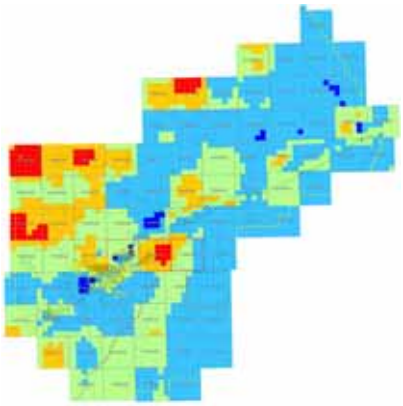
Yellowstone County Montana Cadastral Accuracy Pilot Project Report & Enhancement Plan



A partnership project of
Yellowstone County,
City of Billings,
Montana Department of Administration ITSD, GIS Bureau,
US Department of the Interior, Bureau of Land Management
& Various Private Partners

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TABLE OF CONTENTS

TABLE OF CONTENTS 1
Project Background 2
I. a Stakeholders, interested & affected parties, contributors 2
I. b Project Area Status maps - pre-adjustment 3
I.b.i Parcel Density 3
I.b.ii Population Density 3
I.b.iii Property Value 3
I.b.iv GCDB Accuracy vs. Parcel Density 3
II Project Problem statement 4
II. a Issues 4
II. b Goals & Objectives 4
III Approach used 6
III. a Methods, Options, Procedures to Used for Enhancement 6
IV Results Discussion 7
IV. a GCDB Adjustment 7
IV. b Project Area Status maps - post-adjustment 8
IV.b.i GCDB/Parcel Accuracy 8
IV.b.ii Changes wrought (pre to post adjustment) 8
V Conclusions 9
VI Future Project Areas & Priorities 10
VII Recommendations 11
VIII Scope of Work for Yellowstone County GCDB Adjustment 11

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Project Background

Who, What, When, Where, How, Why

I. a Stakeholders, interested & affected parties, contributors

History:
The cadastral parcel data were originally mapped and geo-referenced to digitized section corners taken from 1:24,000 scale US Geological Survey Topographical maps. Several years ago the data were re-adjusted to the Bureau of Land Management's Geographic Coordinate Data Base (GCDB) coordinates, which resulted in the cadastral data shifting somewhat. The entire County was mapped and the parcel data is sufficiently accuracy for most purposes, however, the cadastral data do not align well with other more spatially accurate GIS data such as aerial imagery and public works infrastructure data. Because of the misalignments some spatial analysis does not yield accurate results, and in many parts of the County the misalignment against the aerial imagery infers incorrect property alignment.

Stakeholder meetings:

Yellowstone County GCDB Enhancement Meeting 12/07/06

The meeting was held in the County Courthouse and was attended by 16 persons. The participants had the most interest centered on the populated areas of the county. Suggestions were made to build on the townships of the pilot in populated areas or areas of future growth. The representatives from Yellowstone Valley Electric Coop were particularly interested in the areas of Billings not included in the pilot, the Huntley area, and Laurel. Some discussion was held on the extension of the pilot either on each side of the Montana Principal baseline that runs east and west through Billings and the county. Annette suggested that rather than build on the baseline, it would make more sense to use the Yellowstone River as the feature that growth would most likely follow. The group agreed that this made more sense.

During this meeting we explained that we would like to have participants in the process, not only in the planning, but if any of the representatives had resources that they could contribute, we could all leverage resources to attain a more efficient project. No offers were brought forward immediately.

The representative from TetraTech asked that we consider the Bull Mountain area to assist with planning for energy development purposes. Annette also mentioned that the towns of Broadview and Custer had some mapping problems. T3NR27E was also mentioned by one of the participants as a possible area of interest.

We agreed to hold another meeting to present the findings of the pilot in several months. At that point we could have a preliminary plan to proceed with the rest of the county project and get further feedback from participants.

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The participants were interested in the overall state process and how Yellowstone County fit into that picture. We mentioned the Bozeman project that improved the mapping and parcel data and that other counties are beginning initiatives with the funding that is being distributed through the State.

Following the meeting, I had a brief discussion with Tom Tully, City of Billings, regarding the Bozeman pilot. We felt it would be valuable to sit down with Stu Kirkpatrick and his staff, along with BLM reps and project participants, to compare the Bozeman project with the Yellowstone County project sometime in the process. A comparison of conditions prior to the projects, techniques used during the projects, the results of each project, and the costs of the projects could provide the basis for future work in these areas and other areas of the state.

Annette has posted documents associated with this meeting on her website: http://www.co.yellowstone.mt.gov/GIS/gcdb/
Annette and I agreed that this was a good start for the project and hope to build on the contacts and interest that this meeting generated.

I. b Project Area Status maps - pre-adjustment

The following maps describe present conditions that are useful for consideration regarding the issues addressed in this report.

- I.b.i Parcel Density
- I.b.ii Population Density
- I.b.iii Property Value
- I.b.iv GCDB Accuracy vs. Parcel Density

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II Project Problem statement

II. a Issues

The Yellowstone County cadastral data in some areas of the county, such as Broadview and Custer, do not spatially align as well as needed with other GIS data, such as aerial imagery. Due to misalignments some GIS processing does not yield accurate results.

Example Misalignment in Yellowstone County

II. b Goals & Objectives

The objects for this project were to perform a pilot GCDB adjustment project to determine the value of GCDB adjustment. The goals of the pilot project were to determine the amount of effort, the cost, the type of work involved, and the magnitude of improvement that a GCDB based adjustment could have on the spatial accuracy of parcels in typical Yellowstone County areas.

The purpose of the plan was to outline the steps, roles & responsibilities, time line and costs involved in improving the spatial accuracy of the Yellowstone County parcel data. The plan identifies specific projects and prioritizes those projects, and thus is a tool for the county to use to move forward with spatial accuracy improvement projects, in a logical and consistent manner. There is a corollary report and plan for the City of Billings (see the document City of Billings Parcel Accuracy Enhancement Project Report).

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Project Task Objectives and Requirements

1. Develop a Plan
   The primary objective is to develop a plan that describes how to improve the spatial accuracy of the parcels in those areas of Yellowstone County that fail to meet the spatial accuracy needs of county business processes. The plan will identify:
   - Accuracy requirements of the county based on such criteria as the development density, number of parcels, size of parcels, value of property, development and or environmental pressures.
   - Problem areas where the accuracy needs are not met.
   - Priorities for areas that require improvement.
   - Project plans (specific projects, timelines, recommended processes, and estimated costs)
   - Success indicators
   - Roles, responsibilities, stakeholders, and funding issues.
2. Input existing PLSS control into the Montana Control Point Database (if the MTCPD is available).
3. Adjust three townships (t01nr26e; t01nr27e, t01nr28e) using a GCDB based adjustment. This involves:
   a. Collecting existing control in townships and surrounding townships;
   b. Identifying where additional control is required on the PLSS;
   c. Collecting, collating, and mapping the corner records (county will do this portion);
   d. Inputting all the available control on the PLSS to the GCDB for those townships;
   e. Adjusting the GCDB;
   f. Adjusting the parcels (and zoning layer) within those townships;
   g. Reporting the resulting spatial accuracy of the new GCDB, and parcel layer for those townships.

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III Approach used

III. a Methods, Options, Procedures to Used for Enhancement

The County of Yellowstone

Background:

During the months of October through December, 2006, DJ&A, P.C. was contracted to survey Public Land Survey System(PLSS) corners throughout 4 different townships within Billings City Limits and Yellowstone County. These corners were to be used for: 1) to verify existing survey quality corner positions, 2) update the existing Bureau of Land Management(BLM) Geographic Coordinate Data Base (GCDB) control and then perform a new adjustment, and 3) control a specific section within the city to compare against aerial photo interpretation.

Survey Procedures Used:

Global Positioning Satellite(GPS) control work was performed in November, 2006 with Trimble 4400 and Trimble 4700 GPS receivers using Real Time Kinematic(RTK), Static and Fast static methodology for 17 PLSS corners in and around the 4 project townships. North American Datum 1983(CORS) Latitude and Longitude positions were established for three local base stations based on ties to the CORS network. The base positions were held fixed in a least squares network adjustment to produce the coordinate values for the GCDB corner ties.

NAVD 88 elevations are based on GPS observation. CORS generated elevations for the three local bases were held fixed and the Geoid03 geoid model was used to produce orthometric elevations for the GCDB corner ties. Post processing of the GPS control network was performed with Trimble Geomatics Office V1.61 software.

The least squares statistical analysis report for the GPS observations indicated that the worst horizontal residual was 0.03 feet and the worst vertical residual was 0.05 feet.

Geodetic values for all Public Lands Survey System(PLSS) corner positions were converted to the North American Datum of 1927 with Trimble Geomatics software. These values were then used to update the existing BLM GCDB control files. New corner positions affected the following townships: T1S R25E, T1N R25E, T1N R26E, T1N R27E, T1N R28E, T2N R27E and T2N R28E. All of these townships were adjusted using Windows Geographic Measurement Management software and then a regional adjustment was conducted using all of the surrounding townships as buffers to get an exact edge-match between all adjoining townships.

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IV Results Discussion

IV. a GCDB Adjustment

All of these townships were adjusted using Windows Geographic Measurement Management software and then a regional adjustment was conducted using all of the surrounding townships as buffers to get an exact edge-match between all adjoining townships. The statistical summary for the region was as follows:

STANDARD ERROR OF UNIT WEIGHT IS 1.288
WITH 1998 DEGREES OF FREEDOM

CHI SQUARED TEST ON ANALYSIS
.748 < 1.288 < 1.208
(LOW) (HIGH)
DOES NOT PASS AT THE 5 % SIGNIFICANCE LEVEL
A STD. ERR. OF UNIT WGT. BETWEEN 0.5 AND 2.5 IS
CONSIDERED SUITABLE FOR MOST APPLICATIONS

The field surveys were carried out by Kurt Luebke, PLS, Steve Cummings and John Shirey. All data reduction and analysis was performed by Kurt Luebke, using Trimble Geomatics Office V1.61 software and Windows Geographic Measurement Management V1.01 software.

Results:
In T1N R26E initial examinations showed an extensive amount of existing high order survey control. It was discussed, between DJ&A and Yellowstone County representatives that this township may not benefit from additional control for this study. We decided to randomly survey three existing corners to verify their geodetic values. The three corners were compared to the existing control and the worst comparison was 0.19 feet; thus the existing control was adequate to meet the county's needs in this township. The new positions were used to readjust this township along with another new control position. The results for this township basically remained the same, the error estimates only changed along the township lines slightly due to adjoining township readjustments.

T1N R25E was surveyed using RTK GPS positions. This township was used as an experiment to see how photo ID points could be used to adjust existing aerial photography to known positions. Six PLSS corners were surveyed around section 33, and these positions were then used to adjust the township. It would be expected that this would be more of a local adjustment around section 33 and the surrounding sections, than an adjustment for the whole township. The results for this township are generally localized around section 33, with improvements of between 37-124 feet in the error estimates; the remainder of the township is seeing improvements of between 0-9 feet in the error estimates.

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The analysis for T1N R27E shows that there is an improvement for approximately one-half of the township corners from 1-211 feet; while the other one-half of the township corners saw a decrease in the error estimate values from approximately 1-32 feet. The decrease could be possibly attributed to poor comparisons of the new corner values to the original surveyed lines and also to fractional surveys up against completion surveys.

The analysis for T1N R28E shows that there is an improvement for approximately one-half of the township corners from 1-140 feet; while the other one-half of the township corners saw a decrease in the error estimate values from approximately 1-13 feet. The decrease could be possibly attributed to poor comparisons of the new corner values to the original surveyed lines and also to fractional surveys up against completion surveys.

IV. b Project Area Status maps - post-adjustment

IV.b.i GCDB/Parcel Accuracy

IV.b.ii Changes wrought (pre to post adjustment)

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V Conclusions

Yellowstone County GCDB and layers dependent on the GCDB could see improvement in spatial accuracy by performing additional field survey work to acquire improved coordinates for GCDB corners. Within any township the additional improved coordinates typically, though not always improve the spatial accuracy of the township. There are instances where the error estimate after the adjustment was worse than before the adjustment. This can happen for a number of reasons. The estimate itself is subjective, that is, assigning error estimates more of an art than a science. If the initial estimate was overly optimistic and the newer estimate more accurate but of a smaller magnitude, the error would *appear* to have gotten worse even if the absolute error was reduced. In other instances, the error *can* worsen. When the new data does actually worsen the accuracy of the GCDB, then the township must be examined in detail to determine the cause. It could be that previously entered measurement data was erroneous, or GCDB ID's were erroneous, or some other cause is making the accuracy worse.

In general, Yellowstone County can expect to see improvement of parcel accuracy through acquiring more field data, or entering recent survey measurement data.

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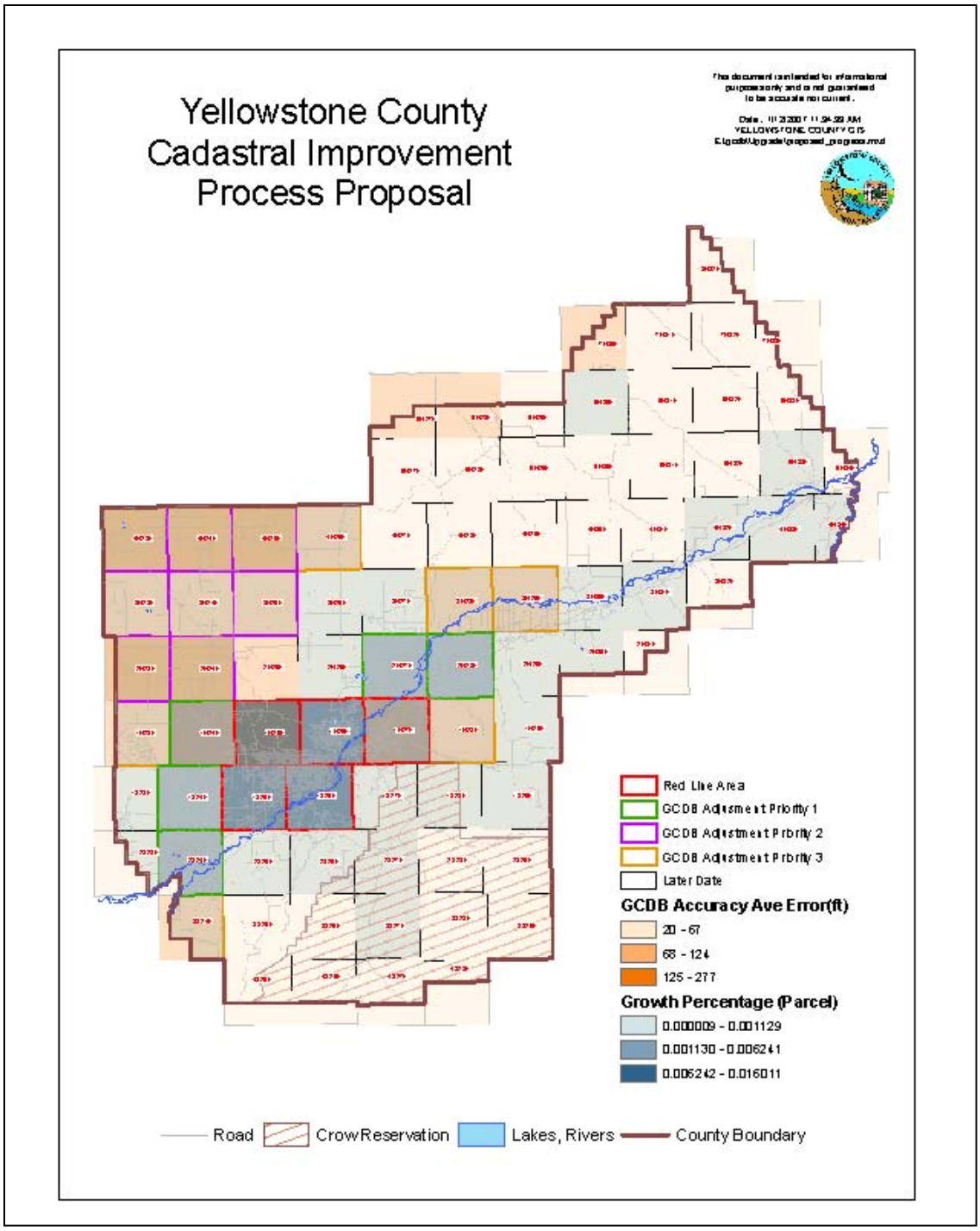
VI Future Project Areas & Priorities

Yellowstone County Proposed Process and Priority Areas



The county identifies five priority 1 townships, eight priority 2 townships, and six priority 3 townships that require GCDB adjustment. These priorities are based on

the growth rates and current GCDB accuracy in those townships. The other the townships in the county do not require immediate adjustment, although most would benefit from an adjustment at some time in the future.

Priority	*# of Townships*
1	**5**
2	8
3	6
Red line	5
Remainder	63

VII Recommendations

Yellowstone County and the City of Billings designate five townships as red-line areas where non-GCDB controls form the basis for adjustment. These five townships contain the majority of the City of Billings and one high growth potential area north east of the city.

Yellowstone County Priorities for GCDB adjustment identified by the county through stakeholders meetings should be adjusted using field ties and input of survey data (where field ties are not practical), in order to improve the reliability of the GCDB coordinates for control points. The affected townships should then be adjusted, and parcels and other related layers adjusted to fit the improved GCDB.

VIII Recommended Scope of Work for Yellowstone County GCDB Adjustment

The county has 19 priority area townships that require GCDB adjustment. The following list outlines the steps required to adjust the GCDB for those townships.

Step One: Preliminary Records Research

- Obtain survey notes from the BLM
- Perform a corner records search at the county records office, to identify which PLSS corners have reliable monuments that can be field surveyed.

Step Two: Create A Survey Plan for Each Township

Create a map showing PLSS corners to field tie based on corner availability in areas where the GCDB accuracy does not meet requirements. A minimum of 10 control points is required for each township (control on township lines typically controls adjoining townships). Control includes existing and proposed coordinated points).

Step Three: Perform Field Ties

Field survey the PLSS corners that identified in Step Two to obtain coordinates (tied to the National Spatial Reference System).

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Step Four: Adjust the GCDB

Adjust the BLM's GCDB to the new coordinate values

Step Five: Review results

Review results for the adjusted GCDB. If the new accuracies are not as required, then input recent vintage survey data (from recorded plats and surveys), and re-adjust if necessary

Step Six: Incorporate the new adjusted GCDB into the BLM's database.

Step Seven: Adjust parcels and related data to the new adjusted GCDB.

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