicable regulatory criteria, or other non-compliances under the Landfill's Operational Certificate.

The CRD received the following questions regarding the RFP:

Question 1:
Are there engineered stamped foundation drawings for the sprung structure?

***Response* 1:**
The CRD does not have engineered stamped foundation drawings for the sprung structure. Questions related to the structure should be directed to Sprung Structures.

Parks & Environmental Services
625 Fisgard Street, PO Box 1000
Victoria, BC, Canada V8W 2S6
T: 250.360.3000
www.crd.bc.ca

Question 2:
Are CRD staff giving direction to people that are coming into the MDTS area backing them into positions to dump or is it up to the contractor to staff the site to do this task?

***Response* 2:**
The contractor will be designated Prime and responsible for providing direction to the people coming to the MDTS area, and for backing them into positions to unload the material at the MDTS.

Question 3:
Currently on page 6 section 6p it stated there is no potable water available at the MDTS site. This is incorrect as it is across the road by the bird storage area. Are we allowed to bring the 2" line across the road. In section q it also states there is no electrical power available. Outside the fence line of Hartland Landfill there is a source of power by the new water tank installed for the Residuals Treatment Facility. Would we not be able to explore electrical power from this power line. Can the CRD not explore with hydro the availability of power from this line?

***Response* 3:**
Proposals should be structured assuming potable water is not available near the MDTS as per Appendix A Section 6.o) Site and Operational Considerations. The CRD may be able to provide small volumes of electricity or water at the site and will discuss this with the preferred proponent, if relevant.

Question 4:
On page 11 of Appendix A Section 10 Operating Hours, it states they MDTS will have current operating hours on weekdays if 9am to 5pm and 7am to 2pm on Saturdays. Currently contractors on weekdays are allowed access from 6am-5pm and Saturdays from 6am-230pm. Are we not allowed to follow the same operating hours?

***Response* 4:**
Proposals should be structured assuming the hours listed in the RFP Appendix A section 10. Operating Hours. The final operating hours will be negotiated with the preferred proponent.

Question 5:
To contain any possible oil spills that may happen in the facility, does the CRD not want oil separators installed?

***Response* 5:**
The proponent shall design and install the required mitigation methods such that all run-off from the MDTS complies with applicable bylaws as referred to in revised Appendix A Section 9.1 Operations and Maintenance (see above *replace with*).

Question 6:
Is there a digital version satellite image of the area or drawings that can be provided in a CAD format that we can work with?

***Response* 6:**
Yes, the CRD will provide ortho and CAD drawings, and will issue these as soon as possible. Ortho and CAD drawings will also be included in the updated drawing package which the CRD is aiming to issue the first week of November.

Question 7:
Regarding Appendix B – Form of Proposal, specifically section 3.3 15% design, would the CRD be so kind as to provide further clarification on the definition and/or quantification of “15% design”?

***Response* 7:**

- Preliminary Site Layout (including usage of the Food Scraps area on an as needed basis if required)
  - General Arrangement of the MDTS to support Project Understanding and Operations and Maintenance Methodology.

- Preliminary Traffic Flow / Traffic Management Plan
  - Preliminary Drawing or Plan to demonstrate general traffic flow patterns into, throughout and out of the MDTS

- Preliminary Stormwater Management Plan
  - Outline of Stormwater Management Plan demonstrating understanding of key stormwater design, construction and maintenance objectives indicated throughout the RFP and MDco’s general approach to achieving these objectives.

- Tie-in and Utility Requirements (if any)
  - List of any tie-in and utility requirements such as potable water, non-potable water, electrical etc.

Question 8:
Regarding the Submittal form “A” Payment Terms, specifically Table 1 – Design and Construction Payment Schedule, can the CRD kindly clarify the meaning of “Approved Issue for Construction Design”?

***Response* 8:**
“Approved Issued for Construction (IFC) Design” refers to the CRD’s approval of the proponent’s final design which shall be signed and sealed by an engineer licensed in the province of British Columbia. The IFC design is the design in which the MDTS will be constructed based on.

Question 9:
Would the CRD be open to a negotiated RFP process? If so, could the CRD provide an outline of this process and its timeline, relative to the CRD Board meeting in December 2023?

***Response* 9:**
As per Addendum No. 3 issued on October 17, 2023, the RFP process timeline has been adjusted. RFP submissions are due January 3, 2024.

Question 10:
In Addendum No. 2, question 6: there are two piles located towards the North side of the site. One is kind of Northeast and one is Northwest. Which pile can we use and set up a crusher at?

***Response* 10:**
A crusher can be set up on the Northeast side shot rock pile. The specific location will be included in the updated drawing package which the CRD is aiming to issue the first week of November.

Question 11:
For the Asphalt pad how thick would the CRD like it 4" or 6"?

***Response* 11:**
Asphalt thickness shall be determined by the proponent based the performance-based requirements outlined in Appendix A Section 8.2. These include but are not limited to ensuring protection of the below grade PVC liner, drainage and MDTS operations and maintenance.

Question 12:
Is the CRD removing or lowering the current gas lines and standpipes that are in the way? Are CRD staff doing this or do you want a contractor to do this task?

***Response* 12:**
The CRD is preparing an updated drawing package based on actual cut/fill and grading design and will include further detail on the existing gas lines and standpipes in this package. We anticipate issuing this package the first week of November.

Question 13:
Who and how are the existing holes in the liner being repaired in the MDTS area before work on the pad begins?

***Response* 13:**
The CRD is aware of and acknowledges the presence of existing holes/tears in the PVC liner. These holes/tears will not be repaired prior to MDTS work commencing. However, the proponent will be required to minimize further damage to the PVC liner by adhering to the requirements in Appendix A Section 8.2. Appendix A, Section 8.2 will be updated and provided via an addendum to be issued the first week of November to reflect this question and response.

Question 14:
Do you have a ditch design that you would like? If so, can we please get a cross section for it or would you like us to come up with a design?

***Response* 14:**
The CRD will be providing a typical asphalted ditch detail for reference only. This will be provided via the revised drawing package to be issued the first week of November. The proponent will be required to design the ditch consistent with the requirements listed in Appendix A to facilitate drainage, operations and maintenance such as allowing for the cleanout of sediment which may build up in the ditch.

Question 15:
The CRD did a recent study to identify end uses for the listed materials in the RFP. Would the CRD be open to sharing those results?

***Response* 15:**
The CRD is aware of the following businesses that may be able to provide end-use markets for the targeted materials streams in this RFP. The CRD does not have relationships with these vendors and MDco is responsible for identifying, contracting and negotiations with End Users (see Appendix A sec. 9.1h).

- Heritage Lumber
- Blue Planet Recycling
- NorthStar Clean Technologies
- Empower Environmental
- Reclaim Plastics
- Ecowaste

Question 16:
Will there be a big stockpile to process for the winning bidder or will the ban be delayed?

***Response* 16:**
The CRD will not be stockpiling materials in advance of the July 1 target in-service date.

Question 17:
We would like to request samples for lab analysis, as detailed in the attached Excel spreadsheet. Could the CRD please advise on the preferred sample pickup/delivery method? Our lab representative can directly collect the samples from the CRD site if that's more convenient.

***Response* 17:**
The CRD can make available samples of materials currently received at Hartland Landfill. The CRD is unable to pre-process samples to meet laboratory specifications and proponents will need to arrange for any necessary preprocessing to meet laboratory analysis requirements. Samples can be picked up at the Hartland Landfill or the CRD can arrange shipping of samples in mega bags or some other means. If a proponent would like to speak further about sampling, please arrange a collaboration meeting.

Question 18:

Would the CRD be willing to provide additional landfill visits, specifically to the location of the future transfer station footprint?

Response 18:
Yes, to arrange for a site visit, please contact Allison Chambers following the Inquiries process (section 1.5) of the RFP.

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All Proponents shall acknowledge receipt and acceptance of this Addendum No. 4 by signing and dating in the spaces provided below and submitting the signed Addendum with the Proposal. Proposals submitted without this Addendum may be considered incomplete.

October 24, 2023

____
PROPONENT - Please print name

______________________________ ______________________________
SIGNATURE DATE

RFP No. ERM2022-010

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CAPITAL REGIONAL DISTRICT
PROCESSING AND UTILIZATION OF SOURCE-SEPARATED MATERIALS FROM HARTLAND LANDFILL
REQUEST FOR PROPOSALS ERM2022-010
ADDENDUM NO. 5

This letter shall serve as confirmation that the revisions included herein as Addendum No. 5 shall form part of the Request for Proposals (RFP) Documents for RFP No. ERM2022-010.

ADDENDUM NO. 5:

Revise the Request for Proposals as follows:

Instructions to Proponents

Delete: From Appendix A Section 6 Site and Operational Considerations

a) The CRD will provide approximately 1.3 hectares, denoted as MDTS Footprint in Drawing No. 24-W1067-1 – Location Plan, Vehicle Access Routing, Table of Contents and General Notes, for the purpose of this Work.
b) The MDTS Footprint currently consists of those features shown on Drawing No. 24-W1067-2 – Hartland Material Diversion Transfer Station Area Development Gravel Grading Plan, Detail and Coordinate Table.
c) The MDTS Footprint consists of a below grade smooth PVC membrane currently covered by 25 millimetres (mm) of sand, approximately 300mm of 25mm minus crush and varying depths of a topsoil, peat and compost mix. This is shown in Drawing No. 24-W1067-2 – Gravel Grading Plan, Detail and Coordinate Table.
d) A Waste Composition Study of Shredded Construction and Demolition Waste at the Hartland Landfill was conducted in February 2023 (Attachment 3).
e) The CRD has a program in place to identify asbestos containing materials and ensure they are properly disposed of. More information can be found in Attachment 4.
f) The CRD will make available a 100 feet (ft) x 110 ft sprung structure at no cost to MDco. Details of the sprung structure can be found in Attachment 5.
g) A paved area currently designated as the "Food Scraps Area" will be made available to the MDco on an as-needed basis, and with approval from the CRD, if additional footprint is required for MDTS operations. This is shown in Drawing No. 24-W1067-1.
h) The CRD has provided a Traffic Plan (Drawing No. 24-W1067, Section 14 Drawings) which outlines traffic flow requirements from the main Landfill gate to/from the MDTS boundary.
i) The CRD has provided a Fire Control Plan in Attachment 6.
j) MDco will not have access to any CRD services other than those explicitly mentioned within this Appendix A.
k) If required by MDco, the CRD can provide a location for a site trailer for MDco staff during operations at the current bird storage location indicated in Drawing No. 24-W1067-1. Two

control buildings may also be available for MDco, pending decommissioning of the existing Gas Plant.

l) The footprint allocated for the MDTS is located on a closed portion of the Landfill; as a result, settlement of this area should be expected and accounted for during design and operation by MDco.
m) MDco will have priority access to the existing CRD weigh scales located at the entrance to the Landfill.
n) MDco will be able to dispose of waste at the active landfill face at no cost; however, MDco will be required to obtain a weigh scale ticket for any waste disposed of.
o) Potable water is not available near the MDTS.
p) Non-potable water is not available near the MDTS. Coordination with the CRD will be required to fill MDco holding tanks if non-potable water is required for operations.
q) Electrical service is not available near the MDTS.
r) The CRD will be stripping and cleaning up the MDTS footprint and a final survey will be provided to confirm the existing grade and fill requirements.
s) MDco will have access to CRD shot rock piles to crush aggregate needed for fill in the area.

Replace with:

a) The CRD will provide approximately 1.3 hectares, denoted as MDTS Footprint in Drawing No. 24-W1067-1 – Location Plan, Vehicle Access Routing, Table of Contents and General Notes, for the purpose of this Work.
b) The MDTS Footprint currently consists of those features shown on Drawing No. 24- W1067-2 – ~~Hartland Material Diversion Transfer Station Area Development~~ Gravel Grading Plan, Detail and Coordinate Table.
c) The MDTS Footprint consists of a below grade smooth PVC ~~membrane~~ liner currently covered by 25 millimetres (mm) of sand, approximately 300mm of 25mm minus crush and varying depths of a topsoil, peat and compost mix. This is shown in Drawing No. 24-W1067-2 – Gravel Grading Plan, Detail and Coordinate Table. The CRD is aware of and acknowledges the presence of existing holes/tears in the PVC liner. While the CRD is aware of these holes/tears they will not be repaired prior to MDTS work commencing.
d) A Waste Composition Study of Shredded Construction and Demolition Waste at the Hartland Landfill was conducted in February 2023 (Attachment 3).
e) The CRD has a program in place to identify asbestos containing materials and ensure they are properly disposed of. More information can be found in Attachment 4.
f) The CRD will make available a 100 feet (ft) x 110 ft sprung structure at no cost to MDco. Details of the sprung structure can be found in Attachment 5.
g) A paved area currently designated as the “Food Scraps Area” will be made available to the MDco on an as-needed basis, and with approval from the CRD, if additional footprint is required for MDTS operations. This is shown in Drawing No. 24-W1067-1.

h) The CRD has provided a ~~Traffic Plan~~ Vehicle Access Routing (Drawing No. 24-W1067-1, ~~Section 14 Drawings~~) which outlines traffic flow requirements from the main Landfill gate to/from the MDTS boundary.
i) The CRD has provided a Fire Control Plan in Attachment 6.
j) MDco will not have access to any CRD services other than those explicitly mentioned within this Appendix A.
k) If required by MDco, the CRD can provide a location for a site trailer for MDco staff during operations at the current bird storage location indicated in Drawing No. 24-W1067-1. Two control buildings may also be available for MDco, pending decommissioning of the existing Gas Plant.
l) The footprint allocated for the MDTS is located on a closed portion of the Landfill; as a result, settlement of this area should be expected and accounted for during design and operation by MDco.
m) MDco will have priority access to the existing CRD weigh scales located at the entrance to the Landfill.
n) MDco will be able to dispose of waste at the active landfill face at no cost; however, MDco will be required to obtain a weigh scale ticket for any waste disposed of.
o) Potable water is not available near the MDTS.
p) Non-potable water is not available near the MDTS. Coordination with the CRD will be required to fill MDco holding tanks if non-potable water is required for operations.
q) Electrical service is not available near the MDTS.
r) The CRD will be stripping and cleaning up the MDTS footprint and a final survey will be provided to confirm the existing grade and fill requirements.
s) MDco will have access to CRD shot rock piles to crush aggregate needed for fill in the area.

Delete: From Appendix A Section 8 Design and Construction

b) Development of Plans including but not limited to:
   i. Schedule incl. Basis of Schedule
   ii. Project Execution Plan
   iii. Traffic Plan – this plan shall incorporate the CRD's Vehicle Access Routing (Drawing No. 24-W1067 – 1 Drawing).
   iv. Permit List – this shall outline any permits required by MDco for construction and operation of the MDTS
   v. Emergency Response Plan - this plan shall incorporate the CRD's Emergency Response Plan
   vi. Environmental Plan
   vii. Site Specific Health and Safety Plan (inclusive of plot plan)
      1) Fire suppression
      2) CRD Contractor Occupational, Health & Safety Project Checklist

   viii. Stormwater Management and Erosions and Sediment Control Plan
   ix. Operations and Maintenance (O&M) Plan

x. Monthly Report Template
xi. Closure Plan

Replace with:

b) Development of Plans including but not limited to:
   i. Schedule incl. Basis of Schedule
   ii. Project Execution Plan
   iii. Traffic Plan – this plan shall incorporate the CRD's ~~Traffic Management Plan~~ Vehicle Access Routing (Drawing No. 24-W1067 – 1 Drawing).
   iv. Permit List – this shall outline any permits required by MDco for construction and operation of the MDTS
   v. Emergency Response Plan - this plan shall incorporate the CRD's Emergency Response Plan
   vi. Environmental Plan
   vii. Site Specific Health and Safety Plan (inclusive of plot plan)
      1) Fire suppression
      2) CRD Contractor Occupational, Health & Safety Project Checklist
   viii. Stormwater Management and Erosions and Sediment Control Plan
   ix. Operations and Maintenance (O&M) Plan
   x. Monthly Report Template
   xi. Closure Plan

Delete: From Appendix A Section 8.2 Design and Construction – Objectives

b) MDco shall design the MDTS such that all operations (storage, processing, hauling, parking, etc.) are completed on an asphalt binder surface with an aggregate base layer. Preference will be given to proposals which utilize recycled materials (such as recycled roadbase or concrete) for the asphalt surface and/or aggregate layer. Both the asphalt surface and aggregate layer shall be designed to adequately protect the below-grade PVC membrane. The CRD is open to alternative cost saving designs, such as modifications to the design surface and/or subgrade once the below grade PVC liner is adequately protected at all times and stormwater and leachate collection objectives are achieved. The gravel and road grading details (ref.: Drawing No. 24-W1067-2) provided are typical details; MDco may propose alternative materials for the asphalt and aggregate layer with approval from the CRD.

c) MDco shall design and operate the MDTS such that the maximum allowable load/stress on the below grade smooth PVC membrane is not exceeded. The technical specifications of the PVC membrane is available for reference as Attachment 8.

Replace with:

b) MDco shall design the MDTS such that all operations (storage, processing, hauling, parking, etc.) are completed on an asphalt binder surface with an aggregate base layer. Preference will be given to proposals which utilize recycled materials (such as recycled roadbase or concrete) for the asphalt surface and/or aggregate layer. Both the asphalt surface and aggregate layer shall be designed to adequately protect the below-grade PVC ~~membrane~~ liner and mitigate further damage. The CRD is open to alternative cost saving designs, such as modifications to the design surface and/or subgrade once the below grade PVC liner is adequately protected at all times and stormwater and leachate collection objectives are achieved. The gravel and road grading details (ref.: Drawing No. 24-W1067-2) provided are typical details; MDco may propose alternative materials for the asphalt and aggregate layer with approval from the CRD.

c) MDco shall design and operate the MDTS such that the maximum allowable load/stress on the below grade smooth PVC ~~membrane~~ liner is not exceeded. The technical specifications of the PVC ~~membrane~~ liner is available for reference as Attachment 8. MDco will be required to demonstrate this in their design.

Delete : From Appendix A Section 9 Operations and Maintenance

m) Overall management of the MDTS including but not limited to:
   i. Educate users on material diversion locations,
   ii. Provide an Environmental, Health and Safety Plan,
   iii. Provide pre-processing capacity for materials on-site as required for End Use facilities
   iv. Coordinate with End Users to determine and conduct any necessary testing and pre-processing requirements of the End Use facility,
   v. Site Maintenance – including but not limited to:
      1) Maintain a clean Site by regularly removing source-separated materials,
      2) Ensuring the Site is free from loose or blowing garbage,
      3) Dust control as required,
      4) Snow removal,
      5) Fire Suppression,
      6) Asphalt/surface maintenance,
      7) Ensuring adequate protection at all times of the below grade smooth PVC membrane system
      8) Maintaining the CRD's Good Neighbour Policy.

Replace with:

m) Overall management of the MDTS including but not limited to:
   vi. Educate users on material diversion locations,
   vii. Provide an Environmental, Health and Safety Plan,
   viii. Provide pre-processing capacity for materials on-site as required for End Use facilities

ix. Coordinate with End Users to determine and conduct any necessary testing and pre-processing requirements of the End Use facility,

x. Site Maintenance – including but not limited to:
   1) Maintain a clean Site by regularly removing source-separated materials,
   2) Ensuring the Site is free from loose or blowing garbage,
   3) Dust control as required,
   4) Snow removal,
   5) Fire Suppression,
   6) Asphalt/surface maintenance,
   7) Ensuring adequate protection at all times of the below grade smooth PVC ~~membrane~~ liner system to mitigate further damage
   8) Maintaining the CRD's Good Neighbour Policy.

Delete: From Appendix A Section 13 Attachments

13. Attachments

- Attachment 1: Staff Report: Meeting the Solid Waste Management Plan Targets through Material Stream Diversion
- Attachment 2: 2022 Solid Waste Stream Composition Study
- Attachment 3: Shredded Composition & Demolition Waste at the Hartland Landfill
- Attachment 4: Pre-approval application for Renovation & Demolition Waste
- Attachment 5: Sprung Structure Drawings
- Attachment 6: Hartland Landfill Fire Safety Plan
- Attachment 7: Current Bird Storage Location
- Attachment 8: Technical specifications of the PVC membrane
- Attachment 9: Source-Separated Materials Available from the Cowichan Valley Regional District
- Attachment 10: Technical Memorandum-Results of Waste Composition Study of Shredded Construction & Demolition Waste

Replace with:

- Attachment 1: Staff Report: Meeting the Solid Waste Management Plan Targets through Material Stream Diversion
- Attachment 2: 2022 Solid Waste Stream Composition Study
- Attachment 3: Shredded Composition & Demolition Waste at the Hartland Landfill
- Attachment 4: Pre-approval application for Renovation & Demolition Waste
- Attachment 5: Sprung Structure Drawings
- Attachment 6: Hartland Landfill Fire Safety Plan
- Attachment 7: Current Bird Storage Location
- Attachment 8: Technical specifications of the PVC liner
- Attachment 9: Source-Separated Materials Available from the Cowichan Valley Regional District
- Attachment 10: Technical Memorandum-Results of Waste Composition Study of Shredded Construction & Demolition Waste
- Attachment 11: Revised Drawing Package and CAD Files

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The CRD received the following questions regarding the RFP:

Question 1:
Does the CRD plan on backing off the January 1 start date or landfilling the segregated material?

***Response 1*:**
Refer to Addendum 4, question 16 for information on stockpiling materials in advance of the in-service target date of July 1, 2024.

Question 2:
Addendum 3, question 6: Is there a digital version satellite image of the area or drawings that can be provided in a CAD format that we can work with?

***Response* 2:**
Appendix A section 14 Drawings has been updated and included in this package as Attachment 11.

Question 3:
Addendum 3, question 12: Is the CRD removing or lowering the current gas lines and standpipes that are in the way? Are CRD staff doing this, or do you want a contractor to do this task?

Response 3:
The CRD has prepared an updated drawing package based on actual cut/fill and grading design, refer to drawing No. 2 in Attachment 11.

Question 4:
Addendum 3, question 13: Who and how are the existing holes in the liner being repaired in the MDTS area before work on the pad begins?

***Response* 4:**
The CRD is aware of and acknowledges the presence of existing holes/tears in the PVC liner. These holes/tears will not be repaired prior to MDTS work commencing. However, the proponent will be required to minimize further damage to the PVC liner by adhering to the requirements in Appendix A Section 8.2. Appendix A, Section 8.2 will be updated and provided via an addendum to be issued the first week of November to reflect this question and response.

Question 5:
Addendum 3, question 14: Do you have a ditch design that you would like? If so, can we please get a cross section for it, or would you like us to come up with a design?

***Response* 5:**
The CRD has provided a typical asphalted ditch detail for reference only. This is provided in Attachment 11 drawing No. 3. The proponent will be required to design the ditch consistent with the requirements listed in Appendix A to facilitate drainage, operations and maintenance such as allowing for the cleanout of sediment which may build up in the ditch.

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All Proponents shall acknowledge receipt and acceptance of this Addendum No. 5 by signing and dating in the spaces provided below and submitting the signed Addendum with the Proposal. Proposals submitted without this Addendum may be considered incomplete.

November 1, 2023

____
PROPONENT - Please print name

______________________________ ______________________________
SIGNATURE DATE

RFP No. ERM2022-010

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CAPITAL REGIONAL DISTRICT
PROCESSING AND UTILIZATION OF SOURCE-SEPARATED MATERIALS FROM HARTLAND LANDFILL
REQUEST FOR PROPOSALS ERM2022-010
ADDENDUM NO. 6

This letter shall serve as confirmation that the revisions included herein as Addendum No. 6 shall form part of the Request for Proposals (RFP) Documents for RFP No. ERM2022-010.

ADDENDUM NO. 6:

Revise the Request for Proposals as follows:

Instructions to Proponents

The CRD received the following question regarding the RFP:

Question 1:
Upon reviewing Addendum No. 5, we noticed on page 6 that bidders are instructed to delete “Attachment 8: Technical specifications of the PVC membrane” and replace it with "Technical specifications of the PVC liner." However, an updated Attachment 8 reflecting this change was not included with the addendum.

Could the CRD please clarify if an updated document will be provided, or should we proceed with the attachment as simply re-titled?

***Response 1*:**
The CRD does not intend to modify the title of Attachment 8, the instruction in Addendum No. 5 to delete/add “Attachment 8 Technical specifications of the PVC membrane” and replace it with "Technical specifications of the PVC liner” was to change how attachment 8 is referred to in the contract, the contents of the report remain the same.

All Proponents shall acknowledge receipt and acceptance of this Addendum No. 6 by signing and dating in the spaces provided below and submitting the signed Addendum with the Proposal. Proposals submitted without this Addendum may be considered incomplete.

November 8, 2023

____
PROPONENT - Please print name

______________________________ ______________________________
SIGNATURE DATE

RFP No. ERM2022-010

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CAPITAL REGIONAL DISTRICT
PROCESSING AND UTILIZATION OF SOURCE-SEPARATED MATERIALS FROM HARTLAND LANDFILL
REQUEST FOR PROPOSALS ERM2022-010
ADDENDUM NO. 7

This letter shall serve as confirmation that the revisions included herein as Addendum No. 7 shall form part of the Request for Proposals (RFP) Documents for RFP No. ERM2022-010.

ADDENDUM NO. 7:

Revise the Request for Proposals as follows:

Instructions to Proponents

Delete: Submittal Form "A"

SUBMITTAL FORM "A"
PAYMENT TERMS

CAPEX
The CRD will pay MDco for the Design and Construction of the MDTS through Milestone Payments. MDco shall provide the expected Milestone Payment amounts equal to the total CAPEX for the Project.

Table 1 – Design and Construction Payment Schedule

Milestone Payment	Amount	Estimated Payment Date
Approved Issued for Construction Design		
Asphalt Paving		
Equipment Delivery		
Construction Completion		
Total		

OPEX
The CRD will pay MDco for the Operation of the MDTS through a monthly Fixed Minimum and Variable Processing costs as outlined in the tables below.

Table 2 – Fixed Minimum Monthly Costs

Fixed Minimum Monthly Costs[1]	Unit Rate	Unit	Quantity	Total Costs ($)
Management Costs		$/month		$ -
Equipment Costs[2]		$/month		$ -
Staffing		$/month		$ -
Maintenance		$/month		$ -
Diesel		$/L		$ -
Electricity		NA		$ -
Potable Water		NA		$ -
Non-Potable Water		$/month		$ -
Total Fixed Minimum Monthly Costs				**$ -**

1. Fixed monthly costs assumes that end user contracts are secured. If end users are unavailable, the CRD retains the right to pause transfer service until end user contracts are in place.
2. MDco may recommend alternative delivery models for financing and owning equipment to maximize the value retention of equipment.

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Table 3 – Variable Monthly Processing Costs

Variable Monthly Processing Costs	Unit Rate[1]	Unit	Quantity (tonnes)	Total Costs ($)
Clean Wood		$/tonne		$ -
Treated Wood		$/tonne		$ -
Asphalt Roofing Shingles		$/tonne		$ -
Carpet and Underlay		$/tonne		$ -
Books		$/tonne		$ -
Rigid Plastics (non-extended producer responsitility)		$/tonne		$ -
Waste to Active Area (Loading, Hauling/Transportation)		$/tonne		$ -
Total Variable Monthly Processing Costs				**$ -**

1. Includes Loading, Processing, Hauling/Transportation

Please note that the costs in Table 4 below is intended to provide indicative costing for the CRD, with the understanding that they are nonbinding to MDco for the purposes of this proposal.

Table 4 – Fixed Monthly End Use Costs

Fixed Monthly End Use Costs	End Use Options	End Use Option Unit Rate[1] ($/tonnes)	Range (tonnes)	Quantity (tonnes)	Total Costs ($)
Clean Wood			0 - 200		$ -
			> 200		$ -
			0 - 200		$ -
			> 200		$ -
Treated Wood			0 - 1000		$ -
			> 1000		$ -
			0 - 1000		$ -
			> 1000		$ -
Asphalt Roofing Shingles			0 - 300		$ -
			> 300		$ -
			0 - 300		$ -
			> 300		$ -
Carpet and Underlay			0 - 150		$ -
			> 150		$ -
			0 - 150		$ -
			> 150		$ -
Books			N/A		$ -
			N/A		$ -
Rigid Plastics (non-extended producer responsibility)			0 - 100		$ -
			> 100		$ -
			0 - 100		$ -
			> 100		$ -
Total Fixed Monthly End Use Costs					**$ -**

1. Includes End User Invoice and markup.

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Table 5 – Total Monthly Costs

Total Monthly Costs	**Total Costs ($)**
Total Fixed Minimum Monthly Costs	$ -
Total Variable Monthly Processing Costs	$ -
Total Fixed Monthly End Use Costs	$ -
Total Monthly Costs	**$ -**

Table 6 – Provisional Costs

Provisional Costs	**Total Costs ($)**
Rock Crushing ($/tonne) [1]	$ -

[1] Shot Rock will be available from the CRD at no cost to MDco for crushing and use on site, if beneficial to MDco.

Replace with:

SUBMITTAL FORM "A" (Revised per Addendum 7)
PAYMENT TERMS

CAPEX

The CRD will pay MDco for the Design and Construction of the MDTS through Milestone Payments. MDco shall provide the expected Milestone Payment amounts equal to the total CAPEX for the Project.

Table 1 – Design and Construction Payment Schedule

Milestone Payment	**Amount**	**Estimated Payment Date**
Approved Issued for Construction Design		
Asphalt Paving		
Equipment Delivery		
Construction Completion		
Total		

OPEX

The CRD will pay MDco for the Operation of the MDTS through a monthly Fixed Minimum and Variable Processing costs as outlined in the tables below.

Table 2 – Fixed Minimum Monthly Costs

Fixed Minimum Monthly Costs[1]	**Unit Rate**	**Unit**
Management Costs		$/month
Equipment Costs[2]		$/month
Staffing		$/month
Maintenance		$/month
Diesel		$/L
Electricity		NA
Potable Water		NA
Non-Potable Water		$/month
Total Fixed Minimum Monthly Costs		

1. Fixed monthly costs assumes that end user contracts are secured. If end users are unavailable, the CRD retains the right to pause transfer service until end user contracts are in place.
2. MDco may recommend alternative delivery models for financing and owning equipment to maximize the value retention of equipment.

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Table 3 – Fixed Unit Rate Monthly Costs

Fixed Unit Rate Monthly Costs	**Fixed Unit Rate[1]**	**Unit**
Clean Wood		$/tonne
Treated Wood		$/tonne
Asphalt Roofing Shingles		$/tonne
Carpet and Underlay		$/tonne
Books		$/tonne
Rigid Plastics (non-extended producer responsibility)		$/tonne
Waste to Active Area (Loading, Hauling/Transportation)		$/tonne
Total Fixed Unit Rate Monthly Costs		

1. Includes Loading, Processing, Hauling/Transportation

Please note that the costs in Table 4 below is intended to provide indicative costing for the CRD, with the understanding that they are nonbinding to MDco for the purposes of this proposal.

Table 4 – Monthly Pass-through End-Use Costs

Monthly Pass through End-Use Costs[1]	**End Use Options**	**End Use Option Unit Rate[2] ($/tonnes)**	**Range (tonnes) per Month**
Clean Wood			0 - 200
			> 200
			0 - 200
			> 200
Treated Wood			0 - 1000
			> 1000
			0 - 1000
			> 1000
Asphalt Roofing Shingles			0 – 400
			> 400
			0 – 400
			> 400
Carpet and Underlay			0 - 150
			> 150
			0 - 150
			> 150
Books			N/A
			N/A
Rigid Plastics (non-extended producer responsibility)			0 - 100
			> 100
			0 - 100
			> 100
Total Monthly Pass-through End-Use Costs			

1. Includes End User Invoice and markup.
2. Monthly Pass-through End-Use costs refers to the costs MDco will receive from the End-User for the processing of various quantities and types of waste materials. These costs shall be actuals provided by the End-User which will be passed from MDco to the CRD (pass-through costs).

Table 5 – Provisional Costs

Provisional Costs	Total Costs ($)
Rock Crushing ($/tonne) [2]	$ -

1. Shot Rock will be available from the CRD at no cost to MDco for crushing and use on site. if beneficial to MDco.

The CRD received the following question regarding the RFP:

Question 1:
In the pricing schedule, **Table 4: Fixed** Monthly End Use Costs: during our meetings we clarified that End Use Cost is **Variable** and will fluctuate over time. Our understanding is that the CRD agreed with this approach (Variable Cost). Please clarify this point.

***Response 1*:**

Please refer to revised Submittal Form "A", appended to this Addendum as Appendix A. For clarity with the Submittal Form "A" – Payment Terms, Table 3 has been renamed to Fixed Unit Rate Monthly Costs. The intent with Table 3 is to obtain a fixed unit rate per tonne per month, with the understanding that the total cost will vary depending on the actual tonnes of material processed.

Table 4 has been renamed to Monthly Pass-through End-Use Costs, and 'Range (tonnes)' has been clarified to be 'Range (tonnes) per month'. The intent with Table 4 is for MDco to provide the CRD with estimated pass-through costs for End Use processing. Invoices that MDco will receive from the End-Users for the processing of various quantities and types of waste materials will be passed on to the CRD for payment.

Question 2:
Please confirm the quantities of the onsite gravel materials (in Cubic meters).

Response 2:
The CRD will make available one of its shot rock stockpiles to allow the proponent to crush the aggregates required for construction. Storage of the finished aggregate piles is limited to the area within the biosolids mixing /diversion depot limits. The Proponent shall provide the following information in its tender: the aggregate specifications, quantity, method of supply (i.e., Crushing CRD shot rock onsite or procuring aggregates from offsite) and cost/m^3 to supply the various aggregates.

Question 3:
Please advise what will be the landfill gate rates for 2024 onwards.

Response 3:
The CRD does not believe that gate rates are relevant for the RFP, to view Hartland rates, please visit https://www.crd.bc.ca/service/waste-recycling/hartland-landfill-facility/rates-accepted-items .

Question 4:
We would like to know if the construction scope can be executed in 2 phases. Is there any timeframe for the biosolids footprint area?

Response 4:
The CRD is open to phasing of construction with a targeted in-service date of July 1, 2024. The CRD would like the biosolids footprint completed as soon as possible. However, the paved biosolids mixing area must be completed no later than September 30, 2024.

Question 5:
We are requesting that the CRD consider a deadline extension for the proposal.

Response 5:
There will be no further deadline extensions, and all responses must be received by the deadline of January 3, 2024 at 10:00 am PST.

All Proponents shall acknowledge receipt and acceptance of this Addendum No. 7 by signing and dating in the spaces provided below and submitting the signed Addendum with the Proposal. Proposals submitted without this Addendum may be considered incomplete.

December 18, 2023

____
PROPONENT - Please print name

______________________________ __________________________
SIGNATURE DATE

RFP No. ERM2022-010

SUBMITTAL FORM "A" (Revised per Addendum 7)
PAYMENT TERMS

CAPEX

The CRD will pay MDco for the Design and Construction of the MDTS through Milestone Payments. MDco shall provide the expected Milestone Payment amounts equal to the total CAPEX for the Project.

Table 1 – Design and Construction Payment Schedule

Milestone Payment	Amount	Estimated Payment Date
Approved Issued for Construction Design		
Asphalt Paving		
Equipment Delivery		
Construction Completion		
Total		

OPEX

The CRD will pay MDco for the Operation of the MDTS through a monthly Fixed Minimum and Variable Processing costs as outlined in the tables below.

Table 2 – Fixed Minimum Monthly Costs

Fixed Minimum Monthly Costs[1]	Unit Rate	Unit
Management Costs		$/month
Equipment Costs[2]		$/month
Staffing		$/month
Maintenance		$/month
Diesel		$/L
Electricity		NA
Potable Water		NA
Non-Potable Water		$/month
Total Fixed Minimum Monthly Costs		

1. Fixed monthly costs assumes that end user contracts are secured. If end users are unavailable, the CRD retains the right to pause transfer service until end user contracts are in place.
2. MDco may recommend alternative delivery models for financing and owning equipment to maximize the value retention of equipment.

Table 3 – Fixed Unit Rate Monthly Costs

Fixed Unit Rate Monthly Costs	Fixed Unit Rate[1]	Unit
Clean Wood		$/tonne
Treated Wood		$/tonne
Asphalt Roofing Shingles		$/tonne
Carpet and Underlay		$/tonne
Books		$/tonne
Rigid Plastics (non-extended producer responsibility)		$/tonne
Waste to Active Area (Loading, Hauling/Transportation)		$/tonne
Total Fixed Unit Rate Monthly Costs		

1. Includes Loading, Processing, Hauling/Transportation

Please note that the costs in Table 4 below is intended to provide indicative costing for the CRD, with the understanding that they are nonbinding to MDco for the purposes of this proposal.

Table 4 – Monthly Pass-through End-Use Costs

Monthly Pass through End-Use Costs[1]	End Use Options	End Use Option Unit Rate[2] ($/tonnes)	Range (tonnes) per Month
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Total Monthly Pass-through End-Use Costs			

1. Includes End User Invoice and markup.
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Table 5 – Provisional Costs

Provisional Costs	Total Costs ($)
Rock Crushing ($/tonne) [1]	$ -

1. Shot Rock will be available from the CRD at no cost to MDco for crushing and use on site, if beneficial to MDco.

Material Stream Diversion – Award of Contract ERM2022-010

Environmental Services Committee

April 19, 2023

Background

- Phase 1 - January 1, 2024 implementation:
  - Clean wood waste ban
  - Tipping fee structure changes
  - Waste Stream Collector Incentive Program
  - Fine rates increases, new warning system
- 104.7 tonnes of clean wood was diverted from landfilling in January
- The Waste Stream Collector Incentive Program’s 22 registrants represent approximately 70% of Hartland’s total general refuse tonnages
- Provided staff with valuable information about market response and participation for implementing subsequent phases

Procurement

- To support Phase 2, a Request for Proposals was issued from September 2023 to January 2024 to construct and operate a Material Stream Diversion Transfer Station at Hartland Landfill to process wood (clean, treated and salvageable), asphalt shingles and carpet and underlay
- Two submissions were received from Emterra Environmental and DL's Bins
- Neither proponent provided an option for salvageable wood and processing costs for carpet and underlay weren't financially sustainable
- Negotiations with the preferred proponent have indicated both could be considered as part of a Phase 3 alternative

Award of Contract

Rethink waste

- Finalize negotiations and enter into a two-year operating and construction contract, for a combined value not to exceed $12,500,000 (excluding GST) with DL's Bins
- DL's Bins will construct and operate the Material Stream Diversion Transfer Station to begin processing clean wood, treated wood and asphalt shingles on July 1, 2024

Waste Flow Restrictions

- Market response to date suggests the $300/tonne mixed renovation and demolition rate will incent Hartland customers to seek lower cost landfill disposal options out of region, rather than divert banned materials, including wood waste.
- Staff recommend adding a Phase 3 (2026) to implement the $300/tonne mixed renovation and demolition rate to allow customers time to adjust to the new policies.
- Staff recommend the CRD begin consultation on policies to restrict the flow of general refuse waste outside the capital region ahead of Phase 3 implementation.

Tipping Fee Schedule

Material Type	Tipping Fee (per tonne)	Landfill Ban Implementation	Date
MANDATORY RECYCLABLES			
Clean Wood	segregated diversion $80	Phase 1	January 1, 2024
Treated Wood	segregated diversion $110	Phase 2	July 1, 2024
Asphalt Shingles	segregated diversion $110	Phase 2	July 1, 2024
Salvageable Wood	segregated diversion $0	Phase 3*	2026
Carpet and Underlay	segregated diversion $110	Phase 3*	2026
RENOVATION AND DEMOLITION WASTE			
Clean	segregated diversion $150	Phase 2	July 1, 2024
Mixed	segregated diversion $150, with $500 fine in effect	Phase 2*	July 1, 2024
Mixed	segregated diversion $300, with $500 fine in effect, potential flow control policies	Phase 3*	2026

* Subject to board direction

Thank you

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X @crdvictoria

Capital Regional District

CRDVictoria

crd.bc.ca

CRD

Making a difference...together

ECA 24-12

REPORT TO ENVIRONMENTAL SERVICES COMMITTEE
MEETING OF WEDNESDAY, MARCH 20, 2024

SUBJECT **Extreme Heat Vulnerability Mapping and Information Portal Project**

ISSUE SUMMARY

To provide the results of the Capital Region Extreme Heat Vulnerability Mapping and Information Portal project.

BACKGROUND

In 2018, a Regional Hazard Risk and Vulnerability Assessment (HRVA) for the capital region of BC was undertaken by the Regional Emergency Management Partnership, and extreme heat was identified as a hazard of regional significance. In the summer of 2021, BC experienced an extreme heat wave that claimed more than 700 lives, with 24 of those in the capital region.

To support emergency planning and local climate adaptation planning efforts, the Capital Regional District (CRD), with support from municipal partners, accessed a $150,000 Union of British Columbia Municipalities grant from the Community Emergency Preparedness Fund to undertake a regional extreme heat vulnerability mapping initiative. The intention of this initiative was to support the integration of extreme heat disaster risk reduction and climate adaptation planning through the development of a mapping product that provides a highly localized picture of vulnerability to heat in the capital region.

The CRD's Climate Action service worked collaboratively with local government climate/sustainability and emergency management program staff, and Island Health, to scope and execute the project. During the technical phase, CRD staff coordinated multiple workshops for representatives from all local governments in the region, including methodology review and project outputs, and undertook other key engagements to get technical input and guidance. Updates have been provided throughout the project via existing inter-municipal staff committees (climate and emergency management) and directly with key stakeholders, as required.

This project involved the development of three main indices:

- Extreme Heat Exposure
- Demographic Vulnerability Index
- Building Vulnerability Index

Each index was developed and analyzed with distinct methodologies, ranging from individual buildings to broader administrative geographic units. Results are provided in a project report (Appendix A).

As part of the grant initiative, the Capital Region Extreme Heat Information Portal has been collaboratively developed with project partners and the Province (GeoBC). This portal presents the data and analyses through interactive geographic maps for public exploration of their risk levels. Additionally, authorities have login access to the portal with more extensive maps and layers. The Extreme Heat Information Portal can be found at: https://heat.prepareyourself.ca.

Next Steps

The project findings can be used for a variety of purposes and will serve as important data input for further regional emergency and climate adaptation related mitigation, planning and policy initiatives.

The public portal, with accompanying geographic information system and products, will be shared directly with CRD and local government staff, regional emergency management programs, Island Health and provincial and federal agencies and can be used in educational initiatives. Staff will continue to connect with First Nations to provide the data and explore its applicability to their needs. As this work is very novel, staff will continue to connect with local governments to share learnings and resources and support the development of a provincial heat mapping guidance resource document.

The CRD remains committed to supporting established inter-municipal and inter-agency committees, seeking opportunities for enhanced collaboration. Recognizing the dynamic nature of technology and scientific advancements, ongoing risk modelling focused on extreme heat will be imperative to continuously update emergency preparedness, planning and response strategies.

ALTERNATIVES

Alternative 1
The Environmental Services Committee recommends to the Capital Regional District Board:
That the results of the Extreme Heat Vulnerability Mapping and Information Portal project for the capital region be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

Alternative 2
That this report be referred back to staff for additional information.

IMPLICATIONS

Alignment with Board & Corporate Priorities

The recommendations align with the Board's priority Climate Action & Environment initiative 3c to increase resilience, community and adaptation planning to address climate-related risks and disasters.

Alignment with Existing Plans & Strategies

The recommendations align with goal 2 of the CRD Climate Action Strategy to support the region on its pathway to livable, affordable and low-carbon communities that are prepared for climate change, and specifically contribute to the completion of action 2-4d to expand data collection and mapping efforts to identify vulnerabilities to the impacts of climate change.

Intergovernmental Implications

The data and mapping components can help local authorities to recognize priority areas for risk reduction and enhanced emergency response efforts. By examining vulnerability to heat, emergency managers can strategically prioritize interventions and resources in areas most in need of attention. The data can also be used when updating local hazard, risk, and vulnerability analyses (i.e., HRVAs). CRD staff will continue to engage the region's local governments through the CRD's Climate Action Inter-Municipal Working and Task Force on better understanding new climate adaptation related policy approaches and supporting implementation of existing programs and policies in a collaborative manner.

CONCLUSION

Working collaboratively with and on behalf of local governments in the capital region, the CRD secured a $150,000 grant from the Union of British Columbia Municipalities Community Emergency Preparedness Fund to initiate the Extreme Heat Vulnerability Mapping and Information Portal Project for the capital region. The data analyzed is provided in the new public Extreme Heat Information Portal. This work will help guide planning and decision-making to improve community resilience, emergency planning and public health strategies across the capital region.

RECOMMENDATION

The Environmental Services Committee recommends to the Capital Regional District Board:
That the results of the Extreme Heat Vulnerability Mapping and Information Portal project for the capital region be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

Submitted by:	Nikki Elliott, BES, MPA, Manager, Climate Action Programs
Concurrence:	Larisa Hutcheson, P.Eng., Acting General Manager, Parks & Environmental Services
Concurrence:	Ted Robbins, B. Sc., C. Tech., Chief Administrative Officer

ATTACHMENT

Appendix A: Heat Vulnerability Data & Analysis Project Final Report – Licker Geospatial Consulting Company and Thrive Consulting (February 2024)

Heat Vulnerability Data & Analysis Project

Final Report

Prepared for Capital Regional District

February, 2024

Licker Geospatial Consulting Co.

2405 East Hastings St
Vancouver BC, V5K 1Y8

Thrive Consulting

Climate & Resilience Planning

Table of Contents

Key Terminology and Abbreviations

2021 extreme heat event	The fatal extreme heat event (also commonly referred to as the "heat dome") that was experienced throughout much of British Columbia in late June, 2021.
Adaptive capacity	The characteristics of a community that increases resilience against extreme heat impacts, such as income and available shade-providing tree canopy.
AHP	Analytical Hierarchy Process
BCCDC	British Columbia Centre for Disease Control
BIR	Building Information Report
CRD	Capital Regional District
DA	Dissemination area
DSM	Digital Surface Model
DTM	Digital Terrain Model
Exposure	The distribution of extreme heat across the community
GCM	Global Circulation Model
IPCC	Intergovernmental Panel on Climate Change
LGeo	Licker Geospatial Consulting Co.
LiDAR	Light detection and ranging
LST	Land surface temperature
NDVI	Normalised difference vegetation index quantifies the greenness of vegetation.
Sensitivity	The characteristics of a community that increase susceptibility to extreme heat impacts, such as age and health
Urban heat island	The effect of urban islands capturing significantly more heat than surrounding, natural environments

List of Tables and Figures

Executive summary

In response to the recent extreme heat events in British Columbia, the Capital Regional District (CRD) has commissioned a comprehensive study to understand and address extreme heat vulnerability in the Capital Region. This report describes the collaborative effort between Licker Geospatial Consulting Co (LGeo), Thrive Consulting (Thrive), and the CRD and participating municipal partners and presents findings and recommendations emergent from the Heat Vulnerability and Data Analysis Project.

The Heat Vulnerability and Data Analysis Project's primary goal has been to develop a holistic understanding of extreme heat vulnerability across the capital region to inform regional partners in decision-making for emergency response, climate change adaptation and resilience planning, and public health initiatives and program design. The Project's significance has been underlined by the extreme heat event in 2021 (referred also as the "2021 heat dome"), which resulted in severe health impacts across the Province and brought to light the urgent need for extreme heat analyses and assessments across various levels of governments.

The methodology of this Project was developed in collaboration with consultants, local governments, and health agencies (Island Health and the BCCDC) involved in the effort. The effort includes three distinct phases in which a vulnerability-related index is produced. The three indices included in this effort are broadly described below.

- The *Socio-demographic Vulnerability Index*, which assesses the levels of community sensitivity to adverse impacts brought upon by extreme heat, and likewise the community's adaptive capacity to mitigate the impacts of extreme heat. Determinants of Socio-demographic Vulnerability include factors such as age, income, and chronic health conditions. The socio-demographic index involved an engagement process in which subject matter experts and those with lived experience helped develop a weighting schema for socio-demographic determinants of vulnerability. This weighting schema provides contextually-specific insight into regional characteristics of community derived vulnerability. The validation of this index showed the highly vulnerable areas in this index are aligned with observed hospitalisations and mortalities during the 2021 heat event.

- The *Heat Exposure Layer*, which describes the distribution of perceived outdoor temperature during the 2021 heat event. Determinants that describe extreme heat exposure include factors such as environmental composition (i.e. whether the local environment is heavily treed), land surface characteristics, measured temperatures during the 2021, and others. The heat exposure layer facilitates a nuanced understanding of outdoor extreme heat distribution across different urban and rural landscapes.

- The *Buildings Vulnerability Index*, which assesses the propensity of individual buildings to absorb and maintain heat during a heat wave. Determinants of building-specific vulnerability include factors such as building type, age, and height. The characteristics of a building contribute to the capacity a building has to cool (or remain cool) during an extreme heat event. Areas that score as highly vulnerable in the buildings index can present opportunities for emergency response, but also longitudinal planning that includes implementation of building retrofit programs.

The development of each index included engagements that spanned across the Project timeline in workshop and meeting formats. These various outreach and connection points helped to include perspectives from subject matter experts, those with lived experience in responding to extreme heat events, and other project stakeholders. The engagement objectives were to (1) confirm direction of approach, (2) confirm and refine selected determinants of vulnerability, and (3) allow for validation and feedback on the created vulnerability indices. The Project also includes an outreach phase, in which data and supporting language are hosted virtually for end-users to freely explore and employ the indices as needed.

The key findings of the vulnerability assessment at a municipal scale are summarised below. The findings are informed by the distribution of vulnerability indices, as well as geospatial analysis of vulnerability at the municipal scale:

- Amongst all of the incorporated areas in the CRD, the top demographic consideration was consistently either: percentage of the population who are renters or percentage of the population who are seniors. The seniors finding is unsurprising as that was the highest weighted variable in the socio-demographic risk model.
- When combining buildings risk with socio-demographic vulnerability we note that Victoria, Saanich and Sidney have the most buildings which are in very vulnerable areas for both buildings and socio-demographics at 1,174, 806 and 628 residential buildings respectively. When examined by percentage of total residential buildings, Sidney, Victoria and Esquimalt are the top three ranked communities with 19%, 13%, and 8% of all residential buildings being in both very high risk categories for buildings and sociodemographics. Conversely, Metchosin, Highlands and North Saanich have no buildings in these two categories.
- With regards to air temperature, we note that Langford, Highlands and Colwood all have significant areas of their community in highest heat quintile (>=36.6℃ daily average air temperature) at 61%, 49% and 32% respectively, which may increase risk in the communities. Conversely, communities more proximal to the ocean all have lower percentages of their communities in the highest heat quintile with Oak Bay, Sidney and Esquimalt at 5%, 2%, 1% of land area respectively.
- As urban heat is in many ways influenced by land use change and development, it is impactful to note that 84%, 56% and 48% of Langford, Colwood and Highlands' residential buildings are in the highest heat quintile. However, all three of these communities have relatively lower socio-demographic risk and only 6% (648), 1% (54) and 0% (0) of Langford, Colwood and Highlands' residential buildings are in both the highest quintiles for air temperature and socio-demographics

Additionally, the distribution of indices allow for the identification of areas that have overlapping vulnerability concerns. These areas score highly vulnerable according to all three indices: heat exposure, socio-demographic, and buildings. They are priority areas for emergency response and extreme heat risk reduction planning. Of note: Saanich has 454 residential buildings in the three highest quintiles for heat risk, buildings risk and socio-demographic risk (1% of all residential buildings in the community), Victoria has 229 (2% of residential buildings) and Langford has 98 (1% of residential buildings in langford). Overall, there are 929 buildings in all three very high risk categories.

The Project's assessment of vulnerability to extreme heat in the Capital region allows for emergent recommendations that aim to actionably and equitably mitigate adverse extreme heat impacts. Key recommendations of this effort are included below.

- Integrate the use of these indices in planning for climate change adaptation, risk reduction, and emergency response with a focus on overlapping vulnerability.
- Nuance urban forestry and green infrastructure with vulnerability data. Tree planting and shade provisioning are elements of extreme heat adaptive capacity, and should be prioritised in areas that are presented as highly vulnerable.
- Strategically allocate resources, such as emergency response. Our analysis presents areas in which there are both high overlapping vulnerabilities and also a dearth of emergency response service coverage.
- Integrate the findings into local governments' hazard, risk, and vulnerability analysis (HRVAs) updates to allow for informed policy-making and climate action planning.
- Prioritise building retrofit programmes to highly vulnerable buildings. Take a multi-hazard perspective.

The Heat Vulnerability Data and Analysis Projects presents a significant step towards the enhancement of the CRD's capacity to support resilience planning through data-informed decision-making. The effort detailed in this report presents insights into region-specific vulnerabilities from heat exposure, socio-demographic, and buildings perspectives. The effort allows for nuanced vulnerability analyses and presents targeted recommendations. Indeed, the implementation of this Project's recommendations is anticipated to significantly contribute to building public health resilience, enhancing emergency preparedness, and equitable building retrofit programs and urban planning in the region. This report serves as both a tool for the CRD and municipal partners and also as a foundational study for ongoing research and adaptation strategies in regional and local government efforts in addressing extreme heat vulnerability.

Introduction

Climate change is already influencing our lives in British Columbia (BC) and more locally in the Capital Region. Over the next years and decades, we expect BC to see an increase in climate-related hazards, specifically extreme heat events[1]. We know these have, and will continue to, negatively affect the physical and mental health of residents living in the Capital Region[2,3]. Indeed, the fatal 2021 extreme heat event in BC (also referred to as the "2021 heat dome") underscored the significance in assessing and analysing localised impacts of extreme heat events. That said, there are many opportunities to act to reduce these impacts through properly understanding the risk, advancing emergency preparedness and response measures, enhancing adaptive capacity, and implementing risk reduction measures.

In this context, the Capital Regional District (CRD), in collaboration with municipal partners, initiated the Heat Vulnerability Data and Analysis Project, which aims to address extreme heat concerns localised to the Capital Region (the "Region"). Supported by the consultant team, Licker Geospatial Consulting (LGeo) and Thrive Consulting (Thrive), the Project has been designed to broaden the CRD's understanding of communities' vulnerability to extreme heat across the Capital Region through the development of three indices that refer to the 2021 heat event as a design event. These indices present an holistic approach to assessing extreme heat, and are summarised below:

- The *Heat Exposure Layer* describes extreme heat as it is distributed across the Region. This index uses factors such as land cover, local environmental factors, and incoming solar radiation to measure perceived temperature.

- The *Socio-demographic Vulnerability Index* describes population-specific determinants of vulnerability across the Region. This index is contextually-specific to the Region's communities and was informed through an engagement process. This index is formed by socio-demographic factors such as age, income, and chronic disease.

- The *Building Vulnerability Index* describes building-specific vulnerability across the Region. This index is described at the building footprint scale, and uses factors such as building type, age, and reflectivity to measure vulnerability.

These vulnerability indices are calculated from a comprehensive process of data collation, engagement, novel methods development, and validation. The Project's engagement and validation process has included a diverse group of subject matter experts, those with lived experience, and other project stakeholders. The Project's outcome is intended to inform the

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[1] Nature. (2021). Climate change made North America's deadly heatwave 150 times more likely. Nature. https://doi.org/10.1038/d41586-021-01869-0
[2] ClimateReady BC. (n.d.). Extreme Heat. Retrieved from https://climatereadybc.gov.bc.ca/pages/extreme-heat
[3] Henderson, S. B., McLean, K. E., Lee, M., & Kosatsky, T. (2021). Extreme heat events are public health emergencies. British Columbia Medical Journal, 63(9), 366-367. Retrieved from https://bcmj.org/bccdc/extreme-heat-events-are-public-health-emergencies

CRD's capacity to support local government's planning and decision-making processes as they relate to extreme heat adaptation and resilience building. The development of each of the three indices was conducted in close collaboration with the CRD, municipal partners and Island Health. The CRD and their project team influenced the design and evolution of the project through their combined expertise, specialised and contextual insights, and subject matter expertise.

1.1. *Objectives and scope*

The primary objectives of this Project have been to:

- Facilitate group workshops and meetings with the project team and other key stakeholders to discuss, refine, and validate data collection and methodology;
- Determine key attributes which contribute to vulnerability, sensitivity or adaptive capacity to extreme heat;
- Assemble and document localised data to be used as inputs for modelling vulnerability/adaptive capacity;
- Create three aforementioned indices based on research, engagement, and data collection;
- Develop extreme heat event vulnerability data layers to be hosted on an interactive dashboard for end-users; and
- Develop a final report that disseminates methods and results to key stakeholders.

1.2. *Issue addressed*

In 2018 the CRD identified extreme heat as a hazard of regional significance through a Regional Hazard Risk and Vulnerability Assessment (HRVA)[4]. In 2021, BC experienced an extreme heat wave that claimed more than 700 lives[5]. To address the growing risks posed by extreme heat, the region requires highly localised extreme heat vulnerability data to serve multiple initiatives related to emergency response, climate resilience and adaptation, forthcoming building retrofit programs, and regional and local/municipal planning activities. To this end, a multiple index-based approach encompassing three individual indices has been developed for this project.

The three developed indices that measure vulnerability through socio-demographic, heat exposure, and buildings lenses provide a *localised* understanding of vulnerability to extreme heat in the region. Potential end-use cases of these vulnerability indices may include:

- Supporting emergency planning and local climate adaptation planning efforts;
- Supporting the integration of extreme heat disaster risk reduction and climate adaptation planning;
- Building risk awareness and setting priorities for the implementation of disaster risk reduction initiatives;
- Supporting risk communication and planning efforts; and

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[4] Regional Emergency Management Partnership in the Capital Region. (2018). Annual Report.
[5] Henderson, S. B. et al (2021)

- Serving multiple initiatives related to emergency response, resilience and climate adaptation, forthcoming building retrofit programs, and regional and local/municipal planning activities.

1.3. *Novelty and significance*

A focus of this project has been to contextualise the extreme heat assessment to the localised scale relevant to the capital region. As a result, in collaboration with the CRD-led project team, this project has developed several novel approaches that may apply to other studies seeking to complete similar assessments. Below are some identified areas of novelty and significance that have been designed to localise the project to the region.

The Socio-demographic Vulnerability Index has been developed through an analytical hierarchy process (AHP), in which a group of project stakeholders, local subject matter experts, and those with lived experience, were engaged. Those engaged included local and regional governments, health practitioners, First Nation representatives, emergency services and first responders, and climatologists and meteorologists. The AHP engagement sought to inform our understanding of the relevance and importance of determinants of Socio-demographic Vulnerability that are specific to the region. Notably, this engagement approach advances from similar, previous assessments that solely employ statistical methods to determine the relevance and importance of determinants of vulnerability[6,7].

This project also introduces novel approaches in assessing building-by-building vulnerability through a highly localised analysis of extreme heat at the building footprint scale. This project addresses a common gap in such assessments, in that a significant discrepancy in the degree of vulnerability exists between outdoor and indoor heat[8]. That is to say, specific building characteristics can affect a building's level of vulnerability despite its position in the distribution of outdoor heat exposure. Many heat-related deaths, especially those observed during extreme events, can be credited to indoor heat exposure[9, 10]. This project successfully attributes multiple determinants of building vulnerability to building footprints throughout the region[11], that include dwelling type, building age, building height, solar insolation, rooftop albedo and cooling capacity.

The measurement of heat exposure has also been advanced in this project. While previous assessments have used varying approaches to assessing the distribution of extreme heat

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[6] Université Laval. (2023). Summary Report. Retrieved from https://vaguesdechaleur.ffgg.ulaval.ca/wp-content/uploads/2023/07/summary-report_ulaval.pdf

[7] Conlon, K. C., Mallen, E., Gronlund, C. J., Berrocal, V. J., Larsen, L., & O'Neill, M. S. (2020). Mapping human vulnerability to extreme heat: A critical assessment of heat vulnerability indices created using principal components analysis. Environmental Health Perspectives. https://doi.org/10.1289/EHP4030

[8] Alam, M., Sanjayan, J., Zou, P. X. W., Stewart, M. G., & Wilson, J. (2016). Modelling the correlation between building energy ratings and heat-related mortality and morbidity. *Sustainable Cities and Society*, *22*, 29–39. https://doi.org/10.1016/j.scs.2016.01.006

[9] Samuelson, H., Baniassadi, A., Lin, A., Izaga González, P., Brawley, T., & Narula, T. (2020). Housing as a critical determinant of heat vulnerability and health. *Science of The Total Environment*, 720, 137296. https://doi.org/10.1016/j.scitotenv.2020.137296

[10] CDC, 2013. Heat illness and deaths—New York City, 2000–2011. MMWR Morb. Mortal. Wkly Rep. 62, 617.

[11] See validation considerations in section 2.3.6

exposure[12,13]; such approaches often fail to capture either the localised distribution of heat exposure or fail to capture the human experience of extreme heat exposure. For example, while weather stations may accurately measure temperature and humidity levels during a heat wave, the interpolation between stations as an assessment of heat exposure distribution results in the loss of nuance that exists at localised contexts. Further, while monitoring land surface temperatures from satellite imagery can provide a localised understanding of the distribution of extreme heat, it inadequately captures the levels of discomfort that is experienced by a typical individual. The project team has sought to find the balance between appropriate measurement and nuanced distribution by developing an assessment of air temperature during the 2021 heat event.

While this approach has recently been employed by researchers elsewhere[14,15] and within the Region[16], the application of such an assessment within a larger extreme heat vulnerability assessment remains, to our knowledge, a first of its kind.

1.4. Engagement and outreach

The focus of engagement and outreach for this project was two-fold: the first being the project team and extensions thereof (i.e. broader end-user groups from around the region) and the second being key stakeholders and local subject matter experts from around the region (e.g. climate scientists, public health officials, etc.) (See figure 1 for a summary of engagement structure). Initial efforts were also made to reach out to First Nations' representatives in the region; some of whom are working on similar extreme heat assessment and response planning projects. Further effort and funding allocation is required in this area to integrate First Nation's data and values into a regional analysis and related efforts going forward.

[12] Typically using landsat surface temperature or degree cooling days
[13] Yu, J., Castellani, K., Yao, A., Cawley, K., Zhao, X., & Brauer, M. (2020). Mapping spatial patterns in vulnerability to climate change-related health hazards. University of British Columbia.
[14] Ho, H. C., Knudby, A., Sirovyak, P., Xu, Y., Hodul, M., & Henderson, S. B. (2014). Mapping maximum urban air temperature on hot summer days. Remote Sensing of Environment, 154, 38-45.
[15] Xu, Y., Knudby, A., & Ho, H. C. (2014). Estimating daily maximum air temperature from MODIS in British Columbia, Canada. International Journal of Remote Sensing, 35(24), 8108-8121. https://doi.org/10.1080/01431161.2014.978957
[16] Steve Young at the City of Victoria partnered with Simon Fraser University to develop an air temperature model (2002-2012) for Victoria, available here: https://vicmap.maps.arcgis.com/apps/webappviewer/index.html?id=ae03a6af3648414fb7bf60f8f7bb4d7d

Figure 1.0 Structure for engagement during Project development.

A kick-off meeting was held to get to know the project team and hear their perspectives on how this mapping and modelling effort may support their ongoing and future work. At this meeting we heard a variety of ways in which these end-users were hoping to and could foresee using the data to inform:

- updates to their local hazard, risk and vulnerability assessments (HRVAs);
- climate adaptation planning/plans;
- planning for tree canopy/planting and urban forestry strategies; and
- assessment of where vulnerable populations are spatially located to inform response and preparedness planning.

The first workshop gathered a small group of those with specific, local subject matter expertise related to Socio-demographic Vulnerability (aka. the AHP workshop). The second workshop gathered a wider group of potential end-users to provide the background into the development of the three indices: socio-demographic vulnerability, heat exposure, and building vulnerability and gain critical feedback before proceeding to the analysis stage. The intent was to ensure project team members and additional stakeholders in the region were comfortable with the methods and approach before proceeding in earnest to the modelling and analysis stages. A third workshop was held with the consultant team and staff project team to review the final products and deliverables and review the draft public dashboard.

Several additional meetings were held to:

- Review the approach to the buildings index with internal stakeholders before completing the modelling effort for that particular index;
- Review various approaches to heat exposure modelling and ensure acceptability of this particular heat exposure approach; including meeting with the Pacific Climate Impacts Consortium (PCIC) and City of Victoria staff who conducted heat modelling for the City of Victoria; and
- Reach out to First Nations' representatives and organisations representing First Nations' interests in the region (e.g. First Nations' Health Authority, to discuss and explore the existing data and gaps in relation to First Nations' in the region and potential uses and improvements going forward.

A final workshop provided a final overview of all the end-products (i.e. including maps, modelling, GeoBC portal, story map) to support capacity building in the use of the mapping products for local government staff and other key end-users in the region.

2. Methods

For each index developed in this Project, considerable data collation and analysis has been undertaken. This Section provides a comprehensive presentation of methodology employed in calculating the three vulnerability indices: exposure, socio-demographic, and buildings. These indices form multiple perspectives on the Region's anticipated level of vulnerability to extreme heat.

Each index is calculated through a specific process of literature reviews, data acquisition and manipulation, analysis, and stakeholder engagement. The methodologies described in this Section present detailed processes in constructing each index and associated data validation, limitations, and quality assurance. The development of these indices aims to capture a comprehensive understanding of determinants of extreme heat vulnerability to both the community and building footprint levels.

This assessment references the 2021 extreme heat event as the design event for extreme heat in the capital region. Though this event is a so-called 'one-in-a-thousand-year' event, experts argue that as climate change progresses BC may experience heat events similar to the 2021 extreme heat event with greater frequency as high as every 5 - 10 years[17]. As such, it is beneficial to

[17] Union of BC Municipalities (2021). Preparing for more heat domes. Available from: https://www.ubcm.ca/about-ubcm/latest-news/preparing-more-heat-domes

consider the worst-case scenario that has been experienced when planning for the future[18, 19]. This assessment leverages available data in the development of each index to be temporarily aligned to the 2021 extreme heat event period[20]. This includes data sources, detailed further below, as census data, satellite observations, weather station data, building assessment data, and health data.

Below is a high-level summary of the methodology employed for each vulnerability index.

- Socio-demographic Vulnerability Index (Section 2.1).
  This index integrates a variety of demographic and health-related data utilising an Analytical Hierarchy Process (AHP) to weigh and prioritise multiple inputs based on their relevance to extreme heat vulnerability. This process involved collaboration with local subject matter experts to identify, weigh, and validate the index.

- Extreme Heat Exposure Layer (Section 2.2).
  This index describes the perceived outdoor air temperatures during the 2021 heat event. Using a non-linear modelling approach, this index considers multiple variables including land surface temperature, solar insolation, elevation, distance to coastline, and more. Climate station data that collected air temperature measurements during the 2021 heat event have also been used to train and validate this modelling process.

- Building Vulnerability Index (Section 2.3).
  This index addresses the physical characteristics of buildings and their local environment that affect the building's capacity to (remain) cool during an extreme heat event. The construction of this index is at the building footprint scale and includes leveraging inputs from multiple data sources, such as remotely sensed lidar (lidar - light detection and ranging) data and building assessment data. Factors that describe this index include building age, dwelling type, solar insolation, and building height.

Each index is underpinned by rigorous data validation and quality assurance processes, involving both technical analyses and stakeholder consultations. The methodologies employed are designed to ensure the indices provide an accurate, transparent, and reproducible representation of heat vulnerability in the Region. The project also includes a data dictionary, which presents a comprehensive view of all datasets used in this project, their currency, and their source. Please contact climateaction@crd.bc.ca if you would like a copy of the data dictionary.

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[18] IPCC. (2021). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (Eds.), Climate Change 2021: The Physical Science Basis. *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. https://www.ipcc.ch/report/ar6/wg1

[19] Philip, S.Y., Kew, S.F., van Oldenborgh, G.J., et al. (2022). Rapid attribution analysis of the extraordinary heat wave on the Pacific coast of the US and Canada in June 2021. *Earth System Dynamics*, 13(4), 1689-1713. https://doi.org/10.5194/esd-13-1689-2022

[20] The 2021 extreme heat event in BC occurred during the 25th of June to the 7th of July. The design event we used for much of the modeling was June 28th, 2021.

2.1. *Socio-demographic Vulnerability Index*

The socio-demographic vulnerability index is designed to assess the *sensitivity* and *adaptive capacity* of communities to extreme heat events at a local level and includes determinants related to population health and socioeconomic status.

- Sensitivity in the context of extreme heat vulnerability refers to the extent to which a population is affected by an extreme heat extent. In the socio-demographic index, this includes factors such as age demographics, pre-existing health conditions, and income.
- Adaptive capacity in this context represents the ability of the community to adjust, absorb, and respond to the adverse impacts associated with extreme heat. In the socio-demographic index, this includes household size, education, and employment.

The socio-demographic vulnerability index has been developed through an Analytical Hierarchy Process (AHP), in which local experts such as epidemiologists, emergency managers, and social, community and climate planners were engaged in a workshop format. The selection of AHP over principal component analysis (PCA) was based on literature reviews and the consulting team's previous project experiences. Indeed, research suggests that PCA does not correlate well with actual heat-related health outcomes and is very sensitive to the input data used in the vulnerability index[21]. As a result, AHP was chosen for its ability to (1) include the engagement of groups that may have been traditionally excluded from such exercises, (2) more easily interpreted than PCA, and (3) provide a more relevant demographic weighting in relation to extreme heat related health outcomes.

The AHP workshop provided a platform for the group to evaluate over 50 identified socio-demographic determinants of vulnerability. The list of indicators was initially identified from an informal literature review and informed by previous studies on the subject[22]. For each indicator, a slide was presented that displayed the spatial distribution of the determinant across the region, as shown in Figure 2.0. Following the workshop, a survey was conducted to assign appropriate weights to each indicator, which were then used to calculate the socio-demographic vulnerability index for each Census dissemination area (DA) across the Region[23]. This approach ensures that the index is regionally relevant through the subject matter expert input in index design.

The full list of indicators used and their associated AHP weights are shown in Table 2.0 below.

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[21] Conlon, K. C., Mallen, E., Gronlund, C. J., Berrocal, V. J., Larsen, L., & O'Neill, M. S. (2020). Mapping human vulnerability to extreme heat: A critical assessment of heat vulnerability indices created using principal components analysis. Environmental Health Perspectives. https://doi.org/10.1289/EHP4030

[22] Bao, J., Li, X., & Yu, C. (2015). The Construction and Validation of the Heat Vulnerability Index, a Review. International Journal of Environmental Research and Public Health, 12(7), 7220–7234. https://doi.org/10.3390/ijerph120707220

[23] Due to time constraints that arose due to the rich discussion during the AHP workshop, remaining tasks were accomplished via survey. The consulting team was then able to run the index once the weightings were complete and the health data was acquired. Results were reviewed in a follow-up meeting with AHP workshop participants as well as a few additional stakeholders with socio-demographic expertise.

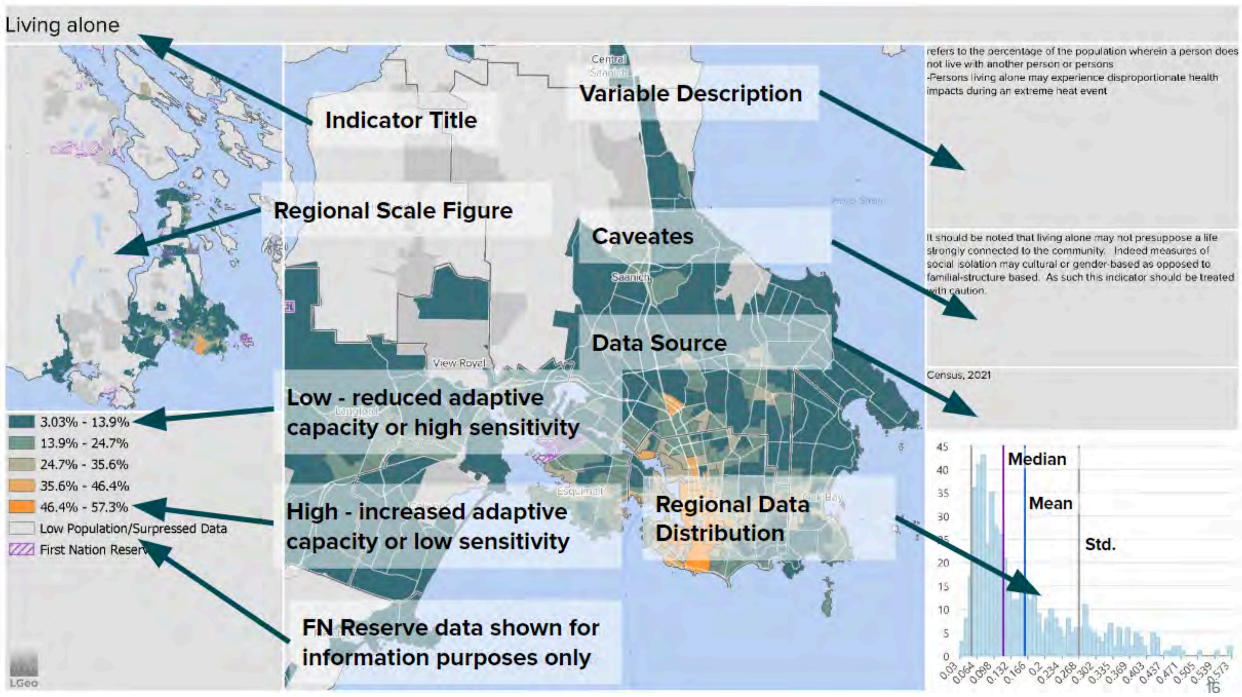

Figure 2.0. Sample slide of the demographic data review during the AHP workshop. Each variable was mapped, the distribution of data was assessed and data caveats and limitations were flagged and discussed.

Table 2.0 Socio-demographic variables and their associated weights. The table is ordered from largest weight to smallest.

Theme	Variable Name	Source	Date	AHP Weight
Age	Population age 65 or older (%)	Census	2021	5.79%
Health	Mental and Substance Use Disorders (crude rate)	BCCDC	2021	5.65%
Income	Low Income Adults	Census	2021	5.34%
Health	Chronic kidney disease (crude rate)	BCCDC	2021	5.26%
Identity	Living alone	Census	2021	5.15%
Health	Hospitalised stroke (crude rate)	BCCDC	2021	5.16%
Health	Chronic Obstructive Pulmonary Disease (Crude Rate)	BCCDC	2021	5.00%
Health	Acute Myocardial Infarction (Crude Rate)	BCCDC	2021	5.00%
Health	Hypertension (crude rate)	BCCDC	2021	4.76%
Health	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)	BCCDC	2021	4.66%
Income	Total - Adjusted after-tax economic family income decile group	Census	2021	4.59%
Health	Asthma (crude rate)	BCCDC	2021	4.21%
Identity	Population that are renters (%)	Census	2021	3.88%
Identity	Indigenous Identity	Census	2021	3.68%
Health	Diabetes (Crude Rate)	BCCDC	2021	3.72%

Employment	Outdoor Workers - Trades, transport and equipment operators etc.	Census	2021	3.30%
Identity	Speaking Neither English Nor French at Home	Census	2021	2.80%
Age	Primary household maintainers - 75 years and over	Census	2021	2.80%
Identity	Recent Immigrants 2016-2021	Census	2021	2.60%
Age	Primary household maintainers - 85 years and over	Census	2021	2.54%
Age	Primary household maintainers - 65 years and over	Census	2021	2.35%
Identity	Has high (secondary) school diploma or equivalency certificate or no diploma/degree	Census	2021	2.10%
Population	2021 Population Density (per Hectare)	Census	2021	2.03%
Housing	Housing Built Before 1960	Census	2021	2.03%
Housing	Major repairs needed at home	Census	2021	1.91%
Housing	Average number of rooms per dwelling	Census	2021	1.91%
Housing	Average spending on windows and doors	Environics	2022	1.78%

2.2. *Heat Exposure Layer*

The accurate measurement of the distribution and intensity of outdoor heat exposure is essential for a range of applications, including public health and urban planning[24, 25]. This assessment of heat exposure aims to provide a comprehensive picture of outdoor extreme heat throughout the capital region, with a focus on the 2021 extreme heat event. Our approach employs advanced remote sensing technology and environmental data analysis to develop a detailed Heat Exposure Layer. This layer visualises the intensity and distribution of extreme heat across the region and includes two key components:

- Land surface temperature (LST), measured in °C, provides a direct measure of heat emitted from the Earth's surface during the heat event. This layer captures the intensity of ground-level heat across the capital region.
- Air temperature, also measured in °C, provides a complementary perspective of how temperatures are experienced by individuals during the extreme heat event. This layer is indirectly measured from multiple inputs that are regressed against observed temperature from weather station data across the regional district.

The following subsections present detail on the components of the Heat Exposure Layer and their implications. This section includes the methodology included in calculating LST and air temperature, a comparison between both LST and air temperature assessments, limitations in the exposure methodologies, and potential future uses for these layers.

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[24]McGregor, G. R., & Vanos, J. K. (2018). Heat: A primer for public health researchers. Public Health, 161, 138-146. https://doi.org/10.1016/j.puhe.2017.11.005
[25]Havenith, G. and Fiala, D. (2015). Thermal Indices and Thermophysiological Modeling for Heat Stress. In Comprehensive Physiology, R. Terjung (Ed.). https://doi.org/10.1002/cphy.c140051

2.2.1. *Forecasting the Heat Exposure Layer*

This assessment initially explored forecasting heat exposure to an end-of-century scenario as aligned with Intergovernmental Panel on Climate Change (IPCC) high-emission relative concentration pathway (RCP 8.5°C), i.e. the "worst case scenario"[26]. However, this additional analysis was dropped given the following key concerns:

- The modelling used in understanding the future distributions of heat are developed from global-scale models that are attributed with resolutions order of magnitudes greater than the current heat exposure layer. While these aggregated global circulation models work well at understanding climate change at larger scales, their impacts are currently homogenous at the capital region level. Further, at an end-of-century, high-emission scenario there are relatively large margins of error introduced to the magnitude of extreme heat described[27].
- Land surface temperature, solar insolation, and other important variables in the exposure layer are closely aligned with land cover. As the region's land cover changes, it is expected that the distribution of the current heat exposure layer would also change. It would therefore be necessary to predict land cover changes to the end-of-century to accurately predict future extreme heat distribution at the localised level. Naturally, such an analysis would introduce many assumptions and uncertainties.
- A missing component of a hypothetical forecasted heat exposure would be an understanding of the forecasted population and infrastructure that will directly experience extreme heat at the end-of-century. Without an understanding of future demographics and density, the construction of a forecasted extreme heat layer would disingenuously present tomorrow's hazards and risks to today's community.

2.2.2. *Land Surface Temperature Analysis*

Land surface temperature (LST) directly measures the heat emitted from the ground. This analysis uses satellite data captured over the 2021 heat event. We use the Landsat-8 constellation to gather multispectral images with a 30 m^2 resolution. The LST analysis includes the following calculations:

- a normalised difference vegetation index (NDVI; i.e. a "greenness" index);
- fractional vegetation (i.e. the proportion of vegetation within the satellite image mosaic pixel);
- emissivity (i.e. the capacity for ground-based objects to retain and emit heat); and
- thermal radiation (i.e. the direct measurement of heat radiated from the Earth's surface).

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[26] IPCC. (2021). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (Eds.), Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg1

[27] ClimateData.ca (n.d.) Uncertainty in climate projects. Available from https://climatedata.ca/resource/uncertainty-in-climate-projections/

2.2.3. *Air Temperature Analysis*

While LST is representative of the distribution of heat across the region during the 2021 heat event, it is less accurate at describing human-observed discomfort to heat during that event. Air temperature, usually measured 2 m above the ground, is a more accurate representation of how extreme heat is experienced by an individual. Air temperature is not a measurement that is captured by spaceborne or airborne remote sensing platforms, such as Landsat.

To align the extreme heat to the human experience, our exposure layer assessment calculated air temperature through a regression-based model that is informed by LST and other local environmental factors, shown to be correlated with air temperature[28,29]. The air temperature regression-model predictor variables include:

- Digital elevation model (DEM), at 1 m^2 spatial resolution and derived from 2019 lidar and for beyond lidar survey extents at 30 m^2, as acquired from the Shuttle Radar Topography Mission (SRTM) data[30];
- Solar insolation (Wh/m^2) at 1 m^2 terrain models from the 2019 lidar data;
- Sky View Factor (SVF), at 1 m^2 spatial resolution that describes the degree of viewable sky for points on the ground and is a representation of multiple other environmental factors[31];
- Land surface temperature (LST; °C), at 30 m^2 and calculated from multiple spectral bands of the Landsat-8 satellite images captured during the 2021 heat event (described in the previous Section);
- Normalised water difference index (NDWI), which measures water content of the environment. NDWI is also roughly 30 m^2 and calculated from multiple spectral bands of the Landsat-8 satellite images captured during the 2021 heat event;
- Distance to coastline (km), which is a euclidean measurement at 30 m^2 pixel resolution; and
- Longitude and latitude.

In addition to the dependent variables listed above, we use an average daytime temperature observed on the 28th June, 2021 between 9:00 to 21:00 from a network of 66 stations located throughout the Region (Figure 2.2) as the independent variable in this regression model. Upon iterative regression analyses, it was found that variables differed significantly in terms of their predictability of air temperature. We found that the regression model performs well with highly significant variables including solar insolation ($p \approx 0$), land surface temperature ($p = 0.0013$),

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[28] Ho, H. C., Knudby, A., Sirovyak, P., Xu, Y., Hodul, M., & Henderson, S. B. (2014). Mapping maximum urban air temperature on hot summer days. Remote Sensing of Environment, 154, 38-45

[29] Xu, Y., Knudby, A., & Ho, H. C. (2014). Estimating daily maximum air temperature from MODIS in British Columbia, Canada. International Journal of Remote Sensing, 35(24), 8108-8121. https://doi.org/10.1080/01431161.2014.978957

[30] NASA Shuttle Radar Topography Mission (SRTM)(2013). Shuttle Radar Topography Mission (SRTM) Global. Distributed by OpenTopography. DOI:10.5069/G9445JDF. Accessed November 15, 2023

[31] Zakšek, K., Oštir, K., & Kokalj, Ž. (2011). Sky-View Factor as a Relief Visualization Technique. Remote Sensing, 3, 398-415. https://doi.org/10.3390/rs3020398

distance to coast (p = 0.0305), and elevation (p = 0.037). The other predictors identified were found to be cross-correlated or not significant and were dropped from the model.

The linear regression model is constructed without an intercept. The assumption here is that in the absence of the environmental factors considered, the perceived outdoor temperature by a typical individual would be 0°C. Our justification for the decision in not including an intercept for this linear regression are summarised below for each predictor variable.

- *Land surface temperature.*
  Given that land surface temperature is a direct measure of the heat emitted by the ground, a value of zero would imply no heat emission, theoretically corresponding to a scenario of absolute zero where no molecular motion—and hence no temperature—exists. However, such a condition is physically impossible on Earth's surface, rendering the inclusion of an intercept unnecessary for this variable.
- *Solar insolation.*
  The presence of solar insolation is a necessary condition for positive temperatures. While the insolation value does not reach zero in our dataset, we suggest that in the absence of insolation, such as during a total solar eclipse or polar night, the temperature would tend toward the lowest possible values observed.

Figure 2.2. Weather stations used in air temperature modelling.

The average daytime temperature is used at each station to account for potentially faulty sensors and/or temperature spikes that cause anomalous in the data, as shown in Figure 2.3.

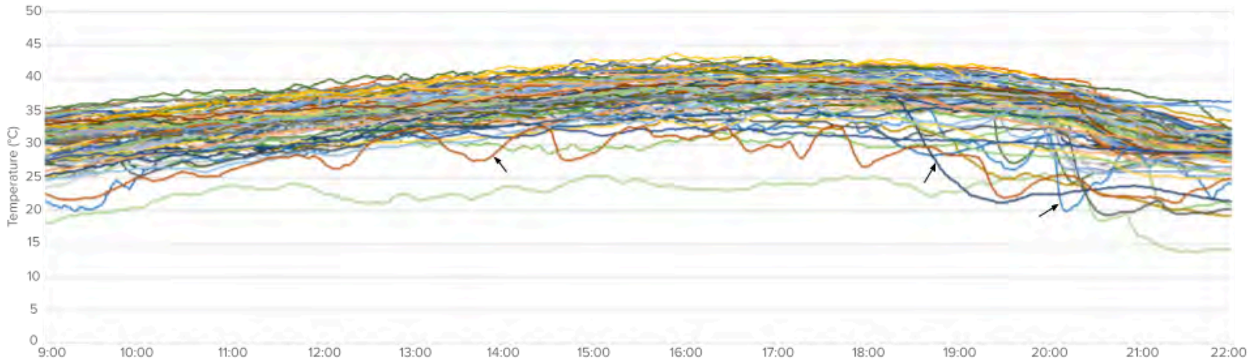

Figure 2.3. Hourly temperature observations at 66 weather stations throughout the Capital Region, as measured from 9:00 to 21:00 on the 28th of June, 2021. Black arrows indicate potentially anomalous and faulty sensor data.

In addition to the linear model, we also used a random forest model to produce predicted air temperature values throughout the Region. Our random forest model produces an R^2 of 0.73 and a root mean square error (RMSE) of 1.97 °C, a performance similar to that of similar studies[32]. While suggesting a strong model performance, the random forest model also produces an unexpected, inverted relationship between solar insolation and air temperature. For this reason, the regression model was selected for this study

2.3. Buildings Index

Building-level heat vulnerability mapping is multifaceted and has been a gap in many heat vulnerability indices that do not consider nuances at the building scale. Our approach aims to fill this gap by integrating multiple models that capture multidimensional factors of building-specific vulnerability to extreme heat events. This project assesses building-by-building vulnerability for all buildings throughout the region[33].

This Building Vulnerability Index Section presents key findings derived from a comprehensive review of relevant literature. Subsequently, each input of the building index is detailed with its respective model methodology, accompanied by discussions on index calculation and data verification.

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[32] Ho, H. C., et al. (2014)

[33] Not included are outhouses and other, non-primary buildings. The building footprint dataset is a combination of municipal and regional datasets, as well as lidar-based building footprint classifications as developed for this project in areas that are beyond the available building footprint data extents. Minor instances of misclassification and/or temporal misalignment are occasionally observed across building footprint datasets.

2.3.1. Buildings Literature Review

The importance of building characteristics in heat vulnerability assessments cannot be understated. Notably, many heat-related deaths—especially during extreme events—can be credited to indoor heat exposure[34, 35]. This is particularly relevant for certain vulnerable groups, such as the elderly or those with limited mobility, who spend much of their time indoors and therefore disproportionately face the heat impacts associated with buildings. Further, research indicates a significant discrepancy between indoor and outdoor temperatures[36], thereby demonstrating the need to complement our previously described efforts on extreme heat exposure modelling (see Section 2.2). Indeed, studies show that heat-related mortality and morbidity resulting from outdoor and indoor exposure may not always be correlated, highlighting that the composition of building characteristics may be more informative than outdoor surface temperature[37]. By considering building-level characteristics, heat vulnerability indices can provide a more comprehensive and nuanced understanding of heat vulnerability and help to facilitate targeted heat response and risk reduction.

In review of the literature around heat vulnerability analysis, some emerging building-level indicators were reviewed and selected based on available and reputable data sources. Through a literature review, we elucidated the following regarding building-specific heat vulnerability:

- While social-vulnerability heat indices can inform where to act in the event of an extreme heat event, analysing housing characteristics of those areas allows for a more nuanced understanding of how to facilitate risk reduction and adaptive strategies before the onset of a heat event[38].
- Indoor heat temperature may be significantly misaligned from outdoor measured temperatures, thereby underscoring the importance of building-specific indoor heat modelling as a required component to heat vulnerability assessments[39].

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[34] Samuelson, H., Baniassadi, A., Lin, A., Izaga González, P., Brawley, T., & Narula, T. (2020). Housing as a critical determinant of heat vulnerability and health. *Science of The Total Environment*, 720, 137296. https://doi.org/10.1016/j.scitotenv.2020.137296

[35] CDC, 2013. Heat illness and deaths—New York City, 2000–2011. MMWR Morb. Mortal. Wkly Rep. 62, 617.

[36] Alam, M., Sanjayan, J., Zou, P. X. W., Stewart, M. G., & Wilson, J. (2016). Modelling the correlation between building energy ratings and heat-related mortality and morbidity. *Sustainable Cities and Society*, *22*, 29–39. https://doi.org/10.1016/j.scs.2016.01.006

[37] Uejio, C. K., Wilhelmi, O. V., Golden, J. S., Mills, D. M., Gulino, S. P., & Samenow, J. P. (2011). Intra-urban societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability. *Health & Place*, *17*(2), 498–507. https://doi.org/10.1016/j.healthplace.2010.12.005

[38] Samuelson et al. (2020).

[39] Alam et al. (2016)

- Buildings can contribute to heat gains[40] during extreme heat events through solar heat gains (via roofs, walls, and windows) and internal heat gains (from appliances and lighting).
- Both forms of heat gains are important in identifying potential vulnerabilities[41], however internal heat gain data is limited and therefore is considered through peer-reviewed proxy indicators that focus on thermal performance, including construction year and dwelling type[42].
- The reflectance or albedo of a rooftop's material contributes to the amount of heat absorbed into the building.
- Floor level and building type are predictors of increased mortality and morbidity during extreme heat events, particularly for those who are aged, have chronic conditions, mobility constraints, or disability[43].

2.3.2. Buildings Index Inputs

To create a buildings level index, individual building footprints for the region were compiled from the various municipalities that make up the capital region. These compiled footprints were derived from various years ranging from 2018 to 2023. However, some areas in the capital region did not have readily available building footprints. Building footprint data gaps were present for Metchosin, parts of East Sooke and areas along the coast, west of Sooke out to Juan de fuca.

For Metchosin, where 2019 classified land cover data[44] was accessible, the project team opted for a cost-effective approach by deriving footprints from the available buildings class and regularising building polygons to simulate building form. Available lidar data was also used for the Metchosin area to derive building height information using a regional building height model (BHM), as detailed in section 2.3.2.4I.

For East Sooke and areas along the coast, west of Sooke out to the Juan de Fuca Electoral Areas, land cover classified data was not available. Instead, building footprints for these remaining areas were derived from Lidar BC's lidar portal containing 2019 lidar data[45]. After

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[40] Heat gains refer to the thermal energy that enters a building. It includes the heat absorbed from external sources, such as solar radiation penetrating through the building's roof, walls, and windows. As well as, from internal sources, including appliances, lighting, and human activities within the building. Heat gains play a crucial role in determining the indoor heat levels and overall thermal conditions within a building during heatwaves. Assessing and understanding heat gains is essential in evaluating the potential heat-related risks and vulnerabilities of buildings and their occupants
[41] BC Housing. (2022). *Extreme Heat and Buildings: An Analysis of the 2021 Heat Dome Related Deaths in Community Housing in British Columbia*.
https://www.bchousing.org/sites/default/files/media/documents/Extreme-Heat-Report%2B2022.pdf
[42] Samuelson et al. (2020).
[43] Haigh, F., Chok, H., & Harris, P. (2011). Housing density and health: A review of the literature and Health Impact Assessments.
[44] Caslys (2021). Capital Regional District Land Cover Classification [Map/Dataset]. Shared under data agreement with the Capital Regional District.
[45] Lidar BC, Open Data Portal. Data collected in 2019. https://lidar.gov.bc.ca/pages/download-discovery.

removing outliers in the lidar point cloud data, building features were classified using ESRI's lidar classification tool[46]. Building features in the lidar data were extracted as raster data and then converted into polygon shapes, regularised, and attributed with building height information from lidar. After quality assurance checks were conducted on footprint delineation, a few gaps remained where manual delineation of footprints was undertaken for completeness[47].

With building footprints delineated and the use of high resolution data inputs, this index has been designed to assess the vulnerability of individual buildings to extreme heat and represents a significant advancement in this field, particularly given the limited body of existing literature on building-specific responses to extreme heat. Our literature review on this topic, as well as engagement with subject-matter experts, found six emergent determinants of building-specific vulnerability: building age, dwelling type, rooftop albedo, building height, solar insolation, and the presence of heat pumps. Each of these determinants is detailed below.

2.3.2.1. Building Age

While older buildings are not definitively hotter in all scenarios, age acts a proxy for multiple other variables such building construction type and thermal properties[48], which were unavailable inputs for this Project. Rather, age primarily acts as a marker for BC step-code adoption. Building age helps to flag buildings that are less likely to be up to code in terms of heat regulation and air tightness within the BC context.

Older buildings are ranked at a higher vulnerability, based off of BC's historic building code[49]. Buildings built before 1970 used building codes under local bylaw standards with no coherence in standards across the District, whereas buildings built after 2012 have higher standards for ventilation (see Table 2.1 below).

Table 2.1. Building age vulnerability based on an understanding of BC building code eras and their respective level of standards.

Building Age	Vulnerability
<1970	Very Vulnerable
1970-1985	Vulnerable

[46] *Classify LAS Building (3D Analyst)—ArcGIS Pro | Documentation*. (n.d.). Retrieved December 20, 2023, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/3d-analyst/classify-las-building.htm
Parameters used in classification: The lidar building feature extraction algorithm was constrained by defining a minimum building height of 2m and a minimum area of 6 m^2.
[47] 446 building footprints were manually delineated.
[48] Samuelson et al. 2019
[49] Government of British Columbia. (2015). *History of British Columbia Building Regulations*. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/guides/history_of_the_codes_2015_update.pdf

1985-1998	Less Vulnerable
1998-2006	Moderately Vulnerable
2006-2012	Mildly Vulnerable
2012-2018	Minimally Vulnerable
> 2018	Not Vulnerable

2.3.2.2. Dwelling Type

Dwelling type is included in the buildings index as research has found that taller, multi-unit buildings may exhibit increased vulnerability to extreme heat[50]. Indeed, Haigh, Chok, and Harris (2011) assert that factors such as building floor level and type serve as predictors for elevated mortality and morbidity during extreme heat events[51]. Furthermore, a report from the BC Coroner in 2022 underscores the correlation between dwelling type and the incidence of heat-related deaths observed during the 2021 heat event.

To derive the vulnerability weight for each dwelling type, rankings were assigned based on the proportions of heat-related deaths by dwelling type during the 2021 extreme heat event, as reported by BC's Coroner. These proportions were then standardised relative to the capital region's housing stock proportions and normalised for the capital region's population per dwelling type (refer to Table 2.2). This standardisation process ensures that the dwelling type vulnerability weight is aligned with the composition of the capital region's housing stock.

Table 2.2. Dwelling type vulnerability ranking. Using the BC Coroner's report BC wide statistics, the proportion of deaths occuring in a dwelling type is normalised for the number of dwellings per dwelling type category within the capital region.

Heat-Related Deaths By Place of Injury	BC Wide Proportion of Deaths (%)	Proportion of capital region Dwelling Type (%)	CRD Proportion of Deaths (%)	CRD Vulnerability Weight
Private Residence - Multi-unit	39.1	30	45	0.36
Private Residence - Detached	33.9	64	39	0

[50] British Columbia Coroners Service (2022) Extreme Heat and Human Mortality: A review of heat-related Deaths in BC in Summer 2021.
[51] Haigh, F., Chok, H., & Harris, P. (2011). Housing density and health: A review of the literature and Health Impact Assessments.

Single Room Occupancy (SRO) or Supportive-/Social-housing	10.0	Data unavailable	Data unavailable	Data unavailable
Trailer Home/Mobile Home/RV/Camper	6.5	2	8	1
Senior/Long-Term Care Home	6.5	3	8	.86
Outside	2.1	N/A	N/A	N/A
Other Residential	1.9	N/A	N/A	N/A

Building age and dwelling type are both attributes taken from the BC Assessment's Building Information Report (BIR). In cases when flattening both the regional parcel fabric and the building information report onto the parcels, where multiple building information records exist for a single parcel, the building type assigned is determined by that of the largest square footage, and the age is designated based on the year corresponding to the largest square footage building type.

2.3.2.3. Albedo

Albedo was selected as a thermal performance proxy metric as it indicates how much solar thermal radiation is absorbed and emitted on building rooftops. Higher albedo surfaces (i.e white roofs) reflect light off the surface while darker surfaces have a low albedo and absorb more heat.

In our approach to calculate albedo, we utilise reflectance data from Sentinel-2 Multispectral Instrument (MSI)[52] imagery and weighting coefficients as developed by Vanino et al[53]. The weights represent the fraction of solar radiation within the spectral range for each Sentinel-2 band. These weights were established based on the spectral irradiance spectrum of the sun, essentially indicating the proportion of sunlight each band receives. Given these weights and the per-band reflectance values, we calculate the mean albedo for each pixel in the image using the following formula, as adaptive from Vinino et al (2018)[54]:

$$\alpha = \frac{\sum|\rho_{bi} \cdot \omega_{bi}|}{\sum \omega_{bi}} \quad (1)$$

where:

- α is mean albedo at a 10 m^2 pixel resolution;

[52] European Space Agency. (2015-present). Sentinel-2 Multispectral Instrument Level-1C data [Data set]. Copernicus Open Access Hub. https://scihub.copernicus.eu/dhus

[53] Vanino, S., Nino, P., De Michele, C., Bolognesi, S. F., D'Urso, G., Di Bene, C., Pennelli, B., Vuolo, F., Farina, R., Pulighe, G., & Napoli, R. (2018). Capability of Sentinel-2 data for estimating maximum evapotranspiration and irrigation requirements for tomato crop in Central Italy. Remote Sensing of Environment, 215, 452-470. https://doi.org/10.1016/j.rse.2018.06.035

[54] See Appendix A for corresponding band weights.

- ω_{bi} is the weight for band i; and
- ρ_{bi} is the reflectance in band i.

This equation computes a weighted average of the reflectances across the different bands (summarised in Appendix A), with weights given by the ω_{bi} values. Each band's reflectance is multiplied by the corresponding weight, and these products are then summed. The sum of these weighted reflectances is divided by the sum of the weights to normalise the result, providing an estimate for mean albedo (α) . Note that we diverge in methods from Vanino et al, in that we normalise our weights, thereby ensuring that the weights sum to 1. This way we maintain the reflectance values' relative importance and avoid artificially inflating or deflating the final albedo estimate.

2.3.2.4. Building Height

Taller buildings are more vulnerable irrespective of air conditioning[55], which is considered in the building index model using building height information derived from LiDAR. A digital surface model (DSM) and a digital terrain model (DTM also referred to as a ground elevation model) were derived from 2019 LiDAR[56] across the region. By subtracting the DTM from the DSM, building height is derived for each building footprint (See equation 2). Building height is averaged for each building footprint.

$$BHM = DSM - DTM \tag{2}$$

where:

- BHM is Building Height Model, in metres;
- DSM is Digital Surface Model, in metres; and
- DTM is Ground Elevation, in metres.

2.3.2.5. Solar Insolation

Solar radiation refers to the amount of daily sun exposure a building receives; more sun exposure equates to hotter conditions. Solar heat gains are assessed using a solar loading model that considers various factors. Firstly, it uses the sun's position (azimuth and altitude), calculated via astronomical equations for different times of the day and year. A clear sky model is employed to estimate solar radiation, taking into account atmospheric conditions that can scatter and absorb radiation. The model also considers the impact of shade and shadows based on digital elevation models (DEMs), as well as the influence of surface characteristics like aspect and slope on radiation received. The tool calculates insolation, expressed in watt hours per square metre (Wh/m^2), for both direct and diffuse radiation, creating a raster output where each cell's value signifies the solar radiation received over a set period of time. The raster output has been averaged across each building footprint to better visualise relative variation in solar insolation.

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[55] Samuelson et al. (2020)
[56] Lidar BC, Open Data Portal. Data collected in 2019. https://lidar.gov.bc.ca/pages/download-discovery.

2.3.2.6. *Heat Pumps*

Lastly, building-specific data is available for residential buildings that have a newly installed heat pump (installed between 2011 and 2022)[57][58]. If a building has a heat pump, the model assumes a heat vulnerability score of 0 as it is likely to have appropriate protective effects against extreme heat[59].

The distribution of heat pumps is unequal in the capital region region with wide degrees of adoption by jurisdiction as well as building type. Based on our analysis of the heat pump data we note that overall 5.8% of residential buildings have confirmed or suspected heat pump installations based on the Technical Safety BC and City of Victoria permit data.

As summarised in table 2.3 below: The highest overall adoption rates in Colwood and View Royal at 9.8% and 9.6% respectively. Notable in Colwood, was the highest regional penetration of heat pumps in single detached homes (8.9%) compared to a regional average of 4.8%. In View Royal we noted a 31.8% penetration rate (by building count) of heat pumps in multi-unit buildings which was the highest in the region and triple the regional average of 11.4%.

Conversely, we note that of larger jurisdictions, Central Saanich, Victoria and Oak Bay all have lower adoption rates for heat pumps (3.3%, 4.5% and 4.0% respectively). Interestingly, Central Saanich has a very low adoption rate for single detached homes (2.5%) whereas the City of Victoria has lower adoption rates across the board but worryingly in multi-unit residential buildings (4.2%) which we note are more risky from a buildings heat perspective more generally). We should note, however, that multi-unit building heat pump adoption rates may be lower in Victoria due to the use of alternate cooling technologies (such as HVAC or traditional AC units) which were not captured for this study.

Table 2.3. Heat pump adoption rates by community for residential buildings

Community	Percentage of heat pumps in residential buildings
Central Saanich	3%
Colwood	10%
Esquimalt	6%
Highlands	6%
Juan de Fuca (Part 1)	4%
Juan de Fuca (Part 2)	0%
Langford	7%
Metchosin	7%
North Saanich	9%
Oak Bay	5%
Saanich	6%

[57] From Technical Safety BC Data for all jurisdictions outside of the City of Victoria and from City of Victoria permits in the locale

[58] We note that heat pumps are but one mechanical cooling technology that can be used during a heat event. More commonly air conditioning is considered as the mitigative factor. However, building level air conditioning data does not exist at a scale that would render it effective for a project such as this one.

[59] Canadian Climate Institute. (2023). *Heat Pumps Pay Off.* https://climateinstitute.ca/wp-content/uploads/2023/09/Heat-Pumps-Pay-Off-Unlocking-lower-cost-heating-and-cooling-in-Canada-Canadian-Climate-Institute.pdf

Saltspring Island	0%
Sidney	7%
Sooke	12%
Southern Gulf Islands	0%
Victoria	4%
View Royal	10%

2.3.3. Buildings Index Calculation

Given the scarcity of comprehensive studies in this area, we use a deterministic approach in modelling the buildings vulnerability index. The index is determined by calculating an equally weighted average of the aforementioned indicators. In cases where data for a specific indicator is unavailable for a particular building, that indicator is excluded from the vulnerability assessment for that building. This ensures that each building's vulnerability score is based only on available and relevant data. See Figure 2.5 below for a summary of the building index compilation.

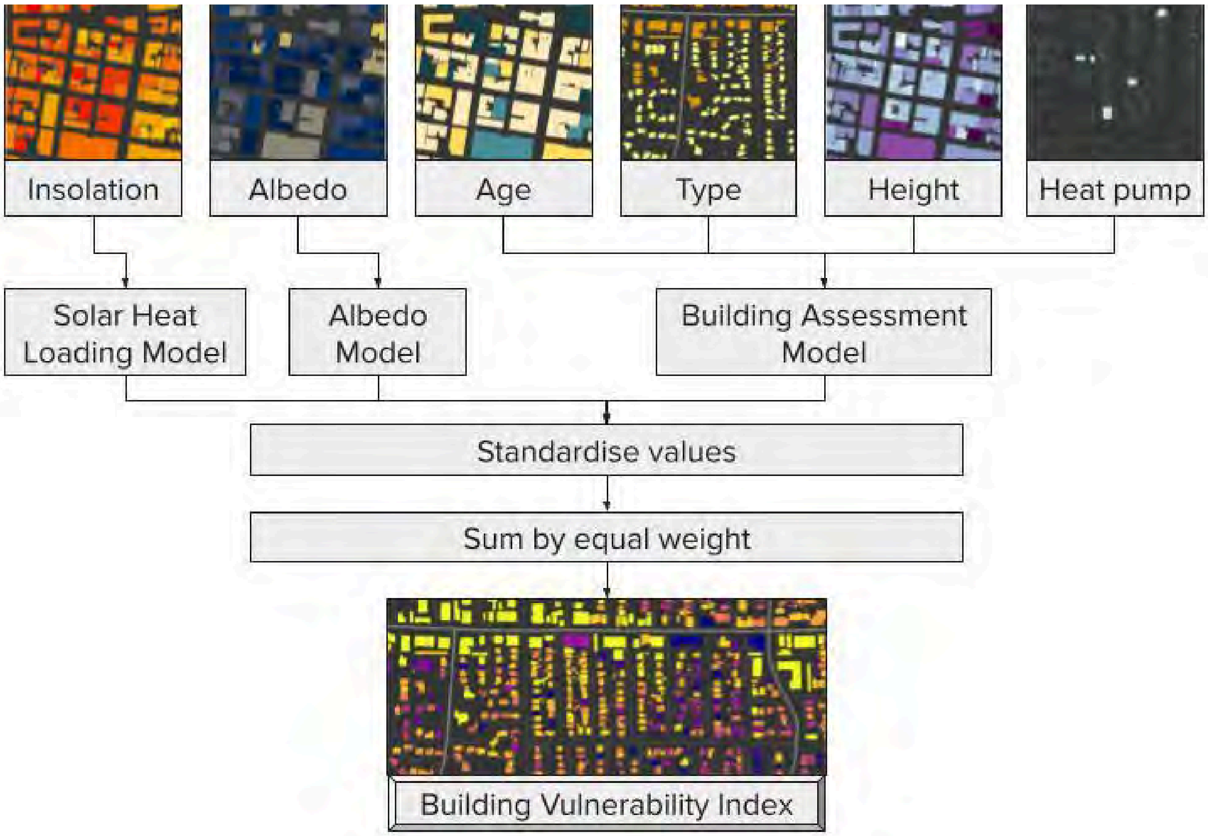

Figure 2.5. The Building Vulnerability Index consists of three models that capture multidimensional factors of building-specific vulnerability to extreme heat events. These factors include building age, dwelling type, building height and presence of heat pumps (Building Assessment Model), solar heat gain (Solar Heat Loading Model) and rooftop albedo (Albedo Model).

2.3.4. Anomalous and Missing Value Correction

The process of relating input values, such as BHM or albedo, to building footprints revealed some inaccuracies that required a specifically designed correction process. These inaccuracies are largely brought about by tree canopy coverage of building footprints and temporally misaligned lidar data.

This correction process applies a lidar-derived land cover classification layer, that distinguishes between treed and non-treed surfaces[60]. Albedo and BHM values are averaged from non-tree footprint segments, so that a more accurate height and reflectance values can be assumed. The correction process also tails height data to account for anomalous averages. Further, the correction process identifies buildings with missing values (either due to a high proportion of tree canopy coverage or due to temporal misalignment between the footprint and lidar dataset) and

[60] Caslys (2021). Capital Regional District Land Cover Classification [Map/Dataset]. Shared under data agreement with the Capital Regional District.

applies an archetypical height value that is representative of buildings of the same type within the local area.

2.3.5. *Building Attribute Verification Process*

The building footprint attribution QA process involves a multi-faceted approach that ensures the reliability of the Building Vulnerability Index inputs, namely height, albedo, solar insolation, dwelling type, and year built.

- *Sample selection for validation.*
  A representative sample of 80 building footprints was selected from both the upper and lower ends of the Buildings Index values. This sampling strategy was designed to cover a broad spectrum of buildings, facilitating a comprehensive evaluation of various attributes.
- *Findings from the attribution quality assurance process.*
  Our analysis revealed patterns consistent with expectations. Buildings identified as highly vulnerable in the index typically exhibited greater height and exposure to solar radiation. Conversely, buildings classified as less vulnerable were generally shorter and had more extensive tree coverage. However, it was observed that smaller buildings, predominantly single-family dwellings, demonstrated more variability in results. This variability included occasional misidentifications of building footprints and potential tree obstructions affecting building height measurements.
- *Albedo assessment.*
  The albedo values for smaller buildings were found to be closely clustered due to the spatial resolution of albedo measurements (10 m^2). This clustering makes it challenging to discern clear patterns for these small buildings. In contrast, larger buildings displayed more distinct albedo values, which more accurately reflected the colour and material of the roofs, ranging from white to dark grey.
- *QA methodology.*
  The quality assurance (QA) process serves as an essential validation measure to verify the rationality and validity of the regional model in its classification of buildings at the individual level. QA checks include the following procedures:
  - Street view analysis: Attributes such as building height, solar insolation, and dwelling type were cross-verified using Google Street View imagery. For example, a building identified as a seniors living building type, 11.1 m height, and high solar insolation (i.e. open environment, low tree cover) was validated through Google Street View, which confirmed the building as a four-storey senior care home with minimal shading and older construction material (Figure 2.6).
  - Satellite imagery analysis: Attributes, such as albedo, were also cross-checked using high resolution, RGB satellite imagery[61]. This cross-check confirmed the

[61] Maxar. (2022, July 24). Vivid RGB 30 cm high resolution imagery. Retrieved from ArcGIS Online: https://www.arcgis.com

accuracy of albedo values alignment with roof colours in the Region. The same building discussed above shows a typical grey roof colour in Figure 2.7

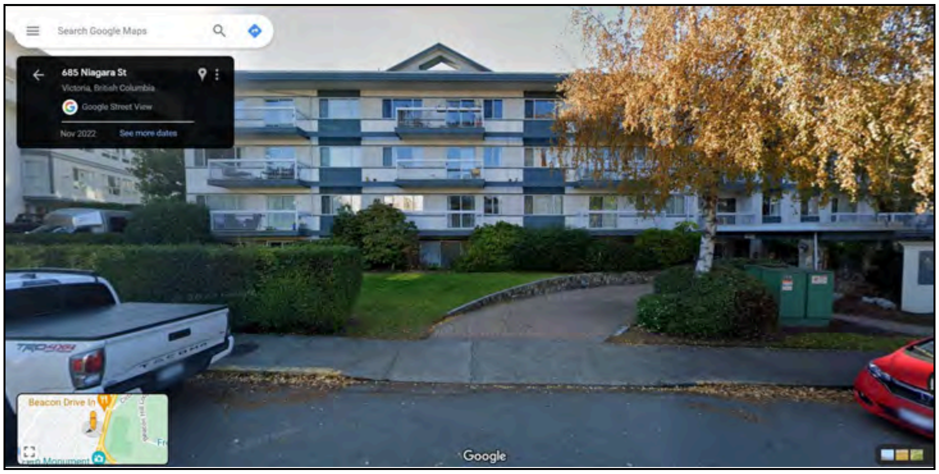

Figure 2.6. QA example of sense check methodology, Google Street View.

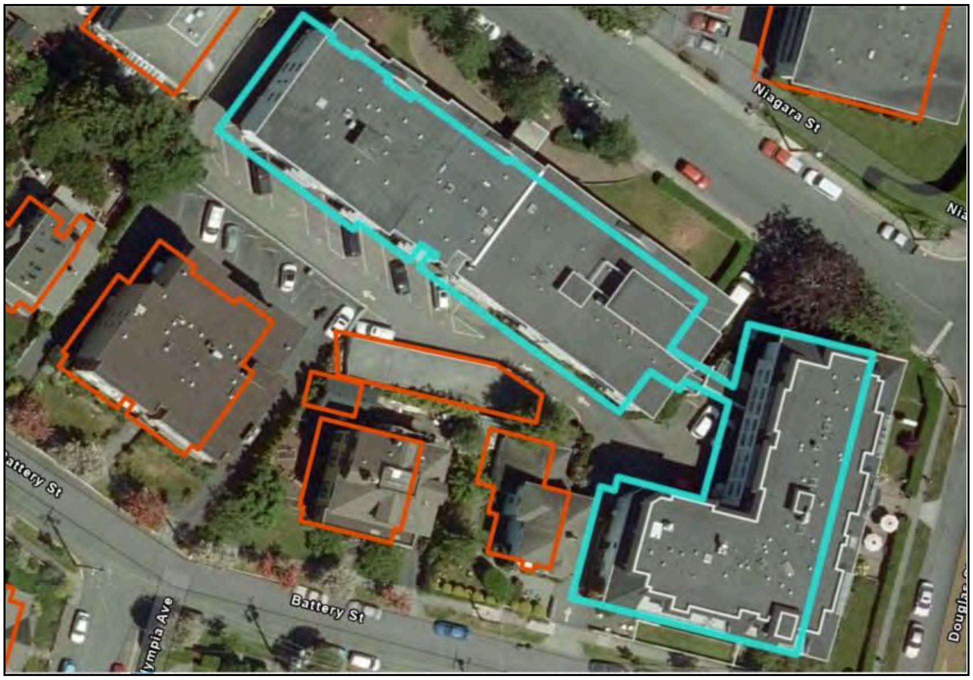

Figure 2.7. QA example of sense check methodology, aerial view.

The QA process concluded that 86% of the assessed buildings accurately represented all examined attributes. Discrepancies in the remaining 14% were attributed to various factors, as detailed in Table 2.4. These included construction-related changes (2.5%), misclassification of structures as buildings (3.7%), building height overestimations (2.5%), and tree interference in rural areas leading to inaccuracies in footprint delineation (4.9%). Imagery resolution challenges in rural areas further compounded these validation issues.

Table 2.4. Summary of error types found during the QA process

Type of error	Proportion of dataset (%)
Construction Related	2.5%
Misclassification of Buildings	3.7%
Building Height Errors	2.5%
Tree Interference	4.9%

In total, 100% of delineated building footprints were attributed a building height, albedo and solar insolation value while 97.12% of buildings were attributed with building construction year and dwelling type. Thus, 2.88% of buildings are left without BIR attributes. For buildings without BIR attributes, 1.43% of those buildings were on First Nations Lands and data is not available from the BIR for these buildings. There is also an estimated 2.28% of buildings missing from the buildings index model, which was gleaned from where a building information record was attached to a parcel, but no building footprint was present.

3. Results

This Section presents results pertaining to the socio-demographic vulnerability index, the heat exposure layer, and the building vulnerability index. For each, key patterns are described and emergent insights from the analysis are discussed. Additionally, the Section presents community-level and municipal analysis findings.

3.1. Socio-Demographic Vulnerability Index

As mentioned in the sections above, the Socio-demographic Vulnerability Index was informed by a rigorous process involving the assignment of weights to each variable during the Analytic Hierarchy Process (AHP) workshop, which was a collaborative effort with regional subject matter experts, including epidemiologists, emergency managers, and social planners. The Socio-demographic Vulnerability Index identifies key contributors to vulnerability, and based on the insights garnered from the AHP workshop, three variables emerged as the most significant risk indicators during extreme heat events. The demographic factors most strongly influencing the vulnerability index encompassed the percentage of the population aged 65 or older, the crude rate of individuals with mental and substance use disorders, and the percentage of low-income adults (see Table 2.0 for the full list of variables with their associated weights). These variables were collectively deemed as the most at-risk populations during extreme heat, as established through the informed perspectives of the workshop participants and antecedent literature review.

The demographic index was further broken down into two distinct sub-indices to gain a more nuanced comprehension of the spatial dynamics influenced by health-related demographic variables and socio-demographic factors. When decomposed, we note that the individual sub-indices performed poorly in comparison to the singular index which suggests that both health and demographic information contribute more or less equally to heat risk.[62] The demographic index, excluding health factors, displays a spatial pattern with a concentration of vulnerability observed in Victoria's downtown core (see fig 3.1). The pattern indicates relatively less vulnerable areas radiating outward from Victoria. In contrast, the demographic index considering only health-related factors illustrates increased vulnerability proportions in Saanich as well as an increased amount of Dissemination Areas (DAs) in Sydney (see figure 3.2). Overall, the combined socio-demographic index highlights a few areas in the region that have a greater proportion of the population that is vulnerable to extreme heat events (see figure 3.3). These highly vulnerable areas include James Bay and the surrounding areas near downtown Victoria, pockets of Saanich, and the town of Sydney (See figures 3.1, 3.2, and 3.3 for maps of the socio-demographic index and the two sub-indices). Additional detailed findings are indicated by municipality in the municipal summaries outlined in section 3.6 below.

[62] While individually, each sub-index had weaker outcomes, on their own each can be used for alternative purposes or be combined with other variables and information to produce value-added outcomes. We suggest further evaluation regarding the combination of these sub-indices and other variables in future studies, as appropriate.

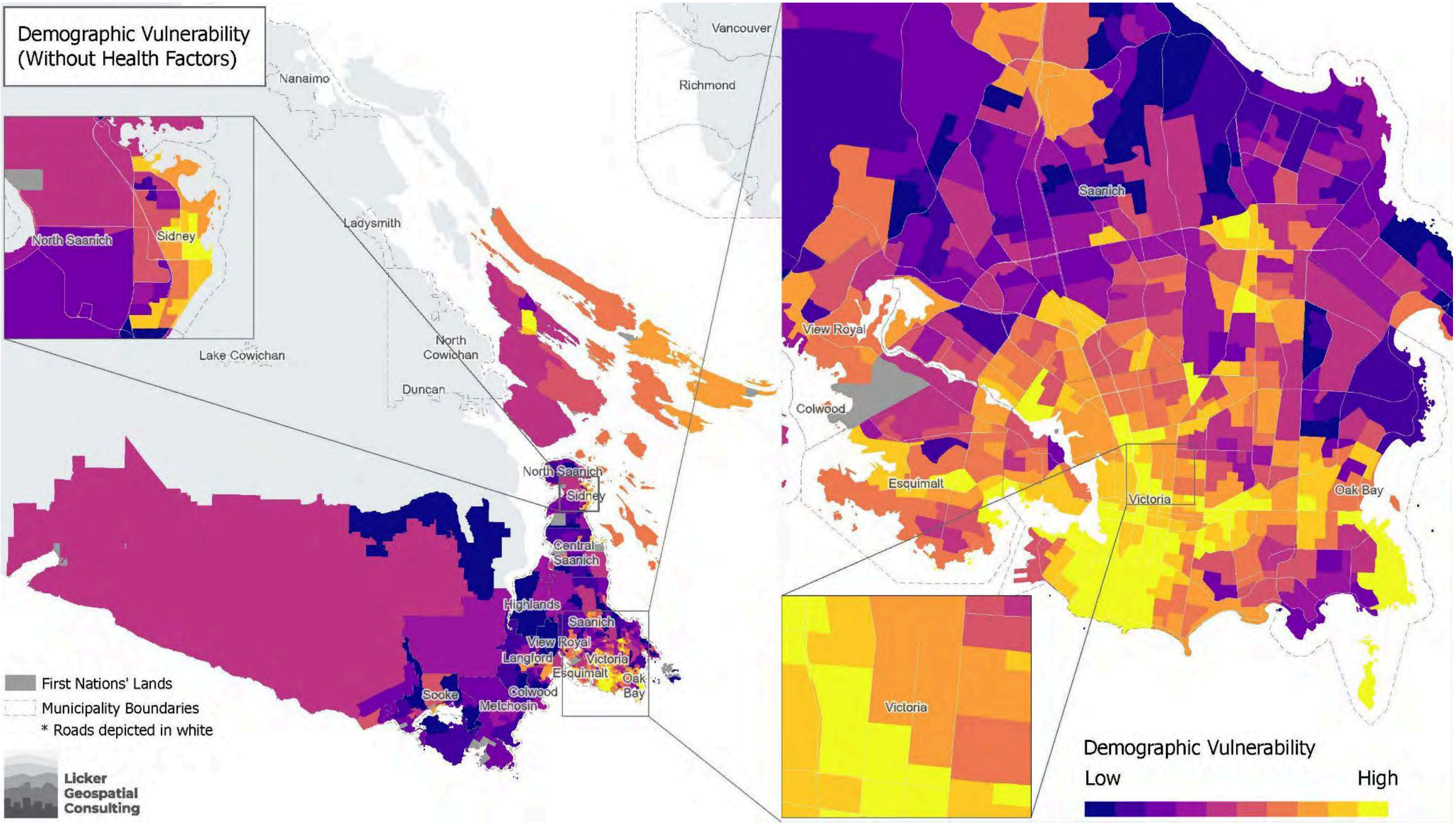

Figure 3.1. Extreme Heat – Demographic Vulnerability sub-index distribution (no health data included).

3.1.1. Concentrations of health vulnerability

When analysed by community, we note that significant health risk is present in Sidney (31% of its population reside in DAs with high health risk mainly due to an older population, however other determinants of health could still be a factor there), Esquimalt and the Southern Gulf Island and Salt Spring Island (Figures 3.1 and 3.3). When considered at a population level, the highest concentration of highly vulnerable populations reside in Victoria (28% share of the top two deciles), Saanich (20% share of the top two deciles) and Langford (11% share). However, when taken in proportion to the population as a whole, Sidney stands out with a 10% share of the highest two deciles compared to an overall 3% share of the capital region's population (resulting in a risk proportion ratio of 3.0). This is distantly followed by Esquimalt (1.43) and Victoria (1.36). (Tables 3.0 and 3.1 below).

Key determinants of health vulnerability in Sidney include:

- High rates of hypertension in the populace - 54^{th} in the capital region
- High rates of episodic mood disorders - 54^{th} in the capital region
- Higher rates of Acute Myocardial Infarction - 47^{th} in the capital region; and
- Higher rates of Chronic kidney disease - 42^{nd} percentile in the capital region

It bears noting that these are average percentile values and as such indicate a high degree of concentration of health risks in the municipality.

For reference, neighbouring North Saanich (which has a much lower index score) shows the following average rates (by capital region percentile):

- Hypertension - 39^{th} Percentile
- Episodic mood disorders - 37^{th} percentile
- Acute Myocardial Infarction - 29^{th} percentile
- Chronic Kidney disease - 27^{th} percentile

Colwood (the second lowest scoring municipality with regards to the health index) continues the trend:

- Hypertension - 17^{th} Percentile
- Episodic mood disorders - 35^{th} percentile
- Acute Myocardial Infarction - 15^{th} percentile
- Chronic Kidney disease - 13^{th} percentile

Indeed, areas such as Colwood, North Saanich and Saanich all have relatively lower proportions of at-risk populations in comparison to their proportionate share of capital region population (ratios of 0.56, 0.22 and 0.61 for Colwood, North Saanich and Saanich respectively). These ratios suggest that these areas have reduced concentrations of health risk overall.

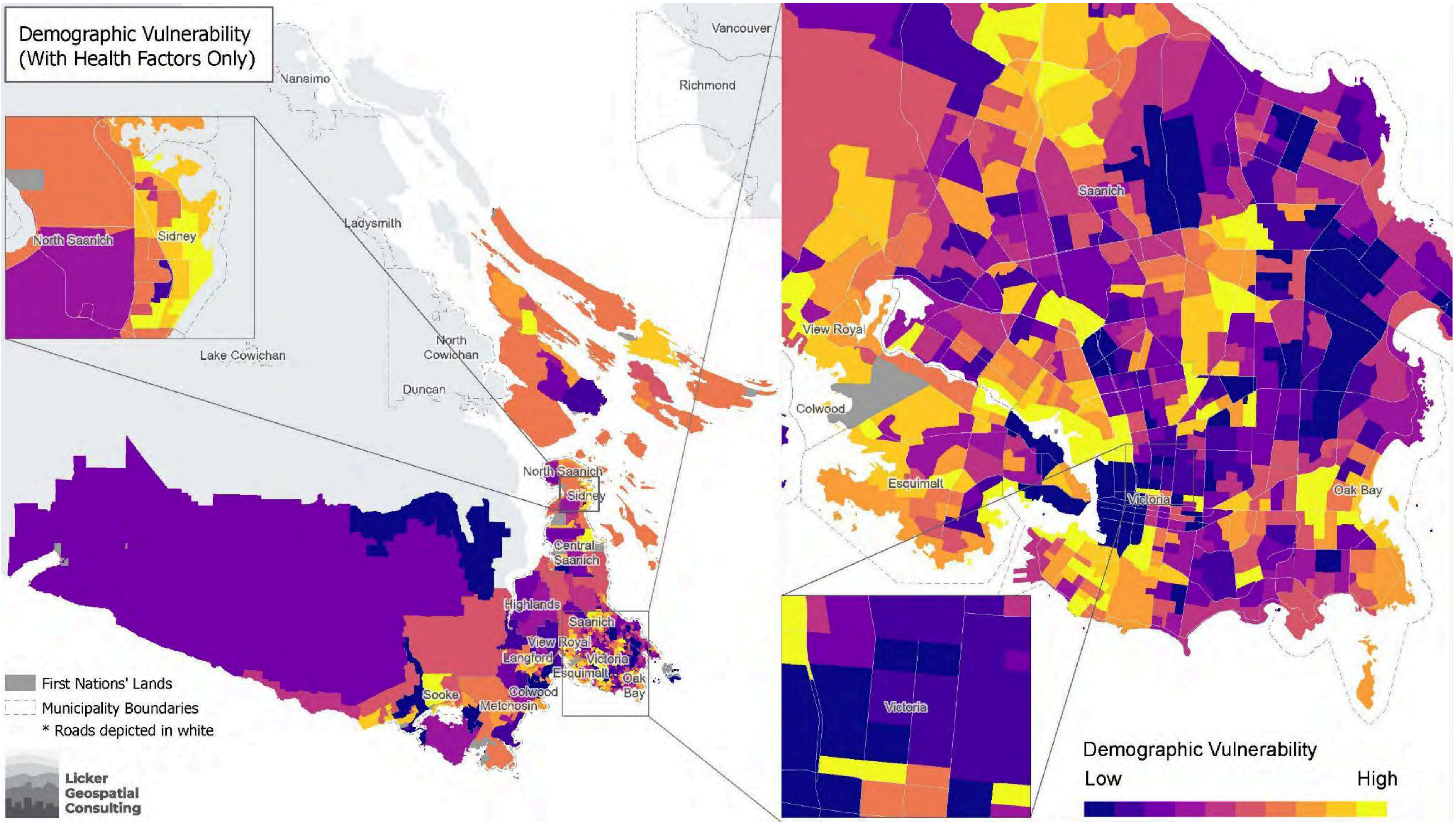

Figure 3.2. Extreme Heat – Health-Only Demographic Vulnerability sub-index distribution.

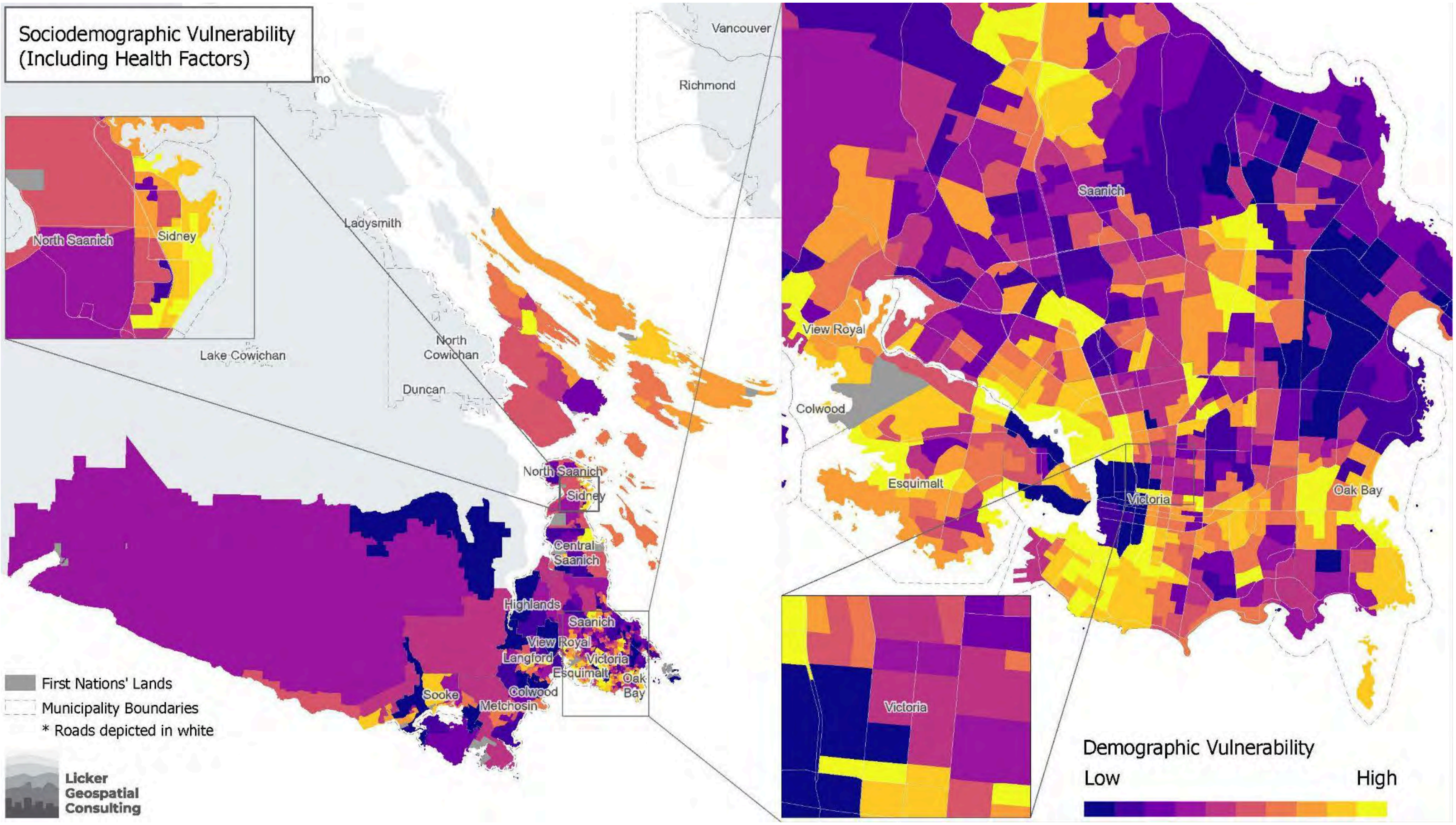

Figure 3.3. Extreme Heat – Socio-demographic Vulnerability Index with both demographic and health-related indicators

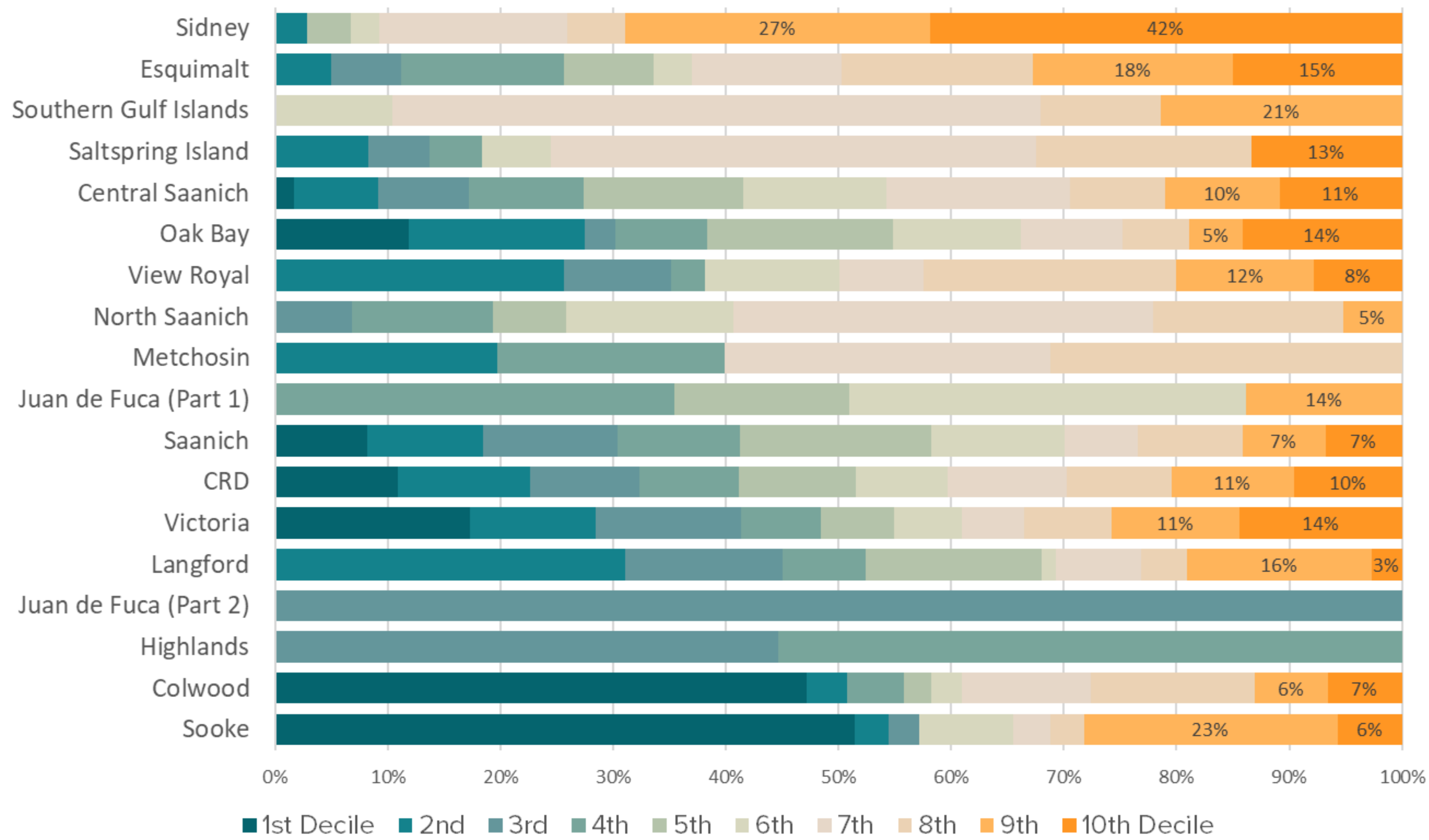

Figure 3.4. Demographic vulnerability (Health sub-index) by jurisdiction in the capital region, displayed by decile. Sidney BC, has the largest proportion of its population falling within the most vulnerable decile, while Juan de Fuca (part 2) and Highlands BC, have 0% of their populations within the most vulnerable decile.

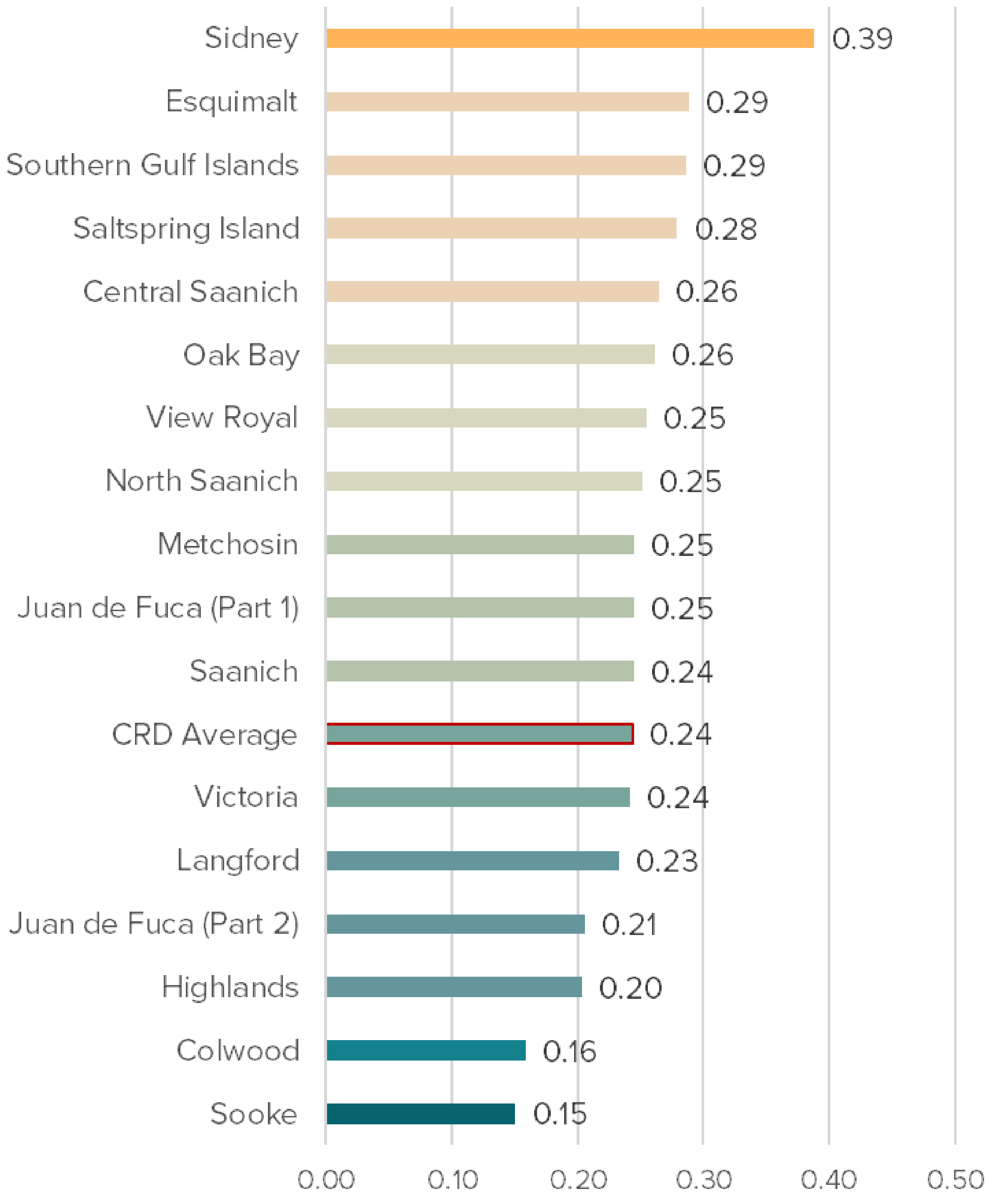

Figure 3.5. Demographic vulnerability by jurisdiction in the capital region (heath sub-index only).

Table 3.0. Population by demographic health sub-index decile by jurisdiction in the capital region (health data only).

Jurisdiction	1st Decile	2nd	3rd	4th	5th	6th	7th	8th	9th	10th Decile
Sooke	7,762	447	411			1,262	502	449	3,396	857
Colwood	8,939	689		947	472	501	2,175	2,762	1,231	1,245
Highlands			1,109	1,373						
Juan de Fuca (Part 2)			399							
Langford		14,476	6,528	3,398	7,288	573	3,532	1,912	7,624	1,253
Victoria		10,266	11,812	6,585	5,966	5,486	5,096	7,084	10,484	13,210
Saanich	9,593	12,181	14,057	12,697	20,076	13,885	7,677	10,936	8,639	7,994
Juan de Fuca (Part 1)				1,817	796	1,808			711	
Metchosin		998		1,025			1,462	1,582		
North Saanich			834	1,531	791	1,818	4,564	2,061	636	
View Royal		2,971	1,097	344		1,382	871	2,593	1,413	904
Oak Bay	2,143	2,799	486	1,475	2,955	2,041	1,639	1,048	856	2,548
Central Saanich	293	1,293	1,413	1,771	2,457	2,212	2,826	1,460	1,778	1,882
Saltspring Island		959	638	536		718	5,004	2,226		1,554
Southern Gulf Islands						637	3,509	651	1,304	
Esquimalt		882	1,077	2,532	1,393	601	2,337	2,976	3,104	2,631
Sidney		352			477	314	2,052	633	3,339	5,151
CRD Total		**48,313**	**39,861**	**36,031**	**42,671**	**33,238**	**43,246**	**38,373**	**44,515**	**39,229**

Table 3.1. Relationship between population in high risk DAs and proportion of regional population.

Jurisdiction	Proportion of Population in Top Two Deciles	Proportion of capital region's Population	Ratio of High Risk Proportion to Proportion of capital region Population
Sooke	5.1%	4.1%	1.2
Colwood	3.0%	5.2%	0.6
Highlands	0.0%	0.7%	0.0
Juan de Fuca (Part 2)	0.0%	0.1%	0.0
Langford	10.6%	12.7%	0.8
Victoria	28.3%	20.8%	1.4
Saanich	19.9%	32.2%	0.6
Juan de Fuca (Part 1)	0.8%	1.4%	0.6
Metchosin	0.0%	1.4%	0.0
North Saanich	0.8%	3.3%	0.2
View Royal	2.8%	3.2%	0.9
Oak Bay	4.1%	4.9%	0.8
Central Saanich	4.4%	4.8%	0.9
Saltspring Island	1.9%	3.2%	0.6
Southern Gulf Islands	1.6%	1.7%	0.9
Esquimalt	6.8%	4.8%	1.4
Sidney	10.1%	3.4%	3.0

3.1.2. *Concentrations of demographic vulnerability*

When analysed by community, we note that there is significant demographic risk in Victoria, Sidney and Esquimalt (Figures 3.6 and 3.7). This risk is driven by key factors such as family income, renting populations, and the overall age of the population. When considered at a population level, the highest concentration of highly vulnerable populations (per the demographic sub-index) reside in Victoria (67% share of the top two deciles), Saanich (12% of the top two deciles) and Sidney and Oak (Both 6.6%).

However, when using a proportionate share approach, Victoria stands out with a 66% share of the top two deciles compared with a 22.4% share of the capital region's population (resulting in a risk to proportion ratio of 3.0). Key factors that drive vulnerability in Victoria include:

- Percentage of renters in the community (59% community average, 18% model weighting)
- Spending on shelter improvements (windows and doors) (89th lowest percentile in the capital region, 12% model weighting)
- Percentage of the population living alone (28% community average, 12% model weighting)
- Percentage of the population that is 65 years and older (23% community average, 11% model weighting)
- Average number of rooms per dwelling (69th lowest percentile in the capital region, 10% model weighting).

Victoria's risk to proportion ratio is subsequently followed by Sidney (2.2) and Oak Bay (1.5) (Tables 3.2 and 3.3 below). Of note is the Oak Bay finding, which raises questions with regards to demographic risk in affluent areas which could suggest hidden poverty or a significant subset of the population who do not own their homes and potentially live in substandard housing. Accordingly, further investigation into this community is warranted.

Conversely, in West Shore communities such as Colwood, Sooke and Langford, we note no populations in highest deciles of the demographic sub-index which suggests very low risk in these communities overall (at least at the population level, noting the ecological fallacy discussed in the section above).

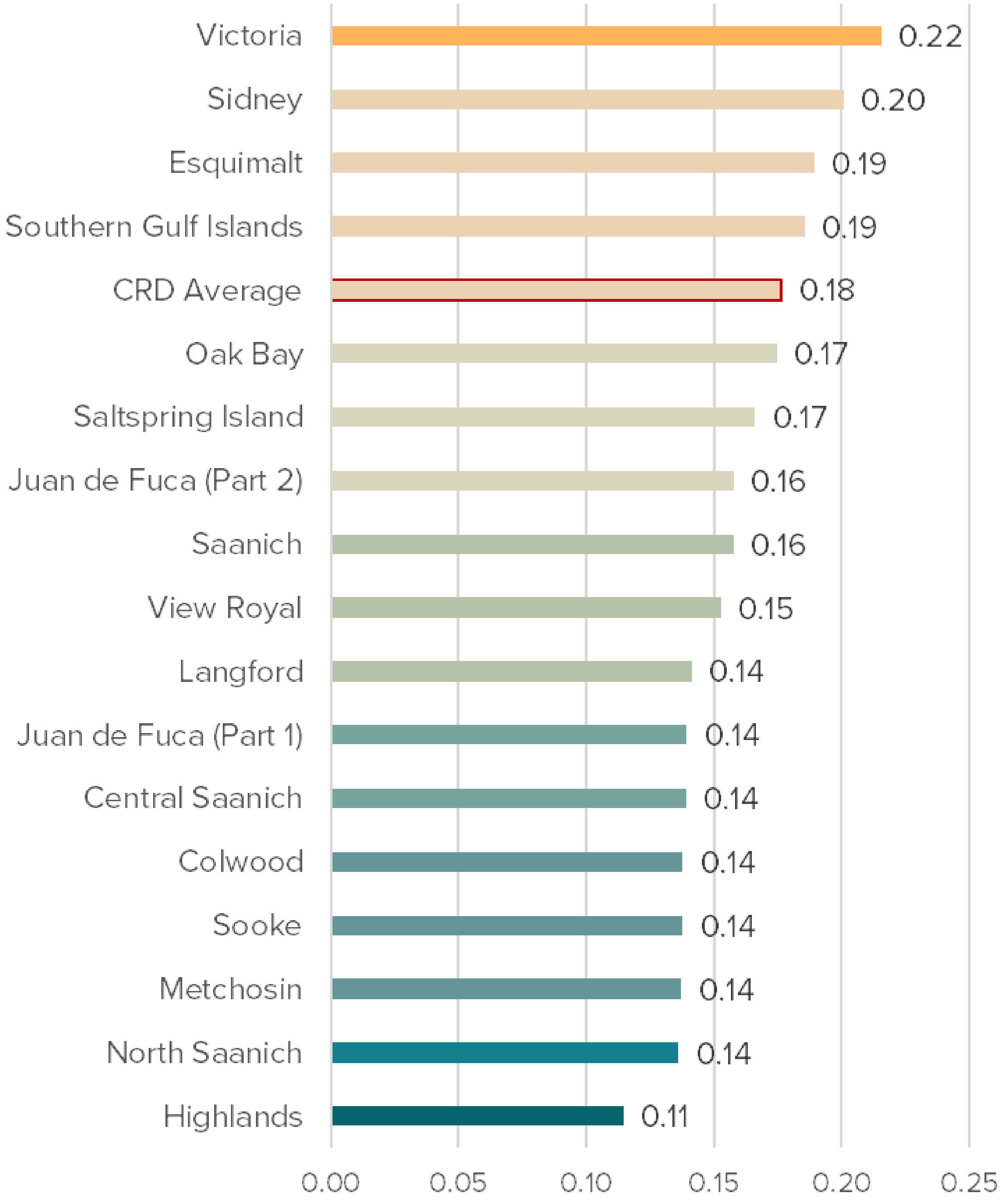

Figure 3.6. Demographic vulnerability by jurisdiction in the capital region (demographic sub-index only).

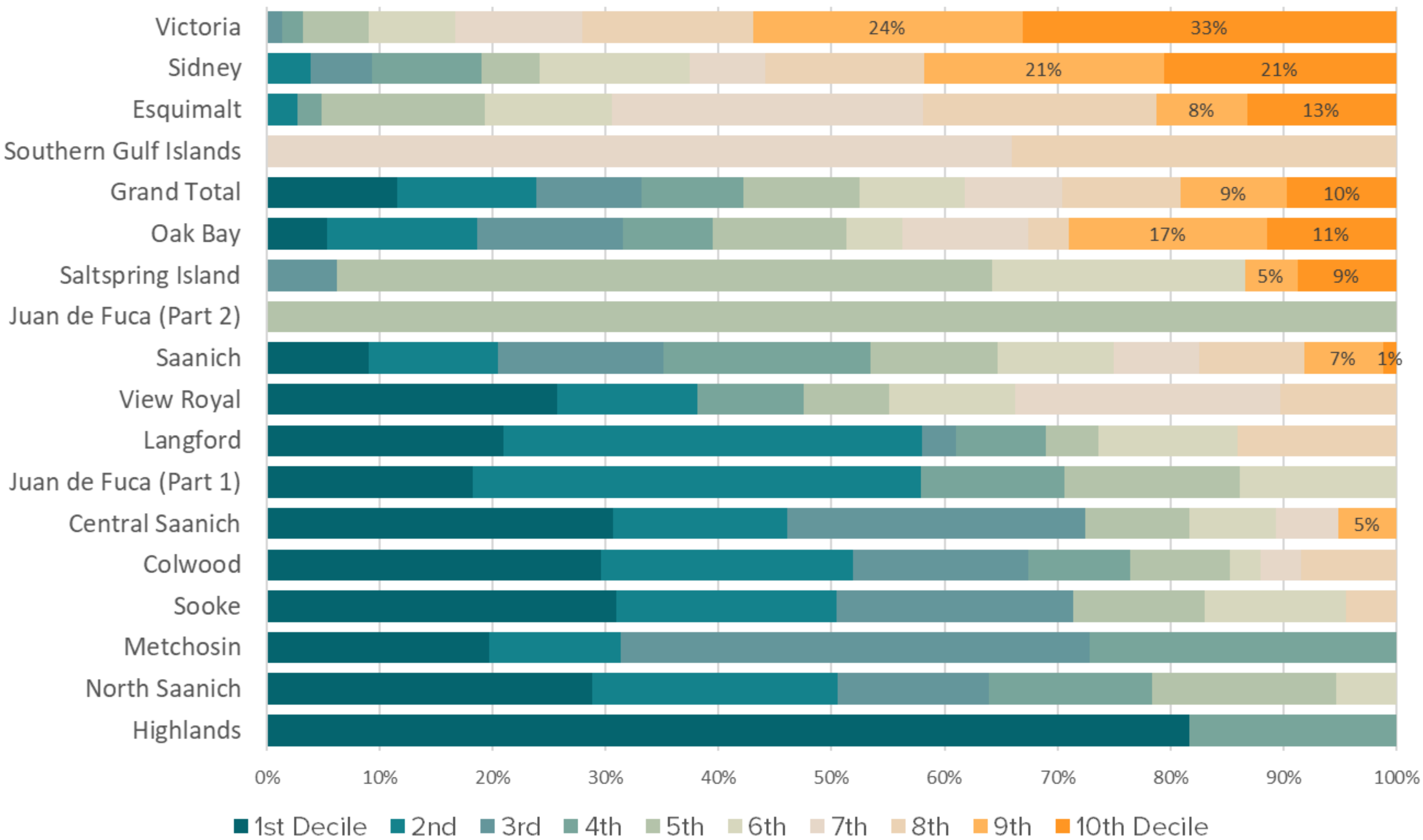

Figure 3.7. Demographic vulnerability (sub-index) by jurisdiction in the capital region, displayed by decile. Victoria, BC, has the largest proportion of its population falling within the most vulnerable decile, while North Saanich and Highlands BC, have 0% of their populations within the most vulnerable decile.

Table 3.2. Population by demographic sub index decile by jurisdiction in the capital region (no health data included).

Jurisdiction	1st Decile	2nd	3rd	4th	5th	6th	7th	8th	9th	10th Decile
Highlands	2,027			455						
North Saanich	3,519	2,668	1,628	1,778	1,990	652				
Metchosin	998	592	2,103	1,374						
Sooke	4,665	2,950	3,149		1,757	1,888		677		
Colwood	5,605	4,228	2,954	1,709	1,674	502	695	1,594		
Central Saanich	5,327	2,679	4,593		1,592	1,338	956		900	
Juan de Fuca (Part 1)		2,037		653	796	711				
Langford		17,239	1,388	3,738	2,127	5,737		6,575		
View Royal	2,971	1,441		1,093	871	1,297	2,709	1,193		
Saanich	10,581	13,472	17,316	21,570	13,282	11,995	9,016	10,891	8,265	1,347
Juan de Fuca (Part 2)					399					
Saltspring Island			718		6,748	2,615			536	1,018
Oak Bay	962	2,392	2,325	1,428	2,132	877	2,006	659	3,144	2,065
Southern Gulf Islands							4,026	2,075		
Esquimalt		477		368	2,537	1,975	4,838	3,621	1,398	2,319
Sidney		477	666	1,199	633	1,636	821	1,735	2,618	2,533
Victoria			1,229	1,707	5,374	6,999	10,342	13,872	21,917	30,427
CRD Total	**47,370**	**50,652**	**38,069**	**37,072**	**41,912**	**38,222**	**35,409**	**42,892**	**38,778**	**39,709**

Table 3.3. Relationship between population in high risk DAs and proportion of capital region population per the demographic sub-index.

Jurisdiction	Proportion of Population in Top Two Deciles	Proportion of capital region's Population	Ratio of High Risk Proportion to Proportion of capital region Population
Highlands	0.0%	0.6%	0.0
North Saanich	0.0%	3.0%	0.0
Metchosin	0.0%	1.2%	0.0
Sooke	0.0%	3.7%	0.0
Colwood	0.0%	4.6%	0.0
Central Saanich	1.1%	4.2%	0.3
Juan de Fuca (Part 1)	0.0%	1.0%	0.0
Langford	0.0%	9.0%	0.0
View Royal	0.0%	2.8%	0.0
Saanich	12.2%	28.7%	0.4
Juan de Fuca (Part 2)	0.0%	0.1%	0.0
Saltspring Island	2.0%	2.8%	0.7
Oak Bay	6.6%	4.4%	1.5
Southern Gulf Islands	0.0%	1.5%	0.0
Esquimalt	4.7%	4.3%	1.1
Sidney	6.6%	3.0%	2.2
Victoria	66.7%	22.4%	3.0

3.1.3. Concentrations of overall socio-demographic vulnerability

When analysed by community, we note a synthesis of patterns as detailed in the subindexes above. Of significance, we observe high index values for Sidney, Esquimalt, the Southern Gulf Island and Victoria. Notably, Victoria's health-related vulnerability is markedly lower compared to demographic factors. Conversely, Sidney is the true hot spot in the region with both high demographic and health sub-index values. (Figures 3.8 and 3.9). Given this prominence, we suggest outreach and proactive engagement in the community as a next step in regional risk reduction.

On a proportional basis, large concentrations of socio-demographic risk are present in both Victoria and Saanich (56% of the share of high risk areas). Notable is the comparatively lower risk profile of Saanich (0.6 ratio of high risk population to share of the capital regions population) in comparison to Victoria (1.7 ratio) (tables 3.4 and 3.5 below).

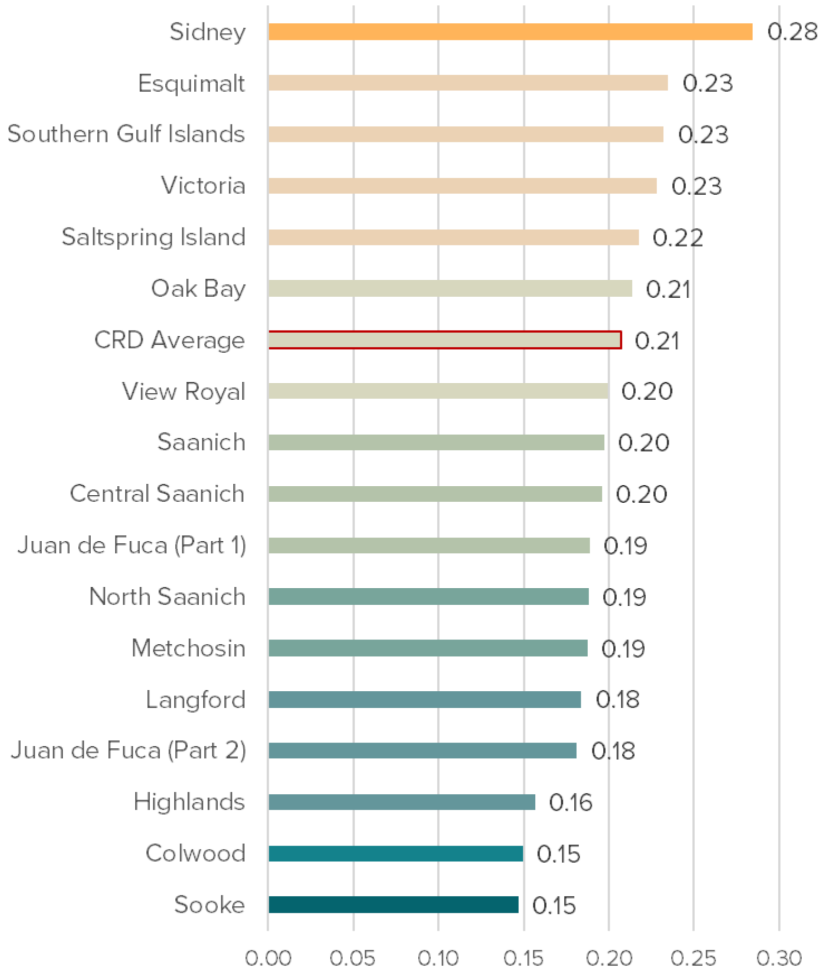

Figure 3.8. Average Socio-demographic vulnerability by jurisdiction in the capital region. Averages are weighted by population

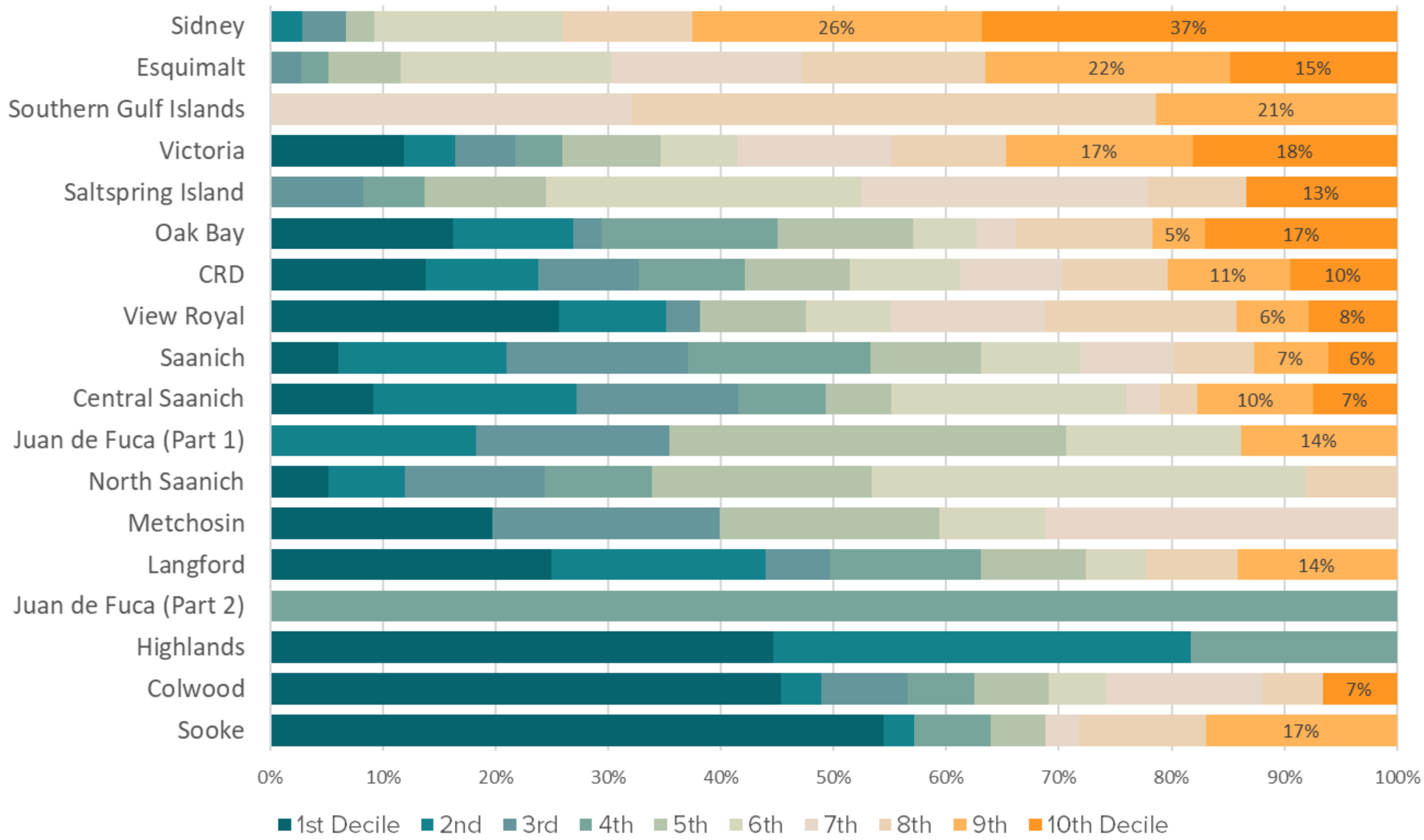

Figure 3.9. Socio-demographic vulnerability by jurisdiction in the capital region. Socio-demographic vulnerability is displayed by decile. Sidney BC, has the largest proportion of its population falling within the most vulnerable decile, while Juan de fuca (part 2) and Highlands BC, have 0% of their populations within the most vulnerable decile.

Table 3.4. Population by combined Socio-demographic Heat Vulnerability Index per jurisdiction in the capital region.

Jurisdiction	1st Decile	2nd	3rd	4th	5th	6th	7th	8th	9th	10th Decile
Sooke		411		1,025	739		449	1,688	2,565	
Colwood		689	1,448	1,112	1,254	985	2,630	1,008		1,245
Highlands	1,109	918		455						
Juan de Fuca (Part 2)				399						
Langford		8,855	2,655	6,270	4,335	2,480		3,802	6,575	
Metchosin	998		1,025		986	476	1,582			
North Saanich	627	834	1,517	1,168	2,383	4,714		992		
Juan de Fuca (Part 1)		935	882		1,808	796			711	
Central Saanich	1,586	3,135	2,506	1,335	1,018	3,629	516	584	1,778	1,298
Saanich	7,112	17,556	19,005	19,023	11,605	10,315	9,877	8,251	7,778	7,213
View Royal	2,971	1,097	344		1,093	871	1,586	1,964	745	904
Oak Bay	2,925	1,907	461	2,807	2,158	1,024	614	2,182	853	3,059
Saltspring Island			959	638	1,254	3,255	2,957	1,018		1,554
Victoria	10,863	4,192	4,942	3,807	7,989	6,312	12,560	9,334	15,204	16,664
Southern Gulf Islands							1,963	2,834	1,304	
Esquimalt			477	426	1,121	3,279	2,964	2,857	3,814	2,595
Sidney		352	477		314	2,052		1,416	3,168	4,539
CRD Total	**56,602**	**40,881**	**36,698**	**38,465**	**38,057**	**40,188**	**37,698**	**37,930**	**44,495**	**39,071**

Table 3.5. Relationship between population in high risk DAs and proportion of capital region population per the combined socio-demographic index.

Jurisdiction	Proportion of capital region Population in Top Two Deciles	Proportion of capital region's Population	Ratio of High Risk Proportion to Proportion of capital region Population
Sooke	3.1%	1.7%	1.8
Colwood	1.5%	2.5%	0.6
Highlands	0.0%	0.6%	0.0
Juan de Fuca (Part 2)	0.0%	0.1%	0.0
Langford	7.9%	8.5%	0.9
Metchosin	0.0%	1.2%	0.0
North Saanich	0.0%	3.0%	0.0
Juan de Fuca (Part 1)	0.9%	1.3%	0.7
Central Saanich	3.7%	4.2%	0.9
Saanich	17.9%	28.7%	0.6
View Royal	2.0%	2.8%	0.7
Oak Bay	4.7%	4.4%	1.1
Saltspring Island	1.9%	2.8%	0.7
Victoria	38.1%	22.4%	1.7
Southern Gulf Islands	1.6%	1.5%	1.0
Esquimalt	7.7%	4.3%	1.8
Sidney	9.2%	3.0%	3.1

3.1.4. *Validation of the socio-demographic vulnerability index*

Validation is a critical step in the process of the index creation and occurred in the development of this index in multiple forms:

- Validation with AHP workshop participants.
  The initial validation process of the socio-demographic vulnerability index was conducted in a workshop setting with participants of the aforementioned AHP workshop. This workshop served as a platform for AHP participants to provide feedback on their assessment of the index performance as based on their expertise.
- Correlation analysis with extreme heat related mortality and hospitalisation observations.
  The index was shared with Island Health Authority, who conducted a correlation assessment with confidential extreme heat related mortality and hospitalisation data that was observed from 2018 to 2023. This rigorous validation exercise allows the validation of the socio-demographic vulnerability index to be supported by statistical assessments of its effectiveness in predicting vulnerable populations across the Capital Region.
- To increase the sample size of mortality and morbidity data to validate against, we created a Vancouver Island-wide socio-demographic index for Island Health to analyse.

During the validation exercise, the socio-demographic index was disaggregated into two sub-indices: demographic sub-index (i.e. health data absent), and health-only sub-index. The validation results revealed different levels of correlations between the mortality and hospitalisation data and the socio-demographic index and sub-indices.

- The health-only demographic vulnerability sub-index showed a correlation coefficient (R^2) of 0.808 with Island Health data, indicating a strong relationship (Figure 2.1).
- The demographic-only vulnerability sub-index had a lower, but still significant, correlation coefficient of 0.66 (Figure 2.2).
- When considering the full Socio-demographic Vulnerability Index, which combines both health and demographic data, the correlation was very strong, with an R^2 value of 0.955 (Figure 2.3).

These findings suggest that the areas with fewer heat-related deaths in the Capital Regional align with lower vulnerability scores on the index, whereas areas with higher heat-related death incidences show higher vulnerability. This strong correlation confirms the performance of the AHP-derived socio-demographic vulnerability index. An important observation from this validation process is that the combined use of both health and demographic sub-indices leads to a very effective assessment tool. This approach is somewhat unique, as it considers both health determinants (demographics) and population-level health data in developing risk profiles for climate-related risks. This comprehensive approach reflects a more holistic understanding of the factors contributing to vulnerability in the context of climate change and extreme heat events.

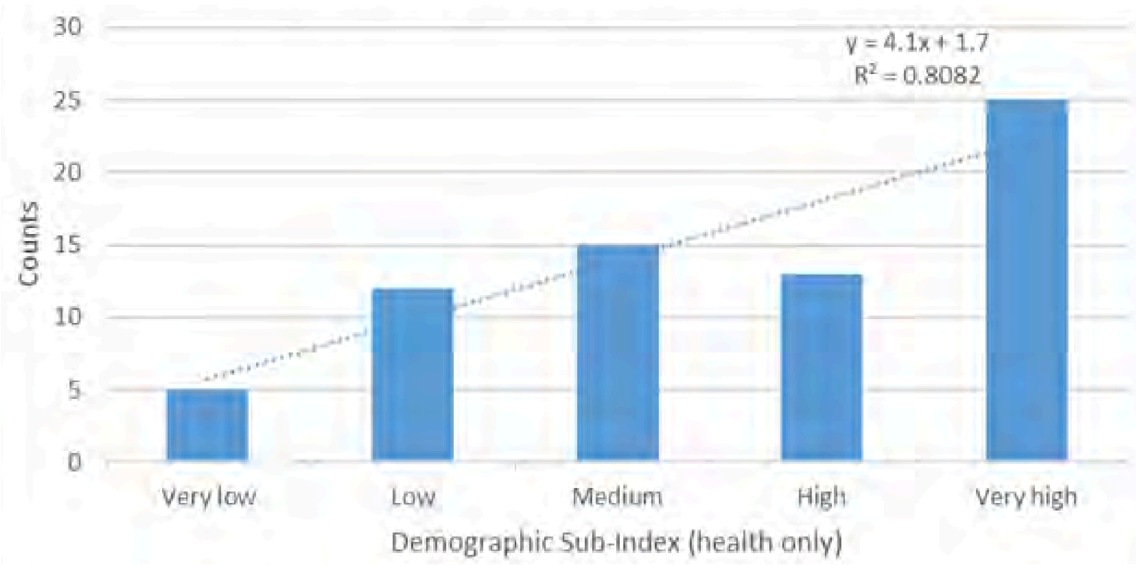

Figure 3.10. The demographic vulnerability sub-index (health data only) plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2018 - 2023) on the y-axis. A strong correlation (R^2 value of 0.8) exists between heat related mortality and morbidity and where the demographic index predicts vulnerability.[63]

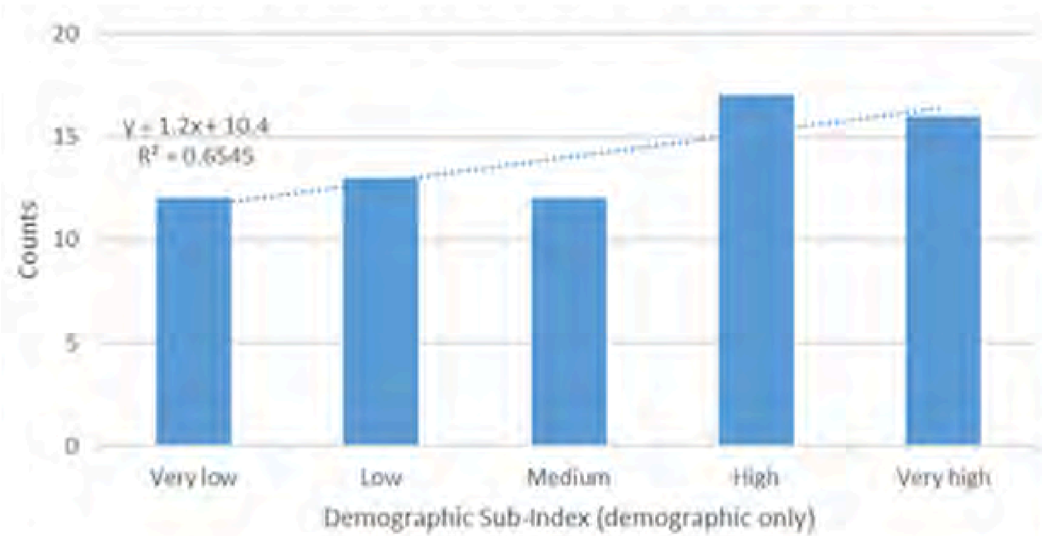

Figure 3.11. The demographic vulnerability sub-index (demographic data only) plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2018 - 2023) on the y-axis. A positive linear relationship, evidenced by an R^2 value of 0.65, is observed between the demographic-only vulnerability sub-index and the counts of heat-related mortality and morbidity outcomes

[63]Note that the demographic-related graphs (figure 2.1 -2.4) are generated by Island Health which is why there is a discrepancy on titles and this will be changed for the final draft.

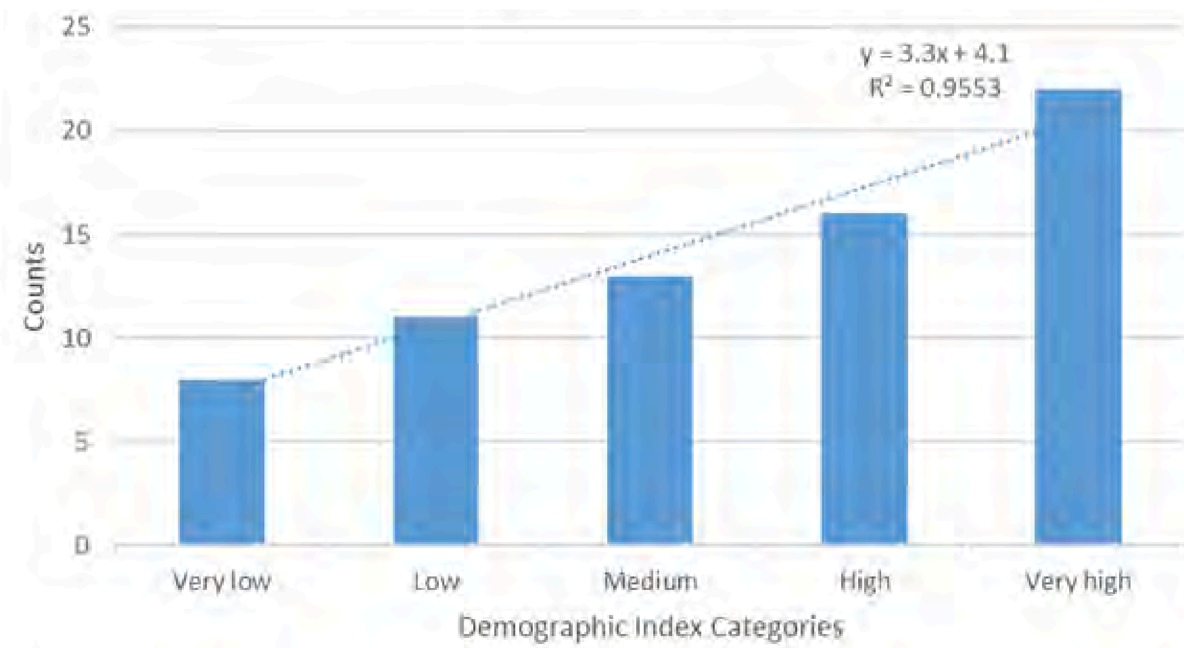

Figure 3.12. Socio-demographic vulnerability plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2018 - 2023) on the y-axis. A strong correlation is present between where heat related health outcomes occurred and where the Socio-demographic Index predicts higher vulnerability.

To increase the sample size of heat related mortality and morbidity validation data points, we created the same Socio-demographic Index for all of Vancouver Island. Island Health validated this larger pool of data and found a 0.87 r2 value, which further confirms the Socio-demographic Vulnerability Index's validity within the CRD and for Vancouver Island as a whole (Figure 2.4). For further visualisation of this index, see the map figure B5 in appendix B.

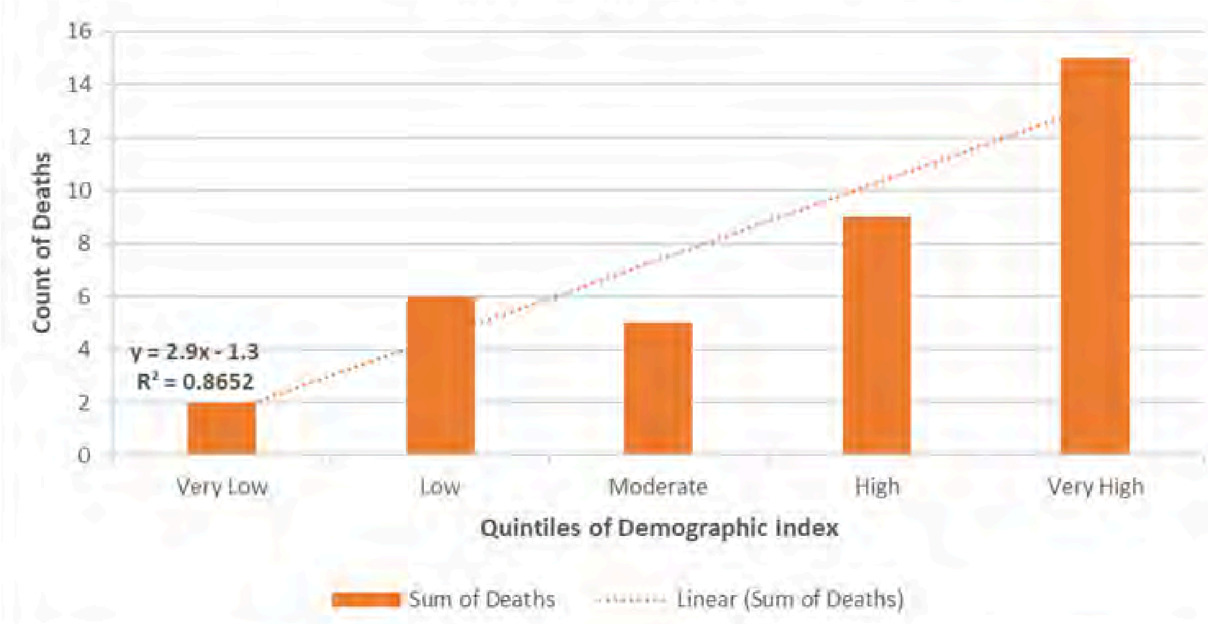

Figure 3.13. Vancouver Island Socio-demographic vulnerability plotted on the x-axis against the counts of heat-related mortality and morbidity outcomes (2021) on the y-axis.

3.2. *Heat Exposure Layer*

The distribution of predicted air temperature during the 2021 heat event is shown in Figure 3.0. The range in air temperatures that are observed in this model output are 23.8 to 39.8 °C. In this figure, the distribution of air temperature during the extreme heat event is evident. Warmer temperatures are mostly concentrated away from the coastline, which suggests that maritime cooling is a significant contributor to mitigating extreme levels of air temperature. Localised climatic variations of air temperature are also evident in urbanised areas (as shown in Figure 3.0 inset maps). Urban structures and surfaces in Victoria, Saanich, and Langford contribute to warmer temperatures. Coastal urban areas such as North Saanich and Sidney benefit from a high density of coastline that helps reduce temperature. Elevation and solar insolation are strong predictors of air temperature in this model, and as such higher, south facing areas appear as relatively warmer than lower elevation, north facing areas. Langford is identified as a higher risk area given its characteristics of being south facing, higher elevation, relative further from the coast, and having land cover characteristics that contribute significantly to higher land surface temperatures.

Note that the decision to represent heat exposure in Celsius rather than using an index distribution, as established in the two other mapping elements, serves to provide a more direct and tangible depiction of how temperatures are experienced during an extreme heat event. Unlike the socio-demographic and building indices that define the maximum value as "high vulnerability," using Celsius avoids imposing an artificial scale. Extreme heat vulnerability does not have a single universal or even Provincial threshold, as it can vary based on local climatic conditions and societal factors. Therefore, presenting the data in Celsius allows for a more flexible and context-specific assessment. Expressing heat exposure in Celsius also allows stakeholders and the general public to easily understand the magnitude of temperatures.

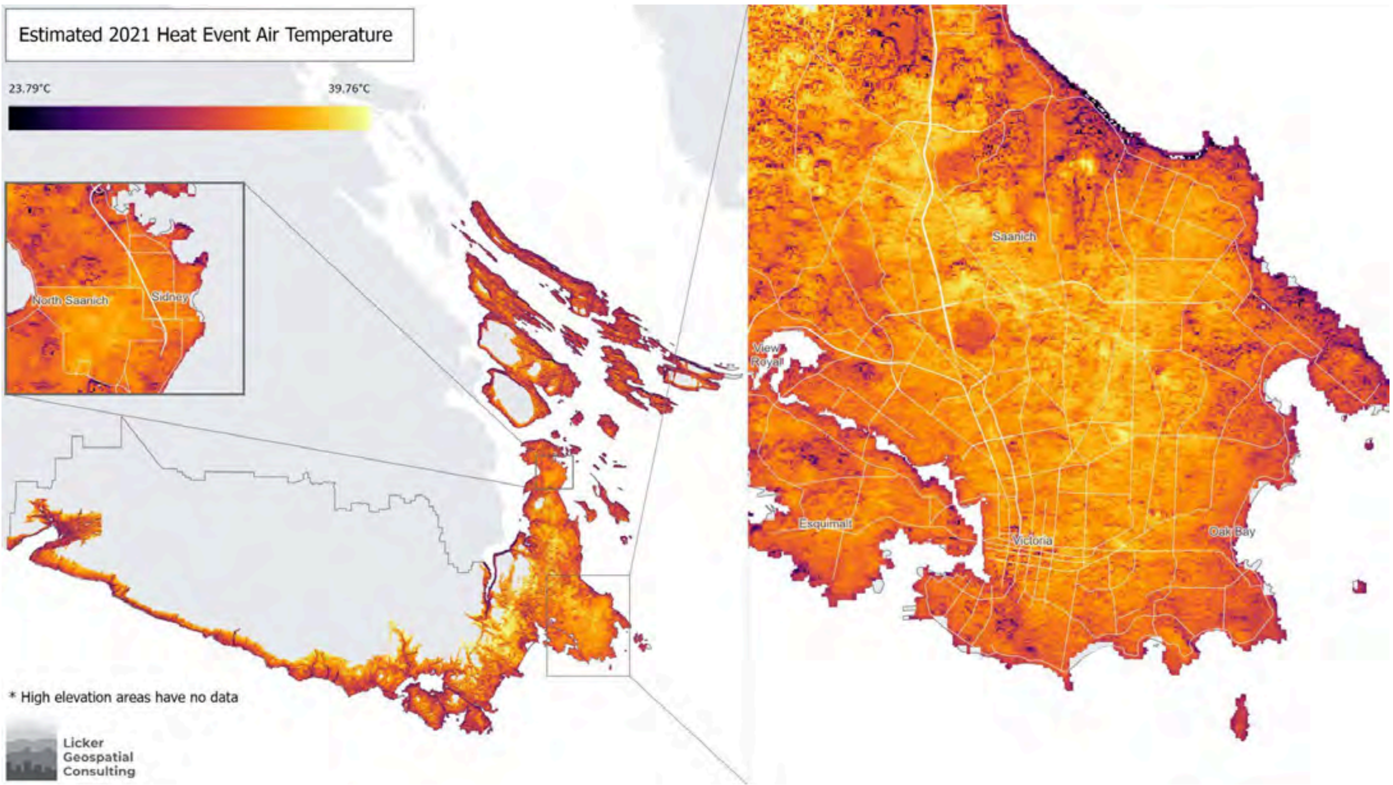

Figure 3.14. Predicted air temperature using a linear regression analysis of elevation, distance to coast, solar radiation, and land surface temperature.

3.2.1. Land Surface Temperature and Comparative Analysis

The distribution of land surface temperature (LST) during the 2021 heat event is shown in layer throughout the regional district. The LST layer considers environmental factors such as natural vegetation that support localised dissipation of heat and impervious material (such as concrete and asphalt) that support greater heat absorption and retention and has range of 18.7 to 36 °C (Figure 3.15).

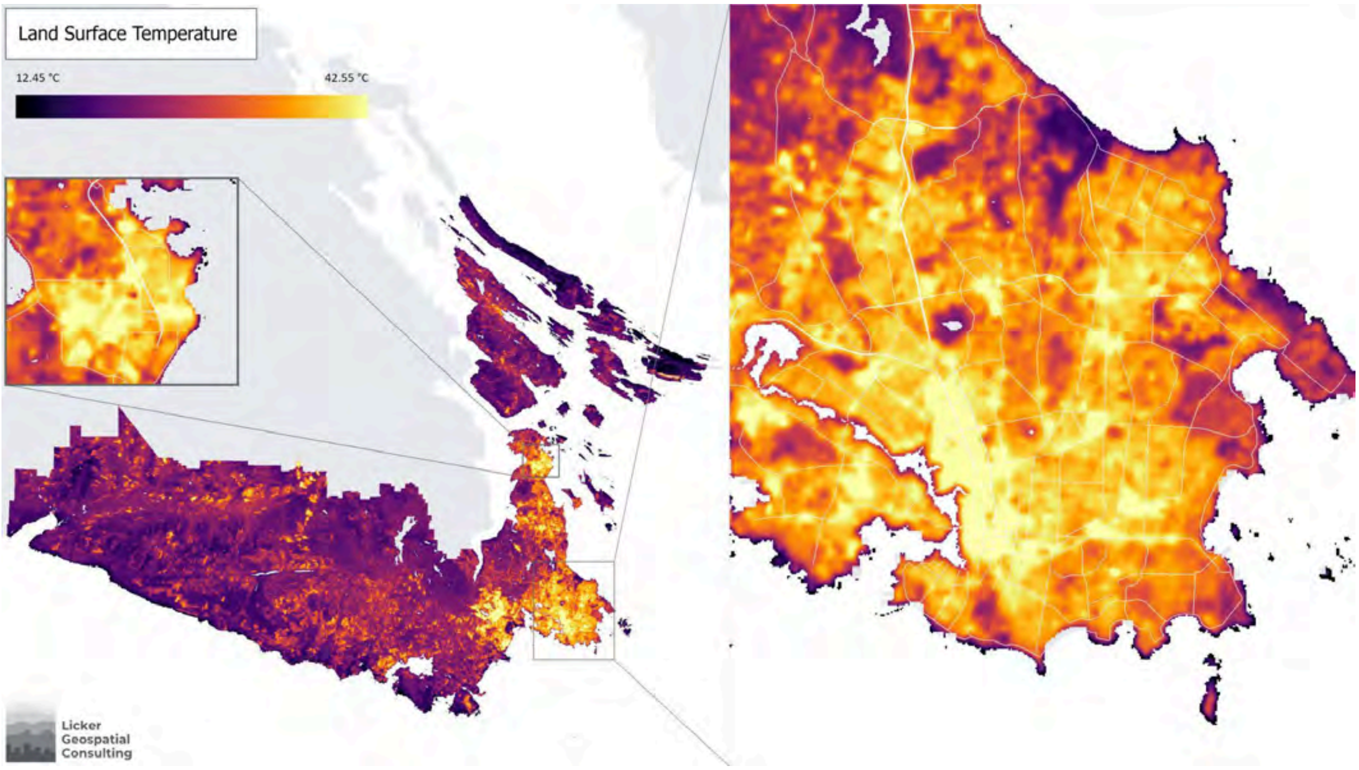

Figure 3.15. Land surface temperature (LST) in °C during the 2021 heat event, as calculated from the Landsat-8 satellite constellation and visualised at a 30 m^2 resolution.

While LST does show general distribution of heat throughout the region, it is not representative of the human experience and discomfort to extreme heat. Indeed, LST is closely associated with land cover, such as urban areas ("urban heat islands"), forestry cut-blocks, and vegetation. Air temperature and LST display different relationships of heat distribution across the capital regional district. While both are within a similar magnitude of temperature, the distribution of differences between these two layers provide a nuanced understanding of the region's effects on how temperature is absorbed, stored, and dissipated across the region (Figure 3.15).

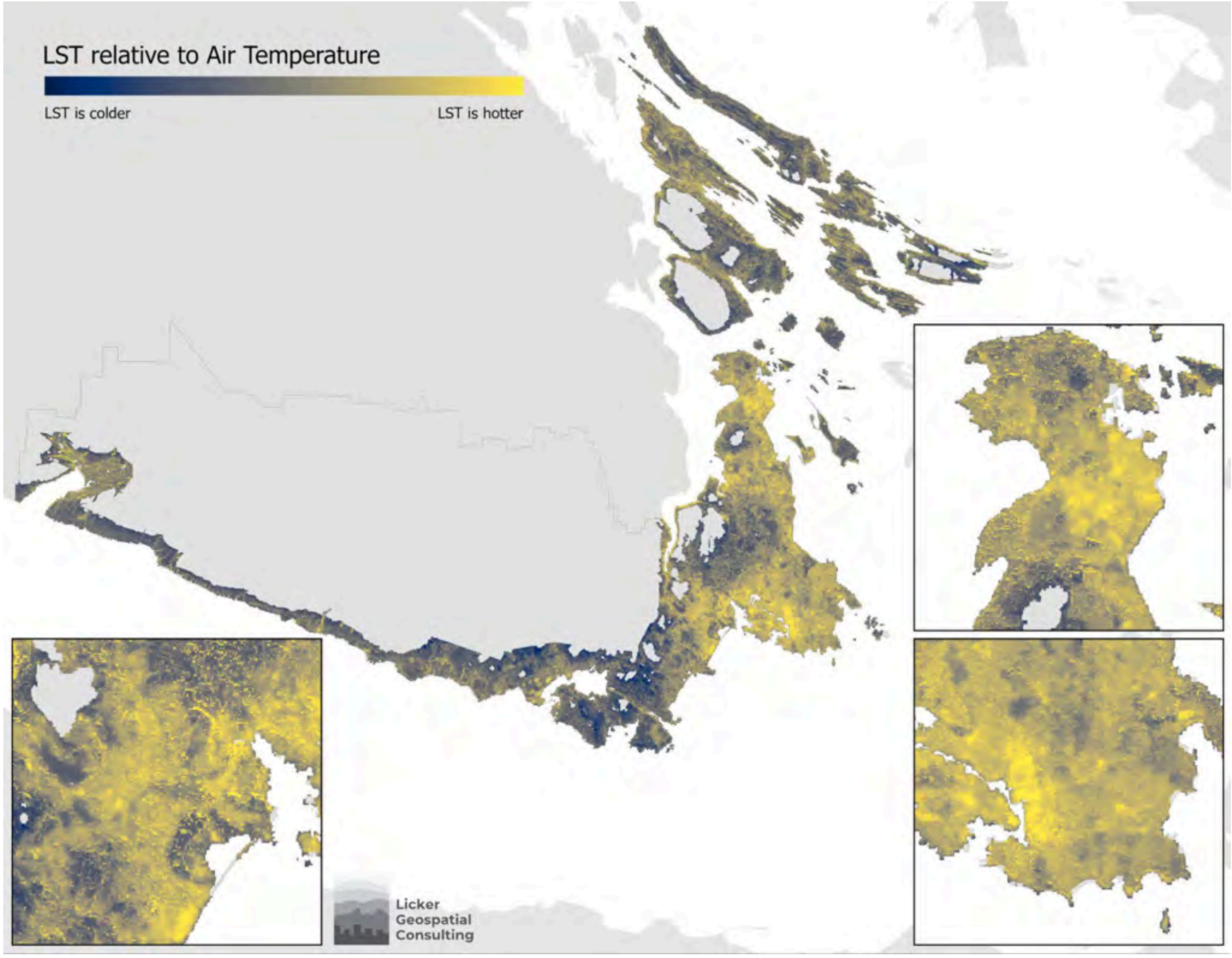

Figure 3.16. Relative difference between LST and air temperature. Blue areas indicate where air temperature is warmer than LST, yellow areas indicate where LST is warmer than air temperature. The range of temperature difference between these two models is -20.1 to 14.6 °C.

Figure 3.16 shows the temperature differences of LST relative to air temperature. Blue areas indicate where air temperature is warmer than LST, yellow areas indicate where LST is warmer than air temperature. The range of temperature difference of LST relative to air temperature is -20.1 to 14.6 °C. Areas in muted grey tones show where LST and air temperature are relatively similar. Not included in this assessment are areas beyond the lidar extent (namely most of the Electoral Area), and high elevations, given that predicted air temperature values are absent in these areas.

Evident in Figure 3.16 is the effect of coastal impacts on air temperature, wherein we see lower predicted air temperatures than observed land surface temperatures. Urban heat islands are also seen to be more clearly delineated in the LST layer. These urban heat islands appear so distinctly in the LST given the absorbing characteristics of roads and rooftops. While the air temperature also considers land cover and evapotranspiration, which correlate with urban heat islands, they are less impactful in the output prediction and thereby mute the effect of urban heat islands temperatures as measured on the surface.

3.3. Building Vulnerability Index findings

Using similar analytical lenses to those discussed in the socio-demographic section above, we can decompose risk factors by community or jurisdiction to understand overall heat risk in residential buildings (Figures 3.19, 3.20 and Tables 3.6, 3.7). Of note are the high concentrations of building risk in Victoria, Esquimalt and Oak Bay which consists of high volumes of older, taller buildings with some degree of prominence. As with the demographic sub-index above, West shore communities exhibit considerably lower risk than capital region core communities due to new construction, greater canopy retention and generally lower densities than the regional average. With the buildings index consisting of various vulnerability metrics, we can also see how the breakdown of each component contributes to the overall vulnerability of buildings at the jurisdictional level (refer to Figures 3.15 - 3.18). As noted in the validation section above, additional care should be taken when reviewing building index results as aggregate building information may misrepresent individual structural risk in some communities.

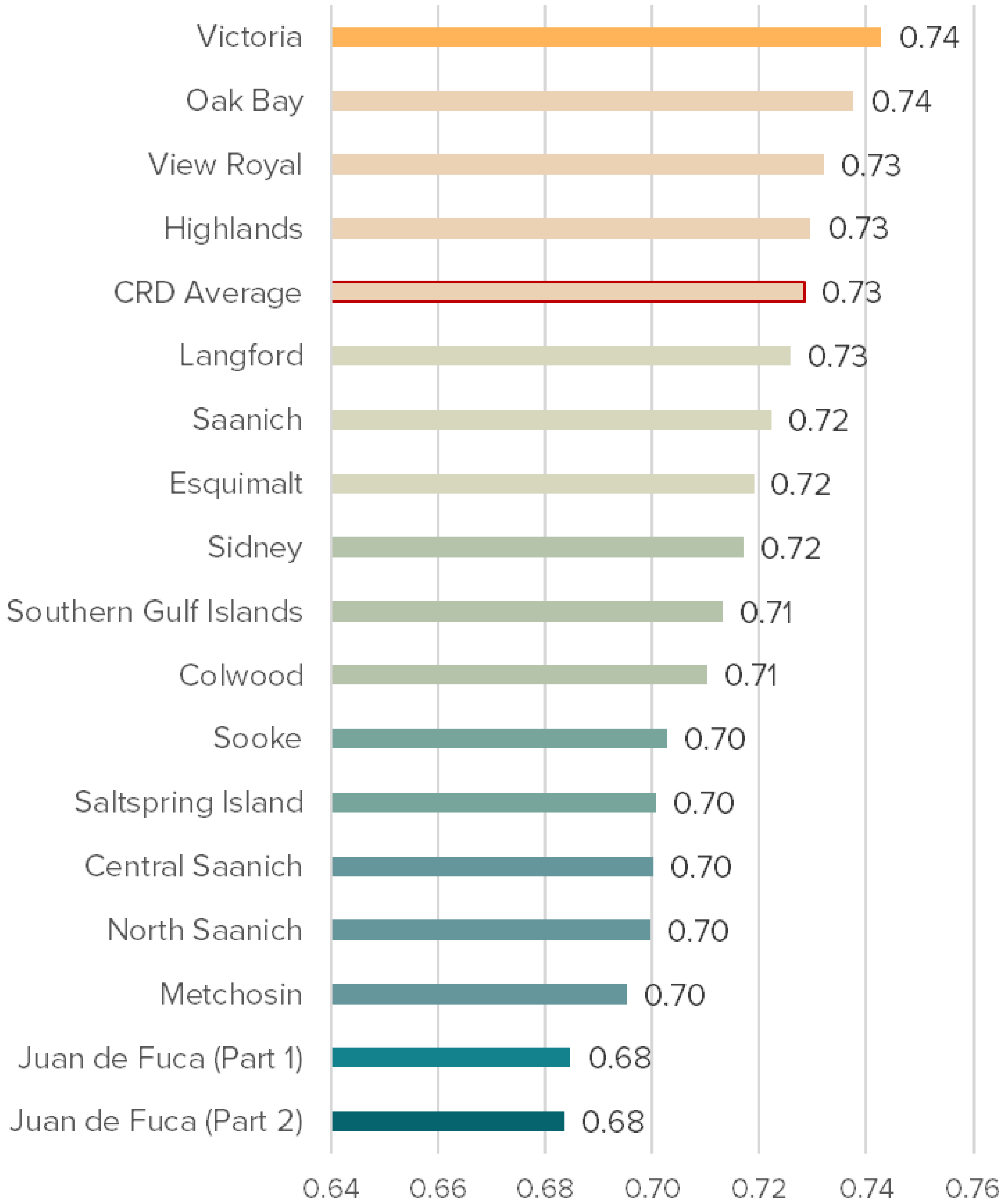

Figure 3.15. Average building albedo by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

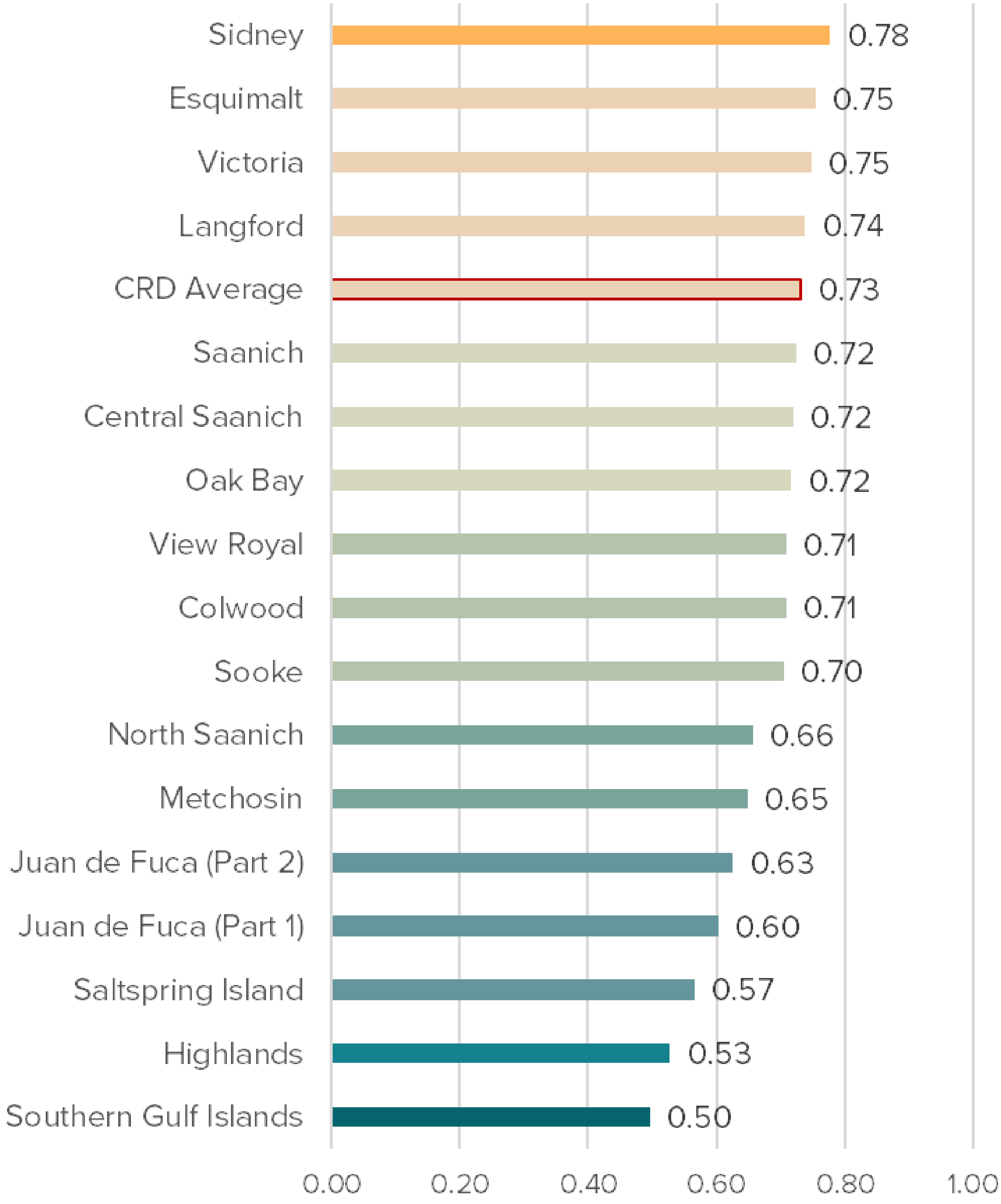

Figure 3.16. Average solar insolation index by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

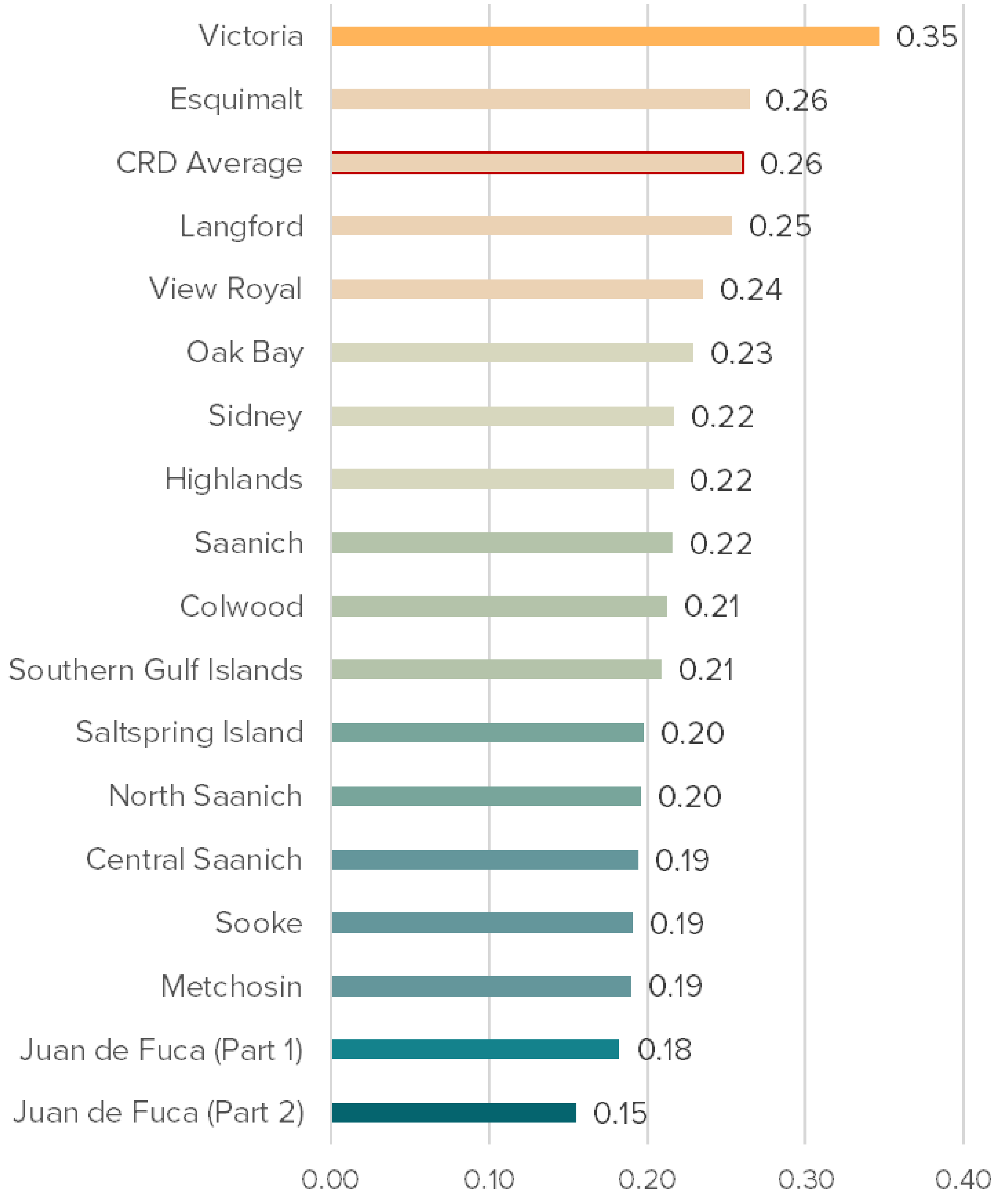

Figure 3.17. Average building height index by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

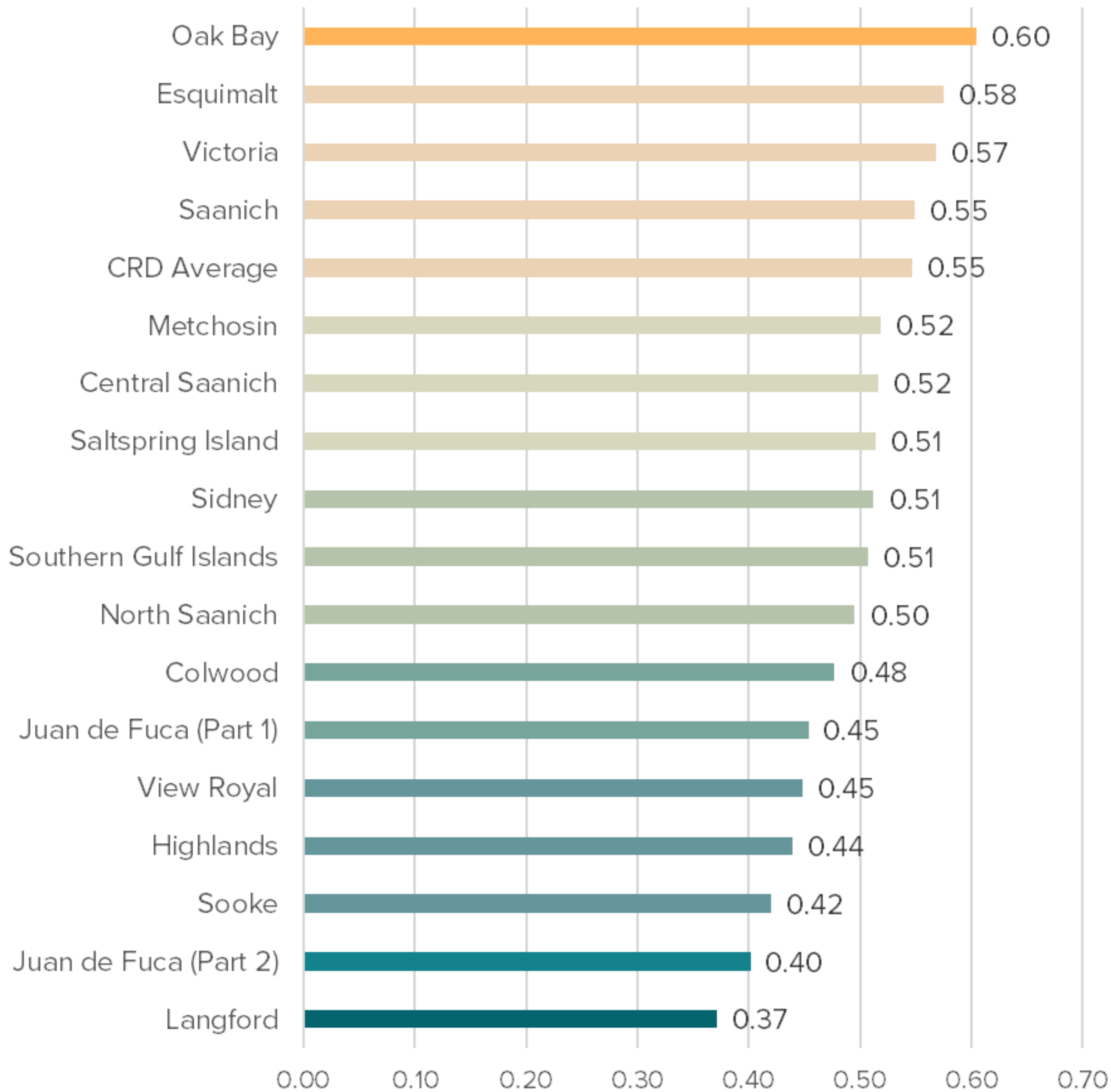

Figure 3.18. Average building age index by jurisdiction in the capital region, for all buildings. Averages are weighted by the assumed interior floor area of buildings per DA.

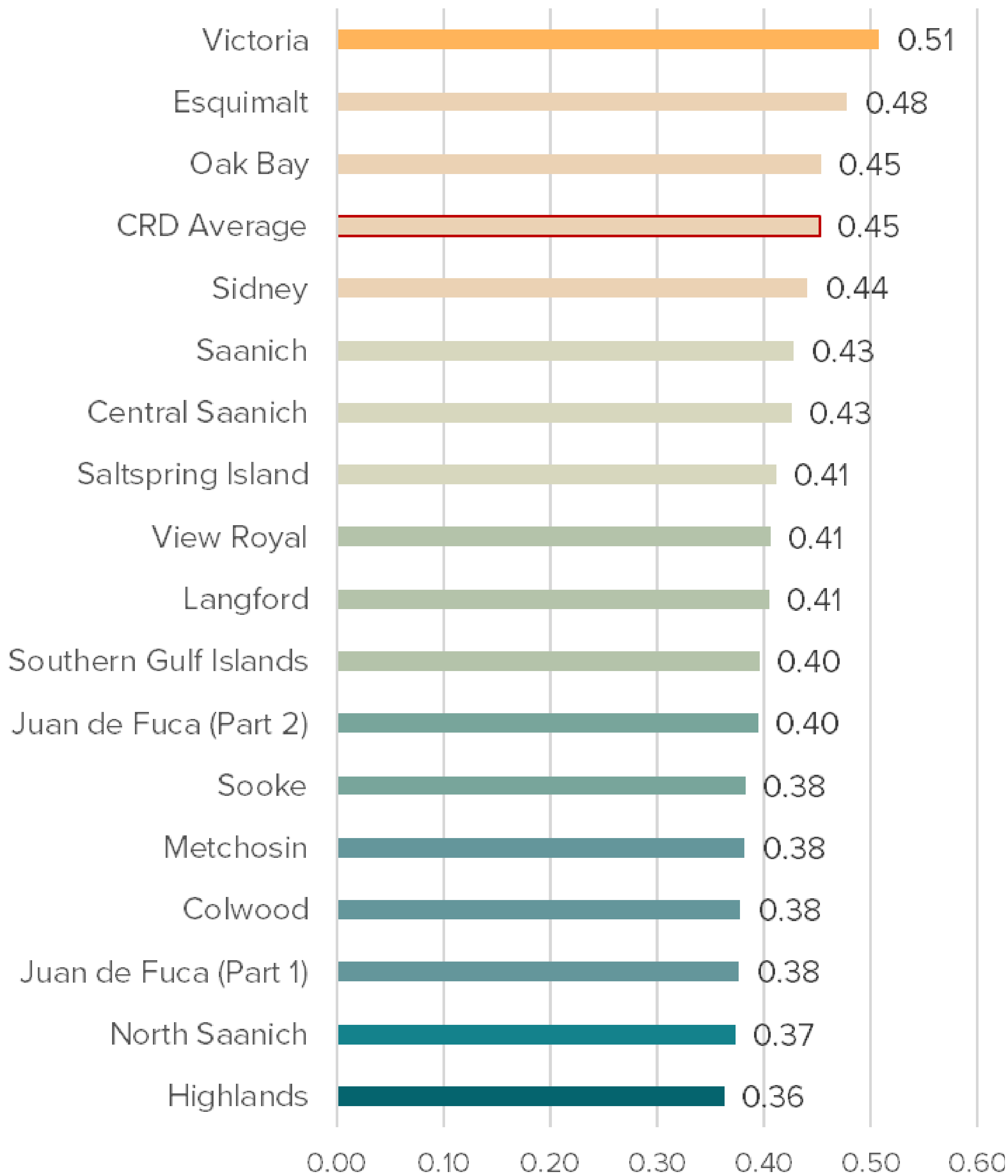

Figure 3.19. Average Building Vulnerability Index by jurisdiction in the capital region, for residential buildings only. Averages are weighted by the assumed interior floor area of buildings per DA.

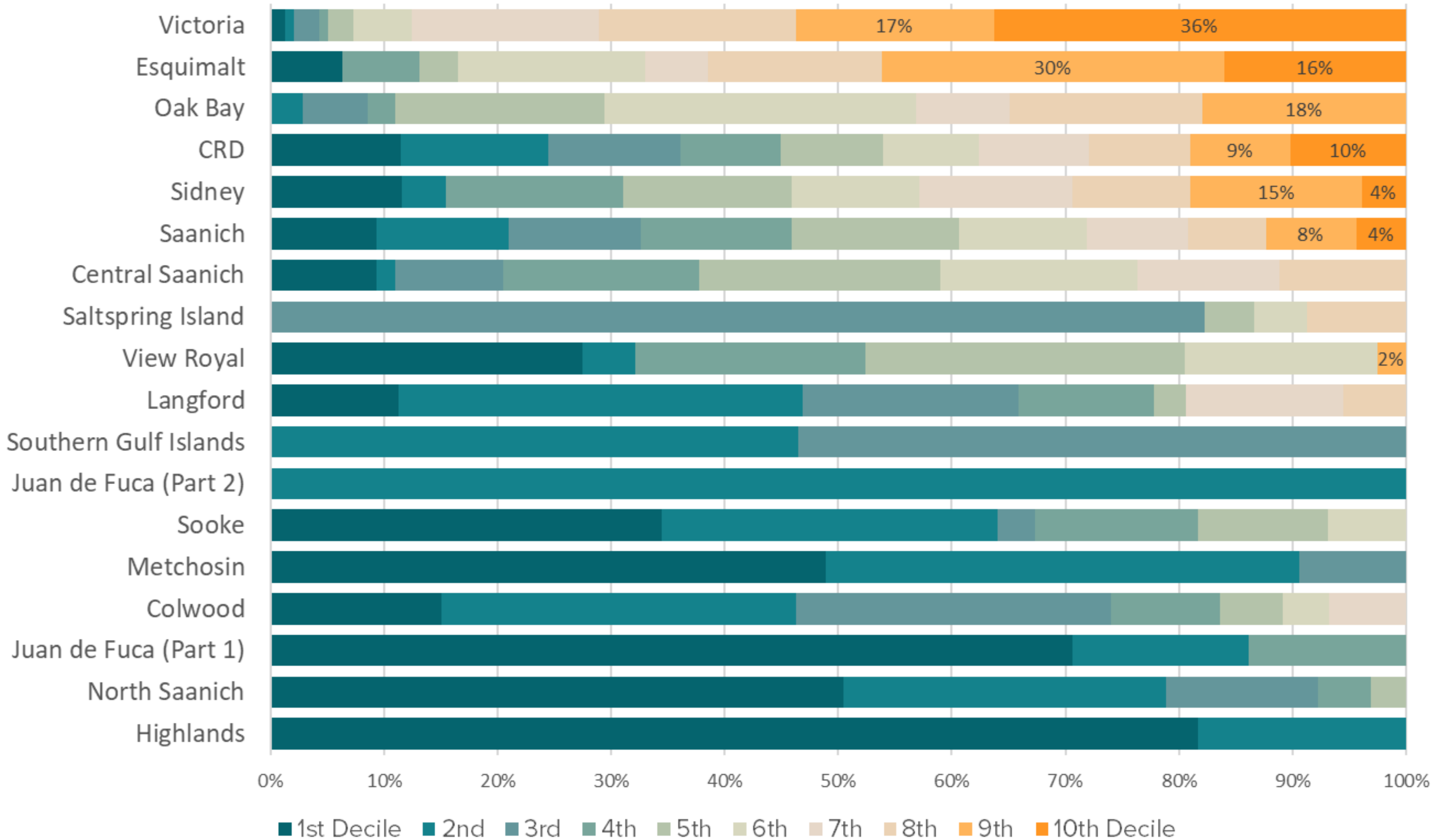

Figure 3.20. Residential building vulnerability by jurisdiction in the capital region, displayed by decile. Victoria, BC, has the largest proportion of its population falling within the most vulnerable decile, while North Saanich and Highlands BC, have 0% of their populations within the most vulnerable decile.

Table 3.6. Population by Residential Buildings Heat Vulnerability Index per jurisdiction in the capital region.

Jurisdiction	1st Decile	2nd	3rd	4th	5th	6th	7th	8th	9th	10th Decile
Highlands	2,027	455								
North Saanich	6,171	3,484	1,627	576	377					
Juan de Fuca (Part 1)	3,625	796		711						
Colwood	2,749	5,711	5,056	1,766	1,008	731	1,245			
Metchosin	2,476	2,115	476							
Sooke	5,203	4,457	502	2,155	1,738	1,031				
Juan de Fuca (Part 2)		399								
Southern Gulf Islands		2,834	3,267							
Langford	5,255	16,568	8,876	5,542	1,322		6,460	2,561		
View Royal	3,181	535		2,345	3,261	1,964			289	
Saltspring Island			9,570		511	536		1,018		
Central Saanich	1,623	293	1,652	2,987	3,708	3,005	2,179	1,938		
Saanich	11,033	13,662	13,723	15,646	17,294	13,282	10,487	8,116	9,344	5,148
Sidney	1,428	471		1,927	1,832	1,376	1,664	1,284	1,861	475
Oak Bay		508	1,030	432	3,324	4,933	1,480	3,053	3,230	
Esquimalt	1,114			1,190	592	2,890	976	2,678	5,297	2,796
Victoria	1,207	671	2,087	656	2,060	4,727	15,131	15,979	16,022	33,327
CRD Total	**47,092**	**52,959**	**47,866**	**35,933**	**37,027**	**34,475**	**39,622**	**36,627**	**36,043**	**41,746**

Table 3.7. Relationship between population in high risk DAs and proportion of capital region population per the residential buildings index

Jurisdiction	Proportion of capital region Population in Top Two Deciles	Proportion of capital region's Population	Ratio of High Risk Proportion to Proportion of capital region Population
Highlands	0.0%	0.6%	0.0
North Saanich	0.0%	3.0%	0.0
Juan de Fuca (Part 1)	0.0%	1.3%	0.0
Colwood	0.0%	4.5%	0.0
Metchosin	0.0%	1.2%	0.0
Sooke	0.0%	3.7%	0.0
Juan de Fuca (Part 2)	0.0%	0.1%	0.0
Southern Gulf Islands	0.0%	1.5%	0.0
Langford	0.0%	11.4%	0.0
View Royal	0.4%	2.8%	0.1
Saltspring Island	0.0%	2.8%	0.0
Central Saanich	0.0%	4.2%	0.0
Saanich	18.6%	28.8%	0.6
Sidney	3.0%	3.0%	1.0
Oak Bay	4.2%	4.4%	0.9
Esquimalt	10.4%	4.3%	2.4
Victoria	63.4%	22.4%	2.8

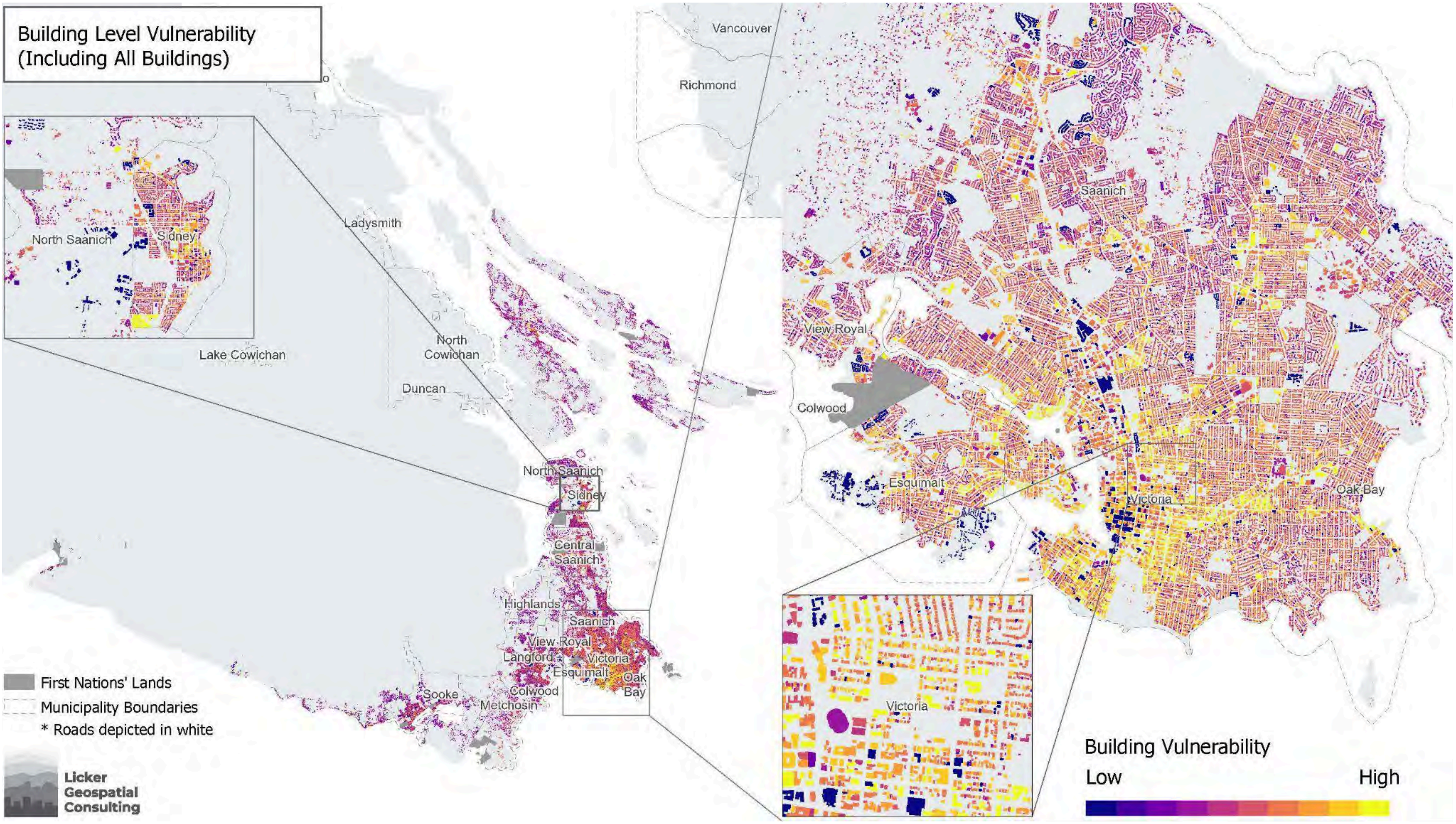

Figure 3.21. Extreme Heat - Building Vulnerability Index with all buildings included by building footprint.

3.3.1. Validation of the building vulnerability index

Much like the socio-demographic index validation, the buildings index went through a validation process to ensure empirical accuracy in estimating the risk associated with extreme heat for different buildings throughout the Capital Region. The buildings index validation process involved conducting a statistical analysis to inform the correlation between the index and historical health outcomes related to extreme heat. This analysis utilises morbidity and mortality data from 2018 to 2023[64], thereby providing a quantitative measurement of the index's predictive potential. The buildings index was disaggregated into two sub-indices that measure building vulnerability for residential and non-residential buildings.

- For non-residential buildings the index showed a moderate correlation, with an R^2 of 0.56, indicating some level of predictability (Figure 2.10).
- For residential buildings the index showed a stronger correlation, with an R^2 of 0.58 that suggests a higher degree of predictive accuracy (Figure 2.11).
- For all buildings (i.e. the complete Building Vulnerability Index), there is a weaker correlation with an R^2 value of 0.12 (Figure 2.12), suggesting a more complex relationship of factors that influence risk in broader buildings context.

The outcomes of this validation exercise support the index's application in regional planning and health strategy formulation. They reflect the nuanced application of the index, which exhibits varying levels of predictability across different building types. These findings underscore the necessity for a nuanced application of the index in planning and risk reduction strategies.

[64] Island Health used heat related morbidity and mortality data from 2018 - 2021 to ensure a large enough sample size in data points given that there were 9 deaths within the capital region during the 2021 heat-event.

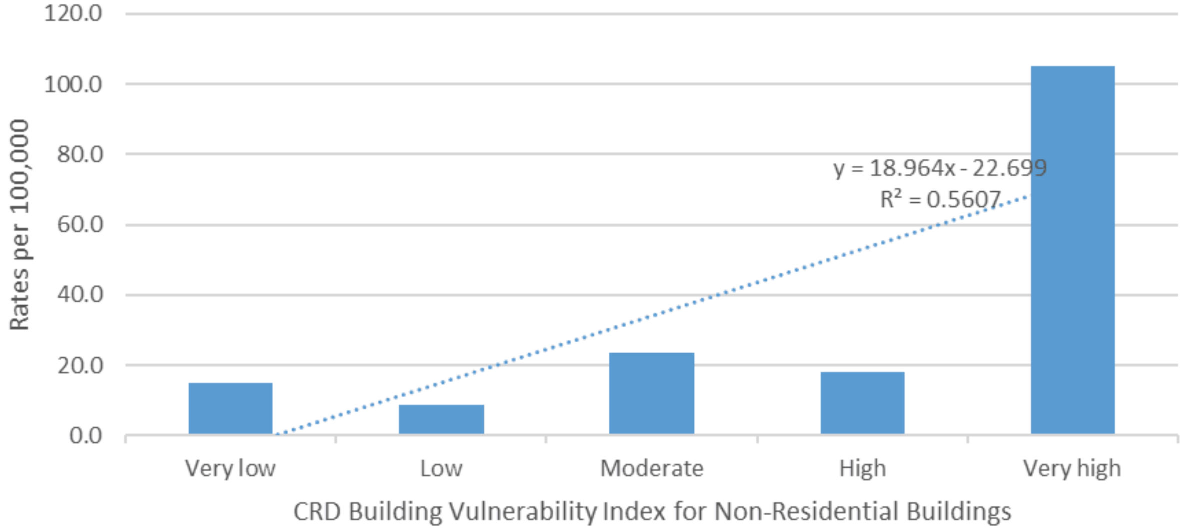

Figure 3.22. Correlation between capital region Building Vulnerability Index for Non-Residential Buildings and Heat-Related Health Outcomes (2018-2023). The bar chart depicts an ascending trend in health outcome rates per 100,000 as the vulnerability index increases from 'Very low' to 'Very high', with a trend line indicating a moderate correlation ($R^2 = 0.5607$).

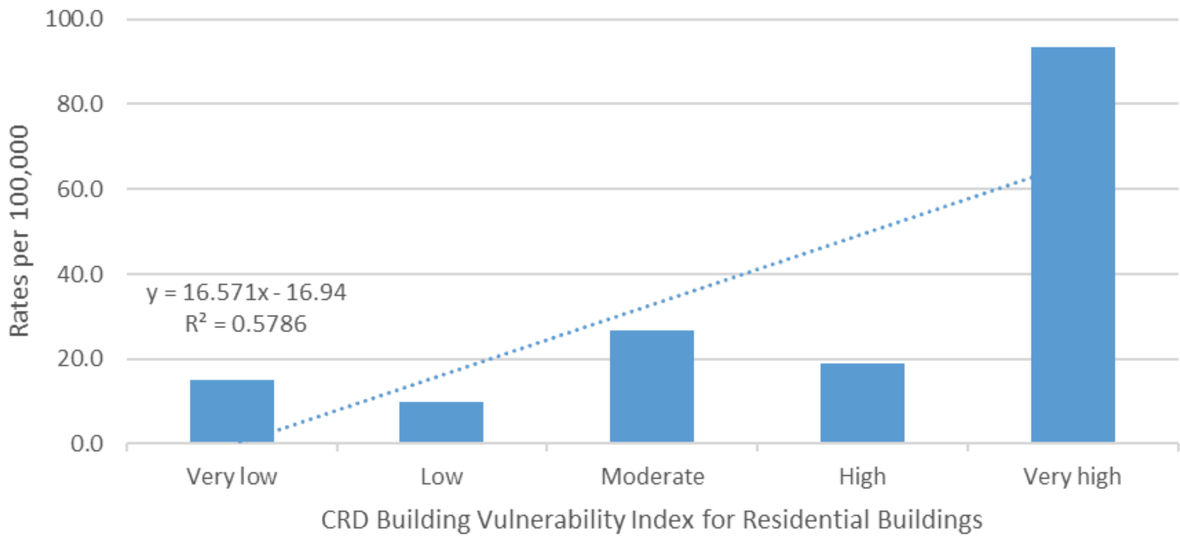

Figure 3.23. Relationship between capital region Building Vulnerability Index for Residential Buildings and Heat-Related Health Outcomes (2018-2023). This bar chart illustrates a clear upward trend in health outcome rates per 100,000 with increasing vulnerability index levels, with a stronger correlation evident for the 'Very high' vulnerability category ($R^2 = 0.5786$).

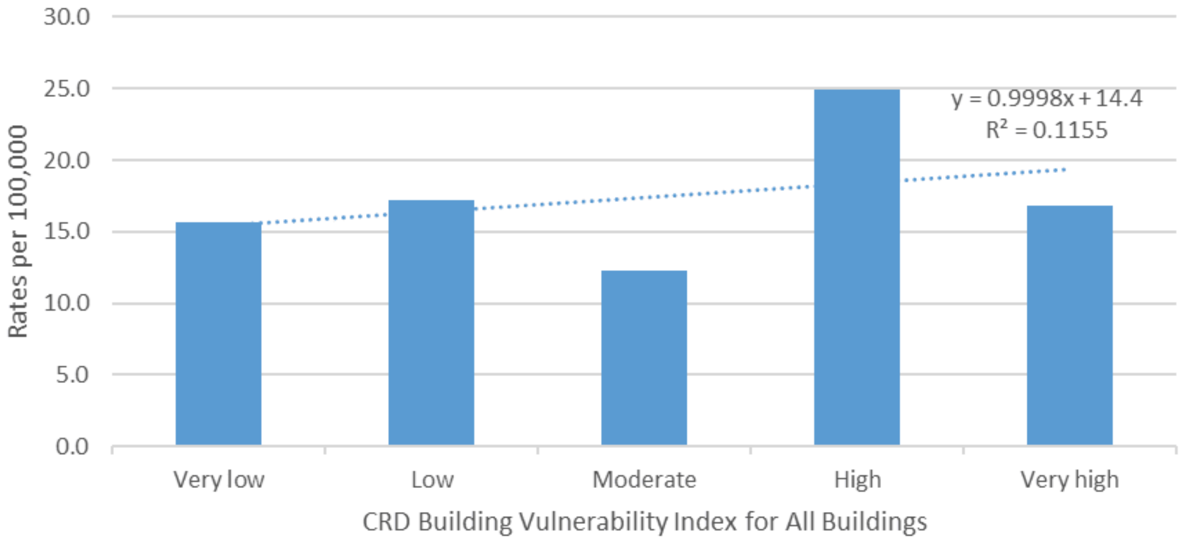

Figure 3.24. Analysis of capital region Building Vulnerability Index Across All Building Types and Corresponding Heat-Related Health Outcomes (2018-2023). The bar chart shows the rates of health outcomes per 100,000 in relation to building vulnerability, with a notable peak at 'High' vulnerability. The overall correlation is weaker (R^2 = 0.1155), suggesting additional factors may influence the rates for a combined analysis of buildings.

3.4. Key patterns and hotspots in the socio-demographic and building vulnerability indices

Given the construction of the two indices (buildings and socio-demographics), it is additionally possible to overlay risk and develop an initial understanding of multiple component risk by community. Pursuant to table 3.8 below we can note that communities such as Sooke, Colwood, Lagnord, Central Saanich and the Southern Gulf Islands all exhibit some degree of socio-demographic vulnerability at the highest risk level and no corresponding vulnerability for residential buildings. Conversely, communities such as Esquimalt and Victoria, exhibit comparatively lower risk with regards to socio-demographics in comparison to residential buildings. Interestingly, the risk profile for Saanich (at least in the top two deciles) is nearly identical between socio-demographics and buildings (though low in comparison to Saanich's share of capital region population 32.2%).

When examining socio-demographic vulnerability in conjunction with building vulnerability, certain areas reveal a confluence of vulnerabilities. Illustrated in Figure 3.25, areas such as Gorge-Tillicum, Burnside, James Bay, and Sidney BC stand out due to their combination of elevated socio-demographic vulnerability and a significant prevalence of buildings with high vulnerability. On the contrary, areas such as Sooke, Metchosin and Gordon head exhibit low socio-demographic vulnerability as well as a lower prevalence of building vulnerability.

Table 3.8 Summary of population in top vulnerability quintile for both socio-demographic and buildings vulnerability indices.

Jurisdiction	Population Residing in Top Sociodemographic Quintile DAs	Population Residing in Top Residential Buildings Quintile DAs	% of Population in Socio Demographic Index Top Quintile	% of Population in Residential Buildings Index Top Quintile
Sooke	2,565	-	3.1%	0.0%
Colwood	1,245	-	1.5%	0.0%
Highlands	-	-	0.0%	0.0%
Juan de Fuca (Part 2)	-	-	0.0%	0.0%
Langford	6,575	-	7.9%	0.0%
Metchosin	-	-	0.0%	0.0%
North Saanich	-	-	0.0%	0.0%
Juan de Fuca (Part 1)	711	-	0.9%	0.0%
Central Saanich	3,076	-	3.7%	0.0%
Saanich	14,991	14,492	17.9%	18.6%
View Royal	1,649	289	2.0%	0.4%
Oak Bay	3,912	3,230	4.7%	4.2%
Saltspring Island	1,554	-	1.9%	0.0%
Victoria	31,868	49,349	38.1%	63.4%
Southern Gulf Islands	1,304	-	1.6%	0.0%
Esquimalt	6,409	8,093	7.7%	10.4%
Sidney	7,707	2,336	9.2%	3.0%
CRD Total	**83,566**	**77,789**	**100.0%**	**100.0%**

Given the lack of granularity at the community scale, it can therefore be more effective to review overlapping risk at the DA level which is presented in figure 3.17 below. Notably the figure indicates where there are concentrations of the two indices coincident in space which suggests localised concentrations of risk that should be further investigated and explored. Of note are high concentrations in Victoria, Esquimalt and Oak Bay. Given the exploratory nature of this work, the next step would be to determine if combining these risk factors makes sense or introduces noise into the work. Additional validation against health outcomes would be highly beneficial in this regard.

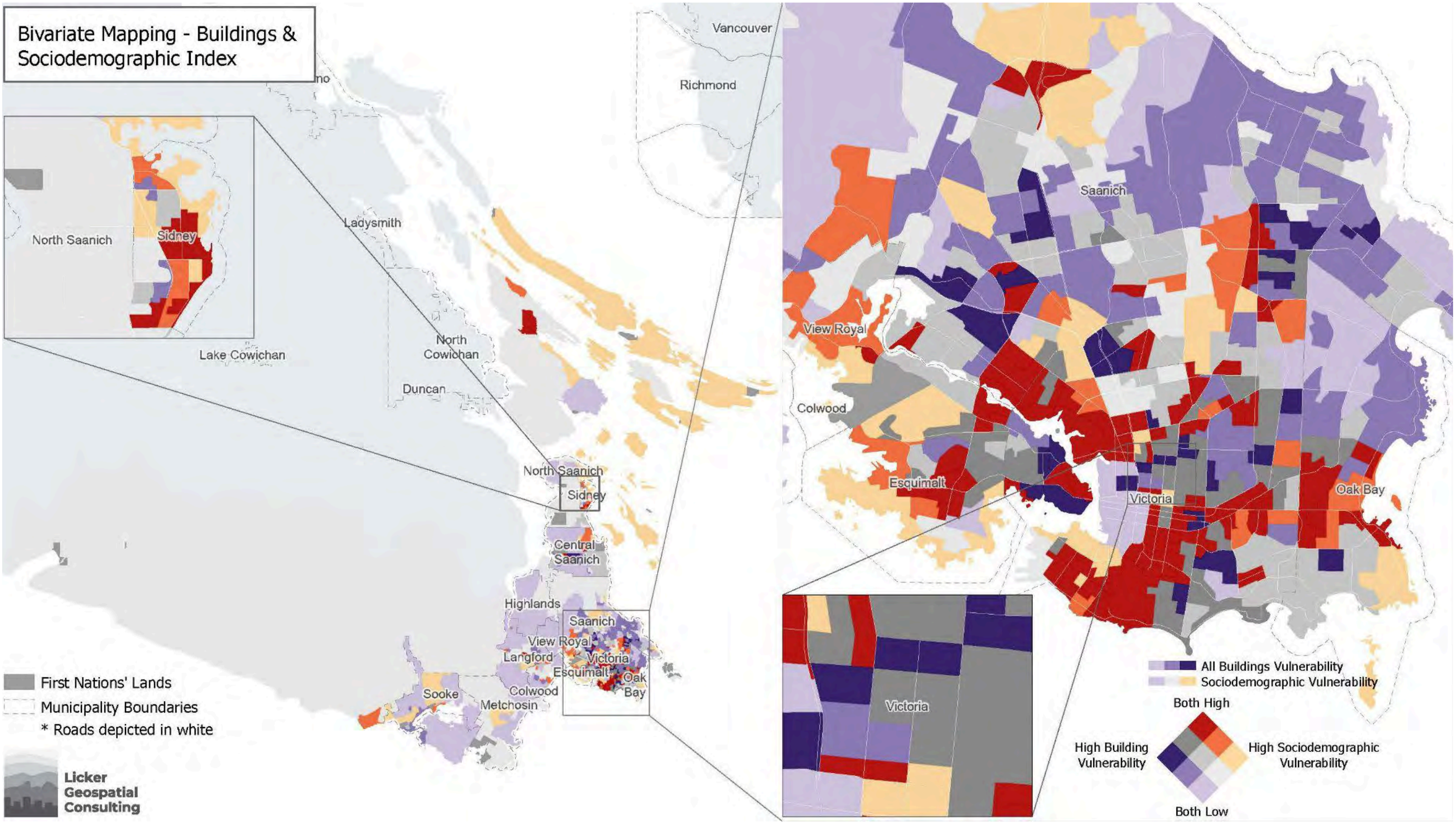

Figure 3.25. Extreme Heat Bivariate Mapping - Buildings and Combined Socio-demographic Vulnerability Index.

3.5. Community Level Summaries

For each of the 13 municipalities and three (3) electoral areas, key findings have been identified for further specificity for each community's specific heat vulnerability characteristics. These community level summaries help to show hot spots of heat vulnerability for each of the three mapping components. Community summaries can be found in appendix C. The community summaries also indicate the top contributing attributes from both the Socio-demographic Vulnerability Index and the residential Building Vulnerability Index, pertinent to each community. In addition, there are statistics relating to how the heat exposure layer overlaps with socio-demographic and building level vulnerability. For example, the District of Saanich's summary statistics table is depicted below in figure 3.26. In the table, very high vulnerability relates to the mapping categories labelled as very high. The District of Saanich is characterised by having 12.7% of its population residing in areas classified as very highly vulnerable according to the Socio-demographic Vulnerability Index. The top contributing demographic factor to the socio-demographic index is "population age 65 or older" (which makes up 23.1% of the population), while the top contributing health factor is "episodic mood anxiety disorders" (crude rate).

Housing type minimally contributed to the District of Saanich's overall building vulnerability (1.6%), as the community is mostly made up of single family dwellings, which was not considered as a vulnerable housing type (see table 2.2 for housing type vulnerability rankings). Rather, albedo and solar insolation are the largest contributing factors to this community's building vulnerability. This means that many building roofs are classified as very dark (absorbing heat), and buildings are exposed to very high amounts of solar insolation (30.4% of buildings). High solar insolation is predominantly due to low proportions of tree cover or shade, building aspect, elevation, and slope. By overlapping both socio-demographic and residential building vulnerability, the District of Saanich has 806 buildings that are classified as very highly vulnerable in both indices. As for modelled heat exposure results, 28% of the community's land area is modelled to have experienced some of the very highest temperatures in the capital region during the 2021 heat event (> 36.1 degrees celsius). Lasty, this community has the greatest amount of residential buildings classified as very highly vulnerable across all three mapping components (454 buildings).

Please note that the heat exposure layer is displayed in quintiles to help show variability in temperatures across each community. Quintiles divide the data into five equal parts, each representing 20% of the distribution of the data. The quintiles help identify areas with varying levels of susceptibility to heat-related impacts, however it should be noted that the range of values are all very warm temperatures during the extreme heat event, displaying that it can get quite hot everywhere. Regardless, quintiles are used to help to show the relative differences in temperature distribution across the region. Per the example below the "Very high" quintile is indicated as any area predicted to reach above 36.1 degrees celsius during the design heat dome event.

The Corporation of the District of Saanich

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

Demographic Vulnerability

Population 2021	117,735
% population in very high Sociodemographic vulnerability	12.70%
% population in very high demographic-only vulnerability	8.20%
% population in very high Health vulnerability	14.10%
Top contributing demographic factor	Population age 65 or older (23.1%)
Second contributing demographic factor	Population that are renters (30.8%)
Third contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (18.2%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Hypertension (crude rate)
Third contributing health factor	Diabetes (Crude Rate)

Building Vulnerability

Total # of residential buildings in the community	35,638
Housing type contribution to building vulnerability	1.60%
Year Built contribution to building vulnerability	24.90%
Albedo contribution to building vulnerability	29.70%
Solar insolation contribution to building vulnerability	30.40%
Building Height contribution to building vulnerability	13.50%
# of buildings with very high demographic & building vuln.	806
# of buildings in very high	6,873
% of residential buildings in very high	11.80%
Average age of buildings in very high	1960

Heat Exposure

% of community area in very high heat exposure	28%
% of residential buildings with very high heat exposure	36%
# of buildings with very high socio-demographic & heat expo.	1,542
# of residential buildings highly vulnerable across all 3 indices	454

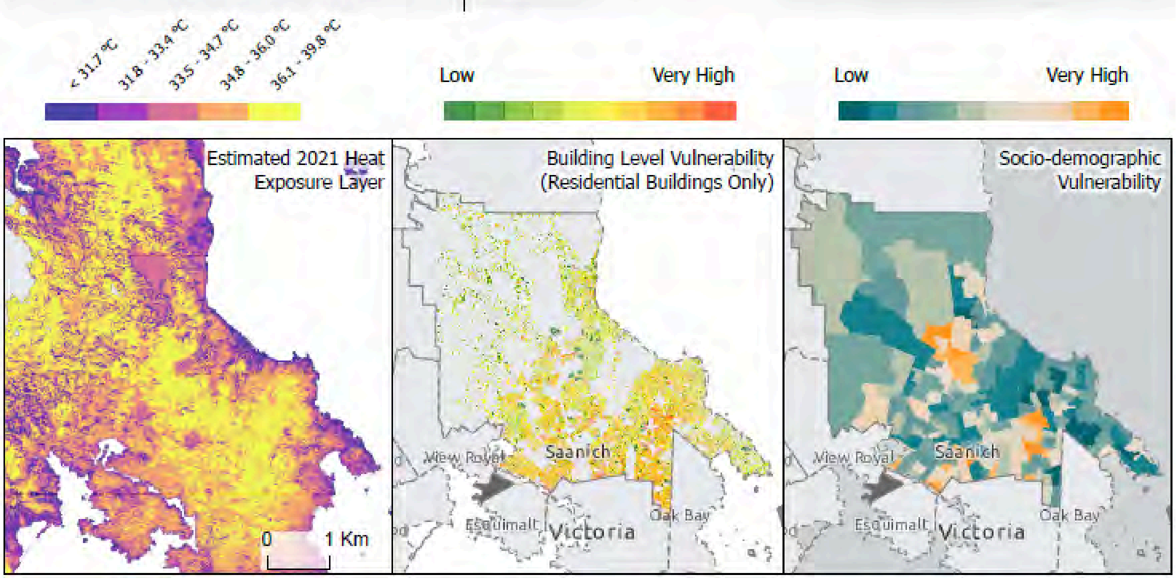

Figure 3.26. The Corporation of the District of Saanich Community Summary highlighting key determinants of heat vulnerability pertinent to Saanich.

3.6. *Community Level Key Findings*

While a detailed community-by-community analysis was out-of-scope for this assignment, we reviewed the summaries detailed above and can share the following key findings:

- Amongst all of the incorporated areas in the CRD, the top demographic consideration was consistently either: percentage of the population who are renters or percentage of the population who are seniors. The seniors finding is unsurprising as that was the highest weighted variable in the AHP model.
- The second highest demographic consideration encompassed considerably more variation including: % of population living alone (Victoria), Average number of rooms per dwelling (Langford), % of the population without post secondary education (Sooke), older housing (Oak Bay), and percentage of outdoor workers (Highlands).
- Low income residents did not factor in the top three for any community which suggests that no individual community in the CRD has elevated levels of poverty (recognizing, of course, that individual pockets of concentrated poverty are prevalent throughout the CRD).
- In most communities the primary health consideration is Episodic Mood Anxiety Disorders Prevalence followed by Hypertension (crude rate). This is noteworthy as neither mood anxiety disorders nor hypertension were weighted extremely highly in our model. This suggests that both of the health considerations are highly prevalent in the CRD and can be potentially addressed through municipal-level health measures which will reduce overall heat risk (for instance municipalities can consider food labelling bylaws or investments in active transportation which will reduce the incidence of hypertension).
- Noteworthy secondary health considerations include: high prevalence of diabetes in Colwood, high prevalence of Chronic Obstructive Pulmonary Disease (COPD)in Sooke, Victoria, Esquimalt and Salt Spring Island, high prevalence of Asthma in Langford and a high prevalence of Acute Myocardial Infarction in the Southern Gulf Islands and Metchosin.
- When unpacking the determinants of building risk, we note that Sidney, Victoria and Sooke all have the highest percentages of multi-family or congregant housing in their communities and therefore see higher values for the building type risk factor (all ~6%). Conversely communities that are nearly or mostly single detached in nature such as the JDF electoral areas, Highlands, North Saanich, Oak Bay and the Southern gulf islands all have the building risk factor contributing less than 1% to buildings risk.
- Owing to their comparatively new building stock, both Sooke and Langford (average age 1991 and 1984 respectively) indicate that era of construction (or building age) contributes less the 20% of building risk (18% and 19% respectively), conversely, Oak Bay, Esquimalt and Saanich all with comparatively older buildings indicate that era of construction contributes more than 25% to building heat risk.
- In general there is very little variance with regards to albedo and solar loading, though we note that Highlands has the lowest contribution for solar loading (24%) and the highest contribution for Albedo (35%) likely this is due to the fact that for the most part the

Highlands are very forested which can artificially increase albedo through shading and reduce solar loading commensurately. Also interesting to note is West facing communities such as Langford and Sidney have higher solar loading contribution percentages than other communities (though Oak Bay is an outlier here).

- When considered using region-wide averages, we note that 55% of Victoria's buildings are in the top quintile for building heat risk, followed by Oak Bay at 39%, Esquimalt at 33% and Sidney at 29%.
- When combined with demographic vulnerability we note that Victoria, Saanich and Sidney have the most buildings which are in very vulnerable areas for both buildings and socio-demographics at 1,174, 806 and 628 residential buildings respectively. When examined by percentage of total residential buildings, Sidney, Victoria and Esquimalt are the top three ranked communities with 19%, 13%, and 8% of all residential buildings being in both very high risk categories for buildings and sociodemographics. Conversely, Metchosin, Highlands and North Saanich have 0 buildings in these two categories.
- With regards to air temperature, we note that Langford, Highlands and Colwood all have significant areas of their community in highest heat quintile (>=36.6℃ daily average air temperature) at 61%, 49% and 32% respectively, which may increase risk in the communities. Conversely, communities more proximal to the ocean all have lower percentages of their communities in the highest heat quintile with Oak Bay, Sidney and Esquimalt at 5%, 2%, 1% of land area respectively.
- As urban heat is in many ways influenced by land use change and development, it is impactful to note that 84%, 56% and 48% of Langford, Colwood and Highlands' residential buildings are in the highest heat quintile. However, all three of these communities have relatively lower socio-demographic risk and only 6% (648), 1% (54) and 0% (0) of Langford, Colwood and Highlands' residential buildings are in both the highest quintiles for air temperature and socio-demographics
- Extending the above analysis to all three indices/layers we note that Saanich has 454 residential buildings in the three highest quintiles for heat risk, buildings risk and socio-demographic risk (1% of all residential buildings in the community), Victoria has 229 (2% of residential buildings) and Langford has 98 (1% of residential buildings in langford). Overall, there are 929 buildings in all three very high risk categories.

3.7. Sub-municipal analysis

Using the vulnerability indices in tandem can help to recognise priority areas for adaptation, risk reduction, and enhanced emergency response efforts. By examining where both building vulnerability is high and where socio-demographic vulnerability is also high, it becomes possible to strategically prioritise interventions and resources in areas most in need of attention. In figure 3.18 below, these overlapping vulnerabilities were identified at the building level and subsequently assessed for proximity to first responder data points. Buildings that are highly vulnerable and also fall within a DA that has a high Socio-demographic Vulnerability Index score are displayed in purple on the map below if they are also further than 2 kilometres away from a first responder dispatch facility. This analysis reveals key hotspots of vulnerability that could benefit from enhanced emergency preparedness and response. Some emergent hotpots of note occur near Gorge-Tillicum, Otter point, Oaklands (Vancouver) & Quadra (Saanich), south Oak Bay, Cordova Bay, and the north and south areas of Sydney, among others.

While an exhaustive analysis of key considerations for each of the abovementioned hotspots is beyond the scope of this study, we note for interest potential concerns in the Oaklands/Quadra areas of Victoria and Saanich which exhibits a high degree of buildings that are at risk, along with sizable concerns with regards to at risk populations and a seemingly longer potential response time for first responders[65]:

- 54% lower adoption rates of heat pumps per capita than the regional average;
- Rates at twice or more the regional average for acute myocardial infarction, chronic obstructive pulmonary disease, chronic kidney disease and hospitalised stroke;
- Population density at 1.8x of the regional average;
- Percentage of population living alone 1.4x of the regional average;
- Unemployment rates 1.3x the regional average;
- Concentrations of recent immigrants 3.5x the regional average;
- Concentrations of poverty with 16% of the households being in the bottom decile of family incomes in the region (compared to an expected 10%);
- Top risk quartile solar insolation (4,400 watt/hrs versus a regional average of 3,950) and building age values (average year built 1954 versus regional average of 1974); and
- A somewhat higher proportion of seniors living in multi-unit buildings than the regional average.

We note that while presented as a conceptual example only, the above risk profiling can be completed for any subset of buildings and/or dissemination areas considered for this study and as such can with some additional effort, be extended to multiple, additional hazards or disaster response scenarios.

[65] We note the very close proximity to Royal Jubilee Hospital, which, to the best of our understanding, does not dispatch ambulances.

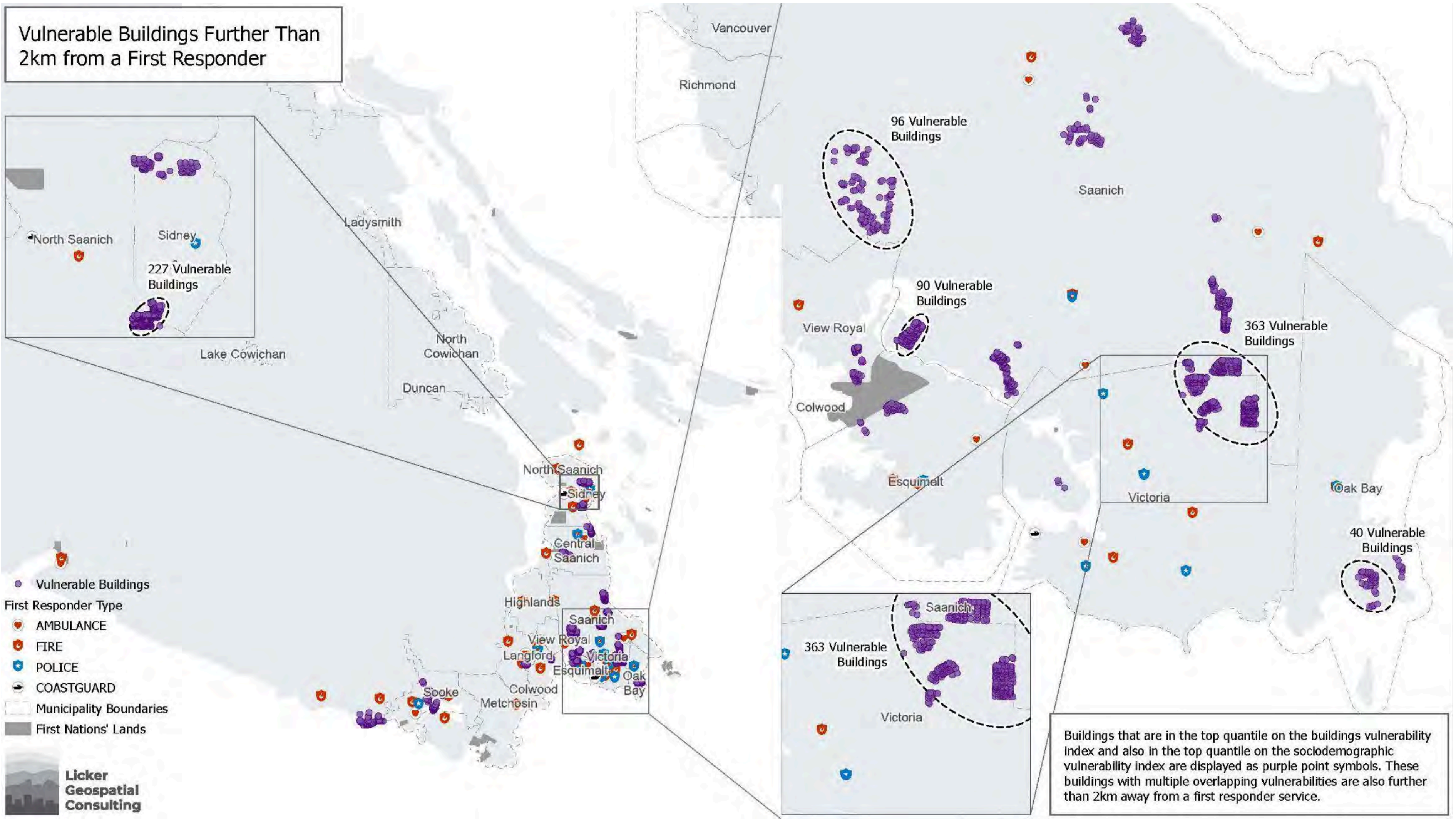

Figure 3.27. Buildings with multiple overlapping vulnerabilities that are also located further than 2 kilometres from a first responder dispatch facility.

4. Discussion

The findings of this study, while underscoring the multifaceted nature of extreme heat vulnerability and resilience in urban and rural environments, also bring to light the inherent complexities and constraints associated with such research. This Discussion section aims to detail these complexities, starting with a presentation of limitations of the socio-demographic vulnerability index, the heat exposure layer, and the building vulnerability index. The recognition of these constraints allows for transparency in our research, provides context of our findings, and also presents opportunities for future research in this area. Following a discussion on limitations, a carefully considered set of recommendations are provided, which have been drawn from our data-driven insights and are intended to guide practical interventions and policy formulations. Lastly, we present potential future uses of the analytical outputs of this study, in which we offer pathways to leverage this work towards the development of innovated solutions and strategies for enhancing resilience against extreme heat at the localised and regional level.

4.1. Methodology Limitations

4.1.1. Limitations of the Socio-Demographic Vulnerability Index

Despite the increase in accuracy in this index through the use of AHP, there are still some limitations to the dataset that should be considered when interpreting the information. These include:

- Census data limitations: Census data is collected through a quinquennial mandatory survey carried out by Statistics Canada. Despite the legal obligation to complete the Census, certain households or individuals may choose to not answer the Census, not be present on Census day or may not answer the questionnaire truthfully. While Statistics Canada makes every effort to guarantee the accuracy of the Census there is a certain degree of non-response rate for all dissemination areas in the Study Area. These non-response rates vary from 0 to 51% in the capital region with an average non-response rate of 4% and can possibly reduce the accuracy of collected information in some cases.

- Ecological fallacy: As both Census and health data are aggregated to the Census Dissemination area level, there is a modest concern that any index prepared using this data is subject to the ecological fallacy[66], which can lead to errors of interpretation. That is to say, rates and values results described at the Dissemination Area level may not describe singular cohesive groups who all share the same attributes. Rather these data describe singular descriptors of different groups of individuals.

- Atemporality of socio-demographic data: The most recent Census was completed in 2021, as such the data are nearly three years old at the time of this study, and the populations that they describe may not conform to the ones that currently reside in the capital region

[66] The ecological fallacy is a common issue in the interpretation of statistical data that occurs when inferences about the nature of individuals are deduced from inferences about the group to which those individuals belong.

or future populations. Accordingly, care should be taken when interpreting index data, to recognize that these data describe relative risk from 2021 with some degree of inaccuracy henceforth.

- During the socio-demographic index design phase we learned that the population with schizophrenia is at the highest risk for death during extreme heat due to a multitude of complex interacting factors[67]. While various health indicators pertaining to increased vulnerability during extreme heat were included in the index, we were unable to acquire data on schizophrenia at the DA level, leaving an important health indicator out of the equation.

- Future engagement could focus on outreach to key end-user groups. Many of these opportunities were discussed but not fully pursued given the timing and budget constraints of the project. Examples discussed were the Capital Region Housing Corporation (CRHC), other building managers/owners (BOMA, Devon properties, etc.), the Electoral Areas, and the health authority (i.e. Island Health).

- This effort did not include cross-tabulated Census data, which describes the intersection of data inputs. For example the spatial distribution of the population that are seniors *and* live alone (cross-tabulated), versus the spatial distribution of the population that are seniors *or* live alone (not cross-tabulated). Cross-tabulated Census data was not included in this project for several reasons, including project capacity limitations in regards to timing and cost, and privacy and confidentiality restrictions that are common for cross-tabulated data at the Census DA level. In regards to spatial resolution, Census data was accessed at the dissemination area level, meaning that any variations within dissemination areas are not fully captured.

- In the development of our AHP, we acknowledge potential limitations regarding representation and inclusion. Despite efforts to engage a diverse array of subject matter experts knowledgeable about the local context of the capital region, some perspectives will have been underrepresented or overlooked, thereby introducing gaps in the index creation. Further, the use of AHP introduces subjectivity due to its reliance on subjective judgments in weighting of inputs. The inherent biases and personal preferences of the analysts involved will influence weight attribution and thereby the demographic vulnerability index.

- The census data deployed in the analysis does not include the homeless population. Their adaptive capacity is perhaps higher for extreme heat as they are more connected to supporting resources during a heat event.

[67] Studies of Mortality in British Columbia During the 2021 Extreme Heat Event. Heat Preparedness Knowledge Exchange, May, 10th, 2023. With Sarah Henderson, Kathleen McLean, Michael Lee, Shirley Chen, Corinne Hohl.

In our analysis of extreme heat, we recognized the importance of considering First Nations' (FNs) communities in the region and sought to engage with them. First Nations representatives were included in the AHP workshop, for example, to ensure their perspectives were integrated in the way socio-demographic vulnerability/adaptive capacity was being defined in the region. Effort was also made to reach out to several other First Nations. The project timeline and budget constraints limited this consultation and inclusion process, as did data availability in certain circumstances. We acknowledge that more input and guidance from local FNs would have been valuable in enhancing our understanding of the specific vulnerabilities and needs of their communities in relation to extreme heat events.

Exploratory work to investigate available data for First Nations was conducted with available Census data. It was found that there were higher Census non-response rates on FN lands, which would decrease the confidence in the vulnerability assessment. Long-form[68] non-response rates [69] for FN reserve DAs has a mean of 35.5%, and for short-form[70] a mean of 20.2%, whereas for non-reserve DAs, the long-form non-response rate averages 4% and for short-form is ~3%. Multiplying non-response rates at the DA level by FN population equates to 27% of the population for long form Census and 13% of the population for the short-form. Whereas for non-reserve DAs, long-form and short-form non-response rates average 3.8% and 2.8% of the population respectively (see Table 2.1). However, Statistics Canada has reported that total non-responses to the long-form questionnaire are compensated for through imputation. Data for households that did not respond to any questions are imputed using data from a respondent household[71].

BC Assessment data (i.e. the buildings information report or BIR), as deployed in the buildings vulnerability index is not available for buildings on First Nations' reserve lands. Further, lived experiences on some First Nations reserves suggests a highly protective factor of living in these communities[72]. Accordingly, more work is required to develop a methodology that would help overcome data limitations and integrate these intercultural considerations.

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[68] The long-form questionnaire complements the short-form questionnaire and is designed to provide more detailed information on people in Canada according to their demographic, social and economic characteristics. It is disseminated to 25% of the population.

[69] Non-response rate is defined by Statistics Canada as the percentage of individuals or households that did not provide a completed response to the Census questionnaire. The non-response rate helps to understand the quality and coverage of Census results.

[70] Short-form refers to Canada's Census form that collects basic demographic and household information and is disseminated to 75% of the population.

[71] Statistics Canada (2022). *Guide to the Census of Population, 2021, Chapter 12 – Sampling and weighting for the long form*. Retrieved June 30, 2023, from https://www12.statcan.gc.ca/census-recensement/2021/ref/98-304/2021001/chap12-eng.cfm

[72] Canadian Climate Institute. (n.d.). Community is the solution. Available from https://climateinstitute.ca/publications/community-solution-2021-extreme-heat-emergency-experience-british-columbia-first-nations/

Table 4.1. Non response rate comparison within the capital region.

Non Response Category	FN Reserve DAs	Non-reserve DAs
Long form - Non-Response	35.5%	4%
Short form - Non-Response	20.2%	~3%
Long form - Proportion of Population - Non-Response	27%	3.8%
Short form - Proportion of Population - Non-Response	13%	2.8%

4.1.2. Limitations of the Heat Exposure Layer

Both the air temperature and LST model have limitations in their calculations and usage. Below are limitations associated with the LST and air temperature layers:

- LST is sensitive to immediate land cover change. Because LST is very closely aligned with what is directly on the ground, any changes to that surface will as a result impact the LST measurement. This LST layer is specific to the 2021 heat event. While land cover may generally be similar in the short-medium term, it is expected that by the long-term, the LST distribution will change significantly from land cover changes alone, notwithstanding changes to the magnitude of extreme heat events.
- As aforementioned, LST can provide a detailed perspective of how the region heats during a heat event. However, the distribution of the layer is less appropriate when relating to the human experience of extreme heat events, given that temperatures differ as they dissipate up to 2 m above the surface.
- Air temperature is based off a regression-model without an intercept. This approach introduces assumptions including that without any input (elevation, solar insolation, distance from coastline, etc.) the air temperature will be 0°C.
- Air temperature also heavily relies on the selected environmental variables for predictions, which may not account for all the factors that influence air temperature (such as windchill).
- The air temperature layer is inflexible and may produce erroneous values when applied in different regions.
- The air temperature layer is a linear model, which may not necessarily be true under all scenarios, especially in complex urban environments.
- The air temperature regression analysis is dependent on a relatively small sample size of weather stations (66), which may have sensor inaccuracies and has a limited distribution. As such the model becomes inflexible at high elevations where there is a gap in reliable station data during the 2021 heat event.

4.1.3. Limitations of the Building Vulnerability Index

While comprehensive, innovative and highly detailed, this index still presents a first attempt at regionally characterising potential heat in buildings and is subject to the following limitations:

- There are potential limitations of this model relating to data availability/accessibility (i.e air conditioning data for commercial buildings, indoor temperature, building wall material, single room occupancy (SROs)/residential hotels) and data nuance (i.e. have building components been updated since the building was built, averaging of building heights over their footprints). These are improvements the consulting team recommends be made in the future if and when possible.
- To help validate the model, ideally indoor air temperature gauges across the region would have been used to help validate the buildings index. Indoor air temperature data was sought after by ecobee. However, data was unavailable at the address level for the Project's use. If building level indoor air temperature data becomes available (for dates durings a heat wave), it would be recommended to incorporate this data into the modelling to help predict vulnerability as well as for model validation.
- Another limitation stems from the fact that, although each building is assigned specific values for height, albedo, and solar insolation, all buildings on a given parcel share a common set of building age and type information sourced from the Building Information Report. Thus, lower overall reliability exists in the ultimate ranking where there are multiple structures on the same parcel.
- Building albedo is based on the reflectance of a building's roof assembly only, that is to say, while the roof is a key element in heat loading, the walls of a building may absorb heat as well. Unfortunately, the albedo analysis, as conceived, can only be completed in planimetric (ie two dimensional) space and accordingly this nuance is lost in the buildings index model. During the meeting to discuss the buildings modelling approach, there were live experience comments that some new buildings, with lots of glass, that are south facing experienced extreme indoor temperatures during BC's 2021 heat event. With this in mind, we suggest that when possible, future model iterations consider building facade materials.
- Building age is a strong determinant of heat risk and it is fortunate that the BC assessment year of construction data captures this information. However, the year of construction of a building may not equate directly to the age of the interiors or exterior walls or windows of the building as these may have been renovated over time.
- A total of 2.9% of buildings lack information on building age or dwelling type. These data gaps can be attributed to four factors: temporal issues with BIR data, building footprint delineation and parcel boundary data, First Nations' Lands are not assessed by BC Assessment, occasional discrepancies when Joining Building Information on PID resulted in a small number of unmatched records, and the inherent potential for a minor degree of error in the BIR assessment process, which involves human evaluation.
- There is conflicting evidence around using building age as a predictor of vulnerability without also knowing construction material. Unfortunately, construction material was not a consistent attribute available for all buildings. Additionally, there is still no consensus among building experts and scientists on which construction materials are best in an extreme heat event, as specific building dynamics need to be considered which are very complex and not within the scope of this project to discern. However, in the context of the

District and BC as a whole, we are able to make approximate inferences about air tightness based on BC's building code history. Therefore using building age gives us a reasonable proxy around building air tightness, however adjustments could be made to this variable based on future potential findings from the building science community.

- As noted in Section 2.3.2, footprints for East Sooke, Metchosin and Juan de Fuca were delineated by LGeo, whereas footprints for the rest of the capital region were sourced from their respective municipalities. Note that footprint delineation errors within the provided source footprints from capital region were not scoped for QA or revisions.
- The buildings index, functions as a regional model, and has undergone thorough quality assurance through comprehensive sense checks across all attribute types. Nevertheless, given the extensive volume of buildings within the region, a meticulous examination of each individual building wasn't feasible, which has the potential for introducing errors or discrepancies. It's essential to acknowledge that, at a certain point, the effort invested in quality assurance encounters diminishing returns when building a regional model.
- While heat pumps are known to provide protective effects against extreme heat, our model assumes that the heat pump is providing cooling for all buildings on the associated parcel, as heat pump data was only available at a base address level. For single family homes this assumption is fairly sound. However, for multi-unit buildings, the heat pump data available does not distinguish if it's for a singular residence, or if the heat pump is able to provide cooling for the entire building.

4.2. Recommendations for usage and future research

- Analysing multiple overlapping vulnerability maps – Using all three mapping components together can help to recognise priority areas for risk reduction (i.e. risk reduction potential) and enhanced emergency response efforts. By examining vulnerability at the dissemination area level, considering both vulnerable populations and buildings along with the presence of urban heat islands, it becomes possible to strategically prioritise interventions and resources in areas most in need of attention.

- Identifying priority areas for tree canopy and green spaces – The data and maps derived from this project can help support urban forest strategies in the region. The vulnerability indices can be used to identify areas with a higher concentration of vulnerable populations that also have low proportions of canopy coverage. These areas can be prioritised for the development and enhancement of urban green spaces, parks, and tree canopies. Planting trees in areas with higher vulnerability can contribute to providing shade, reducing surface temperatures, and improving overall microclimates, thereby enhancing the well-being of vulnerable populations.

- Modelling and forecasting urban heat island effects - Our air temperature index results from a function of topography, urban form and to a lesser extent density and canopy coverage. Given that air temperature is to a some degree anthropogenically influenced, we can potentially model this out into a baseline and design case scenarios. This can be readily accomplished using an exploratory forecasting approach wherein we forecast the correlating factors driving air temperature using a simulation-based approach. This is similar to how climate mitigation modelling is forecasted using land use as a driving factor.

As discussed in the air temperature section above, our air temperature model describes the relative predictive value of insolation and land surface temperature both of which can be forecasted using a future case. Future case considerations could include:

- Generic temperature increases due to climate change (as discussed 2.5 degrees median for South Island)
- Canopy regrowth and degrowth rates by land use typology (we know that there is a generic increase on public lands, modest decrease on infill lands, a spectacular decrease on greenfield development followed by rapid regrowth, static growth in mature single detached areas etc - this can be generated from landsat data and plugged into the Canopy growth model we developed for Vancouver). Cutblock simulations could be included as well.
- Urban intensification (would change energy density, population and employment density - this can be generated from build out models similar to those which have been developed previously for Victoria and Saanich)
- Greenfield development (significantly increasing road network / traffic density and reducing LST)
- Changes to vehicular travel behaviours / shifting to non heat generating modes of travel.

A business as usual or "dark-sky" case could be developed wherein deltas to urban heat could be considered as a result of unchecked development absent any mitigating effects of canopy regrowth and design considerations to increase albedo. Alternative cool-city cases could be developed considering reduced buildings thermal density (or increased r-values), design considerations to increase albedo, reduced vehicular density, road reallocation to greenspace, aggressive tree planting scenarios and secession of aggressive foresting practices. The difference in modelled LST between scenarios could be considered as a positive effect of good urban planning and could mitigate against future heat vulnerability (at least on the exposure side of things).

- Response Resource Allocation – Based on the extreme heat event experienced in British Columbia in 2021, we know that emergency response personnel were at or over capacity in many areas throughout the capital region. Understanding at the dissemination level where there are vulnerable people and where there is a shortage of emergency responders or a long distance for a response team to travel, can help to better plan for where greater emergency response resources are needed. In local authorities where establishing cooling centres is common practice, the mapping produced by this project can provide an evidence base for where cooling centres should be prioritised.

- Updating local hazard, risk, and vulnerability analyses (i.e. HRVAs) - The new Emergency and Disaster Management Act (i.e. EDMA) is ramping up requirements for local authorities to undertake hazard and risk assessments. The effort and investment made via this project can support these obligations for local authorities in the CRD. A large component of the work for an HRVA had been completed, with the ability to add in multi-hazard considerations for the other 'major hazards of concern' in the region.

- Supporting climate action planning and reporting – As mentioned above, this may involve considering changes in land use planning and policies to help mitigate the impacts of extreme heat. Specifically, high heat areas should be tested against canopy coverage to determine the influence of urban canopy on heat. Should the relationship prove durable then tree planting should be prioritised for hotter areas to reduce urban heat island effects.

- Supporting response to and adaptation of high risk buildings – The Building Vulnerability Index can help to inform which buildings are likely in need of retrofitting for extreme heat adaptation. It can also help prioritise areas for redevelopment. In the nearer term, the building modelling can help prioritise outreach and response. For example, in Burnaby, the emergency managers posted flyers in high-risk multi-unit buildings to educate residents about extreme heat hazards and options to help manage it. It can also support in-person wellness checks as first responders can respond to the buildings being mapped as high-risk, as they often cannot get information about the specific socio-demographics at a given building.

- Prioritising subsidies of heat pumps. Based on our findings, there is significant disparity with regards to the distribution of heat pumps in the region. In light of these findings, there should be some consideration for localised subsidies for heat pump adoption perhaps based on socio-demographic factors as well as overall building risk.

- Synergies with buildings benchmarking. As buildings benchmarking for energy performance becomes more common both in the capital region and province-wide, it may prove beneficial to require reporting for indoor air temperatures (as well as indoor air quality!) along with the mandatory energy reporting. Secondly, benchmarking information can be furthermore used to support identification of low or high risk buildings based on interpretation of hourly energy profiles which can indicate the presence of electric cooling or weak r values for instance.

- Community Engagement, Outreach and Education: The demographic and health-related vulnerability information can be used to help facilitate targeted community engagement and education efforts, regarding extreme heat events. This can include outreach programs to educate vulnerable populations on heat-related risks and the importance of preparedness.

4.3. *Future Model Updates*

As noted in the limitations sections for each index, data availability and granularity of validation are the predominant cause for any shortcomings in the model. If pertinent data becomes available at a later date, new indicators can be added in a streamlined fashion. For example, schizophrenia data could be added to the demographic index, if it becomes available at the DA scale. Proportions of the population having schizophrenia would simply need to be multiplied by a decided weighting factor (likely by a high weight percentage in relation to the other demographic variables given its significance) and added to the index score.

As new demographic information becomes available from the next Census, the demographic index could be updated with these new data. Data can be extracted from Statistics Canada's API by dissemination area unique identifier (DAUID)[73]. If you are unfamiliar with Census data scraping, LGeo has automated processes in place that can assist. After acquiring the appropriate Census data variables, adaptive capacity variables will need to be inverted to ensure that high values always represent higher vulnerability. In addition, variables that are not percent values, such as average number of dwellings and population density per hectare, would need to be scaled to have values ranging between 0 and 1. Once variables are configured, each variable is multiplied by their associated AHP assigned weight and then summed together to create the demographic index. We have automated this process through scripting and can assist in updating when needed.

To update the Heat Exposure Layer, a digital elevation model (DEM), at 1 m^2 spatial resolution will need to be derived from the newly available lidar data. Solar insolation (WH/m^2) at a spatial resolution of 30m^2, derived from a digital terrain model (DTM; 30 m^2) will need to be rerun using the newly available lidar data. Then the Sky View Factor (SVF), will need to be re-assessed at 1 m^2 spatial resolution. In addition, land surface temperature (LST; °C), will need to be recalculated from Landsat-8 satellite images captured during the updated heat event time period. Similarly, Normalised water difference index (NDWI), will need to be recalculated with appropriate updated Landsat-8 satellite images. Lastly, if the distance to coastline (km) layer needs to be remade, it can be calculated using one of ESRI's distance tools using coastline polyline data and either a 30m2 raster or polygon-grid covering the Region.

To update the Building Vulnerability Index, effort would need to be made to update parcels with new BIR data including actual use codes, and year built. New LiDAR derived footprints would also need to be created and attributed with building height. New Sentinel-2 imagery can be downloaded from the European Space Agency[74] to process a new albedo layer for the region. And lastly, updated air conditioning or heat pump data would need to be geocoded and attributed to its associated parcel. Additionally, it should be noted that there is a lack of literature from building experts and scientists discussing how particular building characteristics affect

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[73]Statistics Canada. Application Program Interface (API). https://www.statcan.gc.ca/en/microdata/api

[74] European Space Agency. (2023). Sentinel-2 Multispectral Instrument Level-1C data [Data set]. Copernicus Open Access Hub. https://scihub.copernicus.eu/dhus

vulnerability to extreme heat events. As research emerges in this area of study, it would be beneficial to apply any new and relevant findings to future iterations of the buildings index.

With regards to validation we note that our validation efforts are based on aggregate levels of observed hospitalizations that can be attributed to heat. While this is a reasonably effective method for validating the sociodemographic and buildings indices at the dissemination area level, it does not account for risk at the individual or buildings level. Recognizing that individual demographic or health data is practically impossible to gather, disseminate and validate for a public study such as this one, it may prove more effective to produce custom Census cross-tabulations which can then be validated at the DA level with some reassurance that the ecological fallacy has been mitigated to a certain degree. For additional buildings validation, it may prove beneficial to promote the installation of indoor temperature monitors in suspected at-risk-buildings[75] such that real risk data can be captured and validated against modelled information produced for this study.

[75] Note that the project team made reasonable, though unsuccessful efforts, to acquire third party indoor air temperature data from a number of providers as well as to collect anecdotal information from buildings managers who had been present during the 2021 heat event. Our efforts were not successful due, in part to concerns with regards to data privacy which hampered appropriate sharing of sensitive information.

Closing remarks

This study conducted by the Capital Regional District (CRD) and in conjunction with Licker Geospatial Consulting Co (LGeo), Thrive Consulting (Thrive), and municipal partners, represents a significant advancement in both the understanding and identification of extreme heat vulnerability within the capital region, but also the way in which regional and local governments may measure and assess extreme heat vulnerability in their communities. By leveraging a multidisciplinary approach that combines socio-demographic vulnerability, heat exposure, and building vulnerability, this research offers a comprehensive and nuanced perspective on extreme heat vulnerability in the region that offers the identification of key areas and populations that exhibit elevated risk to extreme heat.

This study presents actionable insights and targeted recommendations aimed at enhancing climate change adaptation and mitigation strategies, prioritising emergency response mechanisms, and refining urban planning practices to foster resilience and equity in the face of extreme heat challenges. Key recommendations are identified below as:

- Integrate the use of these indices in planning for climate change adaptation, risk reduction, and emergency response with a focus on overlapping vulnerability;
- Nuance urban forestry and green infrastructure with vulnerability data. Tree planting and shade provisioning are elements of extreme heat adaptive capacity and should be prioritised in areas that are presented as highly vulnerable;
- Strategically allocate resources such as emergency response. Our analysis presents areas in which there are both high overlapping vulnerabilities and also a dearth of emergency response service coverage;
- Integrate the findings into local governments' hazard risk and vulnerability analysis (HRVAs) updates to allow for informed policy-making and climate action planning; and
- Prioritise building retrofit programs to highly vulnerable buildings, whereby a multi-hazard perspective is applied.

The collaboration among various project stakeholders, including local experts and community members, has enriched the study and ensures that the analysis and findings are grounded in local realities and experiences of extreme heat. Such a collaborative and data-informed approach not only maximises the relevancy and efficacy of the study's recommendations, but also underscores the importance of community engagement in addressing climate change-related hazards and vulnerabilities.

Moreover, the study's methodology and findings have a significant implication beyond the immediate scope of extreme heat vulnerability. Indeed, they contribute to a broader understanding of how regional and local governments may integrate scientific research with policy-making and community planning. This effort thereby offers a foundation for future initiatives aimed at addressing various aspects of climate change and public health preparedness. The emphasis on a holistic, evidence-based approach to addressing climate resilience challenges can serve as a guiding framework for other regions and municipalities that face similar challenges.

In summary, the initiative undertaken by the CRD marks a significant advancement in the discipline of local and regional government response and resilience to climate change, and offers a starting point for potential strategies to address heat vulnerability with actions that are informed, inclusive, and evidence-based. This research not only advocates our understanding of the complex dynamics of extreme heat exposure and its impacts, but also champions a proactive and collaborative model for building safer, more resilient communities in the face of escalating climate risks.

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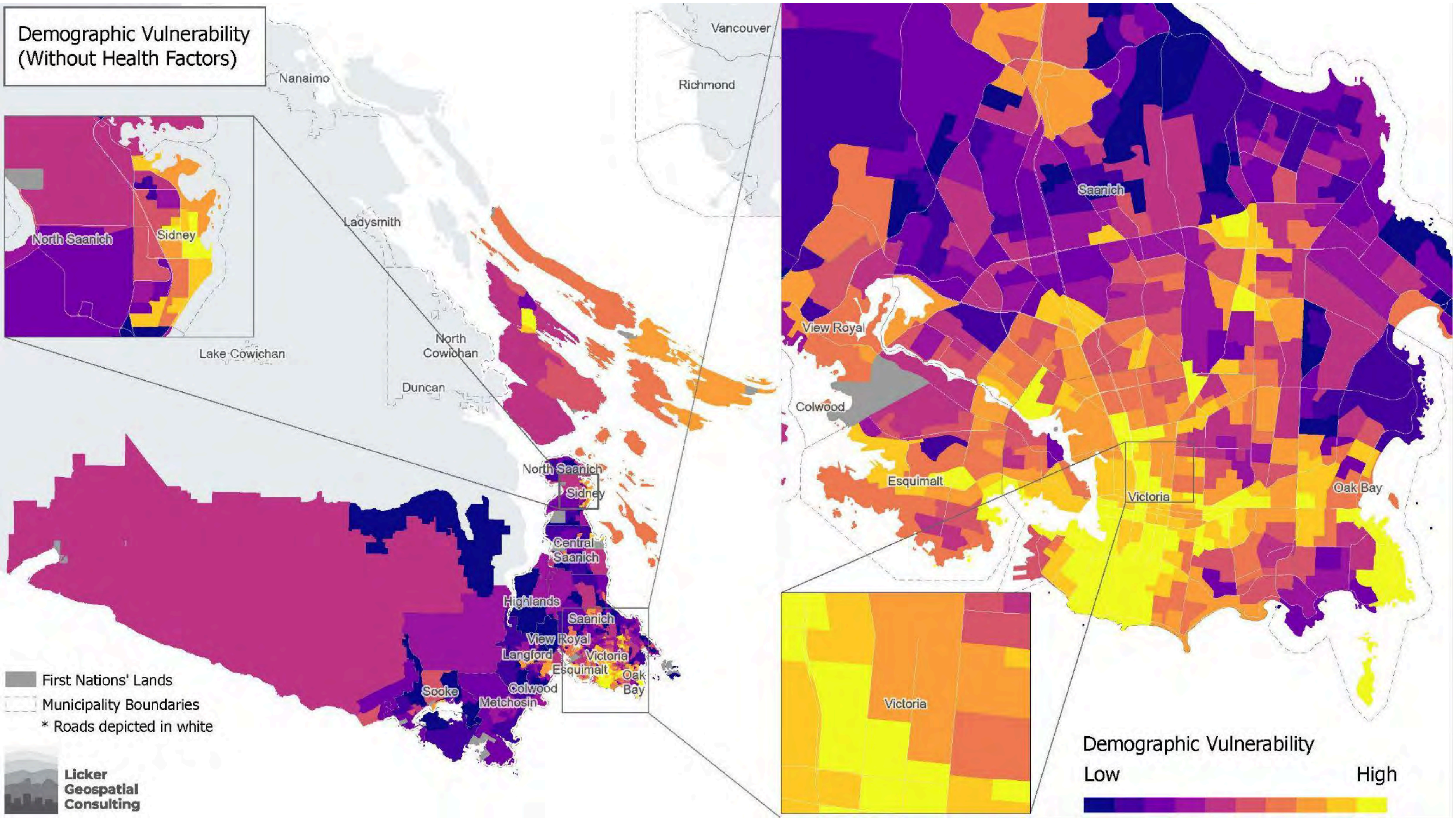
Appendix A. Weights (ωbi) by spectral band for rooftop albedo calculation, derived from Vanino et al (2018)[76].

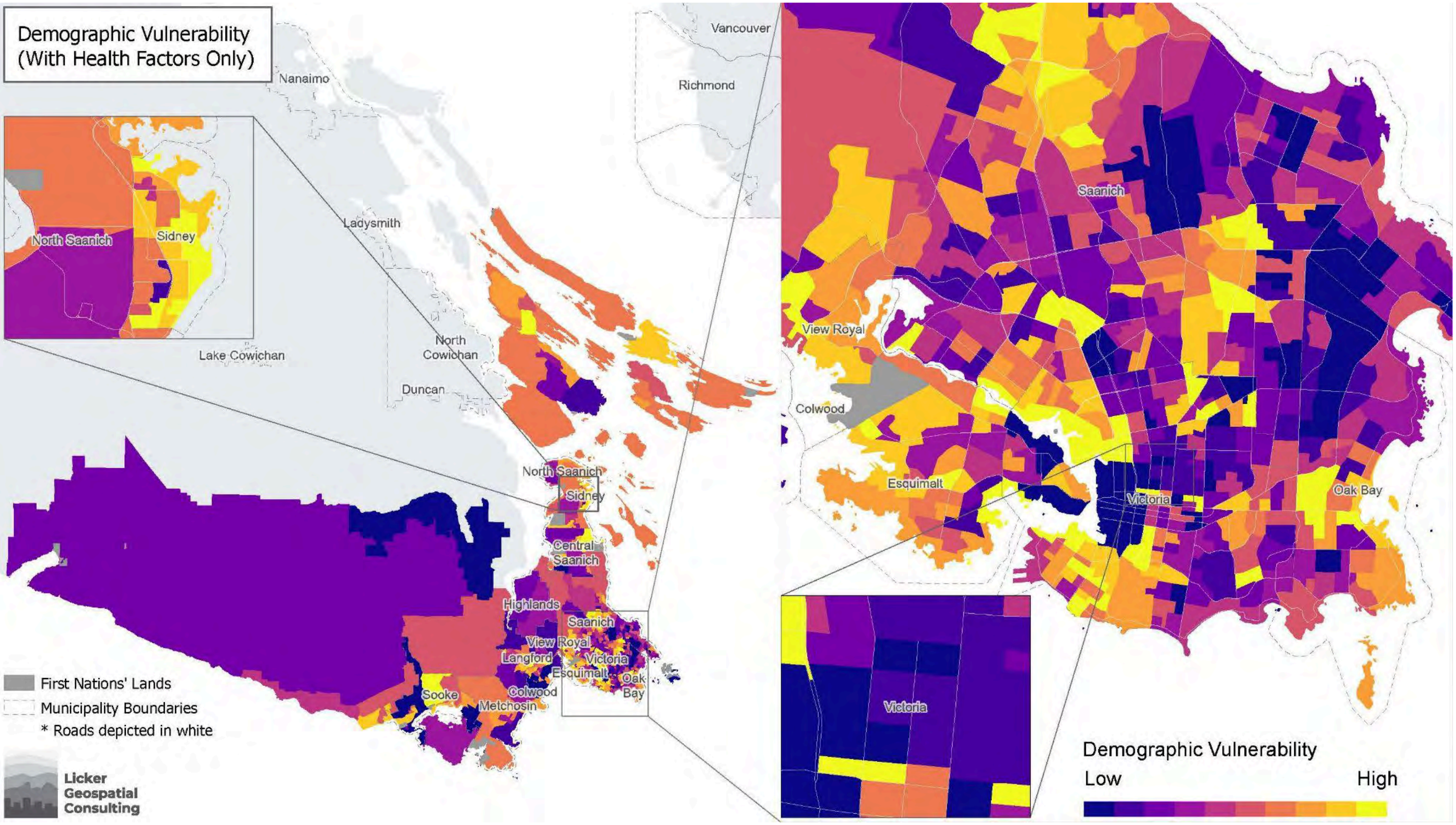
Band	Center λ (µm)	Spectral width Δλ (µm)	Esun (W m−2)	ω_{bi}
1	0.443	0.020	1,893	-
2	0.490	0.065	1,927	0.1324
3	0.560	0.035	1,846	0.1269
4	0.665	0.030	1,528	0.1051
5	0.705	0.015	1,413	0.0971
6	0.740	0.015	1,294	0.0890
7	0.783	0.020	1,190	0.0818
8	0.842	0.115	1,050	0.0722
8a	0.865	0.020	970	-
9	0.945	0.020	831	-
10	1.375	0.030	360	-
11	1.610	0.090	242	0.0167
12	2.190	0.180	3	0.0002

[76] Vanino, S., Nino, P., De Michele, C., Bolognesi, S. F., D'Urso, G., Di Bene, C., Pennelli, B., Vuolo, F., Farina, R., Pulighe, G., & Napoli, R. (2018). Capability of Sentinel-2 data for estimating maximum evapotranspiration and irrigation requirements for tomato crop in Central Italy. *Remote Sensing of Environment, 215*, 452-470. https://doi.org/10.1016/j.rse.2018.06.035

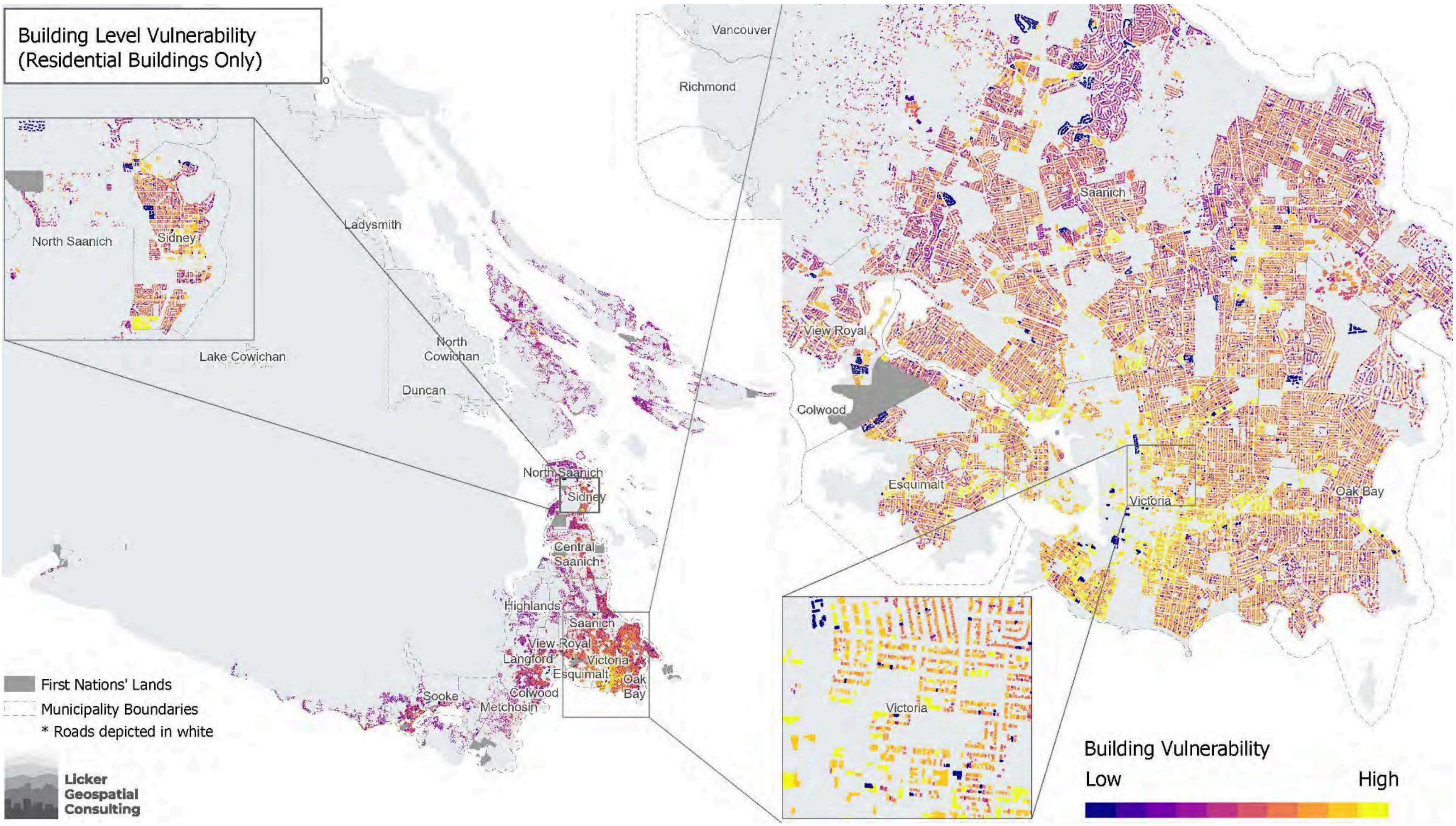
Appendix B - Additional Maps: Sub-Indices



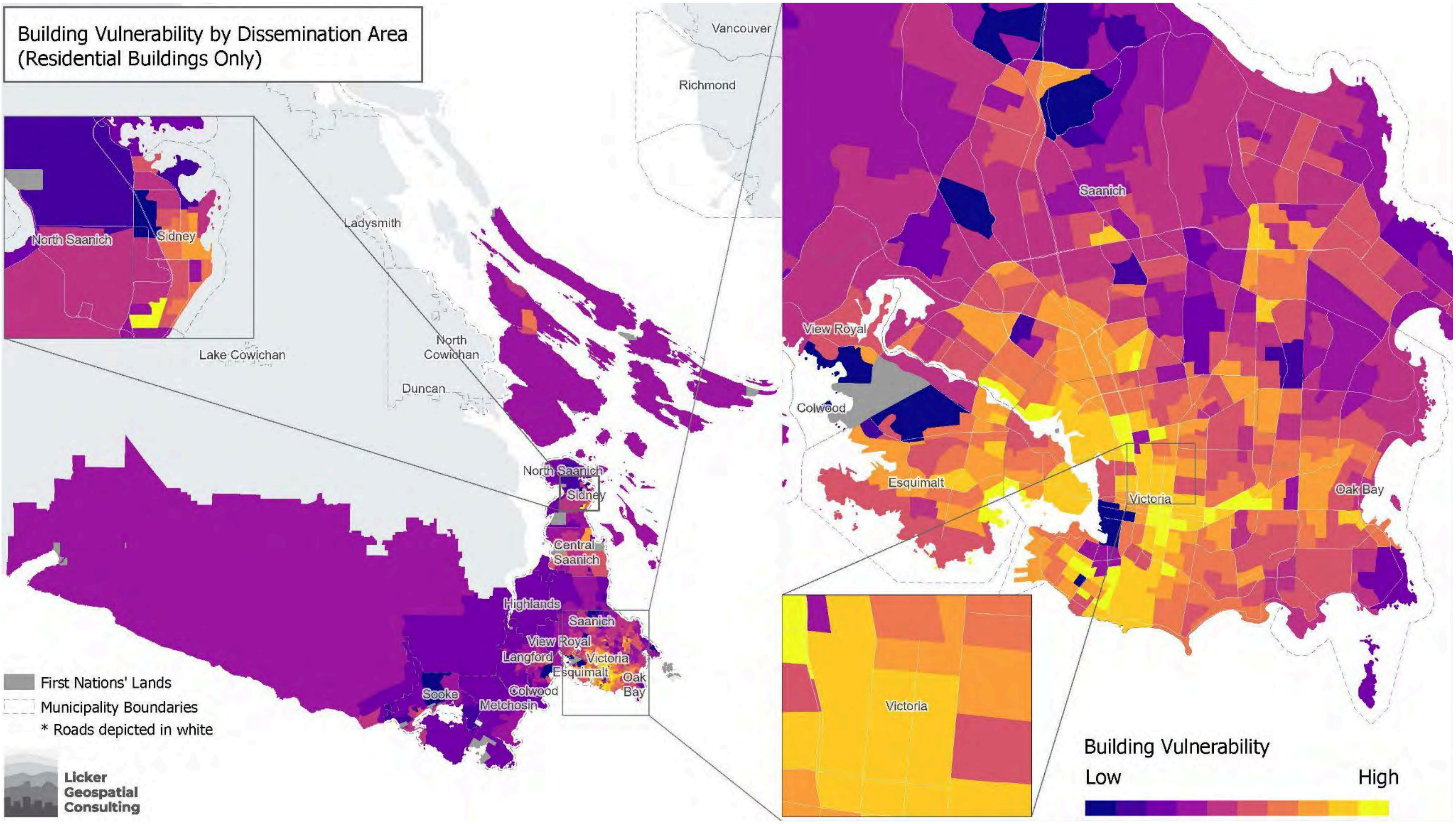
B1. Extreme Heat - Demographic Vulnerability Index without health-related factors.



B2. Extreme Heat - Demographic Vulnerability Index with health-related factors only.



B3. Extreme Heat - Building Vulnerability Index with residential buildings only, by building footprint.



B4. Extreme Heat - Building Vulnerability Index with residential buildings only, by DA.

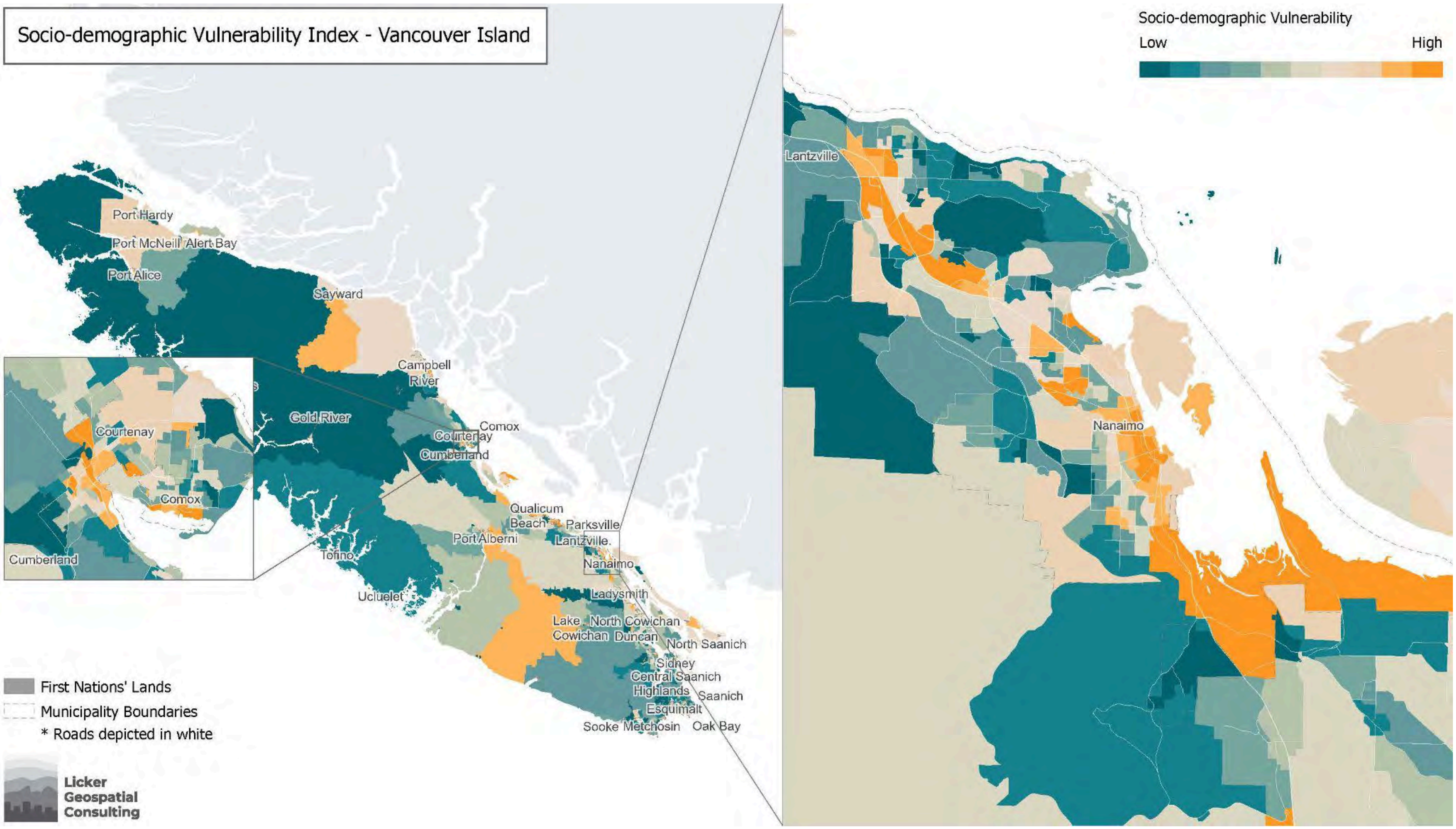


Figure B5. Vancouver Island wide Socio-demographic Vulnerability Index. Used for validation of the index at a greater scale.

Appendix C - Municipality Level Summaries

Extreme Heat Vulnerability Summarised by Community

Licker Geospatial Consulting Co.
2405 East Hastings St
Vancouver BC, V5K 1Y8

City of Colwood

Demographic Vulnerability

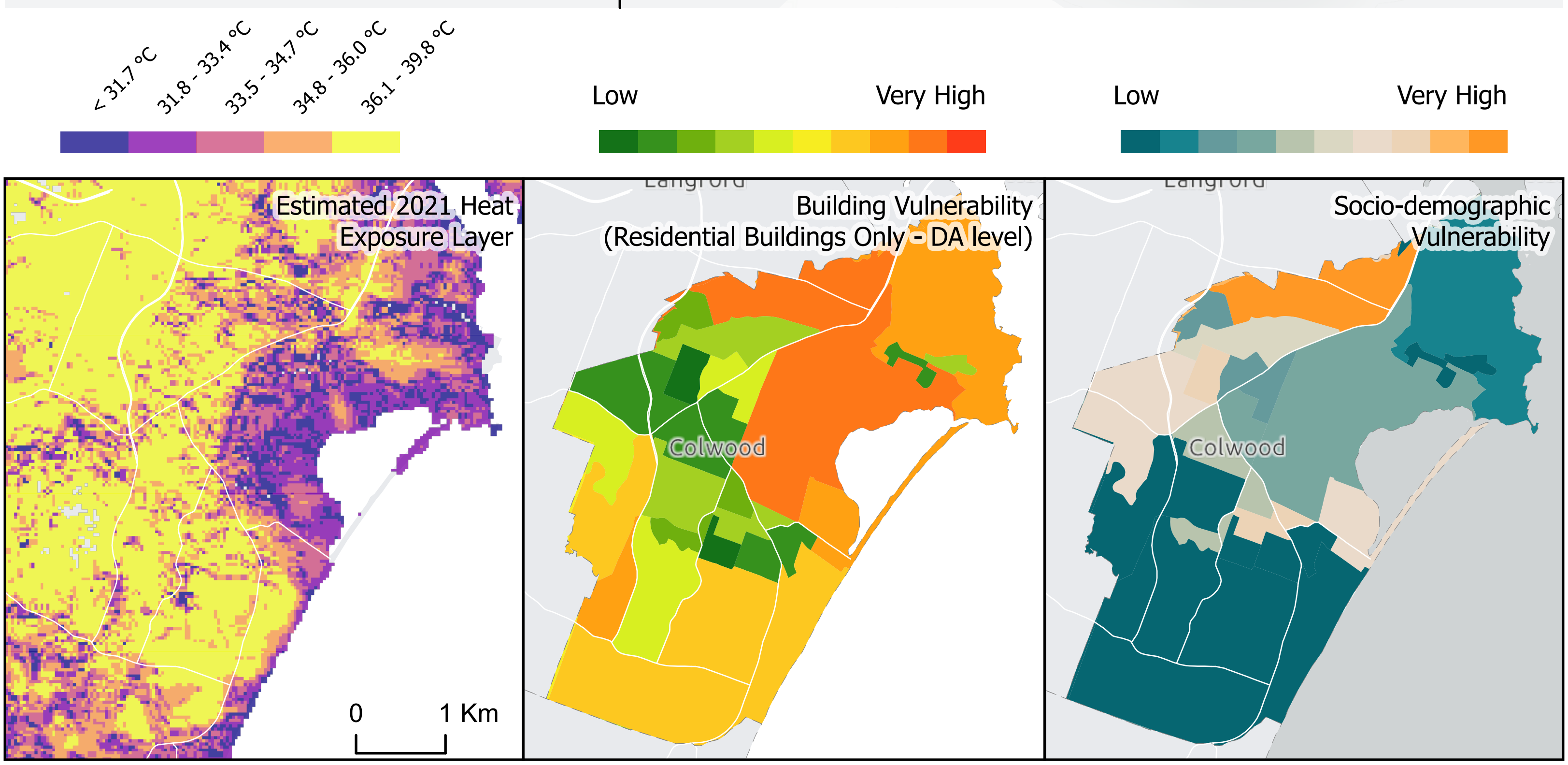
Population 2021	18,961
% population in very high Sociodemographic vulnerability	6.60%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	13.10%
Top contributing demographic factor	Population that are renters (26.7%)
Second contributing demographic factor	Population age 65 or older (19.3%)
Third contributing demographic factor	Has high (secondary) school diploma or equivalency certificate or no diploma or degree (45.3%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Diabetes (Crude Rate)
Third contributing health factor	Hypertension (crude rate)

Building Vulnerability

Total # of residential buildings in the community	5,549
Housing type contribution to building vulnerability	2.00%
Year Built contribution to building vulnerability	22.00%
Albedo contribution to building vulnerability	30.60%
Solar insolation contribution to building vulnerability	31.50%
Building Height contribution to building vulnerability	13.80%
# of buildings with very high demographic & building vuln.	59
# of buildings in very high	476
% of residential buildings in very high	11.80%
Average age of buildings in very high	1981

Heat Exposure

% of community area in very high heat exposure	32%
% of residential buildings with very high heat exposure	56%
# of buildings with very high socio-demographic & heat expo.	54
# of residential buildings highly vulnerable across all 3 indices	14



City of Langford

Demographic Vulnerability

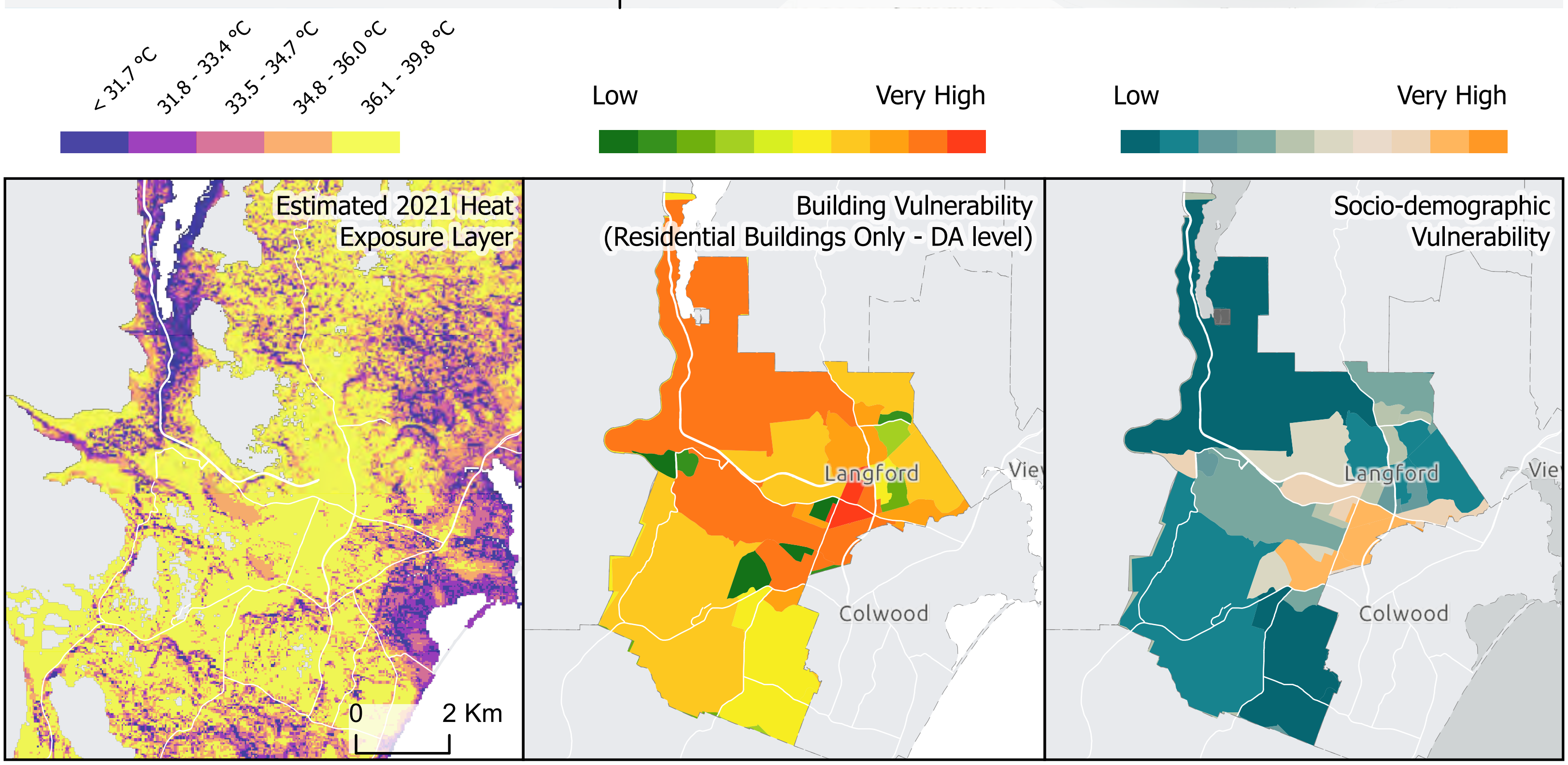
Population 2021	46,584
% population in very high Sociodemographic vulnerability	14.10%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	19.10%
Top contributing demographic factor	Population that are renters (35.2%)
Second contributing demographic factor	Average number of rooms per dwelling (5.6%)
Third contributing demographic factor	Population age 65 or older (13.7%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Asthma (crude rate)
Third contributing health factor	Diabetes (Crude Rate)

Building Vulnerability

Total # of residential buildings in the community	10,437
Housing type contribution to building vulnerability	2.40%
Year Built contribution to building vulnerability	18.20%
Albedo contribution to building vulnerability	31.60%
Solar insolation contribution to building vulnerability	33.20%
Building Height contribution to building vulnerability	14.60%
# of buildings with very high demographic & building vuln.	110
# of buildings in very high	945
% of residential buildings in very high	11.80%
Average age of buildings in very high	1984

Heat Exposure

% of community area in very high heat exposure	61%
% of residential buildings with very high heat exposure	84%
# of buildings with very high socio-demographic & heat expo.	648
# of residential buildings highly vulnerable across all 3 indices	98



District of Highlands

Demographic Vulnerability

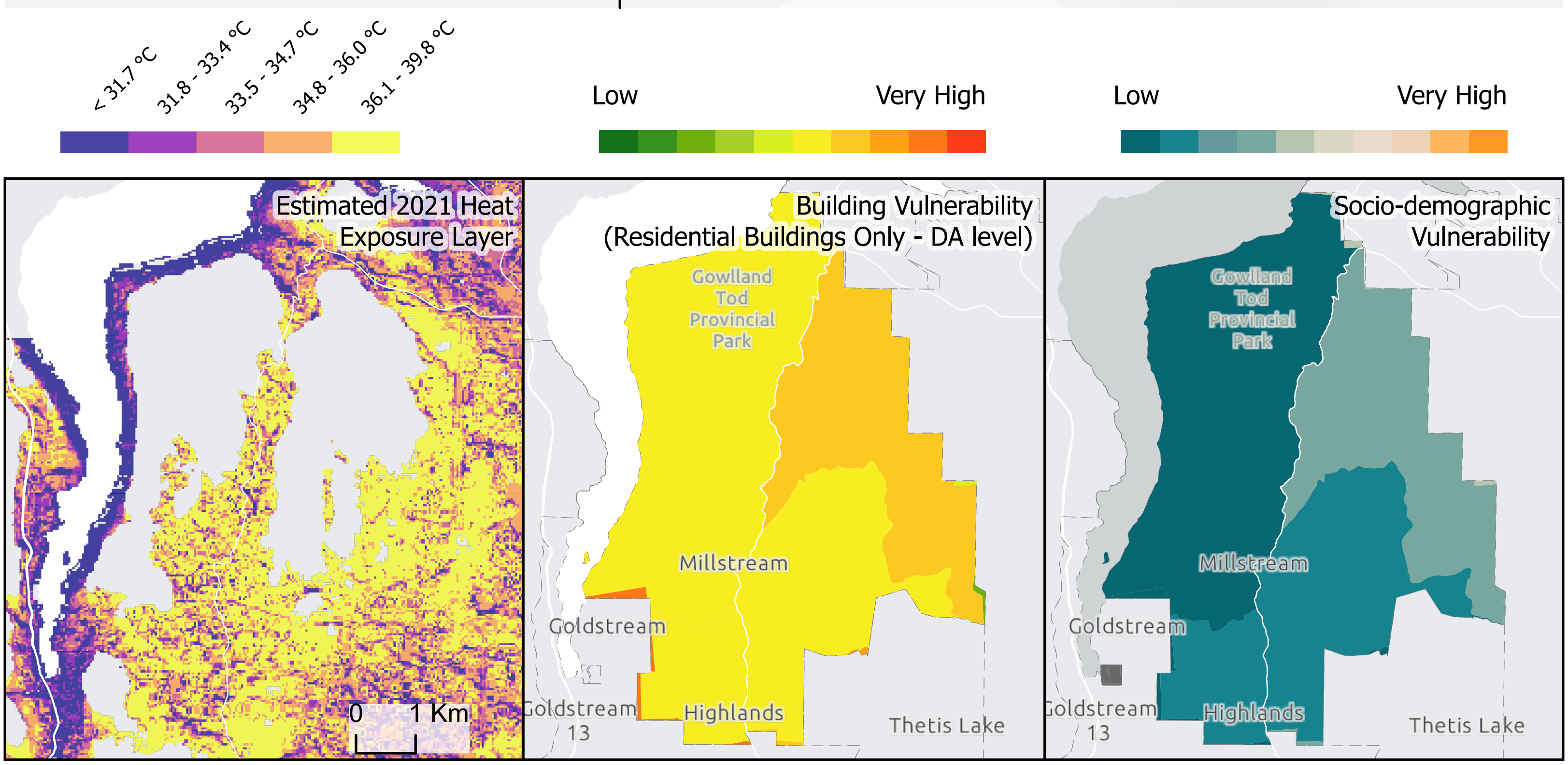
Population 2021	2,482
% population in very high Sociodemographic vulnerability	0%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	0%
Top contributing demographic factor	Population age 65 or older (18.1%)
Second contributing demographic factor	Outdoor Workers - Trades, transport and equipment operators and related occupations (27.1%)
Third contributing demographic factor	Has high (secondary) school diploma or equivalency certificate or no diploma or degree (42.9%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Hypertension (crude rate)
Third contributing health factor	Asthma (crude rate)

Building Vulnerability

Total # of residential buildings in the community	1,432
Housing type contribution to building vulnerability	0.60%
Year Built contribution to building vulnerability	22.00%
Albedo contribution to building vulnerability	34.90%
Solar insolation contribution to building vulnerability	23.90%
Building Height contribution to building vulnerability	18.50%
# of buildings with very high demographic & building vuln.	nan
# of buildings in very high	15
% of residential buildings in very high	11.80%
Average age of buildings in very high	1969

Heat Exposure

% of community area in very high heat exposure	49%
% of residential buildings with very high heat exposure	48%
# of buildings with very high socio-demographic & heat expo.	0
# of residential buildings highly vulnerable across all 3 indices	0



District of Metchosin

Demographic Vulnerability

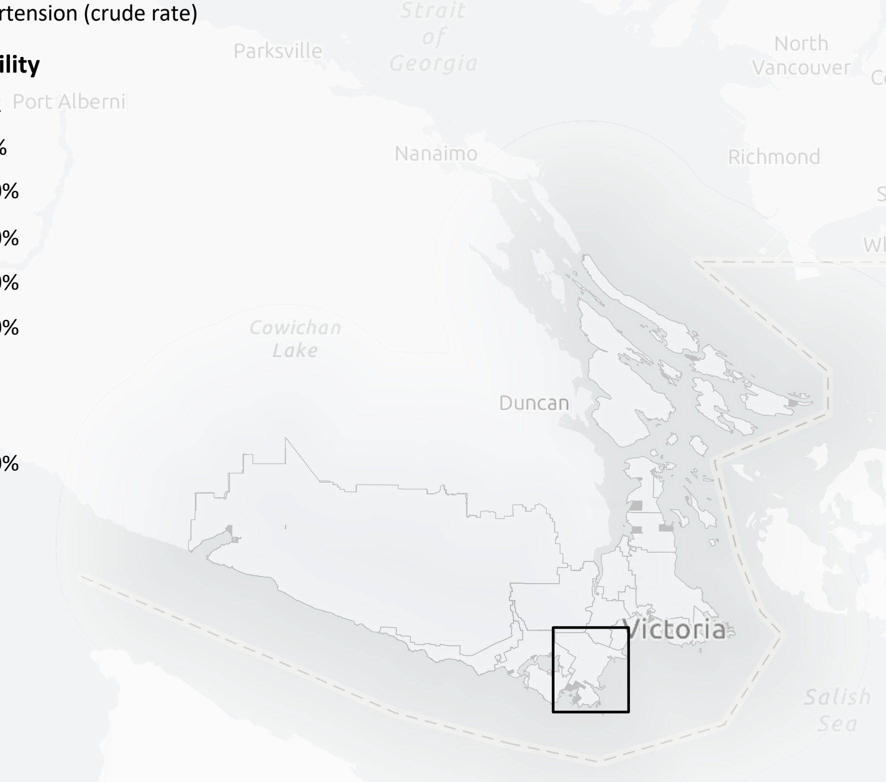
Population 2021	5,067
% population in very high Sociodemographic vulnerability	0%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	0%
Top contributing demographic factor	Population age 65 or older (26%)
Second contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (24.3%)
Third contributing demographic factor	Outdoor Workers - Trades, transport and equipment operators and related occupations (22.9%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Acute Myocardial Infarction (Crude Rate)
Third contributing health factor	Hypertension (crude rate)

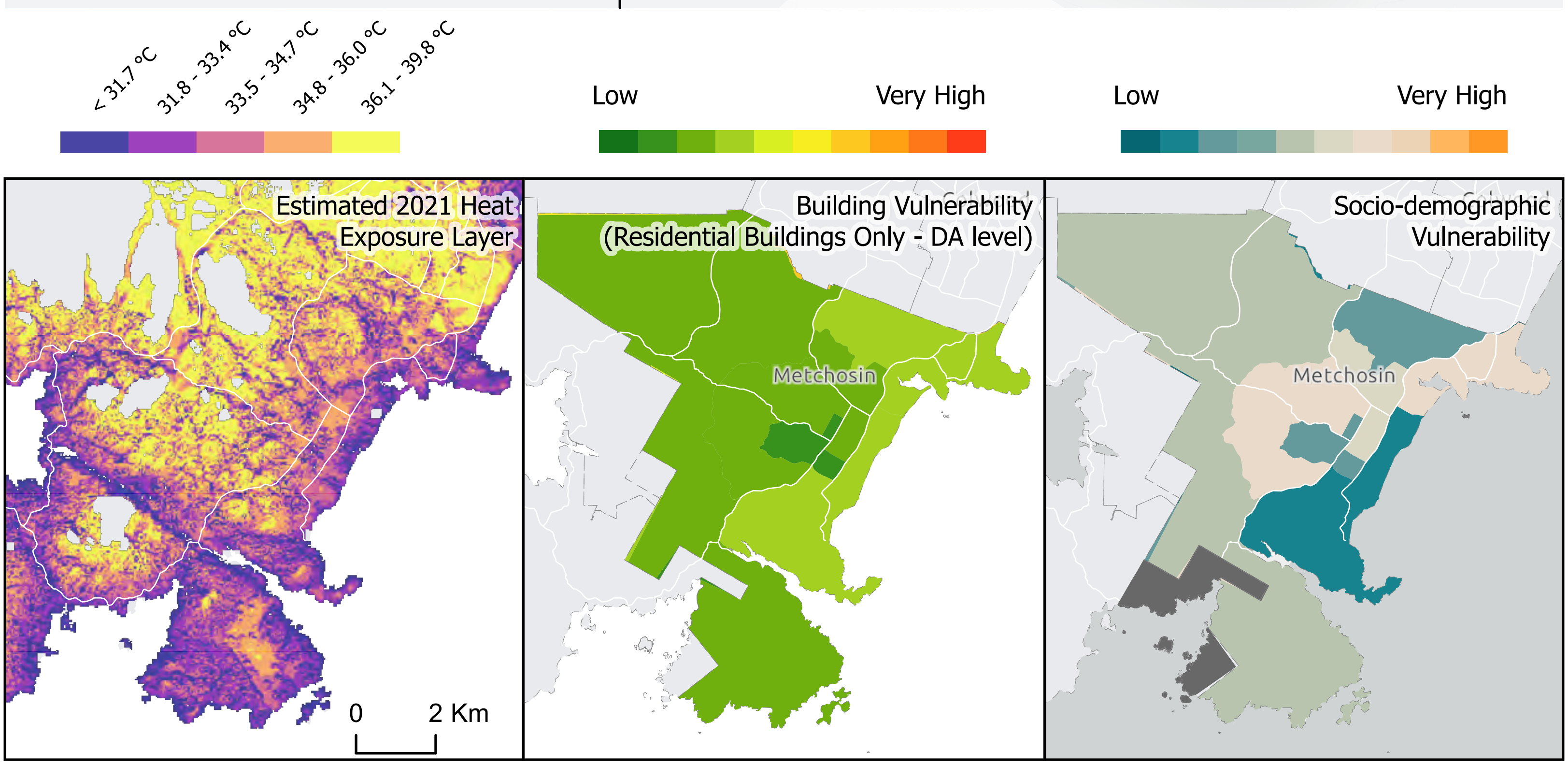
Building Vulnerability

Total # of residential buildings in the community	1,912
Housing type contribution to building vulnerability	2.60%
Year Built contribution to building vulnerability	24.00%
Albedo contribution to building vulnerability	29.10%
Solar insolation contribution to building vulnerability	30.50%
Building Height contribution to building vulnerability	13.90%
# of buildings with very high demographic & building vuln.	nan
# of buildings in very high	133
% of residential buildings in very high	11.80%
Average age of buildings in very high	1968

Heat Exposure

% of community area in very high heat exposure	18%
% of residential buildings with very high heat exposure	12%
# of buildings with very high socio-demographic & heat expo.	0
# of residential buildings highly vulnerable across all 3 indices	0





District of North Saanich

Demographic Vulnerability

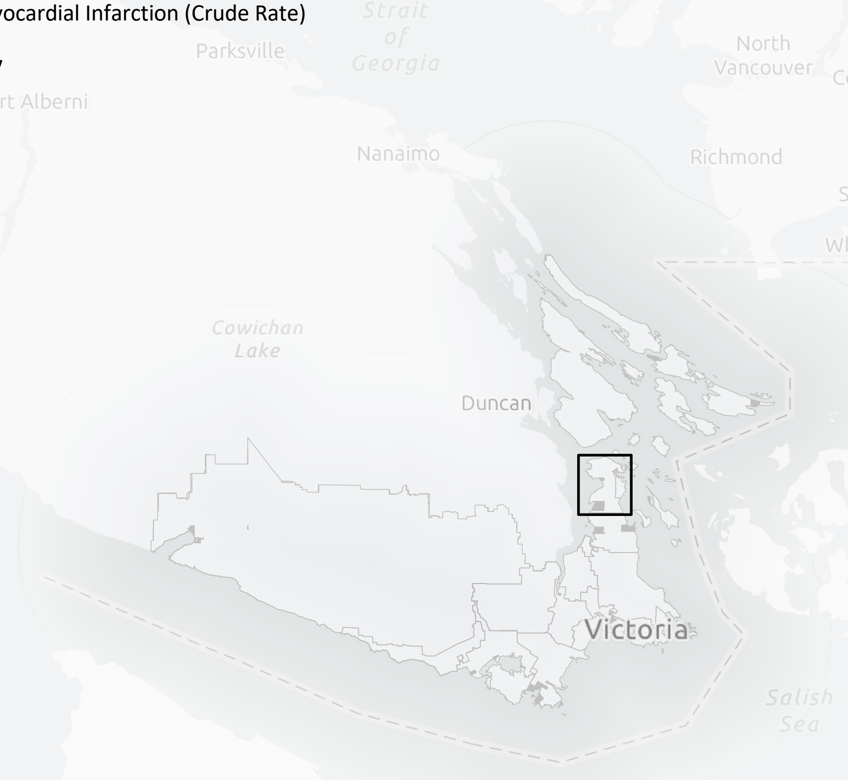
Population 2021	12,235
% population in very high Sociodemographic vulnerability	0%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	5.20%
Top contributing demographic factor	Population age 65 or older (34.7%)
Second contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (27.3%)
Third contributing demographic factor	Private households by age of primary household maintainers - 75 years and over (15.9%)
Top contributing health factor	Hypertension (crude rate)
Second contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Third contributing health factor	Acute Myocardial Infarction (Crude Rate)

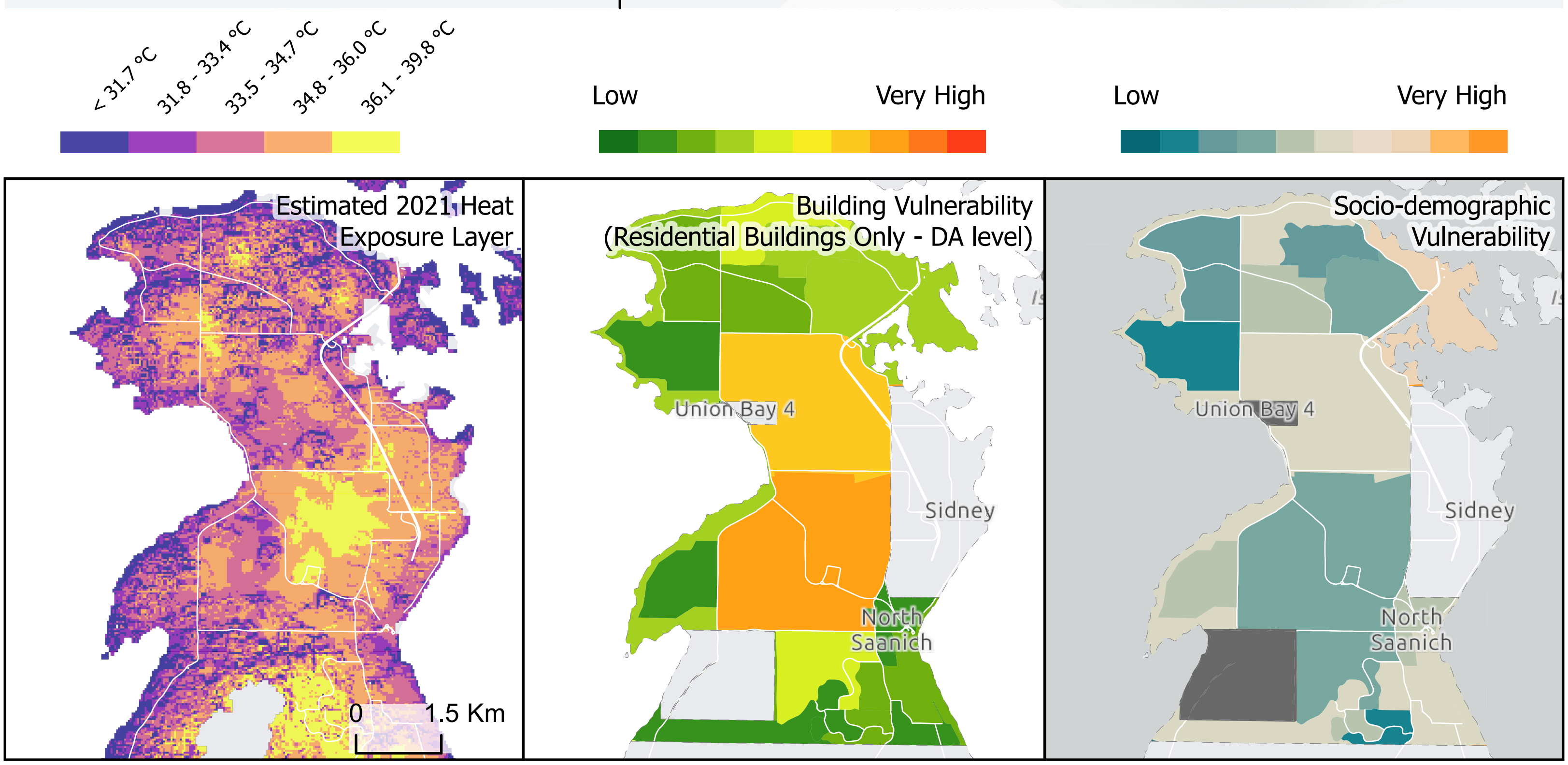
Building Vulnerability

Total # of residential buildings in the community	5,788
Housing type contribution to building vulnerability	0.90%
Year Built contribution to building vulnerability	23.80%
Albedo contribution to building vulnerability	31.00%
Solar insolation contribution to building vulnerability	29.40%
Building Height contribution to building vulnerability	14.80%
# of buildings with very high demographic & building vuln.	nan
# of buildings in very high	270
% of residential buildings in very high	11.80%
Average age of buildings in very high	1968

Heat Exposure

% of community area in very high heat exposure	6%
% of residential buildings with very high heat exposure	10%
# of buildings with very high socio-demographic & heat expo.	0
# of residential buildings highly vulnerable across all 3 indices	0





District of Sooke

Demographic Vulnerability

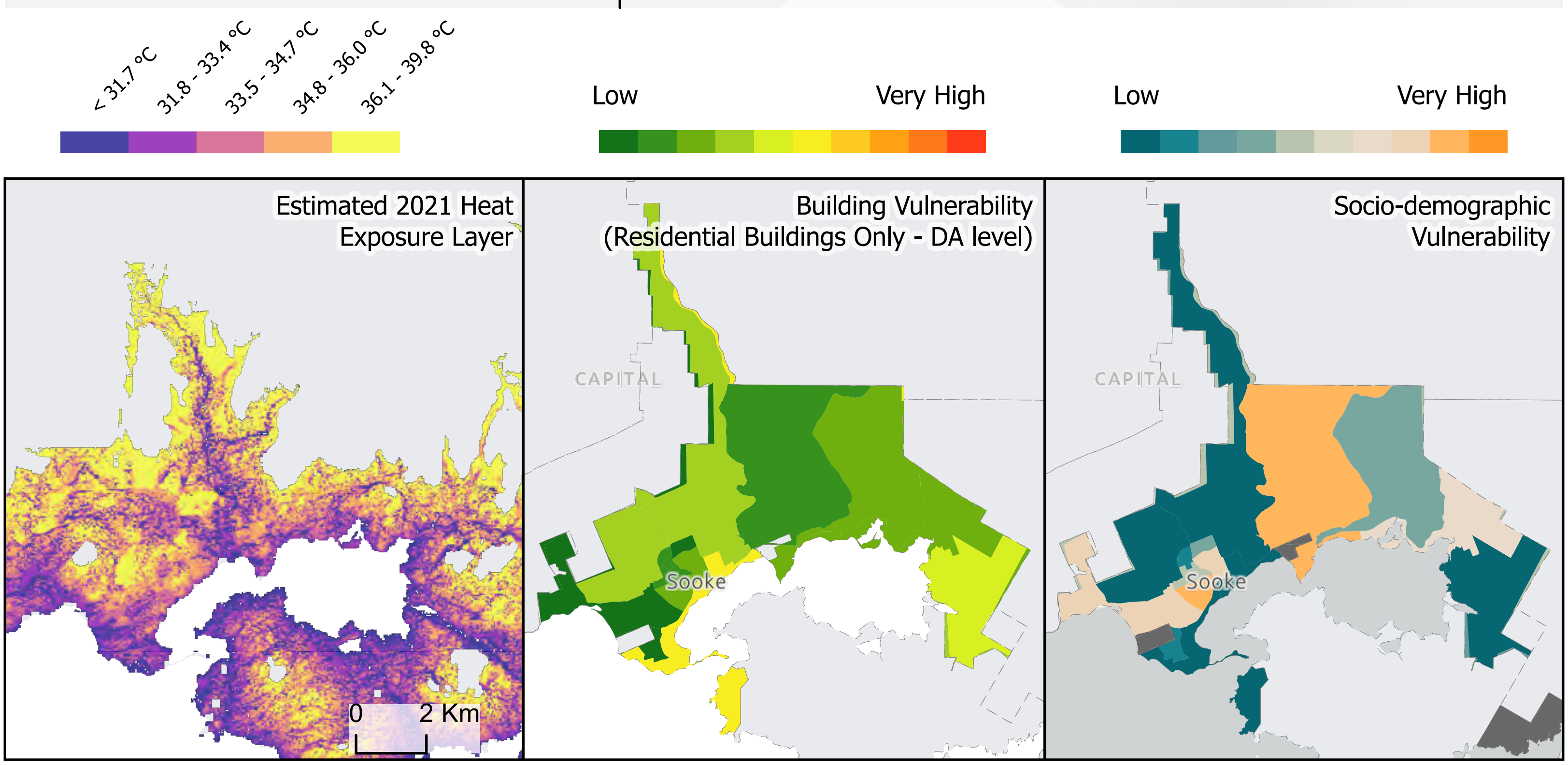
Population 2021	15,086
% population in very high Sociodemographic vulnerability	17.00%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	28.20%
Top contributing demographic factor	Population age 65 or older (20.3%)
Second contributing demographic factor	Has high (secondary) school diploma or equivalency certificate or no diploma or degree (45.9%)
Third contributing demographic factor	Outdoor Workers - Trades, transport and equipment operators and related occupations (23.2%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Chronic Obstructive Pulmonary Disease (Crude Rate)
Third contributing health factor	Hypertension (crude rate)

Building Vulnerability

Total # of residential buildings in the community	6,251
Housing type contribution to building vulnerability	5.60%
Year Built contribution to building vulnerability	19.40%
Albedo contribution to building vulnerability	29.70%
Solar insolation contribution to building vulnerability	31.60%
Building Height contribution to building vulnerability	13.70%
# of buildings with very high demographic & building vuln.	157
# of buildings in very high	753
% of residential buildings in very high	11.80%
Average age of buildings in very high	1991

Heat Exposure

% of community area in very high heat exposure	17%
% of residential buildings with very high heat exposure	15%
# of buildings with very high socio-demographic & heat expo.	9
# of residential buildings highly vulnerable across all 3 indices	0



Juan de Fuca Electoral Area (Part 1)

Demographic Vulnerability

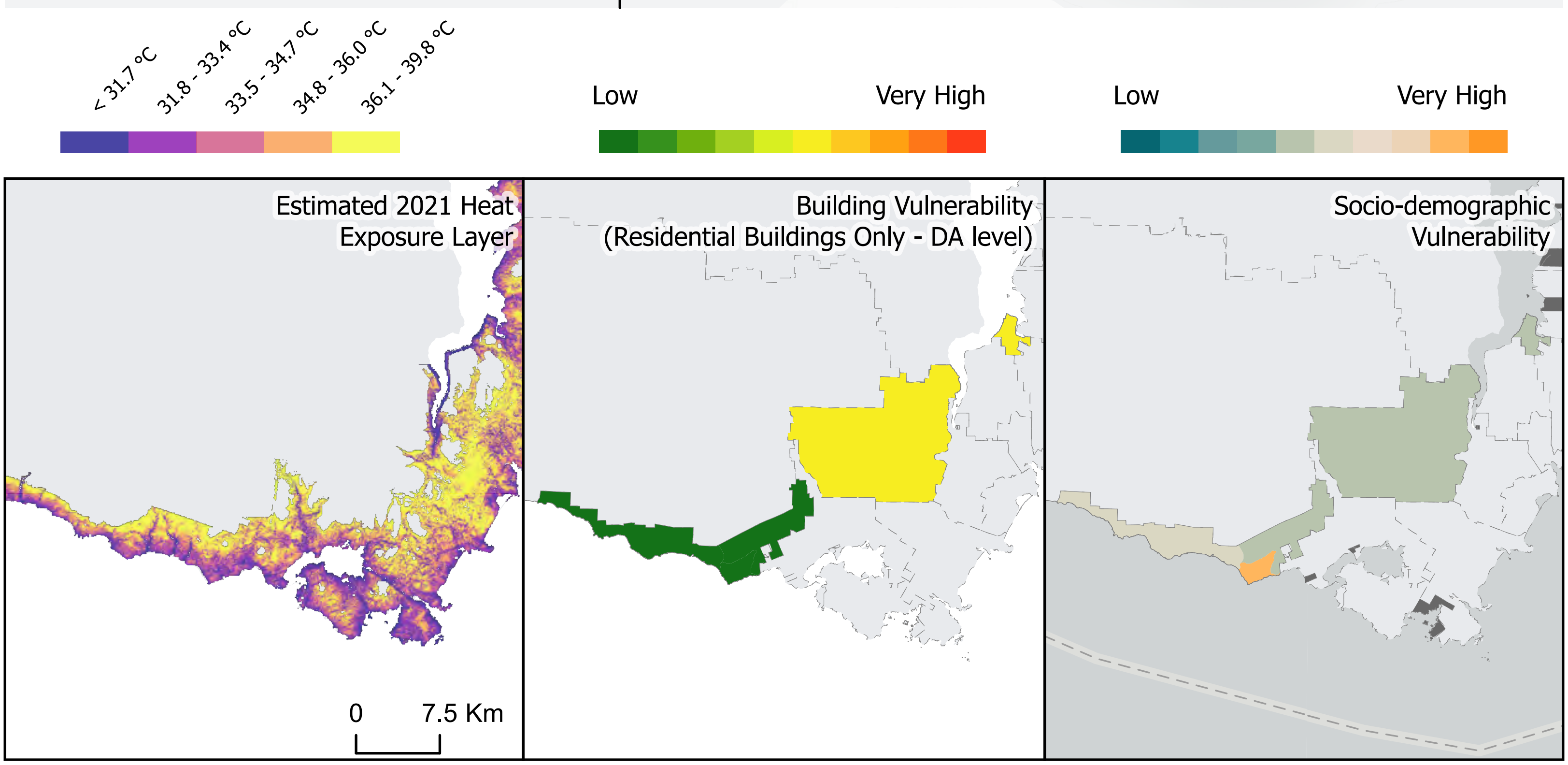
Population 2021	5,132
% population in very high Sociodemographic vulnerability	13.90%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	13.90%
Top contributing demographic factor	Population age 65 or older (20%)
Second contributing demographic factor	Has high (secondary) school diploma or equivalency certificate or no diploma or degree (25%)
Third contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (26.1%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Acute Myocardial Infarction (Crude Rate)
Third contributing health factor	Hypertension (crude rate)

Building Vulnerability

Total # of residential buildings in the community	3,040
Housing type contribution to building vulnerability	0.50%
Year Built contribution to building vulnerability	21.60%
Albedo contribution to building vulnerability	31.80%
Solar insolation contribution to building vulnerability	33.60%
Building Height contribution to building vulnerability	12.60%
# of buildings with very high demographic & building vuln.	114
# of buildings in very high	203
% of residential buildings in very high	11.80%
Average age of buildings in very high	1980

Heat Exposure

% of community area in very high heat exposure	19%
% of residential buildings with very high heat exposure	8%
# of buildings with very high socio-demographic & heat expo.	0
# of residential buildings highly vulnerable across all 3 indices	0



Juan de Fuca Electoral Area (Part 2)

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

Demographic Vulnerability

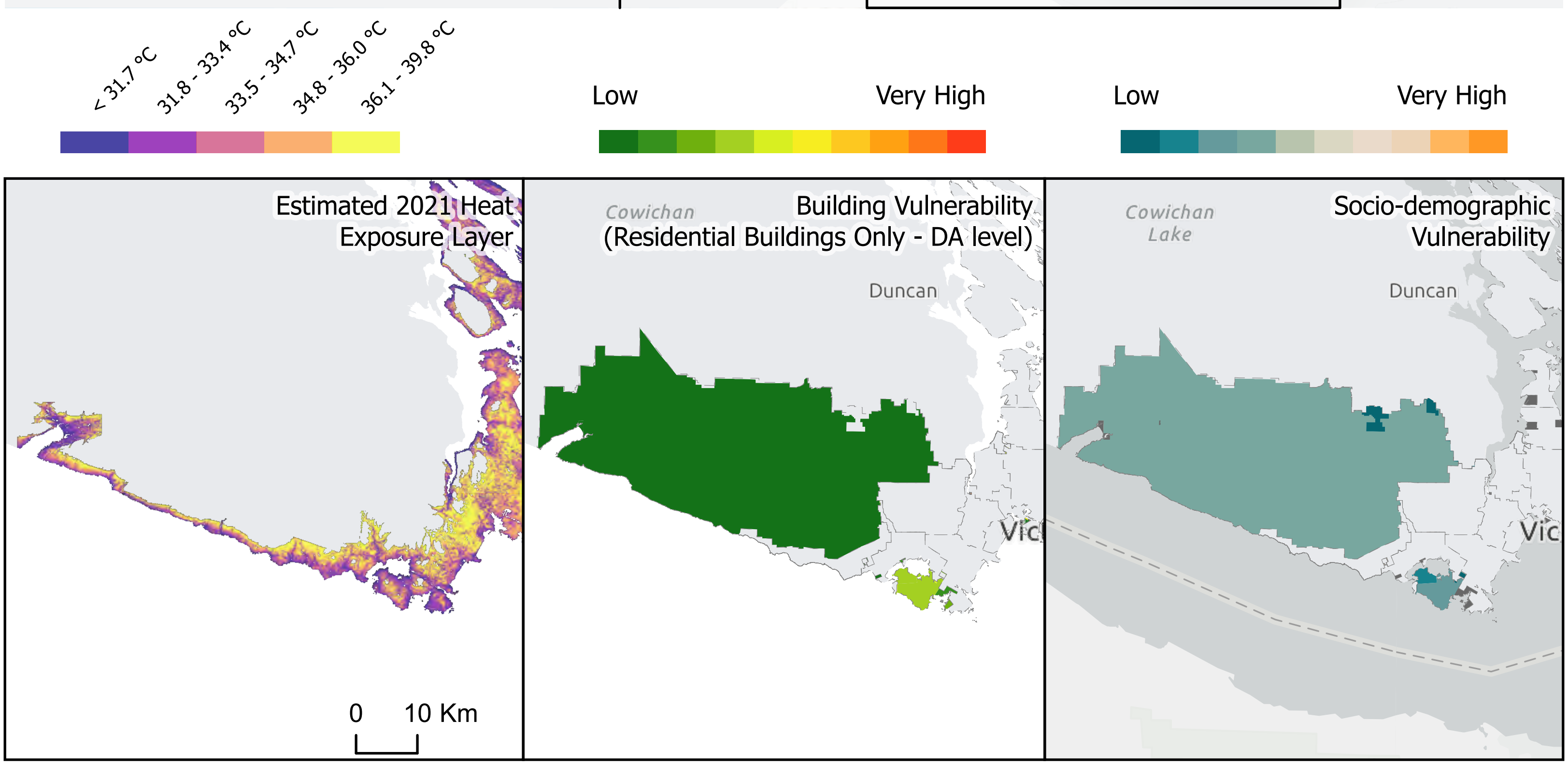
Population 2021	399
% population in very high Sociodemographic vulnerability	0.00%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	0%
Top contributing demographic factor	Average number of rooms per dwelling (6.6%)
Second contributing demographic factor	Population age 65 or older (24.1%)
Third contributing demographic factor	Living alone (10.5%)
Top contributing health factor	Chronic Obstructive Pulmonary Disease (Crude Rate)
Second contributing health factor	Acute Myocardial Infarction (Crude Rate)
Third contributing health factor	Asthma (crude rate)

Building Vulnerability

Total # of residential buildings in the community	438
Housing type contribution to building vulnerability	1.70%
Year Built contribution to building vulnerability	25.60%
Albedo contribution to building vulnerability	34.20%
Solar insolation contribution to building vulnerability	38.60%
Building Height contribution to building vulnerability	0.00%
# of buildings with very high demographic & building vuln.	nan
# of buildings in very high	21
% of residential buildings in very high	11.80%
Average age of buildings in very high	1980

Heat Exposure

% of community area in very high heat exposure	39%
% of residential buildings with very high heat exposure	5%
# of buildings with very high socio-demographic & heat expo.	0
# of residential buildings highly vulnerable across all 3 indices	0



Salt Spring Island Electoral Area

Demographic Vulnerability

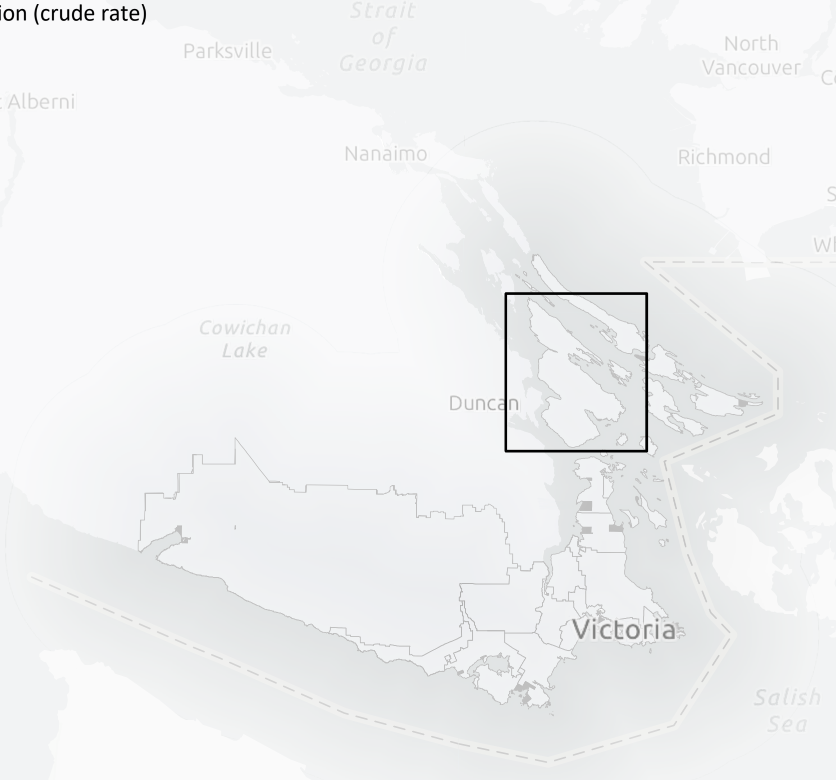
Population 2021	11,635
% population in very high Sociodemographic vulnerability	13.40%
% population in very high demographic-only vulnerability	13.40%
% population in very high Health vulnerability	13.40%
Top contributing demographic factor	Population age 65 or older (34.8%)
Second contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (28.4%)
Third contributing demographic factor	Average number of rooms per dwelling (6.1%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Chronic Obstructive Pulmonary Disease (Crude Rate)
Third contributing health factor	Hypertension (crude rate)

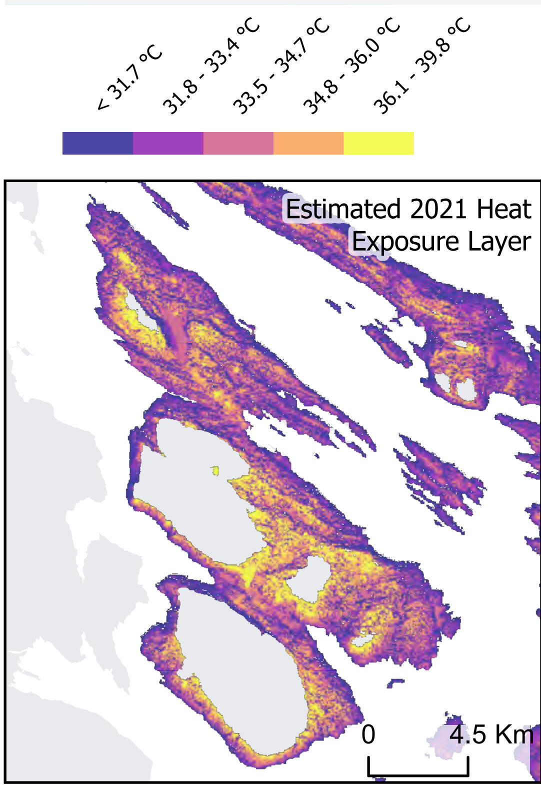
Building Vulnerability

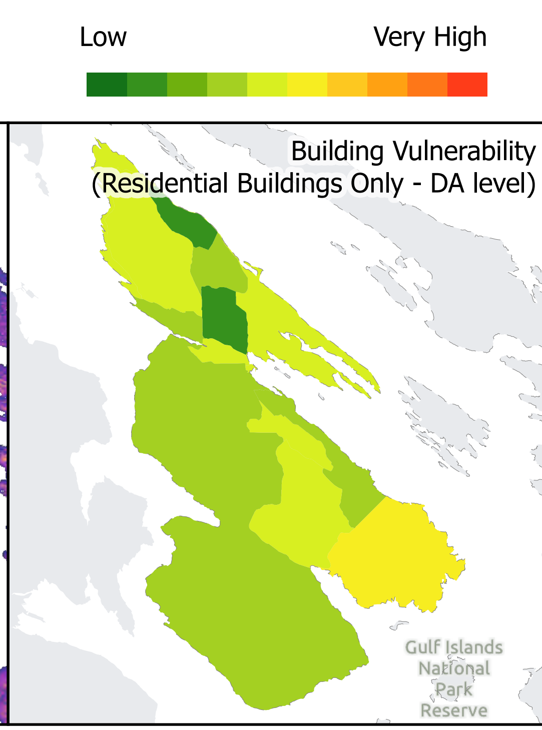
Total # of residential buildings in the community	7,212
Housing type contribution to building vulnerability	2.80%
Year Built contribution to building vulnerability	22.30%
Albedo contribution to building vulnerability	28.60%
Solar insolation contribution to building vulnerability	31.80%
Building Height contribution to building vulnerability	14.50%
# of buildings with very high demographic & building vuln.	303
# of buildings in very high	651
% of residential buildings in very high	11.80%
Average age of buildings in very high	1976

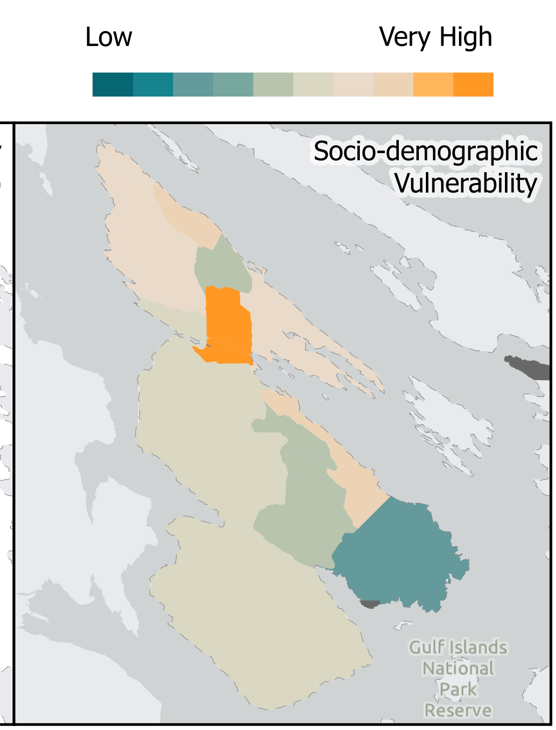
Heat Exposure

% of community area in very high heat exposure	7%
% of residential buildings with very high heat exposure	6%
# of buildings with very high socio-demographic & heat expo.	78
# of residential buildings highly vulnerable across all 3 indices	74









Southern Gulf Islands Electoral Area

Demographic Vulnerability

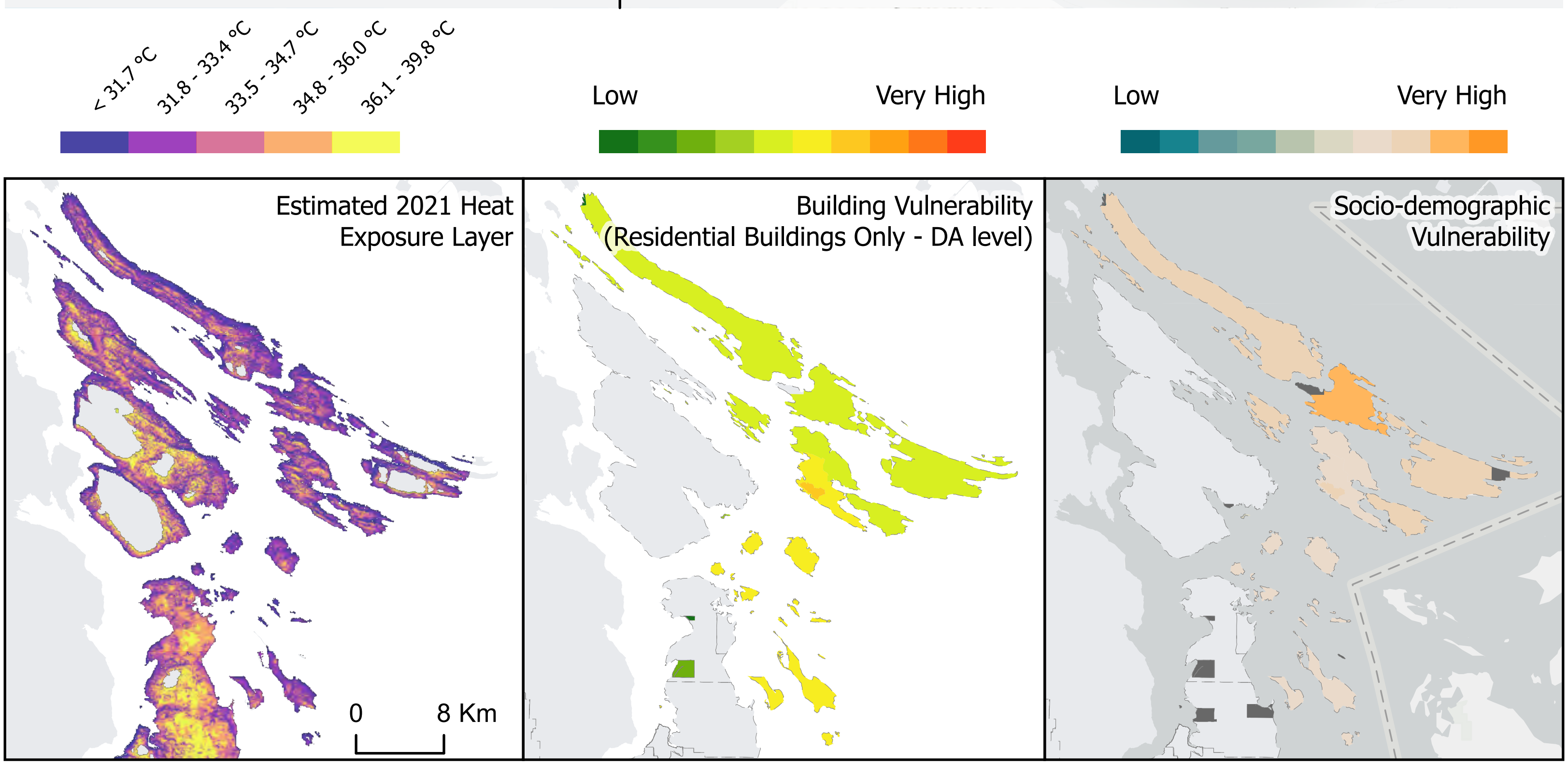
Population 2021	6,101
% population in very high Sociodemographic vulnerability	21.40%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	21.40%
Top contributing demographic factor	Population age 65 or older (42.4%)
Second contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (33.5%)
Third contributing demographic factor	Average number of rooms per dwelling (5.5%)
Top contributing health factor	Hypertension (crude rate)
Second contributing health factor	Acute Myocardial Infarction (Crude Rate)
Third contributing health factor	Chronic Obstructive Pulmonary Disease (Crude Rate)

Building Vulnerability

Total # of residential buildings in the community	6,329
Housing type contribution to building vulnerability	1.40%
Year Built contribution to building vulnerability	22.40%
Albedo contribution to building vulnerability	29.20%
Solar insolation contribution to building vulnerability	31.80%
Building Height contribution to building vulnerability	15.20%
# of buildings with very high demographic & building vuln.	59
# of buildings in very high	271
% of residential buildings in very high	11.80%
Average age of buildings in very high	1970

Heat Exposure

% of community area in very high heat exposure	1%
% of residential buildings with very high heat exposure	0%
# of buildings with very high socio-demographic & heat expo.	8
# of residential buildings highly vulnerable across all 3 indices	0



The Corporation of the City of Victoria

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

Demographic Vulnerability

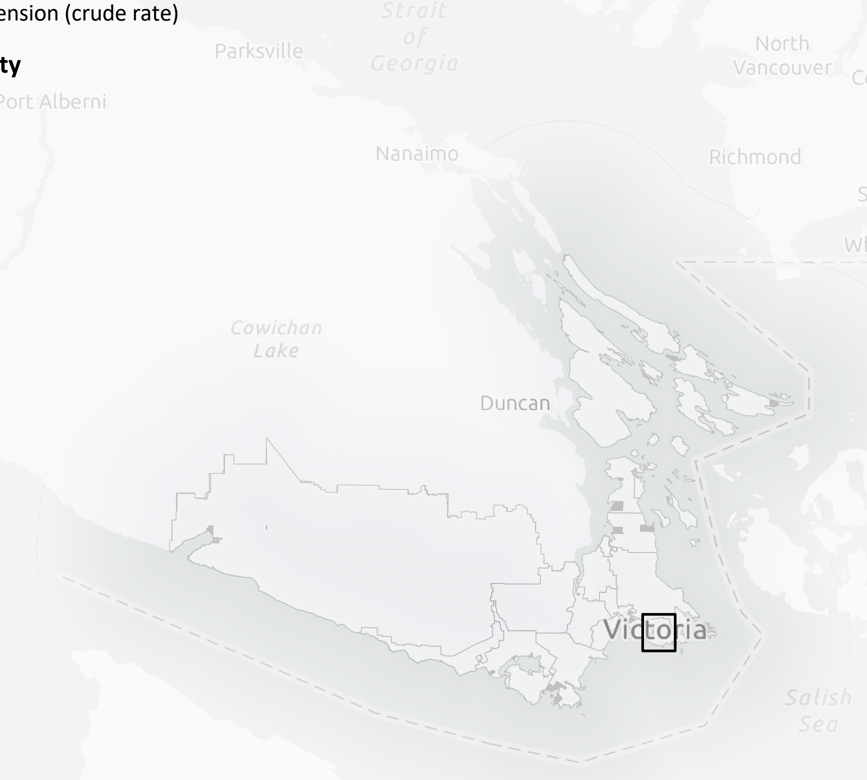
Population 2021	91,867
% population in very high Sociodemographic vulnerability	34.70%
% population in very high demographic-only vulnerability	57.00%
% population in very high Health vulnerability	25.80%
Top contributing demographic factor	Population that are renters (60.5%)
Second contributing demographic factor	Living alone (27.4%)
Third contributing demographic factor	Population age 65 or older (23.2%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Chronic Obstructive Pulmonary Disease (Crude Rate)
Third contributing health factor	Hypertension (crude rate)

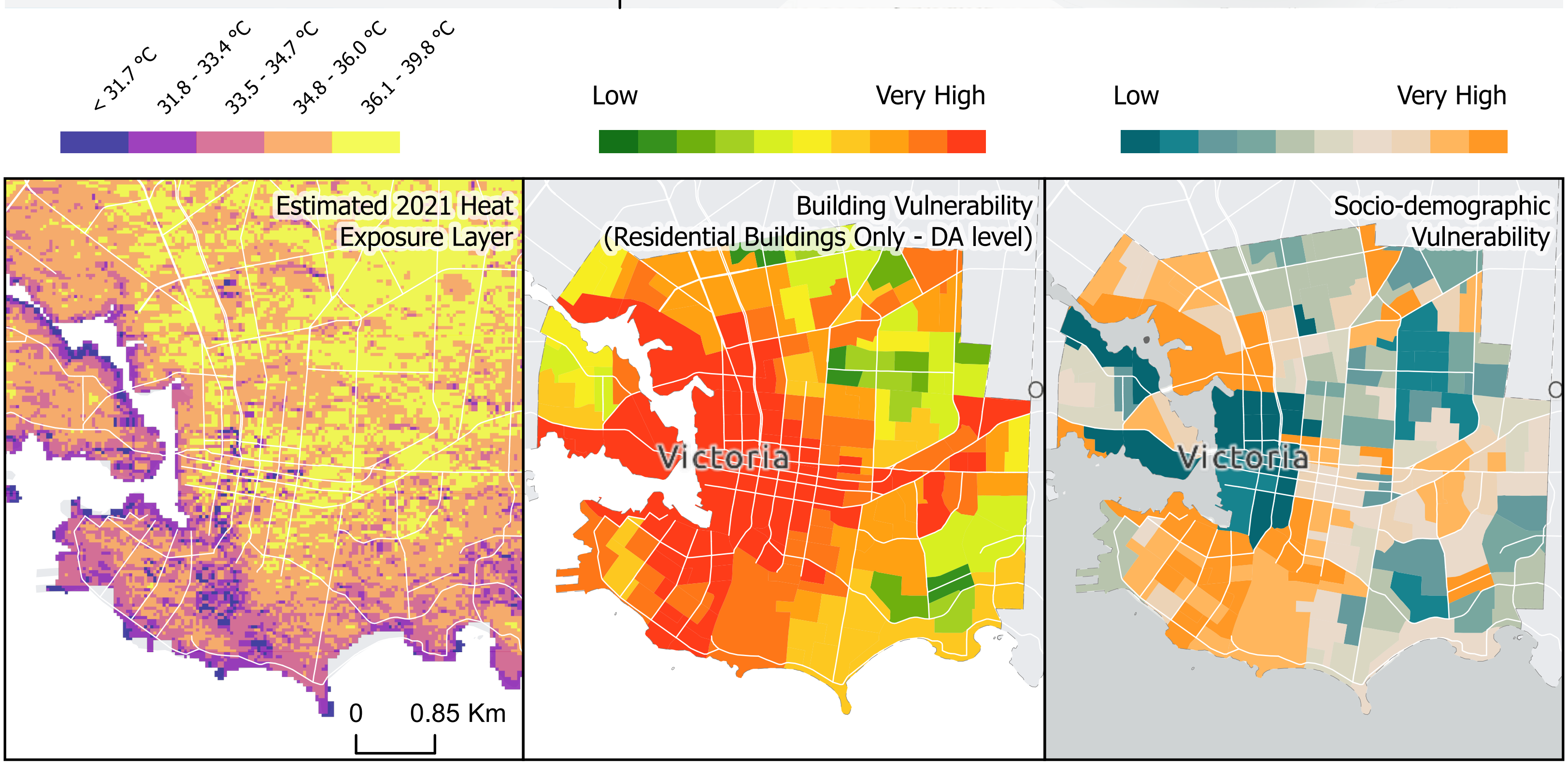
Building Vulnerability

Total # of residential buildings in the community	13,753
Housing type contribution to building vulnerability	5.80%
Year Built contribution to building vulnerability	23.40%
Albedo contribution to building vulnerability	28.00%
Solar insolation contribution to building vulnerability	28.80%
Building Height contribution to building vulnerability	14.10%
# of buildings with very high demographic & building vuln.	1,774
# of buildings in very high	7,583
% of residential buildings in very high	11.80%
Average age of buildings in very high	1941

Heat Exposure

% of community area in very high heat exposure	16%
% of residential buildings with very high heat exposure	19%
# of buildings with very high socio-demographic & heat expo.	485
# of residential buildings highly vulnerable across all 3 indices	229





The Corporation of the District of Central Saanich

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

Demographic Vulnerability

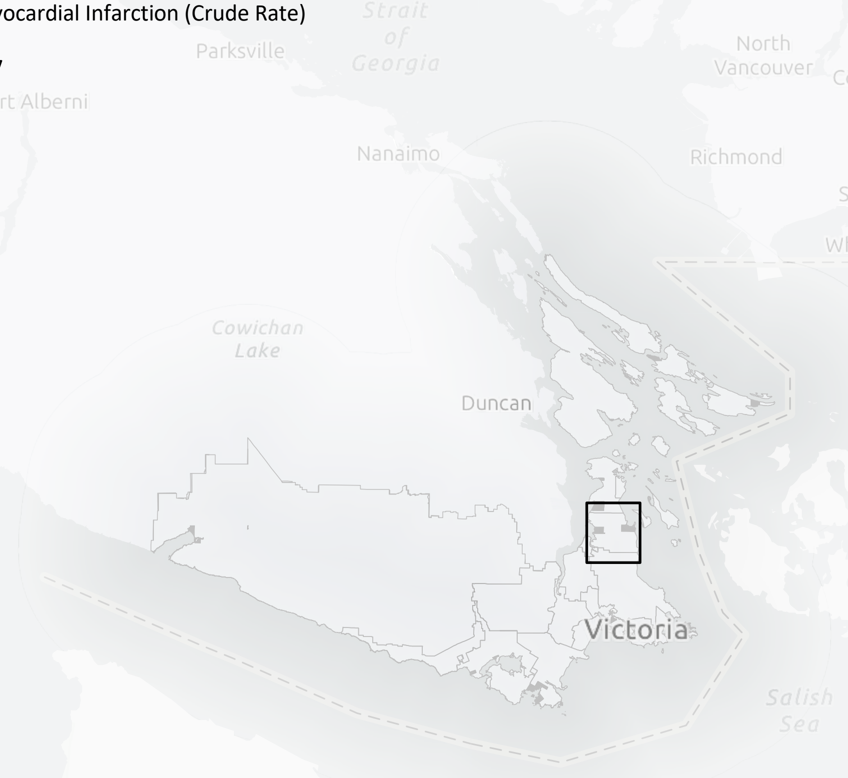
Population 2021	17,385
% population in very high Sociodemographic vulnerability	17.70%
% population in very high demographic-only vulnerability	5.20%
% population in very high Health vulnerability	21.10%
Top contributing demographic factor	Population age 65 or older (27.2%)
Second contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (23.3%)
Third contributing demographic factor	Population that are renters (20.1%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Hypertension (crude rate)
Third contributing health factor	Acute Myocardial Infarction (Crude Rate)

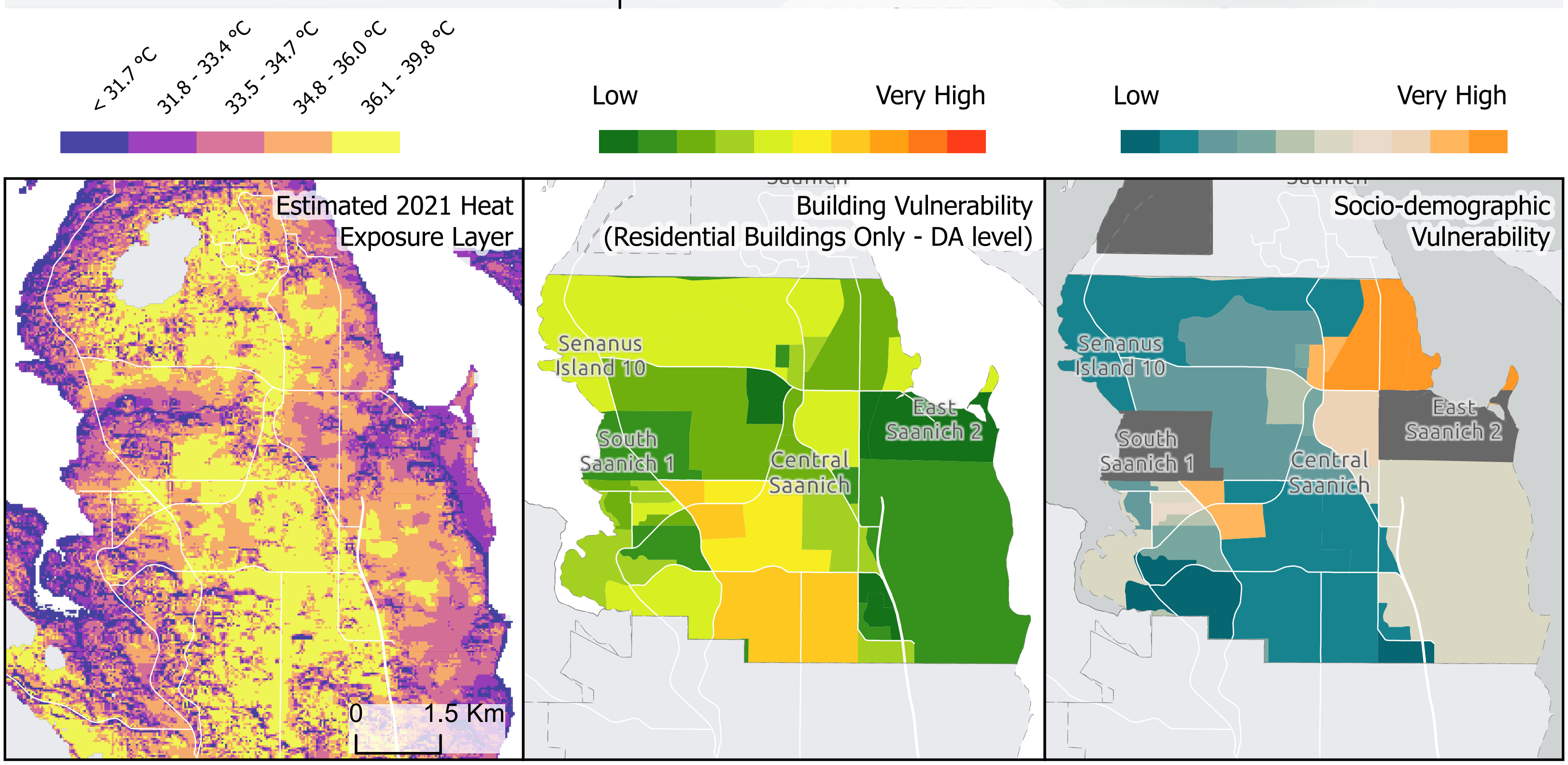
Building Vulnerability

Total # of residential buildings in the community	5,908
Housing type contribution to building vulnerability	2.30%
Year Built contribution to building vulnerability	23.40%
Albedo contribution to building vulnerability	29.80%
Solar insolation contribution to building vulnerability	30.90%
Building Height contribution to building vulnerability	13.70%
# of buildings with very high demographic & building vuln.	113
# of buildings in very high	742
% of residential buildings in very high	11.80%
Average age of buildings in very high	1972

Heat Exposure

% of community area in very high heat exposure	25%
% of residential buildings with very high heat exposure	43%
# of buildings with very high socio-demographic & heat expo.	324
# of residential buildings highly vulnerable across all 3 indices	60





The Corporation of the District of Oak Bay

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

Demographic Vulnerability

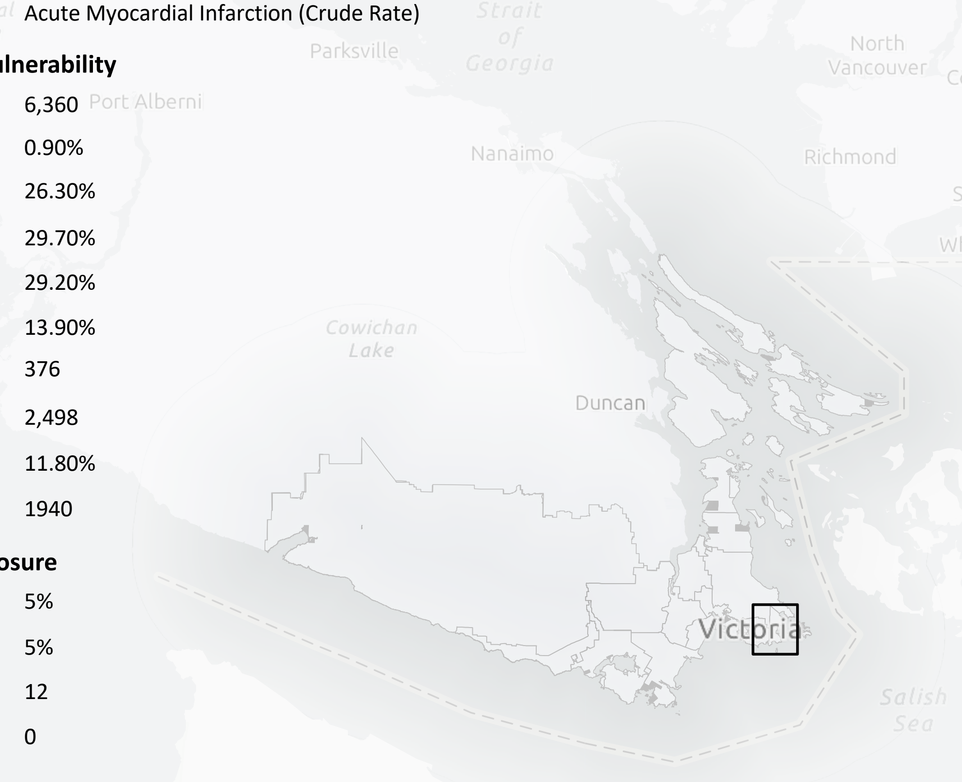
Population 2021	17,990
% population in very high Sociodemographic vulnerability	21.70%
% population in very high demographic-only vulnerability	29.00%
% population in very high Health vulnerability	18.90%
Top contributing demographic factor	Population age 65 or older (34.2%)
Second contributing demographic factor	Housing Built Before 1960 (59%)
Third contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (25.7%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Hypertension (crude rate)
Third contributing health factor	Acute Myocardial Infarction (Crude Rate)

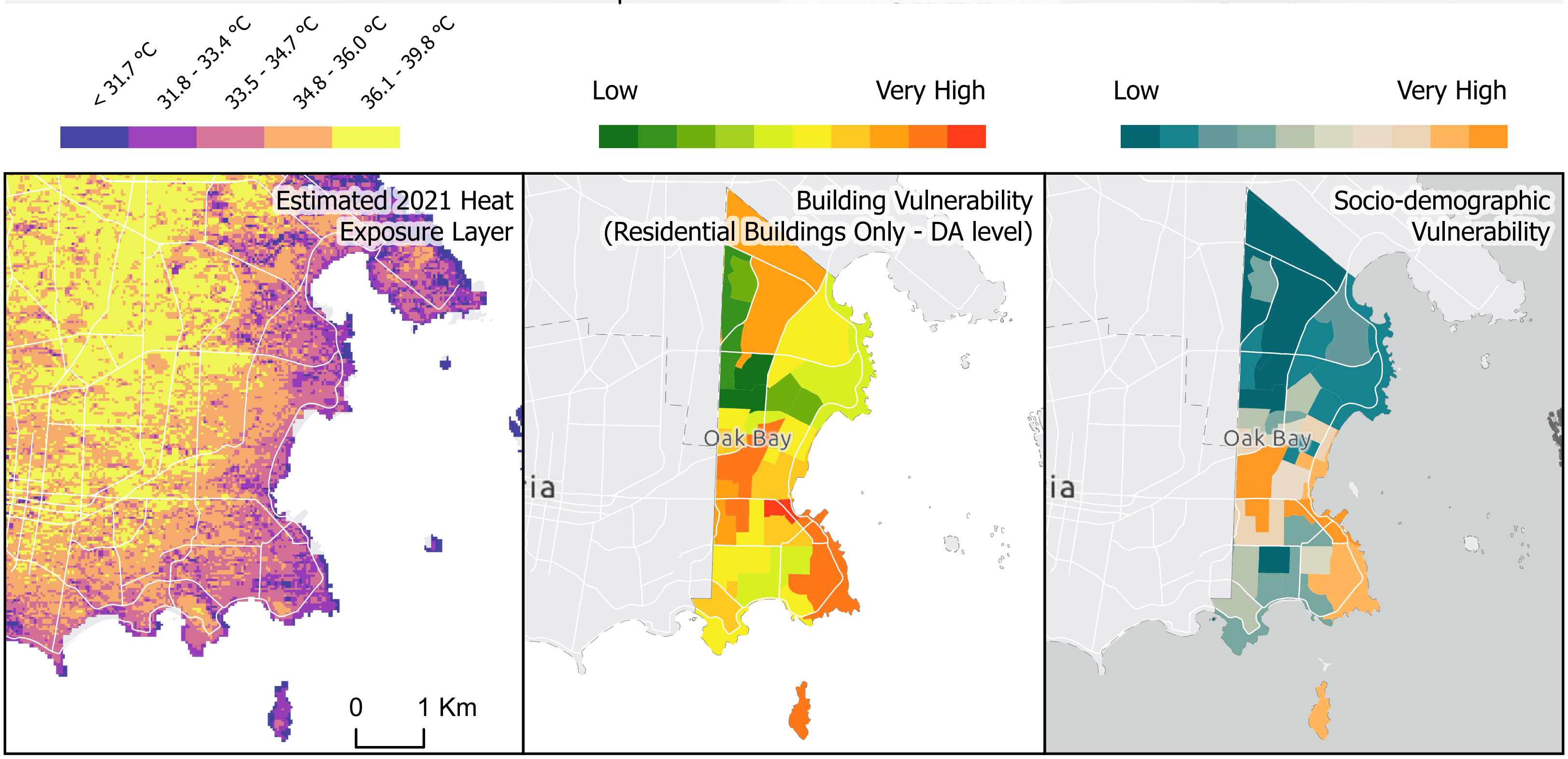
Building Vulnerability

Total # of residential buildings in the community	6,360
Housing type contribution to building vulnerability	0.90%
Year Built contribution to building vulnerability	26.30%
Albedo contribution to building vulnerability	29.70%
Solar insolation contribution to building vulnerability	29.20%
Building Height contribution to building vulnerability	13.90%
# of buildings with very high demographic & building vuln.	376
# of buildings in very high	2,498
% of residential buildings in very high	11.80%
Average age of buildings in very high	1940

Heat Exposure

% of community area in very high heat exposure	5%
% of residential buildings with very high heat exposure	5%
# of buildings with very high socio-demographic & heat expo.	12
# of residential buildings highly vulnerable across all 3 indices	0





The Corporation of the District of Saanich

Demographic Vulnerability

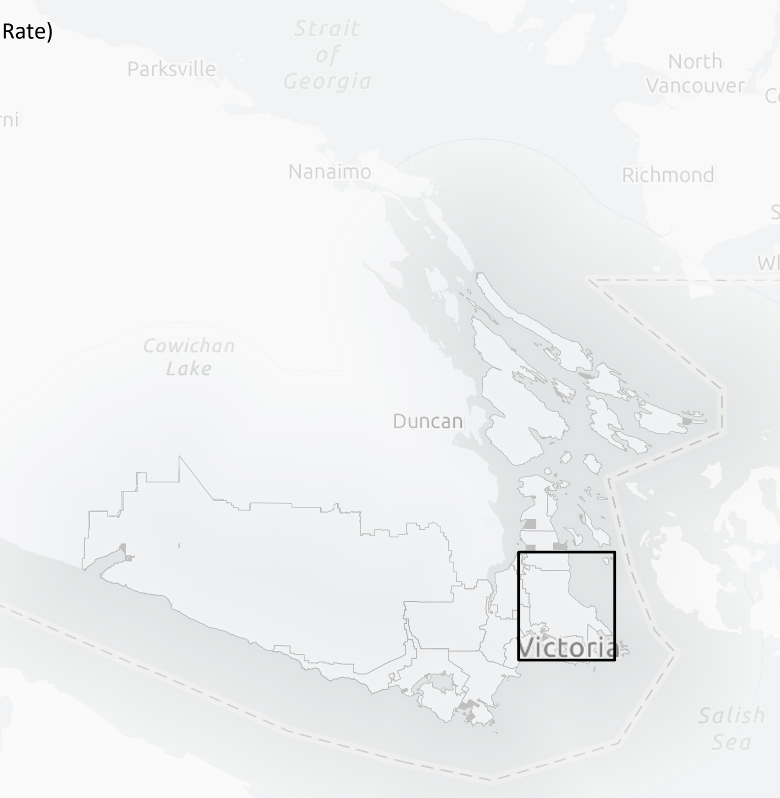
Population 2021	117,735
% population in very high Sociodemographic vulnerability	12.70%
% population in very high demographic-only vulnerability	8.20%
% population in very high Health vulnerability	14.10%
Top contributing demographic factor	Population age 65 or older (23.1%)
Second contributing demographic factor	Population that are renters (30.8%)
Third contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (18.2%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Hypertension (crude rate)
Third contributing health factor	Diabetes (Crude Rate)

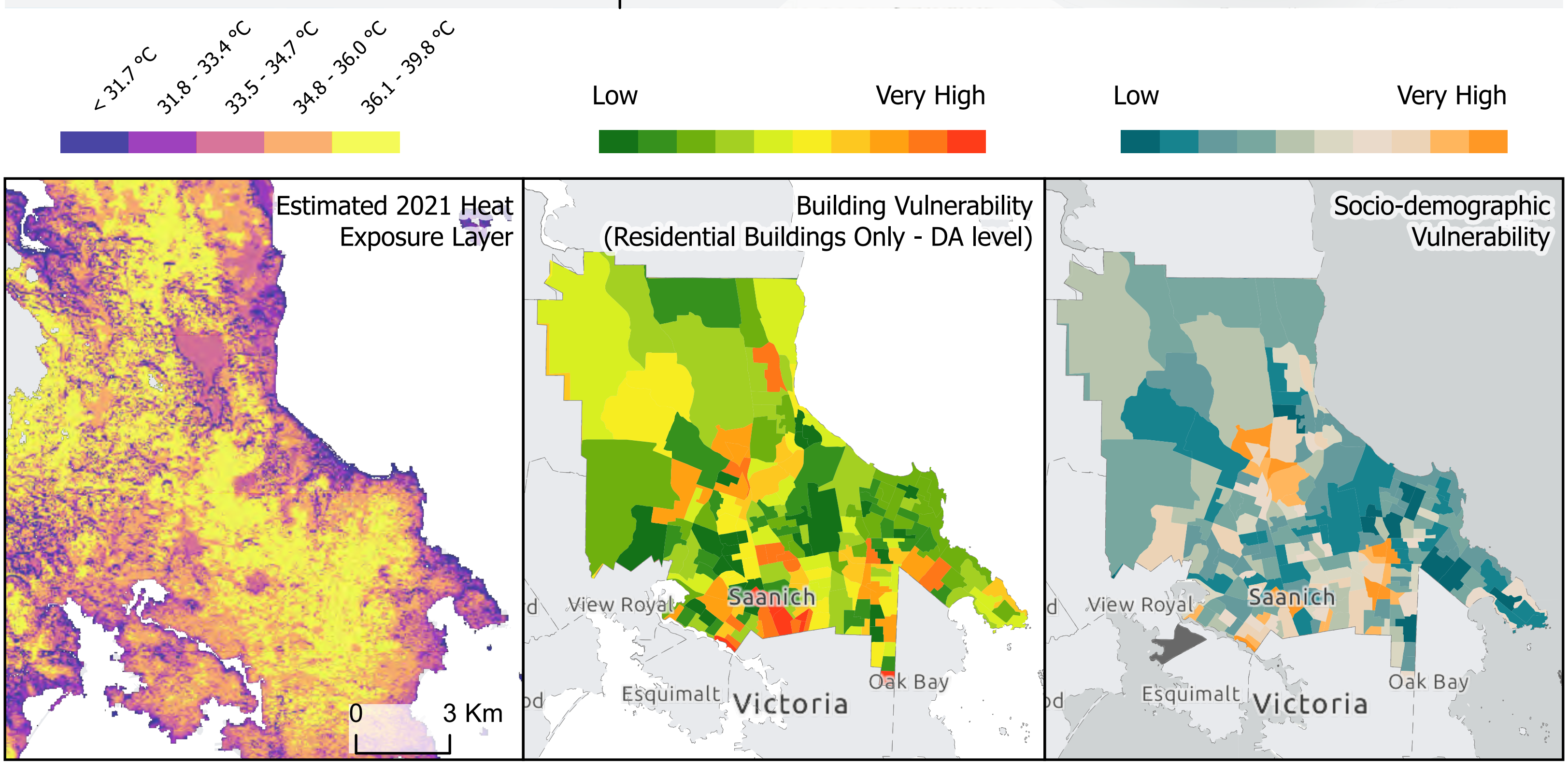
Building Vulnerability

Total # of residential buildings in the community	35,638
Housing type contribution to building vulnerability	1.60%
Year Built contribution to building vulnerability	24.90%
Albedo contribution to building vulnerability	29.70%
Solar insolation contribution to building vulnerability	30.40%
Building Height contribution to building vulnerability	13.50%
# of buildings with very high demographic & building vuln.	806
# of buildings in very high	6,873
% of residential buildings in very high	11.80%
Average age of buildings in very high	1960

Heat Exposure

% of community area in very high heat exposure	28%
% of residential buildings with very high heat exposure	36%
# of buildings with very high socio-demographic & heat expo.	1,542
# of residential buildings highly vulnerable across all 3 indices	454





The Corporation of the Township of Esquimalt

Heat Vulnerability Data & Analysis Project
Prepared for The Capital Regional District

Demographic Vulnerability

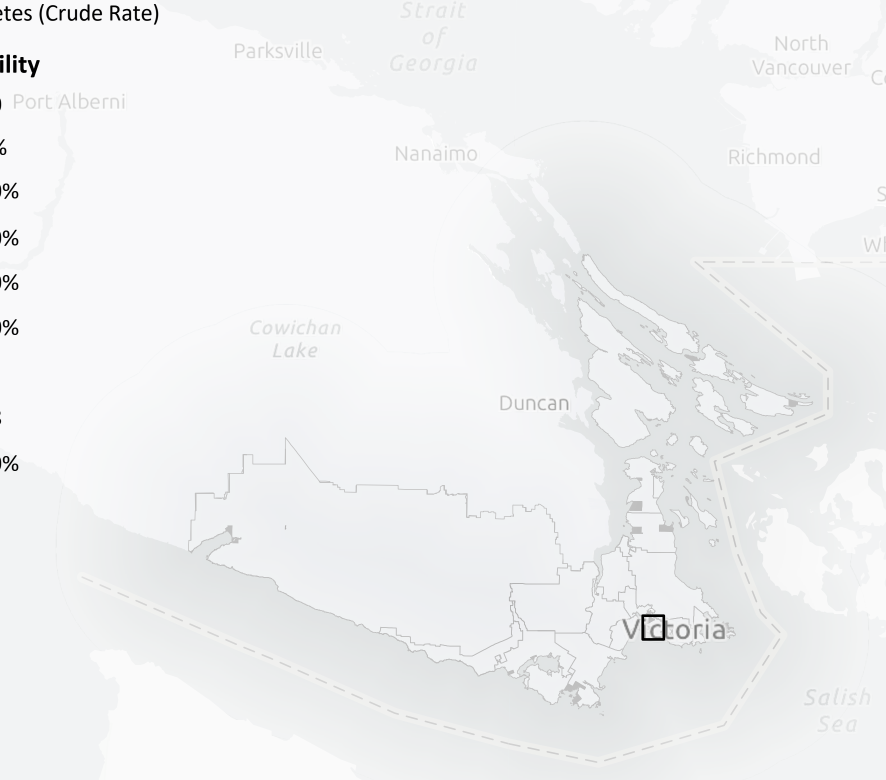
Population 2021	17,533
% population in very high Sociodemographic vulnerability	36.60%
% population in very high demographic-only vulnerability	21.20%
% population in very high Health vulnerability	32.70%
Top contributing demographic factor	Population that are renters (51.1%)
Second contributing demographic factor	Population age 65 or older (20.7%)
Third contributing demographic factor	Average number of rooms per dwelling (5.1%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Chronic Obstructive Pulmonary Disease (Crude Rate)
Third contributing health factor	Diabetes (Crude Rate)

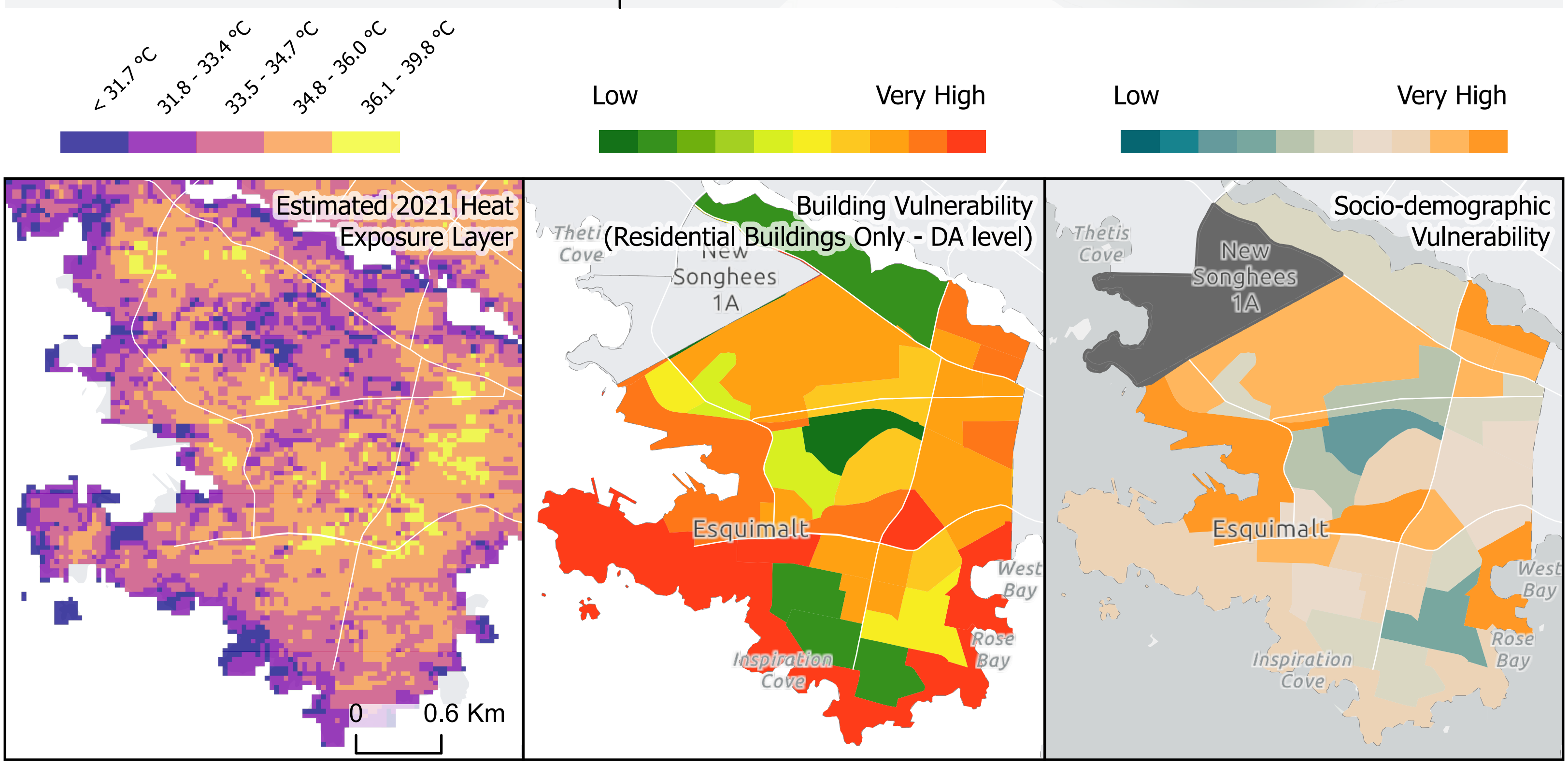
Building Vulnerability

Total # of residential buildings in the community	3,410
Housing type contribution to building vulnerability	3.90%
Year Built contribution to building vulnerability	25.00%
Albedo contribution to building vulnerability	28.40%
Solar insolation contribution to building vulnerability	29.50%
Building Height contribution to building vulnerability	13.20%
# of buildings with very high demographic & building vuln.	289
# of buildings in very high	1,138
% of residential buildings in very high	11.80%
Average age of buildings in very high	1956

Heat Exposure

% of community area in very high heat exposure	1%
% of residential buildings with very high heat exposure	1%
# of buildings with very high socio-demographic & heat expo.	8
# of residential buildings highly vulnerable across all 3 indices	0





Town of Sidney

Demographic Vulnerability

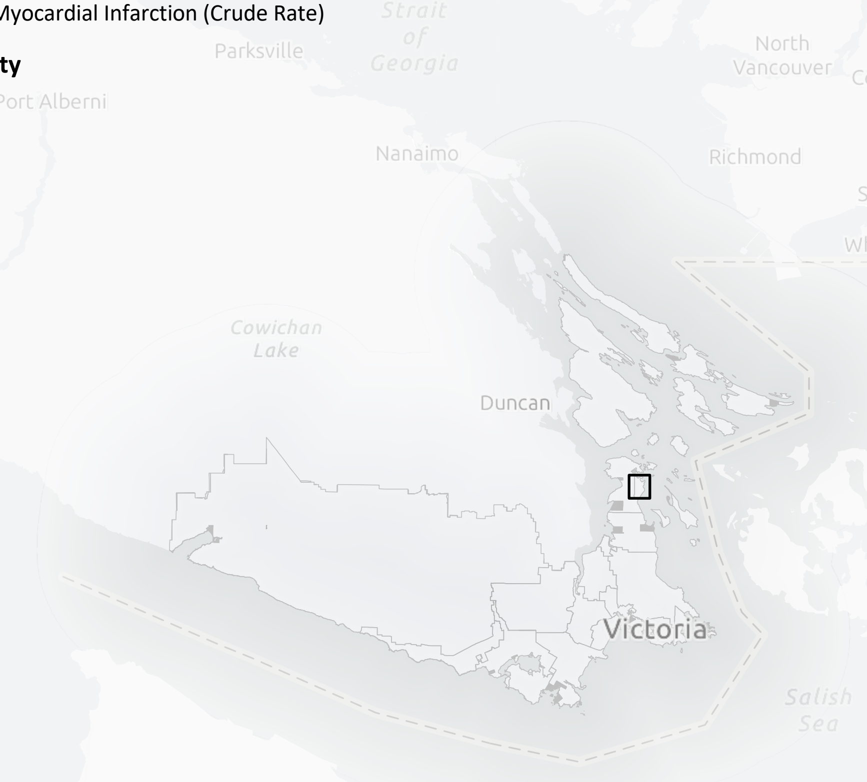
Population 2021	12,318
% population in very high Sociodemographic vulnerability	62.60%
% population in very high demographic-only vulnerability	41.80%
% population in very high Health vulnerability	68.90%
Top contributing demographic factor	Population age 65 or older (45%)
Second contributing demographic factor	Private households by age of primary household maintainers - 65 years and over (25%)
Third contributing demographic factor	Living alone (19.6%)
Top contributing health factor	Hypertension (crude rate)
Second contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Third contributing health factor	Acute Myocardial Infarction (Crude Rate)

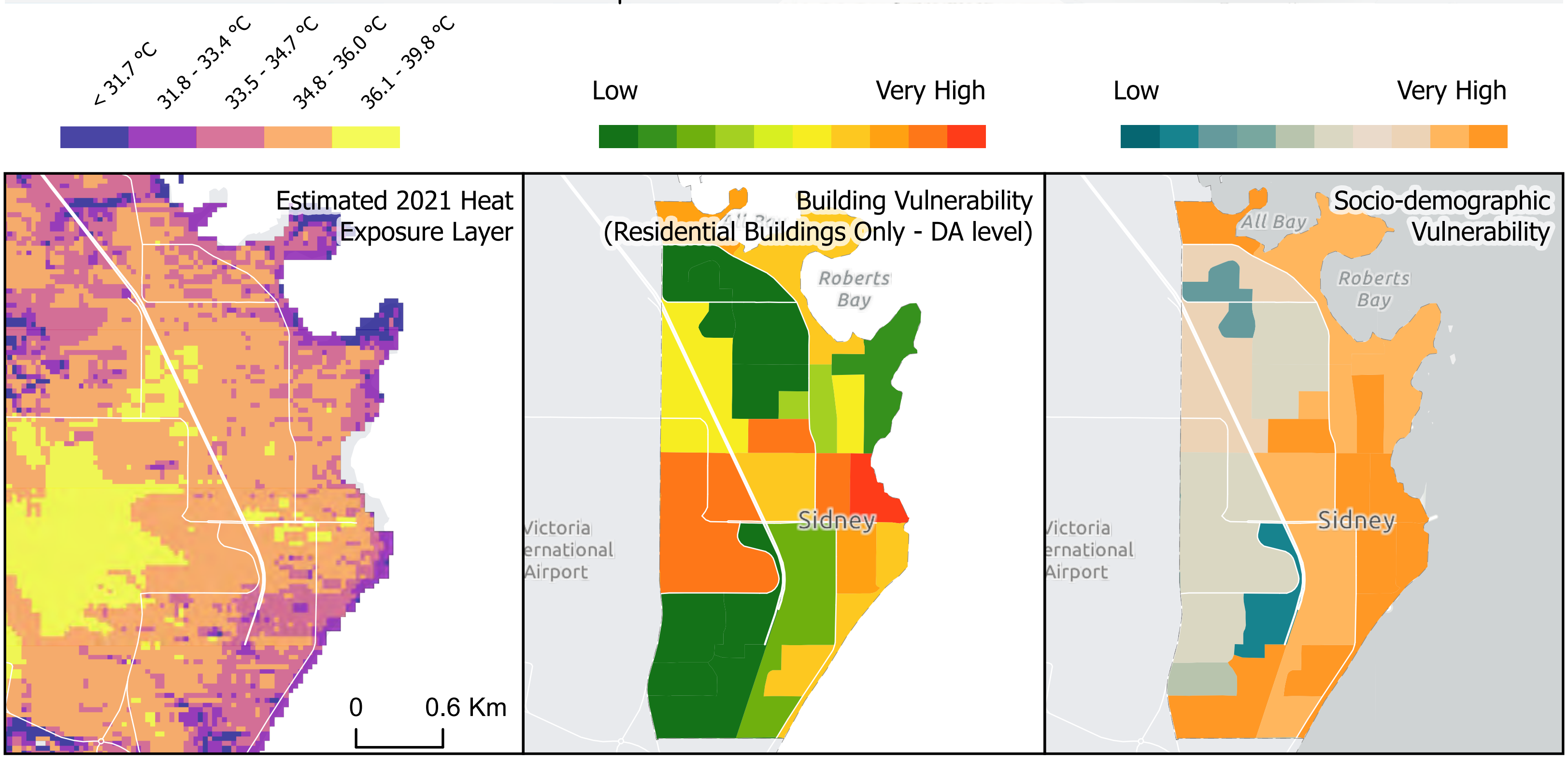
Building Vulnerability

Total # of residential buildings in the community	3,274
Housing type contribution to building vulnerability	5.60%
Year Built contribution to building vulnerability	21.30%
Albedo contribution to building vulnerability	28.20%
Solar insolation contribution to building vulnerability	32.20%
Building Height contribution to building vulnerability	12.80%
# of buildings with very high demographic & building vuln.	628
# of buildings in very high	941
% of residential buildings in very high	11.80%
Average age of buildings in very high	1978

Heat Exposure

% of community area in very high heat exposure	2%
% of residential buildings with very high heat exposure	1%
# of buildings with very high socio-demographic & heat expo.	2
# of residential buildings highly vulnerable across all 3 indices	0





Town of View Royal

Demographic Vulnerability

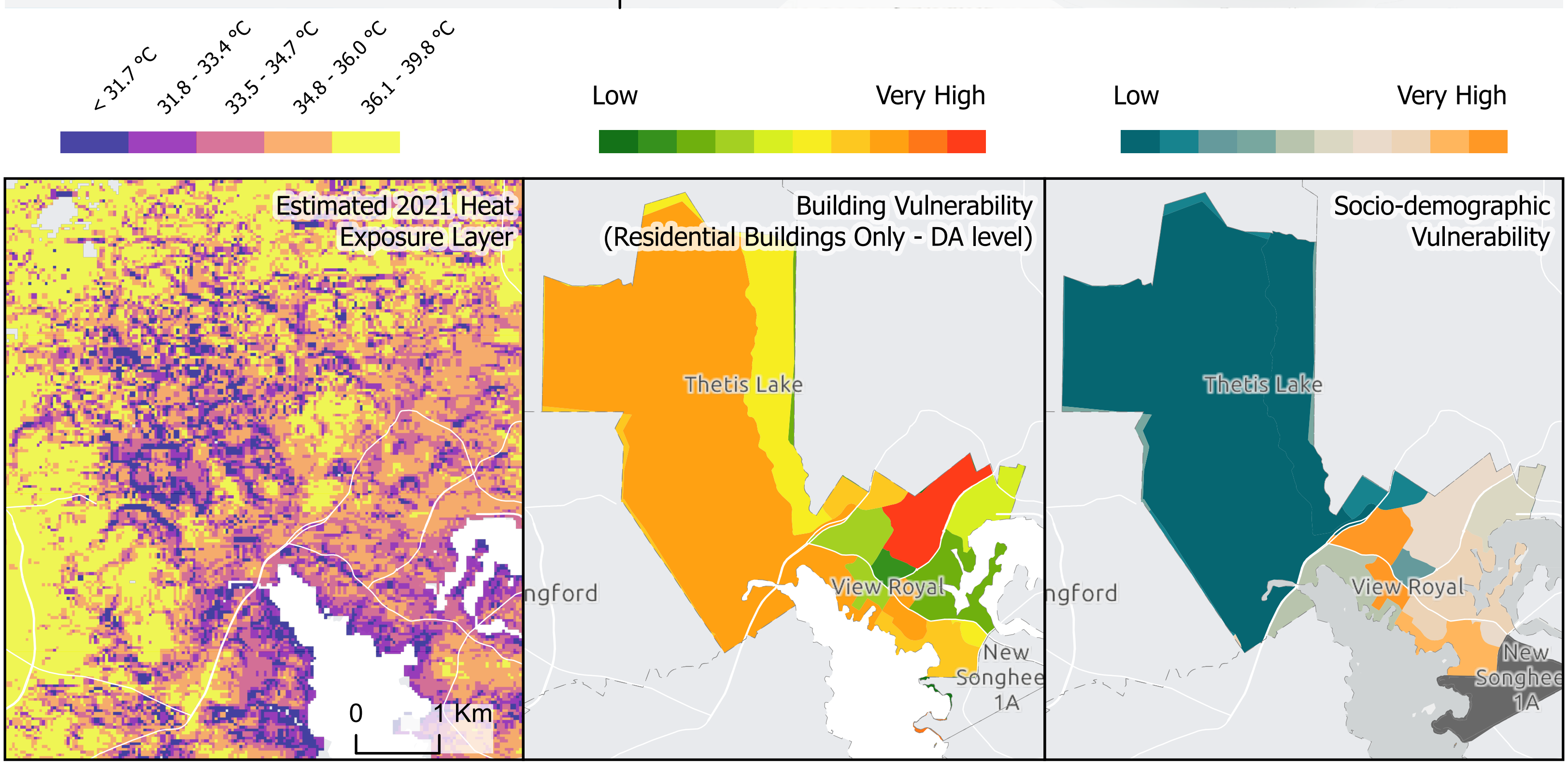
Population 2021	11,575
% population in very high Sociodemographic vulnerability	14.20%
% population in very high demographic-only vulnerability	0%
% population in very high Health vulnerability	20.00%
Top contributing demographic factor	Population that are renters (32.6%)
Second contributing demographic factor	Population age 65 or older (20.9%)
Third contributing demographic factor	Average number of rooms per dwelling (5.9%)
Top contributing health factor	Episodic Mood Anxiety Disorders Prevalence (Crude Rate)
Second contributing health factor	Hypertension (crude rate)
Third contributing health factor	Diabetes (Crude Rate)

Building Vulnerability

Total # of residential buildings in the community	2,788
Housing type contribution to building vulnerability	3.00%
Year Built contribution to building vulnerability	21.50%
Albedo contribution to building vulnerability	30.60%
Solar insolation contribution to building vulnerability	30.60%
Building Height contribution to building vulnerability	14.20%
# of buildings with very high demographic & building vuln.	55
# of buildings in very high	360
% of residential buildings in very high	11.80%
Average age of buildings in very high	1978

Heat Exposure

% of community area in very high heat exposure	11%
% of residential buildings with very high heat exposure	4%
# of buildings with very high socio-demographic & heat expo.	4
# of residential buildings highly vulnerable across all 3 indices	0



Making a difference...together

ECA 24-13

REPORT TO ENVIRONMENTAL SERVICES COMMITTEE
MEETING OF WEDNESDAY, MARCH 20, 2024

SUBJECT **Climate Projections for the Capital Region**

ISSUE SUMMARY

To present the updated report, *Climate Projections for the Capital Region (2024).*

BACKGROUND

In 2017, the CRD Climate Action service engaged the Pacific Climate Impacts Consortium (PCIC) to complete the first scientific analysis of downscaled climate projections for the capital region. In 2023, the PCIC was reengaged to update the downscaled regional climate projections and results are provided in an updated report *Climate Projections for the Capital Region (2024)* (see Appendix A).

Climate science has been evolving since the CRD published the first climate projections report, and new information is now available to reevaluate the projections and provide the most up-to-date information on how the region's climate may change by the middle and end of this century. The report provides a common understanding of how projected changes in temperature and precipitation will play out locally, how impacts will differ throughout the seasons, and what the effect could be of new climate extremes. The report identifies some potential impacts of climate change on different sectors of the region, based on consultation with CRD and municipal staff.

The report is based on new scientific modelling and includes new indices for extreme heat, as well as a new guidance section to support users of the report and accompanying data. The report, along with other data and modelling efforts completed by the PCIC, will serve as a resource for local and regional planners, engineers, land managers, policymakers and decision makers to make better-informed decisions.

At a high level, the results of this study show that in the coming decades, the capital region can expect:

- warmer summer temperatures, with more extreme heat days and heatwaves
- warmer nights and a longer growing season
- less rain and more dry days in the summer months
- warmer winter temperatures and less frequent frost
- more precipitation falling in fall, winter and spring
- less snowfall and more rain in the colder months
- more rain delivered in extreme rainfall events

Next Steps

The CRD Climate Action service will continue to support regional climate adaptation planning efforts. Near-term actions include:

- Sharing the report results with CRD and local government staff, First Nations and other regional stakeholders.
- Developing public educational materials linking report results with associated actions for use by the CRD, local governments and other regional stakeholders.

- Supporting future climate adaptation planning efforts, including identifying data gaps and costs associated with future local or regional studies and programming, with municipal/electoral area governments (i.e., the CRD's Climate Action Inter-Municipal Working and Task Force).
- Supporting the completion of other climate adaptation-related actions identified in the CRD's Climate Action Strategy (2021).

Furthermore, the CRD will consider the results for regional service delivery in operational plans and long-range infrastructure planning.

ALTERNATIVES

Alternative 1
The Environmental Services Committee recommends to the Capital Regional District Board:
That the *Climate Projections for the Capital Region (2024)* report be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

Alternative 2
That this report be referred back to staff for additional information.

IMPLICATIONS

Alignment with Board & Corporate Priorities
The recommendations align with the Board's priority Climate Action & Environment initiative 3c to increase resilience, community and adaptation planning to address climate-related risks and disasters.

Alignment with Existing Plans & Strategies
The recommendations align with goal 2 of the CRD Climate Action Strategy to support the region on its pathway to livable, affordable and low-carbon communities that are prepared for climate change, and specifically contributes to the completion of action 2-4d to expand data collection and mapping efforts to identify vulnerabilities to the impacts of climate change.

Intergovernmental Implications
The data and mapping components can help local authorities prepare for climate impacts. By examining climate projections, community planners and emergency managers can better inform planning and policy initiatives. The data can also be used when updating local hazard, risk and vulnerability analyses (i.e., HRVAs). CRD staff will continue to engage the region's local governments through the CRD's Climate Action Inter-Municipal Working and Task Force on better understanding new climate adaptation related policy approaches and supporting implementation of existing programs and policies in a collaborative manner.

CONCLUSION

The recently completed report, *Climate Projections for the Capital Region (2024)*, expands upon climate change data analysis previously undertaken by the Pacific Climate Impacts Consortium and the CRD. Using the most recent scientific information, the study updated high-resolution climate projections for the capital region to better understand how our climate may change by the 2030s, 2050s and 2080s. The report is based on the work undertaken by the Pacific Climate Impacts Consortium, with support from the CRD, and was developed in consultation with CRD and municipal staff working groups. The report benefits multiple services within the CRD, as well as all local and First Nations governments and community partners in the region in becoming resilient to a changing climate.

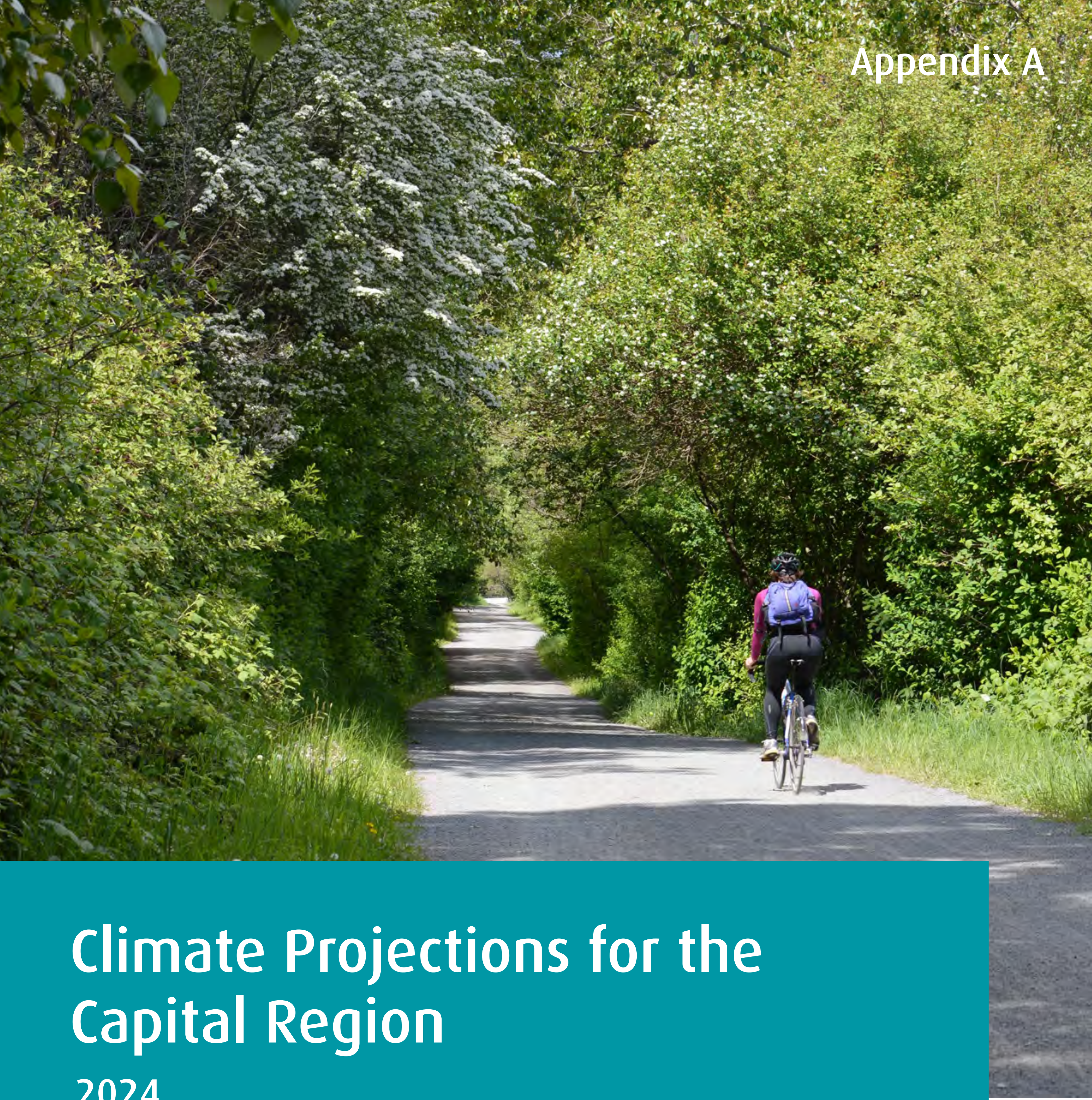
RECOMMENDATION

The Environmental Services Committee recommends to the Capital Regional District Board:
That the *Climate Projections for the Capital Region (2024)* report be referred to municipal councils, the Electoral Areas Committee and First Nations for information.

Submitted by:	Nikki Elliott, BES, MPA, Manager, Climate Action Programs
Concurrence:	Larisa Hutcheson, P.Eng., Acting General Manager, Parks & Environmental Services
Concurrence:	Ted Robbins, B. Sc., C. Tech., Chief Administrative Officer

ATTACHMENT

Appendix A: Climate Projections for the Capital Region Report (2024) – Pacific Climate Impacts Consortium



Appendix A

Climate Projections for the Capital Region

2024

PACIFIC CLIMATE IMPACTS CONSORTIUM

CRD

Making a difference...together

EXECUTIVE SUMMARY

The Earth's climate system is warming, and signs of climate change are becoming evident across the planet. The capital region, located on Southern Vancouver Island and Gulf Islands of British Columbia (BC), is no exception. The Capital Regional District (CRD) has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution regional projections for temperature, precipitation, and related indices of extremes. These projections use the most up-to-date global modeling data (i.e., the Sixth Coupled Model Intercomparison Project, CMIP6) to illustrate how the region's climate may change by the middle of this century. Information provided by this report and the accompanying data is intended to support decision makers and community partners in the region with an improved understanding of projected local climate change and related impacts.

At a high level, the results of this study show that in the coming decades, the capital region can expect:

- Hotter summer temperatures, with more extreme heat days and heatwaves;
- Warmer nights and a longer growing season;
- Warmer winter temperatures and less frequent frost;
- Less rain and more dry days in the summer months;
- More precipitation falling in fall, winter and spring;
- Less snowfall in the colder months;
- Extreme rainfall events becoming wetter.

More specifically, warming temperatures will shift seasonal patterns, prompting a longer growing season and greater cooling demand across the region. Extreme temperatures will continue to get hotter, with heat waves becoming longer and more frequent. By the 2050s, the capital region can expect the number of summer days exceeding 25°C to triple, going from an average of 12 days per year to around 40. Nighttime temperatures in the summer will also increase. Nights where the temperature stays above 16°C (the lower threshold for heat alerts for Southern Vancouver Island) are projected to occur up to 29 times per year by mid-century. The temperature for the 1-in-20-year hottest is projected to increase from 32°C to 36°C.

By the end of this century, annual precipitation is projected to increase modestly (4% increase by the 2050s and 11% by the 2080s). However, these changes will not occur evenly across seasons. In the colder months, rainfall increases notably because of warmer temperatures that convert more snow into rain. (By the 2050s, total rainfall in the winter increases by 25%, while total snowfall drops by nearly 60%.) Much of the rainfall in the colder months will occur during extreme events, with the very wet days becoming wetter by mid-century. In contrast to the fall, winter and spring, the summer months will become increasingly dry. Total rainfall in the summer is projected to decrease by roughly 15% by the 2050s with the duration of dry spells becoming longer.

Many of the projected climate changes described in this report will be felt uniformly across the region. However, the magnitude of some variables will be accentuated by the existing West-to-East climatic gradient in the capital region. For example, the Western region is typically wetter and cooler compared to the Eastern Region, where conditions are typically warmer and drier. In addition, temperatures may be warmer or cooler in specific areas due to other factors including tree canopy cover (or a lack thereof), paved surfaces, and buildings density.

The projected warming for the capital region will have implications for regional ecosystems, watersheds, agriculture and horticulture, housing, energy demand, infrastructure, and community health and safety. Chapter 7 provides a high-level overview of some of the impacts that might be expected from the projected changes in this assessment. This chapter was informed by input from local government staff during a workshop in October 2023 and is not a comprehensive assessment of regional impacts. It is intended to support further discussion and analysis for how climate change may impact the capital region.

The CRD and PCIC also collected input from local government staff to understand how these climatic changes may impact the region as whole. Across the capital region, communities are already witnessing and experiencing varied impacts of climate change. These impacts will persist and, in many cases, intensify over the coming decades based on the future global greenhouse gas emissions trajectory. These impacts will not be experienced equally across the region. People facing the greatest burdens are often the ones who are most affected by climate change, particularly for impacts that are compounding.

Information within this report and the accompanying data provides the region's decision makers, community planners, and community partners with an improved understanding of projected local climate change and related impacts.

CONTRIBUTING AUTHORS

Charles Curry and Stephen Sobie from Pacific Climate Impacts Consortium (PCIC) conducted climate model downscaling, data analysis and interpretation and generated all data products, including maps, figures, and tables, for the report. Charles Curry and Izzy Farmer (PCIC) served as lead authors of this report, with advice and guidance from CRD staff.

ACKNOWLEDGMENTS

We would like to acknowledge the effort and input received from CRD staff, municipal staff, and the CRD Climate Action Inter-Municipal Working Group in the development of this report. Working together ensures that we share knowledge and build on each other's success to create a more resilient region.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Tables

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Figures (continued)

1. INTRODUCTION

Over the last 150 years, the global average temperature has increased by over 1°C and this warming has been clearly linked to the emission of greenhouse gases (GHGs), aerosols, and other aspects of human development. This warming is expected to continue unless we make significant cuts to GHG emissions globally. Understanding, monitoring, and preparing for the regional and local manifestations of climate change is important for supporting safe and resilient communities in the decades to come.

The Capital Regional District (CRD) has undertaken this study to better understand how the climate of our region is expected to change over the coming decades. British Columbia's capital region spans an area of 2,340 km^2 and an elevation range of 1 to 1,100 m above sea level (Figure 1). Since 1950, air temperature observations for Vancouver Island have been increasing by 0.26 ± 0.07 °C per decade.[2] Both global and regional warming are expected to influence other climate variables, such as rainfall.

To explore the changes that may be in store for our region, the CRD has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution climate projections for the capital region. These projections are based on the latest generation of comprehensive global climate models (CMIP6). Like other populated areas worldwide, the region requires up-to-date, science-based, high-resolution information to enable effective planning and policy decisions in a changing climate. This information will be used with other resources to help prepare the capital region for the impacts of climate change.

A selected number of climate indicators are provided in this report to demonstrate how our climate is expected to change over time. In the first section, Chapter 2 provides a brief description of the study methodology and includes support for interpreting the figures and tables. Chapters 3 through 6 provide an analysis of selected climate indicators for the region, including information about summer temperatures, winter temperatures, precipitation, and climate extremes. Each section includes a description of each indicator and a summary of how it is projected to change over time.

In the second section, Chapter 7 identifies potential impacts from climate change expected across the capital region. These impacts are categorized by different sectors, including health and wellbeing, water supply and demand, rainwater management and sewerage, ecosystems and species, buildings and energy systems, transportation, food and agriculture, and recreation and tourism.

It should be noted that the information provided in this report is limited to changes in temperature and precipitation only. Other climate-related phenomena, like surface hydrology, wind, humidity, sea level rise and storm surge require different modelling techniques and are not included in the scope of this report. Therefore, the report should be used alongside other resources to help prepare our region for the impacts of climate change. For example, in 2021, working with and on behalf of municipal partners, the CRD undertook a coastal flood inundation mapping project, which includes an analysis of current and future storm surge due to sea level rise. Since that time, some municipalities in the region have been undertaking efforts to build upon this work.

This report and the supplementary data that accompany it are intended to support climate-focused decision making throughout the region and help community partners better understand how their work may be affected by our changing climate. The information provided here should be used with careful consideration for the local context. For guidance on how climate information can be used to support adaptation planning, see the appendices appearing at the end of this report.

[1] IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001.

[2] Results of an analysis conducted by PCIC for the annual "State of the Pacific Ocean" report; see Curry, C.L. and Lao, I., "Land temperature and hydrological conditions in 2022," pp 17-21. In: Boldt, J.L., Joyce, E., Tucker, S., and Gauthier, S. (Eds.), State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2022. Can. Tech. Rep. Fish. Aquat. Sci. 3542: viii + 312 p. (2023). The nearby Lower Fraser Valley displays a larger trend of magnitude 0.42 ± 0.07 °C per decade, which may be more similar to what the capital region has experienced.

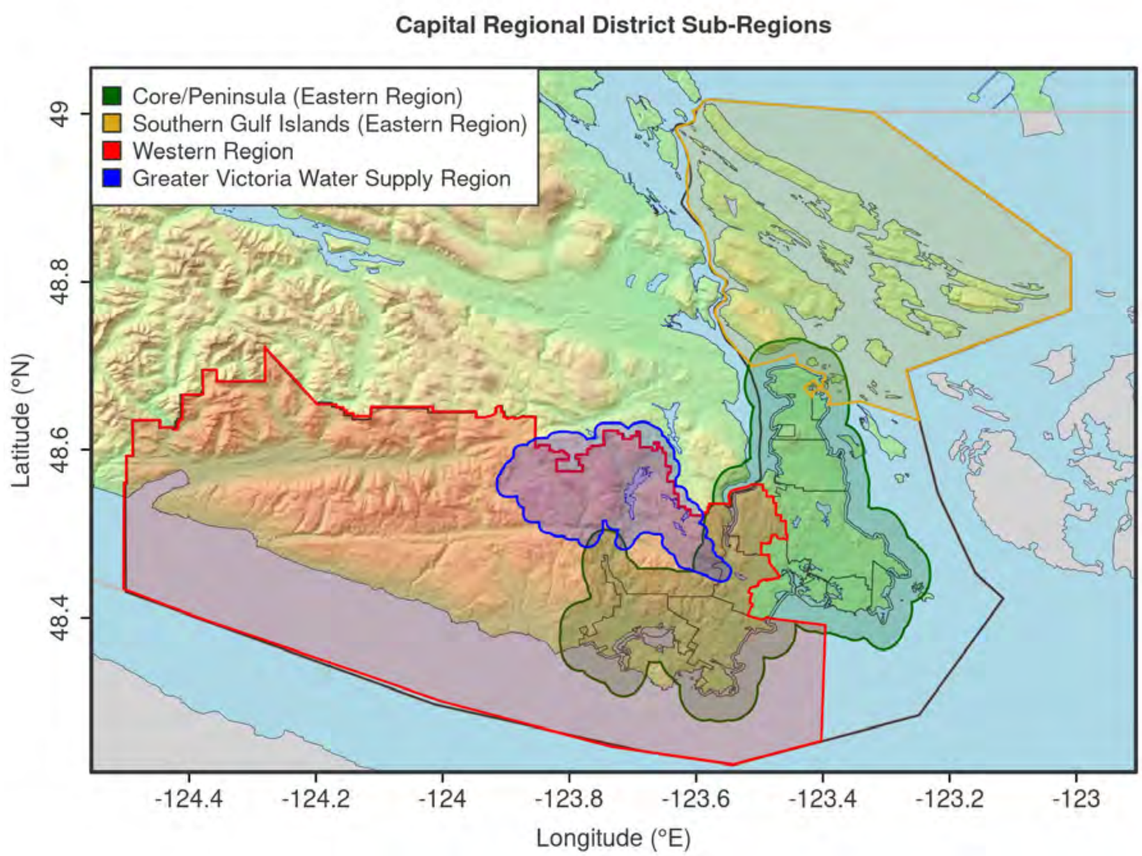


Figure 1. *Domain of interest, the Capital Regional District, with background relief map and four sub-regions of interest. In several of the tables in the report, results for the Core/Peninsula and Southern Gulf Islands are combined into a single Eastern Region.*

2. METHODS AND PRESENTATION

2.1 Climate Model Projections

The climate projections are based on an ensemble of 9 global climate models (GCMs) drawn from a larger collection of models developed during the Sixth Coupled Model Intercomparison Project (CMIP6), coordinated by the World Climate Research Programme. The climate projections presented here are based on a high greenhouse gas emissions scenario, known as the Shared Socioeconomic Pathway 5-8.5 (SSP585), which describes a trajectory of future emissions spurred by continued and expanded use of fossil-fuels worldwide. Two other scenarios are also presented in the data package accompanying this report: a medium-intensity emissions pathway, SSP245, and a low-intensity pathway, SSP126, which covers the possibility of a low-carbon technology transformation of worldwide energy systems.[3] Planning based on climate projections under SSP585 could be considered a "no regrets" strategy for adaptation. By the 2090s under SSP585, global mean surface air temperature reaches a level 4.3°C higher than the 1850-1900 average. The evolution of air temperature and precipitation under the three SSPs, for BC specifically, is shown in Figure 2.

Each GCM represents the climate system using a global, horizontal grid with a limiting resolution between 100 km and 250 km, depending on the model. These coarse-grained data are first bias-corrected against available observations (spanning 1950-2012) and then statistically downscaled to 10 km resolution.[4]

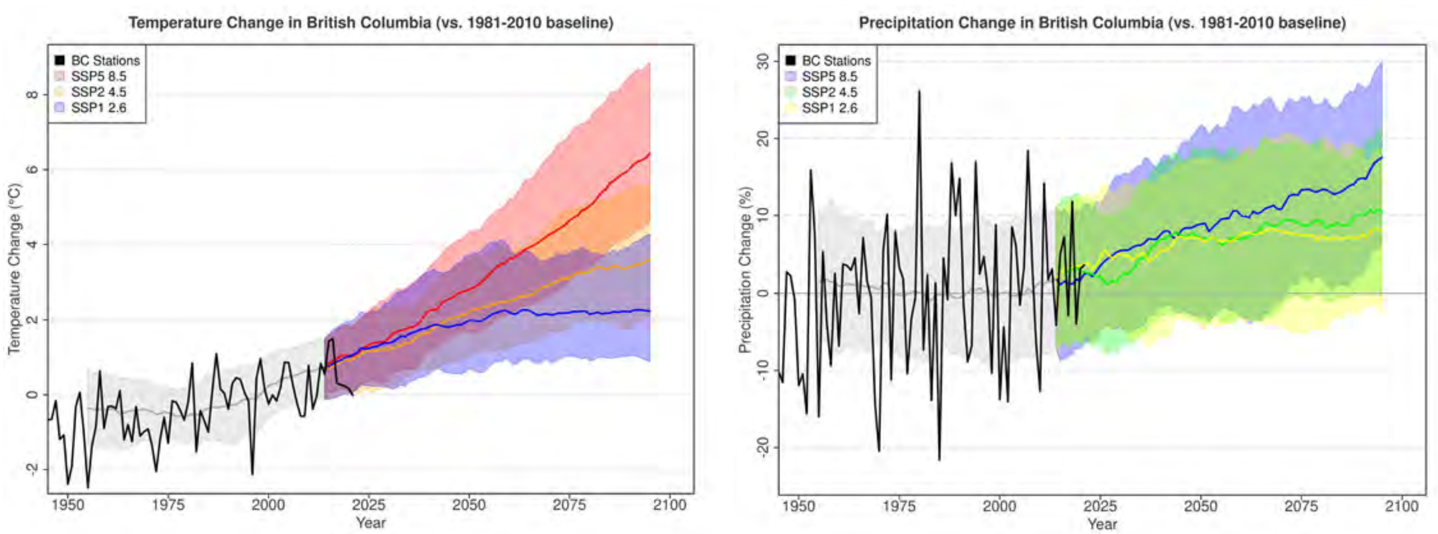


Figure 2. *Changes in annual mean air temperature (left) and total precipitation (right) relative to their values in 1981-2010, averaged over all of BC. The black curves show historical values obtained from the station data in BC from 1948-2021, while the coloured curves show median GCM projections under the three development pathways (SSPs) from 2015-2100. The shaded areas show the 10th-90th percentile range in model-simulated results over the historical and future periods, for each SSP.*

[3] An accessible description of the SSPs may be found at https://climatedata.ca/resource/understanding-shared-socio-economic-pathways-ssps/.

[4] Details on the downscaling methods used at PCIC may be found on the Data Portal section of our website, pacificclimate.org.

In a second downscaling step, the model data are further downscaled to a resolution of 800 m using fine-scale climatological maps. It should be recognized, however, that while the latter account for fine-scale topography, important features of, and influences on, local daily climate are not represented in the dataset.[5]

Downscaled climate model results are presented for three 30-year periods: the historical reference period, 1981-2010 (referred to as the "Past" or "1990s" for short), the near future, 2021-2050 (the "2030s"), mid-century, 2041-2070 (the "2050s") and the end-of-century, 2071-2100 (the "2080s"). These 30-year periods are chosen both to smooth out year-to-year climate variability, and to provide a long enough period to characterize the behaviour of fairly rare events. The seasonal definitions used are "meteorological" seasons: i.e., winter (December 1 to February 28), spring (March 1 to May 31), summer (June 1 to August 31) and fall (September 1 to November 30). A range of indices are computed from daily temperature and precipitation to describe various aspects of the climate. For projections, median estimates from the climate model ensemble are typically emphasized, with the 10th to 90th percentile ranges over the ensemble also provided where appropriate.

It is important to recognize that not all projected changes emerging from the climate model ensemble are necessarily substantial. For a given variable, location, and emissions pathway, each model produces a projected future climate, resulting in a range of possible outcomes. Since no single model is "right," the median value of the ensemble can be used as a practical best-guess projection, with the 10th to 90th percentile spread indicating the uncertainty amongst the models. *If the spread includes zero change, meaning that not all models agree on the sign of the change, then relatively low confidence should be placed in the median value.* In the relatively rare cases when less than half of the models agree on the sign of change, users are alerted to the reduced confidence via a printed message on the maps.

[5] Examples of these being realistic day-to-day variability and co-variability between nearby locations, and fine-scale land cover type, for example. It should also be recognized that since the models are bias-corrected to daily observations spanning a specific time period, here 1981-2010, more recent observations will not be reflected in results displayed for the "Past."

2.2 Interpreting Figures and Tables

The data deliverables for the project comprise: (i) maps of climate variables over the region in Past and Future periods, for each of the three scenarios; and (ii) tables (Excel spreadsheets) of area-averaged results for the same. Results for absolute or relative difference are also provided, where appropriate. References to the tables are occasionally made in the report. Most of the figures presented below are maps, showing the capital region and the surrounding area. Colour contours indicate values of the indicated variable, with a nominal limiting resolution of 800 m. *Due to the limitations of the downscaling methodology mentioned above, along with the inherent uncertainty in future outcomes, the exact position of contours on the maps should not be taken literally.* On each map, the area average shown at bottom left is computed over the capital region only (area inside the black curve).

This report presents results for a number of key indicators, derived from the model-simulated daily temperature and precipitation, representing a "highlight reel" of the much more extensive set of climate indices delivered for this project. In consultation with CRD staff, they were selected either because they have implications for a range of climate-related impacts, because they feature particularly large changes from recent historical conditions, or both. In the next few chapters, a plain language definition is provided for each indicator, followed by a summary of its projected change for the 2030s, 2050s, and 2080s, under the high (SSP585) emissions scenario. Detailed definitions of all indicators are provided in the Appendix.

There are two types of maps: single period and future change. Single period maps, e.g., "Past: 1990s" or "Projection: 2050s," show actual values of a variable, e.g., temperature in °C. Future change maps, e.g., "Projected Change: 2050s - 1990s," show differences between historical and future-simulated periods, and may be in the units of the variable or in relative terms, e.g., percent change in precipitation. In the interest of concision, all future change maps shown in this summary report are for the 2050s under the high emissions (SSP585) pathway. For most indicators, the magnitude of these changes should be roughly comparable to that projected for the 2080s under the moderate emissions scenario (i.e., SSP245).

Other figures in the report use area-averages for the capital region while expressing the range of projected values over models and years for a certain variable. An example of this type of presentation, the "box-and-whisker" plot, is shown in Figures 6 and 9, and an aid to their interpretation is given below. Note that, in these figures, the range shown by the whiskers reflects both year-to-year and model-to-model variability. Finally, note that when cited in the text, values from the spreadsheets are often rounded to indicate the likely precision of the quantity being discussed, given the known model uncertainties. For example, a temperature of 29.8°C would be cited as 30°C, while 2717 degree-days become 2715 degree-days. The tables contain median values with ranges given in parentheses (10th – 90th percentile of different model projections). Usually medians are cited in the text; but ranges encompass the range of possible behaviour, and should not be ignored, especially when the climate variable in question might enter into critical decision-making.

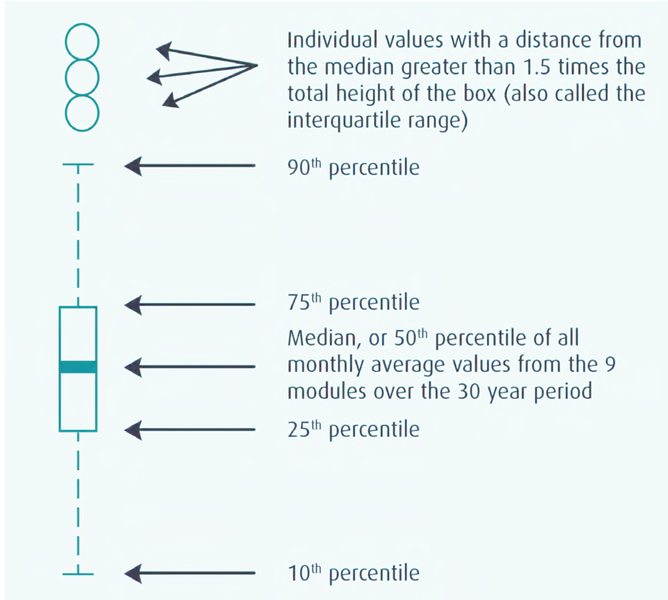


Figure 3. *Explanatory schematic of a box-and-whisker plot.*

Values in tables are averaged over the capital region (within the regional boundary shown on the maps), unless labeled as *Eastern Region* (Greater Victoria and Southern Gulf Islands), *Western Region,* or *Greater Victoria Water Supply Area.*

3. GENERAL CLIMATE PROJECTIONS

3.1 Warmer Temperatures

We begin by examining future temperature change over the region. *Daytime High and Nighttime Low Temperatures* are averaged over each season and annually in the tables and maps below.

In concert with global and regional warming, both daytime and nighttime temperatures are projected to increase in the capital region in future, as detailed in the tables (all changes shown are positive). The accompanying maps show the spatial pattern of Past and future-projected temperatures throughout the region.

Projections

In the Past, winter daytime high temperatures in the region averaged around 7°C, while winter nighttime low temperatures averaged around 1.7°C. The median future-projected TX increases to around 9°C by the 2050s and to 11°C by the 2080s. The median future-projected TN reaches around 4°C by the 2050s and to 5.5°C by the 2080s. Since the likelihood of snowfall rapidly decreases as temperatures rise above 0°C, we can anticipate that this local warming will affect the frequency of snowfall in the region, as detailed further below.

Table 1: Regional Average Daytime High Temperature (TX)

	Past (°C)	2050s Change (°C)	2080s Change (°C)
Winter	6	2.1 *(1.6 to 3.5)*	3.5 *(2.8 to 6.5)*
Spring	12	2.1 *(1.4 to 4.0)*	3.5 *(2.6 to 6.3)*
Summer	20	2.9 *(2.3 to 5.1)*	4.7 *(4.1 to 8.7)*
Fall	13	2.7 *(2.2 to 4.6)*	4.0 *(3.6 to 7.2)*
Annual	13	2.5 *(2.0 to 4.4)*	3.9 *(3.4 to 7.0)*

Table 2: Regional Average Nighttime Low Temperature (TN)

	Past (°C)	2050s Change (°C)	2080s Change (°C)
Winter	1	2.0 *(1.8 to 3.8)*	3.6 *(3.2 to 6.8)*
Spring	4	2.2 *(1.5 to 3.5)*	3.2 *(2.8 to 5.6)*
Summer	10	2.8 *(2.3 to 4.3)*	4.6 *(3.9 to 7.4)*
Fall	5	2.9 *(2.1 to 4.7)*	4.2 *(3.6 to 7.3)*
Annual	5	2.3 *(2.0 to 4.2)*	3.9 *(3.5 to 6.6)*

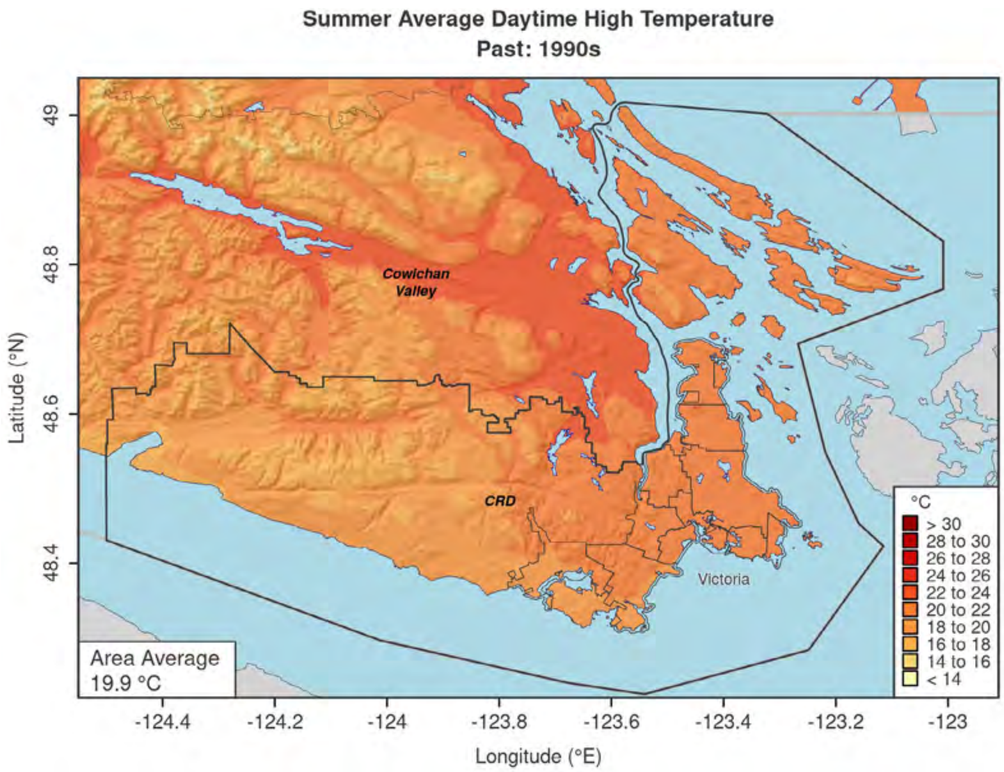


Figure 4a: *Summer average daytime high temperature in the Past.*

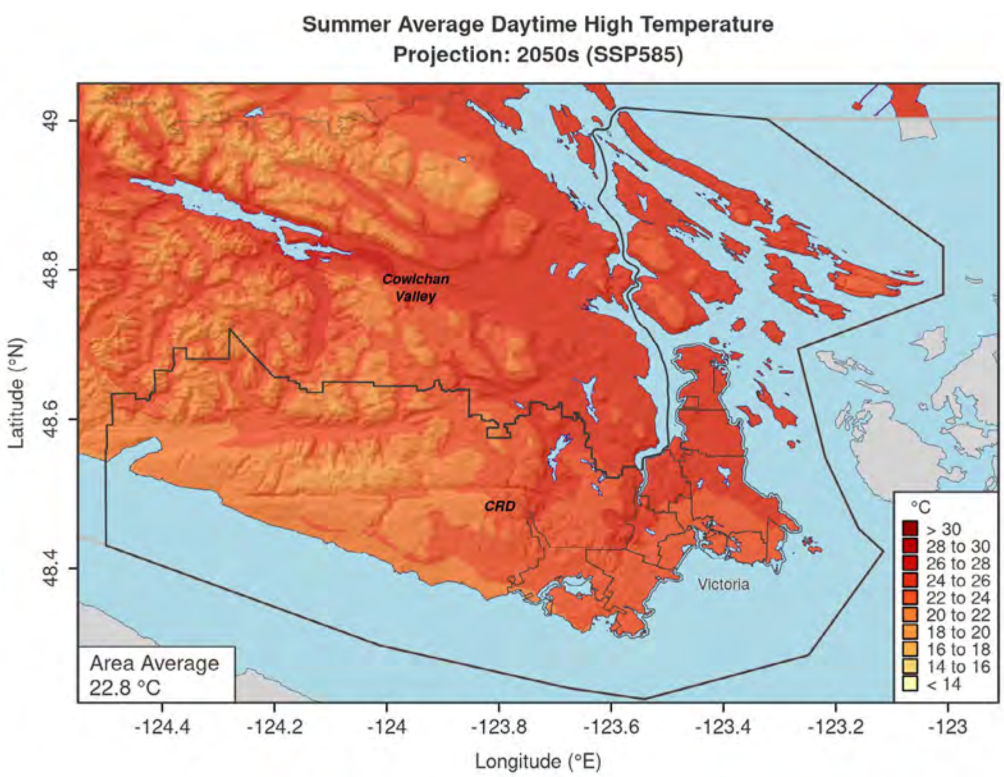


Figure 4b: *Projected summer average daytime high temperature in the 2050s.*

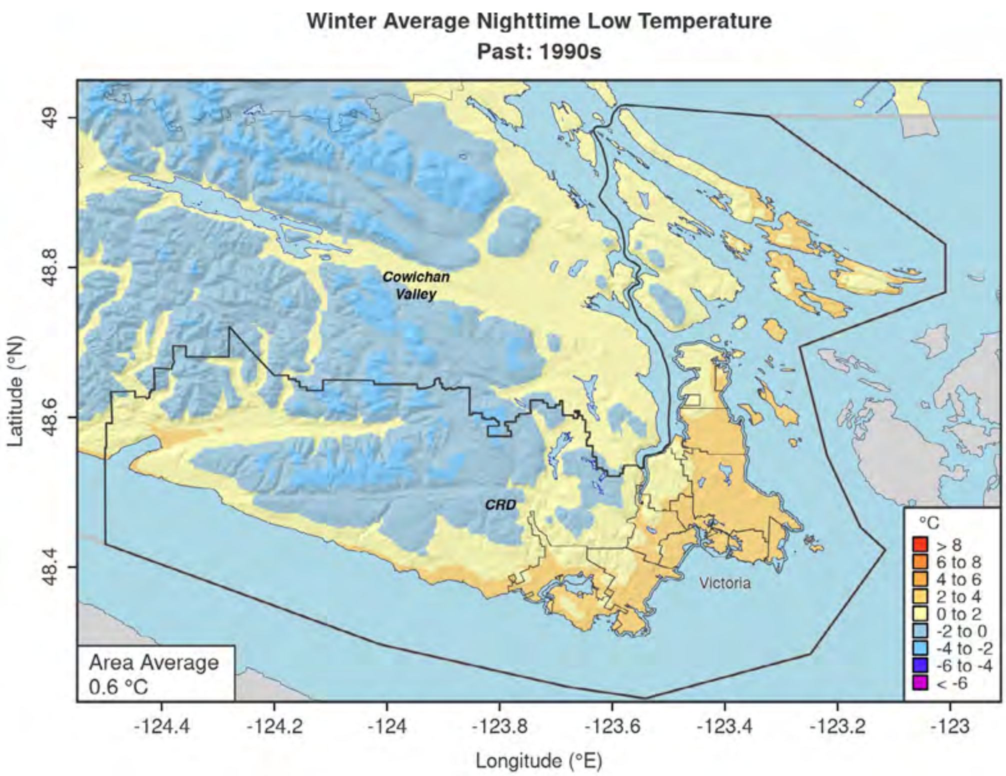


Figure 5a: *Winter average daytime high temperature in the Past.*

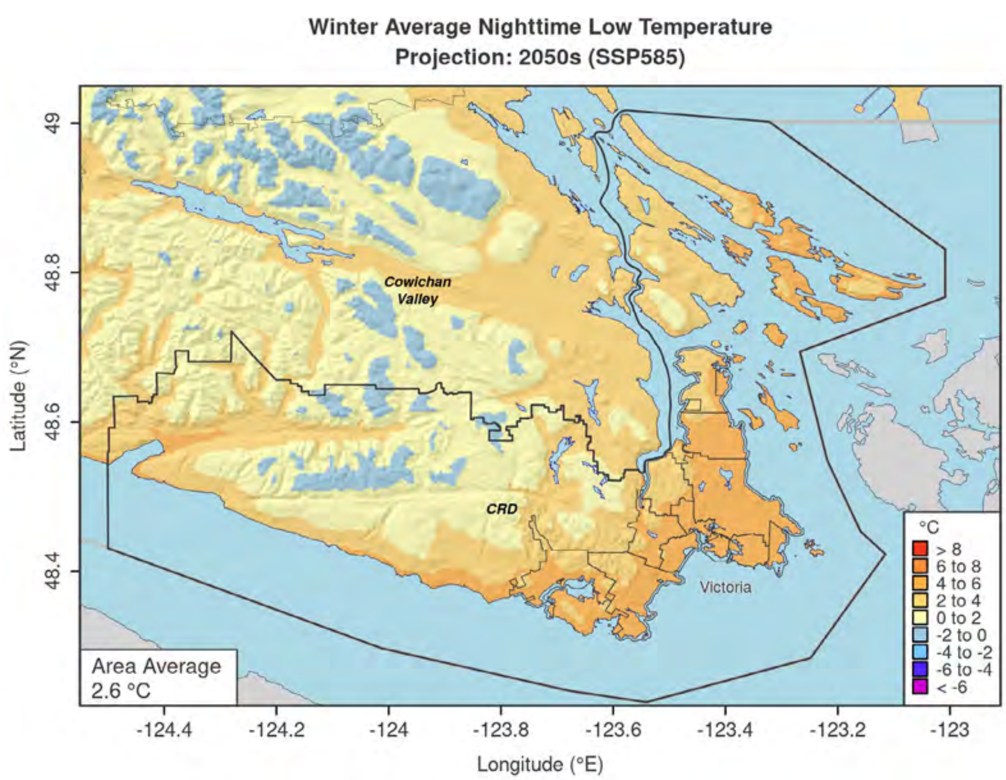


Figure 5b: *Projected winter average daytime high temperature in the 2050s.*

3.2 Seasonal Temperature Change and Variability

Future-projected temperatures are compared with Past temperatures on a monthly basis in the figure below. The box-and-whisker plots reflect both year-to-year and model-to-model variability in all 30 Januaries, Februaries, etc., over the Past and Future periods.

Some features worth noting are:

- Freezing temperatures in the cold months become increasingly rare in the Future.
- Spring—loosely defined as the beginning of the growing season, when daily mean temperature T_m consistently exceeds 5°C; see Temperature Indicators—begins earlier in the Future, while Fall—defined similarly as the end of the growing season—ends later, resulting in an effectively shorter winter season.
- The frequency of high extremes in summer increases notably, with July and August average daytime high temperatures exceeding 23°C in about three-quarters of models and years by the 2050s.

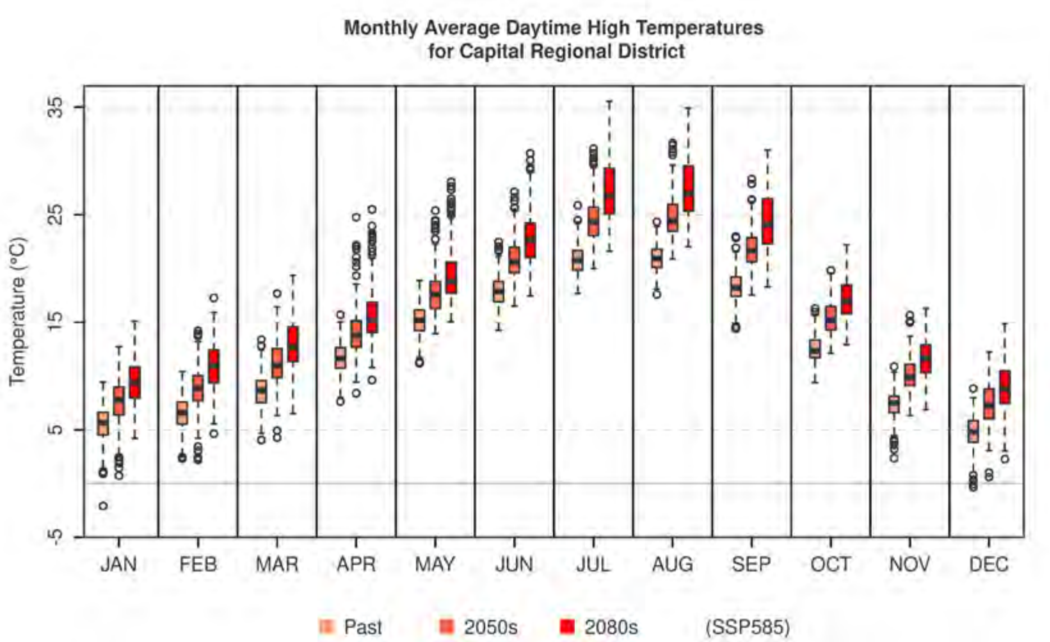


Figure 6a. *Annual cycle of monthly mean daytime high temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

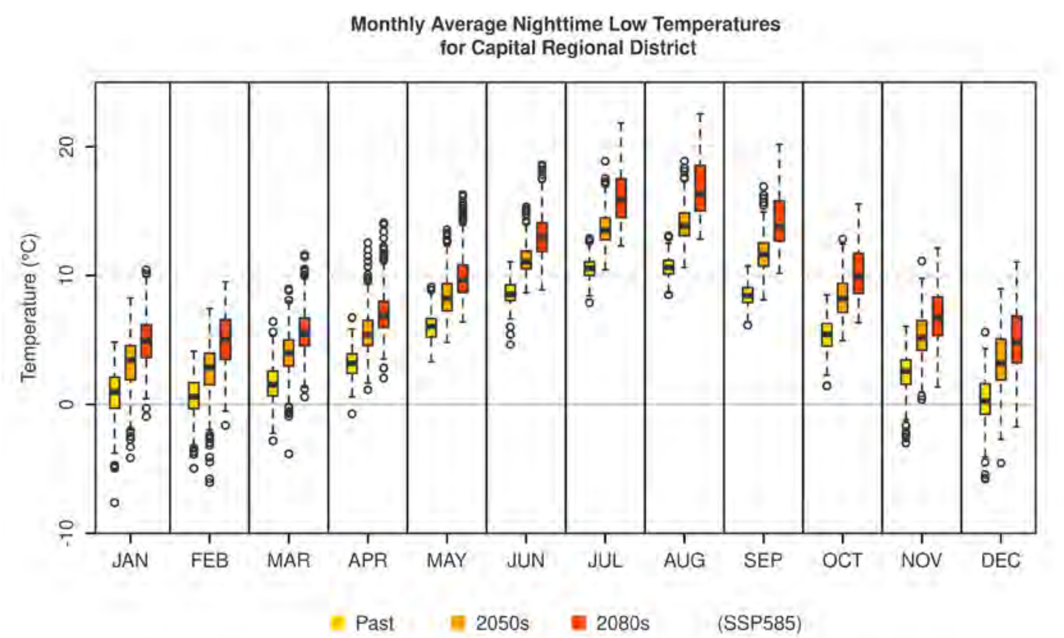


Figure 6b. *Annual cycle of monthly mean nighttime low temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

3.3 Wetter Winters, Drier Summers

Precipitation is the sum of rainfall and snowfall (expressed as water equivalent). Precipitation in the capital region has a strong seasonality, characterized by wet winters and dry summers. In the future projections, this behaviour is reinforced, so that winter becomes wetter (as do spring and fall) while summer becomes drier.

Projections

In tandem with the higher summer temperatures mentioned above— which increase potential evaporation — reduced summer rainfall heightens the possibility of drought conditions. Rainfall increases are highest in winter, displaying a 25% increase in the 2050s region-wide, considerably higher in the west (+145 mm in the Western Region) than in the east (+25 mm in the Gulf Islands). Since the median increase in total winter precipitation by then is only +1%, we conclude that this is primarily due to the conversion of snow to rain under warmer winter conditions. While snowfall comprised about 15% of total precipitation in the Past, it amounts to only 5% in the 2050s. By the 2080s, the capital region should receive as little snowfall annually as it did in spring alone in the Past.

Table 3: Average Precipitation (Rain and Snow) over the Region

	Past (mm)	2050s (mm)	2080s (mm)	2050s Change (%)	2080s Change (%)
Winter					
Rain	643	804	864	25 *(11 to 39)*	34 *(19 to 54)*
Snow	197	83	36	-58 *(-85 to -45)*	-82 *(-97 to -75)*
Spring					
Rain	409	460	477	12 *(7 to 21)*	17 *(3 to 26)*
Snow	37	10	2	-73 *(-95 to -44)*	-95 *(-100 to -78)*
Summer					
Rain	159	135	129	-15 *(-32 to -2)*	-19 *(-46 to -4)*
Fall					
Rain	620	710	770	15 *(9 to 22)*	24 *(13 to 34)*
Snow	38	8	4	-79 *(-95 to -62)*	-89 *(-99 to -83)*
Annual					
Rain	1827	2102	2279	15 *(9 to 25)*	25 *(12 to 28)*
Snow	274	109	40	-60 *(-88 to -50)*	-85 *(-97 to -78)*
Precipitation[6]	2101	2179	2325	4 *(0 to 12)*	11 *(-1 to 13)*

[6] Note that in future, the summed medians of rain and snow may not equal the median precipitation, since the distribution of the two quantities may vary across the model ensemble.

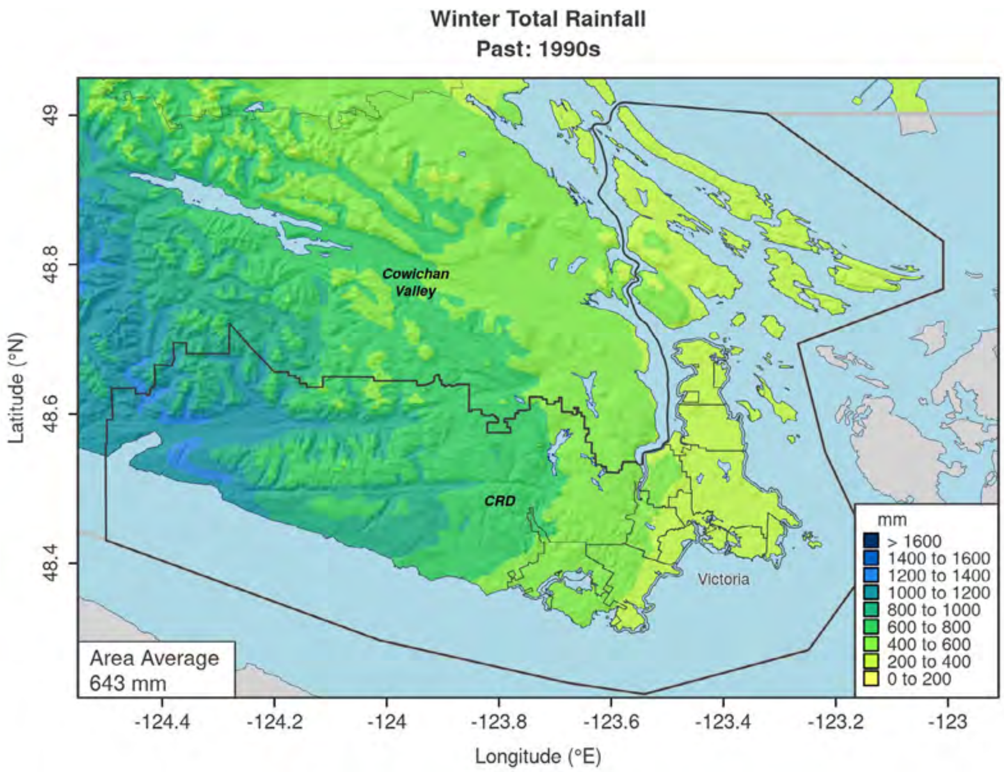


Figure 7a. *Winter rainfall in the Past.*

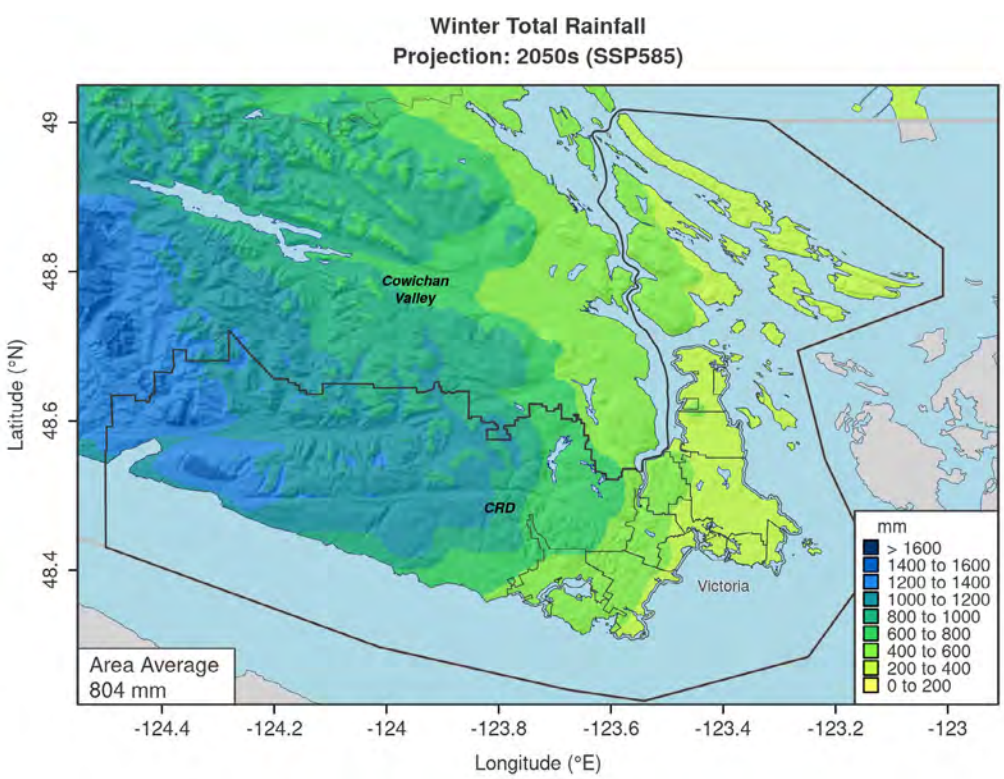


Figure 7b. *Projected winter rainfall in the 2050s.*

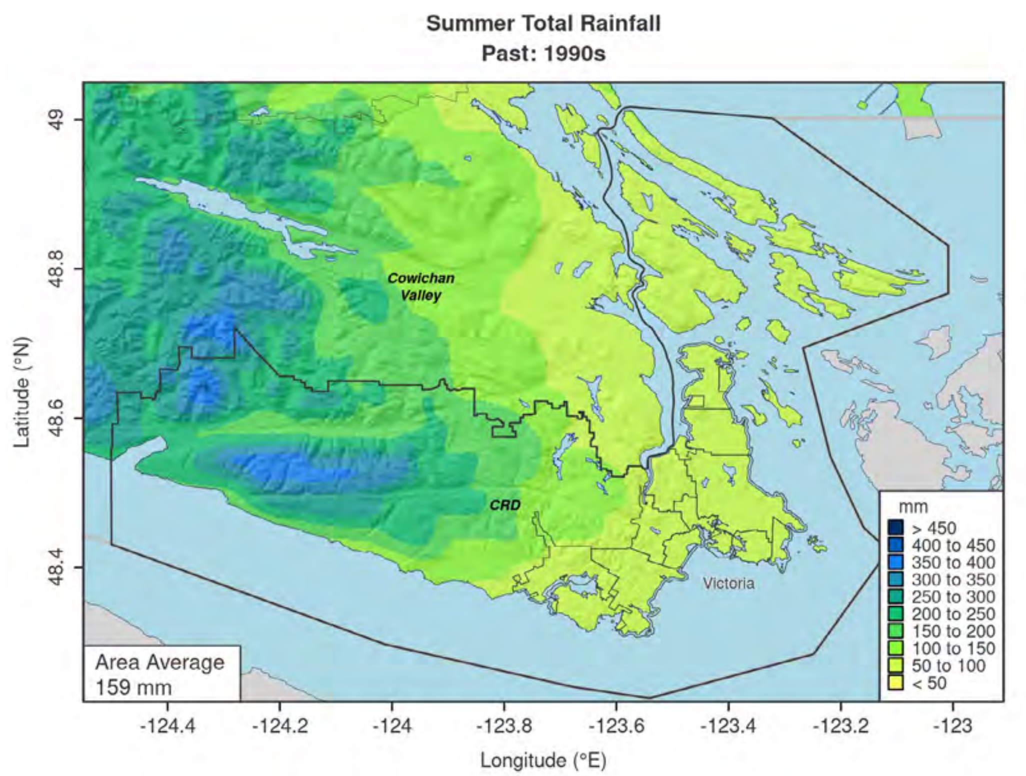


Figure 8a. *Summer rainfall in the Past.*

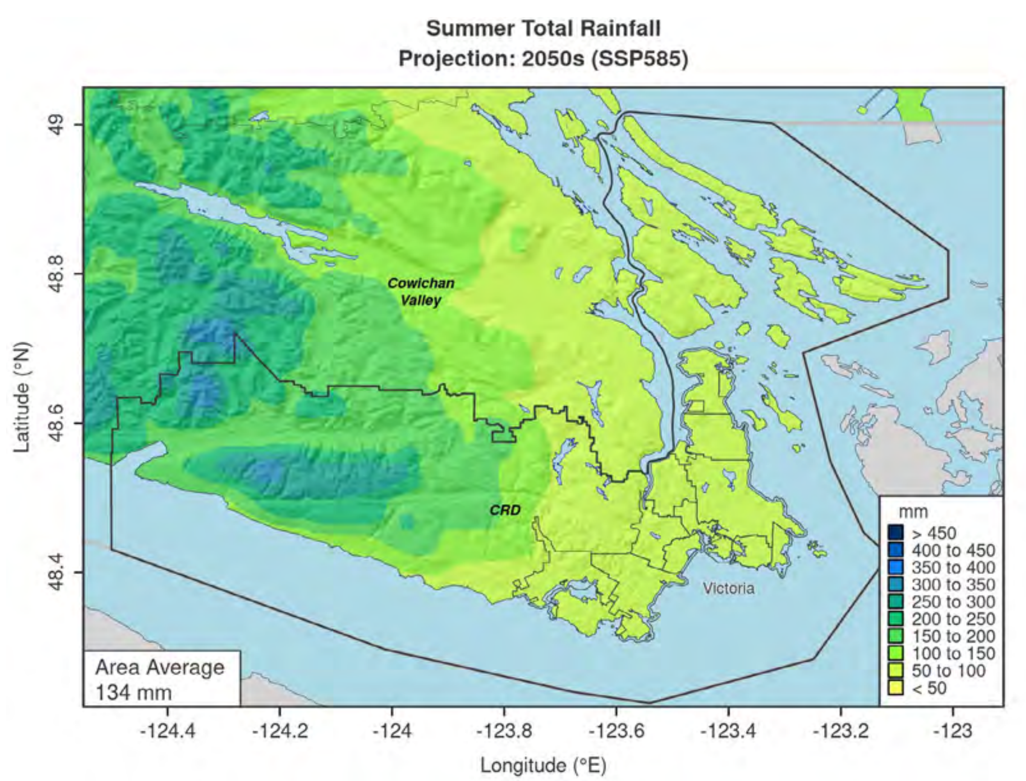


Figure 8b. *Summer rainfall in the 2050s.*

3.4 Seasonal Precipitation Change and Variability

While precipitation in the capital region exhibits a notable seasonality, with far larger amounts in the colder months, this occurs against the background of high year-to-year variability. As a result, a climate change signal is more difficult to distinguish in precipitation than in temperature. One exception is the projected strong decline in snowfall, summarized in Table 3 and Figure 17. Combined with an increase in annual total precipitation of +4%, the resulting median projection of annual total rainfall for the entire region in the 2050s is +15%.

The figure below shows model estimates of monthly total rainfall in the Past and both Future periods. While median values increase in the colder months throughout the century, what is more striking are the changes in variability (occurring across both individual models and years, as shown for temperature above). For example, we note the occurrence of higher extreme monthly rainfall amounts in future periods, especially during the autumn months; some November rainfall totals could exceed 750 mm in future, compared to around 600 mm in the Past.[7]

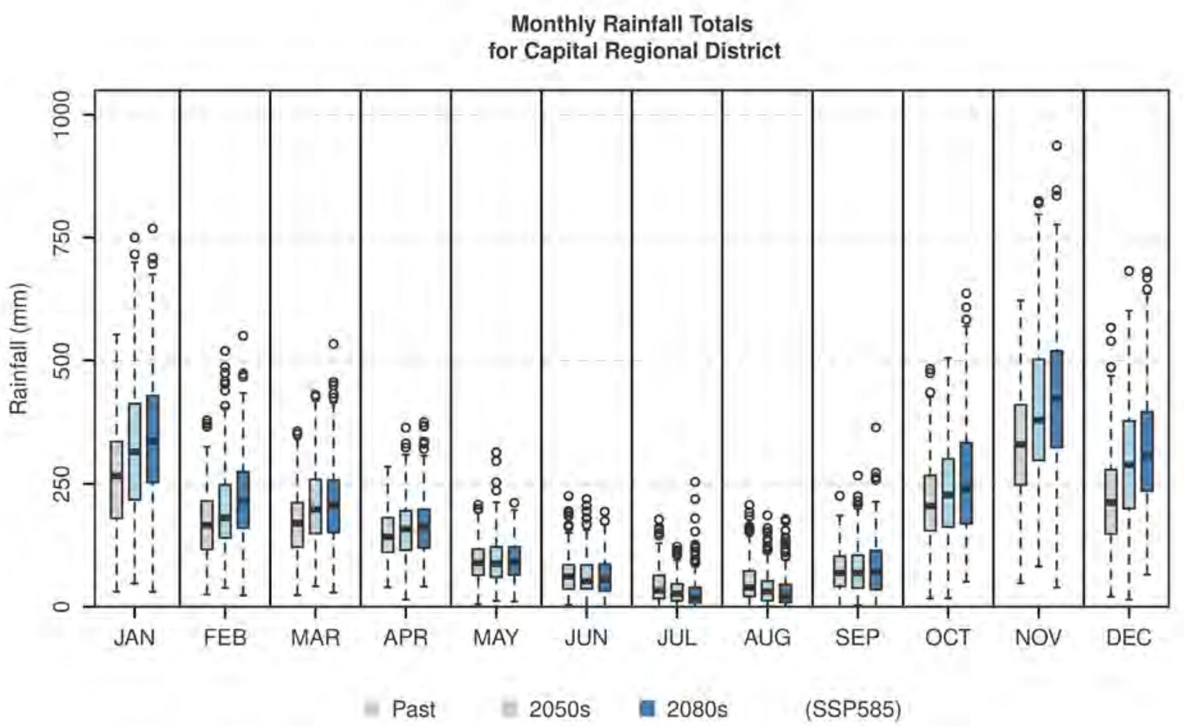


Figure 9. *Annual cycle of total monthly rainfall in the Past, 2050s and 2080s periods.*

[7] 90th percentile values are cited. These totals are averaged across the region, with Past November values spanning a large range from the wetter Western Region (~650 mm) to the drier Gulf Islands Region (~300 mm). For reference, the highest recorded November precipitation at Victoria International Airport is 316 mm (in 2021).

4. WINTER TEMPERATURE INDICATORS

4.1 Warmest Winter Day, Coldest Winter Night

The *Warmest Winter Day* is the highest daily maximum temperature recorded during the winter months, in an average year. When considered along with the *Coldest Winter Night* (i.e., lowest daily minimum temperature), these indicators describe the projected "new normal" for winters in our region.

Projections

By the 2050s, we can expect to see the warmest winter daytime temperature to rise from its Past value of 11°C to about 13°C, with a further increase to about 15°C by the 2080s.

In the Past, the coldest winter night had a temperature of about −8°C. Models project winter lows to increase by roughly 3.5°C by the 2050s, to −4.5°C, and by 6.5°C by the 2080s, to −1.5°C. The maps below illustrate that in the future, temperatures below freezing will usually occur only at the highest elevations in the region.

Warming winter temperatures will lead to an increased fraction of precipitation falling as rain instead of snow. Snow accumulation events, which typically occur a few times each winter in the region, will still occur, but less frequently.

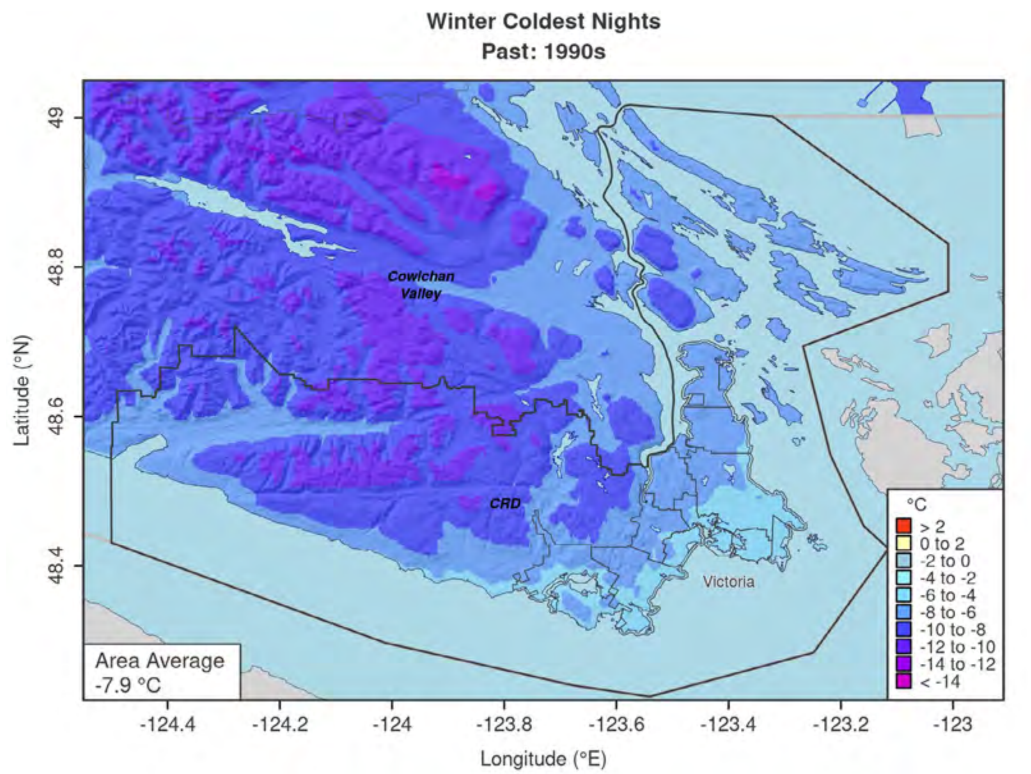


Figure 10a. *Coldest winter night in the Past.*

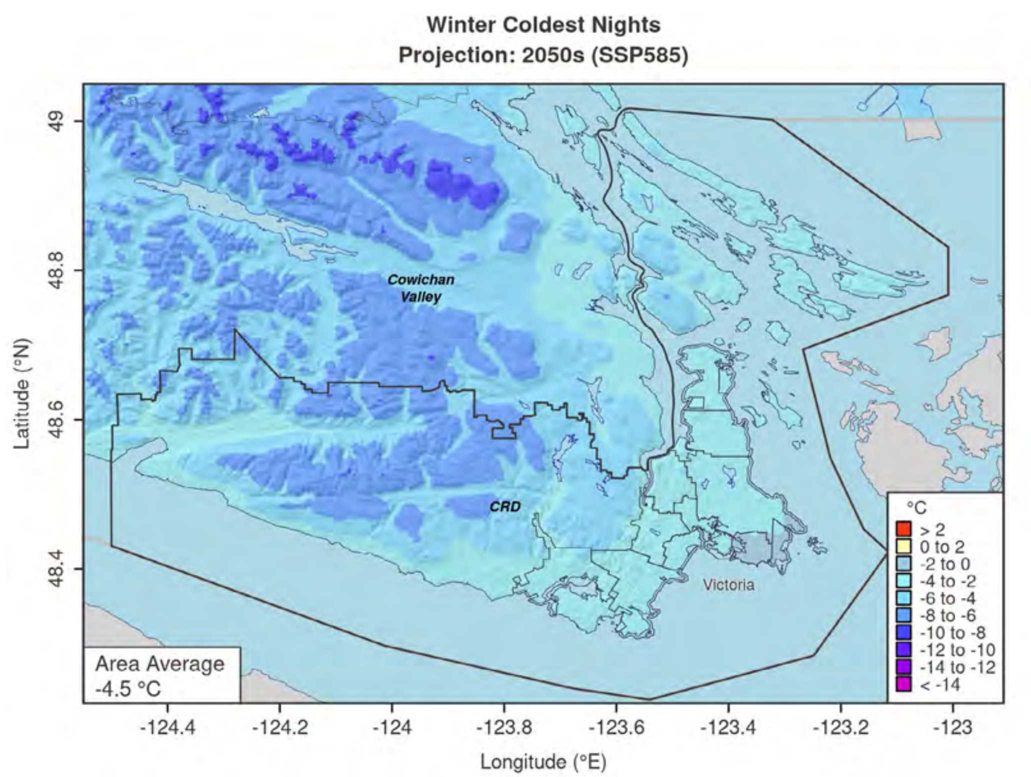


Figure 10b. *Projected coldest winter night in the 2050s.*

4.2 1-in-20 Year Coldest Nighttime Low Temperature

This indicator describes extreme cold temperatures so low that they are expected to occur only once every 20 years in the historical climate. Equivalently, in the recent past the *1-in-20 Year Coldest Night* had a 5% chance of occurring in any given year. [8]

Projections

In the Past, the 1-in-20 year coldest night had a temperature of −15°C. In the Future, the 1-in-20 year coldest night across the region will increase by about 5°C by the 2050s and by about 8.5°C by the 2080s.

[8] Note that the occurrence of such an event in one year doesn't preclude its occurrence in the following years, which is why the annual exceedance probability (i.e. 5% chance, in this case) is a helpful equivalent measure.

4.3 Frost Days and Ice Days

Frost Days is an annual count of days when the daily minimum temperature is less than 0°C which may result in frost at ground level. This indicator is useful to help predict how changes in the number of days with minimal temperatures below freezing could affect native and agricultural plant species.

Ice Days occur when daytime high temperatures do not exceed 0°C. While some of the same effects are expected as for frost days, these freezing temperatures may also affect transportation via the increased chance of icy road conditions.

Projections

In the Past, the capital region experienced an average of 60 frost days and 6 ice days per year. In the 2050s, we should expect far fewer such days: around half as many frost days by the 2050s and only around one-fifth as many by the 2080s. Ice days may be very rare by the mid- to late-century.

Table 4: Warmer Winter Extreme Temperatures

	Past (°C)	2050s (°C)	2080s (°C)	2050s Change (°C)	2080s Change (°C)
Warmest Winter Day	11	13	15	2.4 (*1.7 to 4.2*)	4.2 (*3.2 to 6.9*)
Coldest Winter Night	-8	-4.5	-1.3	3.4 (*2.9 to 5.5*)	6.6 (*5.4 to 10.4*)
1-in-20 Year Coldest Nighttime Low	-15	-10	-6.5	5.0 (*3.2 to 7.2*)	8.5 (*7.5 to 13*)

Table 5: Annual Frost and Ice Days

	Past (°C)	2050s (°C)	2080s (°C)	2050s Change (°C)	2080s Change (°C)
Frost Days (TN <0 °C)					
Region	60	27	12	−33 (*−51 to −27*)	−48 (*−58 to −45*)
Eastern Region*	30	11	3	−19 (*−28 to −16*)	−27 (*−30 to −23*)
Water Supply Area	80	38	17	−42 (*−67 to −36*)	−63 (*−76 to −59*)
Ice Days (TX <0 °C)					
Region	6	2	0	-4 (*-6 to -3*)	-6 (*-7 to -5*)

**The Eastern Region encompasses both the Southern Gulf Islands and Core/Peninsula subregions (Figure 1).*

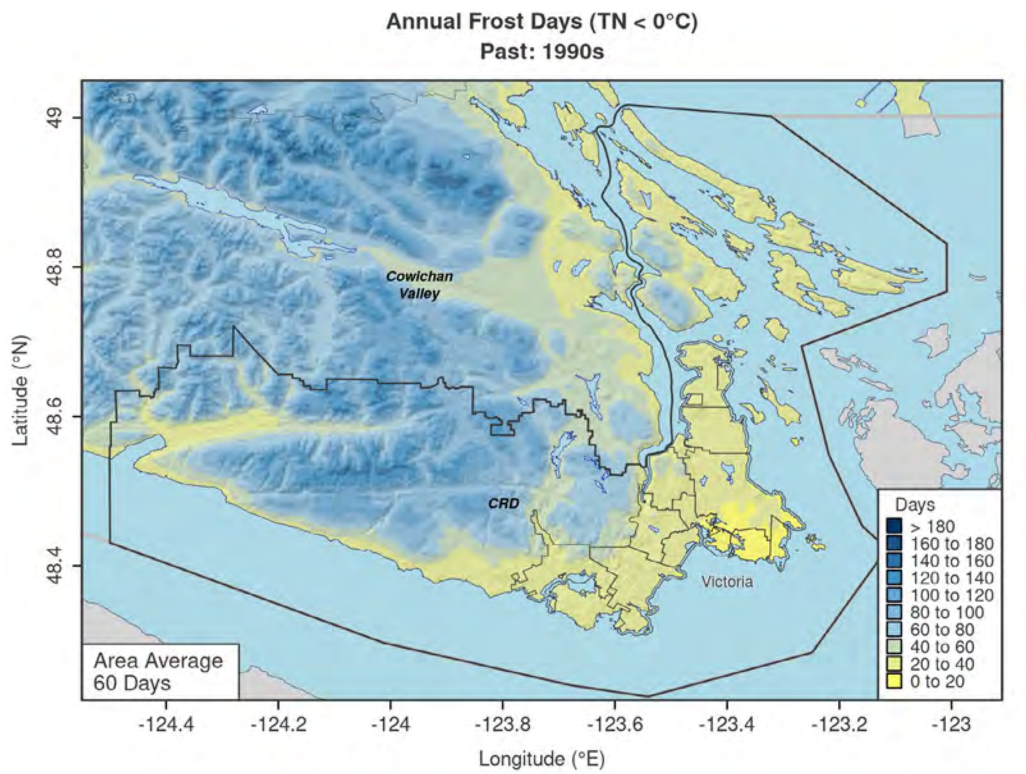


Figure 11a. *Number of annual frost days in the Past.*

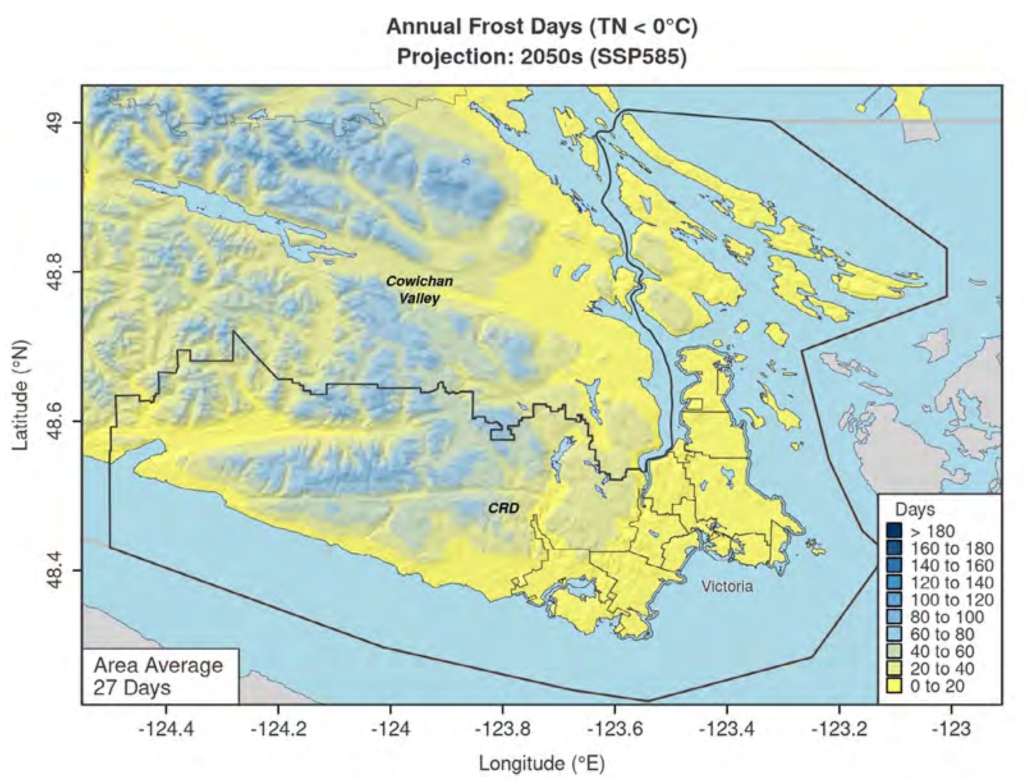


Figure 11b. *Projected frost days in the 2050s.*

4.4 Heating Degree Days

Heating Degree Days (HDD) are calculated by summing the number of degrees that the daily mean temperature falls below 18°C for every day in a year.[9] This measure is commonly used to estimate the heating demand for buildings in the cooler months.

Projections

In the Past, the capital region had a median of roughly 3405 HDD.[10] The median future-projected HDD decreases to 2644 (a 22% decrease) by the 2050s and to 2215 (a 35% decrease) by the 2080s. Due to its cumulative nature, a reduction in HDD is amongst the clearest indicators of warming, both in recent historical observations and in model projections. In addition, it should be noted that HDD varies considerably from west (higher values) to east (lower values) over the region.

Note that while mean winter temperatures will warm throughout the coming decades, the region's continued exposure to easterly polar outflows from Northwestern Canada through the Cascade Range suggests that the potential for multi-day cold snaps will persist in the future, though they should be less frequent. For this reason, building heating systems will still need to be responsive to occasional sub-zero winter temperatures.

Table 6: Heating Degree Days

	Past (°C)	2050s (°C)	2080s (°C)	2050s Change (°C)	2080s Change (°C)
Region	3405	2644	2125	-22 (*-40 to -19*)	-35 (*-56 to -32*)
Southern Gulf Islands	2836	2114	1755	−25 (*-45 to -22*)	−38 (*−63 to −35*)
Core / Peninsula	2904	2164	1773	−25 (*−44 to −22*)	−39 (*−62 to −35*)
Western Region	3387	2613	2158	-23 (*-41 to -20*)	-36 (*-57 to -33*)

[9] For example, if the daily mean temperature on January 1 is 10°C, followed by one day of 4°C, two days of −1°C and three days of 0°C, then HDD for that week are calculated as: (18−10) + (18−4) + 2 × (18−(−1)) + 3 × (18−0) = 114 degree-days. Note that days with a temperature equal to or greater than 18°C are not counted.

[10] Someone consulting the tables for the National Building Code of Canada (NBCC, 2015) will see different values of HDD listed for Victoria locations than the Past values cited in Table 6. One reason for this is the larger area covered by our Core/Peninsula subregion. Another is the different methodology and period of observations used to calculate HDD in the NBCC. As our estimate depends to some extent on coarse-grained climate models, while the NBCC employs interpolated station data, the NBCC value would normally be considered more reliable in this subregion (which contains several meteorological stations). For those interested in future HDD estimates, the relative differences from Past values can be used for HDD projections, regardless of which baseline value is used.

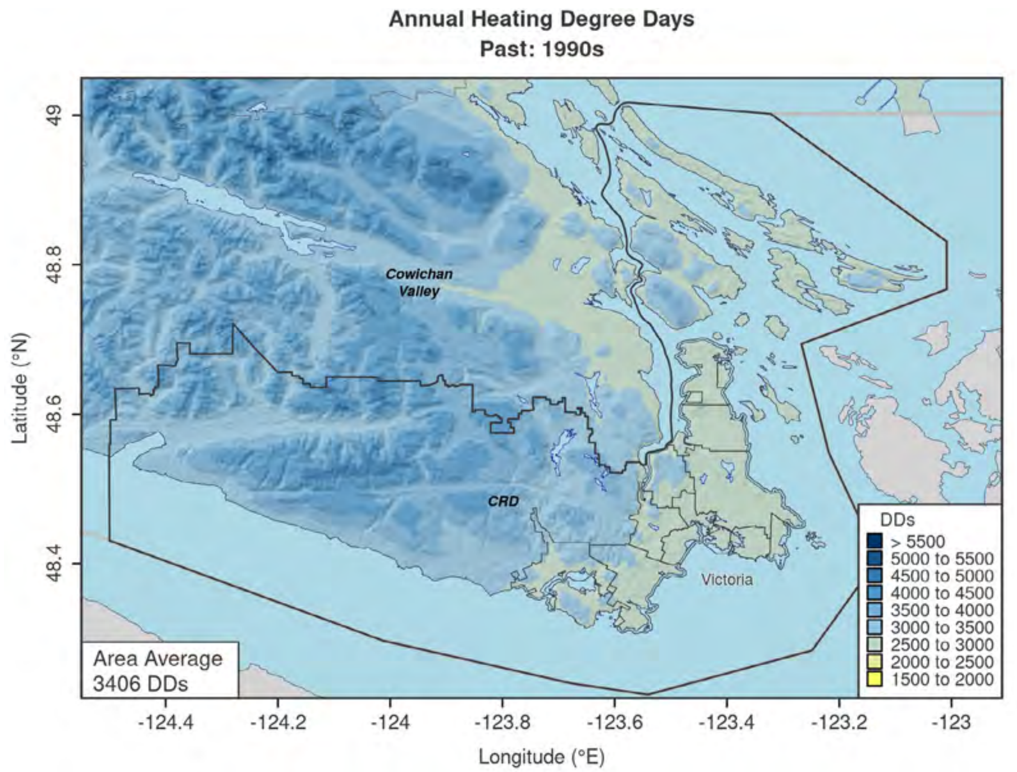


Figure 12a. *Heating Degree Days in the Past.*

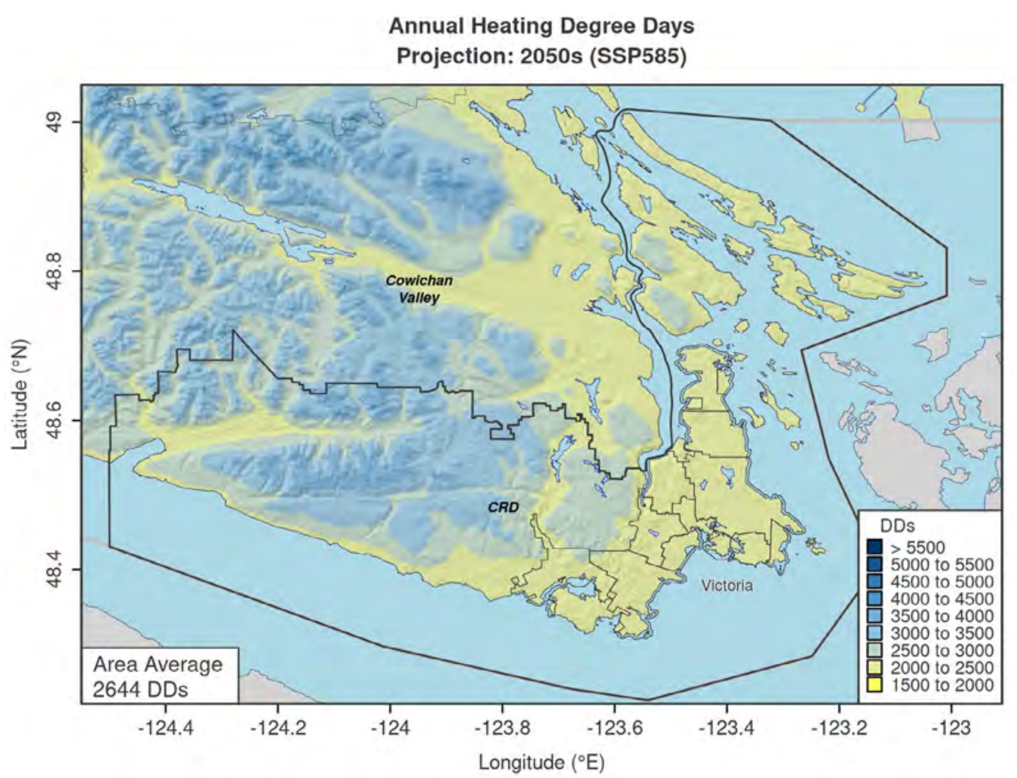


Figure 12b. *Projected (decreased) HDD in the 2050s*

5. SUMMER TEMPERATURE INDICATORS

5.1 Growing Season Length

Growing Season Length (GSL) is an annual measure indicating the period when temperatures are warm enough for most vegetation to grow. The GSL is the number of days between the first span of at least 6 consecutive days with daily average temperatures above 5°C, and the first span, after July 1, of six days with temperatures below 5°C. This measure helps to highlight how urban forests, agricultural and landscaped areas, grasses, weeds (and their pollens) may be affected by climate change.

Projections

In the Past, the growing season lasted roughly 270 days in the region. The median future-projected growing season increases by 47 days to 318 days by the 2050s and by 68 days to 339 days by the 2080s.

Other things being equal, a longer GSL implies potentially more productive vegetation in the future. However, since GSL uses only a lower temperature threshold (and not an upper threshold to account for heat stress) and ignores changes in precipitation (reduced rainfall in the warm season—Section 3.3, Table 3), it should be considered an upper limit for estimates of future productivity.

A related measure to GSL is the length of the frost-free season, which uses a lower threshold of 0°C for minimum daily temperature. As mentioned above, frost days will become increasingly rare in the future, resulting in frost-free conditions nearly year-round in the region by the 2080s.

Table 7: Growing Season Length

	Past (°C)	2050s (days)	2080s (days)	2050s Change (days)	2080s Change (days)
Region	271	318	339	47 (*39 to 71*)	68 (*60 to 86*)
Eastern Region	315	348	358	33 (*25 to 42*)	44 (*37 to 49*)
Western Region	283	324	344	41 (*35 to 64*)	61 (*53 to 76*)
Water Supply Area	245	301	329	56 (*45 to 90*)	84 (*75 to 112*)

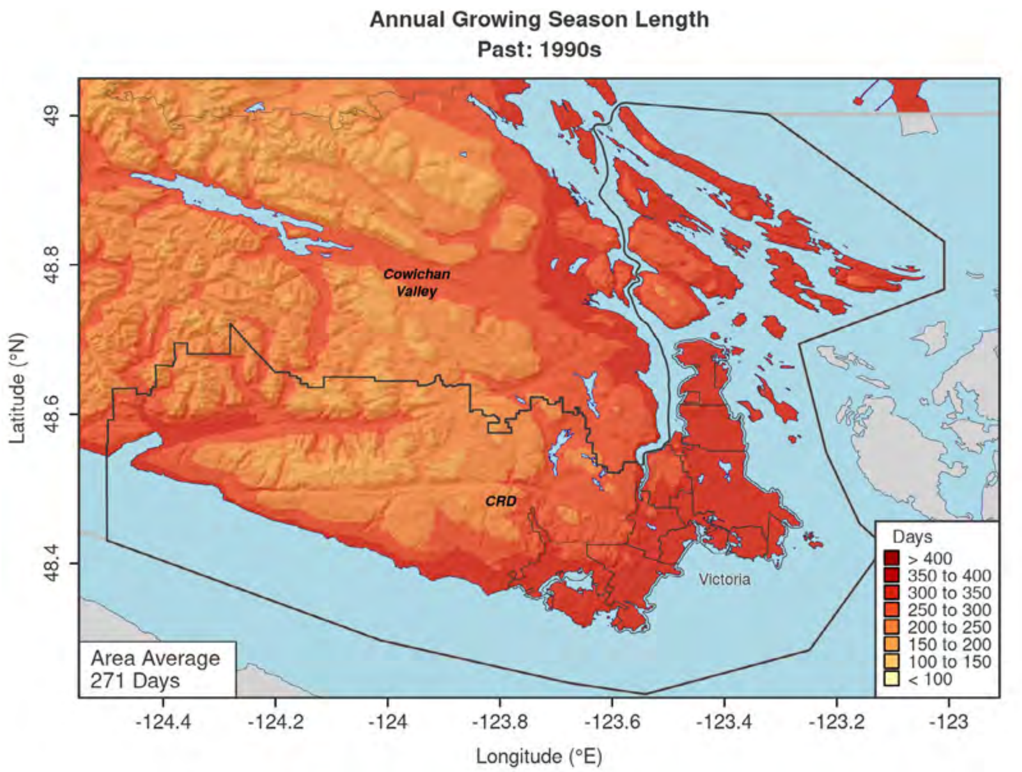


Figure 13a. *Growing season length in the past*

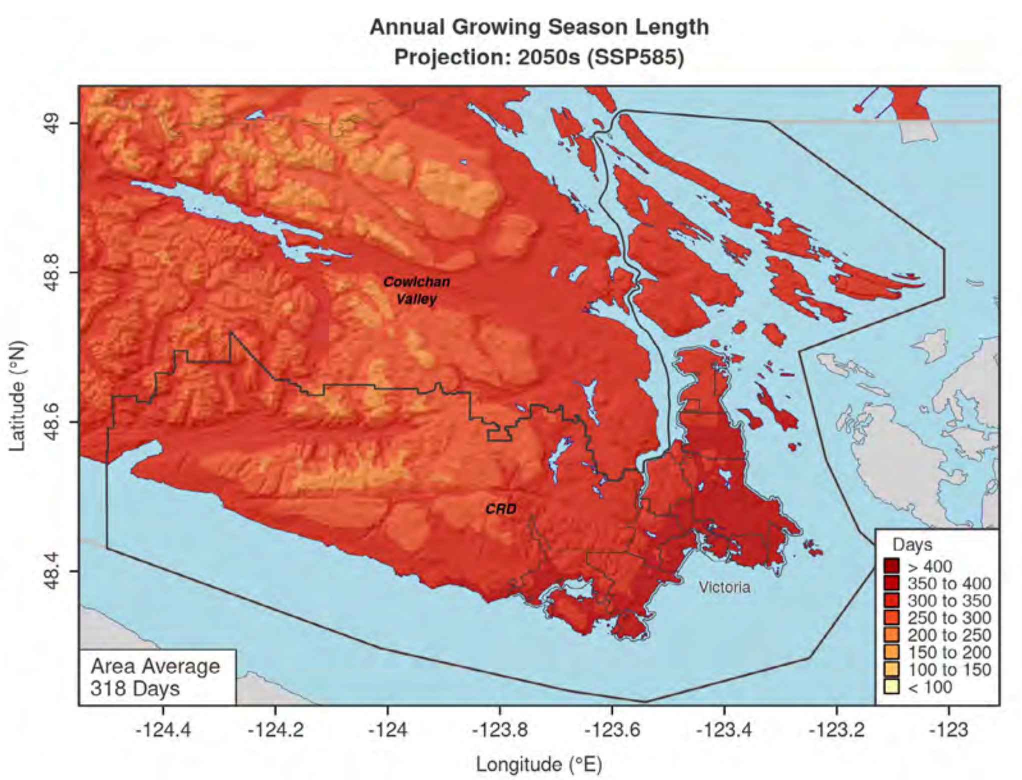


Figure 13b. *Projected (increased) growing season length by the 2050s*

5.2 Cooling Degree Days

The opposite of HDD, *Cooling Degree Days* are calculated by summing the number of degrees that the daily mean temperature exceeds 18°C for every day in a year.[11] This measure is commonly used to estimate the demand for mechanical cooling (i.e., air conditioning) in buildings in the warmer months.

Projections

In the Past, the capital region typically had around 17 cooling degree days, with the vast majority of such days occurring in summer. The median future-projected cooling degree days increase to about 119 (a 7-fold increase) by the 2050s and to nearly 240 (a 14-fold increase) by the 2080s. While most such days will continue to occur in summer, they will increasingly occur during late spring and early fall.

Like the projected decrease in HDD, an increase in cooling degree days is among the clearest indicators of warming, both in recent historical observations and model projections. Moreover, the magnitude of increase varies strongly from west (lower values) to east (higher values) across the capital region. To the extent that this index correlates with demand for cooling, new buildings may need to be designed differently to maintain thermal comfort.

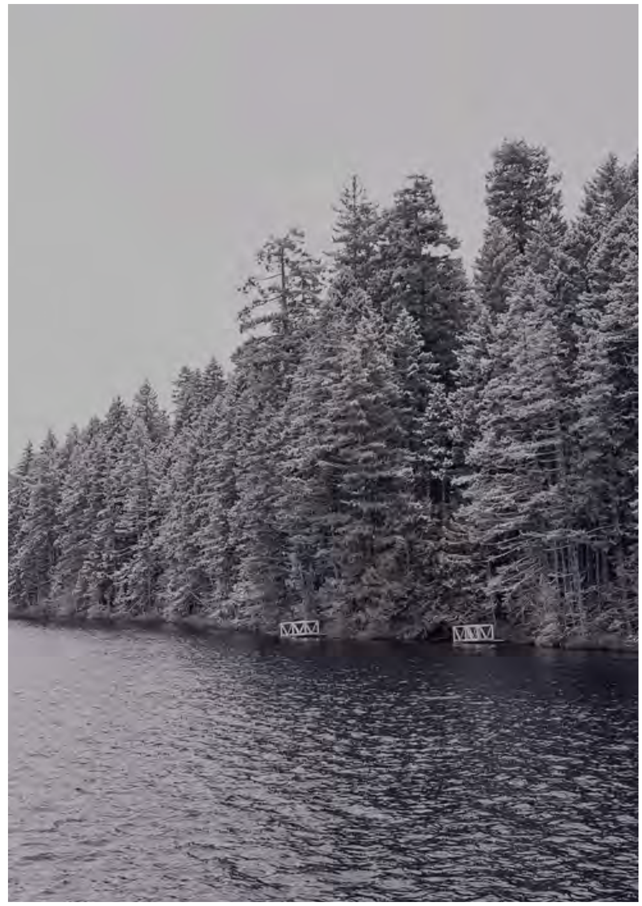


Table 8: Cooling Degree Days

	Past (deg-days)	2050s (deg-days)	2080s (deg-days)	2050s Change (deg-days)	2080s Change (deg-days)
Region	17	119	237	102 (*62 to 235*)	220 (*176 to 592*)
Southern Gulf Islands	38	227	392	189 (*119 to 385*)	354 (*297 to 820*)
Core / Peninsula	25	169	317	144 (*87 to 310*)	292 (*234 to 716*)
Western Region	10	83	185	73 (*41 to 185*)	175 (*135 to 525*)

[11] For example, if the daily mean temperature on July 1 is 20°C, followed by three days of 21°C, one day of 25°C and two days of 16°C, then the cooling degree days for that week are calculated as: (20−18) + 3 × (21−18) + (25−18) = 18 degree-days.

Note that days with temperature equal to or less than 18°C are not counted.

5.3 Warm Summer Days and Nights, Annual Hottest Day and Heatwaves

These indicators highlight the most extreme warm temperatures occurring in the region. The results in the table below are for the Core/Peninsula subregion (see Figure 1) which has the highest population and therefore the highest exposure to many heat-related impacts (values for the Southern Gulf Islands are very similar). Three single-day extreme heat measures are included in the table: the peak temperature of the hottest day of the year (not necessarily occurring during a heatwave), the number of days with TX > 25°C (*Summer Days*), and the number of nights with TN > 16°C (*Temperate Nights*). Episodes of multi-day extreme heat, which were rare in the Past, are captured by several heatwave (HW) indicators defined in the Appendix. These are partly based on threshold temperatures for emergency health alerts used specifically in BC.[12] As with the variables discussed above, each of the indices describes a typical year within the indicated 30-year period.

Projections

In the Past, there were typically around 12 days per year with a high temperature exceeding 25°C, and rarely did nighttime temperatures rise above 16°C. The median future-projected number of Summer Days increases to roughly 40 per year by the 2050s and 62 per year by the 2080s, while Temperate Nights begin to occur by the 2030s, with a frequency of 15 per year in the 2050s and 52 per year in the 2080s.

When it comes to heatwaves, in the Past, there was usually one HW per year, lasting up to 3 days and having a peak daily temperature of around 30°C. The median future-projected number of HWs increases to roughly 3 per year by the 2050s and 5 per year by the 2080s. HWs are also projected to increase in length in the future (approaching 9 consecutive days or more by the 2080s) and will feature both warmer daytime and nighttime temperatures. It is clear that residents of the area will need to adapt to more frequent, longer, and intense HWs in future.

Table 9: Measures of extreme heat (Core/Peninsula subregion)

Core/Peninsula subregion: Heatwave (HW) Indices, Hot Summer Days and Warm Nights*					
Index	**Description**	**Past**	**2030s**	**2050s**	**2080s**
HWD	HW days (days)	1	4 (*3 to 11*)	10 (*6 to 27*)	23 (*17 to 74*)
HWXL	HW Maximum length (days)[13]	3	4 (*3 to 5*)	4.5 (*4 to 10*)	8.5 (*6 to 43*)
HWN	Annual number HWs	1	2 (*1 to 4*)	3 (*2 to 5*)	5 (*4 to 7*)
TXHX	Avg. TX in most extreme annual HW (°C)	30	31 (*30 to 32*)	31 (*31 to 33*)	32 (*32 to 34*)
TNHX	Avg. TN in most extreme annual HW (°C)	15	16 (*15 to 16*)	17 (*16 to 18*)	19 (*18 to 21*)
TXX	TX on hottest day of year (°C)	29	31 (*30 to 32*)	32 (*32 to 35*)	35 (*33 to 38*)
SU	Number of days reaching TX >25 °C	12	28 (*22 to 41*)	40 (*30 to 70*)	62 (*57 to 111*)
TR16C	Number of nights reaching TN >16°C	0	4 (*3 to 13*)	15 (*9 to 47*)	52 (*36 to 108*)

**Upper values in each table cell are the ensemble median, with values in parentheses giving the 10th to 90th percentile range over the model ensemble.*

[12] See the report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning. The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. In addition, a HW must: 1) last at least 2 full days; and 2) have TX and TN exceeding their 95th percentile values in the Past.

[13] It may seem strange that HWD < HWXL in the Past, but this is an artifact of small number statistics. Some years in the Past contained no HWs, leading to a mean annual value of 0.4 for HWD (rounded to 1 in the table, since some years had a HW). Nevertheless, one or more years had HW lengths of 2 or 3 days, leading to the mean HWXL = 2.5 days (rounded to 3) over the 30-year period. As the number of HWs increases in future years of the simulations, the expected behaviour HWD > HWXL emerges.

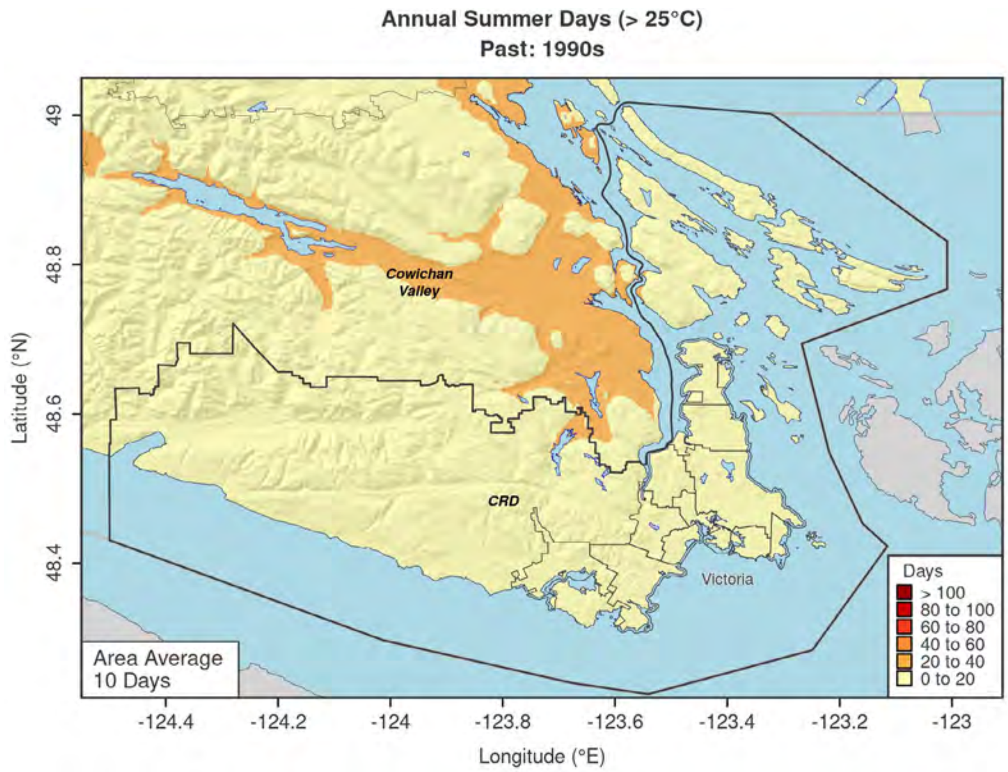


Figure 14a. *Annual count of summer days in the Past*

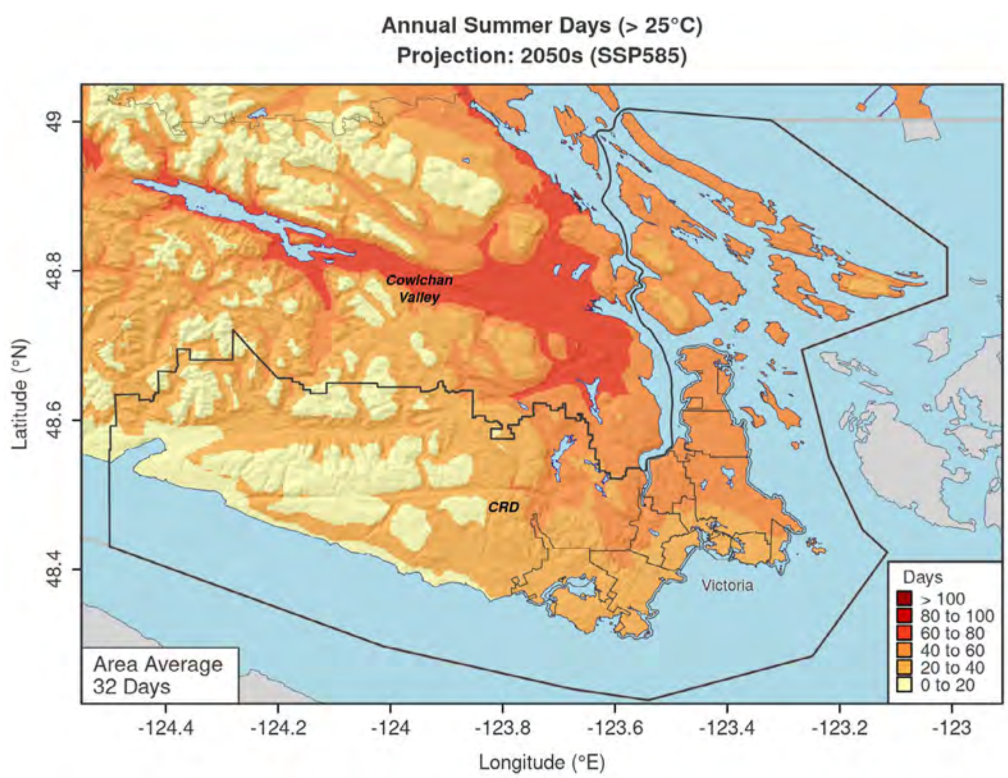


Figure 14b. *Projected number of annual summer days by the 2050s*

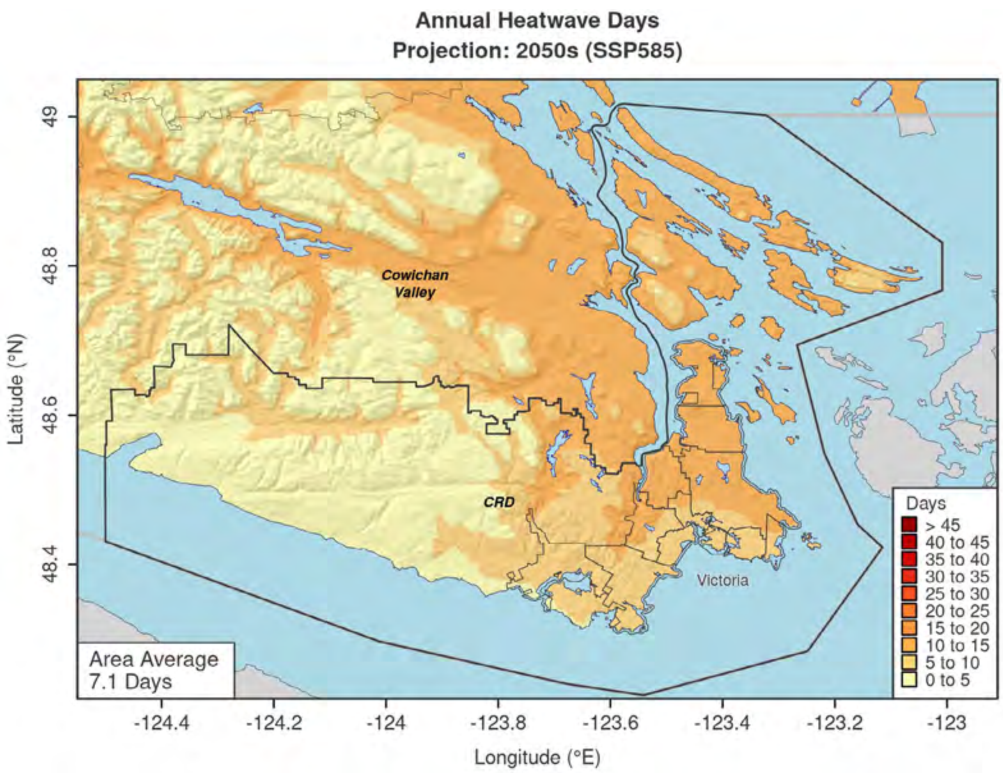


Figure 15a. *Projected annual count of heatwave days in the 2050s.*

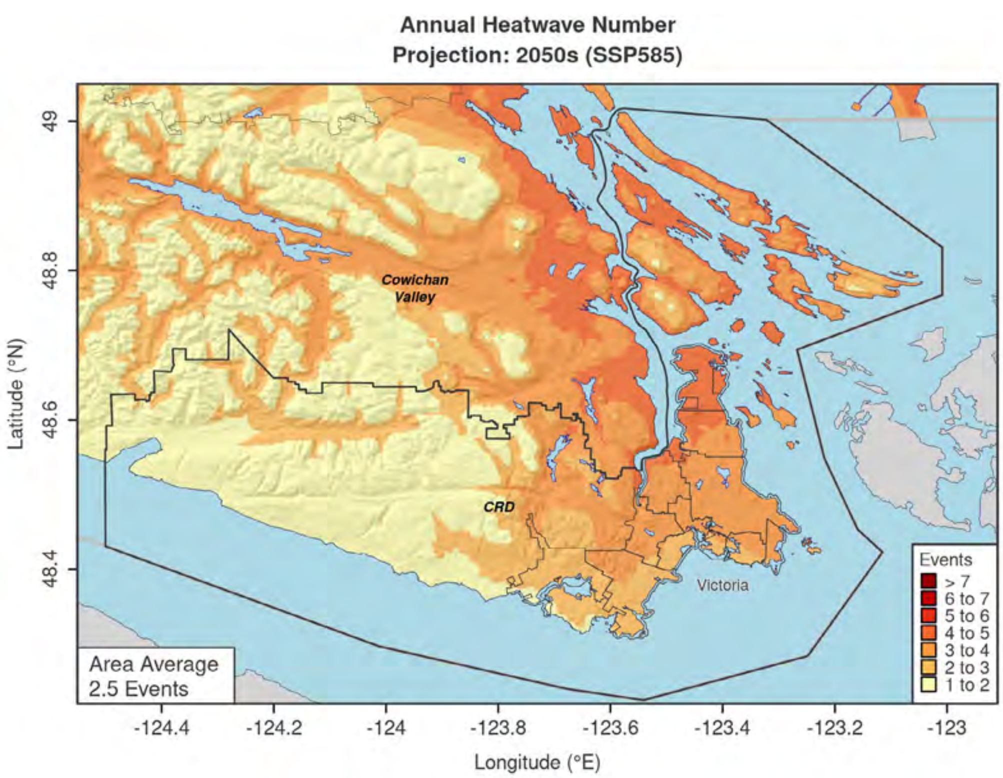


Figure 15b. Projected number of annual heatwaves in the 2050s.

Note that: (i) for both measures, counts in the Past are very low (about 1 per year) and uniform throughout the capital region; and (ii) average values for Core/Peninsula (Table 9) are larger than capital region averages shown on the maps.

5.4 The 1-in-20-Year Annual Hottest Day

This indicator describes extreme daily high temperatures so warm, they are expected to occur only once every 20 years in the historical climate. In other words, the *1-in-20 Year Hottest Day* presently has a 5% chance of occurring in any given year.

Projections

The figure below shows the projected changes in this type of event in two ways: first, in terms of how frequently an event of the same TX value occurs in the future; and second, in terms of how much TX increases for an event occurring with the same frequency (or annual probability) in the future.

For example, in the Past, a daily maximum temperature of 32°C or higher occurred once every 20 years or so in the capital region, or with a 5% annual exceedance probability (AEP). In the projections for the 2050s, this temperature is exceeded around 8 times in a 20-year period, or with a 40% AEP. Alternatively, one can say based on the same projections that in the 2050s, the magnitude of a 1-in-20 year (5% AEP) event increases to around 35.5°C (see the 'Return Levels' tab in the SSP585 Summary Table).

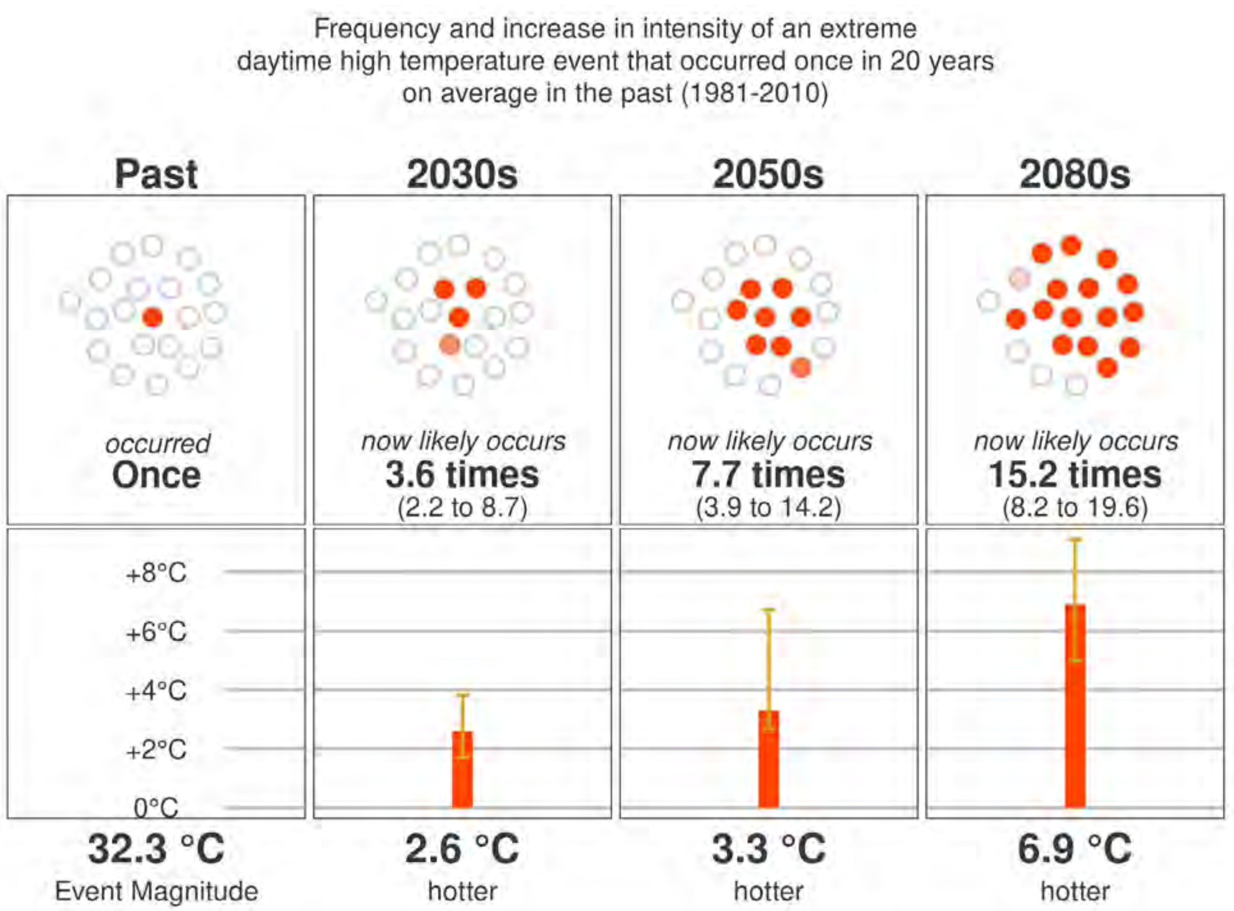


Figure 16. *Upper panels: Frequency of a 1-in-20 year daily maximum temperature (TX) event in the Past and projected frequency of the same magnitude event (i.e. TX = 32°C) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year TX event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

6. PRECIPITATION INDICATORS

6.1 Dry Spells

The *Consecutive Dry Days* indicator tracks the annual longest string of days with less than 1 mm of precipitation.

Projections

In the Past, the median dry spell length in the capital region was 24 days. The median future-projected dry spell length increases by 8% to 26 days (range 24 - 34 days) by the 2050s and by 21% to 29 days (range 26 - 47 days) by the 2080s.

The increase in dry spell length is consistent with the higher summer temperatures and reduced summer rainfall highlighted in the previous chapters. The map of consecutive dry days (not shown) is quite uniform throughout the region, as are its changes in the future periods.

6.2 Snowfall

Snowfall is inferred from the downscaled total daily precipitation and temperature, using a widely validated empirical relationship.[14]

Projections

In the Past, the median annual snowfall in the capital region was around 275 mm (snow water equivalent, or SWE). The median future-projected snowfall decreases by 60% to around 110 mm (range 32 to 134 mm) by the 2050s and by 85% to just 40 mm (range 7 to 60 mm) by the 2080s. Due to the robust projection of an increase in cold season temperature (Chapters 3 and 4), the expectation of a smaller fraction of precipitation falling as snow in future decades is reasonable, even if its magnitude is somewhat uncertain.

Of more concern is the limited model ability to simulate the unique meteorological conditions that lead to the rare, but sometimes heavy, snowfalls in southwest BC. The CMIP6 models used in this study are probably not able to capture this behaviour very well, meaning that the change in frequency of winter storms resulting in heavy snowfall is largely unknown.

[14] Dai, A. (2008). "Temperature and pressure dependence of the rain-snow phase transition over land and ocean," Geophysical Research Letters, 35(12). Snowfall projections should be taken with special caution, for two reasons. First, the amount of total precipitation that falls as snow is a sensitive function of local temperature, so whatever temperature biases remain after the downscaling procedure result in uncertainty in snowfall. Over time, however, as local temperatures exceed 0°C more often in winter, this uncertainty decreases.

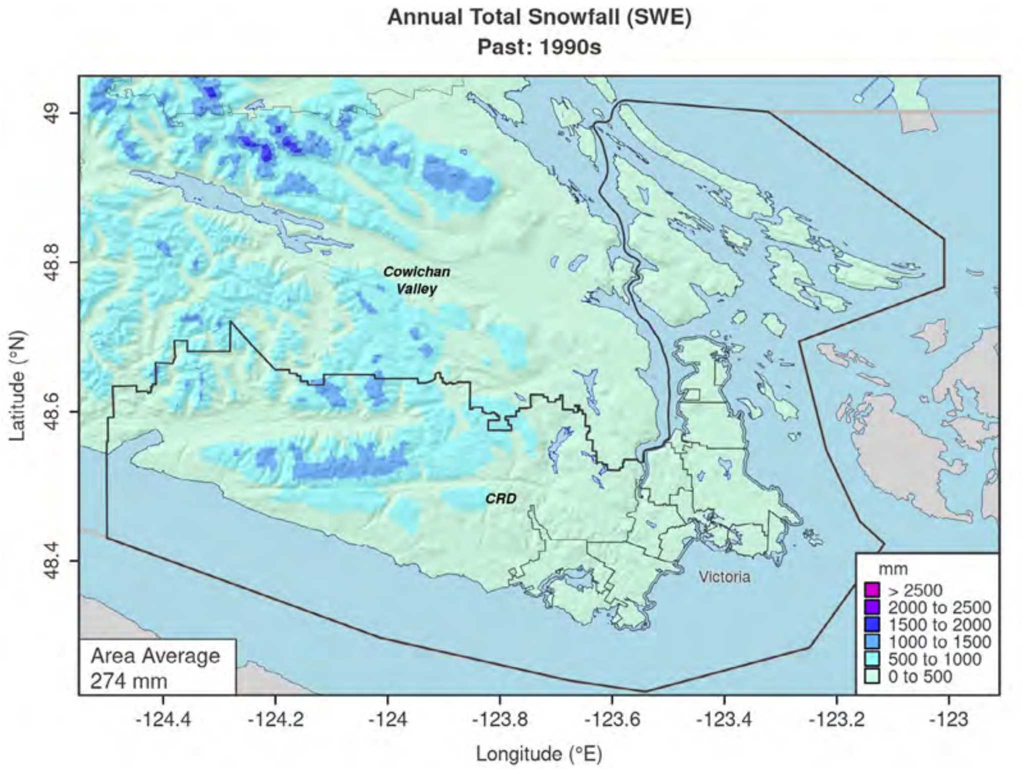


Figure 17a. *Annual total snowfall in the Past.*

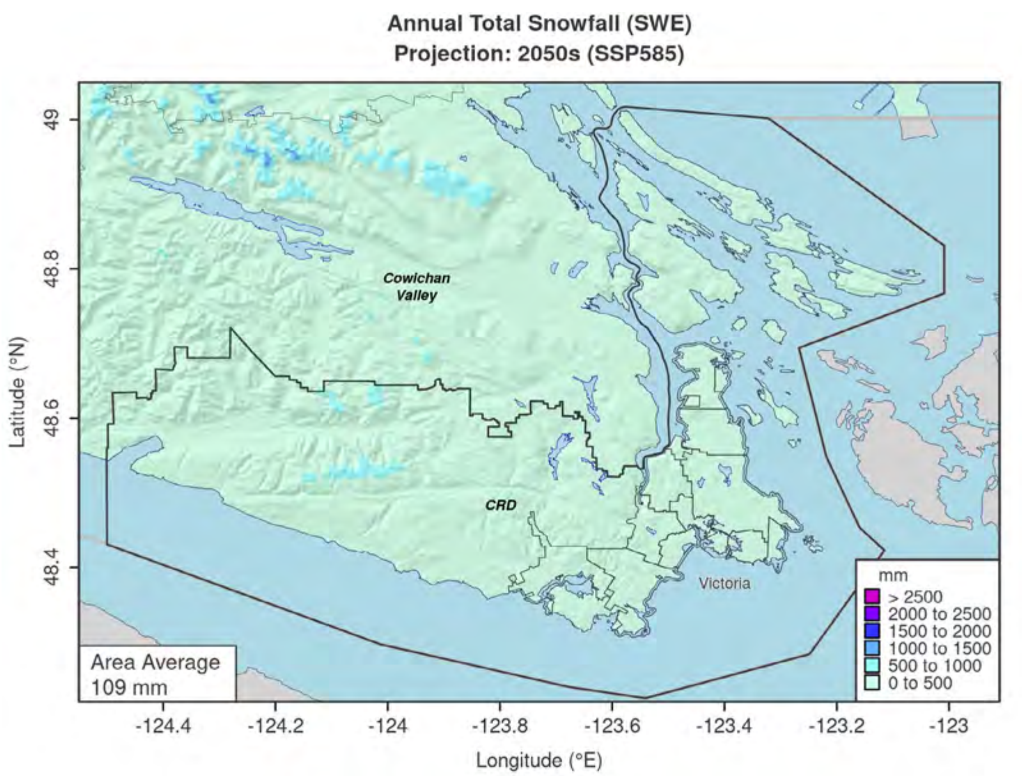


Figure 17b. *Projected snowfall in the 2050s.*

6.3 Annual Maximum One-Day and 5-Day Precipitation and 95th-percentile Wettest Days

These indicators describe the largest precipitation events of the year. The *Annual Maximum One-Day Precipitation* (RX1DAY) is self-explanatory, while the *Annual Maximum 5-Day Precipitation* (RX5DAY) tracks the accumulated amount over consecutive 5-day periods during the year. If we compute the 95th percentile of daily precipitation over all wet days in the Past (i.e. those with a daily amount of at least 1 mm), and then sum the amounts over that threshold that fell on especially wet days, then we obtain the 95th-percentile Wettest Days (R95P) index.

Note that R95P is potentially composed of several large precipitation events in a typical year, and does not (usually) describe single storms.

All amounts in the table below reflect the systematic difference in precipitation amount from west (high) to east (low) across the capital region. Across the region, percent increases for the 2050s differ somewhat for each index: from 10-16% for RX1DAY, to around 10% for RX5DAY to around 30% for R95P. Changes for the 2080s are correspondingly higher, as shown in the table.

Table 10: Annual Extreme Precipitation Indices

	Past (mm)	2050s(mm)	2080s(mm)	2050s Change (%)	2080s Change (%)
One-day maximum precipitation (RX1DAY)					
Region	63	72	77	14 (*4 to 24*)	22 (*17 to 29*)
Western Region*	67	74	80	10 (*4 to 24*)	19 (*17 to 30*)
Eastern Region	37	43	45	16 (*5 to 26*)	22 (*17 to 33*)
5-Day maximum precipitation (RX5DAY)					
Region	163	179	187	10 (*6 to 21*)	15 (*12 to 33*)
Western Region	172	188	197	9 (*6 to 20*)	15 (*13 to 24*)
Eastern Region	88	97	101	10 (*5 to 23*)	15 (*12 to 23*)
95th Percentile Wettest Days (R95P)					
Region	402	527	590	31 (*16 to 46*)	47 (*30 to 77*)
Western Region	423	553	622	31 (*16 to 46*)	47 (*30 to 79*)
Eastern Region	193	245	276	26 (*10 to 41*)	43 (*23 to 64*)

*Values for Water Supply Area and the entire region are slightly lower than those for the Western Region, and well within the spread of model results, so are not shown. Consult the data deliverable spreadsheets for values in all subregions.

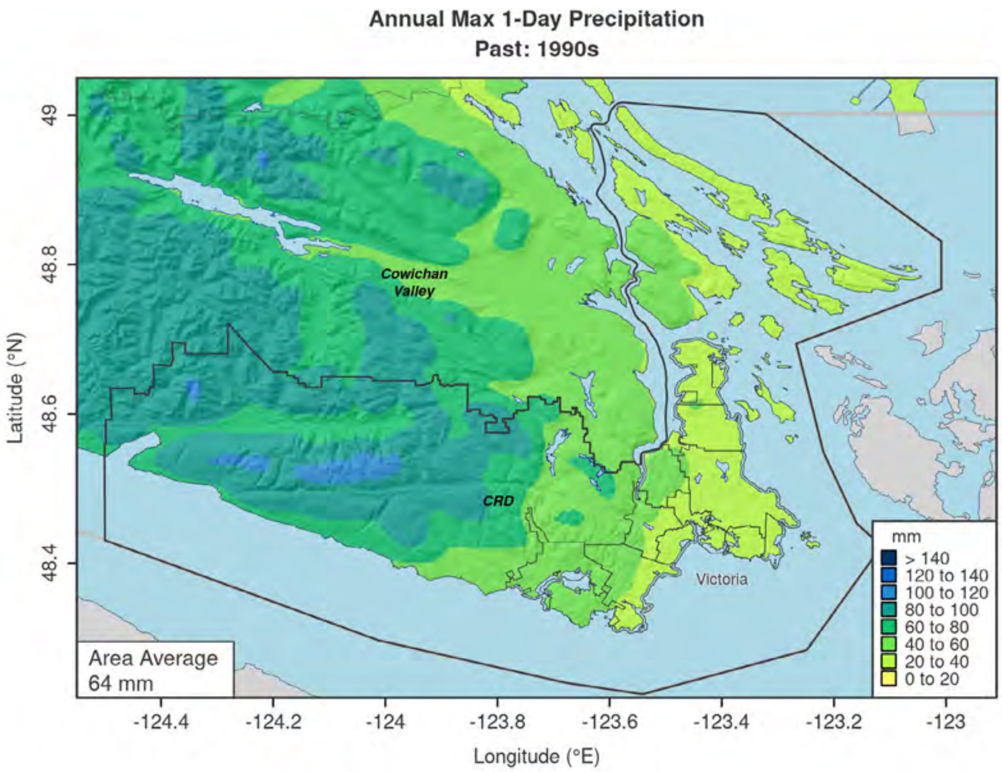


Figure 18a. *Annual maximum 1-day precipitation in the Past.*

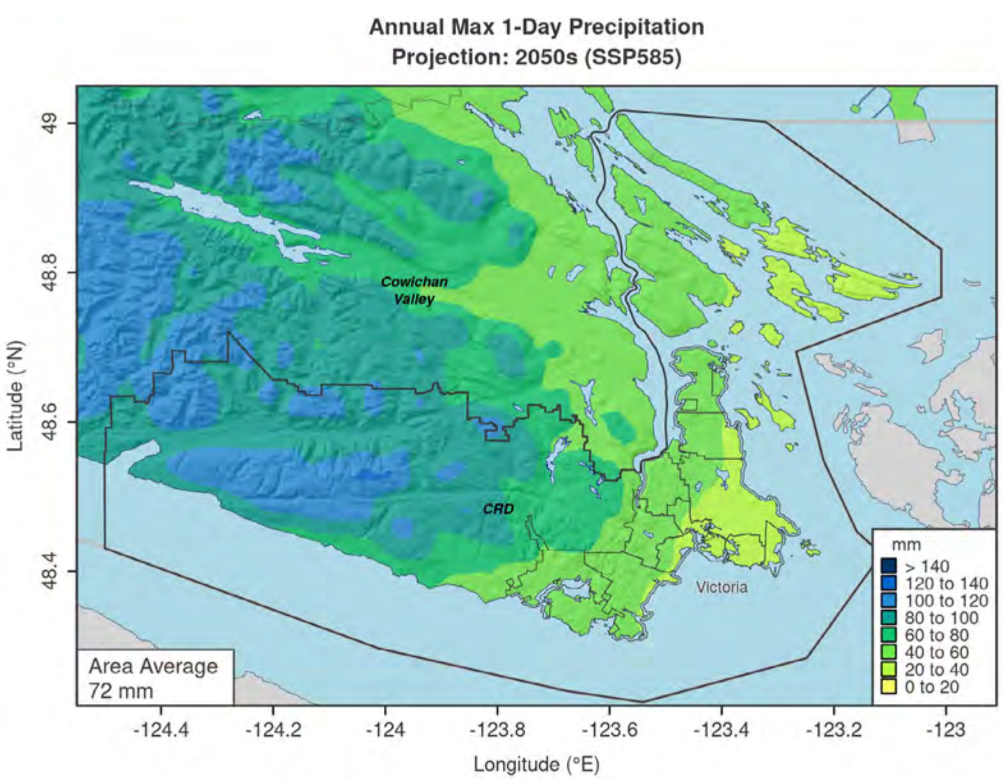


Figure 18b. *Projected Annual maximum 1-day precipitation in the 2050s.*

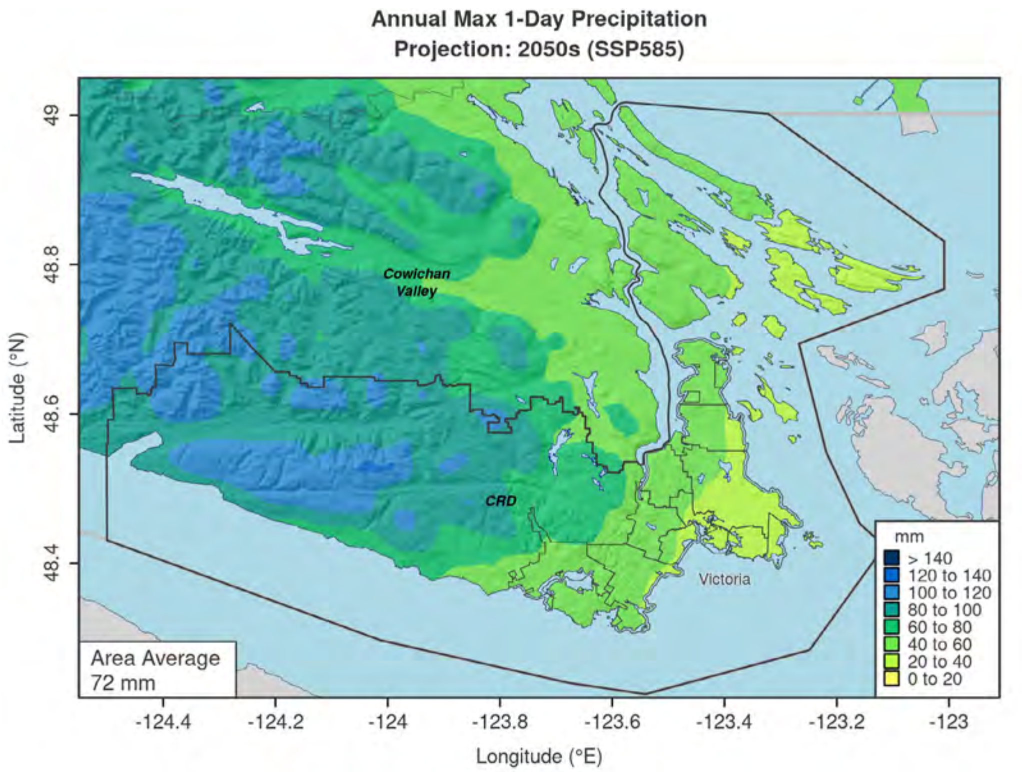


Figure 19a. *1-in-20 year, maximum 5-day rainfall in the Past.*

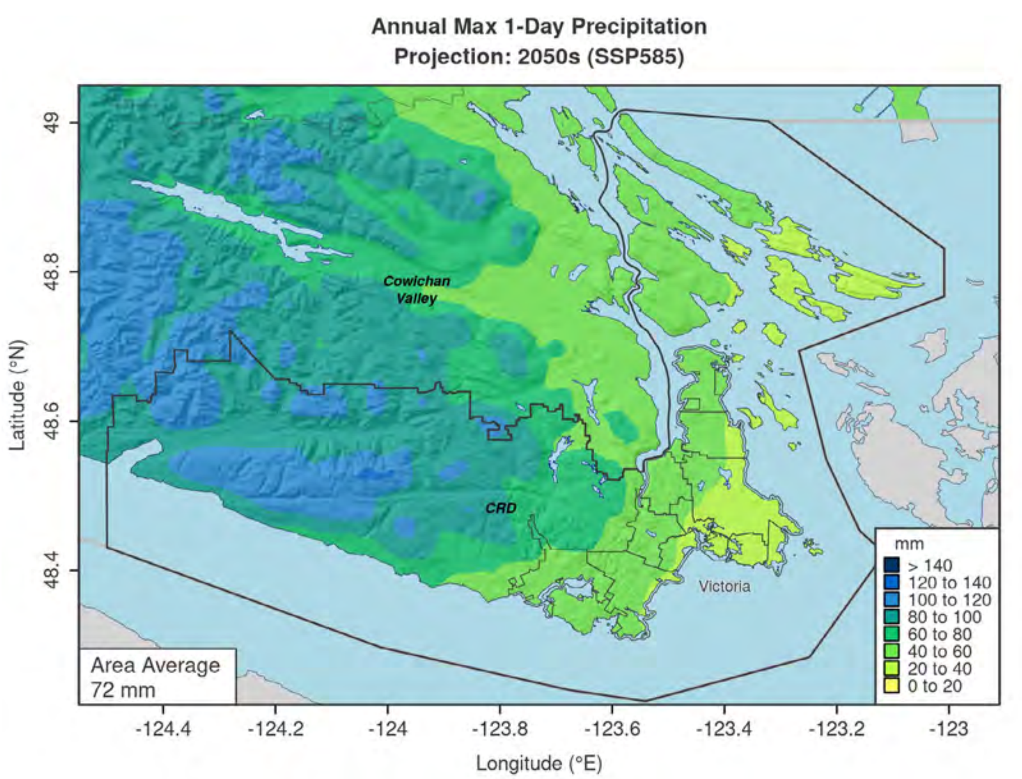


Figure 19b. *1-in-20 year, maximum 5-day rainfall in the 2050s.*

6.4 The 1-in-20 Year Wettest Day and 1-in-20 Year Wettest 5-Day Period

These indicators describe rainfall events so extreme, they are expected to occur only once every 20 years in the Past climate. In other words, the *1-in-20 Year Wettest Day* and *Wettest 5 Days* have a 5% chance of occurring in any given year in the Past.

Projections

In the Past, the median 1-in-20 Year, single-day rainfall in the capital region was around 100 mm, while the median 1-in-20 year, 5-day rainfall was about 230 mm. The median Future-projected 1-in-20 year, single-day rainfall increases by 15% to around 115 mm by the 2050s and by 25% to about 125 mm by the 2080s. The median future-projected 1-in-20 year, 5-day rainfall increases by 15% to around 270 mm by the 2050s and by 20% to about 280 mm by the 2080s. As shown in the maps above, the absolute rainfall amounts for both indices are considerably larger in the west of the region compared to the east.

By comparing these results with those shown in Table 3 of Chapter 3, it is evident that the relative changes in extreme rainfall indices are larger than those for seasonal or annual mean rainfall. Table 12, which gathers relevant results from other tables above, reinforces this point. This behaviour occurs due to the different mechanisms that control how extreme (e.g., daily) and average (e.g., monthly to annual) precipitation respond to warming.

As in the case of rare temperature events, one may express these changes in extreme rainfall in a more visually compelling way, as in the diagram on the following page.

Table 11: 20-Year Return Level Rainfall

	Past (mm)	2050s(mm)	2080s(mm)	2050s Change (%)	2080s Change (%)
1-in-20 Year Maximum One-Day Rainfall					
Region	101	116	124	15 (*9 to 30*)	24 (*22 to 42*)
Western Region[1]	105	122	129	16 (*9 to 28*)	23 (*21 to 39*)
Eastern Region	62	72	79	16 (*10 to 23*)	27 (*23 to 42*)
1-in-20 Year Maximum 5-Day Rainfall					
Region	232	268	281	14 (*3 to 31*)	21 (*11 to 27*)
Western Region	243	274	297	13 (*2 to 32*)	22 (*11 to 27*)
Eastern Region	132	155	159	17 (*0 to 32*)	20 (*10 to 27*)

Table 12: Change in various precipitation indices: Means versus extremes

	Region		Western Region		Eastern Region	
	2050s Change (%)	2080s Change (%)	2050s Change (%)	2080s Change (%)	2050s Change (%)	2080s Change (%)
Annual Mean	4	11	2	8	5	11
RX1DAY	14	22	10	19	15	22
RX5DAY	10	15	9	15	11	15
R95P	31	47	31	47	26	43
1-in-20 RX1DAY	15	24	16	23	16	27
1-in-20 RX5DAY	14	21	13	22	17	20

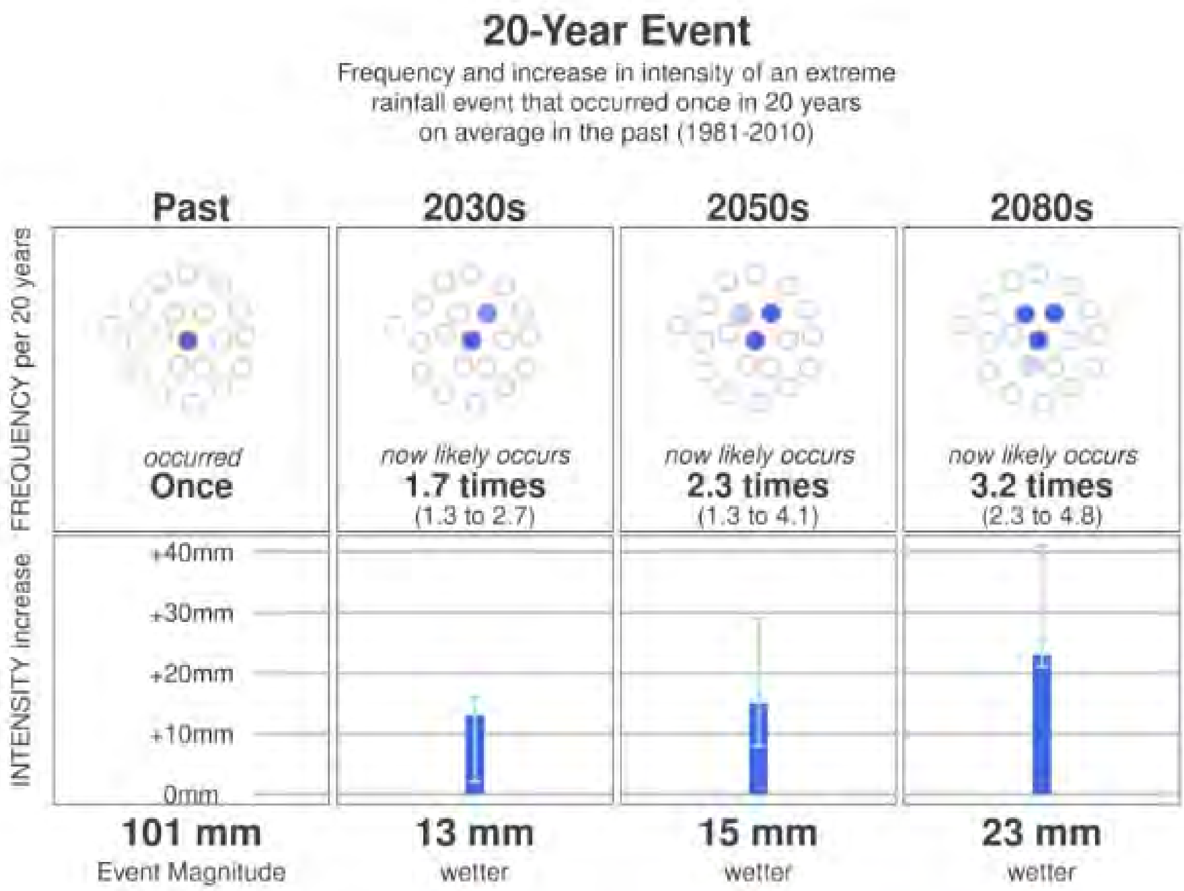


Figure 20. *Upper panels: Frequency of a 1-in-20 year daily maximum rainfall event in the Past and projected frequency of the same magnitude event (i.e. 101 mm) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year single-day rainfall event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

7. REGIONAL IMPACTS

Communities across the capital region are already witnessing and experiencing impacts from climate change. These impacts are likely to persist and, in many cases, intensify over the coming decades based on projected global GHG emissions trajectories. Collective efforts to reduce emissions and thereby slow the rate of global warming will be necessary to lessen the severity of these impacts. Equally important will be action on climate adaptation and preparing for the environment as it will be in the future, not as it was in the past.

Investing in climate adaptation has the potential to support thriving communities and economies for generations to come. Adaptation actions can safeguard communities and their critical infrastructure from extreme weather events, protect and sustain natural ecosystems, increase the resiliency of food systems, and improve the efficiency of energy and water use. Importantly, there is no "one-size-fits-all-solution"; adaptation can take many forms depending on the unique context of the community.

By the 2050s, the capital region can expect a climate that has diverged from that of the past, with warmer year-round temperatures, shifting precipitation patterns, and more noticeable climate extremes. Due to climate variability, these changes may not occur evenly from one year to the next. Although winters will generally become warmer and wetter, it's important to be prepared for some winters in the future to be colder and drier, especially in the near term. Similarly, while summers will become increasingly hot and dry, there will be summers that are cooler and wetter than the average summer in the future. Adaptation strategies must consider the inherent complexity and variability of projected changes to the regional climate.

This section provides a brief overview of the multiple, intersecting climate impacts expected across various sectors in the capital region. **It is not a comprehensive assessment of the impacts that can be expected from the projected changes outlined in this report.** Rather, this chapter reflects a discussion of regional climate impacts that took place among local government staff, emergency planners and environmental scientists in October 2023. It is intended to spark deeper discussion that explores how to prepare for the interrelated climate impacts facing the region.

While the development of this report did not actively involve First Nations in the capital region, it's crucial to recognize that Indigenous Peoples and their traditional territories bear a disproportionate impact from climate change compared to other groups in Canada.[15] Indigenous knowledge systems play a pivotal role in comprehending ecological resilience, monitoring local and regional impacts, and effectively responding to climate change challenges. Future initiatives aimed at exploring and mitigating the impacts of climate change should prioritize meaningful engagement with First Nations throughout the region.

> The case for investing in climate adaptation is clear: for every $1 spent on adaptation measures today, $13 to $15 is estimated to be returned in future years through direct and indirect benefits.[16]

Figure 21. *Infographic summarizing key projections for the 2050s time period.*

[15] BC Centre for Disease Control. Climate Change and Health. http://www.bccdc.ca/health-info/prevention-public-health/climate-change-health

[16] Swayer, D., Ness, R., Lee, C., and Miller, S. (2022). Damage control: Reducing the costs of climate impacts in Canada. Climate Risk Institute.

Climate Equity

The impacts discussed in this chapter will not be experienced the same way by all residents of the region. People facing the greatest economic and social challenges are often the ones most affected by climate change, particularly for impacts that are compounding (see below). During and after climate-related events, some people and communities experience disproportionate impacts because of existing vulnerabilities that often overlap, including:[15]

- People who experience poverty, colonization, racism, inadequate housing, and a lack of access to health care,
- People who are most likely to be exposed to climate impacts because of where and how they live and work,
- People living with disabilities, chronic diseases, and mental illnesses, and
- Babies in the womb, pregnant people, infants, children, and older adults.

Climate equity can be woven into broader efforts to address the socioeconomic, sociocultural, and physical impacts of climate change. This will require collaboration across various sectors to understand where climate change intersects with other crises (e.g., housing, mental health), and to address these issues holistically.

> Climate equity[17] is the goal of recognizing and addressing the unequal burdens made worse by climate change, while ensuring that all people share the benefits of climate action efforts. Achieving climate equity means that all people in our region have access to a safe, healthy, and fair environment.

Impacts

The impacts examined in this chapter occur within a dynamic and increasingly complex global system. As a result, the impacts from projected climate change may be more severe due to the collective impact of multiple drivers. Examples of compounding interactions include, but are not limited to:

- In the warmer months, high temperatures combined with less rainfall can make drought conditions more likely. [18]
- Extended periods of drought can change soil conditions and reduce infiltration of heavy rainfall, exacerbating localized flooding.[19]
- Warmer water temperatures and increased stormwater runoff can promote conditions for algal blooms year-round.[19]
- Wildfire smoke during extreme heat events can aggravate pre-existing health conditions and cause exposure to poor air quality for residents seeking relief from the heat outdoors.[19]
- Ongoing emergency response associated with consecutive extreme events can overwhelm staff capacity and deplete emergency management resources.

[17] United States Environmental Protection Agency. Climate Equity. https://www.epa.gov/climateimpacts/climate-equity

[18] Intergovernmental Panel on Climate Change [IPCC]. 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647

[19] Yumagulova et al. 2022. Lived experience of extreme heat in BC: Final report to the Climate Action Secretariat. Government of BC.

Health and Well-Being

The capital region has a growing and aging population. By 2038, the population is expected to grow by 20% and the number of people aged 65+ is expected to increase by over 50%.[20] Historically, the region has had excellent air quality and comfortable temperatures, with nights cooling off in the summer. In recent years, wildfire smoke and periods of extreme heat during the warmer months have forced residents to seek refuge indoors. Higher temperatures are typically experienced in the eastern parts of the region and in urban areas further from the coast. Developed areas are typically hotter due to the urban heat island effect, which describes how closely packed buildings and widespread paved surfaces in urban areas absorb and re-emit heat more effectively than natural ecosystems and areas shaded by trees and vegetation.[21]

Impacts

In recent years, extreme weather events made worse by climate change have negatively impacted human health and well-being in the capital region. Climate change has the potential to undermine health determinants such as air quality, water supply, food security, cultural practices, and access to a safe environment. Climate change can also place additional strain on healthcare and social systems that are necessary for good health and well-being.

By the 2050s, the capital region can anticipate more multi-day extreme heat events that become longer and more intense by mid-century. The region can also expect hotter summer temperatures, with more days exceeding 25°C and more "temperate nights" where the temperature stays above 16°C.[22] These projected changes will increase the risk of heat-related illnesses and mortality and worsen pre-existing health conditions, particularly among equity-denied populations who do not have access to a cool indoor environment. Notably, these risks are heightened for the region's growing population of older adults.

Warming temperatures and shifting precipitation patterns may worsen air quality in the region. Across the Pacific Northwest, hotter and drier conditions can increase the likelihood of wildfire ignition. This may cause more frequent episodes of wildfire smoke in the capital region, which can irritate the lungs, cause inflammation, and alter immune function, particularly for people with pre-existing conditions.[24] The projected changes in temperature, precipitation and heat wave occurrence may also exacerbate other air pollutants that influence human health such as pollen, mould, and ground-level ozone.

Living through an extreme weather event, or grappling with uncertainty about the future, can impact mental health and wellbeing, often manifesting as stress, anxiety, fear, and exhaustion. During and after an extreme event, people who face property loss or displacement may endure significant and lasting trauma.

In June 2021, an unprecedented[23] "heat dome" event in the Pacific Northwest caused extended periods of record-breaking high temperatures that had severe implications for health and well-being. Over 600 heat-related deaths were recorded across BC, particularly among people with pre-existing medical conditions (including schizophrenia), older adults, people living alone, and people living in socially deprived areas[21]. In response to this event, numerous projects have been launched across the capital region to better understand extreme heat vulnerability and to build resilience towards extreme heat in the future. For more information, see Appendix D: Further Resources.

[20] BC Statistics. 2019. Capital Regional District 2019-2038 Population, Dwelling Units and Employment Projection Report.

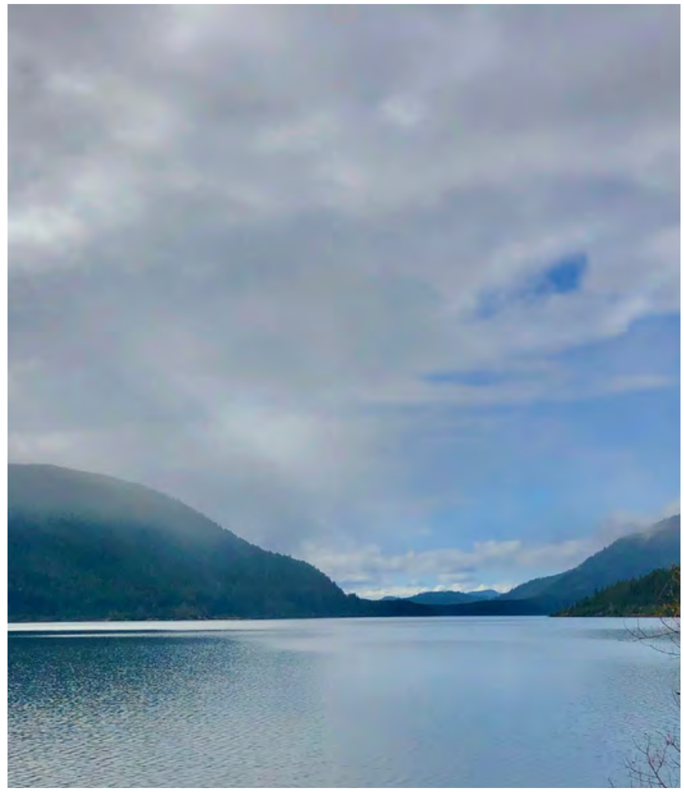
[21] British Columbia Coroners Service. 2022. Extreme heat and human mortality: A review of heat-related deaths in BC in Summer 2021.

[22] The number of temperate nights is an important public health measure that reflects the lower temperature threshold for emergency health alerts used in the capital region. For more, see: Government of British Columbia. 2023. BC Provincial Heat Alert and Response System (BC HARS).

[23] The unprecedented nature of the June 2021 heat dome makes it difficult to estimate its return period (or annual probability of occurrence). Based on analysis of historical data, it was estimated as a 1-in-300-year (or 0.3% annually) at Seattle-Tacoma Airport to a 1-in-1000-year event (or 0.1% annually) in New Westminster (Philip et al., 2022; doi: 10.5194/esd-13-1689-2022). While the capital region can expect more frequent extreme temperatures in the future, estimates for how often an event of this magnitude will occur are difficult because historical records are far shorter than the estimated return periods for this event.

[24] Berry, P., and Schnitter, R. 2022. Health of Canadians in a changing climate. Government of Canada.

Water Supply and Demand



The CRD supplies drinking water to over 390,000 customers from large reservoirs in the Sooke, Leech and Goldstream watersheds that make up the protected Greater Victoria Water Supply Area (GVWSA). The CRD also provides water to small service areas in the Southern Gulf Islands and the western portion of the region through surface water and groundwater systems. Similar privately owned systems provide water in other areas. In some rural and less developed areas, residents rely on groundwater wells on their properties. Residential water use accounts for the largest portion of water use in the region (60%). Water supplies across Southern Vancouver Island are almost entirely replenished from rainwater in the late fall, winter, and early spring (the wet season). Snow melt runoff contributes to groundwater recharge and is needed to sustain summer flows.

Impacts

By the 2050s, less summer rainfall and longer dry spells will increase the risk of drought during the summer and into the early fall. At the same time, hotter temperatures and more extreme heat events will intensify water demand as residents consume more water to keep cool and stay hydrated. Hotter and drier conditions will also increase evaporation and evapotranspiration, raising outdoor watering demand. Water conservation initiatives will remain a priority in the region, given the growing population and the potential for the seasonal decline in water supplies to become more pronounced in the future. Greater densification and anticipated increases in peak demand may also trigger the need for more storage, supplements to existing water supplies, larger capacity infrastructure, and balancing reservoirs in water distribution systems.

> Hotter and drier summer conditions will be particularly challenging for those who rely on groundwater wells or small reservoirs that may not recharge sufficiently. In some instances, these systems may reach dangerously low levels or may even deplete completely. In coastal areas, overdrawing groundwater can lead to saltwater intrusion – an impact that is compounded by rising sea levels.

Hotter and drier conditions also increase the threat of wildfire in the GVWSA and other forested areas that supply water to residents of the region. Although fire is a natural and essential process in forest ecosystems, severe wildfire occurring in water supply areas can affect water quality and supply by increasing erosion during the following rainy season.[25] As the threat of wildfire increases in rural areas, water needs for wildfire protection will gain increasing importance in water conservation planning.

During the wet season, heavier rainfall may increase erosion of saturated slopes, leading to more fine sediment and organic material in streams entering water supply reservoirs. Increased turbidity from fine sediment can interfere with water disinfection and treatment, while excess organic material can promote algal blooms that produce cyanotoxins, cause taste and odour issues, and compromise disinfection and filterability. Where unprotected water supply catchment areas have been developed, more intense rainfall and runoff can lead to greater undesirable substances (pollutants) entering wells and surface reservoirs. Heavy rainfall and increased water inflows also pose a risk to dam safety. To support safe and resilient water supply through a changing climate, the potential for more intense rainfall events (see next section) will need to be considered in the planning and management of water supply systems.

[25] Brown et al. 2019. Long-term climate, vegetation and fire regime change in a managed municipal water supply area, SAGE Journals, 29(9), 1411-12.

Rainwater Management and Sewerage

A myriad of rainwater management and sewerage infrastructure aims to protect quality of life, property, and aquatic ecosystems across the capital region. Local governments in British Columbia are responsible for managing drainage; as a result, much of the region's drainage infrastructure (hard and soft) is integrated into local land use and infrastructure planning and processes. Historically, stormwater infrastructure was designed to move water away from the built environment, channeling high volumes of rainwater into creeks and streams. Recently, local governments are shifting towards the use of green infrastructure, which mimics natural drainage systems that play a crucial role in rainwater management. Natural drainage systems (i.e., creeks and wetlands) slow runoff through water retention, helping to reduce flood magnitude and filter out substances that impact water quality. The use of green infrastructure is particularly important in areas with increasing urbanization and development, where greater impermeable surfaces (i.e., roads, parking lots and buildings) contribute to additional runoff.

Malahat washout during November 2021 extreme rain event (Credit: Emcon Services Inc.)

Impacts

In the past, flooding from extreme events has occasionally overwhelmed stormwater and sanitary systems in the region. With extreme precipitation events becoming wetter in the future, the region can expect aging and undersized infrastructure to continue to be overwhelmed, amplifying stressors on the receiving environment. During high intensity rain events, creeks may overflow and soils may become saturated, intensifying runoff, and increasing the chance of flooding in low-lying areas. This combination can increase erosion, decrease slope stability, and flood wetlands and lakes, impacting public infrastructure, drinking water quality, and surrounding aquatic ecosystems. Heavy rainfall events can also cause inflow and infiltration of rainwater into the sanitary system in crossover areas, increasing the likelihood of highly diluted sewage entering waterways.

When heavy rainfall occurs after prolonged periods of dry weather, the "first flush" of surface runoff typically contains high levels of contaminants that have accumulated on hard surfaces. This runoff makes its way into surface waters that are home to aquatic ecosystems. When paired with warmer water temperatures, increased stormwater runoff of nutrients can make conditions more favorable for algal blooms year-round – a growing issue in that region – that impacts water quality, ecosystems, recreation, and human health.

> Certain areas in the region are at increased risk of flooding during heavy rainfall events due to flat terrain and proximity to the ocean, particularly when these events occur simultaneously with high tides and onshore winds. The CRD Coastal Flood Inundation Mapping Project (2021) may be used in conjunction with the projected changes outlined in this report, to understand how these factors, along with sea level rise, will influence future flood risk for lower-lying areas near the coast.

The projected increase in heavy rainfall may lead to a higher volume of runoff than the current capacity of infrastructure is able to handle. Green infrastructure, low impact development and multijurisdictional watershed management approaches will remain important strategies for reducing the flooding, runoff and pollution associated with extreme precipitation events. Designers of stormwater infrastructure (i.e., culverts, storm drains, etc.) will also need to plan for higher single- and multi-day rainfall amounts. For more information about how future precipitation is estimated using climate model projections, including the adjustment of Intensity-Duration-Frequency (IDF) curves in a future climate, see Appendix D: Further Resources.

Ecosystems and Species

The capital region is home to various ecosystems, including Douglas-fir forests, Garry oak meadows, riparian zones, wetlands, estuaries, shorelines, and more. The diversity in the region brings with it a wide range of flora and fauna, including many species at risk that need protection. Natural assets providing connectivity and ecosystem services are essential for supporting climate resilience. Forests in the GVWSA contribute to the high quality of water in supply reservoirs, and green spaces in urban and suburban areas provide natural cooling capacity, stormwater retention, and help reduce air and water pollution.

Impacts

Warming year-round temperatures and seasonal changes in precipitation will have important impacts on the ecosystems, native species and associated ecological relationships and processes existing in the capital region. Because ecological systems are highly complex, it will be difficult to make specific predictions for how they will be impacted by a changing climate. In general, the speed and scale of climate change may threaten the capability of many species to adapt, altering the ecological landscape. Shifting seasonal patterns, characterized by an earlier onset of spring or a later start to fall, may threaten processes that rely on temperature cues, including predator/prey, parasite/host, and pollinator dynamics. This may cause population declines for certain species, and/or outbreaks of species that are considered pests. Specialist species may be particularly vulnerable, which may threaten regional biodiversity and create new opportunities for invasive species to thrive.

Climate change not only impacts ecosystems and species directly; it also interacts with environmental changes from human development.[26] Impacts from climate change may be amplified for ecosystems where land-use changes have caused fragmentation and, as a result, weakened resiliency. For example, the Bowker Creek watershed – covering 1,028 hectares of the capital region – historically supported coho and chum salmon and cutthroat trout. Today, Bowker Creek is highly urbanized, with roughly 50% now composed of impervious surfaces that cause low summer base flows and reduced water quality for aquatic ecosystems. Long range, multijurisdictional efforts are in place to protect its natural characteristics and reduce impacts from a changing climate.[27]

In the summer, hotter and drier conditions will continue to stress trees and other terrestrial and riparian (streamside) vegetation, particularly for species that are sensitive to drought such as the Western red cedar. Drought conditions can slow decomposition in below-ground communities consisting of bacteria, fungi, and other soil organisms, thereby reducing available nutrients. When plants undergo stress, they become more susceptible to competition with other plants and to damage from insects and diseases.

Warmer year-round temperatures will also raise water temperatures in aquatic ecosystems, which may be problematic for species that require cool water to thrive. In extreme cases, warm water can cause low oxygen levels and mortality, particularly when these conditions are compounded by low water levels and occur during critical life stages such as spawning, rearing, or hatching. Heavy rainfall can also disrupt critical ecological processes. For example, during an atmospheric river event in November 2021, increased channel erosion and sediment deposition resulting from high stream flows severely impacted salmon spawning beds.[28]

[26] IPCC. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group, II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [H.-O. Pörtner et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi: 10.1017/9781009325844.59327/IPCC/AR6-9789291691647

[27] Bowker Creek Initative. 2012. Bowker creek blueprint: A 100-year action plan to restore Bowker Creek Watershed.

[28] CBC. 2021, 21 November. For B.C.'s salmon, floods represent another challenge to survival.

Buildings and Energy Systems

Energy use in buildings accounts for roughly one third of GHG emissions in the region. In the past climate, most buildings and homes in the capital region did not require active cooling capacity. During the 2021 heat dome, 98% of heat-related deaths in BC occurred in private residences, highlighting an urgency to implement cooling measures in homes across the region.[21] Retrofit programs and new building policies not only support the transition to renewable energy and energy efficient technologies but are leading to building envelope considerations and a greater adoption of low emission heat pumps that support thermal comfort. In both urban and rural communities across the region, many homes and other buildings are in coastal and riverine areas where flooding may be a concern.

Impacts

As the climate warms and precipitation patterns change, the case for investing in well-designed, resilient buildings improves. Heavier rainfall events may increase the risk of flooding in the fall and winter, which can cause property damage, personal injury, and economic losses, particularly where development is located on flood plains. More episodes of multi-day extreme heat can also stress foundations and building materials, and potentially affect the functioning of heating, ventilation, and air conditioning (HVAC) systems.

Across the region, warmer year-round temperatures and more days going above 25°C in the summer will shift seasonal and long-term energy demands. Whereas heating demand is expected to decrease in the colder months, hotter temperatures and more multi-day extreme heat events during the warmer months will generate cooling demand where it did not exist previously. In the past, buildings and homes have relied on the region's cool summer nights to support thermal comfort during the warmer months. In the future, an increasing number of "temperate nights" (i.e., nights when the temperature stays above 16°C) will heighten the risk of buildings overheating.

Adaptive design strategies, such as passive cooling, outdoor shading, rainwater capture and reuse, green roofs, resilient landscaping, and rain gardens, can help address challenges from heat, drought, and overland flooding. In addition, concentrating development in already developed areas, balanced with access to urban greenspace, can protect opportunities for the surrounding natural ecosystems to buffer changes to our climate.

The projected increase in cooling degree days by mid-century will require that most buildings have some form of active cooling to maintain thermal comfort and prevent overheating. Certain units, such as older, multi-unit residences, often lack air conditioning and are not designed to handle hot temperatures, leaving occupants at greater risk of heat-related illnesses and mortality. The use of energy efficient technologies like heat pumps will play an important role in aligning with efforts to reduce GHG emissions while avoiding additional costs to residents. Authorities with jurisdiction over building codes should consider how to proactively integrate future climate considerations into the design of new and existing buildings.

Transportation

The region's transportation network includes many local and arterial corridors, three major highway corridors (Highways 1, 14 and 17), two provincial and two international ferry corridors, a regional transit network, international and harbour airports, cruise ship and ferry terminals, and many active and multi-use trails. Regional transportation priorities include full realization of a multi-modal transportation network to help shift away from private vehicles to public transport, walking and cycling. As a coastal community, the capital region is vulnerable to significant transportation disruptions that complicate responses to emergencies and extreme events, and can interrupt the local supply chain.

Impacts

The projected increase in heavy rainfall may intensify flooding across the region, potentially causing more frequent road closures, vehicle collisions and construction delays. Some communities, such as Sooke, have already seen recurrent road closures due to flooding and may be particularly vulnerable to heavy rainfall.[29] Extreme precipitation events may also impede the reliability of major transportation corridors. In November 2021, extreme rainfall and runoff from a landfalling atmospheric river caused extensive damage to the Malahat Highway (Highway 1), prompting its temporary closure. This disruption reverberated through the local supply chain, resulting in shortages of fuel and other essential goods and services across the region. Like flooding from heavy rainfall events, wildfires also pose risk to the closure of regional highways and roads. In the future, hotter temperatures and less rainfall occurring in the warmer months will increase fire danger. Wildfire damage along hillslopes near roadways may also heighten the risk of landslides during the subsequent rainy season.

> The effects of extreme weather on transportation may be particularly challenging for some equity-denied groups. Residents may find themselves unprepared to leave their homes, hindering their ability to access essential supplies and services.

By the 2050s, a shorter winter season characterized by less snowfall and fewer freezing days may lower the costs associated with snow removal and the repair of cracked roads from freeze-thaw cycles. However, equipment to manage severe winter conditions will need to be maintained as changes to the frequency of heavy snowfall events remains largely unknown because they are driven by "Arctic outflow" events from Northern BC.

Warming temperatures may enhance the appeal of active transportation (walking, cycling and transit use) during the colder months. Conversely, high temperatures, multi-day extreme heat events, and poor air quality from wildfires in nearby regions may deter residents from choosing active transportation methods in the summer and early fall. Active transportation routes may also be interrupted by heavy rainfall, which can cause localized flooding and erosion along trails and pathways.

To safeguard transportation across the region, projected changes to temperature and precipitation should be considered in the design and retrofit of transportation infrastructure. These changes should also be considered against the backdrop of other existing weather hazards that will continue to affect the region (e.g., windstorms). Efforts to reduce GHG emissions across the region will rely on a resilient active transportation network. Strategies to support active transportation may involve installing adequate cooling infrastructure (i.e., trees, benches, shade structures, misting stations and water fountains) and supporting nature's capacity to buffer climate impacts through stewardship and community engagement.

[29] Chek News. 2021. Heavy flooding and road closures forces Sooke into temporary isolation.

Food and Agriculture

Food and agriculture are fundamental elements of the long-term sustainability, resilience and health and wellbeing of the capital region. In recent years, changes in climate, energy costs, water availability and agricultural production have drawn attention to the ongoing resilience of the region's food system. Ensuring a stable local food system requires management of changing wildlife populations, flooding and drainage concerns, water availability, as well as the amount of agricultural land in food crop production. The average age of farmers in the capital region remains higher than the Canadian average and represents a warning sign for the future of food production in the region.[30]

Impacts

Increasing year-round temperatures will lead to fewer frost days, an earlier start to spring, and extended summer-like weather into the fall. These changes will result in a longer and warmer growing season that could enhance agricultural productivity in the region. However, climate change is also expected to introduce greater uncertainty for growers, as temperatures become hotter in the warmer months and precipitation patterns change. The projected increase in growing season length by 2050 (estimated to be roughly 17%) should be considered an upper limit for estimates of future productivity. This measure uses only a lower temperature threshold and does not account for reduced summer precipitation, which increases the risk of drought. In addition, shifting seasonal conditions from warming temperatures may cause pollinating species to emerge at misaligned times, limiting potential crop yields.

During the growing season, reduced water availability and extended dry periods leading to drought could have significant impacts on agriculture in the region. Less total rainfall in the summer will reduce water levels in ponds, wetlands and streams used for irrigation, while hotter temperatures will promote further evaporation and evapotranspiration. These conditions can increase heat stress and sun scald, competition for water resources, and may create opportunities for invasive species, pests, and plant diseases to flourish. Increased demand for irrigation strains water supply systems with competing demands, and negatively impacts ecosystems in water bodies, wetlands, and streams. Addressing these challenges will require innovative strategies that improve the efficiency of agricultural irrigation and transition to crops requiring less water. Growers may need to consider alternative soil-management approaches, as changes to soil moisture and composition may accompany the projected changes to the region.

In the fall, heavy rainfall events may impact crop harvest by increasing the risk of flooding and creating more opportunities for diseases and pests. Extreme precipitation can also lead to more runoff onto and off agricultural land, leading to erosion, soil nutrient leaching, and crop loss and damage. For low-lying agricultural areas near the coast, these impacts may be compounded by high tides, storm damage, and saltwater intrusion from rising sea levels.

[30] Capital Regional District. 2018. Regional Growth Strategy.

Recreation and Tourism

With its mild climate, beautiful coastlines, and abundant ecosystems, the capital region continues to be a sought-after destination for visitors from across the globe and tourism remains a key local industry. Tourism is an estimated $1.9 billion dollar industry in Greater Victoria with more than three million visitors to the region annually.[31] The region boasts plenty of outdoor recreation, with more than 26,000 hectares of national, provincial, regional, and municipal parks and ecological reserves and four regional trails on southern Vancouver Island and the Gulf Islands.[32] In 2021, regional trails received over 3.7 million visits and regional parks received over 5 million visits from local residents and tourists. These areas contribute to the cultural, social, and economic vitality of the region.

Impacts

By the 2050s, warmer year-round temperatures could lead to a longer season for summer recreation, providing more opportunities for outdoor activities and potentially boosting economic productivity. However, the rise in the number of hot summer days and multi-day extreme heat events may encourage more people to seek relief near lakes and coastlines, which can place additional stress on freshwater, marine and shoreline ecosystems. Careful protection and monitoring of recreational sites will be important to ensuring ecological health in areas where visitor use may increase.

The projected changes in temperature and precipitation may also influence the access and safety of recreation and tourism across the region. Less summer rainfall and longer dry spells may result in longer and more frequent campfire bans. Increasing fire danger may also result in the closure of parks and campgrounds due to wildfire risk. During the wet season, heavier rainfall may impact trail access and safety, and increase the costs associated with the maintenance of recreational infrastructure. At all times of the year, the potential increase in algal blooms may pose challenges to recreational water users, fishing, and tourism. Ensuring climate-resilient design of new and existing infrastructure and supporting ecosystem health and integrity through a changing climate can benefit both the economy and the physical, mental, and spiritual health of people across the region.

[31] Greater Victoria Chamber of Commerce. Destination Greater Victoria. https://www.tourismvictoria.com/

[32] Capital Regional District. 2023. Regional Parks and Trails Strategic Plan.

Summary and Recommendations

This report uses the most up-to-date climate model projections to examine how climate change may unfold across the capital region in the coming decades. The region can expect an increase in daytime and nighttime temperatures throughout the year. In the summer months, this implies hotter daily highs, warmer nights, and more numerous and longer multi-day heatwaves. By the 2050s, winters will become milder overall with a steep reduction in frost days and snowfall.

The capital region can expect a modest increase in annual precipitation by the 2050s that will be distributed unevenly across the seasons. Whereas rainfall is projected to increase notably in the colder months, summers will become drier. Warmer cold season temperatures will result in less snowfall and increased rainfall, especially in winter. In the warmer months, longer dry spells are expected due to the combination of less rainfall and warmer temperatures. The magnitude and character of these changes will vary locally across the region.

Early action on climate adaptation will enable the region to best prepare for the changes ahead and increase climate resilience. The information provided in this chapter is intended to guide further discussion among decision makers and community partners across the region. Importantly, adaptation can take many forms depending on the unique context of each community. The regional impacts outlined in this report should be considered a starting point for further analysis of climate impacts and adaptation planning that engages relevant stakeholders and is tailored to the local context.

The CRD will continue to use these projections to incorporate climate change adaptation into planning cycles and ongoing activities. Adaptation planning is complex and requires consideration of multiple factors and compounding drivers. As such, continued data collection and monitoring will be important to establish baselines, monitor changes and ensure that adaptation actions are appropriate to the local context. Some examples of how the future climate projections provided in this assessment can be used to support climate adaptation include:

- Raising awareness about how climate change will impact the region
- Informing strategic and long-range planning
- Informing strategic planning for emergency responses to extreme events
- Conducting vulnerability and risk assessments to inform policy, planning, research, and monitoring
- Designing infrastructure that considers the future climate

This report highlights regional projections for the 2050s under a high emissions scenario, but alternative scenarios were also considered for this project. The complete data package includes information for low, moderate, and high emissions scenarios for the 2030s, 2050s and 2080s. It also includes separate assessments for four smaller sub-regions within the capital region. The report Appendices point to further online resources and general guidance for understanding and using climate projections.

Appendix A

BACKGROUNDER ON FUTURE CLIMATE DATA

The Earth's climate is changing due to the burning of fossil fuels, which emit greenhouse gases (GHGs) and aerosols into the atmosphere. Over the past century, these emissions have raised atmospheric GHG concentrations well above preindustrial levels, which has led to widespread warming over Earth's surface.

The global average temperature has increased by over 1°C to date, and Canada is warming even faster (Figure A1). This warming has resulted in widespread impacts in Canada and across the globe, and it is directly proportional to the total amount of GHGs emitted since the beginning of the industrial era. While a 1°C temperature change at your location may not feel like much, changes of only 1 or 2°C on a global scale are very substantial because they are averaged over the globe and a long period of time.

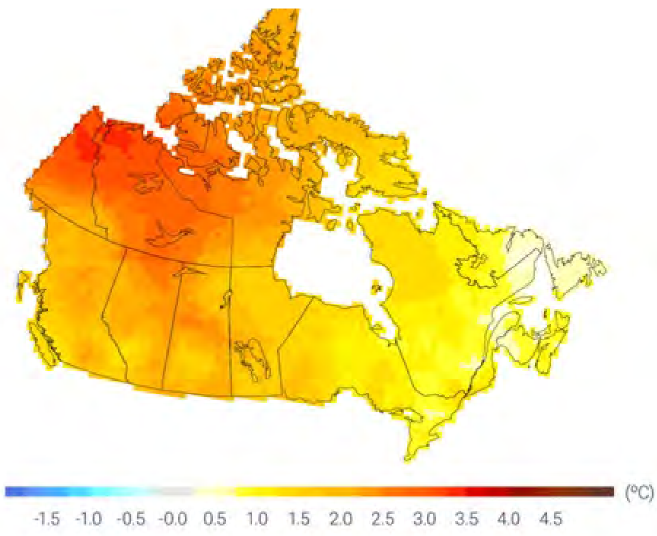


Figure A1. *Warming in Canada between 1948-2018.*

Understanding Weather, Climate, Natural Variability and Climate Change

To understand climate change, it is important to distinguish between weather and climate, and the natural and human influences that affect the climate on different time scales:

- Weather is what we experience when we step outside. It consists of short-term (minutes to days) variations in the atmosphere.
- Climate is the general state of weather, including its extremes, over periods ranging from months to many years. Climate can be thought of as the statistics of weather. Descriptions of normal climate conditions at a particular location are often derived from nearby weather observations and collected over long time periods – typically 30 years or more.
- Natural climate variability causes fluctuations in climate conditions that can span a few months to a few decades or longer. Natural climate variability is not influenced by human activity, but its influence can either mask or enhance human-induced climate change for the periods over which it occurs. Natural climate variability can also affect seasonal weather (e.g., El Niño/La Niña cycles).
- Climate change refers to changes in the state of the climate that persist over an extended period. Both natural processes and human influence can result in changes in climate. Climate science indicates that human influence is the unequivocal cause of the global warming that has been observed since the beginning of the 20th century.

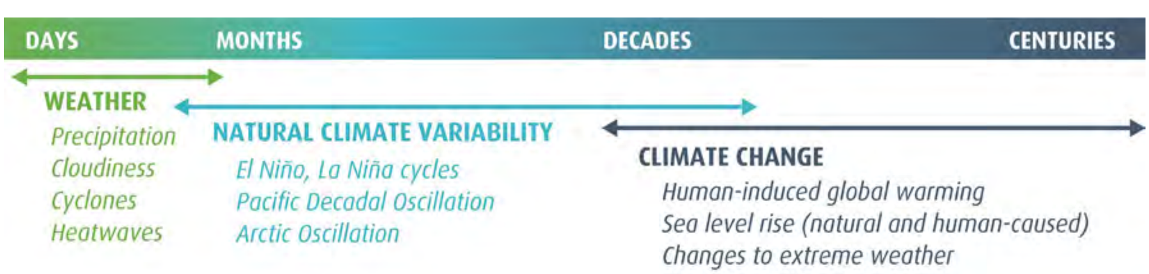


Figure A2. *Timescales for weather, climate, natural climate variability, and climate change.*

What is Future Climate Data?

In the context of a changing climate, historical climate observations are no longer suitable for assessing future climate-related risks. As a result, engineers, planners, and decision-makers are increasingly using future climate data to estimate the growing risks associated with climate change. Practitioners and decision-makers want to know how much climate change (and risk associated with that change) they can expect to encounter over the coming decades.

The extent of further warming depends on how global emissions change in the future. Unfortunately, it is impossible to predict the exact societal conditions of the future that will directly influence global emissions. Therefore, a range of potential futures, or scenarios, can be used to plan for the changes associated with rising global temperatures. These scenarios are based on assumptions about population growth, climate policy, land use changes, energy intensity, economic activity, and more, that lead to different levels of global GHG emissions. The scenarios used in this assessment are known as Shared Socio-economic Pathways, or SSPs for short – but more on that later.

To understand the future climate, scientists develop global climate models (GCMs) to simulate Earth's future climate in detail under each of the various scenarios. GCMs are extensively tested against historical observations and compared to one another. Through the Coupled Model Intercomparison Project (CMIP), we can construct an ensemble of different GCMs that describes a range of plausible climate futures. In Figure A2 below, each red line represents an individual GCM projection, developed by research groups from around the world. The solid black line in this case represents the ensemble median, with the lower and upper dotted lines showing the 10th to 90th percentile range of the model ensemble.

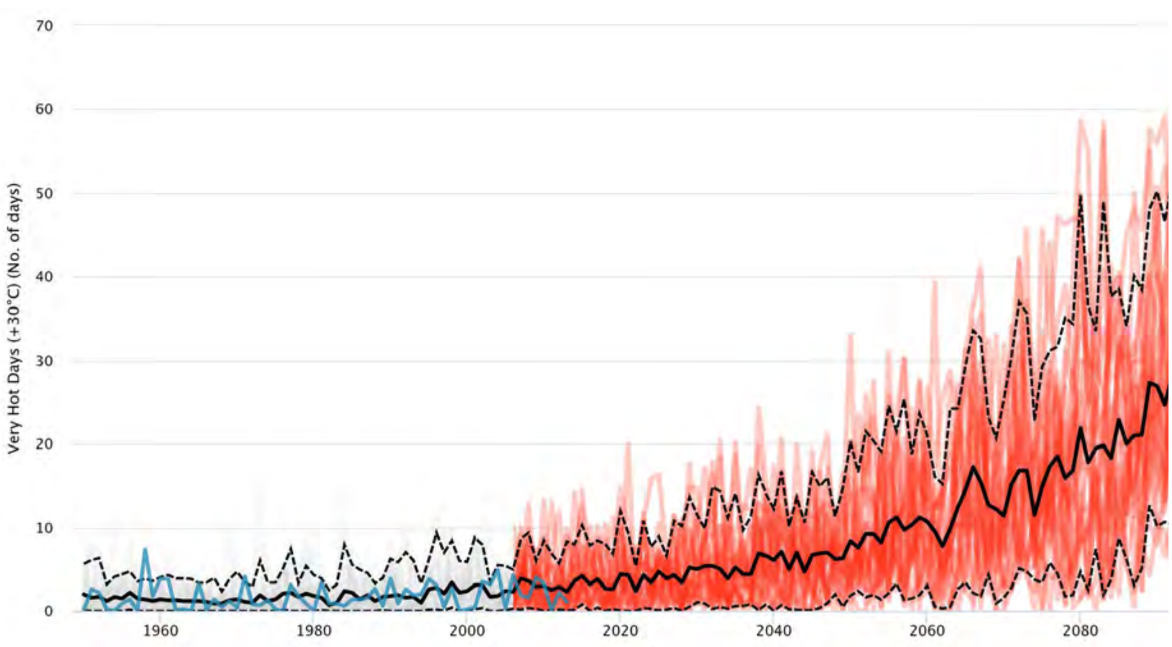


Figure A3. *Example of a GCM ensemble.[1] Each red line represents a single GCM projection for the number of annual days with a maximum temperature exceeding 30°C in British Columbia. The solid black line is the median and the dotted lines are the 10th (lower range) and 90th (upper range) percentile values across all GCMs in the ensemble.*

[1] Retrieved from ClimateAtlas.ca, using modeled data from PCIC.

Understanding Shared Socio-Economic Pathways

As noted above, to project the future climate, GCMs need input about the amount of future industrial emissions. Shared socio-economic pathways (or SSPs, Figure A3a) are such inputs, providing emissions scenarios based on assumptions of various societal decisions, including:

1. How population, education, energy use, technology – and more – may change over the next century, and;
2. The level of ambition for mitigating climate change globally.

The SSPs used in CMIP6 simulations are a set of five main socioeconomic pathways (SSP1 through SSP5) that illustrate different ways in which global societies may develop. They are the successors to the previous emissions scenarios used in CMIP5 called Representative Concentration Pathways, or RCPs. Figures A4a and A4b illustrate projections for GHG emissions and temperature under various SSPs. Here, it is important to note that global temperature projections for the near future are similar across different SSPs. The projections begin to diverge more meaningfully around 2050 (Figure A4b).

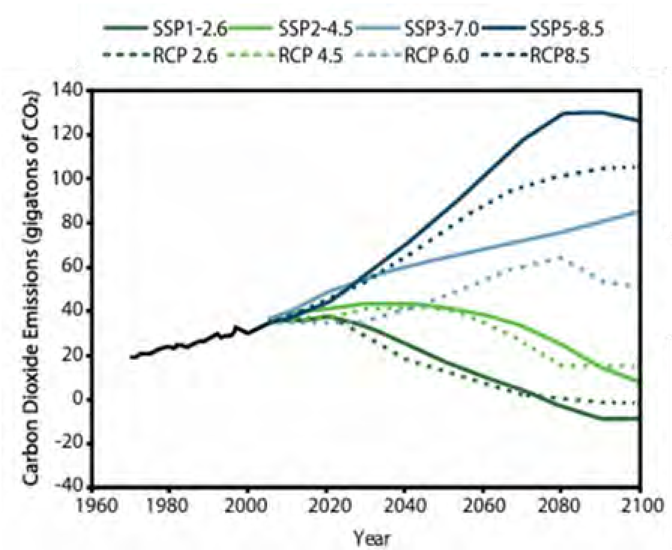


Figure A4a. *SSP scenarios used by CMIP6 models for global CO2 emissions by the end of this century. The scenarios used for CMIP5 (RCPs) are also shown.*

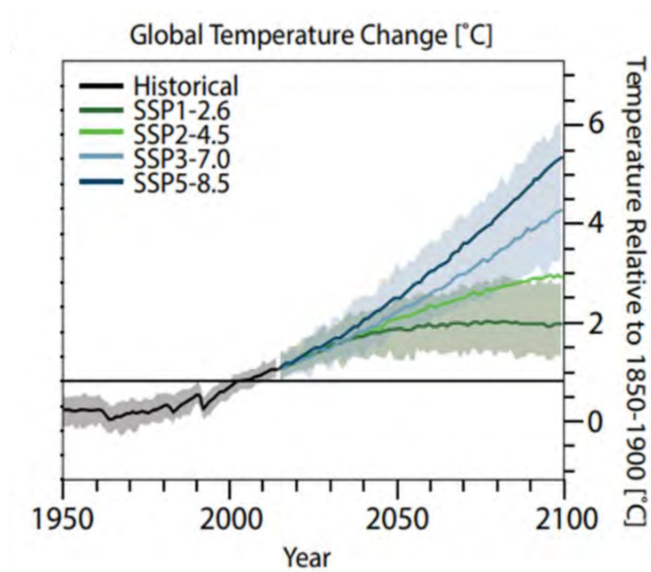


Figure A4b. *Historical and future temperature change from 1950-2100, relative to 1850-1900. After 2014, models are driven by the SSP scenarios indicated, with ranges shown for SSP1-2.6 and SSP3-7.0. The horizontal line shows temperature change that has occurred up to 1995-2014 (about +0.85°C).*

Future Climate Uncertainty

While we know the future climate will be different from the climate of the past, we cannot precisely predict what the future climate will look like. There are three main sources of uncertainty inherent in future climate data: natural climate variability, model uncertainty, and scenario uncertainty. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

- **Natural climate variability** (as discussed above) refers to climatic fluctuations that occur without any human influence (i.e., independent of GHG emissions). Natural climate variability is largely unpredictable and can mask or enhance human-induced climate change.
- **Model uncertainty** arises because models can only represent the climate and earth system to a certain degree. Although they are highly sophisticated tools, GCMs can differ from reality. Furthermore, not all models represent the system processes in the same way, nor do all include the same processes. To help address model uncertainty, it is best practice to use an ensemble (i.e., a set of multiple GCMs), to display a range of possible futures. PCIC uses an ensemble of 9 GCMs that are best suited to analyses focused on British Columbia.
- **Scenario uncertainty** arises because different emissions scenarios lead to different levels of climate response, and it is not possible to know what global emissions will be in the future. The emissions pathway of the future depends on a wide range of policy decisions and socioeconomic factors that are impossible to predict. To help address scenario uncertainty, it is best to evaluate future projections under more than one emissions pathway.

Uncertainty should not stand in the way of action. Decision makers should use climate projections as a guide to the future but should not discount the possibility of changes occurring outside the projected range when managing risk. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

Appendix B

WHAT DATA SHOULD I USE?

The decision tree shown in Figure B1 can help determine which data and information from this assessment might be most useful for a given application. Before using climate projections, it is important to do appropriate background reading, identify relevant stakeholders and determine the appropriate level of stakeholder engagement. Stakeholder engagement is important for ensuring that the projected changes are both meaningful and well-suited to your context.

Users accessing the complete data package should reference the Data Descriptor Document. Contact climateaction@crd.bc.ca for more information.

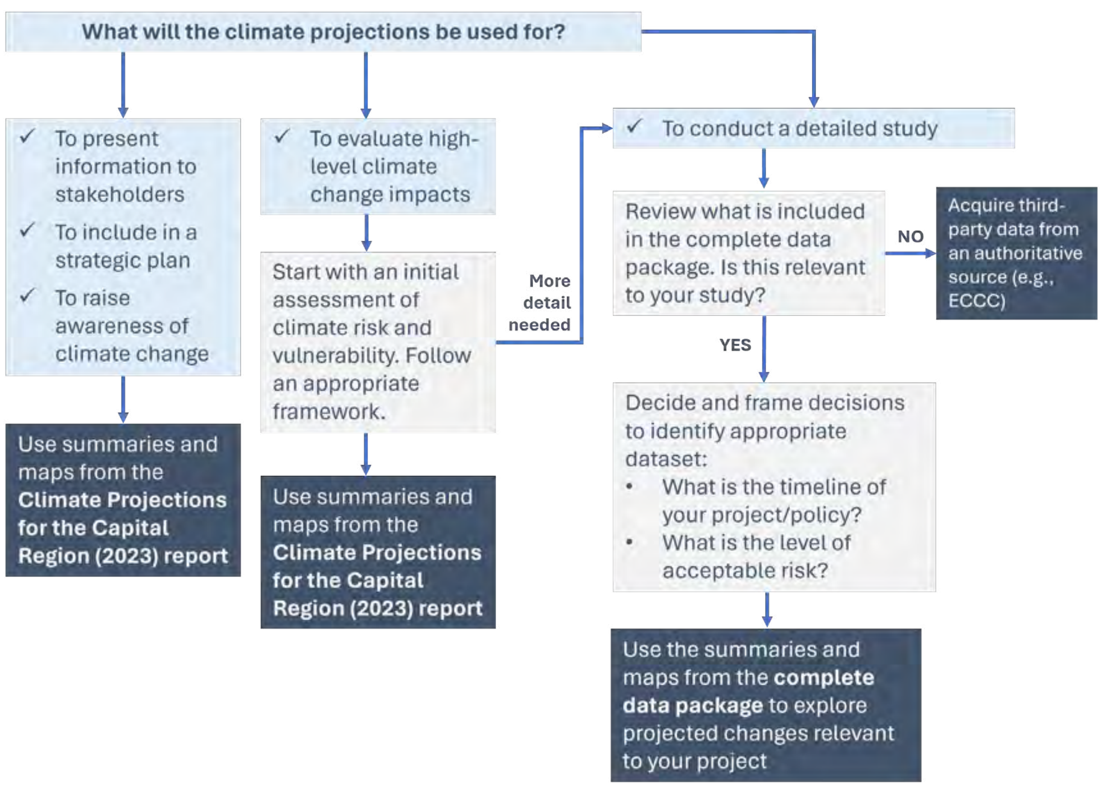


Figure B1. *Decision tree for using climate projections data. This decision tree has been adapted from the Victoria (Australia) Climate Projections 2019 Technical Report (Clarke et al., 2019).*

What is Provided in the Complete Data Package?

The Climate Projections for the Capital Region 2023 report highlights projected changes for a host of indices derived from temperature and precipitation under the highest emissions scenario (SSP5-8.5), mostly for the 2050s. The complete data package contains summary tables (Excel XLSX) and maps (PNG) for the following additional time periods, scenarios and sub-regional breakdowns:

The capital region and four smaller sub-regions.

(see Figure B2 below)

- "Core/Peninsula" (Green)
- "Western Region" (Red)
- "Southern Gulf Islands" (Yellow) and
- "Greater Victoria Water Supply Region" (Blue)

Four time periods.

- 1981-2010 or "1990s" (baseline period)
- 2021-2050 or "2030s"
- 2041-2070 or "2050s", and
- 2071-2100 or "2080s",

Three emissions scenarios.

- Low: SSP1-2.6
- Moderate: SSP2-4.5, and
- High: SSP5-8.5.

77 indices derived from temperature and precipitation. *(see Appendix F for a complete list)*

Gridded data (NetCDF) is also available for all 77 climate indices projected to the 2050s under a high emissions scenario (SSP5-8.5). Contact climateaction@crd.bc.ca to access the complete data package and/or the gridded data.

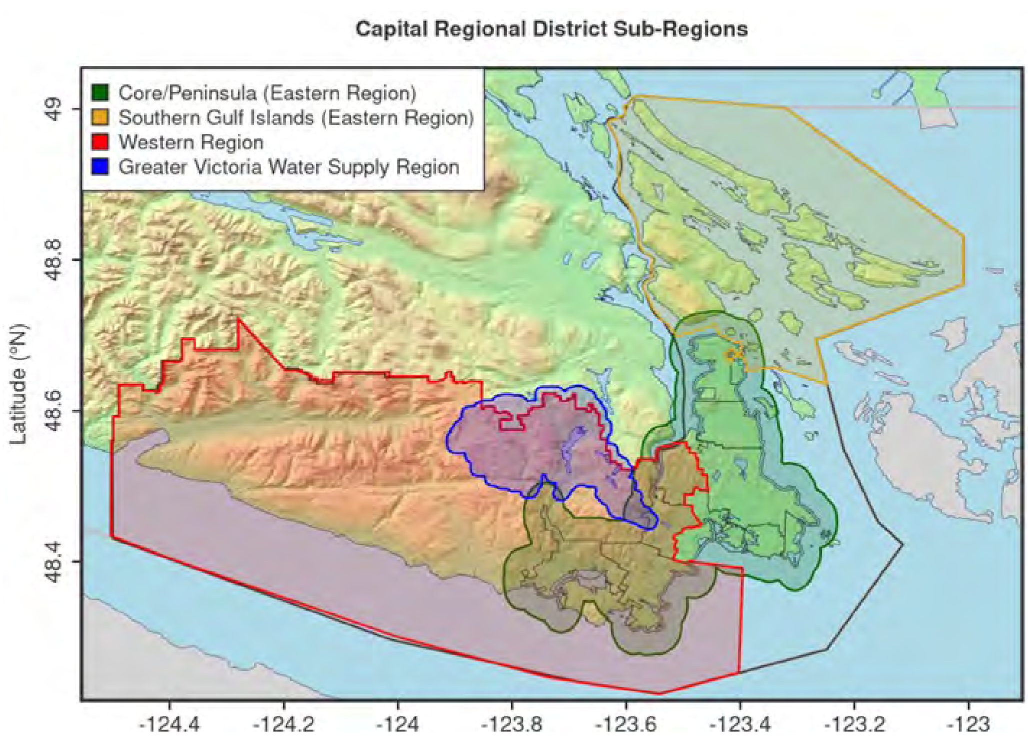


Figure B2. *The capital region and four sub-regions. Separate Excel files are available for each sub-region and for the region as a whole.*

Appendix C

GUIDANCE FOR USING CLIMATE PROJECTIONS

Key Messages

- ✓ Projections of future climate are complex, and you will likely need advice and guidance from experts in the field. Allow adequate time for consultation.
- ✓ The climate has always been naturally variable. This variability now occurs on top of greenhouse-gas/aerosol forced trends. Over shorter time scales, climate variability can mask long-term trends.
- ✓ Since we do not know what future global emissions will be, climate projections are produced for a number of possible scenarios. In the CMIP6 ensemble, near-term projections are similar and diverge more clearly by the middle of this century (e.g., the 2050s).
- ✓ This assessment provides downscaled climate projections for variables derived from temperature and precipitation only. Variables related to other climate-related hazards, such as sea level rise or windstorms, are not provided. For supplemental resources, see Appendix D: Further Resources
- ✓ While climate models are run under different emissions scenarios, there is no such thing as a 'most likely' scenario. Selecting an emissions scenario is highly context-dependent and will depend on considerations such as risk tolerance and the life cycle of your project or policy.
- ✓ Consider multiple climate variables or indices to get a more complete picture for different manifestations of change. Review annual and seasonal projections to get a sense of how projections vary depending on the time of year.
- ✓ In many cases, using only the median climate projections will not be appropriate. Ensure the ranges of projected change (10th and 90th percentiles) are adequately accounted for in your assessment. Do not entirely discount changes above or below the projected range when managing risk – especially for high-impact, low-likelihood events.

Understanding Climate Risk

As shown in Figure C1, climate risk depends on the complex interaction between hazards affected by climate change and natural climate variability, exposure to these hazards, and the vulnerability of the exposed elements. For example, a hazard (e.g., extreme heat) may impact a community more due to its exposure (e.g., occurring in a densely populated area) and/or vulnerability (e.g., demographic factors influencing heat sensitivity).

While future climate data can support the assessment of hazards affected by future climate change, there are different approaches to understanding climate risk. Decision-making about climate risk often involves a combination of top-down and bottom-up approaches.

Top-down approaches start with an analysis of potential climate change that can be used to guide actions and decisions.

Bottom-up approaches start with the project, policy or activity of interest and analyze the factors and conditions that impact the exposure, vulnerability and resilience of systems. These approaches look for pathways to reduce exposure and vulnerability while increasing the capacity to cope (irrespective of the future climate hazard).

Hence, **future climate data can be used to inform a top-down approach** to assessing climate risk.

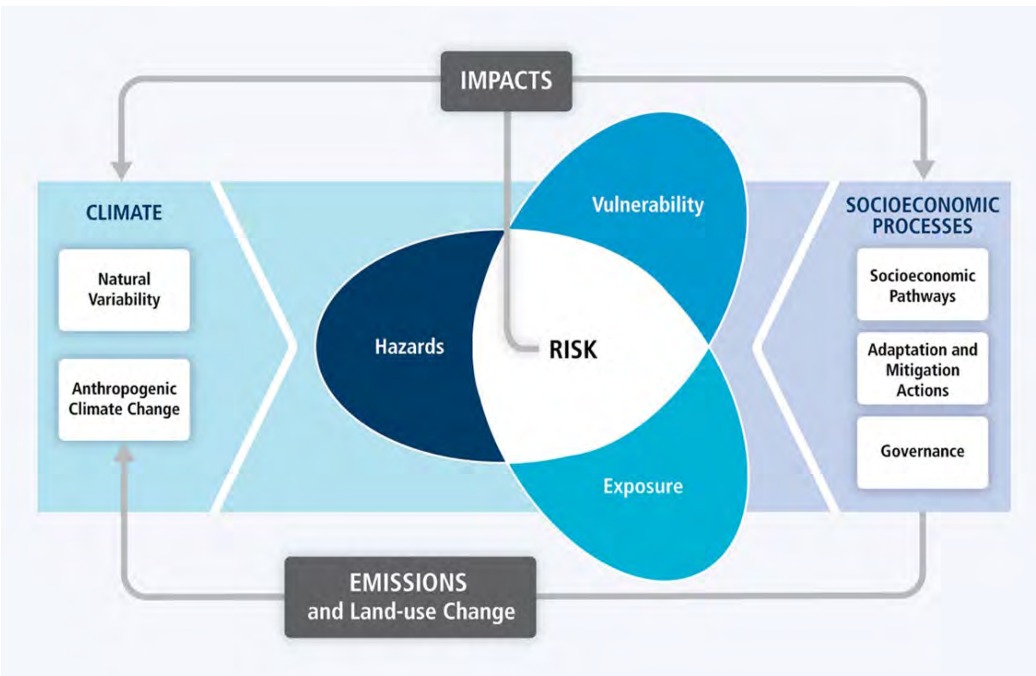


Figure C1. *Climate risk envisioned as the overlap of hazard, exposure, and vulnerability.*[2]

[2]IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

Which Emissions Scenario(s) Should I Use?

Climate projections are generated by different climate models and using a range of emissions scenarios. Differences in the projections due to the use of different climate models reflect the fact that we still have an incomplete understanding of how the climate system functions, and differences due to the choice of emissions scenarios reflect the fact that we have only imperfect knowledge of how society, its land use practices, and its emissions may change in the future. Given these diverse sources of uncertainty, it is best to examine a range of possible futures as represented by different climate models and emissions scenarios.

To reduce climate model uncertainty, PCIC has selected a range of climate models that are best suited to regions in BC. Ultimately, deciding on which emissions scenario(s) to assess will depend on the context of your project or policy, including your risk tolerance and time horizon, as discussed next.

Time Horizon

Users of climate projections should consider the time horizon, or life cycle, relevant to their project or policy before selecting a future scenario. This could be the expected lifetime of a given piece of infrastructure, or a policy that needs to be responsive to changing external conditions. As highlighted above in Understanding Shared Socioeconomic Pathways, in the near term – up to a few decades into the future – climate projections do not differ meaningfully across SSP scenarios. This is true at both the global regional scales. Hence, if there is a recurring opportunity to review a given decision every two to three decades, then the choice of emissions scenario may be less relevant. An example of a recurring decision might be the choice of paving material to use when repaving a roadway.

On the other hand, if an infrastructure element is expected to last 50 to 75 years, the choice of scenario becomes more critical because projected changes from different scenarios will differ substantially by the end-of-life of the structure. An example of a long-term infrastructure design decision might be determining the capacity of an upgraded storm sewer. Hence, planners and designers may be able to minimize the role of scenario uncertainty in adaptation planning by first determining the decision-making time-frame.

Level of Acceptable Risk

Climate scientists can help practitioners and decision makers understand how climate-related hazards that affect the assets they are responsible for (i.e., systems, infrastructure, or policy) may change in the future. This requires dialog among practitioners, decision makers and climate scientists to understand and describe the potential impacts of projected climate change under different emissions scenarios. Because climate scientists are not experts on how risk to assets will materialize, it remains the responsibility of practitioners and decision makers to manage future climate-related risks to their assets.

When assessing future scenarios, decision makers should consider four questions:

1. "What components of my project are vulnerable to climate change?"
2. "How likely is it that society will follow a future emissions pathway that will intensity the hazards to which my assets will be exposed?"
3. "What level of risk am I comfortable assuming?"
4. "What is the trade-off between risk and cost?"

Regardless of the rationale used, understanding the level of risk that is appropriate to your work is complex. It will undoubtedly require engagement with diverse partners and stakeholder groups to understand the range of potential impacts.

Scenario Choice

Ideally, public assets should be managed in a way that limits their vulnerability to plausible future hazards. Climate science has not yet ruled out the plausibility of any of the main socio-economic pathway scenarios that were considered in the most recent IPCC assessment. The choice of scenario will depend critically on the climate hazards that would affect the asset of interest. This is because some hazards will likely decline, such as extreme snow loads on buildings that could cause building collapse, while others, related to heat stress, intense rainfall, and flash flooding, will increase. If an asset is affected by both decreasing and increasing hazards, then the approach that would most completely limit vulnerability to future hazards would involve using a no change (historical climate) scenario for declining hazards, and a rapid change, high emissions scenario (e.g., SSP5-8.5) for increasing hazards.

Tips for Using Climate Data

✓ View multiple variables (indices) within each category

To get a more complete understanding of projected changes, users should consider multiple climate variables. For example, if you want to know how precipitation will change in your region, review both a frequency-based variable (e.g., Number of Wet Days > 20 mm) and a volume-based variable (e.g., Total Precipitation). The Hazard Reference Tables (Appendix E) can help users identify which climate variables may be best suited to a particular context or application.

✓ Review both annual and seasonal data

Annual mean changes can mask important seasonal behaviour. For example, a small annual mean precipitation projection might contain a substantial reduction in the summer along with a projected increase in the fall, winter, or spring. Therefore, users should assess both annual and seasonal projections for certain climate variables.

✓ Select a relevant time period

The complete data package offers projections for the "2030s" (2021-2050), "2050s" (2041-2070) and "2080s" (2071-2100). As highlighted above, users should select the period that is most appropriate to the entire life cycle of their project or policy.

✓ Determine an appropriate emissions scenario(s)

There is no right or wrong emissions scenario to use in decision-making: all scenarios represent possible futures and decision-making is highly context dependent. Selecting a scenario requires consideration of risk tolerance, sensitivity to climate impacts and extreme events, the time horizon of the project, and more. It can be useful to remember that planning for a high emissions scenario can help ensure that adaptation measures are resilient for a longer period of time if, in fact, a lower emissions scenario were to play out.

✓ Examine both means and extremes

The median, 10th percentile, and 90th percentile values have been provided in all summary tables for this assessment. Depending on the application, one, two or all three of these values may be important. For instance, if one were designing a building for general use (e.g., retail space, detached home) with an anticipate lifetime of 50 years or so, then the change in the median of Cooling Degree Days (CDDcool18C) under SSP5-8.5 might be appropriate to consider. Alternatively, if the building were classified as critical, long-lived infrastructure (e.g., a hospital, or power plant) then it might be more appropriate to design to the 90th percentile value for that climate index, to capture the upper range of possibility.

Appendix D

FURTHER RESOURCES

There are a growing number of guidance materials, learning resources, and data tools available to support the use of climate projections for regional assessments. Below is a non-exhaustive list of open access resources suited to a broad range of users. For additional guidance, contact PCIC (climate@uvic.ca) or the CRD Climate Action Program (climateaction@crd.bc.ca).

Additional Climate Projections Tools and Resources

ClimateData.ca

User-friendly tool for exploring climate projections and related data

Developed and maintained by the Canadian Centre for Climate Services, a team of information and outreach specialists at Environment and Climate Change Canada (ECCC), ClimateData.ca is an online, user-friendly data portal providing future climate projections for regions across Canada. Users can explore gridded data at small scales or aggregated by watershed, census subdivision, or health region. ClimateData.ca provides plain language descriptions for all climate variables and has various options for visualizing and analyzing climate data. Temperature and precipitation-based variables (the same as those provided by PCIC) as well as humidex, relative sea level change and climate change-scaled IDF data are available.

ClimateData.ca also includes a comprehensive learning zone (climatedata.ca/learn) that is regularly updated to support climate data users in a variety of applications, including some sector-specific information, as well as a Climate Services Support Desk for general or technical inquiries. The site is continuously evolving with more content and features in development.

PCIC Climate Explorer

Useful for intermediate or advanced users analyzing a specific location

PCIC Climate Explorer (PCEX) is an online map-based tool for viewing gridded historical climate data and future projections at any location of interest across Canada. Users can select an arbitrary region on the map, compare climate variables for that region, and download the results in Excel formats. Additional variables for extreme precipitation and streamflow are also available.

ClimateAtlas.ca

Useful for creating communications materials and learning more about climate adaptation

ClimateAtlas.ca is an interactive tool combining climate projections (again using PCIC's data), mapping, and storytelling to inspire local, regional, and national action and solutions. Users can explore videos, articles, educator resources, and various topic including Indigenous knowledges, agriculture, and health.

Spatial Analogues Tool* (ClimateData.ca)

Useful for visualizing the future climate at a target location

With this tool, starting with a target city of interest**, users can search for other cities whose historical climate closely matches the future-projected climate of the target city. Users can search for spatial analogues under a low or high emissions scenario and considering up to four different climate indices. For example, one combination of indices suggests that by the 2050s, Quebec City may have a climate similar to present-day Boston. By examining how Boston has adapted to its current climate, planners in Quebec City might gain insights on how to prepare and adapt to climate change.

*This tool is a beta app, meaning it is a new tool being carefully monitored and is still under development.

**Target cities for British Columbia are presently limited to: Victoria, Vancouver, Abbotsford, Kelowna, and Prince George.

Infrastructure Design Resources

PCIC Design Value Explorer (DVE)

Engineering design professionals can access future-projected climatic design values

The DVE is an online, open-access technical tool for assessing 19 climate design values based on observed data and projections of how they may change in the future. It provides engineers, architects, planners, and other professionals with quantitative, fine-scale historical and future-projected climate information for designing buildings and infrastructure.

PCIC Future-Shifted Weather Files

Energy Modelers can access future-projected weather files

Weather data adjusted for climate change has been produced for three time periods (2020s, 2050s, and 2080s) using the high emissions pathway RCP8.5 (CMIP5). Data are available for several hundred weather stations across Canada. Future-shifted weather files can help building designers simulate building performance under a changing climate, supporting resilient design. Further work is underway to update the weather files for CMIP6-SSPs and to create weather files that capture both mean change and extreme events.

CSA PLUS 4013-19: Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resource practitioners*

Guidance for Canadian water resource practitioners to better incorporate climate change into IDF information

Technical guidance from the Canadian Standards Association (CSA)—informed by scientists at ECCC and other subject matter experts—for the development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information. Chapters 5 and 6 include guidance for how to incorporate climate change into the formulation and application of IDF information.

*Access fee required

Short-Duration Rainfall IDF Data (ClimateData.ca)

Users can explore historical and climate change-scaled IDF information for weather stations across Canada

ClimateData.ca offers easy access to historical short-duration rainfall IDF data (from 1 to 24 hours) and projected rainfall amounts under low, moderate, and high emissions scenarios at locations across Canada (12 locations within the capital region). This IDF information is consistent with the above-mentioned CSA guidance. Users can download a zip file containing all the historical and future estimated values.

In addition, the Learning Zone on ClimateData.ca has a topic dedicated to using IDF rainfall data to account for a changing climate. For more information on this product and about designing future-ready buildings, visit ClimateData.ca/learn/

Appendix E

HAZARD REFERENCE TABLES

The Hazard Reference Tables help users identify which climate variables included in the complete data package may be best suited to a particular context or application. Users should use the short name (left column) to navigate to the appropriate variable in the complete data package.

Seasonal Patterns and Climate Change

- ✓ Increasing temperatures year-round
- ✓ Fewer frost days and a longer growing season
- ✓ Shifting heating and cooling demands

Key sectors: Agriculture, Biodiversity, Parks, Infrastructure

Temperature	
TX	Daytime high temperature, averaged over all days in a year or season
TM	Mean daily temperature, averaged over all days in a year or season
TN	Daytime low temperature, averaged over all days in a year or season
Seasonal	
FD Frost Days	Number of days in a year when the minimum temperature is below 0°C
ID Ice Days	Number of days in a year when the maximum temperature is below 0°C
GSL Growing Season Length	Number of days between: (i) the first span of 6 or more days in the year with a daily minimum temperature > 5°C and (ii) the first span after July 1st of 6 or more days with a daily minimum temperature < 5°C.
WSDI Warm Spells	A "warm spell" is defined as 6 or more consecutive days when the daily maximum temperature exceeds the 90th percentile value of the historical baseline. This index measures the number of days in a typical year that a warm spell occurs. (A warm spell can occur at any time of year).
CSDI Cold Spells	A "cold spell" is defined as 6 or more consecutive days when the daily minimum temperature is less than the 10th percentile value of the historical baseline. This index measures the number of days in a typical year that a cold spell occurs. (A cold spell can occur at any time of year).
Design	
HDDheat18C Heating Degree Days	Number of degree days below 18°C in a year. A rough estimate for the energy demand needed to heat a building in a typical year.
CDDcold18C Cooling Degree Days	Number of degree days above 18°C in a year. A rough estimate for the energy demand needed to cool a building in a typical year.

Increasing Temperatures and Extreme Heat

- ✓ Hotter daytime temperatures
- ✓ Warmer nighttime temperatures
- ✓ Heat waves becoming hotter and more frequent

Key sectors: Emergency Management, Health, Biodiversity, Watershed

Daytime Temperatures	
TX	Daytime high temperature, averaged over all days in a year or season
TXx	Hottest daytime high temperature in a year or season
SU Summer Days	Number of days in a typical year when the daytime high is above 25°C
SU30 Hot Summer Days	Number of days in a typical year when the daytime high is above 30°C
Nighttime Temperatures	
TN	Daily minimum temperature in a typical year or season
TNx	Warmest nighttime low temperature in a typical year or season
TR16C Temperate Nights	Number of days in a year when the nighttime low stays above 16°C
TR Tropical Nights	Number of days in a year when the nighttime low stays above 20°C
Heat Extremes	
HWD Heat Wave Days	Number of days in a typical year classified as a “heat wave”
HWN Heatwave Number	Number of distinct heat wave events in a typical year
HWXL Heatwave Length	Length (in days) of the longest heat wave in a typical year
TXH Heatwave Intensity (Day)	Daytime high temperature averaged across all heat waves in a typical year
TNH Heatwave Intensity (Night)	Nighttime low temperature averaged across all heat waves in a typical year
TXHX	Daytime high temperature during the most extreme heat wave in a year
TNHX	Nighttime low temperature during the most extreme heat wave in a year
Return Periods (various)	The data package provides return levels and return period changes for the 5-, 10-, 20-, and 30-year Hottest Day.

Extreme Precipitation and Flooding

In this data package, there are no direct indices for flooding.
Rainfall extremes may trigger flooding under certain circumstances.

- ✓ More precipitation occurring over short time periods
- ✓ More days with heavy rainfall

Key sectors: Public Works/Engineering, Infrastructure, Biodiversity, Health, Agriculture, Watershed

Precipitation	
PR Total Precipitation	Total precipitation in a typical year or season
Rain Total Rainfall	Total rainfall in a typical year or season
Snow Summer Days	Total snowfall in a typical year or season
Rainfall Extremes	
RX1DAY	Maximum amount of precipitation (in mm) occurring in a single day in a typical year
RX5DAY	Maximum amount of precipitation (in mm) occurring over a 5-day period in a typical year
R10MM	Number of days in a typical year that receive more than 10mm of total precipitation
R20MM	Number of days in a typical year that receive more than 20mm of total precipitation
R95P / R95DAYS	Amount of precipitation over the year that exceeds the 95th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount.
R99P / R99DAYS	Amount of precipitation over the year that exceeds the 99th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount.
Return Periods (Various)	The data package provides 5-, 10-, 20-, 30-, and 50-year return periods for annual wettest 1-, 2-, and 5-day rainfall events. It also provides changes to rainfall return periods for an event of given magnitude.

Drought

In this data package, there are no direct drought variables. Hotter temperatures, less rainfall and reduced snowpack may lead to drought conditions in the warmer months.

Key sectors: Agriculture, Biodiversity, Health, Watershed

Precipitation	
PR – Summer Total Precipitation in Summer	Total precipitation in a typical summer (may also be important to consider PR for spring and fall)
SNOW Total Snowfall	Total snowfall (fall-winter-spring)
CDD Consecutive Dry Days	Number of days comprising the longest "dry spell" in a typical year. Dry spells are defined as consecutive days with less than 1mm of total precipitation.
Temperature	
TX	Daytime high temperature in a typical year or season
TXx	Hottest daytime high temperature in a typical year or season
SU Summer Days	Number of days in a typical year when the daytime high is above 25°C

Wildfire and Air Quality

In this data package, there are no direct wildfire variables. Hotter temperatures and less rainfall in the warmer months may lead to more favourable conditions for wildfire.

Key Sectors: Health, Biodiversity, Infrastructure, Agriculture

Variables listed under Drought (see above) can also be considered as informative for Wildfire. Additional variables such as humidity, wind speed, and wind direction must also be considered in order to establish favourable conditions for Wildfire. The Canadian Forest Service has analyzed such historical data to develop Fire Weather Normals, which provide insight into how "fire weather" varies spatially and throughout the year. See https://cwfis.cfs.nrcan.gc.ca/ha/fwnormals for more.

Future-projected temperature and precipitation conditions that may be favourable to increased incidence of Wildfire may be obtained from other regional climate projections reports in BC, including:

- Climate Projections for BC Northeast Region
- Climate Projections for the Okanagan Region
- Climate Projections for the Cowichan Valley Regional District
- Climate Projections for Metro Vancouver

Appendix F

COMPLETE LIST OF CLIMATE INDICES

Name	Variable	Definition	Units
		Standard	
PR	Precipitation	Annual/seasonal precipitation totals	mm
RAIN	Rainfall	Annual/seasonal rainfall portion of precipitation using temperature-based rain-snow partitioning	mm
SNOW	Snowfall	Annual/seasonal snowfall (snow water equivalent) portion of precipitation	mm (H2Oeq)
TM	Daily Average Temperature	Annual/seasonal daily average temperature	°C
TX	Daily Maximum Temperature	Annual/seasonal average daily maximum temperature	°C
TN	Daily Minimum Temperature (usually overnight)	Annual/seasonal average daily minimum temperature	°C

Name	Variable	Definition	Units
		CLIMDEX: Temperature Based	
TXX	Maximum TX	Annual/seasonal maximum of TX	°C
TNN	Minimum TN	Annual/seasonal minimum of TN	°C
TXN	Minimum TX	Annual/seasonal minimum of TX	°C
TNX	Maximum TN	Annual/seasonal maximum of TN	°C
TX90P	Hot Days	Annual percentage of days with TX > 90th historical percentile	%
TX10P	Cool Days	Annual percentage of days with TX < 10th historical percentile	%
TN90P	Warm Nights	Annual percentage of days with TN > 90th historical percentile	%
TN10P	Cold Nights	Annual percentage of days with TN < 10th historical percentile	%
DTR	Diurnal Temperature Range	Annual/seasonal diurnal temperature range, TX – TN	°C
SU	Summer Days	Annual number of days with TX > 25 °C	days
SU30	Hot Summer Days	Annual number of days with TX > 30 °C	days
TR	Tropical Nights	Annual number of days with TN > 20 °C	days
TR16C	Temperate Nights	Annual number of days with TN > 16 °C	days
ID	Ice Days	Annual number of days with TX < 0 °C	days
FD	Frost Days	Annual number of days with TN < 0 °C	days
CSDI	Cold Spells	Annual count of days with at least 6 consecutive days when TN < 10th historical percentile	days
WSDI	Warm Spells	Annual count of days with at least 6 consecutive days when TX > 90th historical percentile	days
GSL	Growing Season Length	Growing season length (number of days between first span of at least 6 days with TM >5°C and first span after July 1st of 6 days with TM <5°C)	days

Name	Variable	Definition	Units
		CLIMDEX: Precipitation-Based	
CDD	Consecutive Dry Days	Annual maximum length of consecutive dry days (PR < 1 mm)	days
CWD	Consecutive Wet Days	Annual maximum length of consecutive wet days (PR ≥ 1 mm)	days
SDII	Simple Daily Precipitation Intensity Index	Annual average PR on days with PR ≥ 1 mm	mm
R1MM	Precipitation ≥ 1 mm	Annual count of days with PR ≥ 1 mm	days
R10MM	Precipitation ≥ 10 mm	Annual count of days with PR ≥ 10 mm	days
R20MM	Precipitation ≥ 20 mm	Annual count of days with PR ≥ 20 mm	days
RX1DAY	Maximum 1-Day PR	Annual/seasonal maximum 1-day PR	mm
RX2DAY	Maximum 2-Day PR	Annual/seasonal maximum 2-day PR	mm
RX5DAY	Maximum 5-Day PR	Annual/seasonal maximum 5-day PR	mm
RN1DAY	Maximum 1-Day RAIN	Annual/seasonal maximum 1-day rainfall	mm
RN2DAY	Maximum 2-Day RAIN	Annual/seasonal maximum 2-day rainfall	mm
RN5DAY	Maximum 5-Day RAIN	Annual/seasonal maximum 5-day rainfall	mm
R95P	Very Wet Day PR	Annual total PR when PR > 95th percentile of daily PR in historical period	mm
R95DAYS	Very Wet Days	Annual number of days when PR > 95th percentile of daily PR in historical period	days
R99P	Extreme Wet Day PR	Annual total PR when PR > 99th percentile of daily PR in historical period	mm
R99DAYS	Extreme Wet Days	Annual number of days when PR > 99th percentile of daily PR in historical period	days

Name	Variable	Definition	Units
		Degree Days	
CDDcold18C	Cooling Degree Days	Annual, cumulative TM difference above 18 °C	°C-days
GDDgrow5C	Growing Degree Days	Annual, cumulative TM difference above 5 °C	°C-days
HDDheat18C	Heating Degree Days	Annual, cumulative TM difference below 18 °C	°C-days
FDDfreeze0C	Freezing Degree Days	Annual, cumulative TM difference below 0 °C	°C-days

Name	Variable	Definition	Units
		Heatwave Indices	
HWD	Heatwave (HW) days	Annual count of HW days, where a HW is defined as both TX and TN exceeding: 1) their 95th percentiles (historical), AND; 2) BC HARS thresholds[3] for at least 2 consecutive days.	days
HWN	HW number	Annual number of distinct HWs	#
HWXL	HW duration	Annual maximum HW length	days
TNH	HW intensity (night)	Average TN over all HWs in a year	°C
TXH	HW intensity (day)	Average TX over all HWs in a year	°C
TNHX	Maximum TNH	Average TN during most extreme HW in a year	°C
TXHX	Minimum TNH	Average TX during most extreme HW in a year	°C
HWDD	HW degree days	Annual, cumulative TM difference above HW threshold	°C-days

[3] The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. These are the lowest temperatures found in any region of the map in Figure 3, page 14 of the 2023 report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning.

Name	Variable	Definition	Units
		Return Levels	
TX_RP5	5-Year return level of TX	5-Year return level of TX	°C
TX_RP10	10-Year return level of TX	10-Year return level of TX	°C
TX_RP20	20-Year return level of TX	20-Year return level of TX	°C
TX_RP25	25-Year return level of TX	25-Year return level of TX	°C
TX_RP30	30-Year return level of TX	30-Year return level of TX	°C
TN_RP5	5-Year return level of TN	5-Year return level of TN	°C
TN_RP10	10-Year return level of TN	10-Year return level of TN	°C
TN_RP20	20-Year return level of TN	20-Year return level of TN	°C
TN_RP25	25-Year return level of TN	25-Year return level of TN	°C
TN_RP30	30-Year return level of TN	30-Year return level of TN	°C
RN1_RP5	5-Year return level of RN1DAY	5-Year return level of RN1DAY	mm
RN1_RP10	10-Year return level of RN1DAY	10-Year return level of RN1DAY	mm
RN1_RP20	20-Year return level of RN1DAY	20-Year return level of RN1DAY	mm
RN1_RP30	30-Year return level of RN1DAY	30-Year return level of RN1DAY	mm
RN1_RP50	50-Year return level of RN1DAY	50-Year return level of RN1DAY	mm
RN2_RP5	5-Year return level of RN2DAY	5-Year return level of RN2DAY	mm
RN2_RP10	10-Year return level of RN2DAY	10-Year return level of RN2DAY	mm
RN2_RP20	20-Year return level of RN2DAY	20-Year return level of RN2DAY	mm
RN2_RP30	30-Year return level of RN2DAY	30-Year return level of RN2DAY	mm
RN2_RP50	50-Year return level of RN2DAY	50-Year return level of RN2DAY	mm
RN5_RP5	5-Year return level of RN5DAY	5-Year return level of RN5DAY	mm
RN5_RP10	10-Year return level of RN5DAY	10-Year return level of RN5DAY	mm
RN5_RP20	20-Year return level of RN5DAY	20-Year return level of RN5DAY	mm
RN5_RP30	30-Year return level of RN5DAY	30-Year return level of RN5DAY	mm
RN5_RP50	50-Year return level of RN5DAY	50-Year return level of RN5DAY	mm

Climate Projections for the Capital Region (2024)

Nikki Elliott, Manager, Climate Action Programs

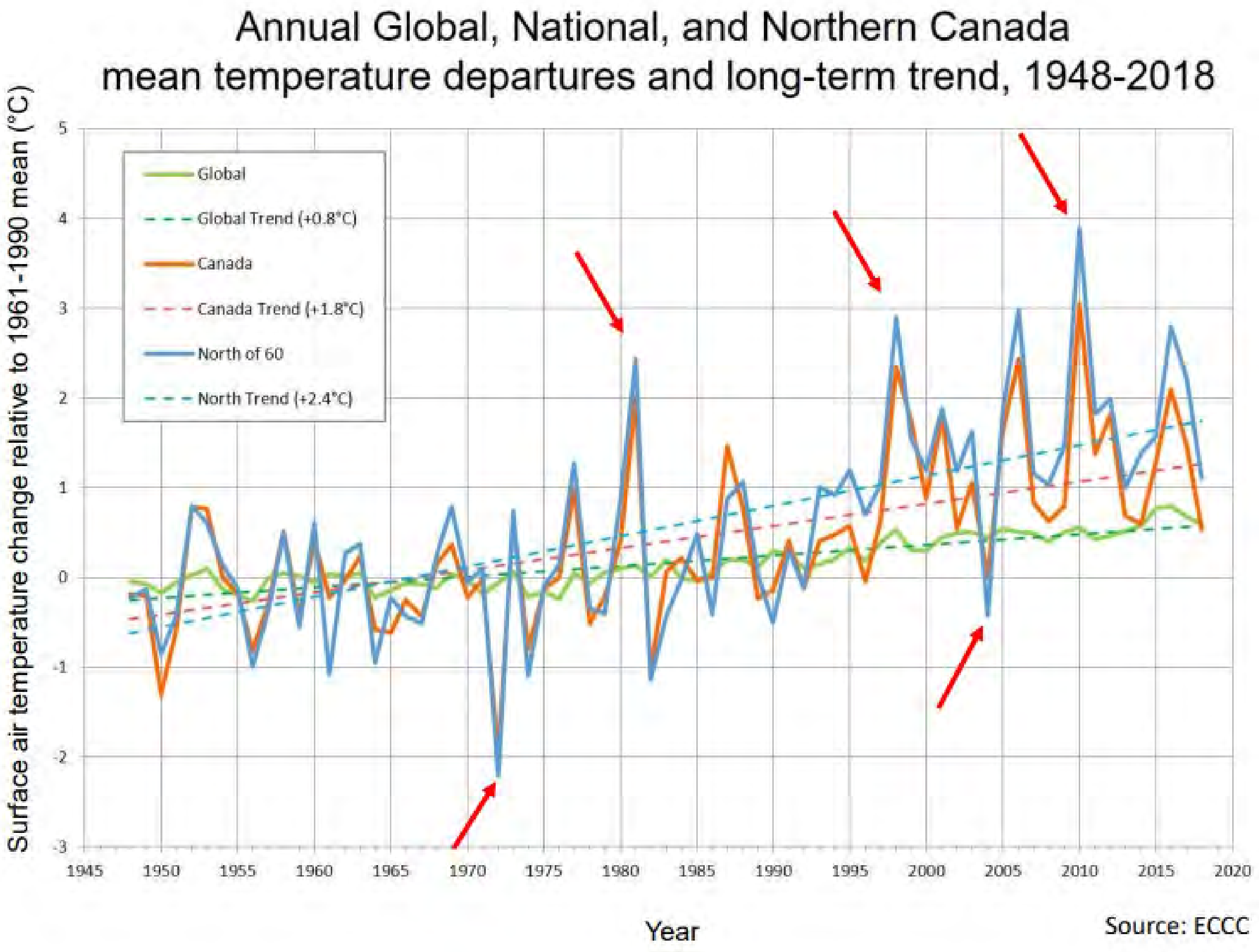
March 20, 2024

Climate Change Trends

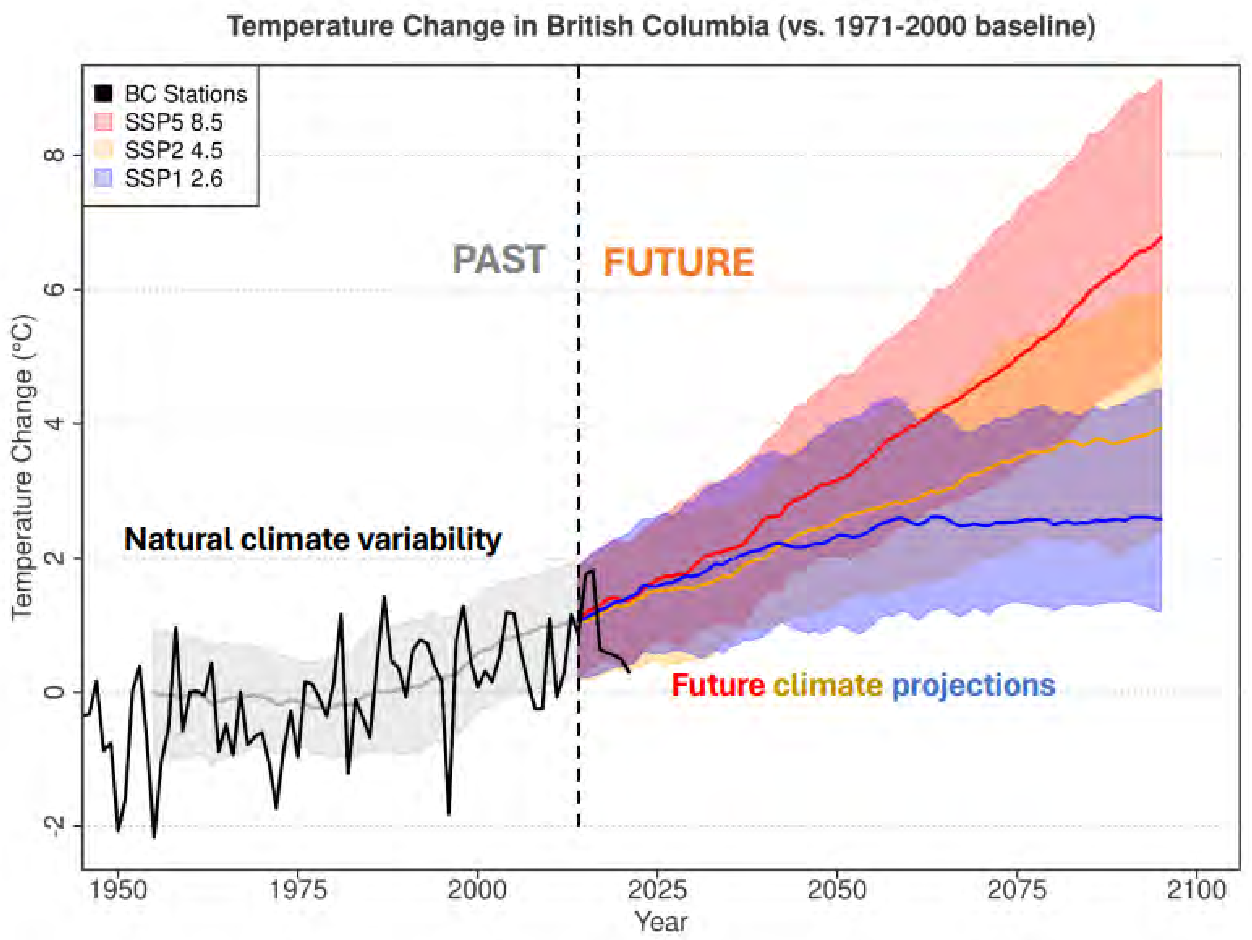
Climate change is both:

(1) Changes in average conditions over long periods time, and

(2) Changes in the frequency intensity of extreme events



Future Warming in BC



Climate projections are simulations of the future climate based on greenhouse gas 'scenarios'

Source: PCIC (2024)

Update Purpose

- Provide updated climate projections for the 2050s and 2080s
- Translate new global climate change projections to the regional and local scale
- Interpret what the projections imply for capital region
- Support and guide local planning and build local government staff capacity
- Provide a foundation of understanding for future, impacts-centered work

CRD

New in 2024

- ✓ Updated modelling
- ✓ New indices for extreme heat
- ✓ Updated 'Regional Impacts' informed by local government staff
- ✓ New guidance section to support users
- ✓ GIS layers

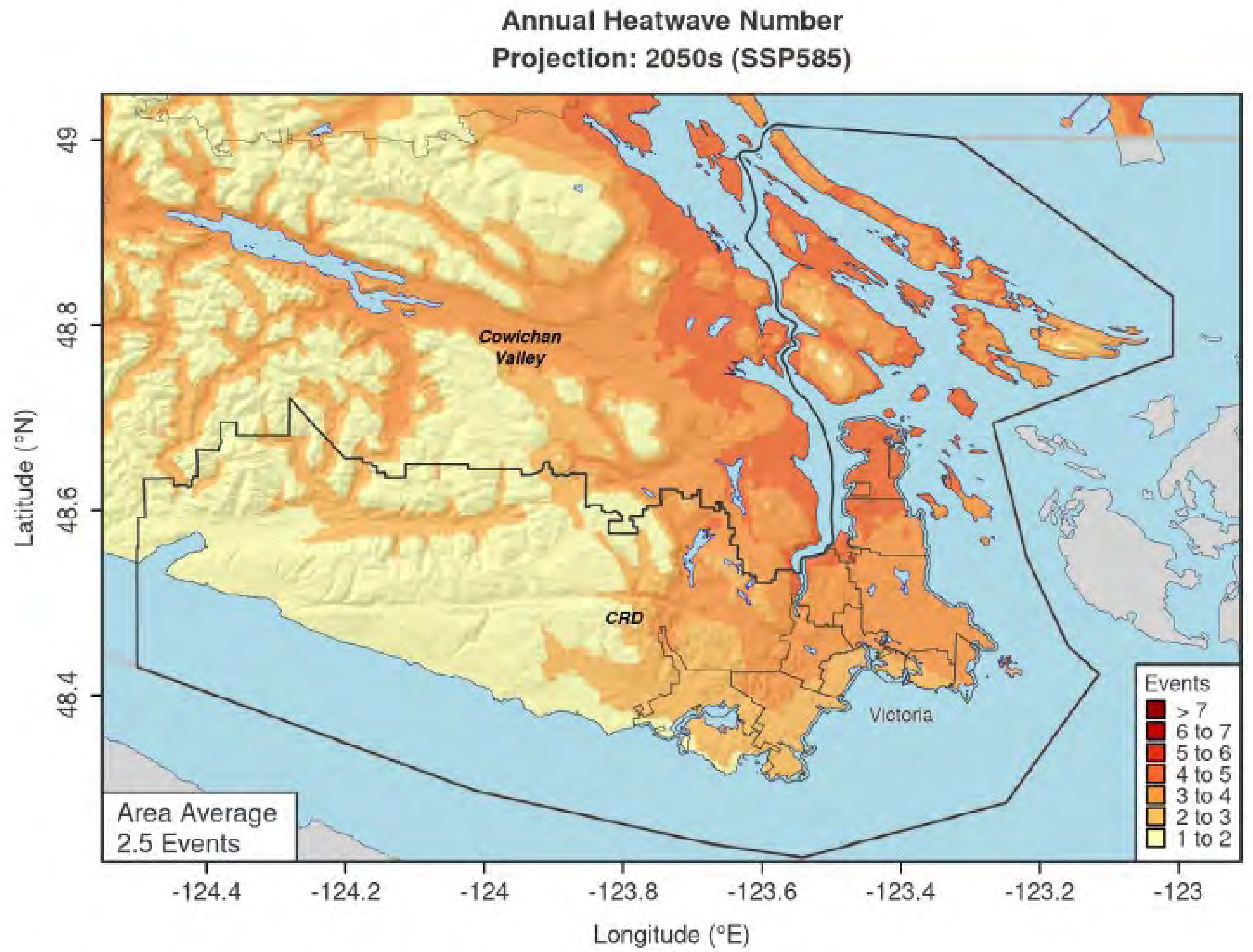


Figure 15b. Projected number of annual heatwaves in the 2050s.

What about other climate variables?

Climate projections

High confidence	Temperature, Extreme Heat	• Hot Days • Days above 25°C, 30°C • Maximum Temperature
Medium confidence	Precipitation	• Wet Days • Total Precipitation • Max one-day precipitation
Low confidence	Wind, storms, snow accumulation, hydrology	• Storminess • Storm Surges • Wind

Coastal Flood Inundation Mapping

High Level Results

- Hotter summer temperatures, with more extreme heat days and heatwaves
- Less rain and more dry days in the summer months
- Warmer winter temperatures, less frequent frost, and less snowfall
- More precipitation falling in fall, winter and spring
- Longer-lasting and more frequent extreme rainfall events

Warmer Temperatures

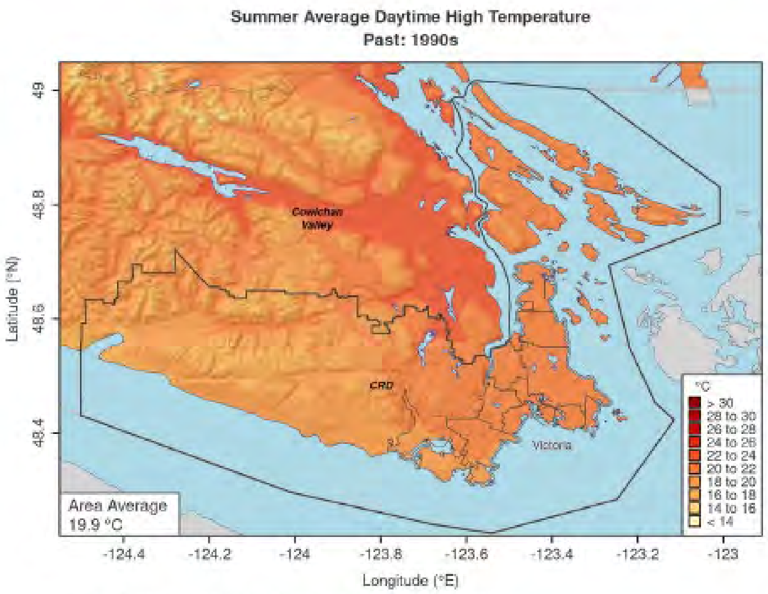


Figure 4a: Summer average daytime high temperature in the Past.

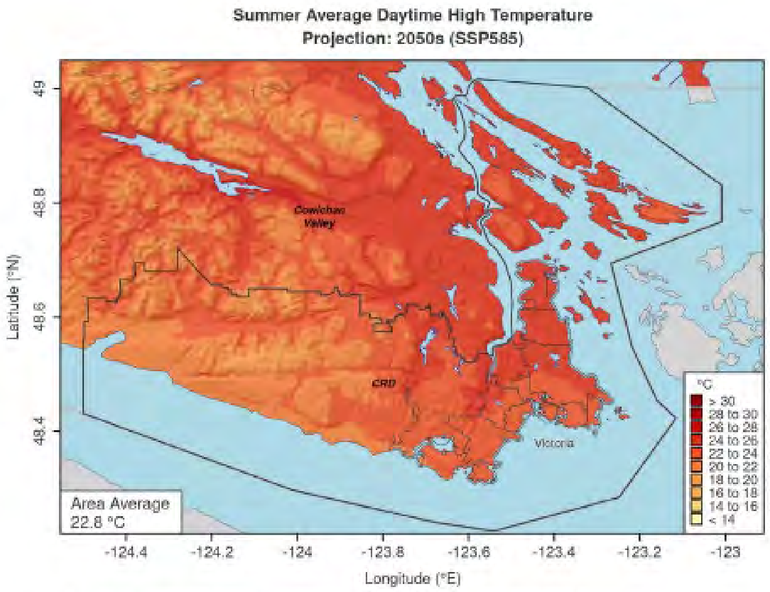
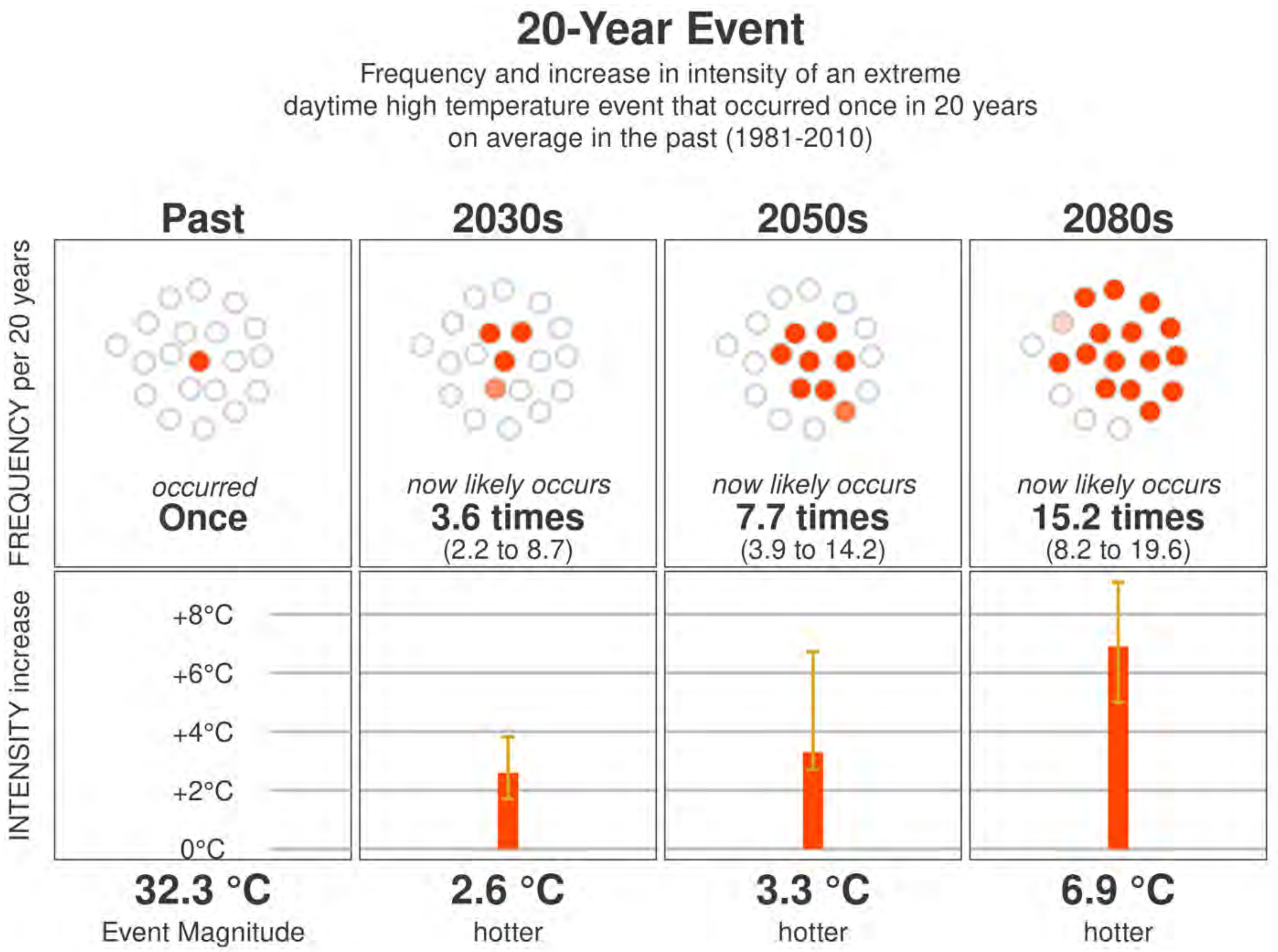


Figure 4b: Projected summer average daytime high temperature in the 2050s.

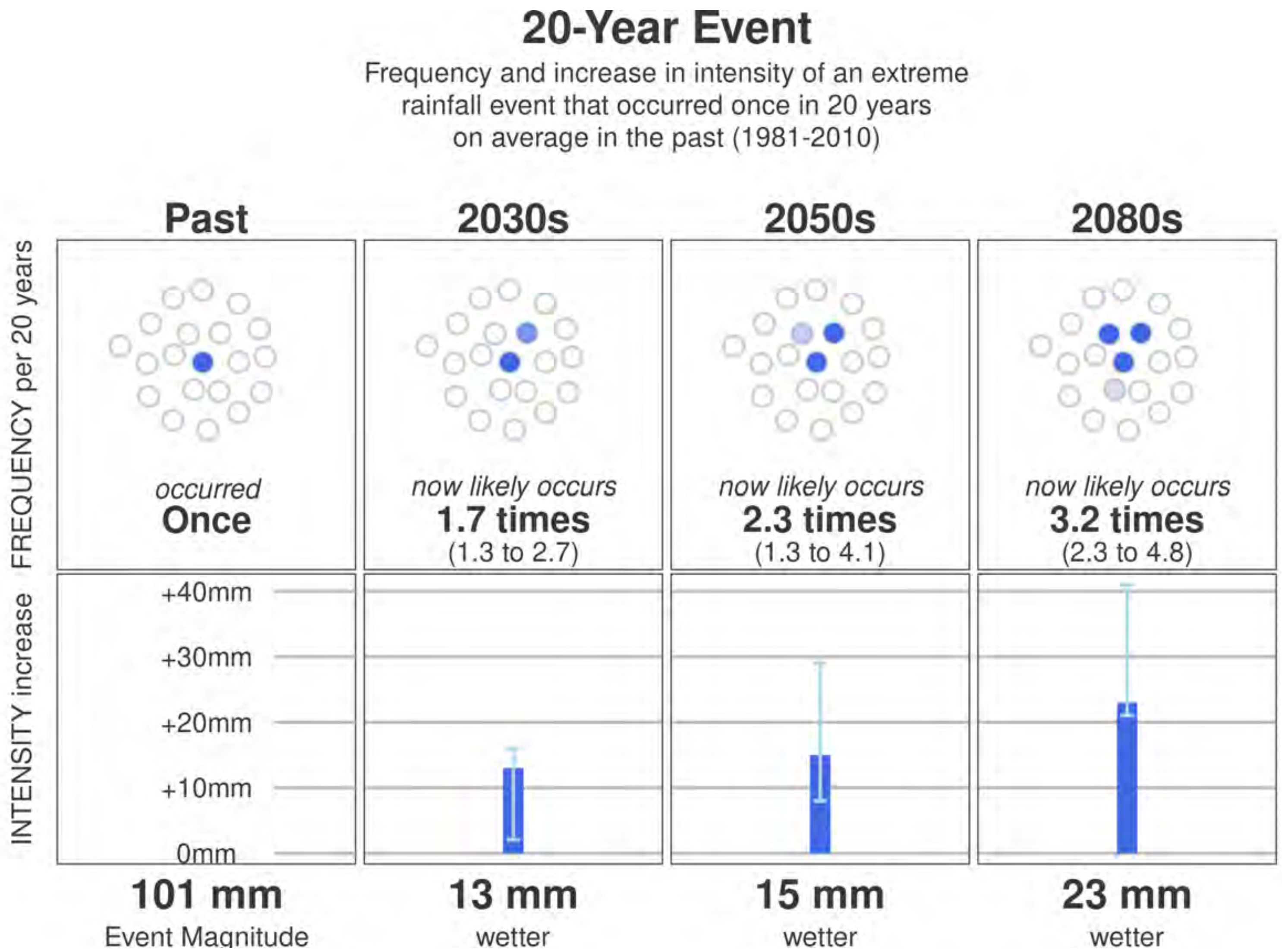
Table 1: Regional Average Daytime High Temperature (TX)

	Past (°C)	2050s Change (°C)	2080s Change (°C)
Winter	6	2.1 *(1.6 to 3.5)*	3.5 *(2.8 to 6.5)*
Spring	12	2.1 *(1.4 to 4.0)*	3.5 *(2.6 to 6.3)*
Summer	20	2.9 *(2.3 to 5.1)*	4.7 *(4.1 to 8.7)*
Fall	13	2.7 *(2.2 to 4.6)*	4.0 *(3.6 to 7.2)*
Annual	13	2.5 *(2.0 to 4.4)*	3.9 *(3.4 to 7.0)*

Heat

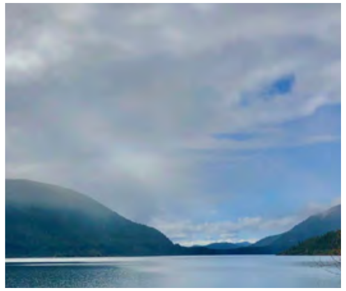

20-Year Event
Frequency and increase in intensity of an extreme daytime high temperature event that occurred once in 20 years on average in the past (1981-2010)
Past
2030s
2050s
2080s
FREQUENCY per 20 years
occurred
Once
now likely occurs
3.6 times
(2.2 to 8.7)
now likely occurs
7.7 times
(3.9 to 14.2)
now likely occurs
15.2 times
(8.2 to 19.6)
INTENSITY increase
+8°C
+6°C
+4°C
+2°C
0°C
32.3 °C
Event Magnitude
2.6 °C
hotter
3.3 °C
hotter
6.9 °C
hotter

Precipitation



Regional impacts

Health and Wellbeing



Water Supply and Demand

Rainwater Management and Sewerage

Ecosystems and Species

Buildings and Energy Systems

Transportation

Food and Agriculture

Recreation and Tourism

Guidance for Users

Seasonal Patterns and Climate Change

- ✓ Increasing temperatures year-round
- ✓ Fewer frost days and a longer growing season
- ✓ Shifting heating and cooling demands

Key sectors: Agriculture, Biodiversity, Parks, Infrastructure

Temperature	
TX	Da
TM	Me
TN	Da

Extreme Precipitation and Flooding

In this data package, there are no direct indices for flooding.
Rainfall extremes may trigger flooding under certain circumstances.

- ✓ More precipitation occurring over short time periods
- ✓ More days with heavy rainfall

Key sectors: Public Works/Engineering, Infrastructure, Biodiversity, Health, Agriculture, Watershed

Precipitation	
PR Total Precipita	
Rain Total Rainfa	
Snow	

Increasing Temperatures and Extreme Heat

- ✓ Hotter daytime temperatures
- ✓ Warmer nighttime temperatures
- ✓ Heat waves becoming hotter and more frequent

Key sectors: Emergency Management, Health, Biodiversity, Watershed

Daytime Temperatures	
TX	Daytime high temperature, averaged over all days in a year or season
TXx	Hottest daytime high temperature in a year or season
SU Summer Days	Number of days in a typical year when the daytime high is above 25°C

Next Steps – Share Results

Climate Projections for the Capital Region report	Complete data package (maps, tables, GIS files)
✓ Raise awareness about climate change ✓ Present information to stakeholders ✓ Include in a strategic plan ✓ Evaluate high-level climate impacts	✓ Conduct a detailed study ✓ Hazard, Vulnerability & Risk Assessments ✓ Specific design variables (e.g., emissions scenario, time period, subregion of interest)

Capital Regional District

Meeting Minutes

Solid Waste Advisory Committee

Friday, March 1, 2024 **12:30 PM** **CRD Boardroom**
625 Fisgard Street
Victoria, BC V8W 2S6

PRESENT: R. Anderson (EP), F. Baker, C. Blanchard, M. Coburn, B. Desjardins (Chair), S. Gose (EP), E. Klimke (EP), M. Kurschner, E. Latta (EP), M. McCullough (EP), D. Monsour (EP), J. Shaw, A. Sibley, R. Tooke (Vice-Chair),

STAFF: A. Chambers (Recorder), R. Smith, L. Ferris (EP), K. Masters (EP), A. Panich (EP), Dominique Moghaddam (EP), Ashley Richter (EP)

GUEST: Kayla Siefried (Compost Education)

REGRETS: M. Hauzer, J. Oakley, R. Pirie, C. Remington, W. Stevens, D. Thran, S. Young Jr.

EP - Electronic Participation

The meeting was called to order at 12:35 pm.

1. Territorial Acknowledgement

2. Approval of Agenda

Agenda for the March 1, 2024 Solid Waste Advisory Committee meeting.

MOVED by R. Tooke, SECONDED by C. Blanchard
That the agenda be approved as circulated.
CARRIED

3. Adoption of Minutes

Minutes from the December 1, 2023, Solid Waste Advisory Committee meeting.

MOVED by F. Baker, SECONDED by R. Tooke
That the minutes of the December 1, 2023, Solid Waste Advisory Committee meeting be adopted as circulated.
CARRIED

4. Chair's Remarks

- Welcome to Elaine Klimke *(Willis Point Representative)* and Andrew Sibley of Tymac (*Private Sector Industry Collection Service Provider).*
- Rory Tooke, Julie Oakley and Dennis Thran have been re-appointed for 3-year terms.
- Welcome to Melissa Hauzer who has replaced Rebecca Newlove on the committee from the District of Saanich
- Jordan Rintoul is no longer with Waste Management and staff are seeking a replacement for the *private sector industry collection service providers.*

5. Presentations/Delegations

There were none.

6. Committee Business

a. Solid Waste Management Plan Monitoring - Solid Waste Advisory Committee Role

R. Smith presented on SWAC's role as the Plan Monitoring Advisory Committee (PMAC). The presentation is attached as Appendix A. Staff will forward SWAC the 2023 Solid Waste Management Plan Progress Report when the April 17, 2024 Environmental Services Committee agenda has been posted.

b. Implications of Regulating Curbside Organics Collection Staff Report (verbal update)

R. Smith provided an update on the Implications of Regulation Curbside Organics Collection staff report that was approved at the November 8 CRD Board meeting. It was highlighted that the Waste Generator Study, scheduled for 2025, will provide clearer information on organics being generated in the region. Staff will send an information report, regarding pathways to mandatory separation of curbside organics to the Environmental Services Committee and the CRD Board in late 2024.

c. Actual and Projected Monthly Refuse Tonnages at Hartland Landfill (standing item)

The tonnage graphs are posted via this link: https://www.crd.bc.ca/about/data/hartland-landfill-tonnage. Staff are preparing a staff report on Materials Stream Diversion that will be issued to the SWAC once it goes live. The report will highlight the larger quantity items that are going to be diverted from the landfill.

7. Correspondence

There was no correspondence.

8. Other Business

a. City of Victoria Zero Waste

R. Tooke provided an update on the City's Zero Waste and its plan to reduce waste by 50% by 2040. R. Tooke will share the report when available. Some highlights are:

- 16-new initiatives proposed for the next year
- Service for all multi-family units
- Easier access for hard to recycle items (e.g., household hazardous waste).

9. Next Meeting

The next Solid Waste Advisory Committee meeting will be April 5, 2024.

10. Closing Comments

There were no closing comments.

11. Adjournment

The meeting was adjourned at 13:50

MOVED by J. Shaw, SECONDED by M. Coburn
That the Solid Waste Advisory Committee be adjourned.
CARRIED

APPENDIX A

Solid Waste Management Plan Monitoring

Solid Waste Advisory Committee

March 1, 2024

Solid Waste Advisory Committee (SWAC)

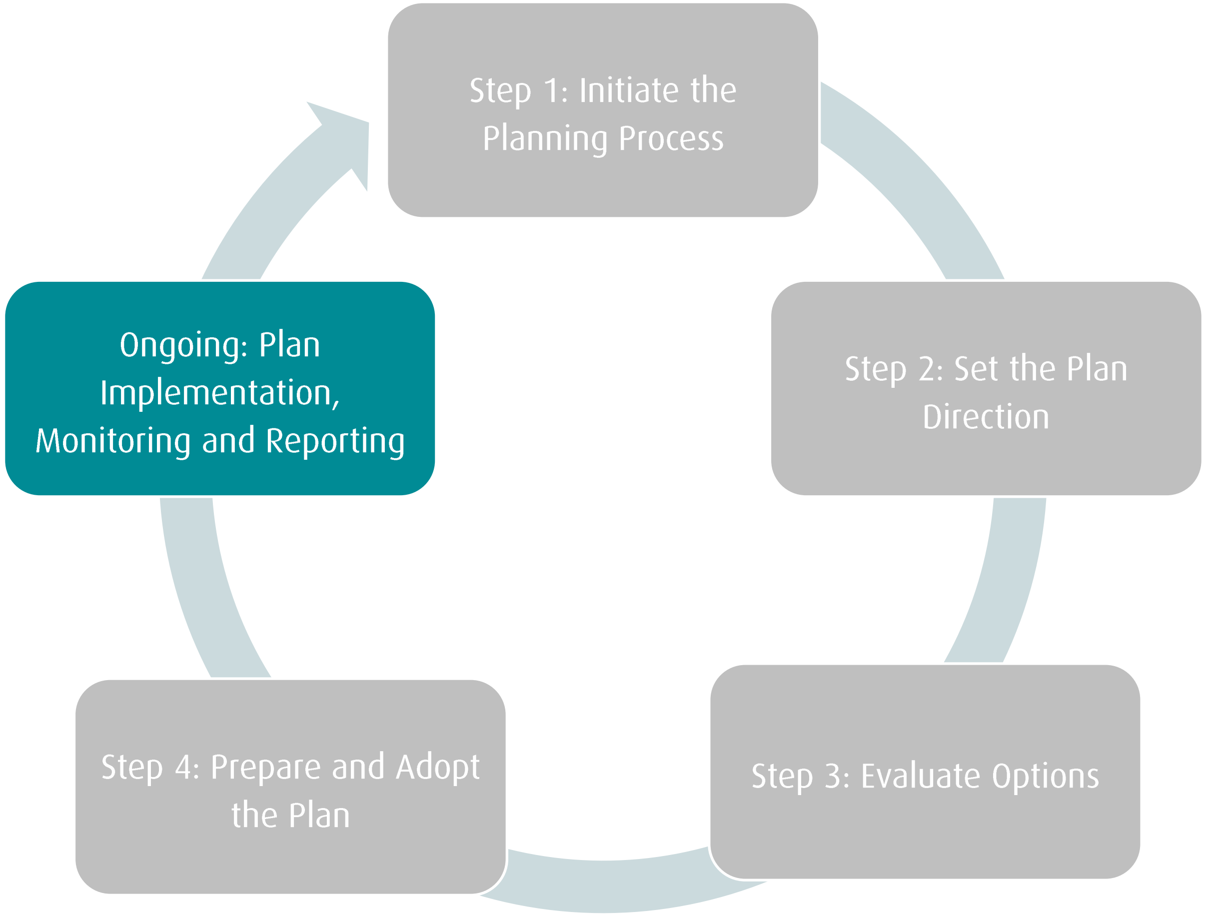
- SWAC is an advisory committee established by the CRD's Environmental Services Committee (ESC).
- SWAC acts as the Solid Waste Management Plan (SWMP) monitoring advisory committee.
- SWAC is a multi-stakeholder committee comprising of members representing a diversity of background, interests and geographical locations, representing a balance between technical and non-technical members and industry and public members.

Rethink waste

CRD

Solid Waste Management Planning

Rethink waste



CRD

Plan Implementation

Environmental Services Committee

Standing committee to oversee and make recommendations to the CRD Board on waste management and resource recovery. Steering committee for the SWMP.

Staff

Receive direction from the CRD Board bylaw and policy changes in alignment with the SWMP

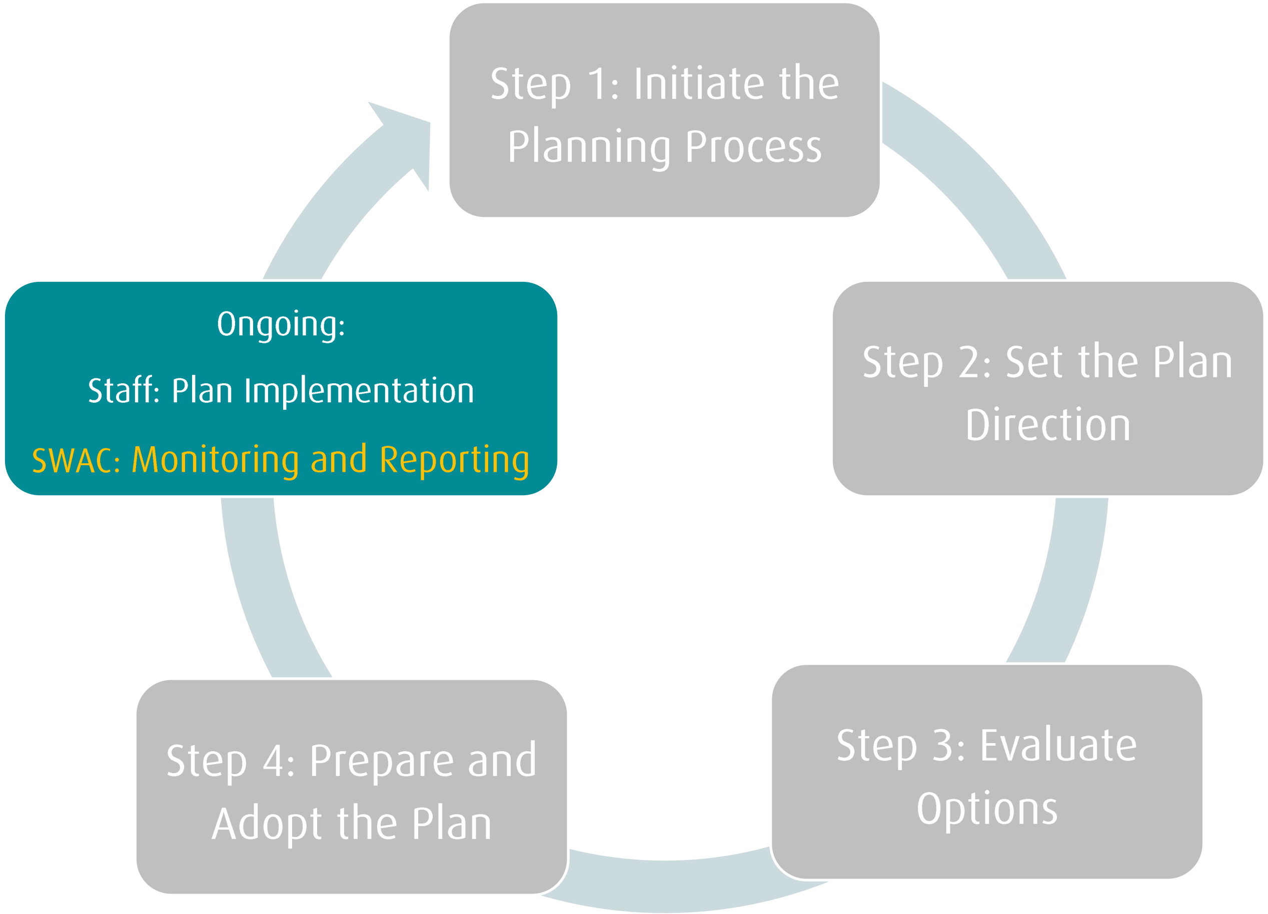
CRD Board

Regional authority for decision making

Solid Waste Advisory Committee

Plan monitoring advisory committee (PMAC). Monitor implementation of SWMP

Solid Waste Management Planning



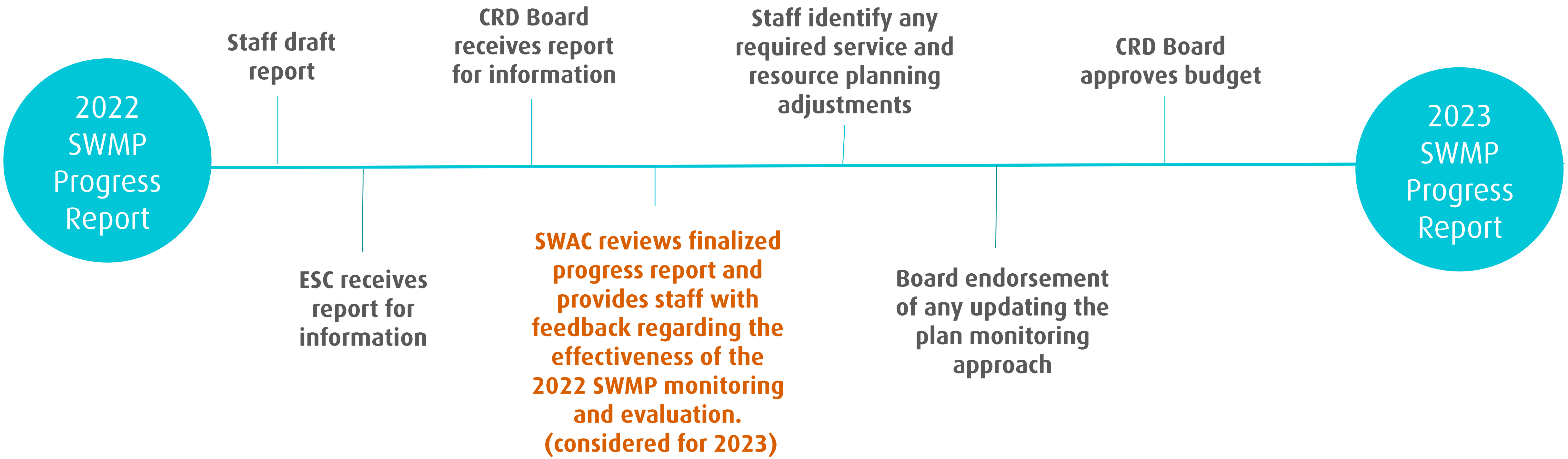
Solid Waste Advisory Committee (SWAC)

<u>SWAC Plan Monitoring mandate</u> – Ministry of Environment & Climate Change Strategy's Guide to Solid Waste Management Planning

- To advise the regional district on all matters involving <u>monitoring the implementation of the plan and evaluating its effectiveness</u>

Monitoring and Reporting Process

Rethink waste



CRD

Additional Studies

Through the 2024 budget, the CRD Board has approved new and more frequent studies to have more data and allow for comparisons over time. These studies rotate on a three-year cycle for the lifetime of the SWMP.

Market Research	Waste Generator Study	Waste Composition Study
• Begin 2024 • Request for Proposals issued In February 2024 • Measure the impact of CRD waste reduction programming, and programs the CRD funds • Understand knowledge of residents and businesses in relation to the SWMP, the general waste system and available services • Budget - $150,000	• Begin in 2025 • Understand how much waste is recycled, composted or put in the garbage at the generator level • Gather data at the source • Sector and material category specific data • Budget - $150,000	• Next study in 2026 • Identify waste landfilled at Hartland Landfill's active face • Sector and material category specific data • Budget - $150,000

Progress Tracking

Rethink waste

Goals			
1 - To surpass the provincial per capita waste disposal target	**2** - To extend the life of Hartland Landfill to the year 2100 and beyond	**3** - To have informed citizens that participate effectively in proper waste management practices	**4** - To ensure that the CRD's solid waste services are financially sustainable

Progress Status

Staff have drafted progress status definitions for each Solid Waste Management Plan goal and would like input from Solid Waste Advisory Committee.

On track

Opportunity for improvement

Attention required

Primary Indicators and Inputs

Reports and data staff will use to help inform the progress status of each goal.

Report Card

Goal 1
To surpass the provincial per capita waste disposal target (350kg/capita/year) and aspire to achieve a disposal rate of 125 kg/capita/year

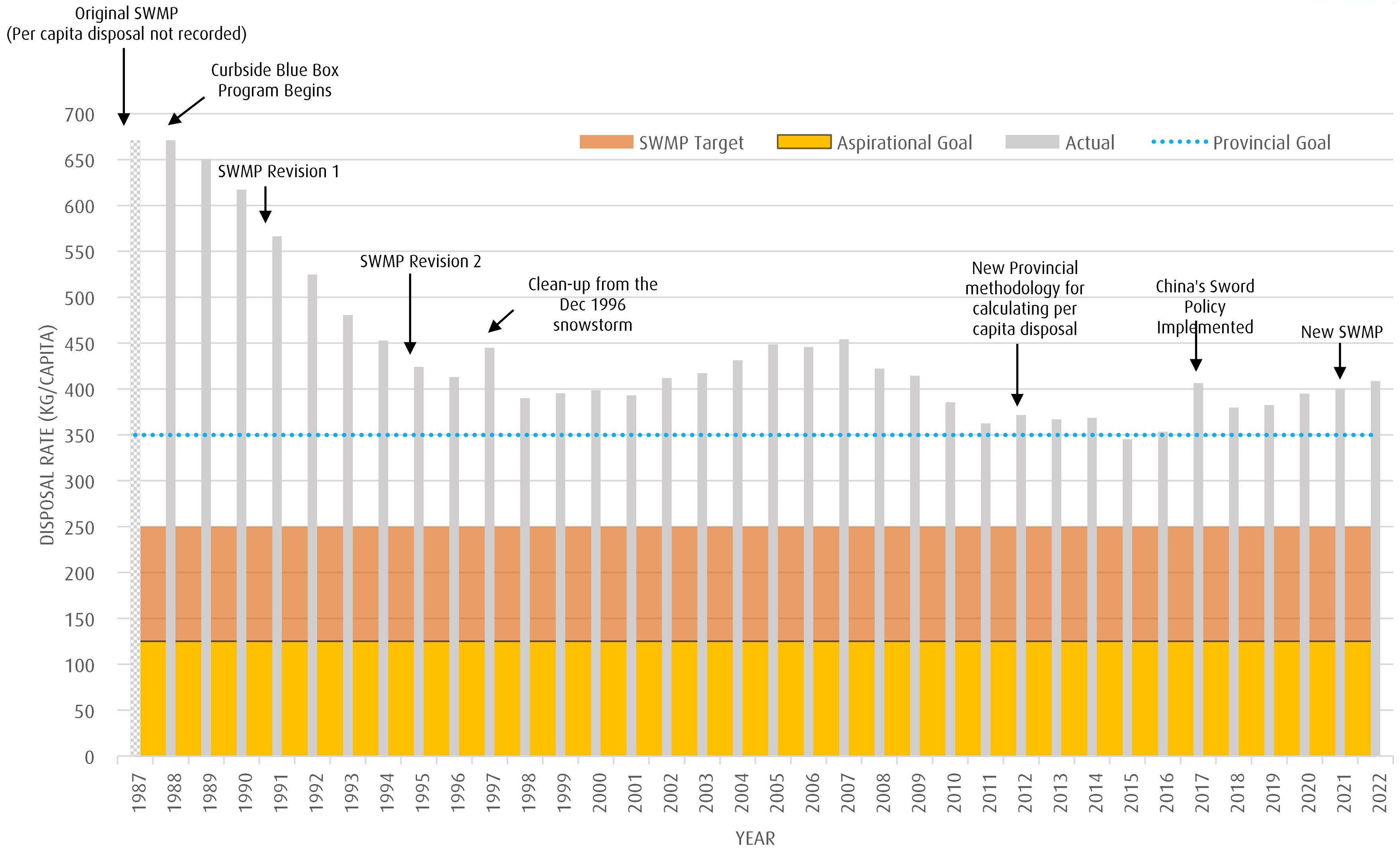
Primary Indicators and Inputs

- Per capita waste disposal
- Waste Composition Study
- Waste Generator Study

Progress Status Definitions

On track	Community is trending towards a per capita disposal rate to be **less than 350 kg/capita** over the life of the plan.
Opportunity for improvement	Community is trending towards a per capita disposal rate of **350 kg/capita** over the life of the plan.
Attention required	Community is trending towards a per capita disposal rate **above 350 kg/capita** over the life of the plan.

Per Capita Disposal Target Tracking



Report Card

Goal 2
To extend the life of Hartland Landfill to the year 2100 and beyond.

Primary Indicators and Inputs

- Hartland Compaction Rate
- Tonnes of material landfilled
- CRD Engineering Reports

Progress Status Definitions

On track	Air space utilization is on track to extend the life of Hartland Landfill to the year **2100 and beyond**.
Opportunity for improvement	Air space utilization is only trending to extend the life of Hartland Landfill to the year **2100**.
Attention required	Air space utilization will **not extend** the life of Hartland Landfill to the year 2100.

Report Card

Rethink waste

Goal 3
To have informed citizens that participate effectively in proper waste management practices.

Primary Indicators and Inputs

- Participation in current and new CRD Programs
- Solid Waste Awareness and Engagement Market Research

Progress Status Definitions

Status	Definition
On track	Engagement and participation in proper waste management practices is **higher** than previous years.
Opportunity for improvement	Engagement and participation in proper waste management practices is **equivalent** to previous years.
Attention required	Engagement and participation in proper waste management practices is **less** than previous years.

Report Card

Goal 4
To ensure that the CRD's solid waste services are financially sustainable.

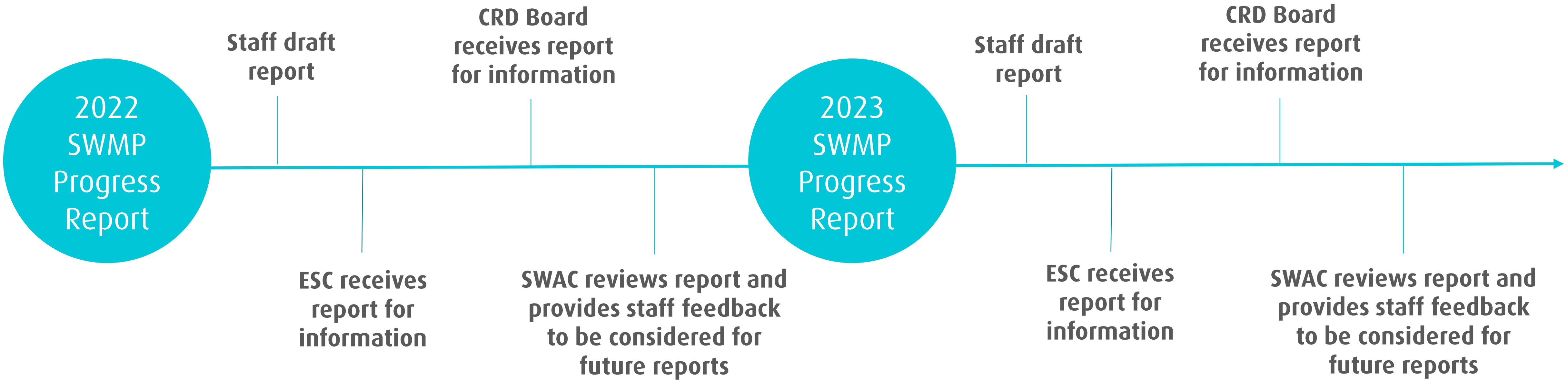
Primary Indicators and Inputs

- Modeling prepared by CRD Financial Services

Progress Status Definitions

Status	Definition
On track	Solid waste service self-funding model is **financially sustainable** for the remainder of the plan.
Opportunity for improvement	Solid waste service self-funding model is **trending in the wrong direction**, adjustments may be necessary.
Attention required	Solid waste service self-funding model is trending in the wrong direction and is currently **not sustainable** for the remainder of the plan.

Monitoring & Reporting Process



2023 Progress Report Monitoring Timeline

- Wednesday, April 17 – ESC Meeting
- Wednesday, May 8 – CRD Board Meeting
- Friday, June 7 – SWAC

Thank you

rsmith@crd.bc.ca | 250.360.3080

@crdvictoria Capital Regional District CRDVictoria crd.bc.ca

TECHNICAL AND COMMUNITY ADVISORY COMMITTEE
CORE AREA WASTEWATER TREATMENT
Meeting Minutes

Friday, October 27, 2023

1:00 pm

City Hall, City of Victoria
Songhees Nation Meeting Room (second floor)
1 Centennial Square
Victoria, BC V8W 1P6

PRESENT: B. Donald, D. Kobayashi (Vice Chair), J. Clary, C. Valeo (EP), J. Roe, C. Coleman (Chair), G. Gillespie, J. Andrews, M. Engelsjord, C. Remington, J. Paul, K. Wilson, D. Monsour, L. Hatch, W. Pugh

STAFF: G. Harris, P. Kickham, D. Green, J. McAloon, L. Maslen (EP), L. Nickerson (Recorder)

GUESTS: K. Hamilton, R. Beise, T. Urquhart, J. Beatty (EP)

REGRETS: I. Leung

(EP) = Electronic Participation

The meeting was called to order at 1:02 pm.

1. Territorial Acknowledgement

2. Welcome and description of TCAC purpose (Chair)

Chair Coleman welcomed everyone and informed the group that this committee is a technical and advisory committee made up of technical and community representatives. This group will provide recommendations to the CRD Board.

3. Introductions (all)

G. Harris introduced himself and CRD staff. Chair Coleman introduced himself and Vice Chair Kobayashi. Other attendees introduced themselves and gave a brief history of their experience and interests relating to this committee. Chair Coleman advised this group will be together for about six months with the first few meetings relating to I&I and the last few meetings relating to biosolids. Chair Coleman advised as the Chair he follows "Robert's Rules of Order" – he is a fan of Robert's Rules being relaxed at first to allow more conversations, but once recommendations are being made, there is a need to have a more formal approach to any recommendations or advice we wish to give because the words that make sense to this committee may not make sense to others.

4. Presentations

a. TCAC process and Liquid Waste Management Plan background (D. Green)

D. Green provided a brief overview of liquid waste management plans (LWMPs) and the process for the TCAC group. LWMPs are tools that allow regional districts and local governments to develop community-specific solutions for the management of liquid waste and environmental protection under the Province of BC Environmental Management Act. TCAC will meet approximately monthly, which will include a combination of presentations, group discussion and some reading work. The output from this group will be reported back to the Core Area Liquid Waste Management Committee.

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b. Inflow & Infiltration (I&I) background and Q&A (J. McAloon)

J. McAloon provided a brief overview of I&I and advised inflow and infiltration refers to "leaky sewers" which can result in overflows to beaches and health concerns. I&I is a capacity issue and will get worse over time if not addressed. The older municipalities (Victoria, Esquimalt and Oak Bay, especially Uplands) have higher I&I rates due to deterioration and/or the types of sewer lines, and the newer municipalities have lower I&I rates. The current LWMP I&I commitment needs to be reviewed and possibly amended.

c. Biosolids background and Q&A (P. Kickham)

P. Kickham provided some background on the process of how the wastewater is managed and treated in the region since the initiation of the new wastewater treatment plant and Residuals Treatment Facility (RTF) in 2021. The process of creating biosolids at the RTF was introduced and discussed. The RTF is already one of the most sophisticated biosolids processing facilities in Canada. To be consistent with provincial requirements, wastewater utilities must not view these biosolids as a waste product but rather as a resource to be beneficially re-used.

LaFarge was contracted to receive the biosolids for beneficial re-use and a contingency plan was put into place allowing the biosolids to be landfilled during LaFarge maintenance periods (anticipated to be 35 days/year). However, due to operational and logistical challenges, LaFarge has only been able to accept a very small amount (5½ days worth in 2023) and the majority of the biosolids have been landfilled. An additional contingency plan was established in the summer of 2023 for reclamation of an aggregate quarry in Cassidy BC, however current space is limited at this location. The province has required broad public consultation on all available beneficial re-use options and a long term biosolids management strategy to be submitted by June 2024 with the expectation that it will be implemented by January 2025. Thermal options and land application options for biosolids were introduced. The CRD requires redundance and resiliency to ensure service delivery and compliance with legislation, and therefore numerous options (e.g., a preferred option, a support option, and contingency options) are required.

d. Biosolids Public Consultation (K. Hamilton)

K. Hamilton presented a public consultation process for long term management of biosolids and sought feedback from the TCAC. TCAC was supportive of the general approach. K. Hamilton's role is to ensure a wide range of audiences have access to complete, educational, quality information on this complex issue. They foresee a multi-month engagement process from November 2023 – February 2024. Their communication and consultation objectives are to raise awareness, provide multiple channels and opportunities for the community to provide input and seek to understand public awareness, perceptions and concerns for how biosolids should be managed in the region. They will provide a detailed consultation summary report in March 2024 which will include what input was collected and how that informed or influenced decisions.

5. Action Items

a. **Chair Coleman** advised he will follow up with Tourism Victoria, the Greater Victoria Chamber of Commerce, Esquimalt Chamber of Commerce and the West Shore Chamber of Commerce regarding the TCAC.
b. **K. Hamilton** will provide an update to the TCAC on the public consultation process prior to launch (mid-November).
c. **CRD staff** will determine if virtual or in-person tours of the RTF are possible for TCAC members and/or the public

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6. Next meeting

The next TCAC meeting will be held on November 24, 2023 at 1:00 pm.

7. Adjournment

The meeting was adjourned at 3:01 pm.

TECHNICAL AND COMMUNITY ADVISORY COMMITTEE
CORE AREA WASTEWATER TREATMENT
Meeting Minutes

Friday, November 24, 2023 | **1:00 pm** | **CRD Boardroom**
625 Fisgard Street
Victoria, BC V8W 2S6

PRESENT: B. Donald, C. Remington, C. Valeo (EP), D. Kobayashi (Vice-Chair), D. Monsour (EP), G. Gillespie, I. Leung, J. Clary, J. Andrews, K. Wilson, L. Hatch, M. Engelsjord, R. Ding, W. Pugh

STAFF: B. Rudolph (EP), D. Green, G. Harris, J. McAloon, L. Nickerson (Recorder), P. Kickham

GUESTS: C. Caunce (EP), C. Johnston, K. Hamilton (EP), R. Beise

REGRETS: C. Coleman (Chair), E. Brown, J. Paul, J. Roe

(EP) = Electronic Participation

Acting Chair D. Kobayashi called the meeting to order at 1:02 pm.

1. Territorial Acknowledgement

2. Introduction of New Members

G. Harris welcomed new committee members Richard Ding and Edward Brown, and shared that Chair Coleman reached out to the Chamber of Commerce's to discuss representation for them.

3. Committee Confidentiality

Committee members signed a non-disclosure agreement (NDA) to maintain confidentiality and internal TCAC discussions need to remain confidential.

Information for public conversations is available on the TCAC page.

Requests for information should be directed to Dale Green, Supervisor, Source Control Programs at dgreen@crd.bc.ca.

The meeting is being recorded for internal use only and recordings will not be posted or distributed.

4. Approval of Agenda

Agenda for the November 24, 2023 Technical and Community Advisory Committee.

MOVED by Greg Gillespie and SECONDED
That the agenda be approved as circulated.
CARRIED

5. Adoption of Minutes of October 27, 2023

Minutes from the October 27, 2023 Technical and Community Advisory Committee.

Corrections:

Item 8 on the October 27, 2023 Agenda “Reading request prior to next meeting” - no documents were sent to the members for review.

Item 4d on the October 27, 2023 Minutes - there is a date error in the presentation by K. Hamilton on page 9 of the “Long Term Biosolids Management Public Engagement Strategy October 2023”. The Public Consultation dates should read “November 2023 - February 2024”.

MOVED by Brenda Donald and SECONDED
That the minutes of the October 27, 2023 Technical and Community Advisory Committee be adopted as circulated.
CARRIED

6. Chair’s Remarks

In the future, CRD staff will endeavor to share information earlier (1 week prior to meeting).

There is a lot of information being shared with members who have a wide range of knowledge on these topics. The aim is to get all members up to speed and at the same level for future discussions. Chair Kobayashi suggested members ask a lot of questions to assist them in making informed decisions and recommendations about these topics.

7. I&I LWMP Commitments – Peter Kickham, CRD

P. Kickham, CRD Manager of Regulatory Services, gave a presentation and discussed the regulatory requirements for Inflow and Infiltration (I&I) and overflows, the current liquid waste management plan (LWMP) commitments, and the current scenario.

8. Environmental Protection Goals for Overflows – Dale Green, CRD

Dale Green, CRD Supervisor, Regional Source Control Programs, gave a presentation on the environmental context for I&I and the environmental protection goals for overflows, and discussed the CRD marine monitoring program and how it relates to I&I.

9. I&I Review – Chris Johnston, Kerr Wood Leidal

C. Johnston, I&I Consultant for the CRD, gave a presentation discussing the objectives and commitments to be made to the Province as part of the BC municipal wastewater regulation relating to I&I and overflows. Changes to the liquid waste management plan are required in order to demonstrate how the CRD and core area municipalities will meet Provincial regulatory requirements in the future.

10. Update of Biosolids Public Outreach – Katie Hamilton, Tavola Strategy Group

K. Hamilton, Communications Consultant for the CRD, discussed the public engagement strategy will begin in early January 2024 with focus groups in February. A virtual tour of the Residuals Treatment Facility (RTF) is being created and will be made publicly available. She will provide reading materials to the TCAC for review.

11. Other Business

See Item 12 below.

12. Next meeting: December 11, 2023

The December 11, 2023 meeting has been cancelled and instead the TCAC will meet at the RTF for a tour from 1:30-3:30 pm.

13. Closing Comments

Automatic notifications are not working on the TCAC page where agendas and minutes are posted. CRD staff will work to correct this issue as soon as possible.

Presentations for Agenda items 7, 8 and 9 are included in the November 24, 2023 Agenda.

14. Adjournment

The meeting was adjourned at 3:11 pm.

TECHNICAL AND COMMUNITY ADVISORY COMMITTEE
CORE AREA WASTEWATER TREATMENT
Meeting Minutes

Friday, January 19, 2024

1:00 pm

City Hall, City of Victoria
Songhees Nation Meeting Room (second floor)
1 Centennial Square
Victoria, BC V8W 1P6

PRESENT: B. Donald (EP), C. Coleman (Chair), C. Valeo (EP), D. Kobayashi (Vice Chair) (EP), I. Leung, J. Andrews, J. Clary, J. Paul, J. Roe (EP), K. Wilson (EP), L. Hatch (EP), M. Engelsjord, R. Ding, W. Pugh (EP)

STAFF: D. Green, G. Harris, J. McAloon, L. Nickerson (Recorder), P. Kickham, Z. Gray (EP)

GUESTS: C. Caunce (EP), C. Johnston, K. Hamilton (EP), R. Beise

REGRETS: C. Remington, D. Monsour, G. Gillespie

(EP) = Electronic Participation

Chair Coleman called the meeting to order at 1:03 pm.

1. Territorial Acknowledgement

Chair Coleman provided a Territorial Acknowledgement.

2. Chair's Remarks

Chair Coleman informed the group that the Technical and Community Advisory Committee (TCAC) will continue to report on Inflow and Infiltration (I&I) to the CRD Core Area Liquid Waste Management Committee but will be reporting on long-term biosolids management planning to the CRD Environmental Services Committee.

3. Approval of Agenda

Agenda for the January 19, 2024 Technical and Community Advisory Committee meeting:

MOVED by J. Andrews and SECONDED by R. Beise
That the agenda be approved as circulated.
CARRIED

4. December 11, 2023 RTF Tour Summary

P. Kickham spoke about the Residuals Treatment Facility (RTF) tour for TCAC members on December 11, 2023. Chair Coleman requested CRD staff organize a second tour if possible, for the members who were unable to attend.

Two tour handouts are available on the TCAC collaboration site. Questions regarding the RTF can be directed to Peter Kickham (pkickham@crd.bc.ca).

5. Collaboration Site

P. Kickham gave an overview of the TCAC collaboration site which contains a collection of materials for TCAC members to review including agendas, minutes, presentations and reports that have been discussed at prior meetings. More information will be provided on biosolids prior to the next TCAC meeting.

6. Review of Core Area LWMP Section 5: Management of I&I and Control of Wastewater Overflows by Kerr Wood Leidal (KWL) - Chris Johnston

C. Johnston presented to the group. The presentation is attached as Appendix A. He discussed the existing and proposed I&I reduction commitments in Section 5 of the current 2019 Consolidated Liquid Waste Management Plan (LWMP). In April 2022, CRD and municipal engineers developed an update of Section 5, and additional changes have been suggested by KWL to provide the current proposed update to Section 5 of the LWMP.

The draft report titled *Review of Core Area LWMP Section 5: Management of I&I and Control of Wastewater Overflows* is attached as Appendix B.

7. BREAK (14 minutes)

8. Municipal Asset Management Planning Update - Municipal Engineers

The municipal engineers each gave updates on their Municipal Asset Management Plans.

I. Leung - Town of View Royal
J. Paul - City of Victoria
J. Clary - Township of Esquimalt
J. Andrews - City of Colwood
L. Hatch - District of Saanich
R. Ding - District of Oak Bay

9. Biosolids Introduction – P. Kickham

P. Kickham introduced the "Get Involved" Long-Term Biosolids Management Plan public engagement website that was launched on January 11, 2024 to provide broad public consultation on all of the biosolids management options available that comply with provincial legislation. This site offers educational material, a survey and FAQs for public review and feedback.

10. Biosolids Engagement Update – K. Hamilton

K. Hamilton advised the "Get Involved" public engagement website will be active until March 6, 2024 and includes a dedicated email (biosolids@crd.bc.ca) to give the public an opportunity to ask questions and submit written feedback. Members of the public can also ask questions of the project team through the site and subscribe for project updates.

A public online information session is being planned offering information from the technical team and the technical advisor on biosolids management uses.

11. Other Business

P. Kickham and G. Harris discussed the use of biosolids in other parts of Canada and answered questions from the committee members.

12. Next meeting: February 13, 2024

The next meeting will be held at 1:00 pm on February 13, 2024.

13. Closing Comments

There were no closing comments.

14. Adjournment

MOVED and ALL IN FAVOR
That the January 19, 2024 Technical And Community Advisory Committee meeting be adjourned at 3:31 pm.
CARRIED.

Making a difference...together

TECHNICAL AND COMMUNITY ADVISORY COMMITTEE
CORE AREA WASTEWATER TREATMENT
Meeting Minutes

Tuesday, February 13, 2024 — **CRD Room 488**, 625 Fisgard Street, Victoria, BC V8W 2S6

1:00 pm

PRESENT: B. Donald, C. Remington, C. Valeo (EP), D. Kobayashi (Acting Chair), D. Monsour (EP), G. Gillespie, I. Leung (EP), J. Andrews (EP), J. Clary (EP), J. Paul (EP), J. Roe (EP), K. Wilson, L. Hatch (EP), M. Engelsjord, R. Ding, W. Pugh

STAFF: D. Green, G. Harris, J. McAloon, L. Nickerson (Recorder), P. Kickham

GUESTS: A. Robiso (EP), C. Johnston (EP), D. Liddy (EP), K. Hamilton (EP), R. Beise

REGRETS: C. Caunce (EP), C. Coleman (Chair), J. Beatty (EP)

(EP) = Electronic Participation

Acting Chair Kobayashi called the meeting to order at 1:02 pm.

1. Territorial Acknowledgement

Acting Chair Kobayashi provided a Territorial Acknowledgement.

2. Approval of Agenda

The order of the Technical and Community Advisory Committee agenda was changed to present items 6 and 7 before item 5.

MOVED by G. Gillespie, SECONDED by W. Pugh
That the agenda be adjusted as above.
CARRIED

3. Adoption of Minutes of January 19, 2024

Minutes from the January 19, 2024 Technical and Community Advisory Committee meeting.

MOVED by G. Gillespie, SECONDED by W. Pugh
That the minutes of the January 19, 2024 Technical and Community Advisory Committee be adopted as circulated.
CARRIED

4. Chair's Remarks

Acting Chair Kobayashi had no remarks.

5. Biosolids Options Evaluation – D. Liddy, GHD Environmental
a. Discussion and Q&A

D. Liddy, Engineering Consultant with GHD Environmental presented their options analysis on the long term biosolids management strategies for the CRD (see Attachment A). The group discussed the short-term and long-term options and had a wide range of questions for D. Liddy. Attachment B shows the approach presented by GHD.

6. Biosolids Public Engagement Update – K. Hamilton, Tavola Strategy Group

K. Hamilton informed the group on the biosolids public consultation currently underway.

An update was provided to the CRD Board on January 31, 2024 about the public consultation process including the information being shared and the various opportunities for the public to provide input, participate and learn more over the two month process. As a result of that meeting, some information has been given greater prominence on the Get Involved website including increased information relating to CRD's historical land application ban and the options analysis presented by GHD. The online survey is open until March 6, 2024 and the website will continue to adapt as needed based on feedback. To date, 298 online surveys have been completed with broad representation from all municipalities and answers to specific questions are available for public viewing on the website. A virtual Open House will be held on February 20, 2024 at 6:00 pm.

Ipsos Reid will lead a representative survey (in parallel with the voluntary survey on the Get Involved website) until March 6, 2024. Results from both surveys will be provided to the TCAC prior to the CRD Board.

Letters regarding the public consultation to shape the long-term biosolids management plan are being sent to a comprehensive list of stakeholder groups this week as part of the public engagement plan.

7. Report to the TCAC - Amendment 13 – D. Green, CRD

D. Green presented a report to the TCAC and discussed the proposed Section 5 updates to the Core Area Liquid Waste Management Plan (the Plan) and the updated Kerr Wood Leidal (KWL) report with the group. The full presentation is attached as Attachment C.

The Inflow and Infiltration (I&I) report by KWL has been updated based on comments and feedback from discussions at the last TCAC meeting on January 19, 2024. In KWL's proposed suggestions for the Plan's Section 5, the yellow highlighting represents items that are significant changes that will require future work to implement. In the final version, highlighting will be removed.

CRD staff will be preparing the Amendment 13 package and materials for the Core Area Liquid Waste Management Committee (CALWMC) meeting in June, and if approved, these amendments will be sent to the municipalities and First Nations for review, then back to the CALWMC for final approval prior to being sent to the Provincial regulator.

If there are any large shifts in direction from the municipalities or First Nations on the proposed updates, the TCAC may be requested to meet again and discuss.

D. Green requested final comments and support from the TCAC for the proposed new Section 5 and KWL report so that CRD staff can forward these items to the CALWMC.

The following motion was passed:

> **The Technical and Community Advisory Committee supports the proposed new Section 5 updates to the Core Area Liquid Waste Management Plan and Kerr Wood Leidal report so that CRD staff can forward it to the Core Area Liquid Waste Management Committee.**
> **MOVED by G. Gillespie, SECONDED by M. Engelsjord**
> **CARRIED**

8. **Other Business**

There was no other business.

9. Next meeting: March 7, 2024

The next meeting will be held at 1:00 pm on March 7, 2024.

10. Closing Comments

There were no closing comments.

11. Adjournment

The meeting was adjourned at 2:46 pm.

> **MOVED and ALL IN FAVOR**
> **That the Technical and Community Advisory Committee meeting be adjourned.**
> **CARRIED**