USER'S GUIDE FOR GNSS OBSERVATIONS AT TIDE AND WATER LEVEL STATION BENCH MARKS

Updated November 2018

Engineering Division
Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration

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1.0 Introduction

This User's Guide for Global Navigation Satellite System (GNSS) Observations at tide and water level station bench marks is prepared to support the Center for Operational Oceanographic Products and Services (CO-OPS) GPS Implementation Plan. The field observation procedures are developed in collaboration with the National Ocean Service (NOS) National Geodetic Survey (NGS), to obtain relative accuracy in connecting water level stations to the International GNSS Service (IGS), and the North American Datum of 1983 (NAD 83) coordinate systems.

The GPS is a valuable tool for tidal surveyors. It provides an easy and accurate way to position marks, track their stability over time on a global reference frame, and increase access to tidal datums by integrating them with nationwide leveling and GPS survey networks for modern mapping and navigation uses.

This guide describes just one GPS method, static GPS surveying, which is accurate, automated, and available at all our tide and water level station locations. The field requirements are simple and the data processing and sharing via NOAA's Online-Online Positioning User Service (OPUS) are quick and easy.

It is assumed that the field personnel are familiar with the basic operating principles of the GPS equipment, the cable connections and the antenna/tripod setup procedures. A detailed discussion of GPS processing software and processing procedures is outside the scope of this Guide. GPS data collected by CO-OPS or CO-OPS' contractors for the National Water Level Observation Network (NWLON), for hydrographic and photogrammetric surveys either by NOS Office of Coast Survey (OCS) or NGS field parties shall be uploaded to NGS OPUS. OPUS allows qualified users to upload results to be shared in the NGS OPUS Share database and all results must be uploaded to OPUS for sharing.

All GPS data must be collected as per NGS specifications and as described later in this document, and processed using OPUS for sharing.

1.1 Requirement

When required in project instructions, or as stated in the field contract documents for each tide or water level station visited, carefully perform at least one static GPS observation for a minimum of four hours on one tidal or water level bench mark and share the data through OPUS.

OPUS Static requires minimum of 7200 seconds (about 2 hours) of data to process, but minimum of four hours of data is required to share a solution. If your observations happen to be in low-lying areas such as valleys, then you may need more than four hours because the observations are based upon the number of satellites observed in the satellite constellation.

Where stated in the Project Instructions or as stated in field contract documents, GPS observations on two bench marks are required for stations to derive a tie to the U.S. National Spatial Reference System (NSRS) and geodetic datums can be published on a bench mark sheet. Refer to Section 3.2.2 for specific guidance on this topic.

2.0. Equipment and Setup

High accuracy static differential GPS surveys require a geodetic quality, dual frequency, full-wavelength GPS receiver with a minimum of 10 channels for tracking GPS satellites. A choke ring antenna is preferred; however, any geodetic quality ground plane antenna may be used. Antenna type must have been calibrated by NGS so that data can be accepted in OPUS. See https://ngs.noaa.gov/ANTCAL/index.xhtml

A fixed height precise GPS antenna tripod is required for this type of a survey. This is a fixed height, two meter pole with three adjustable legs, a bulls-eye bubble to plumb the antenna, and a magnetic compass to align the antenna to the North. Fixed height tripods reduce the chance of introducing a Height of Instrument (HI) error during post-processing of the data. There are situations where it may be necessary to use the adjustable precise GPS antenna tripod, such as when a bench mark is elevated above ground level or when using air transportation. The center pole is adjustable on this tripod and the antenna height should be measured with a steel tape (several times) and entered into the receiver and onto the GPS Observation Log Sheet. It is recommended both the adjustable and the fixed tripod be measured to verify the length. There is a screw-on point at the bottom of the center pole of both types of tripods must be inspected each time the tripod is setup to ensure the point is tight and not bent. The tripod must be stable during observations; therefore, the tripod legs must be secured, preferably with sand bags.

Antenna set-up is critical to the success of the observation. Plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when adjusting to the antenna to plumb. Plumb bubbles must be shaded for at least three minutes before checking and/or adjusting the bubble.

2.1. Data Collection and Setup

Set the epoch update or recording interval (REC INT) for 15-seconds. The elevation mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to zero. Note that the dimple in the bench mark for surface marks will not be accounted for in the ARP height.

It is suggested that as much GPS data as possible should be collected if time and schedule permit, so that errors or invalid data, if any, can be removed during processing still leaving the minimum number of required observations for one GPS session.

3.0 Geodetic and GPS Connections

Water level datums at different locations are local vertical datums which may vary considerably within a geographical area. A geodetic datum is a reference surface relative to which heights are determined. The North American Vertical Datum of 1988 (NAVD 88) is the accepted geodetic vertical datum of the National Spatial Reference System (NSRS) for the conterminous United States and Alaska and is officially supported by NGS. The relationships of tidal datums to geodetic datums such as NAVD 88 and to ellipsoid heights (above GRS 80 ellipsoid) support many hydrographic, coastal mapping, and engineering applications including the monitoring of sea level, the deployment of GPS Electronic Chart Display and Information Systems (ECDIS), and the NOS Vertical Datum (VDatum) transformation tool, etc.

Existing Geodetic Bench Marks (GBM) in the vicinity (up to 1.6 km (1 mile) leveling distance) of a water level station (primary and subordinate) shall be searched for and recovered. If a mark is either not recovered or not used in the survey/project, a separate non-recovery report shall be made using the NGS on-line Mark Recovery Entry Form at http://www.ngs.noaa.gov/ngs-cgi-bin/recvy_entry_www.prl.

An orthometric level connection and ellipsoidal GPS tie is required at each water level station (primary and subordinate) that has at least one GBM located nearby (within 1.6 km (1 mi) leveling distance of a water level station). The required "NAVD 88 Level Tie" is described in the Standing Project Instructions available on the CO-OPS' web page at http://tidesandcurrents.noaa.gov/pub. The required GPS tie is described in Reference 6 of this document under the section "NAD 83 GPS Tie.

3.1. GPS Bench Mark

3.1.1. Criteria for Bench Mark Selection for GPS Observations

The GPS Water Level Station Bench Mark (GPSBM) shall be selected based on the following criteria: (a) Permanence and Stability; (b) Historic GPS use; (c) Satellite Visibility; and (d)

Safety and Convenience.

(a) Permanence and Stability of Bench Marks

NGS has defined the following monumentation quality codes, also called the stability codes, for various bench mark settings.

Stability code A – monuments of the most reliable nature are expected to hold their elevations well; e.g. Class A rod marks, or marks installed on bedrock/rock outcrop.

Stability code B – monuments which will probably hold their elevations well; e.g. Class B rod marks, or marks installed on large concrete footings/foundations.

Stability code C – monuments that may hold their elevations, but which are commonly subject to surface ground movements; e.g. concrete monuments.

The station bench mark selected for GPS observations shall be of stability code A or B and in the rare case of stability C only when NGS has previously acquired GPS observations on that mark. GPS observations on the PBM are preferred (if the PBM has either stability code A or B) and if it is suitable for satellite observations. Leveling history, if available, can indicate the stability of a mark.

(b) Historic GPS Use

In many states, CO-OPS has provided NGS with lists of selected marks suitable for GPS observations at water level stations, and NGS has completed observations on these marks. Some tidal marks designated as Federal Base Network (FBN) or Cooperative Base Network (CBN) marks may be of stability code C. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. If leveling reveals instability of the mark over time, select another mark.

Priority shall be given to a GPSBM for GPS observations because the GPSBM already has a NAVD 88 height. The GPSBM considered here is one of the 10 tidal or water level bench marks at a NWLON water level station, or one of the 5 bench marks for a subordinate station for survey or special projects.

(c) Satellite Visibility

The most desirable GPSBM should have 360 degrees clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have these clearances, if at all possible. If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new stable mark shall be established. This

new mark shall be connected to the station bench mark network through conventional geodetic leveling, and GPS observations shall be made.

All existing bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. A note shall be made, either in the GPS field of the WinDesc file, or on a copy of the published bench mark sheet, stating the suitability of GPS observations for each mark.

(d) Safety and Convenience

The location of the GPSBM should be safe, secure, and convenient. Bench mark locations which allow unattended GPS data collection are desirable as the field crew can multi-task at the same time while collecting the GPS data. The safety of the GPS equipment (from vandalism or theft) should be considered in the bench mark selection process.

The GPSBM should be located on public property rather than on private property, as permissions from private owners may be required in the future to access the bench mark and for collecting GPS data. The distance to the GPS mark from the station Data Collection Platform (DCP) should be no greater than one mile.

Consider adding a new tidal bench mark when practical, in cases where no existing marks meet the above requirements and the new mark would provide a substantial improvement. Information about mark descriptors, images, recovery, reset, etc., is available at http://www.ngs.noaa.gov/marks/.

3.1.2. Planning for GPS Bench Mark Selection

To determine the suitability of a mark for GPS observations, review the historic bench mark information in the station files and level records, if the information is available in the database. Identify stable marks from the level records and make copies of the descriptions and sketches. Descriptions and sketches are examined and marks are eliminated that have obvious obstructions, such as vertical marks, marks set several meters from medium to large structures, etc. Do not eliminate marks that are near poles, fences or about 20 meters from small structures at this time during the preliminary planning. If no other mark is available or found suitable, and time does not permit the installation of a new GPSBM, then it may be necessary to use one of these marks. In selecting a GPSBM, priority should be given to the NWLON PBM or an NGS, NSRS, mark with a First or Second-Order NAVD 88 height on a NGS datasheet.

3.1.3. Recording of Position of the GPS Bench Mark

GPS (horizontal) positions (latitude and longitude) of each bench mark installed or recovered shall be listed on the DESC files for laser levels, if used, or on the bench mark descriptions sheet for optical leveling, as applicable, at each water level station occupied for all projects. The position of each bench mark recovered using a hand held GPS receiver shall be listed in the

following format: degrees, minutes, seconds and tenth of a second (e.g. 45 degrees 34' 45.6"). The position of the bench mark as obtained from OPUS shall be recorded on the site report or E-Site report (where applicable) as degrees, minutes, seconds and one hundred thousandths of a second (e.g. 55 degrees, 42' 25.78912"), and the elevation above the ellipsoid shall be listed as +/- XX.XXX m (e.g. -22.907 m).

Remember once the GPS data is uploaded to OPUS, and accepted, then the position is determined by OPUS. If the bench mark has a Permanent Identification (PID) number assigned by NGS, you may be able to retrieve the position from the NGS web.

3.1.4. Photographs of the GPS Bench Mark

NGS requires a minimum of two photos of the GPS bench mark taken as follows: (1) close-up of the disk face (see Figure 1 A); (2) horizontal view of the location of the bench mark and direction of view (see Figure 1 C).

CO-OPS requires two additional photos as follows: (3) chest level or eye level view of disk and setting (see Figure 1 B); and (4) a horizontal view of bench mark and direction at perpendicular to the direction of the photo taken in (2) above (see Figure 1 D). Thus two photos in the vertical direction (Figures 1A and 1B) and two photos in the horizontal direction (Figures 1 C and 1D) as described above are required. If these four photos have been taken previously and are available to be included in the documentation, another set of photos is not necessary.

There are no file naming rules for OPUS but there are some suggestions for the naming of the files as follows, which are compatible with the file naming for tidal/water level marks.

All digital station bench mark photo files should be named such that the name of the file will indicate the station number, dash, PID number (if available), dash, stamping or designation, dash, photo type, dash, date, dot.jpg. For a new mark, the PID is not applicable as it is unavailable. Close-up photo vertically taken is photo type 1, the eye level photo vertically taken is photo type 2, and the horizontal view taken is photo type 3. For photo type 3 include the cardinal direction (N, NE, S, SE, etc) that the camera is pointing. If there is more than one photo of the same type taken then re-name them as 1A, 1B, 2A, 2B, 3A, 3B, etc. If a PID is available, then use the designation instead of the stamping for the naming of the file. Use a maximum of 30 alpha numeric characters to the left of the dot.

So if you are exceeding 30 alpha numeric characters in the name, then truncate the stamping or designation so that maximum characters in the name are 30. For example, the bench mark E close-up photo for Seattle water level station should be named as 9447130-7130 E 1990-1-20090101.jpg.

Sample file names for photo files:

New bench mark without a PID and disk face photo	9414290-4290A2008-1-20090101.jpg
Existing bench mark with a PID and eye level view photo	9410660-DY2512-BM N-2-20090101.jpg
Existing bench mark without a PID and north direction photo	9447130-7130E1990-3N-20090101.jpg

In addition, put a caption for each photograph, as shown in Figures 10- 12, indicating the stamping or designation of the mark, PID, photo type with cardinal direction, and the date of photograph taken. Additional information about caption is available at the following resource: https://www.ngs.noaa.gov/web/surveys/photo_submissions/

NGS Coastal Mapping Surveys require a slightly different file naming convention as described in Attachment R of the NGS Specs, which is located at http://geodesy.noaa.gov/ContractingOpportunities/CMPSOWV14A_FINAL.pdf. All photos collected for NGS Coastal Mapping Surveys for both contract and in-house projects shall be named according to NGS convention.

Figure 1 A: Close Up View of Face of Mark

Figure 1 B: Eye Level Settings View of Mark

Figure 1 C: Horizontal View 1 of Mark

Figure 1 D: Horizontal view 2 of Mark

3.2. GPS Observations

3.2.1. References

These guidelines are written for establishing a GPS derived ellipsoid height accuracy standard of 2 cm for all NWLON, PORTS®, Hydrography/Photogrammetry survey projects, Coastal Hazards projects, and special project applications.

3.2.2. Static Surveys

Static GPS surveys shall be conducted on a minimum of one tidal bench mark at each water level station. Generally, one bench mark at each station is designated as the GPSBM and observations shall be made to that mark (as per the required GPS observation frequency) unless otherwise specified in the Station Specific Requirements, Project Instructions, or field contract documents.

GPS observations on two bench marks are required if stated in the Project Instructions or field contract documents. Record a minimum of 4-hours observations each on the two network bench marks that are spaced a minimum of 500 meters apart, share the data through OPUS and submit the GPS deliverables. Note that one of network bench mark observed should be the GPSBM. If resources are available, simultaneous GPS observations on two marks are preferred. By conducting GPS observations on two marks, a tie to the U.S. NSRS can be made and geodetic datums can be published on a bench mark sheet.

Static GPS surveys shall be conducted at water level stations periodically over time to establish a history of the relationship between the tidal or water level datums, and the ellipsoid.

Currently, 20 NWLON stations require annual GPS observations because of the sea level change in those areas. These 20 NWLON stations – 8 in Alaska and 12 in the Gulf of Mexico – will be identified in the annual Project Instructions. The remainder of the NWLON stations requires

GPS observations every five years. These guidelines will be updated as GPS technology improves and the policy or regulations change in the future.

As specified in the Annual Project Instructions, Annual Station Specific Requirements, or in the contract documents, the field party shall be required to perform GPS observations at each water level station at specified intervals over time, depending on the rate of sea level change in coastal area of observation.

3.2.3. Connections to the Ellipsoidal Datum – GPS Ties

The connections to the ellipsoidal datum involve the following two ties:

(1) NAD 83 GPS Tie
(2) NAVD88 GPS Tie

3.2.4. North American Datum 1983 (NAD 83) GPS Tie

At each water level station, GPS observations shall be performed as listed in the Annual Project Instructions, Annual Station Specific Requirements, and contract documents.

The NGS OPUS with publication option is now used for processing and storing of the GPS data for a variety of applications.

The expected ellipsoid height accuracy is 1.8 cm, (at the 67% confidence level) for a single four-hour observation OPUS solution. Confidence increases with repeated observations.

For all water level stations, collect a minimum of 4 hours of GPS observations on the GPSBM unless stated otherwise. Extra care shall be taken to ensure that the antenna height is precisely recorded, and that the antenna setup is stable. A continuous session of at least 4 hours is required.

3.2.5. GPS Data Processing Using OPUS

After GPS data is collected, the collector shall upload the GPS data to NGS OPUS for processing the GPS observations and determining the position of the GPSBM. OPUS provides an easily accessible, rapid method for uploading GPS data and receiving an almost instantaneous solution response from NGS via email.

OPUS allows users to upload their GPS data files to NGS, where the data will be processed to determine a NAD-83 position using NGS computers and software. Each data file that is uploaded will be processed with respect to three CORS sites. The CORS sites selected may not be the nearest to the observed site, but CORS sites are selected automatically based upon distance to the observed site, number of observations, site stability, etc. The position for the observed data will be reported back to you via email in both - IGS and NAD 83 coordinates as well as Universal Transverse Mercator (UTM), U. S. National Grid (USNG) and State Plane Coordinates (SPC) northing and easting.

To share OPUS datasheets, you must meet the minimal field and data requirements for OPUS sharing. These evolving requirements are described at http://www.ngs.noaa.gov/OPUS/about.jsp and are hereby superseded where any requirement below exceeds that of OPUS.

- Always use a calibrated 2-meter fixed-height tripod, unless prevented by logistical circumstances (e.g., air cargo limits, unusual setup).
- Alternate tripod or antenna mount must allow precise antenna positioning and height measurement.
- Verify the tripod stability and antenna height at the beginning and end of every session.
- Tripod leveling bubbles should be shaded when not in use.
- A digital camera is required to capture mark close-up and horizon photos.
- In addition to the 2 photos required by OPUS, provide for CO-OPS two additional photos as described in Section 3.1.4 Photographs of the GPS Bench Mark.
- Upload to OPUS all mark information listed as both required and optional on OPUS forms. See figures 7 & 8 below for current form elements.

Step 1 of 4:

A. OPUS requires only a minimal amount of information from the user. The NGS OPUS web page can be obtained at http://www.ngs.noaa.gov/OPUS/. Then enter the following information:

1. The email address where you want the results sent.
2. The GPS data file that you want to process (which you may select using the browse feature; raw or RINEX accepted).
3. The antenna type used to collect this data file (selected from a list of calibrated GPS antennas).
4. The height of the Antenna Reference Point (ARP) above the monument or mark that you are positioning.
5. Customize your solution, report, and sharing options. Click on the Option button.

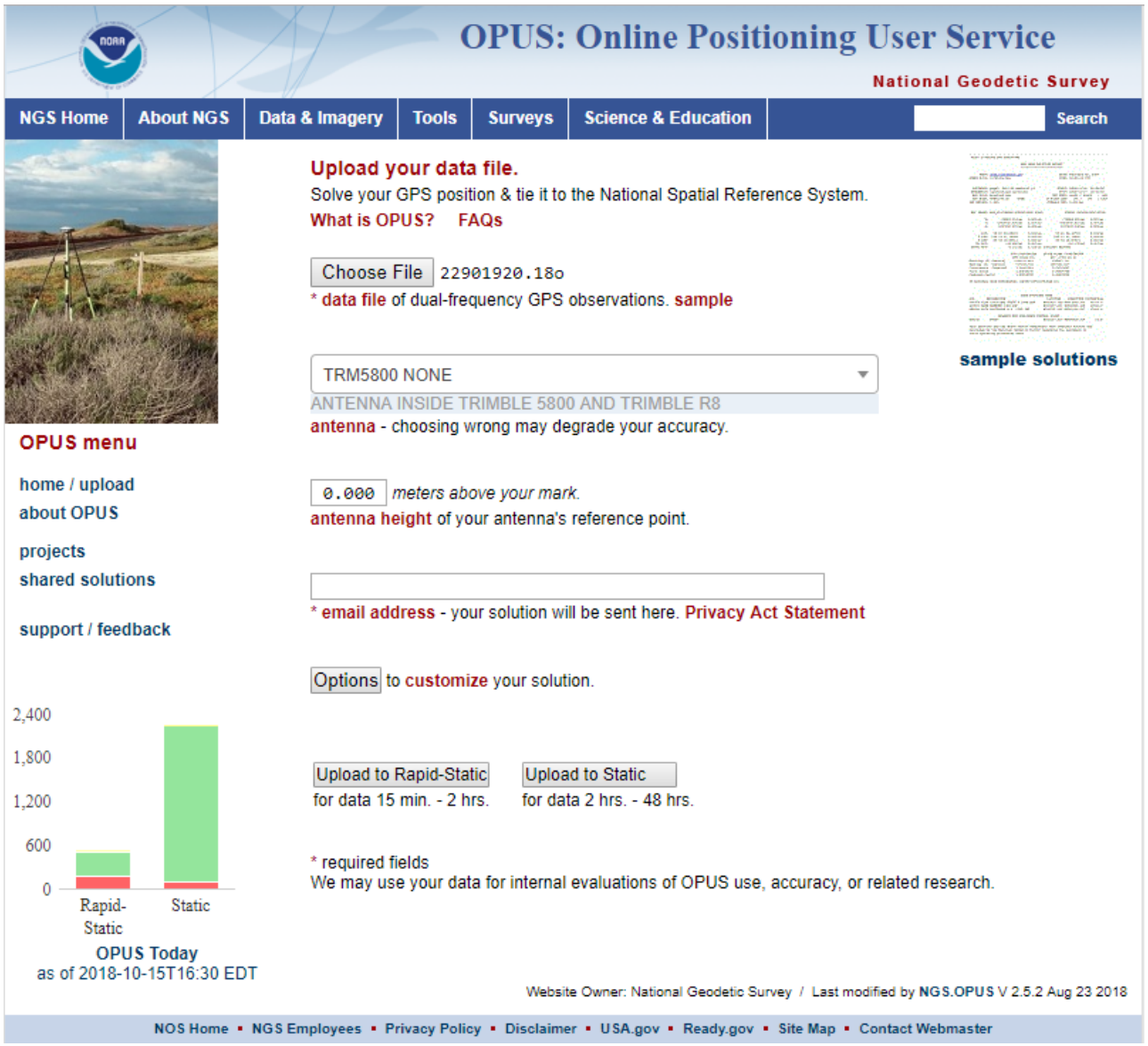


Figure 2: OPUS Step 1 of 4 – OPUS Upload Screen

B. Once this information is complete, you then click the Options button to customize the solution, report, and sharing options. Then you will see a screen like this.

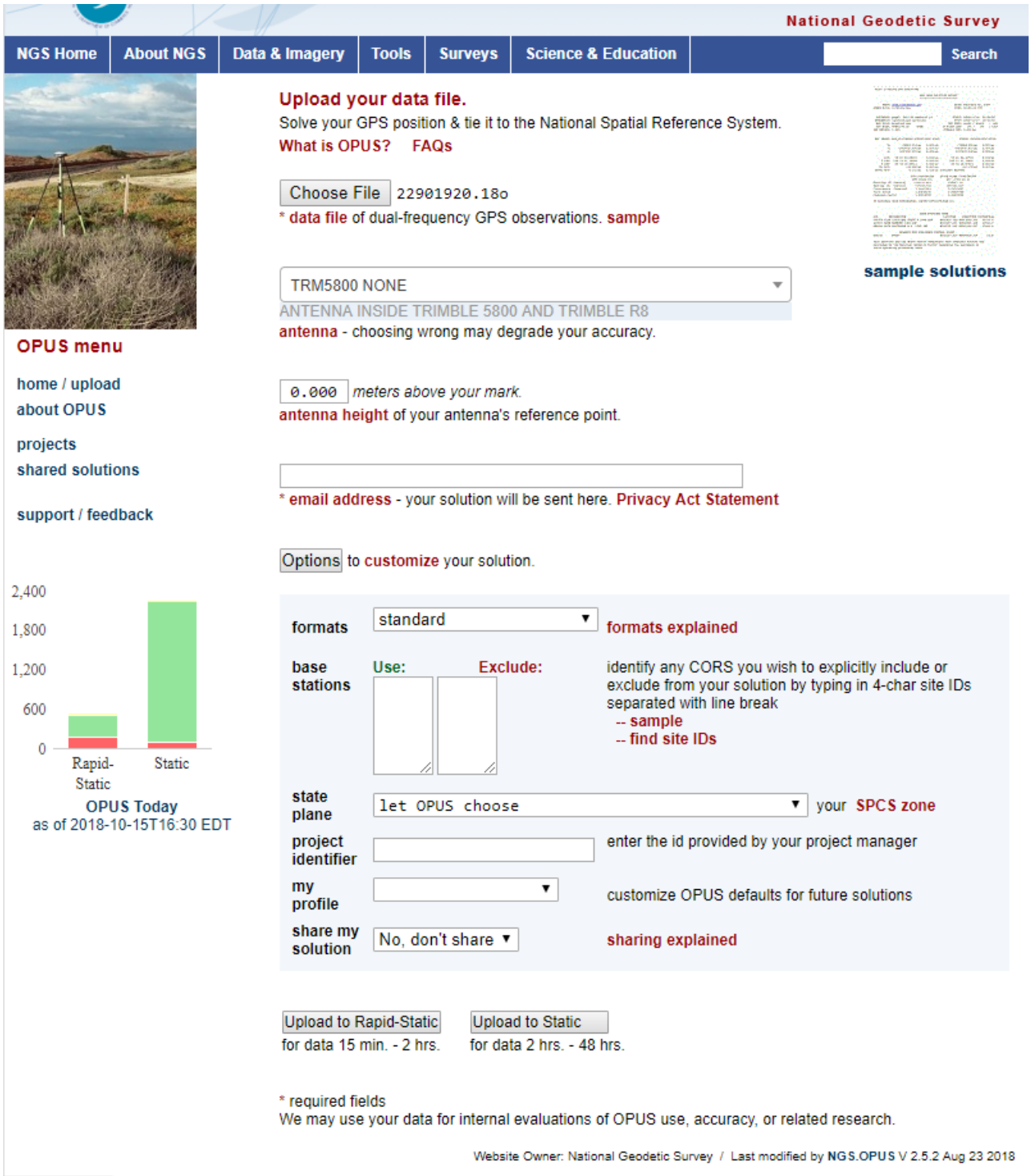


Figure 3: OPUS Upload Screen with Options

The Options button asks you six questions as described below:

<u>Leave options 1 through 5 as defaults and only select option 6 “Share My Solution” for the first try.</u>

1. Select Formats: The default is standard solution, leave this as the default and do not change this option.

2. Select CORS To Use – Or Not Use – As Base Stations:

   On the right side of the above screen, select browse map to look up CORS site IDs by location (city, state, county). CORS can also be selected for use or exclusion by entering the site IDs into the use or exclude box. Please note: the automated selection of base stations has recently improved; this option should now be used only sparingly and set to "Let OPUS Choose".

3. Select State Plane Coordinate zone: The default is "let OPUS choose", leave this as the default and do not change this option.

4. Contribute to a Project: This option is not applicable to CO-OPS' water level installations, removal, or scheduled or unscheduled maintenance and, hence, skip this option. If a GPS campaign is conducted, i.e. using OPUS PROJECTS then select this option.

5. My Profile: Since CO-OPS water level stations are located in various different locations, skip this option.

6. **Share My Solution**: **Make sure you select the option "Yes, Share". Then select the Static button only**. Once you hit the Upload to Static Button, it will bring up the upload successful screen as shown below.

Step 2 of 4:

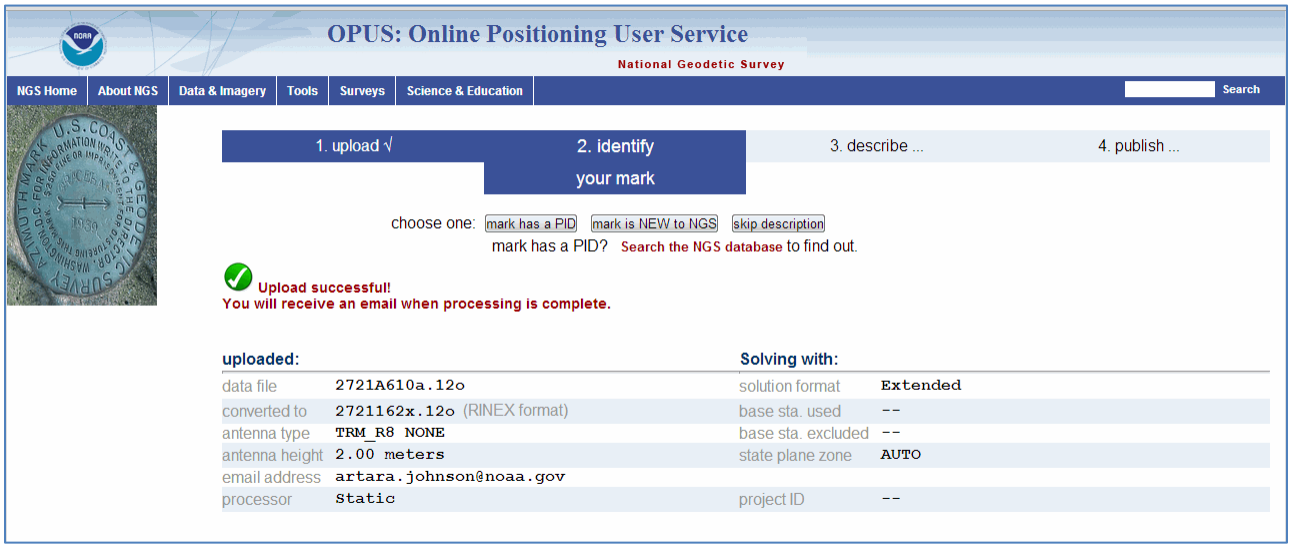


Figure 4: OPUS Step 2 of 4 – Identify Your Mark

Select either of the following two choices– either "Mark has a PID" or "Mark is NEW to NGS", as shown above. If the mark has a PID assigned by NGS, then only you can select the "Mark has a PID" otherwise you must select "Mark is NEW to NGS". CO-OPS requires a

description be entered for the GPSBM therefore the skip description button should not be selected. Select “search the NGS databse” if it is unknown whether the GPSBM has a PID or not.

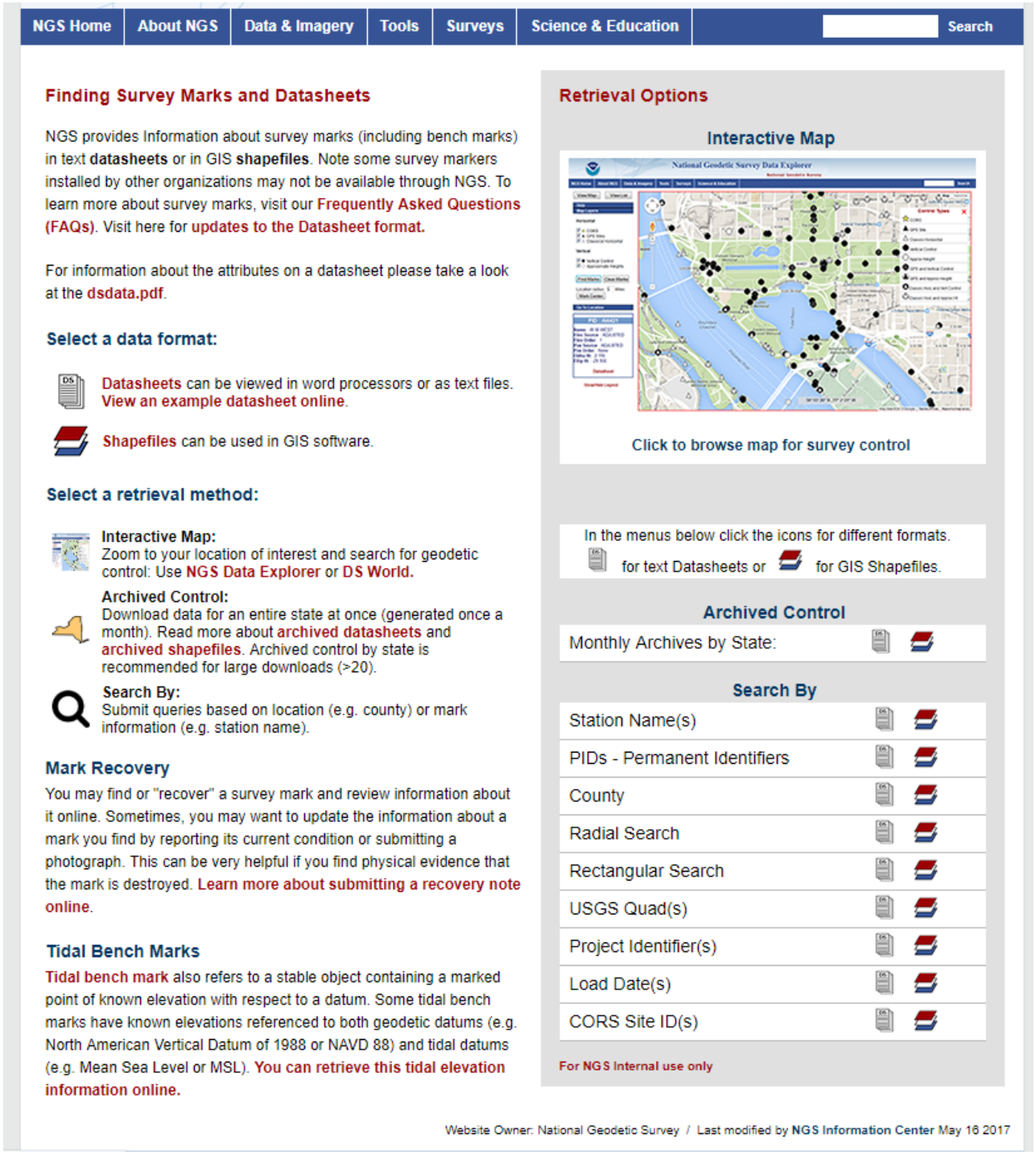


Figure 5: NGS Datasheet Retrieval Page

Close the web browser to return to the OPUS web page.

Step 3 of 4:

If the GPSBM was a recovered mark, the next screen shows you "Step 3 of 4: Describe the Recovered Mark". In this section you must:

1. Fill in the PID number (since it was a recovered mark).

2. Attach two photos of the GPSBM– one for close up photo of disk face and second for horizon photo.

3. Indicate the condition of the mark by selecting the appropriate radio button – good or poor.

4. Provide description of the mark in CO-OPS format as per "User's Guide for Writing Bench Mark Descriptions" which is available at CO-OPS web page at http://tidesandcurrents.noaa.gov/publications/bmguide5.pdf.

5. Hit the "Upload description" button.

Remember, the PID number and the two photos as listed above in (a) and (b) respectively are required; and the mark condition and the mark description as listed in (c) and (d) are optional for an existing mark, but you are encouraged to submit both optional items. If there are any changes needed to the stored description, then please upload the revised description. After completion of the information for this screen, hit the "Upload description" button.

Figure 6: OPUS Step 3 of 4 – Describe Recovered Mark

If the mark was a new bench mark and you selected "Mark is NEW to NGS" in OPUS Step 2 of 4, then you will see the following screen.

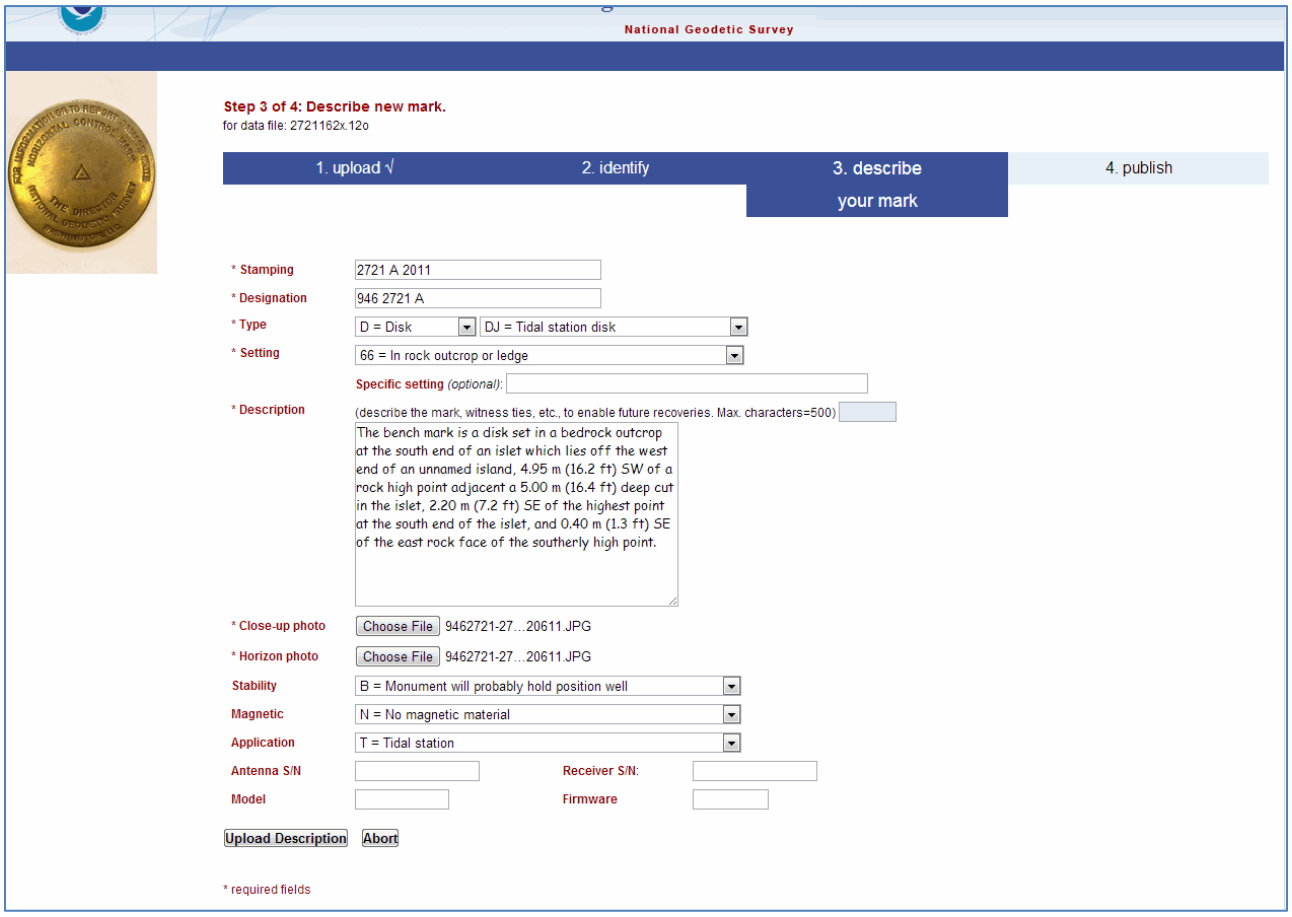


Figure 7: OPUS Step 3 of 4– Describe New Mark

The "Describe New Mark" part as shown above has 7 required elements and 5 optional elements.

The 7 required elements are as follows: designation, stamping, type, setting, descriptions, close- up digital photo, and horizon digital photo. Designation and stamping should be entered as per NOS convention. The selection for type and setting can be done through the choices listed in the drop down boxes as shown. Attach close-up and horizon digital photos of the new mark by indicating the location of the photos on your PC or server, as appropriate.

The 5 optional elements are as follows: stability, magnetic, application, antenna serial number, and receiver serial number, model and firmware. The selection for stability, magnetic, and application can be done through the choices listed in the drop down boxes as shown.

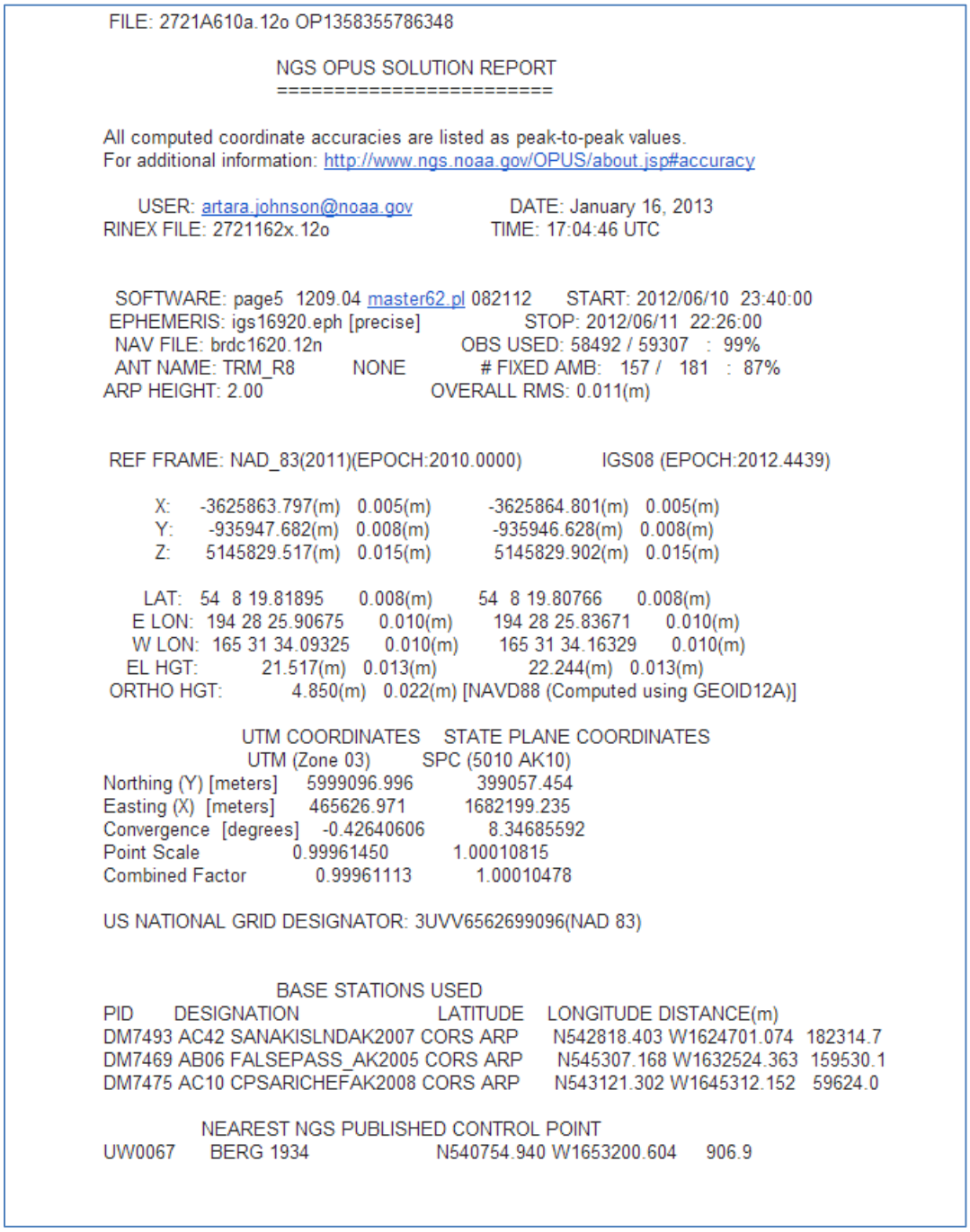
Everyone is strongly encouraged to provide the information about the optional elements also. After completion of the information for this screen, hit the "Upload Description" button.

Then you will get the following message.

Figure 8: OPUS Step 3 of 4 – Approval Pending

You will receive three e-mails; one of the e-mails will provide you NGS OPUS Solution Report and that will look like the following window:

Step 4 of 4:



FILE: 2721A610a.12o OP1358355786348

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: artara.johnson@noaa.gov DATE: January 16, 2013
RINEX FILE: 2721162x.12o TIME: 17:04:46 UTC

SOFTWARE: page5 1209.04 master62.pl 082112 START: 2012/06/10 23:40:00
EPHEMERIS: igs16920.eph [precise] STOP: 2012/06/11 22:26:00
NAV FILE: brdc1620.12n OBS USED: 58492 / 59307 : 99%
ANT NAME: TRM_R8 NONE # FIXED AMB: 157 / 181 : 87%
ARP HEIGHT: 2.00 OVERALL RMS: 0.011(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2012.4439)

X:	-3625863.797(m)	0.005(m)	-3625864.801(m)	0.005(m)
Y:	-935947.682(m)	0.008(m)	-935946.628(m)	0.008(m)
Z:	5145829.517(m)	0.015(m)	5145829.902(m)	0.015(m)
LAT:	54 8 19.81895	0.008(m)	54 8 19.80766	0.008(m)
E LON:	194 28 25.90675	0.010(m)	194 28 25.83671	0.010(m)
W LON:	165 31 34.09325	0.010(m)	165 31 34.16329	0.010(m)
EL HGT:	21.517(m)	0.013(m)	22.244(m)	0.013(m)
ORTHO HGT:	4.850(m)	0.022(m) [NAVD88 (Computed using GEOID12A)]		

	UTM COORDINATES (Zone 03)	STATE PLANE COORDINATES SPC (5010 AK10)
Northing (Y) [meters]	5999096.996	399057.454
Easting (X) [meters]	465626.971	1682199.235
Convergence [degrees]	-0.42640606	8.34685592
Point Scale	0.99961450	1.00010815
Combined Factor	0.99961113	1.00010478

US NATIONAL GRID DESIGNATOR: 3UVV6562699096(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DM7493	AC42 SANAKISLNDAK2007 CORS ARP	N542818.403	W1624701.074	182314.7
DM7469	AB06 FALSEPASS_AK2005 CORS ARP	N545307.168	W1632524.363	159530.1
DM7475	AC10 CPSARICHEFAK2008 CORS ARP	N543121.302	W1645312.152	59624.0

NEAREST NGS PUBLISHED CONTROL POINT

UW0067	BERG 1934	N540754.940	W1653200.604	906.9

Figure 9: OPUS Step 4 of 4 – NGS OPUS Solution Report

The following are some simple guidelines to ensure quality OPUS solutions:

A. Make sure the antenna type and the ARP height are correct.

B. Review the solution statistics:

i. A good quality OPUS run should typically use 70% or more of your observations. (II) OPUS should have fixed at least 70% of the ambiguities.

ii. The overall RMS should seldom exceed 3 cm.

iii. The maximum peak to peak errors should be less than 4 cm for horizontal (for both latitude and longitude) and 8 cm for vertical.

If the OPUS solution e-mailed to you exceeds the allowable tolerances as specified in guidelines under the section above, then you must upload the data again, but select the option for dropping one or more of the three CORS stations selected automatically by the NGS OPUS software and upload the data again. To do so, check the OPUS solution e-mailed to you and select one of the CORS stations that show the maximum errors that exceed the tolerances and then select the Options button in figure (2), and exclude the CORS station name and upload the GPS data by clicking the Upload to Static button. If the second solution provided by the OPUS software does not meet the allowable tolerances as listed above, then send the data to NGS for further evaluation. If your data does not meet OPUS guidelines after second OPUS processing attempt and if you are still at the water level station site, then another option is to collect additional required hours of GPS data and re-upload it for processing.

NGS needs to receive orbit data from International Global Navigation Satellite System Service (IGS) in order to obtain a solution. If the data is uploaded too quickly (before NGS gets the orbit data from IGS), the submitter may need to re-upload the data later. For best results, upload the GPS data to OPUS at least 17 hours after the first midnight (in Greenwich Mean Time) following the time when the observations were recorded. Compare the resultant solution to the last previous solution made at the station, if available, to ensure that you do not have a blunder in the antenna setup. This will be revealed in a noticeable discrepancy in the ellipsoid height. Ensure the rapid ephemeris is used by OPUS. Include a copy of the OPUS solution as shown in figures 11, 12, and 13 in the GPS Deliverables.

WHAT TO DO IF OPUS FAILS?

- The GPS observer should perform data submission to OPUS as soon as is practical, while on-site, details are fresh in memory, and opportunity exists for additional observations.

- Repeat the OPUS submission using the OPUS option #2, "CORS to Exclude"- to remove a transient base station.

- Consider repeating the OPUS submission on the afternoon following the observation day, after the GPS orbit models are updated.

- Consider repeating your GPS observation at a different time of day (night observations may

improve results at lower latitudes.)

- Consult with the OPUS help desk on other suggestions to improve the data.

ADDITIONAL SUGGESTIONS:

- Antenna must be approved and calibrated.
- Collect GLONASS data (in addition to GPS).
- Fixed-height rods should be calibrated prior to fieldwork, ensuring tips are new/sharp, and all pieces are tight and in proper positions.
- More GPS data is better than less. The minimum GPS observation duration requirement is currently 4 hours should be extended whenever practical, e.g., overnight in secure areas.
- Horizon photos should be taken during the GPS observation, thereby documenting the GPS equipment in use and highlighting the mark location. Photos of the mark should not have equipment blocking or obscuring any characteristics or markings of a bench mark.
- Additional photos are helpful alternatives to paper field logs (e.g., to document equipment serial #s, antenna height, the name of the observer and bench mark IDs, observation times, weather conditions, etc.)
- Prior to your field campaign begins; test your GPS equipment by uploading a sample dataset to OPUS to confirm that your data format and GPS antenna type are OPUS- capable.
- Additional suggestions are available at http://www.ngs.noaa.gov/PROJECTS/GPSmanual/

3.2.6. NAVD 88 GPS Tie

The NAVD 88 GPS Tie involves simultaneous GPS observations at the GPSBM and one or more GBMs located up to 10 KM (6.26 mi) from the GPSBM. This tie is deferred until such time as NGS enables user-friendly blue-booking of campaign data (OPUS projects).

4.0 GPS Deliverables

Submit the OPUS results (sample datasheet as shown in Figures 11 or 12 or 13) and four photos of the GPSBM in electronic format for each observation on each bench mark for each water level station. For example, GPS submission for San Francisco tide station shall be provided in a folder as follows:
9414290 San Francisco FY 09 Annual Inspection
/GPS OPUS Results
/Photos of GPSBM

4.1. Points of Contact for GPS Deliverables

All required GPS OPUS deliverables as listed in Section 4.0 above shall be submitted to proper point of contact as listed in the project instructions, contract documents, if applicable; or to NGS or CO-OPS within 15 business days of the GPS observations, the removal of the water level gauge, or as specified in the Statement of Work or contract, whichever is earlier. All GPS data and documentation shall be uploaded to NGS OPUS Share.

For all CO-OPS in-house work, and OCS contract hydrographic surveys, submit GPS Deliverables to:
Chief, Engineering and Development Branch, Engineering Division
CO-OPS, N/OPS1, SSMC 4, Station 6515
1305 East-West Highway
Silver Spring, MD 20910-3233
Tel: 240-533-0491

For all CO-OPS contracts, submit GPS Deliverables to:
Jennifer McCrae
Contracting Officers Representative
CO-OPS Field Operations Division
672 Independence Parkway
Chesapeake, VA 23320-5177
Tel: 757-842-4411

For NGS contract shoreline mapping surveys, submit GPS Deliverables to:
Mr. Mike Espey
Chief, Applications Branch, Remote Sensing Division,
National Geodetic Survey
N/NGS3, SSMC 3, Station # 5342
1315 East-West Highway
Silver Spring, MD 20910-3281
Tel: 240-533-9609

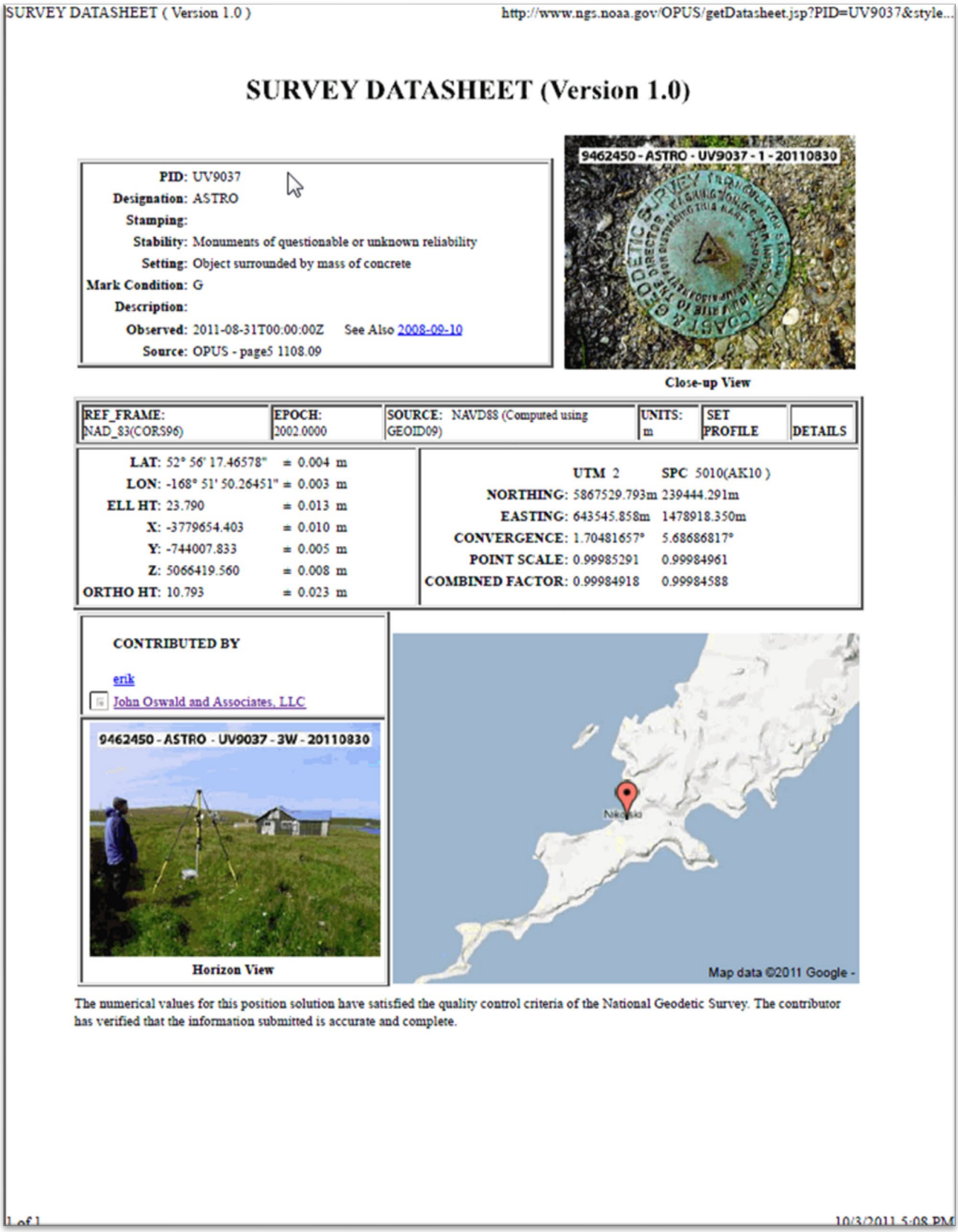


Figure 10 Sample# 1 – OPUS Result

SURVEY DATASHEET (Version 1.0)

PID: DF3653
Designation: 8756 K
Stamping: 8756 K 1992
Stability: Monument will probably hold position well
Setting: Stainless steel rod without sleeve (10FT+ or 3.048M+)
Mark Condition: G
Description: The bench mark is a disk set inside a guard rail at the SE corner of the intersection of Seppala Drive and Port Drive, 11.1 m (36.4 ft) ENE of the centerline of Port Drive, 2.90 m (9.5 ft) east of the guard rail, 2.68 m (8.8 ft) NE of a stop sign, and 0.12 m (0.4 ft) NE of a metal fence post. The bench mark is 15 cm (0.5 ft) below grade, crimped to the top of a stainless steel rod driven 8.5 m (28 ft) to refusal and encased in a 6-inch PVC pipe with NGS logo cover.
Observed: 2011-06-26T05:15:00Z See Also 2001-08-20
Source: OPUS - page5 1106.16

Close-up View

REF_FRAME:	EPOCH:	SOURCE:	UNITS:	SET	
NAD_83(CORS96)	2003.0000	NAVD88 (Computed using GEOID09)	m	PROFILE	DETAILS

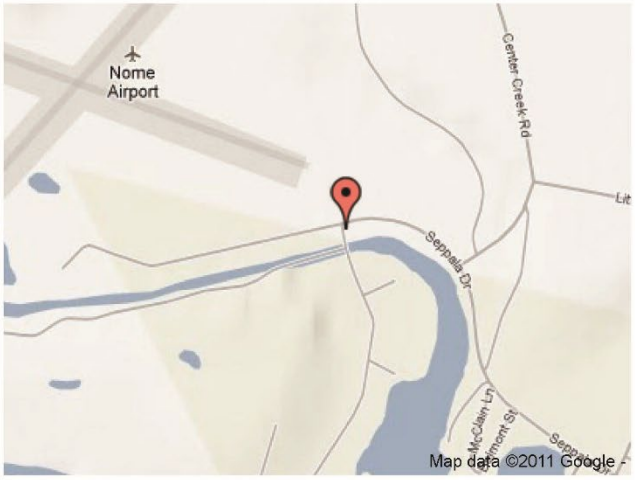
LAT:	64° 30' 26.13212"	± 0.020 m
LON:	-165° 25' 48.09634"	± 0.011 m
ELL HT:	10.240	± 0.011 m
X:	-2664128.827	± 0.018 m
Y:	-692462.874	± 0.014 m
Z:	5734288.687	± 0.016 m
ORTHO HT:	4.999	± 0.020 m

	UTM 3	**SPC** 5008(AK 8)
NORTHING:	7153611.355m	1170493.816m
EASTING:	479348.720m	527380.057m
CONVERGENCE:	-0.38816063°	0.51448370°
POINT SCALE:	0.99960522	0.99990918
COMBINED FACTOR:	0.99960362	0.99990757

CONTRIBUTED BY

erik
John Oswald and Associates, LLC

Horizon View



The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.

Figure 11 Sample# 2 – OPUS Results

SURVEY DATASHEET (Version 1.0)

PID: BBBH93
Designation: 9462719 A
Stamping: 2719 A 2009
Stability:
Setting: Stainless steel rod without sleeve (10FT+ or 3.048M+)
Mark Condition: G
Description: Recovered as described.
Observed: 2011-07-08T03:16:00Z See Also 2010-11-23
Source: OPUS - page5 1106.16

Close-up View

REF_FRAME:	EPOCH:	SOURCE:	UNITS:	SET PROFILE	DETAILS
NAD_83(CORS96)	2003.0000	NAVD88 (Computed using GEOID09)	m		

LAT:	54° 14' 20.08977"	± 0.020	m
LON:	-165° 32' 28.20868"	± 0.011	m
ELL HT:	19.783	± 0.011	m
X:	-3617360.970	± 0.025	m
Y:	-932740.624	± 0.005	m
Z:	5152345.860	± 0.010	m
ORTHO HT:	3.437	± 0.020	m

	UTM 3	**SPC** 5010(AK10)
NORTHING:	6010239.022m	409937.911m
EASTING:	464730.210m	1679612.132m
CONVERGENCE:	-0.43914205°	8.33487653°
POINT SCALE:	0.99961526	1.00014993
COMBINED FACTOR:	0.99961217	1.00014683

CONTRIBUTED BY

glen
John Oswald and Associates, LLC

Horizon View

The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.

1 of 1 7/27/2011 11:54 AM

Figure 12 Sample# 3 – OPUS Result