Twin Falls Soil Analysis and Drone Imagery Updates

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Introduction

In 2021, Anatolijs Venovcevs and James Williamson conducted a one-week survey at the mothballed hydroelectric plant and associated community at Twin Falls, Labrador (Venovcevs and Williamson 2022) (Figure 1). The fieldwork provided detailed documentation on the industrial and settlement areas of the site through a UAV survey and surface documentation of visible remains while producing promising results from limited photogrammetry and test pitting. However, a few vital issues remained unresolved – namely a proper colour correction of the drone imagery, the original function of the remaining buildings, and the results of the soil samples collected from two test pits near Building 1. This report is meant to tie up those loose ends.

The history, geography, and conditions of Twin Falls have been discussed previously and will not be repeated here (see Venovcevs and Williamson 2022). Suffice to say, Twin Falls represents a significant contemporary heritage site of a former hydroelectric community and associated industrial facility dating from 1959 with the start of construction to 1972 when the community was demolished and the plant perpetually mothballed. Despite the rapid rise and fall of one of Labrador's first industrial towns, a dispersed community of former residents and their descendants continues to exist with ties and memories of the place.

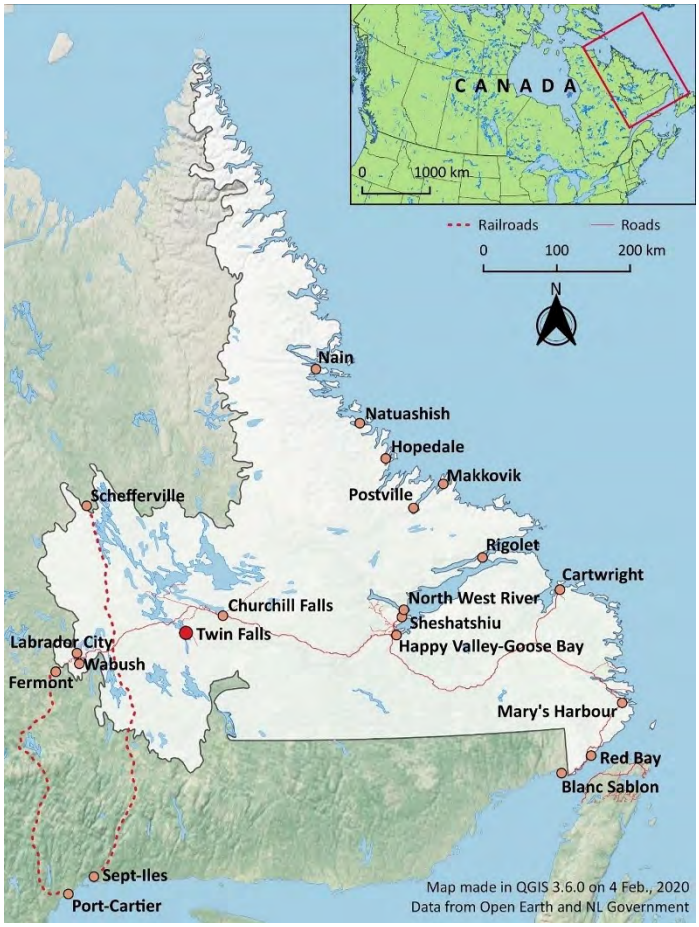


Figure 1: Location of Twin Falls within Labrador (map by Anatolijs Venovcevs).

Colour Correction

The 2021 report offered only preliminary drone imagery of the work camp, settlement area, the power plant, and the dams (see Venovcevs and Williamson 2022:261-264 for details on how these were collected and georeferenced). While the images produced were sufficient for the subsequent publication, the automatic light settings used to mitigate the effects of moving clouds over the surveyed areas, nevertheless produced colour balancing issues that could not accommodate for the variations. These variations caused some photos to appear in different shades showing overlapping areas. A programmatic solution was necessary as we had to edit each photo.

Over the previous year, James Williamson used R Studio to standardize the images by applying histogram equalization using the base R and jpeg packages (R Core Team 2013; Urbanek 2021). Histogram equalizations have been regularly used to improve imagery by re-balancing pixel value counts towards mid-values (Richards & Jia 2006).

Afterwards, he used Agisoft Metashape to prepare the 3D models for the features (Agisoft LLC 2022). The models were processed at a "High Quality" through every option. He then placed the control markers on the appropriate points in the model and checked to ensure they were correct. The models had an average spatial error of less than five centimetres. The next step was to create the export rasters: a DEM and an orthophoto mosaic were generated. These options were all set within a batch process.

The rasters were exported to QGIS, which James used to reproject the data from the original WGS 84 coordinates to the Pseudo-Mercator Projection (QGIS.org 2020).

One thing to note about the new colour corrected imagery is that there is a difference between the colour of alders in the former settlement (greying-purple) and those in the former reservoir (greenish-yellow) (Figure 2 and Figure 3). The difference might be from the relative nutrient levels in the soil leading to differential periods of leaf growth in early June. Photographs from the Twin Falls settlement when it was occupied shows the area as grubbed off and covered with gravel whereas the reservoir was simply filled with water – leaving behind the original nutrient layer.

Building Identification

Since the time of the initial investigation, members of the former Twin Falls community have been engaged to identify the remaining and absent buildings at the former settlement. Namely, Sharon Montague, Joan MacLean, Stan Baikie, Frank Hennebury, Tom Frost, and the rest of the "Twin Falls, Labrador" Facebook page were instrumental at having the buildings identified. These can be seen in Figure 2 and Figure 3 on the new colour corrected imagery. The correlation of field designations for buildings (Venovcevs and Williamson 2022, 267) to the buildings' original functions are summarized in Table 1.

From this, it can now be said that the test pits excavated in 2021 were adjacent to the Recreational Centre. Test Pit 1 was excavated by the door in the southwest corner of the building and Test Pit 2 was excavated within the former greenhouse alcove in the southeast corner (Figure 4). The identification of the former greenhouse would explain why Test Pit 2 produced architectural remains in the form of wood and asbestos (Venovcevs and Williamson 2022, 271).

Methods

On June 8, 2021, Anatolijs Venovcevs and James Williamson collected five soil samples from test pits – two from Test Pit 1 and three from Test Pit 2. In Test Pit 1, the soil samples were taken from the east profile at 18 cm and 38 cm (Figure 5). In Test Pit 2, the soil samples were taken from the east profile at 12 cm, 29 cm, and 52 cm (Figure 6). These were sent to the archaeological laboratory at UiT: The Arctic University of Norway and analysed by Steffen Tjøtta Bakke and Fink Raymond Juhl as part of the course "Introduction to laboratory archaeology and soil chemical analysis" supervised by Johan Eilertsen Arntzen. While these soil samples are too few to provide any definitive knowledge on function and distribution of activity areas at Twin Falls, they may offer an idea of what can be expected if a larger excavation and/or soil sampling survey were to take place at the site.

Table 1: Structural Remains at Twin Falls.

Designation	Foundation	Size in feet	Surface features	Function
Building 1	Concrete	100 x 40	Tile and wall outlines, utilities	Recreational Centre with greenhouse attachment
Building 2	Concrete	70 x 30	Tile and wall outlines, utilities	Arch Goudie School
Building 3	Concrete	100 x 25	Tile and wall outlines, utilities	Grocery Store
Building 4	Concrete	140 x 40	Utilities, machine pit, few pieces of hardware	Garage
Building 5	Concrete	85 x 20	Many pieces of hardware, pull tabs and bottle cans	Carpentry Shop
Building 6	Concrete	20 x 16	Nails, melted lead, glass, charcoal, large pieces of machinery	Pump House
Building 7	Concrete	115 x 40	Wooden supports, couple pieces of hardware	Fuel Storage and Garages
Building 8	Asphalt	95 x 40	Empty	Office
Building 9	Asphalt	(135 x 40) in three parts	Couple pieces of hardware	Mess Hall

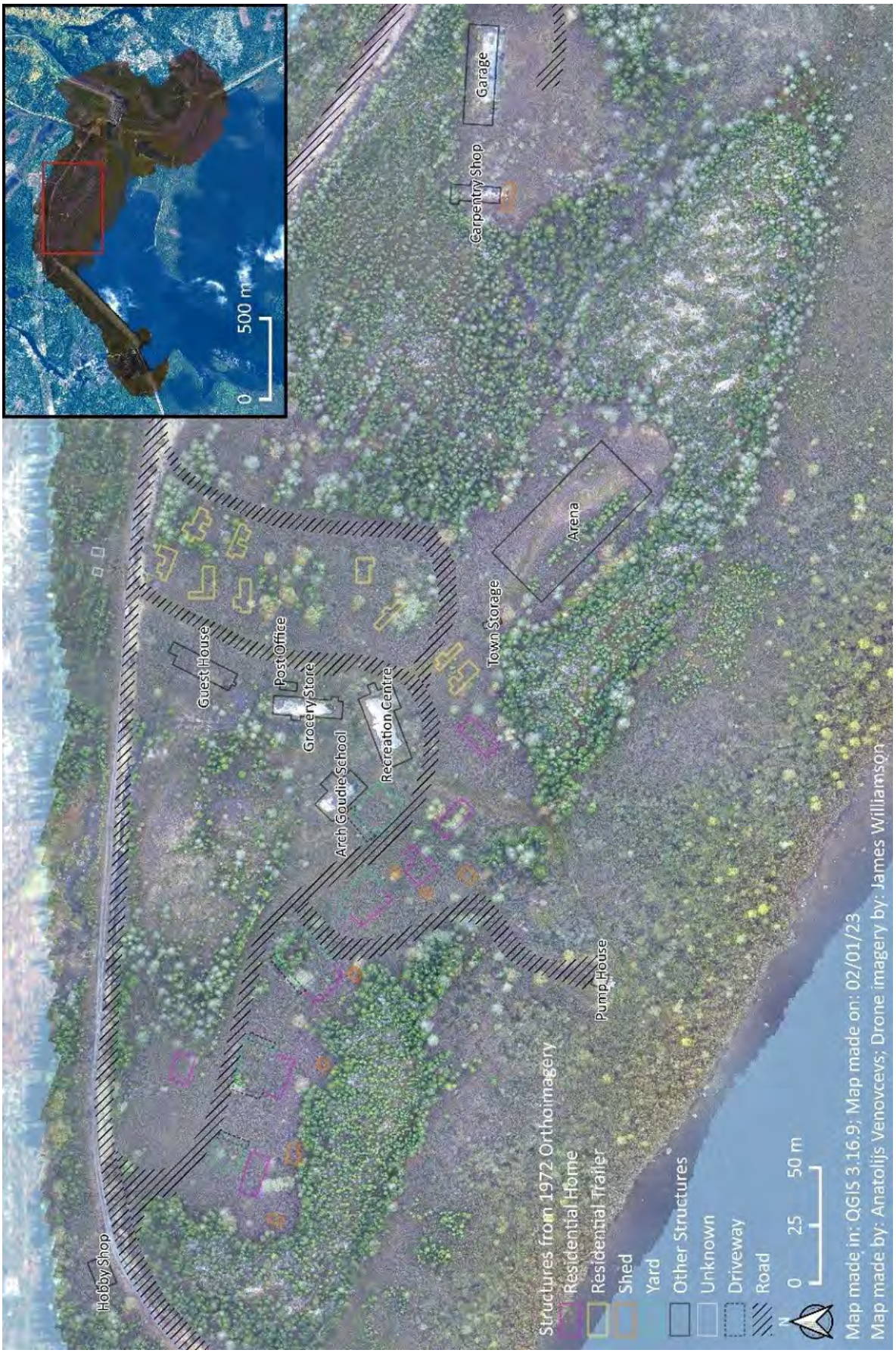


Figure 2: Twin Falls settlement area (map by Anatolijs Venovcevs, colour balanced imagery by James Williamson, structure identification by Twin Falls descendant community).

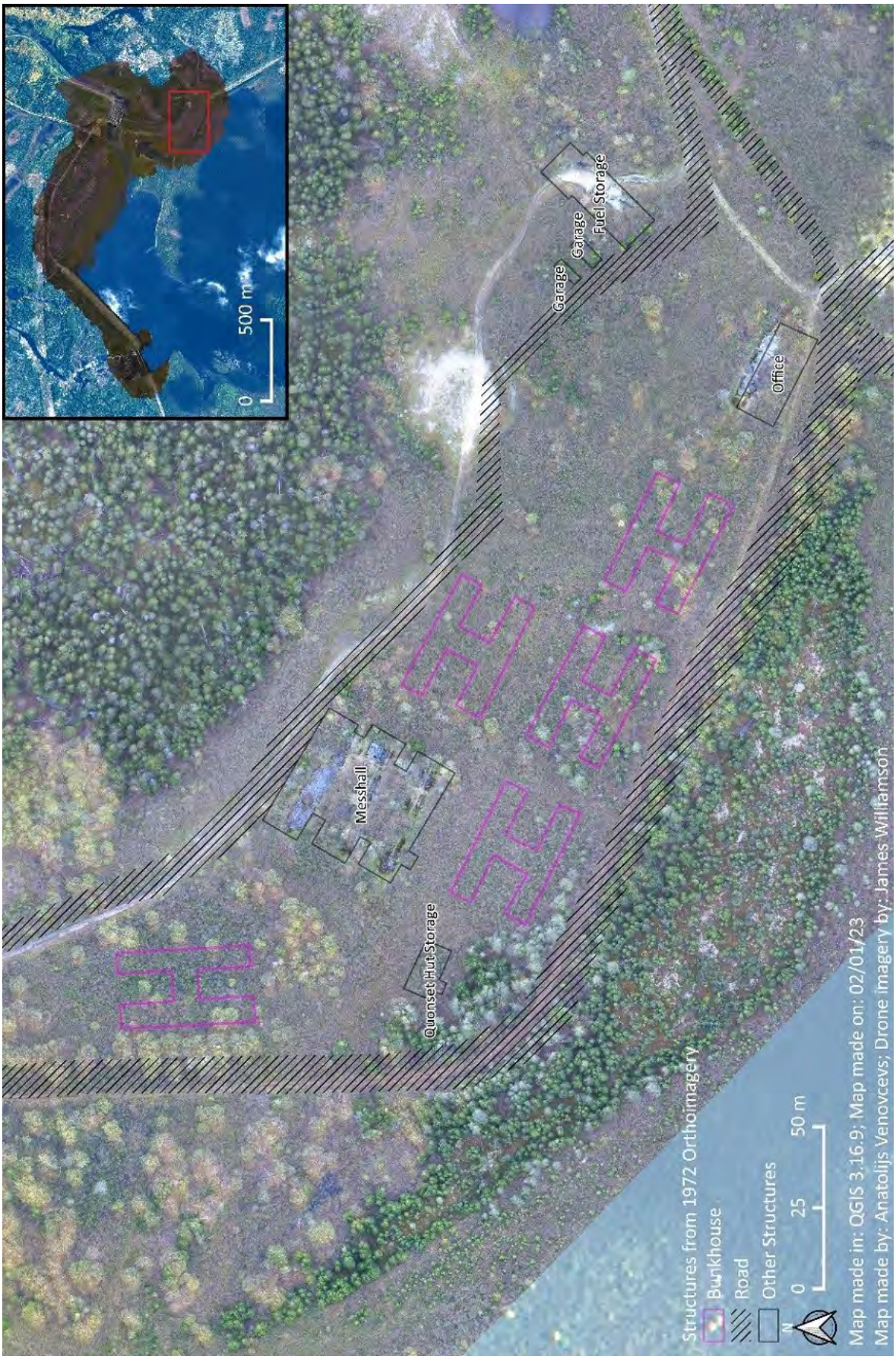


Figure 3: Twin Falls work camp (map by Anatolijs Venovcevs, colour balanced imagery by James Williamson, structure identification by Twin Falls descendant community).

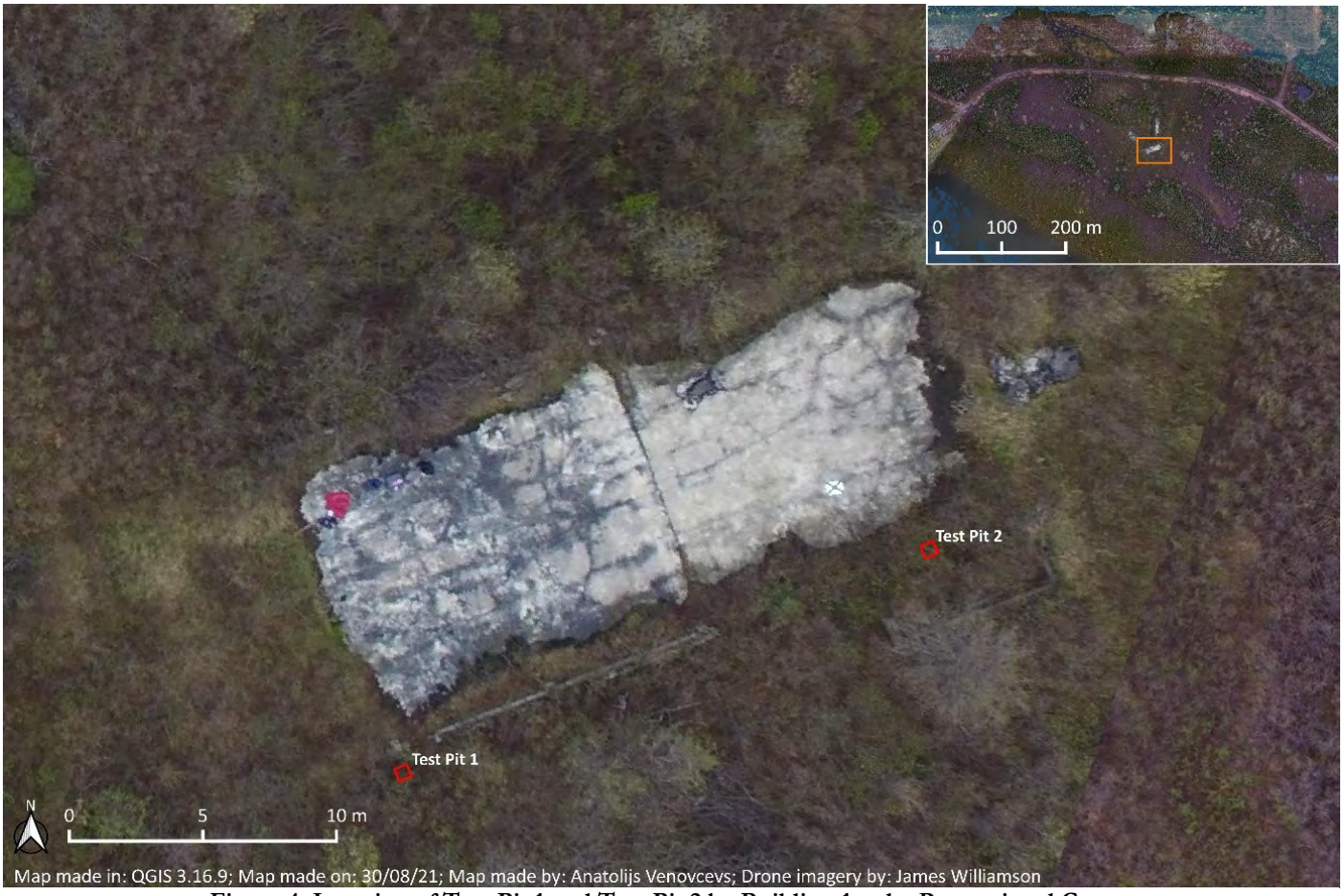


Figure 4: Location of Test Pit 1 and Test Pit 2 by Building 1 – the Recreational Centre (map by Anatolijs Venovcevs, imagery by James Williamson).

Prior to analysis all samples have been dried to constant weight at room temperature, visually described, homogenized, and finally passed through a 1.25 mm sieve. The analytical procedures undertaken were as follows.

First the soil pH was analysed which is indicative of the preservation conditions for archaeological artifacts, like for example bone, shell, and iron. Analysing the pH is also important to evaluate the applicability of different soil analysis procedures.

The soil pH was determined by weighing up 10 g of homogenized soil from each sample in separate beakers. A 0.1 M potassium chloride solution was added to each sample with a ½ soil to solution ratio. The beakers were then moved to an orbital shaker for 30 min and left to settle for another 30 min. The soil pH was measured using a five-point-calibrated glass electrode. This procedure was the same for each soil sample, except sample nr. 2 which had a high proportion of organic material. Because of this the sample had to be centrifuged at 2800 RPM for 5 additional minutes prior to the PH measurement.

To get the soil phosphate levels we used the Olsen soil sample test for plant available P by sodium bicarbonate extraction (Olsen et al. 1954, Olsen 1982). The first step was to measure up 1 g of homogenized soil into a 40-ml Erlenmeyer flask, then adding 20 ml of a 0.5 N sodium bicarbonate extraction solution. The flasks are then covered and moved to an orbital shaker for 30 min. It is important that the ambient temperature is stable at 20 C for all steps of the procedure. After 30 min the liquid is moved to test tubes and centrifuged for 5 min at 2800 rpm. 1 ml of mixture was then transferred to medicine cups using a pipet, then 9 ml of deionized water is added. Afterwards 0.125 ml of a 4M sulfuric acid solution was added. The lids were placed on each cup, and they got three shakes before being left alone to develop CO2. Next, 0.4 ml of an ascorbic-acid solution and 0.4 ml potassium antimony tartrate solution are added. Afterwards the samples were all placed on the

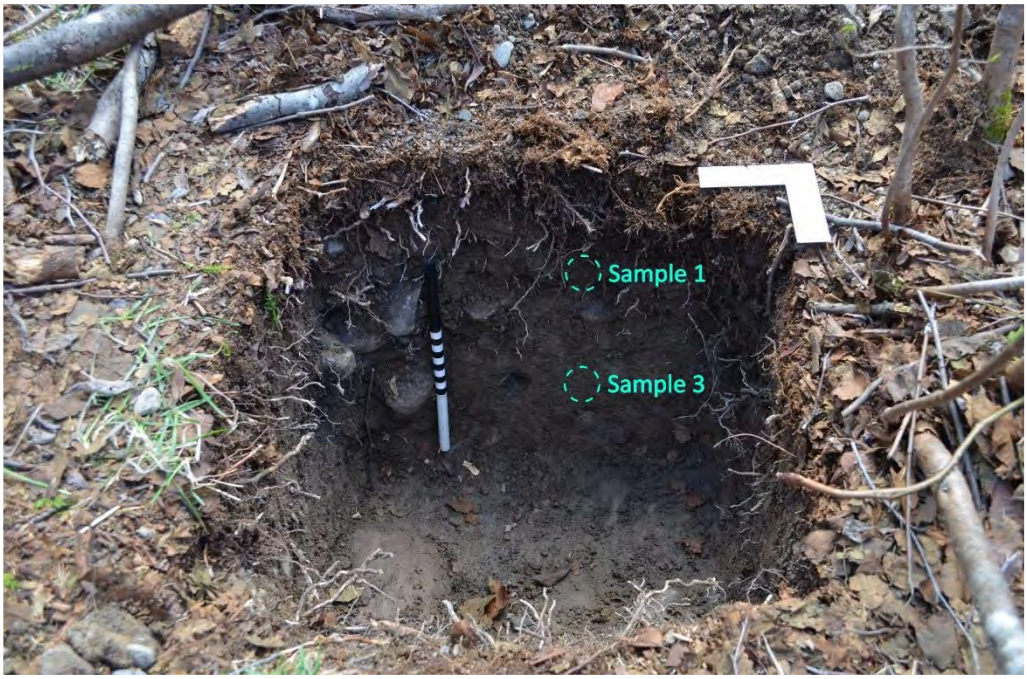


Figure 5: Sample 1 and Sample 3 within Test Pit 1 (photo by James Williamson, figure by Anatolijs Venovcevs).

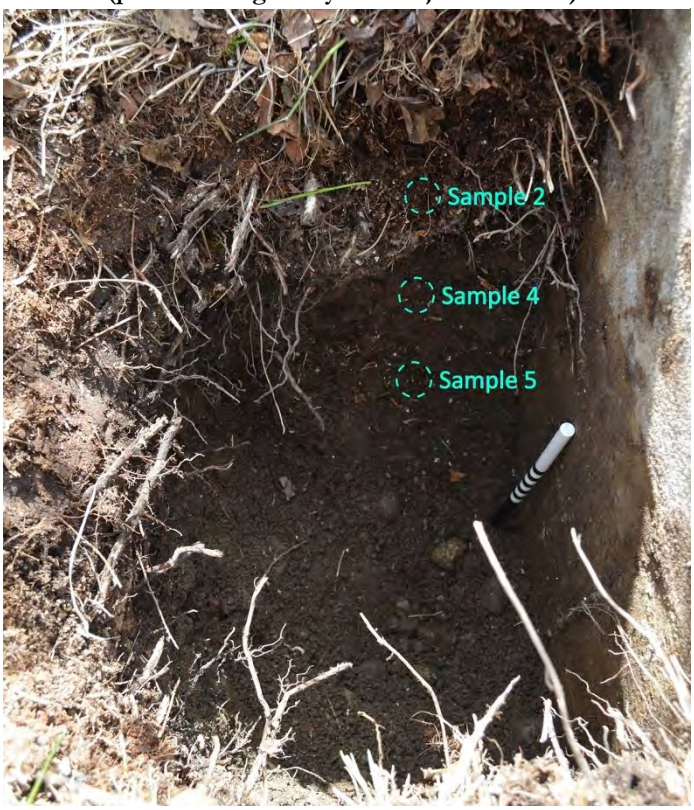
orbital shaker for 10 min, after the shaking they got to stand still for 20 min to develop colour by molybdenum blue reaction. Phosphate content was determined using a standard solution made up from dihydrogen phosphate and 0.1 M sulphuric acid solution. The readings were done using a spectrophotometer operating at a wavelength of 880 nm. The Olsen method recommends using 5 g of soil, but we only used 1 g, this might give somewhat poorer repeatability.

Magnetic susceptibility is the act of measuring how 'magnetisable' different materials are. Different materials, like minerals and/or crystals, all have varying levels of attractions with magnetism, and when these materials get interacted their susceptibility also gets affected. For instance, human actions, like burning and waterlogging, will change how magnetizable these materials are. MS levels in anthropogenic soils are influenced by past human activities and have the potential to explain and delimit specific types of activities or events, especially those connected to the use of fire and heat (Dearing 1999).

For the analysis we used a Bartington MS3 meter and a MS2B laboratory sensor (Dearing 1999). To get accurate data 10 g of homogenized soil was put in individual plastic containers before being analysed one by one. To get the correct MS value one must account for the different masses and shapes the samples have. Identical 10 CC sample cups were therefore used. The reading time for each sample was 1 second, and the instrumental drift between each sample was corrected. When using the calculations described by Dearing (1999) this then give a mass specific MS result of (χlf 10–8 m3 kg–1) SI units per 10 g soil.

Loss on ignition (%LOI) is used to determine the amount of organic material contra mineral within a sample. This is done by comparing the weight of each sample before and after controlled incineration. This way the total amount of organic carbon (OC) lost under the treatment can be calculated (Reitz and Shackley 2012).

Figure 6: Samples 2, 4, and 5 within Test Pit 2 (photo and figure by Anatolijs Venovcevs).



Porcelain crucibles were weighed and filled with 5-10 grams of soil then placed in an oven at 50 C to dry overnight. When the samples reached room temperature, they were weighed with an accuracy of 0.001 grams. They were then placed in a muffle furnace for 1 hour at 250 C, then 3 hours at 550 C. When the time had gone by the door stood open for 15 min to cool down the samples. They were then moved to a desiccator for further cooling and to ensure that the risk of moisture absorption was minimal. After the cooldown they were again weighed to compare the weight before and after.

A Portable X-Ray Fluorescence Spectroscopy (pXRF) can analyse different elemental compounds of a material. This makes it possible for archaeologists to map out areas based on chemical compounds in soil. Human activity can increase the organic content in soil and modify the concentrations of elements such as sulphur and phosphate, which are linked to waste management practices. Industrial activities can also lead to increased levels of heavy metals such as lead or mercury. Analysing these elements can for example be used before excavations to get a better understanding of what might be underneath the ground (Williams, Taylor, and Orr 2020). A pXRF analysis can also be used to support data gathered from magnetic susceptibility by identifying the magnetizable compounds.

The analysis was done using the Thermo Niton XL3t GOLDD+ analyser. The soil was mounted in prolene-film covered sample cups prior to analysis. The pXRF instrument is mounted in a lead covered table stand and controlled remotely by a computer to increase safety and secure identical analytical conditions for each sample. Each of the samples were analysed twice with two different modes, Mining Mode and Soils Mode. The reading time for Mining Mode was 120 sec and the reading time for Soils Mode was 90 sec.

Results

The different samples have all been run through the same process. The results are presented in Table 2. The position of the test pits are shown on Figure 4. Figures 5 and 6 show the stratigraphy and placement of the different samples.

Test Pit 1 had been placed by the remains of a door in the southern corner of Building 1 (Recreational Centre), this test pit was dug to a depth of approximately 44 cm. The first 10 cm of the test pit was made up of organic material followed by a yellow greying layer, 25 cm thick, of very wet sand mixed with some gravel. Under this there was a layer of assumed construction sand. Some artifacts were found in the layers, a nail, 4 pieces of unidentified wood, 2 pieces of metal, 1 tin foil wrapping and 1 fragment of an outdoor lamp (Venovcevs and Williamson 2021, 271).

Test Pit 2 was placed inside a small addition (a former greenhouse) along the southeast of the remains of Building 1. This pit was dug to a depth of approximately 76 cm. The interesting bit about this test pit was that directly under the organic layer,

Table 2: Soil Sample Data.

Lab nr.	Field nr.	Weight (g)	Soil type	Colour	Observations	Weight, dry	LOI (%)	MS	P	pH
1	TP1 SSI 18 cm E Wall	71.85	Medium sand, Gravel	Light Brown, with greytones	Nail found in the soil bag. Some roots in the soil	17.089	4.842	2394.55	2.334	5.58
2	TP2 SSI 12 cm E Wall	35.68	Fine, sand		Flakes of white paint, bigger pieces of asbesthos. Small pieces of foil	16.867	32.551	477.60	2.537	8.4
3	TP1 SS2 38 cm E Wall	135.8	Medium Silt	Light Brown	Traces of small roots, potentional coal flake	17.161	1.565	2512.25	2.219	5.93
4	TP2 SS2 29 cm E Wall	82.98	Silt to small gravel	Light beige	Specks of small gravel with a few bigger pieces	15.065	2.646	2951.37	2.199	7.13
5	TP2 SS3 52 cm E Wall	124.91	Silt, gravel	Light Beige	Some gravel, traces of small roots, white paint flake	17.088	1.563	2884.05	2.275	7.214

where there was a 4 cm thick wooden layer, this was interpreted as a possible floor. This layer contained a wet and compressed layer of asbestos, approximately 2-7 cm thick right underneath it. Under this layer there was a layer of brown thick sand with bits of gravel, this was interpreted as construction fill. The artifacts pulled out of this test pit were 11 pieces of bathroom ceramic, 6 pieces of wood (one was laminated), 1 piece of floor tile (this tile was suspected to also contain asbestos), and 1 metal 11 cm disk with asbestos corroded onto it (Venovcevs and Williamson 2021, 271).

The 5 soil samples all consisted of medium to fine sand. The colour of the samples varied from a light brown to a greyish colour. Most of the samples also contained some traces of other material than just sand. The 5 samples were taken at different depths varying from approximately 20 cm to 50 cm, in two different test pits. The samples were therefore divided into two sections with the field nr. TP1 and TP2. TP1 has samples 1 and 3, whilst TP2 has samples 2, 4 and 5.

Sample 1 (TP1 SSI) was taken at a depth of 18 cm, from the south wall in Test Pit 1. Sample 1 contained medium sand with some traces of medium gravel, the colour was light brown with some grey tones. The sample's weight was 71.85 grams before the drying process and analysis. The sample contained the remains of a corroded nail; small iron nail fragments can have affected the magnetic susceptibility levels. The magnetic susceptibility of each sample will be discussed further in later paragraphs of the results section. Besides the nail, the sample also contained small root fragments.

Sample 2 (TP2 SSI) was taken at a depth of 12 cm, from the east wall in Test Pit 2. It weighed in at 35.68 grams before drying and analysis. The contents were of fine sand with the same colour tone as previous samples. In the sample foreign objects besides dirt were found. Some of the material were flakes of what seems to be white paint, some bigger pieces of asbestos and the remains of what seems to be some sort of foil.

Sample 3 (TP1 SS2) was taken at a depth of 38 cm on the east wall. Its weight before drying was 135.8 grams. The sample's content was medium silt with a light brown colour. Besides small charcoal fragments, no other contamination was noted. Sample 4 (TP2 SS2) also came from a depth of 29 cm at the east wall. Its weight before the drying process was 82.98 grams. The soil properties of the sample was determined to be silt with some small gravel inclusions. The colour of the sample was light brown with a greyish tone.

Sample 5 (TP2 SS3) was taken at a depth of 52 cm by the eastern wall. The sample's weight before the drying process was 124.91 grams. The colour of the sample material was determined as a light brown colour. Root fragments, gravel and white paint flakes, as seen in Sample 2, were noted (TP2 SSI).

The soil samples that were taken during the preliminary survey at Twin Falls all vary in levels of pH from 5.6-8.4. With Sample 1 (TP1 SSI) having the lowest value of 5.6 and Sample 2 (TP2 SSI) having the highest value of 8.4. This high pH level in Sample 2 could be explained by the higher levels of calcium documented by pXRF (Mining Mode) analysis. Sample 1 and 3 had lower pH than the other making them more acidic than the rest. Samples 4 and 5 had a more neutral pH level close to 7, Sample 5 was a little higher than 4. It is worth mentioning that the Olsen P extraction method used is not suitable for acidic soils (pH<5.6). The high pH level in Sample 2 (TP2 SSI) could be influenced by the contamination of foreign material in the sample (asbestos and paint flakes) that was noted during the homogenization process.

The addition of organic matter to most forms of soils will, in some way or another, significantly alter the forms, interactions and redistributions of phosphorus (Holliday & Gardner 2006). The organic material found in the samples varies between 1-5% besides Sample 2 which had a percentage close to 33%. Sample 1 (TP1 SSI) had a LOI percentage of 4.8%. Sample 2 (TP2 SSI) had a LOI percentage of exactly 32.5%. Sample 3 (TP1 SS2) had a LOI percentage of 1.5%. Sample 4 (TP2 SS2) had a LOI percentage of 2.6% and lastly sample 5 (TP2 SS3) had a LOI percentage of 1.5%.

The amount of soil phosphorus is a significant indicator of past human activity among not only agricultural and pre-agricultural societies but also within contemporary archaeology (Grabowski 2012; Grabowski et. al. 2014, 7-13; Figenschau and Arntzen 2019, 134-148), which is why using it as a method to measure the level of activity in the area around Twin Falls can lead to a more detailed understanding of

different human activities during the time of settlement. Many chemical elements deposited in the soil caused by human activity are volatile and more ubiquitous than phosphorus, which remains relatively stable over time. Therefore, the means of detecting phosphorus becomes important in identifying former activity areas during archaeological investigations.

The samples from Twin Falls yielded very low traces of phosphorus. Most of the samples contained levels of phosphorus under 3 mg, with the highest level being Sample 2 (TP2 SSI) with a level of 2.53 mg. These results are verified using pXRF and can therefore not be attributed to methodological errors in the laboratory process.

The results with magnetic susceptibility range between 2400-2900, besides Sample 2 (TP2 SSI) which has a much lower MS value. With a low value of 478, this may be a result of its high organic content as explained in the organic matter section of the results. The organic material is diamagnetic and will therefore result in a low MS value when run through magnetic susceptibility tests. The higher MS values, however, may indicate that the soil has been subjected to heat and/or fire. But seeing as we again had very little samples and a lack of reference samples this claim becomes uncertain.

Since there are only 5 samples, a statistical treatment of the results is unnecessary. Even though we had few samples, some interesting results were documented during this series of analysis. As stated above, Sample 2 (TP2 SSI) has a higher proportion of organic material and a lower MS level than the other samples. The pXRF results from the mining mode calibration show high levels of sulphur (3640 PPM), high levels of calcium, titanium, and c. 200 PPM of lead (Table 3). Burning may have taken place during the abandonment process – while this conclusion is tenuous at best this is not inconsistent with what has been observed at other buildings at Twin Falls (Venovcevs and Williamson 2022, 269).

Finally, the pXRF soils mode results are optimized towards smaller concentrations of trace elements (Table 4). By putting the samples through this process, we were able to confirm the lead (Pb) contents of Sample 2 (TP2 SSI), which had a PPM of 287. This is a higher level than what is present in the other samples. Sample 1 (TP1 SSI) had a lead level of 44 PPM, the last three samples (3-5) had levels between 14-15 PPM. This high level of lead in Sample 2 could be because of the lead paint flakes present in the sample.

It is worth mentioning the presence of mercury (Hg) in Sample 2 (TP2 SSi) (7.24 PPM +- 3.7). The burning and disposal of certain materials that contain mercury (oil, wood and coal) at the site could have made the mercury airborne. The airborne mercury could have been deposited into the ground in some ways like for example by rain or in the form of dust. The levels that were detected were extremely low and were not detected in any of the other four samples. Which could mean this was not a regular place for deposit, at least not of material containing high levels of mercury.

The results of Sample 2 (TP2 SSI) also detected some small levels of uranium (U) at a level of 6.01 PPM. The other four samples did not detect any levels of uranium. In comparison to the other four samples, Sample 2 (TP2 SSI) also detected significantly higher levels of titanium (Ti). Sample 2 (TP2 SSI) measured in at 20731 PPM, while the other four samples varied between 3611 PPM-4807 PPM. Sample 2 (TP2 SSI) also detected higher levels of zinc (Zn) than the other samples with a level of 1690 PPM. The lowest level detected came from Sample 3 (TP2 SS2) and detected a level of 39 PPM. Sample 5 (TP2 SS3) had a zinc level of 59 PPM and Sample 4 (TP2 SS2) had 89 PPM. Sample 1 (TP1 SS1) had the second highest level of zinc (Zn) with a 472 PPM.

Conclusions

In summary, the last year of work surrounding Twin Falls remained productive in that the drone imagery has been colour corrected while the buildings at the settlement and the work camp have been identified (Figures 2 and 3, Table 1). Meanwhile, the results of the preliminary soil survey show that this methodology can be relevant at this archaeological site. The low levels of phosphorus suggest contemporary waste management practices surrounding the investigated buildings in line with a modern industrial community – the first in western Labrador. Sample 2, taken from Test Pit 2 in the former greenhouse alcove, has a unique chemical profile. Elevated levels of lead, sulphur, high organic content and the presence of asbestos and paint show that both the use phase and the abandonment phase of the site lead to modified soil properties. However, this analysis is pre-

liminary and incomplete given the very small sample – going forward a more comprehensive soil sampling strategy will be needed to employ the potential utility of soil chemical analysis at Twin Falls. One sampling strategy would be to cover large portions of the site with evenly spaced sampling points of 5 – 10 meters using a soil auger. Analysing a large dataset covering a larger area would likely uncover areas of interest where a denser sampling grid could be applicable. It is important to also include sampling points where little or no human activity is to be expected, to get a reference of the natural soil chemical baseline.

At the same time, the results of the preliminary soil survey provide room for serious reflections. As highlighted at the conclusion of last year's report (Venovcevs and Williamson 2022, 274-275), Twin Falls is both a unique and significant heritage site with an interested and active community of living descendants as well as a place with a heavy legacy of contamination that include chemicals and compounds such as lead, asbestos, and PCBs. As such, it serves as

Table 3: pXRF (Mining Mode) Measurements in PPM.

SAMPLE	Al	Al Error	Bal	Bal Error	Si	Si Error	P	P Error	S	S Error
1	25007.53	803.96	684614.44	1461.63	208966.48	1344.08	1352.76	202.82	807.42	62.41
2	19138.14	837.2	714128.44	1244.19	138006.3	1166.3	1802.29	213.19	3640.39	111.53
3	25057.11	825.87	659255.81	1544.48	249517.44	1500.83	1411.77	227.61	153.82	54.18
4	28732.69	892.81	674561.44	1528.26	206570.59	1368.95	1699.02	213.15	414.47	59.49
5	29588.83	855.6	677010.63	1505.65	218119.95	1379.27	1312.16	205.44	215.85	53.01
SAMPLE	Cl	Cl Error	K	K Error	Ca	Ca Error	Ti	Ti Error	V	V Error
1	<LOD	44.37	12059.38	230.06	19675.03	438.89	3219.49	70.97	134.27	34.69
2	429.83	33.27	8945.81	198.72	66302.88	741.38	16170.81	159.53	200.48	59.22
3	51.62	26.92	13004.03	229.64	16109.06	386.42	3032.21	66.28	120.34	32.47
4	407.73	30.5	12381.72	245.94	22639.72	494.25	2989.46	74.36	162.89	37.35
5	<LOD	53.03	13975.61	245.98	19181.94	434.07	2822.34	66.75	116.44	32.98
SAMPLE	Cr	Cr Error	Mn	Mn Error	Fe	Fe Error	Co	Co Error	Ni	Ni Error
1	122.45	25.75	394.5	74.58	37270.73	319.08	<LOD	118.49	<LOD	39.43
2	92.57	26.75	1113.71	82.49	21751.19	221.62	<LOD	86.55	<LOD	33.49
3	102.12	24.28	351.64	75.85	30518.66	288.6	<LOD	111.73	<LOD	39.45
4	169.03	27.75	586.36	80.75	45318.14	367.39	<LOD	132.27	<LOD	56.53
5	146.69	25.4	489.08	78.5	32958.48	300.33	<LOD	113.62	<LOD	40.41
SAMPLE	Cu	Cu Error	Zn	Zn Error	As	As Error	Se	Se Error	Rb	Rb Error
1	<LOD	24.04	603.93	22.06	<LOD	7.57	<LOD	2.76	41.55	1.82
2	<LOD	21.85	1472.66	30.77	14.45	7.95	<LOD	2.44	27.99	1.41
3	<LOD	34.42	29.01	9.24	<LOD	7.93	<LOD	2.77	37.69	1.75
4	<LOD	24.76	119.04	12.41	<LOD	7.58	<LOD	2.7	48.14	2
5	<LOD	24.16	60.88	10.25	<LOD	7.65	<LOD	2.49	44.48	1.88
SAMPLE	Sr	Sr Error	Zr	Zr Error	Nb	Nb Error	Mo	Mo Error	Pd	Pd Error
1	286.32	5.13	129.62	3.72	18.63	2.24	<LOD	1.75	<LOD	3.31
2	205.03	3.93	107.03	3.08	12.93	1.97	<LOD	1.97	<LOD	4.06
3	284.96	5.14	223.6	4.63	14.53	2.19	<LOD	1.89	<LOD	3.19
4	349.53	5.9	162.51	4.25	17.02	2.28	<LOD	1.89	<LOD	3.27
5	333.45	5.6	84.68	3.33	9.96	2.1	<LOD	1.67	<LOD	3.15
SAMPLE	Ag	Ag Error	Cd	Cd Error	Sn	Sn Error	Sb	Sb Error	Ba	Ba Error
1	<LOD	3.23	<LOD	6.7	<LOD	12.22	<LOD	13.29	630.74	37.85
2	<LOD	3.96	7.96	4.98	<LOD	11.21	<LOD	13.29	189.75	31.7
3	<LOD	3.11	<LOD	6.59	<LOD	12.23	<LOD	13.06	709.69	37.89
4	<LOD	3.14	<LOD	6.98	<LOD	12.65	<LOD	13.76	787.55	40.07
5	<LOD	3.37	<LOD	6.61	<LOD	12.22	<LOD	12.98	786.73	38.31
SAMPLE	Bi	Bi Error	W	W Error	Mg	Mg Error	Au	Au Error	Pb	Pb Error
1	8.66	5.16	<LOD	63.95	4585.99	1491.13	<LOD	7.66	41	5.49
2	<LOD	6.32	<LOD	69.65	6000.49	1977.53	<LOD	6.97	201.27	8.56
3	<LOD	7.37	<LOD	55.07	<LOD	1897.19	<LOD	7.86	7.88	4.28
4	10.24	5.38	<LOD	58.14	<LOD	2209.94	<LOD	7.97	12.18	4.59
5	<LOD	11.15	<LOD	55.27	2711.55	1398.28	<LOD	8.06	7.42	4.2

both an archetype and a foreshadowing of archaeology to come. Given that we are living in an increasingly contaminated world, recent and future heritage is destined to become increasingly contaminated (Holtorf and Högberg 2016; Stewart 2017; Stewart, Jungkind, and Losey 2020; Witmore and Francisco 2021; Kryder-Reid and May forthcoming). This heritage will be both social and scientifically important while remaining harmful and dangerous. Such a reality is not just an opportunity for theoretical retrospection on what type of an "unruly heritage" (Olsen and Pétursdóttir 2016) is being left behind in the present but also a serious methodological provocation for current and future archaeologists. If Twin Falls should be revisited for further excavation and further soil sampling, as it very much should, how can we keep crew members safe from the toxicants that hide within the soil? Clear procedures, guidelines, and equipment are needed to tackle this challenge. In this way, archaeology of the recent past does not just call for new conceptualizations of what can be heritage but also requires us to consider new sets of methods

Table 4: pXRF (Soils Mode) Measurements in PPM.

SAMPLE	S	S Error	K	K Error	Ca	Ca Error	Sc	Sc Error	Ti	Ti Error
1	361.81	199.33	17394.98	270.51	19079.17	201.62	<LOD	67.08	4589.1	94.96
2	2485.77	309.19	11921.26	236.95	65155.59	355.53	138.28	79.77	20731.92	173.05
3	<LOD	233.25	16490.14	251	15325.81	173.87	<LOD	57.73	3611.21	81.5
4	340.44	200.06	19331.31	286.24	18523.41	201.32	<LOD	66.69	3709.7	89.68
5	<LOD	273.87	20914.45	294.73	19311.69	204.02	<LOD	67.25	4807.83	96.85
SAMPLE	V	V Error	Cr	Cr Error	Mn	Mn Error	Fe	Fe Error	Co	Co Error
1	89.81	24.01	51.7	16.48	480.02	52.65	26950.7	220.88	<LOD	128
2	210.26	39.08	<LOD	23.36	977.38	39.38	15819.4	108.02	<LOD	63.53
3	90.72	21.05	45.26	15.23	488.29	36.49	24773.9	146.24	<LOD	85.63
4	98.7	23.33	117.17	17.39	643.92	40.19	32037.4	167.98	<LOD	97.15
5	99.19	24.5	82.84	16.87	597.24	39.12	28406.1	158.35	<LOD	91.52
SAMPLE	Ni	Ni Error	Cu	Cu Error	Zn	Zn Error	As	As Error	Se	Se Error
1	70.25	18.79	26.08	11.34	472.5	17.09	<LOD	6.94	<LOD	3.67
2	17.27	11.19	28.65	7.32	1690.56	19.76	24.01	6.2	<LOD	2.36
3	69.33	12.96	21.6	7.68	39.98	4.89	3.86	2.41	<LOD	2.51
4	97.14	13.6	32.93	8.11	89.54	6.17	<LOD	3.67	<LOD	2.54
5	83.23	13.33	29.22	8	59.79	5.48	<LOD	3.63	<LOD	2.46
SAMPLE	Rb	Rb Error	Sr	Sr Error	Zr	Zr Error	Mo	Mo Error	Pd	Pd Error
1	67.77	3.23	312.49	5.45	227.4	5.14	<LOD	3.91	<LOD	6.53
2	35.64	1.61	198.66	2.79	118.27	2.53	<LOD	2.34	<LOD	5.89
3	57.2	2.08	305.85	3.72	204.88	3.41	3.15	1.78	<LOD	6.66
4	82.06	2.44	302.85	3.74	152.36	3.13	<LOD	2.63	<LOD	6.49
5	72.23	2.32	390.4	4.23	134.64	3.11	<LOD	2.58	<LOD	6.77
SAMPLE	Ag	Ag Error	Cd	Cd Error	Sn	Sn Error	Sb	Sb Error	Te	Te Error
1	<LOD	5.79	<LOD	8.53	<LOD	6.3	16.68	6.77	44.11	13.8
2	<LOD	5.32	<LOD	7.88	<LOD	5.56	<LOD	9.11	<LOD	18.22
3	<LOD	6.07	9.95	5.96	12.32	4.39	20.42	6.96	73.25	14.38
4	<LOD	5.92	<LOD	8.85	10.12	4.37	24.49	7.05	71.81	14.46
5	<LOD	6.32	<LOD	8.88	13.34	4.51	22.06	7.12	82.13	14.82
SAMPLE	Cs	Cs Error	Ba	Ba Error	W	W Error	Au	Au Error	Hg	Hg Error
1	39.27	4.62	584.24	22.9	<LOD	37.3	<LOD	4.12	<LOD	8.73
2	<LOD	6.1	<LOD	27.03	<LOD	24.76	<LOD	2.61	7.24	3.77
3	54.44	4.79	676.58	23.91	<LOD	24.55	<LOD	2.83	<LOD	5.83
4	50.65	4.8	704.06	24.25	<LOD	25.17	<LOD	2.83	<LOD	5.93
5	61.84	4.94	828.47	25.44	<LOD	25.09	<LOD	2.84	<LOD	5.96
SAMPLE	Pb	Pb Error	Th	Th Error	U	U Error				
1	44.22	5.53	7.15	3.04	<LOD	6.88				
2	287.38	7.52	5.65	2.32	6.01	2.59				
3	14.95	2.85	4.15	1.91	<LOD	4.57				
4	15.97	2.95	5.04	2.02	<LOD	5.02				
5	14.86	2.89	4.63	1.99	<LOD	4.93				

and procedures to carry out a toxic archaeology – simply because we must.

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