Option D: Electrification, including Air Source Heat Pumps

Electrification of all heating and cooking loads with electricity supply coming from BC Hydro, upgrading electrical distribution infrastructure as required. Use air source heat pumps in Amphitheatre.

Inflation rate:	2%				
Discount Rate:	5%				
Electrification cost (2015 dollars):	$4,000,000				
Escalation:	23.6%				
ASHP capacity:	355	kW			
ASHP cost:	2,457	$/kW			
Initial cost:	$5,816,749				
Debt ratio:	100%				
Equity amount:	$0		Incentives:	Year 0:	$0
Loaned amount:	$5,816,749				
Debt interest rate:	5%				
Debt term:	10	years			
Annual debt pmt:	-$753,296				
Maintenance:	2.5%	of capital			
Maintenance cost (Year 0):	$145,419				
Hydro purchased electricity:	2,061,677	kWh/year			
Hydro rate:	0.083	$/kWh			
Annual electricity cost (Year 0):	$171,082				
GHG Savings:	509	tCO_2e/year			
Carbon price (Year 0, 2021):	$160	$/$tCO_2e$			
Carbon cost (Year 0, 2021):	$81,362	$/year			
Carbon price multiplier:	1.06				

Year	Equity investment	Loaned amount	Maintenance	Operating	O&M	Debt	Carbon cost	Cash outlays
0	$0.00	-$5,816,749						
1			-$148,327	-$174,504	-$322,831	-$753,296	$86,244	-$1,076,127
2			-$151,294	-$177,994	-$329,288	-$753,296	$91,418	-$1,082,583
3			-$154,320	-$181,554	-$335,874	-$753,296	$96,903	-$1,089,169
4			-$157,406	-$185,185	-$342,591	-$753,296	$102,718	-$1,095,887
5			-$160,554	-$188,889	-$349,443	-$753,296	$108,881	-$1,102,738
6			-$163,765	-$192,667	-$356,432	-$753,296	$115,414	-$1,109,727
7			-$167,040	-$196,520	-$363,560	-$753,296	$122,338	-$1,116,856
8			-$170,381	-$200,450	-$370,832	-$753,296	$129,679	-$1,124,127
9			-$173,789	-$204,459	-$378,248	-$753,296	$137,459	-$1,131,544
10			-$177,265	-$208,549	-$385,813	-$753,296	$145,707	-$1,139,109
11			-$180,810	-$212,720	-$393,529		$154,449	-$393,529
12			-$184,426	-$216,974	-$401,400		$163,716	-$401,400
13			-$188,115	-$221,313	-$409,428		$173,539	-$409,428
14			-$191,877	-$225,740	-$417,617		$183,952	-$417,617
15			-$195,714	-$230,254	-$425,969		$194,989	-$425,969
16			-$199,629	-$234,860	-$434,488		$206,688	-$434,488
17			-$203,621	-$239,557	-$443,178		$219,089	-$443,178
18			-$207,694	-$244,348	-$452,042		$232,235	-$452,042
19			-$211,848	-$249,235	-$461,082		$246,169	-$461,082
20			-$216,085	-$254,220	-$470,304		$260,939	-$470,304
21			-$220,406	-$259,304	-$479,710		$276,595	-$479,710
22			-$224,814	-$264,490	-$489,304		$293,191	-$489,304
23			-$229,311	-$269,780	-$499,090		$310,782	-$499,090
24			-$233,897	-$275,175	-$509,072		$329,429	-$509,072
25			-$238,575	-$280,679	-$519,254		$349,195	-$519,254

Profitability from different perspectives:

	Investor cashflow:	Investor cashflow w/ carbon cost:
	$0.00	$0.00
	-$1,076,127	-$989,883
	-$1,082,583	-$991,165
	-$1,089,169	-$992,266
	-$1,095,887	-$993,169
	-$1,102,738	-$993,858
	-$1,109,727	-$994,314
	-$1,116,856	-$994,518
	-$1,124,127	-$994,448
	-$1,131,544	-$994,084
	-$1,139,109	-$993,402
	-$393,529	-$239,080
	-$401,400	-$237,684
	-$409,428	-$235,889
	-$417,617	-$233,665
	-$425,969	-$230,980
	-$434,488	-$227,800
	-$443,178	-$224,089
	-$452,042	-$219,807
	-$461,082	-$214,914
	-$470,304	-$209,365
	-$479,710	-$203,115
	-$489,304	-$196,113
	-$499,090	-$188,308
	-$509,072	-$179,643
	-$519,254	-$170,059
NPV:	-$11,364,328	-$9,058,160

Option E: Electrification of Amphitheatre, Renewable Natural Gas (RNG) for Existing Playland Facilities

Electrification of Amphitheatre, continue using existing gas-fired equipment in Playland and purchase renewable natural gas (RNG) from Fortis. Solar PV panels (100 kW) to also be installed on Livestock Roof Area.

Inflation rate:	2%				
Discount Rate:	5%				
Electrification cost (2015 dollars):	$1,000,000				
Escalation:	23.6%				
Solar capacity:	100	kW			
Solar cost:	2,775	$/kW			
Gas infrastructure cost (2020 dollar	$302,800				
Initial cost:	$1,816,300				
Debt ratio:	100%				
Equity amount:	$0		Incentives:	Year 0:	$0
Loaned amount:	$1,816,300				
Debt interest rate:	5%				
Debt term:	10	years			
Annual debt pmt:	-$235,219				
Maintenance:	2.5%	of capital			
Maintenance cost (Year 0):	$45,408				
Solar production:	1,195	kWh/kW			
Solar generated electricity:	119,500	kWh/year			
Hydro purchased electricity:	675,096	kWh/year			
Hydro rate:	0.083	$/kWh			
Annual electricity cost (Year 0):	$56,021				
Fortis purchased RNG:	9,204	GJ			
Fortis rate:	$12.08	$/GJ			
Fortis fixed charge:	$66,542	/year			
Annual RNG cost (Year 0):	$177,730				
Annual elec + RNG cost (Year 0):	$233,751				
GHG Savings:	521	tCO_2e/year			
Carbon price (Year 0, 2021):	$160	$/tCO_2e$			
Carbon cost (Year 0, 2021):	$83,302	$/year			
Carbon price multiplier:	1.06				

Year	Equity investment	Loaned amount	Maintenance	Operating	O&M	Debt	Carbon cost	Cash outlays
0	$0.00	-$1,816,300						
1			-$46,316	-$238,426	-$284,741	-$235,219	$88,300	-$519,961
2			-$47,242	-$243,194	-$290,436	-$235,219	$93,598	-$525,655
3			-$48,187	-$248,058	-$296,245	-$235,219	$99,214	-$531,464
4			-$49,151	-$253,019	-$302,170	-$235,219	$105,167	-$537,389
5			-$50,134	-$258,080	-$308,213	-$235,219	$111,477	-$543,432
6			-$51,136	-$263,241	-$314,378	-$235,219	$118,166	-$549,597
7			-$52,159	-$268,506	-$320,665	-$235,219	$125,256	-$555,884
8			-$53,202	-$273,876	-$327,078	-$235,219	$132,771	-$562,298
9			-$54,266	-$279,354	-$333,620	-$235,219	$140,737	-$568,839
10			-$55,351	-$284,941	-$340,292	-$235,219	$149,181	-$575,512
11			-$56,459	-$290,640	-$347,098		$158,132	-$347,098
12			-$57,588	-$296,453	-$354,040		$167,620	-$354,040
13			-$58,739	-$302,382	-$361,121		$177,677	-$361,121
14			-$59,914	-$308,429	-$368,343		$188,338	-$368,343
15			-$61,113	-$314,598	-$375,710		$199,638	-$375,710
16			-$62,335	-$320,890	-$383,225		$211,617	-$383,225
17			-$63,581	-$327,308	-$390,889		$224,314	-$390,889
18			-$64,853	-$333,854	-$398,707		$237,772	-$398,707
19			-$66,150	-$340,531	-$406,681		$252,039	-$406,681
20			-$67,473	-$347,341	-$414,815		$267,161	-$414,815
21			-$68,823	-$354,288	-$423,111		$283,191	-$423,111
22			-$70,199	-$361,374	-$431,573		$300,182	-$431,573
23			-$71,603	-$368,601	-$440,205		$318,193	-$440,205
24			-$73,035	-$375,974	-$449,009		$337,285	-$449,009
25			-$74,496	-$383,493	-$457,989		$357,522	-$457,989

Profitability from different perspectives:

	Investor cashflow:	Investor cashflow w/ carbon cost:
	$0.00	$0.00
	-$519,961	-$431,660
	-$525,655	-$432,057
	-$531,464	-$432,250
	-$537,389	-$432,222
	-$543,432	-$431,956
	-$549,597	-$431,431
	-$555,884	-$430,629
	-$562,298	-$429,527
	-$568,839	-$428,102
	-$575,512	-$426,330
	-$347,098	-$188,966
	-$354,040	-$186,420
	-$361,121	-$183,444
	-$368,343	-$180,005
	-$375,710	-$176,072
	-$383,225	-$171,608
	-$390,889	-$166,575
	-$398,707	-$160,934
	-$406,681	-$154,642
	-$414,815	-$147,653
	-$423,111	-$139,920
	-$431,573	-$131,391
	-$440,205	-$122,011
	-$449,009	-$111,724
	-$457,989	-$100,467
NPV:	-$6,709,340	-$4,348,181

Option F: Electrification of Amphitheatre, Renewable Natural Gas (RNG) for Existing Playland Facilities

Electrification of Amphitheatre, continue using existing gas-fired equipment in Playland and purchase renewable natural gas (RNG) from Fortis. Use air source heat pumps in Amphitheatre.

Inflation rate:	2%				
Discount Rate:	5%				
Electrification cost (2015 dollars):	$1,000,000				
Escalation:	23.6%				
ASHP capacity:	355	kW			
ASHP cost:	2,457	$/kW			
Gas infrastructure cost (2020 dollars):	$302,800				
Initial cost:	$2,411,549				
Debt ratio:	100%				
Equity amount:	$0		Incentives:	Year 0:	$0
Loaned amount:	$2,411,549				
Debt interest rate:	5%				
Debt term:	10	years			
Annual debt pmt:	-$312,307				
Maintenance:	2.5%	of capital			
Maintenance cost (Year 0):	$60,289				
Hydro purchased electricity:	640,597	kWh/year			
Hydro rate:	0.083	$/kWh			
Annual electricity cost (Year 0):	$53,158				
Fortis purchased RNG:	9,204	GJ			
Fortis rate:	$12.08	$/GJ			
Fortis fixed charge:	$66,542	/year			
Annual RNG cost (Year 0):	$177,730				
Annual elec + RNG cost (Year 0):	$230,888				
GHG Savings:	521	tCO_2e/year			
Carbon price (Year 0, 2021):	$160	$/tCO_2e$			
Carbon cost (Year 0, 2021):	$83,361	$/year			
Carbon price multiplier:	1.06				

Year	Equity investment	Loaned amount	Maintenance	Operating	O&M	Debt	Carbon cost	Cash outlays
0	$0.00	-$2,411,549						
1			-$61,494	-$235,506	-$297,000	-$312,307	$88,363	-$609,307
2			-$62,724	-$240,216	-$302,940	-$312,307	$93,664	-$615,247
3			-$63,979	-$245,020	-$308,999	-$312,307	$99,284	-$621,306
4			-$65,258	-$249,921	-$315,179	-$312,307	$105,241	-$627,486
5			-$66,564	-$254,919	-$321,483	-$312,307	$111,556	-$633,789
6			-$67,895	-$260,017	-$327,912	-$312,307	$118,249	-$640,219
7			-$69,253	-$265,218	-$334,470	-$312,307	$125,344	-$646,777
8			-$70,638	-$270,522	-$341,160	-$312,307	$132,865	-$653,466
9			-$72,051	-$275,932	-$347,983	-$312,307	$140,837	-$660,290
10			-$73,492	-$281,451	-$354,943	-$312,307	$149,287	-$667,249
11			-$74,961	-$287,080	-$362,042		$158,244	-$362,042
12			-$76,461	-$292,822	-$369,282		$167,739	-$369,282
13			-$77,990	-$298,678	-$376,668		$177,803	-$376,668
14			-$79,550	-$304,652	-$384,201		$188,471	-$384,201
15			-$81,141	-$310,745	-$391,885		$199,779	-$391,885
16			-$82,763	-$316,960	-$399,723		$211,766	-$399,723
17			-$84,419	-$323,299	-$407,718		$224,472	-$407,718
18			-$86,107	-$329,765	-$415,872		$237,941	-$415,872
19			-$87,829	-$336,360	-$424,189		$252,217	-$424,189
20			-$89,586	-$343,087	-$432,673		$267,350	-$432,673
21			-$91,378	-$349,949	-$441,327		$283,391	-$441,327
22			-$93,205	-$356,948	-$450,153		$300,394	-$450,153
23			-$95,069	-$364,087	-$459,156		$318,418	-$459,156
24			-$96,971	-$371,369	-$468,339		$337,523	-$468,339
25			-$98,910	-$378,796	-$477,706		$357,775	-$477,706

Profitability from different perspectives:

Investor cashflow:	Investor cashflow w/ carbon cost:
$0.00	$0.00
-$609,307	-$520,944
-$615,247	-$521,582
-$621,306	-$522,021
-$627,486	-$522,244
-$633,789	-$522,233
-$640,219	-$521,970
-$646,777	-$521,433
-$653,466	-$520,602
-$660,290	-$519,453
-$667,249	-$517,962
-$362,042	-$203,798
-$369,282	-$201,544
-$376,668	-$198,865
-$384,201	-$195,730
-$391,885	-$192,106
-$399,723	-$187,957
-$407,718	-$183,245
-$415,872	-$177,931
-$424,189	-$171,972
-$432,673	-$165,323
-$441,327	-$157,936
-$450,153	-$149,759
-$459,156	-$140,738
-$468,339	-$130,816
-$477,706	-$119,932
NPV: -$7,515,244	-$5,152,416

APPENDIX D

Preliminary Solar Modelling

Design 1 (inter-row spacing at 34 degrees) PNE Rooftop Solar PV, 2901 E Hastings St, Vancouver BC

Report

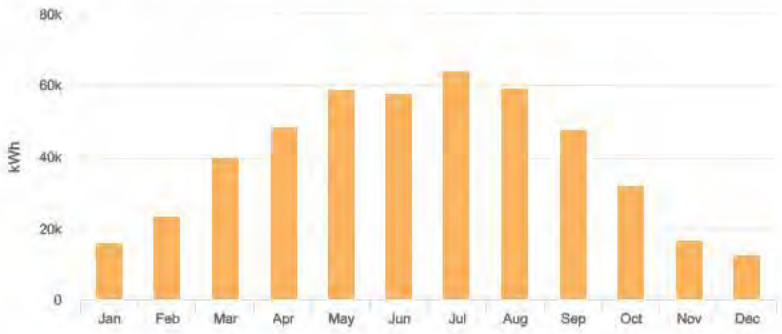
Project Name	PNE Rooftop Solar PV
Project Address	2901 E Hastings St, Vancouver BC
Prepared By	Brie Haley bhaley@urbansystems.ca

System Metrics

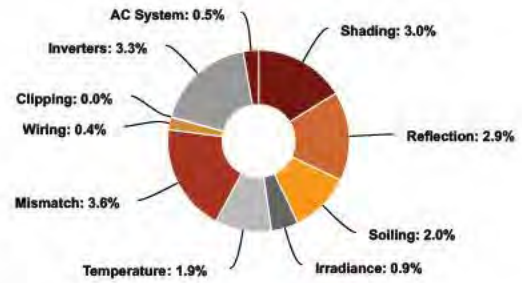
Design	Design 1 (inter-row spacing at 34 degrees)
Module DC Nameplate	401.2 kW
Inverter AC Nameplate	375.0 kW Load Ratio: 1.07
Annual Production	479.4 MWh
Performance Ratio	82.9%
kWh/kWp	1,195.0
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)
Simulator Version	5b2f7a1471-4b0afd94b7-fa79661d9a-a5360c70c7

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,220.4	
	POA Irradiance	1,441.0	18.1%
	Shaded Irradiance	1,397.7	-3.0%
	Irradiance after Reflection	1,356.6	-2.9%
	Irradiance after Soiling	1,329.5	-2.0%
	Total Collector Irradiance	**1,329.5**	**0.0%**
Energy (kWh)	Nameplate	533,616.3	
	Output at Irradiance Levels	528,840.8	-0.9%
	Output at Cell Temperature Derate	519,037.7	-1.9%
	Output After Mismatch	500,573.6	-3.6%
	Optimal DC Output	498,502.9	-0.4%
	Constrained DC Output	498,418.2	0.0%
	Inverter Output	481,855.0	-3.3%
	Energy to Grid	**479,446.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.2 °C
	Avg. Operating Cell Temp		20.1 °C
Simulation Metrics			
	Operating Hours		4589
	Solved Hours		4589

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
HiKu CS3w-400P (CanadianSolar)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
Solstice 125kW CE (400V) (Satcon)	Folsom Labs	Default Characterization

Components

Component	Name	Count
Inverters	Solstice 125kW CE (400V) (Satcon)	3 (375.0 kW)
Strings	10 AWG (Copper)	54 (4,416.2 m)
Module	CanadianSolar, HiKu CS3w-400P (400W)	1,003 (401.2 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	17-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	34°	180°	2.4 m	1x1	249	249	99.6 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	34°	180°	2.4 m	1x1	248	248	99.2 kW
Field Segment 3	Fixed Tilt	Landscape (Horizontal)	34°	180°	2.4 m	1x1	252	252	100.8 kW
Field Segment 4	Fixed Tilt	Landscape (Horizontal)	34°	180°	2.4 m	1x1	254	254	101.6 kW

Detailed Layout

APPENDIX E

Updated Cost Tables

Infrastructure Costs - Amphitheatre Electrification Update (Costs in 2020 Dollars)[5]															
	Phase 1A	Phase 1B	Phase 2	Phase 3A	Phase 3B	Phase 4A	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite	Totals
Storm	$1.1M	$.5M	$.4M	$.6M	$2.M	$2.8M	$6.5M	$2.7M	$.6M	$.9M	$.7M	$1.M	$8.7M	$.M	$28.4M
Green Infrastructure	$.9M	$.6M	$.6M	$1.1M	$.1M	$1.6M	$.3M	$2.1M	$.2M	$1.2M	$1.1M	$1.6M	$.M	$.M	$11.6M
Hastings and Greenway	$.M	$.M	$.M	$.M	$2.8M	$.M	$9.4M	$.M	$.M	$.M	$.M	$.M	$.M	$.M	$12.2M
Sanitary	$2.M	$.1M	$.3M	$1.3M	$.3M	$1.9M	$.7M	$1.7M	$.5M	$.9M	$1.1M	$1.6M	$3.2M	$.M	$15.7M
Gas	$.3M	$.M	$.M	$.4M	$.1M	$.7M	$.M	$.M	$.3M	$.2M	$.M	$.4M	$.3M	$.M	$2.8M
Water	$.8M	$.1M	$.2M	$1.1M	$.4M	$1.M	$.2M	$.4M	$.7M	$.6M	$.2M	$1.M	$1.5M	$.M	$8.4M
Power	$18.1M	$1.9M	$8.5M	$.7M	$.6M	$7.6M	$.1M	$2.3M	$.4M	$2.6M	$1.4M	$6.6M	$.M	$2.2M	$52.8M
Communications	$3.M	$.5M	$.4M	$.1M	$.1M	$1.8M	$.M	$.5M	$.6M	$.6M	$.4M	$.6M	$.M	$.M	$8.5M
Lighting	$.7M	$.2M	$.2M	$.2M	$.2M	$.6M	$.3M	$.9M	$.3M	$.3M	$.4M	$.6M	$.M	$.M	$4.9M
Roadway	$.M	$.M	$.M	$.M	$.M	$2.8M	$.M	$18.9M	$.M	$.M	$.M	$.M	$.M	$.M	$21.7M
Grand Total	$26.9M	$4.M	$10.7M	$5.4M	$6.7M	$20.9M	$17.5M	$29.5M	$3.7M	$7.2M	$5.3M	$13.4M	$13.7M	$2.2M	$167.M

Cost Changes - Renewable Energy Strategy Update (Costs in 2020 Dollars)															
	Phase 1A	Phase 1B	Phase 2	Phase 3A	Phase 3B	Phase 4A	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite	Totals
Storm	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$31,000.00	$31,000.00
Green Infrastructure	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Hastings and Greenway	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Sanitary	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$31,000.00	$31,000.00
Gas	$553,241.09	$0.00	$0.00	$0.00	-$96,258.81	-$41,725.15	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$415,257.13
Water	-$225,962.06	$0.00	-$17,411.27	-$231,754.23	-$146,090.74	-$106,076.28	$0.00	$0.00	-$86,139.26	-$206,075.90	-$108,957.58	-$165,834.31	$0.00	$1,380,434.01	$86,132.37
Power	-$10,997,489.82	$0.00	-$4,237,714.92	-$680,769.08	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$680,769.08	-$15,235,204.73
Communications	-$1,504,330.92	$0.00	-$166,900.62	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$46,000.00	-$1,625,231.54
Lighting	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Roadway	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Grand Total	-$12,174,541.71	$0.00	-$4,422,026.81	-$912,523.31	-$242,349.54	-$147,801.44	$0.00	$0.00	-$86,139.26	-$206,075.90	-$108,957.58	-$165,834.31	$0.00	$2,169,203.09	-$16,297,046.78

Infrastructure Costs - Renewable Energy Strategy Update (Costs in 2020 Dollars)															
	Phase 1A	Phase 1B	Phase 2	Phase 3A	Phase 3B	Phase 4A	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite[6]	Totals
Implementation Order[7]	C	D	B	E	F	G	H	I	J	K	L	M	N	A	
Storm	$1.1M	$.5M	$.4M	$.6M	$2.M	$2.8M	$6.5M	$2.7M	$.6M	$.9M	$.7M	$1.M	$8.7M	$.M	$28.4M
Green Infrastructure	$.9M	$.6M	$.6M	$1.1M	$.1M	$1.6M	$.3M	$2.1M	$.2M	$1.2M	$1.1M	$1.6M	$.M	$.M	$11.6M
Hastings and Greenway	$.M	$.M	$.M	$.M	$2.8M	$.M	$9.4M	$.M	$.M	$.M	$.M	$.M	$.M	$.M	$12.2M
Sanitary	$2.M	$.1M	$.3M	$1.3M	$.3M	$1.9M	$.7M	$1.7M	$.5M	$.9M	$1.1M	$1.6M	$3.2M	$.M	$15.7M
Gas	$.8M	$.M	$.M	$.4M	$.M	$.7M	$.M	$.M	$.3M	$.2M	$.M	$.4M	$.3M	$.M	$3.2M
Water	$.6M	$.1M	$.2M	$.9M	$.3M	$.9M	$.2M	$.4M	$.7M	$.4M	$.M	$.8M	$1.5M	$1.4M	$8.4M
Power	$7.1M	$1.9M	$4.3M	$.M	$.6M	$7.6M	$.1M	$2.3M	$.4M	$2.6M	$1.4M	$6.6M	$.M	$2.9M	$37.6M
Communications	$1.5M	$.5M	$.2M	$.1M	$.1M	$1.8M	$.M	$.5M	$.6M	$.6M	$.4M	$.6M	$.M	$.M	$6.9M
Lighting	$.7M	$.2M	$.2M	$.2M	$.2M	$.6M	$.3M	$.9M	$.3M	$.3M	$.4M	$.6M	$.M	$.M	$4.9M
Roadway	$.M	$.M	$.M	$.M	$.M	$2.8M	$.M	$18.9M	$.M	$.M	$.M	$.M	$.M	$.M	$21.7M
Grand Total	$14.7M	$4.M	$6.2M	$4.5M	$6.4M	$20.7M	$17.5M	$29.5M	$3.6M	$7.M	$5.2M	$13.2M	$13.7M	$4.4M	$150.7M

Notes:
1) Cost allocation to each phase represents the total estimated servicing costs in consideration of trunk infrastructure necessary given the anticipated order of implementation and infrastructure within the footprints of each phase
2) Phase 2 "Amphitheatre" is anticipated to be implemented in advance of the other phases. Costs presented herein consider that implementation of Phase 2 in advance of all other phases, and the original phase numbering has been maintained for consistency with previous reporting.
3) All costs presented are in 2020 dollars, and include a 20% engineering allowance and 30% contingency.
4) The implementation order is presented A through N, with A proposed to occur first.
5) Amphitheatre Electrification Update costs are from the "Hastings Park IMP - Amphitheatre Update Technical Memo" (November 14, 2019), which included initial estimates of electrification for Phases 1A and 2.

Cost Summary By Program Type - Amphitheatre Update (Costs in 2020 Dollars)

Playland Infrastructure Costs - Renewable Energy Strategy Update (Costs in 2020 Dollars)			
	Phase 1A	Phase 4A	Totals
New	$7.6M	$19.9M	$27.5M
Renewal	$6.7M	$.4M	$7.2M
Removal	$.4M	$.4M	$.8M
Grand Total	$14.7M	$20.7M	$35.5M

Heart of the Park Infrastructure Costs - Renewable Energy Strategy Update (Costs in 2020 Dollars)				
	Phase 2	Phase 3A	Phase 3B	Totals
New	$4.4M	$3.2M	$5.1M	$12.7M
Renewal	$1.9M	$1.1M	$1.M	$4.M
Removal	$.M	$.2M	$.2M	$.4M
Grand Total	$6.2M	$4.5M	$6.4M	$17.2M

Remainder of Park Infrastructure Cost - Renewable Energy Strategy Update (Costs in 2020 Dollars)										
	Phase 1B	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite	Totals
New	$2.M	$16.8M	$27.3M	$2.7M	$5.2M	$4.M	$11.5M	$.1M	$.5M	$70.1M
Renewal	$2.M	$.1M	$1.4M	$.9M	$1.7M	$1.1M	$1.6M	$13.2M	$3.8M	$25.9M
Removal	$.M	$.5M	$.7M	$.M	$.1M	$.1M	$.1M	$.4M	$.1M	$2.M
Grand Total	$4.M	$17.5M	$29.5M	$3.6M	$7.M	$5.2M	$13.2M	$13.7M	$4.4M	$98.M

Notes:
1) "New" represents the cost of infrastructure that is triggered by new capacity requirements of the Hastings Park redevelopment.
2) "Renewal" represents the replacement cost of existing infrastructure once it reaches the end of its useful life.
3) "Removal" represents existing infrastructure to be abandoned and is not required to satisfy the new capacity requirements of redevelopment.
4) All costs presented are in 2020 dollars, and include a 20% engineering allowance and 30% contingency.

Item	Renewable Energy Strategy Update Cost Changes per Phase (Costs in 2020 Dollars)													
	1A	1B	2	3A	3B	4A	4B	4C	5A	5B	5C	6	Prerequisite	Net Project Cost
Water														
Playland/Miller Drive Prerequisite Costs - "New"	-$ 176,331.98	$ -	$ -	$ -	$ -	-$ 30,907.52	$ -	$ -	$ -	$ -	$ -	$ -	$ 293,371.87	**$ 86,132.37**
Playland/Miller Drive Prerequisite Costs - "Renewal"	-$ 45,897.67	$ -	$ -	$ -	$ -	-$ 49,513.85	$ -	$ -	$ -	$ -	$ -	$ -	$ 95,411.52	**$ -**
Playland/Miller Drive Prerequisite Costs - "Removal"	-$ 3,732.41	$ -	-$ 17,411.27	$ -	$ -	-$ 25,654.91	$ -	$ -	$ -	$ -	$ -	$ -	$ 46,798.59	**$ -**
Remaining Areas Prerequisite Costs - "New"	$ -	$ -	$ -	-$ 113,005.60	-$ 56,173.03	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 169,178.63	**$ -**
Remaining Areas Prerequisite Costs - "Renewal"	$ -	$ -	$ -	-$ 90,497.22	-$ 60,501.47	$ -	$ -	$ -	-$ 86,139.26	-$ 206,075.90	-$ 108,957.58	-$ 165,834.31	$ 718,005.76	**$ -**
Remaining Areas Prerequisite Costs - "Removal"	$ -	$ -	$ -	-$ 28,251.40	-$ 29,416.23	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 57,667.63	**$ -**
Water Total	-$ 225,962.06	$ -	-$ 17,411.27	-$ 231,754.23	-$ 146,090.74	-$ 106,076.28	$ -		-$ 86,139.26	-$ 206,075.90	-$ 108,957.58	-$ 165,834.31	$ 1,380,434.01	**$ 86,132.37**
Storm														
Various Point Repairs (Item 7 on Pre-Requisite Project Summary) - "Renewal"	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 31,000.00	**$ 31,000.00**
Storm Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 31,000.00	**$ 31,000.00**
Sanitary														
Various Point Repairs (Item 7 on Pre-Requisite Project Summary) - "Renewal"	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 31,000.00	**$ 31,000.00**
Sanitary Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 31,000.00	**$ 31,000.00**
Gas														
RNG Gas - "New"	$ 240,609.34	$ -	$ -	$ -	-$ 96,258.81	-$ 41,725.15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 102,625.38**
RNG Gas - "Renewal"	$ 250,385.83	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 250,385.83**
RNG Gas - "Removal"	$ 62,245.92	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 62,245.92**
Gas Total	$ 553,241.09	$ -	$ -	$ -	-$ 96,258.81	-$ 41,725.15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 415,257.13**
Power														
Power (from DMD) - "New"	-$ 10,997,489.82	$ -	-$ 5,437,714.92	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 16,435,204.73**
100kW Solar Panels on Livestock Roof - "New"	$ -	$ -	$ 300,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 300,000.00**
Optional Cost - Additional 300kW of Solar Panels for Livestock Roof to be confirmed through design development - "New"	$ -	$ -	$ 900,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 900,000.00**
Livestock Transformers (Item 14 on Pre-Requisite Project Summary) - "New"	$ -	$ -	$ -	-$ 680,769.08	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 680,769.08	**$ -**
Power Total	-$ 10,997,489.82	$ -	-$ 4,237,714.92	-$ 680,769.08	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 680,769.08	**-$ 15,235,204.73**
Communications														
Communications (from DMD) - "New"	-$ 1,504,330.92	$ -	-$ 166,900.62	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 1,671,231.54**
Manhole by Coliseum Cable Separation (Item 8 on Pre-Requisite Project Summary) - "Renewal"	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 46,000.00	**$ 46,000.00**
Communications Total	-$ 1,504,330.92	$ -	-$ 166,900.62	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 46,000.00	**-$ 1,625,231.54**
Lighting														
Lighting (from DMD) - "New"	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
Lighting Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
Summary	**-$ 12,174,541.71**	**$ -**	**-$ 4,422,026.81**	**-$ 912,523.31**	**-$ 242,349.54**	**-$ 147,801.44**	**$ -**	**$ -**	**-$ 86,139.26**	**-$ 206,075.90**	**-$ 108,957.58**	**-$ 165,834.31**	**$ 2,169,203.09**	**-$ 16,297,046.78**

Notes:
1) Interim "new" watermains for Playland/Miller Drive required to connect Playland (Phase 1A) and Festival Plaza (Phase 3A) in advance of future water servicing to Phase 4A of the IMP. These costs were not part of the original IMP servicing strategic and are included as additions to the "Prerequisite" Phase without subtraction of costs from other phases.
2) The renewable energy update has refined the phasing of gas mains from the original IMP. As such two "new" segments of gas main have been reallocated from Phases 3B and 4A into Phase 1A.
3) Power, Communications, and Lighting costs "from DMD" based on DMD cost estimate dated October 2, 2020.
4) Costs changes relative to Amphitheatre Electrification Update costs presented in the "Hastings Park IMP - Amphitheatre Update Technical Memo" (November 14, 2019), which included initial estimates of electrification for Phases 1A and 2.

Program Type Cost by Infrastructure - Renewable Energy Strategy Update (Costs in 2020 Dollars)

Row Labels	Sum of 1A	Sum of 1B	Sum of 2	Sum of 3A	Sum of 3B	Sum of 4A	Sum of 4B	Sum of 4C	Sum of 5A	Sum of 5B	Sum of 5C	Sum of 6	Sum of Recently Renewed	Sum of Prerequisite
New	**$ 7,584,518**	**$ 2,011,048**	**$ 4,351,631**	**$ 3,248,342**	**$ 5,146,562**	**$ 19,876,467**	**$ 16,805,285**	**$ 27,337,156**	**$ 2,713,107**	**$ 5,177,062**	**$ 4,030,836**	**$ 11,491,999**	**$ 57,488**	**$ 1,143,320**
Communications	$ 752,165	$ 265,928	$ 117,109	$ 78,443	$ 90,683	$ 1,805,865	$ -	$ 478,448	$ 566,906	$ 566,906	$ 420,590	$ 587,768	$ -	$ -
Gas	$ 309,224	$ 3,709	$ -	$ 279,804	$ -	$ 661,978	$ -	$ -	$ 305,250	$ 29,649	$ 3,709	$ 287,139	$ 11,127	$ -
Green Infrastructure	$ 851,193	$ 634,222	$ 619,387	$ 1,121,943	$ 129,812	$ 1,596,683	$ 328,238	$ 2,091,821	$ 231,806	$ 1,186,849	$ 1,146,051	$ 1,630,063	$ -	$ -
Hastings and Greenway	$ -	$ -	$ -	$ -	$ 2,843,492	$ -	$ 9,395,887	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Lighting	$ 359,393	$ 94,577	$ 104,035	$ 151,323	$ 151,323	$ 643,124	$ 283,731	$ 908,681	$ 340,477	$ 264,816	$ 435,054	$ 586,378	$ -	$ -
Power	$ 3,528,854	$ 967,931	$ 2,945,901	$ 0	$ 562,455	$ 7,588,749	$ 55,634	$ 2,262,987	$ 364,585	$ 2,623,121	$ 1,408,419	$ 6,554,558	$ -	$ 680,769
Roadway	$ -	$ -	$ -	$ -	$ -	$ 2,781,677	$ -	$ 18,915,404	$ -	$ -	$ -	$ -	$ -	$ -
Sanitary	$ 754,939	-$ 0	$ 318,199	$ 849,669	$ 64,318	$ 1,255,690	$ 409,066	$ 342,327	$ 335,296	$ 204,400	$ 40,798	$ 547,093	$ 0	$ -
Storm	$ 1,013,297	$ 44,680	$ 136,000	$ 341,223	$ 1,304,480	$ 2,740,074	$ 6,324,674	$ 2,151,574	$ 201,606	$ 266,764	$ 576,216	$ 738,162	-$ 0	$ -
Water	$ 15,454	$ 0	$ 111,000	$ 425,937	$ -	$ 802,629	$ 8,056	$ 185,915	$ 367,181	$ 34,557	$ -	$ 560,838	$ 46,361	$ 462,551
Removal	**$ 403,835**	**$ 7,907**	**$ 1,776**	**$ 189,551**	**$ 214,556**	**$ 438,784**	**$ 546,184**	**$ 675,610**	**$ 11,405**	**$ 102,811**	**$ 100,403**	**$ 52,084**	**$ 433,444**	**$ 104,466**
Communications	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gas	$ 194,265	$ 7,907	$ 1,776	$ -	$ 17,296	$ -	$ 27,929	$ -	$ -	$ -	$ 11,310	$ 10,466	$ -	$ -
Green Infrastructure	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Hastings and Greenway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Lighting	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Power	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Roadway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sanitary	$ 209,570	$ -	$ -	$ 86,462	$ 58,612	$ 380,957	$ 291,048	$ 162,276	$ 11,405	$ 82,092	$ 60,805	$ 17,679	$ 68,142	$ -
Storm	$ -	$ -	$ -	$ 84,186	$ 111,806	$ -	$ 64,414	$ 411,084	$ -	$ 20,719	$ -	$ 23,940	$ 313,011	$ -
Water	$ -	$ -	$ -	$ 18,903	$ 26,841	$ 57,826	$ 162,793	$ 102,250	$ -	$ -	$ 28,288	$ -	$ 52,291	$ 104,466
Renewal	**$ 6,731,507**	**$ 2,025,065**	**$ 1,888,541**	**$ 1,075,855**	**$ 1,048,059**	**$ 424,243**	**$ 148,457**	**$ 1,448,579**	**$ 850,411**	**$ 1,670,745**	**$ 1,096,079**	**$ 1,647,400**	**$ 13,211,114**	**$ 3,138,917**
Communications	$ 752,165	$ 265,928	$ 117,109	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 46,000
Gas	$ 322,709	$ 27,817	$ -	$ 153,947	$ 9,337	$ 12,608	$ -	$ -	$ -	$ 146,723	$ 31,526	$ 122,735	$ 249,872	$ -
Green Infrastructure	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Hastings and Greenway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Lighting	$ 359,393	$ 94,577	$ 104,035	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Power	$ 3,528,854	$ 967,931	$ 1,319,841	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,217,500
Roadway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sanitary	$ 1,045,389	$ 96,429	$ 30,598	$ 366,304	$ 198,398	$ 251,051	$ 16,506	$ 1,186,041	$ 180,384	$ 601,234	$ 953,504	$ 996,761	$ 3,177,373	$ 31,000
Storm	$ 119,612	$ 435,566	$ 235,354	$ 128,347	$ 597,898	$ 82,128	$ 73,073	$ 120,158	$ 385,444	$ 576,763	$ 91,569	$ 246,869	$ 8,428,034	$ 31,000
Water	$ 603,384	$ 136,817	$ 81,605	$ 427,257	$ 242,426	$ 78,456	$ 58,879	$ 142,380	$ 284,584	$ 346,025	$ 19,481	$ 281,035	$ 1,355,835	$ 813,417
Grand Total	**$ 14,719,860**	**$ 4,044,020**	**$ 6,241,947**	**$ 4,513,748**	**$ 6,409,177**	**$ 20,739,493**	**$ 17,499,926**	**$ 29,461,345**	**$ 3,574,923**	**$ 6,950,618**	**$ 5,227,318**	**$ 13,191,483**	**$ 13,702,046**	**$ 4,386,703**

URBAN systems

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PACIFIC NATIONAL EXHIBITION

Hastings Park IMP

Amphitheatre Update
Technical Memo

MEMORANDUM

URBAN systems

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FIGURES

MEMORANDUM

Date:	October 30, 2019
To:	John Brodie, Pacific National Exhibition
cc:	
From:	Spencer Thompson, Glen Shkurhan
File:	4304.0002.01
Subject:	Hastings Park Infrastructure Master Plan – Amphitheatre Update Technical Memo

This memo presents the updated infrastructure and costs required to address redevelopment of the PNE Amphitheatre (IMP Phase 2) in advance of other IMP phases. This memo serves as an update to the Hastings Park Infrastructure Master Plan (IMP) completed by Urban Systems in 2016 and the IMP Playland Scenario Evaluation Technical Memo by Urban Systems in 2019. This memo should be read in conjunction with, and as an addendum to the Hastings Park IMP.

1. Introduction

Urban Systems was retained by the Pacific National Exhibition to conduct an updated infrastructure assessment for the Hastings Park Infrastructure Master Plan (IMP) to reflect preliminary Amphitheatre designs presented in the recent PNE Amphitheatre Renewal Business Case (John Donnelly & Associates, April 2019). The business case outlined four design scenarios (distinguished 'A' through 'D'), with Scenario D involving the most extensive upgrades and highest attendance projections. Scenario D was selected as the most conservative Amphitheatre design scenario and has been applied for this updated infrastructure assessment.

Amphitheatre design Scenario D includes the following:

- A tensile roof covering the stage, floor and bleachers, and plaza.
- Three support buildings ('A' through 'C') of one, two, and three-story heights.
- Total projected capacity of 9,820 people.

The conceptual layout of the Scenario D is shown in **Figure 1** below.

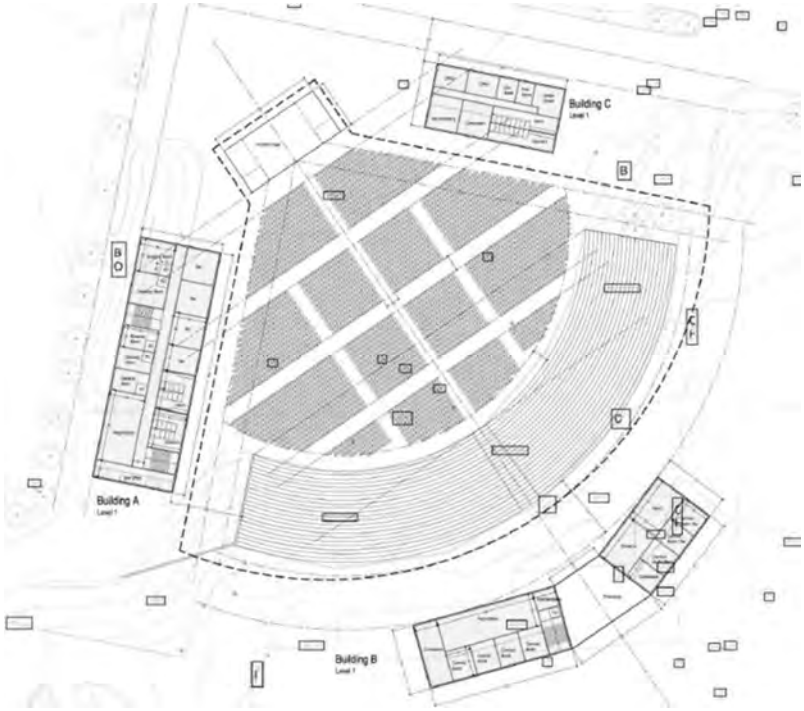

Figure 1 – Scenario D Site Plan

The following sections describe the revised assessment of infrastructure sizes and alignments, including an updated cost estimate associated with the Scenario D Amphitheatre upgrades.

The IMP infrastructure costs have been updated based on four primary drivers:

1. **Phasing** – With the Amphitheatre (Phase 2) anticipated to be redeveloped in the near term prior to other phases, we have reviewed the need to re-allocate infrastructure previously assigned to other phases into Phase 2. We have attempted to minimize the extent of long term infrastructure required to support the Amphitheatre by continuing to rely on existing infrastructure where capacity exists and where this would not diverge from or conflict with the long term infrastructure plans.
2. **Trunk infrastructure sizing** – Using the projected attendance numbers and anticipated facilities within the footprint we reviewed the proposed sizing of all infrastructure types. The modest change in attendance projects has not significantly influenced infrastructure sizing and has the smallest impact to costs relative to the IMP.
3. **Local infrastructure allowances** – The IMP focused on trunk infrastructure to service key facilities and areas of the park. Based on the conceptual redevelopment plans and building layouts, we have included an allowance for local infrastructure services within the Amphitheatre footprint (ie. water, storm, and sanitary services to the buildings).
4. **Site electrification** – The Phase 1 and 2 infrastructure costs have been revised to consider phasing out natural gas in support of renewable energy sources for cooking and heating. This has resulted in the electrification of Phase 1A (existing Playland) and Phase 2 (Amphitheatre) with

upsized electrical equipment and infrastructure to handle all estimated cooking and heating loads which currently utilize natural gas. Electrification of all other phases will be reviewed as a separate assignment and additional considerations are provided in this report.

All four considerations are described for each infrastructure type separately below.

2. Storm

The existing storm system within the Amphitheatre footprint consists of several inlet structures and services that outlet through a 200mm dedicated storm pipe towards the northwest of the Amphitheatre. A sizing assessment of the existing 200mm main has been conducted using the rational method, as runoff for the Amphitheatre will likely involve a short time of concentration. Pipe size calculations have been separated to differentiate between the proposed covered Amphitheatre and the surrounding area, which includes buildings and their dedicated service connections. Calculations have also assumed that storm sewer replacement would maintain the existing inverts and grade.

The recommended upgrades include upsizing from a 200mm to a 300mm storm sewer to service the covered amphitheatre area, and further upsizing to 375mm where proposed local building services that border the Amphitheatre will ultimately tie in, as shown in **Figure 2**. Refer to **Appendix C** for the detailed rational method calculations.

Green infrastructure was not reassessed as part of this Amphitheatre update however it was previously assessed for the entire park. Refer to the IMP Playland Scenario Evaluation Technical Memo Appendix G for the most recent rainwater management approach. The costs for green infrastructure previously identified for each phase have been carried in this assessment.

Notes:
Sewer sizing has not been completed, and replaced or upsized sewers have not been shown.
Reconnect existing catchbasins and building services to proposed storm sewers.
Detailed drainage and sewer servicing to Fair areas, playland and parking lots has not been shown.

New trenchless storm sewer outlet crossing McGill Street and rail tracks.

New ditch inlets

Overflow control structure to trunk sewer

Realigned trunk sewer to remove encumberance from Racecourse

Remove and replace existing Miller Drive storm sewer

Existing control structure to be modified to increase overflow capacity

Reconnect all roof leaders to proposed drainage systems.

Reconnect all catchbasins and local drainage to proposed drainage systems

Reconnect all Playland services to future drainage system

Low Flow Control Structure to Creekway Park

Connection to Creekway Park

Potential storm sewer connection from City system to bypass proposed water quality treatment pond.

Allowance for future separation of City storm sewer from Metro Vancouver trunk.

Existing 200 mm storm main to be upized to 300 mm upstream, and 375 mm downstream of manhole collecting proposed local storm servicing.

Local storm servicing assumed to be 150 mm diameter.

Pond

Lagoon

TUNNEL

Coliseum Plaza

North Agrodome

North Livestock

South Agrodome

Italian Park

Festival Plaza

North Sanctuary

Centre Grounds

East Forum

The Gardens Gardens

Festival Meadows

Momiji

Recirculation Forcemain

IMP Update
Amphitheatre Renewal
Future Storm Servicing Schematic

Legend

- Study Boundary
- Fair Areas
- Infrastructure to be Removed or Abandoned

Future Storm System

- Future Storm Manhole
- Future Control Structure
- Future Pump
- Amphitheatre Local Storm Servicing
- Future Dedicated Storm Sewer
- Future Recirculation Forcemain
- Future Box Culvert

Existing Storm System

- Manhole
- Main
- Metro Vancouver Trunk

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

0 25 50 100 150 200
Metres

Coordinate System:
NAD 1983 UTM Zone 10N

Data Sources:
- All data provided by PNE from various sources, Dec 2014 - Feb 2015
- Imagery provided by the City of Vancouver, Dec 2015
- Cadastral downloaded from VanMap's Open Data catalogue, Jan 2015

Project #:	4304.0002.01
Author:	LP
Checked:	ST
Status:	Final
Revision:	A
Date:	2019 / 10 / 28

URBAN systems

FIGURE 2

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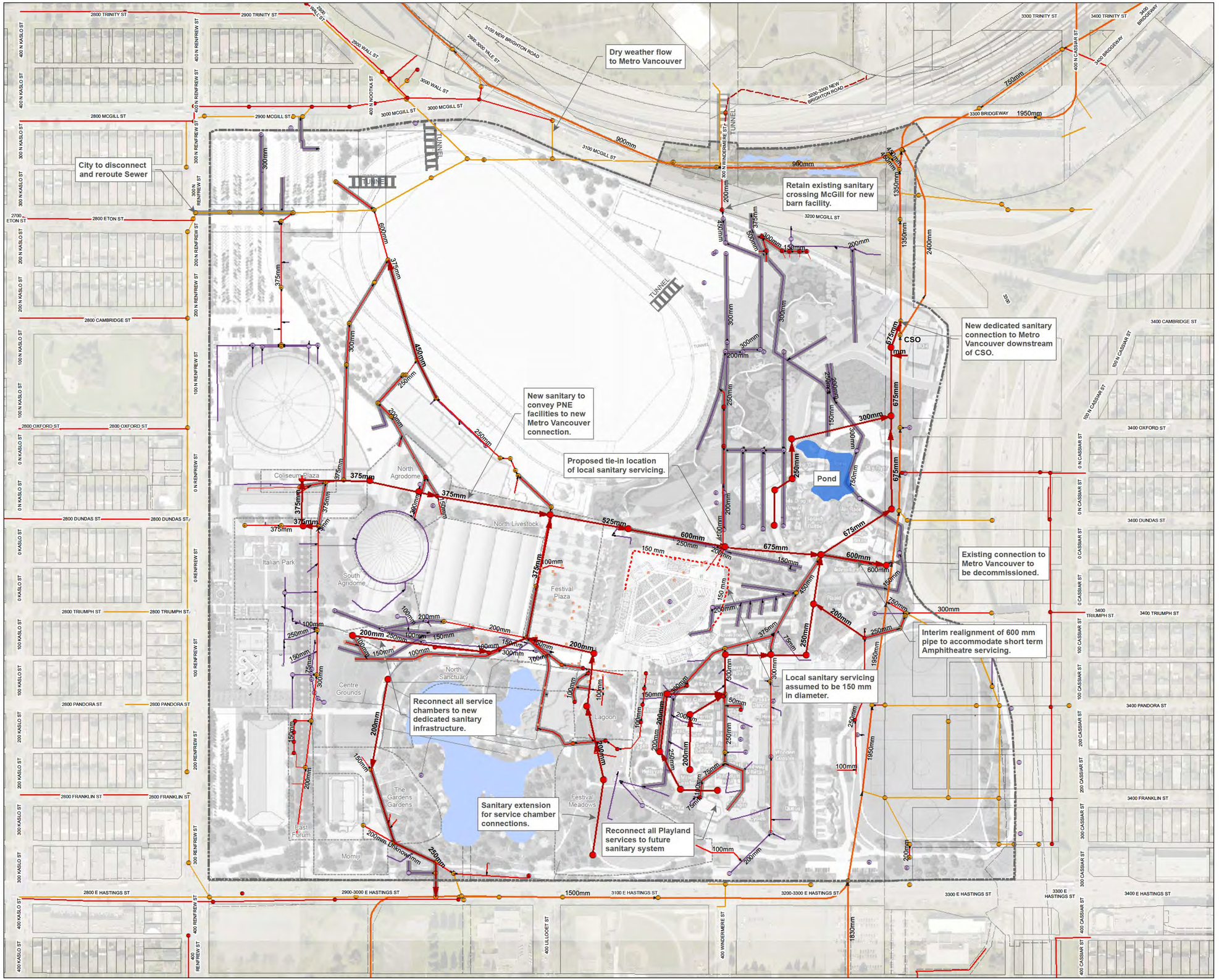
3. Sanitary

The Amphitheatre is currently serviced by a 100mm diameter dedicated sanitary main at the northeast corner of the site which flows northerly through the racecourse barns and connects to Metro Vancouver sewer at the north end of the park. There is also a 300mm diameter combined main at the southeast near the existing Playland Lowerline building. The capacity of the 100mm sanitary sewer and the downstream sewers to which it connects is unknown as a full record of invert elevations, sizes, and loads from other existing facilities are not available.

The PNE reported that no capacity issues have been observed with the existing 100mm sanitary sewer during previous fair events. However, the existing 100mm sanitary sewer may not have sufficient capacity to service the entirety of the updated Amphitheatre demands given its relatively small pipe size. Further, the downstream infrastructure will be abandoned as part of the long term park redevelopment and so it is not recommended that these pipes be explored for upgrades at this stage. The 300mm combined main in the southeast corner of the Amphitheatre may have additional capacity but could only service building B in design Scenario D given its elevation and is also proposed to be abandoned in the future sanitary servicing strategy.

In the absence of relying on existing infrastructure, a dedicated sanitary main flowing east along Miller Drive is proposed to service all of the Amphitheatre facilities as shown in **Figure 3**. Local servicing is proposed within the Amphitheatre to provide connections to each of the three Scenario D buildings.



IMP Update
Amphitheatre Renewal
Future Sanitary Servicing Schematic

Legend

- Study Boundary
- Fair Areas
- Infrastructure to be Removed or

Future Sanitary System

- Future Sanitary Manhole
- Amphitheatre Local Sanitary Servicing
- Future Sanitary Main

Existing Sanitary System

- Manhole
- Valve
- Clean Out
- Main
- Service
- Sanitary Service Chamber

Existing Combined System

- Manhole
- Valve
- Metro Vancouver Trunk
- Main

Sewers that are assumed to be combined unless proven otherwise through field testing

- Manhole
- Valve
- Main

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

0 25 50 100 150 200

Metres

Coordinate System:
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URBAN systems

FIGURE 3

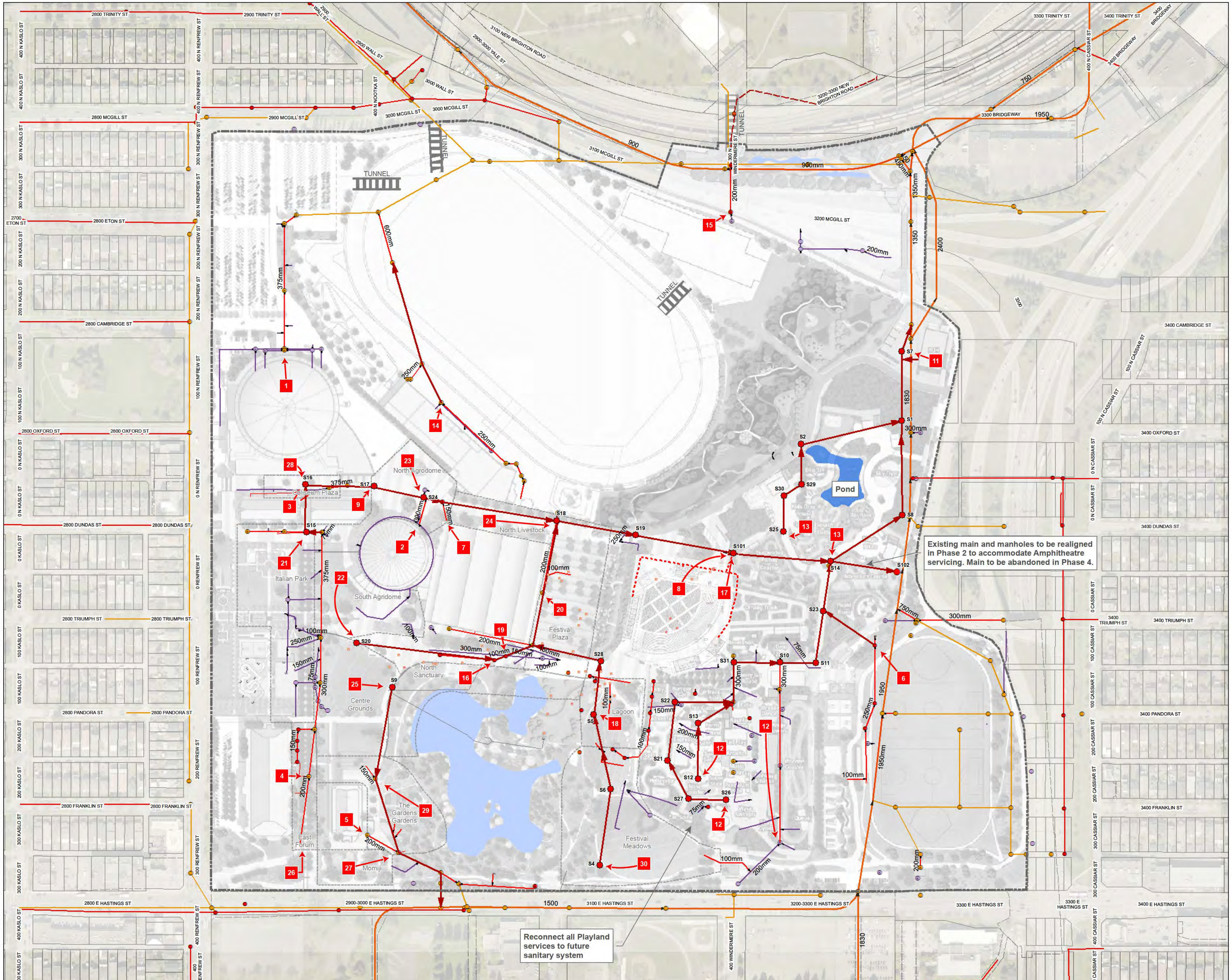
\\us.urban-systems.com\projects\Projects_VAN\4304\0002\01\D-Design\GIS\Projects\MXD\Final Report Figures - 20191028\Figure 3 - Future Sanitary Servicing Schematic.mxd Last updated by lpunt on October 28, 2019 at 2:23:41 PM

Due to topography constraints along Miller Drive, this approach will also require an existing manhole at the north end of Playland to be replaced and lowered to facilitate positive grades from the upstream sewers. This manhole was proposed to be replaced by S14 in Phase 1A of the IMP's future servicing strategy as shown in **Figure 4** and **Figure 5**, but is now a proposed Phase 2 replacement. This will also require part of the existing 600mm pipe connected to the Metro Vancouver combined main to be replaced at a shallower grade until Phase 4 of the servicing strategy is complete.

Loading calculations from the IMP have been applied with Scenario D attendance projections and produced an 11 L/s increase from 41 L/s to 52 L/s under existing conditions, which is a negligible addition compared to the total calculated flow in the pipe of 800 L/s. Despite the minimal flow increase that would result from the Amphitheatre, Metro Vancouver has stated this connection may be subject to further review.

This dedicated sanitary line from the Amphitheatre opens the opportunity to direct all future sanitary flows from the west along Miller Drive, rather than the utility corridor adjacent to the daylight creek as proposed in the original IMP. The would require temporary oversizing of the main servicing the Amphitheatre but would eliminate the need to abandon this main and reconnect Amphitheatre services in future phases. This revised strategy is presented in the figures above, and calculations for existing pipe sizing near the Metro Vancouver connection and the revised trunk sewer alignment are presented in **Appendices D1** and **D2**.

This interim sanitary connection to Metro Vancouver shown in Figure 3 is consistent with the long term plans from the IMP in that a large portion of the sanitary flows from Hastings Park would be directed to the east of the site and connected to the Metro Vancouver trunk sanitary sewer. Metro Vancouver was contacted to explore the feasibility of this interim connection (distinct from the long term connection point which was proposed near the future Playland expansion Back of House). Metro Vancouver noted that additional information on sanitary design flows from Hastings Park would be required prior to making the finalizing the sanitary sewer design and noted that the existing Metro Vancouver sanitary sewer is nearing or at capacity. As the scope of this assignment is primarily to update the IMP costs, particularly those associated with Phase 2, it is recommended that Metro Vancouver be engaged to confirm design details and requirements for connection as part of subsequent phases of work.



CITY OF VANCOUVER

IMP Update Amphitheatre Renewal

Future Sanitary Loading

Legend

- Study Boundary
- Fair Areas

Future Sanitary System

- Sanitary Load Input
- Amphitheatre Local Sanitary Servicing
- Future Sanitary Manhole
- Future Sanitary Main

Existing Sanitary System

- Manhole
- Valve
- Clean Out
- Main
- Service
- Sanitary Service Chamber

Existing Combined System

- Manhole
- Valve
- Metro Vancouver Trunk
- Main

Sewers that are assumed to be combined unless proven otherwise through field testing

- Manhole
- Valve
- Main

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

0 25 50 100 150 200
Metres

N

Coordinate System:
NAD 1983 UTM Zone 10N

Data Sources:
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Status:	Final
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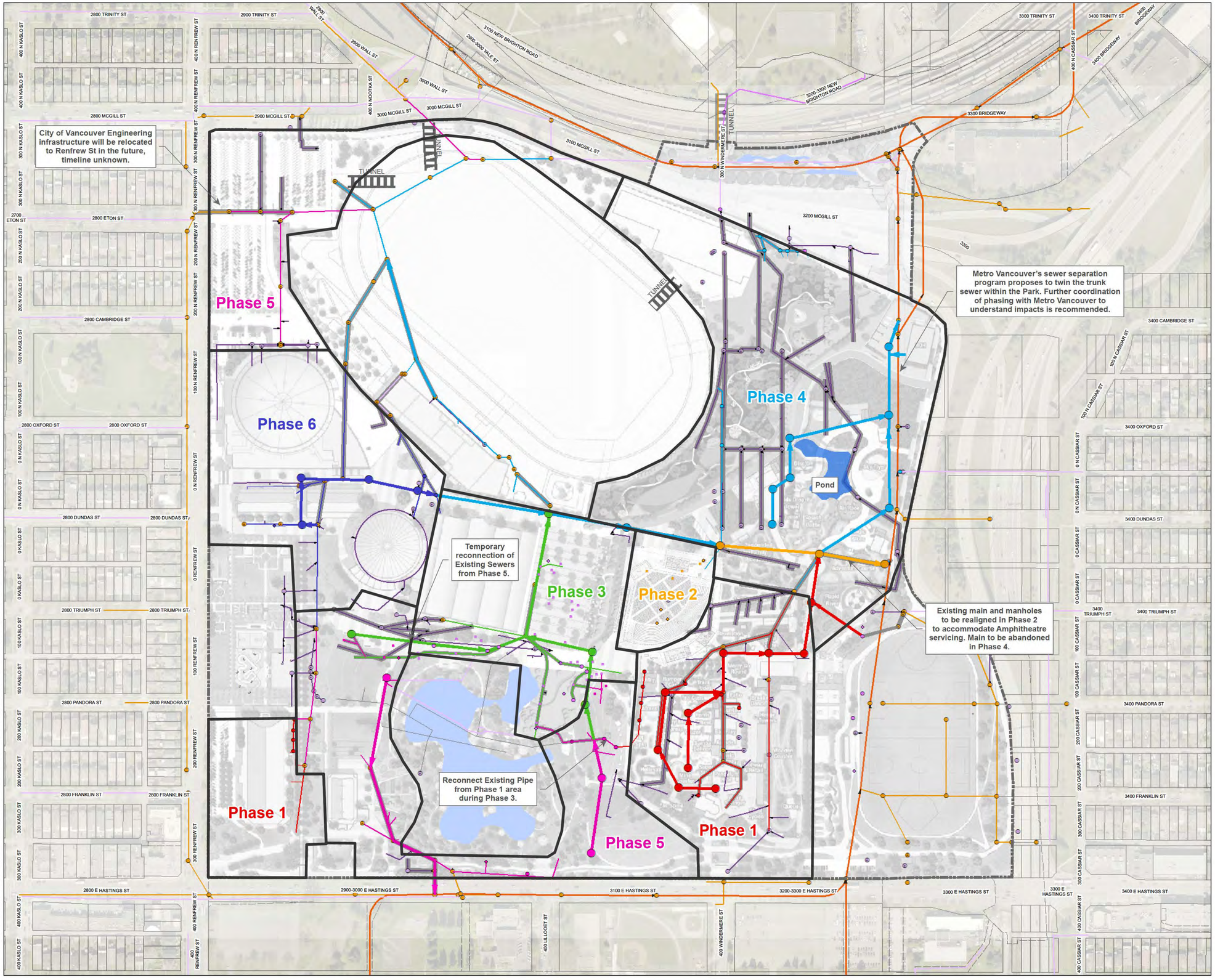
FIGURE 4



IMP Update
Amphitheatre Renewal

Future Sanitary Implementation Strategy

Legend

- Study Boundary
- Master Plan Implementation Timeframe
- Infrastructure to be Removed or Abandoned

Dedicated Sanitary System

- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5
- Phase 6
- Unchanging Areas

Existing Combined System

- Manhole
- Valve
- Metro Vancouver Trunk
- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5
- Phase 6
- Unchanging Areas

Sewers that are assumed to be combined unless proven otherwise through field testing

- Manhole
- Valve
- Main

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0 25 50 100 150 200

Metres

Coordinate System:
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FIGURE 5

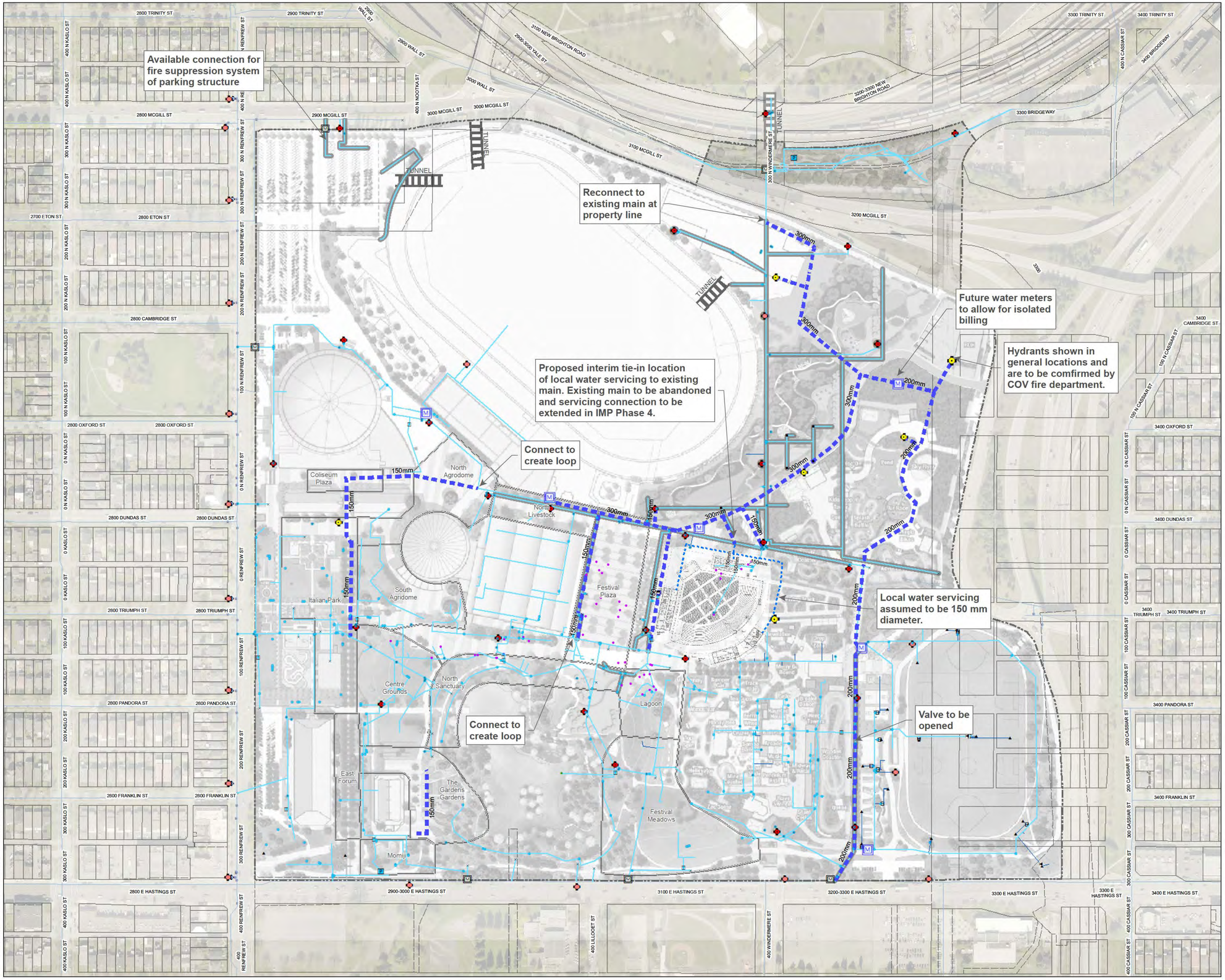
4. Water

The Amphitheatre is adjacent to existing 150mm diameter water mains on the north and west sides, which include four hydrants (two at the north and two at the southwest). The new Amphitheatre facilities proposed in design Scenario D produce a considerable increase in fire flow demands compared to existing conditions, especially the three-story building B. Local servicing of 150mm diameter water mains is proposed for each building to service indoor fire sprinkler systems in the event they are required. This should be reviewed in subsequent phases of design.

A WaterCAD model prepared for the original IMP was modified to analyze the capacity of the existing and future water systems throughout the park, and to support a servicing strategy that meets the needs of the Ampitheatre re-development while utilizing existing infrastructure to the extent possible.

The modelling details and infrastructure recommendations are presented in the technical memo "Amphitheatre Update Water System Analysis" in **Appendix B**. Our analysis indicated that fire flow demands for buildings B can be satisfied by accessing the existing fire hydrant near the southwest lower level Amphitheatre entrance, in conjunction with a new proposed hydrant which would be located near building B to Miller Drive as shown in **Figure 6**.

Although the existing hydrant adjacent to the Lowerline building appears to be a convenient source for building B fire flows, the hydrant's elevation and location within the network did not produce sufficient residual pressure when used in tandem with other hydrants for building B fire flows. Furthermore, the valve located on the 150mm main running east of Playland will need to be opened as previously recommended in the IMP in order to create a looped system. The proposed water servicing strategy and fire fighting approach should be reviewed with the City's fire department and emergency responders prior to design advancement.



IMP Update
Amphitheatre Renewal

Future Water Servicing Schematic

Legend

- Study Boundary
- Fair Areas
- Infrastructure to be Abandoned

Future Water System

- Future Hydrant
- Future Radio Read Water Meter
- Amphitheatre Local Water Servicing
- Future Water Mains

Existing Water System

- Unsurveyed Hydrant
- Surveyed Hydrant
- Pump
- Valve
- Curb Stop Valve
- DCVA
- Backflow Control
- Meter
- Filler Station
- Vault
- DPVH
- Hose Bib
- Outlet
- Water Fountain
- Reducer
- Cap
- Utility Chamber (Water/Sanitary Service)
- Water Mains
- Service

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0 25 50 100 150 200

Metres

Coordinate System:
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Revision:	A
Date:	2019 / 10 / 29

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FIGURE 6

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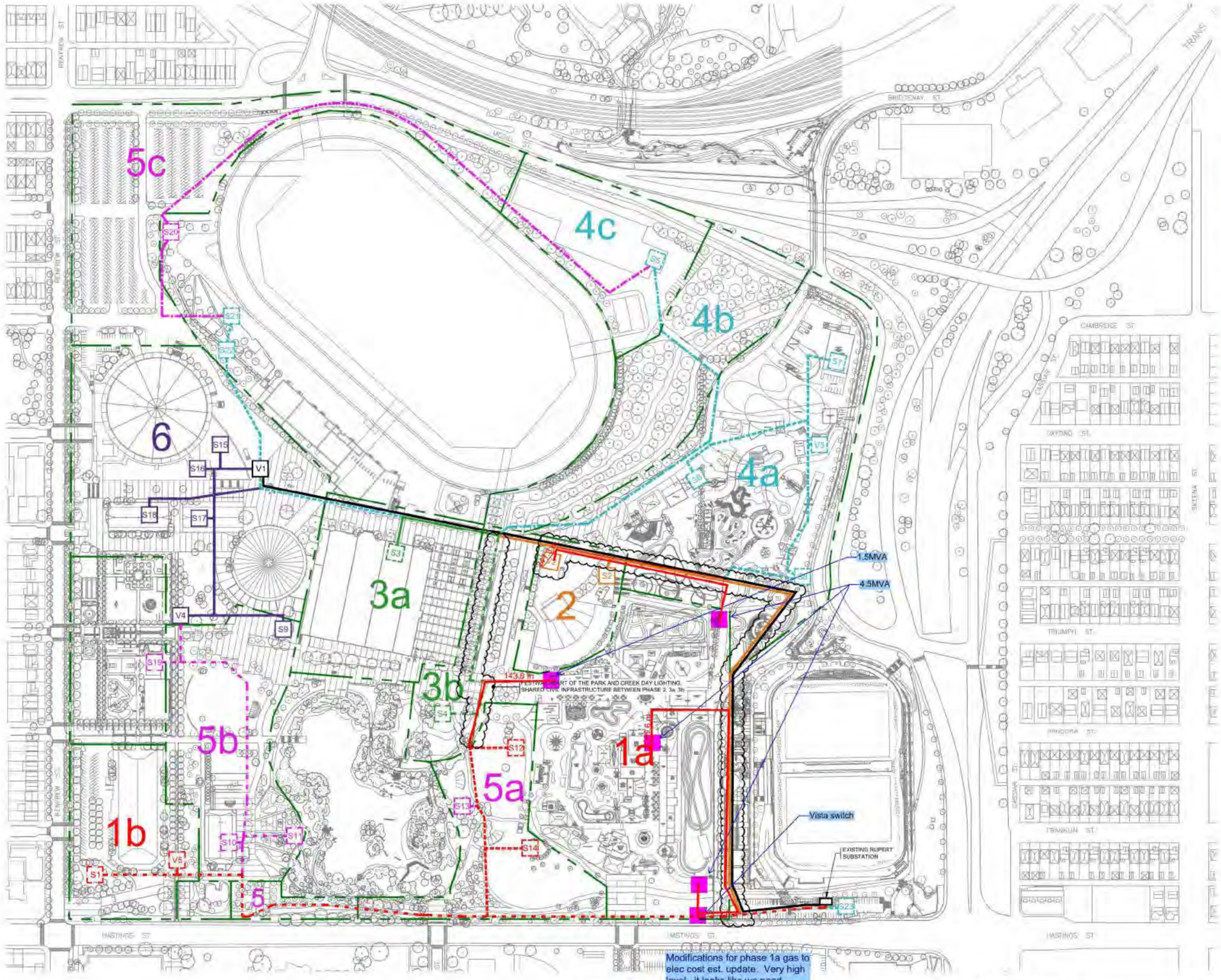
Power, Communications, and Lighting

The electrical servicing strategy has received a number of key changes as a result of revised implementation (Amphitheatre being implemented ahead of other phases). Electrical infrastructure connecting the Amphitheatre to the existing Rupert Substation have been moved from Phase 1A to Phase 2, while duct banks and cables within the Heart of the Park have been shifted from Phase 2 to Phases 1B, 3A, and 3B. Refer to **Appendix E** for further discussion on power and communication infrastructure changes and **Figure 7** for updated site plans showing the power, communications, and lighting infrastructure.

Further to DMD's assessment of the revised Amphitheatre infrastructure requirements, the PNE has also stated the existing Garden Substation failed oil tests by RESA Power Service in August 2018 and require replacement in advance of other IMP Phases. Components within the Garden Substation that are reaching end of life include switch gears, circuit breaks, and two 1750 kVA transformers that transform 12.5kV to 4.16kV for distribution around the park. The two transformers are redundant as each has capacity to meet the Park's existing peak load of 1708 kVA, however, it is expected that failure of one transformer would be soon followed by failure of the other. Replacing or reprocessing of the oil may briefly extend the service life, but full replacement is still required. Like-for-like replacement of the existing transformers does not align with the IMP electrical servicing strategy but was the chosen approach to address immediate needs without upgrading the existing 4.16kV system to 12.5/25kV throughout the park as proposed in the IMP. A budget cost for replacement of this substation has been established by DMD, and is presented in **Appendix A** costs under an additional "Prerequisite" phase to be implemented first. The breakdown of this cost if presented in Section 7 of DMD's report in **Appendix E**.

As part of the 2050 Renewable Action Plan, the City of Vancouver has requested that non-renewable energy, specifically natural gas infrastructure, is to be phased out of the Hastings Park IMP in favour of renewable energy sources. This has implications on the electrical servicing strategy that has been carried throughout the IMP. We have identified two "streams" to address priority work and future work that will satisfy this energy requirement:

- **Stream 1 (included in this assessment) –** Update IMP infrastructure costs to reflect phasing out of gas for heating and cooking and converting to electrical for Phases 1A and 2 as requested by the PNE and City of Vancouver. This electrification is limited to conversion of estimated gas loads to electrical loads by Rocky Point, as presented in **Appendix F2**. This immediate stream does not consider alternative energy strategies that could optimize the cost and implementation of phasing out non-renewable energy sources but acknowledges that options exist for further consideration in Stream 2. Stream 1 continues to carry natural gas for the remaining IMP phases, with a park-wide review suggested for Stream 2.
- **Stream 2 (Future Work)** – Revisit the IMP more broadly to assess the implications of switching to renewable energy park-wide. This would consider if electrification is suitable for all facilities, or whether alternative renewable energy sources may be more appropriate. A preliminary list of alternative energy sources has been identified for consideration below, which include building-scale heat pumps, renewable natural gas, and district energy.



SITE PLAN
0 1:2000 80

LEGEND:

- S1 OUTDOOR UNIT SUBSTATION (No. INDICATES LOCATION)
- V1 VISTA TYPE PRIMARY SWITCHGEAR (No. INDICATES LOCATION)
- DUCTBANKS (TRENCH)

IMPLEMENTATION TIMELINE:

- EXISTING
- PHASE 1a (1 TO 5 YEARS)
- PHASE 1b (1 TO 5 YEARS)
- PHASE 2 AMPHITHEATER SCENARIO D (TO OCCUR FIRST)
- PHASE 3a (5 TO 8 YEARS)
- PHASE 3b (5 TO 8 YEARS)
- PHASE 4a (8 TO 12 YEARS)
- PHASE 4c (8 TO 12 YEARS)
- PHASE 5a (12 TO 15 YEARS)
- PHASE 5b (12 TO 15 YEARS)
- PHASE 5c (12 TO 15 YEARS)
- PHASE 6 (15 TO 20 YEARS)

NOT FOR CONSTRUCTION
2019-09-13

Figure 7

REFERENCE: HASTINGS PARK INFRASTRUCTURE MASTER PLAN DMD 6299A-18 E1, E2 REV A

DMD
DMD & Associates Ltd.
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CHECKED	DON CRONAN
DATE	NOVEMBER 27, 2015
SCALE	1:2000

SEAL

No.	DATE	BY	CHK'D	REVISION
A	2019-09-13	MDGS	DC	REVISED TO SHOW AMPHITHEATER SCENARIO D

Urban Systems Ltd.
550 - 1090 Homer St., Vancouver, B.C., V6B 2W9, Tel: (604) 253-1701

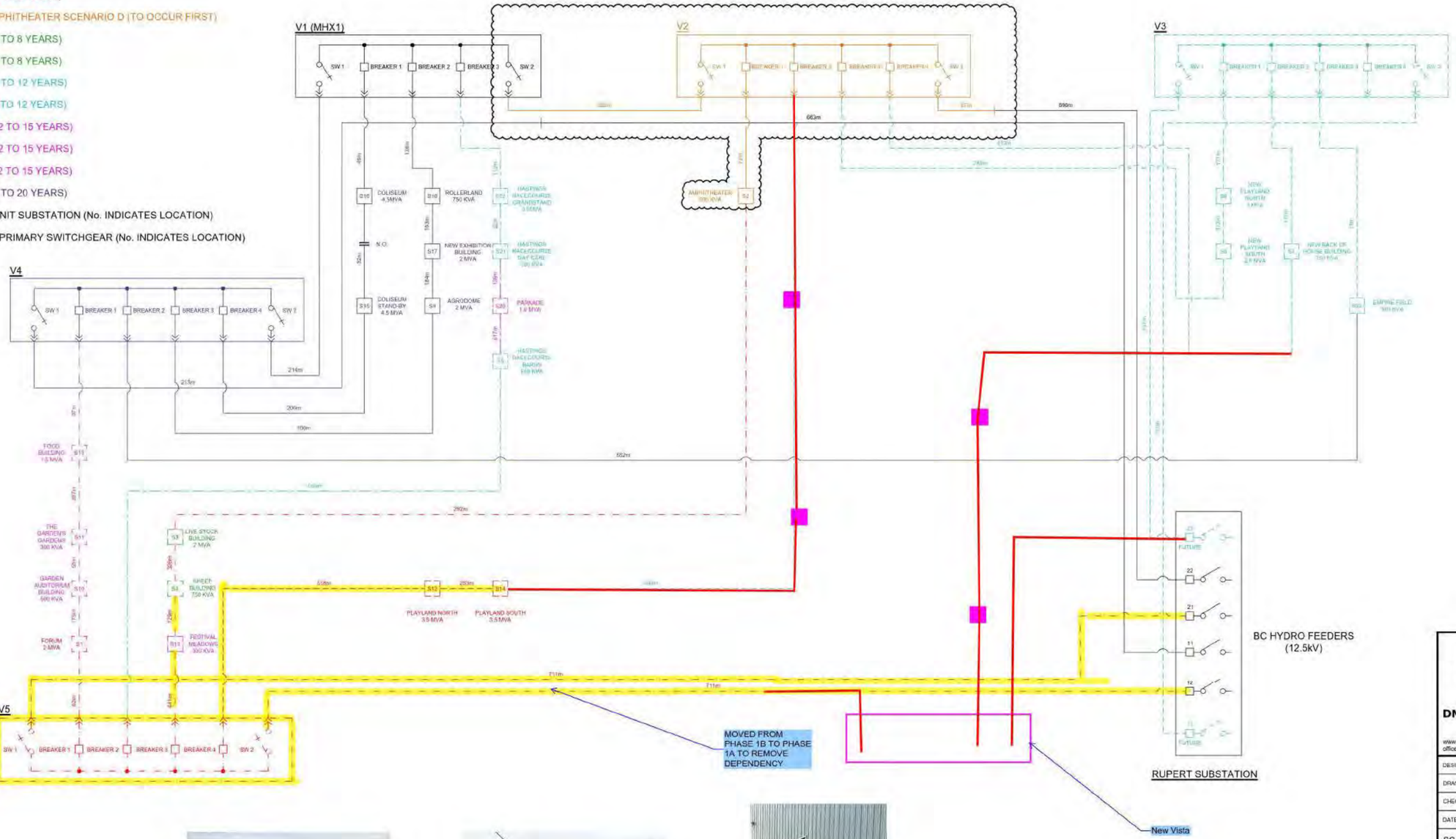
PRIMARY ELECTRICAL SYSTEM
MASTER PLAN AMPHITHEATER SCENARIO D
HASTINGS PARK, VANCOUVER

PROJECT No.	SHEET No.	REVISION
6299A-18-01 of 02	E1	A

DRAWING REFERENCE

LEGEND:

- EXISTING
- PHASE 1a (1 TO 5 YEARS)
- PHASE 1b (1 TO 5 YEARS)
- PHASE 2 AMPHITHEATER SCENARIO D (TO OCCUR FIRST)
- PHASE 3a (5 TO 8 YEARS)
- PHASE 3b (5 TO 8 YEARS)
- PHASE 4a (8 TO 12 YEARS)
- PHASE 4c (8 TO 12 YEARS)
- PHASE 5a (12 TO 15 YEARS)
- PHASE 5b (12 TO 15 YEARS)
- PHASE 5c (12 TO 15 YEARS)
- PHASE 6 (15 TO 20 YEARS)
- S1 OUTDOOR UNIT SUBSTATION (No. INDICATES LOCATION)
- V1 VISTA TYPE PRIMARY SWITCHGEAR (No. INDICATES LOCATION)



NOTES:

1. THIS DRAWING IS A SPECIAL SIMPLIFIED SINGLE LINE DIAGRAM DESIGNED TO SHOW THE OVERALL HASTINGS PARK/PNE MEDIUM VOLTAGE DISTRIBUTION ON A SINGLE DRAWING.
2. PROPOSED PRIMARY SYSTEM VOLTAGE IS 7.2/12.5kV. ALL PRIMARY SERVICE EQUIPMENT MUST BE RATED AND CERTIFIED FOR FUTURE OPERATION AT 14.4/25kV SUPPLY.

TYPICAL OUTDOOR VISTA TYPE PRIMARY SIWTCHGEAR
N.T.S.

TYPICAL OUTDOOR UNIT SUBSTATION INCLUDING PRIMARY SWITCH GEAR & TRANSFORMER - 1
N.T.S.

TYPICAL OUTDOOR UNIT SUBSTATION INCLUDING PRIMARY SWITCH GEAR & TRANSFORMER - 2
N.T.S.

REFERENCE: HASTINGS PARK INFRASTRUCTURE MASTER PLAN DMD 6299A-18 E1, E2 REV A

NOT FOR CONSTRUCTION
2019-09-13

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DATE	JUNE 08/2015
SCALE:	N.T.S.
SEAL	

No.	DATE	BY	CHK'D	REVISION
A	2019-09-13	MDGS	DC	REVISED TO SHOW AMPHITHEATER SCENARIO D

DRAWING REFERENCE

Urban Systems Ltd.
550 - 1090 Homer St., Vancouver, B.C., V6B 2W9, Tel: (604) 253-1701

PRIMARY ELECTRICAL SYSTEM
SINGLE LINE DIAGRAM - PROPOSED
MASTER PLAN AMPHITHEATER SCENARIO D
HASTINGS PARK, VANCOUVER

PROJECT No:	SHEET No:	REVISION
6299A-18-02 of 02	E2	A

To address the Stream 1 electrification requirements, DMD has used the electrifieid gas loads and revised electrical sizing requirements in Phases 1A and 2. The result is a considerable increase in the sizing of electrical infrastructure compared to the previous IMP strategy, which is reflected in the overall cost. However, this is a conservative assessment conducted for Stream 1 and does not consider alternative renewable energy sources that should be considered to reduce the impacts of phasing out non-renewable energy.

The overarching objective of electrification is to reduce or eliminate greenhouse gas (GHG) emissions associated with natural gas use. With respect to cooking, electrification is a practical option to reduce GHGs. However, as shown in DMD's analysis, it plays a large role in increasing the transformer size requirement and has significant cost implications. With respect to heating, the current analysis assumes that resistance heat (e.g. electric baseboards) would be provided. There would be other ways of achieving similar GHG objectives. Below is a list of other options that may warrant further exploration:

1. **Building-Scale Heat Pumps** – Heat pumps can be used to convert electricity into heat at a high efficiency. It is common for heat pumps to operate at an efficiency (coefficient of performance) greater than 300%. This means that one unit of electricity can provide three, or more, units of heat. Heat pumps can be installed instead of other means of heat production such as electric baseboards. It should be noted, however, that heat pumps can often only heat down to +5 ^{0}C, so a secondary back up heating source would be required to accommodate Vancouver's -7 ^{0}C winter design conditions.

2. **Renewable Natural Gas –** Renewable Natural Gas (RNG) is produced from decomposing organic materials from landfills, agricultural waste and wastewater treatment bi-products. Biogas is captured from these decomposing materials and cleaned to create carbon neutral RNG. RNG can be purchased from Fortis at a premium relative to conventional natural gas. This option would have the least impact to the strategy identified in the current IMP, in that gas piping in the park would continue to be renewed and expanded. RNG can be used for cooking purposes as well as heating purposes.

3. **District Energy –** A district energy (DE) system could be established to provide heat, and hot water, to buildings in Hasting Park. A DE system would centralize heat production and provide heat to buildings through a water-based distribution network. The method of centralized heat production can vary and can also include multiple energy sources, such as:
    a. Biomass (e.g. combustion or gasification of wood waste)
    b. Geoexchange (heat from the ground)
    c. Solar (heat from the sun)
    d. Heat recovery (from buildings or wastewater); and
    e. Natural gas (including renewable natural gas).

Energy sources such as geoexchange and heat recovery would require the use of heat pumps, similar to #1 above. The City of Vancouver already has a DE system that provides heat to buildings in the Southeast False Creek neighbourhood. The Vancouver DE system uses heat pumps to extract thermal energy from wastewater.

Phasing is an important consideration with any of the options described above. Renewable natural gas can be purchased and used in existing buildings without any infrastructure impacts. In general, building-

scale heat pumps or district energy systems can be more easily deployed in new construction; however, retrofits to existing buildings are also possible. District energy systems commonly expand with time as additional buildings connect to the network. In the case of Hastings Park, it will be important to develop a phasing strategy to optimize the business case of the selected option(s).

Further analysis is recommended to determine the best option, or combination of options, for Hastings Park. This could begin with a pre-feasibility or feasibility study of some of the options described above. This could also include the development of an Energy Plan for Hastings Park. The advancement of energy studies and an Energy Plan were identified as recommendations in the 2013 Playland Master Plan and associated Sustainability Report. Discussions with City staff may help to refine potential next steps and determine which option(s) to study further.

5. Gas

In accordance with the City's request to phase out natural gas, the IMP gas servicing strategy has been updated in Phases 1A and 2 as part of Stream 1 works (as previously described), with the remaining phases proposed to be considered in Stream 2. This update reduces the IMP costs for gas in Phases 1A and 2, as infrastructure that was previously identified as "new" or upsized has now been deleted (and replaced with electrification as previously discussed) and infrastructure that was to be renewed is now identified as "abandoned" to reflect long term removal at a lower cost.

These updates for Stream 1 impact the overall IMP gas servicing strategy, as proposed gas upgrades in Phase 1A and 2 would service future phases of the gas system. As previously discussed, the IMP gas upgrades and expansions in all other phases have not been modified, and therefore would require further design and costs revisions to reflect the removal of gas from Phases 1 and 2.

However, the purpose of the Stream 1 costs are for funding allocation and project schedule for Phases 1A and 2, so the overall gas servicing strategy will be revisited in Stream 2.

Refer to **Appendix F1** for further information on gas infrastructure servicing and **Appendix F2** for the conversion of gas loads to equivalent electrical loads.

6. Detailed Design Considerations

As implementation of the Amphitheatre Phase 2 nears, several considerations for detailed design have been identified for each infrastructure type. These considerations are as follows:

- **Storm** – Maintaining of existing local services and the location of new services should be confirmed to establish the connection of roof leaders, drains or catchbasins, and the exact replacement size of the existing 200mm main. It has been proposed in the section 2 assessment that replacement should be 300mm upstream, and 375mm downstream of the tie-in location for new local services.

- **Sanitary** – The revised sanitary servicing strategy shown in **Figure 3** proposes the sanitary main servicing the Amphitheatre to be located along the existing Miller Drive. However, this alignment crosses beneath a potential ride footprint on the Mater Plan future site plan. This main would also require shallow grades to direct flows east towards the Metro Vancouver combined trunk sewer. A more detailed review will be required to establish interim and ultimate alignments of the trunk sanitary sewer. Metro Vancouver has also identified that additional detail will be required on anticipated flow rates to support the proposed re-direction of flows to the interim connection identified in the plans.
- **Water** – The updated water servicing strategy included the addition of a new hydrant near building B in design Scenario D to provide sufficient flow flows in conjunction with an existing hydrant to the southwest of the Amphitheatre. Prior to or during detailed design these recommendation hydrant locations should be reviewed in consultation with the Vancouver Fire Department in consideration of the emergency response plan for the Park and access to hydrants.

7. Cost Estimate and Conclusion

A revised cost estimate presenting cost changes associated with the Amphitheatre design Scenario D infrastructure updates is provided in **Appendices A1** through **A4**. Estimated costs are presented by sub-phases and program type (new, renewal, removal), and have been built upon the 2018 Playland IMP Update - Scenario 1 costs (Proposed Playland Redevelopment as per the 2016 IMP). All costs include 20% for engineering and 30% for contingency, consistent with the IMP.

The implementation order of subphases in **Appendix A1** is presented chronologically A though N, beginning with the "Prerequisite Phase" to address the near-term garden substation replacement. **Appendix A4** is provided with an accompanying spreadsheet file so that the breakdown of program type can be viewed for each infrastructure category.

Infrastructure changes for the Amphitheatre update apply unit rates established in 2015, which in addition to results from 2018 IMP Update, have been escalated to 2020 dollars. The 2020 costs have been escalated by approximately 10% from 2015 to 2018, and 12.4% from 2018 to 2020 (based on a 6% annual escalation) using escalation rates recommended by the City of Vancouver. Amphitheatre cost changes are separated into "local servicing" for updated infrastructure within the Amphitheatre footprint, and "trunk infrastructure" for all other costs, including those resulting from phasing implications.

As a result of the Stream 1 electrification gas costs have slightly reduced in Phases 1A and 2, but electrical costs for power, communication, and lighting have significantly increased. This is due to the additional infrastructure required to address electrical loads that have been converted from natural gas. The total cost in 2020 dollars of electrification alone is estimated to be $11.0 million in Phase 1A and $5.3 million in Phase 2. Furthermore, replacement of the existing garden sub-station (including removal of existing transformers, as well as installation and supply of new transformers, switchgears, relays, and breakers) is estimated to be $2.2 million, which includes 20% for engineering and 30% for contingency.

Electrical costs have previously been considered as entirely new infrastructure in the IMP. However, some of the "new" infrastructure is expected to replace end-of-life infrastructure, which is categorized as "renewal" costs for other infrastructure types. Electrical infrastructure costs have been split 50% into "new" and 50% into "renewal" program types based on approximate comparison of proposed versus existing infrastructure footprints.

The total Amphitheatre Phase 2 costs in 2020 dollars have increased by approximately $7.1 million. The total IMP costs have increased $24.0 million compared to infrastructure costs presented in the IMP, with the total infrastructure costs estimate now $167.0 million instead of $142.9 million ($127.1 million in 2018 dollars) determined for Scenario 1 in the 2018 IMP Update.

As described above it is recommended that:

- The local servicing schematics for the Amphitheatre identified be reviewed and adjusted as part of subsequent phases of design once a preferred site layout is selected.
- The water servicing assessment and fire hydrant recommendations presented herein be reviewed with the Fire Department.
- Metro Vancouver be engaged on to review design requirements for reconnection to the existing Metro Vancouver sanitary sewer at the east end of the Park.

Sincerely,

URBAN SYSTEMS LTD.

Kean Ring, EIT

Spencer Thompson, P.Eng.
Project Engineer

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APPENDIX A1 – COST SUMMARY

Infrastructure Costs - IMP Update Scenario 1[5] (Costs in 2020 Dollars)															
	Phase 1A	Phase 1B	Phase 2	Phase 3A	Phase 3B	Phase 4A	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite	Totals
Storm	$1.1M	$.5M	$.2M	$.6M	$2.M	$2.8M	$6.5M	$2.7M	$.6M	$.9M	$.7M	$1.M	$8.7M	$.M	$28.3M
Green Infrastructure	$.9M	$.6M	$.6M	$1.1M	$.1M	$1.6M	$.3M	$2.1M	$.2M	$1.2M	$1.1M	$1.6M	$.M	$.M	$11.6M
Hastings and Greenway	$.M	$.M	$.M	$.M	$2.8M	$.M	$9.4M	$.M	$.M	$.M	$.M	$.M	$.M	$.M	$12.2M
Sanitary	$2.M	$.1M	$.M	$1.3M	$.3M	$2.M	$.7M	$1.7M	$.5M	$.9M	$1.1M	$1.6M	$3.2M	$.M	$15.4M
Gas	$.4M	$.1M	$.M	$.4M	$.1M	$.7M	$.M	$.M	$.3M	$.2M	$.M	$.4M	$.3M	$.M	$3.M
Water	$.8M	$.1M	$.1M	$1.1M	$.4M	$1.M	$.2M	$.4M	$.7M	$.6M	$.2M	$1.M	$1.5M	$.M	$8.2M
Power	$4.2M	$2.9M	$2.M	$.4M	$.2M	$8.5M	$.1M	$2.3M	$.4M	$2.6M	$1.4M	$6.6M	$.M	$.M	$31.5M
Communications	$.8M	$.5M	$.3M	$.M	$.M	$1.9M	$.M	$.5M	$.6M	$.6M	$.4M	$.6M	$.M	$.M	$6.1M
Lighting	$.5M	$.4M	$.2M	$.2M	$.2M	$.6M	$.3M	$.9M	$.3M	$.3M	$.4M	$.6M	$.M	$.M	$4.9M
Roadway	$.M	$.M	$.M	$.M	$.M	$2.8M	$.M	$18.9M	$.M	$.M	$.M	$.M	$.M	$.M	$21.7M
Grand Total	$10.8M	$5.2M	$3.5M	$5.1M	$6.2M	$21.9M	$17.5M	$29.5M	$3.7M	$7.2M	$5.3M	$13.4M	$13.7M	$.M	$142.9M

Cost Changes - Amphitheatre Update (Costs in 2020 Dollars)															
	Phase 1A	Phase 1B	Phase 2	Phase 3A	Phase 3B	Phase 4A	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite	Totals
Trunk Infrastructure															
Storm	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Green Infrastructure	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Hastings and Greenway	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Sanitary	-$10,000.00	$0.00	$204,000.00	$0.00	$0.00	-$76,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$118,000.00
Gas	-$142,000.00	-$33,000.00	-$2,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	-$177,000.00
Water	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Power	$13,851,000.00	-$982,000.00	$6,507,000.00	$288,000.00	$333,000.00	-$887,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,218,000.00	$21,328,000.00
Communications	$2,230,000.00	$9,000.00	$82,000.00	$78,000.00	$91,000.00	-$97,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,393,000.00
Lighting	$189,000.00	-$170,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$19,000.00
Roadway	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Local Servicing Allowances[3]															
Storm	$0.00	$0.00	$136,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$136,000.00
Sanitary	$0.00	$0.00	$104,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$104,000.00
Water	$0.00	$0.00	$111,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$111,000.00
Grand Total	$16,118,000.00	-$1,176,000.00	$7,142,000.00	$366,000.00	$424,000.00	-$1,060,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,218,000.00	$24,032,000.00

Infrastructure Costs - Amphitheatre Update (Costs in 2020 Dollars)															
	Phase 1A	Phase 1B	Phase 2	Phase 3A	Phase 3B	Phase 4A	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite[6]	Totals
Implementation Order[7]	C	D	B	E	F	G	H	I	J	K	L	M	N	A	
Storm	$1.1M	$.5M	$.4M	$.6M	$2.M	$2.8M	$6.5M	$2.7M	$.6M	$.9M	$.7M	$1.M	$8.7M	$.M	$28.4M
Green Infrastructure	$.9M	$.6M	$.6M	$1.1M	$.1M	$1.6M	$.3M	$2.1M	$.2M	$1.2M	$1.1M	$1.6M	$.M	$.M	$11.6M
Hastings and Greenway	$.M	$.M	$.M	$.M	$2.8M	$.M	$9.4M	$.M	$.M	$.M	$.M	$.M	$.M	$.M	$12.2M
Sanitary	$2.M	$.1M	$.3M	$1.3M	$.3M	$1.9M	$.7M	$1.7M	$.5M	$.9M	$1.1M	$1.6M	$3.2M	$.M	$15.7M
Gas	$.3M	$.M	$.M	$.4M	$.1M	$.7M	$.M	$.M	$.3M	$.2M	$.M	$.4M	$.3M	$.M	$2.8M
Water	$.8M	$.1M	$.2M	$1.1M	$.4M	$1.M	$.2M	$.4M	$.7M	$.6M	$.2M	$1.M	$1.5M	$.M	$8.4M
Power	$18.1M	$1.9M	$8.5M	$.7M	$.6M	$7.6M	$.1M	$2.3M	$.4M	$2.6M	$1.4M	$6.6M	$.M	$2.2M	$52.8M
Communications	$3.M	$.5M	$.4M	$.1M	$.1M	$1.8M	$.M	$.5M	$.6M	$.6M	$.4M	$.6M	$.M	$.M	$8.5M
Lighting	$.7M	$.2M	$.2M	$.2M	$.2M	$.6M	$.3M	$.9M	$.3M	$.3M	$.4M	$.6M	$.M	$.M	$4.9M
Roadway	$.M	$.M	$.M	$.M	$.M	$2.8M	$.M	$18.9M	$.M	$.M	$.M	$.M	$.M	$.M	$21.7M
Grand Total	$26.9M	$4.M	$10.7M	$5.4M	$6.7M	$20.9M	$17.5M	$29.5M	$3.7M	$7.2M	$5.3M	$13.4M	$13.7M	$2.2M	$167.M

Notes:
1) Cost allocation to each phase represents the total estimated servicing costs in consideration of trunk infrastructure necessary given the anticipated order of implementation and infrastructure within the footprints of each phase
2) Phase 2 "Amphitheatre" is anticipated to be implemented in advance of the other phases. Costs presented herein consider that implementation of Phase 2 in advance of all other phases, and the original phase numbering has been maintained for consistency with previous reporting.
3) Local servicing allowances represent infrastructure cost allowances for local servicing to buildings within the Amphitheatre footprint based on a high level review of conceptual building plans provided.
4) All costs presented are in 2020 dollars, and include a 20% engineering allowance and 30% contingency.
5) IMP Update Scenario 1 established and described in the "Hastings Park IMP - Playland Scenario Evaluation Technical Memo" (January, 2019) by Urban Systems.
6) "Prerequisite" costs include near-term replacement of the existing garden substation. Replacement costs include removal of existing transformers, as well as installation and supply of new transformers, switchgears, relays, and breakers. Oil change of the two existing tranformers is also included at $35,000 without 50% added for engineering and contingency.
7) The implementation order is presented A through N, with A proposed to occur first.

APPENDIX A2 – COST CHANGES BREAKDOWN

Cost Summary By Program Type - Amphitheatre Update (Costs in 2020 Dollars)

Playland Infrastructure Costs - Amphitheatre Update (Costs in 2020 Dollars)			
	Phase 1A	Phase 4A	Totals
New	$13.8M	$19.9M	$33.7M
Renewal	$12.8M	$.5M	$13.3M
Removal	$.3M	$.5M	$.8M
Grand Total	$26.9M	$20.9M	$47.8M

Heart of the Park Infrastructure Costs - Amphitheatre Update (Costs in 2020 Dollars)				
	Phase 2	Phase 3A	Phase 3B	Totals
New	$5.7M	$4.M	$5.3M	$15.1M
Renewal	$4.9M	$1.2M	$1.1M	$7.2M
Removal	$.M	$.2M	$.2M	$.5M
Grand Total	$10.7M	$5.4M	$6.7M	$22.7M

Remainder of Park Infrastructure Cost - Amphitheatre Update (Costs in 2020 Dollars)										
	Phase 1B	Phase 4B	Phase 4C	Phase 5A	Phase 5B	Phase 5C	Phase 6	Recently Renewed	Prerequisite	Totals
New	$2.M	$16.8M	$27.3M	$2.7M	$5.2M	$4.M	$11.5M	$.1M	$2.2M	$71.8M
Renewal	$2.M	$.1M	$1.4M	$.9M	$1.9M	$1.2M	$1.8M	$13.2M	$.M	$22.7M
Removal	$.M	$.5M	$.7M	$.M	$.1M	$.1M	$.1M	$.4M	$.M	$1.9M
Grand Total	$4.M	$17.5M	$29.5M	$3.7M	$7.2M	$5.3M	$13.4M	$13.7M	$2.2M	$96.4M

Notes:
1) "New" represents the cost of infrastructure that is triggered by new capacity requirements of the Hastings Park redevelopment.
2) "Renewal" represents the replacement cost of existing infrastructure once it reaches the end of its useful life.
3) "Removal" represents existing infrastructure to be abandoned and is not required to satisfy the new capacity requirements of redevelopment.
4) All proposed power, communications, and lighting costs have been split 50% into "new" and 50% into "renewal" for Phases 1 and 2. For all other phases all proposed power, communications, and lighting costs are considered "new".
5) All costs presented are in 2020 dollars, and include a 20% engineering allowance and 30% contingency.

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APPENDIX A3 – PROGRAM TYPE COST SUMMARY

Item	Unit	Quantity	Unit Rate[1]	Cost	E&C (50%)	Total Cost	Original IMP Phase	Proposed Phase	Program Category	Amphitheatre Update Cost Changes per Phase													Net Project Cost
										1A	1B	2	3A	3B	4A	4B	4C	5A	5B	5C	6	Prerequisite	
Storm																							
Storm upgrade 200mm to 300mm dia.	lin. m.	70	$ 556.34	$ 38,943.48	$ 19,471.74	$ 58,415.22		2	New	$ -	$ -	$ 58,415.22	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 58,415.22**
Storm upgrade 200mm to 375mm dia.	lin. m.	25	$ 695.42	$ 17,385.48	$ 8,692.74	$ 26,078.22		2	New	$ -	$ -	$ 26,078.22	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 26,078.22**
Deletion of renewal of 200mm dia. storm	lin. m.	95	$ 370.89	$ 35,234.58	$ 17,617.29	$ 52,851.86	2		Renewal	$ -	$ -	-$ 52,851.86	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 52,851.86**
Local 150mm dia. services to Scenario D buildings	lin. m.	250	$ 278.17	$ 69,541.92	$ 34,770.96	$ 104,312.89		2	New	$ -	$ -	$ 104,312.89	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 104,312.89**
Storm Total										$ -	$ -	$ 135,954.46	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 135,954.46**
Water																	0						
Hydrant near Building B	Each	1	$ 4,327.05	$ 4,327.05	$ 2,163.53	$ 6,490.58		2	New	$ -	$ -	$ 6,490.58	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 6,490.58**
Local 150mm services to Scenario D buildings	lin. m.	250	$ 278.17	$ 69,541.92	$ 34,770.96	$ 104,312.89		2	New	$ -	$ -	$ 104,312.89	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 104,312.89**
Water Total										$ -	$ -	$ 110,803.47	$ -	$ -	$ -	$ -		$ -	$ -	$ -	$ -	$ -	**$ 110,803.47**
Sanitary																							
Manhole S102 between S14 and Metro Van sewer connection	Each	1	$ 6,799.65	$ 6,799.65	$ 3,399.83	$ 10,199.48		2	New	$ -	$ -	$ 10,199.48	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 10,199.48**
Replacement of existing combined manhole 45 with sanitary S14	Each	1	$ 6,799.65	$ 6,799.65	$ 3,399.83	$ 10,199.48	1A	2	New	-$ 10,199.48	$ -	$ 10,199.48	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
Proposed Sanitary Realignment - 600mm main from S19 to S101	lin. m.	111	$ 1,112.67	$ 123,506.46	$ 61,753.23	$ 185,259.69		4A	New	$ -	$ -	$ -	$ -	$ -	$ 185,259.69	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 185,259.69**
Proposed Sanitary Realignment - 675mm main from S101 to S14	lin. m.	98	$ 1,251.75	$ 122,671.96	$ 61,335.98	$ 184,007.93		2	New	$ -	$ -	$ 184,007.93	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 184,007.93**
Proposed Sanitary Realignment - Deletion of 525mm Main from S19 to S2	lin. m.	203	$ 973.59	$ 197,930.23	$ 98,965.11	$ 296,895.34	4A		New	$ -	$ -	$ -	$ -	$ -	-$ 296,895.34	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 296,895.34**
Proposed Sanitary Realignment - Deletion of manhole S3	Each	1	$ 6,799.65	$ 6,799.65	$ 3,399.83	$ 10,199.48	4A		New	$ -	$ -	$ -	$ -	$ -	-$ 10,199.48	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 10,199.48**
Proposed Sanitary Realignment - 300mm from S2 to S1	lin. m.	112	$ 556.34	$ 62,253.93	$ 31,126.97	$ 93,380.90		4A	New	$ -	$ -	$ -	$ -	$ -	$ 93,380.90	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 93,380.90**
Proposed Sanitary Realignment - Deletion of 675mm Main from S2 to S1	lin. m.	112	$ 1,251.75	$ 140,071.35	$ 70,035.67	$ 210,107.02	4A		New	$ -	$ -	$ -	$ -	$ -	-$ 210,107.02	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 210,107.02**
Proposed Sanitary Realignment - 675mm from S14 to S1	lin. m.	195	$ 1,251.75	$ 244,092.16	$ 122,046.08	$ 366,138.23		4A	New	$ -	$ -	$ -	$ -	$ -	$ 366,138.23	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 366,138.23**
Proposed Sanitary Realignment - Deletion of 375mm Main from S14 to S1	lin. m.	195	$ 695.42	$ 135,606.75	$ 67,803.38	$ 203,410.13	4A		New	$ -	$ -	$ -	$ -	$ -	-$ 203,410.13	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 203,410.13**
Local 150mm dia. services to Scenario D buildings	lin. m.	250	$ 278.17	$ 69,541.92	$ 34,770.96	$ 104,312.89		2	New	$ -	$ -	$ 104,312.89	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 104,312.89**
Sanitary Total										-$ 10,199.48	$ -	$ 308,719.79	$ -	$ -	-$ 75,833.15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 222,687.15**
Gas																							
Deletion of "new" gas infrastructure									New	-$ 34,010.68	-$ 24,949.78	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 58,960.46**
Deletion of "renewal" gas infrastructure (to be abandoned)									Renewal	-$ 216,577.88	-$ 15,814.11	-$ 3,551.17	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 235,943.16**
Abandonment of existing gas infrastructure (previously for renewal)									Remove	$ 108,288.94	$ 7,907.06	$ 1,775.58	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 117,971.58**
Gas Total										-$ 142,299.62	-$ 32,856.84	-$ 1,775.58	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 176,932.04**
Power																							
1 MVA Substation	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ -	$ -	-$ 192,862.94	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**-$ 192,862.94**
1.5 MVA Substation	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 259,623.19	$ -	$ 519,246.37	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 778,869.56**
2 MVA Substation	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ -	$ -	$ 300,421.12	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 300,421.12**
4.5 MVA Substation	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 1,346,331.67	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 1,346,331.67**
Vista Switching Cabinet and Vault	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 1,186,848.85	-$ 593,424.43	$ 593,424.43	$ -	$ -	-$ 593,424.43	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 593,424.43**
Primary Duct Bank, Vaults, and Cables	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 6,161,396.00	-$ 443,288.05	-$ 657,236.10	$ -	$ -	-$ 293,986.17	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 4,766,885.69**
Primary Duct Bank and Vaults only	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ -	$ -	$ -	$ 287,625.40	$ 332,503.12	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 620,128.53**
Primary Cables only	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ -	$ 315,701.79	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 315,701.79**
Secondary Ducts and Cables	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 158,555.59	-$ 158,555.59	$ 389,434.78	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 389,434.78**
Secondary Panels and Switchgear	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 4,738,123.15	-$ 101,994.82	$ 5,554,081.74	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 10,190,210.06**
Garden Substation Replacement								Prerequisite	New	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,217,500.00	**$ 2,217,500.00**
Power Total										$ 13,850,878.45	-$ 981,561.09	$ 6,506,509.40	$ 287,625.40	$ 332,503.12	-$ 887,410.60	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,217,500.00	**$ 21,326,044.68**
Communications																							
Duct Bank and Vaults	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 1,114,896.14	-$ 80,112.30	-$ 118,777.61	$ 78,443.29	$ 90,682.67	-$ 48,401.18	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 1,036,731.02**
Fibre Cables	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 557,448.07	$ 44,506.83	$ 100,279.46	$ -	$ -	-$ 24,200.59	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 678,033.77**
Copper Cables	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 557,448.07	$ 44,506.83	$ 100,279.46	$ -	$ -	-$ 24,200.59	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 678,033.77**
Communications Total										$ 2,229,792.28	$ 8,901.37	$ 81,781.30	$ 78,443.29	$ 90,682.67	-$ 96,802.36	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 2,392,798.55**
Lighting																							
Lighting Pole Conduits and Conductors	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 185,445.13	-$ 166,900.62	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 18,544.51**
Adaptive Lighting Controls	Refer to DMD cost estimate						Refer to DMD cost estimate		New/Renewal	$ 3,708.90	-$ 3,338.01	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 370.89**
Lighting Total										$ 189,154.04	-$ 170,238.63	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ 18,915.40**
Summary										**$ 16,117,325.66**	**-$ 1,175,755.19**	**$ 7,141,992.83**	**$ 366,068.69**	**$ 423,185.79**	**-$ 1,060,046.11**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 2,217,500.00**	**$ 24,030,271.68**

Notes

1) Unit rates inflated from 2015 IMP unit rates to 2020 dollars

APPENDIX A4 – PROGRAM TYPE COST BY INFTRASTRUCTURE

Appendix A4 - Program Type Cost by Infrastructure

Row Labels	Sum of 1A	Sum of 1B	Sum of 2	Sum of 3A	Sum of 3B	Sum of 4A	Sum of 4B	Sum of 4C	Sum of 5A	Sum of 5B	Sum of 5C	Sum of 6	Sum of Recently Renewed	Sum of Prerequisite
New	**$13,771,151**	**$2,011,048**	**$ 5,740,908**	**$4,042,117**	**$5,298,994**	**$19,949,099**	**$16,805,285**	**$27,337,156**	**$2,713,107**	**$5,177,062**	**$4,030,836**	**$11,491,999**	**$ 57,488**	**$ 2,217,500**
Communications	$ 1,504,331	$ 265,928	$ 200,559	$ 78,443	$ 90,683	$ 1,805,865	$ -	$ 478,448	$ 566,906	$ 566,906	$ 420,590	$ 587,768	$ -	$ -
Gas	$ 68,615	$ 3,709	$ -	$ 279,804	$ 96,259	$ 703,703	$ -	$ -	$ 305,250	$ 29,649	$ 3,709	$ 287,139	$ 11,127	$ -
Green Infrastructure	$ 851,193	$ 634,222	$ 619,387	$1,121,943	$ 129,812	$ 1,596,683	$ 328,238	$ 2,091,821	$ 231,806	$1,186,849	$1,146,051	$ 1,630,063	$ -	$ -
Hastings and Greenway	$ -	$ -	$ -	$ -	$2,843,492	$ -	$ -	$ 9,395,887	$ -	$ -	$ -	$ -	$ -	$ -
Lighting	$ 359,393	$ 94,577	$ 104,035	$ 151,323	$ 151,323	$ 643,124	$ 283,731	$ 908,681	$ 340,477	$ 264,816	$ 435,054	$ 586,378	$ -	$ -
Power	$ 9,027,599	$ 967,931	$ 4,251,728	$ 680,769	$ 562,455	$ 7,588,749	$ 55,634	$ 2,262,987	$ 364,585	$2,623,121	$1,408,419	$ 6,554,558	$ -	$ 2,217,500
Roadway	$ -	$ -	$ -	$ -	$ -	$ 2,781,677	$ -	$18,915,404	$ -	$ -	$ -	$ -	$ -	$ -
Sanitary	$ 754,939	-$ 0	$ 318,199	$ 849,669	$ 64,318	$ 1,255,690	$ 409,066	$ 342,327	$ 335,296	$ 204,400	$ 40,798	$ 547,093	$ 0	$ -
Storm	$ 1,013,297	$ 44,680	$ 136,000	$ 341,223	$1,304,480	$ 2,740,074	$ 6,324,674	$ 2,151,574	$ 201,606	$ 266,764	$ 576,216	$ 738,162	-$ 0	$ -
Water	$ 191,786	$ 0	$ 111,000	$ 538,943	$ 56,173	$ 833,536	$ 8,056	$ 185,915	$ 367,181	$ 34,557	$ -	$ 560,838	$ 46,361	$ -
Removal	**$ 345,321**	**$ 7,907**	**$ 19,187**	**$ 217,802**	**$ 243,973**	**$ 464,438**	**$ 546,184**	**$ 675,610**	**$ 11,405**	**$ 102,811**	**$ 100,403**	**$ 52,084**	**$ 433,444**	**$ -**
Communications	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gas	$ 132,019	$ 7,907	$ 1,776	$ -	$ 17,296	$ -	$ 27,929	$ -	$ -	$ -	$ 11,310	$ 10,466	$ -	$ -
Green Infrastructure	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Hastings and Greenway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Lighting	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Power	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Roadway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sanitary	$ 209,570	$ -	$ -	$ 86,462	$ 58,612	$ 380,957	$ 291,048	$ 162,276	$ 11,405	$ 82,092	$ 60,805	$ 17,679	$ 68,142	$ -
Storm	$ -	$ -	$ -	$ 84,186	$ 111,806	$ -	$ 64,414	$ 411,084	$ -	$ 20,719	$ -	$ 23,940	$ 313,011	$ -
Water	$ 3,732	$ -	$ 17,411	$ 47,154	$ 56,258	$ 83,481	$ 162,793	$ 102,250	$ -	$ -	$ 28,288	$ -	$ 52,291	$ -
Renewal	**$12,777,929**	**$2,025,065**	**$ 4,903,879**	**$1,166,352**	**$1,108,560**	**$ 473,757**	**$ 148,457**	**$ 1,448,579**	**$ 936,550**	**$1,876,821**	**$1,205,037**	**$ 1,813,235**	**$13,211,114**	**$ -**
Communications	$ 1,504,331	$ 265,928	$ 200,559	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gas	$ 72,324	$ 27,817	$ -	$ 153,947	$ 9,337	$ 12,608	$ -	$ -	$ -	$ 146,723	$ 31,526	$ 122,735	$ 249,872	$ -
Green Infrastructure	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Hastings and Greenway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Lighting	$ 359,393	$ 94,577	$ 104,035	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Power	$ 9,027,599	$ 967,931	$ 4,251,728	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Roadway	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sanitary	$ 1,045,389	$ 96,429	$ 30,598	$ 366,304	$ 198,398	$ 251,051	$ 16,506	$ 1,186,041	$ 180,384	$ 601,234	$ 953,504	$ 996,761	$ 3,177,373	$ -
Storm	$ 119,612	$ 435,566	$ 235,354	$ 128,347	$ 597,898	$ 82,128	$ 73,073	$ 120,158	$ 385,444	$ 576,763	$ 91,569	$ 246,869	$ 8,428,034	$ -
Water	$ 649,281	$ 136,817	$ 81,605	$ 517,754	$ 302,927	$ 127,970	$ 58,879	$ 142,380	$ 370,723	$ 552,101	$ 128,439	$ 446,869	$ 1,355,835	$ -
Grand Total	**$26,894,401**	**$4,044,020**	**$10,663,974**	**$5,426,271**	**$6,651,527**	**$20,887,294**	**$17,499,926**	**$29,461,345**	**$3,661,063**	**$7,156,694**	**$5,336,276**	**$13,357,318**	**$13,702,046**	**$ 2,217,500**

APPENDIX B – Amphitheatre Update Water System Analysis

MEMORANDUM

Date:	October 30, 2019
File:	4304.0002.01
Subject:	Appendix B – Amphitheatre Update Water System Analysis

Date:	October 30, 2019
To:	File
cc:	Spencer Thompson, Steve Brubacher
From:	Kean Ring
File:	4304.0002.01
Subject:	Appendix B – Amphitheatre Update Water System Analysis

1. Introduction

This memo summarizes the analysis for the existing and future potable water systems conducted in support of the Amphitheatre Redevelopment update to the Hastings Park Infrastructure Master Plan. It is supplemental to the technical memo "Hastings Park Future Potable Water System Analysis" included as Appendix J in the 2015 Hastings Park Infrastructure Master Plan by Urban Systems. Please refer to that memo for discussion regarding model development, calibration, and results of the overall water system analysis.

A specific objective of this assessment was to determine the incremental upgrades to the existing Hastings Park water system necessary to support the Amphitheatre Redevelopment, which is anticipated to be re-developed in the next 2 years.

This analysis focuses on changes specific to the Amphitheatre design Scenario D, which is outlined in the Hastings Park Infrastructure Master Plan – Amphitheatre Update Technical Memo. The revised future water system with the Scenario D Amphitheatre site plan is shown in **Figure 6** of the Amphitheatre memo.

2. Demands and Loading

The following sections present the revised data and water demands for Amphitheatre design Scenario D.

2.1 Fire Flow

Using the FUS guidelines (Water Supply for Public Fire Protection, FUS, 1999), the required fire flow was checked for the three buildings proposed in Amphitheatre design scenario D which are summarized in **Table 1** below. The resulting fire flows account for automated sprinkler systems in each building and consider the number of floors and total building areas as stated in design Scenario D of the Amphitheatre Renewal Business Case.

Table 1 – Amphitheatre Fire Flow Requirements

	Total Area (m^2)	Number of Floors	Fire Flow Required		
Amphitheatre Update			L/min	L/s	IGPM
Scenario D - Building A	1,110	1.5	5,000	90	1,330
Scenario D - Building B	1,990	3	7,000	120	1,860
Scenario D - Building C	290	1	3,000	50	800

Note that the building areas presented in Table 1 are based on the concept redevelopment plans and the required fire flows should be confirmed once further building design development is completed. It is also recommended that the required fire flow rates be reviewed with the Fire Department and Fire Underwriters Survey and also be updated once building details are futher refined. It also is advisable to conduct a hydrant flow test at hydrant 11 to verify the actual available fire flows once the Playland valve is opened.

2.2 Amphitheatre Water Demands

Updated water demands were determined following the same approach as the original IMP, which used annual water consumption and attendance data to determine an average daily unit demand that was scaled to Park facilities based on attendance projections. **Table 2** below summarizes revised Amphitheatre water demands that reflect design Scenario D. As previously shown in **Table 1**, the Amphitheatre's fire flow demand is governed by building B at 120 L/s.

Table 2 – Amphitheatre Updated Water Demands

Facility	Maximum Day Demand (MDD) (Future)		Peak Hour (Future)		Required Fireflow (FF)	MDD + FF
	People / day	L/s	People / Hour	L/s	L/s	L/s
Amphitheatre – Scenario D	6,395	6	3,198	59	120	126

As shown in Table 2, the combined maximum day demand plus required fire flow governs over the Peak Hour Demand based on the Amphitheatre design Scenario D. The total 126 L/s was applied in the assessment to determine existing system capacity and upgrade recommendations based on a minimum residual pressure requirement of 140 kPa.

3. Water System Analysis

3.1 Existing System Analysis

The existing system was assessed to determine the ability of current infrastructure to deliver the peak flows required by the Amphitheatre update design Scenario D.

3.1.1 Fire Flow Analysis:

A steady-state analysis was conducted to distribute the required fire flows across multiple nodes (hydrants). Fire flow demands were analyzed concurrently with future condition MDD demands, which have been updated as shown in **Table 2** to reflect the design capacity Scenario D. This multi-hydrant approach considers that the 120 L/s fire flow required by the updated Amphitheatre exceeds the recommended flow range of 75 to 100 L/s available at a single hydrant. 75 L/s was conservatively used as the maximum hydrant flow in the updated analysis.

Based on the proposed location of building B in design Scenario D, the existing hydrants within an 80m radius are the two southwest Amphitheatre hydrants, labelled as “19” and “11” on the model schematic in **Figure 1**. Hydrant 11 is at a lower elevation than hydrant 19 and is capable of delivering 75 L/s while maintaining 140 kPa residual pressure. Hydrant 19, situated at a higher elevation adjacent to the Playland Lowerline building, is not capable of delivering the required flow of 45 L/s at 140 kPa (for a combined 120 L/s), due to its elevation and location within the network.

The analysis confirmed this to be true even if existing valves isolating Playland and the Racecourse Barns were opened to create a looped system. As such, the existing system with existing hydrant locations was determined to be under capacity with regards to updated Amphitheatre fire flow requirements.

3.2 Existing System Upgrade Recommendations

In order to achieve fire flow and residual pressure criteria, an additional hydrant at the east side of the Amphitheatre was added to the existing system model, shown as hydrant “28” on the model schematic in **Figure 1** below. This hydrant would be connected to the 150mm local service to building B as shown on **Figure 6** in the Amphitheatre Update Technical Memo and will serve as long-term Amphitheatre fire protection in the IMP’s future water system.

The location of this hydrant is at a more advantageous point in the system and will be capable of delivering an additional 45 L/s while maintaining 140 kPa, thus satisfying buildings B’s fire flow requirements in conjunction with existing hydrant 11. This will require opening of the valve on the Playland main off Hastings Street to create a looped system, which was originally recommended in the IMP's overall water servicing strategy.

A summary of the fire flow results for hydrants 11 and 28 are presented in **Table 3**:

Table 3 – Updated Amphitheatre Interim Fire Flows

Hydrant ID	Elevation	Fire Flow Demand	Residual Pressure
11 (Existing)	27.0 m	75 L/s	249 kPa
28 (Proposed)	34.0 m[1]	45 L/s	182 kPa

1) Hydrant 28 conservatively assumed to be at the same elevation as hydrant 19 and the ground surrounding building B.

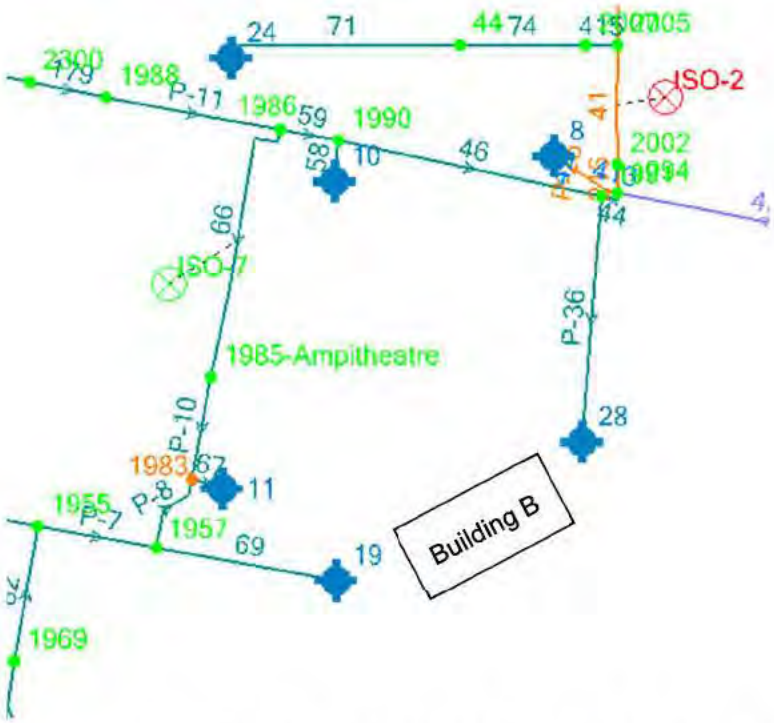

Figure 1 – Model Amphitheatre Update Trunk Water System

As shown in **Figure 1**, hydrant 28 is proposed adjacent to future building B and is serviced from the north side of the Amphitheatre. In conjunction with hydrant 11, the required fire flow of 120 L/s for building B is satisfied while maintaining residual pressures of 140 kPa as presented in **Table 3**. It is also required that hydrants are located within 80m of each facility, with building B located near the edge of hydrant 11's coverage radius. **Figure 2** below presents an updated map of the fire hydrant coverage following implementation of the Amphitheatre Update servicing strategy. These recommendations and hydrant locations should be confirmed in consultation with the Vancouver Fire Department in consideration of the emergency response plan for the Park and access to hydrants.

IMP Update
Amphitheatre Renewal

Existing Fire Hydrant Coverage

Legend

- Study Boundary
- Unsurveyed Hydrant
- Surveyed Hydrant
- 80m Radius
- Water Main
- Amphitheatre Local Water Servicing
- Future Hydrant

Hydrant 28

Hydrant 11

Hydrant 19

Additional fire hydrant coverage for the Phase 2 Amphitheatre Update servicing strategy.

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

0 50 100 200 Metres

Coordinate System:
NAD 1983 UTM Zone 10N

Data Sources:

- All data provided by PNE from various sources, Dec 2014 - Feb 2015
- Imagery provided by the City of Vancouver, Dec 2015
- Cadastral downloaded from VanMap's Open Data catalogue, Jan 2015

Project #:	4304.0002.01
Author:	LP
Checked:	ST
Status:	FINAL
Revision:	A
Date:	2019 / 10 / 28

URBAN systems

FIGURE 2

\\us.urban-systems.com\projects\Projects_VAN\4304\0002\01\D-Design\GIS\Projects\MXD\Final Report Figures - 20191028\Figure 2 - Hastings Water FH Coverage.mxd Last updated by lpunt on October 28, 2019 at 2:15:11 PM

3.3 Future System Analysis

The future water system was analyzed to evaluate performance under peak flows (MDD + FF) from the Amphitheatre update design Scenario D. Refer to Appendix J of the Infrastructure Master Plan for recommended upgrades to the future water servicing strategy.

3.3.1 Fire Flow Analysis:

The recommended future servicing upgrades greatly improve the potential hydraulic capacity of the Hastings Parks water system. The future system model outlined in the Future Potable Water System Analysis was reanalyzed with focus on the Amphitheatre fire flows, as shown in **Figure 3**. Using the same multi-hydrant approach discussed in the existing Amphitheatre analysis, it was determined that hydrant 19 could be used in conjunction with hydrant 11 to deliver a combined 120 L/s fire flow while maintaining sufficient residual pressure within the future system. Hydrant 28, recommended for the existing system to meet fire flow requirements, would offer additional protection after local Amphitheatre servicing is reconnected to the reconfigured future system. Refer to the Future Potable Water System Analysis in Appendix J of the IMP for further discussion and analysis of the entire future water system.

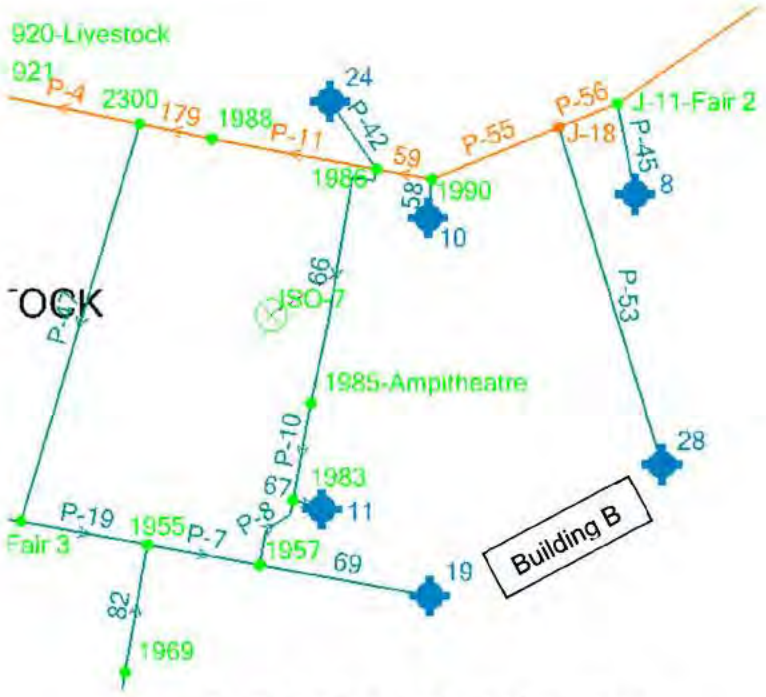

Figure 3 – Model Future Trunk Water System

4. Summary

The existing water system, particularly the location of existing hydrants, is inadequate to deliver required fire protection to the updated Amphitheatre buildings in design Scenario D. Upgrades to the existing system are recommended above and include an additional hydrant (28) attached to local water services near future building B and opening of the existing valve on the Playland main off Hastings Street.

The future water system remains the same as recommendations in the original IMP, with the addition of local Amphitheatre servicing and hydrant 28 that can provide additional fire protection. The required fire flows and hydrant coverage of existing and proposed facilities should be reviewed with the City of Vancouver Fire Department and the Fire Underwriters Survey and adjust as redevelopment occurs. We also recommend that a fire hydrant flow test be completed at hydrant "11"once the Playland valve is opened. Refer to the Infrastructure Master Plan report for an overview of the recommended system upgrades and report Appendix J for further analysis of the entire existing and future water system.

Sincerely,

URBAN SYSTEMS LTD.

Kean Ring, EIT.

Steve Brubacher P.Eng.
Reviewer

/kr

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URBAN systems

APPENDIX C – Storm Rational Method Calculations

STORM DRAIN COMPUTATION SHEET

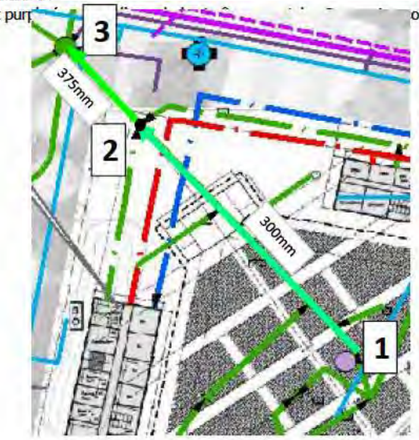
Project Location: Amphitheatre Upgrade
Reference No: 4304.0002.01
IDF Used: 2100
Return Period (yr): 10 A = 31.32 B = -0.55
Min. Inlet Time: 5 min

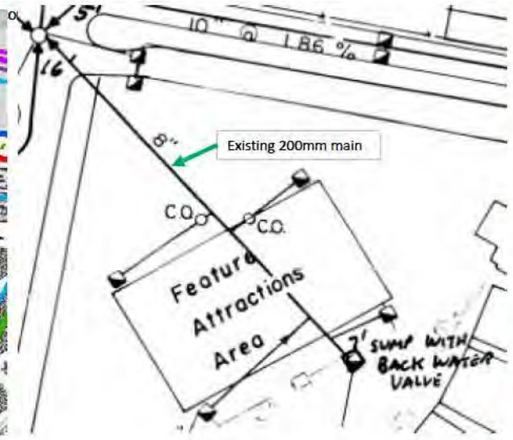
Legend
Red: Input
Black: Calculation

Calculated By: KR **Date:** 8/23/19
Checked: ST **Date:** 10/30/19
Revised By: **Date:**
Checked: **Date:**

Location	Str. ID[1]		Length (m)	Drainage Area[2]		Runoff Coeff C[3]	Area x C		Time of Conc (Tc)		Rainfall (mm/hr)	Runoff (m^3/s)	Pipe Diameter[4]		Pipe roughness (n)	Qfull (m3/s)	Q/Qfull (%)	Velocity			Travel Time (min)	Invert Elevation		Crown Drop (m)	Slope (m/m)
	From Node	To Node		Incremt (ha)	Total (ha)		Incrmt	Total	Inlet (min)	System (min)			Comp (mm)	Use (mm)				Vfull (m/s)	V/Vfull (%)	Design (m/s)		U/S (m)	D/S (m)		
Amphitheatre (covered)	1	2	75.0	0.500	0.500	1.00	0.50	0.50	5.00	5.00	122.8	0.171	275	300	0.013	0.214	80%	3.03	111%	3.36	0.37			0.000	0.0493
Amphitheatre	2	3	25.0	0.694	1.194	0.90	0.62	1.12	5.00	5.37	118.1	0.369	367	375	0.013	0.388	95%	3.52	114%	4.00	0.10			0.000	0.0493
													Existing pipe is 200mm												

Notes
1) IDF parameters from "City of Vancouver Rainfall Study and IDF Update" (Urban Systems, 2015)
2) Total drainage area from Amphitheatre Catchment in PCSWMM model for Hastings Parks IMP
3) Pipe slope as per surveyed inverts of top left green (storm) manhole and bottom right pur





STORM DRAIN COMPUTATION SHEET

Project Location: Amphitheatre Upgrade
Reference No: 4304.0002.01
IDF Used: 2014
Return Period (yr): 10 A = 15.13 B = -0.514
Min. Inlet Time: 5 min

Legend
Red: Input
Black: Calculation

Calculated By: KR **Date:** 9/12/19
Checked: ST **Date:** 10/30/19
Revised By: **Date:**
Checked: **Date:**

Location	Str. ID[1]		Length (m)	Drainage Area[2]		Runoff Coeff C[3]	Area x C		Time of Conc (Tc)		Rainfall (mm/hr)	Runoff (m^3/s)	Pipe Diameter[4]		Pipe roughness (n)	Qfull (m3/s)	Q/Qfull (%)	Velocity			Travel Time (min)	Invert Elevation		Crown Drop (m)	Slope (m/m)
	From Node	To Node		Incremt (ha)	Total (ha)		Incrmt	Total	Inlet (min)	System (min)			Comp (mm)	Use (mm)				Vfull (m/s)	V/Vfull (%)	Design (m/s)		U/S (m)	D/S (m)		
Playland PCSWMM Catchment C-11	1	2		2.205	2.205	0.87	1.92	1.92	5.00	5.00	54.3	0.289	335	600	0.013	1.362	21%	4.82	79%	3.81	0.00			0.000	0.0493
Playland PCSWMM Catchment C-27	2	3		2.135	4.340	0.87	1.86	3.78	5.00	5.00	54.3	0.569	432	600	0.013	1.362	42%	4.82	95%	4.60	0.00			0.000	0.0493
Playland PCSWMM Catchment C-12	3	Metro Van		0.761	5.101	0.87	0.66	4.44	5.00	5.00	54.3	0.669	459	600	0.013	1.362	49%	4.82	99%	4.78	0.00			0.000	0.0493

Notes
1) IDF parameters from "City of Vancouver Engineering Design Manual" (City of Vancouver, 2018)
2) Drainage area from PCSWMM model for Hastings Parks IMP
3) Runoff coefficient from PCSWMM Business as Usual model shown adjacent

Approximate location of existing combined main to Metro Vancouver sewer

APPENDIX D1 – Existing Sanitary Sewer Calculations

SANITARY SEWER COMPUTATION SHEET

Project Location: Hastings Park - Amphitheatre Update
Reference No: 4304.0002.01
Description: Peak Hour Sanitary Demand

Legend
Data manually input
Indicates Deficient Pipe (Q/Qfull > 70%)
Indicates V > 4.0 m/s
Indicates V > 6.0 m/s
Indicates Existing Pipe Size
Indicates Upgraded Pipe Size 2015
Indicates Upgraded Pipe Size 2018
Indicates PDWF Demand Inlet Node

Revisions	Description
Rev 0	Amph 2019

	Name	Date
Calculated By:	K.Ring	9/12/19
Checked:	S.Tan	10/19/19
Revised By:		
Checked:		

Location	Manhole ID		Pipe Length (m)	Runoff (m3/s)	PDWF (m3/s)	PDWF (L/s)	PWWF		Pipe Diameter		Pipe roughness (n)	Qfull (L/s)	Q/Qfull (%)	Velocity			Travel Time	Invert Elevation		Slope (m/m)	Comments
	From Node	To Node					m3/s	L/s	Required (mm)	Existing/ Proposed (mm)				Vfull (m/s)	V/Vfull (%)	Design (m/s)	(min)	U/S (m)	D/S (m)		
To Discharge MV Trunk Sewer East																					
Existing Playland 1-3	MH102	MH103	82.4		2.71E-02	27.06	2.71E-02	27.06	153	300	0.012	161	17%	2.28	73%	1.67	0.82	36.61	34.64	2.39%	
	MH103	MH105	82.1				2.71E-02	27.06	149	300	0.012	174	16%	2.47	73%	1.80	0.76	34.64	32.36	2.78%	
	MH105	(Dwg ID 44)	53.0				2.71E-02	27.06	140	300	0.012	204	13%	2.89	68%	1.98	0.45	32.36	#N/A	3.82%	Length from KML on Google Earth; Slope from record drawing
Existing Playland 2-3	MH097	MH206	63.6		2.71E-02	27.06	2.71E-02	27.06	171	250	0.012	74	37%	1.51	92%	1.39	0.76	34.24	33.50	1.33%	Length from KML on Google Earth; Slope from record drawing
	MH206	(Dwg ID 46)	49.1				2.71E-02	27.06	139	300	0.012	209	13%	2.96	68%	2.02	0.40	33.50	#N/A	4.00%	Length from KML on Google Earth; Slope from record drawing
Existing Playland 3-3	S21	S22	60.1		2.71E-02	27.06	2.71E-02	27.06	178	250	0.012	67	40%	1.36	93%	1.27	0.79	34.54	33.88	1.08%	
	S22	(Dwg ID 46)	69				2.71E-02	27.06	151	250	0.012	104	26%	2.11	83%	1.75	0.66	33.88	#N/A	2.60%	Length from KML on Google Earth; Slope assumed same as nearby pipe; Assumed sump is removed
	(Dwg ID 46)	(Dwg ID 44)	56.2				5.41E-02	54.12	210	375	0.012	254	21%	2.30	79%	1.81	0.52	#N/A	#N/A	1.79%	Length from KML on Google Earth; Slope from record drawing
	(Dwg ID 44)	MH183	49.6				8.12E-02	81.18	184	375	0.012	537	15%	4.87	72%	3.49	0.24	#N/A	27.20	8.04%	Length from KML on Google Earth; Slope from record drawing
	MH183	S14	44.4				8.12E-02	81.18	238	375	0.012	271	30%	2.46	87%	2.13	0.35	27.20	22.31	2.05%	Length from KML on Google Earth; Slope from record drawing; drop into proposed S14 manhole
Amphitheatre	S101	S14	98		5.20E-02	52.03	5.20E-02	52.03	290	525	0.012	253	21%	1.17	79%	0.92	1.77	22.60	22.31	0.30%	manholes lowered to accommodate proposed sanitary main from Amphitheatre along Miller Drive
	S14	S102	72	0.669	0.00E+00	0.00	8.02E-01	802.21	593	600	0.012	825	97%	2.92	114%	3.32	0.36	22.31	21.20	1.54%	manholes lowered to accommodate proposed sanitary main from Amphitheatre along Miller Drive
	S102	Metro Van	12.6				8.02E-01	802.21	446	600	0.012	1767	45%	6.25	97%	6.08	0.03	21.20	20.31	7.07%	Existing Pipe to Metro Van connection is 7.07% per manhole 45 survey & Metro Van tie-in from drawing 03sf1028

APPENDIX D2 – Updated IMP Sanitary Sewer Calculations

SANITARY SEWER COMPUTATION SHEET - PROPOSED SYSTEM

Project Location: Hastings Park - Amphitheatre Update
Reference No: 4304.0002.01
Description: Peak Hour Sanitary Demand

Legend
Data manually input
Indicates Deficient Pipe (Q/Qfull > 70%)
Indicates V > 4.0 m/s
Indicates V > 6.0 m/s
Indicates Existing Pipe Size
Indicates Upgraded Pipe Size 2015
Indicates Upgraded Pipe Size 2018
Indicates Upgraded Pipe Size 2019
Indicates PDWF Demand Inlet Node

Revisions	Description
Rev 0	Pr San 2015
Rev 1	Pr San 2018
Rev 2	Amph 2019

	Name	Date
Calculated By:	K.Ring	9/12/19
Checked:	S.Tan	10/19/19
Revised By:		
Checked:		

Location	Manhole ID		Pipe Length (m)	PDWF (m3/s)	PDWF (L/s)	PWWF		Pipe Diameter		Pipe roughness (n)	Qfull (m3/s)	Qfull (L/s)	Q/Qfull (%)	Velocity			Travel Time	Invert Elevation		Slope (m/m)	Comments
	From Node	To Node				m3/s	L/s	Required (mm)	Existing/ Proposed (mm)					Vfull (m/s)	V/Vfull (%)	Design (m/s)	(min)	U/S (m)	D/S (m)		
To Discharge Point #3																					
Empire Field	11	S23	67.1	1.86E-03	1.86	1.86E-03	1.86	70	200	0.012	0.030	30	6%	0.96	54%	0.52	2.16	28.60	28.11	0.73%	Invert from Empire Field AB Drawings
Existing Playland 1-3	MH102	MH103	82.4	2.89E-02	28.86	2.89E-02	28.86	157	300	0.012	0.161	161	18%	2.28	75%	1.71	0.81	36.61	34.64	2.39%	
	MH103	MH105	82.1			2.89E-02	28.86	153	300	0.012	0.174	174	17%	2.47	73%	1.80	0.76	34.64	32.36	2.78%	
	MH105	S10	29.4			2.89E-02	28.86	198	300	0.012	0.087	87	33%	1.23	89%	1.10	0.45	32.36	32.15	0.69%	
Existing Playland 2-3	S12	S13	55.6	2.89E-02	28.86	2.89E-02	28.86	166	200	0.012	0.047	47	61%	1.49	105%	1.56	0.59	34.77	33.79	1.76%	
	S13	MH206	45.1			2.89E-02	28.86	200	250	0.012	0.052	52	56%	1.06	102%	1.08	0.70	33.79	33.50	0.65%	
Existing Playland 3-3	S26	S27	39.1	2.89E-02	28.86	2.89E-02	28.86	205	250	0.012	0.049	49	59%	0.99	104%	1.03	0.63	35.04	34.82	0.57%	
	S27	S21	49.8			2.89E-02	28.86	206	250	0.012	0.048	48	60%	0.98	104%	1.02	0.81	34.82	34.54	0.56%	
	S21	S22	60.1			2.89E-02	28.86	182	250	0.012	0.067	67	43%	1.36	95%	1.30	0.77	34.54	33.88	1.08%	
	S22	MH206	62.6			2.89E-02	28.86	203	250	0.012	0.050	50	57%	1.02	103%	1.06	0.99	33.88	33.50	0.61%	
	MH206	S31	43.9			5.77E-02	57.72	222	300	0.012	0.128	128	45%	1.81	97%	1.76	0.41	33.50	32.84	1.50%	
	S31	S10	50.4			5.77E-02	57.72	226	300	0.012	0.122	122	47%	1.72	98%	1.69	0.50	32.84	32.15	1.36%	
	S10	S11	38.1			8.66E-02	86.58	277	375	0.012	0.194	194	45%	1.76	97%	1.71	0.37	32.15	31.75	1.05%	
	S11	S23	55.5			8.66E-02	86.58	196	375	0.012	0.486	486	18%	4.40	75%	3.28	0.28	31.75	28.11	6.57%	
	S23	S14	54			8.84E-02	88.44	180	375	0.012	0.621		14%	5.62	70%	3.94	0.23	28.11	22.31	10.74%	
Festival Meadows	S4	S6	84.1	1.00E-02	10.00	1.00E-02	10.00	105	200	0.012	0.056	56	18%	1.78	75%	1.33	1.06	35.05	32.95	2.49%	
	S6	S5	82.3			1.00E-02	10.00	93	200	0.012	0.077	77	13%	2.44	68%	1.67	0.82	32.95	29.08	4.71%	
Lagoon	S5	S28	56.8	1.00E-02	10.00	2.00E-02	20.00	126	200	0.012	0.068	68	29%	2.17	86%	1.86	0.51	29.08	26.97	3.72%	
	S28	MH088	74.7			2.00E-02	20.00	153	200	0.012	0.040	40	50%	1.29	100%	1.29	0.97	26.97	25.99	1.30%	
South Agrodome	S20	8	149.7	1.00E-02	10.00	1.00E-02	10.00	142	200	0.012	0.025	25	40%	0.80	93%	0.74	3.35	34.72	#N/A	0.50%	
North Sanctuary	8	34	12.6	1.60E-02	16.00	2.60E-02	26.00	203	250	0.012	0.045	45	57%	0.92	103%	0.95	0.22	#N/A	#N/A	0.50%	
South Livestock	34	MH088	30.6	1.00E-02	10.00	3.60E-02	36.00	229	375	0.012	0.134	134	27%	1.21	84%	1.02	0.50	#N/A	25.99	0.50%	
	MH088	MH091	57.1			5.60E-02	56.00	213	375	0.012	0.251	251	22%	2.27	79%	1.79	0.53	25.99	24.99	1.75%	
Festival Plaza	MH091	S18	80.8	1.20E-02	12.00	6.80E-02	68.00	229	375	0.012	0.252	252	27%	2.28	84%	1.92	0.70	24.99	23.57	1.77%	
East Forum	MHXX	MH076	73.9	6.00E-03	6.00	6.00E-03	6.00	117	200	0.012	0.025	25	24%	0.80	82%	0.65	1.89	#N/A	38.85	0.50%	MH information not available, assumed 0.5% slope
Forum	MH076	MH077	50.6	3.33E-02	33.28	3.93E-02	39.28	184	300	0.012	0.144	144	27%	2.03	84%	1.71	0.49	38.85	37.90	1.90%	
	MH077	MH072	50.9			3.93E-02	39.28	195	300	0.012	0.123	123	32%	1.74	88%	1.53	0.55	37.90	37.19	1.39%	
	MH072	MH071	47.6			3.93E-02	39.28	184	300	0.012	0.144	144	27%	2.04	84%	1.72	0.46	37.19	36.28	1.91%	
	MH071	MH005	113.5			3.93E-02	39.28	184	375	0.012	0.262	262	15%	2.38	72%	1.70	1.11	36.28	34.10	1.92%	
	MH005	S15	17.5			3.93E-02	39.28	191	375	0.012	0.237	237	17%	2.14	73%	1.57	0.19	34.10	33.83	1.56%	
Italian Park	S15	S16	51	1.80E-02	18.00	5.73E-02	57.28	265	375	0.012	0.145	145	40%	1.31	93%	1.22	0.69	33.83	33.53	0.58%	
Rollarland and Coliseum Plaza	S16	S17	74.1	2.62E-02	26.19	8.35E-02	83.47	205	375	0.012	0.416	416	20%	3.77	78%	2.92	0.42	33.53	29.96	4.82%	
New Exhibition Building	S17	S24	52.6	3.53E-02	35.31	1.19E-01	118.78	233	375	0.012	0.420	420	28%	3.80	86%	3.25	0.27	29.96	27.38	4.90%	
North Agrodome, Agrodome, Livestock Barn	S24	S18	146	5.96E-02	59.61	1.78E-01	178.39	306	375	0.012	0.306	306	58%	2.77	103%	2.86	0.85	27.38	23.57	2.61%	
North Livestock	S18	S19	86.5	8.00E-03	8.00	2.54E-01	254.39	445	525	0.012	0.394	394	65%	1.82	106%	1.93	0.75	23.57	22.95	0.72%	
	S19	S101	111			2.54E-01	254.39	520	600	0.012	0.372	372	68%	1.31	107%	1.41	1.31	22.95	22.60	0.31%	
Amphitheatre	S101	S14	98	6.54E-02	65.42	3.20E-01	319.81	573	675	0.012	0.495	495	65%	1.38	106%	1.47	1.11	22.60	22.31	0.30%	
Playland Expansion 1-2	S14	S8	92.1	4.33E-02	43.29	4.52E-01	451.54	571	675	0.012	0.704	704	64%	1.97	106%	2.09	0.74	22.31	21.76	0.60%	
	S8	S1	102.9			4.52E-01	451.54	477	675	0.012	1.136	1136	40%	3.17	93%	2.97	0.58	21.76	20.16	1.56%	
Playland Expansion 2-2	S25	S30	38.1	4.33E-02	43.29	4.33E-02	43.29	174	200	0.012	0.062	62	69%	1.98	108%	2.14	0.30	24.34	23.16	3.10%	
	S30	S29	22.8			4.33E-02	43.29	189	250	0.012	0.091	91	47%	1.86	98%	1.82	0.21	23.16	22.70	2.02%	
	S29	S2	43.7			4.33E-02	43.29	163	250	0.012	0.134	134	32%	2.74	88%	2.41	0.30	22.70	20.78	4.39%	
	S2	S1	111.9			4.33E-02	43.29	240	300	0.012	0.078	78	55%	1.11	102%	1.12	1.66	20.78	20.16	0.56%	
	S1	S7	73			4.95E-01	494.83	458	675	0.012	1.392	1392	36%	3.89	91%	3.55	0.34	20.16	18.45	2.34%	
Back of the House Building	S7	MH233	30.9	1.86E-03	1.86	4.97E-01	496.69	478	675	0.012	1.247	1247	40%	3.48	93%	3.25	0.16	18.45	17.87	1.88%	

SANITARY SEWER COMPUTATION SHEET - PROPOSED SYSTEM

Project Location: Hastings Park - Amphitheatre Update
Reference No: 4304.0002.01
Description: Peak Hour Sanitary Demand

Legend
Data manually input
Indicates Deficient Pipe (Q/Qfull > 70%)
Indicates V > 4.0 m/s
Indicates V > 6.0 m/s
Indicates Existing Pipe Size
Indicates Upgraded Pipe Size 2015
Indicates Upgraded Pipe Size 2018
Indicates Upgraded Pipe Size 2019
Indicates PDWF Demand Inlet Node

Revisions	Description
Rev 0	Pr San 2015
Rev 1	Pr San 2018
Rev 2	Amph 2019

	Name	Date
Calculated By:	K.Ring	9/12/19
Checked:	S.Tan	10/19/19
Revised By:		
Checked:		

Location	Manhole ID		Pipe Length (m)	PDWF (m3/s)	PDWF (L/s)	PWWF		Pipe Diameter		Pipe roughness (n)	Qfull (m3/s)	Qfull (L/s)	Q/Qfull (%)	Velocity			Travel Time	Invert Elevation		Slope (m/m)	Comments
	From Node	To Node				m3/s	L/s	Required (mm)	Existing/ Proposed (mm)					Vfull (m/s)	V/Vfull (%)	Design (m/s)	(min)	U/S (m)	D/S (m)		
Pacific Coliseum	MH052	MH051	2.5	3.51E-02	35.10	3.51E-02	35.10	227	375	0.012	0.134	134	26%	1.21	83%	1.01	0.04	29.13	29.14	0.50%	manhole invert info resulted in reverse slope, assumed min slope of 0.5%
	MH051	MH050	62.6			3.51E-02	35.10	163	375	0.012	0.320	320	11%	2.90	65%	1.89	0.55	29.14	27.35	2.86%	
	MH050	MH049	71.5			3.51E-02	35.10	158	375	0.012	0.348	348	10%	3.15	63%	2.00	0.60	27.35	24.94	3.38%	
To Discharge MV Trunk Sewer - North																					
Racecourse Grandstand	MH194	MH111	46.1	1.49E-01	148.65	1.49E-01	148.65	342	450	0.012	0.308	308	48%	1.94	98%	1.90	0.40	21.35	21.35	1.00%	manhole invert info resulted in reverse slope, assumed min slope of 0.1%
	MH111	MH219	113.3			1.49E-01	148.65	314	450	0.012	0.386	386	39%	2.42	93%	2.27	0.83	21.35	19.58	1.56%	MH-219 not surveyed, rim 21.0779m, assume invert 1.5m below rim
	MH219	MH107	56.6			1.49E-01	148.65	345	600	0.012	0.648	648	23%	2.29	80%	1.84	0.51	19.58	19.04	0.95%	MH-219 not surveyed, rim 21.0779m, assume invert 1.5m below rim
To Discharge MV Trunk Sewer - North																					
Barns Facility	11-1	66	46.8	7.43E-03	7.43	7.43E-03	7.43	127	200	0.012	0.025	25	30%	0.80	87%	0.69	1.13	#N/A	#N/A	0.50%	MH information not available, assumed 0.5% slope
To Discharge Point South of Park																					
Centre Grounds	S9	MH217	99.1	8.00E-03	8.00	8.00E-03	8.00	130	200	0.012	0.025	25	32%	0.80	88%	0.70	2.35	34.21	33.71	0.50%	
The Garden's Garden	MH217	MH092	83.1	1.00E-02	10.00	1.80E-02	18.00	176	250	0.012	0.045	45	40%	0.92	93%	0.86	1.60	33.71	34.35	0.50%	manhole invert info not available, assumed 0.5% grade, existing pipe size unknown, assumed to be 200 dia.
Momiji and Garden Auditorium	MH092	MH093	49.7	8.39E-03	8.39	2.64E-02	26.39	204	250	0.012	0.045	45	58%	0.92	103%	0.95	0.87	34.35	0.00	0.50%	manhole invert info not available, assumed 0.5% grade, existing pipe size unknown, assumed to be 200 dia.
	MH093	MH033	11.5			2.64E-02	26.39	204	250	0.012	0.045	45	58%	0.92	103%	0.95	0.20	0.00	#N/A	0.50%	manhole invert info not available, assumed 0.5% grade, existing pipe size unknown, assumed to be 200 dia.
	MH033	MH259	26.4			2.64E-02	26.39	204	250	0.012	0.045	45	58%	0.92	103%	0.95	0.46	#N/A	#N/A	0.50%	manhole invert info not available, assumed 0.5% grade, existing pipe size unknown, assumed to be 200 dia.

Hasting Park Infrastructure Master Plan - Amphitheatre Update
Sanitary Loading Summary

Service Box Sewer Demand[1]	0.4 l/s
Unit Demand (24 Hour Period)	0.00089 l/s/c
Unit Demand (1 Hour Period)	0.01858 l/s/c

Loading Summary	Load ID Number Scenario 1	Load ID Number Existing	Inlet Node		Service Box Count		Max Day (Scen 1a) (People /Day)	Max Day Flow (L/s)	Max Day (Existing) (People /Day)	Max Day Flow (L/s)	Peak Hour Population (People/hour)		Peak Hour Flow (L/s)	
			Future	Existing	Future	Existing					Future	Existing	Future	Existing
Pacific Coliseum	1	1	MH052	MH052			18,886	17	16,700	15	1,889	1,670	35	31
Agrodome	2	2	S24	S24			9,769	9	8,600	8	977	860	18	16
Rollerland	3	3	S16	S16			6,512	6	5,700	5	1,302	1,140	24	21
The Forum	4	4	MH076	MH076			14,327	13	12,600	11	1,791	1,575	33	29
Garden Auditorium	5	5	MH092	MH092			2,410	2	2,100	2	344	300	6	6
Empire Field	6	6	11	11			Max Day Attendance Information Not Provided				100	100	2	2
Livestock Barns	7	7	S24	S24			16,932	15	14,900	13	1,693	1,490	31	28
Amphitheatre	8	8	S101	S101			6,395	6	5,600	5	3,198	2,800	59	52
New Exhibition Building (below grade)	9	9	S17	S17			10,000	9		0	1,900		35	0
Total PNE							85,231	76	66,200	59	13,194	9,935	245	185
New Back of House Building	11		S7	-			Max Day Attendance Information Not Provided				100		2	0
Playland (Existing): 1-3	12	12	MH102	MH102									29	27
2-3	12	12	S12	MH097			6,213	6	7,133	6	4,660	4,369	29	27
3-3	12	12	S26	S21									29	27
Playland (Expansion): 1-2	13		S14	-			6,213	6	0	0	4,660	0	43	0
2-2	13		S25	-									43	0
Total Playland							12,425	11	7,133	6	9,419	4,369	175	81
Racecourse Grandstand	14	14	MH194	MH194			12,000	11	12,000	11	8,000	8,000	149	149
Racecourse Daycare[2]							Max Day Attendance Information Not Provided				60	60	1	1
Barns Facility	15	15	11-1	11-1							400	400	7	7
Total Racecourse							12,000	11	12,000	11	8,460	8,460	157	157
North Sanctuary Fair Locations	16	16	8	8	40	30							16	12
Amphitheatre fair locations	17	17	S101	S101	15								6	0
Lagoon Fair Locations	18	18	S5	S5	25	15							10	6
South Livestock Fair Locations	19	19	34	34	25	15							10	6
Festival Plaza Fair Locations	20	20	MH091	MH091	30	20							12	8
Italian Park Fair Locations	21	21	S15	S15	45	30							18	12
South Agrodome Locations	22	22	S20	S20	25	15							10	6
North Agrodome Fair Locations	23	23	S24	S24	25	5							10	2
North Livestock Fair Locations	24	24	S18	S18	20	2							8	1
Centre Grounds Fair Locations	25	25	S9	S9	20	10							8	4
East Forum Fair Locations	26		MHXX		15								6	0
Momiji Fair Locations	27		MH092		5								2	0
Coliseum Plaza Fair Locations	28		S16		5								2	0
The Garden's Gardens	29		MH217		25								10	0
Festival Meadows	30		S4		25								10	0
Total Vendor / Fair					345	142							138	57
Total Park					345	142	109,656	98	85,333	76	31,073	22,764	715	480

Note
1 "Service Box Sewer Demand" of 0.4 L/s taken from loading assumptions in original IMP calculations
2 The Racecourse Daycare is connected to the minor sanitary sewer system so peak hour flows are not included in calculations

APPENDIX E – DMD: Hastings Park Infrastructure Amphitheatre Update

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1 Introduction

DMD was retained by Urban systems to provide an update to the original Infrastructure Master Plan report. In April 2019, the PNE Amphitheatre Renewal Business Case and Preliminary Design Scenarios was completed. This report identified current market demands and provided 5 conceptual redevelopment scenarios for the Amphitheatre Renewal project.

The purpose of this report is to evaluate these redevelopment scenarios with respect to the original December 23, 2015 Hastings Park Infrastructure Master Plan (IMP). Design Scenario D is being considered for loading calculations as infrastructure requirements for Scenario D (largest capacity of the scenarios) will work for the other scenarios.

The items covered under this evaluation are primary power systems, communications and pedestrian lighting and will include:

Capacity Assessments

- Leveraging the assessed capacity of existing infrastructure reported in the IMP, determine their ability to meet future demands

Updated Infrastructure Designs for the Amphitheatre

- Update schematic infrastructure designs

Required Infrastructure Outside of the Amphitheatre Foot Print

- Considering the Amphitheatre may be developed ahead of Playland (Phase 1A and 4A). identify required infrastructure components from other phases of the IMP that would be required for Phase 2 development

Cost Estimates

- Update Class D (-20% to +30%) infrastructure cost estimates and cost allocation for the Amphitheatre project (phase 2)
- Update required infrastructure capital investments located outside Phase 2 that will be required for Phase 2 development

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2 Electrical

Scenario D

For the sake of keeping with the phasing name convention in the original IMP, the Amphitheatre Phase will remain named Phase 2 although it is being proposed to be constructed first.

There is an existing parallel feed to the PNE Agrodome Vista Switch (V1) from the BC Hydro Rupert Substation on East Hastings. This feed travels along the East Side of Playland and on Miller Road to get to the Agrodome. The original IMP plan was to reroute one of the redundant duct banks into a new Vista Switch V2 as part of Phase 4a. This now has to occur in Phase 2 as Vista Switch V2 feeds the Amphitheatre transformer.

Originally, the Amphitheatre transformer would have been fed from a Phase 1a/1b Vista Switch, but as that is being proposed to happen after the Amphitheatre it cannot be relied on as the source. As a result, some of the ducting and cabling that would have been in Phase 2 is now shifted to Phase 1a/1b.

As mentioned above, during the construction of Phase 2, one of the redundant feeds would be rerouted to Vista Switch V2. During the transition V1 would not have redundancy until V2 was energized, however there should not be an outage.

Should the Heart of the Park be developed at the same time as the Amphitheatre, it would be recommended to install the electrical preduct and vaults. There is some shared infrastructure between Phases 2, 3a and 3b as these ducts will ultimately be the secondary source to the Vista Switch V2.

In the August 2019 meeting, the PNE provided preliminary electrical requirements for the Amphitheatre. Based on this, it is recommended that the Amphitheatre transformer be upgraded from 300kva to 500kva. Overall, this upgrade won't affect the original IMP with any meaningful infrastructure or costs.

Refer to Section 6 for additional infrastructure requirements due to electrification of gas fired equipment.

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3 Communications

Scenario D

Based on the IMP record information that was provided, there appears to be an existing communications duct bank along Miller Road that feeds back to the Coliseum. These duct banks appear to have PNE Fibre, Telus Fibre, Bell Fibre and Rogers Fibre. Along the Heart of the Park frontage of the Amphitheatre there appears to be PNE Fibre and Copper duct banks. It is unclear the capacity of the duct banks and conductors, or the requirements for the future Amphitheatre.

It is recommended the entire communications system be documented and a complete system riser diagram be developed in the near future. This can be used to better define specific needs for future phases. This should be undertaken as a pre-design activity.

The current IMP strategy is to place two 100mm duct banks with vaults where ever there are new electrical duct banks installed. Scenario D does not change this. New electrical ducts along the frontage the Amphitheatre will be accompanied by new communication ducts and vaults. This also applies to the Heart of the Park should it be developed at the same time.

As most of the electrical ducts between Rupert Substation to the Agrodome Vista Switch exist, there is not an opportunity to place new communication ducts along the East perimeter of Playland and the parts of Miller Drive where there is no construction this phase.

Other upgrades such as replacing existing copper wiring and relocation of communications hub will still be required as covered in the original IMP.

4 Pedestrian Lighting

Scenario D

For pedestrian lighting, the overall strategy from the original IMP will not change. For new pedestrian pathways adjacent to the proposed Amphitheatre, new pedestrian lighting will be installed and can be fed from the new power distribution in the area.

This will also apply to the Heart of the Park should it be developed at the same time. An approximately 200m stretch of the pedestrian pathway could be fed from the new Amphitheatre power distribution. It is unlikely the rest of the pathway could be illuminated as there wouldn't be any new power distribution in the area (as it is all preduct) unless it was temporarily fed from existing sources nearby. In these areas, it is recommended that at minimum conduit, bases and junction boxes are installed.

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5 Cost Estimate

Please refer to the attached document for the updated Cost Estimate. The major change is the Electrical work that transitioning from Phase 4a to Phase 2 to accommodate the proposed Amphitheatre schedule. The cost estimate is based 2015 dollars (original IMP) and doesn't include taxes, contingencies or inflation factors.

Three Cost Estimates are attached. One will assume that only Phase 2 will go ahead. The other will assume that the Heart of the Park and the Daylighting segments are being installed at the same time as the Phase 2 Amphitheatre. In this second scenario duct banks and vaults that will ultimately service Phases 2, 3a, and 3b can be installed. However, they won't be energized until the Vista switches are installed in Phase 1a/1b. The third cost estimate will be a high level estimate of the costs including the electrification of Gas Fired Equipment in phases 1a and 2 which will be expanded on in the following section.

6 Electrification of Gas Fired Equipment

As part of City of Vancouver's 2050 Renewable Action Plan we have been asked to look at the electrification of gas fired equipment in phases 1a and 2. Loads were provided by the October 22, 2019 Amendment to the Hastings Park Gas Infrastructure Upgrade to Evaluate Electrification of the Site by Rocky Point Engineering Ltd. The overall trend is that the electrification would add a significant amount of load to the system.

Phase 1a

A high-level estimate of 51,000 MBH of natural gas from 17 food and concession buildings was reported. This converted into electrical demand is 14,943kW, or approximately 15MVA. This load would be used for cooking and does not seem to take into account gas heating converted into electrical heating. However, based on the analysis of phase 2, cooking load is the vast majority of the gas load and therefore any new heating load would not be as significant.

In comparison, the previous IMP had 7MVA (2 x 3.5MVA transformers) to feed existing and new equipment in the existing Playland footprint. The additional 15MVA would equate to about 4 new transformers as well as a new Vista Switch and loop of feeder cables and duct to maintain redundancy.

It is unknown how much secondary equipment will be affected so therefore only a very conservative cost estimate adding this additional equipment has been included.

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Phase 2

Based on scenario D, which is the worst case, and only taking into account resistance heating (also worst case and would take over heat pumps in Vancouver's -7C winter conditions) the additional gas load converted to electrical demand is about 3941kW or approximately 4MVA.

In comparison, the scenario D pre electrification of gas fired equipment estimated load was about 500kVA. The new load represents 1 upgraded transformer and 2 additional transformers in the Amphitheatre area.

The buildings will require a significant amount of power and will need an upgraded secondary distribution system.

A conservative design which the cost estimate has been based on is included.

Conclusions

As previously mentioned, the conversion from gas fired equipment to electrical equipment represents a significant increase in demand. It seems that the majority of the new load comes from cooking equipment. The numbers produced in this report are very conservative as it is a straight unit conversion and it would be recommended a kitchen designer be retained to layout the equipment of a typical kitchen and a realistic electrical demand can be determined.

It is also recommended to take a look at the larger impacts to the overall Infrastructure Master Plan. As seen in only two of the phases, the conversion represents an immense load to the system. If the same Renewable Action Plan is intended to stretch Park wide through all the other phases, the IMP would be significantly impacted. More transformers, feeders and vista switches would be required to handle the load and maintain redundancy. Much larger secondary distribution would also be required.

Additionally, BC Hydro would see a significant load to their system. Currently, the Rupert Substation is being fed by 3x 12.5kV feeder circuits from the Horne Payne Substation. A typical 12.5kV circuit has the maximum capacity of 8MVA or 24MVA total. When BC Hydro upgrades the system to 25kV that would be maximum of 16MVA per circuit or 48MVA total. It is advisable to consult with the BC Hydro Key Accounts manager to see what options are available for Hastings Park. BC Hydro would need to upgrade their system and some of those costs would be passed on to the City.

7 Existing Garden Substation

The garden substation is an indoor substation consisting of 2x1750kVA transformers that were manufactured in 1953. They transform the 12.5kV distribution to 4.16kV and feed the 4.16kV line that extends around the park. These two transformers have been noted to be at end of life

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as the most recent Electrical Service Test Report by RESA Power Service in August 2018 indicates.

The existing 4.16kV line is a loop system that is a combination of underground and overhead feeders. Buildings such as the Barns, the Livestock building, the Spirit Plaza as well as the 4 Gayway Substations that feed Playland come off of the 4kV line.

The existing peak load on the transformers is 1708kVA. Therefore, if one of the transformers were to cease functioning, the other transformer would be running at full load. However, it is reasonable to assume that if one transformer failed, the other would soon follow. This is because transformers are physically close to each other, the wall separating the two transformers is aging, and both transformers are at end of life. It would be catastrophic if both transformers failed as the majority of the park would not have power.

In the IMP all distribution will be 12.5/25kV and therefore there will be no need for the Garden Substation transformers. However, the transition will take place over 6 phases and it is expected that until all distribution is 12.5/25kV, some 4kV distribution will be needed. It is reasonable to expect that the Garden Substation will be needed for another 20 to 30 years.

Replacing or reprocessing the oil may extend the transformers' life temporarily. However, due to the importance of these transformers and the service life required it is recommended to replace the transformers. It is also assumed that the switch gear and circuit breakers are nearing end of life and thus may need to be replaced.

Below are high level costs for the replacement of the Garden substation transformers. The transformers have been upsized to 2MVA each to accommodate future interim load while the transition from 4kV to 12.5/25kV occurs.

1) Supply 2 transformers (2-2MVA): $200,000

2) Remove old transformers, drain, dispose, move new transformers in, commission: $155,000

3) Supply only indoor switchgears: $500,000

4) Supply only indoor relays, breakers disconnect switches: $400,000

A detailed design would be required. Important factors to consider are the transition from existing transformers to new transformers to minimize any downtime as well as a physical separation (like a wall) between the transformers to prevent fire from spreading.

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Hastings Park and Playland - Class C Estimate of Probable Costs

Description of Item		Phase 1A Qty	Phase 1B Qty	Phase 2 Qty	Phase 3A Qty	Phase 3B Qty	Phase 4A Qty	Phase 4B Qty	Phase 4C Qty	Phase 5A Qty	Phase 5B Qty	Phase 5C Qty	Phase 6 Qty	Unit Price	Phase 1A Total	Phase 1B Total	Phase 2 Total	Phase 3A Total	Phase 3B Total	Phase 4A Total	Phase 4B Total	Phase 4C Total	Phase 5A Total	Phase 5B Total	Phase 5C Total	Phase 6 Total
Electrical																										
1 MVA Substation	ea	0	0	0	0	1	2	0	2	1	2	1	1	$104,000.00	$0.00	$0.00	$0.00	$0.00	$104,000.00	$208,000.00	$0.00	$208,000.00	$104,000.00	$208,000.00	$104,000.00	$104,000.00
1.5 MVA Substation	ea	1	0	2	0	0	0	0	0	0	1	0	0	$140,000.00	$140,000.00	$0.00	$280,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$140,000.00	$0.00	$0.00
2 MVA Substation	ea	0	1	1	1	0	1	0	0	0	0	0	2	$162,000.00	$0.00	$162,000.00	$162,000.00	$162,000.00	$0.00	$162,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$324,000.00
2.5 MVA Substation	ea	0	0	0	0	0	1	0	0	0	0	0	0	$183,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$183,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3 MVA Substation	ea	0	0	0	0	0	0	0	0	0	0	0	0	$197,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3.5 MVA Substation	ea	2	0	0	0	0	0	0	1	0	0	0	0	$211,000.00	$422,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$211,000.00	$0.00	$0.00	$0.00	$0.00
4.5 MVA Substation	ea	3	0	0	0	0	0	0	0	0	0	0	2	$242,000.00	$726,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$484,000.00
Vista Switching Cabinet and Vault	ea	2	0	1	0	0	1	0	0	0	0	0	1	$320,000.00	$640,000.00	$0.00	$320,000.00	$0.00	$0.00	$320,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$320,000.00
Primary Duct Bank, Vaults and Cables	m	5408	652	721	0	0	3246	0	860	20	1100	756	2500	$830.00	$4,488,640.00	$541,160.00	$598,430.00	$0.00	$0.00	$2,694,180.00	$0.00	$713,800.00	$16,600.00	$913,000.00	$627,480.00	$2,075,000.00
Primary Duct Bank and vaults only	m	0	0	0	282	326	0	0	0	0	0	0	0	$550.00	$0.00	$0.00	$0.00	$155,100.00	$179,300.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Primary Cables only	m	0	608	0	0	0	0	0	0	0	0	0	0	$280.00	$0.00	$170,240.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Secondary Ducts and Cables	m	3230	570	1500	100	100	2200	0	250	240	490	120	850	$150.00	$484,500.00	$85,500.00	$225,000.00	$15,000.00	$15,000.00	$330,000.00	$0.00	$37,500.00	$36,000.00	$73,500.00	$18,000.00	$127,500.00
Secondary Panels and Switchgear	ea	561	11	600	1	1	39	0	4	2	4	2	8	$5,000.00	$2,805,000.00	$55,000.00	$3,000,000.00	$5,000.00	$5,000.00	$195,000.00	$0.00	$20,000.00	$10,000.00	$20,000.00	$10,000.00	$40,000.00
Removal and Disposal of Existing	LS	1	1	0	1	0	0	1	1	1	2	0	2	$30,000.00	$30,000.00	$30,000.00	$0.00	$30,000.00	$0.00	$0.00	$30,000.00	$30,000.00	$30,000.00	$60,000.00	$0.00	$60,000.00
Sub-Total															**$9,736,140.00**	**$1,043,900.00**	**$4,585,430.00**	**$367,100.00**	**$303,300.00**	**$4,092,180.00**	**$30,000.00**	**$1,220,300.00**	**$196,600.00**	**$1,414,500.00**	**$759,480.00**	**$3,534,500.00**
Lighting																										
Lighting Pole conduit and conductors	ea	38	10	11	8	8	34	15	49	18	14	23	31	$10,000.00	$380,000.00	$100,000.00	$110,000.00	$80,000.00	$80,000.00	$340,000.00	$150,000.00	$490,000.00	$180,000.00	$140,000.00	$230,000.00	$310,000.00
Adaptive Lighting Controls	ea	38	10	11	8	8	34	15	0	18	14	23	31	$200.00	$7,600.00	$2,000.00	$2,200.00	$1,600.00	$1,600.00	$6,800.00	$3,000.00	$0.00	$3,600.00	$2,800.00	$4,600.00	$6,200.00
Sub-Total															**$387,600.00**	**$102,000.00**	**$112,200.00**	**$81,600.00**	**$81,600.00**	**$346,800.00**	**$153,000.00**	**$490,000.00**	**$183,600.00**	**$142,800.00**	**$234,600.00**	**$316,200.00**
Communications																										
Duct Bank and Vaults	ea	5408	652	721	282	326	3246	0	860	20	1019	756	2113	$150.00	$811,200.00	$97,800.00	$108,150.00	$42,300.00	$48,900.00	$486,900.00	$0.00	$129,000.00	$152,850.00	$152,850.00	$113,400.00	$316,950.00
Fibre Cables	m	5408	1260	721	0	0	3246	0	860	20	1019	756	0	$75.00	$405,600.00	$94,500.00	$54,075.00	$0.00	$0.00	$243,450.00	$0.00	$64,500.00	$76,425.00	$76,425.00	$56,700.00	$0.00
Copper Cables	m	5408	1260	721	0	0	3246	0	860	20	1019	756	0	$75.00	$405,600.00	$94,500.00	$54,075.00	**$0.00**	$0.00	$243,450.00	$0.00	$64,500.00	$76,425.00	$76,425.00	$56,700.00	$0.00
Sub-Total															**$1,622,400.00**	**$286,800.00**	**$216,300.00**	**$42,300.00**	**$48,900.00**	**$973,800.00**	**$0.00**	**$258,000.00**	**$305,700.00**	**$305,700.00**	**$226,800.00**	**$316,950.00**
Overall Total															**$11,746,140.00**	**$1,432,700.00**	**$4,913,930.00**	**$491,000.00**	**$433,800.00**	**$5,412,780.00**	**$183,000.00**	**$1,968,300.00**	**$685,900.00**	**$1,863,000.00**	**$1,220,880.00**	**$4,167,650.00**
Contingency (30%)															$3,523,842.00	$429,810.00	$1,474,179.00	$147,300.00	$130,140.00	$1,623,834.00	$54,900.00	$590,490.00	$205,770.00	$558,900.00	$366,264.00	$1,250,295.00
Engineering (20%)															$2,349,228.00	$286,540.00	$982,786.00	$98,200.00	$86,760.00	$1,082,556.00	$36,600.00	$393,660.00	$137,180.00	$372,600.00	$244,176.00	$833,530.00
Total Per Phase															**$17,619,210.00**	**$2,149,050.00**	**$7,370,895.00**	**$736,500.00**	**$650,700.00**	**$8,119,170.00**	**$274,500.00**	**$2,952,450.00**	**$1,028,850.00**	**$2,794,500.00**	**$1,831,320.00**	**$6,251,475.00**
Grand Total																										**$51,778,620.00**

Assumptions:

1. Secondary panels and kiosks for Amphiteatre increased to account for outdoor kiosk. It is really only 2 kiosk feeding some subpanels, but the number shown in phase 2 is to approximate the larger cost of the kiosk
2. Scenario assumes that Daylighting and Heart of the park is being installed at the same time as Phase 2 Amphitheatre. However, only duct/vaults can be installed. Cable will be installed in phase 1B.
3. Dependencies from Phase 1b moved over to 1a. Moved over Vista V5 and portion of ductbank/cables.

APPENDIX F1 – Rocky Point: Hastings Park Infrastructure Amphitheatre Update

Hastings Park Infrastructure Master Plan Gas Piping Evaluation

Prepared by:

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1.0 Purpose of the Report

Rocky Point Engineering was approached by Urban Systems to assist in the evaluation on the size, capacity, and life expectancy of the existing natural gas piping distribution system throughout the Hastings Park Site and provide recommendations to extend the gas services to serve new areas / facilities.

2.0 Existing Gas Distribution Systems

Refer to Urban Systems Figure 10 for a single line layout of the existing natural gas piping layout and sizes.

It is illustrated that the existing gas piping system is fed from two Fortis services off of Renfrew Street.

The first service is located near Triumph Street and incorporate a Fortis Gas Meter and PRV Station which provides a 10 PSIG gas pressure service to the site.

The second service is located near Dundas Street, and incorporate a Fortis Gas Meter and PRV Station which provides a 10 PSIG gas pressure service to the site.

The third gas service is fed off of McGill Street and incorporate a Fortis Gas Meter and PRV Station which provides a gas service to the PNE Technical Service Building only. There are no discussions on this service as it is expected to be unused in the future with the occupants / usage of the building to be relocated.

The Renfrew Services:

The 100mm diameter north gas main serves the Coliseum, Rollerland, Agrodome, DND Building, Hastings Horse Race Course grandstands and stables.

The 150mm diameter south gas main serves the Forum, Administration Building, Garden Audit, Live Stock Barns and Playland.

The above-mentioned gas services and meters are the only ones on site, so no individual consumption data is available for any of the existing buildings. Some of the Fortis Records of gas consumption have been made available, which will help to ascertain the volume of gas used during the year on a month by month bases.

There are various private sub-meters, which no record of consumption information was made available.

The following is a general location for the sub-meters:

- East side or the Forum
- South side of Racecourse Grandstand
- South side of the racecourse Jockey Hut
- East side of Field House at Empire Field
- North side of the Playland Maintenance Area, no longer used

As part of this report an evaluation of the overall gas consumption will be reviewed to determine the diversity of the gas service from the heating of the large occupy-able buildings during the winter / heating months and Playland along with the future development, for the summer month when the consumption of gas will be primarily for food preparation.

There are many (PRV) stations throughout the park to reduce the gas pressure to serve individual buildings and Kiosk's.

The existing natural gas distribution piping system is believed to be 60+ years old and is constructed with welded schedule 40 steel piping, a corrosion assessment has not been performed. It has also been reported that approximately 75% of the existing natural gas distribution piping has been cathodically protected, but it is

unclear when this was done and if it has been monitored. We understand there are no drawings available to indicate which mains and branch lines have been protected.

3.0 Estimated Gas-Fired Equipment per Building or Concession (Existing)

Building	North Leg	South Leg
Coliseum	4,200 MBH	
Rollerland	650 MBH	
New Exhibition Bldg.	4,500 MBH	
Horse Track	2,000 MBH	
Agradome		2,000 MBH
Livestock Barn		2,000 MBH
Forum		2,000 MBH
Garden Audition		650 MBH
Administration		450 MBH
Playland		22,000 MBH
Playland Extension		22,500 MBH
Back of House		500 MBH
Totals	11,350 MBH	51,100 MBH

The Table above is an estimate based on building area only and does not include all of the buildings, Barns or Concessions, as no detailed site review was conducted to ascertain what gas fired equipment has been installed at each location.

4.0 Future Gas Service Requirements (Playland Expansion)

Based on the type of cooking equipment that would probably be required to facilitate each future Concession Building, we have provided a (conservative) suggested gas requirement for each piece of equipment to help in the sizing of the new gas distribution services along with evaluating the capacity of the existing services.

New Concession Buildings Large:

• Deep Fat Fryer (six)	6 x 80 MBH
• Grilles (three)	3 x 80 MBH
• Ovens (four)	4 x 75 MBH
• Warming Ovens (two)	2 x 25 MBH
• Building heating system	100 MBH
• Domestic hot water heaters	250 MBH
• Hot water heater for the dishwasher	100 MBH
• Unknown 15% of total	230 MBH
Total per Concession Building	**1,750 MBH**

6 Proposed buildings would be 10,500 MBH load

New Concession Buildings Small:

• Deep Fat Fryer (four)	4 x 80 MBH
• Grilles (two)	2 x 80 MBH
• Ovens (two)	2 x 75 MBH
• Building heating system	100 MBH
• Domestic hot water heaters	150 MBH

- Unknown 15% of total 120 MBH

  Total per Concession Building 1,000 MBH

  11 Proposed buildings would be 11,000 MBH load

  The combined load for the future Playland Expansion is anticipated to be approximately 22,500 MBH

5.0 Future Gas Service Requirements for the Proposed Amphitheatre

Scenario "C" (two new-2 story building)

Building A is expected to containing Banquet Hall, Washrooms, Dressing Rooms, Offices, First Aid, Box Office, and 4 Bars.

Anticipated gas load for Building "A"

- Building fabric heating load 250 MBH
- Outdoor air load based on 300 occupants 100 MBH
- Prep Kitchen 1,750 MBH
- 4 small concessions 1000 MBH X 4 4,000 MBH

  Total building "A" load 6,100 MBH

Building B is expected to containing VIP Suites, Washrooms, Dressing Rooms, Offices, First Aid, Box Office, Prep Kitchen and Concessions.

Anticipated gas load for Building "B"

- Building fabric heating load 270 MBH
- Outdoor air load based on 300 occupants 100 MBH
- Small concessions 1000 1,000 MBH
- Prep Kitchen 1,750 MBH

  Total building "B" load 3,120 MBH

Scenario "C" total anticipated combined gas load for the two buildings would be **9,220 MBH**

Scenario "D" (three new building): Bldg. "A"- two story, Bldg. "B" three story & Bldg. C: single story

Building A is expected to containing VIP Suites, Washrooms, Dressing Rooms, Offices, First Aid, Box Office, Prep Kitchen, 4 Concessions and Bars.

Anticipated gas load for Building "A"

- Building fabric heating load 250 MBH
- Outdoor air load based on 330 occupants 110 MBH
- 4 small concessions 1000 MBH X 4 4,000 MBH
- Prep Kitchen 1,750 MBH

  Total building "A" load 2,110 MBH

Building B is expected to containing VIP Suites, Washrooms, Dressing Rooms, Offices, First Aid, Box Office, Prep Kitchen, 4 Concessions and Bars.

Anticipated gas load for Building "B"

- Building fabric heating load 430 MBH
- Outdoor air load based on 300 occupants 100 MBH
- Prep Kitchen 1,750 MBH
- 4 small concessions 1000 MBH X 4 4,000 MBH

Total building "B" load 6,280 MBH

Building C is expected to containing Washrooms, Offices and Concessions.

Anticipated gas load for Building "C"

- Building fabric heating load 65 MBH
- Outdoor air load based on 10 occupants 3 MBH
- Small concessions 1000 MBH 1,000 MBH

Total building "C" load 1,068 MBH

Scenario "C" total anticipated combined gas load for the two buildings would be **9,458 MBH**

Since both C and D scenarios require a similar gas load, we will use 10,000 MBH as a common value.

6.0 Present & Future Gas Distribution System Capacity

Based on Urban Systems Site Plan Figure 18 that identifies the extension to the existing south gas main up to and around the new Playland Extension, BOH and also connects into the north loop. The proposed pipe sizes should be adequate. Minimal information was made available on the gas fired equipment used within the Playland area during the Fair other than the new extension would probably double the requirements, so with double the amount of gas fired equipment being used will double the amount of gas being consumed.

6.1 Gas Pipe Sizing:

Gas pipe sizing is based on the total length of the main, from the gas meter at the property line to the furthest equipment connection or PRV. Once the total length has been established, published tables based on the pipe size, the incoming gas pressure and the allowable pressure drop through the length of the main determines the expected volume of gas that can be supplied to the furthest equipment or pressure reducing valve.

6.2 Estimated Site Load (Now and Future):

Future gas requirements for the combined distribution system (2 meters off of Renfrew) would include approximately 21,500 MBH for the future Playland Extension, 500 MBH for the future BOH, 4,500 MBH for the future Exhibition Building and 10,000 for the Amphitheatre would total 100,000 MBH +/- which includes the existing buildings. There are still various other locations that there is gas fed to, but no indication on what they serve or the loads, it is not anticipated to be significant based on the redundancy of the summer / winter loads.

6.3 Gas Main Size and Capacity:

The existing 100mm north gas main has a total capacity available of 27,000 MBH available based on an equivalent length of 900 meters, and this is primarily a winter load.

The existing 150mm south gas main has a total capacity available of 67,000 MBH available based on an equivalent length of 1,100 meters, and this is also primarily a winter load.

6.4 Gas Piping Summary:

With the addition of the Amphitheatre the overall combined peak load is greater that the present infrastructure, by a small amount of 6000 MBH.

If the proposed upgrades to the system are evaluated based on diversity of building heating and some cooking in the winter and summer only cooking then the proposed distribution system should be adequate to handle the projected load. Note that a full site assessment would be required to evaluate the total gas load, so this report is only a high-level review of information that we were provided.

6.5 The South Gas Main:

The 150mm south gas main has an expected load of approximately 51,100 MBH plus an additional 10,000 MBH (Amphitheatre) and 20,00MBH for the Playland extension for a total load of 81,000 MBH. Based on the current pipe size there is a total capacity available of 67,000 MBH. The Playland extension main will also be interconnected with the north loop which will back feed gas to make up for the short fall and should provide sufficient capacity based on diversity of building heat and food preparation.

Presently the south gas service reduces in size after the Livestock Barns to 100mm, which reduces the available capacity to 27,000 MBH and further reduces the size to 50mm with a capacity of 4,800 MBH, which explains why they have experiences problems with a shortage of gas during the Fair in the Playland Area.

The gas requirements for the present Playland Concessions was an assumption based on equalling the same suggested quantity as the future Playland Extension.

To fully assess the gas distribution with-in the PNE Site a detailed assessment would need to be conducted to verify exactly what size of gas service and what pressure is being provided to each Concession / Kiosk and what equipment is being served.

Based on Urban Systems Site Plan Figure 18, all of the current 100mm and 50mm gas piping along the south leg will be replaced with 150mm pipe, which will extend around the new Playland Extension and connect into the north loop 100mm service. A second 100mm loop will run around the future Playland Extension to accommodate the future Concessions and Kiosks. A 50mm gas main will then extend out to the BOH at the northeast corner of the site. By upgrading the pipe size and connecting the two legs together will increase the overall capacity of the system. The new total length of the system will be increased to 1,100 meters which reduces to overall capacity to 67,000 MBH for a 150mm pipe and 4,000 MBH for a 50mm pipe. The future Back of House building will only have an anticipated load of 500 MBH, so the 50mm service will more than handle it.

6.6 The North Gas Main:

The 100mm north gas main has an expected load of approximately 11,350 MBH plus an additional 500 MBH for the BOH and 22,500 MBH for the Playland extension which both will also served from the south loop.

The 100mm service presently stops behind the Livestock Barns, but is proposed to be extended with a 100mm service out to the point where it connects into the 150mm main from the south system, and then will continue on with a 50mm to the BOH.

7.0 Hastings Park Gas Consumption for the years 2012 through 2015

		All units are Gigajoules (GJ)		
Billing Month	**2015**	**2014**	**2013**	**2012**
January	266	287	264	
February	162	272	270	
March	170	287	251	
April	132	203	179	
May	141	144	146	53
June		57	51	20
July		38	20	131
August		7	14	15
September		14	22	
October		20	59	30
November		79	127	621
December		226	230	
Annual Total		1634	1633	

The Table above reflects the gas consumption for the majority of Hastings Park infrastructure, based on the readings from the Renfrew gas meter, the Table does not include the gas service to PNE Technical Building off of McGill Street.

As indicated in the Table above, the majority of gas consumption (building heating) happens over the winter months, November through to May which is not expected to increase in any volume, until the new / proposed 14,000 sq. meter Exhibition Building is constructed, and used year round, which we would estimate the heating load for it at 4,500 MBH, plus the Back of House building which would add an additional 500 MBH load during the winter months.

The summer months of June through August which would include the operation of the PNE / Playland and all associated concessions which uses a small proportion of the overall gas load and will increase depending on the extent of the Playland Expansion.

The present gas consumption for Hastings Park has remained consent with slight increases due to colder winter conditions in the year 2014, and warmer winter of 2015.

Based on increasing the gas requirements to add the future Playland Extension, the BOH and the future Exhibition Building and the Amphitheatre buildings to the existing natural gas system, the summer demand would still be less than the winter consumption.

The existing gas service at the meter has the capacity, and with the proposed upgrades in pipe sizes as indicated on Urban Systems Site Plan Figure 18, should easily handle the future loads.

The only issue would be the condition of the existing pipe material.

But the pipe is still 60 years old and will probably need to be replaced in the next 20 years.

8.0 Assessment of Existing Gas Pipe Material

The existing natural gas distribution piping system is believed to be 60 + years old and is constructed with welded schedule 40 steel piping, a corrosion assessment has not been performed on the gas piping itself, but there was one conducted on the water main piping and the condition was found to vary depending on how well the bitumastic coating was applied during installation.

There is no indication that the gas piping was protected in the same way.

It has been reported that approximately 75% of the existing natural gas distribution piping has been cathodically protected, but it is unclear when this was done and if it has been monitored. We understand there are no drawings available to indicate which mains and branch lines been protected.

It would not have been normal practice to provide cathodic protection on the piping when it was installed.

It is recommended that prior to implementing the upgrade of the natural gas piping system that several sections of the pipe be removed and a corrosion assessment be performed to determine the actual condition of the pipe material. Location should be taken from areas were both the pipe was not cathodically protected and were it is protected, and in locations of different pipe sizes and ages.

Information from the Geotechnical Report indicated that the soil conditions have a moderate corrosion potential.

After a pipe assessment has been conducted it is recommended that a future study be conducted to provide an overall review of the condition of the piping system.

The only pipe material the current BC Gas Code allows is schedule 40 steel or malleable iron pipe, corrugated stainless steel tubing (CSST) and type L or G copper tubing externally coated with extruded polyethylene or PVC resin applied at time of manufacture. All of the various pipe materials are sized based on the same method.

The new piping would also be catholically protected and wrapped to protect the material from coming in contact with the soil, which should provide many years of a reliable gas service

9.0 Condition Summary and Recommendation

- The existing gas piping is 60+ years old and a pipe assessment needs to be conducted prior to implementing the upgrades.
- The existing gas piping will probably need to be replaced within the next 20 years.
- The piping system with the extension out to the Playland Extension is adequately sized based on the upsizing the mains as indicated on Urban Systems Site Plan Figure 18.
- The seasonal gas consumption will rise as more services are added to the existing gas distribution network, the winter consumption should not increase until the new Exhibition, Amphitheatre and BOH Buildings are constructed.
- The gas piping has been sized based on a service pressure of 10 PSI with a 5 PSI pressure drop.
- New PRV pressure reducing valves will be required at each branch for future services.
- Branch gas sub-meters should be considered to better evaluate the gas consumption of each facility.
- Provide cathodic protection for the new piping.

10.0 DISCLAIMER OF LIABILITY

The material in this report reflects our professional opinion based on information provided. Any use which a third party makes of this report or reliance on decisions made based on it, are the responsibilities of such third parties. Rocky Point Engineering Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

APPENDIX F2 – Rocky Point: Electrification Update

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Amendment to the Hastings Park Gas Infrastructure Upgrade to Evaluate Electrification of the Site.

Overview:

Based on the City of Vancouver's 2050 Renewable Action Plan to eliminate fossil fueled fired equipment by converting to non-emission producing components, we have been asked to evaluate and provide high level conservative estimates to replace the present gas services to the Hastings Park site and convert to electricity.

Based on the tight time frame for this evaluation we did not have access to visit any of the present facilities in the Playland Area, or any of the existing building on the site.

In general, it is understood that there are minimal building heating requirements for a majority of the structures in the Play Land Area as they only operate during the August Fair, and the major gas consumption is used for cooking.

Along with evaluating the Play Land Area we will also look at the future Amphitheatre complex.

Amphitheatre

The following loads are based on schematic concept sketches along with a written description that references the proposed building areas, expected occupancy and assumed loads for the cooking equipment in the Concessions. We have assumed that the building construction will meet the current City of Vancouver Building By-Laws for the bases of the building fabric heat losses. We will provide separate heating kW values for either conventional resistance heat and the use of heat pump units which have a co-efficient of performance of 3 to 1.

Note: Heat pump units can only heat down to +5 C, so a secondary back up heating source will be required to accommodate Vancouver's -7C winter design conditions.

Building "A"

- Fabric heating load of 250 MBH: Resistance heat 73 kW; RTU Heat Pump heat 25 kW
- Outdoor Air heating load of 100 MBH: Resistance heat 29 kW; RTU Heat Pump heat 10 kW
- Prep. Kitchen cooking load of 1750 MBH 512 kW
- 4 - Concessions of cooking load 4000 MBH 1172 kW

Building "B"

- Fabric heating load of 270 MBH: Resistance heat 79 kW; RTU Heat Pump heat 26 kW
- Outdoor Air heating load of 100 MBH: Resistance heat 29 kW; RTU Heat Pump heat 10 kW
- Prep. Kitchen cooking load of 1750 MBH 512 kW
- Concessions of cooking load 1000 MBH 293 kW

Scenario "C"

The combined load for the Scenario "C" would be the combination of a Building "A" and "B" as identified in Urban Systems Master Plan Report.

- Fabric heating load of 520 MBH: Resistance heat 152 kW
  RTU Heat Pump heat 50 kW
- Outdoor Air heating load of 200 MBH: Resistance heat 58 kW
  RTU Heat Pump heat 20 kW
- Prep. Kitchen cooking load of 3500 MBH 1024 kW
- 5 - Concessions of cooking load 5000 MBH 1465 kW

Scenario "D"

The combined load for the Scenario "D" would be the combination of a Building "A", "B" & "C" as identified in Urban Systems Master Plan Report.

- Fabric heating load of 745 MBH: Resistance heat 218 kW
  RTU Heat Pump heat 72 kW
- Outdoor Air heating load of 213 MBH: Resistance heat 62 kW
  RTU Heat Pump heat 21 kW
- Prep. Kitchen cooking load of 3500 MBH 1024 kW
- 9 - Concessions of cooking load 9000 MBH 2637 kW

Existing Play Land Area

It is understood that there are presently 6 Food Buildings and 11 Concession Building within the Play Land Area, and that they generally only operate during the August Fair. Presently all 17 building are served with natural gas which is primarily used for cooking. The existing building where not visited so we have made educated guesses on quantity of cooking equipment for the various buildings to ascertain a conservative value for the gas requirements so as to provide a suggested electrical value.

We have guesstimated a total quantity of 51,000 MBH of natural gas which equals 14,943 kW.

The 14,943 kW is a very conservative value which is probably over stated. To evaluate the present gas load a detailed review of each building will be required.

Hastings Park Vancouver

Archaeological Overview Assessment

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Musqueam Heritage Research/Investigation Permit MIB-2019-046-AOA
Squamish Archaeological Investigation Permit 19-0120
Stó:lō Heritage Investigation Permit 2019-056
Tsleil-Waututh Nation Cultural Heritage Investigation Permit 2019-042

October 31, 2019
Inlailawatash File: 18-5-15

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Important Notice

This study identifies potential impacts to archaeological resources by works associated with the Hastings Park-PNE Master Plan proposed by the City of Vancouver. It does not address potential impacts to traditional use activities and sites by this development. It is not the intent of this report to document First Nations' interests in the lands at this locality. The study was conducted without prejudice to First Nations' treaty negotiations, Aboriginal rights, or Aboriginal title.

Credits

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2. Tsleil-Waututh Nation
3. Musqueam Indian Band

Executive Summary

A review of baseline archaeological information pertaining to the heritage resources for the Hastings Park Project Area was conducted by the Archaeology Unit of Inlailawatash Limited Partnership. The review was conducted in accordance with the British Columbia Archaeological Overview Assessment (AOA) standards and guidelines (Archaeology Branch 1998, 2009). Archaeological sites are locations with material remains produced by human activities in the past. Archaeological sites older than 1846 are protected under the *Heritage Conservation Act* (*HCA*) (Government of BC 1996). In British Columbia archaeological sites are most frequently attributed to settlement and land use of Aboriginal peoples.

This AOA evaluates archaeological site potential of the Hastings Park Project Area. The assessment consisted of a desk-based literature review and compilation of existing historical knowledge about recorded archaeological site locations, historical First Nations land use and place names, and environmental features in areas likely to effect site location. In addition, a Preliminary Field Reconnaissance was conducted across the Project Area. This information is used to create a potential model of where archaeological sites are expected to be located.

The result of this AOA is that one area of archaeological potential was identified surrounding and adjacent to the historic streams that were once present in the Project Area. No specific development plans for Hastings Park have been provided to Inlailawatash, and the types of resource management recommendations (e.g., monitoring, *Chance Find Procedure*, or subsurface testing) are generally chosen based on the known scope of impacts from specific developments. However, a general management recommendation is made that:

(1) The Area of Potential (AOP) identified surrounding the historic creeks requires an Archaeological Impact Assessment (AIA) if developments will impact the sub-surface deposits in the vicinity of the creeks.

Based on the results of this AOA an Archaeological Impact Assessment (AIA) of the Area of Potential would fulfill Provincial requirements for the protection of potential archaeological sites under the *HCA*. However, the fulfillment of these requirements alone does not address impacts to other cultural resources of interest to First Nations, which may include intangible aspects of heritage in addition to archaeological sites, such as a known place name of spiritual significance on the Hastings Park lands which are beyond the recommendations of an Archaeological Overview Assessment. Given the nature of the Hastings Park—PNE Master Plan, which is a multi-year/multi-phase project, the management of cultural resources may be most effective on a government to government level through direct consultation with First Nations.

Acknowledgments

We thank all those who contributed their time, energy, and experience to this Project. We particularly acknowledge the First Nations communities – Musqueam, Squamish, Stó:lō, and Tsleil-Waututh – within whose territories of interest this assessment occurred. All the Nations supported and acknowledged the work by issuing heritage permits to Inlailawatash Archaeology.

We would like to thank Darrell Guss who provided archaeological field representation for Tsleil-Waututh; his knowledge of the history of Hastings Park and the surrounding landscape was an essential part of the Preliminary Field Reconnaissance. We also thank Kevin Nguyen at the City of Vancouver for his assistance in keeping the project on track.

Abbreviations

AIA	Archaeological Impact Assessment
AOA	Archaeological Overview Assessment
BP	before present
CRM	Culture Resource Management
HCA	*Heritage Conservation Act*
PFR	Preliminary Field Reconnaissance

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1 INTRODUCTION

This report describes the results of an Archaeological Overview Assessment (AOA) that includes both a desktop review and Preliminary Field Reconnaissance of cultural heritage resources for the proposed Hastings Park-PNE Master Plan in the City of Vancouver, British Columbia. The assessment was undertaken by Inlailawatash Limited Partnership on behalf of the City of Vancouver (Figure 1). The purpose of this report is to assess archaeological potential for the Project Area and to make management recommendations for further assessment if required.

The Project is located within the Hastings-Sunrise neighbourhood in the local territories of interest of the Musqueam, Squamish, Stó:lō, and Tsleil-Waututh Nations who are part of a larger Provincial *Consultative Areas Database* (Cowichan Tribes, Lake Cowichan First Nation, Halalt First Nation, Lyackson First Nation, Musqueam Indian Band, Penelakut Tribe, Squamish First Nation, Stó:lō Nation, Stó:lō Tribal Council, Stz'uminus First Nation, and Tsleil-Waututh Nation).

The study was conducted under Musqueam Indian Band Heritage Research/Investigation Permit MIB-2019-046-AOA, Squamish Nation Archaeological Investigation Permit 19-0120, Stó:lō Heritage Investigation Permit 2019-056, and Tsleil-Waututh Nation Cultural Heritage Investigation Permit 2019-042.

1.1 Objectives

The primary objective of the overview assessment is to describe the distribution of known and potential archaeological sites within the local study area and the Project Area. The purpose is to assess whether the proposed Project poses a risk to known or unidentified archaeological sites.

The characteristics of archaeological sites that may be identified within the local study area, based on pertinent biophysical, ethnographic, and ethnohistoric data, are outlined to assess the potential risks of development to cultural resources. Based on this information, recommendations are provided regarding the need for further archaeological investigations (e.g., archaeological monitoring) for potential and known archaeological resources within the Project Area, and to assess the risks associated with proposed developments.

The objectives of this overview assessment are to:

- Review cultural significance of the lands and archaeological resources of the Project;

- Obtain local First Nations heritage investigation permits for work within their traditional territories and engage their field representatives;
- Identify and describe archaeological sites that may conflict with the proposed development Project;
- Identify lands or landforms with the potential to contain archaeological sites within the Project Area through a desk-based analysis and Preliminary Field Reconnaissance;
- Assess potential impacts to archaeological resources that might result from construction activities during development projects; and
- Provide recommendations for measures to avoid, limit, protect or otherwise mitigate potential adverse effects of the proposed project to known or potential archaeological resources.

1.2 Project Description and Potential Development Impacts

This Archaeological Overview Assessment was conducted in advance of development work related to the Hastings Park—PNE Master Plan. The Hastings Park-PNE Master Plan is a multi-year/multi-phase project which proposes to transform Hastings Park into a greener, year-round destination for park use. This AOA does not refer to any specific developments or construction within Hastings Park, but is an assessment of archaeological potential within the overall Project Area (Figures 1, 2). This AOA is meant to inform the planning of future development works with the possible requirement for more intensive archaeological assessments that are based on specific development footprints, or where there is a known conflict with heritage resources.

1.3 Archaeological Heritage Legislation

Heritage resources as a general term are defined as “a human work or a place that gives evidence of human activity or has spiritual or cultural meaning and that has historic value.” The *Canadian Environmental Assessment Act* (Government of Canada 1992) outlines four categories of heritage resources: paleontology, archaeology, historic sites, and traditional land use (Canadian Environmental Assessment Agency 1996). One type of heritage resource, i.e., archaeological sites, are the subject of an AOA, and while other types of heritage resources are important sources of background information, only archaeological resources are assessed in this report.

s.18, s.18.1

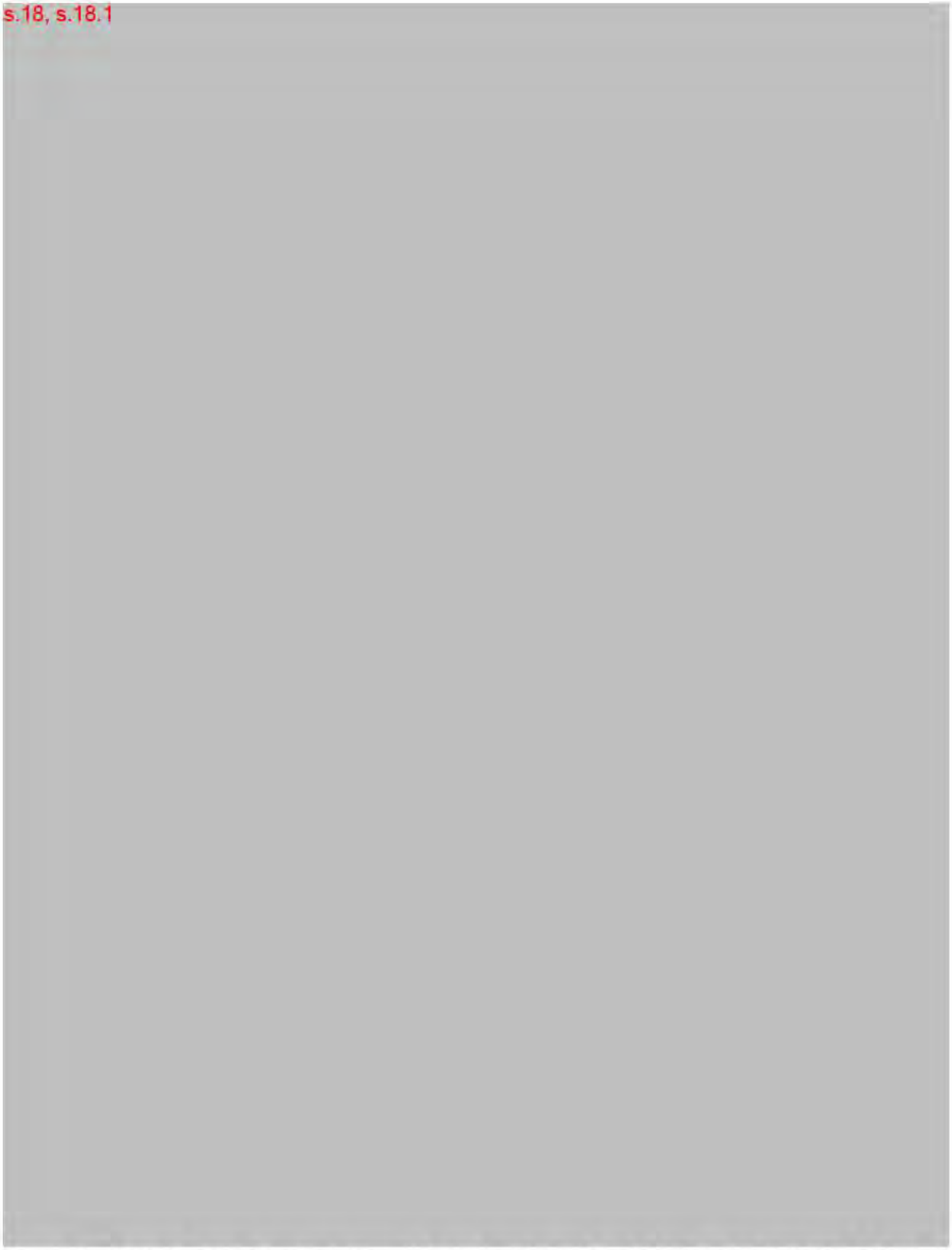

Figure 1. Project Area showing recorded archaeological and heritage sites with 2.5 km.

s.18, s.18.1

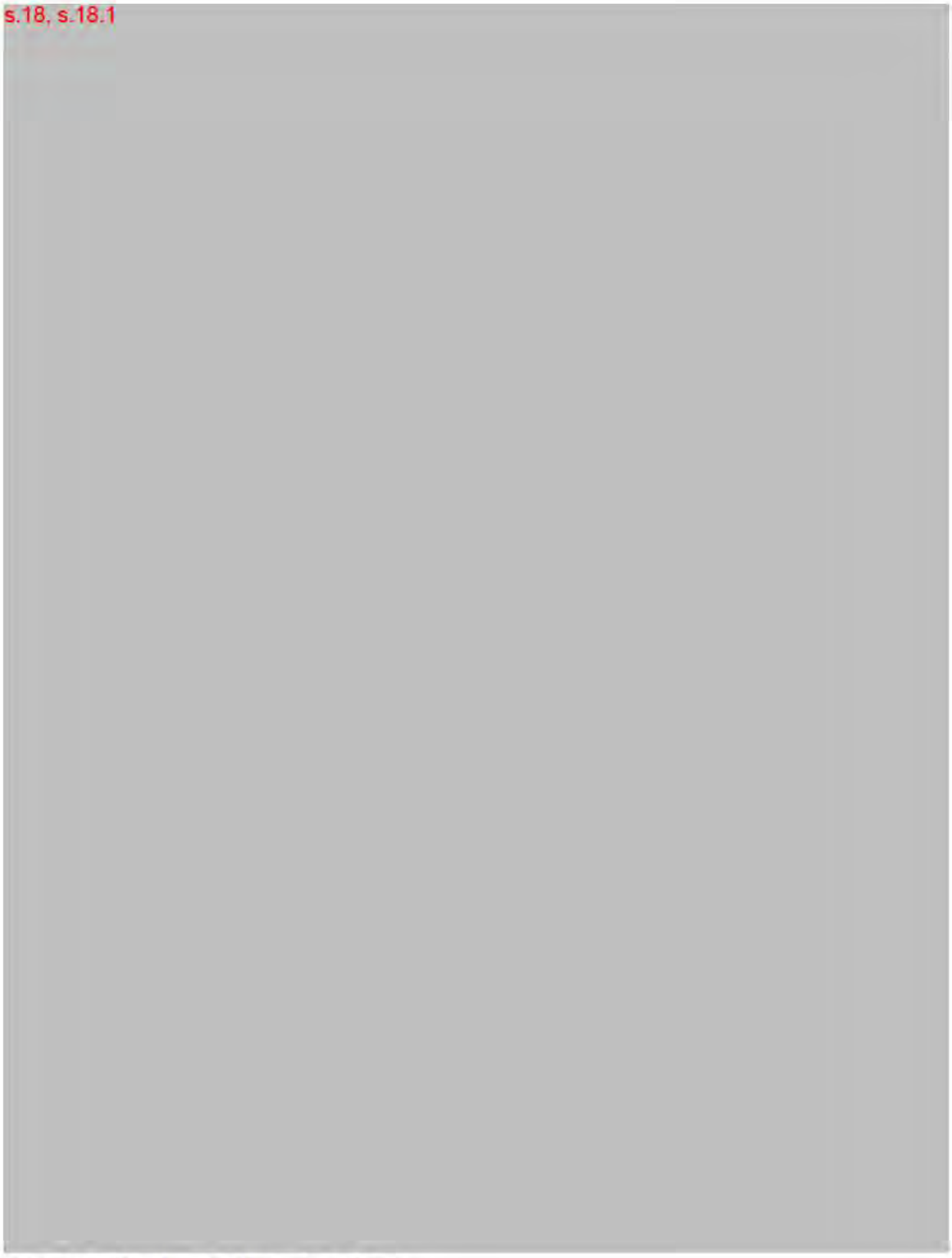

Figure 2. Hastings Park Project Area.

1.3.1 Heritage Conservation Act of British Columbia

For this Archaeological Overview Assessment, the Project Area is situated on lands that fall under British Columbia provincial heritage jurisdiction where archaeological sites are defined as locations that:

> …consist of the physical remains of past human activity. The scientific study of these remains, through the methods and techniques employed in the discipline of archaeology, is essential to the understanding and appreciation of prehistoric and historic cultural development in British Columbia. These resources may be of regional, provincial, national or international significance (Archaeology Branch 1998).

In British Columbia, most archaeological sites are attributable to settlement and resource use by Aboriginal people. All archaeological sites that are located on Provincial Crown or private land that are assumed to pre-date AD 1846 are automatically protected from damage, desecration, alteration, or excavation under the *HCA* (RSBC 1996, Chap. 187). Some sites, including burials and rock art sites, are protected through designation regardless of their age, as "Provincial Heritage Sites" under Section 9 of the *HCA*, or through automatic protection under Section 13 due to their defined historic or archaeological value.

Inspection, investigation, or alterations to archaeological sites require a permit issued by the Archaeology Branch, Ministry of Forests, Lands, Natural Resource Operations, and Rural Development under Sections 12 or 14 of the *HCA*. Sites automatically protected under Section 13 include:

- Archaeological sites occupied or used before AD 1846
- Rock art with historical or archaeological value
- Burial places with historical or archaeological value
- Heritage shipwrecks or aircraft wrecks (after a 2-year abandonment), and
- Archaeological sites of unknown age, with a reasonable possibility of having been occupied or used before AD 1846.

Additionally, archaeological sites of Aboriginal origin may be subject to interpretations of the Supreme Court of Canada decision in *Delgamuukw v. British Columbia* (1997) regarding the fiduciary responsibility of provincial governments for protecting cultural heritage. Furthermore, heritage sites of Aboriginal origin not automatically protected by the *HCA* may still be of interest to First Nations who may wish to discuss their interest in any engagement process.

To assist with the management of archaeological sites the Archaeology Branch issued the *British Columbia Archaeological Impact Assessment Guidelines* (Archaeology Branch 1998), and an updated *AOA Standards and Guidelines* (Archaeology Branch 2009). These guidelines identify several types of archaeological assessments that may be undertaken in response to proposed developments, with the type of assessment dependent on the stage of development design and the kinds of archaeological information required. This assessment type is an AOA as described in the *Guidelines* (1998, 2009).

Archaeological sites are numbered according to the *Borden Site Designation Scheme* used throughout Canada (Borden 1952). This scheme is based on the maps of the National Topographic System and uses latitude and longitude to identify the location of a site. The four-alternating upper and lower-case letters in a site number (e.g., DiRt-) designate a unique block of 10 minutes of latitude and longitude, called a "Borden block." Sites are then numbered sequentially with a "Borden block," usually in the chronological order in which they were found and recorded at the provincial Archaeology Branch. The BC Archaeology Branch is responsible for assigning new Borden numbers for new sites found and recorded in British Columbia, and for maintaining all archaeological site inventory records and reports.

1.3.2 First Nations Heritage Policy and Permitting Processes

Several First Nations in British Columbia have developed their own heritage policies and permits to manage their archaeological and heritage concerns. These permits are separate from the Provincial *HCA* permits, and although they are not required to meet Provincial regulatory standards, Inlailawatash respects the important First Nation oversight that these permits provide for the archaeology that is conducted within the traditional territories. The First Nations permits are generally issued with a set of cultural protocols or policies around the treatment of heritage resources, for which ancestral remains and spiritual places are particularly sensitive.

2 METHODS OF ARCHAEOLOGICAL OVERVIEW ASSESSMENT

2.1 Objectives and Tasks

The Archaeological Overview Assessment involved the following tasks:

- Applications for a Musqueam Indian Band Heritage Research/Investigation Permit, a Squamish Nation Archaeological Investigation Permit, a Stó:lō Heritage Investigation Permit, and a Tsleil-Waututh Nation Cultural Heritage Investigation Permit;

- Desk-based review of background ethnographic and archaeological literature for the Project Area;
- Review of previous AOA and AIA reports in the background study area;
- Search for documented archaeological sites in the Provincial Heritage Register maintained by the Archaeology Branch, accessed via the Remote Access to Archaeological Database system;
- Review of paleoenvironmental, biophysical, and topographic information for landforms within the Project Area;
- Preliminary Field Reconnaissance to assess archaeological potential; and
- Evaluation of archaeological potential within the Project Area to inform future AIA assessment if required.

2.2 First Nations Involvement

Inlailawatash applied for a Musqueam Indian Band Heritage Research/Investigation Permit, a Squamish Nation Archaeological Investigation Permit, a Stó:lō Heritage Investigation Permit, and a Tsleil-Waututh Nation Cultural Heritage Investigation Permit, which were issued to Inlailawatash archaeologist Walter Homewood. These permits have the purpose of informing the local First Nations of the intent to conduct a review of archaeological resources in the area, to allow for their comment and input into the study and its methods, and to engage them in a Preliminary Field Reconnaissance.

2.3 Information Sources and Methods for Baseline Overview Assessment

A desk-based literature review and compilation of existing knowledge about recorded archaeological site locations within 1000 m of the Project Area, historical First Nations land use and place names, and cultural and environmental characteristics and changes in the area likely to effect site location and preservation was conducted. A Preliminary Field Reconnaissance supplements the desk-top overview with a brief in-field survey of the Project Area. All information is synthesized to inform the potential for archaeological sites in the Project Area.

2.3.1 Desktop Study and Document Review

A desktop review includes archaeological and ethnographic sources, along with biophysical characteristics and landform typology, to provide information for presenting a baseline heritage context for understanding the archaeological potential for the Project Area. Documents required to undertake this study are available from the Inlailawatash

Archaeology library, the Simon Fraser University library, and from unpublished reports obtained from the electronic library of the Archaeology Branch. The document review searched for general information on pre-Contact archaeology, ethnographic and archaeological settlement patterns and place names, Aboriginal land use patterns, and historic land use within the Hastings-Sunrise area of Vancouver.

To evaluate the Project Area for archaeological potential several sources of data were reviewed:

- Relevant archaeological records and reports from the background study area;
- Ethnographic, ethnohistoric, and place names data pertaining to the study area;
- Historic maps and photographs; and
- Biophysical and geomorphological landform data pertinent to pre-Contact and post-Contact land use activities.

Recorded archaeological sites with their geo-referenced locations can be downloaded from the Provincial Heritage Register Inventory via the Remote Access to Archaeological Resources system (RAAD), an electronic database maintained by the Archaeology Branch. This system enables access to information about recorded sites within the local and regional study area. Topographic information was gathered from 1:20,000 scale TRIM maps, as well as scalable orthophotos from Google Earth™. Access to previous archaeological overview and impact assessment reports within the study area is provided through the Provincial Archaeological Report Library (PARL).

2.3.2 Field Investigations: Preliminary Field Reconnaissance

The purpose of a Preliminary Field Reconnaissance (PFR) is to visually assess and field-inspect the surficial landscape of the Project Area, assessing landforms, vegetation, sediment exposures, or eroding shorelines that may have the potential to contain archaeological resources. The primary objective is to evaluate the potential for subsurface archaeological materials, but also to identify any existing surficial archaeological materials observable in the field. The PFR is also used to determine what potential archaeological features or site types (e.g., shell middens or artifact scatters) are most likely to exist within the Project Area based on the site types identified during the desktop analysis.

2.4 Evaluation of Biophysical and Landform Potential

Information on past and present biophysical characteristics of the Project Area is important to provide a context for predicting the potential for locating archaeological resources as they pertain to past human occupation and land use. Past hydrology, landforms, and ecological resources are used to inform archaeological potential models. For example, access in the past to food resources, fresh water, and level terrain made an area more suitable for human habitation, therefore increasing the potential of cultural materials being deposited to become part of the archaeological record.

Land use, settlement patterns, and subsistence practices of all people are generally adaptions to specific environments. Environmental conditions influence the availability of natural resources and the suitability of the natural landscape for human habitation, subsistence, technology, and other cultural factors. The location, accessibility, and quantity of culturally-valued minerals, plant, animal, and fish species can influence the type and location of heritage and modern sites. Physical factors such as climate, terrain, proximity to water, and vegetation cover can also determine the location, preservation, and visibility of archaeological sites. Environmental factors may also be instrumental in spiritual and ceremonial aspects associated with special places or landscapes, but unless there are material correlates, an evaluation of this is not within the scope of an archaeological study.

The biophysical evaluation considers the major physiographic processes and climate changes that have created the topography and the primary attributes of the physical landscape, i.e., the landforms, hydrology, and surficial sediments. The ecological environments and geological histories of the region, both past and present, have implications for understanding long-term land-use activities and cultural historical practices.

Geological processes such as erosion and soil conditions can influence the preservation of archaeological evidence. Certain conditions, particularly very dry or wet soils, may enhance preservation of organic (perishable) archaeological materials, while other processes such as flooding, or erosion can destroy archaeological evidence. Over the past 200 years human activities (industrialization and urbanization) have generally had a greater influence on the biophysical setting than natural ones, and these have also likely had the greatest effect on the destruction of archaeological materials in the Project Area.

2.5 Archaeological Site Types

Locations on the land with material remains that were produced by human activities in the past are called archaeological sites. In British Columbia, most archaeological sites are attributed to the past activities of Aboriginal peoples before European contact and are referred to as pre-Contact archaeological sites. There are also post-Contact sites, often called historic archaeological sites, that may have structural remains and material culture associated with both European and Aboriginal technology. Known archaeological sites are recorded in the Provincial Heritage Register and maintained by the Archaeology Branch (Site Inventory Section), the government agency responsible for the management of archaeological resources under the *Heritage Conservation Act.*

Archaeological sites are recorded in the Heritage Register according to site type, which usually specifies the type of features and artifacts known, the size and age of the site, its stratigraphy and sediments, and the kinds of traditional activities inferred to have taken place at the site. Examples of sites types on the coast include shell middens, house depressions, lithic scatters, cache pits, hearth features, rock art, burial sites, canoe runs, fish traps and weirs, clam gardens, and culturally modified trees. A review of known information in the vicinity of the Project Area will suggest the expected age and types of archaeological sites in areas of potential.

2.6 Evaluation of Archaeological Resource Potential

Archaeological resource potential can be defined as the capacity of a landscape, or parts of a landscape, to have supported types of Aboriginal cultural activities that would have produced the formation and preservation of archaeological material cultural remains. Certain types of activities, for example, plant collecting, would probably not result in physical remains, and therefore cannot be archaeologically assessed. Plant processing activities however, such as the use of roasting pits or hearths, would potentially leave subsurface archaeological features or preserved plant remains. Likewise, various places of cultural or spiritual significance may not have any type of material evidence that would identify it as such, but Aboriginal place name information can be used as context for assessing landscape potential for archaeological resources.

Archaeological and landscape potential is assessed on a case-by-case basis, but in general, areas of well-drained level terrain immediately adjacent to existing or relic bodies of water or old shorelines, or places near known archaeological or traditional use sites, or old growth forest with the potential for culturally modified trees, are considered to have archaeological

potential. In urban places sediments with archaeological potential may be obscured due to development or may be deeply buried under modern fill deposits.

Archaeological potential is not the same as probability of site occurrence. Potential simply rates the suitability of lands for possessing archaeological remains, and therefore whether they should be examined in detail in advance of land-altering development activities.

3 OVERVIEW ASSESSMENT RESULTS

A desk-top overview assessment was combined with a Preliminary Field Reconnaissance to predict archaeological potential within the Project Area. The information gathered from the Archaeological Overview Assessment is presented in this section. The assessment was both inductively and deductively based on generalized principles of human behavior, environmental variables considered favourable to human activity, and reference to previously recorded sites and ethnographic data within the background study area.

3.1 Biophysical Review

3.1.1 Glaciations and Sea Level History

While tectonic activity has formed the underlying geology of British Columbia, it is the effects of Pleistocene glaciation that have determined the topographic landscape detail and their surficial sediments. The scouring of the land by both glacial ice and glacial meltwater determined the type of sediments and landscape features present in the Lower Mainland. The sedimentary evidence of the last glaciation provides explanation for the character of the contemporary landscape, a principle concern for understanding human occupation. The timing of deglaciation is around 13,000 - 11,000 years ago, after which the development of habitable environments for human occupation occurred, placing the earliest approximal age for the oldest potential archaeological sites in the Lower Mainland (Armstrong 1981, 1990; Clague 1989).

At the peak of the last glaciation in North America, called the Late Wisconsin, the Lower Mainland was covered by ice up to two km in thickness. The weight of glacial ice and its subsequent melting also determined relative sea-levels which rose and fell between the periods of glaciation and deglaciation. Coastal areas up to about 200 m above sea level were inundated during periods of deglaciation. Relative sea levels stabilized near modern levels by approximately 5,500 year ago (Armstrong 1981, 1990; Church and Ryder 2010; Clague 1989; Clague et al. 1982; Demarchi 2011; Fulton et al. 2004).

The changes in sea level have influenced the location of archaeological sites such that some sites will now be submerged, others close to the shoreline are being eroded due to sea level rise, or other sites may be found far inland from current shorelines when sea levels were higher than today. Any sites found within the Project Area may be associated with times of slightly raised sea levels or may simply represent inland (non-shoreline) cultural activities associated with sea levels of the past 5,500 years. The Project Area increases in elevation from north to south, and the ground surface is currently between 12 m to 48 m above modern sea level.

3.1.2 Ecological Resources

The Project Area is within the Coastal Western Hemlock Dry Maritime (CWHdm) biogeoclimatic zone, one of the most productive zones in British Columbia for overall biomass (Jones and Annas 1978). The climate is typically mild and rainy with annual precipitation averaging around 2000 mm. Western hemlock is the dominant forest cover for this zone, and is typically accompanied by western red cedar, Douglas fir, and Sitka spruce. Amabalis fir, grand fir, western white pine, and bigleaf maple are sometimes present in the southern portions of the zone. Ferns make up most of the understory and several moss species make up the ground cover (Pojar et al 1991:96-98). The Project Area is now completely deforested and covered by asphalt, concrete, buildings, or has been landscaped.

Economically important animal species that would have been found in the Project Area in the past include large mammals such as black bear, elk, and mule deer. Important bird species include various water fowl, grouse, and eagle. Salt water fish and shellfish would have been available nearby along the shoreline of Burrard Inlet, and former streams may have supported salmon runs or other freshwater fish.

For Aboriginal peoples these faunas provided food, as well as hide, bone, antler and horn as raw materials for manufacturing clothing, tools, and other artifacts. Salmon of all species were important for food as well as for ceremonial and social purposes. Birds were hunted for food, but their feathers were also important for ceremonial regalia and other social purposes. While many of these faunas are no longer found in the area due to urbanization, the boney remains of these animals, when found in archaeological sites, provide important data about the environments of the past and the human use of them.

3.1.3 Hydrology and Historical Shorelines, Streams, and Drainages

Hydrology and coastal shorelines within and near the Project Area were significantly different in the past before urbanization. An extensive system of streams and wetlands once existed across the City of Vancouver. The marine shoreline of Burrard Inlet (now located approximately 300 m north of the Project Area) has been extensively modified and in-filled due to historical and industrial land reclamation. It is estimated that 80% of the shoreline in the inner harbour basin of the Burrard Inlet has undergone extensive alteration (Haggarty 2001). Along with the coastal shoreline changes, historic creeks and wetlands have been altered, covered, or filled in by roads and infrastructure, residential, and commercial developments.

Sources were reviewed to reconstruct the original shoreline and historic creeks to help inform the archaeological potential assessment (e.g., Goad 1912; Lesack and Proctor 2011). Goad (1912) is an historical atlas of the City of Vancouver that provides a *Fire Map* that is referenced to legal property lot boundaries and is accurate and comprehensive for determining the location of old shorelines and creeks in and around the Project Area. Fisheries and Oceans Canada (1998) also provides information on shoreline and drainage changes.

The oldest depiction of the shoreline near the study area is shown in an 1884 photo at New Brighton (Figure 3). An historical map of 1891 also provides locational information on the historic Burrard Inlet shoreline (Figure 4). On the 1891 map the shore of Burrard Inlet is shown extending into the northern boundary of Hastings Park at the outflow of Renfrew Creek (not shown on the map). A later map from 1906 (Figure 5) shows the shoreline of the Inlet on the north side of the Canadian Pacific Railway where it no longer intersects with the Park, indicating that infilling along the Inlet occurred between 1891 and 1906. A 1915 planning map (Figure 6) shows Renfrew Creek labelled as a ravine, and another small stream is drawn to the east.

Due to urban development most of the historic streams and drainages were lost or are threatened (Fisheries and Oceans Canada 1998). Renfrew Creek and a tributary once crossed the Project Area and flowed to Burrard Inlet north of the Project Area (Goad 1912). Renfrew Creek is now covered or has been filled in by land use activities at Hastings Park. Most historic creeks in Vancouver would have provided sources of freshwater fish to Indigenous peoples in the past and may be associated with archaeological sites along their old banks, including trails. The network of waterways would have provided access to hunting and planting gathering areas, fishing, and travel routes for the First Nations peoples.

Figure 3. Shoreline at New Brighton 1884, also known as Hastings Summer Resort for New Westminster (City of Vancouver Archives AM1576-S6-12-F12).

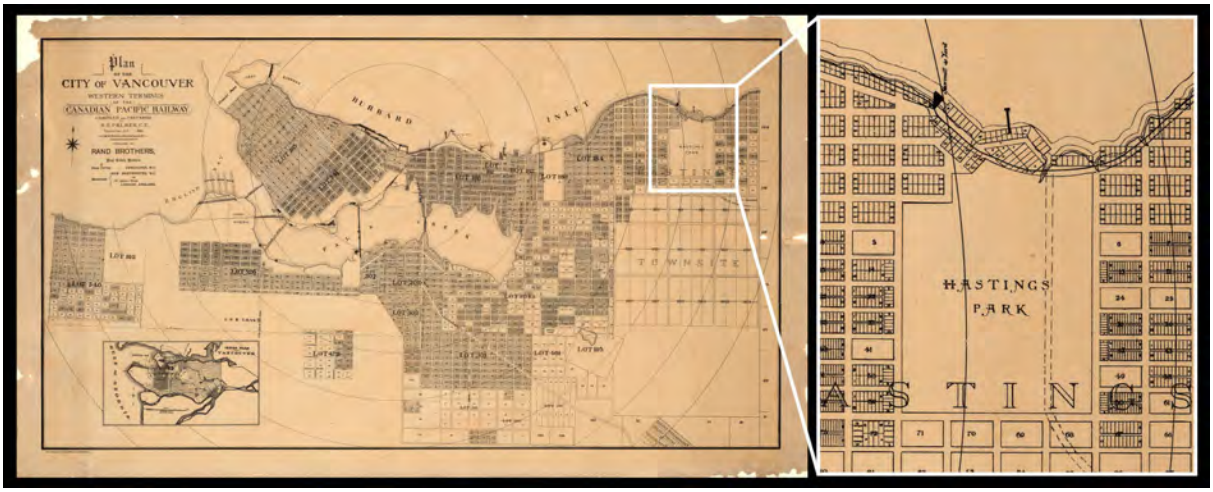

Figure 4. Plan of the City of Vancouver 1891. The map shows Vancouver at the end of the 19th century and includes Hastings Townsite and the Burrard Inlet shoreline at Hastings Park (City of Vancouver Archives AM1594-: MAP 86).

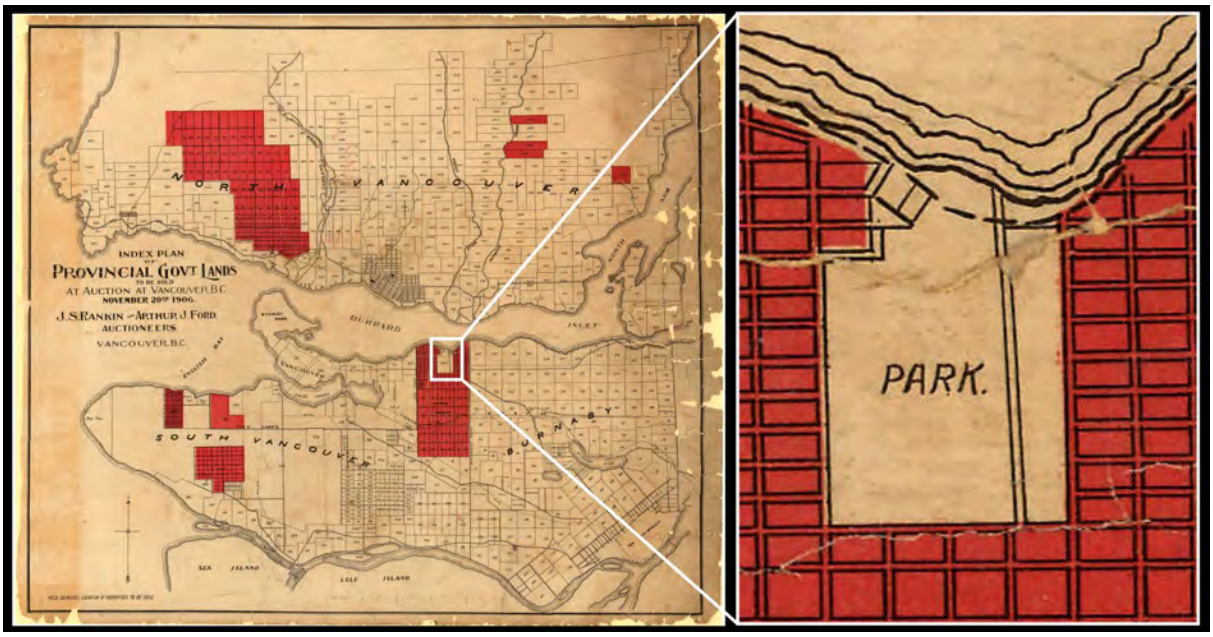

Figure 5. Index plan of provincial government lands to be sold at auction at Vancouver BC November 20, 1906. The map shows Hastings Townsite and the Burrard Inlet shoreline at Hastings Park (City of Vancouver Archives AM1594-: MAP 20).

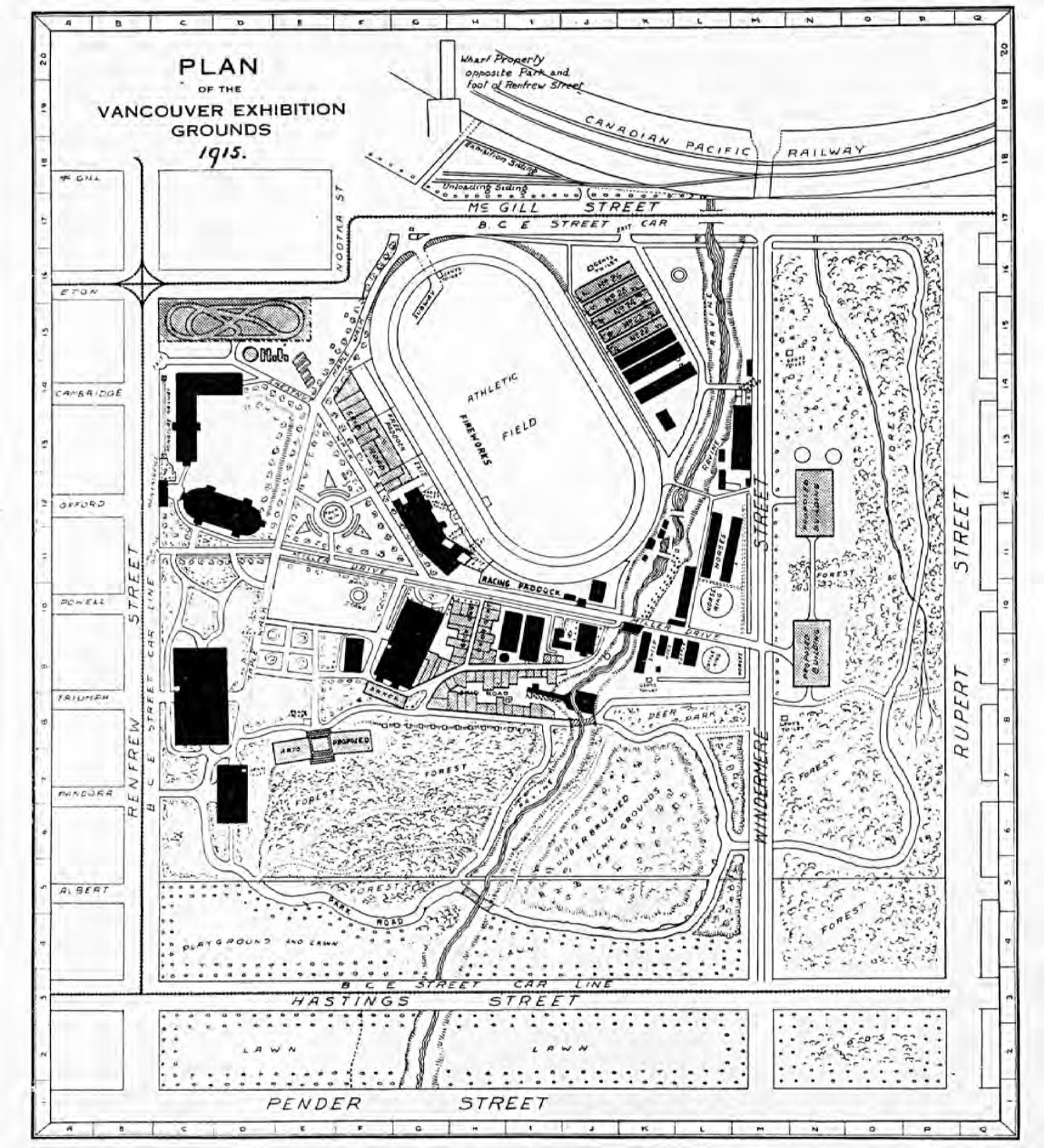

Figure 6. Plan of the Vancouver Exhibition Grounds 1915 (Vancouver City Archives AM281-S8-: CVA 180-3547).

3.1.4 Summary of Biophysical Setting

In the past the Project Area had a highly favourable environmental setting for the location of aboriginal settlements that may be reflected archaeologically. The landforms, hydrology, and ecological resources of the past suggest that the Project Area may contain archaeological sites. Pre-Contact Aboriginal people occupied villages and camps along the shores of Burrard Inlet where a variety of plant, aquatic, and animal resources could have been harvested from the marine and freshwater creek environments. However, urbanization has altered the hydrology and landscape, and may have also destroyed archaeological sites representing various cultural activities associated with marine shorelines, freshwater creeks, wetlands, and other landforms of the past.

3.2 Cultural Setting Review

3.2.1 Regional Archaeological Background

The Project Area is situated within the Northwest Coast Culture Area as defined by anthropologists, which is an immense coastal culture area that encompasses the west coast of North America from southern Alaska to Cape Mendocino in northern California. Archaeologists have defined a chronological sequence of pre-Contact cultural periods within this Culture Area for the south British Columbia coast based on site investigations in the Salish Sea and Lower Fraser River delta. Summaries of the south coast regional prehistory sequences are found in Ames and Maschner (1999), Carlson (1983, 1990), Matson and Coupland (1995), and Mitchell (1990).

Researchers have noted continuities through time in the reliance on marine and riverine resources particularly salmon and other fishing, woodworking technology, food storage, ceremonialism, and the acquisition of wealth and status. Based on diagnostic artifact types and technologies, as well as inferred economic, social and other cultural traits, six distinct cultural chronological periods, variably referred to as ‘Phases’ or ‘Cultures’ are identified with associated time frames expressed in years before present (BP):

- Pebble Tool/Old Cordilleran (ca. 10,000 - 5,500/4,500 years BP)
- Charles (ca. 5,500/4,500 - 3,500 BP)
- Locarno Beach (ca. 3,500- 2,500 BP)
- Marpole (ca. 2,500- 1,200 BP)
- Gulf of Georgia/Developed Coast Salish (ca. 1,200 - 200 BP), and
- Historic or Ethnographic Period (ca. 200 BP to Present)

A summary of the cultural traditions and their site types and artifact assemblages is presented below to provide background context for the possible archaeological materials and their associated age that may be recovered within the Project Area.

Pebble Tool/Old Cordilleran Tradition (12,000 - 5,500/4,500 BP)

The earliest culture tradition identified for the coast is called by various names including the Pebble Tool Tradition (Carlson 1990; Carlson and Della Bona 1996), the Old Cordilleran Tradition (Matson 1976, 1992), the Lithic Culture Type (Mitchell 1990), or the Protowestern Tradition (Ham 1982; McLaren 2017). This early tradition, which dates from approximately 12,000 to 5,500 BP is associated with a period of lower and/or fluctuating sea levels in the early Holocene. The artifact assemblages are dominated by flaked stone artifacts, including cobble/pebble tools and leaf-shaped bifaces, along with rare bone and antler tools (Carlson 1990; Matson 1992).

In the Fraser River delta, the subsistence pattern is diversified towards deer and wapiti hunting, sea mammals (seals), fish (salmon, stickleback, sturgeon, eulachon, flatfish), and shellfish (Matson 1976, 1992). One of the important Pebble Tool Tradition sites for the Fraser delta is the Glenrose Cannery site on the Fraser River in Surrey (DgRr-006) (Matson 1976; Golder 2014) where faunal remains have been found as evidence of this subsistence pattern.

Charles/St. Mungo Culture Type (5,500 to 3,300 BP)

This culture type has been defined based on three sites in the Fraser River delta: St. Mungo (DgRr-002), Glenrose Cannery (DgRr-006), and Crescent Beach (DgRr-001) (Matson and Coupland 1995). There is a continuation of some tool types from the previous period, but new types, including chipped stone scrapers, drills, stemmed bifaces, as well as ground slate, bone, and antler implements are introduced (Ham et al. 1986). The presence of adzes and wedges suggest a well-developed woodworking technology. Wet sites containing fish weirs, basketry, cordage, carved wood, and cedar bark clothing have been found dating to this period in the Fraser River delta (Eldridge 1991; Golder 2014; Stantec 2017).

Locarno Beach Culture Type (3,500/3,300 to 2,500 BP)

Chipped stone tools predominate with a small proportion of large ground stone tools. Flaked tool types include shouldered and lanceolate points, microblades and cores, bilaterally and unilaterally barbed points, one-piece and composite toggling harpoon heads, woodworking tools including abraders, grinding slabs, and wedges, and large faceted ground slate points and thick ground slate knives. Cordage, basketry, and other wood items have been

recovered from wet sites in the Lower Mainland (Bernick 1998; Borden 1968, 1976; Stantec 2017). Faunal remains show a diversified resource utilization pattern (Inlailawatash 2019; Stiefl 1985).

Marpole Culture Type (2,500 to 1,200 BP)

Many artifact types from the Locarno period continue into Marpole, however there is a decrease in the proportion of chipped stone tools and an increase in the refinement of ground stone tools. The non-toggling, barbed harpoon point is exclusive to the Marpole period. Native copper ornaments are present, along with midden burials containing grave inclusions such as shell or slate disc beads. Large-scale woodworking technology and large house outlines and post moulds suggest that the ethnographic pattern of heavy timber frame houses with cedar planks was well-developed by this time. The artistic traditions were also well-developed including the presence of seated human figurine bowls, decorated stone bowls, incised siltstone objects, and carved bone and antler objects with zoomorphic designs. The ability to harvest and preserve large quantities of salmon for winter storage most likely supported the development of large ranked societies during this time (Burley 1980; Mitchell 1990).

Gulf of Georgia/Developed Coast Salish Culture Type (1,200 to 200 BP)

This culture is directly ancestral to the ethnographic Coast Salish culture. Artifacts that define this culture archaeologically include small triangular flaked basalt points, thin ground slate points and knives, unilaterally barbed bone points, composite toggling harpoon heads, large well-made ground stone adzes, and net weights and anchor stones for netting technology. Salmon was a dietary staple, along with a varied use of many land mammal, sea mammal, bird, fish, and plant resources. The resource economy was based on a seasonal round with the presence of large winter villages with heavy timber frame houses, large summer gathering settlements, and smaller seasonal harvesting camps (Mitchell 1990).

3.2.2 Previous Archaeological Assessments

Three broad baseline overview studies summarizing archaeology conducted within the City of Vancouver were first completed from 1975 to 1985 (Cranny and Bunyan 1975; Ham et al. 1979; Bussey 1985). Even though these early summaries occurred more than forty years ago, all three reports emphasized the fast rate at which archaeological sites are being impacted and destroyed in the rapidly developing urban areas of the City. Stressing the immediacy of implementing their management recommendations, Cranny and Bunyan (1975: 9) urged that “these recommendations be followed as quickly as possible since development of the

lands in the area is still proceeding at an alarming rate." Ham et al. (1979:8) recommended that their integrated eight-part management program "requires immediate implementation if further uncontrolled destruction of archaeological deposits is to be halted." Similarly, recommendations from the City-wide survey conducted by Bussey (1985:60) were that "although this study is not being conducted in advance of any specific proposed development, the intensive nature of land use typical of this area necessitates a discussion of the management options."

Since those first overview assessments for the City of Vancouver were performed, various Cultural Resource Management (CRM) assessments (AOA and AIA) have been conducted for development projects. Those assessments with a focus near the shores of east Burrard Inlet include Alexander and Grier (2000), Arcas (2009), Inlailawatash (2011, 2012, 2015, 2016a, 2016b, 2017a, 2017b, 2018a, 2018b), Spafford et al. (1999), and Stantec (2011, 2015). Adjacent to the Hastings Park Project Area, Arcas (2009) assessed site impacts along the Inlet shoreline as a result of the Westridge third party accidental hydrocarbon release. Inlailawatash (2012, 2017) conducted an Archaeological Overview Assessment of Port Metro Vancouver's proposed South Shore Corridor Project, which included stream rehabilitation in New Brighton Park. New Brighton Park is situated on land north of Hastings Park up to the shore of Burrard Inlet, and was considered an area of high archaeological potential although covered in substantial fill deposits (Inlailawatash 2012). New Brighton was known as a small village of cedar slab huts at the mouth of a creek with the place name of X̱í7nam̓ut or Kha-Nah-Moot (Kwi Awt Stelmexw 2017; Matthews 2011[1933]:441) (see place names below).

In addition to the cultural resource management projects in east Burrard Inlet, a few academic-based research projects have also been conducted at some of the large shell midden village sites in the Inlet (e.g., Charlton 1972, 1980; Lepofsky and Karpiak 2001; Lepofsky et al. 2007; Morin 2015, 2017; Pierson 2007; Struthers 1973; Trost 2005). These studies show an extensive and lengthy Aboriginal occupation of Burrard Inlet for at least 3,500 years.

3.2.3 Previously recorded sites

s.18, s.18.1

s.18, s.18.1

Table 1. Archaeological Sites within Five km of the Project Area.

s.18, s.18.1

Historic Heritage Sites

s.18, s.18.1

3.2.4 Post-Contact Regional History and Ethnography

3.2.4.1 Ethnographic Background

The Project Area is located within the territories of interest for the Musqueam Indian Band, Squamish Nation, Stó:lō Nation, and Tsleil-Waututh Nation, which collectively are part of the Central Coast Salish peoples, speakers of either hən̓q̓əmin̓əm̓ or Squamish languages (Duff 1969; Suttles 1990). Local ethnographic accounts of the Central Coast Salish people include those of Barnett (1955), Hill-Tout (1905), Matthews (1955), and Suttles (1955, 1968, 1987). Major J. S. Matthews, the former Vancouver City Archivist, recorded conversations with August Jack Khahtsahlano, covering a wide range of topics on the lifeways of the Aboriginal peoples along Burrard Inlet (Matthews 1955). More recent ethnographic overviews for the

Burrard Inlet area include the Stó:lō Atlas (Carlson 2001), Lepofsky et al. (2007), Morin (2015, 2017), and Tsleil-Waututh and Alexander (2001).

The first European known to have travelled to Burrard Inlet was the Spaniard Jose Maria Narvaez who entered the Inlet by ship in the summer of 1791. From Narvaez's charts and notes it is determined by historians that he called Burrard Inlet "Florida Blanca," however there is no surviving log, so it is not known if he directly interacted with Aboriginal people (Armitage 2001:22-23). The first known direct contact between European explorers and the Aboriginal peoples of Burrard Inlet occurred in June of 1792 as recorded in the journals of Captain George Vancouver where he named "Burrard's Channel" after his navy friend Sir Harry Burrard (Armitage 2001:27).

A few very brief passages from Vancouver's journals are insightful as to how he describes the nature of the physical settings of village sites in the Inlet. Vancouver described how they were met by about fifty people in canoes who were from "a small border of low marshy land on the northern shore intersected by several creeks of fresh water" (Bartroli 1997:71; Matthews 1955:414). Vancouver wrote that "Most of their canoes were hauled up into the creeks…. None of their habitations could be discovered, whence we concluded that their village was within the forest" (Bartroli 1997:75). The explorers camped overnight near the mouth of Indian Arm on the present site of the Barnett Marine Park. They left the Inlet the next morning without having seen any villages, "leading to the conclusion that the villages were hidden from view to provide protection" (Tsleil-Waututh and Alexander 2001:62). Various smallpox epidemics, including one in the early 1700s that affected Burrard Inlet, had spread from Washington and created population losses and abandonment of many of the villages prior to the first European explorers' arrival (Boyd 1990).

At the time of European contact, the First Nations had many villages and camps throughout Burrard Inlet, and the name Tsleil-Waututh means "people of the inlet" (Tsleil-Waututh and Alexander 2001: 61). The locations of former trails along the shores of Burrard Inlet that linked various Aboriginal settlements have also been recorded (Tsleil-Waututh and Alexander 2001: 175). Central Coast Salish peoples along the Inlet practiced lifeways in the past characteristic of the Northwest Coast Culture Area in general. Common cultural traits include a coastal settlement pattern; a diverse subsistence base and associated technologies with a focus on fishing for anadromous fish, but also shellfish, sea mammal, game and bird hunting, and plant collecting; a complex storage economy particularly for the storage of surplus salmon; extensive wood-working and basketry technologies; a social/political organization with families, household, local groups and winter villages; and a myth system

that included shamanism, vision quests, and life-cycle and subsistence cycle celebrations and rituals (Barnett 1955; Suttles 1990).

Cultural activities that may be reflected within the archaeological record near and within the Project Area include resource procurement technologies (e.g., stone, bone, wood, and basketry tools used in fishing, hunting, and gathering; and fishweirs); food preparation and storage (e.g., hearths, roasting pits, post holes for drying/smoking racks); habitation (e.g., house floors, refuse deposits such as middens, post holes); transportation (e.g., canoe skids); and mortuary practices (e.g., burials, cairns).

3.2.4.2 First Nations Place Names

One of the most powerful and direct links between ethnographic information and the physical landscape are place names. Indigenous place names have long since been used by archaeologists to determine areas of archaeological and cultural importance (Basso 1996; Bierwert 1999; Carlson, K. 2001; McHalsie 2001). For example, 1) place names identify locations of specific importance to the culture; 2) place names reflect aspects of the Indigenous ways of understanding and organizing local geography; and 3) place names are associated with 'supernatural' events in the deep past (i.e., the time of transformers).

Place names reference places of historical or cultural events, topographical features such as mountains, islands, streams, and oceans as well as places such as camps, villages, seasonal resource harvesting areas, locations of battles, defensive sites, burials, and transformations. In short, place names provide information about the history of the landscape and how people interacted with their natural surroundings.

Many Nations have created place name maps that provide location and translation data about named places within their traditional territories. Squamish Nation in collaboration with the non-profit Kwi Awt Stelmexw created the *Squamish Atlas* (Kwi Awt Stelmexw 2017). The Language and Culture Department of Musqueam Indian Band collaborated with community members to create the *Musqueam Place Names Mapping Portal* (Musqueam Indian Band 2011), with an interactive online map describing Musqueam Place Names. *A Stó:lō – Coast Salish Historical Atlas* documents Halq'eméylem Place Names in Stó:lō Territory (McHalsie 2001). Place names identified in the vicinity of the Project Area are listed in Table 2.

Table 2. First Nations Place Names Recorded Near the Project Area.

Place Name	Location	Source
X̱í7naṁut	New Brighton Park at the foot of Windermere Street	Squamish (Kwi Awt Stelmexw 2017)
Kha-Nah-Moot	New Brighton Park at the foot of Windermere Street	Matthews (2011[1933])

Matthews (2011 [1933]:441) describes a place at the outflow of a creek in what is now New Brighton Park with a name that he recorded as "Kha-Nah-Moot." About "Kha-Nah-Moot," Matthews records the following information:

> A small creek mouth, now at the foot of Windermere street, which formerly supplied the townsite settlement of Hastings, and of subsequent years known more particularly as the stream which ran through the "RAVINE" in Hastings Park.
>
> On Feb. 13th 1953, Captain Charles Warren Cates, well known, told me that Joe Thomas, Squamish Indian, of "The Mission" Indian Reserve, North Vancouver, who died in 1951 at the age of 90, told him as follows:
>
> At one time a small stream wended its way down through the woods from the direction of Burnaby Lake, and emptied into the sea where Hastings Park is now. One day a man and a woman appeared from out the creek waters; it is supposed that the flowing water conceived them. The descendants of this man and woman lived there until the coming of the white man, and their village of cedar slab huts on the shore at the mouth was known as Kha-Nah-Moot. Apparently, the word interprets the story (Matthews 2011[1933]:441).

The same location appears on the Squamish Atlas (Kwi Awt Stelmexw 2017) using the official writing system for the Sḵwx̱wú7mesh sníchim rather than Matthews' anglicized spelling. The location is named X̱í7naṁut and of the location the atlas has the following information listed:

> Name: X̱í7naṁut [X̱í7 • na • ṁut]
> Meaning: "*appeared from out of the creek waters (Matthews); created oneself (**X̱**)"*
> Feature: Landmark
> Location: small creek at the north foot of Windermere Street
> (Kwi Awt Stelmexw 2017).

Matthews' description that the word interprets the story can be further explored through the *Skwxwú7mesh Sníchim – Xwelíten Sníchim Skexwts* [Squamish – English Dictionary] (Squamish Nation Education Department 2011). The placename X̱í7naw̓ut is made up of a root (xi7) and a suffix (-naw̓ut). As described in the dictionary:

> xi7~ xeỷ [xi7] appear [out of nowhere]; created, be; appear suddenly. *verb(i)* (Squamish Nation Education Department 2011: 211).
>
> -naw̓ut [-na ẃut] {reflexive suffix used with causative stems}. *suffix* (Squamish Nation Education Department 2011: 117).

A recorded place name, referring to either past events or continued use up until European contact, indicates the potential for archaeological materials to be located at X̱í7naw̓ut, at the mouth of a creek that in the past extended south into the Project Area. There is also archaeological potential inland along the creek banks because creek usage and the practice of creek ownership within Burrard Inlet are discussed by Morin (2015:93-94).

3.2.4.3 Post-Contact Urban Development

Hastings Park has seen intensive land use in the post-Contact period and into the modern era. The Park was granted to the City of Vancouver by the Province of British Columbia in 1889 for the use, recreation, and enjoyment of the public (City of Vancouver 2011) and has gone through many historical land use changes. Construction, demolition, and reconstruction activities that have taken place across the Park have possibly resulted in the destruction, disturbance, or displacement of archaeological materials that may have existed within the Park boundaries.

At the time that Hastings Park was granted to the City of Vancouver it was surrounded by the Hastings Townsite; the City of Vancouver boundary extended east only to Nanaimo Street. The Hastings Townsite was located at New Brighton and was established in 1865 where a mill (Stamp's Mill also known as Hastings Mill) was built by Captain Edward Stamp from 1865 to 1867 (Armitage 2001; MacDonald 1992). The City of Vancouver was incorporated in 1886 following the transition of the termination of the Canadian Pacific Railway from Port Moody to the Granville area which created a construction boom for building rail yards, port facilities, and houses for workers (Macdonald 1992).

The Hastings Townsite and Park appear on an 1891 map (Figure 4) compiled by R. E. Palmer and published by Rand Brother Real Estate Brokers. The 1891 map shows Hastings Park and a road to New Westminster cutting through the Park from the Burrard Inlet shoreline; this

road would later become Windermere Street. On the 1891 map the Burrard Inlet shoreline is shown extending into the northern boundary of Hastings Park at the outflow of Renfrew Creek (not shown on map). A later map from 1906 (5) also shows Hastings Park with a road cutting through the Park. On this later map the shoreline is drawn exclusively on the north side of the Canadian Pacific Railway and is no longer intersecting with the Park boundary, indicating that infilling of the area occurred since 1891.

The Exhibition Building was constructed in Hastings Park in 1909, and in 1910 the first Vancouver Exhibition was held (Figure 7). At this time much of Hastings Park was likely forested as a tree line is evident in the background of a plan drawn in 1915 (Figure 6), just beyond the exhibition hall to the south and beyond the athletic field grandstands to the east. The Vancouver Exhibition grounds would eventually expand to claim all the forested areas that once covered Hastings Park. The 1915 planning map (Figure 6) shows some of the early expansion plans of the Park grounds, and Renfrew Creek is shown labelled as a ravine, with another small stream to the east. Windermere Street is shown traversing the Park and connecting to McGill Street near where it crosses Renfrew Creek. The map indicates that the eastern and southern portions of Hastings Park are forested. The forested areas are still extant in a 1919 air photo of the Park (Figure 8).

Figure 7. First Vancouver Exhibition opening in 1910 at Hastings Park with Powell Street streetcars (City of Vancouver Archives AM1584-: CVA 7-106).

Figure 8. Hastings Park 27 May 1919. Oblique view looking southeast along Renfrew Street towards Hastings Street, with parts of Wall Street, Trinity Street, McGill Street, the northern section of Hastings Park, the first roller coaster, the Manufacturing/Industrial Building and the Exhibition Building on the Exhibition Grounds (City of Vancouver Archives AM1535-S1: CVA 1123-1).

The progression of developments within Hastings Park since 1910 over the next 50 years is seen through a series of air photos (Figure 9, 10, 11). In the 1936 air photo (Figure 9) the forested areas in the eastern and southern portions of the Park are shown to be cleared, however a narrow forested strip on the western side of Windermere Street is still visible, indicating that Renfrew Creek had not yet been covered over. By 1947 (Figure 10) the narrow forested strip is gone, Windermere Street is still visible, and a bare ravine at the north end of the Park is all that remains of Renfrew Creek. A later photo from c. 1964 (Figure 11), after the construction of empire stadium a decade earlier, shows Renfrew Creek now completely covered over with no remnant visible on the surface.

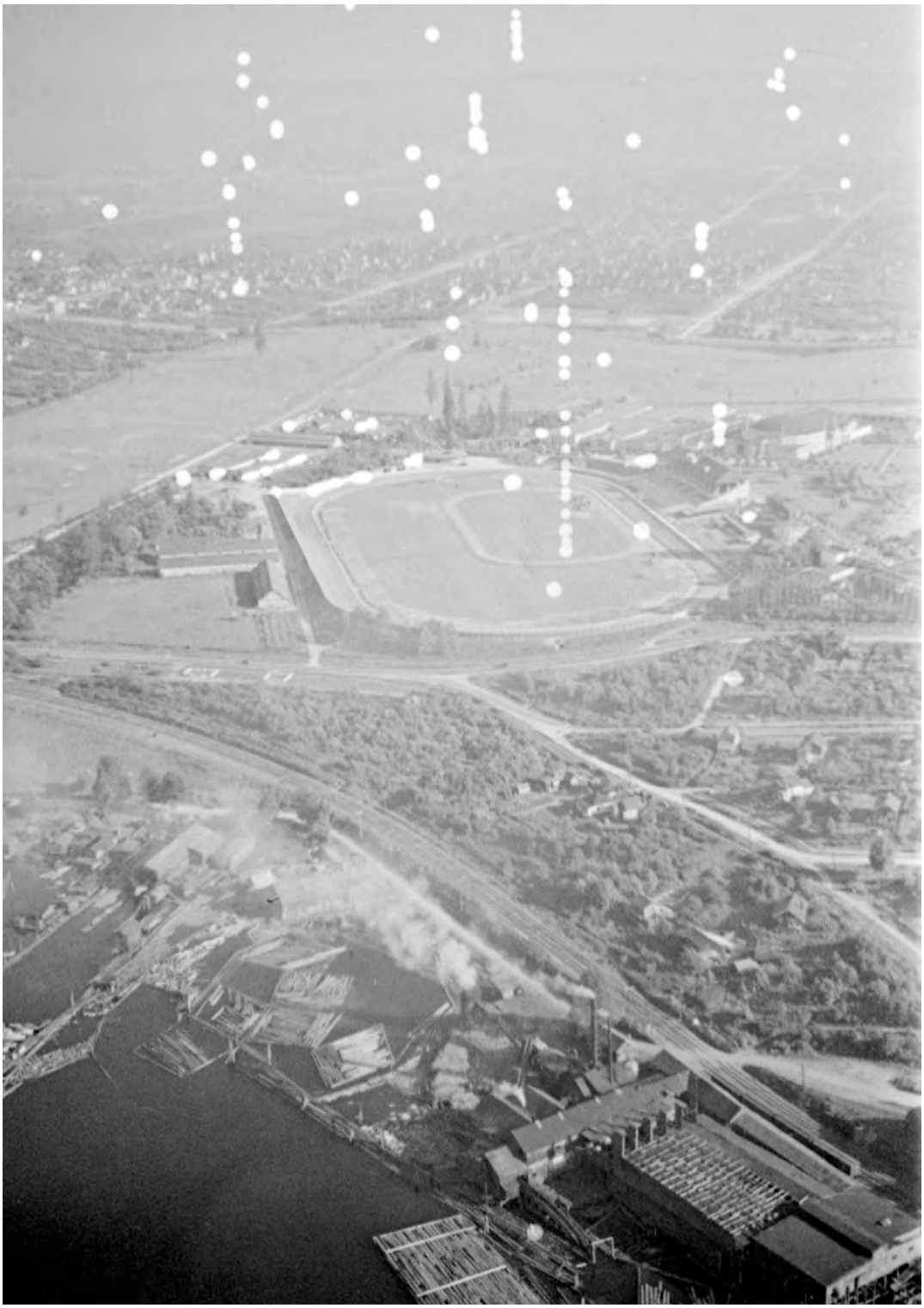

Figure 9. Aerial view 1936 of Hastings Park looking east with log booms on south shore of Burrard Inlet (City of Vancouver Archives AM1376-: CVA 94-28).

Figure 10. Aerial view 1947 looking northeast over Hastings Park. The oblique view shows the Burrard Inlet shoreline, Renfrew Street, the Hastings Park race track, the amusement park including an enlarged roller coaster at its original location, and exhibition buildings (City of Vancouver Archives: AM281-S8-: CVA 180-1468).

Figure 11. Aerial view ca. 1964 looking east of PNE grounds and surrounding area where the roller coaster is shown in its new location after it was moved in 1958 to the southeast portion of Hastings Park (City of Vancouver Archives AM281-S8-: CVA 180-5256.4).

The changing land use across Hastings Park that has occurred since the City of Vancouver took ownership of the property in 1889 has affected the potential to encounter archaeological sites in the Project Area. Major development works which may have negatively impacted archaeological materials include the construction of Empire Stadium in the southeast corner of the Park and its later conversion to Empire Field, the construction of the BC Building and its later conversion to Sanctuary Pond, the construction of the Pacific Coliseum, and the construction of the PNE Agrodome. Other activities, such as infilling and asphalt resurfacing, which did not involve deep excavations, may have capped any potential archaeological materials such that they may still be extant within the Project Area. In particular, the infilling of Renfrew Creek may have buried and preserved archaeological materials along the former creek banks, as well as outside of the Project Area at the creek's outflow to Burrard Inlet.

3.3 Expected Site Types Based on Cultural Overview

Activities that the Aboriginal people living within the area engaged in may be reflected in the archaeological record of the Project Area. Based on the background overview of ethnographic, archaeological, and place name sites, and the environmental context of the local area, these types of sites would probably have existed in the area:

1. Village sites (shell midden, cultural depressions, hearth features, lithic and bone artifacts, faunal remains, burials, canoe runs)
2. Camps (lithic scatters, hearths, cultural depressions)
3. Burials (ancestral remains, funerary objects)
4. Culturally Modified Trees (CMTs)
5. Trails

Based on the geography of the Project Area and proxies from nearby sites, the most common site types/features would be lithic scatters and shell middens, as well as burials and trails. Lithic scatters can range considerably in size, complexity, and density depending on the size of activity group, longevity of stay, persistence of use over time, activity type, and amount of site disturbance. Shell middens can similarly range in size and complexity. In addition, burials are often associated with shell middens on the Northwest Coast. Other site types such as trails or CMT sites likely once existed in the Project Area, but they have long since been destroyed by urbanization.

The urbanization of the Project Area has significantly changed the landscape (i.e., the infilling of New Brighton Park and adjacent shoreline, and the varied and intensive land use and constructions associated with Hastings Park). Any future development along buried creek-ways has the potential to impact unknown or unrecorded archaeological sites. The long and intensive post-Contact land use in the Project Area has likely resulted in only a subset, if any, of the possible site types listed above having survived:

1. Lithic scatters/ fire-cracked rock
2. Shell middens
3. Burials

3.4 Preliminary Field Reconnaissance

On April 2, 2019, Ian Sellers (Inlailawatash), Walter Homewood (Inlailawatash), Darrell Guss (Tsleil-Waututh), and Kody Huard (Musqueam) completed a pedestrian survey of the Project Area (Figure 11). The crew walked the Project Area where access permitted for a total survey length of 4.2 km (buildings, Playland grounds, and racetrack grounds were not accessed). Subsurface exposures were inspected when encountered.

Across the Project Area the landscape is almost entirely paved, developed, or otherwise obscured. Due to the limited visibility of the ground surface, the PFR focused on areas associated with historic streams and shorelines to identify remnant landforms and associated subsurface archaeological potential (Figure 12).

3.4.1 Preliminary Field Reconnaissance Results

The PFR confirmed that the landscape disturbances that were anticipated from the desk-top review of historical urban developments were extensive. The construction for the Empire Stadium and Empire Field, the Pacific Colosseum, the PNE Agrodome, and the Sanctuary Pond has removed any native sediments within each facility footprint that might once have contained archaeological materials. However, in those portions of the Project Area that surround the historic creeks there is potential that archaeological materials may have been buried there by infilling and capping with asphalt or concrete, thus having protected the materials. As a result of the archaeological potential along the historic creek channels, a 50 m buffer for future construction in the Project Area should be applied along both sides of the known historic creeks. The 50 m buffer allows for uncertainty in the historic stream locational data (Figure 12).

s.18, s.18.1

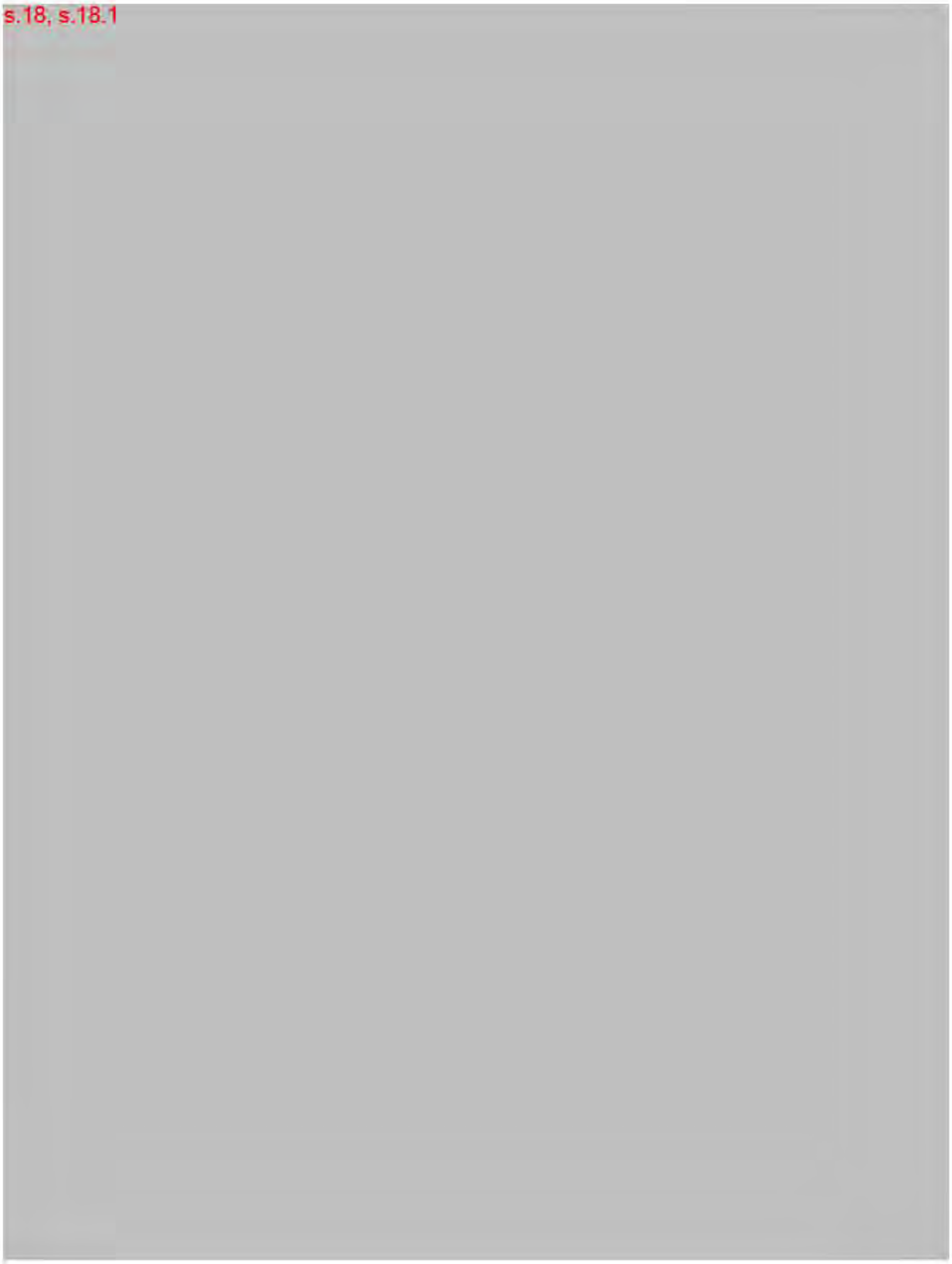

Figure 12. Results of the Preliminary Field Reconnaissance.

4 RECOMMENDATIONS FOR RESOURCE MANAGEMENT

An Area of Archaeological Potential (AOP) was identified surrounding the historic streams that were once present in the Hastings Park Project Area (Figure 12). Recommendations for the type of resource management option (e.g., archaeological monitoring, *Chance Find Procedure*, or subsurface testing) are made based on the scope of impacts from specific developments. At this time no specific development plans for Hastings Park have been provided to Inlailawatash. However, a general management recommendation is made that:

(1) The Area of Potential (AOP) identified surrounding the historic creeks requires an Archaeological Impact Assessment (AIA) if developments will impact the sub-surface deposits in the vicinity of the creeks.

Based on the results of this AOA an Archaeological Impact Assessment (AIA) of the Area of Potential would fulfill Provincial requirements for the protection of potential archaeological sites under the *HCA*. However, the fulfillment of these requirements alone does not address impacts to other cultural resources of interest to First Nations, which may include intangible aspects of heritage in addition to archaeological sites, such as a known place name of spiritual significance on the Hastings Park lands which are beyond the recommendations of an Archaeological Overview Assessment. Given the nature of the Hastings Park—PNE Master Plan, which is a multi-year/multi-phase project, the management of cultural resources may be most effective on a government to government level through direct consultation with First Nations.

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Keystone Environmental
Knowledge-Driven Results

April 5, 2019

Mr. Kevin Nguyen
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Dear Mr. Nguyen:

Re:

Report of Findings – Stage 1 and 2 Preliminary Site Investigation
Portion of 2901 East Hastings Street, Vancouver, BC
Phase 1A – Existing Playland Footprint, Phase 2 – PNE Amphitheatre, Portion of Phase 3A – Festival Heart of the Park, Phase 3B – Creek Daylighting South, and Phase 4A – Future Playland Expansion
Project No. 13639

We have enclosed the report titled *Report of Findings – Stage 1 and 2 Preliminary Site Investigation, Portion of 2901 East Hastings Street, Vancouver, BC; Phase 1A – Existing Playland Footprint, Phase 2 – PNE Amphitheatre, Portion of Phase 3A – Festival Heart of the Park, Phase 3B – Creek Daylighting South, and Phase 4A – Future Playland Expansion.* We are pleased to submit this report to City of Vancouver.

If you have any questions, please do not hesitate to contact us.

Sincerely,

Keystone Environmental Ltd.

Nicole MacDonald, P.Ag.
Project Manager

Raminder Grewal, P.Eng
President

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Environmental Consulting
Engineering Solutions
Assessment & Protection

Keystone Environmental
Knowledge-Driven Results

Report of Findings – Stage 1 and 2 Preliminary Site Investigation

Portion of 2901 East Hastings Street, Vancouver, BC
Phase 1A – Existing Playland Footprint, Phase 2 – PNE Amphitheatre, Portion of Phase 3A – Festival Heart of the Park, Phase 3B – Creek Daylighting South, and Phase 4A – Future Playland Expansion

Prepared for: City of Vancouver

Project No. 13639
April 2019

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EXECUTIVE SUMMARY

This KEYSTONE ENVIRONMENTAL™ Stage 1 and 2 Preliminary Site Investigation (PSI) was prepared at the request of City of Vancouver for Phase 1A – Existing Playland Footprint, Phase 2 – PNE Amphitheatre, Portion of Phase 3A – Festival Heart of the Park, Phase 3B – Creek Daylighting South and Phase 4A – Future Playland Expansion located on an irregularly shaped portion of 2901 East Hastings Street, in the City of Vancouver, BC. The area of the Site is approximately 141,000 m^2.

The Site is divided into five sections as follows:

- **Phase 1A – Existing Playland Footprint** which is occupied by the central and east portions of Playland amusement park (approximately 53,300 m^2 in area).
- **Phase 2 – PNE Amphitheatre** which is occupied by the existing PNE Amphitheatre (approximately 9,725 m^2 in area).
- Portion of **Phase 3A – Festival Heart of the Park** which is currently occupied by a paved parking area (approximately 6,100 m^2 in area).
- **Phase 3B – Creek Daylighting South** which is currently occupied by a paved parking area and vegetated areas associated with Sanctuary Pond (approximately 15,025 m^2 in area).
- **Phase 4A – Future Playland Expansion** which is currently occupied by barns associated with Hastings Park racecourse and a paved parking lot (approximately 56,850 m^2 in area).

ON-SITE SUMMARY

The history of the Site is as follows:

Phase 1A – Existing Playland Footprint: Historical records indicate that from the 1920s, or earlier, to the 1940s, Phase 1A was vegetated or occupied by a golf course. In the 1950s, the area was used as parking lot associated with the adjacent former Empire Stadium. In the late 1950s, an amusement park was constructed on the property (including the Coaster rollercoaster). The area has remained occupied by an amusement park since the late 1950s.

Phase 2 – PNE Amphitheatre: Prior the early 1960s, a former PNE maintenance area/works yard was located in the existing amphitheatre. The 1996 Phase I ESA indicated that a former paint shop, automotive/machinery repair facility, carpentry shop, and a garden maintenance /greenhouse were located in the area. In addition, a gasoline UST was located on the west perimeter of this portion of the Site. In the 1960s, the works yard was moved to the northwest portion of the PNE property (greater than 400 m northwest of the Site) and subsequently the buildings were demolished and the area was paved. It is unknown if the UST was removed at that time. Since the 1970s, the area has been occupied by an amphitheatre which has been periodically used for lumber jack shows and demolition derbies associated with the PNE.

Portion of Phase 3A – Festival Heart of the Park: Historical records indicate that this portion of Phase 3A was vacant and vegetated in the 1930s and was occupied by portions of display barns (poultry swine and sheep) from the 1940s to the 1990s. Since the early 2000s, the area has been vacant and paved for parking.

Phase 3B – Creek Daylighting South: Historical records indicate that the north portion of Phase 3B was vacant and vegetated in the 1930s. From the 1940s to the 1990s, the northwest portion of Phase 3B was occupied by portions of display barns (poultry, swine, and sheep) and the northeast portion of Phase 3B remained vacant. Since the early 2000s, the north portion has been vacant and paved for parking with the exception of a small portion of landscaping. The south portion of Phase 3B was vacant and vegetated (potentially associated with a golf course) from the 1920s to the 1940s. From the 1950s to the 1990s, the Outdoor Bowl was located on the southwest portion of Phase 3B and by the early 2000s, the area was converted to the existing pond and green space.

Phase 4A – Future Playland Expansion: Historical records indicate that from the 1920s, or earlier, to the 1930s, Phase 4A was vacant and vegetated. Since the 1940s, horse barns have existed on the west portion of the area (associated with Hastings Park racecourse) and the central and east portions of the area have remained primary used for parking (Parking Lot 9).

The following on-Site areas of potential environmental concern (APECs) were identified for the Site:

- APEC 1 – On-Site imported gravel, historical staining, former paint storage and historical storage at Corkscrew rollercoaster (Phase 1A)
- APEC 2 – On-Site chain lift, motor shed, and track lubrication at Coaster rollercoaster (Phase 1A)
- APEC 3 – On-Site oil storage area and workshop (Phase 1A)
- APEC 4 – On-Site fill material
- APEC 5 – On-Site unknown vent pipe at Hastings Park (Phase 4A)
- APEC 6 – On-Site hydrocarbon-impacted soil stockpile (Phase 4A)
- APEC 7 – Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)
- APEC 8 – Former potential heating oil UST located at former Display Barns (Phase 3A)
- APEC 9 – Former demolition derby activities at the former Outdoor Bowl (Phase 3B)

OFF-SITE SUMMARY

The remaining portions of 2901 East Hasting Street have been occupied by the PNE grounds since the 1930s. The vicinity of the Site has been used for various purposes including a golf course, amusement park rides, animal display barns, a horse racecourse, and sports fields/stadiums.

The off-Site areas located beyond 2901 East Hastings Street have been primarily residential, or occupied by roadways, highway interchanges, and community parks.

Three off-Site areas were historically or currently occupied by activities of potential environmental concern. However, based on their distance from the Site, the lack of observed staining, and/or the relatively short duration of activities, there is considered to be of low potential for contaminants of concern associated with the three off-Site properties to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the CSR standards. Off-Site APECs were not identified for the Site.

STAGE 2 PRELIMINARY SITE INVESTIGATION

The Stage 2 PSI was conducted in November and December 2018 to investigate the APECs identified in the Stage 1 PSI. The Stage 2 PSI included a ground penetrating radar (GPR) and electromagnetic (EM) survey, the drilling of seventeen boreholes (BH18-1, MW18-2, MW18-3, BH18-4, MW18-5, MW18-6, BH18-7, BH18-8, MW18-9 to MW18-12, BH18-13, MW18-14 to MW18-16 and BH18-17) completing eleven of them as monitoring wells with vapour attachments and the collection of soil, groundwater and vapour samples. The following table presents the APECs, potential contaminants of concern (PCOCs) and corresponding investigation locations advanced during the Stage 2 PSI.

Table ES-1 Summary of APECs, PCOCs and Investigative Locations

APECs	Proposed Investigation Locations	Proposed Analysis		
		Soil	Groundwater	Vapour
APEC 1: On-Site imported gravel, historical staining, former paint storage and historical storage at Corkscrew roller coaster (Phase 1A)	BH18-4 and MW/SV18-5	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 2: On-Site chain lift, moto shed and track lubrication at Coaster rollercoaster (Phase 1A)	BH18-1 and MW/SV18-2	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 3: On-Site oil storage area and work shop (Phase 1A)	MW/SV18-2 and MW/SV18-3	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv

APECs	Proposed Investigation Locations	Proposed Analysis		
		Soil	Groundwater	Vapour
APEC 4: On-Site fill material	BH18-1, MW/SV18-2, MW/SV18-3, BH18-4, MW/SV18-5, MW/SV18-6, BH18-7, BH18-8, MW/SV18-9 to MW18-12, BH18-13, MW/SV18-14 to MW/SV18-16, BH18-17, SP/SS18-2 to SP/SS18-6	LEPH, HEPH, PAH and metals	LEPHw, PAH and dissolved metals	Naphthalene
APEC 5: On-Site unknown vent pipe at Hastings Park (Phase 4A)	GPR and EM Survey to confirm presence or absence of UST			
APEC 6: On-Site hydrocarbon-impacted stockpile (Phase 4A)	MW/SV18-9 SP/SS18-1	LEPH, HEPH, PAH, VPH and metals	LEPHw, PAH, VPHw and dissolved metals	Naphthalene, and VPHv
APEC 7: Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)	GPR and EM Survey to confirm presence or absence of UST MW18-12, BH18-13 and MW/SV18-14 (located in Phase 3B)	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	NA[1]
APEC 8: Former potential heating oil UST located at former Display Barns (Phase 3A)	GPR and EM Survey to confirm presence or absence of UST MW/SV18-16	LEPH, HEPH, PAH, and VPH	LEPHw, PAH and VPHw	Naphthalene, and VPHv
APEC 9: Former demolition derby activities at the former Outdoor Bowl (Phase 3B)	MW/SV18-15	LEPH, HEPH, PAH, VPH and metals	LEPHw, PAH, VPHw and dissolved metals	Naphthalene, and VPHv

LEPH – light extractable petroleum hydrocarbons
HEPH – heavy extractable petroleum hydrocarbons
VOC – volatile organic compounds
VPH – volatile petroleum hydrocarbons
PAH – polycyclic aromatic hydrocarbons
UST – underground storage tank
GPR – Ground Penetrating Radar
EM – Electro Magnetic
MW – monitoring well
SP/SS – stock pile/surficial soil
NA – Not analyzed

Soil samples collected from the fill material across the Site had concentrations of hydrocarbon and metals above the CSR urban park land use (PL) standards. The groundwater analytical results were less than the CSR drinking water (DW), freshwater aquatic life (AW_{FW}) and marine aquatic life (AW_{M}) standards. In vapour, the predicted indoor and outdoor air (attenuated) concentrations were less than the CSR PL standards. The following table summarizes the soil contamination identified during the Stage 2 PSI by Keystone Environmental.

[1] MW18-12 could not be installed with a soil vapour attachment due to the very shallow groundwater table.

Table ES-2 Summary of Soil Contamination

AEC	Location	Depth (m)	Estimated Area (m^2)	Contaminants	Maximum Concentrations
AEC 4 – On-Site fill material	Phase 1A	Surface to 0.4 mbg	225	arsenic	108 µg/g
				chromium	81.4 µg/g
				zinc	245 µg/g
		Surface to 2.1 mbg	750	HEPH	1,300 µg/g
	Phase 2	1 to 1.8 mbg	1,500	LEPH	1,500 µg/g
				VPH	1,100 µg/g
				Naphthalene	0.76 µg/g
	Portion of Phase 3A	Surface to 2.4 mbg	2,000	LEPH	1,200 µg/g
				HEPH	1,500 µg/g
				zinc	265 µg/g
	Phase 3B	Surface to 1.2 mbg	900	HEPH	5,900 µg/g
				benzo(a)anthracene	1.9 µg/g
				benzo(b)fluoranthene	1.6 µg/g
				benzo(b+j)fluoranthene	2.7 µg/g
				indeno(1,2,3-cd)pyrene	1.1 µg/g
				naphthalene	0.78 µg/g
	Phase 4A	Surface to 1.2 mbg	450	Zinc	182 µg/g

CONCLUSIONS AND RECOMMENDATIONS

Contaminants of concern in soil (arsenic, chromium, zinc, LEPH, HEPH, VPH, benzo(a)anthracene, benzo(b)fluoranthene, benzo(b+j)fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene) are present at the Site at concentrations greater than the applicable CSR Urban Park Land Use standards.

We understand that the Site will be redeveloped in Phases with the redevelopment timeline ranging from 1 to 12 years. As the Site use will not change, it is our understanding that a Ministry Instrument is not required for the Site. Instead, we understand that the BC ENV would require an application for a Scenario 2 Release under Administrative Guidance 6 for each Phase to facilitate the City of Vancouver to approve the permit applications.

Additional investigation to delineate the contamination can be conducted prior to release application for each particular Phase, or at the time of the redevelopment for the Phase. If contamination is present within the redevelopment area, it should be remediated under the BC ENV Independent Remediation process. Recommendations per APEC/AEC are presented in the below.

Table ES-3 Recommendations per APEC/AEC

APEC/AEC	Location	Recommendation
APECs 1 and 2: On-Site Imported Gravel, Historical Staining, Former Paint Storage and Historical Storage at Corkscrew Rollercoaster On-Site chain lift, moto shed and on-Site track lubrication at Coaster rollercoaster	Phase 1A	If soil in vicinity of the Corkscrew Rollercoaster is to be removed off-Site in the future, additional soil characterization may be required for disposal purposes.
APEC 3: On-Site oil storage area and work shop	Phase 1A	If soil beneath the workshop or in the vicinity oil storage area is to be removed off-Site in the future, additional soil characterization may be required for disposal purposes.
AEC 4: On-Site fill material	Phases 1A, 2, portion of 3A, Phase 3B and Phase 4A	Additional investigation would be warranted to delineate the meals and hydrocarbon contamination.
APEC 6: On-Site hydrocarbon-impacted stockpile	Phase 4A	If the stockpiled soil continues to be used for motorsports events, it should continue to be stored on a paved surface and be covered with a plastic liner to prevent potential run-off. If future off-Site disposal of the soil stockpile is required, additional testing may be required for disposal purposes.
APEC 8: Former potential heating oil UST located at former Display Barns	Phase 3A	If an UST is encountered during redevelopment activities a qualified environmental professional should be retained to document the tank condition and to characterize the soil around the tank.

This Executive Summary is subject to the same general limitations as contained in the report and must be read in conjunction with the entire report.

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LIST OF ACRONYMS

AEC(s)	area(s) of environmental concern
AIP	Approval in Principle
AL	agricultural land use
ALR	Agricultural Land Reserve
AP	approved professionals
APEC(s)	area(s) of potential environmental concern
AST	aboveground storage tank
AW	aquatic life water use
AW_{FW}	aquatic life water use – freshwater
AW_{M}	aquatic life water use – marine
BC	British Columbia
BC ENV	BC Ministry of Environment and Climate Change Strategy
bgs	below ground surface
BH	borehole
BTEX	benzene, toluene, ethylbenzene and xylenes
CALA	Canadian Association for Laboratory Accreditation
CL	commercial land use
CofC	Certificate of Compliance
COC(s)	contaminant(s) of concern
CoR	Confirmation of Remediation
CSA	Canadian Standards Association
CSAP	Society of Contaminated Sites Approved Professional of British Columbia
CSR	Contaminated Sites Regulation
DNAPL	dense non-aqueous phase liquids
DSI	Detailed Site Investigation
DW	drinking water use
EM	electromagnetic
EMA	Environmental Management Act
EPH	extractable petroleum hydrocarbons
EPQ	Exposure Pathway Questionnaire
ESA	Environmental Site Assessment
GPR	ground penetrating radar
HEPH	heavy extractable petroleum hydrocarbons
HHERA	Human Health and Ecological Risk Assessment
HWR	Hazardous Waste Regulation
IL	industrial land use
IW	irrigation water use

LIST OF ACRONYMS (CONT'D)

km	kilometres
LEPH	light extractable petroleum hydrocarbons in soils
$LEPH_W$	light extractable petroleum hydrocarbons in groundwater
LNAPL	light non-aqueous phase liquids
LW	livestock water use
m	metres
mbg	metres below grade
mbgs	metres below ground surface
Maxxam	Maxxam Analytics
MTBE	methyl tertiary butyl ether
MW	monitoring well
NAPL	non-aqueous phase liquid
NIR	Notification of Independent Remediation
NOM	Notification of Likely or Actual Offsite Migration
NS	no standard
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCOC(s)	potential contaminant(s) of concern
PID	photo-ionization detector
PL	urban park land use
PK	parkade land use
ppm	parts per million
Protocol 2	Protocol 2 for Contaminated Sites
Protocol 4	Protocol 4 for Contaminated Sites
Protocol 11	Protocol 11 for Contaminated Sites
Protocol 12	Protocol 12 for Contaminated Sites
Protocol 21	Protocol 21 for Contaminated Sites
PSI	Preliminary Site Investigation
QA/QC	quality assurance/quality control
RL_{LD}	residential low density land use
RL_{HD}	residential high density land use
RPD	relative percentage difference

LIST OF ACRONYMS (CONT'D)

SRCR	Site Risk Classification Report
SWOG	special waste oil and grease
TDS	total dissolved solids
TEF	toxicity equivalency factor
TEQ	toxicity equivalent value
TG4	Technical Guidance 4 on Contaminated Sites
TG13	Technical Guidance 13 on Contaminated Sites
USEPA	United States of America Environmental Protection Agency
UST	underground storage tank
VH_{W6-10}	volatile hydrocarbons in groundwater
VOCs	volatile organic compounds
VPH	volatile petroleum hydrocarbons
VPHv	volatile petroleum hydrocarbons in vapour
WLN	wildlands natural land use
WL_R	wildlands reverted land use

1. INTRODUCTION

This KEYSTONE ENVIRONMENTAL™ Stage 1 and 2 Preliminary Site Investigation (PSI) was prepared at the request of City of Vancouver for Phase 1A – Existing Playland Footprint, Phase 2 – PNE Amphitheatre, Portion of Phase 3A – Festival Heart of the Park, Phase 3B – Creek Daylighting South, and Phase 4A – Future Playland Expansion, located on a portion of 2901 East Hastings Street in the City of Vancouver, BC. The Site location is shown on Figure 1, and photographs of the Site are included in Appendix A.

It is understood that this report is required for due diligence purposes prior to the redevelopment of the Site in accordance with the Hastings Park / PNE Master Plan.

This report is organized into the following sections:

- Section 1: Introduction
- Section 2: Regulatory Standards
- Section 3: Stage 1 Preliminary Site Investigation
- Section 4: Stage 2 Preliminary Site Investigation
- Section 5: Conclusion
- Section 6: Professional Statement
- Section 7: References

1.1 Site Identification

The Site is located on portions of four legal lots identified as follows:

Portion of 2901 East Hastings Street (Phase 1A, 2, 3A, 3B, and 4A)

Civic Address:	Portion of 2901 East Hastings Street, Vancouver, BC
Parcel Identifier:	008-348-219
Legal Description:	Lot 90 except part in Plan 13045 Town of Hastings Suburban Lands Plan 100

Portion of Lots on Northeast Portion of Phase 1A

Civic Address:	not applicable
Parcel Identifier:	Portion of 015-083-012
Legal Description:	Portion of Block W Town of Hastings Plan 17742
Parcel Identifier:	Portion of 007-260-776

Legal Description:	Portion of Lot A of Lot 6 Town of Hastings Suburban Lands Plan 17749
Parcel Identifier:	Portion of 007-255-071
Legal Description:	Portion of Lot A of Lot 13 Town of Hastings Suburban Lands Plan 17798

Entire Site

Current Registered Owner:	City of Vancouver
Current Zoning:	CD-1 (3B) - Comprehensive Development District
Approximate Area:	141,000 m^2 (approximate)
Latitude:	49º 17’ 2.2” North (approximate)
Longitude:	123º 2’ 8.9” West (approximate)

The approximate latitude and longitude entered for the Site was determined from the BC Water Resources Atlas (http://maps.gov.bc.ca/ess/sv/wrbc/).

1.2 Scope of Work

The scope of work for this study included the performance of:

- Conducting a Stage 1 PSI for Phases 2, Portion of 3A and 3B and updating our 2017 Phase I ESA for Phases 1A and 4A and incorporating the findings into this Stage 1 PSI.
- A Stage 2 PSI was conducted between November and December 2018.

1.3 General Limitations

Findings presented in this report are based upon (i) a limited visual review of accessible areas of the Site and surrounding grounds, (ii) interviews with personnel familiar with Site activities, (iii) a review of previous reports documents prepared by Keystone Environmental and others and historical archive records, and (iv), the results of field investigations including surface soil sampling, boreholes, monitoring wells, vapour wells and soil, groundwater and vapour sample analyses. Geologic observations and analytical results reflect conditions encountered at specific test locations. Site conditions (geologic, hydrogeologic and chemical characterization) may vary from that extrapolated from the data collected during this investigation. Consequently, while findings and conclusions documented in this report have been prepared in a manner consistent with that level of care and skill normally exercised by other members of the environmental science and engineering profession practising under similar circumstances in the area at the time of the performance of the work, this report is not intended nor is it able to provide a totally comprehensive review of past or present site environmental conditions.

This report has been prepared solely for the internal use of City of Vancouver, pursuant with the Standing Offer Agreement between City of Vancouver and Keystone Environmental Ltd., dated August 28, 2014. By using the report, City of Vancouver agrees that they will review and use the report in its entirety. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Keystone Environmental Ltd. accepts no responsibility for damages, if any, suffered by other parties as a result of decisions made or actions based on this report.

2. REGULATORY STANDARDS

The applicable provincial legislation used for comparison of soil, groundwater, and vapour analytical results are contained in the following documents:

- *Environmental Management Act* (EMA), ([SBC 2003], Chapter 53 assented to October 23, 2003 and current to (October 31, 2018)
- Contaminated Sites Regulation (CSR) (375/96 O.C. 1480/96, includes amendments up to BC Reg. 116/2018, June 14, 2018

2.1 Soil Standards

Soil standards are classified into eight categories, based on the type of land use. Sites which contain substances in soil at concentrations greater than the standard for the land use applicable to the Site are considered to be contaminated. The land use categories are summarized as follows:

- Wildlands Natural (WL_N)
- Wildlands Reverted (WL_R)
- Agricultural Land Use (AL)
- Urban Park Land Use (PL)
- Residential Land Use Low Density (RL_{LD})
- Residential Land Use High Density (RL_{HD})
- Commercial Land Use (CL)
- Industrial Land Use (IL)

Within the CSR, there are two types of numerical standards for soil: matrix numerical standards (Schedule 3.1 Part 1); and generic numerical standards (Schedule 3.1 Parts 2 and 3). Matrix Numerical Standards are provided for certain substances in soil and are determined based on the evaluation of potential site-specific factors including the following:

- Human Health
  - Intake of contaminated soil (applicable at all sites)
  - Groundwater used for drinking water
- Environmental Protection
  - Toxicity to soil invertebrates and plants (applicable at all sites)
  - Livestock ingesting soil and fodder
  - Major microbial functional impairment
  - Groundwater flow to surface water used by aquatic life – freshwater and marine
  - Groundwater used for livestock watering
  - Groundwater used for irrigation

Once the applicable site-specific soil matrix factors are determined, the lowest standard from those applicable factors is defined as the matrix numerical standard that will apply to the Site.

The Site is currently used as an amusement park and fairgrounds. The proposed expansion and redevelopment of the Site will not change the land use. As the Site's primary purpose is outdoor recreation, it is classified as urban park under the CSR; therefore, the CSR PL soil standards are considered applicable to the Site. In the event that future off-Site soil disposal is required, we have also compared the soil analytical results to the CSR residential low density ($RL_{LD)}$ and commercial (CL) land use standards.

2.2 Groundwater Standards

Groundwater standards of the CSR (Schedule 3.2) are classified into four categories, based on the type of water use. Furthermore, $EPHw_{10-19}$ and Volatile Hydrocarbons in water (VHw_{6-10}) standards are applicable to all sites, irrespective of water use. Sites which contain substances in groundwater at concentrations greater than the standard for the water use applicable to the Site, or $EPHw_{10-19}$ and VHw_{6-10} standards, are considered to be contaminated. The water use categories are summarized as follows:

- Aquatic Life Water Use (AW) – freshwater and/or marine
- Drinking Water Use (DW)
- Irrigation Water Use (IW)
- Livestock Watering Use (LW)

2.2.1 Aquatic Life Use Standards

The CSR aquatic life water use (AW) standards apply to all groundwater located within 500 m of a surface water body containing aquatic life; which can be further separated into freshwater and/or marine aquatic life, unless it can be demonstrated that groundwater does not flow to that surface water body. At sites where the potential exists for contaminated groundwater to flow through preferential pathways that discharge directly to a surface water body containing aquatic life, or where there is a potential for contaminated groundwater to flow to within 500 m of a surface water body containing aquatic life, the CSR AW standards apply.

The closest surface water body to the Site is a pond which is located on the southwest portion of Site (Phase 3B). The next closest water body to the Site is Burrard Inlet, which is approximately 350 m north of the Site. Therefore, the CSR marine aquatic life (AW_M) standards and the CSR AW_{FW} standards are applicable to the Site.

2.2.2 Drinking Water Use Standards

The evaluation of whether or not the DW standards are applicable to a site is completed in two stages: first for the current situation; and then, for the potential future situation. Both the current and the overall future evaluation must indicate "no drinking water use" before you can eliminate the application of the DW standard to the site. Furthermore, if a natural confining barrier does not protect current or future drinking water use aquifers from shallow groundwater contamination sources then drinking water use applies to the shallow aquifers as well.

Current Use: For current use evaluation, the CSR DW standards are applicable at a site where the groundwater or surface water at or near the site (within 500 m of the site or the leading edge of a groundwater contamination source or, if groundwater flow direction has been demonstrated, 100 m up-gradient or 500 m down-gradient of the site or contamination source) is currently used for drinking water.

Future Use – Aquifer Hydraulic Properties: If there are any suitable aquifer(s) (hydraulic conductivity greater than $1x10^{-6}$ m/s and aquifer yield greater than 1.3 L/min) present beneath the Site, then there is considered to be the potential for DW standards to apply and further evaluation is required. If not, then DW standards do not apply, unless you are assessing a bedrock unit, then further evaluation is required. DW use does not apply to confined aquifers where the average saturated thickness is less than 1 metre, or to unconfined aquifers where the average saturated thickness is less than 2 metres as they are considered unlikely to provide sufficient yield. If an unconfined aquifer is comprised only of imported fill, or present only seasonally, then DW use does not apply to that aquifer.

Future Use – Aquifer Natural Water Quality: The water of an aquifer is considered unsuitable for domestic water supply by the BC ENV if the natural water quality contains total dissolved solids (TDS) at a concentration greater than 4,000 mg/L, or is contained within organic soils or muskeg. DW standards would therefore not apply to that aquifer. Furthermore, aquifer(s) located within and below former fill, or within 500 m of, marine and estuarine foreshore, and spatially across the site contain naturally-occurring chloride and sodium concentrations greater than the DW standard, DW use does not apply.

Hydrogeological investigation for further evaluation of the CSR DW applicability to the Site was beyond the scope of this investigation. The CSR DW groundwater standards are considered applicable to the Site based on currently available information.

Technical Bulletin 3 – Regional Background Concentrations for Select Inorganic Substances in Groundwater: The BC Ministry of Environment & Climate Change Strategy (BC ENV) introduced Technical Bulletin 3 (TB 3) on September 24, 2018. TB 3 establishes regional background concentrations for dissolved arsenic, lithium, selenium, vanadium and uranium in groundwater. The Site is within the Lower Mainland Region, which has two Subregions. The off-Site adjacent Empire Field and a small portion of southeastern portion of the Site (Playland in Phase 1A) are within Subregion 1, the rest of the Site is within Subregion 2. Groundwater monitoring wells were not located within Subregion 1, therefore, only for the concentrations listed in Subregion 2 were applied to the Site.

As per the CSR Schedule 3.2, the CSR standards for dissolved iron and dissolved manganese are only applicable to sites with specific Schedule 2 activities. Although a welding shop and machine shop were located on-Site, they were not carried forward as an APECs, based on the good condition of the concrete floors/pavement and the fact that bulk quantities of constituents of concern are not used in the shop (discussed in further detail in Section 3.8.1). In addition, monitoring wells were installed down-gradient of the machine shop (MW18-6) and welding shop (MW18-2), to investigate other APECs, and the dissolved iron and manganese concentrations were less than CSR DW standards. Based on this, the CSR DW standards for dissolved iron and dissolved manganese are not considered applicable to the Site.

2.2.3 Irrigation and Livestock Water Use Standards

The protection of irrigation (IW) and livestock watering (LW) water use standards apply to groundwater at sites with agricultural land use or are located within a provincial Agricultural Land Reserve (ALR), unless the geological unit where contamination occurs has a hydraulic conductivity less than 1 x 10^{-6} m/s. Similar to the DW standards, the IW and LW standards apply if irrigation or livestock watering wells or surface water intakes are located within a distance of 500 m down-gradient, or 100 up-gradient, from the outer extent of a groundwater contamination plume.

The Site is not located within the ALR. Agricultural land use and operations were not identified within 1 km of the Site. In addition, irrigation and livestock water wells were not identified within 500 m of the Site. The CSR IW and LW standards are not considered to be applicable to the Site.

2.3 Vapour Standards

Vapour standards (CSR Schedule 3.3) are classified into four categories, based on the property usage or if a potential vapour exposure pathway for contaminants of concern (COCs) exists from neighbouring properties within 30 m. Sites which contain attenuated concentrations greater than the standard for the property use applicable to the Site are considered to be contaminated. The property use categories are summarized as follows:

- Agricultural, Urban Park, and/or Residential Use
- Commercial Use
- Industrial Use
- Parkade Use

Receptor zones include indoor and outdoor air.

As discussed in the soil standards section (Section 2.1), the Site is currently an amusement park, therefore the CSR PL standards are applicable. As surrounding land within 30 m to the east, south, west and north of Site was occupied by residential and commercial properties, vapour analytical results were also subsequently compared to the CSR RL and CL vapour standards for evaluating the potential impact from the Site to the surrounding residential and commercial properties.

3. STAGE 1 PRELIMINARY SITE INVESTIGATION

3.1 Stage 1 PSI Scope of Work

A Phase I ESA was conducted by Keystone Environmental for a portion of the Site in 2017 (Phases 1A and 4A). The findings from the 2017 Phase I ESA have been incorporated into this Stage 1 PSI and additional findings for Phases 2, Portion of Phase 3A and Phase 3B have been included in this report.

The scope of work for this Stage 1 PSI was conducted in general accordance with the requirements of the Canadian Standards Association (CSA) Phase I ESA standards as outlined in the CSA publication Z768-01 and included the following tasks:

- A review of historical records including city street directories, aerial photographs, land use maps and fire insurance maps.
- A review of current records including a the BC Ministry of Environment and Climate Change Strategy (BC ENV) on-line Site Registry, a water well search via the BC Water Resources Atlas, historical climate normals via the Government of Canada Climate Archives, and current land titles for the Site.
- A site reconnaissance to observe Site conditions which may indicate the potential presence of contamination and to prepare a photographic record.
- Interviews with individuals with knowledge of the Site.
- A preliminary building survey for special attention substances such as polychlorinated biphenyls (PCBs), asbestos, and urea formaldehyde foam insulation (UFFI).
- A review of documents and reports relating to waste management and site contamination.

During the 2017 Phase I ESA, previous environmental and geotechnical investigations were provided for review and pertinent information is summarized in Section 3.3.8.

Current land titles were obtained via the BC Land Title Survey Authority (LTSA) website. Leases, title transfers, or easements related to site contamination issues, and Section 219 covenants are not listed in the land titles. A copy of the land titles is provided in Appendix B.

3.2 Property Description

The Site is an irregular shaped portion of the property currently referenced as 2901 East Hastings Street, in the City of Vancouver, BC. The portion of 2901 East Hastings Street which the Site occupies is located to the north of the intersection between East Hastings Street and Windermere Street.

The Site is divided into five sections as follows:

- **Phase 1A – Existing Playland Footprint** which is occupied by the central and east portions of Playland amusement park (approximately 53,300 m^2 in area).

- **Phase 2 – PNE Amphitheatre** which is occupied by the existing PNE Amphitheatre (approximately 9,725 m^2 in area).
- Portion of **Phase 3A – Festival Heart of the Park** which is currently occupied by a paved parking area (approximately 6,100 m^2 in area).
- **Phase 3B – Creek Daylighting South** which is currently occupied by a paved parking area and vegetated areas associated with Sanctuary Pond (approximately 15,025 m^2 in area).
- **Phase 4A – Future Playland Expansion** which is currently occupied by barns associated with Hastings Park racecourse and a paved parking lot (approximately 56,850 m^2 in area).

As shown on Figure 3, the Site is bordered to the north by roadways and highway interchanges, to the east by roadways, highway interchanges, and sports fields (Empire Fields) associated with the PNE grounds; to the south (across East Hastings Street) by a community park and a paved parking lot; and to the west by the remaining portions of the PNE grounds (including the remaining portion of Playland and Sanctuary Pond) and Hastings Park racecourse. The Site is shown on Figures 2 and 3 and selected photographs of the Site are included in Appendix A.

3.2.1 Surficial Geology

The local surficial geology of the area was determined by consulting the Geological Survey of Canada Map 1486A (1979). The stratigraphy of the Site consists of three units, as follows:

- The stratigraphy of the north portion of the Site consists of Vashon Drift and Capilano Sediment deposits of the Post Glacial age. This unit consists of glacial drift including lodgement and minor flow till, lenses and interbeds of substratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt; up to 25 m thick. Marine derived lag gravel normally less than 1 m thick containing marine shell casts has been found mantling till and glaciomarine deposits up to 175 m above sea level. Bedrock is located within 10 m, or less, of the surface.
- The stratigraphy of the central and southeast portion of the Site consists of Vashon Drift and Capilano Sediment deposits of the Post Glacial age. This unit consists of glacial drift including lodgement and minor flow till, lenses and interbeds of substratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt; up to 25 m thick; in most places correlates with Vashon Drift; overlain by glaciomarine and marine deposits similar to Capilano Sediments, normally less than 3 m but in places up to 10 m thick. Marine derived lag gravel normally less than 1 m thick containing marine shell casts has been found mantling till and glaciomarine deposits up to 175 m above sea level; above 175 m till is mantled by bouldery gravel that may be in part ablation till, in part colluvium, and in part marine shore in origin. Bedrock is located more than 10 m below surface.
- The stratigraphy of the west and southwest portion of the Site consists of Postglacial and Pleistocene deposits consisting of marine shore and fluvial sand up to 8 m thick and raised beach medium to coarse sand that has been reworked and redeposited by lowland streams.

During the 2018 Stage 2 PSI, the following soil stratigraphy was observed:

Unit A: Grey to dark brown, fine to coarse grained sand (fill) some fine to coarse grained gravel with some silt. Trace garbage or demolition waste was observed at BH18-13, MW18-14 and MW18-15. Loose to dense, moist. This unit was encountered from surface to depths ranging from approximately 0.1 to 4.2 mbg.

Unit B: Dark brown peat. Soft, wet. This unit was encountered from depths ranging from approximately 0.6 to 0.9 mbg. This unit was encountered under Unit B and was only observed at MW18-12 and BH18-13

Unit C: Brown to grey fine grained sand (till) some silt, trace to some fine to coarse grained gravel, trace cobbles, increasing in density with depth and moist to wet with increasing moisture with depth. This unit was encountered from surface or beneath Unit A or B to the maximum depth of investigation.

3.2.2 Hydrogeology

Groundwater is expected to follow topography flowing from areas of higher elevation to areas of lower elevation. Local groundwater flow direction may vary as a result of local conditions such as topography, geology and the presence of drainage channels and buried utilities, and is subject to confirmation with field measurements. The topography on the Site is as follows:

- Phase 1A – the topography is generally sloped downwards to the north (approximately 3% slope).
- Phase 2 – the topography is steeply sloped downwards to the northwest along the south and east perimeters of the area (approximately 20% slope), and is relatively flat on the remaining portions of the area.
- Phase 3A and 3B – the topography is generally sloped downwards to the northwest (approximately 2% slope).
- Phase 4A – the topography is generally sloped downwards to the northwest (approximately 3% slope).

Burrard Inlet is located approximately 350 m north of the Site. Based on the local topography and the proximity to Burrard Inlet, groundwater flow direction is inferred to be towards the north and northwest; therefore, groundwater is anticipated to flow to the Site from adjacent and up-gradient properties located to the south and southeast of the Site.

The closest surface water body to the Site is Sanctuary Pond, located on the southwest portion of the Site (Phase 3B).

A Vancouver Old Stream Map indicates that former tributaries to Renfrew Creek transected the north portion of the Site (Phase 4A) and the west portion of the Site (Phase 3A), as shown on Figure 2.

During the 2018 Stage 2 PSI, the depth to groundwater ranged from 0.0 m below the top of casing (mTOC) at MW18-5 to 8.154 mTOC at MW18-2.

A groundwater monitoring event was conducted on November 28, 2018 and the interpreted potentiometric surface contours indicated groundwater flow direction was towards the northwest.

3.3 Records Review

Various documents were reviewed for information concerning past uses of, and activities at, the Site and for properties located the vicinity of the Site. Based on the topography in the area sloping down toward the north-northwest (Section 2.2), the vicinity of the Site is defined as approximately 120 m south-southeast (up-gradient); 100 m east-northeast and west-southwest (cross-gradient); and 80 m north-northwest (down-gradient) from the Site. The documents reviewed for information concerning historical land use include city street directories, aerial photographs, land use maps, fire insurance maps, the BC ENV on-line Site Registry, the BC Water Resources Atlas, historical climate normals and previous environmental reports.

3.3.1 Street Directories

Selected street directories, dated 1915, 1920, 1925, 1930, 1935, 1940, 1945, 1950, 1955, 1960, 1970, 1975, 1980, 1985, 1991, 1996, and 2001 were reviewed to obtain information regarding the occupancy of the Site and surrounding area. Street directories were not compiled for the vicinity of the Site after 2001. Historical occupants of the Site have been summarized in Table 1. Off-Site historical operations of potential environmental concern were not identified in the vicinity of the Site during the street directory review.

3.3.2 Aerial Photographs

Aerial photographs, dated 1930, 1949, 1954, 1963, 1969, 1974, 1978, 1986, 1990, 1996, 2002, 2009, and 2015 were reviewed. Copies of the historical aerial photographs are provided in Appendix C. A summary of the on-Site observations made during the aerial photograph review is listed in Table 1.

Following is a summary of observations for the off-Site properties located in the vicinity of the Site:

North Portion of the Site

- The area located to the north and east of the north portion of the Site was primarily residential from the 1930s, or earlier, to the 1950s. Since the 1960s, the area has been primarily occupied by roadways and highway interchanges.
- The area located to the west of the north portion of the Site has been occupied by Hastings Park since the 1930s, or earlier.

South Portion of the Site

- The area located to the east of the south portion of the Site was vacant and vegetated from the 1930s, or earlier to the 1940s. From the early 1950s to the early 1990s, the former Empire Stadium occupied the area. In the late 1990s, the stadium was dismantled and the area has been primarily occupied by sports fields (Empire Fields) since the late 1990s.
- The properties located to the south of the Site have been occupied by single family residences and/or community parks since the 1930s, or earlier.
- The area located to the west of the south portion of the Site was vacant and vegetated in the 1930s, or earlier, and was occupied by a golf course in the 1940s. Since the 1950s, the area has been occupied by the Pacific National Exhibition (PNE) grounds.

Observations of the off-Site properties where activities of potential environmental concern were identified are summarized in Table 2.

3.3.3 Land Use Maps

A land use maps dated 1971, 1980, and 1983 were reviewed. Observations for the Site from the land use map review are listed in Table 1. Off-Site historical operations of potential environmental concern were not identified in the vicinity of the Site during the land use map review.

3.3.4 Fire Insurance Maps

Fire insurance maps dated circa 1925-1950 and 1954-1966 were reviewed. Observations for the Site from the fire insurance map review are listed in Table 1. Off-Site historical operations of potential environmental concern were not identified in the vicinity of the Site during the fire insurance map review.

3.3.5 BC ENV Site Registry Search

An on-line search of the BC ENV Site Registry was conducted to determine if it contained information regarding soil, groundwater and/or vapour contamination for properties located within approximately 500 m of the Site. Based on the relatively large site area, searches were conducted for both the north and south portions of the Site, as follows:

- For the north portion of the Site the search was centered on 49º 17’ 8.9” North by 123º 2’ 3.5” West; and
- For the south portion of the Site the search was centered on 49º 17’ 2.2” North by 123º 2’ 13.7” West; and

At the time of the on-line searches (December 6, 2018), the Site Registry had been updated to December 2, 2018. A total of 11 unique properties were listed between the two searches. A copy of the search results is provided in Appendix D.

Of the 11 off-Site listed properties, one property was located within the vicinity of the Site and includes a portion of the north portion of the Site (Phase 4A), as follows:

Site ID: 8355 – Hastings Park Racecourse

Hasting Park Racecourse is located adjacent to the northwest of the Site and includes the southwest portion of Phase 4A. The Detail Report was obtained[2] and indicated the following:

- The property was registered in July 2003 and was last updated in November 2013.
- A Notice of Independent Remediation (NIR) initiation was submitted to the Ministry of Environment in February 2003. Based on Keystone Environmental's experience at the Site, the NIR pertains to the former PNE maintenance area located to the west of the Hastings Park racecourse, greater than 450 m northwest of the Site.
- Further details were not provided in the Detail Report.

Remaining Properties

The remaining 10 listed properties were located outside of the vicinity of the Site (as defined in Section 3.0); therefore, based on the distance from the Site, the properties were not considered to be areas of potential environmental concern (APECs) to the Site and the Detail Reports were not obtained.

3.3.6 Water Well Search

The BC Water Resource Atlas, which displays groundwater management information for the Province of BC, was accessed on July 25, 2017. Water wells were not identified on the Site or within approximately 500 m of the Site. A copy of the water well search has been attached in Appendix E.

3.3.7 Historical Climate Data and Flood Plain Potential

The climate station which is inferred to most accurately represent the climate of the Site is referenced as the 'N Vancouver 2nd Narrows' climate station (49° 17' 52.6" North and 123° 00' 53.7" West), approximately 2.35 north-northwest the Site. The Canadian Climate Normals information that is based on data collected by Environment Canada between 1981 and 2010 is included in Appendix F and is summarized as follows:

[2] The detail report had not been updated since our 2017 Phase I ESA; therefore, a new detail report was not ordered.

N Vancouver 2nd Narrows (Elevation: 4.0 m above sea level)

Precipitation	1,830.8 mm/year
Highest Monthly Precipitation	293.4 mm (November)
Lowest Monthly Precipitation	53.2 mm (July)
Rainfall	1,805.6 mm/year
Snowfall	24.9 cm /year

Site drainage is primarily by runoff to the municipal storm sewers and/or adjacent properties, and by infiltration into unpaved areas on the Site.

According to the Designated Floodplain Areas in BC map, dated May 2007, provided by the BC ENV Water Stewardship Division Science and Information Branch, the Site is not located within a 200-year floodplain.

3.3.8 Previous Reports

The following previous environmental and geotechnical investigations conducted for portions of 2901 East Hastings Street (including the Site) were provided for review:

- *Report of Findings – Phase I Environmental Site Assessment, Pacific National Exhibition Site, Vancouver, BC.* Prepared for City of Vancouver Real Estate Services by Keystone Environmental Ltd. May 1996.
- *Stage 2 Preliminary Site Investigation* – Hastings Park 3C Sanctuary Extension. Prepared for Philips Farevaag Smallenberg, by Keystone Environmental Ltd. August 2001.
- *Hastings Park Infrastructure Study, Geotechnical Factual Report.* Prepared for Urban Systems Ltd. by Thurber Engineering Ltd. June 2015.

3.3.8.1 1996 Phase I ESA

The 1996 Phase I ESA was conducted for 2901 East Hastings Street, including the Site. Pertinent information to the Site is summarized as follows:

On-Site Portion of 2901 East Hastings Street

- During the 1996 investigation, the on-Site portion of 2901 East Hastings Street was occupied as follows:
  - Phase 1A was occupied by the existing Playland amusement park.
  - Phase 2 was occupied by the existing amphitheatre (previously referenced as the Outdoor Logger Theatre).
  - Phase 3A was occupied by the former display barns associated with the PNE.

  - The northwest portion of Phase 3B was also occupied by the display barns associated with the PNE, the northeast portion of Phase 3B was vacant, and the south portion of Phase 3B was occupied by the Outdoor Bowl.
  - Phase 4A was occupied by the existing parking area and stables associated with Hastings Park Racecourse.
- The buildings on the Site were heated by natural gas, propane, and/or electricity. BC Gas records (currently Fortis BC) indicated that the PNE grounds have been serviced by natural gas since 1928.
- The existing maintenance building was located on the northeast portion of Phase 1A and the workshop was used for machining, lubrication, and fibreglass application. Motor oil, grease, lubricants, transmission fluids and solvents were observed to be stored in a secure storage compartment and hydrocarbon staining was noted on the wood floor of the workshop. Waste oil was collected in a 1,350 L AST located outdoors over pavement, adjacent to the maintenance building. Minor staining was observed on the asphalt in the vicinity of the AST[3]. Previously, the AST has been located in a different location adjacent to the main maintenance building, and minor staining was observed in that area. Jerry cans of fuel were stored in a storage locker adjacent to the maintenance building and USTs were reported to have not been located on the Site.
- The existing welding shop was located on the northeast portion of the Phase 1A. Rust staining was observed on the pavement in the welding shop.
- The existing lower line workshop was located on the northwest portion of Phase 1A. Small quantities (approximately 20 L or less) of hydraulic fluid, oils and solvents, and a self-contained parts washer, were observed in the workshop. Minor staining was observed on the concrete floors in the workshop.
- Two paint sheds (for new and waste paint), a paint booth, and a sign shop were formerly located on the north portion of Phase 1A. Two 205 L drums and multiple small capacity containers (less than 20 L) of waste paint were stored in the waste paint shed and paint staining was observed on the concrete floor of the shed. Multiple 4 L and 20 L capacity containers of acrylic, latex, and metal paints, primers, and solvents were observed in the new paint shed. Small quantities of paint and solvents (capacity not provided) were observed in the sign shop. Paint staining was observed on the floor and the metal grate located on the floor of the paint booth.
- A former shipping container located within the Corkscrew rollercoaster area was used to conduct ride maintenance. Hydraulic oil was stored in 4 L and 20 L capacity containers over unpaved ground surface; however staining was not observed.
- The majority of the rides were reported to have hydraulic components. Hydraulic fluid was stored in 20 L to 400 L tanks which were mounted to the rides. Maintenance to the hydraulic components was generally conducted at the ride and staining was observed on the pavement beneath most the rides. With the exception of the existing Coaster and Corkscrew rollercoaster, the remaining rides located on the Site within Phase 1A were located over concrete or pavement.

[3] The previous report did not comment on the condition of the asphalt in the vicinity of the AST.

- The existing Coaster rollercoaster was located on the east portion of Phase 1A. A mixture of diesel and lubricating oil was used to lubricate the tracks. Select train cars had diesel tanks attached to the front of the train which dripped diesel directly onto the tracks (discussed further in Section 4.1.1). Staining was observed beneath most of the Coaster tracks; however heavy staining (approximately 20 m^2 in area) was observed beneath the main gear box. It was reported by Mr. Ken Herbert (PNE Maintenance Department), that two 205 L drums of hydrocarbon contaminated soils were excavated from the area circa 1995. It was not indicated if confirmatory samples were collected once the hydrocarbon contaminated soils were removed. In addition, lubricating oil for the chain lift was formerly stored in a 200 L drum located at the entrance to the Coaster and staining was observed in the vicinity of the drum.
- The existing Corkscrew rollercoaster was located on the north portion of Phase 1A. Collection trays were observed beneath the chain to collect waste lubricant and store in an 80 L drum located beneath the ride. Staining (approximately 10 m^2 in area) was observed beneath the ride over unpaved surfaces. It was reported by Mr. Vance Shaw (Playland Maintenance Department) that the staining came from a spill which occurred when the hydraulic hoses were being changed. Mr. Shaw reported that the vicinity of the Corkscrew was paved prior to the construction of the Corkscrew; however the pavement was removed. Once the pavement was removed, oily gravel from beneath another ride in Playland was transported to the vicinity of the Corkscrew[4].
- Prior the early 1960s, a former PNE maintenance area/works yard was located within the existing amphitheatre (Phase 2). A former paint shop, automotive and machinery repair facility, carpentry shop, and a garden maintenance/greenhouse were reportedly located in the area. In addition, a former gasoline UST was along the east perimeter of the area. By the 1970s, the yard was moved to the northwest portion of the PNE property (greater than 400 m northwest of the Site), the former works yard buildings were demolished and the area was paved. It was unknown if the UST was removed from the area at that time. The location of the UST is shown on Figure 3. From the 1970s to the 2010, the amphitheatre was used for a lumber jack show and a demolition derby associated with the PNE. Currently, the amphitheatre is used for concerts and special events.
- A UST vent pipe (suspected to be heating oil) was observed adjacent to the display barns formerly located on Phase 3A, on the west portion of the Site. The location of the UST is shown on Figure 3.

Off-Site Portion of 2901 East Hastings Street

- Twenty four 205 L drums of waste absorb-all were located adjacent to the east of Phase 1A at Empire Field. It was reported by Mr. Shaw that the drums were previously stored in the Playland welding shop, but due to maintenance activities in the welding shop, the were being temporarily stored at Empire Field. The drums were sealed and staining was not observed in the vicinity of the drums.

[4] Mr. Shaw reported that the ride from which the oily gravel was transported from had pavement located beneath the oily gravel.

- Two USTs were identified on the southwest portion of the PNE property at the administration building (located greater than 175 m west-southwest of the Site) and the former BC Building (approximately 120 m southwest of the Site). The vicinity of the tank that was formerly located at the BC Building is now occupied by Sanctuary Pond. The locations of the two off-Site USTs identified in 1996 are shown on Figure 3.
- A PNE maintenance area was located on the northwest portion of 2901 East Hastings Street. Within the area, two former and two existing USTs were present (approximately 400 m northwest of the Site). It was reported by Mr. Herbert that one of the former USTs had leaked 450 L of gasoline per month for at least 3 months. A diesel AST and multiple 200 L steel drums of diesel were observed in the area. In the off-Site maintenance area was a machine shop, carpentry shop, paint shop, PCB storage facility, road salt storage area, imported fill material storage area, and heavy equipment storage. The location of the off-Site UST is shown on Figure 3.
- Prior the 1960s, the maintenance area at Hastings Park racecourse was located adjacent to the west portion of the track (approximately 400 m northwest of the Site). Since the late 1960s, the maintenance area had been located to the northeast of the track (approximately 150 m northwest of the Site). During the 2017 Site reconnaissance, the existing gasoline UST and diesel AST were observed in the Hastings Park racecourse maintenance area, approximately 150 m northwest of Site. The location of the off-Site UST is shown on Figure 3.

Conclusion

In 1996, there was considered to be a potential for contaminants of concern associated with Playland rides, specifically the Coaster rollercoaster, to be present in the Site soil and groundwater. Further investigation was considered warranted.

3.3.8.2 2001 Stage 2 PSI

The 2001 Stage 2 PSI was conducted for the existing PNE amphitheatre (Phase 2) and the former Renfrew Creek area (Phases 3A and portions of 3B). Pertinent information is summarized as follows:

- The areas investigated included the former PNE works yard, the gasoline UST, and the former creek (Renfrew Creek).
- Six boreholes were advanced to a maximum borehole depth of 7.6 metres below grade (mbg), as follows:
  - Three of the six boreholes, one of which was completed as a monitoring well, were advanced to investigate the former PNE maintenance area (MW01-2, BH01-3, and BH01-4). MW01-2 was located down-gradient of the maintenance area and BH01-3 and BH01-4 were located within the former maintenance area.
  - Two of the six boreholes, one of which was completed as a monitoring well (MW01-1 and BH01-2) were advanced to investigate fill in the former creek area on Phases 3A and 3B.

  - One borehole (BH01-1) was advanced to investigate the former heating oil UST at the former display barns on Phase 3A.
- At MW01-1 (former creek area), groundwater was 4.04 mbg and at MW01-2 (former maintenance yard), groundwater was encountered at approximately 1.1 mbg and it was anticipated that seasonal perched aquifers may be present in the area.
- Various fill units (comprised of sand, gravel, clay and/or wood) were observed within the vicinity of the former creek to a depth of approximately 6.1 mbg. Native silt with gravel was identified below the fill units.
- Six soil samples were submitted for light extractable petroleum hydrocarbons (LEPH), heavy extractable petroleum hydrocarbons (HEPH), polycyclic aromatic hydrocarbons (PAH), volatile organic compounds (VOC), and metals. The concentrations of LEPH, HEPH, PAH, VOC and metals in soil were less than the laboratory detection limit and/or the current CSR PL, RL_{LD}, and CL standards.
- Two groundwater samples were analyzed for LEPH, HEPH, PAH, VOC, volatile petroleum hydrocarbons (VPH) and dissolved metals. The concentrations of LEPH, HEPH, PAH, VOC, and VPH in groundwater were less than the current CSR AW_{FW}, AW_M and DW standards.

3.3.8.3 2015 Geotechnical Report

A geotechnical and environmental investigation was conducted by Thurber Engineering Ltd. (Thurber) for the vicinity of the former Renfrew Creek as part of the Hastings Park / PNE Master Plan in 2015. Six test holes were advanced on the Site (TH15-01 to TH15-06), as shown on Figure 2. Pertinent information from the report is summarized as follows:

On-Site – Phase 3B

- At Phase 3B, to the west of the amphitheatre, fill was identified at TH15-01 and TH15-03 to the depth of the test pit (3.0 mbg). At TH15-02 fill was identified to approximately 1.5 mbg and was underlain by sand and gravel. The observed fill was primarily comprised of sand with some silt and brick fragments and trace organics. Groundwater was encountered at approximately 2.1 mbg at TH15-02.
- Three soil samples were collected by Thurber for LEPH, HEPH, PAH and metals analysis and the concentrations of LEPH, HEPH, PAH and metals in soil were less than the current CSR PL, RL_{LD}, and CL standards.

On-Site – Phase 4A

- At TH15-04 (central portion of Phase 4A), fill was not encountered. The depth of the test pit was 1.7 mbg and groundwater was not encountered.
- One soil sample was collected by Thurber for LEPH, HEPH, PAH and metals analysis and the concentrations of LEPH, HEPH, PAH and metals in soil were less than the current CSR PL, RL_{LD}, and CL standards.

Off-Site

- At TH15-05 and TH15-06 (off-Site to the northwest of Phase 4A), fill was not encountered at either test hole. The depth of the test pits were 2.7 and 2.9 mbg, respectively; and groundwater was not encountered at either test hole.
- Two soil samples were collected by Thurber for LEPH, HEPH, PAH and metals analysis and the concentrations of LEPH, HEPH, PAH and metals in soil were less than the current CSR PL, RL_{LD}, and CL standards.

3.3.9 Other Documents

In 1982, a photographic history of the PNE was prepared by the University of British Columbia Press, titled as follows:

- *The Pacific National Exhibition – An Illustrated History*, By David Breen and Kenneth Coates, University of British Columbia Press, 1982.

The book indicates that starting in the 1970s, daily demolition derbies were held in the Outdoor Bowl (located on Phase 3B of the Site). A photograph shows that the demolition derby was conducted over unpaved ground surface within the Outdoor Bowl.

3.4 Site Reconnaissance

Personnel from Keystone Environmental visited the Site on July 26, 2017, August 2, 2017, and November 14, 2018. The purpose of the visits in 2017 was to observe operations and conditions primarily at Phases 1A and 4A of the Site as well as neighbouring properties to determine the potential for contamination at the Site and to prepare photographic documentation. In 2018, the Site was re-visited to update Site conditions at Phases 1A and 4A and to observe Site conditions Phases 2, 3A, and 3B.

During the Site visits, the Site was occupied as follows:

- Phase 1A was occupied by the central and east portions of Playland amusement park
- Phase 2 was occupied by the existing PNE Amphitheatre
- Portion of Phase 3A was occupied by a paved parking area
- Phase 3B was occupied by a paved parking area and vegetated areas associated with Sanctuary Pond
- Phase 4A was occupied by barns associated with Hastings Park racecourse and a paved parking lot (Parking Lot 9)

Representative photographs taken during the Site reconnaissance are included in Appendix A.

3.4.1 July and August 2017

Keystone Environmental visited the Site on July 26, 2017, accompanied by Ms. Suzanne Rice, Assistant Manager of Tech Services (Playland); Ms. Devon Brownlee, Project Coordinator (Hastings Park/PNE Master Plan); and Mr. John Brodie, Project Manager (Hastings Park/PNE Master Plan); and on August 2, 2017, accompanied by Mr. Darren MacDonald, General Manager (Hastings Racecourse), Ms. Brownlee and Mr. Brodie.

The Site grounds were viewed. Structures and fencing associated with Playland limited observations of underlying areas on the Site grounds. The area located beneath the Corkscrew ride could not be entered due to the ride being in operation. The following was observed on the Site by Keystone Environmental or was reported by Ms. Rice:

- Approximately 15% of the Site was occupied by buildings, approximately 10% of the Site was landscaped or vegetated, and approximately 75% of Site was occupied by paved parking areas and walkways.
- The Site was generally located below grade of properties to the south of the Site and above the grade of properties located to the north of the Site. This was relatively consistent with the topography in the vicinity of the Site sloping down towards the north.
- Storm drains were observed throughout the Site. Site drainage was by runoff to storm drains and adjacent properties, and by infiltration to unpaved areas. It was reported by Ms. Rice that oil/water separators were not located on the Site.
- With the exception of the unknown vent pipe observed at Hastings Park described below (Section 3.4.1.2), vent pipes and/or fill ports, consistent with USTs, were not observed on the grounds of Site.
- With the exception of the waste oil storage area described below (Section 3.4.1.1), former ASTs and/or concrete pads or mounting brackets, consistent with former ASTs were not observed on the grounds of the Site.
- Groundwater monitoring wells and/or drinking water wells were not observed on the Site.
- Cooking oil was stored in metals bins at two locations: adjacent to the east of the concessions on the east portion of Playland (between the concessions and the Coast rollercoaster) and to the south of the restaurant (Triple O's) located on the south portion of Playland. The storage bins were located over pavement and staining was observed on the pavement in vicinity of the metal bins at both locations.

3.4.1.1 Phase 1A – Existing Playland Footprint

Phase 1A was occupied by the central and east portions Playland amusement park. The following was observed:

Northeast Portion

- A workshop was located in the northeast portion of Phase 1A. Workbenches and hand tools were observed in the workshop. Bulk quantities of contaminants of concern were not observed in the workshop. The workshop had wood floors and Ms. Rice indicated that the building was partially located above a gravel crawlspace and partially located on pavement. Staining was not observed on the wood floor of the workshop.

- A covered oil storage area was located on the northeast portion of Phase 1A. The oil storage area was covered (semi-enclosed) and was located over pavement observed to be in good condition (major cracks were not observed); however, a storm drain was observed approximately 5 m from the storage area. The following was observed:
  - An approximately 1,350 L AST of waste hydraulic oil stored over secondary containment. Heavy staining was observed in the secondary containment and minor staining was observed on the paved ground surface in the vicinity of the secondary containment.
  - Approximately 10 drums containing waste oil, used oil filters/rags, and empty oil containers; and approximately ten 20 L pails of waste oil were stored in the oil storage area (secondary containment was not observed). Staining and/or overspill were not observed in the vicinity of the stored items and the pavement was observed to be in good condition (major cracks and/or drains were not observed).
  - A self-contained sand blasting unit was stored in the oil storage area. It was reported by Ms. Rice that the blaster was not in use and evidence of sand blasting grit was not observed in the vicinity of the blasting unit.
  - A parts washer was stored in the oil storage area. It was reported by Ms. Rice that the parts washer was not in use and evidence of solvent storage was not observed in the vicinity of the parts washer.
  - Safety cabinets for flammables were located in the oil storage area. Two cabinets were used to store jerry cans of diesel and gasoline fuel. It was reported by Ms. Rice that the jerry cans were transported off-Site and were filled at commercial gas stations. Re-fuelling activities do not occur on the Site. Staining was not observed in the vicinity of the safety cabinets.
- A shipping container located adjacent to the south of the oil storage area was used for paint and solvent storage. Multiple spray cans and pails of paint and approximately 4 one-gallon (3.78 L) tins of paint thinner were stored in the container. Paint was applied manually as required using brushes and rollers. Spray guns and/or paint booths were not located on the Site. Bulk quantities of waste paint and/or solvents were not produced on the Site. Staining was not observed on the pavement outside of the shipping container.
- A welding shop was located to the south of the maintenance building on the northeast portion of Phase 1A. Welding was primarily conducted indoors over concrete; however, sometimes welding was done on the grounds of the Site as required. With the exception of rust staining; the concrete in the welding shop was in good condition; major cracks and/or floor drains were not observed. Compressed gasses and a scrap metal bin were stored adjacent to the welding shop.
- A lifts and a zoom boom were observed in the area. It was reported by Ms. Rice that the machinery was primarily fuelled with propane; however some require gas and/or diesel (stored in the jerry cans within the oil storage area).

East Portion

- The Coaster rollercoaster located on the east portion of Phase 1A was primarily located over an unpaved ground surface. The following was observed in association with the Coaster:
  - The Coaster uses a chain lift powered by an electric powered motor. The chain lift was located beneath the southwest portion of the rollercoaster and the chain sits in a wooden trough. The chain was greased with oil stored in an approximately 20 L drum (located near the base of the incline) which drips the oil onto the chain. Staining was observed on the unpaved ground surface in the vicinity of the oil drum and the chain lift.
  - The electric motor was located in a wood-floored shed on the southwest portion of the Coaster. Staining was observed on the wood floor in the vicinity of the motor and it was anticipated that the ground surface beneath the wood floor was unpaved.
  - The rollercoaster track was lubricated with diesel which was applied directly to the track from the rollercoaster train. Similar to the 1996 observations (Section 3.7), select trains have approximately 50 L capacity diesel tanks attached to the front of the train which then drip diesel directly onto the track as the train travels. The diesel was transferred to the tanks with jerry cans stored in the oil storage area (discussed above). Diesel was applied to the tracks approximately four to five times at the start of the season (typically in April or May) and sometimes again in the fall depending on the amount of precipitation received.
- A sign shop was located on the east portion of Phase 1A. The sign shop was not viewed, and it was reported by Ms. Rice that it was used to store signs used throughout the Site. Manufacturing activities were not conducted in the shop.
- A carpentry shop was located on the east portion of Phase 1A. Activities conducted in the carpentry shop included the cutting lumber. The shop had mixed concrete and wood floors and it was unknown if pavement was located beneath the wood portions of the floor. It was reported by Ms. Rice that the saw blades were transported off-Site to be sharpened by an external contractor.
- A machine shop was located on the east portion of Phase 1A. The shop had concrete floors observed to be in good condition (major cracks and/or floor drains were not observed). Small quantities of various greases and lubricants (less than 20 L capacity) were observed to be stored within the machine shop. Staining was not observed on the concrete floor of the machine shop.

Northwest Portion

- The ‘lower line’ workshop was located on the northwest portion of Phase 1A. During special events in August and October (The Fair at the PNE and Fright Nights), the workshop was limited to the north portion of the building and the south portion was occupied by a restaurant and mid-way games. For the remainder of the year, the workshop occupies the extent of the building.
- The concrete floor of the building was observed to be in good condition (major cracks and/or floor drains were not observed).

3.4.1.2 Phase 4A – Future Playland Expansion

The central and east portions of Phase 4A were occupied by a paved parking lot (Parking Lot 9) and the west portion was occupied by horse barns associated with the Hastings Park racecourse. The following was observed:

Paved Parking Area (Central and East Portions)

- A berm was located along the north and east perimeter of Phase 4A (approximately 4,500 m^2 in area. It was reported to Ms. Brownlee from an employee of City of Vancouver Parks Board that the source of the material was from the excavation of Empire Field which was a mix of native material and imported fill from an unknown source. The location of the berm is shown on Figure 2.
- A partially covered stockpile (approximately 500 m^2 in area) was located on the west portion of Phase 4A. It was reported by Ms. Brownlee that the source of the material was ground cover (mixed soil and hay) from the Agrodome and the farm buildings located on the PNE grounds. The material was transported from the Site to the farm buildings as required. The stockpile was located over pavement which appeared to be in relatively good condition (observations were limited by the stockpile). The location of the Agrodome stockpile is shown on Figure 2.
- A covered stockpile (approximately 100 m^2 in area) was located on the southeast portion of Phase 4A. It was reported by Ms. Brownlee that the source of the material was ground cover (soil) from the Monster Truck show located on the PNE grounds. The same soil was used repeatedly for events and has been impacted by oil, grease and fuel from demolished vehicles. The stockpile was covered with a liner and it was unknown if the soils beneath the liner were stained. The stockpile was located over pavement which appeared to be in relatively good condition (observations were limited by the stockpile). A vegetated (unpaved) area was located approximately 1 m south of the stockpile. The location of the Monster Truck stockpile is shown on Figure 2.
- Steel bins containing horse manure (from Hastings Park) were located over unpaved surfaces on the northeast portion of Phase 4A. The manure was placed in the bins prior to removal from the Site. The location of the manure storage bins is shown on Figure 2.
- A fenced storage area was located on the west portion of Phase 4A. The fenced area was viewed from the fence line and the area was not entered during the Site reconnaissance. The storage area was used by Playland to store merchandised, themed attraction items, extra rides and maintenance trailers. Seasonally, food, washroom, and games trailers may also be stored in the area. The ground surface of the storage area was paved and staining was not observed on the observable portions of the ground surface.
- With the exception of drips typical of parking areas, staining was not observed on the grounds of Phase 4A.

Hastings Park Racecourse (West Portion)

- The west portion of Phase 4A was occupied by horse barns associated with Hastings Park. The interior of the horse barns were unpaved and the hay was replaced as required (used hay from the floor of the barns was transported to the bins located on the northeast portion of the on-Site paved parking area).
- The barns were connected to electricity for lighting and were not heated.
- Propane powered hot water tanks were located through-out the barns. A laundry facility located approximately 10 m west of the Site utilizes natural gas fired boilers.
- A potential vent pipe was observed adjacent to the east wall of a horse barn. A circular metal plate was located in pavement adjacent to the pipe. It was unknown what the pipe was associated with. Mr. MacDonald was unaware of the purpose of the pipe.
- Pole mounted transformers were located throughout the area; however, staining was not observed on the poles or on the ground surface beneath the poles.
- Three pole transformers were stored on pallets (at ground level) over pavement approximately 10 m northwest of Phase 4A. Staining was not observed on the ground surface in the vicinity of the transformers.

3.4.2 November 2018

Keystone Environmental visited the Site on November 14, 2018, accompanied by Mr. John Brodie, Project Manager (Hastings Park/PNE Master Plan and by Ms. Suzanne Rice, Assistant Manager of Tech Services (Playland) for the Playland portion of the Site visit.

The purpose of the 2018 Site visit was to observe conditions at Phases 2, 3A, and 3B and to confirm that significant changes had not occurred to Phases 1A or 4B since the 2017 Site reconnaissance was conducted.

The grounds of the Site were viewed. Structures and fencing associated with Playland limited observations of underlying areas on the Site grounds. The following was observed on the Site by Keystone Environmental or was reported by Mr. Brodie or Ms. Riced during the Site reconnaissance:

3.4.2.1 Phases 1A and 4A

During the 2018 Site visit, Phases 1A and 4A were viewed and significant changes to operations were not observed since the 2017 Site reconnaissance was conducted.

3.4.2.2 Phase 2

- The Phase 2 portion of the Site was occupied by the existing PNE Amphitheatre. The area was vacant and paved.

- The area was below the grade of the Playland portion of the Site located adjacent to the southeast of the amphitheater and approximately at grade with the areas to the north and west of the amphitheatre.
- Monitoring well MW01-2 was not observed in the amphitheatre and evidence of the diesel UST associated with the former works yard was not observed.
- Activities of potential environmental concern were not observed on the Phase 2 portion of the Site.

3.4.2.3 Portion of Phase 3A

- Portion of Phase 3A was occupied by a paved parking area.
- Evidence of the heating oil UST that was associated with the former barns was not observed.
- Activities of potential environmental concern were not observed on the Phase 3A portion of the Site.

3.4.2.4 Phase 3B

- Phase 3B was occupied by a paved parking area and vegetated areas associated with Sanctuary Pond
- Monitoring well MW01-01 was not observed in the paved parking area.
- Activities of potential environmental concern were not observed on the Phase 3B portion of the Site.

3.5 Special Attention Substances

Based on the age of the structures located on the east portion of Playland (constructed in the 1950s) and on the southeast portion of Hastings Park (constructed in the 1940s), the potential for special attention substances such as asbestos, PCBs, and/or UFFI, to be present, is discussed as follows:

- There is a potential for asbestos (phased out in North America by the mid-1980s) to be present in building materials in the main mall structure such as wallboard/gyproc, ceiling tiles, built-up roof systems, piping insulation, cement products, grouts, plaster, compressed papers and boards, duct tape, floor tiles, sealants, and protective coatings.
- There is a potential for current-regulating ballasts, transformers, and capacitors manufactured prior to 1980, that may potentially contain PCB, to be present on the Site.
- There is a potential for UFFI to be present on the Site since the majority was installed in new and existing structures in Canada between 1975 and 1978.

The presence of such special attention substances have not been confirmed in the Site structures and where the potential has been identified, the further reduction of uncertainty requires the performance of a Hazardous Materials building survey. Where building materials may or do contain asbestos containing materials, WorkSafeBC stipulates requirements for their management during maintenance, renovation or demolition.

3.6 Current Use – Adjacent Properties

The following was observed on adjacent properties during the 2017 and 2018 Site visits.

Off-Site Portions of Playland (located west of Phase 1A)

The following was observed to the west of Phase 1A:

- A shipping container located to the south of the Flume ride (approximately 65 m southwest of the Site) was used to store various types of oils and lubricants, and a mobile oil change machine. The oils and lubricants were stored in approximately 20 L pails (drums and/or ASTs were not observed). Drains and/or staining were not observed on the plywood flooring inside the shipping container, or on the paved ground surface outside of the shipping container.
- A waste and recycling storage area was located to the west of the Flume ride (approximately 80 m southwest of the Site). Empty oil pails, jerry cans, propane canisters, scrap metal, refuse, green-waste, and other materials were stored in the area. The grounds surface in the vicinity of the stored materials was pavement observed to be in good condition. Staining was not observed in the vicinity of the stored materials.
- A storage area was located adjacent to the west of the Site beneath a concrete slab. Fencing, space compressors, ride components, decorations, and building materials were observed to be stored in the area over partially unpaved surfaces. Bulk quantities of contaminants of concern were not observed to be stored in the area and staining was not observed on the ground surface in the vicinity of the stored items.

Off-Site Portions of Hastings Park Racecourse (located west of Phase 4A)

- Maintenance and repairs of the racecourse equipment was conducted in an area located approximately 150 m northwest of the Site. In the maintenance area, a gasoline UST (not in use), diesel AST, oil/water separator, and various workshops were observed. In 2017 staining was not observed on the unpaved ground surface in the vicinity of the gasoline pump station and the diesel AST.

Remaining Off-Site Portions of 2901 East Hastings Street

- The area to the west of Portion of Phase 3A and 3B was occupied by a barn associated with the PNE and the remaining portions of Sanctuary Park. Operations or activities of potential environmental concern were not identified in the area.
- Empire sports fields and a children's play park were located to the east of Playland. Operations or activities of potential environmental concern were not identified in the area.

Portions surrounding the Site and 2901 East Hastings Street

- The properties located to the south of the Site) were occupied by a community park and a community centre (across East Hastings Street) and single family residences (across East Pender Street).
- Off-Site operations of potential environmental concern were not identified within the vicinity of the Site.

3.7 Interviews

An interview was conducted on July 26, 2017, with Ms. Suzanne Rice, Assistant Manager of Tech Services (Playland). She reported the following:

- The workshop located in the northeast portion of the Phase 1A was partially located above an unpaved gravel crawlspace and partially located on pavement.
- Jerry cans were transported off-Site and were filled at commercial gas stations. Refuelling activities do not occur on the Site. Staining was not observed in the vicinity of the safety cabinets.
- Paint was applied manually as required using brushes and rollers. Spray guns and/or paint booths were not located on the Site. Bulk quantities of waste paint and/or solvents were not produced on the Site.
- The sand blaster was not in use and evidence of sand blasting grit was not observed in the vicinity of the blasting unit.
- The parts washer was not in use and evidence of solvent storage was not observed in the vicinity of the parts washer.
- Welding was primarily conducted indoors over concrete; however, sometimes welding was conducted on the grounds of the Site as required.
- The machinery (forklifts, carts, and zoom-booms) were primarily fuelled with propane; however some require gas and/or diesel (stored in the jerry cans within the oil storage area).
- Most rides have hydraulic fluid storage tanks; however, the rides do not contain in-ground hydraulic components and hydraulic fluid was stored above ground.
- With the exception of the Coaster and Corkscrew rollercoasters (and the off-Site Flume ride), the remaining rides on the Site were located over pavement and/or have concrete foundations.
- The Coaster uses a chain lift powered by an electric-powered motor. The chain was greased with oil stored in an approximately 20 L drum (located near the base of the incline) which drips the oil onto the chain.
- Select rollercoaster trains have diesel tanks attached to the front of the train which then drip diesel directly onto the track as the train travels. The diesel was transferred to the tanks with jerry cans stored in the oil storage area approximately four to five times at the start of the season (typically in April or May) and sometimes again in the fall depending on the amount of precipitation received.

- The sign shop was used to store signs used throughout the Site. Manufacturing activities were not conducted in the shop.
- Saw blades from the carpentry shop were transported off-Site to be sharpened by an external contractor.
- During special events in August and October (The Fair at the PNE and Fright Nights), the lower-line workshop was limited to the north portion of the building and the south portion was occupied by a restaurant and mid-way games. For the remainder of the year, the workshop occupies the extent of the building.
- With the exception of the area viewed during the Site reconnaissance and described in Section 4.1.1, bulk quantities of contaminants of concern were not stored on the remaining portions of Playland.

An interview was conducted on August 2, 2017, with Mr. Darren MacDonald, General Manager (Hastings Racecourse). He reported the following:

- The interior of the horse barns were unpaved and the hay was replaced as required (used hay from the floor of the barns was transported to the bins located on the northeast portion of the on-Site paved parking area).
- The barns were connected to electricity for lighting and were not heated.
- Propane-powered hot water tanks were located through-out the barns.
- Mr. MacDonald was unaware of what the cut-off pipe (observed adjacent to the east wall of a horse barn) was associated with.

An interview was conducted on August 2, 2017, with Ms. Devon Brownlee, Project Coordinator (Hastings Park-PNE Master Plan). She reported the following:

- It was reported to Ms. Brownlee from an employee of City of Vancouver Parks Board that the source of the material used to create the berm on the northeast perimeter of Phase 4A was from the excavation of Empire Field. The soils from Empire Field were a mix of native material and imported fill from an unknown source.
- The covered stockpile (approximately 500 m^2 in area) located on the west portion of the paved parking lot (Phase 4A) was ground cover (mixed soil and hay) from the Agrodome and the farm buildings located on the PNE grounds. The material was transported from the Site to the farm buildings as required. The stockpile was located over pavement which appeared to be in relatively good condition (observations were limited by the stockpile).
- The covered stockpile (approximately 100 m^2 in area) located on the southeast portion of the paved parking lot (Phase 4A) was ground cover (soil) from the Monster Truck show located on the PNE grounds. The same soil was used repeatedly for events and has been impacted by oil, grease and fuel from demolished vehicles. The stockpile was covered with a liner and it was unknown if the soils beneath the liner were stained. The stockpile was located over pavement which appeared to be in relatively good condition (observations were limited by the stock.

An interview was conducted on August 10, 2017, with Mr. Shawn Joinson, Manager of Tech Services (Playland). He reported that the sand blaster and parts washer that were located in the oil storage area (on the northeast portion of Phase 1A) were formerly used and stored in a shipping container that was located in the same area. Used blasting grit was removed from the Site by an external contractor.

Interviews were conducted on November 14, 2018 and December 18, 2018 with Ms. Suzanne Rice, Assistant Manager of Tech Services (Playland). She reported the following:

- Significant changes to Playland operations had not occurred since the 2017 Phase I ESA was conducted.
- Welding activities are conducted daily in the welding shop and there is one full time and one part time welder on staff.
- There is one full time machinist; however, machining activities are not conducted on a daily basis.

3.8 Summary and Discussion

This Stage 1 PSI was prepared at the request of City of Vancouver for Phase 1A (Existing Playland Footprint), Phase 2 – PNE Amphitheatre, Portion of Phase 3A – Festival Heart of the Park, Phase 3B – Creek Daylighting South and Phase 4A (Future Playland Expansion), located on a portion of 2901 East Hastings Street in the City of Vancouver, BC.

The area of the Site is approximately 141,000 m^2. The Site location is shown on Figure 1, and photographs of the Site are included in Appendix A.

The Site is comprised of five main sections as follows:

- **Phase 1A – Existing Playland Footprint** which is occupied by the central and east portions of Playland amusement park (approximately 53,300 m^2 in area).
- **Phase 2 – PNE Amphitheatre** which is occupied by the existing PNE Amphitheatre (approximately 9,725 m^2 in area).
- Portion of **Phase 3A – Festival Heart of the Park** which is currently occupied by a paved parking area (approximately 6,100 m^2 in area).
- **Phase 3B – Creek Daylighting South** which is currently occupied by a paved parking area and vegetated areas associated with Sanctuary Pond (approximately 15,025 m^2 in area).
- **Phase 4A – Future Playland Expansion** which is currently occupied by barns associated with Hastings Park racecourse and a paved parking lot (approximately 56,850 m^2 in area).

3.8.1 On-Site Summary

The history of the Site is as follows:

Phase 1A – Existing Playland Footprint

Historical records indicate that from the 1920s, or earlier, to the 1940s, the south portion of the Site (Phase 1A) was vegetated or occupied by the Municipal Golf Course. In the 1950s, the area was used as parking lot associated with the adjacent former Empire Stadium. In the late 1950s, an amusement park was constructed on the property (including the Coaster rollercoaster). The area has remained occupied by an amusement park since the late 1950s.

Phase 2 – PNE Amphitheatre

Prior the early 1960s, a former PNE maintenance area/works yard was located in the existing amphitheatre. The 1996 Phase I ESA indicated that a former paint shop, automotive/machinery repair facility, carpentry shop, and a garden maintenance/greenhouse were located in the area. In addition, a gasoline UST was located on the west perimeter of this portion of the Site. In the 1960s, the works yard was moved to the northwest portion of the PNE property (greater than 400 m northwest of the Site) and subsequently the buildings were demolished and the area was paved. It is unknown if the UST was removed at that time. Since the 1970s, the area has been occupied by an amphitheatre which has been periodically used for lumber jack shows (Outdoor Logger Theatre) and demolition derbies associated with the PNE.

Portion of Phase 3A – Festival Heart of the Park

Historical records indicate that this portion of Phase 3A was vacant and vegetated in the 1930s and was occupied by portions of display barns (poultry swine and sheep) from the 1940s to the 1990s. Since the early 2000s, the area has been vacant and paved for parking.

Phase 3B – Creek Daylighting South

Historical records indicate that the north portion of Phase 3B was vacant and vegetated in the 1930s. From the 1940s to the 1990s, the northwest portion of Phase 3B was occupied by portions of display barns (poultry swine and sheep) and the northeast portion of Phase 3B remained vacant. Since the early 2000s, the north portion has been vacant and paved for parking with the exception of a small portion of landscaping.

The south portion of Phase 3B was vacant and vegetated (potentially associated with a golf course) from the 1920s to the 1940s. From the 1950s to the 1990s, the Outdoor Bowl was located on the southwest portion of Phase 3B and by the early 2000s, the area was converted to the existing pond and green space.

Phase 4A – Future Playland Expansion

Historical records indicate that from the 1920s, or earlier, to the 1930s, the north portion of the Site (Phase 4A) was vacant and vegetated. Since the 1940s, horse barns have existed on the west portion of the area (associated with Hastings Park racecourse) and the central and east portions of the area have remained primary used for parking (Parking Lot 9).

3.8.1.1 Areas of Potential Environment Concern (APECs)

The following on-Site APECs were identified for the Site:

- APEC 1 – On-Site imported gravel, historical staining, former paint storage and historical storage at Corkscrew rollercoaster (Phase 1A)
- APEC 2 – On-Site chain lift, motor shed, and track lubrication at Coaster rollercoaster (Phase 1A)
- APEC 3 – On-Site oil storage area and workshop (Phase 1A)
- APEC 4 – On-Site fill material
- APEC 5 – On-Site unknown vent pipe at Hastings Park (Phase 4A)
- APEC 6 – On-Site hydrocarbon-impacted soil stockpile (Phase 4A)
- APEC 7 – Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)
- APEC 8 – Former potential heating oil UST located at former Display Barns (Phase 3A)
- APEC 9 – Former demolition derby activities at the former Outdoor Bowl (Phase 3B)

The location of the on-Site APECs are shown on Figure 4. Details of the on-Site APECs are discussed as follows:

APEC 1 – Imported gravel, historical staining, former paint storage and historical storage at Corkscrew rollercoaster (Phase 1A)

Aerial photographs show that in 1980s and early 1990s, a former storage area and anticipated former maintenance building were located over unpaved surfaces on the northeast portion of Phase 1A prior to the construction of the existing Corkscrew rollercoaster in 1994. Details of the historical activities conducted in this area are unknown. Aerial photograph observations show that unknown objects were stored outdoors over unpaved surfaces in the vicinity of the anticipated former maintenance building.

During the 1996 Phase I ESA Site reconnaissance, two paint sheds (for new and waste paint), a paint booth, and a sign shop were observed to the north of the Corkscrew rollercoaster. Two 205 L drums and multiple small capacity containers (less than 20 L) of waste paint were stored in the waste paint shed and paint staining was observed on the concrete floor of the shed. Multiple 4 L and 20 L capacity containers of acrylic, latex, and metal paints, primers, and solvents were observed in the new paint shed. Small quantities of paint and solvents (capacity not provided) were observed in the sign shop. Paint staining was observed on the floor and the metal grate located on the floor of the paint booth. It is unknown what was located beneath the metal grate in the paint booth.

During the 1996 Phase I ESA, staining (approximately 10 m^2 in area) was observed beneath the ride over unpaved surfaces and it was reported by Mr. Vance Shaw (Playland Maintenance Department) that the staining came from a spill which occurred when the hydraulic hoses were

changed. Mr. Shaw also reported that oily gravel from beneath another ride in Playland was transported to the vicinity of the Corkscrew when it was constructed[5]. Currently, staining was not observed on the unpaved ground surface during the Site reconnaissance.

Based on the unknown details of the former maintenance building and storage area, the volumes of paints and solvents that were stored in the area, the unknown details of how the paints were applied and clean-up, the oily gravel that was historically imported to the area, and the observed staining in 1996, there is a potential for contaminants of concern to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards in the vicinity of the Corkscrew rollercoaster.

APEC 2 – Chain lift, motor shed, and track lubrication at Coaster rollercoaster (Phase 1A)

The Coaster rollercoaster has been located on the east portion of Phase 1A since circa 1958 and is primarily located over unpaved ground surface. The Coaster uses a chain lift powered by an electric powered motor. The chain lift is located beneath the southwest portion of the rollercoaster and the chain sits in a wooden trough. The chain is lubricated with oil stored in an approximately 20 L drum (located near the base of the incline) which drips the oil onto the chain. Staining was observed on the unpaved ground surface in the vicinity of the oil drum and the chain lift. The electric motor is located in a wood-floored shed on the southwest portion of the Coaster. Staining was observed on the wood floor in the vicinity of the motor and it is anticipated that the ground surface beneath the wood floor is unpaved. The rollercoaster track is lubricated with diesel which is applied directly to the track from the rollercoaster train. Select trains have approximately 50 L capacity diesel tanks attached to the front of the train which then drip diesel directly onto the track as the train travels. The diesel is transferred to the train tanks with jerry cans stored in the oil storage area (discussed further below in APEC 3). Diesel is applied to the tracks approximately four to five times at the start of the season (typically in April or May) and sometimes again in the fall depending on the amount of precipitation received.

During the 1996 Phase I ESA, staining was observed beneath most of the Coaster tracks and an area of heavy staining (approximately 20 m^2 in area) was observed beneath the main gear box. It was reported by Mr. Ken Herbert (PNE Maintenance Department) in 1996, that two 205 L drums of hydrocarbon contaminated soils were excavated from the area circa 1995. It was not indicated if confirmatory samples were collected once the hydrocarbon contaminated soils were removed.

Based on the length of time since that the Coaster has been present (approximately 60 years), the application of diesel and chain oil over unpaved surfaces, and the historical staining that was observed, there is considered to be a potential for contaminants of concern associated with the Coaster rollercoaster to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

[5] Mr. Shaw reported that the ride from which the oily gravel was transported from had pavement located beneath the oily gravel.

APEC 3 – Oil storage area and workshop (Phase 1A)

A workshop was located in the northeast portion of Phase 1A since potentially the late 1950s[6]. The workshop has wood floors and Ms. Rice indicated that the building was partially located above a gravel crawlspace and partially located on pavement. Currently, bulk quantities of contaminants of concern were not observed to be stored in the maintenance area; however, during the 1996 Site reconnaissance, the workshop was observed to be used for machining, lubrication, and fibreglass application. In 1996, motor oil, grease, lubricants, transmission fluids and solvents were observed to be stored in a secure storage compartment and hydrocarbon staining was observed on the wood floor of the workshop.

Since the mid-1990s, or earlier, a covered (semi-enclosed) oil storage area has been located approximately 5 m north of the workshop. The pavement in the storage shed was observed to be in good condition (major cracks were not observed); however, a storm drain was observed within approximately 5 m of the storage area. An approximately 1,350 L AST of waste hydraulic oil stored with secondary containment. Staining was observed in the secondary containment and minor staining was observed on the paved ground surface in the vicinity of the secondary containment. Staining was also reported in the area in 1996. Currently, ten drums containing waste oil, used oil filters/rags, and empty oil containers (secondary containment was not observed); approximately ten 20 L pails of waste oil (secondary containment was not observed); and self-contained sand blasting and parts washing units were observed in the area. It was reported by Ms. Rice that the sand blaster and parts washer and no longer in use and staining and/or overspill were not observed in the vicinity of the stored items. In addition, safety cabinets for flammables containing jerry cans of diesel and gasoline fuel were stored in the oil shed. It was reported by Ms. Rice that the jerry cans and transported off-Site and are filled at commercial gas stations. Re-fuelling activities do not occur on the Site and staining was not observed in the vicinity of the safety cabinets.

Based on the duration of the oil storage (greater than 20 years), there is considered to be a potential for contaminants of concern associated with the waste oil storage area to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

APEC 4 – On-Site fill material

A Vancouver Old Stream Map indicates that a former tributary to Renfrew Creek transected the north portion of Phase 4A (southeast to northwest) and the central portion of Phase 3A, as shown on Figure 2. The creeks were not observed in the 1930 aerial photographs; therefore, it is anticipated that they were filled prior to 1930. During previous investigations two boreholes, one of which was completed as a monitoring well (MW01-1 and BH01-2) were advanced to investigate fill in the former creek area on Phase 3A. Fill material comprised of sand, gravel, clay and/or wood was identified to depths greater than 6.1 mbg. Two soil samples were submitted for LEPH, HEPH, PAH, VOC, and metals and the results were less than the laboratory detection limit and/or the current CSR PL, RL_{LD}, and CL standards.

[6] The building was constructed in the late 1950s; however, it is unknown if it has been used as a workshop since it was constructed.

Although these concentrations were less than the current CSR standards, the sampling density did not meet the Ministry requirements of Technical Guidance 1 – Site Characterization and Confirmation Testing.

During the Site reconnaissance, a berm was observed along the north and east perimeter of Phase 4A (approximately 4,500 m^2 in area), as shown on Figure 2. It was reported to Ms. Brownlee from an employee of City of Vancouver Parks Board that the source of the material was from the excavation of Empire Field which was a mix of native material and imported fill from an unknown source.

Based on the presence the former creek located on Phases 3A and 4A, and the known imported fill in the berms located to the north and east of Phase 4A, there is considered to be a potential for contaminants of concern associated with fill material to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

APEC 5 – Unknown vent pipe at Hastings Park (Phase 4A)

It was reported in the 1996 Phase I ESA, that the PNE grounds have been serviced by natural gas since 1928. In the 1930 aerial photograph, the Site was vacant of structures; therefore, the existing structures on the Site were constructed after 1930. However, during the 2017 Site reconnaissance, a potential vent pipe was observed adjacent to the east wall of a horse barn and a circular metal plate was located in pavement adjacent to the pipe. Mr. MacDonald was unaware of what the pipe was associated with. The horse barns are currently not heated; however, they do have hot water tanks which are fuelled with propane. It is unknown how long the hot water tanks have been present or if a boiler may have been used previously. Therefore, there is a potential that the pipe may be associated with a heating oil UST.

APEC 6 – Hydrocarbon-impacted Soil Stockpile (Phase 4A)

Aerial photographs show that since circa 2015, a stockpile (approximately 100 m^2 in area) has been located on the southeast portion of the paved parking lot. In the 2015 air photograph, the stockpile appeared to be uncovered; however, currently the stockpile is covered with plastic. It was reported by Ms. Brownlee that the source of the material was ground cover (soil) from the Monster Truck show located on the PNE grounds. The same soil is used repeatedly for events and has been impacted by oil, grease and fuel from demolished vehicles. During the 2017 and 2018 Site visits, the stockpile was covered with plastic so it is unknown if the soils beneath the plastic were stained. The stockpile was located over pavement which appeared to be in relatively good condition (observations were limited by the stockpile); however, a vegetated (unpaved) area was located approximately 1 m south of the stockpile. Based on the stockpile being previously uncovered (circa 2015), the unknown quality of the soil, and that the condition of the pavement beneath the stockpile is unknown, there is a potential for contaminants of concern to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards in the stockpile itself and in the vicinity of the stockpile.

APEC 7 – Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)

Prior the early 1960s, a former PNE maintenance area/works yard was located in the existing amphitheatre (Phase 2). The 1996 Phase I ESA indicated that a former paint shop, automotive/machinery repair facility, carpentry shop, and a garden maintenance/greenhouse were located in the area. In addition, a gasoline UST was located on the west perimeter of Phase 2. In the 1960s, the works yard was moved to the northwest portion of the PNE property (greater than 400 m northwest of the Site) and subsequently the buildings were demolished and the area was paved. It is unknown if the UST was removed at that time. Since the 1970s, the area has been occupied by an amphitheatre which has been periodically used for lumber jack shows and demolition derbies associated with the PNE.

In 2001, a Stage 2 PSI was conducted in the area and three investigative locations MW01-2, BH01-3, and BH01-4 were advanced within the vicinity of the amphitheatre to investigate the former maintenance yard activities. From the three locations, soil concentrations of LEPH, HEPH, PAH, VOCs and metals were less than the laboratory detection limit and/or the current CSR PL, RL_{LD}, and CL standards. At MW01-2, concentrations of LEPH, HEPH, PAH, VOC, VPH and dissolved metals in groundwater were less than the current CSR AW_{FW}, AW_{M}, and DW standards. Although the 2001 concentrations were less than the current CSR standards, an investigation location was not advanced within the footprint of the former building, it is unknown if the UST was removed and the quality of the soil, groundwater or vapour within the vicinity of the UST is unknown. Therefore, there remains a potential for contaminants of concern associated with the former maintenance/works yard activities to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

APEC 8 – Former potential heating oil UST located at former Display Barns (Phase 3A)

The 1996 Phase I ESA indicated a UST vent pipe (suspected to be heating oil) was observed adjacent to the display barns formerly located on Phase 3A (west portion of the Site). In 2001, one borehole (BH01-1) was advanced to investigate the former heating oil UST. A soil sample was submitted for LEPH, HEPH, PAH, VOC, and metals and the results were less than the laboratory detection limit and/or the current CSR PL, RL_{LD}, and CL standards; however, vapour and/or groundwater were not previously investigated in the vicinity of the UST, therefore, further investigation is required.

APEC 9 – Former demolition derby activities at the former Outdoor Bowl (Phase 3B)

A photographic history of the PNE was prepared in 1982 by the University of British Columbia Press. The book indicates that starting in the 1970s daily demolition derbies were held in the Outdoor Bowl (located on Phase 3B of the Site). A photograph shows that the demolition derby was conducted over unpaved ground surface within the Outdoor Bowl. In addition, aerial photographs show that the ground surface within the bowl was unpaved prior to the late 1970s. The location of the former bowl is currently occupied by a portion of Sanctuary Pond. It is unknown if the area was excavated prior to construction of the pond; therefore, there is considered to be a potential for contaminants of concern associated with the former demolition derby activities to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

3.8.1.2 Areas of Low Potential Environmental Concern

Remaining rides located over paved surfaces on Phase 1A

The majority of the rides located on Phase 1A have hydraulic components. Hydraulic fluid is stored in 20 L to 400 L tanks which are mounted to the rides. Maintenance to the hydraulic components is generally conducted at the ride and minor staining was observed on the pavement beneath most the rides. With the exception of the existing Coaster and Corkscrew rollercoaster, the remaining rides located are located over pavement or concrete foundations. It was reported by Ms. Rice, that rides do not contain in-ground hydraulic components and hydraulic fluid is stored above ground. Based on the hydraulic fluid being stored above ground and that the rides are located over pavement and/or concrete, there is considered to be a low potential for contaminants of concern associated with the remaining rides to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

Various Playland Maintenance/Repair Shops (Phase 1A)

A welding shop was located on the northeast portion of Phase 1A. Welding activities were observed to be conducted over pavement. The pavement was observed to be in good condition and major cracks and/or floor drains were not observed. During the 1996, 2017, and 2018 Site visits, rust staining was observed on the pavement in the welding shop; however, based on the good condition of the pavement, there is considered to be a low potential for contaminants of concern associated with welding activities to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards

A sign shop was located on the east portion of Phase 1A. In 2017, it was reported by Ms. Rice that the sign shop was used to store signs and that manufacturing activities were not conducted in the shop. Based on the storage nature of the shop, there is considered to be a low potential for contaminants of concern associated with the sign shop to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

A carpentry shop was located on the east portion of Phase 1A. Activities conducted in the carpentry shop were primarily cutting lumber. The shop had mixed concrete and wood floors and it was unknown if pavement was located beneath the wood portions of the floor. In 2017, it was reported by Ms. Rice that the saw blades were transported off-Site to be sharpened by an external contractor and constituents of concern were not stored in the carpentry shop. Based on the nature of activities in the carpentry shop and that constituents of concern are not used, there is considered to be a low potential for contaminants of concern associated with the carpentry shop to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

A machine shop was located on the east portion of Phase 1A. The machine shop had concrete floors observed to be in good condition (major cracks and/or floor drains were not observed). Small quantities of various greases and lubricants (less than 20 L capacity) were observed to be stored within the machine shop; however, staining was not observed on the concrete floor of the

machine shop. Based on the good condition of the concrete floors and that bulk quantities of constituents of concern are not used in the shop, there is considered to be a low potential for contaminants of concern associated with the machine shop to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

A seasonal maintenance shop (lower line workshop) was located on the northwest portion of Phase 1A. Small quantities (approximately 20 L or less) of hydraulic fluid, oils, and solvents, and a self-contained parts washer, were observed in the workshop. The floors of the workshop were concrete observed to be in good condition (major cracks and/or floor drains were not observed) and minor staining was observed on the concrete floors. Based on the relatively small quantities of constituents of concern being used and that activities are conducted over concrete floors observed to be in good condition; there is considered to be a low potential for contaminants of concern associated with the lower line seasonal workshop to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

Heating oil – Phase 1A

It was reported in the 1996 Phase I ESA, that the PNE grounds have been serviced by natural gas since 1928. A former clubhouse/residence associated with the former Municipal Golf Course was located on the south portion of the Site from the late 1940s to the late 1950s. Based on the age of the building, it is anticipated that it was likely connected to natural gas. The remaining structures on the Site were constructed after 1930. Currently, the Site structures are heated with electricity or natural gas. During the Site reconnaissance, evidence of heating oil (such as vent and/or fill pipes) were not observed on Phase 1A. Therefore, there is considered to be a low potential for heating oil USTs to be located on Phase 1A.

Horse manure bins and Agrodome stockpile located over paved surfaces on Phase 4A

The 2015 aerial photograph shows that existing partially covered stockpile (approximately 500 m^2 in area) located on the west portion of the paved parking lot. It was reported by Ms. Brownlee that the source of the material was ground cover (mixed soil and hay) from the farm buildings located on the PNE grounds. The material is transported from the Site lot the farm buildings as required. The stockpile was located over pavement which appeared to be in relatively good condition (observations were limited by the stockpile). In addition, the 1996 aerial photographs show the existing steel storage bins located on the northeast portion of the parking lot. It was reported by Mr. MacDonald that the bins contain horse manure collected from Hastings Park racecourse. The manure is placed in the bins prior to removal from the Site. Given that the partially covered stockpile is located over pavement and that the steel storage bins are self-contained, there is considered to be a low potential for contaminants of concern associated with the animal manure to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable CSR standards.

3.8.2 Off-Site Summary

The history of the area surrounding the Site is summarized as follows:

- The area located to the north and east of Phase 4A was primarily residential from the 1930s, or earlier, to the 1950s. Since the 1960s, the area has been primarily occupied by roadways and highway interchanges.
- The area located to the east of Phase 1A, was vacant and vegetated from the 1930s, or earlier to the 1940s. From the early 1950s to the early 1990s, the former Empire Stadium occupied the area. In the late 1990s, the stadium was dismantled and the area has been primarily occupied by sports fields (Empire Fields) since the late 1990s.
- The properties located to the south of Phase 1A (across East Hastings Street) have been occupied by single family residences and/or community parks since the 1930s, or earlier.
- The area located to the west of Phase 3A was vacant and vegetated or potentially occupied by a golf course from the 1920s, or earlier, to the 1940s. Since the 1950s, the area has been occupied by display barns associated with the Pacific National Exhibition (PNE) grounds.
- The area located to the west of Phase 4A has been occupied by Hastings Park since the 1930s, or earlier.

As shown on Table 3, three off-Site areas were historically or currently occupied by activities of potential environmental concern. Based on their distance from the Site, the lack of observed staining, and/or the relatively short duration of stored materials, there is considered to be of low potential for contaminants of concern associated with the three off-Site properties to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the CSR standards. Further details of the off-Site areas are provided in Table 3.

3.9 Stage 1 PSI Conclusion

It is concluded that there is a potential for contaminants of concern associated with on and off-Site activities to be present in the Site soil, groundwater, and/or vapour at concentrations greater than the applicable BC CSR land and water use standards. Further investigation is warranted.

The APECs associated potential contaminants of concern (PCOCs) identified by the Stage 1 PSI are summarized in the following table and are shown on Figure 3.

Table 3-1 APECs and PCOCs

APECs	PCOCs		
	Soil	Groundwater	Vapour
APEC 1 On-Site imported gravel, historical staining, former paint storage and historical storage at Corkscrew roller coaster (Phase 1A)	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 2 On-Site chain lift, moto shed and track lubrication at Coaster rollercoaster (Phase 1A)	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 3 On-Site oil storage area and work shop (Phase 1A)	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 4 On-Site fill material	LEPH, HEPH, PAH and metals	LEPHw, PAH and dissolved metals	Naphthalene
APEC 5 On-Site unknown vent pipe at Hastings Park (Phase 4A)	GPR and EM Survey to confirm presence or absence of UST		
APEC 6 On-Site hydrocarbon-impacted stockpile (Phase 4A)	LEPH, HEPH, PAH, VPH and metals	LEPHw, PAH, VPHw and dissolved metals	Naphthalene, and VPHv
APEC 7 Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	NA[7]
APEC 8 Former potential heating oil UST[8] located at former Display Barns (Phase 3A)	LEPH, HEPH, PAH, and VPH	LEPHw, PAH and VPHw	Naphthalene and VPHv
APEC 9 Former demolition derby activities at the former Outdoor Bowl (Phase 3B)	LEPH, HEPH, PAH, VPH and metals	LEPHw, PAH, VPHw and dissolved metals	Naphthalene, and VPHv

[7] MW18-12 could not be installed with a soil vapour attachment due to the very shallow groundwater table.

[8] During the Stage 2 PSI field work the contents of this UST were unknown, and therefore the PCOCs at the time were LEPH, HEPH, PAH, VOC, VPH and metals. However, was later identified that the UST contained heating oil and the PCOCs were updated as indicated above.

4. STAGE 2 PRELIMINARY SITE INVESTIGATION

The Keystone Environmental Stage 2 PSI was conducted in November 2018. The purpose of the Stage 2 PSI was to investigate the APECs identified in the Stage 1 PSI. The Stage 1 PSI identified the following APECs:

- APEC 1 – On-Site imported gravel, historical staining, former paint storage and historical storage at Corkscrew rollercoaster (Phase 1A)
- APEC 2 – On-Site chain lift, motor shed, and track lubrication at Coaster rollercoaster (Phase 1A)
- APEC 3 – On-Site oil storage area and workshop (Phase 1A)
- APEC 4 – On-Site fill material
- APEC 5 – On-Site unknown vent pipe at Hastings Park (Phase 4A)
- APEC 6 – On-Site hydrocarbon-impacted soil stockpile (Phase 4A)
- APEC 7 – Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)
- APEC 8 – Former potential heating oil UST located at former Display Barns (Phase 3A)
- APEC 9 – Former demolition derby activities at the former Outdoor Bowl (Phase 3B)

4.1 Scope of Work

The scope of work and the investigative program for the Stage 2 PSI included the following tasks:

- Completing a BC One Call and obtaining utility locate information prior to the drilling programs.
- Performing electromagnetic (EM) and ground penetrating radar (GPR) surveys on the Site and off-Site areas to identify the potential presence of underground utilities.
- Perform a geophysical investigation (EM and GPR) of three areas to confirm presence or absence of USTs.
- Vacuum excavating boreholes with a hydrovacuum truck from Badger Daylighting (Badger) when underground utilities were identified within 2 m of proposed drilling locations during the GPR and EM survey or at locations where all utilities could not be accounted for.
- Drilling of seventeen boreholes (BH18-1, MW18-2, MW18-3, BH18-4, MW18-5, MW18-6, BH18-7, BH18-8, MW18-9 to MW18-12, BH18-13, MW18-14 to MW18-16 and BH18-17) completing eleven of them as monitoring wells with vapour attachments (except for MW18-12 which did not have a vapour attachment[9]) with Southland Drilling Co. Ltd. (Southland) in November 2018. Locations BH18-1 and BH18-4 were advanced with a hand auger by Keystone Environmental due to access restraints.

[9] MW18-12 could not be installed with a soil vapour attachment due to the very shallow groundwater table.

- Collecting six surface soil samples from on-Site fill material (SS18-1 to SS18-6).
- Collecting soil, groundwater and vapour samples for laboratory analyses. Subsequent groundwater samples were collected on December 14 and 19 from monitoring wells MW18-2, MW18-3 and MW18-14.
- Completing a relative elevation survey of the monitoring well locations and groundwater levels to determine relative groundwater elevations and flow direction.
- Tabulate historical analytical results.
- Documenting the results of the investigation in this report.

4.2 Investigative Program

Table 4-1 lists the APECs, PCOCs and the corresponding investigative locations advanced during the Stage 2 PSI. The APECs and associated PCOCs are presented on Figure 3 and the investigation locations are presented on Figure 5.

Table 4-1 APECs, PCOCs and Investigative Locations

APECs	Proposed Investigation Locations	Proposed Analysis		
		Soil	Groundwater	Vapour
APEC 1: On-Site imported gravel, historical staining, former paint storage and historical storage at Corkscrew roller coaster (Phase 1A)	BH18-4 and MW/SV18-5	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 2: On-Site chain lift, moto shed and track lubrication at Coaster rollercoaster (Phase 1A)	BH18-1 and MW/SV18-2	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 3: On-Site oil storage area and work shop (Phase 1A)	MW/SV18-2 and MW/SV18-3	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	Naphthalene, VOC and VPHv
APEC 4: On-Site fill material	BH18-1, MW/SV18-2, MW/SV18-3, BH18-4, MW/SV18-5, MW/SV18-6, BH18-7, BH18-8, MW/SV18-9 to MW18-12, BH18-13, MW/SV18-14 to MW/SV18-16, BH18-17, SP/SS18-2 to SP/SS18-6	LEPH, HEPH, PAH and metals	LEPHw, PAH and dissolved metals	Naphthalene
APEC 5: On-Site unknown vent pipe at Hastings Park (Phase 4A)	GPR and EM Survey to confirm presence or absence of UST			

APECs	Proposed Investigation Locations	Proposed Analysis		
		Soil	Groundwater	Vapour
APEC 6: On-Site hydrocarbon-impacted stockpile (Phase 4A)	MW/SV18-9 SP/SS18-1	LEPH, HEPH, PAH, VPH and metals	LEPHw, PAH, VPHw and dissolved metals	Naphthalene, and VPHv
APEC 7: Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)	GPR and EM Survey to confirm presence or absence of UST MW18-12, BH18-13 and MW/SV18-14 (located in Phase 3B)	LEPH, HEPH, PAH, VOC, VPH and metals	LEPHw, PAH, VOC, VPHw and dissolved metals	NA[10]
APEC 8: Former potential heating oil UST located at former Display Barns (Phase 3A)	GPR and EM Survey to confirm presence or absence of UST MW/SV18-16	LEPH, HEPH, PAH, and VPH	LEPHw, PAH and VPHw	Naphthalene, and VPHv
APEC 9: Former demolition derby activities at the former Outdoor Bowl (Phase 3B)	MW/SV18-15	LEPH, HEPH, PAH, VPH and metals	LEPHw, PAH, VPHw and dissolved metals	Naphthalene, and VPHv

LEPH – light extractable petroleum hydrocarbons
HEPH – heavy extractable petroleum hydrocarbons
VOC – volatile organic compounds
VPH – volatile petroleum hydrocarbons
PAH – polycyclic aromatic hydrocarbons
UST – underground storage tank
GPR – Ground Penetrating Radar
EM – Electro Magnetic
MW – monitoring well
SP/SS – stock pile/surficial soil
NA – Not analyzed

4.3 Investigations Field Methodology

The field investigation and data collection procedures used during the Site investigations are summarized in Appendix G.

4.3.1 Soil Sample Selection Rationale and Analyses

The selection of soil samples for analytical submission was based on the investigation work plan, variations in subsurface stratigraphy, previous samples which had concentrations which exceeded the applicable standards, and organic vapour meter (photo ionization detector [PID]) headspace.

The soil sample depth intervals, headspace measurements and soil characteristics were recorded on Borehole and Monitoring Well Logs (Appendix H).

[10] MW18-12 could not be installed with a soil vapour attachment due to the very shallow groundwater table.

4.3.2 Monitoring Well Construction

A total of 11 monitoring wells were installed within the drilled boreholes. Each well targeted the water table and had a maximum screen length of 1.5 m.

The groundwater monitoring well locations are shown on Figure 5.

4.3.3 Groundwater Development, Purging and Sampling

Monitoring wells constructed during the Stage 2 PSI program were developed, purged, and sampled in November 2018. The monitoring wells were allowed to equilibrate for a minimum period of 24 hours prior to development. Headspace vapours were measured at each location using a PID upon removal of the J-plug and the readings recorded on purge forms. Purge water from groundwater developing and sampling was drummed for off-Site disposal.

Field observations, well purging measurements and sampling information were recorded on the Field Well Purging and Sampling Forms, and are attached in Appendix H.

4.3.4 Vapour Well Construction

In order to investigate the potential for PCOCs in soil vapour at MW18-2, MW18-3, MW18-5, MW18-6, MW18-9, MW18-10 and MW18-14 to MW18-16, soil vapour wells were constructed concurrently with the advancement of pre-determined investigative locations. A vapour well could not be installed at MW18-12. This will be discussed in Section 4.6.2.1.

4.3.5 Location and Elevation Survey

A location and elevation survey was conducted by Keystone Environmental on November 28, 2018. Horizontal locations of installed monitoring wells were referenced to benchmark locations established from the Site building foundation. Vertical elevations of boreholes and monitoring wells were referenced relative to a storm drain grate, south of Parking Lot 9 (Phase 4A), and were set with an arbitrary elevation of 100.000 m.

Measuring points were established at the top of the PVC well casing and at the ground surface in the vicinity of the Stage 2 PSI monitoring wells at the time of the surveys. The top of the well casings surveyed were recorded in order to create a potentiometric map of the groundwater table, based on groundwater elevations measured on November 28, 2018. The survey data is provided in Appendix I.

4.4 Field Observations

4.4.1 Stratigraphy

The soil profile was logged by observation of soil from the solid stem auger flights or vacuum excavation boreholes. The soil was classified in general accordance with the Unified Soil Classification System. The following is a general description of the stratigraphy encountered on and off the Site:

Unit A: Grey to dark brown, fine to coarse grained sand (fill) some fine to coarse grained gravel with some silt. Trace garbage was observed at BH18-13, MW18-14 and MW18-15. Loose to dense, moist. This unit was encountered from surface to depths ranging from approximately 0.1 to 4.2 mbg.

Unit B: Dark brown peat. Soft, wet. This unit was encountered from depths ranging from approximately 0.6 to 0.9 mbg. This unit was encountered under Unit B and was only observed at MW18-12 and BH18-13

Unit C: Brown to grey fine grained sand (till) some silt, trace to some fine to coarse grained gravel, trace cobbles, increasing in density with depth and moist to wet with increasing moisture with depth. This unit was encountered from surface or beneath Unit A or B to the maximum depth of investigation.

Drill cuttings generated during the drilling activities were held in drums before being disposed off-Site as part of the soil and water management activities for the drilling activities.

4.4.2 Soil Characteristic Observations and Field Measurements

The soil sample headspace vapour measurements ranged from 0.1 to 57.2 parts per million by volume (ppmv). Elevated headspace vapour measurements (greater than screening value of 50 ppmv) were only observed at MW18-6(0.6). Odours and/or staining were not observed.

4.4.3 Site Hydrogeology

Groundwater is generally expected to follow regional topography, flowing from areas of higher elevation to areas of lower elevation. Local groundwater flow direction may vary as a result of local conditions such as topography, geology and the presence of drainage channels and buried utilities, and is subject to confirmation with field measurements. The topography in the vicinity of the Site slopes downward (approximately 3%) to the northwest.

Prior to developing and purging of the wells, well headspace vapour measurements were obtained using a PID upon removing the J-plug from each well head. The headspace vapour readings ranged from 0.3 ppmv to 4.26 ppmv measured at MW18-12. These headspace vapour readings are not considered to be elevated. Field indications of petroleum hydrocarbon contamination (such as odours and sheen) were not observed during groundwater developing, purging, or sampling.

Groundwater Flow Direction

A groundwater monitoring event was conducted on November 28, 2018. The groundwater table, where observed, varied from 0.0 m below the top of casing (mTOC) at MW18-5 to 8.2 mTOC at MW18-2. Measured groundwater levels were referenced to benchmark with an arbitrary elevation set at 100 m. Based on the data, the interpreted potentiometric surface contours indicated groundwater flow direction was towards the northwest, as shown on Figure 9. Groundwater was not observed in MW18-11.

The ground level elevations, monitoring well top of casing (TOC) elevations, depth to the groundwater and the calculated groundwater elevations are provided in Appendix I. Groundwater was not observed in MW18-11 on November 23, 26 or 27, 2018.

4.5 Analytical Results

The results from the previous investigations will be discussed in conjunction with the results from this Stage 2 PSI in section 4.6.

4.5.1 Soil Analytical Results

Soil analytical results are presented in Tables 4 to 6, and on Figure 6. The laboratory certificates of analyses are attached in Appendix J. Soil samples were submitted for the analysis of LEPH, HEPH, PAH, VOC, VPH and/or metals. A summary of the soil analytical results is provided below.

LEPH, HEPH and PAH

Five of the 30 samples (including duplicates) analyzed for LEPH, HEPH and PAHs had concentrations which were greater than the CSR PL and RL_{LD} and two samples had concentrations greater than the CL standards. These are presented in Table 4-2:

Table 4-2 Soil Samples which Exceed the CSR PL, RL_{LD} and/or CL Standards

Location	Parameters over CSR PL and RL_{LD} Standards	Parameters over CSR CL Standards
BH18-2(0.3)	HEPH	n/a
MW18-12(1.2)	VPH, LEPH, naphthalene	VPH
MW18-14(0.5)	HEPH, benzo(b+j)fluoranthene	HEPH
MW18-I (duplicate of MW18-14(0.5)	benzo(a)anthracene, benzo(b)fluoranthene, benzo(b+j)fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene	n/a
MW18-16(1.2)	LEPH, HEPH	n/a

Metals

With the exception of BH18-1(0.1), MW18-5(0.5) and MW18-13(1.2), the concentration of metals were less than the CSR PL, RL_{LD} and CL standards. These three samples had concentrations of zinc which exceeded the CSR PL, RL_{LD} and CL standards. Sample BH18-1(0.1) also had concentrations of arsenic and chromium which exceeded the CSR PL, RL_{LD} and CL standards.

VOC and VPH

Ten samples and one duplicate were analyzed for VOCs and VPH. The concentration of VOCs and VPH were less than the CSR PL, RL_{LD} and CL standards.

4.5.2 Groundwater Analytical Results

Groundwater analytical results are presented in Tables 7 to 9, and on Figure 7. The laboratory certificates of analyses are attached in Appendix J. Groundwater samples were submitted for the analysis of LEPHw, PAH, BTEX, VOC, VPHw and/or dissolved metals. A summary of the groundwater analytical results is provided below.

LEPHw and PAHs

With the exception of benzo[a]pyrene at MW18-14, the concentration of LEPHw and PAHs were less than the CSR DW, AW_{FW} and/or AW_M standards in the initial sampling event. To confirm the initial benzo(a)pyrene result at MW18-14, subsequent groundwater samples were collected on December 14 and 19, 2018 from MW18-14 and were analyzed for benzo(a)pyrene. The concentration of these samples were less than the CSR DW, AW_{FW} and AW_M standards, therefore are considered to be representative of the groundwater quality.

Dissolved Metals

With the exception of dissolved vanadium at MW18-2 and MW18-3, the concentration of dissolved metals was less than the CSR DW, AW_{FW} and AW_M standards in the initial sampling event. To confirm the initial dissolved vanadium concentrations at MW18-2 and MW18-3, subsequent groundwater samples were collected on December 14 and 19, 2018 from MW18-2 and MW18-3. The concentration of these samples were less than the CSR DW, AW_{FW} and AW_M standards, therefore are considered to be representative of the groundwater quality.

VOC, BTEX and VPHw

The concentrations of VOCs, BTEX and VPHw were less than the CSR DW, AW_{FW} and AW_M standards.

4.5.3 Vapour Analytical Results

Vapour analytical results are presented in Tables 10 to 12, and on Figure 8. The laboratory certificates of analyses are attached in Appendix J.

Hydrocarbons and Non-Halogenated VOCs

Several samples had non-attenuated concentrations of VPHv, benzene, butadiene, 1,3-, trimethylbenzene, 1,2,4- and trimethylbenzene,1,3,5- exceeding the CSR PL, RL and/or CL standards. However, the predicted indoor and outdoor air (attenuated) concentrations of hydrocarbons and non-halogenated VOCs were less than the CSR PL, RL and/or CL standards.

Halogenated VOCs

Several samples had non-attenuated concentrations of tetrachloroethene which exceed the PL, RL and/or CL standards. However, the predicted indoor and outdoor air (attenuated) concentrations of halogenated VOCs were less than the CSR PL, RL and/or CL standards.

4.5.4 Laboratory QA/QC

Soil, groundwater and vapour samples were analyzed by Maxxam Analytics of Burnaby, BC (Maxxam), which is certified by the Canadian Association for Laboratory Accreditation Inc. Methods employed for analysis of soil, groundwater and vapour were the recommended methods by the BC ENV and other regulatory agencies including the US Environmental Protection Agency.

In addition to field QC samples, the laboratory initiated their own QA/QC measures. The laboratory QA/QC measures included method blanks, duplicate analysis, and spike and matrix spike recoveries which were reviewed in addition to the Maxxam quality assurance and quality control calculations. The laboratory RPD values were within acceptable limits, or were less than five times the detection limits. The sample blank and spike analyses were also within the acceptable limits. Therefore, the samples and duplicates were in agreement and the data was reliable. The laboratory completed QA/QC is provided in the Laboratory Certificates of Analysis in Appendix J.

4.5.5 Soil QA/QC

The following soil QC samples were collected.

Table 4-3 Soil QC

Soil Sample and Field Duplicate	Analysis
SS18-1 & SS18-A	LEPH, HEPH, PAH, BTEX, VOC, VPH, metals
MW18-5(0.5) & MW18-E	LEPH, HEPH, PAH, metals
MW18-14 (0.5) & MW18-I	LEPH, HEPH, PAH, metals

The percentages of soil QC samples selected for analyses by Keystone Environmental are shown in the following table:

Table 4-4 Soil QC Percentage

Parameters	Number of Field Sample Analyses	Number of Duplicate Analyses	Percentage
LEPH, HEPH and PAH	29	3	11%
VOC	10	1	10%
BTEX and/or VPH	13	1	8%
Metals	29	3	11%

The soil QC analytical results and calculated RPDs are presented in Tables 4 to 6. Several samples and their duplicate pair had elevated RPDs compared to the preliminary conservative data quality screening thresholds.

Duplicate pair MW18-5(0.5) and MW18-E had RPDs for lead of 63% and for zinc of 141%. This duplicate pair was collected from fill material, and due to the highly heterogeneous nature of the fill material, it is likely that elevated RPD values would not have been considered representative and would have been considered associated with the non-homogeneity of the fill material. To be conservative, the highest concentration for each parameter of the pair was carried forward as the representative concentration.

Duplicate pair MW18-14(0.5) and MW18-I had RPDs for lead of 75%, tin of 37%, HEPH of 169% and greater than 54% for 20 PAHs. This duplicate pair was also collected from fill material, and due to the highly heterogeneous nature of the fill material, it is likely that elevated RPD values would not have been considered representative and would have been considered associated with the non-homogeneity of the fill material. To be conservative, the highest concentration for each parameter of the pair was carried forward as the representative concentration.

The remaining RPD values were either less than 35% or RPD values could not be calculated because the concentration of the sample or its duplicate were less than the laboratory RDLs or the contaminants concentration in the sample and/or duplicate sample was less than five times the RDL. This provides a qualitative indication that the results were considered reproducible and reliable, and it was concluded that the data meet project requirements for field duplicate QC evaluation.

4.5.6 Groundwater QA/QC

The following groundwater QA/QC samples were collected.

Table 4-5 Groundwater QA/QC

Groundwater Sample and Field Duplicate	Analysis
MW18-12 & MW18-A	LEPHw, PAHs, VOCs, BTEX, VPHw, dissolved metals

The percentages of groundwater QC samples were selected for analyses by Keystone Environmental are shown in the following table:

Table 4-6 Groundwater QA/QC Percentage

Parameters	Number of Field Sample Analyses	Number of Duplicate Sample Analyses	Percentage
LEPHw and/or PAH	10	1	10%
VOCs, BTEX, VPHw	7	1	14%
Dissolved Metals	10	1	10%

The QC analytical results and calculated RPDs are presented in Tables 7 to 9.

The RPD values were either less than 20% or RPD values could not be calculated because the concentration of the sample or its duplicate were less than the RDL or the constituent concentration in the sample and/or duplicate sample was less than five times the RDL. This provides a qualitative indication that the results were considered reproducible and reliable, and it was concluded that the data meet project requirements for field duplicate QC evaluation.

4.5.7 Vapour QA/QC

The following vapour QA/QC sample was collected.

Table 4-7 Vapour QA/QC

Vapour Sample and Field Duplicate	Analysis
SV18-3 & SV18-A	VOC/VPH, naphthalene

The following percentage of soil vapour QA/QC samples were analyzed.

Table 4-8 Vapour QA/QC Percentage

Parameters	Number of Field Sample Analyses	Number of Duplicate Sample Analyses	Percentage
VOC and VPHv	8	1	13%
naphthalene	8	1	13%

The QC analytical results and calculated RPDs are presented in Tables 10 to 12.

The RPD values were either less than 35% or RPD values could not be calculated because the concentration of the sample or its duplicate was less than the RDL or the contaminants concentration in the sample and/or duplicate sample was less than five times the RDL. This provides a qualitative indication that the results were considered reproducible and reliable, and it was concluded that the data meet project requirements for field duplicate QC evaluation.

4.5.8 Vapour Sample Leak Testing

The helium concentration in the tedlar bag was less than 2% of the measured concentration in the shroud at SV18-2, SV18-3, SV18-5, SV18-6, SV18-9, and SV18-14 to SV18-16. Based on this, the vapour analytical results were considered reproducible and reliable.

4.6 Summary and Discussion

The Keystone Environmental Stage 2 PSI was conducted in November 2018. The purpose of the Stage 2 PSI was to investigate the APECs identified in the Stage 1 PSI.

The Stage 1 PSI identified the following APECs:

- APEC 1 – On-Site imported gravel, historical staining, former paint storage and historical storage at Corkscrew rollercoaster (Phase 1A)
- APEC 2 – On-Site chain lift, motor shed, and track lubrication at Coaster rollercoaster (Phase 1A)
- APEC 3 – On-Site oil storage area and workshop (Phase 1A)
- APEC 4 – On-Site fill material
- APEC 5 – On-Site unknown vent pipe at Hastings Park (Phase 4A)
- APEC 6 – On-Site hydrocarbon-impacted soil stockpile (Phase 4A)
- APEC 7 – Former PNE maintenance area/work yard and potential gasoline UST (Phase 2)
- APEC 8 – Former potential heating oil UST located at former Display Barns (Phase 3A)
- APEC 9 – Former demolition derby activities at the former Outdoor Bowl (Phase 3B)

The findings of the Stage 2 PSI relevant to the phases of development are discussed below.

4.6.1 Phase 1A – Existing Playland Footprint

Four APECs were identified by Keystone Environmental's Stage 1 PSI within the existing Playland footprint. To investigate the APECs within this Phase, eight boreholes (BH18-1, MW18-2, MW18-3, BH18-4, MW18-5, MW18-6, BH18-7 and BH18-8) were advanced. The analytical results per APEC are discussed below.

4.6.1.1 APEC 1: On-Site Imported Gravel, Historical Staining, Former Paint Storage and Historical Storage at Corkscrew Rollercoaster

The Stage 1 PSI indicated that in the vicinity of the Corkscrew Rollercoaster there was imported gravel, historical staining, former paint storage and historical storage.

To investigate this APEC, two boreholes, BH18-4 and MW18-5, were advanced and soil, groundwater and vapour samples were collected and submitted for select analysis of LEPH, HEPH/PAHs, VOC, VPH and metals. Due to access constraints, location BH18-4 was advanced with a hand auger and MW18-5 (located in Phase 4A) was advanced/installed approximately 18 m down-gradient to the former paint storage. It was not possible to drill MW18-5 closer to the former paint storage due to the significant slope down-gradient to the former paint storage. The soil, groundwater and vapour results are discussed below.

Soil

With the exception of zinc at MW18-5(0.5), the concentrations of the PCOCs in these samples were less than the CSR PL, RL_{LD} and CL standards. This sample has been vertically delineated by MW18-5(1.2), horizontally delineated to the west by MW18-12(0.6) and broadly to the east by MW18-9(0.3).

The soil sample collected at MW18-5(0.5) was collected above the groundwater table within the fill material. Based on this, it is anticipated that the zinc contamination is associated with the fill material (APEC 4) (discussed in further detail in Section 4.6.4.1) and not APEC 1.

Groundwater

Groundwater LEPHw, PAHs, VOCs, VPHw and dissolved metals concentrations were less than the CSR DW, AW_{FW} and/ or AW_{M} standards.

Vapour

The predicted (attenuated) indoor and outdoor air concentrations of VOCs, VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on soil, groundwater and vapour results, there is considered to be a low potential for wide spread contamination associated with this APEC. Further investigation of this APEC is not warranted at this time.

4.6.1.2 APEC 2: On-Site Chain Lift, Moto Shed and Track Lubrication at Coaster Rollercoaster

The Stage 1 PSI indicated that diesel and chain oil were applied to the Coaster track over unpaved surfaces, and that historical staining was observed.

To investigate this APEC, two boreholes, BH18-1 and MW18-2, were advanced and soil, groundwater and vapour samples were collected and submitted for select analysis of LEPH, HEPH, PAH, VOC, VPH and metals. The soil, groundwater and vapour results are discussed below.

Soil

With the exception of HEPH at MW18-2(0.3) and arsenic, chromium and zinc in BH18-1(0.1), the concentrations of the LEPH, PAH, VOC, VPH and remaining metals for this APEC were less than the CSR PL, RL_{LD} and CL standards. The source of the HEPH, arsenic, chromium and zinc contamination is unknown. However, given that the sample was collected within the fill material and the fact that similar concentrations of HEPH and zinc were reported across the Site within the fill unit, it is anticipated that the contamination may be associated with APEC 4 (discussed further in Section 4.6.1.4).

Groundwater

With the exception of dissolved vanadium in MW18-2 and MW18-3, the groundwater concentrations of LEPHw, PAH, VOC, VPH and the remaining VOCs were less than the CSR DW, AW_{FW} and AW_M standards.

Additional groundwater samples were collected on December 14 and 19, 2018 to confirm the initial concentration of dissolved vanadium in MW18-2 and MW18-3. The concentrations dissolved vanadium in the two subsequent sampling events were less than the CSR DW, AW_M and AW_{FW} standards. Therefore, the initial sample's elevated concentration was likely due to elevated turbidity, common with newly installed monitoring wells and was not representative of groundwater quality.

Vapour

A sample from SV18-2 was collected and analyzed for VOCs, VPHv and naphthalene. The predicted (attenuated) indoor and outdoor air concentrations of VOCs, VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on soil, groundwater and vapour results, there is considered to be a low potential for wide spread contamination associated with this APEC. Further investigation of this APEC is not warranted at this time.

4.6.1.3 APEC 3: On-Site Oil Storage Area and Work Shop

The Stage 1 PSI indicated that a workshop (used for machining, lubrication, and fibreglass application and the storage of oil, grease, lubricants, transmission fluids and solvents) with a wooden floor was located in the northeast portion of Phase 1A since as early as the late 1950s.

To investigate this APEC, two boreholes, MW18-2 and MW18-3, installed as monitoring wells with soil vapour probes were advanced and soil, groundwater and vapour samples were collected and submitted for select analysis of LEPH, HEPH, PAH, VOC, VPH and metals. The soil, groundwater and vapour results are discussed below.

Soil

With the exception of HEPH at MW18-2(0.3), the concentrations for LEPH, HEPH, PAH, VOC, VPH and metals associated with this APEC were less than the CSR PL, RL and CL standards. As discussed above in APEC 2, this sample was collected in fill material and it is anticipated that the contamination is associated with the fill material (discussed further in 4.6.1.4).

Groundwater

With the exception of dissolved vanadium (as discussed in Section 4.6.1.2), the groundwater concentrations of for these LEPHw, PAH, VOC and VPH and the remaining dissolved metals were less than the CSR DW, AW_{FW} and AW_M standards.

Vapour

Sample from SV18-2 and SV18-3 (including its duplicate SV18-A) were collected and analyzed for VOCs, VPHv and naphthalene. The predicted (attenuated) indoor and outdoor air concentrations of VOCs, VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on soil, groundwater and vapour results, there is considered to be a low potential for wide spread contamination associated with this APEC. Further investigation of this APEC is not warranted at this time.

4.6.1.4 APEC 4: On-Site Fill Material

As indicated in the Stage 1 PSI and shown on Figure 2, a former tributary to Renfrew Creek transected the north portion of Phase 4A (southeast to northwest) and the central portion of Phase 3A. In addition, previous investigations conducted by Keystone Environmental and others identified fill material on other areas of the Site. To investigate the potential presence of fill material, seven boreholes (BH18-1, MW18-2, MW18-3, BH18-4, MW18-6, BH18-7 and BH18-8) were advanced. Soil, groundwater and vapour samples were submitted for select analysis of LEPH, HEPH, PAH and metals and the results are discussed below.

Soil

During the Stage 2 PSI drilling, sand and/or gravel fill material was observed at varying thickness at BH18-1, MW18-2, MW18-3, BH18-4, MW18-6, BH18-7 and BH18-8 in Phase 1A. With the exception of arsenic, cadmium and zinc at BH18-1(0.1) and HEPH at MW18-2(0.3), the concentrations of LEPH, PAH and the remaining metals were less than the CSR PL, RL_{LD} and CL standards.

The HEPH exceedance at MW18-2(0.3) has been vertically delineated by MW18-2(2.1) and horizontally delineated to the northwest by MW18-3(0.5). The metals exceedance at BH18-1(0.1) has been vertically delineated by BH18-1(0.4).

Groundwater

With the exception of dissolved vanadium in MW18-2 and MW18-3, the concentrations of LEPHw, PAH and the remaining metals were less than the CSR DW, AW_{FW} and AW_M standards. The vanadium exceedances were discussed in section 4.6.1.2.

Vapour

Sample from SV18-2, SV18-3 (including its duplicate SV18-A) and SV18-6 were collected and analyzed for VOCs, VPHv and naphthalene. The predicted (attenuated) indoor and outdoor air concentrations of VOCs, VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on the soil analytical results, hydrocarbon and metals contamination is present within the fill material.

4.6.2 Phase 2 – PNE Amphitheatre

Two APECs were identified by Keystone Environmental's Stage 1 PSI within the existing PNE Amphitheatre (Phase 2). Within Phase 2, investigation locations MW18-12 and BH18-13 were advanced and a GPR and EM survey was conducted in the vicinity of former UST. In addition, MW18-14 was installed on Phase 3B, approximately 15 m northwest (down-gradient) of the former UST to investigate APEC 7. The analytical results per APEC are discussed below.

4.6.2.1 APEC 4: On-Site Fill Material

As indicated in the Stage 1 PSI and shown on Figure 2, a former tributary to Renfrew Creek transected the north portion of Phase 4A (southeast to northwest) and the central portion of Phase 3A. In addition, previous investigations conducted by Keystone Environmental and others identified fill material on other areas of the Site. During the Stage 2 PSI drilling, fill material was observed at MW18-12 and BH18-13. To investigate the potential presence of contaminants of concern within the fill material, soil and groundwater samples were submitted for select analysis of LEPH, HEPH, PAH and metals and the results are discussed below.

Soil

With the exception of VPH, LEPH and naphthalene at MW18-12(1.2), the concentration of these HEPH, remaining PAHs and metals were less than the CSR PL, RL_{LD} and CL standard. The petroleum hydrocarbon exceedances at MW18-12(1.2) were vertically delineated by MW18-12(1.8). The LEPH and naphthalene exceedances have been broadly delineated to the southwest by MW18-14(1.2) and to the west by MW01-1-3.5.

Groundwater

A sample, and its duplicate, from MW18-12 were analyzed for LEPHw, PAH and dissolved metals. The concentrations of these PCOCs were less than the CSR DW, AW_{FW} and AW_M standards.

Based on the soil analytical results, hydrocarbon contamination is present in soil.

4.6.2.2 APEC 7: Former PNE maintenance area/work yard and potential gasoline UST

The Former PNE Maintenance Area/Work Yard and associated potential gasoline UST, was identified in the Stage 1 PSI within Phase 2 as an APEC. This area was previously investigated in 2001 by Keystone Environmental. Although the 2001 soil and groundwater concentrations were less than the current CSR standards, an investigation location was not advanced within the footprint of the former building, it was unknown if the UST was removed and the quality of the soil, groundwater or vapour within the vicinity UST is unknown.

To investigate this APEC, GPR and EM surveys were conducted and MW18-12, BH18-13 and MW18-14 (located on Phase 3B) were advanced and soil, groundwater and vapour samples were collected and submitted for select analysis of LEPH, HEPH, PAH, VOC VPH and metals.

GPR and EM Survey

A GPR and EM survey was conducted on the west side of Phase 2 in the area of the suspected UST. Subsurface anomalies consistent with the size and/or shape of UST were not observed.

Soil

Concentrations of VPH, LEPH and naphthalene at MW18-12(1.2), several petroleum hydrocarbons in MW18-14(0.5) and its duplicate MW18-I exceeded the CSR PL, RL_{LD} and/or CL standards. The petroleum hydrocarbon exceedances at MW18-12(1.2) were vertically delineated by MW18-12(1.8). The LEPH and naphthalene exceedances have been broadly delineated to the southwest by MW18-14(1.2) and to the west by MW01-13.5. The petroleum hydrocarbon exceedances in MW18-14(0.5) were vertically delineated by MW18-14(1.2) and fully horizontally delineated to the northeast by MW18-12(0.6) and to the southeast by BH18-13(0.4).

Groundwater

Samples from MW18-12, and its duplicate MW18-A, and from MW18-14 was analyzed for LEPHw, PAH, VOC, VPHw and dissolved metals. With the exception of benzo(a)pyrene in MW18-14, concentrations of LEPHw, remaining PAHs, VOC, VPHw and dissolved metals were less than the CSR DW, AW_{FW} and AW_{M} standards.

Additional groundwater samples were collected on December 14 and 19, 2018 to confirm the concentration of benzo(a)pyrene in MW18-12. The concentrations benzo(a)pyrene in these samples were less than the CSR DW, AW_{M} and AW_{FW} standards. Therefore, the initial sample's elevated concentration was likely due to elevated turbidity, common with newly installed monitoring wells and was not representative of groundwater quality.

Vapour

Due to the groundwater in this area being a few centimetres below grade and was possibly artesian, it was not possible to install a vapour probe. A picture of the very shallow water table in the open borehole for MW18-12 is attached in the photographic log in Appendix A.

4.6.3 Portion of Phase 3A – Festival Heart of the Park

Two APECs, on-Site fill material (APEC 4) and a potential former suspect heating oil UST (APEC 8) were identified by Keystone Environmental's Stage 1 PSI within the Portion of Phase 3A. To investigate this Phase and the APECs, two boreholes (MW18-16 and BH18-17) were advanced and a GPR and EM survey was performed in the vicinity of the UST. The analytical results per APEC are discussed below.

4.6.3.1 APEC 4: On-Site Fill Material

The Stage 1 PSI indicated that a former tributary to Renfrew Creek transected the central portion of Phase 3A, as shown on Figure 2. The creeks were not observed in the 1930 aerial photographs; therefore, it is anticipated that they were filled prior to 1930. In 2001, two boreholes, one of which was completed as a monitoring well (MW01-1 and BH01-2) were advanced to investigate fill in the former creek area on Phase 3A. Fill material comprised of sand, gravel, clay and/or wood was identified to depths greater than 6.1 mbg. Two soil samples were submitted for LEPH, HEPH, PAH, VOC, and metals and the results were less than the laboratory detection limit and/or the current CSR PL, RL_{LD}, and CL standards. To further investigate this APEC, Two boreholes MW18-16 and BH18-17 were advanced.

Soil

During the Stage 2 PSI drilling, fill material was observed at MW18-16 and BH18-17. Samples MW18-16(1.2), MW18-16(2.4) and BH18-17(0.3) collected from the fill layer and were analyzed for LEPH, HEPH, PAHs and metals. Concentrations of LEPH, HEPH and zinc at MW18-16(1.2), were greater than the CSR PL, RL_{LD} and/or CL standards. The LEPH, HEPH and zinc contamination at MW18-16(1.2) has been vertically delineated by MW18-16(2.4), horizontally delineated to the south by MW18-15(1.2) and to the east by MW18-14(1.2). The LEPH and HEPH contamination has also been delineated to the north by MW01-1-3.5.

Groundwater

A groundwater sample from MW18-16 was analyzed LEPHw, PAHs and dissolved metals and the concentrations were less than the CSR DW, AW_{FW} and AW_{M} standards.

Vapour

A sample from SV18-16 was collected and analyzed for naphthalene. The predicted (attenuated) indoor and outdoor air concentration of naphthalene was less than the CSR PL, RL and CL standards.

4.6.3.2 APEC 8: Former potential heating oil UST located at former Display Barns (Phase 3A)

The 1996 Phase I ESA indicated a UST vent pipe (suspected to be heating oil) was observed adjacent to the display barns formerly located on Phase 3A, on the west portion of the Site. In 2001, one borehole (BH01-1) was advanced to investigate the former heating oil UST. A soil sample was submitted for LEPH, HEPH, PAH and VPH and the results were less than the laboratory detection limit and/or the current CSR PL, RL_{LD}, and CL standards; however, given that the exact location of the potential former UST is unknown and that the area has not been redeveloped, further investigation was considered to be warranted.

A GPR and EM Survey and investigation location MW18-16 was advanced to investigate this APEC in Phase 3A. The results are discussed below.

GPR and EM Survey

A GPR and EM survey was conducted on the middle of Phase 3A in the area of the former UST. Subsurface anomalies consistent with the size and/or shape of USTs were not observed.

Soil

As discussed above, concentrations of LEPH, and HEPH at MW18-16(1.2), exceeded the CSR PL and RL_{LD} standards. The LEPH and HEPH contamination at MW18-16(1.2) has been vertically delineated by MW18-16(2.4) horizontally delineated to the south by MW18-15(1.2) and to the east by MW18-14(1.2). The LEPH and HEPH contamination has also been delineated to the north by MW01-1-3.5.

While this location was advanced to investigate APEC 4 (fill material) and APEC 8 (potential heating oil UST), it is anticipated that these exceedances are associated with the fill material (APEC 4), and not APEC 8, given that a subsurface anomaly consistent with a UST was not found during the GPR and EM survey, the sample was collected from the fill and the exceedances were above the water table and as discussed below, groundwater and vapour results are less than the CSR land and water use standards.

Groundwater

A groundwater sample from MW18-16 was analyzed VOCs, VPHw, LEPHw, PAHs and dissolved metals and the concentrations were less than the CSR DW, AW_{FW} and AW_M standards.

Vapour

A sample from SV18-16 was collected and analyzed for VOCs, VPHv and naphthalene. The predicted (attenuated) indoor and outdoor air concentrations of VOCs, VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on these results, further investigation of this APEC was not warranted at this time.

4.6.4 Phase 3B – Creek Daylighting South

Two APECs, on-Site fill material (APEC 4) and former demolition derby activities at the former outdoor bowl (APEC 9) were identified by Keystone Environmental's Stage 1 PSI within Phase 3B – Creek Daylighting South. To investigate this Phase and APECs, two boreholes (MW18-16 and BH18-17) were advanced and a GPR and EM survey was performed around the area where USTs were suspected to have been.

4.6.4.1 APEC 4: On-Site Fill Material

To investigate this APEC, monitoring wells MW18-14 and MW18-15 were installed. The results from MW18-14 were initially discussed above in Section 4.6.3.

Soil

During the Stage 2 PSI drilling, fill material was observed at MW18-14 and MW18-15. Samples MW18-14(0.5), its duplicate MW18-I, MW18-14(1.2) and MW18-15(1.2), collected from the fill layer, were analyzed for LEPH, HEPH, PAHs and metals. The concentrations HEPH and various PAH exceeded the CSR PL, RL_{LD} and/or CL standards at MW18-14(0.5) or its duplicate MW18-I.

Groundwater

A groundwater sample from MW18-15 was analyzed for LEPHw, PAHs and dissolved metals. The concentrations of these PCOCs were less than the CSR DW, AW_{FW} and AW_{M} standards.

Vapour

A sample from SV18-15 was collected and analyzed for VOCs, VPHv and naphthalene. The predicted (attenuated) indoor and outdoor air concentration of VOCs, VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on the soil analytical results, hydrocarbon contamination is present.

4.6.4.2 APEC 9: Former Demolition Derby Activities at the Former Outdoor Bowl

Demolition derby activities were formerly conducted in the former Outdoor Bowl. Photographs indicate that the grounds surface within the bowl was unpaved. The location of the former bowl is currently occupied by a portion of Sanctuary Pond.

Borehole MW18-15 was advanced to investigate this APEC. The soil, groundwater and vapour results are discussed below.

Soil

Sample MW18-15(1.2), from the fill layer, was analyzed for LEPH, HEPH, PAHs, VPH and metals and the concentrations were less than the CSR PL, RL_{LD} and CL standards.

Groundwater

A groundwater sample from MW18-15 was analyzed LEPHw, PAHs, VPH and dissolved metals and the concentrations were less than the CSR DW, AW_{FW} and AW_{M} standards.

Vapour

A sample from SV18-15 was collected and analyzed for VPHv and naphthalene. The predicted (attenuated) indoor and outdoor air concentration of VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on the analytical results, further investigation of this APEC was not warranted.

4.6.5 Phase 4A – Future Playland Expansion

Three APECs were identified in the Stage 1 PSI within the Future Playland Expansion. To investigate this Phase, a GPR and EM survey was performed, six surface soil samples (SS18-1 to SS18-6) were collected and four boreholes (MW18-5, MW18-9 to MW18-11) were advanced.

4.6.5.1 APEC 4: On-Site Fill Material

In 2015, TH15-04 to TH15-06 were advanced (by others) across the northern part of Phase 4A and off-Site adjacent to Phase 4A.Soil concentrations of LEPH, HEPH, PAH and metals were less than the laboratory detection limit and/or the current CSR PL, RL_{LD} and CL standards. Although these concentrations were less than the current CSR standards, the sampling density did not meet the Ministry requirements of Technical Guidance 1 – Site Characterization and Confirmation Testing.

Uncovered, vegetated berms, which are along the east and north boundaries for Phase 4A, consist of a mixture of native soil from the excavation for Empire Stadium and fill material. These berms were not previously investigated.

Five surface samples, SS18-2 to SS18-6 were collected within the berms and four boreholes (MW18-5 and MW18-9 to MW18-11) were advanced to investigate this APEC in Phase 4A.

Soil

With the exception of zinc at MW18-5(0.5), the concentration of LEPH, HEPH, PAH and the remaining metals were less than the CSR PL, RL_{LD} and CL standards. The zinc exceedance has been vertically delineated by MW18-5(1.2) and broadly horizontally delineated to the west by MW18-12(0.6) and to the southwest by BH18-13(0.4) and to the east by MW18-9(0.3).

Groundwater

Samples were collected from MW18-5, MW18-9, and MW18-10 and were analyzed for LEPH, PAH and dissolved metals. The groundwater concentrations of these parameters were less than the CSR DW, AW_M and AW_{FW} standards.

Vapour

Samples from SV18-5 and SV18-9 were collected and analyzed for naphthalene. The predicted (attenuated) indoor and outdoor air concentrations of VOCs, VPHv and naphthalene were less than the CSR PL, RL and CL standards.

4.6.5.2 APEC 5: On-Site Unknown Vent Pipe at Hastings Park

A potential vent pipe was observed adjacent to the east wall of a horse barn and a circular metal plate was located in pavement adjacent to the pipe. The horse barns are currently not heated; however, they do have hot water tanks which are fuelled with propane. It is unknown how long the hot water tanks have been present or if a boiler may have been used previously. Therefore, there is a potential that the pipe may be associated with a heating oil UST. A GPR and EM survey was conducted to scan for subsurface anomalies which are consistent with the size and/or shape of UST(s) in the vicinity of the pipe. The GPR and EM survey did not identify subsurface anomalies consistent with the size and/or shape of USTs. The utility locator commented that the potential vent pipe was likely a water pipe.

4.6.5.3 APEC 6: On-Site Hydrocarbon-Impacted Stockpile

Since 2015, a stockpile (approximately 100 m^2 in area) has been located on the southeast portion of the paved parking lot. The source of the material was ground cover (soil) from the Monster Truck show located on the PNE grounds. The same soil is used repeatedly for events and has been impacted by oil, grease and fuel from damaged vehicles. The stockpile was previous uncovered and vegetated area was observed to be adjacent to the stockpile.

One surface sample SS18-1 was collected from the stockpile and a borehole, installed as a monitoring well (MW18-9) was advanced down-gradient of the stockpile to investigate this APEC.

Soil

Sample SS18-1 (and its duplicate SS18-A), MW18-9(0.3) and MW18-9(4.5) were analyzed for LEPH, HEPH, PAHs and metals. Samples SS18-1/SS18-A and MW18-9(4.5) were also analyzed for VPH. The LEPH, HEPH, PAH, VPH and metal concentrations were less than the CSR PL, RL_{LD} and CL standards.

Groundwater

A groundwater sample collected from MW18-9 and was analyzed for LEPH, PAH, VPHw and dissolved metals and the concentrations were less than the CSR DW, AW_M and AW_{FW} standards.

Vapour

A vapour sample from SV18-9 was collected and analyzed for VPHv and naphthalene. The predicted (attenuated) indoor and outdoor air concentrations of VPHv and naphthalene were less than the CSR PL, RL and CL standards.

Based on these soil, groundwater and vapour analytical results, further investigation of this APEC is not warranted at this time.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the soil, groundwater and vapour analytical results, it was concluded that contaminants of concern in soil are present at the Site at concentrations greater than the applicable CSR land use standards.

Table 5-1 summarizes the soil contamination identified during the Stage 2 PSI by Keystone Environmental:

Table 5-1 Summary of Soil Contamination

AEC	Location	Depth (m)	Estimated Area (m^2)	Contaminants	Maximum Concentrations
AEC 4 – On-Site fill material	Phase 1A	Surface to 0.4 mbg	225	arsenic	108 µg/g
				chromium	81.4 µg/g
				zinc	245 µg/g
		Surface to 2.1 mbg	750	HEPH	1,300 µg/g
	Phase 2	1 to 1.8 mbg	1,500	LEPH	1,500 µg/g
				VPH	1,100 µg/g
				Naphthalene	0.76 µg/g
	Portion of Phase 3A	Surface to 2.4 mbg	2,000	LEPH	1,200 µg/g
				HEPH	1,500 µg/g
				Zinc	265 µg/g
	Phase 3B	Surface to 1.2 mbg	900	HEPH	5,900 µg/g
				benzo(a)anthracene	1.9 µg/g
				benzo(b)fluoranthene	1.6 µg/g
				benzo(b+j)fluoranthene	2.7 µg/g
				indeno(1,2,3-cd)pyrene	1.1 µg/g
				naphthalene	0.78 µg/g
	Phase 4A	Surface to 1.2 mbg	450	Zinc	182 µg/g

Contaminants of concern in soil (arsenic, chromium, zinc, LEPH, HEPH, VPH, benzo(a)anthracene, benzo(b)fluoranthene, benzo(b+j)fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene) are present at the Site at concentrations greater than the applicable CSR Urban Park Land Use standards.

We understand that the Site will be redeveloped in Phases with the redevelopment timeline ranging from 1 to 12 years. As the Site use will not change, it is our understanding that a Ministry Instrument is not required for the Site. Instead, we understand that the BC ENV would require an application for a Scenario 2 Release under Administrative Guidance 6 for each Phase to facilitate the City of Vancouver to approve the permit applications.

Additional investigation to delineate the contamination can be conducted prior to release application for each particular Phase, or at the time of the redevelopment for the Phase. If contamination is present within the redevelopment area, it should be remediated under the BC ENV Independent Remediation process. Recommendations per APEC/AEC are presented in Table 4-9 below.

Table 5-2 Recommendations per APEC/AEC

APEC/AEC	Location	Recommendation
APECs 1 and 2: On-Site Imported Gravel, Historical Staining, Former Paint Storage and Historical Storage at Corkscrew Rollercoaster On-Site chain lift, moto shed and on-Site track lubrication at Coaster rollercoaster	Phase 1A	If soil in vicinity of the Corkscrew Rollercoaster is to be removed off-Site in the future, additional soil characterization may be required for disposal purposes.
APEC 3: On-Site oil storage area and work shop	Phase 1A	If soil beneath the workshop or in the vicinity oil storage area is to be removed off-Site in the future, additional soil characterization may be required for disposal purposes.
AEC 4: On-Site fill material	Phases 1A, 2, portion of 3A, Phase 3B and Phase 4A	Additional investigation would be warranted to delineate the meals and hydrocarbon contamination.
APEC 6: On-Site hydrocarbon-impacted stockpile	Phase 4A	If the stockpiled soil continues to be used for motorsports events, it should continue to be stored on a paved surface and be covered with a plastic liner to prevent potential run-off. If future off-Site disposal of the soil stockpile is required, additional testing may be required for disposal purposes.
APEC 8: Former potential heating oil UST located at former Display Barns	Phase 3A	If an UST is encountered during redevelopment activities a qualified environmental professional should be retained to document the tank condition and to characterize the soil around the tank.

6. PROFESSIONAL STATEMENT

Keystone Environmental Ltd.[11] confirms that this report titled *Report of Findings – Stage 1 and 2 Preliminary Site Investigation, Portion of 2901 East Hastings Street, Vancouver, BC; Phase 1A – Existing Playland Footprint, Phase 2 – PNE Amphitheatre, Portion of Phase 3A – Festival Heart of the Park, Phase 3B – Creek Daylighting South, and Phase 4A – Future Playland Expansion.* We are pleased to submit this report to City of Vancouver.

Report authors Jodine Restiaux and Stewart McBride, Professional of Record Nicole MacDonald, and Senior Reviewer Michael Geraghty have demonstrable experience in the investigation of the type of contamination at the Site and are familiar with the investigation carried out at the Site.

The report is subject to the Standing Offer Agreement between City of Vancouver and Keystone Environmental Ltd., dated August 28, 2014.

If you have questions regarding the information contained in this report, please contact Nicole MacDonald at nmacdonald@keystoneenvironmental.ca

April 5, 2019
Date

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Project Manager

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7. REFERENCES

Aerial photographs dated:

- 1930, 1949, 1954, 1963, 1969, 1974, 1978, 1986, 1990, 1996, and 2002 were obtained from the UBC Geographic Information Centre
- 2009 and 2015 obtained from City of Vancouver mapping software (VanMap)

BC ENV Site Registry via BC Online: www.bconline.gov.bc.ca

Canadian Climate Normals via Environment Canada: http://climate.weather.gc.ca/climate_normals/index_e.html

Contaminated Sites Regulation (CSR), BC Reg. 375/96 O.C. 1480/96, includes amendments up to BC Reg. 253/2016, November 1, 2017.

City of Vancouver online mapping software (VanMap): http://vanmapp.vancouver.ca/pubvanmap_net/default.aspx

Environmental Management Act (EMA), [SBC 2003], Chapter 53 assented to October 23, 2003 and current to February 28, 2018.

Fire Insurance Maps, dated circa 1925-1950 and 1954-1966, obtained from the City of Vancouver Archives

Freeze, R. Allan, Cherry, John A., (1979), Groundwater, Englewood Cliffs, N.J., Prentice-Hall

Geological Survey of Canada Surficial Geology Map 1486A (1979).

Hazardous Waste Regulation (HWR) BC Reg. 63/88 O.C. 268/88, includes amendments up to BC Reg. Reg. 243/2016, November 1, 2017.

Interviews with:

- Ms. Suzanne Rice, Assistant Manager of Tech Services (Playland)
- Mr. Shawn Joinson, Manager of Tech Services (Playland)
- Ms. Devon Brownlee, Project Coordinator (Hastings Park-PNE Master Plan)
- Mr. John Brodie, Project Manager (Hastings Park-PNE Master Plan)
- Mr. Darren MacDonald, General Manager (Hastings Racecourse)

Land Title via the BC Land Title Survey Authority website: http://www.ltsa.ca/

Land Use Maps, dated 1971, 1980, and 1983, obtained from UBC: https://open.library.ubc.ca/collections/gvrdmaps

The Pacific National Exhibition – An Illustrated History, By David Breen and Kenneth Coates, University of British Columbia Press, 1982.

Previous Reports:

- *Report of Findings – Phase I Environmental Site Assessment, Pacific National Exhibition Site, Vancouver, BC.* Prepared for City of Vancouver Real Estate Services by Keystone Environmental Ltd. May 1996.
- *Stage 2 Preliminary Site Investigation* – Hastings Park 3C Sanctuary Extension. Prepared for Mr. Philips Farevaag Smallenberg, by Keystone Environmental Ltd. August 2001.
- *Hastings Park Infrastructure Study, Geotechnical Factual Report.* Prepared for Urban Systems Ltd. by Thurber Engineering Ltd. June 2015.

Street directories, dated 1915, 1920, 1925, 1930, 1935, 1940, 1945, 1950, 1955, 1960, 1970, 1975, 1980, 1985, 1991, 1996, and 2001, obtained from Vancouver Public Library (VPL)

Water well search via the BC Water Resources Atlas: http://maps.gov.bc.ca/ess/sv/wrbc/

FIGURES

Keystone Environmental

Hasting Park - Playland Redevelopment and Heart in the park
Vancouver, B C
City of Vancouver

REVISION No.	DATE	PROJECT No.
00	Apr. 2019	13639-02

Figure 1
Location Plan

DRAWN BY: CY DOCUMENT PATH: I:\13600-13699\13639\Phase 00002\Figs\Fig1-LocationPlan-R0.mxd

MCGILL ST.

N

MAINTENANCE AREA & FUEL STORAGE

TH15-06

TH15-05

HORSE MANURE BINS

(FORMERLY WINDERMERE ST.)

(FORMERLY RUPERT ST.)

PLAYLAND FENCED STORAGE AREA

TH15-04

AGRODOME STOCKPILE

PARKING LOT 9

HORSE BARNS

PHASE 4A
FUTURE PLAYLAND EXPANSION

OBSERVED PIPE

MONSTER TRUCK STOCKPILE

MW01-1

TH15-03

MW01-2

FORMER PAINT STORAGE

CORKSCREW ROLLER COASTER

AMPHITHEATRE (FORMER PNE WORKS YARD)

TH15-02

BH01-4

BH01-3

PARKING

BH01-1

FORMER DISPLAY BARNS

CHAIN LIFT

LOWER LINE WORKSHOP

TH15-01

PHASE 1A
EXISTING PLAYLAND
FOOT PRINT

BH01-2

MAINTENANCE BUILDING (WORKSHOP)

OIL & PAINT STORAGE

FORMER OUTDOOR BOWL

WELDING SHOP

SIGN SHOP

STORAGE AREA

CARPENTRY SHOP

CONCESSIONS

COASTER RO
COASTER

MACHINE SHOP

MOTOR SHED

RESTAURANT

CHAIN LIFT

(375)

FLUME RIDE

SCRAP METAL, WASTE & PROPANE STORAGE

OIL STORAGE

E. HASTINGS ST.

LEGEND

- PHASE 1A EXISTING PLAYLAND FOOTPRINT
- PHASE 2 PNE AMPHITHEATRE
- PORTION OF PHASE 3A FESTIVAL HEART-OF-THE-PARK
- PHASE 3B CREEK DAYLIGHTING SOUTH
- PHASE 4A FUTURE PLAYLAND EXPANSION
- PROPERTY LINE
- LOT LINES
- BUILDING OUTLINE
- FORMER BUILDING OUTLINE
- BERM
- STOCKPILE
- FORMER ROAD
- FORMER STREAM
- (....) FORMER ADDRESS
- UST AS INDICATED BY 1996 PSI 1 (KEYSTONE ENVIRONMENTAL)
- TEST HOLE (BY OTHERS)
- KEYSTONE BOREHOLE (2001)
- DESTROYED KEYSTONE MONITORING WELL (2001)

20 0 100 m

SCALE: 1:2,000 (approx.)

LOCAL GROUNDWATER FLOW DIRECTION

Keystone Environmental

NOTES:
1) THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.
2) DATE OF AERIAL PHOTO IS 2015.

Hasting Park - Playland Redevelopment and Heart in the park
Vancouver, B C
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Figure 2
Site Plan

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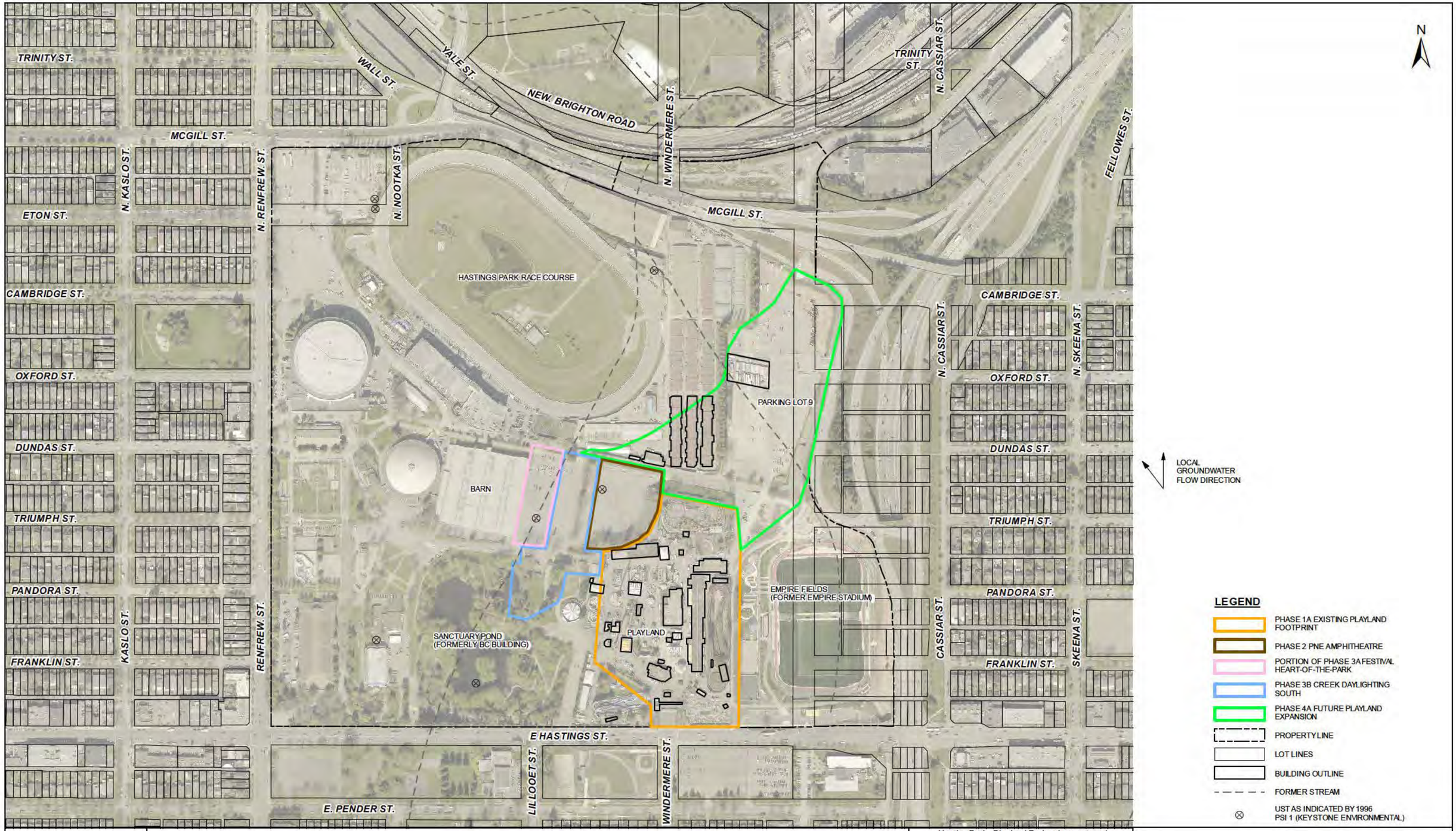

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NOTES:
1. THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.
2. DATE OF ORTHO PHOTO IS 2015.

50 0 200 m

SCALE: 1:5,000 (approx.)

Hasting Park - Playland Redevelopment and Heart in the park
Vancouver, B C
City of Vancouver

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Figure 3
Site & Surrounding Land Use Plan

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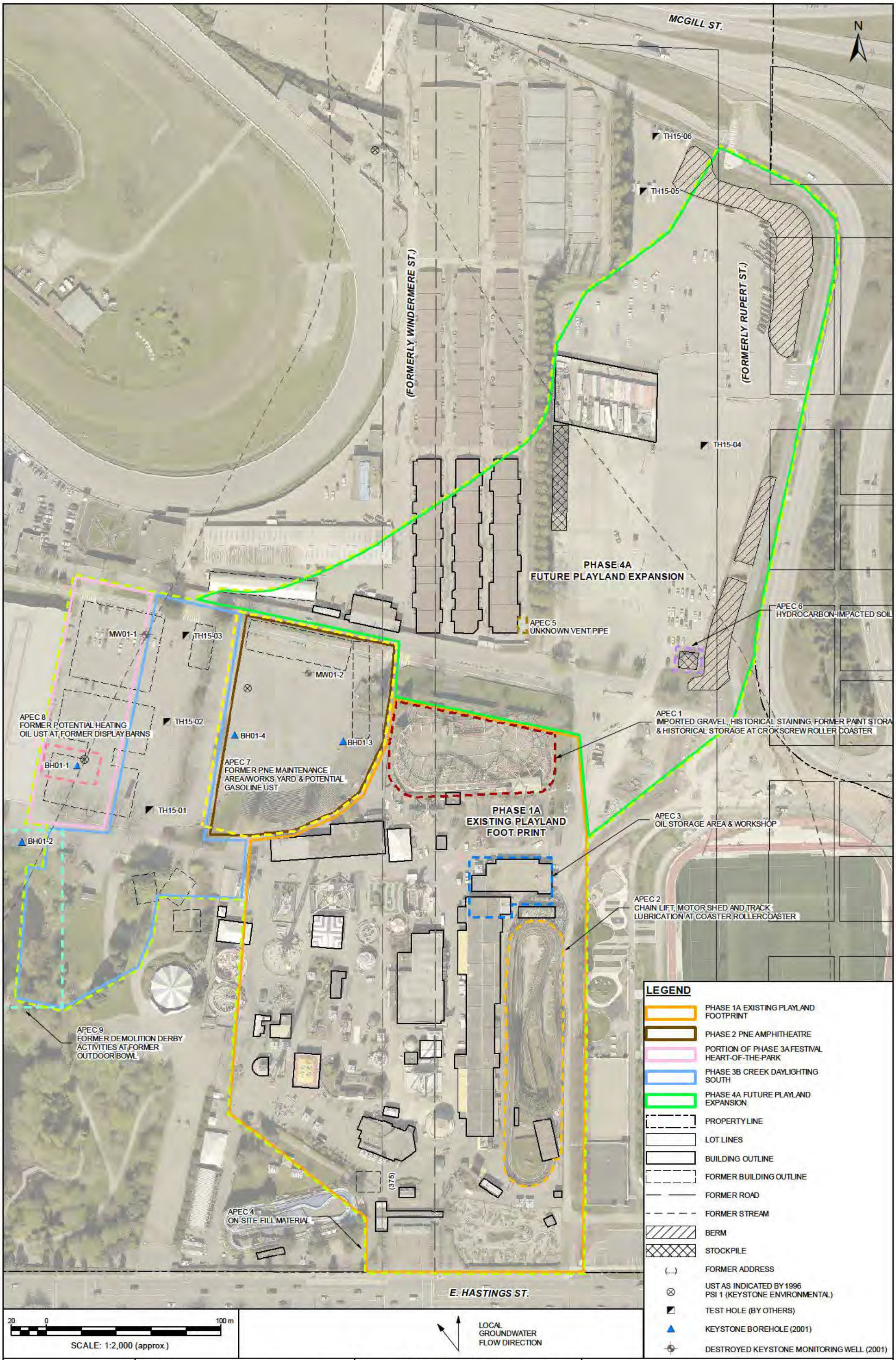

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Figure 4
Areas of Potential Environmental Concern

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McGill ST.

E. HASTINGS ST.

HWY #1

TH15-06
TH15-05
TH15-04
TH15-03
TH15-02
TH15-01

SS/SP18-06
SS/SP18-05
SS/SP18-04
SS/SP18-03
SS/SP18-02
SS/SP18-01

MW18-11
MW18-10
MW18-12
MW18-14
SV18-14
MW18-05
SV18-05
MW01-1
MW01-2
MW18-16
SV18-16
MW18-15
SV18-15
MW18-06
SV18-06
MW18-03
SV18-03
MW18-02
SV18-02
SV18-09
MW18-09

BH01-1
BH01-2
BH01-3
BH01-4
BH18-04
BH18-07
BH18-08
BH18-13
BH18-17

LOCAL GROUNDWATER FLOW DIRECTION

LEGEND

- PHASE 1A EXISTING PLAYLAND FOOTPRINT
- PHASE 2 PNE AMPHITHEATRE
- PORTION OF PHASE 3A FESTIVAL HEART-OF-THE-PARK
- PHASE 3B CREEK DAYLIGHTING SOUTH
- PHASE 4A FUTURE PLAYLAND EXPANSION
- PROPERTY LINE
- LOT LINES
- BUILDING OUTLINE
- FORMER BUILDING OUTLINE
- BERM
- STOCKPILE
- PROPOSED GPR/EM SURVEY AREA
- FORMER STREAM
- FORMER ROAD
- UST
- TEST HOLE (BY OTHERS)
- KEYSTONE BOREHOLE (2001)
- KEYSTONE MONITORING WELL (2018)
- DESTROYED KEYSTONE MONITORING WELL (2001)
- KEYSTONE SURFICIAL SOIL/STOCKPILE SAMPLE (2018)
- KEYSTONE VAPOUR WELL (2018)

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NOTES:
1. THIS DRAWING IS FOR GENERAL INFORMATION ONLY. LOT BOUNDARIES AND FEATURES ARE APPROXIMATE.
2. DATE OF AERIAL PHOTO PHOTO IS 2015.

15 0 75 m
SCALE: 1:1,500 (approx.)

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Figure 5
Sample Location Plan

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