CONSTRAINED ADJUSTMENT GUIDELINES
Last Update: February 2003

# INTRODUCTION

These Guidelines were originally developed for internal use at NGS. Some software or procedures may not be available to the public. Any program that is required is available.

The following instructions are a step-by-step approach for adjusting survey projects to the NAD 83. They are meant to be used only as a guide. Occasionally, a project will have some special circumstances that require a deviation from the set procedure.

The guidelines are subject to change as the user requirements change, as in the completion of HARN's in various states.

Read the guidelines thoroughly before beginning your project. There are some procedures which you may want to perform in an order differing from that arranged here (e.g. corrections to the Blue Book before the final adjustment). If you see any procedures consistently incorrect, notify Renee Shields at 301-713-3198, x129.

SECTION 1

GATHER ALL SOURCE MATERIAL FOR THE PROJECT

I. Necessary items include:

Project report
**Approved Recon Sketch** and Project Sketch
Project Instructions or Contract Specifications
Final Station List
Station Visibility Diagrams
Final Observing Schedule
Observation Logs
Equipment Failure Logs (NGS Projects)
Loop Misclosures (optional)
Free Adjustment with Analysis
Free Adjustment with Accuracies
Constrained Horizontal Adjustment
Constrained Vertical Adjustment (NAVD 88 Heights)
Meteorological Instrument Comparison Logs (if specified)
Photographs of Views from Stations (if specified)
Photographs or Rubbings of Station Marks
COMPGB Output (Validation Program - B/G-file)
OBSDES Output (Validation Program - B/D-file)
OBSCHK Output (Validation Program - B/G-file)
CHKDESC Output (Validation Program - D-file)
NEWCHKOBS Output (Validation Program - T-file)
ELLACC Output
BBACCUR Output
Digitized Data Files:
Raw Phase Data (R-files)
Base Line Vectors (G-file)
Project and Station Occupation Data(final B-file)
Descriptions or Recovery Notes(D-file)
Terrestrial Horizontal Observations(T-file)
Differential Leveling Observations(L-file)
Abstracts and List of Directions (classical projects)
Distance reduction sheets (classical projects)

II. A project log can be useful in writing the project report. List station names, azimuth marks, whether a station was described or recovered, and whether it was fixed, readjusted, or new. Note bench marks on the station list. Also note any unusual situations or procedures.

III. Note in the log any problems mentioned in the field report, especially those which affect the adjustment or analysis. Review the format checking program outputs which were submitted. Note

any unresolved error messages from these listings in the log. If you are checking this project for inclusion in the NGSIDB, verify that the positions submitted as final have the correct adjusted position and height values, and that the files are still free of format errors.

IV. For GPS projects, verify the Solution Coordinate Reference System Code in cc 52-53 of the B-records in the GFILE. The code represents the reference system of the position used to reduce the vectors. The following codes should be used:

01 -- WGS 72 Precise (post fit) Ephemeris [DMA] fm beginning through 1/3/87
02 -- WGS 84 Precise (post fit) Ephemeris [DMA] fm 1/4/87 through 1/1/94
03 -- WGS 72 Broadcast (Predicted) Ephemeris [DOD] fm beginning through 1/22/87
04 -- WGS 84 Broadcast (Predicted) Ephemeris [DOD] fm 1/23/87 through 6/28/94
05 -- ITRF 89 (epoch 1988.0) (International Earth Rotation Service Terrestrial Reference Frame 1990)
**Not Used as a GPS Reference Frame**
06 -- NEOS 91.25 (National Earth Orientation Service) Epoch 1988 [NGS] - Spring 1991 through /10/19/91
**Special VLBI Coordinate Solution written by Mike Abell**
07 -- NEOS 90 (National Earth Orientation Service 1990) Epoch 1988.0 [NGS] fm 10/20/91 through 8/15/92
08 -- ITRF 91 Epoch 1988.0 [NGS] - 8/16/92 through 12/19/92
09 -- SIO/MIT 1992.57 Epoch 1992.57 [NGS] fm 12/20/92 through 11/30/93
10 -- ITRF 91 Epoch 1992.6 [NGS] (transformed fm Epoch 1988.0) fm 12/1/93 through 1/8/94
11 -- ITRF 92 Epoch 1994.0 [NGS] fm 1/9/94 through 12/31/95
12 -- ITRF 93 Epoch 1995.0 [NGS] fm 1/1/95 through 6/29/96
13 -- WGS 84 (G730) Epoch 1994.0 [DMA] (precise) fm 1/2/94 through 9/28/96
14 -- WGS 84 (G730) Epoch 1994.0 Broadcast [DOD USAF] fm 6/29/94 through 1/28/97
15 -- ITRF94 Epoch 1996.0 [NGS] fm 6/30/96 through present
16 -- WGS 84 (G873) Epoch 1997.0 [NIMA] (formerly DMA) fm 9/26/96 through present
17 -- WGS 84 (G873) Epoch 1997.0 Broadcast [DOD USAF] fm 1/29/97 through present
18 -- ITRF 96 Epoch 1997.0 NGS fm 3/1/98 through 7/31/99
19 -- ITRF 97 Epoch 1997.0 NGS fm 8/1/99 through 6/3/00
20 -- IGS 97 Epoch 1997.0 NGS fm 6/4/00 through present
21 -- ITRF 00 Epoch 1997.0
22 -- IGS 00 Epoch 1998.0 NGS fm 12/2/01 to the present

V. If you are working on a project in California or southern Alaska, determine the epoch the project requires for the final positions. Program HTDP can be used to update the observations to the correct epoch.

SECTION 2

PRELIMINARY PROCESSING

Examine the Blue Book observation deck for any obvious errors which need correction. Verify that the Organization symbol in cc 19-24 of the first record matches the organization which did the survey.

Run the following series of checking programs on the observation and description decks.

I. Run COMPGB, NEWCHKOBS, and OBSCHK. Resolve error messages and note the resolutions in the log. Ignore messages about *10*, *11*, *13*, *83*, and *90* records. Information in these records is not used in the adjustment process, or loaded onto the NGSIDB, but it may be helpful in researching problems which arise during processing. Record any unresolved anomalies in the log.
NOTE: In NEWCHKOBS and OBSCHK, an error message is generated for a "0" antenna height. If the station is a CORS station, this message can be ignored. Other stations in the project must not have "0" antenna heights.

II. If necessary, use DESCUP to change the SSN's in your description file to match your Blue Book observation file. Make sure the station names in the files are correct. You may want to sort the descriptions alphabetically using DESCSRT.

For descriptions processed in the field, i.e. in unified format, run OBSDES and CHKDESC. In the office, run OLDU2NEW to convert the unified descriptions to D-file format. Run CHKDDESC, NEIGHBOR, DISCREP, and OBSDES. Messages which are 'errors' **MUST** be corrected. Messages flagged as 'warnings' should be checked, and corrected if appropriate. Only change description codes flagged by DISCREP messages if your have verification that such a change is warranted. Refer to Appendix F for more detailed processing instructions.
NOTE: Programs NEIGHBOR and DISCREP require access to the database, since they perform database comparisons.

**NOTE: If excessive errors are found in the checking programs, files will be returned to the agency responsible for the survey to be corrected. (See Sharon Faber)**

Rerun the format validity checking programs (part I. above) on the final files to ensure changes do not generate new errors.

SECTION 3

## CHECK THE BLUE BOOK POSITIONS AGAINST FILES AND LISTINGS OF PUBLISHED STATIONS

I. Determine which horizontal and vertical datums will control the adjustment and note them in the log. Also note whether ellipsoid heights will be computed for this project (required by NGS).

II. Retrieve a file of published positions in Blue Book format from the NGSIDB (or, in the field, create one from the data on the CD-ROM). Use program CLUSTER to compare the *80* records in your Blue Book observation deck with those in the file of published positions. Be especially aware of HARN's, state readjustments, and other projects in progress involving your area or neighboring areas. Be aware of the requirements of your project. If upgrades are requested, determine how this will affect what control is used.

III. If the blue book observation deck does not already have them, run MAKE86 to create the *86* records which will contain the various heights for each station.

IV. Research orthometric and ellipsoid heights. For the vertical adjustment (orthometric heights), if you have good control on the NAVD 88 datum, use only that control. If insufficient control exists on the NAVD 88 datum, look for NGVD 29 elevations. Use VERTCON to transform the NGVD 29 elevations to the NAVD 88 datum. (The *86* record for the transformed stations should have a "D" in the elevation code field.) Verify elevation codes in the *86* records for all stations.

If the field crew leveled from a known bench mark, accept those elevations. Be sure to include a paragraph in your project report discussing any leveling used. The *86* record should have an elevation code of "L" or "T" for stations with leveling. ADJUST will not use *45* or *47* records in processing. To use this information in the adjustment, code a "CH" record in the A-file. Leveling done to be included in the NGSIDB should be forwarded to Davy Crockett or Kathy Koepsell, at 301-713-3187 or -3184.

Position any bench mark stations which have never been positioned horizontally, if possible.

V. Make certain that station names match the current naming conventions in the *80* records, i.e. remove dates and agency abbreviations. If a name change from the published name is desirable, note this in your report. Sort the *80* records alphabetically (optional).

Verify station order-and-type codes. For old stations, the order-and-type should be what the project requires, not what is published. If the station is used as control, and fits well in the adjustment, the NGSIDB will be updated with the new order-and-type code. If the station does not fit, it should not be used as control. Document in your report any stations published as a lower order than your job which were used for control. For stations with order-and-type code 47, blank out the elevation.

VI. If there are any classical observations in your deck, and if you have not yet run MODBB, run it

now.
NOTE: Make certain the elevations in the *86* records are correct, since they will affect the distance reductions computed by MODBB.

VII. If you have any classical observations in your project, run DEFLEC on your observation file. This will compute the ETA value for the LaPlace correction if you have astro azimuths. The deflection correction is generally negligible for other types of observations, e.g. directions and distances, but can be significant for some, therefore DEFLEC should be run on all terrestrial observation files.

SECTION 4

ADJUST THE PROJECT WITH MINIMUM CONSTRAINTS

I. Run ADJUST with minimum constraints. Constrain only one station position per component. For classical projects, add inversed azimuths and distances to the AFILE for solvability where necessary.

A) If there are GPS observations, and the project contains at least 2 published ellipsoid heights, run a 3D adjustment,
holding one adjusted ellipsoid height per component. Make sure the geoid height field in the *86* record is blank for all stations. NOTE: If insufficient ellipsoid height control exists, run GEOID and constrain one bench mark elevation.

B) If there are no GPS observations, run GEOID, using the
most current geoid model. Run a 2D adjustment.

II. Use PLOTRES to plot residuals for GPS projects. Resolve large residuals by checking for blunders. Reject, only as a last resort, those redundant observations which have a high normalized residual. Don't leave a station no-check by rejecting.

The vector standard errors in all GPS projects, lower than B-order, are scaled. The standard errors assigned to GPS vectors are generally overly optimistic. Scaling the standard errors makes all the different projects consistent with each other. This is done by running MODGEE which scales the standard errors of the vectors. Use a scale factor equal to the square root of the variance of unit weight of the free adjustment.

**NOTE: Never scale a GPS project of B-order accuracy or better.**

If classical observations are involved, save the adjusted positions for the vertical run.

III. Before beginning constrained runs, be sure the inversed azimuths and distances are removed from the AFILE.

NOTE: Run all adjustments in mode 3 (normalized residuals). This mode computes residuals scaled relative to the standard deviation of the residual (normalized residuals). For classical observa-tions, outliers are more easily identified from the normalized residuals.

## SECTION 5

## RUN THE CONSTRAINED HORIZONTAL ADJUSTMENT

I. If there are GPS observations run ADJUST in 3D. Hold all previously published positions. Constrain all adjusted ellipsoid heights. Again, make sure your geoid heights in the *86* record are blank. A minimum of 2 ellipsoid heights is needed to adjust ellipsoid heights in your project. (Otherwise, run GEOID and constrain one elevation. No ellipsoid height adjustment will be performed.) Compare the results with the free adjustment. Were there any large shifts in the positions?

II. If there are no GPS observations, run ADJUST in 2D and mode 3 holding the positions of all previously published stations. Be sure the elevations are correct.
**NOTE:** For classical projects, you should run the vertical adjustment first. If you run the horizontally constrained adjustment first, be sure the elevations do not change significantly from those used in this run. Incorrect elevations can cause problems with distance observations.

III. Large residuals in this run, which were not in the free adjustment, are the result of problems with the constraints. Do not reject any observations due to constraints. Verify that the control used is correct and on a consistent datum. For observations with large residuals, check for misidentifications. If no problems can be identified, determine whether you should readjust some of the existing positions. Consider the requirements of your project. If a station you are readjusting is well positioned in your project, readjust with only the GPS vectors in your project.
Save the adjusted positions from this run.

## SECTION 6

## RUN THE CONSTRAINED VERTICAL ADJUSTMENT

If you have good control on the NAVD 88 datum, use only that control. If insufficient control exists on the NAVD 88 datum, look for NGVD 29 elevations, and transform them to the NAVD 88 datum using the transformation program VERTCON. Select bench marks first. If, upon examination of the results of the first vertically constrained adjustment, it appears that GPS-derived elevations fit the project, add them to your list of constraints. If further control is still needed, use elevations computed from vertical angles.

I. If there are GPS observations, run GEOID using the option to create *86* records. Run 2 adjustments in 3D. In the first, constrain one previously adjusted elevation and one NAD 83 adjusted position to get a vertically free adjustment. In the second, constrain previously adjusted elevations as specified above, and one NAD 83 adjusted position.

II. If there are no GPS observations use the adjusted positions from the 2D free adjustment and run ADJUST in 1D. Hold previously adjusted elevations as specified above. (The adjustment from Section Four will serve as the vertical free adjustment.)

Investigate observations with large residuals, and stations whose elevation shifted significantly between the free and vertically constrained adjustments. The same rule applies as in the horizontal constrained adjustment: no rejections due to constraints. Look for inconsistent shifts as opposed to areas where the shifts, even high shifts, are consistent. Likewise, look at the geoid heights to see if they are consistent. You may want to plot these shifts on a sketch to facilitate analysis. For inconsistent shifts, look at the recovery notes to see if any movement is indicated, or if the wrong mark was observed, such as the underground mark instead of the surface mark. If no cause for the shift can be found, the elevation may need readjusting. Free the elevations in question and rerun as a test. Note the differences between the published elevations and the readjusted elevations obtained from the vertically constrained test adjustment. Consider the requirements of the project before deciding whether to readjust.

For classical projects, if there are any significant changes in the elevations between preliminary and adjusted values, then you need to re-reduce the distances to mark-to-mark. To do so, run MODBB with the original unreduced distances and the adjusted elevations. Then, rerun the 2D free adjustment and the 1D adjustment. See Appendix E for tables demonstrating the impact of the elevation change on the distance reduction.

Use program ELEVUP to combine the Blue Book decks from the vertically and horizontally constrained adjustments so that the final Blue Book observation deck contains the positions and ellipsoid heights from the horizontally constrained adjustment and the elevations and geoid heights from the vertically constrained adjustment.

## SECTION 7

## RUN FINAL FREE ADJUSTMENT WITH ACCURACIES

Run a final adjustment with minimal constraints as in SECTION FOUR. Use QQRECORD to generate the QQ records for your AFILE. For multiple-order projects, you will have to edit the order on the QQ records in your Afile. Input the blue book observation file created by the horizontal constrained adjustment.

If you're project is A- or B-order, you did not scale the standard errors in the gfile. In order to compute the accuracies correctly, the gfile standard errors must be treated as scaled. To do this, change cc4 to "Y," the option to "scale the standard deviations with a-posteriori standard deviation" in the MM record of the Afile. The value ADJUST will use is the "STD. DEV. OF UNIT WEIGHT" shown on the summary residual statistics page. Note this value in your adjustment report.

List in your report any accuracies which do not conform to the specifications of your project. Run BBACCUR to create a formatted listing of all accuracies to attach to your report.

Check both sets of accuracy estimates, the internal and external, to see that the standards of the project are met. If internal accuracies do not meet the standards, then perhaps the specifications were not adhered to. Verify the field procedures.

If internal accuracies look good, but external accuracies are low, then perhaps a station or stations need to be readjusted. Do a test constrained adjustment where the stations associated with low accuracies are freed up. Then do a test free adjustment with accuracies to see if the standards are now met. If the second adjustment is significantly better, consider the project requirements to determine which adjustment should be accepted.

If it was necessary to compute ellipsoid heights for your project, run ELLACC to classify ellipsoid height order and class. Submit the printout with your project. Complete the *86* records with information from the ELLACC output, making sure the datums and order and class fields are filled in.

SECTION 8

POST PROCESSING

I. Prepare the Blue Book observation deck for submission. Most of these items should be done before the final adjustment, but should be double-checked at this time. Use the Blue Book checklist (Appendix C).

A. Identify horizontal and vertical no-check stations in the project. In the *80* record, change cc 5 to 'N' for vertical no-checks, cc 6 to 'N' for horizontal no-checks.
(Elevation codes M and P will default to no-check.) A new station is no-check when all of its observations get a zero residual in the constrained adjustment. There are instances when the 'N' in the observational summary is not an accurate means of identifying no-check stations:

1. In a dangling traverse, a station can have 2 directions from, 2 to, and 2 distances and still be no-check.
2. In a GPS project, a station determined by only one vector might be correlated with other vectors and therefore get a non-zero residual. The observational summary will show an 'N'. Document these cases in your report. NGS will determine which stations will be saved in the NGSIDB as no-check.

B. Verify that station names conform to the new naming conventions, i.e., no dates or agency abbreviations.

C. Check order-and-type codes. Determinations of upgrades or downgrades to order-and-type will be based on both accuracy achieved and, for classical work, geometric strength of the ties of the new project to the network. Carefully document all changes.

D. In order to load any leveling observations in the Blue Book, *80* records must exist for both ends of the line, even if one of them cannot be positioned horizontally. If neither standpoint nor forepoint is positioned, remove the leveling observation from the deck. If one end of the line is unpositioned, add a *82* record in your deck for that point, giving it an SSN as if it were a peripheral for the standpoint.

E. Check all elevation codes and values. Remove elevations (including zero elevations) and elevation codes from the *86* records of landmark stations if there are no distance observations involving the landmarks. Order-and-type 47 should not have an elevation. If a distance is involved the order-and-type should be 43.

F. Add the PID to the recovery notes for existing stations. (See the datasheet for the PID.)

G. Sort the *80* records alphabetically.(optional)

H. Rerun the checking programs. If you have a file (or database file) of existing adjusted positions, run CLUSTER on the final Blue Book deck comparing these positions.

I. Verify state abbreviations.

J. The first record in the Blue Book deck must contain the initials of the observing organization (left-justified).

II. Write the report.

A. Pages one and two of the project report are NOAA forms 76-161 and 76-162 respectively. These forms include the order classification, horizontal and vertical datums, dates of field work and computation, chief of party, a summary of station

information including number of new stations, number of fixed and readjusted stations, a breakdown of the number of main scheme stations versus supplemental, non-monumented, or temporary stations, the variance of unit weight for the free and constrained adjustment, and the ratio of the constrained variance to the free. If you do not use the forms, put this information in the text of the report.

B. Include the following for each field project involved in the adjustment:

Locality:
Project ID:
Year of observations:
(Sketch number: if applicable)
Number of occupied stations:
Number of unoccupied stations:
Degrees of freedom (free adjustment) :
Variance of unit weight (free adjustment, scaled and unscaled):

C) In the text of the report, include the following:

1) The order and type of the project and its purpose.
2) Notes from the log concerning problems in the field report. How were they resolved?
3) Free adjustment - were any problems encountered? What was done to resolve the problem? Do any large residuals remain? Scaling factor used for GPS projects.
4) Constrained horizontal adjustment - list all fixed positions and their source. Discuss problems encountered and the results. If ellipsoid heights were adjusted, list the ellipsoid height values constrained.
5) Constrained vertical adjustment - list all fixed elevations and their source (L-number, G-number, or bench mark levelled from). Were any previously published elevations not held fixed? Why?
6) Notes from the log - list the stations not described or recovered. Discuss anything in the log that's noteworthy.
7) List all horizontal and vertical no-check stations.
8) List rejected observations, if noteworthy.
9) Discuss the accuracy results from the final free adjustment.
10) If Ellipsoid heights were computed, discuss the resulting accuracies.
11) Note any problems encountered from the checking programs. Include any problems with the description

file.

AFTER THE PROJECT HAS BEEN APPROVED:

III. Save and archive, (or submit to NGS) the following items:
Printouts of final validity checking runs
Constrained Horizontal Adjustment
Constrained Vertical Adjustment
Final Free Adjustment
Copies of the B-file, G-file, and Description file
Typed report, signed by you, your supervisor, and the Branch Chief
Copy of the project sketch

IV. Copy the files to the directory /home/maralyn/Projects. The program maralyn.go will prompt you for the files to be copied. The following naming convention should be used:
gnumber.filetype.comment.
where gnumber is the GTZ° or GPS° of your project, filetype is the kind of file (bbook, gfile, desc) and comment refers to any other necessary identifier (e.g. part1, part2, main, suppl, or stfaa, where "st" is the state abbreviation code). The Blue Book should contain the adjusted positions and elevations from your constrained runs.

Once the files are copied onto /maralyn/Projects, run one final run of all of the checking programs. Include the following as they apply: CHKOBS, CHKDDESC, CHKDESC, OBSDES, OBSCHK, and BBLOAD.DESCHK (optional). These runs should be free of errors and will ensure that the correct files are being saved for loading. Give Maralyn Vorhauer copies of the program printouts, as well as printouts of each file, run from the laser printer.

## APPENDIX A

### Adjustments Processing Programs

**ADJUST** - required

Performs least-squared adjustment in up to 3 dimensions of horizontal, vertical angle, GPS, and Doppler data.

*Input - bfile (blue book observations, positions), afile (ADJUST instruction parameters), gfile (GPS vectors), dfile (doppler observations)*

*Output - adjustment output (messages, results, statistics)*
*updated bfile (positions updated with adjusted values), if requested*

Programmer - Jim Mosier.

**ADJUSTA** - in-house use only, requires data base access

Performs a station adjustment using IDB observations at a specified station.

Programmer - Craig Larrimore.

**AFILELK**

Lists all fixed positions and elevations, along with station name, for inclusion in the project report.

*Input - afile, bfile*

*Output - formatted listing of constraints*

Programmer - Ed Carlson.

**AFLELEV**

Creates fixed height records using ellipsoid height from ADJPOS file.

*Input - adjusted position file*

*Output - file of CC records*

Programmer - Ed Carlson.

**BBACCUR2** - required

Generates a file of single line accuracies from an ADJUST output file. Produces an efficient listing for use with the project report.

*Input - adjust output from free adjustment with accuracies*

*Output - formatted listing of accuracies*

Programmer - Ed Carlson.

**BBLOAD.DESCHK** - in-house use only

Compares observation deck and unified description deck for inconsistent SSN's, station names, and positions. Optional.

Programmer - Craig Larrimore.

**BIGADJUST**

Same as ADJUST except the array size has been increased to handle state adjustments. Has

extended file record formats to accomodate jobs with more than 10,000 stations. This program is not available through the menu.
Programmer - Jim Mosier.

**BIGED** - in-house use only
Interactive program to edit large Blue Book data files.
Programmer - Jim Mosier.

**CHBBOOK** - used with COMBINE
For a Blue Book deck (and G file) with different SSN's assigned to stations with duplicate names, changes the SSN's to be the same. Duplicate position records must be deleted by the processor.
Programmer - Ed Carlson.

**CHKDDESC** - required
Validity checks D-file format description file.
*Input - D-file format description file*
*Output - listing of format error messages*
Programmer - Janet Menscher.

**CLUSTER**
Compares *80* records between decks, e.g. a Blue Book observational deck and a Database retrieval file or another Blue Book file. See Ed Carlson to run CLUSTER on a file greater than 3000 stations.
*Input - 2 bfiles or files of blue book *80* records*
*Output - listing showing the positional differences between the same stations in the 2 files, file of common stations*
Programmer - Ed Carlson.

**COMBINE**
Combines two Blue Books and/or G files together. Input old or new format Blue Books and the output is in new Blue Book format.
Programmer - Ed Carlson.

**COMP80** - in-house use only
Computes preliminary NAD 83 positions for any blank *80* records using a direction and a distance. To save the inverse computations, run in demand.
No documentation available.
Programmer - Steve Frakes.

**COMPGB** - required
Performs validity checks on G-file and B-file for consistency and compatibility.
*Input - gfile, bfile, serfil*
*Output - listing of inconsistencies between the 2 files*

Programmers/Contacts - Mary Oleson, Madeline White.

**CRAFILE**

An interactive program which creates or modifies an existing AFILE. The program will also update the observation deck with the values from the afile.

*Input - Interactive or* **CLUSTER** *output, i.e. "common" file*

*Output - afile,* optional *bfile*

Programmer - Ed Carlson.

**CREFIL** - in-house use only, requires data base access

Retrieves horizontal position and observation data from the database and puts it in one of several useable formats, e.g. Blue Book.

Programmer - Craig Larrimore.

**DEFLEC**

Computes the ETA value necessary for making LaPlace corrections to astronomic azimuths.

*Input - bfile*

*Output - updated bfile*

Programmer - Dennis Milbert.

**DIFLATLON**

Computes the differences between stations with the same SSN in two different Blue Book decks, e.g. free adjustment results versus constrained. Lists the difference in latitude, longitude, and elevation as well as the shift.

*Input - 2 bfiles or files of blue book *80* records*

*Output - listing of differences between the same stations in the 2 files*

Programmer - Ed Carlson.

**DISCREP** - in-house use only, requires data base access

Validity checks d-file format description files against the NGSIDB.

*Input - d-file format description file*

*Output - error list file*

Programmer - Janet Mencher.

**ELEVUP** - required

Combines *80* and *86* records from constrained horizontal and constrained vertical blue book decks to produce a final deck containing the final adjujsted positions and heights.

*Input - 2 bfiles, one with adjusted elevations with geoid heights and one with adjusted positions and adjusted ellipsoid heights*

*Output - 1 updated bfile containing all adjusted values*

Programmers - Steve Frakes/Ed Carlson.

**ELLACC** - required

For projects where Ellipsoid height was adjusted, uses the final free adjustment with accuracies output run and computes the order and type of the ellipsoid height.

*Input - final free adjustment output*

*Output - listing of totals of ellipsoid height accuracies produced*

Programmer - Steve Frakes.

**FORWARD**

Computes the geodetic position given the geodetic azimuth and distance from a known position. (Also FORWRD3D, for 3-dimensional marks.)

*Input - Interactive*

*Output - coordinate*

Programmer - Steve Frakes.

**GEOID** - required

Updates *86* records with Geoid heights from NGS' latest geoid model.

*Input - bfile*

*Output - updated bfile*

Programmers - Dru Smith/Dan Roman

**GPPCGP**

Computes state plane coordinates from geodetic positions (or vice versa) on the NAD 27 datum.

*Input - Interactive or file of positions or coordinates*

*Output - file of coordinates or positions*

Programmer - Ed Carlson.

**HTDP**

Predicts and updates coordinates and/or observations to a user-specified date to facilitate adjusting survey data to particular epochs in crustal motion areas.

*Input - bfile, gfile*

*Output - updated bfile, gfile*

Programmer - Richard Snay.

**IDB_RET** - in-house use only, requires data base access

Retrieves positions, elevations, observations, and descriptive data from the database. For retrievals of large areas see Craig Larrimore.

Programmer - Craig Larrimore.

**INVERSE**

Computes the geodetic azimuth and distance between two stations given their geodetic positions. (Also, INVERS3D, which computes distance for 3-dimensional marks.)

*Input - Interactive*

*Output - azimuth and distance*

Programmer - Steve Frakes.

**LOCUS**

Identifies the stations in a file which fall within a user defined radius of a specified central location. Can be used for 3- or 4-digit Blue Book decks.

For documentation list /home/vixen/steve/locus.doc.

Programmer - Steve Frakes.

**MAKE86** - required

Creates *86* records in blue book observations files. Will not remove existing *86* records. Uses orthometric height from the *80* record.

*Input - bfile*

*Output - updated bfile*

Programmer - Ed Carlson.

**MARALYN.GO** - in-house use only

Transfers the final decks to Maralyn Vorhauer's project directory.

No documentation necessary.

Programmer - Ed Carlson.

**MODBB** - required for terrestrial surveys

Computes standard error and reduces to mark-to-mark zenith distances, distances, and position records, both 3- and 4-digit SSN's.

*Input - bfile*

*Output - updated bfile*

Programmer - Bessie Thompson.

**MODGEE** - required for projects lower than B-order

Scales standard errors of observations in Blue Book GPS observation decks.

*Input - gfile, scale factor*

*Output - updated gfile*

Programmer - Mary Oleson.

**NADCON**

Compute positional data (latitudes and longitudes) from NAD 27 to NAD 83 and vice versa. The latest version is continually being updated to include those states where high accuracy GPS surveys have been used for state readjustments.

*Input - Interactive or file of blue book *80* records*

*Output - file of updated *80* records*

Programmers/Contacts - Cindy Craig/Dave Doyle.

**NEIGHBOR** - in-house use only, requires data base access

Validity checks d-file format description files against the NGSIDB.

*Input - d-file format description file*

*Output - output file of neighboring (clustered) stations*
Programmer - Janet Mencher.

**NEWCHKOB** - recommended
Validity checks Blue Book observation deck.
*Input - bfile*
*Output - listing of format error messages*
Programmer - Jim Mosier.

**OBSCHK** - required
Validity checks a Blue Book observation deck, and will perform some checks on the gfile if one exists.
*Input - bfile, gfile*
*Output - listing of validity errors*
Programmer - Jim Mosier.

**OBSDES** - required
Validity checks a Blue Book observation deck against a unified or d-file format description file
*Input - unified or d-file format description file, bfile*
*Output - listing of inconsistencies*
Programmer - Jim Mosier.

**PLOTRES** - in-house use only
Plots residuals to facilitate analysis of adjustment results. *Input - adjustment output file*
*Output - graphic plot showing horizontal and/or vertical residuals*
Programmer - Ed Carlson

**PLTPRJ** - in house use only
To plot observation decks with 3-, 4-, or 5-digit SSN's. PLTPRJ4 has an option to plot elevation differences of constrained stations using the Blue Book files and the afile for the vertical adjustment.
Programmer - Jim Mosier.

**PROMPTER**
Creates *80* records by prompting the user for each value.
*Input - Interactive*
*Output - file of blue book *80* records*
Programmer - Ed Carlson.

**QQRECORD**
Generates and adds QQ records to an AFILE using a Blue Book or GFILE. Only one QQ record will be generated over each line of observation.
*Input - afile, bfile or gfile*
*Output - updated afile*

Programmer - Ed Carlson.

**SHIFTVPLOT** - in-house use only
Computes shifts in coordinates between 2 Blue Book files. Output is a file of shifts for input into program VPLOT.
Documentation not available.
Programmer - Ed Carlson.

**SPCS83**
Computes state plane coordinates from geodetic positions (or vice versa) on the NAD 83 datum. (Also SPCS83EH, showing ellipsoid heights).
*Input - Interactive, or file of positions or coordinates*
*Output - file of updated coordinates or positions*
Programmer - Ed Carlson.

**UTMS**
Computes UTM coordinates from geodetic positions and vice verse for NAD 27 and NAD 83.
*Input - Interactive or file of coordinates or positions*
*Output - file of updated positions or coordinates*
Programmer - Ed Carlson.

**VERTCON**
Transforms NGVD 29 elevations to NAVD 88
Programmer - Mary Oleson.

**VPLOT** - in-house use only
Plots shifts between positions in 2 Blue Book files on the laser printer. Uses as input the shift file from program SHIFTVPLOT.
Documentation not available.
Programmer - Ed Carlson.

---

The following programs are for in-house use only, as they apply to backlogged jobs whose descriptions are in a different format.

**CHKDESC**
Validity checks unified description file.
*Input - unified description file*
*Output - listing of format error messages*
Programmer - Janet Menscher.

**CONVRT**
Converts a travdeck or vertdeck into Blue Book format.
Programmer - Ed Carlson.

**DESCSRT**

Sorts a description file alphabetically.

*Input - unified description file*

*Output - updated unified description file*

Programmer - Ed Carlson.

**DESCUP**

Changes SSN's in description files to match the Blue Book deck numbers (searches by name).

*Input - unified description file, bfile*

*Output - updated unified description file*

Programmer - Ed Carlson.

**NAMES**

Converts a NUMNAM deck into a travdeck.

Programmer - Ed Carlson.

**OLDU2NEW**

Translates unified description files into new d-file format files.

*Input - unified description file*

*output - d-file format description file*

Programmmer - Janet Mencher

**TONEW**

Converts 3-digit SSN bbook to 4-digit format.

*Input - 3-digit bfile*

*Output - 4-digit bfile*

Programmer - Gloria Edwards.

APPENDIX B

Constrained Adjustments Processing Outline

**I. Gather Source Material**

- A. bfile, gfile, dfile, tfile
- B. sketches, reports, logs
- C. verify Solution Coordinate System Reference System Code, cc 52-53 of B-records in gfile

**II. Preliminary Processing**

- A. Run checking programs
  1. COMPGB
  2. CHKOBS
  3. OBSCHK
- B. Verify codes, eg. elevation code, order and type, no-check code
- C. Run HTDP if needed
- D. Verify descriptions
  1. DESCSRT
  2. DESCUP
  3. CHKDESC
  4. OBSDES
  5. OLDU2NEW
  6. NEIGHBOR
  7. DISCREP
  8. CHKDDESC

**III. Identify Control**

- A. Choose horizontal and vertical datums, and epoch as needed
- B. Retrieve horizontal positional control
- C. Run MAKE86 - create *86* height records
- D. Retrieve orthometric height control
- E. Retrieve ellipsoid height control
- F. Verify station designations against NGS IDB designations
- G. If classical observations
  1. Run MODBB
  2. Run DEFLEC

**IV. Adjust with Minimum Constraints**

- A. Create afile
  1. Constrain 1 position per component
  2. For GPS, constrain 1 ellipsoid height per vertical component
     a. Geoid ht in *86* should be blank
  3. If insufficient ellipsoid height control
     a. Run GEOID - latest model
     b. Constrain 1 orthometric height per vertical component
- B. Run ADJUST

C. Resolve singularities, misclosures
D. If GPS observations, run residual plotting program
Resolve large residuals
1. For A order: 1 cm
For B order: 3 cm
For 1st order: 5 cm
2. correct blunders
3. reject badly fitting observations - don't create no-checks
E. If less than B order results are required, run MODGEE
F. Rerun ADJUST till clean

**V. Adjust Horizontal Constrained**

A. Create afile
1. Constrain all published positions
2. For GPS, constrain all published ellipsoid heights (at least 2)
a. Geoid height in *86* should be blank
3. If insufficient ellipsoid height control
a. Constrain 1 orthometric height per vertical component
B. Run ADJUST
1. Input bfile created by free adjustment
C. Determine if any stations should be readjusted based on large residuals
D. Rerun ADJUST until satisfactory
E. If adjusting classical data, run vertical constrained adjustment before horizontal constrained

**VI. Adjust Vertical Constrained**

A. Create vertical free afile
1. Constrain 1 position for each component
2. Constrain one published orthometric (bench mark) height per component
3. Note: if there are no published ellipsoid heights, the free adjustment also serves as the vertical free
B. Run GEOID - latest model
1.Input bfile from horizontal constrained adjustment
C. Run ADJUST
1. Resolve large residuals
D. Create vertical constrained afile
1. Constrain 1 position per component
2. Constrain all published orthometric (bench mark) heights (at least 3)
E. Run ADJUST
1.Determine if any stations should be readjusted
a. Large residuals
b. Inconsistent height shifts between results of vertical free and vertical constrained adjustments

F. Rerun ADJUST until satisfactory

**VII. Adjust with Minimum Constraints Computing Accuracies**

A. Create afile
   1. Use afile from original free adjustment
   2. Run QQRECORD to create QQ records

B. Run ADJUST
   1. Input bfile from horizontal constrained adjustment

C. Look at internal accuracies to measure internal consistency

D. Look at external accuracies to measure fit to control used
   1. Run BBACCUR to created formatted list of accuracies
   2. Should some stations be freed to meet accuracy requirements
   3. If yes, return to step V.

E. Run ELLACC to compute ellipsoid height accuracies

**VIII. Post Processing**

A. Run ELEVUP
   1. Input bfiles from final horizontal and vertical constrained adjustments
   2. Output final bfile containing adjusted positions, orthometric heights, and ellipsoid heights
   3. Edit bfile to add ellipsoid height accuracy to cc54-55 of *86* records

B. Make any other corrections necessary to bfile
   1. Rerun checking programs on final bfile
   2. Confirm all codes and values - run CLUSTER

C. Write adjustment report
   1. 1st 2 pages are NOAA forms 76-161 and 76-162 summarizing project
   2. In text discuss
      a. Purpose of project
      b. Notes on field problems
      c. Results of free and constrained adjustments - with list of constraints
      d. Rejections
      e. Readjusted positions, heights
      f. Accuracy results
      g. Problems resulting from checking programs
      p. Processing of description file

D. Print and submit
   1. Final validity checking programs
   2. Final adjustments
   3. Copies of bfile, gfile, description file
   4. Sketches or plots
   5. Signed report

# APPENDIX C

## Blue Book Checklist

Names follow current conventions.

Order-and-type codes, state codes, and elevation codes are correct.

*80* or *82* records exist for both ends of leveling observations.

Horizontal and vertical no-checks have been identified with 'N' in cc 6 and cc 5 respectively in the *80*
record.

*80* records are sorted alphabetically (optional).

Blank out elevation field for stations whose OT is 47.

Checking programs have been rerun.

The 1st Blue Book observation file record contains the observing organization's initials.

# APPENDIX D

## Project Report Checklist

Title Pages - NOAA Forms 76-161 and 76-162 (or equivalent information)

Project statistics

Order and type of project, datums, purpose

Problems encountered in the field and resolution

Checking program results

Geoid model used

Discussion of results of Free, Horizontally constrained, and vertically constrained adjustments

Discussion of procedural changes, solutions to unusual problems

List of horizontal and vertical fixed control

List of no-check stations

List of accuracies which fall below expectations, and discussion

Discussion of any readjusted stations

Discussion of overall results

Notes on description file - missing descriptions, etc.

Finally, verify numerical statistics on first pages of report

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Adm.

**COMPUTATION**
**of**
**HORIZONTAL CONTROL**

N A D  8 3  (  )

N A V D  8 8

State: _____

LOCALITY

_____
_____

.....
_____

Year of Observation, _____
Year of Computation, _____
_____

Chief of Party_____

Observer_____

Computer_____

U.S. DEPARTMENT OF COMMERCE
National Oceanic & Atmospheric Administration
National Ocean Service
National Geodetic Survey

REPORT OF HORIZONTAL CONTROL COMPUTATIONS

**********

State:

Classification:

Horizontal Datum: NAD 83 ( ) Vertical Datum: NAVD 88

Locality:

Acc. No.:

Date of Field Work: Chief of Party:

*******OFFICE COMPUTATION*******

Acc. No.: Date of Computation:

Number of Stations in project:

| | | | |
|---|---|---|---|
| New: | = | Main Scheme: | = |
| Old: | | Supplemental: | = |
| Fixed: | = | Non-monumented: | = |
| Readjusted: | = _____ | Temporary: | = _____ |
| Total | = | Total | = |

Free adjustment variance of unit weight ($\sigma^2_o$): =
Constrained adjustment variance of unit weight ($\sigma^2_1$) =
Ratio: $\sigma^2_1/\sigma^2_o$ =

_____
Geodesist in charge of work

_____
Chief of Branch

APPENDIX E
Reduction of Slope Distances to Mark-to-Mark

The following tables show the changes in the reduced distances based on elevation changes of one meter and ten meters. As you can see, the line length and the t-o are important factors in determining how much a reduced distance is going to change.

For a 100.000 meter line:

| | | Delta H 1m | Delta H 10m |
|---|---|---|---|
| | 0m | .000 | .000 |
| | 1m | .010 | .100 |
| | 2m | .020 | .200 |
| | 3m | .030 | .301 |
| | 4m | .040 | .401 |
| t-o | 5m | .050 | .502 |
| | 6m | .060 | .603 |
| | 7m | .070 | .704 |
| | 8m | .080 | .806 |
| | 9m | .090 | .908 |
| | 10m | .100 | 1.010 |

For a 500.000 meter line:

| | | Delta H 1m | Delta H 10m |
|---|---|---|---|
| | 0m | .000 | .000 |
| | 1m | .002 | .020 |
| | 2m | .004 | .040 |
| | 3m | .006 | .060 |
| | 4m | .008 | .080 |
| t-o | 5m | .010 | .100 |
| | 6m | .012 | .120 |
| | 7m | .014 | .140 |
| | 8m | .016 | .160 |
| | 9m | .018 | .180 |
| | 10m | .020 | .200 |

For a 1000.000 meter line:

| | | Delta H 1m | Delta H 10m |
|---|---|---|---|
| | 0m | .000 | .000 |
| | 1m | .001 | .010 |
| | 2m | .002 | .020 |
| | 3m | .003 | .030 |
| | 4m | .004 | .040 |
| t-o | 5m | .005 | .050 |
| | 6m | .006 | .060 |
| | 7m | .007 | .070 |
| | 8m | .008 | .080 |
| | 9m | .009 | .090 |
| | 10m | .010 | .100 |

For a 5000.000 meter line:

| | | Delta H 1m | Delta H 10m |
|---|---|---|---|
| | 0m | .000 | .000 |
| | 1m | .000 | .002 |
| | 2m | .000 | .004 |
| | 3m | .000 | .006 |
| | 4m | .001 | .008 |
| t-o | 5m | .001 | .010 |
| | 6m | .001 | .012 |
| | 7m | .001 | .014 |
| | 8m | .002 | .016 |
| | 9m | .002 | .018 |
| | 10m | .002 | .020 |

# UPDATES

September 2000:

Section 7, step added to process ADJUST using a-posteriori standard deviation of unit weight for A- and B-order projects to assure the accuracies are computed correctly.

Input blue book filename changed from *final.bbk* to *cons1.bbk*.

Add Solution Coordinate Reference System Codes 18-20 to Section One.

July 2002:

Recommended filenames removed since they are inconsistent with other documentation and therefore confusing.

Appendix describing description processing removed. These procedures are no longer used since new description formats have been in place. Refer to instructions which come with WDDPROC software.

Add Solution Coordinate Reference System Codes 21 and 22 to Section One.

February 2003

Remove references to OBSDESED since program is obsolete.

Added information to Appendix A identifying which programs are appropriate for in-house use, and which programs were required for project submission.