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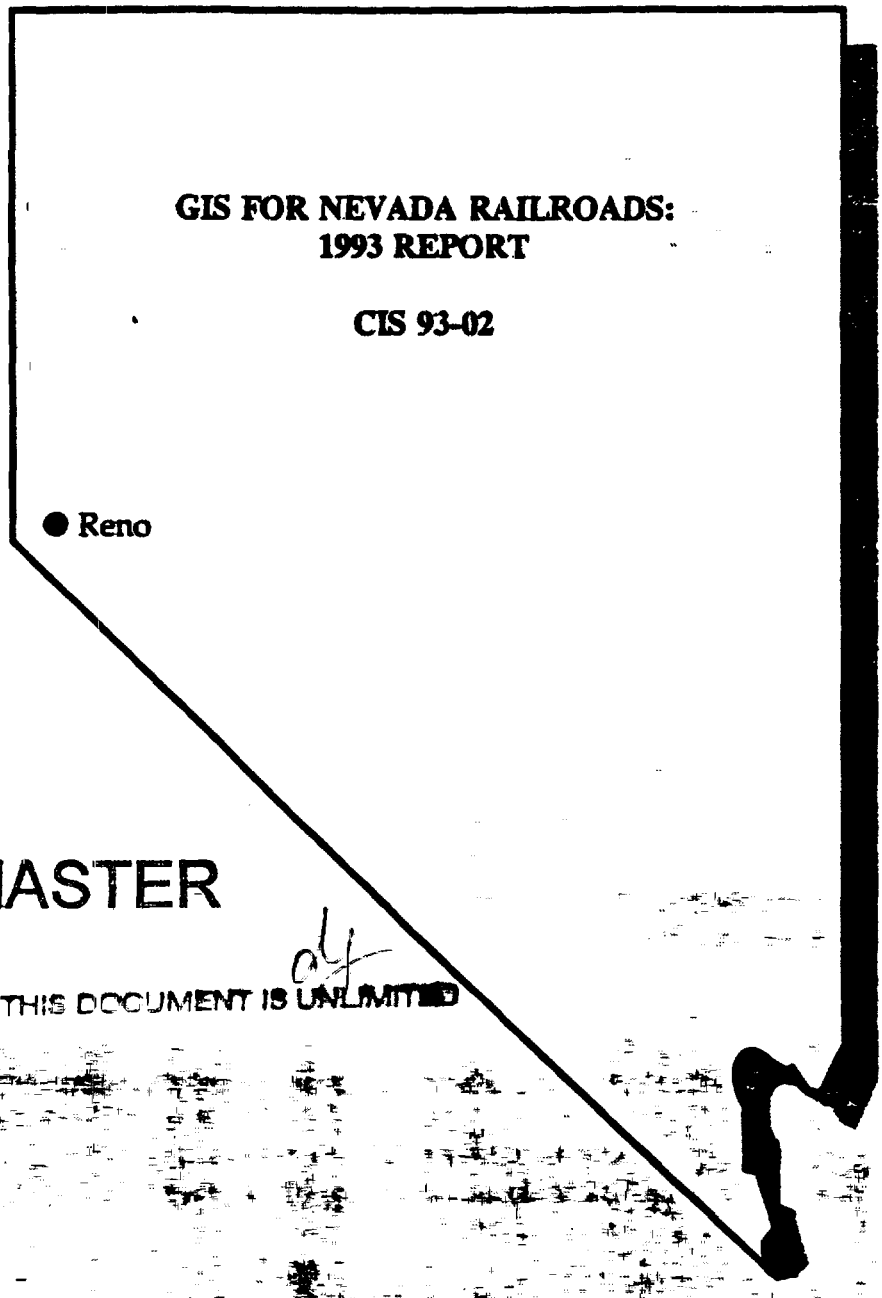
Center for Infrastructure Studies

GIS FOR NEVADA RAILROADS:
1993 REPORT

CIS 93-02



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GIS FOR NEVADA RAILROADS: 1993 REPORT

CIS 93-02

Prepared for:

U. S. Department of Energy

Prepared by:

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December, 1993

Center for Infrastructure Studies

The following report is one of a series of some 40 studies of Nevada's infrastructure completed under the management of the Center. These studies are part of an overall research plan conducted for the U. S. Department of Energy.

This study, and its part in the overall research plan, are discussed in Report No. CIS 93-17, "Studies of Nevada's Infrastructure: an Overview," which places the individual studies in context.

Each study produced the specific findings with which it had been tasked. It also led to more general conclusions concerning the relationship between the proposed Yucca Mountain Repository and Nevada's infrastructure. These general conclusions are the subject of CIS 93-17.

GIS FOR NEVADA RAILROADS: 1993 REPORT

CIS 93-02

EXECUTIVE SUMMARY

This is an interim report on a task within a large, ongoing study by the University of Nevada, Reno to examine the safety of Nevada railroads. The overall goal, of which this year's research is a middle stage, is to develop models based on the use of geographic information systems (GIS). These models are to enable the selection of the best and safest railway routes for the transport of high-level nuclear waste across Nevada to the proposed repository at Yucca Mountain.

Last year's research concluded that the databases are adequate and that GIS are feasible and desirable for displaying the multi-layered data required to reach decisions about safety. It developed several database layers.

This report deals with work during 1993 on the use of geographic information systems (GIS) for rail-route selection. The goal was to identify and assemble many of the databases necessary for the models. In particular, the research aimed to identify (a) any problems with developing database layers; and (b) the level of effort required.

This year's effort developed database layers for two Nevada counties: Clark and Lincoln. The layers dealt with:

- topographic information
- geologic information
- land ownership

These are among the most important data base layers.

The database layers were successfully created. No significant problems arose in developing them. The level of effort did not exceed the expected level. The most effective approach is by means of digital, shaded relief maps. (Sample maps appear in plates.) Therefore, future data base development will be straightforward.

Research may proceed on the full development of shaded relief elevation maps for Elko, White Pine, Nye and Eureka counties and with actual modeling for the selection of a route or routes between the UP/SP line in northern Nevada and Yucca Mountain.

Table of Contents

List of Plates

GIS FOR NEVADA RAILROADS: 1993 REPORT

CIS 93-02

1.0 INTRODUCTION

This is an interim report on a task within a large, ongoing study by the University of Nevada, Reno to examine the safety of Nevada railroads. The study is funded by the U. S. Department of Energy in anticipation of the proposed high-level nuclear waste repository at Yucca Mountain, Nevada. This report deals with work undertaken during 1993 on the use of geographic information systems (GIS) for rail-route selection.

The report should be read in conjunction with last year's parallel report, Safety of Nevada Railroads (CIS 92-29). It deals with portions of both Task 2 and Task 3 as defined in that report.

1.1 Objectives

The overall goal, of which this year's research is a middle stage, is to develop models based on the use of geographic information systems (GIS). These models are to enable the selection of the best and safest railway routes for the transport of high-level nuclear waste across Nevada to the proposed repository at Yucca Mountain.

The narrower goal this year was to identify and assemble many of the databases necessary for those models. In particular, the research aimed to identify (a) any problems with developing database layers; and (b) the level of effort required.

Specifically, the effort was to develop the database layers for two Nevada counties: Clark and Lincoln. The layers dealt with:

- topographic information
- geologic information
- land ownership

These are among the most important data base layers. Layers previously developed for the two counties cover road networks, county boundaries, and population density.

The final specific objective was to develop the capability for three-dimensional modeling with ARC/INFO.

1.2 Background

Major rail accidents are comparatively rare, and there have been no serious accidents involving the rail transport of spent nuclear fuel. Nonetheless, all care will be taken to select the best and safest routes for rail transport to the proposed spent fuel repository at Yucca Mountain, Nevada.

A very important method for route selection will be the use of three-dimensional GIS maps. The quality of these maps is determined by the quality of the data that make up the various layers of the maps.

In previous work (see CIS 92-29), the present researchers had the following preliminary goals:

1. **To demonstrate the utility of GIS for displaying the required information** by creating a data base layer to show the frequency of accidents along existing routes, emphasizing at-grade crossings. (This required researchers to collect and evaluate accident data for Nevada railroads from January 29, 1975 through July 16, 1990.)

2. **To design and provide an example of the data layers that will be used by GIS** to create the required statewide maps. For this purpose, researchers fully developed a map for a single stretch of rail-line (Caliente to Jean). The five data base layers in the map are: roadways, railways, county boundaries (township and range), accidents, and firestations.

Among the products of that research were:

(a) A sample of the rail accident data base for the State of Nevada, January 29, 1975 through July, 16, 1990. This sample (Caliente to Jean) shows that **the data base is generally adequate.** GIS data base layers were also developed for all existing rail routes.

(b) Three maps demonstrating GIS displays of selected data bases, accompanied by ARCVIEW displays of the maps. These samples show that **GIS are feasible and desirable for displaying the multi-layered data required to reach decisions about safety.**

Accordingly, the research in 1992-1993 proceeded to develop further GIS databases as precursor to the model for route selection and to continue previous study of the Caliente to Jean rail route.

It is proposed in the near future to proceed with actual modeling of the route selection for the rail alternatives between the Union Pacific/Southern Pacific line in northern Nevada and

Yucca Mountain.[1]

1.3 Summary of Conclusions

No significant problems arose in developing the database layers.

The level of effort did not exceed the expected level.

The most effective approach is by means of digital, shaded relief maps.

Future data base development will be straightforward.

1.4 Report Organization

Section 2.0 deals in succession with Geologic Base Map Layers, Topographic or Elevation Models and Land Ownership Layers. Section 3.0 presents the findings of the research and recommendations for the next stage. The Plates follow.

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[1] The original proposal called for the evaluation of VAX-compatible magnetic tapes owned by Deleuw-Cather Associates. The aim was to determine the compatibility of their data with ARC/INFO data; to discover if the data is accessible to other VAX VMS-based computers or UNIX-based computers. The evaluation proved not to be possible because of the dismantling of the School of Mines' VAX 11/780 computer. Lincoln and Clark Counties are currently examining the Deleuw-Cather tapes.

2.0 SUBTASK REPORT

2.1 Geologic Base Map Layers

The objective of this subtask was to complete the map layers dealing with the geologic base for both Lincoln and Clark Counties. These layers show rock types and zones of alluvial cover.

Plate 1 shows the developed map layer for the geological base of Clark County, and Plate 2 shows the same for Lincoln County. These plates show rock type by color code and faults (heavier black lines) as well as contacts between lithologic units (lighter black lines).

Plate 1a shows the legend for the Clark County map and Plate 2a shows the legend for Lincoln County's map. The maps use standard geologic symbols designating rock type and age for the various lithologies. For example, **Qa1** is Quaternary (age) alluvium (ground type).

2.2 Elevation (Topographic) Models

The objective of this subtask was to create map layers dealing with topography or elevation. The researchers obtained digital elevation data for the entire state, then extracted the data for the two counties.

Plate 3 is a topographic (contour) map for Clark County and Plate 4 is the same for Lincoln County. Also, the road network layer is overlaid on each plate. This shows the major roadways across the two counties. Highways tend to avoid higher terrain.

A topographic map does not make it easy to appreciate differences in actual elevation. A three-dimensional grid with shaded relief shows topography better. Plate 5 shows such a display for Clark County and Plate 6 for Lincoln County.

These displays are line-printer plots from original screen displays, a method which sacrifices the number of gray levels used to represent elevation. The displays, however, clearly show regions of higher relief contrasted with regions of lower relief. Each display was created by placing the sun to the west; hence west-facing slopes appear bright and east-facing slopes dark, simulating sunset. (To achieve various shaded relief displays, the sun may be placed anywhere in a 360 degree arc.)

The GIS database layer showing the network of major roads has also been overlaid on these shaded relief maps. The combined display shows where the roadways traverse higher terrain and where they traverse more level terrain. The optimal highway right-of-

ways are those involving minimal traversing of higher terrain.

2.3 Land Ownership Layers

Plate 7 shows the GIS data base layer showing land ownership for the entire state of Nevada. The map clearly shows a "checkerboard" pattern on either side of the original trans-continental rail route in the northern part of the state. The pattern alternates between public land and land privately owned by the Southern Pacific Railroad. The map shows U. S. Forest Service lands in bright green. In the southern part of the map, lands under the administration of the U. S. Department of Defense and the U. S. Department of Energy show clearly.

Land ownership, especially the division between public and private lands, is a major factor in determining the selection of a rail route. A single database layer showing land ownership throughout the entire state now exists. The research effort proposed as the next step, which is to study the modeling for route selection for a dedicated rail route from Carlin to Yucca Mountain, will be greatly assisted by this GIS database layer.

3.0 CONCLUSIONS AND FUTURE RESEARCH

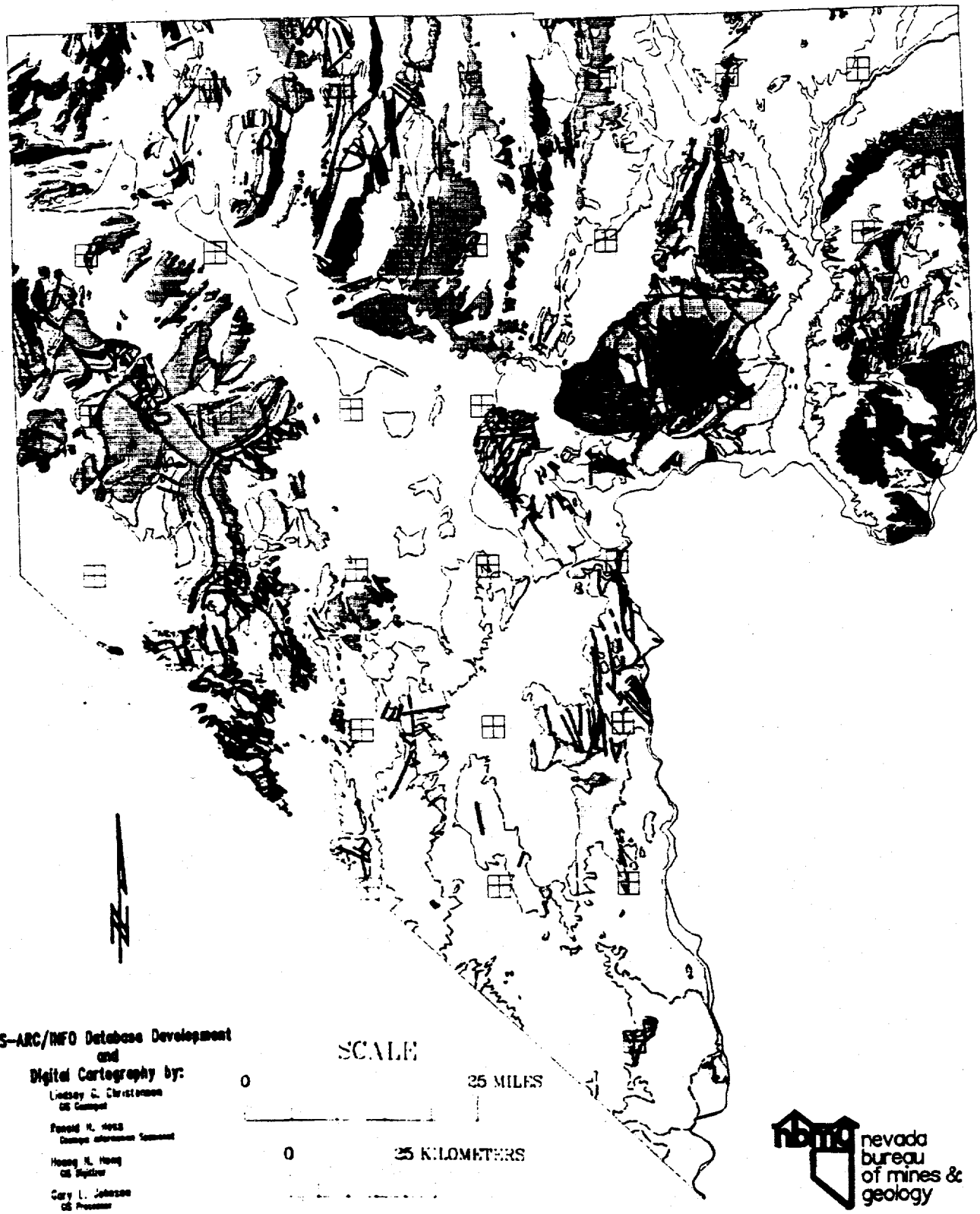
Information about topography, geology and land ownership is among the most important data in selecting a route. The three GIS database layers now exist for two crucial counties. Two of the database layers (land ownership and topography) exist for the entire state and the third can be easily created.

The research encountered no significant problems were encountered in developing these layers. The level of effort was not greater than expected, especially if the topographic information is developed as digital, shaded relief maps.

The next logical step is to proceed with actual modeling for the selection of a route or routes between the UP/SP line in northern Nevada and Yucca Mountain. The development of data bases will be straightforward. At the time of writing (October, 1993) work is proceeding to develop shaded relief elevation maps for Elko, White Pine, Nye and Eureka counties in preparation for the modeling of the whole route.

PLATES

CLARK COUNTY GEOLOGY



GIS-ARC/INFO Database Development and Digital Cartography by:

Lindsey E. Christensen
GIS Cartographer

Ronald R. Hess
Database Administrator/Programmer

Hoang N. Hoang
GIS Digitizer

Gary L. Johnson
GIS Processor

Completed June 1988

SCALE

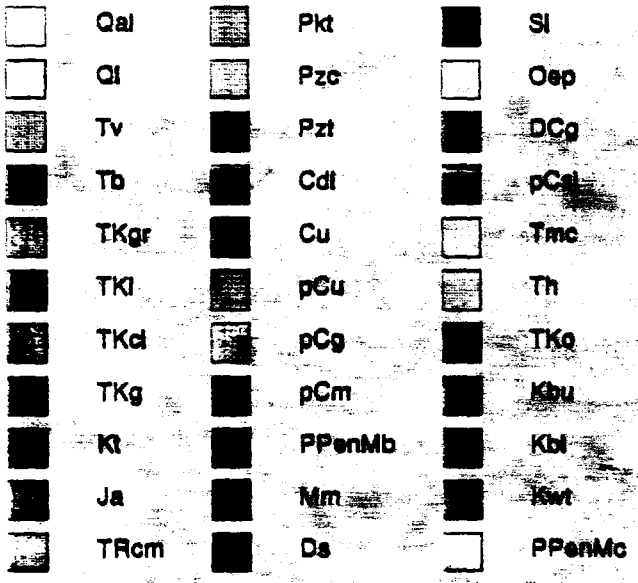
0 25 MILES

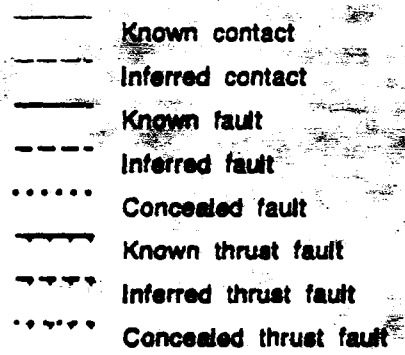
0 25 KILOMETERS

nbmg nevada bureau of mines & geology

CLARK COUNTY GEOLOGY

EXPLANATION





GIS-ARC/INFO Database Development
and
Digital Cartography by:

Lindsay C. Christensen
GIS Geologist

Ronald H. Hess
Geologic Information Specialist

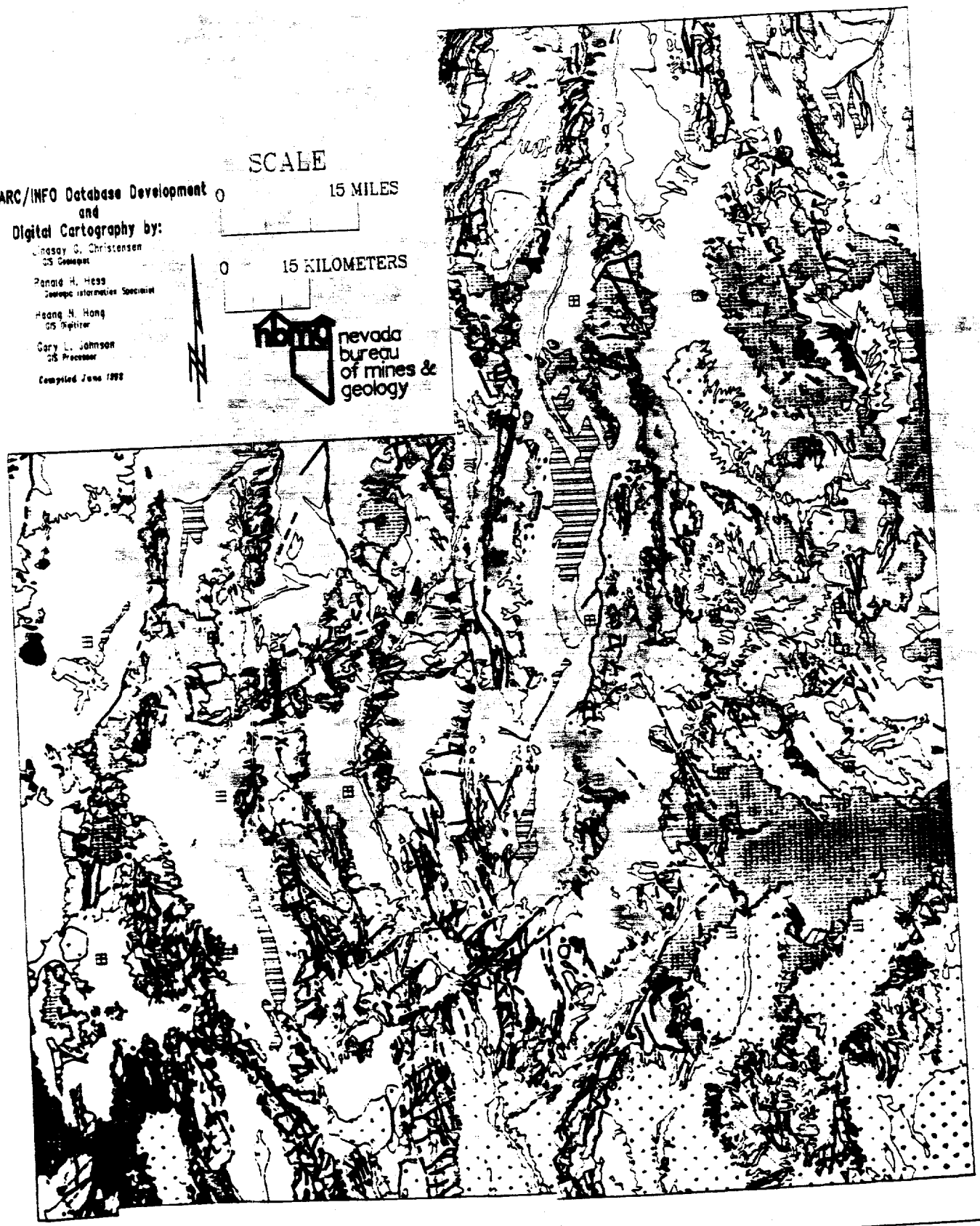
Hoang N. Hong
GIS Digitizer

Gary L. Johnson
GIS Processor

Completed June 1993

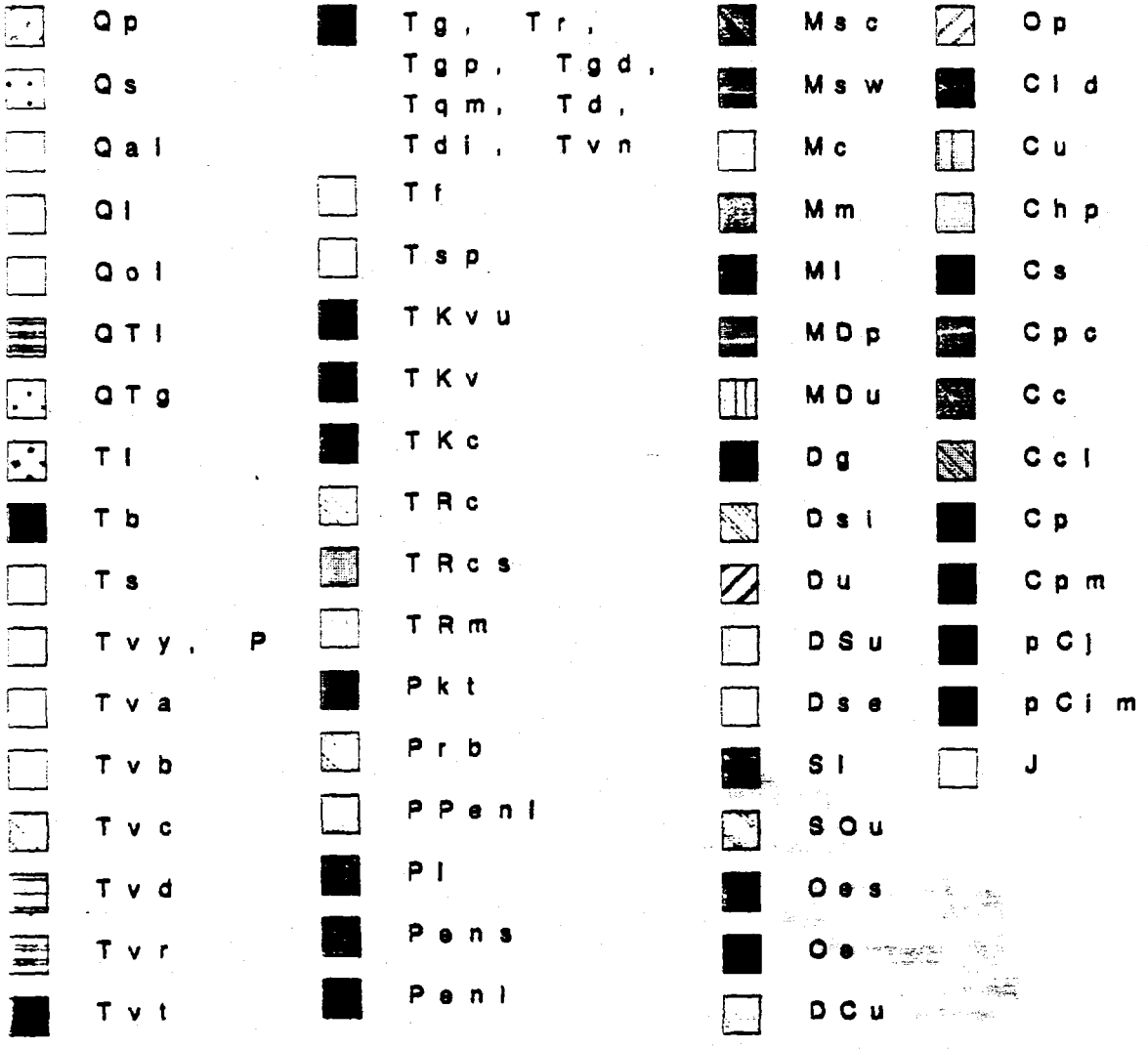
nbmg nevada bureau of mines & geology

LINCOLN COUNTY GEOLOGY



LINCOLN COUNTY GEOLOGY

EXPLANATION



Known contact

Inferred contact

Known fault

Inferred fault

Concealed fault

Known thrust fault

Inferred thrust fault

Concealed thrust fault

GIS-ARC/INFO Database Development and Digital Cartography by:

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GIS Geologist

Ronald H. Hess
Geologic Information Specialist

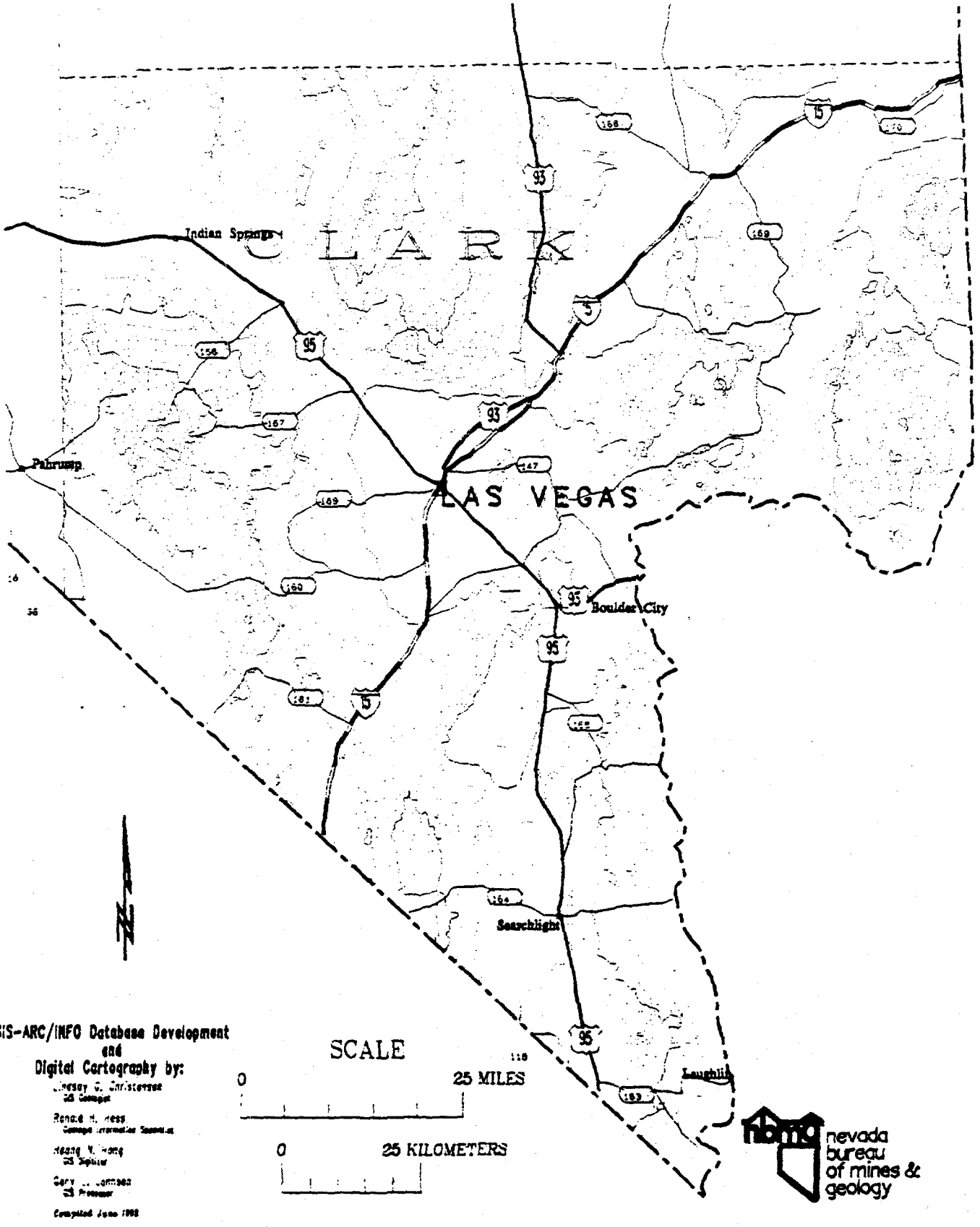
Heong N. Heng
GIS Digitizer

Gary L. Johnson
GIS Processor

Compiled June 1992

nbmg nevada bureau of mines & geology

CLARK COUNTY ELEVATIONS



LINCOLN COUNTY ELEVATIONS

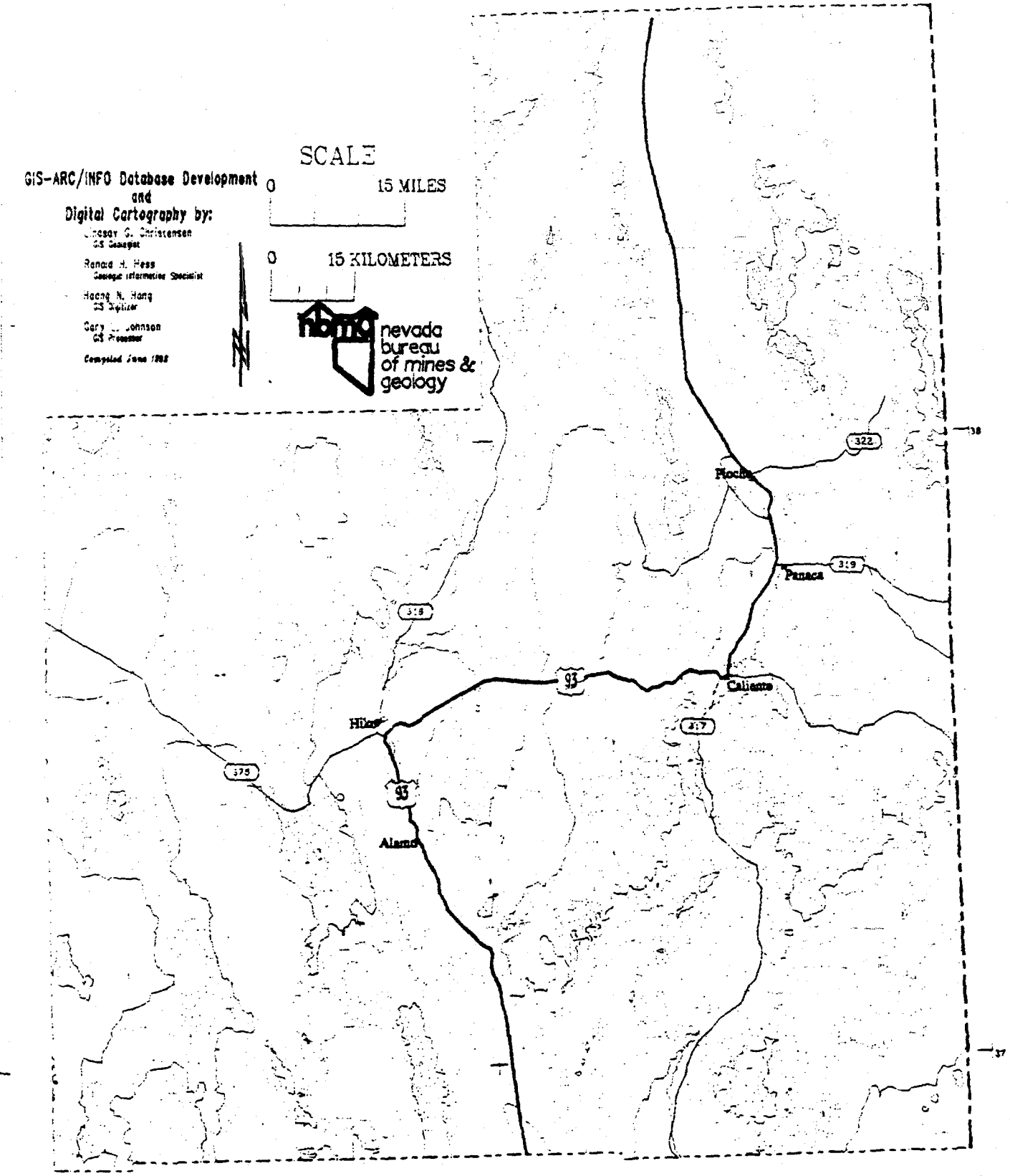
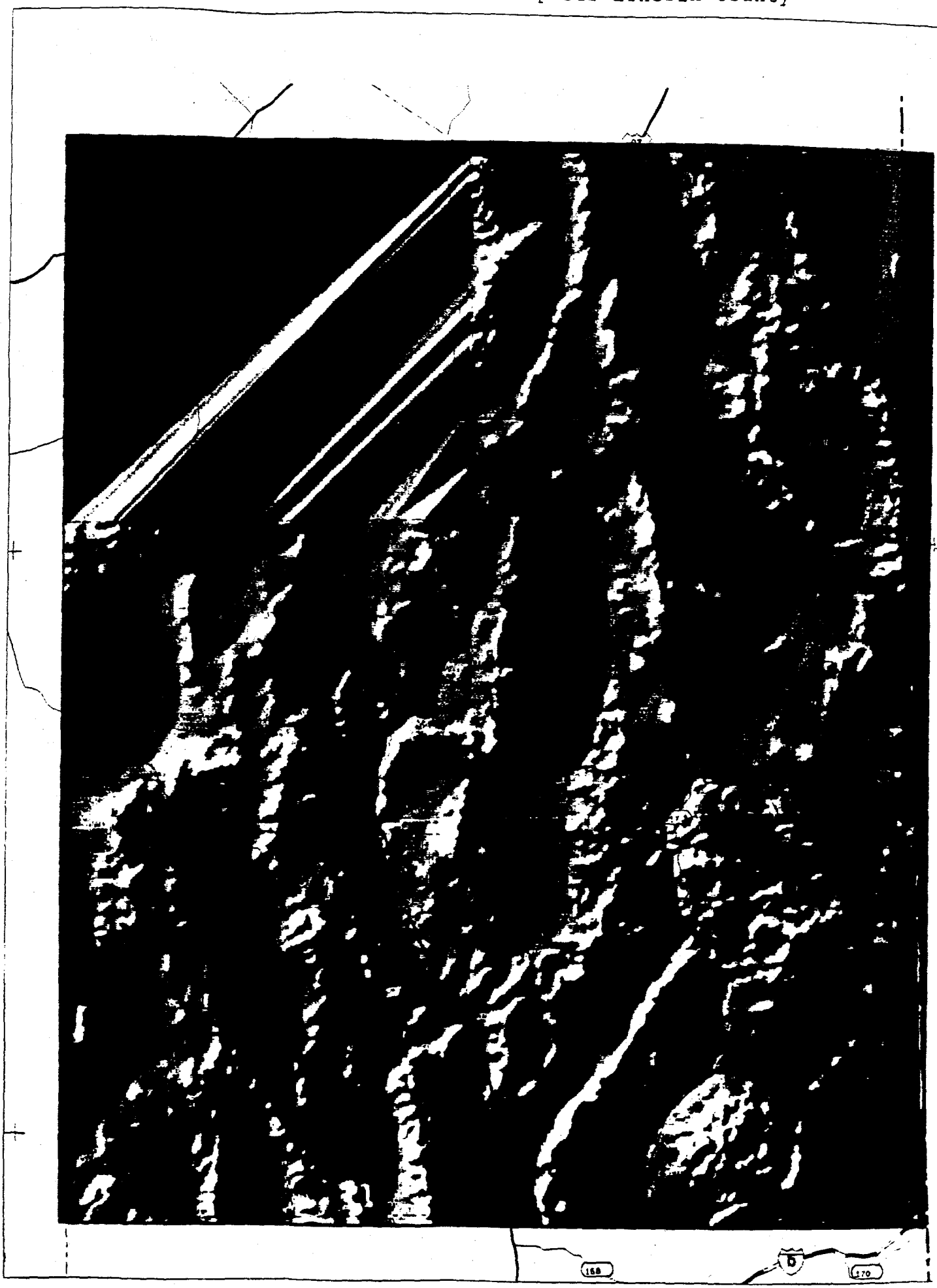
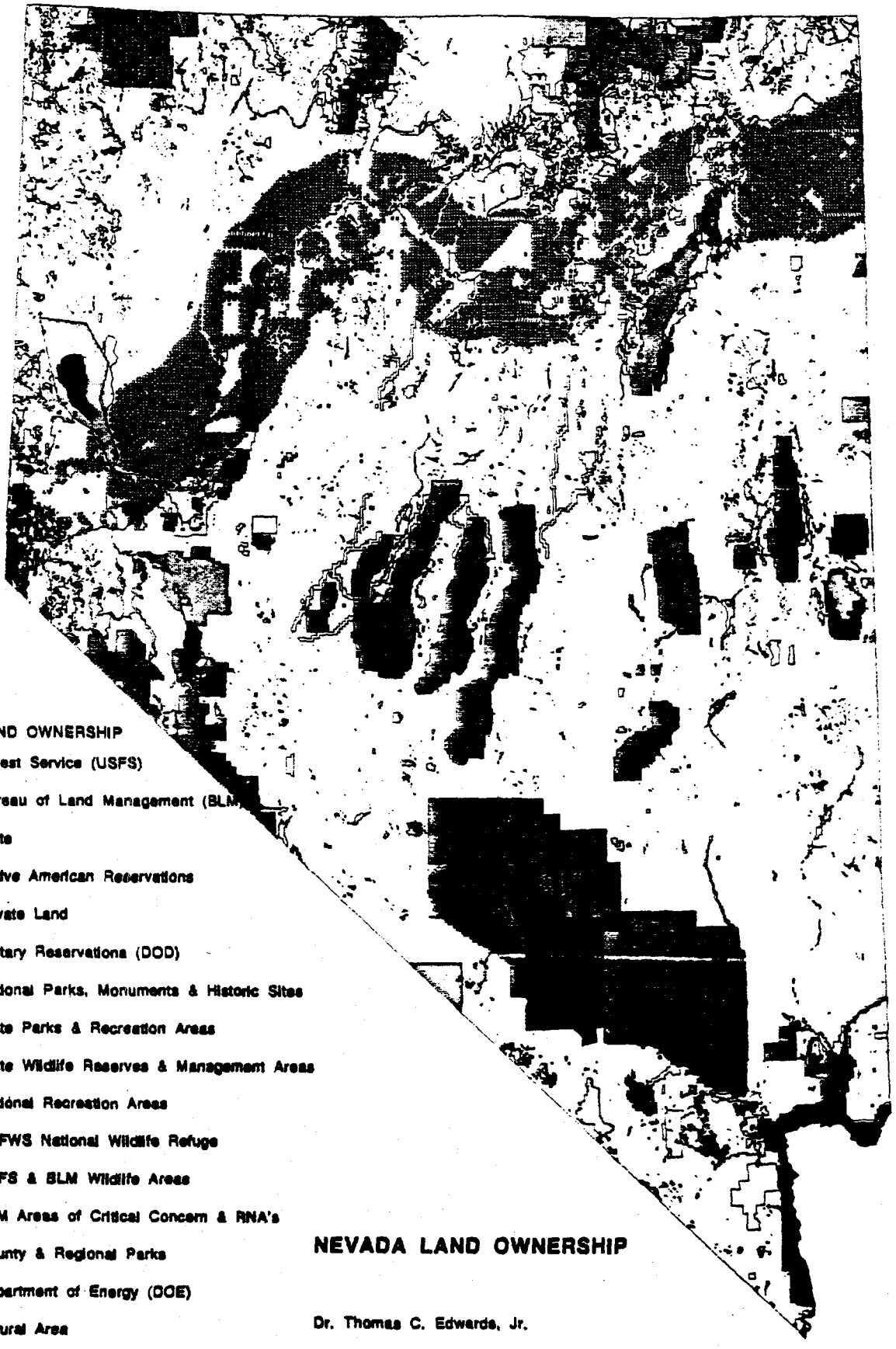


Plate 5: Shaded Relief Contour Map for Clark County

Plate 6: Shaded Relief Contour Map for Lincoln County





NEVADA LAND OWNERSHIP

Dr. Thomas C. Edwards, Jr.

Utah State University

Logan, UT.

PROGRESS REPORT - ROCK BOLT STUDY - 1330-114-0680

PRINCIPAL INVESTIGATOR: ROBERT J. WATTERS

JULY 1 - SEPTEMBER 30, 1993

This time period was exceedingly busy with field trips to underground excavations and continuation of the literature review. During August field trips were made to the WIPP site in New Mexico, and three underground mines near Timmons, Ontario, Canada. The WIPP site is for defence level waste, and although excavated in salt, innovative rock bolt procedures are being used. In Ontario, the three active mines are in volcanic/metavolcanic rock, at depths up to 5000 feet. A wide range of rock bolts are in use, including swellex, point anchors, split sets, and cable bolts. The mines visited were Detour, Dome and the Falkonbridge operations. My research assistant accompanied me on the trips.

OCTOBER 1 - DECEMBER 31, 1993

During this period, continuation of the literature research proceeded together with the successful defence of Mr. Skip Leedy's MS thesis entitled "Assessment of Rock Bolt Systems For Underground Nuclear Waste Storage" in December. Mr. Leedy was awarded the MS degree in Geological Engineering.

An abstract was published and a paper presented at the 36th. Association of Engineering Geologists meeting in San Antonio, Texas. The abstract was entitled " Rock Bolt Performance in Underground Storage of High Level Nuclear Waste, Yucca Mountain, Nevada.

JANUARY 1 - MARCH 31, 1994

The completion of the research portion of the grant has enabled the results to be disseminated. A research paper was written, submitted and accepted for the Fifth International High Level Radioactive Waste Management Conference in Las Vegas, May 22 - May 26, 1994. The paper is entitled " Assessment of Rock Bolt Systems for Underground Waste Storage".

PROGRESS REPORT - ROCK MECHANICS EQUIPMENT - 1330-114-0677

PRINCIPAL INVESTIGATOR: ROBERT J. WATTERS

JULY 1 - SEPTEMBER 30, 1993

1. Data acquisition equipment consisting of IBM clones and Macintosh computers together with the necessary printers, cables, ether net cards and accessories were purchased.

2. Rock bolt pull-out equipment together with gages, load cells and read out unit.

OCTOBER 1 - DECEMBER 31, 1993

1. Assorted small items for data acquisition, including optical drive, and cables.

2. Computer software for numerical modelling using the results obtained from laboratory testing and field data. Two major packages, UDEC and an upgrade to the existing FLAC software, plus smaller rock mechanics software items.

3. Laboratory supplies including an oven, tools, freight costs for equipment.

JANUARY 1 - MARCH 31, 1994

1. Direct shear equipment and accessories.

2. Triaxial cell and accessories.

3. Point Load test equipment.

4. Freight costs for the above equipment purchases.

5. Small items for existing computer and laboratory equipment.