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Technical Memorandum

Date: August 10, 2021 **Project No.:** 300041559.0001

Project Name: Elements Condominium - Hydrogeology Brief

Client Name: Bistro 6 - Subdivision

Submitted To: Mike Flis - Jones Consulting

Submitted By: Dwight Smikle, M.Sc., P.Geo.

Reviewed By: Stephanie Charity, B.Sc., P.Geo

1.0 Background

R.J. Burnside & Associates Limited (Burnside) has been requested to prepare the following hydrogeological brief to respond to comments from the Lake Simcoe Region Conservation Authority (LSRCA) regarding site-specific conditions within Block 598 of the Bistro 6 West subdivision in Barrie. Block 598 forms part of the larger Bistro 6 West subdivision that was studied by Burnside and for which a report entitled "Hydrogeological Study in Support of Draft Plan- Bistro 6 West Subdivision" was completed in October 2019. The current hydrogeology brief draws extensively from the work previously completed.

2.0 Hydrogeological Setting

The local soils were investigated by various studies including the Burnside hydrogeological study and geotechnical studies completed by Peto McCallum. Details of local soils and soil stratigraphy are outlined in the Burnside 2019 report. The report indicates that the local soils consist of sandy silt to silty sand with localized units of silty clay. Geological cross-sections were produced as part of the Burnside study and indicated that the Bistro 6 West lands are underlain by a layer of sand and silt that overlies a sand and silt till. Cross-section B-B' from the Burnside report is attached as it represents the hydrogeological setting interpreted to occur beneath Block 598.

3.0 Significant Groundwater Recharge Areas

The available LSRCA mapping indicates that a Significant Groundwater Recharge Area (SGRA) extends unto the northwestern corner of Block 598. The Burnside 2019 report indicates that the borehole log for monitoring well CD-1 was used to interpret that the area of coarse-grained sediments mapped in this area and assumed to be associated with the SGRA was not proven by the borehole. It was interpreted that the SGRA did not extend into Block 598. More recent boreholes completed by Peto McCallum and included in their "Geotechnical Investigation Proposed Bistro 6 West Development Kneeshaw Drive Barrie, Ontario" Peto McCallum (May 2021) indicate that the sediments in the area of Block 598 are mainly sandy silt to sandy silt till that are compacted and very dense. These sediments are not likely to form high capacity recharge areas due to both compaction and the fine-grained sediments that are also present. The additional data is interpreted as confirming the previous submission that the SGRA does not extend unto Block 598.

4.0 Seasonal Groundwater High

Seasonal groundwater high was mapped by Burnside in 2019 and was noted to vary between approximately 252 meters above sea level (masl) and 254 masl near the east end of Block 598. It is our understanding that the east end of Block 598 is the area where Low Impact Development (LID) measures to promote infiltration are proposed. More recent work completed by Peto McCallum (May 2021), indicates that groundwater in the vicinity of the proposed LIDs varies between 252 masl and 254 masl. Specifically, the report references groundwater measurements conducted in May 2021 that confirm that the depth to water in the area is within this range. The report goes on to recommend elevations for the base of the proposed LID measures that are at least 1 m above the measured seasonal high. Based on the consistency between the Burnside measurements and those completed by Peto McCallum, it is our opinion that the measurements are representative of the seasonal groundwater high in the vicinity of the proposed LID measures.

5.0 Groundwater Balance

A groundwater balance was completed for Block 598 in keeping with LSRCA requirements and based on the Thornthwaite and Mather approach. The assumptions of the calculation were kept the same as those used for the entire subdivision in the Burnside 2019 report in order to remain consistent with those calculations. The methodology for the calculations is outlined in the Burnside 2019 report. The infiltration factors used for the calculation are summarized in the Table 1 below:

Table 1: Infiltration Factors

	Pre-Development		Post-Development	
	Agricultural		Urban Lawn	
	Factor	Rationale	Factor	Rationale
Topography	0.1	Slope of 4%	0.1	Similar to pre-conditions
Soils	0.40	Sandy loam soils	0.40	Same soils as pre-conditions
Cover	0.1	Predominantly cultivated land	0.15	Urban lawns
Total	0.60		0.65	

Using data from the Barrie WPCC climate station the calculations were completed and a summary of the water balance component values is provided in Table 2.

Table 2: Water Balance Component Values

Water Balance Component	Agricultural Lands	Urban Lawn
Average Precipitation	933 mm/year	933 mm/year
Actual Evapotranspiration	593 mm/year	555 mm/year
Water Surplus	340 mm/year	378 mm/year
Infiltration	204 mm/year	246 mm/year
Runoff	136 mm/year	132 mm/year

The water balance component values from Table WB-1 and Table WB-2 (attached) were used to calculate the average annual volume of infiltration across Block 598. Based on these component values, the total pre-development infiltration volume for the block is calculated to be about 6,400 m^3/year.

To assess potential development impacts on infiltration, the post-development infiltration volumes have been calculated for the block on Table WB-3 (attached). The proposed land use areas were provided by Jones Consulting Group. The calculated post-development infiltration volume (without mitigation) for the block is about 3,500 m^3/year.

Comparing the pre- and post-development infiltration volumes, shows that development has the potential to reduce the average infiltration on the block by 45 % or 2,900 m^3/year (Table WB-3, attached).

6.0 Mitigation Strategies for Infiltration

To minimize the potential impacts of development on the water balance, the use of Low Impact Development (LID) measures for stormwater management are generally recommended by the conservation authority. It is our understanding that LID measures are proposed in three locations within the block. Based on calculations completed by the design engineers at Jones Consulting, we understand that a total infiltration volume of approximately 11,400 m^3/year would be generated at the three infiltration facilities. This available infiltration is significantly above the calculated deficit and indicates that the proposed LID measures would mitigate for the loss in natural infiltration caused by the development process.

R.J. Burnside & Associates Limited

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DS/SC:cl

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Hydrogeologist

Enclosure(s) Water Balance Tables WB-1, WB-2 and WB-3
Figure 5 – Borehole, Well and Cross-Section Locations
Figure 7 – Interpreted Geological Cross-Section B-B'

WATER BALANCE CALCULATIONS
Block 598
Bistro 6 West Subdivision
Barrie, ON
PROJECT No.300041559

TABLE WB-1

Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 150 mm (moderately-rooted vegetation in sandy loam soils)

Precipitation data from Barrie WPCC Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-7.7	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5	**6.9**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.19	3.91	6.90	8.66	7.97	5.44	2.31	0.39	0.00	**36.8**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	25.18	58.76	88.02	103.48	97.59	74.33	40.47	11.47	0.00	**499**
Adjusting Factor for U (Latitude 44° 20' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	83	62	58	62	82	85	77	90	94	78	89	74	**933**
Potential Evapotranspiration (PET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
P - PET	83	62	58	34	8	-29	-57	-27	17	39	80	74	**340**
Change in Soil Moisture Storage	0	0	0	0	0	-29	-57	-27	17	39	58	0	**0**
Soil Moisture Storage max 150 mm	150	150	150	150	150	121	64	37	53	92	150	150	
Actual Evapotranspiration (AET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
Soil Moisture Deficit max 150 mm	0	0	0	0	0	29	86	113	97	58	0	0	
Water Surplus - available for infiltration or runoff	83	62	58	34	8	0	0	0	0	0	22	74	**340**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	50	37	35	20	5	0	0	0	0	0	13	44	**204**
Potential Direct Surface Water Runoff (independent of temperature)	33	25	23	13	3	0	0	0	0	0	9	29	**136**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	933	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	140	mm/year											
P-PE (surplus available for runoff from impervious areas)	793	mm/year											

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 150 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - hilly land (avg slope ~ 4%)	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - sandy loam	0.4	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - predominantly cultivated land	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.6**	

Latitude of site (or climate station) 44 ° N.

WATER BALANCE CALCULATIONS
Block 598
Bistro 6 West Subdivision
Barrie, ON
PROJECT No.300041559

TABLE WB-2

Post-Development Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 75 mm (urban lawn in sandy loam soils)

Precipitation data from Barrie WPCC Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-7.7	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5	**6.9**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.19	3.91	6.90	8.66	7.97	5.44	2.31	0.39	0.00	**36.8**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	25.18	58.76	88.02	103.48	97.59	74.33	40.47	11.47	0.00	**499**
Adjusting Factor for U (Latitude 44° 20' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	83	62	58	62	82	85	77	90	94	78	89	74	**933**
Potential Evapotranspiration (PET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
P - PET	83	62	58	34	8	-29	-57	-27	17	39	80	74	**340**
Change in Soil Moisture Storage	0	0	0	0	0	-29	-46	0	17	39	19	0	**0**
Soil Moisture Storage max 75 mm	75	75	75	75	75	46	0	0	17	56	75	75	
Actual Evapotranspiration (AET)	0	0	0	28	75	114	123	90	77	38	9	0	**555**
Soil Moisture Deficit max 75 mm	0	0	0	0	0	29	75	75	58	19	0	0	
Water Surplus - available for infiltration or runoff	83	62	58	34	8	0	0	0	0	0	60	74	**378**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	54	40	38	22	5	0	0	0	0	0	39	48	**246**
Potential Direct Surface Water Runoff (independent of temperature)	29	22	20	12	3	0	0	0	0	0	21	26	**132**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	933	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	140	mm/year											
P-PE (surplus available for runoff from impervious areas)	793	mm/year											

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 75 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - hilly land	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - sandy loam	0.4	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - urban lawn	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.65**	

Latitude of site (or climate station) 44 °N.

WATER BALANCE CALCULATIONS
Block 598
Bistro 6 West Subdivision
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TABLE WB-3

Water Balance for Pre- and Post-Development Land Use Conditions (with no SWM/LID measures in place)

Land Use Description	Approx. Land Area* (m^2)	Estimated Impervious Fraction for Land Use*	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration from Pervious Area** (m/a)	Infiltration Volume from Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Pre-Development Land Use												
Open Space /Agricultural	31,500	0.00	0	0.793	0	31,500	0.136	4,280	0.204	6,421	4,280	6,421
TOTAL PRE-DEVELOPMENT	**31,500**		**0**		**0**	**31,500**		**4,280**		**6,421**	**4,280**	**6,421**
Post-Development Land Use (with no LID measures in place)												
Landscape/ Open Space	16,800	0.15	2,520	0.793	1,998	14,280	0.132	1,889	0.246	3,509	3,887	3,509
Residential Building	6,400	1.00	6,400	0.793	5,075	0	0.132	0	0.246	0	5,075	0
Parking	8,300	1.00	8,300	0.793	6,582	0	0.132	0	0.246	0	6,582	0
TOTAL POST-DEVELOPMENT	**31,500**		**17,220**		**13,655**	**14,280**		**1,889**		**3,509**	**15,544**	**3,509**
% Change from Pre to Post											363	45
Effect of development (with no mitigation)											3.6 times increase in runoff	45% reduction of infiltration

* data provided by Jones Consulting Group Ltd.

** figures from Tables WB-1 and WB-2

To balance pre- to post-,
the infiltration target (m^3/a)= **2,912**

LEGEND

SUBJECT LANDS

MONITORING WELL (PML, JULY 2017)

MONITORING WELL (PML, JUNE 2017)

MONITORING WELL (RJB, 2014)

TEST PIT (PETO MacCALLUM, 2019)

MECP WELL RECORD

OVERBURDEN

UNKNOWN

CROSS SECTION LOCATION KEY

Sources:

1. Ministry of Natural Resources and Forestry, © Queen's Printer for Ontario
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.

N

0 50 100 150 200 250 300

Metres

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Client

CRISDAWN CONSTRUCTION LIMITED
BARRIE, ONTARIO

HYDROGEOLOGICAL STUDY
BISTRO 6 SUBDIVISION

Figure Title

BOREHOLE, WELL AND CROSS-SECTION LOCATIONS

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SK	SC	August 2019	5
Scale		Project No.	
1:4,000		300041559	

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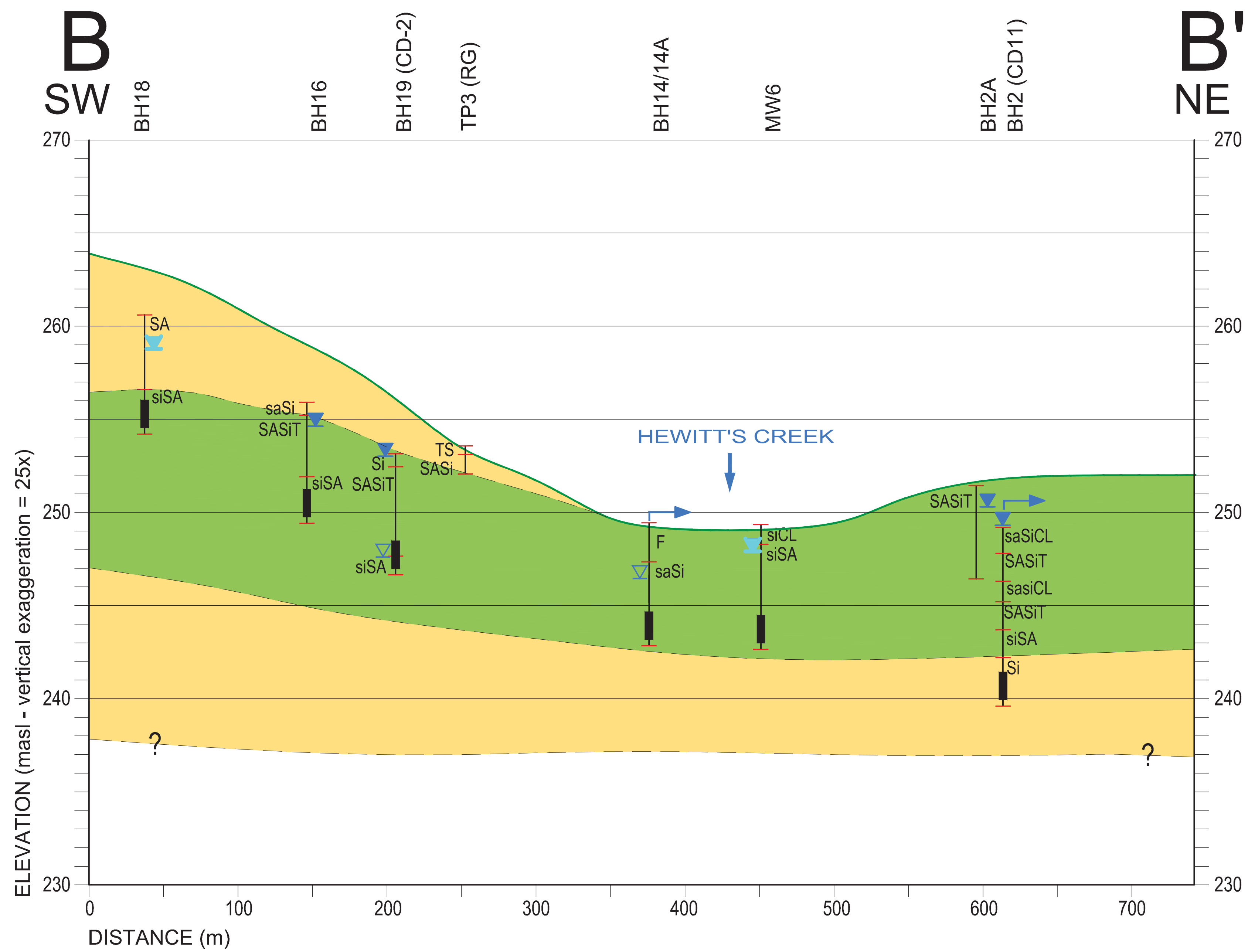

LEGEND

MW10 — WELL / BOREHOLE ID
4901807 — MOE WELL RECORD NUMBER
— WELL
CLGR — GEOLOGICAL STRATIGRAPHY
— WATER LEVEL AT FIRST STRIKE (REPORTED ON BOREHOLE AND TEST PIT LOGS (PETO)
— MEASURED WATER LEVEL (SEASONAL HIGH) FROM ARTESIAN SYSTEM
— MEASURED WATER LEVEL (SEASONAL HIGH) FROM SHALLOW SYSTEM
— WELL SCREEN

SAND / SILT / TILL
SAND / SILT
— — — INTERPRETED GEOLOGICAL CONTACT
WATERCOURSE CROSSING
INDICATES FLOWING

si	SILTY
cl	CLAYEY
sa	SANDY
F	FILL
T	TILL
SA	SAND
Si	SILT
GR	GRAVEL
CL	CLAY
PRDG	PREDUG

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BISTRO 6 SUBDIVISION

Figure Title
INTERPRETED GEOLOGICAL CROSS-SECTION B-B'

Drawn	Checked	Date	Figure No.
SK	SC	August 2019	7
Scale		Project No.	
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