



WorleyParsons

resources & energy

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

EUREKA CIVIL CONSULTING SERVICES

PROJECT NO.: R.015466.001

Appendix 5 Digital Topographic Survey Report

FIELD REPORT – 2010

**Topographic Survey
Eureka Weather Station
Eureka, Nunavut**



PREPARED FOR:

WorleyParsons Canada Services Ltd.

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October 14, 2010 2010



Inukshuk File 35062

EXECUTIVE SUMMARY

From August 14th to August 20th, 2010, Inukshuk Nunasi Geomatics (ING) carried out a topographic survey of the Eureka Weather Station including air strip; water reservoir; proposed lagoon locations; and buildings, as required by WorleyParsons Canada Services Ltd. The purpose of the survey was to derive elevations of the existing surfaces to facilitate the design of a lagoon and airstrip upgrade.

Surveyed co-ordinates and elevations were based on published values for GSD Monument 749167A and confirmed by means of check ties to NRCan Geodetic Survey Division (GSD) Monument 749167 along with post process to Canadian Active Control System (CACS) Station M059000 as well as using the NRCan Precise Point Positioning (PPP) Web site.

The survey included all areas required under the contract, as well as additional areas requested by WorleyParsons on site representative.

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1 Introduction

From August 14th to August 20th, 2010, Inukshuk Nunasi Geomatics (ING) carried out a topographic survey of the Eureka Weather Station, Nunavut, including the air strip; water reservoir; proposed lagoon locations; and buildings, as required by WorleyParsons Canada Services Ltd. The purpose of the survey was to derive elevations of the existing surfaces to facilitate the design of a lagoon and airstrip upgrade.

The topographic survey was performed with Real Time Kinematic (RTK) GPS using Leica 1200 Systems; Total Station survey using Lieca Robotic TPS 1201; and scanning using Lieca C10 3D Scanner.

Presented in this report are the results of the topographic survey.

2 Project Execution & Equipment

2.1 Project Planning

Prior to mobilization a field execution plan was developed taking into consideration the survey scope along with factors such as remoteness of project area, weather conditions and time available to execute the field project. Analysis was performed at Inukshuk's Calgary office to evaluate the appropriate survey data collection equipment for the project that would be cost effective; reliable; accurate; provide redundancy in the case of equipment failure; and gather the maximum amount of data in a short period of time.

A total of three survey data collection systems were dedicated and used on the project including Real Time Kinematic (RTK) GPS using Leica 1200 Systems; Total Station survey using Lieca Robotic TPS 1201; and scanning using Lieca C10 3D Scanner.

RTK GPS was chosen for topographic pick-up at the airstrip and water reservoir along with potentially using for topographic data collection at the Weather Station. RTK GPS requires a radio connection to a local base station but doesn't need a line of visual site therefore if fog or snow were encountered the RTK GPS would not be affected. Ionosphere activity may be a factor for RTK as during the summer of 2010 there has been significant Ionosphere activity which has had a detrimental effect on GPS positioning.

Robotic TPS 1201 would be used to pick-up buildings and as back up to RTK GPS for topographic data collection. The TPS 1201 is a one person system and data collection at times can be collected as expediently as RTK GPS. The TPS 1201 is a line of site instrument and therefore fog or snow would affect productivity.

The Lieca C10 3D Scanner is a leading edge data collection instrument enabling the gathering of data points at spacing of a few centimeters to a radius of 200 metres with an accuracy of less than 10 mm. All objects within the scanner field of views are captured allowing the preparation of comprehensive three dimensional plans showing all buildings, features and surfaces.

The 3D Scanner would be used in congested areas around the Weather Station and for gathering topographic shots in the areas of the proposed lagoons. The Scanner is a line of site instrument therefore fog, rain or snow would affect productivity.

Before mobilizing to Eureka, all three systems were checked and tested by the project party chief to confirm operator expertise and identify any technical issues. In addition the project party chief was briefed on the execution plan and survey scope.

In addition to the GPS equipment, the field crew was also equipped with:

- Laptop with Leica software
- Personal protective equipment
- First aid kit
- Personal gear
- Tripods and prisms

The laptop with Leica software was used by the field crew to initially verify and inspect the integrity of the daily field data that had been collected in addition to reviewing the completeness and precision of the survey. The remaining equipment was taken for safety and communication.

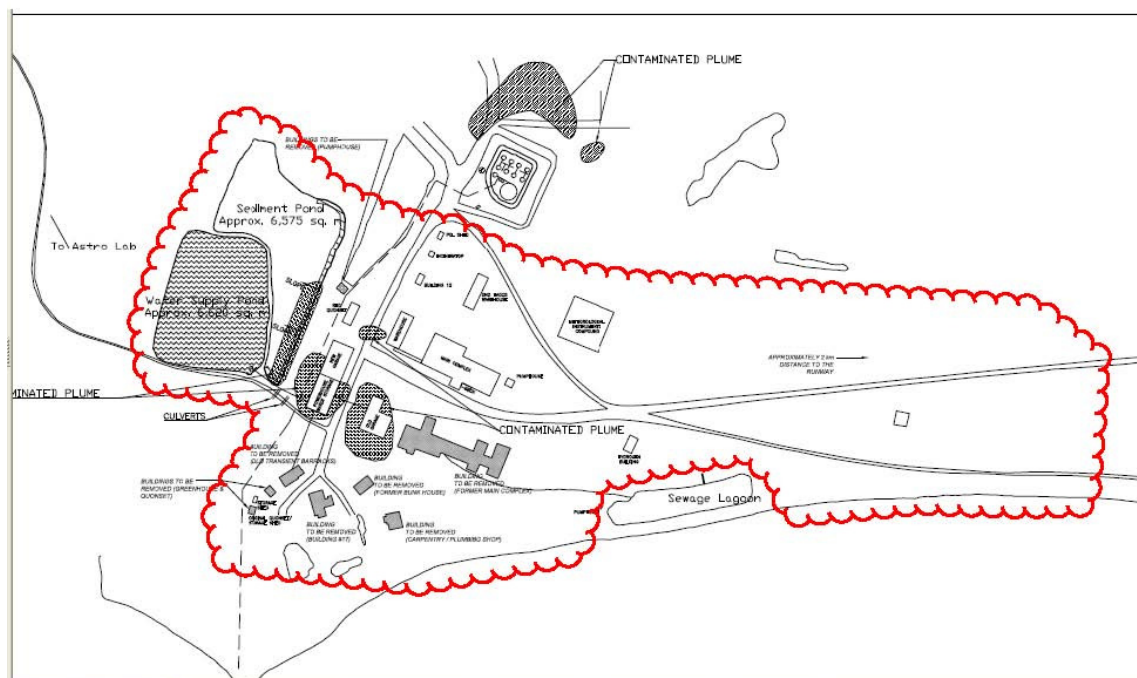
2.2 Field Execution

The field data was collected from August 14th to August 20th, 2010 utilizing the Leica 1200 GPS Systems, Lieca Robotic TPS 1201 and Lieca C10 3D Scanner.

The survey covered all areas specified under the contract including:

1. The airstrip portion of the topographic survey is to include runway; taxiways; adjacent areas; airstrip buildings; signage and lighting; windsock; navigation aids.
2. The runway is to have a 5 point cross section at 20 metre intervals over the length of the 1500 metre runway plus an additional 3 point cross section on the shoulder on each side of the runway also at 20m intervals.

3. The sewage lagoon topo survey is to include the sites for the two proposed lagoon options with elevations obtained at a spacing of no further than 20 metres.
4. In addition to the above, we would gather topographic data between the proposed sewage lagoons and the ordinary high-water mark (OHM) of the adjacent fiord at a maximum spacing of 20m.
5. We would survey a 3 point cross section at 20m intervals along the routes of the proposed force main between the lagoon options and the main weather station.
6. The weather station area survey will include all occupied or abandoned buildings, utilities and obtain topographic data around the buildings and reservoir at a minimum of 20m spacing.
7. Soundings are required in the water supply reservoir and sediment pond at a maximum spacing of 20m.
8. Topographic survey doesn't include the existing lagoon; fuel storage; access roads between weather station and airstrip.
9. In general all topographic data will be gathered at a maximum spacing of 20m with additional shots as is necessary to accurately and unambiguously define features and break lines at a relative accuracy of 15mm or less.



Survey Area at Weather Station and Proposed Lagoon Sites

10. Survey will be tied to the local GSD monuments including Canadian Active Control Station (CACS) Eureka.
11. Deliverables include ASCII point files in grid and ground; 1:1000 ACAD drawing with 0.2m contours; survey report

NRCan Geodetic Survey Division (GSD) Monuments 749167A and 749167, in the project area and adjacent to the airstrip were located and used as reference points for the survey project. The GSD published station coordinates for both monuments were derived using GPS methods with the CGVD28 elevations designated as Fourth Order or Consult Agency. The GSD Reports for each of the monuments are appended to this report.

The airstrip survey was performed using RTK GPS. A base station GPS receiver was set on 749167A with a rover receiver used to gather topographic data around the air strip along with surveying the buildings adjacent to the airstrip. The Leica Robotics was used to fill in some gaps in the GPS data to achieve the desired point density.

Quality control during the RTK and Robotics survey was maintained in each set-up by re-tying at least two previous observed points such as ground shots, fixed features such as landing lights or control points.

RTK GPS was also used to survey the ordinary high water mark (OHWM) of Slidre Fiord adjacent to Eureka; the water reservoir; and as requested by WorleyParsons on site representative, cross sections were obtained along Station Creek next to the water reservoir.

8 control points to be used during the 3D Scanner survey on the main Weather Station were also set using RTK GPS.

A total of 29 3D Scanner set-ups were used to survey the Weather Station buildings and adjacent areas along with the site of the proposed lagoon. The Scanner position for each set up was derived from resection using control points set by RTK GPS and overlapping control points set in each scan.

2.3 GPS Processing and Adjustment

Leica Geomatics Office software (LGO) was used to process all data. Final processing relative to GSD published values was performed in the Inukshuk's Calgary office and the results are given in this report.

Surveyed NAD83 CSRS co-ordinates were based on GSD monument 749167A with an onsite check to GSD Monument 749167. The horizontal position checked within 0.07m and vertical checked within 0.040m of published values.

In addition static GPS data gathered at each monument was post processed relative to the local Canadian Active Control System M059000, CACS-Eureka. The published horizontal position of 749167A and 749167 checked within 0.15 m horizontally and 0.20 m vertically of processing to CACS M059000. The coordinate comparisons between 749167A, 749167 and CACS-Eureka are shown in the Control Co-ordinate Comparison appended to this report.

In reviewing the vertical data for GSD 749167A and 749167 it is noted that although CGVD28 elevations are published for each monument, the elevations accuracy are classed as Consult Agency and Fourth Order.

Considering the poor accuracy of the published CGVD28 elevations for the GSD monuments we defaulted to use an Ellipsoid-Geoid based elevation derived from the published NAD83CSRS Ellipsoid Height and HTv2.0 Geoid. Appended to this report are the GSD Monument reports for the published ellipsoid heights and HTv2.0 Geoid Separation in addition to the ACP Report for CACS Eureka.

2.4 Scanner Processing and Adjustment

The control points set using RTK were integrated in the 3D Scanner processing with adjustments made as necessary. The nature of the Scanner data with the overlapping surfaces and overlapping control points facilitates the isolation of errors and the adjustment of control point values. The overlapping control is compared with overlapping features or surfaces to add in redundancy. Using the cyclone processing software the mean absolute error in the control network is 0.011m which is seen in the appended registration diagnostics report.

Appended to this report is a listing of final coordinates for scanner control points along with their residuals.

3 Summary

This report summarizes a RTK GPS, Robotic Total Station and 3D Scanner topographic survey conducted from August 14th to August 20th, 2010, by Inukshuk Nunasi Geomatics at the Eureka Weather Station, Nunavut. The survey included the air strip; water reservoir; proposed lagoon locations; buildings; in addition to a survey of cross sections along Station Creek.

Surveyed co-ordinates and elevations were based on published values for GSD Monument 749167A and confirmed by means of check ties to GSD Monument 749167 along with post process to Canadian Active Control System (CACS)

Station M059000 as well as using the NRCan Precise Point Positioning (PPP) Web site.

Weather conditions and Ionosphere activity were not factors during the survey allowing the Inukshuk party chief to survey all data required in the project scope on schedule principally using the 3D Scanner and RTK GPS. Over 2200 data points were surveyed using RTK GPS with another 2.6 gigs of Scanner data.

Under separate cover is published a ACAD dwg file; CSV file with grid coordinates; and TXT file with ground co-ordinates.

NRCan GSD - ACP Report

CANADIAN ACTIVE CONTROL SYSTEM
ACTIVE CONTROL POINT (NAD83CSRS)

SITE IDENTIFICATION

Site name : EUREKA
ID code : EUR2
Geodetic Station No : M059000
Location : Eureka, NU

SITE INFORMATION

EUR2 is a continuously tracking GNSS site of the CACS network. Antenna is located on the roof of the Environment Canada Weather Station building in Eureka, Nunavut.

Antenna is mounted on the New Environment Canada Weather Station building in Eureka, Nunavut. Antenna mounted on steel pole secured to railing attached to platform on roof of new building. Platform secured to buildings steel beam infrastructure.

STATION COORDINATES

Reference system : NAD83CSRS

X = 78805.61 m Y = -1109591.58 m Z = 6259356.55 m

Latitude : N79 59' 20.1677
Longitude : W85 56' 15.1804
Ellipsoidal Height : 28.68 m

Geoid Separation (HT2.0) : 7.116 m
Orthometric Height (CGVD28) : 22.0 m
Adjustment Net : M05715
Epoch : 2002.0

Note:

The coordinates above are the most accurately known positions for this station relative to the NAD83CSRS coordinate system. Although these coordinates are very accurate within the Canadian Spatial Reference System and with respect to the defined NAD83 datum, they may not be consistent with NAD83 coordinates officially adopted and published by provincial agencies for monumented geodetic control points.

ANTENNA HEIGHT

Height of antenna is the vertical offset from the monument mark to the antenna L1 phase center. The L2 phase center is currently 0.029 m above the L1 phase center.

09-Oct-2005 14:00:00 UT to Present - L1 height: 0.091 m

GPS EQUIPMENT ON SITE

The following equipment is presently in operation at the site:

GPS Receiver : AOA SNR-12 ACT
Antenna Type : Dorne Margolin AOAD/M_T
Frequency Standard Type : Rubidium
Meteorological Sensor : Humidity, Pressure, Temperature.

ACP_CACS Eureka data_sheets.txt

CGVD28 - Canadian Geodetic Vertical Datum 1928, mean sea level (adopted, public vertical reference system). The average height of the surface of the sea for all stages of the tide. Usually determined by averaging height readings observed hourly over a minimum period of 19 years.

FOR FURTHER INFORMATION CONTACT :

NATURAL RESOURCES CANADA
GEODETIC SURVEY DIVISION
INFORMATION SERVICES
615 Booth Street
Ottawa, Ontario
K1A 0E9
Telephone: 613-995-4410
Fax: 613-995-3215
Internet: information@geod.nrcan.gc.ca

2010-08-26

GSD LONG Report

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Natural Resources Canada
Geodetic Survey Division
615 Booth Street, Ottawa, Ontario
Telephone: 613-995-4410
Fax: 613-995-3215
Internet: information@geod.nrcan.gc.ca

Horizontal Datum: NAD83CSRS

Vertical Datum: CGVD28

Note: Users of Geodetic Survey Division markers must obtain permission from the landowner before entering private property.

Selection Criteria : **Radial Search**

.1 km 79 59 38 85 49 059

Data Type Requested : **Any Horizontal or Vertical stations (NAD83CSRS/CGVD28)**

Number of Stations Retrieved : 2

Definition of Reference Systems

NAD83(CSRS) : North American Datum 1983 (Canadian Spatial Reference System). The updated three-dimensional realization of the NAD83 reference system, still based on the GRS80 reference ellipsoid. In agreement with the US, this realization is defined in terms of a common procedure for transforming from recent versions of the International Terrestrial Reference Frame (ITRF). This realization is based on a 7-parameter transformation from ITRF96 (7 parameters were computed but the scale set to zero in order to adopt the scale of ITRF). Incremental transformations between ITRF96 and other ITRF realizations are used to update the transformation to any version of ITRF. NAD83(CSRS) is consequently a more accurate and stable realization of NAD83 that can be accurately referenced to other global and regional reference frames. The absolute accuracy of NAD83(CSRS) is of the order of a couple of cm or better, the accuracy of recent versions of the ITRF.

It is important to realize that NAD83(Original) and NAD83(CSRS) are based on the same fundamental NAD83 reference system. They are merely different realizations or adjustments with different levels of error. Taking into account these errors, NAD83(Original) and NAD83(CSRS) are completely compatible with one another.

NAD83(Original) : North American Datum 1983 (Original). The near-geocentric three dimensional reference system for the U.S., Canada and Central America, based on the Geodetic Reference System 1980 (GRS80) reference ellipsoid. Although originally intended to be geocentric, it is now known to be offset from the true geocenter by about 2 m due to the limited accuracy of absolute positioning at the time.

NAD83(Original) adjustments were based on a set of VLBI constraints from the first NAD83 adjustment. This set of constraint coordinates was used as the definition of NAD83(Original) until the last federal horizontal control adjustment in 1993. Note that these adjustments were 2D horizontal (latitude and longitude) solutions only. Some provinces still use these solutions for their horizontal networks but most have or are moving to the NAD83(CSRS) realization of the NAD83 reference system. The absolute accuracy of NAD83(Original) varies from several cm to over a couple of meters, with an average of about 0.3 meters. However, these errors are locally fairly coherent so that the relative accuracy can be much better.

NAD27 : North American Datum 1927. A non-geocentric horizontal control datum for the U.S., Canada and Mexico, defined by a coordinate and azimuth with origin at Meades Ranch, on the Clarke 1866 reference ellipsoid.

CGVD28 : The Canadian Geodetic Vertical Datum 1928 (CGVD28): Official height reference system in Canada The reference frame for the CGVD28 is the mean sea level at six tide gauges in dates of 1928. These tide gauges were located on both the Pacific and Atlantic Oceans as well as on the St-Lawrence River. The datum is propagated across Canada (mostly southern Canada) by a first-order levelling network and is accessible to users through some 80,000 federal benchmarks.

GSD LONG Report

23/09/2010 17:33:35 EDT

Station 1 of 2

SITE IDENTIFICATION

Unique Number : 749167

Name : EUREKA DOP

Established by : Geodetic Survey Division

Province : NT

Prov. Identifier : None

NTS Map No : 049G15

STATION COORDINATES

Horizontal Datum : NAD83CSRS

Method : Global Positioning System

Latitude : N79° 59' 38.4637" +/- 0.011 m Std Dev. (68% confidence level)

Longitude : W85° 49' 58.5226" +/- 0.004 m Std Dev. (68% confidence level)

Ellipsoid Height : 85.56 m +/- 0.042 m Std Dev. (68% confidence level)

Geoid Separation (HTv2.0) : 7.154 m

Agency : Geodetic Survey Division

Adjustment Net : M04711

Coordinate Version No. : 3.0.1.BM.3

Epoch : 1997.0

UTM : Zone = 16 Scale Factor = .9996 N = 8881145.15 m E = 522636.56 m

XYZ Coords. : X = 80791.80 m Y = -1108898.31 m Z = 6259511.19 m

Horizontal Datum : ITRF2005

Latitude : N79° 59' 38.5028"

Longitude : W 85° 49' 58.6274"

Ellipsoid Height : 85.73 m

Epoch : 1997.0

XYZ Coords. : X = 80791.16 m Y = -1108897.19 m Z = 6259511.57 m

VERTICAL DATA

Vertical Datum : CGVD28

Elevation : 78.3 m

Order : Fourth Order

Method : Differential

Adjustment Line : NOVA1987

Published Year : 1987

STATION MARKER INFORMATION AND LOCATION

Marker Type : Brass/Bronze Tablet Or Cap

Inspected in : 2004

Status : Good

Inspection Comments : None

Accessible by four wheel drive and a walk of less than 50 m

STA IS LOCATED ON FOSHEIM PEN OF ELLESMERE IS AT THE AIR- STRIP OF THE EUREKA WEATHER STA, ON BRADLEY AIR SERVICE PROPERTY, 1 M S OF SW COR OF THE SLEEPING QUARTERS. IT IS MKD BY A GSC BR TAB ON 1.8 M OF COPPERWELD ROD PROTRUDING 10 CM AGL. THERE IS A 10 CM CONC CAP REINFORCING THE PLUG STPD 749167. IT CAN BE REACHED BY AIRCRAFT.

REFERENCE STATIONS INFORMATION:

Reference name, Marker type, AZ/DIR/BRNG (DEG MIN SEC), (H)orizontal or (S)loped distance (m),

and Diff. in elev. (cm)

749167A AZ	BRASS/BRONZE TABLET OR CAP	181 05' 18	S	16.04
749167B AZ	BRASS/BRONZE TABLET OR CAP	263 26' 03	S	2.48

HISTORICAL COORDINATES NOTE: Coordinates listed below are no longer maintained by GSD.

Horizontal Datum : NAD83

Method : Multiple Methods

Latitude : N79° 59' 38.40468"

Longitude : W85° 49' 58.61344"

UTM : Zone = 16 Scale Factor = .9996 N = 8881143.307 m E = 522636.109 m

Horizontal Datum : NAD27

Method : Doppler Positioning

Latitude : N79° 59' 34.73300"

Longitude : W85° 49' 59.88500"

UTM : Zone = 16 Scale Factor = .9996 N = 8880899.057 m E = 522632.609 m

PROJECTS IDENTIFIERS:

ASTRO74	CACRC74	D268601	DOPPLER	D268701	D268302	JUNCTION
FRMNAD83	JUNE90	PRIMDOP	PRIM_HORI			

Station 2 of 2

SITE IDENTIFICATION

Unique Number : 749167A

Name : EUREKA REF A

Established by : Geodetic Survey Division

Province : NU

Prov. Identifier : None

NTS Map No : 049G15

STATION COORDINATES

Horizontal Datum : NAD83CSRS

Method : Global Positioning System

Latitude : N79° 59' 37.9467" +/- 0.006 m Std Dev. (68% confidence level)

Longitude : W85° 49' 58.5793" +/- 0.004 m Std Dev. (68% confidence level)

Ellipsoid Height : 85.00 m +/- 0.042 m Std Dev. (68% confidence level)

Geoid Separation (HTv2.0) : 7.153 m

Agency : Geodetic Survey Division

Adjustment Net : M04711

Coordinate Version No. : 3.0.1.BM.3

Epoch : 1997.0

UTM : Zone = 16 Scale Factor = .9996 N = 8881129.11 m E = 522636.58 m

XYZ Coords. : X = 80792.64 m Y = -1108913.98 m Z = 6259507.86 m

Horizontal Datum : ITRF2005

Latitude : N79° 59' 37.9858"

Longitude : W 85° 49' 58.6841"

Ellipsoid Height : 85.17 m

Epoch : 1997.0

XYZ Coords. : X = 80791.99 m Y = -1108912.86 m Z = 6259508.23 m

VERTICAL DATA

Vertical Datum : CGVD28

Elevation : 77.9 m

Order : Consult Agency (Unique Condition)

Method : Consult Agency

Adjustment Line : NOVA2004

Published Year : 2004

STATION MARKER INFORMATION AND LOCATION

Marker Type : Brass/Bronze Tablet Or Cap

Inspected in : 1996

Status : Good

Inspection Comments : None

LOCATED ON FOSHEIM PEN OF ELLESMERE ISLAND AT THE AIRSTRIP OF THE EUREKA WEATHER STATION, ON BRADLEY AIR SERVICE PROPERTY, 16.04 M FROM MAIN STATION "749167". MARKED BY A BRASS TABLET SET ON A COPPER ROD.

HISTORICAL COORDINATES NOTE: Coordinates listed below are no longer maintained by GSD.

None

PROJECTS IDENTIFIERS:

GPS

Number of Stations Retrieved : 2

35062 - Eureka Airstrip Survey - Control Co-Ordinate Comparison										
Monument Name	Published NAD83 CSRS			Surveyed NAD83 CSRS (Fixed to 749167A)						
	Northing	Easting	Elev.	Northing	Easting	Elev.	ΔN	ΔE	ΔH	
749167	8881145.150	522636.560	78.406	8881145.218	522636.522	78.447	0.068	-0.038	0.041	
749167A	8881129.110	522636.580	77.847	Held Fixed			—	—	—	
CACS-Eureka	8880539.099	520617.802	21.564	—	—	—	—	—	—	
				Surveyed NAD83 CSRS(Fixed to CACS-Eureka)						
				Northing	Easting	Elev.	ΔN	ΔE	ΔH	
				749167	8881145.063	522636.413	78.257	-0.087	-0.147	-0.149
				749167A	8881128.955	522636.471	77.657	-0.155	-0.109	-0.190
				CACS-Eureka	Held Fixed			—	—	—
				Surveyed NAD83 CSRS (Fixed to PPP)						
				Northing	Easting	Elev.	ΔN	ΔE	ΔH	
749167	—	—	—	—	—	—				
749167A	8881128.959	522636.491	77.715	-0.151	-0.089	-0.132				
CACS-Eureka	—	—	—	—	—	—				

Notes: Elevations shown are Orthometric, HTv2

All co-ordinate comparisons shown are relative to published values

Coordinates for CACS Eureka was computed using X, Y and Z values from ACP Report .