Washington County
Iowa

G.P.S.
Countywide Survey

Control Network
in
Support of
Geographical
Information
System

1996

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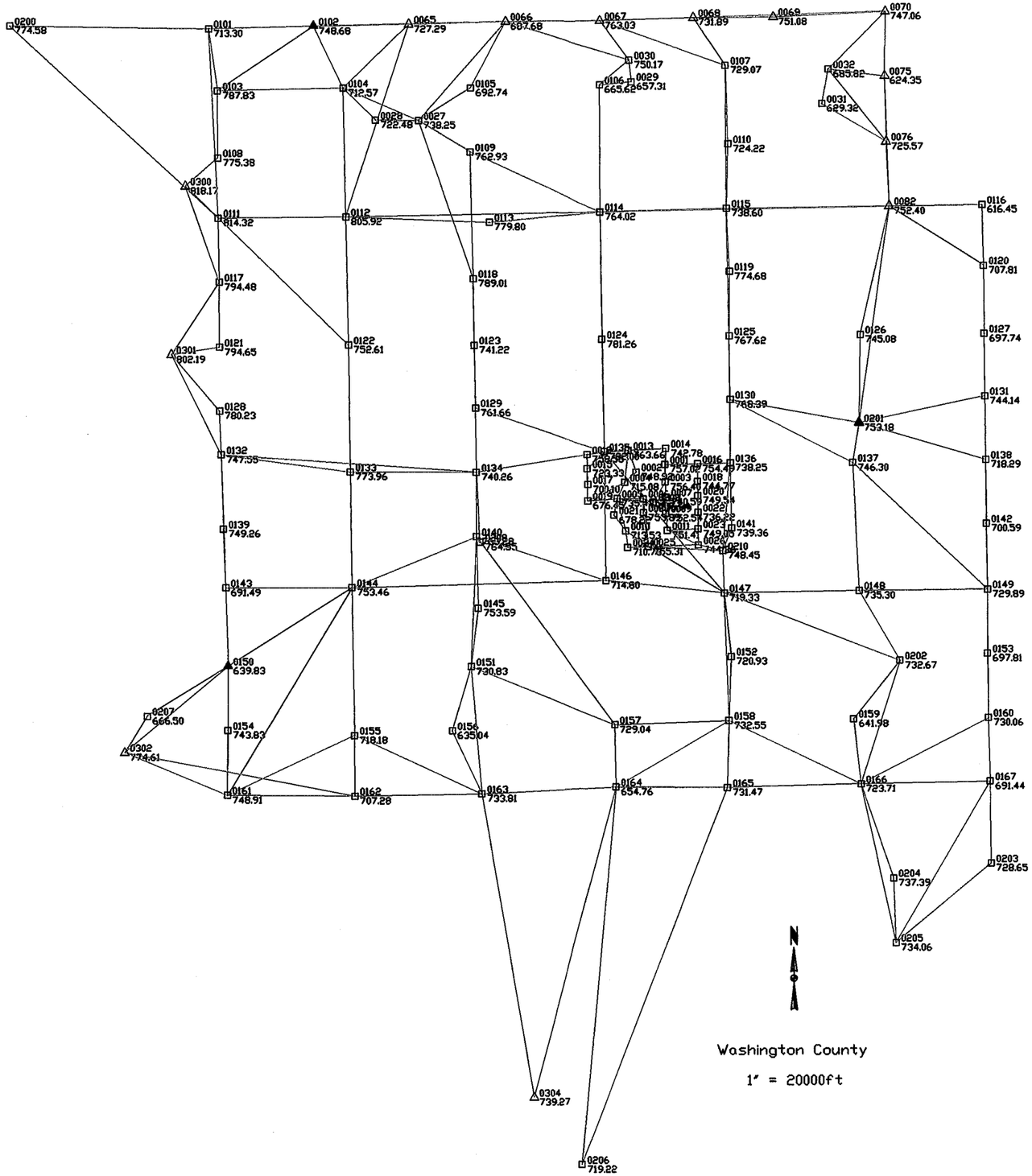
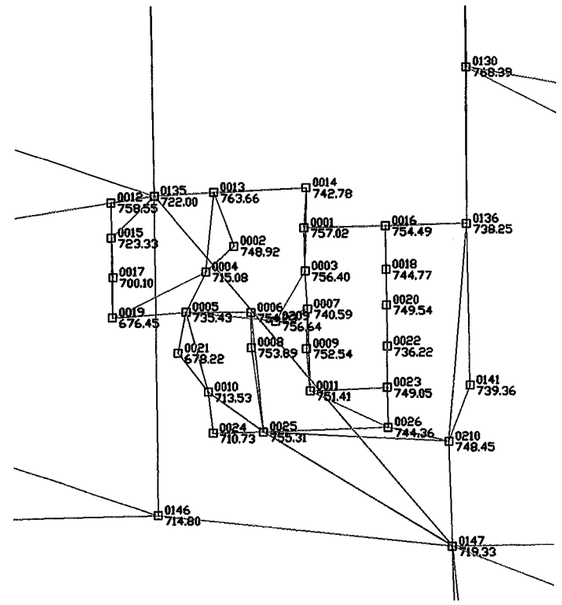




GPS
BASELINE
NETWORK

SECTION I

Project Report

INTRODUCTION

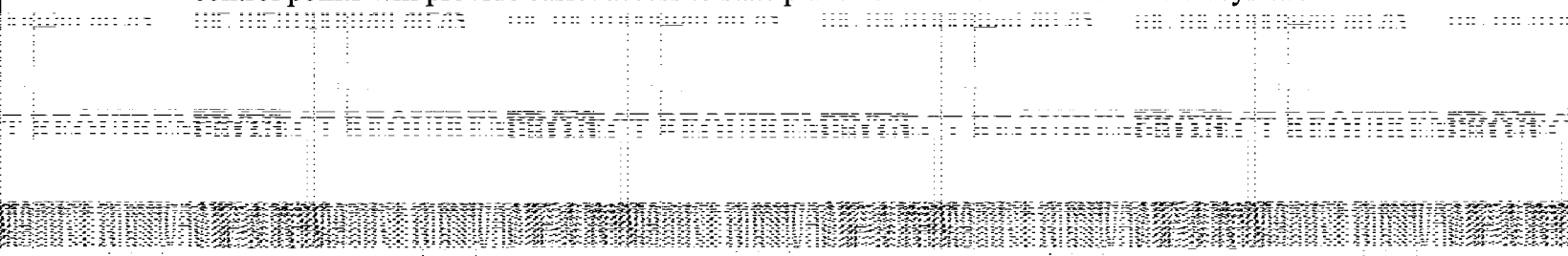
Washington County, Iowa chose to modernize their existing parcel mapping system with a new county-wide high accuracy geographical information system. The project was designed around two phases. Phase I consists of the GPS control and photogrammetric services. Phase II consists of the cadastral mapping GIS services. Aerial Services Inc. of Cedar Falls, Iowa was selected as the Phase I service provider and The Sidwell Company of West Chicago, Illinois was chosen as the Phase II provider.

To complete the new survey, specific products and map accuracies were selected to support the project. The final line cadastral overlays were to be based on accurate fully rectified orthophoto base maps. To accomplish this task as accurately as possible, photo flights were designed for coverage of rural and urban areas to produce 1" = 400' scale and 1" = 100' scale orthophoto maps respectively. For the best control, a Global Positioning System Survey was selected to densify sparse existing first-order control. Sixty seven (67) control stations were selected to control the orthophotography.

Under a separate contract, the City of Washington, Iowa commissioned twenty-six (26) additional GPS control points to support a city-wide mapping project. Of the twenty-six control points, eleven (11) are permanent monuments and fifteen (15) are temporary monuments.

The cities of Riverside, Kalona and Wellman each commissioned two (2) additional permanent GPS control points.

All of the additional control points were included in the county-wide network. These additional control points will provide easier access to state plane coordinates for all future surveys within



horizontal control network using GPS survey equipment and techniques. This network was to be tied to existing NGS NAD83 first-order horizontal control. It was also the intent of the County to obtain elevations on each new monument which would be tied NAVD 1988. Because this control would be utilized to control the analytical triangulation of aerial photography, the network geometry was ideal for a strong GPS survey. All point locations for control were selected with the needs of both the analytical triangulation and GPS survey requirements in mind. In some instances, all of the needs could not be met due to physical obstructions or existing land features. In these instances, the needs of analytical triangulation were held primary and the GPS survey needs were satisfied second.

Nine existing GPS control stations set by Johnson County in 1993 were also included in the new control network.

MONUMENTATION

To perpetuate the new control measurements, 84 permanent monuments and 15 temporary monuments were set. The monuments will provide permanence and future survey accessibility for conventional survey ties. Bernsten driven aluminum rod monuments were selected for the

RECONNAISSANCE

The most important criterion for GPS observations at any given location is a clear view to the sky. In terms of network design, it is desirable that the horizontal control be located near the perimeter of the project site. With this in mind, five existing NGS first-order horizontal stations were recovered near Washington County, of the five existing stations, four were chosen to be included in the network. The four stations are Nira (300), Keota (301), Richland (302) and Lock (304).

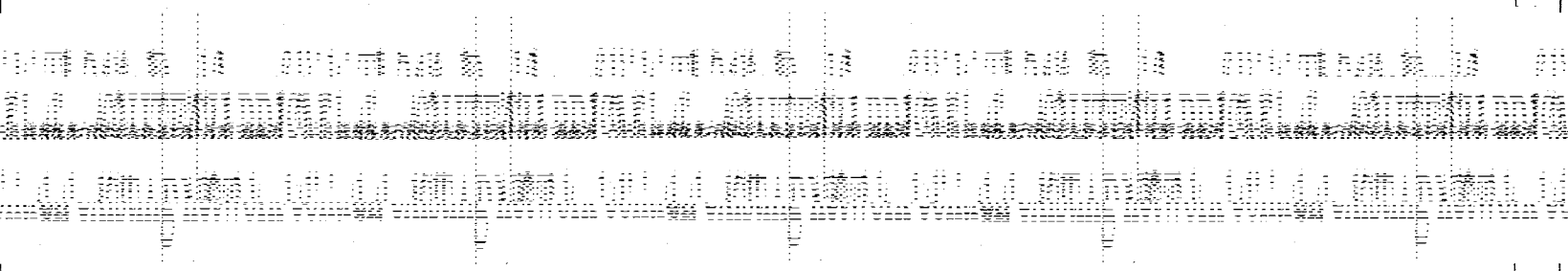
Vertical control was selected to provide as much coverage as possible, both at the periphery and in the interior of the job area. Eleven existing NGS benchmarks were recovered and included in this survey. Ten of the benchmarks were occupied directly. One benchmark, which was not suitable for GPS was tied to a temporary point by a direct third-order closed level loop.

The total network is comprised of four (4) NGS horizontal control stations, eleven (11) NGS benchmarks, ninety-nine (99) new control monuments, and nine (9) Johnson County GPS control stations for a total of 123 stations.

FIELD SURVEY

Three Ashtech Z-12 dual frequency receivers were used in this survey. GPS observations began Monday morning, October 28th. Five full days of GPS observations were made from Monday, October 28th through Friday, November 1st.

Fast static GPS techniques were utilized to minimize the time and cost of the survey. The satellite "window", where at least five satellites were observable was open for much of the day. Each measurement period, during which all receivers observe satellites simultaneously, lasted from 8 minutes to 20 minutes depending on the distance being measured and the geometry of the



satellite constellation. A total of 87 measurement periods were observed using the three receivers. Tuesday a major storm front moved across the county. The adverse weather conditions did not stop the GPS survey although it did slow down the progress.

DATA ADJUSTMENT

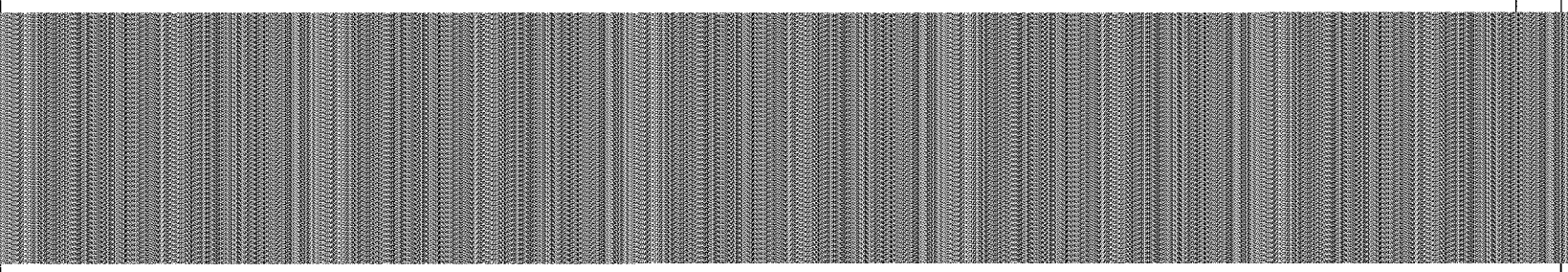
software. An initial free adjustment was performed in NAD83 to check the overall quality of the GPS data and the nature of the control. The initial unconstrained (free) adjustment yielded baseline precisions which ranged from 1:100,000 to 1:2,000,000. Once the horizontal and vertical control was verified, subsequent adjustments were performed to arrive at the optimal solutions for each datum.

NAD83

The initial free adjustment was performed holding 301 (Keota) fixed horizontally with the vertical adjustment disabled. Coordinate values on the other horizontal control stations were then checked against the published values to verify the first-order status. One at a time, each of the three remaining first-order horizontal control points were added to the network and a new adjustment performed. After each adjustment a comparisons of coordinates vs published values was made. Next the 9 Johnson county control stations were added to the network. By holding all 13 of the existing horizontal control stations fixed, the extraordinary baseline precisions of the "free" adjustment degraded, although the network still yielded results well in excess of first-order control. Several additional adjustments were performed releasing and then holding onto point 304 (Lock). A decision was made to include point 304 (Lock). This would allow the best fit to all existing network control.

Therefore, a final adjustment was performed, held to all 11 benchmarks.

A final adjustment of both horizontal and vertical was then performed. Because the control was so reliable, the final adjustment in NAD83 was very straight forward. All horizontal control was held fixed in x and y, and all vertical control were held fixed in z. This fully constrained adjustment solved for scale and rotation. In the final adjusted network 96% of the adjusted vectors have an estimate error of 1:100,000 or less. The results are well in excess of first-order



CONCLUSION

The initial control accuracy specification for the project was established as 0.2 ft. $\pm$ in x, y and 0.3 ft. in z. Because of existing control point strength, geometric network layout and vertical datum stability, it was possible to well exceed this specification. All measured points will be usable for better than first-order control in horizontal position and within $\pm$ 0.1 ft. vertically for benchmark use.