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January 20, 2022 Project Number: 2089-21

Sunset Lakes Developments
1705 Old Prescott Road
Greely, ON
K4P 1M6

Attention: **Dan Anderson**

Subject: **Catchment Divide Analysis & LiDAR Data Review**

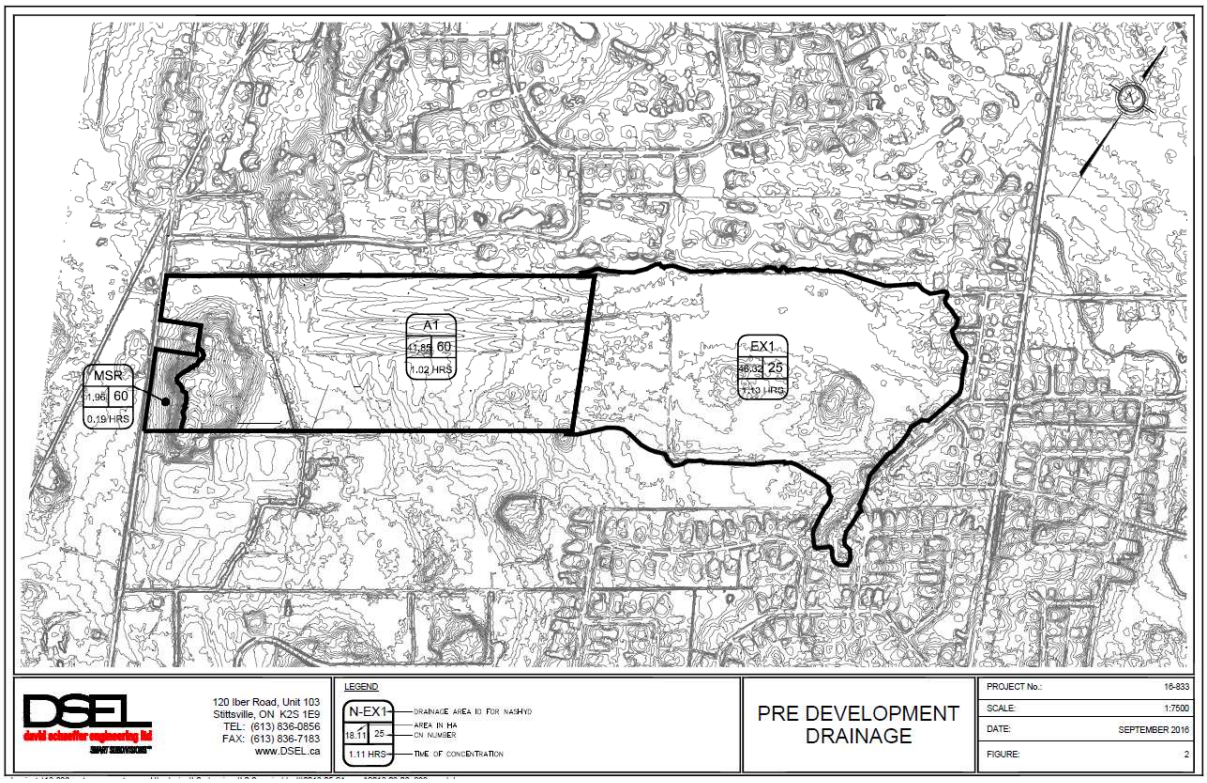
Introduction

This memorandum has been prepared to support the delineation of an accurate catchment area divide for the subject area; located in and about 6544 Jack Pine Crescent in Greely, ON. This work is intended to utilize accurate site-specific elevation information in order to determine the localized sub-catchments on-site and indicate the general direction of flow across the subject property.

Background Information

An application for development by way of subdivision is under review for the subject site. Municipal staff have noted the discrepancy between the watershed delineation as proposed in the stormwater management plan and, the existing documentation of surface water direction contained in the Grey's, Dancy and Osgoode Gardens Municipal Drains (MD) Engineer Reports. Specifically, the subdivision stormwater proposal directs all surface flows to the western edge of the site where they would outlet to a recently constructed drainage channel within a city-owned corridor, associated with the Emerald Links Phase III subdivision. This drainage corridor, and the upstream contributing area are described and approved through the registered plan of subdivision and associated ECA approval. These approvals are based on sizing the drainage corridor to accommodate the flows from the existing external catchment area that encompasses the subject site, and thus maintaining the existing watershed boundary between Grey's Creek and the Osgoode Garden MD. The approved Stormwater Management Report and Pond Design Brief for Emerald Links Phase III (DSEL, 2016-REV 4) states in section 1.1 "Existing conditions: External drainage area exists to the east of the property. The existing surface topography was prepared based on a combination of LIDAR data from the City of Ottawa in addition to site visits. It is anticipated that **46.32 ha** of external area is tributary to the site. See **Figure 1** below for existing drainage areas directed to Manotick Station Road, Grey's Creek Municipal Drain, and from the external area to the east.

Figure 1: Figure 2 from DSEL Emerald Links Ph.3 Report



The report goes on to say in section 3.2.2.2 “Post-development analysis was completed for the limits of development and external undeveloped area modeled in the pre-development analysis.” Further, that “A ditch system is proposed at the east edge of the property to convey flow from the external area around the site, bypassing the stormwater facility, eventually discharging to the GCMD”.

The external area is depicted in Figure 2 of the report, shown above. The undeveloped area is EX1, accounting for most of the subject site. An ECA (#1727-AR5UP6) was issued by MECP for Emerald Links Phase III which includes “rear yard ditches: rear yard ditches to be constructed along the rear of Lot 11 to Lot 18, receiving run-off from the rear of Lots 11 to 18, designed to accommodate up to and including the 100-year return storm runoff from an internal catchment area of approximately 5.04 ha and an external area of 46.32 ha, discharging to Grey's Creek Municipal Drain.”

The existing Engineers Reports for Grey's Creek MD (1990) and Osgoode Gardens Cedar Acres MD (2001) indicate a catchment area dividing the subject property approximately down the middle, with flows splitting to the east and west.However, on-site observations and survey points from both the landowners, the consulting engineer and Ontario Land Surveyor do not conform with these records. Water on site was observed to only flow to the west. As such, J.F. Sabourin and Associates Inc. was retained to investigate and establish the watershed divide for the subject site.

It is noted that based on historic air photos of the site, the property has remained substantially undisturbed since 1976. The presence of dense and mature vegetation on site indicates that it is unlikely that the property was regraded, or elevations significantly changed since this time.

An initial watershed divide review to clarify the RVCA and SNCA watershed jurisdiction was prepared and provided by JFSA in December 2021, although it relied on older topographic data (LiDAR from 2015). This updated report is based on recently available LiDAR from Natural Resources Canada, which was acquired by the City of Ottawa in 2020. The findings of that initial investigation are not changed by this memo. The subdivision boundary has been refined based on this latest topographic data and additional site observations and survey points.

Procedure

A cursory check of watercourses in the area was completed on the Ottawa geoportal and South Nation Conservation Authority mapping tool and identified the following watercourses as potential outlets:

- Grey's Creek Municipal Drain: tributary to Middle Castor River
- Osgoode Gardens Municipal Drain: tributary to North Castor River

The relationship between the subject site and these two municipal drains is displayed in **Figure 2**.

Using the City of Ottawa's latest available LiDAR mapping (1m DEM, 2020), the drainage area to each receiver (municipal drain) was determined by the application of watershed delineation tools using GIS software. The GIS software uses a raster-based approach to calculating drainage areas, where each cell is assigned an elevation and the subsequent flow paths are calculated by finding the lowest elevation cell adjacent to the original cell. The drainage areas derived by this process were then verified manually and refined using contour mapping.

The GIS analysis was augmented by the collection of on-site survey points along road crowns and culvert inverts and obverts on Jack Pine Crescent and White Oak Drive by ARK Engineering. This survey identified a high point at the intersection of Jack Pine Crescent and White Oak Drive that would impede normal flow from the site to the east, to Stagecoach Road.

Results

The results of the analysis are visually displayed in **Figure 3**. Three sub-watersheds were identified which drain towards the west, ultimately out letting to Greys Creek Municipal Drain. No portion of the subject site has flows draining to the Osgoode Gardens Municipal Drain, despite the boundaries indicated by the Municipal Drain Engineers Reports. We note that the area where this correction occurs is through the middle of the site where grades are quite flat. Additional scrutiny on site and in the data supports the findings of this report, however it is understandable how the older MD Engineer Reports would struggle to refine this divide in the area.

N

Legend

- Site Boundary
- Watercourses

SCALE: 1:9000

0 250 500 m

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Figure 2: Location of Significant Municipal Drains

PROJECT	2089-21
DRAWN	TE
DATE	11-01-2022

C:\OneDrive\J.F. Sabourin and Associates Inc\JFSA-OTTAWA-SERVER - Documents\PROJ\2089-21\ENGINEERING\GIS\20211209 - Watershed Divide & Ground-truthing 2020 LiDAR

N

Legend

- Site Boundary
- Low Points
- Outlet Points
- Greys Creek North
- Greys Creek Mid
- Greys Creek South

SCALE: 1:4500

0 100 200 m

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Figure 3: Drainage Delination - 2020 LiDAR

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DATE	11-01-2022

LiDAR Data Review

The catchment analysis was based on the 2020 LiDAR data. LiDAR data directly affects the accuracy of the simulated drainage catchments, it is paramount to have confidence in the elevation data used. Therefore, JFSA completed an analysis to ensure that the LiDAR data applied in this topographic analysis is dependable.

JFSA acquired LiDAR data flown in 2020 from Natural Resources Canada (NRC) on December 8th, 2021. Two (2) tiles were obtained, with each tile providing 10 km x 10 km of coverage at a resolution of 1 m. **Figure 4** outlines the extent and location of the LiDAR data obtained. JD Barnes Limited completed a topographical boundary survey of the subject lands in March 2021. The majority of points collected by JD Barnes were boundary markers and therefore did not establish the true ground elevation. However, the survey did establish geodetic benchmarks for on-site work.

Using the JD Barnes survey markers as benchmarks, ARK engineering completed a survey of proposed road centerlines, at actual ground surface elevations, in March of 2021. The area surveyed overlapped with elevation data from one (1) of the LiDAR tiles. JFSA undertook a comparison between the spot elevations obtained from the ARK Engineering survey and the elevations obtained from the 2020 LiDAR at the same locations. Attachment A contains the elevation differences for all points in the analysis, with a visual representation of the results provided in **Figure 5**.

JFSA completed a statistical analysis of the difference between the two data sets. Error! Reference source not found. is a summary of this analysis and **Error! Reference source not found.** is the difference distribution, indicating the percentage of points that fall within given accuracy ranges.

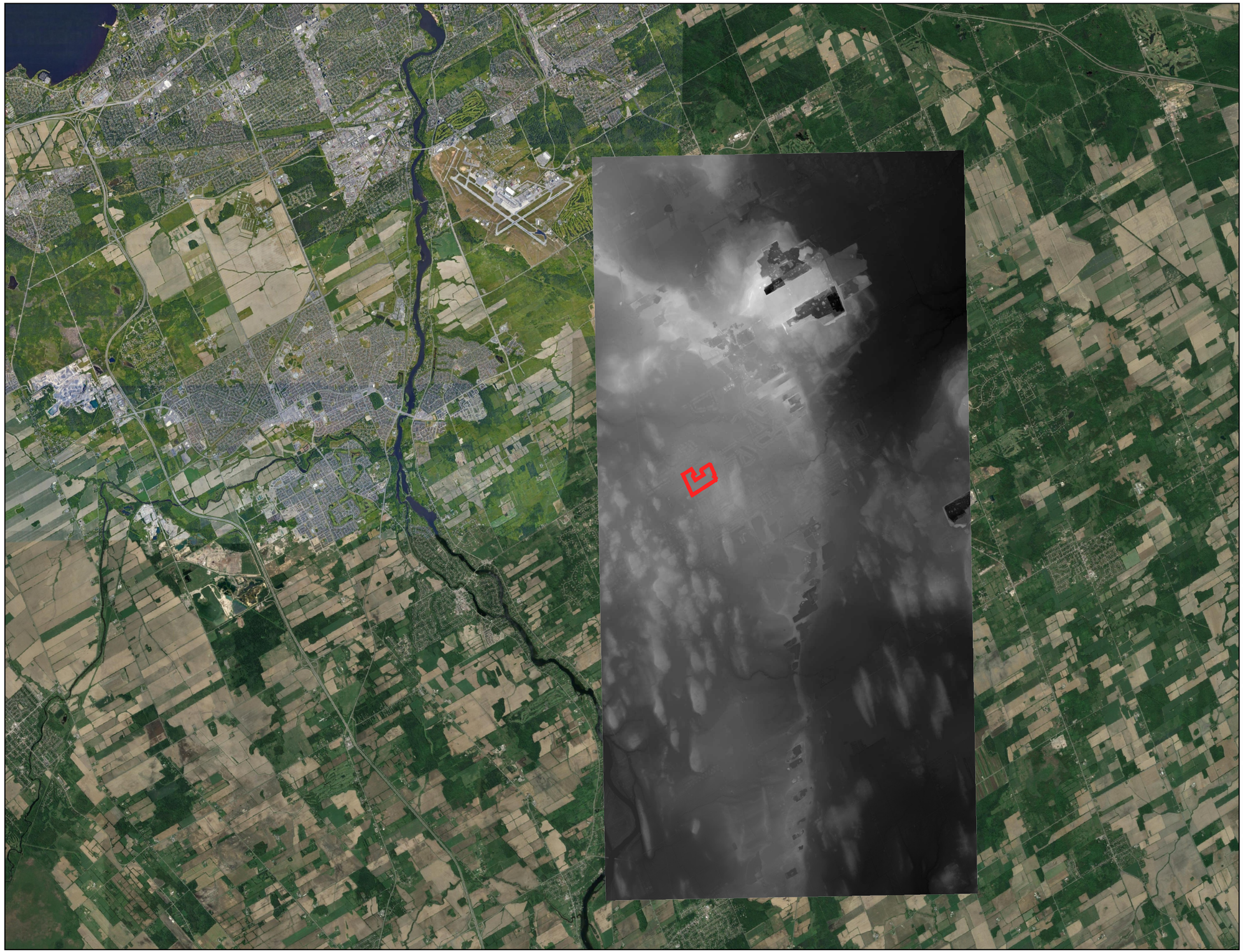
Table 1: Statistical Analysis of LiDAR to Survey Elevation difference

Statistical Analysis	(m)
Average Difference	-0.34
Max + Difference	0.70
Max - Difference	-0.84
1 Standard deviation (68%)	0.25
2 Standard deviations (95%)	0.49
3 Standard deviations (99.7%)	0.74

*Note: negative values indicate that the LiDAR elevations are lower than the field survey and vice versa.

Table 2: Elevation Difference Distribution Summary

Elevation Difference	% Of Total Points
± 5 cm	5.6%
± 10 cm	9.3%
± 25 cm	24.1%
± 50 cm	81.5%
± 75 cm	94.4%
±100 cm	100%



N

Site Boundary

SCALE: 1:100000

0 2.5 5 km

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Figure 4: LiDAR Tiles

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DATE	10-12-2021

N

Legend

- ± 5 cm
- ± 10 cm
- ± 25 cm
- ± 50 cm
- ± 75 cm
- ± 100 cm
- Site Boundary

SCALE: 1:4000

0 100 200 m

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Figure 5: Elevation Difference LiDAR & Survey

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DRAWN	TE
DATE	21-12-2021

This analysis found that the average difference between the LiDAR and Survey was -34cm with 81.5% of all applicable points within ±50cm of the LiDAR value. Upon closer investigation of the data, the variation between the survey and LiDAR elevations was determined to be the result of systematic error rather than random error. The most likely cause of this discrepancy is due to differences in the vertical datum used between the survey data and the LiDAR data.

The 2020 LiDAR released by NRC was the first LiDAR dataset to use the new Canadian Geodetic Vertical Datum of 2013 (CGVD2013), which is now the new standard for heights across Canada. This vertical datum is based on changes to the height reference system from CGVD28 to CGVD2013. NRC released a guide to the *Heights Reference System Modernization* (2020) which provides guidance on how to approach systematic differences of the new vertical datum:

- Pg 11 states that: “the difference between benchmarks on previous GNSS models and the new CGG2013 model varies from a minimum of -0.678 metres to a maximum of 0.349 metres, with an average of -0.157 metres”.
- Pg 6 states: “those who transfer heights with precision of less than 2 cm over small regions (e.g. municipal infrastructure). For these users, the difference between CGVD28 and CGVD2013 should be considered, but generally applying a constant offset will suffice”.

The height difference we found (-0.34 metres), lies within the range specified by NRC. Based upon the guidance document we have determined it is appropriate to use a constant offset to adjust the LiDAR upwards by 0.34 metres. Undertaking this adjustment found that 42.6% of all points were within ±10cm and 75.9% of all applicable points were within ±25 cm of the adjusted LiDAR values. Given the level of vegetation present at this location, JFSA believes that this is a reasonable and acceptable degree of variation between the two data sets. **Table 3** is the difference distribution of the adjusted values, indicating the percentage of points that fall within given accuracy ranges. A visual representation of the adjusted elevation points is provided in **Figure 6**.

Table 3: Adjusted Elevation Difference Distribution Summary

Elevation Difference	% Of Total Points
± 5 cm	20.4%
± 10 cm	42.6%
± 25 cm	75.9%
± 50 cm	96.3%
± 75 cm	98.1%
± 100 cm	98.1%

N

Legend

- ± 5 cm
- ± 10 cm
- ± 25 cm
- ± 50 cm
- ± 75 cm
- ± 100 cm
- Site Boundary

SCALE: 1:4000

0 100 200 m

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Figure 6: Adjusted Elevation Difference LiDAR & Survey

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DATE	22-12-2021

Summary

The results of the catchment area analysis indicate that the entire site drains to the west to Greys Creek Municipal Drain. This finding is based on current site-specific survey and LiDAR topographic data. The drainage divide recorded in municipal drainage documents should be revised to reflect this refined catchment area information.

This watershed divide was based in a large part upon the 2020 LiDAR data obtained from Natural Resources Canada on December 8th, 2021. JFSA verified and reviewed the LiDAR data using survey points collected on-site by ARK Engineering. Although a systematic difference in elevation was found, it was determined to be appropriate to adjust the LiDAR elevations by applying a constant offset of 34 cm due to a discrepancy between vertical datums in the two datasets. Based on the adjusted LiDAR elevations, JFSA is confident that the LiDAR data obtained reflects the surveyed ground surface, and that the drainage area divide provided in this analysis is reflective of real-world conditions.

J.F Sabourin and Associates Inc.

Tim Eisner, M.Pl., LEED Green Associate
Planner, JFSA

Reviewed By:

Jonathon Burnett, B.Eng., P.Eng.
Water Resources Engineer

Tables

Figures

Attachments

Documents Referenced

Natural Resources Canada (2020) *Height Reference System Modernization*. Published by the Government of Canada.
https://www.nrcan.gc.ca/sites/nrcan/files/files/pdf/Height_reference_system_modernization_(EN).pdf

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Attachment A

Point Evaluation Comparison

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Attachment A: Point Evaluation Comparison

[1] Point ID	[2] X (MTM 9)	[3] Y (MTM 9)	[4] 2020-LiDAR Elevation (m)	[5] Survey Elevation (m)	[6] (4-5) Elevation Difference (m)
1	375020.9264	5013172.14	101.69	102.50	-0.81
2	374999.9012	5013158.615	101.77	102.45	-0.68
3	374978.8753	5013145.09	101.72	102.50	-0.78
4	374957.8501	5013131.565	101.82	102.43	-0.61
5	374936.8242	5013118.04	101.85	102.15	-0.30
6	374913.0109	5013102.722	102.05	102.20	-0.15
7	374894.7732	5013090.99	101.96	102.43	-0.47
8	374873.7479	5013077.465	102.48	102.88	-0.40
9	374852.7221	5013063.94	102.41	102.58	-0.17
10	374831.6968	5013050.414	102.18	102.80	-0.62
11	374925.6495	5013079.708	101.56	102.40	-0.84
12	374942.8442	5013048.397	101.93	102.56	-0.63
13	374952.4714	5013030.867	102.17	102.36	-0.19
14	374967.5127	5013003.478	102.03	102.24	-0.21
15	374993.5088	5012956.141	101.94	102.49	-0.55
16	375052.601	5012848.538	102.47	102.70	-0.23
17	375062.4353	5012819.712	102.57	102.86	-0.29
18	375069.1237	5012799.809	102.55	102.83	-0.28
19	375082.0336	5012761.396	102.55	102.85	-0.30
20	375097.9581	5012714.004	102.11	102.38	-0.27
21	375127.9911	5012624.633	101.76	102.08	-0.32
22	375116.6566	5012658.362	101.66	101.95	-0.29
23	375171.0331	5012808.348	102.70	102.97	-0.27
24	375145.8341	5012792.068	102.59	102.96	-0.37
25	375196.236	5012824.621	102.97	103.00	-0.03
26	375221.4344	5012840.901	102.66	102.97	-0.31
27	375413.9467	5012965.272	102.23	102.66	-0.43
28	375380.3477	5012943.568	102.14	102.66	-0.52
29	375355.1487	5012927.288	102.15	102.60	-0.45
30	375304.7507	5012894.73	102.29	102.75	-0.46
31	375279.5511	5012878.452	102.39	102.72	-0.33
32	375266.9519	5012870.312	102.38	102.78	-0.40
33	375258.5519	5012864.886	102.38	102.82	-0.44
34	375329.9497	5012911.009	102.20	102.64	-0.44
35	375539.9423	5013046.667	102.13	102.58	-0.45
36	375514.7433	5013030.388	102.23	102.66	-0.43
37	375489.5443	5013014.109	102.31	102.77	-0.46
38	375464.3447	5012997.831	102.38	102.78	-0.40

Attachment A: Point Evaluation Comparison

[1] Point ID	[2] X (MTM 9)	[3] Y (MTM 9)	[4] 2020-LiDAR Elevation (m)	[5] Survey Elevation (m)	[6] (4-5) Elevation Difference (m)
39	375439.149	5012981.547	102.34	102.72	-0.38
40	375638.302	5013110.211	102.38	102.74	-0.36
41	375617.3028	5013096.645	102.22	102.69	-0.47
42	375596.3035	5013083.079	102.25	102.60	-0.35
43	375565.1413	5013062.946	102.22	102.64	-0.42
44	375516.8309	5013138.812	103.71	103.73	-0.02
45	375489.6822	5013180.8	105.27	105.50	-0.23
46	375503.2565	5013159.806	104.86	104.16	0.70
47	375543.9794	5013096.825	102.58	102.56	0.02
48	375530.4052	5013117.819	103.15	103.08	0.07
49	375462.5336	5013222.787	103.52	103.68	-0.16
50	375476.1079	5013201.794	104.55	104.66	-0.11
51	375452.0997	5013245.445	103.00	102.91	0.09
52	375442.3508	5013268.466	102.09	102.38	-0.29
53	375431.3973	5013290.848	101.93	102.30	-0.37
54	375404.264	5013332.845	101.92	102.25	-0.33