US Army Corps
of Engineers
New Orleans District

USACE New Orleans District Guide for Minimum Survey Standards

FOR PERFORMING
HYDROGRAPHIC, TOPOGRAPHIC, AND GEODETIC SURVEYS

December 2006

Contents

Section A
Introduction

Purpose:
This document provides guidance on performing detailed engineering surveys of facilities and civil works projects. Technical specifications, procedural guidance, and quality control criteria are outlined for surveying services performed in a consistent manner for the New Orleans District in support of hurricane and flood protection, hydrologic studies, construction, and mapping projects.

Applicability:
This document applies to all in-house and A-E contract surveying services having responsibility for the planning, engineering and design, operation, maintenance, construction, and related real estate and regulatory functions of civil works, and environmental restoration projects. It is intended for use by hired-labor personnel, construction contractors, and Architect-Engineer (A-E) contractors. It is also applicable to surveys performed or procured by local interest groups under various cooperative or cost-sharing agreements.

Distribution:
This document is approved for public release; distribution is unlimited. Current copies may be obtained from:
http://www.mvn.usace.army.mil/ed/edss/index.asp

References:
Referenced USACE publications and related bibliographic information are listed in Appendix 4. Where applicable, primary source material for individual chapters may also be noted within that section.

Definitions:
Definitions are listed in Appendix 1

Acronyms:
Acronyms are listed in Appendix 2

Use of Manual:
This document is intended to be a reference guide for control surveying, site plan mapping, utility and infrastructure utility feature mapping. These activities may be performed by hired-labor forces, contracted forces, or combinations thereof.

Scope:
This document is a compilation from several sources such as USACE Engineering Manuals, The Louisiana Department of Natural Resources Surveying Specifications, etc…

The first few chapters in this document are intended to provide a general overview of control, hydrographic, and topographic survey procedures, equipment, and standards.

Sample scopes of works to field personnel are provided, including typical data deliverable requirements. A sample estimating spreadsheet is included in the supplied CD.

Evolving Technology And Procedures:

Survey equipment, operation, calibration, and procedural methods for acquiring, logging, processing, and plotting survey data are adequately detailed in operation manuals provided by the various survey equipment manufacturers and software vendors. Since instrument and data collector operations and data processing methods are unique to each vendor, and are being constantly updated, this document will only provide a general overview of the techniques required by the New Orleans District.

Other Corps regulations may dictate mandatory requirements for processing, displaying, transferring, and archiving survey data (e.g., Metadata archiving). These mandatory regulations are not superseded by this document.

Survey Data Submittal:

A softcopy duplicate of all deliverables shall be submitted to CEMVN-ED-SS, Survey section for all survey work. Survey section serves as the central data archive library / clearing house for the district's survey data holdings.

Updates and supplements to this manual may be found at:
http://www.mvn.usace.army.mil/ed/edss/index.asp

Section B
General Contractor's Responsibilities

General:

The Contractor shall perform surveys and related services in accordance with specifications contained within. The types of surveys include: inland automated hydrographic, conventional hydrographic, overbank surveys, topographic, static GPS, RTK, and control surveys within the New Orleans District. In performing the surveys and related work, the Contractor shall supply all vehicles, boats, survey equipment, safety equipment, communications, and supplies not otherwise specified within the scope of work as Government furnished. The Contractor shall furnish professional management and surveying personnel necessary in planning, supervising, performing, verifying and certifying all work.

The Contractor shall furnish all supervision, labor, transportation, fuel, materials, and supplies necessary to ensure expeditious completion of services requested in each task order.

Office assignments requested will include, but are not limited to the following: computing, compiling, verifying, plotting, mapping, constructing Bentley InRoads Select CADD and ESRI Grid Analyst compatible Digital Terrain Models (DTMs), constructing MicroStation DGN file drawings, digitizing hydrographic survey chart data, graphically depicting the collected survey data and certifying by a registered land surveyor the resulting hard copy as a validity check, drawings, graphically depicting the survey data and, and preparing benchmark descriptions and survey field books. Processing, filtering, and extraction of airborne and terrestrial LiDAR data, creating LIDAR derived digital elevation models (DEMs) and associated visualization products. Other office assignments include researching titles and preparing abstracts for servitudes and right-of-way, preparing benchmark descriptions and survey field books. All survey data shall be furnished on Compact Disks (CD) and data shall be optionally electronically delivered via e-mail or a Contractor-provided password protected File Transfer Protocol (FTP) Server.

The Contractor assumes responsibility for all site investigations to determine the nature and location of the work, the general and local conditions, availability of roads, boat ramps, the topography and conditions of the ground, the uncertainties of the weather, tidal action and flood stages, the character of equipment and facilities needed during prosecution of the work, and all other matters upon which information is reasonably obtainable and which can in any way affect the work or the cost thereof. Any failure by the Contractor to acquaint themselves with all the available information shall not relieve them from the responsibility for estimating properly the difficulty or cost for successfully performing the work.

The Government assumes no responsibility for any understanding or representations made by any of its officers or agents during or prior to the execution of the work unless (1) such understanding or representations are expressly stated in the scope of work and (2) the contract expressly provides that the Government thereof assumes the responsibility. Representations made but not so expressly stated and for which liability is not expressly assumed by the Government in the scope of work shall be deemed only for the information of the Contractor.

The Contractor shall assure that all computations are neat and orderly and provided as Portable Document Format (PDF) digital files complete with a table of contents. Presentation shall be such that the computations are easily followed. All drawings shall be in the MicroStation format, using government supplied seed file with appropriate working units and subunits.

The Contractor shall submit PDF files of survey field books to the COR for review after the completion of fieldwork. The PDF files shall be multi-page and contain all pages of the field book. After notification of approval of the field data, the Contractor shall submit the original survey field books to the COR prior to final payment.

Surveys shall be generally of third order accuracy. The field survey notes and computations shall be certified by a Registered Land Surveyor (RLS) (not necessarily registered in Louisiana) as being of the accuracy requested prior to furnishing survey data to the COR. All plans, plots, CADD drawings, related GIS products, and other finished products required shall also be stamped and signed by the RLS as follows: "I hereby certify that the information shown hereon is true and correct to best of my knowledge and belief."

The Contractor shall furnish all survey field books, concrete and survey disks necessary to accomplish assigned work. See referenced “U.S. Army Corps of Engineers Manual”, EM 1110-1-1002, Survey Markers and Monumentations for monument specifications.
http://www.usace.army.mil/usace-docs/eng-manuals/em1110-1-1002/toc.htm

Any equipment which the COR considers unsatisfactory for accurately performing the service shall be replaced by the Contractor immediately upon notification by the COR.

Each survey crew shall consist of personnel duly qualified and experienced to perform the type of required services in a manner satisfactory to the COR. The Contracting Officer reserves the right to require the replacement of any work unit immediately upon determining that a unit is not performing the required services in accordance with recognized standards of surveying and safety procedures (work practice as well as safe equipment and apparel). Payment of services of the work unit released shall cease immediately upon such determination. The Contractor shall make a satisfactory replacement for the work unit released and payment for the replacement shall begin upon the date such replacement reports for work. *No payment shall be made for travel in connection with replacement.*

All Contractor costs in connection with supervision, outfitting and re-supplying of employees, equipment, safety apparel and supplies shall be included in the contract unit prices listed in Section B, Supplies or Services and Prices/Costs.

All equipment and Contractor personnel used in this contract shall comply with the provisions of "US Army Corps of Engineers Safety and Health Requirements Manual," EM 385-1-1, dated 3 November 2003.

Technical Survey Provisions:

The Horizontal Survey Data shall be referenced to North American Datum 1983 (NAD 83), National Spatial Reference System (NSRS), Louisiana State Plane Coordinate, South Zone 1702, and U.S. Survey Feet.

The Government will furnish all available data in digital data files. The Contractor may be required to establish third order class II supplemental control points, (Louisiana State Plane) at locations closer to the survey site to perform the work. The Contractor shall adjust all traverse baseline surveys using the Government-furnished software. The contractor shall prepare and submit the **T-files** and **J-files**. (See section F)

All Vertical Survey Data shall be referenced to North American Vertical Datum (NAVD) 1988, U.S. Survey Feet. **All benchmarks shall be verified either by GPS or conventional levels from an adjacent mark.**

All GPS derived elevations shall be established referenced to NAVD 88 following the guidelines in "NOAA Technical Memorandum NOS NGS-58" published in November 1987 (http://www.ngs.noaa.gov/PUBS_LIB/NGS-58.pdf), and DRAFT Guidelines for Establishing GPS-derived Orthometric Heights (Standards: 2 cm and 5 cm) (http://www.ngs.noaa.gov/PUBS_LIB/DRAFTGuidelinesforEstablishingGPSderivedOrthometricHeights.pdf).

Character And Extent Of Services:

The Contractor shall not release any data, analyses, results, conclusions or computations relative to any work performed under a USACE contract to any agency, business concern, or individual outside the government without advance express approval of the COR.

Deliverables shall include completed surveys certified by a RLS via digital and hard copy products complying with the Spatial Data Standards (SDSFIE) for GIS and the A/E/C CADD Standards for CADD Products.

The COR and the Contractor's representative shall discuss each proposed assignment to develop a mutual understanding of:

(1) Type of work to be done
(2) Existing data available
(3) Specific benchmarks, datum's, epochs, and elevations to be used
(4) Format, content, and manner of transmission of deliverables
(5) End results, plans, plots, comparative plots, computer aided design drafting (CADD) drawings, GIS products, DTMs, DEMs and other finished products, etc., expected by the COR
(6) Task order completion date expected by the COR

The Contractor shall submit scope of work questions, a time and cost proposal and detailed plans for performance of the work to the COR for each proposed assignment.

When the Government invites the Contractor to perform services on a "labor-hour basis," a mutual understanding of the location and general scope shall be reached between the Contracting Officer and the Contractor.

The Contacting Officer shall issue a task order setting forth the tentative completion date and the labor-hours with a ceiling price necessary to perform the work. The ceiling price on a labor-hour type task order, if exceeded, is done at the Contractor's own risk.

All "raw" data, residual data, and final data shall be delivered for digital data and digital data products. Data at significant process steps during product development shall be preserved and provided to the government. (e.g. A data set that is output from one software program, before it is input into a second software program)

Where applicable, the contractor shall provide a report of all significant software products and their version numbers used to produce a final product, to include government-provided software. The contractor may be called upon to provide products in-phases or in preliminary form, where urgency merits.

Metadata Records:

The Contractor shall develop FGDC-compliant Metadata records for all collected data and CADD/GIS data products where applicable. The Metadata records shall parse through the USGS **mp** Metadata compiler (or equivalent) without errors or warnings. CorpsMet95 Metadata Generator (or equivalent) may be used to generate this data.
(Ref: http://corpsgeo1.usace.army.mil)

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Section C
Topographic Surveys

General:

All topographic surveys shall follow the Topographic Surveying Manual, EM1110-1-1005.

The contractor shall submit all raw data files (total station or Real Time Kinematic (RTK)) and ASCII coordinate XYZ files (EM format). The ASCII coordinate file shall be referred to as the EM file in this document. All coordinates shall be referenced to the North American Datum of 1983 (NAD83) and the North American Vertical Datum of 1988 (NAVD88) unless otherwise specified in the scope of work.

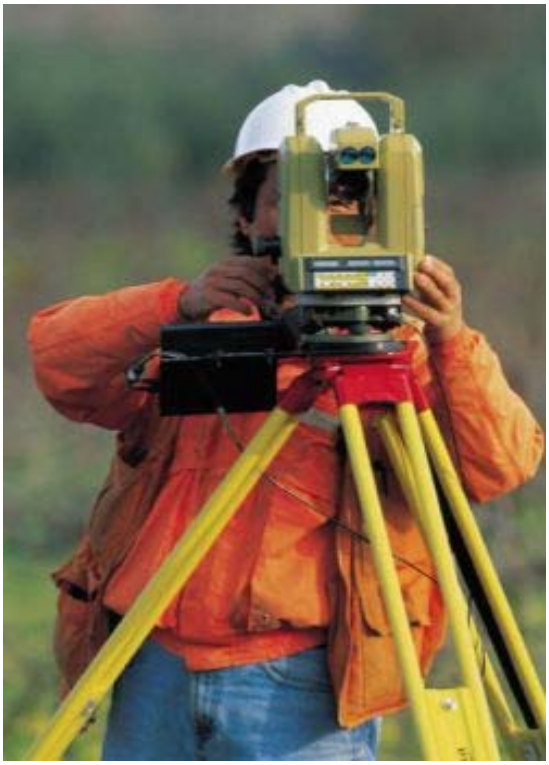
The EM file shall contain all comments concerning problems or special procedures that would not be commonly found such as special procedures to compute the water surface elevation, the reason for missing data due to obstructions, etc.

Raw L1/L2 data at the base station must be collected and submitted for all RTK surveys accompanied with an OPUS report for each occupation. The preferred method to resolve the integer ambiguity during RTK surveys is to initialize on a known point. When one does not exist at the project site, one can be set On-The-Fly (OTF). Once this is complete, the user looses lock and begins the initialization process on the known point. This method minimized the chances for a bad initialization and should be done each time the rover looses lock or fixed mode.

Minimal field notes should be kept to document changes in setup, backsight, HI, rod heights, cross section station numbers, etc.

Bridge Sections:

All sections shall be submitted ordered from the left descending bank (LDB) to the right descending bank (RDB). When the direction of flow is undetermined, indicate the direction (North-South, East-West, etc) of the section. Shots are required at each pier station. These shots shall include centerline road profile shots, top of curb, top of guard rail, low chord or top of bent, and ground shots. These shots shall be collected at each pier and shall be perpendicular to the bridge C/L at the pier station. When the bridge is a railroad bridge, the rails shall be collected as curbs. The centerline of the stream shall be collected in every section. Bridge data shall be submitted in contiguous segments.



Bridge Section Specifications are included on supplied CD.

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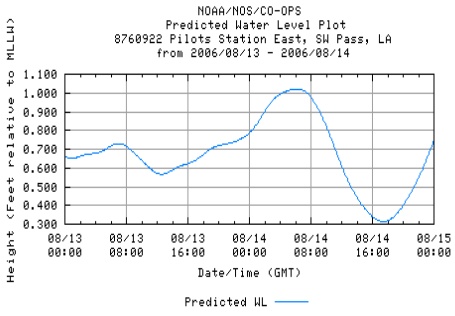
Section D
Hydrographic Surveys

General:

All hydrographic surveys shall follow the Hydrographic Surveying Manual, EM1110-2-1003.

All soundings shall be reduced to NAVD 88 and tabulate them to the nearest tenth of a foot. Tie all contractor-established gages to the National Geodetic Reference System Permanent Bench Marks (PBMs). The contractor shall utilize the government's existing gages when possible. The contractor shall establish the reference to NAVD 88 at the existing gages. The contractor shall access all PBM descriptions and elevations from the following Website: http://www.ngs.noaa.gov/ or as indicated in the scope of work. The contractor is not to use any elevations from an epoch older than 2004.65 unless specifically directed to in writing.

A Differential Global Positioning System (DGPS) shall be used for horizontal positioning for hydrographic surveys. Control to be used shall be the USCG navigational beacon broadcast signal.



Determine the water surface elevation to the nearest tenth of a foot and record it at the beginning and closing of each day or at an interval to ensure a correct determination of the tidal curve such as at the predicted high and low tides. The predicted tides shall be included in the survey report.
http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Tide%20Data&state=Louisiana&id1=876

The Contractor shall prepare a final report of survey to include pictures of all vertical control monuments, descriptions, published and found elevations, network adjustments, reconnaissance notes, field notes, sketches, etc. The Contractor shall furnish pictures, descriptions and elevations of all Bench Mark established for vertical control. Two (2) hard copies of the final survey report shall be submitted.

The Contractor shall check all control levels and shall submit Portable Document Format (PDF) files of the survey field books and the final survey report on CD.

When one is performing Hydrographic Surveys, use a depth sounder capable of taking not less than 10 soundings per second and making a permanent record on a scroll with a vertical scale approved by the COR. The transducer shall have a beam width of not more than five degrees. In areas of suspended sediment, a low frequency fathometer shall be used and set such that the hard bottom is digitized.

Make bar check readings twice daily (to adjust the depth sounder for water temperature and salinity); once before commencing work and one at the closing of each day and must be performed in the project area. When making bar checks, the Contractor shall follow the operating procedures in the referenced "US Army Corps of Engineers Manual," EM 1110-2-1003, Hydrographic Surveying,

http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1003/toc.htm

The Contractor shall inspect each survey site to determine if waterway obstructions such as moored barges prevent the use of automated positioning and sounding equipment for portions of ranges. At these ranges, the Contractor shall obtain the hydrographic surveys by the conventional method of using a distance wheel (or substitute device) and Fathometer or lead line or by utilizing a system capable of measuring water depths under surface obstructions.

Hydrographic survey soundings are at 20-foot intervals unless otherwise specified.

Overbank elevations shall be taken at 20-foot intervals and at all abrupt changes (+/- 2') in elevation unless specified in the scope of work. Elevations shall be carried to Third Order accuracy or better.

A final survey report shall be submitted in PDF format, including baseline computations, survey control, survey procedures, photos, tabulation of monuments with elevations, feature descriptions, etc.

The Contractor shall reduce, edit, correct and combine overbank and hydrographic survey data in the logical record format specified in the referenced "US Army Corps of Engineers Manual", EM 1110-1-1005 and if specified, the "MVN Extended LMN830 Format", Latest Revision, dated 19 July 2001 (check website for latest version).

Profile data shall be submitted in the specified Profile Format. All hydrographic and GPS raw data, processed vectors, network adjustments, reports, field notes, fathometer scrolls, etc. shall be submitted. Record all the data/photos on CD and submit the data files/photos to the COR. The Contractor shall retain a copy of the CDs furnished to the COR until completion of the job or receiving notification from the COR that the data was successfully read into the system.

1. All submitted data shall be delivered on CD in the format provided.
2. A PDF file shall be submitted which includes all data, correspondence, images, documents, etc. The format and structure of the PDF file shall conform to the sample provided.
3. All survey data points shall be submitted in the format described in EM1110-1-1005, Topographic Surveying
4. Engineering Manuals may be obtained from: http://www.usace.army.mil/inet/usace-docs/eng-manuals/cecw.htm

All fathometer scrolls shall be annotated with station numbers, bar check notes, job number, contract number, date, gauge readings, etc and submitted to the COR along with the survey report and field data.

Section E
Geodetic Control Surveys

General:
All control surveys shall follow the Geodetic and Control Surveying Manual, EM1110-1-1004.

Monumentation:
All permanent monuments shall be set following EM1110-1-1002, Survey Markers and Monumentations and shall be stamped with the Job number followed with the designation. (i.e. 06-047-1, 06-047-2, 06-047-etc.)

Datum Definitions:
A datum (plural datums) is a reference from which measurements are made. In surveying and geodesy, a **datum** is a reference point on the earth's surface against which position measurements are made, and an associated model of the shape of the earth for computing positions. Horizontal datums are used for describing a point on the earth's surface, in latitude and longitude or another coordinate system. Vertical datums are used to measure elevations or underwater depths. In engineering and drafting, a **datum** is a reference point, surface, or axis on an object against which measurements are made.

Horizontal Datums:
The horizontal datum is the model used to measure positions on the earth. A specific point on the earth can have substantially different coordinates, depending on the datum used to make the measurement. There are hundreds of locally-developed horizontal datums around the world, usually referenced to some convenient local reference point. Contemporary datums, based on increasingly accurate measurements of the shape of the earth, are intended to cover larger areas. The WGS84 datum, which is almost identical to the NAD83 datum used in North America, is a common standard datum.

Vertical Datums:
A vertical datum is used for measuring the elevations of points on the earth's surface. Vertical datums are either tidal, based on sea levels, or geodetic, based on the same ellipsoid models of the earth used for computing horizontal datums.

In common usage, elevations are often cited in height above sea level; this is a widely used tidal datum. Because ocean tides cause water levels to change constantly, the sea level is generally taken to be some average of the tide heights. Mean Lower Low Water (MLLW) — the average of the lowest points the tide reached on each day during a measuring period of several years — is the datum used on most nautical charts, for example. While the use of sea-level as a datum is useful for geologically *recent* topographic features, sea level has not stayed constant throughout geological time, so is less useful when measuring very long-term processes. In some situations sea level does not apply such as in areas along inland rivers where river datums are used.

A geodetic vertical datum takes some specific zero point, and computes elevations based on the geodetic model being used, without further reference to sea levels. Usually, the starting

reference point is a tide gauge, so at that point the geodetic and tidal datums might match, but due to sea level variations, the two scales may not match elsewhere. An example of a gravity-based geodetic datum is NAVD88, used in North America, which is referenced to a point in Quebec, Canada. Ellipsoid-based datums such as WGS84, GRS80 or NAD83 use a theoretical surface that may differ significantly from the geoid .

On nautical charts, depths of water are relative to chart datum which is generally the lowest tide caused by gravity alone.

NGVD29:

In 1929, the U.S. Coast and Geodetic Survey established Sea Level Datum of 1929 by constraining the local mean sea level at 26 tide gage stations held at 0.0 elevation. Of these, 21 gages were in the US and 5 were in Canada. At Biloxi, they still had only 5 non-contiguous years of record to determine MSL.

Mean Sea Level (MSL) at Biloxi, was one of the stations used to establish Sea Level Datum (SLD) of 1929.

In 1973 SLD was renamed to National Geodetic Vertical Datum of 1929 (NGVD29). Thus, in 1929, zero NGVD was equal to local MSL at Biloxi and was used to establish vertical control for the United States. (Canada did not adopt the datum.)

Actual differences between mean sea level at tide stations on the West Coast, East Coast and Gulf Coast were adjusted out as surveying errors in the precise level lines. This results in a warped plane (imperfect geoid) of the earth, akin to taking a sheet of paper and wadding it into a ball and then flattening it out again. As additional miles of precise levels were added to the level net, the network was re-wrinkled.

When SLD became NGVD29, the misconception that MSL and NGVD29 were the same continued. Since then, we have been using MLG as –0.78 feet NGVD29. Most recently, we have used Sea Level Datum of 1929, renamed to be National Geodetic Vertical Datum of 1929 with various epochs of revision based on a year of precise leveling through our area, for example, 1956, 1964, 1983, 1984/85. Note that we have different dates when NGS updated NGVD benchmarks through the years:

1938 - adjustment based on SLD 1929
1951 - adjusted forward in time to 1955
1955 - tied to Morgan City & Mobile (‘29)
1963 - tied to Norco well (‘29 value)
1969 - tied to ‘63 lines
1973 - SLD’29 changed to NGVD 1929
1976 - tied to Index, AR & Logtown, MS (Line Cost MVN $1,500,000)
1983 - Free Adjustment - Large Differences Found Caused Concerns 1984-85

MLG:

In 1911, the U.S. Army Corps of Engineers established Mean Low Gulf Datum as equal to Mean Low Water at Biloxi (-0.78 feet MSL at Biloxi). *Note that Mean Low Gulf Datum was set equal to MSL minus half the tide range at Biloxi (MSL - (1.57/2) = -0.78 feet MSL).*

The Biloxi gage had only 5 non-contiguous years of data (1882, 1884, 1896, 1897, and 1898). A metonic cycle of 19 years is required for a full Tidal Datum Epoch. In 19 years (actually, 18.6) the sun, the moon and other primary tide producing celestial bodies cycle into the same alignment.

In recent years, as a result of subsidence, global sea level rise, and possibly other geologic factors, the elevation of local MSL has changed with respect to NGVD, at Biloxi and elsewhere around the world. The relationship between tidal datums and NAVD88 may be required as indicted in the scope of work. Information on determining these relationships may be found at http://tidesandcurrents.noaa.gov/

NAVD88:

And now, the New Orleans District has adopted the North American Vertical Datum of 1988. NAVD88 is a result of a free adjustment of the vertical network. One point was held at Father's Point on the St. Lawrence Seaway in Quebec and the precise level lines were adjusted throughout North America.

It is reasoned that by not holding to the 26 gauges, the local separation of the geoid to local mean sea level will not show up in the adjustment as leveling errors.

Approximately 625,000 km of leveling has been added to the National Geodetic Reference System (NGRS) since NGVD 29 was created. Many existing benchmarks were affected by crustal motion associated with earthquake activity, postglacial rebound (uplift), and subsidence resulting from the withdrawal of underground liquids, soil compaction, and sediment loading. As indicated earlier, other problems (distortions in the network) were caused by forcing the 625,000 km of leveling to fit previously determined NGVD 29 height values.

The difference between NGVD29 and NAVD88 in the New Orleans area was between -0.20 and -0.30 in 1992-93 before the effects of subsidence took place.

Datum Transformations:

CORPSCON shall not be used for vertical transformations.

The NAVD88 was developed as a replacement for the NGVD29 because the NGVD29 had become unreliable and out-of-date. The NAVD88 was published for most of the country by 1990, except for those regions of known crustal motion which included Louisiana. In 1992, the NAVD88 was published for Louisiana, but because of the continuing crustal motion of subsidence the lifespan of the NAVD88 benchmark elevations in Louisiana was limited to a few years.

CORPSCON uses the data files developed for VertCon by the National Geodetic Survey. The data files represent a snapshot in time for the instant when the NAVD88 was ***first*** published for Louisiana. Those data files are static; they do not change, and they only represent the differences in elevations at certain benchmarks in Louisiana in 1992. Using CorpsCon and/or VertCon in Louisiana will provide conversions that are ***at least 6 inches in error,*** an amount that is not acceptable for engineering and design applications.

CORPSCON shall not be used for vertical transformations without written waiver signed by the COR.

NGVD29 to NAVD88:

The methodology used to shift historical survey data (NGVD29) to NAVD88 (2004.65) will vary dependent upon many factors such as time, funds, accuracy requirements, etc. Generally four methods can be used to determine the datum/epoch shift.

1. Field Measurements w/ Known Historical Elevation:

This method will yield the most accurate values based on the historical reference marks. The reference marks will need to be recovered and occupied/surveyed using the guidelines in NGS 58. The difference between the elevation used for the original survey and the elevation established from the new network will directly tie in the old work to the latest control. This will not account for any differential subsidence that occurred between the reference mark and the survey positions.

2. Field Measurements w/o Known Historical Elevation:

When the reference benchmark is not recorded and unknown, some assumptions will be required such as what mark was used and what its elevation was. Again follow the procedures in NGS 58 to establish new elevations on the reference mark. The historical elevation will have to be assumed based on what was available at the time of design. The difference between the assumed historical elevation and the newly

established elevation will be used to shift the survey to the new datum/epoch.

3. Common Published Marks in Survey Area:
When time and money are constraints, the closest marks with published elevations in both datum/epochs can be used to determine an average shift for the area. This method contains many assumptions and therefore is the least accurate but may be of some use for projects that don't require a high level of accuracy.

4. CORPSCON:
This method is the least accurate and does not account for subsidence or the changes in elevation from epoch to epoch. The CORPSCON model was developed with the published elevations at the time the model was created. Those published elevations contained errors associated with the already deteriorating vertical network accuracies. This method should not be used for anything other than a pure datum shift keeping in mind that subsidence is not accounted for.

CORPSCON shall not be used for vertical transformations without written waiver signed by the COR.

NAD27: North American Datum of 1927

The North American Datum of 1927 (NAD27) is a datum based on the Clarke Ellipsoid of 1866. This Ellipsoid was created by way of manual surveying of the entire continent. The geodetic "center" of NAD27 is a base station at Meades Ranch in Kansas

NAD83: North American Datum of 1983

In the last 25 years, as satellite and remote sensing technology have both improved and made available for civilian applications it became obvious that the NAD27's approximations were no longer accurate for broader scopes.

The North American Datum of 1983 was created to respond to these changes. It is based on the GRS80 ellipsoid; an ellipsoid derived from satellite geodesy.

Comparisons Between NAD-27 and NAD-83:

A point having a given latitude and longitude in NAD27 may be displaced on the order of many tens of meters from another point having the identical latitude and longitude in NAD83. So it is important to define your datum as well as your coordinates. The North American Datum of 1927 is defined by the latitude and longitude of an initial point (Meade's Ranch in Kansas), the direction of a line between this point and a specified second point, and two dimensions that define the spheroid. The new North American Datum of 1983 is based on a newly defined spheroid (GRS80); it is an Earth-centered datum having no initial point or initial direction

Current Engineering Division Policy directs the exclusive use of NAVD88 for all surveys (see FIGURE 1). Any deviation from NAVD88 shall require a written waiver from the Chief/ Engineering Division. The COR, CO, or Survey Requestor is not authorized to grant any waiver.

All projects located in southern Louisiana shall use the latest adjustment (currently 2004.65) for all surveys.

Current Engineering Policy (FIGURE 1)

CEMVN-ED-S 4 December 2002

MEMORANDUM FOR : All Engineering Division Personnel

SUBJECT: Vertical Datum Policy

1. It is be the policy of Engineering Division to use the North American Vertical Datum of 1988 (NAVD88) for all vertical control, gages, engineering studies, design and construction documents, and for the reporting of all levels of protection, etc. All new work shall be referenced to NAVD88.

2. The Survey Section shall not sanction mathematical conversions such as CORSPCON, to NAVD88 from permanent benchmark elevations published in the National Geodetic Vertical Datum of 1929 (NGVD29) datum. Prior to any field data collection effort either in-house, through contracts, by sponsors or their AEs, the project shall fund to validate benchmarks and to establish vertical controls in the project area.

3. Historic data to include topographic and hydrographic surveys, flowlines, hydrologic data, benchmarks, map elevation contours, and all such field information collected referenced to non-NAVD88 datums is suspect and cannot easily be used in conjunction with current NAVD88 data. No meaningful conversion between old datums and NAVD88 is possible without proper field investigations and even then could result in an approximation at best. Therefore, Survey Section will be consulted for each instance of attempted use of historic data. The degree of their involvement will depend on the purpose for which the data is to be used and the acceptable magnitude of error. As a minimum, a quick validation of the vicinity benchmark elevation without cost to the project is required to determine the magnitude of the problem.

4. To ensure adherence to proper surveying practices, the use of acceptable benchmarks and their assigned values, and the conformance of the data to Corps standards and datums, all planned field surveying effort shall be reviewed by the Chief, Surveying Section. This includes the field data gathering effort performed by District design and planning, AE contractors, sponsors, and the sponsor's AE contractors.

5. Plans and specifications shall identify the permanent benchmarks and their assigned elevations to be used for each construction contract. It will be incumbent upon the design engineer to assure that all designs and data are compatible with the elevations assigned to the permanent benchmarks used in the contract documents. (In addition, the methodology used for any Datum shift shall be included in the documentation)

6. It is the intent of this policy to affirm our position that the assigned benchmark elevations represent a "snapshot", and may change on future contracts depending on benchmark movement. Engineers must use sound engineering judgment in employing the NAVD88 datum, recognizing that projects have already been designed and/or constructed using the NGVD29 datum against various epochs and that projects may require a significant number of years from conception to completion, and therefore allowances must be made for vertical movement.

CF: CEMVN-OD
CEMVN-PA
CEMVN-PM
CEMVN-CD

GERARD S. SATTERLEE, Jr.
Chief, Engineering Division

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Section F
Traverse / Baseline

General:

All traverses shall be to 3rd order class II specifications unless otherwise specified in the scope of work. Where short tangents (less than 800') are required, a sub-traverse shall be run in which the angles shall close to no more than 10"/setup and the positional error shall be no more than 1:2500. All traverses shall be adjusted and labeled using the supplied government Least Squares Adjustment software (included in government furnished CD). All traverse measurements shall be recorded in field books.

Sample Traverse Computation

JOB NO: 00-036 ADJUSTED DATE OCT-90
SURVEY REQUESTED BY: ST. CHARLES PARISH TRAVERSE
BOOK NO: 900593

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

N E W O R L E A N S D I S T R I C T

TRAVERSE COMPUTATIONS

NORTH AMERICAN 1983 DATUM

LOUISIANA SOUTH ZONE

FILE NO. STATION	ADJ. ANGLE MEAS. ANGLE	ADJ. DISTANCE MEAS. DISTANCE	BACK GEOD. AZIMUTH FWD. GEOD. AZIMUTH	SCALE FACTOR PLANE DISTANCE	CONVERGENCE PLANE AZIMUTH	LATITUDE DEGS-MIN-FT Y-COORDINATE DEGS-MIN-SEC	LONGITUDE DEGS-MIN-FT X-COORDINATE DEGS-MIN-SEC
B. S. = LMS 9 BONNET CARRE LGL							
(1) P.I. 1			52-14-34.9	.9999258	0-27-41.3	30- 1+ 591.570	90-24+3293.229
0+ .00	78-57-28.6	2274.665	131-12- 3.5	2274.496	130-44-22.2	553321.19599	3572912.77699
	78-57-29.2	2274.710				30- 1- 5.85569	90-24-37.45885
(2) P.I. 2			311-12-13.2	.9999258	0-27-51.0	30- 0+5154.689	90-24+1581.899
22+74.71	179-10- 7.6	2439.659	130-22-20.8	2439.478	129-54-29.8	551836.81247	3574636.12797
	179-10-10.7	2439.710				30- 0-51.02402	90-24-17.99257
(3) P.I. 3			310-22-31.4	.9999258	0-28- 1.6	30- 0+3574.341	90-23+4998.717
47+14.42	179-58-38.2	2756.905	130-21- 9.5	2756.700	129-53- 7.9	550271.74046	3576507.38438
	179-58-41.2	2756.970				30- 0-35.38086	90-23-56.85310
(4) P.I. 4			310-21-21.5	.9999257	0-28-13.6	30- 0+1789.209	90-23+2897.999
74+71.39	180- 0-11.6	1546.169	130-21-33.0	1546.055	129-53-19.5	548503.99043	3578622.67483
	180- 0-14.5	1546.190				30- 0-17.71063	90-23-32.95888
(5) P.I. 5			310-21-39.7	.9999257	0-28-20.3	30- 0+ 787.926	90-23+1719.898
90+17.58	179-58-23.6	1684.606	130-20- 3.4	1684.480	129-51-43.1	547512.50728	3579808.94882
	179-58-26.5	1684.630				30- 0- 7.79935	90-23-19.55982
(6) P.I. 6			310-20-10.7	.9999257	0-28-27.6	29-59+5759.021	90-23+ 435.806
107+ 2.21	179-58-46.7	2101.512	130-18-57.4	2101.356	129-50-29.8	546432.85579	3581101.94035
	179-58-49.5	2101.550				29-59-57.00616	90-23- 4.95613

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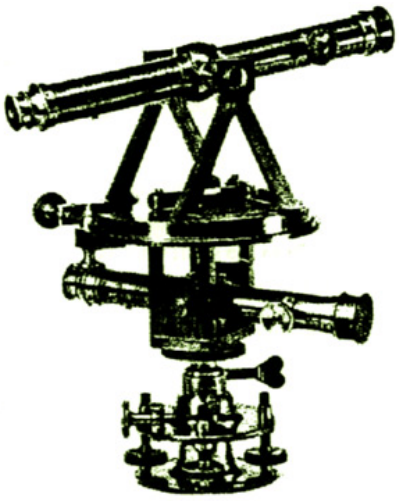


Section G
Global Positioning System

General:
All GPS surveys shall follow the NAVSTAR Global Positioning System Surveying Manual, EM1110-1-1003.

Introduction:
In an effort to maintain quality, consistency and accuracy when performing GPS surveys on projects contracted by the U.S. Army Corps of Engineers, New Orleans District (MVN). It is imperative that all contractors recognize and follow the recommendations and guidelines established in this document. The information in this document is not intended to be used as a standard for contractors or surveyors performing GPS surveys for other agencies, federal or local, but as a minimum standard exclusively for surveyors contracted by MVN. This document was written as a general reference guide and is not intended to be a GPS training manual for individuals on the technical aspects of performing GPS surveys and assumes that survey contractors performing projects for MVN will employ personnel that are educated and experienced in the basics of geodesy and GPS technology.

For more technical information on GPS-derived heights and in depth guidelines, refer to NOAA Technical Memorandum NOS NGS-58 developed by the National Geodetic Survey (NGS) in November 1997 titled "*Guidelines for Establishing GPS-Derived Ellipsoid Heights*", Version 4.3 and "A *Guide for Establishing GPS-Derived Orthometric Heights*", Version 1.1, as well as the U.S. Army Corps of Engineers Technical Letter No. 1110-1-183 dated April 1, 1998 and titled "*Using Differential GPS Positioning for Elevation Determination*".

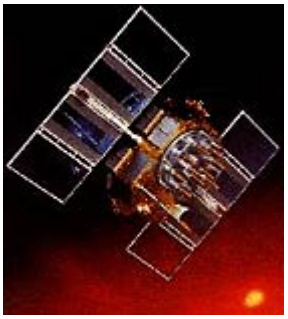
Determining Orthometric Heights using GPS:
There are three basic rules, three control requirements, and five procedures that need to be followed when estimating GPS-derived orthometric heights.

Rules for Measuring GPS-Derived Orthometric Heights:

Rule 1: Follow MVN's guidelines outlined in this booklet for establishing GPS-derived ellipsoid heights when performing GPS surveys.

Rule 2: Use NGS' latest National Geoid Model, e.g., GEOID03(05), when computing GPS-derived orthometric heights.

Rule 3: Use the latest NGS adjusted height values found in the National Spatial Reference System Database:
http://www.ngs.noaa.gov/cgi-bin/datasheet.prl



Network Design Planning
When permanent GPS Secondary monuments are required in a project area, as specified in the "Scope of Work" for a NOD project, a GPS network plan is necessary to establish the values of those secondary monuments. The GPS network should be designed as to incorporate a minimum of four Primary Control monuments, one at each extreme corner that is nearest to the project area. A GPS Network Plan and Sessions Schedule will be required and must be submitted with the cost proposal to CEMVN-ED-SS for approval prior to commencing work.

Sessions Planning and GPS Schedule:

On the Primary GPS control survey, the sessions should be scheduled so that points are occupied for a minimum of 2 hours and a minimum of 2 sessions on different days. The purpose is to ensure different atmospheric conditions (different days) and significantly different satellite geometry (different times) for the two occupations.

For example, if the first day occupation were made between 8:00 am to 11:00 am, the second observation would be made on the next day anytime between 1:00 pm and 5:00 pm. If the second observation is not made for a couple of days or even a week, be sure to compensate for the daily 4-minute change in the GPS satellite constellation. It has been shown that the average ellipsoid height of repeat observations is closer to the truth, with a few exceptions, than the ellipsoid height of a single observation.

For Secondary GPS control, the sessions should be scheduled so that points are occupied a minimum of 1 hour and a minimum of 2 sessions at different times of the day with a minimum of 4 hour offset, or on different days, at different times. For example, if the first occupation is made between 8:00 am to 9:00 am, the second observation could be made on the same day anytime after 12:00 am. If the second observation is not made for a couple of days or even a week, be sure to compensate for the daily 4-minute change in the GPS satellite constellation. Make sure to work around or compensate for periods when PDOP and/or VDOP are high.

Using the Session Schedule form (Section K), input a proposed start time and session duration time for each session. Travel times should be calculated using a road map to compute distance and travel times between set-ups. Input the GPS operator and in the corresponding row, input the station names of the points that will be occupied by each operator.

GPS Equipment:

Fixed height tripods are required to be used for each set-up. Fixed height tripods provide a consistent station occupation method that can reduce the likelihood of antenna height measurement blunders. In the event that a setup cannot be performed with a fixed height tripod because of an obstruction such as a fence, then an adjustable tripod can be used. In this case make certain that the procedure for antenna height measurement using an adjustable tripod is used.

The use of dual frequency receivers can correct GPS measurements for ionosphere based range errors. This will extend the feasible baseline length and resolve integer ambiguities reliably within 20 km. **Dual frequency receivers shall be used on all baselines**.

Use identical geodetic quality antennas with ground plane. Different makes and models of GPS antennas can have different phase centers. Mixing of different type of antennas can cause errors in the vertical component up to 100 mm. Only if the processing software can account for the phase center difference in the GPS antennas should mixing of antenna types occur. The ground plane on the antenna will reduce the amount of ground reflecting multipath.

The GPS Schedule and Log Sheet

The Session Schedule provides a guide as to start and stop times, station name set-ups for each survey technician, travel times and cell phone numbers for the crew. Once a schedule has been planned and established, it is important that any deviation from the schedule such as late

start times, power failures, travel delays, etc. should be communicated to the Project Manager or Party Chief so that the schedule can be revised. It is important to remember that the processed data in a GPS session is only as good as the last person that starts collecting data on his GPS receiver and the first person to stop survey. (See Section I for a sample copy)

GPS Log Sheets (See Section K) are the field notes for the GPS survey and should be filled out in their entirety. The information on this sheet is important at the time of check-in, download and processing of the raw data. If problems are encountered with the raw data, the problem can be traced back to a particular GPS receiver that may be malfunctioning or configured incorrectly.

The data required to be logged on the GPS Log Sheets by the technician include the following: Operator, Station Name, Monument Type, Julian Date, Session Number, Receiver Serial Number, GPS Antenna Number, Antenna Height, Start and Stop Times, and Session Notes.

A Station Sketch with reference ties is required on the back page of the sheet for future relocation and confirmation that the correct monument was used in the survey. If you are occupying an existing monument, make a note on the GPS Log Sheet as to the condition of the monument. Note if the monument may have been disturbed and report to NOD if any effort is required to re-ensure its stability.

Measuring Antenna Height If Using a Variable Height Tripod (Required When Establishing Horizontal Control)

When performing GPS Control Surveys to establish horizontal coordinates, it is preferable to use conventional slip leg tripods with optical plummets. Fixed height 2 meter antenna rods are required when performing vertical surveys.

Record the measurement in meters on GPS log sheet and repeat procedure at 180° from previous measurement. Record the average value on the GPS Log Sheet. Now re-measure the height in feet and tenths or inches using measuring tape. Record this value on GPS Log Sheet. Divide the foot measurement by 3.2808 and compare the answer to the average of measurements. IMPORTANT!!! THIS IS YOUR SURVEY QUALITY CONTROL CHECK MEASUREMENT! Make certain that the measurement is recorded properly ie: Inches or Feet & Tenths. If the two values differ by more than 0.016 feet or 5 mm, begin the measurement procedure all over again.

If a second session is scheduled on the same GPS Station, the surveyor shall break setup and re-measure the antenna height. This will eliminate the possibility of the wrong antenna height being used for both sessions.

Measuring Antenna Height If Using a Fixed Height Tripod (Required When Establishing Vertical Control)

The fixed Height tripods are normally **2.000 meters** from the bottom tip of pole to the antenna reference point. This can vary and the length of the pole must be verified and documented.

Complete GPS Log Sheet

Now you are ready to complete GPS log sheet. Be aware of your scheduled stop time for this session. Also be aware not to stand near and block the GPS antenna or park a vehicle nearby, blocking the antenna view to the sky. A sample Log Sheet is contained on the furnished CD.

Processing the GPS Data Files

All processed baselines shall use the rapid or precise ephemeris. Since most baselines are less than several hundred kilometers, the differences between using the IGR (rapid orbit) and the IGS (precise orbit) is barely detectable if at all. There is a latency for the precise orbit data and can be downloaded from NGS' website at the following internet address:
http://www.ngs.noaa.gov/GPS/GPS.html

All GPS static sessions shall be converted to RINEX and submitted on CD. Antenna type

and antenna heights shall be recorded and indicated in the RINEX file. All field session logs shall be included in the PDF report.

GPS Control Network Approval:

All GPS network results shall be submitted to MVN-ED-SS for approval prior to conducting additional survey operations. Any additional work may not be acceptable and will be at the contractor's risk. The contractor shall submit both the minimally constrained adjustment showing the network's internal consistency and the fully constrained adjustment holding a minimum of four (4) valid NAVD88 benchmarks along with a tabulation showing the adjusted values compared to OPUS values.

RTK Surveys:

All RTK surveys shall be accompanied by a complete report outlining the QA/QC methods used for the data collection. The report shall include all control used, and both their given and found positions. This tabulation shall also include any common points used to check between setups.

All base station occupations shall collect and store the GPS data. This data will be submitted to OPUS to check for setup blunders. It is also suggested that the rover store the raw GPS positions which can later be used to post process the survey. This would be particularly advantageous when the survey is located near a CORS site.

Each initialization shall be checked against a known baseline. This can be accomplished by using OTF initialization to establish a point. The newly established point will then serve as a known point in the known baseline initialization thus providing a higher degree of confidence in the resolution of the integer ambiguities.

Section H
Format Specifications

General:

All ASCII surveys data shall follow the format specifications in the Topographic Surveying Manual, EM1110-1-1005.

Coordinate File Coding:

This section describes a coding scheme used by New Orleans District that is intended to define the general parameters associated with a survey project. This coding format is a mandatory submittal item for AE contractors performing surveys for the New Orleans District. These code records are inserted into the ASCII coordinate file produced by the data collector and were developed for general USACE topo survey requirements. These records are used when importing the data into a GIS to create the required Metadata file. Additional codes may need to be developed to suit particular applications.

The EM file format is a plain ASCII text format file designed to be both easily parsed by a program or easily read by a person. The file consists of two distinct sections: the header section, which contains global header information about the survey, and the data section, which contains the geospatial coordinate metadata. This format is also used for hydrographic surveys.

All code records will begin with a " # " in column 1, and are limited to 80 characters (4 for the code, 1 space, and 75 for text). All comment records will begin with a ";" in column 1, and are also limited to 80 characters. The submitted file is in chronological order, thus the code records will define the attributes of the records that follow. If the field data collection was completed in 7 days, the file would contain 7 #H02 records. Each would be placed at the beginning of the data collected on that day to indicate that the following records were collected on that date.

INDEX OF RECORD CODES

Alignment/Baseline Records
#B01 - Coordinates and station of baseline PI.
#B00 - Name of datafile containing the reference alignment/baseline.
#BC1 - Coordinates and station of point of curve.
#BI1 - Coordinates and station of point of intersection.
#BT1 - Coordinates and station of point of tangent

Survey Crew Members
#C01 - Party Chief.
#C02 - Instrument Man.
#C03 - Rodman.

Gage Metadata
#G01 - Staff gage code number.
#G02 - Name of gage.
#G03 - Water surface elevation as read on gage.
#G04 - Time of gage reading based on 24 hr clock.
#G05 - LMSL Reference
#G06 - LMMW Reference
#G07 - Horizontal position of the gage
#G10-#G99 - Descriptions and or comments.

Survey Job General Parameters
#H01 - Standard DOS file name of ASCII file.
#H02 - Date (MM/DD/YYYY).
#H03 - Order (accuracy) of survey. (1,2,3..AA).
#H04 - Horizontal datum
#H05 - Job number of survey. (YY-JJJ).

#H06 - Unit of linear measure (FT, MT, MI, ...).
#H07 - Map projection.
#H08 - Location of survey
#H09 - Survey firm or organization.
#H10 - Index number of survey field book
#H11 - Page number of field book
#H12 - Combined scale factor.
#H13 - County Name
#H14 - Quad Name
#H15 - Contract number
#H20 - Title of survey job.
#H21-#H29 - Continuation of survey job title.
#H30 - Comments about the survey job.
#H31-H99 - Continuation of comments

Equipment/Instrument Metadata Records

#E01 - Instrument.
#E02 - Serial number.

Miscellaneous Dataset
#M01-#M99 - Description of miscellaneous survey points that follow.

Profile Dataset
#P01 - The profile segment's beginning x-y coordinates and stationing.
#P03 - Time of profile. Only needed if elevations of points are relative to prorated water surface.
#P04 - Prorated water surface elevation used for elevation of points in profile.

Cross-Section Dataset
#X01 - The range line definition which contains the end point coordinates, station, and name of the range.
#X02 - Range code or index number.
#X03 - Time of cross-section. Only needed if elevations of points are relative to prorated water surface.
#X04 - Prorated water surface elevation used for elevation of points in cross-section.

Vertical Control -Temporary Benchmark Metadata
#T01 - Name of temporary benchmark (TBM).
#T02 - Given elevation of TBM.
#T05 - Condition of TBM.
#T06 - Found elevation of TBM.
#T10-#T99 - Description of TBM.

Vertical Control - Permanent Benchmark Metadata
#V01 - Name of permanent benchmark
#V02 - Given elevation of PBM
#V03 - Epoch (date of adjustment)
#V04 - Vertical Datum (NAVD88, MLLW, Etc)
#V05 - Condition of PBM
#V06 - Found elevation of PBM
#V07 - Horizontal Position of PBM
#V08 - NGS PID Designation
#V09 - Vertical adjustment
#V10 - LMSL Relationship
#V11 - MLLW Relationship
#V12 - NTDE Period
#V20-#V99 - Description of PBM

Weather Metadata Records
#W01 - Temperature.
#W02 - Pressure.
#W03 - Humidity.
#W04 - Cloud conditions
(0-10%: clear
10-50%: scattered
50-90%: broken
90-100%: obscured)
#W05 - Wind speed.
#W06 - Wind direction (N,S,E,W,NE,NW,SE,SW

Section I
Survey Deliverables

Survey Report:

Upon completion of a project, a Survey Report shall be provided to the COR in a digital format and written to a compact disk (CD) attached to one (1) hardcopy in a 8 ½" x 11" bound booklet.

- All control monuments shall be documented on the supplied benchmark description form.
- All GPS occupations shall be logged on form: http://www.ngs.noaa.gov/PROJECTS/NGSforms/obslog.pdf
- All occupations shall be submitted on CD to CEMVN-ED-SS in both the native and RINEX format.
- All logs and forms shall be submitted in PDF file and included in the survey report

The Survey Report shall contain and not be limited to the following information:

Methodology Report

The Methodology Report shall be in a digital format, such as Microsoft Word, and written to the compact disk (CD) along with hard copies, signed and stamped by the Registered/Professional Land Surveyor who was directly involved with the project. The hard copies shall be bound in the Survey Report.

The report shall contain but not be limited to the following information:
(Include dates for each job task and key personnel involved)

- ***Project Description***
- ***Pre-planning***
- ***Information on Monument Reconnaissance***
- ***Survey Methods and Procedures***
- ***Equipment used for data collection***
- ***Downloading, Processing and GPS Network Adjustment procedures***
- ***GPS Network Accuracy Results***

Monument Information Datasheets:

Information Datasheets (included in supplied CD) shall be created for each control monument for the project. The Datasheet shall be in a digital format such as Microsoft Word and written to a compact disk (CD) hard copies bound in the final GPS Survey Report.

The information to be included on the Datasheet will be as follows:

- ***Location Map with monuments location plotted***
- ***Monument Name***
- ***Written directions to the monument***
- ***Monument Description/Type***
- ***Date that monument was established and Job#***
- ***Contractors Name***
- ***Adjusted NAD83 Geodetic & Lambert Coordinate (1702) Positions***
- ***Adjusted NAVD88 Position***
- ***Monument Photograph(s)***

Drawing Files

A map shall be created for the project area with all monuments clearly labeled and plotted using the final adjusted coordinates. The drawing files shall be in a Microstation digital format and written to the compact disk (CD) along with hard copies each bound in the final GPS Survey Report and folded to 8 ½" x 11".

The information to be included on the Project Map will be as follows:

- ***Project Name***
- ***Contractor Name***

- ***Digital aerial or USGS Quadrangle with monuments plotted correctly***
- ***Monument Names***
- ***Horizontal and Vertical Datum***
- ***Map***

Field Notes

The information to be included on the field notebook will be as follows:

- ***Project name***
- ***Job Number***
- ***Date of survey***
- ***Crew members***

Final Adjusted GPS Data

A tabulation sheet containing the final adjusted results of all GPS Primary and Secondary Control points in the project network shall be included in the final bound GPS Survey Report. The tabulation shall include the following information:

- ***Station Name***
- ***Latitute/longitude (NAD83)***
- ***Geoid Height (USFt)***
- ***Ellipsoid Height (USFt)***
- ***Orthometric Height (USFt)***
- ***Published Elevation & Differences***

The final adjusted GPS project shall be archived in Excel (*.xls) digital format and written to compact disk (CD) and shall be included in the final bound Survey Report. Also the GPS data should be exported in "Rinex" format.

DATA SUBMITTALS:

All data submitted will be combined (overbank and hydrographic) in the logical record format specified in EM 1110-1-1005, Topographic Surveying, Chapter 6 and all cross-section data shall be submitted in the MVN "Extended LMN- 830" Format. All profile data shall be submitted in the profile format (see CD).

All digital data will be submitted on CD's.

File Type - Ext - Description

1) Field Files:
Jobnumber.FLD/.RW5.
Data Collector Raw Data

2)Coordinate Files:
Jobnumber.EM
ASCII Point Coordinate Listing

3) Profiles:
Jobnumber.PRO
Profiles

4) Alignment
Jobnumber.BL
Baseline or Centerline

5) Codes
Jobnumber.FCD
ASCII Descriptive Feature Codes

6) Design
Jobnumber.DGN
MicroStation CADD

7) LMN830
Jobnumber.830
Extended LMN830 Survey Format

8) Metadata
Jobnumber.MET
FGDC Metadata Format

File names will consist of job number, submittal, and extension. In the event a job number assigned by USACE, Survey Section has not been issued, a combination of the contract number and task order number shall be used. See the example below:

YYJJJS.Ext or CCTTS.Ext

Y = Year	C = Contract
J = Job #	T = Task Order Number
S = Submittal	S = Submittal

All data submitted for each task order of work will be separated for each item or segment of work, (i.e. Traverse, Cross Sections, Centerline Profiles) and furnished on CD with their appropriate file name.

The Contractor shall prepare a final survey report for all task orders. The directory structure shall follow the following outline, as appropriate.

Outline for Survey Reports:

Section 1: General Project Description
Overview of the project including location, purpose, and parties involved.

Section 2: Background
Reason for project (more detailed description) and more specific location description including a map. Accuracy and deliverables should be discussed in this section.

Section 3: Project Planning
How the project was planned including but not limited to: reconnaissance results; PDOP and satellite availability, DGPS method(s) selected; feature and attribute standards selected, Tide Predictions, Session Schedules, Survey Control and description forms, etc.

Section 4: Data Collection
Overview of how data was collected including but not limited to: Equipment used (make and model); data collection method(s) and/or techniques used; control points used; amount of data collected; number of crews and personnel per crew; how long the data collection took; data processing/error checking performed in field;
Field Data
- Data Collection Summary
- Raw Data Collector Files
- Field Book Page Index
- Feature Codes
- Observation Logs
- Gauge Readings
- Recovery Logs
- Bridge Section Logs
- GPS Data
  - RINEX
  - Raw Files
  - Network Map
  - Observation Schedule

Data File Names
- Cross Sections
- Profiles
- Topo (Misc)

Section 5: Data Processing
How was the data processing performed including but not limited to process followed.

Subsection 5.1: Baseline Processing:
Software used; baseline processing results (summary); reprocessed baselines and reason for; parameters for baseline processing (elevation mask, type of ephemeris used); summary results or loop closures (if applicable)

Subsection 5.2: Network Adjustments:
Software used; results of unconstrained adjustment, minimal constrained adjustment, and fully constrained adjustment; summary of weights used, general statistics, GPS Network Vector Summary, Adjustment Report (Free and Constrained), Adjusted Coordinates

Section 6: Project Summary and Conclusion
This section shall include overall results of the processing, products produced, listing of deliverables being submitted, overall accuracy of the data collection (based on results from data processing section), problems encountered during data collection and data processing, recommendations for future data collection efforts of this type or in this area (lessons learned), Pictures, Safety Meeting Reports, Accident Reports, Daily Work Reports, Correspondence, etc.

Section 7: Output and Reports from Software
This section shall include the detailed reports and output from software packages used during the data processing. This section might have multiple subsections, one for each step in the processing that has output which is critical in evaluating results.

All survey information collected for any office of MVN, HPO, etc. shall be duplicated and submitted to CEMVN-ED-SS for archival into Survey Data System.

Sample File Index:

Job YYJJJC - Title Here

ED-SS_Corrrespondence:
List on e-mail and hard copy corrrecpondence
ED-SS_Dgn:
List files here with short description
YYJJJ.dgn - Final map of project w/ 2' countours and breaklines
reference.dgn - Included a reference file
ED-SS_EM_Format:
YYJJJA.em - survey of riverbank (WE to FST) 123+00 to 447+00
YYJJJB.em - sections along haul road
ED-SS_FieldBooks:
060305 - pgs 1-46, control levels, sections 123+00 to 447+00
060307 - pgs 1-22, topo survey of haul road, control point descriptions
ED-SS_GPS:
YYJJJ.rpt - GPS adjustment report
*.dat - GPS raw data files
*.opus - various OPUS results
observation_logs.pdf - scanned GPS observation logs in chrological order
ED-SS_LiDAR:
list any LiDAR support files such as reports, logs, supplimental data
ED-SS_LMN830:
YYJJJA.830 - survey of riverbank (WE to FST) 123+00 to 447+00
YYJJJB.830 - sections along haul road
ED-SS_Metadata:
YYJJJ.met - metadata for job YYJJJ, Title
ED-SS_Miscellaneous:
YYJJJA.so - station and offset of topo points relativee to baseline mess.bl
codes.dat - listing of feature codes used on this job (delete the ones not used)
ED-SS_Multibeam:
List any multibeam data files here
ED-SS_Photos:
YYJJJ1.jpg - Bridge#1 looking downstream
YYJJJ2.jpg - Encroaching horse stable
ED-SS_Profile:
YYJJJ.pro - profile, centerline haul road
ED-SS_Raw_Data:
YYJJJA.rw5 - raw data for YYJJJA.em and YYJJJB.em
ED-SS_SOW:
YYJJJ_SOW.pfd - scope of work
ED-SS_Survey_Control:
YYJJJ-1.PDF - benchmnark description form for point YYJJJ-1 established this job (seperate files for each point)
T95-123.83 - ASCII traverse listing
YYJJJ.bl - reference baseline along levee C/L
T-234DS.PDF - PDF file for PBM T-234's datasheet from NGS
ED-SS_Survey_Report:
YYJJJ_Final_Report.pdf - Final report for YYJJJ, Job Title
ED-SS_Technical_Review:
List any files supporting your QA/QC process

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Section J
Common Errors to Avoid

Increasing Field Accuracies
Meeting the minimum standards can be difficult and sometimes impossible when errors are introduced into a survey. The cause is usually faulty equipment and/or careless field procedures. If the equipment is faulty, the errors are compounded with every set-up. Eliminating these errors will insure meeting the minimum standards required as well as reducing the time spent trouble shooting where problems exist.

The first step to increasing field accuracies should begin with the equipment being used. Regular maintenance and calibration checks will save hours of frustration.

Eliminating Systematic Errors due to Faulty Equipment

- Tripod:
  Insure the stability of your tripod. Frequently check for loose screws and play in the mounting head. Check lock-down screws, pivot joints and feet.

- Tribrach:
  Check that plumb bob aligns with optical plumb. Also check that bulls eye bubble is level with instrument.

- Prism Poles:
  Bulls eye bubble should be checked for vertical accuracy. Also check that centering point is tight.

Common Errors to Avoid
These are common BAD PRACTICES that corrupt survey integrity and should be eliminated altogether!

- Set-up on the wrong station
- Setting GPS Monuments under obstructions
- Transporting tribrachs and/or instruments attached to tripod
- Leaving equipment unattended
- Unleveled Tripod
- Not tightening lock-down screws on tripod
- GPS Antenna height miss-measurement and not checked using QC procedure
- Not communicating problems such as late start time with Party Chief or PM
- Hurrying up to save time

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Survey Quality Control Checklist

Job# Checked By:

General
[ ] In correct format (EM, 830, Pro, etc)
[ ] Fathometer Scrolls annotated with survey information
[ ] Fathometer Scrolls annotated with survey information
[ ] Were MetaData Files Submitted
[ ] Were field books recorded in EM File
[ ] Were Equipment records included in EM File
[ ] Maps stamped and signed by RLS
[ ] Field Books stamped and signed by RLS

Horizontal Control
[ ] Datum Correct (NAD-27, NAD-83)
[ ] Are Traverse files on disk (T-Files and J-Files)
[ ] Primary Traverse Adjusted (1:5000, 5" /setup)
[ ] Secondary Traverse Adjusted (1:2500, 10"/setup)
[ ] Horizontal Control included in EM File
[ ] Are Traverses Stationed and Labeled

Vertical Control
[ ] Datum Correct and in EM File
[ ] Epoch Correct and in EM File
[ ] Are PBMs included in EM File (#V Records)
[ ] Are TBMs included in EM File (#T Records)
[ ] Was specified control used
[ ] Do levels meet accuracy requirements
[ ] Benchmark Description Forms Completed

Staff Gage
[ ] Were all gage readings included in EM file
[ ] Spot check of W.S. interpolation performed
[ ] Gage readings documented

Cross Sections
[ ] Spikes checked
[ ] Are sections normal to B/L or C/L as specified
[ ] All sections included
[ ] Sections lengths checked
[ ] Gaps Checked and Documented in EM File

Miscellaneous Points
[ ] Descriptions included in data file (#M-Records)
[ ] Were all features located and included in EM File.

---

o = acceptable
x = unacceptable
n = not applicable

Comments:

Required GPS Sessions Schedule Form

GPS Sessions Schedule Form

Client - Project – Location

OPERATOR	PHONE #	Session 1	Travel	Session 2	Travel	Session 3
	JULIEN DATE-SESSION#	**001-1**		**001-2**		**001-3**
	START SESSION:	**8:00 AM**		**10:00 AM**		**12:30 PM**
	DURATION & TRAVEL	1:00	*1:00*	*1:30*	*1:00*	*1:00*
	END SESSION:	**9:00 AM**		**11:30 AM**		**1:30 PM**

Bridge Section Submittal Form

1.) Job Number: _____ 2.) Date: _____

3.) Bridge: _____ 4.) U/S or D/S (circle one) 5.) Length: _____

6.) Width: _____ (Measured along Bents) 7.) Curb: _____

8.) Flow Angle: _____ 9.) Bent Angle: _____ 10.) Bents: _____ 11.) Bent Size: _____ (H x W)

12.) Piers per Bent: _____ 13.) Pier Type: _____ 14.) Pier Size/Shape: _____ (H x W)

15.) Image Files: _____ 16.) Sketch Book # _____ Page: _____

(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
Station Number	C/L Profile	Natural Ground	Top Bent	Pier's N/G	Top Curb	Top Rail	Intersect N/G L/C	Comments

26.) Comments:

Signature: _____

Title: _____

CEMVN-ED-SS

Bridge Section Submittal Form (Cont). 1.) Job Number: ________ 2.) Date: ________

3.) Bridge: ________________ 4.) U/S or D/S (circle one)

(17) Station Number	(18) C/L Profile	(19) Natural Ground	(20) Top Bent	(21) Pier's N/G	(22) Top Curb	(23) Top Rail	(24) Intersect N/G L/C	(25) Comments

CEMVN-ED-SS

GPS Log Sheet

GPS STATION OBSERVATION LOG (01-Nov-2000)

Station Designation: (check applicable: FBN / CBN / PAC / SAC / BM) | Station PID, if any: | Date (UTC):

General Location: | Airport ID, if any: | Station 4-Character ID: | Day of Year:

Project Name: | Project Number: GPS- | Station Serial # (SSN): | Session ID:(A,B,C etc)

NAD83 Latitude ° ' " | NAD83 Longitude ° ' " | NAD83 Ellipsoidal Height meters | Agency Full Name:

NAVD88 Orthometric Ht. meters | Operator Full Name:

Observation Session Times (UTC): Sched. Start _____ Stop _____ Epoch Interval=____ Seconds
Actual Start _____ Stop _____ Elevation Mask =_____ Degrees

GEOID99 Geoid Height meters | Phone #: ( )

e-mail address:

GPS Receiver:
Manufacturer & Model:

P/N:

S/N:

Firmware Version:

• CamCorder Battery, • 12V DC, • 110V AC, • Other

GPS Antenna:
Manufacturer & Model:

P/N:

S/N:

Cable Length, meters:

Vehicle is Parked _____ meters ____(direction) from antenna.

Antenna plumb before session?	(Y / N)	Circle Yes or No -If no, explain "
Antenna plumb after session?	(Y / N)	
Antenna oriented to true North?	(Y / N)	
Weather observed at antenna ht.	(Y / N)	
Antenna ground plane used?	(Y / N)	
Antenna radome used?	(Y / N)	If yes, describe. Use Vis. form
Eccentric occupation (>0.5 mm)?	(Y / N)	
Any obstructions above 10°?	(Y / N)	
Radio interference source nearby	(Y / N)	

Tripod or Ant. Mount: Check one:
• Fixed-Height Tripod, • Slip-Leg Tripod, • Fixed Mount
Manufacturer & Model:

P/N:

S/N:

Last Calibration date:

Tribrach: Check one:
• None, • Wild GDF 22, • Topcon, • Other (describe)

Last Calibration date:

** ANTENNA HEIGHT **
(see back of form for measurement illustration)

	Before Session Begins: measure and record both Meters AND Feet		After Session Ends: measure and record both Meters AND Feet	
A= Datum point to Top of Tripod (Tripod Height)				
B= Additional offset to ARP if any (Tribrach/Spacer)				
H= Antenna Height **= A + B** = Datum Point to Antenna Reference Point (ARP)				

Note: Meters = Feet X (0.3048)
Height Entered Into Receiver = _____ meters

Please note &/or sketch **ANY** unusual conditions.
Be **Very Explicit** as to where and how Measured!

Barometer:
Manufacturer & Model:

P/N:

S/N:

Last Calibration or check Date:

Psychrometer:
Manufacturer & Model:

S/N:

Weather DATA	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar	Weather Codes *
Before									
Middle									
After									
Average of Readings				Calculate					* See back of form for codes

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

Note: Entries are Required in all Unshaded areas.

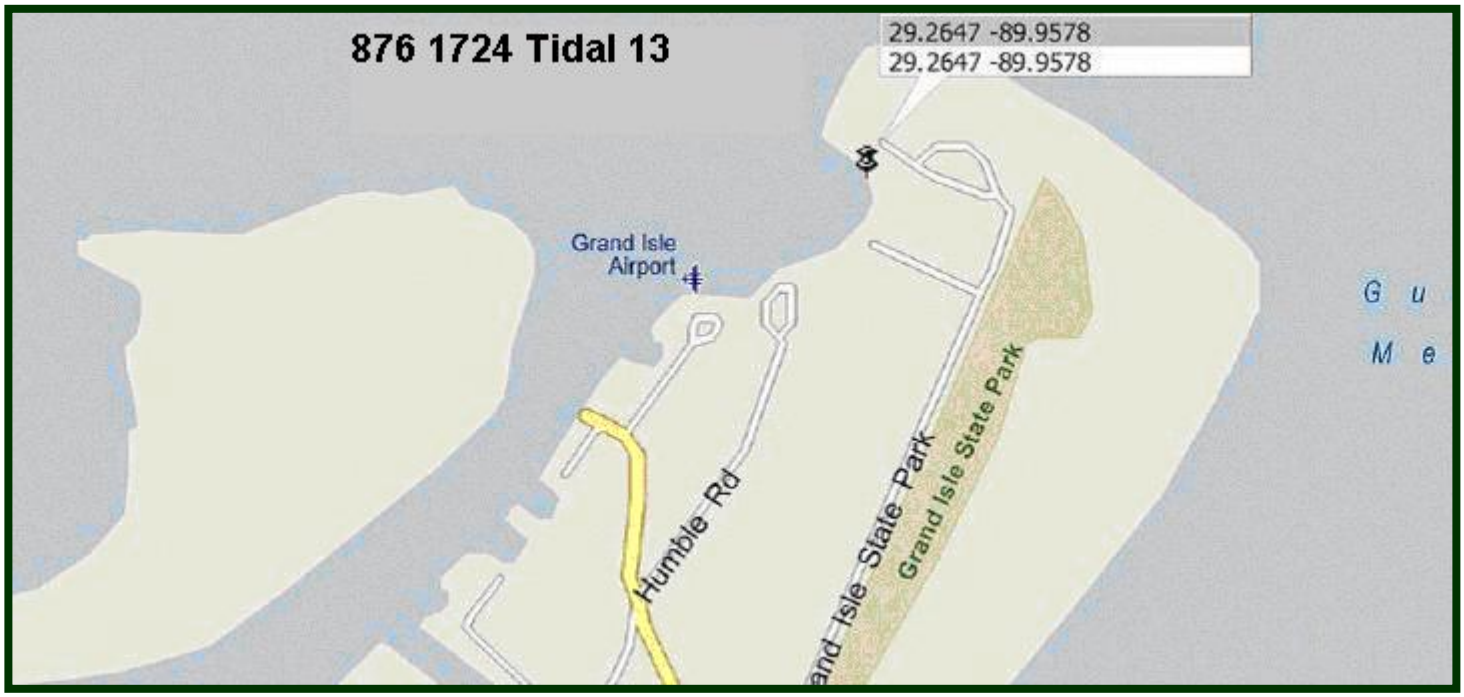
Data File Name(s):

(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: • Attached • Submitted earlier
Visibility Obstruction Form: • Attached • Submitted earlier
Photographs of Station: • Attached • Submitted earlier
Pencil Rubbing of Mark: • Attached

LOG CHECKED BY:

Sample Monument Datasheet



VICINITY MAP

Station Name: "876 1724 Tidal 13"

Monument Location: 2.40 MI NORTHEASTERLY ALONG STATE HIGHWAY 1 FROM THE POST OFFICE IN GRAND ISLE, THENCE 1.3 KM (0.80 MI) NORTHEASTERLY ALONG A PAVED ROAD, THENCE 0.3 KM (0.20 MI) NORTHWESTERLY ALONG SEMPER ROAD, THE BENCH MARK IS SET IN TOP OF A CONCRETE BULKHEAD AT THE COAST GUARD STATION, 44.99 M (147.60 FT) NW OF THE NW FACE OF A BOAT HOUSE, 29.70 M (97.44 FT) SW OF THE EXTENDED CENTER OF THE ROAD, 9.90 M (32.48 FT) SE OF THE NW END OF THE CONCRETE BULKHEAD, AND 0.30 M (0.98 FT) ABOVE THE LEVEL OF THE ROAD.

Monument Description: Brass cap on seawall

Date : September 2003 (Job 03-045)

Monument Established By: NOAA.

Adjusted NAD 83 Geodetic Position
Lat. 29-15-51.47138
Long. 089-57-19.26968

Adjusted NAD 1983 Datum
LSZ (1702) Feet
N= 280,936.05
E= 3,719,370.69

Adjusted NAVD88 (Feet) /Geoid03
Elevation = 3.97

Adjusted Position Established by Simple Surveying Firm, Inc. for the U.S. Army Corps of Engineers, District New Orleans, Survey Section

Appendix 1
Acronyms

CADD	Computer Aided Drafting & Design
COR	Contracting Officer's Representative
CORS	Continuously Operating Reference Station
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EM	Engineering Manual
FGDC	Federal Geodetic Data Committee
FTP	File Transfer Protocol
GIS	Geographic Information System
GPS	Global Positioning System
HI	Height of Instrument
MLG	Mean Low Gulf
MLLW	Mean Lower Low Water
MSL	Mean Sea Level
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NAVD88(2004.65)	North American Vertical Datum of 1988, 2004.65 Epoch
NGS	National Geodetic Survey
NGVD29	National Geodetic Vertical Datum of 1929
NOD	New Orleans District
NTP	Notice to Proceed
NOAA	National Oceanic and Atmospheric Administration
NSRS	National Spatial reference System
OPUS	Online Positioning User Service
OTF	On The Fly
PBM	Permanent Bench Mark
PDOP	Positional Dilution of Precision
RH	Rod Height
RTK	Real Time Kinematic
SOW	Scope of Work
TBM	Temporary Bench Mark
USACE	U.S. Army Corps of Engineers
VDOP	Vertical Dilution of Precision

Appendix 2
Feature Codes

AC; TOP OF A.C. PAD
AP; ABANDONED PIPE
APR; APRON
ASP; ASPHALT
ATO; ABUTMENT TOE
ATP; ABUTMENT TOP
BAL; BALLAST
BBP; BOTTOM OF BORROW PIT
BBT; BOTTOM OF BENT
BCR; BRIDGE CORNER
BFB; BRICK FLOWER BED
BF; BRIDGE FENDER
BL; BASELINE
BM; BENCH MARK
BLD; BUILDING
BLK; BULKHEAD
BNT; BENT OF BRIDGE
BOD; BOTTOM OF DITCH
BOS; BOTTOM OF STREAM
BOT; BOTTOM
BRC; BRIDGE CONCRETE
BRF; BRIDGE FENDER
BRK; BREAKLINE
BRW; BREAK WALL
BS; BUSH
BW; BRICK WALL
CAR; CENTERLINE OF AGGREGATE ROAD
CAP; CONCRETE APRON
CA; CONCRETE ASPHALT
CB; CATCH BASIN
CBC; CABLE LINE
CBK; CONCRETE BULKHEAD
CBL; CABLE
CBT; CONCRETE BLUT TOE
CCL; CENTERLINE OF CONCRETE CULVERT
CCP; CENTERLINE OF CONCRETE PAD
CCR; CENTERLINE OF CONCRETE CURB
CDR; CONCRETE DRIVE
CFP; CORNER FLAG POLE BASE
CG; CATTLE GUARD
CH; CORNER HOUSE
CHW; CENTERLINE OF HEAD WALL
CLG; CENTERLINE GABION
CL; CENTERLINE
CLB; CENTERLINE OF BRIDGE
CLC; CENTER OF CONCRETE
CLD; CENTER OF DITCH
CLI; CENTERLINE
CLR; CENTERLINE OF ROAD
CLW; CENTERLINE OF WALKWAY
CND; CONDUIT
CNL; CANAL
COH; CONCRETE HEAD WALL
CON; CONCRETE
COR; CORNER
CP; CYPREMERTLE TREE
CPG; CONCRETE PILING
CPT; CYPRESS TREE
CRD; CROWN OF DIKE
CRK; CENTERLINE ROCK
CRA; CENTERLINE OF RAIL
CRB; CURB
CR; CROWN OF LEVEE
CRN; CROWN
CRT; CROSSTIE
CRW; CONCRETE RETAINING WALL
CSP; CONCRETE AT SWIMMING POOL
CTD; CENTER OF DRAIN
CTH; CATCH BASIN
CTN; COTTONWOOD TREE
CUB; BOTTOM OF CULVERT
CUL; CULVERT
CYP; CYPRESS TREE
CYS; CYPRESS TREES
DGS; DOGWOOD TREES
DKE; DIKE
DRI; DROP INLET
DRN; DRAIN
DDR; DEAD DOG ON ROAD
DRV; DRIVE
EAR; EDGE OF AGGREAGATE ROAD
ECR; EDGE CONCRETE BRIDGE
EC; EDGE CONCRETE
ECC; EDGE CONCRETE CURB
ECR; EDGE CONCRETE ROAD
ECW; EDGE OF WALL
EDR; EDGE OF DIRT ROAD
EFB; EDGE OF FLOWER BED
EGL; EDGE OF GRASS LINE
ELS; EDGE OF LIMESTONE
ELM; ELM TREE
ELS; ELM TREES
EMG; EDGE OF METAL GRATING
EOA; EDGE OF ASPHALT
EOB; EDGE OF BRIDGE
EOC; EDGE OF CULVERT
EOR; EDGE OF RIP RAP
EOM; EDGE OF MEDIAN
EP: EDGE OF PLATFORM
EPL; EDGE OF PARKING LOT
ER; EDGE OF ROAD
ERF; EDGE OF ROAD FLOOD SIDE
ERP; EDGE OF ROAD PROTECTED SIDE
ESH; EDGE SHELL ROAD
ESL; EDGE OF SLAG ROAD
ESP; EDGE SHEET PILE
ESR; EDGE SHELL ROAD
EW; EDGE WOODS
FEP; FENCE POST
FC; FENCE CORNER
FIP; 4" POST
FL; FENCE LINE
FLB; FENCE LINE BRICK
FLC; FENCE LINE CHAIN LINK FENCE
FLD; FLOOD WALL
FLW; FENCE LINE WOODEN
FP; FLY POINT
FS; FLOOD SIDE LEVEE

FSC; FLOOD SIDE CROWN
FST; FLOOD SIDE TOE
FTG; FOOTING
GAC; GROUND AT CULVERT
GAP; GROUND AT PIER
GAT; GATE
GGE; GAGE
GL; GAS LINE
GM; GAS METER
GRN; GROUND
GR; GUARD RAIL
GRV; GRAVEL
GTB; GAS TEST BOX
GUY; GUY WIRE
GVL; GAS VALVE
HBK; HIGH BANK
HBS; HACKBERRY TREES
HED; HEDGES
HL; HEDGE LINE
HSE; HOUSE
HT; 10" HACKBERRY TREE
HUB; HUB
HWL; HEAD WALL
HYD; FIRE HYDRANT
INV; PIPE INVERT
IP; IRON PIPE
IRL; IRON RAIL
IR: IRON ROD
LC; LOW CORD
LPL; LIGHT POLE
LW; LOW WIRE
MB; MULLBERRY TREE
MBX; MAIL BOX
MET; METAL; TOP OF GATES
MF; MUD FLAT
MGT; MAGNOLIA TREE
MH; MANHOLE COVER
MON; MONUMENT
MSH; MARSH
MTR; METER
MTX; METER BOX
NG; NATURAL GROUND
NGP; NATURAL GROUND AT PILING
NS; NORTH SIDE
OH: OVERHEAD POWER LINES
OT; OAK TREE
OTS; OAK TREES
PC; PECAN TREE
PCS; PECAN TREES
PIC; PIPE INVERT, CONCRETE
PIM; PIPE INVERT, CMP
PIN; PIPE INVERT
PIP; PIPE INVERT, PLASTIC
PIR; PIER
PIS; PIPE INVERT, STEEL
PL; PIPELINE CROSSING
PLC; POWER LINE CROSSING
PLG; PILING
PLT; PLATFORM
POR; PORCH
PPE; PIPE
PPL; POWER POLE
PP; PICTURE POINT
PRK; PIPE RACK
PSC; PROTECTED SIDE CROWN
PST; PROTECTED SIDE TOE
PS; PROTECTED SIDE LEVEE
PT; 10" PINE TREE
PTS; PINE TREES
PVC; PVC PIPE
PWC; 4" POST WITH CABLE
PWL; POWERLINE
RAL; GUARD RAIL
RCK; ROCK
RCP; INV. RCP
RD; ROAD
RMP; RAMP
RDM; RED DAY MARKER
ROW; RIGHT OF WAY
RP; RIP RAP
RR; RAILROAD
RRP; RAILROAD POST
SCO; SEWER CLEAR OUT
SGN; SIGN
SGP; SIGN POST
SS; SOUTH SIDE
SHD; SHOULDER
SP; SHEET PILING
SHL; SHELL
SLP; SLOPE SHOT
SND; SOUNDINGS
SNG; SOUNDINGS
SOC; SLOPE ON CONCRETE
SRR; SLOPE ON RIP RAP
SPT; TOE OF SHEET PILING
SPV; SLOPE PAVING
STP; STEPS
SWK; SIDEWALK
TEP; TELEPHONE PEDESTAL
TB; TOE OF OLD RR BED
TBK; TOP OF BANK
TBL; TOE OF BALLAST
TBP; TOP OF BORROW PIT
TBR; TOE OF BERM
TBS; TOP OF BALLAST
TC; TOP CONCRETE
TCB; TOP CONCRETE BANK
TCR; TOE CURB
TCS; TOP OF CONCRETE PAVEMENT (ON SLOPE)
TCW; TOP OF CONCRETE WALL
TEC; TOP ON EDGE OF CONCRETE WALL
TED; TOP EDGE OF DITCH
THR; THRESHOLD
TIP; 3" POST
TNK; TANK
TOB; TOE OF BORROW PIT
TOC; TOE OF CONCRETE WALL
TOD; TOE OF DITCH
TOE; TOE ON NATURAL GROUND
TOL; TOP OF LEVEE
TOP; TOP ON NATURAL GROUND
TOR; TOE ROCK
TOW; TOP OF WALL
TPC; TOP CURB
TEL; TELEPHONE LINE
TP; TOP OF OLD RR BED
TPB; TOP OF BERM
TPL; TELEPHONE POLE
TPR; TOP ROCK
TPT; TOP SETTLEMENT PLATE

TPW; TOP OF CONCRETE WING WALL
TR; TREE
TRA; TOE OF GUARD RAIL
TRK; RR TRACK
TRL; TREE LINE
TRN; TRANSFORMER
TRW; TOE OF CONCRETE RETAINING WALL
TSP; TOP OF THE SHEET PILING
TWB; TOP WOOD BANK
TWR; TOWER
TWW; TOE OF CONCRETE WING WALL
UBX; UTILITY BOX
UGT; UNDERGROUND TELEPHONE LINE
UTL; UTILITIES
VAL; VALVE
WF; WATER FAUCET
WLN; WATER LINE
WBT; WOOD BANK TOE
WBK; WOOD BULKHEAD
WDP; WOOD PILING
WE; WATER EDGE
WES; WATER EDGE SURFACE
WFL; WOOD FENCE LINE
WL; WOODLINE
WLK; WALKWAY
WLS: WILLOW TREES
WM; WATER MAIN - METER
WMA; WATER MAIN HOLE
WRW; WOODEN RETAINING WALL
WS; WATER SURFACE
WSB; WISTERA BUSH
WV; WATER VALVE
WW; WING WALL
XBR; BRIDGE CROSS BRACE

Appendix 3
References

- EM1110-1-1005 Topographic Surveying Manual
  - http://www.usace.army.mil/publications/eng-manuals/em1110-1-1005/toc.htm
- EM1110-2-1003 Hydrographic Surveying Manual
  - http://www.usace.army.mil/publications/eng-manuals/em1110-2-1003/toc.htm
- EM1110-1-1002 Survey Markers and Monumentations Manual
  - http://www.usace.army.mil/publications/eng-manuals/em1110-1-1002/toc.htm
- EM1110-1-1003 GPS Surveying Manual
  - http://www.usace.army.mil/publications/eng-manuals/em1110-1-1003/toc.htm
- EM1110-1-1004 Geodetic and Control Surveying
  - http://www.usace.army.mil/publications/eng-manuals/em1110-1-1004/toc.htm
- US Army Corps of Engineers Safety and Health Requirements Manual," EM 385-1-1, dated 3 November 2003.
- NOAA Technical Memorandum NOS NGS-58" published in November 1987 (http://www.ngs.noaa.gov/PUBS_LIB/NGS-58.pdf), and DRAFT Guidelines for Establishing GPS-derived Orthometric Heights (Standards: 2 cm and 5 cm) (http://www.ngs.noaa.gov/PUBS_LIB/DRAFTGuidelinesforEstablishingGPSderivedOrthometricHeights.pdf
- ETL 1110-1-152 - Engineering and Design, CONVERSION TO THE NORTH AMERICAN VERTICAL DATUM OF 1988