McGEE SURVEYING CONSULTING
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Survey Report
for the
Quality Control – Quality Assurance Data Collection
for
Dewberry & Davis
on the
Island of Oahu Along the Westerly and Southerly Coastlines

OVERVIEW

Surveyed by: *McGee Surveying Consulting of 5290 Overpass Rd., Ste#107 Santa Barbara, CA 93111*
Survey Method: *GPS static, RTK and conventional*
Client: *Dewberry & Davis Corp.* **; Project. Number***: EMF-2003-CO-0047* **Project Name***: TO-26*
Location: *West and South Coastlines of Oahu Island*
City: *none* **; County:** *Honolulu***; State:** *Hawaii*
Attachments: *Find the following Documents*

- *-Coordinate Information: XCL Spreadsheet Listing Control Points with Geodetic Coordinate & Ellipsoid Heights, State Plane Grid Coordinate & Local Tidal Elevations in meters and feet; Points Descriptions, Land Categories and Photos*
- *-GPS Network Maps: GPS Control Network of measured vectors (7 pages)*
- *-Point Location Maps: QAQC Points, New Control, NGS project Control (5 pages)*
- *-Photos of Points (on a separate CD)*
- *-NGS Data Sheets: Station/Benchmark Descriptions Referenced in this Survey*

This document serves as a summary report on the above referenced QAQC survey. The purpose of which is to establish ground truthing points for validation of the Lidar measurements and DEM for the westerly and southerly coastlines up to 10 meters above sea level on the Island of Oahu. The lidar mapping survey was performed by Airborne 1 Corporation of Los Angeles, California and utilized a laser mounted in an aircraft. The project required that 60 elevation test points be collected in three Land Categories as follows : A- Open Bare Terrain; B- Vegetated Terrain, Forests, Crops; and C- Built Up, Paved Streets, Parking Lots, Buildings. Included in this survey are 67 points with photos in six general locations listed on the attached QAQC Point List.

The main concern for the survey of Oahu was to develop elevations of the QAQC points that would be recoverable and in harmony with future surveys on the Island. There exists sufficient HARN and CORS stations to establish consistent and reliable horizontal positions and ellipsoid heights as noted below. There exists an extensive network of benchmarks around the Island to establish consistent and reliable vertical orthometric heights as noted below. Most benchmarks were also Second Order Triangulations Stations for which their horizontal positions are updated by this survey.

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PROJECT DATUMS, REFERENCE SYSTEM

Horizontal Datum: *North American Datum of 1983 (NAD83)(PACP00)*; **Epoch:** *1993.62* (CORS 2002.00*)*
Reference Network: *High Accuracy Reference Network (HARN) & CORS*
Vertical Datum: *"Local Tidal" per NGS Data Sheets which is based on a leveling network established circa 1969. Local Tidal is apparently, the observed Mean Sea Level Tidal Epoch at the time of the survey.*
Reference Network: *NGS Benchmarks in the NSRS*
Geoid Model: *Geoid03*
Projection: *Hawaii State Plane Zone 3*
Units for Deliverables: *Feet & Meters*
Transformations: *none* **HTDP Applied to Stations:** *none*
Notes/Comments: *The horizontal datum in Hawaii and this Pacific Region is consistent with an NAD83 Datum realization for an epoch date of 1993.62 (Aug. 14, 1993) and is designated as NAD83(PACP00). Quoting from "Introducing Two Spatial Reference Frames for Regions of the Pacific Ocean" by Richard Snay available from the NGS, "users of these frames do not have to cope with changing positional coordinates". This survey utilized CORS published on the 2002.00 Epoch which is shown hereafter to be consistent with the 1993.62 Epoch.*
History: *Circa 1969 a First Order Class 2 leveling network was established around the perimeter of the Island. Circa 1993 the NGS performed a High Accuracy Reference Network (HARN) GPS survey on the Island from which the 1993.62 Epoch Adjustment originated. Prior Triangulations Networks were re-adjusted to conform to the 1993.62 Epoch.*

NETWORK ADJUSTMENTS & ANALYSIS

Adjustment Type: *Minimally Constrained & Constrained listed hereafter*
Horizontal Control*: HNLC an NGS CORS was fixed 2002.00 Epoch in the Minimally Constrained Adjustment and found in good agreement with other NGS stations as shown below. The CORS and two HARN stations were fixed in the Constrained Adjustment to develop positions for this survey.*
Vertical Control*: Ellipsoid Heights are based on the CORS in a Minimally Constrained Adjustment; Orthometric Heights are based on the NGS Benchmark TU0295 fixed in a Minimally Constrained Adjustment and various NGS benchmarks were fixed in a Constrained Adjustment to develop orthometric heights for this survey addressed below.*
Number of Points in Network*: 83*
New Points*: QAQC Points and Primary Control established by this survey are Points in the 101+ and 201+ series*
Station Comments*:. Existing NGS Stations were assigned their PID for identification in this survey. Two HARN stations AA6423 and TU1679 and one CORS HNLC were included as listed below in the "3D/Ellipsoid Height Adjustment"; the balance of existing Control are First Order Class II Benchmarks, some of which are also Second Order Triangulation Stations indicated where north and east differences are listed in the "Orthometric Heights Adjustments" below.*

Network: *This survey was conducted by creating a linear network of Primary Base Stations along the coastline interconnected by vectors from HNLC CORS to add strength and redundancy to the adjustment. Six "Areas" along the coastline were identified as candidate areas for testing because of the near shore and low lying commercial and residential uses. A base receiver was setup at a secure site within an Area while a roving receiver occupied QAQC and Control points in a radial fashion. Simultaneously, a second operation was running in an adjacent Area resulting in inter-Area connections and connections to CORS based on 2-6 hour vectors. The survey of each Area was repeated and all points were occupied a second time generally at a different time of the day on different days. RTK vectors were used to position the intra-Area QAQC points. The Control and Base Stations were connected with static vectors. The rinex files for the CORS were imported from the NGS with the rapid or precise ephemeris.*

3D/Ellipsoid Heights: Minimally Constrained Adjustment Results:
The adjustment results follow with Coordinate Changes from record to computed in meters.

Station	dN	dE	dZ	Comment
AA6423	-0.024	0.012	-0.022	HARN
HNLC	0.000	0.000	0.000	CORS Fixed
TU1679	-0.008	0.015	-0.171	HARN

A final constrained adjustment for ellipsoid heights was deemed unnecessary for the purpose of this survey

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Orthometric Heights: Minimally Constrained Adjustment Determined by Combining the Measured Ellipsoid Height Differences with Geoid Heights.

In the following adjustment results, the Geoid99 modeled heights were utilized, the NGS benchmark TU0295 in Waikiki was fixed at its orthometric height, the HNLC CORS was fixed horizontal and the differences from record to computed in meters listed below.

Station	dN	dE	dZ	
AA6423	-0.024	0.011	0.043	
AA6427	n/a	n/a	0.041	
TU0245	n/a	n/a	-0.009	
TU0247	n/a	n/a	0.010	
TU0295	0.059	0.083	0.000	
TU0329	n/a	n/a	0.027	
TU0333	0.036	0.031	0.077	Estimated height, brass cap gone, do not use
TU0573	0.041	0.026	-0.032	
TU0595	n/a	n/a	-0.007	
TU0597	n/a	n/a	-0.016	
TU0617	0.034	0.042	-0.027	
TU0624	0.033	0.030	-0.002	
TU0671	n/a	n/a	-0.028	
TU0672	n/a	n/a	-0.027	
TU1679	-0.007	0.013	-0.036	

In the following adjustment results, the Geoid03 modeled heights were utilized, the NGS benchmark TU0295 in Waikiki was fixed at its orthometric height, the HNLC CORS was fixed horizontal and the differences from record to computed in meters listed below.

Station	dN	dE	dZ
AA6423	-0.024	0.011	0.046
AA6427	n/a	n/a	0.042
TU0245	n/a	n/a	-0.004
TU0247	n/a	n/a	0.015
TU0295	0.058	0.083	0.000
TU0329	n/a	n/a	0.022
TU0333	0.035	0.032	0.071
TU0573	0.041	0.023	-0.016
TU0595	n/a	n/a	0.008
TU0597	n/a	n/a	-0.002
TU0617	0.032	0.040	-0.017
TU0624	0.033	0.029	0.007
TU0671	n/a	n/a	-0.023
TU0672	n/a	n/a	-0.022
TU1679	-0.007	0.013	-0.031

Notes/Comments: *These results indicate the Geoid 03 Model is a marginal improvement over the Geoid 99 Model. The Geoid model is not correlated to the Local Tidal Datum as in the case of NAVD88 in the continental US and applying geoid heights to ellipsoid heights will not result in correct orthometric heights without removing the bias.*

All benchmarks are in good agreement at 1-2 cm with the exception of AA6423 and AA6427 which differ by 4.5 cm and 4.1 cm respectively and were leveled in 2001 (other benchmarks were leveled circa 1969). At TU0333 at the easterly end of the network only the stub of the brass cap was found which may account for the 7 cm difference. TU1679 (a HARN station) was not a leveled benchmark, however TU0671 and TU0672 nearby, are leveled benchmarks and were held fixed.

A final constrained adjustment fixed HNCL CORS, AA6423 (HARN) and TU1679 (HARN) as horizontal constraints. Those benchmarks indicated below with a zero in the dZ column were fixed for vertical constraints. The results follow and the final coordinate lists are attached. Note, the stations below with differences are updated by this survey. Tri-station TU0260 was single occupied, differed by over a meter vertically with the record, is not necessary for this survey and is therefore set aside. The vertical difference at HNLC is a result of applying the Geoid03 height to the record ellipsoid height and should be ignored because Geoid03 is not correlated to the Local Tidal Datum. A Geoid 03 bias of -49 cm is evident at HNLC.

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Station	dN	dE	dZ
AA6423	0.000	0.000	0.039
AA6427	n/a	n/a	0.049
HNLC	0.000	0.000	-0.493
TU0245	n/a	n/a	0.000
TU0247	n/a	n/a	0.000
~~TU0260~~	~~0.179~~	~~0.089~~	~~-1.187~~
TU0295	0.059	0.082	0.000
TU0329	n/a	n/a	0.000
TU0333	0.036	0.032	0.077
TU0573	0.041	0.024	0.000
TU0595	n/a	n/a	0.000
TU0597	n/a	n/a	0.000
TU0617	0.032	0.040	0.000
TU0624	0.035	0.031	0.000
TU0671	n/a	n/a	0.000
TU0672	n/a	n/a	0.000
TU1679	0.000	0.000	-0.013

DATA COLLECTION& PROCESSING

Date of Field Surveys: *10/12/2006 to 10/17/2006;* **Description:** *Network Control and QAQC Data Collection*
GPS Survey Parameters:
Epoch Rate (seconds): *10" for static, 8-16 measurements averaged for RTK collection*
Minimum Satellites: *5* **; PDOP=<** *5* **; Elevation Mask for Data Collection & Processing (degrees):** *10 & 15*
GPS Observables: *L1 & L2 Carrier wave, C/A Code and P-Code*
Boulder K Index: *2-3*
Ephemeris*: Rapid and Precise for Static Post-Processing*

GPS Base Receiver Unit No.: *M3,* **Operator:** *McGee;* **Station Identification:** *varies*
Receiver Make & Model*: Leica 530* **; Antenna Make & Model**: *Leica AT502*
Antenna Mount: *Tripod***; Antenna Height***: varies*
GPS Rover Receiver Unit No.: *M4,* **Operator:** *McGee,* **Station Identification***: varies*
Receiver Make & Model*: Leica 530* **; Antenna Make & Model**: *Leica AT502*
Antenna Mount: *Fixed Height Pole***; Antenna Height***: 2.085m*
GPS Base Receiver Unit No.: *R1,* **Operator:** Reese*;* **Station Identification:** *varies*
Receiver Make & Model*: Ashtech Z-Extreme* **; Antenna Make & Model**: Novatel 702v3.0
Antenna Mount: *Fixed Ht pole***; Antenna Height***: 2.00m*
GPS Rover Receiver Unit No.: *R2,* **Operator:** *Reese,* **Station Identification***: varies*
Receiver Make & Model*: Leica 530* **; Antenna Make & Model**: *Leica AT502*
Antenna Mount: *Fixed Ht Pole***; Antenna Height***: 2.00m*

ACCURACY

Vector Residuals*: In the constrained adjustment the two dimensional residuals average 2 cm. The vertical residuals average 2-3 cm with a maximum range of 5 cm on the RTK measurements to control the QAQC points.*
Relative Accuracy*: Expected to be better than 5 cm vertical at 95% Confidence. The accuracy of lidar mapping on clearly defined test points is expected to be greater than 15 centimeters, therefore the test points are at a level of accuracy of better than 3 times the lidar points.*
Absolute Accuracy*: Expected to be 0.03 meters horizontal and 0.05 meters vertical at 95% level of confidence relative to the constraints introduced in the adjustments. .*

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QAQC ANALYSIS

Not included here, see Dewberry & Davis for analysis

REFERENCE POINTS/STATIONS/CORS DESCRIPTIONS (see attached file)

SURVEYOR'S STATEMENT

This Report on the criteria and procedures used on this QAQC Survey was originally prepared by me December 26, 2006 and revised January 06, 2007 for the purpose of validating the lidar acquired Digital Elevation Model (DEM) at the request of Tim Blak of Dewberry & Davis Inc.

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Michael R. McGee, CA PLS 3945