GIS as a method for handling environmental data from Antarctica

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Abstract

The Swedish Polar Research Secretariat wants to compile all data from the Swedish environmental monitoring programme in Antarctica and present it using a Geographical Information System, GIS, in order to get a better follow-up on performed activities. The assignment of this master's thesis has been to build a database containing geographic information for the areas around the Swedish research stations Wasa and Svea in Dronning Maud Land. The geodatabase will serve as a platform for future GIS-applications used by the Swedish Polar Research Secretariat.

The work is divided into three parts, project planning, project development and an analysis. A part of the project planning consisted of a survey of the environmental monitoring programme and the existing data. A number of shortcomings in the existing data were discovered during the survey, it was therefore decided to amend the environmental monitoring programme and update the data handling methods in order to get better-suited data to use in a GIS.

The choice of GIS-software fell on ArcGIS ArcView 9.2 from ESRI and data from the Antarctic Digital Database was used as a basemap. Additional data from the Antarctic Digital Database was used in order to build the database. A file geodatabase structure was chosen which consists of a number of feature datasets containing all the geographical information.

An analysis and a discussion about the existing monitoring programme have been performed and proposals on how to improve the monitoring programme have been presented.

Sammanfattning

Polarforskningssekretariatet vill sammanställa all data från det svenska miljöövervakningsprogrammet på Antarktis och presentera resultatet i ett geografiskt informationssystem, GIS, för att få en bättre uppföljning av utförda aktiviteter. Uppgiften för detta examensarbete har varit att bygga en databas med geografisk information för området runt de svenska forskningsstationerna Wasa och Svea i Dronning Maud Land. Denna geodatabas kommer sedan att fungera som plattform för framtida GIS-applikationer användbara för Polarforskningssekretariatet.

Arbetet har delats upp i tre delar, projektplanering, projektutformning och analys. En del av projektplaneringen bestod av att kartlägga miljöövervakningsprogrammet och den existerande datan. Under kartläggningen upptäcktes ett antal brister i den existerande miljödatan, varför det bestämdes att förändra miljöövervakningsprogrammet och uppdatera metoderna för datahantering för att få bättre lämpad data att använda i ett GIS.

Valet av mjukvara föll på ArcGIS ArcView 9.2 från ESRI Inc och data från the Antarctic Digital Database användes som bakgrundskarta. Ytterligare data från the Antarctic Digital Database användes vid uppbyggnaden av databasen. En fil-geodatabasstruktur användes som består av ett antal dataset som innehåller den geografiska informationen.

En analys samt en diskussion om det existerande övervakningsprogrammet har också utförts och förslag till förbättringar har presenterats.

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1 Introduction

The opening chapter presents the background to the project as well as aim & objectives and delimitations. It also contains reading advice for the report.

1.1 Background

Antarctica is the coldest, driest and most inaccessible continent on earth. It is remote, isolated and frozen all year round and therefore has had a limited exposure to the outside world. The extreme climate, the remoteness and the sparse human presence have contributed to the continents' pristine environment. Still it is not immune to human impacts. Today most of the human activities in the Antarctica are related to scientific research and the associated logistic support. The environmental awareness has grown considerably since the early explorations of Antarctica and now scientists recognize the value of a clean Antarctica and are taking steps to avoid contaminating it. [Hempel et al, (1994)]

The *Protocol on Environmental Protection* states in Article 3 *Environmental Principles* that all member states have agreed to enhance the protection of the Antarctic environment and the dependent and associated ecosystems. Therefore all activities in Antarctica must be planned and conducted so as to limit adverse impacts.
Further on, Article 3.2 (d) states, *"regular and effective monitoring shall take place to allow assessments of the impacts of ongoing activities, including the verification of predicted impacts."* [Polar]

Environmental monitoring programmes are therefore performed around the Swedish research stations Wasa and Svea. Most of the known human impacts are local and concentrated to the surrounding areas around research stations and field camps. The main contribution to the environmental impact related to Swedish activities in Antarctica is related to transports between stations as well as transport to research areas. [Polar]

The Antarctic treaty states in Section III.1.c, *"Scientific observations and results from Antarctica shall be exchanged and made freely available."* Understanding that geographic location is a fundamental element for integrating and communicating knowledge about the state of environment learned from environmental monitoring and research in Antarctica. The Swedish Polar Research Secretariat has decided to make a system that will provide with adequate tools for assessment and analysis of environmental data. With a perspicuous presentation of the sampling sites from the monitoring programme shown on a map, more conclusions could be drawn and improvements cold better be directed. [Polar]

1.2 Problem

The monitoring programme has been going on since 1991 and there is a lot of information gathered about the environmental impacts from the research expeditions. However, the results from the monitoring programme has up to now not been analysed and synthesized in a clear way. The existing information is very unstructured, it is hard to grasp and presented in different formats, most of it handwritten.

1.3 Aim and objectives

The Swedish Polar Research Secretariat wants to compile all environmental data and present it using a Geographical Information System, GIS, as a tool, in order to get a better follow-up on performed activities. Also, using a GIS-based monitoring programme, The Swedish Polar Research Secretariat can better manage all kinds of data, and provide the Antarctic research community with geospatial information and maps of areas where research is on-going, or what kind of research that has been conducted during past expeditions.

The aim of the project is to compile the information and build a database containing geographic information for the areas around Wasa and Svea in Dronning Maud Land.

This will be done by:

- A survey of the existing information as well as what kind of information that is needed for the construction of the database.
- Provide basemaps suitable for GIS-applications.
- Present an overview of the geodatabase.
- Develop suggestions on how the environmental monitoring should be presented in the future so the results could be used for analysis of environmental impacts.

The project will form a platform for future GIS-applications used by the Swedish Polar Research Secretariat.

1.4 Delimitations

The work is divided in two parts, a theoretical part and a practical part. The theoretical part consists of a literature study, data collection and report writing. The practical part consists of the creation of the database.

1.5 Acronyms

ADD Antarctic Digital Database
AEON Antarctic Environmental Officers Network Research
BAS British Antarctic Survey
CEP Committee for Environmental Protection
COMNAP Council of Managers of National Antarctic Programmes
EIA Environmental Impact Assessment
ESRI Environmental System Research Institute
GIS Geographical Information Systems
JCADM Joint Committee on Antarctic Data Management
SCAR Scientific Committee on Antarctic Research
SWEDARP the Swedish Antarctic Research Programme
IMW International Map of the World
WFS Web Feature Service
WMS Web Map Service

1.6 GIS Concepts

ArcCatalog   GIS software from ESRI Inc. Used for file handling and organise the geographical data. Included in ArcView 9.2

ArcMap   GIS software from ESRI Inc. Used for visualisation and editing geographical data. Included in ArcView 9.2.

Attributes   Nonspatial information about a geographic feature usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name and length.

Basemap   A map showing background reference information such as landforms, roads and landmarks.

Dataset   Any collection of related data usually grouped or stored together.

Feature   A representation of a real-world object on a map.

Feature class   A collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allows information of the same type to be grouped in to a single unit, for example highways, primary roads and secondary roads can be grouped together into a line feature class named "roads".

Feature dataset   A collection of feature classes stored together that share the same spatial reference; that is, they share a coordinate system, and their features fall within a common geographic area. Feature classes with different geometry types may be stored in a feature dataset.

Geodatabase   A collection of geographic datasets such as feature classes, attribute tables, raster datasets, network datasets or topologies.

GIS   Acronym for Geographic Information System. An integrated collection of computer software and data used to view and manage information about geographic places, analyse spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organising spatial data and related information so that it can be displayed and analysed.

Interchange formats A file format that allows easy exchange of data between different software programs.

Map layers   The visual representation of a geographic dataset in any digital map environment and is more or less equivalent to a legend item on a paper map. On a road map, for example, roads, national parks, political boundaries, and rivers might be considered different layers.

Shape-file   A vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.

1.7 Reading advice

This report first presents the background to the project followed by a frame of reference with an introduction to Antarctica and Geographical Information Systems. Afterwards is a description of the methodology, followed by how the project has been implemented and an analysis. Finally the report covers what conclusions have been made as well as recommendations for future development. At the end of the report are references and appendices.

For readers who already are informed about the project chapter 4 *Implementation*, chapter 5 *Analysis*, and chapter 6 *Conclusions* are recommended.
For readers who are not informed about the project chapter 1 *Introduction* are recommended before reading chapter 4 *Implementation*, chapter 5 *Analysis*, and chapter 6 *Conclusions*.
For readers who whish to learn more about the theories behind the project and more about the project itself chapter 2 *Frame of Reference* and chapter 3 *Method* are recommended.

2 Frame of Reference

In this chapter the theory behind the project is presented. It contains an introduction to Antarctica and to Geographical Information Systems.

2.1 Antarctica

Antarctica is Earth's southernmost continent and is situated in the southern hemisphere, the continent covers an area of about 14 million km^2. [NE]
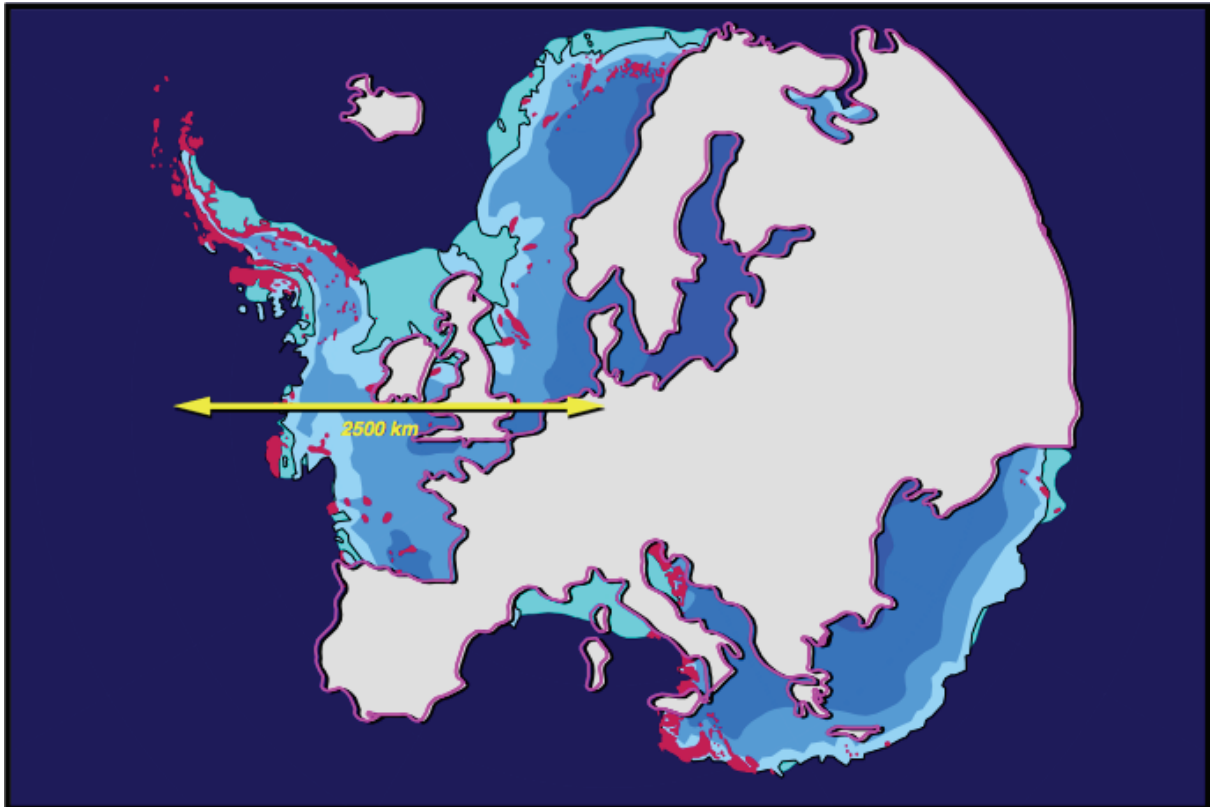

Figure 2.1 Size comparison Europe-Antarctica [Wikipedia]

Approximately 98 percent of the surface is covered by snow and ice, which contains about 70 percent of the world's fresh water resources. The remaining two percent of bare land is the most suitable environment for flora and fauna. Most of this land is found around the Antarctic Peninsula and around the coastline. The flora consists mostly of lichens, mosses, algae and fungi. The climate is determined by a number of things, such as the geographical location, the elevation and the belt of sea ice that surrounds the continent during winter.
Antarctica and the surrounding area are important places for scientific research. Since it has an effect on the world's climate and ocean systems it is a perfect place for the study of global processes, such as climate change and ozone depletion. [BAS]
Today there are between 70-80 research stations on the continent.

Antarctica plays a key role in many scientific questions – of which those related to global climate change are probably the most prominent examples.
In Antarctica it is possible to learn about the evolution of the earth during million of years, a knowledge which is necessary to be able to take care of tomorrow's environmental problems.

Through international agreements Antarctica has therefore been designated a natural reserve, devoted to peace and science. [Polar]

2.2 The Antarctic Treaty

Antarctica was the last continent to be discovered and explored. In the late 19th century, a series of expeditions were carried out, one reason was to search for new whaling areas, and others were for scientific research. In 1908 Great Britain was the first country to claim territorial sovereignty. In the following decades a number of other countries followed. [Auburn (1982)]
Increasing rivalry and disputes over territories grew, and the sovereignty problem proved a major interference to scientific cooperation across nations. In 1957-58 the first substantial multi-nation research programme in Antarctica was carried out. The twelve countries active in the research agreed that their territorial claims would be put aside and allow the scientists to cooperate. The programme was so successful that these nations agreed that peaceful scientific cooperation in the Antarctic should continue indefinitely. [Beck (1986)]

The Antarctic Treaty was signed in 1959 and came into force on June 23rd 1961. As of now there are 46 counties that have singed the treaty, 28 of theses as Consultative Parties and 18 as Acceding States. Any country that shows commitment to Antarctica by conducting significant research in Antarctica can gain Consultative status. Sweden became a Consultative party in 1988. [ATS]

The Antarctic Treaty consists of 14 Articles containing purposes and principles on how Antarctica shall continue to be a place used exclusively for peaceful purposes and scientific knowledge. [Polar]

2.2.1 The protocol on Environmental Protection

The protocol on Environmental Protection is an extension of the Antarctic Treaty and covers all issues of environment and protection. The protocol on Environmental Protection consists of 27 Articles concerning assessment of environmental impacts from on-going and planned activities in Antarctica. [Polar]

The protocol states that Antarctica is a *"natural reserve, devoted to peace and science"*, and provides basic principles and detailed mandatory rules related to human activities in Antarctica. [ATS]

2.3 Swedish research

The Swedish Polar Research Secretariat was founded 1984 and is a government authority. The main purpose is to promote Swedish Polar research by organising and leading research expeditions to Antarctica and the Arctic. The Secretariat maintains the Swedish research stations in Antarctica. [Polar]

There are two Swedish research stations in Antarctica, Wasa and Svea. Svea was the first to be built during the Antarctic Expedition 1987/88. It is located in the Heimefront Range and is a small station with only four beds that is used periodically as a field station.

Figure 2.2 Research Station Svea [Polar]

Wasa was built one year later at the nunatakk Basen in Dronning Maud Land. Wasa have room for 12-16 people and is only occupied during the Antarctic summer when the weather conditions are the most suitable for research. The Finish research station Aboa is located very close, about 200 meters away, and together they form the Nordenskiöld Base Camp. The stations cooperate both in research and logistics. [Polar]

Figure 2.3 Research Station Wasa [Polar]

2.4 Environmental monitoring

The Swedish Polar Research Secretariat is carrying out an environmental monitoring programme in accordance with the Environmental Protocol in order to identify the impacts around the Swedish research stations. The monitoring programme was initiated in the season

1991/92, and key environmental values were identified for Wasa, Svea and the surrounding areas. These values include:

- Flora
- Fauna
- Freshwater environment
- Soil
- Air
- Wilderness
- Aesthetic values

To be able to identify the impacts the monitoring programme includes snow-/ground sampling, bird inventory, lichen studies and freshwater/drinking water quality. The programme also includes environmental management systems for the research stations.
The main focus for the monitoring programme is pollution levels in snow/ice/soil, studies of microfauna/lichen/mosses and the whole station area.
So far the results from the monitoring programme have shown that the impacts from human activities are considered to be minor, or less than minor. The only exception is the station footprint area. More facilities have been added to the research station Wasa and as a result the footprint area has increased. Another significant impact comes from fuel spillage, however they are in small and well-defined areas. [Polar]

2.5 Geographical Information Systems

GIS is short for "Geographical Information Systems", the most common definition is one provided by the National Centre of Geographic Information and Analysis "*a GIS is a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modelling, representation and display of georeferenced data to solve complex problems regarding planning and management of resources*"
GIS is an essential tool for resource planning and management. The capacity to store, retrieve, analyse, model and map large areas with large volumes of spatial data and associated attributes makes it ideal for displaying geographical-referenced information. A GIS allows the user to analyse the spatial information, edit data and maps and present the results. GIS is used in a wide field of applications, it is used for ecosystem modelling, landscape assessment/planning, transportation/infrastructure planning and visual impact analysis among others. [University of Melbourne]

The strength of a GIS comes from the ability to create interactive queries, to relate different information in a spatial context and to reach a conclusion about this relationship. In a GIS the storage and the presentation of data are separated. New information could be created and presented in different ways to suit special purposes. The information consists in one or several different separated layers, which contains a geographic reference such as latitude, longitude and possibly elevation so they could be linked together. [ERG]
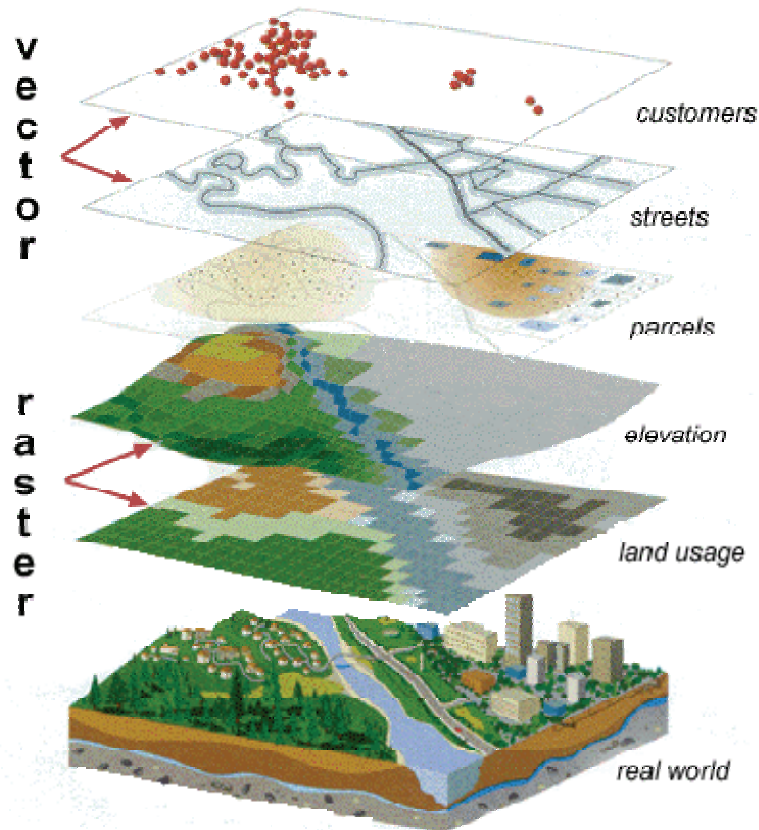
Figur 2.4 GIS layers [ESRI]

Each layer consists of one type of information, and together they form a database with information that could answer the questions *what, where, when* as well as *how much*. This makes GIS a good tool for different kinds of analyses, for instance the consequences of some kind of toxic discharge to water and air could be assessed and a suitable action plan could be prepared.

2.5.1 Data representation

Two methods are used to represent geographic data in digital form, raster and vector.
In raster representation, the world is divided into arrays of cells and then a value is assigned to each cell. When information is represented in raster form all detail about variation within the cell is lost, and instead the cell is given a single value. This could be done in several ways, some of the most common approaches are that the cell gets the same value as the largest share of the cell's area, another way is that the cell gets assigned the same value as the central point of the cell. [Lonely, P (2001)]
In vector representation, all lines are captured as a series of points, coordinate pairs, connected by straight lines. To represent a straight line at least two coordinates are needed, to represent a curved line several more coordinates are required. [Eklundh, L (2001)]

When modelling the world for representation in a GIS, entities of the same geometric type for example points, lines or polygons are grouped together. A collection of entities of the same geometric type is referred to as a class or layer. Each layer is a distinct dataset and is more or less equivalent to a legend item on a paper map. [Lonely, P (2001)]

2.5.2 Software

ESRI Sweden is specialized in software for a more efficient way of handling spatial information. The company is the Swedish distributor of software from ESRI Inc. ESRI designs and develops the world's leading GIS technology. [ESRI Sweden]

ArcGIS is an integrated collection of GIS software products for building a complete GIS. ArcGIS enables the users to organize GIS functionality where it is needed. The software is divided into four groups. Desktop GIS, Server GIS, Mobile GIS and Hosted GIS. Desktop GIS was selected since it provides a collection of different software products that fulfils the desires of the Swedish Polar Research Secretariat. [ESRI]

For this project ArcView 9.2 was chosen, it is full-featured GIS software for visualising, analysing, creating, and managing data with a geographic relation. With ArcView it is possible to visualise, explore, and analyse data, revealing patterns, relationships, and trends that are not readily apparent in databases, spreadsheets, or statistical packages. [ESRI]

2.5.3 Antarctic Digital Database (ADD)

ADD is an Antarctic topographic database that is compiled from a variety of Antarctic maps and satellite image sources. It is a digital map of the Antarctic based on the most appropriate map sources available. The data is provided by various nations and the database is maintained by the British Antarctic Survey, BAS, for SCAR. [ADD]

All data provided in the ADD are projected into the Polar Stereographic projection, with standard latitude of 71°S, and a central meridian of 0°. The coordinates are in metres with the origin at the South Pole and the spheroid used is WGS84. [ADD]

3 Method

This chapter describes the working process and discussions about the collection of data as well as methodology.

3.1 Working process

The project has followed an hourglass model according to Figure 3.1. It starts with a wide description of the background to the project, then the area becomes narrower as the aim and delimitations are set. Finally the area expands again so the analysis and discussion could be seen in a lager perspective.
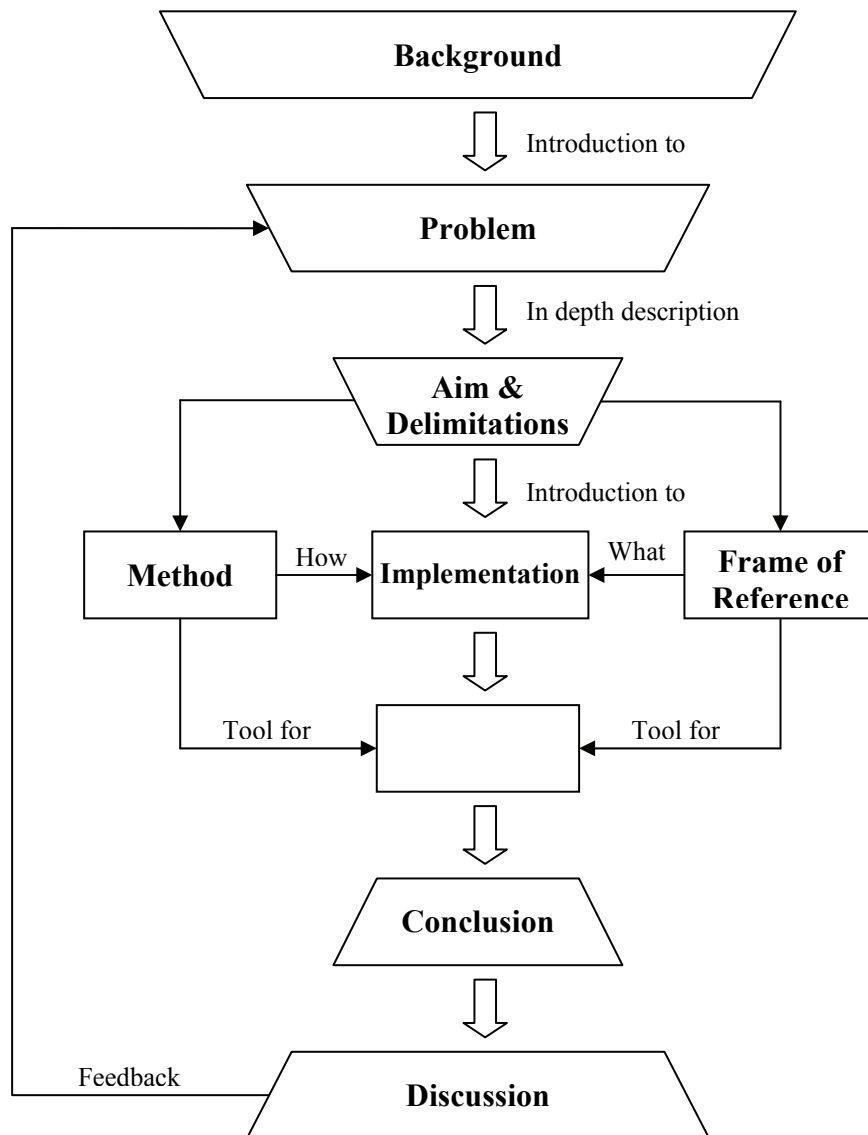

Figure 3.1 Working process (freely interpreted from Davidson)

3.1.1 Procedure

The main part of the project is to produce a geodatabase that will provide a platform for future GIS-applications used by the Swedish Polar Research Secretariat. The process to obtain a well functioning GIS from partly incoherent data demands a procedure that is methodical and well planned with regard to selected software and the implementation of data.
The project has been divided into three parts, project planning, project development and project analysis. Every part of the process is summarized in Figure 3.2 and is described in further detail below.
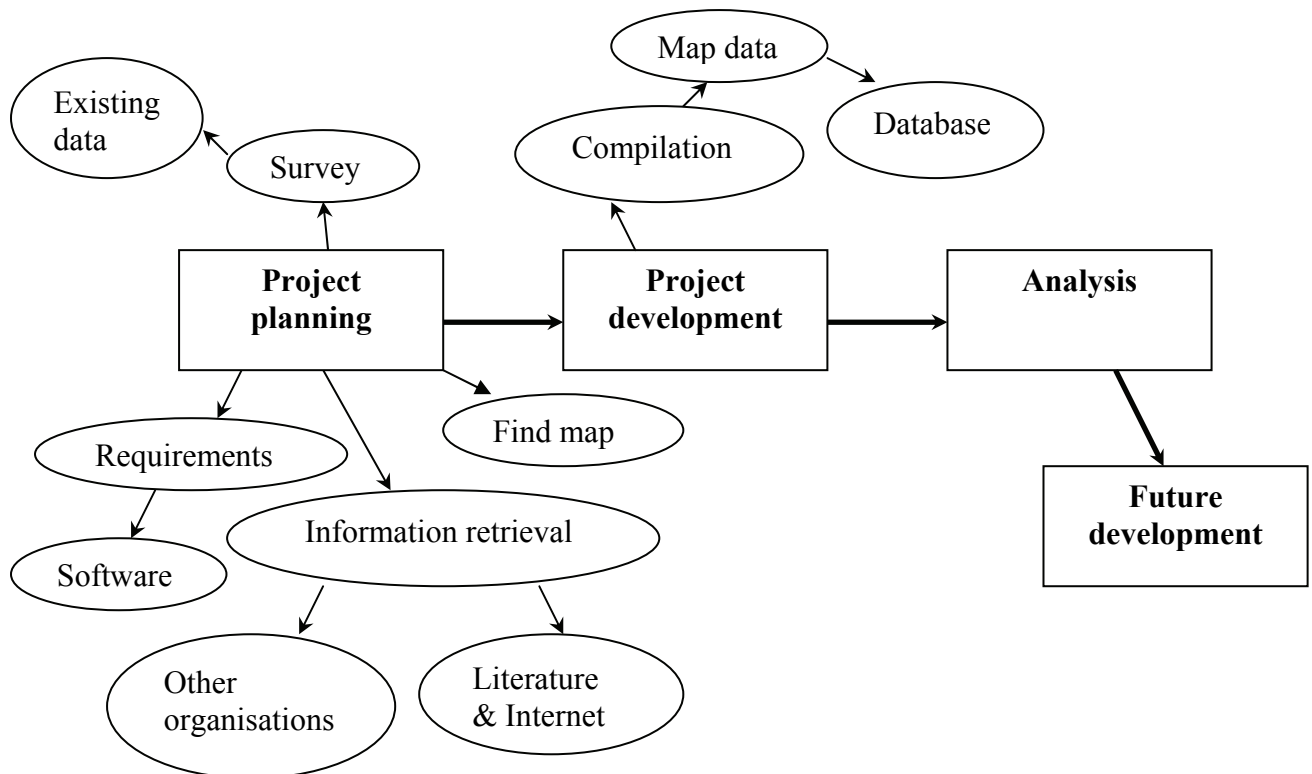
Figure 3.2 Working procedure

The first part, project planning, consisted of a survey of the environmental monitoring programme. All environmental data has been reviewed and appropriate software has been chosen with regard to the requirements of the Swedish Polar Research Secretariat. Information about GIS and other information needed for the project have been sought after on the Internet, in literature & manuals and in reports covering the topic.

The second part, project development, was to provide a basemap over the area and compile the information in a geographical database. In order to find suitable maps and other information about database structures was queries sent to other organizations.

During the last part an analysis was performed of the implementation in order to be able to evaluate the project and give recommendations about further developments.

3.2 Data collection

The collection of data could be divided into two categories. Data is collected either from primary sources or secondary sources. Primary sources are according to Olsson & Sörensen (2001) information that has been gathered in an accepted scientific way, such as information gathered directly from the source by for example an interview. Information from secondary sources is data that has already been collected by someone else usually for another purpose.

3.2.1 Primary sources

Information from primary sources was received by correspondence with appropriate persons concerned or involved in organizations concerning Antarctica.
Data available at the ADD-website is developed as an aid for monitoring purposes, hence it could be seen as a primary source.

Knowledge and understanding of the programme ArcView was received through practical use of the programme. Comprehension of the map data was received through practical use of the data in ArcView.

3.2.2 Secondary sources

The information behind the theories used in the project is derived from Internet and literature.

Information about geographical databases and ArcView has been achieved by studying different educational materials, manuals and the system itself.

3.3 Criticism of the sources

The results are dependent on the gathered information. To get reliable results the study must be conducted in a certain way. The chosen method is decisive for a study's validity and reliability. A discussion about the projects validity and reliability will be presented below.

3.3.1 Validity

Validity is according to Eriksson & Wiedersheim-Paul (2001) a methods ability to measure what is intended to be measured, i.e. to measure the correct thing. Information from primary sources was verified to avoid misinterpretation. Information from secondary sources is collected from the latest possible reference in order for the information to be updated.

Internet sources have been used to get as much information as possible about GIS and geographical databases. The collected information is technical facts and therefore hard to distort.

Good maps suitable for GIS-applications may be hard to find, good detailed maps over Antarctica are even rarer so most maps are made based on assumptions. Data from the ADD-website is derived from maps from different counties made in diverse scales and accuracy, therefore some approximations have been used in order to put them together.

3.3.2 Reliability

According to Olsson & Sörensen (2001) is reliability the congruence between different measurements performed in the same way. The same result should be derived if a different person carried out the same study using the same methods.

Information about GIS is to be considered as facts and hence not affected by someone's personal gain. The same is with information on how to design a geographical database. However there is not one single solution on how to design a geographical database. Therefore a suitable solution should be sought after.

Other information that has been found on the Internet is derived from official interest organizations in order to increase the reliability. In order to secure the information, numerous sources have been compared.

A consideration about information derived from contacts with other people is that the information is based on the values of that person and is limited to what that person knows. Therefore the suggested solution may not be the best possible but it is nonetheless valuable. The same is with information from ESRI since they are a selling organisation and as a result has an interest in selling their solution. Therefore has information from ESRI been viewed upon critically to achieve a high reliability.

4 Implementation

This chapter discusses how the project has been implemented in order to achieve the aim and objectives of the project.

4.1 Project planning

4.1.1 Survey

In order to get a general idea about the quality of the existing information from the environmental monitoring programme, a survey was performed. The information from the environmental monitoring programme that is available at the Swedish Polar Research Secretariat is available either in handwritten form on old non-reliable paper maps or as plain text in reports. The survey showed that much information that has been collected over the years is sill with the scientist that collected the data. It would require much time and effort to locate all the scientists and ask for it, moreover, the data available at the Swedish Polar Research Secretariat is not adequate to be presented in a GIS at its present form. Therefore the aim and objectives were changed.

4.1.2 Information retrieval

Information about the different parts of the project has been sought after on the Internet, in literature and in reports that cover the topic. Contact by mail has also been made to appropriate persons in different organizations concerning Antarctica and Geographical Information Systems.
A query was sent to the Norwegian Polar Institute in order to find information about suitable basemaps that could be used in a GIS. Queries were also sent to other organizations asking about how they perform their environmental monitoring and suggestions on how to build the database structure.
However the only answers that were obtained were concerning the basemap, no answers about how other countries have done regarding their monitoring was received.

4.1.3 Choice of Software

ESRI designs and develops the world's leading GIS technology, ESRI S-GROUP is the Scandinavian equivalent and the software was chosen after consultation with the responsible person for county administration. ArcGIS ArcView was chosen with the regard to the desires of the Swedish Polar Research Secretariat. One major factor in deciding on a programme from ESRI was that they have numerous ways of support. They administer courses covering several topics for beginners up to advance users. They also supply self-study courses in a virtual campus and they have a huge support administration. In addition they have much web based help available for free. Furthermore they have published numerous books on different subjects regarding Geographical Information Systems.

4.2 Project development

4.2.1 Map data

The map data from the ADD-website are available in several ways, either by downloading the data and store it locally or access it from the new experimental website by connecting to Internet Web Services using a Web Map Service, WMS, or a Web Feature Service, WFS.

The map data available for download are available in ArcInfo files, e00, witch is an interchange data format also known as an export file, which is developed to enable users to move data into and out of ArcInfo. The data is best suited for use with ArcInfo, ArcView and ArcExplorer.

The map over Antarctica is divided into smaller sections, IMW sheets, available for download. They are arranged in alphanumeric order, where the outermost sections are numbered beginning with SP, farther in they are arranged in the consequential order SQ to SW in the middle.
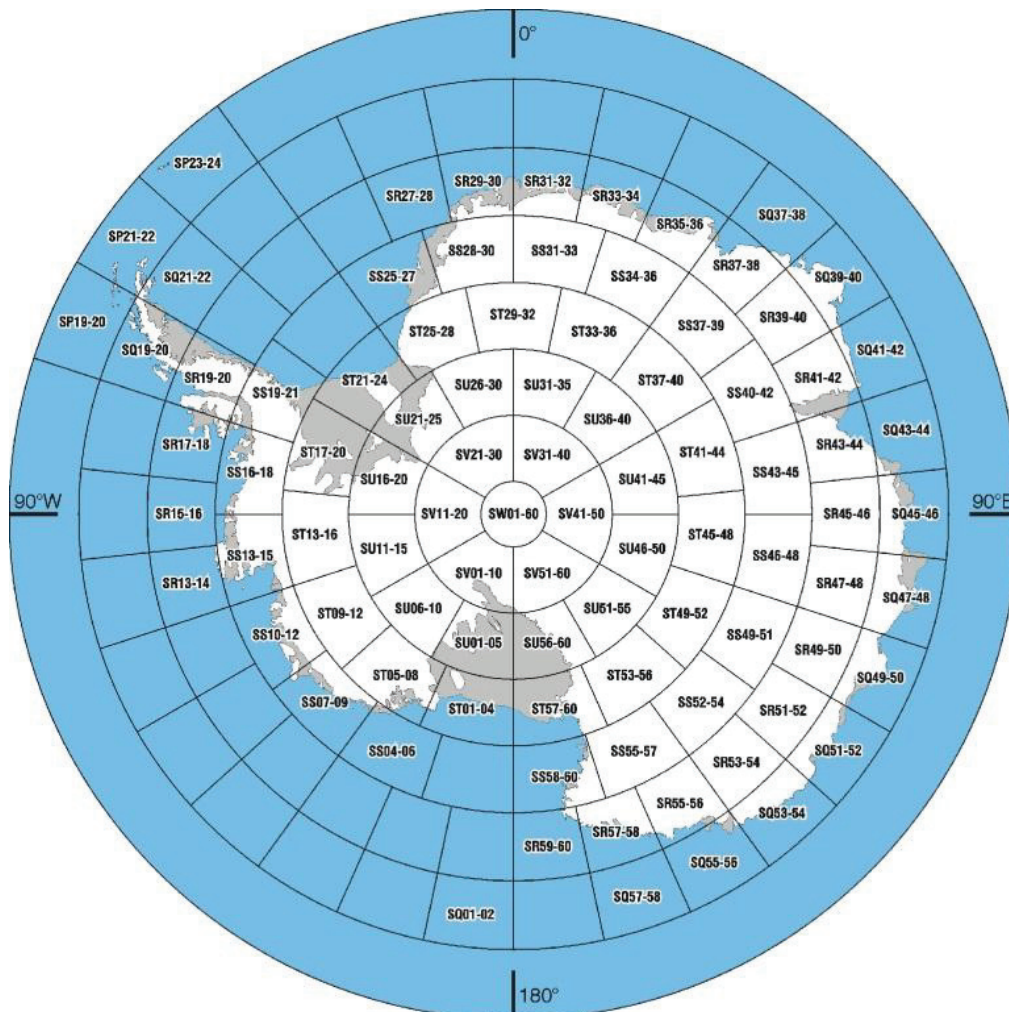

Figure 4.1 IMW-sheets [ADD]

By using the Internet Web Services the ADD data remains on the servers at BAS and are delivered directly over the Internet and could be added as a layer in ArcView. The difference between the WMS and the WFS is that the WMS provides a map and no attribute data but on the other hand it is relatively fast. The WFS provides the attribute data but is quite a bit slower.

The advantage of the Internet-based approach is that there is no need to manage the data locally providing a potentially significant savings of time including the time spent to update the data. The disadvantage is that the system is dependent upon an external service.

Due to difficulties to connect to the Internet Web Services the option to download the data and store it locally was selected.

4.2.2 Overview of the geodatabase

In ArcGIS is geographic information managed in geodatabases. The geodatabase is the native data structure for ArcGIS and is the primary data format used for editing and data management. The geodatabase is a collection of geographic datasets of various types held in a common file system folder, a Microsoft Access database, or a multi-user relational database. The primary dataset types are: feature classes, raster data and attribute tables. [ESRI]

4.2.3 Types of geodatabases

There are three types of geodatabases namely:
- File geodatabases where the datasets are stored as folders in a file system. Each dataset is held as a file that can scale up to 1 TB in size. The file geodatabase is recommended by ESRI over personal geodatabases.
- Personal geodatabases where all datasets are stored in a Microsoft Access data file which is limited to 2 GB in size.
- ArcSDE geodatabases where the datasets are stored in a relational database using Oracle, Microsoft SQL Server, IBM DB2, or IBM Informix. The geodatabases can be unlimited in size and numbers of users.

The file geodatabase is a new geodatabase type released in ArcGIS version 9.2. The database can be created with ArcView, ArcEditor and ArcInfo. It can be used by a single editor and multiple readers i.e. one editor per dataset at one time. It is therefore possible to have more than one editor providing they are editing in different datasets. There is no limit on the geodatabase size, however each dataset can scale up to 1 TB but this limit cold be extended to 256 TB if needed. The file geodatabase provides a portable geodatabase that works across operating systems and the data structure is optimised for performing and storage. It only use about one third of the feature geometry storage required by shapefiles and personal geodatabases. Since vector data can be compressed into a read-only format the storage requirements cold be reduced even further. [ESRI]

Personal geodatabases are the original geodatabase format, it uses the Microsoft Access data file structure and are designed for a single user working with smaller datasets. The geodatabase is limited to 2 GB. However the effective database is much smaller, in reality it should be between 250 and 500 MB since otherwise the database performance starts to slow down. Personal geodatabases are only supported on the Microsoft Windows operating system. [ESRI]
However, it is common that the users has access to multiple file or personal geodatabases for their data collections and access these simultaneously for their GIS-work.

ArcSDE geodatabase requires the use of ArcSDE technology, which is an integrated part of ArcGIS Server. It is a multi-user geodatabase that is stored in relational database management systems, RDBMSs that can be edited and used simultaneously by many users. [ESRI]

4.2.4 Compilation

ArcGIS consists of a number of programmes and extra programmes are available for additional costs. For this project ArcCatalog and ArcMap is used.
The map data was downloaded from the ADD-website. The IMW-sheets that covers Dronning Maud land was used. Since the data is available as export files they had to be converted to a

suitable format for further handling. The export files were firstly converted to coverage files, which can further be converted into Shape files.

A file geodatabase structure was chosen for the development of the project. Firstly a workspace called Antarctica was created for the database, the database was then named Antarctica database and consists of a number of feature datasets, one for each IMW-sheet that has been used. The feature datasets have been named accordingly to the IMW-sheets for an easy identification.
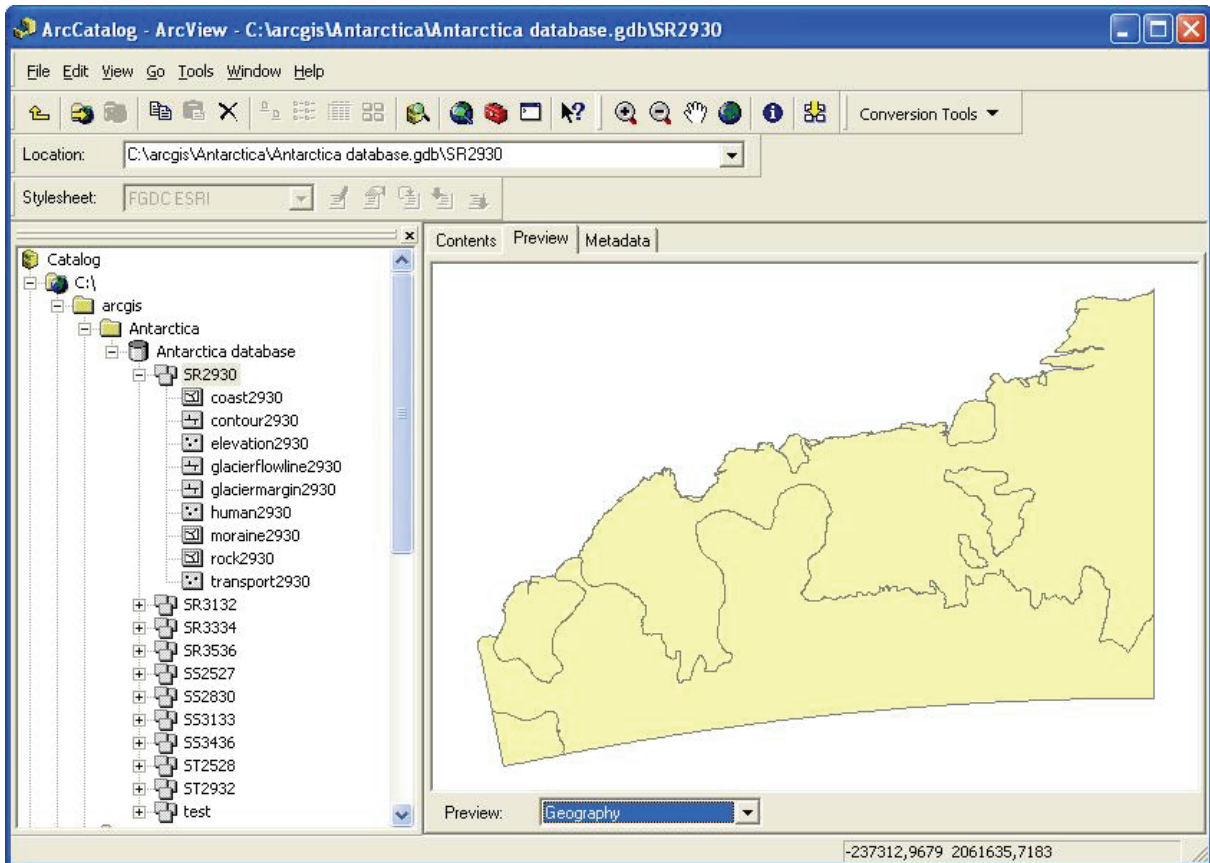

Figure 4.2 Database structure in ArcCatalog

The structure of a feature datasets could either be created or imported from another dataset. Since no former feature dataset existed a new one was created and used as a template. For the coordinate system was Projected Coordinate System, South Pole Stereographic, World WGS1984 chosen. The coverage file can be imported into a feature dataset directly without being converted into a shape file first. However a coverage file can only be presented visually in ArcMap but is not editable. The shape file on the other hand could both be presented visually and it is editable in ArcMap. The data at the ADD-website contains much information, each IMW-sheet is subdivided into feature layers which can be downloaded separately.

The feature layers are:

- Cliff
- Coast
- Contour
- Elevation
- Fauna
- Flowline
- Glacier margin
- Human
- Ice dome
- Lakes
- Moraine
- Rock
- Streams
- Traverse

This structure made it easy to implement the data into the feature datasets.
The layer Human contains all point data relation to human activity; aerodromes, radio masts, scientific stations, buildings, oil tanks, water tanks, automatic weather stations, Historic Monuments and Sites of Special Interest.
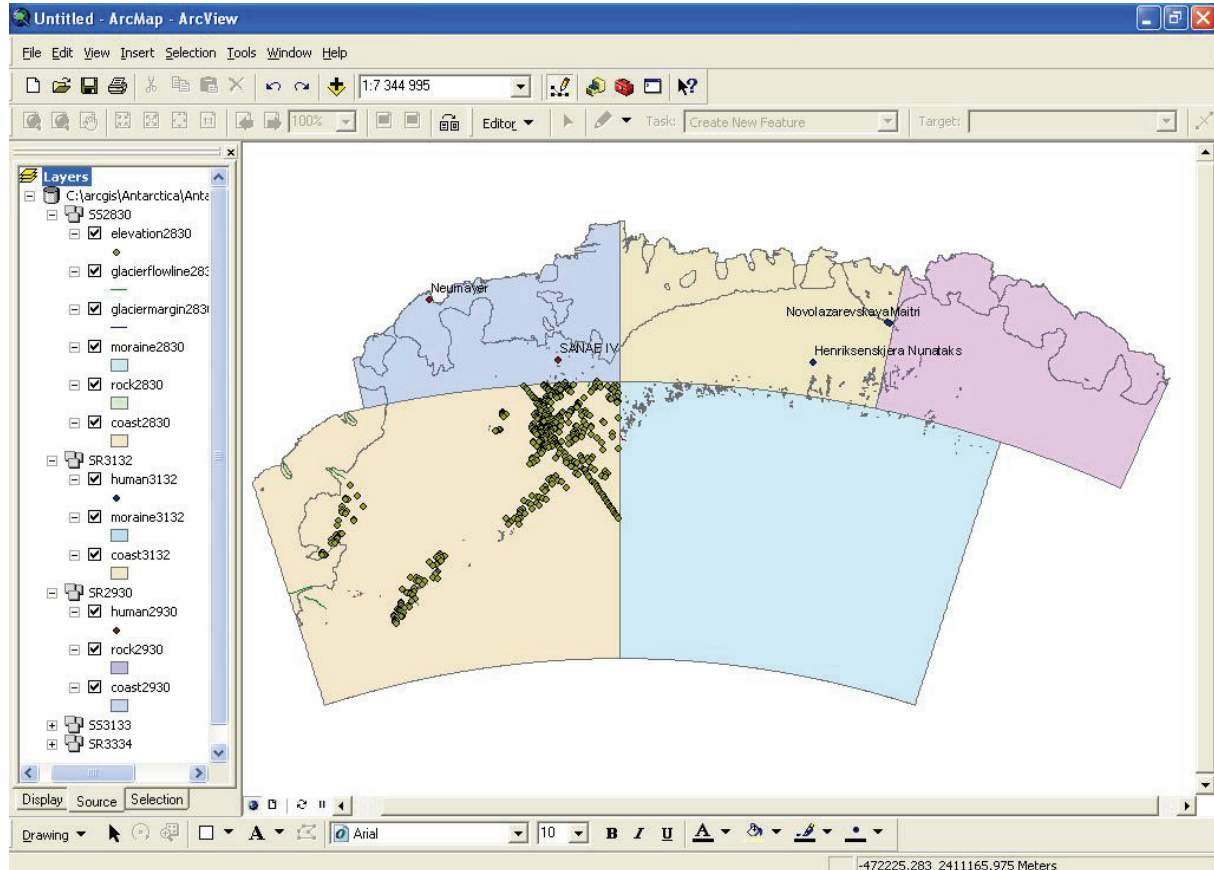

Figure 4.3 Map view of layers in ArcMap

The Swedish research Station Wasa and the Finish research Station Aboa is located at the IMW-Sheet SS28-30. However when examined more thorough it was noticed that the coordinates for the stations where wrong. This has probably to do with the fact that the coordinates were derived from very crude maps in 1999. Also the Swedish research Station Svea was missing. To change the coordinates and add a third station proved to be a lot of trouble. At first Svea could not be added to the right IMW-sheet, probably due to some mishap with the reference points. Then there was some trouble when changing the coordinates of Wasa and Aboa. The coordinates are changed, but the changes do not take affect for some reason. As of now Svea has finally been successfully added at the right place without loosing the reference points but Wasa and Aboa is still at their original place even if the coordinates have been changed. One reason for this could be that ArcView is installed instead of ArcInfo. However this solution has not been tested and is only a theory.
An additional attempt to solve the problem could be to delete the old information completely and then add it again to see if the changes take place.

5 Analysis

In this chapter an analysis is presented on how the project has proceeded.

5.1 Initiate a GIS

When a new system is introduced, it is important that all parties concerned are involved in the process. It is also important to know why the system is being implemented and how it functions. Otherwise there is a chance that the system not will be used at all or used to its full potential.

GIS is one of the key tools in the environmental data framework. It can serve as the ultimate communication form for environmental information since it is can be used for data retrieval, and distribution as well as analysis. Moreover, with growing concern for spatial data standards, the next generation of GIS technology and the use of Internet, all types of users can access the environmental information in its proper spatial context.

GIS is also a powerful tool for environmental data analysis and planning. A digital basemap can be overlaid with data or other layers of information in order to view spatial information and relationships. There are basically six tasks performed in a GIS, namely input, manipulation, management, query/analysis, visualisation and output. GIS provides both simple point to click query capabilities and more sophisticated analysis tool to provide information. GIS technology is a really good tool when used to analyse geographic data such as looking for patterns and trends and to undertake "what if" scenarios since the outcome from an event can be analysed by exploring different environmental conditions. Therefore GIS is not only useful for analyses of present environmental scenarios, it can be used for future environmental studies as well.
The result can be visualised on a map or in a graph or some other output, the map can be displayed as a tree-dimensional view or be integrated in a report for example.

One potential problem that may occur is with identification in data distribution and retrieval, however this should not be a huge problem since all data should be associated with meta-data that provides detailed information about the origin of the data such as who collected the data and if it was for scientific research or as part of a monitoring programme.

GIS is a perfect tool to use for the Swedish Polar Research Secretariat for environmental monitoring purposes. Other areas where GIS is commonly used as a foundation for planning decisions are in environmental planning, ground water contamination, fresh water/saltwater interface, water quality, solid waste/waste water management and air/water pollution.

5.2 Project analysis

The redefining of the aim and objectives were successful and it resulted in a better-adapted extent. Even if the survey showed that the existing data was not adequate to be used in a GIS at the moment, the problems with the data has been discovered and improvements in the collection and handling phase has been identified. Thus the monitoring data should be useable in a GIS in the future as was the intention.

There has been a series of inconveniences during the course of the project. GIS is a new area for me so I have spent much time reading literature about the subject and the software

manuals. Therefore, when a problem have arise there has been some trouble to know what to do so some things have taken longer time for me to implement compared to a practiced GIS-user.

Another problem has also been was the inadequate monitoring data, and as a result the whole project had to change its aim. It is hard to find good quality data or examples of how other nations have implemented their environmental monitoring programmes. There is a lot of information about Antarctica and data available for download at numerous websites, however the data is not easy accessible, usually a password is required and the websites are not very user friendly in finding what is sought after.

For now the database only consists of data from the ADD-website, however this is a relatively small problem when the new and improved monitoring programme is introduced. Moreover, during the course of this project there has been some trouble to access the data from the ADD experimental website. Firstly there was some trouble to log in to the website, then the server was down for quite some time.

Furthermore, ESRI Shape files are not yet available for the WFS and it has not been possible to download data from the wanted area in other file formats suitable for ArcView either, due to internal server error. Moreover, the WMS is not possible to connect to ArcCatalog for some reason. Therefore only the option to download the map data has been tried and no other option has been evaluated.

6 Conclusions

This chapter contains a discussion about the situation today and the situation in Sweden as well as recommendations for future development of the environmental monitoring programme.

6.1 Discussion

The insufficient data available at the Swedish Polar Research Secretariat proves that some kind of data policy in required. As of now there is no clear understanding of who owns the data. Is it the scientist's or does it belong to the monitoring programme? Some of the data is still in the hands of the researcher who performed the study and there is no time limit from the end of the study to when the results should be handed back to the Swedish Polar Research Secretariat. With a data policy that clearly defines when the results should be handed back to the Swedish Polar Research Secretariat and how the data could be used, new insights could be gained when many people can get hold of data that previously has been excluded. This is also along the lines of the Antarctic Treaty that in Article III states, *"scientific observations and results from Antarctica shall be exchanged and made freely available."*

6.2 Situation today

It is widely agreed among nations that Antarctica is a place devoted to peace and science and it is therefore agreed to protect and conserve the unique environments for future generations as well. As a result the same nations have decided that environmental monitoring in Antarctica is an essential part of the environmental management. A number of national environmental monitoring programmes have been developed and conducted for local assessments of the impacts from human activities. Yet there has been little coordination of methodologies, study designs or data interpretations.

Much information is already collected each year such as fuel consumption for the different nations, but it is never compiled and presented. Much of the monitoring on Antarctica is performed due to legislation, but the interest is probably not larger than what is needed according to the legislation. Many small actors in Antarctica think that their impacts is so small that it is insignificant compared to larger nations, but combined they will have a large impact as well. The financial factor is also a contribution to the lack of interest. There are some costs involved in introducing and implementing new measures and programmes. Another major question is who will take responsibility for the compilation of all nations monitoring programmes, how much will that cost and is anyone willing to pay that price? One nation that has contributed much information is the Australian Government Antarctic Division that leads Australia's Antarctic Programme. They have an informative website and the possibility to download metadata. Their focus is the Australian Antarctic Territory and the Territory of Heard Island and McDonald Islands so the information has not been used for this project, however this may be a good approach for sharing data. [AAD]

With coordinated standardized approaches to environmental monitoring, sharing of experiences and findings from the monitoring amongst Antarctic operators will maximise the return from invested resources. An international coordination of monitoring programmes will significantly contribute to the management of human activities in Antarctica. Still there are some difficulties that have to be solved before an international collaboration of monitoring programmes is viable.

6.2.1 In Sweden

Today an Environmental Impact Assessment, EIA, needs to be performed in order to assess possible impacts before every expedition to Antarctica and environmental monitoring programmes has been developed for evaluation of long-term impacts from human activities in the area. This is a good approach, in theory. First of all, the EIA is only a framework for how the assessment should be carried out and it does not take cumulative effects into account. Furthermore many contributions do not need to be included in the analysis if they could be seen as a part of another project. Thus the Swedish Polar Research Secretariat always obtains the same result every time an EIA is performed, namely "*The current EIA indicates that the environmental impacts of planned activities under DML XX/YY will be small, which is why a comprehensive environmental evaluation is considered unnecessary. Minor or transitory environmental impact is expected in the area around Wasa station, while other environmental impacts are considered to be less than minor or transitory. Therefore, from an environmental point of view there is no reason not to carry out the DML XX/YY expedition.*"

As for the environmental monitoring, both Sweden and Finland has a national monitoring programme. Since the Swedish station Wasa and the Finish station Aboa is basically at the same place it is hard to decide if the environmental impacts is derived from Swedish or Finish activity. As of now there is no collaboration between the Swedish Polar Research Secretariat and the Finnish equivalent, the Finnish Institute of Marine Research. With a joint monitoring programme or at least cooperation between the nations much time and effort will be saved since the risk of making the same measurements twice is considerable when no collaboration is taking place. The work could be divided among the nations or they could take turn of who is in charge of the monitoring. The costs will also be reduced since they could be divided as well. In this way the environmental monitoring will be much more efficient and more accurate analyses of future scenarios could be achieved.

6.3 Recommendations

The data collection is the most time consuming and resource demanding part in a GIS. The quality of the input data is decisive to the reliability of the results, hence there is every reason to be thorough and utilize much time and effort for data collection and compilation.
One requirement for input data in a GIS is that there needs to be some sort of geographic connection, such as coordinates, to be able to use the information correctly. The input data required for a GIS useable for the Swedish Polar Research Secretariat is basically:

- List of human impacts
- A geographical point of reference for the places where the human impacts are visible
- A digital background map useable for orientation.

With a number of changes in the existing environmental monitoring programme, the results could be visualised using a GIS. It could also be used as intended as a tool to provide decision-makers with sound scientific information from which environmental management decisions are made.

6.3.1 Monitoring programme

Monitoring of the impacts from activates in Antarctica is a fundamental part of environmental management. Some guidelines for developing and designing an environmental monitoring programme have been developed by AEON for COMNAP. The objective for the guidelines is to provide practical advice to national Antarctic operators in developing and designing

environmental programmes. The guidelines have no mandatory status and are available for use by national Antarctic programmes at their own discretion.

The guidelines consist of a tree-step approach to design and develop en environmental monitoring programme in Antarctica. [COMNAP]

1. Scoping the Monitoring Programme
   - **Setting objectives**
   - Undertaking background research
   - *Allocating resources*
   - Baseline monitoring

2. Defining the Monitoring Programme
   - Deciding what to monitor
   - **Sampling methods and statistical design**
   - Consultation

3. Implementing the Monitoring Programme
   - Undertaking a Pilot project
   - Collecting Baseline data
   - **Data handling**
   - **Report and publishing**
   - **Programme review**

Since there already is a monitoring programme in place there is no need to design a complete new one, however there is no documentation about the environmental monitoring programme or how the monitoring should be carried out so the existing monitoring programme could use a revision. Parts of the above suggestions have been performed therefore much of the already collected environmental data should be suitable for usage.

6.3.1.1 Scoping the Monitoring Programme

The first part of the guidelines is the scope of the Monitoring Programme. Most of the tasks are more or less fulfilled but the first step for the new and improved environmental monitoring programme should be to set the objectives. If there is no clearer understanding on why the monitoring is taking place the results will be thereafter. These objectives should be meaningful, achievable and concise, and they need to identify what is to be achieved and over what time period.

As of now, an EIA is performed before each expedition in order to identify the likely influence an expedition may have on the environment. This is a good start but it will give a false impression since many factors may be excluded from the assessment. Besides it could be interesting to follow up the interpreted impacts from the EIA in the monitoring programme.

It is also worth noting that some improvements in allocating resources could be done. Some of the suggestions in the guidelines from COMNAP are:
- A programme manager to oversee the implementation of the monitoring programme
- The availability of expert scientist to take responsibility for sample collection and analysis
- Collaborative opportunities with other national Antarctic operators and/or researchers

Most of the above suggestions are fulfilled but they could be developed further. There is a programme manager responsible for the whole monitoring programme, but there could be a second temporary person responsible during an expedition. For instance, one person from the Swedish Polar Research Secretariat that is responsible for that the actual data is collected mainly for monitoring purposes instead of for some scientist's personal desires.
Another major improvement would be to collaborate with Finland and maybe make a joint monitoring programme.

6.3.1.2 Defining the Monitoring Programme

The second part of the guidelines is to define the Monitoring Programme. Key environmental values have already been identified but the sampling methods could use an update. It is important to ensure that the sampling methods and statistical design follow recognised scientific procedures. The technical requirements needed to measure the key environmental values could be found in the COMNAP Technical Handbook. However since there is a scientist who will perform the collection, it will be done in a scientific accepted way. Nevertheless, the Swedish Polar Research Secretariat can provide the scientist with a number of directives in order to increases the comparability with other scientists' results and over a long time period.

6.3.1.3 Implementing the Monitoring Programme

The last part of the guidelines is how to implement the monitoring programme. Since the Swedish monitoring programme has existed for some time much of the data already collected could be used as baseline data.
Given that the existing data from the Swedish monitoring programme was in less adequate form, the data handling should be the main concern in a new monitoring programme to be able to realize the goal of presenting environmental data in a GIS. The data handling consists of data collection, storage and analysis.

Today most of the data used in the monitoring programme is collected by the scientist for their research and is therefore not collected for monitoring purposes. For a successful monitoring programme the data should be collected and analysed for this reason. Data collected mainly for environmental monitoring could be used in others research as well, particularly if the scientist can use other scientists' data and combine them to make a thorough analysis of the current situation as well as possible scenarios for future and past situations as well. This can also give an incentive to the scientists' to perform the data collection as requested.
One way of mapping the monitoring area is to divide the area into squares and select one as a reference area. What to monitor and where could be decided before the expedition so the responsible person in place only have to make sure that the data is collected in the preferred place.

The guidelines also recommended that the results from environmental monitoring programmes in Antarctica should be made available to others for data comparison and knowledge sharing. This could be done by:
- Making information available via COMNAP reporting procedures and website
- Publishing on national programme websites

This has not been done so far but it will be a small but nonetheless significant contribution to the mapping of Antarctica.
Moreover, the guidelines also recommend that the monitoring programme should be reviewed periodically. If the Swedish monitoring programme ever had been critically evaluated several weaknesses had been found and the programme could have been amended sooner.
The review should focus on the three phases of the monitoring activity: data collection, data analysis and usage of the results in management decisions.

The data collection should be reviewed once the analysis has begun to ensure that the design is adequate and that the collected information meets the objectives of the monitoring programme. Furthermore, more knowledge of the area, new activates and/or new technology might bring forth changes in the objectives.

6.3.2 Further development

Further development would be to make an application as was intended at the beginning of the project, to link data with the database. As a suggestion it should be easy for the researcher to write down their data in a pre-defined table in for instance Excel that will generate a feature dataset.

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Appendices

Appendix I – Monitoring Programme

1. Scoping the Monitoring Programme
   - **Setting objectives**
   - Undertaking background research
   - *Allocating resources*
   - Baseline monitoring

2. Defining the Monitoring Programme
   - Deciding what to monitor
   - **Sampling methods and statistical design**
   - Consultation

3. Implementing the Monitoring Programme
   - Undertaking a Pilot project
   - Collecting Baseline data
   - **Data handling**
   - **Report and publishing**
   - **Programme review**

Scoping the Monitoring Programme

Setting the objectives.
The aim of the monitoring programme is to find out what the environmental impacts are on the area around the Swedish research stations during a long time period to be able to make valid analyses about possible future scenarios.
Setting a number of objectives will help fulfil this aim.
The objectives for the Swedish monitoring programme could be:
- To demonstrate compliance with the requirements of the Environmental Protocol
- To capture information that may show environmental changes/impacts around the stations that may result from station and related field activities.
- To undertake the monitoring for a period of x years before conducting a major review of the programme.
- To utilise existing equipment, station personnel and scientists as much as possible without appointing additional staff to minimize costs.
- To amend the structure and processes in the organisation to ensure monitoring information is used as a part of management decisions.

Defining the Monitoring Programme

Deciding what to monitor
The boundaries of the monitoring programme are what is intended to be monitored. In this case the key indicators have already been chosen. They are:
- Flora
- Fauna
- Freshwater environment
- Soil
- Air
- Wilderness

- Aesthetic values

Another area that would be interesting to monitor further is the total impact from the station area and make some predictions of what the impacts will be as the area expands.

Sampling methods and statistical design
In order to increase the comparability with other scientists' results a number of directives can be handed out before the data collection begins.

Implementing the Monitoring Programme

Data handling (collection, storage and analysis)
The data collected for monitoring purposes should be assessed in order to find out if the monitoring goals are being achieved. If not the data handling should be looked over. The aim and objectives for the monitoring programme may have to change when greater knowledge is achieved.

Data collection and analyses are intended to provide decision-makers with sound scientific information from which environmental management decisions are made. Therefore the programme review should consider:

- If the data and the results of the monitoring are providing managers with the information that was envisaged in the original design. If not adjustments must be made.
- Whether management's use of the data has resulted in measurable decreases in human impacts.

Reporting and publishing
The results from the monitoring programme could be published on the website. Some web-based GIS could also be used for visual presentation.

Programme review
The review should focus on three areas of the monitoring activity, data collection, data analysis and the use of the results in management decisions.

Data collection
The sampling process should be reviewed to ensure that:

- The original design of sampling location, frequency, replication and measured variables is being followed consistently. If costs, operational difficulties, changing technologies, etc. are limiting the intended design, appropriate changes must be put in place.
- The quality of the data is as originally specified.

A standardised reporting and data handling method will be important to ensure comparability of data collected from various sources.

Data analysis and use
The results from the analysis are intended to provide decision-makers with sound scientific information to facilitate decisions. The programme review should consider:
- If the data and the results of the monitoring are providing information as foreseen at the start. If not it should be adjusted.
- Whether management's use of the data has resulted in a measurable decrease in human impact.

Appendix II – Eleven steps to geodatabase design [ESRI]

Identify the information products that you will create and manage with your GIS

Your GIS database design should reflect the work of your organization. Consider compiling and maintaining an inventory of map products, analytical models, Web mapping applications, data flows, database reports, key responsibilities, 3D views, and other mission-based requirements for your organization. List the data sources you currently use in this work. Use these to drive your data design needs

Identify the key data themes based on your information requirements

Define more completely some of the key aspects of each data theme. Determine how each dataset will be used—for editing, for GIS modelling and analysis, representing your business workflows, and for mapping and 3D display. Specify the map use, the data sources, the spatial representations for each specified map scale; data accuracy and collection guidelines for each map view and 3D view; how the theme is displayed, its symbology, text labels, and annotation. Consider how each map layer will be displayed in an integrated fashion with other key layers. For modelling and analysis, consider how information will be used with other datasets (for example, how they are combined and integrated). This will help you to identify some key spatial relationships and data integrity rules. Ensure that these display and analysis properties are considered as part of your database design

Specify the scale ranges and spatial representations of each data theme at each scale

Data is compiled for use at a specific range of map scales. Associate your geographic representation for each map scale. Geographic representation will often change between map scales (for example, from polygon to line or point). In many cases, you may need to generalize the feature representations for use at smaller scales. Rasters can be resampled using image pyramids.

Decompose each representation into one or more geographic datasets

Discrete features are modelled as feature classes of points, lines, and polygons. You can consider advanced data types such as topologies, networks, and terrains to model the relationships between elements in a layer as well as across datasets.
For raster datasets, mosaics and catalog collections are options for managing very large collections.
Surfaces can be modelled using features, such as contours, as well as using rasters and terrains.

Define the tabular database structure and behavior for descriptive attributes

Identify attribute fields and column types. Tables also might include attribute domains, relationships, and subtypes. Define any valid values, attribute ranges, and classifications (for use as domains). Use subtypes to control behaviors. Identify tabular relationships and associations for relationship classes

Define the spatial behavior and integrity rules for your dataset

For features, you can add behaviour and capabilities for a number of purposes using topologies, address locators, networks, terrains, and so on. For example, use topologies to model the spatial relationships of shared geometry and to enforce integrity rules. Use address locators to support geocoding. For rasters, you can decide if you need a raster dataset or a raster catalog.

Propose a geodatabase design

Define the set of geodatabase elements you want in your design for each data theme. Study existing designs for ideas and approaches that work.

Design editing workflows and map display properties

Define the editing procedures and integrity rules (for example, all streets are split where they intersect other streets and street segments connect at endpoints). Design editing workflows that help you to meet these integrity rules for your data. Define display properties for maps and 3D views. These will be used to define map layers.

Assign responsibilities for building and maintaining each data layer

Determine who will be assigned the data maintenance work within your organization or assigned to other organizations. Understanding these roles is important. You will need to design how data conversion and transformation is used to import and export data from your partner organizations.

Build a working prototype and review and refine your design

Test your prototype design. Build a sample geodatabase copy of your proposed design using a file, personal, or ArcSDE Personal geodatabase. Build maps, run key applications, and perform editing operations to test the design's utility. Based on your prototype test results, revise and refine your design. Once you have a working schema, load a larger set of data (such as loading it into an ArcSDE geodatabase) to check out production, performance, scalability, and data management workflows. This is an important step. Settle on your design **before** you begin to populate your geodatabase.

Document your geodatabase design

Various methods can be used to describe your database design and decisions. Use drawings, map layer examples, schema diagrams, simple reports, and metadata documents.
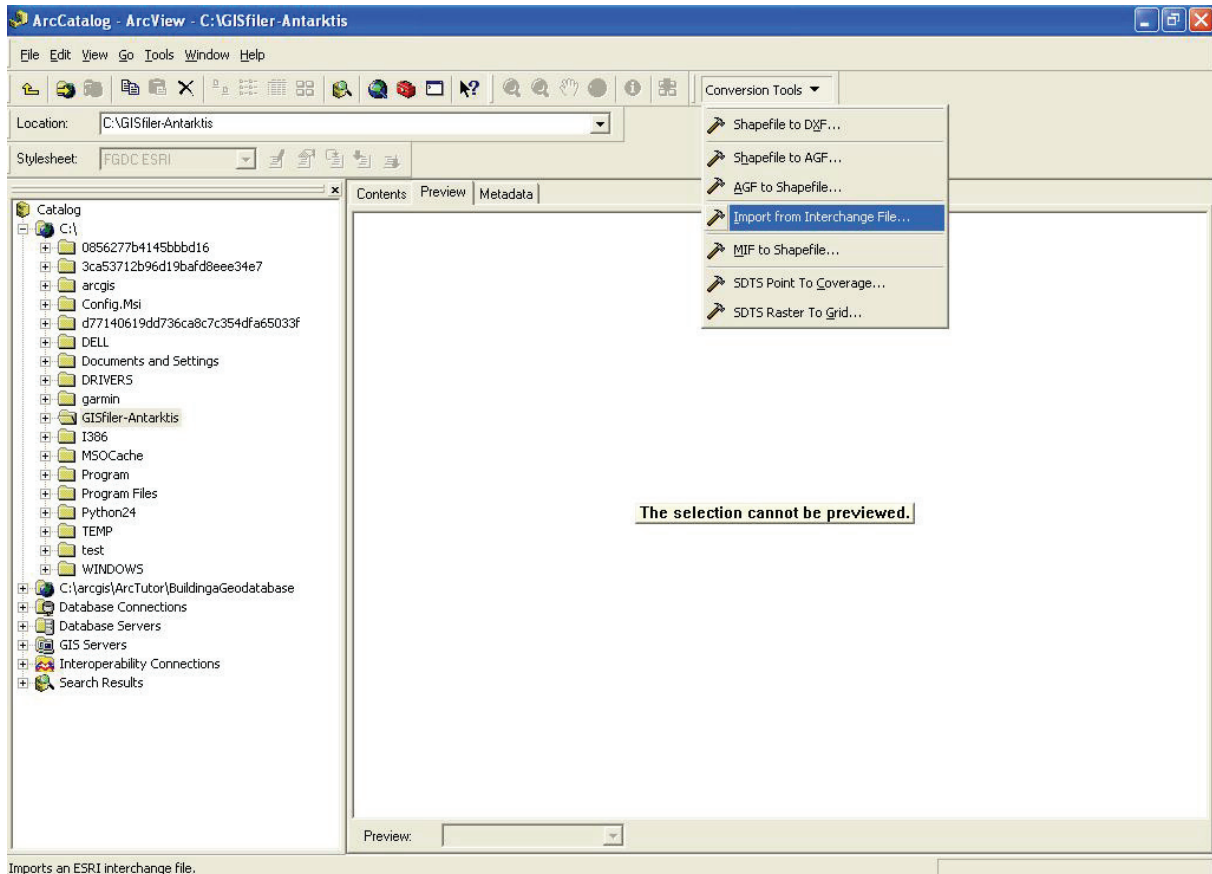Some users like using UML. However, UML is not sufficient on its own. UML cannot represent all the geographic properties and decisions to be made. Also, UML does not convey the key GIS design concepts such as thematic organization, topology rules, and network connectivity. UML provides no spatial insight into your design.
Many users like using Visio to create a graphic representation of their geodatabase schema such as those published in the ESRI data models. ESRI provides a tool that can help you capture these kinds of graphics of your data model elements using Visio.
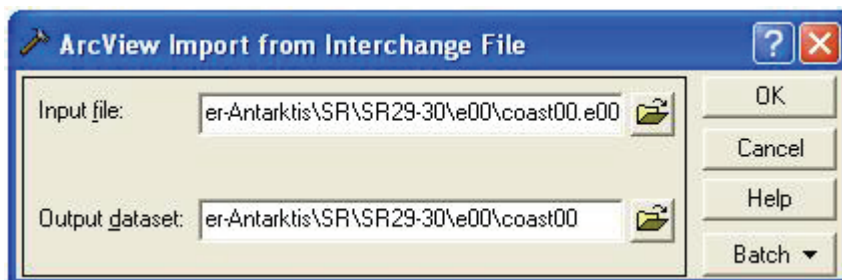
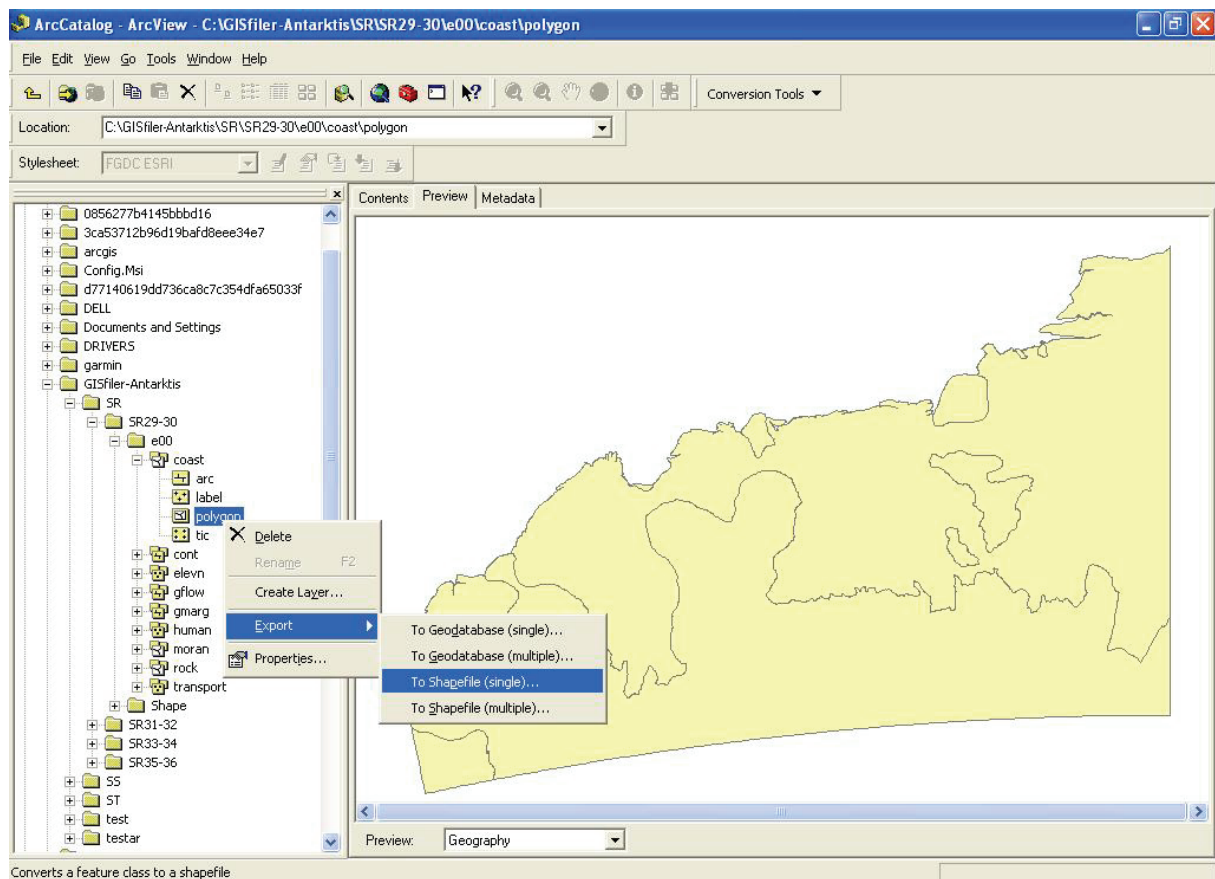## Appendix III – Importera ArcInfo interchangefiler (.e00) (Swedish only)

I ArcCatalog, välj View/Toolbars/ArcView 8.x Tools.
Välj Import from Interchange File i menyn från Conversion tools.

Välj en Input file och en Output dataset. Kan med fördel sparas i samma mapp.

I filträdet till vänster bör den importerade filen synas i "coverage" format.

Det finns flera filer att välja på, "arc" en slags outline av området, "label" en punkt, "polygon" en yta samt en fil som heter "tic" som är en slags orienteringsfil för att bilden skall hamna på rätt ställe.

Polygon är en färdig yta medans arc är en ytlinje med tillhörande label. Två olika sätt att visa samma sak men om man ska ändra på ytans form är det mycket lättare att editera en ytlinje än en yta. Så det lättaste är att editera i ytlinjen och skapa en yta när den är klar.

Härifrån är det möjligt att exportera filen till en shapefil men även till en databas.

Välj Export To Shapefile (single), välj sedan Output Location. (den mapp där den ska hamna.) Hitta på ett lämpligt namn.
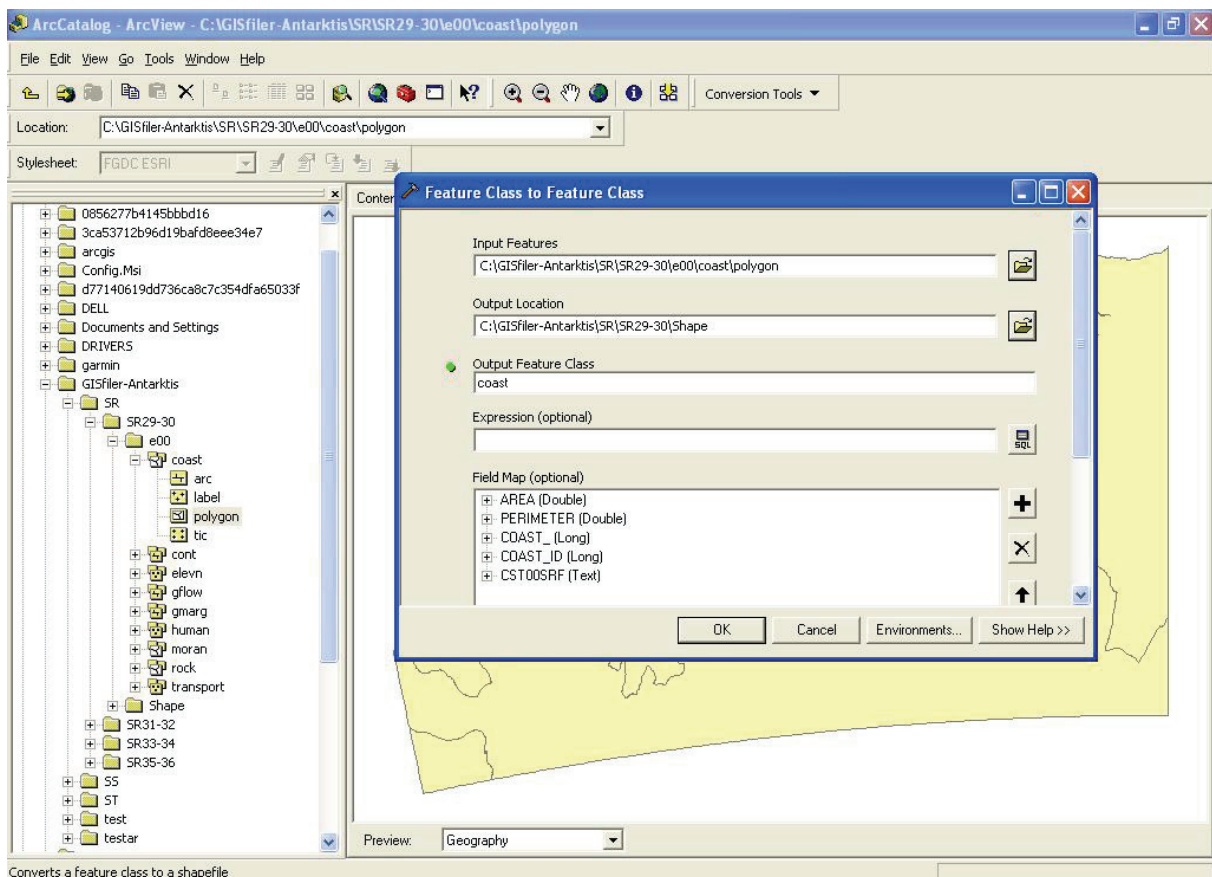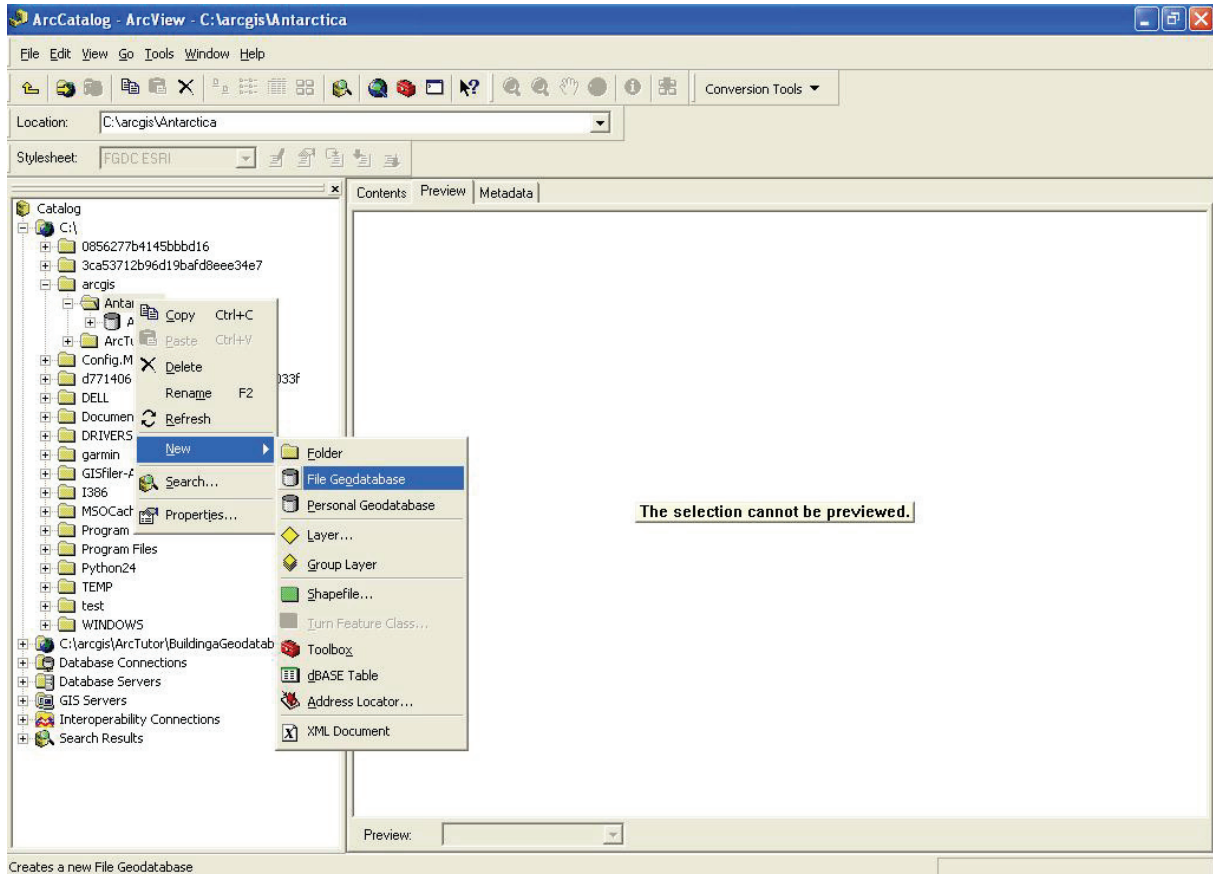
I ArcCatalog finns nu en fil som heter filnamn.shp. Om den inte syns kan man behöva trycka på "Refresh".

Öppna ArcMap

Välj att börja med en ny tom karta. Välj File/Add data. Bläddra fram till shapefilen, markera och tryck på add.

Appendix IV – Skapa en geodatabas (Swedish only)

Börja med att skapa en arbetskatalog. Skapa sedan en ny databas av lämplig typ.

Innehållet i databasen kan antingen importeras från annat håll eller genom att skapa nya
feature dataset, feature class eller table. Information kan även importeras till de nya dataseten.
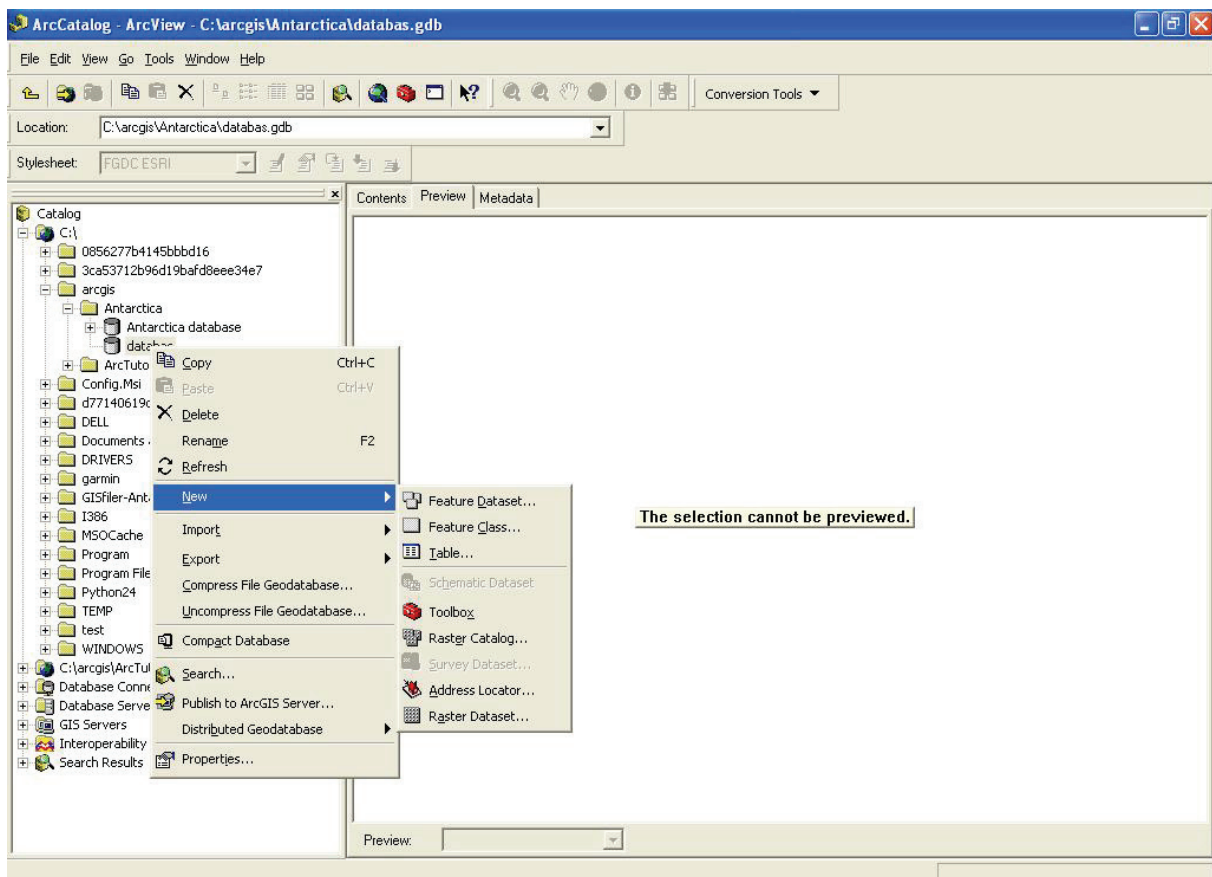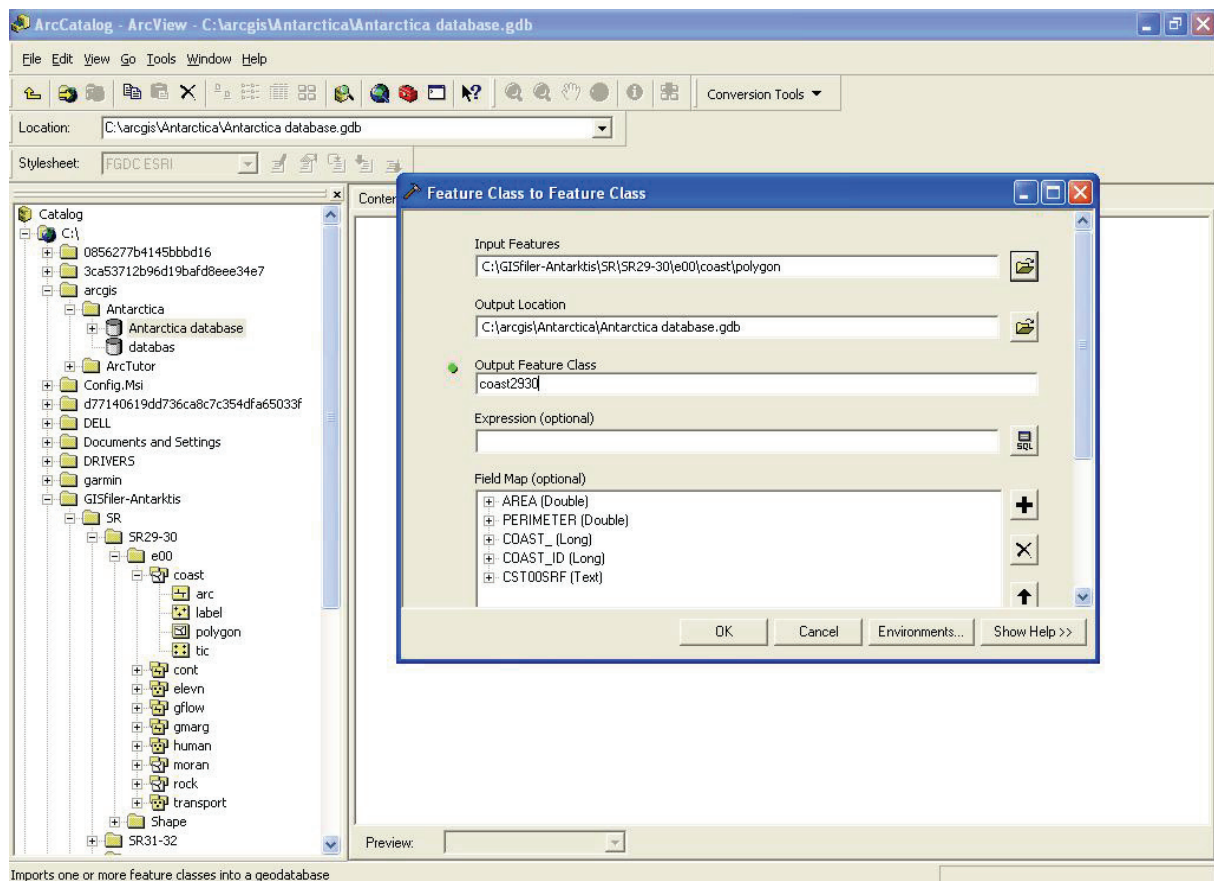
Innehållet i databasen kan antingen importeras från Shape- och coveragefiler, eller exporteras till databasen från shape- och coveragefilen.

Importera shape- eller coveragefilen till databasen.
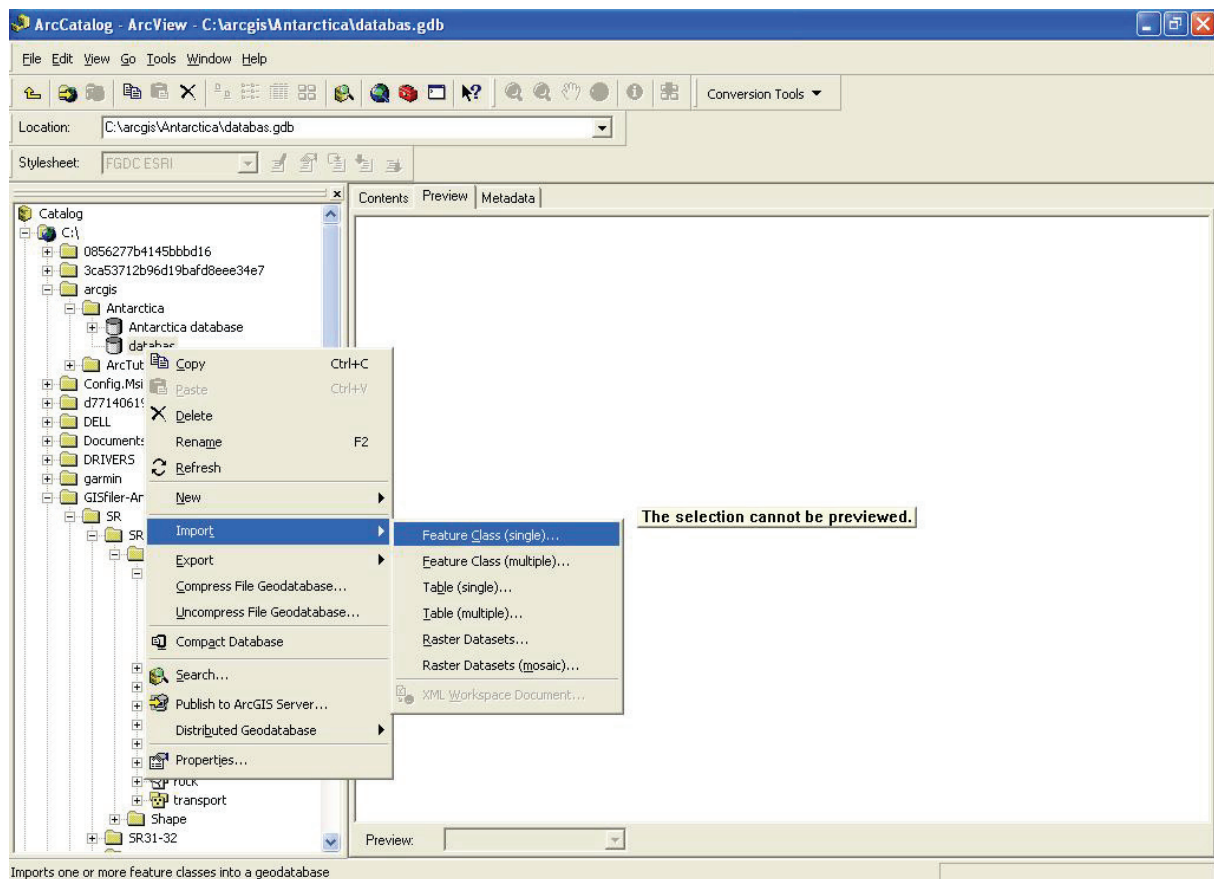
Välj Input Features, dvs. varifrån skall filen hämtas, och välj ett filnamn i Output Feature Class.

Filen kommer nu att hamna i databasen och kan adderas som ett lager i ArcMap.