Appendix I
Application: Rio Guamani, Puerto Rico Section 205 Flood Control Project--GPS Horizontal and Vertical Control Densification (Jacksonville District)

This appendix is an example of a constrained adjustment of a static GPS survey performed to set basic horizontal and vertical control for a flood control project near Guayama on the south coast of Puerto Rico. The survey was performed in March 2002 by Renan L. Lopez de Azua & Associates (RLDA) under contract for the Jacksonville District. The Trimble GPSurvey screen capture below is a sketch of the 14 points that were occupied on this survey. GPS observations between points are shown by solid lines. Nine of the 14 points were held fixed in the constrained adjustment Five new 3D control points were located. No conventional observations were included in this sample adjustment although some conventional leveling was performed. These leveling observations were later included in a subsequent readjustment

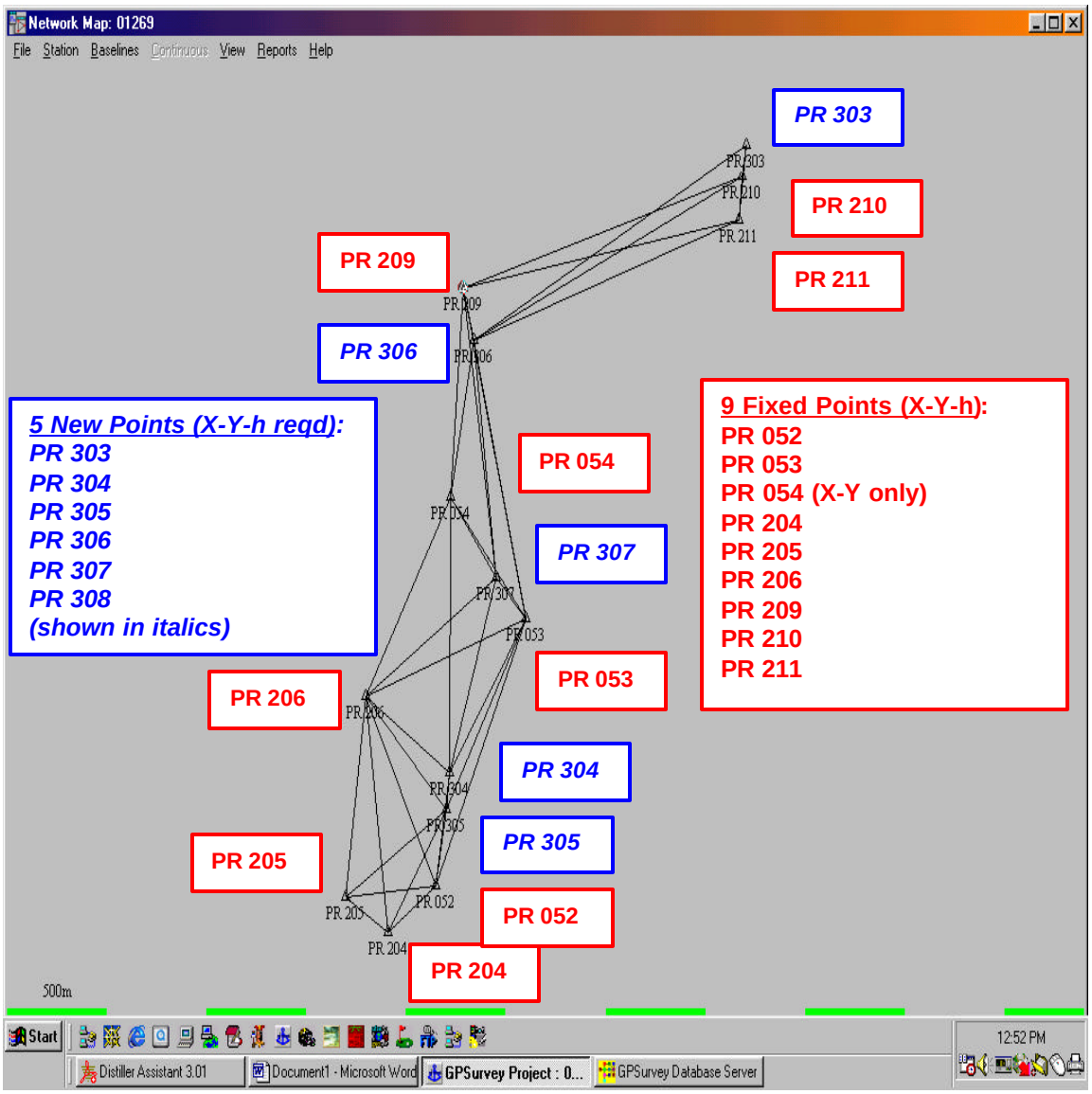

Figure I-1. Diagram of constrained network adjustment

a. A total of 46 baselines were observed on the network shown in Figure I-1 above. Since vertical densification was being performed, duplicate baseline observations were performed. One baseline was subsequently excluded from the final constrained adjustment, resulting in 45 vectors. This produced 135 3D observation equations in the final adjustment. With the 14 geoid heights, a total of 149 observations were adjusted.

b. Initially, a free adjustment was performed over the network and outliers are removed. Next, the geoid model in inserted and adjusted and revised geoid model files are inserted back into GPSurvey before the final constrained adjustment is run. These preliminary adjustments are not shown in this example--only the final constrained adjustment is illustrated on the following pages.

c. The vertical orthometric datum used for this project in Puerto Rico is "Mean Sea Level," which is often termed NGVD 29 even though there is no direct relationship with the CONUS NGVD 29 datum.

d. The following pages contain excerpts from the Technical Instructions issued by the Jacksonville District for this project.

REQUEST FOR PROPOSAL

Engineering Division
Design Branch

SUBJECT: Contract No. DACW17-02-D-0002

Mr. Renan Lopez De Azua
R. Lopez De Azua & Associates, Inc.
1959 Loiza Street
San Juan, Puerto Rico 00911-1422

Dear Mr. De Azua:

Reference contract number DACW17-02-D-0002 for Surveying and Mapping Services. The Government desires to execute a delivery order under subject contract for the following project:

RIO GUAMANI AT GUAYAMA, SECTION 205,
FLOOD CONTROL PROJECT, ADDITIONAL SURVEYS,
PLANS AND SPECIFICATIONS SURVEY, GUAYAMA, PUERTO RICO (Survey No. 01-269)

Please review the enclosed scope of work outlining the technical requirements and submit an itemized fee proposal for this work within 10 working days of receipt of this document. Please furnish this fee proposal to the attention of the Chief, Design Branch.

This request does not constitute a notice to proceed for the delivery order. Please do not commence work or incur any costs chargeable to the Government. You are cautioned that preparation of this fee proposal is entirely at your own risk and the Government can assume no obligation for payment of any related expenses incurred by your firm.

Mr. Robert Jenkins of the Survey Section is the point of contact. Please call him at 904-232-1610 if you have questions or need additional information.

Sincerely,

Walter Clay Sanders, P.E.
Assistant Chief, Engineering Division

Enclosures

TECHNICAL REQUIREMENTS
RIO GUAMANI AT GUAYAMA, SECTION 205 FLOOD CONTROL PROJECT, ADDITIONAL SURVEYS PLANS AND SPECIFICATION SCOPE SURVEY, GUAYAMA, PUERTO RICO (Survey 01-269)

1. LOCATION OF WORK. The project is located in the vicinity of Rio Guamani at Guayama, Puerto Rico.

2. SCOPE OF WORK.

2.a. The services to be rendered by the Contractor include obtaining hydrographic and topographic data of project features to be surveyed as shown on Enclosure 2 (plan plot). The project area was originally surveyed by Survey No. 98-062. The required surveys are to provide additional information not shown on the original survey. The additional data shall be merged with the original data and provide it as a single survey. All survey work shall be done in the Metric System.

2.b. The services to be rendered by the Contractor include all the work described in these technical requirements. Details not specifically described in these instructions are nevertheless a firm requirement if they can be identified as an item, or items, commonly a part of professional grade work of a comparative nature.

2.c. The Contractor shall furnish all necessary materials, labor, supervision, equipment, and transportation necessary to execute and complete all work required by these specifications.

2.d. The Corps of Engineers, Survey Section shall be contacted the same day that the Contractor plans to commence the work.

2.e. Rights-of-Entry must be obtained verbally and recorded in the field book before entering on the private property. Enter in the field book the name and address of the property owner contacted for rights-of-entry.

2.f. COMPLIANCE. : Surveying and Mapping shall be in strict compliance with EM-1110-1-1000 for Photogrammetric Mapping, EM-1110-1-1002 Survey Markers and Monumentation, EM-1110-1-1003 NAVSTAR Global Positioning System Surveying, EM-1110-1-1004 Deformation Monitoring and Control Surveying, EM-1110-1-1005 Topographic Surveying, EM-1110-2-1003 Hydrographic Surveying, EM-1110-1-2909 Geospatial Data and System, Tri-Services A/E/C CADD Standards, Tri-Services Spatial Data Standards, Related Spatial Data Products and Chapter 177, Chapter 472, and Chapter 61G17 of the Minimum Technical Standards set by the Puerto Rico Board of Professional Surveyors and Mappers

2.f(1). STANDARDS FOR DIGITAL GEOSPATIAL METADATA.
Metadata are “data about data”. They describe the content, identification, data quality, spatial data organization, spatial reference, entity and attribute information, distribution, metadata reference, and other characteristics of data. Each survey project shall have metadata submitted with the final data submittal. Furnish a digital file using CORPSMET 95 (Metadata Software) with the appropriate data included. Enclosure 5 is an example of the metadata file printed. Point of contact in Survey Section is William Mihalik at 904-232-1462.

2.g. All digital data shall be submitted on CD ROM's.

3. FIELD SURVEY EFFORT. The area of work is outlined in Enclosure 1 (technical requirements) and depicted in yellow on Enclosure 2 (prints), Enclosure 3 (digital design file), Enclosure 4 (control monuments and descriptions).

Technical Requirements: Rio Guamani at Guayama, Section 205 Flood Control Project (Continued)

3.a. CONTROL. The Horizontal datum shall be based on the Lambert Projection for Puerto Rico and the US Virgin Islands, North Zone (NAD 1983 meters). The vertical datum shall be NGVD of 1929. All control surveys shall be Third Order, Class II accuracy. Establish (replace missing or disturbed control monuments and/or set) by any of the following methods.

3.a(1) The basic control network shall be accomplished using precise differential carrier-phase Global Positioning System (GPS). Differential GPS baseline vector observations shall be made in strict accordance with the criteria contained in the engineering manual EM-1110-2-2003 and with the Geometric Geodetic Accuracy Standards And Specifications For Using GPS Relative Positioning Techniques by Federal Geodetic Control Committee, version 5.0.

3.a(2) Network design, station and baseline occupation requirements, for static and kinematic surveys, satellite observation time per baseline, baseline redundancies, and connection requirements to existing networks, shall follow the criteria given in the above said engineering manual. A field observation log shall be completed at each setup in the field.

3.a(3) GPS derived elevation data shall be supplied in reference to the above said datum. Existing benchmark data and stations shall be used in tandem in a minimally constrained adjustment program to model the geoid. All supporting data used in vertical adjustment shall be submitted. The GPS plan shall be submitted and approved by Mr. David J. Robar prior to commencing work.

3.a(4) Existing Corps of Engineers control data shall be utilized for horizontal and vertical control at the project site. The GPS network shall commence from the control shown on Enclosure 3. All established or recovered control shall be fully described and entered in a FIELD BOOK, in accordance with the Technical Requirements of this contract. All control surveys shall be Third Order, Class II accuracy. The Contractor shall submit the field data and abstracts for the control networks to Survey Section for computation before commencing the mapping. The monument designations shall be furnished as requested.

3.a(5) All horizontal and vertical control (double run forward and back) established shall be a closed traverse or level loop no spur lines, with third order accuracy. All horizontal and vertical control along with baseline layouts, sketches, and pertinent data shall be entered in field books.

3.a(6) All monuments, survey markers, etc., recovered shall be noted on the copies of control descriptions. Control points established or recovered with no description or out-of-date (5 Years old) description shall be described with sketches for future recovery use.

3.a(7) All original field notes shall be kept in standard pocketsize field books and shall become the property of the Government. The first four pages of the field books shall be reserved for indexing and the binding outside edge shall be free of all marking.

3.b. FIELD SURVEY EFFORT: A Contract Plans and Specification Scope Hydrographic, Topographic and Utility Surveys are requested of the project area.

3.b(1) Topographic Survey: Take conventional spot elevations and cross sections (field data) at intervals sufficient to calculate earthwork quantities for plans and specifications in accordance with FAR 52.236-16 QUANTITY SURVEYS. Collect additional data points necessary to define the existing terrain at alignment and grade changes, and where roads, and other feature alignments cross through or run adjacent to the survey area. The surface model shall be of adequate density and quality to produce a one-foot contour interval derived from the original digital terrain model (DTM) file. Locate and detail culverts, utilities, fences, and other structures. Locate tree lines and other planimetric features. Locate all property irons and monuments in the survey area. Plot all field data points (x,y,z) unless thinning is required for readability of text.

3.b(1)a Locate all power poles, power lines, extend limits of fencing and extend topography as noted on the enclosure.

3.b(1)b PR 53 Bridge: From north side of bridge to the intersection with PR3. Include gabions at intersection of PR 3 and PR 53.

3.b(1)c Pozo Hondo Bridge: Bridge has been replaced since previous survey and therefore must be resurveyed.

3.b(1)d At the west end of the project, determine limits of pavement, sanitary manhole and distribution, extend topo to fence along back of housing project.

3.b(1)e Fill area near northeast corner of PR 3 and PR 53.

3.b(1)f For siphon structure crossing the river, determine location and top elevation. For the structure along the edge of the street, determine location, top elevation, inverts and pipe sizes.

3,b(1)g Concrete irrigation channel, determine location, size and inverts at 50m intervals. For structure, determine location, invert and pipe size.

3.b(1)h For channel, located on southwest side of project approximately 500 meters west of PR 53, locate and provide topography from end of concrete to where it intersects with Rio Guamani.

3.b(2) PLANIMETRICS: All standard, geographic, and surface-visible features which are visible or identifiable shall be located with (X, Y, & Z) angles and distances including land use features, structural features, hydrographic features, and scale-dependent features.

3.b(3) LAND USE FEATURES: Land use features include parks, golf courses, and other recreational areas, historic areas, archeological sites, buildings, fences and walls, canals, ditches, reservoirs, trails, streets, roads, railroads, quarries, borrow pits, cemeteries, orchards, boundaries of logged-off areas and wooded areas, individual lone large trees, the trace of cross-country telephone, telegraph, and electric power transmission lines and their poles and towers, fence lines, billboards, rocks, and other walls, and similar details.

3.b(4). STRUCTURAL FEATURES: Structural features include bridges, trestles, tunnels, piers, retaining walls, dams, power plants, transformer and other substations, transportation terminals, and airfields, oil, water, and other storage tanks, and similar detail.

3.b(5) HYDROGRAPHIC FEATURES: Hydrographic features included rivers, stream, lakes, ponds, marshes, springs, falls and rapids, glaciers, water wells, and similar details.

3.b(6) CULVERT/WEIRS: Provide survey of the weirs and culverts and all appurtenances to include invert elevation of outflow pipe, diameter of pipe, waterside length of pipe to discharge, and invert elevation of pipe at discharge. Locate with X, Y, and Z all culverts and weirs. Obtain invert elevations, top elevations at both ends, length of culverts, size, and direction for the existing culverts.

3.b(7) BRIDGE SURVEYS: Elevation shall be taken every 5 meter and at any grade change in both directions. The limit shall extend 20 meter upstream and downstream of each bridge, and the width of the adjacent channel survey. Survey shall be in accordance with US ARMY CORPS OF ENGINEERS TECHNICAL REQUIREMENT FOR SURVEYING, MAPPING AND PHOTOGRAMMETRIC SERVICES Section 12.7 “Bridge Surveys”.

3.b(7)a An efforts shall be made by the survey contractor to obtain as-built data and prints of these structures which can be field verified and incorporated into the final submission. Should the survey contractor experience any difficulty in coordinating and obtaining information, the survey contractor should seek assistance from CESAJ-EN-DT Mr. Rob Jenkins at 904-232-1610 and the local sponsor's designated representative.

3.b(8) Property Corners: Locate all property irons and monuments that are found (NO PROPERTY SURVEY).

3.b(9) UTILITIES: The scope of this survey should include locating and providing data on all the existing aerial/underground utilities within the two areas. Locate all the existing aerial/surface utilities. Data required includes but is not limited to the field location of sanitary and storm sewer mains, trunks, laterals, catch basin and manholes, potable water mains, meters and valves, fire protection mains, electrical lines and poles and lowest point along the lines, transformers, junction boxes, and manholes, telephone lines, junction boxes, and manholes, cable television lines and junction boxes and Gas/Natural Mains. All utility information secured for this survey must be shown on the drawings.

3.b(9)a. SANITARY AND STORM SEWERS: The survey should include a manhole diameter, manhole construction material, size of lines, type of pipe, line size invert elevations, drop elevations in the manholes and top elevation of manholes. Obtain invert elevation and top elevations for all catch basins.

3.b(9)b. POTABLE WATER: The survey should indicate the location and elevations of the valves, meters mains.

3.b(9)c. FIRE PROTECTION MAINS: Locate all fire protection mains, fire hydrants, size of mains, type of pipe, and the type and location of valves in the survey area.

3.b(9)d. ELECTRICAL POWER LINES AND TELEPHONE LINES AND BOXES: Locate all aerial and underground lines and manholes within the survey area. Indicate the height and location (in X-Y coordinates) of poles for all aerial lines. The survey shall include the channel crossing and a minimum of two supporting structures (poles, towers,) beyond. In the event the crossing creates a junction within the two supporting structures the survey shall include two supporting structures in the direction of each leg created. Indicate the low wire elevation of all lines crossing the channel and at the power pole. The survey Contractor shall indicate electrical lines supported on bridges, and sizes of conduit, etc.

3.b(9)e. CABLE TELEVISION: Locate and name all aerial and underground cable television lines and manholes. Indicate the height and location (in X-Y-Z coordinates) of poles or manholes lines. Indicate the low wire elevation of all lines crossing the channel.

3.b(9)f. HIGHWAY RIGHT-OF-WAY/EASEMENTS. All highway or road right-of-way or easements shall be researched for recorded as-built data. Obtain additional Real Estate data as necessary including deeds, maps, title and parcel data in the vicinity to determine the correct positions of the subject right-of-way or easements. Perform a field survey traversing and connecting all available corners for each parcel or tract of land. The recorded data shall be included in the digital files.

3.b(9)g. UTILITY RIGHT-OF-WAY OR EASEMENTS. All electrical, telephone, sewer, water, cable, and electrical easements shall be researched for recorded as-built data. Obtain additional Real Estate data as necessary including deeds, maps, title and parcel data in the vicinity to determine the correct positions of the subject parcels. Perform a field survey traversing and connecting all available corners for each parcel or tract of land as needed. The record data shall be included in the digital files.

3.c BREAKLINE. Breaklines shall be located for all natural or man-make features as needed (on sections). The breaklines shall be located with X, Y, and Z and identified.

3.d DATA COLLECTION (KINEMATIC/RTK OR TOTAL STATION). Data collection will be allowed for data points only, showing all instrument positions, calibration, backsites and closing readings in the field book. Mr. Robar shall be contacted if you plan to use GPS (RTK) before utilizing. If RTK is utilized Q1 and Q2 files shall be furnished. Before using RTK, one session shall be performed around the expected survey area. After observation of the primary control (four monuments; one on each corner of the work area) the geoid model shall be prepared utilizing the four occupied monuments data. The geoid model shall be furnished to the Corps of Engineers for review and acceptance. CAUTION, unless the one session is observed with the four monuments before modeling the geoid, all data will be rejected and returned to the Contractor.

4. DATA PROCESSING. The Contractor shall make the necessary computations to verify the correctness of all measurements and apply the proper theory of location in accordance with the law or precedent and publish the results of the survey. The Contractor shall submit advance copies of the horizontal control so that USACE can compute the final positions before setting property corners that shall be established. Compute and tabulate the horizontal and vertical positions on all work performed. Review and edit all field data for discrepancies before plotting the final drawings.

4.a. Furnish X, Y, Z and descriptor ASCII file for each cross section and locate feature and one X, Y, Z, and descriptor ASCII file with all sections and features included.

5. CADD. The survey data shall be translated or digital capture into Intergraph IGDS 3D design files according to the specifications furnished. The survey data (cover, control, site plan, plan sheets, and section drawings) shall be provided in Intergraph MicroStation (PC or 32) Version 4.0 or higher, AT&T System V UNIX, CLIX R3.1 Vr. 6.3.2 format as shown in the letter dated 30 September 1992. The neat mapping area on all sheets (covers and plans) shall be 30-inches by 25-inches.

5.a. GLOBAL ORIGIN. The IGDS 3-D design file shall be prepared with a global origin of 0,0, 2147483.658, Design file master units: MM., Sub units: 1,000, and positional units: 1. The file name shall be the survey number prefixed to a "C," i.e., C269S1.DGN. All reference file's name shall commence with the C269 also.

5.b. DIGITAL TERRAIN MODEL (DTM) DATA. The Contractor shall develop and deliver a surface model of the survey area using Intergraph compatible Digital Terrain Modeling software and the model file shall have the .dtm extension. The digital terrain model shall be developed from cross sections, spot elevations, and breaklines. Breaklines should include ridges, drainage, road edges, surface water boundaries, and other linear features implying a change in slope. The surface model shall be of adequate density and quality to produce at 1-Foot minor contour interval and major contours on an interval of 5-Foot derived from the original DTM (Digital Terrain Model) file. The contour data shall be incorporated as a reference file into the final data set. All data used to develop the DTM's shall be delivered in Intergraph 3-D design files.

5.b(1) CONTOURS. The contours shall be developed in the digital terrain model (DTM). The contours shall be provided in one or more master DGN files and attached as a reference file to all sheet files utilizing the clip bounds methods. Each contour shall be drawn sharp and clear as a continuous solid line, dashed contours are not acceptable. Every index contour shall be accentuated as a heavier line than the intermediate and shall be annotated according to its actual elevation above NGVD 29. Whenever index contours are closer than one-quarter (1/4) inch, and the ground slope is uniform, the intermediate shall be omitted (in this case only plot the 5-Foot contours). Labeling or numbering of contours shall be placed on top of the contour line, so that the elevation is readily discernible, do not break contours. Labeling of intermediate contours may be required in areas of low relief.

5.c. MASTER DGN FILES. (Scale 1:1)

5.c(1) The survey data (DTM data points) points shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods.

5.c(2) The planimetric data shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods.

5.c(3) The culvert/weirs data shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods.

5.c(4) The bridge data shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods.

5.c(5) The road data shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods.

5c(6) The utility data points shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods.

5.c(7) The contours shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods.

5.c(8) The breaklines shall be provided in one or more master DGN file and attached as a reference file to all sheet files utilizing the clip bounds methods DO NOT PLOT THE BREAKLINES.

5.d. COVER AND CONTROL SHEET. The first sheet shall be a cover sheet showing the control sketch, survey control tabulation, sheet layout or index, legend, project location map, survey notes, north arrow, graphic scale, grid ticks, and large signature block. Tabulate, plot, and list the horizontal control used for the survey on the final drawings.

5.e. PLAN SHEETS : The plan sheets shall be prepared to a scale of 1:1000 and 1:200 (METRIC), in the Corps of Engineers format (reference letter and instruction dated September 30, 1992) showing notes, title block, grid, north arrow, graphic scale, legend, sheet index, and D. O. File Number. Sheets shall be oriented with north to the top. The extreme right 177.8MM/7 inches of the sheet shall be left blank for notes, legends, etc. The second sheet and all sheets following shall be a continuation sheet and shall have a minimum of two notes, note 1: See Drawing number 1 for notes, note 2: Refer to Survey No. 01-269. Plans sheets title block shall be labeled as shown in Enclosure 4.

5,e(1) Section Views. The sections shall be extracted and displayed from the digital terrain model (DTM OR TNT) utilizing INROADS OR INXPRESS. The sections shall be generated or extracted along the same azimuth as the section was collected in the field. The sections shall be displayed at a 10 to 1 vertical exaggeration. The planimetric lines (alignment of extraction), alignment, stations, and cross sections shall be displayed in one DGN file, **"DO NOT PLOT"** .

6. MAP CONTENT.

6a. Coordinate Grid: Grid ticks (English) of the applicable State Plane Coordinate System shall be properly annotated at the top, bottom and both sides of each sheet. Spacing of the grid ticks shall be 127MM/5 inches apart.

6.b. CONTROL. All horizontal and vertical ground control monuments shall be shown on the maps in plan and tabulated. In addition, show the channel limits (station, range and R/W) on the completed drawings.

6.c. PLANIMETRIC. The maps shall contain all surface-visible utilities and planimetric which are visible or identifiable.

6.d. TOPOGRAPHY. The map shall contain all representable and specified topographic features which are visible or identifiable.

6.e. SPOT ELEVATIONS. Spot elevations shall be shown on the maps in proper position. In areas where the contours are more than 3 inches apart at map scale, spot elevations shall be shown. The horizontal distance between the contours and such spot elevations or between the spot elevations shall not exceed two (2) inches at scale of delivered maps.

6.f. CONTOURS. The contours shall be developed in the digital terrain model (DTM). Each contour shall be drawn sharp and clear as a continuous solid line, dashed contours are not acceptable. Every index contour shall be accentuated as a heavier line than the intermediate and shall be annotated according to its actual elevation. Whenever index contours are closer than one-quarter (1/4) inch, and the ground slope is uniform, the intermediate shall be omitted. Labeling or numbering of contours shall be placed on top of the contour line, so that the elevation is readily discernible, do not break contours. Labeling of intermediate contours may be required in areas of low relief.

6.g. MAP EDIT. All names, labels, notes, and map information shall be checked for accuracy and completeness. All commercial buildings, roads and man made features shall be labeled with the type of construction, purpose and name. All residences shall be labeled with the type of construction.

6.h. SHEET INDEX AND LEGEND. On plan drawings a small scale sheet index shall be shown on each sheet of the series; highlighting the sheets in the standard manner. Planimetric and topographic feature legends shall be shown on each sheet. Contractor logo shall be shown on each drawing.

6.i. MAP ACCURACY. All mapping shall conform to the national map accuracy standards except that no dashed contour line will be accepted.

7. SURVEY/QUALITY CONTROL REPORT. The Contractor shall furnish a digital (*.doc) file on the final CD. The report shall include Right-of-Entry information, Control monuments Designation recovered, destroyed, fixed, included in control network, tide gauge location and monument used, dates of field survey collection, types of equipment used, quality control checks, and digital files. Unique circumstances and/or issues related to this survey, general approach/methodology to this survey. Along with any other data required in accordance with the law or precedent and for the Corps of Engineers to publish the results of the survey.

8. DELIVERIES. On completion, all data required shall be delivered or mailed to Design Branch, Survey Section at the address shown in contract, and shall be accompanied by a properly numbered, dated and signed letter or shipping form, in duplicate, listing the materials being transmitted. All costs of deliveries shall be borne by the Contractor. Items to be delivered include, but are not limited to the following:

8.a. GPS network plan, (before GPS work commences).
8.b. GPS raw data log sheets filled out in field with all information and sketches.
8.c. Plan sheet layout.
8.d. Computation files with Horizontal and Vertical abstracts along with any Q1 and Q2 files.
8.e. Horizontal and Vertical Field Books.
8.f. Furnish X, Y, Z, and descriptor ASCII file for each cross section and one merged with all data collected for all cross section.
8.g. DTM File.
8.h. DGN files to a scale of 1:1000 and 1:200.
8.i. Furnish a digital file using CORPSMET 95 (Metadata Software) with the appropriate data included.
8.j. Advance paper plots of all plan sheets, cover sheet and control sheets for approval.
8.k. Final paper plots on standard sized (30-inches by 42-inches, 2 set paper plots).
8.l. Survey Report C269*.doc file.

I-1. Loading RINEX Files for Baseline Processing

This screen capture in Figure I-2 below shows how the RINEX baseline observation files (e.g., *.02o) are loaded from the source file directory into the program GPSurvey. At this stage baselines can be selectively included or excluded from the adjustment.

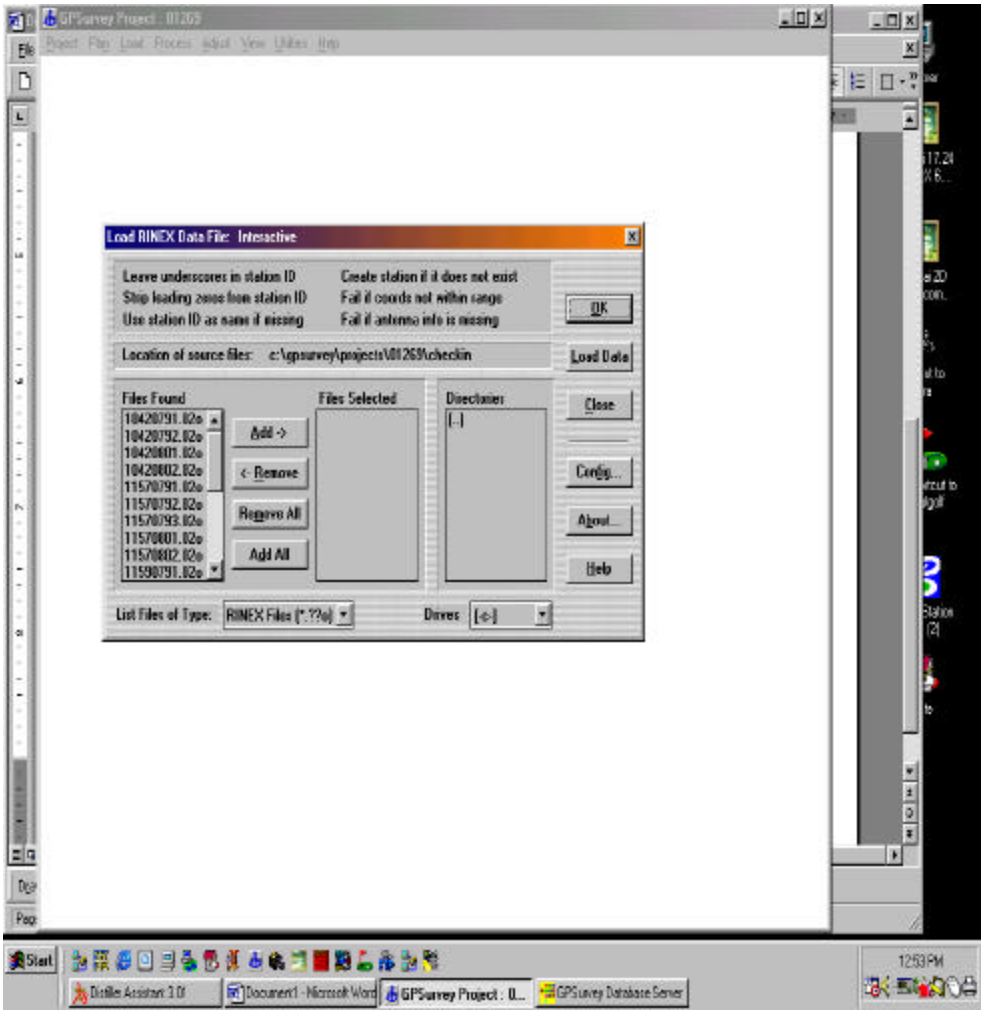

Figure I-2. Loading RINEX data files

The screen capture in Figure I-3 below taken from GPSurvey shows which files were actually selected to be loaded for the project. In this example, all the observed lines were included.

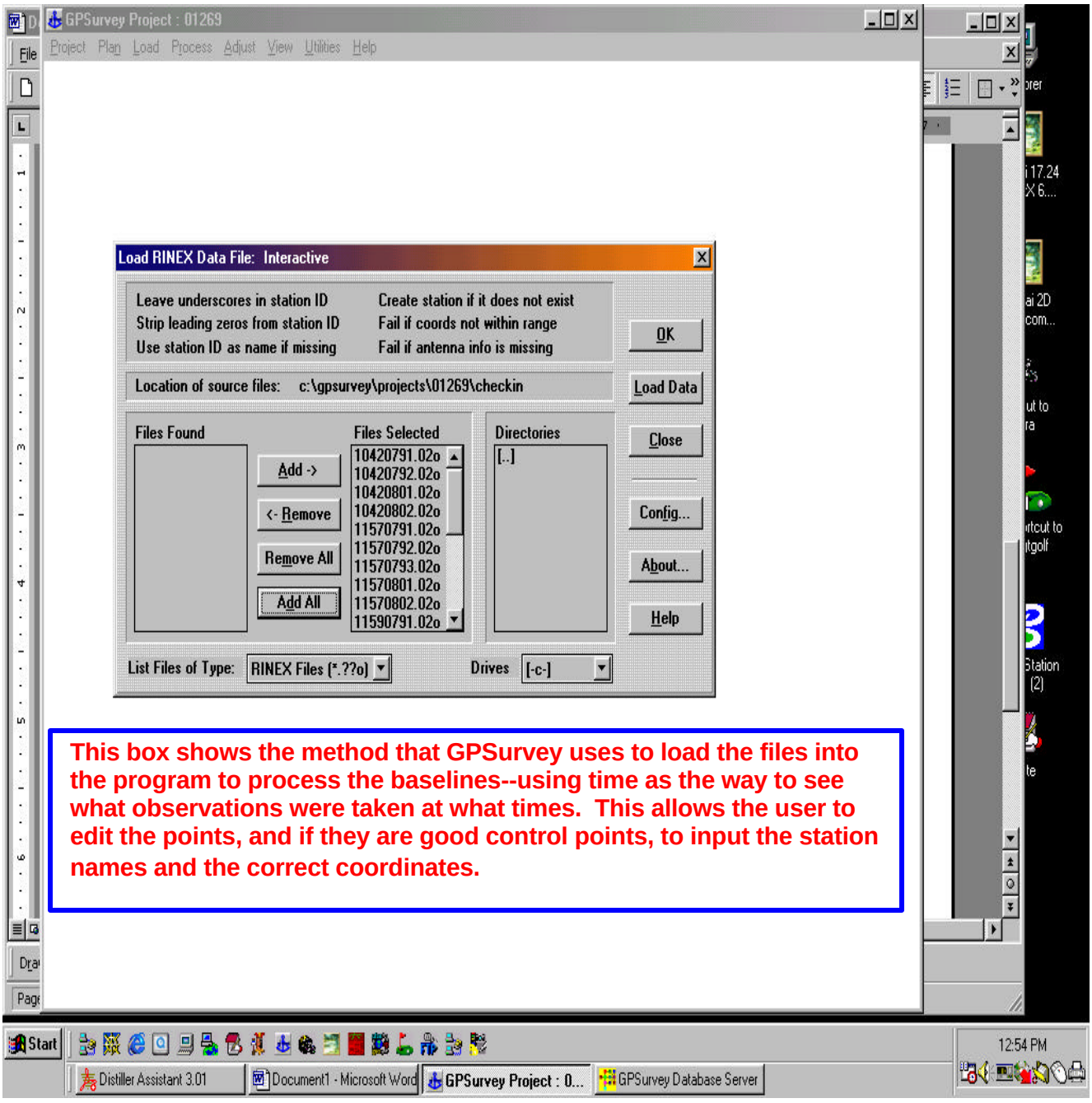

Figure I-3. Selected files for baseline processing

This screen in Figure I-4 shows the RINEX navigation file (e.g., *.02n) that is selected for the processing with the baseline file.

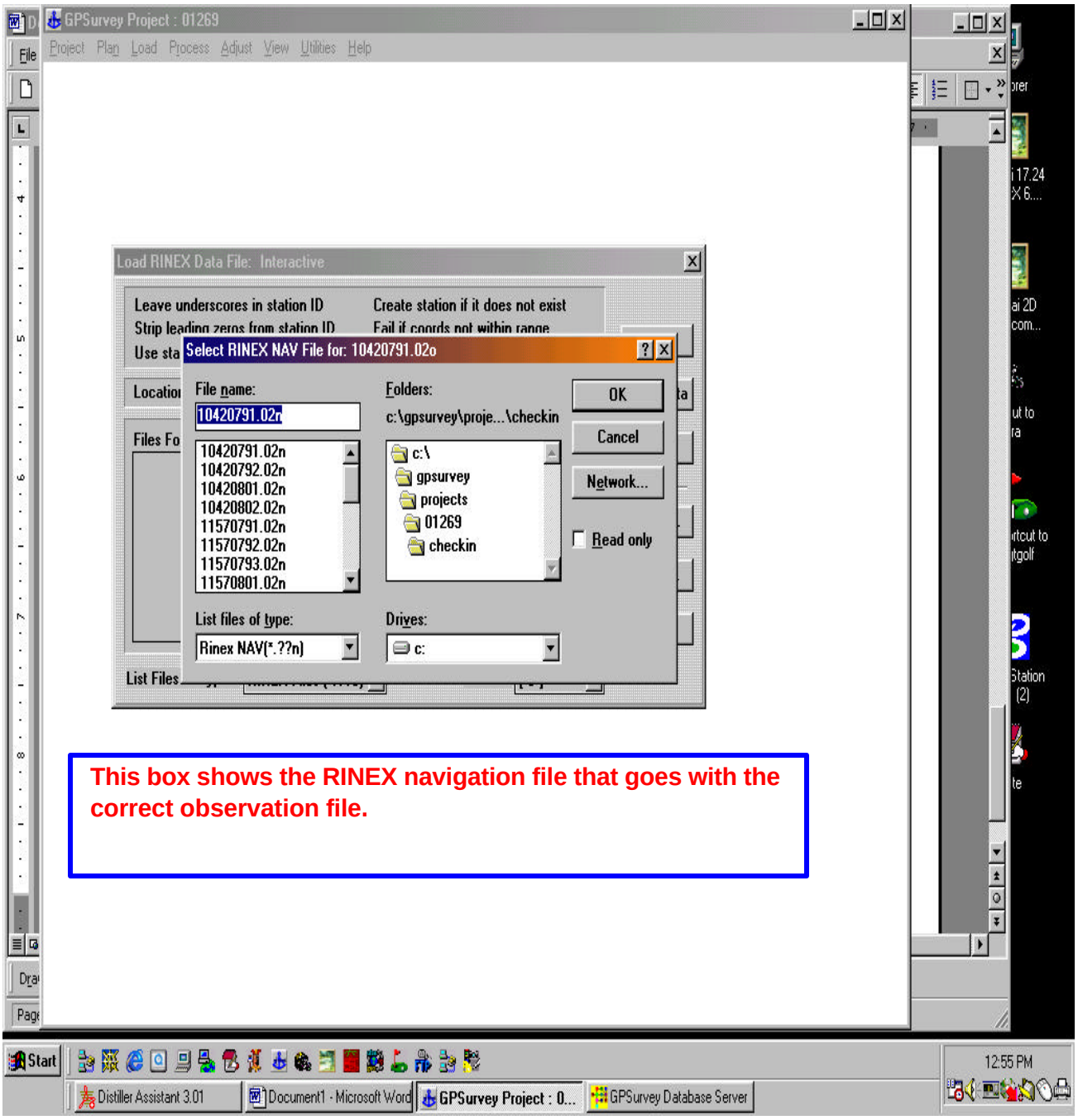

Figure I-4. Loading RINEX navigation files

This screen capture (Figure I-5) from the Trimble WAVE Baseline Processor shows what baselines will be processed using the times of the observation as the key to processing.

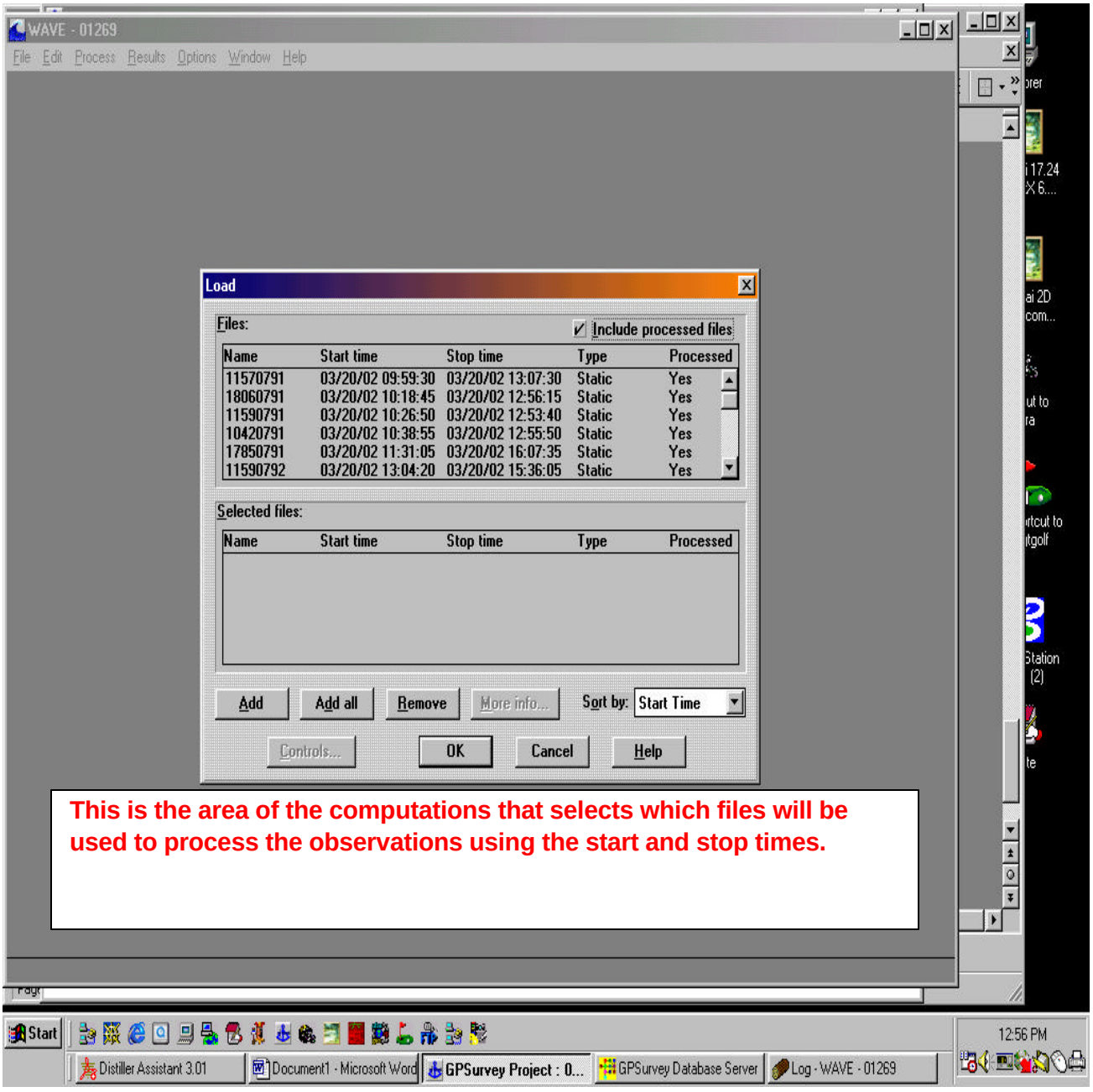

Figure I-5. Trimble WAVE Baseline Processor file listing

Figure I-6 depicts the files transferred and loaded for baseline processing. The files are sorted by observation time. All files were selected for processing.

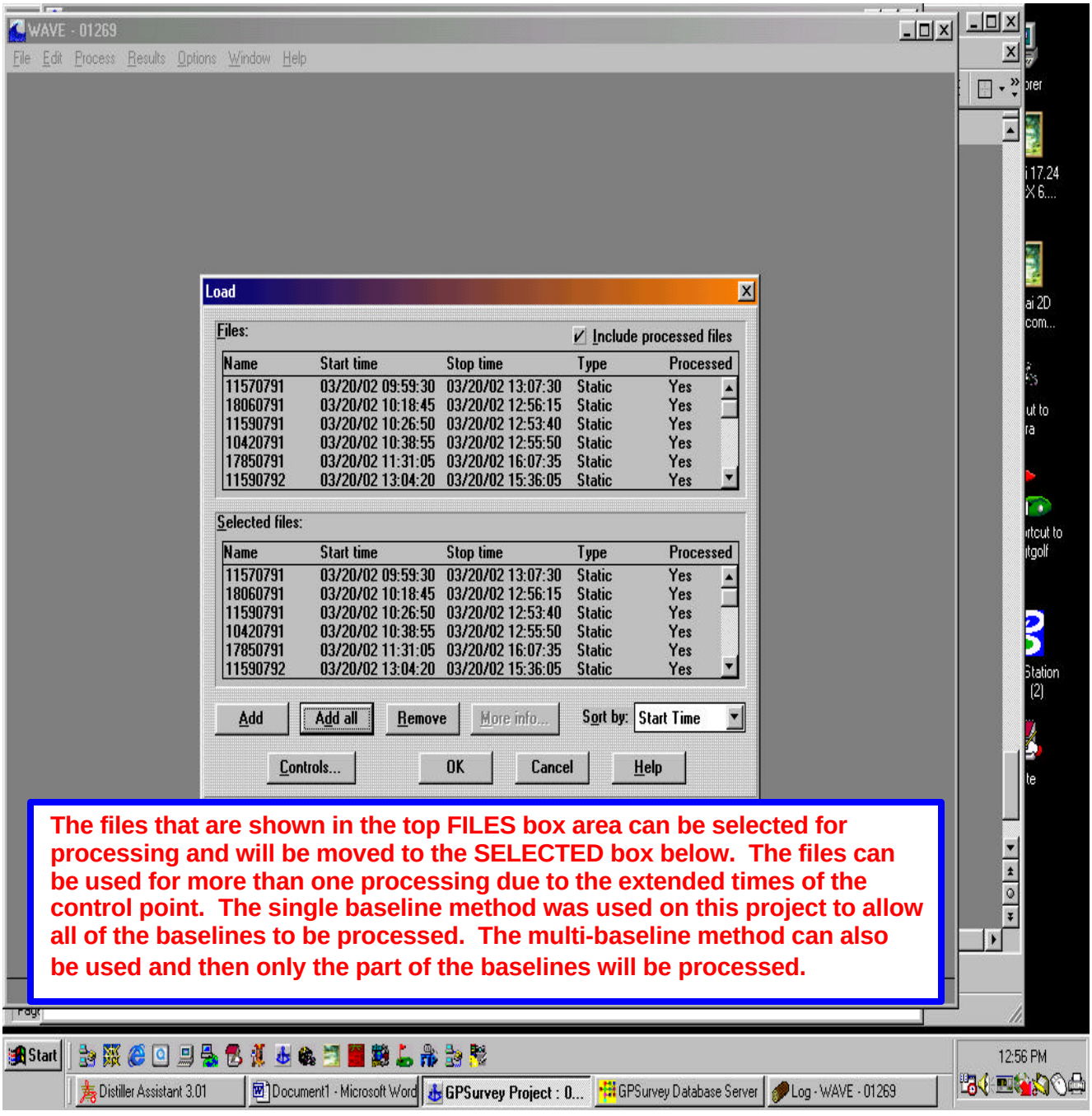

Figure I-6. Loaded files sorted by observation times

Figure I-7 shows the file loading status--with observation 11570791 currently loading.

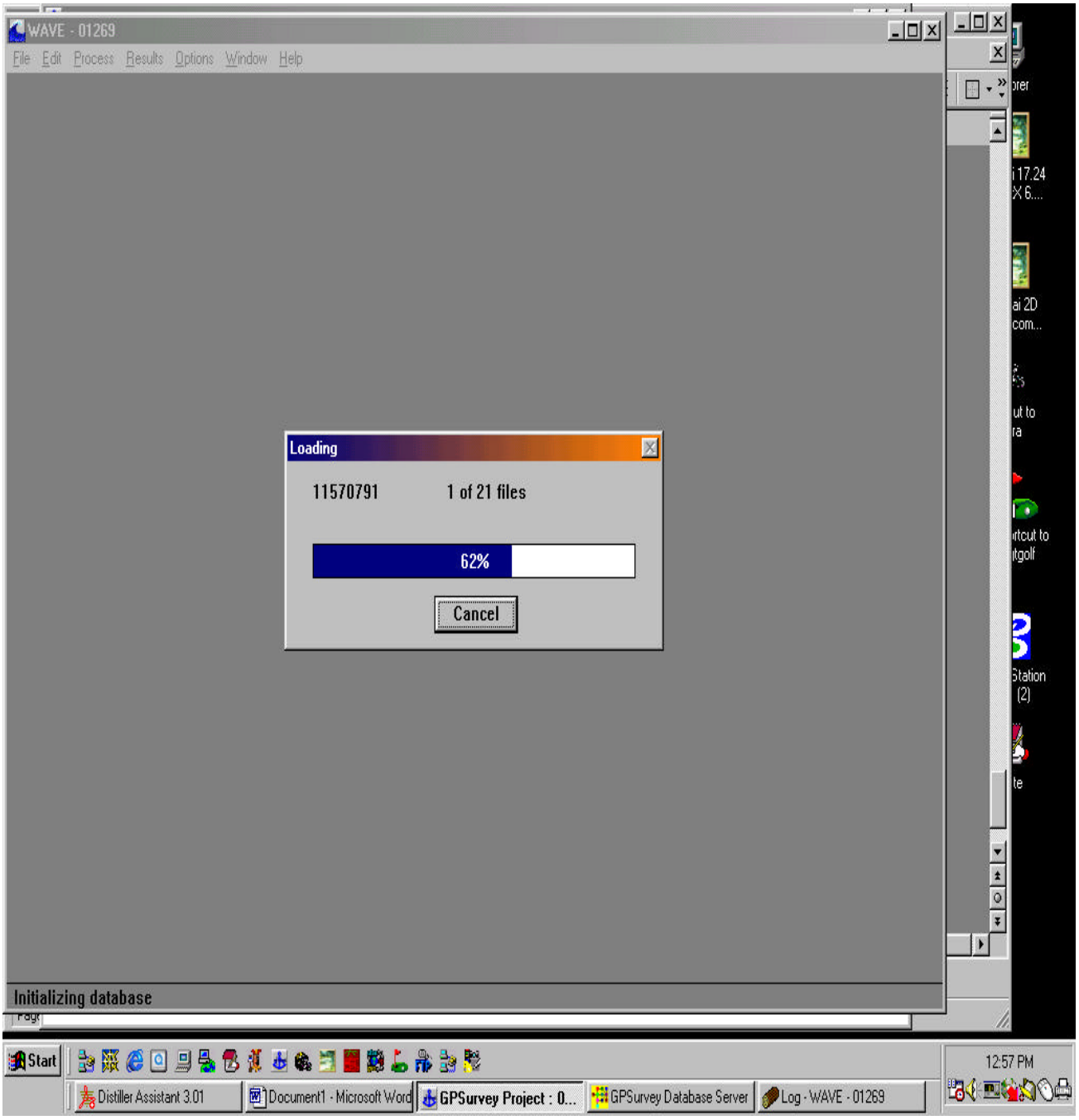

Figure I-7. Loading individual baseline observation files

I-2. Static Baseline Processing (Trimble WAVE Baseline Processor)

This screen (Figure I-8) shows the setup for processing static baseline observations. Start and stop times are indicated. In this example, "All Baselines" were selected. "Independent" or "User Defined" baselines could have been opted at this stage.

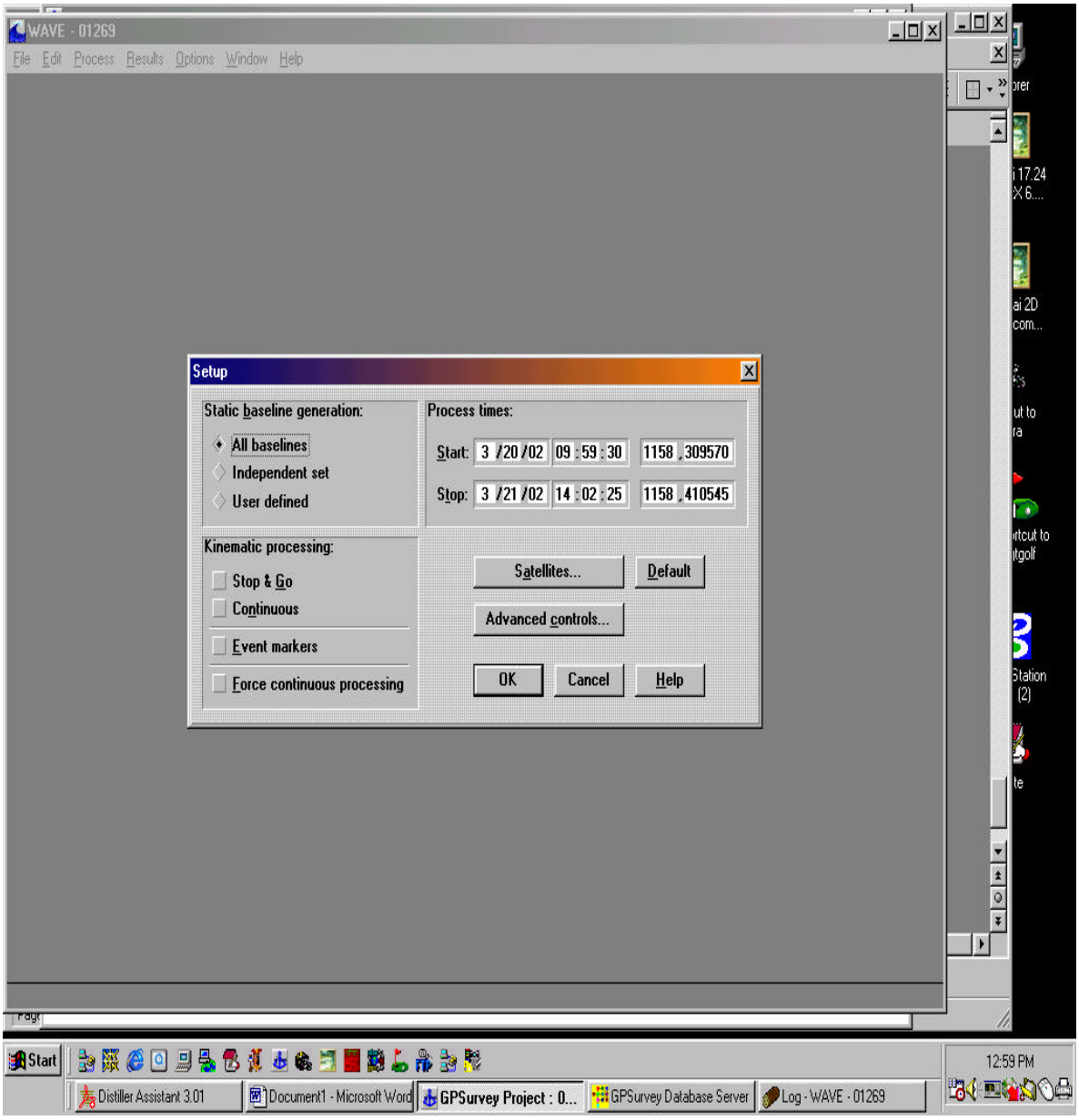

Figure I-8. WAVE setup for baselines to be processed

This screen capture (Figure I-9) shows the Advanced Control options that can be specified--e.g., satellite elevation mask, iterations, search times, etc. The Broadcast Ephemeris is selected in this example--if the Precise Ephemeris were available, then this file could have been loaded. Residual Generation and Antenna Phase Correction options are also turned on for these baseline reductions.

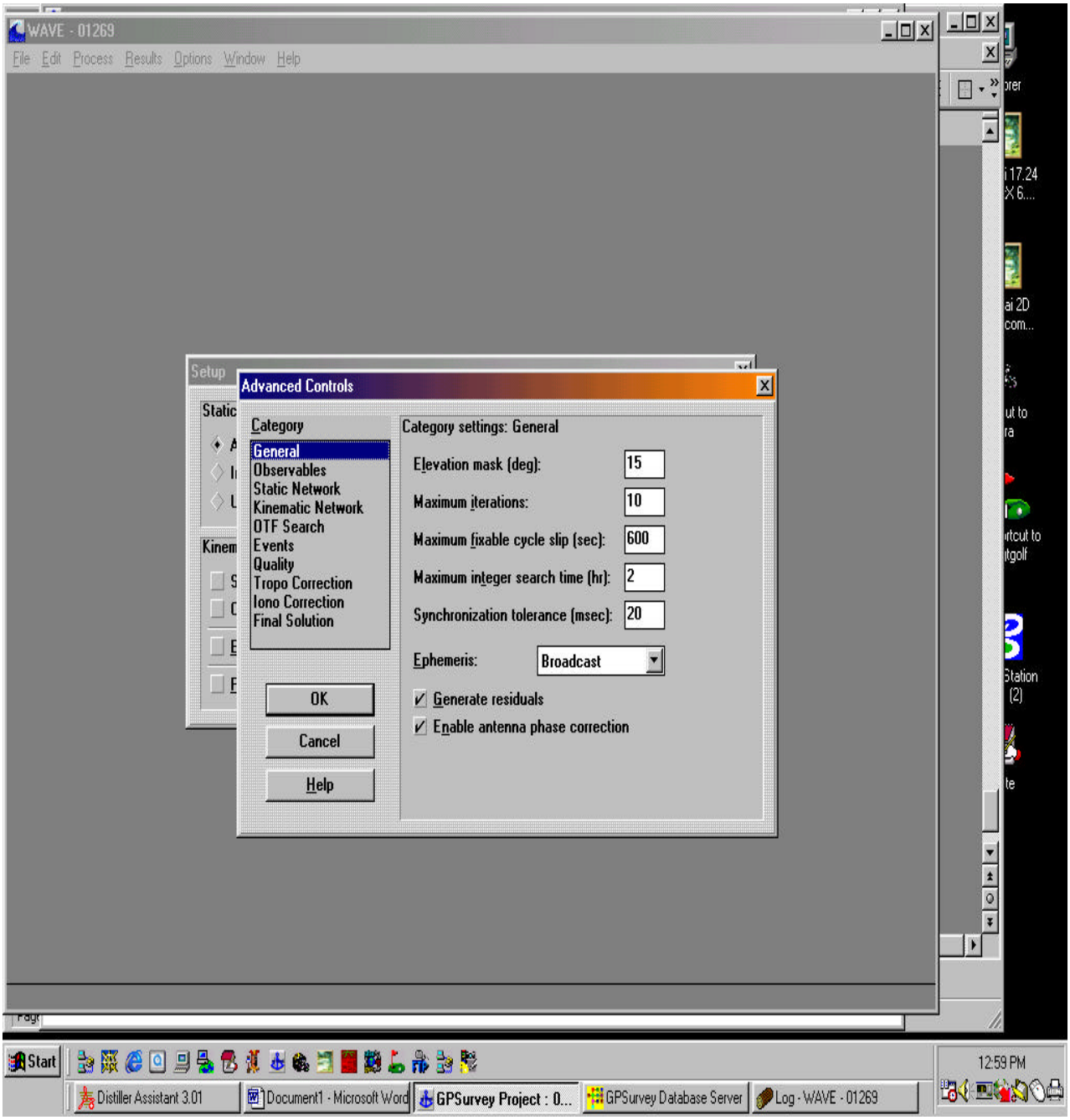

Figure I-9. Trimble WAVE Baseline Processor Advanced Controls screen

As baselines are being processed, this screen (Figure I-10) shows which specific baseline is currently being processed and its completion status.

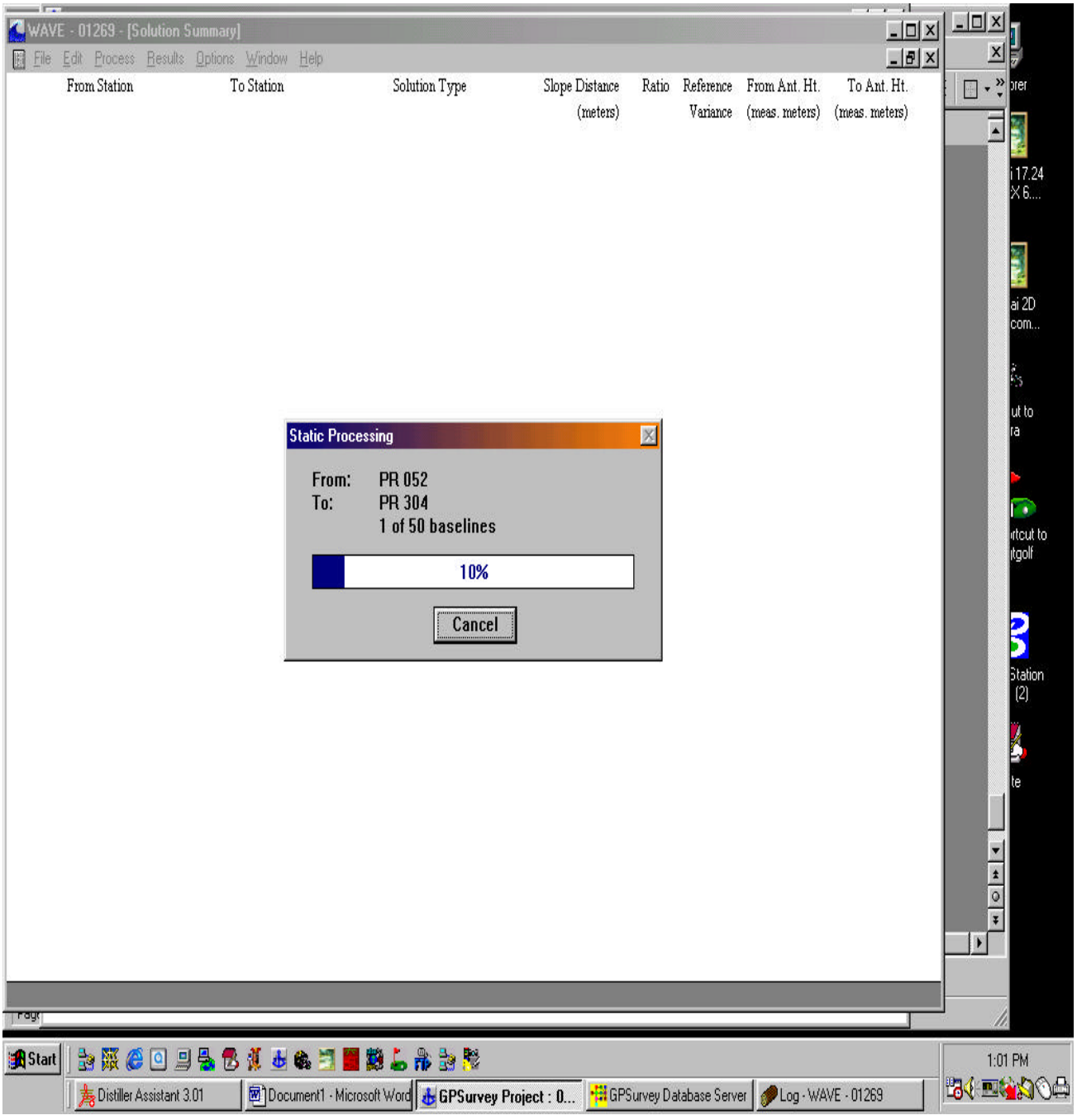

Figure I-10. Trimble WAVE Baseline Processor--Static Processing screen

As processing progresses, for each completed baseline the WAVE Baseline Processor outputs the display shown in Figure I-11 below. From Station, To Station, Solution Type, Slope Distance, Ratios, Reference Variances, and Antenna Height data are tabulated for code, triple, float and/or fixed solutions. The adequacy of the baseline solutions is evaluated from the resultant ratios and variances, as was described in Chapter 10. (A detailed baseline reduction summary report is not shown for lines on this project--see Chapter 10 for a typical example).

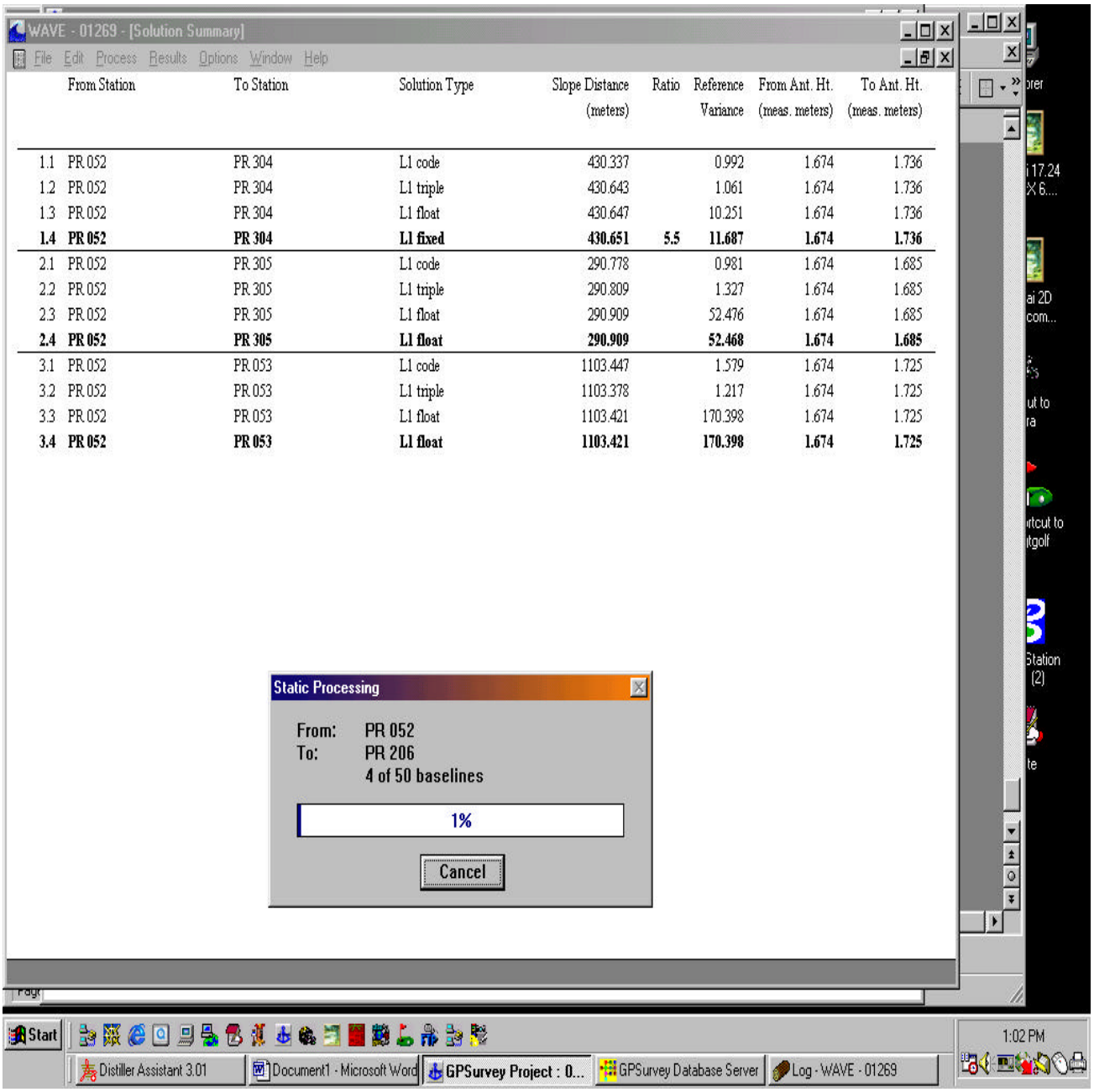

Figure I-11. Trimble WAVE Baseline Processor--Static Processing screen

I-3. Constrained Network Adjustment (Trimble GPSurvey)

Figure I-12 below shows the screen that starts the loading of all of the baselines into the GPS network for the free and final adjustments. During this process one can change the names of baselines if errors were made and were not put on the observation log sheets.

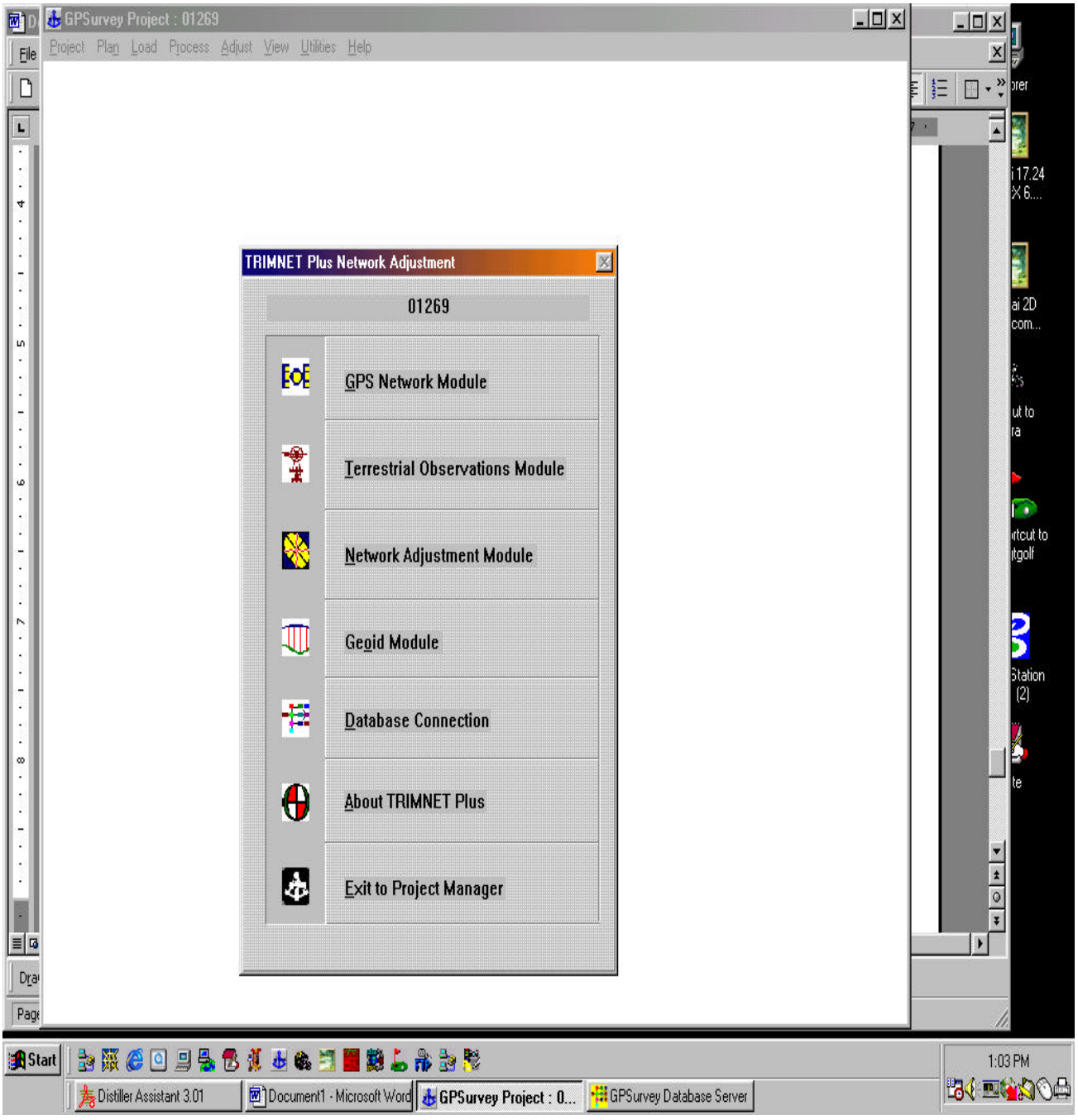

Figure I-12. Trimble GPSurvey option screen

Fixed values are set for the known control points. (Only 6 of the 9 fixed points are listed below). All are fixed in X, Y, and orthometric elevation, except point PR 054 which is fixed only in X-Y.

COORDINATE EDITING FIELD

PT#	NAME	NORTH/EAST	ELL(H)/ORTH(h)	FIX	KNWN
1	PR 052	215011.4802	-7.5431	YX-h	YXHh
		232319.5773	33.8990		
2	PR 053	216017.8960	4.0567	YX-h	YXHh
		232771.9230	45.4270		
3	PR 054	216466.5690	20.4581	YX--	YXHh
		232394.4000	61.7864		
4	PR 204	214840.3600	-10.9963	YX-h	YXHh
		232081.2180	30.4390		
5	PR 205	214972.4560	-10.4586	YX-h	YXHh
		231867.1890	30.9650		
6	PR 206	215719.3160	52.5379	YX-h	YXHh
		231966.5380	93.8970		

ESC=EXIT ENTER=SAVE ,TAB=CURSOR PgUp PgDn (ALT)F2-F5=(SET)CLEAR FIX

ADJUSTMENT ACTIVITY LOG
NETWORK = 01269
TIME = Tue Aug 20 13:09:54 2002

Adjustment process underway.
Computing closures.
Closures have been computed.
Indexing observation equations and unknowns.
Number of sub-networks = 1.
Number of inner constraints sub-network 1 = 0.

Sub-network 1: Fixed y = 9 Fixed x = 9 Fixed H = 0
Fixed h = 8.

Points included in sub-network 1:
- PR 052
- PR 053
- PR 054
- PR 204
- PR 205
- PR 206
- PR 209
- PR 210
- PR 211
- PR 303
- PR 304
- PR 305
- PR 306
- PR 307

Initializing parameter group 1: GPS Observations.
90 horizontal observations
45 vertical observations
45 observed azimuths
45 observed distances
Located in sub-network 1.
9 fixed latitudes
9 fixed longitudes
0 fixed ellipsoid heights
8 fixed orthometric heights
Y rotation parameter 1 = 31.
X rotation parameter 2 = 32.
Azimuth rotation parameter 3 = 33.
Network scale parameter 4 = 34.
Omitting parameter 5 by user choice
Omitting parameter 6 by user choice
Omitting parameter 7 by user choice

Initializing parameter group 3: Geoid Model.
0 horizontal observations
14 vertical observations
0 observed azimuths
0 observed distances
Located in sub-network 0.
0 fixed latitudes
0 fixed longitudes
0 fixed ellipsoid heights
8 fixed orthometric heights
Transformation 1 ruled ineligible.
Transformation 2 ruled ineligible.
Transformation 3 ruled ineligible.
Transformation 4 ruled ineligible.
Transformation 5 ruled ineligible.
Transformation 6 ruled ineligible.
Transformation 7 ruled ineligible.

Number of fixed horizontal coordinates = 18.
Number of fixed vertical coordinates = 8.
Number of observation equations = 149.
Number of vertical observation equations = 59.
Number of unknowns = 34.
Number of inner constraint equations = 0.
The following observations are excluded from the adjustment:
39
40
41

The following points were excluded from the adjustment:
none

Proceeding with observation equations.
Turning on graphics before going into adjustment iteration.
Beginning adjustment iteration 1.
Forming observation equations.
Performing observation covariance inverses.
Forming constants and normal equations.
Computing normals inverse.
Computing observation residuals.
Solutions from iteration 1:
1 2.854913e-005
2 -2.935114e-005
3 -9.454666e-006
4 -1.135234e-006
5 -1.135234e-006
6 1.091846e-007
7 2.731083e-008
8 -5.073252e-006
9 1.715210e-005
10 1.715210e-005
11 -1.007466e-006
12 4.382808e-007
13 6.931903e-006
14 6.931903e-006
15 6.961781e-007
16 -2.403132e-007
17 8.987806e-006
18 1.346934e-005
19 1.346934e-005
20 2.070258e-005
21 1.626538e-005
22 1.626538e-005

ADJUSTMENT ACTIVITY LOG (Continued)

23 -1.993965e-005
24 -4.512070e-007
25 -1.089678e-005
26 -3.463680e-006
27 -4.153571e-006
28 -4.153571e-006
29 6.861524e-007
30 -1.480108e-007
31 2.050461e-004
32 1.875429e-003
33 6.811946e-005
34 -6.488047e-010

Recomputing closures for check on residuals
Iteration check on residuals (tolerance = 1.0e-005):

```
eq #    1 obs #    1 = -1.172920e-002 - -1.172920e-002 = +1.809317e-015
eq #    2 obs #    2 = -2.725732e-003 - -2.725732e-003 = +3.192759e-015
eq #    3 obs #    3 = -3.388132e-021 - +0.000000e+000 = +3.388132e-021
eq #    4 obs #    4 = +2.743241e-003 - +2.743241e-003 = +4.312089e-015
eq #    5 obs #    5 = +1.184806e-003 - +1.184806e-003 = +1.869165e-016
eq #    6 obs #    6 = +1.445093e-002 - +1.445093e-002 = +1.059916e-015
eq #    7 obs #    7 = -9.747927e-003 - -9.747927e-003 = +5.759282e-016
eq #    8 obs #    8 = +1.903540e-003 - +1.903540e-003 = +1.575563e-015
eq #    9 obs #    9 = +3.920341e-003 - +3.920341e-003 = +1.554312e-015
eq #   10 obs #   10 = +0.000000e+000 - +0.000000e+000 = +0.000000e+000
eq #   11 obs #   11 = -8.470329e-022 - +0.000000e+000 = +8.470329e-022
eq #   12 obs #   12 = +2.117582e-022 - +0.000000e+000 = +2.117582e-022
eq #   13 obs #   13 = +0.000000e+000 - +0.000000e+000 = +0.000000e+000
eq #   14 obs #   14 = +6.776264e-021 - +0.000000e+000 = +6.776264e-021
eq #   15 obs #   15 = -6.987002e-001 - -6.987002e-001 = +3.958023e-011
eq #   16 obs #   16 = +3.973133e-003 - +3.973130e-003 = +3.200652e-009
eq #   17 obs #   17 = +5.760878e-002 - +5.760878e-002 = +1.616346e-013
eq #   18 obs #   18 = +1.586500e+000 - +1.586500e+000 = +5.998612e-008
eq #   19 obs #   19 = -2.164304e-002 - -2.164304e-002 = +5.047094e-009
eq #   20 obs #   20 = +6.403900e-003 - +6.403901e-003 = +7.033141e-010
eq #   21 obs #   21 = +2.027594e+000 - +2.027594e+000 = +2.697398e-011
eq #   22 obs #   22 = +4.625992e-002 - +4.625992e-002 = +5.238827e-010
eq #   23 obs #   23 = -6.325114e-003 - -6.325114e-003 = +1.996675e-013
eq #   24 obs #   24 = +9.153852e+000 - +9.153853e+000 = +3.238207e-007
eq #   25 obs #   25 = +6.079804e-003 - +6.079805e-003 = +1.324542e-009
eq #   26 obs #   26 = +1.030900e-002 - +1.030900e-002 = +2.308817e-010
eq #   27 obs #   27 = -1.284557e+001 - -1.284557e+001 = +4.230263e-007
eq #   28 obs #   28 = +1.100492e-002 - +1.100492e-002 = +1.224835e-009
eq #   29 obs #   29 = +3.674400e-002 - +3.674400e-002 = +5.064874e-010
eq #   30 obs #   30 = +9.199836e+000 - +9.199836e+000 = +6.668890e-007
eq #   31 obs #   31 = +7.156526e-002 - +7.156526e-002 = +1.585227e-009
eq #   32 obs #   32 = -8.199078e-003 - -8.199080e-003 = +2.176101e-009
eq #   33 obs #   33 = +3.572660e+000 - +3.572660e+000 = +6.910694e-011
eq #   34 obs #   34 = -6.813613e-002 - -6.813613e-002 = +4.435793e-009
eq #   35 obs #   35 = +1.161688e-002 - +1.161688e-002 = +1.747977e-013
eq #   36 obs #   36 = -4.230644e+001 - -4.230644e+001 = +2.053469e-012
eq #   37 obs #   37 = -6.084741e-002 - -6.084741e-002 = +8.463078e-010
eq #   38 obs #   38 = +1.902216e-002 - +1.902216e-002 = +9.575674e-016
eq #   39 obs #   42 = +6.152651e+000 - +6.152651e+000 = +5.531042e-011
eq #   40 obs #   43 = -4.564548e-003 - -4.564547e-003 = +1.372292e-009
eq #   41 obs #   44 = -5.731869e-003 - -5.731869e-003 = +1.098175e-013
eq #   42 obs #   45 = -7.877954e-001 - -7.877955e-001 = +1.334509e-007
eq #   43 obs #   46 = +3.354646e-002 - +3.354646e-002 = +1.968335e-009
eq #   44 obs #   47 = +1.752018e-002 - +1.752019e-002 = +5.410225e-010
eq #   45 obs #   48 = +6.442804e-001 - +6.442799e-001 = +4.696995e-007
eq #   46 obs #   49 = -8.173709e-003 - -8.173708e-003 = +6.671547e-010
eq #   47 obs #   50 = +4.028200e-003 - +4.028195e-003 = +4.943828e-009
eq #   48 obs #   51 = +7.818527e+001 - +7.818527e+001 = +5.998611e-008
eq #   49 obs #   52 = +4.574225e-001 - +4.574225e-001 = +5.047094e-009
eq #   50 obs #   53 = -2.897678e-001 - -2.897678e-001 = +7.036552e-010
```

ADJUSTMENT ACTIVITY LOG (Continued)

```
eq #   51 obs #   54 = -1.433430e+000 - -1.433430e+000 = +2.697398e-011
eq #   52 obs #   55 = +1.431538e-002 - +1.431537e-002 = +5.238827e-010
eq #   53 obs #   56 = -7.738471e-004 - -7.738471e-004 = +1.996680e-013
eq #   54 obs #   57 = -6.310346e+001 - -6.310346e+001 = +4.630607e-011
eq #   55 obs #   58 = +5.137484e-001 - +5.137484e-001 = +1.054321e-009
eq #   56 obs #   59 = -2.815387e-001 - -2.815387e-001 = +1.278977e-013
eq #   57 obs #   60 = +8.221172e+001 - +8.221172e+001 = +1.446183e-007
eq #   58 obs #   61 = +3.601027e-001 - +3.601027e-001 = +1.398636e-009
eq #   59 obs #   62 = -2.123748e-001 - -2.123748e-001 = +1.761587e-009
eq #   60 obs #   63 = +1.433463e+002 - +1.433463e+002 = +2.587701e-007
eq #   61 obs #   64 = +3.651871e-001 - +3.651871e-001 = +3.239688e-009
eq #   62 obs #   65 = -7.682988e-002 - -7.682989e-002 = +4.859315e-010
eq #   63 obs #   66 = -8.057405e+000 - -8.057408e+000 = +2.663404e-006
eq #   64 obs #   67 = -2.428793e-002 - -2.428794e-002 = +1.056293e-008
eq #   65 obs #   68 = +1.022291e-002 - +1.022291e-002 = +2.236477e-009
eq #   66 obs #   69 = +1.043459e+000 - +1.043459e+000 = +4.850657e-007
eq #   67 obs #   70 = +3.335514e-002 - +3.335514e-002 = +6.000156e-009
eq #   68 obs #   71 = -3.885174e-003 - -3.885173e-003 = +1.363619e-009
eq #   69 obs #   72 = -2.530377e+001 - -2.530377e+001 = +5.300641e-007
eq #   70 obs #   73 = +1.943408e-001 - +1.943408e-001 = +1.436075e-009
eq #   71 obs #   74 = +5.981976e-002 - +5.981976e-002 = +6.784776e-010
eq #   72 obs #   75 = -3.876707e+002 - -3.876707e+002 = +6.668890e-007
eq #   73 obs #   76 = -5.318146e-001 - -5.318146e-001 = +1.585227e-009
eq #   74 obs #   77 = -1.246179e-001 - -1.246179e-001 = +2.177010e-009
eq #   75 obs #   78 = -4.999991e+000 - -4.999992e+000 = +2.567016e-007
eq #   76 obs #   79 = -8.464778e-004 - -8.464774e-004 = +4.184973e-010
eq #   77 obs #   80 = +5.878313e-002 - +5.878313e-002 = +3.522176e-010
eq #   78 obs #   81 = -3.041574e+001 - -3.041574e+001 = +1.918465e-013
eq #   79 obs #   82 = +6.040496e-001 - +6.040496e-001 = +8.466833e-010
eq #   80 obs #   83 = -7.491374e-002 - -7.491374e-002 = +2.220446e-016
eq #   81 obs #   84 = -8.818368e+000 - -8.818368e+000 = +6.838974e-013
eq #   82 obs #   85 = +5.804676e-002 - +5.804676e-002 = +1.436223e-009
eq #   83 obs #   86 = -5.248905e-002 - -5.248905e-002 = +7.896461e-015
eq #   84 obs #   87 = -1.775986e+001 - -1.775986e+001 = +6.124193e-007
eq #   85 obs #   88 = +7.135368e-002 - +7.135368e-002 = +1.861621e-009
eq #   86 obs #   89 = -4.440025e-002 - -4.440025e-002 = +5.002584e-010
eq #   87 obs #   90 = -6.772805e+000 - -6.772805e+000 = +1.807343e-007
eq #   88 obs #   91 = -7.871768e-003 - -7.871767e-003 = +1.556578e-009
eq #   89 obs #   92 = -8.291872e-003 - -8.291872e-003 = +3.354864e-010
eq #   90 obs #   93 = -1.806235e+001 - -1.806235e+001 = +1.588827e-006
eq #   91 obs #   94 = -4.562904e-003 - -4.562893e-003 = +1.067908e-008
eq #   92 obs #   95 = -4.474693e-003 - -4.474691e-003 = +2.553851e-009
eq #   93 obs #   96 = +1.623485e+000 - +1.623485e+000 = +5.698642e-011
eq #   94 obs #   97 = +2.373179e-002 - +2.373180e-002 = +1.653033e-009
eq #   95 obs #   98 = +2.825941e-003 - +2.825941e-003 = +2.628063e-014
eq #   96 obs #   99 = -1.054534e+001 - -1.054534e+001 = +1.824318e-012
eq #   97 obs #  100 = -2.877803e-002 - -2.877803e-002 = +1.195649e-009
eq #   98 obs #  101 = -4.835661e-002 - -4.835661e-002 = +4.281298e-015
eq #   99 obs #  102 = -8.425857e+001 - -8.425857e+001 = +9.947598e-014
eq #  100 obs #  103 = +3.183408e-001 - +3.183408e-001 = +8.360663e-010
eq #  101 obs #  104 = +1.388665e-001 - +1.388665e-001 = +8.049117e-016
eq #  102 obs #  105 = -2.764462e-001 - -2.764464e-001 = +2.750273e-007
eq #  103 obs #  106 = -1.645783e-002 - -1.645783e-002 = +2.075703e-009
eq #  104 obs #  107 = -9.338660e-003 - -9.338667e-003 = +7.330924e-009
eq #  105 obs #  108 = -6.531868e+000 - -6.531868e+000 = +1.349563e-007
eq #  106 obs #  109 = -2.225955e-002 - -2.225956e-002 = +2.050959e-009
eq #  107 obs #  110 = -4.099432e-002 - -4.099433e-002 = +4.002003e-009
eq #  108 obs #  111 = -9.038680e+001 - -9.038680e+001 = +3.029304e-007
eq #  109 obs #  112 = +2.265426e-001 - +2.265425e-001 = +2.131102e-009
eq #  110 obs #  113 = +1.169143e-001 - +1.169143e-001 = +2.070887e-009
```

ADJUSTMENT ACTIVITY LOG (Concluded)

```
eq #  111 obs #  114 = +2.037355e+001 - +2.037355e+001 = +2.851333e-007
eq #  112 obs #  115 = +9.310192e-003 - +9.310186e-003 = +6.041398e-009
eq #  113 obs #  116 = +4.737690e-003 - +4.737689e-003 = +1.041203e-009
eq #  114 obs #  117 = -1.192683e+002 - -1.192683e+002 = +1.931255e-011
eq #  115 obs #  118 = +2.685878e-001 - +2.685878e-001 = +5.685091e-009
eq #  116 obs #  119 = +3.448002e-001 - +3.448002e-001 = +2.232659e-013
eq #  117 obs #  120 = -4.574976e+002 - -4.574976e+002 = +5.053889e-007
eq #  118 obs #  121 = +1.969103e-001 - +1.969103e-001 = +8.038071e-010
eq #  119 obs #  122 = +4.035390e-001 - +4.035390e-001 = +5.586175e-010
eq #  120 obs #  123 = +4.347293e+000 - +4.347293e+000 = +6.027581e-007
eq #  121 obs #  124 = +2.905365e-002 - +2.905365e-002 = +4.957338e-009
eq #  122 obs #  125 = +9.965576e-003 - +9.965577e-003 = +8.288416e-010
eq #  123 obs #  126 = -3.646539e+000 - -3.646539e+000 = +1.978812e-008
eq #  124 obs #  127 = -2.164740e-002 - -2.164740e-002 = +2.524004e-010
eq #  125 obs #  128 = -1.541062e-002 - -1.541062e-002 = +1.220997e-009
eq #  126 obs #  129 = +9.490985e+000 - +9.490985e+000 = +2.209788e-012
eq #  127 obs #  130 = +3.390364e-002 - +3.390364e-002 = +2.073581e-009
eq #  128 obs #  131 = +2.135251e-001 - +2.135251e-001 = +1.421085e-014
eq #  129 obs #  132 = -2.072900e+001 - -2.072900e+001 = +2.623430e-010
eq #  130 obs #  133 = +2.839774e-002 - +2.839773e-002 = +9.410564e-009
eq #  131 obs #  134 = +1.905402e-002 - +1.905402e-002 = +1.155499e-013
eq #  132 obs #  135 = +5.346306e+001 - +5.346306e+001 = +1.856001e-006
eq #  133 obs #  136 = -4.327163e-002 - -4.327162e-002 = +1.013239e-008
eq #  134 obs #  137 = -2.995442e-003 - -2.995444e-003 = +2.334752e-009
eq #  135 obs #  138 = +9.531944e-001 - +9.531939e-001 = +5.226953e-007
eq #  136 obs #  139 = -5.585728e-003 - -5.585722e-003 = +5.518201e-009
eq #  137 obs #  140 = +7.454290e-003 - +7.454295e-003 = +4.226804e-009
eq #  138 obs #  141 = +2.174733e-001 - +2.174733e-001 = +2.825215e-011
eq #  139 obs #  142 = +1.392240e-002 - +1.392241e-002 = +3.276267e-009
eq #  140 obs #  143 = +2.256987e-002 - +2.256987e-002 = +1.521283e-013
eq #  141 obs #  144 = +1.819094e+000 - +1.819094e+000 = +3.490333e-007
eq #  142 obs #  145 = +2.807063e-002 - +2.807064e-002 = +6.859983e-009
eq #  143 obs #  146 = +2.239743e-003 - +2.239741e-003 = +1.289568e-009
eq #  144 obs #  147 = -1.721200e+001 - -1.721200e+001 = +1.612694e-006
eq #  145 obs #  148 = +7.842632e-003 - +7.842637e-003 = +4.262680e-009
eq #  146 obs #  149 = -3.978830e-003 - -3.978828e-003 = +2.201065e-009
eq #  147 obs #  150 = -6.138768e+000 - -6.138769e+000 = +7.859648e-007
eq #  148 obs #  151 = +2.141678e-002 - +2.141677e-002 = +5.741399e-010
eq #  149 obs #  152 = +8.847308e-003 - +8.847305e-003 = +2.683643e-009
```

Successful adjustment 1 iterations
Beginning adjustment summary in stats.log.
Beginning coordinate adjustment in coords.log.
Coordinate adjustment summary complete.
Beginning plots of error ellipses.
Ellipse plotting complete.
Proceeding with adjustment of observations.
Observation adjustment complete.
Statistics summary complete.
Plot histograms.
Histogram plotting complete.
Computing covariances in azimuth, distance and height.
Covariance processing complete.
Iterations complete, so turning graphics off.
Graphics turned off.
Closing activity log.
TIME = Tue Aug 20 13:09:56 2002.

CLOSURES LOG
NETWORK = 01269
TIME = Tue Aug 20 13:09:54 2002

OBS#	TYPE	BACKSIGHT	FORESIGHT	CLOSURE	TRANSFORM
1	hgoid	PR 052		-0.011729m	0.000000m
2	hgoid	PR 053		-0.002726m	0.000000m
3	hgoid	PR 054		0.000000m	0.000000m
4	hgoid	PR 204		0.002743m	0.000000m
5	hgoid	PR 205		0.001185m	0.000000m
6	hgoid	PR 206		0.014451m	0.000000m
7	hgoid	PR 209		-0.009748m	0.000000m
8	hgoid	PR 210		0.001904m	0.000000m
9	hgoid	PR 211		0.003920m	0.000000m
10	hgoid	PR 303		0.000000m	0.000000m
11	hgoid	PR 304		0.000000m	0.000000m
12	hgoid	PR 305		0.000000m	0.000000m
13	hgoid	PR 306		0.000000m	0.000000m
14	hgoid	PR 307		0.000000m	0.000000m
15	gpsaz	PR 206	PR 204	-0.698700"	-3.394764"
16	gpsht	PR 206	PR 204	0.003973m	-0.228487m
17	gpsds	PR 206	PR 204	0.057609m	0.083265m
18	gpsaz	PR 206	PR 305	1.586500"	-3.391457"
19	gpsht	PR 206	PR 305	-0.021643m	-0.216107m
20	gpsds	PR 206	PR 305	0.006404m	0.054952m
21	gpsaz	PR 206	PR 052	2.027594"	-3.393058"
22	gpsht	PR 206	PR 052	0.046260m	-0.263303m
23	gpsds	PR 206	PR 052	-0.006325m	0.074304m
24	gpsaz	PR 305	PR 205	9.153853"	-3.394245"
25	gpsht	PR 305	PR 205	0.006080m	0.082280m
26	gpsds	PR 305	PR 205	0.010309m	0.056380m
27	gpsaz	PR 305	PR 204	-12.845573"	-3.394136"
28	gpsht	PR 305	PR 204	0.011005m	-0.011935m
29	gpsds	PR 305	PR 204	0.036744m	0.050882m
30	gpsaz	PR 305	PR 052	9.199836"	-3.392437"
31	gpsht	PR 305	PR 052	0.071565m	-0.046754m
32	gpsds	PR 305	PR 052	-0.008199m	0.027313m
33	gpsaz	PR 052	PR 205	3.572660"	-3.392647"
34	gpsht	PR 052	PR 205	-0.068136m	0.129742m
35	gpsds	PR 052	PR 205	0.011617m	0.042640m
36	gpsaz	PR 052	PR 204	-42.306444"	-3.392533"
37	gpsht	PR 052	PR 204	-0.060847m	0.035526m
38	gpsds	PR 052	PR 204	0.019022m	0.027557m
39	gpsaz	PR 204	PR 205	31.946543"	-3.390954"
40	gpsht	PR 204	PR 205	-0.010386m	0.095248m
41	gpsds	PR 204	PR 205	0.062515m	0.023619m
42	gpsaz	PR 206	PR 205	6.152651"	-3.394882"
43	gpsht	PR 206	PR 205	-0.004565m	-0.134274m
44	gpsds	PR 206	PR 205	-0.005732m	0.070769m
45	gpsaz	PR 206	PR 307	-0.787796"	-3.386272"
46	gpsht	PR 206	PR 307	0.033546m	-0.101236m
47	gpsds	PR 206	PR 307	0.017520m	0.074743m
48	gpsaz	PR 206	PR 304	0.644280"	-3.390719"
49	gpsht	PR 206	PR 304	-0.008174m	-0.189596m
50	gpsds	PR 206	PR 304	0.004028m	0.047512m
51	gpsaz	PR 206	PR 305	78.185273"	-3.391457"
52	gpsht	PR 206	PR 305	0.457422m	-0.216107m

Geoid Model Closures

GPS Baseline Closures

azimuth (")
height (m)
distance (m)

Excluded from adjustment

CLOSURES LOG (Continued)

OBS#	TYPE	BACKSIGHT	FORESIGHT	CLOSURE	TRANSFORM
53	gpsds	PR 206	PR 305	-0.289768m	0.054952m
54	gpsaz	PR 206	PR 052	-1.433430"	-3.393058"
55	gpsht	PR 206	PR 052	0.014315m	-0.263303m
56	gpsds	PR 206	PR 052	-0.000774m	0.074304m
57	gpsaz	PR 206	PR 053	-63.103459"	-3.386483"
58	gpsht	PR 206	PR 053	0.513748m	-0.178852m
59	gpsds	PR 206	PR 053	-0.281539m	0.080682m
60	gpsaz	PR 304	PR 054	82.211724"	-3.385721"
61	gpsht	PR 304	PR 054	0.360103m	0.223656m
62	gpsds	PR 304	PR 054	-0.212375m	0.096682m
63	gpsaz	PR 304	PR 307	143.346314"	-3.386373"
64	gpsht	PR 304	PR 307	0.365187m	0.088764m
65	gpsds	PR 304	PR 307	-0.076830m	0.072159m
66	gpsaz	PR 304	PR 305	-8.057408"	-3.391576"
67	gpsht	PR 304	PR 305	-0.024288m	-0.026103m
68	gpsds	PR 304	PR 305	0.010223m	0.013164m
69	gpsaz	PR 304	PR 052	1.043459"	-3.393177"
70	gpsht	PR 304	PR 052	0.033355m	-0.073299m
71	gpsds	PR 304	PR 052	-0.003885m	0.040451m
72	gpsaz	PR 304	PR 053	-25.303768"	-3.386585"
73	gpsht	PR 304	PR 053	0.194341m	0.011146m
74	gpsds	PR 304	PR 053	0.059820m	0.065489m
75	gpsaz	PR 305	PR 052	-387.670687"	-3.392437"
76	gpsht	PR 305	PR 052	-0.531815m	-0.046754m
77	gpsds	PR 305	PR 052	-0.124618m	0.027313m
78	gpsaz	PR 305	PR 053	-4.999992"	-3.385844"
79	gpsht	PR 305	PR 053	-0.000846m	0.037693m
80	gpsds	PR 305	PR 053	0.058783m	0.077383m
81	gpsaz	PR 052	PR 053	-30.415742"	-3.384242"
82	gpsht	PR 052	PR 053	0.604050m	0.085161m
83	gpsds	PR 052	PR 053	-0.074914m	0.103621m
84	gpsaz	PR 053	PR 054	-8.818368"	-3.389982"
85	gpsht	PR 053	PR 054	0.058047m	0.212127m
86	gpsds	PR 053	PR 054	-0.052489m	0.055061m
87	gpsaz	PR 053	PR 307	-17.759856"	-3.390630"
88	gpsht	PR 053	PR 307	0.071354m	0.077236m
89	gpsds	PR 053	PR 307	-0.044400m	0.019765m
90	gpsaz	PR 307	PR 054	-6.772805"	-3.390188"
91	gpsht	PR 307	PR 054	-0.007872m	0.134036m
92	gpsds	PR 307	PR 054	-0.008292m	0.035398m
93	gpsaz	PR 209	PR 306	-18.062349"	-3.391626"
94	gpsht	PR 209	PR 306	-0.004563m	-0.062671m
95	gpsds	PR 209	PR 306	-0.004475m	0.019314m
96	gpsaz	PR 206	PR 054	1.623485"	-3.385611"
97	gpsht	PR 206	PR 054	0.023732m	0.033654m
98	gpsds	PR 206	PR 054	0.002826m	0.080868m
99	gpsaz	PR 209	PR 054	-10.545342"	-3.394912"
100	gpsht	PR 209	PR 054	-0.028778m	-0.156773m
101	gpsds	PR 209	PR 054	-0.048357m	0.073623m
102	gpsaz	PR 209	PR 053	-84.258567"	-3.395767"
103	gpsht	PR 209	PR 053	0.318341m	-0.369270m
104	gpsds	PR 209	PR 053	0.138867m	0.119357m
105	gpsaz	PR 306	PR 307	-0.276446"	-3.394771"
106	gpsht	PR 306	PR 307	-0.016458m	-0.231562m
107	gpsds	PR 306	PR 307	-0.009339m	0.083548m
108	gpsaz	PR 306	PR 054	-6.531868"	-3.394121"
109	gpsht	PR 306	PR 054	-0.022260m	-0.096678m
110	gpsds	PR 306	PR 054	-0.040994m	0.055759m

CLOSURES LOG (Continued)

OBS#	TYPE	BACKSIGHT	FORESIGHT	CLOSURE	TRANSFORM
111	gpsaz	PR 306	PR 053	-90.386796"	-3.394977"
112	gpsht	PR 306	PR 053	0.226543m	-0.309177m
113	gpsds	PR 306	PR 053	0.116914m	0.100033m
114	gpsaz	PR 054	PR 307	20.373552"	-3.391484"
115	gpsht	PR 054	PR 307	0.009310m	-0.136809m
116	gpsds	PR 054	PR 307	0.004738m	0.035406m
117	gpsaz	PR 054	PR 053	-119.268323"	-3.391690"
118	gpsht	PR 054	PR 053	0.268588m	-0.214424m
119	gpsds	PR 054	PR 053	0.344800m	0.055080m
120	gpsaz	PR 307	PR 053	-457.497609"	-3.391042"
121	gpsht	PR 307	PR 053	0.196910m	-0.078470m
122	gpsds	PR 307	PR 053	0.403539m	0.019768m
123	gpsaz	PR 211	PR 306	4.347293"	-3.397813"
124	gpsht	PR 211	PR 306	0.029054m	0.299146m
125	gpsds	PR 211	PR 306	0.009966m	0.131473m
126	gpsaz	PR 209	PR 307	-3.646539"	-3.395561"
127	gpsht	PR 209	PR 307	-0.021647m	-0.291657m
128	gpsds	PR 209	PR 307	-0.015411m	0.102740m
129	gpsaz	PR 211	PR 209	9.490985"	-3.397023"
130	gpsht	PR 211	PR 209	0.033904m	0.358618m
131	gpsds	PR 211	PR 209	0.213525m	0.131534m
132	gpsaz	PR 211	PR 210	-20.728997"	-3.389977"
133	gpsht	PR 211	PR 210	0.028398m	0.026161m
134	gpsds	PR 211	PR 210	0.019054m	0.015150m
135	gpsaz	PR 210	PR 303	53.463059"	-3.390187"
136	gpsht	PR 210	PR 303	-0.043272m	0.015632m
137	gpsds	PR 210	PR 303	-0.002995m	0.011081m
138	gpsaz	PR 210	PR 306	0.953194"	-3.398670"
139	gpsht	PR 210	PR 306	-0.005586m	0.269392m
140	gpsds	PR 210	PR 306	0.007454m	0.138704m
141	gpsaz	PR 210	PR 209	0.217473"	-3.397880"
142	gpsht	PR 210	PR 209	0.013922m	0.328864m
143	gpsds	PR 210	PR 209	0.022570m	0.136789m
144	gpsaz	PR 303	PR 306	1.819094"	-3.399319"
145	gpsht	PR 303	PR 306	0.028071m	0.250078m
146	gpsds	PR 303	PR 306	0.002240m	0.145324m
147	gpsaz	PR 306	PR 209	-17.212003"	-3.390045"
148	gpsht	PR 306	PR 209	0.007843m	0.056902m
149	gpsds	PR 306	PR 209	-0.003979m	0.019312m
150	gpsaz	PR 211	PR 303	-6.138769"	-3.389327"
151	gpsht	PR 211	PR 303	0.021417m	0.045389m
152	gpsds	PR 211	PR 303	0.008847m	0.026218m

SUMMARY OF COVARIANCES
NETWORK = 01269
TIME = Tue Aug 20 13:09:55 2002

This adjustment output file shows the precision of the 3D line vectors between each of the points in the network. Since 14 points were in this network (9 fixed and 5 new), a combination of 91 connecting lines are output ... only a selected few of which are shown in this tabulation. The precisions shown are from each point in the survey to every other point in the survey even if there wasn't a baseline measured between the points. This summary is used to show the precision even though the baselines were not measured and how the entire network fits relative to the 9 fixed control points.

Definition of precision (E x S)ý = Cý + Pý:
  Horizontal:
    Precision (P) expressed as: ratio
    Propagated linear error (E): U.S.
      (standard error of adjusted horizontal distance)
    Scalar (S) on propagated linear error: 1.0000
    Constant error term (C): 0.0000
  3-Dimensional:
    Precision (P) expressed as: ratio
    Propagated linear error (E): U.S.
      (standard error of adjusted slope distance)
    Scalar (S) on propagated linear error: 1.0000
    Constant error term (C): 0.0000
    Using orthometric height errors

FROM/ TO	AZIMUTH/ DELTA H	1.00σ	DISTANCE/ DELTA h	1.00σ	HOR PREC/ 3-D PREC
PR 052	-**-	-**-	-**-	-**-	-**-
PR 053	+11.5998m	0.0292m	-**-	-**-	-**-
PR 052	-**-	-**-	-**-	-**-	-**-
PR 054	+28.0013m	0.0395m	+27.8874m	0.0414m	-**
PR 052	-**-	-**-	-**-	-**-	-**-
PR 204	-3.4532m	0.0290m	-**-	-**-	-*
•					
•					
•					
PR 052	-**-	-**-	-**-	-**-	-**-
PR 209	+41.5643m	0.0307m	-**-	-**-	-**-
PR 052	-**-	-**-	-**-	-**-	-**-
PR 211	+46.9522m	0.0294m	-**-	-**-	-**-
PR 052	29ø16'46"	1.46"	3173.919m	0.0172m	1: 184743
PR 303	+46.7669m	0.0541m	+46.5919m	0.0547m	1: 184743
PR 052	8ø54'01"	7.71"	430.678m	0.0158m	1: 27341
PR 304	+3.2057m	0.0535m	+3.1648m	0.0584m	1: 27341
•					
•					
•					
PR 053	31ø58'26"	2.25"	2077.146m	0.0170m	1: 122324
PR 303	+35.1671m	0.0539m	+35.0639m	0.0547m	1: 122324
PR 053	213ø34'58"	5.08"	697.314m	0.0146m	1: 47849
PR 304	-8.3941m	0.0569m	-8.3632m	0.0584m	1: 47849
PR 053	209ø02'33"	2.34"	823.967m	0.0086m	1: 96335
PR 305	-8.7670m	0.0481m	-8.7264m	0.0509m	1: 96335
•					

(a total of 91 precisions are output ... all similar to the above examples)

Precision between two fixed points

PR 054 "h" not held fixed

1-s azimuth accuracy

1-s distance accuracy

Precision ratio

Precision between fixed points and new points

1-s ortho elev accuracy

OBSERVATION ADJUSTMENT SUMMARY
NETWORK = 01269
TIME = Tue Aug 20 13:09:55 2002

OBSERVATION ADJUSTMENT (Tau = 3.50)

GPS Parameter Group 1 GPS Observations
Azimuth rotation = +3.3908 seconds 1.00σ = 1.2360 seconds
Deflection in latitude = -45.7925 seconds 1.00σ = 6.9026 seconds
Deflection in longitude = -62.5723 seconds 1.00σ = 7.5689 seconds
Network scale = 0.999906082080 1.00σ = 0.000005772833

This is the adjustment summary of all of the control that was used in this survey. The points have a difference in the geoid, horizontal and vertical observations that were performed in this survey based on the geoid model that was used to adjust the observation data from the RINEX files.

OBS# BLK#/ TYPE BACKSIGHT/ UDVC/ OBSERVED/ 1.00σ/ TAU
REF# INSTRUMENT/ UDPG/ ADJUSTED/ 1.00σ/
FORESIGHT SBNT RESIDUAL 1.00σ

1 -**- hgoid -**- -**- -41.4304m 0.0223m 0.40
1 PR 052 -**- -41.4421m 0.0207m
-**- 1 -0.011729m 0.0084m

2 -**- hgoid -**- -**- -41.3676m 0.0223m 0.12
2 PR 053 -**- -41.3703m 0.0214m
-**- 1 -0.002726m 0.0065m

3 -**- hgoid -**- -**- -41.3282m 0.0223m OPEN
3 PR 054 -**- -41.3282m 0.0223m
-**- 1 +0.000000m 0.0000m

4 -**- hgoid -**- -**- -41.4381m 0.0223m 0.12
4 PR 204 -**- -41.4353m 0.0213m
-**- 1 +0.002743m 0.0065m

5 -**- hgoid -**- -**- -41.4248m 0.0223m 0.05
5 PR 205 -**- -41.4236m 0.0212m
-**- 1 +0.001185m 0.0070m

6 -**- hgoid -**- -**- -41.3735m 0.0223m 0.36
6 PR 206 -**- -41.3591m 0.0192m
-**- 1 +0.014451m 0.0114m

7 -**- hgoid -**- -**- -41.2740m 0.0223m 0.42
7 PR 209 -**- -41.2838m 0.0213m
-**- 1 -0.009748m 0.0067m

8 -**- hgoid -**- -**- -41.2747m 0.0223m 0.08
8 PR 210 -**- -41.2728m 0.0211m
-**- 1 +0.001904m 0.0072m

9 -**- hgoid -**- -**- -41.2858m 0.0223m 0.16
9 PR 211 -**- -41.2819m 0.0212m
-**- 1 +0.003920m 0.0070m

10 -**- hgoid -**- -**- -41.2671m 0.0223m OPEN
10 PR 303 -**- -41.2671m 0.0223m
-**- 1 +0.000000m 0.0000m

OBSERVATION ADJUSTMENT SUMMARY (Continued)

OBS# BLK#/ TYPE BACKSIGHT/ UDVC/ OBSERVED/ 1.00σ/ TAU
REF# INSTRUMENT/ UDPG/ ADJUSTED/ 1.00σ/
FORESIGHT SBNT RESIDUAL 1.00σ

```
 11  -**- hgoid          -**- -**-      -41.4013m  0.0223m   OPEN
     11             PR 304 -**-      -41.4013m  0.0223m
                    -**-   1     +0.000000m  0.0000m

 12  -**- hgoid          -**- -**-      -41.4110m  0.0223m   OPEN
     12             PR 305 -**-      -41.4110m  0.0223m
                    -**-   1     +0.000000m  0.0000m

 13  -**- hgoid          -**- -**-      -41.2891m  0.0223m   OPEN
     13             PR 306 -**-      -41.2891m  0.0223m
                    -**-   1     +0.000000m  0.0000m

 14  -**- hgoid          -**- -**-      -41.3539m  0.0223m   OPEN
     14             PR 307 -**-      -41.3539m  0.0223m
                    -**-   1     +0.000000m  0.0000m

 15    1 gpsaz           -**- -**- 172ø34'03.2773"  5.7761"   0.04
     1              PR 206 -**- 172ø34'02.5786"  1.2360"
                    PR 204   1     -0.698700"  5.6423"

 16    1 gpsht           -**- -**-     -63.3097m  0.0807m   0.02
     1              PR 206 -**-     -63.3058m  0.0370m
                    PR 204   1     +0.003973m  0.0717m

 17    1 gpsds           -**- -**-     886.2649m  0.0238m   0.71
     1              PR 206 -**-     886.3225m  0.0051m
                    PR 204   1     +0.057609m  0.0233m

 18    2 gpsaz           -**- -**- 136ø08'10.5143"  7.3927"   0.07
     1              PR 206 -**- 136ø08'12.1008"  3.1584"
                    PR 305   1     +1.586500"  6.6841"

 19    2 gpsht           -**- -**-     -57.0105m  0.0777m   0.10
     1              PR 206 -**-     -57.0322m  0.0461m
                    PR 305   1     -0.021643m  0.0625m

 20    2 gpsds           -**- -**-     584.9467m  0.0261m   0.08
     1              PR 206 -**-     584.9531m  0.0099m
                    PR 209   1     -0.003979m  0.0133m
```

Azimuth (gpsaz)

Height (gpsht)

Distance (gpsds

Observations 21 thru 149 similar (#39, 40, 41 excluded)

```
150   46 gpsaz           -**- -**-   8ø13'20.3253"  19.3844"   0.15
     1              PR 211 -**-   8ø13'14.1866"  15.1696"
                    PR 303   1     -6.138768"  12.0680"

151   46 gpsht           -**- -**-     -0.2522m  0.0570m   0.19
     1              PR 211 -**-     -0.2308m  0.0470m
                    PR 303   1     +0.021417m  0.0323m

152   46 gpsds           -**- -**-     279.1379m  0.0253m   0.15
     1              PR 211 -**-     279.1468m  0.0192m
                    PR 303   1     +0.008847m  0.0164m
```

ADJUSTMENT STATISTICS SUMMARY

NETWORK = 01269
TIME = Tue Aug 20 13:09:54 2002

ADJUSTMENT SUMMARY

Network Reference Factor = 1.00
Chi-Square Test (σ = 95%) = PASS
Degrees of Freedom = 115.00

Degrees of Freedom =
No. of obs - no. of unk = 149-34 = 115

GPS OBSERVATIONS
Reference Factor = 1.00
r = 114.04

GPS Solution	1	1.51	2.69	GPS Solution	24	0.73	2.88
GPS Solution	2	0.31	2.31	GPS Solution	25	0.66	2.76
GPS Solution	3	0.44	2.71	GPS Solution	26	0.49	2.43
GPS Solution	4	0.96	2.45	GPS Solution	27	1.07	1.89
GPS Solution	5	1.77	2.41	GPS Solution	28	0.26	2.56
GPS Solution	6	0.65	2.36	GPS Solution	29	2.30	2.56
GPS Solution	7	0.51	2.92	GPS Solution	30	0.28	2.99
GPS Solution	8	2.20	2.95	GPS Solution	31	0.39	2.11
GPS Solution	9	1.00	0.00 *	GPS Solution	32	1.97	2.20
GPS Solution	10	0.57	2.72	GPS Solution	33	0.15	2.99
GPS Solution	11	0.58	2.34	GPS Solution	34	1.72	2.06
GPS Solution	12	0.13	1.92	GPS Solution	35	0.20	2.99
GPS Solution	13	3.08	2.91	GPS Solution	36	0.22	2.99
GPS Solution	14	0.16	2.81	GPS Solution	37	1.11	2.25
GPS Solution	15	0.40	3.00	GPS Solution	38	1.01	2.13
GPS Solution	16	0.26	2.99	GPS Solution	39	0.10	2.99
GPS Solution	17	0.25	2.99	GPS Solution	40	1.17	2.90
GPS Solution	18	0.42	1.63	GPS Solution	41	0.15	2.82
GPS Solution	19	0.34	2.01	GPS Solution	42	0.13	2.75
GPS Solution	20	0.19	3.00	GPS Solution	43	0.80	2.11
GPS Solution	21	0.51	2.99	GPS Solution	44	0.44	1.67
GPS Solution	22	0.95	2.56	GPS Solution	45	0.75	2.24
GPS Solution	23	0.31	3.00	GPS Solution	46	0.53	1.10

* excluded baseline

GEOID MODEL
Reference Factor = 1.00 r = 0.96

Geoid Heights: Reference Factor = 1.00 r = 0.96
Delta Geoid Heights: Reference Factor = 1.00 r = 0.00

WEIGHTING STRATEGIES:

GPS OBSERVATIONS:
Scalar Weighting Strategy:
Alternative Scalar Set Applied Globally = 30.04

No summation weighting strategy was used

Station Error Strategy:
H.I. error = 0.0030
Tribrach error = 0.0030

GEOID MODEL:
Scalar Weighting Strategy:
Alternative Scalar Set Applied Globally = 0.36

No summation weighting strategy was used

Results of adjusted Geoid model:
Noise in vertical GPS observations: 0.31669041
Variance of geoid model: 0.00049794
Further use of correlated Geoid Model not recommended

**** Adjusted Coordinates ****

Projection Group: NAD-83 SP Lambert
Zone Name: P.R. and V.I.
Linear Units: meter
Angular Units: degrees
Datum Name: NAD-83

Station Short Name	North	East	Ortho. Height
PR 052	215011.48020	232319.57730	33.89900
PR 053	216017.89600	232771.92300	45.42700
PR 054	216466.56900	232394.40000	61.85600
PR 204	214840.36000	232081.21800	30.43900
PR 205	214972.45600	231867.18900	30.96500
PR 206	215719.31600	231966.53799	93.89700
PR 209	217248.07400	232454.47800	75.30500
PR 210	217663.82000	233850.78100	79.55900
PR 211	217503.61100	233831.92799	80.69100
PR 303	217779.91745	233871.84091	80.47200
PR 304	215436.97244	232386.20863	37.04600
PR 305	215297.53496	232371.91574	36.72700
PR 306	217049.36699	232507.43018	68.77300
PR 307	216167.62873	232624.01503	50.46767

Fixed Points

New Points

***** End of Report *****

[See Figure I-16 for screen capture view of the adjusted points]

I-4. Adjustment Output Plots

Horizontal and elevation errors are graphically depicted, as shown in Figures I-13 and I-14 below. Figure I-13 contains fixed points, so no error ellipses are generated. Station PR 054 was held fixed in position but not in elevation; thus, the elevation and height standard errors are shown.

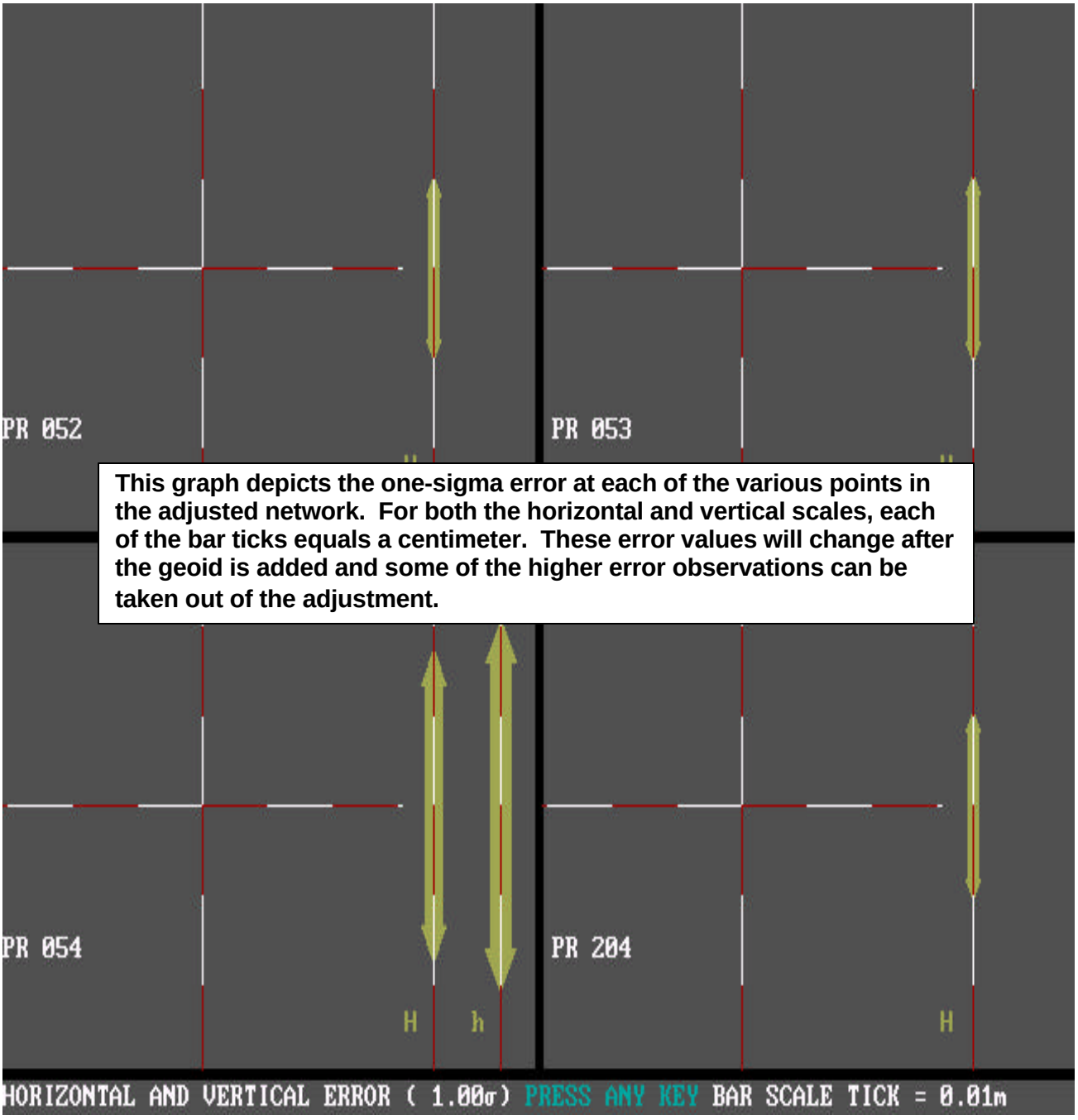

Figure I-13. Trimble GPSurvey positional error plots

This GPSurvey output graph shows one-sigma error ellipses and scales for some selected new points in the adjustment. Displays should be set to depict 95% accuracies instead of one-sigma values.

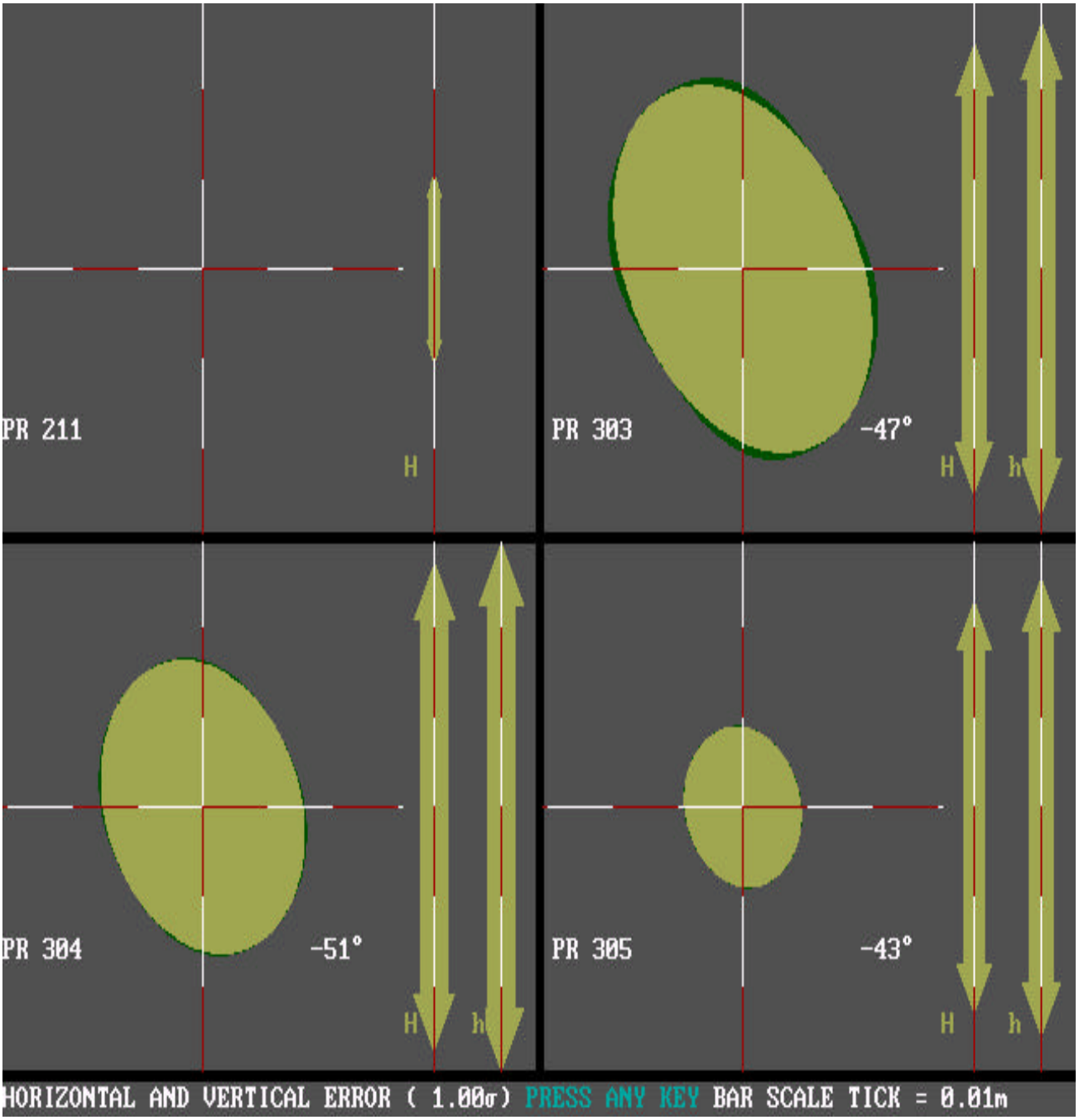

Figure I-14. Trimble GPSurvey positional error ellipses at adjusted points

The following screen capture (Figure I-15) of the adjustment output shows a histogram of the network's standardized (or normalized) residuals. The top figure shows the histogram for combined horizontal and vertical residuals. These residual plots should resemble a bell curve, as is apparent. A rough evaluation of potential outliers can be observed by noting residuals falling outside the 3-sigma level. As can be seen below, a few observations are outside the 3-sigma level, but none exceed 4-sigma.

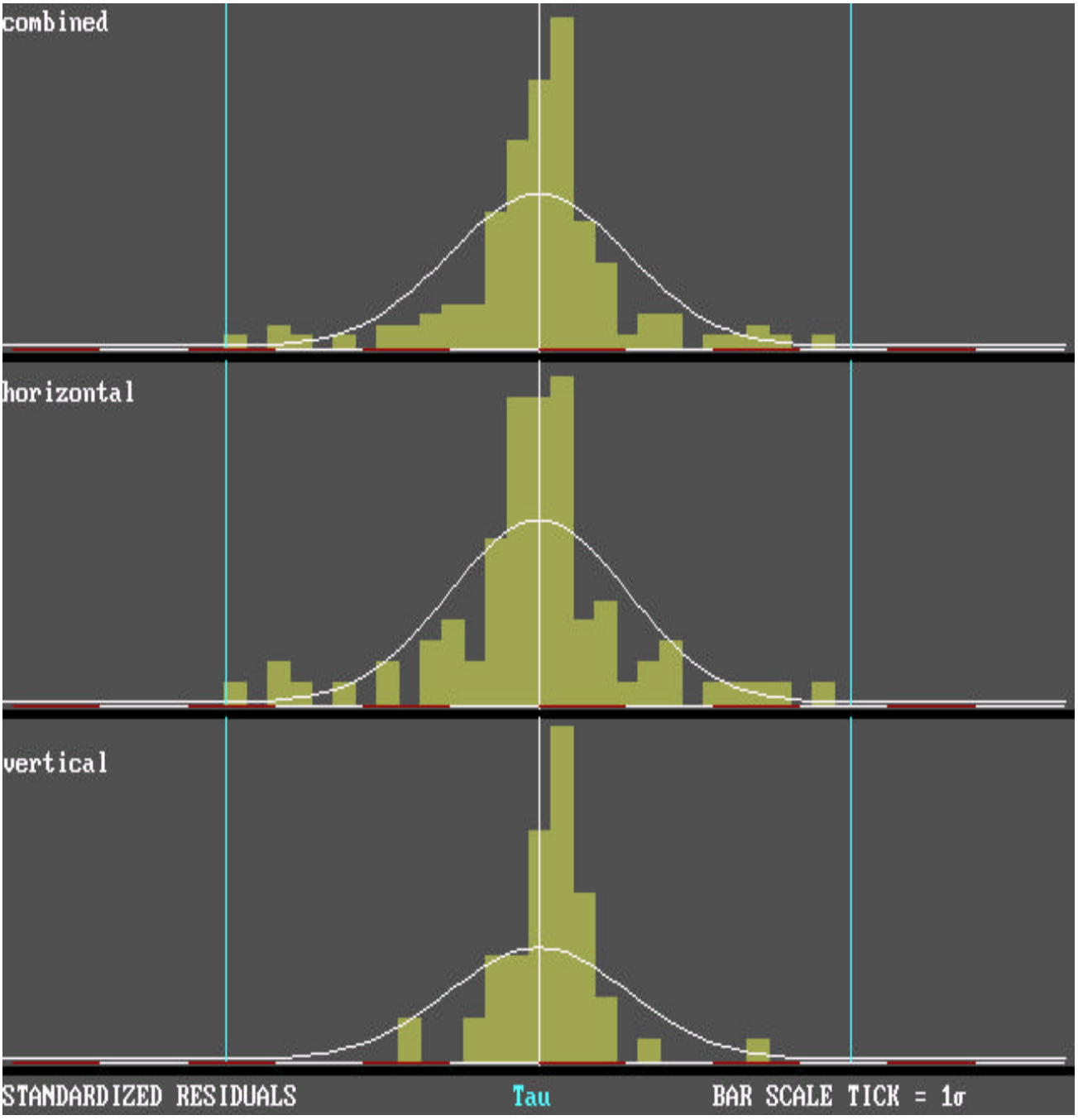

Figure I-15. Trimble GPSurvey Standardized Residual histograms

Figure I-16 is a screen capture of the adjusted coordinates.

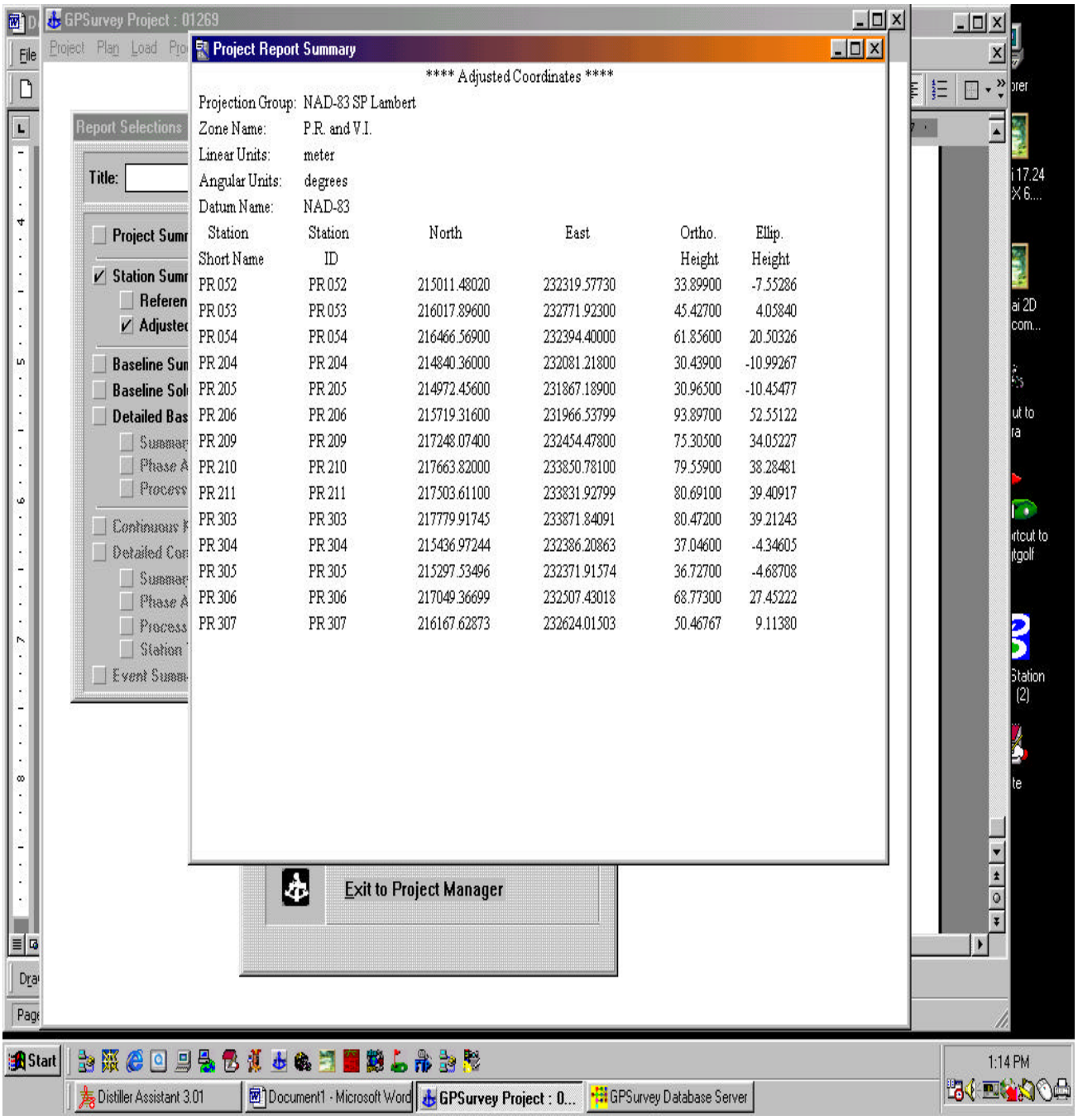

Figure I-16. Trimble GPSurvey listing of adjusted coordinates