Geographic Coordinate Data Base

Geographic Measurement Management For Windows®

WinGMM

Version 1.00 - 10262001

WinGMM Technical Reference Manual

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WinGMM TECHNICAL REFERENCE MANUAL

TABLE OF CONTENTS

INTRODUCTION TO GEOGRAPHIC MEASUREMENT MANAGEMENT FOR WINDOWS®
USER GUIDE

Geographic Measurement Management for Windows® (WinGMM) is a suite of programs designed for data entry, computation and analysis of survey information necessary to support the Geographic Coordinate Data Base (GCDB). These programs are capable of translating data entered from graphic sources into a configuration usable by numerous processes in an electronic automated environment.

The Public Land Survey System (PLSS) grid is not always correctly displayed on some maps that are commonly digitized to obtain coordinates for corners. In addition, some features of the PLSS grid, particularly corners of some special surveys such as river meanders and Tracts are not usually shown on maps and therefore the coordinates of these PLSS corners are not available.

WinGMM was initially developed to (1) compute the geographic coordinates for corners of the PLSS using official survey record data; (2) provide an estimate of the positional dependability of the computed corner coordinates; (3) preserve the survey measurement data and resulting computed coordinates in an easily accessed data base while providing for data flexibility to facilitate integration of data between various systems.

PURPOSE AND SCOPE OF THE WinGMM USER GUIDE

This *WinGMM Reference manual* highlights case studies of actual township computations using WinGMM. The manual illustrates the analytical and decision-making processes you will be involved in as you work through the computations.

This *WinGMM Technical Reference Manual* assumes that the user has read and become familiar with the *WinGMM Program Reference*. It also assumes that the user has a competent understanding of various survey methods and a working knowledge of the Windows® interface.

Think of this *WinGMM User Guide* as a manual to facilitate data organizing, entry, analysis and management. The manual illustrates aspects of what the job requires and what tools you will need to accomplish that task. Refer to the *WinGMM Software User Guide* to find out exactly how to use the tools.

Please do not hesitate to contact the Service Center Lands & Resources (303-236-0188) if you have any questions or problems concerning this document.

GCDB BACKGROUND AND HISTORY

The GCDB project originated as a means to provide a common frame of reference for resource data, which relies on geographic coordinates and land parcel information based on the PLSS. WinGMM assigns geographic coordinate values to PLSS corners, allowing resource data and land parcel data to be graphically portrayed.

The locations of resources (e.g., wildlife habitat, archeological sites, etc.) can be determined with sufficient accuracy by using a variety of techniques. Many resources can be photographed and mapped reasonably accurately; these mapped areas can then be digitized from United States Geological Survey (USGS) maps to obtain geographic coordinates.

Unfortunately digitizing does not work well with survey data. This grid cannot be photographed and mapped as easily as the more visible resource boundaries. It is possible and in many areas necessary to map the PLSS to higher accuracy than can be portrayed on standard maps. This can be accomplished by combining the best geometric information available and, through analysis, resolve the inconsistencies inherent in the data from various sources and

time periods. The nature of the collected data allows for ease of maintaining and updating the information contained within GCDB. Other GCDB data specifically needed to link legacy BLM lands data with resource data can be collected efficiently through WinGMM.

GCDB COMPUTATIONS USING WinGMM'S LEAST SQUARE ANALYSIS

The Bureau of Land Management (BLM) recognizes that for a Land Record Information System to work and remain useful into the future GCDB must be updateable. The GCDB data model reflects this understanding by maintaining all features of the data. The type of information stored within the database will remain stable; what will improve over time are coordinate values of established corner positions.

WinGMM users can in one process combine two well-defined types of geometric data. The first is control point data derived from various sources. This data consists of coordinate pairs that may be digitized from USGS quadrangle sheets, derived by traditional methods (terrestrial traverses) or collected using Global Positioning System (GPS). The second type of data is derived from survey records. This survey data consists of bearing and distance information entered from the official plats. Both types of data contain a wide range of quality and must be resolved and analyzed to ascertain reliability. We have only a nebulous idea of the merit of any given piece of data and only mathematical analysis will reveal the true quality of how each point and line statistically fit the combined data set. By identification of reliable data it is possible to make low precision data less influential in its effect on the overall scheme.

CONTROL COORDINATES
　　　　　- information about monumented points.

Visiting a specific monument and collecting survey measurements to determine latitude/longitude (Lat/Long) is a special and expensive process, one that was not often done before the advent of some of the newer measuring methods, i.e., GPS. Surveyors are comfortable with the concept that no true or exact values are ever known for any measurement and that a published coordinate value is simply a snapshot in time. A coordinate measurement is meaningless outside the context of its reliability.

Lat/Long coordinates must also be tied to statistical results. The coordinate by itself is not static, coordinate values change as better data becomes available. Every survey can and frequently does acquire dissimilar coordinates for the same described location. There are many cases where surveyors have determined differing coordinates for a given monument.   We can expect this by the very nature of survey work. The question then becomes which coordinate has more reliability? Some additional apprehensions then emerge. Does this information refer to the same monument? Was the correct monument incorrectly measured? Is there a typographic error? Is there exaggeration in the quality of work? Pondering even the simplest of situations results in no conclusive answer, yet seamless parcel data is based on a complex network of individual elements that must be interpreted in context.

PLAT DATA - information about the lines between adjacent monument points

Overall, there is very little usable Lat/Long data on survey plats, as coordinates are not intended to define legal rights. What plats do contain are the bearing and distance measurements between adjacent monuments. These line segments can be combined into a continuous interconnected network.

Since there are imperfections in measurements from normal inherent errors associated with surveying and from measurements derived at various points in time, the network doesn't fit geometrically with itself. Take any two monuments derived from plat data; numerous, slightly different bearings and distances can be computed between them, conditional on what combination of connecting lines is used in the computations. If the two monuments are held as control coordinates, we can also apply a certain geometry to the latitudes/longitudes to determine yet another bearing and distance.

It is this uncertainty that makes bearing and distance information difficult to interpret.

COMBINING SOURCE DATA
         - control coordinates and plat bearings/distances

The result of adjusting the control coordinates with plat bearings and distances is that latitudes/longitudes of all the intermediate monuments will be computed. This is the only clue we have as to the position of monuments that may not have been visited since they were set. How good these computed Lat/Long coordinates are depends ultimately on the reliability of the source data. It is imperative to discern the quality of our source data before we can arrive at an optimal solution of Lat/Long values.

The quality of plat bearings and distances range from precise to nearly worthless and the quality of control coordinates differ just as dramatically. The determination of whether weaknesses exist in the control data or in the plat data perhaps requires extensive research and analysis. The data of the PLSS must be examined using various reliability values for the data to determine quality results. This may involve knowledge of the work quality of the surveyors by comparing the original work with more recent surveys. This comparison can result in quite accurate estimates of the quality of the original work. In most cases, the final determination is that credence should be given to all the measurements, but in different degrees. Who or what has the time to do an extensive mathematical analysis of every possible combination of data? The process of comparing multiple error estimates with multiple line segments is a daunting task and these computations can only be accomplished effectively with computers.

WinGMM USES THE TECHNIQUE OF LEAST SQUARES ANALYSIS

The technique of least squares analysis is used by the scientific community to analyze complex data sets. Many students were exposed to the concept when they were attending college, but its application was not needed on the linear data sets that surveyors normally encounter. Least squares analysis is well suited to the task of data comparisons from a variety of survey sources.

Every bearing, distance and control coordinate is considered by WinGMM to be a measurement, and is assumed to have some error associated with that measurement. Each piece of data is tagged with the users first estimations concerning the amount of error inherent in the data. Users want to resolve all the geometric discrepancies in this data, but protect the integrity of the better data. Least squares analysis combines all this data, ascertains the ambiguity and figures out how deviations with each coordinate and bearing and distance affect the entire project. It then reconciles the network conducting multiple iterations, adjusting the suspect data more than it adjusts the trusted data (to the degree specified by the user's assumptions), until the complete project is resolved to its "best fit".

Each time this analysis program is run, it provides a Lat/Long for every point in the adjusted area and an item-by-item report of how much each measurement was adjusted. This is where the user begins interacting with the process to refine the final answer. The report includes a numeric value (residual) for each bearing, distance and control coordinate that compares the user's expectations with the amount of adjustment each point or bearing received to achieve the best solution. A second number called a snoop number, determined by the amount of error estimated and the amount actually incorporated in the adjustment, is also reported. A snoop number of 7.0 translates to: "You thought this spot had good data, but in order to make everything fit together, I had to bend the measurement seven times as much as you asked me to." In this way, all the problem areas are brought into focus. This is how data entry mistakes are easily detected, what WinGMM literature refers to as "automatic blunder detection".

Once data entry mistakes are corrected, it is up to the user to determine why certain areas do not achieve satisfactory results. A conceptualization of the network adjustment process, blended with a sense of cadastral history and data analysis is used to focus on the reason an area doesn't "fit". Users can easily revise assumptions about the quality of certain surveys or control points, and then rerun the adjustment. The result is successively better final results and more importantly, a much clearer idea of how reliable the source data is and consequently how reliable the computed

coordinate values are.

Not only will WinGMM present a definite idea of the reliability of the data processed, but also the results will be expressed in standard statistical convention. The GCDB data model has been designed to accommodate the crucial data provided by WinGMM and any other true least squares adjustment. Refer to GCDB's draft Baseline Data Collection Model, Version 1.3 03/27/90, Attribute Numbers 9044, 9048, 9150 and 9152.

EASE OF MAINTENANCE

WinGMM remembers the interaction the previous user had with the data. This data makes upgrading GCDB very simple. Any new data that enters the database is tagged with assumptions as to how good it is. This new data replaces the data that resided there previously. There is little more interaction - WinGMM readjusts the geometry of the plat data, and then re-subdivides the sections automatically.

Once data for a contiguous set of townships has been collected, blunders removed from RAW data, and error estimates refined, they can be combined into a regional set of data. This provides a means of maintaining a seamless data set. The boundaries of adjacent townships will have exact coordinate matches for every corner. After the region is adjusted, each individual township data set is updated using <u>regional</u> coordinates. Then they are re-subdivided by using the instructions recorded during the data collection.

Using WinGMM, the individual land parcels can then be linked to the BLM's Legacy inventory of legal land descriptions (LLD). This process attributes each polygon, created by WinGMM, with the legal land description, as collected from the BLM's Master Title Plats and survey plats.

COORDINATE GEOMETRY IS USED TO FURTHER DIVIDE THE MEASUREMENT NETWORK

The survey lines and points that comprise the survey plat do not always completely describe land parcels. Another process, using coordinate geometry, is used to break land units into smaller pieces as prescribed by deed descriptions or normal subdivision rules. In PLSS this is known as section subdivision. Other survey systems have concepts such as an offset line, i.e., "a 25 foot strip along the western lot line". Section subdivision occurs mostly with understood rules of construction. In some cases WinGMM-customized coordinate geometry (COGO) instructions must be specified to achieve desired results. This is commonly referred to as manual subdivision. WinGMM stores these instructions for reuse after each adjustment of the network of survey measurements.

ABSTRACTION

CHAPTER INTRODUCTION

The process to extract the best and most recent information on the surveyed lines that comprise a township is abstraction.
Information, including bearing, distance, elevation, control, type of survey line, and SID label is compiled from survey plats, field notes, topographic maps, protraction diagrams, Master Title Plats, other source documents and data already in the database. The SID label is a source identifier that GCDB assigns to each survey. Data is entered/edited-using INRAWW.

Control

Abstraction is a two-fold process. The first step is to determine the control available. A data table should be maintained with all control values. The latitudes/longitudes values are referenced either to the 1927 North American Datum (NAD27) or the 1983 North American Datum (NAD83).

NOTE:
   See GCONW, below, for information on converting between NAD27 and NAD83.

Plat Data

The second abstraction step consists of extracting information from the surveyed lines that make up a township (section lines and township boundaries). This information includes bearing, quadrant, distance, and SID label (source). This information is annotated on township diagrams, enlargements of survey plats, or detailed drawing, listed on abstraction forms, entered directly into the .RAW file, or any combination of these methods depending on the complexity.

Point identifiers, called GCDB IDs, are assigned to each corner. Values of these point identifiers are rule-based, when possible, to help make subdivision and parcel identification more automatic. The remainder of the naming rules provide for a consistent system to help people more quickly recognize corner types and help visualize the basic spatial relationships among the corners. Appendix A describes the conventions of numbering GCDB IDS.

ABSTRACTING A STANDARD RECTANGULAR TOWNSHIP

The steps necessary to abstract information for a standard rectangular township are as follows:

1. Obtain copies of all pertinent plats for the township so that the best and latest record is used. Include copies of the plats for the townships to the north, south, east, and west plus the corner townships if an overlap exists.

2. If necessary, check the field notes to see how lotting and subdivision were done where irregular lotting exists.

3. It helps to create a sketch of the area encompassed by your data set, like a township. Color-code the different surveys. Make a legend cross-referencing each color with the SID number.

4. If necessary, make use of detailed drawings and/or abstract sheets for complicated areas of survey, such as meanders, small holding claims, surveyed lines with two or more sets   of corners, etc.

ABSTRACTION

5. Assign GCDB IDS to each corner. Refer to Appendix A. GCDB Naming Conventions, including figure **A-1** for an example of ID coding for a standard township and figure **A-2** for an example of labeling a standard section.

6. If applicable, transfer abstracted information to appropriate abstract sheets. See Appendix B for descriptions of example abstraction sheets.

ABSTRACTING SPECIAL SURVEYS

The following steps are performed in abstracting special surveys:

1. Obtain copies of all pertinent special survey plats. Enlarge or draw detailed areas for clarity.

2. Check for resurveys.

3. Assign Point Identifiers. Refer to Appendix A. GCDB Naming Conventions.

4. Annotate each special survey boundary line with the corresponding distance and bearing on the plat copy, enlargement, drawing, or abstraction sheet being used.

5. In cases of overlapping surveys from various sources, digitize the plats to form one picture that shows the interrelation of all the surveys. Hard copies of the overall picture and of enlarged details will provide a useful worksheet that will greatly organize your efforts.

ABSTRACTING MEANDERS

Check the meander line field notes for:

! Original meanders
! Adjusted record meanders
! New meanders
! Duplicates (handwritten, typed)
! Fixed and limiting boundary
! Informative traverse

Evaluate meanders (see example in Figure **A-8**). Determine which meander lines continue to control property rights.

1. Ascertain whether meanders have been superseded by new meanders.

2. Where duplicate meanders exist, note that the rectangular meander line will normally control.

3. Determine whether record meanders have been adjusted.

4. Determine which informative traverse must be abstracted.

    a. Traverses must be abstracted if they form the boundary of an accreted area, which is divided, by division of accretion lines based on the informative traverse.

    b. If the traverse is only for area determination or for   locating a certain feature, it is not shown.

ABSTRACTION

Identify rivers that have meanders on only one bank.   Determine the best method for identifying banks without meanders.

1. Digitize the plat.

2. Use the width of the river.

Assign the segment identifier. Refer to Appendix A.

PREPARING THE COMPUTER FOR A NEW TOWNSHIP

1) Name the project according to GCDB Township naming convention.

Use the GCDB Township naming convention to create a name of your next project. See Appendix A, pg. A-1. If your township is T 34 N, R 07 W, then your project name will be T34NR07W. Although WinGMM Version 1.00 will work entirely with any project name, use of the standard naming conventions in such processes as getting boundary data from adjacent townships must be considered. In addition it facilitates WinGMM's ability to automatically combine and adjust data from several townships in a region. See WinGMM Users Manual, *Regional Adjustment of Data.*

2) Preparing the data files; .DEF .SID .CON and TEMP.JOB

WinGMM can create any file that it needs, using data that is manually input by you. However, where this data already exists in data tables, a great deal of trouble can be avoided by converting the existing data into WinGMM files.   The three files .DEF, .SID, and .CON are required files that can be created with SQL queries. TEMP.JOB can be created by a batch file instead of running PROJECW. A printout should be made of the .SID and .CON files to inspect them for completeness and correctness.

.DEF and TEMP.JOB - required before running INRAWW

The .DEF file can be created from within PROJECW. Refer to Appendix B - File Formats for WinGMM Data Files.

TEMP.JOB has no more than eight characters of data inside it, the name of your current project. In MS-DOS, the contents of TEMP.JOB will change each time you change to another township.

.SID - required before entering plat data (INRAWW)

The .SID file can be created and edited from within INRAWW or created through an external process customized to your existing database. Refer to Appendix B - File Formats for more in-depth information.

.CON - required before processing coordinates (GEN)

The .CON file can be created and edited from within INRAWW or an external process customized to your existing control database.   Sometimes there are two sources (different coordinate values) for the same corner and one of the lines should be "commented out" so WinGMM will not use it in the adjustment. Refer to WinGMM Program Reference, INRAWW - (7) Control Station Maintenance - (3) Import Control from a .CON file. In short, if you put a non-space character in the first column of a line in the .CON file, then WinGMM interprets that line to be a comment to the user, not a piece of valid data to use in the adjustment. Merge control, where coordinates from adjacent townships are used to assist in the merging of townships during regional processing, may also be coded in the .CON on a

ABSTRACTION

comment line. See *Regional Adjustment of Data.*

RUN PROJECW TO STORE DEFAULTS if there is no .DEF file or TEMP.JOB file.

The .DEF file and TEMP.JOB must exist in the township subdirectory. Running PROJECW to define the project name will result in the creation of those files.

GCONW and GCONHPW - NAD Datum Conversions

GCONW uses National Geodetic Survey (NGS's) NADCON (NAD27 to NAD83 and NAD83 to NAD27 geodetic program), which has been adapted to WinGMM. GCONW requires NGS files CONUS.LAS and CONUS.LOS, which provide data for the NAD27 to NAD83 and NAD83 to NAD27 conversion. GCONHPW is for conversions to HARN from NAD83 or NAD83 to HARN. Operation for GCONHPW is the same as for GCONW, except it can only use NAD83 coordinates and conversion can only be done in one direction during a run.

GCONW looks in the .CON file for NAD27 coordinates without NAD83 coordinates and computes the NAD83 values and writes the data on the next line. It also looks for NAD83 coordinates without NAD27 coordinates and computes them. The computed values are placed into the .CON and coded 27 or 83, in columns 56 & 57. All comment lines are preserved (lines with non-space character in column 1). GCONHPW does the same thing for HARN, but codes it HP in.

INRAWW looks for a datum in columns 56-57 of the .CON file. Anything but 83 or HP in those columns means NAD27. The project datum is defined in the .DEF file, and control coordinates are imported in that datum. If "Update .con file" option is used, and NAD27 is defined, all NAD83 coordinates are simply written back to the .CON and are not made comments. Same for NAD27 coordinates if in NAD83 is defined. NOTE: Delete the .LSA and .SD files before running INRAWW.

All other WinGMM program's computations will be based on whichever datum was set by PROJECW and is defined in the .DEF file.

A .CON file, after GCONW has ran, will have a 1:1 match of NAD27 and NAD83 coordinates. After GCONHPW the .CON file will have a 1:1:1 match of NAD27, NAD83 and HARN coordinates. GCONW and GCONHPW will ignore any lines that have been commented out with an asterisk.

This is a .con file before GCONW:

```
TEST.CON
 ORIGIN   451019.2345  683125.6772  140.000  0   0 2000.0000 5000.0000
* EXAMPLE OF COMMENT
 100100   451019.2345  683125.6772  140.000  8   3  27
 100200   451029.3457  683126.1267  140.000  3  100 83
* EXAMPLE OF COMMENT #2
 100300   451129.5671  683127.1234  140.000  9  52  27
* EXAMPLE OF COMMENT #3
* EXAMPLE OF COMMENT #4
```

This is the same .con file after GCONW:

```
TEST.CON
```

```
ORIGIN   451019.2345 683125.6772 140.000  0   0 27
ORIGIN   451019.4482 683123.7636 140.000  0   0 83
* EXAMPLE OF COMMENT
100100   451019.2345 683125.6772 140.000  8   3 27
100100   451019.4482 683123.7636 140.000  8   3 83
100200   451029.3457 683126.1267 140.000  3 100 83
100200   451029.1324 683128.0404 140.000  3 100 27
* EXAMPLE OF COMMENT #2
100300   451129.5671 683127.1234 140.000  9  52 27
100300   451129.7780 683125.2088 140.000  9  52 83
* EXAMPLE OF COMMENT #3
* EXAMPLE OF COMMENT #4
```

Note columns 56-57 are reserved for a NAD27, NAD83 or HARN. If it is blank, or something besides NAD83 or HARN is there, a NAD27 is assumed. Thus present .CON files (all NAD27) will work fine without the NAD27 in the file.

ABSTRACTION

DATA ENTRY AND EDITING

INRAWW

CHAPTER INTRODUCTION

This chapter deals with getting information from the survey plats or abstraction sheets into the computer. In WinGMM this task is done by INRAWW. Please, refer to INRAWW *Program Reference* for additional details. Data entry also refers to control data and the error estimates in the .SID and .CON file. INRAWW has many features that are appropriate during data entry. Those features, in the order we will explore them, are:

- Adding plat data for rectangular surveys: beginning, continuing
- Switching SIDs to indicate another survey is being input
- Importing plat data from boundaries of adjacent townships
- Importing coordinates from boundaries of adjacent townships (optional)
- Adding plat data from special surveys and complex rectangular surveys
- Importing known control coordinates from the .CON file
- Listing data on the screen to review and verify file content of: .RAW, .CON, .SID.
- Editing or deleting record data
- Adding to, changing or deleting control data
- Adding to or changing SID data
- Creating approximate coordinates of each point
- Provide a traverse closure report
- Updating .CON, .RAW, .SD, and, .LSA files.

We will start with just getting rectangular plat data into the computer, then focus on the other INRAWW features you will need to know about.

We assume that files .SID and .DEF already contain data values that are correct to our best knowledge. Files such as .CON .LSA .SD and .RAW need not exist at this point.

If .DEF does not exist, run PROJECW and answer the prompts. If .SID does not exist, run INRAWW - (5) SID Maintenance - (2) Add SIDs. Refer to the *WinGMM Program Reference*, INRAWW.

BEGIN THE INPUT OF RECTANGULAR PLAT DATA, - NO .RAW EXISTS
Refer to *WinGMM Program Reference*, INRAWW

Chose "Edit/Input/Edit Record data (INRAWW).
If no .RAW file has been established, then INRAWW will place you at point 100100 and prompt you for the distance of the line going Northerly along the W boundary of your township. It is at this time that you should key **[S]** to get the prompting for defining the default SID number. The purpose of the default SID is to save you from having to type the SID number after each line of data. Another choice you have in this prompting cycle is to type **[Q]**, which will quit the prompting cycle and return you to the main INRAWW menu.

If you didn't quit, then you will answer the prompt for distance, then the prompt for bearing, then the prompt for the "NEXT" ID, and the one at the other end of the line. Remember, if you answer the prompt with **640**, then INRAWW will apply the values of line 100100-100140 to each half-mile leg up to 100640 and you will then put in the data for 100640-100660.

CONTINUING THE INPUT OF RECTANGULAR PLAT DATA, - .RAW EXISTS

If the .RAW file exists when you start up INRAWW, then you will be brought to the main menu. Choose (2) RETURN TO INPUT OF CARDINAL LINES to input more section line data. You must then indicate your starting corner (GCDB ID).

PUTTING IN DATA FROM A DIFFERENT SURVEY - TIME TO SWITCH SIDS

Often, townships are comprised of data from different surveys. Each survey line entered into GCDB must be tagged with a reference to the source of the data (SID): surveyor, survey type, field note number and date. The SID number serves as that reference. The SID number is placed at the end of every line of the .RAW file. The database will use the SID number to match line/bearing/dist with the source. WinGMM puts that number on automatically, but you must tell WinGMM what survey you are working on. This is the "current" SID. Whenever you change from one survey to another, then you must "switch" SIDs and the new "current" SID will be appended to each line. This new current SID is a reference to the survey that you are just about to begin entering. There are two ways to switch SIDs. The easiest is to hit the **[S]** key when you are being prompted for the distance, bearing or GCDB ID. Another way is through INRAWW's main menu (5) SID MAINTENANCE - (4) SWITCH SIDS.

IMPORTING DATA FROM ADJACENT TOWNSHIPS

IMPORTING PLAT DATA

If any townships adjacent to your current township have been entered, you have the option of transferring the pertinent plat data from those township boundaries and adding it to your .RAW file. The .RAW files for these adjacent townships must be in your current directory. You will be prompted for the offset to be applied to the IDS to convert them into your townships numbering scheme, i.e. an offset of -3 will cause a 203100 in the township to the north to become 200700 in your township. Also, you can bring in a portion of a township. This is handy where township boundaries are offset or a portion of the boundary is offset.

IMPORTING COORDINATE DATA

If any townships adjacent to your current township have been adjusted, you have the option of transferring the computed coordinates from the adjacent township's .PGC file. These points become listed as fixed control in the current .LSA and .SD files. This option would be used to put control into a township that has no true control.

While importing plat data from an adjacent township, see above, the .PGC file for the adjacent township must be in the same directory as its .RAW file. If the .PGC file is present, the coordinates and plat data are imported, otherwise only the plat data is imported.

The error estimates for these points have to be set at .001, .001, in the project .DEF file, which prevents the Lat/Long values from changing (fixed boundary). The error estimates for the survey lines must be artificially raised by the user to allow all the adjustment to occur on the bearings and distances. Holding the error estimates impossibly low on the control and artificially high on the bearings and distances prevents WinGMM from computing realistic error ellipses.

AUTO-IMPORTING SELECTED COORDINATES DATA - MERGE CONTROL

The purpose is to help automate importing of merge control, which is used to merge townships during FORMLSA. And it allows for importing merge control from adjacent townships without importing the entire boundary. This lessens the effects of having to set artificial error estimates on the survey lines,

caused by importing the entire boundary. It is most importantly, a tool for allowing the merging of townships during FORMLSA.

Setup:

1) The value of the error estimates of the imported control are based on the values set by PROJECW in the .DEF file. It is recommended, if control is to be held fixed, that they be set to .001 before running INRAWW.

2) Append a comment line, with a text editor, to the .CON file of the form:

*MtxxXRxxX ffffff tttttt

Where:

*M   = comment line coded for merge control .

TxxXRxxX =the adjacent township that coordinates are to be imported from.

ffffff   =the point id of the station coordinates are to be imported from.

tttttt   =the point id of the station coordinates are to be imported to.

CAUTION:

DO NOT import actual control. It should already exist in both townships. FORMLSA throws out control that exists in only one township. If the adjacent townships .PGC file is not in the same directory, no control can be imported. If there are changes in the adjacent township, the township with merge control should be reprocessed after it.

3)   Before starting INRAWW delete the existing .LSA and .SD files, then start INRAWW:
      Select (4) CONTROL STATION MAINTENANCE
      Select (5) IMPORT CONTROL FROM A .CON FILE
      and then select <1> READ ALL CONTROL IN .CON FILE.

INRAWW reads in the coordinates of the station specified on the comment line in the .CON file. When quitting INRAWW, it is saved as a control point to .LSA and .SD files, at the specified station. Unless (4) CONTROL STATION MAINTENANCE - (6) UPDATE .CON FILE, is selected before quitting, the .CON file is not updated.

Every time control is imported using INRAWW, it will read the comment line and import the control as specified. During each subsequent adjustment, coordinates will always be imported. Therefore the values of the coordinates may change when the adjacent township has changed. This gives FORMLSA a better chance to merge data between the two townships, with the least effect on the reliabilities.

ADDING PLAT DATA FROM SPECIAL SURVEYS AND COMPLEX RECTANGULAR SURVEYS
Refer to *WinGMM Software User Guide* INRAWW

When the GCDB scheme deviates far from the standard township, it is possible to enter data in a more freeform style. In INRAWW's (1) RECORD DATA MAINTENANCE - (2) ADD RECORD INFORMATION, the "next" ID and other defaults are automatically generated using a different set of rules than in (2) RETURN TO INPUT OF CARDINAL LINES. How these defaults act depend on

RAW DATA ENTRY

whether you are entering rectangular survey data, GCDB IDS between 100100 and 710710 or special survey data, below 100100 or above 710710.

IMPORTING KNOWN CONTROL COORDINATES FROM THE .CON FILE

This feature controls what points are to be included in the least squares adjustment. Control points are "imported" from the .CON file into the .SD and .LSA files. LSGMMW does not read the .CON file.

Strategy: Although you must eventually choose #1, option #2 is provided to allow you to initially use **GEN**/LSGMMW adjustment analysis to test the data in the .RAW file. After importing just one control point (into .SD and .LSA), you run the data through **GEN**, LSGMMW and CHECKER. All three programs give you reports on where the most adjustment occurred. These are spots to look for possible data entry errors. Once the data errors are corrected, the same adjustment reports are used to refine your error estimates. Refer to the discussions on interpreting the .GEN file, .ADJ file and the .CHK file, below.

Once satisfied that the .RAW file is correct, you run:
INRAWW (4) CONTROL STATION MAINTENANCE - (5) IMPORT CONTROL FROM A .CON FILE - (1) READ ALL CONTROL IN .CON FILE.

LISTING DATA ON THE SCREEN TO REVIEW AND VERIFY YOUR WORK
Refer to *WinGMM Software User Guide* INRAWW

There will be many times that you will want to see the data that you have input:
- To find out where you left off
- To check for completeness
- To check for correctness
- To find the RECORD # of a particular piece of data
- To see your distances displayed in a different unit of measure
To list plat data, choose (1) LIST RECORD INFORMATION from INRAWW's main menu. You will also be presented with an opportunity to LIST plat data from within INRAWW's (1) (3) EDIT RECORD INFORMATION and (1) (4) DELETE RECORD INFORMATION features.

To list control data, choose (4) CONTROL STATION MAINTENANCE - (1) LIST CONTROL from INRAWW's menu. You will also be presented with an opportunity to LIST control data from within INRAWW's (4) CONTROL STATION MAINTENANCE - (3) EDIT (CHANGE) CONTROL DATA and from within INRAWW's (4) CONTROL STATION MAINTENANCE - (4) DELETE DATA.

To list SID data, choose (5) SID MAINTENANCE - (1) LIST SIDS from INRAWW's menu. You will also be presented with an opportunity to LIST control data from within INRAWW's (5) SID MAINTENANCE - (3) EDIT SIDS and from within INRAWW's (5) SID MAINTENANCE - (4) SWITCH SIDS, although SWITCH SIDS does not show error estimates.

INRAWW EDITING

EDITING OR DELETING RECORD DATA

Although INRAWW will prevent you from making a wide range of data entry blunders, there are just some things that get entered wrong. Using INRAWW's (1) (3) EDIT RECORD INFORMATION feature and INRAWW's (1) (4) DELETE RECORD INFORMATION feature ensures that the changes you make are reflected properly in all the appropriate files; .RAW, .SD and .LSA. Both features allow you to perform these operations individually or by a block.

RAW DATA ENTRY

The appropriate files are updated after you choose to quit INRAWW.

ADDING TO, CHANGING OR DELETING CONTROL DATA

Refer to *WinGMM Software User Guide* INRAWW

The same reasons that INRAWW should be used to EDIT or DELETE plat data also applies to ADDING TO, CHANGING and DELETING control data. Inside INRAWW's (4) CONTROL STATION MAINTENANCE feature are: (2) ADD CONTROL, (3) EDIT (CHANGE) CONTROL DATA and (4) DELETE CONTROL. The delete feature allows you to delete data individually or by a block (RECORD # to RECORD #). Error estimates can be edited by a range of line numbers or by groups of identical error estimate, by (7) BLOCK EDIT CONTROL ERROR ESTIMATES.

The .CON file will be updated only upon your request. This is accomplished by choosing INRAWW's (4) CONTROL STATION MAINTENANCE - (6) UPDATE .CON FILE.

ADDING TO OR CHANGING SID DATA

Refer to *WinGMM Software User Guide* INRAWW

The same reasons that INRAWW should be used to EDIT plat data and control data also apply to ADDING and EDITING SIDs. Inside INRAWW's (5) SID MAINTENANCE feature are: (2) ADD SIDS and (3) EDIT SIDS. Your changes will be automatically written to the .SID file and the .SD file.

QUITTING THE PROGRAM: CREATION OF THE NEWEST .RAW, .SD AND .LSA FILES

When you choose INRAWW's (8) QUIT feature, all new and changed data in the INRAWW session will be written out to the appropriate files. Also, as mentioned in the *WinGMM Program Reference*, INRAWW strips out many midpoint 1/4 section corners and combines those affected lines into one-mile lengths.
As noted above, functions within INRAWW can be used to edit the .SID file and the .CON file. These files will be updated only while you exit from the respective functions and only upon your command.

IF YOU NEED TO:	*THEN USE INRAWW FEATURE:*	
Add plat data	*(1)*	*(2) ADD RECORD INFORMATION*
Change plat data	*(1)*	*(3) EDIT RECORD INFORMATION*
Delete plat data	*(1) (4) DELETE RECORD INFORMATION*	
Add control data	*(4)*	*(2) ADD CONTROL*
Change control data	*(4)*	*(3) EDIT CONTROL DATA*
Change estimates	*(4)*	*(7) BLOCK EDIT ... ESTIMATES*
Delete control data	*(4)*	*(4) DELETE CONTRL*
Add SID data	*(5)*	*(2) ADD SIDS*
Change SID data	*(5)*	*(3) EDIT SIDS*
Delete SID data	*(5) (4) DELETE SIDS*	

RAW DATA ENTRY

ADJUSTMENT AND ANALYSIS OF GEOMETRIC DATA

CHAPTER INTRODUCTION

As mentioned in the introduction to this User Manual, WinGMM is designed to merge two kinds of data that sometimes conflict. Both the control and survey data are given error estimates for this purpose and these error estimates play a very important role in the adjustment and analysis of the two data types.

The program **GEN** prepares the data for Least Mean Square Adjustment. LSGMMW is a term we use to describe the adjustment via a variety of Least Mean Square programs. LSGMMW also provides an analysis of the adjustment. The process is a repetitive cycle of adjustment and analysis of the data until adjustments become so small as to become insignificant.

Normally, LSGMMW runs without any user input, the exception being when robusting is turned on. The robusting process is described in more detail in this User Manual, *BLUNDER DETECTION TOOLS AND STRATEGY*, and the WinGMM Program Reference, *LSMINW* and *LSGMMW*.

THE ADJUSTMENT/ANALYSIS PROCESS

There are three major programs/processes used to adjust and analyze the merging of the survey and control data. A more comprehensive explanation of these programs can be found in the WinGMM Program Reference.

    GEN generates approximate coordinates by running traverses between control points and performing compass rule adjustments where possible. It produces two files: 1) The .GEN file which is an ASCII file showing you misclosures of survey data by section and; 2) A new .LSA, which appends approximate coordinates to the bottom of the .LSA file produced by INRAWW.

    LSMINW performs a least square adjustment of the survey data using only one control point. Because a single control point is used, it must be assumed to be without error. LSMINW reads the .SD file created by INRAWW to determine how much relative adjustment to apply to each survey measurement entered in the RAW file. LSMINW produces a .MIN file that is similar to an .ADJ file (see LSGMMW below). It lists how much each measurement was adjusted and compares it to how much you estimated it would adjust. This file is very useful in tracking down any data entry blunders and to help gauge the quality of the survey data.

    LSGMMW refers to a process where a least square adjustment and analysis of the survey data and all control points that have been imported from the .CON file is performed. As with LSMINW, LSGMMW reads the .SD file to determine how much relative adjustment to apply to survey measurements. In addition, it also reads the .CON file to determine how much relative adjustment to apply to control points. There are several versions of the least squares programs that differ depending on the Operating System used and how much computer memory (RAM) is available. A description of these various versions is contained in the WinGMM Program Manual, LSGMMW. LSGMMW produces an .ADJ file that, among other information about the adjustment, lists how much each measurement was adjusted (residual) and compares that value against the input estimate of how much it should adjust (snoop number). When a measurement adjusts excessively (more than 3 times the estimate), data is marked with asterisks to indicate a higher probability of a blunder. This file is extremely useful in identifying potential blunders in, and help gauge the quality of, survey and control data.

ADJUSTMENT

BLUNDER DETECTION TOOLS AND STRATEGY

CHAPTER INTRODUCTION

WinGMM utilizes a least squares adjustment to merge survey and control data. Due to a combination of the laws of physics and human nature, there are errors in every measurement used in the WinGMM process. For the purposes of WinGMM processing, a blunder is defined as an error in an individual measurement (survey data or control) that is large enough in magnitude so as to cause significant effect on the adjustment of the overall data set.

These significant errors, or blunders, can be introduced to the WinGMM process a number of ways. We might have transposed or otherwise incorrectly entered record survey information from the plat. We may have assigned an incorrect Point Identifier to an otherwise valid control coordinate. These types of errors can be corrected if identified by editing the incorrect data. However, not all blunders are so easily addressed. In some cases, we may have entered the data correctly from the survey plat but that data is inconsistent geometrically with other measurements. Most of the WinGMM programs offer clues to finding data that was keyed in wrong or was bad in the first place. This chapter lists the programs you can run and some strategies you will find useful in finding and dealing with blunders.

In most cases, there will be several sources of survey and control data in a township data set. These situations are the most complex data sets to analyze and there is an advantage to analyzing the survey data alone. The procedure to accomplish this is to import only one control point from .CON, forcing GEN and LSGMMW to perform an adjustment based only on plat data. The .GEN and .ADJ files can then be reviewed for analysis of this plat only processing.

The plat data can also be checked for data entry blunders and general quality with the programs LSMINW, RAWW and CKW, as well as the graphics programs. For tracking down the not-so-obvious errors, you can use "robusting" to localize the adjustments into the areas where data isn't fitting. Once blunders have been removed from the .RAW file, robusting should be abandoned. LSMINW is run to make a permanent copy (.MIN) of the adjustment of the plat data. Then the remainder of the .CON file is imported and the network is readjusted via GEN and LSGMMW. It is at this time that bad control (or bad point identifiers for good control) can be found and fixed.

GEN

Technique: Interpreting the .GEN file.

The .GEN file is your first opportunity to review how the data fits together geometrically. There are three kinds of information contained in the .GEN file that are useful in finding blunders. The first part consists of loop closures around all sections possible based on the survey data contained in .RAW and looks like this:

```
********************
LOOP TRAVERSE REPORT FOR SECTION 17
CLOSURES
NORTHING (Y)  EASTING (X)     LINEAR    PRECISION      TRAVERSE DIST.
   5.8 FT.    -.9 FT.     5.8 FT.   1/   3641.       4.0 MI.
STATIONS IN TRAVERSE
200400-200500-240500-300500-300440-300400-240400-200400-

********************
```

These sections are very useful in tracking down blunders as we expect the plats to close within the limits

required at the time of survey. The obvious exception to this would be is when the data for a section is comprised of different sources such as an original 1891 survey and a resurvey performed in 1981 on a portion of the section boundaries where significant distortion in the original survey was identified. When data for sections are from the same source and there are misclosures reported for adjoining sections that are similar but opposite in direction, there is a higher probability of blunder on the line common to those sections. Most of the time, these blunders will be in data entry and are corrected by editing the .RAW file to reflect the correct information. Sometimes, they are measurement or platting errors that can be dealt with by assigning a separate error estimate to the individual line(s) of data in the .RAW file.

Users must be aware of how many sections can be closed based on their input .RAW data and ensure a closure was calculated for all possible sections.
At the end of the section in .GEN that performs these loop closures around sections, there is a summation of the loop closures including an overall average precision of closures for all sections evaluated.

Following the section of the .GEN file on LOOP closures is information regarding LINK traverses. LINK traverses are traverses of the .RAW information to generate approximate coordinates of all unknowns (non-control points) for LSGMMW. These traverses will also include non-rectangular data traverses if they exist in the .RAW file and will sometimes be closed traverses of this type of data. As with closure around sections, these types of information can be extremely useful in identifying blunders in data entry. Because the purpose of these traverses is to calculate approximate coordinates once and only once for all unknown stations, the user may not see all closures they wish to evaluate contained in the .GEN file. The program CKW (covered later in this chapter) allows users to input specific traverses for evaluation.

The third type of information contained in the .GEN file is a listing of all points for which approximate coordinates were developed but for which a compass rule adjustment can not be performed. These types of information are listed in the format "STATION XXXXXX LOCATED BY DISTANCE-BEARING FROM STATION YYYYYY" and can be found by performing a search for the word LOCATE. While this type of data is most often legitimate, this can be useful in identifying blunders like incorrect data entry of point IDS in the .RAW file. This is especially true in data sets where the data is so good, two points that were meant to have the same point ID are created at coordinates so close that it is extremely difficult to catch such errors by graphical methods.

PROJECW

Technique:
ROBUSTING   Refer to *WinGMM Program Reference*, LSGMMW

PROJECW must be run to specify that you want to robust by setting option (15) READJUST WITH ROBUSTED ERROR ESTIMATES to YES. This causes an additional prompt to occur just before the normal exit from LSGMMW that asks "DO YOU WANT TO READJUST WITH NEW WEIGHTS (Y/N)?".   When you answer YES, LSGMMW will ask you which measurements you want to robust.

So what is robusting?   Here is an example: Say a bad E-W distance was entered. This could be a data entry error or correct entry of a bad measurement, but otherwise the survey data was good. During LSGMMW, the least squares adjustment will find the bad geometry, but will not know if it is the E-W distances or the bearings coming into the end points from the N and S. Your error estimates may tell LSGMMW not to adjust any of this data very much because you believe the source data is accurate. LSGMMW will spread the error over a wide area to make it fit, but the measurements closest to the bad data will be adjusted more.

If robusting is turned on, LSGMMW gives you the option to "re-weight" control, distances, angles, or

BLUNDER DETECTION

bearings after performing a least squares adjustment. You may choose to re-weight one or all of these measurements and you may robust repeatedly on any individual measurement type(s). When you quit this prompting cycle, LSGMMW will run through the adjustment again reweighing the selected measurements based on actual adjustments observed as opposed to error estimates from the original least squares adjustment. As noted in the previous paragraph, the measurements closest to a blunder will be adjusted the most in a standard (no robusting) LSGMMW run. So in robusting the example above, the error estimate for a bad distance would change the most, followed by the error estimate for the nearby angles. This tends to localize the adjustments into the area where the blunder occurred. Repeated robusting localizes the adjustment even more.

Robusting distances twice and angles twice normally localizes blunders sufficiently to make them easily recognizable in the output .ADJ file. Robusting distances first is not a random decision but based on the fact it is generally easier to measure distances than bearings and if an error in an individual distance is made, it tends to be relatively severe and thus more easy to isolate with a least squares adjustment. Once blunders have been identified and addressed, by editing errors in the .RAW file or using an individual SID, the user can import all control points and use robusting to analyze control problems if they exist.

Robusting is particularly useful in identifying control points with incorrect Point Identifiers. If a control point was erroneously given an identifier that indicated it was located 2 miles away from where it actually was, this control point would be "moved" the most in a least squares adjustment. However, as with distances and bearings, other data would also be affected including bearings and distances. This can result in an .ADJ file that is confusing and very difficult to interpret correctly. By robusting a few times on control, the erroneous control point may be localized and become much easier to identify.

Note the output .ADJ file is appended to, not overwritten when robusting is performed. This allows the user to see what steps were taken in robusting a data set and analyze the effect of each action.

Finally, robusting is meant to serve as a blunder detection tool, is not an acceptable process for least squares adjustments, and **_must_** be turned off for the final LSGMMW of a data set.

INRAWW

Technique: Viewing distances in different units of measure

The .RAW file stores all distances in chains. If the plat has distances in feet, then the distances have to be converted to a common unit in order to check them. Fortunately, INRAWW is capable of displaying .RAW data in chains, feet or meters.

Example: a mineral lode line is 612.15 feet across the end line, according to the plat. INRAWW will normally list this line in chains, and you read 9.275 chains. You can change the distance units to feet through INRAWW's (7) CHANGE DISTANCE UNITS - (2) FEET, then listing the same mineral lode line will produce the distance in feet: 621.15 feet instead of 9.275 chains. Here is where you can detect the mistake; the actual plat distance should be 612.15 feet, not 621.15.

In areas where feet were used on the plat, you can print out the .RAW in the correct units, using INRAWW's (1) LIST RECORD INFORMATION in conjunction with your operating system's facility for printing out scrolled data. You can press Ctrl P to print whatever scrolls through your monitor.

An added benefit in using INRAWW to list your .RAW file data is that bearings are displayed more like a plat, see immediately below in feet:

```
REC # FROM   TO  DIST. (FT) ERR. (FT)  BEARING  ERR.   SID
 495 100140 940020   86.592   1.043 S 49-16- 0 E  0- 0-20 33752
 496 940020 939020  1499.982   1.750 S 79-40- 0 E  0- 0-20 33752
```

```
497 940010 939010  1499.982   1.750 S 79-40- 0 E  0- 0-20 33752
498 939020 938010  1496.022   1.748 S 79-40- 0 E  0- 0-20 33752
```

Then back to chains:
```
REC # FROM   TO  DIST. (CH) ERR. (FT)  BEARING  ERR.   SID
 495 100140 940020    1.312   1.043 S 49-16- 0 E  0- 0-20 33752
 496 940020 939020   22.727   1.750 S 79-40- 0 E  0- 0-20 33752
 497 940010 939010   22.727   1.750 S 79-40- 0 E  0- 0-20 33752
 498 939020 938010   22.667   1.748 S 79-40- 0 E  0- 0-20 33752
```


CKW

Technique: User defined traverses.

The program CKW is similar to the program GEN in that it automatically performs RAW data traverses around any sections possible writing this information to the .CHK file. The format of this section closure data in the .CHK file is different from .GEN as follows:

```
********************
 TRAVERSE CLOSURE REPORT FOR SECTION 31
 SUM OF DISTANCES ALONG TRAVERSE IS     4.00 MILES
 CLOSURE IN NORTHING  (Y) =     -5.9 FT.
 CLOSURE IN EASTING   (X) =      .8 FT.
 LINEAR ERROR OF CLOSURE IS     6.0 FT.
 STANDARD PRECISION IS 1/      3549.
 STATIONS IN TRAVERSE
 100100-100140-100200-120200-140200-200200-200140-200100-163100-140100
 123100-100100-

 ********************
```


CKW differs from GEN in that after running all possible RAW closures around sections, it does not automatically calculate LINK traverses, but rather asks the user if they wish to perform any additional traverses. If the user answers yes, CKW prompts for the point of beginning for the desired traverse. It then checks the .RAW file for all possible lines of data into and out of this point and gives the user a menu of all possible directions the traverse could be in. It continues in this manner until the user enters a zero to signify the end point of the desired traverse has been reached.

When a user defined traverse in CKW closes back on the point of beginning, CKW recognizes this and performs a traverse based on RAW survey data alone. If a traverse does not close against the point of beginning, CKW compares a geodetic traverse of the lines from .RAW against coordinates in the .COR file. Therefore, as the .COR file is produced by LSGMMW, CKW can only be run after LSGMMW has been completed. The information regarding user-defined traverses is written to the .CHK in the format:


```
********************


TRAVERSE CLOSURE REPORT
 SUM OF DISTANCES ALONG TRAVERSE IS     1.87 MILES
 CLOSURE IN NORTHING  (Y) =      .2 FT.
 CLOSURE IN EASTING   (X) =    -12.6 FT.
```

BLUNDER DETECTION

LINEAR ERROR OF CLOSURE IS   12.6 FT.
LINEAR ERROR OF CLOSURE (AFTER ROTATION) IS   .6 FT.
STANDARD PRECISION IS 1/   781.
AFTER ROTATION PRECISION IS 1/   16702.
STATIONS IN TRAVERSE
500546-940070-940080-940090-940100-940110-940120-940130-940140-940150
940160-940170-940180-940190-940200-500504-

****

In this manner, the user can perform specific traverses that may not be included in the .GEN file. This is particularly useful in complex data sets where a problem has been localized, but could be due to any of a number of individual surveys that are tied to each other such as mineral surveys. Generally, it is advisable to perform closed traverses of such types of surveys any time WinGMM processes indicate they may the source of problems.

LSGMMW

Technique: Viewing .ADJ for analysis of the least squares adjustment.

LSGMMW produces an .ADJ file. The .ADJ file is the most valuable file for analyzing the data set. It lists input measurements in the same order as the .LSA file, how much it adjusted (residual), how much you expected it to adjust (error estimate) and most importantly for you right now, the "snoop" number. The snoop number is the residual number divided by your error estimate. Assuming error estimates are reasonable, when a measurement adjusts more than three times as much as you expected, there is a high probability this measurement is a blunder and LSGMMW will put asterisks to either side of the snoop number in the .ADJ file. The higher the snoop number, the higher the probability of blunder but, to maintain consistent format of the .ADJ file, snoop numbers can never be higher than 9.9. Low snoop numbers can be an indication of poor error estimates and can result in statistically invalid data adjustment. Optimal snoop numbers are between 0.5 and 1.0 but generally, snoop numbers up to 3.0 are not considered cause for undue concern.

The .ADJ file starts by listing some very important information regarding the least squares adjustment of the data set:

HEADER INFORMATION - Information regarding the overall data set including the datum the data was processed in, coordinate units, projection, network (average) elevation used, number of relevant measurements input and generated, and a multiplier needed to derive a 95% positional confidence of the final coordinates error values.

RESULTS OF ADJUSTMENT - A listing of all point identifiers, their adjusted coordinates, and information regarding the statistical quality of each point based on the least squares adjustment.

Following this section of overall information, the .ADJ file contains very important information regarding individual measurements in the data set:

CONTROL POINT COORDINATES - The control portion of .ADJ lists point identifiers, how much the control point was adjusted (residual), the input estimated quality (error estimate), and a snoop value in northing and easting for each control point used and looks like this:

CONTROL POINT COORDINATES

BLUNDER DETECTION

STATION	NORTHING (Y) RESIDUAL	NORTHING (Y) EST. ERROR	EASTING (X) RESIDUAL	EASTING (X) EST. ERROR
100100	-7.309 (.2)	30.000	43.951 (1.5)	30.000
100200	-5.818 (.2)	30.000	25.101 (.8)	30.000
100500	40.152 (1.3)	30.000	-10.616 (.4)	30.000

(repeat for every control point used in the adjustment)

At the bottom of the control section of the .ADJ file, a listing of the average adjustment, average snoop value, and maximum adjustment in northing and easting is listed and looks like this:

NORTHING CONTROL RMS =   25.257 SNOOP RMS = 1.1
MAX. NORTHING RESIDUAL AT 600100   OF   64.569
EASTING CONTROL RMS =   32.390 SNOOP RMS = .8
MAX. EASTING RESIDUAL AT 500300   OF   69.382

DISTANCES - The next section of the .ADJ lists information regarding every distance input consisting of From point identifier, To point identifier, input distance, how much that distance was adjusted (residual), a snoop value, and the input error estimate and looks like this:

MINIMUM DISTANCE RESIDUAL PRINTOUT =   .000

DISTANCES

OCCUPIED STATION	SIGHTED STATION	DISTANCE	RESIDUAL	EST. ERROR
700100	700200	5280.000	.012 (.0)	6.224
700200	700300	5280.000	-1.538 (.2)	6.224
700300	700400	5280.000	-.011 (.0)	6.224

(*repeat for every distance*)

At the bottom of the distance section of the .ADJ file, there is a listing of the average adjustment, average snoop value, and maximum adjustment of the entire data set that looks like this:

DISTANCE RMS ERROR =   2.335 SNOOP RMS = .7
MAX. DISTANCE RESIDUAL 700600   - 700640   OF   10.621

The overall snoop value listed here is a very important value. In the vast majority of data sets, it is desirable to have a snoop value between 0.5 and 1.0 here. This would indicate confidence that, on an overall basis, the user has input valid error estimates for the distances in the data set.

BEARINGS - The next section of the .ADJ lists information regarding every bearing input consisting of From point identifier, To point identifier, input bearing, how much that bearing was adjusted (residual), a snoop value, and the input error estimate and looks like this:

MINIMUM BEARING RESIDUAL PRINTOUT =   .0 SECONDS

BEARINGS

OCCUPIED STATION	SIGHTED STATION	MEASUREMENT (D-M-S)	RESIDUAL (D-M-S)	ERROR EST.
700100	700200	N 0- 0- 0E	- 0- 0-11 (.2)	0- 1- 0

BLUNDER DETECTION

```
700200        700300        N  0- 0- 0E    0- 0- 2 ( .0)    0- 1- 0
700300        700400        N  0- 0- 0E    0- 0-13 ( .2)    0- 1- 0
```
(*repeat for every distance*)

At the bottom of the bearing section of the .ADJ file, there is a listing of the average adjustment, average snoop value, and maximum adjustment of the entire data set that looks like this:

```
 BEARING RESIDUAL RMS =   0- 0-12 (D-M-S) SNOOP RMS =   .3
 MAX. BEARING RESIDUAL 700700        -600700        = 0- 0-55 (D-M-S)
```

As with distances, in the vast majority of data sets, it is desirable to have a snoop value between 0.5 and 1.0 here. This would indicate confidence that, on an overall basis, the user has input valid error estimates for the bearings in the data set.

RAWW

Technique: Prepares unadjusted .RAW data for graphical viewing on your screen. It also writes data inconsistencies into the .CLS file.

Despite the best efforts, human nature is such that sometimes relatively minor errors are made in data entry that will result in an adjustment that cannot be analyzed using normal WinGMM processes. When problems like lines missing from your .RAW file, mis-numbered point IDS, wrong quadrants, transposed numbers and other hard to find mistakes in your textual files exist, you may use RAWW to get a graphical representation of what your .RAW and .CON files look like. The WinGMM program RAWW produces the RAW.LSA file that can be used to actually get the picture, and a .CLS (closure) file, which is an ASCII report of common data entry errors.

DXFW

Technique: Store data in a graphic file so it can be displayed or plotted.

DXFW will give you more flexibility because you can import the picture into any software capable of reading a .DXF file. There are many ways to view, print, plot or even edit the picture from these graphic programs. A printout of a .DXF file can even be made through Word Perfect.
DXFW has several options to select from in creating a .DXF file. When looking for a blunder during abstraction of the raw data it is best to use coordinates and lines from the .LSA file. For a view of the final WinGMM product, it is best to use coordinates from the .COR file and lines from the .LXN file. DXFW is an invaluable tool for determining if APROPW correctly created all polygons in a township, by using coordinates from the .COR file and lines from the .LXN file. After a region has been merged with FORMLSA, DXFW can be used to create a .DXF file using coordinates and lines from the .LSA file. Then the region can be graphically inspected for a proper merge of township boundaries.

LSMINW

 Technique: Track down blunders in plat data.

The program LSMINW performs a least squares adjustment using a single control point. This allows statistical analysis based solely on information in the .RAW file. As most surveys are required to close within certain limits, use of low error estimates can identify extremely minor errors in data entry. LSMINW is also useful in identifying and handling platting blunders where required closures were not met or there were discrepancies between the plat and the notes. Finally, introduction of multiple control coordinates in

BLUNDER DETECTION

LSGMMW, allows us to identify errors in the survey not reflected by the plat resulting in the ability to generate truly useful error estimates of the survey data and the geographical positions generated from that data. For the purpose of this analysis, LSMINW outputs the .MIN file containing identical information as in the .ADJ file with the exception of the sections on RESULTS OF ADJUSTMENT and CONTROL POINT COORDINATES.

SNOOPER

All of the blunder detection tools discussed so far were designed to do overall analysis of a complete data set on a township basis. In the vast majority of situations, these overall data sets are comprised of data from several different sources. Using a vastly over-simplified example, it is conceivable a data set containing 50 measurements with a Root Mean Square (RMS) value of 5.0 and 200 measurements with a RMS of 0.0 could yield an overall RMS of 1.0 leading to a false statistical validation.

SNOOPER is a program developed in FORTRAN by California GCDB staff whose purpose is to provide analysis of individual sources of data based on the Source Identifier (SID) field of the .RAW file. Data from the .ADJ file is gathered for each separate source and a mean actual adjustment *by source* is computed. This is an extremely powerful tool for refining errors.

After computing the mean actual adjustment for each source in an overall data set, SNOOPER compares each individual measurement of that source data and calculates a RMS by dividing the actual adjustment of individual measurements by the mean adjustment it just calculated. Individual measurements which are adjusted more than twice the mean are written to a .JNK file that looks like this:

```
B100300       100340 R03120363 N  5- 3- 0W      3-12-13 (1.6
B100340       100400 R03120363 N  5- 3- 0W      3-12- 4 (1.6
B236400       220400 R03120363 N 83-18- 0W      3-47-41 (1.9
B220400       200400 R03120363 N 83-18- 0W **   6- 6- 1 (3.1
D200300       200400 R03120363  5280.000 *** -33.122 (3.1
```

Note each line starts with a "B" or "D" indicating whether the measurement is a bearing or distance, followed by the "from" and "to" point IDS, The SID, the input data value from the .RAW file, the actual adjustment from LSGMMW, and the snoop value from the .ADJ file. Each measurement listed in the .JNK file should be checked against the original source data for data entry errors.

STRATEGIES

Following is a routine using all of the processes above. Because there are so many processes that allow the user to identify errors, it is left to the user to decide which ones work best for them.

STRATEGY: TRACKING DOWN BLUNDERS IN RAWW DATA

1) Run INRAWW using a single point of control, GEN, LSGMMW and SNOOPER. If the CHI Squared value at the bottom of the .ADJ file is very high or LSGMMW fails to run, you will probably want to run RAWW and input the resulting RAW.LSA file to check the .RAW and .CON data.

2) Check any measurements listed in .JNK against the original source data and correct any data entry errors found. If errors are found, return to step #1.

3) Run DXFW with coordinates read from the .COR file and lines from the .LSA file. Import the resultant

.DXF file into any program capable of reading a DXF. Note the above options cause lines to be drawn in separate colors by the source ID in the .RAW and .SID files.

4) Copy the project .SID file to ORIGINAL.SID and then copy the .SNO file created by SNOOPER to the project .SID file.

5) Run INRAWW using a single point of control, GEN, LSMINW, LSGMMW and SNOOPER.

6) Check any measurements listed in .JNK against the original source data and correct any data entry errors found. If errors are found, return to step #5.

7) Review the .GEN file for section closures and obvious LINK traverse problems.

8) Review the .ADJ file and look for asterisks. Check RMS and maximum values for distances and bearings. With a single point of control and error estimates based on step 4, these values should be between 0.5 and 1.0 and the CHI Squared test will probably pass.

9) If there are asterisks or RMS values and CHI Squared do not fall within the limits above, use PROJECW to turn robusting on. Run LSGMMW and robust twice on distances and twice on bearings to localize problems.

10) If there is an indication of problems in areas involving complex non-rectangular data, use CKW to perform specific traverses in those areas. Review the .CHK file to identify misclosures and check that data against the original source correcting any errors found. If errors are found, return to step #5.

STRATEGY: TRACKING DOWN BLUNDERS IN CONTROL DATA

When you are satisfied data entry blunders have been eliminated, you are ready to introduce an independent check of the plat information in the form of all available control. As with the steps above to eliminate errors in the plat data, it will be left to the individual user to determine which steps in the process below should be run on a regular basis.

1) Copy the ORIGINAL.SID created in step 4 above to the project .SID file.

2) Run INRAWW using all available control, GEN, LSGMMW and SNOOPER. If LSGMMW won't run or the solution diverges, you have bad control data of some kind. Run RAWW to find the error. If there are no apparent errors, set robusting on in PROJECW and robust twice on control to localize the problem keeping in mind robusting must not be used in deriving a final LSGMMW adjustment.

3) Review the .ADJ file to analyze how much each control point was moved, RMS values for control, distances and bearings, and the CHI Squared test. Also look for asterisks.

4) Review the .REP and .JNK files created by SNOOPER. Note that each run of SNOOPER appends the results to the end of this file and so contains a history of what has been done and the effects on the data.

5) As errors in control are found and addressed, return to step 2. Any errors in RAW data that weren't found in the previous strategy for tracking down those blunders, will rarely (not never) justify rerunning that process.

In many cases, the survey and control data support each other. When this happens, no control point will move more than it's estimated error, all RMS values will be acceptable and the CHI Squared test will pass.

BLUNDER DETECTION

When survey and control data do not support each other, some professional judgment is required to determine where the errors are. Properly interpreting results in these cases requires knowledge about plat data and control data. The more you know about both types of data, the easier your judgment will be. The question is, where is the corner? In many cases, you can't be sure unless someone goes to the field and verifies the true location of the corner.

If a single digitized control point is "way off" and a recent survey has to bend a great deal to fit it in, you might conclude the control coordinates are in error and you can comment out that piece of control. Be aware that eliminating control coordinates is tantamount to saying the plat data is correct. Again, unless you have intimate knowledge of the survey or control data, it is difficult to make such a statement. Furthermore, by eliminating the control point, there is no longer anything to indicate there may be uncertainty and error estimates on the coordinates generated by LSGMMW will not reflect this.

In a similar situation where you have reason to doubt the accuracy of the survey, such as a survey performed prior to 1900, you may choose to loosen the survey data error estimates to stop excessive movement of the control point. The most difficult decision in these cases is determining where the errors in the survey data might be. In the case of a section corner, are there errors in all lines into and out of the control point or is there an error in only one of those measurements? Robusting distances and bearings can be extremely useful in resolving this dilemma. While lack of sufficient knowledge carries similar risks as elimination of control in the previous paragraph, you have not eliminated the survey data so uncertainty you have associated to the survey data is reflected in the error estimates on coordinates generated by LSGMMW.

The above discussion is not meant to confuse the reader but merely to outline the options and potential pitfalls for handling these types of problems when they are encountered. These situations, while not necessarily common, are also not rare. The most difficult decisions that must be made are when there is a high degree of confidence in both survey and control data. Take for example the following real life data set:

An original survey of a township was executed in 1945 by an individual with a reputation of excellent survey work. The 1945 brass caps were found by USGS and placed on a 7.5 minute quad dated in the late 1970's. Our analysis of the survey data alone supports our knowledge of the excellent reputation of the surveyor, but when combined with the digitized control, several of the digitized control points are moving in excess of our estimated accuracy with the largest movement of 110 ft. at the NE corner of the township. We re-mount the quad sheet and verify the coordinates of the control point. While we know even the best surveyors make occasional mistakes, there is no reason to suspect this level of error by the surveyor. On the other hand, we also know that USGS location of found corner symbols is generally of a much higher accuracy than indicated in this data set.

Following the process above, after introducing the control data, we robust twice on control in LSGMMW and, predictably, the error is localized to the control point at the NE corner of the township and the other control points that were moving excessively are now consistent with the observed average quality of control in the .ADJ file. In this particular case, as the corner in question is common to 3 other townships originally surveyed in the same era, we defer final decision until those townships are completed. WinGMM processing of those data sets supports the uncertainty of the control at the township corner but may not be considered to be conclusive as there is no indication the adjoining original surveys visited the corner in question. However, based on the preponderance of evidence the decision is made the control point is bad and it is eliminated in the processing of all four townships, resulting in small error estimates on the corner in question.

So we made a decision, but is it the right one? Is that corner really in a significantly different position as we are showing in GCDB? Have we done the user of GCDB any favors by eliminating the control and thus "hiding" the uncertainty that exists. On the other hand, if we had kept the control position and let it affect many dependent corners, would we be introducing uncertainty where none may exist? This is the dilemma you will face in processing data through WinGMM. To finish this story, we did what is really necessary to be sure and had the corner location verified by GPS. In this case, we made the correct decision as GPS showed the corner to be actually located almost exactly the shift from the digitized coordinates.

BLUNDER DETECTION

REFINING ERROR ESTIMATES

CHAPTER INTRODUCTION

Finding blunders in data sets as described in Chapter 5 is a very important part of the analysis process, but we must also detect where our error estimates may need to be refined. You will notice that many of the same tools are used for both detecting blunders and refining error estimates. This chapter describes the tools for detecting and refining error estimates.

Examples requiring error estimate refinement:

    Scenario 1: With initial survey data error estimates in a township and running through the LSGMMW process you see 3 digitized control points have residuals of 240 feet or more in the .ADJ file. You suspect the survey data.

    Scenario 2: After robusting a data set, you find several E-W section lines have taken most of the error, perhaps 500 feet or more.

    Scenario 3: After importing a boundary from an adjacent township, the residual values on the boundary become very high.

    Scenario 4: After importing a boundary from an adjacent township, residual values get excessively high on the lines running into that boundary.

When you have large error values showing up in either residuals or standard error of unit weight, this can be due to 3 basic classes of problems.

1) Error estimates not truly reflective of quality

    This is the situation where the WinGMM user has made estimates that are not consistent with the actual data quality. A good example would be placing bearing error estimates of 10 seconds and 1 link on 1858 plat data when the survey was actually performed to 20 links per mile and 4 minutes. Another example might be holding digitized control fixed if such control is closely spaced, etc.

    Users should recognize that the original surveys of the public lands are known to contain many errors due to many conditions among them hazardous terrain, low cost and low land values. In difficult terrain it is not uncommon to find that the original surveyor did not run all the lines reported, and since closures were not thus obtained they may not have detected other blunders, usually in chaining, that affected the work. In some areas local magnetic attraction or steep side slopes bias bearings.

2) Correctable blunders

    WinGMM is extremely good at identifying problems with data, while it takes some experience to ferret out some of the less obvious errors or blunders in the data, there are a number of methods and tools provided in WinGMM to assist in this process. Examples of this class of problem are: incorrect or bad control coordinates, incorrect entry of plat data, and incorrect or inconsistent point naming. In all of these cases the blunder can and should be found and corrected.

3) Unresolvable blunders

Sometimes, errors or blunders in data exist where it is very difficult or even impossible to determine the exact location or nature of. These can fall into several classes:

Control: You digitized several found corner symbols off of a 7.5 minute quad and analysis indicates that one of these points does not agree with the survey. You do not know if the USGS identified the wrong point, misplaced a correct point on the quad, or the actual corner on the ground is where they say and it is the survey that has a blunder in it. If you cannot go to the field to verify the location, you may not be able to do much to find out what USGS did. Lacking any concrete knowledge of the survey data, you must make a judgment call based on preponderance of WinGMM information. Keep in mind that when the contract method of surveys was abandoned in favor of a civil service approach, very rigorous quality control measures were put in place and, in the vast majority of cases, adhered to. On the other hand, USGS places a 90% confidence on the placement of found corner symbols on 7.5 minute quads and our analysis of hundreds of thousands of digitized found corner symbols combined with survey data indicates a much better confidence level than that. By using the procedure outlined in the chapter on Blunder Detection, WinGMM programs will almost always provide a preponderance of evidence to help you make a decision. If not, you should presume the control is good and proceed accordingly.

Surveys: Many older surveys and occasionally more recent surveys contain field blunders. In addition, there are periods in history in which fraudulent surveys are known to have been performed under the contracting system throughout the western United States. In fact, the unacceptably high incidence of poor quality surveys was the main impetus behind abandoning the contracting system of performing PLSS surveys in 1910. Some examples of blunders which you may encounter are discrepancies between the notes and the plat, individual measurement blunders, fictitious closings, invalid basis of bearing, ties and lines not actually run in the field, or reported random and true lines that were in fact stubbed out.

These types of errors can be quite large and are often in areas where, for obvious reason, little or no control has been identified. Without adequate control or significant additional information, it is very hard to identify all these blunders. Again, you may not be able to justify going to the field to verify suspected blunders in the survey. Where control is available, WinGMM's LSGMMW analysis process will usually assist you in determining the most likely place such blunders are located. When faced with a data set where there is little or no control, the user should be very wary of assigning good error estimates to survey data especially on contracted GLO surveys. Lack of control, in and of itself, is normally sufficient evidence to suspect the quality of those surveys. Fortunately, because error estimates are dependent on error estimates and not just adjustments, your uncertainty will be reflected.

Boundary transfers: The current GCDB data collection process allows individual township computation with rigid coordinates from adjacent completed townships transferred in as control. This leads to points of varying accuracy and uncertainty assigned no error as fixed control. Thus 1885 survey data and two digitized control points, used to compute the first township and known to only be reliable to 100 feet, are held as perfect in the adjoining township. This violates the concept of the least squares analysis being performed in the current township and almost always requires placing more flexible error estimates on the boundary and lines closing into the transferred boundary than are appropriate for those lines under normal circumstances.

This is an unfortunate byproduct of a rigid township boundary approach, it must be recognized and dealt with, but basically you have to live with this as a necessary evil in the boundary transfer regime.

Scenario 1: After making initial data estimates in a township and running through the LSGMMW process you notice that 3 of your digitized control points have residuals of 240 feet or more in the .ADJ file. What

REFINING ERROR ESTIMATES

should you do?

Scenario 2: After robusting a data set, you find several E-W section lines have taken most of the error, perhaps 500 feet or more.

Unless you have reason to suspect your control, the problem is probably in the survey. Survey error estimates are normally rigid relative to the weighting on digitized control. Thus a blunder in the survey will `push' the control around.  The proper solution is not to `tighten' the control error estimates, but to loosen the overall survey error estimates or try to determine what lines the blunder most likely occurred and assign those individual lines a lower error estimate `junk' SID.

One tool to do this is to use PROJECW to set robusting on and then robust your survey data in LSGMMW twice on distances and evaluate the .ADJ file to see if the error becomes isolated to some particular line(s). Robusting distances first is not a random decision but based on the fact that it is generally easier to measure distances than bearings and if an error in an individual distance is made, it tends to be relatively severe and thus more easy to isolate with a least squares adjustment. If no obvious blunders in distances are found, robust twice on bearings. If you identify data that looks bad, create a `junk' SID or sub-SID (see INRAWW below) with error estimates based on the actual adjustment in .ADJ and edit the suspect lines in the .RAW file to that SID. If no obvious errors are found in bearings, robust twice on control to see if the error becomes isolates in a particular control point. If all these steps still fail to identify the error, you must assume the control is good and proceed accordingly. The goal is to keep the residuals on any control used in an adjustment to within a reasonable proximity of your original error values.

Scenario 3: After importing a boundary from an adjacent township, the residual values on the boundary become very high.

Scenario 4: After importing a boundary from an adjacent township, residual values are excessively high on the lines running into that boundary.

Both of these problems are by-products of holding transferred boundaries fixed. This logically requires movement of survey measurements along or into the fixed corners. It must be recognized and dealt with as an un-avoidable evil in the boundary transfer regime. One solution is to create a boundary transfer SID or sub-SID (INRAWW) with a lower weight to place these lines into.

A more efficient and preferred approach to these scenarios is the regional adjustment as outlined in this *WinGMM User Guide - REGION*.

As discussed, changing original error estimates on control should be avoided. While we attempt to put legitimate error estimates on survey data to begin with, when the data conflicts, it is survey error estimates that need to be refined. The following is a discussion of some of the specific WinGMM programs that can be used to refine survey data error estimates.

LSGMMW

The summary at the bottom of the .ADJ file produced by LSGMMW looks like:

STANDARD ERROR OF UNIT WEIGHT IS   .933
 WITH 140 DEGREES OF FREEDOM

CHI SQUARED TEST ON ANALYSIS

REFINING ERROR ESTIMATES

.748 < .933 < 1.208
(LOW)   (HIGH)
PASSES AT THE 5 % SIGNIFICANCE LEVEL

The STANDARD ERROR OF UNIT WEIGHT (SEUW) is a special number. If your network adjusted exactly as much as you estimated this number would be equal to 1.000. If the network adjusted more than you estimated then this number will be greater than 1. On the other hand, if the data adjusted less than you expected, this value will be less than 1. A general rule of thumb is if the SEUW is a less than 0.7, your error estimates are probably too loose and if it is greater than 2.5, your estimates are probably too tight or there may be blunders in your data. A large value can be a good indicator of the presence of large blunders somewhere in the data.   Only after any blunders have been removed is SEUW a valid indicator of your overall error estimation.

The CHI Squared test is dependent on the Root Mean Squared (RMS) values of control, distances and bearings contained in the .ADJ file. In addition, a SNOOP number for all three types of measurements that shows the relative quality of error estimates on these data types is given. As with CHI Squared, a SNOOP value of 1.0 is optimal with a range of 0.7 - 2.5 being consider acceptable. Unacceptable RMS and SNOOP numbers may be indicative of blunders in data, but if the plat checks with the data in the .RAW file and the residuals and snoop numbers are still too high or low, the associated error estimates for those measurements should be refined.

The CHI SQUARED TEST ON ANALYSIS tests the standard error of unit weight at .05 (95 %) two-tailed confidence level for the overall data set. If all individual RMS values are acceptable and CHI Squared passes you probably have no large blunders and you did a very good job at error estimation. This is a very rigid statistical test. For a further discussion of a Chi-Squared test refer to a statistics text.

If you are sure all blunders have been handled, RMS values for distances, bearings and control are acceptable, and your data set fails CHI squared but is within the 0.7 - 2.5 range, do not spend time trying to refine error estimates. Spending a lot of time tweaking error estimates to make the chi squared test pass is unnecessary as it will make little difference in the final coordinates computed.

SNOOPER

The LSGMMW discussion above relates to the overall data set analysis. In most cases, WinGMM processing involves data from several different sources. The program SNOOPER was developed by the BLM California GCDB staff to read information from the .ADJ file produced by LSGMMW and analyze data for each source within the overall data set. Analysis of each source along with critical information discussed in LSGMMW above is written to the .REP file. This allows the user to analyze and refine error estimates for each individual source. The .REP file is appended to in multiple runs of SNOOPER providing the user a history of the processing and refinement of error estimates for a township. SNOOPER also provides some blunder detection capabilities. For a more complete discussion of SNOOPER, refer to the WinGMM Software User Guide *SNOOPER AND REGSNOOP*.

NOTE: While WinGMM programs allow for SID values up to 16 characters, SNOOPER only allows for 10 characters in the SID value. If you choose to use SNOOPER, this must be accounted for and dealt with appropriately.

INRAWW

The error estimate refinement process consists of a cycle of INRAWW, GEN, LSGMMW, analysis of results, blunder detection, and error estimate refinement if necessary. This cycle of events may need to be

REFINING ERROR ESTIMATES

repeated several times. If analysis indicates a need to edit error estimates for a data source, the SID MAINTENANCE option within INRAWW is selected followed by selection of the EDIT SIDS option. A list of SIDs from the .SID file is offered and the user chooses the SID to be edited whereupon INRAWW enters into a prompting cycle for each component of that SID. If no change is desired for a particular component of the SID, the user accepts the existing value by simply pressing return. Upon exit from INRAWW, the user is ready to complete the cycle by running GEN and LSGMMW and then perform analysis of the results again.

To change error estimates for a single individual measurement (blunder), it will be necessary to place a unique error estimate on that individual measurement. This is a two-step process of editing the SID value in the .RAW file and creating a corresponding error estimate in the .SID file. To edit the SID value in .RAW, choose the RECORD DATA MAINTENANCE and EDIT RECORD INFORMATION options in INRAWW. Locate the target record(s) by using the listing function and edit their SID value. Next, use the SID MAINTENANCE and EDIT SIDS options to create a new SID. Many users choose to use the original SID value to indicate the original source. So a record that originally had a SID of 1893 might be given a SID value of 1893J. If an error is made in this process and a corresponding SID from .RAW is not found in the .SID file, error estimates are assigned based on default error estimates set in PROJECW and a SID is appended to the bottom of the existing .SID file indicating this happened. Any SID value from the .SID file that is not found in the .RAW file has no effect on the adjustment nor is this situation identified in any output file.

CHAPTER INTRODUCTION

After the adjustment process is complete it is time to subdivide the sections. The goal in subdivision with PCCS was to produce coordinates of the subdivision points. In WinGMM the main goal is to record the procedures used in subdividing each section and save the procedures as a future template for subsequent rerunning of the subdivision program (APROPW). The coordinates are temporary byproducts that change with each readjustment of the network. The lines file, .LXN, is another byproduct of APROPW. The .NOT file is a list created by the user of lines and points that are not to be included in the lines file.

When APROPW is run, it calculates the parentheticals and subdivides the sections with standard rules, utilizing normal GCDB IDS. Sometimes WinGMM will not recognize unusual situations and will compute incorrect procedures for creating some points, but you can anticipate these situations. If WinGMM recognizes that an unusual situation exists, it will decide that it cannot or should not compute coordinates for the affected corner points.

APROPW expects you to tell it how to treat unusual situations. Interpreting some plats can be complex, but once you have determined what rules are used to subdivide any section, then it is a simple matter of communicating those rules through APROPW's interactive prompts. APROPW stores the results of your interaction in three data files; .IRR, .ADD and .NOT. APROPW (and other yet unwritten programs in the upcoming NILS) will <u>automatically</u> subdivide sections of finished townships using the information in .IRR and .ADD. There are no more prompts for future users.

SUBDIVIDING NORMAL TOWNSHIPS

A normal section has no lotting against <u>interior</u> lines, no subdivision lines closing onto special surveys and no offset lines (exterior or interior). The normal section is neither foreshortened nor elongated.

To subdivide a normal section you will run APROPW, then when the main menu appears, choose <6> PROPORTION AND QUIT - <3> UPDATE .COR, .GEO, & .PGC FILES WITH GENERATED STATIONS. Refer to WinGMM Program Reference, *APROPW* for step-by-step instructions. Review the .SUB file to verify that everything happened correctly. Refer below to the topic **INTERPRETING THE .SUB FILE**. That is all there is to it.

SUBDIVIDING NON-NORMAL TOWNSHIPS, .IRR AND .ADD FILES

The .IRR file is populated with rules you specify using APROPW's (1) EDIT/INPUT NON-STANDARD SECTION BREAKDOWN INFORMATION. The .ADD file is populated with rules you specify in APROPW's (2) ADD EXTRA COMPUTATIONS.
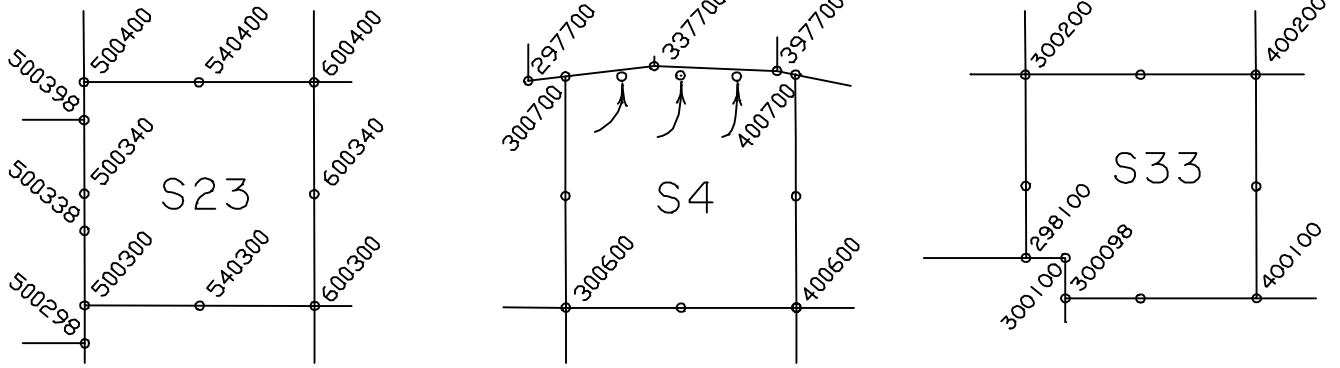
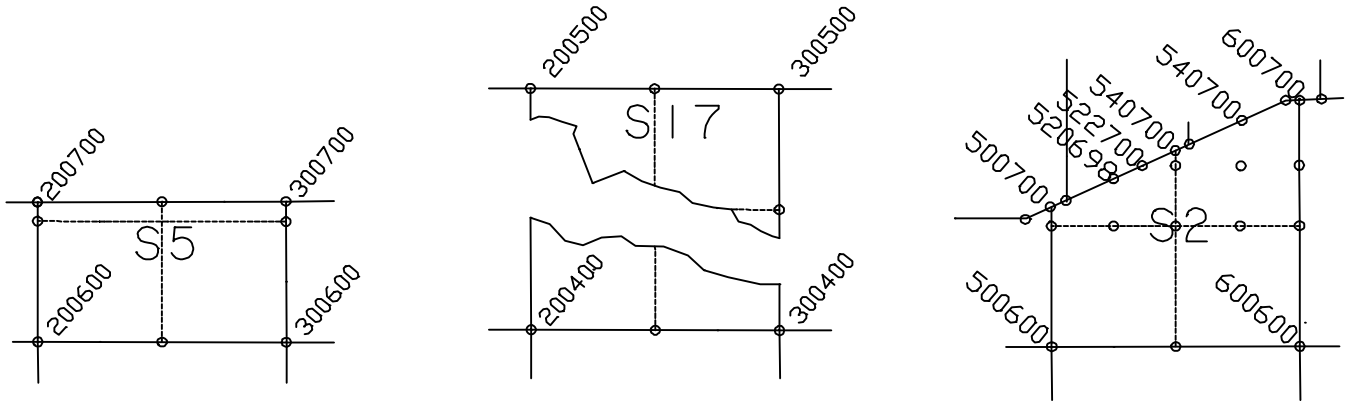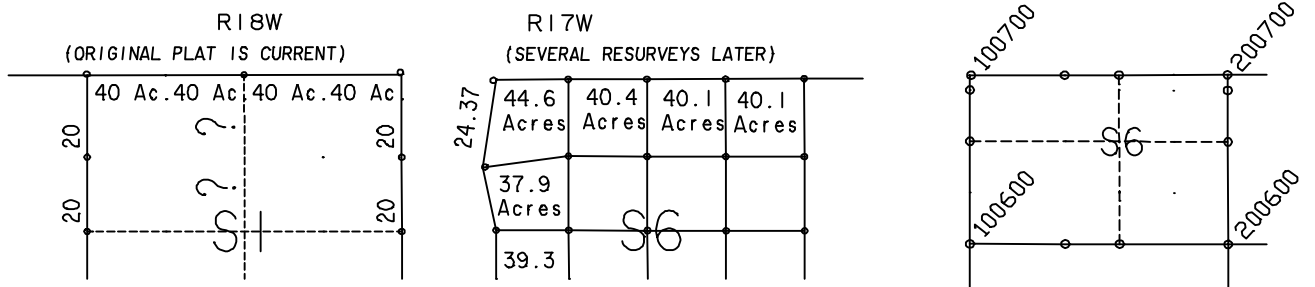REFINING ERROR ESTIMATES

Figure 7-1

Figure 7-2

Figure 7-3WHAT .IRR IS USED FOR: The situations that pertain to the .IRR file:

Normal rules are used for subdivisions involving aliquot corners that have non-normal GCDB IDS. Section corners on offset lines and triple section corner situations apply here.   See Figure **7-1**, above.

REFINING ERROR ESTIMATES

<u>Normal GCDB IDS that should not be computed using normal rules</u>. Corners that do not exist (foreshortened sections) and corners that should be computed using a specific method are the two main examples. See Sections 5 and 17 in Figure **7-2**, above. Remember, APROPW will not compute coordinates for a point that already has coordinates.

<u>Normal rules are used for corners that have normal GCDB IDS, but must be put in at proportions that are not discernable from the .RAW file</u>. Examples: Sections that are lotted against an offset interior line. Parenthetical distances where section centerlines are not at geometric midpoint are computed correctly by Version 1.00 of WinGMM. See Figure **7-3**, above.

WHAT .ADD IS USED FOR: All remaining situations.

The .ADD file stores the results of a GCDB-customized coordinate geometry (COGO). It can compute corners at a specified or proportioned distance and along a specified or computed bearing, such as parallel or weighted mean bearing. It can compute intersections. It can compute either geodetically or it can treat the data as if it is on a plane.

If you assign a point ID like 620640 or 440440 to a corner, then that point will be used to control subsequent subdivision processes.

Non-computables: Sometimes corners exist that would be computed wrong if the section was subdivided using "normal" rules. First you tell the .IRR file that these corners are "non-computable", and then you put the correct solutions in the .ADD file. Otherwise APROPW might generate wrong coordinates for these corners, and then will ignore your instructions on how to compute them correctly. Reason: APROPW will not compute a corner whose coordinates already exist.

An example non-computable corner is the N 1/4 corner of sec 2, corner 540700 from Figure **7-2** above. In a case like this you want to define 540700 to be at intersection of the N boundary line (543700-503700) with the weighted mean bearing from 540600. APROPW would normally compute 540700 at midpoint easting between 500700 and 600700 and on the N boundary line, which is not exactly right with such a large bearing of the N line. You would define 540700 to be non-computable. Then, after computing 540640 at intersection (weighted mean bearing from 540600)(500640-600640), 540700 can be computed as an intersection of the N boundary with the N-S centerline through 540640.

What happens in this example. When you leave APROPW with the <8> PROPORTION AND QUIT - <3> UPDATE .COR, .GEO.... option, the .ADD file is read and all corners in it will be computed if possible. Corner 540700 will not be one of those corners since 540640 has not been computed. APROPW then reads the .IRR file and computes all the subdivision corners including 540640 (only the .IRR file can specify weighted mean bearing or parallel) and all corners dependent on it. Now the .ADD file is read again and it can compute 540700 by extending a line through 540640 (only the .ADD file can do intersections with non-aliquot lines such as the N boundary. What happens if you reenter APROPW with readjusted section corner coordinates? GEN and LSGMMW will flush out all the old subdivision coordinates. You resubdivide by running APROPW. It will either subdivide the township automatically through <8> PROPORTION AND QUIT or it will await any more entries to the .IRR and/or .ADD. Your previous work is intact until you choose to edit it.

WHAT APROPW DOES The order in which calculations takes place is important.

COMPUTES CORNERS SPECIFIED IN .ADD, IF POSSIBLE:

APROPW reads the .ADD file to see if there are any corners that it can generate using what information is available. Many corners you put in the .ADD file depend on corners that will later be generated through information from the .IRR file. There may not be enough information at this point to perform all the

REFINING ERROR ESTIMATES

processes in the .ADD file. The order in which the processes are entered in the .ADD file is not significant.

COMPUTES PARENTHETICALS:

When you start APROPW, it reads both the .COR file and the .RAW file. It will look for irregular distances on lines closing into the township lines i.e. the existence of xxx120 xxx660 120yyy 660yyy IDS in the .RAW file. APROPW will then use these parenthetical distances to compute the proportion of the 1/16ths on the section centerline going into the boundary.

READS .IRR FILE:

The .IRR, if it exists, contains the data where you specified which corners not to compute, which corners to use to control the subdivision and where to put proportioned corners.

COMPUTES REMAINING CENTER 1/4s

All center 1/4s that were not in the .RAW file or the .ADD file and not specifically excluded by you through the .IRR file, will get computed at intersection of center of section lines.

COMPUTES REMAINING EXTERIOR 1/16ths

All 1/16ths along section lines that were not in the .RAW file or the .ADD file or not specifically excluded by you through the .IRR file will get computed at midpoint.

COMPUTES REMAINING CENTERLINE OF SECTION 1/16ths

All 1/16ths along the centerline of sections that were not in the .RAW file or the .ADD file and not specifically excluded by you through the .IRR file will get computed at midpoint or at the proportion that was computed from the parenthetical distances.

COMPUTES REMAINING 1/16ths.

All NE, SE, SW, and NW 1/16ths that were not in the .RAW file or the .ADD file or not specifically excluded by you through the .IRR file will get computed at intersection of lines between the appropriate 1/16th corners.

COMPUTES REMAINING CORNERS SPECIFIED IN .ADD.

APROPW reads the .ADD file again to see if there are instructions on how to compute any more corners. At this point APROPW is ignoring the functionality of the corners and ignoring rules of subdivision; it just computes corners as you have specified.

WHAT YOU DO

AUTO-AUTOIRR option:
  (4) AUTOMATIC PRELIMINARY NON-STANDARD BREAKDOWN OF ALL SECTIONS

First. We have the option of using the AUTO-AUTOIRR to give us a quick, automatic creation of the entries in the .IRR file. This is just APROPW's first guess, yet it is a very good guess and will suffice for almost all situations. See **Table 1** below and WinGMM Program Reference, *APROPW*.

    1)   Examine plat for any unusual situations. Tell APROPW how to do it.
Table 1 Plat Unusual Situations

REFINING ERROR ESTIMATES

UNUSUAL SITUATION:	WHERE IN APROPW TO REMEDY THE SITUATION:
a)Offset lines. Non-Normal IDS act as full sec. corners. Refer to Fig 7-1, S23.	(1) EDIT/INPUT NON-STANDARD SECTION (2) STATION NAME SUBSTITUTIONS You tell APROPW the IDS to use.
b)Offset lines. Junior corners need offset to line. Refer to Fig 7-1, S4.	(1) EDIT/INPUT NON-STANDARD SECTION (9) DEFINE PROPORTIONED STATIONS
c) Triple sec corners. 2 corners each control 1 direction. Refer to Fig 7-1, S33.	You list the IDS of corners to move. (1) EDIT/INPUT NON-STANDARD SECTION. (3) DEFINE DOUBLE SECTION CORNERS List IDS, which direction they control.
d) Quarter corner does not exist for a 1-mile line. Refer to Fig 7-2, S17.	(1) EDIT/INPUT NON-STANDARD SECTION (4) QUARTER CORNER EDIT
e) Foreshortened section or Special Survey cuts thru sec. Some corners do not exist. Refer to Fig 7-2, S5 **NOTE:** Once a corner is non-computable, the corners whose positions IT controls will not be computed.	List the ID of the non-computable corner (1) EDIT/INPUT NON-STANDARD SECTION (5) CENTER OF SECTION EDIT or (6) EXTERIOR SIXTEENTH EDIT or (7) INTERIOR SIXTEENTH EDIT or (8) CENTER OF QUARTER SECTION EDIT
f) Exterior parentheticals are not normal. Refer to Figure 7-3.	List the corners that should not be computed (non-computables). (1) EDIT/INPUT NON-STANDARD SECTION (7) INTERIOR SIXTEENTH EDIT.
g) Elongated section Refer to Figure A-6, Appendix A.	You must determine the parenthetical distances of the section centerline and specify them here. There are two choices: -manually as follows (2) ADD EXTRA COMPUTATIONS (3) INPUT ADDITIONS (1) TRAVERSE/PROPORTION (2) GENERAL INTERSECTIONS You must input computations to compute the necessary proportions and intersections. -automatically as follows (2) ADD EXTRA COMPUTATIONS (3) INPUT ADDITIONS (5)AUTOMATIC ELONGATED SECTION COMPUTATIONS You follow the necessary prompts.

INTERPRETING THE .SUB FILE

This file contains valuable information for QA/QC. The .SUB file is a report file that can be viewed or

REFINING ERROR ESTIMATES

printed for inspection/verification that the proper procedures were performed in APROPW. The .SUB file contains a report of each irregular calculation, add calculation and calculated parentheticals.

When errors are found in the .SUB file the user will return to APROPW and edit the section(s) containing errors.

Using a text editor to view the .ADD file will also point out data entry blunders that might otherwise be hard to detect.

AUTO INTERSECTION AND POPULATING THE .NOT FILE

The WinGMM software incorporates the AUTO INTERSECTION program as an automatic subroutine of the APROPW program. This subroutine identifies and computes the point of intersection of all lines, which haven't previously been created in the .add file.   The .LXN file is utilized and updated during AUTOI. It also creates an .INT file which list the newly computed intersections and the point id string of every polygon in the township. This subroutine allows the user to realize significant time savings with respect to computing intersections, especially if a township contains multiple special surveys. AUTO INTERSECTION utilizes a unique point id naming convention with point IDs starting at 950100, 950101, 950102,...etc. The user may edit the point id numbers in the .ADD file in order to satisfy point id standards for their GCDB database. AUTO INTERSECTION is to be utilized as a QC step for the collection process, as there should be zero intersections identified at the end of the subroutine when the creation of the subdivision template is complete. The intersections generated by AUTO INTERSECTION must be inspected to assure their desirability, as undesired intersections are indicators of problems with the template.

Points and lines used in the adjustment or subdivision are not always parcel lines. Examples of unwanted points and lines are 1) ties to special surveys, 2) ties to control, and ties between non-sequential corners. Including these lines in the .LXN file causes two annoyances:

    1) The unwanted points and lines are distracting when viewing the file in a graphic environment (AutoCAD, AutoSketch) - these lines are not on the survey plats.

    2) AUTO INTERSECTION treats these unwanted lines as parcel boundaries, creating intersection points and breaking parcels into too many polygons, where it is inappropriate to do so. A user, during the QLINK process, would just have to recombine the polygons into the proper parcels.

Refer to (5) INPUT/DELETE "NOT" FUNCTIONS in WinGMM Program Reference; *APROPW* for an explanation of how to populate the .NOT file with a list of unwanted points and lines.

USING AUTOIRR, AUTO-AUTOIRR, AND AUTO-ELONGATION

APROPW can derive a great deal of intelligence out of the .RAW file by studying the point IDS and the connectivity of the lines. It is possible to avoid a great deal of data entry by letting APROPW outguess what your interaction would be to nonstandard sections.

AUTOIRR, listed in APROPW's (1) EDIT/INPUT NON-STANDARD SECTION BREAKDOWN INFORMATION menu as (11) PRELIMINARY IRREGULAR IDENTIFICATION, will make an entry in the .IRR file for the section that you are currently in. AUTO-AUTOIRR, listed on the main APROPW menu as "AUTOMATIC PRELIMINARY NON-STANDARD BREAKDOWN OF ALL SECTIONS", will make entries for all nonstandard sections including calculating and <u>storing</u> parentheticals for all sections lotted against the exterior. It does not take out 1/4 corners and 1/16th corners on foreshortened sections. (Strategy: Once AUTO-AUTOIRR has stored the parentheticals, you may remove the nonexistent corners without having to calculate and force them into .IRR.) Note there are very unusual situations that AUTOIRR

REFINING ERROR ESTIMATES

functions are not able to treat properly - it is your responsibility to inspect the .SUB file for correctness and to make appropriate changes through APROPW.

AUTO-ELONGATION, listed under (2) ADD COMPUTATIONS as (5) AUTOMATIC ELONGATED SECTION COMPUTATIONS, makes entries into your .ADD file for all elongated 1/16ths for the prompted section. There are certain conditions that must be met in order for AUTO-ELONGATION to generate acceptable results: 1) All 1/16ths between the 1/4 corner and the township exterior must be left out of the .RAW file, so the distance is the overall distance from the 1/4 corner to the township exterior. Or if the do exist they must have point ID's in multiples of 5; for example if the 1/4 corner is 140400 and the W 1/16th is 120400, the W 1/16 - 80 must be 115400.   2) The point IDS generated by AUTO-ELONGATION deviate from the standard point ID scheme - they are all multiples of 5, for example a W 1/16 usually called 120400 might be given an ID of 130400. Refer to WinGMM Program Reference, *APROPW*.

SUBDIVISION STRATEGIES

As stated earlier, the WinGMM software has been designed to create a template for the subdivision of each township. The template is the combination of .IRR , .ADD, and .NOT files, and once created will automatically subdivide the township on subsequent runs of the program APROPW. It is important to keep in mind a few collection concepts when creating the initial template. For while the perceived goal is to recreate digitally the official survey record, integration into LR2000 is equally important, and sometimes these goals are conflicting. For example,(refer to attribution examples) when the official record identifies lotting against mineral surveys, the polygons created by WinGMM should match the record. LR2000 always deals in the concept of nominal parcels and polygons are either all or parts of nominal parcels. Nominal lines are the lines that segregate the aliquot parts of any section (1/16th, 1/4, and section lines). For the survey record, those aliquot lines do not exist within mineral surveys. So in the example described, the strategy for creating the subdivision template would be to identify the lots, the mineral survey, and the nominal lines. Currently, the WinGMM software has limited functionality that respect to recreating the correct template for all intersection situations. The options for general intersections include either bearing input or bearing defined by two point ids, excepting the subroutines for editing center of section and center of quarter sections. Those subroutines have the options of projecting lines, which are parallel to a line defined by point ids, or weighted mean of two lines defines by point ids. With general intersection, parallel or weighted mean bearings methods are accomplished either by using **CSTUF** to determine the post adjustment bearing (which must be recalculated subsequent to each adjustment)or by using the record bearing from the plat(which is not correct, due to adjustment.

Creating the template for elongated sections has become automated (wizard) in. It was formerly a manual process of inputting additional computations. Often each user kept a generic .add for the most frequently occurring elongated situations, and edited to get the correct distances in the file. With the automated function the prompting cycle leads the user through the necessary parameters, but the user is forced to follow the point id naming convention of the wizard. If the user requirements demand a different point id naming convention for the elongated 1/16ths, then the process must be accomplished manually.

REFINING ERROR ESTIMATES

REGIONAL ADJUSTMENT OF DATA

FORMLSA

Data collection in a township by township (piece by piece) approach, complete with township boundary transfers is a convenient way to collect data. It does however lead to buildup of systematic error in results. In order to eliminate that systematic error and to define a more meaningful reliability, a larger data set should be analyzed. The <u>ideal situation is to readjust all data</u> each time changes are made to the data set, but this may end up with some management problems due to the size of the generated data sets. Someday, we may have computers powerful enough to allow all of a principle meridian to be run at once. FORMLSA allows one to merge .LSA township files into one correctly merged data set for simultaneous analysis.

The purpose of merging the data from the individual townships, into a region, is to obtain edge match and get the best possible coordinate values from the least squares adjustment. By merging townships it increases the amount of redundancy on township exterior boundaries.

Edge match between regions is obtained by including townships from a previously processed region in the new region. These are called **FIXED** townships. The boundaries of the fixed townships are held as **FIXED CONTROL**. This means the edges of these townships will not adjust in the new region and will retain the regionally adjusted coordinate values from their adjustment in the previously adjusted/processed region. When determining what townships should be held fixed, it is important to look at the number of control points and their array in a region. Quality of survey data may also be a determining factor. Just remember that the township files being used for the fixed boundary must be from the previously adjusted region and contain regional coordinate values. The TARGET townships should be from either the individual township adjustment or the previous region's results. The fixed and target townships, that are from a previous regional adjustment target area have previously been merged and should merge with no problems. The most common reason for an incorrect merge between them, is that single adjustment townships are being used for the FIXED townships. Once all the data is merged correctly with FORMLSA the data set is adjusted with LSGMMW. FORMCOR is then run to parse the newly computed coordinate data back to the individual township .PGC, .COR and .GEO files. The .LSA file's coordinates (bottom of the .LSA) are also updated by FORMCOR. The reliabilities in the .PGC files are those generated during the adjustment of the individual townships. To obtain reliabilities that are common to adjacent townships FORMREL has to be run. FORMREL calculates the reliabilities using all of the data surrounding a township, based on user input search area and Standard Error of Unit Weight (SEUW).

PREPARING THE INDIVIDUAL TOWNSHIP DATA FOR MERGING

The first time that townships are merged into a region, the coordinates used are from the adjustments of the individual townships. Because FORMLSA uses coordinates for a search area, the coordinates of adjacent township boundaries have to be close in value to each other. When these values are too great the merge tolerance, which determines the search area, has to be so large that it causes merge problems in other areas of the region. Therefore, an individual township's data must meet certain requirements. These requirements are easily met when each township has been correctly analyzed and has the appropriate error estimates.

The most important requirement is that the RAW data of a township's exterior boundaries is exactly the same data as the adjacent township's exterior boundaries. This includes that the direction of lines are identical. The value of error estimates of one township should be <u>similar</u> to the adjacent township's error estimates, especially if surveyed by the same surveyor or within the same time frame using similar survey methods and instruments. Small discrepancies in error estimates within a township for the interior subdivision lines have a minimal influence on the adjustment of exterior boundaries. If there is a large discrepancy, the interior will have too much influence on the exterior boundaries and the townships will not merge properly with FORMLSA and/or the adjustment may fall outside of acceptable limits. Large differences in error estimates can also cause difficulties in the order that townships are merged.

REGIONAL ADJUSTMENT

- No Buffer
Originally, the concept of regional adjustments was one of adjusting and merging the coordinates of a set of townships within a given geographic location to get the best possible coordinate values from the least squares adjustment. This is still the goal, but often the results tend to be that the townships with the least control and/or least accurate control tend to adjust the most within the region. This is especially true for the peripheral townships of any given region. Buffer townships around the periphery are used to lessen this effect and provide better coordinate values within the target region. Sometimes this is not possible, as along a state boundary or a boundary of unsurveyed lands. Regions with no adjoining fixed boundaries and no buffers are still produced as necessary and are still the best possible coordinate value results from the least squares adjustment of the region.

- With Buffer
Buffer townships should merge correctly with the other buffer and fixed townships with no problems, and their boundaries with the new region's townships should be checked for RAW data and error estimate problems. In other words, the buffer townships are treated exactly the same as any of the townships within the target region. The buffer townships serve to provide redundancy for the target townships exterior boundaries. One difference is that the final coordinate results for buffer townships are not retained, but will be recomputed at a later date when these townships are included in another, adjoining regional adjustment.

Note: See the description and figure under, "MERGING THE INDIVIDUAL TOWNSHIP DATA, FORMLSA", for an explanation of FIXED, TARGET and BUFFER townships.

MERGING THE INDIVIDUAL TOWNSHIP DATA, FORMLSA
FORMLSA uses a command file called .HOW, instead of .HW, which controls the merging of the .LSA files. The .HOW file is created with a text editor and should consist of a list of the townships, one township per line, to be included in the region. Buffer townships should also be included, along with the townships that their boundaries are to be fixed against. Those fixed townships are placed below the word FIXED.

Using the below diagram, an example of the .HOW would look like this (*Italics are comments*):

T05SR91E   *Target Tp.*
T05SR92E   *Target TP.*
T05SR93E   *Target TP.*
T05SR94E   *Target TP*
T06SR91E   *Target TP.*
T06SR92E   *Target TP.*
T06SR93E   *Target TP.*
T06SR94E   *Target TP.*
NOREL
T05SR95E   *Buffer Tp.*
T06SR95E   *Buffer Tp.*
T07SR91E   *Buffer Tp.*
T07SR92E   *Buffer Tp.*
T07SR93E   *Buffer Tp.*
T07SR94E   *Buffer Tp.*
T07SR95E   *Buffer Tp.*
FIXED
T04SR90E
T04SR91E
T04SR92E
T04SR93E
T04SR94E

REGIONAL ADJUSTMENT

T04SR95E
T05SR90E
T06SR90E
T07SR90E

T04SR90E **FIXED**	T04SR91E **FIXED**	T04SR92E **FIXED**	T04SR93E **FIXED**	T04SR94E **FIXED**	T04SR95E **FIXED**
T05SR90E **FIXED**	T05SR91E **TARGET**	T05SR92E **TARGET**	T05SR93E **TARGET**	T05SR94E **TARGET**	T05SR95E **BUFFER**
T06SR90E **FIXED**	T06SR91E **TARGET**	T06SR92E **TARGET**	T06SR93E **TARGET**	T06SR94E **TARGET**	T06SR95E **BUFFER**
T07SR90E **FIXED**	T07SR91E **BUFFER**	T07SR92E **BUFFER**	T07SR93E **BUFFER**	T07SR94E **BUFFER**	T07SR95E **BUFFER**

FORMLSA DIAGRAM

If all the townships have the correct RAW data and error estimates, then the order of the .HOW file is not usually important. However, some unusual offsets between townships may dictate the order. Trial and error is the only way to find the best order in these circumstances. The order of FIXED townships has not been found to be a problem.

NOTE: Townships that each contain only a single point from the other will NOT merge at that point. From the above example diagram, if the townships were ordered in the .HOW file, like below, the 700100 point of T06SR92E will NOT merge with the 100700 point of T07SR93E.

T06SR92E
T07SR93E
T06SR93E
T07SR92E

The result being 2 coordinate pairs for the same point in the regional files. Even the merging of the other 2 townships does not fix the problem. So townships should NEVER be listed in the .HOW file in an order that will try to merge them at only a single point, they must also include RAW data that is the same. In some cases this requires including additional RAW data from adjacent townships in the RAW data of each. This problem occurs even with control on the point.

REGIONAL ADJUSTMENT

Adjusting a Region

1) A project name for the combined project must be defined and set to be the current job.

2) Create the .HOW file.

3) Run the program FORMLSA
FORMLSA identifies the common lines by coordinates and assumes all boundary checks have been completed. FORMLSA merges data from the individual .LSA and .SD files. Using CMM's COMBIN concept of if it is control in one and unknown in another, it becomes an unknown because it was only held to keep coordinates consistent with some previous work. This is especially true with coordinates imported from an adjacent township, which is done to give coordinates to a township that may not have control at all. FORMLSA will properly recognize these imported points as **__NOT__** control; the regional adjustment will be performed with only true control.

Since the error estimates for each township are similar, the order of the merge, defined in the .HOW file, is not restricted. FORMLSA can then use either townships error estimates, in the .SD files, and the adjustment will give satisfactory results.

FORMLSA also creates a file called *region*.MAT that is read by FORMCOR for creating the individual township .COR files. *region*.MAT tells, as an example, what 700142 are in the combined .COR file. FORMCOR thus also does not worry about offsets, etc. as everything is defined by *region*.MAT.

4) Run QCMAT to determine if the merge was successful. The lines shown in the display are those that have merged.
NOTE – It is possible to make a DXF file from QC.LSA and view it in AutoCAD.

5) Run LSGMMW -- because of the size of these multi-township adjustments, the larger versions of LSGMMW should be used on the PC. The version may also be dependent on the configuration of the PC.

6) Run FORMCOR to parse out the individual township .COR files. FORMCOR will create .COR, .GEO, and .PGC files for each individual township. FORMCOR uses the *region*.MAT file created by FORMLSA to associate a township ID with a big adjustment ID. If you computed error analysis in the big adjustment these are transferred to the proper .PGC file. The individual township .LSA file's coordinates are updated.

7) Follow the steps below to setup and run FORMREL. Run FORMREL when error analysis is turned off or fixed boundaries were used. FORMREL calculates reliabilities for each township above the NOREL line in the .HOW file and updates the reliabilities in their .PGC files. If properly setup FORMREL will use the data from ALL townships in the region, including the townships used for the FIXED boundaries, to calculate reliabilities for the target townships.

A) Backup your .COR, .HOW, .LSA, .MAT, and .SD files by renaming them, i.e. .1CO, .1HO, .1LS, .1MA and .1SD for future use.

B) Reformat your .HOW file to include all townships, by deleting the "FIXED" line from it.

C) Run FORMLSA to create a region that includes all townships being used. Insure that all townships merged correctly, see 4 above.

D) Copy your backup copy of .HOW to .HOW, i.e. copy .1HW to .HOW

E)   Run FORMREL.

F)   Copy your backup files to their original names.

NOTE: A batch or script routine could be used to backup and restore files.

8) Run **APROPW** on the target townships to update township subdivisions.

SOLUTIONS TO COMMON MERGE PROBLEMS

Merge Tolerances

For FORMLSA to work correctly it is necessary to determine what would be the best merge tolerance to use. A too small or large of a merge tolerance and the townships will merge with undesirable results. There are several ways that this can be handled. One is to test, which is the best tolerance by running FORMLSA at different merge tolerances, until it merges correctly. Another, is to always use a merge tolerance of 1500 feet and when necessary use merge control to get correct merges. Any method that will get the data to merge will work. FORMLSA is for creating a regional data set from the single township data and as long as the data is merged correctly it is unimportant how it is accomplished.

Merge Control

Sometimes the quality of the RAW survey data is so poor it is almost impossible to merge townships. In these cases it may become necessary to use MERGE control. MERGE control is <u>temporary</u> control that is used to facilitate merging of townships. See *Data Entry and Editing, AUTO-IMPORTING SELECTED COORDINATES DATA FROM THE BOUNDARIES OF ADJACENT TOWNSHIPS - MERGE CONTROL*, for an explanation and WinGMM Program Reference, *USING INRAWW TO ADD MERGE CONTROL FOR FORMLSA MERGES*, for instructions on it's use. Merge control is a tool of last resort and should only be used in those rare instances where error estimates could not be adjusted enough to take in account the poor quality of survey data. It should never be used in areas of good quality survey data. If it is not merging in those areas there is some other problem.

Crossing State Plane Zone edges

One problem that may be encountered is the use of files from townships that were processed in a State Plane Zone that is different than the region being worked on. Use the program CHZONEW to change the files of these townships to the appropriate zone. Refer to this document Chapter 9, "CHZONEW", and the WinGMM Software User Guide document.

FORMREL

The formrelw.exe program allows the User the ability to calculate the reliabilities of individual townships in a region, where rigid control along regional boundaries was used, and to then replace a reliability of zero with the actual reliability calculated in the regional adjustment. The results of the adjusted values are then entered into the coordinate files for the individual townships after a regional adjustment is completed.

WinGMM UTILITIES

Using WinGMM utility programs

WinGMM utility programs are described in this chapter. Each of these program's input and output requirements are described below with a statement of the purpose of the program. To START: Select the desired operation from the main Windows® pull down menu.

SORTLSAW

Input files: .SD, .LSA
Output files: .LSA, .LSB, .SD, .SDB

Batch mode program that will backup your existing .SD and .LSA files to .SDB and .LSB, then restructures the .SD and .LSA files to the structured format required by LSGMMW. This program need only be run if GEN reports that your file has been corrupted. If such a condition exists, you will be instructed to run setup.

COMPARW

Input files: .COR, .PGC (optional)
Output file: user - defined name, often called .OUT

During the computation process, one is provided with many choices that will result in different coordinate values. This program will allow the user to quickly see the difference in coordinate values from two input .COR files. For example, one may choose a certain adjustment tactic, compute a .COR file with LSGMMW, then desire to play a 'what if?' strategy to try different weighting, different control, etc. COMPARW would then be invoked to report the effect of the new strategy. Another example could be when 'what if?' strategies are used in the subdivision process. This program reports the coordinate difference for each point found in both files.

When different adjustment strategies are being tried, be sure to rename your .COR file to some convenient filename because rerunning LSGMMW or APROPW will overwrite your project .COR file automatically.

Another option in COMPARW is to compare coordinates from a .PGC file. Any combination can be used, 2 .COR files, 2 .PGC files, or one of each.

UTMW

Input files: .DEF, .COR
Output file: .UTM

UTMW reads the zone number from the .DEF file, point id's and coordinates from a .COR file. It produces an .UTM file that is equivalent to a PCCS U-file. This is a batch process requiring no user input.

TOLXNW

Input files: .LX, identical to the "L" file of PCCS
Output file: .LXN

UTILITIES

TOLXNW reads the .LX file and generates an .LXN file. The .LXN file is about 8% of the size of the .LX file and will be used in WinGMM.

GETLXW

Input files: .LXN
Output file: .LX, identical to the "L" file of PCCS

GETLXW reads the .LXN file and generates an .LX file. The BETA version of DXFW.LSA required the .LX format for making graphics of subdivision lines. Version 3.00.000 DXFW require the .LXN instead.

NODUP

Input files: .RAW PCCS 'R' file
         .PGC PCCS 'P' file
      TEMP.JOB for project name

Output files: .RA2 The original RAW file, backed up
         .RAW The WinGMM format RAW file, no duplicates
         .DUP The report file of NODUP's activities

The purpose of NODUP is to find identical coordinates in a coordinate file and assign them all one GCDB ID. This automates the conversion of PCCS data into WinGMM standards.

CHGIDS

Input files: All project files defined by CHGIDS.CFG

Output files: All project files defined by CHGIDS.CFG

This is a simple program to allow you to globally change GCDB IDs on the default project's files. It uses a file called CHGIDS.CFG to define valid file extensions to check. It would be wasteful, if not destructive, to change things in binary files. When you first invoke
CHGIDS, without a CHGIDS.CFG in the current directory, it will return a file error, but then will create a default file. In most cases this file will be adequate, however you may edit it to add any special files you may generate or delete ones you do not want to change.

WARNING: This program changes PIDs with no test for existing or incorrect PIDs, therefore be sure to backup your job before using it, and check it afterward.

The program is mouse driven but you can also navigate with the tab and
enter keys.

CHGIDS will skip files whose extensions are not in the CHGIDS.CFG file.

        The program will only change PIDS that are:
                * at the beginning of a line, or
                * at the end of a line, or
                * have a leading or trailing space, or
                * in an LXN file are located at proper multiples of 6 characters along the line of IDs.

CAUTION:

NEVER use CHGIDS on regional files. Change them at the single township level, the next time that township is included in a regional adjustment it will use the new PID. The single township will also now use the new PID.

CHZONEW

Input files   .DEF, .PGC

Output files: .LSA, .COR, .DEF

The purpose of CHZONEW is to allow regional adjustment edge match across State Plane Zones. CHZONEW works the same as PROJECW and any changes made will change the .DEF files definitions. When a menu item is selected to change, CHZONEW first goes to the zone selection menus. If only changing the zone select (4). When existing CHZONEW, DO NOT change the project. When CHZONEW is exited, the plane coordinates of the selected zone are calculated. The .LSA and .COR files are updated with those plane coordinates. This allows FORMLSA to be used across zone boundaries. Some townships may have to be converted back to their original zones after regional adjustment.

CMM2GMM

Input files: CMM *project*.COR
                            CMM *project*.DEF

Optional files: CMM *project*.LEV
                            CMM *project*.CHN

Output files: WinGMM *project*.RAW
                            WinGMM project.CMM
                            WinGMM *project*.LSA If coordinates imported as control.
                            WinGMM *project*.SD   If coordinates imported as control.
                            user filename   If chain file did not exist.

When CMM2GMM is invoked, it uses a chain file or user input to determine which PID's are the end points of each survey line. It then uses the CMM *project*.COR file to inverse between these points, and determine Bearing and Distances to create a *project*.RAW file.

A chain file is an ASCII text file that is a list of PID's to be read from the CMM .COR file for inversing between. The order of the chain file determines the inverse. Each chain must end in a 0 (zero)line.

Example Chain file:

100100
100140
100200
.
.
and intervening stations with WinGMM PIDs

.

.

100640
100700
0
200100
200140

.

.

and intervening stations with WinGMM PIDs

.

.

200640
200700
0
etc., thru all stations with WinGMM PIDs

GCONW

Input files: .COR
                        .DEF
                        .CON
            CONUS.LAS   NGS file
            CONUS.LOS   NGS file
        NAD27.CON   NGS file
            NAD83.CON   NGS file

Optional files: .GEO   If .GEO is missing, it will be built from .CON
                        .LSA
                        .SD
                        .SID
                        .PGC
                        .AN
                        .IID
                        .LX
                        ASCII list of townships

Output files: The existing WinGMM Input and Optional files are updated based on the new datum.

When GCONW is invoked, the coordinates in the existing WinGMM Input and Optional files are converted either from NAD 27 to NAD 83, or from NAD 83 to NAD 27. GCONW reads the .DEF file to determine which way to go. GCONW input is either form the keyboard or from the optional ASCII list of townships. The .CON file will get both NAD27 and NAD 83 coordinates, which are labeled as such. Projects can go from NAD 27 to NAD 83, and others can go from NAD 83 to NAD 27 in the same run.

    Note: The existing project files are wiped out as the transferred data replaces it.

An Example of ASCII township list:

T03NR17E
T03NR18E
T03NR19E
T03NR20E

T03NR21E
T04NR17E
T04NR18E
T04NR19E
T04NR20E
T04NR21E

GCONW will run thru the list reading the .DEF file of each project to determine which DATUM to convert to. As it does a conversion it changes the .DEF file DATUM to the proper DATUM. If a project is in the list twice, it will first convert it to one DATUM and then back to the original DATUM.

GCONHPW

Input files: .COR   All files created from GCONW
                .DEF
                .CON
                .GEO
                .LSA
                .SD
                .SID
                .PGC
                .AN
                .IID
                .LX
(state or region).LAS   NGS file
(State or region).LOS   NGS file
        NAD27.CON   NGS file
            NAD83.CON   NGS file

Output files: The existing GCONW produced files are updated based on the new datum.

When GCONHPW is invoked, the coordinates in the existing GCONW produced files are converted either from NAD 83 to HARN, or from HARN to NAD 83. When converting from NAD 27 to HARN, GCONW must be run first, then GCONHPW. The .CON file will get HARN coordinates, which are labeled as such, as well as NAD27 and NAD 83 coordinates produced with GCONW. Unlike GCONW, GCONHPW can only convert from NAD 83 to HARN or vice versa in one run.

In order to convert WinGMM data to HARN, GCOMHP requires specific state or region HARN .las and .los files. These files can be downloaded from the NGS web site. While running GCONHPW these files have to be defined (see first PROMPT below). They are then saved in a file HARN.INF, until you elect to use a different one.

Note: The existing project files are wiped out as the transferred data replaces it.

An Example of ASCII township list:

T03NR17E
T03NR18E
T03NR19E
T03NR20E
T03NR21E
T04NR17E
T04NR18E

T04NR19E
T04NR20E
T04NR21E

GCONHPW will run thru the list reading the .DEF file of each project to determine which DATUM to convert to. As it does a conversion it changes the .DEF file DATUM to the proper DATUM. All projects in NAD 27 must first be converted to NAD 83 with GCONW before they can be converted to the HARN datum. Therefore all projects in the list must be in NAD 83.

CSTUF

The cstuff.exe program is a utility that performs coordinate geometry calculations on coordinates that exist within the .cor file for any given project. Cstuff.exe requires a .def, and .cor file in order to operate.

QCMAT

The qcmatw.exe program creates QC.LSA, QC.COR, and QC.INF (Report) from Region .LSA and .MAT files. This is a similar quality control tool as used by formlsaw.exe that can be used to view matches and mismatches between exterior project boundaries.

LINKING GCDB TO THE LLD

LINKING THEORY

The purpose of the WinGMM Linking process is to support the BLM=s Legacy Rehost 2000 (LR2000) system. It is not within the scope of this chapter to explain LR2000. This chapter will explain the linking process and only include information regarding LR2000 that pertains to linking. For a more in depth dissertation of LR2000 contact the BLM office of your choice.

One component of LR2000 is a product called Legal Land Description (LLD). The LLD file contains basic land information regarding the polygons found in a given township. The BLM has other title information tied to the LLD, such as information regarding mining claims, status of the land and so on. All of this information, including LLD, will be used to populate LR2000. GCDB is the PLSS spatial component of LR2000, basically the geographic coordinates of corners, and how the lines between the geographic coordinates should be connected. Note that some of the GCDB data is attribute information that, like LLD, is not of a spatial nature. The PLSS coordinates and lines from GCDB are used to define polygons for the PLSS. The correlation between the LLD and GCDB will give LR2000 the >link= to a spatial product needed to determine where the LR2000 attribute information is located in the United States, and enable graphical depiction of this data, hence the term linking.

UNDERSTANDING THE PORTION OF LLD NECESSARY FOR LINKING

It is not necessary to have a complete understanding of LR2000 and subsequently LLD to complete the linking process. It is only necessary to know the parts of LLD that need to be correlated to GCDB polygons to support LR2000, i.e. LLD polygon data. Below is a sample of a portion of LLD, followed by an attempt at explaining it.

000000 08 0030E 0520N 010 A ,,,,, ,, XXXXXXXXXXXXXXXX 00640000 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 011 A ,,,,, ,, XXXXXXXXXXXXXXXX 00640000 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 A ,,,,, ,, ,,XX,,,XX,,XXXXX 00360000 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 L 1,,,, ,, X,,,,,,,,,,,,, 00025350 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 L 2,,,, ,, ,X,,,,,,,,,,,, 00025300 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 L 3,,,, ,, ,,,,X,,,,,,,,, 00025250 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 L 4,,,, ,, ,,,,,X,,,,,,,, 00021670 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 L 5,,,, ,, ,,,,,,X,,,,,,, 00034560 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 L 6,,,, ,, ,,,,,,,,X,,,,, 00034790 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 L 7,,,, ,, ,,,,,,,,,X,,,,, 00035020 , ID 079 01 06 48 00 10010600/////
000000 08 0030E 0520N 006 H 804,, ,, ,,,,,,XXXX,,,,, 00070930 D ID 079 01 06 48 00 10010600/////

The first two lines contain a portion of LLD for two sections that are all aliquot with no special surveys or lots in them. This represents an example of LLD for a section in its simplest form. Notice the sixteen X=s, they represent the sixteen portions of a normal section broken down to the one-sixteenth or forty-acre parcel level. The rest of the lines represent a section that contains some forty-acre aliquot parcels, some lots, and a special survey (HES 804.) To understand where the sixteen meaningless X=s fall in a section, and to facilitate their use in the linking process, it is necessary to decipher them with the sixteen letters A-P, A for the first X and P for the last. The following diagram (Figure 10-1) depicts which aliquot part of a section the X=s fall in, this is referred to as a nominal location.

F	E	B	A
G	H	C	D
J	I	N	M
K	L	O	P

FIGURE 10-1

COMBINING GCDB AND LLD WITH THE .AN FILE

The final product of the linking process is the .AN file. This file contains a centroid, or area point, for GCDB generated polygons, along with part of the information found in LLD. A centroid is a point (node) that is located within a polygon. It is not necessary for the centroid to be centrally located within a polygon, it is only necessary for the centroid to fall somewhere completely in the polygon. Below is an example of an .AN file for section 6 of the same township as the previous example of LLD above.


```
Sec_006 A T_L 1        25.350; M08T0520NR0030E 475322.3578 1160703.3912
Sec_006 B T_L 2        25.300; M08T0520NR0030E 475322.3573 1160722.8508
Sec_006 C T_A          40.000; M08T0520NR0030E 475311.7160 1160722.8250
Sec_006 D T_A          40.000; M08T0520NR0030E 475311.7212 1160703.3765
Sec_006 E T_L 3        25.250; M08T0520NR0030E 475322.3723 1160742.3046
Sec_006 F T_L 4        21.670; M08T0520NR0030E 475322.3739 1160800.4082
Sec_006 G T_H 804   N_D   70.930; M08T0520NR0030E 475311.6426 1160800.3922
Sec_006 G T_L 5        34.560; M08T0520NR0030E 475311.6426 1160800.3922
Sec_006 H T_A          40.000; M08T0520NR0030E 475310.7549 1160745.4111
Sec_006 H T_A          40.000; M08T0520NR0030E 475311.6993 1160742.2464
Sec_006 H T_H 804   N_D   70.930; M08T0520NR0030E 475310.7549 1160745.4111
Sec_006 G T_L 5        34.560; M08T0520NR0030E 475317.2489 1160800.3780
Sec_006 I T_A          40.000; M08T0520NR0030E 475258.6644 1160742.2087
Sec_006 I T_A          40.000; M08T0520NR0030E 475304.5981 1160750.9985
Sec_006 J T_H 804   N_D   70.930; M08T0520NR0030E 475302.0830 1160800.3897
Sec_006 J T_L 6        34.790; M08T0520NR0030E 475258.8009 1160800.3698
Sec_006 J T_L 6        34.790; M08T0520NR0030E 475302.0830 1160800.3897
Sec_006 K T_L 7        35.020; M08T0520NR0030E 475245.6312 1160800.3637
Sec_006 L T_A          40.000; M08T0520NR0030E 475245.6460 1160742.1613
Sec_006 M T_A          40.000; M08T0520NR0030E 475258.6949 1160703.3712
Sec_006 N T_A          40.000; M08T0520NR0030E 475258.6817 1160722.7948
Sec_006 O T_A          40.000; M08T0520NR0030E 475245.6621 1160722.7720
Sec_006 P T_A          40.000; M08T0520NR0030E 475245.6768 1160703.3788
```

The .AN file contains a single line for each GCDB PLSS polygon, as opposed to the LLD format where multiple polygon=s are represented on one line. The .AN file contains section number, the nominal A-P letter, survey type, survey number, survey note if it exists, acreage, principle meridian code, township, range, and lastly the SPC=s of the centroid.

The .AN file is the >link= between the GCDB and the LDD. This is what linking is all about, allowing alphanumeric parcel data to be associated with spatial data from GCDB to support LR2000. The theory behind all of this is to start with GCDB lines and points of the PLSS, convert the lines and points to polygon=s, determine a centroid for the polygon, and define which line and nominal location it is associated with in LLD.

LINKING PROGRAM ORDER

The linking programs must be executed in proper sequence as one program creates files that the next program reads. The order in which these programs are run is: GETLLD, ROPLY, LLD. An explanation of each of the linking programs can be found below.

Before the linking programs are run an .LLD file containing LLD for the project township must be created from the >master= LLD, which is a file that contains LLD for the entire state. The township.LLD file must be in the directory containing the rest of the GCDB township files for the township to be linked.

GETLLD

Input file: township.LLD
Output file: .LOT

GETLLD prompts for the extent and direction (N. ,S. , E. , W.) of elongation for each lot, by section number, in townships that contain elongated sections. GETLLD runs in batch mode if the elongated section scenario does not exist in a township. GETLLD reads the .LLD file and makes a lot file. The .LOT file contains section number, the numbers 1-16 for the A-P nominal locations, identifies elongation and how it is elongated, the lot number if it exists, the acreage, survey type, and survey number.

RPLOY

Input file: .COR, .DEF, .NOT, .RAW
Output file: .RPO

RPLOY runs in batch mode, there are no interactive prompts. RPLOY reads the .RAW file and creates polygon=s from the abstracted survey measurements, and annotates the polygons as S (standard), I (inny), or O (outy). A standard RPO polygon is a section or fractional section with no special surveys in it. An inny RPO polygon is a polygon which encloses a special survey of some type (HES, Tract, Mineral Survey, etc.), abstracted lots in normal sections are not inny=s. An outy RPO polygon is a remainder polygon created when a special survey invades or extends into another section and does not enclose the entire special survey.

LLD

Input files: .COR, .DEF, .INT, .LOT, .RAW, .RPO, .SID
Output files: .IID, .AN

LLD runs in batch mode, there are no interactive prompts. **LLD** is the most important and complicated of the suite of linking programs. The .IID file LLD creates is large and cumbersome to edit manually. LLD reads the files indicated above and for each polygon computes a centroid and post adjustment area. LLD

then utilizes the area and PID=s for the polygon to match them with the appropriate corresponding data in the other files it reads. All of the matched data is parsed out to the .IID file to create a parcel report of each polygon with information that is needed for that polygon. LLD also includes a statistical type of report at the end of the .IID file regarding each section and the entire township. The last thing LLD does is to make an .AN file.

VERIID

Input files: .INT, .IID
Output file: .VER

VERIID checks to see if a previously linked township has to be linked again after the township is readjusted. VERIID prompts for a centroid distance tolerance. VERIID reads an old .IID file and compares the new polygon PID's with the old polygon PID's to see if they still match, differences are reported in the .VER file. VERIID checks to see if the old centroid still falls in the new polygon, and compares the distance between the old and new centroid for a polygon to see if it exceeds the centroid distance tolerance. If the centroid distance tolerance is exceeded VERIID reports this in the .VER file. VERIID updates all the new centroids' in the .AN and .IID file for all polygons that have the same PID's and have an old centroid that still falls in the new polygon. VERIID can also be utilized to create an .AN file from an existing .IID file.

DXFW

The dxfw.exe program, which creates Drawing Interchange Format (dxf) files, has evolved from individual creation programs (one for Least Square Analysis, one for Raw Polygons, one for all polygons, and one for LX file conversion) to a pull-down, menu-driven program allowing the user different options for final drawing output. In addition to the new menu items, the ability to change text height, add raw data, and draw error ellipses continue to be menu driven.

AN2IID

Input files: .DEF, .COR, .INT, .AN
Output files:.IID

The an2iidw.exe program converts PCCS attribute (.AN) files to .IID file format. Since GMM is now the official collection software for GCDB, and because WinGMM requires an .iid file for maintenance of the attribution of legal land descriptions within a given project, this program performs a conversion that will allow maintenance of attributes in the future. The program reads .DEF, .COR, .INT, and .AN files.

If there is mismatch between the .INT and .AN files, the program stops and warns the User and is then prompted to press the ENTER button to continue. The offending parcels are then labeled with the word "ERROR" in the .IID file. Searching with a text editor to find the word "error", within the .IID file will inform the User of possible conflicts. If AN2IID does not stop it is assumed that no conflicts exist between the .AN and .INT files.

AN2GLD

Input files: .AN
Output files: .GLD

The an2gld.exe program converts a previously created .AN file to the newly identified GCDB Legal Land Description (GLD) file. The .GLD file contains a number of new entity fields, such as discrepancy, acreage source, conflict, and validation codes, which are populated with null values when this program is run. These

LINKING

new entity fields will be populated with actual data once the National Integrated System is deployed.

APPENDIX CONTENTS

APPENDIX

APPENDIX A - GCDB NAMING CONVENTIONS

TOWNSHIP NAMING CONVENTION, Eight-Characters

A normal **township** would be called T23NR07W. If a township or range has a fraction, has a value over 100 or a combination of the above, the T or R is replaced with a letter code. If there is a duplicate or triplicate township, the R is replaced with a letter code.

Some townships have a duplicate or even triplicate. The township that has its SE township corner closest to first the baseline, then the principal meridian (if necessary to further differentiate), will get a normal letter code. The next closest gets a duplicate letter code and the next closest after that gets the triplicate letter code.

The following quick reference chart and cross reference chart shows the letter codes to use and cross-referenced examples.

Quick Reference Chart: What character replaces the T or R:

	No frac	1/4	2	3/4	Duplicates	Triplicates
<100:		Q	H	L	A	B
>100<200	C	D	E	F	G	I
>200<300	J	K	M	N	O	P

Cross-Reference Chart for various BLM Township Naming Conventions:

Survey Plats/
  Notes: =   WinGMM: = LR2000 DED: = PCCS R file:

  T 22 N, R 1 W = T22NRO1W = 0220N0010W = R22N01W
  T 22 N, R 1 E = T22NRO1E = 0220N0010E = R22N01E
  T 14 N, R 4 W = T14NRO4W = 0140N0040W = R14N04W
  T 112 S, R 6 W = H11SRO6W = 0112S0060W = R112S06W
 T 152 S, R 223 W = H15SQ22W = 0152S0221W = R152S221W(too big)
  T 109 N, R 13 E = C09NR13E = 1090N0130E = R109N13E
 T 1092 N, R 13 E = E09NR13E = 1092N0130E = R1092N13E(too big)
 T 106 N, R 224 W = C06NJ24W = 1060N2240W = R106N224W(too big)
 T 1013 N, R 226 E = D01NJ66W = 1011N2660E = R1011N266W(too big)
T 1002 N, R 1002 E = E00SE00E = 1002S1002E = R1002S1002E(too Big)

Some townships defy standard rules, like "Sec. 17 of T. 11 N., R. 2 E. above the river" and "Sec. 17 of T. 11 N., R. 2 E. below the river". In cases like this, define a letter code that has not been used.

STANDARD TOWNSHIP, includes townships with offset boundary lines

GCDB uses a **point identification** scheme that assigns a six-digit point identifier to each corner of a township relative to its position in the township. Each point identifier has two halves: the first three digits are an x-coordinate and the second three are a y-coordinate (XxxYyy).

The point identifiers for the section corners are incremented up in the x and y directions (west to east and south to north) by the number of whole miles they are away from the southwest corner of the township. This affects the hundreds-place, i.e. the first of the three digits of each point id pair (XxxYyy). As an example, 100200 is the southwest corner of section 30, one mile north (y-direction) of 100100. Refer to Figure A-1 - Township showing ID numbering for full section corners.

Corners that are not full section corners are incremented by the number of whole chains they are away from the southwest corner of the section. This affects the tens-place or second digit of each pair (XxxYyy). For example, 120600 is the west sixteenth corner of the section line between Sections 6 and 7 and is 20 chains away from the
section corner, 100600. Refer to Figure A-2 - Section 8 with GCDB IDs down to the 1/16th level.

The third digit (XxxYyy) or ones-place in the x or y coordinate has special functionality in the post-processing functions. The recommended values for these are:

0   a rectangular corner point. Example: 160660 is the NE 1/16 corner of Section 6. The standard point identifier for a section corner indicates that the corner is a maximum interior control section corner common to four sections. Refer to Figures A-1 and A-2.

1,2,8 or 9 (i.e., 1 or 2 from a rectangular corner)
is used for offset corners no matter what the actual distance of the offset, usually on the interior of the township. The database will default to the value for interior offset section corners. See Figure A-4 - GCDB IDs for offset corners in township interior.

3 or 7 (i.e., 3 from a rectangular corner)
is used for offset corners no matter what the actual distance is of the offset, usually on the boundaries of a township. APROPW will determine that these are corners, angle points, etc. from adjacent townships. See Figure A-3 - GCDB IDs for offset corners along township exteriors.

3, 4, 6 or 7 (i.e., 3 or 4 from a rectangular corner)
A 3, 4, 6 or 7 may also be used when assigning point identifiers to elongated section subdivision corners and to corners at the intersection of special survey lines with rectangular lines. See Figure A-6 and Figure A-8.

5   is used for 1/256th corners.

Currently, provisions for subdivision below 1/256th corners are not part of the GCDB ID rules. If such parcels are surveyed, the corners should be assigned IDs similar to intersections with special survey
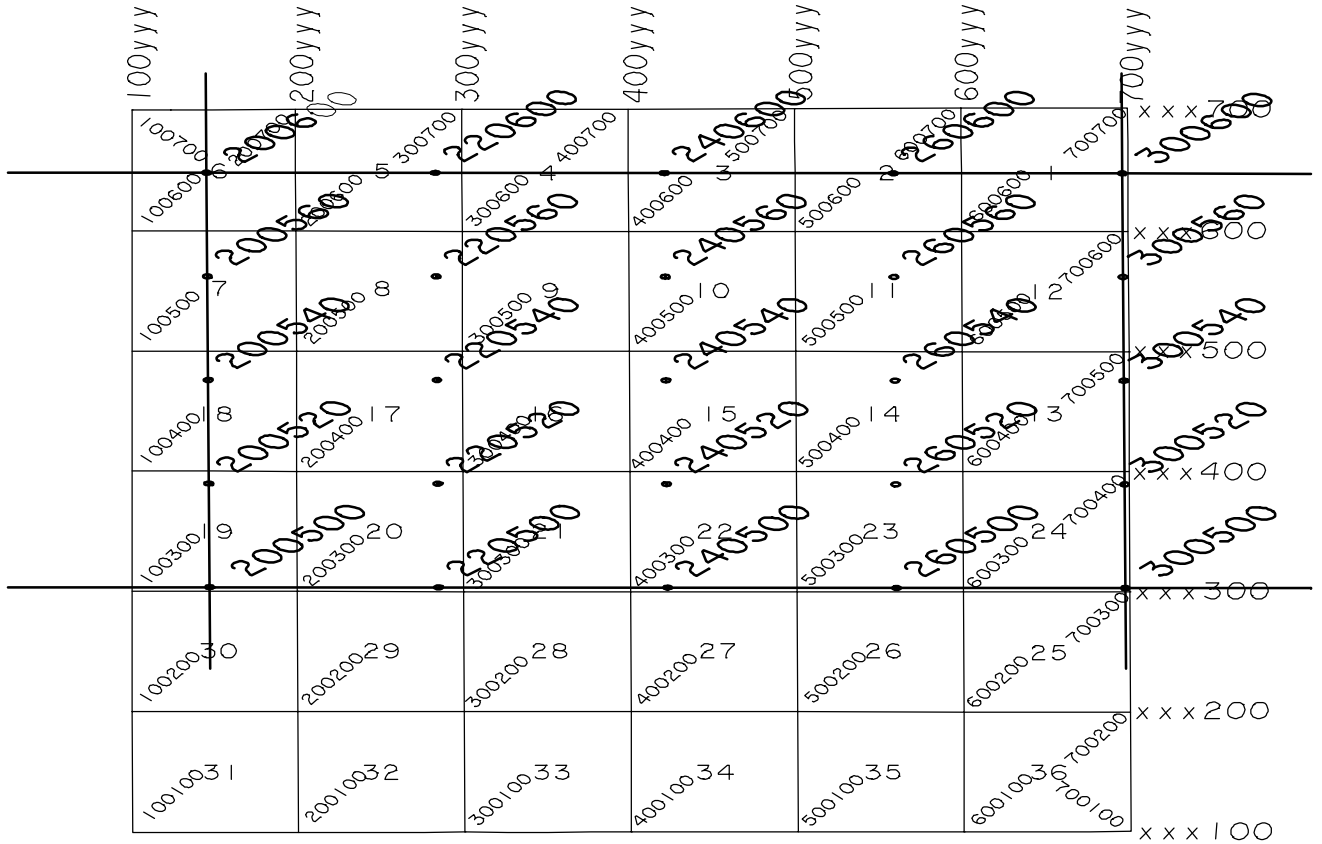
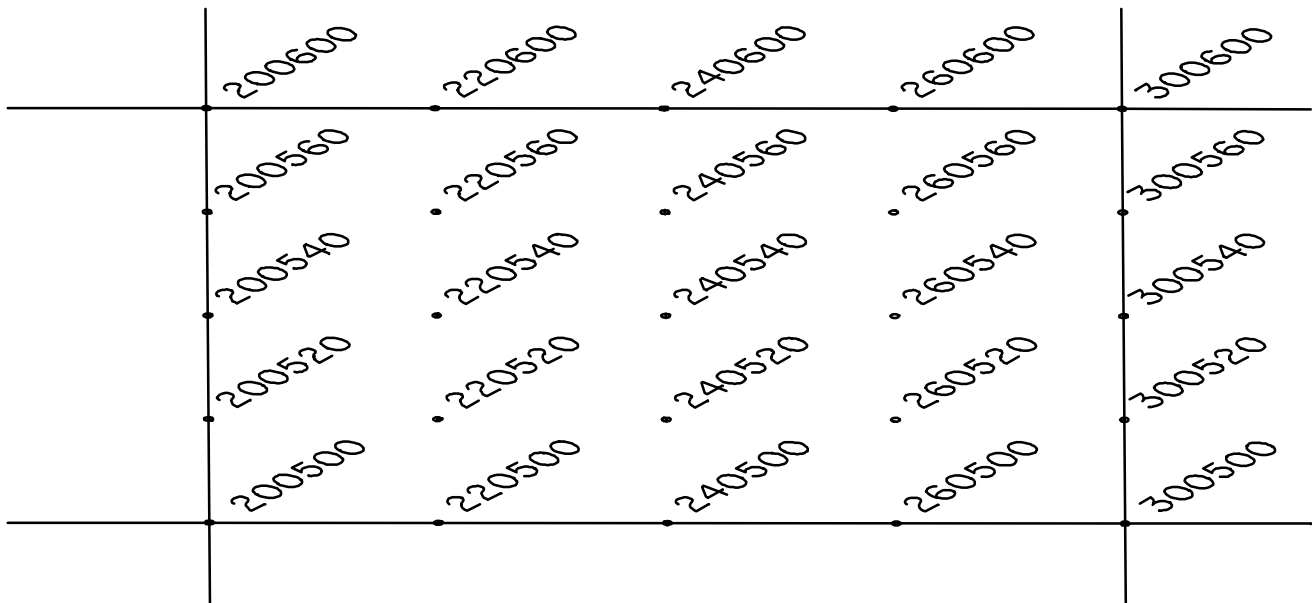Figure **A-1** – Township With GCDB ID Number For Full Section Corners

Figure **A-2** – Section 8 With GCDB ID's to the 1/16th Level
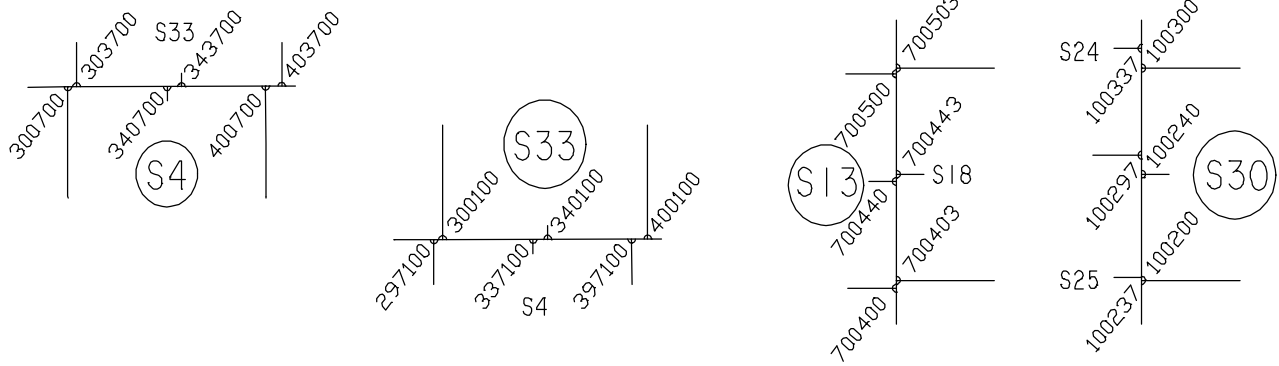
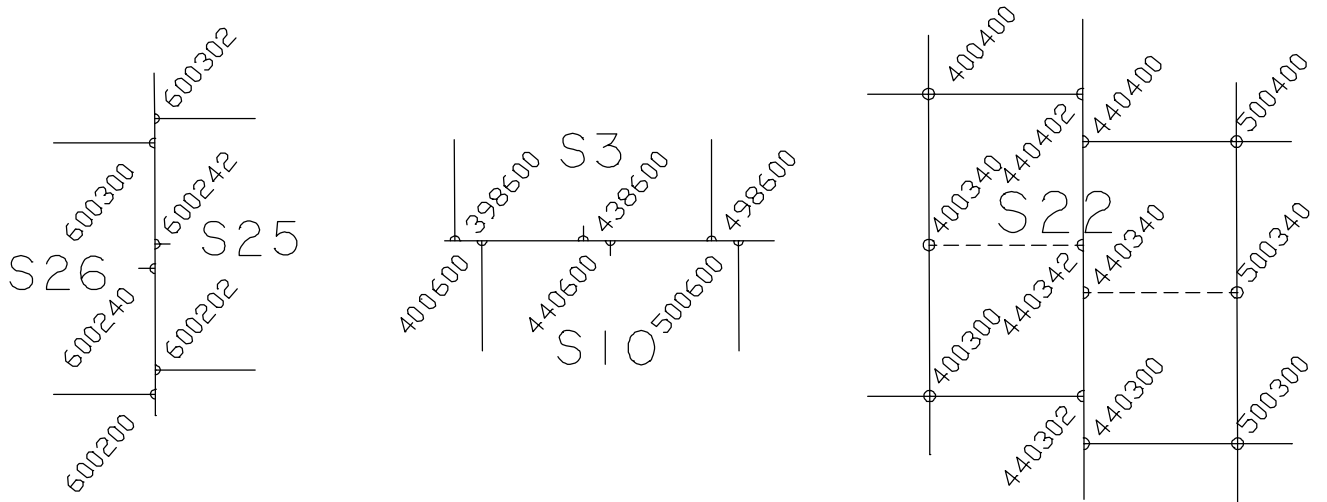**Figure A-3** – GCDB IDs For Offset Corners Along Township Exteriors = +/- 3

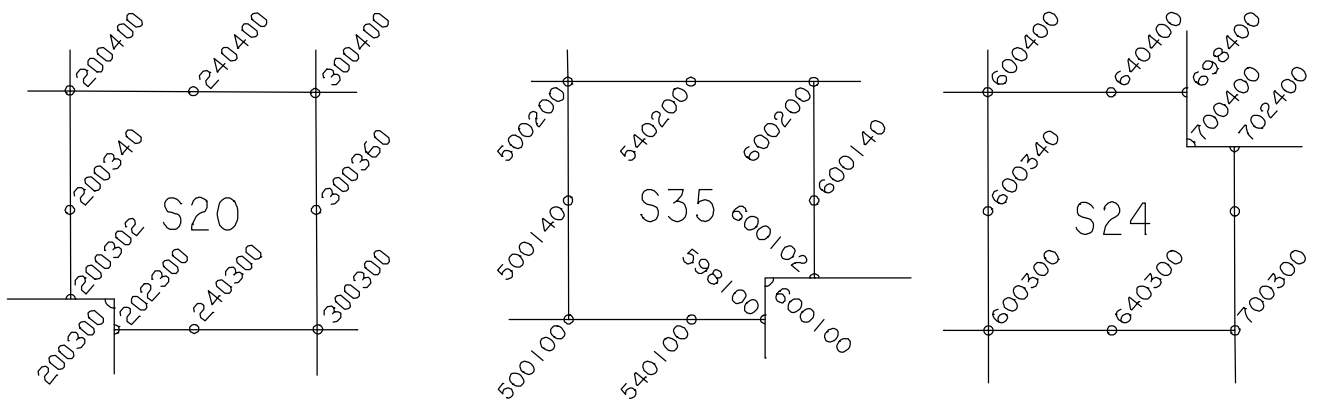Figure **A-4** – GCDB IDs For Offset Corners in Township Interior = +/- 2

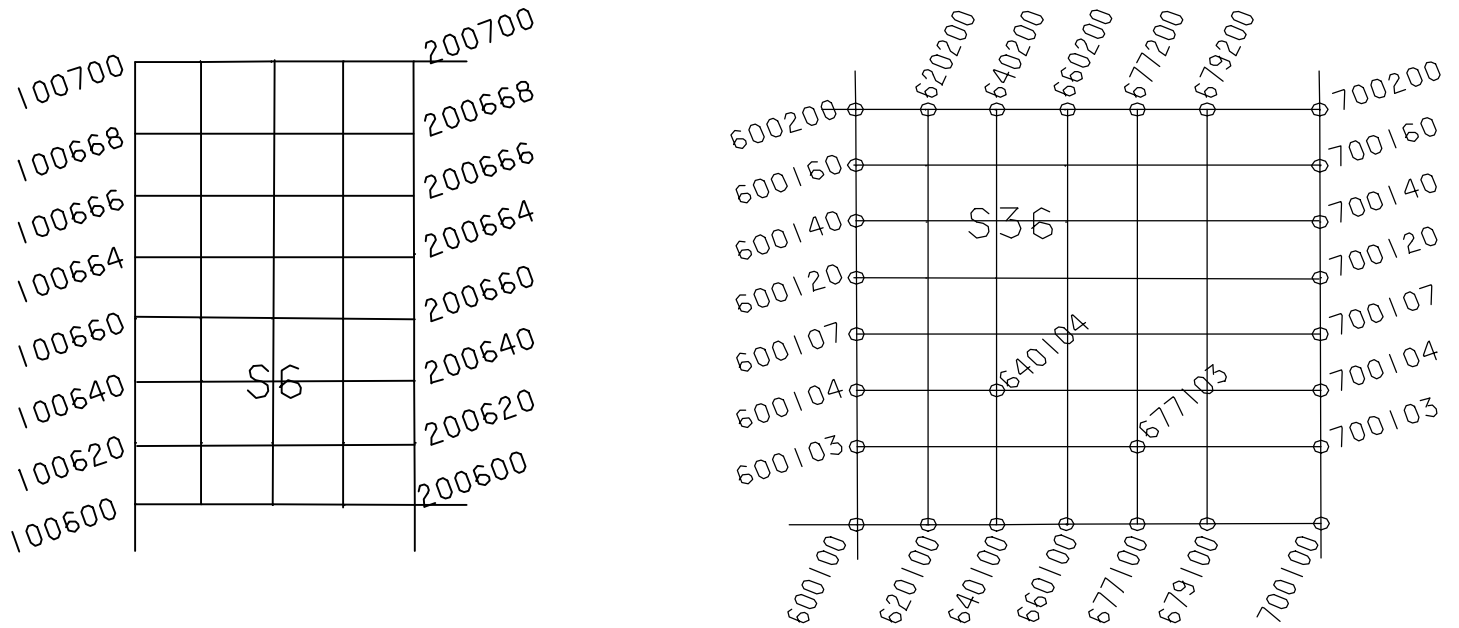
Figure **A-5** – GCDB IDs For Triple Section Corners

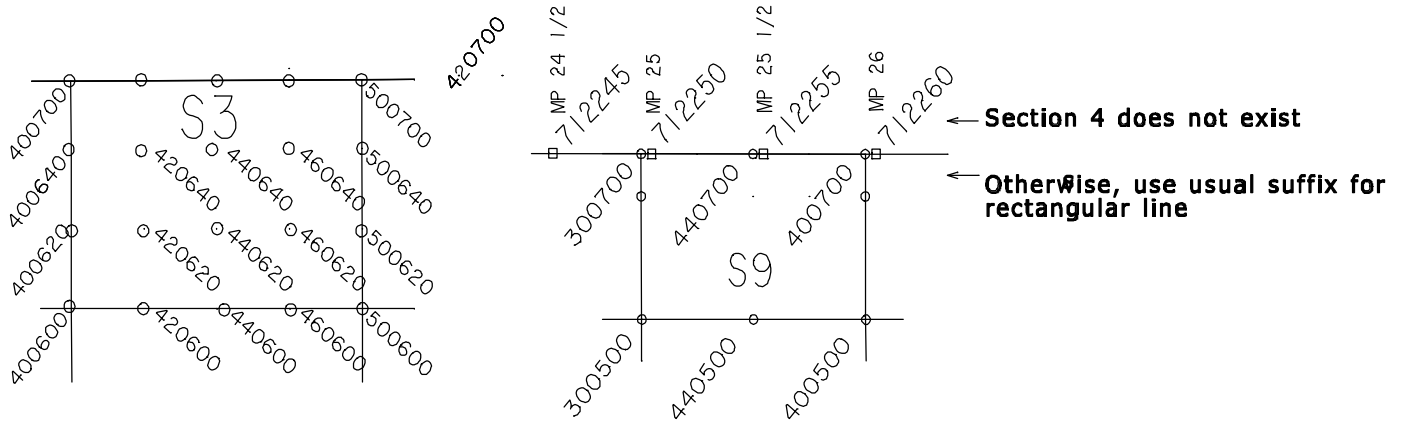Figure **A-6** – GCDB IDs For Elongated Sections

Figure **A-7** – GCDB IDs For Shortened Or Missing Sections And Milepost Surveys
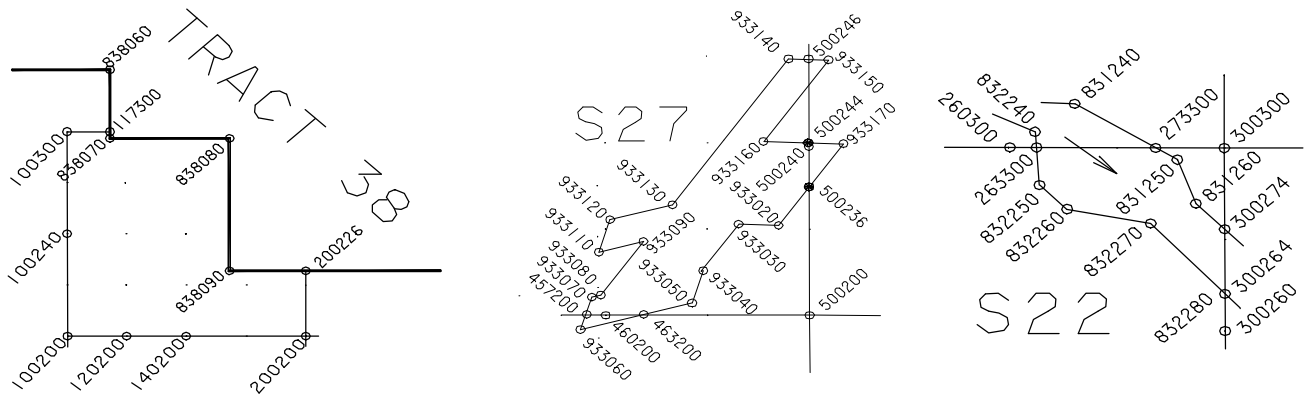
Figure **A-8** – GCDB IDs For Special Surveys = +/-3 or +/-4

Each XxxYyy has a prefix, Xxx, and a suffix, Yyy.

X and Y start at 1 and increase by miles east or north.

xx and yy increase by tens of chains within each mile.

The one's place (Xx<u>x</u> or Yy<u>y</u>) is reserved for:
0   a rectangular corner point.
1,2,8 or 9 (12) offset corners in Tp interior.
3 or 7 (3)   offset corners on Tp boundaries,
3,4,6 or 7 (34) intersection with special surveys.
5   for 1/256th corners.

SUMMARY
Point Identifier Standards
In summary, location-based numbering is used along lines of the rectangular system. The point identifier, a six-digit number, is constructed of two three-digit sets. The first three digits pertain to the East and West direction only and should progress from the West boundary of the township in increasing values to the East boundary of the township. The second three digits of the point identifier pertain to the North and South direction only and should progress from the South boundary of the township in increasing values to the North boundary of the township.

NONSTANDARD TOWNSHIPS, includes offset interior lines, Triple Section Corners, elongated sections, shortened sections.

To develop the point identifier for triple section corners and any other odd situations, keep in mind the dual purpose of the ID system:

1)   To define the corner's function. WinGMM anticipates that you will follow the rules for naming GCDB IDs. This speeds up data entry (INRAWW) and automatic subdivision (APROPW).

2)   To define the corner's general position along a line. This helps <u>us</u> quickly differentiate among several angle points; the software is not reliant on the numbering system.

If you must use a non-standard ID for a corner <u>that plays a part in subdivision</u>, then you must later tell the software what the corner's function is. Refer to the Subdivision chapter. The only thing you have lost is that

the software couldn't AUTOMATICALLY figure out what it needs to know.

<u>Offset Interior Lines</u>, see figure A-4

A great deal of time, confusion and some disk space can be minimized with a new variation on the point ID scheme for offset interior corners. There is no longer any need to place1 or2 values on both the prefix and suffix, nor is they're a need to make both IDs non-nominal. You may now choose one side to be the "normal" section with nominal IDs and put the offset IDs on corners for the adjacent section to indicate the relative position from the "normal" corner. There is no need to indicate which side the corner controls, AUTOIRR can determine that from connectivity.

<u>Triple Section Corners</u>, see figure A-5
Triple section corners are common for completion surveys. There is one corner that is a full section corner for the "senior" section. One of the other two corners is a full section corner to the section to the side of the "senior" section, but is only a partial section corner for the section corner on the diagonal from the "senior" section; it controls proportions only along the line that closes into the "senior" section.

In Section 20 of figure A-5, corner IDs 200300, 200302 and 202300 are perceived by us and by the software to be of section corner status. WinGMM's AUTOIRR function deduces the proper relationship of each of these: 200300 only to the SW, 200302 a full corner to the NW, but only controlling to the North on Sec 20, and so on. Using 200300 as the NE corner of Sec 30 means that there will not necessarily need to be an entry in the .IRR file for Sec 30.

<u>Elongated Sections</u>, see figure A-6

Elongated sections are special cases of rectangular surveys. The corners should generally follow the recommended rules listed above, but when the obvious values are exhausted it does no harm to use other values. Preferred values are 103, 104, 107, 108 on the W and S elongations and 664, 666, 668, 672 on the N and E elongations. Other possibilities are 105, 109, 111 and 662, 676, 678. See figure A-6 for examples. Note that these 1/16ths can be left out if AUTO-ELONGATION is used.

<u>Shortened Sections and Missing Sections</u>, see figure A-7

Assign point identifiers to short sections using the standard section point IDs. See figure A-7 for an example.

The standard point identifiers are also used for townships missing sections. See figure A-7. If a township is only 5 miles high, then use the point identifiers usual for that section.

SPECIAL SURVEYS, includes Tracts, Milepost Surveys and Mineral Surveys

You are advised to use the "rectangular" ID number where a special survey intersects or bounds the section lines as described earlier (3 or4). See figure A   -8.

For the remaining survey corners, assign a six-digit GCDB "segment identifier" that is used for special survey corners; there is no relation as to the corner's position within the rectangular scheme. Instead the segment identifier describes a particular survey type. The segment identifier is made up of two parts:

 -    The first three digits of the segment identifier (prefix) are assigned according to survey type and each survey has at least one unique prefix that is used for each corner of the survey.

 -    The second three digits (suffix) are numbered sequentially from 000-999 and may be incremented by 2, 5, or 10 to leave room for subsequent additions, if needed, around the survey.

APPENDIX A

Note that WinGMM will work with totally random numbers for special surveys as long as they are unique. These rules are made to help you and those in the future make sense out of complex data sets. Also some post-processing software depends on the prefixes to speed automatic cataloging of the data for BLM's LR2000.

Tracts, see figure A-8

The segment identifiers for tracts have a prefix of 8 plus the tract number. These values can range from 837 to 899. The second three digits (suffix) range from 000-999, as described above, for each tract corner. Figure A-8 illustrates the numbering convention for Tract 38

Boundary/Milepost Surveys

Number milepost corners and all the corners along the boundary (reservation or grant boundary) with a segment identifier whose prefix ranges from 711-799. The second three digits may increment up the line or reflect the milepost number.

Mineral Surveys, see figure A-8

The prefix of the mineral surveys "segment identifier" can range from 900-999. The second three digits are assigned the same as all special surveys, i.e., incrementing around the survey (figure A-8).

Meander Lines, see figure A-8

The prefix will be a number between 800-836. The entire meander line will have this prefix through the whole township. For rivers, right bank meanders will be prefixed by even numbers (for example, 806), while left bank meanders will be prefixed by odd numbers (for example, 807). Right and left banks are determined as you look downstream. Lakes will have only one segment identifier prefix. Each meander line should have a segment identifier, i.e., right bank meanders, informative traverse, lakes, islands, and fixed boundary.

The last three digits (suffix) of the segment identifier for each angle point on the meander line will begin 000 after the meander intersects the township or section line and be numbered sequentially downstream (002, 004, etc.).

Non-boundary points

Monuments of known position and not part of the land net, such as triangulation stations and U.S. Mineral Monuments, are sometimes given PIDs that start with A99".

For each XxxYyy, Xxx =

100 – 710 Rectangular
711 – 799 Boundaries with Mileposts
800 – 836 Meanders
837 – 899 Tracts
900 – 999 Mineral Surveys, Homestead Entries, etc.

    Yyy increments by tens, sequentially along the survey.
    Groups of similar surveys may have one segment identifier prefix

SUMMARY
Segment Identifiers

SID SUFFIX NAMING CONVENTIONS

SID (Survey Identifier) is a reference to a particular survey (dates, surveyor, volume/page, etc). Each line in the .RAW file must have a SID as part of GCDB's data base requirements. WinGMM also uses the SID to more fully automate the assignment of error estimates. Experience has shown that the SID can be embellished to accomplish more, so WinGMM is built to recognize suffixes to the SID. Suffixes are used to:
- isolate areas of a survey that need a different error estimate
- identify lines that are ties, not boundary lines
- identify lines that are long chords

SID values 4588, 4588a, 4588-TIE, 4588-LCS all point to the same survey 4588. The suffixes are used for various purposes as described below.

- ISOLATE AREAS OF A SURVEY THAT NEED A DIFFERENT ERROR ESTIMATE

Initially error estimates are based on values that are tied to a SID in the .SID file. All surveys, however, are not of the same quality. Upon discovering that certain areas need higher or lower error estimate you are expected to assign the error estimates accordingly. Prior to SID suffixes, the .SD file was edited, via SD.EXE or a text editor. Because these estimates were not tied to a SID, they were hard to recreate if the .SD file was deleted. Also, the lines that were custom edited were very difficult to identify from those tied to SIDs. The suffixes were implemented to allow all error estimates to be tied to a SID in the .SID file. Alphabetic characters are appended to the base SID to create a new SID. The new SID and its values are placed in the .SID file and the .RAW file is edited accordingly.

- IDENTIFY LINES THAT ARE TIES, NOT BOUNDARY LINES

In preparing the data for merging with LLD, APROP will identify all the polygons. These minimal polygons will later be combined to form parcels as listed in LLD. Normally a tie between rectangular and a special survey would divide any parcel it crosses into two polygons, forcing more work to the user who must then combine them. To prevent this extra work, AUTOI will not include lines that have been identified in the .RAW file with a suffix of TIE.

- IDENTIFY LINES THAT ARE LONG CHORDS

The long chord of curves are entered into the .RAW file just as any surveyed line, except that the .SID value must contain a suffix of LC

APPENDIX B - FILE FORMATS of WinGMM FILES

TEMP.JOB

The first 1-8 characters of the file are the project name, usually just township/range. There is no other data in this file.

.DEF

A sample .DEF file is on the left, descriptive comments on the right: (comments in parenthesis are not user-definable in PROJEC)

```
Y                       not applicable to WinGMM
   5 ARIZONA WEST MERCATOR       state plane zone

1                       NAD27=1   NAD83=2
2                       (Survey ft=2  meters=1 Int. ft=3)
   5000.000                default elevation
N                       read elevations from .LEV file
Y                       read error estimates from .SD
     .100     1000.0        default for distance error estimate
      4.0                default for angle error estimate
     120.0                 default for bearing error estimate
      40.000               default for control N error estimate
      40.000               default for control E error estimate
Y                       (mean geodetic brgs=Y, grid brgs=N)
     .000                 (Distance residual printout limit)
      .0                  (Angle residual printout limit)
      .0                  (Azimuth residual printout limit)
N                        error ellipses computed
N                        readjust w/ robusted error estimates
N                        (print adjusted grid brgs/dists)
Y                        (update .COR file)
T05NR14W                 Project name
14                       Meridian
AZ                        State designation
 12                       UTM zone number
                         not applicable to WinGMM
1                        not applicable to WinGMM
```

.SID

Below is a shortened example of a .SID file created by an Oracle query:

```
S5071          1.000 9999.0 1800.0  30.000  30.000
C GLO 11-DEC-1872 O FOREMAN
S5905          1.000 9000.0 1600.0  30.000  30.000
C GLO 04-APR-1880 O VULTURE CITY
C --------------------------------------MINERALS:
S22151          1.000 7000.0 1200.0  30.000  30.000
C GLO 05-JUL-1908 O MS2511     m2400
```

APPENDIX B

For the lines starting with "S":
The 1st field in Column 1 identifies SID data(S).
The 2nd field is the SID number and must start in the +2nd column.
The 3rd field is the Distance Error Estimate Constant, ft units.
The 4th field is the Distance Error Estimate PPM, no units.
The 5th field is the Bearing Error Estimate Constant, second units.
The 6th and 7th fields are obsolete.
Lines following the SID data are comment lines and start with the letter C. In the BLM, the standard for the first comment line after each "S" line is:
The 1st field in Column 1 identifies line as a Comment line(C).
The 2nd field is Source Agency, 3-4 character abbreviation, i.e. BLM, USFS.
The 3rd field is the Survey Type, O = original, D = dependant resurvey, etc
The 4th field is the Surveyor's name or MS number and Volume number.

Next is an entry in a .SID file specifying "non-Cadastral" units

```
S36970BT          0.100  5000.0  900.0   0.001   0.001
C BDY TR FROM T33NR30E
C DT:P             <dist type grid>
C DC:-1 +50          <correct dist by -1 ft. and + 50 ppm>
C BT:GA 0.0530 <bearings are grid, convert to angles error est. 5'30">
C BC:-2.1040 <rotate bearings counter-clockwise 2-10-40>
```

The 2 unit types are:
(1) DT: distance type, value consists of 1 character value
Allowable values: G (ground), E (ellipsoid), or P (plane/grid)
(2) BT: bearing type, value consists of 1 char value or 2 char value followed by a numeric value.
Allowable values: M (mean), F (forward), G (grid), C (compass/magnetic), or L (local/assumed). Column 7 can be blank or an A (convert bearings to angles). If an A exists in column 7 it must be followed by an error estimate for the angles in DD.MMSS (HP) format. The error estimate can immediately follow the A or have leading spaces

The 2 corrections are:
(1) DC: distance correction (two numeric values)
The two numbers are the constant correction and the ppm correction. A negative value means the distance will get shorter. The constant correction is in the units of the desired linear units in .L.A. (ft. or meters). The constant correction can immediately follow the : or any number of spaces can exist. Any number of spaces must exist between the constant correction and the ppm. You can have a zero constant and a non-zero ppm, and vice versa.

(2) BC: bearing correction (one numeric value)
DMZ "HP" format with positive being clockwise and negative being a counter-clockwise correction.

.CON

Below is a shortened example of a .CON file after GMMCON has been run.

```
 TWP 0070N  RNG 0260E  PM GilaSalt R       Arizona(AZ)    DATE 93/12/15
 ORIGIN    337976.0000 1093540.0000 5000.000   0   0  2000.0000 5000.0000
 700140    335733.0015 1093232.0338 9600.000  23   23   27
 700140    335733.1745 1093234.3656 9600.000  23   23   83
*700700    340220.2080 1093232.0520 9200.000  15   15   27
```

APPENDIX B

*700700   340220.3764 1093234.3880 9200.000 15   15 83

The control data fields are:
First column, if non-space, is a comment line, data will not be used.
Point ID 6-digit format,
Latitude in DDMMSS.SSSS format,
Latitude in DDDMMSS.SSSS format,
Elevation in feet units,
Estimated Northing error in whole feet units,
Estimated Easting error in whole feet units,
North American Datum, either 27 or 83. The top of each pair is the native unit. Above example, source data is NAD27, NAD83 is calculated from NAD27.
WinGMM does not use everything to the right of column 58 at this time.

Optional: "Merge control" data.
*MT08NR26E 200100 200700

*M is a special comment line code for merging control.
T08NR26E is the adjacent township that is the source of coordinate data.
200100 is the point ID in the adjacent township
200700 is the point ID to be used in the current township, T07NR26E.

.RAW

T09NR13E   14   AZ   11111   0.000   0.000 5000.000 1 1
        999999   100100   100140   40.070 1   500.0 11340

100140   100200   40.000 1   0.0 11340
100200   100240   40.110 1   100.0 11340
...
120700   100700   20.02   3   895900.0 6010
999998

The data between the 999999 and 999998 lines represent data from survey plats. The fields are:

The 1st field is the Point Identifier for the beginning of the line.
The 2nd field is the Point Identifier for the ending of the line.
The 3rd field is distance, in chain units.
The 4th field is the quadrant of the bearing; 1 = NE, 2 = SE.
The 5th field is the value of the bearing, DDMMSS.S format.
The 6th field is the Survey Identifier number (SID), more about the survey is listed in the .SID file.

.LSA

The .LSA. has 5 segments. Below is a shortened list:

700100   653137.527   1055152.756   0
700200   653126.637   1060413.534   0
700300   653100.770   1065747.464   0
700700   653010.374   1086873.400   1
700100   700200   5280.000   0
700200   700300   5280.000   0
700300   700400   5280.000   1
0   0   0   0 0 .00 1

APPENDIX B

B-3

700100	700200	0 0	.00	0
700200	700300	0 0	.00	0
700300	700400	0 0	.00	1
700600	653059.258	1081552.147	0
600660	647756.151	1085478.873	0
700640	653046.086	1084201.999	0
700660	653039.534	1085526.250	1

The first segment is a list of known control imported from .CON.
The second segment is the distance. The third segment is the angle.
The fourth segment is the azimuth.
The fifth segment is the approximate coordinates that GENER computed for points that are not control.
Each line is ended with a 0 or 1. The 1 signifies the end of the segment.

.SD

The .SD has 4 segments. Below is a shortened list:

700503	33.000	33.000	0
700600	33.000	33.000	0
700603	33.000	33.000	0
700700	33.000	33.000	1
100100	100200	32.680	0
100200	100300	32.680	0
100300	100400	32.680	0
600200	910010	3.430	0
600300	920010	2.585	1
0	0	0	4.00 1
100100	100200	600.00	0
100200	100300	600.00	0
100300	100400	600.00	0
600200	910010	240.00	0
600300	920010	400.00	1

The first segment is a list of known control imported from .CON.
The second segment is the distances
The third segment is the angles.
The final segment is the azimuths.

.ADD

```
1 107140 100140 140140   .00000  1   15.310   55.310
2 107120 100120 140120   .00000  1    .000     .000
2    0 107100 107140   .00000  1    .000     .000
2 107160 100160 140160   .00000  1    .000     .000
2    0 107140 107200   .00000  1    .000     .000
1 910040 910030     1  89.59380  1   22.720    0.000
1 910050 910040     1  89.59380  1    9.090    0.000
2 908025 910050     3   0.01170  1   0.000     0.000
2    0 908030 908020  0.00000  2   0.000     0.000
3 910040 901004     0        0   0.000    0.000
```

The first 5 lines show how elongated 1/16ths (107xxx) of sec 31 are stored.

107140 is put in at proportion between two point IDs and the other 1/16ths are put in at intersection of two lines, whose endpoint IDs are stored.

The 1st field describes the type of action. 1 = traverse/proportion, 2 = intersection, 3 = add a line. Intersections require 2 lines of data.

The 2nd field is the point being generated. Value is 0 if not applicable.

The 3rd field is the known point starting the procedure. Intersections have two such points.

The 4th field is either the endpoint ID defining the bearing from the base point or the quadrant of a user-entered bearing. Not applicable = 0.

The 5th field is the bearing value of a user-entered bearing. Not applicable value is 0. The 6th field is a digit describing whether the computation is based on a geodetic line (1) or plane line (2).

The 7th field is the record distance to the new corner.

The 8th field, if nonzero, is the record distance to the endpoint, in which case the record distances will be used as a proportion to apply to the adjusted overall distance.

In add a line –
2nd field is point from
3rd field is point to
all other fields are not applicable so = 0

.NOT

```
  2
991534
990003
  4
100565 813020
100568 813020
240132 260126
260126 300123
```

The first line describes how many "NOT points" will follow.

The next segment is the listing of NOT points. NOT points are non-boundary points whose lines must be removed for post-subdivision display. The points will be removed from the COR file. This feature will become obsolete, so all lines touching this kind of point should be entered into the "lines" segment.

The number after the "NOT" points describes how many "NOT lines" will follow.

The last segment is the listing of lines to be removed for post-subdivision display. These must be entered in the same order as they exist in the .RAW file. Points (950xxx) generated through automatic intersections in APROP can be entered in this file, however subsequent changes in the base files may result in a different numbering scheme for 950xxx points. All lines in .RAW file W/-TIE must be in the .NOT file.

APROP has a limit of 500 lines for the .NOT file.

APPENDIX B

.LX

The .LX file is a PCCS-compatible file that is used to support the BLM's LR2000 environment. It is produced by WinGMM, but not used by it. The format is described on the GCDB website, http://www.blm.gov/gcdb/.

.AN

The .AN file is a PCCS-compatible file that is used to support the BLM's LR2000 environment. It is produced by WinGMM, but not used by it. The format is described on the GCDB website, http://www.blm.gov/gcdb/.

.DXF

The .DXF file is an AutoCAD-compatible file that is used to export GCDB data into AutoCAD and other graphic environments. It is produced by WinGMM, but not used by it. The format is described in documentation about AutoCAD.

APPENDIX B

APPENDIX C - WinGMM Glossary

Bandwidth Optimization - There are many ways to speed up the solution of a system of equations and reduce the number of terms in the equations. Some methods other than bandwidth optimization include column profile minimization, Helmert blocking, and recursive partitioning. If a computer program does not use one of these methods the results will be produced very slowly. LSAQ uses a bandwidth optimization routine that has been extensively modified for better performance. For most survey networks the bandwidth will probably range from 5-30% of the total number of stations. This process enables more efficient solution of least squares problems, and especially allows "big" problems to be solved on a personal computer.

Degrees of freedom - number of measurements minus number of unknowns; or the number of measurements beyond what is necessary to uniquely define coordinates for each station.

Error ellipses - It should be apparent that the reliability of a traverse point's position will not usually be the same in all directions. The position is generally stronger in the traverse direction, and weakest away from the traverse directions. The error region is an ellipse, defined by a radius (semi-major axis) of maximum error (SU), radius (semi-minor axis) of minimum error (SV), and the angle from north (positive clockwise) of the direction of maximum error (T). Since an error ellipse is two-dimensional, the one-sigma error ellipse only denotes 35% confidence (roughly 68.3% squared). The same statistical significance reasoning for coordinate standard errors applies to error ellipses - it is an internal evaluation of your data and does not relate to external information such as other surveys or existing coordinates.

Error estimate - A surveyor's error estimates of measurements assigns appropriate weighting of measurements in a least square adjustment. An angle with an error estimate of 2 seconds will be treated as more weighted (stronger, less chance of adjustment) than an angle with an error estimate of 10 seconds. This does not mean the angle with the smaller error estimate will always get a smaller adjustment since geometric constraints (such as sum of angles in a closed figure) also play a major role in dictating amount of adjustment. A distance error estimate is usually modeled by a constant plus a ppm addition to account for larger errors generally occurring in longer lines. An angle or azimuth error estimate is a function of the instrument's least count, the number of repetitions, the instrument operator's abilities, and the prevailing environmental conditions. Experience with instrumentation and the least squares adjustment will allow the surveyor to develop confidence in error estimation. Error estimating allows the simultaneous analysis of different measurement types

 (distances, angles, azimuths, control coordinates).

NAD 83 - North American Datum of 1983 - a datum based on the GRS 80 Ellipsoid, and fixed position and orientation at the center of the earth. The measurements used in NAD 27, and additional measurements made by the National Geodetic Survey subsequent to 1927, were subjected to a least squares adjustment - this time using a computer. This results in a different latitude and longitude for a station when compared to its NAD 27 values, with the difference often amounting to hundreds of feet.

NAD 27 state plane coordinates - These are based on zone constants that include false northings and eastings so that negative coordinates do not result. The published units are U.S. Survey Feet.

NAD 83 state plane coordinates - These are based on different zone constants than NAD 27. The most notable change is that different values were assigned for false northings and eastings, and the coordinates published by NGS are in meters instead of U.S. Survey Feet. Even when converted to feet, NAD 83 coordinates look dramatically different than the NAD 27 coordinates for the same point because the false northings and eastings are different.

NAD 27 - North American Datum of 1927 - a datum based on the Clarke Ellipsoid of 1866, and fixed position and orientation at Meade's Ranch in Kansas. Based upon this information, latitudes and longitudes

were calculated for all National Geodetic Survey control points based primarily on triangulation. The calculation involved a least squares adjustment by hand calculations!

Number of measurements - equals # of distances + number of angles + number of azimuths + number of control coordinates.

Observation - a fancy word for measurement.

Residual - the difference between a measurement and its computed quantity based on coordinates; it is how much the measurement adjusted.

Residual vs. error estimate - These quantities should be of approximately the same magnitude. Since measurements contain random error a plot of residuals should look like the "bell-shaped" curve from statistics that centers about zero. If residuals tend to be predominantly of one sign this means systematic error may exist. This would occur if your survey tied into two precise control coordinates and your EDM was measuring systematically long. All adjusted distances would be shorter than their measured values. It could also occur if horizontal angles were only measured in the direct position and a large horizontal collimation error existed. Residuals which are larger than three times their respective error estimate are generally considered suspect.

RMS error - root mean square error - it is the average of a series of residuals in which the sign of the residual is eliminated through summing squared residuals, dividing by the number of that type of measurement, then computed that value's square root.

Robustness - This is a method of using least squares as a filtering mechanism for detection of blunders. Robustness averages the absolute value of a measurement's residual with its error estimate, and that average becomes the new error estimate in a readjustment. The measurements with large residuals get reassigned larger error estimates, and vice-versa. This enables the adjustment to be filtered to the suspect measurement. The success of robustness in blunder detection is a function of size of the blunder, number of blunders, and the geometry and redundancy of the traverse network.

Simultaneous Solution - This means all coordinates are being solved for in one solution; in the compass rule process you must adjust one traverse into another traverse which is held as "fixed". This is not correct since the fixed traverse contains error.

Solution Convergence - the last iteration has insignificant updates and thus the solution terminates.

Solution Divergence - blunders or poor initial approximations will cause updates to grow as iterations proceed; This indicates something is wrong with the data, and it needs to be corrected.

Standard error of unit weight - This is a number which tells you how well it appears that you are estimating your measurement errors. It is generated by the summing the squares of all residuals divided by their error estimates. That quantity is divided by the degrees of freedom and the square root is taken. If a residual and error estimate are of the same magnitude note that the residual divided by the error estimate will generally produce a number close to one. The standard error of unit weight is a number that evaluates all residuals and corresponding error estimates. If the standard error of unit weight is near one (0.7-2.5) you are estimating your errors well. Uncorrected systematic errors, blunders, or generally poor measurements will result in larger residuals and thus a large standard error of unit weight. If you are pessimistic in
 estimation or you have very few redundant measurements a very small standard error of unit weight will result.

Standard error of adjusted coordinates - these are the least squares error estimates of adjusting N,E coordinates. They are a function of proximity to existing control points. The statistical significance of these quantities is that if you went and made the same measurements with the same instrument using the same

APPENDIX C

procedures, you would have a one sigma (68.3% confidence) chance of being within plus or minus the standard error of the first solution's coordinate. It has nothing to do with additional traverse legs and readjustment, comparing to someone else's coordinates, or evaluating retracement evidence.

State Plane Coordinates - projections which uniquely relates a geodetic position (latitude, longitude) to a plane coordinate pair (N,E). The relation is truly a one-to-one correspondence; for a unique state plane coordinate pair there is only one latitude, longitude pair, and vice-versa. The two types of projections that exist are Lambert - a conic projection for states elongated east-west, and Mercator - a cylindrical projection for states elongated north-south. The size of a zone was limited by defining a state plane distance will not differ from its geodetic counterpart by 1/10000 of the distance. Thus larger states are covered by more than zone.

System of Equations - in a least squares adjustment you solve an "n x n" system of equations each iteration where n equals the number of unknown quantities. In a 20-station traverse there are 40 unknowns (20 N, 20 E coordinates). This means a 40 equations, 40 unknowns system of equations must be solved. Even for a computer this is a slow process.