200 Craig Street | Duncan BC
V9L 1W3 Canada
www.duncan.ca
T 250.746.6126

CITY of DUNCAN

DEVELOPMENT PERMIT

Permit No: DP-2021-03

Registered Owner: 1117943 B.C. LTD
6289 St. George Street

Subject Property: **446 & 454 Ypres Street and 455 Festubert Street**

Description of Land:
Parcel Identifier: 005-546-338, 000-000-418, and 004-593-375
Legal Description: **LOTS 6, 7 and 17, BLOCK 5, SECTION 17, RANGE 6, QUAMICHAN DISTRICT, PLAN 1063**

Proposal: 5-storey, 33-unit Affordable Residential Development

Conditions of Permit:

1. This permit is issued subject to compliance with all relevant City of Duncan bylaws, except as specifically varied or supplemented by this permit. This permit is not a building permit
2. This permit applies to the lands described above (the "Land"), and any buildings, structures, and other development on the Land.
3. This permit will lapse two years from the date of issuance, unless construction, in accordance with the terms and conditions of this permit, has substantially started. Construction is considered to be substantially started when a valid building permit for the authorized development has been issued and remains valid, and excavation or construction works associated with the authorized development have commenced to the satisfaction of the Manager of Planning. Demolition does not constitute construction.
4. Where the City of Duncan considers that:
    a) *A condition in the Permit with respect to landscaping has not been satisfied, or*
    b) *where, as a result of the contravention of a condition in a Permit, an unsafe condition has resulted.*

    The City of Duncan may undertake and complete the works required to satisfy the landscaping condition or carry out any construction required to correct the unsafe condition, at the cost of the Permit holder, and may apply the security in payment of the cost of the works with any excess to be returned to the Permit holder.
5. Where any security is required by the City of Duncan, the security provided by the Permit holder is to be submitted at the time of Building Permit application submission.
6. Where the development authorized by this Permit has lapsed prior to commencement of any work pursuant to this Permit, the security shall be returned to the Permit holder.

Authorized Development

7. The Land shall be developed strictly in accordance with the terms and conditions of this permit and the following schedules:

   Schedule 1 – Site Plan
   Schedule 2 – Building Plans
   Schedule 3 – Landscape Plan
   Schedule 4 – Landscape Estimate
   Schedule 5 – Geotechnical Report

Variances

8. This Development Permit includes the following variances to Zoning Bylaw No. 3166, 2017:

   - Part 3, Section 3.11.1 (Height Exemptions), to increase the permitted roof area coverage for elevator penthouses and mechanical equipment components and enclosures, which project above the maximum building height, from 10% to 26.3%.
   - Part 4, Section 4.11.1 (Development Regulations), to permit the principal building to be sited beyond the maximum front parcel line setback of 6.0 m, and
   - Part 7 (Definitions), to redefine the parcel line abutting Festubert Street from a “front parcel line” to a “rear parcel line”.

Energy Efficiency

9. The proposed building must be designed and constructed to meet Step 4 of the BC Energy Step Code.

Geotechnical

10. The Land shall be developed strictly in accordance with the Geotechnical Report, as shown in Schedule 5 of this permit.

Lot Consolidation and Demolition

11. The Land shall be consolidated into one parcel and the existing structures and buildings shall be removed from the Land prior to the issuance of a building permit.

Title Charge Release

12. Any existing or redundant charges must be released from title prior to the issuance of a building permit.

Landscaping

13. Landscape bonding in the amount of $152,598.75, which amounts to 125% of the hard and soft landscaping costs for the proposed Landscape Plan (Schedule 3) as outlined in the Landscaping Estimate provided in Schedule 4, shall be submitted, prior to the issuance of a Building Permit, in the form of a letter of credit to ensure that any conditions with respect to landscaping are satisfied or to ensure that no conditions of the permit are being breached resulting in an unsafe condition of the Land.

Date of Development Permit Approval/Issue by Council:

This permit was approved on **April 4, 2022.**

This permit expires on **April 4, 2024**.

The City of Duncan

_____

Corporate Officer

I have reviewed the amended drawing package that includes the addition of rooftop mechanical equipment and an elevator shaft projection that was not shown on the initial DP drawing package presented to Council. I approve the changes. The updated drawings have been incorporated into this permit.

The City of Duncan

_____

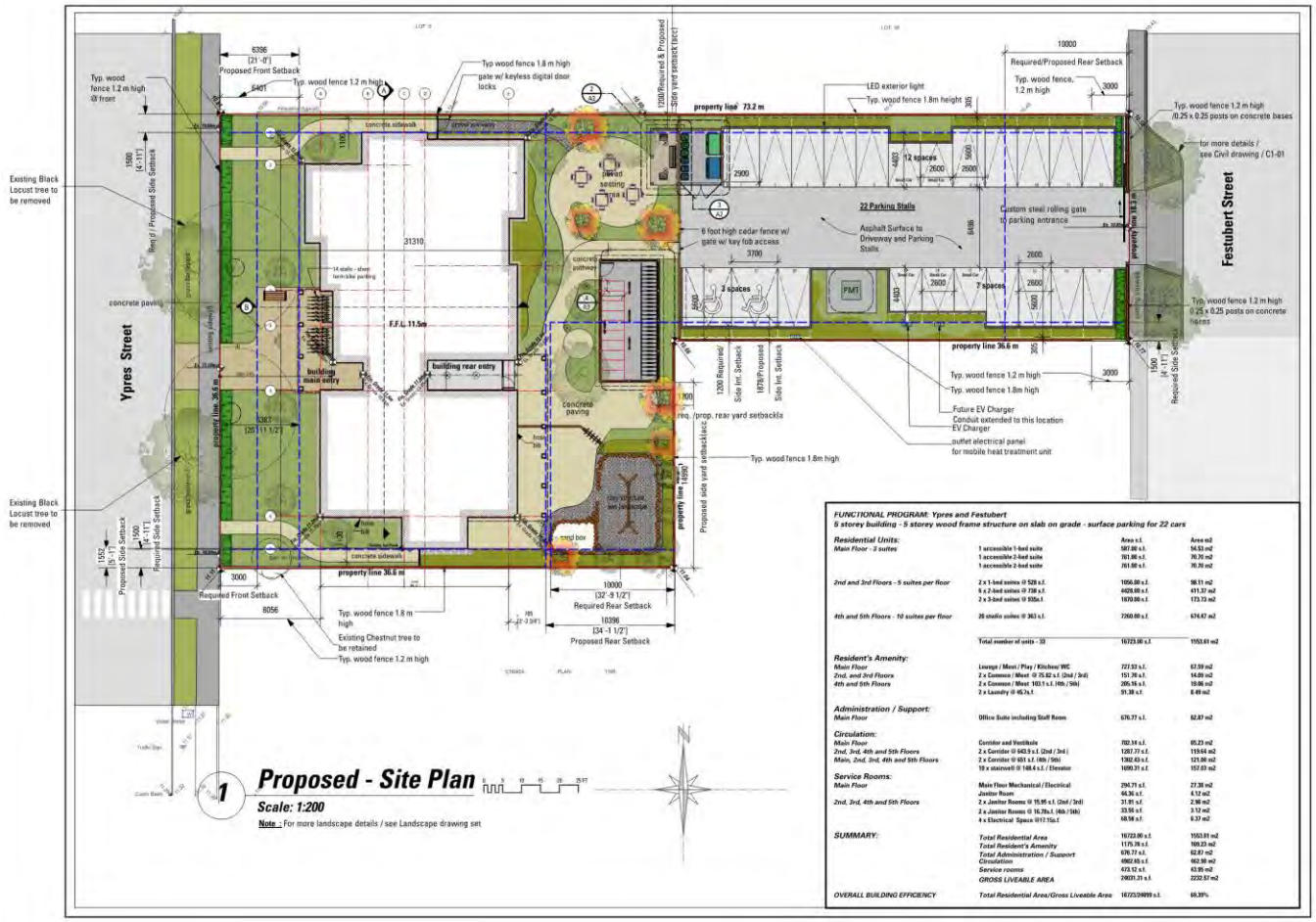
Chief Administrative Officer

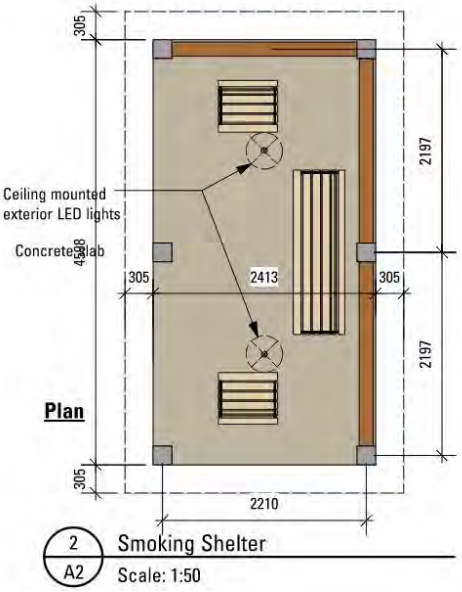
I HEREBY CERTIFY that I have read the terms and conditions of the Development Permit contained herein. I understand and agree that the City of Duncan has made no representations, covenants, warranties, guarantees, promises, or agreements (verbal or otherwise) with the registered property owner, other than those contained in this Permit.

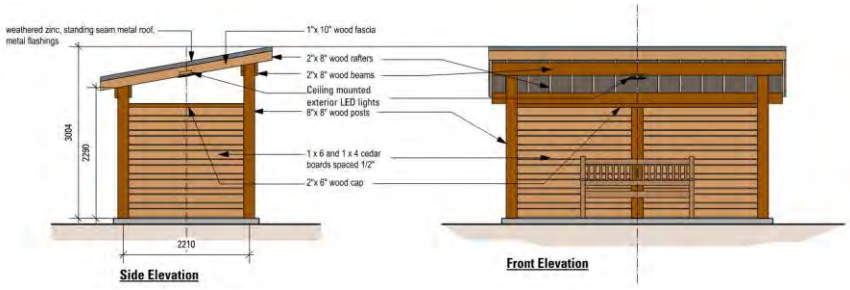
_____	_____
Owner/Agent (signature)	**Witness (signature)**
_____	_____
Print Name	**Print Name**
_____	_____
Date	**Date**

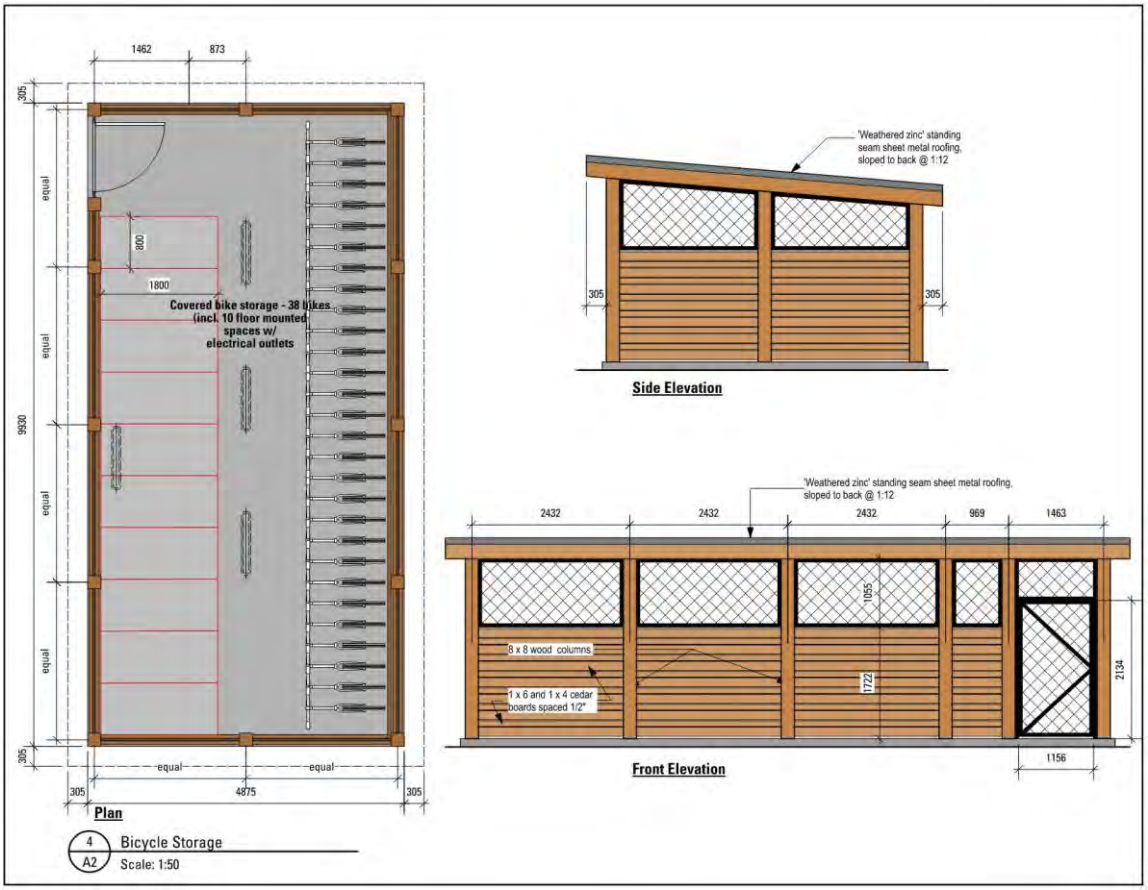
Schedule 1

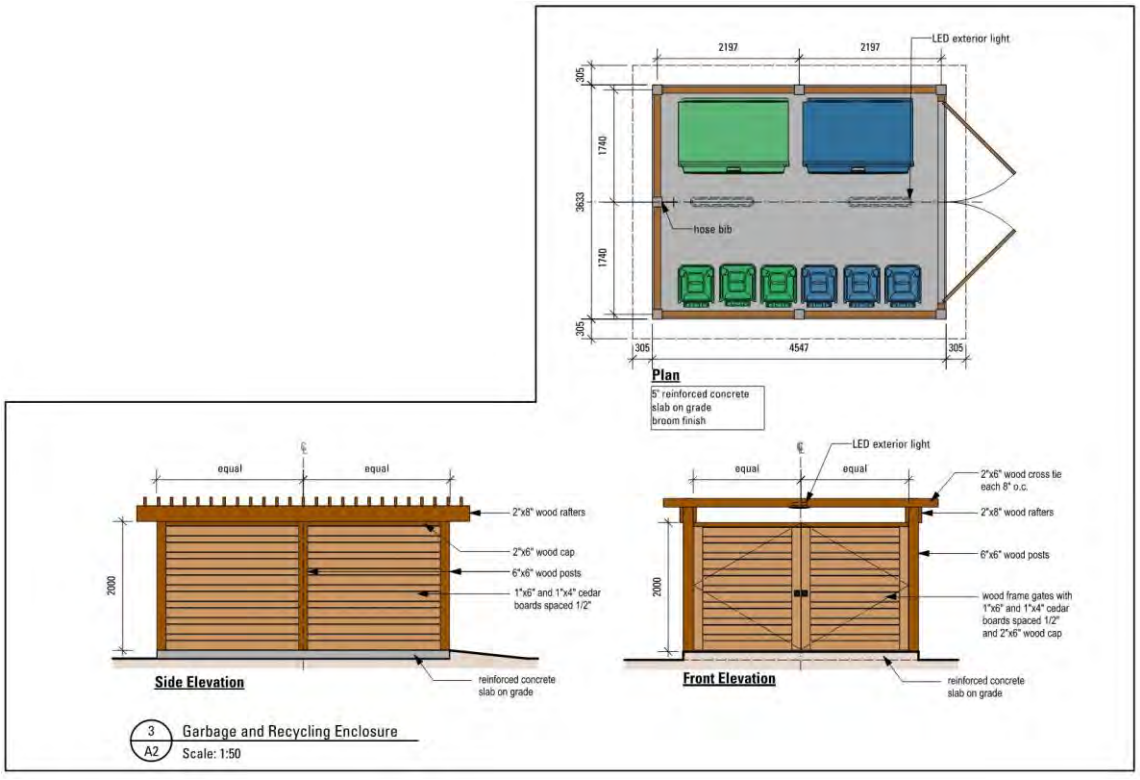
Site Plan





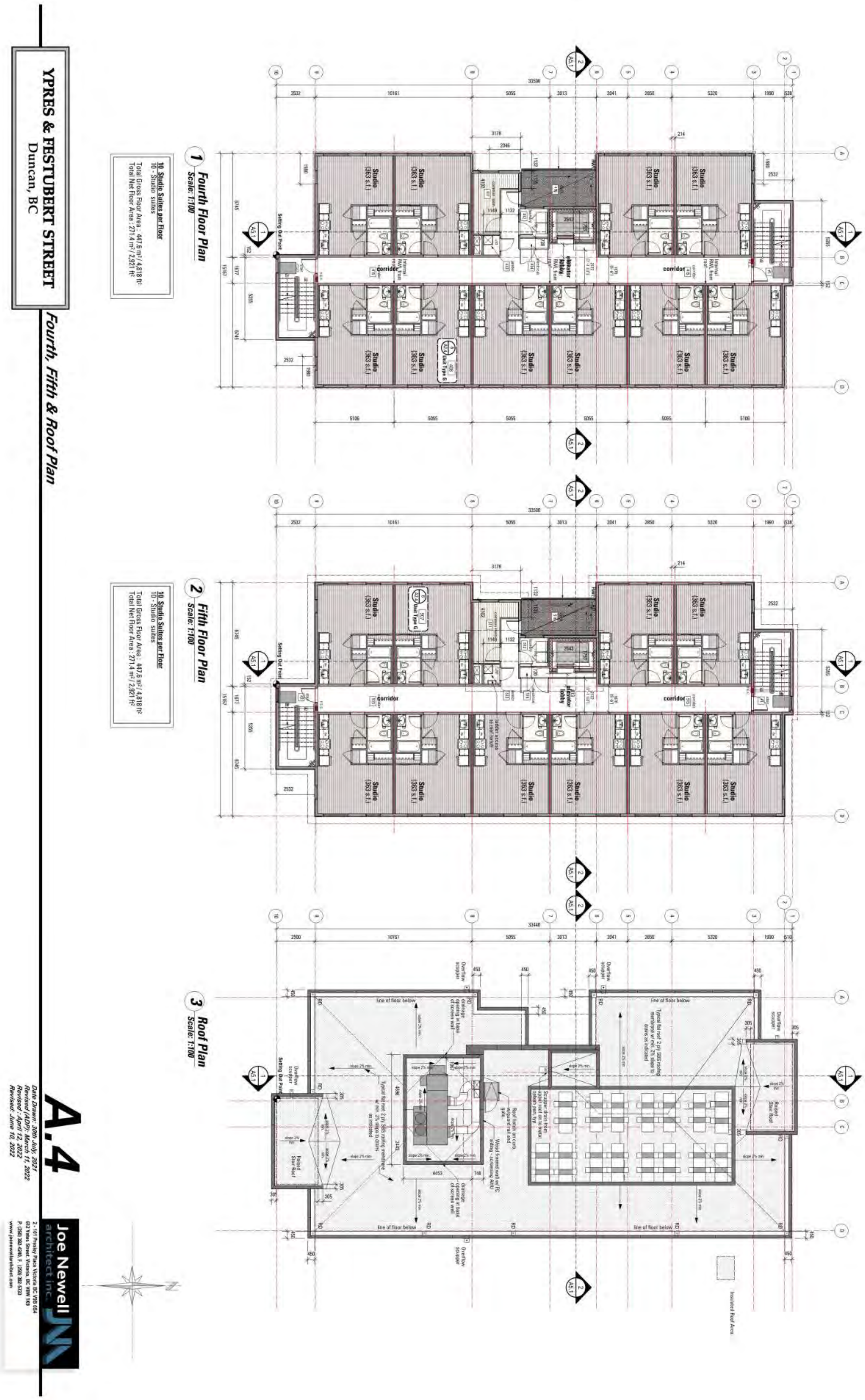



1462
873
305
equal
890
1800
Covered bike storage - 38 bikes (incl. 10 floor mounted spaces w/ electrical outlets
9930
4875
Plan
'Weathered zinc' standing seam sheet metal roofing, sloped to back @ 1:12
Side Elevation
2432
969
1463
1055
8 x 8 wood columns
1 x 6 and 1 x 4 cedar boards spaced 1/2"
1722
2134
1156
Front Elevation
4
A2
Bicycle Storage
Scale: 1:50


2197
LED exterior light
1740
3633
hose bib
4547
Plan
5" reinforced concrete slab on grade broom finish
2"x8" wood rafters
2"x6" wood cap
6"x6" wood posts
1"x6" and 1"x4" cedar boards spaced 1/2"
2000
reinforced concrete slab on grade
Side Elevation
2"x6" wood cross tie each 8" o.c.
wood frame gates with 1"x6" and 1"x4" cedar boards spaced 1/2" and 2"x6" wood cap
Front Elevation
3
A2
Garbage and Recycling Enclosure
Scale: 1:50

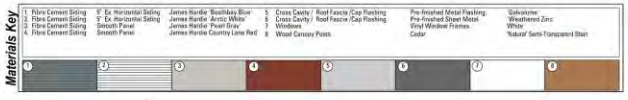
Schedule 2

Building Plans


YPRES & FESTUBERT STREET
Duncan, BC
Fourth, Fifth & Roof Plan
A.4
Date Drawn: 30th July, 2021
Revised (ADP): March 11, 2022
Revised: April 12, 2022
Revised: June 10, 2022
Joe Newell architect inc.
1 Fourth Floor Plan Scale: 1:100
10 Studio Suites per Floor
10 - Studio suites
Total Gross Floor Area : 447.6 m² / 4,818 ft²
Total Net Floor Area : 271.4 m² / 2,921 ft²
2 Fifth Floor Plan Scale: 1:100
10 Studio Suites per Floor
10 - Studio suites
Total Gross Floor Area : 447.6 m² / 4,818 ft²
Total Net Floor Area : 271.4 m² / 2,921 ft²
3 Roof Plan Scale: 1:100

1 **East Elevation**
Scale: 1:100

2 **North Elevation**
Scale: 1:100



YPRES & FESTUBERT STREET
Duncan, BC

A.6

Date Drawn: 30th July, 2021
Revised (ADP): March 11, 2022
Revised : April 12, 2022
Revised: June 10, 2022

Joe Newell architect inc.
2 - 101 Presley Place Victoria BC V9B 0S4
612 Yates Street, Victoria, BC V8W 1K9
P: (250) 382-4240, F: (250) 382-5733
www.joenewellarchitect.com

1 **West (Ypres) Elevation**
Scale: 1:100

2 **South Elevation**
Scale: 1:100

Materials Key

1. Fibre Cement Siding	5" Ex. Horizontal Siding	James Hardie 'Boothbay Blue'	5 Cross Cavity / Roof Fascia /Cap Flashing	Pre-finished Metal Flashing	Galvalume/
2. Fibre Cement Siding	5" Ex. Horizontal Siding	James Hardie 'Arctic White'	6 Cross Cavity / Roof Fascia /Cap Flashing	Pre-finished Sheet Metal	'Weathered Zinc'
3. Fibre Cement Siding	Smooth Panel	James Hardie 'Pearl Gray'	7 Windows	Vinyl Window Frames	White
4. Fibre Cement Siding	Smooth Panel	James Hardie Country Lane Red'	8 Wood Canopy Posts	Cedar	Natural/ Semi-Transparent Stain

YPRES & FESTUBERT STREET
Duncan, BC

Elevations

A.5

Date Drawn: 30th July, 2021
Revised (ADP): March 11, 2022
Revised : April 12, 2022
Revised: June 10, 2022

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1 **Section A**
Scale: 1:100

2 **Section B**
Scale: 1:100

YPRES & FESTUBERT STREET
Duncan, BC

Sections

A.7

Date Drawn: 30th July, 2021
Revised (ADP): March 11, 2022
Revised : April 12, 2022
Revised: June 10, 2022

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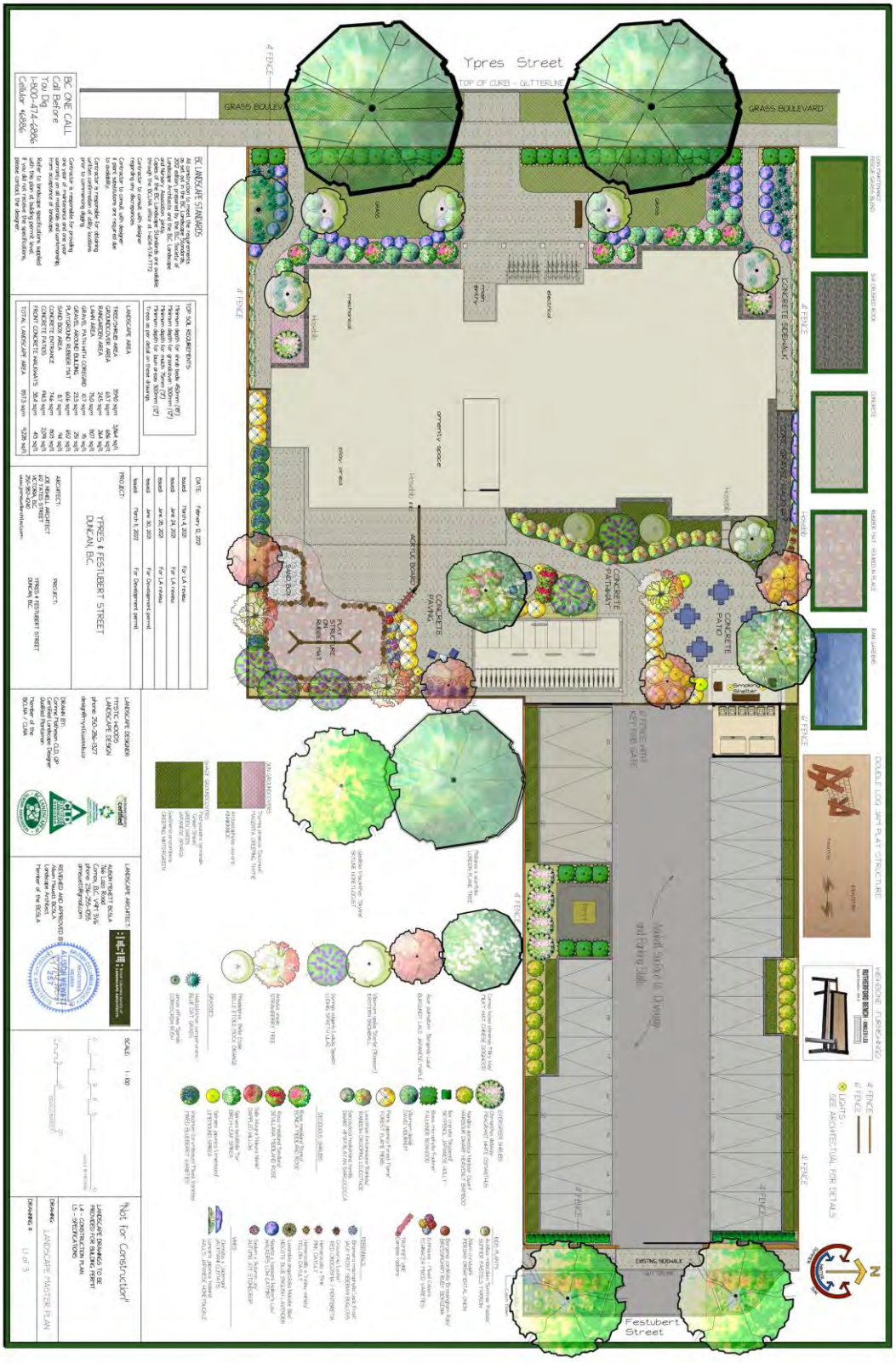
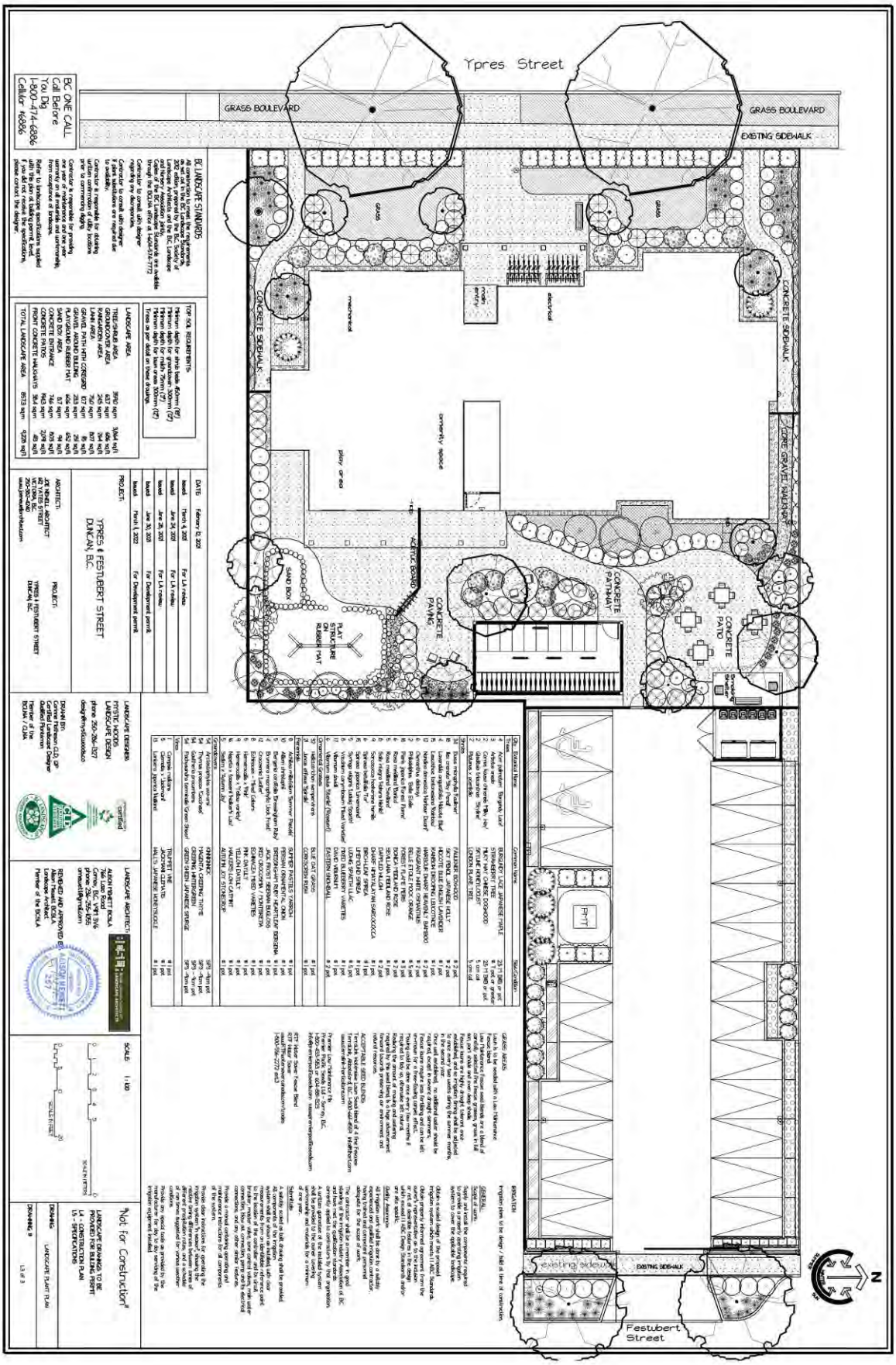
Schedule 3

Landscape Plan




"Not for Construction"
BC LANDSCAPE STANDARDS
PLANT IMAGES
L 2 OF 3


Ypres Street
GRASS BOULEVARD
EXISTING SIDEWALK
CONCRETE SIDEWALK
CORE GRAVEL WALKWAY
CONCRETE PATHWAY
CONCRETE PATIO
CONCRETE PAVING
SAND BOX
PLAY STRUCTURE
ACRYLIC BOARD
existing sidewalk
Festubert Street
N

Schedule 4

Landscape Estimate

LANDSCAPE INSTALLATION ESTIMATE

March 11, 2022

LANDSCAPE ARCHITECT
Alison Mewett, BCSLA
766 Lazo Road, Comox, BC V9M 3V6
(236) 255-1055
amewett@gmail.com

PROJECT
Ypres & Festubert Street
Duncan, BC

Planting beds: 359m^2 (3,864 ft^2)
Lawn/groundcover: 138.7m^2 (1,644 ft^2)
Rubber Mat: 60.6m^2 (652 ft^2)
Concrete patio/walkways: 232.7m^2 (2,504ft^2)
Raingardens: 24.5m^2 (264 ft^2)
Gravel: 23.3 m^2 (251 ft^2)
Sandbox: 8.7 m^2 (94 ft^2)
CorePath: 10.7m^2(115ft^2)

Plant material	$ 9,770
Topsoil delivered (shrubs) @ 18" – 214 cuyds @ $40	8,560
Topsoil delivered (lawn/groundcover) @ 12" – 61 cuyds @ $35	2,135
Fine mulch delivered @ 4" – 62 cuyds @ $55	3,410
Gravel/COREpath, plus building gravel edge @ 6" – 7 cuyds @ $35	245
COREgrid @ $3/sq ft	345
Hydroseed lawn area	340
Fertilizers, tree stakes, and miscellaneous	750
Machine work to grade and move materials	3,000
Labour to install plant materials and other work to complete	8,800
Irrigation system installed	6,500
Planting Sub-total (not including taxes)	**$ 43,855**
1.2m (4') wood fence @ 150m @ $78/linear m	$ 11,700
1.83m (6') wood fence @ 72m @ $115/linear m	8,280
Patio/walkways @ $6/sqft	15,024
Hardscape Sub-total (not including taxes)	**$ 35,004**
Rubber Mat @ 60.6m^2 (652sqft) @ $ 20/sqft	$ 13,020
"Log Jam" play system w/ net	26,400
Log rounds	3,000
Play sand	800
Play equipment Sub-total	**$ 43,220**
Total (not including taxes)	**$ 122,079**

Materials estimated at cost.
This estimate is approximate and may not reflect actual cost to install.

Alison Mewett, BCSLA
Landscape Architect

RYZUK GEOTECHNICAL
Engineering & Materials Testing

28 Crease Avenue, Victoria, BC, V8Z 1S3 Tel: 250-475-3131 Fax: 250-475-3611 www.ryzuk.com

February 28, 2020
File No: 9774-1

1117943 BC Ltd.
#38 – 3205 Gibbins Road
Duncan, BC
V9L 1G7

Attn: Mandeep Sindhi (By E-mail: mandeepsindhi1@gmail.com)

Re: Proposed 5 Story Residential Development
454, 446 Ypres St. & 455 Festubert St. – Duncan, BC

As requested, we have completed a geotechnical investigation of the above referenced site proposed for development. Our associated observations, comments and recommendations are contained herein. Our work has been carried out in accordance with, and is subject to, the previously sent Terms of Engagement.

PROPOSED DEVELOPMENT

Although there are currently no architectural plans, we understand that the concept for development would consist of a four or five story building constructed on 454 and 446 Ypres Street, with surface parking provided on neighboring 455 Festubert Street to the east. We understand that the building would be constructed at-grade, with no basement or underground parking, and would be wood framed construction. At this stage, we expect the building will be designed with a natural period of less than 0.5 seconds.

The site is bounded by Ypres Street to the west, multi-family buildings to the north and south, and Festubert Street to the east. There are currently two single family homes on the 454 and 446 Ypres Street lots, with associated driveway areas, which would be demolished to allow for the proposed development. Other than the houses, these lots are vegetated with a few small to medium sized trees, hedges, and lawn areas. The 455 Festubert Street lot is currently vacant and undeveloped. Topography of the site is relatively flat, gently sloping from west to east.

INVESTIGATION PROCEDURE

Our geotechnical investigation comprised an office-based desktop study, followed by an on-site subsurface investigation. The desktop study consisted of a review of geological maps, our file information from previous projects in the area, topographical maps, and flood hazard mapping.

This study identified possible organic layers and potentially liquefiable soils at depth. To confirm the anticipated conditions, a drill investigation was carried out on February 3rd, 2020.

The drill investigation involved advancing two test holes, test holes TH20-01 and TH20-02, within the proposed building footprint using a Boart-Longyear sonic drill rig. The holes were drilled using water/mud to help control heave while drilling below the water table. Standard Penetration Testing (SPT) was undertaken at 1.5 m intervals in TH20-01 to determine the strength characteristics of the subsurface soils, and the samples were collected for additional laboratory testing. In test hole TH20-02, SPT readings were taken at two select depths to help identify the transition between the liquefiable and non-liquefiable soils. A Direct Cone Penetration Test (DCPT), which is generally faster than drilling, was conducted in the lower portion of TH20-02 due to time constraints, to reach refusal on bedrock.

Further to this, four microtremor survey measurements were acquired in areas where the drill could not access (or to calibrate the unit with the soil conditions). The microtremor surveys were done using our microtremor unit (Tromino), which measures and records ambient ground vibrations at the ground surface that can then be interpreted to provide an estimate of depth to bedrock. For test hole and microtremor survey locations see attached drawing number 9774-1-1 – Test Hole Location Plan, dated February 2020.

SURFACE AND SUBSURFACE CONDITIONS

As noted, the desktop study indicated that the subsurface soil conditions within the area comprise fluvial deposits. These deposits generally consist of loose to compact silty sands and gravels at depth overtop of dense gravel, and possible shallow/surficial silty, sandy organic layers.

Soil conditions encountered in the two test holes were similar within the upper layers but differed near the base of each hole. Stratigraphy in the upper portions of both holes consisted of a thin layer of surficial fill, overtop of loose silty brown sand, overtop of compact brown/grey sand and gravel, atop loose to compact orange-brown silty sand. Below this layer, soil conditions in the two holes differed. In TH20-01, the loose to compact silty sand layer continued down to a depth of 10.1 m, where it transitioned to firm bluish-grey silt, over a thin layer of dense sand and gravel overtop of bedrock (bedrock was encountered at a depth of 15 m in TH20-01). A silt lens containing trace to some organic material was identified in this test hole at a depth of 1.5 m. Soils in TH20-02 transitioned to compact sand and gravel below the loose to compact sand layer and continued to a depth of 11 m, where soil conditions transitioned to compact sand with variable silt, overtop of firm bluish-grey silt, overtop of bedrock (bedrock was encountered at 18 m in TH20-01). Minor silt and sand lenses were noted at various depths in each of the test holes as well. The microtremor survey results were fairly consistent with the depths of refusal on bedrock, with interpreted depths on dense sand and gravels or bedrock being between 14.5 m and 15.5 m, with the north side of the site being deeper. From samples collected in TH20-01, we expect that bedrock underlying the site consists of shale and/or siltstone of the Nanaimo Group.

The eight SPT samples from TH20-01 were analyzed to assess the % fines content of the noted soils. These percentages varied from 13% in the sandy gravels to >50% in the sandy silts and silt layers. These values were inferred to represent the site, and were used in the liquefaction assessments.

In each test hole the groundwater table elevation was observed to be 2.2 m below the surface. Long term groundwater monitoring was undertaken near to the site by Thurber Engineering in 2012 and 2013 for the City of Duncan. Test hole TH12-4 was installed by Thurber at the intersection of Queens Road and Ypres Street, just southwest of the site, and groundwater levels were monitored from October 2012 to October 2013. The data from the monitoring indicated that groundwater elevations fluctuated between 2.5 m (in December 2012) and 4.0 m (in September 2013) below the surface over the period. As such, we expect that the groundwater level will continue to fluctuate seasonally between 2.0 m and 4.0 m below the surface, with temporarily higher levels possible during periods of heavy and/or sustained rainfall.

Based on our review of the Lower Cowichan/Koksilah Integrated Flood Mapping and Management Plan – Flood Hazard Map, prepared by Northwest Hydraulic Consultants and dated September 2009, the site is located outside of the Floodway Zone. This zone delineates areas within the 200-year return period flood plain (which includes 0.6 m of freeboard) deep and fast flowing water are expected, which could lead to possible erosion and scouring, as well as flood water damage. The proposed development site is located within the Flood Fringe Zone of the 200-year return period flood plain, with an expected flood elevation of 11.0 m to 11.5 m. This zone is characterized by low velocity flowing water and ponding, which could result in flood water damage.

LIQUEFACTION CONSIDERATIONS

It is generally understood that loose to compact granular soils below the water table are susceptible to liquefaction during a large scale seismic event. Liquefaction can cause a significant decrease in bearing capacity, which can result in large differential settlements, lateral spreading, and earthflow. Based on the soil conditions noted above, we consider this site to be susceptible to seismically induced liquefaction.

For buildings constructed on liquefiable soils, a Seismic Site Classification of 'F – Other soils' is required under the current BC Building Code, for buildings with natural periods of greater than 0.5 seconds. For buildings with a period of less than 0.5 seconds, such as the proposed building at this site, the code allows for Seismic Site Classification and spectral accelerations to be determined without considering liquefaction. This avoids the need for a site-specific seismic analysis, but induced settlements and potential earthflows resulting from liquefaction will still need to be mitigated.

GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS

On the basis of our investigation, analysis, and our experience in the area, we consider the development to be feasible from a geotechnical perspective. However, careful consideration will need to be taken to mitigate the risks posed by potential liquefaction of the underlying soils at the site.

Excavation Considerations

It is expected that excavations of 1 – 3 m will be required for the installation of building foundation elements and underground services. Because of the fluctuating water table, excavations may extend below the water table at certain times of the year, making it difficult to achieve open cutslopes for excavation. As such, dewatering and/or temporary shoring may be required under these conditions, and will need to be assessed at the time of the excavation. We recommend that deeper excavations be carried out at drier times of the year, when groundwater levels are expected to be at their lowest. Given the soil conditions encountered, and provided that the excavation does not extend below the water table, we expect cutslopes will be stable at the following configurations:

- 0.75 H : 1.0 V for the fills and granular surficial deposits above the water table;
- Recommendations for excavations below the water table will depend on the size, depth and duration of the proposed work.

Adjustments to the above configurations may be required upon site inspection during construction if variations of the soil conditions or seepage are observed. According to WorkSafeBC guidelines, excavations deeper than 1.2 m must be inspected and approved by a qualified geotechnical professional, unless sloped in accordance with the guidelines. Excavation along property lines should be carried out with care so as not to induce settlement of adjacent properties, and encroachment agreements should be in place if excavating over property lines.

Seismic Considerations

Duncan is situated in a region of relatively high seismicity. Considerable earthquake risk exists, stemming from our proximity to the Cascadia subduction zone and numerous more local faults in southwestern BC and northwestern Washington State. Based on the SPT results in TH20-01, a harmonic mean SPT N value of less than 15 was obtained within the upper 30 m of soils on this site. In accordance with 2018 BC Building Code, this corresponds to a seismic site classification of 'E – Soft soil' for buildings with a natural period of less than 0.5 seconds. From the 2015 National Building Code (NBC) Seismic Hazard Calculation, for a 2% probability of exceedance in 50 years, the Peak Ground Acceleration (PGA) and Spectral Acceleration Values for Site Class 'C', and corrected values for 'E', are summarized in Table 1:

Table 1. Summary of PGA and Spectral Acceleration Values (NBC 2015)

Period (sec)	0.2	0.5	PGA (g)
Response (g) Site Class 'C'	1.169	1.086	0.511
Response (g) Site Class 'E'	**1.270**	**1.270**	**0.378**

Liquefaction Assessment, Induced Settlement and Lateral Displacements

To determine the potential for seismically induced liquefactions of the subsurface soils at the site, an assessment was carried out using the conventional cyclical stress ratio to cyclical resistance ratio (CSR/CRR) approach. These values were estimated through correlations based on the obtained SPT data in TH20-01 and assumed to be representative of the building site.

To assess liquefaction potential the Seed (1983), NCEER (1997), and Idriss & Boulanger (2004) methods were applied, while settlements were estimated based on Ishihara & Yoshimine (1992), Tokimatsu & Seed (1984), Shamamato (1998), Wu (2003) and Cetin (2009). Industry standard within the southern portion of BC is to base results on Idriss & Boulanger and Tokimatsu & Seed for liquefaction potential and settlements respectively.

Based on our analyses, the observed soils are anticipated to liquefy to depths of approximately 15 m below grade, however, this liquefaction is only expected to result in significant settlements to a depth of approximately 12 m. Based on these results, we anticipate total settlements to range from 100 mm to 200 mm. Lateral spread was neglected because no noticeable slope was observed on the site or within the surrounding terrain.

Foundation Considerations and Soil Remediation Options

Because of the expected settlements due to liquefaction within the site, measures will be required to ensure the proposed building can withstand the associated differential and total settlements. While there are several methods to address this, we expect that the most economical and practical for the proposed development will be the installation of deep foundations, or reinforced shallow foundations supported by a rock mat. Ultimately, the option chosen will depend on post-earthquake requirements of the proposed building.

Deep foundations generally consist of either driven piles or drilled cast-in-place concrete caissons, and these elements transfer the building loads from the surface to a denser strata below the liquefaction elevation. Of these, driven piles are generally more suited to this development. Because of the anticipated liquefaction, significant loads will be induced by the settlement (down-drag) on any potential piles. This will mean that the piles will need to be designed to accommodate loads that are substantially higher than the structural loads from the building. As well, given the depth to suitable bearing strata, and the size of the proposed building, this option

may be cost prohibitive. From previous experience in the area we expect that 324 mm diameter steel pipe piles with a 9.5 mm wall thickness, infilled with concrete, will be the most economical option. Based on our preliminary calculations, a working load of 700 kN per pile can be assumed for design purposes. This capacity will need to be reassessed once pile locations and building loads are known. All piles would need to be sound and include a proper 100 mm diameter Oslo Tip to ensure adequate bearing on the underlying bedrock is achieved. Pile installation will require monitoring using Pile Driving Analyzer (PDA) equipment to verify the bearing capacity of the piles. It should be noted that there is significant noise and vibration associated with pile driving, which can cause disturbance to neighbors and potential damage to neighboring property (from vibrations).

Reinforced shallow foundations typically aim to reduce differential settlements within the building footprint to a level where the structure can provide safe egress after a seismic event. Note that while differential settlements are managed using this methodology, total liquefaction induced settlements are still expected to occur. As such, it is common for this methodology to be used for smaller buildings on liquefiable soils, provided that the buildings do not need to be serviceable post-disaster. Of the available methods to achieve this, reinforced rock mats and raft slabs are the most commonly used in the area, and both are feasible for the proposed development. If the reinforced shallow foundations option is chosen, base shear resistance will need to be provided through the use of the constructed rock mat or thickened perimeter grade beams to transfer the loads. Rock mats are installed directly beneath the building footings, and typically comprise a layer of engineered fill with geotextile and/or geogrid incorporated into the rock. The thickness of the rock mat and geogrid orientation are largely dependent on the building loads, and further recommendations can be provided on this once the building information is known. Details regarding raft slabs will need to be provided by the structural engineer.

Because the site is located within the 200-year return period floodplain of the Cowichan River floodplain, a flood hazard assessment has been done for this site. Based on a review of the above noted flood hazard mapping, the maximum flood elevation of the Flood Fringe Zone at the site will be at an elevation of 11.5 m. This elevation includes a freeboard of 0.6 m, and as such we recommend that the minimum Flood Construction Level of the building should be at an elevation of 11.5 m geodetic. Currently the site elevation is approximately 11.0 m based on our review of available mapping. Given the above, we expect that the site can be safely used for the use intended, that being multi-family residential. This is in conformance with the City of Duncan Floodplain Designation Bylaw No. 1975, dated November 2012, and is pursuant to Section 56 of the Community Charter.

Other Settlement Considerations

Depending on the selected site mitigation option, static settlements over time will vary. While these are expected to fall within structural tolerances, they may impact service connections to the structures. It is recommended that this possibility be reviewed once a site remediation technique has been selected.

Engineered Fill

Engineered fill may be required to raise grades back to design grade after removal of topsoil/fill material, or for constructing a rock mat for foundations. Engineered fill is to consist of approved well-graded select granular material placed in maximum 0.3 m lifts and compacted to a minimum of 95% of Standard Proctor Maximum Dry Density (SPMDD) or judged equivalent. We recommend in-situ density testing or fill placement monitoring to ensure compaction in the engineered fill. The engineered fill must have a footprint that extends horizontally beyond the footings a distance equal 0.3 m plus the thickness of the engineered fill, to provide adequate splay for foundation loads. In perimeter areas, it is inadvisable to have the engineered fill/foundation load splay extend beyond property lines.

Grade Supported Floor Slab

We expect that use of a grade supported lower floor slab is feasible for lower floor area. A minimum 150 mm layer of medium to coarse sand or 19 mm minus gravel is recommended beneath the slab, as well as a subslab moisture barrier, to avoid capillary rise of moisture into the slab. All subslab fill should be compacted to at least 95% of SPMDD.

Foundation Drainage

Conventional perimeter foundation drainage consisting of perforated drain pipe surrounded by free draining granular material containing low fines, tied into the recommended free draining backfill material, is recommended. To prevent the migration of fine-grained soil particles into the drainage system, a layer of medium weight, non-woven geotextile should be placed between the clean drain rock around the perforated pipe and the granular backfill material. The geotextile should encompass the entire drain rock / drain pipe system.

Pavement / Road Structure Considerations

Generally for parking and light traffic areas, a pavement structure consisting of 50 mm of asphalt surfacing overlying at least 100 mm of 19 mm minus crushed base course and a minimum of 200 mm of 75 mm minus subbase is recommended over compact to dense native soils, or engineered fills over compact to dense native soils. For heavier traffic areas, the thickness of the asphalt surfacing should be increased to minimum 75 mm, and the base course thickened to 150 mm. Base and subbase layers should be compacted to 100% of SPMDD. The above noted pavement structures may need to be revised based on actual subgrade conditions within the proposed parking area, and could included thickening of the base and subbase and/or the addition of a geotextile layer beneath the road structure. This could be determined with an additional test-pit investigation as discussed below, or at the time of construction.

FURTHER INVESTIGATION

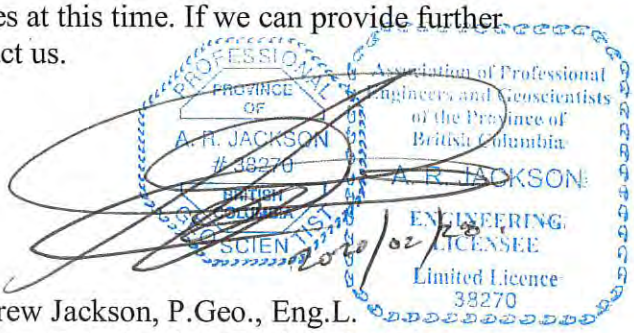
It is recommended that an additional shallow test-pit investigation be done within the building and parking areas. This would help to determine the budget for excavation works required on site, and provide fill depths within the proposed parking area on the 455 Festubert Street lot.

CLOSURE

We trust that the preceding is suitable for your purposes at this time. If we can provide further information or clarification in this regard, please contact us.

Sincerely,
Ryzuk Geotechnical

Shane Haxton, P.Eng.
Project Engineer



Andrew Jackson, P.Geo., Eng.L.
Review Geoscientist / Engineering Licensee

Attachments:
- Test Hole Location Plan, drawing 9774-1-1
- Test Hole Logs, TH20-01 & TH20-02
- Liquefaction Analyses – TH20-01
- Duncan Flood Hazard Map and Integrated Floodplain Mapping

Legend:

TH20-XX - Test Hole Location
TR20-XX - Tromino Survey Location

Notes:

1. Base imagery and property features taken from Google Maps
2. Sonic test holes advanced on February 4, 2020 with drill rig supplied by Drillwell Enterprises Ltd.
3. Tromino surveys completed on February 4 & 6, 2020
4. Test hole locations based relative to site features; actual locations may vary by +/- 2 m.

1117943 BC Ltd.

TEST HOLE LOCATION PLAN

Proposed 5 Storey Residential Development

454, 446 Ypres St. & 455 Festubert St. Duncan, B.C.

RYZUK GEOTECHNICAL Engineering & Materials Testing

DRAWN	ZTH
DATE	February, 2020
APPROVED	
SCALE	NTS
DRAWING No.	9774-1-1

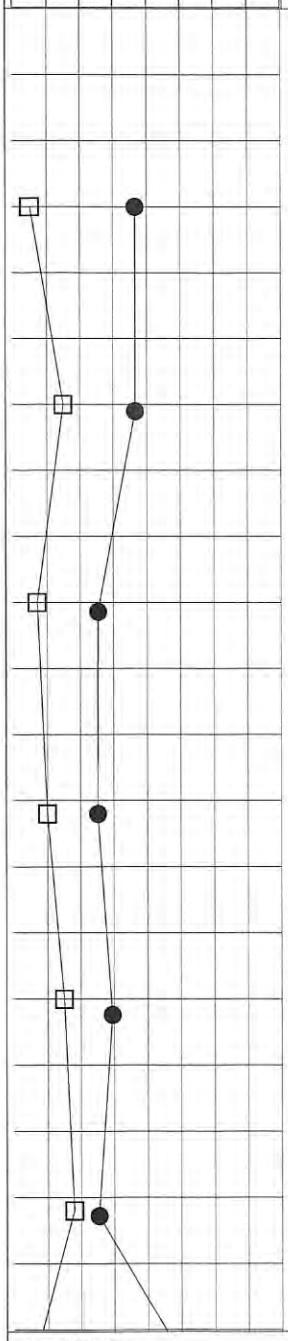
RYZUK GEOTECHNICAL
ENGINEERING & MATERIALS TESTING

28 Crease Avenue
Victoria, BC
V8Z 1S3
Tel. 250-475-3131 Fax. 250-475-3611
mail@ryzuk.com www.ryzuk.com

TEST HOLE LOG

TH20-01

Project: Proposed 5 Storey Residential Development
UTM: 448360 m E; 5403196 m N
Client: 1117943 BC Ltd. Job #: 9774-1
Location: 454, 446 Ypres St & 455 Festubert St Method: Sonic/SPT
Duncan, BC Driller: Drillwell
Drill Date: February 4, 2020 Inspector: ZTH



SPT Field 'N' Value (Blows / 150 mm)	Recovery %	Sample	Stratigraphy	Stratigraphic Description	Depth (m)
				Fill - Gravel and sand	0.0
				SAND - loose, silty, brown, trace gravel, roots and organics, slightly moist	
		■		SILT - firm, sandy, some organics and roots, brown, slightly moist	1.0
4-2-3-5	70	☒		SAND - loose, silty, brown, trace gravel, slightly moist	
				SAND and GRAVEL - compact, brown, coarse grained sand, trace silt, moist	2.0 ▼
		■			
9-10-5-4	20	☒		GRAVEL - compact, some coarse sand, trace silt, well graded, moist	3.0
				SAND - loose to compact, orange-brown, medium grained, some silt, moist	
2-3-4-4	90	☒			4.0
					5.0
				silty lense from 5.7 to 5.9 m	
3-5-5-7	95	☒		becomes fine grained after 6.1 m	6.0
					7.0
7-7-8-10	80	☒			
					8.0
					9.0
7-9-9-8	75	☒			
					10.0

LEGEND
☒ Split Spoon ● Fines Content
□ 'N' Value
▲ Moisture Content ■ Grab Sample

COMMENTS:
Test hole backfilled with cuttings and bentonite seal

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ENGINEERING & MATERIALS TESTING

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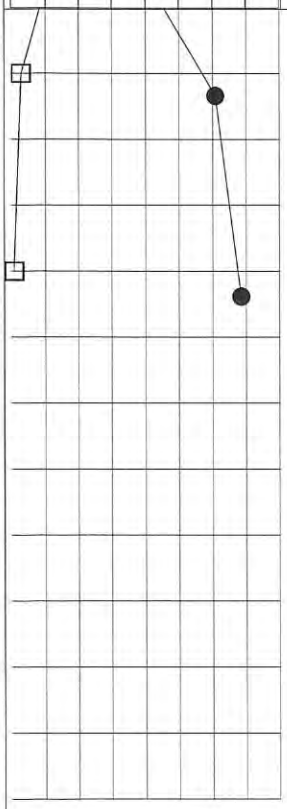
Victoria, BC
V8Z 1S3
Tel. 250-475-3131 Fax. 250-475-3611
mail@ryzuk.com www.ryzuk.com

TEST HOLE LOG

TH20-01

Project: Proposed 5 Storey Residential Development
UTM: 448360 m E; 5403196 m N
Client: 1117943 BC Ltd. Job #: 9774-1
Location: 454, 446 Ypres St & 455 Festubert St Method: Sonic/SPT
Duncan, BC Driller: Drillwell
Drill Date: February 4, 2020 Inspector: ZTH



SPT Field 'N' Value (Blows / 150 mm)	Recovery %	Sample	Stratigraphy	Stratigraphic Description	Depth (m)
				SAND - loose, silty, fine grained, blue-grey, moist to wet	
1-2-1-1	65	⊠			
		■		SILT - firm, clayey, blue-grey, moist to wet	11.0
0-0-1-0	100	⊠			12.0
					13.0
		■		In-situ shear vane test at 13.5 m: Su= 44 kPa	
					14.0
		■		SAND - dense to very dense, till like, silty, grey, slightly moist to dry	
				BEDROCK	
				End of test hole at 15.0 m - desired depth	15.0
					16.0

LEGEND
⊠ Split Spoon ● Fines Content
□ 'N' Value
▲ Moisture Content ■ Grab Sample

COMMENTS:
Test hole backfilled with cuttings and bentonite seal

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Tel. 250-475-3131 Fax. 250-475-3611
mail@ryzuk.com www.ryzuk.com

TEST HOLE LOG

TH20-02

Project: Proposed 5 Storey Residential Development
UTM: 448360 m E; 5403196 m N
Client: 1117943 BC Ltd. Job #: 9774-1
Location: 454, 446 Ypres St & 455 Festubert St Method: Sonic/SPT
Duncan, BC Driller: Drillwell
Drill Date: February 4, 2020 Inspector: ZTH

SPT 'N' Value / Fines Content % (0 20 40 60 80)	DCPT blows/ft (0 10 20 30 40 50)	SPT Field 'N' Value (Blows / 150 mm)	Recovery %	Sample	Stratigraphy	Stratigraphic Description	Depth (m)
						Fill - Topsoil & gravel	0.0
						SAND - loose to compact, silty, brown, slightly moist	
						some roots and organics 0.3 to 1.0 m	1.0
						trace gravel from 1.3 to 1.6 m	
							2.0 ▼
				■		becomes moist at 2.4 m	
						SAND and GRAVEL - compact, coarse grained, well graded, well rounded, trace cobbles, trace silt, grey-brown, moist	3.0
				■			4.0
				■		SAND - compact, silty, orange-brown, moist	5.0
● □		5-8-11-10	90	☒		GRAVEL and SAND - compact, coarse grained, well graded, well rounded, trace silt, grey-brown, moist	6.0
				■			7.0
						SAND and GRAVEL - compact, medium grained, grey, well rounded gravel, moist	8.0
● □		8-11-10-11	10	■			9.0
							10.0

LEGEND
☒ Split Spoon ● Fines Content
□ 'N' Value
▲ Moisture Content ■ Grab Sample

COMMENTS:
Test hole backfilled with cuttings and bentonite seal

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28 Crease Avenue
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TEST HOLE LOG

TH20-02

Project: Proposed 5 Storey Residential Development
UTM: 448360 m E; 5403196 m N
Client: 1117943 BC Ltd. Job #: 9774-1
Location: 454, 446 Ypres St & 455 Festubert St Method: Sonic/SPT
Duncan, BC Driller: Drillwell
Drill Date: February 4, 2020 Inspector: ZTH

SPT 'N' Value / Fines Content % (0 20 40 60 80)	DCPT blows/ft (0 10 20 30 40 50)	SPT Field 'N' Value (Blows / 150 mm)	Recovery %	Sample	Stratigraphy	Stratigraphic Description	Depth (m)
							11.0
	19			■		SAND - compact, medium grained, some gravel, trace silt, orange-brown, moist	12.0
	18						
	19						
	16					SAND - compact, silty, orange-brown, moist	13.0
	14						
	22			■			
	16						14.0
	15						
	21						
	21						15.0
	20						
	15						
	11			■		SILT - firm, clayey, blue-grey, moist to wet	16.0
	9						
	9						
	10						
	8			■			17.0
	7						
	7						
				■		BEDROCK	18.0
						End of test hole at 18.0 m - desired depth	
							19.0

LEGEND
☒ Split Spoon ● Fines Content
□ 'N' Value
▲ Moisture Content ■ Grab Sample

COMMENTS:
Test hole backfilled with cuttings and bentonite seal

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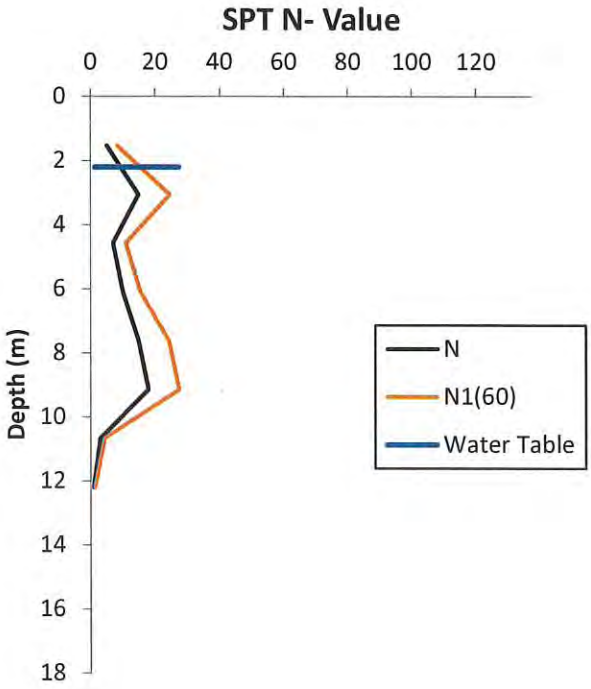
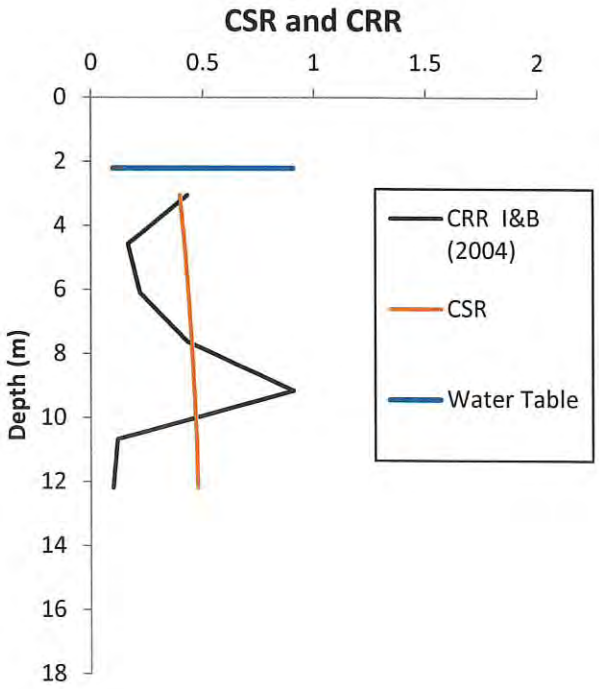
V8Z 1S3 mail@ryzuk.com

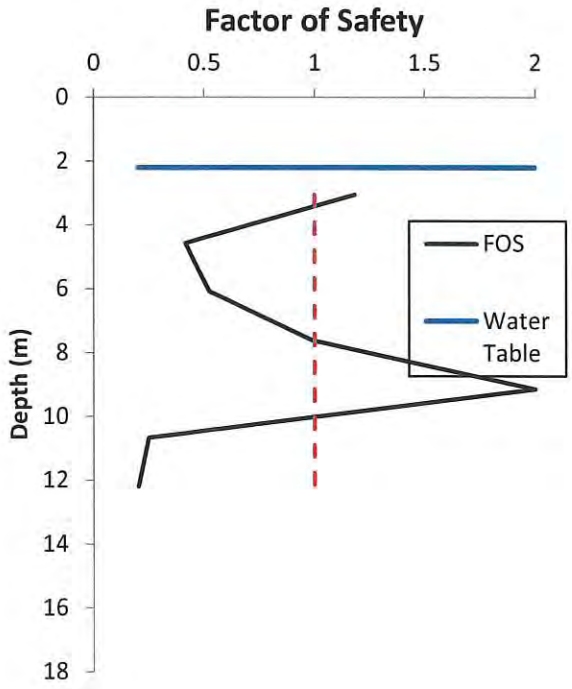
LIQUEFACTION ANALYSIS RESULTS

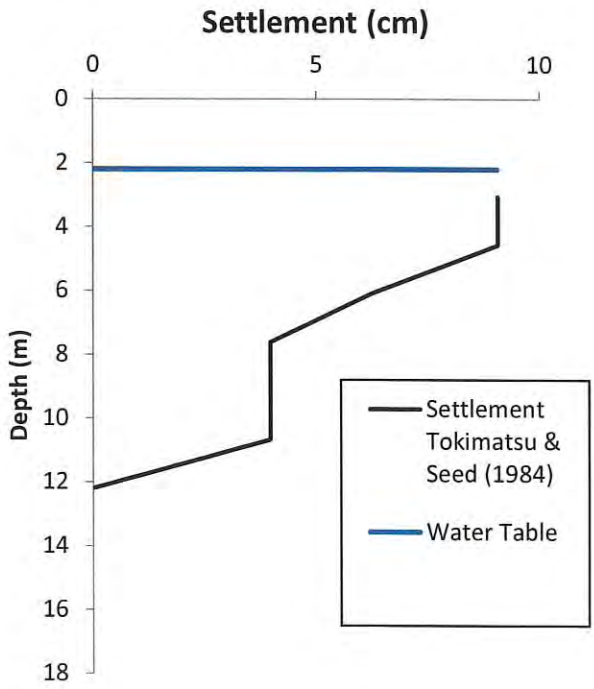
Project: Proposed 5 Story Building
Test Hole: TH20-01

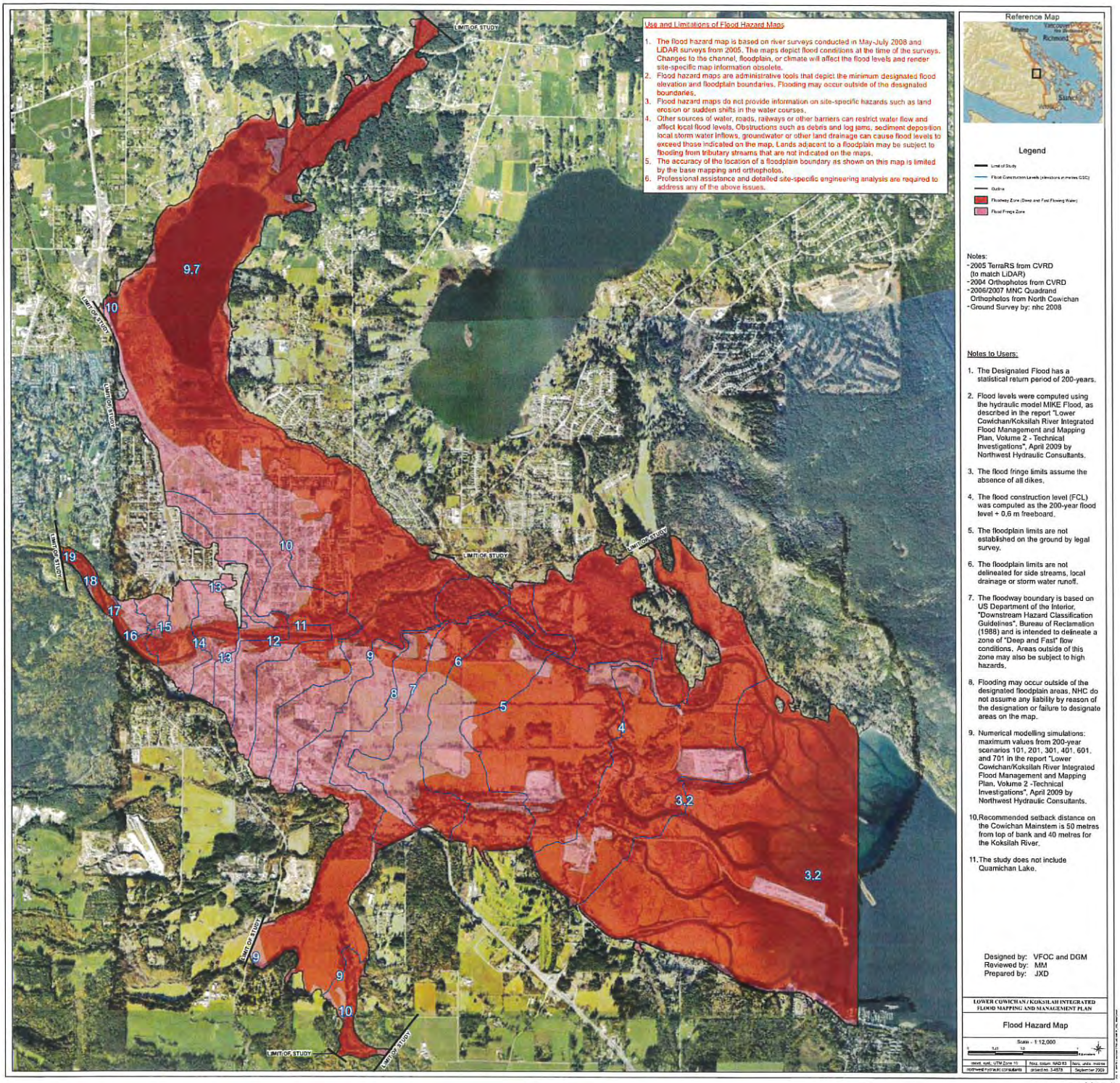
File No.: 9774-1
Earthquake: 1/2475 yr
M = 7.5 PGA = 0.6g











Use and Limitations of Flood Hazard Maps

1. The flood hazard map is based on river surveys conducted in May-July 2008 and LiDAR surveys from 2005. The maps depict flood conditions at the time of the surveys. Changes to the channel, floodplain, or climate will affect the flood levels and render site-specific map information obsolete.
2. Flood hazard maps are administrative tools that depict the minimum designated flood elevation and floodplain boundaries. Flooding may occur outside of the designated boundaries.
3. Flood hazard maps do not provide information on site-specific hazards such as land erosion or sudden shifts in the water courses.
4. Other sources of water, roads, railways or other barriers can restrict water flow and affect local flood levels. Obstructions such as debris and log jams, sediment deposition local storm water inflows, groundwater or other land drainage can cause flood levels to exceed those indicated on the map. Lands adjacent to a floodplain may be subject to flooding from tributary streams that are not indicated on the maps.
5. The accuracy of the location of a floodplain boundary as shown on this map is limited by the base mapping and orthophotos.
6. Professional assistance and detailed site-specific engineering analysis are required to address any of the above issues.

Reference Map

Legend

- Limit of Study
- Flood Construction Levels (elevations in metres GSC)
- Outline
- Floodway Zone (Deep and Fast Flowing Water)
- Flood Fringe Zone

Notes:
- 2005 TerraRS from CVRD (to match LiDAR)
- 2004 Orthophotos from CVRD
- 2006/2007 MNC Quadrand Orthophotos from North Cowichan
- Ground Survey by: nhc 2008

Notes to Users:

1. The Designated Flood has a statistical return period of 200-years.
2. Flood levels were computed using the hydraulic model MIKE Flood, as described in the report "Lower Cowichan/Koksilah River Integrated Flood Management and Mapping Plan, Volume 2 - Technical Investigations", April 2009 by Northwest Hydraulic Consultants.
3. The flood fringe limits assume the absence of all dikes.
4. The flood construction level (FCL) was computed as the 200-year flood level + 0.6 m freeboard.
5. The floodplain limits are not established on the ground by legal survey.
6. The floodplain limits are not delineated for side streams, local drainage or storm water runoff.
7. The floodway boundary is based on US Department of the Interior, "Downstream Hazard Classification Guidelines", Bureau of Reclamation (1988) and is intended to delineate a zone of "Deep and Fast" flow conditions. Areas outside of this zone may also be subject to high hazards.
8. Flooding may occur outside of the designated floodplain areas. NHC do not assume any liability by reason of the designation or failure to designate areas on the map.
9. Numerical modelling simulations: maximum values from 200-year scenarios 101, 201, 301, 401, 601, and 701 in the report "Lower Cowichan/Koksilah River Integrated Flood Management and Mapping Plan, Volume 2 -Technical Investigations", April 2009 by Northwest Hydraulic Consultants.
10. Recommended setback distance on the Cowichan Mainstem is 50 metres from top of bank and 40 metres for the Koksilah River.
11. The study does not include Quamichan Lake.

Designed by: VFOC and DGM
Reviewed by: MM
Prepared by: JXD

LOWER COWICHAN / KOKSILAH INTEGRATED FLOOD MAPPING AND MANAGEMENT PLAN

Flood Hazard Map

Scale - 1:12,000

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no: 3-4578	September 2009

Map 1

INTEGRATED FLOODPLAIN MAPPING - DUNCAN B.C.