HEROLD ENGINEERING

April 26th, 2022 0017-420

City of Nanaimo
Engineering and Public Works
2200 Labieux Road
Nanaimo, BC V9T 6J9

Via email: taaj.daliran@nanaimo.ca

Attn: Mr. Taaj Daliran
Manager, Sanitation, Recycling and Cemeteries

Re: Townsite Road Chinese Cemetery
Gateway & Pagoda Condition Assessment

Dear Taaj:

Herold Engineering Limited (Herold Engineering) is pleased to submit this report on the concrete condition assessment of the two concrete structures located in the Townsite Road Chinese Cemetery at 1598 Townsite Road, in Nanaimo, BC.

Structure Description

The Townsite Road Cemetery features two cast-in-place concrete structures. The first is located over the drive lane entrance to the cemetery (the 'Gateway') and the second structure (the 'Pagoda') is located at the center of the cemetery covering a concrete altar and shrine.

Both structures have similar concrete components including:

- Footings (not visible), supporting
- Pedestals (12" square), supporting
- Columns, four 12" (~300 mm) diameter columns, supporting
- Beams (12" x 18" deep), supporting
- A cast-in-place concrete roof system

The date of construction is not known, however based on the general condition of the concrete it is expected to be several decades old. It has been reported[1] that the cemetery was originally constructed in 1924 and a refurbishment was completed in circa 1970. It is possible that the Gateway and Pagoda were constructed during as part of the 1970's refurbishment.

The assessment was completed on September 2nd, 2021 and consisted of a visual and tactile survey of the concrete structures. The survey also included non-destructive field testing and laboratory testing to understand the overall condition of the concrete.

Observations

The results of the visual and tactile survey, as well as test locations, have been summarized in the following report sections. The following general issues were noted:

1) Concrete Damage – There appears to be three general types (and associated locations) of damage present within the two structures:
    a. Roof slab edge cracking/spalling – These cracks were relatively wide, often with exposed reinforcing just below the surface and were observed extensively along the architecturally formed roof slab edges of both structures. (See Photos 5, 6 & 7)
    b. Roof slab honeycombing – Concrete voids of varying extent with exposed reinforcing and reinforcing ties observed on the underside of both roof slabs. (See Photos 8 & 9)
    c. Column cracking – These cracks were relatively narrow in width and minor in extent and were observed in multiple locations on all four Gateway columns. (See Photo 10)
    d. Miscellaneous cracking/spalling – Isolated areas of concrete cracking or spalling, noted in various locations on both the altar and shrine under the Pagoda structure and in two locations on the Pagoda ridge beams. (See Photos 11 & 12)
2) Coating Failure – In general the painted coatings on both structures were found to be failing with widespread cracking and peeling noted. (See Photos 13 & 14)
3) Timber Deterioration – The timber nailing strips which support the concrete roof tiles on both structures are generally at or nearing the end of their service life. (See Photo 15)

In addition, encroachment of nearby trees to both structures is resulting in moderate moss growth and debris accumulation on the roof tiles, as well as extensive moss growth along the perimeter beams around the northeast corner of the Pagoda slab on grade.

Non-Destructive Materials Testing

Several materials tests were conducted on the concrete to better understand the extent and possible causes of deterioration. Testing including the following:

- A total of two small diameter concrete core samples were retrieved from one location on each of the structures. These concrete samples were analyzed for depth of carbonation, as discussed below.
- A rebar detector was used to measure the depth of the reinforcing steel from the surface of the concrete (also known as rebar cover).
- Concrete powder samples were retrieved from one location on each structure. These samples were analyzed for chloride content in conformance with *CSA A23.1-6B*.
- A rebound hammer was used at one location on each structure to estimate the in-situ concrete compressive strength in conformance with *ASTM C805 - Standard Test Method for Rebound Number of Hardened Concrete.*

The results of the testing are summarized in Table 1, below.

Table 1 – Summary of Non-destructive concrete Test Results

Sample ID	Location	Est. Compressive Strength (MPa)	Chloride Con. by mass cement, %	Carbonation Depth (mm)	Rebar Cover (mm)
1	Gateway – South-west column, approximately 1m above grade	37 MPa	<0.06 %	3 – 8 mm	~ 50 mm
2	Pagoda – Interior vertical face of the north support beam	53 MPa	<0.06 %	10 – 13 mm	~ 50 mm

Concrete carbonation is a process in which concrete absorbs carbon dioxide (CO_2) from the atmosphere. In this case, it is expected that the absorption would be a result of the age of the structure and length of exposure time. This absorption of CO_2 neutralizes the pH of the concrete. Although this chemical process has little material effect on the concrete, it creates a durability issue for the embedded reinforcing steel as the reinforcing steel is naturally protected from corrosion by the concrete's alkalinity. Once the concrete becomes carbonated to the depth of the reinforcing steel (in this case, typically ~50 mm), the steel is no longer passivated and, in the presence of moisture and oxygen, the steel is free to corrode.

Along the architecturally formed edges of the roof slabs, the concrete cover was typically within the range of 0 mm to 10 mm where block outs had been formed in the concrete, compared to ~50 mm cover typically around the rest of the concrete members in both structures. At these locations, it is likely that the concrete carbonation has progressed past the depth of reinforcing steel, resulting in the widespread cracking/spalling and corroding reinforcing steel observed.

Discussion

The concrete within the two structures has suffered from carbonation induced damage, particularly in areas of reduced concrete cover, and a moderate amount of deterioration, which is expected considering the age of the structure and length of exposure time.

1) The cracking/spalling along the edge of the roof slabs is likely due to the corroding and expanding reinforcing steel, which is expected from the combination of largely reduced concrete cover and concrete carbonation.

2) The concrete honeycombing noted on the underside of the roof slabs is likely the result of improper vibration and/or distribution of the concrete during construction. These voids present further opportunity for corrosion of the reinforcing steel and carbonation.

3) The minor cracking noted on the four gateway columns may be the result of early stages of stirrup corrosion, as horizontal reinforcing was noted behind each of the observed cracks where the typical concrete cover was ~40 mm. In any case, these cracks present a pathway for further carbonation.

4) The general failure of the painted coatings on both structures is likely the result of the age and exposure of the structures, causing the coatings to crack and peel throughout.

5) The noted deterioration of the timber strips supporting the concrete roof tiles may be a result of exposure to moisture and/or fungal attack, however it is unclear whether or not the timber members were treated and if so, whether any treatment remains.

It is noted that all the issues listed above can all be repaired locally. And, the repairs will likely extend the life of that local portion of the structure. However, holistically, it is expected that new areas of damage will emerge at an accelerating rate going into the future. As the concrete continues to carbonate, more embedded steel elements will become susceptible to corrosion damage and this will result in concrete cracking & spalling.

Recommendations

Intervention is now required to repair the damaged concrete and to extend the life of the structure. The following is a list of issues requiring repair/intervention:

1) The damage to the edges of the roof slabs on both structures as noted above require repair. Much of the damage is loose overhead and poses a falling hazard. Repair of this damage will typically include removal of loose/deteriorated concrete, replacement of deteriorated reinforcing steel, installation of galvanic anodes and patching with an appropriate repair mortar/concrete.

2) In areas where honeycombing is present on the underside of the roof slabs, it is recommended that the voids be cleaned and patched with an appropriate repair mortar/concrete. Where corroded reinforcing steel is discovered, replacement of the deteriorated reinforcing steel and installation of galvanic anodes is recommended.

3) It is recommended that all existing painted coatings be removed and repainted. In general, it is recommended that all exposed concrete be painted or sealed on both structures.

4) It is recommended that the roof tiles be removed from both structures in order to seal the topside of the concrete roof slabs and to replace the deteriorated timber nailing strips with new pressure treated members. Prior to reinstalling the roof tiles, it is recommended that the tiles be cleaned free of moss and other accumulated debris.

5) Upon removal of the Gateway roof tiles, it is recommended that the timber framing supporting the tiles be removed and replaced.

6) It is recommended that all areas of miscellaneous concrete damage be repaired, including the cracking and spalling noted on the Pagoda altar and shrine, as well as the exposed reinforcing noted in two locations on the Pagoda ridge beams.

7) Pressure washing of the concrete perimeter beams around the Pagoda slab on grade is recommended in order to remove the moss growth and accumulated debris.

8) It is recommended that the tree branches surrounding both structures be trimmed back to prevent further vegetative growth and accumulation.

9) It is recommended that the existing steel gate anchored to the Gateway structure be sandblasted and repainted.

Opinion of Probable Costs

An opinion of probable costs has been provided with the assistance of a Victoria area concrete contractor with sufficient experience in the concrete refurbishment and paint coating industry. Typically, concrete repair projects are deigned/tendered on a unit rate basis (area of concrete repair) due the uncertainty of total amount of damage. However, in this case the total quantity of the concrete repairs is relatively small and it is likely that a lump sum payment basis is most practical.

The scope of the work for the opinion of probable cost has been based on the recommendations above and the attached damage drawings.

Concrete Repairs & Painting:	$50,000.00
Engineering Design & Review (15%):	$7,500.00
Total (excluding applicable taxes):	$57,500.00

Closing

Herold Engineering is available to assist with the next stages of this project, including repair designs & specification and the preparation of repair budgets.

I trust this information is sufficient. Please call with any questions.

Per: HEROLD ENGINEERING LIMITED

Prepared by:

Taylor MacLean, EIT
Design Engineer

Reviewed by:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA C. T. APPELMAN # 38915

26 APRIL 2022

Craig Appelman, P.Eng.
Materials Engineer

References:

1- https://www.findagrave.com/cemetery/2409822/chinese-cemetery

Attachments:

- Site Photos
- Damage Drawing
- Test results

Unit 600 - 1112 Fort St Victoria, BC V8V 3K8
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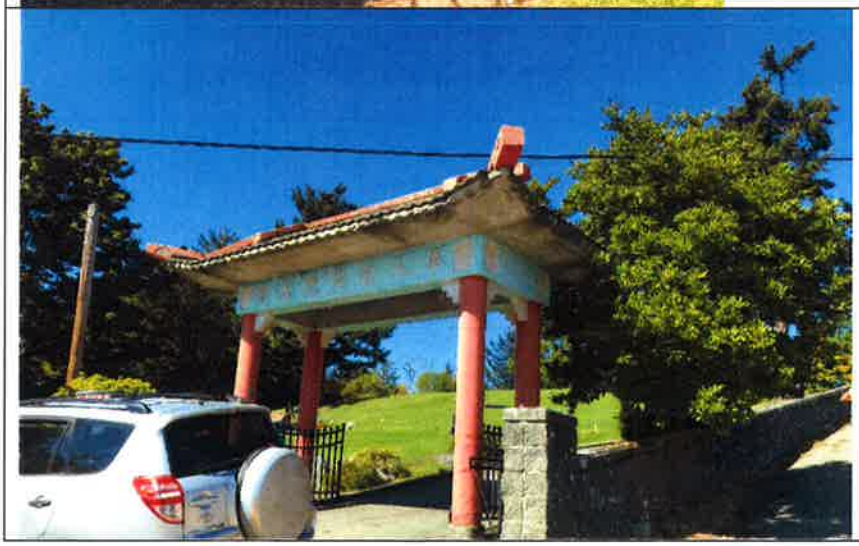
	Photo 1 – General view of the Pagoda structure, looking north
	Photo 2 – General view of the Pagoda structure, looking east
	Photo 3 – General view of the Gateway structure, looking northeast

	Photo 4 – General view of the Gateway structure, looking south
	Photo 5 – View of the architecturally formed roof slab edges
	Photo 6 – View of typical cracking/spalling along the roof slab edges

	Photo 7 – Close view of typical roof slab edge cracking/spalling with exposed reinforcing steel
	Photo 8 – View of typical concrete honeycombing on underside of Gateway roof slab

	Photo 9 – Close view of concrete honeycombing/voids in Gateway roof slab with exposed ties and reinforcing steel
	Photo 10 – View of a typical minor crack in the Gateway structure columns

	Photo 11 – Close view of cracking/spalling on Pagoda altar
	Photo 12 – View of exposed reinforcing steel on Pagoda shrine

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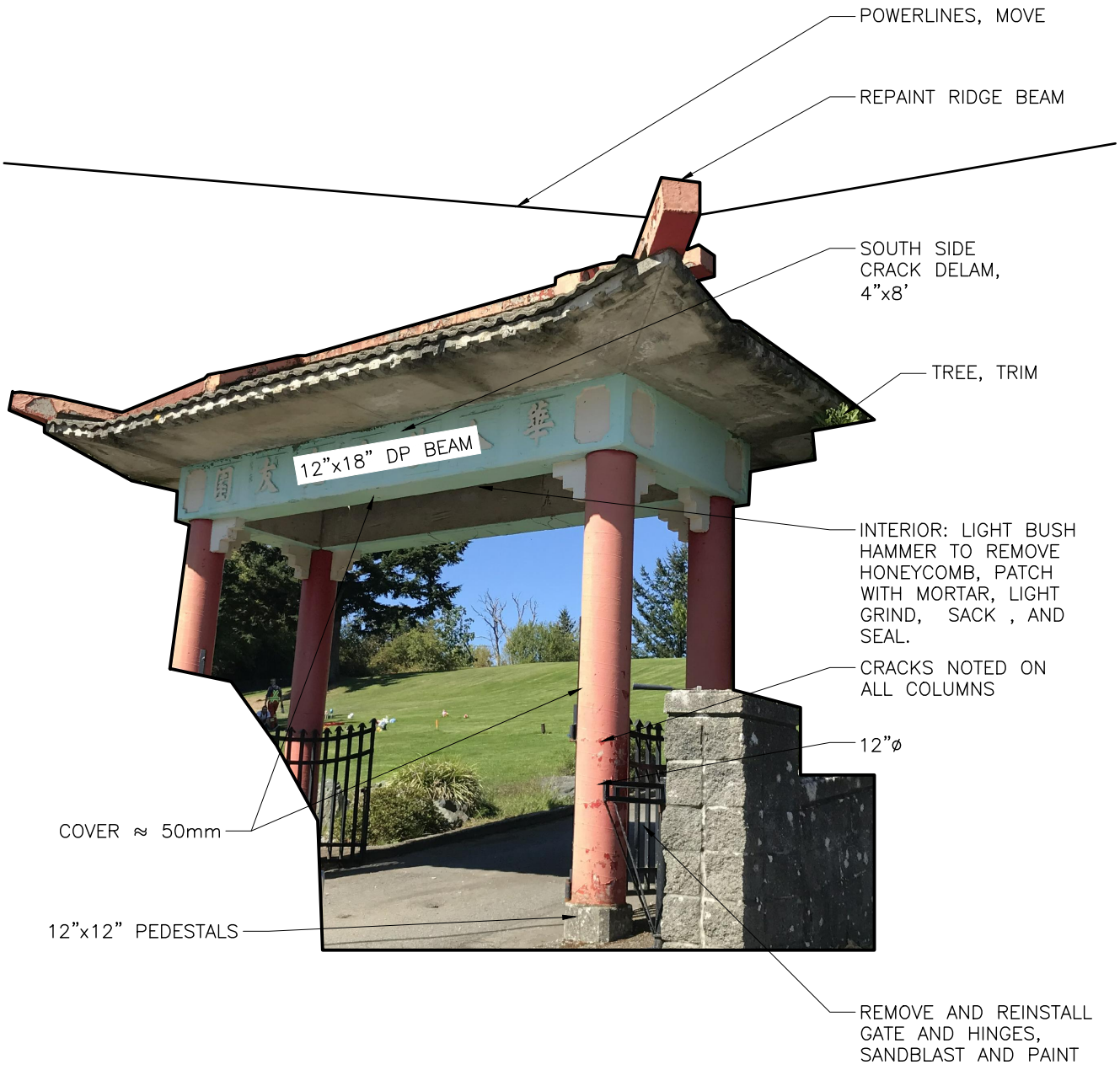
	Photo 13 – Example of the typical condition of the existing painted coatings (Pagoda ridge beam)
	Photo 14 – Example of the typical condition of the existing painted coatings (Gateway beam)
	Photo 15 – View of the deteriorated timber members supporting the roof tiles



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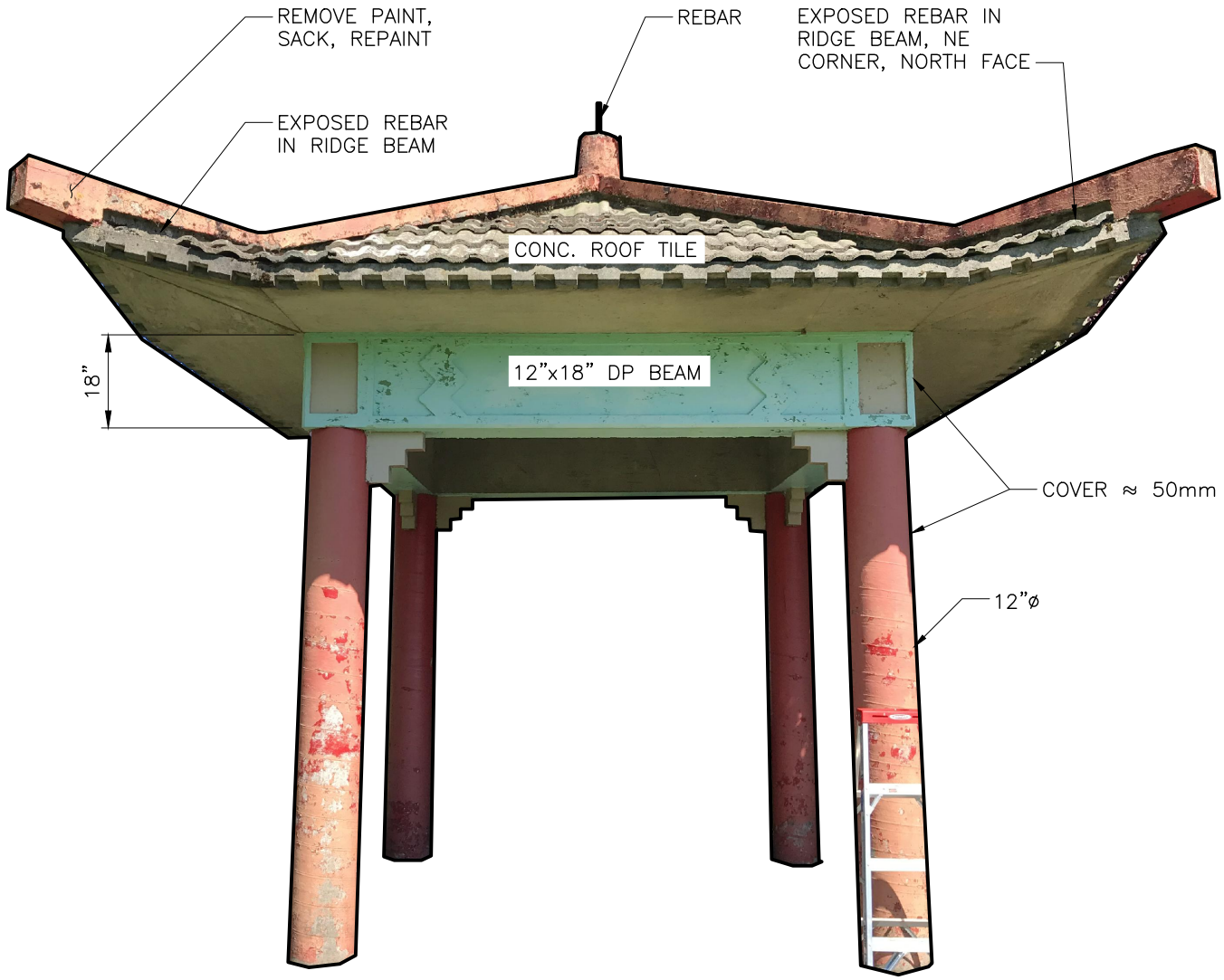
Permit to Practice: 1000201

NANAIMO TOWNSITE ROAD CEMETERY GATEWAY ASSESSMENT

ENTRANCE

PROJECT No.	DESIGNED	DESIGN REVIEW	DRAFTED	DRAFTING REVIEW	SCALE	DRAWING No.	REV.
0017-420					N/A		

DESTROY ALL DRAWINGS SHOWING PREVIOUS REVISION



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NANAIMO TOWNSITE ROAD CEMETERY GATEWAY ASSESSMENT

PAGODA

PROJECT No.	DESIGNED	DESIGN REVIEW	DRAFTED	DRAFTING REVIEW	SCALE	DRAWING No.	REV.
0017-420					N/A	SK1	

DESTROY ALL DRAWINGS SHOWING PREVIOUS REVISION

Your Project #: DO17-420
Site Location: TOWNSITE CEMETERY
Your C.O.C. #: 08494935

Attention: Craig Appelman

Herold Engineering
3701 Shenton Road
Nanaimo, BC
CANADA V9T 2H1

Report Date: 2021/09/21
Report #: R3074338
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C168230
Received: 2021/09/14, 12:45

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride in Soil (5:1 DI extract)	4	2021/09/20	2021/09/20	BBY6SOP-00011	SM 23 4500-Cl- E m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

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Attention: Craig Appelman

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CANADA V9T 2H1

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BV LABS JOB #: C168230
Received: 2021/09/14, 12:45

Encryption Key

AUTHORIZED REPORT
RAPPORT AUTORISÉ

Bureau Veritas
21 Sep 2021 10:46:59

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Customer Solutions, Western Canada Customer Experience Team
Email: customersolutionswest@bureauveritas.com
Phone# (604) 734 7276

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BV Labs Job #: C168230
Report Date: 2021/09/21

Herold Engineering
Client Project #: DO17-420
Site Location: TOWNSITE CEMETERY
Sampler Initials: CA

RESULTS OF CHEMICAL ANALYSES OF SOIL

BV Labs ID		AFW826	AFW827	AFW828	AFW829		
Sampling Date		2021/09/02 12:00	2021/09/02 12:00	2021/09/02 12:00	2021/09/02 12:00		
COC Number		08494935	08494935	08494935	08494935		
	UNITS	TOWNSITE, LOC#1, 0-15MM	TOWNSITE, LOC#1, 15-30MM	TOWNSITE, LOC#2, 0-15MM	TOWNSITE, LOC#2 15-60MM	RDL	QC Batch
ANIONS							
Chloride (Cl)	ug/g	<100	<100	<100	<100	100	A359145
RDL = Reportable Detection Limit							

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BV Labs Job #: C168230
Report Date: 2021/09/21

Herold Engineering
Client Project #: DO17-420
Site Location: TOWNSITE CEMETERY
Sampler Initials: CA

GENERAL COMMENTS

Results relate only to the items tested.

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BV Labs Job #: C168230
Report Date: 2021/09/21

QUALITY ASSURANCE REPORT

Herold Engineering
Client Project #: DO17-420
Site Location: TOWNSITE CEMETERY
Sampler Initials: CA

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
A359145	Chloride (Cl)	2021/09/20	97	75 - 125	102	75 - 125	<100	ug/g	NC	30

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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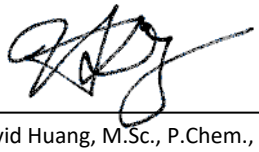
BV Labs Job #: C168230
Report Date: 2021/09/21

Herold Engineering
Client Project #: DO17-420
Site Location: TOWNSITE CEMETERY
Sampler Initials: CA

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:



David Huang, M.Sc., P.Chem., QP, Scientific Services Manager

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Victoria: 460 Tennyson Place, Unit 1, Victoria, BC V8Z 6S8 Toll Free (866) 385 6312
maxxam.ca

08494935

CHAIN OF CUSTODY RECORD

Invoice Information		Report Information (if differs from invoice)		Project Information		Turnaround Time (TAT) Required	
Company:	Herold Engineering Ltd.	Company:		Quotation		☑ 5 - 7 Days Regular (Most analyses)	
Contact Name:	Craig Appelman	Contact Name:		P.O. #/AFE#:		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS	
Address:	1112 Fort Street, Victoria BC	Address:				Rush TAT (Surcharges will be applied)	
	PC: V8V 3K8		PC:	Project #:	0017-420	☐ Same Day ☐ 2 Days	
Phone/Fax:	236 464 0981	Phone/Fax:		Site Location:	Townsite Cemetery	☐ 1 Day ☐ 3-4 Days	
Email:	cappelman@heroldengineering.com	Email:		Site #:	NA	Date Required:	
Copies:		Copies:		Sampled By:	CA	Rush Confirmation #:	

Laboratory Use Only

	YES	NO	Cooler ID			
Seal Present		X				
Seal Intact	N	A	Temp			
Cooling Media		X				
	YES	NO	Cooler ID			
Seal Present						
Seal Intact			Temp			
Cooling Media						
	YES	NO	Cooler ID			
Seal Present						
Seal Intact			Temp			
Cooling Media						

Depot Reception

Analysis Requested

Sample Identification	Date Sampled (yyyy/mm/dd)	Time Sampled (hh:mm)	Matrix	# of Containers	VOC / BTEXS / VPH	BTEXS / VPH	VOC / BTEX / F1	BTEX F1	LEPH / HEPH / PAH	PAH	F2 - F4	TEH	EPH	Preserved?	Filtered?	Preserved?	Filtered?	Field Preserved?	Dissolved Metals	Field Preserved?	Dissolved Mercury	Total Metals	Total Mercury	Sulphate	Fluoride	Chloride	COD	TDS	TSS	Alkalinity	Conductivity	pH	Ammonia	Nitrate	Nitrite	HOLD - DO NOT ANALYZE	Special Instructions
1 Townsite, Loc #1, 0 - 15 mm	02/09/2021	12:00	Powder																							X											Per ASTM C1218 Method
2 Townsite, Loc #1, 15 - 30 mm	02/09/2021	12:00	Powder																							X											Per ASTM C1218 Method
3 Townsite, Loc #2, 0 - 15 mm	02/09/2021	12:00	Powder																							X											Per ASTM C1218 Method
4 Townsite, Loc #2, 15 - 60 mm	02/09/2021	12:00	Powder																							X											Per ASTM C1218 Method

Regulatory Criteria: ☐ BC CSR ☐ YK CSR ☐ CCME ☐ Drinking Water ☐ BC Water Quality ☐ Other

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Relinquished by: (Signature/ Print)	Date (yyyy/mm/dd):	Time (hh:mm):	Received by: (Signature/ Print)	Date (yyyy/mm/dd):	Time (hh:mm):	Maxxam Job #
Craig Appelman	14/09/2021	12:00	SNA Shayna Nicholson	2021/09/14	1245	

COC-1020

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