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2022 Fitzsimmons Creek Flood Protection and Maintenance Program – Gravel Removal Plan

Final Report

Resort Municipality of Whistler

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SNC-Lavalin Project: 689494

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Signature Page

Prepared By:

for C. Beth Robertson

Allanah Bonnici, MSc.
Water Resources Professional

Environment Practice
Engineering Services Canada

Reviewed By:

SNC-Lavalin Inc.
Permit to Practice #1002642

PROFESSIONAL
PROVINCE OF
C. B. ROBERTSON
46521
BRITISH COLUMBIA
ENGINEER

C. Beth Robertson 2022-06-22

C. Beth Robertson, MSc, P.Eng.
Hydrotechnical Engineer

Environment Practice
Engineering Services Canada

Executive Summary

Fitzsimmons Creek is a gravel/cobble bed creek that typically aggrades along the reach flowing through Whistler, BC due to the flattening of channel slope and resulting generation of an alluvial fan. This aggradation significantly reduces the channel capacity and minimum freeboard available on the protective diking system along Fitzsimmons Creek.

SNC-Lavalin Inc. (SNC-Lavalin) was retained by the Resort Municipality of Whistler (RMOW) to provide services for hydraulic modelling of the 1:200-year flood to develop a gravel removal plan for the 2022 Flood Protection Maintenance of Fitzsimmons Creek, inform the Fitzsimmons Creek Consultation Committee stakeholders, and meet the requirements of the gravel removal permit. The study reach is divided into eight sub-reaches from the most upstream at Blackcomb Way Bridge, Sub-Reach 0, to the most downstream location at the confluence with Green Lake, Sub-Reach 7. The RMOW currently has a permit from the British Columbia Ministry of Forests, Lands and Natural Resource Operations, and Rural Development (FLNRO) *Water Sustainability Act*[1] (WSA) to extract up to 10,000 m^3 of gravel annually in the study reach (Reference: A2006185).

Survey information from March 2020, April 2021, and March/April 2022 was provided by McElhanney Ltd., including target cross-sections (surveyed annually) and gravel bar cross-sections (capturing 2022 gravel bar configuration) (see Drawings A-1 and C-1 to C-4).

The 2021 hydraulic model channel geometry was updated to include all cross-sections from the 2022 survey. Manning’s n-values, overbank geometry, and bridge information was kept consistent with 2020 and 2021 geometry. The flow, boundary conditions, and model flow conditions were consistent with the 2020 and 2021 hydraulic model.

The 2022 updated 1:200-year modelled flow was used to complete a freeboard analysis. Dike elevations along Fitzsimmons Creek were compared with modelled water elevations and recommended freeboard (0.6 m in Sub-Reach 0 – 3 m / 0.5 m in Sub-Reach 4 – 7). Four areas were found to have insufficient freeboard:

- Sub-Reach 2 (Target Station 1+031.534) upstream of the Spruce Grove Bridge (0.5 m);
- Sub-Reach 4 (Target Station 2+300) upstream of the Scandinave Bridge (0.2 m);
- Sub-Reach 5 (Target Stations 3+200 and 3+400) between the Valley Trail Bridge and the Disc Golf Bridge (0.0 – 0.4 m); and
- Sub-Reach 7 (Target Station 3+530 and 3+569.482) downstream of the CN Railway Bridge (0.1 m – 0.2 m).

A gravel removal plan was developed based on the following four criteria:

- Improve freeboard along the channel and prioritizing gravel bar extraction where there is insufficient freeboard along that section of the channel;
- Minimize environmental impact by prioritizing gravel bars near banks as opposed to mid-channel;
- Minimize extraction cost through maximizing volume extracted at a particular gravel bar; and
- Ease of access by prioritizing gravel bars with defined access routes.

A ranking matrix was produced to help assess the prioritization of each gravel bar based on optimizations of volume and accessibility. Gravel bars chosen for extraction were modelled to quantify the impacts to the 1:200-year water elevation. Freeboard was increased in several areas, but minimum freeboard

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[1] *Water Sustainability Act* (WSA) [SBC 2014], Chapter 15, May 29, 2014.

requirements were not met at all locations. Factors that limited the ability to achieve the freeboard objective include:

- Extraction locations were limited (e.g., no removal within CN Railway bridge right-of-way);
- Gravel was only removed above the water elevation (as recommended by the Environmental Management Plan, Cascade 2016; and
- Sediment supply may be exceeding extraction when reviewed on a long-term basis, eventually resulting in the complete filling of the creek.

A summary of the proposed gravel removal plan is provided in the following table. The updated hydraulic modelling (including gravel extraction) showed that water levels generally decreased. A few locations had increased in water elevation, but this was due to the proximity to a bridge and not in insufficient freeboard areas. The extraction of gravel is still beneficial as it reduces the available sediment and aggradation potential downstream.

The actual gravel removal for 2022 might deviate from this plan as the removal will be dependent on field conditions, water levels, and accessibility at the time of extraction.

Gravel Bar #	Sub-Reach Area	Notes	Station	Proposed Extracted Volume (m^3)	Water Level Difference (m)	Matrix Ranking
27*	Sub-Reach 6/ Sub-Reach 7	Upstream and Downstream of CN ROW	3+487.254 to 3+569.482	442	0 (0.0 to -0.15)**	1
26*	Sub-Reach 5		3+400	519	+0.01 (-0.01)	6
23	Sub-Reach 4	Removal lowers WEL at Gravel Bar 21	2+400	444	+0.03	6
21*	Sub-Reach 4		2+300	316	-0.01	6
8*	Sub-Reach 2		1+031.534	272	-0.03	6
9	Sub-Reach 2		1+100	1,402	+0.03	2
15	Sub-Reach 3		1+808.320	2,669	+0.05	1
17	Sub-Reach 3/ Sub-Reach 4		1+903.137 to 1+923.999	731	-0.19	1
18	Sub-Reach 4		2+000	1,516	-0.01	2
19	Sub-Reach 4		2+200	1,644	-0.06	1
Total				9,955		

*Required freeboard not met at or upstream of gravel bar

** Water Level Difference in brackets represent removal of all of Gravel Bar 27 (including under CN Bridge)

First Priority for Removal: do not meet minimum freeboard requirements and favourable final ranking

Second Priority for Removal: near stations that do no meet minimum freeboard requirements and favourable final ranking

Third Priority for Removal: favourable final ranking

Table of Contents

Table of Contents (Cont'd)

In-Text Tables

Appendix

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1 Introduction

SNC-Lavalin Inc. (SNC-Lavalin) was retained by the Resort Municipality of Whistler (RMOW) to provide services for hydraulic modelling of existing freeboard conditions to develop a gravel removal plan for the 2022 Flood Protection Maintenance of Fitzsimmons Creek to inform stakeholders. Stakeholders include local First Nations, CN Rail, BC Hydro, Nicklaus North Golf Course, the Fitzsimmons Creek IPP operator, Whistler Blackcomb, Whistler Fisheries Stewardship Group, Ministry of Transportation and Infrastructure, Whistler Angling Club, FLNRORD, Department of Fisheries and Oceans, and RMOW; a representative from each group comprises the Fitzsimmons Creek Consultation Committee (FCCC).

Fitzsimmons Creek is a gravel/cobble bed creek that typically carries a sediment load from the upstream catchment and deposits it in the reach flowing through Whistler, BC. This aggradation significantly reduces the channel capacity and reduces the minimum freeboard available on the protective diking system along Fitzsimmons Creek. The RMOW currently has a permit to extract up to 10,000 m^3 of gravel annually from Blackcomb Way Bridge to the confluence with Green Lake of Fitzsimmons Creek, which is valid until December 31, 2024 (Reference: 2006185).

1.1 Study Area

The study area for this project is limited to a 4.3 km reach on Fitzsimmons Creek extending from just upstream of Blackcomb Way Bridge to its mouth at Green Lake. This reach encompasses the works done in previous years' Flood Protection Maintenance Programs. The study area has been divided into eight sub-reaches as seen in the overall site plan in Drawing A-1 (Appendix I) and outlined in Table 1-1. The sub-reach areas are named for neighbourhoods or important sites within the study area. This is consistent with the requirements detailed in Fitzsimmons Creek Survey and Monitoring Method Statement (KWL 2016).

Table 1-1: Sub-Reaches of Fitzsimmons Creek

Flow	Sub-Reach	Length (m)	River Station Start	River Station End	Area
Upstream → Downstream	0	420	Blackcomb Way Bridge (-0+420)	Rebagliati Park (0+000)	Bus Loop and Day Parking
	1	350	Rebagliati Park (0+000)	Lorimer Road Bridge (0+350)	Day Parking
	2	890	Lorimer Road Bridge (0+350)	Nancy Greene Bridge (1+240)	White Gold
	3	665	Nancy Greene Bridge (1+240)	Spruce Grove Bridge (1+905)	Spruce Grove
	4	525	Spruce Grove Bridge (1+905)	Scandinave Bridge (2+430)	Mons
	5	1030	Scandinave Bridge (2+430)	Valley Trail Bridge (3+460)	Riverside
	6	54	Valley Trail Bridge (3+460)	CN Railway Bridge (3+514)	Nicklaus North
	7	326	CN Railway Bridge (3+514)	Green Lake (3+840)	

1.2 Scope of Work

The objective of this study was to assess the impacts of existing sediment aggradation on Fitzsimmons Creek by hydraulically modelling the 1:200-year flood level to complete an analysis that will identify locations with insufficient freeboard from dike crest elevations to inform FCCC stakeholders. The insufficient freeboard locations identified were used to develop priority gravel removal works for 2022. Additional gravel removal options were ranked based on a volume versus ease of access matrix.

Tasks to complete this work that are presented in this report include:

- Data collection and review;
- Update existing hydraulic model to include 2022 channel;
- Freeboard analysis to identify dike sections with insufficient freeboard;
- Development of matrix to rank gravel bars for prioritization;
- Selection of priority gravel bars for gravel removal plan;
- Modification of hydraulic model to include proposed gravel removal plan; and
- Preparation of Gravel Removal Plan report.

Tasks to complete after acceptance of this gravel removal plan include:

- Class B cost estimate of proposed gravel removal works (±15% – 25%);
- Tender preparation and support;
- Contract administration during gravel removal phase; and
- Project completion report.

2 Data Collection and Review

SNC-Lavalin collected and reviewed relevant background information for the project as provided by RMOW. This review allowed SNC-Lavalin to better understand RMOW's objectives, site-specific environmental considerations, as well as learnings from previous scopes of work.

Information collected included:

Reports

- Fitzsimmons Creek Flood Protection Method Statement (Tetra Tech EBA Inc. [Tetra Tech] 2014);
- Environmental Management Plan – Fitzsimmons Creek Channel Maintenance Program V3 (Cascade Environmental Resource Group Ltd. [Cascade] 2016);
- Fitzsimmons Creek Flood Protection Survey and Monitoring Method Statement (Kerr Wood Leidal [KWL] 2016);
- Fitzsimmons Creek Flood Protection Maintenance (KWL 2020a);
- Fitzsimmons Creek Flood Protection Maintenance – Completion Report (KWL 2020b);
- 2021 Fitzsimmons Creek Flood Protection and Maintenance Program – Gravel Removal Plan (SNC-Lavalin, 2021a); and
- Fitzsimmons Creek Flood Protection and Maintenance Program 2021 Fitzsimmons Creek Completion Report (SNC-Lavalin, 2021b).

Geographic Data

- 2020, 2021, and 2022 survey of Fitzsimmons Creek (performed by McElhanney Ltd. [McElhanney]);
- 2018 LiDAR data in the study area (from RMOW);
- 2018 aerial photography in the study area (from RMOW);
- Cadastral data in the study area (from McElhanney); and
- Access route data (from Cascade).

Models

- 2020 hydraulic model (HEC-RAS) geometry file (from RMOW); and
- 2021 hydraulic model (HEC-RAS developed by SNC-Lavalin, 2021a).

This information was reviewed and used for the development of the 2022 hydraulic model and complete the freeboard analysis.

2.1 2022 Survey Data Summary

McElhanney Ltd. completed the annual Fitzsimmons Creek survey in March and April 2022. The *Fitzsimmons Creek Survey and Monitoring Method Statement* (KWL 2016) was followed, which included the collection of two types of survey sections:

- Target: specific cross-section locations that are maintained from previous surveys; and
- Gravel bar: variable cross-section locations that identify the head, body, and toe of existing gravel bars.

All cross-section surveys included top of banks, bottom of banks, and water elevations.

2.1.1 Target Cross-Sections

The target cross-sections (or monitoring stations) are consistently surveyed to capture gravel bar movement and changes in-channel geometry. There are 61 target cross-sections, as outlined in the *Fitzsimmons Creek Survey and Monitoring Method Statement* (KWL 2016), which are located approximately every 100 m along the study reach and upstream and downstream of bridges. All the target cross-sections were surveyed in 2022, which are outlined in Table 2-1 and shown in Drawings C-1 to C-4 (Appendix I). The survey stations did not match the target stations exactly, but were generally within 5 m. Only seven stations were greater than this (between 6 m and 15 m).

Table 2-1: Target Cross-sections Surveyed in 2022

Flow	Sub-Reach	Cross-Section	Target Cross-Section Station	2022 Surveyed Cross-Section Station
Upstream ↓ ↓ ↓ ↓ Downstream	Sub-Reach 0	1	Blackcomb Way Bridge (-0+420)	-0+411
		2	Blackcomb Way Bridge (-0+400)	-0+392
		3	-0+300	-0+300
		4	Pedestrian Bridge (-0+200)	-0+188
		5	Pedestrian Bridge (-0+180)	-0+177
		6	-0+100	-0+097
	Sub-Reach 1	7	0+000	0+004
		8	0+040	0+044
		9	0+100	0+101
		10	0+138.253	0+140
		11	0+200	0+200
		12	0+276.182	0+278
		13	Lorimer Road Bridge (0+340)	0+345
	Sub-Reach 2	14	Lorimer Road Bridge (0+365)	0+361
		15	Lost Lake Entrance Bridge (0+410)	0+412
		16	Lost Lake Entrance Bridge (0+420)	0+418
		17	0+454.148	0+455
		18	0+583.419	0+581
		19	0+733.027	0+733
		20	0+800	0+799
		21	0+878.157	0+880
		22	1+031.534	1+032
		23	1+100	1+100
		24	1+200	1+199
		25	Nancy Greene Bridge (1+235)	1+233

Table 2-1 (Cont'd): Target Cross-sections Surveyed in 2022

Flow	Sub-Reach	Cross-Section	Target Cross-Section Station	2022 Surveyed Cross-Section Station
Upstream ↓ ↓ ↓ ↓ Downstream	Sub-Reach 3	26	Nancy Greene Bridge (1+245.000)	1+247
		27	1+279.000	1+279
		28	1+361.000	1+362
		29	1+378.434	1+379
		30	1+415.302	1+415
		31	1+441.000	1+440
		32	1+500	1+501
		33	1+585.015	1+586
		34	1+700	1+701
		35	1+808.320	1+809
		36	Spruce Grove Bridge (1+903.137)	1+902
	Sub-Reach 4	37	Spruce Grove Bridge (1+923.999)	1+926
		38	2+000	2+001
		39	Pedestrian Bridge (2+060)	2+066
		40	Pedestrian Bridge (2+075.000)	2+070
		41	2+200	2+201
		42	2+300	2+300
		43	2+356.094	2+355
		44	2+400	2+401
	Sub-Reach 5	45	2+500	2+503
		46	2+614.807	2+616
		47	2+750.000	2+749
		48	2+900.000	2+898
		49	2+985.714	2+986
		50	Disc Golf Bridge (3+081.205)	3+081
		51	3+200.000	3+200
		52	3+315.000	3+315
		53	3+400	3+400
		54	Valley Trail Bridge (3+460.659)	3+458
	Sub-Reach 6	55	3+487.254	3+488
		56	CN Rail Bridge (3+514.723)	3+511
	Sub-Reach 7	57	3+530	3+520
		58	3+569.482	3+570
		59	Golf Cart Bridge (3+631.722)	3+630
		60	3+700	3+685
		61	3+800	3+807

2.1.2 Gravel Bar Cross-Sections

Gravel bar cross-sections surveyed in March and April 2022 are outlined in Table 2-2 and shown in Drawings C-1 to C-4 (Appendix I). There were 33 gravel bars identified, with numbering from upstream to downstream. Note that numbers are not related to previous years numbering (e.g., Gravel bar 27 is not in the same location in 2022 as it was in 2021).

For each gravel bar between 1 and 5 cross-sections (average of 3) were surveyed to capture the head, body, and toe of the gravel bar. They are identified starting from upstream (A). Several gravel bars extended over Sub-Reaches (mostly beneath bridges) and some gravel bars overlapped in the same cross-section (see Stationing). Several gravel bar cross-sections lined up with target cross-sections, which can be identified by the Cross-Section column and Stationing in Table 2-2.

Table 2-2: Gravel Bar Cross-sections Surveyed in 2022

Flow	Sub-Reach	Cross-Section	Gravel Bar Identifier	2022 Surveyed Gravel Bar Cross-Section Station
Upstream ↓ ↓ ↓ ↓ Downstream	Sub-Reach 0	None	None	None
	Sub-Reach 1	10, 11, N/A	1 (A, B, C)	0+140, 0+200, 0+225
		N/A, 12, N/A	2 (A, B, C)	0+261, 0+278, 0+284
		N/A, 13	3 (A, B)	0+284, 0+345
		13	4 (A)	0+345
	Sub-Reach 2	14, 14	3(C), 4 (B)	0+361, 0+361
		N/A, 18, N/A	5 (A, B, C)	0+563, 0+581, 0+622
		N/A, N/A, 19	6 (A, B, C)	0+622, 0+664, 0+733
		N/A, 21, N/A	7 (A, B, C)	0+838, 0+880, 0+926
		22, N/A, N/A	8 (A, B, C)	1+023, 1+043, 1+064
		N/A, 23, N/A	9 (A, B, C)	1+086, 1+100, 1+139
		24, N/A, 25	10 (A, B, C)	1+199, 1+215, 1+233
	Sub-Reach 3	N/A, 27, N/A	11 (A, B, C)	1+269, 1+279, 1+289
		29, N/A, 30	12 (A, B, C)	1+379, 1+400, 1+415
		N/A, N/A, N/A	13 (A, B, C)	1+517, 1+547, 1+567
		N/A, 33, N/A	14 (A, B, C)	1+567, 1+586, 1+600
		N/A, 35, N/A	15 (A, B, C)	1+778, 1+809, 1+855
		N/A, N/A, N/A	16 (A, B, C)	1+855, 1+866, 1+883
		N/A, 36	17 (A, B)	1+883, 1+902
	Sub-Reach 4	37, N/A, N/A	17 (C, D, E)	1+926, 1+964, 1+993
		N/A, 38, N/A	18 (A, B, C)	1+993, 2+001, 2+036
		N/A, N/A, N/A	19 (A, B, C)	2+124, 2+170, 2+191
		41, N/A, N/A	20 (A, B, C)	2+201, 2+217, 2+233
		N/A, 42, N/A	21 (A, B, C)	2+287, 2+300, 2+331
		43, N/A, N/A	22 (A, B, C)	2+355, 2+362, 2+383
		N/A, 44	23 (A, B)	2+383, 2+401

Table 2-2 (Cont'd): Gravel Bar Cross-sections Surveyed in 2022

Flow	Sub-Reach	Cross-Section	Gravel Bar Identifier	2022 Surveyed Gravel Bar Cross-Section Station
Upstream ↓ ↓ ↓ Downstream	Sub-Reach 5	N/A	23 (C)	2+414
		N/A, N/A, N/A	24 (A, B, C)	2+711, 2+721, 2+743
		N/A, N/A, N/A	25 (A, B, C)	3+326, 3+346, 3+359
		N/A, 53, N/A	26 (A, B, C)	3+359, 3+400, 3+446
	Sub-Reach 6	55, 56	27 (A, B)	3+488, 3+511
	Sub-Reach 7	57, 58	27 (C, D)	3+520, 3+570
		58, N/A, N/A	28 (A, B, C)	3+570, 3+585, 3+596
		N/A, N/A, N/A	29 (A, B, C)	3+585, 3+596, 3+613
		N/A, N/A, N/A	30 (A, B, C)	3+694, 3+702, 3+714
		61, N/A, N/A	31 (A, B, C)	3+807, 3+839, 3+887
		N/A	32 (A)	3+887
		N/A	33 (A)	3+887

2.1.3 Sediment Volume Aggradation

The total sediment volume aggradation was calculated using the surveyed 2021 and 2022 gravel bar areas. SNC-Lavalin estimated the gravel volumes based on 2.0 m depth below the surveyed water surface and 1H:1V excavation slopes.

The total gravel aggradation volume for 2022 is estimated to be 9,938 m^3 and is summarized in Table 2-3 below.

Table 2-3: 2022 Gravel Aggradation

	Volume (m^3)	
	2021	2022
Total Gravel Bar Volume	24,103	26,797
Excavated Volume	7,244	N/A
Total Aggradation	**N/A**	**9,938**

3 Hydraulic Analysis

A one-dimensional (1D) hydraulic model was developed to simulate flow in Fitzsimmons Creek using the latest Hydraulic Engineering Center River Analysis System (HEC-RAS version 5.0.7). HEC-RAS is developed by the U.S. Army Corps of Engineer and it is widely used in the industry to model hydraulics of water flow through natural rivers and other channels.

3.1 Previous Modelling Work

A hydraulic model of Fitzsimmons Creek in the study area was developed by Golder Associates Ltd. in 2004. The model channel geometry has been updated annually or semi-annually since 2009 to assess the impacts of sediment aggradation in the creek. Channel cross-sections were surveyed and updated in the model in 2009, 2011, 2013, 2015, 2017, 2017, 2018, 2019, 2020 (KWL 2020a), and 2021 (SNC-Lavalin, 2021a).

In-channel roughness coefficients were previously calibrated using water surface elevations surveyed at bridge crossings during a relatively high flow event on July 28, 2011 (8.6 m^3/s) (Tetra Tech 2014). Calibrated Manning's n roughness values in the channel ranged from 0.030 to 0.055; Manning's n roughness values on the overbank flow areas were selected to be 0.1 (Tetra Tech 2014).

The design flood was the 1:200-year return period, which was estimated to be 250 m^3/s (Tetra Tech 2014). A portion of the flow splits into the East Floodway (upstream of the CN Railway bridge) which was estimated to be 75.85 m^3/s (EBA 2012). A portion of the flow splits again at the West Floodway (upstream of the Golf Cart bridge) which was estimated to be 1.83 m^3/s (KWL 2020a).

Flow was modelled as steady state with no allowance for sediment movement or bridge blockage. The downstream boundary condition was 1:200-year water elevation on Green Lake (635.6 m). Due to the steepness of the channel, the downstream boundary condition was found to have little impact on the flood elevations (KWL 2020a referencing a Tetra Tech report from 2011). The upstream boundary condition was the normal depth assumption associated with the design flood, channel slope, geometry, and roughness (KWL 2020a). However, in 2020 and 2021 the model was calculated as subcritical flow, and the upstream boundary condition would not have an effect on the water elevation.

3.2 2022 Hydraulic Model

The 2022 hydraulic model was developed by updating the 2021 HEC-RAS geometry file developed by SNC-Lavalin. The geometry file included five river reaches (not associated with sub-reaches):

- **Fitzsimmons Creek**: main channel including cross-sections from Blackcomb Bridge to just upstream of CN Railway Bridge;
- **East Floodway**: channel that branches off from Fitzsimmons Creek upstream of CN Railway Bridge. This channel travels along the south side of the CN Railway before passing through four culverts and into Green Lake;
- **Downstream of East Floodway**: main channel including cross-sections from upstream and downstream of CN Railway Bridge;

- **West Floodway**: channel that branches off from Fitzsimmons Creek upstream of the Golf Cart Bridge. It appears this channel flows beside the golf course and into Green Lake; and
- **Golf Course Reach**: main channel including cross-sections from upstream of the Golf Cart Bridge to the mouth.

The stream profiles and cross-sections in the 2021 geometry were georeferenced using the historic alignment that the cross-section stationing is based on (provided by McElhanney in an AutoCAD file). Top of banks were georeferenced using surveyed 2022 data. Overbank extents coordinates were estimated based on lengths and stream alignment. Georeferencing does not change the hydraulic calculations but provides an easier visualization of the model.

The target cross-sections in the 2021 geometry were updated with the 2022 surveyed data. Only the channel geometry was updated. Overbank information, including topography, dike (levee) elevations, and ineffective flow areas remained the same as the 2021 geometry. Manning's n roughness coefficients were kept the same as the 2021 geometry.

The 2022 gravel bar cross-sections were added to the 2021 geometry and reach lengths were adjusted accordingly. Overbank information was either copied from nearby target cross-sections or interpolated from upstream and downstream target cross-sections (including topography, dike elevations, and ineffective flow areas). 2021 gravel bar cross-sections that were not surveyed in 2022 were deleted from the geometry as it was assumed these bars had moved or been excavated. Manning's n roughness coefficients were kept the same as nearby target cross-sections from the 2021 geometry.

The 2021 geometry included five cross-sections upstream of the furthest target cross-section (i.e., upstream of station -0+420 outside of the defined study reach). These cross-sections were included in the 2022 updated model as it reduces the effects of uncertainty of the upstream boundary condition. Water elevations from this upstream section were not included in the results.

Bridge and culvert data were kept the same as the 2021 geometry.

The flow, boundary conditions, and model flow conditions were taken from the 2020 hydraulic model (KWL 2020a) which was also used in the 2021 model. These inputs are consistent with previous modelling works described in Section 3.1. The hydraulic model inputs are summarized in Table 3-1.

Table 3-1: 2022 Hydraulic Model Inputs

Parameter	Input	Comments
Flow (1:200 year flood)	250 m^3/s	Fitzsimmons Creek upstream.
	75.85 m^3/s	East Floodway split flow.
	174.15 m^3/s	Fitzsimmons Creek downstream of East Floodway.
	1.83 m^3/s	West Floodway split flow.
	172.32 m^3/s	Fitzsimmons Creek downstream of West Floodway.
Boundary Conditions	Upstream*	Normal Depth (estimated by SNC-Lavalin 0.044).
	Downstream	Known Water Elevation (Green Lake 1:200-year: 635.6 m).
Model Flow Regime	Subcritical	Steady state, subcritical flow.

Table 3-1 (Cont'd): 2022 Hydraulic Model Inputs

Parameter	Input	Comments
Cross-Sections	2022 Target	March/April 2022 channel updated at 61 cross-sections; overbanks same as 2021.
	2022 Gravel Bar	March/April 2022 channel added at 33 gravel bars (additional 52 cross-sections); overbanks interpolated.
Manning's n Roughness Coefficient	0.030 to 0.055	Channel roughness (same as calibrated values, TetraTech 2011).
	0.1	Overbank roughness (same as values used by TetraTech 2011).
Dike Elevations	2021 Geometry	Kept 2021 geometry consistent. Values used by Tetra Tech (2014) with updates based on 2015 dike survey.

*Note: upstream boundary condition does not affect hydraulic calculations for subcritical flow.

The 1:200-year flood profile was calculated for the updated 2022 hydraulic model and used to complete the freeboard analysis (see Section 4).

3.3 Model Limitations

The updated hydraulic model is a steady state model and this assessment provides a snapshot in time of a naturally dynamic situation. Steady state assumes that flow and channel conditions do not change over time. The flow is an estimate of the peak 1:200-year flood, so the steady state should represent the highest water. However, variations in-channel conditions from those modelled, such as debris jams, bank erosion, channel degradation or aggradation, and channel scour can cause flood levels to differ from those calculated. The action of removing gravel will in itself remove a natural equilibrium and induce the redistribution of the existing gravel. Thus, the predicted hydraulic model will likely never be observable and should only be considered as a relative comparison of different hypothetical gravel removal scenarios.

The updated hydraulic model is a 1D model. Although 1D models can predict flood levels quite well, there are limitations on the detailed information of propagation and velocities on the floodplain.

Flood profiles were modelled using a subcritical flow regime (deeper and slower). However, supercritical flow (shallower and faster) is characteristic of steep mountain streams. Forcing subcritical flow calculates the most conservative water levels. If hydraulic analysis was needed for bank erosion or scour estimates, it is recommended to use a supercritical or mixed flow regime.

Based on the review of previous modelling work on Fitzsimmons Creek, the channel roughness values have not been validated. Validations is done by simulating other (independent) flood events with your calibrated model and comparing to observed water surface elevations to ensure the results are reasonable and the model can be used for a variety of floods.

Based on the review of previous modelling work on Fitzsimmons Creek, the overbank roughness values have not been calibrated. A consistent Manning's n roughness coefficient of 0.1 could be considered too high for some areas (e.g., parking lots, golf course). This high coefficient provides a more conservative (higher) water level. However, water level is generally not as sensitive to overbank roughness as it is to channel roughness.

4 Freeboard Analysis

The 1:200-year flood profile was calculated using the updated 2022 hydraulic model. This profile was compared to the dike crest elevations (obtained from KWL 2020a report) to identify areas with insufficient freeboard. Freeboard criteria for the 1:200-year flood peak was recommended by Fitzsimmons Creek Technical Committee (FCTC) to be 0.6 m upstream and 0.5 m downstream of Spruce Grove Bridge (Tetra Tech 2014).

A summary of the 1:200-year flood profile, dike crest elevations, and freeboard for 2022 channel conditions is provided in Table 4-1. Insufficient freeboard elevations are highlighted with red text. Four sub-reaches were found to have insufficient freeboard and are summarized as follows:

Sub-Reach 2 (Target Station 1+031.534)

This target station is located about 870 m upstream of the Spruce Grove Bridge. It coincides with Gravel Bar 8 (see Drawing C-2). The dike on the right (northeast) side of the stream provides insufficient freeboard for the 1:200-year flood (0.5 m).

Sub-Reach 4 (Target Station 2+300)

This target station is located about 120 m upstream of the Scandinave Bridge. Fitzsimmons Creek has two 90 degree bends in this area and it coincides with Gravel Bar 21 (left bank gravel bar) (see Drawing C-3, Appendix I). Based on conversations with Cascade (Candace Rose-Taylor, personal communication), the right bank of this area is inaccessible for gravel removal due to a wetland area.

The dike on the left (northwest) side of the stream provides insufficient freeboard for the 1:200-year flood (0.2 m). Based on the 2021 Gravel Removal Plan (SNC-Lavalin, 2021a), conversations with RMOW and the 2020 Gravel Removal Plan (KWL 2020a), this location has consistently been modelled to have insufficient freeboard. In 2020, the model predicted overtopping in this area (KWL 2020a) and material from the gravel bar along the left bank was excavated (1,429 m^3, KWL 2020b). In 2021, the model predicted near overtopping in this area with a freeboard of only 0.08 m (SNC-Lavalin, 2021a) and material from the gravel bar along the left bank was excavated (1,021 m^3, SNC-Lavalin 2021b).

Sub-Reach 5 (Target Stations 3+200 and 3+400)

These target stations are located from about 60 m upstream of the Valley Trail Bridge upstream to downstream of the Disc Golf Foot Bridge. Fitzsimmons Creek is relatively straight in this reach. The downstream area coincides with Gravel Bar 25 (left bank gravel bar) and Gravel Bar 26 (right bank gravel bar) (see Drawing C-4, Appendix I). The dike on the left (northwest) side of the stream provides insufficient freeboard for the 1:200-year flood (0.0– 0.4 m).

About 50 m downstream of the Valley Trail Bridge is the CN Railway Bridge, which is straddled by Gravel Bar 27. Based on conversation with RMOW (Chelsey Roberts, personal communication), gravel usually accumulates under this bridge. This is a control point for the upstream water levels, and the reduced bridge opening area is backing up the flow somewhat. It is understood that gravel removal works cannot be planned within CN's bridge right-of-way (ROW) and they complete their own gravel removal annually or semi-annually.

Sub-Reach 7 (Target Station 3+530 and 3+569.482)

These target stations are located about 15 m to 50 m downstream of the CN Railway Bridge. Fitzsimmons Creek is relatively straight in this area. This area coincides with Gravel Bar 27 (left bank gravel bar) and Gravel Bar 28, (situated in the middle of the channel) (see Drawing C-4, Appendix I). The dike on the left (west) side of the stream provides insufficient freeboard for the 1:200-year flood (0.1 m – 0.2 m).

Table 4-1: 1:200-year Flood Profile, Dike Crest Elevations, and Freeboard for 2022 Channel

Free-board	Sub-Reach	Cross-Section	HEC-RAS Chainage	Target Cross-Section Station	Left Dike Elevation (m)[1]	Right Dike Elevation (m)[1]	Water Surface Elevation (m)	Left Dike Freeboard (m)	Right Dike Freeboard (m)
Recommended Freeboard = 0.6 m	Sub-Reach 0	1	4925.11	Blackcomb Way Bridge (-0+420)	N/A	N/A	686.76	N/A	N/A
		2	4910.11	Blackcomb Way Bridge (-0+400)	N/A	N/A	685.93	N/A	N/A
		3	4857.5	-0+300	685.5	N/A	680.16	5.3	N/A
		4	4752	Pedestrian Bridge (-0+200)	681.9	N/A	676.95	4.9	N/A
		5	4747	Pedestrian Bridge (-0+180)	681.4	N/A	675.65	5.8	N/A
		6	4661.4	-0+100	678.3	N/A	672.90	5.4	N/A
	Sub-Reach 1	7	4614.3	0+000	674.4	N/A	668.09	6.3	N/A
		8	4529.5	0+040	672.6	N/A	665.58	7.0	N/A
		9	4469.5	0+100	669.8	N/A	664.01	5.8	N/A
		10	4431.23	0+138.253	668.0	N/A	663.01	5.0	N/A
		11	4369.5	0+200	666.2	N/A	662.77	3.4	N/A
		12	4293.3	0+276.182	664.0	N/A	662.36	1.6	N/A
		13	4222.28	Lorimer Road Bridge (0+340)	663.3	N/A	662.06	1.2	N/A
	Sub-Reach 2	14	4208.63	Lorimer Road Bridge (0+365)	662.7	N/A	662.07	0.6	N/A
		15	4156.99	Lost Lake Entrance Bridge (0+410)	662.2	N/A	660.65	1.6	N/A
		16	4145.6	Lost Lake Entrance Bridge (0+420)	662.2	N/A	660.39	1.8	N/A
		17	4115.33	0+454.148	662.0	N/A	658.69	3.3	N/A
		18	3986.06	0+583.419	660.5	N/A	657.45	3.0	N/A
		19	3836.45	0+733.027	658.9	658.1	657.03	1.9	1.1
		20	3768.1	0+800	658.1	657.2	655.86	2.2	1.3
		21	3691.32	0+878.157	657.2	656.1	655.42	1.8	0.7
		22	3537.95	1+031.534	655.4	654.4	653.92	1.5	**0.5**
		23	3468.6	1+100	N/A	654.2	652.54	N/A	1.7
		24	3369.5	1+200	N/A	654.2	651.93	N/A	2.3
		25	3335.04	Nancy Greene Bridge (1+235)	N/A	654.2	651.62	N/A	2.6
	Sub-Reach 3	26	3325.24	Nancy Greene Bridge (1+245.000)	653.5	654.2	651.55	2.0	2.7
		27	3283.74	1+279.000	653.1	653.2	651.51	1.6	1.7
		28	3201.74	1+361.000	652.6	652.6	650.85	1.8	1.8
		29	3184.31	1+378.434	652.6	652.6	651.01	1.6	1.6
		30	3159.74	1+415.302	652.2	652.3	650.88	1.3	1.4
		31	3121.74	1+441.000	652.2	651.9	650.10	2.1	1.8
		32	3074.1	1+500	N/A	651.2	649.15	N/A	2.1
		33	2990.03	1+585.015	N/A	650.3	649.00	N/A	1.3
		34	2868.6	1+700	649.6	649.1	647.26	2.3	1.8
		35	2767.5	1+808.320	648.9	648.0	646.86	2.0	1.1
		36	2672.34	Spruce Grove Bridge (1+903.137)	N/A	647.8	646.01	N/A	1.8
	Sub-Reach 4	37	2645.479	Spruce Grove Bridge (1+923.999)	N/A	N/A	645.84	N/A	N/A
		38	2571.3	2+000	N/A	N/A	645.55	N/A	N/A
		39	2504.5	Pedestrian Bridge (2+060)	N/A	N/A	645.36	N/A	N/A
		40	2492.1	Pedestrian Bridge (2+075.000)	N/A	N/A	644.94	N/A	N/A
		41	2368.71	2+200	N/A	N/A	643.94	N/A	N/A
		42	2269.2	2+300	643.6	N/A	643.40	**0.2**	N/A
		43	2213.38	2+356.094	644.5	N/A	643.10	1.4	N/A
		44	2150.8	2+400	645.2	N/A	642.90	2.3	N/A
Recommended Freeboard = 0.5 m	Sub-Reach 5	45	2052.2	2+500	643.3	N/A	641.96	1.3	N/A
		46	1950.02	2+614.807	642.4	N/A	641.27	1.1	N/A
		47	1814.327	2+750.000	642.3	N/A	640.60	1.7	N/A
		48	1664.327	2+900.000	641.4	N/A	640.44	1.0	N/A
		49	1576.613	2+985.714	640.7	N/A	639.52	1.2	N/A
		50	1488.28	Disc Golf Bridge (3+081.205)	640.3	N/A	639.37	0.9	N/A
		51	1366.985	3+200.000	639.3	N/A	639.32	**0.0**	N/A
		52	1220.82	3+315.000	638.8	N/A	638.24	0.6	N/A
		53	1171.3	3+400	638.5	N/A	638.13	**0.4**	N/A
		54	1111.32	Valley Trail Bridge (3+460.659)	N/A	N/A	637.40	N/A	N/A
	Sub-Reach 6	55	1082.23	3+487.254	N/A	N/A	637.59	N/A	N/A
		56	1057.76	CN Rail Bridge (3+514.723)	N/A	N/A	637.53	N/A	N/A
	Sub-Reach 7	57	1039	3+530	637.5	N/A	637.31	**0.2**	N/A
		58	1000	3+569.482	637.4	N/A	637.30	**0.1**	N/A
		59	939.71	Golf Cart Bridge (3+631.722)	N/A	N/A	636.78	N/A	N/A
		60	868.5	3+700	N/A	N/A	635.78	N/A	N/A
		61	764.1	3+800	N/A	N/A	635.67	N/A	N/A

5 Gravel Removal Plan

Fitzsimmons Creek experiences aggradation of gravel/cobble sediments from the upstream catchment which deposits in the reach flowing through Whistler, BC. This aggradation is due to a reduction in stream slope and the resulting generation of an alluvial fan. The alluvial fan is confined by dikes and the natural process of channel migration is restricted. This continual aggradation in the same channel significantly reduces the capacity and the minimum freeboard available on the protective diking system along Fitzsimmons Creek. Freeboard analysis of existing 2022 cross-sections has identified four areas with insufficient freeboard. Therefore, a gravel removal plan was developed, with the intention of meeting the minimum freeboard requirements along Fitzsimmons Creek and reducing available sediment load (up to the permitted 10,000 m^3).

5.1 Previous Gravel Removal Programs

The KWL (2020a) and SNC-Lavalin (2021b) reports document previous gravel removal programs on Fitzsimmons Creek. Gravel has been removed most years between 1996 and 2021, with the exceptions being the years 2000, 2006, 2008, and 2014.

A summary for the past 26 years of gravel removal in Fitzsimmons Creek is presented in Table 5-1 below. This includes the entire study reach except within the CN Railway Bridge ROW. It is understood that RMOW is not permitted to work within CN's ROW and that CN excavates gravel from beneath their bridge annually or semi-annually, but no record of volumes is available.

Table 5-1: Summary of Recent Gravel Removal Programs Undertaken by RMOW

Year	Volume of Gravel Removed (m^3)	Year	Volume of Gravel Removed (m^3)	Year	Volume of Gravel Removed (m^3)
1996	8,640	2005	16,300	2014	0
1997	22,050	2006	0	2015	15,419
1998	4,627	2007	70,000	2016	10,620
1999	16,275	2008	0	2017	4,882
2000	0	2009	6,986	2018	7,994
2001	2,056	2010	3,550	2019	6,363
2002	16,852	2011	7,966	2020	6,487
2003	4,230	2012	10,659	2021	7,244
2004	14,000	2013	5,537		

5.2 Development of the 2022 Gravel Removal Plan

The 2022 gravel removal plan was developed by considering the following:

- Minimum freeboard requirements (prioritized gravel bars near insufficient freeboard areas);
- Low Environmental Impact (prioritized gravel bars near banks over mid-channel bars);
- Low Cost of Extraction (through maximizing volume of extraction at a particular site); and

- Ease of Accessibility (choose gravel bars with defined access routes from previous years).

Gravel bars were ranked for removal based on a matrix of the volume available for extraction versus the ease of accessibility, as seen in Table 5-2.

Table 5-2: Ranking Matrix of Volume versus Accessibility

Gravel Bar		Volume		
Ranking Matrix Score		**High (H)**	**Moderate (M)**	**Low (L)**
Access	Easy (E)	1	2	3
	Moderate (M)	2	4	6
	Difficult (D)	3	6	9

Gravel bar extraction volumes were estimated based on the extraction management scenarios provided by Cascade (2016). Scenario 2 (Full Bar Excavation) and Scenario 3 (Wet Channel Crossing for Bar Access) were considered as they have relatively low environmental impact with relatively high-volume for extraction. The design criteria for these extraction management scenarios include the following:

- 2.0 m removal depth below the average water level at each gravel bar;
- Excavated side slopes of 1H:1V; and
- 0.5 m high x 1.0 m wide berm around the perimeter.

Ease of accessibility was assessed based on existing access routes provided by Cascade, which are identified in Drawings C-1 to C-4 in Appendix I.

All 33 bars were ranked for potential removal based on the matrix. A summary of the results is shown in Table 5-3. Gravel bar removal priority was guided by these rankings in conjunction with the freeboard analysis. Gravel bars chosen as first priority for extraction had insufficient freeboard with 6 or less matrix ranking. Gravel bars chosen as second priority for extraction were near stations with insufficient freeboard with a favourable matrix ranking or providing an increase in freeboard.

The total volume of first priority and second priority gravel bars was 3,395 m^3. To reduce the sediment supply to the stream, additional gravel bars were proposed for removal up to a volume of 10,000 m^3. Third priority gravel bars were chosen based on the highest matrix ranking and highest volumes.

Table 5-3: Gravel Bar Ranking

Gravel Bar #	Volume	Volume Ranking	Access	Access Ranking	Matrix Ranking
	Low / Moderate / High (m^3)		Easy / Moderate / Difficult		
1	H (1223)	1	D	3	3
2	L (3)	3	E	1	3
3	M (255)	2	E	1	2
4	M (337)	2	D	3	6
5	H (1644)	1	D	3	3
6	H (1066)	1	D	3	3
7	L (184)	3	D	3	9

Table 5-3 (Cont'd): Gravel Bar Ranking

Gravel Bar #	Volume	Volume Ranking	Access	Access Ranking	Matrix Ranking
	Low / Moderate / High (m^3)		Easy / Moderate / Difficult		
8*	M (272)	2	D	3	6
9	H (1402)	1	M	2	2
10	H (764)	1	D	3	3
11	L (50)	3	M	2	6
12	L (111)	3	M	2	6
13	L (154)	3	M	2	6
14	L (6)	3	D	3	9
15	H (2669)	1	E	1	1
16	L (95)	3	E	1	3
17	H (731)	1	E	1	1
18	H (1516)	1	M	2	2
19	H (1644)	1	E	1	1
20	L (84)	3	D	3	9
21*	M (316)	2	D	3	6
22	L (76)	3	D	3	9
23	M (444)	2	D	3	6
24	M (288)	2	D	3	6
25*	L (72)	3	D	3	9
26*	M (519)	2	D	3	6
27*	H (442)	1	E	1	1
28	M (262)	2	D	3	6
29	M (202)	2	D	3	6
30	L (182)	3	D	3	9
31	H (4166)	1	D	3	3
32	M (650)	2	D	3	6
33	H (4968)	1	D	3	3

*Required freeboard not met at or upstream of gravel bar

First Priority for Removal: do not meet minimum freeboard requirements and favourable final ranking

Second Priority for Removal: near stations that do no meet minimum freeboard requirements and favourable final ranking

Third Priority for Removal: favourable final ranking

Gravel removal is proposed at ten bars with a total proposed extraction volume of 9,955 m^3. Table 5-4 below summarizes the proposed gravel bars in order of their priority together with their associated proposed extracted volumes for gravel removal in 2022.

These bars will be re-assessed in August 2022 to confirm their suitability. The actual gravel removal for 2022 might deviate from this plan as the removal will be dependent on field conditions, water levels, and accessibility at the time of extraction.

Table 5-4: 2022 Proposed Gravel Bar Removal

Gravel Bar #	Sub-Reach Area	Notes	Proposed Extracted Volume (m^3)	Matrix Ranking
27*	Sub-Reach 6/ Sub-Reach 7	Upstream and Downstream of CN ROW	442	1
26*	Sub-Reach 5		519	6
23	Sub-Reach 4	Removal lowers WEL at Gravel Bar 21	444	6
21*	Sub-Reach 4		316	6
8*	Sub-Reach 2		272	6
9	Sub-Reach 2		1,402	2
15	Sub-Reach 3		2,669	1
17	Sub-Reach 3/ Sub-Reach 4		731	1
18	Sub-Reach 4		1,516	2
19	Sub-Reach 4		1,644	1
Total			9,955	

*Required freeboard not met at or upstream of gravel bar

First Priority for Removal: do not meet minimum freeboard requirements and favourable final ranking

Second Priority for Removal: near stations that do no meet minimum freeboard requirements and favourable final ranking

Third Priority for Removal: favourable final ranking

5.2.1 Hydraulic Model Modification

The 2022 hydraulic model was modified to estimate the potential changes to the 1:200-year water elevation from proposed gravel bar removal works. The cross-sections were modified by deepening the gravel bars by 2.0 m with 1(H):1(V) side slopes and including a 0.5 m high x 1.0 m wide berm at the wetted edge.

The gravel bar excavation was modelled in stages, beginning with gravel bars at insufficient freeboard areas that were accessible (i.e., 21/23, 8, 26, 27 [outside of CN ROW]). Next, gravel bars that were near insufficient freeboard areas were excavated (i.e., 9), followed by gravel bars that are favourable due to ease of access and high volumes of extraction (i.e., 15, 17, 18, 19). With each iteration of gravel bar removal, modelled water elevations for the 1:200-year flood generally dropped a few centimeters in the vicinity of the removed gravel bar.

When gravel bar 27 (a side-channel bar spanning the CN ROW) was partially removed (upstream and downstream of the ROW), the water elevation did not change at the freeboard location (3+520). However, when the entire gravel bar 27 was removed (including under the CN Bridge), the water elevation dropped up to 0.15 m in the vicinity of gravel bar 27. It was recommended to include this bar in the gravel removal plan, as the bar under the CN Bridge could be pushed through naturally or could be removed by CN, both of which would help the freeboard in the that area.

A summary of the 1:200-year water surface elevation for the modified 2022 model (with proposed gravel bar removal) is provided in Table 5-5. Values shown in brackets indicate where the water levels differ should gravel bar 27 be fully excavated (including under the CN ROW).

The hydraulic model modifications indicate that the areas with insufficient freeboard remained even after gravel bar excavation. However, water levels in three areas were improved:

- The freeboard at target station 1+031 (Sub-Reach 2, upstream Lost Lake Entrance Bridge) increased by 3 cm; and
- The freeboard at target station 2+300 (Sub-Reach 4, upstream Scandinave Bridge) increased by 1 cm (and by 6 cm nearby); and
- The freeboard near target station 3+400 (Sub-Reach 5, upstream Valley Trail Bridge) increased by up to 15 cm.

As well, water elevations in the reaches with gravel bar removal generally dropped between 1 cm and 19 cm (see ‘Modified vs. Existing WEL’ column in Table 5-5.

Table 5-5: 1:200-year Flood Profile and Freeboard for Modified 2022 Channel (proposed gravel bars removed)

Free-board	Sub-Reach	Cross-Section	HEC-RAS Chainage	Target Cross-Section Station	Modified Water Surface Elevation (m)	Modified vs. Existing WEL (m)	Modified Left Dike Freeboard (m)	Modified Right Dike Freeboard (m)
Recommended Freeboard = 0.6 m	Sub-Reach 0	1	4925.11	Blackcomb Way Bridge (-0+420)	686.76	0	N/A	N/A
		2	4910.11	Blackcomb Way Bridge (-0+400)	685.93	0	N/A	N/A
		3	4857.5	-0+300	680.16	0	5.3	N/A
		4	4752	Pedestrian Bridge (-0+200)	676.95	0	4.9	N/A
		5	4747	Pedestrian Bridge (-0+180)	675.65	0	5.8	N/A
		6	4661.4	-0+100	672.9	0	5.4	N/A
	Sub-Reach 1	7	4614.3	0+000	668.09	0	6.3	N/A
		8	4529.5	0+040	665.58	0	7.0	N/A
		9	4469.5	0+100	664.01	0	5.8	N/A
		10	4431.23	0+138.253	663.01	0	5.0	N/A
		11	4369.5	0+200	662.77	0	3.4	N/A
		12	4293.3	0+276.182	662.36	0	1.6	N/A
		13	4222.28	Lorimer Road Bridge (0+340)	662.06	0	1.2	N/A
	Sub-Reach 2	14	4208.63	Lorimer Road Bridge (0+365)	662.07	0	0.6	N/A
		15	4156.99	Lost Lake Entrance Bridge (0+410)	660.65	0	1.6	N/A
		16	4145.6	Lost Lake Entrance Bridge (0+420)	660.39	0	1.8	N/A
		17	4115.33	0+454.148	658.69	0	3.3	N/A
		18	3986.06	0+583.419	657.45	0	3.0	N/A
		19	3836.45	0+733.027	657.03	0	1.9	1.1
		20	3768.1	0+800	655.86	0	2.2	1.3
		21	3691.32	0+878.157	655.42	0	1.8	0.7
		22	3537.95	1+031.534	653.92	-0.03	1.5	**0.5**
		23	3468.6	1+100	652.57	0.03	N/A	1.6
		24	3369.5	1+200	651.93	0	N/A	2.3
		25	3335.04	Nancy Greene Bridge (1+235)	651.62	0	N/A	2.6
	Sub-Reach 3	26	3325.24	Nancy Greene Bridge (1+245.000)	651.55	0	2.0	2.7
		27	3283.74	1+279.000	651.51	0	1.6	1.7
		28	3201.74	1+361.000	650.85	0	1.8	1.8
		29	3184.31	1+378.434	651.01	0	1.6	1.6
		30	3159.74	1+415.302	650.88	0	1.3	1.4
		31	3121.74	1+441.000	650.1	0	2.1	1.8
		32	3074.1	1+500	649.15	0	N/A	2.1
		33	2990.03	1+585.015	649	0	N/A	1.3
		34	2868.6	1+700	647.26	0	2.3	1.8
		35	2767.5	1+808.320	646.91	0.05	2.0	1.1
		36	2672.34	Spruce Grove Bridge (1+903.137)	646.04 (645.82)	-0.19	N/A	2.0
	Sub-Reach 4	37	2645.479	Spruce Grove Bridge (1+923.999)	645.65	-0.19	N/A	N/A
		38	2571.3	2+000	645.54	-0.01	N/A	N/A
		39	2504.5	Pedestrian Bridge (2+060)	645.36	0	N/A	N/A
		40	2492.1	Pedestrian Bridge (2+075.000)	644.94	0	N/A	N/A
		41	2368.71	2+200	643.94 (643.88)	-0.06	N/A	N/A
		42	2269.2	2+300	643.39	-0.01	**0.21**	N/A
		43	2213.38	2+356.094	643.07	-0.03	1.4	N/A
		44	2150.8	2+400	642.93	0.03	2.3	N/A
Recommended Freeboard = 0.5 m	Sub-Reach 5	45	2052.2	2+500	641.96	0	1.3	N/A
		46	1950.02	2+614.807	641.27	0	1.1	N/A
		47	1814.327	2+750.000	640.6	0	1.7	N/A
		48	1664.327	2+900.000	640.44	0	1.0	N/A
		49	1576.613	2+985.714	639.52	0	1.2	N/A
		50	1488.28	Disc Golf Bridge (3+081.205)	639.37 (639.36)	0 (-0.01)*	0.9	N/A
		51	1366.985	3+200.000	639.32	0	**0.0**	N/A
		52	1220.82	3+315.000	638.24 (638.19)	0 (-0.05)	**0.56** (0.61)	N/A
		53	1171.3	3+400	638.14 (638.13)	0.01 (-0.01)	**0.37 (0.38)**	N/A
		54	1111.32	Valley Trail Bridge (3+460.659)	637.41 (637.27)	0.01 (-0.13)	N/A	N/A
	Sub-Reach 6	55	1082.23	3+487.254	637.59 (637.44)	0 (-0.15)	N/A	N/A
		56	1057.76	CN Rail Bridge (3+514.723)	637.53 (637.44)	0 (-0.09)	N/A	N/A
	Sub-Reach 7	57	1039	3+530	637.31 (637.32)	0 (0.0)	**0.2**	N/A
		58	1000	3+569.482	637.3	0	**0.1**	N/A
		59	939.71	Golf Cart Bridge (3+631.722)	636.78	0	N/A	N/A
		60	868.5	3+700	635.78	0	N/A	N/A
		61	764.1	3+800	635.67	0	N/A	N/A

* Values in brackets represent WEL differences and freeboards with removal of all of Gravel Bar 27 (including under CN Bridge)

6 Summary and Recommendations

6.1 Summary

Target cross-sections and gravel bar cross-sections were surveyed by McElhanney in March and April 2022. The estimated total gravel aggradation between 2021 and 2022 (including 7,244 m^3 removed in 2021) was 9,938 m^3.

The 2021 hydraulic model was updated with the March and April 2022 channel cross-sections and the 1:200-year flow was modelled. Insufficient freeboard was found in four sub-reaches (six target sections) including the following:

- Sub-Reach 2 (Target Station 1+031.534) upstream of the Spruce Grove Bridge (0.5 m);
- Sub-Reach 4 (Target Station 2+300) upstream of the Scandinave Bridge (0.2 m);
- Sub-Reach 5 (Target Stations 3+200 and 3+400) between the Valley Trail Bridge and the Disc Golf Bridge (0.0 – 0.4 m); and
- Sub-Reach 7 (Target Stations 3+530 and 3+569.482) downstream of the CN Railway Bridge (0.1 m – 0.2 m).

A gravel bar removal plan was developed by creating a ranking matrix comparing volume available for extraction versus ease of access. More favourable results were given to easy access, high-volume bars.

All gravel bars were ranked in the matrix then prioritized for extraction (up to a volume of 10,000 m^3) as follows:

1. First Priority: do not meet minimum freeboard requirements and matrix ranking of 6 or less;
2. Second Priority: near stations that do no meet minimum freeboard requirements and favourable matrix ranking; and
3. Third Priority: favourable matrix ranking.

Ten gravel bars were selected for the gravel removal plan, resulting in a total extracted volume of 9,955 m^3. The updated 2022 hydraulic model was modified to include these extracted cross-sections to understand the changes to the 1:200-year water elevations.

The proposed gravel bars for removal are listed in Table 6-1, along with their approximate volumes and resulting water level reductions (water level differences if all of gravel bar 27, including volumes under the CN ROW, were to be removed are shown in brackets). The actual gravel that will be removed will differ from this proposed amount due to field conditions encountered during gravel removal.

Table 6-1: 2022 Proposed Gravel Removal Plan

Gravel Bar #	Sub-Reach Area	Notes	Station	Proposed Extracted Volume (m^3)	Water Level Difference (m)
27*	Sub-Reach 6/ Sub-Reach 7	Upstream and Downstream of CN ROW	3+487.254 to 3+569.482	442	0 (0.0 to -0.15)**
26*	Sub-Reach 5		3+400	519	+0.01 (-0.01)
23	Sub-Reach 4	Removal lowers WEL at Gravel Bar 21	2+400	444	+0.03

Table 6-1 (Cont'd): 2022 Proposed Gravel Removal Plan

Gravel Bar #	Sub-Reach Area	Notes	Station	Proposed Extracted Volume (m^3)	Water Level Difference (m)
21*	Sub-Reach 4		2+300	316	-0.01
8*	Sub-Reach 2		1+031.534	272	-0.03
9	Sub-Reach 2		1+100	1,402	+0.03
15	Sub-Reach 3		1+808.320	2,669	+0.05
17	Sub-Reach 3/ Sub-Reach 4		1+903.137 to 1+923.999	731	-0.19
18	Sub-Reach 4		2+000	1,516	-0.01
19	Sub-Reach 4		2+200	1,644	-0.06
Total				9,955	

*Required freeboard not met at or upstream of gravel bar

** Water Level Difference in brackets represent removal of all of Gravel Bar 27 (including under CN Bridge)

First Priority for Removal: do not meet minimum freeboard requirements and favourable final ranking

Second Priority for Removal: near stations that do no meet minimum freeboard requirements and favourable final ranking

Third Priority for Removal: favourable final ranking

6.2 Recommendations

It is recommended to remove 9,955 m^3 of gravel from Fitzsimmons Creek in 2022.This estimate was based on channel geometry surveyed in March and April 2022.

- First priority gravel bars for removal are identified to be #27 (excluding CN ROW), #26, #23, #21, and #8. These bars are identified as critical for removal since minimum freeboard requirements are not met at these stations and have a matrix ranking of 6 or less.
- The gravel bar identified as second priority to be removed is #9. This gravel bar is identified as second priority since it's near stations that do not meet minimum freeboard requirements and has a favourable matrix ranking.
- Other bars recommended for removal in 2022 include gravel bars #15, #17, #18, and #19 due to their favourable matrix ranking.

Final removal volumes that are extracted are subject to change due to variable site conditions at the time of extraction including water level, accessibility, and gravel bar migration. Accessibility will be confirmed during a site visit enabling these results to be refined.

A completion report detailing actual gravel removal volumes in 2022 together with any change of plans from this 2022 gravel removal plan should be developed after the construction work has been completed.

Gravel removal works should be undertaken conforming with the Fitzsimmons Creek Flood Protection Method Statement (Tetra Tech 2014) and the Environmental Management Plan – Fitzsimmons Creek Channel Maintenance Program Version 3 (Cascade 2016).

The 2020 Gravel Removal Plan (KWL 2020a) mentions new water elevation survey data collected following two significant high flows in January and April of 2020. High flow water elevation data should be collected in 2022 (if any) and both sets of data should be used to recalibrate / validate future hydraulic models in relation to the gravel removal works.

7 Notice to Reader

This report has been prepared and the work referred to in this report have been undertaken by SNC-Lavalin Inc. (SNC-Lavalin) for the exclusive use of Resort Municipality of Whistler (RMOW), who has been party to the development of the scope of work and understands its limitations. The methodology, findings, conclusions and recommendations in this report are based solely upon the scope of work and subject to the time and budgetary considerations described in the proposal and/or contract pursuant to which this report was issued. Any use, reliance on, or decision made by a third party based on this report is the sole responsibility of such third party. SNC-Lavalin accepts no liability or responsibility for any damages that may be suffered or incurred by any third party as a result of the use of, reliance on, or any decision made based on this report.

The findings, conclusions and recommendations in this report (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect SNC-Lavalin's best judgment based on information available at the time of preparation of this report. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our original contract and included in this report. The findings and conclusions contained in this report are valid only as of the date of this report and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered, site conditions change or standards are amended, modifications to this report may be necessary. The results of this assessment should in no way be construed as a warranty that the subject site is free from any and all environmental impact.

This report must be read as a whole, as sections taken out of context may be misleading. If discrepancies occur between the preliminary (draft) and final version of this report, it is the final version that takes precedence. Nothing in this report is intended to constitute or provide a legal opinion.

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8 References

Cascade Environmental Resource Group Ltd. [Cascade]. (2016). *Environmental Management Plan – Fitzsimmons Creek Channel Maintenance Program V3.* Report prepared for RMOW.

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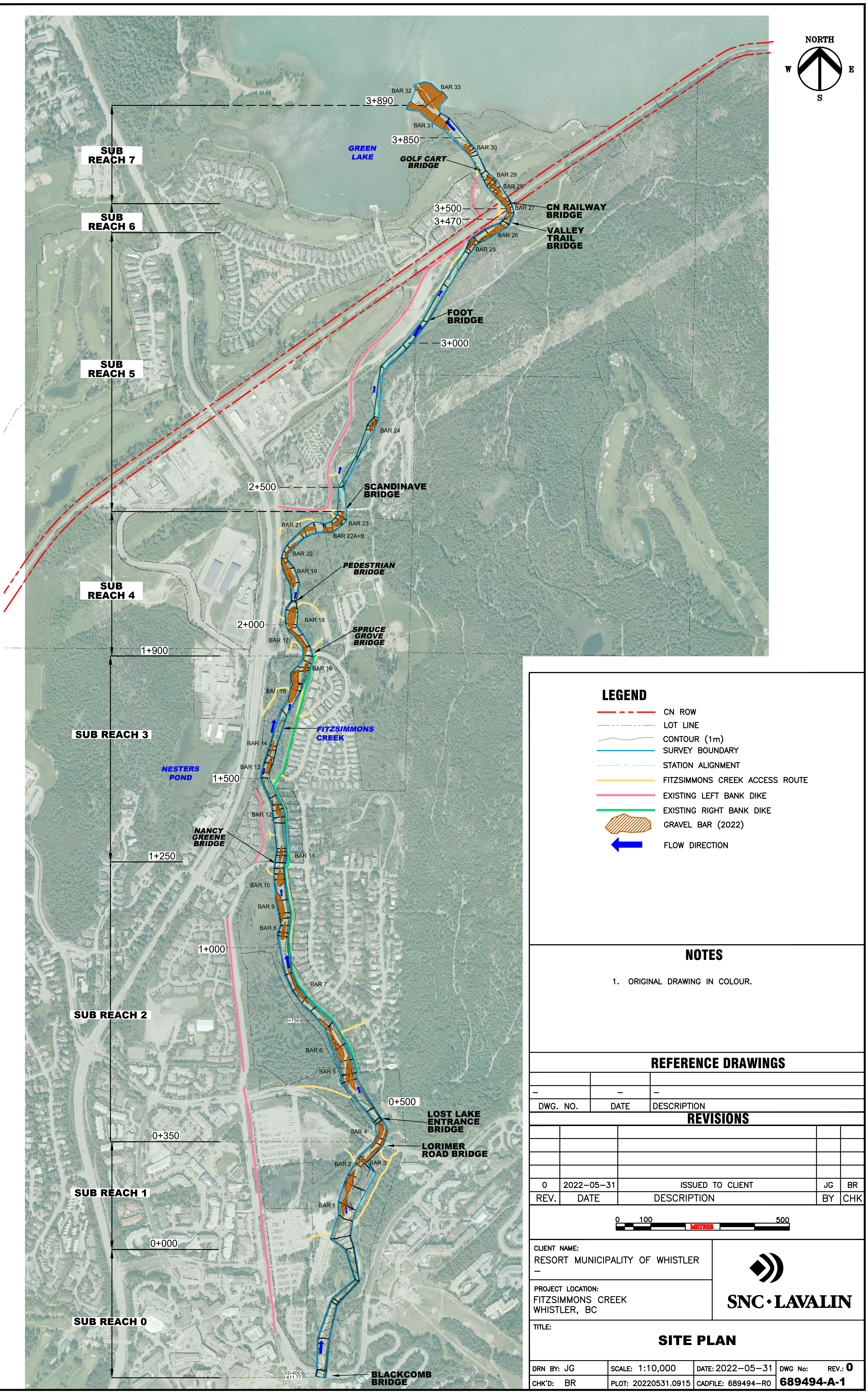
Tetra Tech EBA Inc. [Tetra Tech EBA]. (2014). *Fitzsimmons Creek Flood Protection Method Statement*. Report prepared for RMOW.

Appendix I

Drawings

- A-1: Fitzsimmons Creek- Overall Site Plan
- C-1: Fitzsimmons Creek Flood Protection Plan 2022 X-Sec 1-18 & Gravel Bar Survey Existing Conditions
- C-2: Fitzsimmons Creek Flood Protection Plan 2022 X-Sec 19-33 & Gravel Bar Survey Existing Conditions
- C-3: Fitzsimmons Creek Flood Protection Plan 2022 X-Sec 34-47 & Gravel Bar Survey Existing Conditions
- C-4: Fitzsimmons Creek Flood Protection Plan 2022 X-Sec 48-61 & Gravel Bar Survey Existing Conditions
- C-5: Fitzsimmons Creek Flood Protection Plan 2022 Gravel Removal Plan
- C-6: Fitzsimmons Creek Flood Protection Plan 2022 Gravel Removal Plan
- C-7: Fitzsimmons Creek Flood Protection Plan 2022 Gravel Removal Plan
- C-8: Fitzsimmons Creek Flood Protection Plan 2022 Gravel Removal Plan



LEGEND

━ ━	CN ROW
─ · ─	LOT LINE
─	CONTOUR (1m)
─	SURVEY BOUNDARY
─ · ─	STATION ALIGNMENT
─	FITZSIMMONS CREEK ACCESS ROUTE
─	EXISTING LEFT BANK DIKE
─	EXISTING RIGHT BANK DIKE
▨	GRAVEL BAR (2022)
⬅	FLOW DIRECTION

NOTES

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REFERENCE DRAWINGS

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REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
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0 100 500
METRES

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

PROJECT LOCATION:
FITZSIMMONS CREEK
WHISTLER, BC

SNC·LAVALIN

TITLE:

SITE PLAN

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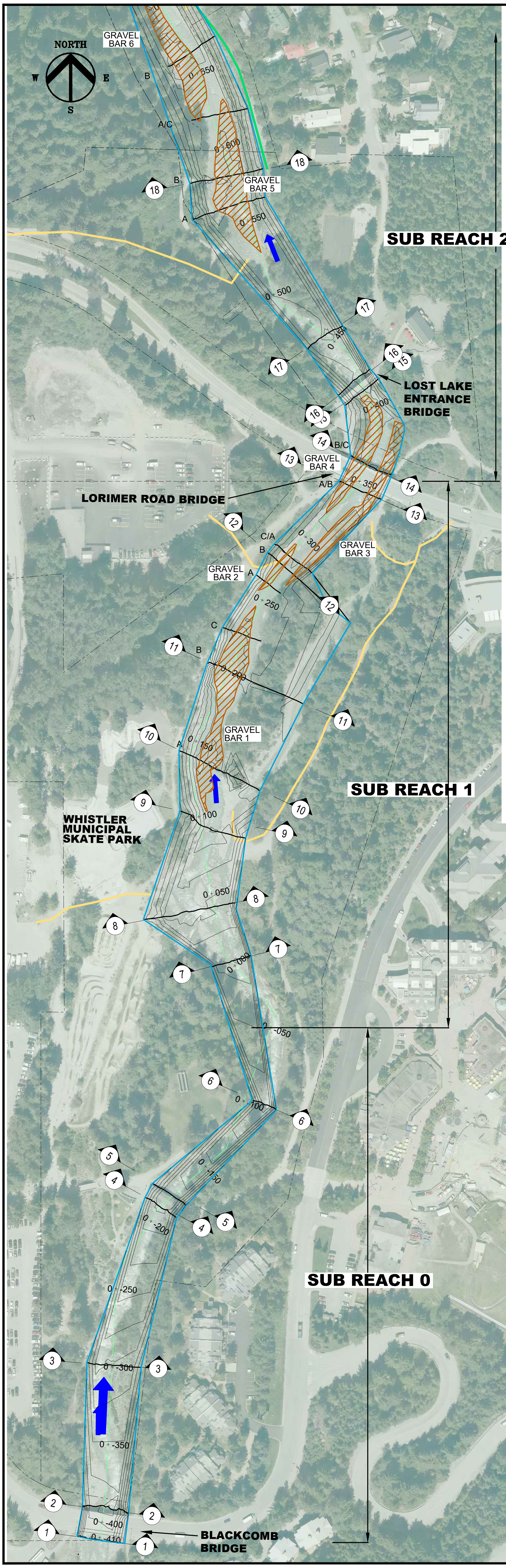

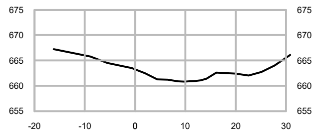
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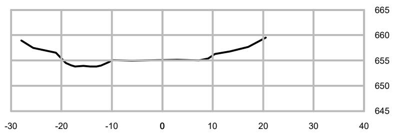
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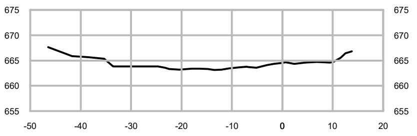
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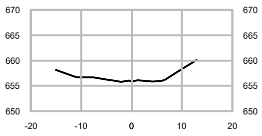
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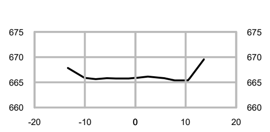
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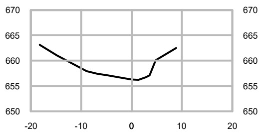
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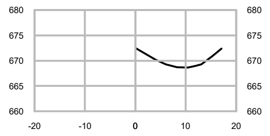
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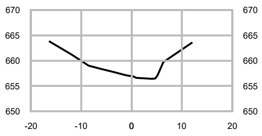
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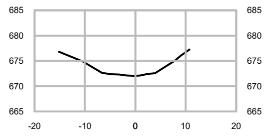
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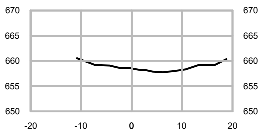
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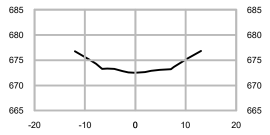
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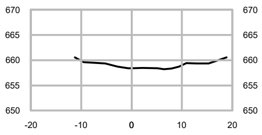
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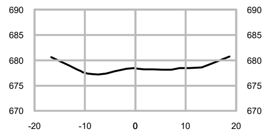
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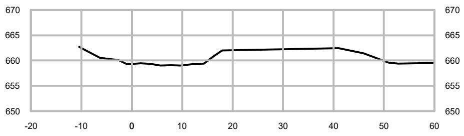
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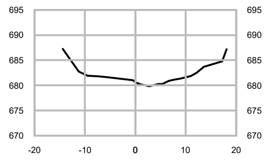
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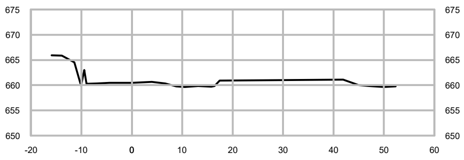
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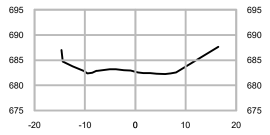
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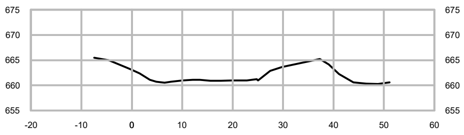
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—·—·—	STATION ALIGNMENT
—	FITZSIMMONS CREEK ACCESS ROUTE
—	EXISTING LEFT BANK DIKE
—	EXISTING RIGHT BANK DIKE
▨	GRAVEL BAR (2022)
⬅	FLOW DIRECTION

NOTES

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REVISIONS

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CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

PROJECT LOCATION:
FITZSIMMONS CREEK
WHISTLER, BC

SNC·LAVALIN

TITLE:
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2022 X-SEC 1-18 & GRAVEL BAR SURVEY
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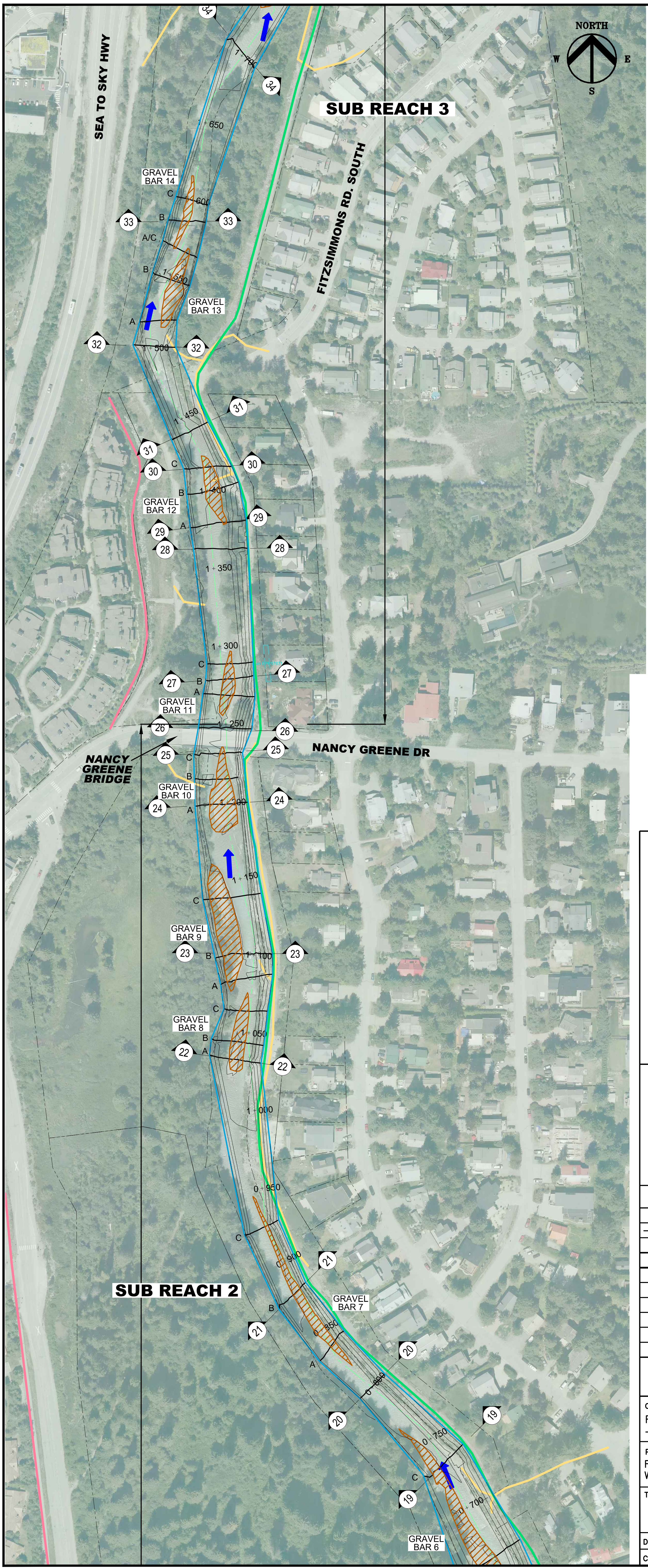

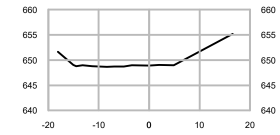
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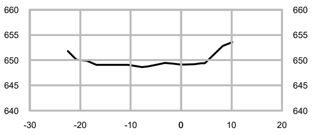
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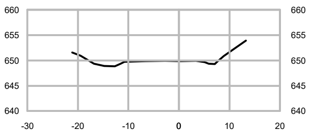
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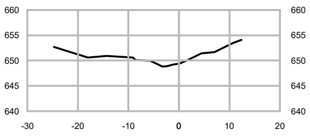
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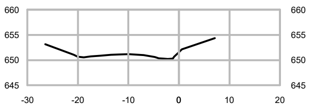
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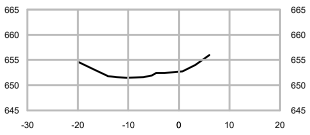
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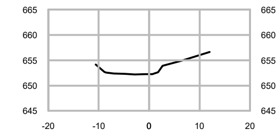
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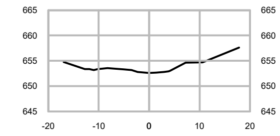
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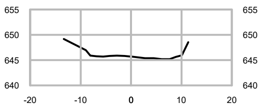
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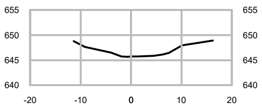
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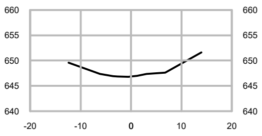
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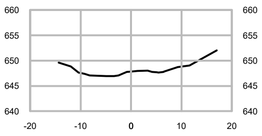
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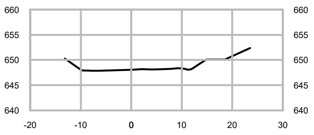
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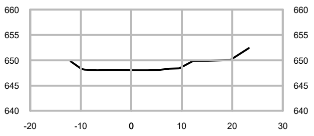
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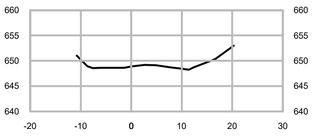
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— · — · —	LOT LINE
～～～	CONTOUR (1m)
———	SURVEY BOUNDARY
— · —	STATION ALIGNMENT
———	FITZSIMMONS CREEK ACCESS ROUTE
———	EXISTING LEFT BANK DIKE
———	EXISTING RIGHT BANK DIKE
▨	GRAVEL BAR (2022)
⬅	FLOW DIRECTION

NOTES

1. ORIGINAL DRAWING IN COLOUR.

REFERENCE DRAWINGS

–	–	–
DWG. NO.	DATE	DESCRIPTION

REVISIONS

0	2022–05–31	ISSUED TO CLIENT	JG	BR
REV.	DATE	DESCRIPTION	BY	CHK

5 25 100
METRES

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

PROJECT LOCATION:
FITZSIMMONS CREEK
WHISTLER, BC

SNC·LAVALIN

TITLE:
FITZSIMMONS CREEK FLOOD PROTECTION PLAN
2022 X-SEC 19-33 & GRAVEL BAR SURVEY
EXISTING CONDITIONS

DRN BY: JG	SCALE: 1:2,500	DATE: 2022–05–31	DWG No: REV.: **0**
CHK'D: BR	PLOT: 20220531.0921	CADFILE: 689494–R0	**689494 C-2**

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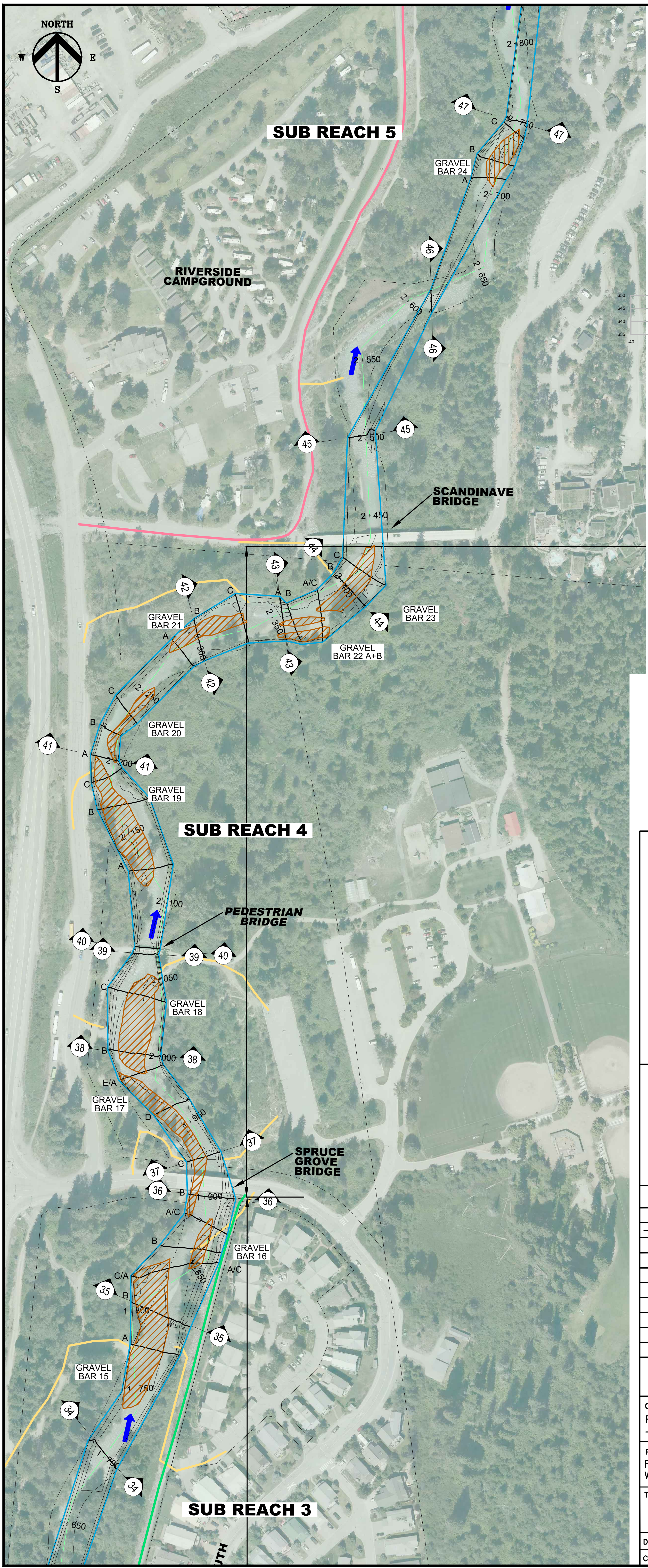
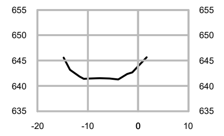
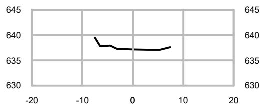
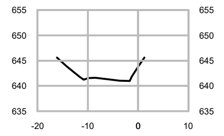




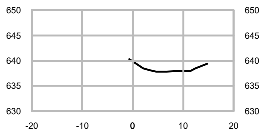
SECTION 40 (2+069.62)



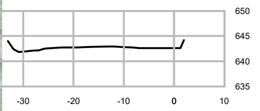
SECTION 47 (2+750.05)



SECTION 39 (2+066.13)



SECTION 46 (2+616.25)



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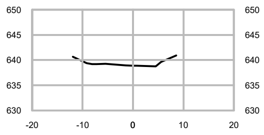
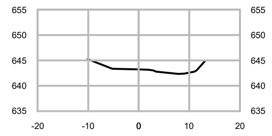
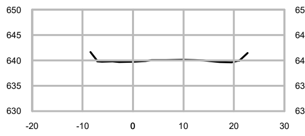


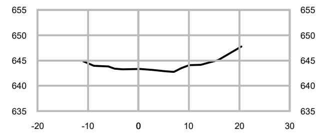
SECTION 45 (2+501.68)



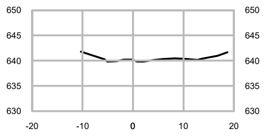
SECTION 37 (1+925.24)



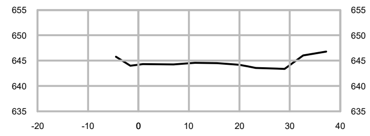
SECTION 44 (2+400.24)



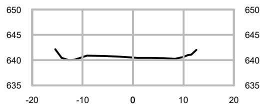
SECTION 36 (1+900.44)



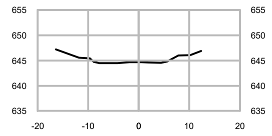
SECTION 43 (2+356.86)



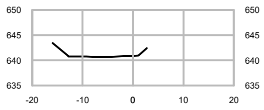
SECTION 35 (1+806.11)



SECTION 42 (2+300.32)



SECTION 34 (1+701.66)



SECTION 41 (2+200.83)

LEGEND

― ― ―	CN ROW
―·―·―	LOT LINE
～	CONTOUR (1m)
―	SURVEY BOUNDARY
―·―	STATION ALIGNMENT
―	FITZSIMMONS CREEK ACCESS ROUTE
―	EXISTING LEFT BANK DIKE
―	EXISTING RIGHT BANK DIKE
▨	GRAVEL BAR (2022)
←	FLOW DIRECTION

NOTES

1. ORIGINAL DRAWING IN COLOUR.

REFERENCE DRAWINGS

–	–	–
DWG. NO.	DATE	DESCRIPTION

REVISIONS

0	2022–05–31	ISSUED TO CLIENT	JG	BR
REV.	DATE	DESCRIPTION	BY	CHK

5 25 METRES 100

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

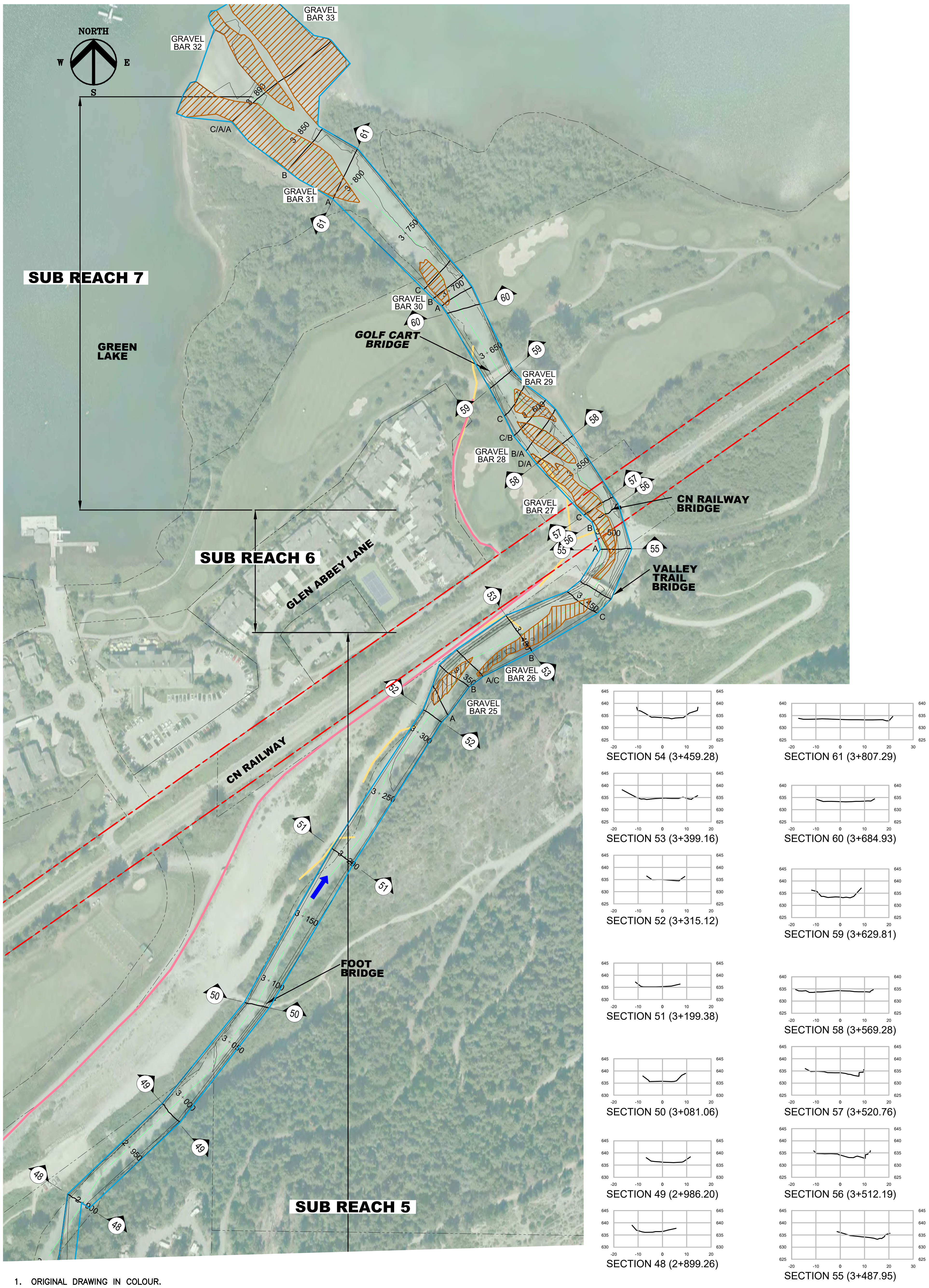
PROJECT LOCATION:
FITZSIMMONS CREEK
WHISTLER, BC

SNC·LAVALIN

TITLE:
FITZSIMMONS CREEK FLOOD PROTECTION PLAN
2022 X-SEC 34-47 & GRAVEL BAR SURVEY
EXISTING CONDITIONS

DRN BY: JG	SCALE: 1:2,500	DATE: 2022–05–31	DWG No: REV.: 0
CHK'D: BR	PLOT: 20220531.0923	CADFILE: 689494–R0	689494 C-3

PATH: R:\689494–FITZSIMMONS CREEK GRAVEL REMOVAL\40_EXECUTION\45_GIS_DWGS\CAD\689494–R0.DWG



1. ORIGINAL DRAWING IN COLOUR.

LEGEND

- CN ROW
- LOT LINE
- CONTOUR (1m)
- SURVEY BOUNDARY
- STATION ALIGNMENT
- FITZSIMMONS CREEK ACCESS ROUTE
- EXISTING LEFT BANK DIKE
- EXISTING RIGHT BANK DIKE
- ▨ GRAVEL BAR (2022)
- FLOW DIRECTION

REFERENCE DRAWINGS

–	–	–
DWG. NO.	DATE	DESCRIPTION

REVISIONS

0	2022–05–31	ISSUED TO CLIENT	JG	BR
REV.	DATE	DESCRIPTION	BY	CHK

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

PROJECT LOCATION:
FITZSIMMONS CREEK
–

SNC·LAVALIN

TITLE:
FITZSIMMONS CREEK FLOOD PROTECTION PLAN
2022 X-SEC 48-61 & GRAVEL BAR SURVEY
EXISTING CONDITIONS

DRN BY: JG	SCALE: 1:2,500	DATE: 2022–05–31	DWG No: REV.: **0**
CHK'D: BR	PLOT: 20220531.0930	CADFILE: 689494–R0	**689494 C-4**

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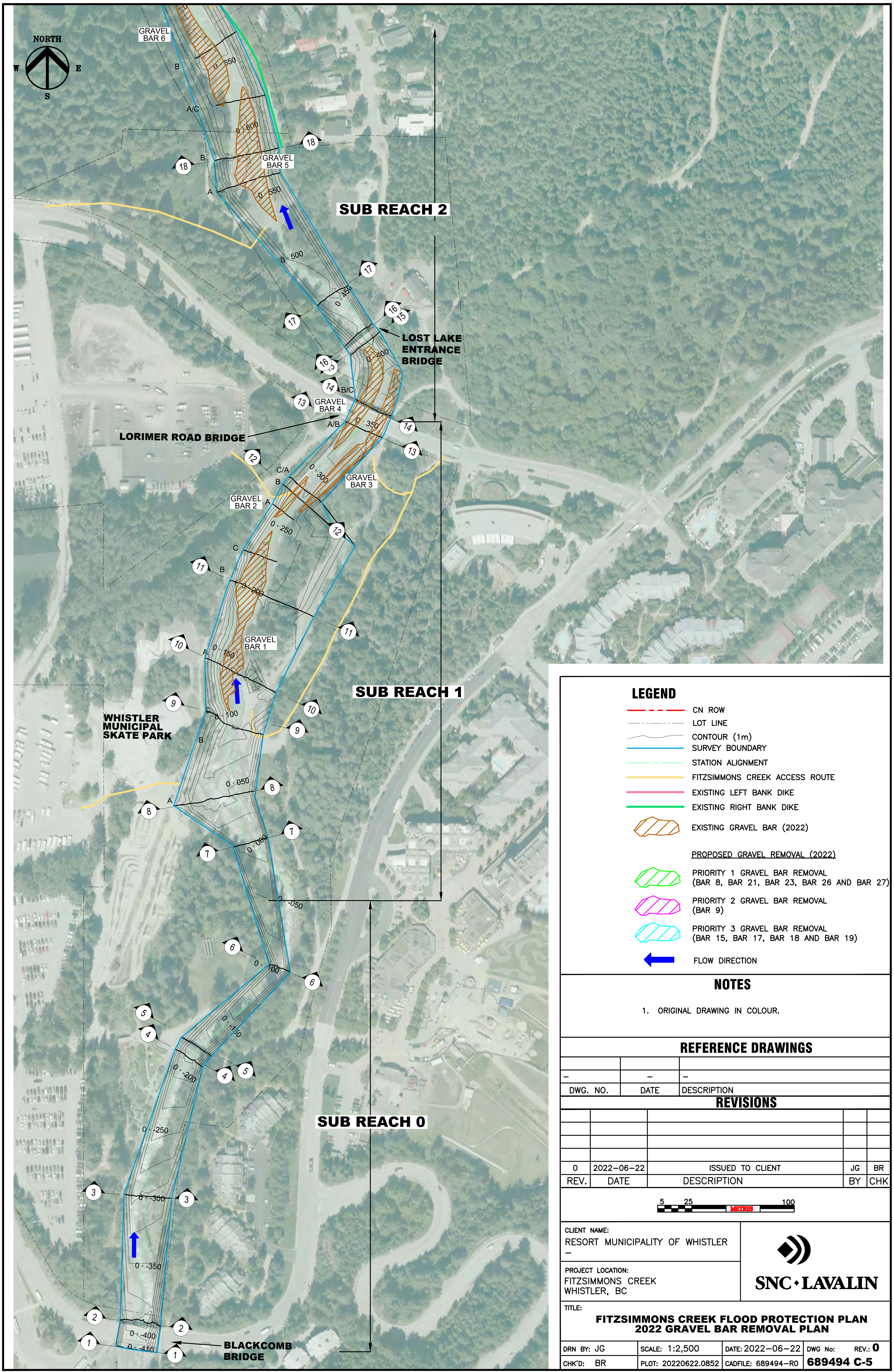

LEGEND

— — —	CN ROW
— · — · —	LOT LINE
～	CONTOUR (1m)
—	SURVEY BOUNDARY
— · —	STATION ALIGNMENT
—	FITZSIMMONS CREEK ACCESS ROUTE
—	EXISTING LEFT BANK DIKE
—	EXISTING RIGHT BANK DIKE
▨	EXISTING GRAVEL BAR (2022)

PROPOSED GRAVEL REMOVAL (2022)

▨	PRIORITY 1 GRAVEL BAR REMOVAL (BAR 8, BAR 21, BAR 23, BAR 26 AND BAR 27)
▨	PRIORITY 2 GRAVEL BAR REMOVAL (BAR 9)
▨	PRIORITY 3 GRAVEL BAR REMOVAL (BAR 15, BAR 17, BAR 18 AND BAR 19)
⬅	FLOW DIRECTION

NOTES

1. ORIGINAL DRAWING IN COLOUR.

REFERENCE DRAWINGS

DWG. NO.	DATE	DESCRIPTION
–	–	–

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
0	2022–06–22	ISSUED TO CLIENT	JG	BR

5 25 METRES 100

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

PROJECT LOCATION:
FITZSIMMONS CREEK
WHISTLER, BC

SNC·LAVALIN

TITLE:
FITZSIMMONS CREEK FLOOD PROTECTION PLAN
2022 GRAVEL BAR REMOVAL PLAN

DRN BY: JG	SCALE: 1:2,500	DATE: 2022–06–22	DWG No: REV.: 0
CHK'D: BR	PLOT: 20220622.0852	CADFILE: 689494–R0	689494 C-5

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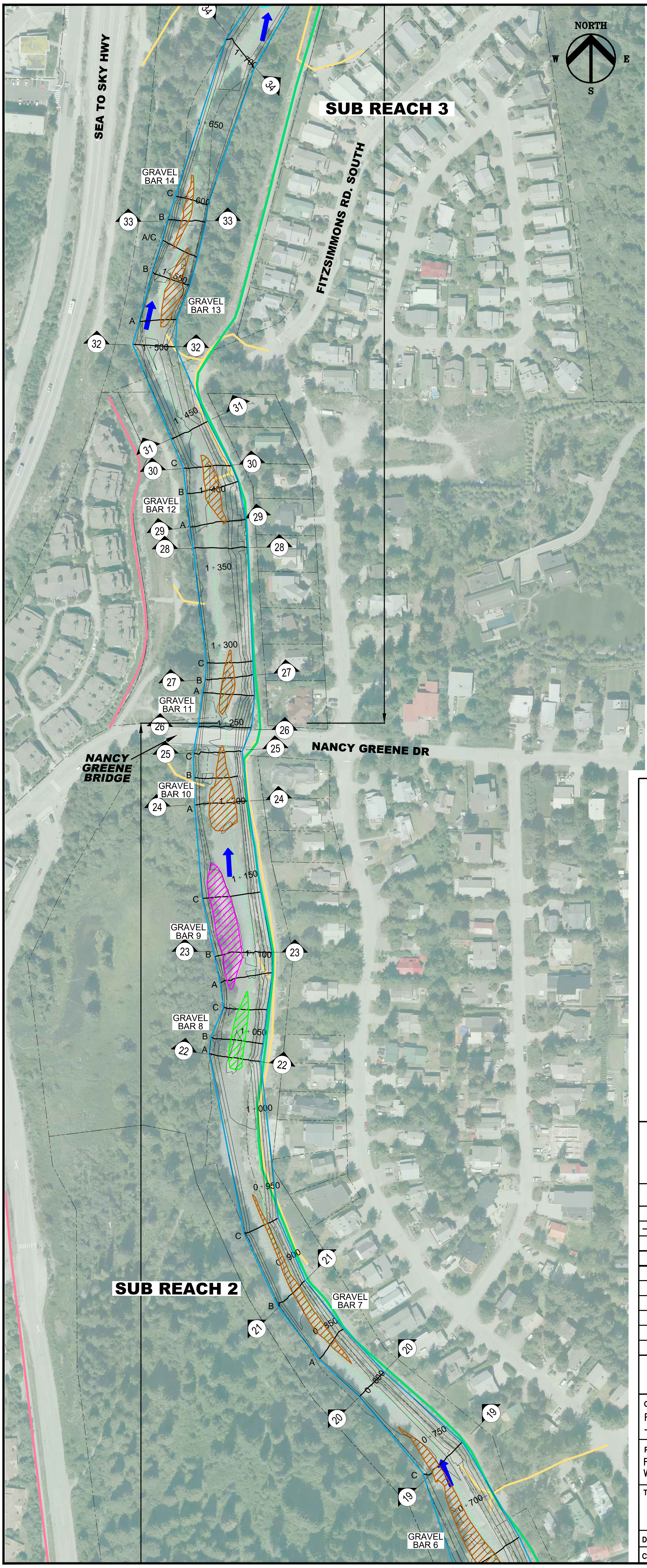
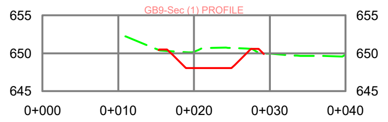
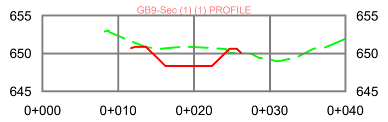
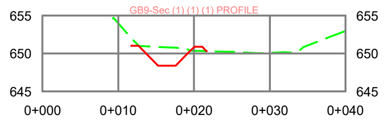




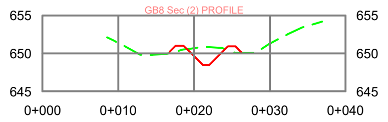
GRAVEL BAR 9C (1+138.93)



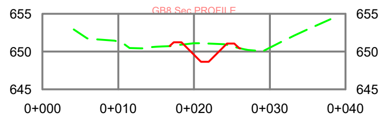
GRAVEL BAR 9B (1+100.63)



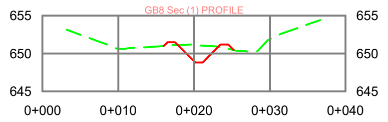
GRAVEL BAR 9A (1+085.82)



GRAVEL BAR 8C (1+063.85)

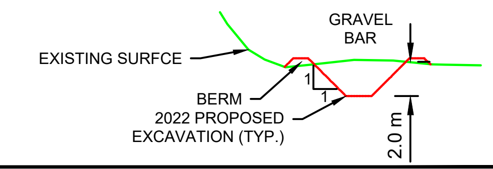


GRAVEL BAR 8B (1+043.30)



GRAVEL BAR 8A (1+031.42)

EXTRACTED VOLUME = FULL - BERM



LEGEND

▬ ▬	CN ROW
─ · ─	LOT LINE
─	CONTOUR (1m)
─	SURVEY BOUNDARY
─ · ─	STATION ALIGNMENT
─	FITZSIMMONS CREEK ACCESS ROUTE
─	EXISTING LEFT BANK DIKE
─	EXISTING RIGHT BANK DIKE
▨	EXISTING GRAVEL BAR (2022)
	PROPOSED GRAVEL REMOVAL (2022)
▨	PRIORITY 1 GRAVEL BAR REMOVAL (BAR 8, BAR 21, BAR 23, BAR 26 AND BAR 27)
▨	PRIORITY 2 GRAVEL BAR REMOVAL (BAR 9)
▨	PRIORITY 3 GRAVEL BAR REMOVAL (BAR 15, BAR 17, BAR 18 AND BAR 19)
←	FLOW DIRECTION

NOTES

1. ORIGINAL DRAWING IN COLOUR.

REFERENCE DRAWINGS

–	–	–
DWG. NO.	DATE	DESCRIPTION

REVISIONS

0	2022–06–22	ISSUED TO CLIENT	JG	BR
REV.	DATE	DESCRIPTION	BY	CHK

5 25 100
METRES

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

PROJECT LOCATION:
FITZSIMMONS CREEK
WHISTLER, BC

SNC·LAVALIN

TITLE:
FITZSIMMONS CREEK FLOOD PROTECTION PLAN
2022 GRAVEL BAR REMOVAL PLAN

DRN BY: JG	SCALE: 1:2,500	DATE: 2022–06–22	DWG No: REV.: 0
CHK'D: BR	PLOT: 20220622.1313	CADFILE: 689494–R0	689494 C-6

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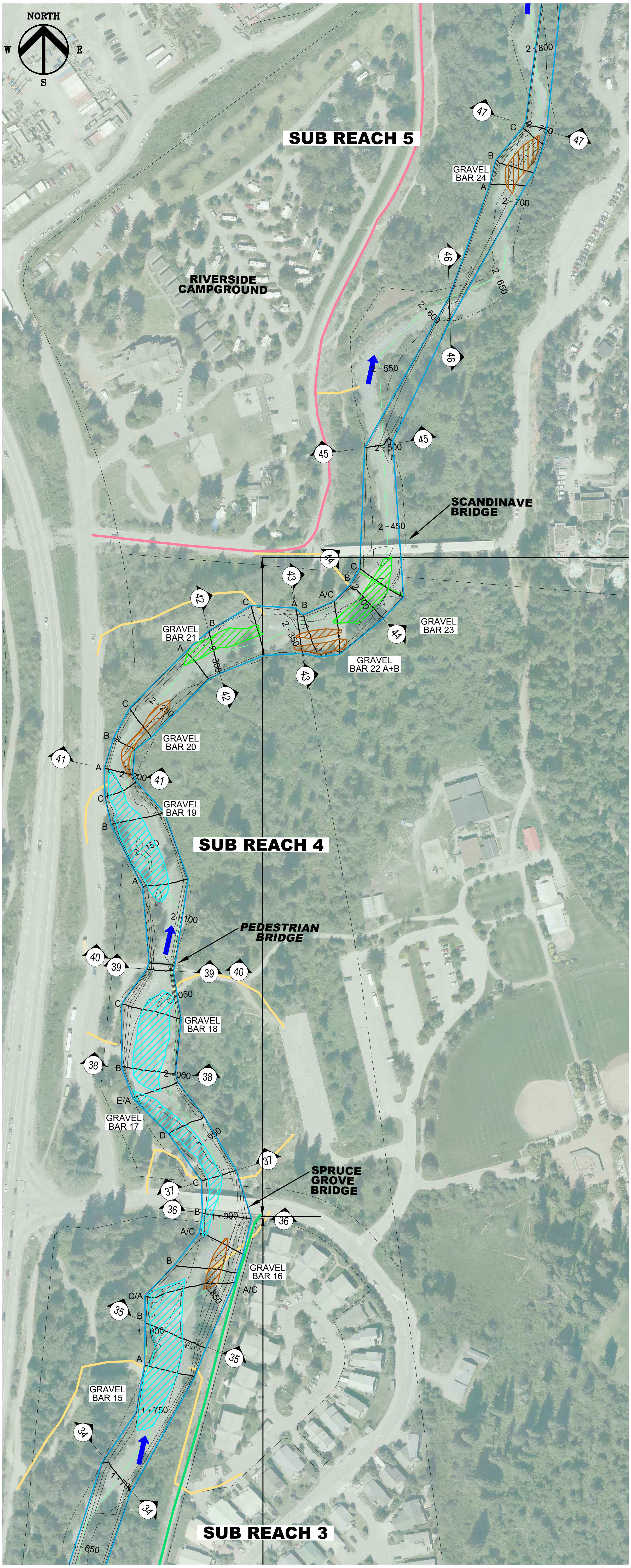
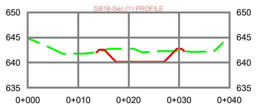
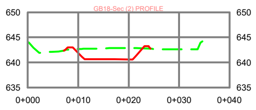
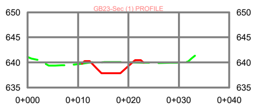
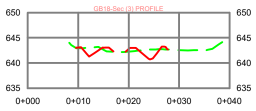


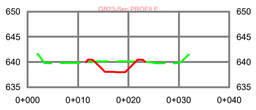


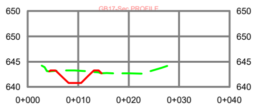
GRAVEL BAR 18C (2+035.72)

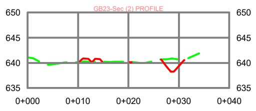

GRAVEL BAR 18B (2+000.29)

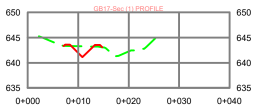

GRAVEL BAR 23C (2+414.35)

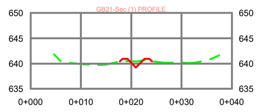

GRAVEL BAR 17E 18A(1+992.88)

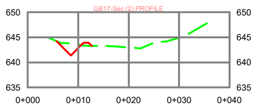

GRAVEL BAR 23B (2+400.24)

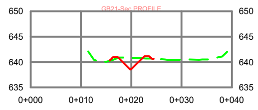

GRAVEL BAR 17D (1+964.44)

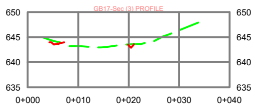

GRAVEL BAR 23A (2+383.06)

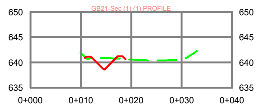

GRAVEL BAR 17C (1+925.24)

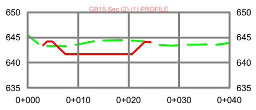

GRAVEL BAR 21C (2+330.75)

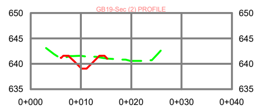

GRAVEL BAR 17B (1+900.44)

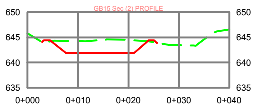

GRAVEL BAR 21B (2+300.32)

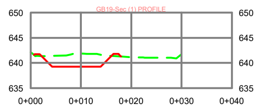

GRAVEL BAR 16C 17A (1+883.34)

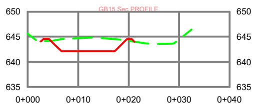

GRAVEL BAR 21A (2+286.70)

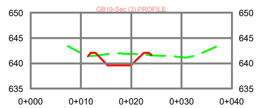

GRAVEL BAR 15C (1+855.43)


GRAVEL BAR 19C (2+191.12)

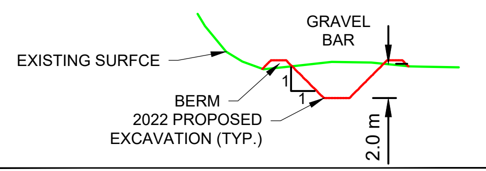

GRAVEL BAR 15B (1+806.11)


GRAVEL BAR 19B (2+170.09)


GRAVEL BAR 15A (1+778.43)


GRAVEL BAR 19A (2+124.08)

EXTRACTED VOLUME = FULL - BERM



LEGEND

— - — -	CN ROW
— · — ·	LOT LINE
～～～	CONTOUR (1m)
——	SURVEY BOUNDARY
— · — ·	STATION ALIGNMENT
——	FITZSIMMONS CREEK ACCESS ROUTE
——	EXISTING LEFT BANK DIKE
——	EXISTING RIGHT BANK DIKE
▨	EXISTING GRAVEL BAR (2022)
	PROPOSED GRAVEL REMOVAL (2022)
▨	PRIORITY 1 GRAVEL BAR REMOVAL (BAR 8, BAR 21, BAR 23, BAR 26 AND BAR 27)
▨	PRIORITY 2 GRAVEL BAR REMOVAL (BAR 9)
▨	PRIORITY 3 GRAVEL BAR REMOVAL (BAR 15, BAR 17, BAR 18 AND BAR 19)
←	FLOW DIRECTION

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
0	2022–06–22	ISSUED TO CLIENT	JG	BR

5 25 METRES 100

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

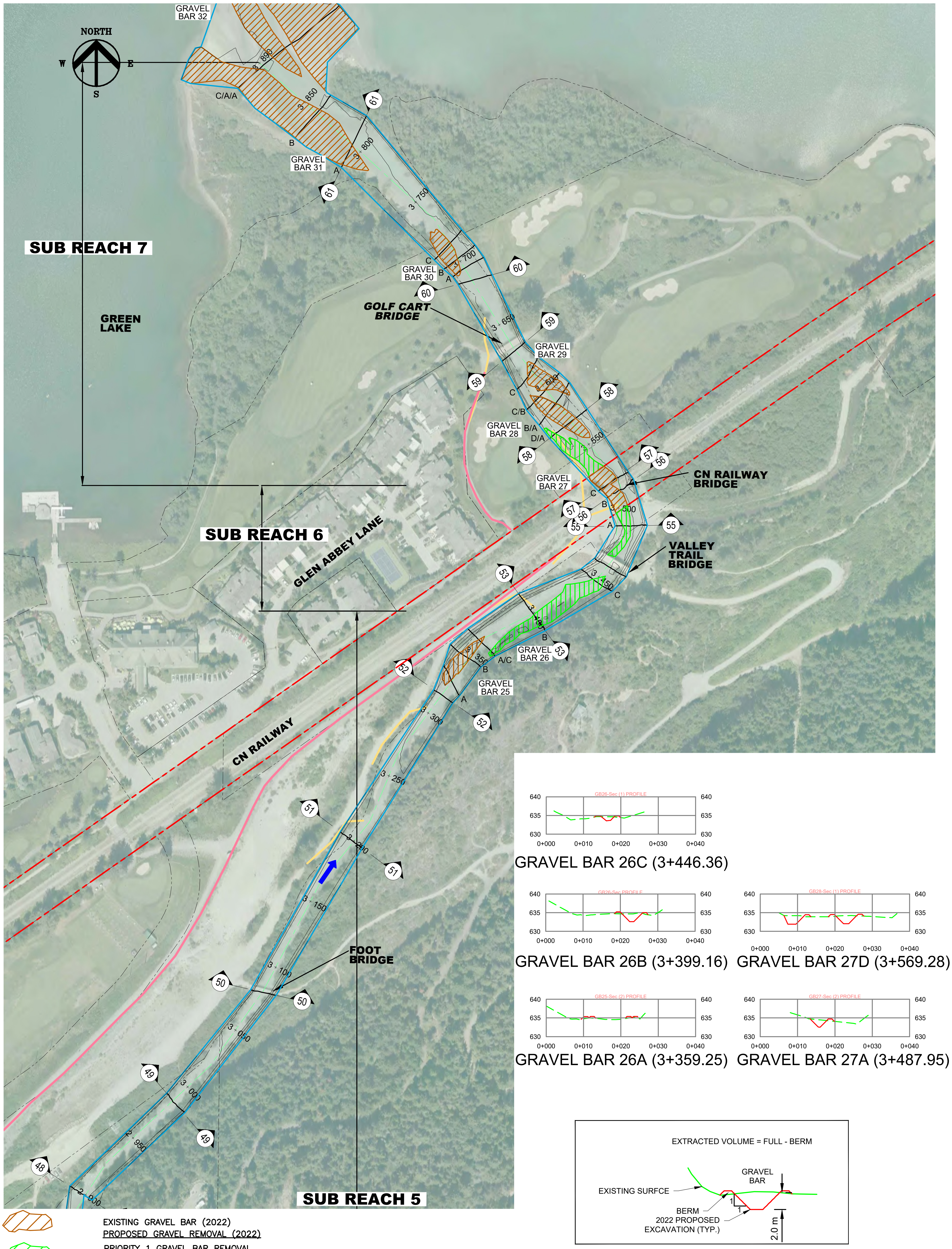
PROJECT LOCATION:
FITZSIMMONS CREEK
WHISTLER, BC

SNC·LAVALIN

TITLE:
FITZSIMMONS CREEK FLOOD PROTECTION PLAN
2022 GRAVEL BAR REMOVAL PLAN

DRN BY: JG	SCALE: 1:2,500	DATE: 2022–06–22	DWG No: REV.: 0
CHK'D: BR	PLOT: 20220622.0857	CADFILE: 689494–R0	689494 C-7

PATH: C:\USERS\GENGG\DOCUMENTS\689494 WHISTLER\689494–R0.DWG



GRAVEL BAR 26C (3+446.36)

GRAVEL BAR 26B (3+399.16)

GRAVEL BAR 27D (3+569.28)

GRAVEL BAR 26A (3+359.25)

GRAVEL BAR 27A (3+487.95)

▨ EXISTING GRAVEL BAR (2022)

PROPOSED GRAVEL REMOVAL (2022)

▨ PRIORITY 1 GRAVEL BAR REMOVAL
(BAR 8, BAR 21, BAR 23, BAR 26 AND BAR 27)

▨ PRIORITY 2 GRAVEL BAR REMOVAL
(BAR 9)

▨ PRIORITY 3 GRAVEL BAR REMOVAL
(BAR 15, BAR 17, BAR 18 AND BAR 19)

← FLOW DIRECTION

1. ORIGINAL DRAWING IN COLOUR.

LEGEND

5 25 METRES 100

— — —	CN ROW
— · · —	LOT LINE
～	CONTOUR (1m)
—	SURVEY BOUNDARY
— · —	STATION ALIGNMENT
—	FITZSIMMONS CREEK ACCESS ROUTE
—	EXISTING LEFT BANK DIKE
—	EXISTING RIGHT BANK DIKE

FLOW DIRECTION

REFERENCE DRAWINGS

DWG. NO.	DATE	DESCRIPTION
–	–	–

REVISIONS

REV.	DATE	DESCRIPTION	BY	CHK
0	2022–06–22	ISSUED TO CLIENT	JG	BR

CLIENT NAME:
RESORT MUNICIPALITY OF WHISTLER
–

PROJECT LOCATION:
FITZSIMMONS CREEK
–

SNC·LAVALIN

TITLE:
FITZSIMMONS CREEK FLOOD PROTECTION PLAN
2022 GRAVEL BAR REMOVAL PLAN

DRN BY: JG	SCALE: 1:2,500	DATE: 2022–06–22	DWG No: REV.: **0**
CHK'D: BR	PLOT: 20220622.0908	CADFILE: 689494–R0	**689494 C-8**

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SNC·LAVALIN

SNC-Lavalin Inc.
Suite 1300 – 3777 Kingsway Avenue
Burnaby, British Columbia, Canada V5H 3Z7
t. 604.515.5151
www.snclavalin.com