IS-T--1479

DE90 011811

Sand and Gravel Mine Operations and Reclamation Planning Using Microcomputers

by

Jamel Bin Ariffin

Master of Landscape Architecture Thesis submitted to Iowa State University

Ames Laboratory, U.S. DOE
Iowa State University
Ames, Iowa 50011

Date Transmitted: February 1990

PREPARED FOR THE U. S. DEPARTMENT OF ENERGY
UNDER CONTRACT NO. W-7405-Eng-82.

DISCLAIMER

The following pages are an exact representation of what is in the original document folder.

DISCLAIMER

1479

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1. INTRODUCTION

Mined-land reclamation planning is a very vital issue in the mining industry. For decades the industry has played an important role in altering landscapes and creating derelict lands. The product of their operations has resulted in an outcry from the public and government agencies for a reclamation planning.

To the mine operators, a prime motivation for reclamation is the legal requirement: they cannot get the next permit without reclamation plans (Simpson, 1985). To the public, derelict lands due to the mining industry are considered as useless if something is not done to eliminate the situation. It is from these two extremes that Landscape Architects, who are uniquely equipped by education and expertise to create value out of a seeming wasteland, can play a major role.

The National Sand and Gravel Association which is now known as the National Aggregates Association (NAA), is an organization that started to look for ideas and direction in dealing with the increasingly complex land use problems related to the sand and gravel mining industry. One group of professionals that this organization looked to are Landscape Architects. To many Landscape Architects, the perception towards mined-land reclamation planning is still not convincing. Therefore it is the duty of those who have knowledge and expertise in this field, especially among Landscape Architects, to demonstrate to others the importance of mined-land reclamation planning.

Mining planning and reclamation have been carried out by many mining operators, professionals and educators interested in seeing the potentially derelict lands created by the sand and gravel mining industry be planned and reclaimed to a more usable landscape. These people do not envision the mined out lands as wastelands, but as something that has the potential of pleasing and useful landscapes. With regard to the planning aspect of mine reclamation and operation, conventional or traditional methods are normally used to execute concepts in planning for this kind of work. Few mining operators or professionals are using microcomputer aided methods to plan the mine operations and reclamation, even though we are living in an era when computer technology can be implemented effectively in managing the unique problems of mined-land reclamation.

CHAPTER 2. STATEMENT OF THE PROBLEM

The purpose of this study is to focus on the application of microcomputers, also known as personal computers, in planning for sand and gravel mine operations and reclamation at a site in Story County, Iowa. This site, called the Arrasmith Pit, is operated by Martin Marietta Aggregates, Inc. The Arrasmith site, which encompasses an area of about 25 acres, is a relatively small site for aggregate mining. However, planning for the concurrent mine operation and reclamation program at this site is just as critical as with larger sites and the planning process is the same.

In the past, most of the reclamation planning was done by traditional or conventional methods. That is, such as drawings, sections, plans, earthwork computations and reports were done manually by using pencils, pens, erasers, drafting tables, T-squares, planimeters and so on.

The planning of concurrent sand and gravel mine operations and reclamation through conventional or manual techniques are labor intensive and time consuming. Manual techniques are ineffective and sometimes incapable of generating alternatives in a very short period of time. This is especially true in planning for a sand and gravel mine operation and reclamation where alternatives in solving the environmental problems are vital (Dietrich, 1988).

Therefore, to help minimize the problems discussed earlier, microcomputer assisted techniques can be used to improve the productivity and efficiency.

With advances in technology, especially in microcomputer hardware and software, the traditional drafting equipment can be replaced by microcomputers such as the IBM PC/XT/AT and compatibles, which are widely used by the various environmental design professions.

There are many "off-the-shelf" programs software which Landscape Architects can use to explore the potentials and limitations of using microcomputer aided methods in planning for integrated mine operation and reclamation. The purpose of this research is to focus on the application ot microcomputers in planning for concurrent sand and gravel mine operation and reclamation.

Sub-problems:

There are three sub-problems to this thesis:

1. Identifying the benefits that can be gained by using microcomputer aided methods in planning for a sand and gravel mine operation and reclamation planning.
2. Evaluating the potentials and limitations of using CAD microcomputer aided methods which involve using hardware and software available in the Department of Landscape Architecture at Iowa State University.
3. Determine what type of information techniques can be

provided by microcomputers that cannot be provided by conventional techniques and methods in sand and gravel mine operation and reclamation planning.

Delimitations of the Problem

1. This study will not attempt to established a post-mining land use for the study site.
2. The primary microcomputer software used in this research is AutoCAD program version 2.62. This program was used more than the others due to the fact that the researcher is more knowledgeable in using this program as compared to the other microcomputer software available in the Department of Landscape Architecture such as Surfer program.

Definition of the Terms

Microcomputers - A stand-alone small computer that uses a microprocessor as its central processing unit (CPU), keyboard as the input device, 512K to 4 Megabyte RAM memory and the output devices (printer/plotter and the video monitor).

Reclamation - A process of returning the disturbed areas resulting from the sand and gravel mining to a level of productivity that will support one or more planned post-mining land uses.

Overburden - The combination of topsoil and subsoil that covers the sand and gravel deposit. This could be considered as waste material and is used as landforming material.

Wet operations - A excavation process for sand and gravel that occurs below the water table.

Computer Aided Design - The application of interactive computer graphics to product design.

Concurrent mine operation and reclamation planning - A concept of integrating the mining operation with the reclamation and mitigation program.

Off-the-shelf software - Commercial computer software packages that are easily available on market for example AutoCAD, Surfer, Drafix, ProDesign, and so on.

Pan command - An AutoCAD command that allows the user to change the portion of the drawing displayed while retaining the current display magnification.

Digitizer - An input device with a flat surface on which the user traces drawings with a special stylus and which senses each location where the stylus touches the surface. This produces signals communicating to the computer the x-y coordinates of the contact points.

Polylines - A Polyline is a connected sequence of line and arc segments. It is treated by AutoCAD as a single entity.

The Hypothesis

The Computer aided design using microcomputers can be an alternative to inefficient conventional or manual techniques for the landscape architects, planners or mining operators to communicate ideas and aid them in planning for a concurrent sand and gravel mining operation and reclamation. This thesis documents the steps and procedures taken to accomplish the planning process for the mine operation and reclamation planning using microcomputer hardware and software available in the Department of Landscape Architecture at Iowa State University. In order to achieve the above, all plans, sketches, earthwork calculations and quantification, and text are generated and manipulated using microcomputers (IBM PC/XT/AT and compatibles).

CHAPTER 3. LITERATURE REVIEW

Background

Sand and gravel are very essential to our economic growth and development. They are so important that virtually every construction project requires them. The construction of parking lots, buildings, airports, dams, and roads all require these materials. They are so important that their use provides one of the most accurate indices of economic activity that we have.

The demand for these non-renewable resource increases with an increase in the population. In the United States, there is an average of five tons of sand and gravel used annually for every man, woman and child in the population (Swanson, 1982). The total production of sand and gravel in United States during 1986 was 883 million short tons (Tepordei, 1986). Of the 883 million tons produced, 25 percent was used as concrete aggregate, including concrete sand, for airports, buildings, dams, and highways; 15 percent for road base and coverings; 10 percent as asphaltic concrete aggregates and other bituminous mixtures; 7 percent as construction fill; 2 percent for concrete products such as blocks, bricks, pipes, decorative, and so on; 1 percent in plaster and gunite sands; and the remainder for railroad ballast, snow and ice control, road stabilization, roofing granules, and other miscellaneous and unspecified uses

(Tepordei, 1986).

Table 1 indicates the major uses of sand and gravel nationally in 1986 and variations in per ton value based on use.

Table 1. Construction Sand and Gravel Sold or Used in the United States in 1986, by Major Use (Mineral Yearbook, 1986)

Use	Quantity (thousand short tons)	Value (thousands)	Value (perton)
Concrete aggregates	219,009	$814,860	$3.72
Plaster and gunite sands	10,049	39,972	3.98
Concrete products	16,274	55,648	3.42
Asphaltic concrete aggreg.	87,410	322,666	3.69
Road base and coverings	128,112	354,740	2.77
Road stabilization (cement)	1,509	3,928	2.60
Road stabilization (lime)	901	3,342	3.71
Fill	66,094	128,780	1.95
Snow and ice control	5,797	17,210	2.97
Railroad ballast	1,512	5,662	3.74
Roofing granules	564	3,102	5.50
Other	13,981	55,706	3.98
Unspecified	331,792	941,558	2.84
Total or average	883,000	2,747,200	3.11

Of the four major geographic regions, the West region led the nation in terms of production with 315 million tons or 36 percent of the U.S total, followed by the North Central with 240 million tons or 27 percent of the total, the South with 217 million tons or 25 percent, and the Northeast with 111 million tons or 13 percent (Tepordei, 1986). California still ranks first in the nation in production, and is followed in descending order of tonnage by Texas, Michigan, Arizona, Ohio, New York, Florida, Illinois, Alaska and Washington (Tepordei, 1986).

The State of Iowa ranked 24th in the nation in the production of sand and gravel. Iowa produced 14.5 million tons of sand and gravel in 1986 compared to 12 million tons of sand and gravel in 1985 (Tepordei, 1986). In 1986, according to the Bureau of Mines, there were 169 total active operations in Iowa. In 1984, a total of 109 companies and government agencies mined sand and gravel from 199 pits in 72 counties (White et al. 1985). Polk, Boone, Plymouth, and Sioux Counties, respectively, had the largest output and collectively accounted for about one-third of the state's production (White et al. 1985).

Paone et al. (1974) reported that between 1930 and 1971 the percentages of the land surface mined for sand and gravel were 18 percent, while stone commodity accounts for 14 percent of the land surface mined in the United States. Even though this percentage may not seem significant according to the Bureau of Mines, from 1930 through 1980, a total of 5.7 million acres of land had been utilized by the mining industry for mineral extraction and processing. The land reclaimed during the same period was 2.7 million acres, or 47 percent of the land utilized. Paone et al. (1974)

made another dramatic comparison between the land utilized and reclaimed by the mining industry in the United States from 1930 through 1971. They mentioned that land utilized by the mining industry in the United States from 1930 through 1971 was 3.65 million acres, while the land reclaimed during the same period of time was 1.46 million acres or 40 percent of the land utilized. In 1971 alone, a total of 206,000 acres of land had been utilized for mining and 163,000 acres or 79 percent of the land utilized had been reclaimed.

For centuries it has been known that mining produces a range of harmful side-effects, and that through careful planning they can be minimized or eliminated. Unsightliness of sand and gravel mining operations is one of the most prevalent and difficult negative impacts for mine operators to deal with (Dietrich, 1986). Society in the past has often been willing to ignore harmful side-effects of mining and quarrying because it depends on minerals for agriculture, building and industry. However in the twentieth century, and especially since 1970, in the United States there is increasing concern over the harmful side-effects of aggregate mining.

The Need for Concurrent Mine Operation and Reclamation Planning for Sand and Gravel Mines

In the twentieth century there has been increasingly comprehensive control over the environmental side-effects of mineral extraction. Globally, Australia was one of the first countries to legislate for the restoration of mineral workings (Turner, 1987). The New South Wales Coal Mines Regulation Act of 1912 required topsoil to be replaced and depressions to be drained. In 1939 West Virginia became the first American state to control mineral working, but only seven states required the reclamation of coal workings by 1967.

Since the early 1970s mineral workings, especially coal in North America and Australia, have been regulated by laws dealing with particular industries and by general Acts concerned with the assessment of environmental impacts. Thus in America surface mining of coal is regulated by the National Environmental Policy Act (NEPA) of 1970, numerous state laws, and by the Surface Mining Control and Reclamation Act of 1977 (Turner, 1987). However, sand and gravel mines are excluded from the Federal Surface Mining Control and Reclamation Act of 1977 (PL 95-87) by Congress (Dietrich, 1986). Because of this situation, some states do regulate other kinds of mining. For example, Iowa and California require permitting for all mining operations, whereas Texas regulates only coal and uranium mines (Dietrich, 1986).

The level of monitoring and enforcement can vary from state to state for mining products other than coal. Even though sand and gravel mining is not under the jurisdiction of the Surface Mining Control and Reclamation Act (SMCRA), many states now have laws regulating the reclamation of sand and gravel mined-land. Turner (1987) states that by the year 1976, thirty-nine states had established regulatory reclamation programs pertaining to coal and, in some cases, other minerals including sand and gravel.

Sand and gravel mining, like coal mining, can create significant impacts, not only to environment but also to society. The National Academy of Science states seven common areas of perceived and potential impacts due to sand and gravel mining:

1. unsightliness
2. truck traffic
3. erosion
4. habitat loss
5. unproductive / unattractive post-mining land use
6. fugitive dust
7. noise

To minimize or mitigate the potential impacts to the environment, landscape, and society, a concept of concurrent, sequential and integrated mine operation and reclamation planning has to be implemented. Generally, the reclamation of aggregate mines (including sand and gravel mines) does not occur progressively over time with the mining operation, but is assumed or presumed to occur after the mining operations (Dietrich, 1986).

Microcomputer Application in Landscape Planning

The application of microcomputer technology in landscape architecture and planning, especially in the sand and gravel mines operations and reclamation planning, is comparatively new compared to some other professions such as medicine and the physical sciences. In the medical field, computer technology has been used to analyze sophisticated medical tests, giving quick results of tests that once took days to analyze. Advances in computer technology in this field presently allow the computer to assist the doctors in diagnosing ailments through a dialogue between a computer and a person being admitted to a hospital (Wolff, 1985).

Many fields of science have also benefitted from the computer applications. Computers, for example, allow us to obtain a greater understanding of the earth and the universe around us. They help provided us with color enhanced photographs of the moon and other planets of the solar system. However, the application of microcomputer technology in landscape planning is far from reaching the level of accomplishments described above. According to surveys conducted by Iowa State University's Design Research Institute in 1984 and by the American Society of Landscape Architects in 1985, microcomputers have not had a significant impact on landscape design and planning (Hahn, 1986). Apart from the U.S. Forest Service and the visual assessments of private practitioners using computer simulation, only a small percentage of landscape architects are routinely using computers for site design (Hahn, 1986).

A quote from MacDougall's Microcomputers in Landscape Architecture (1983) can best describe why microcomputers have not had a significant impact on landscape design and planning. MacDougall says,

> " The suitability and acceptance of computers in various types of business and professional practice have varied considerably. In these areas that require much data processing or many calculations, such as retail business or engineering, microcomputers have become widely accepted. In areas that involve less data and calculations and more human judgment, such as Landscape Architecture, there has been a more skeptical view. Many people in the field have seen them as largely unnecessary, and their value

basically unproven except for very specialized tasks."

However, with the current development in computer technology, especially with the introduction of microcomputer, such as IBM PC compatibles, the applications of microcomputers in landscape architecture and planning have increased tremendously. There are various levels of involvement in microcomputers for landscape architecture and planning fields. Some of the computer applications in landscape architecture and planning include word processing, specification writing, accounting, job management, cost estimation, engineering and construction, information management, spreadsheets and landscape assessments and regional planning and graphics (Crone, 1983).

Word Processing: Word Processing is a very useful tool for landscape architects. It allows the user to develop the texts into specific formats, easily make corrections, shift paragraphs, and insert or delete data. Word processing is just like a turbo-charged typewriter. It can produce articles, advertisements, letters, proposals, and reports quickly. Most importantly, it can produce a very high standard of appearance when coupled with desk-top publishing.

There are many off-the-shelf word processing software packages that are available and easy to learn. For example, Word Perfect version 4.2 and the latest version of WordPerfect, version 5.0, edges into the realm of desktop publishing with its ability to produce text in newspaper-style columns, integrate text and graphics, draw rules, shuffle fonts in the same line without losing track of margins, and finally, fast-feeding all of these creations to almost any laser printer (PC Computing, Aug.1988).

Specification Writing: Specification writing is another important document in landscape architecture and planning. The drawings, plans, and graphics cannot be considered as a complete package without written specifications included in the documents. Microcomputer technology has played a very important role by allowing planting and construction specification to be entered, edited and stored in programs or data base for easy referencing and insertion into project plans.

Accounting: Landscape Architecture students have little business accounting in their program curriculum, but in landscape architecture and planning firms accounting is an important function. Off-the-shelf software packages such as Dac-Easy can provide a quicker and faster way of maintaining and producing the ledger, accounts receivable and payable, and the payroll. In the DAC-Easy Accounting Version 2.0 there are seven powerful accounting modules integrated in one program: General Ledger, Accounts

Payable, Accounts Receivable, Inventory, Purchase Orders, Billing and Budgeting (PC Computing, Aug. 1988).

Job management: Job management can be planned and monitored using systems like Critical Path Method (CPM) or Program Evaluation Review Technique (PERT).

Job estimating software can analyze a variety of cost options for a potential job. Final estimates can be calculated by simply adjusting original figures (Kane, 1986).

Cost estimation: Microcomputer cost estimating software and databases, like KerrCost are other important tools for landscape architects. The main objective of this user-friendly software is to provide all the cost information needed to estimate the construction costs of projects designed or specified by landscape architects (Dietrich, 1988).

Engineering and construction: There are many off-the-shelf software packages available for engineering and construction purposes that are applicable to landscape architects and planning projects. One example is Horizontal Traverse II - a program to facilitate design of horizontal road alignments and curves; adjust boundary surveys and compute areas; and convert bearings and lengths to coordinates. Vertical Curve II is another program that can be used to compute parabolic curve data and facilitate design of vertical road profiles. Another engineering computer application that is also important to landscape architects is earthwork computations. An example is Earthworks II+, which allows easy and rapid calculation of cut and fill earth volumes.

Information management: Landscape architects can use information management software to assist them in selecting plants and other materials for projects. Products can be specified by features such as color, form, texture, or price, and the database will find suitable products (Kane, 1986).

Spreadsheets: These programs, such as Lotus 1-2-3 and Excel, are easily adapted to specific needs in computing quantities, allowing such applications as bid worksheets, cost estimating, accounting, engineering calculations, as well as many others (Kane, 1986).

Landscape assessment and regional planning: This planning software can be used for visibility analysis (viewshed mapping), site selection, suitability studies, impact assessment, watershed analysis, soil analysis and so on. One such tool is the microcomputer version of Multi-Scale Data Analysis and Mapping Program (Micro-MSDAMP) which was written in MS-FORTRAN by Prof. Paul F. Anderson based on the concepts developed with Glenn H. Beavers of the Land Use Analysis Laboratory at Iowa State University (Anderson, 1986).

Graphics: There are numerous "off-the-shelf" software packages that can assist landscape architects to alleviate many of the tedious and time consuming tasks that are basic to some aspects in landscape architecture profession. Drawings, sections, or plans can be done once, saved, then retrieved and inserted into any new drawing as needed. Computer aided design (CAD) software packages, such as AutoCAD, Drafix, Surfer and others, are some of the tools that offer such opportunities. The primary computer application described and used in this thesis is Computer aided design.

Microcomputers

A microcomputer can be defined as a small, stand-alone computer that uses a microprocessor (a single electronic chip) as its central processing unit (CPU). Microcomputer have become accepted tools in the business and professional world, and are fast becoming another appliance in the home. A microcomputer opens doors for the general public and can be considered a "tool for modern times" (PC Computing, August 1988). Microcomputers are best understood as personal computers, machines mostly used by a single individual, or shared by a small group to perform functions such as Computer Aided Design and Drafting (CADD) for graphics, word processing or database management (Norton, 1985).

The term microcomputer also typically applies to any general purpose, stand alone desktop microcomputer priced less than $10,000.000 (Norton, 1985). Although minicomputers and workstations have been used by large businesses, microcomputers have raised the awareness of public to the usefulness of the small computers, and have produced a revolution in the industry.

Microcomputer consists of four basic part: the input device (usually a keyboard), the central processing unit (CPU), the memory (RAM), and the output device (usually a video monitor) (Carberry, 1985). Personal computers are designed for both professionals and non-professionals who do not have specialized knowledge of computers (Norton, 1985).

In general, most personal computers or microcomputers that use CAD software are 16-bit machines, with at least 256 K bytes of random access memory (RAM). To execute CAD work, these machines must be equipped with dual disk drives with floppy disks or fixed disks and a display monitor (preferably color) having a resolution of at least 320 x 200 pixels (PC Computing, August 1988).

CHAPTER 4. TOOLS

Introduction

Computer-Aided Design, known as CAD, has been used since 1964 (Carberry, 1985). However, it wasn't widely used until around 1982, when CAD systems such as AutoCAD became available for microcomputers (now widely and better known as "personal computer", as opposed to mainframes and minicomputers) (Omura, 1987). CAD has evolved to a point where most design disciplines are already exposed to its capabilities and capacities. Today, designing with the aid of the computer is not reserved for only certain well trained professionals. Almost anyone who has the interest to work with computers has the opportunity to purchase a CAD software package for a few hundred dollars and begin computer-aided design.

The decision to use microcomputers in landscape architecture and planning, especially in concurrent sand and gravel mine operation and reclamation planning, came about from the researcher's participation in the 1987 National Landscape Architecture Student Competition emphasizing concurrent mine operation and reclamation planning. Throughout the planning process of developing a concurrent mining and reclamation plan, the conventional or traditional techniques were used.

The opportunity to use microcomputers in planning for the concurrent mine operation and reclamation planning is a new challenge. The potential for microcomputer application in planning for sand and gravel mine operation and reclamation planning has not been fully developed, particularly in the area of sequential mining and earthwork distribution planning. Therefore the application of microcomputers in planning the expansion of the Arrasmith Pit in Story County provides the opportunity for planning, designing, and assessing visual implications resulting from the mining activity; and for communication between the mining industry and the public. In this study a IBM PC-XT clone with 640 K RAM memory and a 30-Megabytes hard disk and Northgate AT compatible with 1 Megabyte RAM memory were used.

Microcomputer as a tool comprise of three-step process:

1. Information is input into the computer.
2. The computer processes the information.
3. Results of the processing are output.

The information is input into the computer through a input device called a keyboard. The keyboard has a microprocessor inside it and is actually a small computer in itself. The information will then be processed in the mother board. The results of the processing are the output and it can be seen in several ways. A monitor which is similar to a television set is one of the output device.

The other output devices that will be discussed in a little more detail are printers and plotters.

Printer

Among the printers most commonly used by microcomputer users are the dot matrix printers. Dot matrix printers have a print-head that constructs character images by means of a vertical column of eight, nine or twenty-four pins that is struck repeatedly against the ribbon and paper, forming successive columns of dots that make up the characters. Dot matrix printers are more commonly used on personal computers than any other type of printer. One of the reasons for this is the relatively low price of the printers - as low as $ 200.00.

In this study a dot matrix printer (Epson LX-800) was used for printing the text. The operation starts when the computer sends information to the printer. It is normally stored in the print buffer. After the print buffer receives the information, the printhead motion is activated in either a forward or reverse direction. This is accomplished by relieving a break-type mechanism and by activating a forward or reverse clutch. When the printhead moves across the paper, the appropriate solenoids are energized, driving the print wires against the print ribbon and the platen. The result of this operation is a dot or a series of dots on the paper (Carberry, 1985). There are three basic methods available for feeding paper into a printer: roller feed, tractor feed, and a combination of both methods. The paper is placed within two rollers, and the paper can be rolled up or down by turning a knob.

Plotter

A plotter is an output device used to make drawings on paper using a CAD system (Carberry, 1985). The biggest advantage when a plotter drawing replaces a conventional drawing or sketch is the ability of plotters to draw quickly and consistently. Plotters can also be used to create color transparencies, overhead projections, and multicolor plots.

A large number of low-cost graphic plotters are available for microcomputer users. The plotter used in this study was the Hewlett Packard 7475A Series. The HP 7475A plotter utilizes a B-size, or 11" x 17" sheet size paper or A-size, which is 8.5" x 11" paper. If the 11" x 17" sheet size paper is used, the maximum plotting range is 16.3 in. for the X-axis and 10.15 in. for the Y-axis. If the 8.5" x 11" sheet is used, the maximum plotting range is 10.15 in. for the X-axis and 7.8 in. for the Y-axis.

Software Program

AutoCAD

AutoCAD is one of the popular microcomputer CAD programs that is used in the Department of Landscape Architecture at Iowa State University for drawing landscape plans and sections. AutoCAD can produce two-dimensional drawings. In AutoCAD version 10.0, it can also produce three-dimensional drawings. It runs on the IBM PC and IBM PC compatible computers. AutoCAD is a general purpose drawing system and can be used for applications in architecture, interior design, engineering, and landscape architecture and design. AutoCAD is operated by selecting choices from a series of menus and by typing drawing commands. Drawings are created and edited via the menus and an input device (such as tablet or mouse). There are many microcomputer CADD systems available with similar features, but AutoCAD is by far the most popular (Omura, 1987).

AutoCAD drawings are actually mathematical databases that describe the geometry of drawn objects. The position of each object in a drawing is stored as a series of coordinates in a database. The database is then translated into an image on the screen. Whenever a drawing view changes, usually when it is zoomed or panned, it must be regenerated by recalculating the values in the database (Omura, 1987).

Omura in his book "Mastering AutoCAD" described eight basic elements involved in creating and editing drawings using AutoCAD program:

a. Lines: automatically drawn to the smallest resolvable thickness on the video monitor, printer or plotter.

b. Circles: specified either with a center point and radius, or by entering any three points on the circumferences.

c. Arcs: which join three specified points.

d. Points: drawn to smallest resolvable solids, solid-filled quadrilateral or triangular sections.

e. Text: inserted at any point, to any desired size and rotation, with automatic positioning of multiple lines.

f. Repeats: allowing rapid construction of arrays of objects once drawn (or called in from disk) to specified number of rows and columns and separation between rows and columns.

g. Shapes: user-defined simple shapes that can be saved on disk and loaded into main memory as a library and then manipulated very rapidly.

h. Other drawings: can be called in from disk and inserted at any point in the current drawing at desired rotation, with different X and Y scaling if required.

In AutoCAD, drawings are created and edited either using a light pen, a touch pen and on-screen menu, keyboard commands, a digitizing tablet, mouse or any combination of all five. In this study all drawings are created using either a mouse, keyboard commands or a digitizing pad. A 11" x 11" Hitachi Tiger Digitizing Tablet was used to digitize the original hand-drawn base drawing.

Drawing aids: A full zoom capability allows work on the drawing at any level of detail. The portion of the drawing to be viewed can be specified either as a numeric factor of the whole, or by simply pointing to the lower left and upper right corners of the window desired. A pan command allows moving the display window up, down, right, or left, without changing the current scale.

A reference grid of dots, at any defined separation, can be displayed as an aid to alignment and positioning. In AutoCAD lines can be forced to run only horizontally or vertically. Also in AutoCAD, the distance between any two points or the area of the polygon enclosed by any number of points can be calculated and displayed automatically. The status and list commands display the current status of a drawing, or detailed characteristics of any objects within it.

Standard configuration for AutoCAD: A microcomputer

AutoCAD system consists of the following:

a. IBM PC (or PC-XT/AT or Compatibles) with 256K, 512K, 640K or more memory.

b. Two double-sided floppy disk drives, or one double-sided floppy and a hard disk.

c. IBM Color Graphic Adapter, with color or black and white monitor (minimum resolution 200 by 320 pixels). It was found out that the resolution is much better if a monochrome monitor is used. The reason for this is that, in the monochrome monitor, the Cathode Ray Tube (CRT) have only one color phosphor (usually green or amber) and the pixels are usually very close together. The color system has three electron beams, one each for the red, green and blue and it must be lit up by beams from three different guns. For instance, the red dots are separated by the green and blue dots, so the resolution is not as good in the standard color monitors as in the monochrome.

d. PC-DOS Version 2.0 or 3.0 operating system.

e. Digitizing tablet or mouse. Both digitizer and mouse were used.

f. Plotter. There are three kind of plotters that were used to plot the drawings generated from AutoCAD. The HP7475A plotter, the Houston Instrument DMP 40

Series and the HP 7580B. The HP 7475A plotter could plot only small size drawings (11"x17" or smaller). The DMP 40 series and HP 7580B could plot large size drawings and can, for example, use sheet sizes up to 24" x 36".

g. Intel 8087 Numeric Processor Chip (optional). This 8087 co-processor can speed up the operations especially when the computer is used for math and heavy number crunching and spread sheet operations.

CHAPTER 5. APPLICATION OF MICROCOMPUTERS IN MINED-LAND RECLAMATION PLANNING

Introduction

Developing a sequential, concurrent and integrated mined-land reclamation plan can be a complex task. It involves the interests of land owner and the mine operators. It should also respond to the needs and concerns of the community. A mining and reclamation plan that is developed after the deposit has been depleted or after the mines has been shut down is an "after thought" plan. Reclamation planning should be perceived as an integral part of the planned mining activity. It uses the mining operation as a means to carry out the reclamation which is also part of the total mine mitigation planning.

Various techniques or methods have been used by planners to communicate to the public or the mine operators the importance of reclamation planning. Graphic drawings have played a major role in this communication process. In the past, most drawings were created by conventional or manual techniques without computers. Microcomputers were used in this study to determine their effectiveness and compatibility in communicating the integrated reclamation methods and goals.

Vicinity Analysis

The importance of vicinity analysis

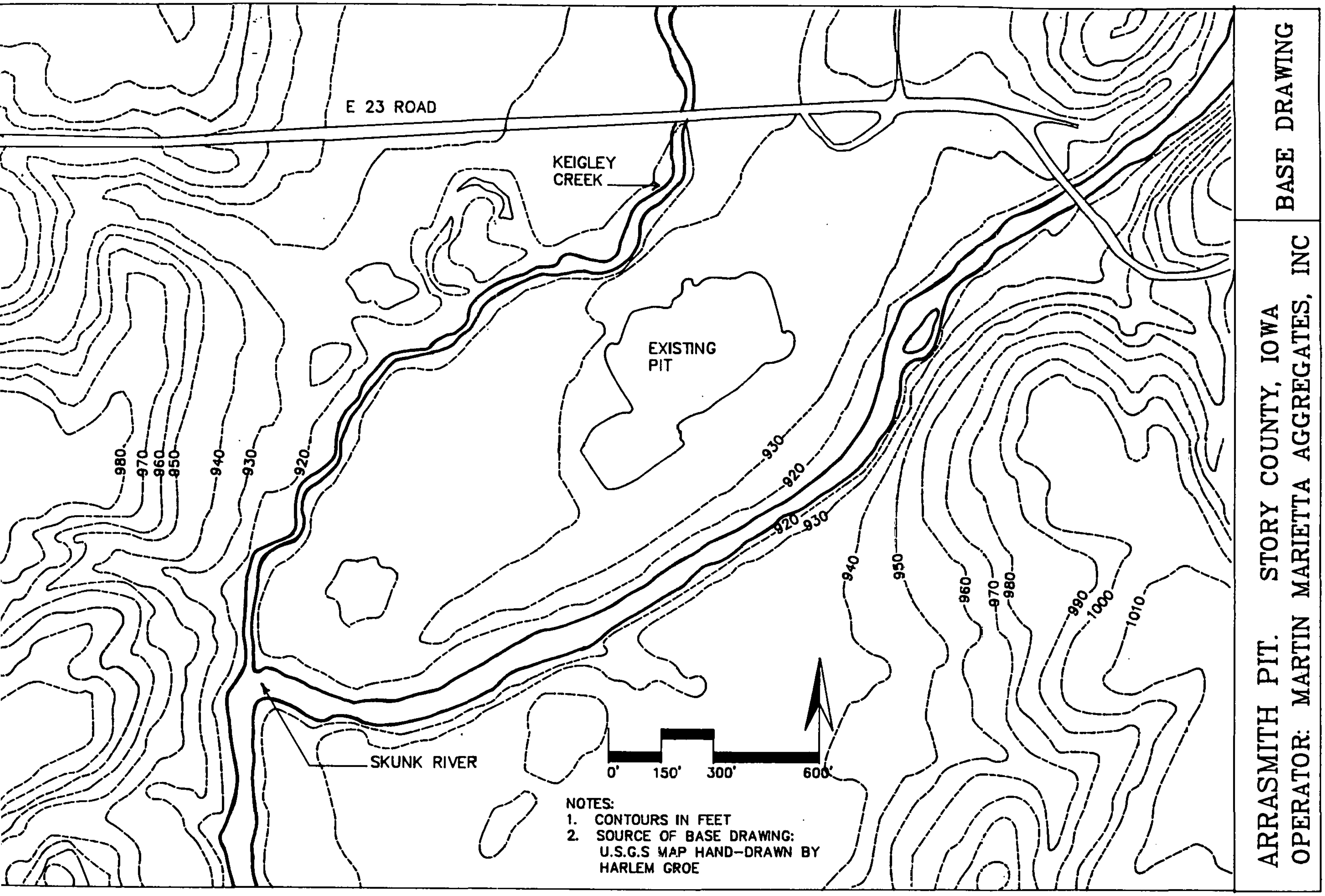
In mined-land reclamation planning, vicinity and/or location analysis are essential parts of the study. This analysis should be completed before a sequential mine operation and reclamation plan. This component of a reclamation plan in essence involves factors:

1. Landscape characteristics of the surrounding area.
2. The surrounding land use map.
3. Transportation network of the area studied.
4. Developmental growth trends.
5. Population.

There are many ways that microcomputer applications can facilitate studying the relationship between the mine site and the surrounding area. Remote sensing, aerial photo interpretation and computer digitizing are among the methods used to study the regional characteristics.

In this study Computer Aided Design (CAD) software was used to create the graphics and computations involved in the vicinity analysis. One of the most important documents involved in the vicinity analysis is the base drawing of the site and immediate area. See Figure 1.

Figure 1. Computer-generated base drawing


E 23 ROAD
KEIGLEY CREEK
EXISTING PIT
SKUNK RIVER
980
970
960
950
940
930
920
930
920
920
930
940
950
960
970
980
990
1000
1010
0'
150'
300'
600'
NOTES:
1. CONTOURS IN FEET
2. SOURCE OF BASE DRAWING: U.S.G.S MAP HAND-DRAWN BY HARLEM GROE
BASE DRAWING
ARRASMITH PIT. STORY COUNTY, IOWA
OPERATOR: MARTIN MARIETTA AGGREGATES, INC

Preparation of the base drawing

The base drawing is an important point of beginning in any kind of planning, including sand and gravel mined-land reclamation planning. Having a good base drawing is as important as having a good foundation before constructing a building. In this study, a U.S.G.S map of the Arrasmith pit and the surrounding area was blown up and drawn conventionally. It was later converted into a computer drawn hard-copy 24" x 36" or 11" x 17" sized paper (refer to Figure 1 for 11" x 17" size base drawing). The Hitachi Tiger digitizing tablet (size 11"x 11") and an IBM PC/XT/AT and compatible microcomputers were used. The purpose was determining the compatibility or incompatibility of microcomputer generated base drawing as compared to a conventionally drawn base drawing. The comparison of computer-generated and conventional techniques will be discussed in a later section.

In this study, a minimum of fifteen to twenty hours was required to complete the task of digitizing the base drawing and configuring and calibrating the digitizing tablet. This does not include the editing part of the task and the length of time varies depending on the size of the area studied.

Before a digitizing tablet can be used to digitize the hand-drawn base map, it has to be configured and calibrated to conform to the size of the base map that is going to be digitized. Graphics tablets or digitizers come in many sizes ranging from 6 x 6 inches up to 60 x 40 inches (Carberry, 1985). Unless a large size digitizer, such as 60 x 40 inches is used, a large size base map must be sub-divided and digitized in several smaller sections. The descriptions that follow explains the methods of digitizing the base drawing and how to configure and calibrate the digitizing tablet to correlate with the size of the base drawing.

Methods of digitizing the base drawing: The program used for this purpose is AutoCAD version 2.62. Methods of digitizing the base drawing will be sub-divided into two stages.

Stage one is the "To Begin A New Drawing".

a. In this stage, the new drawing will be named "Base".

b. Limits to the drawing are set using the root directory command "LIMITS". In this study, a limit of 36" for the X axis, 24" for the Y axis is used for the base drawing.

c. Setting units for the drawing is also required in AutoCAD. Setting units does two things to the drawing: (1) sets up the input format for entering distances and angles from the keyboard and (2) sets up the output format AutoCAD will use when displaying distances and angles. This is accomplished by using the command "UNITS" in the AutoCAD program. For this base drawing, a decimal systems is used for the units rather then the architectural units.

d. Set grid by pressing F7 key or ALT. G in the AutoCAD program.

e. Also set coordinate display by pressing F6 key or ALT.D. Setting grid and coordinate to "on" is important because the program will give directions for drawing or digitizing a drawing. These will be displayed on the video monitor.

Stage two is setting up several working layers.

In this base drawing, a total of 13 layers were used. For example, for contour line drawing, layer can be called contour or "C" with "hidden 1" linetype and color white (7). If the color white is chosen for the contour, the output or the hardcopy will be in black dashed lines which will represent existing contour lines. Other layers can be created for text, river, and project boundary lines. The "layer" command can be found in the root directory command of the AutoCAD program.

Configuring and calibrating the digitizing tablet for a base drawing: Use the "tablet" command, either by screen menu or enter through keyboard.

a. Choose "CFG" (Configure) to begin configuring the tablet, and locate the upper right hand corner of the tablet to determine the active drawing area on the digitizer surface.

b. The next step is to choose the "CAL" (Calibrate) option to calibrate the specific drawing scale to be digitized. Make sure to locate the exact coordinate on the original drawing to be transferred to the screen.

When stage one and stage two are completed, the program is ready for any task that needs to be performed. In this case, start drawing the contour lines.

"POLYLINES" is the best option to be used in drawing contour lines because they can be manipulated later to form a smooth and continuous curve by using a sub-command named "PEDIT" in the AutoCAD program (Polyline Edit under the Fit Curve option). Raker and Rice (1988) in "Inside AutoCAD", describe polylines or PLINE (in AutoCAD command) as a single drawing entity that includes line and curve segments. PLINE has the capability of drawing two basic kinds of segments: straight and curved.

In this study, an attempt was made to digitize the hand-drawn base map and make a computer-generated base map match it. The major problem in pursuing this task is getting a uniform, smooth, dashed lines that represents existing contour lines on the hand-drawn base map. However, this problem can be solved by picking points along the contours that are close and uniformly spaced. A good device in achieving this task is using the cursor on the digitizer instead of using the keyboard. In this study, points on contours were selected at intervals of 1/4" to 1/2" to achieve contour lines that have evenly spaced dashed lines. Another option is to set the line scale (LTSCALE) to a certain value so that the dashed line will appear short enough to represent contour lines when the final paper plot is done. The line scale also can be set to be a default value by using the LINETYPE command; however, this will involve a re-programming procedure.

Determining the area of the site using a microcomputer: AutoCAD can be used when the area of the site is required. This is the case with the Arrasmith Pit where the area is divided into two portions: (1) the existing mine site and (2) the area for future expansion. With conventional techniques, a hand operated planimeter is often used to measure the area. AutoCAD has the ability to quickly measure the areas, so this device is not needed.

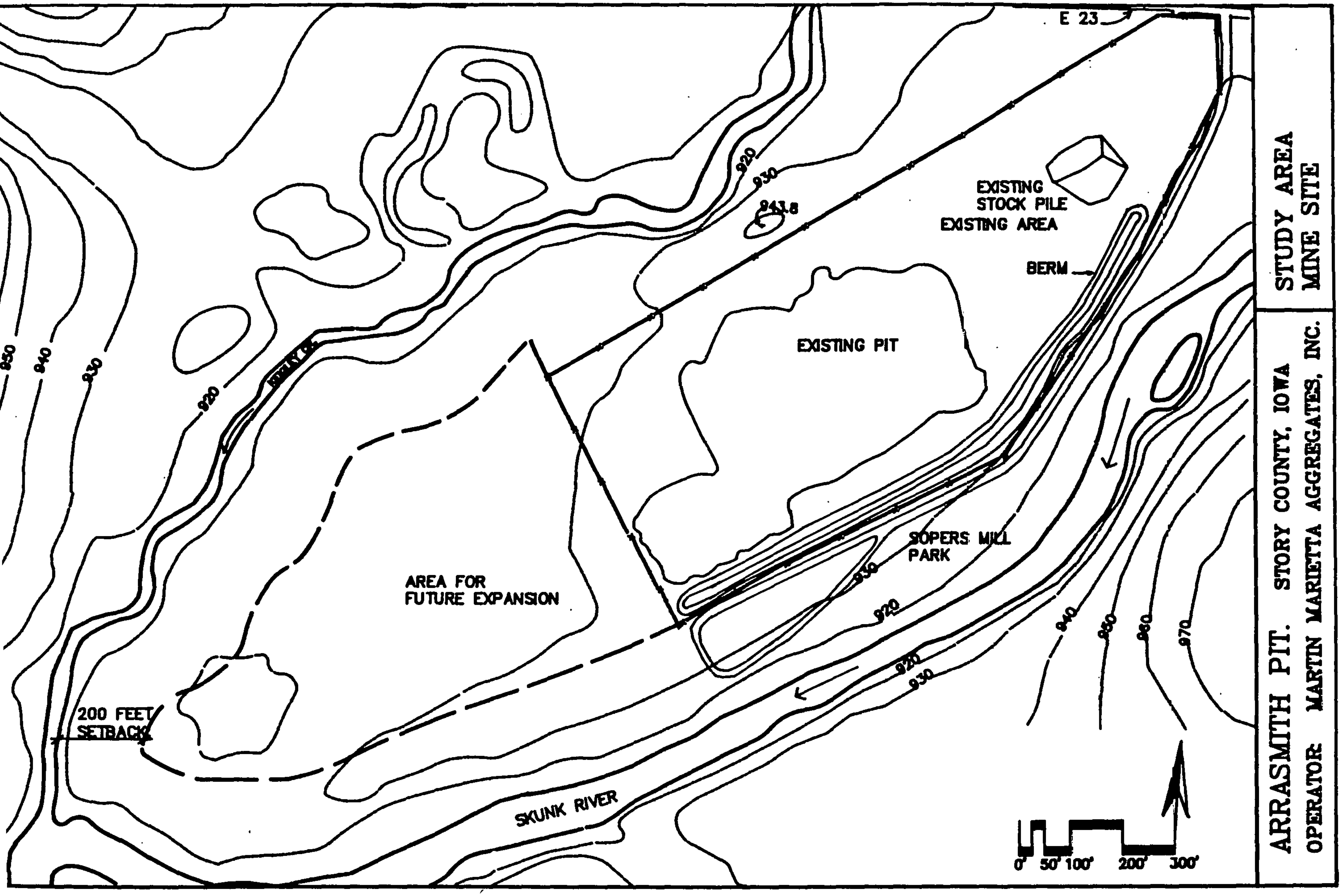
The method is very simple. Use the command "Area". AutoCAD asks you to select an entity such as a pline, circle and automatically calculates its area. In this case, a cursor or mouse is used to pick a point on the entity. With a planimeter, the pointer of the planimeter is used to circle the entire perimeter to get an accurate reading. The time needed to find the area of this mine site using the AutoCAD command "area" is less than a minute. If a planimeter is used, the time required is much longer about ten to fifteen minutes depending on the size of the drawings. This illustrates how an off-the-shelf program like AutoCAD is superior to conventional techniques not only in terms of time, but it also has a high degree of accuracy. Figure two illustrates the area of the existing pit, and the area of the future expansion of the Arrasmith Pit. A detailed description of this site is discussed in Chapter Six.

Site Analysis

The importance of site analysis

In planning for concurrent sand and gravel mines operations and reclamation, site analysis is critical. Site analysis inventories on the details and facts of the site and surroundings. This information is then analyzed to determine the potentials and limitations in mining, landforming, reclamation and mitigation and also their implications in planning post mining land use of the sand and gravel site. In this analysis, soil types, deposit characteristics, surface drainage, vegetative cover, access

Figure 2. Study area of the mine site

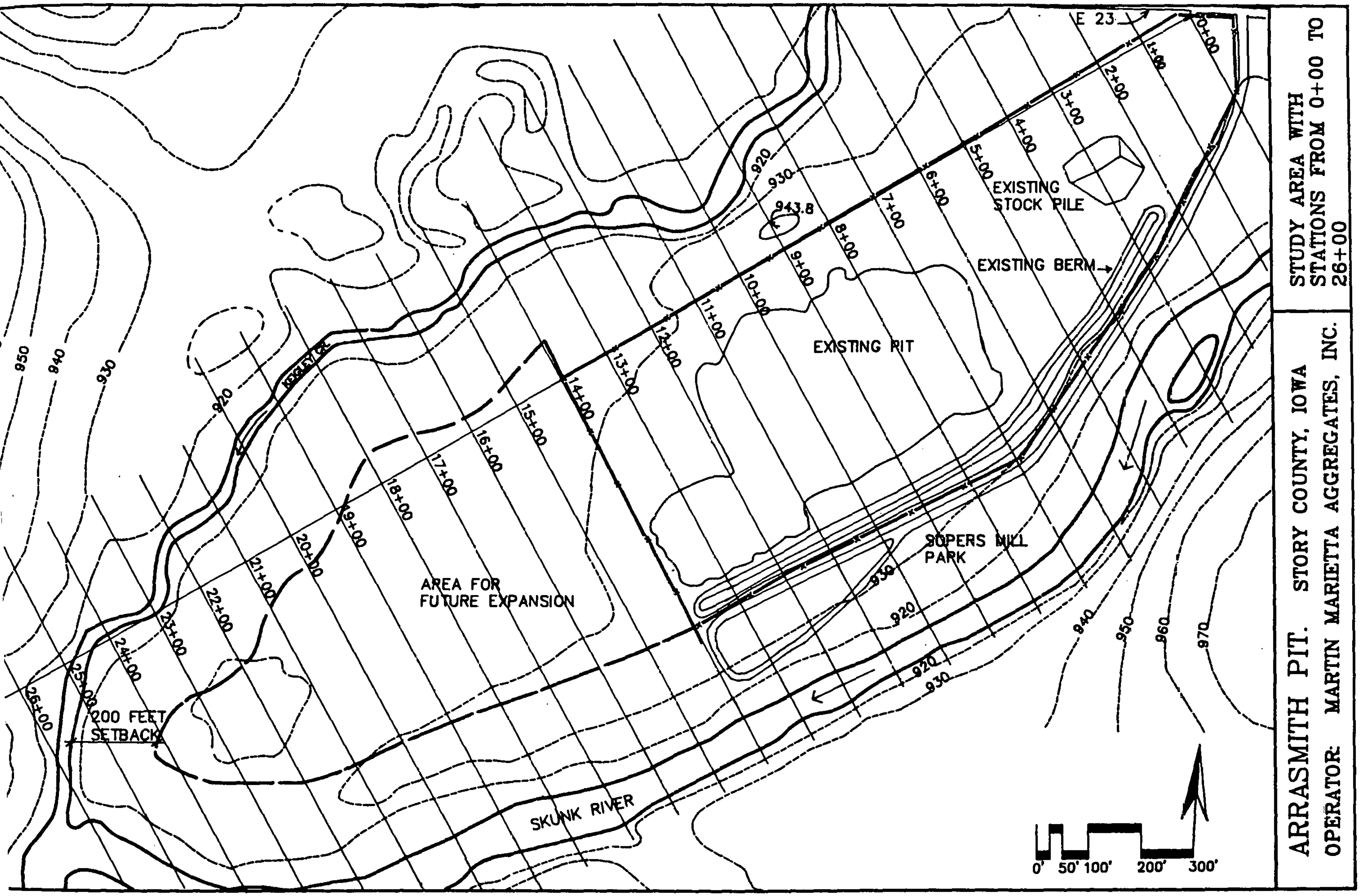

E 23
920
930
943.8
EXISTING
STOCK PILE
EXISTING AREA
BERM
EXISTING PIT
SOPERS MILL
PARK
AREA FOR
FUTURE EXPANSION
200 FEET
SETBACK
SKUNK RIVER
950
940
970
0' 50' 100' 200' 300'
STUDY AREA
MINE SITE
ARRASMITH PIT. STORY COUNTY, IOWA
OPERATOR: MARTIN MARIETTA AGGREGATES, INC.

to the site, topography, and visual analyses are some of the relevant factors that are considered. The recommendations at the end of the study will be directly influenced by the above factors.

Site analysis can also be categorized into two phases. The first phase is an inventory phase, in which all relevant site data, maps and other information are assembled and drawn to the same scale (Laurie, 1981). Good graphics can play a major role in determining the success of this first phase. This can be achieved by having an appropriate base drawings of the existing condition in the form of plan drawings, sections, and profiles.

In this phase the study area plan drawing (Figure 2) is again retrieved and used to produce another study area plan drawing with 100-foot stations along a baseline (Figure 3). It is along this baseline that profiles and sections were computed and drawn. Section drawings from station 0+00 to 26+00 showing the existing topography of the entire site were included in the Appendix A. The application of computer aided design to site analysis can help planners analyze the site with the flexibility to add, delete, and modify the analysis as needed. Previous drawings can be saved, edited, stored, retrieved, changed, and additional drawing objects and layers can be included.

Figure 3. Study area of the mine site showing the stations from 0+00 to 26+00


E 23
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00
23+00
24+00
25+00
26+00
943.8
EXISTING STOCK PILE
EXISTING BERM
EXISTING PIT
SOPERS MILL PARK
AREA FOR FUTURE EXPANSION
200 FEET SETBACK
SKUNK RIVER
950
940
930
920
960
970
0' 50' 100' 200' 300'
ARRASMITH PIT. STORY COUNTY, IOWA
OPERATOR: MARTIN MARIETTA AGGREGATES, INC.
STUDY AREA WITH STATIONS FROM 0+00 TO 26+00

The second phase is the site assessment phase. In this phase, functional, physical and all the visual values and relationships, feelings, and moods are recorded and evaluated (Laurie, 1981). This assessment stage provides information required to determine the limitations and opportunities in land development and their implications in planning the ultimate use of the site. The data that are obtained from this assessment is used to formulate concepts and result in a set of recommendations for the concurrent sand and gravel mine operations and reclamation planning of the study site.

There are three major components of the site analysis that will be discussed here: accessibility, topography, and visual resources. These three are major components from among the many factors that influence the study of the site analysis.

Accessibility: In concurrent mining operations and reclamation planning, accessibility of the study site is a critical element of the site analysis. Even though sand and gravel, like many other non-renewable resources can be extracted only where nature placed the deposits, access to the site is also crucial in determining the actual location of the mines. Many sand and gravel mines are located near urban centers which enables mine operators to market their products while minimizing transportation costs. Sand and gravel are bulky, heavy low cost materials, and the transporting or hauling distance from the plant to the consumer has a direct relationship on the price of the final delivered product and in determining economically accessible deposits (Swanson, 1982).

A good location map is always included as part of the site analysis. The preparation of the location map using a microcomputer is much faster than digitizing the contour lines for the base map as described in the vicinity analysis. Configuring and calibrating the digitizing tablet can be omitted in this process because a location map can be computer-generated by the use of "mouse". In this study, "Logitec" mouse using a serial port on the computer was used for the preparation of the location map. Figure 4 illustrates the computer generated location map of Arrasmith Pit in Story County, Iowa.

Computer-drawn location map using AutoCAD program: The following will illustrate the commands using the mouse:

a. Sizing up the drawing. Before a mouse can be used to draw a line or an arc, the size of the drawing has to be determined. Use the pointer to pick the SETTINGS key from the ROOT MENU. Look for the LIMITS on the SETTINGS screen menu. Pick LIMITS. If a keyboard is used, just type "limits". Use X=0, Y=0 (in Cartesian coordinates) for the

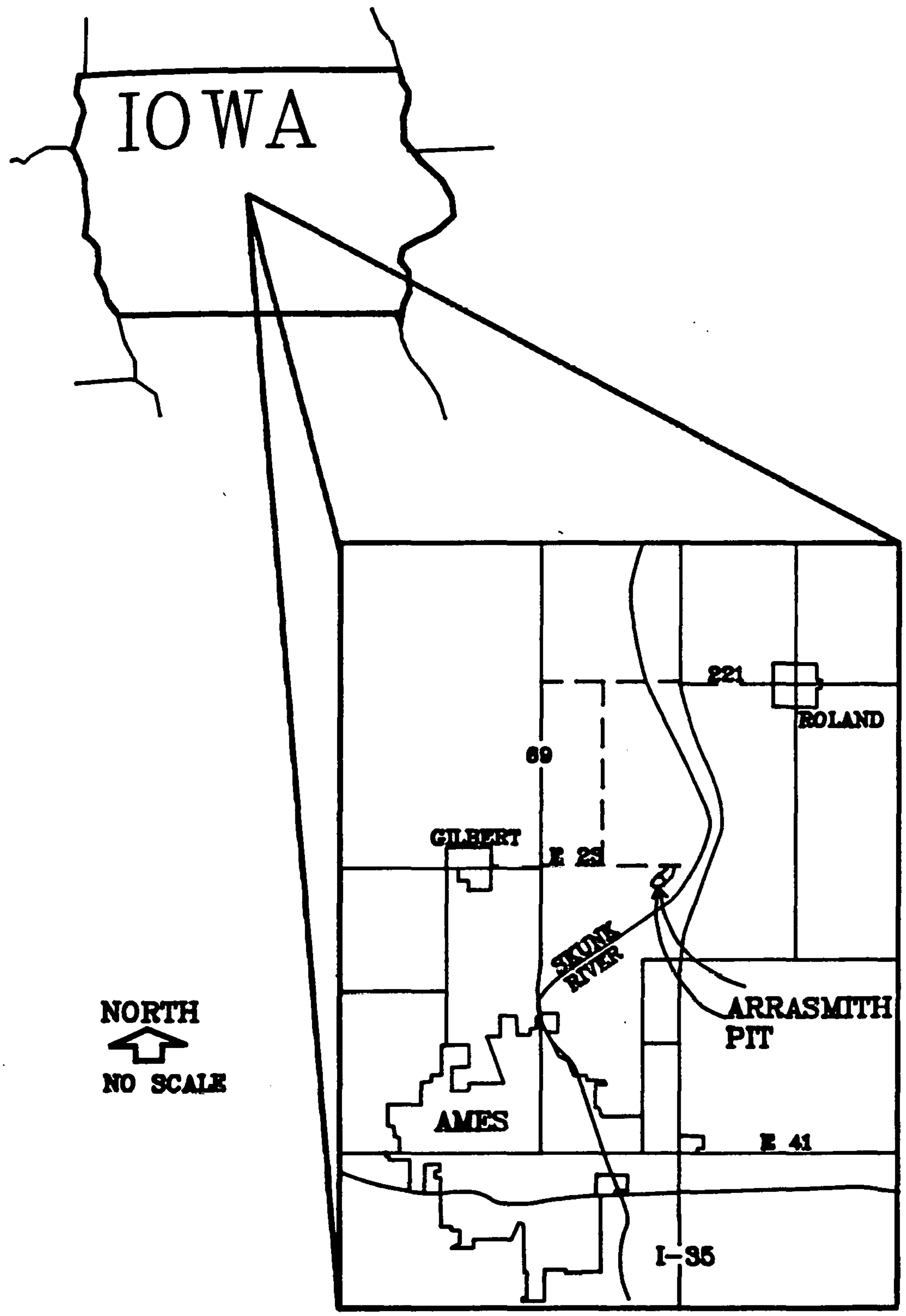


Figure 4. Computer generated location map of Arrasmith Pit

lower leftmost boundary of the drawing.

b. Set UNITS. This is the second command that is required when AutoCAD program is used to generate the computer-drawn location map. Setting UNITS does two things for the drawing:

   i. Sets up the input format for entering distances and angles from the keyboard.

   ii. Sets up the output format AutoCAD will use when displaying distances and angles.

Go to the ROOT MENU to SETTINGS, pick "next", and then pick UNITS to set up a unit system. In this drawing a decimal system was used.

c. When the limits and units have been set up, the mouse can then be used to draw the location map. In this process, a digitizing tablet is not used.

d. There are many commands in AutoCAD that can assist the user or the designer to accomplish the computer-drawn location map. Among them are the line, pline, edit and pedit commands.

Topography: In sand and gravel mining operations and reclamation planning, the study of the topography of the site is also an important factor to consider before any concurrent reclamation can be planned. Topographic information is beneficial in identifying areas with limitations for certain land uses due to the steepness of slopes and for identifying areas where soil erosion may be a concern. The Arrasmith Pit, which lies within the 500 year flood limits of the Skunk River, is also located in an area which relatively flat with 0 to 2 percent slope. These flat slopes or gradients does not pose any environmental constraints because they present no prohibitive construction limitations. The Story County Planning and Zoning Commission characterized slopes of 9 - 14 percent as moderate and slopes of greater than 14 percent as 'severe' limitations to construction (Story County Planning and Zoning Commission, 1988).

To landscape architects, planners and others who are directly involved with the mining industry, they perceive the study of topography as being as important as other components of site analysis. The information on the type of topography of the site may be used to develop policies to manage the type of processing plant that may be used, the phasing plan for the concurrent mining operations, landforming, reclamation, and the opportunities for the final land use.

To achieve the above, graphics mode could play a very important role in studying the topography of the area. Topographic drawings which combine mechanical drawing with considerable free hand drawing or computer generated drawing will pictorially express large amounts of information as efficiently as possible. One of the topographic drawings is the contour map which represents the "lay of the land" by showing land surface elevation. There are many types of topographic maps, but the three major types are culture, relief, and hydrographic topographic maps (Laurie, 1981). A culture topographic map represents features that are man made and describe such things as highways, railroads, bridges, fences, towns, cities, houses and property boundaries. Relief topographic maps show and contrast the landforms, surfaces, and features such as mountains, hills, valleys, and plateaus. Hydrographic topographic maps depict the depth of the oceans, lakes, pits and rivers and are usually used for navigational and commercial purposes (Laurie, 1981).

In sand and gravel mined-land reclamation planning, all three types of topographic maps are useful and microcomputers can play a major role in achieving good topographic maps. Microcomputers can assist planners, landscape architects or mining operators to produce an accurate topographic maps which later can be used to produce a perspective drawing of the site.

Visual resources: Visual resources are composed of numerous natural and man-made elements forming a visual scene. In sand and gravel mining, visual resource management methods analyze the visual impact of the mining operation and help locate and design facilities so that they will not be visually obtrusive to the public. Baxter (1969) in his article "Site Planning for Sand and Gravel Operations", states that vision in motion is most important consideration, especially because many sand and gravel sites are located in urban areas and most public observers view the mining operation during highway travel. Therefore, the primary objective of visual analysis is to study the visual impact due to the mining activities that has been carried out at the site. It is from this study that a design concept could be established with the main aim to locate the processing plant, stockpile, or other visible elements at a location where it will not be visible from nearby roads or house.

One method that can be used to study visual qualities is computer simulation techniques. Computer simulation techniques usually involve a powerful microcomputer, minicomputer or workstation in order to get a highly sophisticated visual analysis (color, shadow, motion, weather effects, and so on). For example, the computer used to generate the visual simulations for the Red Mesa project in Colorado is the Silicon Graphics IRIS 2400 (Visual Resource, Inc.). This study does not use computer simulation techniques because of the unavailability of the equipment, expertise and software.

Deposit Analysis

Sand and gravel deposits occur in two basic land forms: hilly and flat. In these two landforms are two basic types of mining operations: dry and wet. In a dry operation, most sand and gravel mines are located in hilly areas. Excavation seldom continues below ground water table in this type of deposit (Jensen, 1967). The resultant pit form is steep-banked on three sides with the height of the bank diminishing toward the initial point of excavation (Bauer, 1965).

Many sand and gravel mine operations in Iowa utilize wet operations because they are located within the floodplain or terrace of a river or stream. The author has worked on the Arrasmith Pit, Manatt's sand and gravel mines in Tama, Iowa, and the Libertyville Pit in Illinois. All are located within the floodplain of a river or stream. The result of the excavation in these wet operations is a water filled pit which is walled on four sides, the 'visual' depth of which depends on the elevation of ground water. Alluvial sand and gravel deposits are generally composed of material ranging from 90 percent sand to 90 percent coarse aggregates (Bauer, 1965). The deposits depth range from five feet to 200 feet. The Arrasmith Pit has a deposit depth of 20 feet to 30 feet with 10 feet of overburden covering above it.

Sources of sand and gravel

Sand and gravel are formed as the result of the breaking-up of pre-existing rock material. It consists of unconsolidated mineral and rock particles resulting from the erosive forces of water, wind and ice (Werth, 1981). The distinction between sand and gravel is based on particle size. Sand grains range in size from 0.06 mm to 2.0 mm which is small enough to pass through a screen with a one-quarter-inch square opening and be retained on a screen with 200 meshes per square inch (Bauer, 1965). The size range for gravel is commonly considered to ranges from 4 mm to 64 mm (Goldman, 1975).

Sources of sand and gravel include fluvial, glacial and glacial-fluvial, marine and residual deposits. Fluvial and alluvial deposits are those formed by stream action. These deposits usually contain a wide range of well sorted material. The thickness of the beds varies considerably, and may range from 2 or 3 feet to over a thousand feet deep. Glacial deposits are formed as a result of several past glaciation coverages. Glacial-fluvial deposits are those transformed, reworked and deposited by the meltwaters from the glacier (Beard, 1984). Marine or lake deposits include deltas, bottom deposits, and terraces. These deposits are frequently well sorted and an important source of construction aggregate. Residual deposits are formed by in-place weathering and disintegration of bedrock material. The deposits contain an unstratified mixture of particle sizes from clay to boulders.

Earthwork computation using microcomputers

One aspect that microcomputers can be of benefit in planning for sand and gravel mine operation and reclamation is earthwork computations. There are many different software programs available that can assist in doing the earthwork computation. Among the more popular in the Department of Landscape Architecture is Earthwork II+ which is a software program design only for earthwork computation and is not a CAD program. In this study, AutoCAD is used to do the earthwork computations. The command that is useful in this CAD program is "area" and "distance" command. By knowing the depth of the top soil, overburden and the deposits, AutoCAD can assist the researcher to measure or calculate the area. The volume of deposits and overburden can then be computed.

Take for example the Arrasmith Pit. Using the command "area" in the AutoCAD program, the future expansion area is computed to be 41.370 sq. inches. With the original scale of the plan (1 inch = 100 feet), and the depth of deposits and overburden (20 feet and 10 feet respectively), the volume of deposits and overburden that will be available can be calculated. The information on the depth of the deposits and overburden were obtain from Martin Marietta Aggregates, Inc.

1. Area of future expansion:

$$\frac{41.370 \text{ sq.in} \times 100 \text{ ft.per in.} \times 100 \text{ ft.per in.}}{43560 \text{ sq.ft. per acre}}$$
$$= 9.49 \text{ acres.}$$

2. Volume of deposits that will be available:

$$\frac{41.370 \text{ sq.in} \times 100 \text{ ft.per in.} \times 100 \text{ ft.per in.} \times 20 \text{ ft.}}{27}$$
$$= 306,444 \text{ cu.yd.}$$

3. Volume of overburden that will be available:

$$\frac{41.370 \text{ sq.in} \times 100 \text{ ft.per in.} \times 100 \text{ ft.per in.} \times 10 \text{ ft.}}{27}$$
$$= 153,222 \text{ cu yd.}$$

Operational Analysis

Sand and gravel operations are in a unique situation for reclamation. The mining process utilizes heavy earth moving machinery. It often has large volumes of material unsuitable for marketing (such as overburden, fines and waste sand) which is available for creating functional landforms. Johnson (1966) states that each operational step contributes in its own way to the production of sand and gravel and each step also offers opportunities for site development.

Sand and gravel operations are typically located in or near urban areas. The main reason is to minimize transportation costs. Sand and gravel are bulky, heavy, low cost materials. According to Swanson (1982), the materials that have to be transported to a customer located 20 to 25 miles away from the processing plant will double the final cost per ton of the material.

Bauer (1965) states that the size of an operation is influenced not only by the size of the deposits but also by local demand, property boundaries, zoning restrictions, jurisdictional boundaries and permanent surface developments particularly residential and commercial development. Sand and gravel pits can range from 10 to greater than 1000 acres, but most sites fall in the 100 to 500 acre range (Bauer, 1965).

There are four basic steps in a sand and gravel mining operation (Figure 5):

1. Stripping of top soil and overburden
2. Excavation or extraction of sand and gravel
3. Transportation from pit to processing plant and from processing plant to market
4. Processing

1. Stripping of top soil and overburden: This process is the beginning of a sand and gravel operation. It involves the removal of vegetation and any material covering the deposit which is usually the topsoil and the overburden. The stripping of top soil and the overburden from the entire

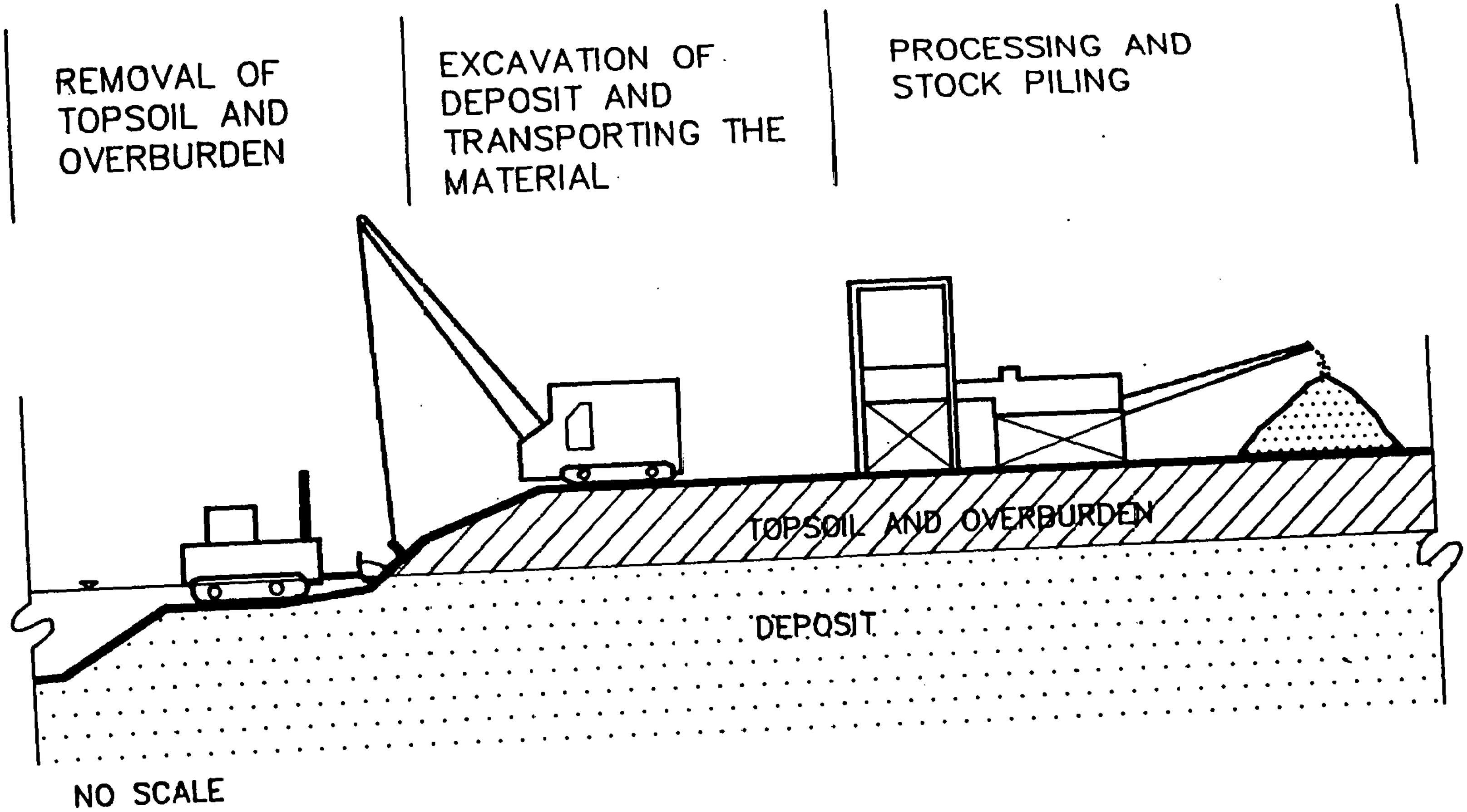


Figure 5. Operation Plan

area to be mined is not done at one time. Generally, the mine operator has to comply with the mining plan and only the area covering the anticipated yearly excavation is stripped. The top soil that is stripped from the site is either sold to local nurseries and home owners or stockpiled to comply with reclamation requirements for regrading and revegetating the site. The equipment used to strip off the top soil and overburden depends also on the size of the operation. Larger operations generally use front-end loaders, scrappers and draglines, but smaller operations like the (Arrasmith Pit) use only a dragline to strip off the topsoil and overburden.

Excavation: Extraction of sand and gravel in Iowa and at Arrasmith Pit is by open pit mining. Excavation is a process that involves the removal of material from the sand and gravel deposit for transport to the processing plant (Bauer, 1965). Sand and gravel deposits above the ground water table are mined with combinations of several types of equipment such as: power shovels, tractor scrappers, front-end loaders or draglines (Goldman, 1975). Deposits that occur below the ground water table (as at Arrasmith Pit) can be excavated with clamshells, dredges or draglines. Again, the use of equipment also depends on the size of the operations. Larger size operations might use a combination of all three mentioned above, but smaller operations (like the Arrasmith Pit) may use a portable dragline to accomplish the work.

Transportation: Transporting the material from the excavated area to the processing plant also depends on the size and method of the mining operation. The equipment used to transport the material can be trucks, tractor scrappers, front-end loaders or conveyor belts. Small size operations may use just trucks or front-end loaders to transport the material from the pit to processing plant and processing to market.

Processing: The processing plant is the heart of sand and gravel operation. Small size operations like Arrasmith Pit use portable processing plants. This type of processing plant can be moved from site to site and is capable of producing only a limited range of grades. The portable processing plant in the Arrasmith Pit utilizes only a screener to remove the sand from the gravel. But the processing plant in Tama, Iowa, operated by Manatts uses a more complex fixed processing plant which consists of screener, log washer, classifier and crusher.

Zoning and Other Related Regulations

Counties and municipalities can regulate sand and gravel operations, as well as other land uses, through land use and zoning control powers granted to them by the states.

Zoning was originated as a means to control nuisance operations and protect the public health, safety and welfare of the people (Beard, 1984). For example, in Story County where the Arrasmith pit is located, the Story County Board of Supervisors in June 1978 adopted an amendment to the County's "Land Use Policies, Zoning Ordinance, and Subdivision Regulations". The amendment created a Greenbelt/Conservation District zoning classification (Patchett, 1982). Patchett (1982) states that the basic intent of a Greenbelt/Conservation Zoning District is to promote water quality and conservation to protect aquifers, alluvial soils and slopes, and to protect areas which possess outstanding scenic, vegetation, wildlife habitat, travel corridors, geological, historic or recreational values.

Mineral extraction and reclamation in the greenbelt areas is allowed as a conditional use. As a conditional use, mining operations are subject to a set of specific requirements in addition to the general requirements of the use district. Conditional use provisions stipulate permit application requirements, public hearings, permit grants conditions, permit renewals, and may include operation and reclamation standards. Operating standards can cover days and hours of operation, buffer widths, screening, fencing, dust, noise, erosion and water pollution control, and truck traffic. Reclamation standards can cover the phasing plan or mining plan, slope gradients and treatments, revegetation, regrading and creating large water bodies.

Public Awareness and Concerns

Public awareness and concerns may not directly restrict sand and gravel resource supplies, but has provided the driving force for more strict regulatory control of the sand and gravel industry. As mentioned previously, many sand and gravel operations are located in or near the urban areas. Regardless of the location, sand and gravel operations are always subject to rules, criteria, and requirements that have to comply with community and county zoning ordinances and/or state and federal laws established to protect and secure the welfare and health of the public.

Sand and gravel operations do not require blasting but there are other factors that were raised by the public concerning sand and gravel operations. Among the concerns are noise generated by truck traffic or the processing equipment, dust and the unsightliness of the operations. Baxter (1969) categorized public awareness and concerns into three types:

1. public safety
2. atmospheric nuisance
3. surface contamination

Public safety

Baxter (1969) defines public safety hazards as any object or activity which involves risk or a chance of danger. Sand and gravel operations do not produce any extreme public hazards such as vertical cliffs and/or fly rock as in limestone quarries. However, in sand and gravel operations, vehicle circulation and hazardous land forms and water bodies are common concerns among the public.

Of the total amount of construction sand and gravel produced, 52 percent is transported from the plant to the consumer by truck, 2 percent by waterway, 1 percent by rail and 45 percent by other means of transportation (Mineral Yearbook, 1986). Therefore, a poorly design entry or lack of entrance definition could result in vehicle congestion and hazardous movement problems (Baxter, 1969).

Atmospheric nuisance

As has been mentioned, trucks are the major means of transporting of sand and gravel from the processing plant to the customers (Mineral Yearbook, 1986). Truck traffic raises dust and is noisy. The noise problems come not only from traffic, but also from the mechanized mining activities. The Arrasmith Pit has problems related to dust and noise due to trucks and the dragline, according to the Story County Zoning and Planning Commission. There are a number of ways that dust and noise could be minimized.

frequent watering of the unpaved, paved or gravel road can reduced the dust problem. Some noise problem can be limited by limiting the hours of operations and/or no operation or hauling at night. In terms of noise that generated from the equipment such as a dragline or dredge, the use of electrically operated machines instead of diesel motors can greatly reduce the noise generated (Johnson, 1966).

Surface contamination

The third category that raises public awareness or concerns is surface contamination. This could result from the hauling of sand and gravel by trucks over the streets and highways and from the condition in which the land is left after completion of operations (Baxter, 1969). Baxter (1969) states there are three primary causes of contaminations: soil erosion, deposition, and material spillage. Soil erosion which can occur due to excavation process could contribute to water contamination by discoloring the water to nearby streams and rivers. Material spillage involves the dropping of undesirable sands and gravels upon public highways. Poorly drained vehicle routes within the site can produce considerable amounts of mud which can be carried on to public highways.

Concept Development

Six major components have already been discussed: vicinity, site, deposits, operations, zoning ordinances and public concerns. Inventory and analysis help planners and/or researchers synthesize the information and later develop the concepts for the concurrent sand and gravel mining operations and reclamation planning. The planning design concept developed for the site should integrate the mining operations with the potential land use selected for the site.

The concept of integrating the mining operation and reclamation program should emerge from the goals and objectives of the mine operation and reclamation plan. These goals and objectives are to be developed from the analysis discussed previously.

Typical goals for the sand and gravel mining operations and reclamation planning could include the following:

1. Maximum utilization of the deposit.
2. Minimum second handling and hauling distance of material for landforming and reclamation.
3. Enhanced visual image of the mining operations.
4. Maximum cost effectiveness of the mining operations, reclamation and mitigation (Dietrich, 1986).

These and other goals must be established by the mining operators taking into consideration the needs and concerns of society and local government agencies (for example, the county planning and zoning commission).

The planning design concept(s) for a sand and gravel mining operation and reclamation also emerge from the objectives or the specific targets used to achieve the project goals. Some of the objectives for a sand and gravel mine operation and reclamation planning could include the following:

1. Mitigate visual, social, and environmental impacts brought about by the mining process and thereby project a positive image of the operator and the mining industry to the public.
2. Prevent off-site water pollution, erosion and sedimentation around the project site due to mining activities.
3. Blend in the mining operation with the existing landscape and its landform and vegetation.
4. Mitigate and control fugitive dust from truck traffic and/or processing plant as much as possible.

There are many different techniques by which goals and objectives mentioned above can be achieved. For example, the visual impact of the processing plant and the mine site can be mitigated by the following:

1. Providing transition or buffer zones. This can be achieved by the use of existing vegetation.

2. Use of earth berms for visual screening.
3. Combinations of vegetation and earth berms for visual screening.

Design and landforming

The mitigation measures mentioned above involve designing and landforming activities and this can be more clearly described and communicated with graphics. In this study, microcomputers were again used to generate the details of the landforming activities that will help mitigate the visual, social, and environmental impacts to the site and vicinity.

One computer program that has potential uses in sand and gravel mined land reclamation planning for landform studies is "Surfer". This user friendly program can be used on any IBM PC/XT/AT or compatible and is very helpful in studying landforms and topography of the project site by creating three-dimensional perspective drawings of the land surface.

In this study, the Surfer program was used to transform the computer generated base drawing of the study area into perspectives drawings (Appendix B). The process employed in this techniques includes the following:

1. The base drawing which uses the scale of 1"=200' is divided into grid squares of 23 rows and 30 columns. Each grid square has an actual dimensions

of 75' x 75'. The 23 rows and 30 columns of the grid squares represent the X axis and Y axis.

2. The elevation at each grid line intersection represents the Z axis and is interpolated from the contour map.

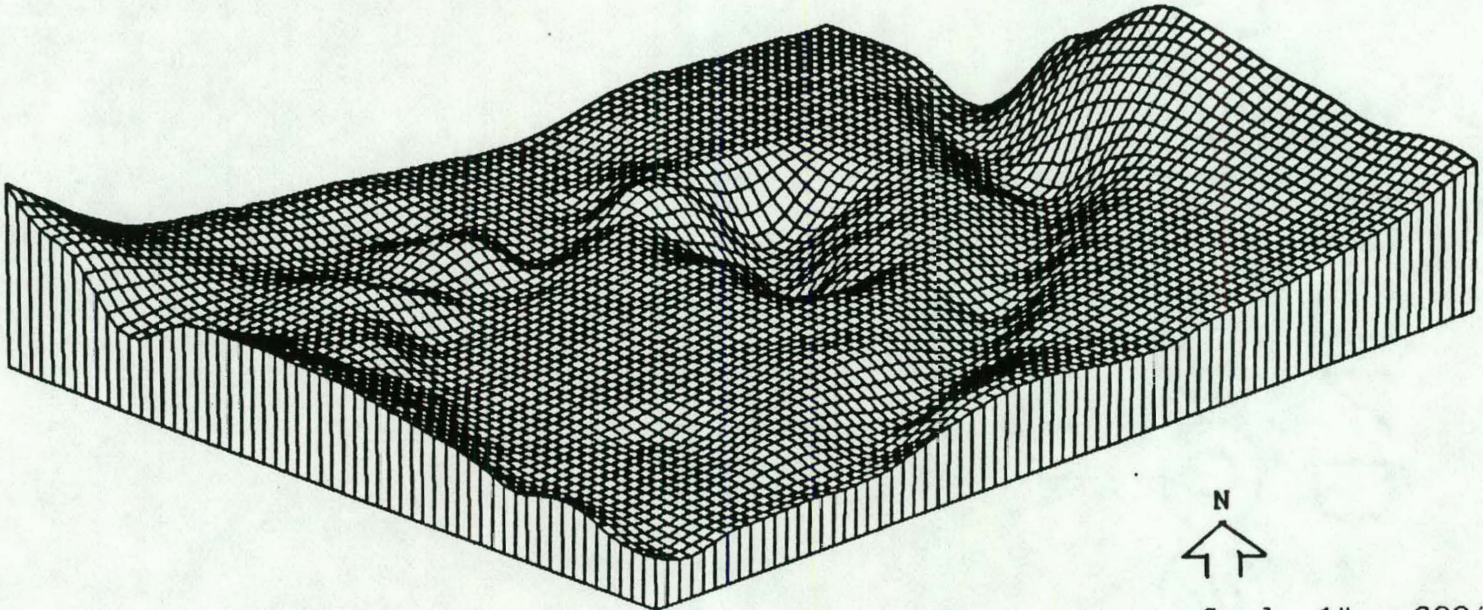
3. Choose the command "Grid" from the main menu and type in all the X, Y, and Z data coordinates. The "Grid" command creates a grid file for "Surf" which is another command in the main menu.

4. Exit the "Grid" program and enter the "Surf" program. In the "Surf" program there are eleven sub-commands to choose before a perspective or orthographic drawing can be created. Among the important ones that were used in this study were "input", "view", "linetype", "base", "title", "axes", and "output". Use the "input" sub-command to specify an input grid file to plot. Use the "view" sub-command specify the projection type and viewing parameters. The two types of projections are orthographic and perspective drawing. Use the "linetype" sub-command to specify surface line direction and type. Use the "base" sub-command to specify parameters for opaque surface base. The "title" sub-command gives the opportunity to add a map title and orientation legend to the plot. Use

the "axes" sub-command to specify X, Y, and Z parameters. Finally, the "output" sub-command creates a plot file to send to a hard copy device (printer or plotter).

5. After the appropriate sub-commands are chosen, exit the "Surf" program. Go back to the main menu and choose the "View" command. The program will ask for the name of the plot file before the perspective or orthographic drawing can be seen on the screen.
6. To plot this perspective drawing, exist the "Surf" program and go back to the main menu and choose the "Plot" command.

Figure 6 shows the perspective drawing of existing topography at Arrasmith Pit and the surrounding area using "Surfer" program. The elevations are based on the base contour drawing entered into AutoCAD as described earlier. Surfer could be a useful tool in studying the landforms before mining, during mining, and after mining. It can be a useful tool because the Surfer program has the capabilities to create a perspective drawing which can be rotated to different angle. This will help the planners, landscape architects and mining operators to study the impacts of the mining operation to the site and the surrounding areas.



Scale 1" = 600′

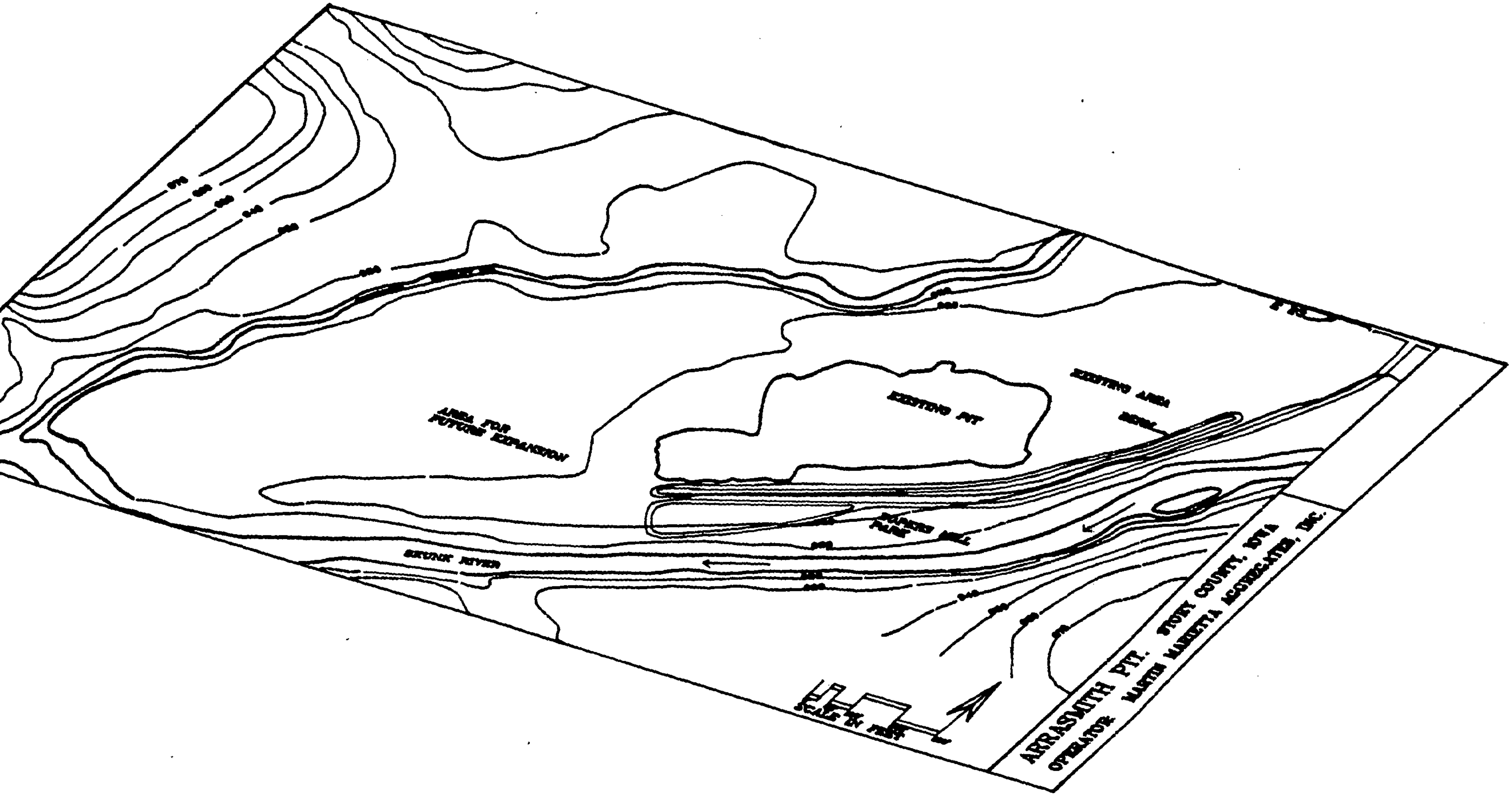
Figure 6. Computer generated three-dimensional drawing of Arrasmith Pit topography using "Surfer" program

Unlike the Surfer program, AutoCAD Version 2.62 does not have the capability to produce an aerial perspective drawing with contours. A newer version of AutoCAD (version 9) can only transform a plan drawing to axonometric two or three-dimensional drawing. Figure 7 shows the axonometric two-dimensional contour drawing transformed with AutoCAD from the contour plan drawing.

The methods employed to transform a plan drawing to a axonometric drawing are the following:

1. Use a "change" command to change the layer "C" which is the contour layer.
2. Create new layers to every contour line and give an elevation to every layer.
3. Choose "View" command in order to see the plan drawing transformed to axonometric drawing.

Figure 7. Computer generated axonometric two-dimensional drawing of Arrasmith Pit using AutoCAD version 2.62 taken from base map in Figure 2


AREA FOR
FUTURE EXPANSION
EXISTING PIT
SKUNK RIVER
SCALE IN FEET
ARRASMITH PIT. STORY COUNTY, IOWA
OPERATOR: MARTIN MARIETTA AGGREGATES, INC.

Comparison of Computer-generated Drawings Versus Conventional/Manual Techniques

To a person who is proficient in hand-drawing with pencils, pens, erasers, and a T-square, using a microcomputer to generate drawings is a new challenge. This new challenge can open up new areas of professional skills and efficiencies, but the necessary time and effort required learning the microcomputer is considerable though not unlike the time needed to learn how to use manual drawing techniques and equipment.

Major differences between microcomputer techniques and conventional manual techniques are two: (1) the time required to complete the tasks and (2) the skill/experience of the person using the microcomputer hardware and software.

Time

There were two major tasks involved in the application of microcomputer techniques in this study. The first was the preparation of the base drawing and sections drawings of the existing conditions. These were two types of drawings that this researcher devoted a lot of the time in the early stage of the project. The time required to complete both types of drawings with AutoCAD was about 488.5 hours. The time taken to produce similar drawings using conventional manual techniques took about 192 hours. The researcher has used conventional techniques previously in two similar types of studies related to sand and gravel pits (the Manatts Sand and Gravel Pit in Tama, Iowa and Libertyville Pit in Lake County, Illinois).

In comparing the two methods for generating base drawings of the existing conditions, the conventional techniques required less time than computer techniques. This is especially true if the computer user is relatively inexperienced. However, with practice, computer skills are developed and the time needed to produce a drawing using microcomputer techniques would be faster than the conventional techniques. In this study, the time taken to produce details, three-dimensional landform topography and axonometric drawing of the site took about three days. Three dimensional landform/topographic drawings using Surfer program and axonometric drawings using AutoCAD took about six hours to produce from the base information stored in the computer files as part of the base drawings. However, to produce a similar types of drawings mentioned above, the author had taken three weeks to finish when manual techniques were used for the Manatts Sand and Gravel Pit in Tama, Iowa.

In some ways there is less flexibility in drawings using microcomputers especially CAD compared to drawings by conventional techniques. Microcomputers use symbols and are more mechanical. Any drawings that need to be drawn has to fix in with the pre-defined entity of the program. As compared to using manual techniques, computer assisted techniques are rather limited in the use of color, line weight, shading, and texture.

The quality of the computer-generated drawings and hand-drawn drawings produced also depend on the exposure of a person to using both techniques. However, the quantity of original hard copy that can be produced by using microcomputers with no traces of revisions is incomparable to conventional techniques.

Skills and user experience

The skills and user experience are also important in determining the speed and the quality of graphics produced using microcomputers. A designer or planner who has a high level of skill and knowledge in the use of microcomputers will take significantly less time to produce the type of graphics previously mentioned. However, the person who is a beginner in microcomputer application needs to take longer time. This is especially true in the case of the author who has three and a half years of experience in drawing using conventional techniques compared to only six months of experienced (since June 1988) in drawing using microcomputers. But the main point here is that with practice, skills are developed and the time required can then be reduced.

In sum, advantages of microcomputers in this study were the following:

1. Editing can be quickly done as often as required, and the data can be saved on hard-disk or on various revision diskettes.
2. The output or the hard copy can be easily done in a wide variety of scales and sheet sizes. In this study, the 24" x 36" size base map was done using a Hewlett Packard 7580B Graphic Plotter and the 11" x 17" size base map and drawings were done using a Hewlett Packard 7475A Graphic Plotter.
3. Materials that are to be used repeatedly for multiple applications (for example, a plan view of a tree) can be easily stored, retrieved and manipulated using a computer.
4. The ability to make corrections in drawings and especially in word processing (shift paragraphs around, insert and delete without leaving any proof of editing will in fact give computer novices the confidence to increase their use of microcomputers and ultimately their proficiency and speed.

The disadvantages of using microcomputers that the researcher have learned from this study are the following:

1. At this time any microcomputer user cannot depend only on one software package to fulfill all the

needs in planning for mine operation and reclamation. The combination of at least two software packages is the most desirable.

2. Microcomputers and peripherals are machines and there is always a chance that machines will break-down. If this happens, it can delay the work to be carried out.
3. Additional time is required in training to use the microcomputers and also the software packages.
4. There is always a tendency to upgrade the microcomputer capabilities and to have other specialized equipment in carrying out the work and this will require additional cost.

CHAPTER 6. ARRASMITH PIT CASE STUDY

Inventory and Assessment

Regional inventory and analysis

Location: The site chosen for the case study is a sand and gravel operation located four miles northeast of the city of Ames, Iowa, sections 7 and 23 of the Milford township, Story County. Ames, home of Iowa State University, lies in the central part of the state of Iowa and thirty-three miles north of the capital city of Des Moines. Nearby towns to the study site include Gilbert (2 miles west), Story City (6 miles north), and Roland (5 miles northeast of the study site) (Figure 4).

History: The history of the city of Ames traces back to October 1864, when the Chicago and Northwestern Railroad, which passes east and west through Ames, was completed. Even though the railroad to Ames was finished in October 1864, regular freight and passenger trains did not commence running until June 1865.

The city of Ames was laid out in the fall of 1864 by the "Railroad King" of Iowa, John I. Blair, of Blairstown, New Jersey, who was president of the Cedar Rapids and the Missouri River Railroad Co. (Turner, 1871). The city of Ames gets it name from Oakes Ames of Massachusetts, an active pioneer in western railroad enterprise.

In 1869, with a population of about eight hundred people (of whom a large proportion are of New England origin), steps were taken to incorporate the city of Ames. This action was approved by a large majority. Ames then became a center of hardy immigrants, business and (most important of all) the seat of one of the most flourishing educational institutions in the midwest, Iowa State University (Turner, 1871).

Landscape Characteristics: Like many other counties in Iowa, Story County's landscape is generally flat to gently rolling except where streams and rivers have cut into the plain. The city of Ames is surrounded by rich farmlands. Trees are found primarily along the floodplain of streams such as the Skunk River where the Arrasmith Pit is located. Due to the Skunk River's importance to the natural resources of Story County, the Story County Conservation Board has started to acquire the land within the Skunk River Greenbelt. The main goal of the Story County Conservation Board is to see that the Skunk River Greenbelt is used as a non-motorized public use area to link the park systems of Ames and Story City (Patchett, 1982).

The study site, the existing Arrasmith Pit, is located within the floodplain of the Skunk River (Figure 8). This study site is a small sized operation encompassing an area of about twenty-five acres. Fifteen acres of the land have been mined out and the remaining ten acres are still covered

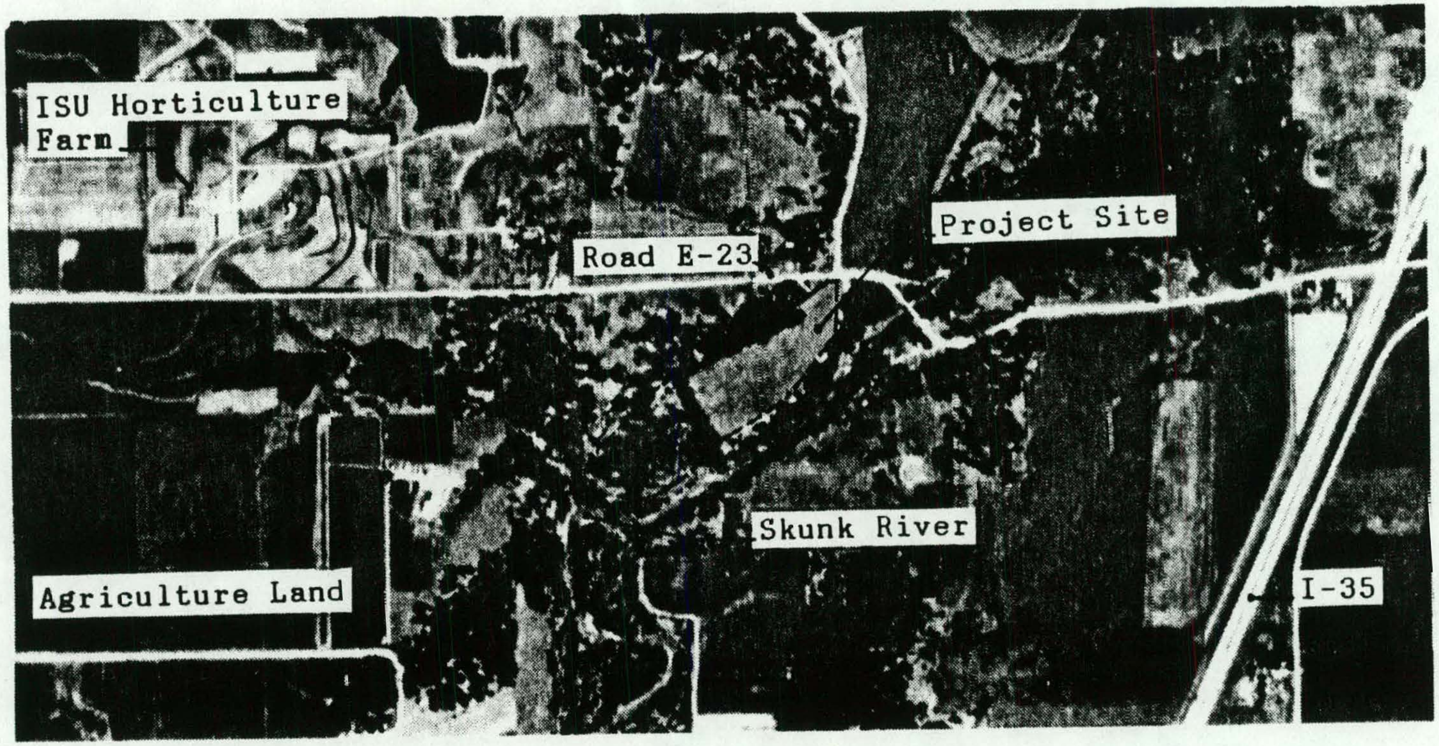


Figure 8. Aerial photograph of the study site taken in 1972 before the site was mined

by riparian woodland. The area is bordered by the Skunk River on the east, the unpaved county road E 23 on the north, Keigley Creek on the west, and riparian woodland area to the south.

Transportation: The transportation network in Story County is excellent. Story County is easily accessible by Interstate 35 which runs north and south through Iowa, U.S highway 30 which runs east and west, and numerous other county roadways. The railway lines which run through the city of Ames link as far as Chicago to the east and Omaha, Nebraska to the west. The municipal airport, located about one mile south of the city of Ames, also serves Story City, Roland, and Gilbert.

Climate: As is typical in the midwest, Story County experiences wide variations in weather conditions. Story County is cold in the winter and is quite hot, with occasional cool spells in the summer. Precipitation during the winter frequently occurs as snowstorms. During the warmer months there are showers, often heavy, when warm moist air moves in from the south. Total annual rainfall is between 30" to 35" and is normally adequate for corn, soybeans, and small grains. The average winter temperature is 20 degrees Fahrenheit, and the average daily minimum temperature is 11 degrees. In summer the average temperature is 71 degrees, with the average daily maximum temperature of 82 degrees.

The total annual precipitation is 34 inches. Of this, 25 inches, or 75 percent, usually falls as rain in April through September. The average seasonal snowfall is 25 inches.

Population: The population of Story County is not likely to feel the intense pressure of dramatic population growth. In 1960 Story County had a population of 49,327. In 1970 the population was 62,783 and in 1980 the population of Story County was 72,326. According to the population projection by the Story County Planning and Zoning Commission prepared in 1987, the population of Story County in 1990 will be 78,082 and by the year 2000, the population projection for Story County will be 85,469 (Story County Planning and Zoning Commission, 1988).

Parks and recreation: In Story County, there are 1,700 acres of county parks and natural areas, including lakes, rivers, streams, timber, prairies, marshes, wildlife habitats, and outdoor learning and recreation areas. All these parks and natural areas are under the jurisdiction of the Story County Conservation Board. Conservation Board areas are grouped into two management units - the Skunk River Conservation Unit and the Indian Creek Conservation Unit. There are four parks and natural areas that are under the jurisdiction of the Skunk River Conservation Unit.

The four parks and natural areas are McFarland Park, Peterson Park, prairies and marshes and the Skunk River Greenbelt. The Indian Creek Conservation Unit's area of jurisdiction includes Dakins Lake, Hickory Grove Park, Prairie Rail Trail and Robison Wildlife Acres. McFarland Park, which encompasses an area of 200 acres, is located about one mile south of the study area. Peterson Park encompasses an area of 200 acres and lies in the Skunk River Greenbelt west of McFarland Park. Peterson's park contains abandoned gravel pits which to a certain extent have been reclaimed for wildlife habitat and recreational activities, including swimming.

The Skunk River Greenbelt, which encompasses some private land and an area of 800 acres of public land along the upper Skunk River between Ames and Story City, provides valuable recreational opportunities, wildlife habitat, and preservation of the lands bordering the Skunk River. The Greenbelt includes canoe accesses, forest, river, streams, meadows, and prairie habitat, public hunting areas, backpacking, equestrian trails, primitive camping, historical and archeological areas. Soper's Mill, located between the Arrasmith Pit and the Skunk River, is one of the historical sites. Soper's Mill site was one of the first grist mills in Story County. The other historical site which is adjacent to the study site is the one century old

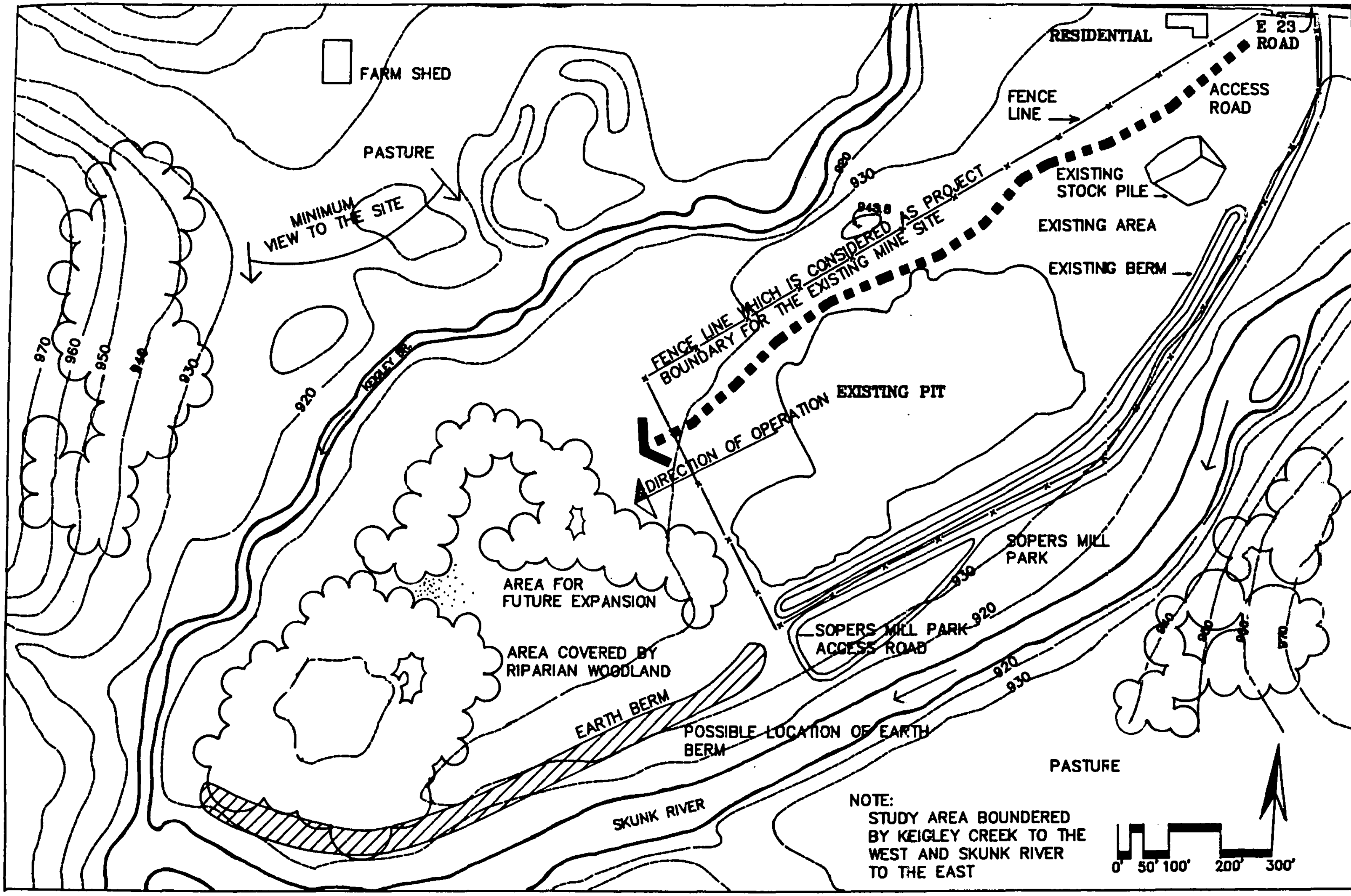
Rainbow Bridge located across the Skunk River just north of the site (Allen, 1975).

Site inventory and analysis

Accessibility: Arrasmith Pit, operated by Martin Marietta Aggregates, Inc., is located about four miles northeast of Ames. Access to this gravel pit is by Highway 69 and county road E 23 which is an unpaved gravel surface road. The distance from the junction of Highway 69 and E 23 to the entrance gate of the Arrasmith Pit is about one mile. The entrance to the site is not obvious to passers-by. One can see only the entrance gate with no sign identification. However, with a huge stockpile located about three hundred feet from the entrance gate one can see that a mining operation is occurring here. Vehicular access within the mine site is limited. The existing mine site that has been mined out is accessible, but there is no entrance from the public road to the area for future expansion (Figure 9).

Current Land Uses: Arrasmith Pit sand and gravel operation lies in an area west of the Skunk River Greenbelt area where there is a need to preserve natural resources. The Skunk River forms the eastern boundary of the study site. The Skunk River Greenbelt is very important not only to Story County but also to the people of Iowa because of its potential to provide numerous kinds of outdoor activities such as canoeing, fishing, and nature studies.

Figure 9. Site inventory and analysis



ARRASMITH PIT. STORY COUNTY, IOWA

SITE INVENTORY

Numerous trees that are native to Iowa are also found along the Skunk River (Patchett, 1982).

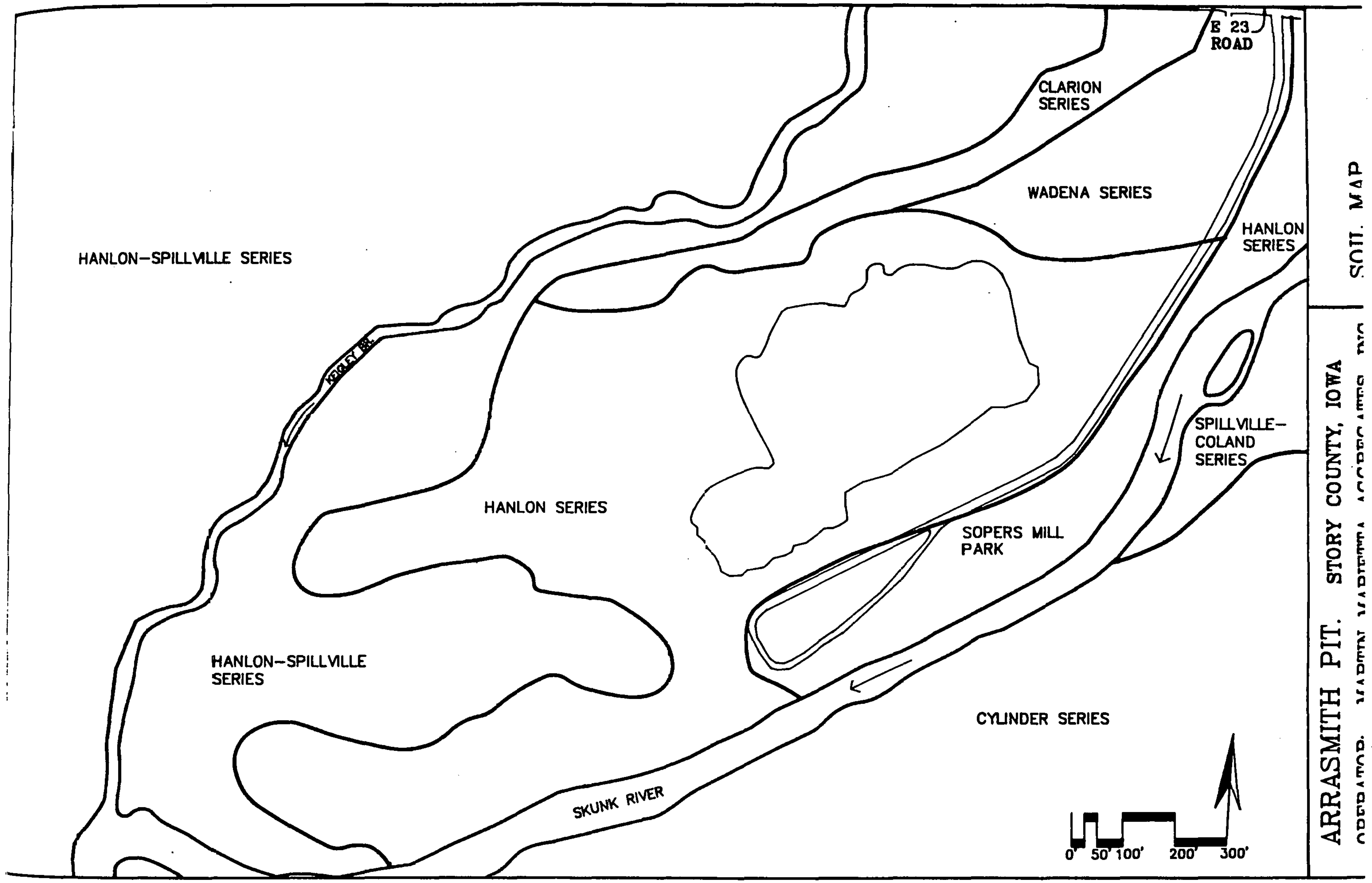
To the west of the study site is Keigley Creek. This stream forms the western boundary the study site. The open area on both sides of the creek is used for cattle grazing. This is also apparent in the area south of the study site.

Soil: There are three types of soil series found in this study site: Wadena, Hanlon, and Clarion series (Figure 10).

Wadena Series: The Wadena series is found primarily in the northern part of the study site. This portion has been used to stockpile sand and gravel. The Wadena series consists of well drained soils. These soils formed in loamy alluvium that is underlain by sand and gravel on stream terraces and outwash areas on uplands. Permeability is moderate in the solum and rapid in the substratum. Native vegetation was prairie grasses. Slopes range from 0 to 5 percent (Soil Survey Report for Story County, 1984).

Hanlon Series: The Hanlon series consists of moderately well drained soils on natural levees along streams. Permeability is moderately rapid. These soils were formed in loamy alluvium under a native vegetation of prairie grasses. Slopes range from 0 to 2 percent (Soil Survey Report for Story County, 1984). This soil series is

Figure 10. Soil map of the study site


E 23 ROAD
CLARION SERIES
WADENA SERIES
HANLON SERIES
HANLON-SPILLVILLE SERIES
HANLON SERIES
SPILLVILLE-COLAND SERIES
SOPERS MILL PARK
HANLON-SPILLVILLE SERIES
CYLINDER SERIES
SKUNK RIVER
0' 50' 100' 200' 300'
SOIL MAP
ARRASMITH PIT. STORY COUNTY, IOWA

mostly located primarily in the existing pit area and the area for future expansion.

Clarion Series: The Clarion series consists of well drained, moderately permeable soils on uplands. These soils formed in calcareous glacial till under prairie vegetation. Slopes range from 2 to 14 percent (Soil Survey Report for Story County, 1984). This soil series is located in the northwestern portion of the study site.

Topography: Generally, the site is characterized by gentle to almost flat relief with abrupt changes in elevation occurring only in the eastern part of the study site along the Skunk River and near Keigley Creek (Figure 6). The elevation ranges from a maximum of 1000 feet to 915 feet at the water level of the Skunk River. The Skunk River is parallel to the operation site and flows southwest. Even though the Skunk River is adjacent to the site and the site itself lies within the floodplain of the Skunk River, the area subject to flooding is quite minimal. This is confirmed by the "Ames Two-mile Area Study" (a study carried out by the Story County Planning and Zoning Commission) which showed that this area does not pose any severe limitation for erosion.

Vegetation: A dense wooded area occupies the perimeter of the Skunk River and the southern portion of the site (Figure 11). This area consists of a variety of mature

Figure 11. Vegetation map of Arrasmith Pit and surrounding area.
Source: Aerial photograph

TM-1664
June 6, 1990

Guidelines for Structural Bolting in accordance with AISC Ninth Edition "Manual of Steel Construction"

by: Jeffrey L. Western

1. INTRODUCTION

This paper specifies the usage of structural bolts in terms of their design, selection and application, in accordance with the the American Institute of Steel Construction (AISC) Ninth Edition. " Manual of Steel Construction ".

2. GENERAL GUIDELINES

2.1 All bolts used shall have identification or grade marks as specified by the American Society for Testing and Materials (ASTM), the Society of Automotive Engineers (SAE), or the International Organization for Standardization (ISO), as identified by Industrial Fasteners Institute (IFI) guidelines. See the attached table "Properties of Steel Fasteners" for common fasteners.

2.2 All structural bolting shall conform to the standard specifications as specified in AISC " Manual of Steel Construction ".

2.3 Bolts not having identification shall not be used, unless material verification has been obtained.

2.4 Preventative steps to alleviate corrosion shall be taken when bolts are exposed to corrosive environments.

2.5 All bolts subjected to a fatigue loading shall be designed for such loads.

2.6 Washers and nuts shall be of the same material as the bolting material, unless compatibility of different materials can be demonstrated.

3. STRUCTURAL BOLTING GUIDELINES

3.1 All structural bolting shall conform to the standard specifications as stated in AISC.

3.1.1 Reference Sections:

a) AISC Part 4; p. 4-3 thru p. 4-8. Bolts, Threaded Parts and Rivets.
b) AISC Section J3; p. 5-71 thru p. 5-77. Specification: Bolts, Threaded Parts and Rivets.
c) AISC Section C-J3; p. 5-165 thru p. 5-170. Commentary: Bolts, Threaded Parts and Rivets.
d) AISC p. 5-263 thru p. 5-307. Specification for Structural Joints Using ASTM A325 or A490 Bolts.

3.2 All bolts that are designated for support application shall follow AISC provisions for allowable, minimum, and maximum stresses.

3.3 All bolts subjected to a fatigue loading shall be in accordance with AISC Appendix K Section K4; p. 5-106 thru p. 5-116.

3.4 The minimum end distance from center of bolt hole shall be in accordance with AISC J3.9; p. 5-75 thru 5-77.

3.5 The maximum edge distance shall not exceed provisions set in AISC Section J3.10; p. 5-77.

3.6 All bolts shall be spaced in accordance with AISC J3.8; p. 5-75.

3.7 The maximum size of fastener holes shall be specified by AISC J3.2; p. 5-71.

3.8 A325 or A490 bolts, that are to be used within a friction or bearing type connection, shall have a minimum pretensioning force of $.7F_u$ applied to them. See AISC Table J3.7; p. 5-77, Section M2.5; p. 5-88 and Section C-M2.5; p. 5-182. AISC provisions for friction shear connections only apply to high strength bolts (A325 and A490).

3.9 Bolts that encounter extraneous loads or stresses such as eccentric shear, prying action, connection bearing stress, or block shear shall be designed under AISC guidelines.

3.10 Bolts that are subjected to **tension** shall follow the following AISC code provisions. See AISC Table 1-B; p. 4-3.

3.10.1 $F_t = P / A_g \leq .33F_u$ for allowable tensile stress in threaded fasteners and:

3.10.2 $F_t = P / A_g \leq .60F_y$ for the allowable tensile capacity on the gross area of the bolt.

3.10.3 Reference Tables / Sections;

a) AISC Table 1; p. 5-117. Allowable stress in terms of F_y.
b) AISC Table 2; p. 5-118. Allowable stresses as a function of F_u.
c) AISC Table J3.2; p. 5-73. Allowable stress on fasteners.
d) AISC Table 1-A & 1-B; p. 4-3. Allowable stresses and loads on bolts and threaded fasteners.

3.11 Bolts that are subjected to **shear** with a **bearing-type connection** shall follow AISC guidelines. See AISC Table 1-D; p. 4-5.

3.11.1 $F_v = V / A_g \leq .17\ F_u$ where bolts create a bearing-type connection and threads are in the shear plane.

3.11.2 $F_v = V / A_g \leq .22\ F_u$ where bolts create a bearing-type connection and threads are excluded from the shear plane.

3.11.3 Reference Table / Sections:

a) AISC Table 1-D; p. 4-5. Allowable shear load.
b) AISC Table J3.2; p. 5-73. Allowable stress on fasteners.
c) AISC Table 2; p. 5-118. Allowable stresses as a function of F_u.

3.12 Bolts that are subjected to **shear** with a **friction-type connection** shall follow AISC "Structural Joints Using ASTM A325 or A490 Bolts" p. 5-263 thru p. 5-307.

3.12.1 Reference Tables / Sections:

a) AISC Section J3.2; p. 5-73. Allowable stress on fasteners.
c) AISC Section M2.5; p. 5-88. High-strength bolted construction assembly.

d) AISC Section C-M2.5; p. 5-182. Commentary: High-strength bolted construction assembly.

3.13 Bolts that are subjected to **combined tension and shear** shall follow AISC Section J3.5; p. 5-72 thru 5-74. Bolts that are not identified in AISC Table J3.3; p. 5-74 shall adhere to the following:

3.13.1 $F_t \leq .43F_u - 1.8F_v \leq .33F_u$; for a connection where threads are in the shear plane.

3.13.2 $F_t \leq .43F_u - 1.4F_v \leq .33F_u$; for a connection where threads are excluded from the shear plane.

3.14 Nomenclature

T - denotes the tension force (lbs or kips) on the bolt.

V - denotes the shear force (lbs or kips) on the bolt.

A_g - denotes the gross area (in^2) of the bolt based on the nominal diameter of the bolt.

F_u - denotes the specified minimum tensile stress (psi or ksi) of the type of steel or fastener being used.

F_y - denotes the specified minimum yield stress (psi or ksi) of the type of steel being used.

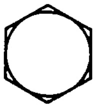
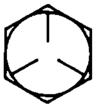
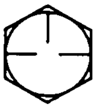
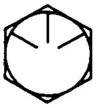
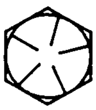
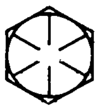
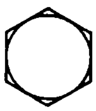
F_v - denotes the shear stress (psi or ksi) applied to the bolt.

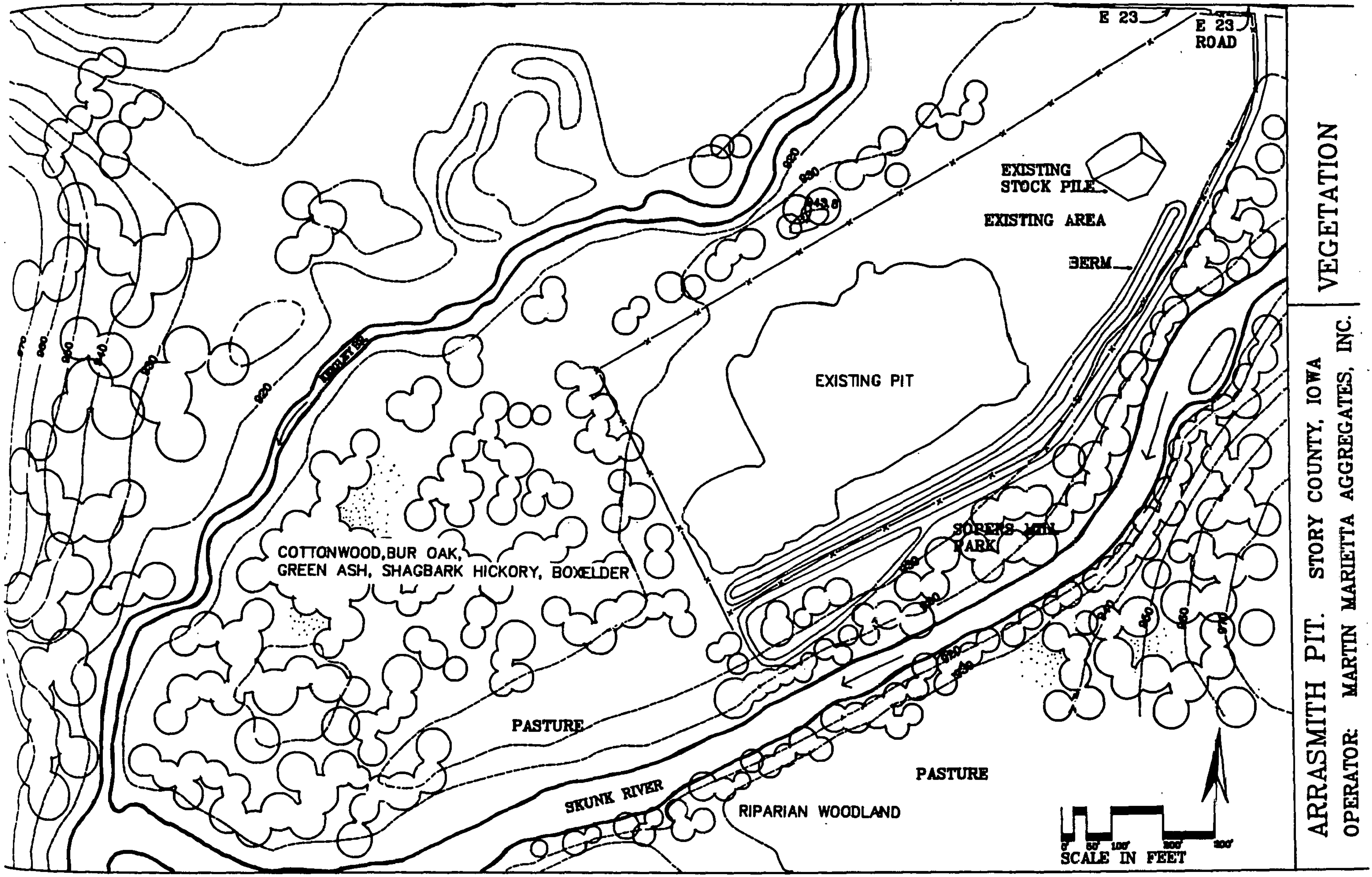
F_t - denotes the tensile axial stress (psi or ksi) applied to the bolt.

4. INTENDED USAGE

This paper is intended to give the engineer an understanding of structural bolting as specified by the AISC code. This paper is not intended to be a substitute for the AISC code, but rather a guide to locate specific requirements in the code.

PROPERTIES OF STEEL FASTENERS

IDENTIFICATION GRADE MARK	SPECIFICATION	FASTENER DESCRIPTION	NOMINAL SIZE RANGE (IN)	MECHANICAL PROPERTIES		
				PROOF LOAD (psi)	YIELD STRENGTH MIN (psi)	TENSILE STRENGTH MIN (psi)
 NO GRADE MARK	ASTM A307 Grades A&B	BOLTS, SCREWS, STUDS	1/4 THRU 4			60,000
	SAE J429 Grade 5	BOLTS, SCREWS, STUDS	1/4 THRU 1 OVER 1 THRU 1-1/2	85,000 74,000	92,000 81,000	120,000 105,000
	ASTM A449		1/4 THRU 1 OVER 1 THRU 1-1/2 OVER 1-1/2 THRU 3	85,000 74,000 55,000	92,000 81,000 58,000	120,000 105,000 90,000
	SAE J429 Grade 5.1	SEMS	NO. 6 THRU 3/8	85,000		120,000
	SAE J429 Grade 5.2	BOLTS, SCREWS, STUDS	1/4 THRU 1	85,000	92,000	120,000
	ASTM A325 Type 1	HIGH STRENGTH STRUCTURAL BOLTS	1/2 THRU 1 1-1/8 THRU 1-1/2	85,000 74,000	92,000 81,000	120,000 105,000
	ASTM A325 Type 2		1/2 THRU 1	85,000	92,000	120,000
	ASTM A325 Type 3		1/2 THRU 1 1-1/8 THRU 1-1/2	85,000 74,000	92,000 81,000	120,000 105,000
	SAE J429 Grade 7	BOLTS, SCREWS	1/4 THRU 1-1/2	105,000	115,000	133,000
	SAE J429 Grade 8 ASTM A354 Grade BD	BOLTS, SCREWS, STUDS	1/4 THRU 1-1/2	120,000	130,000	150,000
 NO GRADE MARK	SAE J429 Grade 8.1	STUDS	1/4 THRU 1-1/2	120,000	130,000	150,000
	ASTM A490	HIGH STRENGTH STRUCTURAL BOLTS	1/2 THRU 1-1/2	120,000	130,000	150,000 MIN 170,000 MAX


E 23
E 23
ROAD
EXISTING
STOCK PILE
EXISTING AREA
BERM
EXISTING PIT
COTTONWOOD, BUR OAK,
GREEN ASH, SHAGBARK HICKORY, BOXELDER
PASTURE
PASTURE
SKUNK RIVER
RIPARIAN WOODLAND
SCALE IN FEET
VEGETATION
ARRASMITH PIT. STORY COUNTY, IOWA
OPERATOR: MARTIN MARIETTA AGGREGATES, INC.

deciduous native trees. Some of the native trees that occupy this area are Bur Oak, Hackberry, Green Ash, Silver Maple and Shagbark Hickory.

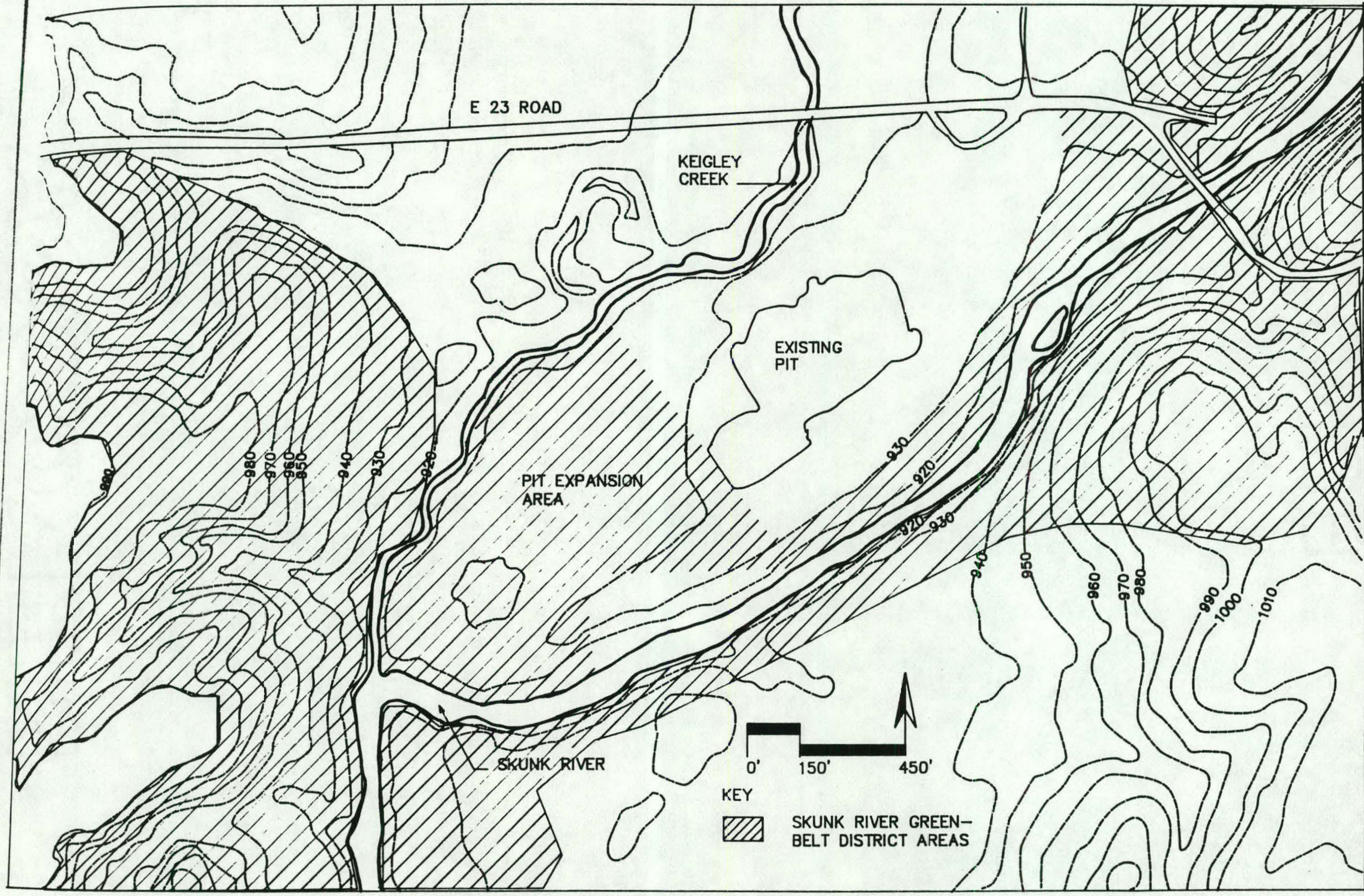
Visual analysis: The existing Arrasmith Pit mining site, with its low profile operation presents a minimal visual intrusion to the surrounding areas. The existing riparian woodland communities along the Skunk River effectively block the view from the east. The existence of the wooded area along the west edge partially blocks the view from county road E 23. The berm constructed along the eastern boundary of the study site almost completely screens the view along the access road to the Soper's Mill park which is located adjacent to the east property line of the mine site. Refer to Figure 9.

The highest visibility side is from the entrance and county road E 23. The whole stockpile located about 300 feet from the entrance gate is highly visible.

Zoning: Arrasmith Pit sand and gravel mine is located on section 7 and 24 of T84N, R23W in Milford Township. This section (according to the Story County Planning and Zoning Commission) has been zoned under Greenbelt/Conservation Zone District (Figure 12). Their growth management plan for Story County categorizes this mine site under the designation of the Critical Resource Area. Areas designated as Critical Resource Areas indicate

Figure 12. Greenbelt district areas of Arrasmith Pit and adjacent site

it and



ARRASMITH PIT. STORY COUNTY, IOWA

GREENBELT

lands which contain natural resource elements which present significant limitations to development and/or which contain sensitive environmental conditions which require special management of the aesthetic, environmental or recreational assets of Story County (Story County Planning and Zoning Commission, 1988).

Mineral extraction is a permitted conditional use in the Greenbelt/Conservation District, and a permit for the Arrasmith Pit was issued in 1982 (Story County Planning and Zoning Commission, 1988). The "conditional use permit" requires the mining operator to submit a concurrent mining operation and reclamation and mitigation plan prior to starting the mining activities. The Story County Planning and Zoning Commission reviews the plan to judge the adequacy of the reclamation plan. The plan is then sent to the Board of Adjustment for evaluation. According to the Story County Planning and Zoning Commission administrator Mr. Leslie Beck (1988), the conditional use permit for the Arrasmith Pit was first issued to the Maudlin Construction Company from Webster City in 1982.

Deposit inventory and analysis

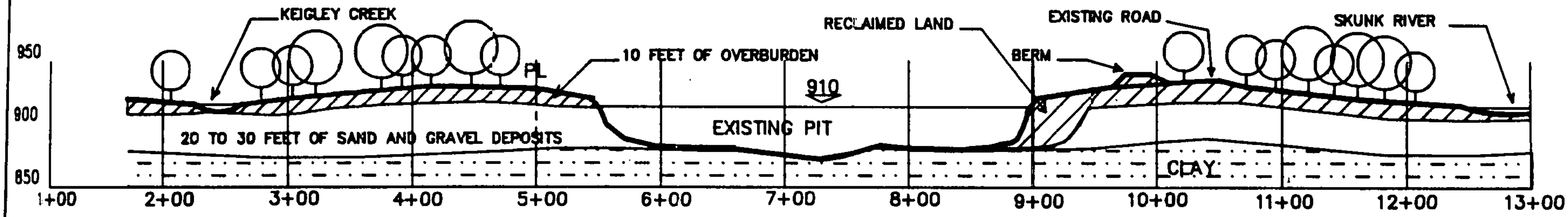
The Deposit: Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. According to Mr. Joseph McQuire (1989), the Environmental Engineer of Martin Marietta Aggregates, Inc., the sand and gravel deposit present at this site is overlain with an average of four feet of topsoil and six feet of overburden. Beneath the overburden is the deposit, with a depth ranging between twenty feet to thirty feet (Figure 13). The average annual production at this site is 50,000 tons of sand and gravel. The ground water table lies at ten feet below the ground surface, at the top of the sand and gravel deposits.

Operations inventory and analysis

The Arrasmith Pit sand and gravel mine operation has been temporarily halted because the existing permitted area for excavation has almost been mined out. This mined out area encompasses an area of fifteen acres and at present only about one acre is still available for mining. The area for future expansion that has been proposed is located to the south of the existing pit areas. This proposed area encompasses a total area of about ten acres is still covered by riparian woodlands. The mining operations at this site, first was carried out by Maudlin Construction Company and then by Martin Marietta Aggregates, Inc., involved five steps:

a. Stripping of topsoil and overburden
b. Excavation
c. Transportation
d. Processing
e. Stockpiling

Figure 13. Deposit information of the Arrasmith Pit



7+00

SCALE: 1" = 100' VERTICAL AND HORIZONTAL

SOURCE: INFORMATION GIVEN BY JOSEPH MCQUIRE (MARTIN MARIETTA AGGREGATES, INC.)

DEPOSIT INFORMATION

ARRASMITH PIT. STORY COUNTY, IOWA

Stripping of top soil and overburden: The removal of topsoil and overburden is accomplished by using bulldozers. Bulldozers are used to strip the topsoil (about four feet deep) and the same equipment was used to haul the topsoil to the designated areas for either temporary stockpiling or sale to local nurseryman. The overburden is then excavated to a depth of about six feet to the top of the deposit. Previously, some of this overburden was placed at the eastern portion of the pit where it forms a visual barrier to users of the access road to the Soper's Mill park.

Excavation: Excavation involves the removal of the sand and gravel deposits which are then transported to the processing plant. The Arrasmith Pit sand and gravel operation is a wet type operation and produces an average of 50,000 tons of sand and gravel annually. This site is very well suited to the wet type of operation because of the high ground water table. In this operation, a dragline and bulldozers are used to excavate the deposit which is located below the water table.

Transportation: Transportation is the process of hauling the materials that have been excavated from the mine site to the processing plant. In this operation a dragline is also used to haul the deposit to the portable processing plant located near the pit.

Processing: The processing plant is the heart of a sand and gravel operation. At this mine, a typical portable processing plant is used and consists of a portable roll crusher and screening equipment. The process of separating the sand and gravel takes place when the material arrives at the portable processing plant. As the material reaches the processing plant, it is screened and separated into sand and gravel sizes. The portable roll crusher was used to crush the gravel to sizes ranging from 1/2 inch to 3/4 inch gravel. The sand and gravel are then taken for stockpiling.

Stockpiling: Excavation operations include material stockpiled and areas for storage and maintenance of equipment. Stockpiling of sand and gravel at this site is carried out by using trucks. Because this site is a small operation, there is no significant impact of discarded or abandoned equipment found at the site.

Post-mining Land Use Determination

Planning of the post-mining land use can be approached from two different directions: (1) the desired post-mining land use is already known and all reclamation, landforming activities and revegetation is directed towards that use, or (2) the reclamation, landforming and revegetation activities is directed towards creating landforms which have the highest potential for a variety of possible, but unknown, land uses (Dietrich, 1986). For the Arrasmith Pit mine site, the planning of post-mining land use should be geared toward the needs of the society and also the goals set by the Story County Planning and Zoning Commission. According to Story County Planning and Zoning Administrator, Mr. Leslie Beck, the Arrasmith Pit post-mining land use should be geared toward preservation of the natural character of the site and also simultaneously enhanced the low-intensity recreational activities such as nature study, fishing, and so on. This could be done by revegetation with indigenous species on the areas that are already mined and also by taking advantage of the mining activities to design a low-intensity recreational areas.

Factors influencing the post-mining land use at this small mine site are (a) that Arrasmith Pit mine site lies within the zoned known as "Critical Resource Areas" or "Greenbelt district" and (b) this area is vital for the preservation of the natural character and landscape because the greenbelt along the Skunk River is an important wildlife corridor in Story County. Because there are many other recreational areas that were already established along this river greenbelt, this site also has potential to serve as low-intensity recreational areas for the communities around the neighboring towns.

Mining and Landforming Operations

The mining of sand and gravel presents many opportunities in terms of landforming operations. The Arrasmith Pit sand and gravel mine operation is basically a wet type operation and the presence of ten feet of overburden at this site provides a great opportunity for landforming. These landforming materials can be used to fulfill the desired concurrent mining and reclamation programs. To be most effective and useful, the mining and landforming operations must be clearly defined and identified and this could be achieved by setting up clear goals and objectives.

Landforming goals and objectives

The following are the goals for the mining and landforming operations for the Arrasmith Pit:

1. Maximum use of overburden as a landforming material to achieve the desired post-mining land use.
2. Minimum second handling and hauling distance of the overburden.
3. Minimum environmental and visual disturbances to the site and the surrounding area.
4. Enhanced visual image of the sand and gravel mining operations.

Based on the above goals established for this site, specific targets to achieve the goals are also established. The following are the objectives set up for the mining and landforming operations at this site:

1. The overburden is to be used to minimize and/or mitigate visual, cultural, and environmental impact on the surrounding areas, especially because this site lies within the Greenbelt or Critical Resource areas.
2. The mining and landforming operations will be used to enhance visual and public image of the sand and gravel mining industry.
3. The mining and landforming operations are to blend in with the existing landscape in terms of landform and vegetation.

Potential landforms

In sand and gravel mine operations, the presence of significant overburden (topsoil and subsoil) should be considered as an asset rather than a liability. Overburden is the material that must be removed to uncover the deposit. It is also a material that has many uses in a landforming program. For this site, overburden will be used for the following purposes:

1. Visual screening by constructing earth berms along the east portion of the new mining areas and the existing entrance at Road E 23.

2. Visual enhancement of the pit by using overburden to create interesting curvilinear shorelines.
3. Mitigation measures which include dust, noise, and water pollution control.

Visual screening: To minimize or mitigate visual impacts of the mine operation to the surrounding areas, overburden can be used to screen the areas seen by neighbors and the public. By so doing, it not only controls but also minimizes the visual impact and attractive nuisance. Attractive nuisance can be defined as places that are visually attracted but they are very hazardous. Arrasmith Pit is an example of a place that has the visual impact and also attractive nuisance because this site is adjacent to the Soper's Mill Park.

Constructing the earth berm along the east boundary of the existing mine site has been carried out by Maudlin Company. The main aim was to establish a physical and visual separation between the mine and the Park access areas. This will be continued in the proposed berm expansion. Figure 14 illustrates the section of the earth berm that will be constructed as a continuation to the existing earth berm constructed by the Maudlin Company.

Visual enhancement: Visual enhancement at this site will focus on the creation of water bodies in the future expansion areas and also stabilization of the existing pit.

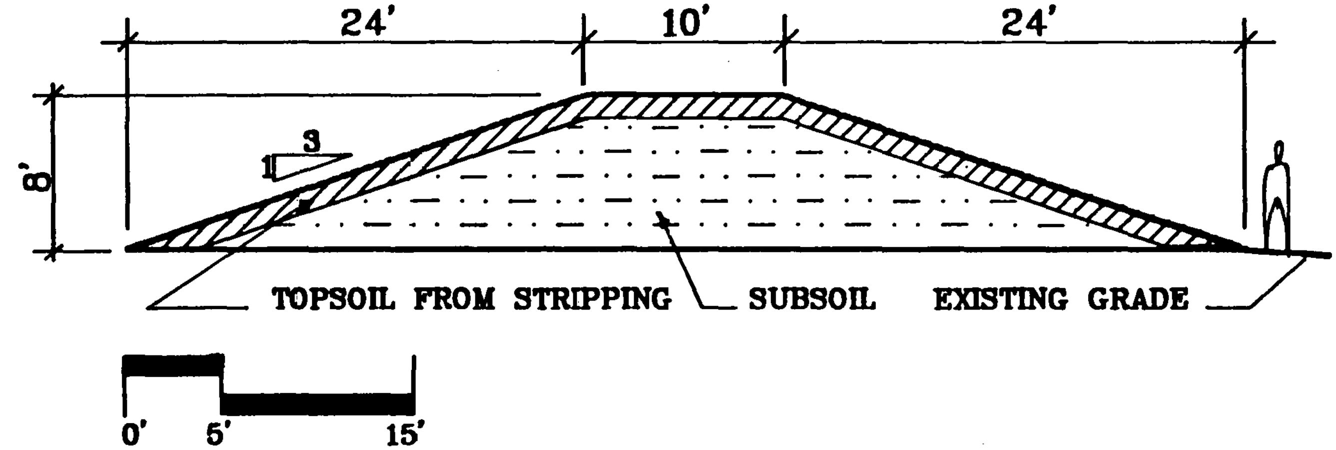


Figure 14. Typical cross section of a proposed earth berm

The slope gradient of the existing pit will be graded to a 3:1 slope to reduced erosion (Figure 15). The overburden will be used to expand some of the shoreline areas of this existing pit to create visually interesting curvilinear shorelines.

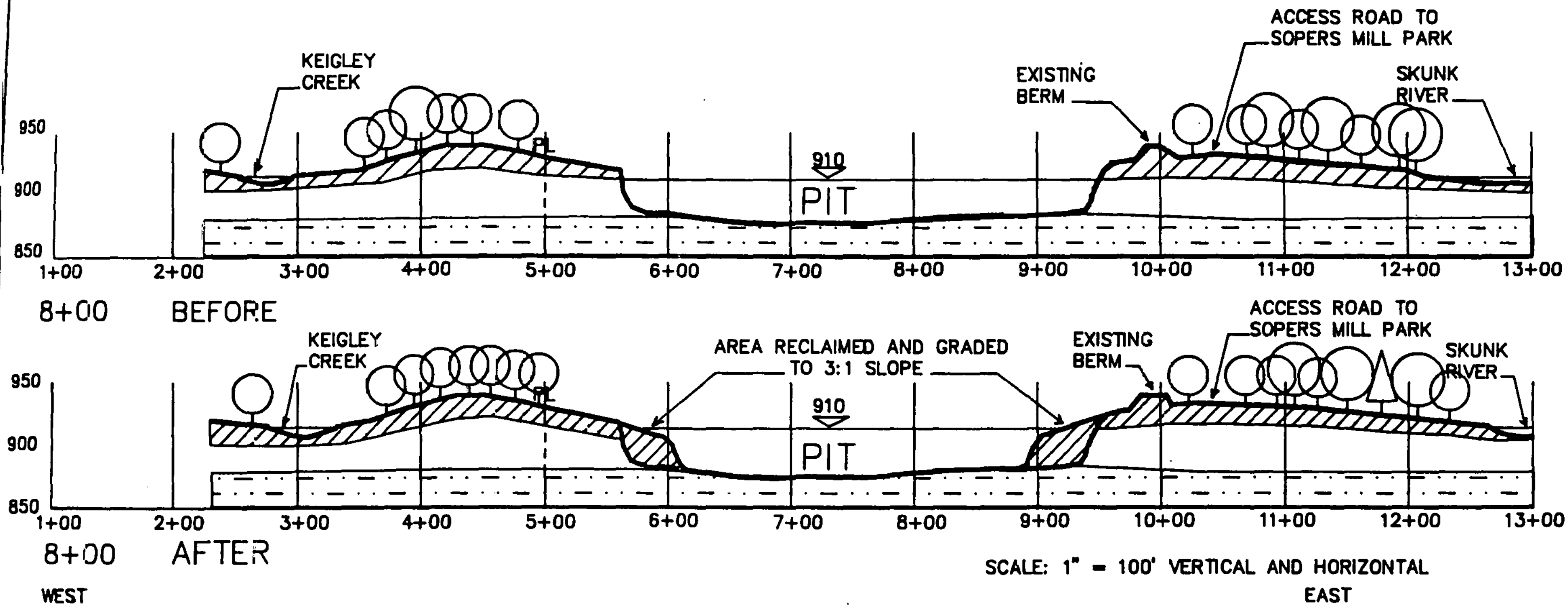
The existing entrance, which lacks entrance definition, also needs visual enhancement. Earth berms will be constructed and trees will be planted at this entrance which will act as both as a physical barrier and a visual barrier.

Mitigation: Mitigation may be defined as a process to decrease or eliminate visual, cultural, and environmental impacts caused by sand and gravel mine operations to a level which is acceptable to the community and the public. For this site, emphasis will be on the mitigation of dust, noise, and water pollution.

Mitigation measures employed at this site will include construction of berms along the perimeters of the east boundary of the expansion area (Figure 16). A set-back of 200 feet from the permanent water bodies (Skunk River and Keigley Creek) to the project boundary will mitigate any potential water pollution.

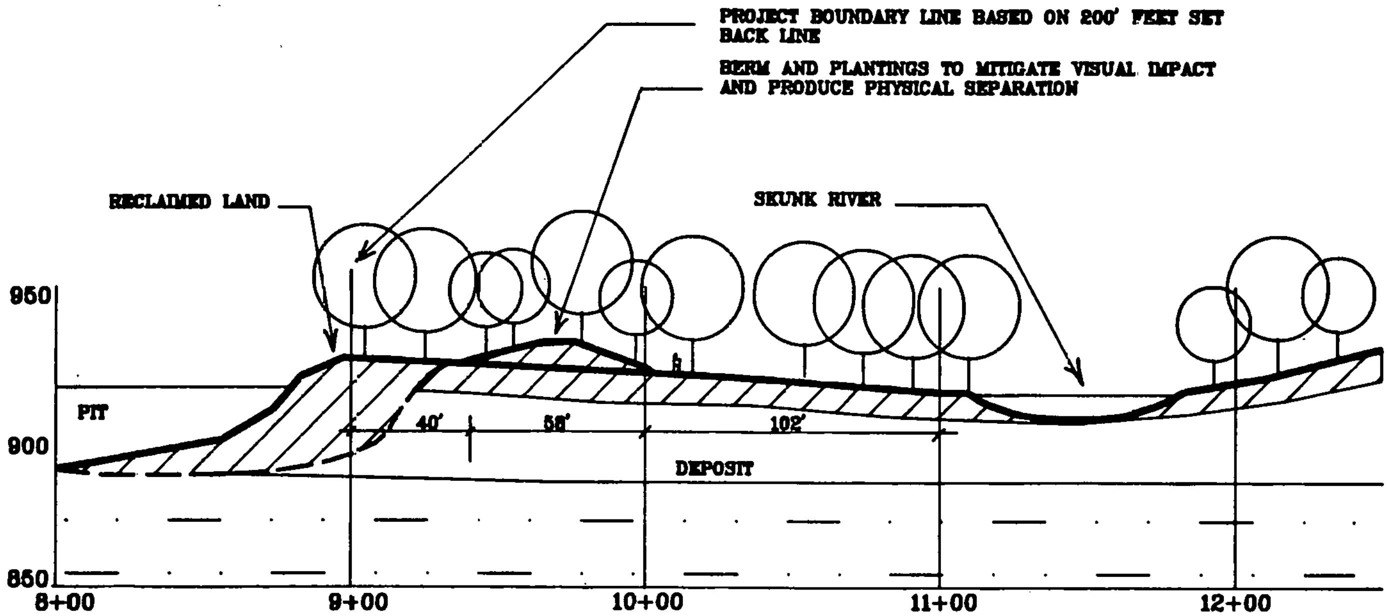
The construction of berms along with planting of trees will also help mitigate potential noise and dust problems that may occur when this plant is in operation again.

Figure 15. Detail - Slope treatment of a pit



ARRASMITH PIT. STORY COUNTY, IOWA DETAIL - SLOPE

Figure 16. Detail - Earth berm constructed to mitigate visual impact and provide physical separation



SCALE: 1" = 50'

ARRASMITH PIT. STORY COUNTY, IOWA

DETAIL

te
tion

Phasing Plan

The concurrent sand and gravel mining operations and reclamation of the Arrasmith Pit can be divided into four phases. The first phase will be carried out in the southern portion of the existing pit area and the remaining three phases will be carried out in the new expansion area. This phasing plan will encompass an area of ten acres in the new expansion area and one acre in the existing pit area with a predicted economic lifespan for another eleven years.

The criteria for this phasing plan comply with the Greenbelt/Conservation District zoning ordinance which is intended to protect and enhance critical natural resource areas in Story County. Mineral extraction and reclamation in the Greenbelt/Conservation district are subject to the following criteria:

1. A 200 feet set back along the Skunk River to protect the river from potential pollution by the mining activities. It is also intended to protect the greenbelt areas which are wildlife corridors in the Story County (Beck, 1988).
2. A 50 feet set back from all property lines.

The following figures illustrate the phasing plan. Each phase is followed by a synopsis. The description of the activities, landforming operations, and the quantity of the overburden required for landforming are also included.

This is also followed by an explanation of the procedures of sequential mining operation of each phase.

Phase one

Synopsis

Acreage: 1 acre.

Duration: 1 year (1989-1990)

Amount of deposits: 32,300 cu.yd.

Amount of topsoil: 6,500 cu.yd.

Amount of overburden: 9,700 cu.yd.

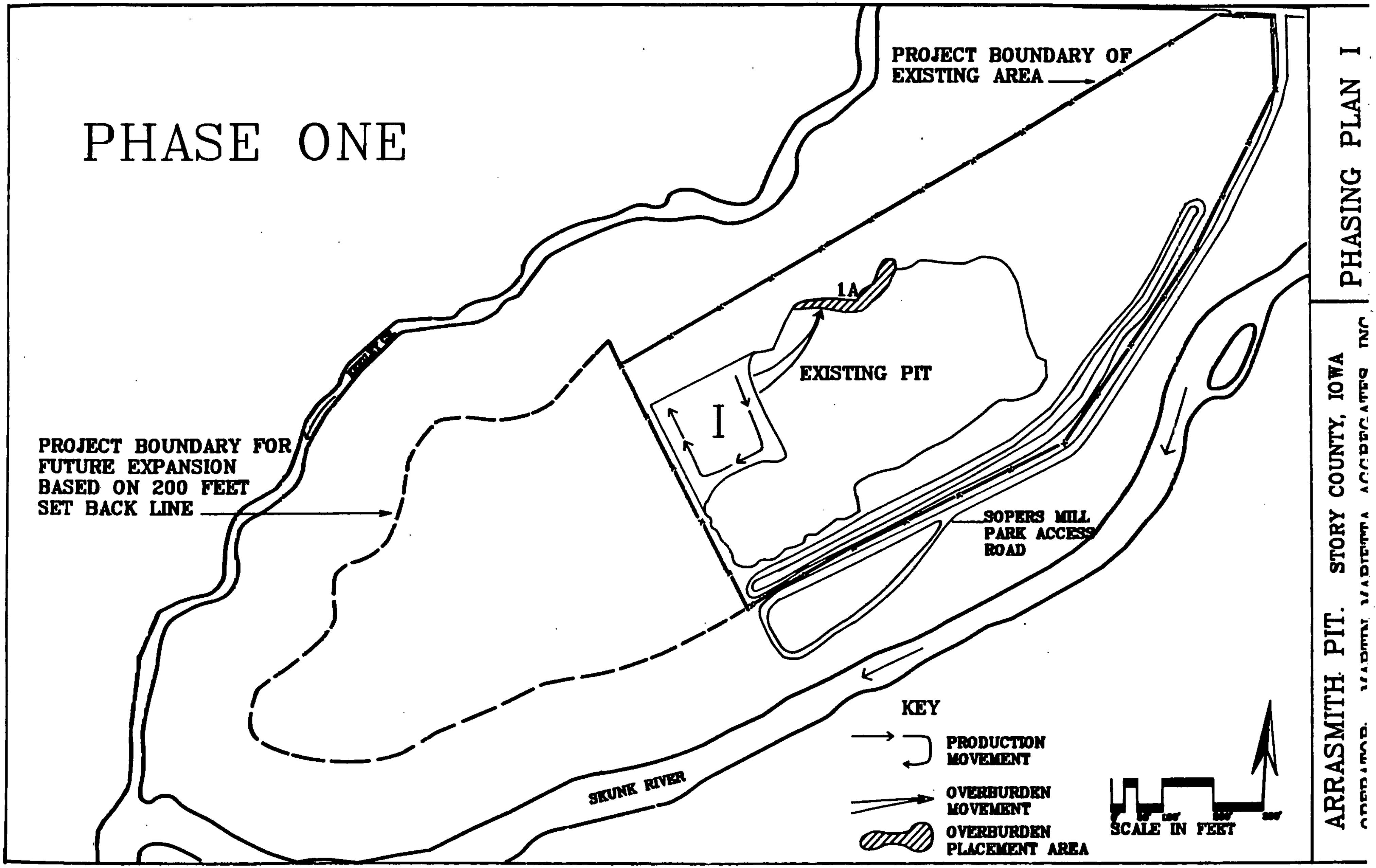
Landforming operations:

#	Activity	Quantity
1A	Extension of shoreline along north portion of existing pit	16,000 cu.yd.

Explanation of phase one:

The mining operation in the first phase will resume at the southern tip of the existing pit where approximately one acre is still available for mining. The mining and landforming operations will run concurrently. This phase will involve the extraction of 32,300 cu.yd of deposits with 6,500 cu.yd of topsoil and 9,700 cu.yd of subsoil or overburden available for landforming operation. The landforming operation will begin with the expansion of the shoreline of the existing pit in the area marked 1A (refer to Figure 17 for phase one of the plan). This

Figure 17. Phase One of the phasing plan


PHASE ONE
PROJECT BOUNDARY OF
EXISTING AREA
1A
EXISTING PIT
I
PROJECT BOUNDARY FOR
FUTURE EXPANSION
BASED ON 200 FEET
SET BACK LINE
SOPERS MILL
PARK ACCESS
ROAD
SKUNK RIVER
KEY
PRODUCTION
MOVEMENT
OVERBURDEN
MOVEMENT
OVERBURDEN
PLACEMENT AREA
SCALE IN FEET
PHASING PLAN I
ARRASMITH PIT.
STORY COUNTY, IOWA

expansion is intended to reduce the steep slope along the north bank of the existing pit and also to expand the land area along the north portion of the pit which is adjacent to the access road. The recommended slope for the pit bank is 3:1 side slope. This expansion will create more area for the access road which is important when the mining operation starts to resume at the expansion area.

<u>Phase Two</u>

Synopsis

Acreage: 3.3 acres

Duration: 3 years (1990-1993)

Amount of deposits: 106,500 cu.yd.

Amount of top soil: 21,300 cu.yd.

Amount of overburden: 32,000 cu.yd.

Landforming operation:

#	Activity	Quantity
2A	Create berm for visual barrier at the west of Skunk River	6,500 cu.yd.
2B	Expand/reclaim the area marked 2B	46,800 cu.yd.

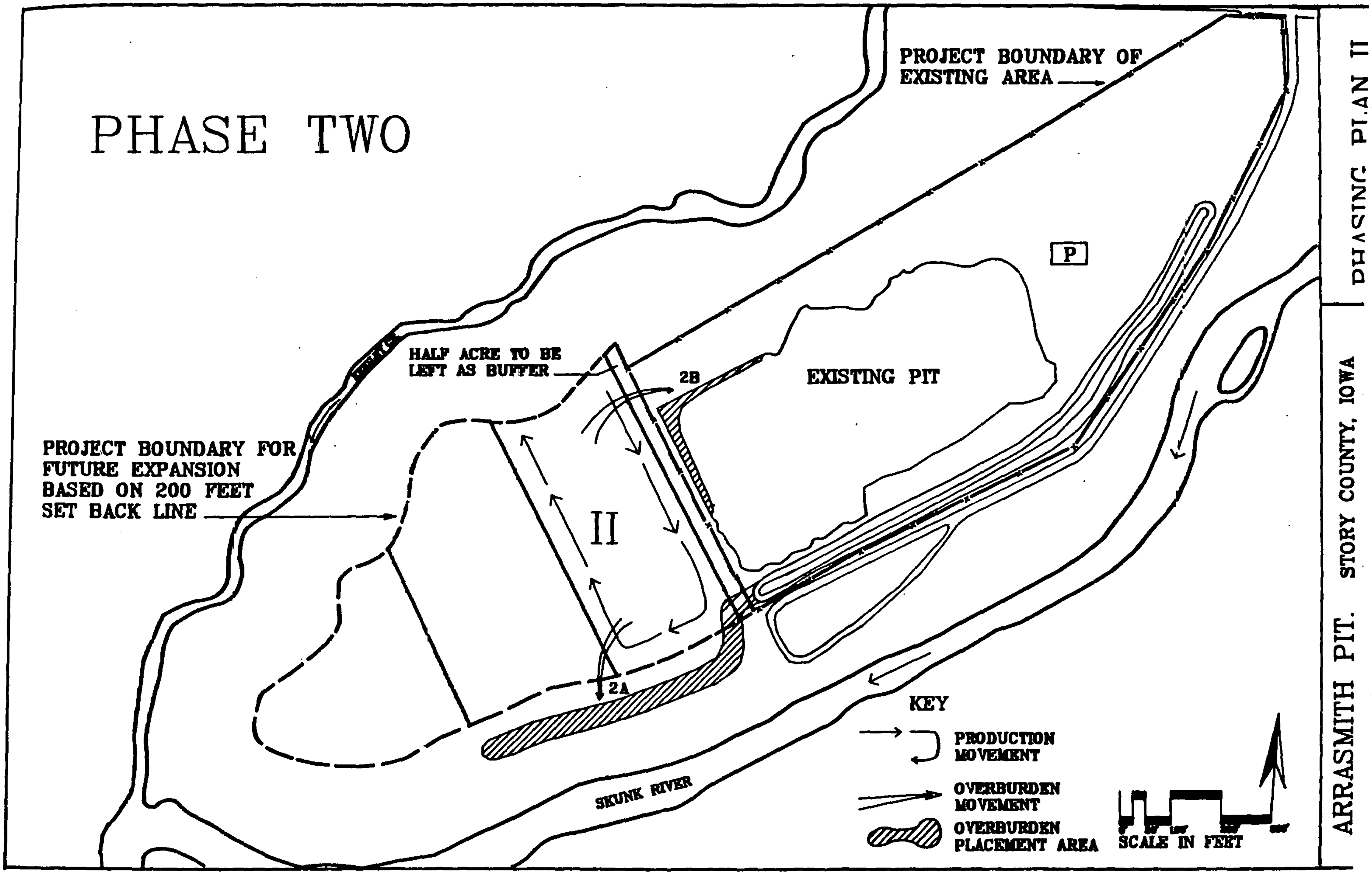
Explanation of phase two:

In this second phase (Figure 18), the operation will start at the new site towards the west of the existing pit. The amount of deposits that will be extracted in this phase will be 106,500 cu.yd with 21,300 cu.yd of topsoil and 32,000 cu.yd of overburden. This phase will involve the formation of a visual berm constructed along the project boundary of the new expansion area. A set back of 200 feet is needed to protect the Skunk River. The visual berm is 650 feet long with a cross sectional area of 272 square feet (Figure 16) and will be constructed within this set-back lines. The visual berm will be established first, as soon as the top soil and the overburden are stripped. The reclamation program at 2B will progress gradually as the top soil and the overburden are stripped from the second phase.

Mining at the new site will begin in the northeast corner of the new phase. The portable processing plant will still be located to the area marked P (Figure 18). Expansion of the shoreline at 2B will take place concurrently as the mining of sand and gravel proceeds. In this second phase, a total of half an acre will be left as a buffer (separation zone) between the existing pit and the new expansion area.

Visual screening and planting of trees will be carried out near the pit entrance to minimize visual impacts. The existing berm will not be levelled off because this berm has formed a good physical and visual separation between the park users and the mining site.

Figure 18. Phase Two of the phasing plan


PHASE TWO
PROJECT BOUNDARY OF EXISTING AREA
HALF ACRE TO BE LEFT AS BUFFER
2B
EXISTING PIT
P
PROJECT BOUNDARY FOR FUTURE EXPANSION BASED ON 200 FEET SET BACK LINE
II
2A
SKUNK RIVER
KEY
PRODUCTION MOVEMENT
OVERBURDEN MOVEMENT
OVERBURDEN PLACEMENT AREA
SCALE IN FEET
PHASING PLAN II
ARRASMITH PIT. STORY COUNTY, IOWA

Phase Three

Synopsis

Acreage: 3.5 acres

Duration: 4 years (1993-1997)

Amount of deposits: 113,000 cu.yd.

Amount of top soil: 22,600 cu.yd.

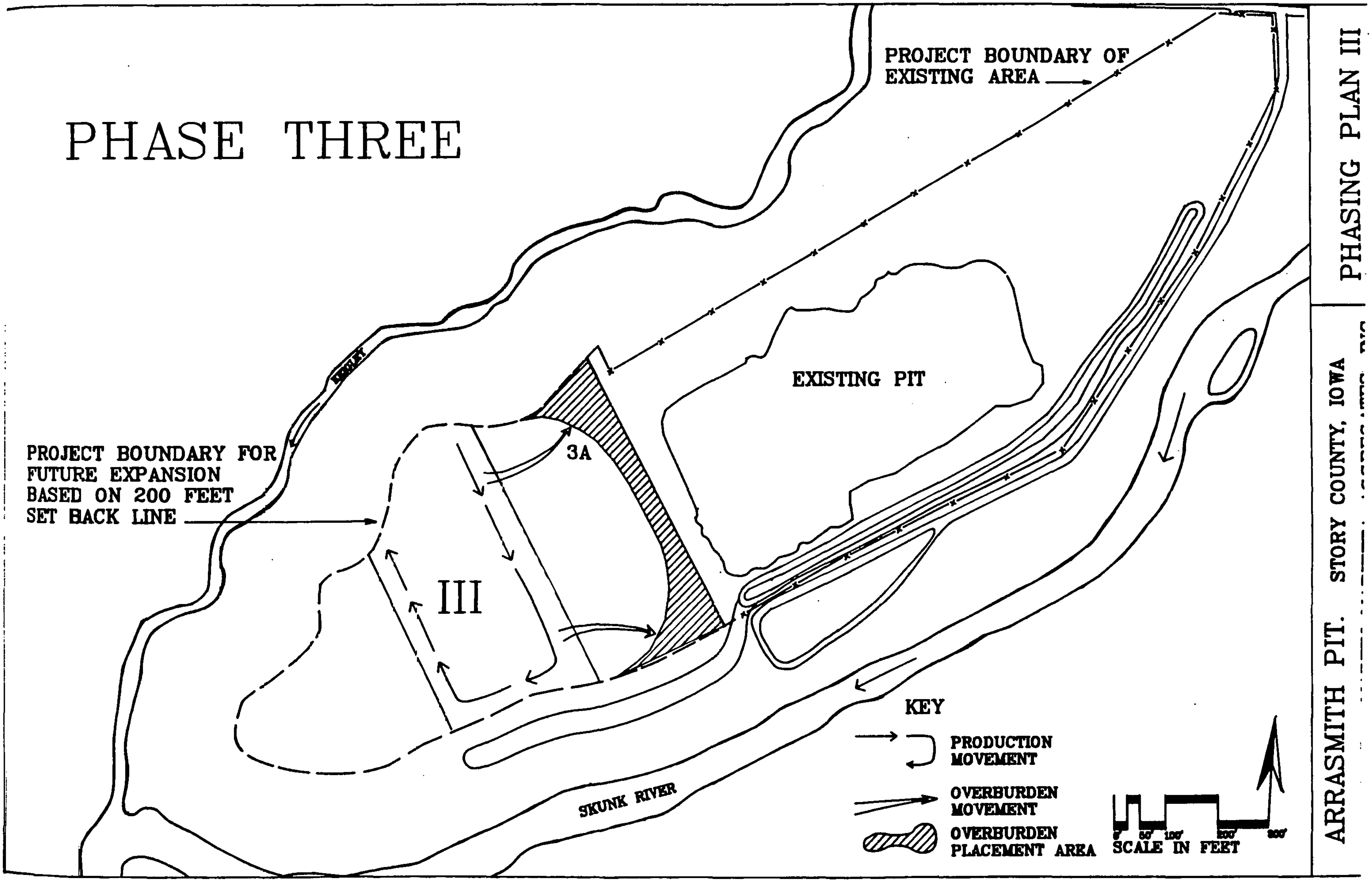
Amount of overburden: 33,900 cu.yd.

Landforming operation:

#	Activity	Quantity
3A	Reclaimed the east portion of phase two pit in the area marked 3A	56,500 cu.yd.

Explanation of phase three:

The mining operation for phase three (Figure 19), begins adjacent to the newly-formed pit of the phase two. The mining operation will progress from north to south. The volume of deposits that will be extracted from this phase is 113,000 cu.yd. of sand and gravel. A total of 22,600 cu.yd. of top soil and 33,900 cu.yd. of overburden will be used to reclaim the pit formed during phase two. This reclamation program will increase the buffer zone area.


PHASE THREE
PROJECT BOUNDARY OF EXISTING AREA
EXISTING PIT
PROJECT BOUNDARY FOR FUTURE EXPANSION BASED ON 200 FEET SET BACK LINE
3A
III
SKUNK RIVER
KEY
PRODUCTION MOVEMENT
OVERBURDEN MOVEMENT
OVERBURDEN PLACEMENT AREA
0' 50' 100' 200' 300'
SCALE IN FEET
PHASING PLAN III
ARRASMITH PIT. STORY COUNTY, IOWA

Phase Four

Synopsis

Acreage: 2.5 acres

Duration: 3 years (1997-2000)

Amount of deposits: 80,700 cu.yd.

Amount of top soil: 16,000 cu.yd.

Amount of overburden: 24,000 cu.yd.

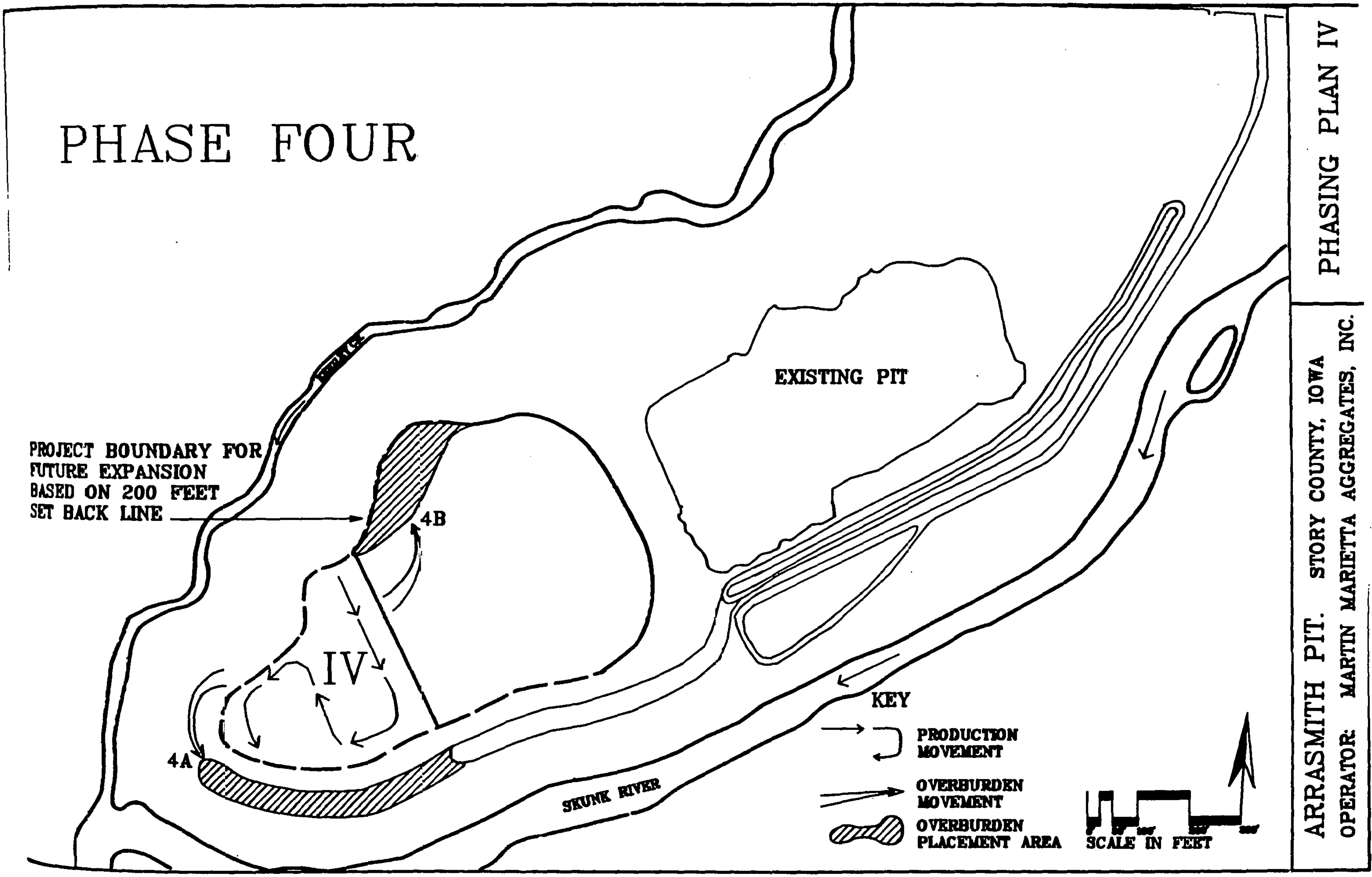
Landforming operation:

#	Activity	Quantity
4A	Extend the visual berm created during the second phase	5,500 cu.yd.
4B	Expand land area at the north of the pit formed by phase two and three at the area marked 4B	35,000 cu.yd.

Explanation of phase four:

This phase will be the last phase encompassing an area of 2.5 acres. In this phase (Figure 20), the mining operation will reach the southern tip of the new expansion area. The mining operation starts at the north portion of the new phase. In this operation, the volume of deposits that will be extracted is 80,700 cu.yd. with 16,200 cu.yd. of top soil and 24,000 cu.yd. of overburden. The top soil and overburden from this phase will be used to expand the

Figure 20. Phase Four of the phasing plan


PHASE FOUR
EXISTING PIT
PROJECT BOUNDARY FOR FUTURE EXPANSION BASED ON 200 FEET SET BACK LINE
4B
IV
4A
SKUNK RIVER
KEY
PRODUCTION MOVEMENT
OVERBURDEN MOVEMENT
OVERBURDEN PLACEMENT AREA
SCALE IN FEET
PHASING PLAN IV
ARRASMITH PIT. STORY COUNTY, IOWA
OPERATOR: MARTIN MARIETTA AGGREGATES, INC.

land area of the pit formed in the phase two and three and also to be used to extend the visual berm already formed during the second phase.

Final End Condition

The demand for preserving natural areas and establishing native plant communities, coupled with the equally important need for outdoor recreation has focused the attention on proposing this sand and gravel site for a low-intensity outdoor recreation use while simultaneously giving emphasis to the re-establishment of native plant communities. At present, there is no economic pressure to develop the site for any specific post-mining land use. However, the Arrasmith Pit end condition planning must respond to the fact that it lies within the Skunk River Greenbelt District. There is much concern relating to the preservation of the visual landscape and native plant communities in this area because (1) the Skunk River Greenbelt is considered as one of the few areas covered by riparian woodlands left in Story County and (2) it is considered an important wildlife corridors in Story County. Therefore, the final end condition of this site undoubtedly will be directed towards the re-establishment of appropriate native plant communities and enhancement of low-intensity outdoor recreation opportunities such as nature walks, fishing, bicycling and so on.

Re-establishment of native plant communities will be carried out first at the existing mined-out areas while the expansion area is in active mining. This type of land use would involve only minimal site improvements because it does not involve any intensive site improvements or construction of buildings. Because the access road for transporting the materials will still use the existing entrance, native trees will be grown along this access road to form a visual separation between the reclaimed (existing pit) area, and the access road.

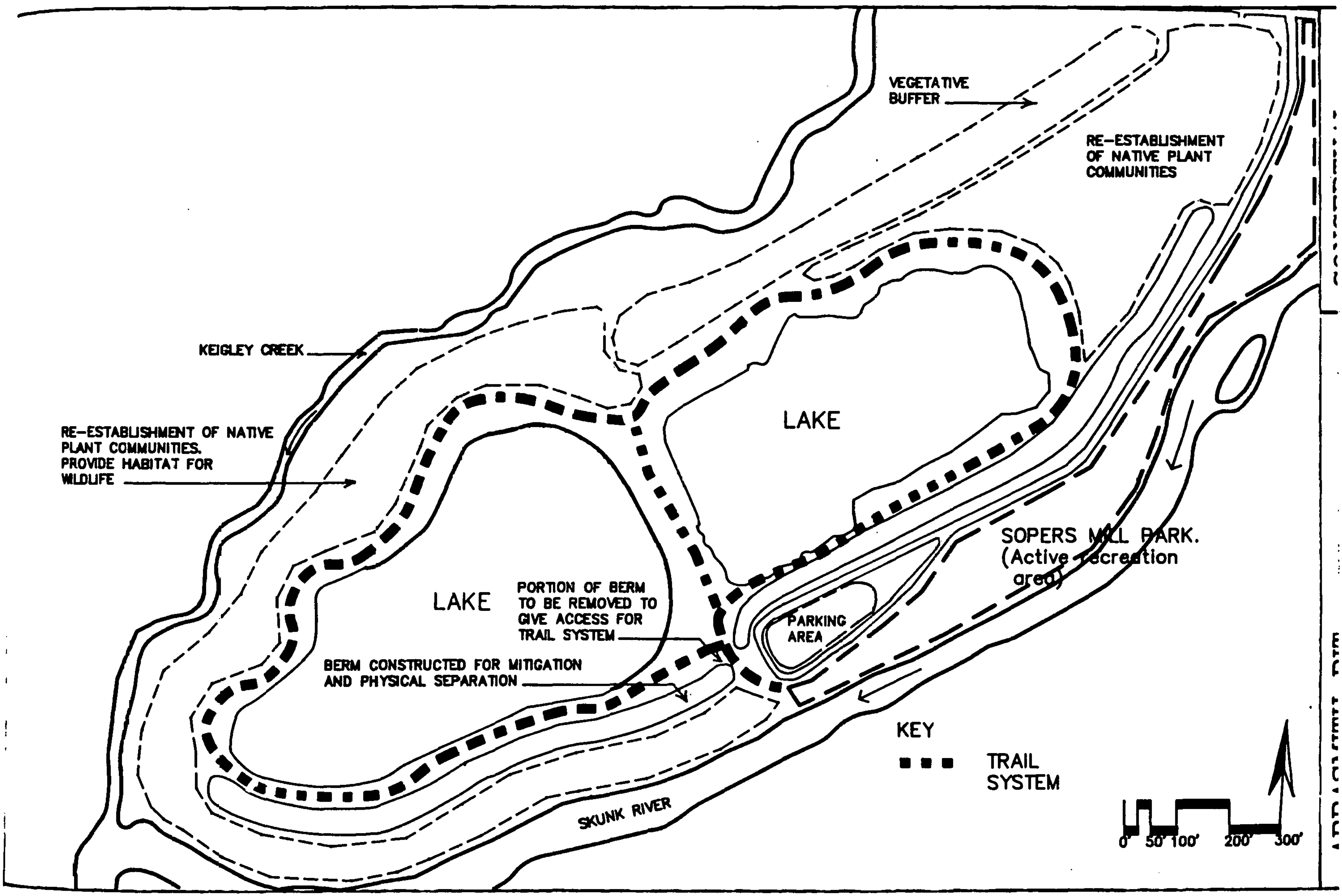
The re-establishment of native plant communities will not only blend in with the existing landscape of the area but will also be highly suitable for the enhancement of wildlife habitat. The existence of the two pits will also have the potential to produce valuable fish and wildlife habitat. The earth berm that was established along the eastern portion of the existing pit and the expansion pit areas may also be an added amenity. Many wildlife species use different habitats for different activities and this site will be a suitable place for wildlife which prefer secluded areas because the earth berm will act as a physical barrier as well as a visual barrier between the active recreation site (Soper's Mills park) and this mining area.

The combined use of recreation and wildlife habitat seems to be the most appropriate and practical post-mining activities on this mine site. These will also blend in with the concept of re-establishing native plant communities on this mine site. Figure 21 shows a conceptual diagram of the post-mining condition of the site. Recreation use can be divided into two categories: passive and active. Any type of recreation programmed for the Arrasmith Pit would probably emphasize the passive recreational uses such as nature trail. This is due to its small size, location, and the physical nature of the site.

The final end condition of this site provides opportunities for reclamation and soil stability in keeping with the goals of the Greenbelt. The presence of two large water bodies will enhance this kind of wildlife habitat. Swimming is not recommended at this mine site. This is due to the low percentage of waste or fine sand available for forming the beach and also the existence of swimming facilities at the Peterson Pit located nearby. However, this site can be directed towards an educational experience where various kinds of native trees are grown in a more controlled situation.

Designing facilities are also suggested that have the appeal and value to visitors while preserving the natural character and dynamics of the environmental resources. To establish this site as a passive recreational area and

Figure 21. Conceptual diagram of the study site

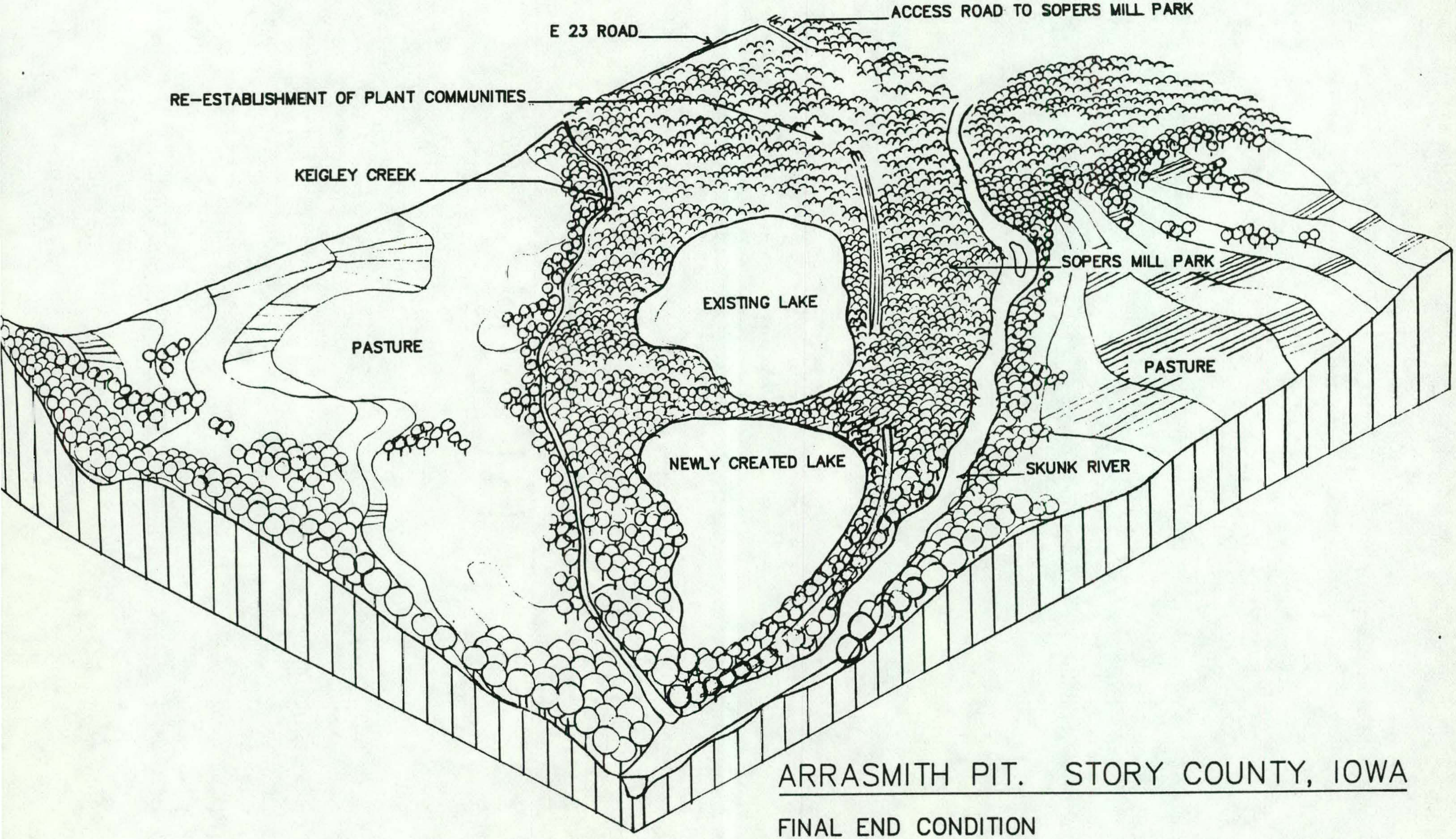

VEGETATIVE BUFFER
RE-ESTABLISHMENT OF NATIVE PLANT COMMUNITIES
KEIGLEY CREEK
RE-ESTABLISHMENT OF NATIVE PLANT COMMUNITIES. PROVIDE HABITAT FOR WILDLIFE
LAKE
LAKE
PORTION OF BERM TO BE REMOVED TO GIVE ACCESS FOR TRAIL SYSTEM
BERM CONSTRUCTED FOR MITIGATION AND PHYSICAL SEPARATION
PARKING AREA
SOPERS MILL PARK. (Active recreation area)
KEY
TRAIL SYSTEM
SKUNK RIVER
0' 50' 100' 200' 300'

wildlife habitat, the development can also focus on the following:

1. providing parking facilities at the Soper's Mill park.
2. providing a small trail system from the Soper's Mill park to the site.
3. re-establishment of native plant associations to illustrates succession.

Figure 22 illustrates the final end condition of the site.

Figure 22. Final end condition of the site



ARRASMITH PIT. STORY COUNTY, IOWA

FINAL END CONDITION

CHAPTER 7. CONCLUSIONS

Evaluation

There were two major goals of this study: (1) to describe concurrent sand and gravel mining operations and reclamation planning and make mine operators and planners aware that the most effective methods of mining operation is by using the concept of integration, sequential or concurrent mining operation and reclamation program, and (2) to describe and evaluate the usefulness of microcomputer aided design (CAD) methods in a sand and gravel mine operation and reclamation planning.

The microcomputer application techniques used in this study are geared primarily to the potential of using microcomputers with 'off-the-shelf' programs that can provide alternative graphic tools in sand and gravel mine operation and reclamation planning. The benefits, skills, experiences and time requirements discussed previously relate only to the application of microcomputers on sand and gravel mine operations and reclamation planning specifically in this study.

Computer Aided Design (CAD) methods involved were mainly AutoCAD and Surfer software. These were used to replace hand-drawn techniques of preparing the concurrent mining and reclamation program for a sand and gravel operation near Ames, Iowa. By virtue of its size (which is just about twenty-five acres of land where about fifteen acres had been mined out), location, and type of operation, this site seemed to have a limited potential for some type of post-mining land use. This is especially true because this site is located in a "Critical Resource Areas" where the preservation and re-establishment of plant communities and wildlife habitat are very important. However, because the use of microcomputer aided design in mined land reclamation planning is the main focus of this study, this site like any other larger mine site will provide the same opportunity to the author to carry out the research and to use microcomputers as a tool to communicate the ideas.

There were some variables in this kind of application research. Proficiency in the use of the microcomputer equipment and programs is a critical factor influencing the outcome of the study. This study was focused on the needs for concurrent, integrated sand and gravel mine operations and reclamation planning with an emphasis on the application of microcomputers as an alternative to conventional technique in this microcomputers planning process. During the research, there were both advantages and disadvantages of the microcomputer techniques and the discussion below summarizes them.

Advantages

Chapter five on the application of microcomputers has shown that microcomputers have the potential to be used in integrated mine planning and progressive landforming. Even though in this study, only two graphics software program (AutoCAD and Surfer) were used, but it has shown that it is sufficient to be used in the mined-land reclamation and planning process.

Microcomputer can also provide information that cannot be provided by conventional techniques. One example is in the area of earthwork calculation. AutoCAD program, besides a useful tool for graphic works can also provide information on the volume of overburden excavated and the area of the mine site.

<u>AutoCAD:</u> The AutoCAD program, even though the Version 2.62 was used in this study, it was an excellent program. It is a very flexible program where commands can be entered either from a keyboard, digitizing board or mouse. This program requires a minimum of 512 K of random access memory (RAM), but 640 K is recommended for maximum efficiency. The calculation of an area can be done by just picking all the vertices of a polygon or by selecting points on the circumferences of a circle.

<u>Surfer:</u> Like AutoCAD program, Surfer program is very flexible and it is easy to use. The help command can assist the user to carry out the computation. The Surfer program requires a minimum of 512K of RAM, but like AutoCAD,

640 K is recommended. Unlike AutoCAD program, Surfer program can produces orthographic and perspective drawings.

Disadvantages

The computer applications in this study were limited to off-the-shelf programs for MS-DOS microcomputers available in the Department of Landscape Architecture. The graphics produced were also rather limited.

In the Surfer program, trees cannot be created in three-dimensional form to the Surfer perspective drawing. For example in the final end condition drawing (Figure 22) the researcher have to use manual techniques to draw trees in perspective form.

The disadvantage of using AutoCAD version 2.62 program is that it cannot create perspective drawing. Also, both programs cannot apply simulation techniques. Computer simulation techniques can be done on workstation or mainframe computers by using other software, such as Movie BYU, a program developed at the Brigham Young University.

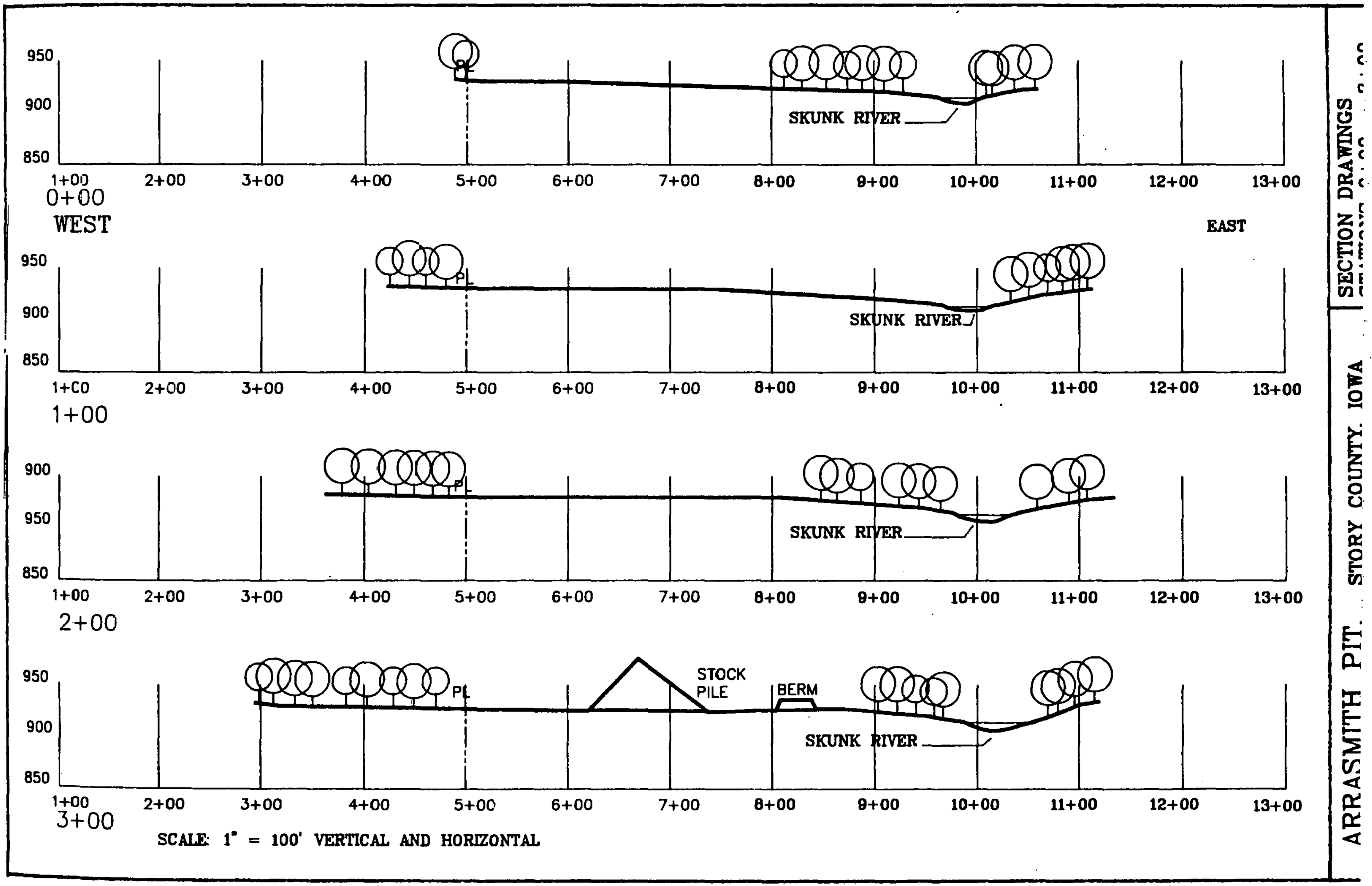
Recommendations for Future Research

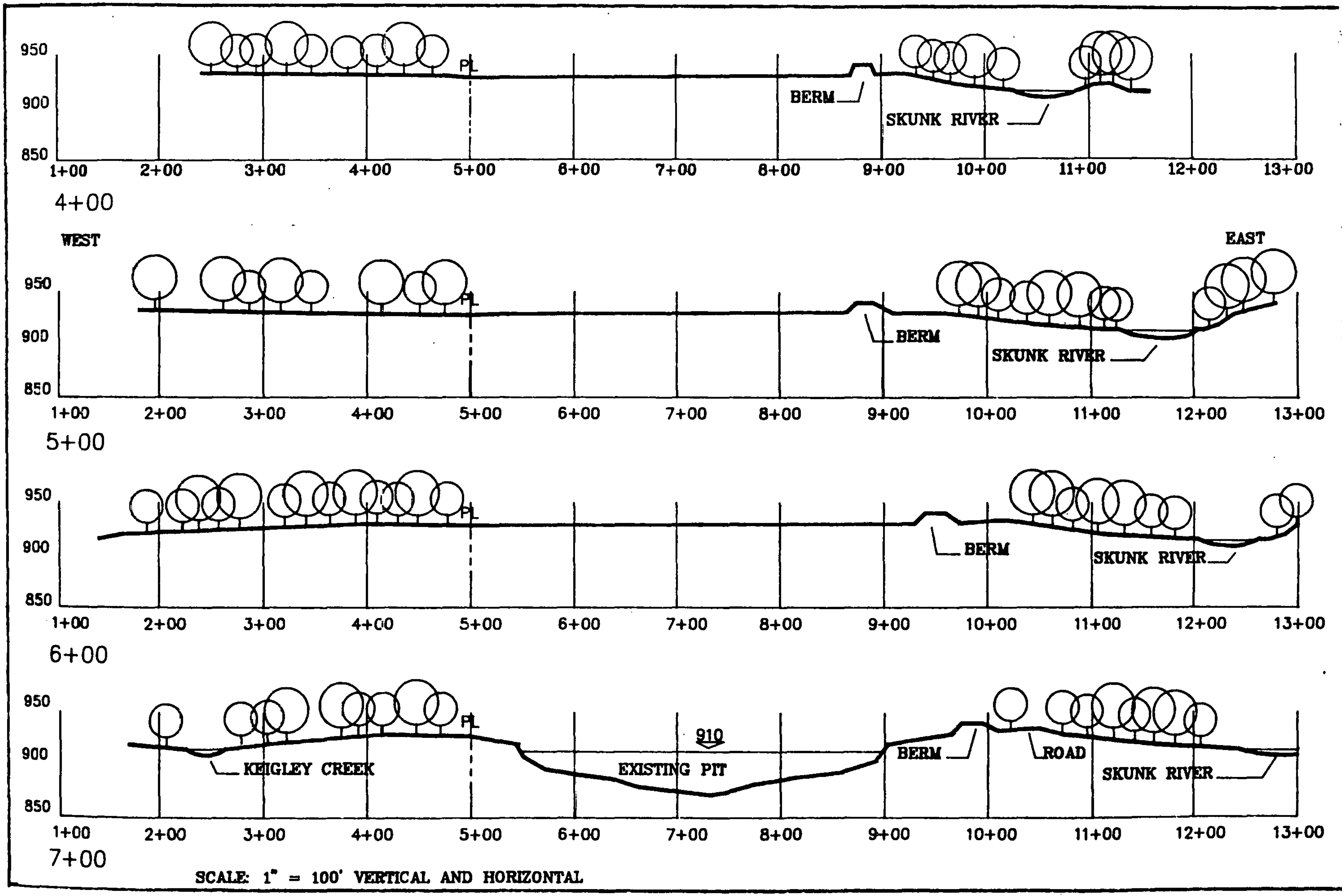
The primary program used was AutoCAD version 2.62. It is recommended that other programs (for example Drafix 3-Plus and AutoCAD version 10) be evaluated. Also, more powerful microcomputers for example, machines with 80386 processors and more memory should be evaluated. Computer

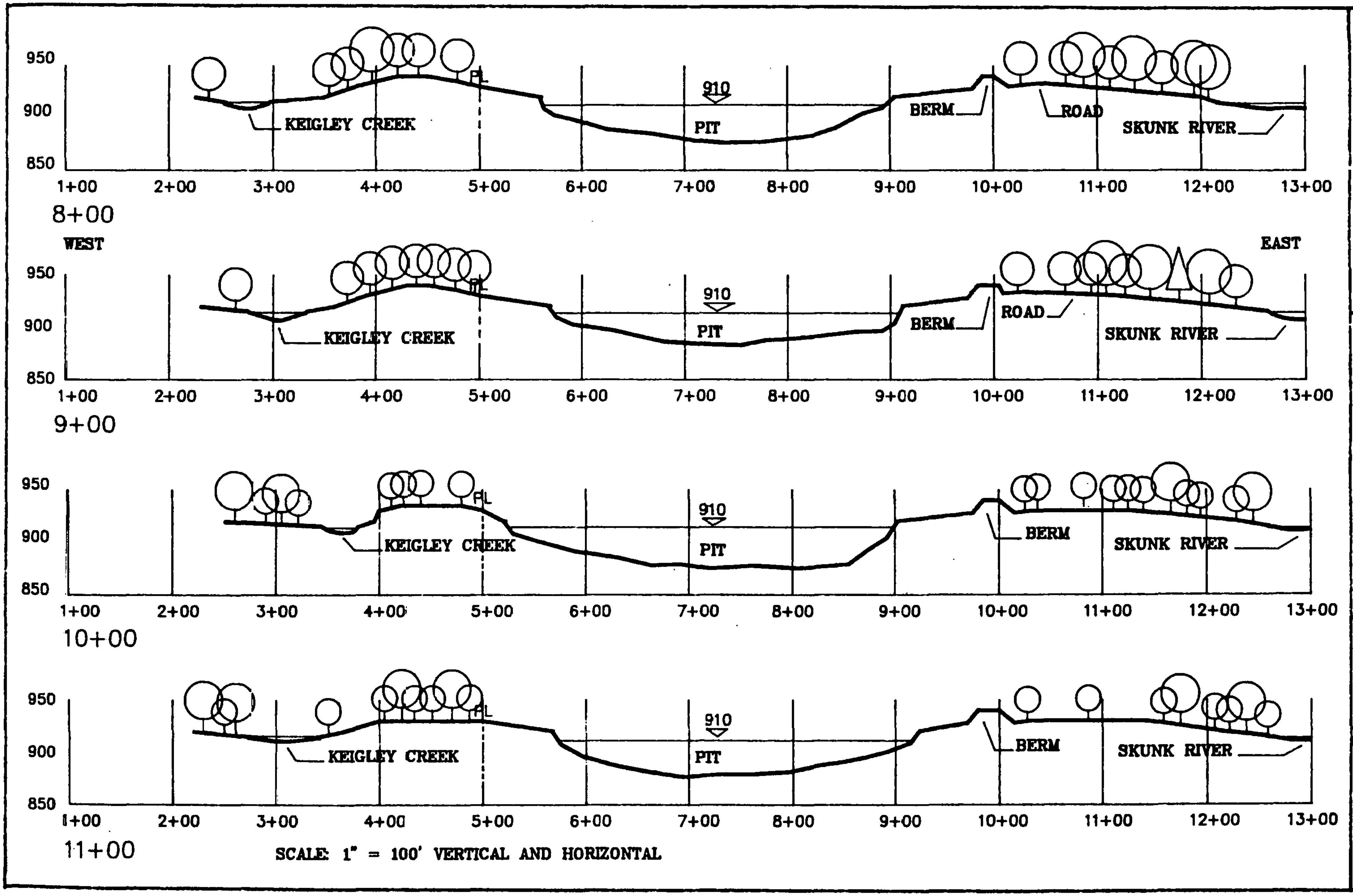
computer programming skills to become an effective and creative designer. Third, microcomputer applications provides a wide opportunity to evaluate plans, sections, and details very quickly with different combinations of information and also different design solutions to problems. Fourth, some programs (such as "Surfer" used in this study) allow the designer to convert the plans into 3-dimensional drawings which can be very useful for visual analysis of the site.

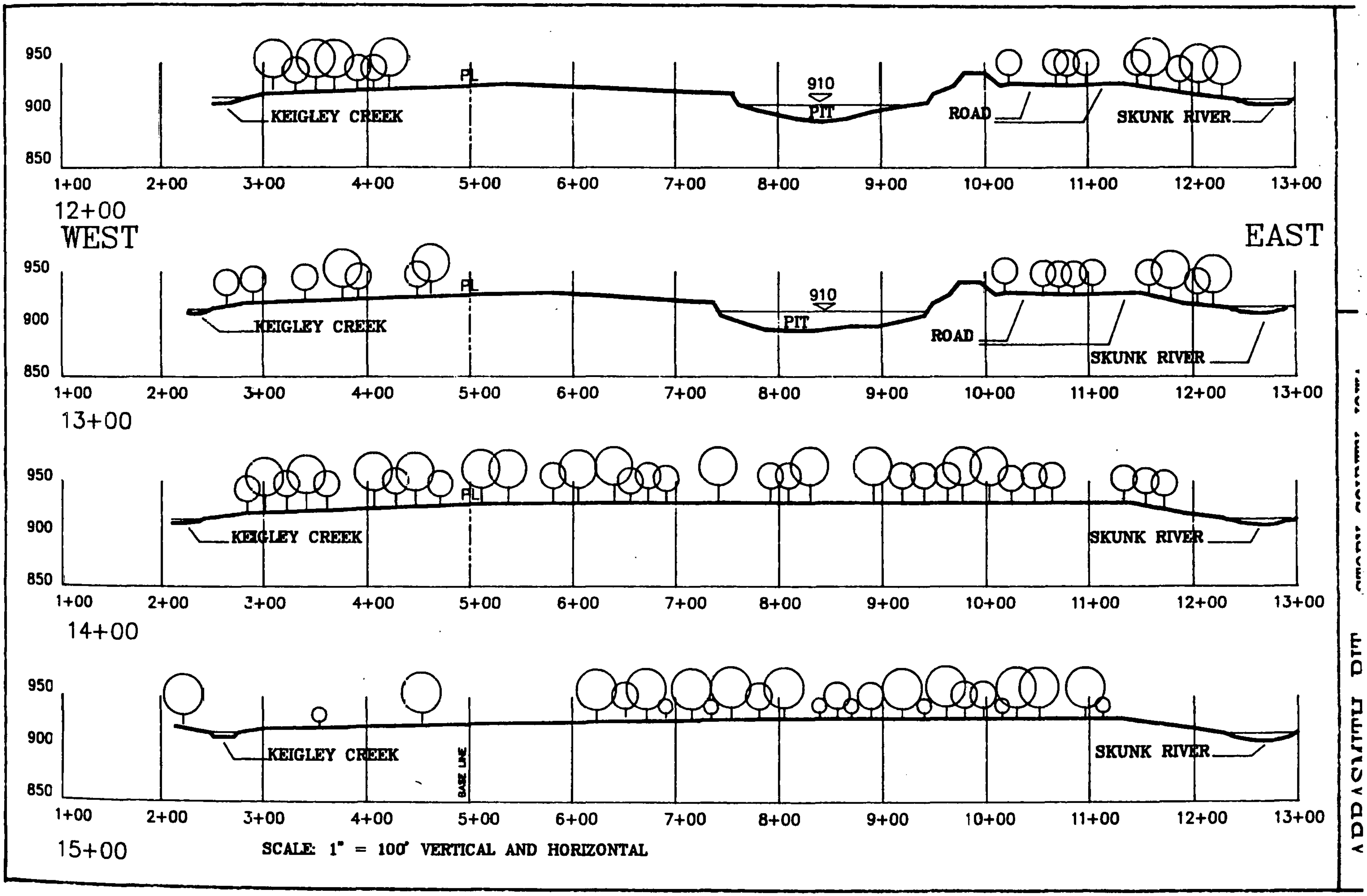
The two computer programs used in this study have proven successful in planning sand and gravel mining operations and reclamation. Use of microcomputers and off-the-shelf programs can be an important tool for landscape architects and planners in developing the sequential, integrated and concurrent sand and gravel mining operations and reclamation planning. However, computer techniques, as tools, must work with (and not replace) their professional knowledge and judgment.

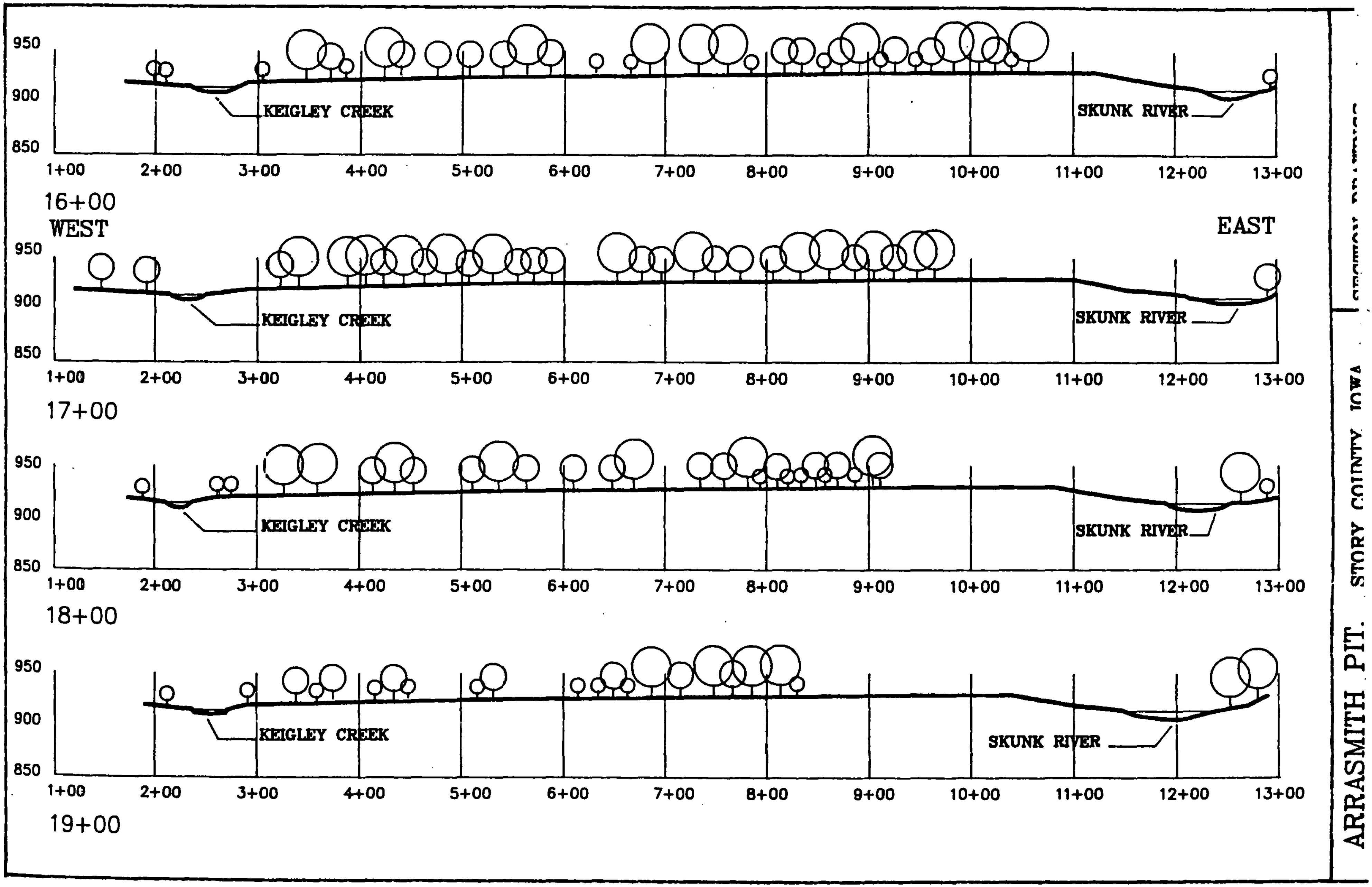
APPENDIX A: SECTION DRAWINGS SHOWING STATIONS FROM 0+00 TO 26+00


SECTION DRAWINGS
ARRASMITH PIT. STORY COUNTY, IOWA
WEST
EAST
0+00
1+00
2+00
3+00
950
900
850
PL
SKUNK RIVER
STOCK PILE
BERM
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
SCALE: 1" = 100' VERTICAL AND HORIZONTAL

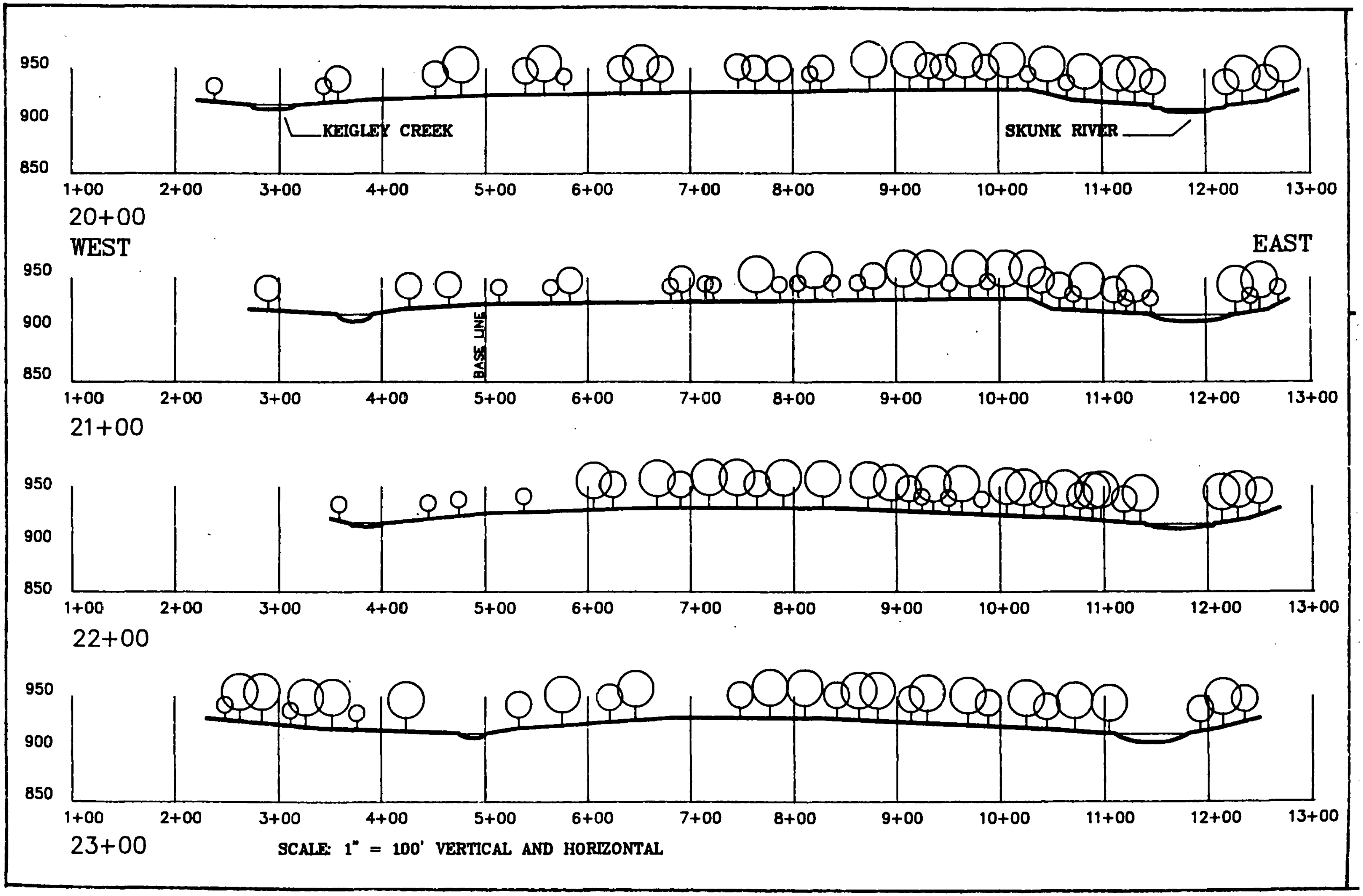

950
900
850
PL
BERM
SKUNK RIVER
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
4+00
WEST
EAST
BERM
SKUNK RIVER
5+00
BERM
SKUNK RIVER
6+00
910
KEIGLEY CREEK
EXISTING PIT
BERM
ROAD
SKUNK RIVER
7+00
SCALE: 1" = 100' VERTICAL AND HORIZONTAL

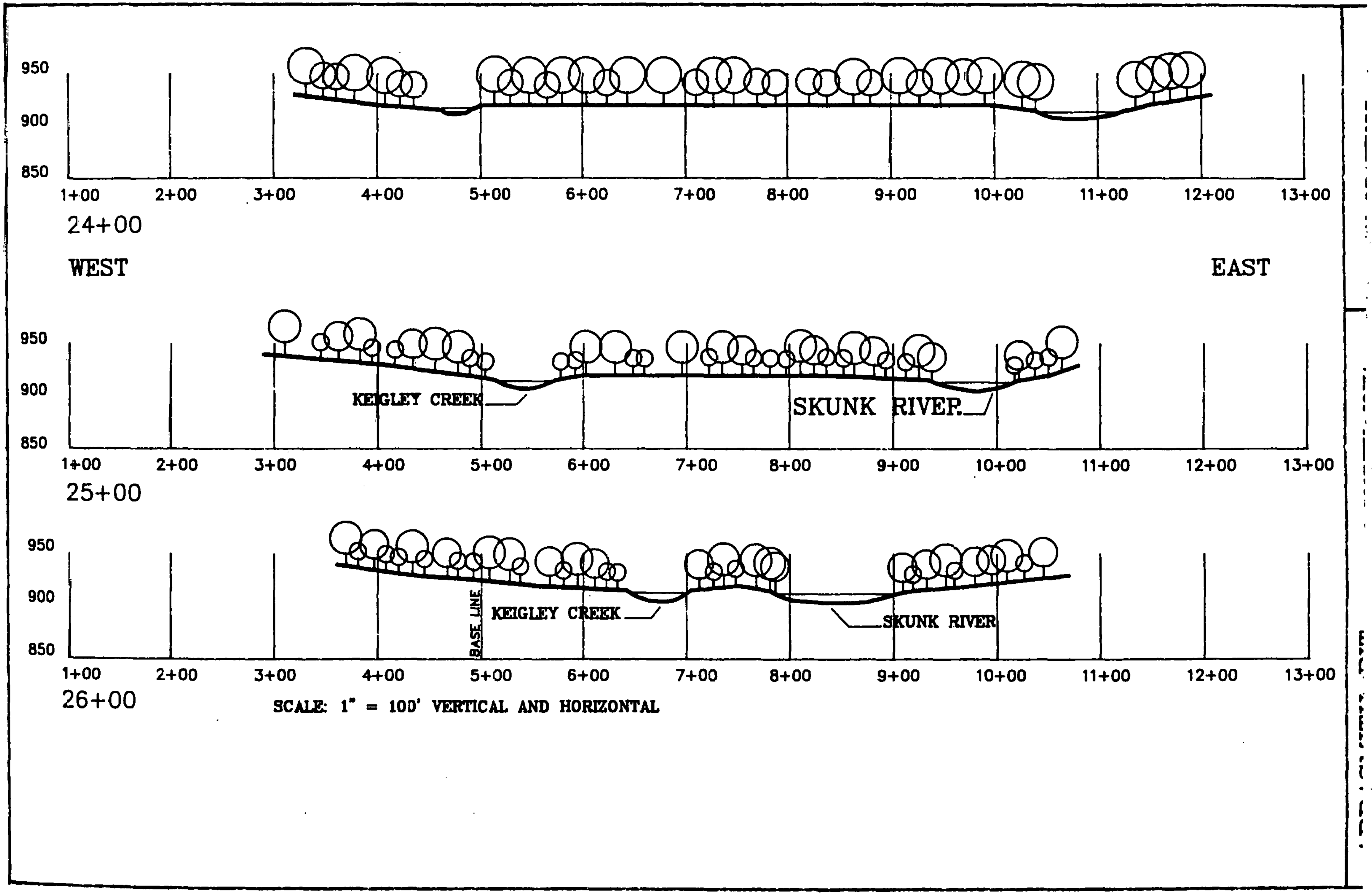

950
900
850
910
PIT
KEIGLEY CREEK
PL
BERM
ROAD
SKUNK RIVER
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
8+00
WEST
EAST
9+00
10+00
11+00
SCALE: 1" = 100' VERTICAL AND HORIZONTAL


950
900
850
FL
910
PIT
KEIGLEY CREEK
ROAD
SKUNK RIVER
1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00
12+00
WEST
EAST
13+00
14+00
BASE LINE
15+00
SCALE: 1" = 100' VERTICAL AND HORIZONTAL

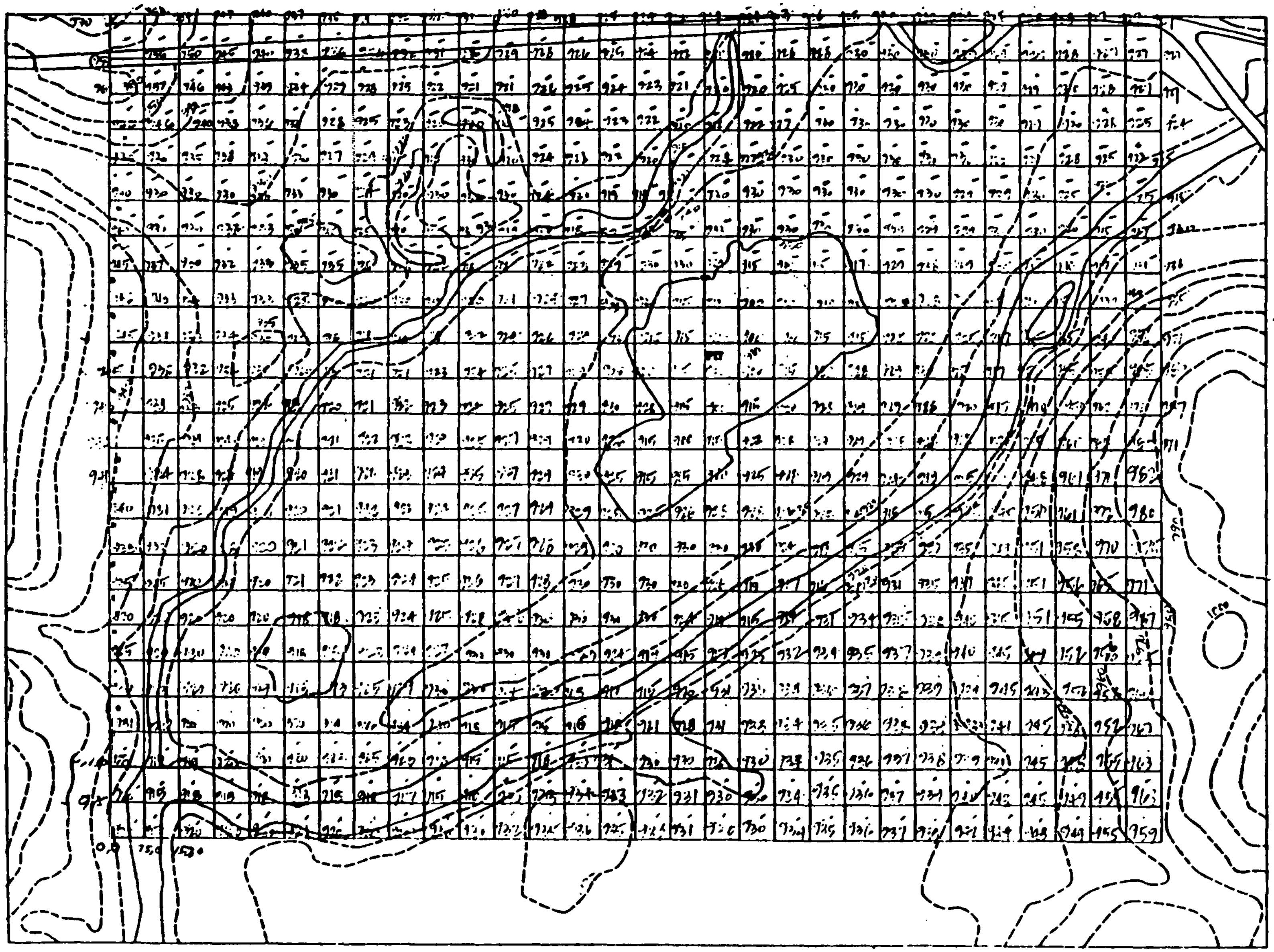


16+00
17+00
18+00
19+00
WEST
EAST
950
900
850
KEIGLEY CREEK
SKUNK RIVER
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
ARRASMITH PIT. STORY COUNTY, IOWA


950
900
850
KEIGLEY CREEK
SKUNK RIVER
1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00
20+00
WEST
EAST
BASE LINE
21+00
22+00
23+00
SCALE: 1" = 100' VERTICAL AND HORIZONTAL


950
900
850
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
24+00
WEST
EAST
KEIGLEY CREEK
SKUNK RIVER
25+00
BASE LINE
26+00
SCALE: 1" = 100' VERTICAL AND HORIZONTAL

APPENDIX B: TRANSFORMATION PROCESS FROM AUTOCAD DRAWING TO SURFER



BIBLIOGRAPHY

Ahearn, Vincern P. Land Use Planning and the Sand and Gravel Producer. Silver Spring: National Sand and Gravel Association, 1964.

Allen, William G. A History of Story County, Iowa. Marceline, Missouri: Walsworth Publishing Co., Inc., 1975.

Anderson, P.F. MicroMSDAMP Primer. Unpublished manuscript. Iowa State University, Department of Landscape Architecture, Ames, Iowa, 1985.

Bauer, Anthony M. Simultaneous Excavation and Rehabilitation of Sand and Gravel Sites. University of Illinois Research Project #1. Silver Spring: National Sand and Gravel Association, 1965.

Baxter, John G. Site Planning for Sand and Gravel Operations. University of Illinois Research Project #4. Silver Spring: National Sand and Gravel Association, 1969.

Beacham, Deborah and Walton Beacham. Using WordPerfect. 3rd Edition. Carmel, Indiana: Que Corporation, 1987.

Beard, Mary K. "An Application of Geographic Information System Technology to Sand and Gravel Resource Planning." Master's Thesis, University of Wisconsin, 1984.

Beck, Leslie. Story County Planning and Zoning Commission. (Personal communication with Jamel Ariffin regarding the post-mining land use of the site.), 1989.

Brown, Darrell. Reclaiming Disturbed Lands. Washington, D.C.: USDA, 1984.

Brown, D. J., A. R. Ashton, J. A. Croghan, S. M. Johnson. "Concepts in Computer Aided Mine Design and Planning." Mining Science and Technology 7 (1988): 99-119.

Carberry, Patrick. CAD/CAM with Personal Computers. Blue Ridge Summit, PA: TAB Books Inc., 1985.

Coates, William E. "Mining Creatively to Structure Future Landscapes." Proceedings: Shaping Land for Tomorrow.

School of Urban Planning and Landscape Architecture, Michigan State University, East Lansing, MI, 1982.

Crone, J. V. "Debugging the Computer Purchase. Landscape Architecture, 22(2) (1983): 77-79.

Dietrich, N. L. Associate Professor in the Department of Landscape Architecture, Iowa State University. (Personal communication with Jamel Ariffin).

Dietrich, N. L. Cost Data for Landscape Construction. 8th Edition. Minneapolis, Minnesota: Dietrich/Kerr Associates, 1988.

Dietrich, N. L. "Integrated Sequential Mine and Reclamation Planning for Aggregate Mines." Pp. 197-207 in National Symposium on Mining, Hydrology, Sedimentology, and Reclamation. University of Kentucky, Lexington, Kentucky, 1986.

Goldman, H. B., and Reining, D. "Sand and Gravel" Pp. 97-108 in: Industrial Minerals and Rocks, S. J. Lefond. New York: American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1975.

Gordon, Steven. I. Computer Models in Environmental Planning. New York: Von Nostrand Reinhold Company, 1985.

Hackett, Brian, Ed. Landscape Reclamation Practice. Guildford, Surrey: IPC Science and Technology Press, 1977.

Hahn, Howard D. Site Design. Landscape Architecture Magazine. 76, No. 4 (July/August 1986): 72-78.

Hewlett, John D. Principles of Forest Hydrology. Athens, Georgia: University of Georgia Press, 1983.

Jensen, David R. Selecting Land Use for Sand and Gravel Sites. University of Illinois Research Project #3. Silver Spring: National Sand and Gravel Association, 1967.

Johnson, Craig. Practical Operating Procedures for Progressive Rehabilitation of Sand and Gravel Sites. University of Illinois Research Project #2. Silver Spring: National Sand and Gravel Association, 1966.

Kane, K.L. "Integration of Landsat data into the MSDAMP geographic information system for regional recreation planning applications." Master's Thesis, Iowa State University, 1986.

Kuennen, Tom. "Land Rehabilitation: A Fresh Look." Pp. 20-48 in Rock Products. Chicago, Illinois: Maclean Hunter Publishing Co., 1984.

Landphair, Harlow C. " Managing the Visual Impact of Surface Mining." Pp.151-160 in Proceedings: Shaping Land for Tomorrow. School of Urban Planning and Landscape Architecture, Michigan State University, East Lansing, Michigan, 1982.

Laurie, Michael. An Introduction to Landscape Architecture. New York, New York: Elsevier, 1981.

Lyle, E. S. Surface Mine Reclamation Manual. New York, NY: Elsevier Science Publishing Co., Inc., 1987.

MacDougall, E. Bruce. Microcomputers in Landscape Architecture. New York, NY: Elsevier Science Publishing Co., Inc., 1983.

Marsh, William. M. Landscape Planning: Environmental Applications. Cambridge, Massachusetts: Addison-Wesley Publishing Co., 1983.

McQuire, Joseph. Martin Marietta Aggregates, Inc. (Personal Communication with Jamel Ariffin regarding the mining operation at Arrasmith Pit.), 1989.

Mineral Yearbook 1986. United States Department of Interior, Bureau of Mines, Washington, D.C., 1986.

Nadler, Gerald. The Planning and Design Approach. New York, NY: John Wiley and Sons, Inc. 1981.

Norton, Peter. Inside the IBM PC Revised and Enlarged. New York, NY: Prentice Hall Press, 1985.

Norton, Peter. Peter Norton's DOS Guide, Revised and Expanded. New York, NY: Prentice Hall Press, 1987.

Omura, George. Mastering AutoCAD. San Francisco, CA: Sybex Inc., 1987.

Paone, J., J. L. Morning, and L.Giorgetti. Land Utilization and Reclamation in the Mining Industry, 1930-1971. U.S Dept. of Interior, Bureau of Mines Information Circular 8643, 1974.

Patchett, James M. "Conservation, Recreation, Mining, and Rehabilitation in Story County, Iowa." Symposium Proceedings: Wildlife Values of Gravel Pits. Crookston, Minnesota: University of Minnesota, 1982.

Personal Computing. Product Review: WordPerfect 5.0 New York, New York: Ziff-Davis Publishing Company, August 1988.

Pickels, George. Realizing the Recreation Potential of Sand and Gravel Sites. University of Illinois Research Project #5. Silver Spring: National Sand and Gravel Association, 1970.

Raker, Daniel and Herbert Rice. Inside AutoCAD. Thousand Oaks, CA: New Riders Publishing, 1988.

Simpson, J. "Waste Not." Landscape Architecture, 75(3), (1985): 41-42.

Story County Planning and Zoning Commission. "Ames Two-Mile Area Study: Growth Management Plan." Background Report. Story County Planning and Zoning Commission, Nevada, Iowa, May 1988.

Soil Survey Report of Story County, Iowa. Soil Conservation Service, U.S. Department of Agriculture, 1984.

Svedarsky, Daniel W., and Richard D. Crawford, Eds. Wildlife Values of Gravel Pits. Symposium Proceedings, University of Minnesota, St. Paul, MN, 1982.

Swanson, Gustav A. Summary of Wildlife Values of Gravel Pits Symposium. Symposium Proceedings: Wildlife Values of Gravel Pits. Crookston, Minnesota: University of Minnesota, 1982.

Tepordei, Valentine V. "Sand and Gravel." Mineral Yearbook 1986, Vol.1. United States Dept. of Interior, Bureau of Mines, Washington, D.C., 1986.

Turner, K. L. History of the Town of Ames, Story County, Iowa. Ames, Iowa: Ames Intelligencer, 1871.

Turner, Tom. _Landscape Planning_. New York, NY: Nichols Publishing Co., 1987.

U.S. Department of Interior. _Mine Reclamation, Abandoned Mine Lands and Policy Issues_. Washington, D.C.: Bureau of Mines, 1986.

U.S. Department of Interior. _Proceedings: Prime Farmlands Reclamation Workshop_. Washington, D.C.: Bureau of Mines, 1979.

Visual Resources, Inc. Red Mesa. A Project of the Denver Technological Center, 1988.

Werth, J. "Sand and Gravel Resources: Protection, Regulation, and Reclamation." _Planning Advisory Service Report No 347_. Chicago, Illinois: American Planning Association, 1981.

White, D. H., James J. Hill, Wanda J. West. "The Mineral Industry of Iowa." Pp. 213-223 in _Mineral Yearbook, Vol.II_. Washington, D.C.: Bureau of Mines, 1985.

Wolff, Terris B. _Microcomputer Applications: Using Small Systems Software_. Boston, Massachusetts: Boyd and Fraser Publishing Company, 1985.

ACKNOWLEDGEMENTS

Several people have been particularly helpful to me during the course of this research. I especially thank my major professor, Norman L. Dietrich, whose enthusiastic interest in mining operation and reclamation planning has given me the great courage to pursue this research. I am very grateful for his sincere willingness to help me and his confidence in my abilities, not only during this study, but also throughout my undergraduate and graduate school.

I also extend thanks to my graduate committee, Dr. Dah Yinn Lee and Prof. Paul Anderson for their insight and assistance.

I thank the Iowa State Mining and Mineral Resources Research Institute because this study was supported (in part) by the Institute through the U.S. Department of Interior's Mineral Institutes program administered by the U.S. Bureau of Mines under Allotment Grants G1174119 and G1184119.

I also thank Martin Marietta Aggregates, Inc. for allowing me to use their mine site for the case study. Also, I thanks Anuar Mohd. Noor and Doug Madsen for their assistance in the early part of the study.

Last, but not least, I extend my thanks to my wife Ku Faizah binti Ku Ahmad and to our two daughters, Noorhaniza and Nursabirah for their patience, understanding, and

encouragement over the past four years and ten months in the United States.