Lower Nueces River GIS Project

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Abstract

The Lower Nueces River Geographical Information System (GIS) Project (LNRGP) determines which areas are impacting the water quality of the Nueces River between Weasly Sealy Dam and the salt-water barrier. The project is bounded to a one mile area on each side of the river between the two dams. Using aerial imagery, Global Positioning System (GPS) target points will be used to determine points and areas which possibly impact the water quality along the river are investigated. Nearest neighbor and grid analysis will be used to determine the degree of impact areas have on the water quality of the river. The results of the LNRGISP showed the degree to which an area impacts the water quality of the Nueces River. The LNRGISP shows that a GIS can be used to determine the areas and degree of impact on the Nueces River.

Introduction

The lower portion of the Nueces River, from Lake Corpus Christi to the saltwater barrier at Labonte Park is a vital waterway as it provides water for both the City of Corpus Christi and the City of Robstown. This portion of the Nueces River is approximately 36 miles in length along the river.

The Nueces River Authority at the request of the City of Corpus Christi developed a project to determine what was located along the Nueces River and to determine the potential impact of certain features that fell within a specified area around the lower portion of the Nueces River. The project became known as the Lower Nueces River GIS Project (LNRGP). The scope of this project was to look at the region from Weasly Sealy Dam downstream to the saltwater barrier at Labonte Park and a region of one mile on either side of the Nueces River. Items of concern to the city other then those which lie directly along the river include active and non-active gravel pits, and manmade and natural water bodies. The goal of the LNRGP is to develop a geographical information system (GIS) which will contain the data requested by the City of Corpus Christi and also be able to model an approximation of the potential impacts of the study region on the water quality of portion of the Nueces River being studied.

The LNRGP is ideally suited for development in a GIS because of the technical and operational characteristics which a GIS contains. Characteristics such as the development of industry standards which make it easier to share data, the ability to use off the shelf software which can perform spatial analysis, input/output functions and database administration, ability to present the results of information graphically and its support for multi-user environments (Lo & Young, 2002).

Literature Review

Using GIS to study environmental impact is not a new practice and many people have done impact studies which also use a raster based spatial analysis to determine the potential impact. Most the studies which have been done have involved only non point source pollution. N.D.K. Dayawansa conducted a study in Sri Lanka involving Agricultural Non-point source pollution. The model which was developed used a raster overlay analysis to calculate the potential environmental impact (1997). GIS and spatial analysis were used to manage the water quality problems in rural areas. This project used both vector and grid analysis to determine potential impact and nutrient loading on surface water (Kusangaya 2003).

Methods and Materials

The LNRGP employed different methods for data collection and compilation. Much of the area being examined in the LNRGP is privately owned and not easily accessible. Another obstacle to the data collection and compilation is the sheer size of the study area which is greater then 200 kilometers^2. These obstacles lead to the search for suitable aerial imagery which could be used for both a base map and digitizing from. Another obstacle which imposed limitation upon the digital data which is used in the LNRGP is money. One of the goals of this project was to keep it as low cost as possible. Because cost is an issue with this project existing software had to be utilized. Environmental Systems Resources Inc's., (ESRI's) ArcGIS 8.3 platform was used along with ESRI's Spatial Analyst extension for ArcGIS.

In order to determine the location and size of gravel pits, and water bodies which fall within the one mile region surrounding the 36 mile stretch of the Nueces River which is being studied; the need for high resolution aerial images of the region were needed. Because of the obstacles imposed on data collection aerial images available free of charge through the Texas Natural Resources Information System (TNRIS) were used. These images are Digital Orthoquads (DOQs) with a pixel resolution of one meter and were collected between 1995 and 1997 by a joint effort between the State of Texas and the United States Geological Service (USGS).

One meter pixel resolution was chosen because the creation of water bodies and gravel pits located with in the projects area of interest would have to be digitized from these images. Before digitization of the water bodies and gravel pits could be done an accurate center line of the Nueces River along with a one mile boundary on either side of this centerline had to be created. The portion of the Nueces River being studied was digitized from the DOQs at a scale of 1:2000. The centerline which was digitized has a spatial accuracy, based on the images used, of approximately ± 5 meters. Once the centerline was created a buffer with a radius of one mile was generated to provide a boundary defining the area of interest for the project.

After the boundary was created a search grid was created with each grid member having an area of approximately one square kilometer. This grid has many uses from acting a guide when searching the aerial images for items to digitizes to also acting as a grid from which spatial queries can be preformed. The table behind the grid contained a field labeled GridID which contains a unique integer value assigned to each grid member (see Figure 1.)

Attributes of Selction Grid

FID	Shape*	Id	GridID	HydroCk
0	Polygon	0	1	N/A
8	Polygon	0	2	N/A
16	Polygon	0	3	N/A
24	Polygon	0	4	N/A
46	Polygon	0	5	N/A
68	Polygon	0	6	N/A
90	Polygon	0	7	N/A
112	Polygon	0	8	N/A
134	Polygon	0	9	N/A
156	Polygon	0	10	N/A
178	Polygon	0	11	N/A
200	Polygon	0	12	N/A
222	Polygon	0	13	N/A
244	Polygon	0	14	N/A
267	Polygon	0	15	N/A
266	Polygon	0	16	N/A
1	Polygon	0	17	N/A
9	Polygon	0	18	N/A
17	Polygon	0	19	N/A
25	Polygon	0	20	Y
47	Polygon	0	21	Y
69	Polygon	0	22	Y
91	Polygon	0	23	N/A
113	Polygon	0	24	N/A
135	Polygon	0	25	Y
157	Polygon	0	26	Y
179	Polygon	0	27	Y
201	Polygon	0	28	Y
223	Polygon	0	29	N/A
245	Polygon	0	30	N/A
269	Polygon	0	31	N/A
268	Polygon	0	32	N/A
2	Polygon	0	33	N/A
10	Polygon	0	34	N/A

Record: 0 Show: All Selected Records (0 out of 544 Selected.) Options

Figure1 – table for the selection grid

Once the selection grid was created the water bodies and gravel pits where digitized from the DOQ's. Both the water bodies and gravel pits where digitized at a scale of 1:1000 from the aerial images. The water bodies where separated into two different types, natural and man made. In order to determine whether or not a body of water being digitized was either man made or natural a number of different features where used. By examining the shape, pattern, tone, size, texture and relationship to surrounding objects, a feature was then classified (Chipman et. al, 2004). Other aids used the determination of whether a body of water is natural or man made include the use of USGS 7.5 minute quad maps. The classification of the water bodies is 80 percent accurate. This accuracy was determined by a process of field checking a selected number of water bodies. The gravel pits were also separated into two different types, gravel pits and old gravel pits. The designation of old gravel pit is used to classify gravel pits which are no longer in use. Generally these gravel pits have been filled in and the land terraced as is required by the State of Texas. The same methods used to distinguish between man made and natural water bodies were used to distinguish between the different types of gravel pits.

After the water bodies and gravel pits layers where digitized the next phase of the project was to gather information about what was actually along the river itself. The dense foliage and poor quality of the aerial images meant that trying to determine what features where along the river from the aerial images was not possible. The only way to gather information about what was actually on the river was to be on the river and physically observing the features. A Trimble TSC 1 data collector and a Trimble Pro XRS global position system (GPS) receiver where used to collect GPS positions of the features which where deemed important to the City of Corpus Christi.

The only way to obtain these GPS positions was to actually be on the river in a boat. Two different boat trips where scheduled as it was not feasible to attempt to collect all the points in a single trip. The GPS unit was set to collect the data in static mode as there was no base station set up to collect real time DGP data. Once the data was collected it was post processed using the Trimble Pathfinder Office 2.5 software. The data was differentially corrected using base station data from the CORS station located in Corpus Christi and yielded 68 percent accuracies between 0.9 and 2 meters. Because the in many cases the boat was unable to get right up against banks do to impeding trees, shallow water, or other issues the GPS positions may have been taken as much as 3 meters or more from the actual point of interest. After the positions where corrected they were then exported to a shapefile and the data was further cleaned. It was not necessary to add a large amount of additional attributes to the tables of the shapefiles which were exported from the Trimble Pathfinder Office software. Instead the data was cleaned and a few fields where added so that ID values and hyperlinks to pictures taken of the features could be added.

Once all the data was created and collected the analysis portion of the project could begin. A spatial analysis of the collected data was preformed to predict approximately which areas in the study area could have an environmental impact on the water quality of the Nueces River and to what relative degree that impact could be. Before any spatial analysis could be preformed the gravel pit, water bodies, and all the GPS layers were converted to GRID format so that they could be used in a raster overlay analysis. Before the GPS point layers could be converted to GRID format a buffer was created around each feature and those buffers where then converted to GRID format. A five meter buffer was decided on for the GPS point features as this is the maximum size of any boat that would be on the river and trash would most likely not travel farther then five meters from a dock or source before landing in the water. Once the five meter buffers were created and converted into a GRID format all the layers to be used for the analysis had to go through a process of reclassification. The different features amongst the layers to be used in the analysis were given weighted values which were assigned to features through the reclassification process. By assigning weighted values to the layers we can then use an overlay analysis which involves an arithmetic operation of addition. By using this type of raster analysis the resulting layer is the addition of all the cells in the same location from all the overlying layers (Lo & Young, 2002). Once the reclassifications of the GPS points, water and gravel layers where complete a new buffer layer around the river was created. This layer was divided into ¼ miles sections with each section having a weighted value. The values ranged from one to four and decreased the farther away from the river the section lays. All the GRID layers have a cell size of one meter. By using one meter cells greater accuracy can be obtained when conducting the final analysis.

The final spatial analysis was conducted using an arithmetic overlay analysis. The arithmetic process applied was addition because the resulting values needed to be the total of all the cells which occupied a single location. In other words the resulting layer would be the sum of the cell from all the layers which occupied the same location (Lo & Young, 2002).

Besides datasets which where used for analysis or the creation of other data, there where also datasets that where used as base layers. The county boundaries and city limits where obtained from the Texas General Land Office (GLO) website. The roads dataset was obtained from TNRIS and was originally produced by the Texas Department of Transportation. The rivers dataset was also obtained from the TNRIS website but it is actually from the national hydrological dataset which is put out by USGS.

The DOQ's which were used came already had a projected into North American Datum 1983 (NAD 83) with a Universal Transverse Mercator zone 14 north (UTM 14N). It was not feasible to reproject the DOQ's and this projection was also suitable for the area which was being mapped it was decided to convert all other datasets so that they would match up with the DOQ's. This mean that many of the datasets which where obtained from TNRIS and the Texas GLO had to be reprojected and in some cases a transform had to be preformed to convert the datum the which was originally assigned to the dataset.

Results

Once the initial spatial analysis was complete the resulting layer contained a total of 15 different values for the level of potential environmental impact (see figure 2). These values ranged from 0 to 14, with 0 representing areas where there was no data and 14 representing the greatest potential impact. In order to make the resulting GRID easier to read it was reclassified into three different categories: low, medium and high (see figure 3). The final results of the analysis confirmed what was already known about the environmental impact that the gravel pits have. The analysis also showed that along the river there are portions which have a medium to high levels of potential impact. These areas were not very large in their individual sizes but there are a large number of them. The accuracy with respect to the amount of impact which each site actually exhibits can not be validated without conducting field testing of the sites.

The final hardcopy maps proved to be somewhat of a challenge to create. For the purposes of printing hardcopy maps the project was split into four different maps. The first map is an overview of the study region with an emphasis on roads and administrative boundaries. The final map was created at a scale of 1:40,000 so that it would be easily plotted, show the road network and still be able to see a reasonable level of detail with respect to the DOQ's. The second map to be produced in hardcopy form was the map showing all the gravel pits and water bodies within the one mile buffer zone. This map was created at a scale of 1:36,000 so that the smaller bodies of water could still be seen, to allow for greater detail from the DOQ's and still be easily plotted on a standard E size sheet of paper. The third map produced in the series showed the location of all the points along the river which were collected. This map proved to be especially difficult because of the sheer number of different symbols needed for the data which was collected along the river. Scale was also another area of concern with this map because it was not possible to produce a single map which showed all the GPS points and still be able to plot the map on a single sheet of paper. In order to produce a map which would fit on a single plot and still show the detail needed a series of inset maps where created and placed on the final plot along with an overview map which covered the entire project area. The overview map was produced a scale of approximately 1:52,000 so that it would fit on plot that was 60 x 34 and still leave room for the inset maps. A total of five inset maps where created with one of them at a scale of 1:20,000 and the other four with a scale of 1:5,000. The final map produced was the map showing the results of the potential environmental impact analysis. The problems of scale which plagued the map showing the GPS points also plagued this map. The solution of creating inset maps which was used in the previous map was also applied to this map. Instead of having only 5 insets this time there are a total of nine inset maps were produced. The overview map was created at a scale of approximately 1:70,000. The inset maps range in scale from 1:2100 up to 1:5000. The final map was set up to be plotted on a sheet of paper the same size as the map showing the GPS points.

Conclusion

The LNRGP is a good use of GIS to evaluate the potential environmental impact point sources and non-point sources could have on surface water quality. There are many things which could have been improved upon which would have yield more accurate results and greater detail. The quality of the aerial imagery used in the project left much to be desired at times. Using high resolution satellite images would have been nice except that they where more expensive then the budget allowed for and they also would not have been available in a timely enough manner.

The LNRGP is just a starting point in evaluating the environmental impact of both point source and non-point source pollution on the Nueces River. From this field samples need to be taken to further validate the results of this project. Besides being used to model the environmental impact of the area, the LNRGP is also capable of serving as management tool for development along the river. The GPS points will have hotlinks assigned to pictures of the sites. This allows the City of Corpus Christi to know exactly what is built along the river and what extends out into the river.

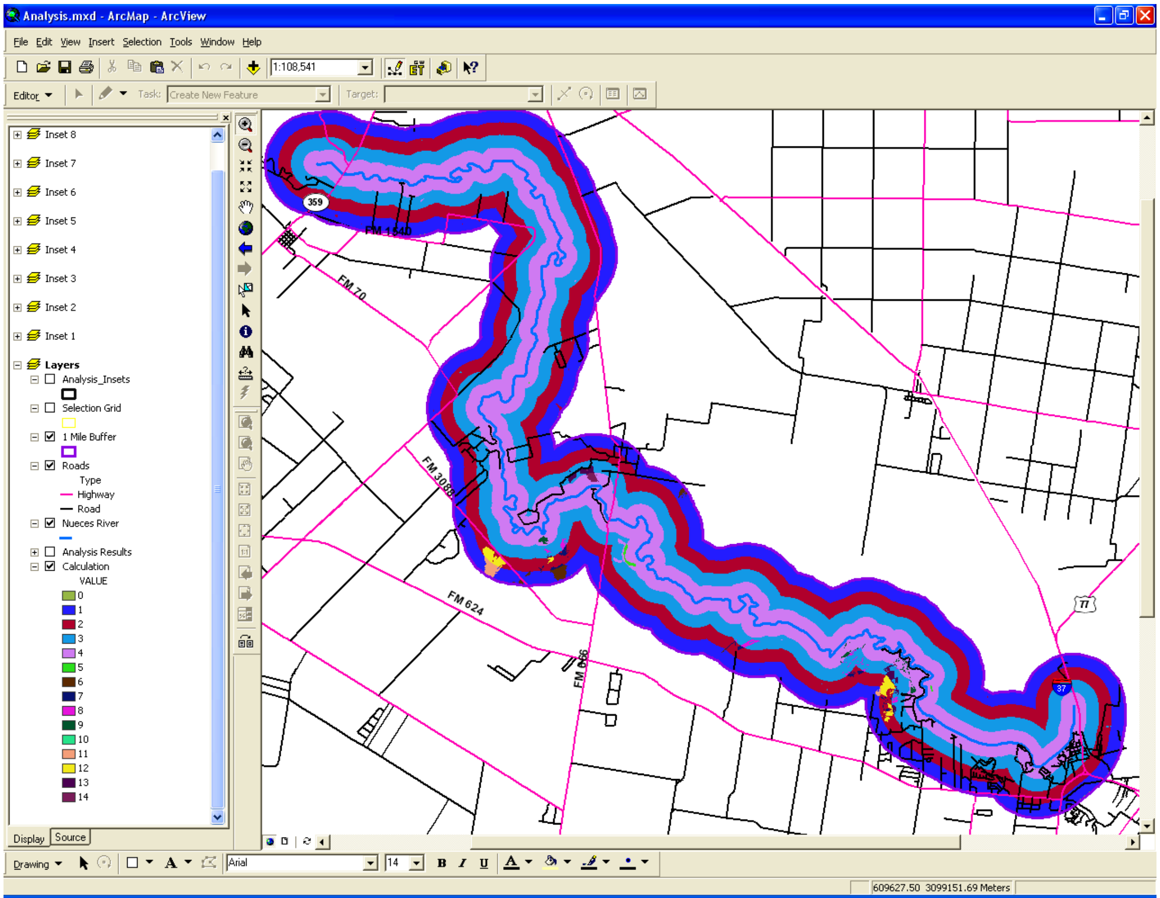

Figure 2 – results before reclassification

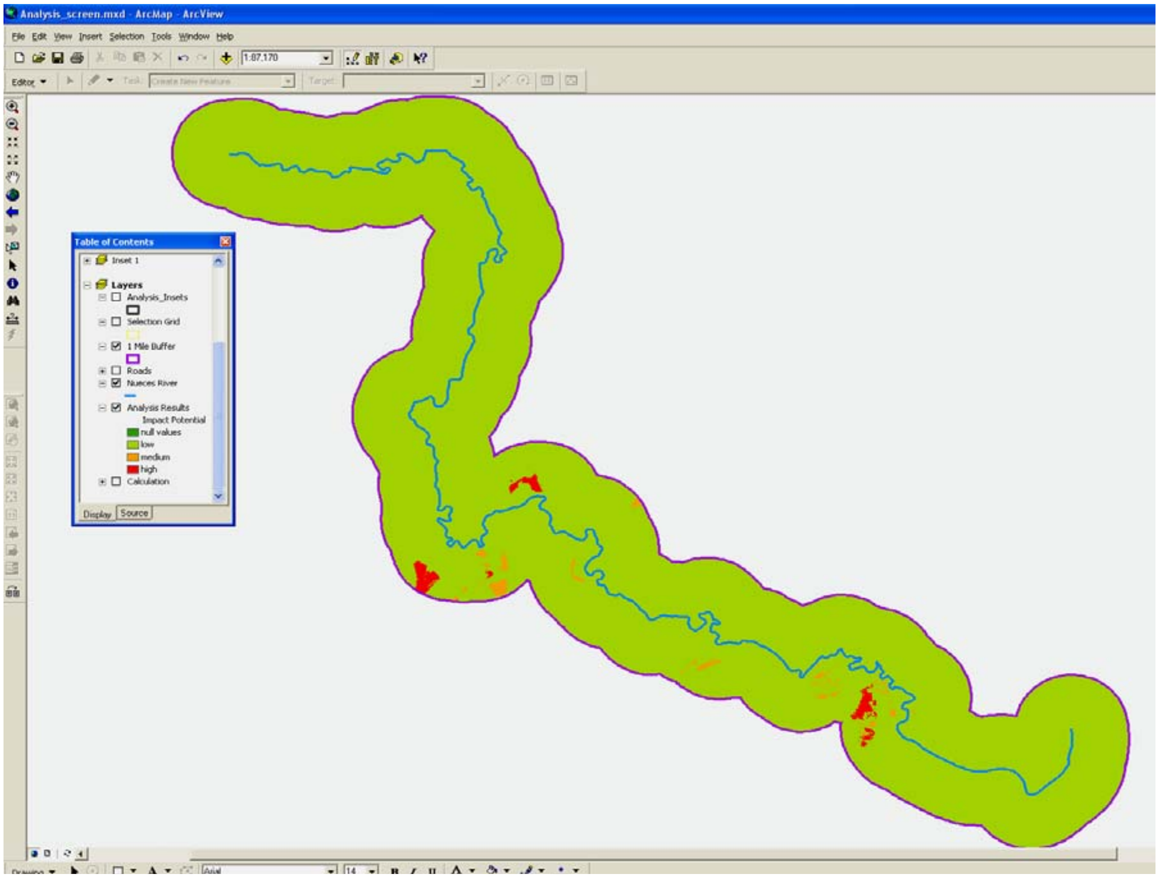

figure 3 – results after reclassification

References

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Acknowledgements

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Data Sources

Texas GLO http://www.glo.state.tx.us/gisdata/gisdata.html

TNRIS http://www.tnris.org