Final Project:

Eagle Creek Topographic Survey

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GIS 656: Spatial Data Collection

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Introduction:

For this project an elevation survey of a stream corridor and surrounding bluffland was performed using total station and GPS. The purpose of mapping the two approaches is to visually and quantitatively compare accuracy. A number of data collection and post-processing methods were performed to accomplish this comparative study. The area of interest was Eagle Creek Aquatic Management Area (AMA) in Savage, MN. AMA's are state owned and DNR managed parcels of land which serve to provide riparian protection of waterways for water quality, fish and wildlife habitat, and angler access. The specific survey area included approximately 0.18 acres along Eagle Creek.

Methods:

The chosen area was selected for having a range of interesting topography, but also enough openness for the total station line of sight, which was positioned in a bottomland area. Much of the AMA was heavily wooded, but the chosen section had been cleared out from an ongoing habitat restoration project. The total station tripod was positioned in the northeastern part of the study area and calibrated to north. The benchmark reading was then taken southerly using the total station instrument and stadia prism.

A Garmin Montana GPS was also used to capture elevation waypoints. To maximize positional accuracy the Wide Area Augmentation System (WASS) and European Geostationary Navigation Overlay Service (EGNOS) were enabled on the GPS. These features serve to augment the GPS by offering additional satellites for triangulation and provide a network of ground based reference stations for differential correction. The elevation readings on the GPS were captured using an internal altimeter. Altimeters use atmospheric pressure readings as a measure of ones position above mean sea level. The greater the altitude the lower the pressure. Altitude and elevation are interchangeable terms for the same measurement (position above or below sea level), but are most often used in different contexts.

Subsequent total station and GPS target readings were taken in a clockwise fashion along the surrounding topography and within the the stream bed, with a radius ranging up to 70ft (benchmark). A distributed survey approach was used to collect the data, in which a total of 62 elevation points were captured, plus the benchmark. Elevation points were limited in the southeast and central west parts of the study area due to the thickness of vegetation along the steep bluffs and inability to capture adequate line of site for the total station.

Upon returning from the field the GPS waypoints were transferred from the device onto the computer using DNRGPS software. The resulting point shapefile was then brought into ArcGIS and projected to UTM NAD 83 Zone 15N. A new attribute field named elevation was created using a floating data type with a precision of 5 and accuracy of 2. Using the field calculator on the elevation field, the altitude values were converted from meters to feet by multiplying by 3.28. The spatial analyst spline tool was then used to create a digital elevation model (DEM), using elevation as the z field. The output cell size, spline type, weight, and number of points were all left to default. The spatial analyst contour tool was run from the newly created DEM, using a contour interval of 0.5, base contour of 0, and z factor of 1. Lastly, a hillshade was created using the DEM, with an azimuth of 315, altitude of 45, and z factor of 1.

In the interest of showing spatial and quantitative relationships, the total station survey points were spatially referenced to the GPS coordinates of the instrument location. To expedite the otherwise tedious process of manually entering transects lines, the ‘bearing distance to line’ tool and ‘feature vertices to points’ tool was used. In using this tool there are some extra spreadsheet formatting steps. The source spreadsheet for running this tool was numbered with point values 1 to 62 and BM for the benchmark, and included the respective horizontal distance (HD) values for each point. The spreadsheet also included the x-y coordinates of the total station instrument location, as recorded by the GPS. These values were copied for all of the point rows, since this will be the starting point for the distance to line tool. The horizontal angle (HR) was then transferred to the spreadsheet as recorded in north azimuth (degrees, minutes, seconds), with each value in separate column. Another column called bearing was created, and a formula was used to convert the angular measurements (degrees, minutes, seconds) to decimal degrees. The spreadsheet was then exported as comma separated value (CSV) for use in ArcGIS.

Using the newly formatted CSV in ArcGIS the 'bearing distance to line tool' was executed using the x-y fields as the starting location, the HD as distance, and the HR (decimal degrees) as the bearing field. The output was 63 lines features radiating from the instrument location point. To create the total station points, the 'feature vertices point' tool was run using 'end' as the point type. Now that the total station points have been generated a join was performed using the point ID field with the field note spreadsheet, which contains the relative elevation field (VD) and a new field was generated for the corrected elevation values.

The corrected elevation field was populated using the field calculator and adding the benchmark values from the GPS (732.424 ft) to the respective vertical distance values. This way a consistent benchmark value is being used, so that the elevation values can be compared. The spatial analyst tool was then run using the corrected elevation field as the z value. Again the output cell size, spline type, weight, and number of points were left to default. The spatial analyst contour tool was run from the newly created DEM, using a contour interval of 0.5, base contour of 0, and z factor of 1. Lastly, a hillshade was created using the DEM, with an azimuth of 315, altitude of 45, and z factor of 1.

Results:

The locational differences of the total station and GPS data points are analyzed first. The resulting contour maps of each data set are displayed side by side. Visually it is apparent the total station and GPS produced different results for each data point location. For example data point 2 shows the point in the water on the total survey map, but on the GPS map it east of the stream area. Of the data points, there are only three of the 62 points taken that are less than a foot in difference between total station and GPS readings. The difference in distance between the total station and GPS reading of each data point is shown in figure 3. The average distance between the total station and GPS readings is 6.41 feet beginning from a minimum of .74 feet to a maximum of 17.08 feet with a range of 16.34 feet.

There are a few reasons why the total station and GPS units would produce different results when a reading was taken at the same location. The first reason is the accuracy limitations of the equipment utilized. The total station unit is accurate to 2 millimeters, and the GPS unit has an accuracy that ranges from 10 to 30 feet. There are also other factors that further affect the accuracy of the GPS unit. The day the survey was conducted it was overcast and rainy. This weather causes atomic errors in the GPS signal received by the GPS unit during the survey distorting the accuracy of the signal. Additionally the area surveyed was heavily vegetated. The vegetation impacts the GPS signal causing a multipath error where the signal bounces off vegetation causing distorted accuracy before the signal makes it to the GPS unit. There are also other errors that contribute to GPS inaccuracy such as ephemeris, selective availability, and position dilution of precision. It is hard to verify if any of those errors were occurring, but it is expected they are occurring at some level.

The next part of the results analyzed are the elevational differences of the total station and GPS points. The contour map of the GPS data shows an elevation range of 26.31 feet from 717.53 to 743.84 feet. Whereas, the contour map of the total station data shows an elevation range of 15.35 feet from 728.62 to 743.97 feet. The overall distance between the ranges of elevation values for total station and GPS was 10.96 feet, with the GPS data having the larger range in elevation. Interestingly, the two maximum elevation values for the TS and GPS are surprisingly similar and are the same elevation points (point 43), with values of 743.97 feet and 743.84 feet respectively. Although, this maybe a mere coincidence, given the location differences between the points when mapped.

The elevation data from each data point for both total station and GPS readings were compared and shown in figure 4. The range difference in elevation between total station and GPS is 14.92 feet from .05 to 14.97 feet with an average difference of 2.96 feet. As stated in the location analysis, the total station naturally has a much higher accuracy than a GPS unit. During the post processing of the data the total station data was adjusted to the benchmark so the data gathered from both the total station and GPS could be analyzed equally. The main source of error in elevation data from a GPS unit will be the position of dilution of precision. This is because the further away satellites are from each other the more accurate the data, but the earth itself will block the satellites from each other. Therefore, it is difficult to attain good quality vertical measurement. Additionally, the other GPS errors such as atomic, ephemeris, multipath and selective availability will also play a role in the accuracy.

Overall the data analysis of both location and elevation shows the GPS having greater variation in data. The GPS contour map is extremely exaggerated and not as representative of the area as the total station contour map. Even though the use of total station may produce a more accurate result, overall there are limitations. One problem experienced during this survey is line of sight with the total station. It is hard to utilize the total station in heavily vegetated areas because a clear line of sight between the unit and the prism. This is not an issue with GPS units because the unit works in conjunction with satellites. However, the accuracy of GPS can be distorted by multipath errors such as heavy vegetation.

Conclusion:

The purpose of mapping the area utilizing both total station and GPS was to visually and quantitatively compare accuracy. The contour map of the GPS unit shows and exaggerated localized elevation of the area. Whereas, the total station contour map was more representative of the area showing a lower riverbed area moving to a surrounding bluff area. Both methods of data collection have good and bad aspects. While total station may be very accurate, it is not as mobile as a handheld GPS unit. The choice between the two products will depend on the accuracy needs of the project as well as time and cost.

Appendix:

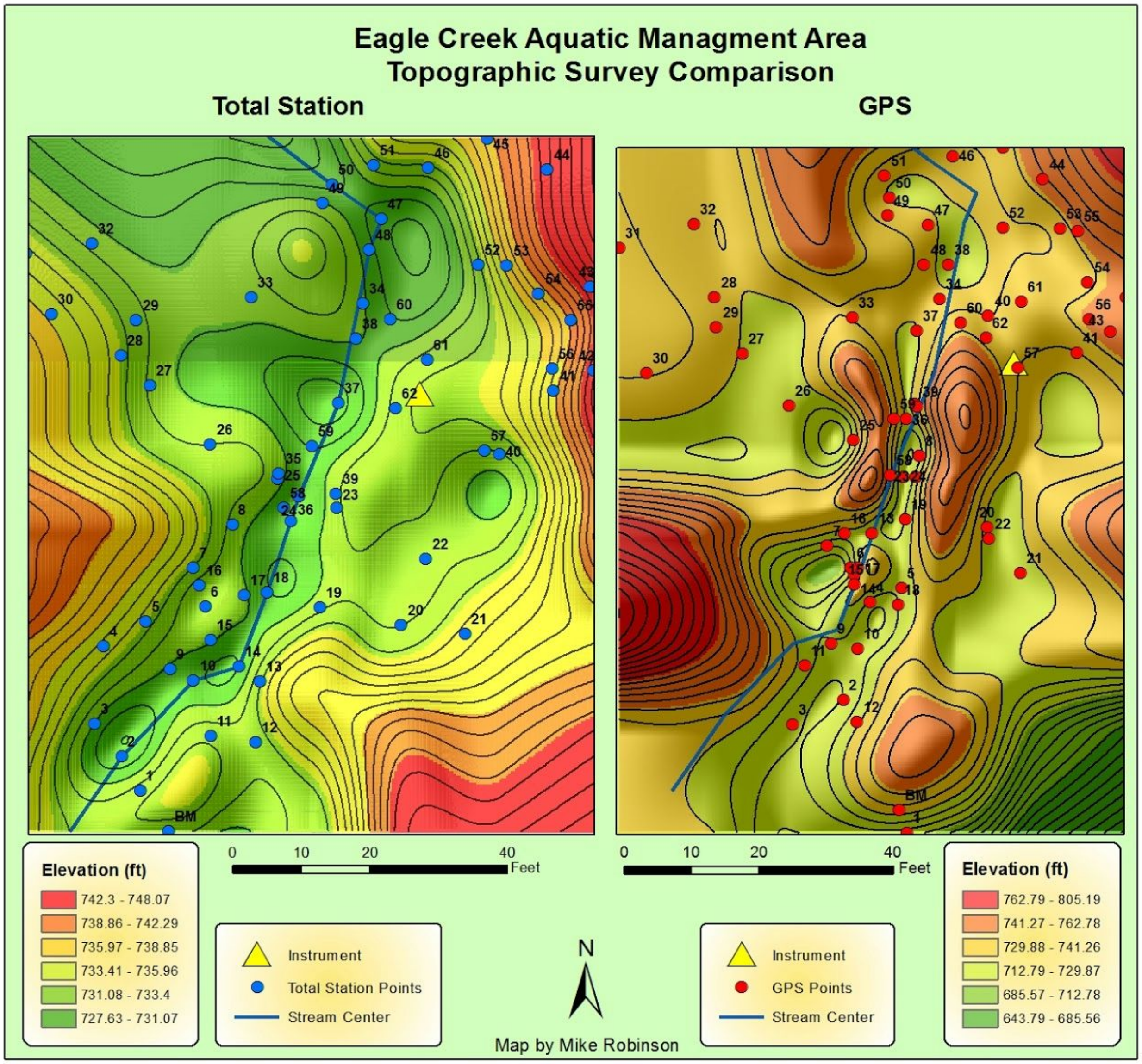

Figure 1: Total Station & GPS contour maps with numbered data points.

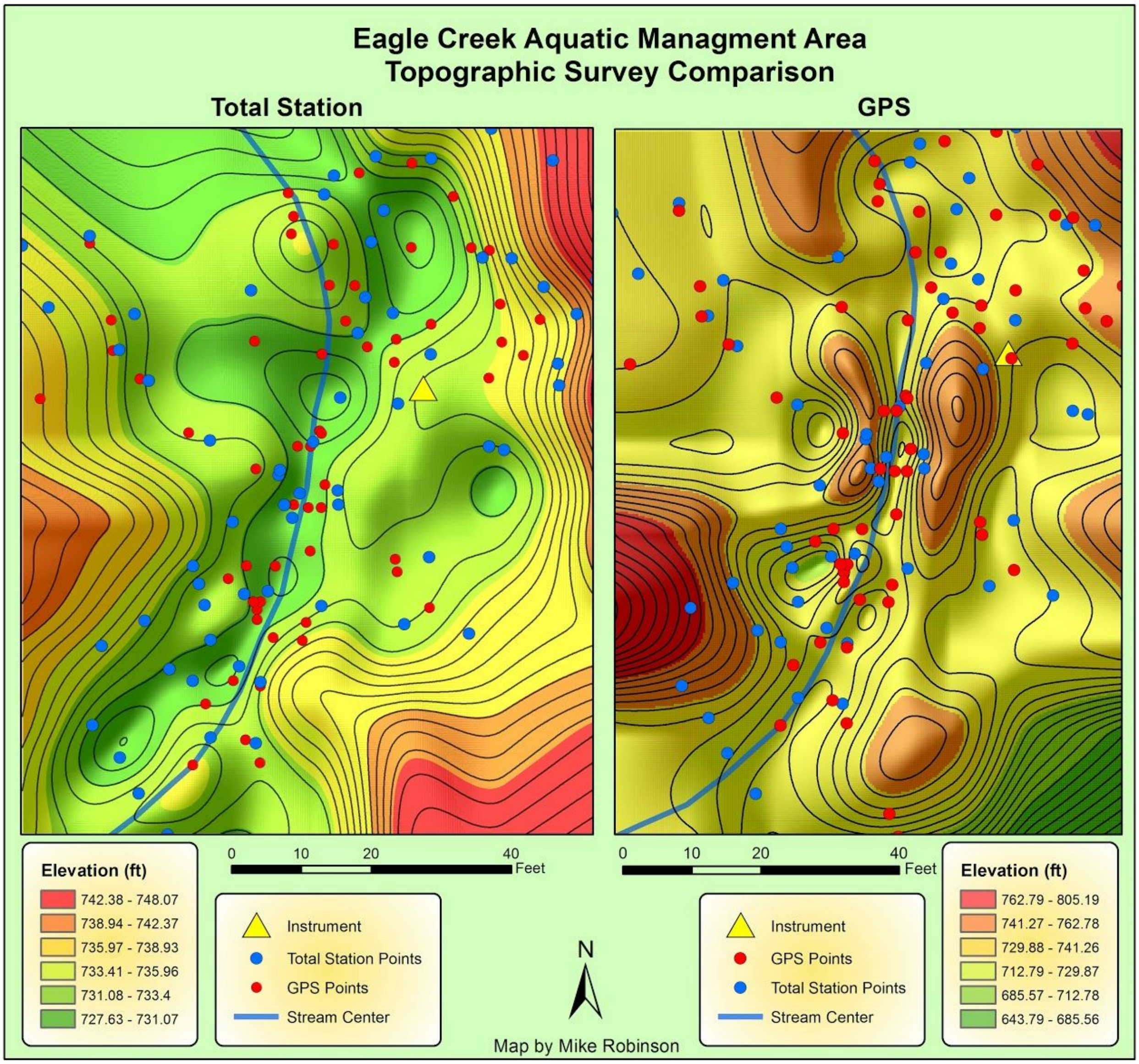

Figure 2: Total Station & GPS contour maps with opposite dataset overlaid to show positional differences.

Point ID	Location Error (ft)
BM	13.63
1	19.15
2	12.60
3	10.69
4	17.08
5	16.03
6	4.85
7	3.73
8	9.87
9	6.43
10	6.71
11	3.34
12	1.99
13	11.58
14	5.90
14	12.30
15	5.03
16	5.01
17	1.81
18	5.96
19	5.57
20	6.49
21	4.69
22	3.51
23	1.77
25	2.36
26	2.23
27	0.89
28	3.06
29	4.25
30	9.14
31	2.48
32	0.74
33	5.05
34	3.10
35	5.52
36	7.32
37	4.68
38	4.70
39	5.87
40	15.33
41	7.03
42	7.47
43	10.42
44	10.53
45	8.61
46	7.33
47	6.06
48	6.01
49	5.10
50	5.71
51	9.46
52	7.14
53	4.15
54	4.68
55	10.70
56	5.98
57	8.12
58	0.93
59	1.59
60	4.24
61	2.99
62	4.12

Average	Min	Max	Range
6.41	0.74	19.15	18.31

Figure 3: Table showing difference in feet between location of Total Station & GPS data for same point

POINT ID	ELV Error (ft)
BM	0
1	14.97
2	8.68
3	9.88
4	10.83
5	6.81
6	10.96
7	11.16
8	8.12
9	6.42
10	7.06
11	5.47
12	3.44
13	5.82
14	5.21
15	1.61
16	3.43
17	2.86
18	5.2
19	6.41
20	3.43
21	7.31
22	3.96
23	4.58
24	8.67
25	4.51
26	3.97
27	2.28
28	1.37
29	0.63
30	0.47
31	1.79
32	0.6
33	3.24
34	0.37
35	0.39
36	1.76
37	1.08
38	3.42
39	1.15
40	3.1
41	3.76
42	0.26
43	0.13
44	0.18
45	0.49
46	0.75
47	1.79
48	2.57
49	1.66
50	0.05
51	0.17
52	0.98
53	0.82
54	1.26
55	2.64
56	4.43
57	3.45
58	6.92
59	8.25
60	8.09
61	6.48
62	5.93

Average	Min	Max	Range
2.96	0.05	14.97	14.92

Figure 4: Table showing difference in elevational feet for Total Station & GPS data for each point