University of Alberta

# Records Management for Aggregate Source Inventory

by



AKBAR KARSAN

A Thesis
submitted to the faculty of graduate studies and research
in partial fulfillment of the requirements for the degree
of Master of Science
in
Transportation
Department of Civil Engineering

Edmonton, Alberta

Fall, 1991

ISBN 0-315-70064-5

**FOCUS**

Focus Surveys Ltd.

205, 8915 - 51 Avenue
Edmonton, Alberta T6E 5J3
Phone (403) 466-6555
Fax (403) 466-8200

1625, 700 - 6 Avenue SW
Calgary, Alberta T2P 0T8
Phone (403) 269-2252
Fax (403) 269-8353

September 27, 1991

**ALBERTA FORESTRY, LANDS AND WILDLIFE**
810, 9942 – 108 Street
108 Street Building
Edmonton, Alberta T5K 2J5

Attention: N. Barry Giffen, Executive Director
LRIS Project

**RE: USE OF LRIS COPYRIGHT MATERIAL**
**THESIS: MASTER OF SCIENCE IN TRANSPORTATION**
**PAGES 38, 39, 41, 48**

Dear Sir:

Further to our telephone conversation, please find attached herewith five (5) illustrations that I wish to use in a Thesis to be presented to the University of Alberta. Some of the illustrations have been modified from those found in the literature published by LRIS Group.

The Faculty of Graduate Studies requires written approval of your permission. I would appreciate a quick response from your office. Thank you.

Yours truly,

Akbar Karsan

Akbar Karsan, A.L.S., C.L.S., S.L.S.

AK/dde

Encl.

Alberta
FORESTRY, LANDS AND WILDLIFE
Land Information Services Division

(403) 422-1413

810, 108th Street Building, 9942 - 108 Street N.W., Edmonton, Alberta, Canada T5K 2J5

September 30, 1991

Akbar Karsan
Focus Surveys Ltd.
#205, 8915 - 51 Ave. N.W.
Edmonton, Alberta
T6E 5J3

Re: USE OF COPYRIGHT MATERIAL IN M.Sc. THESIS IN TRANSPORTATION

Dear Mr. Karsan:

We have reviewed the four illustrations requested to be used in your thesis.

The only illustration we find requires correction is your Fig. 3.5 Structure of the LRIS Committees, where there are two spelling errors. The words in error are CABINET (not CABNET) and LRIS Network System Management (i.e., singular, not the plural Systems as you have it).

The illustrations shown in figures 3.6, 3.7 and 4.1 are fine to be used as presented.

For your further information, we have changed our name to the Land-Related Information Systems Project, from Branch. Also, in the evolving nature of the Project there is one update you should be aware of; there are now two "user groups" that report to the LRIS Network System Management Committee: the LRIS Spatial Database Working Group and the LRIS Gateway User Group. However, for your purposes, neither of the above naming changes will affect the figures and do not need to be changed.

With the spelling errors corrected, you have our permission to use the illustrations in your thesis.

We wish you the best of luck in your thesis defense.

Yours sincerely,

Barry Giffen
Executive Director, LRIS Project

FOCUS

Focus Surveys Ltd.

205, 8915 - 51 Avenue
Edmonton, Alberta T6E 5J3
Phone (403) 466 6555
Fax (403) 466 8200

1625, 700 - 6 Avenue SW
Calgary, Alberta T2P 0T8
Phone (403) 269-2252
Fax (403) 269-8353

September 27, 1991

**ALBERTA TRANSPORTATION AND UTILITIES**
**Twin Atria, 4th Floor**
**4999 - 98 Avenue**
**Edmonton, Alberta T6B 2X3**

Attention: Mr. Ken Yau, Acting Assistant Director
Aggregate Services

**RE: USE OF AT&U COPYRIGHT MATERIAL**
**THESIS: MASTER OF SCIENCE IN TRANSPORTATION**
**PAGES 65, 66, 68, 69, 70**

Dear Sir:

Further to our telephone conversation, please find attached herewith four (4) illustrations that I wish to use in a Thesis to be presented to the University of Alberta. Some of the illustrations have been modified from those found in the literature published by AT&U Group.

The Faculty of Graduate Studies requires written approval of your permission. I would appreciate a quick response from your office. Thank you.

Yours truly,

Akbar Karsan

Akbar Karsan, A.L.S., C.L.S., S.L.S.

AK/dde

Encl.

Alberta
TRANSPORTATION
Materials Engineering Branch

Twin Atria Building, 4999 - 98 Avenue, Edmonton, Alberta, Canada T6B 2X3 (403) 427-3101

October 1, 1991

Focus Survey Ltd.
205, 8915 - 51 Avenue
Edmonton, Alberta
T8E 5J3

Attention: Mr. Akbar Karsen

Re: Use of AT&U Copyright Material

Dear Mr. Karsen:

We are pleased to grant you permission to use the copyright material, as detailed and outlined in your September 27 letter, in a thesis to be presented to the University of Alberta.

Yours truly,

Ken Yau, P. Eng.
Acting Assistant Director
Aggregate Services
Materials Engineering Branch

KY/tm

**University of Alberta**

Release Form

Name of Author: Akbar Karsan

Title of Thesis: Records Management for Aggregate Source Inventory

Degree: Master of Science

Year This Degree Granted: 1991



Akbar Karsan
(Student's Signature)

Akbar Karsan
56 Andrew Crescent
St. Albert, Alberta
T8N 2V3

Date: 1991 10 11

**University of Alberta**

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Records Management for Aggregate Source Inventory, submitted by Akbar Karsan in partial fulfillment of the requirements for the degree of Master of Science.

A.E. Peterson (Supervisor)

K.O. Anderson

W.J. Sproule

I.A. Campbell

Date: Sept. 16/91

# Abstract

Aggregate source records are information used for management of aggregate resource for such functions as, planning for aggregate demand quantities during construction season, availability of each type of aggregate and changes in ownership of the subject lands. Aggregate source inventory refers to hard copy or computerized collection of data for aggregate sources.

Until recently, all land related records were stored in hard copy manuscripts (e.g., map, plan, etc.). With rapid advance in computer technology it was quickly realized that large amounts of data can be stored on disks, magnetic tapes, etc. which require a fraction of the space necessary for storage of hard copy manuscripts. It was further realized that once the data was stored in this way, it could be quickly retrieved, merged with other data, analyzed and displayed as required.

This thesis explores recent advances in information system technology and makes recommendations towards better aggregate management through aggregate source records modernization. In the discussion, frequent references are made to the Alberta Department of Transportation and Utilities (AT&U) procedures, its aggregate records and management.

## Acknowledgements

This paper has been funded in part by Alberta Transportation and Utilities, Materials Engineering Branch, Aggregates Section. The research work was carried out under the guidance of Professor A.E. Peterson, University of Alberta. I am grateful to Loran W. Nichols, Director of Alberta Transportation and Utilities for allowing me to use the Alberta Government computer and facilities. I am also indebted to Kim Mah and Mohamed Ashraf of Alberta Transportation and Utilities for their valuable comments. I am grateful for the information provided by the Ontario Ministry of Transportation and the documentation and source code provided by the State of Oregon Transportation Department.

## Table of Contents

Page

## List of Figures

## Glossary

**Aggregation** Combining of various data or layers of data into one composite display.

**Algorithm** Statement of steps to be followed in the solution of a problem.

**Arc** Directed line connecting a set of points. May also be referred to as Chain, String, or Edge. In a GIS, an arc is usually stored internally as part of a directed graph or network data structure.

**Attribute** Non-graphic information or qualitative properties associated with a point, line, or area in a GIS. An example of an area attribute would be soil type.

**Batch Processing** Processing of execution of system commands without the direct supervision of an operator. Most commands executed in batch mode are also executable in interactive (supervised) mode.

**CAD** Computer Assisted Drafting.

**CAM** Computer Assisted Mapping.

**CCSM** Acronym often used to refer to topological digital exchange format being promoted by the Canadian Federal government.

**Centroid** Selected coordinate point within an area (polygon) on a map. A point identifying an area (polygon) is referred to as seed point. Centroid and seed point are used interchangeably in

GIS literature. The point is not necessarily the mathematical centroid of the polygon.

**Coverage** Refers to all of the graphic and attribute information (in one or more files) related to a specific area of interest.

**CPU** Central Processing Unit.

**Database** Collection of related information. A GIS database includes information about the location and attributes of geographical features.

**Database Management System (DBMS)** Set of programs and utilities for organizing and manipulating the information in a database.

**Database Structure** Particular organization of data elements within a database.

**DEM** Digital Elevation Model.

**DMDF** Digital Map Data Format. Exchange format used by the Alberta government primarily for the distribution of 1:20,000 scale maps.

**Draping** Display technique where planimetric information is visually overlaid on 3-D perspective models (usually DTM), e.g., the display of soil polygons or a road network on a perspective plot of terrain elevation.

**Exchange Format(s)** The way in which data is structured and organized to facilitate exchange between different systems.

**Export** Formatting and transferring data out from a system.

**Feature** General term (in GIS) to describe a phenomena with spatial position, attributes, and relationships, e.g., a feature could be a road, a railway, or a lake.

**Fourth Generation Language (4GL)** Refers to a group of high level languages used primarily for the manipulation of databases. The languages have a syntax mimicking the English language and operate on sets or subsets of data rather than on single elements as do most conventional languages (e.g., FORTRAN, PASCAL).

**Generalize** Involves a reduction of detail, either by resampling to a larger cell size (as a raster operation) or reducing the number of points (as a vector operation).

**GIS** Geographic Information System. Set of hardware, software, and procedures used to capture, manage, manipulate, analyze, model, and display spatially referenced data for problem solving/planning purposes.

**IGDS** Intergraph Graphics Design System.

**Image Processing** Techniques and procedures dealing with the acquisition, analysis, and output of digital images.

**Import** The process of bringing in (and usually transforming) data from another system.

**Interactive (System mode)** System mode of operation where the user can input information and initiate or modify program execution by means of an input device (terminal) and receive information from the system regarding progress, performance, errors, etc.

**Layer(s)** Refers to a set or grouping of data which may be treated as an "overlay". Each set of data usually deals with one topic or theme (e.g., rivers, roads, forest type) and each "overlay" is related to each other by a common coordinate system.

**Menu** Display of functions or options available. On a display screen this can take the form of tables, side bars or lines at the bottom/upper part of the screen. On a digitizing table, it consists of a document (either in a fixed or user specified location) illustrating the various commands.

**Model** Representation of reality which can be displayed and manipulated.

**Overlay - Graphic** Visual display only. Consists of separate images being simultaneously displayed, one on top of the other.

**Pixel** Refers to picture element. Is the most basic element in an image or grid map. The words pixel and cell are often used interchangeably in GIS.

**Polygon** Closed figure representing an area on a map. A polygon can be represented by a single arc or string which closes upon itself.

**Raster** — Refers to a coverage partitioned into a set of grid cells (usually square) with each cell assigned a value describing some spatially related characteristic (e.g., land use). Usually when the word "raster" is used, the cells are organized by rows and columns.

**Raster Model** — A special case (squares and rectangles) of a tesselated model.

**Slivers** — Refers to tiny polygons which are formed when the sides of two adjacent polygons do not totally match up. Often slivers are considered spurious in nature.

**Software** — A set of instructions for the computer to perform tasks.

**Tessellation** — Process of splitting an area into tiles.

**Tesselated Model** — A regular grid of tiles (e.g. hexagon) covering an area.

**Tiles** — Refers to small planar polygons used to cover a surface. An element of tessellation.

**Topology** — Way in which geographic elements are structured or connected together; a mathematical representation of spatial relationships among geographic entities.

**Turn-key system** — A system of hardware and software that is designed, supplied and supported by a single manufacturer ready for use for a given class of work.

**User Interface** — The way a computerized system communicates with the user in terms of presenting information and soliciting replies.

**VDU** Video Display Unit.

**Vector** Quantity having both magnitude and direction. In the GIS context it is represented as an ordered pair of points.

**Vector to Raster Conversion** Conversion of points, lines and/or polygons from vector format to raster format. This is known as rasterization.

## List of Abbreviations

| | |
|---|---|
| **AFLW** | Alberta Forestry Lands and Wildlife (Department of) |
| **ALTA** | Alberta Land Titles Automation |
| **ANALYZER** | Software developed by Pamap Graphics Ltd. of Victoria, British Columbia, Canada |
| **ARC/INFO** | GIS marketed by Environmental Systems Research Institute (ESRI) California, United States |
| **ASIS** | Aggregate Source Information System (AT&U) |
| **ASDB** | Aggregate Source Database |
| **AT&U** | Alberta Transportation and Utilities (Department of) |
| **AutoCAD™** | Graphics software marketed by Autodesk Inc. of California. |
| **FOCUS** | A fourth generation Database management system |
| **FORTRAN** | Formulae Transformation, a computer language mainly for engineering applications |
| **GWN DTM™** | Digital terrain modelling software marketed by GWN Systems of Edmonton, Alberta, Canada |
| **LISD** | Land Information Services Division (Alberta Forestry, Lands & Wildlife), Edmonton, Alberta, Canada |
| **LTO** | Land Titles Office |
| **LSAS** | Land Status Automated System |
| **MAIDB** | Mineral Aggregate Inventory Database (Ontario) |
| **MEB** | Materials Engineering Branch (of AT&U) |

| | |
|---|---|
| **MUNMAP/ GEO/SQL** | GIS system marketed by Generation 5 Technology Ltd. of Edmonton, Alberta |
| **NETWORK** | A Module within ARC/INFO |
| **ORACLE™** | A database management system |
| **OSHD** | Oregon State Highway Division |
| **SPANS** | A Spatial Analysis System marketed by Tydac Technology Inc. of Ottawa, Canada |
| **SPATIAL EDITOR** | A Software designed by Intergraph Corp. of Edmonton, Alberta, Canada |
| **SPATIAL ANALYST** | A Software designed by Intergraph Corp. of Edmonton, Alberta, Canada |
| **TERRASOFT** | A GIS Software marketed by Digital Resource Systems Limited of Nanaimo, B.C. |
| **TOPOS** | Software for manipulation of data collected by total station survey equipment. |

# CHAPTER 1

## 1.1 Introduction

Several transportation agencies have made attempts at computerization of aggregate source records. The State of Oregon Highways Division and the Ontario Ministry of Transportation have operational systems. Other agencies including Alberta Transportation and Utilities (AT&U) have systems at various stages of development. Geographic Information System (GIS) technology has a great potential for improved aggregate management.

At Alberta Transportation and Utilities (AT&U) the most up to date information today is stored in a manual filing system. There are two main drawbacks with the present manual filing system. Firstly, the field returns of revised data are not received promptly and consequently there are delays in updating the inventory files. Secondly, when a number of requests for aggregates to be used in different projects have to be processed at the same time, there is usually not enough time to carry out a detailed search through the manual filing system. This problem is aggravated when the relevant data files have not been updated. Some systems store information and provide a utility to store and retrieve data. Currently a computerized aggregate database is being created on the mainframe computer at Alberta Transportation and Utilities.

The objective of the research covered in this thesis is to investigate the potential of information system technology towards improved aggregate management primarily through computerization of aggregate source records. Several transportation agencies have created or are in the process of creating computerized database systems for aggregate management. The State of Oregon and The Ontario systems have been examined in this report. Geographic Information System (GIS) technology provides a great potential for improved aggregate management. GIS systems were investigated and some turn-key systems have been evaluated based on available literature. It is demonstrated how a variety of public and private sector databases may interact using Geographic Information Systems and networks in the future. This work does not represent a comprehensive study on the subject, but provides information on how aggregate management can be improved particularly with respect to current methodology at Alberta Transportation and Utilities.

## 1.2 Background

Witczak investigated the type and distribution of aggregates in the United States (Witczak 1972). His report also indicated areas of quality aggregate shortages. Synthesis of Highway Practice 33 (NCHRP 1976) states that earthwork, subbase and paving account for over 50% of transportation facility costs. Aggregate management, therefore, has a considerable impact on the costs and benefits (both long and short term) to society. Computerized geotechnical data banks exist in South Dakota (USA), Indiana (USA), Sweden, Kentucky (USA) and Alberta (Canada). Research papers dealing with problems related to aggregates and Alberta Transportation and Utilities annual reports were reviewed. Several transportation agencies have attempted computerization of aggregate inventory. These are at various levels of development. The Oregon State Highway Division (OSHD) in the United States has a computerized aggregate inventory system. This system uses a fourth generation language called FOCUS. This system supports queries using simple English language phrases. The system is interactive and provides fast storage and retrieval of data. Ontario Ministry of Transportation also has a computerized aggregate inventory system. Originally the system was based on the FORTRAN computer language but the programs have since been converted to FOCUS. These systems provide interactive storage and retrieval of information and save considerable amounts of time. Hard copy index maps are still required for reference. The systems do not have graphics capability. The databases in both cases are non-spatial, i.e., they do not support spatial analysis.

Geographic Information System (GIS) technology provides a powerful set of tools for analysis and display of spatial interrelationships of various factors or themes that are relevant for a particular parcel of land such as a gravel pit. Gravel pits generally contain a variety of aggregate types and silt deposits. They may also contain creeks and ponded water. A portion of the pit may also be on very steep slopes. These factors together with haulage distances, ecological concerns and noise pollution problems may have to be analyzed. Geographic Information Systems (GIS) are computerized database management systems used for the capture, storage, retrieval, analysis and display of spatial (land related) data. Most advances in GIS technology have occurred during the last ten or fifteen years. A great deal of literature is found either in conference papers or promotional material published by the companies marketing components of GIS.

Review of research papers dealing with geographic information processing, computerized cartography and spatial databases suggests that Geographic Information System (GIS) techniques offer significant potential for better management of aggregate resource. The International Federation of Surveyors (Weir, 1989) has defined a Land Information System (a GIS) as:

> a tool for legal, administrative and economic decision-making and as an aid for planning and development which consists on the one hand of a database containing spatially-referenced, land-related data for a defined area and, on the other hand, of procedures and techniques for the systematic collection, updating, processing and distribution of the data. The base of a land information system is a unified spatial referencing system for the data which also facilitates the linking of data within the system and with other land-related data.

It is a long cumbersome definition but it does spell out the basic principles. For a system to qualify as a Land Information System (LIS) or more generally a Geographic Information System (GIS) it must satisfy the above definition. Applying this definition, the aggregate inventory systems of Oregon and Ontario are not LIS/GIS systems as they do not provide for spatial analysis. These databases cannot be easily merged with other spatial databases.

Over the past 20 years, the Provincial Governments (LRIS, 1989) and the Federal Government (Schaubel 1991) have embarked on major GIS initiatives. The Alberta Government has developed Land-Related Information Systems (LRIS) Network (LRIS 1989). The Alberta Government is developing primary spatial systems. They are also developing a spatial database for the primary systems. The public will be able to access these data via remote access terminals in 1992. The next phase includes access to thematic systems or subsystems such as AT&U aggregate inventory subsystem. At this time it is not very clear who will convert approximately 200 thematic systems/subsystems in the Alberta Government to make them compatible to LRIS specifications. The Federal Government has created a spatial database of soils in Canada lands. Most of the National Topographic Series 1:250,000 maps have been scanned and the information is stored in a spatial database. A number of countries have developed GIS spatial databases. The Digital Chart of the World (DCW) is a research and development cooperative project with participants from Canada, United States, Australia and the United Kingdom.

A feasibility study for computerized aggregate source inventory was carried out by the author (Karsan et al 1989) for Alberta Transportation and Utilities. A technical paper on the use of GIS techniques for aggregate management (Karsan et al 1990) was published as a result of this study.

Alberta has approximately 166,000 kilometres of roads which include about 14,000 kilometres of primary highways and about 22,300 kilometres of secondary and local roads in rural Alberta. About 28,000 kilometres of roads are paved (Cook 1988). Review of the Alberta Transportation and Utilities Annual Reports for the last few years (1984–1989), indicates that AT&U on average continues to use over 10 million cubic metres of aggregates a year for construction and maintenance of transportation facilities. The aggregates are obtained from privately held lands, lands administered by other government departments and those lands belonging to Alberta Transportation and Utilities.

The availability and selection of good quality mineral aggregate is one of the more significant highway design factors. Aggregate may be classed as natural sand and gravel, crushed stone or artificial aggregate. All three types are currently used in construction and maintenance of transportation facilities. The origins of sand and gravel are glacio-fluvial, alluvial, lacustrine or marine. Crushed stone includes limestone and dolomite. Perlite, vermiculite, slag, clay, shale, slate, cinders and coke breeze are called artificial aggregates. A wide variety of aggregates are currently used for base/subbase, rigid pavement and flexible pavement for roads, airstrips and taxiways. Materials engineers select aggregate types based on traffic volume projections, environment, and pavement type whether rigid or flexible. Durability and soundness are desirable aggregate qualities to ensure minimum maintenance costs. Durability refers to the ability of an aggregate to remain unchanged over a fairly long period of time whereas soundness refers to the ability of an aggregate to resist excessive changes in volume due to changes in physical conditions. Aggregate in roads degrade over time due to weathering, chemical action particularly in cement mixes and loading particularly by heavy trucks.

Not all areas of Canada are blessed with large quantities of high quality aggregates. In areas with severe shortages of good quality aggregates, rock has to be quarried and hauled over long distances. Alternatively artificial additives have to be used with local aggregates. Alberta has been reasonably blessed with deposits of good quality aggregates by the retreating ice sheets. During the last few years, aggregate prospectors in Alberta have continued to find between 25 and 35 million cubic metres (AT&U Annual Reports, 1984–1985, 1985–1986, 1988–1989) of new potential aggregate sources each year. However, there are locations within Canada where either good quality aggregate sources are nearly depleted or the distribution of sources is such that long haulage is essential.

In the Town of Inuvik in the Northwest Territories, for example, aggregate is very expensive. The current gravel pit in Inuvik is almost depleted. A side hill adjacent to the pit contains gravel but it is covered with an overburden of several metres of silt. In order to gain access to this gravel, the silt would have to be removed and an access road would have to be built. In the Medicine Hat area, in southern Alberta, there are very few gravel pits. In this area there is little choice as to which pit can be dedicated to a project as long as there is enough suitable material in the pit. However, difficult decisions are required when the existing sources are depleted and no new sources are discovered. The long term performance of a highway may have to be compromised if not enough gravel is available locally and economic constraints do not allow for long haulage of materials.

The design engineer has to consider the impact of both the actual cost of construction and the annual maintenance cost of a transportation facility. Annual maintenance costs can be expected to be lower for a well built road. On the other hand budget constraints may only allow limited funding for facility construction and in this case the annual maintenance costs will be higher. Usually various alternatives (including a do-nothing alternative) are prepared for consideration. Each alternative includes construction costs, annual maintenance costs, carrying charges and costs incurred by the public for such things as fuel, travel time and vehicle maintenance. The least costly alternative is then chosen within the overall financial constraints. Availability of good quality aggregate has a major impact on different alternatives under consideration. The design engineer must know the unit costs at site of each aggregate type to prepare alternative action plans. Once an alternative is chosen, a request for final quantities is sent to the aggregate management unit.

## 1.3 Aggregate Management at Alberta Transportation and Utilities

The Aggregate Services Section of Alberta Transportation and Utilities is responsible for managing the aggregate supplies required for the Department's construction and maintenance programs. This includes the location, sampling, assessment, acquisition and allocation of aggregate and the provision of aggregate related specifications and recommendations and standards for aggregate source reclamation. It must be recognized that natural aggregate is a non-renewable resource (AT&U Annual Report 1988-1989) that has to be managed in such a way that a high level of service in transportation facilities is provided at minimum cost to society.

The management of aggregate resource includes the following:

- prospecting for aggregate;
- geotechnical testing;
- recording of locations of aggregate sources and access to them;
- determining volumes of aggregate, type and quality;
- recording of all relevant data regarding each aggregate source;
- selecting 'best' haul routes which may not be the shortest haul distance;
- committing aggregate sources to projects; and
- supplying a blend of local aggregates and additives appropriate to produce high quality pavement at a reasonable cost.

### 1.3.1 Field Surveys

Field surveys to determine aggregate location, type and volumes are carried out by the department prospectors and consultants as required. Generally, a survey (see Appendix B) is carried out and referenced to the boundaries of the quarter section in which the aggregates lie. Depths are measured to the various soil layers and volumes of each aggregate type are computed. If the aggregate source has been mined (i.e., some material is removed), revised volumes are determined in the field and the basic field information summaries sent to the head office in Edmonton include the following:

- land owner's name;
- legal description of land;
- volume by each aggregate type; and
- a plan of survey (sketch).

### 1.3.2 File Records

The aggregate records are kept in a manual filing system with referencing determined by location, i.e., by quarter section, township, range and meridian. Figure 1.1 illustrates the layout of a township in the third system of survey. A township contains 36 sections, each approximately one mile square. In Alberta, townships are used as basic geographic units even in unsurveyed portions of the Province.

The basic filing unit of an aggregate source is a quarter section. A separate file folder is maintained for each separately owned parcel of land in which a potential aggregate source is located. There are over 18,000 such files maintained by the Aggregates Section. Each file is marked with the quarter–section, township,

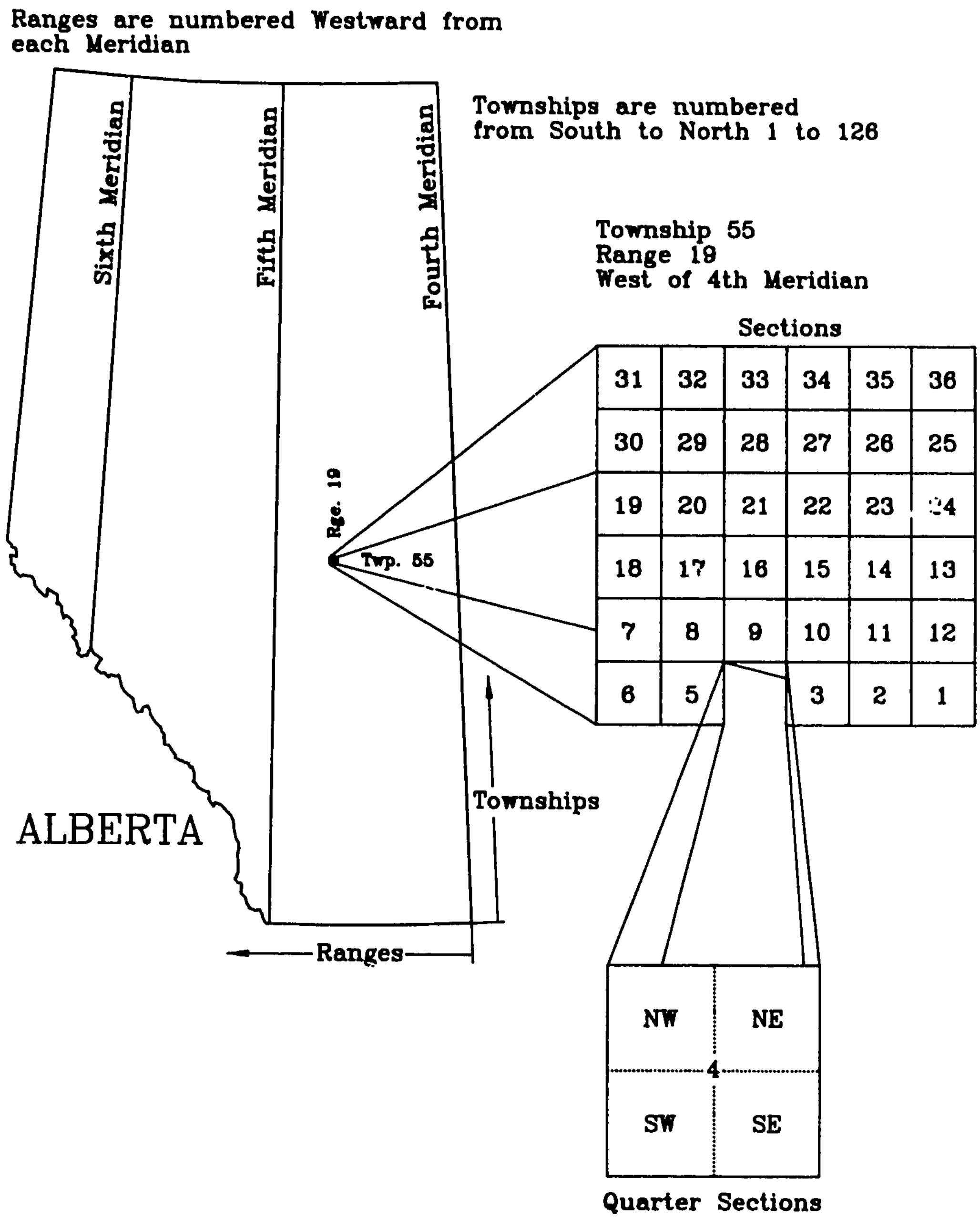



*Figure: I.I Township layout of the Third System of Survey* range and meridian and contains historical and current information. Each file is updated as information is received from the field. The locations of the aggregate sources are marked on a set of maps (1:50,000 and 1:250,000 National Topographic Series) and these maps serve as an index system for the aggregate source files.

### 1.3.3 Computerized Aggregate Source Inventory System

The Aggregate Services Section of the Materials Engineering Branch has developed a computerized Aggregate Source Inventory System (ASIS). This database contains some of the information stored in the manual files. A listing of the inventory can be obtained from the computer system (in batch mode) by keying the name of the landowner, source number or legal description of the land as a key field. The first column of a listing shows alphabetical names of land owners, ascending source numbers, or sequential legal land descriptions depending on the key field chosen. Attempts have been made to keep the ASIS up to date, however, it contains only a few of the data items normally required to satisfy department or contractor queries. The ASIS complements the set of index maps maintained by the section and forms a secondary index system. Appendix A shows a sample of output from ASIS runs. The ASIS is of limited use for interactive work. However, it does provide a quick reference for routine day to day queries regarding land owners and legal land descriptions.

## 1.4 Problems related to aggregate management

The records and procedures related to aggregate management at Alberta Transportation and Utilities were reviewed and several problems were identified. The problems mentioned in this section deal with AT&U records but they are more or less applicable to any agency with a large aggregate source inventory.

### 1.4.1 Updating file folders

As mentioned earlier, information related to an aggregate source is recorded in a file folder. Information in the file folder is supposed to be updated each time a source is used. However, it is common that the field returns are not received promptly and as a result the file folders are not always up-to-date.

### 1.4.2 Retrieval of information

The Department awards over 200 contracts a year for paving, surfacing and upgrading of transportation facilities. For each of these projects, the quantity, type and quality of aggregates required for a particular level of service is known. It is then the responsibility of the Aggregates Services Section to commit one or more aggregate sources to the project. When a limited number of aggregate sources exist within a reasonable haul distance of the project, it is usually easy to pull out the folders related to those few sources, analyze the data manually and recommend the sources to be used.

Where there are many gravel pits in the vicinity (say within 50 kilometres) of the project it is necessary to evaluate:

- the type, quality and quantity of aggregate at each pit;
- the spatial relationship of all the pits to the project site (along access routes);
- whether it is necessary to use a blend of materials from various pits; and
- if any additives are required (cement, etc.).

It is then necessary to select one or more pits for a given project based on the following:

- minimization of haulage cost to the project site;
- minimization of quantity of materials from far away pits;
- preservation of ecological areas;
- preservation of high quality aggregates for surfacing;
- recognition of weight restrictions on bridges;
- provision for recycling of pavement, if necessary; and
- reduction of noise pollution for surrounding communities.

It is possible to use the manual filing system to optimize aggregate utilization. One can, for example, plot the subject corridor on an index map and pull out all file folders to determine spatial relationships, review the data in the file folders and then carry out all the necessary computations to commit a set of aggregate sources to the project. Due to the short construction season and budgetary reasons, projects tend to come on stream a few at a time. There is, then, little lead time to pull out several files, to compute, and to analyze data and make recommendations for the best use of the sources.

The computerized Aggregate Source Inventory System (ASIS) is also, not very useful for the optimization task due to the following reasons:

- the information is not up to date nor easy to update;
- all the necessary information is not included; and
- the database is not suitable for interactive access.

In addition to the information included in the ASIS output (for an example see Appendix A) it is necessary to know the name and phone number of the owner, the name and phone number of the lessee, last date used, date reported, permit expiration date, the volumes of various types of aggregate reserves and pertinent remarks.

In practice all relevant file folders are not reviewed. Usually, aggregate are selected based on the experience, knowledge and memory of the field personnel. The field employees who have been with the department for over ten years usually provide reliable information. Due to human limitations mistakes are sometimes made in committing aggregate sources to a given project. Changes to cost estimates are necessary when another source is added to the project. The change in source can be drastic if the additional source is far away from the project.

### 1.4.3 Manual records

Most of the information regarding aggregate sources is kept on hard copy in file folders. Information in the file folders is either hand written or typed. The files also contain photocopies of documents such as certificate of title and drawings. Since most of the tasks are manual there is a great potential for duplication of effort and of errors or omissions.

## 1.5 Scope of Research

The State of Oregon Highway Division and the Ontario Ministry of Transportation systems were investigated for possible application to aggregate management at Alberta Transportation and Utilities. Geographic Information System technology was also investigated and some turn-key systems have been evaluated. Suggestions are been made as to how a variety of databases may interact in the future and possible applications to aggregate management. Further studies are also suggested.

## 1.6 Outline of Study

Due to the increased complexity of aggregate management requirements (supply, engineering, prospecting and recording), and both capability and attractions of modern technology, several agencies with large amounts of data have considered computerization. Alberta Transportation and Utilities officials recommended that the systems used in Ontario and Oregon be investigated for their possible application in Alberta. Documentation was requested and obtained from both agencies. The State of Oregon Department of Transportation also provided the source code of all their programs which were tested using a small data set on the Government of Alberta IBM mainframe computer. These systems are described in Chapter 2.

The turn-key GIS systems were evaluated based on documentation from vendor companies. The state of Oregon provided the source code for their system. This system was tested for its applicability to Alberta. Any thematic system such as an aggregate source inventory must adapt to overall Government-wide GIS initiatives.

Information technology has advanced rapidly with the advent of the computer. The first information systems created dealt with financial management, i.e., budgets, accounting, etc. whereas Geographic Information Systems (GIS) are relatively new and deal with spatial data. GIS technology, concepts and turn-key systems are described in Chapter 3.

The Federal Government has played a key role in the development of GIS technology since the 1960's. The Canadian Geographic Information System (CGIS) was one of the first in the world (Allam et al 1991). It manages Canada Lands digital land resource information. At the Provincial level Alberta has spent millions of dollars in the development (LRIS 1989) of the Land Related Information System (LRIS). This means that a variety of publicly funded digital spatial databases and systems are available to an individual or organization (private or public). To avoid 'reinventing the wheel' and to take advantage of such information, any records modernization initiative should be compatible with government GIS initiatives. These systems are described in Chapter 3.

In discussions with the Aggregates Section (AT&U) personnel, the short, middle and long term requirements of the section were identified. These requirements together with the necessity and practicality of automation are described in Chapter 4. It should be noted that while reference is made to AT&U requirements, all issues (with modification) are applicable to any agency with a large inventory of aggregate sources.

Computerization of any process may affect many people in an organization. The success of computerization, then, depends upon how the people affected by it accept and use the system. Recommendations are made in Chapter 6.

# CHAPTER 2

Various Transportation agencies have attempted computerization of their aggregate inventory. Only a few agencies have gone beyond the stage of a computerized index system. The State of Oregon and the Ontario systems are described in the following sections.

## 2.1 Oregon State Highway Division (OSHD) Aggregate Source Database

Essentially, this inventory (OSHD 1987) system consists of three sets of FOCUS™ (fourth generation computer language) programs that provide for data entry, retrieval of aggregate source information and lab test data.

QUARRY is a set of FOCUS programs for data entry and retrieval of aggregate source information using the QUARRY database. These programs are intended for use by regional geologists and their staff only. The QUARRY program provides the main selection menu for the selection of various aggregate source database activities. There are seven options that can be selected including data entry, revision, report generation and logoff.

ASDB is a set of FOCUS programs for data entry and retrieval of laboratory test result data using ASDB database to be used by laboratory personnel only. The ASDB program provides the main selection menu for the selection of various aggregate source database activities. There are six options (similar to the

QUARRY program) that can be selected.

AGGVIEW is a set of FOCUS programs for data retrieval of aggregate source and laboratory test data using QUARRY and ASDB databases to be used by engineering field offices and others for online queries. The AGGVIEW program provides the main selection menu for the selection of various aggregate source database activities. There are eleven options that can be selected for retrieval of data in reports format including aggregate source data and lab test data.

## 2.2 The Ontario Mineral Aggregate Inventory Database (MAIDB)

The Ministry of Transportation and Communications' (now Ministry of Transportation) of Ontario Mineral Aggregate Inventory Database (Brohm et al 1985; MAIDBS 1987) has retained the main structure of a manual system. The manual indexing system is similar to the one used in Alberta. The aggregate sources are still plotted on topographical maps which in turn are referenced to an electronic filing system through a computer terminal. The same type of information which had been kept on the card system is now recoded in an electronic filing system.

The MAIDB system was programmed in FORTRAN. The programs have now been converted into FOCUS by Ministry employees. The new MAIDB has the following features:

- each region has its own regional files;

- regional staff update their own regional files via panels which provide menu options;
- regional staff generate their own regional reports from their regional files;
- aggregate source reports are produced from the regional files with confirmed data stored in a file which can be used to update the master and historical files;
- head office staff update the master and historical files by means of the confirmed data;
- eleven types of reports can be generated from the master file; and
- twelve types of reports can be generated from the historical file.

Further MAIDB system developments include development for batch input/output for the five regional files and production of formal documentation. Further system modifications and enhancements including graphic output and microcomputer version are also anticipated.

The two systems -- the OSHD and the MAIDB (as modified) are very similar. The MAIDB may include some additional features since it is still under development. THE OSHD programs (on a computer diskette) provided by the courtesy of the State of Oregon Transportation Department were used for demonstration. The programs were modified to the AT&U computer. The FOCUS™ (IBI 1986) system has the following advantages:

- it is a total information control system for entering, maintaining, retrieving and analyzing data;

- it is a quasi-procedural language and the command syntax uses simple english phrases;
- using FIDEL (FOCUS Interactive Data Entry Language), full screen forms for data entry and application development can be designed such that only a portion of the screen is unprotected for fill-in-the-form type data entry;
- it can access external files (in another computer language) mostly transparent to the user; and
- it provides for several levels of security through passwords to control the read and write access to files.

## 2.3 Demonstration Database and Report Generation

The application programs from the State of Oregon (OSHD 1987) provides several screens for report generation. These programs were modified by the author and stored in two FOCUS files on the Government of Alberta IBM mainframe computer. The master file descriptions were stored in a partitioned data set (PDS) called HTCBT23.FOCMAST.DATA. The FOCUS executable statements (FOCEXEC's) were stored in a PDS called HTCBT23.FOCEXEC.AGG. A FOCUS Database file called HTCBT23.ASDB.DATA was created to hold the actual data.

Although random access techniques are used with FOCUS data files, the files appear to the operating system as simple blocked sequential data sets with a fixed length record format of 4096 bytes, one record to a block.

The Aggregate Source Database (ASDB) resided in a file called HTCBT23.ASDB.DATA with a single segment file structure. Thirty three aggregate sources from district number 04 from the ASIS listing (Appendix A) were entered in ASDB.

Hypothetical volumes of various types of aggregate reserves were added to ASDB. The ASDB can be accessed interactively by aggregate source number. For example, the following screen image shows the contents of ASDB related to aggregate source number 00-845-1.

```
AGGREGATE SOURCE #:  00-845-1                     DOGAMI #:

QUARRY NAME:  ROBINSON
OWNERS NAME:                                                PHONE:
LESSEE NAME:                                                PHONE:
NATIVE MATERIAL:   G
USES:
LAST DATE USED:                   DATE REPORTED:
PERMIT TYPE:                      EXPIRATION DATE:
SECTION:     03           TOWNSHIP:   024         RANGE:      04
HIGHWAY #:                                MILE POST:
RIVER:                            RIVER MILE:
MAP #:   82001
CRUSHABLE RESERVES:       1000    RIP-RAP RESERVES:         2000
PIT RUN RESERVES:         300     FILL RESERVES:            1500
REMARKS:         TP                               PRVA
                 $0.100                   EXPIRES 57/12
                 3166-0845
```

The following shows a listing of aggregate sources with decreasing reserve 1 (say, crushable reserves as a key field) volume and data for those aggregate sources containing greater than 10000 cu. metres of crushable reserves.

```
>  > table file quarry
> print avr2 and avr3 and avr4 and agsn
> by highest avrl
> if avrl gt 10
> end
PAUSE .. PLEASE ISSUE CARRIAGE RETURN WHEN READY

AVAIL_RESER1  AVAIL_RESER2  AVAIL_RESER3  AVAIL_RESER4  AGG_SOURCE_N
------------  ------------  ------------  ------------  ------------
       43009            23          4698        143000      01-451-1
                       203         11435           212      00-866-1
```

The following listing shows data for aggregate sources with increasing volumes of crushable reserves. Note that an identical value to a previous value in any column is not printed out. The 43009 in the first volume of both examples is not printed out.

```
> end
>  > table file quarry
> print avr2 and agsn and avr3 and avr4
> by lowest avrl
> if avrl gt 1
> end
 PAUSE .. PLEASE ISSUE CARRIAGE RETURN WHEN READY

AVAIL_RESER1  AVAIL_RESER2  AGG_SOURCE_N  AVAIL_RESER3  AVAIL_RESER4
------------  ------------  ------------  ------------  ------------
         212         43008      00-940-1         26980          4300
        1000          2000      00-845-1           300          1500
        7689         23467      00-869-1         43008          4876
       43009            23      01-451-1          4698        143000
                       203      00-866-1         11435           212
```

A small Database using TSO/ISPF and application FOCUS programs from the State of Oregon was created. The above examples demonstrate interactive retrieval of data and ad hoc query processing. The key field used in the above examples was the volume of crushable reserves. Any field in the database can be chosen as a key field. Alternatively, a new key field can be created such that it is a function of some of the fields in the database. As shown above, report generation in FOCUS™ is quite simple using ordinary English phrases.

Both of the above systems are now operational and provide fast storage and retrieval of aggregate data. While some analysis is possible, they do not provide advanced analysis and display support. Geographic Information System technology has a great potential for such support.

# CHAPTER 3

Geographical Information Systems are the result of linking parallel developments in many separate spatial data processing disciplines e.g., cartography, computer aided design, surveying and photogrammetry, remote sensing, mathematics, etc. as shown in Figure 3.1. Essentially, all these disciplines are attempting similar sorts of operations, namely to develop powerful tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world to meet a particular requirement. Such a set of tools constitutes a Geographical Information System (Burrough 1986).

Geographic Information Systems (GIS) have three important components consisting of computer hardware, sets of application modules (Figure 3.2), and a proper organizational context (Burrough 1986). These three components need to be in balance if the system is to function satisfactorily. Computer hardware may include a Central Processing Unit (CPU), a digitizer, a disk drive, a plotter, a tape drive and a Video Display Unit (VDU). Typical GIS software modules are subsystems for:

- data input and verification;
- data storage and database management;
- data output and presentation;
- data transformation; and
- interaction with the user.

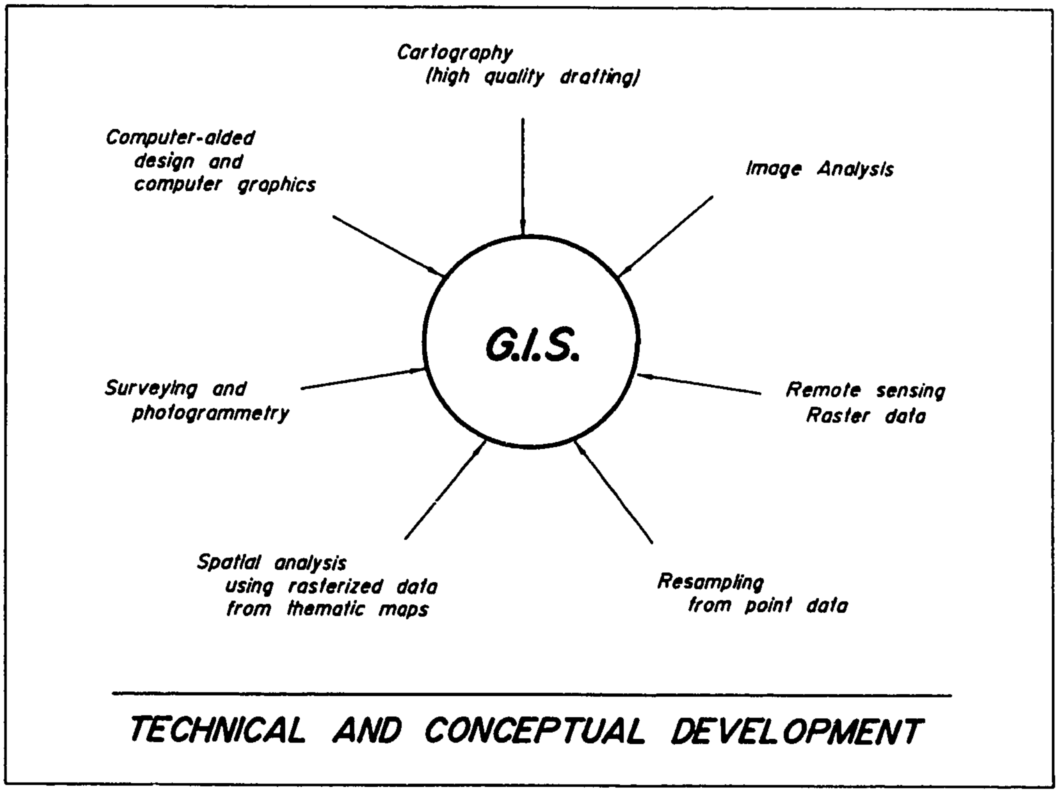



*Figure 3.1 Geographical Information System - parallel development in separate fields (Adapted from: Burrough, 1986)*

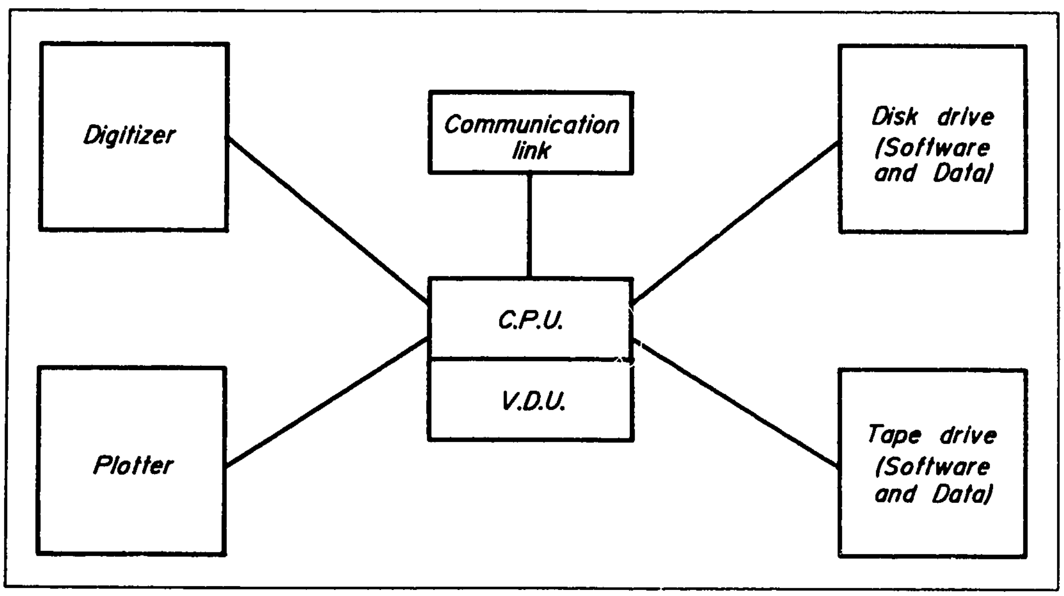



*Figure 3.2 The major components of a geographical information system. (Adapted from: Burrough, 1986)*

In order to be used effectively, the GIS needs to be placed in an appropriate organizational context. It is singly not sufficient for an organization to purchase a computer, some software and to hire or retrain one or two enthusiastic individuals and then to expect instant success. To do this properly requires not only the necessary investments in hardware and software, but also the retraining of personnel and managers to use the new technology in the proper organizational context. One of the greatest problems with geographic information processing has always been the sheer volume of data. A proper and efficient Database Management System (DBMS) is a necessity for the overall performance of a Geographic Information System (GIS) (Frank 1984).

## 3.1 Database Management Systems (DBMS)

Computer assisted design and computer assisted mapping systems such as AutoCAD™ are very useful for local computations and visual investigations. They have a lot of redundant data. For example a line forming a block boundary and a lot boundary is stored twice on different layers. They are also of limited use in spatial analysis of overlapping themes. All geographic features can be reduced to points, lines and polygons. A scale change would normally necessitate generalization (the change of a feature representation from one type to another). For example, upon scale reduction an area symbol (e.g., extent of a town) could be reduced to a point. An aggregate source may contain gravel of several types, silt, vegetation, water, etc. Each theme can be represented by a polygon. Spatial database systems should have the ability to very quickly break polygons and make new polygons in response to an operator's query. For example, polygons representing water could be combined with polygons representing a given aggregate type to create polygons with water and given aggregate type.

### 3.1.1 Spatial Data Models

Two basic types of spatial data models (Monmonier 1982) have evolved for storing digital data. These are vector and tessellated data models (Buckley 1988).

Vector data models involve use of vectors to represent geographic features. A polygon would be represented by a series of vectors starting from a point and ending at the same point. Topology refers to connectedness of features. Topologic vector data structures are those that include topology explicitly. Computer assisted design (CAD) or polygon data structure stores each polygon separately. Thus, there is no preservation of topology and much of the data is redundant.

Tessellated data models represent geographic features by a regular pattern of triangles, rectangles, squares, hexagons, etc. as shown in Figures 3.3 and 3.4. A point may be represented by a single very small square. A line may be represented by a collection of such squares. Raster models contain a regular grid of squares and are a special case of tessellated data models. Topology is implicit

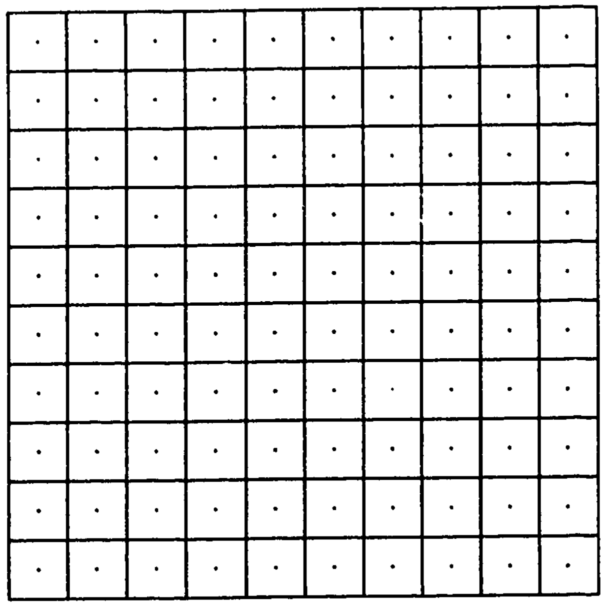


*Figure 3.3 Tessellated data model with square cells*

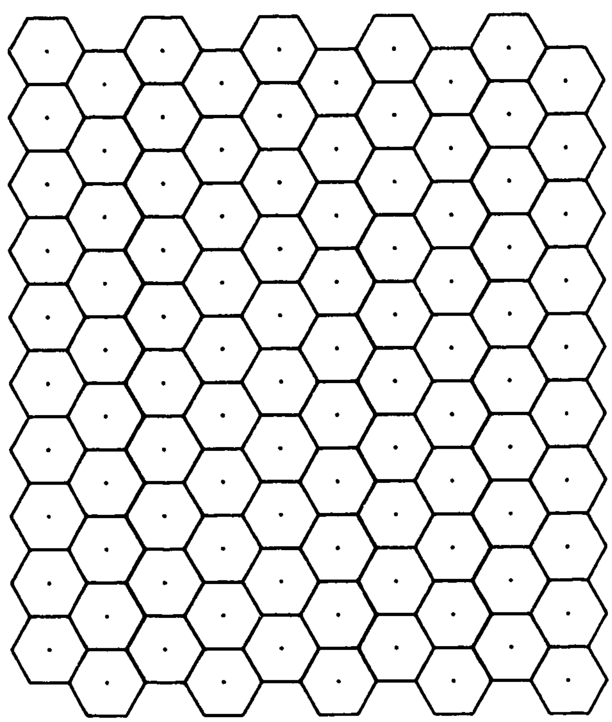


*Figure 3.4 Tessellated data model with hexagonal cells*

in tessellated structures.

Both vector and tessellated data models have advantages and disadvantages. A task at hand may be more easily done by one or the other method. Research and development is continuing simultaneously at the present time for both data models.

### 3.1.2 Non-graphic or Attribute Data Models

The location (e.g., coordinates) is an example of spatial data whereas land cover type (e.g., sand, gravel, muskeg, etc.) is typical attribute data. A variety of different data models exist for the storage and management of attribute or thematic data. The most common models are tabular, hierarchial, network, relational, and object-oriented. A tabular model stores data commonly as sequential files with fixed formats. The hierarchial database organizes data in a downward hierarchy. A father can have many children but a child may have only one father. The network model stores data in a network or plex structure. Any item can be linked to any other item. In this method a child can have more than one parent. The relational database organizes data in tables. Each table is identified by a unique table name. Each column also has a unique name and is called an item which represents a particular attribute. Tables can be referred to each other by common items (attributes) e.g., an identification number. An object-oriented DBMS manages data through objects. An object is a collection of data elements and operations that together are considered a single entity. This is a relatively new approach and needs to be further developed.

Most GIS organize data into layers or themes (e.g., forestry, soils, roads, etc.). This approach allows data to be overlaid based on the theme. Each data layer would be input individually and topologically integrated to create a combined data layer. Based on the topological structure and attribute data indexed to the topological features data analysis functions could be undertaken.

Data collected in a database are valuable as much effort is necessary to collect and insert the data in the system and keep the data updated. These data must be available for a long period of time to justify the expenses and permit new, unforeseen applications that will inevitably occur during the lifetime of the database. Storage and retrieval of data by using different and varying key fields should be provided. Access to database must be standardized and data storage and retrieval functions must be separated from the programs using the data. This makes database and application programs independent of each other, and changes in the one do not necessarily lead to changes in the other. This independence is important in order to accommodate the changes during the lifetime of a database.

The interface between database and application programs should be based on a logical description of the data and not make any detail of the physical storage visible to the applications. Access functions in applications must be made independent of the physical storage structure, so adaptations to expanding storage needs do not influence the application programs. Access to the data by several users at a time should be allowed. Consistency constraints for the data which will be automatically enforced must be defined. A database management system should provide the above functionalities (Frank 1984). Consistency constraints are rules which must hold for all data stored, and are an excellent way to reduce the number of errors in a large data collection.

For an aggregate source information system one needs to store spatial information (e.g., coordinates) and attribute information (e.g., aggregate type). If the database is to prove useful for a number of years, the integrity of the data must be guaranteed. A data model best suited for the application may be chosen. However, the database should be independent of the application programs. One also needs interactive tabular reports for analysis of a given project. It should be noted that for an interactive application the data must be retrieved and displayed in a few seconds. This will require physical clustering (preserving vicinity) and buffering (for repeated use).

For a given problem a particular data model may be preferred over other data models. It is possible to create a database structure which combines several of the above data models. One to one, one to many or many to one relationships between various data items or groups of data items need to be identified before a database structure can be designed.

## 3.2 Turn-Key Geographic Information Systems

GIS technology principles are now well accepted in computing, mapping and imaging industry and a number of manufacturers or service companies are marketing a range of systems as GIS systems. However, only a few of these can actually be classed as true GIS. A number of them are merely data storage and retrieval systems (Buckley 1988). Four turn-key GIS systems (ARC/INFO, Intergraph, Pamap and SPANS) were evaluated on documentation provided by vendors. The systems and their modules are described briefly in Appendix C.

The most attractive feature, particularly to large organizations, is the relatively low price of turn-key systems. The normal practice in industry is to charge a fixed charge at the time of purchase plus an annual service charge for system updates. When compared with the cost of system development (in house or by consultants), the price for such systems is usually very reasonable. Most turn-key systems have been developed, primarily for a particular user and then modified to a certain extent for other applications. Therefore, purchasers may only beneficially use small portions of a system. The system may also not solve all the desired tasks. Obviously, it is impossible to design a system that satisfies all the different users. Most systems provide for only limited modifications to the programs by the user.

The above systems appear to provide solutions for various types of spatial analyses. The system may prove to be an expensive one if most of the algorithms are not useful and yet key required functions are missing and have to be developed. The systems include either stand alone work stations or micro computers and will require additional hardware investment to meet the anticipated aggregate management requirements. In general, these systems allow for very limited user modifications since source codes are normally not provided. Obtaining such systems may not be very attractive with respect to the staged development plan in a proper organizational context.

### 3.3 Public Sector GIS Initiatives

The Federal Government and several provinces have embarked on major GIS projects. Dollars from general revenue are spent in the hope that these expenditures will be recovered by selling the digital data to the public.

Major federal GIS initiatives are presently being undertaken by the Department of Energy, Mines and Resources (EMR Canada). EMR Canada now has a GIS division and a GIS Technology Centre in its Surveys, Mapping and Remote Sensing Sector (Allam et al 1991). EMR Canada has also initiated the Geographic Information Technology Development Program to promote cooperation between EMR Canada and the provinces. An Inter-Agency Committee on Geomatics (IACG) has also been formed. The Canadian Geographic Information System (CGIS) developed by EMR Canada was among the first in the world. National Topographic 1:250,000 Series are general purpose maps covering all of Canada.

They are used for planning large projects, indexing of projects, etc. EMR Canada has converted these hard copy series to digital data by scanning hard copy originals. These digital data may be merged with data from another source to prepare a composite drawing. The Federal Government is participating with other countries in the preparation of the digital chart of the world (Hum 1991).

The Land-Related Information Systems (LRIS) Project is an Alberta Provincial Government initiative to make land-related data available through a network of distributed computer systems. Efficient access to land-related information through the LRIS Network will support improved planning and decision-making by the public and private sectors. The project has three main goals (LRIS, 1989).

1. To build on the Provincial LRIS Project's foundation by developing an information delivery system to provide service and benefits into the next century.
2. To improve the efficiency and effectiveness of the private and public sectors in making land-related decisions. As information becomes more accessible, user's efforts can be focused on data analysis rather than collection. Specialized analysis tools that use LRIS Network information will result in more efficient and effective planning and decision-making.
3. To reduce the overall cost of information collection through information sharing and reduction of redundant information storage. The Provincial

LRIS Project's on-line environment will provide the necessary information storage and maintenance and eliminate the need for multiple copies of data sets.

The LRIS Network is an interdepartmental and province-wide initiative under the direction of the department of Forestry, Lands and Wildlife. The LRIS committee structure is as shown in Figure 3.5.

There are three main components to the LRIS network. The Primary Systems contain geopositioning mapping and land registry data. The Network Systems provide for processing of the queries originating with the end users.The Thematic Systems provide data for a variety of themes. These are shown in Figure 3.6. Benefits will accrue to those with a need for land-related data.The most current information will be located and accessed through one computer access point. Individuals will not need to visit numerous government offices to secure information, nor be restricted by government hours of operation. Information will be available in a standard format, eliminating the need to computerize or modify information. Information will move directly from the LRIS Network to the user's systems for analysis. Faster access to information will improve the competitive position of the private sector and local government. Public sector land management will be enhanced, resulting in improved resource, economic and political decisions. Information will be verified and records will be matched. The expensive process of converting computer maps into spatial database necessary for information management and analysis will be performed only once by the

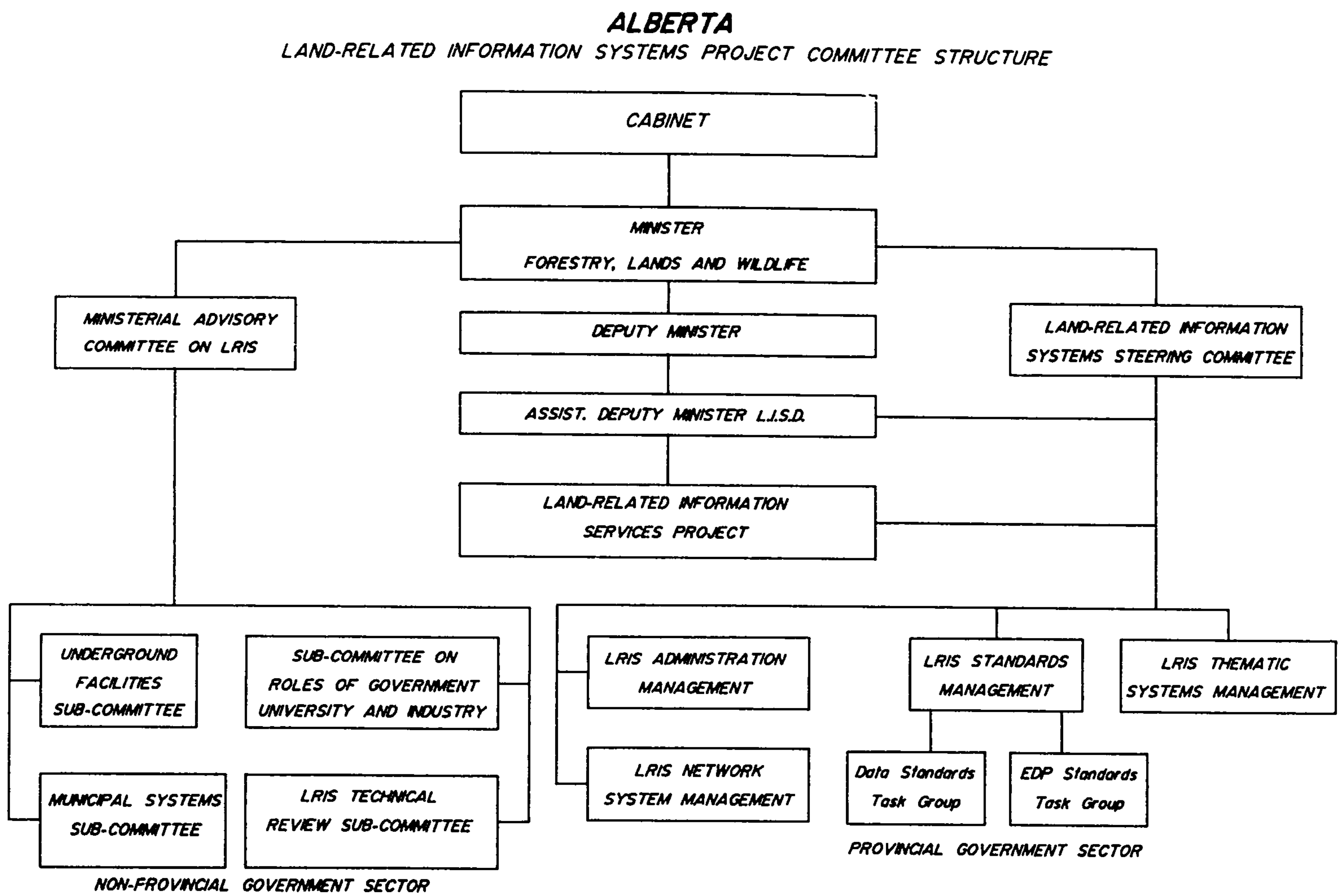



Figure 6.1 Structure of the LRIS committees (Source: LRIS, 1989)

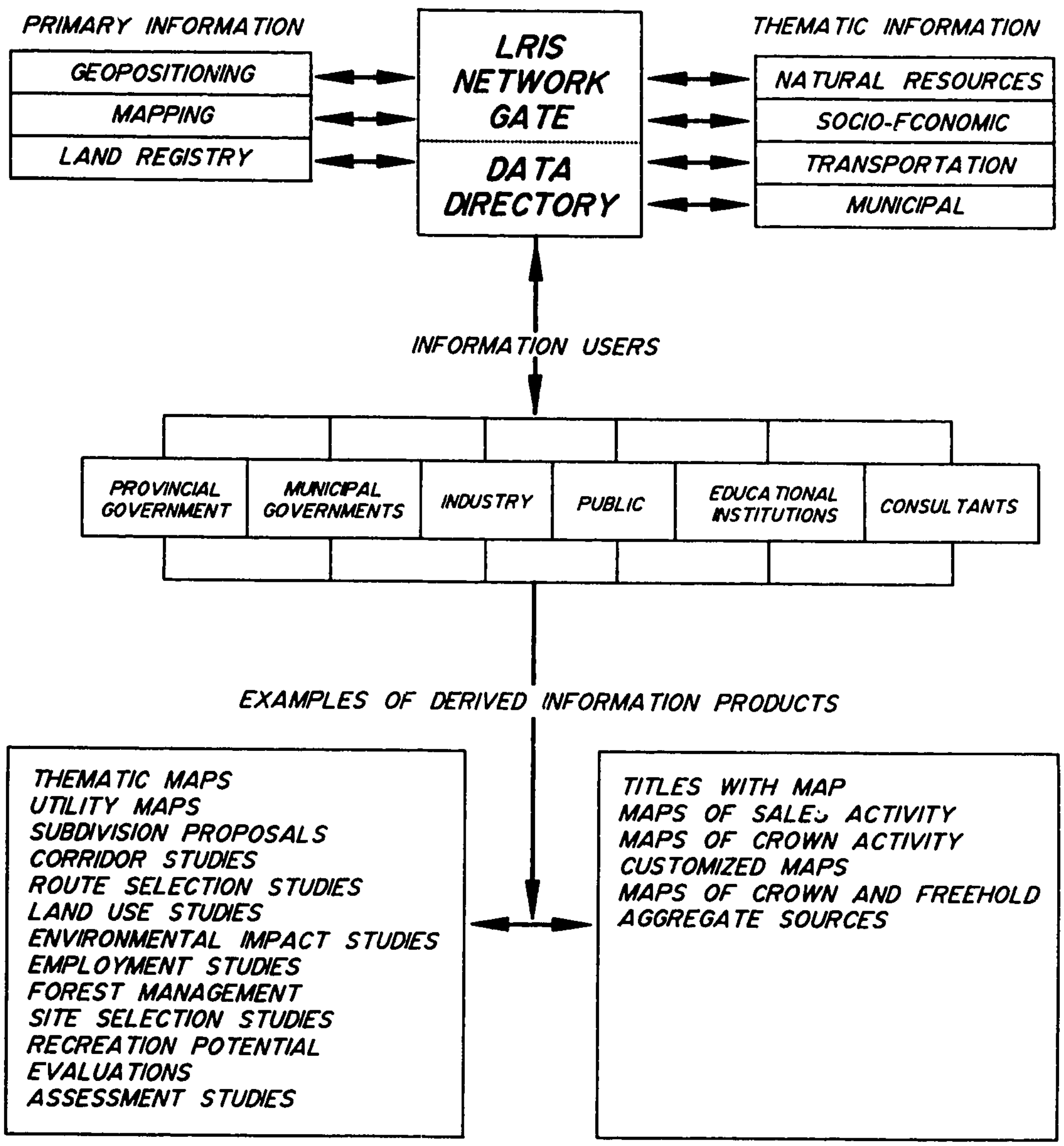



*Fig. 3.6 LRIS Network Information Flow*

*Source: LRIS Business Plan*
*(Source LRIS,1989)*

Province.

The LRIS and user interface is shown in Figure 3.7. The LRIS Gateway will be the user interface. All queries from the public will be addressed to the LRIS Gateway. The Gateway will obtain the information from a variety of databases and respond to the query. An example of LISD geopositioning data is shown in Figure 3.8. The figure shows a Parcel Map of a quarter section. A parcel map can be merged with land registry data and aggregate source data.

The LRIS Network will be an expedient development to support land-based decision-making. It is anticipated that some components of the LRIS Network will be operational by the end of 1991. Any private or public subsystem must therefore be developed with due consideration given to future links to LRIS Gateway and use of other public and private computerized databases. An aggregate subsystem will be able to take advantage of other databases such as the ALTA land title information which are kept up-to-date by other agencies.

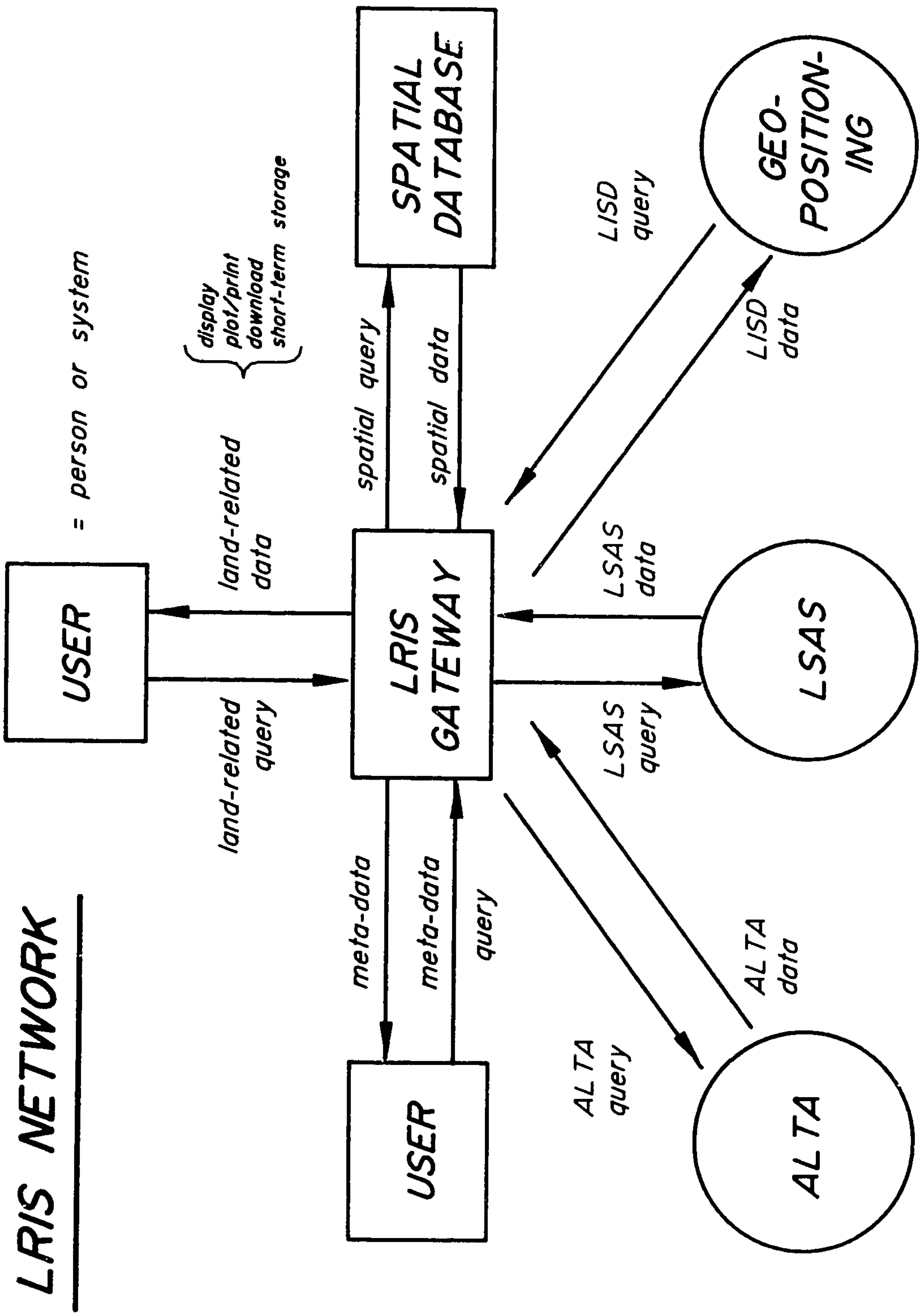



Fig. 3.7 LRIS Network (Source: LRIS,1989)

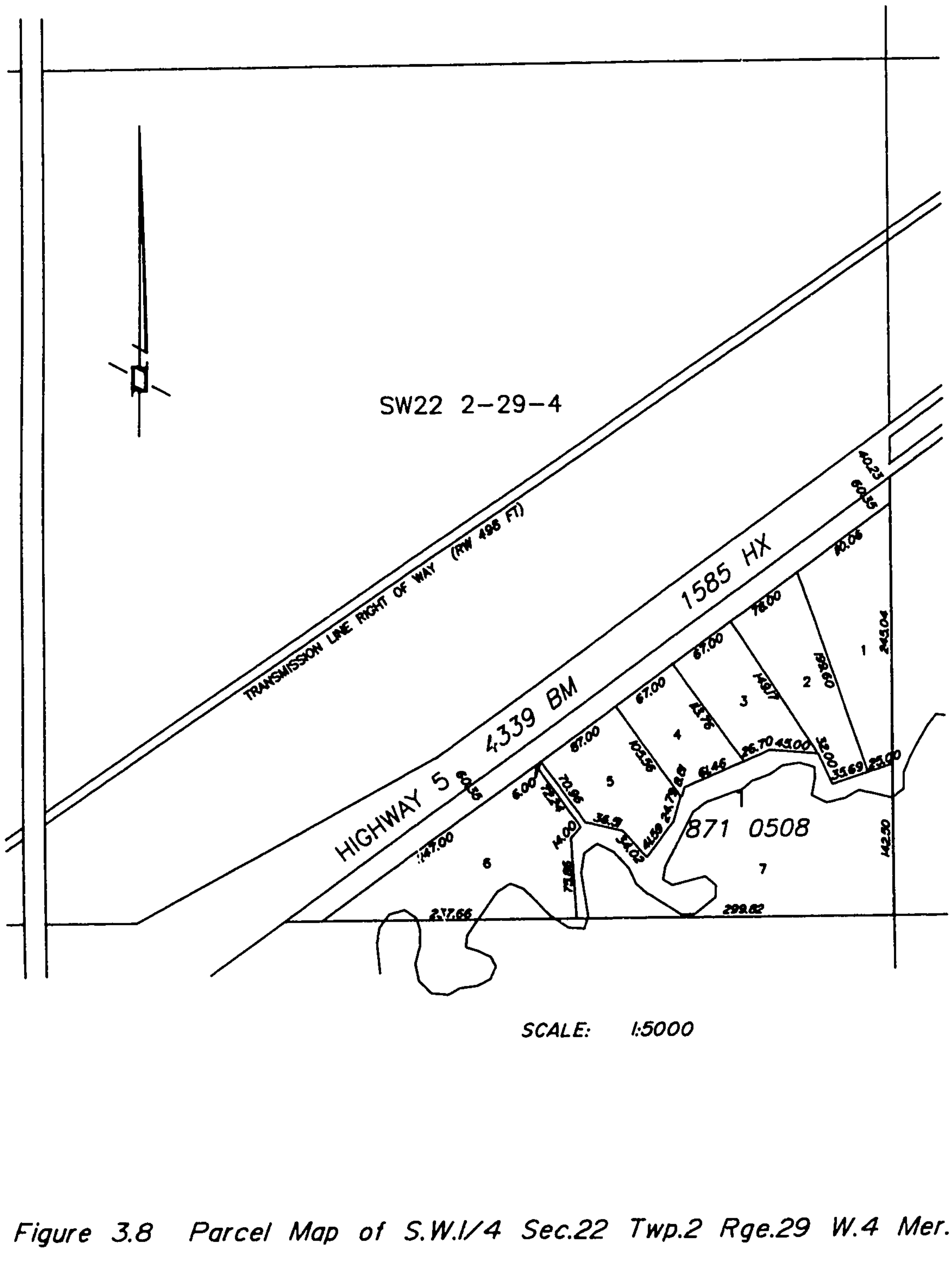



*Figure 3.8 Parcel Map of S.W.1/4 Sec.22 Twp.2 Rge.29 W.4 Mer.*

# CHAPTER 4

The Materials Engineering Branch (MEB) has expressed an interest in non-graphic data processing of attribute data associated with their manuscript aggregate records as well as graphic design files. At present non-graphic data processing on the intergraph work station has not been fully explored. Use of an Aggregate Data Management Subsystem (ADMS) could save significant amounts of work if a database were referenced to maps of Alberta so that information could be retrieved in a visual geographic manner rather than searching through paper files. The major need for a database revolves around the time consuming task of accessing the large amount of paper files to obtain data for a given geographic area. Even if the proposed ADMS could be used to extract paper file numbers for a specific geographic area, which could then be accessed manually, the subsystem would save MEB a significant amount of time.

The main objective of the proposed ADMS is to provide a complete list of data available in a given geographic area. This will prevent duplication of aggregate and geotechnical testing in areas where it has already been done. The bore hole log information should be managed by the proposed Geotechnical Data Management Subsystem (GDMS). The two subsystems will communicate with each other. The major constraints for the proposed subsystems should be the necessary resources in terms of memory and data storage to accommodate what appears to be a large amount of data. This requirement is most critical and should be given the utmost consideration.

## 4.1 Specific Needs of Alberta Transportation and Utilities

The Materials Engineering Branch (MEB) needs an Aggregate Data Management Subsystem and a Geotechnical Data Management Subsystem. Aggregate Data Management Subsystem (ADMS) would contain data such as current land owner and phone number, legal description of the source, pit name, quantity available of each type, quantity removed. date of survey, area excavated, plan of survey, etc. The Geotechnical Data Management Subsystem (GDMS) would contain data such as legal land description, project number, bore hole logs, date of survey, profile data and plan of survey.

### 4.1.1 Short term

The most urgent need of MEB is for fast data storage and retrieval of aggregate and geotechnical attribute (textual) data. The need for quick retrieval of information is the greatest at the beginning of and during the construction season. These data could be used with hard copy index maps for Request for Proposal (RFP) purposes.

### 4.1.2 Middle term

As pointed out earlier, MEB has approximately 2,000 gravel pit plans digitally (IGDS format) stored on an Intergraph system. In the middle term MEB will require interaction between the graphics and attribute information. The Branch may continue to use hard copy index maps for a few more years.

### 4.1.3 Long term

The long term objective of MEB is to have a fully operational Aggregate Records Automation System which is user friendly to such an extent that all functions are transparent to the user. The system would also include a graphics engine to support visual spatial evaluation.

## 4.2 The Do-Nothing Alternative

It is an accepted practice in transportation engineering to consider a do-nothing alternative (MCFR 1991). This approach generally helps in defining the bottlenecks in an existing system and helps put the problem in proper perspective. Acceptance of a do-nothing alternative usually results in a conscious effort by those involved towards improving the overall system performance. Alternatively, a do-nothing solution may result in continuing with an approach that is too costly, time consuming or inconvenient and thus should be rejected. An alternative approach is then more desirable.

The present filing system for aggregate inventory has been described in Chapter 3. There are two main drawbacks with the present manual filing system. Firstly, the field returns of revised data are not received promptly and consequently there are delays in updating the inventory files. Secondly, when a number of requests for aggregates to be used in different projects have to be processed at the same time, there is usually not enough time to carry out a detailed search through the manual filing system. This problem is aggravated when the relevant data files have not been updated.

As stated earlier, the advantages of computerization are fast storage and retrieval of data and minimization of duplication of effort in report generation. Accuracy is increased since manual tasks are eliminated. Some improvement in efficiency of the present system can be brought about by encouraging good practices and hiring more people. There will be a greater need for information exchange between government departments and between governments and the public. Obviously, this transfer of information can be made much more efficient through computer linkage. Since 1985, gravel pit plans in Alberta have been stored in graphics files on the Intergraph system. This system has proved useful for rapid generation of pit plans (see examples in Appendix B). A logical next step is the creation of an attribute database linked to graphics files. Such an integrated system could provide a powerful analytical tool. Based on the present system drawbacks and increased future system demands the do-nothing alternative is not desirable.

## 4.3 Interaction with other Information Systems

Figure 4.1 shows a conceptual overview of the relationship of the proposed AT&U subsystems and LRIS network. Ownership information from ALTA and Parcel Mapping and topographic data from LISD would be downloaded (and merged with data from) AT&U subsystems.

Topographic Mapping Division (TMD) of Energy Mines and Resources (EMR) Canada completed topographic mapping of Canada at 1:250,000 scale in 1967, and has currently completed more than 11,100 of the 12, 922 maps required for complete national coverage at the 1:50,000 scale. These maps are a compromise product which attempts to serve many types of users and a variety of purposes. Hard copy maps, produced by conventional means, are currently being used by MEB for indexing aggregate sources. By September 1989, after working intensively for five years, TMD had produced digital topographic data for all of Canada by scanning the 1:250,000 scale map series. For some areas of Canada 1:50,000 scale topographic maps are being scanned by TMD.

Since 1985 LISD has been compiling 1:20,000 topographical digital maps of Alberta at the rate of few hundred sheets a year from existing 1:60,000 scale aerial photography. LISD has compiled digital base maps of the entire Province at

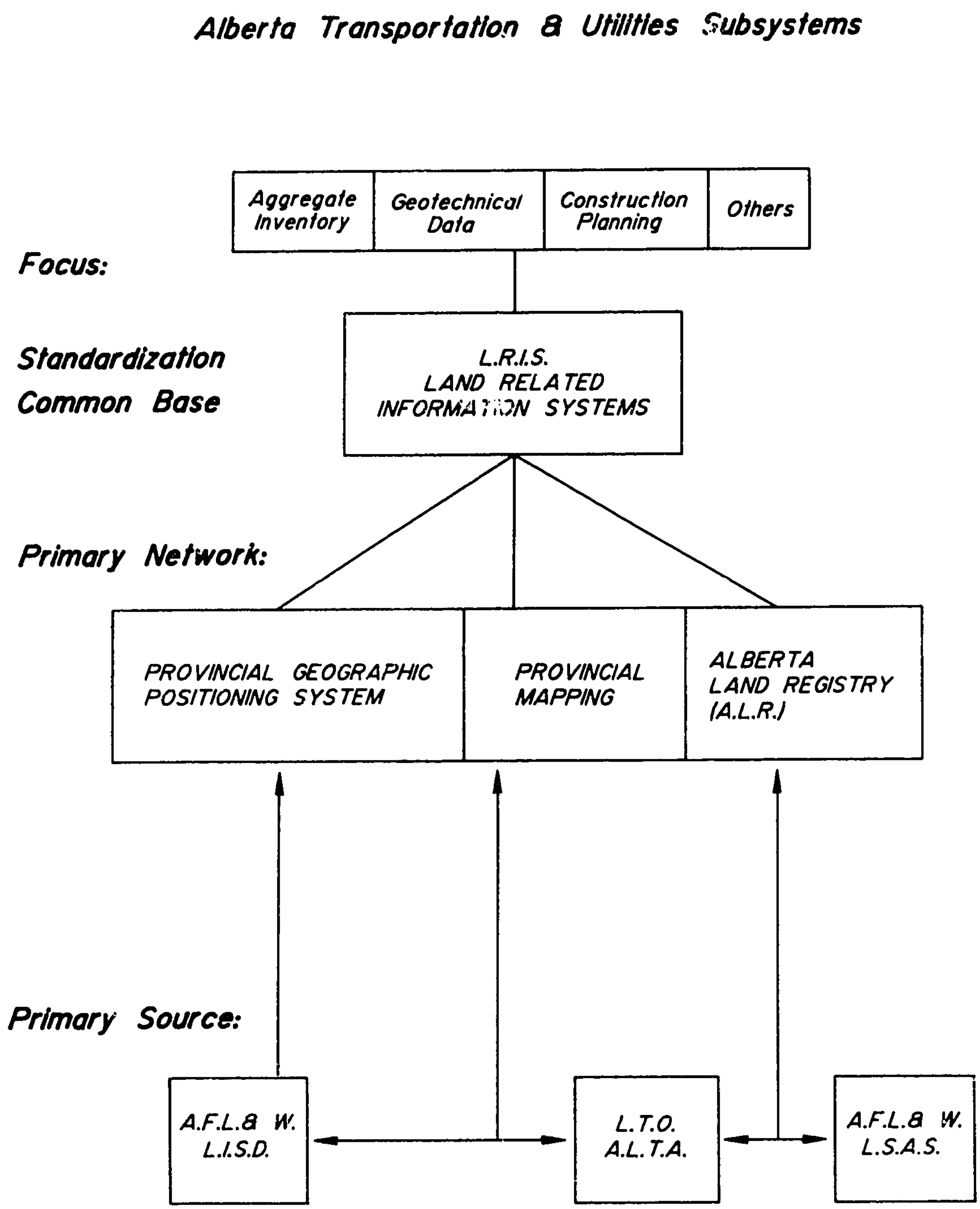



Figure 4.1 A.T.& U. Subsystems - Conceptual Overview
( Adapted from LRIS, 1989 )

1:1,000,000 and 1:2,000,000 scales. These base maps show transportation corridors, administration boundaries, hydrography, etc.

4.3.1 Automated Record-matching

Under the ALTA system every parcel of land in Alberta will have a unique identification number called Land Identification Numerical Code (LINC). The intent is to use this code for record matching of data from different sources. NTS and LISD topographic digital data are suitable for indexing of aggregate sources. Figure 4.2 shows how data from different sources may be used in a fully operational Aggregate Records Automation System.

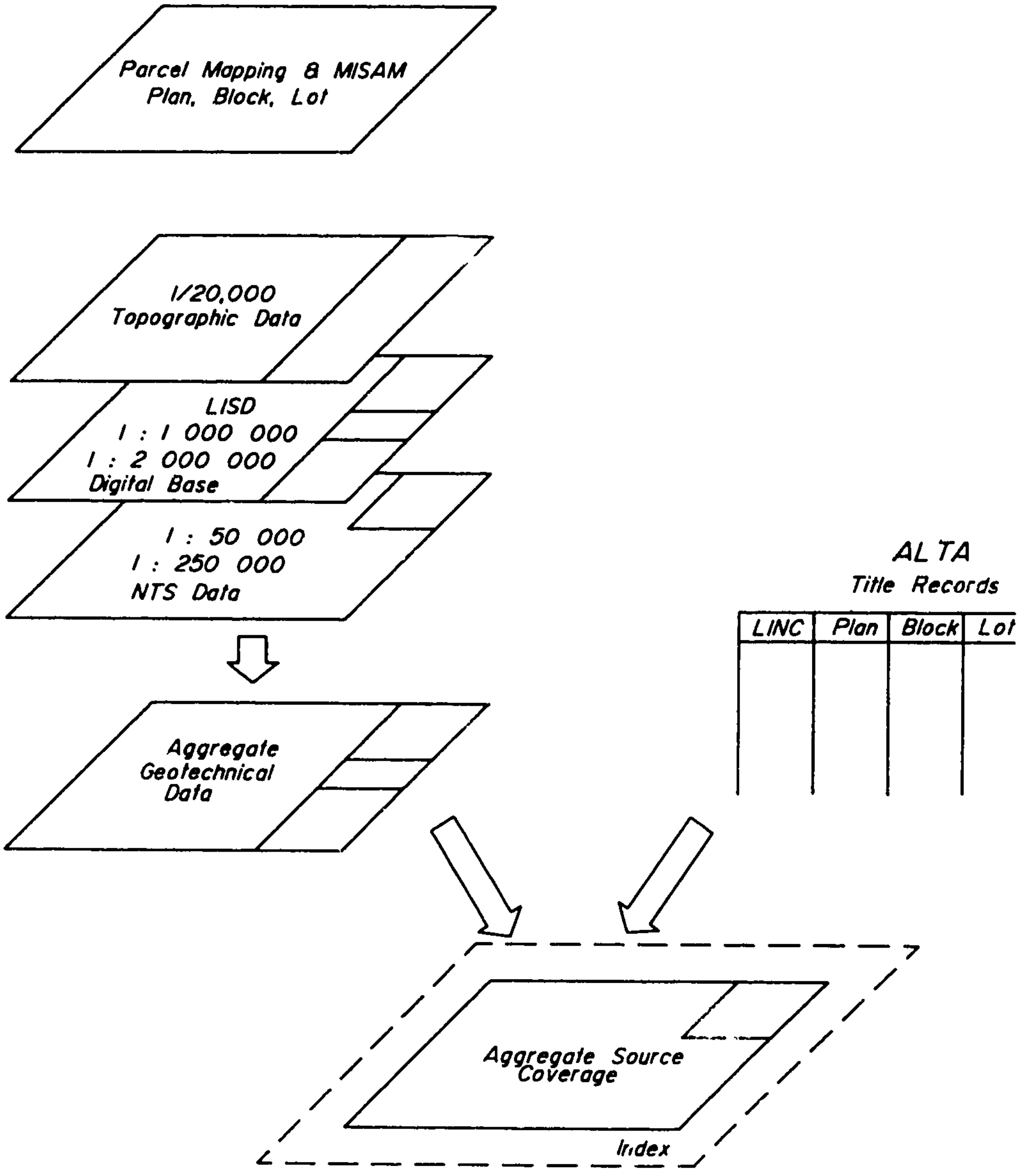



Figure 4.2 Automated Record Matching

**CHAPTER 5**

Computerization of a process usually imposes certain changes in the way different elements of the process are dealt with in an organization. Needless to say that the full benefit of computerization cannot be achieved unless those changes take place. In addition, there are budgetary constraints which dictate an incremental approach (Al-Ankary 1991). It is, therefore, necessary for an organization to carry out a feasibility study, a pre-pilot study, and a pilot project, a post-pilot evaluation study before a successful implementation can be effected. Such studies are necessary for the following reasons:

- they tend to keep the problem in focus;
- they encourage participation of more people in the process which in turn increases the chances of success;
- they identify all the bottlenecks and problem areas in the current system; and
- they provide budget estimates for the decision makers.

The diagram shown in Figure 5.1 is intended to demonstrate the benefits of such studies. Any scale may be used on the axes. For example, if the feasibility study took six months to complete at a cost of $10,000, then a pre-pilot study would cost $20,000 and take six months to complete. The horizontal dashed line indicates the accumulated cost of implementation provided successful pre-implementation studies are carried out. The heavy dashed line shows that without

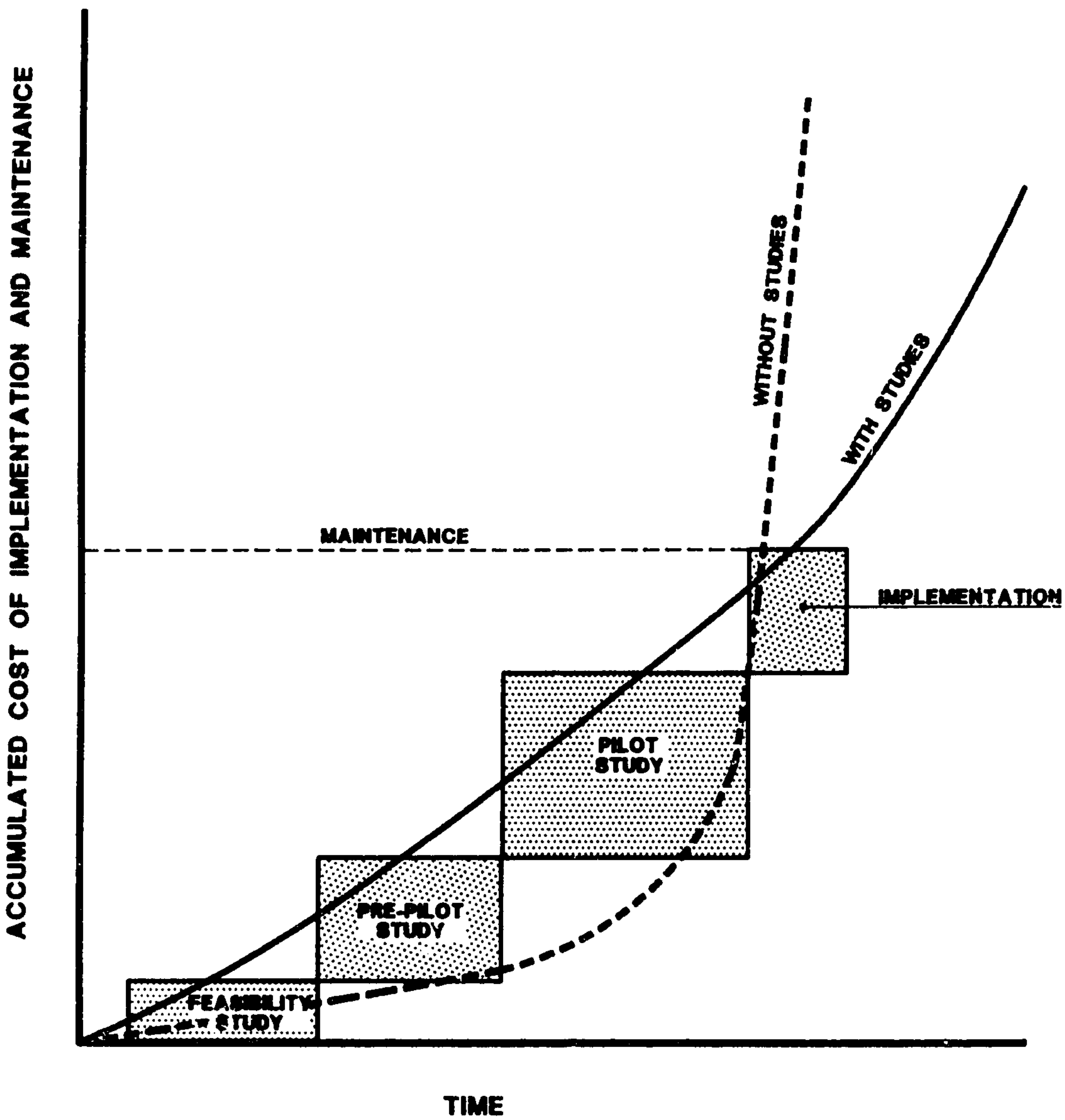



*Figure 5.1 Cost of Implementation and Maintenance.*

any studies the costs increase slowly in the beginning but increase rapidly afterwards. In practice, this curve would tend to have peaks and valleys but would generally follow the curve shown. The heavy solid line shows the accumulated cost of implementation and maintenance. Maintenance requires on going funding. While no real costs were used in the design of the illustration, it nevertheless postulates increased long term cost overruns without the experience derived from such studies before implementation.

The ASIS system can be upgraded and made interactive. However, substantial development costs would be incurred for system development and therefore this approach is not recommended. It is advisable to use a fourth generation language (e.g. FOCUS) with extensive reporting facilities for aggregate inventory management.

There is no immediate need for acquiring a turnkey GIS system in Alberta. The FOCUS system provides for all the desirable functionalities referred to earlier (Frank, 1984).

The MAIDB system in the Province of Ontario is being converted from FORTRAN language to FOCUS. When completed the MAIDB system may well have some advantages over the OSHD system. The OSHD system is FOCUS based, the system is already operational and AT&U has the source code of the application programs which are easy to use and modify.

System development in house or by consultants tends to be rather expensive venture. The OSHD system with modifications may be adopted very easily.

## 5.1 Implementation Strategy – Phase 1

It is desirable at this time to create a database on the IBM mainframe computer. Database maintenance would be carried out on the mainframe using FOCUS. A personal computer version of FOCUS with data downloaded from the mainframe should be used for retrieval of information. Creation of graphics files for individual gravel pit plans should be continued. Hard copy topographic index maps would compliment the above.

The OSHD system from the State of Oregon is recommended for Phase 1 for the following reasons:

- the source code for the programs is already in hand and can be modified relatively easily;
- the programs are prepared for mainframe FOCUS under the Time Sharing Option (TSO) and, therefore, the database can be used by many users simultaneously; and
- no additional investment in hardware is necessary at the present time.

The database structure should be designed with present and future needs in mind. For example, FOCUS supports an external database such as ORACLE™ which is also supported by several GIS systems on the market. FOCUS also supports a combination of database structures – tabular, hierarchial, network and relational.

A database is not very useful if absolute file integrity is not maintained. Retrieval of data from the database is faster if the data is already internally sorted using the desired output order.

Creation of a database for aggregate inventory is a very important first step. Depending on the budget restraints there are a number of alternatives available for maintaining a database. Initial entering of data may be contracted out, the database could be created in stages by Agency employees or a full time person could be hired for the task.

The need for proper documentation cannot be over-emphasized. A system without documentation is not of much use. Database security and modifications to programs should be well documented

## 5.2 Implementation Strategy - Phase 2

A personal computer (PC) based GIS network should be acquired in order to interact with LRIS data for up-to-date property and ownership information through LRIS gateway. Hard copy topographic index maps may still be used to compliment the above products.

## 5.3 Implementation Strategy - Phase 3

It is desirable that the following be considered for the long term requirements:

- the use of NTS and LISD topographic digital data for index;
- the use of electronic data collectors for field surveys;
- the maintenance of database by regional personnel; and
- development of GIS expertise for total Aggregate Records Automation.

## 5.4 Cost Implications

The cost of any system development will depend on the number of variables and the complexity of the desired system functions. The cost would be minimum for a basic system. A system designed for construction purposes when a large amount of detailed information is required would cost considerably more than that designed for general planning purposes. The system cost also increases when graphics and GIS applications are included. At the present time a database on the main frame computer is being developed for AT&U by a company under contract. Future enhancements are expected to be developed in the same manner. Once all desired data has been entered into the database, there will be ongoing maintenance costs. Unless the data is kept up to date, the database will not be very useful. Existing personnel will have to be trained to use the system. It is anticipated that one extra person will have to be hired to manage the system. Development, training and maintenance will have to be considered in the annual budget. The system is expected result in improved decision making.

# CHAPTER 6

## 6.1 Summary

Manual records keeping at Alberta Transportation and Utilities have been reviewed and the needs of the Aggregates Services Section identified. The literature review included books and research papers on the subject of aggregate management, Database Management Systems and Geographic Information software and system manuals and brochures provided by vendors of systems. Several turn-key systems were evaluated.

Much research in GIS is presently being conducted and a few new GIS systems are introduced every year. Since the GIS technology is still in its infancy it is not surprising that many of these systems do not deliver the required level of service to the users.

Federal and Provincial Government-wide GIS initiatives, in particular the LRIS project, were discussed. The Alberta Government wants to distribute digital data through the LRIS Gateway. Therefore, any thematic subsystems such as aggregate inventory must follow standards and procedures dictated by the LRIS Gateway. The need for communication between AT&U subsystems and LRIS network have been addressed. The OSHD system from the State of Oregon with modifications may be easily adopted for phase 1 objectives. Approaches have been recommended for phases 2 and 3 towards complete Aggregate Records

Automation.

## 6.2 Conclusions

Over the years, manual record keeping for aggregate data at Alberta Transportation and Utilities has been improved upon. It is also possible that further improvements in manual records can be made. Because of rapid advancement in computer technology, downward trend on hardware costs and advantages of computerization, most agencies with a large amount of data are moving towards computerization. It has been demonstrated that information system technology provides a set of tools for better management of aggregate resource through aggregate source records computerization.

The following conclusions are drawn from this study.

1. Manual records at AT&U do not provide adequate utility since manual tasks are error prone and recording and retrieval of data is slow and cumbersome.
2. The State of Oregon Highway Division and the Ontario Ministry of Transportation already have operational systems. It has been demonstrated that the Oregon system can readily be adapted to AT&V requirements.
3. The merit in computerization has been proven by the fast storage and retrieval of data in the Oregon and the Ontario systems.

4. Geographic Information techniques are now ell accepted and these provide a powerful methodology for analysis and display of data.
5. Significant costs will have to be budgeted for system development, loading, data, maintenance training and hiring extra personnel.
6. Computerization will improve construction planning process and the degree of improvement will depend upon the speed of system response to an operator query.

## 6.3 Recommendations

The Alberta Government is currently preparing strategies for the creation of a spatial database (Wiltse-Charters 1991) for the primary geopositioning, mapping and land registry information. It will be necessary to create a spatial database for a thematic system such as an aggregate management system before the system can interact with the LRIS Gateway. This spatial database may be created by Alberta Transportation and Utilities as the owner of the system. A number of spatial data models are being used in GIS. It is suggested that further research is required in order to test several data models, to recommend a data model and to prepare strategies for implementation of the system.

Recently remote sensing by satellites such as Multispectral Scanning (MSS), radio detection and ranging (radar) and thermal imagery has gained considerable popularity for the determination of land use and land cover classifications (Lillsand et al 1979). The Government of Canada will be launching a Radar Satellite in 1994 (Forrest 1991). Radar systems are very sensitive to moisture. In the absence of moisture, radar imagery may provide evidence of aggregate under overburden of silt. It is suggested that the use of radar together with MSS and aerial photography imagery be investigated to improve aggregate location methods.

Alberta Transportation and Utilities is currently investigating better methods for aggregate prospecting. GIS may be used for prediction purposes. Generalized soils maps may be compared with existing aggregate sources. Potential sources of aggregate may then be predicted based on similar soil classification. This approach may be investigated using raster data.

## References


Al-Ankary, K.M. 1991. An incremental approach for establishing a Geographical Information System in a developing country: Saudi Arabia. Geographical Information Systems. Vol. 5 No. 1.

Allam, M.; Templin, A. 1991. Mapping Sector Charts a New Field. GEOS. Vol. 20 No. 1. Energy, Mines and Resources Canada, Ottawa

Alberta Transportation and Utilities. 1984-85. Annual Report., Edmonton, Alberta

Alberta Transportation and Utilities. 1985-86. Annual Report., Edmonton, Alberta

Alberta Transportation and Utilities. 1988-89. Annual Report., Edmonton, Alberta

Brohm, D.R.; Katona, Z.L. 1985. Computerized aggregate information system: Fieldwork to contract sources list. Ontario Ministry of Transportation and Communication, Toronto, Ontario.

Buckley, D.J. 1988. Forestry GIS Workshop, URISA (Urban and Regional Information Systems Association), Edmonton, Alberta.

Burrough, P.A. 1986. Principles of geographical information systems for land resources assessment. Clarendon Press, Oxford, 193p.

Cook, R. 1988. Alberta experience in cold region highway planning, construction and operations. Alberta Transportation and Utilities.

Forrest, D. 1991. Canada to Launch Radar Satellite in 1994. GIS Canada.

Frank, A.U. 1984. Requirements for database systems suitable to manage large spatial databases. International Symposium on Spatial Data Handling, Zurich, Switzerland.

Hum, Jennifer 1991. Digital Chart of the World. GEOS vol. 20 no. 1, Energy Mines and Resources Canada,Ottawa.

(IBI) Information Builders, Inc. 1986. Focus Users Manual Release 5.0.

Karsan, A. and Peterson, A. E. 1989. A Feasibility Study for a proposed Aggregate Source Information System for Alberta Transportation and Utilities.

Karsan, A. and Peterson, A. E. 1990. Use of GIS techniques for Aggregate Management. CSCE conference proceedings, annual meeting, Hamilton, Ontario.

Lillsand, T.M.; Kiefer, R.W. 1979. Remote Sensing and Image Interpretation. John Wiley & Sons, New York, U.S.A..

L.R.I.S. (Land Related Information System) 1989. The Alberta LRIS Network System. Alberta Forestry, Lands and Wildlife, Province of Alberta, Edmonton.

MAIDBS (Mineral Aggregate Inventory Data Bank System) 1987. User's guidebook. Ontario Ministry of Transportation and Communications.

MCFR (Management Committee Final Report) 1991. Land Related Information System. Alberta Planning Board.

Monmonier, Mark S. 1982. Computer-assisted Cartography. Prentice Hall, Inc. Englewood Cliffts, N.J., 214p.

NCHRP (National Cooperative Highway Research Program) 1976. Acquisition and use of geotechnical information. Synthesis of Highway Practice No. 33.

OSHD (Oregon State Highway Division) 1987 Documentation for Oregon State Highway Division Aggregate Source Database.

Schaubel, Earl V. 1991. The National Topographic Data Base. A Digital Map, GEOD Volume 20, No. 1, Energy Mines and Resources, Canada, Ottawa

Weir, C.H.; Walker, W.J. 1989. Geographic Information Systems Symposium, Regina.

Wiltse-Charters, J. 1991. Request for proposal for LRIS Spatial Database (SDB) System, Business Area Analysis.

Witczak, M.W. 1972. Relationships between physiographic units and highway design factors. National Cooperative Highway Research program ( NCHRP) No. 132.

# Appendix A

Aggregate Source Information System (ASIS) Listing

| LAND LOCATION | MAP AREA | KEY SOURCE NUMBER | NAME | P.S.T. CONDTN | MATER TYPE | LAND STAT | RES. NUM. ROYALTY UNIT COST | AUTHOR AREA | EXPIRY DATE | OLD PIT S.P. NO | LIC APP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NE28-054-08-4 | 73E11 | A246521 | MYRNAM | | | PRVA | | .00 | / | | |
| SE34-054-08-4 | 73E11 | A213351 | | OP | | PRVA | $0.100 | 1.50 | / | | |
| NE08-054-09-4 | 73E11 | A252821 | GOYAN | TT | | | | .00 | / | | |
| SW08-054-09-4 | 73E11 | A280061 | KRYRIAK | NT | | | | .00 | / | | |
| NE11-054-09-4 | 73E11 | A213411 | | | | PRVN | | .00 | / | | |
| NW11-054-09-4 | 73E11 | A213391 | MYRNAM | OP | CLG | TRAN | | .00 | / | 3077-0246 | |
| NW11-054-09-4 | 73E11 | A213401 | YOUZWYSHYN | OP | G | PRVA | $0.400 | .00 | 87/12 | 3166-0480 | |
| NE13-054-09-4 | 73E11 | A273971 | EWANCIW | TT | BLDS | PRVA | $0.480 | .00 | 90/12 | | |
| NW14-054-09-4 | 73E11 | A255321 | PROSKIW | NT | | | | .00 | / | | |
| SE22-054-09-4 | 73E11 | A255331 | PROSKIW | NT | | | | .00 | / | | |
| TSHP-054-10-4 | 73E11 | A213461 | | T | G | | | .00 | / | | |
| SE05-054-10-4 | 73E11 | A279141 | LUCYSHYN | TT | G | | | .00 | / | | |
| SW06-054-10-4 | 73E11 | A262151 | GOLOMOWSKI | NT | | | | .00 | / | | |
| NW07-054-10-4 | 73E11 | A213421 | PYLYPIUK | OP | CLG | PRVA | $0.100 | 8.00 | / | 3166-0610 | |
| SE09-054-10-4 | 73E11 | A256461 | YARMECHUK | NT | | | | .00 | / | | |
| SW09-054-10-4 | 73E11 | A256451 | YARMECHUK | NT | | | | .00 | / | | |
| NW10-054-10-4 | 73E11 | A275751 | HEALEY | NT | | | | .00 | / | | |
| NE11-054-10-4 | 73E11 | A213441 | YACHIMEC | | | PRVA | $0.100 | 159.00 | / | 3166-1496 | |
| SW11-054-10-4 | 73E11 | A213431 | YACHIMEC | TT | | PRVA | $0.100 | 159.00 | / | 3166-1496 | |
| NW15-054-10-4 | 73E11 | A275541 | TOPOLINSKY | NT | | | | .00 | / | | |
| SW15-054-10-4 | 73E11 | A270921 | TOPOLINSKI | T | S | | | .00 | , | | |
| SW18-054-10-4 | 73E11 | A2134[illegible]1 | SAGANIUK | OF | CLG | PRVA | $0.070 | .00 | / | 3166-0256 | |
| SW25-054-10-4 | 73E11 | A2726[illegible]1 | JELLETTE | NT | | | | .00 | / | | |
| NW01-054-11-4 | 73E11 | A276321 | MANDRUSIAK | T | G | PRVA | $0.40 | .00 | 89/12 | | |
| SC01-054-11-4 | 73E12 | A280091 | SASKIW | T | G | | | .00 | / | | |
| NE08-054-11-4 | 73E12 | A272531 | | T | S | | | .00 | / | | |
| NW09-054-11-4 | 73E12 | A256481 | ELKOW | NT | | | | .00 | / | | |
| NW10-054-11-4 | 73E12 | A273981 | | T | | | | .00 | / | | |
| NE12-054-11-4 | 73E11 | A213471 | BOIDA | | GPRV | A$0. | 100 | .00 | / | 3166-1209 | |
| SE13-054-11-4 | 73E11 | A213551 | HAAG | TT | | PRVA | $0.350 | .00 | 86/12 | | |
| SW13-054-11-4 | 73E11 | A272661 | HAAG | NT | | | | .00 | / | | |
| SE1?-054-11-4 | 73E12 | A213481 | ELKOW | LP | G | PRVA | $0.350 | 160.00 | 86/12 | 3166-1208 | |
| SW1?-054-11-4 | 73E12 | A267731 | MILNE | T | G | | $0.350 | .00 | 86/12 | | |

| NAME | KEY SOURCE NUMBER | MAP AREA | LAND LOCATION | P.S.T. CONDTN | MATER TYPE | LAND STAT | RES. NUM. ROYALTY UNIT COST | AUTHOR AREA | EXPIRY DATE | OLD PIT S.P. NO | LIC APP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HINGER | A020821 | 82009 | SW14-070-01-5 | OP | G | PRVE | $0.050 | .00 | 46/12 | 3077-0082 | |
| HINKELMAN | A047101 | 83G16 | SE02-056-03-5 | TT | S | | | .00 | / | | |
| HINNICKY | A009641 | 83N06 | NE03-075-21-5 | P | MCOG | PRVE | $00.080 | .00 | 59/12 | 3166-0964 | |
| HINNICKY | A055241 | 83N06 | SW09-075-21-5 | P | G | PRVE | $00.080 | .00 | 60/12 | | |
| HINNICKY | A055251 | 83N06 | SW09-075-21-5 | P | COS | PRVE | $00.030 | .00 | 60/12 | | |
| HINNICKY | A055261 | 83N06 | NW04-075-21-5 | | | PRVE | $00.080 | .00 | 60/12 | | |
| HINNICKY | A055291 | 83N06 | SW09-075-21-5 | | | PRVL | $290.00 | .00 | / | | |
| HINTER | A044671 | 83F07 | NW05-052-18-5 | | | PRVE | $0.100 | .00 | 67/12 | | |
| HINTER HAUL ROAD | A067441 | 83N10 | ST06-074-17-5 | | | DHP4 | DRS810203 | .00 | / | | |
| HINTERBURN | A208531 | 83H05 | NE29-051-25-4 | | | | | .00 | / | 3166-0746 | |
| HINTERBURN | A211831 | 83H12 | SW36-052-26-[illegible] | TS | | | | .00 | / | | |
| HINTERBURN S.P.#2 | A276931 | 83H12 | SW07-053-25-4 | S | | | | .00 | / | | |
| HINTERING HILL #2 | A080741 | 82P07 | NE28-026-18-4 | OP | | | | .00 | / | 3077-0234 | |
| HINTERING HILL #2 | A256011 | 82P01 | NW28-02[illegible] 18-[illegible] | | | | | .00 | / | | |
| HINTERING HILLS #2 | A082391 | 82P08 | NE28-02[illegible] 18-4 | | | | | .00 | / | | |
| HINTERING HILLS #3 | A080711 | 82P08 | NW27-026-18-4 | TP | | | | .00 | / | | |
| HIRAT | A281571 | 83A01 | NE24-037 15-4 | NT | | | | .00 | / | | |
| HIRSTUK | A266931 | 83I01 | NE22-058-16-4 | NT | | | | .00 | / | | |
| HIRTZEL | A206821 | 83H05 | SW10-050-22-4 | NT | | PRVN | | .00 | / | | |
| HITHERS | A031091 | 83M01 | NW02-072-04-6 | S | B | PRVC | | .00 | / | | |
| HITSCHEN | A274591 | 83G13 | S[illegible]30-055-11-5 | TT | G | PRVA | $0.400 | .00 | 89/12 | | |
| HITHER | A085021 | 82P11 | NE16-031-25-4 | OP | G | PRV | | .00 | / | 3166- 138 | |
| HITHICHI | A268001 | 83H16 | NW34-057-17-4 | TT | BLDS | | | .00 | / | | |
| HITHICKY | A222061 | 83I01 | SW27-058-16-4 | OP | VCLG | PRVA | $0.100 | .00 | / | | |
| HITHICKY | A222131 | 83I01 | SW26-058-16-4 | OP | G | PRVN | | .00 | / | | |
| HITZKE | A085061 | 82P12 | NE34-031-28-4 | OP | G | PRV | | .00 | / | 3166- 785 | |
| HIZARD LAKE STOCK | A203531 | 83H04 | NW36-047-27-4 | | | | | .00 | / | | |
| HM.HAINS | A2025[illegible]1 | 83H04 | SW18-047-25-4 | TP | SCOG | PRV | | .00 | / | 3166- 816 | |
| HOCKNITZ | A063251 | 82H07 | NE36-005-22-4 | P | G | PRVE | $0.100 | .00 | / | | |
| HOITT | A274971 | 83A12 | NW25-042-26-4 | NT | | | | .00 | / | | |
| HOITTE | A257691 | 72E05 | SE26-005-15-4 | TT | BLDS | PRVA | $1.00 | .00 | 89/12 | | |
| HOLANSKI | A278461 | 83I01 | NE15-059-16-4 | NT | | | | .00 | / | | |
| HOLBECK | A096731 | 83A09 | NW12-043-15-4 | NT | | PRVN | | .00 | / | | |

## Appendix B

Samples of Gravel Pit Plans from

AT&U Departmental Intergraph System

**METRIC**

Alberta
TRANSPORTATION
MATERIALS
ENGINEERING BRANCH

# PIT PLAN

REQUIRED PROCEDURE FOR OPERATIONS IN THE FOURTH CREEK PIT

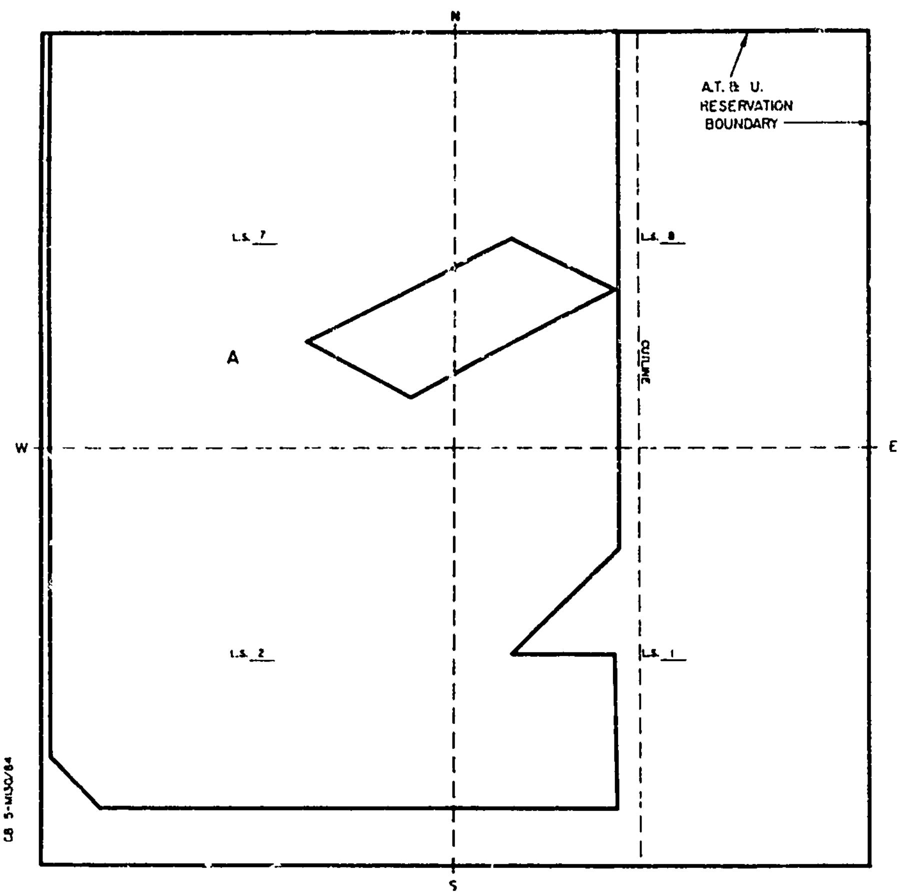
SE 1/4 SEC. 23 TP. 82 RGE. 7 W. 6 M.

0 m 50 m 100 m 150 m 200 m 250 m 300 m

NOTE:
- BEGIN AGGREGATE EXCAVATION IN AREA "B" OUTLINED WITH A DASHED LINE
- BEGIN AGGREGATE EXCAVATION IN AREA DESIGNATED BY THE ENGINEER
- PLACE OVERBURDEN IN AREA "P" OUTLINED WITH A DASHED LINE
- PLACE OVERBURDEN IN AREA DESIGNATED BY THE ENGINEER

LEGEND:

| | | | |
|---|---|---|---|
| OP | O[illegible] PIT | SP. | STOCKPILE |
| A | AGGREGATE AREA | C.S.P. | CRUSH STOCKPILE |
| D | DEPLETED AREA | A.T. RESV. B.D. | BOUNDARY OF [illegible] AREA |
| STR. | STRIPPING | A.T. AGR. BDY. | BOUNDARY OF AGREEMENT AREA |
| T | TOPSOIL | HWY. R/W. | HIGHWAY RIGHT OF WAY |
| GF | GRAVEL FACE | - x - | FENCE LINE |
| SF | SAND FACE | [illegible] | MARKER |




CB 5-M130/84

DATE ________________ 19 ____

FOR MATERIALS ENGINEERING BRANCH

FARA2 IOA BOX24

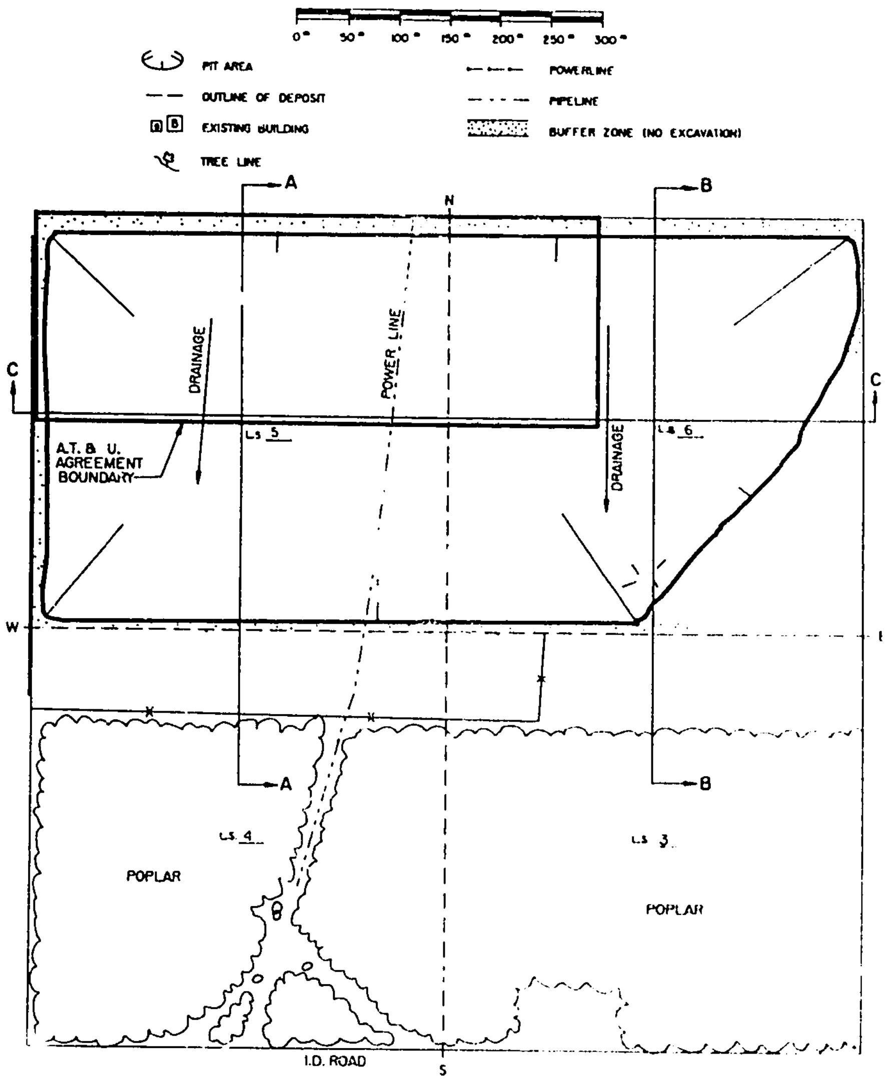
Alberta
TRANSPORTATION
MATERIALS
ENGINEERING BRANCH

**METRIC**

# RECLAMATION PLAN

REQUIRED PROCEDURE FOR OPERATIONS IN THE RICHARDS PIT

SW 1/4 SEC. 26 TP. 84 RGE. 22 W. 5 M




DATE ______________ 19 ___

ASST. DIR. (AGG. SERVICES)

**Alberta**
TRANSPORTATION
MATERIALS
ENGINEERING BRANCH

# PIT PLAN

**METRIC**

REQUIRED PROCEDURE FOR OPERATIONS IN THE RICHARDS PIT

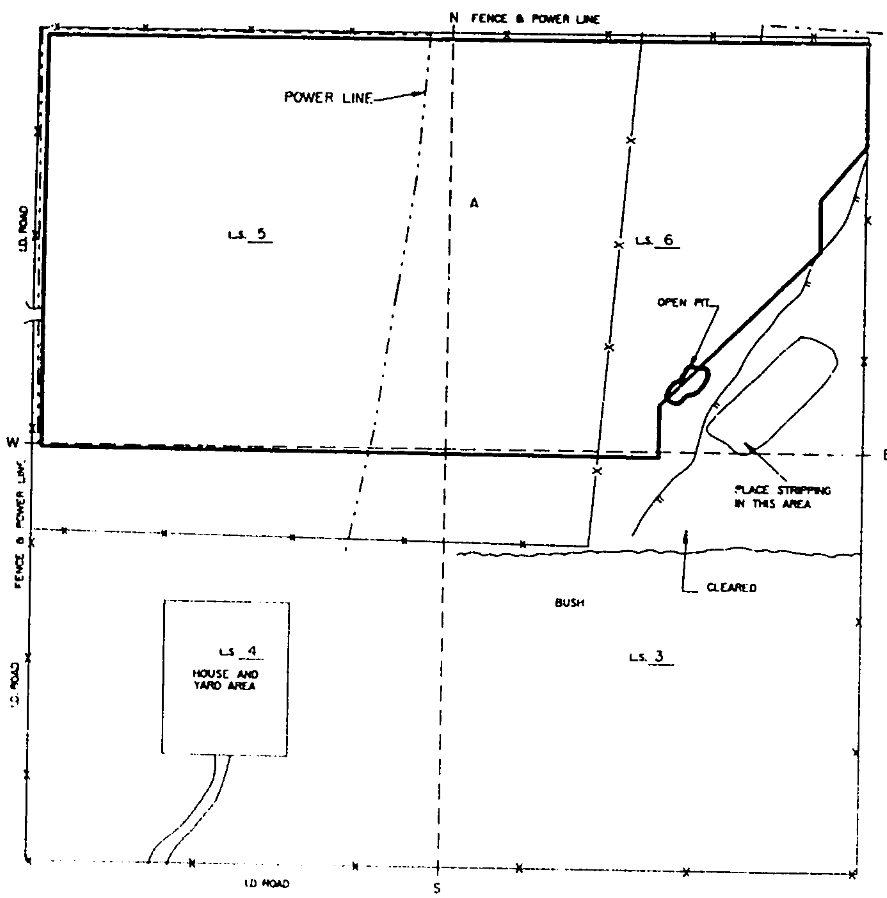
SW 1/4 SEC. 26 TP. 84 RGE. 22 W. 5 M.

0 m 50 m 100 m 150 m 200 m 250 m 300 m

NOTE:
- ☐ BEGIN AGGREGATE EXCAVATION IN AREA "B" OUTLINED WITH A DASHED LINE
- ☐ BEGIN AGGREGATE EXCAVATION IN AREA DESIGNATED BY THE ENGINEER
- ☐ PLACE OVERBURDEN IN AREA "P" OUTLINED WITH A DASHED LINE
- ☐ PLACE OVERBURDEN IN AREA DESIGNATED BY THE ENGINEER

LEGEND:

| | | | |
|---|---|---|---|
| OP | OPEN PIT | "P" | STOCKPILE |
| A | AGGREGATE AREA | C.S.P. | CRUSH STOCKPILE |
| D | DEPLETED AREA | A.T. RESV. BDY. | BOUNDARY OF RESERVATION AREA |
| STR. | STRIPPING | A.T. AGR. BDY. | BOUNDARY OF AGREEMENT AREA |
| T | TOPSOIL | HWY. R/W. | HIGHWAY RIGHT OF WAY |
| GF | GRAVEL FACE | - x - | FENCE LINE |
| SF | SAND FACE | | MUSKEG |




DATE ................ 19 ....

FOR MATERIALS ENGINEERING BRANCH

# Appendix C

Turn-key Geographic Information Systems

## APPENDIX C

### A. ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)

#### 1. The ARC/INFO

ARC/INFO is a geographic information system designed for managing cartographic and spatially associated tabular data. It is designed to serve as a generic tool box of data entry manipulation, analysis and display procedures. As such, it can be used for a variety of applications ranging from urban land records management to natural resources inventory and planning applications. The system includes over 300 software procedures for handling many commonly encountered problems.

#### 2. Network

Networks made up of intersecting line segments are stored topologically in ARC/INFO database format. Attributes can be associated with a network to describe variables such as travel time, distance and direction along each line segment; and the demand for specific facilities or services located along segments or at intersections. These attributes form the basis for analytical networking operations such as moving resources from one location to another along an optimum path, or distributing resources from a center throughout a network. Since networks are defined in ARC/INFO database format, they can be analyzed and manipulated further using any of the software tools available in the ARC/INFO system (e.g., overlay, display, etc.).

### 3. ARC/INFO Database Concepts

ARC/INFO organizes geographic data into a database structure known as a coverage. Each coverage is composed of a series of files which contain cartographic data and their related attributes. Feature numbers are used to link cartographic data with attribute data. Relationships between arcs, nodes and polygons (topology) are explicitly structured in a table and used by many of the analytic commands.

## B. INTERGRAPH

### 1. Spatial Editor

SPATIAL EDITOR software is designed for the input, editing and verification of graphic and non-graphic data in the Intergraph environment. SPATIAL EDITOR prepares data for input to SPATIAL ANALYST processing software for GIS applications based on querying topological data structures. It is also used for general map digitizing and clean-up. Specialized processes within SPATIAL EDITOR speed and ease the validation of data files. SPATIAL EDITOR accepts input from a range of Intergraph application packages and designed specifically to prepare data for processing by Intergraph's SPATIAL ANALYST product.

2. Spatial Analyst

SPATIAL ANALYST creates buffer zones in IGDS/DMRS data, resulting in centroids and line work that define area features. Topologically structured files can then be generated from existing multi-theme IGDS/DMRS data. SPATIAL ANALYST is particularly strong in query/analysis operations. It saves the results of the queries for subsequent plotting or reporting and creates tabular reports based on the results. The design of SPATIAL ANALYST utilizes topological data structures to complement existing IGDS capabilities in the VAX environment. Results of topologically based queries may be displayed in IGDS reference files. These topological files contain faces, edges, and points--the fundamental base map elements with "meaningful" attributes attached.

## C. PAMAP

### 1. Analyzer

ANALYZER converts the lines, points and polygons of the mapping line work, together with the attribute data to a grid-cell format. The size of the grid-cell is user specified. As it converts a thematic map layer to grid-cell format, ANALYZER automatically forms polygons from the linework, computing their areas and perimeters and storing them in the database. Its analysis tools include aggregation, corridor analysis, sliver removal and overlaying points, lines or polygons. ANALYZER will also convert from grid-cell to vector format.

## D. SPANS

The Tydac Spatial Analysis System (SPANS) is a micro-computer based GIS. The vendor claim that the system has been designed for those who really need to analyze and model spatial information rather than just retrieve and display input data. They further claim that the data structure is such that the system can work efficiently with complex geographically referenced databases and images of varying resolution. The system is menu-driven and accessible to a wide range of "non-programmers".