LA-SUB--96-114

Geographic Information System (G.I.S.)

Research Project

at

Navajo Community College - Shiprock Campus

Summer, 1995

by

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ABSTRACT:

The Navajo and Hopi GIS Project was established to assess the feasibility and impact of implementing GIS tecnology at Tribal institutions. Los Alamos and Lawrence Livermore National Laboratories funded the Navajo and Hopi Geographic Information System (G.I.S.) Project and assigned a mentor from LANL to help guide the project for three summer months of 1995. The six organizations involved were: LANL, LLNL, Navajo Community College, Navajo Nation Land Office , Northern Arizona University and San Juan College. The Navajo Land Office provided the system software, hardware and training. Northern Arizona University selected two students to work at Hopi Water Resource Department. Navajo Community College provided two students and two faculty members. San Juan College provided one student to work with the N.C.C. group. This made up two project teams which led to two project sites. The project sites are the Water Resource Department on the Hopi reservation and Navajo Community College in Shiprock, New Mexico.

The project's aim was to give Navajo and Hopi, students, faculty and Tribal staff an opportunity to learn G.I.S. and to demonstrate the usefulness of G.I.S. The projects objectives were to install a model program for increasing the tribes training,and improve the infrastructure; to plan the assessment of the impact of GIS on the Navajo and Hopi Nations; and to develope an evaluation instrument for the project. Some of the tasks were to start the GIS project, document the project, and note the lessons learnerd. Other tasks were to give college students a chance for employment and career enhancement and to utilize mentors from the tribes, NCC and NAU.

The data collected consisted of a digitized map of N.C.C. campus, a building lay-out drawing, vegetation types around the building, shadow zones taken at three different time of the day, water drip zones and an area map. The data were used to run a heat loss analysis of the building and to propose xeriscaping for the campus. The results indicated that there are three types of plant environment existing around the campus. They are delicate, medium and desert. The degree of the dripzone combined with the shaded areas determined the three environments. The college can utilize the xeriscaping method to landscape where the desert environment exists because it will require less water and maintenance. The heat loss calculation/analysis indicated that there are four types of wall condition: "excellent", "acceptable", "poor" , and "rotten." The "rotten" and "poor" walls had the most heat loss and require better insulation. They are situated in about nineteen places throughout the building. Also, eighty percent of the walls and the roof are considered poor are on the outside surface.

The plan for documenting the impact of using GIS to acertain its economic utility for the Navajo and Hopic tribes involes the interviewing of the present GIS users. The results of the interviews would give a picture of the present cost and benefits of GIS and a glimps of what the future of GIS will be. It is here assumed that the present Tribal GIS users would be the best group to survey.

The project evaluation instrument was designed to find the opinions about the projects appropriateness from students and instructors. Questions about the time of the year, effectiveness of instruction, tours, and training are asked. In addition , there are open ended questions about the future of GIS to the Navajo Nation. The project participants would like to see an earlier training of students and instructors and the availability of ARCVIEW software during the project.

TASK 1.0 Install a model program to provide the mechanism for increasing the Tribes' capabilities, training, technology transfer, student participation, research and socio-economic infrastructure development.

Navajo Project

BACKGROUND:

Navajo Community College is located on the Navajo Indian reservation in Shiprock, New Mexico in northwestern New Mexico. The Navajo reservation covers three states, New Mexico, Arizona and Utah. N.C.C. was established to meet the educational needs of the Navajo people. The mission of the college is to prepare students for careers and further studies; promote and perpetuate Navajo language and culture; and to provide community services and research.

The purpose of the G.I.S. project is to introduce G.I.S. technology and provide hands-on applications to young Native American college science students; develop data to be utilized by the Navajo Nation; and build G.I.S. capabilities of both tribes (Navajo and Hopi) through staff training, equipment and technical assistance. To accomplish these goals, the college is assisted by various organizations such as Los Alamos (LANL) and Lawrence Livermore (LLNL) National Laboratory. The laboratories provide their expertise in various technical areas. For this project, LANL provided a mentor. The project's task are identified with a ➻in the text.

➻Employment Opportunities and Career Enhancement

The N.C.C. team consisted of two faculty members, Doug Isely and Rose Grey, and three students, Rufus Yazzie, Craig Peter and Byron Aaspas. Doug Isely is faculty member at the college responsible for Computer Science. Rose Grey is a full time employee at the City of Farmington, New Mexico. She took three months leave to assist the college with the project. She also teaches technical drafting at the college utilizing AutoCAD software. Rufus Yazzie is a former N.C.C. student and going to be a senior majoring in Mechanical Engineering and Physics at the University of New Mexico. Craig Peter is a N.C.C. student transferring to Arizona State University. Craig will be a junior and majoring in Mathematics. Byron Aspaas was a student at San Juan College majoring in Electrical Engineering. He will be transferring to New Mexico State University as a sophomore.

➤System Hardware and Software Installation

The system hardware were loaned to the college by the Navajo Nation Land Department. and was set up by them. Jonah Begay assisted the team with his ARC/INFO expertise. He was granted permission by the publisher to use ARC/INFO manuals. Jonah conducted the training for one week. Jeff Weinrach, a Staff member at LANL, is the mentor. Jeff set up an orientation with the G.I.S. group at LANL to visit and plan the project with the group. The touring of the map production room gave a good picture of what G.I.S. can do. The group also work with a more user-friendly software, ARCVIEW, being use by the Laboratory.

The project will eventually demonstrate the skills of young Native Americans to their tribe and facilitate an exchange of information about G.I.S. and its uses. N.C.C. can fulfill the role of enhancing their community development by being a resource center. N.C.C, in conjunction with LANL and LLNL will be providing a valuable service to the Navajo Nation and other Indian nations.

INTRODUCTION:

The Geographic Information Systems is a powerful data base system for managing spatially related data. G.I.S. can be used as a decision-making and tracking tool. It can consist of layers such as land-use, utility lines, roads and political boundaries. Data can be spatial and non-spatial. Spatial data are actual, physical points or lines on earth such as roads or power poles. The non-spatial data are attributes, description of spatial, point data such as population, culture, soil type, or age. Data can also be in vector or raster form. Vector is a line type data like roads, contour lines or sewerline. Raster is an image like a photograph or an aerial photograph where each point is defined and which can be used as a background. There are various software packages which implement G.I.S. capabilities. Examples are IDRISI, GRASS, ATLAS, ARCCAD and ARC/INFO. The software can be interfaced with each other. For example an AutoCAD drawing can be imported into a G.I.S. software. AutoCAD is a computer aided design software. Another method of obtaining data for transfer to G.I.S. is through the use of the Global Positioning System (G.P.S.). G.P.S. is a system used to show your exact location on earth. G.P.S. receives signals from the 24 satellites in orbit. From these signals a known coordinates on earth are obtained. The earth is sectioned into a numbered grid systems similar to a Cartesian coordinate system. Universal Transversal Mercador and State Plane are the two main coordinates used. ARC/INFO, version 6.1 was used in the project. ARC/INFO is published by the Environmental Systems Research Institute, Inc. located in Redlands, California. ARC/INFO is a command driven software. Two weeks of training in using ARC/INFO was provided by the Navajo Nation Land Department. There are three modules that were introduced; arc, arcedit and arcplot. Arc is the main program environment and starts each modules. Arc has the capabilities to manipulate and manage data and the workspace. Arcedit allows you to edit your coverage by changing, moving, adding or deleting features and adding annotations. Coverage is the current drawing displayed on the graphic device. Digitizing can also be done in arcedit. Digitizing is a process where a line is traced and transferred to a workstation in digital form. Arcplot is the output module supported by the query and cartographic production. Map elements such as the north arrow, key legends, scale bars and neat lines can be positioned and scaled to produce the most appropriate presentation. These presentations can be generated on computer monitors referred to as workstations. The DEC workstations manufactured by Digital Corporations were used in the project. The workstation was programmed with the UNIX computer operating system. Two more Tektronix 4207 terminals were hooked to the DEC workstation. There were two more hardware units connnected up to the workstation: the CALCOMP 9100 digitizing table and CALCOMP 1023 pen plotter. This plotter can only draw vector data.

G.I.S. involves the six steps to carryout a project; 1.) Identify the problem 2). Data Acquisition 3.) Preprocess the data 4.) Data management 5.) Manipulation and Analysis and 6.) Production and Output. These six steps were closely followed throughout the NCC-Navajo project.

METHODS, MATERIALS AND ANALYSIS:

TRAINING

➼Initial Steps

The project started with the students and instructors having very little knowledge of ARC/INFO and UNIX computer operating system. The project definition and data identification was done initially and the AutoCAD drawing was started. The ARC/INFO training was conducted during the third week and it brought the group up to a starting level with the software. The students then started the data collection for the vegetation, shadow areas and drip zones. The polygons for these data were then constructed and cleaned up. At this stage, the instructors had little time working with the software. The INFO part needed more retraining and the instructors had to retrained the students. The students did not initially understand the difference between the polygons and the attributes. But by the end of the project, the students overcame this deficiency. A copy of the ARCINFO command summary developed by the faculty for the students is included in the appendix.

➼Lessons Learned

The other aspect of the training process are:

1.) The completion of this project was done only with the insistance of the instructors.
2.) The students became comfortable with the software about three fourths way of the project.
3.) The G.P.S. data was late and it was not used formally but just for a reference.

The project sequence puts data acquisition near the start of the project.

DIGITIZING

Digitizing represents one of the newest generation of high performance graphic input method. By placing a drawing or sketch on the surface of a digitizer tablet and tracing over it, one can easily convert spatial features on a map into accurate digital format. To capture the spatial data, a cursor is used and its position is sensed by the digitizer tablet. This tablet consists of a fine wire grid embedded in the surface that can receive information from the cursor and process this information to digital format to a computer work station.

The steps needed to begin digitizing a map or coverage will be listed in order to successfully begin digitizing:

1. Place a mylar overlay or a quadrangle map containing data on the digitizing table.
2. Initialize the terminal along with the digitizer.
3. Start up the digitizing software.
4. Enter the command
   arc:ads filename
   Here, ads is the abbreviation for arc digitizing system command, and the argument is the filename for the coverage to be digitized.
6. At least four tic-id's need to be digitized on the coverage so that the coverage can be registered to a coordinate system.
7. A coverage extent or boundary must be defined, slightly larger than the data to be digitized.
8. The coverage extent contains the minimum and maximum coordinates for all coverage features.

Upon the conclusion of these steps one can start to digitize a coverage.

Our initial procedure to begin working on digitizing, was through a training session. This training session was instructed by Jonah Begay of the Navajo Nation Land Department from Window Rock, Arizona. To practice digitizing a photo model of the Shiprock mountain was placed on the digitizing tablet. Digitizing the mountain was fairly easy, so another coverage was built so that it would contain the San Juan River and the major highways entering and exiting Shiprock, New Mexico. Digitizing was easy to comprehend once the knowledge of what to do was put into practice.

The steps that were taken to begin digitizing, were needed so that a map could be digitized to be used as a base map for a project. The college campus map was chosen for the base map. The map was then digitized with all of its environment such as trees, power poles, sidewalks and prairie dog holes.

Digitizing is one way to get spatial data into the computer. Scanning and digital image files can also be used for image input. Though the process of digitizing is not error proof, the use of mylar maps and an experienced digitizer reduces the error.

GLOBAL POSITIONING SYSTEM (G.P.S.)

G.P.S., Global Positioning System, is defined as a network of radio emitting satellites deployed by the U.S. Department of Defense. G.P.S. was developed only to meet those needs of the Department of Defense but many new uses are constantly being found. As for ground-based G.P.S. receivers, they can be used automatically to derive accurate surface coordinates for all kinds of G.I.S. mapping and surveying data collection.

It is the only system today able to show the exact positioning on the Earth anywhere, in any weather, at anytime. G.P.S. works with 24 satellites which are located 11,000 miles in the orbit. The satellites transmit signals that can be detected by anyone with a receiver. The system works in a triangulation method. It is able to find the angle between each satellite and receiver, defining the point at which the receiver is stationed on earth. There are two main components of G.P.S.; the receiver and the ground stations. The receiver can be hand carried or install on vehicles. They are very similar to hand held calculators. There are a total of five stations that make sure the satellites are working properly, which are based around the world. The main station is at the Falcon Air Force Base in Colorado Springs, Colorado. The stations also have the ability to track and monitor the satellites in the orbit.

G.P.S. has many used in today's society. It proves to be a valuable possession during drastic times. The military have put great use in the G.P.S. system. Without its reliability of the navigation system, the U.S. troops could not performed the maneuvers of Operation Desert Storm. More than 9,000 receivers were put to use and placed on many soldiers, vehicles, helicopters and aircraft. Navy ships maneuvered around mines and successfully landing aircraft on board. G.P.S. has been currently put to use in today's civilization. It helps to save lives by helping emergency medical services directing emergency vehicles through the quickest way as possible routes.

G.P.S. was introduced to us by Mr. John Mulligan of the Navajo Tribal Utility Authority (N.T.U.A.). We were given the opportunity to perform a hands on application of their G.P.S. equipment. A temporary ground station was erected on an existing control points with known coordinates. The ground stations was used for a reference point. Using the receiver with an antenna, readings were taken on the out-skirts of the building. This data was used for georeference of the building. The raw data from the receiver was then decoded and imported into the AutoCAD software. The AutoCAD version was imported into the workstation in a binary format. The points were then overlaid with the digitized feature of the building. The digitized building was only off five feet northwesterly. The Hopi project site made extensive use of GPS for determine the location of water sites. See the appendix.

VEGETATION

Vegetation around the campus played a vital role in the G.I.S. project. A survey of the campus was taken so that we could get an idea of what types of vegetation exists. Specific areas around the campus were measured to help with vegetation identification. The sole purpose of vegetation identification was to determine what areas would be best suited for growing xeriscaping plant.

A plan needed to be implemented in our procedure for plant identification. A buffer zone of about twenty five feet was measured around the campus so that an appropriate distance was laid out. A ground check of the campus was taken, so that we could determine specific areas where vegetation existed and where the greatest amount of vegetation grew. A distance of about five feet away from the campus building was the area where the most healthy vegetation grew. Randy Coronet of the Bureau of Indian Affairs(BIA) Land Operations also made a ground check to determine what vegetation he could identify. Samples of vegetation that was not identified, was taken to Ken Heil of San Juan College in Farmington, New Mexico, so that he could also help in identifying the remaining plants. A list of the vegetation around the Shiprock Campus is charted below:

1.Globe Mallow	11.Wheatgrass	21.Cottonwood Tree
2.Russian Thistle	12.Grass	22.Apple Tree
3.Kochia	13.Dead Grass	23.Chinese Elm Tree
4.Russian Olive	14.Timothy Grass	24.Bluespruce Tree
5.Alfalfa	15.Wild Lettuce	25.Juniper Tree
6.Plantain	16.Bullheads	26.Singleleaf Tree
7.Sweet Clover	17.Goatheads	27.Malus/Prunus Tree
8.Virginia Creeper	18.Knotweed	28.Hollyhock
9.Dandelion	19.Burrobush	29.Summer Cyprus
10.Tumble Mustard	20.Locust Tree	30.A uknown type of pricky bush

A thorough ground check around the building, was then taken to map out polygons which contained vegetation. See Figure 1 For example, on the north side of the building, three polygons were mapped out with their dimensions and what types of vegetation existed in those polygons. For example, in the polygon which was next to the building and extended to 18' away from the building, a layer of mixed vegetation existed. For the next polygon which was another 3' from the first polygon, a layer of Russian Thistle existed. And for the third polygon which extended another 9 feet from the second polygon, a layer of barren ground existed. Polygons such as these were mapped out for the whole campus and charted down in our log books. The polygons were sampled by selecting an area of 1m x 1m was from the vegetated polygons. These small areas were to be a representation of the vegetated polygons. An estimate of the percent of the each type of vegetation existing in the 1m x 1m area was charted and recorded in the log books. For example, in polygon 1, mentioned above, a sample of an area was studied and a count of the vegetation existing was recorded. In that sample, we found that 70% was barren, 9% was grass, 7% was dead grass, 7% was Tumble Mustard, 5% was Russian Thistle, 1% was Bullheads, and another 1% was Summer Cyprus. Samples such as these were taken from each of the vegetated polygons surrounding the campus and recorded.

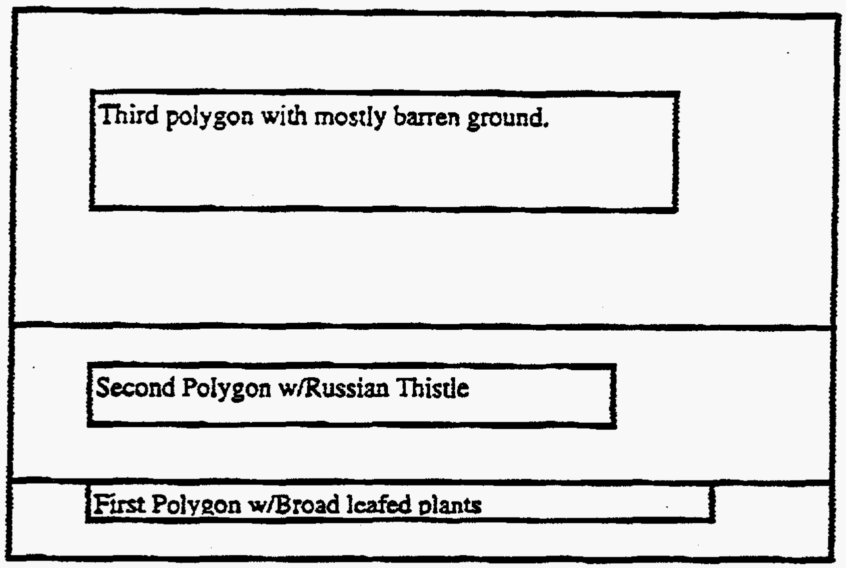


Figure 1

To complete the vegetation identification and population count, we found and realized that it was necessary to input the polygons of the vegetated areas into a coverage. The new coverage , POLYVEG, needed to include the campus and the surrounding vegetated polygons. This was made possible by using the **put** command, which enables you to put certain features into a new coverage. The put command was used to add the digitized campus to the POLYVEG coverage. We used the previous digitized campus because it had real world coordinates, Universal Transverse Mercador (UTM's). After the campus building was put into the POLYVEG coverage, we used the command, **copy parallel**, which copied an arc and put that arc parallel to an existing campus wall. The different sections of the campus were split so that the vegetated polygons could be created. From there on, one could finish building the vegetated polygons from the parallel arc. Another coverage was created, but it had the small polygons of samples that represented each of the populated vegetated areas. These areas were digitized on the digitizing table and the put command was also used to put the campus building on the sample coverage. The sample coverage created was called NCCVEGUTM, which contained the sample polygons surrounding the campus.

Attributes were needed for the coverage's so that the vegetation could be labeled. This was done in the polygon attribute tables (polyveg.pat) in the information table. The vegetated polygons and the sample polygons were all given id's so that a list of what

vegetation existed could be recorded. We correlated the samples and vegetated polygons, and added the sample information to the polygon attribute table. We used the command **joinitem** to add the sample attribute data to the vegetated polygons attributes.
The result of the vegetated study, shows that most of the vegetated polygons had a dominant plant type of dead grass or barren. Because of the dominance of dead grass and barren, xeriscaping will be proposed. This xeriscaping can be implemented without much maintenance.

DRIP ZONES AND SHADED ZONES

Measurements were taken of both the drip zones and shaded areas because it was believed that both characteristics had a major influence and effect on how the vegetation grew around the vicinity of the building. The data that was gathered for the shaded coverage were collected at the following times:

TIME	NAME OF COVERAGE'S
10:00 A.M.	AMSHD
1:00 P.M.	HIGHSHD
4:00 P.M.	PMSHD

By using a 50 ft. measuring tape measurements were taken where shaded region existed. After each measurement was taken, a Hewlett Packard 48 calculator was used to convert our measurements from feet to meters. By using the **put** command we were able to use the coverage NCCUTM to make a copy of the building. Next, we used the **copy parallel** command in Arc/Info, where we were able to make the lines parallel with the sides of the building. All the shade coverage's including the AMSHD, HIGHSHD, AND PMSHD were compiled and transformed into UTM's (Universal Transverse Mercador).

The drip zones contained a large percentage of living vegetation around the building. The measurement were taken on the outskirts of the building and categorized into four levels.

DRIP LEVELS
LEVEL ZERO; no drip action
LEVEL ONE; some drip action
LEVEL TWO; moderate drip action
LEVEL THREE; excessive drip action

These measurements were soon compiled onto the POLYVEG coverage, then the measurements were once again converted into UTM's. By using the **copy parallel** command we were once again able to make parallel lines of the building. The process of using **clean** and **build**, produced the polygons that enabled us to shade the polygons needed. After the polygons were completed, the shading was then able to be processed into the computer of the different levels. To create a final coverage, using the **put** command to put AMSHD, HIGHSHD, and PMSHD, we were able to put all three into one coverage, NCCBLDG.

ANALYSIS:

By taking all four level of drip zones and three levels of shade zones, we compiled the certain drip zones with the certain shade zones. Thus, creating new coverage's of:

a. **DELICATE**
b. **MEDIUM**
c. **DESERT**

Each new coverage confirmed the existing areas of both the good and bad vegetated areas. To make the **delicate** coverage, we took **highshd** (1:00 p.m. shadows) and **highdrip** (level 3), then applied the **intersect** command. This command enabled us to intersect both coverage's, creating polygons that overlapped with one another. This new coverage confirmed that the broad-leaved plants grew best on the northern sides of the building and where drippage was high. This effect is shown in Figure 2

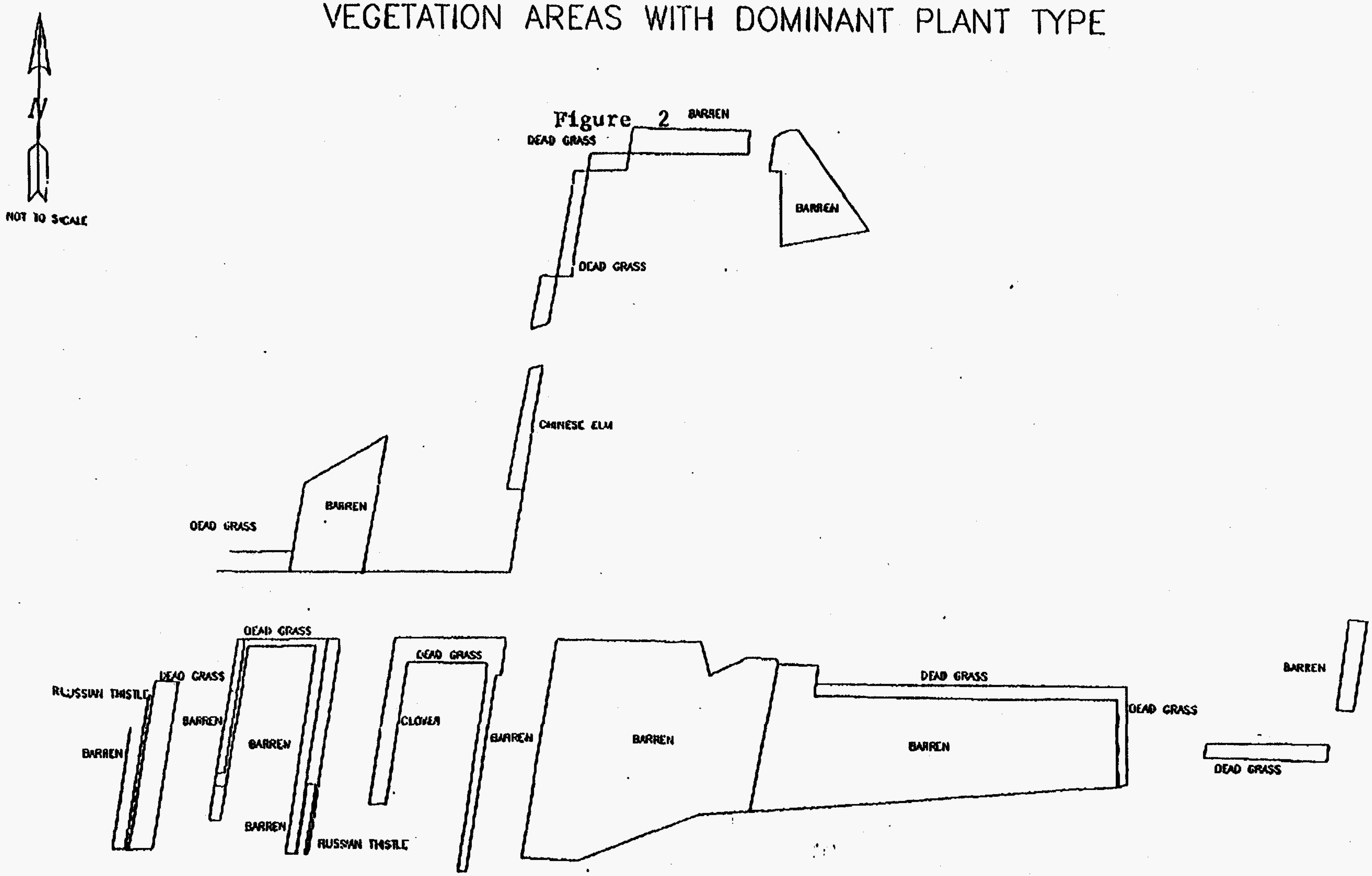
Following the same procedures for **medshd** (both pmshd and amshd) and **meddrip** (levels 1 & 2). We created **medium**, confirmed areas of where narrow leaf types of plants grew such as grass. By using the **erase** command, we subtracted the total shade and drip areas from the total campus study area. Thus, creating the desert environment. Showing environments around the building of where desert plants grew the most. See Figure 3. The delicate and dessert coverages, in Figures 2 and 3,are the xeriscaping products of this projects.

HEAT LOSS CALCULATION

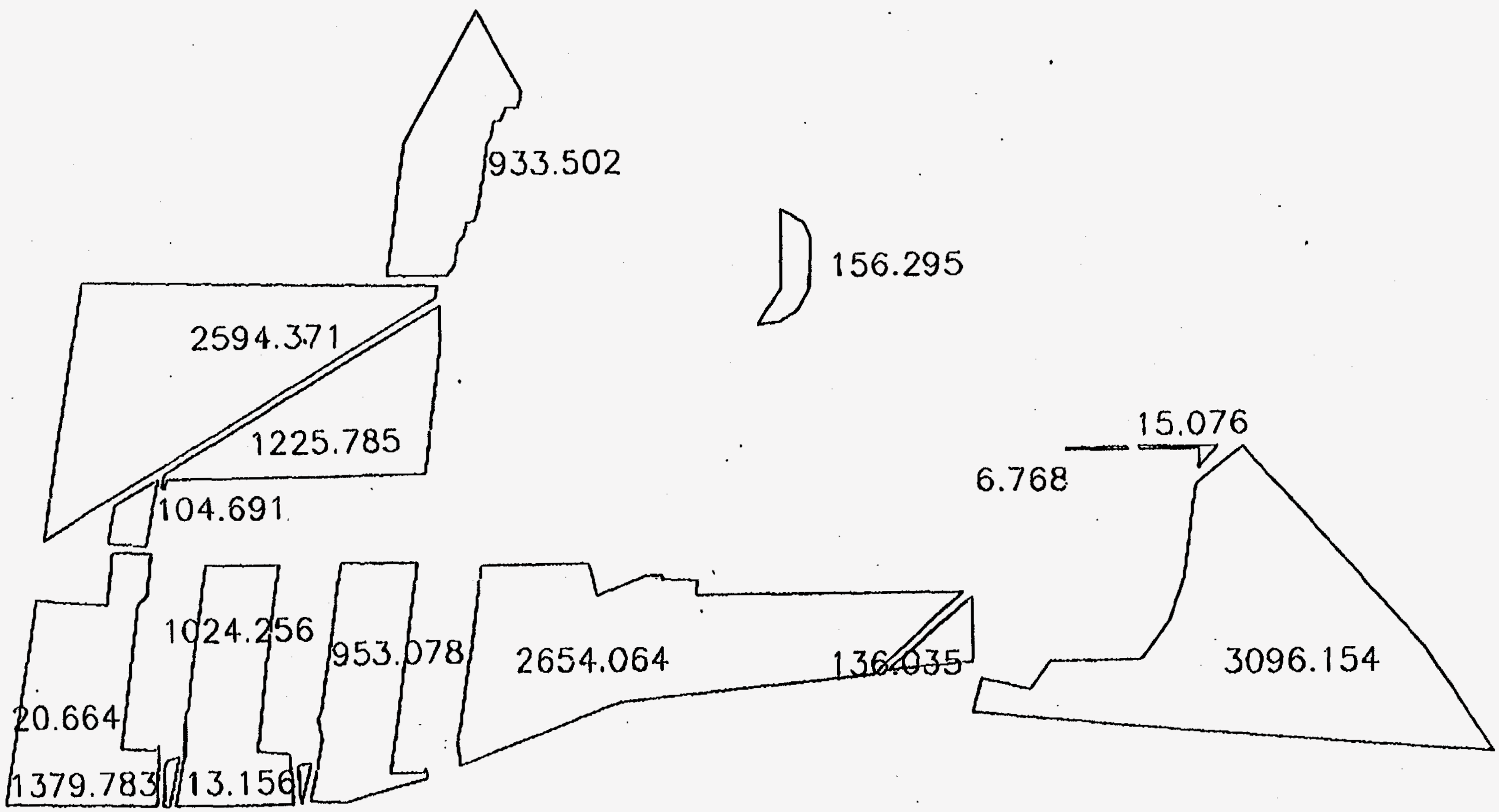
The floor plan of the building was obtained from a recent blueprint which was reproduced in AutoCAD software drawing using one of N.C.C's GATEWAY 2000 P5-60 personal computer. The AutoCAD drawing was first put into binary form then exported by using a DXFOUT command within AutoCAD. While the drawing was in binary form the AutoCAD drawing was imported to the DEC workstation to be decoded by ARC/INFO. The file was then transferred to the appropriate directory where it could be modified. Modifications of the floor plans were made and attributes were added using ARC/INFO commands. Each major type of wall was drawn from a side section view, so the materials and its dimension and properties could be noted. As result, the information obtained on the exterior walls is used to determine the heat loss of the building. The heat transfer equation used is:

VEGETATION AREAS WITH DOMINANT PLANT TYPE

Figure 2



DESSERT PLANT ENVIRONMENT
GIS PROJECT



NUMBERS ARE AREA IN SQ. METERS

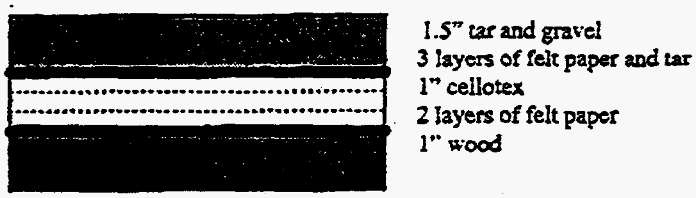
Figure [illegible]

$$q = (A*\Delta T) / (\sum_{n=1} 1/h_n + \sum_{m=1} L_m / k_m)$$

where n and m are integers 1 for inside and, 2 for outside; q is heat transfer rate; A is area; ΔT is the change in temperature; k is thermal conductivity; L is material thickness; j is the number of layers of wall materials and h is thermal convective coefficient. The thermal convective coefficients were $h_1 \cong 4.5$ for the outside wall and $h_2 \cong 2.0$ for the inside wall. The length (l) of the walls were converted to feet and; wall height (h), heat transfer rate per area (q/A) for a cold day and mild winter day were input into the arc attribute table (aat) file. Then using arcedit commands, arcedit is a subdirectory which attributes could be added and manipulated, within the arc program the q values were calculated from aat or attribute file. The walls were then categorrized into four major groups and were color coded as shown below.

Wall Rating	q/A (BTU / hr * ft^2)	Color
excellent	0.000 - 3.000	blue
acceptable	3.000 - 6.000	green
poor	6.000 - 9.000	red
rotten	9.000 - greater	black

The materials in the roof were consistent and a typical section view of the roof is as shown below:



ANALYSIS:

T_h represents the temperature inside the building and T_c the temperature outside. The cold winter day temperatures were estimated to be $T_h = 70°F$ and $T_c = 20°F$, and the mild winter day temperatures were estimated $T_h = 75°F$ and $T_c = 40°F$ with wind velocity of 10 mi /hr. The heat loss results of the four major walls are shown in the following tables:

Wall Rating	Area (ft^2)	q - mild winter day (BTU/hr)	q - cold winter day (BTU/hr)
excellent	9,400	18,800	26,800
acceptable	10.100	37,000	52,900

poor	35,000	273,300	390,400
rotten	17,300	179,500	256,500

The heat loss through the roof of the building is shown below:

Wall Rating	Area (ft^2)	q- mild winter day (BTU/hr)	q- cold winter day (BTU/hr)
poor	110,300	602,500	1,587,300

The total *q* out of the NCC building were estimated from the walls and roof is:

	Area (ft^2)	q - mild winter day (BTU/hr)	q - cold winter day (BTU/hr)
Total	182,100	1,111,100	2,313,900

The results of the heat loss shows that the building is inefficient. A typical six inch wall with fiberglass insulation has $q/A = 2.4$ where the majority of the building has a heat loss much more than 2.4 BTU/ft^2. The heat loss results show that over two million BTU per hour is lost on a cold day with sixty eight percent of the heat lost through the roof.

HOPI PROJECT

MEMORANDUM

DATE: August 16,1995

TO: Phillip Tuwaletstiwa
Environmental Engineer

FROM: Carl Seweyestewa *Carl H. Seweyestewa*

SUBJECT: General Summary of GPS and GIS Projects

INTRODUCTION

SUBJECT AND PURPOSE

The potential for water contamination to occur is greatly increased if there are outside contributing factors such as underground storage tanks, open dumpsites and septic tanks which may contribute pathogens or chemicals to the water source. Because water contamination poses serious health risks it is important to identify not only possible sources of contamination, but also sources of water whether it be a windmill, a spring or a watershed.

BACKGROUND

Because this project is still relatively new, data concerning some of these sites were scarce. However sites on the original Hopi reservation were up to date and on hand, thus we concentrated on Hopi Partitioned Land(HPL). Because water contamination poses problems over a wide spectrum, the Hopi Tribe in conjunction with other agencies are concentrating there efforts to identify possible sources of contamination, recovery problems and methods of eliminating and/or controlling potential contamination.

Water contamination is a problem of great significance here on the Hopi reservation. While it is costly in terms of recovery and getting back into compliance with the Enviromental Protection Agency(EPA), there is the more important question of not only short term health problems but also long term health problems. In order to treat and prevent future contamination, it is essential to also idemify possible bacterial and chemical contaminants which may pose health problems.

SUMMARY

The phase concerning identifying these various water sources and possible contamination sources progressed slowly due to a lack of maps, lack of knowledge of the terrain and the vast distances between sites. We have, however recieved help by employees of the Office of Hopi Lands who are knowledgeable not only in the original Hopi reservation but also in the Hopi Partitioned Lands.

PROGRESS ON WORK BY PHASES

Below are the main procedures for conducting this project, which has fallen into three main phases:

Phase 1: Identification of water and contamination sources

Phase 2: Entry of Data into Computer

Phase 3: Manipulation of Data using Geographic Information System(GIS)

IDENTIFICATION

WORK COMPLETED

Most of the sites have been identified and their approximate latitude, longitude and altitude have been recorded using the Global Positioning System(GPS).

WORK REMAINING

While most sites have been identified, there are just a few open dump sites which have not been recorded. All sites on Hopi Partitioned Land have been identified and recorded.

ENTRY OF DATA

WORK COMPLETED

We have started entry of data into the computers using well logs. The software program can provide dimensions of the site as well as surrounding geologic formations. This program should be helpful in determining which layers of sandstones are more vulnerable to seepage which may contribute to water contamination.

WORK REMAINING

This phase of the project started slow due primarily to malfunctioning computer hardware. As of late, entry of data is picking up and should be completed in the next couple weeks.

GIS

This phase has also proceeded slowly due to the slow entry of data and a lack of knowledge of GIS.

CONCLUSION

In addition to the main project described above, there were several tasks that we performed on a daily basis. One such task was monitoring the evaporation station. This station recorded the daily evaporation rate, precipitation and the average temperature. Another station is the weather station which recorded the wind direction, wind speed and the average temperature at fifteen minute intervals.

Over the course of this internship, we attended a few workshops on such subjects as Global Positioning Systems, Geographic Information Systems and water systems for tribal operators.

Because this is the water resources departments, it was also the departments responsibility to conduct water test at certain intervals throughout the year. Some of the test conducted were to test for nitrates, PH, conductivity and others.

Another main task was to get the lower village of Moencopi back into compliance with the EPA due to their waterworks system testing positive or total coliform. This consisted of cleansing the water system with chlorine for 24 hours and monitoring for another 24 hours.

These projects are the main jobs that we conducted over the summer.

TASK 2.0 Provide a plan for documenting the impact of using GIS in a practical application to ascertain its economic utility for the tribes.

TASK 2.1 Include the opportunities for college students to receive employment, job experience, and career enhancement.

The current users of GIS are the Navajo Land Office, the Navajo-Hopi Commission, the Navajo Forestry Department and the Navajo Water Resources Department. Another agency, the Hopi Water Resource Department should also be included because the Hopi GIS project gave them some data this summer.

The users of GIS should be interviewed and asked the following questions:

1. How long have you used GIS.
2. List the project your department has completed since you have been here.
3. Have using GIS on these projects enabled :
   a. Better Planning,
   b. Job opportunities.
   c. Student Job Opportunities.
   d. Career enhancement.
   e. Student Career enhancement.
4. Has the use of GIS had an economic impact on the tribe.
   a. What amount.
   b. Amount due to cost of equipment.
   c. More efficient planning process.
   d. Contracts with other agencies.

5. Open ended questions on the future of GIS with the tribe, and the future opportunities with GIS.

Upon the completion of this task the data should be checked for accuracy and the dollars should be checked for overlap. Then an average response and a total jobs, career enhancement, and money saved would be made.

TASK 3.0 Develop and provide an evaluation instrument to measure the success of the project

The project evaluation instrument was designed to find the students, mentors and instructors opinions about the projects appropriateness. Mentors will use the instructor questionnaire. Questions about the time of the year, effectiveness of instruction, tours to

GIS experts, and training are asked. In addition , open ended questions about the future of GIS to the Navajo Nation is asked. The evaluation instrument is in the Appendix.

The specific areas of questions was determined by the need to improve a future project. Thus questions of the timing of the project and the training sessions were asked. The quality of instruction was also asked to give the instructors feedback.

➛Mentors

The Hopi project utilized a mentor from NAU but the Navajo project having two instructors had less need of a mentor for the students. LANL did provide a mentor in Jeff Weinrich to the NCC project in Shiprock.

CONCLUSION:

In conclusion, the project's aim to give Navajo and Hopi students an opportunity to utilize G.I.S. and to show the usefulness of G.I.S was successful. The joint funding by LANL and LLNL with Navajo Nation Land Department accommodating their system hardware, ARC/INFO software, and training showed that cooperation among various agencies can yield productive results. N.T.U.A. assistance with a brief use and training of Global Positioning System shows promise for future projects. The research project sites were at Navajo Community College - Shiprock Campus and Hopi Indian reservation. The focus of the Navajo project was vegetation and wildlife type, heat loss of the building, and an economical landscaping surrounding the campus building. The group discovered that it was convenient and important to have a single database to perform the heat loss analysis of NCC building. Furthermore, GIS is a single and powerful database that can perform daily management and proposed projects such as environmental cleanups.

Some of the recommendations the group proposed are that if any improvements are going be done to the building insulation should be added to the roof. The training schedule should have the software (ARC/INFO) training in the first week and have some additional training about halfway through. The ARCVIEW software should been available during the project.

One measure of the success of the project is the interest shown by the members of the Shiprock community. Interest was shown by Shiprock Planning Commission, Navajo Agriculture Department, NCC Environmental Department and Navajo Tribal Utility Authority. These interests indicates that G.I.S. should remain and continue at NCC.

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APPENDIX

GIS STUDENT EVALUATION INSTRUMENT

Areas of inquiry:

TRAINING

The training was Thorough.
The Training was offered at the correct time of the year.

Student Work

The students had enough work to do.
The work was challenging.

Education

The students learned a great amount
The learning was in a needed area.
The training session by GIS experts outside the project was helpful.

Pay

The student pay was sufficient.

Length

The length of the training period was not too long.

Tours

The tours were useful.

Administration

The administration of the project was helpful.

Instructors

The instructors were knowledgeable about GIS

The instructors were effective teachers.

Future

What should be done in future projects.

Comment on the future of GIS for the Navajo Nation.

Instructor Mentor Evaluation Instrument

Answer each question by choosing one of the choices such as Strongly Agree, Strongly Disagree or Somewhat Agree etc. Check off an answer box to the right of the question.

	Strongly	Somewhat Agree	No Opinion Agree	Somewhat	Strongly Disagree
Your teaching was Thorough.	☐	☐	☐	☐	☐
The Training was offered at the correct time of the year,	☐	☐	☐	☐	☐
The students had enough work to do.	☐	☐	☐	☐	☐
The teaching was challenging.	☐	☐	☐	☐	☐
The students learned a great amount	☐	☐	☐	☐	☐
The teaching was in a needed area.	☐	☐	☐	☐	☐
The training session by GIS experts outside the project was helpful.	☐	☐	☐	☐	☐
The instructor pay was sufficient.	☐	☐	☐	☐	☐
The length of the training period was not too long.	☐	☐	☐	☐	☐
The tours were useful.	☐	☐	☐	☐	☐
The administration of the project was helpful.	☐	☐	☐	☐	☐
The students became knowledgeable about GIS	☐	☐	☐	☐	☐
The students were effective learners.	☐	☐	☐	☐	☐

What should be done in future projects. ______________________________

Comment on the future of GIS for the Tribal Nations. ______________________________

Student Evaluation Instrument

Answer each question by choosing one of the choices such as Strongly Agree, Strongly Disagree or Somewhat Agree etc. Check off a box to the right of the question.

	Strongly	Somewhat Agree	No Opinion Agree	Somewhat	Strongly Disagree
The training was Thorough.	☐	☐	☐	☐	☐
The Training was offered at the correct time of the year	☐	☐	☐	☐	☐
The students had enough work to do.	☐	☐	☐	☐	☐
The work was challenging.	☐	☐	☐	☐	☐
The students learned a great amount	☐	☐	☐	☐	☐
The learning was in a needed area.	☐	☐	☐	☐	☐
The training session by GIS experts outside the project was helpful.	☐	☐	☐	☐	☐
The student pay was sufficient.	☐	☐	☐	☐	☐
The length of the training period was not too long.	☐	☐	☐	☐	☐
The tours were useful.	☐	☐	☐	☐	☐
The administration of the project was helpful.	☐	☐	☐	☐	☐
The instructors were knowledgeable about GIS	☐	☐	☐	☐	☐
The instructors were effective teachers.	☐	☐	☐	☐	☐

What should be done in future projects. ______________________________

Comment on the future of GIS for the Navajo Nation. ______________________

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