

Development Application Referral

Please send your reply to planning@sechelt.ca

Application No:	3360-2022-08	Referral Date:	October 17, 2023	X	OCP Amendment
File Manager:	Sven Koberwitz, Senior Development Planner			X	Rezoning
File Manager Contact:	skoberwitz@sechelt.ca 607-740-8497				Subdivision
Applicant:	Sawarne Lumber Co.				Variance
Applicant Contact:	Davy Sangara dsangara@sawarne.com 604-418-3632				Development Permit

Please comment on the attached referral for potential effect on your interests. If you require additional time, please contact the File Manager to request an extension.

PLEASE RESPOND TO THIS REFERRAL BY November 17, 2023.

PROPERTY ADDRESS:	Derby Road
LEGAL DESCRIPTION:	DISTRICT LOT 1384 GROUP 1 NEW WESTMINSTER DISTRICT EXCEPT: PART ON PLANS 14180, PLAN BCP31726, EPP31745, EPP75215 AND EPP120158

SUMMARY OF APPLICATION:

Sawarne Lumber Co. Ltd. has applied to rezone a portion of District Lot 1384 to facilitate a 52-unit strata townhouse development located on the north side Derby Road just east of the Trellis Silverstone Care Facility. The proposal requires both a Zoning Bylaw Amendment and an Official Community Plan Bylaw Amendment.

Please provide comment on the proposed land use, density, and site plan, including any constraints that may affect the development. A development permit for form and character and more detailed site planning will be considered by Council later should the rezoning application be supported.

ATTACHMENTS:

- | | |
|----------------------------|------------------------------------------------|
| 1. Title and Charges | 6. Civil Servicing Proposal |
| 2. Design Narrative | 7. Stormwater Management & Environmental Study |
| 3. Architectural Plans | 8. Water Management Feasibility Study |
| 4. Landscape Plans | |
| 5. Geotechnical Assessment | |

This referral has also been sent to the following agencies:

X	FortisBC		Ministry of Transportation & Infrastructure	X	SCRD – Utility Engineering
	Telus		Agricultural Land Commission	X	SCRD – Mapping
X	B.C. Hydro	X	Sechelt Volunteer Fire Department	X	shíshálh Nation Government District
X	Canada Post	X	District of Sechelt Engineering Department	X	School District 46
	Other:	X	District of Sechelt Building Department		Vancouver Coastal Health Authority

Community Associations and Groups:

	Selma Park/Davis Bay/Wilson Creek Community Association	X	Sechelt Village Resident Association
	East Porpoise Bay Community Association	X	West Sechelt Community Association
	Sunshine Heights Owners and Residents Association		Tillicum Bay Community Association
	Tuwanek Ratepayers		Sechelt Downtown Business Association
	Sandy Hook Community Association		Sechelt and District Chamber of Commerce
	Transportation Choices Sunshine Coast (TRAC)		Sunshine Coast Car Co-op



August 31, 2022

Project No.: 22-664-SC

Sawarne Lumber Co., Ltd
300 –1785 W 4th Avenue,
Vancouver, British Columbia
V6J 1M2

e: dsangara@sawarne.com t: 604.235.1755 Ext. 204

**Re: Geotechnical Assessment: Proposed Silverstone Heights Phase III Development
Derby Road, Sechelt, British Columbia (Part of PID: 024-694-118)**

Arya Engineering Inc. (Arya) presents the following report providing the results of a geotechnical assessment recently performed for a proposed multi-family townhome development to be located at Derby Road in Sechelt, British Columbia. The intent of this document is to determine the suitability of the land for the proposed works from a geotechnical perspective and to provide the client and the District of Sechelt with the relevant geotechnical information required for permit application. It is also the intention of this document to provide the contractor and additional key stakeholders with preliminary geotechnical information needed to guide the geotechnical aspects of the proposed works.

We trust this report contains the relevant information required for project continuation at this time. Should additional information be required, please do not hesitate to contact our office.

Sincerely,

Arya Engineering Inc.

Benjamin Tomasz, P.Eng.

Principal | Senior Geotechnical Engineer



EXECUTIVE SUMMARY

Based on the findings of this assessment and provided that all of the recommendations presented herein are implemented, there are no reasonably conceivable geotechnical issues that would preclude the safe development of the proposed works on the subject site. The land can be considered safe for the use intended provided the recommendations in this report are adhered to. It is important to note that the term “safe” as presented in the above statement, should be understood in terms of tolerable risk and does not constitute a guarantee. In this context, the land can be considered within the limits of tolerable geotechnical risk, as defined by society and related in applicable building codes, national design standards, professional practice standards (EGBC), and design and construction policies presented in the District of Sechelt’s Official Community Plan (OCP), adopted July 20, 2011.

A portion of approximately 0.04 ha, on the southwestern extent of the subject site falls within the District of Sechelt’s Development Permit Area (DPA) 5 – Steep Slopes (Slope > 20% – 30%). The tables presented below provide reference to the sections in this report that address development permit area criteria outlined by the District for the subject site.

Section	DPA #5 - Steep Slopes (Slope of 20% – 30% and >30%)
2.0,3.0	(a) An inventory and accurate plan of site features, including tree cover, rock outcroppings, watercourses and assessment of soil types, depths and conditions;
2.0	(b) Plans showing the location of all existing and proposed buildings and structures, building envelopes, utility services, driveways and other impervious surfaces;
6.0	(c) A slope analysis, geotechnical assessment, and slope stability plan providing assessment of the potential for landslide, landslip or erosion, detailing how the proposed development is to be designed and constructed to prevent any destabilization or erosion of the slope. This will include plans showing lands with 0-10%, 10-20%, 20-30% and 30% and over grades at a 1 m contour interval.
7.3	(d) Location and amount of anticipated removal of fill.
*	(e) View corridor analysis to determine the visual impact of development. The District may also require a 3D digital terrain model illustrating pre and post-development conditions, illustrating extents of cuts and fills, clearing and building placements;



*	(f) A site grading plan including sections through each lot that clearly shows building envelopes, including the top of cut and toe of slopes, and the slopes of adjacent uphill and downhill adjacent lots.
6.0,7.0,7.1	(g) Recommendations on appropriate building envelopes or setbacks in relation to potential slope hazard, with specific recommendations and criteria for design, construction and maintenance.
*	(a) Detailed measure to safeguard neighboring properties and structures arising from the proposed construction or site preparation (including blasting).
N/A	(b) Identify the anticipated effects of septic and drainage systems on slope stability.
**	(c) Any geotechnical reports must meet the report guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia published by the Association of Professional Engineers and Geoscientists of British Columbia, dated March 2006 and revised May 2010, including submission of Appendix D (Landslide Assessment Assurance Statement) to specify that the land may be safely used for the use intended.

*Additional criteria with respect to DPA 5 should be provided by a separate qualified profession if required.

**Appendix D to be submitted as a separate document upon request.



1.0 INTRODUCTION

Arya Engineering Inc. (Arya) presents the following report providing the results of a geotechnical engineering assessment and recommendations for the proposed townhomes development to be located at Derby Road in Sechelt, British Columbia. This report provides geotechnical engineering recommendations with respect to foundation design, continued site and subgrade preparation, seismic classification, groundwater and drainage recommendations, and other associated construction considerations.

2.0 BACKGROUND INFORMATION / SCOPE OF WORK

Based on conversations with the Client's representative (Maycon Construction Management Ltd) and a review of the IFCR site plan No. 21157 Rev 4, dated March 15, 2021 by CREUS Engineering provided by the Client's representative, it is our understanding that the proposed development will consist of single family dwelling structures, which are expected to be located on the site as shown in Image 1 appended in Appendix A

It is our understanding that structural plans for the proposed structures are currently being developed. Upon completion, our office should be provided the opportunity to review both the final architectural and structural plan sets prior to the commencement of construction.

The scope of work for this assessment included the following:

- A geotechnical site reconnaissance conducted on August 22 and 29, 2022, to observe current conditions of the site, including observations of surficial soils, topographic conditions, vegetation, and drainage conditions. This is exclusive of subsurface exploration which have been deferred to the start of construction per the client's representatives request.
- A desktop review of relevant background information including available topographical information for the site and surrounding area, related published subsurface information, and satellite imagery.
- Geotechnical engineering analysis and evaluation of the collected data.
- Preparation of a geotechnical assessment report summarizing Arya's findings.

The scope of this assessment did not include items related to other disciplines. Written authorization to proceed was received from Davy Sangara on behalf of Sawarne Lumber Co., Ltd on August 26, 2022.



3.0 SITE CONDITIONS

The subject site is located at Derby Road in Sechelt, British Columbia. The property is approximately rectangular in shape and encompasses a total area of approximately 4.6 ha. The lot is bounded by a property under development to the east and by Derby, Granite and Oracle Roads to the south, west and north respectively. Based on the LiDAR topographic data obtained from the Sunshine Coast Regional District (SCRD) public web-maps for the area, the proposed lot largely slopes from north to south with an approximate slope gradient of 12H:1V (Horizontal: Vertical) towards the southern property line, with the exception of a portion of approximately 0.04 ha, on the southwestern extent of the subject site as shown in Image 2 appended in herein. This area appears to be comprised of boulders and sandy silt fill material that was end dumped.

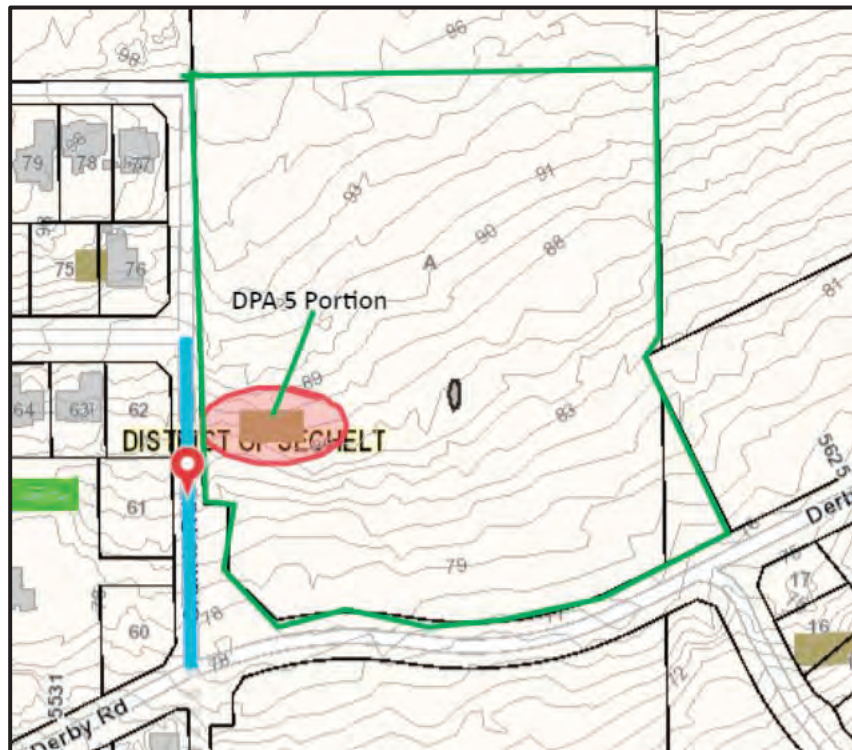


Image 2 – Lot Topography (From SCRD Maps)

3.1 Vegetation

During the site reconnaissance it was observed that the understory vegetation on the site primarily consisted of sword ferns, salal, blackberries, and salmonberries, while trees present included mostly juvenile maple, alders, Douglas fir and cedar growth.



3.2 Surface Water and Runoff

Surface water was not observed across the subject site during the site investigation. In consideration of the topographic conditions that characterize the site and the expected subsurface conditions, infiltration of precipitation into surficial granular soils is expected. When the infiltration capacity of the granular soils is exceeded, and/or where low permeable subgrade soils are present near surface, ponding is expected. Precipitation is expected to runoff via sheet-flow from north to south following the natural contours of the lot.

4.0 SUBSURFACE CONDITIONS

Preliminary subsurface soils review for the subject site were largely through desk studies, hand probing, visual observations at the time of the site reconnaissance, Groundwater Wells and Aquifer Registry of British Columbia groundwater wells borehole logs information from WTN - 11683, - 5434 and - 5498 located within 1,000 m from the subject property, Arya's previous site work and experience in the vicinity of the site, and published surficial geologic information were also considered. However, a more concise subsurface review through machine test pitting is required prior to subgrade approval and placement of foundation elements.

4.1 Soil Stratigraphy

Published surficial geologic maps for the Sunshine Coast area (McCammon, 1977) describe the site geology as comprising of Capilano Sediments consisting of marine and glacio-marine deposits. This material generally consists of varied gravelly, sandy, stoney, clay and clay veneer, normally over till materials. This description has been consistent with Arya's project experience in the area.

The anticipated stratigraphic profile for the site as inferred, is expected to consist of approximately 0.4 m of organic laden topsoil, underlain by approximately 0.8 m of reddish to yellowish brown, loose to compact, gravelly sand with some silt. The material is expected to transition into a more compact to dense sandy silt with some gravels. Due to variability in strata thickness within marine and glacio-marine depositions, excavation depth ranging from 1 - 3 m into the compact to dense subgrade material could be expected to site foundation elements for the proposed structures. if deemed required, ground improvement works could be implemented in order to achieve design foundation elevation objectives where weak soils strata are encountered. However, as earlier noted, a subsurface investigation that may include machine test pitting is recommended to confirm subgrade conditions as well as foundation bearing elevation.



4.2 Bedrock

Bedrock outcropping was not observed within the vicinity of the proposed development area during the site assessment and rock boulders noted at the site appears to be anthropogenic. While the presence of bedrock is not expected to negatively influence the performance of the proposed structure from a geotechnical perspective, if bedrock is encountered during site clearing, excavation and subgrade exposure, our office should be contacted to review and update the commentary herein as needed.

4.3 Groundwater Conditions

The presence of permanent groundwater, including groundwater seepage, was not observed during the geotechnical investigation. However, should groundwater and seepage conditions be encountered during test pitting and/or construction, our office should be notified to enable us to update this report accordingly. It is important to note, temporary groundwater management plans are generally the responsibility of the general contractor. Our office is available to provide additional consultation and to provide site specific temporary groundwater management plans if required.

5.0 SEISMIC ANALYSIS

The proposed structure should be designed under the seismic provisions of the British Columbia Building Code 2018 (BCBC 2018) and the National Building Code of Canada (NBCC 2015). Horizontal Peak Ground Acceleration (PGA) and 5% damped spectral response acceleration values $S_a(T)$ for four different periods (0.2, 0.5, 1.0 and 2.0 seconds) are outlined in TABLE 1 for the site (coordinates 49.475 ° N, -123.781° W) for a seismic event with a 2% probability of exceedance within 50 years (1 in 2,475-year event).

The seismic provisions of NBCC 2015 incorporate site effects by categorizing a wide variety of possible soil conditions into six site classes (Class A to Class F) according to the average properties of the top 30 m of the soil profile. The factors F_a and F_v given in the BCBC (2018) reflect the effect of possible soil amplification (or de-amplification) and soil-structure interaction resonance into the estimation for the seismic design forces for buildings having no unusual characteristics.

Based on the expected soil conditions at the proposed development site, a Site Classification “D” – Stiff Soil should be used for seismic site response in accordance with Table 4.1.8.4.A of BCBC (2018). The seismic design parameters for the proposed development site are included in Table 1 as reference.



TABLE 1: SEISMIC DESIGN PARAMETERS (NBCC 2015)

S _a (T) - Spectral Response Acceleration (g)*				Horizontal Peak Ground Acceleration (g)	Values of F	
Sa (0.2)	Sa (0.5)	Sa (1.0)	Sa (2.0)	PGA	F _a	F _v
0.87	0.87	0.55	0.35	0.360	0.96	1.27

* g = 9.81 m/s²

6.0 GEOTECHNICAL HAZARD ASSESSMENT

As noted herein, a portion of the subject site is located in the District of Sechelt’s Development Permit Area (DPA) 5 – Steep Slopes (Slope of 20% – 30%). DPA 5 applies to lands with topographic gradients greater than 20% for a horizontal distance greater than 10 m (District of Sechelt, 2010).

A qualitative slope assessment was conducted for the portion of the site prescribed with DPA 5. Based on data obtained from the SCRDP public web-maps, the area had a 4H:1V slope gradient, the slopes material appears to comprise of fill consisting of boulders, sand, silt and gravels. Background review suggests that relatively competent granular materials are located at relatively shallow depth across the parcel.

While deep-seated landslide potential is considered low for this area, localized slopes across the lot may exhibit potential for minor instabilities. To mitigate localized landslide potential on this portion of the site, the area should be regraded, and materials removed from slopes should be evaluated for reuse where possible. Foundations should be implemented on flat or stepped subgrade soils as approved by the geotechnical engineer. Excavation depth ranging from 1 - 3 m into the compact to dense subgrade material could be expected to site foundation elements for the proposed structures below reasonably conceivable, landslide failure planes. To verify this condition, at a minimum Arya should be retained to review test pits excavated to a depth prescribed in the field, and to evaluate the conditions of exposed building excavation prior to construction. Additional works may be requested at that time.

7.0 RECOMMENDATIONS

In consideration of this assessment, provided the recommendations provided herein are considered and adhered to, the proposed structure can be considered outside the influence of reasonably conceivable geotechnical hazards. The land may be considered safe for the use intended.



7.1 Foundation Design

7.1.1 General

In accordance with the National Building Code of Canada, the foundation recommendations included in this report are based on limit state design (LSD) methodology. The geotechnical resistance factor for shallow foundations used to determine the LSD values presented herein was considered to be 0.5.

7.1.2 Conventional Strip and Spread Footings

Shallow foundations (i.e., strip and spread footings) can be considered for the proposed development site provided recommendations in this report are followed.

Spread and strip footings should be placed a minimum 450 mm below the final grade to satisfy frost protection requirements. Strip and spread footings should have a minimum width of 450 mm and 600 mm, respectively. Shallow spread and/or strip footings supported on a compact, natural, undisturbed granular subgrade should be considered to have factored ultimate bearing capacity of 150 kPa. It is expected that a maximum allowable bearing pressure of 100 kPa would be appropriate for serviceability limit (SLS) state design of the above-noted strip and spread footings. This would be based on an estimated post-construction total settlement of less than 25 mm with a differential settlement of less than 25.0 mm over a horizontal distance of approximately 6.25 m.

All prepared foundation and engineered fill subgrades should be reviewed by an Arya representative prior to engineered fill placement or footing construction to verify suitability of the exposed soil conditions, and to confirm that the recommendations provided in this report are valid.

Footings should be stepped at no steeper than 2H:1V where adjacent footings should be placed at different elevations. Stepped subgrade in excess of 1.2 m should be reviewed by the geotechnical engineer prior to forming and pouring of concrete. Subgrade slopes between footings at different elevations should be constructed to expose undisturbed, compact soils. If this is not achievable, in the case that a maximum 2H:1V slope is not achievable, the lower footing and foundation soils should be designed to carry the load of the higher footing. Where buried services lie below the building foundations, the footing edge should be below a 2H:1V line, projected up from the invert elevation of the utility, to reduce the risk of undermining. Special conditions should be reviewed by the geotechnical engineer prior to construction.



7.2 Grade-Supported Slab

The proposed grade-supported slab should be underlain with a minimum of 150 mm layer of free-draining 19 mm clear crushed gravel with less than 5% silt (particles finer than 0.075 mm) or an approved equivalent, compacted to a minimum of 100% of SPMDD. The gravel should be supported on natural, undisturbed subgrade or engineered fill placed on natural, undisturbed subgrade, approved by our office during construction.

A vapor barrier consisting of a minimum of 0.15 mm polyethylene sheeting, or approved equivalent, should be installed between the bedding and the underside of the floor slab. Consideration should be given to the effect of any vapour barrier on concrete slab curing. Sanitary and water lines beneath floor slab should be leak proofed.

7.3 Temporary Excavations

Worksafe BC guidelines for stable excavations should be followed for excavations more than 1.2 m. WorkSafe BC guidelines for excavations should be adhered to in accordance with Section 20 of the Occupational Health and Safety (OHS) Regulation. Temporary excavation stability is the responsibility of the contractor.

Per WorkSafe BC guidelines, a qualified professional must be retained to conduct a WorkSafe BC Excavation Review in case excavation of more than 1.2 m is required for the project. This document should specify instructions to promote excavation stability during construction and may include such items as sloping and shoring requirements. This office is available to provide WorkSafe BC Excavation Reviews upon request, or as needed to satisfy WorkSafe BC criteria. Trenching, utility installation, and backfilling should be carried out in accordance with local municipal specifications.

7.4 Site Preparation

Construction surfaces and footing subgrades should be flat, and all topsoil and organics, fill/disturbed soils, and loose/soft soils, and any other deleterious materials should be removed below the proposed building foundations and grade-supported slabs to expose the natural, undisturbed compact to dense soils. Any local loose areas identified during subgrade preparation should be removed and replaced with lean concrete or suitable engineered fill, as approved by Arya.

Where needed, engineered fill should be placed on competent subgrade to raise grades.



7.5 Engineered Fill and Backfill

Engineered fill is defined as a material designed to be placed directly beneath any load bearing areas. The subgrade for the engineered fill must be approved by Arya prior to placement of engineered fill. All engineered fill material should be free of any organics and other deleterious material and consist of non-expansive/non-sensitive soil. Granular engineered fill below grade-supported slab should consist of non-organic, clean, well-graded, 75 mm minus sand and gravel with less than 5% silt particles (finer than 0.075 mm). Alternatively, 19 mm clear crushed gravel could also be used as engineered fill under foundations, grade supported slabs and behind the foundation walls.

Engineered fill should be tested and approved by Arya prior to use in any load bearing areas. The material should be compacted within 2% of the optimum moisture content (OMC) and a minimum of 100% standard proctor maximum dry density (SPMDD).

Engineered fill should extend beyond the building a distance equal to or greater than the depth of the engineered fill below the structural elements. Granular engineered fill should be placed sequentially in lifts exhibiting a maximum thickness of 300 mm in loose condition.

Pipe bedding and surroundings should be implemented as specified in local municipal specifications. Trench backfill soils under buildings should be compacted to within 2% of the material's OMC and a minimum of 100%, SPMDD. Laboratory standard proctor analysis (ASTM 698) and field density testing should be performed to confirm that the required compaction standards are achieved.

7.6 Site Grading and Drainage

A perimeter drainage system should be installed to minimize the potential for water infiltration into the soil surrounding the shallow foundations and floor slabs. Perimeter drainage should be comprised of perforated rigid PVC pipe and should be placed around the external sides of the building and below the base of the shallow foundations (undersize footings, beyond a 1H:1V projection from the toe). The perimeter drainage should be designed to promote positive drainage, and a 2% slope is recommended for the drain pipes.

The perimeter drainage pipes should be provided with permanent, non-perforated cleanouts. The drainage pipe should be surrounded by a minimum of 150 mm of drain rock. A layer of non-woven geotextile should be wrapped around the gravel drainage layer to act as a filter against piping of fines from the general backfill and surrounding natural soil. The perimeter drainage system should be designed to direct water by gravity flow to approved discharge locations.



The roof and surface runoff should be collected and directed to a storm sewer or permanent drain in solid wall pipes separate from the perimeter drainage. Arya should be given the opportunity to review the perimeter drain installation prior to placing backfill material and covering the drainpipes, as proper drainage installation and maintenance is necessary to endorse the bearing capacity and allowable bearing pressures provided herein.

Based on final site plans, a temporary groundwater management plan may be required to keep the subgrade dry and to control groundwater during construction. Our office is available to provide design recommendations for temporary groundwater management upon request and upon finalization of site plans.

7.7 Lateral Earth Pressure Coefficients

Below grade walls, foundations and grade beams should be adequately designed to resist the lateral earth pressures acting on them and any additional loads caused by surcharge loads. Lateral loading coefficients on these elements have been provided for several situations. Coefficients have been provided for At-Rest Pressure (K_O) and Active Pressure (K_A) conditions. Coulomb's theory was used to calculate the active pressure coefficient while the Mononobe-Okabe method was used to calculate an earthquake induced dynamic active pressure coefficient (K_{AE}).

The PGA value detailed in this report was utilized in calculating the earthquake induced dynamic active pressure coefficient. The coefficients have been calculated in accordance with the 4th edition of the Canadian Foundations Engineering Manual (CFEM 2006). Table 2 provides the lateral earth pressure coefficients that should be used for applicable below grade elements.

TABLE 2 – LATERAL EARTH PRESSURE COEFFICIENTS

Pressure Condition	Coefficient Symbol	Coefficient Value
At-Rest Pressure	K_O	0.43
Active Pressure	K_A	0.27
Active Pressure (Including Seismic Effects)	K_{AE}	0.29

Lateral earth pressure coefficients were determined assuming a free draining backfill. A unit weight of 19 kN/m^3 should be considered for compacted, approved backfill. It is assumed that free draining backfill will extend horizontally from the top of below grade elements to a lateral distance equivalent to the element's height. In the case that a level backfill is not achievable, higher earth pressures can be expected and this office should be retained to provide updated design values.



The at-rest pressure, active pressure, and active (with seismic effects) pressure conditions can be designed according to the CFEM 2006.

7.8 Field Review

The preceding conclusions constitute preliminary geotechnical recommendations for the development of the proposed structure and related works. It is essential that all project stakeholders review the results of this assessment prior to commencement of final design and construction activities.

For the conditions in this report to be considered valid, this office must be provided the opportunity to conduct field reviews during construction. Arya should be informed 48 hours in advance prior to the following inspections for each structure.

- Excavation/test pit review to assess ground conditions prior to construction.
- Subgrade conditions for shallow foundations and grade supported slabs (all bearing surfaces).
- Perimeter drainage as installed, prior to backfilling.
- Review of engineered fill below grade-supported slab, shallow foundations, and behind retaining walls and foundation walls (backfill).
- Closure review / final walkthrough.

It is important to note that additional field review services may be required based on final site plans, construction sequencing, actual ground conditions, and the extent of design services that Arya is retained for. In the case that field reviews are not requested by the Client or Clients agent, final sign-off (Schedule CB) may not be provided by this office, or additional scope items may become required prior to final sign-off.

8.0 CLOSURE

Recommendations presented herein are based on the geotechnical evaluation made during Arya's site reconnaissance. The findings in this report reflect Arya's best judgment based on the information that was available to Arya at the time of preparation of this report. If conditions other than those are noted during subsequent phases of the development, Arya should be given the opportunity to review and revise the recommendations included in this report, as necessary.

This report has been prepared for the exclusive use of Sawarne Lumber Co., Ltd, their consultants, contractors and representatives for the specific application of the developments described within this report. Any use of this report by third parties, or any reliance on or decisions made based on



it are the responsibility of such third parties. Arya accepts no responsibility, if any, suffered by any third party because of decisions made or actions taken based on this report.

We appreciate the opportunity to be of service to you. If you have any questions regarding the contents of this report, please contact us at (604) 886 1515.

Sincerely,

Arya Engineering Inc.

Prepared By:

Reviewed By:

Ufuoma Oki, P.Geo, M.Eng, PMP
Senior Engineering Geoscientist

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer

Attached: Photograph 1-6
Appendix A
Terms and Conditions

Permit to Practice No.: 1002217



Photographs 1 & 2: Gentle Slope Condition



Photographs 3 & 4: Steep Slope Portion with Rock Boulders



Photographs 5 & 6: Vegetation



APPENDIX A

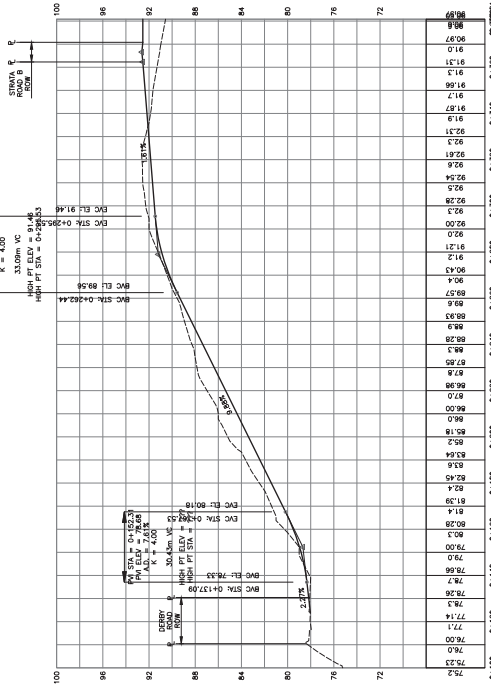
Silverstone Heights

Phase 3

Site Layout Plan

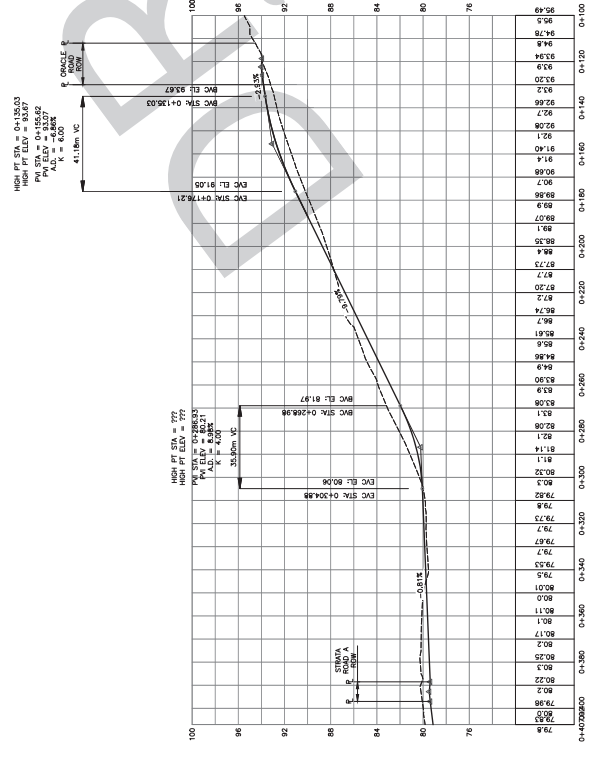
(Image 1)

CONTRACTOR TO VERIFY & LOCATE
 ALL EXISTING UTILITIES, MARKERS,
 CONNECTIONS & NOTIFY THE
 ENGINEER OF ANY DISCREPANCIES
 PRIOR TO BEGINNING CONSTRUCTION



STRATA ROAD A

ORACLE ROAD EXTENSION



STRATA ROAD B

DRAWING LEGEND

SYMBOL	DESCRIPTION
(Symbol)	PROPOSED
(Symbol)	EXISTING
(Symbol)	TO BE REMOVED
(Symbol)	TO BE RELOCATED

PROPOSED

ITEM	DESCRIPTION	QUANTITY
1	ROADWAY	100
2	GRAVEL	200
3	CONCRETE	100

EXISTING

ITEM	DESCRIPTION	QUANTITY
1	ROADWAY	100
2	GRAVEL	200
3	CONCRETE	100

TO BE REMOVED

ITEM	DESCRIPTION	QUANTITY
1	ROADWAY	100
2	GRAVEL	200
3	CONCRETE	100

TO BE RELOCATED

ITEM	DESCRIPTION	QUANTITY
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2	GRAVEL	200
3	CONCRETE	100

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3	CONCRETE	100

TO BE RELOCATED

ITEM	DESCRIPTION	QUANTITY
1	ROADWAY	100
2	GRAVEL	200
3	CONCRETE	100

CLIENT INFORMATION

CLIENT NAME	SILVERSTONE HEIGHTS DISTRICT OF SECHelt
CLIENT ADDRESS	
CLIENT CONTACT	
CLIENT PHONE	
CLIENT FAX	
CLIENT EMAIL	

PROJECT INFORMATION

PROJECT NAME	ROADWORKS PROFILES
PROJECT ADDRESS	
PROJECT CONTACT	
PROJECT PHONE	
PROJECT FAX	
PROJECT EMAIL	

DRAWING INFORMATION

DRAWING NO.	R-1
DATE	2021-03-15
SCALE	1:1
PROJECT NO.	21157
DISTRICT	SECHelt
CLIENT	SILVERSTONE HEIGHTS

REVISIONS

NO.	DESCRIPTION	DATE
1	ISSUED FOR CLIENT REVIEW	2021-03-15

APPROVALS

ENGINEER	[Signature]
CHECKED	[Signature]
DATE	2021-03-15

CLIENT APPROVAL

CLIENT REPRESENTATIVE	[Signature]
DATE	2021-03-15

PROJECT LOCATION

PROJECT ADDRESS	
CITY	
STATE	
COUNTRY	

PROJECT CONTACT

PROJECT CONTACT NAME	
PROJECT CONTACT ADDRESS	
PROJECT CONTACT PHONE	
PROJECT CONTACT FAX	
PROJECT CONTACT EMAIL	

PROJECT INFORMATION

PROJECT NO.	21157
DISTRICT	SECHelt
CLIENT	SILVERSTONE HEIGHTS

PROFESSIONAL ENGINEER'S CERTIFICATE NO. 1456
REGISTERED ENGINEER'S BOARD OF SOUTH AFRICA
MEMBER OF THE ENGINEERING COUNCIL OF SOUTH AFRICA

DATE	REVISIONS

DATE	REVISIONS

DATE	REVISIONS

SAWARNE LUMBER COMPANY LTD

SILVERSTONE HEIGHTS DISTRICT OF SECHHELT

SERVICING PLAN

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CONTRACTOR TO VERIFY & LOCATE ALL EXISTING SERVICES AND CONNECTIONS & NOTIFY THE ENGINEER OF ANY DISCREPANCIES PRIOR TO BEGINNING CONSTRUCTION



THE INFO EXISTING SANITARY MAINS AND RECORDS TO BE MAINTAINED AND RECORDED FOR THE PROJECT.

THE INFO EXISTING STORM MAINS AND RECORDS TO BE MAINTAINED AND RECORDED FOR THE PROJECT.



TERMS AND CONDITIONS OF ENGAGEMENT

1. **GENERAL:** Arya Engineering Inc. (ARYA) shall render the Services, as specified in the attached Scope of Services, to the Client for the Project in accordance with the following terms and conditions of engagement and related articles. ARYA may, at its discretion and at any stage, engage sub-consultants to perform any part or all of the Services.
2. **DEFINITIONS:**
 - a. Agreement – is this Prime Agreement for professional Services.
 - b. Consultant – shall mean professionals and other specialists other than ARYA or its officers, employees and agents engaged by the Client directly.
 - c. Contractor – is the party contracting with the Client for the provision of labour, materials and equipment for the execution and quality control of the Work.
 - d. Contract – is the agreement between the Client and the Contractor for the provision of labour, materials and equipment for the execution of the Work by the Contractor.
 - e. Contract Documents – shall comprise all documents relating to the Project issued by or through ARYA, including the plans, drawing, specifications and schedules, and all variations and modifications thereto approved by ARYA.
 - f. Field Services – shall mean applying such selective sampling and inspection procedures at the project site during construction as ARYA, and at ARYA’s professional discretion, considers necessary to enable ARYA to ascertain whether the Contractor is carrying out the Work in general conformity with the design concept for the Project.
 - g. Project– shall refer to the project described in the recital clauses to this Agreement.
 - h. Services – shall mean ARYA’s duties and responsibilities to the Client as set forth in the attached Scope of Services and Authorization to Proceed.
 - i. Sub-Consultant – shall mean any registered professional engineers or other specialists engaged by ARYA in connection with the Project.
 - j. Work – is the totality of all labour, materials and equipment used or incorporated into the Project by the Contractor pursuant to the Contract Documents.
3. **REPRESENTATIVES:** Each party shall designate a representative who is authorized to act on behalf of that party and receive notices under this Agreement.
4. **AUTHORIZATION TO PROCEED:** Verbal authorization by the Client, either in person or over the telephone, or by written instructions will serve as authorization for ARYA to proceed with the services called for in this services agreement and those delineated in related correspondence between ARYA and Client. This Agreement, including attachments incorporated herein by reference, represents the entire agreement between ARYA and Client. This Agreement may be altered only by written instrument signed by authorized representatives of both Client and ARYA.
5. **EXTENT OF AGREEMENT:** Work beyond the Scope of Services or redoing any part of the Project through no fault of ARYA, shall constitute extra Work and shall be paid for on a time-and-materials basis in addition to any other payment provided for in this Agreement. If, during the course of performance of this Agreement, conditions or circumstances are discovered which were not contemplated by ARYA at the commencement of this Agreement, ARYA shall notify the Client either verbally or in writing of the newly discovered conditions or circumstances, and the Client and ARYA shall renegotiate, in good faith, the terms and conditions of this Agreement.
6. **COMPENSATION:** Charges for the Services rendered will be made in accordance with ARYA’s Schedule of Fees and Disbursements in effect from time the services are rendered. ARYA’s Schedule of Fees and Disbursements are included in ARYA’s budget estimate. All charges will be payable in Canadian Dollars. ARYA shall invoice the Client for the services performed under this Agreement and shall provide a summary of costs upon request. The Client shall pay such invoice upon receipt. Invoices not paid within thirty (30) days of the invoice date shall be subject to a late payment charge of 1.5 percent per month (18% per annum) from the date of billing until paid. The invoice amounts shall be presumed to be correct unless the Client notifies ARYA in writing within fourteen (14) days of receipt. Overdue accounts over ninety (90) days will be forwarded to a collections agency. The Client and ARYA expressly agree that ARYA’s fee shall be payable by the Client even in the event that the Client does not, for any reason, proceed with the Project as described in the Contract Documents. The Client and ARYA further expressly agree that payment of the ARYA’s fee by the Client pursuant to this Agreement shall be a condition precedent to the Client’s use of the Contract Documents and models for the execution of the Work.
7. **PROBABLE COSTS:** ARYA does not guarantee the accuracy of probable costs for providing Engineering Services. Such probable costs represent only ARYA as a professional and are supplied only for the general guidance of the Client. The parties expressly acknowledge and agree that the cost of the Services and contract time estimates provided by ARYA to the Client under this Agreement are subject to change and are contingent upon factors over which ARYA has no control. ARYA does not guarantee the accuracy of such estimates.



TERMS AND CONDITIONS OF ENGAGEMENT

8. **STANDARD OF CARE:** ARYA shall perform its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing under similar conditions in the geographic vicinity and at the time the Services are performed. This Agreement neither makes nor intends a warranty or guarantee, either expressed or implied.
9. **INDEMNITY:** Client waives any claim against ARYA, its officers, employees and agents and agrees to defend, indemnify, protect and hold harmless ARYA and its officers, employees and agents from any and all claims, liabilities, damages or expenses, including but not limited to, delay of the project, reduction of property value, fear of or actual exposure to or release of toxic or hazardous substances, and any consequential damages of any nature, which may arise directly or indirectly, to any party, as a result of the services provided by ARYA under this Agreement, unless such injury or loss is caused by the sole negligence of ARYA.
10. **INSURANCE, LIMITATION OF LIABILITY:** The Client agrees to limit ARYA and its officers, employees, and agents liability due to professional negligence and to any liability arising out of or relating to this Agreement to fifty thousand dollars (\$50,000) or the amount of ARYA's fee, whichever is less. This limit applies to all services on the project, whether provided under this or subsequent agreements, unless modified in writing, agreed to, and signed by authorized representatives of the parties. No claims may be brought against ARYA in contract or tort more than two (2) years after Services were completed or terminated under this engagement. If for any reason such insurance shall not be available or shall not apply to any claim made by the Client against ARYA in respect of the Services, then the liability of ARYA to the Client under this Agreement shall be absolutely limited to the amount of any professional liability available at the time such claims are made. In this case, any liability arising out of or relating to this Agreement will also be limited to fifty thousand dollars (\$50,000), or the amount of ARYA's fee, whichever is less. Note: ARYA will not be responsible for water ingress related problems as ARYA's insurance policy contains an Absolute Water Ingress Exclusion. For special projects, higher liability limits are available from our underwriter for an additional fee. ARYA warrants it is protected by WorkSafe BC Insurance, General Liability Insurance, Professional Errors and Omissions Insurance, and Automobile Liability Insurance. Certificates for such policies of insurance shall be provided to the Client upon request.
11. **RESPONSIBILITY:** ARYA is not responsible for the completion or quality of work that is dependent upon or performed by the Client or third parties not under the direct control of ARYA, nor is ARYA responsible for their acts or omissions or for any damages resulting there from. ARYA shall not be responsible for the following:
 - a. The failure of a Contractor, retained by the Client, to perform the Work required for the Project in accordance with the applicable Contract Documents;
 - b. The design of or defects in equipment supplied or provided by the Client for incorporation into the Project;
 - c. Any cross-contamination resulting from subsurface investigations;
 - d. Any damage to subsurface structures and utilities which were identified and located by the Client;
 - e. Any Project decisions made by the Client if the decisions were made without consultation of ARYA or contrary to or inconsistent with ARYA's recommendations;
 - f. Any consequential loss, injury, or damages suffered by the Client, including but not limited to, loss of use, earnings, and business interruption; and,
 - g. The unauthorized distribution of any document or report prepared by or on behalf of ARYA for the exclusive use of the Client.
12. **CLIENT'S RESPONSIBILITIES:**
 - a. Make available to ARYA all relevant information or data pertinent to the project which is required by ARYA, and instruct ARYA fully in writing as to the Client's total requirements in connection with the Project. ARYA shall be entitled to rely upon the accuracy and completeness of such information and data furnished by or through the Client, including information and data originating with Consultants, whether such Consultants are engaged at the request of ARYA or otherwise. Where such information or data originates either with the Client or with Consultants, then ARYA shall not be responsible to the Client for the consequences of any error or omission contained therein or arising from ARYA's use of this data;
 - b. When required by ARYA, to engage Consultants directly to perform services necessary to enable ARYA to carry out its duties and responsibilities. Such Consultants engaged by the Client shall be subject to the joint approval of the Client and ARYA;
 - c. Authorize ARYA to act as the Client's for such purposes as are necessary to ARYA's rendering of its Services pursuant to this Agreement;
 - d. Give prompt consideration to all sketches, drawing, specifications, tenders, proposals, contracts and other documents relating to the Project laid before the Client by ARYA, and whenever prompt action is necessary inform ARYA of the Client's decisions in such reasonable time so as not to delay the Services of ARYA, or to prevent ARYA from forwarding drawings or instructions to the Contractor or the Consultants or to Sub-Consultants in good time;
 - e. Pay ARYA's fee and reimbursable expenses as provided for in this Agreement;



TERMS AND CONDITIONS OF ENGAGEMENT

- f. Provide necessary advertising incidental to obtaining tenders, and provide or reimburse ARYA for obtaining necessary legal, accounting and insurance counseling services;
 - g. Arrange and make provision for ARYA's entry and ready access to property (public and private) as well as to the Project site, as necessary to enable ARYA to perform its Services;
 - h. Give prompt written notice to ARYA whenever the Client or the Client's representative becomes aware of any defects or deficiencies in the Work or in the Contract Documents; and,
 - i. Obtain required approvals, licences and permits from municipal, governmental or other authorities having jurisdiction over the Project so as not to delay ARYA in the performance of Services. The Client expressly undertakes not to enter into contracts in connection with the Project which describe duties and responsibilities of ARYA which are inconsistent with the duties and responsibilities of ARYA provided for in this Agreement without obtaining ARYA's prior written agreement thereto.
13. **EXCLUSIVE USE:** Services provided under this Agreement, including all reports, drawings, plans, models, specifications and other documents, information or recommendations prepared or issued by ARYA, are instruments of service for the execution of the Project. ARYA retains the property and copyright in these documents, whether the Project is executed or not. No other use of these documents is authorized under this Agreement without the prior written agreement and remuneration of ARYA.
 14. **SAMPLES:** All non-consumed samples shall remain the property of the Client, and Client shall be responsible for and promptly pay for the removal and lawful disposal of samples, cuttings and hazardous materials, unless otherwise agreed to in writing. If appropriate, ARYA shall preserve samples obtained for the project for not longer than thirty (30) days after the issuance of any document that includes the data obtained from those samples.
 15. **ENVIRONMENTAL:** ARYA's field investigation, laboratory testing and engineering recommendations will not address or evaluate pollution of air, soil and/or groundwater, unless otherwise specifically listed in the attached Scope of Services. ARYA will co-operate with the Client's environmental consultant during field work phase of the investigation is requested.
 16. **FIELD SERVICES:** Where applicable, Field Services recommended for the Project are the minimum necessary, at the sole discretion of ARYA, to review whether the Work of a Contractor retained by the client is being carried out in general compliance with the intent of the Services and in compliance to information and recommendations presented in all reports, drawings, plans, models, specifications and other documents provided in the deliverables prepared by ARYA in fulfillment of the Scope of Services. It is understood and agreed by the Client that the performance of the Contract is not ARYA's responsibility, nor are Field Services rendered for the Contractor's benefit. The Contractor alone is responsible for the quality control of the Work. Any reduction from the level of services recommended will result in ARYA not providing qualified certifications for the Work. ARYA shall issue certifications only where Field Services have been performed by ARYA.
 17. **TERMINATION:** This Agreement may be terminated by either party upon ten (10) days written notice to the other. Upon the receipt of such written notice from the Client to ARYA, ARYA shall perform no further Services other than those reasonably necessary. In the event of a termination, the Client shall pay for all charges for services performed and demobilization by ARYA, in addition to reasonable termination expenses incurred to the date of notice of Termination. The limitation of liability and indemnity obligations of this Agreement shall be binding notwithstanding any Termination of this Agreement.
 18. **DISPUTE RESOLUTION:** If requested in writing by either the Client or ARYA, the Client and ARYA shall attempt to resolve any dispute between them arising out of or in connection with this Agreement by entering into structured, non-binding negotiations with the assistance of a mediator on a without prejudice basis. The mediator shall be appointed jointly by the parties. If a dispute cannot be settled within a period of thirty (30) calendar days with the mediator, the dispute shall be referred to and finally resolved by arbitration under the rules of British Columbia or by an arbitrator appointed by agreement of the parties or by reference to a Judge of the Supreme Court of British Columbia. No one shall be nominated to act as an arbitrator who is in any way financially interested in the conduct of the Project or in the business affairs of either the Client or ARYA. The award of the arbitrator shall be final and binding upon the parties.
 19. **GOVERNING LAW:** This Agreement is governed by the law British Columbia, and any litigation shall be brought and tried in, the judicial jurisdiction of the ARYA office that entered this Agreement, as stated herein.
 20. **NON-SOLICITATION:** The Client agrees they shall not recruit for employment or hire any ARYA employees who provide services pursuant to this Agreement during the term of this Agreement and for a period of one (1) year following its termination.



August 31, 2022

Project No.: 22-662-SC

Sawarne Lumber Co., Ltd
300 –1785 W 4th Avenue,
Vancouver, British Columbia
V6J 1M2

e: dsangara@sawarne.com t: 604.235.1755 Ext. 204

Re: Geotechnical Assessment: Proposed Derby Townhomes Development
Derby Road, Sechelt, British Columbia

Arya Engineering Inc. (Arya) presents the following report providing the results of a geotechnical assessment recently performed for the proposed multi-family townhomes development to be located at Derby Road in Sechelt, British Columbia. The intent of this document is to determine the suitability of the land for the proposed works from a geotechnical perspective and to provide the client and the District of Sechelt with the relevant geotechnical information required for permit application. It is also the intention of this document to provide the contractor and additional key stakeholders with preliminary geotechnical information needed to guide the geotechnical aspects of the proposed works.

We trust this report contains the relevant information required for project continuation at this time. Should additional information be required, please do not hesitate to contact our office.

Sincerely,

Arya Engineering Inc.

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer



EXECUTIVE SUMMARY

Based on the findings of this assessment and provided that all of the recommendations presented herein are implemented, there are no reasonably conceivable geotechnical issues that would preclude the safe development of the proposed works on the subject site. The land can be considered safe for the use intended provided the recommendations in this report are adhered to. It is important to note that the term “safe” as presented in the above statement, should be understood in terms of tolerable risk and does not constitute a guarantee. In this context, the land can be considered within the limits of tolerable geotechnical risk, as defined by society and related in applicable building codes, national design standards, professional practice standards (EGBC), and design and construction policies presented in the District of Sechelt’s Official Community Plan (OCP), adopted July 20, 2011.

Based on our review of the Official Community Plan (OCP) of the District of Sechelt (DoS), the subject site is considered to be outside of the District of Sechelt’s Development Permit Area classifications for geotechnical hazards.



1.0 INTRODUCTION

Arya Engineering Inc. (Arya) presents the following report providing the results of a geotechnical engineering assessment and recommendations for the proposed multi-family townhomes structure development to be located at Derby Road in Sechelt, British Columbia. This report provides geotechnical engineering recommendations with respect to foundation design, continued site and subgrade preparation, seismic classification, groundwater and drainage recommendations, and other associated construction considerations.

2.0 BACKGROUND INFORMATION / SCOPE OF WORK

Based on conversations with the Client's representative (Maycon Construction Management Ltd) and the site plan No. 2211, dated July 06, 2022 by Mobius Architecture provided by the Client's representative, it is our understanding that the proposed development will consist of townhome dwelling structures, which are expected to be located on the site as shown in Appendix A

It is our understanding that structural plans for the proposed structures are currently being developed. Upon completion, our office should be provided the opportunity to review both the final architectural and structural plan sets prior to the commencement of construction.

The scope of work for this assessment included the following tasks:

- A geotechnical site reconnaissance conducted on August 22 and 29, 2022, to observe current conditions of the site, including observations of surficial soils, topographic conditions, vegetation, and drainage conditions. This is exclusive of subsurface explorations which has been deferred to the start of construction per the client's representatives request.
- A desktop review of relevant background information including available topographical information for the site and surrounding area, related published subsurface information, and satellite imagery.
- Geotechnical engineering analysis and evaluation of the collected data.
- Preparation of a geotechnical assessment report summarizing Arya's findings.

The scope of this assessment did not include items related to other disciplines. Written authorization to proceed was received from Davy Sangara on behalf of Sawarne Lumber Co., Ltd on August 26, 2022.



3.0 SITE CONDITIONS

The subject site is located at the intersection of Derby Road and Kingbird Avenue in Sechelt, British Columbia. The property is rectangular in shape and encompasses a total area of approximately 1.25 ha. It is bounded by a property under development to the west, undeveloped properties to the east and north, and by Derby Road to the South. Based on the LiDAR topographic data obtained from the Sunshine Coast Regional District (SCRD) public web-maps for the area, the proposed lot largely slopes from north to south with an approximate slope gradient of 14H:1V (Horizontal: Vertical) towards the southern property line as shown in Image 1 appended in herein.

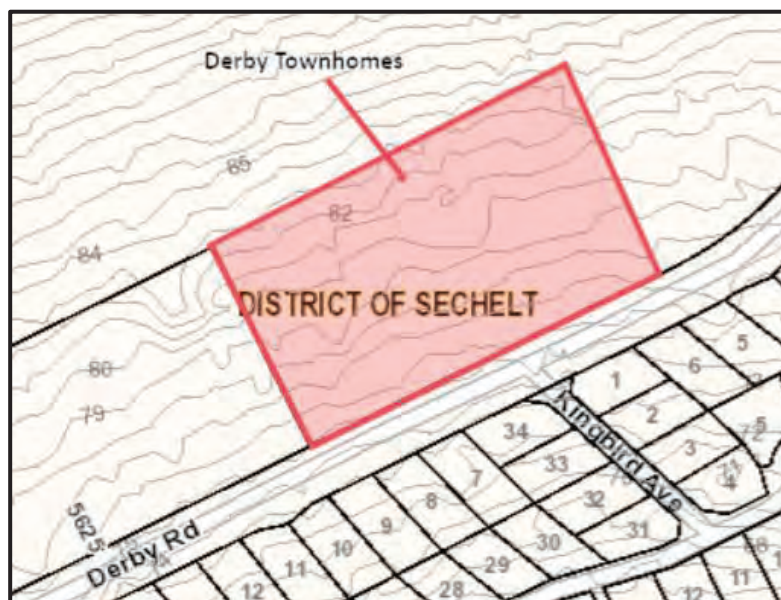


Image 1 – Lot Topography (From SCR D Maps)

3.1 Vegetation

During the site reconnaissance it was observed that the understory vegetation on the site primarily consisted of sword ferns, salal, blackberries, and salmonberries, while trees present included mostly juvenile maple, hemlock, Douglas fir and cedar growth.

3.2 Surface Water and Runoff

Surface water was not observed across the subject site during the site investigation. In consideration of the topographic conditions that characterize the site and the expected subsurface conditions, infiltration of precipitation into surficial granular soils is expected. When the infiltration capacity of the granular soils is exceeded, and/or where low permeable subgrade



soils are present near surface, ponding is expected. In these cases, precipitation is expected to runoff via sheet-flow from north to south following the natural contours of the lot.

4.0 SUBSURFACE CONDITIONS

Preliminary subsurface soils review for the subject site were largely through desk studies, hand probing, visual observations at the time of the site reconnaissance, Groundwater Wells and Aquifer Registry of British Columbia groundwater wells borehole logs information from WTN - 11683, - 5434 and - 5498 located within 1000 m from the subject property, Arya's previous site work and experience in the vicinity of the site, and published surficial geologic information were also considered. However, a more concise subsurface review through machine test pitting is recommended prior to placement of foundation.

4.1 Soil Stratigraphy

Published surficial geologic maps for the Sunshine Coast area (McCammon, 1977) describe the site geology as comprising of Capilano Sediments consisting of marine and glacio-marine deposits. This material generally consists of varied gravelly, sandy, stoney, clay and clay veneer, normally over till materials. This description has been consistent with Arya's project experience in the area.

The anticipated stratigraphic profile for the site as inferred, is expected to consist of approximately 0.4 m of organic laden topsoil, underlain by approximately 0.8 m of reddish to yellowish brown, loose to compact, gravelly sand with some silt. The material is expected to transition into a more compact to dense sandy silt with some gravels. Due to variability in strata thickness within marine and glacio-marine depositions, excavation depth ranging from 1 - 3 m into the compact to dense subgrade material could be expected to site foundation elements for the proposed structures. if deemed required, ground improvement works could be implemented in order to achieve design foundation elevation objectives where weak soils strata are encountered. However, as earlier noted, a subsurface investigation that may include machine test pitting is recommended to confirm subgrade conditions as well as foundation bearing elevation.

4.2 Bedrock

Bedrock outcrop was not observed within the vicinity of the proposed development area during the site assessment. While the presence of bedrock is not expected to negatively influence the performance of the proposed structure from a geotechnical perspective, if bedrock is encountered during site clearing, excavation and subgrade exposure, our office should be contacted to review and update the commentary herein as needed.



4.3 Groundwater Conditions

The presence of permanent groundwater, including groundwater seepage, was not observed during the geotechnical investigation. However, should groundwater or seepage be encountered during construction, our office should be notified to enable us to update this report accordingly. It is important to note, temporary groundwater management plans are generally the responsibility of the general contractor. Our office is available to provide additional consultation and to provide site specific temporary groundwater management plans if required.

5.0 SEISMIC ANALYSIS

The proposed structure should be designed under the seismic provisions of the British Columbia Building Code 2018 (BCBC 2018) and the National Building Code of Canada (NBCC 2015). Horizontal Peak Ground Acceleration (PGA) and 5% damped spectral response acceleration values $S_a(T)$ for four different periods (0.2, 0.5, 1.0 and 2.0 seconds) are outlined in TABLE 1 for the site (coordinates 49.4747 ° N, -123.7766° W) for a seismic event with a 2% probability of exceedance within 50 years (1 in 2,475-year event).

The seismic provisions of NBCC 2015 incorporate site effects by categorizing a wide variety of possible soil conditions into six site classes (Class A to Class F) according to the average properties of the top 30 m of the soil profile. The factors F_a and F_v given in the BCBC (2018) reflect the effect of possible soil amplification (or de-amplification) and soil-structure interaction resonance into the estimation for the seismic design forces for buildings having no unusual characteristics.

Based on the expected soil conditions at the proposed development site, a Site Classification “D” – Stiff Soil should be used for seismic site response in accordance with Table 4.1.8.4.A of BCBC (2018). The seismic design parameters for the proposed development site are included in Table 1 as reference.

TABLE 1: SEISMIC DESIGN PARAMETERS (NBCC 2015)

$S_a(T)$ - Spectral Response Acceleration (g)*				Horizontal Peak Ground Acceleration (g)	Values of F	
Sa (0.2)	Sa (0.5)	Sa (1.0)	Sa (2.0)	PGA	F_a	F_v
0.87	0.87	0.55	0.35	0.360	0.96	1.27

* $g = 9.81 \text{ m/s}^2$



6.0 GEOTECHNICAL HAZARD ASSESSMENT

The subject site is not located within a classified District of Sechelt's Development Permit Area per the DoS OCP. As such, further geotechnical hazard assessment was not considered as part of this report.

7.0 RECOMMENDATIONS

In consideration of the results of this assessment, provided the recommendations provided herein are considered and adhered to, the proposed structure can be considered outside the influence of reasonably conceivable geotechnical hazards. The land may be considered safe for the use intended.

7.1 Foundation Design

7.1.1 General

In accordance with the National Building Code of Canada, the foundation recommendations included in this report are based on limit state design (LSD) methodology. The geotechnical resistance factor for shallow foundations used to determine the LSD values presented herein was considered to be 0.5.

7.1.2 Conventional Strip and Spread Footings

Shallow foundations (i.e., strip and spread footings) can be considered for the proposed development site provided that recommendations in this report are followed.

Spread and strip footings should be placed a minimum 450 mm below the final grade to satisfy frost protection requirements. Strip and spread footings should have a minimum width of 450 mm and 600 mm, respectively. Shallow spread and/or strip footings supported on a compact, natural, undisturbed granular subgrade should be considered to have factored ultimate bearing capacity of 150 kPa. It is expected that a maximum allowable bearing pressure of 100 kPa would be appropriate for serviceability limit (SLS) state design of the above-noted strip and spread footings. This would be based on an estimated post-construction total settlement of less than 25 mm with a differential settlement of less than 25.0 mm over a horizontal distance of approximately 6.25 m.

All prepared foundation and engineered fill subgrades should be reviewed by an Arya representative prior to engineered fill placement or footing construction to verify suitability of



the exposed soil conditions, and to confirm that the recommendations provided in this report are valid.

Footings should be stepped at no steeper than 2H:1V where adjacent footings should be placed at different elevations. Stepped subgrade in excess of 1.2 m should be reviewed by the geotechnical engineer prior to forming and pouring of concrete. Subgrade slopes between footings at different elevations should be constructed to expose undisturbed, compact soils. If this is not achievable, in the case that a maximum 2H:1V slope is not achievable, the lower footing and foundation soils should be designed to carry the load of the higher footing. Where buried services lie below the building foundations, the footing edge should be below a 2H:1V line, projected up from the invert elevation of the utility, to reduce the risk of undermining. Special conditions should be reviewed by the geotechnical engineer prior to construction.

7.2 Grade-Supported Slab

The proposed grade-supported slab should be underlain with a minimum of 150 mm layer of free-draining 19 mm clear crushed gravel with less than 5% silt (particles finer than 0.075 mm) or an approved equivalent, compacted to a minimum of 100% of SPMDD. The gravel should be supported on natural, undisturbed subgrade or engineered fill placed on natural, undisturbed subgrade, approved by our office during construction.

A vapour barrier consisting of a minimum of 0.15 mm polyethylene sheeting, or approved equivalent, should be installed between the bedding and the underside of the floor slab. Consideration should be given to the effect of any vapour barrier on concrete slab curing. Sanitary and water lines beneath floor slab should be leak proofed.

7.3 Temporary Excavations

WorkSafe BC guidelines for stable excavations should be followed for excavations more than 1.2 m. WorkSafe BC guidelines for excavations should be adhered to in accordance with Section 20 of the Occupational Health and Safety (OHS) Regulation.

Per WorkSafe BC guidelines, a qualified professional must be retained to conduct a WorkSafe BC Excavation Review in case excavation of more than 1.2 m is required for the project. This document should specify instructions to promote excavation stability during construction and may include such items as sloping and shoring requirements. This office is available to provide WorkSafe BC Excavation Reviews upon request, or as needed to satisfy WorkSafe BC criteria. Trenching, utility installation, and backfilling should be carried out in accordance with local municipal specifications.



7.4 Site Preparation

Construction surfaces and footing subgrades should be flat, and all topsoil and organics, fill/disturbed soils, and loose/soft soils, and any other deleterious materials should be removed below the proposed building foundations and grade-supported slabs to expose the natural, undisturbed compact to dense soils. Any local loose areas identified during subgrade preparation should be removed and replaced with lean concrete or suitable engineered fill, as approved by Arya.

Where needed, engineered fill should be placed on competent subgrade to raise grades.

7.5 Engineered Fill and Backfill

Engineered fill is defined as a material designed to be placed directly beneath any load bearing areas. The subgrade for the engineered fill must be approved by Arya prior to placement of engineered fill. All engineered fill material should be free of any organics and other deleterious material and consist of non-expansive/non-sensitive soil. Granular engineered fill below grade-supported slab should consist of non-organic, clean, well-graded, 75 mm minus sand and gravel with less than 5% silt particles (finer than 0.075 mm). Alternatively, 19 mm clear crushed gravel could also be used as engineered fill under foundations, grade supported slabs and behind the foundation walls.

Engineered fill should be tested and approved by Arya prior to use in any load bearing areas. The material should be compacted within 2% of the optimum moisture content (OMC) and a minimum of 100% standard proctor maximum dry density (SPMDD).

Engineered fill should extend beyond the building a distance equal to or greater than the depth of the engineered fill below the structural elements. Granular engineered fill should be placed sequentially in lifts exhibiting a maximum thickness of 300 mm in loose condition.

Pipe bedding and surroundings should be implemented as specified in local municipal specifications. Trench backfill soils under buildings should be compacted to within 2% of the material's OMC and a minimum of 100%, SPMDD. Laboratory standard proctor analysis (ASTM 698) and field density testing should be performed to confirm that the required compaction standards are achieved.

7.6 Site Grading and Drainage

A perimeter drainage system should be installed to minimize the potential for water infiltration into the soil surrounding the shallow foundations and floor slabs. Perimeter drainage should be



comprised of perforated rigid PVC pipe and should be placed around the external sides of the building and below the base of the shallow foundations (undersize footings, beyond a 1H:1V projection from the toe). The perimeter drainage should be designed to promote positive drainage, and a 2% slope is recommended for the drain pipes.

The perimeter drainage pipes should be provided with permanent, non-perforated cleanouts. The drainage pipe should be surrounded by a minimum of 150 mm of drain rock. A layer of non-woven geotextile should be wrapped around the gravel drainage layer to act as a filter against piping of fines from the general backfill and surrounding natural soil. The perimeter drainage system should be designed to direct water by gravity flow to approved discharge locations.

The roof and surface runoff should be collected and directed to a storm sewer or permanent drain in solid wall pipes separate from the perimeter drainage. Arya should be given the opportunity to review the perimeter drain installation prior to placing backfill material and covering the drain pipes, as proper drainage installation and maintenance is necessary to endorse the bearing capacity and allowable bearing pressures provided herein.

Based on final site plans, a temporary groundwater management plan may be required to keep the subgrade dry and to control groundwater during construction. Our office is available to provide design recommendations for temporary groundwater management upon request and upon finalization of site plans.

7.7 Lateral Earth Pressure Coefficients

Below grade walls, foundations and grade beams should be adequately designed to resist the lateral earth pressures acting on them and any additional loads caused by surcharge loads. Lateral loading coefficients on these elements have been provided for several situations. Coefficients have been provided for At-Rest Pressure (KO) and Active Pressure (KA) conditions. Coulomb's theory was used to calculate the active pressure coefficient while the Mononobe-Okabe method was used to calculate an earthquake induced dynamic active pressure coefficient (KAE).

The PGA value detailed in Section 5.0 of this report was utilized in calculating the earthquake induced dynamic active pressure coefficient. The coefficients have been calculated in accordance with the 4th edition of the Canadian Foundations Engineering Manual (CFEM 2006). Table 2 provides the lateral earth pressure coefficients that should be used for applicable below grade elements.



TABLE 2 – LATERAL EARTH PRESSURE COEFFICIENTS

Pressure Condition	Coefficient Symbol	Coefficient Value
At-Rest Pressure	K_0	0.43
Active Pressure	K_A	0.27
Active Pressure (Including Seismic Effects)	K_{AE}	0.29

Lateral earth pressure coefficients were determined assuming a free draining backfill. A unit weight of 19 kN/m³ should be considered for compacted, approved backfill. It is assumed that free draining backfill will extend horizontally from the top of below grade elements to a lateral distance equivalent to the element's height. In the case that a level backfill is not achievable, higher earth pressures can be expected and this office should be retained to provide updated design values.

The at-rest pressure, active pressure, and active (with seismic effects) pressure conditions can be designed according to the CFEM 2006.

7.8 Field Review

The preceding conclusions constitute preliminary geotechnical recommendations for the development of the proposed structure and related works. It is essential that all project stakeholders review the results of this assessment prior to commencement of final design and construction activities.

For the conditions in this report to be considered valid, this office must be provided the opportunity to conduct field reviews during construction. Arya should be informed 48 hours in advance prior to the following inspections for each structure.

- Excavation/test pit review to assess ground conditions prior to construction
- Subgrade conditions for shallow foundations and grade supported slabs (all bearing surfaces).
- Perimeter drainage as installed, prior to backfilling.
- Review of engineered fill below grade-supported slab, shallow foundations, and behind retaining walls and foundation walls (backfill).
- Closure review / final walkthrough.

It is important to note that additional field review services may be required based on final site plans and the extent of design services that Arya is retained for. In the case that field reviews are



not requested by the Client or Clients agent, final sign-off (Schedule CB) may not be provided by this office, or additional scope items may become required prior to final sign-off.

8.0 CLOSURE

Recommendations presented herein are based on the geotechnical evaluation made during Arya’s site reconnaissance. The findings in this report reflect Arya’s best judgment based on the information that was available to Arya at the time of preparation of this report. If conditions other than those are noted during subsequent phases of the development, Arya should be given the opportunity to review and revise the recommendations included in this report, as necessary.

This report has been prepared for the exclusive use of Sawarne Lumber Co., Ltd, their consultants, contractors and representatives for the specific application of the developments described within this report. Any use of this report by third parties, or any reliance on or decisions made based on it are the responsibility of such third parties. Arya accepts no responsibility, if any, suffered by any third party because of decisions made or actions taken based on this report.

We appreciate the opportunity to be of service to you. If you have any questions regarding the contents of this report, please contact us at (604) 886 1515.

Sincerely,

Arya Engineering Inc.

Prepared By:

Reviewed By:

Ufuoma Oki, P.Geo, M.Eng, PMP
Senior Engineering Geoscientist

Benjamin Tomasz, P.Eng.
Principal | Senior Geotechnical Engineer

Attached: Photograph 1-4
Appendix A
Terms and Conditions

Permit to Practice No.: 1002217



Photograph 1 and 2: Gentle Sloping Lot Condition



Photograph 3 and 4: Vegetation

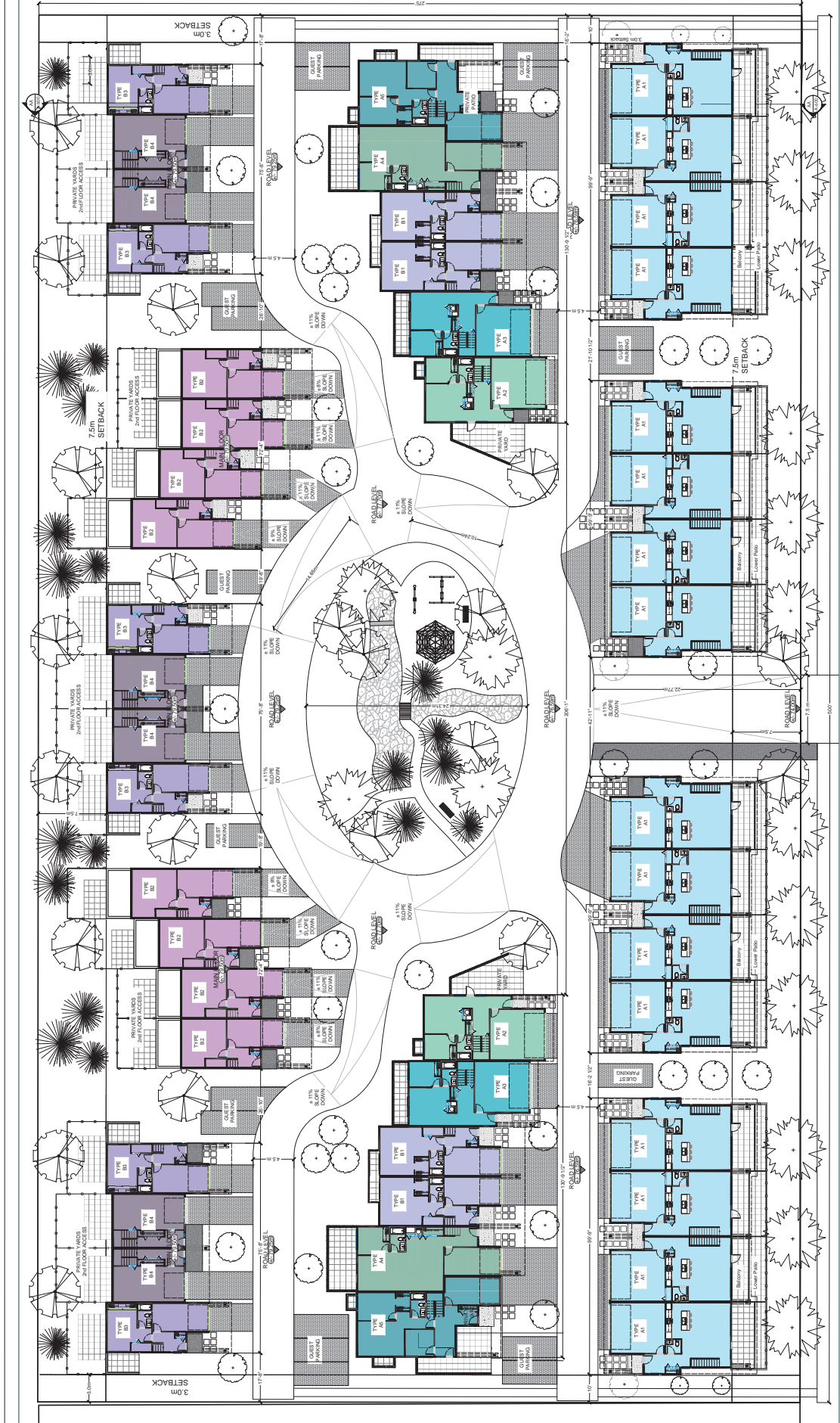


APPENDIX A

Derby Townhomes

Site Layout Plan

(Image 1)



Site Plan - ALT. - WIDER

Project No.: 2211

Date: July 6th, 2022

Scale: 1/16" = 1'-0"

Drawn: CB

Sheet No. **A-02**

Derby Townhomes

MULTI-FAMILY

DERBY ROAD, SECHELT



TERMS AND CONDITIONS OF ENGAGEMENT

1. **GENERAL:** Arya Engineering Inc. (ARYA) shall render the Services, as specified in the attached Scope of Services, to the Client for the Project in accordance with the following terms and conditions of engagement and related articles. ARYA may, at its discretion and at any stage, engage sub-consultants to perform any part or all of the Services.
2. **DEFINITIONS:**
 - a. Agreement – is this Prime Agreement for professional Services.
 - b. Consultant – shall mean professionals and other specialists other than ARYA or its officers, employees and agents engaged by the Client directly.
 - c. Contractor – is the party contracting with the Client for the provision of labour, materials and equipment for the execution and quality control of the Work.
 - d. Contract – is the agreement between the Client and the Contractor for the provision of labour, materials and equipment for the execution of the Work by the Contractor.
 - e. Contract Documents – shall comprise all documents relating to the Project issued by or through ARYA, including the plans, drawing, specifications and schedules, and all variations and modifications thereto approved by ARYA.
 - f. Field Services – shall mean applying such selective sampling and inspection procedures at the project site during construction as ARYA, and at ARYA’s professional discretion, considers necessary to enable ARYA to ascertain whether the Contractor is carrying out the Work in general conformity with the design concept for the Project.
 - g. Project– shall refer to the project described in the recital clauses to this Agreement.
 - h. Services – shall mean ARYA’s duties and responsibilities to the Client as set forth in the attached Scope of Services and Authorization to Proceed.
 - i. Sub-Consultant – shall mean any registered professional engineers or other specialists engaged by ARYA in connection with the Project.
 - j. Work – is the totality of all labour, materials and equipment used or incorporated into the Project by the Contractor pursuant to the Contract Documents.
3. **REPRESENTATIVES:** Each party shall designate a representative who is authorized to act on behalf of that party and receive notices under this Agreement.
4. **AUTHORIZATION TO PROCEED:** Verbal authorization by the Client, either in person or over the telephone, or by written instructions will serve as authorization for ARYA to proceed with the services called for in this services agreement and those delineated in related correspondence between ARYA and Client. This Agreement, including attachments incorporated herein by reference, represents the entire agreement between ARYA and Client. This Agreement may be altered only by written instrument signed by authorized representatives of both Client and ARYA.
5. **EXTENT OF AGREEMENT:** Work beyond the Scope of Services or redoing any part of the Project through no fault of ARYA, shall constitute extra Work and shall be paid for on a time-and-materials basis in addition to any other payment provided for in this Agreement. If, during the course of performance of this Agreement, conditions or circumstances are discovered which were not contemplated by ARYA at the commencement of this Agreement, ARYA shall notify the Client either verbally or in writing of the newly discovered conditions or circumstances, and the Client and ARYA shall renegotiate, in good faith, the terms and conditions of this Agreement.
6. **COMPENSATION:** Charges for the Services rendered will be made in accordance with ARYA’s Schedule of Fees and Disbursements in effect from time the services are rendered. ARYA’s Schedule of Fees and Disbursements are included in ARYA’s budget estimate. All charges will be payable in Canadian Dollars. ARYA shall invoice the Client for the services performed under this Agreement and shall provide a summary of costs upon request. The Client shall pay such invoice upon receipt. Invoices not paid within thirty (30) days of the invoice date shall be subject to a late payment charge of 1.5 percent per month (18% per annum) from the date of billing until paid. The invoice amounts shall be presumed to be correct unless the Client notifies ARYA in writing within fourteen (14) days of receipt. Overdue accounts over ninety (90) days will be forwarded to a collections agency. The Client and ARYA expressly agree that ARYA’s fee shall be payable by the Client even in the event that the Client does not, for any reason, proceed with the Project as described in the Contract Documents. The Client and ARYA further expressly agree that payment of the ARYA’s fee by the Client pursuant to this Agreement shall be a condition precedent to the Client’s use of the Contract Documents and models for the execution of the Work.
7. **PROBABLE COSTS:** ARYA does not guarantee the accuracy of probable costs for providing Engineering Services. Such probable costs represent only ARYA as a professional and are supplied only for the general guidance of the Client. The parties expressly acknowledge and agree that the cost of the Services and contract time estimates provided by ARYA to the Client under this Agreement are subject to change and are contingent upon factors over which ARYA has no control. ARYA does not guarantee the accuracy of such estimates.



TERMS AND CONDITIONS OF ENGAGEMENT

8. **STANDARD OF CARE:** ARYA shall perform its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing under similar conditions in the geographic vicinity and at the time the Services are performed. This Agreement neither makes nor intends a warranty or guarantee, either expressed or implied.
9. **INDEMNITY:** Client waives any claim against ARYA, its officers, employees and agents and agrees to defend, indemnify, protect and hold harmless ARYA and its officers, employees and agents from any and all claims, liabilities, damages or expenses, including but not limited to, delay of the project, reduction of property value, fear of or actual exposure to or release of toxic or hazardous substances, and any consequential damages of any nature, which may arise directly or indirectly, to any party, as a result of the services provided by ARYA under this Agreement, unless such injury or loss is caused by the sole negligence of ARYA.
10. **INSURANCE, LIMITATION OF LIABILITY:** The Client agrees to limit ARYA and its officers, employees, and agents liability due to professional negligence and to any liability arising out of or relating to this Agreement to fifty thousand dollars (\$50,000) or the amount of ARYA's fee, whichever is less. This limit applies to all services on the project, whether provided under this or subsequent agreements, unless modified in writing, agreed to, and signed by authorized representatives of the parties. No claims may be brought against ARYA in contract or tort more than two (2) years after Services were completed or terminated under this engagement. If for any reason such insurance shall not be available or shall not apply to any claim made by the Client against ARYA in respect of the Services, then the liability of ARYA to the Client under this Agreement shall be absolutely limited to the amount of any professional liability available at the time such claims are made. In this case, any liability arising out of or relating to this Agreement will also be limited to fifty thousand dollars (\$50,000), or the amount of ARYA's fee, whichever is less. Note: ARYA will not be responsible for water ingress related problems as ARYA's insurance policy contains an Absolute Water Ingress Exclusion. For special projects, higher liability limits are available from our underwriter for an additional fee. ARYA warrants it is protected by WorkSafe BC Insurance, General Liability Insurance, Professional Errors and Omissions Insurance, and Automobile Liability Insurance. Certificates for such policies of insurance shall be provided to the Client upon request.
11. **RESPONSIBILITY:** ARYA is not responsible for the completion or quality of work that is dependent upon or performed by the Client or third parties not under the direct control of ARYA, nor is ARYA responsible for their acts or omissions or for any damages resulting there from. ARYA shall not be responsible for the following:
 - a. The failure of a Contractor, retained by the Client, to perform the Work required for the Project in accordance with the applicable Contract Documents;
 - b. The design of or defects in equipment supplied or provided by the Client for incorporation into the Project;
 - c. Any cross-contamination resulting from subsurface investigations;
 - d. Any damage to subsurface structures and utilities which were identified and located by the Client;
 - e. Any Project decisions made by the Client if the decisions were made without consultation of ARYA or contrary to or inconsistent with ARYA's recommendations;
 - f. Any consequential loss, injury, or damages suffered by the Client, including but not limited to, loss of use, earnings, and business interruption; and,
 - g. The unauthorized distribution of any document or report prepared by or on behalf of ARYA for the exclusive use of the Client.
12. **CLIENT'S RESPONSIBILITIES:**
 - a. Make available to ARYA all relevant information or data pertinent to the project which is required by ARYA, and instruct ARYA fully in writing as to the Client's total requirements in connection with the Project. ARYA shall be entitled to rely upon the accuracy and completeness of such information and data furnished by or through the Client, including information and data originating with Consultants, whether such Consultants are engaged at the request of ARYA or otherwise. Where such information or data originates either with the Client or with Consultants, then ARYA shall not be responsible to the Client for the consequences of any error or omission contained therein or arising from ARYA's use of this data;
 - b. When required by ARYA, to engage Consultants directly to perform services necessary to enable ARYA to carry out its duties and responsibilities. Such Consultants engaged by the Client shall be subject to the joint approval of the Client and ARYA;
 - c. Authorize ARYA to act as the Client's for such purposes as are necessary to ARYA's rendering of its Services pursuant to this Agreement;
 - d. Give prompt consideration to all sketches, drawing, specifications, tenders, proposals, contracts and other documents relating to the Project laid before the Client by ARYA, and whenever prompt action is necessary inform ARYA of the Client's decisions in such reasonable time so as not to delay the Services of ARYA, or to prevent ARYA from forwarding drawings or instructions to the Contractor or the Consultants or to Sub-Consultants in good time;
 - e. Pay ARYA's fee and reimbursable expenses as provided for in this Agreement;



TERMS AND CONDITIONS OF ENGAGEMENT

- f. Provide necessary advertising incidental to obtaining tenders, and provide or reimburse ARYA for obtaining necessary legal, accounting and insurance counseling services;
 - g. Arrange and make provision for ARYA's entry and ready access to property (public and private) as well as to the Project site, as necessary to enable ARYA to perform its Services;
 - h. Give prompt written notice to ARYA whenever the Client or the Client's representative becomes aware of any defects or deficiencies in the Work or in the Contract Documents; and,
 - i. Obtain required approvals, licences and permits from municipal, governmental or other authorities having jurisdiction over the Project so as not to delay ARYA in the performance of Services. The Client expressly undertakes not to enter into contracts in connection with the Project which describe duties and responsibilities of ARYA which are inconsistent with the duties and responsibilities of ARYA provided for in this Agreement without obtaining ARYA's prior written agreement thereto.
13. **EXCLUSIVE USE:** Services provided under this Agreement, including all reports, drawings, plans, models, specifications and other documents, information or recommendations prepared or issued by ARYA, are instruments of service for the execution of the Project. ARYA retains the property and copyright in these documents, whether the Project is executed or not. No other use of these documents is authorized under this Agreement without the prior written agreement and remuneration of ARYA.
 14. **SAMPLES:** All non-consumed samples shall remain the property of the Client, and Client shall be responsible for and promptly pay for the removal and lawful disposal of samples, cuttings and hazardous materials, unless otherwise agreed to in writing. If appropriate, ARYA shall preserve samples obtained for the project for not longer than thirty (30) days after the issuance of any document that includes the data obtained from those samples.
 15. **ENVIRONMENTAL:** ARYA's field investigation, laboratory testing and engineering recommendations will not address or evaluate pollution of air, soil and/or groundwater, unless otherwise specifically listed in the attached Scope of Services. ARYA will co-operate with the Client's environmental consultant during field work phase of the investigation is requested.
 16. **FIELD SERVICES:** Where applicable, Field Services recommended for the Project are the minimum necessary, at the sole discretion of ARYA, to review whether the Work of a Contractor retained by the client is being carried out in general compliance with the intent of the Services and in compliance to information and recommendations presented in all reports, drawings, plans, models, specifications and other documents provided in the deliverables prepared by ARYA in fulfillment of the Scope of Services. It is understood and agreed by the Client that the performance of the Contract is not ARYA's responsibility, nor are Field Services rendered for the Contractor's benefit. The Contractor alone is responsible for the quality control of the Work. Any reduction from the level of services recommended will result in ARYA not providing qualified certifications for the Work. ARYA shall issue certifications only where Field Services have been performed by ARYA.
 17. **TERMINATION:** This Agreement may be terminated by either party upon ten (10) days written notice to the other. Upon the receipt of such written notice from the Client to ARYA, ARYA shall perform no further Services other than those reasonably necessary. In the event of a termination, the Client shall pay for all charges for services performed and demobilization by ARYA, in addition to reasonable termination expenses incurred to the date of notice of Termination. The limitation of liability and indemnity obligations of this Agreement shall be binding notwithstanding any Termination of this Agreement.
 18. **DISPUTE RESOLUTION:** If requested in writing by either the Client or ARYA, the Client and ARYA shall attempt to resolve any dispute between them arising out of or in connection with this Agreement by entering into structured, non-binding negotiations with the assistance of a mediator on a without prejudice basis. The mediator shall be appointed jointly by the parties. If a dispute cannot be settled within a period of thirty (30) calendar days with the mediator, the dispute shall be referred to and finally resolved by arbitration under the rules of British Columbia or by an arbitrator appointed by agreement of the parties or by reference to a Judge of the Supreme Court of British Columbia. No one shall be nominated to act as an arbitrator who is in any way financially interested in the conduct of the Project or in the business affairs of either the Client or ARYA. The award of the arbitrator shall be final and binding upon the parties.
 19. **GOVERNING LAW:** This Agreement is governed by the law British Columbia, and any litigation shall be brought and tried in, the judicial jurisdiction of the ARYA office that entered this Agreement, as stated herein.
 20. **NON-SOLICITATION:** The Client agrees they shall not recruit for employment or hire any ARYA employees who provide services pursuant to this Agreement during the term of this Agreement and for a period of one (1) year following its termination.

Derby Road, SECHELT DEVELOPMENT PERMIT

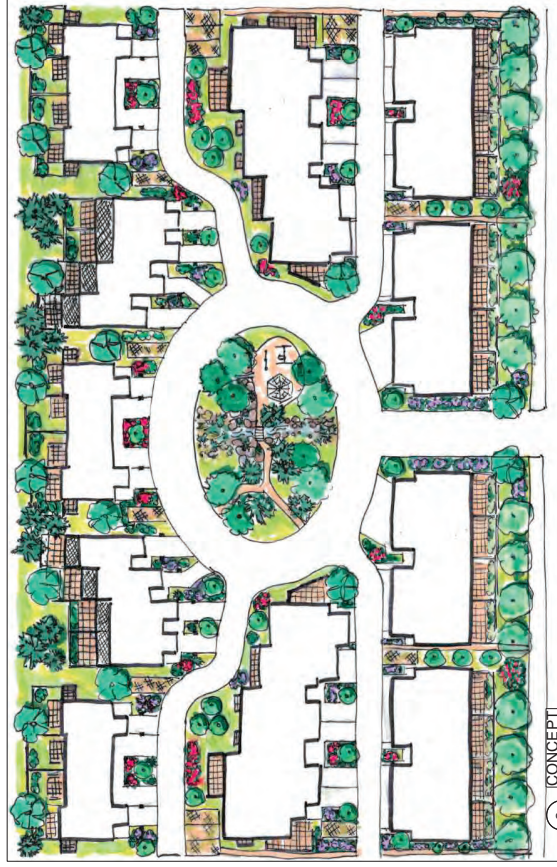
FIGURE NO.	FIGURE TITLE
A-01	Site Location
A-02	Site Plan
A-03	Site Plan
A-04	Site Plan
A-05	Site Plan
A-06	Site Plan
A-07	Site Plan
A-08	Site Plan
A-09	Site Plan
A-10	Site Plan
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A-100	Site Plan



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1 [RENDERING] Scale: NTS



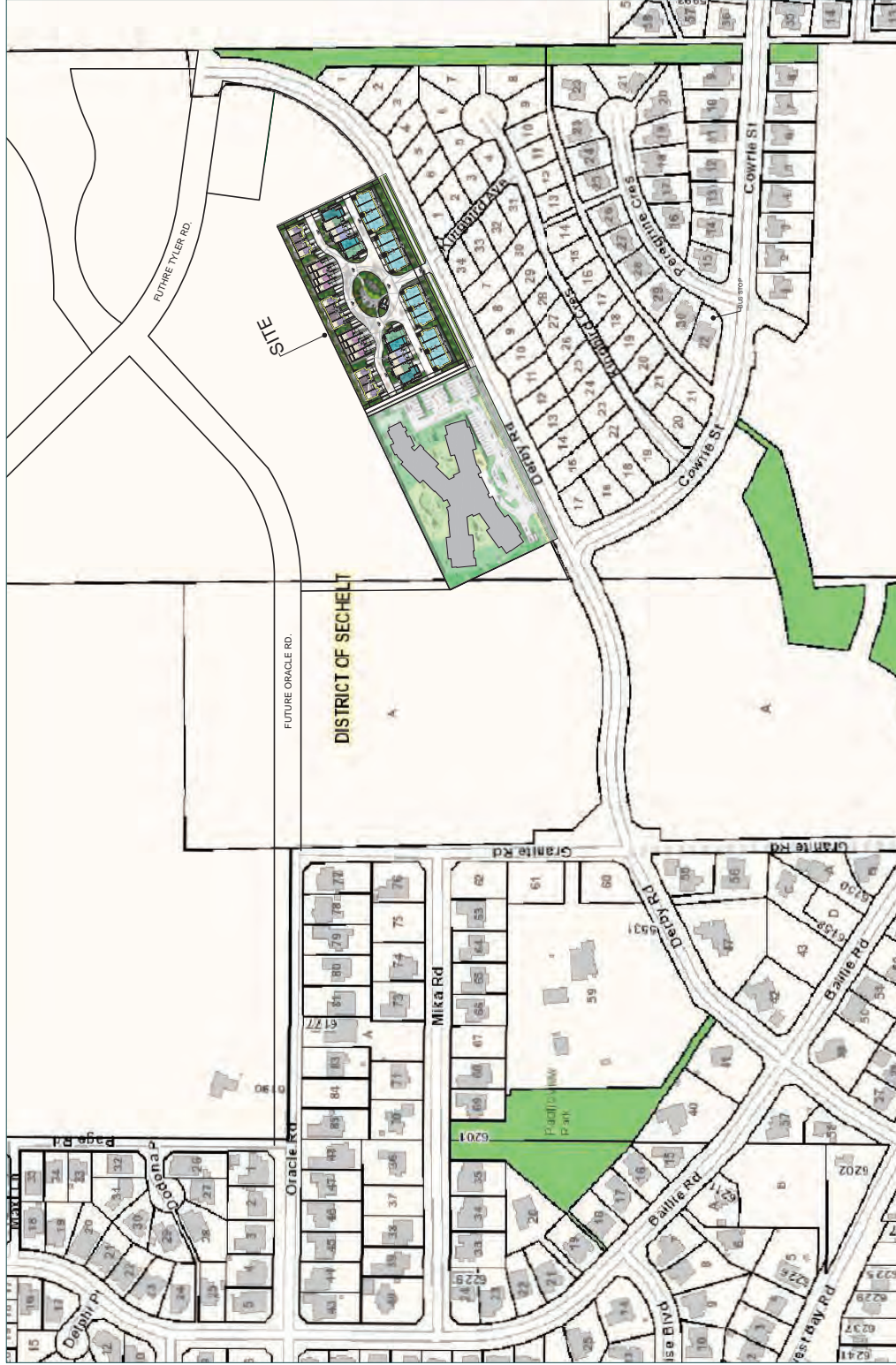
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Derby Townhomes MULTI-FAMILY DERBY ROAD, SECHELT

Cover Sheet

Project No: 2211
Date: November 9, 2022
Scale: 1/16" = 1'-0"
Drawn: CB
Sheet No.

A-0

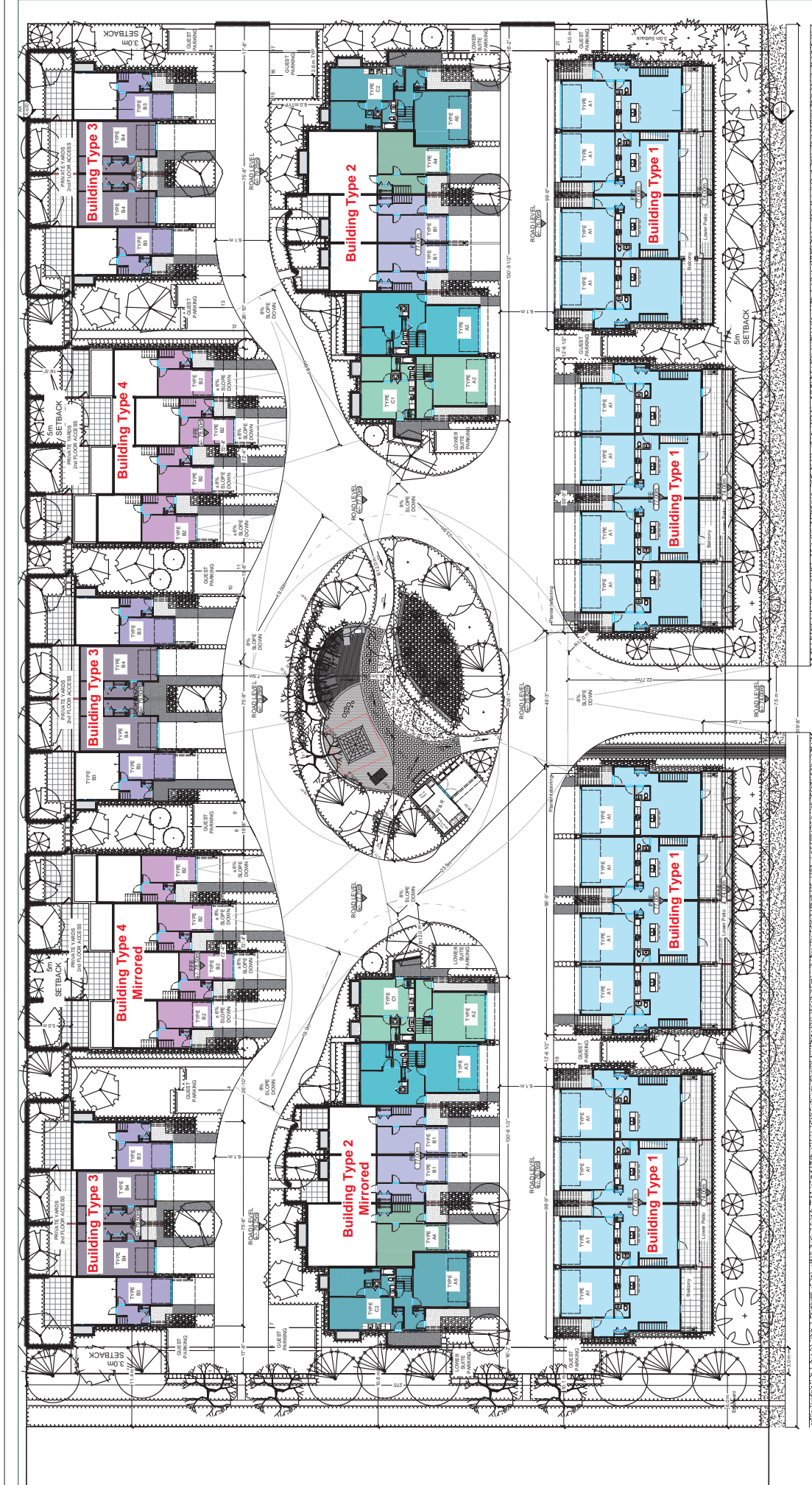


Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT

Area Plan

Project No.:	2211
Date:	November 9, 2022
Scale:	1/8" = 1'-0"
Drawn:	CS
Sheet No.:	A-01





Derby Townhomes

MULTI-FAMILY

DERBY ROAD, SECHELT

Site Plan

Project No.:	2211
Date:	November 9, 2022
Scale:	1/16" = 1'-0"
Drawn:	CB
Sheet No.:	A-02



Statistics - 2211 Derby Townhomes
 Acres: 3.40
 Ha: 1.375
 m²: 13,750
 ft²: 148,000

No. of Buildings on Site

4

Gross Areas By Building

Building 1
 Basement: 153.9 m²
 Patio (@ grade): 1092.0 m²
 Level 1: 4082.2 m²
 Balconies: 617.3 m²
 Largest Roof: 5249.7 m²
 Sum of Enclosed Space: 6615.8 m²

Building 2
 Main Floor: 5769.1 m²
 Patio (@ grade): 342.0 m²
 Level 1: 1652.5 m²
 Level 2: 107.87 m²
 Level 3: 1217.2 m²
 Largest Roof: 7489.4 m²
 Sum of Enclosed Space: 12654.4 m²

Building 3
 Main Floor: 2283.5 m²
 Patio (@ grade): 0.0 m²
 Level 1: 2518.3 m²
 Balconies: 649 m²
 Yard Space: 102.2 m²
 Level 2: 233.96 m²
 Level 3: 2356.8 m²
 Largest Roof: 7489.4 m²
 Sum of Enclosed Space: 12654.4 m²

Building 4
 Main Floor: 2475.3 m²
 Level 1: 3340.7 m²
 Yard Space: 719.0 m²
 Balconies: 654.4 m²
 Level 2: 2427.4 m²
 Level 3: 225.51 m²
 Largest Roof: 4470.7 m²
 Sum of Enclosed Space: 8243.4 m²

TOTAL COVERAGE (m²)
 PROJECT GFA (m²): 8336.62
 Project Floor Area Ratio: 0.61
 Number of Units: 52
 Density (Units/Ha): 37.8
 Coverage with Hardsc.: 70%

Roads: 28109.00
 Soft Landscaping (approx.): 45000.00

UNIT TYPE	UNIT STATISTICS										TOTAL Units	Gross Bldg
	No. Units	No. Bath	No. Bedrooms	Garage	Lower	Main Floor	Upper	TOPFL Levels	Gross Bldg			
A1.1	5	2.5	2	379	647	470	1317	969				
A1.2	5	2.5	2	379	616	607	1223	962				
A2	2	3	3	382	153	862	1145	927				
A3	2	3	3	382	575	820	1145	977				
A4	2	2	2	356	137	1019	1195	912				
A5	2	3	3	429	189	1114	1283	972				
B1	4	3	3	277	137	791	607	1535	912			
B2	5	3	3	220	96	835	606	1537	977			
B3	5	2.5	2	224	96	680	604	1382	966			
B4	5	2.5	2	390	154	544	576	1276	966			
C1	2	1	1	0	461		491	491				
C2	2	1	1	0	614		614	614				

VEHICLE PARKING - Townhouse (DUAL)	REQUIRED	PROVIDED
	96	96
VEHICLE PARKING - Suite (1/Unit)	4	4
VISITOR PARKING (60%)	20	21

	HEIGHT (m/ft)			
	TYPE 1	TYPE 2	TYPE 3	TYPE 4
SOUTH FACADE	20	29	29	29
NORTH FACADE	10	22.5	20	20
AVERAGE HEIGHT (m/feet)	15	25.75	24.5	24.5
AVG HEIGHT (m/feet)	4.57	7.85	7.67	7.67

ZONING	OLD BYLAW	NEW BYLAW
	R4B	R5
HEIGHT	15m	10.5m
FRONT SETBACK	7.5m	5.0m
INT. SIDE SET.	6.0m	1.5m
EXT. SIDE SET.	3.0m	3.0m
DENSITY	30/ha	35/ha
FAR	0.60	0.60
MAX COVERAGE	70%	50%

Derby Townhomes

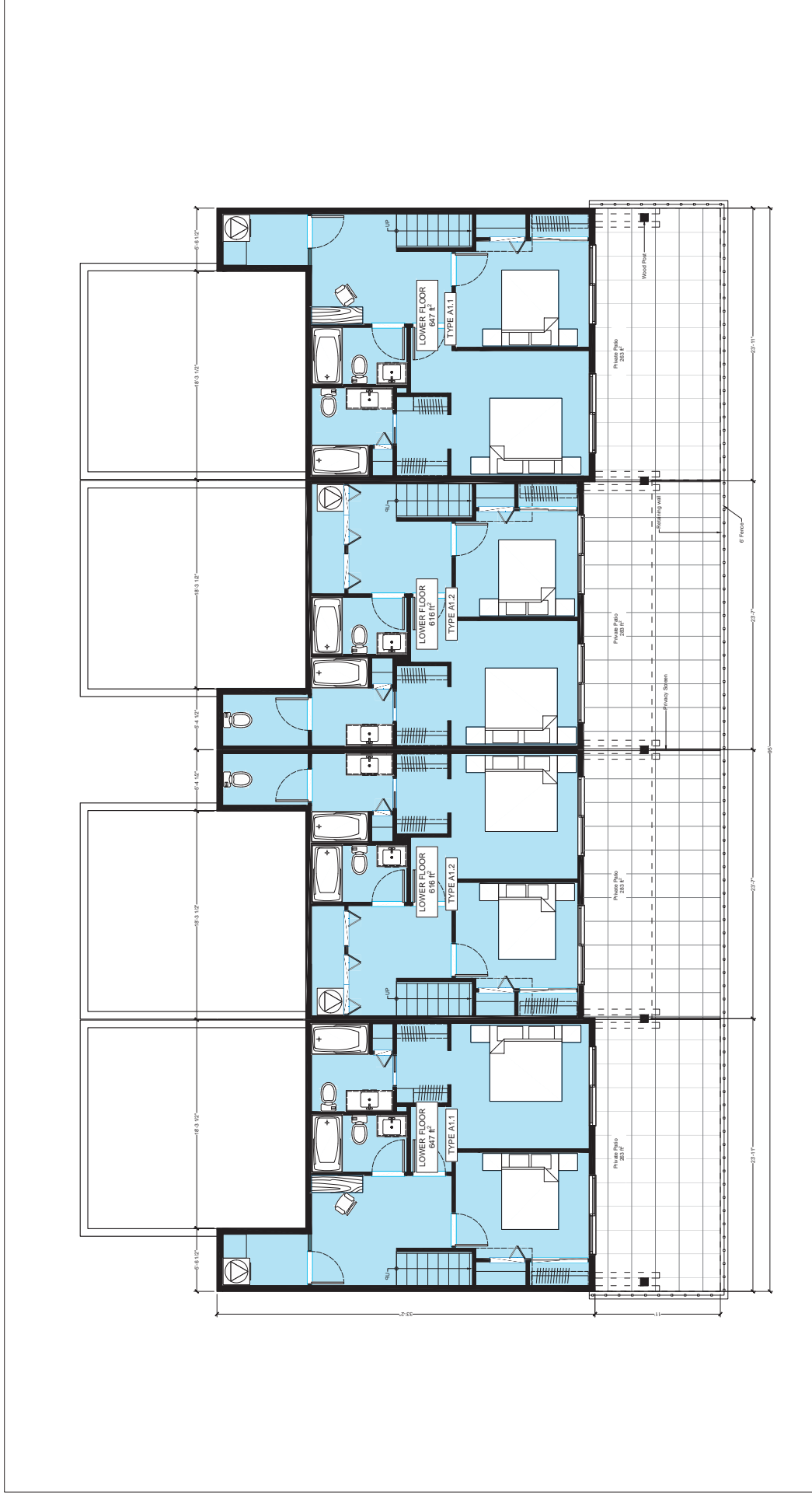
MULTI-FAMILY

DERBY ROAD, SECHELT

Statistics
 Project No.: 2211
 Date: November 9, 2022
 Scale: NTS
 Drawn: CB
 Sheet No.



A-03



Basement - Building 1

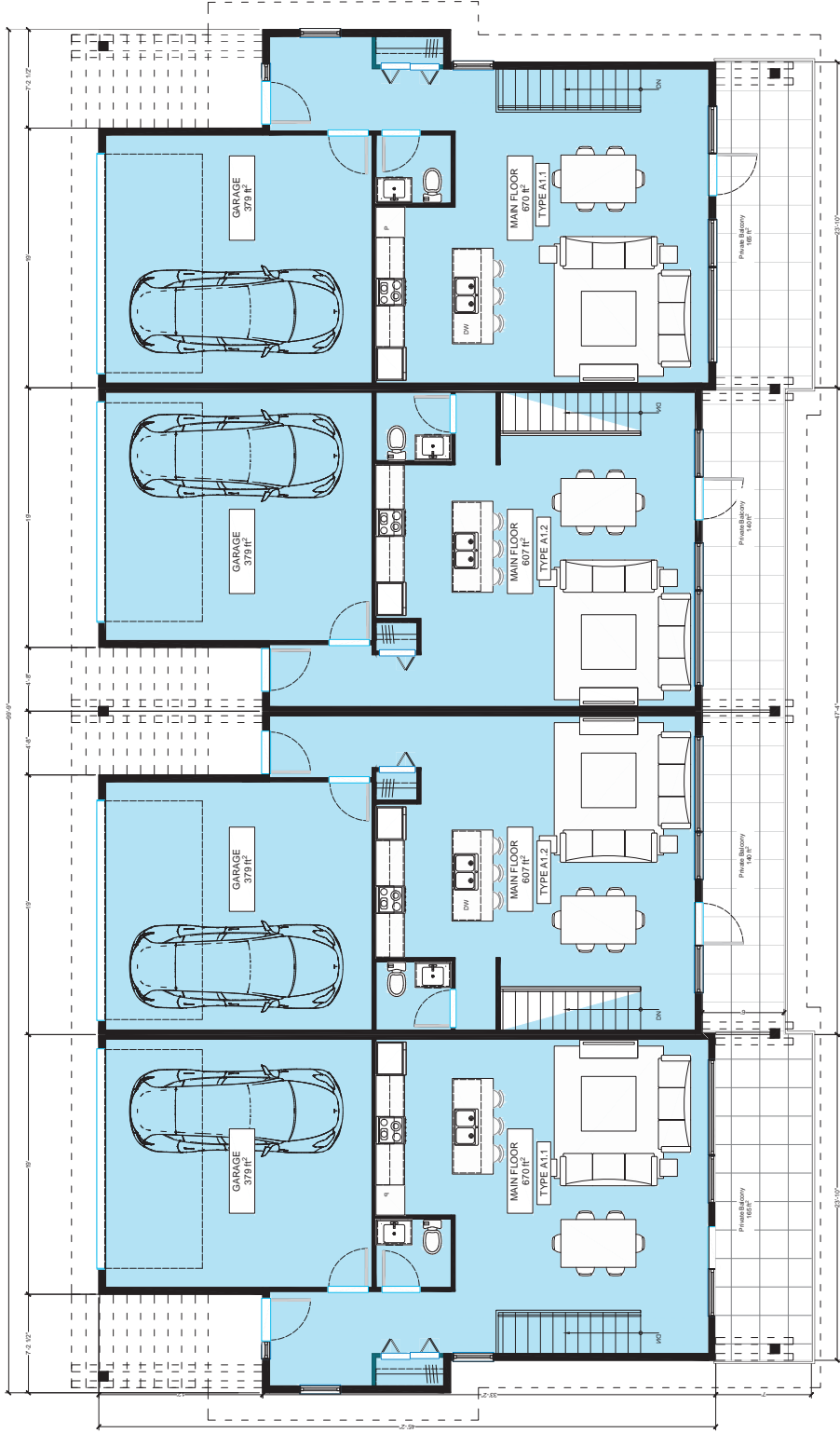
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 Date: October 24, 2022
 Scale: 1/4" = 1'-0"
 Drawn: CB
 Sheet No.

A-10.1

Derby Townhomes
MULTI-FAMILY
DERBY ROAD, SECHELT



MOBIUS ARCHITECTURE
 3-4750 HIGHWAY 101
 SUITE 100
 PRINCE GEORGE BC V3N 4S9
 TEL: 604 885-6372
 FAX: 604 885-6372



Derby Townhomes

MULTI-FAMILY

DERBY ROAD, SECHELT

Main Floor - Building 1

Project No.: 2211

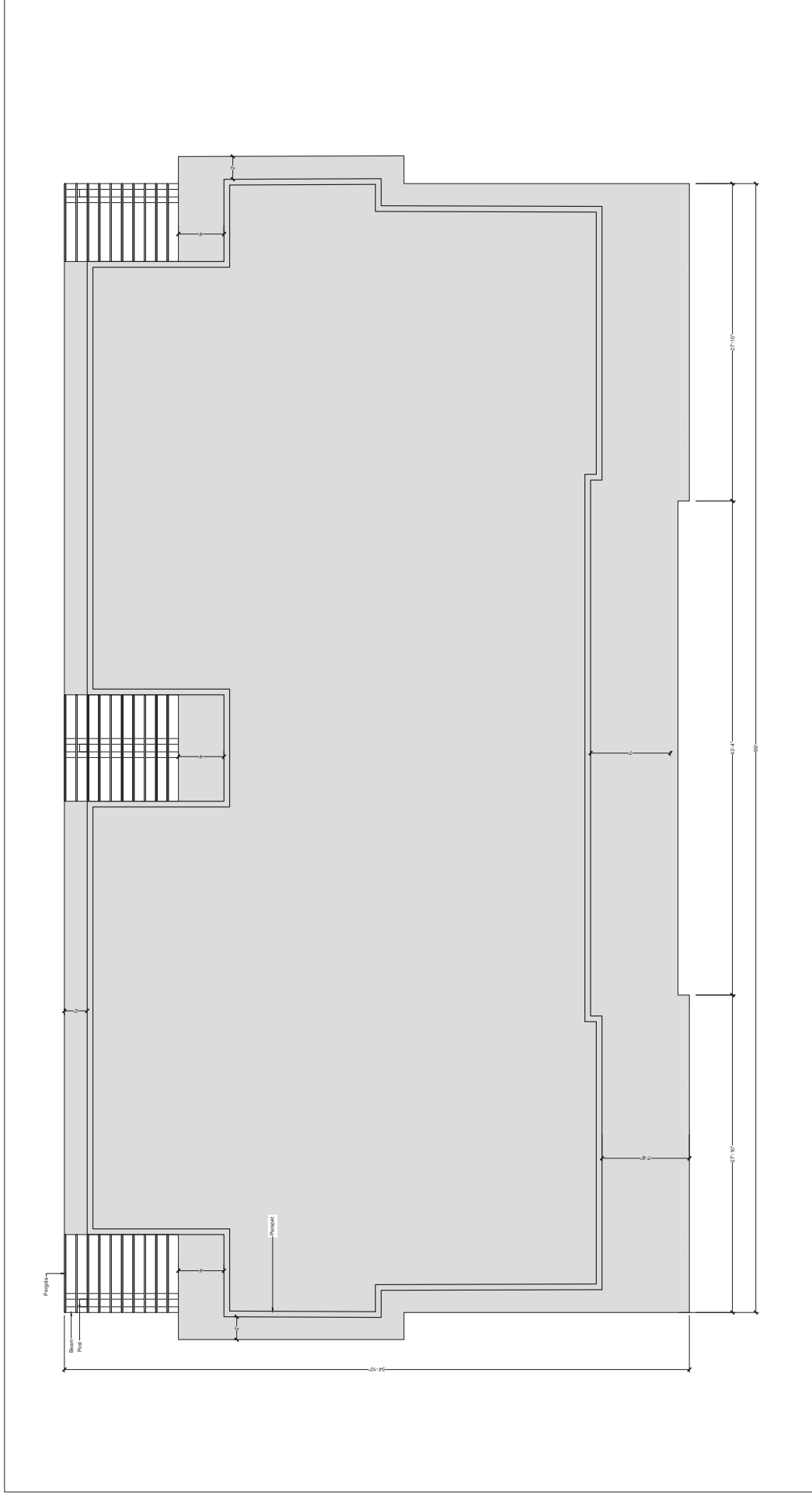
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Scale: 1/4" = 1'-0"

Drawn: CB

Sheet No.

A-11.1



Roof - Building 1

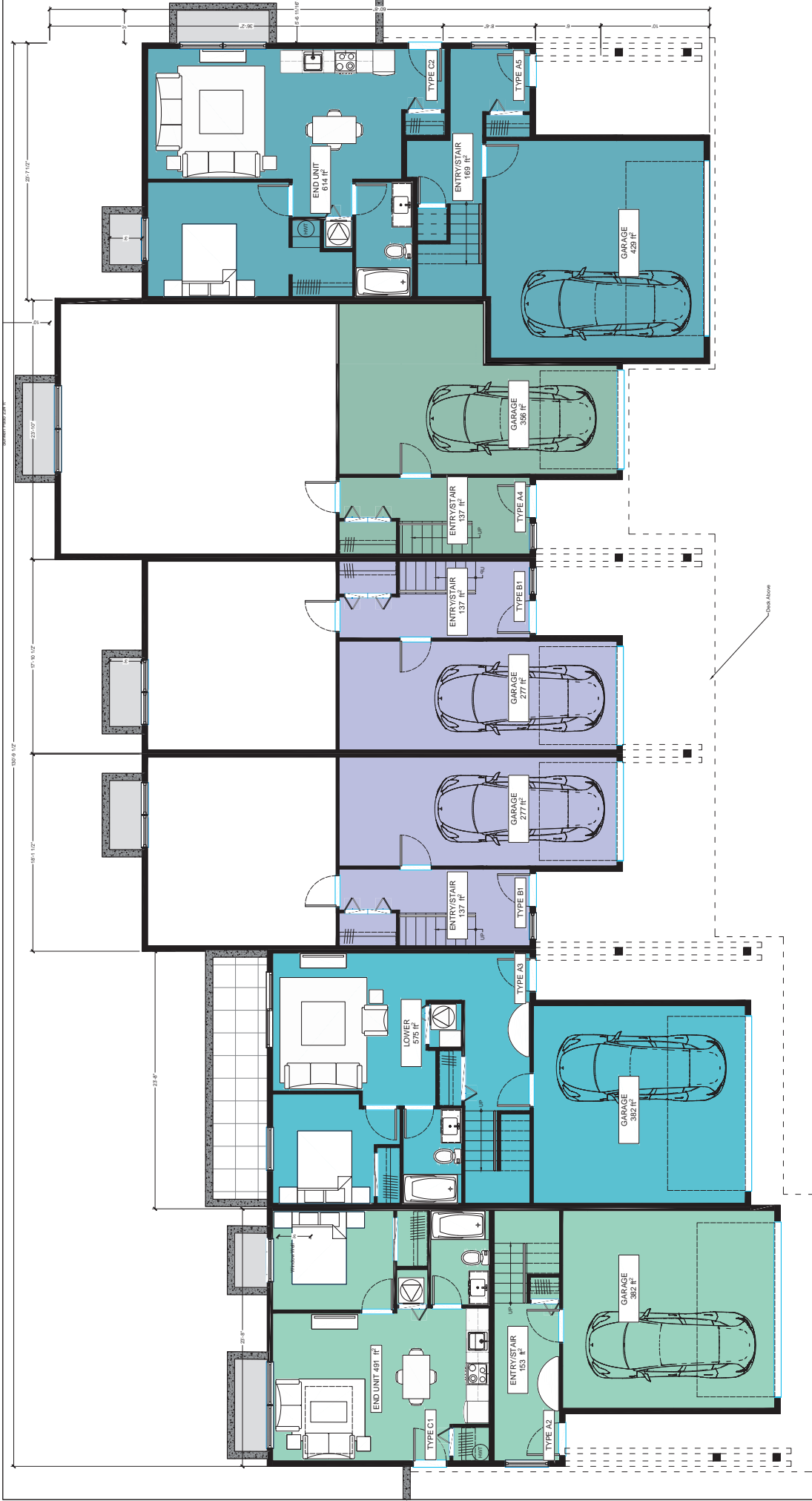
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 Scale: 1/4" = 1'-0"
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 Sheet No.

A-12.1

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



MOBIUS ARCHITECTURE
 24750 HIGHWAY 101
 SUITE 100
 PRINCETON, MA 01904-1300
 PHONE: 508.854.4300
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Main Floor - Building 2

Project No.: 2211

Date: November 9, 2022

Scale: 1/4" = 1'-0"

A-11.2

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



MOBIUS ARCHITECTURE
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Second Floor - Building 2

Project No.: 2211

Date: November 9, 2022

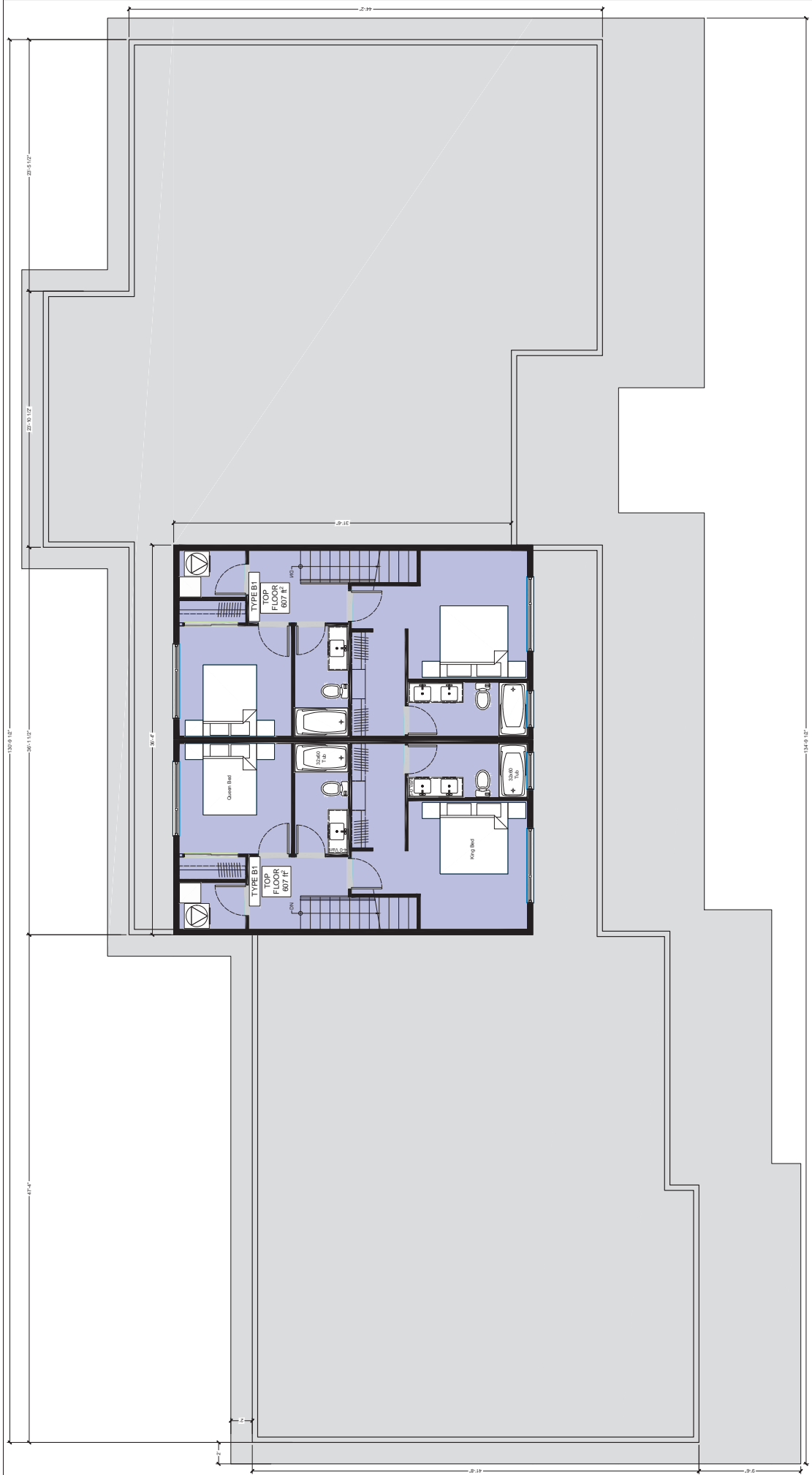
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A-12.2

Derby Townhomes
MULTI-FAMILY
 DERBY ROAD, SECHELT



MOBIUS ARCHITECTURE
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 WILMINGTON, MA 01897
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Third Floor - Building 2

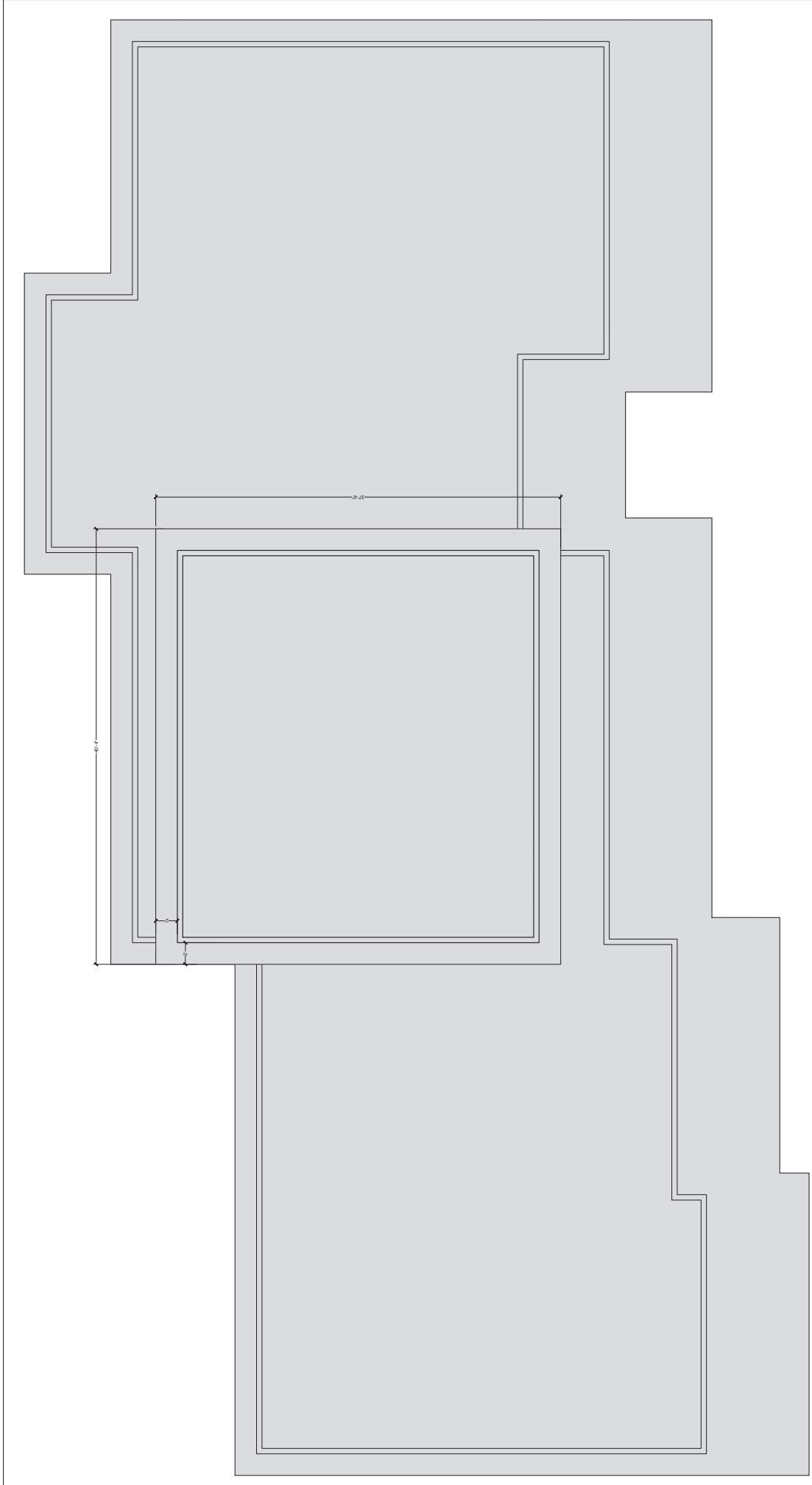
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 Date: November 9, 2022
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A-13.2

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



MOBIUS ARCHITECTURE
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Roof - Building 2

Project No.: 2211

Date: October 24, 2022

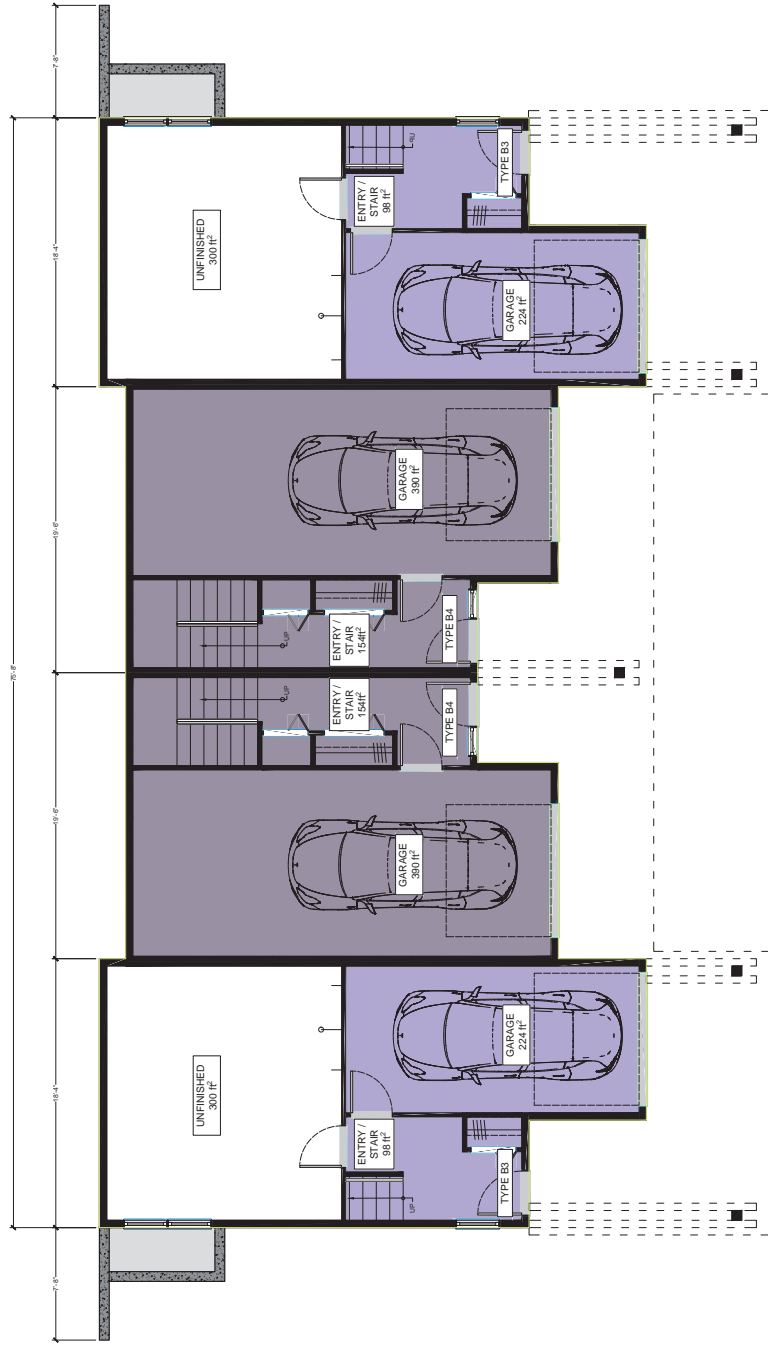
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A-14.2

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



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Main Floor - Building 3

Project No.: 2211

Date: October 24, 2022

Scale: 1/4" = 1'-0"

A-11.3

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



Second Floor - Building 3

Project No.: 2211

Date: October 24, 2022

Scale: 1/4" = 1'-0"

A-12.3

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



Third Floor - Building 3

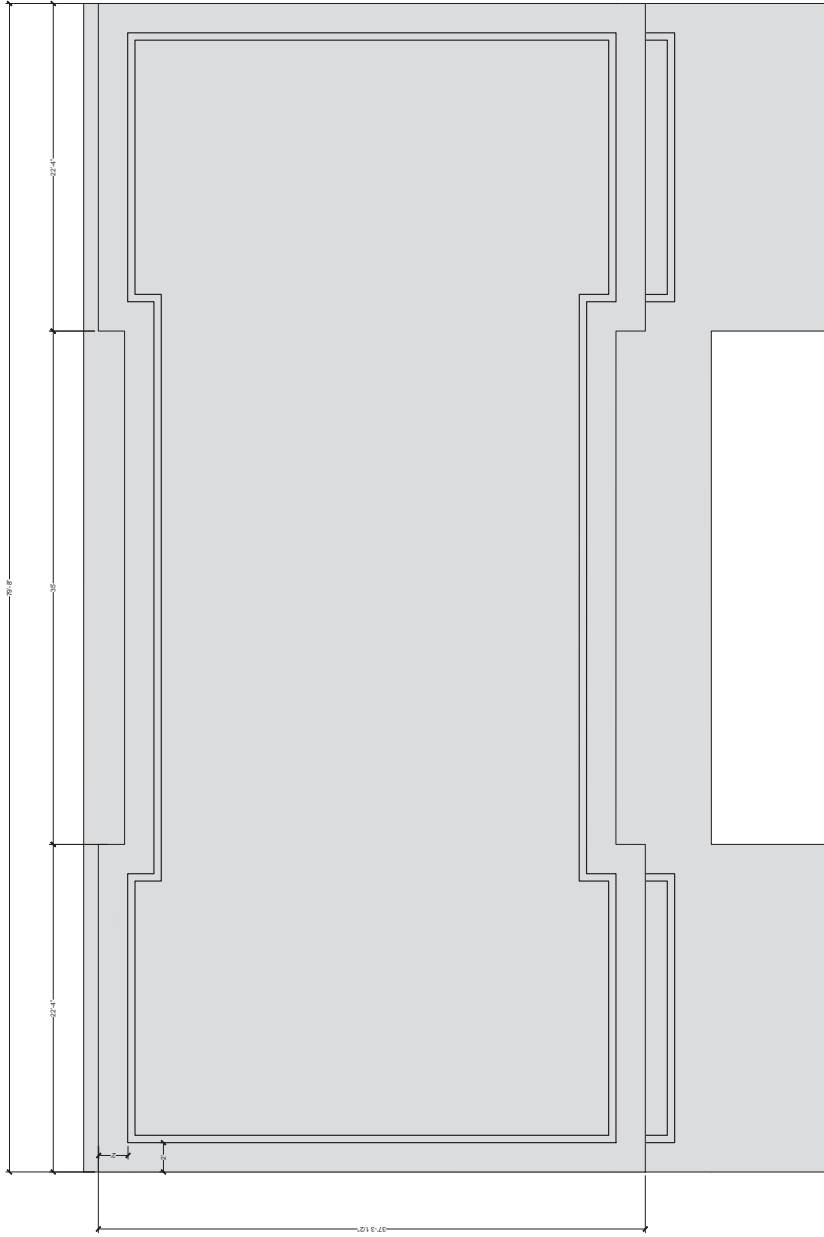
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Date: October 24, 2022

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A-13.3

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



Roof - Building 3

Project No.: 2211

Date: October 24, 2022

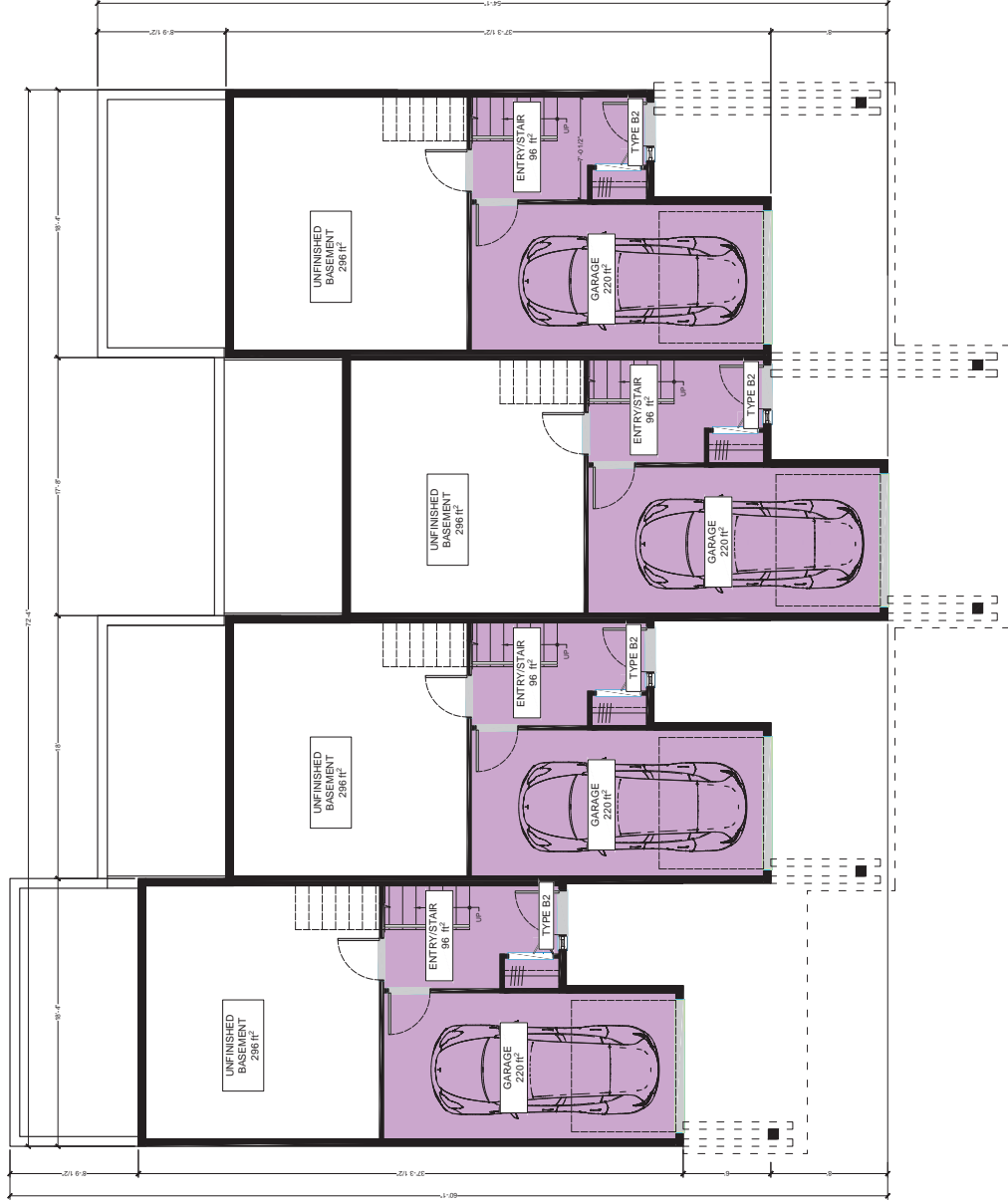
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Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



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Main Floor - Building 4

Project No.: 2211

Date: October 24, 2022 Scale: 1/4" = 1'-0"

A-11.4

Derby Townhomes
MULTI-FAMILY
DERBY ROAD, SECHELT



Second Floor - Building 4

Project No.: 2211

Date: October 24, 2022

Scale: 1/4" = 1'-0"

A-12.4

Derby Townhomes
MULTI-FAMILY
 DERBY ROAD, SECHELT



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 PHOENIX, AZ 85026-5200
 FAX: 604 885-8372



Third Floor - Building 4

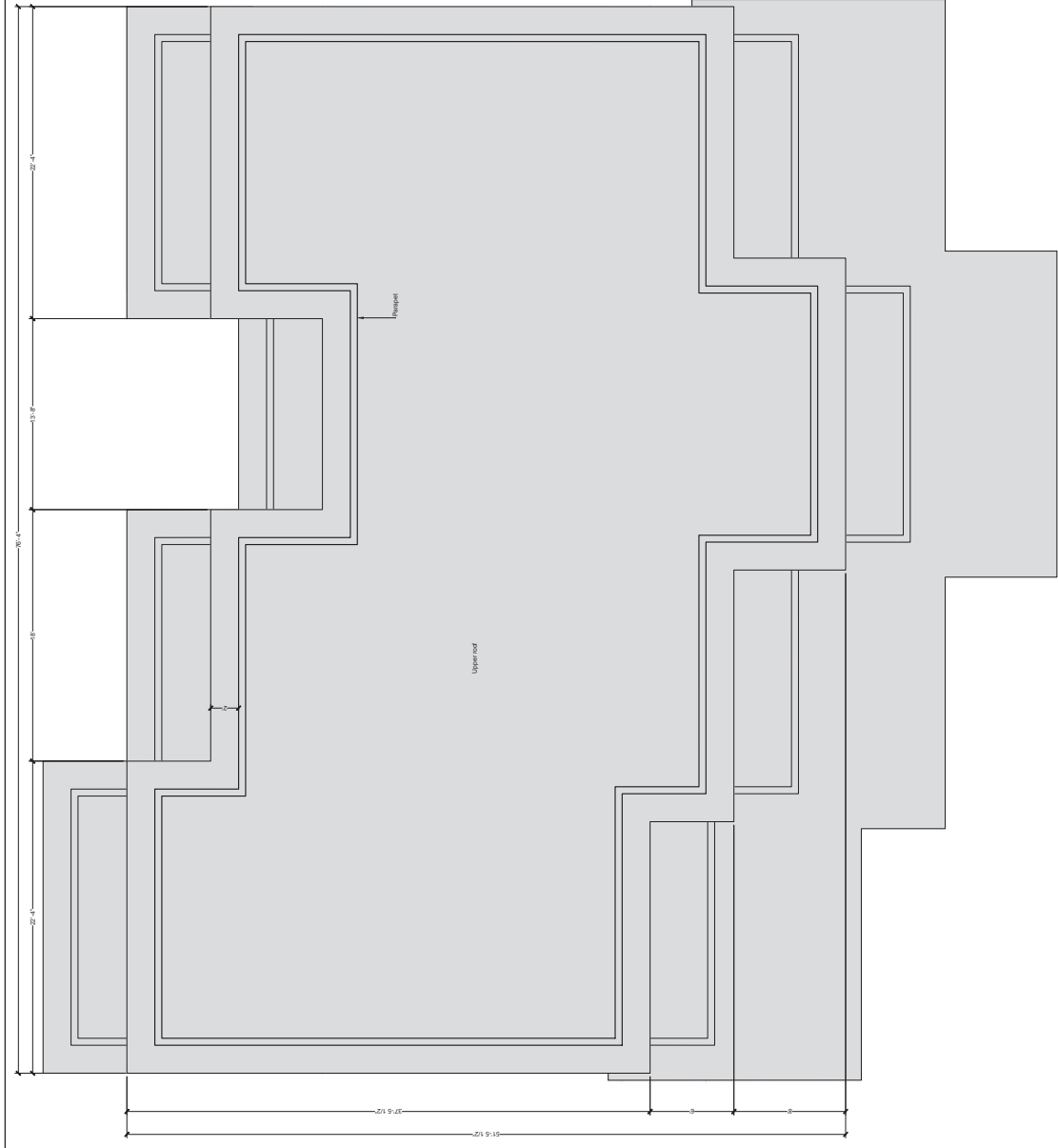
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Date: October 21, 2022

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A-13.4

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



Roof - Building 4

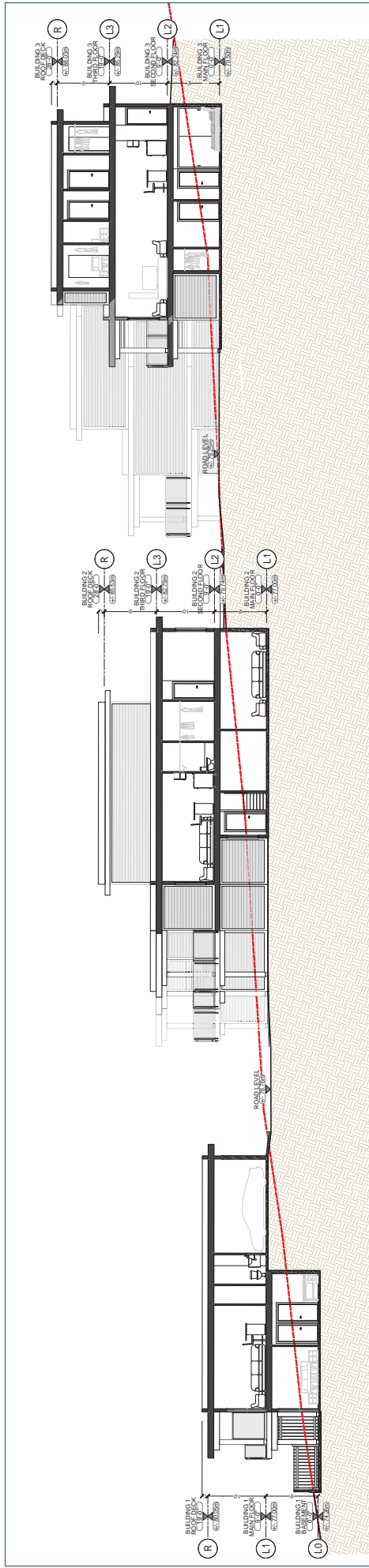
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A-14.4

Derby Townhomes
 MULTI-FAMILY
 DERBY ROAD, SECHELT



MOBIUS ARCHITECTURE
 34720 HIGHWAY 101
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1 SITE SECTION
Scale: 1/8" = 1'-0"

Derby Townhomes

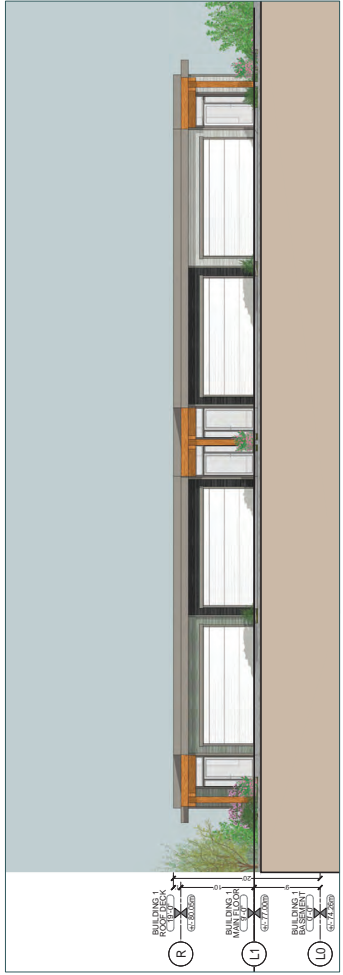
MULTI-FAMILY

DERBY ROAD, SCHELT

Site Section

Project No.: 2211
 Date: October 24, 2022
 Scale: 1/8" = 1'-0"
 Drawn: CB
 Sheet No.

A-40.1



1 NORTH ELEVATION
Scale: 1/8" = 1'-0"



2 EAST ELEVATION
Scale: 1/8" = 1'-0"



3 SOUTH ELEVATION
Scale: 1/8" = 1'-0"



4 WEST ELEVATION
Scale: 1/8" = 1'-0"

Derby Townhomes

MULTI-FAMILY

DERBY ROAD, SCHELT

Elevations - Building 1

Project No.:	2211
Date:	October 24, 2022
Scale:	1/16" = 1'-0"
Drawn:	CB
Sheet No.:	A-50.1



1 NORTH ELEVATION
Scale: 1/8" = 1'-0"



2 EAST ELEVATION
Scale: 1/8" = 1'-0"



3 SOUTH ELEVATION
Scale: 1/8" = 1'-0"



4 WEST ELEVATION
Scale: 1/8" = 1'-0"

Derby Townhomes

MULTI-FAMILY

DERBY ROAD, SCHELT

Elevations - Building 2

Project No.: 2211
 Date: October 24, 2022
 Scale: 1/16" = 1'-0"
 Drawn: CB
 Sheet No.

A-50.2



1 NORTH ELEVATION
Scale: 1/8" = 1'-0"



2 EAST ELEVATION
Scale: 1/8" = 1'-0"



3 SOUTH ELEVATION
Scale: 1/8" = 1'-0"



4 WEST ELEVATION
Scale: 1/8" = 1'-0"

Derby Townhomes

MULTI-FAMILY

DERBY ROAD, SCHELT

Elevations - Building 3

Project No.: 2211
 Date: October 24, 2022
 Scale: 1/16" = 1'-0"
 Drawn: CB
 Sheet No.

A-50.3



1 NORTH ELEVATION
Scale: 1/8" = 1'-0"



2 EAST ELEVATION
Scale: 1/8" = 1'-0"



3 SOUTH ELEVATION
Scale: 1/8" = 1'-0"



4 WEST ELEVATION
Scale: 1/8" = 1'-0"

Derby Townhomes

MULTI-FAMILY

DERBY ROAD, SCHELT

Elevations - Building 4

Project No.:	2211
Date:	October 24, 2022
Scale:	1/16" = 1'-0"
Drawn:	CB
Sheet No.:	A-50.4



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Water Management Feasibility Study

23-808 Sechelt Coast Water Management (Derby Development – 52 Units)

Date: July 19, 2023

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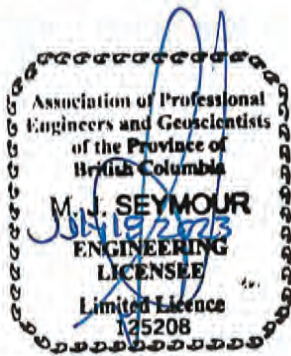
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1.0 Introduction

Sawarne Lumber Co., Ltd. is in the planning and approval process for a new development within the SilverStone Heights community. The Derby Townhomes development is the first of several multi-family projects scheduled to be built within the SilverStone Heights community. The proposed development is located within the District of Sechelt, between West Sechelt and Sechelt, along the Strait of Georgia. A series of eleven buildings is proposed, each being a cluster of 4 to 6 townhouses. A total of 52 townhomes are proposed, with a variety of 2, 3, and some 4-bedroom units. The development will be connected to Chapman Water System within the Sunshine Coast Regional District (SCRD). The Chapman Water System supplies water to approximately 90% of the population of the Sunshine Coast, including Electoral Areas B, D, E, F, District of Sechelt, and shíshálh Nation.



Figure 1: Location of Proposed Development

2.0 Background

In many areas of British Columbia, including the Sunshine Coast, the climate is characterized as ‘wet coastal’ where the winters are mild and rainy, and the summers are warm and generally dry. The dry, warm summers result in a significant increase in water usage over this period which can put stress on source waters (e.g., streams and lakes, and groundwater tables). To reduce these stresses, water conservation measures are often implemented regionally. As of May 1, 2023, the SCRCD is in Stage 1 Water Conservation Regulations which limits irrigation.

Climate change is increasing the stresses on Canadian water systems. In British Columbia, climate change is expected to increase average annual temperatures and precipitation quantities (B.C. Ministry of Environment, 2023). Although precipitation is expected to increase, this may not occur during summer months, and may only occur in some areas while others experience decreases in precipitation (B.C. Ministry of Environment, 2023). The impact of climate change on the Sunshine Coast is anticipated to be warmer and drier summers, necessitating more extreme water conservation measures that last for longer periods.

Based on this, as part of the approval process for the proposed Derby Townhomes development, the District of Sechelt have requested a report be prepared by a registered professional, evaluating water conservation methods including, but not limited to rainwater harvesting for outdoor irrigation and greywater re-use within dwelling units. The conservation methods should aim to significantly reduce SCRD water consumption. Concurrently, they must also be cost-effective from both capital and operational perspectives in keeping with the consideration of affordable housing costs. Whether this can be offset by additional storage at the regional level is a consideration the District will have to address as well.

3.0 Purpose and Scope

MSR Solutions (MSRS) was retained by Sawarne Lumber Co., Ltd. to complete a water management feasibility study for the proposed Derby Townhomes development.

The report includes the following:

- Estimation of water demand for the proposed 52 townhouses, including toilet flushing and irrigation demand.
- An overview of six water conservation measures; the feasibility, water usage reduction potential, and any challenges associated with each.
- A cost assessment for each alternative.
- A water reduction analysis of each alternative.

4.0 Water Demand (Average Daily Demand)

The Average Daily Demand (ADD) represents the total water demand that is exerted on the system by all users on a normal day. The ADD estimation is reviewed for the proposed Derby Townhomes development considering different methods.

4.1 Rural Residential Guideline

The ADD includes indoor demand, irrigation, and water loss. Based on the Design Guidelines for Rural Residential Community Water Systems (2012), the ADD can be calculated using the following equation.

$$\textit{Average Daily Demand (ADD)} = \textit{Indoor Demand} + \textit{Irrigation} + \textit{Water Loss}$$

Using the above equation, the ADD for the entire development is estimated at 43.6 m³/day. Considering 52 townhomes, the ADD is estimated at 839 L/day/unit (271 liters per capita per day (LPCD)), all as detailed following.

4.1.1 Indoor Demand

According to the guideline, indoor demand shall be based on a water use rate of 230 LPCD with the following typical occupancy rates:

- a) 3.5 persons per single detached dwelling and duplexes.
- b) 2.5 persons per multi-family residential.
- c) 4 persons per commercial recreation on lakes, golf courses, and other recreational destinations.

According to the BC guideline, recommended occupancy rates differ based on the type of dwelling. For duplexes, a typical occupancy rate of 3.5 persons per unit (PPU) is recommended, while for multi-family residences, including condos and apartments, a rate of 2.5 PPU is suggested. Townhouses, which are technically more similar to duplexes, fall in between, and their occupancy rate can range from 2.5 to 3.5 PPU.

For the proposed Derby Townhomes development, which includes 2-, 3-, and 4-bedroom units, an assumed occupancy rate of 3.1 PPU is being considered. This rate takes into account the specific characteristics and dwelling types of the townhomes, ensuring a more accurate assessment.

It is worth noting that over time the occupancy rates will vary and 3.1 PPU is a reasonable assumption to allow for a factor of safety in calculations.

Based on the occupancy rate of 3.1, the total population for the proposed 52 townhomes is estimated at 161. Considering the water use of 230 LPCD, the indoor water demand is calculated at 37 m³/day for the entire development, and 712 L/day/unit.

4.1.2 Irrigation Demand

The irrigation demand is dependent on several parameters such as evapotranspiration, crop type, irrigation area, soil types, and irrigation efficiency.

According to B.C. Design Guidelines for Rural Residential Community Water Systems (2012), B.C. can be divided into 6 climatic zones according to specific evapotranspiration rates. Based on this, Sechelt is located in the Northern/Wet Coastal area.

Since the proposed development is for a residential subdivision, it is assumed that grass is the typical crop being irrigated. Additionally, since all new water systems must provide metering to customers, an irrigation efficiency of 70% should be used.

With 70% efficiency irrigation in a Northern/Wet Coastal area, a peak irrigation rate of 20 m³/ha/day is assumed.

Based on the proposed green space and area to be irrigated, it has been determined that an irrigated area of 25 m² will be allocated for each unit. Considering an irrigation rate of 20 m³/ha/day, the irrigation demand for each

unit can be estimated at 50 L/day/unit, or 2,600 L/day (2.6 m³/day) for the entire development. This is already below the potential irrigable design consideration.

4.1.3 Water loss

For existing infrastructure, the water loss should preferably be calculated following the International Water Association (IWA) and the American Water Works Association (AWWA M36). Losses are based on physical system parameters including length of mains, number of service connections, and average operating pressure. When reliable data about existing network systems is not available or the project is a new water system, the design engineer shall consider an average of 10% water loss. From this, the water loss can be estimated at 77 L/day/unit, or 4,000 L/day for the entire water system.

5.0 Comparative Water Demand as Baseline ADD

5.1 Chapman Water System

The SCRCD supplies water to the community via the Chapman Water System and the proposed development will be connected to this water system. The Chapman Water System has several water sources, including Chapman Creek as a primary source, and Gray Creek and Aquifer 560 as the secondary sources in summer months.

In 2021, the Chapman Water Treatment Plant provided 4.2 million m³ of potable water to approximately 10,600 active service connections. For future detailed design, more information about the type of each connection, metering data, and pumping records should be reviewed to determine accurate water demand based on actual data for this community.

Considering a total of 10,600 single-family equivalents (SFEs) for all connections and 3.1 people per SFE (as explained in Section 4.1.1), the ADD can be estimated at 350 LPCD, and 56 m³/day for the entire development.

This is significantly higher than what is expected from estimates from the proposed development. This is in part to a reduced irrigation area for the development compared to current averages, as well as water conservation measures already employed within the BC Building Code, Plumbing Code for water efficient fixtures, compared to existing infrastructure in Sechelt.

5.2 Sechelt Water Resource

The community wastewater is treated at the Sechelt Water Resource Centre (WRC), which was constructed in 2015. From a wastewater perspective, indoor water usage can be determined by considering dry weather flow data from the sewer systems. WRC was noted to receive an average flow of 2,200 m³/day from a connected population of 6,000 people. Therefore, the average sewage flow is estimated at 367 LPCD which represents indoor demand as well as inflow and infiltration (I&I).

The water flow can be estimated based on sewage flow considering a conversion factor of 1.1, since water demand is typically 10% higher than sewage flow. However, the I&I contribution should be eliminated, and only dry

weather sewage flow used to estimate the water demand. Comparing WRC sewage flow and Chapman water flow, the sewage flow is about 5% higher than the water flow. This demonstrates that the I&I contribution impacts determination of comparative baseline ADD. Since the exact contribution of I&I in WRC sewage flow is not clear, this approach will not provide an accurate estimation of the community water demand, and we have considered the Chapman Water system as current expectations from the site, without conservation.

5.3 Water Demand Summary

The ADD for the Derby Townhomes development was assessed by considering three approaches, including Rural Residential Guidelines, Chapman Water System, and Sechelt Water Resources flow data.

The water demand should preferably be established from reliable water consumption records. When data is not available, the design engineer shall calculate the critical demands based on guidelines and regulations methods. For this assessment, the BC Rural Residential Guideline was used to estimate the water demand, with the results summarized in Table 1.

Table 1: Water Demand Estimation

Development	Population	Indoor demand	Irrigation Demand	Water Loss	Total ADD
Derby Townhomes (52 units)	161	37 m ³ /day	2.6 m ³ /day	4 m ³ /day (10%)	44 m ³ /day (271 LPCD)
Baseline Current Chapman Flows	161				56 m ³ /day (350 LPCD)

The ADD is estimated for each unit at 840 L/day/unit, or 44 m³/day for the entire development. It is worth mentioning that the current assessment only considers the ADD which represents the average demand on a normal day. All recommended water conservation measures are based on reducing this estimated ADD for the proposed development.

6.0 Water Conservation Measures

To accommodate the water demand for the proposed Derby Townhomes development, while also considering current and future water supply challenges, six water conservation measures have been proposed. These water conservation measures include:

- Rainwater Harvesting
- Greywater Reuse
- Xeriscaping™

- Leak Detection
- Indoor Conservation
- Public Education

The water demand contains different components including indoor, irrigation, and water loss, and each of the above measures can reduce one or more of these component demands.

To propose a comprehensive framework for reducing water demand, the contribution of each component demand should first be determined. The average water demand for each unit is estimated at 840 L/day/unit, allocating 713 L/day for indoor demand, 50 L/day for irrigation, and 77 L/day for water loss.

Toilet flushing is one of the most frequently discussed applications of greywater reuse and rainwater harvesting, which can decrease household indoor water consumption. The toilet flushing demand is estimated for the proposed development as follows.

The Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing (2010) have been developed to reduce water consumption, in response to the growing interest in water conservation in Canada. The guideline focuses on required water quality for safe reuse rather than information on the required demand for toilet flushing. Therefore, the National Plumbing Code of Canada (NPC) 2020 is used to determine the toilet flushing demand for the 52 proposed townhouses.

The NPC specifies a maximum water usage of 4.8 L per single flush for residential water closets. To calculate flushing demand, 5 flushes per person per day is assumed (D.D. Baumann, J.J. Boland, and W.M. Hanemann, 1998). Considering an occupancy rate of 3.1, the toilet flushing demand is estimated at 74 L/day/unit, or 3.9 m³/day for the entire development.

It should be noted that Table 3-8 of Metcalf & Eddy Wastewater Engineering compares indoor water use without and with water conservation practices in the United States. This comparison shows that water demand without water conservation (281 LPCD) can reduce to 197 LPCD by considering water conservation practices. This table shows that water usage through leakages and toilet flushing can be significantly reduce by water conservation measures.

6.1 Rainwater Harvesting

Rainwater can be collected onsite and used to offset water demand. The B.C. Plumbing Code allows rainwater to be used for non-potable purposes including flushing toilets and for direct connection to underground irrigation systems. Alternatively, rainwater could potentially be used for potable use.

Rainwater Harvesting for drinking purposes is usually regulated by guidelines from regional districts. If the harvested rainwater is going to serve more than one family home, permission must be obtained from Vancouver Coastal Health (VCH) according to the *Drinking Water Protection Act* and the *Drinking Water Protection Regulation*. Additionally, under these regulations, the collected rainwater must be disinfected and meet bacteriological drinking water quality standards to protect human health.

Since the developer is only interested in rainwater harvesting for irrigation of common areas and private yards, storage calculations for this report only considered irrigation water demand.

6.1.1 Rainfall Data

An understanding of rainfall trends near the proposed development site is important to evaluate the feasibility of rainwater harvesting for various purposes. Historical, average monthly rainfall for Sechelt BC was obtained from the Government of Canada website. The average rainfall between 2015 and 2023 is presented in Figure 2.

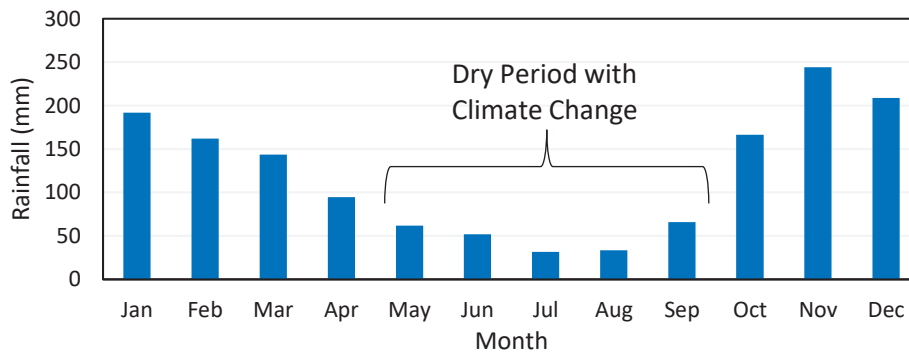


Figure 2: Average Monthly Historical Rainfall Data for Sechelt BC

This rainfall data is used to assess the feasibility of using rainwater harvesting on an individual lot scale to meet water supply requirements.

With climate change, there is anticipated to be longer periods of drought, especially during warmer months from May to September (Figure 2). However, this does not necessarily mean that the total annual rainfall quantity will be reduced. More rainfall may occur during the winter months, which can still be harvested and used throughout the rest of the year.

6.1.2 Storage Potential

To assess the potential for utilizing rainwater capture to provide supply water on an individual lot scale, several assumptions were made.

- The roof area available for rainwater capture was assumed to be 100 m² (~1080 ft²) for each townhouse based on average townhouse sizes.
- Water losses were based on the ‘first flush’ principle, in which the initial 1 mm rainfall is diverted to remove accumulations of dust and other solids, with a ‘first flush’ volume of 100 L used.
- Additional water losses will commonly occur due to factors such as splashing, evaporation, leakage, etc. A loss volume of 200 L is used, totaling 300 L when combined with the first flush losses.
- The rainwater storage unit begins empty.
- Rainwater collection begins in January.

6.1.2.1 Rainwater to Meet Irrigation Demand

With a roof capture area of 100 m², there is a potential to recover about 80% of the rainfall across this roof area annually. With an irrigation demand of 50 L/day/unit over a dry summer, a 9.6 m³ (9,600 L) storage tank can capture sufficient water to cover the irrigation demand for each residence. This tank size assumes that there are four consecutive months (i.e., 120 days) without rain over the summer. Based on this, the storage tank has to be relatively large to store rainwater during extended dry periods. The rainwater storage versus water consumption for irrigation is shown in Figure 3.

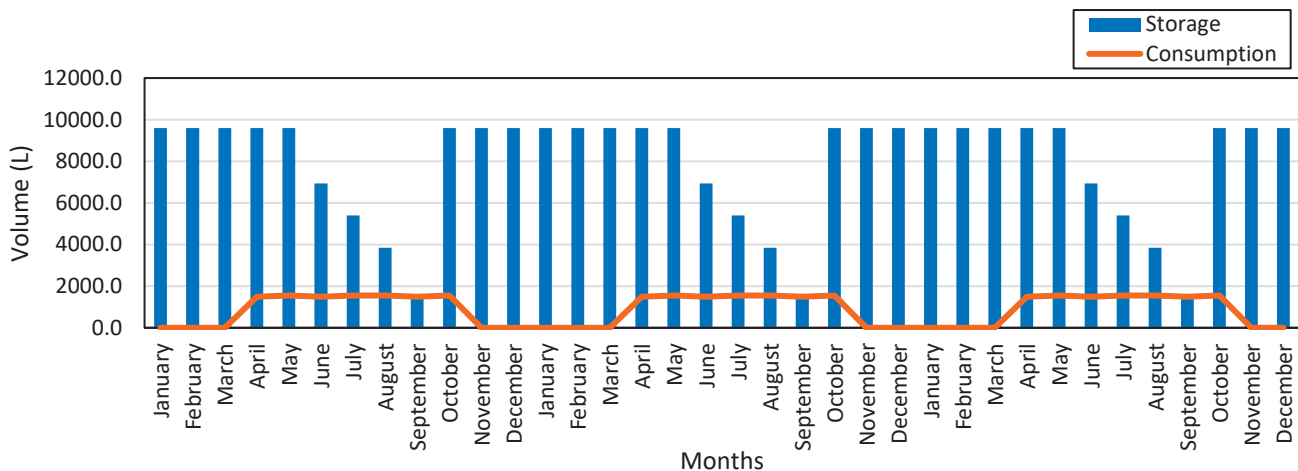


Figure 3: Water Consumption for Irrigation Versus Storage During Rainwater Harvesting

While utilizing rainwater harvesting to offset all irrigation water demand was considered for this report, smaller storage tanks could be installed to partially offset this demand or be used for smaller irrigated areas.

6.2 Greywater Reuse

Greywater reuse systems collect greywater from households (e.g., from sinks, laundry, dishwashers, bathtubs, and showers) and treat the water to a quality that can be reused for non-potable purposes such as toilet flushing.

Prior to reuse, collected greywater must be treated. Due to the presence of chemicals and other constituents from household products (e.g., sulfates from soaps and detergents), and properties of captured greywater (e.g., temperature), the required treatment is more extensive than for collected rainwater. For example, warmer temperature showers and bath water produce conditions that are favorable for microbiological growth. The treatment would need to be similar to typical wastewater treatment systems, e.g., an aerobic biofilm-based system. However, this type of system is also expensive and requires specially trained operators.

In addition to the complexity of operations and maintenance, the construction and commissioning of these systems can also present challenges. Greywater recycling systems require twice the amount of piping within a residence relative to typical plumbing. Blackwater and greywater leaving a residence will need to be separated, where greywater would be diverted to an onsite treatment system. After treatment, the greywater would need to be conveyed back to each residence for reuse for toilet flushing. This would require a second water line into

each residence, separate from potable water. Color-coated piping and rigorous inspections during construction are required to mitigate against the potential of cross-connecting potable and non-potable sources.

6.2.1 Produced Greywater

The BC Ministry of Health manual recommends that greywater flows be estimated by taking the applicable sewage Daily Design Flow (DDF) and applying an adjustment factor to account for the portion of total wastewater flow that is diverted to the greywater system.

The sewage flow can be estimated based on indoor water demand considering a conversion factor of 0.9, since water demand is typically 10% higher than sewage flow.

For the purposes of this report, the sewage DDF (considering a conversion factor of 0.9) is estimated at 210 LPCD, or 640 L/day/ unit.

The BC Ministry of Health manual lists an adjustment factor of 0.65 for light greywater and 0.35 for laundry greywater. For this report, we will assume an adjustment factor of 0.35 to be conservative. Using an average sewage flow of 640 L/unit/day and an adjustment factor of 0.35, the average greywater collected would be 225 L/day/unit with a total of 11,500 L/day for all units.

The average greywater collected for each unit (225 L/day/unit) exceeds the toilet flushing demand of 74 L/day/unit. Therefore, due to the complexity of the greywater reuse system, if it is considered, it is recommended to reuse it for toilet flushing and irrigation demands. The irrigation demand for each unit is estimated at 50 L/day. Therefore, 125 L/day of produced greywater can be reused for both toilet flushing and irrigation demands. This would eliminate rainwater tanks.

6.3 Xeriscaping™

Outdoor water usage increases the MDD for a community, which in turn increases requirements for water conveyance, storage, and treatment. Furthermore, in regions that experience droughts and dry seasons, such as the Sunshine Coast, local water demands can significantly increase during these periods which can stress water systems and sources.

A method of reducing outdoor water demand is incorporating Xeriscaping™. Xeriscaping™ incorporates the following principles into landscaping (USEPA, 1998):

- **Planning and design:** the first and most important step in Xeriscaping™ is creating a plan. The plan should include information on the site including soil conditions, sunlight, wind, weather, etc.
- **Limited turf areas:** while lawns provide pleasant recreational and outdoor living space, they also typically have large water requirements relative to other plants. Lawn space should be minimized to help reduce water requirements.
- **Efficient irrigation:** irrigation requirements will depend on many factors (e.g., plant type, weather, etc.). When irrigation is required, it should be done more efficiently to minimize water usage, e.g., watering




deeper into soils and less frequently can encourage deep rooting of plants and make them more drought resistant.



- **Soil improvement:** it is easier to find plants that can grow in existing site soil; however, amendments can be added to improve soil quality (e.g., adding compost to improve moisture holding capacity).
- **Mulching:** adding mulch around plants has many benefits including adding nutrients to the soil, controlling weeds, and protecting roots from heat, cold, and drought.
- **Appropriate plant selection:** plant selection is important and highly location specific, e.g., use of lower water demand plants in dry and drought prone regions.
- **Appropriate maintenance:** Xeriscaping™ can help reduce maintenance requirements over time, however, general maintenance is still required including weeding, mowing, pruning, fertilizing, and watering.

Xeriscaping™ is recommended and promoted by the SCR D for reducing outdoor water usage.

The Okanagan Xeriscape™ Association (OXA) plant database can be used to select plants for the climatic zone of the proposed development (i.e., Zone 4), light and water requirements, and other plant characteristics (e.g., height, colour, etc.) and features (e.g., deer resistant, attracts pollinators, etc.). Some examples of plants for Zone 4, which grow in dry conditions and partial sun that also resist deer are included in Table 2.

Table 2: Examples of Drought Resistant Plants Able to Grow at the Development Site (from OXA Plant Database)

Common Name	Type	Features	Photo
Common Juniper	Ground Cover, Shrub	Deer resistant, edible, excellent heat resistance	
Cushion Spurge	Perennial	Deer resistant, self-seeder, excellent heat resistance	
Daffodil	Bulb	Deer resistant, fragrant, excellent heat resistance	

Common Name	Type	Features	Photo
Elfin Thyme	Ground Cover	Attracts pollinators, deer resistant, excellent heat resistance, fast growth rate	
Douglas Fir	Tree	Food for birds, too large for an urban yard but good for naturalized setting, fair heat resistance, moderate growth rate.	

6.3.1 Cost and Benefits

Xeriscaping™ typically costs \$75 to \$300 per m² (Spiridon, 2023). The actual cost will vary based on several factors including the landscaping style, location and climate, and soil and subsurface conditions. This cost range includes both the design and installation of the Xeriscape™. The cost of Xeriscape™ has no impact on the house price as landscaping initial costs are assumed similar.

Planting low-water and drought-resistant plants that are suitable for the location of the proposed development can reduce outdoor water requirements by more than 50% as shown in Kamloops, BC (Kamloops, n.d.). Based on the estimated irrigation demand, this would reduce the irrigation demand for the proposed development by about 1,300 L/day.

6.4 Leak Detection

A key component that is often overlooked in water conservation strategies and initiatives is leakages on the supply side. This water conservation measure has a direct impact on the assumed 10% water loss through the water system. Water accounting systems can be implemented to track water throughout the distribution network to identify areas that may need maintenance or repairs, in particular, where there are large volumes of unaccounted water. Unaccounted water, also known as ‘non-account water’, can include water that is metered but not billed, and also all unmetered water (USEPA, 1998).

Unmetered water can include any of the following:

- Public uses (e.g., fire hydrants)
- Unauthorized uses

- Malfunctioning system controls
- Thefts
- Inaccurate meters
- Leaks

On an individual space, smart meters on homes can be used to diagnose leakage within properties. Flow monitoring into the development can also be used to diagnose leakage in the water mains.

6.4.1 Cost and Benefits

Smart meters can provide many benefits for homeowners including (Brears, 2019):

- Setting water consumption thresholds and time of use controls (e.g., setting times for irrigation)
- Track the timing and volume of water consumed each day to identify inefficiencies
- Identify leaks and water wastage (e.g., run test where meter should read zero, if above zero, indicates a leak or water wastage)
- Provide metrics for water conservation efforts
- Can reduce water bills

The cost of smart water meters in Canada can vary depending on various factors, such as the brand, model, and features of the meter, as well as the installation and maintenance costs. However, based on industry estimates and data from suppliers, the average cost of a smart water meter in Canada can range from \$200 to \$500 per meter plus installation cost.

It's important to note that this cost may not include additional expenses such as installation, data management software, and ongoing maintenance costs. These additional costs can vary depending on the specific supplier, installation requirements, and the number of meters needed.

In terms of the benefits of installing smart water meters, there have been a limited number of studies specifically examining the impact of smart water meters on water demand in Canada. However, studies conducted in other countries with similar water systems and usage patterns suggest that the potential water demand reduction through the use of smart water meters in Canada could be significant.

For example, a study conducted in the UK found that households with smart water meters reduced their water usage by an average of 12% (UKWIR, 2019). Another study conducted in California found that the use of smart water meters led to an average reduction in water consumption of 6-8% (Schultz, Javey, & Sorokina, 2018). These findings suggest that the use of smart water meters in Canada could lead to similar water savings. Additionally, several municipalities as the City of Guelph in Ontario and the City of Kelowna in British Columbia in Canada have implemented smart water meter programs with positive results.

Overall, while the exact amount of water demand reduction achieved through the use of smart water meters in Canada may vary depending on various factors such as user behavior and the effectiveness of conservation

programs, the potential for water savings is significant, and smart water meters can be an important tool in achieving more sustainable and efficient water use.

A 10 % water loss is assumed for the water system of the proposed development and by the installation of a smart water meter it can reduce to 5%. The water loss for the entire system is estimated at around 4,000 L/day and by using this system it can decrease to 2,000 L/day (40 L/day/unit).

6.5 Indoor Conservation

Since the proposed development will consist of 52 newly constructed townhouses, all residences will be equipped with modern, low-flow fixtures as required under Section 10.3 of the B.C. Plumbing Code. Section 10.3 specifies maximum flow rates for residential bathroom faucets, kitchen faucets, and shower heads and maximum flush cycles for toilets. Water reductions using low-flow fixtures relative to full flow fixtures are outlined in Table 3.

Table 3: Estimation of Water Reductions Using Low-Flow Fixtures

Parameter	Fixture			
	Kitchen Faucet	Bathroom Faucet	Shower Head	Toilet
Typical Usage ¹	0.5-5 faucet-use minutes per person per day (avg. 2.75 min/person/day)	0.5-3 faucet-use minutes per person per day (avg. 1.75 min/person/day)	5-15 shower-use minutes per person per day (avg. 10 min/person/day)	4-6 flushes per person per day (avg. 5 flushes/person/day)
Flows for Low-Flow Fixtures ²	8.3 L/min	5.7 L/min	7.6 L/min	4.8 L/min
Total Daily Flows for Low-Flow Fixtures ³	71 L/day	31 L/day	236 L/day	74 L/day
Percent Water Reduction Relative to Full Flow Fixtures ³	30%	30%	25%	20%
Flow Reduction Per Household with Low-Flow Fixtures	~21 L/day	~10 L/day	~59 L/day	~15 L/day
Flow Reduction for Entire Development with Low-Flow Fixtures ⁵	~1,100 L/day	~520 L/day	~3,100 L/day	~800 L/day
Total Flow Reduction for Entire Development with Low-Flow Fixtures	~5,500 L/day			

¹ From D.D. Baumann, J.J. Boland, and W.M. Hanemann (1998)

² From Section 10.3 of B.C. Plumbing Code

³ Assuming an occupation rate of 3.1 people per unit

⁴ From O’Leary Plumbing, Heating & Electrical

⁵ Based on 52 townhouses

Implementing low-flow fixtures in all of the 52 proposed townhouses results in an estimated total flow reduction of about 5,500 L/day relative to full flow fixtures. Since the installation of low-flow fixtures is already required by the B.C. government, this conservation measure would not cost the developer any additional capital above current housing costs.

6.6 Public Education

Providing information and educating the public is essential for the success of all water conservation measures. It has been shown that customers that are informed and involved in water conservation initiatives are more likely to support the measures and reduction goals (USEPA, 1998).

Some examples of individual and public education initiatives for water conservation are outlined in Table 4.

Table 4: Examples of Public Education Initiatives for Water Conservation

Education Measure	Example Initiatives
Providing Information Directly to Homeowners:	<ul style="list-style-type: none"> • Pamphlet on simple water conservation practices for the home (example provided in Appendix A) • Pamphlet on outdoor water conservation measures
Public Education Programs:	<ul style="list-style-type: none"> • Advertise water conservation measures in public spaces, e.g., the communal community greenspace • Run a water conservation education campaign with a pop-up information booth within the community • Provide content for community groups, e.g., pamphlets or slideshows on water conservation

Water savings directly related to public education is difficult to quantify. The reduction in water demand through education can vary widely depending on the effectiveness of the educational program, the region and population size, and other factors. However, many studies have shown that education can be an effective tool in promoting water conservation and reducing water demand.

In some cases, education programs have led to significant reductions in water use, upwards of 20% in residential water consumption (March, H., Domènech, L., Saurí, D., 2013). However, most studies have found more modest reductions in water demand through education programs. For example, a study in the United States found that an education and outreach program in a suburban community led to a 5% reduction in water use (Renwick M.E., Green R.D., 2000). Similarly, a study in the Canadian province of Ontario found that an educational program aimed at promoting water-efficient behaviors in households led to an average reduction in indoor water use of 3.8% (Atwood, C., Kreutzweiser, R. and De Loë, R., 2007).

Overall, while the specific reduction in water demand through education can vary depending on a variety of factors, education has been shown to be an effective tool in promoting water conservation and reducing water

use. The USEPA Water Conservation Plan Guidelines (1998) recommends combining public information and education campaigns with other, direct water conservation measures (e.g., low flow fixtures or leak repairs), to maximize results.

Assuming an overall reduction in household water demand of 5% through public education programs, each household would reduce their ADD by about 40 L/day/unit.

7.0 Cost Assessment of Proposed Conservation Measures

The cost assessment of proposed conservation is a rough estimation based on MSR experience in similar projects as presented in Table 5.

Table 5: Cost Assessment

Conservation Measure	Water Saved	Estimated Cost / Unit	Annual Strata Fee Contribution / Unit
Greywater Recycling	~220 L/day/unit, or ~11.5 m ³ /day for Entire Development	\$8,000 - \$10,000 (Treatment Equipment and external piping)	\$350 - \$400
Rainwater Harvesting	25 L/day/unit, or 1.3 m ³ /day for Entire Development (If Reused for 50% of Irrigation Demand)	\$5,000 - \$8,000	\$200 - \$350
Xeriscaping™	25 L/day/unit, or 1.3 m ³ /day for Entire Development (50 % of Irrigation Demand)	Same as landscaping	---
Leak Detection	40 L/day/unit, or 2 m ³ /day for Entire Development (Reduce Water Loss to 5%)	\$2,000 per water meter	\$150
Indoor Conservation ^a	No Additional Water Reduction	---	---
Public Education	40 L/day/unit, or 2 m ³ /day for Entire Development		\$150
Dual Piping	As part of separate plumbing systems additional stack and distribution systems required inside buildings	\$10,000 - \$15,000	\$200 - \$300
Engineering and Contingency (35%)	Allowance for engineering design, and contingency	\$8,750 - \$12,250	\$370 - \$470
Total Impact on House Price		\$34,000 - \$47,000	\$1,400 - \$1,800

^a Low-flow fixtures required under B.C. Plumbing Code

The base costs are typical of a housing development connected to municipal sewer and water. The service costs and annual costs are based on typical sewer and water meter charges by the local government.

Table 5 summarizes the cost of different conservation measures for the proposed development. While providing the largest water reduction relative to the other proposed conservation measures, greywater recycling has the highest capital cost due to the collection, treatment, conveyance and operations aspects. Maintenance costs are to allow for power, chemicals, and other consumables as well as for equipment maintenance. A capital replacement fund will also be required for greywater recycling to support major component replacement (typically every 10 to 15 years). In addition to maintenance costs, a trained operator will need to be retained to operate the treatment system.

A \$130/m² or total of \$145,000 for the entire development is assumed for Xeriscaping™ which had no impact on the house price since it is assumed that the costs are similar to traditional landscaping. The Xeriscaping™ gives guidance on selecting appropriate plants that require low water for initial landscaping.

8.0 Discussion of Water Conservation Methods

Six water conservation measures, including their water usage reduction potential, have been assessed and rough cost estimations for each have been included. These water conservation measures include rainwater harvesting, greywater reuse, Xeriscaping™, leak detection, indoor conservation, and public education.

Greywater reuse systems can significantly reduce water consumption by about 125 L/day per unit (15% of the total demand of 839 L/day). However, the cost and complexity of operating and maintaining a greywater system make this option less viable for water conservation at the proposed development.

For a much lower capital cost, as well as less operation and maintenance requirements, rainwater harvesting could be implemented to supply the demand for toilet flushing or irrigation throughout the year. With rainwater being a much cleaner source, the operation and maintenance of a rainwater systems are typically easier and less expensive compared to a greywater system. Rainwater harvesting is only considered for irrigation of common areas and private yards. Water harvesting can supply an irrigation demand of 50 L/d/unit.

Xeriscaping™ has a lower cost compared to rainwater harvesting and has the potential to reduce 50% of irrigation demand with the potential for complete elimination of irrigation. Furthermore, this option results in lower ongoing operation and maintenance costs relative to traditional landscaping.

The installation of smart water meters is an economical and effective method of reducing water demand. The costs are lower than greywater reuse, rainwater harvesting, or Xeriscaping™, and the water reduction is similar to Xeriscaping™. The ongoing maintenance of these meters would be the homeowner's expense. A 10% water loss is initially assumed, and the installation of smart water meters can reduce this water loss to 5%.

The installation of low-flow fixtures results in water savings similar to greywater reuse when compared to traditional fixtures. Since the installation of low-flow fixtures is already required by the B.C. government, no new water savings is achieved, and this conservation measure would not cost the developer any additional capital.

Public education programs are inexpensive methods of getting individuals involved in water conservation initiatives, can reduce water demand by about 5% on average, and can easily be combined with other measures.

The total water usage reduction potential is highly dependent on which of the proposed water conservation measures will be implemented. Table 6 compares the original water demand with no water conservation measures and considers potential water demand reduction for two scenarios. The first scenario considers all water conservation measures that were implemented, and the second scenario assumes only those measures that are recommended by MSR.

Table 6: Water Demand Comparison

Scenario	Indoor demand	Irrigation Demand	Water Loss	Total ADD	Cost
Original Demand: No Water Conservation Measures	37 m ³ /day	2.6 m ³ /day	4 m ³ /day (10%)	44 m ³ /day (271 LPCD)	---
Scenario 1: All Water Conservation Measures are Implemented. <ul style="list-style-type: none"> • Greywater Recycling • Rainwater Harvesting • Xeriscaping™ • Leak Detection • Public Education 	24 m ³ /day	Zero	2 m ³ /day (5%)	26 m ³ /day	\$34,000 - \$47,000 per Unit Plus Annual Strata Fee Contribution of \$1,400 - \$1,800 per Unit
	(2 m ³ /day Reduction by Public Education. 11.5 m ³ /day Supply with Greywater Reuse System)	(50% Reduction with Xeriscaping™ Method 50% Supply with Rainwater Harvesting)	(50% Reduction by Installation of Smart Water Meters)	(41% Reduction of Total ADD)	
Scenario 2: Following Water Conservation Measures are Implemented. <ul style="list-style-type: none"> • Public Education • Xeriscaping™ • Leak Detection • Indoor Conservation 	35 m ³ /day	1.3 m ³ /day	2 m ³ /day (5%)	39 m ³ /day	\$2,700 per Unit Plus Annual Strata Fee Contribution of \$400 per Unit
	(2 m ³ /day Reduction by Public Education)	(50% Reduction with Xeriscaping™ Method)	(50% Reduction by Installation of Smart Water Meters.)	(14% Reduction of Total ADD)	

9.0 Summary and Recommendations

Housing affordability and benefits of water conservation are an important consideration in determining the feasibility of system improvements. Water is supplied by the SCRD via the Chapman water system. Without

adequate water storage capacity, the SCRCD is seeking ways to offset this through innovative means to new development construction. The implications of a full suite of water saving features will severely impact housing affordability, and consideration of the most practical and achievable methods should be considered by the SCRCD in determining ways to most efficiently reduce water consumption.

Currently, water use practices as noted by the SCRCD suggest an equivalent water demand for this development would be in the area of 56 m³/day (350 LPCD). Using Design Guidelines for Rural Residential Community Water Systems (2012), the average demand for this development would be 44 m³/day (271 LPCD). As shown in Table 6, a 41% water reduction is achievable by implementing all water conservation measures. This option has a total cost of \$34,000 - \$47,000 per unit in addition to \$1,400 - \$ 1,800 annual costs.

The scenario with the best cost-benefit for housing affordability while still having a large water reduction (14% to 39 m³/day (242 Lpcd) includes smart water meter installation, Xeriscaping™ for 25 m² landscaping per residence, and ongoing public education. The cost for this option is about \$2,700 per home, with an annual strata fee of \$400 per unit.

We recommend the use of public education, indoor water conservation fixtures, leak detection systems, and Xeriscaping be implemented for this development. Xeriscaping eliminates the need for a rainwater harvesting system, as there is no irrigation demand.

The use of an overall rainwater harvesting system and greywater reuse are not recommended primarily due to the impact to housing affordability as well as operation and maintenance when region wide opportunities may prove much more cost effective.

In the event, the development decides to have an irrigation area as part of the building permit process, they will institute a rainwater harvesting system sized to the irrigation need.

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A. Appendix A: Example Water Conservation Pamphlet

Be Water Wise in the CRD

✓ Save this checklist and join others in helping conserve water for our ecosystems & community

💧 Taps off when brushing teeth

💧 Strive for a five minute shower

💧 Know what to flush

💧 Find your main water shut-off in case of an emergency water leak

💧 Check for leaky taps and toilets

💧 Replace outdated, inefficient water fixtures & appliances for high-efficiency models

To learn more, visit:
www.crd.bc.ca/water

Why Conserve Water?



Did you know that only one per cent of water on the Earth's surface is drinkable fresh water? Our region's primary drinking water source is the Sooke Reservoir.



The winter rainfall captured in the Sooke Reservoir must last through the region's dry summer months. With our growing population and a changing climate, we can all take steps to be water wise in the capital region.



Since bathroom use makes up to 65% of all indoor water use, saving water can be as easy as changing our daily habits.

The Sooke Lake Reservoir



Making a difference...together

Capital Regional District

Water Conservation
625 Fisgard Street
Victoria, BC V8W 1R7
waterwise@crd.bc.ca
www.crd.bc.ca/water

Water Wise Bathrooms



Environmental Services



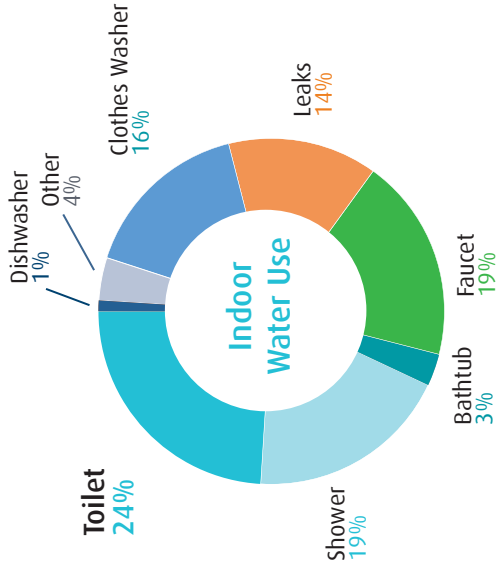
Making small changes
adds up to BIG savings!

Water Wise Toilets

Replace outdated toilets with high-efficiency models. High-efficiency toilets use no more than 4.8 L of water per flush while older toilets can use up to 20 L. Replacing inefficient toilets is the best way to save the most water in your bathroom. A family of four can save over 100,000 L of water a year by making the switch!

Reduce your daily flush count. Every time you flush your toilet, several litres of drinking water go down the drain, so limit the number of times you flush to save water.

Don't use the toilet as a trashcan. Flushing anything other than pee, poo or toilet paper is not safe for our sewer systems. Common bathroom products like flushable wipes and dental floss can cause big and costly pipe blockages.



Toilets use the highest amount of water of all indoor water consumption

Water Wise Showers

Replace inefficient showerheads. High-efficiency showerheads use between 5.6 to 7.6 litres per minute (lpm) while older models use up to 20 lpm.

Shorten your shower. Keep activities like shaving and brushing your teeth outside of the shower. Use a timer in the shower to strive for five minutes. Fill your bathtub only as full as you need.

Reuse water where possible. When waiting for your water to become warm, try capturing it for other uses, such as watering plants outside.

Check your showerhead efficiency. Contact us for a FREE shower bag to test how much water your showerhead uses. Learn more at our website.



Shorten your shower to five minutes to reduce your energy consumption and save up to 10,000 litres of water per year

Why Check for Leaks?

Household leaks make up to 14% of all indoor water use. Simple and inexpensive repairs can prevent our drinking water from being wasted.

Repair any leaky fixtures and check your toilet at least once a year for undetected leaks.

Test your tank

Most toilet leaks are easily solved by replacing worn or misaligned parts in your tank.

How to test your toilets for leaks using food colouring or a dye tablet:

- Carefully remove the toilet tank lid and place your tab or dye into the tank. Return the lid.
- Wait 15 minutes. If you see coloured water in the bowl, you have a leak.
- If you have a leak, you can fix it yourself or call a plumber, depending on your comfort level.

Contact waterwise@crd.bc.ca for FREE dye tablets.

Intermittent drips

An intermittent drip from your faucet or showerhead can waste more than 35,000 litres of water a year, costing you money. This wasted water could fill a bathtub over 100 times!

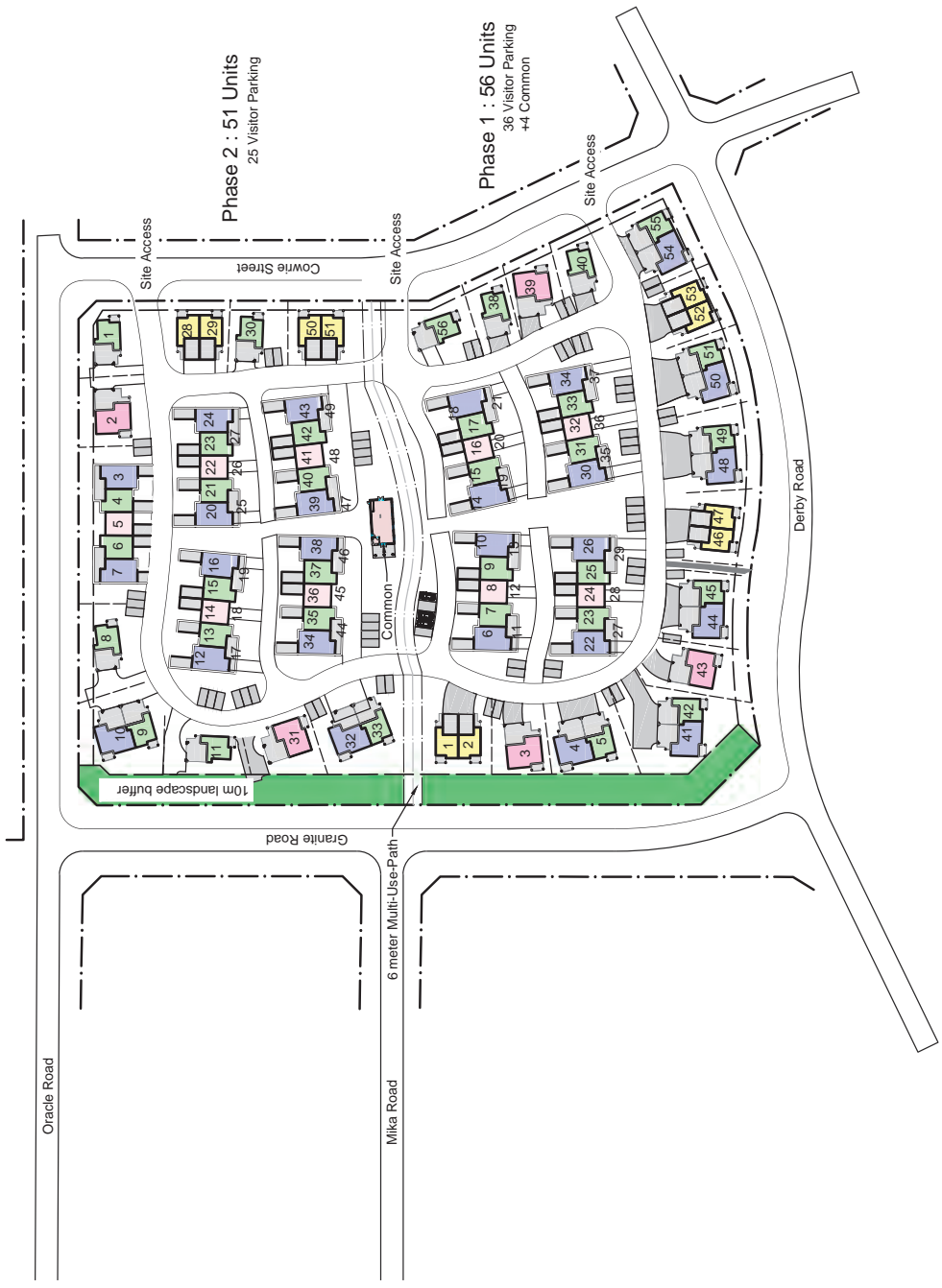
If you have a dripping faucet, don't delay — fix it right away.

Keep track of your water bill

Your water use may fluctuate throughout the year, but if you see an unexpected increase you have a leak. Be sure to check your toilets — the most common indoor culprit (outdoor irrigation systems are another common cause). Consider calling a plumber or your water service provider for additional information.

Emergency shut-off

Find your main water shut-off in case of an emergency water leak.



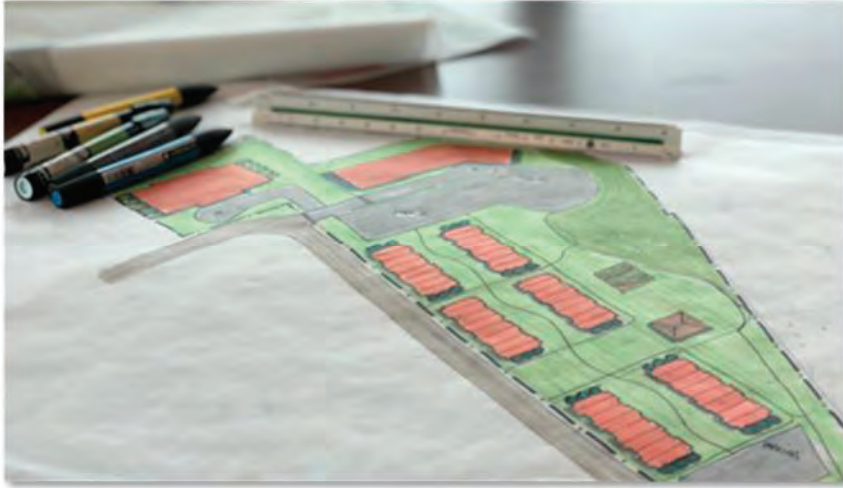
Date: March 13, 2024
Scale: 1/128" = 1'-0"



Silverstone Cluster Housing

Site Planning Concept

3.0



DISTRICT OF
SECHELT

SILVERSTONE HEIGHTS

STORM WATER
MANAGEMENT PLAN
FINAL REPORT



Client:

Sawarne Lumber Company
Ltd.
Davy Sangara



APLIN MARTIN

March 27, 2024
Project No.: 22-1019



STATEMENT OF LIMITATIONS

Aplin & Martin Consultants Ltd. prepared this report for the District of Sechelt, BC and Sawarne Lumber Company Ltd. The material in this report reflects the best judgment of Aplin & Martin Consultants Ltd. in the light of the information available at the time of preparation. Any use of, or reliance placed upon, the material contained in this report by third parties, or decisions based upon this report are the sole responsibility of those third parties. Aplin & Martin Consultants Ltd. accepts no responsibility for damages suffered by any third parties as a result of decisions made, or actions taken, based upon information contained within this report.

Revision History

Revision	Date	Details	Name	Title
0	September 7, 2023	First Draft	Jordan Beach, P.Eng	Project Manager
1	March 27, 2024	Second Draft	Jordan Beach, P.Eng	Project Manager



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Reviewed by:



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Project Manager



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APPENDICES

- APPENDIX A - Hydrological Assessment
- APPENDIX B - Environmental Sensitivity Report
- APPENDIX C - Stream Classification Assessment



1.0 INTRODUCTION

Aplin & Martin Consultants Ltd. (Aplin Martin) was retained by Sawarne Lumber Company Ltd. to conduct a drainage analysis for a 67.98ha collection of properties within West Sechelt, BC governed by the District of Sechelt (DoS). The proposed development area is located on the sloped, forested land to the north of the Sunshine Coast Highway and to the east of Norwest Bay Road. The development is proposed to be constructed in phases and accommodate up to 2300 housing units over a diverse range of land uses,

Aplin Martin performed a drainage analysis to determine the anticipated flows from the proposed development areas, considering runoff from the upstream catchment areas, and any potential groundwater flows in alignment with the DoS bylaw #430, 2003. This report discusses the key components of the hydraulic model development process, hydraulic model results, and the stormwater management plan including pipe and storage pond sizing.

2.0 SITE PLAN & BACKGROUND

The 68ha site consists of undeveloped land parcels with a diverse range of proposed land uses including low and medium density residential, institutional, commercial, parkland, and village centre mixed use spaces. The development site is within a Primary Growth Area as determined by the District of Sechelt's Official Community Plan (2010) Bylaw #492.

The initial two phases of the total development have been constructed, comprised of single-family lots and residential streets constructed off a westward extension of Cowrie Street, which ultimately intersect with an eastward extension of Derby Road. This extension of Derby Road bisects the entire development site roughly in half north to south, with proposed development areas remaining in both the northern and southern portions of the site. The current, existing site plan is shown in **Figure 1**.

Much of the undeveloped land onsite features natural, undisturbed forested lands. To incorporate the proposed land uses while preserving the existing ecosystems found within the project site, environmental considerations have been taken throughout the design and construction of this project.



Figure 1 – Current Site Plan

3.0 EXISTING SITE CONDITIONS

3.1 TOPOGRAPHY

The portion of the remaining undeveloped land south of Derby Road consists of dense, undisturbed forest sloping approximately 9-30% southeast towards existing ditching along the Sunshine Coast highway. The land exists within one, continuous catchment area draining to the southeast towards the Strait of Georgia. The development plans propose for areas of multi-family residential, dedicated park space, and an urban village center within the parcel.

The undeveloped lands to the north of Derby Road feature sloped lands within three separate drainage basins. The northern most portion, consisting of 11.6 hectares of land, drains to the northeast as part of the Cook Creek basin. There is an existing B.C. Hydro Right-of-Way that roughly follows the natural ridgeline and outlines the drainage basin boundary. The 11.6ha of land is proposed to feature 4.8ha of residential and 6.8ha of agricultural development at the ultimate buildout.

A small 1.1ha portion of land on the eastern property line of the subject site, just south of the B.C. Hydro Right-of-Way, drains eastward into a separate drainage basin, flowing to downtown Sechelt. This portion features proposed residential development lands, with drainage infrastructure to be designed and implemented at time of development.

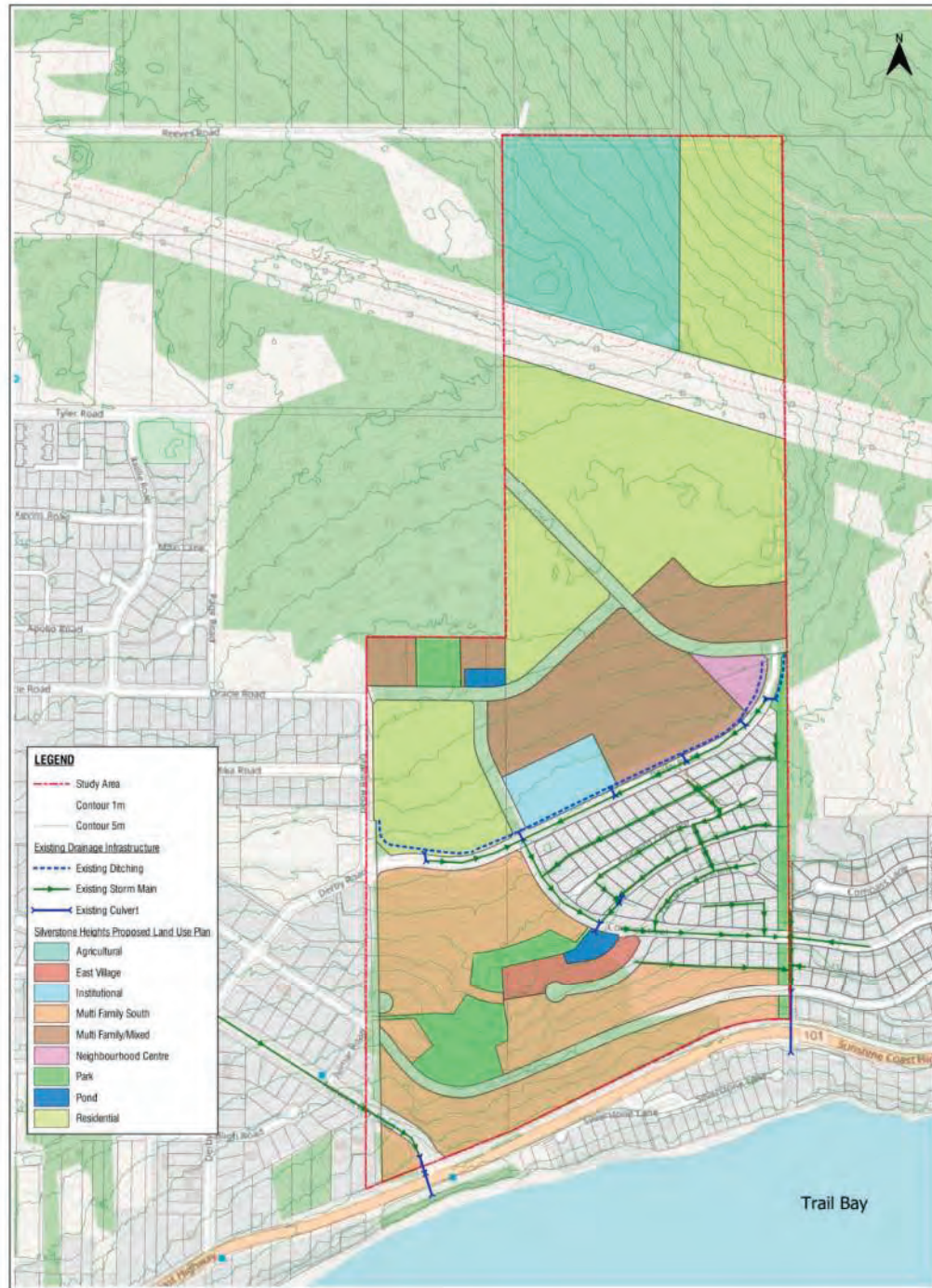
The rest of the undeveloped lands slope to the southeast, contributing to the storm water flows of the drainage basin comprising the vast majority of the development site. The slopes in this portion range from 4% to 8%. Proposed development for this portion consists of residential, multi-family/mixed residential, a neighborhood center, and an institutional parcel. The stormwater management plan discussed in this report will detail the strategies proposed to attenuate the flows produced from the development in this drainage basin. The proposed land use plan can be seen in **Figure 2**.



3.2 EXISTING DRAINAGE OVERVIEW

One primary, onsite drainage basin encompasses most of the development site, with a total basin area of 104.8 hectares. This 104.8ha drainage basin includes an upstream subcatchment area of 41.6ha of undeveloped, forest land. The water drainage flows from this undeveloped region follow existing, natural water courses to flow onto the development property to be included into the proposed storm water management system.

Once within the subject property, the current, existing drainage system features undisturbed, natural water courses which culminate into two identifiable, forested wetland areas. These natural wetlands' existing outflow streams flow southeast until Derby Road intercepts the flows. At this point, drainage ditching on the north side of Derby Road conveys the drainage flows towards the existing piped system, while promoting infiltration. Once within the piped system, existing infrastructure routes the drainage flows southeast along Cowrie Street to an existing outfall to the Strait of Georgia, located along the southern most stretch of the eastern property line of the proposed development. South of Derby Road currently features natural, undeveloped drainage courses flowing to the Sunshine Coast Highway. Lining the north of the Sunshine Coast Highway, roadside ditching and culverts convey the flows to another outfall to the Strait of Georgia, located at the south of the subject property. **Figure 3** depicts the current, existing onsite drainage of the subject property.



M:\PLAN\2022\22-1019\AH\2024\2024-03-27-2019 - Silverstone Stormwater Management Plan - BASE GIS.mxd Location of Proposed Development & Existing Infrastructure

<p>City of SECHULT Silverstone Heights</p> <p>THE ACCURACY & COMPLETENESS OF INFORMATION SHOWN ON THIS DRAWING IS NOT GUARANTEED, AS THE RESPONSIBILITY OF THE USER TO VERIFY ACCURACY OF ALL INFORMATION SHOWN ON THE DRAWINGS.</p>	<p>FIGURE 2 Proposed Land Use & Existing Infrastructure</p> <p>Proj. No: 22-1019 Creator: MAP Reviewer: JDB Revision: A Date: 2024-03-27</p> <p>Scale: 1:5,000 Coordinate System: UTM 50N UTM Zone 10N</p>	<p>APLIN MARTIN ENGINEERING ARCHITECTURAL PLANNING DESIGNING</p> <p>NSIC Permit to Practice #100103018 1358 Hill Street, Kelowna, B.C. Canada V1Y 1L4 Tel: (250) 448-9437, Email: general@aplinmartin.com</p>	<p>District of Sechelt</p>
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Figure 2 - Location of Proposed Development & Existing Infrastructure



3.3 ENVIRONMENTAL STUDIES

Native soil conditions were determined with test pit soil gradient studies conducted by MDM Groundwater Consulting Ltd. (MDM) and online soil mapping, provided by the B.C. provincial government¹. The onsite soil type was determined to be predominantly Loamy Sand. British Columbia surficial soils mapping in the study area denotes well draining Loamy Sand is present in much of the development site. Rainfall is typically infiltrated and routed laterally subsurface, although runoff does occur after storm events and during freshet.

Groundwater monitoring was conducted by MDM throughout the study area to accumulate detailed data on the subsurface groundwater conditions for the site. Through the use of test pits, monitoring wells, and bore holes, site specific soil hydraulic conductivity and peak groundwater flow rates, both lateral and vertical, were determined. Conducting the testing throughout the winter season, soil characteristics during their most restrictive period were determined. Through data collected by MDM over a period from November 2021 to August 2022, the groundwater flow discharged from a 10-year return 24-hour storm event was found to be lower than MDM's originally assumed rates. As such, conservative soil hydraulic conductivity and infiltration rates have been implemented into this stormwater management design.

A further study, conducted by Metro Testing + Engineering (Metro), expanded the groundwater testing conducted on the proposed institutional parcel within the overall development site. This study by Metro was very site specific to the institutional parcel, with detailed groundwater behaviors mapped out. Through this, building drainage recommendations by Metro have been proposed to accommodate the institutional development parcel.

An environmental study was also conducted by Barsanti Environmental Services Ltd. (Barsanti) to identify existing water courses and sensitive ecosystems within the development site. Examining the on-site watercourse flows, it was found that the outflows from the site do not flow into freshwater fish habitats and will not necessitate the use of the Riparian Area Protection Regulation (RAPR). Barsanti did identify one sensitive ecosystem, located in the southwest of the site (**Figure 3**) and mostly contained within one of the proposed parklands of the development. No instances of Species At Risk (SAR) were recorded within the study area. Further, two distinct wetland areas were identified and located within the development site (**Figure 3**).

Additionally, an assessment by Phoenix Environmental Services Ltd. (Phoenix) has been conducted to analyze identified water features and determine whether flows are subsurface or qualify as protected streams. Through the site observations conducted by Barsanti and the groundwater data collected by MDM, Phoenix was able to determine the source of the watercourse flows as either a consistently flowing groundwater fed flow path or as conveyance paths for rainfall event driven surface flows. As such, the onsite flow paths were classified as shallow ephemeral streams too shallow to interact with groundwater or corridor ditches draining surface runoff from adjacent roadways. In both instances, the water courses do not classify as streams under the Water Sustainability Act (WSA) and will not require authorization to change the flow paths.

¹ BC Soils Information Finder Tool, 2018, Provincial Soils Working Group, BC Ministry of Environmental and Climate Change Strategy and Ministry of Agriculture, open access
<https://governmentofbc.maps.arcgis.com/apps/MapSeries/index>,



3.4 ENVIRONMENTAL CONSIDERATIONS

To preserve the existing ecosystems within development site, considerations have been made to integrate environmentally conscious design into the proposed storm water system.

Wetlands Preservation

The existing wetlands found onsite are integral parts of the local ecosystems found within the development site. As a key point of wildlife habitat and natural water systems, the wetlands will be incorporated into the design process of the development to preserve the wetlands as natural space. With the wetlands existing within a proposed residential development, the wetlands can be featured as natural space for the neighborhood, providing green space and walking trails while preserving the wetland's integrity.

Parklands

By dedicating parklands within the site, natural ecosystems can be preserved while providing outdoor communal spaces for the community. Additionally, the recognized environmentally sensitive ecosystem recognized onsite through the study conducted by Barsanti can be preserved through dedicated parkland. By establishing the environmentally sensitive ecosystem as parkland, key habitats for wildlife can be maintained, protecting local species.

Open Course Drainage Ditching

Drainage ditching is a useful method of conveying storm water flows while also providing effective opportunities for storm water infiltration. Promoting infiltration is important for ensuring existing aquifers and subterranean water levels recharge during a rainfall event. With ground water flows feeding local water courses, ensuring post development infiltration levels is vital to local flora and fauna reliant on the ecosystems created around these water courses. To promote this increased infiltration and preservation of the natural ecosystems, open course drainage ditching has been implemented heavily within the design of the proposed storm water system.

Onsite Detention Best Management Practices

In addition to the proposed storm sewer system attenuating the combined drainage flows of the total development site, individual parcels will be required to retain storm water. This will provide a diversified storm water system with many nodes and methods of ground water infiltration. By applying Best Management Practices (BMP's) to individual parcel storm water management solutions, infiltration and retention of stormwater flows can be greatly increased.

- Absorbent Landscape - Where pervious areas are proposed within the development's site plan, absorbent landscaping can be implemented within the on-site storm water disposal system. In these pervious areas, using a top layer of amended topsoil, 300mm for grassed spaces and 450mm for vegetated spaces, provides capillary storage for drainage flows. The absorbent topsoil provides both storage and attenuation of outflows as well as ensuring inground infiltration, recharging subterranean groundwater and aquifers. Implementing a heavy layer of topsoil within pervious areas can be utilised in any proposed land use type. Soil absorbency can be further promoted with the use of detached roof leaders and sloping on-site impervious areas to drain to a proximal pervious area.
- Infiltration Chambers - Infiltration chambers, such as rock pits, are a cost-effective BMP that can be implemented to reduce storm water outflows. As the infiltration chambers can be scaled to suit any respective development parcel, in size and complexity, there are



many beneficial applications that can be considered. While considering individual lot on-site minor disposal systems, the addition of infiltration chambers to residential development areas is an effective method of reducing the overall flows on the total storm sewer system. The infiltration chambers can be either dry storage, featuring unlined storage cells aimed to promote groundwater infiltration, or wet storage, featuring geotextile-wrapped storage cells storing storm water and reducing the volume of flows released to the municipal sewer system.

- Pervious Paving - Within paved walkways, driveways, or patio spaces implementing porous asphalt or concrete, plastic grid pavers, or permeable unit pavers can provide permeability to otherwise impervious surfaces. While regular maintenance is required to mitigate clogging, pervious paving is an effective way of promoting onsite infiltration.
- Infiltration Trenching - Stormwater ditching and trenching can be used to direct and infiltrate stormwater flows. Trenching is an effective BMP and can be utilised in multiple fashions such as to provide drainage alongside roadways and multi-use paths and to intercept storm flows directed at onsite buildings footings and foundations. Trenching can feature a vegetated lining, increasing filtration of storm flows and extending habitat for local wildlife and vegetation.

On-site minor disposal systems are to be implemented, as best fits, for the individual parcels as they are designed and developed. With integrated drainage solutions, the development process will have minimal impacts on the total drainage outflow volume and quality.



4.0 STORMWATER MANAGEMENT REQUIREMENTS

After having conducted thorough site investigations and a review of the reports from the previously mentioned external consultants, design of the ultimate drainage system was initiated. Deferring to the District of Sechelt's Bylaw #430, system capacity requirements were determined. In **Table 1**, bylaw requirements for the different aspects of the system are outlined.

Table 1 - District of Sechelt Bylaw #430 Stormwater System Capacity Requirements

Stormwater Capacity Targets	
On-site Minor Disposal System (where proven to be appropriate)	On-site disposal features to retain 50% of the Mean Annual Rainfall (MAR) volume.
Minor System (piped storm sewers, driveway culverts, low flow channels, and watercourses)	1:10 year design storm with winter condition antecedent moisture condition.
Minor System Storage (permanent community storage or interim on-site storage)	Storage capacity to reduce the post-development flows to their respective pre-development levels up to the 1:5 year storm event.
Major System (surface flow paths, roadways, storage facility overflow, and watercourses)	1:100 year design storm with winter condition antecedent moisture condition. Sufficient freeboard above the maximum hydraulic grade line shall be provided to protect buildings.
Culverts, bridges, and other crossing structures	1:100 year design storm and/or with safe overflow to protect town infrastructure and private property.
Drainage System Design Parameters	
Minimum Pipe Size	250mm
Minimum Culvert Size	600mm (unless driveway culvert, then 450mm)
Minimum Velocity	0.75 m/s

The proposed storm water management system has been designed to conform to and satisfy these requirements. A detailed account of the modelling used to define the site-specific storm water requirements will be discussed in detail.



5.0 STORMWATER DESIGN & MODELLING

A dynamic hydrological and hydraulic PCSWMM model has been developed based on detailed pre-development and post-development condition parameters. This model has been utilised to support the design of the proposed development's subdivision plan and the preliminary sizing of the respective drainage system. Through running iterations of various storm conditions, the model was utilised to size the onsite storm piping, ditching, overland flow routing, and storage ponds that comprise the proposed drainage system. The impacts on existing, downstream infrastructure were simulated through the model to determine where infrastructure upgrades are to be required to support the proposed development.

Preliminary piped system design was conducted through the PCSWMM modelling program. Deferring to the District of Sechelt's Bylaw #430, a generic ground cover of 1m was implemented on the piped system. The modelled piped system terminates with free-flowing outfall nodes discharging to the Strait of Georgia at sea-level. Parcels were distinguished through proposed land-use, with modelling parameters determined by DoS Bylaw #430, as per future land-use. Through iterative simulations, the PCSWMM hydraulic model was utilised to create detailed reports of the onsite pre-development, current, and post-development conditions and storm event responses.

The following section will outline the methodology and rationale behind the developed hydraulic model. To conclude, the results from the simulated storm responses will be discussed.

5.1 DESIGN STORM

To simulate real-time storm events, regional rainfall data was analyzed and implemented within the PCSWMM hydraulic model. Within DoS's Bylaw #430, Intensity-Duration-Frequency (IDF) data from Environment Canada's (EC) Vancouver UBC Climate Station, located approximately 44km away from the development site, is provided with data collected over the time period of 1958-1990. Alternately, IDF data is also available from the EC Sechelt AUT station, located 4.5km from the development site adjacent to the Sechelt Airport. This IDF data from the Sechelt AUT station is based on 29 years of record (1983-2021) and has been considered much more applicable for use in this analysis. Using the data derived from the Sechelt AUT station, climate change impacts were used to further tailor the available data to provide the most accurate depiction of storm events for the service span of the proposed infrastructure. Future climate conditions were applied to the IDF data through an online IDF-cc tool². Based on 5-year, 10-year and 100-year design storms, total rainfall amounts per storm event have been scaled up to simulate increased future rainfall. Within the online IDF-cc tool, SSP5.85 emission scenario (the worst-case emission scenario assuming the business-as-usual emission condition) increases were applied the existing climate condition IDF values to model future rainfall amounts estimated for the years 2070-2100.

² Simonovic, S.P., A. Schardong, R. Srivastav, and D. Sandink (2015), IDF_CC Web-based Tool for Updating Intensity-Duration-Frequency Curves to Changing Climate - ver 6.0, Western University Faculty for Intelligent Decision Support and Institute for Catastrophic Loss Reduction, open access <https://www.idf-cc-uwo.ca>.



Table 2 – Rainfall Amount Comparison for Current and Future 2070-2100 Climate

Duration	Current Climate Condition (mm)			Future 2070-2100 Climate Condition (mm)		
	5-Year	10-Year	100-Year	5-Year	10-Year	100-Year
30-min	8.62	10.92	15.74	10.68	13.47	20.83
1-hr	12.73	14.75	20.92	15.81	18.21	27.69
2-hr	17.80	20.61	31.55	22.05	25.67	41.24
6-hr	29.74	32.20	37.31	37.28	40.38	50.45
12-hr	41.77	45.88	56.53	52.23	57.55	75.73
24-hr	61.49	68.58	87.01	76.96	86.02	116.68

Single storm event simulations were performed to determine size requirements for both the existing and proposed drainage systems. **Table 3** provides the design storms used for modelling and their respective data source.

Table 3 – Design Storms Used for Modelling

Design Storm Event	Data Source
5, 10, & 100-year: 0.5, 1, 2, 6, 12, 24-hour duration events with 2070-2100 climate condition	Future climate IDF data based on the PCIC - Bias Corrected CMIP6 SSP5.85 scenario (2070-2100) & Storm Hyetographs from the District's Bylaw
5, 10, & 100-year: 0.5, 1, 2, 6, 12, 24-hour duration events	Historical IDF data based on the environment Canada rainfall data (1983-2021) at Sechelt AUT station & Storm Hyetographs from the District of Sechelt's Bylaw #430

5.2 MODEL PARAMETERS

The PCSWMM storm water model utilizes the Non-Linear Reservoir rainfall/runoff method of applying land-use specific parameters to each delineated parcel. Additionally, in accordance with the requirements laid out in the DoS Bylaw #430, an existing groundwater model was implemented to simulate the effects of the steep onsite terrain, the high-infiltration in-situ soils, and the seasonal effects of winter soil conditions on the site's water table. The rationale in how these parameters were included in the model is presented in the tables below.

The hydrological parameters used for the modelling individual parcels based on future land use are summarized in **Table 4**. Values were based on standards derived from DoS Bylaw #430, unless specified otherwise.



Table 4 - Hydrologic and Hydraulic Modelling Parameters

PCSWMM Model Parameters		Value
Subcatchment Parameters Based on Various Land Uses	Forest	
	Imperviousness (%)	10 (Based on DoS - Final Drainage Report 1999)
	Flow Length (m)	3-800 (Based on parcel geometry)
	Slope (%)	10-17% (Based on DEM Slope)
	Park	
	Imperviousness (%)	20
	Flow Length (m)	130-182 (Based on parcel geometry)
	Slope (%)	5-25% (Based on DEM Slope)
	Low Density Residential	
	Imperviousness (%)	45
	Flow Length (m)	14-231 (Based on parcel geometry)
	Slope (%)	5-17% (Based on DEM Slope)
	Medium Density Residential	
	Imperviousness (%)	65
	Flow Length (m)	14-280 (Based on parcel geometry)
	Slope (%)	5-25% (Based on DEM Slope)
	Commercial	
	Imperviousness (%)	90
	Flow Length (m)	120 (Based on parcel geometry)
	Slope (%)	15% (Based on DEM Slope)
	Institutional/Mixed Use	
	Imperviousness (%)	80
	Flow Length (m)	45-160 (Based on parcel geometry)
	Slope (%)	5-17% (Based on DEM Slope)
Road		
Imperviousness (%)	90	
Flow Length (m)	20 (Based on parcel geometry)	
Slope (%)	0.5-16% (Based on DEM slope)	



The hydrological parameters used for modelling site-wide characteristics, based on local conditions within the development site, are summarized in **Table 5**. Values were based on standards derived from DoS Bylaw #430, unless specified otherwise. The hydraulic characteristics of Loamy Sand have been portrayed below and used within the PCSWMM storm model to define the subcatchment infiltration parameters.

Table 5 - West Sechelt Modelling Parameters

PCSWMM Model Parameters		Value
Global Parameters	Depression Storage (mm) (Based on DoS - Final Drainage Report 1999)	
	- Impervious	1
	- Pervious	2
	Manning's n (Based on DoS - Final Drainage Report 1999)	
	- Impervious	0.013
	- Pervious	0.03
	Green Ampt (Loamy Sand)	
	- Conductivity Rate (mm/hr)	61
	- Suction Head (mm)	61.2
	- Initial Moisture Deficit	0.335
	Roughness Coefficient	
	- Conduit	0.013
	- Culvert	0.024
	- Ditches	0.035

With regards to the subsurface water flow, seasonal climate conditions will affect infiltration and total flow volume. During the colder, wetter months of winter, soil saturation levels will be greater, limiting the capacity of the ground soils to infiltrate and convey storm water flows. To model these limited flows, a groundwater module, containing seasonal extremes, was included in the model to account for seasonal groundwater surcharges. The parameters used for the groundwater module were based on the subsurface soil characteristics derived from Loamy Sand soil attribute types and from onsite groundwater data collected by MDM Groundwater Consulting. MDM Groundwater Consulting conducted a series of tests using test pits across the development site to monitor seasonal saturated and unsaturated groundwater levels. Using this data, a site-wide groundwater table was interpolated, utilising the most extreme seasonal values. With a groundwater table representing winter soil conditions created for the site, surface elevation and groundwater table elevations could be assigned to each respective subcatchment parcel. The determined parameters are as shown in **Table 6**.



Table 6 - PCSWMM Groundwater Parameters

Stormwater Model Parameters		
Groundwater Aquifer Parameters	Porosity (fraction)	0.437
	Wilting Point (fraction)	0.047
	Field Capacity (fraction)	0.120
	Conductivity (mm/hr)	61.0
	Lower GW Loss Rate (mm/hr)	0.002
	Bottom Elevation (m)	0
	Initial Water Table Elevation (m)	5
Groundwater Parameters	Surface Elevation (m)	Parcel Surface Elevation
	Groundwater Flow Coefficient (A1)	0.2
	Groundwater Flow Exponent (B1)	1
	Groundwater Flow Coefficient (A2)	0
	Groundwater Flow Exponent (B2)	0
	Surface Water Depth (m)	Parcel Unsaturated Water Table Elevation
	Threshold Water Table Elevation (m)	Parcel Saturated Water Table Elevation

5.3 MODEL RESULTS

To design a proposed storm water management system for the development site, multiple iterations of storm events were conducted in PCSWMM to determine various design parameters necessitated by the DoS bylaw #430. For each storm event modelled, a full range of storm duration values were trialed. The storm durations causing the greatest response to the system were used to determine the final values derived from the models. In this section the methodology and results of the iterative storm modelling will be discussed in brief.

Existing Conditions Storm Simulation

As specified in DoS Bylaw #430, permanent storage infrastructure must limit post-development outlet flows of a 1:5-year storm event to be equal to the outlet flows of a 1:5-year storm event with pre-development conditions. To determine the site's pre-development ultimate outflows, a pre-development model was created in PCSWMM. All upstream subcatchments of the outfall were defined as undisturbed, forested lands and assigned the corresponding modelling parameters. As well, to adequately model the complexity of the natural water courses, the flow paths between subcatchments were assigned a longer length than the respective parcel's geometry would require. With the longer flow paths, the PCSWMM storm model allows for a more realistic time period for the surface flows to infiltrate. Using the PCSWMM storm model to simulate the project site's pre-development drainage conditions, the resultant peak outflows of the pre-development condition were determined to be $1.20\text{m}^3/\text{s}$.



Post Development Conditions Storm Simulation

Within the post-development model, flow limitations were applied to the detention pond's outlets to restrict the system's peak outflows to that of the pre-development condition. Restricted outflows for the detention ponds are seen in **Table 7**, resulting in a 1:5-year storm event peak system outflow of 1.16m³/s. Using the PCSWMM model to calculate the excess storm water accumulation caused by the restricted outflows, minimum storage volumes were also determined to attenuate the flows without flooding.

Table 7 - Detention Pond Sizing Details

Detention Pond Sizing Details			
Detention Pond	1:5-Year Storm Duration	Outflows (m ³ /s)	Minimum Storage Volume (m ³)
Upper Pond	1 hour	0.518	2566
Lower Pond	1 hour	0.781	2507

With the two proposed detention pond's sizing and outflow rates calculated, detailed pipe sizing was determined. Designed to convey the 1:10-year storm event without surcharging, as per DoS Bylaw #430, proposed pipe sizes were subject to storm simulations of varying durations to determine the maximum system response. With this development site, it was found that the 1-hour 1:10 year storm event produced the greatest system response. All piped systems were ultimately sized to convey these resultant flows without flooding or surcharging.

Utilising the same post-development model, proximal, existing drainage infrastructure was also subjected to the proposed post-development flows of the 1:10-year storm event. Existing storm pipes and infrastructure down-stream of the proposed development site was checked for flooding and surcharging in the model due to the increased piped flow quantities of the ultimate build-out.

Additionally, DoS Bylaw #430 requires the storm water flows of the 1:100-year storm event to be safely conveyed by over-land flow paths without damaging adjacent infrastructure. With established or proposed roadways providing the flow paths of much of the proposed drainage system, over-land flow paths are easily established within the respective roadways in the event of storm surcharge. Downstream of the Lower Detention Pond, however, features a piped span of the network, not falling within a roadway. In order to accommodate the storm flows of a 1:100-year storm event, it is imperative that an over-land flow route is integrated into the design of the respective development parcel. Alternatively, the piped system in this parcel can be upsized to convey the increased flow demand.

Utilising PCSWMM to determine these parameters and conduct the system failure checks, a functional drainage system for the Silverstone Heights project has been designed. In **Figure 4**, an overview of the post-development subcatchments is provided. In **Figure 5**, an overview of the system with pipe sizing and detention pond details has been provided.

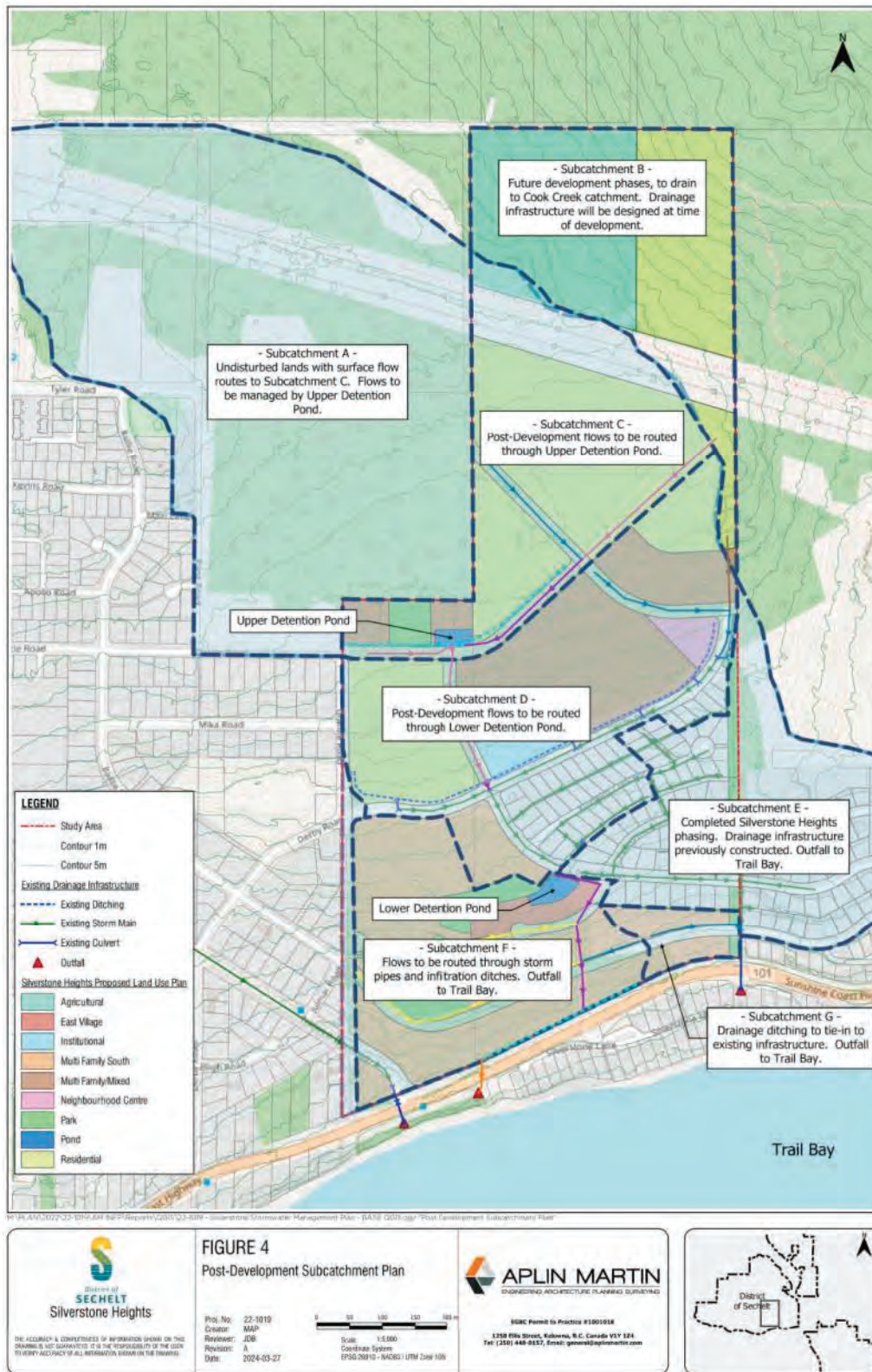
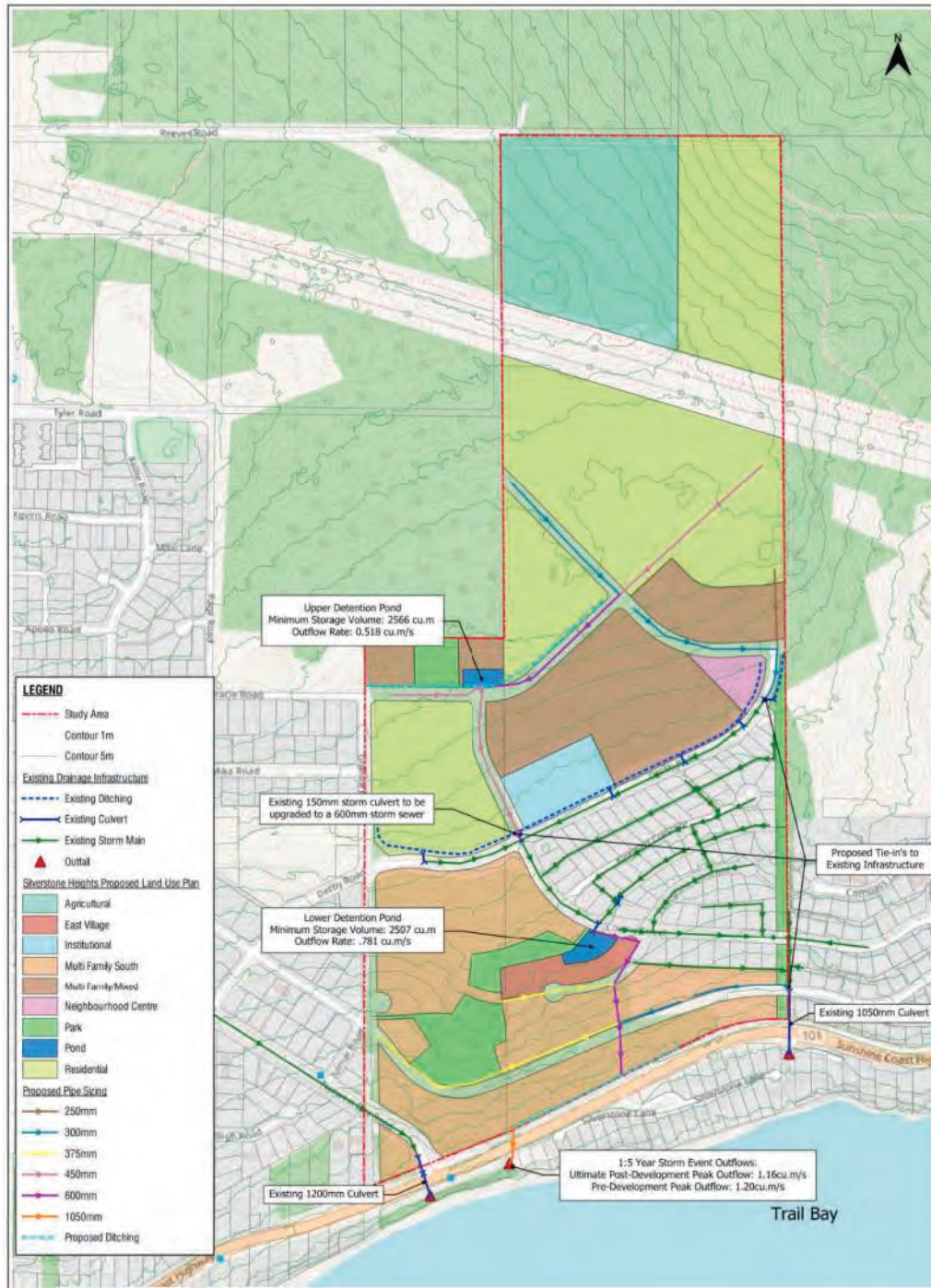
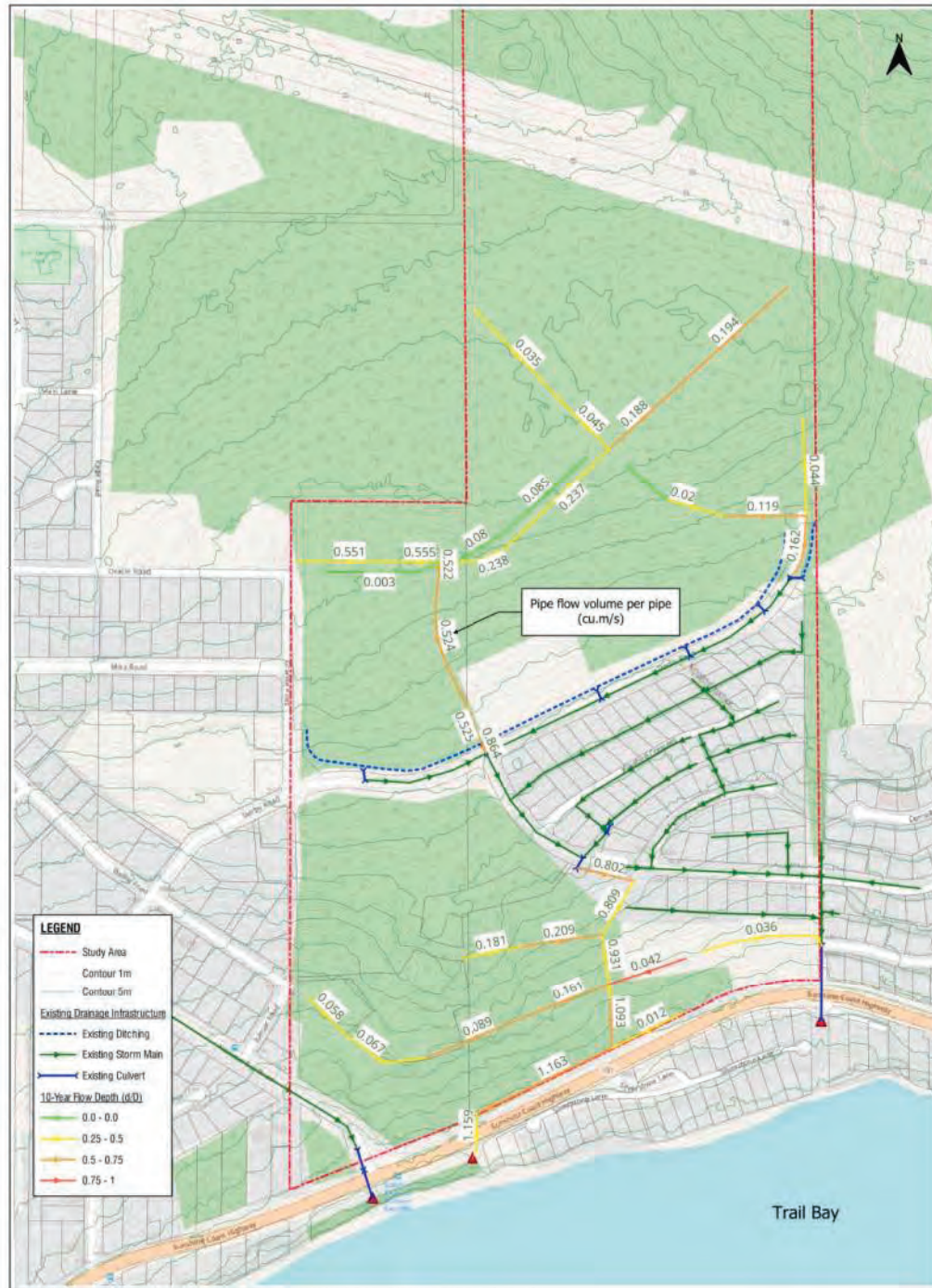


Figure 4 - Post-Development Subcatchment Plan




<p>FIGURE 5 Preliminary Pipe & Detention Pond Sizing</p>	<p>Proj. No: 22-1019 Creator: MAP Reviewer: JCB Revision: A Date: 2024-03-27</p>	<p>Scale: 1:1 Coordinate System: EPSG:26910 - NAD83 / UTM Zone 10N</p>	<p>APLIN MARTIN ENGINEERING ARCHITECTURE PLANNING SURVEYING EGBC Permit to Practice #1001018 3258 Bilo Street, Kelowna, B.C. Canada V1Y 1Z4 Tel: (250) 848-0100, Email: general@aplinmartin.com</p>	
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Figure 5 – Stormwater Pipe & Detention Pond Sizing



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FIGURE 6
Pipe Flow Capacities

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Client: MAP
Reviewer: JOB
Revision: A
Date: 2024-03-27

Scale: 1:4,000
Coordinate System: UTM Zone 18N



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Figure 6 - Pipe Flow Capacities



6.0 CONCLUSION AND RECOMMENDATIONS

The proposed, onsite drainage system has been designed to convey and store stormwater flows in accordance with DoS Bylaw #430, 2003. The minor system, consisting of storm sewers, roadside ditching, and culverts, has been sized to convey the 1:10-year design storm without the Hydraulic Grade Line (HGL) surcharging while implementing winter groundwater conditions. Ponds have been provided with storage capacities designed to reduce the post-development outflows to the respective pre-development levels of a 1:5-year design storm. Surface flow paths along roadways have been integrated into the design to allow the 1:100-year design storm to be routed without increasing the maximum hydraulic grade line above a level dangerous to surrounding buildings. Individual lots will provide onsite stormwater storage equal to 50% of the Mean Annual Rainfall for the respective parcel. These storages are to be designed and constructed at time of development.

A summary of the proposed drainage infrastructure is as follows:

1. Two (2) proposed storm water detention ponds, limiting ultimate outflows to 1:5-year storm event pre-development quantities. Flows are limited by calculated orifices. Overflow diversion flow routes will be constructed to provide overflow routes for storm events greater than the 1:5-year event.
2. Storm water conveyance system, consisting of piped sewer mains, infiltration ditching, and a proposed ocean outfall, sized to convey the 1:10-year storm event flows.
3. One (1) upgrade proposed to existing infrastructure.
 - I. Upgrade of an existing 150mm storm sewer inlet to a 600mm storm sewer pipe.
4. Three (3) proposed tie-ins to existing, proximal drainage infrastructure.
5. Individual development lots will employ Best Management Practices to provide onsite storage and flow attenuation equal to 50% Mean Annual Rainfall at time of development.

The development site is proposed to be constructed over a series of phases. The storm water management system detailed in this report is designed to manage the drainage flows of the site in its ultimate build-out state. While the storm water system can be constructed in phases as well, there are some limitations. From the Lower Detention Pond to its ultimate outfall is integral infrastructure for proposed infrastructure upstream to function. Constructing the Lower Detention Pond and the piped system downstream to the ultimate outfall is a key initial phase of the storm water system. Once this is completed, phased construction can be completed as best fits the proposed development.

This proposed storm water drainage system will convey storm water flows safely and without negative impact to the development site and surrounding neighborhoods. Verified through storm modelling conducted in PCSWMM, all of the District of Sechelt's drainage requirements for new developments, as stated in Bylaw #430, have been addressed and satisfied.

It is recommended that this storm water management plan be implemented in conjunction with the proposed site development plan for the Silverstone Heights project in Sechelt, B.C.



APPENDIX A:

Hydrological Assessment

MEMORANDUM

To:	Meghan Lee, P.Eng. Manager-Development Engineering and Sustainability	Date:	January 27, 2022	Pages:	4
		Project No.:	WF36787		
Company:	District of Sechelt	T.	604-741-5030	F.	
		E.	mlee@sechelt.ca		
Cc:	Callum Crawford Wheeler Crawford + Sons	T.	639-259-5889	F.	
		E.	callum@wcsons.com		
From:	Percy Villa, P.Eng.	T.	604.385.4244	TF.	
		E.	pvilla@metrotesting.ca		
Project:	Silverstone Care Centre – 5625 Derby Road, Sechelt, BC				
Subject:	Total Peak 10-year Groundwater Flow Estimate				

1.0 INTRODUCTION

As requested by the District of Sechelt through email communication from the Development Engineering and Sustainability Department dated January 17, 2022, Metro Testing + Engineering Ltd. (Metro) has prepared this memorandum to provide estimate of the total peak 10-year return, 24-hour duration groundwater (i.e., 10Y₂₄) flow expected to be discharged from the proposed Silverstone Care Centre, based on information provided by our hydrogeological sub-consultant MDM Groundwater Consulting Ltd. (MDM) on its letter-report dated January 21, 2022. This memorandum also provides general recommendations for the layout of perimeter drains, interior drains and proposed interceptor/diversion ditch.

2.0 EXPECTED TOTAL 10Y₂₄ GROUNDWATER FLOW

2.1 General Background

On February 26, 2021, Metro submitted the MDM Hydrological Assessment for Geotechnical Investigation as an Appendix of our Geotechnical Assessment Report. The MDM Assessment was based on Metro's exploratory test pit (7 test pits) and borehole (two boreholes) programs completed at the site between January and February, 2021. The MDM's Assessment provided estimated peak lateral and vertical groundwater flows for proposed buried structures such as the level 1 (L1) foundation/slab footprint and two retaining walls located near/along the northern property boundary. These flows were estimated assuming a conservative hydraulic conductivity (K_b) value of 3 x 10⁻⁴ m/s (metres per second) for the identified surficial SAND strata.



After communications with the District of Sechelt and the consulting team and due to the limitations of the January and February, 2021 investigations, Metro completed additional drilling and installation of eight (8) nested monitoring wells during November 8-10, 2021. In addition, hydraulic conductivity tests were completed on November 16 and 17, 2021 in four (4) shallow and four (4) deep monitoring wells and long-term groundwater level was recorded during November 17 and December 6, 2021 in data loggers installed in eighteen (18) monitoring wells which included shallow and deep screens. Based on this information, MDM was able to update characterization of Site groundwater flow attributes and to provide more accurate hydraulic conductivity (K_b) values and revised estimates of peak groundwater flow rates (lateral and vertical) to proposed permanent drains (MDM's Interim Review and Assessment, dated November 24, 2021). In general, the subsurface conditions reported for Metro's November 2021 drilling program agreed with the stratigraphic characterization and interpretations provided in MDM's assessment dated February 2021. Hydraulic conductivity (K_b) values, however, were observed to be significantly lower (approximately 70 times lower for the surficial SAND and 200 lower for the deeper SILT/SAND units) than estimated. Groundwater flow rates were revised accordingly.

On December 22, 2021, MDM produced the letter-report "Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)" providing predicted Site groundwater levels during a $10Y_{24}$ rain event and estimating corresponding lateral and vertical peak groundwater inflow rates for shallow and deep groundwater. The analysis also identified the gross area where project components will potentially interact with upward flowing groundwater.

On January 21, 2022, MDM revised Section 4.2.2 of their December 22, 2021 report and added Section 4.3 including comments regarding off-site groundwater interception ditch. MDM's January 21, 2022 letter-report has been attached to this memorandum.

2.2 Expected Total $10Y_{24}$ Groundwater Flow

Metro has delineated sub-regions within the gross area of influence indicated in Attachment # 6a of the MDM's January 21, 2022 letter-report. The sub-regions are shown in Drawing G-01 appended to this memorandum. Areas outside the gross area of influence are assumed to receive no groundwater inflows. Using the revised peak groundwater inflows ($10Y_{24}$) provided in Section 4.2 of MDM's January 21, 2022 letter-report for each sub-region and their correspondent area/length, the total expected $10Y_{24}$ groundwater flow discharged from the site is 5.69 L/s. Detailed calculation is shown in Table 1 below.



ESTIMATED PEAK 10-YEAR 24-HOUR FLOWS									
Sub-region	Area (m ²)	Length (m)		Vertical (upward) Flow		Lateral Flow	Vertical and Lateral Flows Combined		
		West	East	Rate	Flow		Rate		Total L/s
				L/s/m ²	L/s	L/s/m West	L/s/m East		
A1	985	0	0	0.00046	0.45	0.00			0.45
A2	620	0	0	0.0001	0.06	0.00			0.06
A3	440	0	0	0.0001	0.04	0.00			0.04
A4	478	0	0	0.0001	0.05	0.00			0.05
A5	735	0	0	0.0001	0.07	0.00			0.07
A6	233	0	0	0.0001	0.02	0.00			0.02
A7	459	0	0	0.0001	0.05	For A7, A8 and A9 3.00			2.17
A8	1050	0	0	0.0001	0.11				
A9	233	0	0	0.0001	0.02				
A10	1146	0	0	0.0001	0.11	0.00			0.11
A11	50	0	0	0.0001	0.01	0.00			0.01
A12	122	0	0	0.0001	0.01	0.00			0.01
Upper RW	0	80	70				0.007	0.01	0.98
Lower RW	0	90	80				0.01	0.01	1.70
									5.69

Table 1: Estimated Peak 10Y₂₄ Groundwater Flows

The estimated total peak flow 10Y₂₄ is significantly lower than the initially estimated of 192 L/s which was based on the February 2021 conservative assumptions.

3.0 SUGGESTED PERIMETER DRAINS LAYOUT

Vertical and lateral groundwater flows collected by each sub-region as indicated in Table 1 are very low. The exterior perimeter drain for the level 1 (L1) structure including Building A and Building B (north side of sub-regions A7, A8, and A9 on Table 1) will be buried at a maximum depth of about 3.0 to 3.5 m below ground with a combined (lateral and vertical) peak flow of 2.17 L/s.

Groundwater peak flows for exterior spaces such as A1, A5, and A6 can be drained using shallow drain pipes along the perimeter of each sub-region. Sub-regions A11 and A12 cover relatively small areas and can be drained using only one drain pipe through the centre of the region. Sub-region A10 can be drained using shallow drain pipes along its northern and western perimeter and the remainder through the middle of the region, partially deeper to accommodate the pipe below proposed detention tank.

Groundwater peak flows for interior spaces such as A4, A7, A8, and A9 can be drained using shallow drain pipes along the perimeter of each sub-region and longitudinally along interior



partitions such as corridors. Metro can coordinate layout of drains below slab with the mechanical consultant to optimize drainage of expected groundwater flows.

Groundwater peak flows behind upper and lower wall were estimated in 0.98 and 1.70 L/s respectively. These are total flows (vertical and lateral) for the whole length of the walls. Table 1 shows estimated flows for the west and east side of the total length of the drain pipes, for use of the civil designer.

It should be noticed that the final size of the drain pipes should include flows collected from other sources (roof rain water, infiltrated rain water, infiltrated water for watering in landscaping areas, etc) if applicable.

4.0 ESTIMATED 10Y₂₄ PEAK FLOW ALONG THE PROPOSED CUT-OFF DITCH

MDM's January 21, 2022 revised letter-report (Revised Groundwater Inflows Estimates) considers only "unmitigated" groundwater flow (no cut-off ditch). The proposed cut-off ditch would intercept only lateral groundwater flow estimated in 0.7 L/s (10Y₂₄) through the surficial SAND layer. This peak flow occurs approximately 18 hours minimum after the peak rainfall occurrence. No upward groundwater flow is anticipated according to data from monitoring wells BH21-06 and BH21-07 along the ditch. Please refer to Section 4.3 of attached MDM's January 21, 2022 letter-report for further comments regarding the proposed cut-off ditch.

Although the cut-off ditch would not be required for the Silverstone Care Centre from a geotechnical perspective, it is understood that the civil consultant's preference is to keep the ditch to address overland flow from the catchment north of Silverstone Care Centre until further development to the north takes place or permanently, meeting design guidelines.

5.0 CLOSURE

The 10Y₂₄ total flows and analysis provided on this memorandum have been estimated based on the information provided by MDM's report dated January 21, 2022. We trust that this meets your current requirements. If you have any questions, please do not hesitate to contact us.

Metro Testing + Engineering Ltd.



Percy Villa, P.Eng.
Geotechnical Engineer

Jan 27, 2022

PERMIT TO PRACTICE	
METRO TESTING & ENGINEERING LTD.	
RR SIGNATURE	
RR EGBC ID #	30941
DATE	January 27, 2022
PERMIT NUMBER: 1000648	
Engineers and Geoscientists of British Columbia (EGBC)	

Attachments:

Drawing G-01: Inferred Areas of Upward Groundwater Flow

MDM's Letter-report: Revised Peak Groundwater Inflow Estimates dated January 21, 2022

MDM Groundwater Consulting Ltd.
4255 Sunrise Road
Duncan, BC V9L 6G6
Tel: (236) 999-2254
info@mdmgroundwater.ca



January 21, 2022

Project No: BC21-0007

Metro Testing and Engineering

401 – 6741 Cariboo Road
Burnaby, BC V3N 4A3

Attention: Mr. Percy Villa, P.Eng.

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

Mr. Villa,

1 INTRODUCTION

As requested by Metro Testing and Engineering's ("Metro") client for the above-referenced project, MDM Groundwater Consulting Ltd. ("MDM") has prepared this letter-report with an updated characterization of groundwater conditions (i.e., hydrostratigraphy) at the above-referenced site (the "Site") based on review and analysis of data from a Groundwater Monitoring Program established by Metro on November 17, 2021 in nine (9) nested monitoring wells located on and near the Site. The updated hydrogeological characterization also considers the results of Metro's in-situ hydraulic testing previously reported in MDM's letter-report "Interim Review and Assessment" delivered to Metro, the Silverstone Care Centre project team and the District of Sechelt (the "District") on November 24, 2021.

Metro's installation of a Site monitoring well network, completion of standardized hydraulic testing and implementation of a wet-season monitoring program into early-December satisfies the data acquisition and testing/monitoring objectives of the "Supplementary Data Work Plan" (the "Work Plan") delivered to the District on September 1, 2021. The ultimate objective of the Work Plan is the issuance of a revised Hydrogeological Assessment Report (MDM February 26, 2021) based on the Work Plan data and including revised high-confidence estimations of peak groundwater inflows to Project subsurface drains. Accordingly, this letter-report describes MDM's analysis of Groundwater Monitoring Program data to predict Site groundwater levels during a 10-year return, 24-hour duration (i.e., $10Y_{24}$) rain event (per Table 2.3.5 of District Bylaw No. 430) and estimations of corresponding peak groundwater inflow rates.

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

This document is intended for the consideration and reliance of the District and the Silverstone Care Centre project team for ongoing project permitting and drainage design purposes. MDM's pending (revised) Hydrogeological Assessment Report will reference all data, analysis and 10Y₂₄ groundwater inflow estimates presented in this letter-report. Readers should consider this document in its entirety, including the Section 5.0 Limitations, and concurrently with MDM's November 24, 2021 "Interim Review and Assessment" letter-report.

2 WET-SEASON MONITORING

2.1 Groundwater

On November 17, 2021, Metro personnel installed eighteen (18) automated pressure transducers with programmable data loggers in nine (9) nested (i.e., paired shallow and deep) monitoring wells designated BH21-04 through BH21-11 (constructed November 8 to 10, 2021) and BH21-01 (constructed February 2021) at the locations shown on the attached Metro site plan (Figure 1, Attachment #1). All devices were programmed to record deep and shallow standpipe groundwater levels on a synchronized 5-minute frequency. A barometric device was also installed at Site to record atmospheric pressure on a 5-minute frequency to facilitate subsequent data reduction. For reference, Metro manually measured groundwater levels in all standpipes immediately prior to installing the devices. Metro field staff returned to Site on December 6, 2021 to download data from the monitoring devices. Manual measurements of standpipe water levels were obtained immediately prior to removing each device.

Monitoring device data were initially corrected for atmospheric variations and converted to equivalent elevations (m-geod [metres geodetic]) based on Strait Land Surveying Ltd.'s topographic survey and equivalent metres-below-ground surface (m-bgs) values. Manual water level measurements obtained at the time of device installation and removal were utilized to identify device "drift" effects and to quantify any required corrections. Graphical summaries of the resulting paired (i.e., shallow and deep) groundwater elevations and depths for the 20-day monitoring period of November 17 to December 3, 2021 are provided on the attached Figures 2 through 10 for wells BH21-01 and BH21-04 through BH21-11 (Attachment #2).

2.2 Precipitation

The nearest active Environment Canada climate station to the Site is the Gibsons Gower Point station located approximately 25 km (kilometre) to the southeast, which reports daily precipitation totals. The nearest active Environment Canada facility reporting both daily and hourly precipitation totals is the West Vancouver AUT station located approximately 45 km southeast of the Site. Linear regression analysis of the two daily datasets for the period of November 17 to December 6, 2021 indicates a strong positive correlation based on a Pearson coefficient of 0.77. On this basis, the West Vancouver AUT hourly rainfall values were accepted as surrogate data for examination of the correlation of Site groundwater levels to rainfall

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

intensity. Context for the groundwater-rainfall correlation is the District's 10Y₂₄ storm event; therefore, a running 24-hour sum of hourly total precipitation for the West Vancouver AUT station is provided with each Groundwater Monitoring Program summary (Figures 2 through 10, Attachment #2) to facilitate comparisons of Site groundwater levels and rainfall intensity.

3 SITE GROUNDWATER-RAINFALL CORRELATIONS

3.1 Groundwater Responses

During the 7-day monitoring interval of November 25 to December 1, 2021, three (3) discrete 24-hour rainfall events occurred with interim periods of comparatively low rainfall intensity (Figures 2 through 10). Peak intensities for each event ranged from a maximum of 76.0 mm on November 28, an intermediate peak of 72.7 mm on December 1 and minimum peak of 48.6 mm on November 26. Comparison of the rainfall data with BH21-01 groundwater monitoring data (Figure 2) indicates a strong correspondence of both shallow and deep groundwater level trends with rainfall intensity. In general, the groundwater data exhibits downward trends with troughs and upward trends with peaks that correspond to periods of lower and higher rainfall intensity, respectively. The groundwater data includes three (3) distinct peaks during the period of November 26 to December 3, 2021, which are associated with the three (3) successive rainfall peaks (Figure 2). The time lag from peak rainfall intensity to peak groundwater response increases progressively from approximately 17 hours to 27 hours and 44 hours, due to progressively reduced rainwater infiltration rates induced by repetitive rainfall events of moderate to high intensity.

Correspondence of the three (3) rainfall peaks with groundwater peaks is similarly evident in monitoring data for the other eight (8) nested wells (Figures 2 through 10); however, lag times and groundwater fluctuation magnitudes vary. A notable exception is BH21-05 (Figure 5) where deep groundwater trends are significantly attenuated (i.e., subdued) compared to the shallow groundwater response. This attenuation effect is also apparent in the BH21-07 groundwater data (Figure 6) but can be attributed to the graphing scale (i.e., 3.5 m range) required for the significant vertical separation of the shallow and deep groundwater data. Figure 5 (BH21-06) also depicts an apparently subdued deep groundwater response, due to the vertical separation of groundwater from the local ground surface, and also lacks a continuous record for shallow groundwater due to an intermittently "dry" shallow standpipe.

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
 Hydrogeological Assessment for Geotechnical Investigation
 Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

3.2 Return Period Correlation (10Y₂₄)

Groundwater elevations/depths (shallow and deep) at each monitoring well location were predicted using a linear extrapolation of Site groundwater elevation data corresponding to the three (3) discrete peak rainfall events (i.e., intensities). Plots of groundwater elevation versus 24-hour rainfall intensity were constructed for each monitoring well and a linear data fit projected to the District's 10Y₂₄ value of 81.2 mm (Table 2.3.5 of Bylaw No. 430) to estimate resultant groundwater elevations. Instances where the source data (i.e., three [3] groundwater elevation and rainfall intensity peaks) departed from the linear data fit line, a conservative upper-bound linear fit line was substituted using the two (2) data pairs with higher elevation and likewise projected to the 81.2 mm intersection. Graphical summaries of the nine (9) correlations are provided as Figures 11 through 19 (Attachment #3) and the resultant 10Y₂₄ groundwater elevations also summarized in Table 1.

Table 1. 10Y₂₄ Groundwater Elevations

Monitoring Well	Predicted Q _{10₂₄} Groundwater Level		Vertical Gradient ^{3,4} (m/m)
	m-bgs ^{1,2}	m-geod	
BH21-01S	0.72	76.78	-0.06
BH21-01D	0.53	76.97	
BH21-04S	0.64	81.36	+0.03
BH21-04D	0.74	81.26	
BH21-05S	0.23	81.77	-0.03
BH21-05D	0.14	81.86	
BH21-06S	-	-	-
BH21-06D	2.75	81.25	
BH21-07S	0.63	83.27	+0.67
BH21-07D	3.07	80.93	
BH21-08S	-0.22	80.22	+0.05
BH21-08D	0.03	79.97	
BH21-09S	1.13	73.87	-0.02
BH21-09D	1.07	73.93	
BH21-10S	0.50	81.00	+0.05
BH21-10D	0.64	80.86	
BH21-11S	-0.09	78.09	-0.02
BH21-11D	-0.13	78.13	

- NOTES
- 1) "-" denotes insufficient data for analysis (i.e., dry standpipe).
 - 2) Negative water depth indicates an above-ground position
 - 3) Negative gradient value indicates a component of upward flow
 - 4) Positive gradient value indicates a component of downward flow

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

3.3 10Y₂₄ Groundwater Configuration

Gross groundwater flow attributes during a 10Y₂₄ event can be approximated from shallow and deep groundwater elevation contours for the projected data (Table 1). Shallow groundwater contours representing the 10Y₂₄ water table are shown on Figure 20 (Attachment #4) and indicate a gross southeastward flow direction with horizontal gradients ranging from approximately 0.08 (m/m) within the northern half of the Site to approximately 0.15 within the remaining southern Site extents. Deep groundwater contours representing the 10Y₂₄ deep piezometric surface are shown on Figure 21 (Attachment #5) and also indicate a gross southeastward flow direction with horizontal gradients ranging from approximately 0.08 to 0.15.

Vertical flow gradients determined from comparison of the projected shallow and deep groundwater elevations are summarized in Table 1. Downward vertical flow gradients ranging in magnitude from 0.03 to 0.05 were determined for monitoring wells BH21-04, BH21-08 and BH21-10 and a significantly higher gradient of 0.67 for BH21-7. Upward vertical flow gradients ranging from 0.02 to 0.06 were determined for monitoring wells BH21-01, BH21-05, BH21-09 and BH21-11.

Predicted 10Y₂₄ groundwater elevations in BH21-08 (shallow) and in BH21-11 (shallow and deep) exceed the local ground elevation by 0.09 m to 0.22 m (Table 1). These shallow groundwater elevations do not represent the physical water table and instead are indicative of the shallow groundwater "hydraulic potential". Accordingly, assessment of shallow subsurface flow at these locations can be based practically on an assumed fully-saturated soil profile. Similarly, the above-ground deep groundwater elevation predicted for BH21-11 represents the deep piezometric potential and not a physical water table.

Predicted below-ground groundwater elevations (Table 1) for the remaining seven (7) monitoring wells can be utilized to estimate the saturated thickness of subsurface profiles intersected by various below-ground project components. This applies to BH21-06 despite the absence of a continuous shallow groundwater monitoring record (Figure 5) since the available data infers a relatively deep below-ground 10Y₂₄ position based on the limited vertical separation from the deep piezometric levels that exceed 2 m below ground.

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

4 SITE GROUNDWATER DRAINAGE

4.1 Vertical Groundwater Drainage (10Y₂₄)

CREUS Engineering Ltd.'s site plan and site cross-sections¹ were used as base drawings to represent the Site hydrostratigraphy (Attachments #6a/b) by introducing MDM's predicted 10Y₂₄ groundwater elevations and Metro's stratigraphic information obtained during monitoring well drilling. The three (3) Site cross-sections (Attachment #6b) indicate there is limited vertical separation between the shallow 10Y₂₄ water table and deep 10Y₂₄ piezometric surface, except at locations north of the Site, and that both surfaces reside relatively near-surface within the dense surficial SAND stratum throughout the Site. The surficial SAND profile exhibits an overall thinning trend from east-to-west, which results in project components (i.e., buildings, walls, courtyards etc.) more commonly intersecting the underlying Till-Like SILT within the central and western portions of the Site (Attachment #6b) and, conversely, there is limited project interaction with the deeper Till-Like SILT within the eastern-most portion of the Site.

Project components with potential for interaction with upward flowing groundwater are identified on the Attachment #6b cross-sections with a thick red line placed along the project/soil interface and was delineated based on the following criterion:

- The project component either partly, wholly or potentially intersects the deep Till-Like SILT, or significantly approaches the SAND/SILT interface, in an area with confirmed or potential upward groundwater flow.

On this basis, the imposed red line extends fully through the "WEST" cross-section southward from the upper retaining wall area to the northern side of the ditch along the southern property boundary. Within the "MIDDLE" cross-section the red line extends southward from the lower retaining wall fully to the southern edge of the main building. No project components meet the red line criterion with the "EAST" cross-section.

Converting these 2-dimensional interpretations to a plan view area (i.e., Attachment #6a) was achieved by first introducing the "WEST" and "MIDDLE" red lines to the corresponding plan section lines and then applying the above-noted criterion outside the cross-section lines based primarily on Metro's stratigraphic interpretations for the Site area between the "MIDDLE" and "EAST" section lines and also within the Site area south of the main building between section lines "WEST" and "MIDDLE". The resultant gross polygon represents the Site area where project components will potentially interact with upward flowing groundwater.

¹ CREUS Engineering Ltd. "KEYPLAN" Drawing KEY-2 and "Site Sections" Drawing X-S-1 dated 21-02-04.

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

4.2 Revised Peak Groundwater Inflows (10Y₂₄)

Estimation of peak groundwater inflow rates to proposed project subsurface drains were initially assessed in MDM's February 26, 2021 "Hydrogeological Assessment" report, based on assumed sediment hydraulic conductivities, strata encountered during drilling of two (2) on-site monitoring wells (BH21-01 and BH21-02) and one-time groundwater level measurements on February 23, 2021. The assessment scope was also limited to inflow determinations for the L1 slab/wall drains and two (2) retaining walls located along/near the northern property boundary.

MDM's subsequent "Interim Review and Assessment" letter-report (November 24, 2021) provided revised peak groundwater flow estimations and recommendations to eliminate previously recommended on-centre drain pipes, based on the results of Metro's November 2021 hydraulic conductivity testing and initial groundwater level measurements in the eight (8) new Work Plan monitoring wells.

The current assessment provides further refinement of estimated peak groundwater inflow rates to project components based on predicted 10Y₂₄ groundwater levels/elevations (Table 1), Metro's revised stratigraphic interpretations (Attachment #6a/b) and recently determined soil bulk hydraulic conductivity (K_b) values (MDM, November 2021) .

4.2.1 Vertical Flow Rates

MDM's November 2021 assessment of vertical flow rates conservatively accepted an upper-bound (maximum) K_b value of 1.4×10^{-6} m/s for the Till-Like SILT and also accepted the highest-ever recorded vertical flow gradient of 0.33 from BH21-2 in February 2021. The Table 1 summary of 10Y₂₄ gradients indicates a maximum upward gradient of 0.06 at BH21-01, which is five (5) times less than the former BH21-02 value. However, because BH21-02 was not available (i.e., destroyed) for Metro's Groundwater Monitoring Plan, the historical high gradient of 0.33 is reasonably accepted for vertical upward flow rate estimations within the portion of the Site area (Attachment #6a) situated north of the main building and east of the "WEST" cross-section line. In this sub-area of potentially highest vertical gradients, a unit vertical flow rate of 0.00046 L/s/m² (litre per second per square metre) is estimated for the affected portion of the northern courtyard and sections of both the lower and upper retaining walls.

In all remaining Site areas potentially affected by upward groundwater flow (Attachment #6a) the maximum Table 1 gradient of 0.06 can be reasonably accepted with a corresponding peak unit rate of upward groundwater flow of 0.0001 L/s/m². For perspective, applying this unit flow rate to the entire L1 slab area produces a gross vertical (upward) groundwater volumetric flow rate of 0.06 L/s. This very low unit area flow rate can be readily managed with conventional perimeter drains placed within discrete fill drainage polygons under slabs, asphalt surfaces and paving stone surfaces.

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

4.2.2 Retaining Wall Flow Rates

The "upper" retaining wall length is approximately 150 m. Accepting the upper-bound K_b value of 4.6×10^{-6} m/s for the surficial SAND and a conservative water table gradient of 1.0 (induced by wall drains) and a saturated sediment profile of 1.25 m above the foundation perimeter drain (per the $10Y_{24}$ depth at BH21-05 [Table 1]), the gross lateral groundwater inflow rate (peak) to the "upper wall" perimeter drain is estimated to be 14.3 USgpm (0.90 L/s). Vertical flow to the perimeter drain is interpreted to occur only within the west-most 55 m section of the upper wall (Attachment #6a) with an estimated peak inflow rate of 0.8 USgpm (0.05 L/s). Accordingly, the "upper wall" drain can be designed to collect and convey groundwater at a gross peak rate ($10Y_{24}$) of 15.1 USgpm (0.95 L/s). The upper wall drain design includes a mid-point (approximately) "divide" to convey intercepted water eastward within the east-most 70 m section of drain pipe and westward within the west-most 80 m section of drain pipe. The eastern section will collect groundwater at a peak rate 6.7 USgpm (0.42 L/s) with an average of 0.029 USgpm per lineal foot (0.006 L/s per metre). The western section will collect groundwater at a peak rate 8.4 USgpm (0.53 L/s) with an average of 0.034 USgpm per lineal foot (0.007 L/s per metre).

Assuming the same hydraulic conductivity parameters for the 170 m long "lower wall" and an increased fully-saturated sediment profile of 2.0 m above the foundation perimeter drain (per the $10Y_{24}$ depth at BH21-05 [Table 1]), the gross lateral groundwater inflow rate (peak) to the "lower wall" perimeter drain is estimated to be 25.4 USgpm (1.60 L/s). Vertical flow to the perimeter drain is interpreted to occur only within the west-most 110 m section of the upper wall (Attachment #6a) with an estimated peak inflow rate of 1.8 USgpm (0.11 L/s). Accordingly, the "lower wall" drain can be designed to collect and convey groundwater at a gross peak rate ($10Y_{24}$) of 27.2 USgpm (1.72 L/s). The lower wall drain design includes a mid-point "divide" to convey intercepted water eastward within the east-most 80 m section of drain pipe and westward within the west-most 90 m section of drain pipe. The eastern section will collect groundwater at a peak rate 12.3 USgpm (0.77 L/s) with an average of 0.048 USgpm per lineal foot (0.010 L/s per metre). The western section will collect groundwater at a peak rate 14.9 USgpm (0.94 L/s) with an average of 0.048 USgpm per lineal foot (0.010 L/s per metre).

4.2.3 Level 1 Perimeter Drain Inflows

The exterior perimeter drain for the Level 1 (L1) structure including Building A and Building B will have the deepest burial depth of all Site building drains. The north-most section of this drain will run approximately 130 m from the northwest corner of Building A to northeast corner of Building C at an average depth of approximately 3.0 m below the $10Y_{24}$ water table elevation determined for monitoring wells BH21-01 and BH21-11 (Attachment 6b). The drain will continue approximately 20 m along both the western and eastern sides of this footprint at an average depth of 1.7 m below the local $10Y_{24}$ water table (Attachment #6b). Foundation depths along

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

the building front will be near finished grades and, therefore, the front section of perimeter drain will be shallowly buried. Accepting the vertical separation of the drain pipe to the 10Y₂₄ water as representing the saturated soil thickness and assuming an lateral flow gradient of 1.0 (induced by the drains), the resultant gross lateral groundwater inflow rate to the entire L1 perimeter drain is estimated to be 2.0 L/s (31.7 USgpm) under predicted 10Y₂₄ conditions.

Peak rates of upward groundwater inflow to the L1 perimeter drain can be calculated based on the Section 4.2.1 unit rate of 0.0001 L/s/m² and a sub-drain contributory area defined by the gross drain length of approximately 300 m and drainage pathway width of 1.0 m. On this basis, the resultant gross vertical groundwater inflow rate to the entire L1 perimeter drain is estimated to be 0.03 L/s (0.5 USgpm) under predicted 10Y₂₄ conditions

4.3 Off-Site Groundwater Interception Ditch

The preceding sections characterize the Site hydro-stratigraphy and project interactions with the groundwater system based on the current condition (i.e., undeveloped) of lands situated up-gradient (i.e., north, upslope) of the Site. Accordingly, the assessed rates of groundwater inflow to project drainage works (described above) represent an “unmitigated” condition that will vary as the upslope lands are developed. It is understood of an approximately 2 m deep off-site ditch is being considered for construction immediately north of the northern Site property boundary to intercept groundwater flowing southeastward toward the Site. Groundwater monitoring near the ditch alignment in wells BH21-06 and BH21-07 during November-December 2021 (Figures 5 and 6, Attachment #2) indicates a persistent downward flow gradient, which confirms the proposed ditch would only intercept groundwater flowing laterally within the surficial SAND. Metro’s borehole records confirm the surficial SAND extends more than 7.6 m-bg at BH21-06 and more than 3.3 m-bg at BH21-07, which indicates the proposed ditch would be constructed entirely within the surficial SAND. Accepting the upper-bound K_b value of 4.6×10^{-6} m/s for the surficial SAND, a conservative water table gradient of 1.0 (induced by the ditch depression), and a saturated sediment profile of 1.0 m above the ditch invert (per the 10Y₂₄ depths at BH21-06 and BH21-07 [Attachment #2]), the gross lateral groundwater inflow rate (peak) to the off-site interception ditch is estimated to be 11.1 USgpm (0.7 L/s).

**Reference: Revised Peak Groundwater Inflow Estimates (Supplementary Data Work Plan)
Hydrogeological Assessment for Geotechnical Investigation
Silverstone Care Centre, 5625 Derby Road, Sechelt, BC**

5 LIMITATIONS

This letter has been prepared for the consideration of Metro Testing and Engineering Ltd., the Silverstone Care Centre project team, District of Sechelt staff, and the subject property owners. Any use that a third party makes of this document, are the responsibilities of such third parties. MDM Groundwater Consulting Ltd. accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken, based on this document.

MDM Groundwater Consulting Ltd. has prepared this letter in a manner consistent with the level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services were provided, subject to limits and constraints applicable to the letter. No other warranty, expressed or implied is made.

This letter has been prepared according to the objectives identified in Section 1.0 of this document and is not applicable to any other project or site location. All opinions, interpretations and recommendations presented in this document are based on review of the information referenced in the preceding sections.

6 CLOSURE

We trust this letter meets your current needs. If you have questions regarding any aspect of the document, please contact the undersigned directly.

Regards,

MDM Groundwater Consulting Ltd.
BC Permit to Practice #1001291

Matthew D. Munn, M.Sc., P. Eng.
Principal Hydrogeologist



- Attachments: #1 – Site Plan (Metro Testing and Engineering Figure 1)
#2 – Figures 2 to 10. Groundwater Monitoring Program Summaries
#3 – Figures 11 to 19. Groundwater-Rainfall Correlations
#4 – Figure 20. Shallow Groundwater Contours (10Y₂₄)
#5 – Figure 21. Deep Groundwater Piezometric Contours (10Y₂₄)
#6 – CREUS "KEYPLAN" with Metro Drainage Polygon
CREUS "SITE SECTIONS" with Metro Stratigraphy and MDM 10Y₂₄ Data



Legend

- Site Boundary
- Borehole/Monitoring Well Location

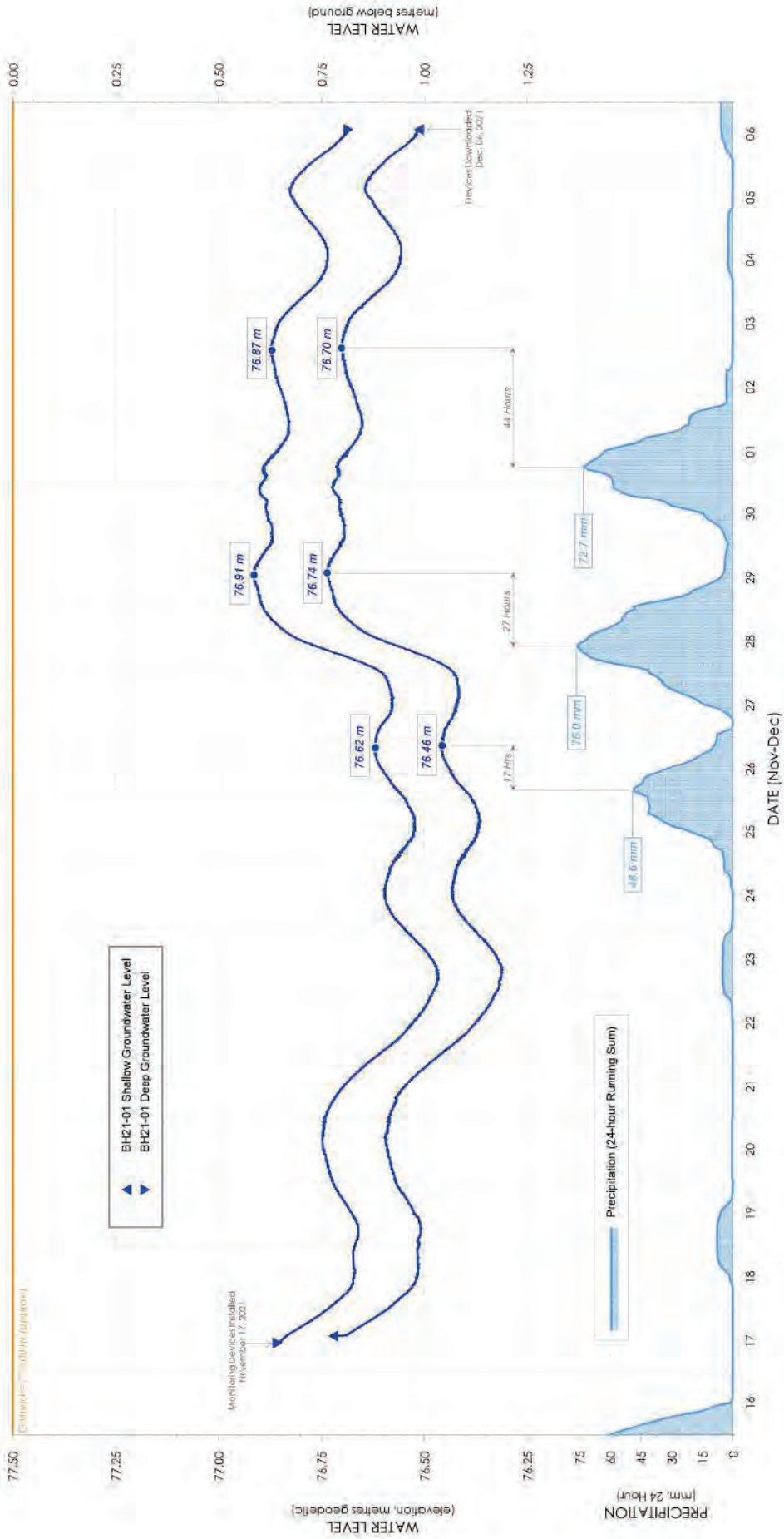
* All measurements are approximate

	ATTACHMENT #1	Project No.: TT39435
		Figure No.: 1
		Drawn By: Google
		Drafted By: AR
		Checked By: RP
		Date: November 2021
		Scale: As Shown
Figure Title: Site Plan and Investigation Locations	Project Title: Hydrogeological Services	
Address: 5625 Derby Road, Sechelt, BC	Client Name: Silverstone Care Centre	
Rev.	Date	Description



**ATTACHMENT #2
GROUNDWATER MONITORING PROGRAM
WELL BH21-01**

Nov. 17 To Dec. 06, 2021



NOTES: 1) All data collected in this report as described in the scope of work are data recorded on-site in the field.
 2) Calculated and derived data were manually reviewed for accuracy.
 3) Elevations from Strat Land Surveying Inc. drawing 15122-1-007 (dated Sept 30, 2020) (rev)
 4) Precipitation data (hourly) from Environment Canada's West Vancouver AUV climate station.

Project No. 8520-0307
 Drawn: MDM
 Reviewed: [Signature]
 Date: December 2021



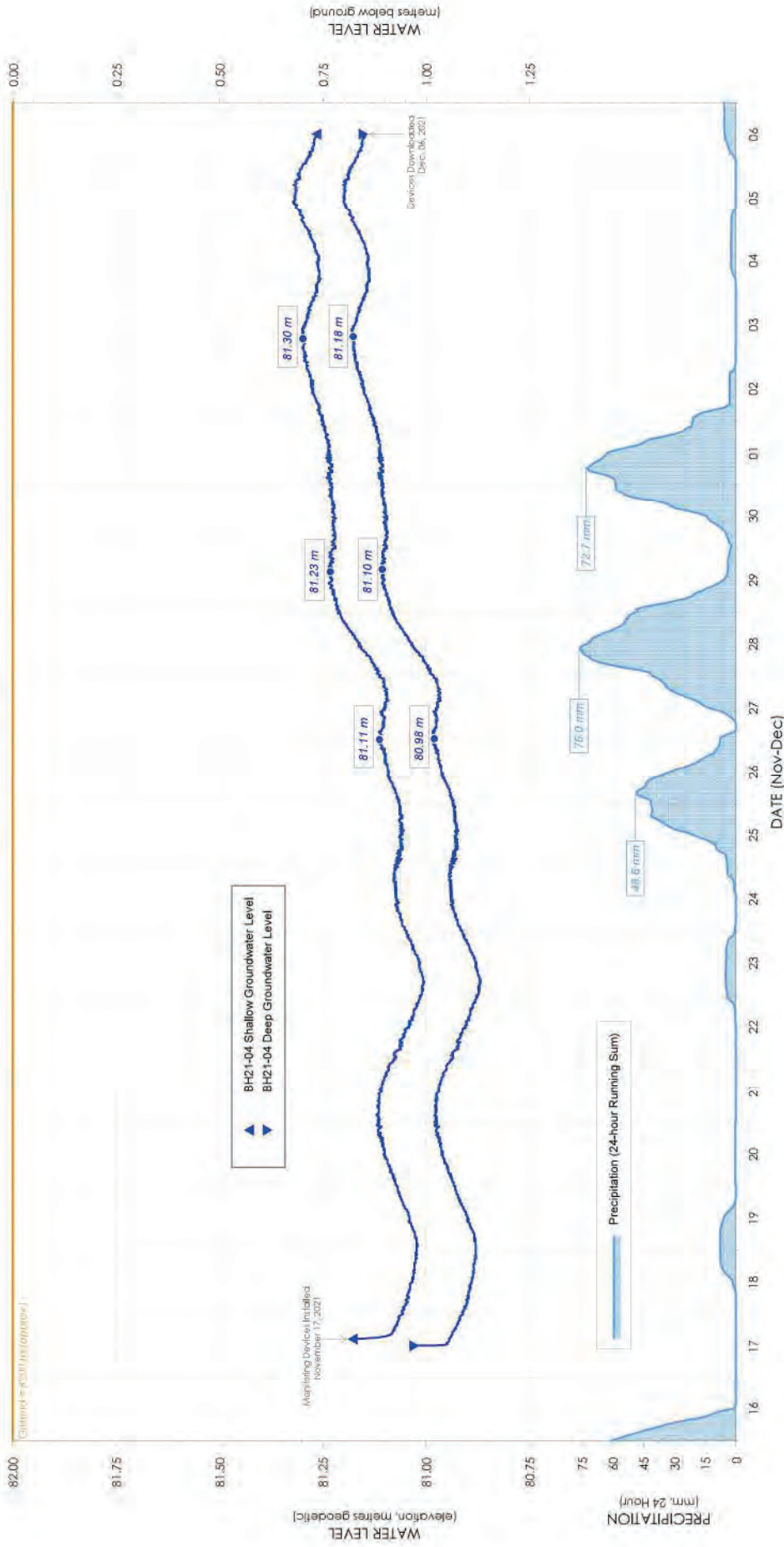
HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 Silverstone Care Centre (Derby Road at Cowrite Street)
 Sechelt, BC

Fig. 2

GROUNDWATER MONITORING PROGRAM

WELL BH21-04

Nov. 17 To Dec. 06, 2021



NOTES: 1) All data values are in SI units unless otherwise specified.
 2) All data values are based on the most current data available.
 3) All data values are based on the most current data available.
 4) Precipitation data (hourly) from Environment Canada's West Vancouver AUT climate station.

Project No. EC21-0307
 Drawn: MDM
 Reviewed: MDM
 Date: December 2021

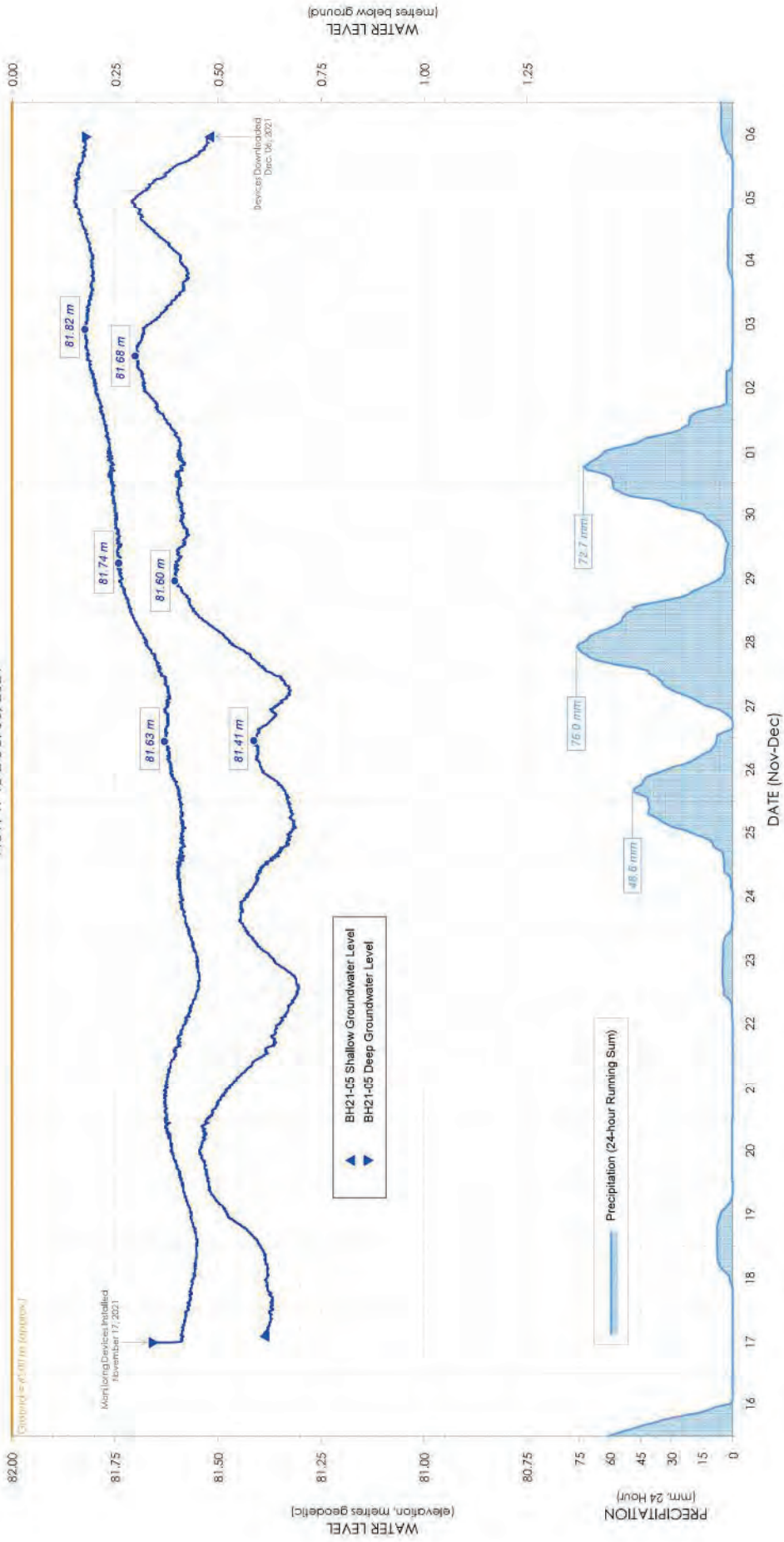


HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 3

GROUNDWATER MONITORING PROGRAM WELL BH21-05

Nov. 17 to Dec. 06, 2021



NOTES: 1) Solid red lines represent as downloaded from user data included on Scribble Method
 2) Coloured lines represent manual water level logs
 3) Elevations from Strat Land Surveying Inc. drawing 15127-1007 dated Sept 30, 2020 (rev)
 4) Precipitation data (hourly) from Environment Canada's West Vancouver AUT climate station

Project No. 82010307
 Drawn: MDM
 Reviewed: MDM
 Date: December 2021

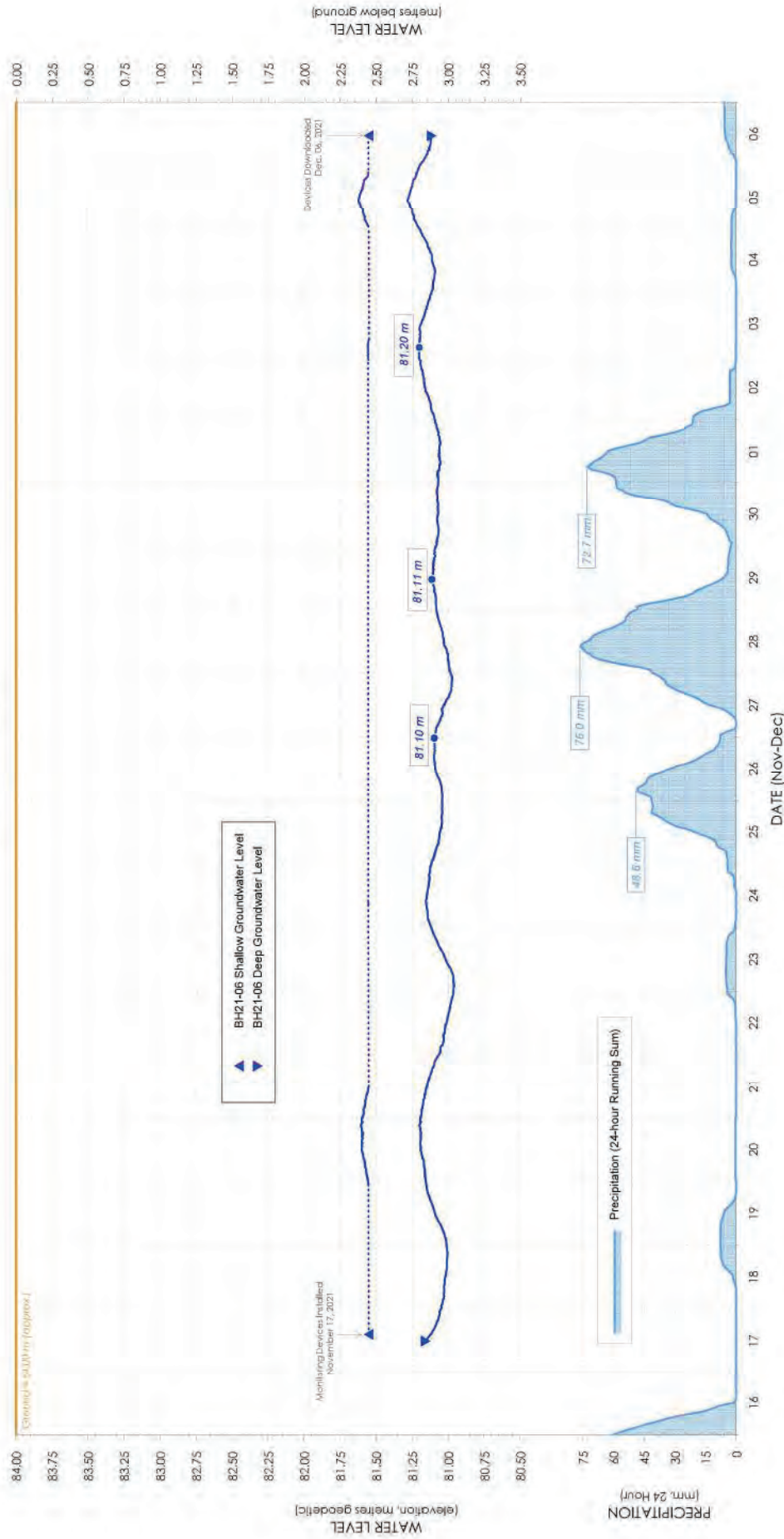


HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 4

GROUNDWATER MONITORING PROGRAM WELL BH21-06

Nov. 17 To Dec. 06, 2021



NOTES: 1) Solid red lines represent as measured levels; use data recorded on 5-minute interval
 2) Coloured shaded areas represent manual water level measurements
 3) Elevations from Strat Land Surveying Inc. drawing 15127-1007 dated Sep 30, 2020 (rev)
 4) Precipitation data (hourly) from Environment Canada's West Vancouver APT climate station
 5) Dotted groundwater elevation data line indicates no information available (i.e., dry standpipe)

Project No. 82010207
 Drawn MDM
 Reviewed
 Date December 2021



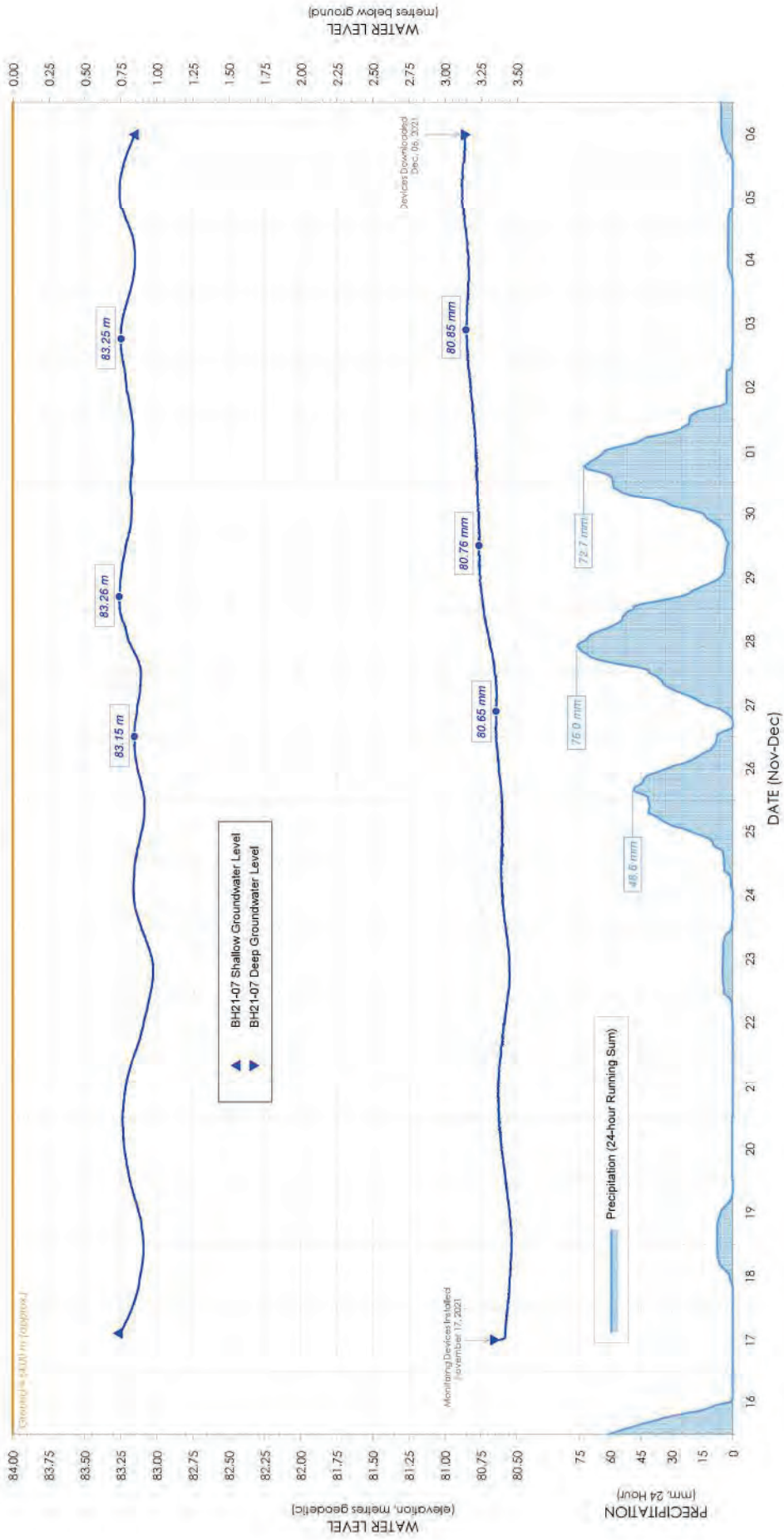
HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 5

GROUNDWATER MONITORING PROGRAM

WELL BH21-07

Nov. 17 To Dec. 06, 2021



NOTES: 1) Solid red lines represent as described in project file; 2) see data included on specific interval
 3) Coloured data represent manual water level observations
 4) Elevations from Strat Land Surveying Inc. drawing 15127-1007 dated Sept 30, 2020 (rev)
 5) Precipitation data (hourly) from Environment Canada's West Vancouver AUT climate station

Project No. 82010207
 Drawn: MDM
 Reviewed: MDM
 Date: December 2021

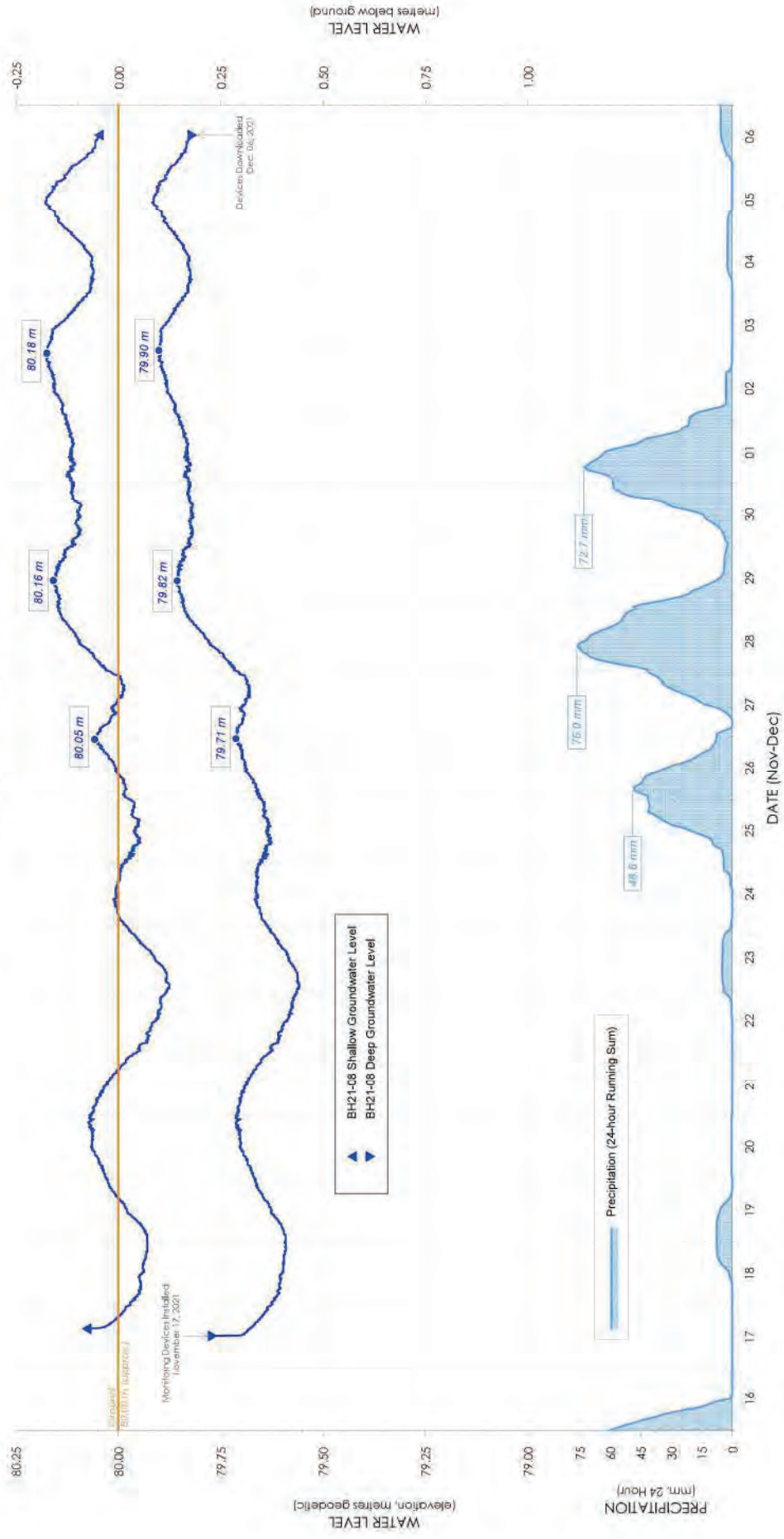


HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 Silverstone Care Centre (Derby Road at Cowrite Street)
 Sechelt, BC

Fig. 6

GROUNDWATER MONITORING PROGRAM WELL BH21-08

Nov. 17 to Dec. 06, 2021



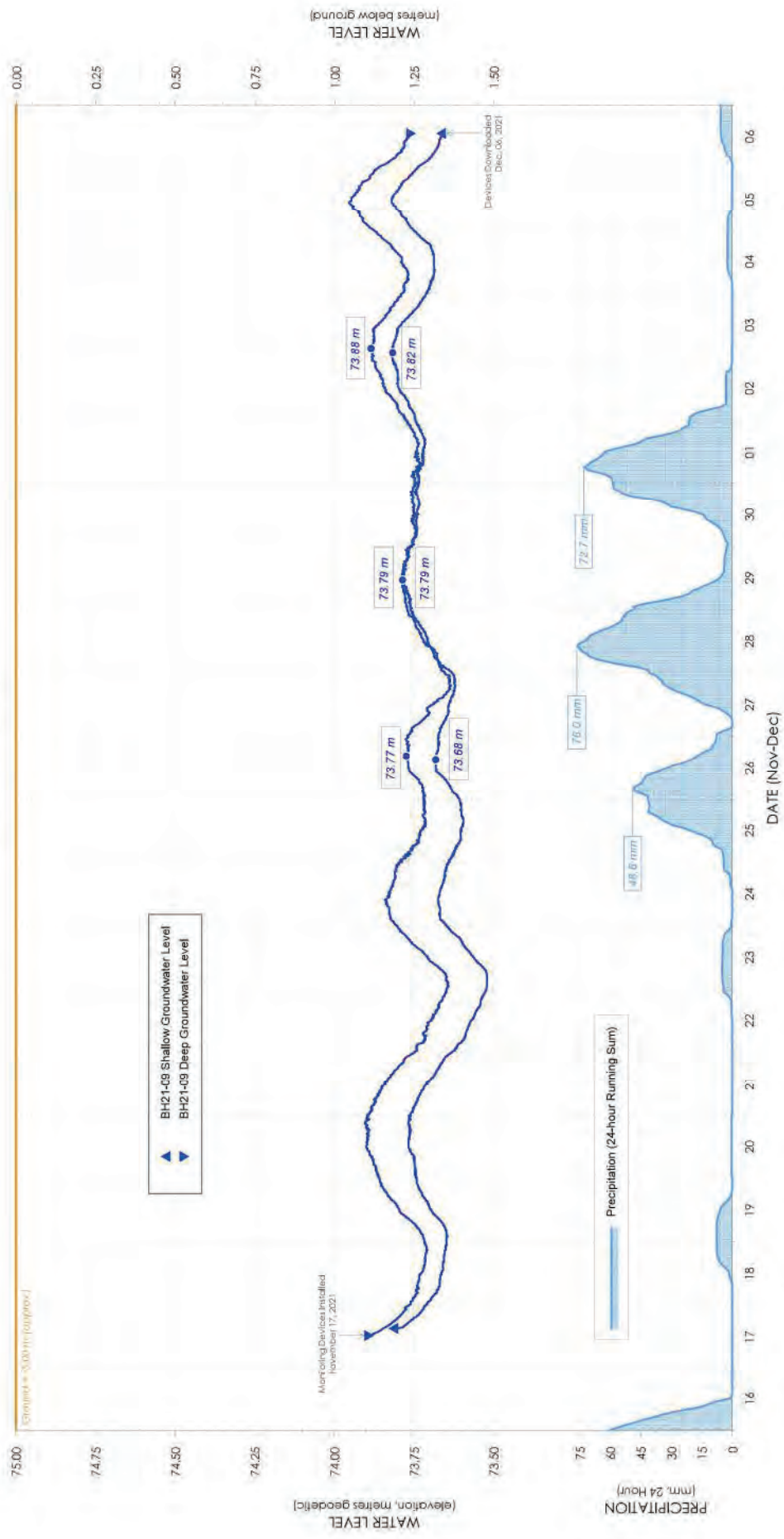
NOTES: 1) All data values in this report are derived from original field data unless otherwise noted on specific sheets.
 2) Coloured data points in this report were manually reviewed.
 3) Elevations from Stratix Land Surveying Inc. drawing 15127-1-007, dated Sept 30, 2020 (rev)
 4) Precipitation data (hourly) from Environment Canada's West Vancouver AUT climate station

Project No. EC210307 Drawn MDM Reviewed Date December 2021		HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION Silverstone Care Centre (Derby Road at Cowrite Street) Sechelt, BC	Fig. 7
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GROUNDWATER MONITORING PROGRAM

WELL BH21-09

Nov. 17 To Dec. 06, 2021



NOTES: 1) All data are in SI units unless otherwise specified. 2) Precipitation data is based on a 24-hour period. 3) Coloured data points represent manual water level readings. 4) Elevations from Stratix Land Surveying Inc. drawing 15127-1007 dated Sept 30, 2020 (rev 1). 5) Precipitation data (hourly) from Environment Canada's West Vancouver Air Climate Station.

Project No. EC21-0307
 Drawn: MDM
 Reviewed: MDM
 Date: December 2021



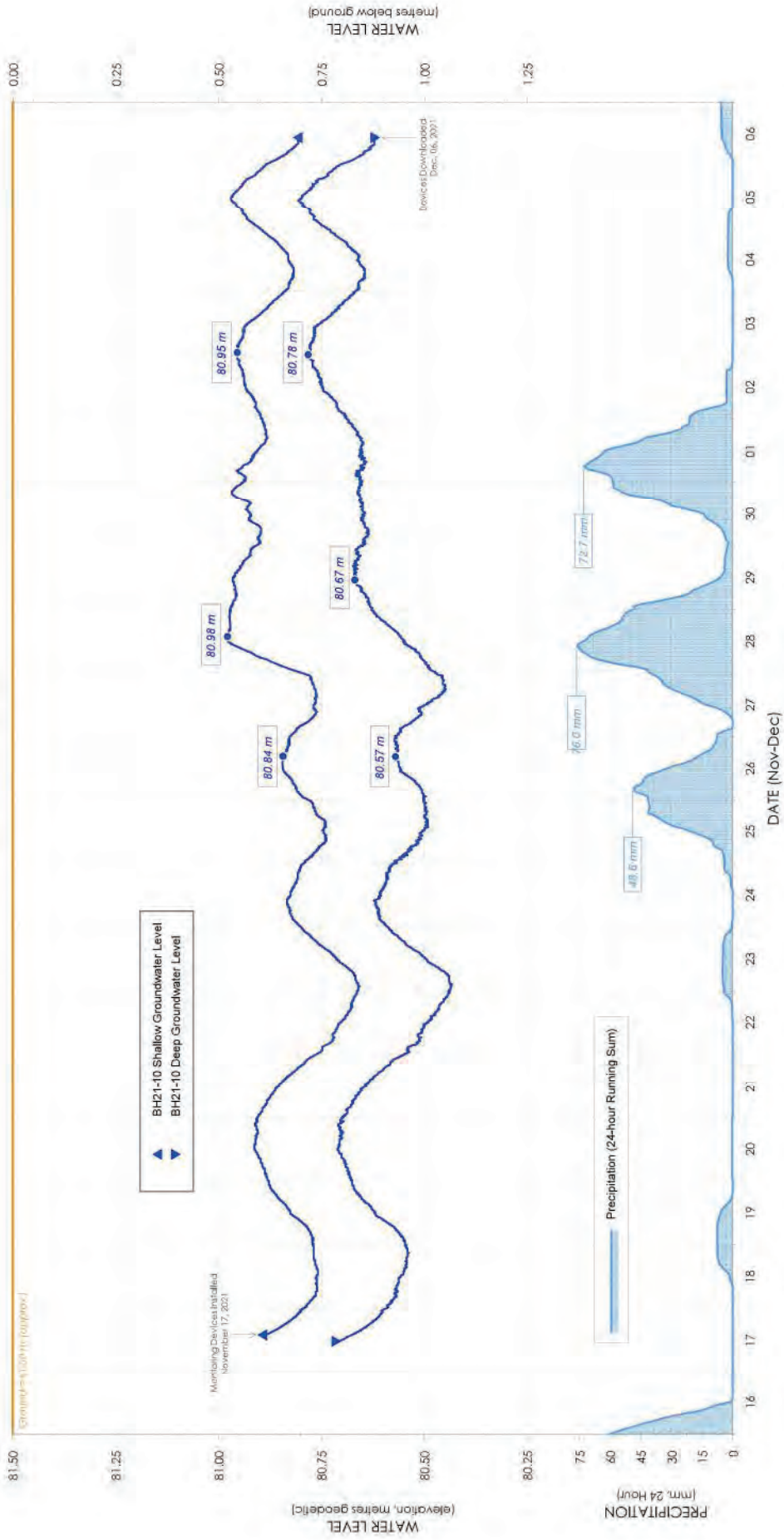
HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 8

GROUNDWATER MONITORING PROGRAM

WELL BH21-10

Nov. 17 To Dec. 06, 2021

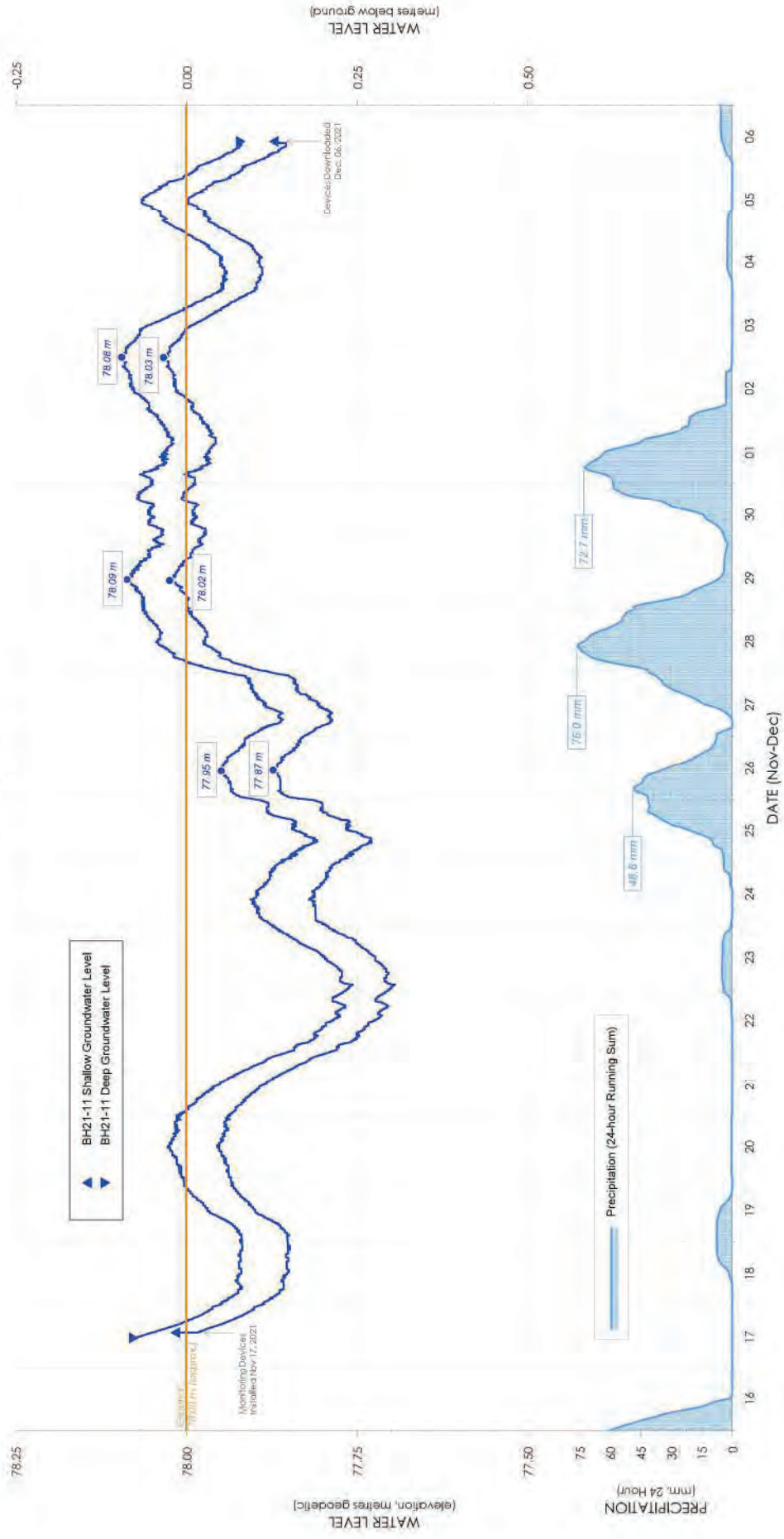


NOTES: 1) All data values are in SI units unless otherwise specified. 2) All data values are based on the same datum. 3) All data values are based on the same datum. 4) All data values are based on the same datum.

Fig. 9

GROUNDWATER MONITORING PROGRAM WELL BH21-11

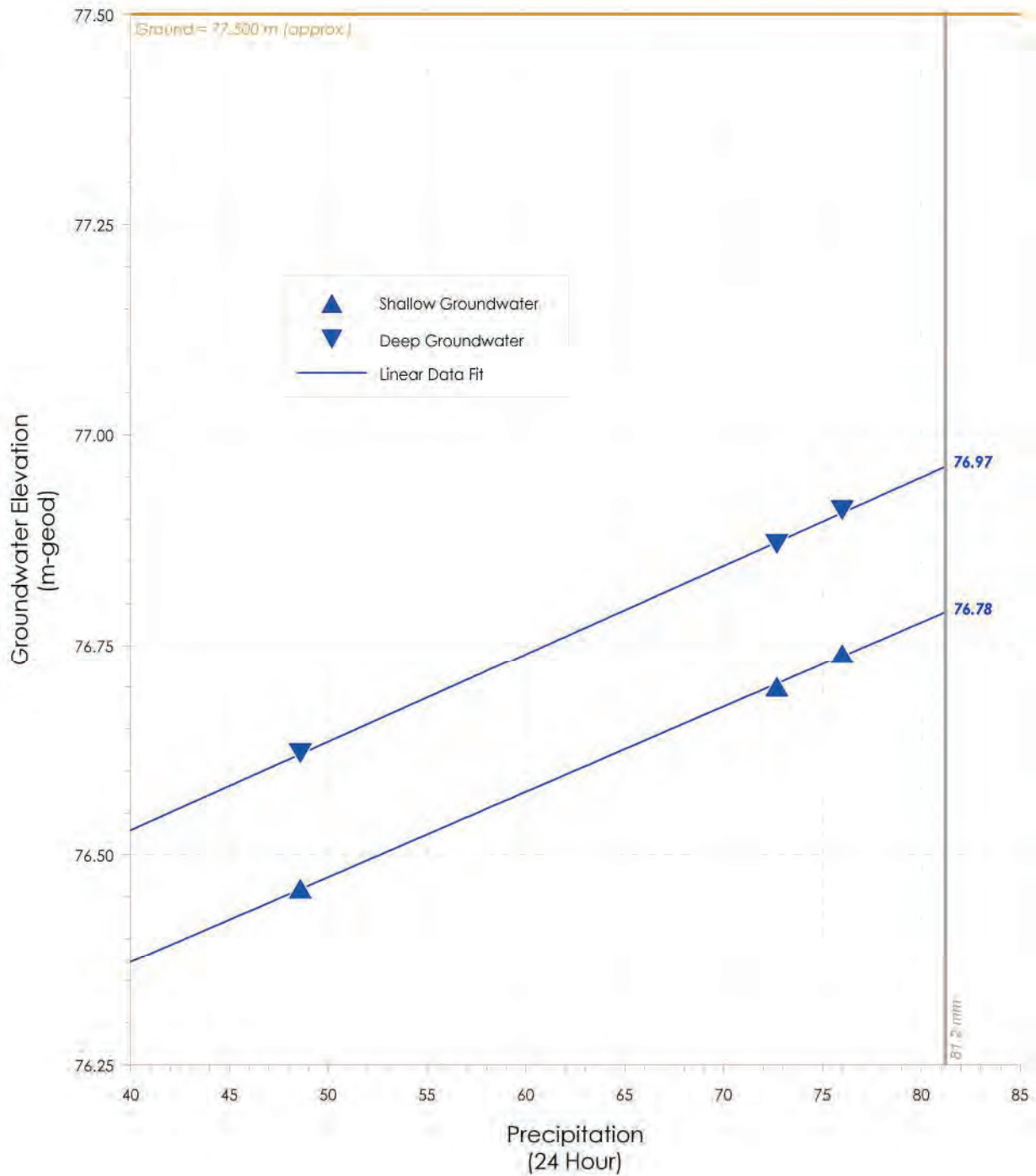
Nov. 17 to Dec. 06, 2021



NOTES: 1) All data values are in SI units unless otherwise specified. 2) All data values are based on the current date. 3) All data values are based on the current date. 4) All data values are based on the current date.

<p>Project No. EC21-0307 Drawn: MDM Reviewed: MDM Date: December 2021</p>	<p>MDM Groundwater </p>	<p>HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION Silverstone Care Centre (Derby Road at Cowrite Street) Sechelt, BC</p>	<p>Fig. 10</p>
------------------------------------------------------------------------------------------------------------------	-------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------

MONITORING WELL BH21-01 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-01 monitoring summary (Figure 2)

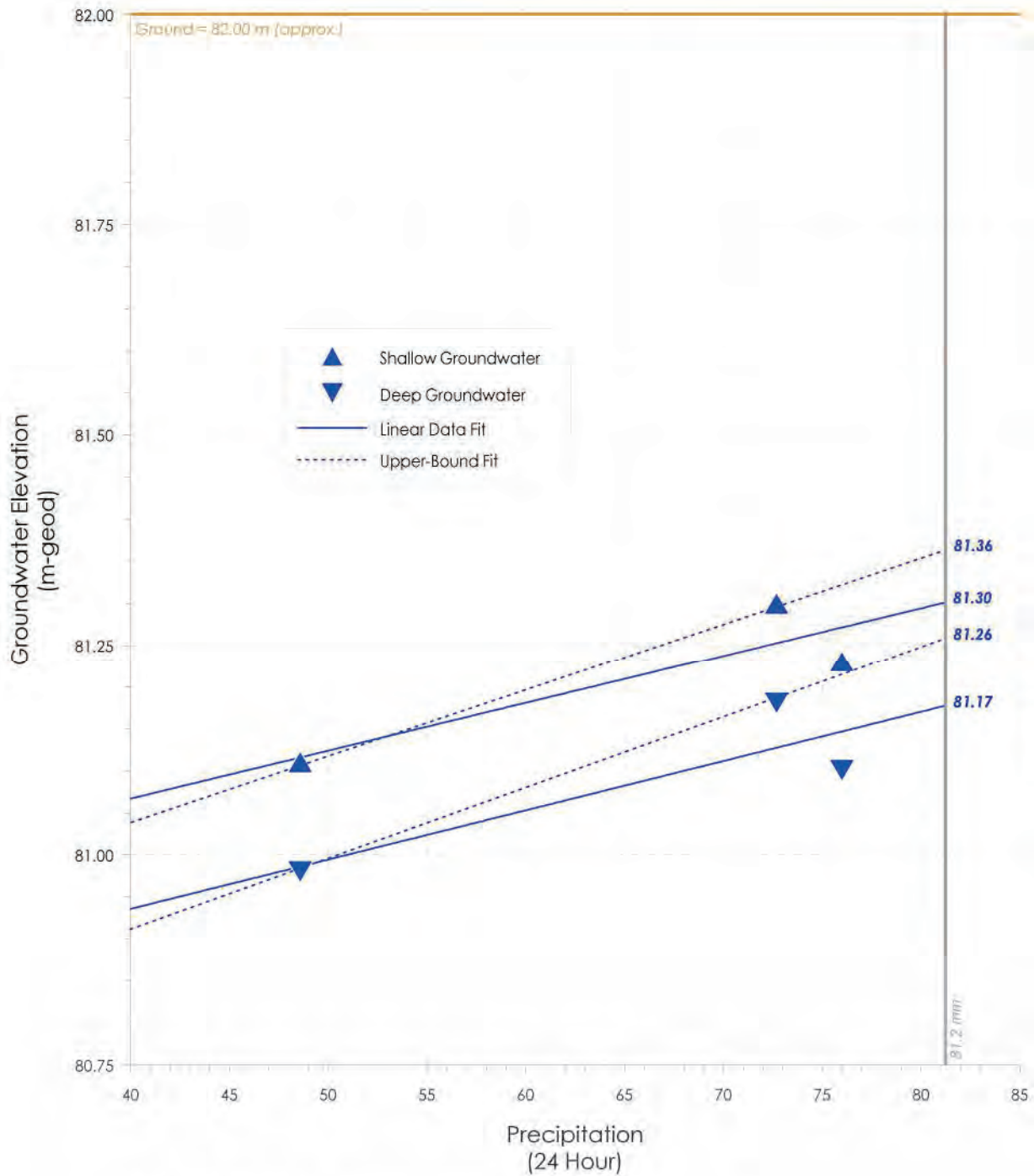
Project No. BC210007
 Drawn MDM
 Reviewed NCT/Alison
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 11

MONITORING WELL BH21-04 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-04 monitoring summary (Figure 3)

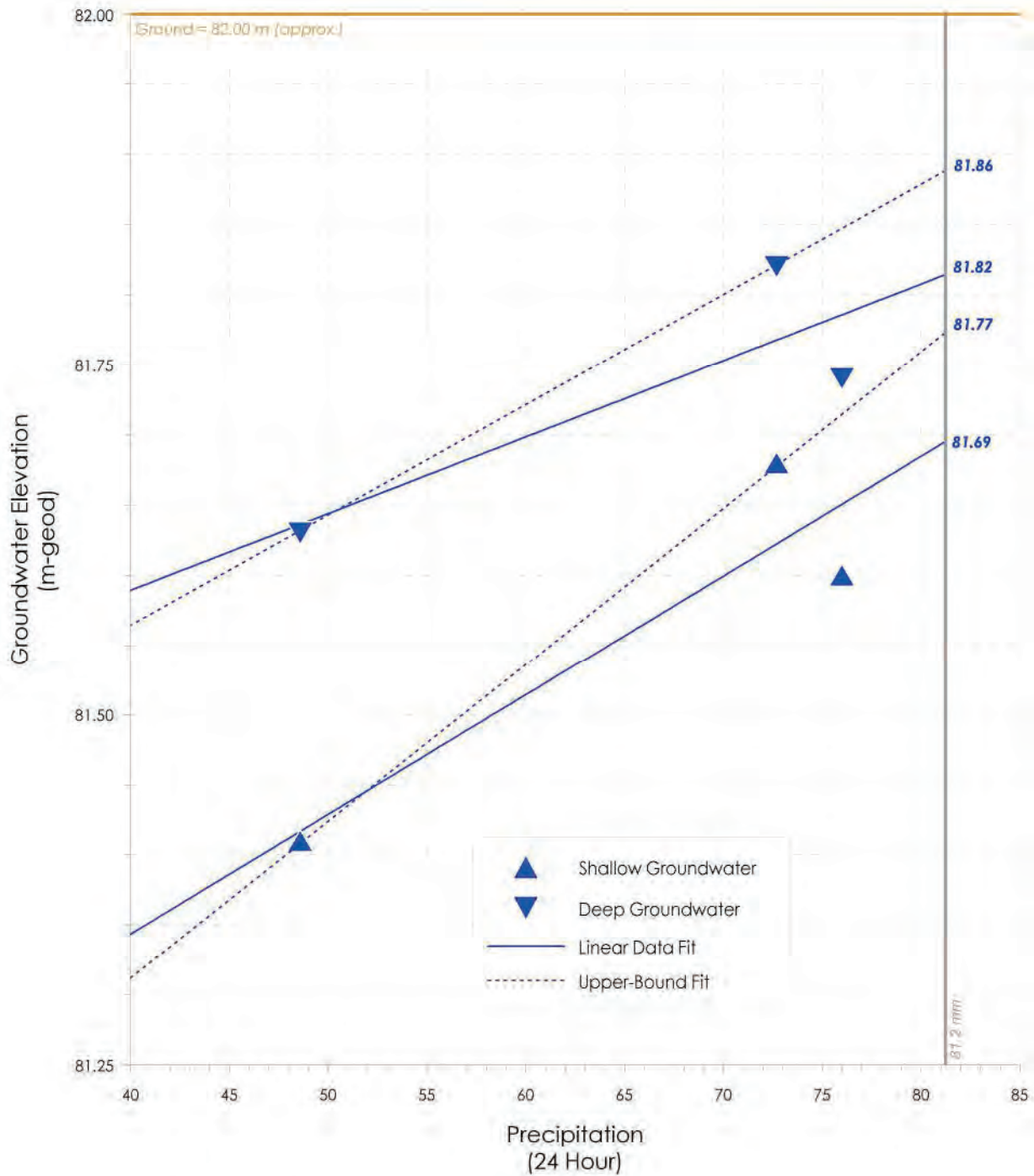
Project No. BC210007
 Drawn MDM
 Reviewed MDM
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 12

MONITORING WELL BH21-05 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-05 monitoring summary (Figure 4)

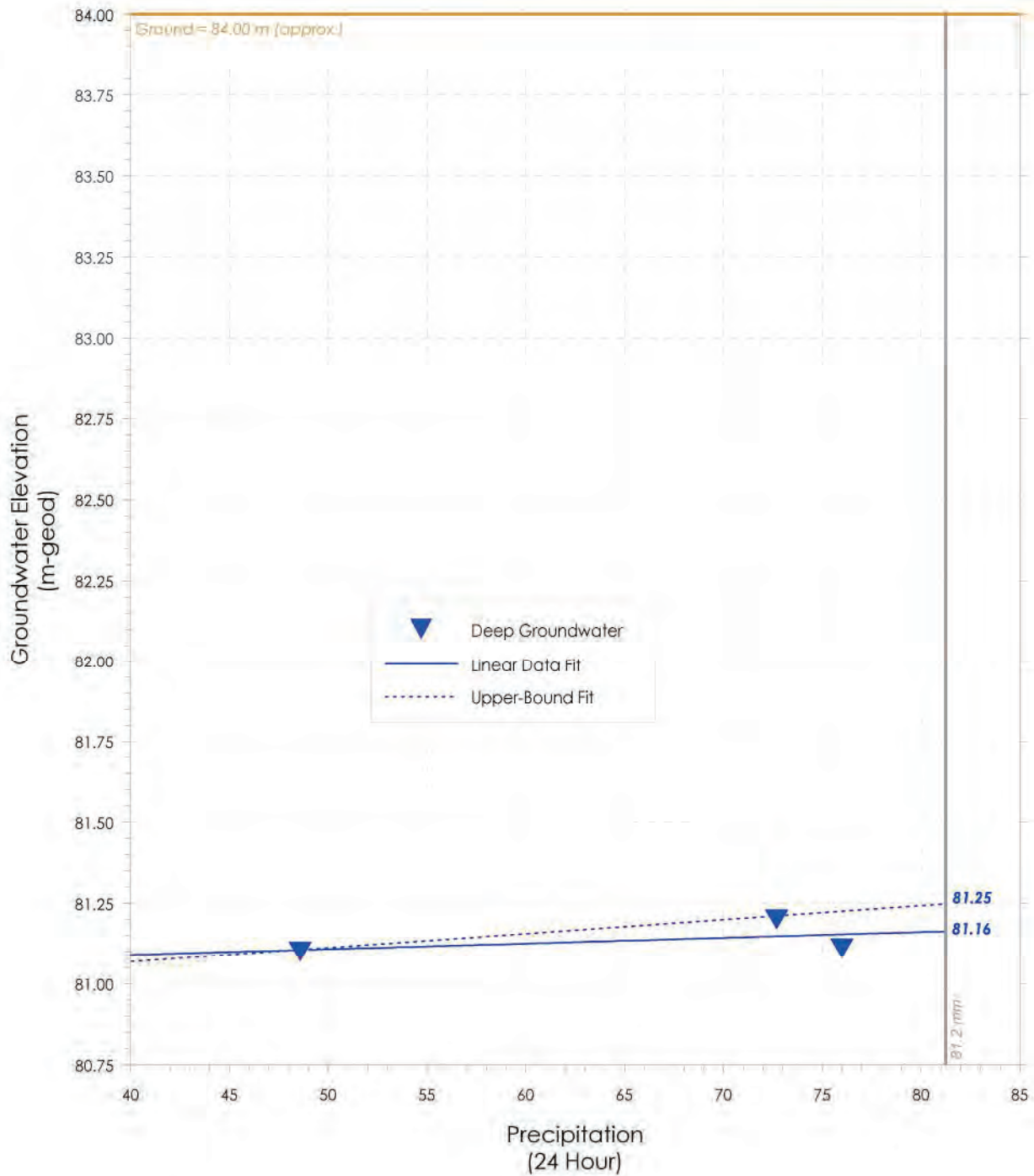
Project No. BC210007
 Drawn MDM
 Reviewed [Signature]
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 13

MONITORING WELL BH21-06 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-06 monitoring summary (Figure 5)

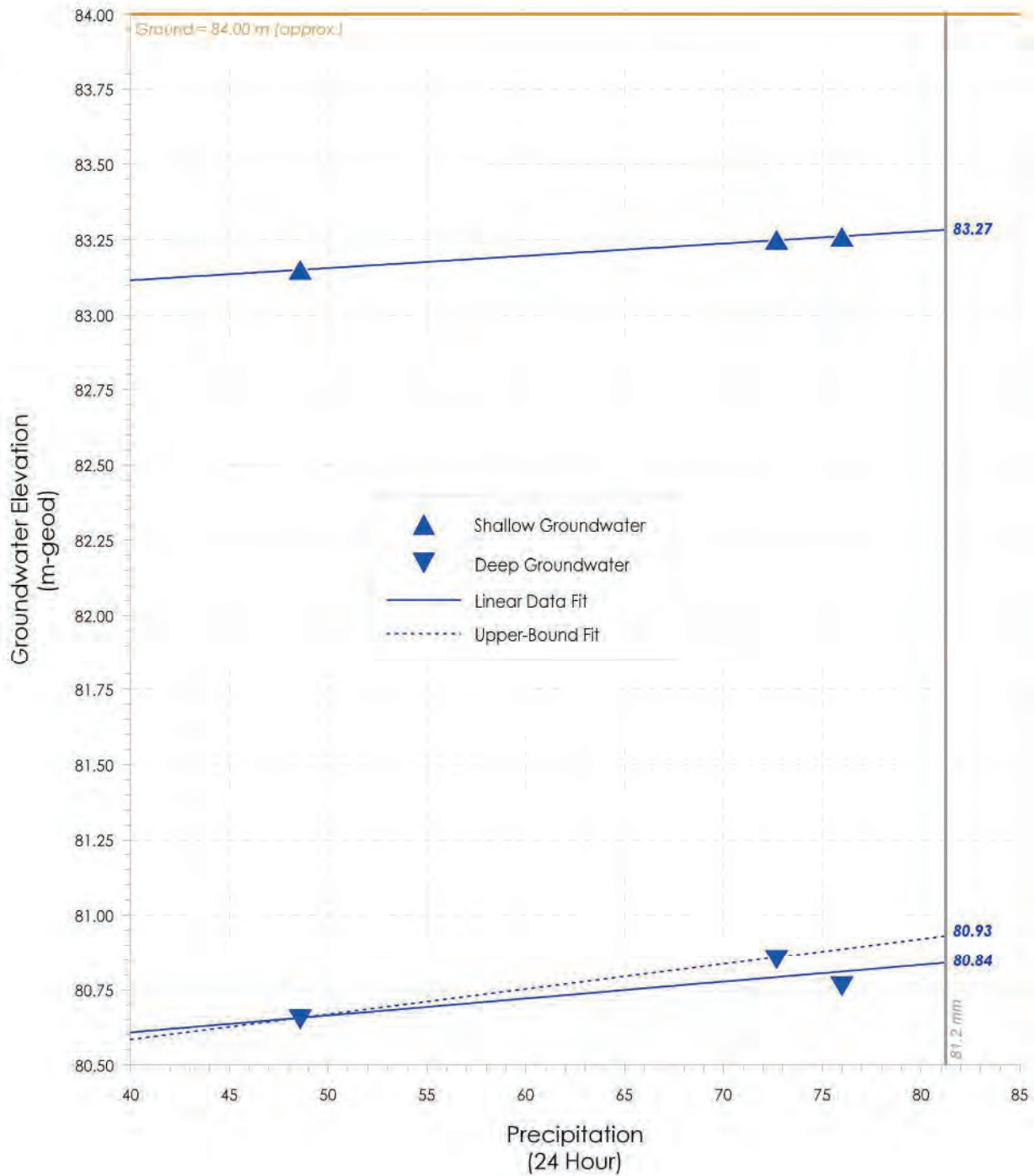
Project No. BC210007
 Drawn MDM
 Reviewed MDM
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 14

MONITORING WELL BH21-07 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-07 monitoring summary (Figure 6)

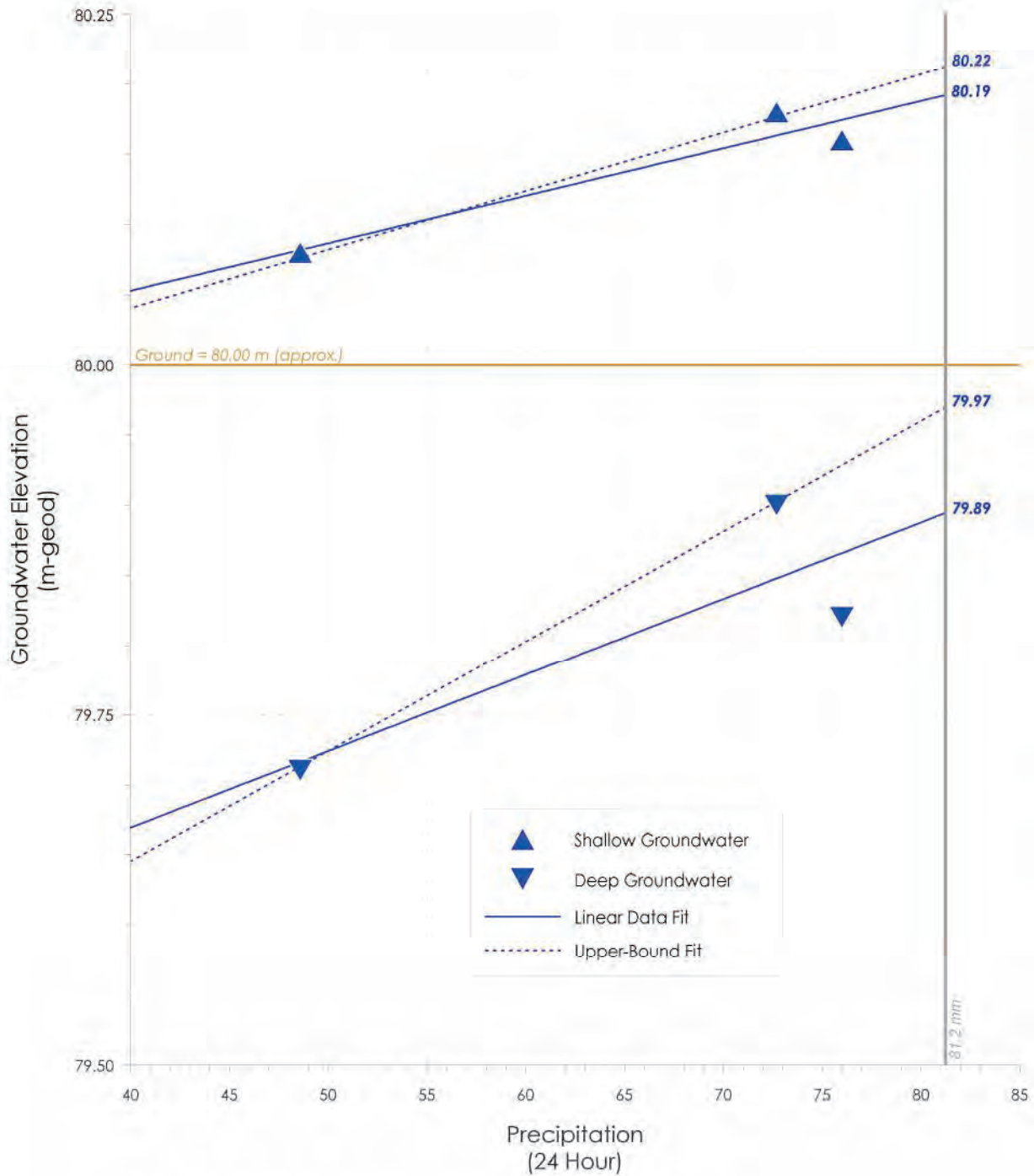
Project No. BC210007
 Drawn MDM
 Reviewed MDM
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
 FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 15

MONITORING WELL BH21-08 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-08 monitoring summary (Figure 7)

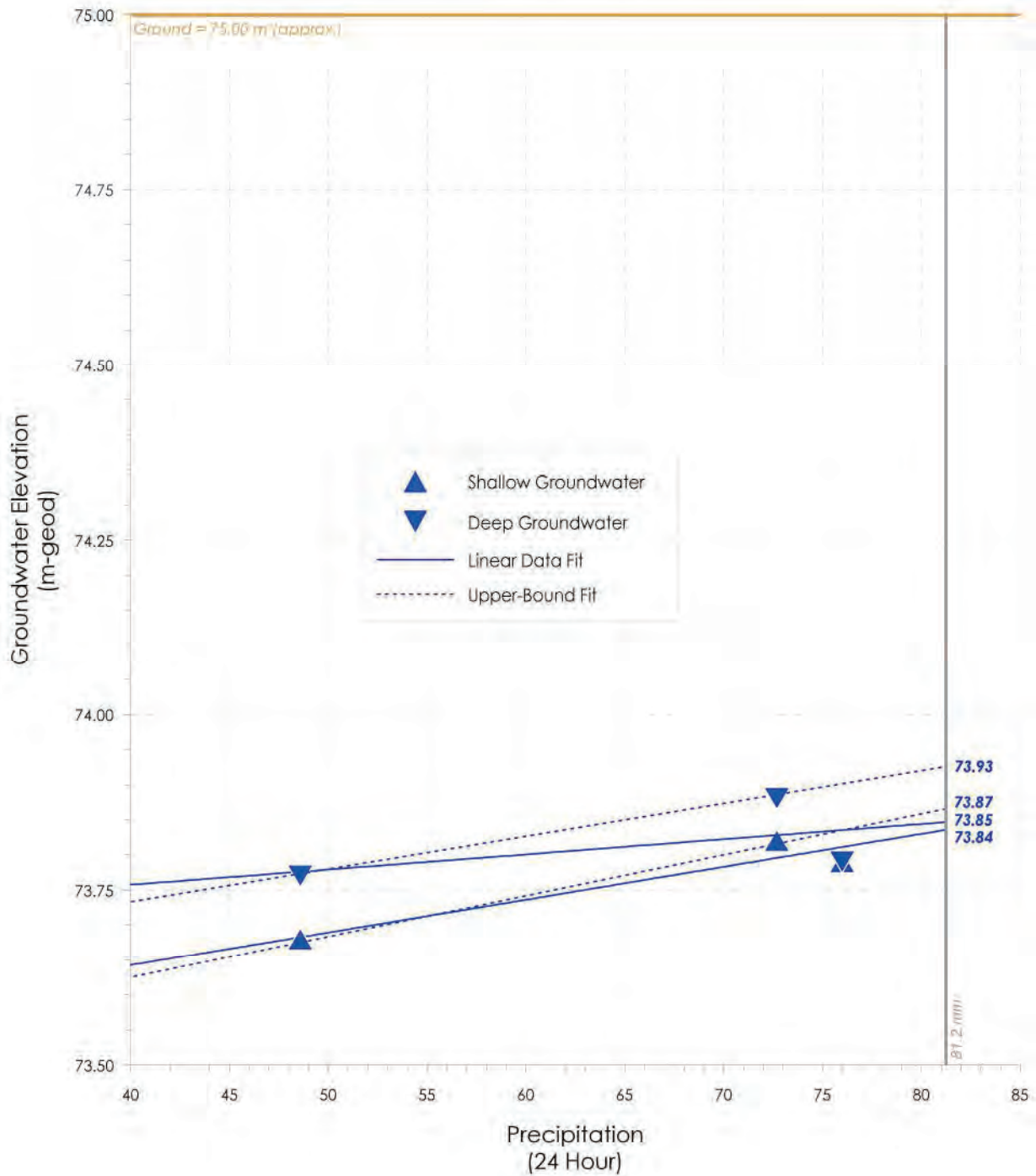
Project No. BC210007
 Drawn MDM
 Reviewed MDM
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
 FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 16

MONITORING WELL BH21-09 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-09 monitoring summary (Figure 8)

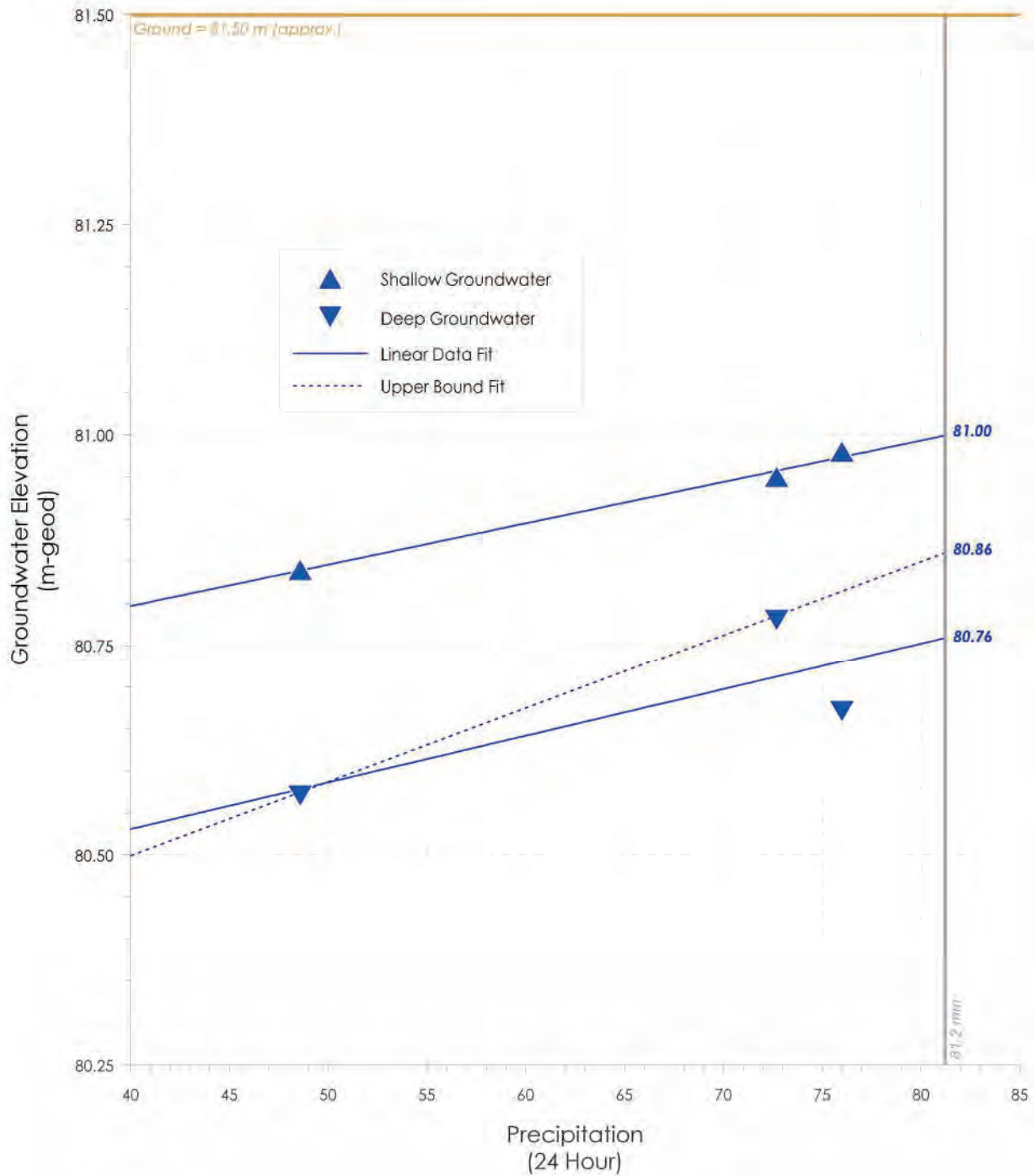
Project No. BC210007
 Drawn MDM
 Reviewed [Signature]
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 17

MONITORING WELL BH21-10 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-10 monitoring summary (Figure 9)

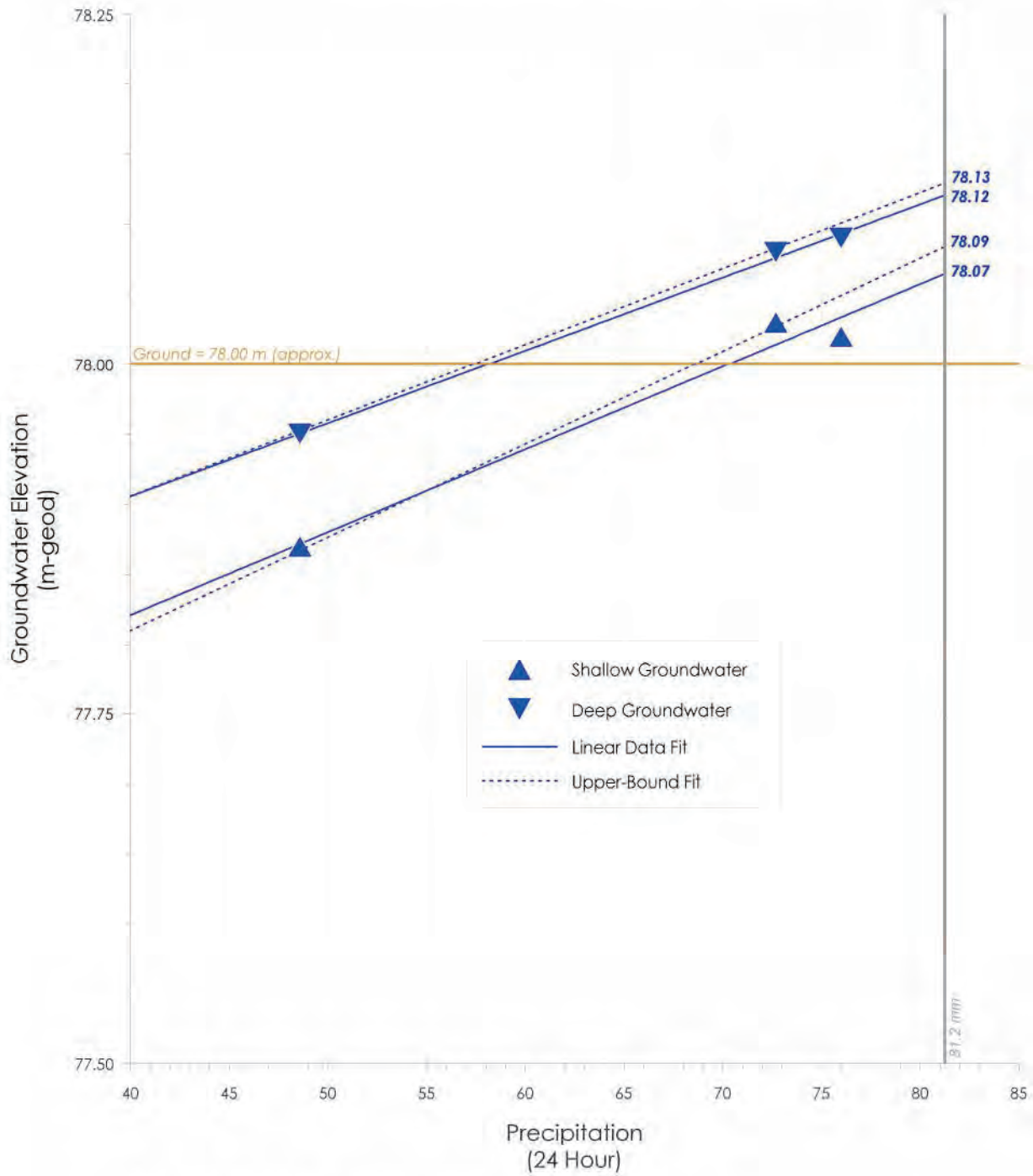
Project No. BC210007
 Drawn MDM
 Reviewed [Signature]
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
 FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 18

MONITORING WELL BH21-11 GROUNDWATER-RAINFALL CORRELATION



NOTE - Source data from BH21-11 monitoring summary (Figure 10)

Project No. BC210007
 Drawn MDM
 Reviewed MDM
 Date December 2021



**HYDROGEOLOGICAL ASSESSMENT
FOR GEOTECHNICAL INVESTIGATION**
 Silverstone Care Centre (Derby Road at Cowrie Street)
 Sechelt, BC

Fig. 19



CLIENT:

SILVERSTONE CARE CENTRE

SHALLOW GROUND WATER PIEZOMETRIC CONTOURS (10Y₂₄)
 HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 5625 DERBY ROAD, SECHELT, BC

PROJECT NUMBER: WF36787
 SHEET NUMBER: FIGURE 20
 DRAWING DATE: DECEMBER 15, 2021

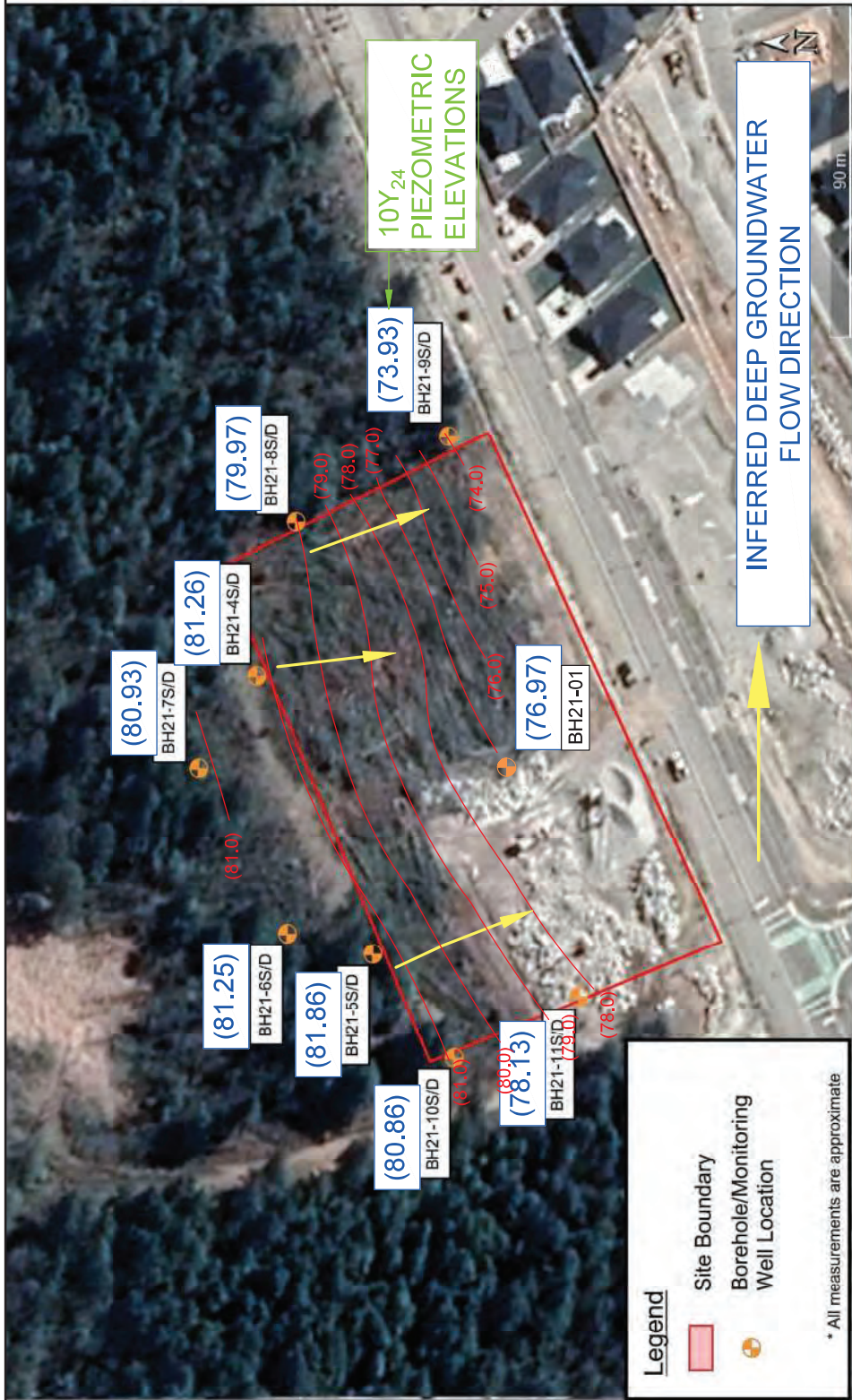
DRAWN BY: GL
 REVIEWED BY: PV
 SCALE: AS SHOWN

NOTES:

- 10Y₂₄ = 10-YEAR RETURN PERIOD 24 HOURS DURATION EVENT

ATTACHMENT #4





NOTES:
 - 10Y₂₄ = 10-YEAR RETURN PERIOD 24 HOURS DURATION EVENT

CLIENT: SILVERSTONE CARE CENTRE

DEEP GROUND WATER PIEZOMETRIC CONTOURS (10Y₂₄)
 HYDROGEOLOGICAL ASSESSMENT FOR GEOTECHNICAL INVESTIGATION
 5625 DERBY ROAD, SECHELT, BC

PROJECT NUMBER: WF36787
 SHEET NUMBER: FIGURE 21
 DRAWING DATE: DECEMBER 15, 2021

DRAWN BY: GL
 REVIEWED BY: PV
 SCALE: AS SHOWN

CLIENT:





Unit 20-3275 McCallum Road,
Abbotsford, BC V2S 7W6
TEL: 604.385.4244
FAX: 1.877.853.5650
e. info@metrotesting.ca
www.metrotesting.ca

LEGEND
 AREA OF INFLUENCE
 UPWARD GROUND WATER
 FLOW

ATTACHMENT #6a

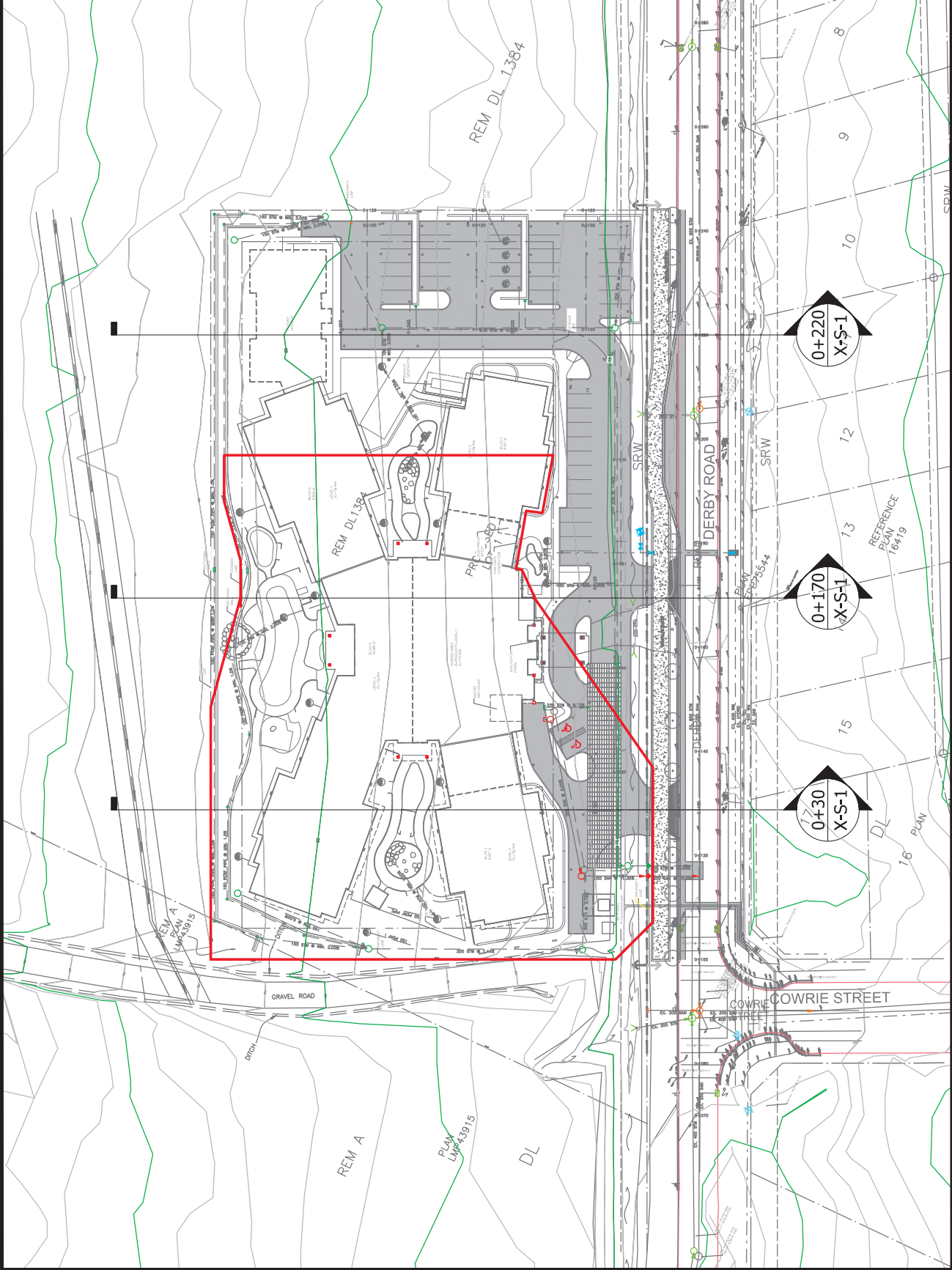
PROFESSIONAL SEAL

INFERRED AREAS OF UPWARD
 GROUND WATER FLOW (KEY PLAN)
 SILVERSTONE CARE CENTRE, SECHelt, BC

DESIGNED BY:	PV
DRAWN BY:	GL
REVIEWED BY:	PV
(AS PER COM)	
PROJECT NUMBER:	WF36787

REV	DESCRIPTION	BY	DATE
02	REV AS PER MDM DES.	GL	2021-12-15
01	PRELIMINARY DRAWINGS	GL	2021-09-29
00	PRELIMINARY DRAWINGS	GL	2021-09-21

SHEET NO: **G-01** SCALE: NTS





APPENDIX B:

Environmental Sensitivity Report



Overview Environmental Analysis For: Silverstone Heights West Sechelt

May 15, 2023
Project No. 22.0073

Client:
Sawarne Lumber Co. Ltd.

Jason Barsanti, R.P.Bio.
BARSANTI ENVIRONMENTAL SERVICES LTD.

www.barsantienviro.ca

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Executive Summary

This overview environmental analysis (OEA) was prepared for Sawarne Lumber Co. Ltd. (the Client) who is conducting a due diligence investigation of the study area for potential development.

An OEA is a qualitative assessment of the presence, or potential presence of aquatic and terrestrial wildlife habitat on and near the site and, on potential impacts of those elements to the proposed development. OEAs are the starting point for development planning on greenfield properties.

It was found that several habitat types are present on the site including natural and manmade watercourses, shrub, and upland forest types and one sensitive ecosystem. A diverse array of terrestrial wildlife, including most small and large mammals present in the region, would be expected in a site like this which is contiguous with virtually unbounded forest lands. Natural aquatic habitat is present in wetlands which provides breeding and rearing habitat for amphibians. Pileated woodpecker and barred owl were observed on the site, and nest holes of pileated woodpecker are present.

Manmade and natural watercourses (ditches) are present on the site, it is understood that changes to watercourses will be proposed therefore approval through Section 11 of the *Water Sustainability Act* (WSA) will be required. It was found that, with the potential exception of the Reeves Road ditch, no watercourse flows into freshwater fish habitat, therefore an assessment through the Riparian Area Protection Regulation (RAPR) will not need to be conducted.

It is not foreseen that development options are greatly impacted by the environmentally valuable resources (EVR) present on the lot, though careful planning must be taken to mitigate harm to known elements. Additional assessment for the delineation of the sensitive forest type and the wetlands is recommended to inform development layouts. It is recommended that the development layout include reserving strips of land for wildlife movement corridors. No noxious invasive plants were observed during the assessment. General guidance is provided here which is expected to be useful to the Client for anticipating timelines and scheduling development events to avoid impacts to EVRs during the development process.

1 Introduction

Barsanti Environmental Services Ltd. (Barsanti Environmental) is retained by Sawarne Lumber Co. Ltd. (the Client) to provide the services of a Qualified Environmental Professional (QEP) to conduct an Overview Environmental Analysis (OEA) on two lots in District of Sechelt (DoS) BC (the Site, Figure 1).



Figure 1. Location of the study area in Sechelt, BC.

2 Objective

It is understood that the Client is seeking information on potential encumbrances to development of the subject property from environmental protection regulations.

An OEA, or bio-inventory, is designed to provide an overview of the potential presence of environmentally valuable resources (EVR) and species-at-risk (SAR) on and near the study area.

The scope of this report is geared towards a high-level review of the site to guide development decisions at the early stages of the process. As the specific plan for re-development of the site becomes realized and the layout is further evolved, more detailed analysis may be required.

The specific objectives of this OEA are to:

1. Describe existing conditions of the site.
2. Ascertain the potential presence of SAR, or their habitat within the site.
3. Ascertain the potential presence of other EVRs and invasive plants within the site.
4. Identify streams and aquatic habitat and describe stream protection measures.
5. Provide recommendations for project design to mitigate environmental impacts.

2.1 Limits of Assignment

- Our investigation is limited to ecological conditions – fish, wildlife vegetation and bird habitat.
- Our investigation is based on information obtained from publicly available resources and through our visual inspection of the site and the surrounding area. No sampling was conducted for this report.

3 Contributing Professionals

Jason Barsanti, R.P.Bio. is the Principal of Barsanti Environmental and is a registered professional with the College of Applied Biology (CAB). Mr. Barsanti is a qualified environmental professional (QEP) with 17 years' experience working on wildlife, fisheries and wetland habitat assessments including surveys for rare and endangered plants, small mammals, amphibians, conducting surveys for songbird breeding habitat, developing habitat restoration plans, surveying for invasive plants, and conducting environmental monitoring of construction works and performing fish, amphibian, and wildlife salvages for works in environmentally sensitive areas.

4 Methodology

The analysis broadly relies on Terms of Reference for Bio-Inventory, Appendix C of Environmental Best Management Practices for Urban and Rural Land Development¹ as a guidance document.

Background research was conducted prior to undertaking fieldwork. The Sunshine Coast Regional District (SCRD) Webmap system was referenced for baseline site information. Additional reference material for background information on fish, plants, and wildlife was obtained from Conservation Data Center (CDC)² and Habitat Wizard³ and Sunshine Coast Habitat Atlas⁴.

Site visits were conducted on January 17 and 18, March 7 and 23, 2023.

¹ Published by BC Environmental Protection & Sustainability, June 2004.

http://www.env.gov.bc.ca/wld/documents/bmp/urban_ebmp/EBMP%20PDF%202012.pdf Accessed on 2022-09-06.

² Conservation Data Center. <http://maps.gov.bc.ca/ess/hm/cdc/> Accessed on 2023-01-11.

³ Habitat Wizard. <https://maps.gov.bc.ca/ess/hm/habwiz/> Accessed on 2023-01-11.

⁴ Sunshine Coast Habitat Atlas. <https://cmnmaps.ca/SCRD/> Accessed on 2023-05-10.

5 Federal and Provincial Regulatory Framework

The following is an overview of the Federal, Provincial and Local Government Acts, and Regulations applicable to the development on the site.

Federal Species at Risk Act, Schedule 1: The Species at Risk Act (SARA) Schedule 1 identifies wildlife species considered ‘at risk’ in Canada, categorizing them as Threatened, Endangered, Extirpated, or of Special Concern, and prohibits a number of specific activities related to listed species including killing, or harming the species, as well as the destruction of critical habitat identified in management plans required under SARA for the species.

Federal Migratory Bird Conventions Act (MBCA): Legal protection of raptors and owls, including Bald Eagles, is derived from the British Columbia *Wildlife Act*. Protection for birds includes their eggs, chicks, and nests. As stated in Section 34 of the *Wildlife Act*:

“A person commits an offence if the person, except as provided by regulation, possesses, takes, injures, molests, or destroys:

- a) a bird or its egg,
- b) the nest of an eagle, peregrine falcon, gyrfalcon, osprey, heron, or burrowing owl, or
- c) the nest of a bird not referred to in paragraph (b) when the nest is occupied by a bird or its egg.”

For select species of raptors including the Bald Eagle the protection is extended to year-round and includes protection of the structure holding the nest. Furthermore, activities occurring within range of a nesting eagle that lead to disturbance of nesting behaviour or nest abandonment can be construed as a violation of Section 34.

Birds are protected by the federal *Migratory Bird Convention Act*, the BC *Wildlife Act*, and for some species, the *Species-at-Risk Act* (SARA).

The migratory bird breeding season is generally defined as spanning from March 1 to August 31. As for all birds, the preferred conservation strategy for migratory birds is to avoid any disturbance during the breeding period. However, bird nest surveys conducted by a qualified professional (QP) prior to vegetation clearing are a routinely accepted measure of due diligence. Therefore, any clearing activities that need to take place during a period with potentially active nests should only occur following a SBNS.

BC Wildlife Act: Prohibits possessing, taking or destroying (i) a bird or its egg, (ii) the nest of an eagle, peregrine falcon, gyrfalcon, osprey, heron or burrowing owl, or (iii) the nest of a bird not in (ii), when the nest is occupied by a bird or its egg unless authorized under permit.

BC Weed Control Act: Requires landowners to control ‘noxious weeds’ growing or located on their property. Noxious weeds within all regions of the province are regulated under the BC Weed Control Act, Weed Control Regulation, Schedule A, Part 1 – Provincial Weeds. Under this Act, “an occupier must control noxious weeds growing or located on land and premises, and on

any other property located on land and premises, occupied by that person”. Section 2 (1) (b) (iii) of the Community Charter, Spheres of Concurrent Jurisdiction - Environment and Wildlife Regulation, states that “municipalities may regulate, prohibit and impose requirements in relation to control and eradication of alien invasive species”.

Streamside Protection

Two levels of streamside protection regulations are in effect in British Columbia. The *Riparian Areas Protection Regulation* (RAPR) is a joint undertaking by the Federal, Provincial and Local Government. Definitions and Assessment Methodology are prescribed in the RAPR for use in determining the Streamside Protection and Enhancement Area (SPEA) to restrict development in the riparian area.

The RAPR provides for devolution of streamside protection to local government on the condition that local bylaws “meet or beat” SPEA prescriptions defined by the RAPR.

Instream Protection

Projects that involve working below HWM, i.e. in the water, are regulated by The *Water Sustainability Act* (WSA). The WSA regulates all surface freshwater aquatic elements weather connected to fish habitat or not and includes groundwater. The WSA and the *Water Sustainability Regulation* (WSR) do not provide prescriptive streamside protection areas, however, environmental best practices generally dictate a deferral to methodology in the RAPR.

Any proposed changes of or near surface water or groundwater, for example stream crossings or wells, must be approved according to terms in the *Water Sustainability Regulation* (WSR) or *Groundwater Protection Regulation* (GPR).

Federal Fisheries Act: Administered through Fisheries and Oceans Canada (DFO), changes to or near watercourses that provide habitat for fish of commercial or recreational value, or with aquatic species at risk, must be made in accordance with rules and procedures in the *Federal Fisheries Act*.

6 Property Description

The study area is composed of two undeveloped lots in West Sechelt. For the purposes of this report these will be referred to as West Lot and East Lot where necessary for clarity (Figure 2, Figure 3). Highway 101 forms the south side, urban residential development is present on the southwest and southeast sides. Reeves Road forms the northern boundary of the East Lot; rural and undeveloped greenfield space is present around the northern perimeter. A BC Hydro Right-of-Way (ROW) transects the northern portion of the East Lot. Derby Road transects midway through both lots.



Figure 2. The subject properties in District of Sechelt.

6.1 Property Data

East Lot

Address	No civic address
PID	024-694-118
District Lot	4295A
Site Area	~ 33.8 acres
OCP Designation	RU-1

West Lot

Address	No civic address
Legal Description	No PID
District Lot	1384
Site Area	~ 104 acres
OCP Designation	RU-1 and AG-1

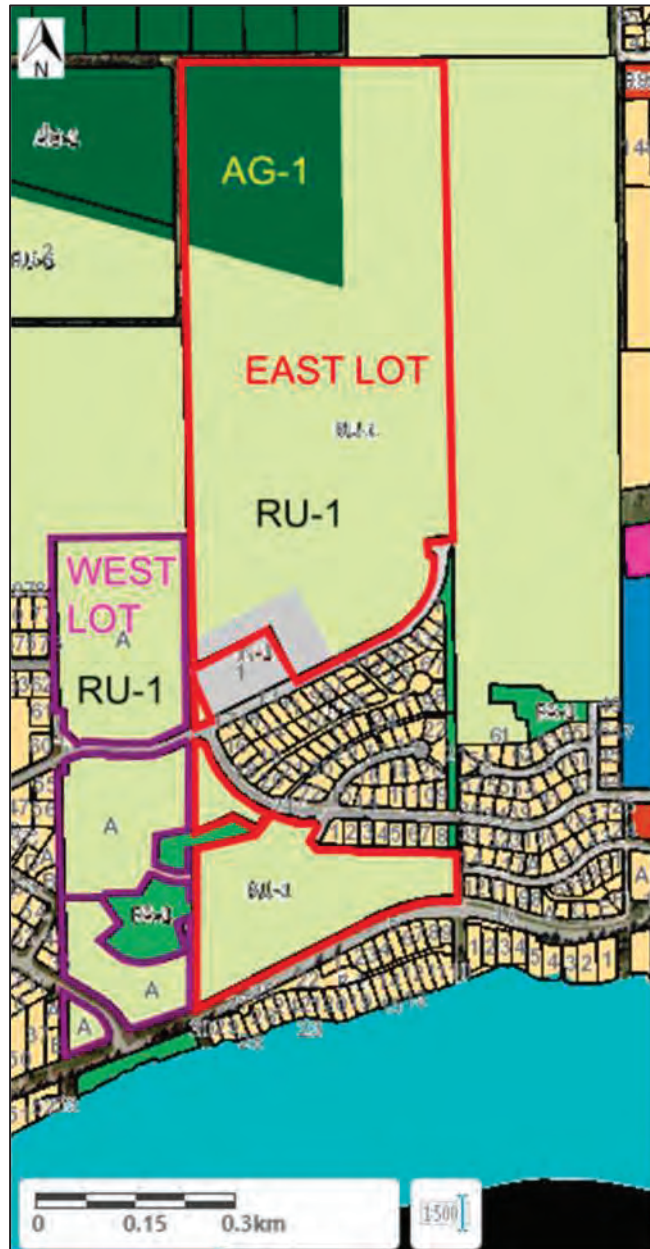


Figure 3. OCP mapping of the study area. SCRD Webmap, 2023-01-11.

6.2 Development Permit Areas

Two Development Permit Areas (DPA) are present in the study area (Figure 4):

- DPA-5 Steep Slopes >20%-30%
- DPA-5 Steep Slopes >30%

Slope assessment is not within the limits of this assignment and is not discussed further.

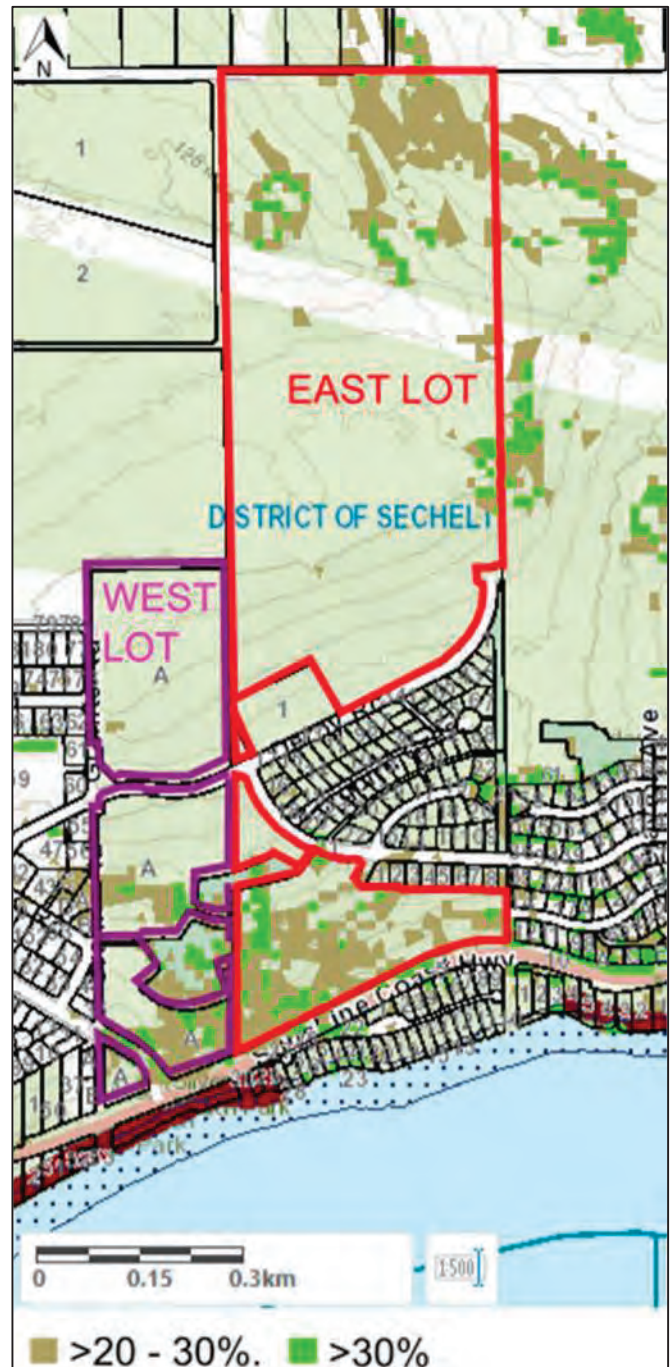


Figure 4. Overview of DPA 5 in the study area.
SCRD Webmap, 2023-01-11.

7 Natural Resources Inventory Information

7.1 Ecological Setting: *Coastal Western Hemlock very-dry maritime*

The Biogeoclimatic Ecosystem Classification (BEC) system is used to describe broad divisions in landscape-scale ecosystems, referred to as, BEC zones. BEC zones are generally based on dominant vegetation and climate descriptors. BEC zones are subdivided into Variants which are based on vegetative adaptations to local micro-climates.

The site is located within the Coastal Western Hemlock very dry-maritime zone (CWHxm-1, Figure 5).

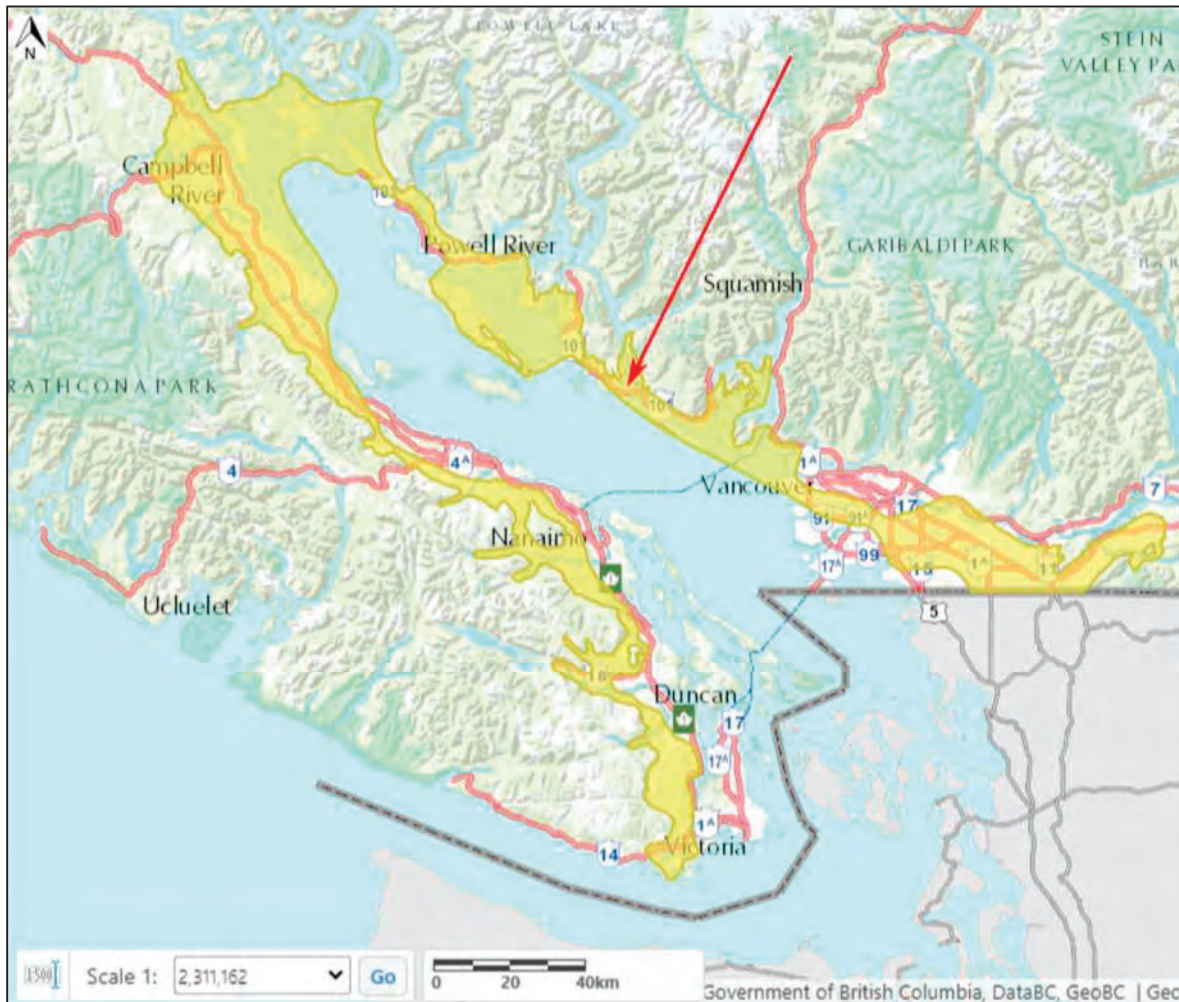


Figure 5. Coastal Western Hemlock very dry-maritime zone is shaded in yellow, and dry-maritime zone shaded in green. Image obtained from Habitat Wizard, 2023-01-11.

CWH is the dominant BEC zone throughout the entire west side of the Coast Mountains in the low to middle elevations (sea level to 1050 m)⁵. The zone is characterized by cooler

⁵ Paraphrased from, Meidinger, D., & Pojar, J. (Eds.) (1991). *Ecosystems of British Columbia* (342 p). Special Report Overview Environmental Analysis of Silverstone Heights West Sechelt
May 15, 2023. Version 1.0
File No. 22.0073

temperatures, the mean annual temperature throughout the zone being 8°C, though higher in southern latitudes where summers are warm and dry. It is the rainiest BEC zone in the province but less than 15 percent of precipitation occurs as snow in the south.

In these dry maritime variants Douglas-fir (*Pseudotsuga menziessii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*) are the dominant tree species. Red alder (*Alnus rubra*) is widespread in disturbed areas, and black cottonwood (*Populus balsamifera*) commonly occupies floodplains and riparian zones of large water bodies. Common members in the shrub layer include salal (*Gaultheria shallon*), dull Oregon-grape (*Mahonia nervosa*) and red huckleberry (*Vaccinium parvifolium*), prince's pine (*Chimaphila umbellata*) also occurs in this variant.

Ocean spray (*Holodiscus discolor*) and baldhip rose (*Rosa gymnocarpa*) are examples of two shrub species that are more common in XM-1.

Cascara sagrada (*Rhamnus purshiana*) and arbutus (*Arbutus menziesii*) are tree species that are considered under protected and of conservation concern.

7.2 Sensitive Ecosystems

Background

British Columbia commissioned a sensitive ecosystem inventory (SEI) project in the late 1990's with results and mapping published in 2005. The SEI project was undertaken to inform decision makers, landowners, and developers of the presence of landscape-sized areas where fragile or rare ecosystem conditions are present, and to flag sites of conservation concern⁶.

One sensitive ecosystem is mapped on the south end of the study area in West Lot (Figure 6). The SEI largely corresponds with a local park but portions of it are within the bounds of the subject property.

Study Area

SEI description in the study area:

Woodland – Conifer Dominated (WD co) are defined as:

Dry open forests, generally between 10 and 30% tree cover, can be conifer dominated or mixed conifer and arbutus stands; because of open canopy, will include non-forested openings, often with shallow soils and bedrock outcroppings.

Subclasses:

Conifer Dominated (co): Greater than 75% coniferous species.

Series 6, Victoria, BC: B.C. Ministry of Forests and Range Research Branch.

⁶ This section paraphrased from: Province of BC, Environmental Protection and Sustainability. *Sensitive Ecosystems Inventory of the Sunshine Coast and Adjacent Islands* >http://a100.gov.bc.ca/appsdata/acat/documents/r3758/SEI_301_ml_1129668527899_de87a3f0bcb140dd9730f8a927346762.pdf<

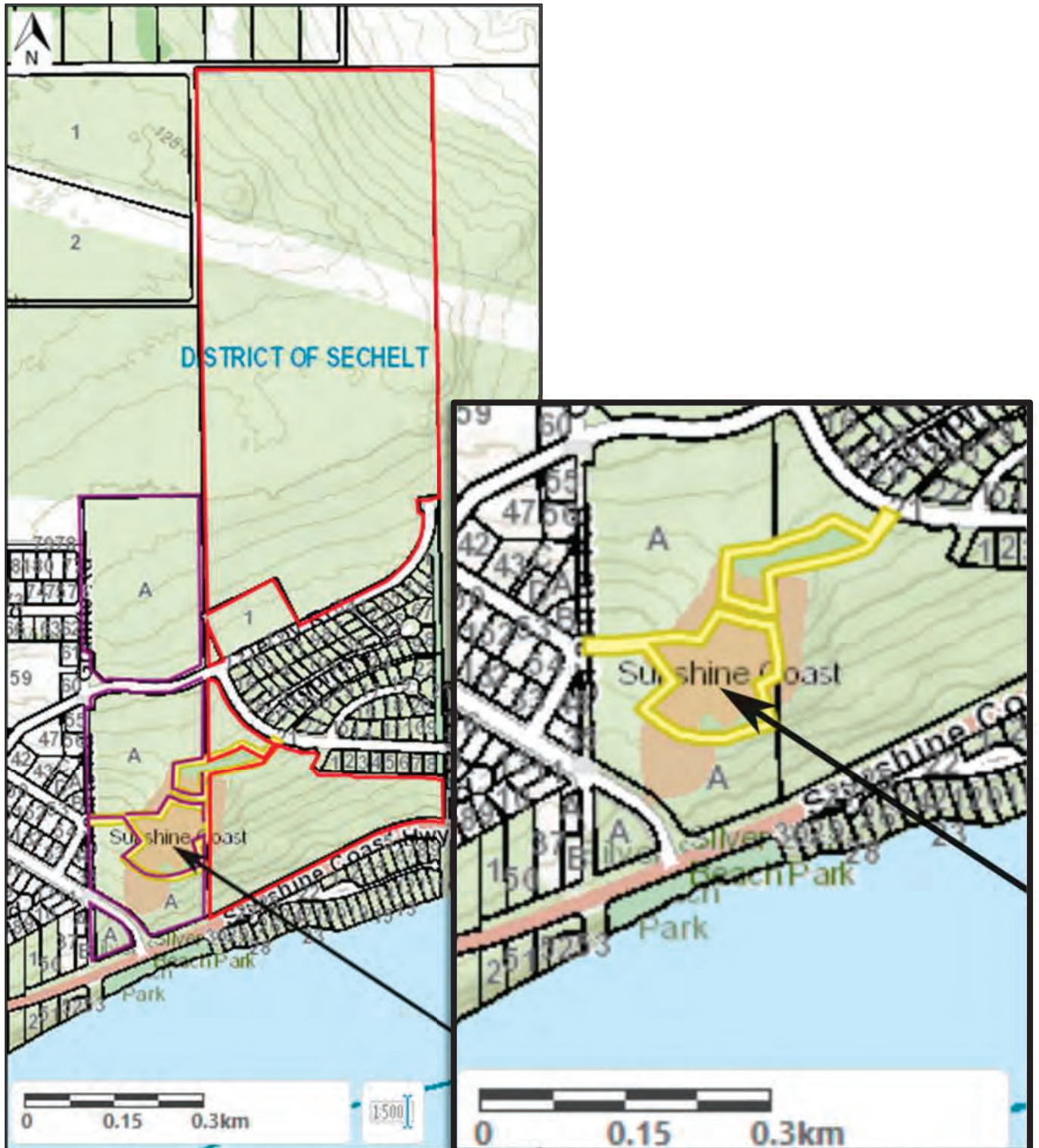


Figure 6. SEI Mapping in the study area. Yellow lines on inset diagram delineate a DoS park. SCRD Webmap, 2023-01-11.

7.3 Species and Ecosystems at Risk

Background

In BC organisms and ecosystems that are designated as being of conservation concern, are classified as,

“Red-listed or Blue-listed species ... based on their provincial Conservation Status Rank. Red-listed species and ecological communities are Extirpated, Endangered, or Threatened in British Columbia. Blue-listed species and ecological communities are of Special Concern (formerly Vulnerable) and Yellow-listed species and ecological communities are secure.”⁷

Nationally, at the federal level, species of concern are designated through the *Species-at-Risk Act* (SARA) and Committee on the Status of Endangered Species in Canada (COSEWIC).

Study Area

No occurrences of SAR are recorded in the study area (Figure 7). This site is contiguous with forest lands in which the Blue-listed Red-legged Frog⁸ (*Rana aurora*) is present.

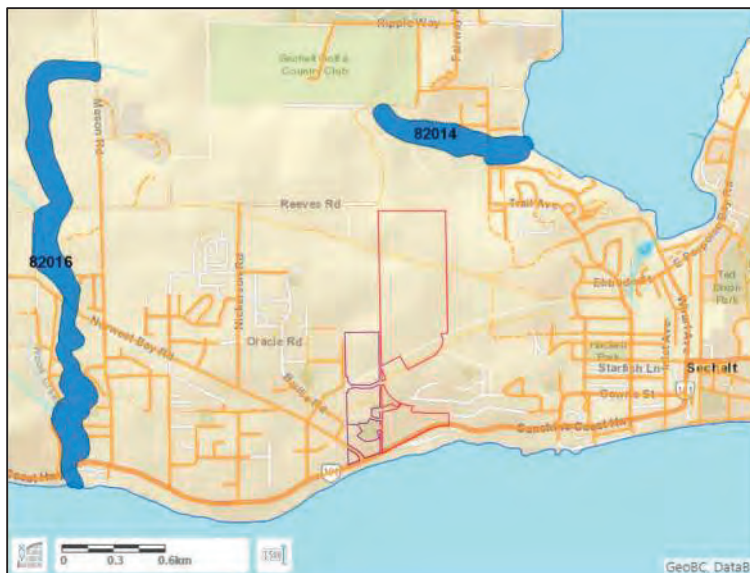


Figure 7. Recorded occurrences of species-at-risk surrounding the study area. Habitat Wizard, 2023-05-10.

7.4 Watercourse Information

Watercourse inventory mapping is limited to a minimum scale of 1:50,000 and would not show minor watercourses at the site level. No major watercourses are mapped in the study area.

⁷ BC Species and Ecosystems Explorer. Accessed on 2022-11-14.

<https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorerh>

⁸ Red-legged frog. BC Blue List, COSEWIC Special Concern, SARA Schedule-1

8 Observations from Field Survey

Four site visits were taken in the study area; GPS tracking of the survey routes are illustrated in Figure 8.

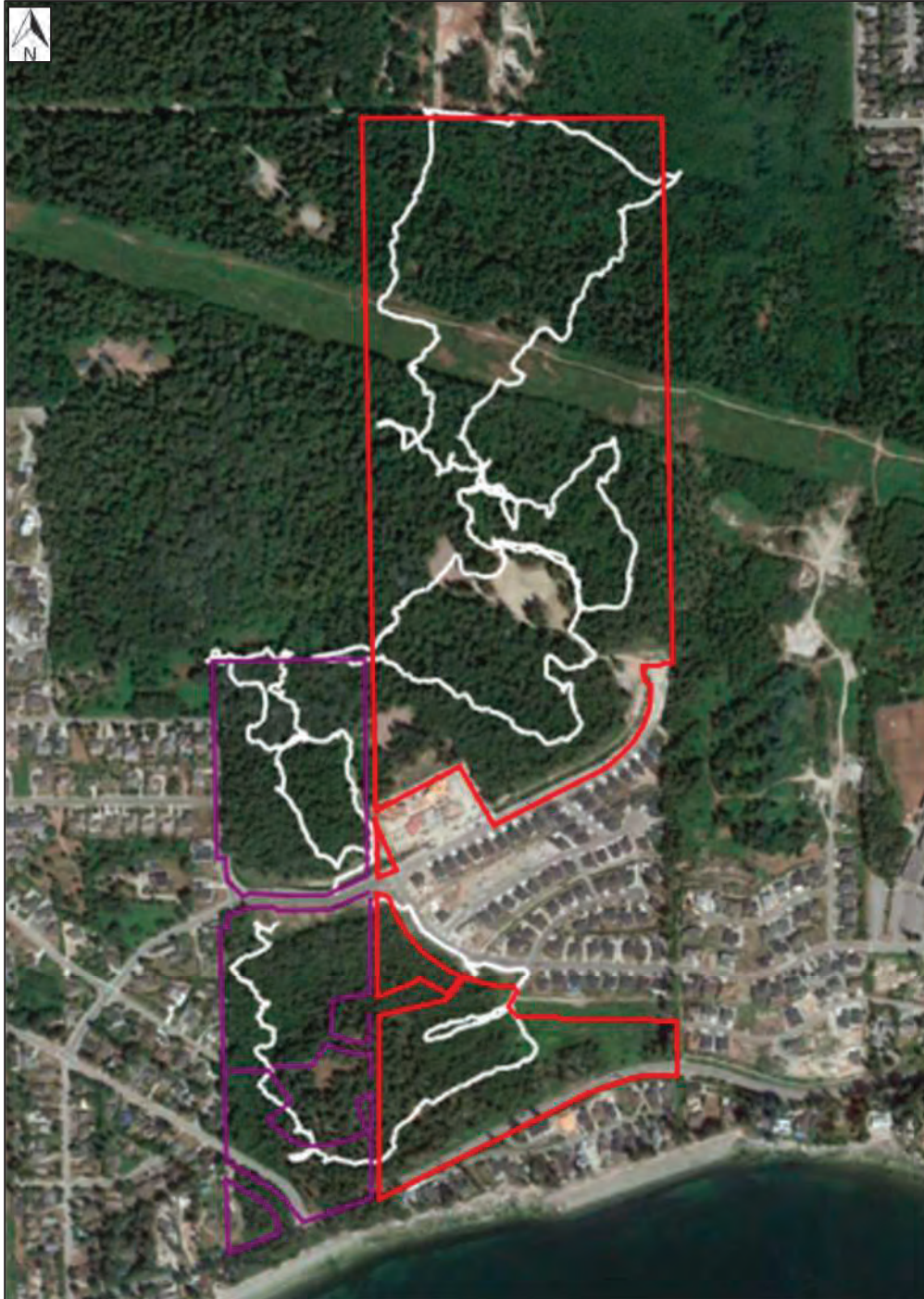


Figure 8. Survey routes (White Lines) recorded by GPS during assessment survey on January 17 and 18, 2023.

8.1 Site Disturbance History

A review of historical air photos obtained from Google Earth revealed very limited site disturbance back to 2004, the earliest available image. The site was logged historically, at least 60 to 80 years ago, or more based on the current age class of the forest. Remnant logging roads have evolved into popular walking trails now.

8.2 Terrain

Terrain throughout the central portion of the is gently sloping, with a large, relatively flat area north of Derby Road (Figure 9). The northeast corner of East Lot has slopes of approximately 15 to 20 percent with a northeast aspect. The site steepens between Derby Road the Highway 101 where slopes are up to 30 percent.

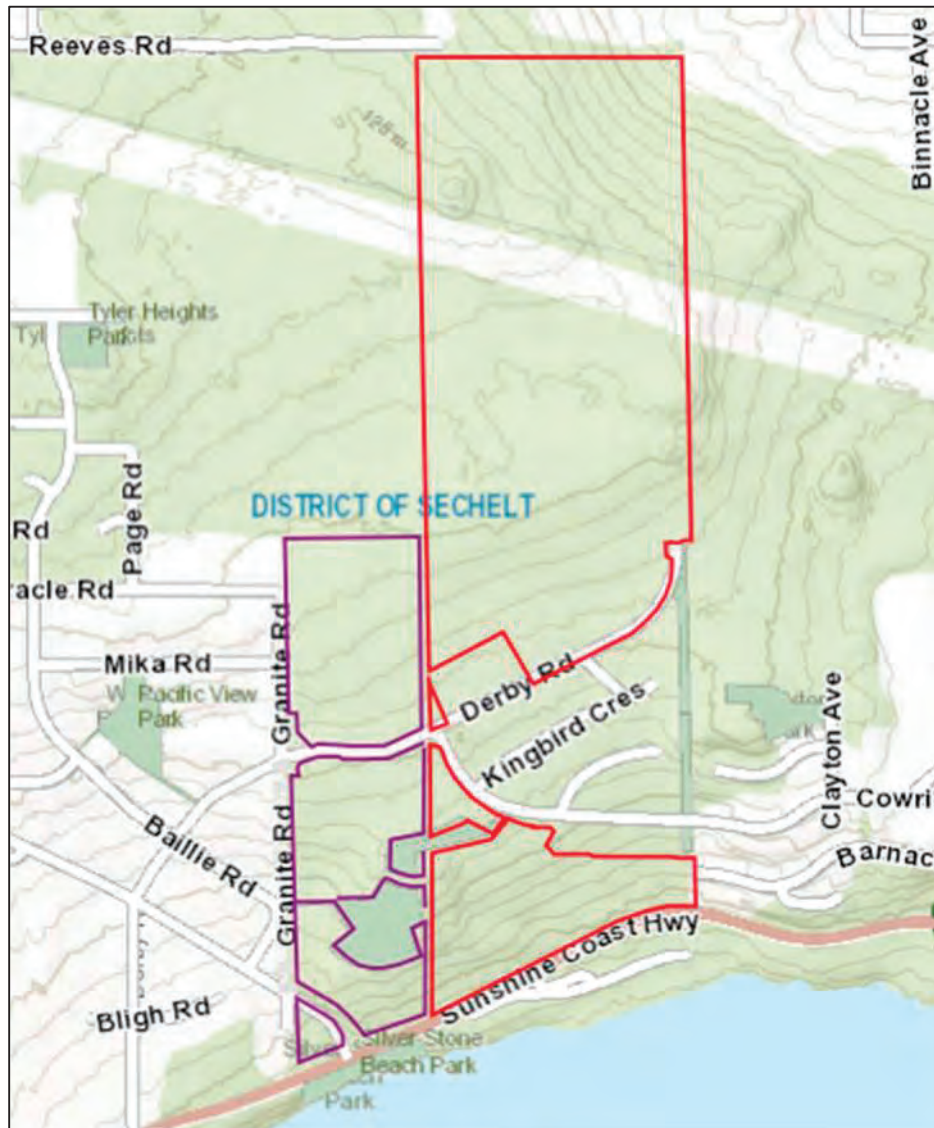


Figure 9. Contour lines illustrating terrain characteristics on the site. SCRD Webmap, 2023-05-11.

8.3 Vegetation

Forest cover on the site falls into two primary categories which coincide with forest cover mapping and the soil moisture regime on the site.

Forest cover in the northern section of the site is dominated by western redcedar. Bigleaf maple western hemlock are the co-dominant trees in the farthest northern portion of the site where they make up 30 to 40 percent of the canopy. Douglas-fir is the co-dominant species in the mid-to-lower section of the upper site where it makes up 30 to 40 percent of the canopy. In general, trees fall into two categories, mature trees are approximately 70 to 80 cm diameter breast height (DBH) and young trees are approximately 30 to 40 cm DBH.

Dominant plants in the understory, shrub and fern layer include, salal, Oregon grape and vaccinium species in variable compositions throughout the northern section; sword fern is abundant throughout the site.

Forest cover in the southwest zone of the site, coinciding with the SEI polygon, is developed on very dry soils with bedrock outcroppings. The dominant tree species is Douglas-fir with Arbutus as a co-dominant. The understory is composed of ocean spray, baldhip rose, Oregon grape and sword fern. This zone resembles the Coastal Douglas-fir (CDF) BEC zone.

8.4 Watercourses and Aquatic Habitat Areas

Please refer to Figure 10 for watercourse mapping on the site.

Reeves Road Ditch

The ditch conveys flow towards the east along the north boundary of the East Lot where it flows into a trail and changes into unconstrained surface flow, eventually turning north and into the forest. The survey was conducted in the rainy season, and it is presently unknown if the ditch conveys only stormwater runoff or if there is a groundwater component.

Wetland 1

This is a relatively large wetland with swamp characteristics. This classification is based on pools of standing water and the presence and abundance of obligate and facultative wetland plants. The illustration in Figure 10 approximates the swamp zone, additional wetland sampling of vegetation and soils will be necessary if an accurate delineation is desired.

On the southeast edge of the swamp a channel was constructed which is providing an outlet to convey flow away from the wetland. The outflow eventually disperses into the forest and appears to dissipate into the ground.

Wetland 2

This is a small, pocket wetland with swamp characteristics. This classification is based on pools of standing water and the presence and abundance of obligate and facultative wetland plants. The illustration in Figure 10 approximates the swamp zone, additional wetland sampling of vegetation and soils will be necessary if an accurate delineation is desired.

Watercourse 1

This watercourse has characteristics of natural stream flow but appears to have originated from anthropogenic changes. Two ditches on the north boundary of the West Lot flow along an abandoned farm road, they converge at a culvert and flow into West Lot as shown in Figure 10. Water moves through the upper section of West Lot in a wide, unconstrained corridor which resembles a flooded forest wetland type in general but with stretches of constrained stream flow, where it coincides with a walking trail. The flow splits in two at or about the northwest corner of the Trellis development; one portion continues down a forest corridor, and the other in a roadside ditch. Both channels converge in a small detention pond at Derby Road before being conveyed through a pipe and released into the lower section of West Lot, where it eventually flows into in the highway ditch and then into marine waters.

Seepage Zone

A linear seepage zone is present on the western side of the West Lot. This does not have characteristics of a watercourse, but rather appears to be groundwater seeping from the hillslope and is presently assumed to be ephemeral. Vegetation characteristics include facultative plants (equally likely to occur in wetlands or non-wetlands) and facultative upland plants (usually occur in non-wetlands but occasionally found in wetlands). With these conditions present the seepage zone is not being considered a wetland.

West Side Swale

A shallow swale is present at the west side of West Lot, south of Derby Road. It appears to have been constructed during recent development to control and convey stormwater runoff.

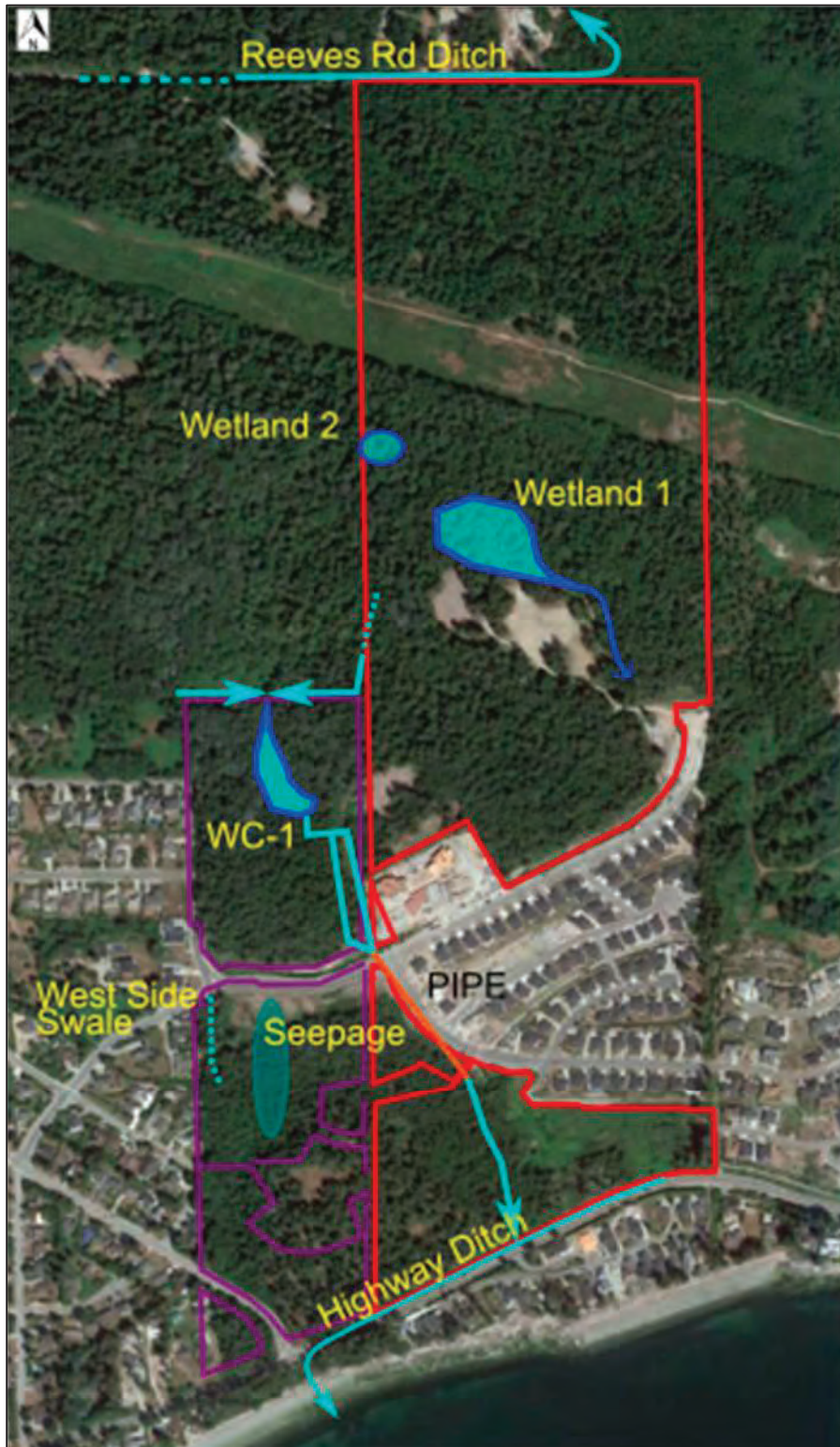


Figure 10. Watercourse mapping in and around the subject property. Linework is for illustrative purposes and is not to scale.

8.5 Wildlife Habitat

The terrestrial portion of the study area is contiguous with unbounded forest lands. The potential for all small and large mammals present in the region is possible on the site. Examples of species with ranges that potentially extend into the study area include black bear, deer, Roosevelt elk, cougar, bobcat, coyote, racoon, skunk etc. Mature forest cover, diversity of terrain and freshwater features in the study area all contribute to high value habitat elements for mammals. Scat and trails of black bear were observed on the site, scat of deer was widespread. A wide diversity of small mammals should be expected in the forest, which provides prey for larger mammals, owls and raptors.

8.6 Amphibian and Reptile Species

Aquatic habitat for wetland species of invertebrates and amphibians –breeding and rearing, is present in the study area, as described in Section 8.4. Pacific chorus frog was heard in several locations. The forest characteristics represent high value habitat for red-legged frog.

Open, rocky spaces for basking are present in the SEI zone which is high value habitat for northern alligator lizard and these spaces would also be valued by other regional garter snakes.

8.7 Songbird and Raptor Habitat

Vegetation communities, terrain and aquatic and riparian features in the study area combine to result in a diverse array of habitat niches that would support a rich diversity of songbird species. High value habitat is present throughout the site. Standing dead and dying mature trees are found throughout the site and provide habitat for cavity nesters for example, chestnut-backed chickadee, pileated woodpecker, and owl species. Hawks and other raptors would use the study area for foraging opportunities on small mammals and songbirds.

Barred Owl was observed in the north portion of the East Lot and should be expected throughout the site.

Pileated Woodpecker cavity trees were observed in various locations on the site.

8.8 Invasive Plants

No noxious invasive plants, for example knotweed species or giant hogweed, were observed during the site assessment. Himalayan blackberry is the most abundant invasive species on the site. It is present along most of the road shoulders and is encroaching into the logged areas. Scotch broom and English ivy were observed during the survey in varying abundance throughout the site.

9 Site Photos

The following pictures were taken on site January 17, 18 and March 7, 2023, please refer to the map in Figure 11 to find photo point locations.



Figure 11. Photo point locations.



Photo 1. Reeves Road Ditch on the walking trail beyond Reeves Road, where it turns north.



Photo 2. Outflow channel from Wetland 1.



Photo 3. Outflow from Wetland 1 where it flows into the forest.



Photo 4. Viewing windthrown tree with poorly developed shallow root system due to hydric / anaerobic soil conditions in Watercourse-1.



Photo 5. Typical conditions in Watercourse-1 where it flows over a walking trail.



Photo 6. Stormwater management pond on Watercourse-1, at the north side of Derby Road upstream of the pipe.



Photo 7. Watercourse-1 downstream of Derby Road.



Photo 8. West Side Swale.



Photo 9. Typical cavity nest hole of Pileated Woodpecker.



Photo 10. Typical cavity nest hole of Pileated Woodpecker.



Photo 11. Pileated Woodpecker.



Photo 12. Barred Owl.

10 Discussion

10.1 Terrestrial Conservation Concerns

SEI

One sensitive ecosystem is present on the site (Figure 6). The province considers “sensitive ecosystems [as] those which are fragile and/or rare, or those ecosystems which are ecologically important because of the diversity of species they support.”

The purpose of SEI is to flag delicate or rare spaces at the front-end of development planning and to assert a preference for preservation of these areas.

The scope of the present project being a preliminary bio-inventory revealed that the woodland conifer dominated / dry open forests SEI is present as mapped and represent a small patch of Coastal Douglas-fir (CDF) BEC zone. More detailed assessment of the study area to field check and fine tune the true boundaries of the SEI may be helpful to inform the development layout planning to avoid a loss of the most sensitive elements.

Wildlife Travel Corridors

It is recommended that wildlife travel corridors be integrated into the development layout to retain dedicated pathways for wildlife use in the local area and to help avoid potential conflicts with wildlife in the future.

10.2 Aquatic Resources

RAPR

Except for the Reeves Road Ditch, no watercourses on the site flow into freshwater, fishbearing streams. Therefore, no watercourses on the site are regulated under the RAPR.

If changes are proposed to Reeves Road Ditch an additional assessment of downstream connectivity will be required to determine if it is regulated under the RAPR.

WSA

All watercourses on the site are regulated under the WSA. Prior to making changes to any watercourse an Approval for Authorization of Instream Works will be required.

10.3 Bird Habitat

Habitat conditions in the study area provide breeding habitat for a wide diversity of bird species.

Songbirds

As required by the *Migratory Birds Convention Act (MBA)*, the *Wildlife Act* and *Species-at-Risk Act* removing or altering any vegetation on the site should be conducted outside of the breeding bird season to avoid harming or disturbing nests, eggs, or nestlings of migratory birds.

The **breeding bird season** for songbirds generally spans from March 1 to August 31, but the overriding principle is avoidance of harm to birds, their eggs, and nests *at any time*.

In general, if habitat disturbance during the bird breeding season is unavoidable, then a site-specific bird management plan needs to be developed by a QEP.

Raptors and Owls

Protections for **raptor and owl nests** are more robust and longer lasting throughout a year than for songbirds. No incidental observation of a raptor nest was made during the site assessment, but Barred Owl was observed on the site, therefore a more detailed survey of raptor and owl nesting is recommended prior tree clearing.

Pileated Woodpecker

The MBA was recently updated to increase protection for cavity nesters such as the **Pileated Woodpecker**. Nest trees of pileated woodpecker are now protected for up to three years -- *whether the nests are occupied or not*. Pileated woodpecker activity was observed on the site therefore a nesting survey is prudent measure to help guide development works timing.

11 Environmental Management of Site Development

This overview environmental assessment report was prepared to assist the Client create a development plan with the least amount of impact on environmentally sensitive areas that are present on and near the study area. The Client is encouraged to use this information as a starting point for development design decisions. Working around nature is the most straightforward approach for efficient use of time and space. As the development progresses the following environmental guidance plans should be obtained:

1. Detailed delineation of the SEI habitat.
2. Detailed delineation of wetland habitat to determine the spatial extent of wetland riparian protection areas for the maintenance of environmental flow needs and hydrological connectivity.
3. Determination of the applicability of WSA on Reeves Road ditch.
4. Invasive Plant Management Plan. As time goes by the status and presence of noxious weeds changes. Management and eradication can be time consuming therefore monitoring for new establishments of noxious weeds is recommended.
5. Watercourse Management Plan. It is understood that alterations to watercourses are being considered. The Client should note that under the WSA, review of applications for Approvals of instream works can take up to 18 months, or more. And in many circumstances extensive long term baseline hydrological information is required for reporting on environmental flow needs and other background conditions.
6. Nest Surveys will be required if vegetation clearing cannot be completed outside of the bird nesting season. Surveys for Pileated Woodpecker nesting are a prudent measure to determine presence and help guide project timing.

12 Limitations

Barsanti Environmental Services Ltd. conducts projects and prepares reports in a manner consistent with the level of care normally exercised by environmental professionals currently practicing in the area under similar conditions and budgetary constraints. Barsanti Environmental Services Ltd. offers no other warranties, either expressed or implied. Barsanti Environmental Services Ltd. will prepare our reports for your use for the purposes for which they are commissioned and for use by government agencies regulating the specific activities to which they pertain. Observations and results discussed in our reporting are valid for six months from the date of issue, and no longer unless explicitly specified otherwise. However, nature and the environment are a dynamic system in which stochastic events randomly occur thereby potentially limiting the duration of the validity of the results presented in our reporting. This report is prepared for Sawarne Lumber Co. Ltd. (the Client) and it will not be reasonable for other parties to rely on the observations or conclusions of the reports and the Client may not give, lend, sell, or otherwise make available the report or any portion to any other party without Barsanti Environmental Services Ltd. express written consent.

13 Closing

Sawarne Lumber Co. Ltd. has conducted an important measure of due diligence by commissioning this overview environmental assessment report to determine the potential presence of EVRs and species-at-risk on the site prior to development planning.

We trust that the information supplied in this document is helpful and meets your current needs. Should more information or clarification on any part of this memo be required please do not hesitate to contact us.

BARSANTI ENVIRONMENTAL SERVICES LTD.

Jason Barsanti. R.P.Bio.
Principal Biologist





APPENDIX C:

Stream Classification Assessment



PHOENIX

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MEMO

June 5, 2023

Davy Sangara
Sawarne Lumber Co. Ltd.
via email: dsangara@sawarne.com

**Re: Stream Classification Assessment, Proposed Residential Phase III Cluster Homes/Duplex Site,
East of Granite Rd. and North of Derby Rd., Sechelt, BC**

Phoenix Environmental Services Ltd. (Phoenix) is pleased to present our findings for a Stream Classification Assessment of stream features observed within the property north of Derby Rd. and east of Granite Rd. in Sechelt, B.C (the Site). Refer to the attached Preliminary Stream Mapping drawing showing the location of the Site within the larger holdings in the vicinity proposed for development by Sawarne Lumber Co. Ltd. (Sawarne), which have been referred to as Silverstone Heights West Sechelt.

Methodology

Phoenix has collaborated with hydrogeologist Matthew Munn, P.Eng., MDM Groundwater Consulting Ltd. (MDM), to assess water features identified at the Site by Jason Barsanti, R.P.Bio., Barsanti Environmental Services Ltd. (Barsanti) during March 2023 field assessments conducted by Barsanti for an Overview Environmental Analysis of the Silverstone Heights West Sechelt area. MDM has been conducting a Groundwater Monitoring Program since 2021 of the larger land holdings by Sawarne, part of which has included installation of four (4) monitoring wells at two locations at the Site; specifically, MW21-04 and MW21-05. MW21-04 and MW21-05 each have two nested monitoring wells screened at different depths to intersect shallow and deeper groundwater. Refer to the attached MDM Monitoring Well Network location map. Phoenix also has worked with Aplin & Martin Consultants Ltd. to review development planning for the Silverstone Heights parcels and to provide input to the Aplin & Martin consultant team for an Integrated Stormwater Management Plan (ISMP) being prepared by Aplin & Martin.

Field assessments have been conducted at the Site on April 20 and May 17, 2023. On April 20, Ken Lambertsen, R.P.Bio. (Phoenix), Matthew Munn, and Julian Burtnick, Maycon Construction Management Ltd. (Maycon) traversed the Site to observe 'water features' that had been identified by Barsanti. On May 17, Phoenix and MDM returned to the Site to collect groundwater samples from MW21-04 and MW21-05, collect surface water samples from select remaining wetted areas within the Site, and to analyse the groundwater and surface water samples for water chemistry physical parameters using a multi-parameter field instrument (YSI 556 Multi-Parameter Sampler). The water chemistry field testing results have been reviewed to determine values for temperature, electrical conductivity (EC), pH (e.g. acidity), Total Dissolved Solids (TDS), and Dissolved Oxygen (DO) that may distinguish groundwater from surface water and aid in determining if surface water observed at the Site is sourced from groundwater.

Phoenix has referenced data and documentation provided by MDM. The MDM monitoring well records indicate the soil lithology encountered at MW21-04 and MW21-05 during well installation. MDM water level data at both wells collected by dedicated data loggers over a year and a half have also been reviewed and discussed with MDM. The Overview Environmental Analysis report dated May 2023 by Barsanti also



has been referenced for this stream assessment. A Technical Guidance document regarding the B.C Water Sustainability Act (WSA) entitled “A User’s Guide for Changes In and About a Stream in British Columbia. Version 2022.01.” has been referenced to aid in determining when a watercourse is a stream regulated under the WSA.

Discussion

During the April 20 field observations, several areas of open water were observed extending from the north boundary of the Site downslope through the forest on the eastern half of the Site. Flowing water was observed entering the north edge of the Site through a log culvert draining a linear constructed channel (ditch) along the south edge of the adjacent property to the north. According to Julian Burtnick, the adjacent property to the north had been a farm property that has since been vacated. The ditch on the adjacent property conveyed flows west from another linear watercourse draining south within the adjacent property to the north. Further east, the adjacent ditch became dry within a short (~10 m) distance from the confluence with the N-S watercourse in the adjacent parcel. The ditch in the adjacent property was dry to the west of the log culvert discharging flows into the Site and became poorly defined further to the west of the log culvert.

Downslope and downstream of the log culvert discharging flows into the Site, there was a small ‘tailing pool’ from which water spread out over the forest floor in numerous braided shallow channels that exhibited discontinuous flows with areas of open water occurring within low-lying depressions along the forest floor sloping to the south. Scoured flowpaths exposing water-formed alluvial deposition and gravel bars, as well as rafted vegetation, were observed along numerous braided channels that had dried out by April 20, 2023. A few isolated pools of open water also were scattered across the east side of the Site. The field assessment used flagging hung and labelled for subsequent survey by Barsanti as a guide to areas previously identified within the Site as water features by Barsanti during his March field assessment. Flows were being intercepted and conveyed east along an existing trail toward a constructed drainage ditch on the west side of an access road extending north from Derby Rd. into the Site which terminates around the location of MW21-05. A couple of locations along the forest trail exhibited indications of flows evulsing and continuing to drain south through the Site toward Derby Road. The flowpaths on the south side of the forest trail also exhibited multiple shallow braided channels with discontinuous open water and indications of scour and rafted vegetation associated with higher flow volumes draining south across the forest slope. Closer to the south edge of the Site, indications of flowpaths were absent suggesting that the flowpaths in the southern part of the Site infiltrate and terminate to ground before the southern Site boundary. It is evident that more abundant volumes of surface flows occur within multiple shallow (<15 cm deep) and braided channels following micro-topography within the east side of the Site during winter and higher precipitation periods of the year. Refer to the attached Preliminary Stream Mapping for approximate locations of observed streams at the Site.

During the May 17 field assessment, Phoenix traversed the western part of the Site along a trail leading to Granite Rd. near MW21-04 and also followed a meander pattern to the north of the trail. There were no indications of flowpaths or streams within the west half of the Site.

A gravel access road has been constructed north and upslope along the east side of the Site and commences near Derby Rd. adjacent to the west of the care home site (Trellis) under construction immediately east of the Site. There is a steep-sided ditch around 1m deep along the west side of the access road and a shallower ditch along the east side of the access road. Continuous flows were observed within the ditch on the west side of the access road on April 20 as well as during the May 17 field



assessment. Flows were also observed within the ditch on the east side of the access road but were of lower volume and terminated to ground when observed on May 17, 2023. Numerous rills are present along the surface of the access road which indicate higher flow volumes flow along and across the access road during high precipitation periods of the year. During both field assessments, shallow flows were observed flowing as sheet flow across the upper extent of the gravel surface of the access road. The sheet flows appear to emanate from a constructed pool and short ditch across the top (upslope) end of the gravel access road nearby monitoring well MW21-05. The cutbanks of the ditch on the west side of the access road exhibited seepage slightly above the base of the ditch from more fine-textured soil units beneath the surface layer on the adjacent forest floor. The flows within the ditch on the west side of the access road drain over a rip-rap armoured channel into a constructed settling pond nearby Derby Road. The settling pond discharges into a storm sewer pipe that connects to storm sewers in Derby Road and Cowrie Street. Refer to the Tailing Pool label on the attached Preliminary Stream Mapping for the location of the access road ditches and settling pond north of Derby Road.

During the May 17 field assessment, Phoenix followed drainage discharging from a storm outfall on the west side of Cowrie St. a short distance south from the intersection with Kingbird Crescent. Minor flows were discharging from the storm outfall and steady flows continued downslope in a natural channel through the forest west and south of Cowrie St. and north of Sunshine Coast Highway. Continuous flows were observed along the stream within the forest although dried-out side channels were also observed near the mainstem of the stream. The stream drained in braided channels across two constructed access roads crossing the stream alignment south of Cowrie St. before return to the stream channel flowing to the south edge of the Silverstone Heights parcels. At the confluence with the Sunshine Coast Highway, stream flows entered a ditch along the north side of the highway and continued flowing west to a headwall for a storm sewer crossing of the highway a short distance east of the highway intersection with Northwest Bay Road. From the headwall, it is apparent that the stream south of Cowrie St. drains to the ocean. The approximate location of the stream south of Cowrie St. is shown on the attached Preliminary Stream Mapping.

The borehole and monitoring well logs prepared by MDM for MW21-04 of the west side of the Site and for MW21-05 on the east side of the Site indicate a difference in soil lithology (layers) between the west side and east side of the Site. Additional soil stratigraphy across the Site has yet to be determined through geotechnical assessment of the Site or through additional monitoring well installation. On the west side of the Site, soil encountered in the borehole for MW21-04 comprises compact sand, slightly silty, medium-coarse grained and gravel (fine-coarse) to 2.13 m below the ground surface (mbgs). This sandy unit is underlain by very dense silt with trace gravel and fine sand to 4.87 mbgs with another unit of very dense silt that is very gravelly (medium-coarse) to the 6.2 mbgs depth of exploration. The shallow well has been screened in the upper unit and the deeper well has been screened in the lower unit. The soil unit closest to the ground surface at MW21-05 on the east side of the Site comprises stiff to very stiff silt with some fine sand and fine gravel to a depth of 1.83 mbgs. This fine-textured soil unit is underlain by dense sand with trace silt and some medium to coarse gravel to 3.65 mbgs followed by dense very sandy silt with some gravel to the 6.1 mbgs depth of exploration. The shallow well at MW21-05 is screened within the sand unit underneath the near-surface silt unit. The deep well is screened in the lower sandy silt unit at MW21-05. It is evident that the near surface silty (fine-textured) soils on the east side of the Site likely limits the infiltration potential for rainfall and surface runoff to soak into the ground below the thin organic silty sand topsoil layer observed across the forest floor. Whereas, near surface sandy soils on the western part of the Site have greater infiltration capacity / permeability. The difference in near surface soil permeability appears to account for the presence of multiple shallow braided flowpaths across the



eastern side of the forest floor at the Site observed by Phoenix, MDM and Barsanti, and the absence of evident flow paths over the west part of the Site.

During the May 17 field assessment, a marked reduction of open water areas was observed within the same areas of the eastern side of the Site compared to April 20 observations. There were just a few pockets of open water at and downslope of the log culvert at the north edge of the Site. There was no flow within the washed gravel surface of the trail mid-slope at the Site where flows had been observed during the April 20 field assessment and the March field assessment by Barsanti. The evulsion flowpaths south of the trail were also dry during the May 17 field assessment. However, around midway between the forest trail and the south edge of the Site at Derby Rd., Phoenix and MDM observed a small (~1.5 m round) pool on the forest floor which did not exhibit flows out of the downslope side nor was nearby one of the dried-out flowpaths previously observed in this part of the Site. This pool contained water that is groundwater-fed, as discussed in the following sections.

An objective of the May 17 field assessment was to collect surface water samples and groundwater samples and use field instrument water chemistry parameters to determine if there are physical parameters that might distinguish groundwater from surface water at the Site. This approach using geochemistry has been used to differentiate groundwater in other hydrogeological investigations such as contaminated sites. Groundwater samples were obtained from the shallow and the deep well screens at each monitoring well location at MW21-04 (west) and MW21-05 (east). Surface water sampling locations were few but fortunately still present on May 17. Surface water samples were collected from the pool downstream of the wooden culvert (US1 Wooden Culvert) and a pool closer to the forest trail around mid-slope above the trail (US2 – Mid Way Pool). The part of the Site upslope of the forest trail bisecting the Site was identified for surface water sample identification as “US” while the part downslope of the trail was identified as “DS” samples. The water sample from the small pool in the forest south of the trail mentioned above has been identified as DS1 – Woods Pool. Surface water samples were also collected from a pool adjacent to MW21-05 (MW5 Pool) and along the gravel access road within the ditch on the west side of the road near the middle of the access road (ROW stakes) and lower extent at the confluence of the ditch on the east side of the access road and the ditch on the west side of the road. A water sample was collected in the settling pond (Confluence Pool).

The attached summary data table compiled by MDM presents the water chemistry physical parameters used to test each water sample collect on May 17, 2023 using the field instrument and corresponding location of each sample. Table 1 presents the analytical data obtained for groundwater samples and Table 2 presents the data for surface water samples. Of the parameters, the distinction between surface water and groundwater was most evident by values obtained for temperature, electrical conductivity (EC), and Total Dissolved Solids (TDS); particularly EC and TDS. There is a distinct difference between groundwater EC (mean 132.5) and surface water EC (mean 30.8); likewise with TDS values. Temperature was less differentiating and included some aberrant results for MW21-05 deep and Woods Pool. The elevated temperature for MW21-05 deep (12.6) may have been a result of prolonged exposure of the sample to sun during sample collection, whereas temperature of groundwater from the same well obtained by data logger records indicate a lower temperature (9.4) of ‘in-situ’ groundwater. The 8.9 temperature at the Woods Pool is comparable to groundwater temperature, unlike other surface water temperatures. DO and pH data were not as relatively different, and some surface water DO samples were affected by aeration from flows (e.g. access road ditch). The field water chemistry data indicates that surface water sampled at the Site is distinguishable from the physical parameters for groundwater.



Conclusions

The following conclusions have been derived from the observations and data reviewed for this stream classification assessment:

1. The numerous shallow braided flowpaths observed at the Site within the forest east side are classified as ephemeral streams with surface water baseflows.

The streams within the forest at the Site are watercourses that flow briefly in direct response to precipitation in the immediate locality and have channels that are at all times above the water table. The flows in the ephemeral streams are sourced from surface water runoff as evident from indications of scour and alluvial deposition and rafted vegetation resulting during high and prolonged precipitation events and increasingly going dry as precipitation abates. Water sample geochemistry results also confirm the source of flows in the ephemeral streams are from surface water runoff.

2. The ditches on both sides of the access road on the east side of the Site drain a combination of surface water and perched groundwater.

The ditches along and rilling on top of the gravel access road receive flows that appear to be primarily surface water runoff. However, due to continuing flows observed in May following extended periods of no rainfall and as evident from seepage zones observed in the cut bank of the ditch on the west side, some of the baseflows appear to be groundwater-fed. The sources of groundwater draining into the ditch on the west side of the access road appear to be from higher elevations upslope and to the northeast of the Site. The groundwater monitoring program by MDM has determined that groundwater in the wells at and nearby the Site are recharging a deeper aquifer, as distinct from emerging as springs at the ground surface. The Woods Pool within the Site appears to be an instance where groundwater is emerging at the surface, possibly by a small lense of porous soils reaching the ground surface. Further assessment to determine if there are perched shallow aquifers still draining toward the ditch is warranted.

3. The ephemeral streams in the forest and the roadside ditches are not streams under the Water Sustainability Act (WSA).

The ephemeral streams are natural watercourses but are not “a natural source of water supply”. Groundwater is a natural source of water supply. The ephemeral streams do not convey groundwater as these are too shallow to intersect the water table and go dry soon after rainfall events abate. The ditches along the access road meet the definition of a “corridor ditch” which does not require WSA authorization for changes in and about a stream. A corridor ditch, as defined in the January 2022 WSA Technical Guidance document, is “a ditch constructed alongside a road or a railway line, for the purpose of draining surface runoff from the road surface or railway bed or to divert water from an aquifer to lower the water table, to protect the road or railway line.” Note the reference to “divert water from an aquifer to lower the water table”.

4. The streams at the Site are fish habitats and require authorization under the federal Fisheries Act for any change or modification.



As a source of seasonal flow and exporting of nutrients and food (insect drop) for fish populations further downstream, the streams at the Site provide indirect fish habitat even though there are no fish in the streams. As streams that drain to the marine environment, rather than a freshwater body of water, the streams are not regulated under the RAPR. This might be questioned with regard to the ditch along the Sunshine Coast Highway receiving flows from the streams at the Site and being a freshwater stream (ditch) prior (upstream) of the confluence with the stream south of Cowrie St, where the stream becomes channelized along the highway. Regardless, any changes or modifications are subject to DFO review as the streams are not WSA streams.

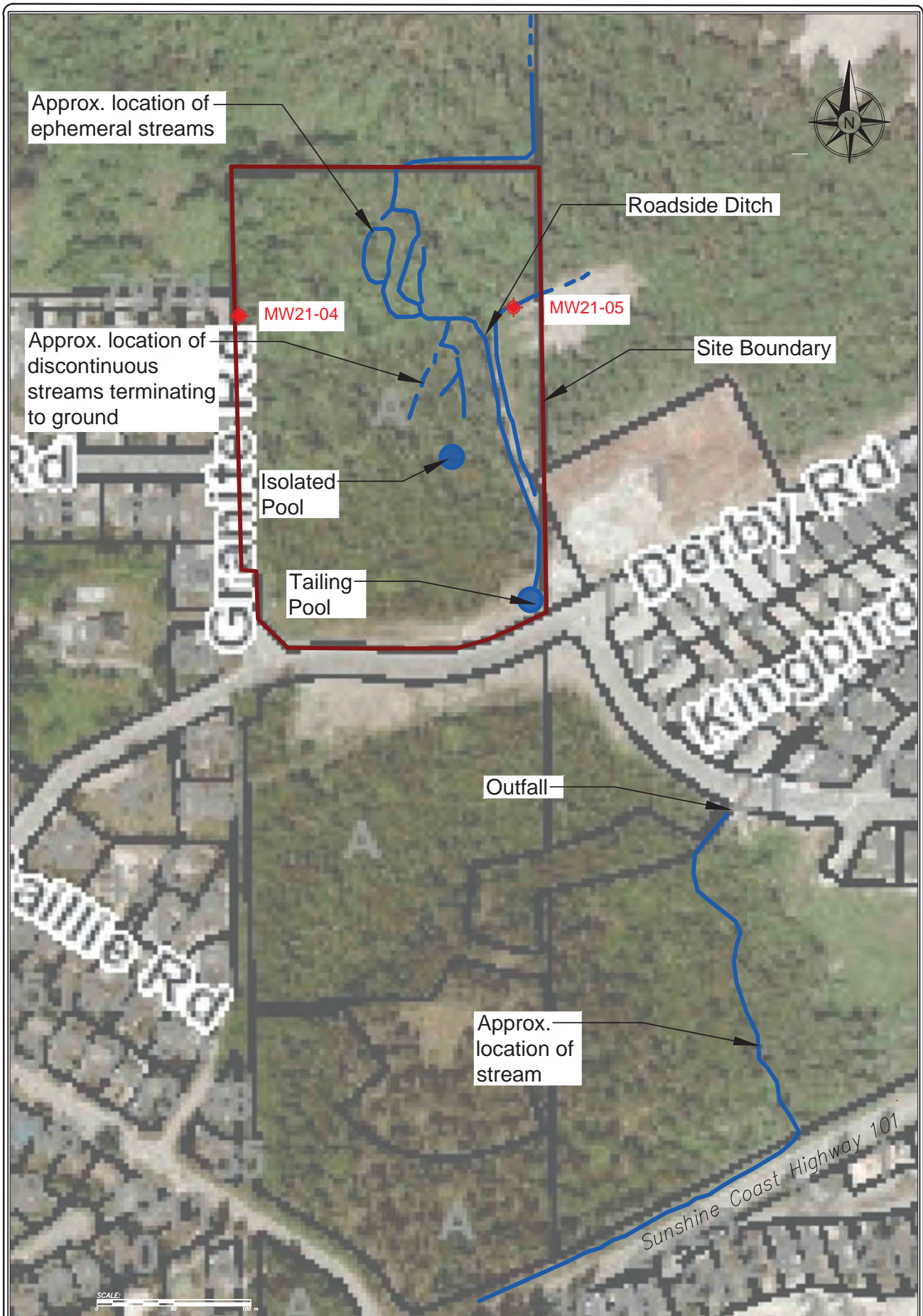
It is recommended that the ephemeral streams at the Site be re-inspected under winter heavy rainfall conditions so that the various braided channels can be more confidently delineated and then surveyed by a surveyor. The surveyed extent of streams and determination of riparian setbacks using RAPR Detailed Assessment methods will be needed to calculate the fish habitat losses that would be associated with future residential development at the Site and thereby calculate the amount of wetted and riparian habitat needing to be replaced (offsetting) in order for proposed drainage modifications to be acceptable under the federal Fisheries Act through DFO review.

Please contact me if additional information or clarification is desired.

Sincerely,

Phoenix Environmental Services Ltd.

Ken Lambertsen, R.P.Bio.
Principal



Approx. location of ephemeral streams



Roadside Ditch

Approx. location of discontinuous streams terminating to ground

MW21-04

MW21-05

Site Boundary

Isolated Pool

Tailing Pool

Outfall

Approx. location of stream



LEGEND:

- SITE BOUNDARY
- APPROX STREAM LOCATIONS
- - - UNCONFIRMED EXTENT OF STREAM
- APPROX LOCATIONS OF MONITORING WELLS

PRELIMINARY STREAM MAPPING

SAWARNE LUMBER CO. LTD.
 5625 Derby Road,
 Sechelt, BC



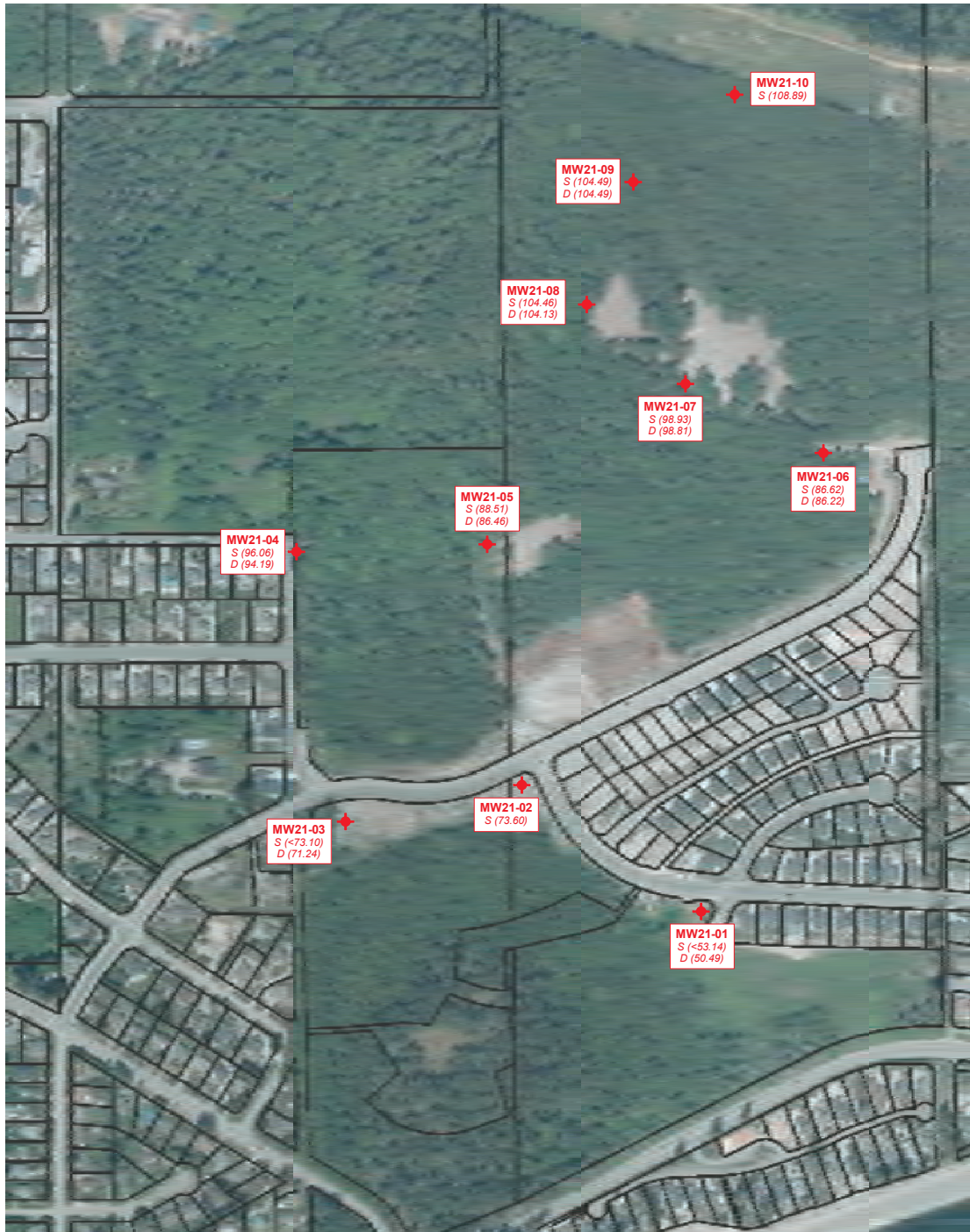
DATE: JUNE.02.2023

DRAWN BY: EL

SCALE: As Shown

DWG: PrelimStreamMap.5625 DerbyRd.dwg

MONITORING WELL NETWORK
South of BC Hydro R.O.W. to Highway 101



LEGEND

- Monitoring Well (Constructed Nov. 4 to 6, 2021)
- Groundwater Elevations (m-geod) on Jan. 11, 2022
- Shallow Monitoring Well Screen
- Deep Monitoring Well Screen
- Indicates Dry Standpipe

NOTES - 1) Base plan from SCRD Property Viewer with north direction up-page
2) Scale = 1:4,000

TABLE 1. GROUNDWATER SAMPLING SUMMARY

Descriptive Location	Temp (Celcius)	EC (mS/cm)	pH	TDS (g/L)	DO (%)
MW21-05 Shallow	10.6	157	6.13	139	36.1
MW21-05 Deep	12.6	222	7.01	222	40.4
MW21-04 Shallow	9.5	65	6.41	59	15.1
MW21-04 Deep	9.3	86	6.86	80	6.1
GW MAX	12.6	222	7.01	222	40.4
GW MIN	9.3	65	6.13	59	6.1
GW MEAN	10.5	132.5	6.60	125	24.4

TABLE 2. SURFACE WATER SAMPLING SUMMARY

Descriptive Location	Temp (Celcius)	EC (mS/cm)	pH	TDS (g/L)	DO (%)
US1 - Wooden Culvert	12.1	38	5.88	33	48.0
	12.1	38	5.64	32	39.7
DS1 - Woods Pool	8.9	24	4.62	23	36.4
DS2 - Corner Pool	11.1	26	5.44	22	44.1
MW5 Pool	18.2	27	5.35	20	79.0
US2 - Mid Way Pool	12.2	29	5.20	25	25.8
	11.7	29	4.92	25	14.2
East Gravel Road Ditch (near ROW stake)	15.7	31	6.65	25	100
East Gravel Road Ditch (confluence)	17.8	33	6.67	25	96.7
Confluence Pool	17.7	33	6.19	33	100
SW MAX	18.2	38	6.67	33	100
SW MIN	8.9	24	4.62	20	14.2
SW MEAN	13.8	30.8	5.66	26.3	58.4