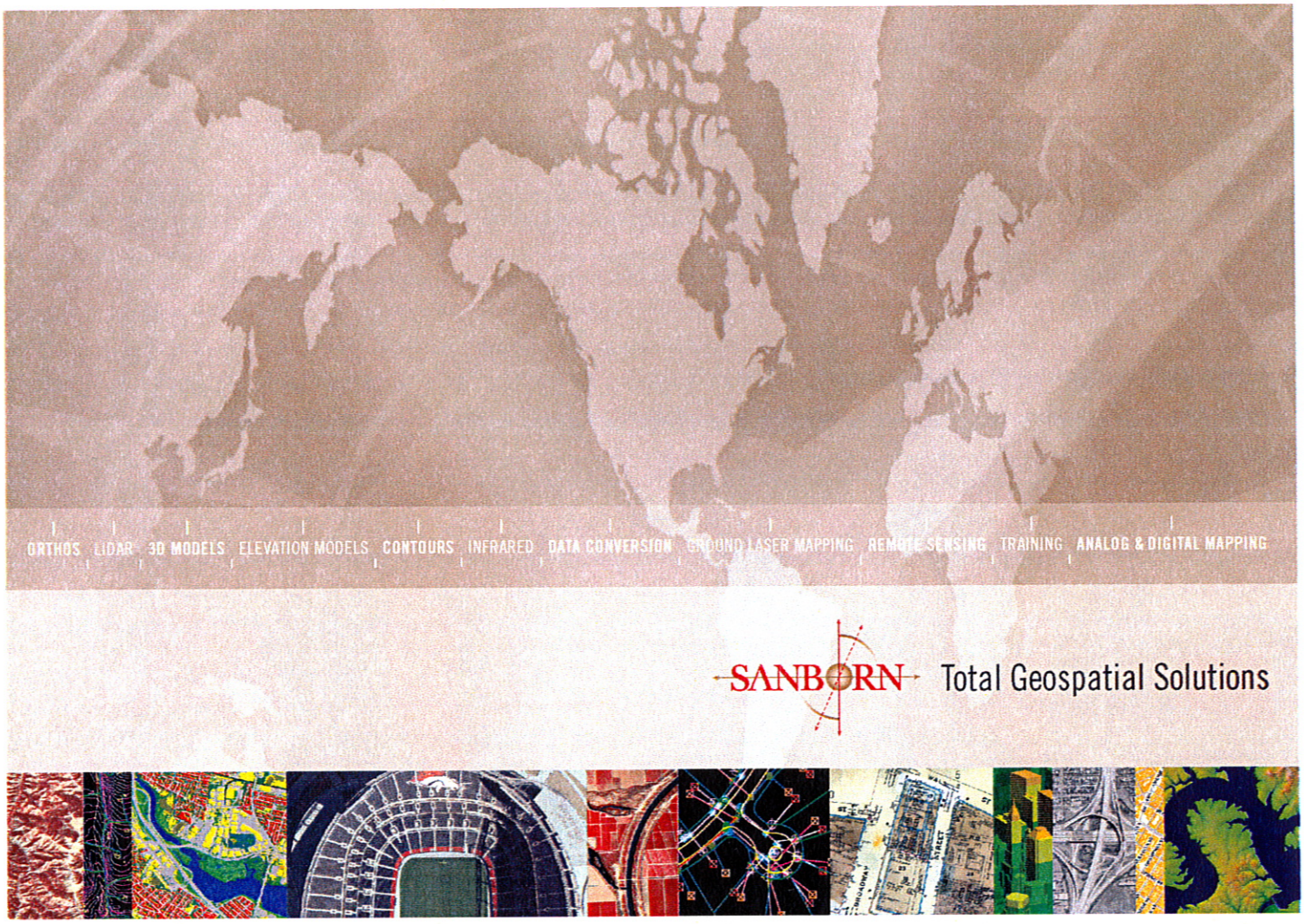

CDM LiDAR

LiDAR Campaign (Fort Kent, ME) Report of Survey

2009

EXECUTIVE SUMMARY

CDM contracted with Sanborn to provide LiDAR mapping services for Fort Kent, Maine. Utilizing multi-return systems, Light Detection and Ranging (LiDAR) data in the form of 3-dimensional positions of a dense set of mass points was collected for approximately 188 square miles on May 13th and 14th. All systems consist of geodetic GPS positioning, orientation derived from high-end inertial sensors and high-accurate lasers. The sensor is attached to the aircraft's underside and emits rapid pulses of light that are used to determine distances between the plane and terrain below.

Specifically, the Leica ALS-50 LiDAR system was used to collect data for the survey campaign. The LiDAR system is calibrated by conducting flight passes over a known ground surface before and after each LiDAR mission. During final data processing, the calibration parameters are inserted into post-processing software.

Four airborne GPS (Global Positioning System) base stations were used in the Maine project. Three out of the four base stations were set up at National Geodetic Survey (NGS) markers. NGS point with PID SF0088 is located near Highway 1 and State Highway 161, and SF0072 is located off State Route 11, about 10 miles south of Fort Kent. The third NGS point is PID AB2651 and is located at the Northern Aroostook Regional Airport. Finally, the 501 point was set 1 mile south of Pelletier's Mill. These four base stations were tied to each other to create a GPS survey network. The coordinates of these stations were checked against each other with the three dimensional GPS baseline created at the airborne support set up and determined to be within project specifications.

The acquired LiDAR data was processed to obtain first and last return point data. The last return data was further filtered to yield a LiDAR surface representing the bare earth.

The contents of this report summarize the methods used to establish the base station coordinate check, perform the LiDAR data collection and post-processing as well as the results of these methods.

Contents

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

This document contains the technical write-up of the LiDAR campaign, including system calibration techniques, the establishment and processing of base stations by a differential GPS network survey, and the collection and post-processing of the LiDAR data.

1.1 Contact Information

Questions regarding the technical aspects of this report should be addressed to:

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719-264-5584 (Fax)
alucero@sanborn.com

1.2 Purpose of the LiDAR Acquisition

As stated in the Statement of Work for Acquisition and Production of High Resolution Elevation data for Fort Kent, this LiDAR operation was designed to create high resolution data sets that will establish an authoritative source for elevation information for the State of Maine.

1.3 Project Location

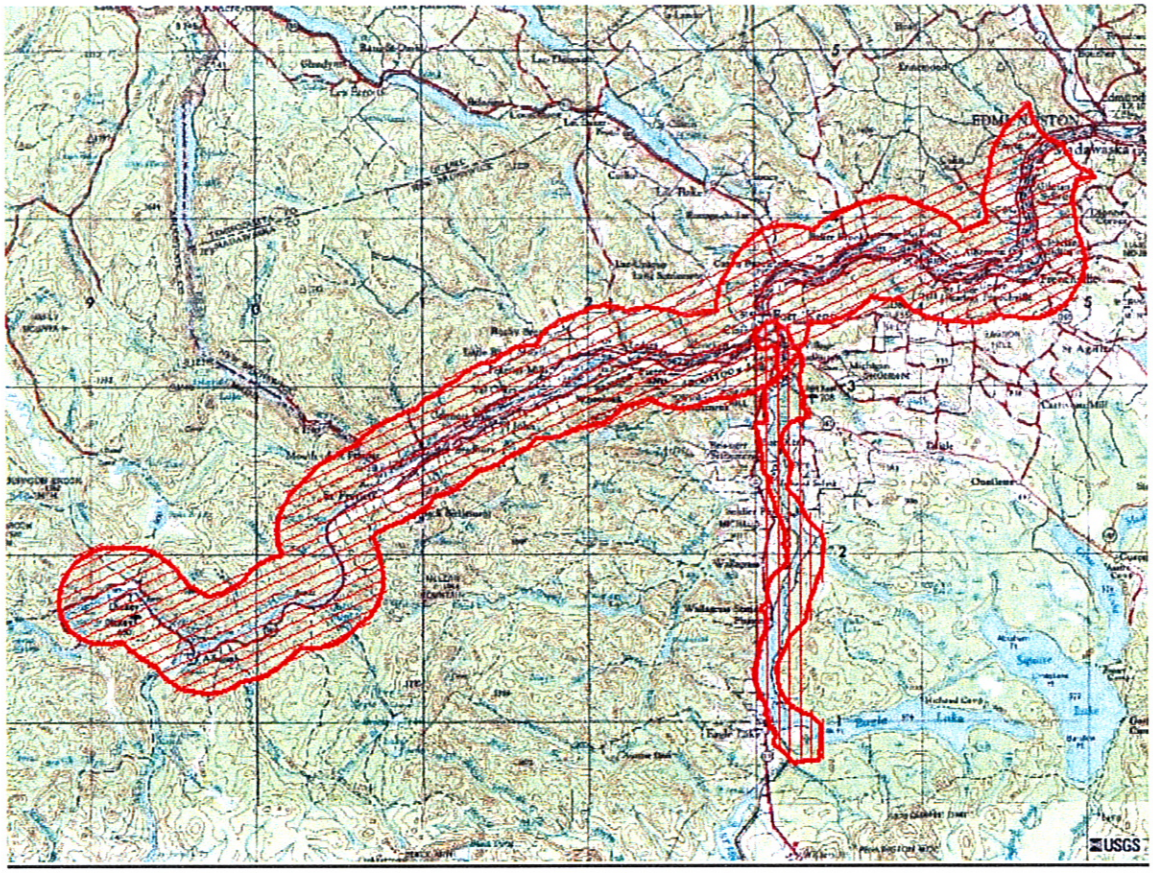

Figure 1: Area of Collection

1.4 Standard Specifications for LiDAR

Table 1: Project Specifications

Fort Kent, ME	
Sanborn Product Type	FEMA
Project Area (sq miles)	188
Point Spacing (Nominal)	1.4-meter
Vertical Accuracy	18.5cm 37.0cm
Horizontal Accuracy	1-meter
Field Verification	~20 points per ground class
File Format	LAS (v.1.1) 1. Unclassified (above ground) 2. Ground – bare earth
Tile Size	2500'x2500'
Coordinate System	Maine State Plane East, NAD83, NAVD88, US Survey Foot
Metadata	FGDC-XML (project level)

2 LIDAR CALIBRATION

2.1 Introduction

LiDAR calibrations are performed to determine and therefore eliminate systematic biases that occur within the hardware of the Leica ALS-50 system. Once the biases are determined they can be modeled out. The systematic biases are corrected for include scale, roll, and pitch.

The following procedures are intended to prevent operational errors in the field and office work, and are designed to detect inconsistencies. The emphasis is not only on the quality control (QC) aspects, but also on the documentation, i.e., on the quality assurance (QA).

2.2 Calibration Procedures

Sanborn performs two types of calibrations on its LiDAR system. The first is a building calibration, and it is done any time the LiDAR system has been moved from one plane to another. New calibration parameters are computed and compared with previous calibration runs. If there is any change, the new values are updated internally or during the LiDAR post-processing. These values are applied to all data collected with the plane and the ALS-50 system configurations.

Once final processing calibration parameters are established from the building data, a precisely-surveyed surface is observed with the LiDAR system to check for stability in the

system. This is done several times during each mission. An average of the systematic biases are applied on a per mission basis.

2.3 Building Calibration

Whenever the ALS-50 is moved to a new aircraft, a building calibration is performed. The rooftop of a large, flat, rectangular building is surveyed on the ground using conventional survey methods, and used as the LiDAR calibration target. The aircraft flies several specified passes over the building with the ALS-50 system set first in scan mode, then in profile mode, and finally in both scan and profile modes with the scan angle set to zero degrees.

Figure 2 shows a pass over the center of the building. The purpose of this pass is to identify a systematic bias in the scale of the system.

Figure 3 demonstrates a pass along a distinct edge of the building to verify the roll compensation performed by the Inertial Navigation System, INS.

Additionally, a pass is made in profile mode across the middle of the building to compensate for any bias in pitch.

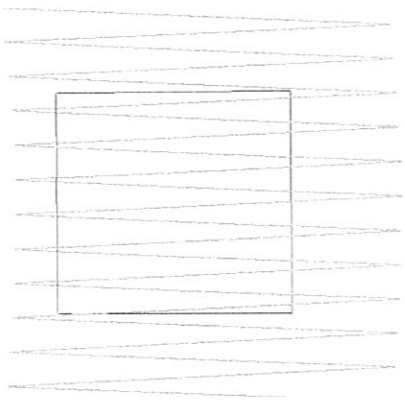

Figure 2: Calibration Pass 1

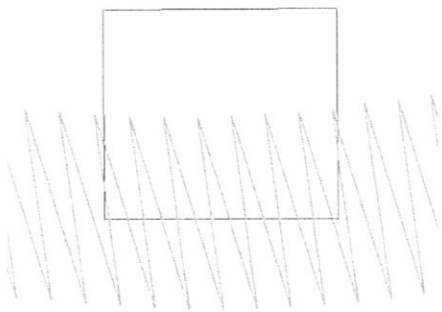

Figure 3: Calibration Pass 2

2.4 Runway Calibration, System Performance Validation

An active asphalt runway was precisely-surveyed at the Northern Aroostook Regional Airport for Fort Kent, ME using kinematic GPS survey techniques (accuracy: ±3cm at 1σ, along each coordinate axis) to establish an accurate digital terrain model of the runway surface. The LiDAR system is flown at right angles over the runway several times and residuals are generated from the processed data. Figure 4 shows a typical pass over the runway surface.

Approximately 25,000 LiDAR points are observed with each pass. A Triangulated Irregular Network (TIN) surface is created from these passes. The ground control x,y,z points are then compared with the z of the LiDAR surface to compute vertical residuals of the LiDAR data. After careful analysis of noise associated with non-runway returns, any system bias is documented and removed from the process.

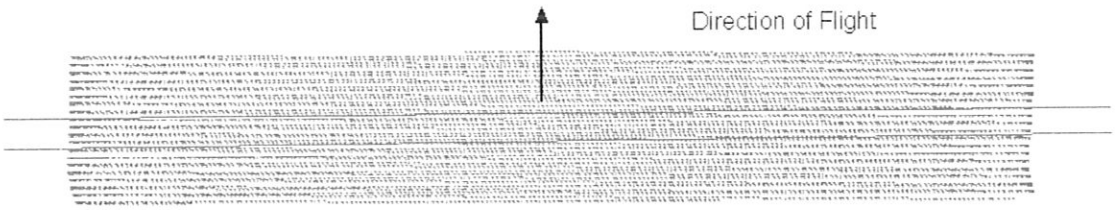

Figure 4: Runway Calibration

3 RUNWAY CALIBRATION AND SYSTEM PERFORMANCE VALIDATION

3.1 Calibration Results

The LiDAR data captured over the building is used to determine whether there have been any changes to the alignment of the Inertial Measurement Unit, IMU, with respect to the laser system. The parameters are designed to eliminate systematic biases within certain system parameters.

The runway over-flights are intended to be a quality check on the calibration and to identify any system irregularities and the overall noise. IMU misalignments and internal system calibration parameters are verified by comparing the collected LiDAR points with the runway surface.

Figure 5 shows the typical results of a runway over-flight analysis. The X-axis represents the position along the runway. The overall statistics from this analysis provides evidence of the overall random noise in the data (typically, 7 cm standard deviation – an unbiased estimator, and 8 cm RMS which includes any biases) and indicates that the system is performing within specifications. As described in later sections of this report, this analysis will identify any peculiarities within the data along with mirror-angle scale errors (identified as a "smile" or "frown" in the data band) or roll biases.

The calibration is done based on a kinematic survey on the runway. Given that the Kinematic survey RMSE is no better than 4 centimeters as a result of none exact height of the antenna and weight of the aircraft. Sanborn was required to do additional check points in the project area to meet the 18.5 centimeter vertical accuracy requirement knowing that the calibration site is only good to 6 centimeters RMSE. A z bump adjustment was made to the entire data set based on the survey points in the project area and the relative accuracy of the data to itself and in all areas.

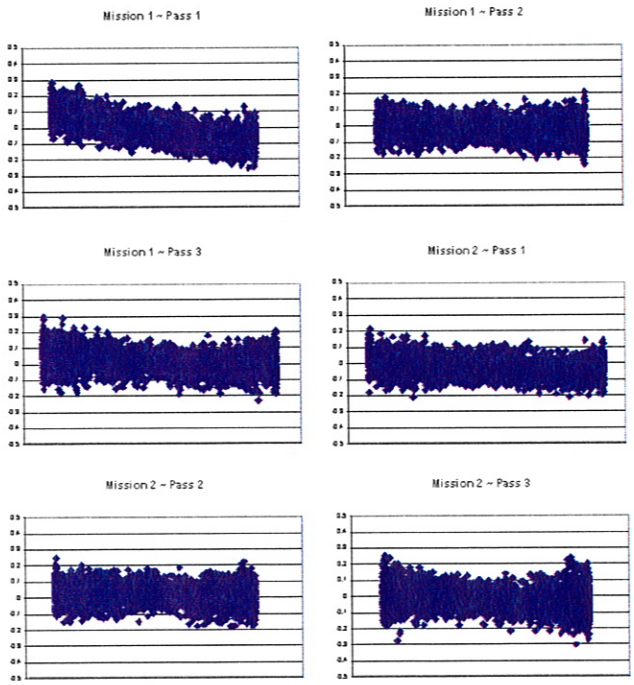

Figure 5: Runway Calibration Results

3.2 Daily Runway Performance/Data Validation Tests

Performance flights over the runway test field were performed before and after each mission. Table 2 shows the standard deviation and RMS values of the residuals between the test flights and the known surface of the test ranges for each pass. The maximum RMS value is 0.054 meters and the maximum standard deviation is 0.053 meters.

Table 2: Runway Validation Results for Clovis, NM (Meters)

Mission	Passes	Standard Deviation	RMS
133_Leica	4	0.047	0.052
134_Leica	4	0.053	0.054

4 LIDAR FLIGHT AND SYSTEM REPORT

4.1 Introduction

This section addresses LiDAR system, flight reporting and data acquisition methodology used during the collection of the CDM Fort Kent, ME campaign. Although Sanborn conducts all LiDAR with the same rigorous and strict procedures and processes, all LiDAR collections are unique.

4.2 Field Work Procedures

A minimum of two GPS base stations were set up, with one receiver located at the airport set up on AB2651, and the secondary GPS receiver placed at another survey control point SF0088, which is within the project area or within the required baseline specifications of the project.

Pre-flight checks such as cleaning the sensor head glass are performed. A four minute INS initialization is conducted on the ground, with the engines running, prior to flight, to establish fine-alignment of the INS. GPS ambiguities are resolved by flying within ten kilometers of the base stations.

The flight missions were between four and five hours in duration including runway calibration flights flown at the beginning and the end of each mission. During the data collection, the operator recorded information on log sheets which includes weather conditions, LiDAR operation parameters, and flight line statistics. Near the end of the mission GPS ambiguities are again resolved by flying within ten kilometers of the base stations, to aid in post-processing.

Table 3 shows the planned LiDAR acquisition parameters with a flying height of 1400 meters above ground level (AGL) for the Leica ALS-50 on a mission to mission basis.

Table 3: LiDAR Leica Acquisition Parameters

Average Altitude	1400 Meters AGL
Airspeed	~120 Knots
Scan Frequency	36 Hertz
Scan Width Half Angle	20 Degrees
Pulse Rate	76,200 Hertz

Preliminary data processing was performed in the field immediately following the missions for quality control of GPS data and to ensure sufficient overlap between flight lines. Any

problematic data could then be re-flown immediately as required. Final data processing was completed in the Colorado Springs office.

Table 4: Collection Dates, Times, Average Per Flight Collection Parameters and PDOP

Mission	Date	Sensor	Start Time	End Time	Altitude (m)	Airspeed (Knots)	Scan Angle	Scan Rate	Pulse Rate	PDOP
133	May 13th	Leica	22:48	02:16	1400	120	40°	35	76200	1.7
134	May 14th	Leica	03:29	08:03	1400	120	40°	35	76200	1.9

4.3 Final LiDAR Processing

Final post-processing of LiDAR data involves several steps. The airborne GPS data was post-processed using Waypoint's GravNAV™ software (version 7.5). A fixed-bias carrier phase solution was computed in both the forward and reverse chronological directions. The data was processed for both base stations and combined. In the event that the solution worsened as a result of the combination of both solutions the best of both solutions was used to yield more accurate data. LiDAR acquisition was limited to periods when the PDOP was less than 3.2.

The GPS trajectory was combined with the raw IMU data and post-processed using Applanix Inc.'s POSPROC (version 4.3) Kalman Filtering software. This results in a two-fold improvement in the attitude accuracies over the real-time INS data. The best estimated trajectory (BET) and refined attitude data are then re-introduced into the LEICA ALS post processor to compute the laser point-positions. The trajectory is then combined with the attitude data and laser range measurements to produce the 3-dimensional coordinates of the mass points.

All return values are produced within ALS Post processing software for the Leica system. The multi-return information is processed to obtain the "Bare Earth Dataset" as a deliverable. All LiDAR data is processed using the binary LAS format 1.1 file format.

LiDAR filtering was accomplished using TerraSolid, TerraScan LiDAR processing and modeling software. The filtering process reclassifies all the data into classes with in the LAS formatted file based scheme set using the LAS format 1.1 specifications or by the client. Once the data is classified, the entire data set is reviewed and manually edited for anomalies that are outside the required guidelines of the product specification or contract guidelines, whichever apply. Table 5 indicates the required product specifications.

The coordinate and datum transformations are then applied to the data set to reflect the required deliverable projection, coordinate and datum systems as provided in the contract.

The client required deliverables are then generated. At this time, a final QC process is undertaken to validate all deliverables for the project. Prior to release of data for delivery, Sanborn's quality control/ quality assurance department reviews the data and then releases it for delivery.

Table 5: Processing Accuracies and Requirements

Accuracy of LiDAR Data (H)	1m RMSE
Accuracy of LiDAR data in bare areas	18.5 cm RMSE
Accuracy of LiDAR data in vegetated areas	37 cm RMSE
Percent of artifacts removed (terrain and vegetation dependent)	90%
Percent of all outliers removed	95%
Percent of all vegetation removed	95%
Percent of all buildings removed	98%

5 GEODETIC BASE NETWORK

5.1 Network Scope

During the LiDAR campaign, the Sanborn field crew conducted a GPS field survey to establish final coordinates of the ground base stations for final processing of the base-remote GPS solutions. NGS points AB2651, SF0072, SF0088 and also 501 were used for the LiDAR mission. See Table 6 for station names, orders and constraints. NGS Datasheets are located at the end of the report.

5.2 Data Processing and Network Adjustment

The static baselines created between points 501, AC2651, SF0072, and SF0088 were processed using Trimble Geomatics Office™ (Ver. 1.62) software. Fixed bias solution was obtained for the baselines. The broadcast ephemeris was used, since the accuracy and extent of the network does not warrant the use of the precise ephemeris. The results were satisfactory; therefore, fulfilling project specifications for first order control network. See Table 7 for loop closure summary.

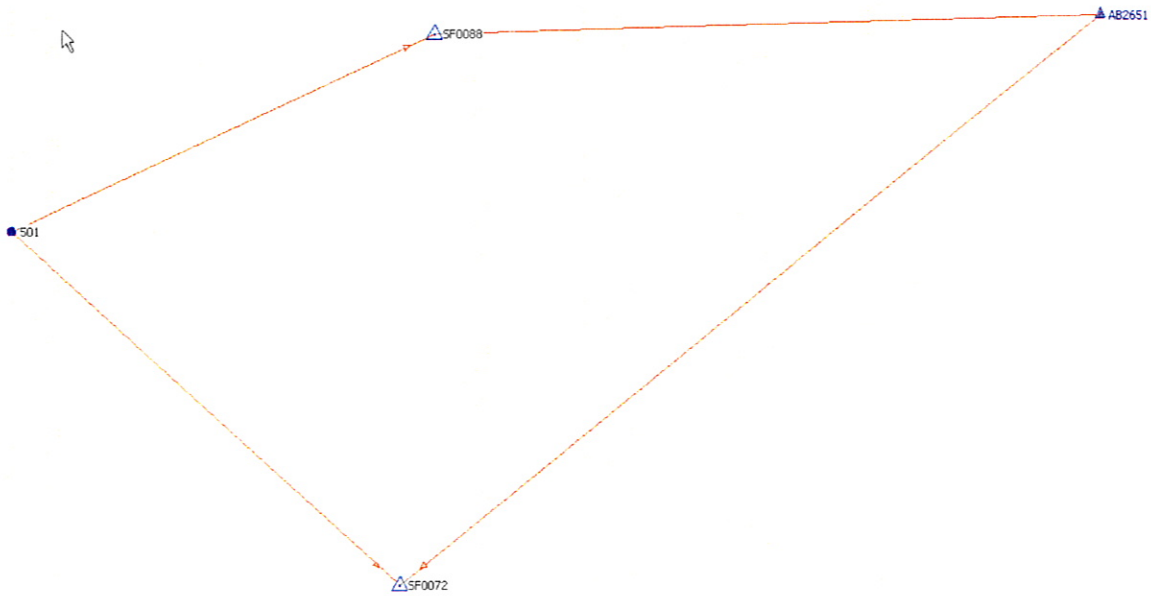

Figure 6: Survey Network Diagram

Table 6: NGS Control Constraints

Horizontal

Code	NGS Station Name	PID	Constrain
AB2651	DILEOR	AB2651	Constrained
SF0072	Y 173	SF0072	Constrained
SF0088	J 173	SF0088	Constrained
501	Point Set	N/A	Checkpoint

Vertical

Code	NGS Station Name	PID	Constrain
AB2651	DILEOR	AB2651	Checkpoint
SF0072	Y 173	SF0072	Checkpoint
SF0088	J 173	SF0088	Constrained
501	Point Set	N/A	Checkpoint

Table 7: Survey Loop Closure Summary

Loop	Δ Horiz (cm)	Δ Vert (cm)	Dist. (m)	ppm
501: SF0088: AB2651: SF0072: 501	0.010	0.021	81115.678	0.286

5.3 Final LiDAR Verification

The LiDAR data was evaluated using a collection of 16 GPS surveyed checkpoints. Six points were collected in each bare earth, low grass, and urban vegetation classes, see Figure 7 for diagram. For Fort Kent, ME the standard deviation is 0.201 feet and the root mean squared is 0.195 feet. The LiDAR data was compared to each of these classes yielding much better result than was required for the project. Table 8 indicates the results for Fort Kent and each point including the overall results as it compares to the LiDAR data set.

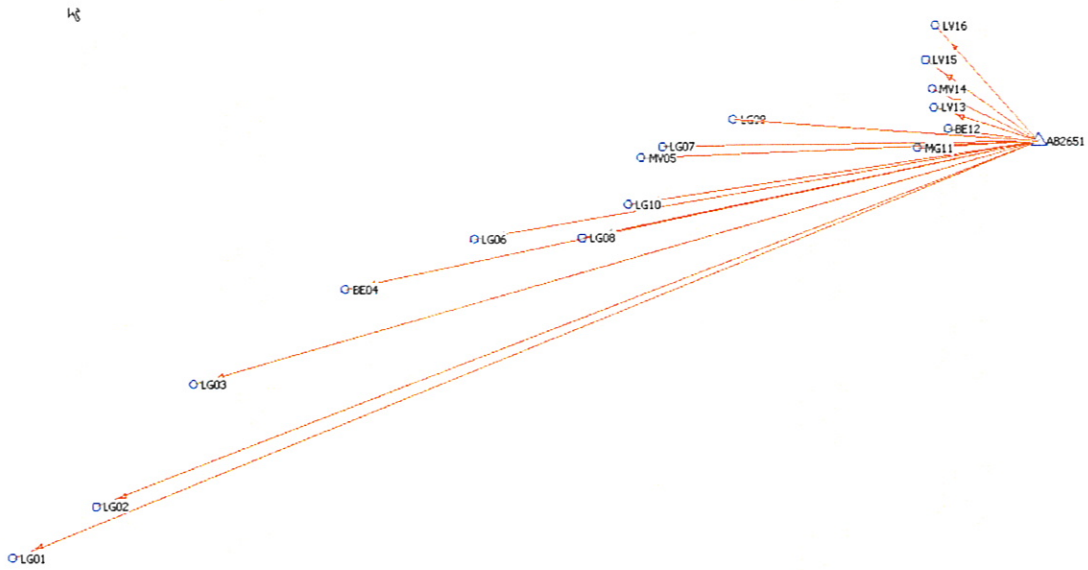

Figure 7: Fort Kent, Maine Survey Checkpoint Diagram

Table 8: LiDAR Accuracy Assessment based on the Checkpoint Survey (Feet)

Name	Vegetation Class	Easting	Northing	Known Z	Laser Z	Dz
LG01	Low Grass	852570.563	1246991.728	629.308	629.710	+0.402
LG03	Low Grass	884574.340	1276977.424	650.850	651.240	+0.390
BE04	Bare Earth	911286.930	1293271.299	575.236	575.420	+0.184
MV11	Med. Veg.	1011791.545	1317410.548	489.190	489.280	+0.090
LG06	Low Grass	933982.505	1301887.825	551.903	551.980	+0.077
LG07	Low Grass	967154.301	1317805.315	556.294	556.330	+0.036
LV13	Low Veg	1014755.828	1324405.588	505.919	505.950	+0.031
MV05	Med. Veg.	963357.733	1315946.704	561.629	561.630	+0.001
LG02	Low Grass	867208.570	1255830.344	590.720	590.700	-0.020
LG08	Low Grass	952902.873	1302041.132	586.834	586.810	-0.024
LG10	Low Grass	961070.575	1307833.639	518.389	518.340	-0.049
BE12	Bare Earth	1017232.431	1320697.820	525.849	525.660	-0.189
MV14	Med. Veg.	1014477.740	1327614.499	595.075	594.880	-0.195
LV16	Low Veg	1015110.743	1338688.270	576.447	576.240	-0.207
LG09	Low Grass	979502.574	1322490.447	533.370	533.140	-0.230
LV15	Low Veg.	1013359.952	1332661.986	510.713	510.450	-0.263

Average dz	+0.002
Minimum dz	-0.263
Maximum dz	+0.402
Average Magnitude	0.149
Root Mean Square	**0.195**
Std deviation	0.201

6 COORDINATES AND DATUM

6.1 Introduction

The final adjustment was constrained to the published NAD83 geodetic coordinates (ϕ, λ) and NAVD88 elevations. The adjustment was cross-referenced to the GEOID03 model to enable the estimation of orthometric heights.

6.2 Horizontal Datum

The final horizontal coordinates are provided in the State Plane coordinate system on the North American Datum of 1983 (NAD83 adjustment of 1992) units of U.S feet.

6.3 Vertical Datum

The final orthometric elevations were determined for all points in the network using Geoid03 model and are provided on the North American Vertical Datum of 1988 in units of U.S Survey feet.

The NGS Data Sheet

See file dsdata.txt
<http://www.ngs.noaa.gov/cgi-bin/ds_lookup.prl?Item=DSDATA.TXT> for
more information about the datasheet.

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DATABASE =  ,PROGRAM = datasheet, VERSION = 7.65
1       National Geodetic Survey,   Retrieval Date = MARCH 19, 2009
 AB2651 ***********************************************************************
 AB2651  SACS      - This is a Secondary Airport Control Station.
 AB2651  DESIGNATION -  DILEOR
 AB2651  PID       - AB2651
 AB2651  STATE/COUNTY-  ME/AROOSTOOK
 AB2651  USGS QUAD   -  MADAWASKA (1986)
 AB2651
 AB2651                  *CURRENT SURVEY CONTROL
 AB2651  ______________________________________________________________________
 AB2651* NAD 83(2007)-  47 16 57.62669(N)    068 18 09.97476(W)     ADJUSTED
 AB2651* NAVD 88    -      299.76   (meters)     983.5    (feet)  GPS OBS
 AB2651  ______________________________________________________________________
 AB2651  EPOCH DATE  -       2002.00
 AB2651  X         -  1,602,597.754 (meters)              COMP
 AB2651  Y         - -4,027,717.273 (meters)              COMP
 AB2651  Z         -  4,663,343.100 (meters)              COMP
 AB2651  LAPLACE CORR-         5.43  (seconds)              DEFLEC99
 AB2651  ELLIP HEIGHT-       275.872 (meters)         (02/10/07) ADJUSTED
 AB2651  GEOID HEIGHT-        -23.84  (meters)              GEOID03
 AB2651
 AB2651  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
 AB2651  Type   PID    Designation                 North   East  Ellip
 AB2651  ----------------------------------------------------------------
 AB2651  NETWORK AB2651 DILEOR                      1.22   0.71   2.63
 AB2651  ----------------------------------------------------------------
 AB2651
 AB2651.This mark is at Northern Aroostook Regional Airport (FVE)
 AB2651
 AB2651.The horizontal coordinates were established by GPS observations
 AB2651.and adjusted by the National Geodetic Survey in February 2007.
 AB2651
 AB2651.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
 AB2651.See National Readjustment <http://www.ngs.noaa.gov/NationalReadjustment> for more information.
 AB2651.The horizontal coordinates are valid at the epoch date displayed above.
 AB2651.The epoch date for horizontal control is a decimal equivalence
 AB2651.of Year/Month/Day.
 AB2651
 AB2651.The orthometric height was determined by GPS observations and a
```

AB2651.high-resolution geoid model.
AB2651
AB2651.GPS derived orthometric heights for airport stations designated as
AB2651.PACS or SACS are published to 2 decimal places. This maintains
AB2651.centimeter relative accuracy between the PACS and SACS. It does
AB2651.not indicate centimeter accuracy relative to other marks which are
AB2651.part of the NAVD 88 network.
AB2651
AB2651.The X, Y, and Z were computed from the position and the ellipsoidal ht.
AB2651
AB2651.The Laplace correction was computed from DEFLEC99 derived deflections.
AB2651
AB2651.The ellipsoidal height was determined by GPS observations
AB2651.and is referenced to NAD 83.
AB2651
AB2651.The geoid height was determined by GEOID03.
AB2651
AB2651; North East Units Scale Factor Converg.
AB2651;SPC ME E - 401,865.541 314,919.674 MT 0.99990273 +0 08 41.7
AB2651;SPC ME E - 1,318,453.86 1,033,198.96 sFT 0.99990273 +0 08 41.7
AB2651;UTM 19 - 5,236,813.146 552,726.938 MT 0.99963417 +0 30 44.2
AB2651
AB2651! - Elev Factor x Scale Factor = Combined Factor
AB2651!SPC ME E - 0.99995676 x 0.99990273 = 0.99985949
AB2651!UTM 19 - 0.99995676 x 0.99963417 = 0.99959095
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AB2651 SUPERSEDED SURVEY CONTROL
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AB2651 NAD 83(1996)- 47 16 57.62721(N) 068 18 09.97513(W) AD( ) 1
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AB2651.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
AB2651.See file dsdata.txt <http://www.ngs.noaa.gov/cgi-bin/ds_lookup.prl?Item=HOW_SUP_DET>to
determine how the superseded data were derived.
AB2651
AB2651_U.S. NATIONAL GRID SPATIAL ADDRESS: 19TEN5272736813(NAD 83)
AB2651_MARKER: DD = SURVEY DISK
AB2651_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
AB2651_STAMPING: DILEOR 1988
AB2651_MARK LOGO: MEDT
AB2651_MAGNETIC: N = NO MAGNETIC MATERIAL
AB2651_STABILITY: C = MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO
AB2651+STABILITY: SURFACE MOTION
AB2651_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
AB2651+SATELLITE: SATELLITE OBSERVATIONS - October 17, 2007
AB2651

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AB2651  HISTORY    - 19951015 GOOD          CHANCE
AB2651  HISTORY    - 19960627 GOOD          NGS
AB2651  HISTORY    - 20071017 GOOD          MEDT
AB2651
AB2651                  STATION DESCRIPTION
AB2651
AB2651'DESCRIBED BY JE CHANCE AND ASSOCIATES 1995 (DS)
AB2651'THE STATION IS LOCATED ABOUT 5.6 KM (3.45 MI) EAST OF FRENCHVILLE, AT
AB2651'THE NORTHERN AROOSTOOK REGIONAL AIRPORT.  OWNERSHIP--NORTHERN
AB2651'AROOSTOOK REGIONAL AIRPORT AUTHORITY, AIRPORT MANAGER, ROLAND MARTIN,
AB2651'PHONE 207-543-6300  TO REACH THE STATION FROM THE JUNCTION OF U.S.
AB2651'HWY 1 AND STATE HWY 162 IN FRENCHVILLE, GO NORTH 1.1 KM (0.70 MI)
AB2651'ALONG U.S.  HWY 1 TO A PAVED ROAD ON THE RIGHT.  TURN RIGHT AND GO 0.3
AB2651'KM (0.20 MI) ON THE PAVED ROAD TO A PAVED ROAD ON THE RIGHT.  TURN
AB2651'RIGHT AND GO SOUTHEAST FOR 1.3 KM (0.80 MI) ON THE PAVED ROAD TO A
AB2651'FORK.  FOLLOW THE LEFT FORK AND GO EAST FOR 3.7 KM (2.30 MI) TO THE
AB2651'END OF ROAD AT THE TERMINAL BUILDING AND A GATE TO THE TARMAC.  PASS
AB2651'THROUGH GATE, THEN BEAR RIGHT FOR 90 M (295.3 FT) TO RUNWAY 14-32.
AB2651'TURN LEFT AND GO SOUTHEAST 1.0 KM (0.60 MI) ALONG THE RUNWAY TO THE
AB2651'END.  THE STATION IS APPROXIMATELY ANOTHER 120 M (393.7 FT) SOUTHEAST
AB2651'BEYOND THE END OF THE RUNWAY  THE STATION IS A 8.89 CM DIA MAINE DOT
AB2651'SURVEY DISK SET IN A ROCK OUTCROP.  THE STATION IS LOCATED 121.8 M
AB2651'(399.6 FT) EAST OF THE CENTERLINE END OF RUNWAY 14-32, 115.0 M (377.3
AB2651'FT) EAST-SOUTHEAST OF THE SOUTHEAST CORNER OF THE END OF ASPHALT
AB2651'PULLOUT, AND 5.50 M (18.04 FT) SOUTHWEST OF A METAL WITNESS POST  THE
AB2651'STATION IS DESIGNATED AS A SECONDARY AIRPORT CONTROL STATION (SACS) -
AB2651'MAINE ANA SURVEYS 1995.
AB2651
AB2651                  STATION RECOVERY (1996)
AB2651
AB2651'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1996 (KRN)
AB2651'THE STATION IS LOCATED ABOUT 5.6 KM (3.45 MI) EAST OF FRENCHVILLE, AT
AB2651'THE NORTHERN AROOSTOOK REGIONAL AIRPORT.  OWNERSHIP--NORTHERN
AB2651'AROOSTOOK REGIONAL AIRPORT AUTHORITY, AIRPORT MANAGER, ROLAND MARTIN,
AB2651'PHONE 207-543-6300 TO REACH THE STATION FROM THE JUNCTION OF U.S. HWY
AB2651'1 AND STATE HWY 162 IN FRENCHVILLE, GO NORTH 1.1 KM (0.70 MI) ALONG
AB2651'U.S.  HWY 1 TO A PAVED ROAD ON THE RIGHT.  TURN RIGHT AND GO 0.3 KM
AB2651'(0.20 MI) ON THE PAVED ROAD TO A PAVED ROAD ON THE RIGHT. TURN RIGHT
AB2651'AND GO SOUTHEAST FOR 1.3 KM (0.80 MI) ON THE PAVED ROAD TO A FORK.
AB2651'FOLLOW THE LEFT FORK AND GO EAST FOR 3.7 KM (2.30 MI) TO THE END OF
AB2651'ROAD AT THE TERMINAL BUILDING AND A GATE TO THE TARMAC.  PASS THROUGH
AB2651'GATE, THEN BEAR RIGHT FOR 90 M (295.3 FT) TO RUNWAY 14-32. TURN LEFT
AB2651'AND GO SOUTHEAST 1.0 KM (0.60 MI) ALONG THE RUNWAY TO THE END.  THE
AB2651'STATION IS APPROXIMATELY ANOTHER 120 M (393.7 FT) SOUTHEAST BEYOND THE
AB2651'END OF THE RUNWAY THE STATION IS A 8.89 CM DIA MAINE DOT SURVEY DISK
AB2651'SET IN A ROCK OUTCROP.  THE STATION IS LOCATED 121.8 M (399.6 FT) EAST
AB2651'OF THE CENTERLINE END OF RUNWAY 14-32, 115.0 M (377.3 FT)
AB2651'EAST-SOUTHEAST OF THE SOUTHEAST CORNER OF THE END OF ASPHALT PULLOUT,
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AB2651'AND 5.50 M (18.04 FT) SOUTHWEST OF A METAL WITNESS POST THE STATION IS
AB2651'DESIGNATED AS A SECONDARY AIRPORT CONTROL STATION (SACS) - MAINE ANA
AB2651'SURVEYS 1995.
AB2651
AB2651 STATION RECOVERY (2007)
AB2651
AB2651'RECOVERY NOTE BY MAINE DEPARTMENT OF TRANSPORTATION 2007 (KCR)
AB2651'RECOVERED IN GOOD CONDITION.

*** retrieval complete.
Elapsed Time = 00:00:01

The NGS Data Sheet

See file dsdata.txt
<http://www.ngs.noaa.gov/cgi-bin/ds_lookup.prl?Item=DSDATA.TXT> for
more information about the datasheet.

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DATABASE =  ,PROGRAM = datasheet, VERSION = 7.65
1       National Geodetic Survey,   Retrieval Date = MARCH 19, 2009
 SF0072 ***********************************************************************
 SF0072  FBN        - This is a Federal Base Network Control Station.
 SF0072  DESIGNATION -  Y 173
 SF0072  PID        - SF0072
 SF0072  STATE/COUNTY-  ME/AROOSTOOK
 SF0072  USGS QUAD   -  EAGLE LAKE (1985)
 SF0072
 SF0072                  *CURRENT SURVEY CONTROL
 SF0072  ______________________________________________________________________
 SF0072* NAD 83(2007)-  47 07 16.92038(N)    068 35 48.52463(W)     ADJUSTED
 SF0072* NAVD 88     -      222.619  (meters)     730.38   (feet)  ADJUSTED
 SF0072  ______________________________________________________________________
 SF0072  EPOCH DATE  -       2002.00
 SF0072  X          -  1,586,689.428 (meters)                COMP
 SF0072  Y          -  -4,048,091.270 (meters)               COMP
 SF0072  Z          -  4,651,101.584 (meters)                COMP
 SF0072  LAPLACE CORR-          4.29  (seconds)              DEFLEC99
 SF0072  ELLIP HEIGHT-        198.322 (meters)        (02/10/07) ADJUSTED
 SF0072  GEOID HEIGHT-         -24.31  (meters)               GEOID03
 SF0072  DYNAMIC HT  -         222.646 (meters)     730.46  (feet)  COMP
 SF0072
 SF0072  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
 SF0072  Type   PID   Designation                  North   East   Ellip
 SF0072  ----------------------------------------------------------------
 SF0072  NETWORK SF0072 Y 173                      0.71   0.47   1.51
 SF0072  ----------------------------------------------------------------
 SF0072  MODELED GRAV-     980,731.2   (mgal)                  NAVD 88
 SF0072
 SF0072  VERT ORDER  -  FIRST     CLASS II
 SF0072
 SF0072.The horizontal coordinates were established by GPS observations
 SF0072.and adjusted by the National Geodetic Survey in February 2007.
 SF0072
 SF0072.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
 SF0072.See National Readjustment <http://www.ngs.noaa.gov/NationalReadjustment> for more information.
 SF0072.The horizontal coordinates are valid at the epoch date displayed above.
 SF0072.The epoch date for horizontal control is a decimal equivalence
 SF0072.of Year/Month/Day.
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SF0072
SF0072.The orthometric height was determined by differential leveling
SF0072.and adjusted in June 1991.
SF0072
SF0072.The X, Y, and Z were computed from the position and the ellipsoidal ht.
SF0072
SF0072.The Laplace correction was computed from DEFLEC99 derived deflections.
SF0072
SF0072.The ellipsoidal height was determined by GPS observations
SF0072.and is referenced to NAD 83.
SF0072
SF0072.The geoid height was determined by GEOID03.
SF0072
SF0072.The dynamic height is computed by dividing the NAVD 88
SF0072.geopotential number by the normal gravity value computed on the
SF0072.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
SF0072.degrees latitude (g = 980.6199 gals.).
SF0072
SF0072.The modeled gravity was interpolated from observed gravity values.
SF0072
SF0072; North East Units Scale Factor Converg.
SF0072;SPC ME E - 383,919.711 292,654.262 MT 0.99990066 -0 04 15.4
SF0072;SPC ME E - 1,259,576.59 960,149.86 sFT 0.99990066 -0 04 15.4
SF0072;UTM 19 - 5,218,730.157 530,583.071 MT 0.99961149 +0 17 43.6
SF0072
SF0072! - Elev Factor x Scale Factor = Combined Factor
SF0072!SPC ME E - 0.99996891 x 0.99990066 = 0.99986958
SF0072!UTM 19 - 0.99996891 x 0.99961149 = 0.99958042
SF0072
SF0072 SUPERSEDED SURVEY CONTROL
SF0072
SF0072 ELLIP H (04/26/01) 198.311 (m) GP( ) 4 1
SF0072 NAD 83(1996)- 47 07 16.92099(N) 068 35 48.52483(W) AD( ) B
SF0072 ELLIP H (07/24/97) 198.302 (m) GP( ) 1 1
SF0072 NAD 83(1992)- 47 07 16.92055(N) 068 35 48.52479(W) AD(1995.00) 1
SF0072 ELLIP H (04/19/96) 198.278 (m) GP(1995.00) 3 1
SF0072 NAD 83(1986)- 47 07 16.92331(N) 068 35 48.54179(W) AD( ) B
SF0072 NAD 83(1992)- 47 07 16.91770(N) 068 35 48.52397(W) AD( ) B
SF0072 ELLIP H (04/16/93) 198.401 (m) GP( ) 4 1
SF0072 NAVD 88 (04/16/93) 222.62 (m) 730.4 (f) LEVELING 3
SF0072
SF0072.Superseded values are not recommended for survey control.
SF0072.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
SF0072.See file dsdata.txt <http://www.ngs.noaa.gov/cgi-bin/ds_lookup.prl?Item=HOW_SUP_DET>to
determine how the superseded data were derived.
SF0072
SF0072_U.S. NATIONAL GRID SPATIAL ADDRESS: 19TEN3058318730(NAD 83)
SF0072_MARKER: DV = VERTICAL CONTROL DISK
SF0072_SETTING: 49 = STAINLESS STEEL ROD W/O SLEEVE (10 FT.+)
SF0072_SP_SET: METAL ROD DRIVEN INTO GROUND

SF0072_STAMPING: Y 173 1978
SF0072_MARK LOGO: NGS
SF0072_MAGNETIC: N = NO MAGNETIC MATERIAL
SF0072_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
SF0072_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
SF0072+SATELLITE: SATELLITE OBSERVATIONS - April 10, 2000
SF0072
SF0072 HISTORY - Date Condition Report By
SF0072 HISTORY - 1978 MONUMENTED NGS
SF0072 HISTORY - 19920621 GOOD NGS
SF0072 HISTORY - 19951005 GOOD CHANCE
SF0072 HISTORY - 20000410 GOOD NGS
SF0072
SF0072 STATION DESCRIPTION
SF0072
SF0072'DESCRIBED BY NATIONAL GEODETIC SURVEY 1978
SF0072'6.75 MI NORTH FROM EAGLE LAKE.
SF0072'6.75 MILES NORTH ALONG STATE HIGHWAY 11 FROM ST. MARYS CHURCH AT
SF0072'EAGLE LAKE, 1.45 MILES NORTH OF A CROSSING OF THE BANGOR AND AROOSTOOK
SF0072'RAILROAD, OPPOSITE OF A TWO STORY WOOD HOUSE, 29.9 FT. EAST OF THE
SF0072'CENTER LINE OF THE HIGHWAY, 52.0 FT. SOUTHEAST AND ACROSS THE HIGHWAY
SF0072'FROM THE NORTH END OF A 15-INCH METAL PIPE CULVERT UNDER A DRIVEWAY,
SF0072'2.4 FT. NORTH OF A POWER POLE, THE DISK IS 3 INCHES BELOW GROUND,
SF0072'ACCESS TO WHICH IS HAD THROUGH A 4-INCH PLASTIC SCREW PLUG FLUSH WITH
SF0072'THE GROUND.
SF0072
SF0072 STATION RECOVERY (1992)
SF0072
SF0072'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1992
SF0072'THE STATION IS LOCATED ABOUT 16 KM (9.95 MI) SOUTH OF FT. KENT, 4.0 KM
SF0072'(2.50 MI) SOUTH OF Y-JUNCTION OF A PAVED ROAD LEADING TO SOLDIER POND
SF0072'AND ON THE EAST SIDE OF HIGHWAY 11. OWNERSHIP--HIGHWAY RIGHT-OF-WAY.
SF0072'TO REACH THE STATION FROM THE JUNCTION OF U.S. HIGHWAY 1 AND STATE
SF0072'ROUTE 11 AT THE PUBLIC LIBRARY IN FT. KENT, GO SOUTH ON STATE ROUTE
SF0072'11 12.0 KM (7.45 MI) TO A PAVED ROAD LEFT LEADING TO SOLDIER POND.
SF0072'CONTINUE AHEAD ON STATE ROUTE 11 3.9 KM (2.40 MI) TO THE STATION ON
SF0072'THE LEFT.
SF0072'THE STATION IS STANDARD NGS BENCH MARK DISK SET ON TOP OF A METAL ROD
SF0072'DRIVEN IN THE GROUND, SUROUNDED BY A 4-INCH PVC PIPE WITH ACCESS
SF0072'THROUGH A 4-INCH SCREW CAP. LOCATED 8.8 M (28.9 FT) SOUTHEAST FROM
SF0072'THE CENTERLINE OF STATE ROUTE 11 AND 0.4 M (1.3 FT) SOUTHWEST FROM A
SF0072'METAL WITNESS POST. NOTE--PARKING ON SIDE OF ROAD, CONES SHOULD BE
SF0072'USED.
SF0072
SF0072 STATION RECOVERY (1995)
SF0072
SF0072'RECOVERY NOTE BY JE CHANCE AND ASSOCIATES 1995 (KB)
SF0072'RECOVERED AS DESCRIBED.
SF0072
SF0072 STATION RECOVERY (2000)

SF0072
SF0072'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2000 (CSM)
SF0072'RECOVERED AS DESCRIBED. NOTE--THE STATION IS ABOUT 1.22 M (4.00 FT)
SF0072'ABOVE THE HIGHWAY ON THE WEST EDGE OF A CUT BANK.

*** retrieval complete.
Elapsed Time = 00:00:00

The NGS Data Sheet

See file dsdata.txt
<http://www.ngs.noaa.gov/cgi-bin/ds_lookup.prl?Item=DSDATA.TXT> for
more information about the datasheet.

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DATABASE =  ,PROGRAM = datasheet, VERSION = 7.65
1       National Geodetic Survey,   Retrieval Date = MARCH 19, 2009
 SF0088 ***********************************************************************
 SF0088  DESIGNATION -  J 173
 SF0088  PID         -  SF0088
 SF0088  STATE/COUNTY-  ME/AROOSTOOK
 SF0088  USGS QUAD   -  FORT KENT NORTH (1985)
 SF0088
 SF0088                    *CURRENT SURVEY CONTROL
 SF0088  ______________________________________________________________________
 SF0088* NAD 83(1996)-  47 16 39.19718(N)    068 34 52.62272(W)     ADJUSTED
 SF0088* NAVD 88     -      172.297  (meters)     565.28   (feet)  ADJUSTED
 SF0088  ______________________________________________________________________
 SF0088  X           -  1,583,121.258 (meters)                COMP
 SF0088  Y           -  -4,035,768.281 (meters)               COMP
 SF0088  Z           -  4,662,862.935 (meters)                COMP
 SF0088  LAPLACE CORR-          6.60  (seconds)              DEFLEC99
 SF0088  ELLIP HEIGHT-        147.876 (meters)          (03/06/98) ADJUSTED
 SF0088  GEOID HEIGHT-         -24.42  (meters)               GEOID03
 SF0088  DYNAMIC HT  -         172.321 (meters)     565.36  (feet)  COMP
 SF0088  MODELED GRAV-      980,751.7   (mgal)                 NAVD 88
 SF0088
 SF0088  HORZ ORDER  -  FIRST
 SF0088  VERT ORDER  -  FIRST     CLASS II
 SF0088  ELLP ORDER  -  FOURTH    CLASS I
 SF0088
 SF0088.The horizontal coordinates were established by GPS observations
 SF0088.and adjusted by the National Geodetic Survey in March 1998.
 SF0088
 SF0088.The orthometric height was determined by differential leveling
 SF0088.and adjusted in June 1991.
 SF0088
 SF0088.The X, Y, and Z were computed from the position and the ellipsoidal ht.
 SF0088
 SF0088.The Laplace correction was computed from DEFLEC99 derived deflections.
 SF0088
 SF0088.The ellipsoidal height was determined by GPS observations
 SF0088.and is referenced to NAD 83.
 SF0088
 SF0088.The geoid height was determined by GEOID03.
```

SF0088
SF0088.The dynamic height is computed by dividing the NAVD 88
SF0088.geopotential number by the normal gravity value computed on the
SF0088.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
SF0088.degrees latitude (g = 980.6199 gals.).
SF0088
SF0088.The modeled gravity was interpolated from observed gravity values.
SF0088
SF0088; North East Units Scale Factor Converg.
SF0088;SPC ME E - 401,280.790 293,850.560 MT 0.99990046 -0 03 35.0
SF0088;SPC ME E - 1,316,535.39 964,074.71 sFT 0.99990046 -0 03 35.0
SF0088;UTM 19 - 5,236,093.526 531,667.870 MT 0.99961232 +0 18 27.4
SF0088
SF0088! - Elev Factor x Scale Factor = Combined Factor
SF0088!SPC ME E - 0.99997682 x 0.99990046 = 0.99987728
SF0088!UTM 19 - 0.99997682 x 0.99961232 = 0.99958915
SF0088
SF0088 SUPERSEDED SURVEY CONTROL
SF0088
SF0088 NAD 83(1992)- 47 16 39.19251(N) 068 34 52.61885(W) AD( ) 1
SF0088 ELLIP H (01/28/95) 148.050 (m) GP( ) 4 2
SF0088 NAD 83(1986)- 47 16 39.19886(N) 068 34 52.61814(W) AD( ) 1
SF0088 NGVD 29 (11/20/87) 172.44 (m) 565.7 (f) LEVELING 3
SF0088
SF0088.Superseded values are not recommended for survey control.
SF0088.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
SF0088.See file dsdata.txt <http://www.ngs.noaa.gov/cgi-bin/ds_lookup.prl?Item=HOW_SUP_DET>to determine how the superseded data were derived.
SF0088
SF0088_U.S. NATIONAL GRID SPATIAL ADDRESS: 19TEN3166836094(NAD 83)
SF0088_MARKER: DB = BENCH MARK DISK
SF0088_SETTING: 49 = STAINLESS STEEL ROD W/O SLEEVE (10 FT.+)
SF0088_SP_SET: STAINLESS STEEL ROD
SF0088_STAMPING: J 173 1978
SF0088_MAGNETIC: N = NO MAGNETIC MATERIAL
SF0088_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
SF0088_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
SF0088+SATELLITE: SATELLITE OBSERVATIONS - 1985
SF0088
SF0088 HISTORY - Date Condition Report By
SF0088 HISTORY - 1978 MONUMENTED NGS
SF0088 HISTORY - 1985 GOOD NGS
SF0088
SF0088 STATION DESCRIPTION
SF0088
SF0088'DESCRIBED BY NATIONAL GEODETIC SURVEY 1978
SF0088'2.05 MI NE FROM FORT KENT.
SF0088'2.05 MILES NORTHEAST ALONG U.S. HIGHWAY 1 FROM THE JUNCTION OF STATE
SF0088'HIGHWAY 11 AT FT. KENT, AT A COMBINATION SERVICE STATION AND GROCERY
SF0088'STORE, OPPOSITE THE T-JUNCTION OF A RESIDENTIAL STREET LEADING

SF0088'SOUTHEAST, 26.1 FT. NORTHWEST OF THE CENTER LINE OF THE HIGHWAY,
SF0088'67.8 FT. SOUTHEAST OF THE EAST CORNER OF THE STORE, 41.4 FT. NORTH-
SF0088'EAST OF THE NORTHEAST END OF A 14 INCH METAL PIPE CULVERT UNDER
SF0088'THE SOUTHWEST ENTRANCE TO A PARKING LOT, 1.6 FT. NORTHWEST OF POWER
SF0088'POLE 81/S, THE DISK IS 4 INCHES BELOW GROUND, ACCESS TO WHICH IS HAD
SF0088'THROUGH A 4 INCH PLASTIC SCREW PLUG 1 INCH BELOW GROUND.
SF0088
SF0088 STATION RECOVERY (1985)
SF0088
SF0088'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1985 (MRM)
SF0088'THE STATION WAS RECOVERED AT THIS DATE.
SF0088'
SF0088'THE STATION IS LOCATED ABOUT 2.4 KM (1.5 MI)
SF0088'NORTH-NORTHEAST OF FORT KENT, ALONG U.S. HIGHWAY 1, AT THE
SF0088'NORTHEAST END OF A SMALL GRASS STRIP BETWEEN HIGHWAY AND PARKING
SF0088'AREA TO A SMALL CONVENIENCE STORE.
SF0088'OWNERSHIP--HIGHWAY RIGHT-OF-WAY.
SF0088'
SF0088'TO REACH THE STATION FROM THE JUNCTION OF U.S. HIGHWAY 1 AND STATE
SF0088'HIGHWAY 161 IN FORT KENT, GO NORTH AND EAST FOR 0.8 KM (0.5 MI) ON
SF0088'HIGHWAY 1 TO THE NORTHERN MAINE MEDICAL CENTER ON THE LEFT.
SF0088'CONTINUE AHEAD FOR 1.6 KM (1.0 MI) ON HIGHWAY 1 TO A STREET RIGHT
SF0088'AND THE STATION AND CONVENIENCE STORE ON THE LEFT.
SF0088'
SF0088'THE STATION IS A STANDARD NGS VERTICAL CONTROL DISK
SF0088'STAMPED---J 173 1978---,
SF0088'ATTACHED TO A STAINLESS STEEL ROD ENCASED IN A PLASTIC PIPE RECESSED
SF0088'10 CM BELOW GROUND. LOCATED
SF0088'23.1 METERS (75.8 FT) EAST FROM THE WEST CORNER OF THE STORE,
SF0088'16.0 METERS (52.5 FT) NORTHEAST FROM THE EXTENDED CENTER OF PARK
SF0088'CIRCLE (STREET),
SF0088'7.8 METERS (25.6 FT) NORTHWEST FROM THE APPROXIMATE CENTER OF THE
SF0088'HIGHWAY,
SF0088'0.4 METERS (1.3 FT) SOUTHWEST FROM A METAL WITNESS POST AND
SF0088'0.2 METERS (0.7 FT) NORTHWEST FROM UTILITY POLE NUMBER 81 S.
SF0088'
SF0088'FAA AIRPORT SURVEYS, MAINE, OCTOBER-NOVEMBER 1985.
SF0088'
SF0088'THIS STATION SUITABLE FOR GPS SURVEYS.
SF0088'
SF0088'DESCRIBED BY G.R. HEID.

*** retrieval complete.
Elapsed Time = 00:00:01