USER'S GUIDE

FOR

ELECTRONIC LEVELS

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Requirements and Development Division
Center For Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration

USER'S GUIDE FOR ELECTRONIC LEVELS
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USER'S GUIDE FOR ELECTRONIC LEVELS

This document provides the standards and procedures required to perform vertical control levels with the electronic digital/barcode leveling systems at water level stations. It is intended to supplement the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations (User's Guide).* This document only addresses those standards and specifications that differ from conventional three wire level methods covered by the *User's Guide.* Electronic leveling performed at water level stations shall adhere to Federal Geodetic Control Subcommittee (FGCS) Standards and Specifications. Any requirement not addressed can be assumed to be unchanged. Reference is made in this document to *"Input Formats and Specifications of the National Geodetic Survey Data Base"* (NGS Bluebook), September 1994.

1 Standards and field procedures

1.1 Use of even number of stations for multiple rods

When two Invar rods are used, the difference of staff zero-point errors must be taken into account. The rod zero-point difference is nullified if leveling for a section between two bench marks is ended (on a bench mark) on the same rod it was started with. This is possible only with an even number of leveling stations (setups) between the two bench marks. Thus, if possible, for every section between two bench marks, use the same rod on both bench marks by having even number of leveling stations. Generally a station refers to a water level station, but in NGS terms station is referred to as level equipment position (or level section) in the NGS Bluebook.

1.2 Differences with previous methods

Field standards and procedures differ from the previous methods in only three aspects when using the digital systems;

A Use of the multiple reading option to obtain each observation

FGCS standards state that a minimum of 3 readings with a standard deviation equal to or less than 1.0 mm shall be taken to obtain a complete observation. If after 3 readings are taken, the standard deviation exceeds 1.0 mm, the readings shall continue to be taken until the standard deviation decreases to less than 1.0 mm, or the observation shall be repeated with a different or shorter setup.

NOTE: This standard may be impossible to meet when levels are conducted on piers subject to heavy wind or wave action, or other inherently unstable platforms, that can be encountered in water level station leveling. Under such conditions, the following procedure shall be followed:

Continue to take multiple readings as long the standard deviation exhibits a decreasing trend. Accept the measurement when the standard deviation levels off and additional readings do not decrease it.

B Use of single run section leveling

The single run method can be used to re-level historic bench marks that have previously established Differences in Elevation (DE), provided that the leveling line does not exceed 10 km. Historic DE between marks will be computed by the Requirements and Development Division (RDD) using Data Processing and Analysis Subsystem (DPAS) Stability Analysis, and information will be provided to the Field Operations Division (FOD) prior to leveling operations. In general newly installed bench marks or bench marks that do not have historic DE information need to be double run for at least three years so that Historic DE can be computed. For existing bench marks for the control stations in the National Water Level Observation Network (NWLON), the DE will computed based on rolling five or ten years data from DPAS.

A new bench mark requires double run methods when it is at the end of a level line, but can be single run in special circumstances if it is between two historic bench marks whose elevation difference agrees with the history. Water level staffs, Electric Tape Gauges (ETGs), spikes, and sensor leveling points always require double run methods.

The historic DE between two bench marks is substituted as the backward run and is compared with the single observed forward run using the tolerance limit of the survey to determine if closure has been met. If the closure exceeds the tolerance limit, then the section must be double run, and closed according to the standard double run procedures. The published DE is no longer used in computing the section closure.

C Use of DESC program for bench mark descriptions

The surveyor shall run the NGS DESC program noting the recovery codes for the bench marks recovered, or adding new descriptions for bench marks previously not described. The running of DESC program and incorporation of all necessary data as listed in the next section is essential prior to processing the level data for electronic levels and significantly differs from the methodology of three wire leveling system.

NOTE: Throughout this document XXXXXXX refers to a seven digit water level station number and XXX XXXX refers to the water level station number with a space between the three digit state/body of water identifier and four digit station number in that state or body of water.

Prior to beginning of the station leveling operations, three files XXXXXXX.HA, XXXXXXX.AFI, and XXXXXXX.INX are required on a level diskette; where XXXXXXX refers to the seven digit station number. Refer to instructions provided in Appendix C to create a level diskette. Generally, RDD will create and provide a level diskette to FOD. The line number for each state is assigned each year by NGS, and the part number is unique for each station (see details in Section II.2 and Appendix C).

2 Guidelines for using the NGS Bench Mark Description Program

2.1 The NGS DESC program

The bench mark description program DESC.EXE is one of the suite of VFPROC programs available from NGS. NGS documentation on using the description program is contained in the *Vertical Field Data Processing User's Manual*. Chapter 6 of the User's manual is included as Appendix F of this manual and should be referred to for general operation of the DESC program. The NGS Bluebook contains detailed specifications on the format and content of bench mark description data. The intent of this section is to provide guidance on using the description program where the NGS documentation does not specifically address issues related to survey points at coastal (tide) and Great Lakes (lake) stations.

2.2 The Data Set Information Screen

This three-part screen contains information about a particular description file. Guidance on completing the screen is as follows:

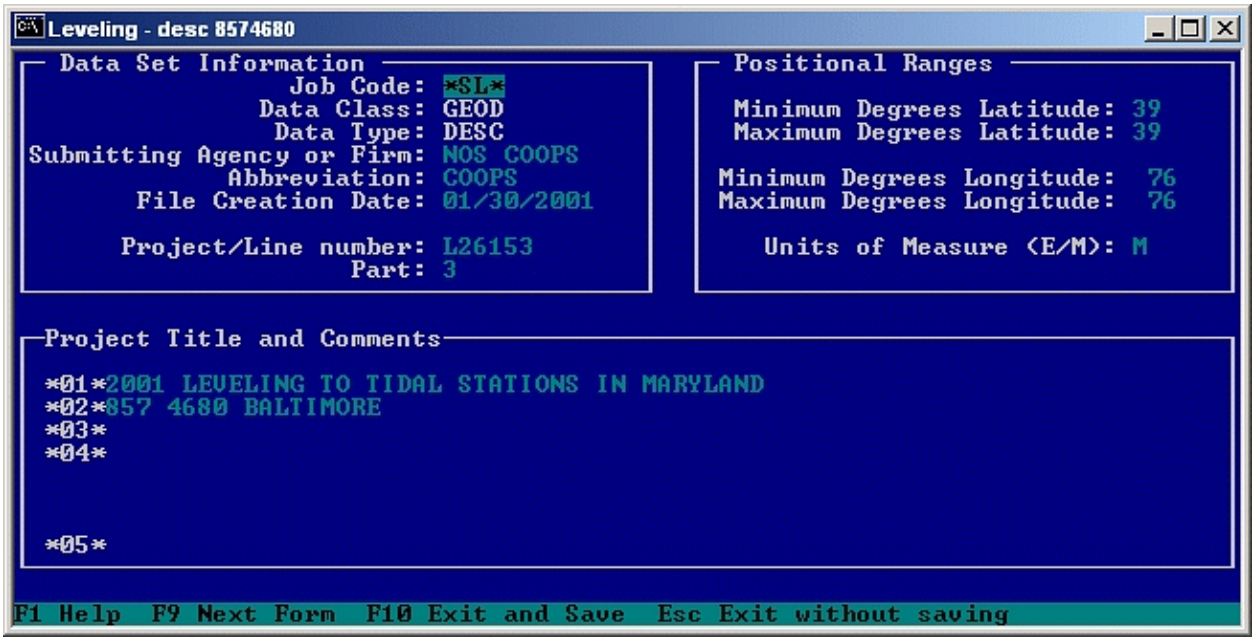


Figure 1: Data Set Information Screen

Data Set Information

Job Code: ***SL*** for tide stations and ***SI*** for lake stations

Data Class: GEOD (Not editable)

Data Type: DESC (Not editable)

Submitting Agency: ***NOS COOPS***

Abbreviation: ***COOPS***

File Creation Date: Current date

Project/Line No: The line number is set by NGS and follows the format ***LNNNNN***. For tide stations, each state has its own line number. For the lakes, each body of water, lake or river has its own line number. New line numbers are assigned each calendar year by NGS.

Part No: Each station under the same line number must have a unique part number. NWLON and long term secondary stations have been assigned permanent part numbers to facilitate SPSN file generation. Short term stations will have the next available part number assigned to them within each year. The same part number may be used for a different station in a succeeding year.

Project Title and Comments

01 ***YYYY LEVELING TO TIDE STATIONS IN (State name)***
{for tide stations} or
01 ***YYYY LEVELING TO WATER LEVEL STATIONS ON (body of water)***
{for lake stations} (where YYYY is the four digit year e.g.1999.)
02 ***XXX XXXX*** {7 digit station number} ***Station Name***

Positional Ranges

Minimum Degrees: Latitude Degree of the bench mark having the lowest latitude for the whole state or area. (Required when submitting multiple level data files to NGS.)

Maximum Degrees: Latitude Degree of the bench mark having the highest latitude for the whole state or area. (Required when submitting multiple level data files to NGS.)

Minimum Degrees: Longitude Degree of the bench mark having the smallest longitude for the whole state or area. (Required when submitting multiple level data files to NGS.)

Maximum Degrees: Longitude Degree of the bench mark having the greatest longitude for the whole state or area. (Required when submitting multiple level data files to NGS.)

Units: ***M***

2.3 The Geodetic Control Station Screen

Figure 2: Geodetic Control Station Screen

This screen contains fields that allow descriptive data to be entered for a survey point. Some fields may only accept preset information. A list of choices for these fields may be viewed by pressing the F2 function key when the cursor is in that field. The choice may be selected by moving the cursor to the appropriate choice and pressing *Enter*. Some fields, when populated may require other related fields to also be populated, or if skipped, will not allow any data to be placed in those same fields.

Each survey point is uniquely identified by the Station Serial Number (SSN), also called Survey Point Serial Number [SPSN]. The term SPSN is preferred over SSN and is used in this document. Entering a SPSN existing in the XXXXXXX.HA file will retrieve that survey point record. Entering a SPSN not existing in the XXXXXXX.HA will create a new survey point record.

Many bench mark descriptive data may already be in the NGS database. Descriptive data for these bench mark shall be retrieved from the NGS database (see Appendix C), and assigned SPSN numbers as shown in the following section, and updated whenever they are recovered. Descriptive data for bench marks not in the NGS database shall be created by entering the next available SPSN in the file and populating the appropriate fields. Generally at NWLON stations, most of the marks in the local leveling network will have SPSN numbers assigned by RDD based on the position of each mark in the leveling sequence.

FIELD:	**DESCRIPTION AND GUIDELINES**
SPSN:	The following standard convention has been adopted for numbering survey points at tide and lake stations: The first SPSN at each station shall be numbered ZZ01 where ZZ is the station part number in that state or body of water area. The first ten SPSNs (ZZ01 - ZZ10) have been standardized as ETGs, staffs, spikes, acoustic sensor leveling points, Barometer, etc. SPSN PP11 shall always be used for the PBM. See Table 1 for a listing.

Table 1 - Standard SPSNs

STANDARDIZED SURVEY POINT SERIAL NUMBER (SPSN) LIST	
SPSN ZZ01:	**TBM XXX XXXX ETG READ MK** - Existing (old) ETG or ETG to be replaced.
SPSN ZZ02:	**TBM XXX XXXX ETG READ MK** - New or replacement ETG.
SPSN ZZ03:	**TBM XXX XXXX Staff** - Existing (old) staff or staff to be replaced.
SPSN ZZ04:	**TBM XXX XXXX Staff** - New or replacement staff.
SPSN ZZ05:	**TBM XXX XXXX Spike/SRM** - Existing (old) spike or spike to be replaced (lakes only); or SRM -temporary sensor reference mark (tides only) that is not a bench mark.
SPSN ZZ06:	**TBM XXX XXXX Spike** - New or replacement spike (lakes only)
SPSN ZZ07:	**TBM XXX XXXX Aquatrak** - Existing (old) Aquatrak or Aquatrak to be replaced.
SPSN ZZ08:	**TBM XXX XXXX Aquatrak** - New or replacement Aquatrak.
SPSN ZZ09:	**TBM XXX XXXX Aquatrak level fix or Barometer** - Aquatrak leveling fixture held on old Aquatrak or Aquatrak sensor head to be replaced; or Barometer.
SPSN ZZ10:	**TBM XXX XXXX Aquatrak level fix** - Aquatrak leveling fixture held on new or replacement Aquatrak sensor head.
SPSN ZZ11:	Primary bench mark for a station

This table is for reference purposes only. Select the appropriate SPSNs in the XXXXXXX.HA file, that are necessary for leveling.

Pressing F2 on many of the fields displays choices for that field, use up and down arrows and Enter on the computer keyboard to select the choice. Also some of the fields as listed require an appropriate entry. Most common choices have been shown at appropriate locations below.

FIELD:	**DESCRIPTION AND GUIDELINES**
DR CODE:	Entry required. There are three options: ***P*** - Preliminary: Select this option to reserve a SPSN and pre-enter some information for a survey point to be established. NOTE: The standardized SPSNs (ZZ01-ZZ10) have all been created with the DR CODE set to P. The abstract program will not recognize them until they have been reset to D or R DR code, as appropriate. ***D*** - Described: Select this option to submit an original description when a brand new survey point is established. ***R*** - Recovered: Select this option when an existing bench mark is recovered (regardless of whether or not it is in the NGS data base).
REC CODE:	Entry required. If DR code has been set to D, then REC code entry is not available. There are three options, which can only be selected if the DR CODE has been set to R: ***F*** - Select this option when submitting a full description for a survey point not in the NGS database (no PID# - see PID field below). ***M*** - Select this option when a survey point is already in the NGS database and has been recovered as described (no changes to descriptive fields or text). ***T*** - Select this option when a survey point already in the NGS database requires changes to the descriptive fields or text.
LAT/LON:	Entry required. Survey point latitude and longitude. Use F2 to view the proper format.

FIELD:	DESCRIPTION AND GUIDELINES
	NOTE: If specific coordinates for the survey point are available from GPS measurements, prior NGS surveys, or other sources, use those coordinates. If not, use the coordinates assigned to the station. Also, the coordinates entered must fall within the minimum/maximum latitude/longitude defined in the Positional Information screen, or they will not be accepted.
LAT/LONG (continued)	For latitude, use two digits for degrees, two digits for minutes, two digits for seconds, and one digit for North (N) or South (S) hemisphere position.
	For longitude, use three digits for degrees, two digits for minutes, two digits for seconds, and one digit for East (E) or West (W) of Greenwich Meridian of the hemisphere position.
APPROX ELEV:	Leave blank/do not change.
QUAD:	Leave blank/can not edit this field.
STATE:	Entry required. Type two character state abbrev. or use F2 to select state or country code.
COUNTY:	Entry required. Type county or use F2 to select.
APP:	Application Code: Select ***T*** for tidal stations regardless of what agency established the marks; also select ***P*** for site suitable for receiving GPS/satellite signals; or ***N*** for site not suitable for GPS signals. Lake stations have this field left blank. Appendix I of the NGS Bluebook provides information on the special application code.
PID:	(Also known previously as ACRN.) It is a unique, permanent survey point identifier assigned by NGS. This field will be populated if the record was downloaded from the NGS database. Leave blank for bench marks not yet in NGS database.
DESIGNATION:	Entry required. NGS names or "designates" survey points in accordance with the conventions specified in the Bluebook. A selected summary is cited here:

FIELD:	DESCRIPTION AND GUIDELINES
DESIGNATION (continued)	The convention for assigning a designation to a tidal or lake bench mark is as follows; the designation shall start with the 7 digit station number, with a space between the 3 digit state number and the 4 digit station number. Next, after the station number, shall come the complete survey point stamping (see Special Notes below), except the year. For NOS bench marks stamped in accordance with the *User's Guide*, all that is required is to add the letter identifier. For example, NOS bench mark 1234 A 1994 in New Jersey would be designated as "853 1234 A". An example of an older USC&GS survey point designation for NOS bench mark NO 1 1974 at tide station 853 1234 in New Jersey would be "853 1234 RM 1" or "853 1234 TIDAL 1", since NO or No can not be used in the Designation even if stamped on the disk. In that case use the word TIDAL for tidal marks or RM for reference mark. If a survey point was established by some other organization, but has been incorporated into the water level station's local network, the designation may not have the 7 digit station number if already designated by NGS. But for new designations always use the seven digit station number. Designate the survey point by using the stamping (see Special Notes below) except the year. For example, a survey point stamped MON JOHN and designation would be "853 1234 MON JOHN" for a mark in New Jersey. The standardized first 10 SPSNs designations start with "TBM" as listed in Table 1. SPECIAL NOTES: These notes apply to the designation convention regardless of what agency set the mark. SPECIAL CHARACTERS: Do not use special characters such as parentheses, quote marks, commas, etc. unless they are essential to the stamping (i.e., if the stamping includes an elevation where the period acts as a place holder). The only special characters allowed are +, -, =, . (period), /, and blank ( ). ELEVATION: Some bench mark stampings include an elevation. Do not include the elevation unless it is the only way to make the designation unique with other marks bearing similar stampings.

FIELD:	DESCRIPTION AND GUIDELINES
	SAME STAMPINGS: Sometimes a series of bench marks are recovered that are stamped the same. Add a 1 to the designation of the first mark, and increment the others as necessary. (Alias field listed below also can be used if stamping are same and designations are too long.) NO STAMPING: If a bench mark is not stamped, it sometimes may be known by some name. Incorporate the name into the designation following the normal conventions. If there is no known name, designate the first un-stamped mark as XXX XXXX NO STAMPING 1, and increment as necessary for any additional un-stamped marks.
UNDERGROUND MARK TYPE:	Leave blank (for horizontal marks)
MAG CODE:	Leave blank (for horizontal marks)
SET CODE:	Leave blank (for horizontal marks)
TR CODE:	Entry required. TR code is for Transportation Code. Use F2 to view choices and select the most common method of reaching the survey point. Most common choices are ***C*** for car, ***B*** for Boat, ***P*** for light truck, ***T*** for truck larger than 3/4/ ton, ***X*** for four wheel drive vehicle.
PACK TIME:	Leave blank.
ALIAS:	This field is used when a survey point is stamped and designated with one name but commonly or locally known by another name. Fill in this field only if necessary for improved identification of the bench mark.
CODE/SET BY:	Entry required only for newly installed marks that are not in the NGS database. Use F2 to select the organization. Type in the specific organization acronym when the cursor goes to the text field.
YEAR:	Enter the year the bench mark was set. If this is unknown, leave blank.
CHIEF:	Enter initials or leave blank if unknown.
CODE/ RECOVERY:	Entry required only for existing mark. Use F2 to select the organization. Type in the specific organization acronym when the cursor goes to the text field. (e.g. ***8*** for NOS; ***1*** for NGS/CGS, etc.)

FIELD:	DESCRIPTION AND GUIDELINES
DATE:	The current date will automatically appear. Change if necessary.
CHIEF:	Enter initials.
CONDITION:	Entry required. Use F2 to view choices and select the appropriate. (***G*** for Good status, ***X*** for destroyed marks, ***N*** for Not Recovered/Not Found, ***P*** for Poor, ***O*** for see descriptive text, etc.)
TYPE:	Entry required. Use F2 to view choices and select the appropriate. Code ***DB*** (Bench Mark Disk) is the most commonly selected type for lake stations and Code ***DJ*** (Tidal Station Disk) is the most commonly selected type for tide stations, respectively. (For other types use code ***Z*** or ***00*** for ETG, Aquatrak, etc., code ***B*** for bolt, code ***DS*** for Triangulation Disk, code ***DV*** for Vertical Control Disk, code ***I*** for Metal rod, ***F*** for Flange encased rods, ***P*** for Pipe caps, ***DR*** for reference marks, ***R*** for Rivets, etc.)
MAG CODE:	Entry required. Use F2 to view choices, however, ***N*** is the most common selection.
CODE/SETTING:	Entry required. Use F2 to view choices and select the most appropriate code. Certain choices allow entries where a more specific setting description would be appropriate.
STABILITY CODE:	Automatically set based on the setting code selected. This field can be changed, but, generally do not modify without a specific purpose.
AGENCY INSCRIPTION:	Enter the acronym of the agency name cast on the bench mark or deep rod logo cap. Use NOS for National Ocean Survey and National Ocean Service bench marks.
STAMPING:	Enter the complete stamping, not casting, of the bench mark or deep rod logo cap. Leave blank for un-stamped bench marks.
UNITS M:	Metric units are automatically expected as selected in section 2.2 - Positional Ranges of The Data Set Information Screen.
ROD DETAILS:	The rod details such as depth, sleeve depth, and bench mark setting whether flush, projecting or recessed with the surface are available only if the code setting is set to rod marks. Enter the deep rod mark measurements and parameters prompted by the program.

2.4 The Descriptive Text Screen

Specifications on writing tidal bench mark descriptions are contained in Appendix E and guidance is provided there. Great Lakes bench mark text descriptions are written following the NGS specifications in all respects.

If no changes are required to a bench mark description (REC CODE choice ***M***), simply type ***RAD*** at the beginning of the description and press *Enter* - this will move the description down two lines, leaving a blank line between RAD and the description.

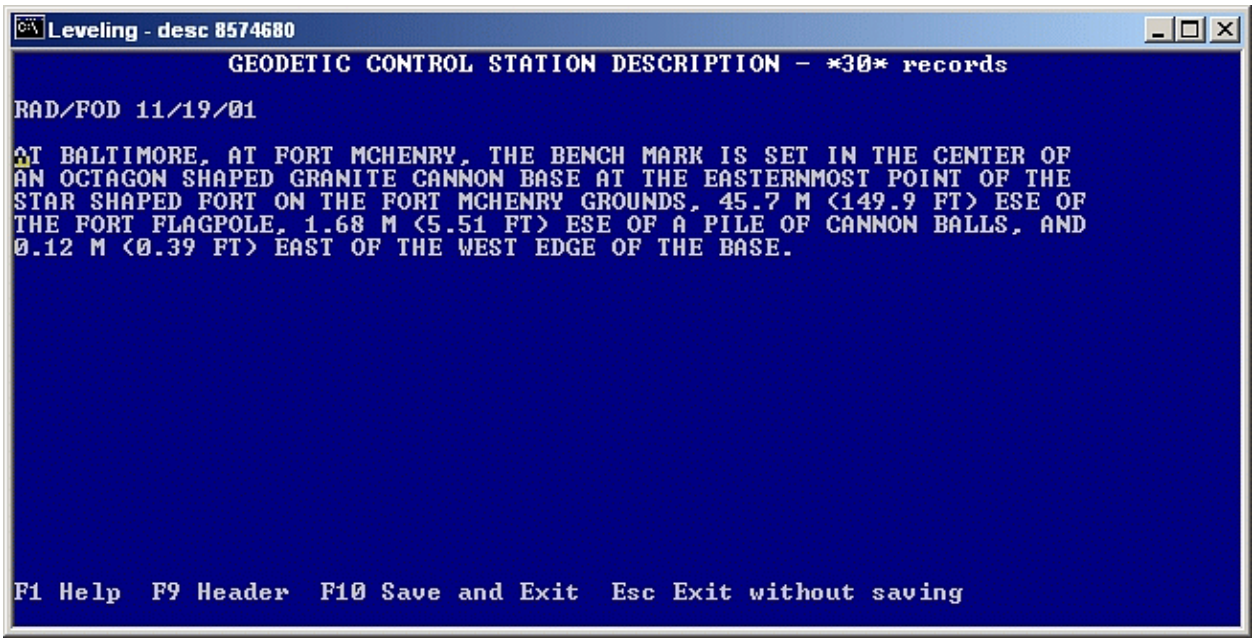
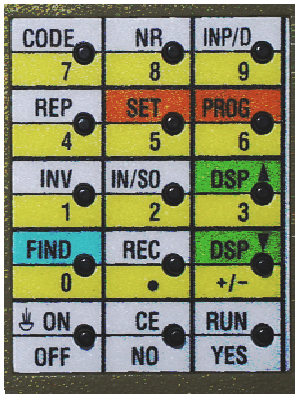


Figure 3: Bench Mark Description

3 Procedures for leveling with the Wild NA3000 series

Figure 4



This section supplements the Leica NA3003 User Manual provided with the Wild NA3000 and NA3003. A copy of the Leica manual should always be kept with the level and all observers should have read it before using the level instrument. Consult the manual for basic information on how to operate the level, the function of each key on the keypad, the programs, etc. This section provides specifics on configuration parameters, battery management, calibration procedures, code formats, and operational procedures. Figure 4 shows the level instrument panel.

3.1 Configuration Parameters

It is the responsibility of each Party Chief to ensure that the appropriate parameters are configured properly in the instrument before running levels. In general, with the exception of one parameter in the *CONFIG* submenu (**INP/D**), there will be little reason to change a parameter once set properly. Instructions on how to change parameters using the **SET** button are in the Leica NA3003 User Manual. The Table 2 below lists the parameters, their settings, and remarks for the six options available at the SET Main menu.

Table 2 - SET Main Menu Parameters

PARAMETER	SETTING	REMARKS
TEST	battery	Shows battery level
MEASURE	Mean σm 5 12 0.03	Mean value with automatic stop Minimum number of measurements Maximum number of measurements Standard deviation at 20 m rod distance
INCREM	show incr	Increment is displayed for inspection
FIX	precise	Full number of decimal places displayed
RECORD	module	Enables REC-module recording
CONFIG	see Table 3 below	CONFIG has 12 submenu parameters available.

CONFIG is the sixth option of the SET Main menu and there are 12 options available under it. The desired choices are as shown below in the Table 3.

Table 3 - CONFIG Submenu Parameters

PARAMETER	SETTING	REMARKS
DSP_TIME	4	Sets LCD display time @ 4 seconds
INT TIME	0	System value for integration time
BEEP	high	Sets beep volume
KEY	Dist input	The INP/D key reads the rod distance Select this only when in input mode
ROD	3m/2m	Level will recognize the 3m/2m rods
EARTH C.	without	Earth curvature correction for all measurements
ACCURACY	extended	System accuracy
TOLERANCE	STAT TOL DIST TOL	Input of station tolerance (0.25 mm) Input of distance tolerance (5.0 m)
AUTO-OFF	5 min	Turns level off after 5 min of inactivity
UNIT	m	Selects metric units
COLLIM	0.00	Display and input of the absolute collimation error; Do NOT change setting which is Factory Set by WILD.
SERVICE		Do Not input anything, leave it blank
COMM	standard	Since we do not use the comm port leave the options as standard

3.2 Battery Power Management

Two rechargeable batteries and a charger have been provided with each level. Battery instructions are covered in section 14 of the Leica NA3003 User Manual. The most important thing to remember is: *Run the batteries down as low as possible before recharging or always discharge first when using the Intelligent charger.*

The batteries can develop a "memory" if proper recharging procedures are not followed. A sign that this is happening is if the batteries will no longer attain the maximum charge levels (8-9). If this starts to happen, discharge the battery(s) all the way down to 0, and then put on a full 14 hour recharge. This may have to be repeated several times. The best way to discharge the batteries is to disable the *AUTO-OFF* parameter (see previous section) and leave the level turned on with the backlight activated (Leica manual Section 3.1.2). Do not forget to re-enable the *AUTO-OFF* parameter to 5 min before placing the level back into service.

An intelligent charger is also available (GKL23) that will automatically first discharge

the battery and then fully charge it. Consult the *Leica GKL23/GKL23-1 User Manual* for further information on operating the charger. Note that the GKL23 will not work with the batteries originally supplied with the NA3000 level, but it will work with NA 3003 levels.

3.3 Run Rod Level Bubble and Level Collimation Checks

Check all rod level bubbles with the level instrument to ensure vertical accuracy and adjust if necessary:

- Level the instrument and have the rod person set up a rod on a stable highpoint.
- First, have the rod person hold the rod facing the level. Using the level's vertical cross-hair as a reference, instruct the rod person to hold the rod perfectly vertical. If the bubble is touching, or out of, the centering circle it must be adjusted.
- Next, have the rod person hold the staff sideways to the level. Using the level's vertical cross-hair as a reference, instruct the rod person to hold the rod perfectly vertical. If the bubble is touching, or out of, the centering circle it must be adjusted.

If the circular level bubble of the level equipment needs adjustment, first secure the rod using struts. Then with a plumb bob check the verticality of the rod from two observation directions at right angles to one another. Then use the three adjustment screws beneath the circular level to bring the bubble into the middle. Make sure the bubble stays in the middle, when the rod is turned at two different directions at right angles to each other.

The level shall have a collimation check performed:

- at the start of each day's leveling;
- at the start of each new station level run;
- anytime the level is subjected to substantial shock, vibration, etc..

When bringing the level out into a significantly different thermal environment, allow at least a half-hour for adjustment to ambient temperature, as a sudden thermal change can affect the collimation check.

Instructions on performing the collimation check are contained in the Leica NA3003 User Manual Section 7.1. The level has a self contained program that will automatically compute the error and expects a specific method to be used.

Lay out a course following the 1/3-2/3 (15 m - 30 m) course illustrated in the Leica NA3003 User Manual. Using the COLLIM option of the CONFIG submenu as shown on page 12, the operator should first confirm that the absolute collimation error (*absColl*) presently stored in the instrument is 0.0". If not, note the displayed value, and inform RDD prior to next use. The instrument should be returned to Leica for adjustment of the stored collimation error.

Next, run the collimation check following the instructions contained in the manual and

the prompts provided by the levels' A X X B collimation program.

When the last reading has been taken the instrument will ask whether or not to compute a new collimation error (*compute Coll?*). Answer yes and note the value (*CollDif*). This value is required later on when entering code information into the level. A value less than or equal to +/- 10.0 seconds meets the standard while any value larger than +/- 10.0 seconds exceeds it.

The program will then ask if you wish to store the new value (*store newColl?*). **ALWAYS ANSWER NO!** If you mistakenly answer yes, make a note and inform RDD. The stored collimation error should always be 0.0.

If the collimation check fails, rerun it for verification. First, double-check the course setup for proper layout. If the instrument was recently brought out from a much different thermal environment, give it additional time to adjust to the ambient temperature.

If the level continues to fail the collimation check, note the last value determined, continue on with the levels, and notify RDD. There is no way to adjust the level in the field, it must be returned to Leica for adjustment.

3.4 Erase REC-Module

Instructions on how use the *ERASE DATA* program to erase the REC-Module are contained in the Leica NA3003 User Manual Section 7.3. The password is 951.

The REC-Module is the leveling data storage media used by the instrument. **In general, the REC-Module should be erased before starting to perform the levels, assuming any existing data has already been downloaded and saved on floppy diskette(s)**. If this step is omitted, the new data will be appended to the end of the existing data file, and will be downloaded as one file. The file will then have to be edited to remove the previously existing data.

If levels at a station are performed over several days, it is permissible not to erase the REC-Module each day and allow new data to append onto the REC-Module. Alternatively, if substantial editing is required to correct the file downloaded from the first days' leveling, it may be desirable to copy the files on laptop and then erase the REC-Module before continuing the levels and to later merge the downloaded files together on a personal computer.

3.5 Enter the initial CODES

Prior to running the *START LEVELING* program, it is necessary to enter several data code blocks that contain various types of information. Instructions on entering data codes are in the Leica NA3003 User Manual Section 8.5 or on the laminated card that can be made in-house from the Table 4 below for the leveling operations. Code definitions are summarized in Table 4.

Table 4 - CODE Definitions

Code 1 **Start of Level Run**

Date:	mmddyy
Time:	hhmm
Weather:	ws*
Observer:	xxx**

Code 2 **Start of Level Run**

Instrument Number	xxxxx
Collimation Error	xxxxx
Rod 1 Serial Number	xxxxx
Rod 2 Serial Number	xxxxx

Code 11 **Start of Level Section**

Time:	hhmm
Weather:	ws*
Starting SPSN	xxxx
Rod # on Mark	x

Code 22 **Reject Previous Setup**

Code 33 **Temperatures**

Lower Probe °C	xx
Upper Probe °C	xx

Code 44 **Reject Level Section**

Code 66 **Manual Entry**

Top hair	xxxx
Middle hair	xxxx
Bottom hair	xxxx

Code 99 **End of Level Section**

Time	hhmm
Weather	ws*
Ending SPSN	xxxx
Rod # on Mark	x

Code 9999 **End of Level Run**

Date:	mmddyy
Time:	hhmm
Weather:	ws*
Observer:	xxx**

* Weather Codes are made up of Wind and Sun codes. Use a combined Wind and Sun code such as 11 for the Weather code.

Wind codes

0 < 10 km/hr
1 = 10-25 km/hr
2 > 25 km/hr

Sun Codes

Sunny 0 < 25%
1 = 25 - 75 %
2 > 75 %

** Observer Code
Use the three digit numeric personnel code from DPAS, or as assigned by RDD for contractor personnel.

There are three data code blocks that must be entered in the following order prior to starting the leveling operations. Codes 1 and 2 contain "header" information for the start of the level run while Code 11 contains information on the start of an individual leveling section. Enter Code 1, then Code 2, then Code 11 at the beginning of leveling operations. If these codes are not present in this order at the beginning of the data file downloaded from the level, then the data processing will return an error message and terminate. Table 4 lists all the codes used by the processing programs. Note that all of Codes 1, 2, 11, 99, 9999 entries in the program require four entries of particular information as listed in Table 4.

A two digit weather code is made up of a one digit Wind code and a one digit Sun code as listed in the Table 4.

Three digit numeric observer codes have been assigned for CO-OPS personnel and are available from RDD. Note that a three digit numeric code for the observer is required and alphabetic initials of the person would not work for code 1 and 9999. Observer codes for contractor personnel can be obtained from RDD.

3.6 Run the START LEVELING program

Instructions on starting to level are contained in Leica NA3003 User Manual Section 6.5. Select the *START LEVELING BF* program and answer yes to the question (*START L sure?*). The program will next show *pt. No*. The program will next request *GrHt* and display a number. Push the "NO" button and then reset the ground height to zero. This has to be done at the beginning of each level section as shown in Table 5. The program does not use ground height to derive the abstract, instead ground height is set to zero ONLY after entering code 11 at the beginning of each section so that section elevation differences from one bench mark to another can be viewed after each section level setup. It is anticipated that the field crew will have this information available from prior level runs and will help determine movement or stability problems. Do not set ground height to zero in the middle of a section; otherwise the level run will have problems. If the REC Module is not inserted in the level equipment before the leveling program is started, then error 79 will appear.

Table 5 - Setting Ground Height to Zero

Enter ***Program***
Program displays: P CONT LEVELING
Enter ↑ (Up arrow) twice till
Program displays: P START LEV BF
Enter ***YES***
Program displays: START L SURE?
Enter ***YES***
Program displays momentarily START LEVELING and then
Program displays: Pt NO and some number which changes as leveling progresses.
Enter ***YES***
Program displays: INCREM and a number which changes as leveling progresses.
Enter ***YES***
Program displays: Gr Ht ? +/-x.xxxx where x.xxxx is some number.
Enter ***NO***
then Enter ***0*** (zero number)
and then Enter ***YES*** to accept and set the ground height to zero.

At this point the program will automatically transition into *CONT(inue) LEVELING*.

3.7 Use the CONT(inue) LEVELING program

The display screen should be displaying *BACK* with the measurement prompt (horizontal bars) in the upper right corner. This indicates that it is ready to take a reading.

Before taking and recording the backsight and foresight readings for an individual setup, it is good practice to first shoot a distance to each rod by using the **INP/D** key. Aim and focus the level at a rod and press the **INP/D** key. Distances measured by the **INP/D** key are only displayed and not recorded. The rod distance is measured and displayed for a few seconds. Note the distance, repeat the process for the other rod, and verify that the setup is balanced for the appropriate order and class of the levels.

NOTE: The instrument does not check the setup balance against the allowable during the actual level run. If the setup is unbalanced, an error message will be generated later when the data is being processed.

Another good reason to first measure both rod distances is that it verifies that the level can read the rods. Sometimes obstructions, shadows, glare, etc. can prevent the level from locking in on a rod that at first glance appears to be readily visible. Spotting and resolving any sighting problems before recording a backsight can save time.

For very short distance setups, verify that the total distance is greater than 5 meters. Although the level will successfully record setups under 5 meters, they are not allowed by NGS, and the processing software will return an error message. The key word here is total distance which is sum of backsight (BS) and foresight (FS). For situations where BS (or FS) is less than 2.5 m, unbalance FS (or BS whichever is appropriate) so as to take the reading. The unbalanced BS/FS is allowed in this special situation. To compensate for the unbalanced BS/FS setup, on the next setup adjust the FS/BS distance such that total of all backsights and total of all foresights shall be within tolerance.

There are two knobs on the right side of the level when pointing at the rod that are used for focusing on the barcoded rods. The larger knob zooms in or out and brings the barcoded rod readings in focus, whereas the smaller knob provides micrometer adjustment for centering on the rod either from the left or right. Always center vertically on the rod before taking a reading. Also, the equipment must be level, i.e. the bubble must be in the center before taking any reading. Generally, make sure the level bubble stays in center at two directions 90˚ apart. A good way to start centering the level bubble is to turn the level first perpendicular to the direction of leveling and center the bubble; then rotate the level and point it to BS/FS and make sure the bubble stays in the center. Then check the BS/FS distances by hitting **INP/D** key.

The backsight or foresight measurement is taken by aiming and focusing the level on a rod and pushing the red measurement button on the right side of the level. A series of arrows (>>>>) are shown on the screen as the level locks in on the rod and determines a measurement. This typically takes about 4 seconds, but can take longer if the level is having trouble reading the rod for some reason.

The screen then either displays an *Error 51* (cannot complete measurement) or a set of values. The value in the upper left corner is the measurement number (how many readings have been taken), the value in the upper right corner is the standard deviation for the series of readings used to make a measurement, and underneath these values is the mean value of all the readings taken. This is the value that will be stored in the memory and used in processing the computations.

As noted in Section I of this guide, a minimum of three readings with a standard deviation less than or equal to 1.0 mm is required for a valid measurement. Taking more than three readings is acceptable provided the standard deviation standard is met.

The level will continue taking readings until maximum number of readings as set in the SET main menu is reached. If external conditions such as heavy winds, shaky structures, heat waves, etc., result in the standard deviation exceeding 1.0 mm at the first attempt, first try to improve conditions by setting up in a better location (if possible), and using the **REP** (repeat) key to repeat the measurement, or at a better time of the day (if possible). If this is not possible, or the readings again exceed the 1.0 mm standard, continue to take multiple readings and watch the standard deviation trend. If additional readings result in the standard deviation exhibiting a decreasing trend, continue the readings until the 1.0 mm limit is met, or until the standard deviation levels off, or the maximum number of sample limit is reached. Accept the measurement by pressing yes on level keypad when the standard deviation levels off and additional readings do not decrease it. It may be necessary to repeat an individual shot a number of times due to

Table 6 - Typical Leveling Sequence

```
CODE 1
CODE 2
CODE 11
SET GROUND HEIGHT TO 0.0000 *
BS
FS
CODE 33
BS
FS
CODE 33
.
.
BS
FS
CODE 33
CODE 99
CODE 11
SET GROUND HEIGHT TO 0.0000 *
.
.
.CODE 99
CODE 9999
```

* GROUND HEIGHT IS ZEROED OUT BY RUNNING THE START LEVELING PROGRAM AS SHOWN IN TABLE 5.

occasional standard deviation spikes caused by a sudden wind gust, traffic vibration, etc.

After completing each foresight measurement and prior to moving level, enter a Code 33 to record the temperature gradient for the setup. Failure to enter the code will generate an error message during processing.

Continue running setups until the foresight measurement falls on a survey point. After entering a Code 33, enter a Code 99, which contains information about the end of an individual leveling section. For successive setups/sections, repeat the above process until the survey is completed.

NOTE: Always end or start the survey on a survey point.

A Code 11 indicates beginning of a level section from a bench mark or an Aquatrak Leveling Point (ALP) and a Code 99 indicates the ending of a level section on a bench mark or ALP. Thus a pair of Codes 11 to 99 indicate a level section from a bench mark/ALP to another bench mark/ALP.

After Code 11 information has been entered, the ground height needs to be set to zero as listed in Table 5. Intermediate points within a section, where the rod is held on a turning point, do not require any Code entries except Code 33.

Before the leveling equipment is moved from one station to another a code 33 needs to be entered and bottom and top temperature readings in that order need to be recorded. At the end of the survey, or the end of the day enter a Code 9999, which contains information about the end of the entire survey. If the survey spans several days, enter a Code 9999 at the end of each day's survey, and enter Codes 1, 2, and 11 to start the next day's survey.

3.8 Special functions

If levels must be terminated in the middle of a section, enter a Code 44. This will tell the data processing software to ignore the preceding values. Re-enter the Code 11 and begin again, or enter a Code 9999 to end the survey.

In cases where a vertical mark is too high for the instrument to reach, it is possible for the instrument to read the 60 cm scale upside down. Before taking the measurement, press the **INV** button and a small **i** will appear on the instrument screen next to the measurement prompt symbol, and will slowly blink. The instrument is now expecting an inverted rod/scale and an *Error 51* will appear if the rod/scale is not held upside down. The **INV** button must be pressed again to switch the instrument back to normal operation.

If the barcode rods or scale cannot be used, it is possible to use the instrument to read three wires from a conventional rod, steel rule, or downshot steel tape. A single reading and distance can be entered into the instrument by using the **INP** button.

- The observer should first read the rule/tape and write down the three wire values. The observer should then check the thread intervals for closure and, if they close, compute the mean and the distance.

- The observer should next enter a Code 66 (see Table 4).

- To use the **INP** button, it is first necessary to change the *KEY* parameter in the *CONFIG* submenu from *dist* to *input* as described in Section 1 of this chapter. Instructions on how to use the **INP** button are contained in Leica NA3003 User Manual Section 8.4.

- At the *ROD FR* prompt, enter the mean rod reading in meters to the mm level, using the decimal point (X.XXX m) . At the *Dist* prompt, enter the computed distance in meters to the cm level, using the decimal point (X.XX m). Remember the units are set to meters in CONFIG submenu as shown in Table 3. All length entries must be in meters.

- Reset the *KEY* parameter in the CONFIG submenu back to *dist* from *input* before performing the next electronic measurement.

- Section 3.1 of the Leica information manual provides further information about the constants used in reading the staff and distance measurement by eye and optical distance measurement.

3.9 Potential problems

This section addresses problems that may occur in the field. Section 11 of the Leica NA3003 User Manual contains a complete list of Error Codes and definitions that the instrument will display when some problem occurs. For convenience, Table 7 contains a partial list of the most common Error codes listed in Section 11.

Section 12 of the Leica NA3003 User Manual discusses in detail many of the typical causes that can result in an *Error 51* and how to rectify them. The *Error 51* message is the most commonly encountered problem in the course of performing a survey, however, as the experience is gained with the Wild NA3003, many of the problems can be anticipated and corrected prior to taking a reading.

Table 7 - Error Messages

Error#	Cause	Action(s)
BAT	Battery charge low	Change battery ASAP
05	Rod too far away (>60 m)	Shorten sighting distance to rod.
12	Battery too weak	Change battery immediately
51	Cannot read rod due to; - rod partially shaded, - rod partially obstructed, - rod not illuminated, - rod not vertical, - rod inverted, - sun/lights shining directly into instrument from ahead or behind, - instrument not focused.	Correct cause
58	Instrument not level	Level instrument
79	REC-module not inserted	Insert REC-module

4 Downloading and processing leveling data from the Wild NA3000 series

This section covers transferring the data from the Wild REC-module to a PC by using the Wild GIF-10 and using a combination of NGS and in-house software to process the leveling data. The NGS data processing software works in conjunction with the NGS bench mark description software, but does not require the description file (XXXXXXX.HA) to generate the abstract file. If the bench mark description file is absent, the bench mark designations will not be pulled into and displayed in the abstract file.

4.1 Download the leveling data to a PC or diskette

A. Connect the GIF-10 module to the PC using the cable from the GIF-10 to the PC RS232 port.

B. Insert the REC MODULE into the GIF-10.

C. Turn on the PC, go into the leveling directory, and find the GIF-10.EXE file.

D. Turn on the GIF-10 and ensure that the cursor is on the "***SEND***" command displayed in the LCD window.

E. Run the ***GIF-10*** executable file and follow prompts;

- Select menu option ***1 - DATA FROM REC MODULE TO PC***.
- Select submenu option ***3 - ON DISK***.
- Reply ***1*** to request for ***REC File Number***.
- Reply ***1*** to request for ***Start Block Number***.
- Reply ***999*** to request for ***End Block Number***.
- Reply ***A:XXXXXXX.IN*** to request for Output File Number to be saved at the A drive, as applicable for the appropriate storage drive. The .IN extension is required. When you hit *ENTER* key after the last question, you should see the data scroll across the PC screen and the GIF-10 module window showing the file and block numbers being transferred.

F. Select *option 8* ***END PROGRAM***, this completes the data download. Turn off the GIF-10 and disconnect the GIF-10 from the PC.

4.2 Edit the XXXXXXX.IN file to correct or remove any known mistakes

A. Make a copy of the ***XXXXXXX.IN*** file before editing it, call it as ***XXXXXXXo.IN*** for the original file.

B. Use a text editor to edit the .IN file. If using WordPerfect or some other word processor program be sure to save the .IN file as an ASCII (DOS) text file.

4.3 Process the level data

A. A batch file program, PROC-GIF.BAT, is used to run the various NGS and in-house programs required to process and merge the leveling and bench mark description software. PROC-GIF.BAT program is located in the leveling directory. See Appendix A for instructions on how to configure a PC with the NGS and in-house software programs.

B. Three files must be present on the data diskette in order to run PROC-GIF.BAT program and obtain an abstract with bench mark designations.

XXXXXXX.IN - Leveling data file (ASCII)
XXXXXXX.HA - BM description file (BINARY)
XXXXXXX.AFI - Header information file (ASCII)

Matching SPSN numbers must be used in the .IN and .HA files in order for the leveling data and bench mark descriptions to be properly matched up.

C. To run PROC-GIF.BAT program, type ***PROC-GIF XXXXXXX***. Do not put an extension after the 7 digit station number.

D. The program will then check the ***XXXXXXX.IN*** file for proper formatting. If it finds a noncritical problem (such as a missing temperature code) it will stop, display a warning message describing the problem, and prompt you to continue. If it finds a critical problem (will prevent proper processing of the file), it will display the line number, a message describing the problem, and may or may not immediately terminate. It will also write the error message(s) to a file named ***XXXXXXX.ERR***. Refer to Appendix B for a list of error messages. If a critical error message is encountered, edit the ***XXXXXXX.IN*** FILE, correct the problem, and then reprocess.

E. PROC-GIF.BAT program will first create (open) two new files named ***XXXXXXX.RPT*** and ***XXXXXXX.BBK*** as listed below.

XXXXXXX.RPT - Section leveling differences (ASCII)
XXXXXXX.BBK - Blue book format level data (ASCII)

F. PROC-GIF.BAT program will then prompt you for the current date, the leveling start date, the leveling end date, appropriate time zone, the party chief initials, and single or double run levels as listed below.

Today is :	***Year***	_____
	Month	_____
	Date	_____
Leveling Started:	***Year***	_____
	Month	_____
	Date	_____
Leveling ended:	***Year***	_____
	Month	_____
	Date	_____

Select appropriate timezone:

Q - Atlantic Standard Time (Eastern Daylight Savings Time)
R - Eastern Standard Time (Central Daylight Savings Time)
S - Central Standard Time (Mountain Daylight Savings Time)
T - Mountain Standard Time (Pacific Daylight Savings Time)
U - Pacific Standard Time
V - Yukon Standard Time
W - Alaska-Hawaii Standard Time
X - Bering Standard Time

Press Corresponding letter to select the time zone of the area leveled.

Then Program asks for ***Party Chief Initials***.

Then Program asks to select ***Level Type: 1 - Single run, 2- Double Run***

G. The program prompts to select the "HGZ" and "HA" files that are needed for the level abstract. Either type the 7 digit number (no extension is necessary), or use the "F2 - help" function key to find and select the appropriate file. Press the "ENTER" key when the appropriate file is displayed in the window. The cursor and highlight should now move down to the prompt asking you for the .HA file. Follow the same guidance provided here for selecting .HGZ file, since three digit extension of a file name is not required. Press the **F10 - ACCEPT** function key to continue processing.

H. The program will then prompt you for a starting SPSN, an ending SPSN, a

starting elevation, units of the elevation, and units of the section distance used for leveling as follows:

Enter the SPSN of the Starting Control Point: _____
Enter the SPSN of the Ending Control Point: _____
Enter the Elevation of the Starting Point: _____
Enter Units of Elevation (FT, MT, SM): ***MT***
Enter Units of Section Distance (KF, KM, SM): ***KM***

The starting SPSN can be the primary bench mark, the ALP, staff, or ETG. But generally, the PBM shall be the starting control point, elevation above the station datum as starting elevation, and ALP as the ending control point.

I. The program will then create a file named ***XXXXXXX.ABS*** which contains the abstract.

J. View or print the ***XXXXXXX.ABS*** file to confirm that all sections have closed and met requirements. Pay particular attention to the error messages section at the end of the abstract as this may identify problems requiring resolution.

This completes the process. Submit all leveling files associated with a level run on a diskette identified by station number, name, and date performed. Hard copies of the bench mark descriptions and abstract should also be submitted, or as advised by RDD.

Note: The serial numbers for all barcode rods, scales, and NA3000/NA3003 levels are stored in the files in the leveling program. If equipment is rented or borrowed from another group, those serial numbers will not be in the programming files, and an error message will appear after attempting to generate the abstract. No abstract will be generated. Considerable work is involved to correct the data files and programming files to accommodate outside user's equipment.

Appendix A - Programs Required on Personal Computer (PC)

If running Windows 95/98/NT/Me/2000 operating system, then all the programs listed here needs to be run in a MS-DOS window.

Programs and files required:

Vertical Control Field Data Processing System (VFPROC) - Diskettes and documentation as supplied by NGS.

GIF10.EXE -	File supplied by Wild with GIF10 module.
NA2VBBK.EXE -	NGS program modified for CO-OPS use.
PROC-GIF.BAT -	In-house batch file
LEVELREC.EXE -	In-house executable file
MAKE_AFI.EXE -	In-house executable file
CHECK-IN.EXE -	In-house executable file
*.CAL, *.ROD, INST.DAT -	Rod and instrument calibration files

To configure a PC for processing leveling data:

In the following instructions C denotes the hard drive of the PC or laptop where level files will be processed. If the file storage location is on network drive or some other drive, select the appropriate drive letter instead of C.

1. Create a directory on the ***C:*** drive named ***LEVELING***. E.g. ***MD C:\Leveling***

2. Install ***VERTPGM*** in ***C:\LEVELING\VERTPGM*** following NGS installation instructions. Answer yes to the question regarding AUTOEXEC.BAT file changes. (VERTPGM will create automatically the directory C:\LEVELING\VERTPGM.) If original NGS program installation disk is not available, then create two folders C:\LEVELING and C:\LEVELING\VERTPGM and copy all files listed below.

   Be sure to also copy all: *.ROD
   *.CAL
   INST.DAT
   files to the VERTPGM subdirectory.

3. Copy these files to ***C:\LEVELING*** directory:

   LEVELREC.EXE ***H2O-TRAN.EXE*** ***CHECK-IN.EXE***
   PROC-GIF.BAT ***GIF10.EXE*** ***NA2VBBK.EXE***
   NASINGLE.DOC

4. The AUTOEXEC.BAT file modifications required are;

The path must contain: ***C:\LEVELING;C:\LEVELING\VERTPGM***

Add the following SET VERTPGM statement to the end of the AUTOEXEC.BAT file. The environment variable statement should be located immediately after the path statement:

SET VERTPGM=C:\LEVELING\VERTPGM

Reboot so that the above AUTOEXEC.BAT file modifications take effect.

Files required for, and created by, the PROC-GIF batch file are as follows:

REQUIRED TO RUN PROC-GIF.BAT ON DISKETTE OR HARD DRIVE OF A PC

XXXXXXX .IN -	Leveling data (ASCII)
XXXXXXX .HA -	Bench mark description data (binary)
XXXXXXX .AFI -	Header information (ASCII)

HARD DRIVE

CHECK-IN.EXE -	Checks .in file for format errors (binary)
NA2VBBK.EXE -	Processes leveling data (binary)
LEVELREC.EXE -	Merges .AFI and .BLB files (binary)
ABSTRA.EXE -	Creates abstract (binary)
MAKEFILE.EXE -	Converts ASCII .AHZ file to binary .HGZ file (binary)
LLLLLXXX.ROD -	Contains rod s/n and cal data (binary)
LLLLL.CAL -	Contains rod s/n and cal data (ASCII)
INST .DAT -	Contains instrument s/n and cal data (ASCII)

where LLLLL is a five digit number representing serial number(s) of the level rod.

CREATED BY PROC-GIF.BAT

XXXXXXX .ERR -	Leveling data format errors (ASCII)
XXXXXXX .BBK -	Section elevation differences listing (ASCII)
XXXXXXX .RPT -	Listing of sections (ASCII)
XXXXXXX .AHZ -	Combination of .afi and .BBK files (ASCII)
XXXXXXX .DPS -	Same as .AHZ file except observer code set for dpas
XXXXXXX .ABS -	Abstract (ASCII)
XXXXXXX .HGZ -	Leveling data output (BINARY)
XXXXXXX.INN -	Intermediate leveling data file (ASCII)

Appendix B - CHECK-IN.EXE Program Error Message List

NON-CRITICAL ERRORS

NON Critical Error - missing Ground Height Entry!
NON Critical Error - missing Code 33 Entry!
Setup ImBalance - +###.###, maximum allowable 5 meters
Section ImBalance - +###.###, maximum allowable 10 meters
Backsight Distance Less than 2.5 Meters
Foresight Distance Less than 2.5 Meters

CRITICAL ERRORS - FILE PROCESSING CONTINUES

Two Ground Height Data Blocks in a row
Code 1 Block - DATE Entry INVALID!
Code 1 Block - TIME Entry NOT 0000 to 2400!
Code 1 Block - WEATHER CODE Entry INVALID!
Code 1 Block - OBSERVER ENTRY Greater than 1000
Code 11 Block, Start Time Greater than 2400 (########)
Code 11 Block, Start Time same as Last Code 11 Entry
Code 11 Block - WEATHER CODE Entry INVALID!
Two Code 33 Blocks in a row
Code 99 Block - TIME Entry NOT 0000 to 2400!
Code 99 Block - WEATHER CODE Entry INVALID!
Code 9999 Block, did NOT follow Code 99 Block
Code 9999 Block - DATE Entry INVALID!
Code 9999 Block - TIME Entry NOT 0000 to 2400!
Code 9999 Block - WEATHER CODE Entry INVALID!
Code 9999 Block - OBSERVER ENTRY Greater than 1000

CRITICAL ERRORS - FILE PROCESSING TERMINATES

No Gauge Number specified on command line
Command Line Gauge Number More then 7 Digits
NA3003 Data File xxxxxxx.IN NOT Found on diskette
Ground Height Data Block does NOT follow:
    Level Method Block for NA3003
    Code 11 or Code 9999 Block for NA3000
Backsight Data Block does NOT follow Code 33, Code 11, Code 22, or Ground Height Block
Foresight Data Block does NOT follow Backsight Block
Invalid Automatic Instrument Reading Block
Distance Information Block Does NOT Follow Foresight Block
Invalid Instrument Reading Block
Section difference less than 5.0 meters
Instrument Set for Double Simultaneous (BFFB) Mode

CRITICAL ERRORS - FILE PROCESSING TERMINATES (continued)

Leveling Method NOT 1 or 2
Invalid Character in column 8 of field
Invalid Character in column 13-15 of field
Code 1 Block, was NOT 1st Block or did NOT follow Code 9999 Block
Code 1 Block missing ALL 4 entries
Code 1 Block missing 3 entries
Code 1 Block missing 2 entries
Code 1 Block missing 1 entry
Code 2 Block missing ALL 4 entries
Code 2 Block missing 3 entries
Code 2 Block missing 2 entries
Code 2 Block missing 1 entry
Code 2 Block, did NOT follow Code 1 Block
Code 11 Block, did NOT follow Code 2, Code 44 or Code 99 Block
Code 11 Block missing ALL 4 entries
Code 11 Block missing 3 entries
Code 11 Block missing 2 entries
Code 11 Block missing 1 entry
Code 33 Block, did NOT follow Instrument Reading Block
Code 33 Block missing Both Temperature entries
Code 33 Block missing 1 Temperature entry
Code 33 Block, Temperature 1 (char 24-31) > 99.9 degrees
Code 33 Block, Temperature 2 (char 40-47) > 99.9 degrees
Code 99 Block, did NOT follow Temperature or Instrument Reading Block
Code 99 Block missing ALL 4 entries
Code 99 Block missing 3 entries
Code 99 Block missing 2 entries
Code 99 Block missing 1 entry
Code 9999 Block missing ALL 4 entries
Code 9999 Block missing 3 entries
Code 9999 Block missing 2 entries
Code 9999 Block missing 1 entry
Invalid Code Block
Block does NOT begin with 11 or 41
Last block of file NOT Code 9999 Block

Appendix C - Transferring NGS Data Sheets to Create a Level Disk

This appendix provides instructions for creating a BM description file, XXXXXXX.HA, by downloading descriptions from the NGS database on Internet, and merging those descriptions with standardized descriptions for water level bench marks, station staffs, ETGs, etc., from DPAS. These level disks will be created by RDD, generally, and provided to FOD. If DPAS descriptions are not used or descriptions are created at FOD, then the steps 9 and 10 need to be modified by ignoring the references to DPAS bench mark descriptions and network drive file locations.

(1) Gather all information needed for a station, viz station package (490s) , station and bench mark location sketch, list of VM# and PID# for that station, Line #, station part number in that state, etc.

(2) Looking at the bench mark sketch and level history, identify the active bench marks at a station in the leveling scheme. Including the part number, number all the bench marks sequentially (following the leveling history) starting with the PBM. All bench marks in the leveling scheme will have a four digit number (SPSN) as ZZYY, where ZZ is the station part number in that state and YY is a two digit number as stated here. The TBM XXX XXXX Aquatrak will be ZZ08, PBM will be ZZ11, and all other marks (active and destroyed) will be sequentially numbered starting with ZZ12. XXX XXXX is the station number. Include active marks first and then include destroyed or dropped marks at the last.

(3) Start the web browser and go to http://www.ngs.noaa.gov/datasheet.html and go to data retrieval options. Select "*Retrieve single data sheet from the NGS database by PID*" and enter the PID# for each sheet and save as ASCII TXT file with PID# as file name to the appropriate network location (e.g. RDD COMMON Drive on CO-OPS server N:\levels\1999\station#\NGS); e.g. save as OA0075 for PID# OA0075. Save all applicable bench marks data sheets with PIDs as ASCII TXT files.

(4) Go to a DOS window or NORTON COMMANDER (NC) and copy all (10 or so) ASCII TXT files into a single file using COPY command as follows. Stay in the same subdirectory NGS; e.g. N:\LEVELS\FY1999\STATION#\NGS. Arrange the bench marks in the sequence that you would like them to be in the list (as stated in step 2 above), in the COPY command:

COPY OA0075+ OA0785+ OA0786+.....+OA0783 XXXXXXXN.AH0

where XXX XXXX is the station number and OA0075, OA0785, OA0786 and OA0783 are files with appropriate PID#s for a particular station listed in a desired order.

(5) Go to a DOS window and start *DS2BB* (data sheet to blue book) program. E.g. ***DS2BB***

Then select option 1 ***CONVERT TO BLUE BOOK*** and
then ***ENTER DSDATA FILENAME*** AS ***XXXXXXXN.AH0***,
then ***ENTER OUTPUT FILENAME***: ***XXXXXXXN.AH1***,

then select the option 1 ***ASSIGN SSN ONE PER STATION*** for creating the file in the blue book format.

(6) Go to the same ***DS2BB*** program and select option 2 for ***utilities*** and then select ***Option 4*** "***MERGE ALL 30 RECORDS IN SINGLE SET***".

Enter Description BLUE BOOK Input file name: XXXXXXXN.AH1
Enter Output file name: XXXXXXXN.AH4

(7) Go to the same ***DS2BB*** program and select ***utilities option 3*** "***REVERT *20* AGENCY_GROUP TO OLD BLUE BOOK NUMBER CODE***" to convert the file created in step 6 to the old NGS format. The old format converts agency codes to numbers rather than alpha-numerals.

Enter Description BLUE BOOK Input file name: XXXXXXXN.AH4
Enter Output file name: XXXXXXXN.AHA

Then exit DS2BB program by selecting "***Q***" at the main level.

(8) Create the HA file using MAKEFILE command as follows:

MAKEFILE XXXXXXXN.AHA XXXXXXXN.HA

The following two steps provide specific information about copying bench mark descriptions from DPAS. If access to DPAS is not available, then type in the descriptions in uppercase letters in Area A5 of the step 10 below.

(9)Now open *WordPerfect 8.0, NORTON COMMANDER*, and *DPAS POWERBUILDER 6.0 (PB6.0) Bench Mark General Information* screen, all in windows (not full screen). Adjust the three windows such that all three are visible at the same time. A good way is to keep *PB6.0 Bench Mark* window in top half with 20% of right half monitor screen unoccupied, *WordPerfect* window in bottom half with 20% of right half monitor screen unoccupied, and *NORTON COMMANDER* window or *DOS* window in the middle on the right side of the monitor screen. Now you are set to do the copy and paste operations from DPAS into your bench mark file using *DESC* program.

(10) GO to *DOS window or NORTON COMMANDER* and stay in the directory you want files stored, e.g. N:\LEVELS\FY1999\XXXXXXX/NGS. Start *DESC* program using the file created in step 8 e.g. XXXXXXXN.HA.

E.g. ***DESC XXXXXXXN.HA***

Modify the data set information? (Y/N) Y

There are total five areas (as identified A1-A5 below) that need to be filled in (for new marks that are not in NGS database) or edited (for marks that exist in NGS database), as appropriate.

The first three areas are common to all bench marks at a station. The last two areas are specific to each bench mark.

(A1)

Job Code: xx (***SL*** for Tides, ***SI*** for Great Lakes)
Submitting Agency: ***NOS COOPS***
Abbreviation: ***COOPS***
File Creation Date: Enter current (Today's) date.
Project/Line number: ***LNNNNN***
Part : ***ZZ*** (see part # sheet provided for each station in each state)

Use [F9] to move to the next title area

(A2)

This area describes Project Title and Comments for the leveling job, up-to four lines can be entered..

1st line: ***1999 LEVELING IN STATE-NAME*** *(e.g. FY 1999 LEVELING IN OREGON)*
2ND line: ***XXXXXXX STATION NAME*** *(e.g. 9431647 PORT ORFORD)*

Use [F9] to move to the latitude and longitude area.

(A3)

Select minimum and maximum latitude and longitude for the **WHOLE STATE**. E.g. for the state of California the range is shown as follows:

	Latitude Range	*Longitude Range*
California	31 to 42	117 to 125

Select units of measure as metric. ***UNITS OF MEASURE (E/M): M***

Hit [F10] to save and move to next area.

(A4)

This area describes *GEODETIC CONTROL STATION DESCRIPTION*. Enter SPSN # as 11, 12 ....N and then select ***modify Y/N? Yes*** to go into edit mode for each bench mark. Set the SPSN # for each bench mark as needed and refer to guidance provided in section II at the beginning of this Guide on codes/info that need to entered in this area. Hit [F9] to go to the BM description area for each bench mark.

(A5)

Use DPAS bench mark description to be inserted here as described. Copy DPAS description into a buffer using copy command (CONTROL C), paste (CONTROL V) the description into *WordPerfect* and highlight all and capitalize all (EDIT/CONVERT CASE UPPERCASE). Then copy highlighted description into buffer and paste into *DESC* program (in *NORTON COMMANDER*) using right mouse button. Make sure the cursor is in replace mode(-) and not in insert mode (■) and cursor is at the right place. If there are any lines left from old description that need to be deleted, hit enter first to move that portion to a new line and then use [F6] to delete line by line. Adjust bench mark description and codes as required. (Use [F9] to go from screen to screen in *DESC* and [F10] to save the description before working on another description.)

If a mark description is not in DPAS, then the NGS description needs to be rewritten to fit to the NOS format.

Insert the SPSN # for new marks (not in NGS database but in DPAS) here and add descriptions from dpas. After everything is done or if you need to exit DESC program, hit escape twice and enter ***yes*** to ***EXIT PROGRAM***? Then enter ***NO*** to ***GENERATE STATISTICAL BREAKDOWN, Y/N*** ? And quit the program.

(11) Copy all relevant files from NGS directory to ORIGINAL directory, leaving only .TXT files in the NGS directory. Then to preserve the original XXXXXXXN.HA file created so far from working file, copy that file to XXXXXXXP.HA as follows:

COPY XXXXXXXN.HA XXXXXXXP.HA

(12) Stay in the same working directory ORIGINAL and run *CLEAN-HA* program on XXXXXXXP.HA.

CLEAN-HA XXXXXXX (No need to add any three digit extension)

(select the option ***output by SSN***)

CLEAN-HA procedure creates two files named SXXXXXXX.HA and XXXXXXXP.AHA.

(13) Stay in the same working directory ORIGINAL and run *NEW-HA* program on SXXXXXXX.HA

NEW-HA XXXXXXX (No need to add any three digit extension)

(select the option ***output by SSN***).

NEW-HA program removes old recovery information and creates two new files XXXXXXX.HA and XXXXXXX.AHA file for use by field crew.

(14) Stay in the same working directory ORIGINAL and use *EXTRACTL* program to create index of bench marks that are in XXXXXXX.HA file.

EXTRACTL

(a) After starting the program go first to utilities menu and select option ***SORT to SSN.***
(b) Then at the main level select input file as ***O:XXXXXXX.HA*** (Include the appropriate drive letter with file name.)
(c) Then at the main level select output file as ***XXXXXXX.HA*** (Do not include drive letter with file name here, so that input and output file locations are different, even though the same file is being worked on by the EXTRACTL program.)
(d) Then hit *Escape* key twice, and select each mark wanted in the diskette for leveling by pressing space bar for each mark. Generally, select all marks since most of the marks are already edited in the DESC program.
(e) Press [F10] to exit this selection menu and go back to main menu.
(f) Go to utilities menu again and select option ***CREATE INDEX FILE***.
(g) Since the index file is automatically saved in the working directory as XXXXXXX.INX, there is no additional need to save the index file. Hence quit the program by going to ***FILE - QUIT*** and then selecting ***YES to EXIT ANYWAY***.
(h) Print the index file by COPY XXXXXXX.INX LPT1:
(i) File the page listing the bench marks (XXXXXXX.INX) in the station package at the proper location.

(15) Create XXXXXXX.AFI file for use in field leveling by using *MAKE-AFI* program.

MAKE-AFI

(a) Enter station number ***XXXXXXX.***
(b) Enter station name (max 60 characters).
(c) Enter two digit state code ***SS***.
(d) Enter four digit fiscal year of leveling for which diskettes are prepared ***YYYY***.
(e) Program will present Line Title and it is editable, otherwise leave it as it is.
(f) Enter L number ***LNNNNN***.
(g) Enter part number ***ZZ***.
(h) Enter ***Finished*** for this file or select ***Enter another file*** to create another .AFI file.

(16) Place paper label on diskette listing station number, station name, L number and part number.

(17) Copy these three files on the diskette prepared for field leveling.

XXXXXXX.HA	(Bench mark description file)
XXXXXXX.AFI	(ASCII header file for BM processing)
XXXXXXX.INX	(BM Index file/List of marks)

NOTE: Files could also be zipped or placed on field office server via FTP.

Appendix D - Preparing Vertical Data for Submission to NGS

Data should be prepared for submission to NGS after all the stations (part numbers) have been completed for a particular line number within a calendar year. This information is specifically written for RDD only, since RDD will be generally forwarding information to NGS.

(1) The files received from field are stored at CO-OPS common network drive, e.g. at O:\Levels\1999\XXXXXXX\Crew. First check the relevant XXXXXXX.HA file received from field crew for correctness and completeness by running PROC-GIF.EXE program on it. If everything is okay, then proceed to step (2), otherwise correct the file.

(2) Copy the XXXXXXX.HA file in the process folder, viz O:\Levels\1999\XXXXXXX\Process. Also check dates of leveling and the list of marks recovered for each XXXXXXX.HA file for the line number LNNNNN. The marks recovered means bench marks connected and also bench marks that are not connected but physically checked for condition, status, etc. Then run EXTRACTL on the XXXXXXX.HA file by selecting only the recovered marks. Thus XXXXXXX.HA file will only contain recovered bench marks after this step.

(3) Copy all relevant XXXXXXX.HA files from all the stations in that state or body of water to the appropriate Lnumber, viz O:\Levels\1999\LNUMBER\LNNNNN. Where LNNNNN is the line number for that state/body of water. If multiple level runs are made at a station during the fiscal year, then the part number of the XXXXXXX.HA file that is latter run needs to be changed to a new unused part number in that state.

(4) All of the ***XXXXXXX.HA*** files are merged using the ***MERGFILE*** program into one combined file. Only two files can be merged at a time, so rename intermediate merged files as mergtmp1, mergtemp2, etc. till all XXXXXXX.HA files are merged together and the final merged file is named ***LNNNNN.HA***.

(5) If there are bench marks that are known as destroyed but NGS needs to informed, then a separate LDESTROY.HA file can be created for all destroyed bench marks in that state and can be merged with LNNNNN using the ***MERGFILE*** program. The final product shall be labeled LNNNNN.HA. Thus at this step the combined LNNNNN.HA file contains all recovered and destroyed marks that need to be informed to NGS. The LDESTROY.HA file needs to be generated only one time for a state when the first time data is sent to NGS.

(6) The Data Set Information Screen is modified as follows for the final merged ***LNNNNN.HA*** file; The Part No. field is left blank, line *02* of the Project Title block is deleted, and the min/max latitude/longitudes are adjusted (if not done before) to include all survey point coordinates within that state or area as appropriate.

(7) All other files required for submission are listed below, where PP is the part number. The additional files required are ***LNNNNNPP.ABS , LNNNNNPP.AHZ, LNNNNNPP.HGZ, LNNNNNPP.IN, and LNNNNNPP.LST.***

Place all files for a line number on one diskette and submit to NGS.

USER'S GUIDE

FOR

WRITING BENCH MARK DESCRIPTIONS

FOR

ELECTRONIC LEVELS

Updated January 2003

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

USER'S GUIDE FOR WRITING BENCH MARK DESCRIPTIONS FOR ELECTRONIC LEVELS

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BACKGROUND

This document provides specifications for writing the descriptive text used 1) to locate a water level station site (TO REACH statement) and 2) to recover an individual bench mark using electronic levels. This document supplements the Input Formats and Specifications of the National Geodetic Survey Data Base (Volume I and II, September 1994) "Bluebook". The vertical descriptive data of Volume II is actually in Volume I, Chapter 3 and is available on the NGS web site (www.ngs.noaa.gov/FGCS/tech_pub.html). Items that conform to NGS Bluebook format such as DR (Description/Recovery) code, recovery type code, setting code, marker type (monumentation) code, agency code, condition code, and stability code are not repeated here.

The bench mark text descriptions for electronic digital levels shall be provided to the Requirements and Development Division of the Center for Operational Oceanographic Products and Services in NGS DESC program format on diskettes and as a paper copy for records in station files. The next version of the DESC program (to be released soon) will not perform the conversions automatically, therefore Metric measurements followed by English units in parenthesis will have to be listed in the descriptions.

GENERAL INFORMATION

Consistent Referencing Procedures

The following referencing techniques are recommended for measurements:

1. All measurements are assumed to be horizontal unless labeled "sloped".

2. Distances measured from a line (e.g., centerline of road or a fence line) are assumed measured perpendicular to that line.

3. The origin of measurement of the junction of two roads is assumed to be the intersection of centerlines of both roads.

4. Measurements made are assumed to be from the center of an object unless another starting point is selected such as edge of the curb. In general, all measurements are assumed to be made from (and to) the center of the bench mark disk.

5. Reference objects selected shall be fairly permanent and will not likely be moved or destroyed.

6. The vertical tie gives the height of the mark above or below the surrounding area; e.g., level with the ground or 0.20 m (0.7 ft) above or below ground. The word flush should only be used if the edge of the disk is countersunk into the setting; e.g., set flush in the base of the flagpole.

Measuring New Distances

All new distances shall be measured in Metric units.

Taped distances shall be measured and recorded to the nearest 0.01 meter for distances less than 100 m; all other distances shall be measured and recorded to the nearest 0.1 meter. Distances measured while driving an automobile shall be recorded to the nearest 0.1 kilometer.

All distances shall be documented in Metric units with the English unit equivalent immediately following in parenthesis. The only exception is when an item's name contains a nominal size, i.e., a ½ inch bolt, a 4-inch diameter PVC pipe, etc. These names shall remain unchanged with no equivalent given.

Abbreviate meter as m, kilometer as km, feet or foot as ft, mile as mi, and nautical mile as nm. Measurements made in centimeters (cm), millimeters, inches, etc., shall be changed to meters or feet as appropriate, except for the vertical reference measurements for rod marks which are reported in cm.

Conversions

Conversion rules between English and Metric units are as follows:

Metric to English	English to Metric
3.2808 x X m = Y ft	0.3048 x Y ft = X m
0.6214 x X km = Y mi	1.6093 x Y mi = X km
0.5400 x X km = Y nm	1.8520 x Y nm = X km

A procedure is described below for documenting these measurements in Metric and English units for both new measurements and past historic measurements. All new measurements are required to conform to these specifications. Past historic measurements which do not conform to these specifications such as approximate values without decimal place shall be re-measured.

(A) New Measurements: Original measurements in Metric units.

Conversion from Metric units to English units: When measurements are made in meters to the hundredth, or meters to the tenth place, as described in the previous section titled Measuring New Distances; then when converting from meters to feet, round the converted number as appropriate, but do not exceed the tenth's place.

Converting from meters to feet: Some examples;

0.20 m = 0.7 ft	10.55 m = 34.6 ft
1.00 m = 3.3 ft	102.4 m = 336.0 ft

Converting from kilometers to miles: When converting from kilometers to miles, convert to miles and the tenth's place. Some examples;

0.5 km = 0.3 mi	2.8 km = 1.7 mi

(B) Historic (old) Measurements: Original measurements in English units.

Conversion from English units to Metric units: Distances measured in English units such as feet or inches are converted from feet to meters using an extra decimal place in the converted Metric value, round the number as appropriate but do not exceed the hundredth place for distances less than 328 ft. If the original distance measured exceeds 328 ft, round the converted Metric value to meters, or meters and the tenth's place, as appropriate. If the decimal place is not shown, then the original measurement is assumed approximate and no decimal place is required in the converted value. An exception to this rule is when the past measured distance is 1 ft, as illustrated in the conversion examples below.

Converting from feet to meters: Some examples;

0.5 ft = 0.15 m	30.0 ft = 9.14 m
1 ft = 0.3 m	30 ft = 9 m
3 ft = 1 m	365.6 ft = 111.4 m
3.0 ft = 0.91 m	365 ft = 111 m

Converting from miles to kilometers: When converting from miles to kilometers, use only one decimal place if the original number has a decimal place, otherwise the original number is deemed approximate. Mileage is usually made in statute miles on land and nautical miles on water. Some examples;

0.3 mi = 0.5 km	1.0 mi = 1.6 km
1 mi = 2 km	1.3 mi = 2.1 km
2.5 nm = 4.6 km	3 nm = 6 km

TO REACH STATEMENT TEXT

The TO REACH statement for use on the tidal published bench mark sheet is only required for tide stations, and not for Great Lakes water level stations. The purpose of the TO REACH statement is to provide easily followed directions on how to reach the tidal bench marks and station site, with a statement on the specific location of the water level sensor. The assumption is made that the user is unfamiliar with the area. Thus, the TO REACH statement should start from a readily found prominent landmark, use the mode of transportation most common to the area, and guide the user to the bench marks and tide station via the most direct, main, route.

For electronic digital levels, the descriptive text for each individual mark must begin with a series of phrases on how to reach the mark from a local landmark such as highway intersection, post office, etc. This is required by NGS for inclusion of the mark in their database, and is an integral part of the text description in the HA file. This aspect of the description is not required for other types of leveling such as optical levels that will not be submitted to NGS.

The DESC program does not provide the "TO REACH" statement that is used in the header paragraph of the tidal published bench mark sheet. Hence, the "TO REACH" statement to be used on the published bench mark sheet shall be provided in a separate digital file with filename as an seven digit station number and a three digit extension as TOR; e.g., 9414290.TOR.

This statement may also be used for each individual bench mark description in the DESC program, with perhaps minor editing depending on the location of the mark.

Directions

When describing a turn, always note the compass direction. Spell out north, east, south, and west. Use standard two or three capital letter symbols for intercardinal points of the compass.

north	NNE	NE	ENE
east	ESE	SE	SSE
south	SSW	SW	WSW
west	WNW	NW	NNW

Right and left may be also be used if it clarifies a direction.

Landmark

A landmark should be a permanent location, public building, or structure that can be easily located by any person with a common road map or other guide. Typical landmarks are the intersection of two roads, town hall, post office, airport, etc. It should be as close as is reasonable to the site and offer as direct a route as is possible.

TO REACH Statement Format (For Published Bench Mark Sheet)

> To reach the tidal bench marks from (landmark), proceed (direction) on (name and/or road number) for X km (Y miles) to (next salient point), then (turn, proceed, etc.) (direction) on (name and/or road number) for X km (Y miles) to (next salient point), then (repeat statement as necessary) to (the station facility). The bench marks are in the vicinity of (general area description). The tide station was/is (location on the facility and its name).

Some examples are;

To reach the tidal bench marks from the U.S. Post Office on Main Street, proceed north on Main Street for 1.3 km (0.8 mi) to the intersection with Second Avenue, then west on Second Avenue for 3.2 km (2.0 mi) to its termination with Harbor Road, then SW on Harbor Road for 5.6 km (3.5 mi) to the small boat harbor and fishing pier. The bench marks are along Harbor Road and the waterfront area. The tide gage and staff were located 4.51 m (14.8 ft) south of the offshore end of the wharf.

TO REACH STATEMENT Example #1

To reach the tidal bench marks from the fishing village of Nunchuk via boat, proceed NNE along the Snowamish Channel for 23.3 km (12.6 nm) to the entrance to Chiklik Bay, then NW along Chiklik Bay for 9.8 km (5.3 nm) to Lonely Island, then east for 0.9 km (0.5 nm) along the south coast of Lonely Island to the sole fishing pier on the west side of Isolation Bay. The bench marks are along the shoreline adjacent to both sides of the pier. The tide gage and sensor were located at the offshore end of the fishing pier.

TO REACH STATEMENT Example #2

BENCH MARKS DESCRIPTION TEXT

The bench mark descriptive text should provide clear, concise, and accurate instructions on how to recover a bench mark using easily identified objects located within a reasonable distance from the bench mark. The assumption is made that the user is not familiar with the surroundings. In this document, the term “bench mark” is used as a generic expression for a vertical control point whose height above a tidal datum has been, or will be, determined.

NOTE: For electronic digital levels, each individual mark description on the HA file must include a statement on how to reach the mark from a local landmark or highway intersection. This is a requirement for inclusion of the mark in the NGS database. When the descriptive text is entered into the CO-OPS tidal bench mark database and for the published bench mark sheet, the statements on how to reach each individual mark are deleted, and the more general "To Reach" statement about how to reach the tidal marks and tide station is used in the header paragraph of the published bench mark sheet.

Bench mark descriptive texts for other types of levels, i.e. Third Order levels for hydro or control leveling in Alaska or the Pacific Islands, DO NOT require the statement on how to reach the mark for each individual mark because those levels are not currently submitted to NGS.
The following general format shall be used for describing all surface bench marks for electronic levels (for rod marks or 3-D rod marks refer to the special requirements below).

A bench mark descriptive text is made up of four parts, as listed below.

From the intersection of ___(1)___, ___(2)___, ___(3)___, ___(3)___, ___(3)___, and ___(4)___.

Part (1) consists of general locator phrases that lead the user to the individual mark from a local landmark or highway intersection.

Part (2) consists of three critical pieces of information: A) the marker (monumentation) type; B) how it is set; and C) a specific locator. For a primary bench mark, use the words primary bench mark in the above sentence.

Part (3) provides taped measurements and compass directions from at least three objects in the immediate area of the bench mark, recorded in the descending order of distance.

Part (4) is a vertical reference to grade, or other appropriate reference, used only if the bench mark setting is not level with its immediate surroundings. The relationship of the bench mark to grade need be cited only if the difference exceeds 0.05 m (0.2 ft). For rod marks the vertical reference to grade is reported in centimeters in the NGS DESC program.

Other details such as the condition and agency responsible for setting the bench mark are typically not recorded in the descriptive text field unless directed as such from the description header screen.

Part (1): General Locator

The descriptive text starts with this series of phrases that describes how to reach the mark from a local landmark or highway intersection, i.e. From the Post Office, from the intersection of..., etc. Ideally, this section should lead the user to the immediate vicinity of the mark.

From the intersection of US Highway 322 and Washington Avenue in (city), proceed east on Washington Avenue for 2.4 km (1.5 mi), then go north on Christopher Columbus Avenue for 0.3 km (0.2 mi),

From the Post Office in (city), proceed north on Main Street for 3.4 km (2.1 mi), then go east on Columbia Boulevard for 0.8 km (0.5 mi) to the city harbor and Municipal Pier No. 11 North,

From the local marina at (town), proceed SW by boat for 9.5 km (5.1 nm) to Shag Island,

(Part 1) General Locator Examples

Part (2 A): Marker Type

The marker (monumentation) type identifies the object used to monument the vertical control point such as a disk, bolt, rivet, flanged encased rod, etc. This immediately tells the user what physical object is being searched for. In the NGS DESC program a marker type code will be entered for marker types such as code B for bolt, or R for Rivet, but use a more specific descriptor for the text portion such as brass bolt or monel rivet as shown below.

Even though marker monumentation information is coded in the DESC program, it is included in the bench mark description so as to be compatible with CO-OPS published bench mark format and for ease of reading the description on the data sheet and this matter has been discussed with NGS and is acceptable.

the bench mark is a disk ...
the bench mark is a brass bolt ...
the bench mark is a monel rivet ...
the bench mark is a flange encased rod ...
the bench mark is a chiseled cross ...

(Part 2 A) Marker Type Examples

Part (2 B): Setting

The setting indicates how the bench mark has been installed and whether it is set in concrete, rock, structures, etc. If the bench mark is a rod mark of some type, note how the disk or point is attached to the rod. In the NGS DESC program a setting code will be entered for a marker, such as code 31 for pavements (street, sidewalk, curb, apron, etc.), but describe the setting in particular to what is applicable such as granite curb as shown below. The marker shall be assumed to be set horizontally unless noted as set vertically.

... set in a granite curb ...
... set vertically in the brick wall ...
... cut in a rock ledge ...

(Part 2 B) Setting Examples

Part (2 C): Specific Locator

The specific locator statement directs the user to the specific vicinity of the bench mark. It should identify something that can be readily found once the user has reached the location described in Part 1 of the description (how to reach the mark). It does not usually contain a distance and direction from a landmark, unless there is no other way to locate the mark. The general locator statement should be a continuous phrase if at all possible.

... at the bottom of the east entrance to the U.S. Post Office, ...
... at the NW corner of the First National Bank on Fifth Street, ...
... of the old munitions factory along Fort Avenue, ...
... in the park near the intersection of First and West Avenues, ...
... just south of the residence at 111 Jones Road on the west side of the street, ...

(Part 2 C) Specific Locator Examples

Part (3): Taped Measurements and Compass Directions

... 14.51 m (47.6 ft) west of telephone pole numbered E345C6, 12.66 m (41.5 ft) south of the centerline of Main Street, and 4.94 m (16.2 ft) north of a fire hydrant, ... 64.07 m (210.2 ft) WSW of bench mark 9601 B 1980, 10.85 m (35.6 ft) south of the SW corner of the old fort, 3.22 m (10.6 ft) north of a USPS mailbox, ... 11.58 m (38.0 ft) north of the north edge of Highway 101, 1.95 m (6.4 ft) east of a 1.49 m (4.9 ft) square concrete pad, and 0.55 m (1.8 ft) west of the east end of the bridge abutment.

(Part 3) Specific Locator Example

Notes for part (3): Taped Measurements and Compass Directions.

1. Always attempt to reference the bench mark to objects in three different directions so that the mark may be located more easily through triangulation in the event that it becomes buried, grown over, etc..

2. More than three landmark references are recommended if they are necessary to ensure locating the bench mark, or if some landmarks appear semipermanent.

3. Other bench marks may be used as references, but only use them if good local landmarks are scarce. When referencing another bench mark in the text, use the full stamping or designation, preceded by bench mark; ... west of bench mark 1234 A 1995, ...

4. If there are no immediate landmarks, distant objects may be used by determining the angular relationship (azimuth), in lieu of a distance between the object and the bench mark. Azimuths are given in parenthesis after the direction and cite the reference meridian used, for example, SSW (202^0 magnetic).

5. Items that are identified by nominal sizes (3/4 inch bolt, 5 inch diameter pipe, 4 x 6 timber, 12 mm screw) do not have their sizes converted into the opposite units. The size is considered a descriptive name and not a measurement. When an object is measured, however, such as the dimensions of a concrete slab, the units are converted.

Part (4): Vertical Reference

... and 1.25 m (4.1 ft) above grade. ... and 0.60 m (2.0 ft) above the base of the retaining wall. ... and 0.33 m (1.1 ft) above road level.

(Part 4) Vertical Reference Examples

The vertical tie gives the height of the disk above or below the surrounding area. It is assumed to be about level with its surroundings if no vertical reference is given.

If the bench mark is a rod type, an additional statement is included at the end that provides more detailed information on the rod mark. For a rod type mark use the following format:

> ... The bench mark is set XX cm (Y.Y ft) below grade, crimped to a (rod type) driven X.X m (Y ft) to (refusal/substantial resistance), and encased in a (Z-inch) PVC pipe with concrete kickblock or 5-inch (NOS/NGS) logo cap.

If the bench mark is a sleeved rod type, an additional statement is included at the end in the following format:

> ... The bench mark is set XX cm (Y.Y ft) below grade, crimped to a (rod type) driven X.X m (Y ft) to (refusal/substantial resistance), in a sleeve extending to a depth of X.X m (Y ft), and encased in a (Z-inch) PVC pipe with concrete kickblock or 5-inch (NOS/NGS) logo cap.

If the bench mark is a flange encased rod type, an additional statement is included at the end in the following format:

> ... The datum point is set XX cm (Y.Y ft) below ground, being the top of a (rod type) driven X.X m (Y ft) to (refusal/substantial resistance), in a sleeve extending to a depth of X.X m (Y ft) and encased in a 5-inch (NOS/NGS) logo cap.

... The bench mark is set 10 cm (0.3 ft) below grade, crimped to a copper-clad steel rod driven 11.9 m (39 ft) to refusal, and encased in a 4-inch PVC pipe with concrete kickblock.

... The bench mark is crimped to a galvanized steel rod driven 22.9 m (75 ft) to refusal, and encased in a 4-inch PVC pipe.

... The bench mark is set 15 cm (0.5 ft) below grade, crimped to a stainless steel rod driven 6.1 m (20 ft) to refusal, in a sleeve extending to a depth of 3.0 m (10 ft), and encased in a 5-inch PVC pipe with concrete kickblock.

... The datum point is set 8 cm (0.3 ft) below grade, being the top of a stainless steel rod driven 15.9 m (52 ft) to refusal, and encased in a 5-inch NOS logo cap.

Rod Mark Vertical Reference Examples

Notes for part (4): Vertical Reference to Grade.

1. The rod type information specifies the material the rod is made of, typically galvanized, stainless, or copper-clad steel.

2. The term "refusal" shall be used only if refusal conditions are actually met. Otherwise, the term "substantial resistance" shall be used.

3. The PVC pipe diameter shall be specified in the original nominal units only.

4. If the rod mark is set in a sleeve, the sleeve depth shall be noted also. The depth of a rod or sleeve is given to 0.1 meter and its English equivalent to the nearest foot (without decimal point).

5. Flange-encased rods can be found with or without disks crimped to the rod, and with or without a grease-filled sleeve.

6. Document whether a NGS or NOS stamped logo cap is used on the pipe, as applicable.

BENCH MARK DESCRIPTION EXAMPLES

The following are three typical examples of bench mark descriptions found in general cases. The statements on how to reach the marks are fictitious. Example #4 is a typical bench mark description for subordinate hydrographic tide stations in Alaska.

From the intersection of US Highway 322 and Washington Avenue in (city), proceed east on Washington Avenue for 2.4 km (1.5 mi), then go north on Christopher Columbus Avenue for 0.3 km (0.2 mi), the primary bench mark is a disk located near the front lawn of the USCG Marine Safety Office property, 45.90 m (150.6 ft) NW of the flagpole at the entrance of the main building, 24.69 m (81.0 ft) south of the light pole on the east side of Christopher Columbus Avenue, 9.20 m (30.2 ft) NNE of the north curb of Washington Avenue, 8.41 m (27.6 ft) SE of the eastern curb of Christopher Columbus Avenue, and 8.14 m (26.7 ft) east of the traffic signal post at the NE corner of Washington and Christopher Columbus Avenues. The bench mark is set 18 cm (0.6 ft) below ground, crimped to a stainless steel rod driven 11.9 m (39 ft) to refusal, and encased in a 5-inch PVC pipe with concrete kickblock.

Primary Bench Mark Description Example #1

From the Post Office in (city), proceed north on Main Street for 3.4 km (2.1 mi), then go east on Columbia Boulevard for 0.8 km (0.5 mi) to the city harbor and Municipal Pier No. 11 North, the bench mark is a disk set in top of the concrete footing for a building on the east end of Municipal Pier No. 11 North (Marine Police and Fire Boat Pier), 14.57 m (47.8 ft) north of the south face of the pier, 9.81 m (32.2 ft) south of the north face of the pier, 6.49 m (21.3 ft) west of the east end of the pier, and 0.37 m (1.2 ft) south of the north end of a steel door opening.

Bench Mark Description Example #2

From the intersection of Baltimore Street and Moale Avenue in (city), proceed north on Baltimore Street for 1.4 km (0.9 mi), the bench mark is a flange-encased rod set 23.59 m (77.4 ft) SW of the center and at the end of Baltimore Street, 7.32 m (24.0 ft) SSW of the approximate centerline of Baltimore Street, 0.49 m (1.6 ft) NE of the SE corner of a 3.00 m x 3.00 m (9.8 ft x 9.8 ft) concrete pad that surrounds a drainage culvert, and 0.40 m (1.3 ft) NE of a 3-inch PVC witness post. The datum point is set 15 cm (0.5 ft) below the ground, being the top of a stainless steel rod driven 17.1 m (56 ft) to refusal, and encased in a 5-inch NGS logo cap.

Flange Encased Rod Bench Mark Description Example #3

From the local marina at (town), proceed SW by boat for 9.5 km (5.1 nm) to Shag Island, the bench mark is a disk set in bedrock located 5.50 m (18.0 ft) south of the tree-line, rising above the surrounding grass and driftwood, 35.61 m (116.8 ft) NE (54^0 magnetic) from bench mark 1234 B 1996, 35.39 m (116.1 ft) NW (324^0 magnetic) from bench mark 1234 A 1996, and 5.45 m (18.2 ft) above the approximate high water line.

Alaska Hydro Gauge Bench Mark Description Example #4

From Cape Vincent, Jefferson County, New York, at the foot of Murray street, in the east face at the southeast corner of the stone wall face of the U.S. Fish Hatchery building, the bench mark is the center punch in a 1/4-inch brass rod (bolt) cemented in the stone wall, 18 m (59 ft) south of the NE corner of the building, 4.42 m (14.5 ft) west of the west edge of the side walk on the east side of the property, 0.37 m (1.2 ft) north of the SE corner, and 0.91 m (3.0 ft) above the ground.

Great Lakes Bench Mark Description Example # 5

APPENDIX

The following information was obtained from ANSI/IEEE Standard 268-1982 "American National Standard Metric Practice" (ANSI Standard) and is provided here for technical detail.

Conversion of quantities should be handled with careful regard to the implied correspondence between the accuracy of the data and the given number of digits. Any digit that is necessary to define the specific value or quantity is said to be significant. In all conversions, the number of significant digits retained should be such that accuracy is neither sacrificed nor exaggerated. When converting integral values of units, consideration must be given to the implied or required precision of the integral value to be converted. Obviously, the converted value must be carried to a sufficient number of digits to maintain the accuracy implied or required in the original quantity.

It is therefore necessary to determine the intended precision of a quantity before converting. The estimate of intended precision should never be smaller than the accuracy of the measurement and should usually be smaller than one tenth the tolerance if one exists. After estimating the precision of the dimension, the converted dimension should be rounded to a minimum number of significant digits such that a unit of the last place is equal to or smaller than the converted precision.

Distance measured	Examples of the distance measured	Implied range of the distance measured	Implied tolerance of the distance measured
< 100 m	10.85 m	10.845 m to 10.855 m	0.01 m
100 m to 1000 m	124.5 m	124.45 m to 124.55 m	0.1 m
> 1 km	1.2 km	1.15 km to 1.25 km	0.1 km

TABLE NO A-1: Implied Range and Tolerance of the Distance Measured

In the case of bench marks descriptions one comes across distances as small as a few mm or inches to a few hundred meters or feet. For example, a distance of 9 m can signify a range from 8 m to 10 m or from 8.5 m to 9.5 m, depending upon the tolerance desired. Also for the past measured distances, the precise tolerances to which the distances were measured would be unknown and whether original distances were measured in the Metric system or English units also would be unknown. Table A-1 provides information regarding the scope of distances measured for the bench mark descriptions and the implied range and implied tolerances of the distance measured.