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DRAFT

COMPREHENSIVE

ENVIRONMENTAL EVALUATION

(CEE)

of the proposed new SANAE IV facility at Vesleskarvet, Queen Maud Land, Antarctica

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PREFACE

When I first set foot on Antarctica I was overwhelmed by the awe inspiring nature of this great continent. My preconditioned mind, sculptured by fleeting discussions of logistics, finances and research projects of the South African National Antarctic Programme, did not quite prepare me for what I encountered. The dramatic landforms of the Ahlmannryggen painted on a vast canvas of undulating glaciers evoked mixed emotions of serenity, majesty, desolation and peace. On the one hand I felt that it was impossible for man to impact on such greatness, but on the other hand it seemed like a crime even to be in such a pristine place. This inner conflict remained within me for a long time until I finally came to terms with, what I believe, is the fundamental aspect of South Africa's signature on the Antarctic Treaty. Many may interpret the signature as a mandate to conduct research and explore the Continent. While it is true in a sense it is not the complete story. By signing the Treaty South Africa willingly undertook to be a custodian of a portion of Antarctica. I therefore contend that South Africa's presence on the continent should not merely be justified by the research or exploration benefits that are derived but rather by our responsibility as co-custodians to protect and nourish our portion. This duty that we undertook cannot be priced in strict financial terms. It should be our nation's contribution to all people on this earth, especially for generations still to come. The day we fail to recognise this will signal the death of our nation's soul and end all justification to have a National Antarctic Programme. This might sound emotional or naive but it is what separates us as spiritual beings from the other creatures on this earth. Besides the guiding norms that were used, our aim with this document is not to minimize negative impacts but rather to strive to eliminate them altogether. If we adopt this approach as part of our mission and philosophy for the South African National Antarctic Programme there should be no doubt about the justification of a new facility in Antarctica.

Paul Claassen

ACKNOWLEDGEMENTS

Many individuals provided inputs to this Comprehensive Environmental Evaluation and the preceding Initial Environmental Evaluation. The co-ordinators, on behalf of the Department of Environment Affairs, wish to thank all these people for their time, enthusiasm, professional advice and technical support.

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GLOSSARY OF TERMS

LIST OF ABBREVIATIONS

ANOKS	- Antarctic Research on Cosmic Rays (from Afrikaans)
AMIGO	- Antarctic Magnetosphere, Ionosphere Ground-based Observations
ATCM	- Antarctic Treaty Council Meeting
BS	- British Standard
CEE	- Comprehensive Environmental Evaluation
dB	- Decibel
DEA	- Department of Environment Affairs
DPW	- Department of Public Works
EHS	- Environmental, Health and Safety
EHSMS	- Environmental, Health and Safety Management System
EHSIA	- Environmental, Health and Safety Impact Assessment
HF	- High Frequency
IEE	- Initial Environmental Evaluation
IEM	- Integrated Environmental Management
nT	- Nanotesla
PABX	- Private Automatic Telephone Exchange
RH	- Relative Humidity
RSA	- Republic of South Africa
SABS	- South African Bureau of Standards
SACAR	- South African Council for Antarctic Research
SANAE	- South African National Antarctic Expeditions
SANAE IV	- Roman numerals refer to the fourth generation facility
SANAE 34	- Numerals refer to a particular annual expedition
SANAP	- South African National Antarctic Programme
STEP	- Solar, Terrestial Energy Programme
UPS	- Uninterruptible Power Supply
ULF	- Ultra Low Frequency
UV	- Ultra Violet
VLF	- Very Low Frequency

LIST OF TERMS

BASELINE INFORMATION
Information derived from data which:
Records the existing trends in environmental, health and safety.
Records the characteristics of a given project proposal.

CONSERVATION
The act of maintaining all or part of a resource (whether renewable or non-renewable) in its present condition in order to ensure its continued or future use.

COST-BENEFIT ANALYSIS
An objective, careful, explicit analysis of the costs and benefits of a proposal within a structured framework.

CUMULATIVE IMPACT
An action that in itself is not significant but is significant when added to the impact of other similar actions.

DEVELOPMENT
The act of altering or modifying resources in order to obtain potential benefits.

ENVIRONMENT
The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group. These circumstances include biophysical, social, economic, historical, cultural and political aspects.

ENVIRONMENTAL, HEALTH AND SAFETY AUDIT
A systematic, documented, periodic and objective evaluation to determine whether or not the environmental management system and its performance comply with planned arrangements, and whether or not the system is implemented effectively and is suitable to fulfil the organization's environmental policy.

ENVIRONMENTAL, HEALTH AND SAFETY IMPACT ASSESSMENT
The process of collecting, organising, analysing, interpreting and communicating data that is relevant to some decision (of environmental, health and safety evaluation).

ENVIRONMENTAL, HEALTH AND SAFETY IMPACT
Any direct or indirect impingement of the policies, activities, products

and services of an organization which may lead to an environmental, health or safety change, whether adverse or beneficial.

ENVIRONMENTAL, HEALTH AND SAFETY IMPACTS REGISTER
A list of the impacts known, or suspected, of the policies, activities, products, by-products and services of an organization upon the environment, including health and safety aspects.

ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT
Those aspects of the overall management function which ensure that all environmental, health and safety considerations are fully integrated into the determination and implementation of organizational policies.

ENVIRONMENTAL, HEALTH AND SAFETY PROGRAMME
A documented programme which organizes and co-ordinates environmental, health and safety management objectives and targets.

ENVIRONMENTAL, HEALTH AND SAFETY OBJECTIVES
The goals, in terms of environmental, health and safety performance which an organization sets itself to achieve and which should be quantified wherever practicable.

ENVIRONMENTAL, HEALTH AND SAFETY POLICY
A documented public statement of the intentions and principles of action of the organization regarding its environmental, health and safety impacts, giving rise to its objectives and targets.

ENVIRONMENTAL, HEALTH AND SAFETY TARGETS
Detailed performance requirements, quantified wherever practicable, applicable to the organization or parts thereof, which arise from the environmental objectives and which need to be met in order to achieve those objectives.

IMPACT
The outcome of an action or actions, whether considered desirable or undesirable.

INTEGRATED ENVIRONMENTAL MANAGEMENT
A philosophy which prescribes a code of practice for ensuring that environmental considerations are fully integrated into all stages of the development process in order to achieve a desirable balance between conservation and development.

INTERESTED AND AFFECTED PARTIES
Those individuals or groups concerned with, or affected by an

organization's activities, facilities, equipment, services and their consequences. These include those exercising environmental control over the organization, neighbours, local residents, the organization's investors, insurers and work force, customers and consumers, environmental interest groups and the general public.

MITIGATE
The implementation of practical measures to reduce adverse impacts or enhance beneficial impacts of an action.

MONITORING
An activity which ensures that the requirements of the environmental, health and safety management programme are met.

OBJECTIVE
A conclusion verifiable by independent study.

OPTIMISE
To find a solution to a problem which maximises the benefits and minimises the negative impacts.

ORGANIZATION
Any organized body or establishment, for example a business, company, government department, charity or society.

PLANNING REQUIREMENTS
Policy, legal and administrative requirements governing the development of a proposal.

POLLUTION
The residue of human activity which adversely affects the next user of some environmental resource.

PROCEDURE
A series of prescribed steps for guiding or accomplishing a scientific inquiry (cf technique).

RESOURCE
Any good, service or environmental condition which has the potential to enhance social well-being.

REVIEWER
The individual or group with responsibility for determining whether an assessment has been carried out correctly and/or whether it is adequate for decision-making.

EXECUTIVE SUMMARY

INTRODUCTION

When the present Antarctic base SANAE III started showing serious signs of structural collapse, it became necessary for the SANAP managers to initiate the planning of a new base to ensure South Africa's continued participation in activities on the continent.

After receipt of the draft documentation of the Madrid Protocol of 4 October 1991 (accepted and signed by South Africa but not yet ratified), it was decided to adhere as strictly as possible to Articles 1 and 2 of Annex 1 of the Protocol that deal with Environmental Impact Assessment. This report represents a "Comprehensive Environmental Evaluation" as described in Article 2 of the Annex.

The Department of Environment Affairs (DEA) of the Republic of South Africa released a set of six documents entitled "The Integrated Environmental Management Guideline Series" in September 1992. These documents provide guidelines concerning the implementation of the Integrated Environmental Management (IEM) procedure during all development activities. Many of the terms and concepts (such as public participation, interested and affected parties and external review), used in this report are integral parts of IEM. The project will be executed by the DEA and the Department of Public Works (DPW).

PROJECT DESCRIPTION

A feasibility study was conducted by consulting engineers Engelbrecht, van den Berg, Inc. for the DPW. Phase one of that study was completed in 1989, and phase two in 1991. It entailed the consideration of the following options for a new facility:

A sea base utilising a second-hand drilling platform;
A sea front base in a natural bay;
A new base at the existing SANAE III base; or
A new base on an inland nunatak.

The decision was taken to establish the new SANAE IV facility at an inland nunatak, subject to a suitable site being found.

Thereafter a comparison was made of two possible design options, namely a surface or a sub-surface structure. In view of the psychological and environmental advantages of the surface structure over the sub-surface option, it was decided to plan for a surface base.

Six nunataks lying in the Ahlmannryggen in western Queen Maud Land were then evaluated against a set of environmental, design and constructional criteria drawn up between the DEA and the DPW.

The nunataks considered were:

Vesleskarvet;
Krylen;
Valken;
Marsteinen;
Lorentzenpiggen and
Schumachersfjellet.

Nunataks south of the present Sarie Marais field base at Grunehogna were not considered, due to the negative logistic aspects arising from their long distance from the coast.

Vesleskarvet was chosen as the site holding the lowest environmental, health and safety hazards, and being the most suitable from a construction point of view.

The mission was then set to:
"Plan, design and construct a new high quality South African base in Dronning Maud Land, Antarctica. The operative "high quality" refers to the planning, design, construction, materials and all operational systems, both internally and eternally."

The objectives then set in support of the mission were that the base must be:

User friendly with low maintenance;
structurally safe and stable in the adverse Antarctic conditions;
environmentally safe;
able to operate at optimum efficiency;
an effective balance between high quality and low cost, and
of a high standard internally and externally.

A set of design criteria which were used by the design team were established from these objectives.

An Initial Environmental Evaluation (IEE) was then completed according to the requirements of the Madrid Protocol on Environmental Protection under the Antarctic Treaty. This IEE showed that a Comprehensive Environmental Evaluation (CEE) should be done before planning progressed.

ENVIRONMENT

Two site visits were conducted by the co-ordinators of the IEE and CEE during the 1991/1992 and 1992/1993 take-over periods. The co-ordinators were accompanied on both occasions by specialists from the engineering, biological and surveying fields as well as by SANAE managers and DPW officials.

The baseline environmental state at Vesleskarvet was found to be the following:

The nunatak has a broken rock surface of approximately 40 000 m^2, which is comprised mainly of coarse grained diorite and some coarsely grained pegmatite. The surface slopes down from west to east, with a cliff of between 150 m and 210 m forming the western boundary. To the east the rock surface slopes gently into the snow surface.

No breeding colonies of birds or mammals exist at Vesleskarvet. The nearest bird breeding colony is at the Robertskollen nunatak, some 25 kilometres away.

Micro-organism communities exist on both buttresses, the northern buttress supporting the most diverse life forms. The southern buttress, however, hosts a strong community of tardigrades. Two new species under the genus *Hebesencus* and *Macrobiotus* were discovered in the soil samples taken from both buttresses.

Four scientific exclusion areas were demarcated on the nunatak, three on the northern buttress and one on the southern. The exclusion area on the southern buttress will not be maintained, as the tardigrades discovered there were found to also exist on the northern buttress. These areas are demarcated by means of metal poles and nylon cord. Each has an explanatory signboard.

Magnetic susceptibility tests were conducted to determine the best sites for various scientific instruments, and suitable areas were found where these instruments could be situated.

A gap exists in the climatic data for Vesleskarvet, as no scientific weather recording has been done on the site. The most serious gaps are those data regarding wind and precipitation. Figures for SANAE III had to be used as a departure point in estimating what conditions at Vesleskarvet would be like. As the base design caters for winds up to 300 km/h, no major problems are envisaged.

PROJECT PROPOSAL

The design process resulted in a base consisting of three interlinked double-storey units of approximately 14 m X 44 m each. They will be joined at the lower level by interleading passageways, which will also serve as the access and exit points. All three units will be raised 3.5m above the rock surface of the nunatak on stilts.

Wind tunnel tests were conducted at the CSIR to determine the most ideal shape and proportion of the structure. Rounded corners and smooth surfaces have been employed to minimise the effect of wind.

The base will be able to accommodate 20 over-wintering team members and 60 summer take-over personnel. A helipad and double hangar will be provided as part of the structure. The latter will serve as storage for the challenger vehicles during winter. The helipad will incorporate two screw drive lifts to raise the caterpillars and provisions into the base.

The frame will be constructed from steel, and the cladding will be rigid, pre-constructed foam and glass-fibre resin panels.

The interior temperature will be fully controlled, and use will be made of heat exchangers utilising electricity generator exhaust and coolant heat to warm the base interior. Fresh water will be obtained from a remote, manually operated snow melter.

A sealed effluent treatment plant will be located in the structure, and all sewage will be pumped through the plant to be treated. The discharged effluent will conform to standards for release into rivers in the Republic of South Africa (RSA). The concentrated sewage sludge will be containerised and removed to the RSA during summer take-overs. All other waste will be sorted, containerised and removed to the RSA. This will include waste generated by field teams.

Electricity generation will be by means of three 250kW water cooled Caterpillar D6 diesel generating sets, one of which will be a spare. An uninterruptible power supply (UPS) system will be installed to cater for scientific and medical equipment in case of a system failure.

A computer monitoring system will also be installed to relay system performances back to DEA and DPW. This will enable fault diagnosis and maintenance to be directed by experts in the RSA.

The main research conducted from the new base for the foreseeable future will be:

Biological research (mainly seals, avifauna, flora and micro-organisms);
Earth Sciences (Geological and surveying disciplines)
Antarctic Magnetosphere, Ionosphere Ground-based Observations (project AMIGO) and
Antarctic Research on Cosmic Rays (project ANOKS).

FUEL AND OIL PRODUCTS

Various options were considered for the transport and bulk storage of fuel.

Fuel will be pumped from the ship into a 30 000 l bladder on the ice-shelf. From this, 7 000 l bladders will be filled and transported to the base at Vesleskarvet. This greatly reduces the chance of a large spill occurring.

The chosen storage option entails six 100 000 l flexible bladders, each in a leak-proof, sealed metal container with its own installation. The storage facility will be located approximately 50 m away from the main structure, off the vehicle routes. Fuel will be pumped into the main base day tank which will hold approximately 3 000 l.

ASSESSMENT OF POTENTIAL IMPACTS

The difficulty in identifying and quantifying potential impacts led the co-ordinators to make use of the identification and addressing of key issues in assessing the environmental, health and safety (EHS) impacts of the proposed facility. The 13 key issues identified were drawn up from comments offered by all interested and affected parties (I&AP's), SANAP management and the assessment team. A list of activities related to the proposed facility was produced, and the potential impacts of each of these activities evaluated.

The assessment focused on unmitigated impacts, and evaluated them according to the nature, extent, duration, intensity, probability of occurrence and significance of each impact. Possible mitigatory actions were then considered. The next step was to return to the key issues and evaluate how they had been addressed through the design process.

In summary, there is no single potential impact which could have a major detrimental environmental, health or safety effect in the long term. This does not, however, imply that the potential for major detrimental EHS effects does not exist. The effect of cumulative or synergistic impacts could well be of high significance.

The most significant non-transitory impacts are:

a) The cleared base foundation platform of 3600 m^2 and the resulting displaced rock;
b) Two neutron monitor hut foundation platforms of approximately 90 m^2 in total and the resulting displaced rock;
c) The holes drilled for the rock anchors for the base, neutron monitor huts and safety rail.
d) An ice-road of 1320 m^2;
e) An ice-path of 263 m^2;
f) Treated effluent which is to be discharged over the cliff edge on the southern buttress.

CONCLUSION

Many environmental, health and safety concerns were addressed during the different stages of planning, design and placement of the proposed SANAE IV facility. The evaluation of alternatives was often a subtle process, and many trade-offs were necessitated. Environmental, health and safety aspects were always the guiding elements in these trade-offs however, and this reduced the potential impacts significantly.

Those transitory impacts which still occur can be mitigated and managed to levels which are currently and futuristically acceptable.

The non-transitory impacts mentioned above are considered to be of medium significance in the long term, but are deemed to be acceptable in the light of the advantages to be gained from the proposed new facility.

Taken that no single potential impact has a major detrimental effect, it can be stated that the key to minimizing the overall impact lies in the stringent management of all activities relating to the proposed facility. This is especially important in the light of the nature of the environment at Vesleskarvet, which is not as forgiving as the site of the existing SANAE III facility.

The recommendations thus centre mostly on the establishment and implementation of an Environmental, Health and Safety Management System or EHSMS. The implementation of this EHSMS will be crucial to the success of the proposed base and its related activities.

RECOMMENDATIONS

It is recommended that an Environmental, Health and Safety Management System be produced and adopted in principle before construction of the proposed facility begins. This EHSMS must cover the following aspects:

1. Management structure.

   The re-structuring of SANAP to allow for the integration of the EHSMS.

2. Management responsibility.

   An EHS policy statement must be issued. The necessary organizational duties must be defined, and personnel identified or appointed for the necessary verification, auditing, reviewing and other management tasks.

3. EHSMS.

   An EHSMS must be produced, documented, distributed and maintained in order to ensure that all SANAP activities conform to the EHS policy statement.

4. EHS management programme.

   This programme should cover all aspects of SANAP activities and facilities, and address impacts arising from all stages of these activities.

5 Contract review.

   All contracts, including research contracts, must be reviewed in order to ensure that they do not give rise to any unacceptable EHS impacts.

6. EHS impacts and planning.

   Any new facility, activity, equipment or process must be evaluated in terms of its potential EHS impact, and a management programme must be developed to control any impacts arising. The Integrated Environmental Management Procedure (IEM) must be followed wherever possible.

7. Document and data control.

   Only documents which have been officially approved and authorised by the DEA may be used.

8. Process control.

   The DEA and other SANAP members must identify and plan all processes which directly or indirectly affect the EHSMS.

9. Inspection and testing.

   The DEA must establish, document and maintain procedures for verification of compliance with specified EHS requirements for maintaining records of the results.

10. Corrective and preventive action.

    The DEA must establish and maintain procedures for corrective and preventive actions whenever EHSMS non-conformities are detected.

11. EHS management records.

    The DEA must establish and maintain a system of records in order to demonstrate compliance to the EHSMS. This must include contractual, procurement, auditing, review and training records.

12. EHS management audits.

    The DEA must establish and maintain procedures for EHS audits in order to determine whether EHS management activities conform to the EHS management programme, and the effectiveness of the EHSMS in fulfilling the EHS policy.

13. Training.

    Appropriate EHS training needs must be identified and provided for all personnel in the SANAP.

14. Dedicated EHS management personnel.

    A new DEA sub-directorate is recommended to implement and maintain the EHSMS. The addition of environmental officers to the summer take-over teams is considered essential.

15. Consultants.

    Adequate funds must be provided for consultants to help draw up the EHSMS.

16. Additional research programmes.

    It is recommended that a technology research programme and an EHS management research programme be established.

The EHS policy statement, an EHS code of conduct, contingency plans, an initial EHS management programme, an EHS audit procedure and monitoring programmes must be drawn up before the start of the 1993/1994 take-over period. Any additions to the scientific exclusion areas on Vesleskarvet must be effected.

These actions should then be implemented and integrated into the SANAP for the remainder of the project phases.

CHAPTER 1

PROJECT DESCRIPTION AND SITE SELECTION

1. APPROACH TO THE STUDY
2. NEED AND DESIRABILITY
3. INITIAL CONSIDERATION OF AVAILABLE OPTIONS
4. SITES CONSIDERED
5. MISSION AND OBJECTIVES
6. DESIGN CRITERIA

CHAPTER 1

PROJECT DESCRIPTION AND SITE SELECTION

1.1 APPROACH TO THE STUDY

1.1.1 INTRODUCTION

The sub-directorate: Environmental Impact Management of the DEA was tasked to complete the evaluation process as stipulated in the Madrid Protocol, as this sub-directorate is responsible for national policy regarding impact assessment in South Africa. The sub-directorate had also released a set of six documents entitled "The Integrated Environmental Management Guideline Series". These documents were aimed at impact assessment practitioners, developers and controlling authorities. They provide guidelines on the incorporation of environmental concerns into all stages of the development process. Many principles of Integrated Environmental Management (IEM) are embodied in this document, and the process leading up to it's realisation.

1.1.2 CONTRIBUTORS

The approach adopted in the environmental assessment and subsequent reports was based on a commitment to make use of those local structures and professionals which could supply a high quality expertise in their particular field.

It was accepted that the best people to use would be those with previous Antarctic experience. For this reason many of the contributors are specialists involved through their respective organisations and institutions with research under the South African National Antarctic Programmes (SANAP).

1.1.3 PLANNING PROCESS

a) **1991/1992.**

A ten day site inspection was conducted by the co-ordinator of the Initial Environmental Evaluation (IEE). He was accompanied by a surveyor, an engineer, biologists a physicist, a geologist, a geo-physicist and a logistics expert, all members of the assessment team. During this visit, the following aspects were covered:

i) The nunatak was surveyed and spot heights determined, using a theodolite and staff.
ii) Photo ground control points were laid out in preparation for an aerial survey.
iii) Aerial photography of the nunatak was undertaken.
iv) Beacons for Geographic Positioning Systems (GPS) were fixed.
v) The proposed siting for the base was changed.

vi) The placement of most scientific structures was decided on in principle.
vii) The position of the safety handrail was finalised.
viii) The location of the access road route was determined.
ix) The orientation of the base was evaluated.
x) Biological samples were obtained for analysis by specialists.
xi) Acceptable alternatives for the design and placement of the bulk fuel storage facility were generated.
xii) The placing of the construction base was finalised.
xiii) Geophysical and geomagnetic surveys were conducted.

The above points were discussed on site between the EIA team, the consulting engineer and the DPW team leader. The placement of the design elements was a synthesis between all parties on site.

b) **1992/1993.**

This inspection lasted two weeks and was conducted by the co-ordinator of the CEE. He was accompanied by the Deputy Director: Environmental Impact Management of the DEA, head of the section responsible for completing the CEE. Also present were two biologists from the University of Cape Town. During this time the following tasks were undertaken:

i) Four scientific exclusion areas were demarcated by means of metal poles and nylon rope. Each area has an explanatory signboard.
ii) The previous year's decisions were again evaluated.
iii) A total of fifty biological samples were obtained from the nunatak for further analysis.
iv) A further study was conducted on the possibility of bird nesting sites on the northern buttress.
v) Alternative positions for the treated waste water discharge pipe were investigated.

c) On both occasions various specialist contributors and researchers were present, and discussed their concerns and interests on the site with the other parties.

1.1.4 INTERESTED AND AFFECTED PARTIES

a) **Requirements**

In terms of paragraphs 3 and 4 of Article 3 of Annex 1 of the Madrid Protocol, the Draft CEE report should be made available for comment.

The IEE was also circulated to all interested and affected parties (I & AP's) so that comments, suggestions and potentially valuable inputs could be included at an early stage of the process.

b) **Parties consulted**

It was also decided to ask all local organisations that are involved in Antarctic research and the management and logistic aspects thereof for their inputs and comments. Greenpeace International has also been provided with a copy of this report.

The IEE report was also available, on request, to the public at large. A full list of organizations to which the IEE and CEE reports have been sent and all other parties involved in this process is attached as Appendix 7. The comments received on the IEE are included as Appendix 8.

This Draft CEE has been distributed to all those parties which received the IEE, and any others which expressed a desire to receive it.

1.2 NEED AND DESIRABILITY

1.2.1 MOTIVATION FOR SOUTH AFRICA'S PRESENCE IN ANTARCTICA

a) South Africa is an active participant in international Antarctic research programmes on the Antarctic continent and has established itself as a member of the Scientific Committee on Antarctic Research (SCAR) with a proud record in four of the five research disciplines supported by SCAR, namely physics, earth sciences, biology and oceanography.

b) Over the years of active participation in Antarctic research a vast pool of expert knowledge in the various disciplines has been developed by South African researchers. Scientists participating in South African sponsored research programmes have contributed considerably to the international arena of Antarctic research.

c) South African researchers are active in an area in Antarctica which has never been thoroughly explored and this will probably remain an area of interest to the international scientific community for the foreseeable future (Appendix 2, Figure 1 illustrates SANAE III's position on the continent). This should motivate South Africa to maintain a presence in Antarctica and involve itself in expanding man's knowledge of this continent.

d) Being one of the original twelve signatories of the Antarctic Treaty, South Africa has committed itself to the principles and spirit of the Treaty and will therefore endeavour to maintain an active presence in Antarctica with the purpose to conduct research with the prime objective of protecting the environment.

e) During a time when South Africa found many doors closed in the international political arena, the Antarctic Treaty Council Meetings remained open. Excellent international relations were established, and South Africa found support from Treaty member countries.

f) The decade of the eighties was a difficult time for South Africa to maintain a presence on the continent. This continued presence will only be truly valued in the years to come, provided of course such a presence is maintained.

1.2.2 MOTIVATION FOR THE REPLACEMENT OF THE PRESENT BASE

a) SANAE III, the present South African base in Antarctica, was commissioned in 1979. The expected life span for this base was to be approximately 15 years, thus giving an end-of-cycle date of 1993.

b) Problems with, and a slow collapse of, the structure were first detected during the 1987/88 take-over period. Planning and budgeting for a new SANAE base started in 1989, and it is planned to have the new base ready for occupation in December 1994. It is expected that this will also be the last date for relative safe occupation of the present base.

c) The existing SANAE III base is currently approximately 22 m below the snow surface and has progressively deteriorated over the past four years. The deterioration has been caused by excessive snow pressures on the steel protective shells which has resulted in significant structural damage to both the steel structures and the encapsulated insulated buildings of the living quarters, sleeping quarters and power generation facility. The deterioration has accelerated in the past two years and serviceability of the base as a whole has been reduced to a very uncomfortable and psychologically disturbing level. Although sudden collapse is not envisaged, the deflected structures are reaching potentially dangerous levels with a recommended cut-off proposed at the end of 1994 for final evacuation.

d) The result of the above-mentioned deterioration has been high inputs, both in terms of maintenance and personnel, in order to keep the base operating at minimum acceptable levels. The need for a new SANAE base has therefore become a necessity if South Africa is to continue it's Antarctic activities safely, efficiently and professionally.

1.3 INITIAL CONSIDERATION OF AVAILABLE OPTIONS

1.3.1 SITE OPTIONS

a) SEA BASE

This alternative comprised the upgrading of a second-hand oil drilling platform and anchorage near the existing SANAE base. High cost and inherent dangers of bulk ice movements were prohibitive in pursuing this option any further. Factors such as a compact design, ease of logistic operations, water production from sea water and extended marine research possibilities were, however, noted.

b) SEA FRONT BASE IN A NATURAL BAY (ROCK FOUNDATIONS)

The present South-African Base at 70° 18'S, 2° 21'W is built on the Fimbulisen (ice-shelf) that covers the continental terrace. The coastline in this region is marked by irregularities consisting mainly of partially submerged or drowned glacial troughs. The 20 m - 22 m protrusion of this ice-shelf above sea level complicates the off-loading operations to the extent that all cargo must be lifted off by helicopters when no bay ice is available for the construction of loading ramps. The search for an alternative site resulted in a proposal to move away from this area to a natural bay with a solid rock coastline, similar to the new Italian base or the American base at McMurdo. This is in all respects the most economic and suitable option if an appropriate site could be identified. The integrity of the 30-year old scientific data base of the existing SANAE base excluded this as a possible option. Available sites could be found to the east and west along the coastline from the SANAE base but were already populated by countries such as England, The Soviet Union, Japan and India (see Appendix 2, Figure 1). A new South African base in these areas would thus not contribute justifiably to International Antarctic Research.

c) **A NEW BASE AT THE EXISTING SANAE BASE**

The construction of a new base in the immediate vicinity of the existing base implies a repeat of a sub-surface structure or a combination of a surface and sub-surface structure in the moving Fimbulisen (ice-shelf). The advantages were considered to be the following:

i) Experience of this type of structure has been gathered over the past 30 years. The planning and design would thus be simplified.

ii) Existing infrastructure could be used to a large extent and impacts will be restricted to the existing area. A new site would result in further environmental disturbances as a result of the relocated human activities.

iii) Logistic lines are relatively short and safe with well-marked depots and routes.

iv) The base would be protected from the full effect of external environmental conditions.

The disadvantages are:

i) The base has a limited life-span of 10 to 15 years due to ice movements and the resulting stresses placed on the structure.

ii) A base being gradually covered with snow, and the psychological impact of living in areas devoid of natural light or views of the surrounding environment has been found to be detrimental to the general well-being of the inhabitants over a period of time.

iii) Fresh water production and sewage disposal are difficult to contend with.

iv) If the required structure is erected on the surface, its effect on snow drift deposition over an extended area will be considerable. The existing base caused local snow deposition that affected an area of at least 250 m by 1 000 m, up to a height of approximately 5 m above the surrounding snow surface.

v) Most of the structural elements cannot be removed at a later stage when the base is evacuated.

vi) Proper earthing of scientific equipment is difficult.

A base utilizing both surface and sub-surface components would be more advantageous from a psychological and research point of view but its effect on the surrounding environment remains significant.

d) A NEW BASE ON AN INLAND NUNATAK

This site option was considered after initial discussions and evaluations pointed to several scientific research advantages. It was decided to investigate several nunataks during the 1990/91 take-over for their suitability to accommodate the construction of a new base. Each site was evaluated in terms of the following: (Not in order of importance)

i) Estimated useable size.
ii) Accessibility.
iii) Foundation potential.
iv) Landing potential for fixed wing aircraft in the vicinity.
v) Area available for development, taking communication antennae, scientific monitoring equipment, fuel storage, base structures and operational requirements into consideration.
vi) Waste removal and fresh water production opportunities.
vii) Construction feasibility in terms of site suitability, erection constraints and structural concepts.
viii) Safety and health considerations.
ix) Possible biological communities (for example bird colonies) which might be impacted on by the base or it's related activities.
x) Any other environmental factors which might become apparent during the evaluation.

Several sites were identified during the problem definition and feasibility study phase. The initial survey inspected sites that would require different structural concepts at various geographic locations, with their relative advantages and disadvantages. Appendix 2, Figure 2 shows the location of these sites.

1.3.2 DESIGN OPTIONS

a) **Sub-surface structure**

This type of structure is used by several Antarctic Treaty members and has the following advantages:

i) A compact base layout is achievable as no access routes between buildings are required for movement or maintenance activities.

ii) The base is not exposed to external environmental conditions and can therefore also not effect the environment in terms of the surrounding landscape by irregular snow depositions. This of course assumes that the base is built in trenches level to the surrounding snow surface and all excavated snow dispersed evenly over a large area.

iii) Fuel consumption for a base of this type can be lower than a surface base if the air intake is through the surrounding snow. Lower down the temperature is mostly constant at between -20°C to -25°C. This reduces the amount of energy required to heat the air to +18°C and hence lower fuel consumption during the winter months.

The major disadvantages are:

i) A sub-surface structure has a major psychological effect on expeditionaries and requires them to stay below in an artificial environment for extended periods of time, especially during storms that may range from two to three weeks.

ii) Interviews conducted with previous expeditionaries showed a premium placed on a surface structure and the confined sub-surface containment was perceived to be the singular most important factor contributing to periods of depression and strained interpersonal relationships.

iii) Ice loading and inherent stresses in the ice-shelf, combined with the inevitable heat losses that cause melting and creates uneven loading patterns on the structure, reduce the life expectancy of this type of base to about 15 years. By this time, serviceability is severely restricted by structural deflections and local failures and maintenance costs escalate.

iv) As the structure is covered with consecutive snow layers, access becomes more difficult.

v) Sewage disposal is difficult and requires discharge at significant distances from the base to ensure that melt cavities do not affect the structure. These disposal lines require constant attention.

vi) Relative movements between structures due to compressive straining of the surrounding snow results in constant attention to service links between them.

vii) Fire is a major hazard for individual units as escape routes are limited.

viii) The fact that major structural components cannot be removed after expiry of the base's useful life is a major disadvantage.

The above-mentioned advantages and disadvantages set certain design criteria for detailed planning, and it will require a specific type of structure with its associated sub-systems to satisfy those criteria.

b) Surface structure

The advantages are:

i) A definite psychological advantage due to the visual contact with the outside environment and natural light.

ii) The structure is totally removable at the end of it's useful life of at least 20 years. (15 Years for the sub-surface structure).

iii) The structure can be of lighter design than a sub-surface type, and fire is less of a hazard in the sense that there are several escape routes via windows etc. onto the surrounding surface.

iv) The rock foundations are fixed and stable and no stresses or strains are induced into the structure as is the case with the sub-surface structure. This reduces the long term maintenance requirements.

v) More conventional types of buildings are possible and space restrictions are not as severe as with a sub-surface structure.

The major disadvantages are:

i) The entire structure is subject to all external environmental hazards and conditions. The need for determining the most adverse set of circumstances is therefore greater.

ii) The sealing off of the buildings is critical and difficult to achieve.

iii) The base is more energy-demanding in the winter months when differences in temperature between -50° C (external) and +18° C (internal) may exist.

iv) The design is more critical in terms of dynamic loadings, such as wind, and the structure has to be of sufficient stiffness to reduce oscillatory deflections to within acceptable limits. This is necessary to ensure that scientific equipment is not affected and that personnel do not perceive the structure as unsafe.

v) The structure will influence the surrounding topography to some extent due to snow drift depositions. The aerodynamic response can, however, be optimized through design to minimize the extent of this influence.

Both of the above-mentioned design options are feasible and require different solutions to offset disadvantages and accentuate advantages.

1.3.3 PREFERRED OPTIONS

a) Site options

After completion of the feasibility study and consideration of the site options, it was decided by the Department of Environment Affairs to locate the new base **at an inland nunatak** if a suitable site could be found.

b) Design options

Greater scientific advantages, coupled to the psychological and hence health advantages of the surface base, together with the prospect of complete removal after use (environmentally more acceptable) as well as a significantly longer lifespan, led to the decision in favour of **a surface base.**

All efforts and expertise were then focused to optimize this option in order to ensure efficiency and minimize environmental, health and safety risks.

1.4 SITES CONSIDERED

A second inspection was carried out in the 1990/91 take-over period, during which several nunataks were visited and evaluated against a set of requirements for the construction of a new base (see Section 1.6: Design criteria). A short summary of each site is given.

The nunataks considered were:

1.4.1 VESLESKARVET, 71° 40'S - 2° 51'W (APPENDIX 3, PLATE A)

This was the only site complying to the evaluation criteria in section 1.3.1 (d) above and section 1.6.

a) **Estimated size**

Two "lobes" protrude at a gradual slope from the surrounding snow, providing 250 000 m² of exposed and semi-exposed rock.

b) **Accessibility**

There is a height difference of between 150 m to 210 m between the top surface of the nunatak and the bottom of the wind scoop.

The northern and southern sides are flanked with gradual gradient ice ridges that provide access from the existing Sarie Marais field station route. The distance from the nunatak to the route is about 10 km. Access is therefore possible.

c) **Foundation potential**

The exposed surface is covered with boulders ranging from 1500 x 1 000 x 500 mm to 300 x 300 x 300 mm. Below this the rock surface is jointed, but closes between 500 mm and 1 000 mm deep. Rock anchors will be required and the design must prevent a freeze / thaw process being initiated after the anchors are positioned. Although specialized anchorage and particular precautions will be required, the founding of the structure will be possible.

d) **Landing facilities**

A landing platform for helicopters can be erected as part of the base and space is available for this purpose. To the east of the nunatak the snow levels off and there is sufficient space to land fixed wing aircraft. There are also a number of alternative landing areas which could be used within a 10 km radius.

e) **Scientific requirements**

There is sufficient space available for antennae and monitoring equipment. The dolerite rock formation was assessed to determine it's potential for producing magnetic interference on sensitive instruments. No major problems in this regard are envisaged.

f) **Waste removal**

The site itself poses no restrictions on the implementation of an acceptable waste management plan.

g) **Water supply**

A remote snow melter on the snow surface will have to be used and the water pumped to the base in a heated pipe over the rock surface. This will require manual input. The possibility of using a heated bell system which forms a melt cavity is being investigated. Such a bell system would require no manual operation.

h) **Construction feasibility**

This nunatak provides a suitable size for the construction of the proposed base. The uneven surface can be catered for in the design of the specialized foundation system.

1.4.2 KRYLEN, 71° 33'S - 2° 10'W (APPENDIX 3, PLATE B)

a) **Estimated size**

A suitable platform for a new base of about 3 000 m² is available on the northern slopes.

b) **Accessibility**

Access to the nunatak is from Vesleskarvet, a route which is flanked to the north by crevasses. A safe route is however possible. Local access to the site is via a steep ice slope from the crest of the snow-covered section of the nunatak on the western slope. This access route will be dangerous, as vehicles and sledges could gain enough momentum to tumble over the cliff edge should they go out of control.

c) **Foundation potential**

Similar to Vesleskarvet.

d) **Landing facilities**

Similar to Vesleskarvet.

e) **Scientific requirements**

The available rock surface is limited, and antennae will have to be located on the snow surface about 1 km from the potential site.

f) **Waste removal**

Similar to Vesleskarvet.

g) **Water supply**

Similar to Vesleskarvet.

h) **Construction feasibility**

Although construction will be possible at this site, access problems and limited space do not make this a feasible site.

1.4.3 VALKEN, 71° 29'S - 1° 59'W (APPENDIX 3, PLATE C)

a) **Estimated size**

This location consists of various outcrops scattered over a large area, each with areas of about 3 000 m². The surfaces are however faulted with sharp peaks and valleys.

b) **Accessibility**

This is a major problem since crevasses in the surrounding areas are ubiquitous. Access to this site is treacherous.

c) **Construction feasibility**

This is not a feasible option.

1.4.4 MARSTEINEN, 71° 26'S - 1° 42'W (APPENDIX 3, PLATE D)

The surface of this nunatak is very rugged, with sharp peaks and valleys and does not offer a suitable construction site.

1.4.5 LORENTZENPIGGEN, 71° 45'S - 2° 50'W (APPENDIX 3, PLATE E)

This site has high peaks with a rugged surface and valleys with no suitable areas for the construction of a new base. Access is also problematic.

1.4.6 SCHUMACHERSFJELLET, 71° 55'S - 2° 58'W (APPENDIX 3, PLATE F)

There are two separate areas of about 3 000 m² each that may be adequate for a new base but their layout and orientation do not make them feasible options.

1.4.7 NUNATAKS SOUTH OF GRUNEHOGNA

Logistic restrictions made sites further south impractical, and they were therefore not considered.

1.5 MISSION AND OBJECTIVES

1.5.1 MISSION

To plan, design and construct a new high quality South African base in Dronning Maud Land, Antarctica. The operative "high quality" refers to the planning, design, construction, materials and all operational systems, both internally and externally.

1.5.2 OBJECTIVES

The objectives set in support of the mission were identified and are listed below (not in order of importance):

a) **User friendly with low maintenance.**

The philosophy originates from the principle that a well planned and functional base with appropriate simplicity will lend itself to low effort operations allowing maximum concentration and time for the scientific effort for which the facilities are created. Low maintenance follows from the above but also reduces the ratio between maintenance and scientific costs.

b) **Structurally safe and stable in the adverse Antarctic conditions.**

This speaks for itself.

c) **Environmentally safe.**

In this regard a wide interpretation is given to the word safe and reference is made to minimizing damage to the rock surfaces at base anchorages and during other construction activities. It also includes backup and monitoring systems to prevent fuel spillage and energy wastage and ensure low generator smoke emissions. Also energy conservation by efficient thermal insulation and recovery of excess heat, which reduces fuel requirements, logistic support and ultimately pollution.

Furthermore, waste management must ensure retrieval of solid waste out of Antarctica, purification of waste water before it is let out into the surrounding environment and a structural concept that would minimize changes to the surroundings by adverse snow drift accumulation and allowing removal of all structures after decommissioning.

This objective also influenced the decision of the appropriate site.

d) **Operations at optimum efficiency.**

Efficient processes and systems are cost effective. A cumulative chain reaction links all the functional activities that make up the operational base. Efficiency in all aspects will not only minimize cost, but also EHS effects, necessary effort and logistic support.

e) **Effectiveness.**

A balance must be maintained between the conflicting priorities of quality with high standards and the nominal satisfaction of requirements with its associated lower cost implications.

f) **High quality internally and externally.**

Within the norms of effectiveness and efficiency the appropriate quality standards will crystallize and should be evaluated objectively for synergy in terms of all the objectives and requirements.

It must be noted that the above-mentioned broad objectives were used as directives by the DPW design team during the detailed design phase.

1.6 DESIGN CRITERIA

1.6.1 GENERAL ACCOMMODATION REQUIREMENTS

The requirement set by the DEA was an Antarctic base which would safely and comfortably accommodate the usual wintering-over personnel, summer season researchers and the take-over maintenance and support personnel. At present these groups are accommodated in three separate, self-contained facilities. The proposed base will accommodate all personnel in three interlinked structures at one location. To achieve this it was determined that the new base must be able to accommodate at least 80 people during the summer seasons and up to 18 for over-wintering periods.

The summer contingent would consist of:

(a) maintenance personnel;
(b) land surveyors and geologists using the facilities as first base;
(c) programme managers;
(d) helicopter pilots and support personnel;
(e) administrative personnel;
(f) scientists;
(g) environmental officers;
(h) the old and the relief over-wintering teams and
(i) international visitors.

1.6.2 SLEEPING QUARTER REQUIREMENTS

The quality/size of sleeping quarters in the SANAE III base were dictated by economic and psychological factors. While the economic factor remains a real consideration, the psychological viewpoint has changed somewhat and has been supplemented with new attitudes and ideas on the interaction between humans and their environment.

Previously psychologists suggested that smaller sleeping quarters would promote better team cohesion and prevent individual withdrawal. Time has proved that this theory is not entirely valid, and indicated that problems in wintering-over teams stem rather from individual attitudes and manifestations than from immediate surroundings and facilities. In support of this consideration, modern views on ergonomics and human nature suggest that higher efficiency could be attained by acknowledging the individual and his requirements for privacy and "own space". This has led to larger sleeping quarters being specified, especially for over-wintering personnel.

1.6.3 LABORATORY AND OFFICE REQUIREMENTS

Laboratory and office requirements were determined from requests and suggestions supplied by researchers in all four disciplines and from members of previous over-wintering teams. Possibilities of expansion and international co-operation in the long term also contributed to the final requirement/specification for laboratories and offices.

1.6.4 GENERAL STORAGE REQUIREMENTS

Accommodation for stores were based on requirements of previous years. Alternative methods for containerisation, transport and storage did, however, influence the requirements for access to the bulk food and the mechanical stores, including facilities for removing empty containers and old stock in bulk.

1.6.5 WORKSHOP REQUIREMENTS

Workshop requirements were based on experience gained from the facilities available in the SANAE III base, experience and suggestions from previous wintering-over maintenance personnel teams and from anticipated transport- and accommodation facilities. This led to a change in maintenance philosophy regarding vehicles in the sense that preventative maintenance and major repairs on vehicles will be done in South Africa.

Facilities must also be such that it will not be required of wintering-over maintenance personnel to spend unnecessarily long hours repairing or servicing vehicles while being exposed to the elements.

1.6.6 HANGAR AND GARAGE REQUIREMENTS

Requirements for hangars and garages were based on covered parking facilities for two Puma helicopters during the summer season and approximately six caterpillar vehicles during the winter months. This hangar/garage should also serve as a workshop area for both the helicopters and vehicles and must also serve as a recreation area if and when circumstances allow.

1.6.7 KITCHEN AND DINING REQUIREMENTS

Kitchen and dining facilities must provide for a maximum of eighty people and allow two people to provide a meal for eighty people three times a day. Whereas the kitchen must facilitate this requirement throughout the day, the dining facility may be arranged in such a way that meals may be taken in shifts, with a minimum seating requirement for twenty people (this is to allow the over-wintering team to have a meal at least once a day as a team).

1.6.8 MEDICAL REQUIREMENTS

Medical facilities will be based on existing equipment, allowing for small operations, dentistry work, X-rays and general medical support. A well-equipped pharmacy, consulting room, doctor's office and full ablution facilities must also be supplied.

1.6.9 RECREATION REQUIREMENTS

Requirements for the accommodation of recreation facilities include provision for facilities which are available in SANAE III such as table-tennis, three-quarter size pool table, lounge with video/hi-fi equipment, bar-lounge area and gymnasium. A separate library facility was an additional requirement.

CHAPTER 2

ENVIRONMENT

1. GEOLOGY AND LANDFORMS
2. CLIMATE
3. BIOLOGY

CHAPTER 2

ENVIRONMENT

2.1 GEOLOGY AND LANDFORMS

2.1.1 GENERAL OVERVIEW OF LANDFORMS ON A REGIONAL SCALE

Vesletskarvet nunatak lies approximately 50 km south of the hinge zone, where the flat ice shelf gives way to the undulating landscape of the northern part of the Alhmannryggen (mountain range).

The Jutulstraumen (glacier) to the east, and the Schyttbreen (glacier) to the west provide natural boundaries for this area. Rock outcrops are scarce in this region, and occur as scattered nunataks and groups of nunataks (See Appendix 2, Figure 2).

The elevation of the general snow surface slopes northwards from approximately 1400 m above mean sea level (a.s.l.) in the southeastern part of the Ahlmannryggen to approximately 100 m a.s.l. in the northern part. The northward dipping slope in snow level is also reflected in a progressive decrease in peak heights in the region from approximately 1800 m a.s.l in the south to less than 200 m a.s.l in the north. In addition, the abundance and size of outcrops also decreases northwards.

Erosion is typically of an alpine nature in the Ahlmannryggen, and exposed surfaces are frost-shattered. Scarp recession and the formation of cirques results in arêtes and pyramidal horns, the best example of which is Istind. The landscape is highly dissected with isolated rock exposures, and is mature.

The Ahlmannryggen is separated from the Borgmassivet to the south by the east north-east trending Viddalen (ice stream), which is a tributary of the Jutulstraumen.

2.1.2 DETAILED LANDFORMS ON ROUTE FROM SANAE III TO VESLESKARVET

The majority of the route from SANAE III to Vesleskarvet is on the relatively gently undulating Fimbulisen and Jelbartisen (ice shelves). These present no significant obstacles to overland travel, and the route is part of a well-established route to Sarie Marais field base.

On approaching the Ahlmannryggen, however, the ice shelf comprises a number of small ice rises in addition to the major influence of both the Jutulstraumen and Schyttbreen glaciers. Both these major glaciers result in a complex high zone, producing north-west / south-easterly trending crevasse areas on the Fimbulisen and Jelbartisen.

The established SANAE III - Grunehogna route follows the Bakenesdokka valley close to Robertskollen, but a direct approach from this direction results in a major slope to be negotiated at the base of Vesleskarvet cliff.

The easiest route is to follow this established route south past Vesleskarvet until close to Lorentzenpiggen, then swinging south-east and east up a relatively shallow slope to the top of the ridge, then heading back towards Vesleskarvet to avoid large crevasses on this ridge. The distance from the established route is approximately 16 km from the turn-off point.

A more direct route from the eastern flank of Vesleskarvet is possible by traversing eastward from Robertskollen between Baken and Knerten, then swinging southwards to follow the undulating, unnamed valley. Distance, however, is equal to that of the established route along Bakenesdokka. A shorter route is possible by approaching Baken more directly, and no large crevasse fields were noted on the hinge zone.

2.1.3 DETAILED LANDFORMS AT VESLESKARVET

Vesleskarvet comprises one main nunatak and one smaller outlying outcrop to the south (Peak 790), both relatively flat approximately 850 m a.s.l. It lies on the eastern flank of a northerly-trending snow valley called Bakenesdokka. The snow surface in this valley is approximately 700 m a.s.l., and slopes gently to the north. Vesleskarvet comprises a westerly-facing cliff approximately 150 m to 210 m high, with a prominent wind scoop and a small number of crevasses (see Appendix 2, Figures 7 and 8). A large field of glare ice is present between the main outcrop and Peak 790, and large crevasses are present along the ridge. The snow surface grades gently eastward towards the regional snow surface, and presents no significant topographic silhouette in this direction.

The snow surface to the east is dominated by the regional northwardly decrease in height, coupled with easterly-facing snow ridges formed by wind action on north-south trending ridges, of which only Knerten and Baken are exposed. The Bakenesdokka snow valley is the most prominent morphological feature of this area, but a smaller, unnamed valley also runs parallel to this approximately 10 km to the east. The snow surface to the east of Vesleskarvet thus comprises a series of step-like features down to the Fimbulisen, creating a complex series of slopes in this area.

2.1.4 DETAILED GEOLOGICAL ACCOUNT OF VESLESKARVET

The outcrop at Vesleskarvet comprises entirely mafic igneous rocks of the Borgmassivet Intrusions, which dominate outcrops in the northern Ahlmannryggen.

The rock is a medium to coarse-grained diorite, probably tholeiitic in composition, but also contains areas of more coarsely-grained pegmatite.

The main minerals are plagioclase, amphibole and pyroxene with minor quartz. Peak 790 appears somewhat different in that the facies is consistently coarser-grained, and shows modal variation defined by grain-size differences. It is possible that Peak 790 is more akin to the nearby Robertskollen intrusion.

Both the main outcrop and Peak 790 are cut by small (less than 2 m), east-west trending vertical dykes composed of an ultrabasic material, also possibly related to Robertskollen. On the main cliff, this dyke forms the prominent gulley in the centre of the outcrop. The intrusion forms a major sill which intruded the sedimentary rocks of the Ritscherflya Supergroup.

No sediments are exposed at Vesleskarvet, although small glacial erratics of such sedimentary rocks were found at Peak 790, which were probably derived from nearby Lorentzenpiggen. The intrusive rocks have not been specifically dated, but are probably in the order of 1500-1400 million years old, and have undergone relatively little alteration since 1100-1000 million years ago.

Well developed jointing is characteristic of the outcrop, with two main directions (270° - 280° and 350° - 360°) and two sub-sets (320° - 340° and 20° - 30°). The prominent jointing results in a very blocky surface, with up to 1 m to 2 m angular boulders forming a frozen surface scree. This frost-shattered boulder layer is from 500 mm to 4 000 mm deep. The boulders are oxidized to a dull reddish-brown colour, but no other major weathering is present. Within this boulder layer, some erosional fines have been formed into a crude patterned ground, and proto-soils are present. In other areas, surface water and ice is abundant, and running water was detected beneath the surface on warm days.

The suitability of the bedrock for construction purposes is undoubted, since the rock is relatively homogeneous, with no major bedding or facies variation. It is very hard and durable, and similar material is used world-wide as road-stone.

The shape of the outcrop at Vesleskarvet indicates that the ice forms only a thin veil on the eastern flanks, gradually increasing in depth with distance from the outcrop. Ablation by wind, and through the warming effect of the rock, are significant. No crevasses are anticipated on the eastern flank.

2.1.5 FOSSILIZED MATERIAL

Due to the igneous nature of the rock outcrop, there are no fossils at this site. No fossilized material has been described at any outcrop in the Ahlmannryggen area, the rocks being Proterozoic in age and therefore too old.

2.1.6 GEOPHYSICAL NATURE OF VESLESKARVET

a) Introduction

Approximately one week was spent at Vesleskarvet at the start of the 1991/1992 season, prior to any construction activities. The objectives of the geophysical surveys which were conducted included:

i) Ground total-field magnetic coverage of the intended localities for the new base and associated scientific stations. The objective was to map the magnetic fields present in the southern buttress of Vesleskarvet, and in so doing to identify an area of lowest possible field gradient as a future site for the three-component base magnetometer (see Appendix 2, Figure 3).

ii) A point of concern raised in the initial site suitability report is the possible magnetic effect of the nunatak's rocks on the future base magnetometer observations, induced by magnetic storms and normal Sq variations. For this purpose, a magnetic susceptibility survey of both buttresses was done.

iii) Depth soundings using the seismic refraction technique were conducted at selected localities. These surveys were performed using the University of the Witwatersrand's Geometrics seismograph.

b) **Total-field ground magnetic survey**

Three preliminary paced, magnetic traverses over the southern buttress of the nunatak were conducted. This was done so as to obtain a preliminary idea of the magnetic field of the nunatak. A preliminary magnetic-field contour map, based on these results, was used to determine both the extent of the grid and the optimum grid spacing.

The preliminary survey showed that a suitable base magnetometer site could be conveniently located on the ice to the east of the nunatak surface. The presence of a hidden ultra-mafic dyke, striking in a roughly easterly direction from the gulley between the two buttresses of the nunatak, was discovered. The gulley was formed by differential weathering of this dyke.

The final total-field magnetic contour map (Appendix 2, Figure 3) adequately fulfils the initial objective.

c) **Induced magnetic effects**

A total of 430 magnetic susceptibility readings were taken *in situ* on the exposed rock at 18 different localities evenly distributed over the two buttresses.

A Scintrex CTU susceptibility meter supplied by the University of the Witwatersrand was used. The susceptibility was found to vary by up to 50 % or more on a small scale, even within the scale of one boulder. This is not unusual and reflects the normal variation of magnetic concentration within rocks of a diabasic nature. For this reason 20 to 30 readings were taken at each locality, within a radius of 20 m.

The average values for each locality were found to be statistically similar when considering the standard deviation at each locality. This indicates that the rocks comprising the nunatak are essentially homogenous from a bulk point of view. Since it is the bulk effect of the nunatak that is of interest, it was decided to calculate a mean value from the 18 locality averages.

The mean value of susceptibility for Vesleskarvet (based on the 430 readings) is thus:

$k = 0.01005$ SI system
(standard deviation = $+ 0.0014$)

The magnetic induction effect of the rocks on the base magnetometer may be calculated from the formula

$$M = kH = 0.01H$$

where:

M = induced magnetic field
H = induced field variation

The induced magnetic field will therefore be 1% of a time-variable magnetic storm or Sq value.

For example, a magnetic storm of maximum amplitude 2000 nT will induce an additional field component in the rocks (additional to the local field value) of 20 nT.

From a practical point of view, the position is only 300 m from the scientific block of the new base. This fulfils the requirements that the maximum length for the cables of the 3-component magnetometer and the ULF pulsation magnetometers, running from the sensors to the magnetometers, should not exceed 500 m.

The site as identified above is thus suitable for geomagnetic field recordings for the geo-physical programme at Vesleskarvet.

d) **Depth determinations**

Forward and reverse seismic refraction soundings were conducted at three localities. Two of the localities were situated in line with each other from the gulley to the construction base. The third sounding was positioned a few hundred metres south of the southern buttress at a possible site for the HF radar. Forward and reverse profiles were conducted from which depths were determined. More depth soundings were conducted during the 1992/93 season at the locality of the base magnetometer.

The seismograph used employs a hammer and striker plate as an energy source. This limits the depth that can be probed. Nevertheless, a minimum possible depth can be calculated based on the 100m survey line to the south of the nunatak. The minimum possible depth to bedrock is 35 m at this locality. A weigh-drop system or explosives would be needed to probe to greater depths in the future should this be required. In addition, the application of seismic reflection techniques, using a hammer as a source, should be investigated.

e) **Conclusion**

The geophysical surveys described above have provided valuable information for the planning of scientific programmes at Vesleskarvet. No further work than the investigations already described above is necessary.

2.2 CLIMATE

2.2.1 INTRODUCTION

a) No meteorological observations have been done at the proposed new site and very little data from similar inland sites are available from which expected weather conditions at Vesleskarvet could have been derived. Comments regarding expected weather conditions must be considered as "best estimate". For a true assessment at least two years comparative data would be required.

b) The main source of meteorological information for this assessment is the present SANAE III weather station, and this data was used as a point of departure in an attempt to estimate possible conditions at the new site.

c) While the above situation is far from ideal, in the absence of better baseline data, nothing more could be done other than to be aware of these shortcomings.

2.2.2 WIND

One of the most important elements, and also the one around which the most uncertainty exists.

a) **General wind conditions**

The most frequent and severe winds at SANAE are from the north-east, east and south-east (see Appendix 5, Table 1 and Table 6). Average speed for east and south-east winds is 10,6 m/sec., the highest hourly speed was north-east at 49,5 m/sec. and the highest recorded was east-south-east at 64,8 m/sec. The total occurrence from these two directions is 64 %. These winds are generally caused by a belt of low pressure systems around the coast. The low pressure systems do not normally reach far inland, but it is not known how far they actually do penetrate. At Vesleskarvet the effect of these systems will be less and winds caused by them should be more moderate.

Winds (at SANAE III) from the south and south-west are the next most frequent at 18,2 %. Although severe blows from these directions sometimes do occur, wind speeds are on average about half the force as easterly winds. Only one thing is certain about these (catabatic) winds and that is that they exist. They are caused by cold (heavy) air flowing from the inland plateau down the valleys towards lower lying areas - gathering speed along the way. At Vesleskarvet they will not yet have reached their full force. It is not known whether catabatic winds gain or lose speed over the ice shelf. Speed of catabatic winds at Vesleskarvet should be expected to be of the same magnitude as at SANAE III.

It is known that winds in the Antarctic plateau are moderate in comparison to those at the coast. Vesleskarvet, however, is on the edge of the plateau, and winds should therefore not be expected to be much lighter than at SANAE III.

b) **Local wind conditions**

The direction of sastrugis at the site of the base indicates the prevailing wind direction, and the size of the sastrugis give an indication of wind force.

Upper air data from SANAE III at the height of Vesleskarvet indicates a mean vector wind direction of 96° and wind speed of 4.4 m/sec.

Considering the size of the base in relation to the size of the mountain, it will have a small additional effect on wind flow patterns. The form of the base, being on stilts and having rounded edges, will also contribute greatly to reducing the impact on wind flow patterns (see Appendix 6, Diagram A).

i) Local Easterly winds

Less drifting snow (with resulting less accumulation) is expected than at SANAE III due to the reduced effect of coastal lows. Drifting snow should be further reduced by the rocky ground cover. The fact that the rocks are not covered by snow indicates that there is not enough drifting snow to cause any marked accumulation.

Due to the slight rise of the surface from east to west, there is a slight local increase in the wind speed which helps to clear the rocks from snow.

Heat from the sun is also absorbed by rocks and snow melts away. This might lead to another problem, in that water might run into tiny crevices in the rocks, freeze at a later stage, expand, and cause the rocks to crack.

ii) Local southerly and westerly winds

Winds from these directions will find the 150 m to 210 m cliffs a direct obstacle in their path. This will result in unpredictable, turbulent and gusty conditions above the edge of the cliff, whilst at the base itself where the wind sensors will be situated, there might be no indication that a wind is blowing. This could be dangerous for unsuspecting visitors or personnel. The dangers of helicopters landing in these conditions are obvious. As a precaution, a number of wind socks along the edge of the cliff should be considered essential.

iii) Catabatic winds

These are caused by cold air flowing from the Antarctic plateau towards the coast. The dynamics of these winds are not yet fully understood. They can be unpredictable, severe and very local. It is believed that severe local catabatic winds are more likely to occur in uneven mountainous areas and in deep valleys.

Although it is believed that Jekselen suffers from local catabatic winds, there is no reason to suspect that Vesleskarvet will be subject to similarly severe local conditions, being relatively isolated and high.

2.2.3 TEMPERATURE FLUCTUATIONS

a. General

Temperature data from SANAE III was used as point of departure. Increased height above sea level will cause temperatures to be about 7 degrees lower than at SANAE III. Temperatures will be further reduced due to an additional 16 days of darkness. Being away from the moderating influence of the sea will cause temperature ranges to increase (Appendix 5, Table 2).

b. Summer temperatures

Average temperatures are expected to be between -10° C and -15° C. Extremes from +7° C to -25° C should be expected. During calm, cloudless days the rocks will have a warming effect.

c. **Winter Temperatures**

Average temperature is expected to be around -35° C. An absolute minimum of -60° C should be expected.

(A study of upper air temperatures at SANAE III at the height of Vesleskarvet proved fruitless because the new site is situated in an inversion range).

2.2.4 PRECIPITATION

Precipitation is expected to be negligible. Nil at the base itself, and 20 mm - 40 mm annually in surrounding areas.

2.2.5 CLOUD COVER

SANAE III has an average of 1 463 hours of sunshine annually, and 5/8 of cloud cover. A major cause of clouds at SANAE III are the coastal low pressure systems. It is not known how far the influence of these reach inland, but cloud cover is expected to be less than at SANAE III. In addition, the warming effect of clouds will be reduced, contributing to the drop in average temperatures.

Local orographic clouds which normally cover only the tops of the mountains are not expected to be a frequent occurrence. (Appendix 5, Table 2).

2.2.6 DAYLIGHT AND DARKNESS

(The only element which can be calculated with absolute certainty).

Compared to SANAE III, the number of days with the sun continuously **above** the horizon will increase from 70 to 78.

The number of days with the sun continuously **below** the horizon will increase from 56 to 72.

"Sun above" days: from 13 November to 29 January.

"Sun below" days: from 17 May to 27 July.

Solar elevation:
22 December 12:00 - 41.78°, 00:00 - 05.12°.

Solar depression:
21 June 12:00 - 05.12°, 00:00 - 41.78°.

These are 1.37° lower than at SANAE III (Appendix 5, Table 3 and Table 4).

2.2.7 DEPLETION OF THE OZONE LAYER

a) **Background**

The ozone layer, approximately 20-35 km above the earth's surface, consists of molecules made up of three oxygen atoms. It screens out harmful radiation, in particular, ultra-violet rays. Man-made gases such as chlorofluorocarbons (CFC's) and halons, which have several uses in industry, yield atoms of chlorine and bromine which attack and destroy ozone molecules causing depletion of the ozone layer. It is still too early to identify definite trends in ozone depletion, but the situation is expected to deteriorate for several more years before any improvement could be expected.

b) **Current trends**

Independent observations from ground-based Dobson and M-83/124 instruments and the TOMS satellite instruments all show for the first time, that there are significant decreases in total-column ozone. This is after accounting for natural variability in winter, spring and summer in both the northern and southern hemispheres, at middle and high latitudes. Strong indications of Antarctic ozone holes have continued to occur. The recorded composition of the ozone layer in the late 1970's was used as a base for this comparison.

Significant increases in surface ultraviolet radiation have been observed in Antarctica during periods of intense ozone depletion. As a rule of thumb, for every 1 % decrease in total-column ozone, there is a 2 % increase in surface ultraviolet radiation.

Increased surface ultraviolet radiation may cause building materials such as plastic and fibre-glass to deteriorate faster. This will have to be taken into account in the construction of SANAE IV. Obviously the risk of contracting skin cancer will increase if precautions are not taken, and the issue of high-quality eye and skin protection to all personnel is imperative.

2.3 BIOLOGY

2.3.1 INTRODUCTION

As far as can be ascertained Vesleskarvet was first visited by scientists in 1971/72 (Schaefer 1973). The locality has since been visited a number of times by South African geological field teams (e.g. Schonfeld & van Zyl 1974).

The only detailed biological study that has previously been undertaken in the Ahlmannryggen was carried out at Robertskollen during 1987 and 1988 (Ryan et al. 1989), which supports a breeding population of 600 pairs of Snow Petrels. The nutrient input from this bird colony contributes to a relatively higher biotic diversity at Robertskollen than at other nearby nunataks.

Robertskollen is also known to support the following:

a) Three species of mite,
b) four species of moss,
c) 20 lichen species,
d) 17 algal species,
e) various micro-biota

(Ryan et al. 1989).

The foliose lichen (*Neuropogon sp.*) collected at Vesleskarvet in 1991 had not previously been recorded in this area. It is concluded that this was because of the low level of sampling that had been done in the area.

A two-man biological team from the Percy FitzPatrick Institute of African Ornithology, University of Cape Town, spent seven days at Vesleskarvet during December 1991 carrying out a preliminary biological survey of the area. Two biologists from the same institute again visited the site for eight days during the 1992/1993 take-over period.

2.3.2 FAUNA

a) Avifauna

No presence of birds has previously been reported from Vesleskarvet (Schaefer 1973; Schonfeld & van Zyl 1974; Krynauw et al. 1983; Ryan & Watkins 1988; Swart 1989).

During the preliminary biological survey (1991/1992) four species of birds were recorded at the nunatak. Snow Petrels Pagodroma nivea were the most common animals. They were most often seen flying over the northern buttress of Vesleskarvet, and their numbers varied between ten and thirty birds at any one time. The birds appeared to be attracted to the northern buttress, wheeling and flying very close to the rock for up to an hour at a time. Similar observations were made during the 1992/1993 survey.

Snow Petrels are not thought to breed at Vesleskarvet for a number of reasons. At the time the biological survey was conducted, Snow Petrels would have been incubating eggs (e.g. Ryan & Watkins 1989). The cliffs at Vesleskarvet which could not be scaled were searched for signs of breeding using binoculars, but no nests or mumiyo (a subfossilized mixture of cream coloured guano and regurgitated proventricular oil which marks the entrance to many Snow Petrel nest chambers) were seen.

None of the Snow Petrels seen at Vesleskarvet had stomachs stained with dirt - a common occurrence in incubating birds. Snow Petrels undertake courtship feeding which leaves individuals with clearly visible orange stains of proventricular oil on their white plumage but, although Snow Petrels at Robertskollen colony were seen with stained plumage throughout the breeding season (pers. obs: Dr WK Steele), no stained birds were seen at Vesleskarvet.

Snow Petrels were not heard to call at Vesleskarvet whereas at breeding colonies, birds do sometimes call from the nest chamber.

Neither were courtship flight displays seen at Vesleskarvet, whereas these distinctive displays were common over the breeding colonies at nearby Robertskollen.

Although Snow Petrels were twice seen to land at the northern buttress of Vesleskarvet only one individual stayed in the rocks for longer than a few minutes and it is probable that these were non-breeders investigating potential nest sites rather than breeding birds. The remains of a Snow Petrel egg were found in the regurgitated cast of a South Polar Skua Catharacta maccormicki cast at Vesleskarvet, but this egg may have been collected from the nearby Snow Petrel colony at Robertskollen.

Flocks of Antarctic Petrels *Thalassoica antarctica* were twice seen overflying Vesleskarvet during the period of the first biological survey. The remains of an Antarctic Petrel were found in a second South Polar Skua cast collected at Vesleskarvet. Antarctic Petrels usually breed in large, easily identifiable colonies but no evidence of breeding by this species was found on or in the vicinity of Vesleskarvet.

Only one Wilson's Storm Petrel *Oceanites oceanicus* was seen during the 1991/1992 survey at Vesleskarvet.

During the 1991/1992 visit, single South Polar Skuas were seen flying close to Vesleskarvet. Other evidence of the species' presence, in the form of footprints and two regurgitated casts, were found on Vesleskarvet itself. One of the birds seen was flying towards Robertskollen. It is known that Robertskollen supports a resident pair of skuas which prey on the breeding Snow Petrels as well as on other birds (pers. obs: Dr WK Steele). Signs of breeding by South Polar Skuas were searched for but not found at Vesleskarvet and it would appear that during the summer months a small number of skuas occasionally visit Vesleskarvet from other nunataks but do not breed there.

The transport route between Penguin Bukta (the ship off-loading point) and the proposed site of the new base is likely to be overflown by flocks of those four seabird species which breed on continental Antarctica (Snow Petrel, Antarctic Petrel, Wilson's Storm Petrel and South Polar Skua), flying between inland breeding sites and their foraging grounds at sea.

b) **Arthropods and microbiota**

Rocks and soil down to 25mm within the fixed quadrants and at a number of other sites were searched for arthropods using a 10x hand-lens. No mites or collembolans were found at Vesleskarvet, although this should not be taken to indicate that these taxa are totally absent.

Small soil samples were collected from each quadrat in order to determine the species composition and abundance of the microbiotic communities. Three replicate soil samples were collected from each quadrat for the enumeration of each of the following taxonomic groups:

i) Arthropods;
ii) tardigrade;
iii) nematodes;
iv) fungi;
v) microalgae;
vi) protozoans and
vii) bacteria.

In addition, larger samples were collected from which to identify micro-organisms and obtain species lists for each of the taxonomic groups listed above.

Finally, soil samples were collected from quadrants to determine soil variables including chlorophyll content, percent organic matter and nutrient levels.

Two new species of terrestrial tardigrade, one from each of the genus Hebesuncus and Macrobiotus, were discovered in samples taken from the southern buttress during the 1991/1992 visit. During the 1992/1993 visit, 50 soil samples were taken from the nunatak.

From these samples, it was determined that the range of these undescribed species extends to both lobes, and that the proposed base will therefore not constitute a threat to their survival. It does, however, hold implications for human activities on the northern lobe, and these are addressed in Chapter 7: Recommendations.

The analysis of these samples was done by Dr Hieronim Dastych of the Zoologische Institut und Zoologische Museum der Universitat Hamburg, who completed the sample analyses at very short notice for the Department.

2.3.3 FLORA

During the preliminary biological survey at Vesleskarvet two transects were set up across the upper plateau of the nunatak. The positioning and direction of these transects were essentially random, although a transect was positioned across each of the two lobes of Vesleskarvet. Three quadrants of 2,5 m x 2,5 m were then established along each transect and the centre of these quadrants permanently marked with a short, numbered metal stake. These fixed quadrants and a further 30 randomly positioned plots of 2 m x 2 m were searched for signs of plant growth.

From these and later observations, it is concluded that the vegetation at Vesleskarvet is restricted to lichens. Although four moss and at least three macroalgae species are found at Robertskollen, no moss or macroalgae were found at Vesleskarvet during the biological survey. A total of nine lichen species were identified:

a) *Buellia spp.* (two species);
b) *Umbilicaria decusata;*
c) *Usnea sphacelata;*
d) *Acarospora gwynii;*
e) *Lecanora expectans;*
f) *Pseudephebe minisculata;*
g) *Xanthoria elegans;*
h) *Rhizocarpon acographicum.*

The most densely vegetated area comprises less than 0,5 % of the ice-free area, and is dominated (30 % cover) by the foliose lichen *Umbilicaria decusata* and fruticose lichen *Usnea sphacelata*. Their range is restricted to the northern buttress of Vesleskarvet which is a relatively wind-free area, and both were found only in this area. The remaining area of the nunatak is very sparsely vegetated, with the southern buttress being distinctly more barren than the northern. Of the 30 random plots surveyed, only nine had lichens present, the largest patch being no more than 60 mm. The lichen patches were invariably found in wind-sheltered crevices.

During the same summer (1991/1992), all of these species were found at Robertskollen and Boreas. No species endemic to Vesleskarvet were found during the survey. At this stage it is not possible to say therefore what plant life there is on the cliffs of Vesleskarvet, but from experience at Robertskollen *Xanthoria elegans* is expected to be present in a low density.

2.3.4 SUMMARY

It can be stated with a fair degree of certainty that in the absence of the proposed activity, i.e. building a new South African Antarctic base, the future environmental reference state (cf Madrid Protocol, Article 3, paragraph 2b) at Vesleskarvet would be no different to the present state described above.

CHAPTER 3

PROJECT PROPOSAL AND SCIENTIFIC STRUCTURES

1. INTRODUCTION
2. STRUCTURAL AND ARCHITECTURAL DESIGN CONCEPT
3. MECHANICAL DESIGN CONCEPT
4. ELECTRICAL DESIGN CONCEPT
5. SCIENTIFIC STRUCTURES
6. LOGISTIC CONSIDERATIONS: CONSTRUCTION PHASE

CHAPTER 3

PROJECT PROPOSAL AND SCIENTIFIC STRUCTURES

3.1 INTRODUCTION

The design of the base was a joint effort between the DPW, the DEA and various private consultants. The chief consultant is the consulting engineering firm of Engelbrecht, van den Berg Inc. The base is to be constructed by a DPW team, but all components will be manufactured privately on separate tenders.

A rehearsal at assembling the basic structure will be held by the construction team in Cape Town before they move to the site.

3.2 STRUCTURAL AND ARCHITECTURAL DESIGN CONCEPT

In principle, the structure shall consist of numerous prefabricated components which will be assembled on site. This is to facilitate transport operations over the long distances involved. The following details are representative of the design concepts:

3.2.1 FORM

The external shape of the structure was dictated by wind flow, turbulence and snow drifts effects. In other words, SANAE IV was designed from the outside-in, forcing trade-offs between normal architectural design practice and near optimum wind profiling.

The result was a base consisting of three interlinked double storey units each with plan dimensions of approximately 14 m by 44 m (see Appendix 2, Figure 4). The units are to be spaced 10 m apart, and joined by interlinking passageways on the lower level. The main entrances will extend to ground level from the passageways.

The internal arrangements have been done so as to separate non-compatible activities (see Appendix 2, Figure 5a, Figure 5b and Figure 5c). Block A contains the laboratories and over-wintering team's sleeping quarters, Block B the summer personnel and visitors sleeping and recreation facilities, as well as the over-wintering team's dining and recreation areas. The food stores separate the kitchen and dining from the recreation areas. Block C contains the effluent treatment plant, generators, workshops, waste treatment and storage and hangar spaces.

Rounded corners and edges with a 1.6 m radius on all buildings were utilized to reduce drag and minimize the effect on the oncoming snow bearing winds. Together with the minimum clearance height of 3.5 m and approximately 50 m from the base to the edge of the nunatak, snow drift deposition will be reduced to the extent that it would require minimum maintenance. Design parameters for the base structure were obtained from wind tunnel tests done on a scale model by the CSIR in Pretoria.

3.2.2 FOUNDATION

The column supports will be fixed to 220 mm diameter steel columns anchored to the rock surface by 1,5 m to 2 m long rock anchors. Drilling will start below the weathered zone of the rock surface, and all holes will be sealed to prevent further deterioration due to thawing and freezing action.

3.2.3 STRUCTURE

The main structure will consist of appropriately shaped rectangular steel frames at 3,2 m centres clad with fibre-glass panelling. The frames will be constructed of hollow sections of grade 300 WA steel. These will rest on 200 mm square steel hollow sections in a triangulated braced configuration.

3.2.4 CLADDING AND MATERIALS

Suitable materials for the structural walls were investigated and measured against the following parameters:

a) Antarctic Treaty requirements (as interpreted by the DEA). In this respect, the use of polyurethane was considered unacceptable and the use of panels utilized in previous designs was precluded. A comprehensive fire protection system was designed, which included protective coatings to a CFC-free, rigid polyisocyanurate foam used as core for the building panels. The foam has an oxygen depletion potential of less than 0.1.

b) Cost effectiveness. The initial concept proposal required the application of carbon fibre or kevlar insulated composite panels and columns. These elements would weigh at least 1/5 (one-fifth) of a comparable steel element. It was planned that the panels would be connected together to form an integrated tubular structure, thus eliminating a distinct structural supporting framework and utilizing the composite skin as part of the structural strength. This option proved to be inhibitively expensive.

3.2.5 DESIGN ELEMENTS

Further investigations were done applying the above-mentioned concept but utilizing polyester resin and glass-fibre composite panels. This option was still not cost effective, so further alternatives were considered, resulting in a design incorporating the following design elements:

(a) A combination of conventional steel structural frames with polyester resin glass-fibre sandwich panels with rigid polyisocyanurate foam cores was eventually decided on. This option achieved the desired balance between handling capabilities, design loading requirements, frame spacings, anchor bolt sizing and logistic constraints.

(b) Fibre-glass cladding panels will locate between the structural frames with appropriate connections and silicone seals. To ensure that there is no ingress of wind and moisture, sealants remaining elastic in the -60° C temperature range will be used. The panels will be pigmented in the required colours ensuring UV-resistance, colour retention and immunity to the abrasive actions of snow carrying winds.

(c) The inner living spaces will be protected by a double panel system with a 120 mm thick insulated outer panel consisting of glass-fibre reinforced polyester resin skins, separated by a CFC-free polyisocyanurate foam. The outer panel will be followed by a 100 mm cavity filled with glass-fibre insulation, followed by a 200 mm thick internal fibre-glass panel of similar construction as the outer (see Appendix 6, Diagram B). The internal panels will also be coated with fire retardant resins and anti-fume coatings to give a fire rating of 60 minutes while retaining structural integrity. The effective U-value is approximately 0.15 $W/m^2{}^\circ C$. The concept utilizes these properties by protecting the steel frame from any internal fires for more than 60 minutes. The probability of an external fire with damaging capabilities on the steel structure is taken as insignificant. The sound attenuation of the panel is approximately 40 dB.

(d) The windows are to be triple glazed with a 6 mm shatterproof armour-plated anti-sun grey external glass pane, a 13 mm void, a 4 mm shatterproof armour-plated low E glass pane with a grey coating, another void of 13 mm followed by another 4 mm glass pane, surrounded by acoustic foam set in a UPVC frame (see Appendix 6, Diagram C). This results in a 40 mm total width. This design will dampen any external noise and gives a thermal U-value of better than 1,2 W/m^2 °C to minimize heat loss. Maximum possible energy conservation is of concern here.

(e) Internal partition walls will have similar properties as the external panels. This will effectively contain fires to the space enclosed by these walls. All carpets and wall paper will be of non-combustible and non-toxic fabric where possible.

(f) Service shafts are located along the perimeters on each floor as well as two vertical shafts at the ends of each building and in a false ceiling along the passage. The internal partitioning within the service shaft effectively isolates the individual services from each other, so that no fire transfer or interference is possible. No lining is needed in the ventilation shaft as the units are hermetically sealed during the manufacturing process of complete panel segments.

g) Reticulation outlets from the partitioned cavities will be from below at positions pre-determined by the service layouts. False floors on the lower floor will be placed only as required in areas where services specifically need to be reticulated i.e. in ablutions.

3.3 MECHANICAL DESIGN CONCEPT

3.3.1 VENTILATION AND CLIMATE CONTROL

a) Climate control will consist of three components:

i) Fresh air supply to each room at 18° C.
ii) Space heating, thermostatically controlled at 18° C to off-set space heat losses.
iii) Humidifying of fresh air supply to 50 % RH at 18° C.

b) The fresh air will be heated in a hot water coil in the air handling unit and distributed through a perimeter duct with an outlet in each room.

c) Each space will be heated with a skirting type heater (thermostatically controlled). Heaters can be pulsed and individually switched on or off through the energy management system if so required.

d) Humidifying will be done at each air handling unit.

e) The heating loads were calculated with following assumptions:

   i) Indoor temperature = 18°C @ 40% - 50% RH
   ii) Glass U-value = 1,2 W/m^2°C
   iii) Wall/floor U-value = 0,15 W/m^2°C
   iv) Fresh air supply = 1 1/s/m^2
   v) No infiltration due to high wind speeds as building is virtually air tight.
   vi) Minimum ambient temperature is -50° C and maximum ambient temperature is -4° C.
   vii) All areas are occupied for 12 hours per day throughout the take-over period, while in summer 70 % and in winter 50 % of all areas are occupied for another 12 hours per day .

3.3.2 WATER PRODUCTION, HEATING, RETICULATION AND STORAGE

a) Snow melting will utilise electric elements, in a similar way as the existing snow melter. A bell type heater and sump pump system is an option which is being considered for possible future use.

b) Hot water will be generated using heat reclaimed from the generator engine coolant liquid and exhaust gases.

c) Heated fresh air is to be produced using hot water generated in the same way as described in paragraph 3.3.2 (b) above.

d) Hot water will be stored in a thermal storage vessel with a capacity of 3 300 litres.

e) Projected water consumption is based on the following figures:

   i) Permanent staff: 18.
   ii) Temporary staff: 62 (for a 10 week period per year during the summer months).
   iii) Hot water usage per day: 85 l/person.
   iv) Cold water usage per day: 65 l/person.

   (These figures are absolute maximums).

f) Hot water will be distributed at +60° C through-out the base via insulated copper piping.

g) Cold water will be distributed at +5° C throughout the base, also via insulated copper piping.

h) Cold and hot water circulation is done by means of circulating pumps.

i) The proposed system allows a 30 % reclamation of the generator engine exhaust heat and 90 % of the engine coolant heat. Based on this, the heat reclaimed from the exhaust gases and coolant are sufficient to generate hot water and heat the fresh air throughout the year except for a few months when additional electricity will be required to meet the maximum demand.

j) The diesel fuel consumption per year, based on the aforementioned and with no variation is approximately 520 000 l, including the fuel requirements for generating electricity for lighting, kitchen equipment, etc. The corresponding figure with assumed deviations for the various installations is 455 000 l/year.

k) The absolute maximum (theoretical) electrical load for the base is 420 kVA.

3.3.3 SEWAGE RETICULATION

a) Water supply pressures are based on close-coupled cisterns.

b) All drainage and sewage piping is insulated and has trace heating to prevent freezing.

c) All sewage will be drained to a reservoir in block C from where it will be pumped/macerated into the water treatment plant. The treated effluent water will be discharged over the edge of the nunatak. The concentrated sludge will be pumped into containers and be removed to the RSA for final disposal.

d) Valeathene piping is used throughout the building for the sewage reticulation.

3.3.4 GANTRIES, HOISTS AND ACCESS PLATFORMS

a) Gantries and hoists are also provided for the dry bulk store, over the generator units and in the hangar, for both vehicle maintenance and off-loading of equipment into the stores.

b) Two electrical screw drive lifts each 6 m x 8 m will be used to raise the vehicles to a height of 3 m above rock level to gain access to the hangar via the helipad. Provision is made to also manually operate the lifts in case of a complete power failure. In the raised position, the lift platforms form part of the helipad.

3.3.5 FIRE PROTECTION AND DETECTION

a) The proposed fire detection installation will be a standard (non-addressable), 24 V system. It will consist of the following main components:

   i) Ionization detector(s) in all the rooms, offices, laboratories, stores, hangar area, etc.
   ii) A mimic panel in the leader's office.
   iii) Batteries and battery charger.
   iv) Alarms
   v) Break glass units.
   vi) Conduit and wiring.

   Special attention will be given to static arrestor circuits.

b) Portable, dry chemical powder extinguishers (DCP) will be supplied and installed at strategic points throughout the complex.

3.3.6 FUEL RETICULATION

Polar diesel shall be pumped from the bulk fuel storage facility at the snow/rock interface to the generator plant room into a day tank with level control. Pumping will be controlled from the base and a double valve system will be on all the supply pipes. The responsible team member must refill the day tank by switching on the pumps at a maximum interval of 3 days. The sealed day tank will lie in an open topped container which will allow visual inspection of the bottom surface. The interior colour of the open container must be light, to facilitate visual inspection. An automatic monitoring system will also be installed. Specifications are listed in Chapter 5, section 5.3.3.

3.3.7 MEDICAL GAS

Oxygen and nitrous oxide are provided in the theatre, complete with isolating valve box, pressure gauges, etc.

3.3.8 ENERGY MANAGEMENT

a) Heat exchangers will be used to reclaim heat from the exhaust system and engine coolant liquid. For a typical 250 kVA generator unit, the input/output of energy is as follows:

i) 60 l/hr diesel consumption (energy input) which is equivalent to + 610 kW.
ii) 250 kVA electricity generated.
iii) 200 kW heat output through exhaust.
iv) 110 kW output through coolant.
v) 50 kW heat output through engine block.

b) Without reclaiming heat, the yearly diesel consumption would be approximately 750 000 l, compared with the 455 000 l as noted previously.

c) Energy management will also entail switching off of heaters, pumps, lights, etc. when not in use.

3.4 ELECTRICAL DESIGN CONCEPT

3.4.1 ELECTRICAL POWER GENERATION

a) Electrical power will be generated by water cooled Caterpillar D6 diesel generating sets with the cooling water and exhaust heat being recovered by means of heat exchangers.

b) Estimates indicate that the total connected electrical load for the new base is 1255 kW.

c) Maximum and minimum Electrical loads, taking variations into account for different times during the day was estimated for the following periods:

	Max	Min
Summer during takeover	267 kW	176 kW
Summer (non takeover)	264 kW	175 kW
Winter	364 kW	275 kW

d) From suitable options, either one 400 kW or two 250 kW generating sets would be required. Taking into account a de-rating factor of approximately 13 % due to the higher altitude of the site, the effective output of the engines would be 348 kW and 217 kW respectively. However, two small sets are preferred to one large set for the following reasons:

i) Ease of transportation. Weight limitations as well as ease of handling are major considerations.

ii) Flexibility. During low load conditions, one small set can be run, whereas one large set would be severely under loaded with detrimental effects to the engine. The larger unit will also consume more diesel.

iii) Ease of installation. A 400 kW set would not fit into the single storey accommodation allowed for the generator room and a double volume would be required.

iv) Upgrading. Allowance can be made for future expansion by alteration of the busbars and change over switches to allow 3 sets to be run.

e) A third unit will be installed as a spare, to enable maintenance of the two main sets and as an emergency plant. It is envisaged that the two generator sets running concurrently during peak loads would be synchronised. A manual control panel with mechanically interlocked switchgear will also be provided to implement the change-over from one set to another in the event that the automatic synchronisation fails. From the above estimates, two sets would only run together during the winter and the take-over period in summer.

3.4.2 UNINTERRUPTIBLE POWER SUPPLY (UPS)

a) The load requiring uninterruptible power is estimated at 20 kVA. The cost of one large UPS (R 100 000) is less than that of several smaller units. However, due to the difficulties of maintenance at such a remote site, it is recommended that two 10 kVA UPS's supply the load. A third UPS will be held as a spare, and will have to be connected to a supply source in order to keep the batteries charged. The output terminal of the spare will be disconnected unless required.

b) The UPS's will supply "clean power" to the scientific equipment and other emergency services (i.e. emergency lighting) for a period of 15 minutes, which should be sufficient to allow the starting of the remote emergency generator.

c) Departmental policy only allows for the connection of operating theatre services to emergency power. However, as uninterruptible power will be available, the operating theatre will be supplied with it and 15 minutes is regarded as an adequate time interval.

3.4.3 ELECTRICAL LIGHTING

a) Due to fuel consumption being a major consideration, lamps with the highest efficiency must be used where possible. After gas discharge lamps of the high and low pressure sodium variety (which provide monochromatic light output and are therefore unsuitable for domestic indoor lighting), fluorescent tubes have the next highest efficiency rating.

b) Luminaries will be provided with 9 and 18 Watt PL fluorescent lamps for the main lighting. "Warm white" lamps will be used throughout to provide a comfortable effect. These lamps are available with a built in electronic igniter, eliminating the need for a separate igniter to be installed in the luminaire.

c) The types considered will be restricted to aluminium luminaries with glass lenses as opposed to polycarbonate, which becomes brittle under extremely dry conditions.

d) Only two types of luminaires will be used, thereby eliminating a variety of stock and facilitating maintenance.

3.4.4 ELECTRICAL INSTALLATION

a) The electrical installation includes all socket outlets and power points for the various appliances required, both inside and outside the new base, including the trace heating of water and sewerage pipes.

b) Busbar trunking, which can be pre-installed in the walls, is proposed to allow easy installation on site. This method will also allow greater flexibility in the positioning of socket outlets at a later stage, should the requirements of the scientists change. Similarly, busbar trunking will be used for the lighting circuits and can form part of the ceiling support. Channels will be built in the wall panels to allow for switches and wiring.

3.4.5 ELECTRICAL RETICULATION

Special cables able to withstand the low temperature and low humidity will be used for all cables subject to such conditions. Indoor cables will be neoprene. Outside cables will possibly be run on a catenary. The number of different cable sizes will be limited to a minimum, ie: 4 mm^2, 25 mm^2 and 120 mm^2. By using heavier conductors the number of circuits can be reduced to the minimum practicable.

3.4.6 ELECTRONIC RETICULATION

This comprises the wiring between the scientists' computers Local Area Network, instruments, PABX, heater tape alarm system and monitoring systems. Where possible the same cable sizes as the electrical reticulation will be used to ensure a robust system and to reduce the variety of spares necessary.

3.4.7 PABX SYSTEM

An Integrated Service Digital Network (ISDN) is proposed for the PABX system to allow future telephone communication facilities with the RSA via satellite. A normal PABX system cannot be used and later upgraded. It is estimated that a system comprising 40 extensions would be required.

3.4.8 FIRE ALARM SYSTEM

A "Firefite" fire alarm system has been installed at the present Antarctic and Island bases and has operated reliably under conditions of high static electrical discharges. Because of this and in order to maintain compatibility with the existing systems and reduce the number of spares, the "Firefite" will be installed.

3.4.9 EARTHING SYSTEM

A satisfactory electrical earth was measured during the 1991/92 summer take-over via the rock where the anchors will be placed. Additional earthing can be obtained by inserting earthing rods connected to earth conductors into holes drilled into the rock. All metal parts of the building will be joined to this, including the generator's neutral connections (these by means of $70mm^2$ bare earth conductors).

3.4.10 ANTI-STATIC PROTECTION

"Energon" and "Tranzorb" devices will be supplied at distribution boards for the protection of all electronic equipment against any electrical surges and spikes which might occur.

3.4.11 CLOSED CIRCUIT TV SYSTEM

Allowance will be made for a closed circuit TV system between the TV lounges and the bedrooms. This is to enable team members to watch TV from their rooms if they do not wish to sit in the lounge. A simple distribution board employing amplifiers and co-axial cable leads to sockets in the rooms is proposed. The team members will be required to provide their own TV sets if they wish to use the system.

3.4.12 COMPUTER MONITORING SYSTEM

a) A base monitoring system is envisaged to cover the following:

- i) temperatures
- ii) fuel consumption
- iii) air flow
- iv) water consumption
- v) structural stresses
- vi) electrical power consumption
- vii) coolant water temperatures
- viii) exhaust temperatures.

These are to be electronically recorded and stored on a personal computer.

b) The data could be transmitted daily via the DEA to the DPW for analysis. Such a system requires analogue to digital convertors for each of the transducers, communications with the central control unit and a personal computer to analyze the data received.

c) The minimum platform required would be a 386SX CPU.

d) It is essential that the software must be supplied with the source code and must be written in a commonly used language to enable on site maintenance if necessary, as no technical support will be available.

e) The main purpose will be to give early warning of abnormal deviations from resident systems' operations. Fault finding and advice by experts in the RSA, based on the detailed available information, will be possible via satellite.

3.5 SCIENTIFIC STRUCTURES

3.5.1 MOTIVATION AND OBJECTIVES

a) **Antarctic Magnetosphere, Ionosphere Ground-based Observations (Project AMIGO)**

As stated in the SACAR 1 (South African Committee on Antarctic Research) Project Proposal, the goal of AMIGO is to contribute to the international cooperative programme STEP (Solar-Terrestrial Energy Programme), and to train high-level manpower by making coordinated ground-based observations of plasma and high energy particle phenomena at SANAE. To achieve this goal the following objectives are proposed:

i) To investigate energy transfer processes in the magnetosphere and ionosphere, especially those associated with substorms, VLF-particle interactions, radio propagation, hydro-magnetic waves, ionospheric irregularities and disturbances, by carrying out a programme of coordinated ground-based observations of wave and particle phenomena in the magnetosphere-ionosphere system using *inter alia*:

* Three component magnetometers, including instruments with sensitivity (a few nanotesla) for recording main field components and for studying ULF pulsations (frequency 1 Hertz).

* 64-imaging rheometers to measure ionospheric absorption of galactic radio noise. Of especial interest is the imaging rheometer with spatial resolution of approximately 20 km - 50 km at an altitude of 90 km.

* Auroral imaging devices. An all-sky low-light-level CCD television imaging system is the minimum instrumentation.

* VLF receivers which are capable of direction- finding.

ii) To observe and elucidate the nature of magnetospheric and ionospheric convection by installing an HF radar to follow the motions of irregularities in the ionosphere.

iii) To set up collaborative international programmes with scientists of the other Antarctic nations to meet the objectives of STEP.

iv) To use opportunities to collaborate with satellite experimenters as well as other special programmes such as SOLAR to provide further understanding of the energy transfer processes.

v) To train high-level manpower in advanced techniques of measurement and data analysis which have a wide variety of applications, in particular time- series analysis, image processing, software development and use of state-of-the-art technology (for example: CCD devices and advanced radar techniques).

b) **Antarctic Research on Cosmic Rays, or "Antarktiese Navorsing op Kosmiese Strale" (Project ANOKS)**

The purposes of this project are:

i) To investigate transport and acceleration of solar and galactic cosmic ray-charged particles in the heliosphere from neutron monitor recordings and to integrate these recordings with data obtained by neutron stations at other locations and by satellite and spacecraft observations.

ii) To continue hourly neutron monitor count rate data to World Data Centres for long-term investigations and small count rate data from studies of ground level solar events.

iii) To collaborate in international programmes such as COSTEP and STEP.

iv) To train high-level manpower in advanced techniques of data recording, data transfer and processing which have a wide variety of applications in geo-physics and technology.

3.5.2 PERMANENT OUTSIDE STRUCTURES REQUIRED

a) **Project AMIGO**

i) *Pulsation Magnetometers*

The sensors of these instruments will be enclosed in a small wooden box (a metre or less on a side) which will probably be buried in the snow at a distance of 100 m from the base, with cables running back to the observatory.

ii) *Imaging Rheometer:*

The imaging rheometer operating at 38.2 MHz employs a 64-element crossed dipole array, phased to produce 49 independent beams, each approximately 13° wide. The full set of beams is sampled by rheometer receivers. The array is a circularly polarized crossed dipole turnstile antenna, which projects a zenithal circular beam when placed a quarter wavelength above a perfect wire mesh ground plane.

The horizontal separations between the elements is one-half wavelength along each of two mutually perpendicular axes. One axis is aligned with the magnetic north-south line. The array covers an area of 50 m x 50 m.

The dipole elements are constructed of telescoping aluminium tunes, the length adjusted to the resonant length of an isolated dipole, elevated a quarter-wavelength over the ground plane.

Vertical support for the turnstile elements is provided by a telescoping pole, which is screwed into the rock. The antenna is situated 300 m from the main base, in an area unaffected by the other antennae. One power-cable and a set of eight co-axial cables are laid to the base.

iii) *Auroral Imaging*

This is all carried out from the base observatory itself, using low-light level TV cameras mounted on the roof of the building, and no outside structures are required.

iv) *VFL Receiver*

This requires a pair of crossed-loop antennae mounted on a tubular steel mast, as is currently installed at SANAE III. The mast is 12 m high and is anchored using nylon cables and steel chains to sleepers ("deadmen") buried in the snow.

With the loop aerials and stays, the antenna covers an area of approximately 50 m. It will be situated a few hundred metres from the base in order to minimize noise.

A small wooden box or hatch, approximately 1 m on a side, next to the mast will house the pre-amplifiers. Four co-axial cables will run from the pre-amplifiers to the remainder of the receiver in the base.

v) *HF Radar*

This will require a large antenna array situated within the area demarcated in Appendix 2, Figure 7. The antenna array consists of a series of 16 tubular aluminium antennae each 15 m long in line 300 m long overall.

A second identical row 15 m to the north of the first can be added later to improve performance if necessary. The height of the tubular masts on which the antennae will be mounted will depend on the position of the "ground plane", i.e. the depth of the rock below the snow at that point.

A small hut, of the size of a standard container or less, must be sited adjacent to the antenna array to house the transmitter, and cables will run from the hut to the antennae.

b) **Project ANOKS**

Two aluminium panelled 4,8 m x 3,6 m neutron monitor huts are bolted onto a square tubing framework. These frameworks are supported by four pillars each, that are screwed onto the rock foundation. After both huts have been erected they are hoisted roughly 1 metre above the rock surface.

The two huts contain three and four NM64 detectors respectively, with a combined weight of 8 000 kg. The huts are powered by one power cable and recordings are fed to the base by 18 co-axial cables.

c) **General**

An ice-path is to be provided over the rocks for scientists to gain access from the base to their equipment safely.

All co-axial and power cables will be suspended on a single handrail next to the ice-path. This will ensure ease of maintenance and augmentation of the system.

3.5.3 ENVIRONMENTAL, HEALTH AND SAFETY CONSIDERATIONS

a) **Project AMIGO**

The components of the project listed under 3.5.2 a) i) to 3.5.2 a) iv) above are all passive experiments, i.e. they monitor different events in the magnetosphere without, for example, transmitting any signal. There are however no high voltages involved (other than the normal voltages generated inside TV's etc.) or other possible hazards to the safety of the operators.

The HF radar on the other hand is an active project i.e. it transmits as well as receives. However, it merely transmits radio waves on frequencies in the normal HF ("short wave") band with a power lower than most commercial radio transmitters, and there are therefore no environmental concerns here either. The proposed radar is identical to instruments already installed at Goose Bay in Labrador (Canada) and the British Halley base in Antarctica. It therefore clearly satisfies the most stringent environmental impact criteria. While there are some fairly high radio frequency voltages on the transmitter, there are no dangerously high DC voltages.

b) **Project ANOKS**

The neutron monitor recording of cosmic rays is a passive experiment using computerized electronic equipment with no hazards to the safety of operators or the environment.

Other than the erection of the structures listed in section 3.5.2, the above projects should have no significant impact on the environment.

3.6 LOGISTIC CONSIDERATIONS: CONSTRUCTION PHASE

3.6.1 INTRODUCTION

The construction phase will extend over the 1993/1994 and the 1994/1995 take-over periods. It is planned that the base-shell and electrical and mechanical components will be completed by the end of the 1993/1994 take-over. The following year, the base interior will be fitted out, and the scientific structures will be erected.

3.6.2 PERSONNEL REQUIREMENTS

The personnel required for the construction phase for each of the two take-overs will entail approximately the following:

a)	DPW construction team to be based at Vesleskarvet:	64
b)	Environmental officers to be based at Vesleskarvet:	2
c)	Caterpillar drivers to transport materials and personnel from the ship off loading point to Vesleskarvet:	10
d)	Personnel who will visit the site periodically during the take-over (The DEA take-over co-ordinator and support staff, expedition members, helicopter crews of the two Puma helicopters, a chaplain, 2 photographers and 2 officials from the Department of Foreign Affairs):	19

3.6.3 VEHICLE REQUIREMENTS

a)	D6H LGP Caterpillar vehicles, each using a 3 306 direct injection engine with fuel consumption of 6 l / km:	4
b)	D6H LGP Caterpillar vehicles, each fitted with a 21 tonne crane:	2
c)	D4E Caterpillar vehicles, each using a 3 304 engine delivering 60 kW and a fuel consumption of 3 l / km:	2
d)	D4E Caterpillar vehicle fitted with a 9 tonne crane:	1
e)	Challenger vehicle using a 3 306 direct injection engine with fuel consumption of 4 l / km	1
f)	29 tonne Russian DT30 coupled track vehicles, each with a payload of 30 tonnes and a 540 Hp supercharged V8 engine:	2
g)	Alpine II skidoos, using 2-stroke ROTEX 503 engines with a fuel consumption of 4 km / l:	12
h)	20 tonne sledges, including those for fuel bladders:	20
i)	5 tonne sledges:	25
j)	Fuel pump stations on sledges:	2
k)	Personnel caravans, each to carry 20 personnel:	2
l)	Stationary 2 tonne cranes, each mounted on a sledge:	2

3.6.4 SUMMARY

6 Additional accommodation containers are to be added to the construction base. These, the total 920 tonnes of base construction materials and all support components (food, clothing, etc) will be transported by Caterpillar trains on the existing SANAE III -Grunehogna route to Vesleskarvet, as described in paragraphs 3 and 4 of section 2.1.2 of this report.

CHAPTER 4

WASTE MANAGEMENT

1. LEGAL REQUIREMENTS
2. SOLID WASTE MANAGEMENT
3. EFFLUENT MANAGEMENT
4. EMISSIONS

CHAPTER 4

WASTE MANAGEMENT

4.1 LEGAL REQUIREMENTS

4.1.1 INTRODUCTION

The key issue in addressing the legal and environmental aspects regarding the waste and effluent management of the new base is the formulation of a Waste Management Plan to maintain the pristine state of the Antarctic Treaty areas to the maximum extent practicable. The elements of the Waste Management Plan must comply with the requirements of the Handbook of the Antarctic Treaty System and contain methodologies and procedures to ensure its continuous implementation. It is believed that the conditions of the Antarctic Treaty encompass the objectives of international and South African legislation which are practicable for the protection of the Antarctic environment.

The applicable requirements of the **Antarctic Treaty System** are reflected in Annex 3 of the Madrid Protocol, which is included in Appendix 4 to this report.

4.1.2 FORMULATION OF A WASTE MANAGEMENT PLAN

The formulation of a Waste Management Plan is considered a key issue in addressing the legal requirements and environmental aspects with regard to the new base in Antarctica.

The Waste Management Plan must be reviewed and circulated in accordance with Article 9 of Part 2 of the Handbook of the Antarctic Treaty System. The final Waste Management Plan should be assessed and approved by the Department of Water Affairs and Forestry as well as by the Chief Directorate: Environmental Conservation of the DEA.

The Waste Management Plan should state the environmental conservation objectives and should address the following elements:

a) The appointment of a waste management officer responsible for the annual review and updating of the Waste Management Plan, to keep track of international environmental standards and to ensure the implementation of the Plan and a Code of Conduct.

b) The training of personnel involved in the Antarctic Project.

c) The separation of waste from both base and field operations into the different categories as required by the Madrid Protocol of 1991.

d) A waste disposal plan which considers both wastes generated at the base or as a result of field operations must be drawn up. It is suggested that in this plan the disposal of solid waste in the Antarctic Treaty area be prohibited. The waste should rather be compacted, stored and transported back to the RSA. Approximately 12 tonnes of compacted wastes will have to be removed every 12 months.

e) The Waste Management Plan should include an engineering plan, trouble-shooting and solution index and an operation plan of the selected sewage treatment system.

f) Materials prohibited for disposal in the Antarctic Treaty Area should be clearly listed. Examples of these materials are given below:

i) Radioactive materials;

ii) electrical batteries;

iii) fuel, both liquid and solid;

iv) wastes containing harmful levels of heavy metals or acutely toxic or harmful persistent compounds;

v) polyvinyl chloride (PVC), polyurethane foam, polystyrene foam, rubber and lubricating oils, treated timbers and other products which contain additives that could produce harmful emissions if incinerated;

vi) all other plastic wastes, except low density polyethylene containers (such as bags for storing wastes), provided that such containers shall be incinerated;

vii) fuel drums and

viii) other solid, non-combustible wastes.

These restricted materials must be stored in special containers before they are returned to South Africa.

The obligation to remove drums and solid non-combustible wastes should not apply in circumstances where the removal of such wastes by any practical option would result in greater adverse environmental impact than leaving them in their existing location.

g) Clean-up activities must be formulated, and carefully scheduled to ensure execution.

4.2 SOLID WASTE MANAGEMENT

4.2.1 INTRODUCTION

Whilst incineration is permitted under the Antarctic Treaty, SANAP managers have taken the decision to return all solid waste to the RSA. Material will be separated, compacted and stored in specialized containers before being returned.

4.2.2 WASTE VOLUMES

Based on the project proposal and personnel numbers given in Chapter 3, the following waste volumes are assumed. These are considered the maximum which the system will have to process.

Approximately eighteen people will on average be permanently resident in the base. These people will produce approximately 20 kg of solid waste and 4000 litres of sewage effluent daily.

The 20 kg of solid waste produced per day will, in accordance with normal calculations, consist of approximately the following:

a) 7 kg of perishables;
b) 4,5 kg of paper;
c) 2 kg of metal;
d) 2 kg of glass;
e) 0,5 kg of leather and cloth;
f) and 4 kg of miscellaneous waste.

These deductions are based on the typical municipal situation in the Republic of South Africa. As all items brought to the proposed base will be containerised with the minimum of packaging, these volumes are seen as maximums, and provision will initially be made for the full volume. The system will be scaled down as time progresses to a level entailing minimum logistic input without sacrificing safety or health considerations.

The summer field teams will return their solid waste (including excrement) to the base for inclusion into the system. It is foreseen that a maximum of 5 500 kilograms of sewage sludge will be generated per annum. The construction phase will also generate more metallic and plastic waste than normal operating seasons.

It is likely that research will be done resulting in the production of liquid and chemical waste as well animal tissue. More information on quantities will only become available once the type and extent of research has been determined, but provision will be made for these to be transported back to South Africa in dedicated containers.

4.3 EFFLUENT MANAGEMENT

4.3.1 INTRODUCTION

The sewerage effluent will be processed and the outflow will conform to general standards for outflow into rivers as prescribed by the South African Government Gazette No. 9225/18 May 1984.

4.3.2 PHYSICAL DESIGN CRITERIA

a) The plant will be placed within the structure on the normal floor finishes.

b) The plant will be a closed system with joints or gaps sealed with natural rubber packing.

c) The floor loads will be limited to 20 kN/m^2.

d) Permanent or temporary outlets of the system will occur outside the base.

e) Sewage products or sludge will not be handled inside the base. Extraction pipes and valves will allow sludge extraction in containers below the base.

4.3.3 PROCESS DESIGN CRITERIA

a) The design criteria used will be as published in "Manual on Design of Small Sewage Works" by "The Water Institute of South Africa" in 1988.

b) The sewage sludge will be transported back to South Africa in sealed containers.

4.3.4 PLANT PROCESS

The proposed plant employs the following three stage process (see Appendix 6, Diagram D):

a) **Primary Settlement**

Similar to the normal septic tank system with the following design elements:

i) Sludge storage capacity for 80 people for a period of 3 months plus 20 people for 9 months.

ii) In addition to the above, the hydraulic capacity at normal outflow conditions maintains a 6 hour retention period after sludge accumulation or one year with the sewage effluent of 80 people. A 24 hour retention period is maintained with a population of 20 people.

b) **An Activated Sludge Process**

i) The effluent from the primary settlement tank will flow directly into an activated sludge basin.

ii) Aeration in this basin will be by means of coarse bubble aeration.

iii) Average sludge age in the basin will be 15 days, and a total biological oxygen demand will be 6 kg/day (80 people @ Biological Oxygen Demand of 75 g/c/d).

iv) Withdrawal of the sludge to the secondary compartment of the primary settlement tank at appointed times by means of a recirculation pump in the aeration basin.

c) **Clarification of final effluent**

i) The activated sludge basin will incorporate the upward flow settlement process. The purpose is to drop the settlement sludge directly in the aeration tank without using the pumps.

ii) The settlement rate will be controlled so that the maximum upward speed will be 1 m/hr if the sewage discharge is limited to 3,3 l/sec.

d) **Contingency**

The internal layout of the plant is such that in the case of a total discontinuance of the proposed process, it can act as a septic tank with 1,9/7,6 days retention in the event of 80/20 member respective occupancy at the base.

4.3.5 DISCHARGE OF TREATED EFFLUENT

The final effluent will be pumped 50 m from the base over the western edge of the rock face. The following design elements will be included:

a) The discharge pipe will be fitted to steel columns above the ground due to the nature of the rock surface.

b) This will be a closed system sewage plant. The air bubbled through the active sludge basin will also exit through the discharge pipe. The result is that the pipe will have a continuous air flow of 18° C, which will in turn reduce the demand for heating of the outlet pipe.

c) The pipe will also be supplied with a defrosting element as well as 3 layers of heater tape to prevent freezing. The outlet point will also be heated to prevent ice stalactite formation. The heating element around the pipe will automatically be activated by the temperature of the pipe. A phase failure indicator will be provided every 10 m on the element.

d) An additional hand controlled discharge valve will be provided directly under the plant if the pipe has frozen closed.

e) It is not necessary to chlorinate the treated effluent as all bacterial activity will be terminated due to the low environmental temperature.

f) The clarity (colour) of the treated effluent is important as an indicator of effluent quality.

4.3.6 MECHANICAL APPARATUS

The sewage plant will include two permanent mechanical installations, namely:

a) One compressor with a standby unit, which will require checking on a regular basis regarding the oil consumption and general serviceability.

b) One centrifugal recycling pump with a standby unit which requires no maintenance, only testing regarding serviceability.

The primary settlement tank of the plant will be emptied using a portable sludge pump before desludging. Two of these pumps will be provided.

4.3.7 LOGISTIC REQUIREMENTS

The primary settling basin of the plant will be desludged once a year by the maintenance team during the take-over period. According to design criteria, 5 m^3 of sludge will be generated per annum. This sludge will be stored in approximately 27 specially designated 200 litre drums and transported back to South Africa along with the other solid waste containers.

Only after the first year of operation can an indication of the real number of drums required be obtained, as practical results have shown that the volume of sludge can be considerably less than estimated.

4.4 EMISSIONS

4.4.1 LEGAL REQUIREMENTS

a) **Antarctic Treaty and international law**

The Antarctic Treaty provides for the burning of waste preferably in incinerators designed to reduce harmful emissions to the maximum extend practicable. Should it be necessary to dispose of wastes by open burning, Article 3.1 of Annex III to the Protocol on Environmental Protection to the Antarctic Treaty states:

"Allowance shall be made for the wind and the type of wastes to be burnt to limit, as far as practicable, particulate deposition on land and to avoid such deposition over sensitive areas."

With regard to the use of chlorofluorocarbons (CFC's) by expeditions, the Vienna Convention on the Ozone Layer and the Montreal Protocol on Chlorofluorocarbons (of which the RSA is a signatory) provide for the phasing out of most CFC's by the year 2000.

b) **South African legislation**

South African legislation is not enforceable outside South African borders. Although the application of most South African acts in the Antarctic area is impracticable, the Atmospheric Pollution Prevention Act, 1965 (Act No 45 of 1965) has some relevance to the control of emissions at an Antarctic base. This Act makes provision in section 15 for the installation of fuel burning appliances :-

"1 No person shall install or cause or permit to be installed in or on any premises-

(a) any fuel burning appliance, unless such appliance is so far as is reasonably practicable capable of being operated continuously without emitting dark smoke or smoke of a colour darker than may be prescribed by regulation: Provided that in applying the provisions of this paragraph due allowance shall be made for the unavoidable emission of dark smoke or smoke of a colour darker than may be prescribed during the starting up of the said appliance or during the period of any breakdown or disturbance of such appliance;"

The guideline for power generators is:

Opacity of chimney emissions may not exceed 20%. (Opacity is the factor with which the air is darkened by smoke, measured in the chimney).

Section 16 of the Act provides for the siting of fuel burning appliances and construction of chimneys:-

"(1) No local authority shall approve of any plan which provides for the construction of any chimney or other opening for carrying smoke, gases, vapours, fumes, grit, dust or other final escapes from any building or for the installation of any fuel burning appliance, unless it is satisfied-

(a) in the case of any such chimney or other opening, that the height thereof will as far as practicable be sufficient to prevent smoke or any other product of combustion from becoming prejudicial to health or a nuisance to occupiers of premises in the surrounding areas; or

(b) in the case of any such fuel burning appliance, that it is suitably sited in relation to other premises in the surrounding areas."

4.4.2 ENVIRONMENTAL CONSIDERATIONS

Air pollution problems either arise when excessive amounts of gases/particulates are emitted into the atmosphere, or when under particular conditions the atmosphere is incapable of dispersing the emissions, or through a combination of these factors. Meteorological conditions, particularly wind speed and vertical temperature structure, determine atmospheric diffusion rates and patterns at any location. Wind speed is the most basic factor controlling air pollution levels - the higher the wind speed the greater the dilution of emissions.

In view of the strong and fairly regular winds occurring in the region of the proposed base, air pollution is not regarded as a potential significant environmental impact. Any emissions will normally be rapidly and thoroughly dispersed. It may happen that, during periods of temperature inversion, emissions will accumulate in the stable air layers, producing some air pollution. Due to the remoteness of the proposed base from any other point source of emissions, air pollution, even during periods of atmospheric stability, should be insignificant.

4.4.3 HEALTH AND SAFETY CONSIDERATIONS

Emissions from the two diesel generators motors will not be a health hazard provided that the necessary precautions are taken and the building is sufficiently ventilated. Outlets will be tall enough for proper venting of emissions to the atmosphere.

4.4.4 POSSIBLE IMPACTS

The expected environmental impact of the combustion of diesel oil will be insignificant.

4.4.5 MITIGATION

Alternative methods of electricity generation could be utilised (probably phased in). In view of the windy nature of the area the utilisation of wind power should be seriously considered. Even solar power could be considered as an option during the summer months. Although wind and solar power could not replace diesel oil generators, they could reduce the load on this polluting electricity source and thus limit air pollution as well.

4.4.6 PREFERRED ALTERNATIVES

A clean source of electricity such as wind and solar energy would be preferable to the proposed use of diesel oil generators. Since the former choice is obviously not practical at this stage, the use of supplementary sources of clean electricity in addition to diesel oil, should be seriously considered for the long term.

CHAPTER 5

POLLUTION POTENTIAL: FUEL AND OIL PRODUCTS

1. LEGAL REQUIREMENTS
2. ALTERNATIVE FUEL TRANSPORTATION OPTIONS
3. REVIEW OF BULK FUEL STORAGE OPTIONS

CHAPTER 5

POLLUTION POTENTIAL: FUEL AND OIL PRODUCTS

5.1 LEGAL REQUIREMENTS

5.1.1 INTERNATIONAL LAW

A number of international conventions exist to control the release of oil or fuel products to sea. These are listed below:

a) **THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION OF THE SEA BY OIL, 1954 (OILPOL):**

The general rule established by this convention prohibits oil discharges by vessels at sea within 50 sea miles of land. Later amendments prescribe structural characteristics of ships to limit the possibility of oil pollution occurring. South Africa is not a Contracting Party to this convention.

b) **INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973 AND 1978 (MARPOL):**

Annex 1 sets out detailed standards of operation and construction for ships carrying oil. This convention also prohibits the discharge of oil from a vessel (not a tanker) of 400 tons and above within 12 miles of land. The discharge of oil/water mixtures with an oil content of more than 100 ppm is prohibited outside the 12 mile zone. Antarctic waters have been designated as a "Special Area" where no oil discharges may take place. South Africa has acceded to Annex 1 of this convention which is embodied in local legislation in the form of the International Convention for the Prevention of Pollution from Ships Act, 1986 (No. 2 of 1986).

c) **Regulation 26**

This will shortly be introduced into Annex 1 of MARPOL which will require every ship other than an oil tanker of 400 tons and above to carry on board an oil spill response plan approved by the flag state administration.

d) **CONVENTION OF THE PREVENTION OF MARINE POLLUTION BY DUMPING OF WASTES AND OTHER MATTER, 1969:**

Also known as the London Dumping Convention (LDC), regulates the deliberate dumping of substances, including oil, from ships and aircraft. This excludes the disposal of waste incidental to the normal operation of ships and aircraft. South Africa is a Contracting Party to this convention which is embodied in the Dumping at Sea Control Act, 1980 (No. 73 of 1980).

e) **INTERNATIONAL CONVENTION RELATING TO INTERVENTION ON THE HIGH SEAS IN CASES OF OIL POLLUTION CASUALTIES, 1969:**

Provides that parties to the convention may take such measures as may be necessary on the high seas to prevent, mitigate or eliminate grave or imminent danger to their coastline or related interests from pollution or threat of pollution of the sea by oil following a marine casualty. It is unlikely that the provisions of this convention apply to South Africa's interests in Antarctica. South Africa is a Contracting Party to this convention which is embodied in the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties Act, 1987 (no. 64 of 1987).

f) **INTERNATIONAL CONVENTION ON CIVIL LIABILITY FOR OIL POLLUTION DAMAGE, 1969:**

Also known as the Civil Liability Convention or CLC. This deals with liability for oil pollution damage from ships carrying oil as cargo, i.e. it provides (with certain exceptions) that a party whose territory is damaged by oil pollution from a ship carrying oil as cargo may claim compensation from the owner of the vessel. The convention also requires all owners of ships carrying more than 2 000 tonnes of oil as cargo, and registered in a Party State, to be insured. As South Africa cannot claim Coastal State status in Antarctica it is unlikely that compensation can be sought in the event of an oil spillage. South Africa has ratified this convention which is embodied in the Prevention and Combating of Pollution of the Sea by oil Act, 1981 (No. 6 of 1981).

5.1.2 SOUTH AFRICAN LAW

a) **Dumping at Sea Control Act, 1980 (Act No. 73 of 1980):**

Unlike the London Dumping Convention, this Act does not prohibit the dumping of oil at sea. A permit, issued by the Department of Environment Affairs, is however required if this activity is envisaged. This only applies to oil that is dumped in South African territorial waters or loaded in our waters for the purpose of dumping elsewhere.

b) **Prevention and Combating of Pollution of the Sea by Oil Act, 1981 (Act No. 6 of 1981):**

This makes provision for the control of oil discharges within 50 nautical miles of the South African coast and hence does not apply in Antarctic waters. In terms of the CLC portion of this Act, South Africa would only be able to make claims against a ship owner for oil pollution damage if the vessel that caused the spill was carrying more than 2 000 tons of oil as cargo, was registered in a Party State and the damage was caused to some South African property i.e. one of its vessels. Environmental claims would not apply as South Africa does not have territorial rights in this region.

c) **International Convention for the Prevention of Pollution from ships Act, 1986 (No. 2 of 1986).**

In terms of this Act, South African vessels must comply with the Regulations relating to oil discharge monitoring, oily-water separating equipment, tanks for oil residues, etc. The details of these can be found in the Regulations contained in Annex 1. South Africa is also bound by the oil discharge regulations contained in Regulations 9 and 10 of the Act. Antarctic seas have now also been declared a "Special Area" where no oil discharges may take place.

5.1.3 ANTARCTIC TREATY

The following Antarctic Treaty Council Meeting (ATCM) recommendations apply to the control of oil pollution in Antarctica:

a) **1964 ATCM III:**

Article VII, paragraph 3, of the agreed measures makes it obligatory for each participating government to "take all reasonable steps towards the alleviation of pollution of the waters adjacent to the coast and ice shelves (of Antarctica)."

b) **1977 ATCM IX:**

Recommendation IX-6 drew attention to the need to examine the possible contamination of the Antarctic marine environment by oil.

c) **1979 ATCM X:**

Recommendation X-7 called on Treaty Party Governments to "...review their respective obligations under existing international agreements to which they are parties which relate to the reduction of contamination of the sea by oil and, in the light of the particularly hazardous nature of the Antarctic for ship operations, consider whether their compliance with these obligations adequately minimizes the risk of oil contamination of the Antarctic marine environment".

d) **1981 ATCM XI:**

The report records the following conclusions:

"a) In view of the nature of the present ship operations in the Treaty area, the application of the provisions contained in the existing international conventions for the prevention of oil pollution of the sea provide for the time being an adequate and sufficient basis for minimizing the risks of pollution.

b) Ship operations, especially tankers, always create some risk of pollution and this question should remain under continuing review by the Consultative Parties to ensure the adoption of the most appropriate prevention measures.

c) The setting up of protective walls around storage tanks where practical was appropriate for some areas on a voluntary basis."

e) **1989 ATCM XV:**

A recommendation to the Governments of the Treaty Parties on marine pollution included the following provisions:

"6. They establish contingency plans for marine pollution response in the Antarctic region, including plans for vessels operating in the Antarctic Treaty area, particularly vessels carrying oil. To this end they shall:

a) cooperate in the formulation and implementation of such plans and in responding to pollution emergencies in Antarctica; and

b) draw on the advice of IMO and other international organizations, as appropriate.

7, They convene, in accordance with Recommendation IV-24, a meeting of experts to consider and provide advice on the establishment of contingency plans for marine pollution response and additional requirements to reduce and prevent pollution of the Antarctic marine environment, giving due consideration to the need to avoid detrimental effects on dependent and associated ecosystems outside the Antarctic Treaty area".

5.2 ALTERNATIVE FUEL TRANSPORTATION OPTIONS

Two main options were considered for the transportation of fuel oil from the supply vessels in Penguin Bukta to the fuel storage tanks at the SANAE IV base.

5.2.1 STEEL CONTAINER TANKS.

This would involve the fuel being transported from Cape Town in 30 000 l steel tanks, with cradles, on board the S A Agulhas. At Penguin Buckta the tanks would be lifted off the S A Agulhas, using the ships cranes, and landed directly onto the sled on the ice shelf for transport to the base 220 km away. The capital cost of supplying tanks smaller than 30 000 l and the increased number of shuttle runs that would be needed to transport the annual supply of 600 000 l makes the use of smaller tanks impracticable.

The advantages are:

a) Elimination of the need to transfer the oil by pipe discharge from the ship to a shore tank, from the shore tank into a tank on the sled and from the sled tank to the permanent storage tank at the base. Each transfer operation contains an element of risk in spilling the oil.

b) The supply tanks could be used for permanent storage at the base, feeding directly into the day tanks.

c) The tanks, once empty, could be used as receptacles for liquid wastes that needed to be removed from the base to the vessel.

The disadvantages are:

a) Some difficulty could be experienced in off-loading tanks of this size from the vessel onto the ice shelf, with the possibility that the tanks may be dropped or damaged during the process which could result in an oil discharge into the sea.

b) Very substantial sledges would be required to transport such large tanks.

c) The possibility of wall failure due to slopping of the fuel, collision or other damage en route which would result in the release of large volumes of oil, cannot be ruled out.

d) Double-walled tanks cannot be used, so the inherent safety of this design feature is precluded.

e) A crane would be needed at the base to off-load the tanks from the sled.

5.2.2 FLEXIBLE BLADDERS

This would involve pumping the oil from the vessel to 12 000 l bladder tanks on the ice-shelf by means of hoses with quick-coupling connections and valves. The oil would then be transferred to smaller bladder tanks (7 000 - 9 000 l) contained in leak-proof cradles on a flat-bed sled behind a caterpillar. Once at the base, the fuel would be pumped from the bladder tanks to the permanent storage tanks.

The advantages are:

a) Large tanks, with the associated risk of a major spillage occurring during handling operations, would not be involved.

b) During transportation on the sled, the bladder tanks will be contained in leak-proof cradles which will contain small leaks that might occur on route.

c) Smaller tanks will be transported on the sled which reduces the risk of a large spill resulting from a major accident if larger tanks were involved.

d) The smaller tanks will be more manageable on route.

The disadvantage is that three transfer operations are required. This results in the risk of leakage or a spill at each stage.

5.2.3 SUMMARY

Each of the above options have clear merits, but it would appear that at present the flexible bladder option would be more acceptable from a practical handling point of view.

Which ever option is adopted, clear guidelines need to be developed for the transfer operations as human error is the prime cause of mishaps during these activities.

The piping and pumping arrangements will also have to be designed to minimize the risk of spillage from leaking joints, over-filling tanks, pipe maintenance, flushing of used piping, valve failure, etcetera.

5.3 REVIEW OF BULK FUEL STORAGE OPTIONS

5.3.1 FUEL STORAGE OPTIONS

A number of measures can be taken to reduce the risk and impact of fuel spillages at the fuel storage depot. The various design options for containment of fuel spillages from fuel storage facilities are depicted in Appendix 6, Diagram E.

Some of the more feasible options are assessed below:

a) **Horizontal double-walled storage tanks - inner wall steel, outer wall glass fibre.**

Advantages:

i) Provides a definite containment for tank wall failure leaks.
ii) Provides protection on inner tanks from corrosion and physical elements.
iii) The failure of valves and nozzles at or near the tank wall could be contained through local collection devices, and monitoring systems.
iv) Over-filling spillages could be reduced and contained through the use of sensing systems.
v) Reduced fire risk to whole tank farm from leaks and spillages.
vi) Reduced risk of large fuel losses.

Disadvantages:

i) Additional sensing and monitoring is required thus increasing the technical complexity of operations at the station.
ii) Puncturing of outer skin by wind-blown objects may not be evident until the system is used.
iii) Visual inspection of inner shell made more difficult.

b) **Steel-encased bladder tank**

Advantages:

i) Definite containment of any spillage.
ii) Ease of inspection and maintenance.
iii) Ability to compartmentalise to reduce risk of loss by fire and amount lost.
iv) Protection from wind dispersion of leaked oil.
v) Protected work environment.

Disadvantages:

i) Requires venting of fumes.
ii) Sealing of steel shell required to prevent snow ingress and spill leakage.
iii) In-built system of bladder removal/replacement needed.

c) **Local Bund Construction**

Containment bund walls would provide additional containment for any large oil spillage from the storage tanks. They could also provide sufficient area to contain the sledge during reception of fuel supplies thus providing an additional safety measure to contain any oil spilled during transfer operations.

Advantages:

i) The system is low technology, relatively simple to construct and operate.
ii) A definite containment of leaks from tanks and valves is achieved, as well as during transfer operations.
iii) Spillages are readily noticeable through inspection and snow discolorations.
iv) Only affects the area immediately around tank or farm, as opposed to remote bunding where any spillages would be diverted to if local bunding was not possible due to practical reasons.

Disadvantages:

i) Area becomes filled with snow and eventually ice forms in sumps requiring heating and pumping out to maintain capacity. Flexible roof covering for bund area overcomes this problem.
ii) Wind dispersion of leaks and spills is not prevented by open bund options but this can be overcome, to a certain degree, by the use of flexible roof covering.
iii) Fire damage to whole tank farm is possible in the event of a leak or spillage.

d) **Local Bunding Roofed with Headroom**

Advantages:

i) Fire protection can be installed.
ii) Snow/ice build up eliminated, provided structure is adequately sealed.
iii) Wind dispersion of spills is eliminated.
iv) A clear area is maintained for inspection and thus leaks and spillages can be detected at an early stage.
v) The area is protected from the elements thus ensuring that spillages can be collected and remedial action taken quickly and effectively.
vi) A protected work environment is assured for maintenance work.

Disadvantages:

i) Requires venting of fumes.
ii) Fill-sensing equipment is required to reduce headroom requirements of dipstick procedures.
iii) Vehicle access to tanks is restricted.

e) **Local Bunding - Uncovered Bunds**

Aerodynamic shaping by means of steel wind/drift detectors and fairing around tanks.

Advantages:

i) Low technology, relatively simple to construct and operate.

Disadvantages:

i) Requires wind tunnel analysis of varying factors and trial shapes.
ii) May require larger area around tanks due to wind shaping.
iii) Does not resolve wind dispersion of spills and may increase likelihood of this event.

f) **Aggregate fill to prevent snow/ice accumulation.**

Advantages:

i) Low technology required.

Disadvantages:

i) Snow/ice build up may still occur.
ii) Quarry operations required to produce aggregate.
iii) Larger bund size required to meet containment volume standards, due to allowance for volume of aggregate.

5.3.2 PIPING

The main forms of failure of piping occur at valves, joints and through physical damage of the line. To overcome this, an elevated double-walled pipe from the storage tanks to the day-tanks should be considered.

Advantages:

a) Provision of a definite containment for the fuel line and valves.

b) Protection of line from corrosion and physical damage.

Disadvantages:

a) Outer skin could be punctured by wind-blown objects without this being detected.

b) Increased maintenance and monitoring required due to additional sensing to detect leaks.

5.3.3 PREFERRED ALTERNATIVE

The design includes the following features:

a) A steel encased bladder system, entailing six sealed steel reservoirs, each containing one 100 000 l flexible rubber bladder.

b) Each reservoir placed on a separate installation.

c) Continuous gauging of tank level by remote (a remote liquid level read out with an audio warning device) and manual means.

d) Pressure vacuum vents as breather valves with few moving parts and designed for easy maintenance.

e) Filling valves located at the tops of the tanks.

f) Vehicle impact protection will be provided.

g) Lighting will be provided for the facility.

h) An elevated double-walled pipe system is to be utilised for pumping fuel from the storage tanks to the day-tank inside the base.

i) Pipe supports will be away from traffic lanes.

j) Pipe supports will be on proper foundations to avoid settling.

k) Reinforced pipe supports will be employed to prevent brittle failure at tank connections.

l) There will be labelled thermal relief valves in all pipes.

5.3.4 SUMMARY

The design of the bulk fuel storage facility is shown in Figure 6 of Appendix 2. Figure 7 of Appendix 2 shows the position of the structure in relation to other elements of the proposed base. The structure is situated just above the rock/snow interface, and is removed from the vehicle routes

Colourants could be added to the polar diesel so that any fuel leaks onto the snow can be easily detected, but this should only be done if non-toxic colourants can be obtained.

CHAPTER 6

ASSESSMENT

1. INTRODUCTION
2. KEY ISSUES
3. ASSESSMENT OF IMPACTS
4. ADDRESSING OF KEY ISSUES

CHAPTER 6

ASSESSMENT

6.1 INTRODUCTION

Previous experience has shown that it is often not feasible or practical to only identify and address possible impacts. The rating and ranking of impacts is often a controversial aspect because of the inherent difficulties involved in attaching values to impacts.

It was therefore decided to concentrate on addressing key issues. The methodology employed in this report thus results in a circular route, which allows for evaluation of the efficiency of the process itself. The assessment phase actions were conducted in the following order:

a) Identification of key issues

b) Analysis of the activities relating to the proposed base.

c) Assessment of potential impacts arising from the activities, without mitigation.

d) Investigation of relevant mitigatory actions.

e) A return to the key issues, and an assessment of how they had been addressed.

6.2 KEY ISSUES

6.2.1 INTRODUCTION

The key issues listed in the next section were determined through the comments of interested and affected parties and reviewers, the knowledge gained from the EIA team, SANAE managers and staff, and specialist contributors to the study. It is felt that by addressing key issues, environmental, safety and health considerations will be sufficiently addressed.

6.2.2 LIST OF KEY ISSUES

Key issue 1:

It must be ensured that Vesleskarvet does not pose any direct or indirect threat to:

a) The safety of the people who are going to inhabit it (within reasonable bounds of safety design considerations that can be incorporated into the facility).

b) The facility itself (within reasonable bounds of safety design requirements).

Key issue 2:

It must be ensured that there is no aspect of the physical and biological environments at Vesleskarvet having special conservation, scientific or educational value, that will be destroyed or damaged in the process of constructing and operating the new base.

Key issue 3:

It must be ensured that the ground access route to be chosen does not pose any direct or indirect threat to:

a) The safety of the people who are going to travel on it.

b) Any aspect of the physical and biological environments along the route that might have special conservation, scientific or educational value.

Key issue 4:

It must be ensured that there is no aspect of the environment (including base and scientific facilities) or the safety of people that can be detrimentally affected by:

a) The flight paths of any aircraft that are used at present or might be used in future.

b) The landing sites of aircraft that are used at present or might be used in future.

Key issue 5:

It must be ensured that there are no environmental factors that pose any unacceptable direct or indirect threat to the operational aspects of aircraft especially at Vesleskarvet.

Key issue 6:

It must be ensured that the proposed facility will not cause any significant changes to the landscape that could affect the functioning and stability of the facility especially with regard to snow deposition.

Key issue 7:

It must be ensured that waste management, storage and disposal (including sewage) practices will at least conform to the waste management and disposal obligations of the Madrid Protocol of 1991.

Key issue 8:

It must be ensured that fuel is transported within acceptable risk parameters with regard to possible safety and pollution implications, and that all Treaty obligations must at least be met.

Key issue 9:

It must be ensured that fuel is stored within acceptable risk parameters with regard to possible safety and pollution implications, and that the Treaty requirements are met.

Key issue 10:

It must be ensured that electricity generation is as "clean" as possible and that any pollution generated thereby poses no threat to the health of the base personnel or to the environment.

Key issue 11:

A constant supply of clean water to the base must be ensured.

Key issue 12:

The base must be designed to ensure that its inhabitants can maintain a high degree of mental and physical health.

Key issue 13:

The base must be aesthetically pleasing, neat, functional and in context with the surrounding environment so that it can install a sense of moral responsibility towards the base and its surroundings in both base personnel and visitors.

6.3 ASSESSMENT OF IMPACTS

6.3.1 INTRODUCTION

Activities within the framework of the proposed base and scientific programmes, and their respective construction and operation give rise to certain impacts. For the purposes of assessing these impacts, the project has been divided into four phases from which impacting activities can be identified, namely:

a) **Pre-construction phase**

All activities on and off site up to the start of construction. Not including the transport of materials, but including initial site preparation.

b) **Construction phase**

All activities on and off site, including the transport of materials but not fuel to the site. The foundation preparation for, and construction of, the base shell during the 1993/1994 take-over period and the fitting out of the interior during the 1994/1995 take-over period.

c) **Operational phase**

All activities, including operation and maintenance of the base and scientific structures. The transport of provisions and fuel from the bukta to the base, pumping and storage of fuel between the sledges and the bulk storage and between the bulk storage and the day tanks in the base. The servicing of all vehicles. The re-fuelling of all vehicles and helicopters. The storage of all sledges and mobile containers.

d) **Decommissioning phase**

Any activity related to the physical dismantling of the main base and related structures, including scientific apparatus. Including the transport of these items or components thereof back to the RSA, but not their disposal. This phase has not been considered in this report, as the envisaged operational lifespan of the base precludes making relevant judgements now concerning decommissioning.

The activities arising from each phase have been included in the assessment tables. This is to facilitate the identification of those activities which require certain management actions to mitigate the impacts arising from them. Tables 1 to 3 illustrate the assessment of the impacts. The criteria against which they were assessed are given in the next section (6.3.2)

6.3.2 ASSESSMENT CRITERIA

The assessment of the impacts was done according to a synthesis of criteria required under both the Antarctic Treaty and the IEM procedure. The criteria and their definitions are listed below:

a) **Nature of the impact**

This is an appraisal of the **type** of **effect** the activity would have on the affected environmental component. It's description should include **what is being affected**, and **how.**

b) **Extent**

The physical, or **spatial size** of the impact. This is classified as:

i) ***Local***

The impacted area extends only as far as the activity. eg: a footprint.

ii) ***Site***

The impact could affect the whole, or a measurable portion of, the nunatak.

iii) ***Regional.***

The impact could affect the area including Vesleskarvet, SANAE III and the off-loading depot at the coast, and the transport routes between the depot, the proposed base and field stations.

c) **Duration**

The lifetime of the impact: This is measured in context to the life-time of the proposed base.

i) ***Short term***

The impact will either disappear with mitigation or will be mitigated through natural process in a time span shorter than the construction phase of the base, ie: one seasonal cycle.

ii) ***Medium term***

The impact will last up to the end of the construction phase of the proposed base, whereafter it can be entirely negated.

iii) ***Long term***

The impact will continue or last for the entire operational life of the base, but will be mitigated either by direct human action or natural process thereafter.

iv) ***Permanent***

The only class of impact which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.

d) **Intensity**

Is the impact destructive, or benign. Does it destroy the impacted environment, alter it's functioning, or slightly alter it. Rated as:

i) ***Low***

The impact alters the affected environment in such a way that natural processes or functions are not affected.

ii) ***Medium***

The affected environment is altered, but function and process continue, albeit in a modified way.

iii) ***High***

Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases. Also if the impact is deemed to constitute a Health or Safety hazard to personnel.

This will be a relative evaluation within the context of all activities and other impacts within the framework of the project.

e) **Probability**

The likelihood of the impact actually occurring. (the impact might occur for any length of time during the life cycle of the activity, and at any given time.) Rating classes:

i) ***Improbable***

The possibility of the impact occurring is very low, due either to circumstance, design or historic experience.

ii) ***Probable***

There is a possibility that the impact will occur to the extent that provision must be made therefore.

iii) ***Highly probable***

It is most likely that the impact will occur at some stage of the activity. Plans must be drawn up before the undertaking of that activity to mitigate possible impacts.

iv) ***Definite***

The impact will occur regardless of any prevention plans, and there can only be relied on mitigation actions or contingency plans to contain the effect.

f) **Determination of significance**

Significance was determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required.

Unmitigated impacts were considered. This provides a more realistic consideration of the actual and potential impacts of the project, and allows for a prioritisation of mitigation. Alternative mitigation techniques can also be included at a later stage.

These criteria were defined within the context of the proposed base and it's related activities and their potential relationship with the surrounding environment.

Each impact has been numbered to facilitate referencing in the management plan which must be drawn up.

It should be noted that, due to the incorporation of environmental principles and specialists in the planning process, many potential impacts have been mitigated through the design and planning processes. Other potential impacts could be further mitigated through the application of management plans. This is especially so for potential waste disposal, pollution and physical disturbance impacts. Potential impacts originally identified by the interested and affected parties have all been included in the tables.

ASSESSMENT OF POTENTIAL IMPACTS **TABLE 1** **PRE-CONSTRUCTION PHASE**

ACTIVITY / ELEMENT		IMPACT							POSSIBLE MITIGATION	
NATURE	DURA-TION	No	NATURE	EXTENT	DURA-TION	INTEN-SITY	PROBA-BILITY	SIGNIFI-CANCE	YES / NO	DESCRIPTION
Erection and operation of construction base	Dec '91 to Jan '96	1	Visual	Site	Medium	High	Definite	Low	Yes	Total removal of structure after construction phase.
		2	Snow de-position	Site ± 13 500m²	Medium	High	Definite	Low	Yes	Level snow surface with caterpillar after removal of construction base.
Safety handrail	Long term	3	Visual	Site	Long	Low	Definite	Low	Yes	Remove after decomissioning of base.
		4	Anchor holes (frost shatter-ing)	Local	Permanent	Medium	Definite	Medium	Yes	Plug holes with inert filler after removing anchor bolts.
Access ice-road for vehicles	Perm-anent	5	Disturb-ance of surface	Local	Permanent	High	Definite	High	Yes	Reduce size to minimum necessary. Ensure road does not block drainage.

ASSESSMENT OF POTENTIAL IMPACTS

TABLE 1 (CONTINUED)

PRE-CONSTRUCTION PHASE

ACTIVITY		IMPACT							POSSIBLE MITIGATION	
NATURE	DURA-TION.	No.	NATURE	EXTENT	DURA-TION	INTEN-SITY	PROBA-BILITY	SIGNI-FICANCE	YES/NO	DESCRIPTION
Establishment and operation of construction materials depot.	Medium term	6	Visual	Site	Medium	Low	Definite	Low	Yes	Remove depot structures and all unused materials on completion of construction phase.
		7	Snow deposition	site	Medium	High	Definite	Medium	Yes	Level snow surface with caterpillar after depot is removed.
		8	Litter	Site	Short	High	Highly probable	High	Yes	Implement a clean up plan and audit annualy.
91/92 EIA team site visit	10 days	9	P.G.C.P's for aerial photo-graphy	Local	Short	Low	Definite	Low	Yes	Ensure removal of all points. Leave single stake at each
		10	Survey point	Point	Medium	Low	Definite	Low	Yes	Remove loose or broken points
		11	Removal of soil samples	Local	Permanent	Low	Definite	Low	No	
		12	Biological samples	Site Point	Permanent	Low	Definite	Low	No	

ASSESSMENT OF POTENTIAL IMPACTS TABLE 1 (CONTINUED) PRE-CONSTRUCTION PHASE

ACTIVITY		IMPACT							POSSIBLE MITIGATION	
NATURE	DURA-TION	No.	NATURE	EXTENT	DURA-TION	INTEN-SITY	PROBA-BILITY	SIGNI-FICANCE	YES/ NO	DESCRIPTION
92/93 EIA Team site visit	14 days	13	Rocks displaced	4 Plots ±25x25m each site	Long	Medium	Definite	Medium	No	
		14	Removal of soil samples	Local	Permanent	Low	Definite	Low	No	
Activities of construction personnel	91/92 take-over	15	Litter, habitat disturb-ance	Site Local	Short	Medium	Highly Probable	High	Yes	Environmental officer to audit site after construction team has left

ASSESSMENT OF POTENTIAL IMPACTS

TABLE 2

CONSTRUCTION PHASE

ACTIVITY / ELEMENT		IMPACT							POSSIBLE MITIGATION	
NATURE	DURA-TION	No.	NATURE	EXTENT	DURA-TION	INTEN-SITY	PROBA-BILITY	SIGNI-FICANCE	YES/ NO	DESCRIPTION
Activities of construction team personnel (50)	93/94 and 94/95 Take-over periods	16	Trampling of habitats	Site	Permanent	High	Definite	High	Yes	Demarcate larger "out of bounds" areas
		17	Litter	Local / Site	Medium	High	Probable	High	Yes	Education of all personnel and provision of suitable waste containers
		18	Human Waste	Site	Medium	High	Definite	High	Yes	Containerise and remove to South Africa
		19	Solid waste	Site	Medium	High	Definite	High	Yes	Classify, containerise separately and return to South Africa
		20	Grey water	Site	Medium	High	Definite	High	Yes	Treat water before release
Power Generation	Long-term	21	Exhaust emissions -diesel	Site	Long-term	Low	Definite	Low	Yes	Scrubbing, filtering, ventilation
Fresh water production	Long-term	22	Snow deposition & removal	Local	Long-term	High	Definite	Low	No	

ASSESSMENT OF POTENTIAL IMPACTS | **TABLE 2 (CONTINUED)** | **CONSTRUCTION PHASE**

ACTIVITY / ELEMENT		IMPACT							POSSIBLE MITIGATION	
NATURE	DURA-TION	No.	NATURE	EXTENT	DURA-TION	INTEN-SITY	PROBA-BILITY	SIGNI-FICANCE	YES/NO	DESCRIPTION
Souvenir collecting	Long-term	23	Removal of rocks, soil and biota	Site	Long-term Perm	Medium	Highly Probable	High	Yes	Education of personnel, disciplinary measures
Bulk fuel storage facility	Long-term	24	Anchor holes (frost shattering)	Local	Permanent	High	Definite	High	Yes	Plug with inert sealant after removal of anchor bolts.
		25	Snow deposition	Site	Long	High	Definite	Medium	Yes	Sympathetic design and placement of facility
Ice-path to Neutron Monitor huts	Perm-anent	26	Rock displace-ment	Local	Permanent	High	Definite	High	Yes	Keep to minimum size necessary
		27	Obstruc-tion of water flow	Site	Long	High	Probable	High	Yes	Sympathetic design of path

ASSESSMENT OF POTENTIAL IMPACTS **TABLE 2 (CONTINUED)** **CONSTRUCTION PHASE**

ACTIVITY / ELEMENT		IMPACT							POSSIBLE MITIGATION	
NATURE	DURATION	No	NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	SIGNIFICANCE	YES/ NO	DESCRIPTION
Importation of construction materials	93/94 and 94/95 take-over periods	28	Introduction of alien species	Regional	Medium	Medium	Highly Probable	Medium	Yes	Sterilize all materials before loading in Cape Town
Base shell construction and fitting out	93/94 and 94/95 take-over periods	29	Moving of rock and dumping it	Site	Permanent	High	Highly Probable	High	Yes	Disturb absolutely the minimum area necessary
		30	Snow deposition	Down wind of structure	Long	High	Highly Probable	High	Yes	Base design and placement
		31	Litter of material off-cuts, etc	Site Local	Long/ medium	High	Highly Probable	High	Yes	Waste management plan and containers implemented. Returned to South Africa
		32	Anchor holes (frost shattering)	Site Local	Permanent	High	Definite	High	Yes	Plug holes with inert sealant
Neutron monitor huts foundations	Long	33	Anchor holes	Local	Permanent	High	Definite	Medium	Yes	Plug holes with inert sealant

ASSESSMENT OF POTENTIAL IMPACTS **TABLE 3** **OPERATIONAL PHASE**

ACTIVITY / ELEMENT		IMPACT							POSSIBLE MITIGATION	
NATURE	DURATION	No	NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	SIGNIFICANCE	YES/ NO	DESCRIPTION
Base structures	Long-term	34	Birds attracted to facility by lights	Site	Long-term	Summer - low Winter - high	Low	Medium	Yes	Blinds, minimum use of lights
		35	Birds flying into aerials	Site	Long-term	Low	Low	Medium	Yes	Colour mast, stays, etc. or use plates on stays
Fuel Transport	Long-term	36	Fuel spill on route to base	Local, maximum 7000 l	Short	High	Probable	High	Yes	Contingency plan, design of sledges and bladders/ containers
Fuel Pumping	Long-term	37	Fuel spill at bladder/ storage facility	Site / Local	Short	High	Probable	High	Yes	Thorough operational procedures and contingency spill plans
Bulk fuel storage	Long-term	38	Fuel spill 100 000 l to 600 000 1	Local	Short	High	Low	High	Yes	Thorough operational procedures and contingency spill plans

ASSESSMENT OF POTENTIAL IMPACTS — TABLE 3 (CONTINUED) — OPERATIONAL PHASE

ACTIVITY / ELEMENT		IMPACT							POSSIBLE MITIGATION	
NATURE	DURATION	No	NATURE	EXTENT	DURATION	INTENSITY	PROBABILITY	SIGNIFICANCE	YES/NO	DESCRIPTION
Refuelling of all vehicles	Long-term	39	fuel spill	Local	Short	High	Highly probable	High	Yes	Apply thorough refuelling procedures and fuel spill contingency plan
		40	Air and ground pollution due to fire	Local / Site	Short	Medium	Low	High	Yes	Institute fire-fighting plan Provide suitable equipment and training to personnel
Waste disposal: field and base	Long-term	41	Solid waste	Site	Long-term	High	Low	High	Yes	Classify, containerise separately and remove to South Africa
		42	Treated effluent	Site	Long-term	High	Definite	Low	Yes	Ensure standard of treated effluent
Sewage plant failure	Short term	43	Untreated effluent discharge	Local	Permanent	High	Low	High	Yes	Provide containers for septic tank facility and design of plant
Alternative helipad sites	Long-term	44	Safety hazard	Local	Short term	High	Low	High	Yes	Ensure alternative sights are away from all structures, aerials, etc

ASSESSMENT OF POTENTIAL IMPACTS **TABLE 3 (CONTINUED)** **OPERATIONAL PHASE**

ACTIVITY / ELEMENT		IMPACT							POSSIBLE MITIGATION	
NATURE	DURA-TION	No	NATURE	EXTENT	DURA-TION	INTEN-SITY	PROBA-BILITY	SIGNIF-ICANCE	YES / NO	DESCRIPTION
Human activities: Base operation and scientific programmes	Long-term	45	Trampling habitat destruction	Site	Long-term	High	Definite	High	Yes	Education of personnel, Demarcation of areas, Cat walks
		46	Litter	Site Regional	Long-term	Medium	Highly probable	High	Yes	Education of personnel, Provision of containers for field personnel
		47	Vehicle accidents	Local	Short	High	Low	High	Yes	Strict routes; well marked, education and training of drivers. Quality maps and navigation aids
		48	Removal of rocks, soil, boita for souvenirs	Site, Regional	Perma-nent	Low in region, High on Site	Highly probable	High	Yes	Training, disciplinary measures
Vehicle and helicopter servicing and maintenance	Long-term	49	Fuel and oil spill	Local	Short term	High	Highly probable	High	Yes	Servicing only in hangers, effluent returned to South Africa for disposal
Storage of sledges and vehicles	Long-term	50	Snow deposition	Site	Long-term	High	Definite	Medium	Yes	Store indoors

6.4 ADDRESSING OF KEY ISSUES

Key issue 1

The safety of personnel and the base has been ensured through a design process which fulfils the design criteria as set out in Chapter 3.

The uneven surface and vertical cliffs at Vesleskarvet pose a very real danger to unsuspecting persons. The erection of the safety handrail and the provision of ice-paths will ensure that personnel are not required to traverse unstable or potentially dangerous areas. All personnel's training in the future must include a description of Vesleskarvet and all potential hazards in the area.

Key issue 2

The base and all structures except the bulk fuel storage facility have been placed on the southern buttress of the nunatak (see Figure 7). This departure from the original plan was initiated by the EIA team, when, after study of the site, it became apparent that the northern lobe was biologically of higher conservation value than the south.

A single area on the southern buttress that was identified as being of scientific interest was demarcated and access prohibited without written permission of the Director General of the DEA or his designate. It has since been determined that the micro-organisms present in the area also occur on the northern buttress. It is therefore not considered necessary to retain this exclusion area, and it will be removed before construction. Three exclusion areas were also demarcated on the northern buttress in the same manner as the one mentioned above (see Appendix 2, Figure 7), and these must be extended to include further habitats since identified.

Key issue 3

The present access route to the Sarie Marais field base (as explained in Chapter 2, section 2.1.2) passes 10 km to the west of Vesleskarvet, from which there is a turn off. The route is safe and marked, but it is not the shortest possible.

A new route from the coast to Vesleskarvet will be surveyed using helicopters and ground teams, and in future use will be made of Geographic Positioning Systems (GPS) for navigation in the vehicles. The entire route will be on ice-fields or snow fields, and there are no known biological communities which will be disturbed by even heavy traffic such as will occur during the construction phase.

Key issue 4

From the absence of breeding colonies of birds within a 20 km radius it can be accepted that no danger is posed, either by the flight paths or the landing areas identified to date, to the nearest colonies. The birds observed visiting Vesleskarvet have also exclusively been seen at the northern buttress, some 250 m from the nearest landing area.

When it is decided to begin with the provision of the landing area for fixed-wing aircraft, then the situation must be re-appraised, an investigation undertaken and a report detailing the findings be produced and circulated according to Treaty requirements.

Key issue 5

The position of the base relative to the cliff, and the implications it holds regarding possible gusts of wind in the vicinity of the helipad should not be ignored. If winds are at any time such that landing on the helipad might pose a danger to personnel, then use must be made of the open snow area to the east of the base. This is far enough from any aerials for safety purposes, yet still close enough for personnel to walk to and from the base.

Key issue 6

The positioning of the base 50 m from the cliff edge and 3.5 m off the rock surface, will ensure that minimal snow will be deposited on the downwind surface of the nunatak, and most will be carried over the edge of the cliff. The 150 m drop in that area combined with the eddying effects of the topography / wind combination, will ensure that minimal changes in topographical elements occur on the western side of the nunatak. The positioning of the base was determined through a combination of wind-tunnel tests conducted by the CSIR in Pretoria and on-site discussion between the EIA team and the consulting engineer.

Key issue 7

SANAP managers have taken the decision to return all waste, including concentrated excrement, to the RSA. As the design of the base does not allow for an incineration plant nor the use of heat energy generated by such a plant, removal of all waste is the only other alternative. Whilst the logistic implications are significant, the benefits to the Antarctic environment justify this step. The formulation of this policy and it's implementation will put the RSA ahead of the requirements of the Madrid Protocol.

Key issue 8

The design of specialised fuel transport sledges coupled to a new oil spill contingency plan and the proper training of personnel, are considered as adequate measures for reducing the risk of a fuel pill and the consequent pollution.

Key issue 9

The design and placement of the bulk fuel storage facility were dictated mostly by environmental and safety factors. The use of double valves, containment and piping and the placing of the structure off the vehicle routes in an area where, in the event of a fire, the prevailing winds will carry smoke away from personnel and biologically important areas, all contribute to a minimum risk scenario.

Key issue 10

The use of diesel engines to generate electricity will be combined with a heat management/exchange system to optimise energy output and reduce fuel consumption. This will be coupled to a strict maintenance regime to ensure the engines are kept in optimum running order.

Key issue 11

Water will be produced in an area upwind from the base and off the vehicle routes. The melter will also be so positioned that failure of either the bulk fuel storage facility or the treated effluent discharge pipe will not affect the snow reserves for the melter.

Key issue 12

This was one of the main reasons which led to the choice of a surface structure. Extensive use has been made of windows to optimise the outside views from the base, and the internal allocation of space has been done in such a way that individuals will be able to conduct their activities in suitable environments.

Key issue 13

The design of the base and the layout of all outside infrastructure has been done so as to contribute to a functional, neat environment. The layout is compact when compared to the present SANAE III facility. This was the result of a conscious effort to minimise infrastructure and also environmental disturbance, and thereby clutter. The training of the team members will also play a role in engendering a feeling of responsibility towards SANAE IV and the environment.

6.5 CUMULATIVE IMPACTS

It is unlikely that any single environmental impact could have a major detrimental effect in the long term. This could, however, be misleading if the potential effect of a combination of any number of impacts is overlooked. Cumulative impacts are often difficult or even impossible to predict. This is a common problem that occurs in impact assessments.

Cumulative impacts have the potential to have a major negative effect on the area surrounding the proposed base. These impacts occur when even rather individually insignificant impacts take place so frequently or so densely in space that the effects cannot be assimilated by the environment. The effects of cumulative impacts can be further compounded if impacts from one activity combine with those of another to produce a greater or new impact (referred to as a "synergistic effect").

The nature of the environment at Vesleskarvet, where subtle variations of exposed rock, rock/snow interfaces and ice occur, is particularly vulnerable to such cumulative impacts. This is not the case in the more forgiving environment at the present SANAE III facility.

Dealing with cumulative impacts requires co-ordinated organisational arrangements which are difficult to achieve in the absence of a comprehensive management system.

6.6 CONCLUSION

Many environmental concerns were addressed in the different stages of the planning, design and placement of SANAE IV. The evaluation of alternatives (sites, design options, materials and processes) were often subtle. Many trade-offs have been made, but always with the environmental, health and safety (EHS) aspects as the guiding elements. This has led to a great reduction of possible impacts during the planning and design processes.

Those transitory impacts which still occur can be mitigated and managed to levels which are acceptable at this time, and should in fact be acceptable for the foreseeable future.

Non-transitory impacts are considered to have medium significance in the long term, but are deemed acceptable in the light of the advantages to be gained from the new base.

From the previous chapters it is clear that there are no major impacts that stand out clearly above the rest. It is also clear that most potential impacts can either be avoided or be mitigated to a large extent.

There is however a danger that the cumulative effects of various impacts might be overlooked. This could very easily give rise to unacceptable environmental conditions.

The key to minimizing the overall impact of the new facility lies in the stringent management of human activities and behaviour.

The recommendations contained in Chapter 7, therefore, centre mostly around the establishment of an environmental, health and safety management system (EHSMS). If such a system is developed, and it's implementation is integrated into SANAP, the realisation of a new South African base on Vesleskarvet, Queen Maud Land, Antarctica, can be justified in terms of the Antarctic Treaty and the Madrid Protocol. It must be noted, however, that such integration and implementation will be crucial to the success of the proposed base and related activities.

CHAPTER 7

RECOMMENDATIONS

12. ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT RECORDS

13. ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT AUDITS

14. TRAINING

15. DEDICATED ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT PERSONNEL FOR ANTARCTICA AND ISLANDS

16. CONSULTANTS

17. ADDITIONAL RESEARCH PROGRAMMES

18. STEPS THAT MUST BE TAKEN BEFORE THE 1993/1994 SUMMER TAKE OVER PERIOD

19. RECOMMENDED CONDITIONS FOR THE REMAINING PHASES OF THE PROJECT

CHAPTER 7

RECOMMENDATIONS

7.1 INTRODUCTION

In conducting this Environmental, Health and Safety Impact Assessment (EHSIA) it became quite clear, even during the early stages in the compilation of the Initial Environmental Evaluation, that the potential impacts of the proposed facilities and equipment in itself does not pose any major direct threat to the Antarctic environment. The significance of potential impacts rather depends on the conduct of personnel in managing their activities relating to the provision and maintenance of logistic's, facilities and equipment, and the execution of scientific research programmes.

Personal observation during the 1991/92 and the 1992/93 take over periods by various members of the environmental impact assessment team confirmed that the major cause of EHS impacts, at present, is the lack of a well defined management system.

A well defined EHSMS to which all participants in the SANAP adhere is a prerequisite if high EHS standards are to be attained.

The international emergence of a need for "Environmental Management Systems" (EMS) - "the organizational structure, responsibilities, practices, procedures, processes and resources for implementing environmental management" (from BS 7750:1992) - is a further motivation for the implementation of such a system.

The International Standards Organization, of which South Africa is a member, is already in the process of establishing a specification for EMS. The British Standards Organization has already produced a specification for EMS (BS 7750:1992). The South African Bureau of Standards (SABS) is currently in the process of producing a similar document (target date : mid 1993). Many of the recommendations contained in this report are based on the BS 7750:1992 and draft documentation of the SABS:1993.

Due to the nature of potential impacts associated with the establishment, maintenance, logistical support and activities to be conducted from the proposed new base as well as ever more stringent Antarctic Treaty obligations, it is strongly recommended that an EHSMS is developed, implemented, enforced and maintained. The different elements which should make up the EHSMS are discussed as separate recommendations in paragraphs 7.2 to 7.14.

It is also important to note that all organizational activities, facilities and equipment interact, and have some impact upon the environment as well as on health and safety aspects. An effective EHSMS needs to be capable of dealing with this complexity. The EHSMS components (described in the recommendations below) will be inextricably interwoven with most, if not all, of the overall management system of the SANAP. Clear linkages must be established.

7.2 MANAGEMENT STRUCTURE

The SANAP is dependent on major inputs from many participating organizations. This complicates the introduction and enforcement of an EHSMS.

The most important factor for the effective introduction of an EHSMS is management commitment and accountability. Therefore, it is essential that strong management structures with clear roles and responsibilities are established. There must be a clear division in the structure between those who are accountable for and those who only participate in the SANAP.

It is recommended that the present Antarctic Management Committee be restructured into a two tier management structure. The accountable officers of the DEA and DPW should make up the first tier of the management structure, thereby forming the executive management of SANAP. It is also recommended that the final responsibility for all EHS aspects must rest with the Director General of the DEA. It is, however, important that the DEA liaise closely with other affected organizations.

The second tier of the management structure should be constituted out of participants in the various Antarctic research programmes. Its role should only be advisory. All management decisions that have a bearing on the EHS must be left to the first tier of the management structure.

In the following recommendations the responsibility is placed on the DEA. Whenever appropriate responsibilities should be delegated to the DPW or (with regard to safety) the South African Air Force, provided that they agree thereto.

7.3 MANAGEMENT RESPONSIBILITY

7.3.1 ENVIRONMENTAL POLICY

The executive management of SANAP must define and document its environmental policy with regard to its Antarctic programme. They must ensure that this policy :

(a) is relevant to its activities, facilities, equipment and processes and their environmental consequences;
(b) is understood, implemented and maintained at all levels in the SANAP;
(c) is publicly available;
(d) provides for the setting of EHS objectives and targets.

7.3.2 ORGANIZATION

The organizational co-ordination and harmonization of all actions necessary to carry out the EHS management programme (EHSMP) (see 7.5) must be ensured.

a) **Responsibility, authority and resources**

The DEA, in consultation the DPW must define and document the responsibility, authority and interrelations of key personnel who manage, perform and verify work affecting the EHS including those who need the organizational freedom and authority to:

(i) provide sufficient resources and personnel for implementation;
(ii) initiate action to ensure compliance with EHS policy;
(iii) identify and record any EHS problems;
(iv) initiate, recommend or provide solutions to those problems through designated channels;
(v) verify the implementation of such solutions;
(vi) control further activities until any EHS deficiency or unsatisfactory condition has been corrected and
(vii) act in emergency situations.

b) **Verification resources and personnel**

The DEA, in collaboration with the DPW must identify in-house verification requirements and procedures, provide adequate resources and assign trained personnel for verification activities.

Verification activities must include:

(i) EHS impact evaluations for all facilities, equipment, activities and processes;
(ii) compliance with Antarctic Treaty environmental requirements and in-house EHS standards;
(iii) evaluation of emergency and contingency plans;
(iv) auditing of organizational EHS activities and management systems and
(v) evaluation of the effectiveness of EHS training programmes.

c) **Management representative**

The DEA must appoint a management representative who must have defined authority and responsibility for ensuring that the Antarctic treaty and in-house EHS requirements and the requirements of the management system are implemented and maintained. He must report on the performance of the EHSMS to the executive management of SANAP for review and as a basis for improvement of the EHSMS.

d) **Environmental, health and safety management review**

The DEA must review the environmental management system at defined intervals sufficient to ensure its continuing suitability and effectiveness in satisfying the requirements of the Antarctic Treaty and SANAP's stated EHS policy and objectives. Management reviews must include assessment of the results of environmental management audits (see 7.13).

7.4 ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT SYSTEM

The DEA must establish, document and maintain an EHSMS as a means of ensuring that the effects of the activities of the organization conform to its EHS policy and associated objectives and targets (see 7.3.1(d)).

This must include the preparation of documented system procedures and instructions and the effective implementation of the system procedures and instructions.

In implementing the EHSMS system the SANAP executive must take account of any pertinent code of practice to which it subscribes and may integrate this system with other management systems.

This documented EHSMS must be established and maintained in the form of a manual or manuals to:

(a) collate the EHS policy, objectives and targets, and programme;
(b) document the key roles and responsibilities;
(c) describe the interactions of system elements;
(d) provide direction to related documentation and describe other aspects of the EHSMS, where appropriate; and
(e) achieve compliance with the requirements of the EHSMS and demonstrate such compliance to others.

In addition to dealing with the normal activities of the SANAP, the manual (or related documentation) must cover abnormal and contingency conditions, and incidents and accidents and potential emergency situations. Emergency and contingency plans must contain relevant EHS information and instructions.

7.5 ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT PROGRAMME

Following an EHS management programme is the key to compliance with the SANAP's EHS policy. The implementation of the programme should involve a clear and unequivocal commitment from all personnel, and in particular from management at the most senior levels.

The programme should cover all new facilities, activities equipment and processes and address the EHS impacts arising at all stages of the life cycle, to ensure that adverse EHS impacts are controlled by effective planning and design. The programme should also include actions to deal with the EHS consequences of the SANAP's past activities.

The DEA must establish and maintain a programme for achieving objectives and targets. It should include designation of responsibility for targets at each function and level of the SANAP, and explain the means by which they are to be achieved.

Separate programmes should be established in respect of the EHS management of projects relating to new facilities, or to new or modified equipment, processes and activities to define:

(a) the EHS objectives to be attained;
(b) the mechanisms for their achievement;
(c) the procedures for dealing with changes and modifications as projects proceed;
(d) the corrective mechanisms which must be employed should the need arise, how they should be activated and how their adequacy must be measured in any particular situation in which they are applied.

7.6 CONTRACT REVIEW

The DEA and all other parties participating in the SANAP must establish and maintain procedures for contract review and for the co-ordination of these activities. This includes all contracts - even research contracts. Each contract must be reviewed by the DEA to ensure that:

(a) the EHS requirements are adequately defined and documented;
(b) any EHS requirements differing from those specified in tenders are resolved;
(c) the SANAP has the capability to meet contractual EHS requirements; and
(d) any procurement and supply contract requirements do not conflict with Antarctic Treaty environmental requirements or in-house EHS policies; and
(e) the environmental impacts of the execution of contracts are not unacceptable.

Records of such contract reviews must be maintained.

7.7 ENVIRONMENTAL, HEALTH AND SAFETY IMPACTS AND PLANNING

7.7.1 GENERAL

Any new facility, activity, equipment or process must be fully investigated to determine its potential impact on the environment and a management programme must be developed to control these impacts (see 7.5). The South African Integrated Environmental Management Procedure must be followed whenever applicable. The DEA must establish and maintain procedures for receiving, documenting and responding to communications (internal and external) from interested and affected parties concerning the EHS impacts of such new facilities, activities, equipment and processes.

7.7.2 ANTARCTIC TREATY REQUIREMENTS AND REGISTER

The DEA must establish and maintain documented procedures to identify all Antarctic treaty requirements pertaining to the EHS aspects of its facilities, activities, equipment and processes. Such requirements must be recorded in a register.

7.7.3 ENVIRONMENTAL, HEALTH AND SAFETY IMPACTS REGISTER

(a) The DEA must establish and maintain procedures for examining and assessing the EHS impacts and consequences, both direct and indirect, of its facilities, activities, equipment and processes, and for compiling a register of those impacts. The procedures must include, where appropriate, consideration of:

(i) controlled and uncontrolled emissions to atmosphere;
(ii) controlled and uncontrolled liquid discharges;
(iii) solid wastes and other wastes;
(iv) contamination of land;
(v) use of land, water, fuels and energy, and other natural resources;
(vi) noise, odour, vibration and visual impact; and
(vii) effects on specific parts of the EHS.

(b) The procedures must include impacts arising, or likely to arise, as consequences of:

(i) normal operating conditions;
(ii) abnormal operating conditions;
(iii) incidents, accidents and potential emergency situations; and
(iv) past activities, current activities and planned activities.

7.8 DOCUMENT AND DATA CONTROL

7.8.1 GENERAL

Documents issued for use by the DEA, must be controlled. Only approved and authorized documents must be used at the relevant location and any subsequent change to such documents must be authorized and approved by the DEA.

7.8.2 DOCUMENT APPROVAL AND ISSUE

The DEA must establish and maintain procedures for controlling all documents and data that relate to the EHSMS to ensure that:

(a) they can be identified with the appropriate organization, division, function or activity;
(b) they are reviewed and approved for adequacy by authorized personnel prior to issue;
(c) the current versions of relevant documents are available at all locations where operations essential to the effective functioning of the system are performed; and
(d) invalid or obsolete documents, or both, are promptly removed from all points of issue or use, or otherwise protected from unintended use.

7.9 PROCESS CONTROL

7.9.1 GENERAL

The DEA in collaboration with the other members of SANAP must identify and plan the processes which directly or indirectly impact on the EHS and must ensure that these processes are carried out under controlled conditions.

7.9.2 CONTROL

The DEA must identify functions, activities and processes which impact on, or have the potential to impact on the EHS and are relevant to its policy, objectives and targets. The Department must plan such functions and activities to ensure that they are carried out under controlled conditions. Particular attention must be paid to the following:

(a) documented work instructions defining the manner of conducting the activity. Such instructions must be prepared for situations in which their absence could result in infringement of the EHS policy;
(b) monitoring and control of relevant process characteristics (e.g. effluent streams and waste disposal);
(c) approval of planned processes and equipment; and
(d) criteria for performance, which must be stipulated in written standards.
(e) Records of process control must be maintained.

7.10 INSPECTION AND TESTING

The DEA must establish, document and maintain procedures for verification of compliance with specified EHS requirements and for establishing and maintaining records of the results.

For each relevant activity or area, the Department must:

(a) identify and document the EHS verification information to be obtained;
(b) specify and document the EHS verification procedures to be used;
(c) establish and document EHS acceptance criteria and the action to be taken when results are unsatisfactory; and
(d) assess and document the validity of previous EHS verification information when EHS verification systems are found to be malfunctioning.

7.11 CORRECTIVE AND PREVENTIVE ACTION

7.11.1 GENERAL

The DEA must establish and maintain procedures for implementing corrective and preventive actions whenever non-conformities (to the EHSMS) are detected.

7.11.2 CORRECTIVE ACTION

This must include:

(a) determination of the cause;
(b) the drawing up of a plan of action to correct the non-compliance;
(c) the effective handling of complaints and reports of non-conformities;
(d) application of controls to ensure that effective corrective action is taken to prevent the recurrence of non-conformities;
(e) implementing and recording changes in procedures resulting from corrective action; and
(f) ensuring that relevant information on corrective actions taken, including changes to procedures, is submitted for management review.

7.11.3 PREVENTIVE ACTION

This must include, corresponding to the risks encountered:

(a) the use of appropriate sources of information such as processes and work operations which affect EHS requirements concessions, audit results, EHS management records and service reports to detect, analyze and eliminate potential causes of non-conformities;
(b) initiating preventive actions to deal with problems;
(c) applying controls to ensure that preventive action is taken and that it is effective;
(d) implementing and recording changes in procedures resulting from preventive actions; and
(e) ensuring that relevant information on actions taken, including changes to procedure, is submitted for management review (see 7.3.3).

7.12 ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT RECORDS

The DEA must establish and maintain a system of records in order to demonstrate compliance with the requirements of the EHSMS, and to record the extent to which planned environmental, health and safety objectives and targets have been met. It must also establish and maintain procedures for the identification, collection, indexing, filing, storage, maintenance and disposition of EHS management records. Pertinent contractor and procurement records and the results of audits and reviews and training records must form an element of these records.

All EHS records must be legible and identifiable to the activity, facility or equipment involved. EHS records must be stored and maintained in such a way that they are readily retrievable and protected against damage, deterioration or loss, and their retention times must be established and recorded.

Policies must be established and implemented regarding the availability of records, both within the SANAP and to interested and affected parties.

7.13 ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT AUDITS

7.13.1 GENERAL

The DEA must establish and maintain procedures for audits to be carried out, in order to determine:

(a) whether or not EHS management activities conform to the EHS management programme, and are implemented effectively; and
(b) the effectiveness of the EHSMS in fulfilling the SANAP's EHS policy.

For this purpose, the DEA must establish and maintain an audit plan.

7.13.2 AUDIT PLAN

The audit plan must deal with the following points:

(a) the specific activities and areas to be audited, which include:
- organizational structures;
- administrative and operational procedures;
- work areas, operations and processes;
- documentation, reports and records; and
- state of EHS;

(b) the frequency of auditing of each activity area, audits being scheduled on the basis of the nature and EHS importance of the activity concerned, and the results of previous audits;
(c) the responsibility for auditing each activity area;
(d) the personnel requirements, and specifically those carrying out the audits:
- are independent, as far as is possible, of the specific activities or areas being audited;
- have expertise in relevant disciplines; and
- have support, where necessary, from a wider range of specialists, who may be internal or external to the SANAP;

(e) the protocol for conducting the audits, which may involve the use of questionnaires, checklists, interviews, measurements and direct observations, depending on the nature of the function being audited;
(f) the procedures for reporting audit findings to those responsible for the activity area audited, who must take timely action on reported deficiencies where the reporting must address:
- conformity or nonconformity of the EHSMS elements with specified requirements;
- the effectiveness of the implemented EHSMS in meeting objectives and targets;
- implementation and effectiveness of any corrective actions recommended in previous audits; and
- conclusions and recommendations;

(g) the procedures for publishing audit findings.

7.14 TRAINING

The DEA must establish and maintain procedures for identifying training needs, and for providing appropriate EHS training for all personnel involved in the SANAP. The Department must ensure that SANAP's members, at all levels, are aware of:

(a) the importance of compliance with the EHS policy and objectives, and with the requirements of the EHS management system;
(b) the potential EHS impacts of their work activities and the EHS benefits of improved performance;
(c) their roles and responsibilities in achieving compliance with the EHS policy and objectives, and with the requirements of the EHSMS; and
(d) the potential consequences of departure from agreed operating procedures.

Personnel performing specific assigned tasks must be qualified on the basis of appropriate education, training or experience, or both, as required. Records of training must be maintained and reviewed as necessary.

7.15 DEDICATED ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT PERSONNEL FOR ANTARCTICA AND ISLANDS

It is recommended that a sub-directorate is created within the Directorate: Environmental Protection of the DEA for the implementation and maintenance of the EHSMS. Expertise in the fields of EHS in general, environmental impact assessment, environmental auditing and general management should be vested in such a sub-directorate. It is important that it functions in close co-operation but independent from and at the same level as the existing Antarctic Section.

Additional tasks such as Antarctic research evaluation may also be assigned to the proposed sub-directorate. This sub-directorate should also be responsible for the EHS management on Marion and Gough Islands.

Yearly participation in take overs by environmental officers of the proposed sub-directorate will be essential.

7.16 CONSULTANTS

Adequate funds must be earmarked for the appointment of consultants to help develop the EHSMS.

7.17 ADDITIONAL RESEARCH PROGRAMMES

It is recommended that the following additional research programmes be established:

7.17.1 TECHNOLOGY RESEARCH PROGRAMME

The purpose of this programme should be to develop more appropriate alternatives for:

- electricity generation;
- water provision and optimal use of water;
- navigation;
- communication;
- transportation of fuel, personnel and supplies; and
- any other design or construction related work.

7.17.2 ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT RESEARCH PROGRAMME

The purpose of the programme should be to refine environmental, health and safety management techniques so as to be appropriate for use in Antarctica. The new facility at Vesleskarvet also provides the DEA with a unique opportunity to test environmental management and control measures, which have been developed for general use, in practice.

An on-going monitoring project to monitor EHS changes on Vesleskarvet must form part of this programme. The results of this project should be fed into the EHSMS.

7.18 STEPS THAT MUST BE TAKEN BEFORE THE 1993/1994 SUMMER TAKE OVER PERIOD

7.18.1 EHS POLICY STATEMENT.

The DEA must issue a comprehensive policy statement that clearly explains the mission and goals of South Africa in its Antarctic involvement (see 7.3.1).

7.18.2 ENVIRONMENTAL, HEALTH AND SAFETY CODE OF CONDUCT.

A code of conduct for base personnel and visitors to the new base should accompany the policy statement.

7.18.3 RESTRICTED AREA DEMARCATION.

Sensitive areas in the region of the proposed new base have been clearly demarcated. Access to such areas must be limited to scientists who are in possession of a letter of consent issued by the Director General of the DEA or his designate. Additions to existing restricted areas, or new areas which, after scientific investigation warrant exclusion, may be added after discussion thereof with SANAP management.

7.18.4 CONTINGENCY PLANS.

It is important that contingency planning is completed to cater for accidents, breakdowns and other types of systems failure such as:

(a) fuel spills;
(b) sewage process failure;
(c) fire contingency plans;

(d) vehicle accidents; and
(e) personnel injuries in the field requiring evacuation.

7.18.5 INITIAL ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT PROGRAMME.

A management programme to control the impact of activities in and around the construction area and along the route should be drawn up in order to minimize all types of impacts that are caused by human negligence or complacency. This management plan should be based on the analysis of impacts in chapter 6 of this document, and must form part of the eventual EHSMS.

7.18.6 ENVIRONMENTAL, HEALTH AND SAFETY AUDIT PROCEDURE.

An audit procedure should be in place for the construction phase.

7.18.7 MONITORING PROGRAMMES.

Monitoring programmes must be set up for every aspect of the development that could result in environmental health or safety impacts arising from some kind of malfunction.

7.19 RECOMMENDED CONDITIONS FOR THE REMAINING PHASES OF THE PROJECT

7.19.1 CONSTRUCTION PHASE

(a) Conditions for the construction phase:

(i) A suitable depot must be clearly demarcated for all construction material. No material is to be stored outside of this demarcated area.

(ii) The necessary waste bins for construction waste must all be in position before construction begins.

(iii) No work may begin unless the environmental officer is satisfied that the site is in an acceptable state.

(iv) Wind-socks must be placed on the edge of the cliff on the southern buttress in the vicinity of the base.

(b) Work areas must be demarcated and the construction supervisor must be made responsible for any disturbance to physical or biological environmental components outside these areas. The demarcated work areas must be cleaned up thoroughly before the construction team leave the area. (The prepared site will be visited by environmental officers who must conduct an audit on the state of the base and site).

(c) No biological or geological material may be removed from the site unless it is needed for the purposes of environmental evaluation or for engineering tests.

(d) Nobody in the construction team may work outside of the safety handrail. The safety of these people must be the responsibility of the construction supervisor.

(e) A construction team member must be allocated, or specially appointed (possibly on a rotary basis), to remove all waste from the site, separate it, and place it in the marked containers. This will ensure that construction workers do not waste valuable time executing this exercise.

(f) An environmental officer must be on site at all times, and have the authority to ensure that any aspect or element that poses a threat to the EHS is rectified immediately.

7.19.2 OPERATIONAL PHASE

All activities must be conducted within an approved EHS management programme within an EHSMS.

7.19.3 DECOMMISSIONING AND REHABILITATION PHASE

The base can either be removed and a replacement base erected elsewhere, or replaced with a base utilising SANAE IV elements. Depending on circumstances, the latter would appear to be the most suitable from an EHS and a logistic point of view.

Planning must start well in advance in order to accommodate the latest thinking and technologies.

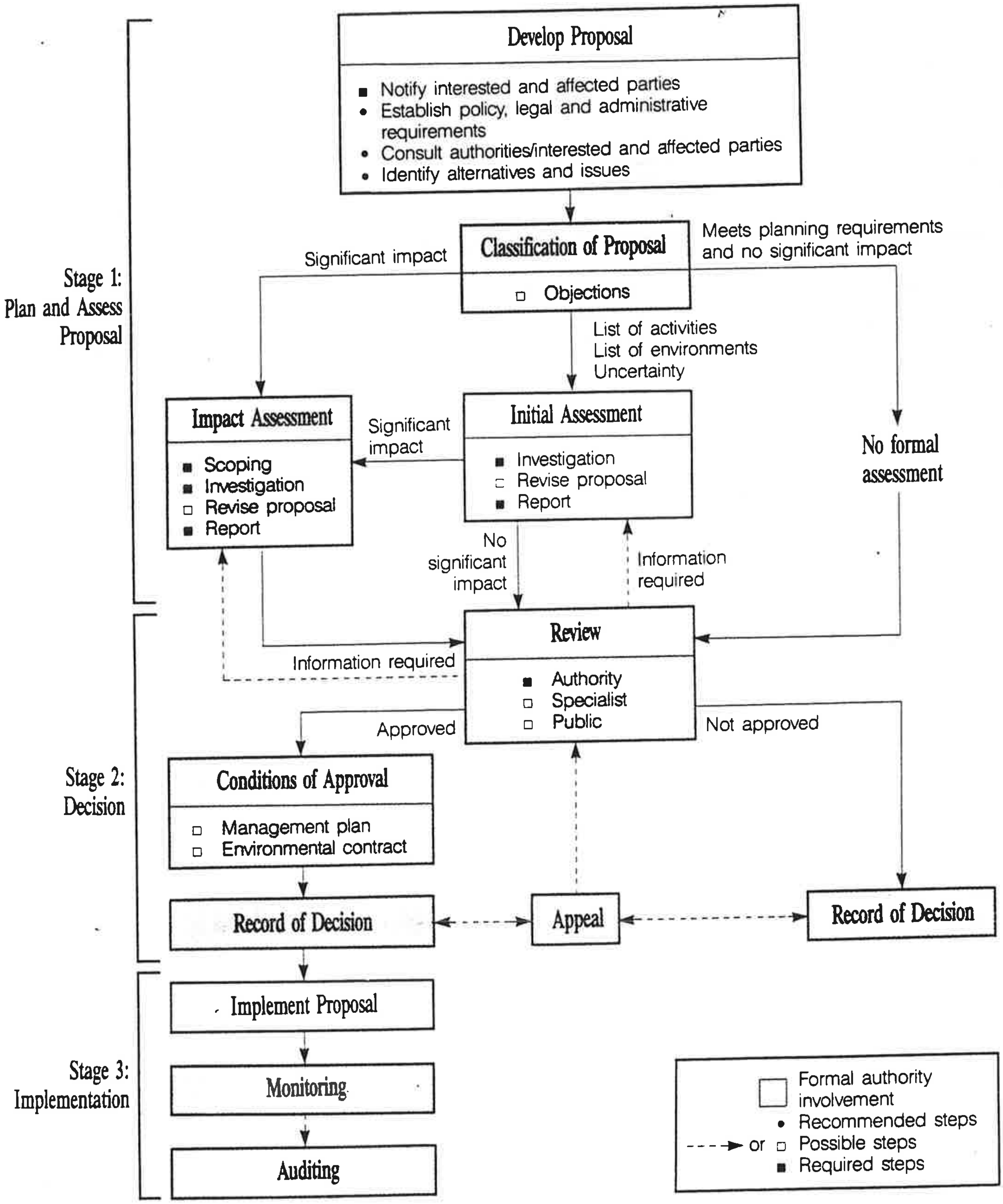
The CEE process for the decommissioning and rehabilitation phase must be completed at least two years before the decommissioning date, to allow enough time for sufficient planning.

7.19.4 FUTURE SANAE BASES

Cost-benefit analyses must be included in any CEE for future SANAE bases. These evaluations must be completed at least two years before the construction date.

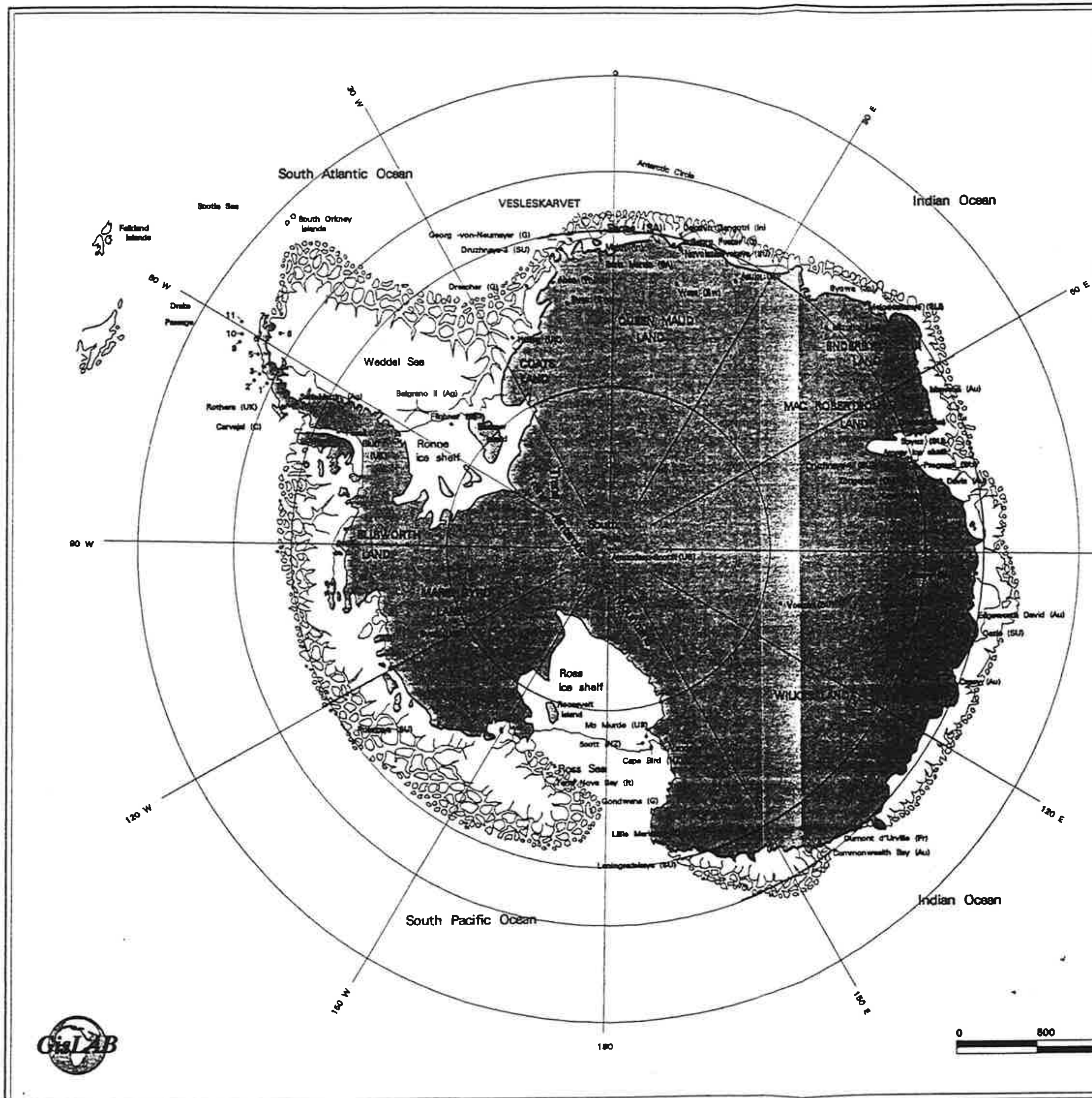
APPENDIX 1

THE INTEGRATED ENVIRONMENTAL MANAGEMENT PROCEDURE


Stage 1:
Plan and Assess Proposal
Develop Proposal
■ Notify interested and affected parties
• Establish policy, legal and administrative requirements
• Consult authorities/interested and affected parties
• Identify alternatives and issues
Classification of Proposal
□ Objections
Significant impact
Meets planning requirements and no significant impact
List of activities
List of environments
Uncertainty
Impact Assessment
■ Scoping
■ Investigation
□ Revise proposal
■ Report
Significant impact
Initial Assessment
■ Investigation
□ Revise proposal
■ Report
No formal assessment
No significant impact
Information required
Review
■ Authority
□ Specialist
□ Public
Information required
Approved
Not approved
Stage 2:
Decision
Conditions of Approval
□ Management plan
□ Environmental contract
Record of Decision
Appeal
Record of Decision
Stage 3:
Implementation
Implement Proposal
Monitoring
Auditing
Formal authority involvement
• Recommended steps
or □ Possible steps
■ Required steps

APPENDIX 2

FIGURES



KEY TO COUNTRIES REPRESENTED

Ag - ARGENTINA
Au - AUSTRALIA
C - CHILE
Ch - CHINA
Fn - FINLAND
Fr - FRANCE
G - GERMANY
In - INDIA
It - ITALY
Jp - JAPAN
SA - SOUTH AFRICA
Sp - SPAIN
Sw - SWEDEN
SU - RUSSIA
UK - UNITED KINGDOM
US - UNITED STATES OF AMERICA

KEY TO BASES ON ANTARCTIC PENINSULA AND KING GEORGE ISLAND

1. Faraday (UK)
2. Palmer (US)
3. Yelcho (C)
4. Gabriel G Videla (C)
5. Primavera (Ag)
6. Bernardo O'Higgins (C)
7. Esperanza (Ag)
8. Marambio (Ag)
9. Juan Carlos (Sp)
10. Arturo Prat (C)
11. King George Island:
    - Comandante Ferraz (Brazil)
    - Arctowski (Poland)
    - Jubany (Argentina)
    - Bellingshausen (Russia)
    - Rodolfo Marsh/Frey (Chile)
    - Great Wall (China)
    - Artigas (Uruguay)
    - King-Sejong (South Korea)
    - Macchu Picchu (Peru)

Figure 1

ANTARCTICA

SANAE IV

COMPREHENSIVE ENVIRONMENTAL EVALUATION

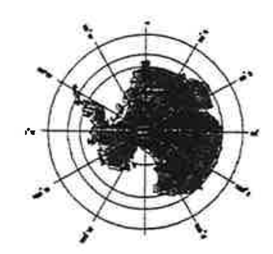


Figure 2

LOCALITY

SANAE IV

COMPREHENSIVE ENVIRONMENTAL EVALUATION

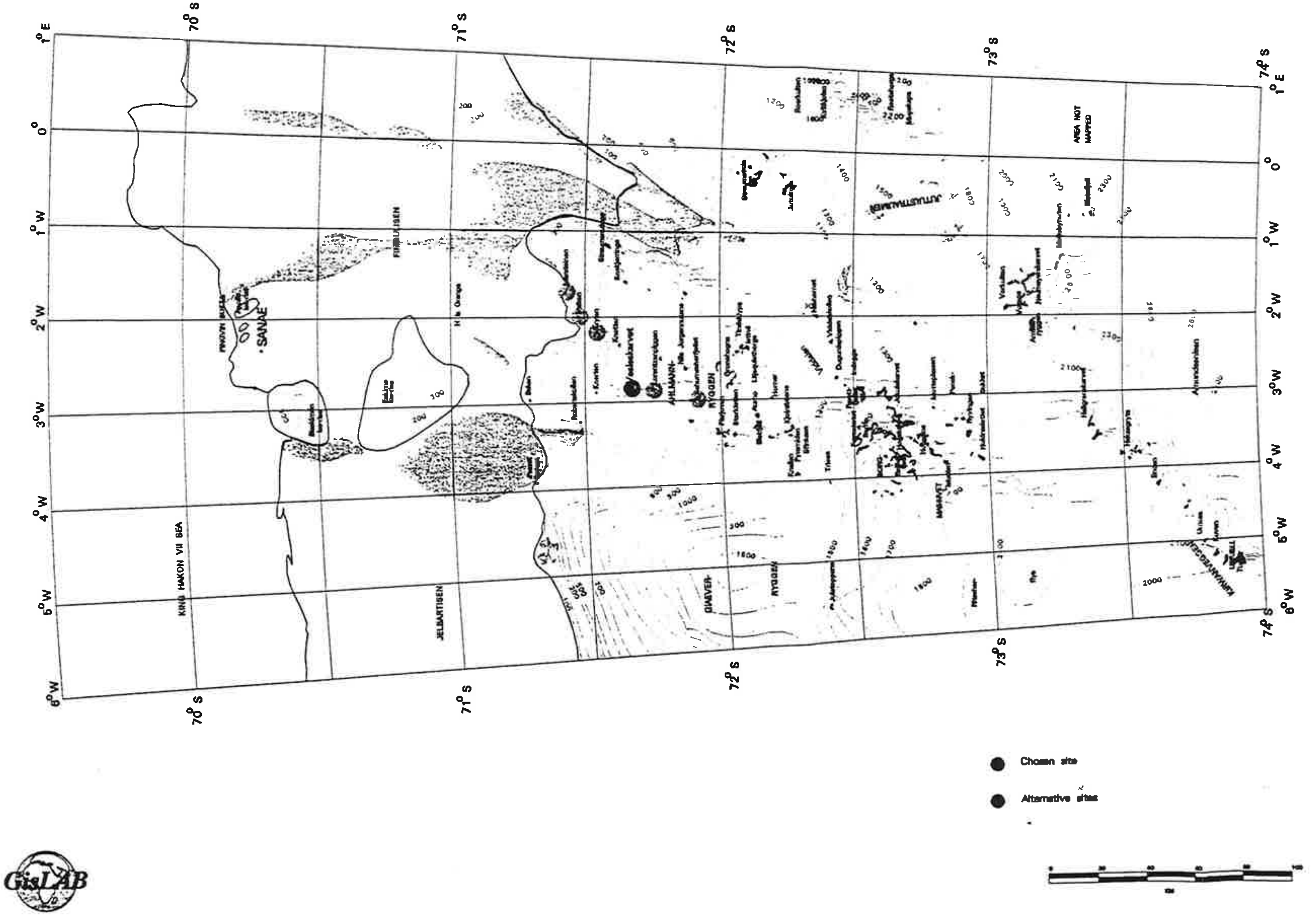


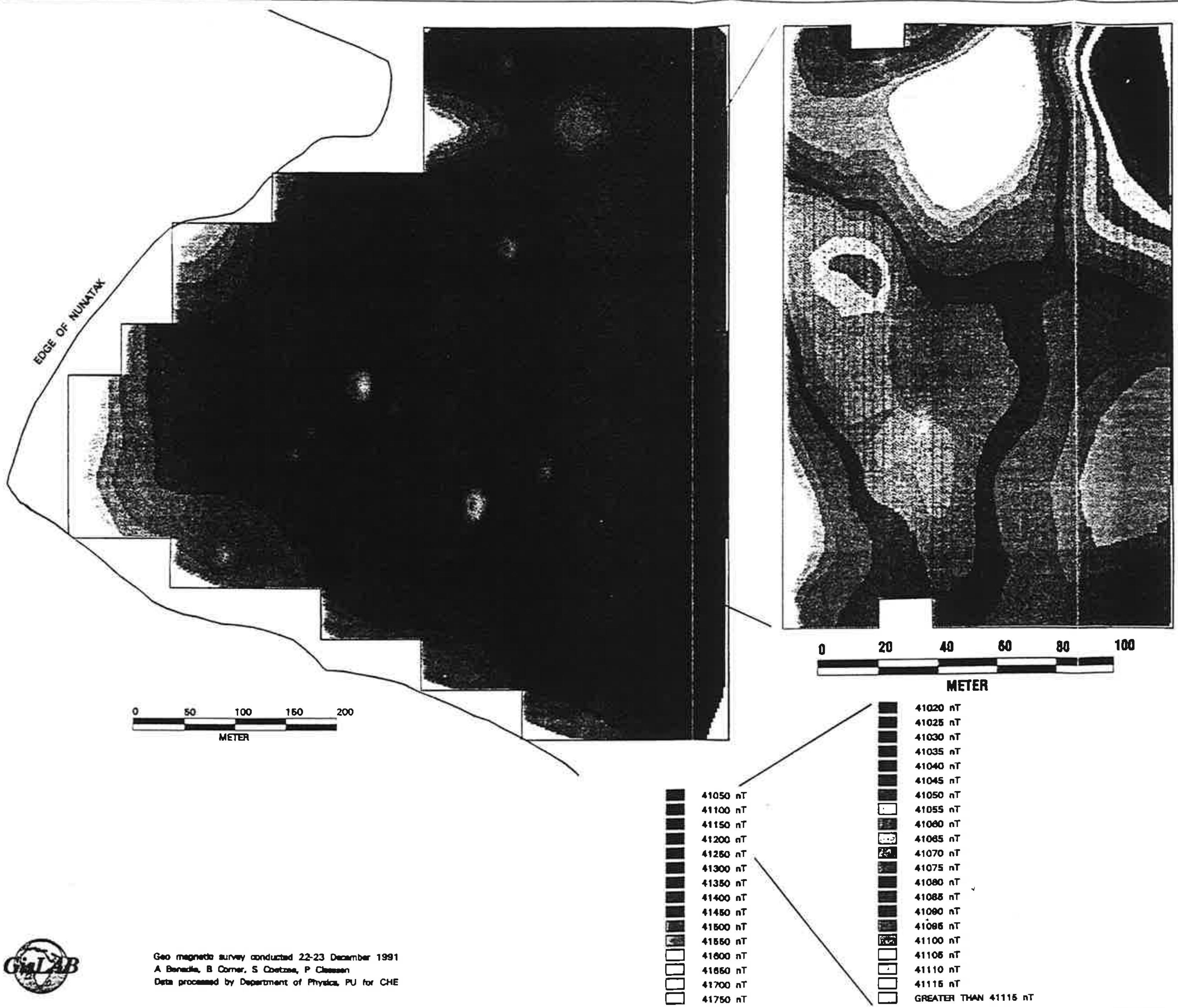
Figure 3

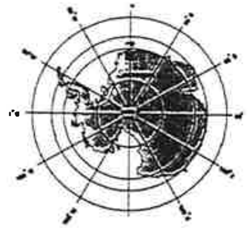
GEO MAGNETIC RANGES

SOUTH BUTTRESS VESLESKARVET

SANAE IV

COMPREHENSIVE ENVIRONMENTAL EVALUATION





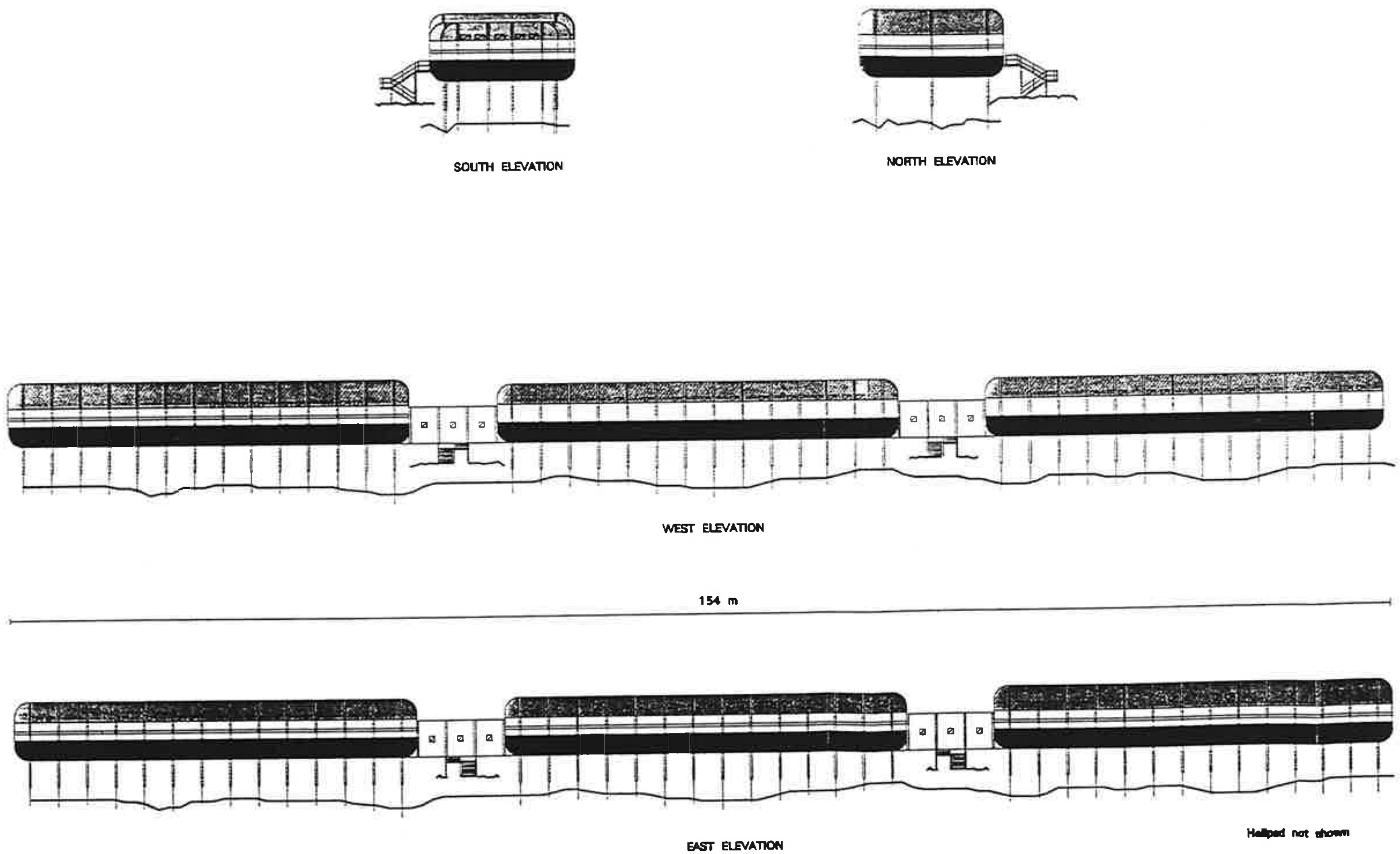
Geo magnetic survey conducted 22-23 December 1991
A Benadie, B Corner, S Coetzee, P Claassen
Data processed by Department of Physics, PU for CHE

Figure 4

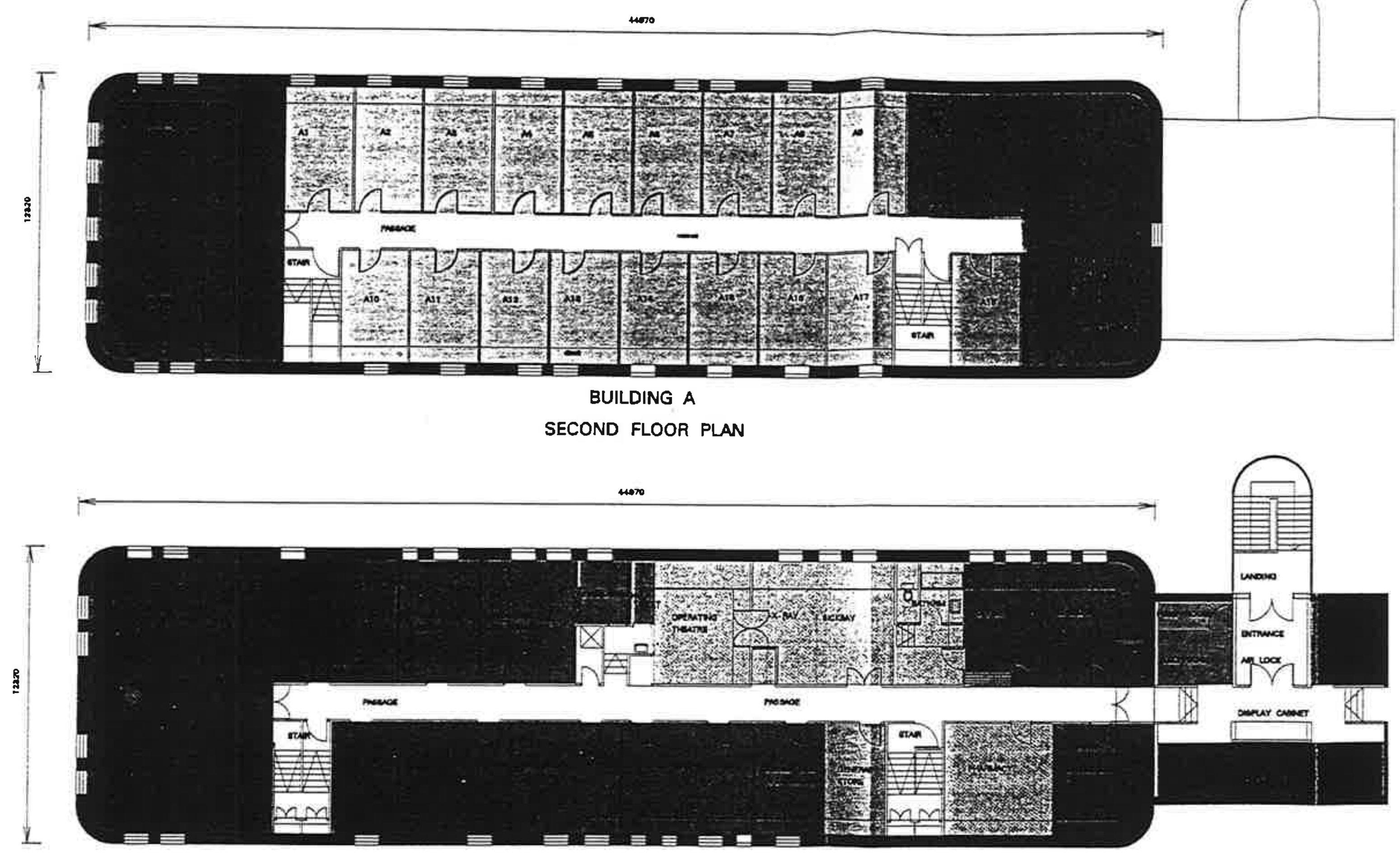
BASE ELEVATIONS

SANAE IV

COMPREHENSIVE ENVIRONMENTAL EVALUATION



Original plans supplied by the Department of Public Works



BUILDING A
SECOND FLOOR PLAN

BUILDING A
FIRST FLOOR PLAN

LEGEND

- LABORATORY / SCIENTIFIC AREAS /OFFICES
- ABLUTIONS / LAUNDRY / CHANGE ROOMS
- SLEEPING QUARTERS
- DINING ROOM / KITCHEN
- FOOD STORAGE
- RECREATION
- WASTE TREATMENT & STORAGE
- GENERAL STORAGE
- POWER GENERATION
- WORKSHOP / VEHICLE HOUSING
- MEDICAL

Original plans supplied by the Department of Public Works

GisLAB

Figure 5a

BASE PLAN
LAYOUT
AND ZONING

BLOCK A

SANAE IV

COMPREHENSIVE
ENVIRONMENTAL
EVALUATION

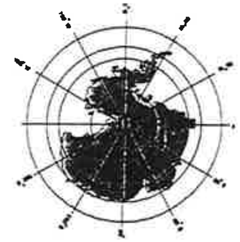


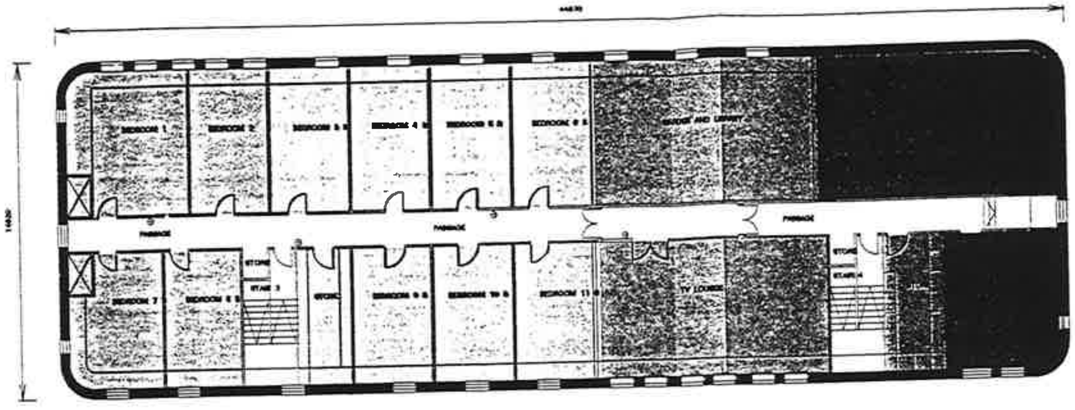
Figure 5b

BASE PLAN LAYOUT AND ZONING

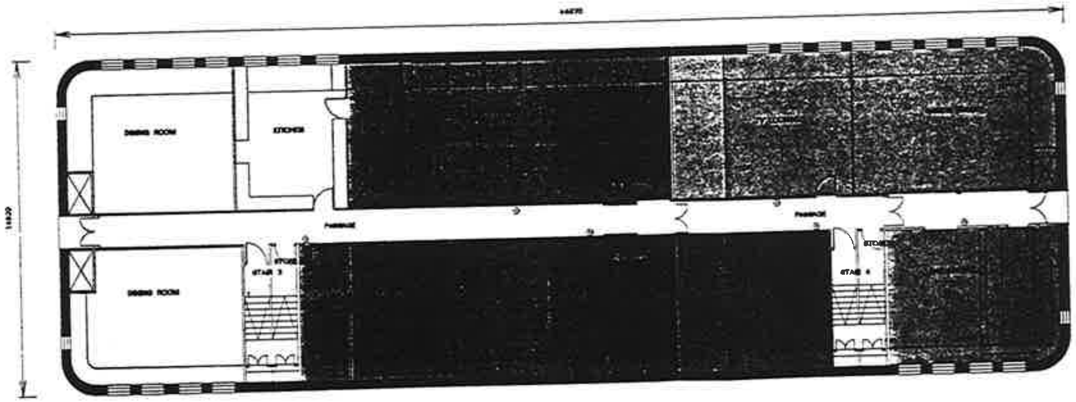
BLOCK B

SANAE IV

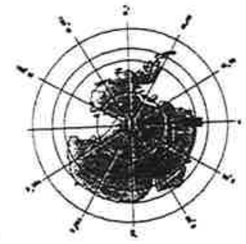
COMPREHENSIVE ENVIRONMENTAL EVALUATION



BLOCK B
SECOND FLOOR PLAN



BLOCK B
FIRST FLOOR PLAN



LEGEND

- LABORATORY / SCIENTIFIC AREAS /OFFICES
- ABLUTIONS / LAUNDRY / CHANGE ROOMS
- SLEEPING QUARTERS
- DINING ROOM / KITCHEN
- FOOD STORAGE
- RECREATION
- WASTE TREATMENT & STORAGE
- GENERAL STORAGE
- POWER GENERATION
- WORKSHOP / VEHICLE HOUSING
- MEDICAL

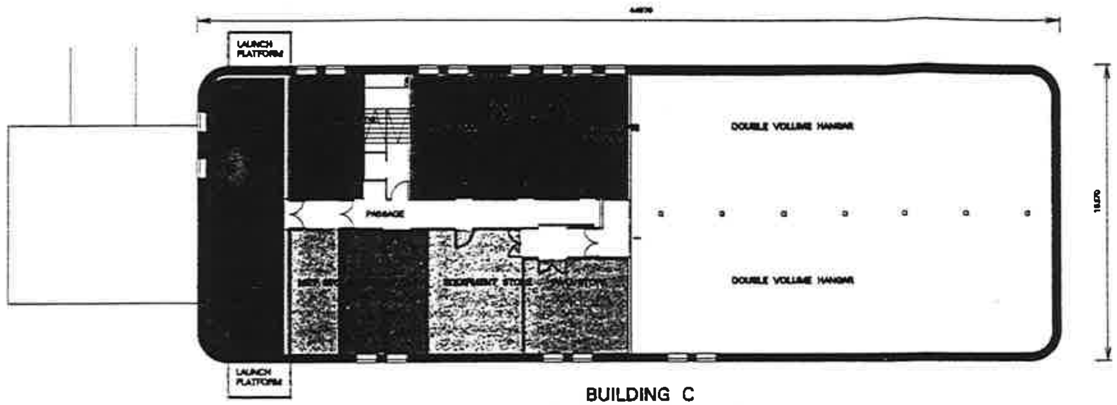
Original plans supplied by the Department of Public Works

Figure 5c

BASE PLAN LAYOUT AND ZONING BLOCK C

SANAE IV

COMPREHENSIVE ENVIRONMENTAL EVALUATION

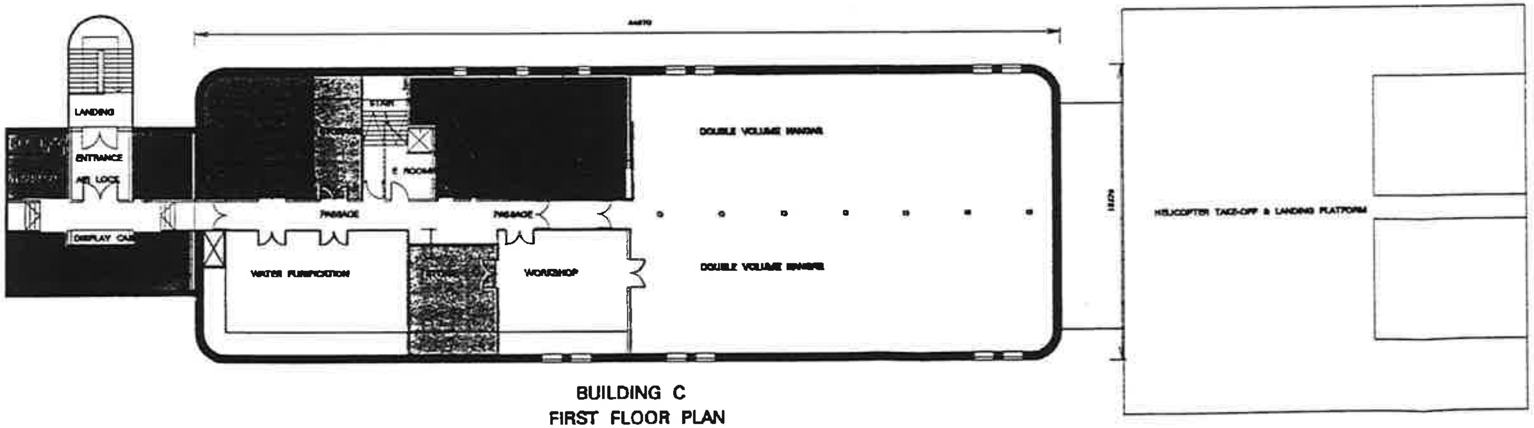


BUILDING C
SECOND FLOOR PLAN

LEGEND

- LABORATORY / SCIENTIFIC AREAS /OFFICES
- ABLUTIONS / LAUNDRY / CHANGE ROOMS
- SLEEPING QUARTERS
- DINING ROOM / KITCHEN
- FOOD STORAGE
- RECREATION
- WASTE TREATMENT & STORAGE
- GENERAL STORAGE
- POWER GENERATION
- WORKSHOP / VEHICLE HOUSING
- MEDICAL

Original plans supplied by the Department of Public Works



BUILDING C
FIRST FLOOR PLAN

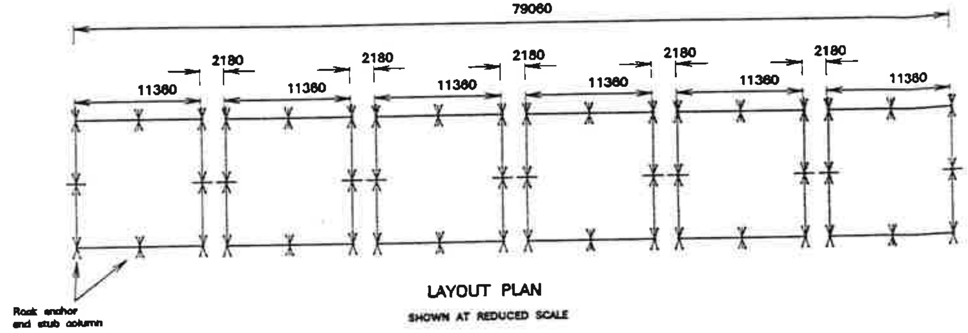
Original plans supplied by the Department of Public Works

Figure 6

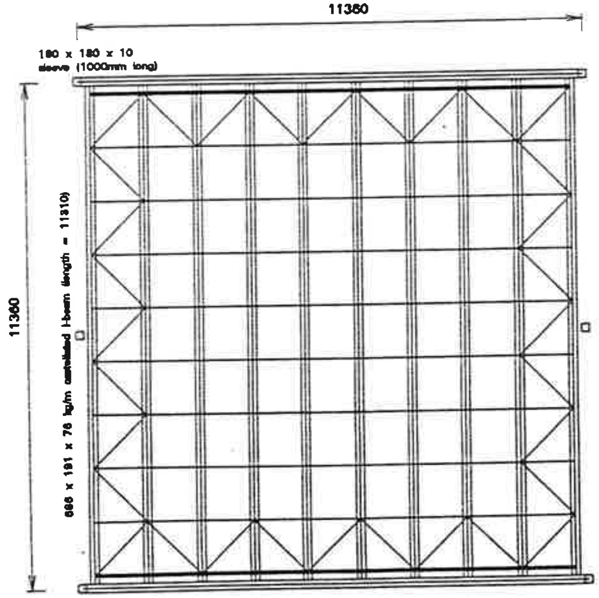
BULK FUEL STORAGE FACILITY

SANAE IV

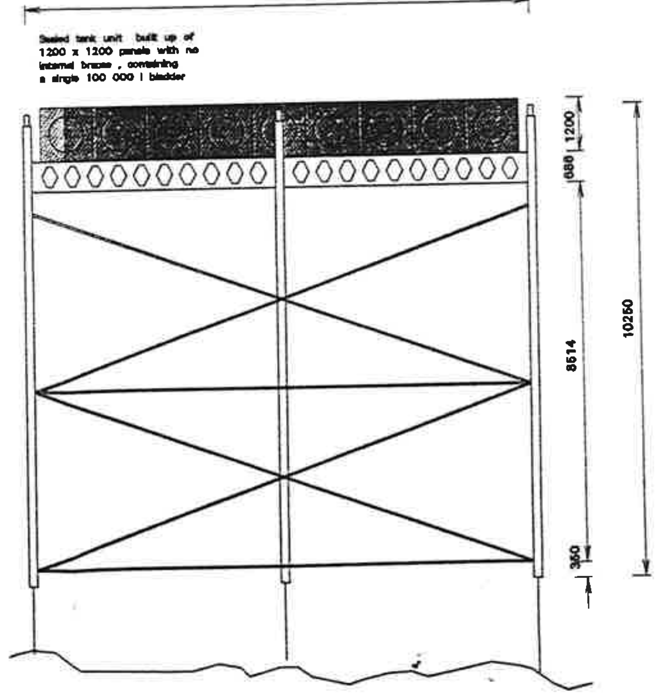
COMPREHENSIVE ENVIRONMENTAL EVALUATION



LAYOUT PLAN
SHOWN AT REDUCED SCALE



PLAN OF DIESEL BUNKER STAND PLATFORM (6 OFF)



TYPICAL ELEVATION

Original plans supplied by the Department of Public Works

GisLAB

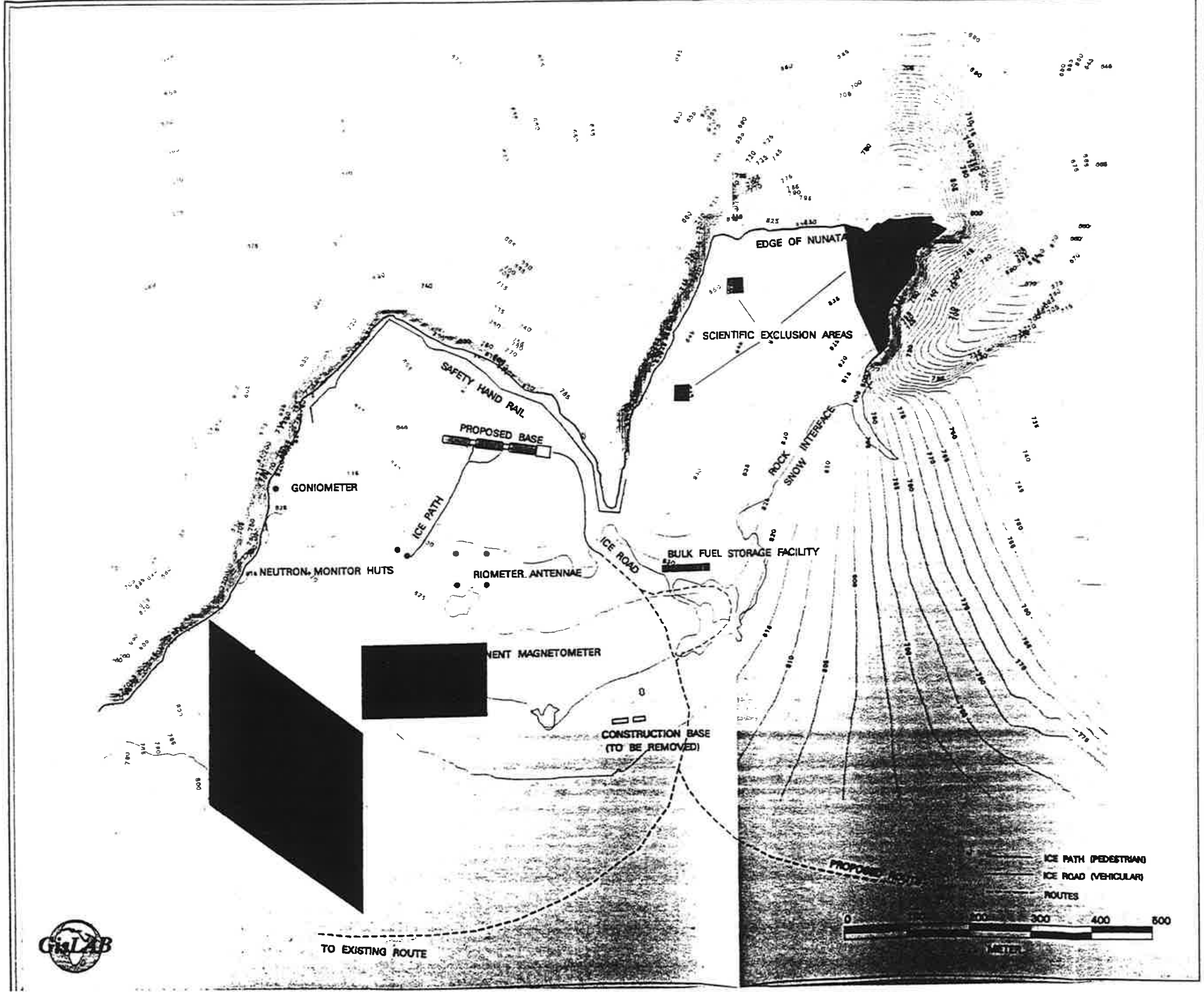
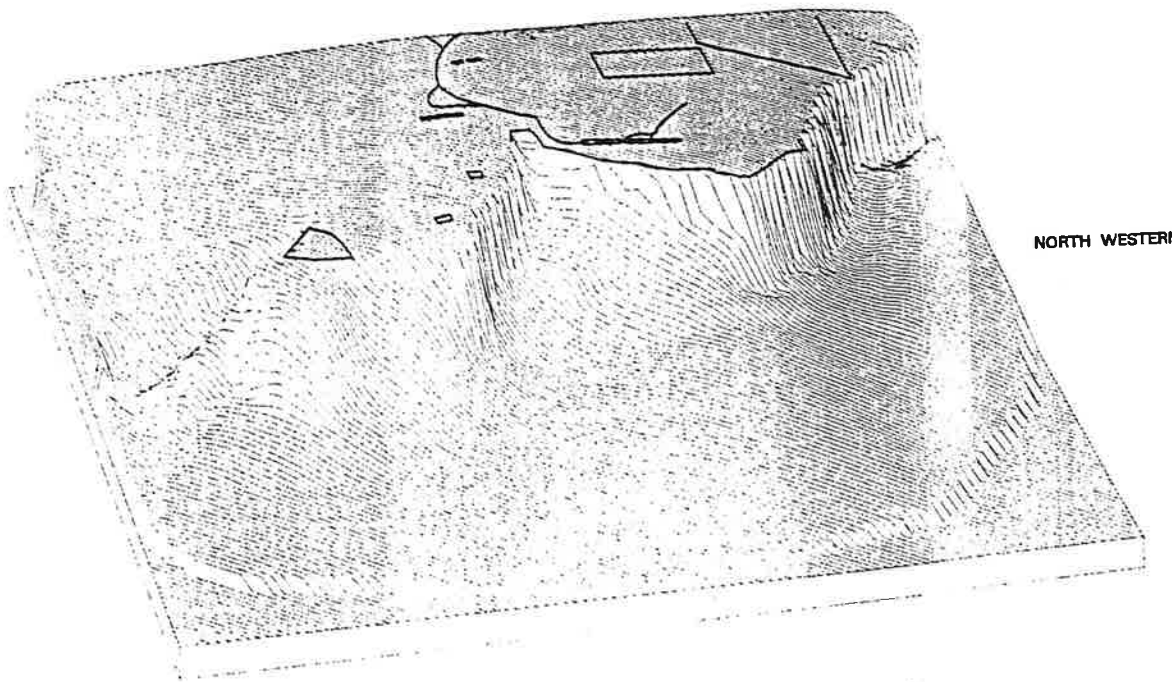


Figure 7

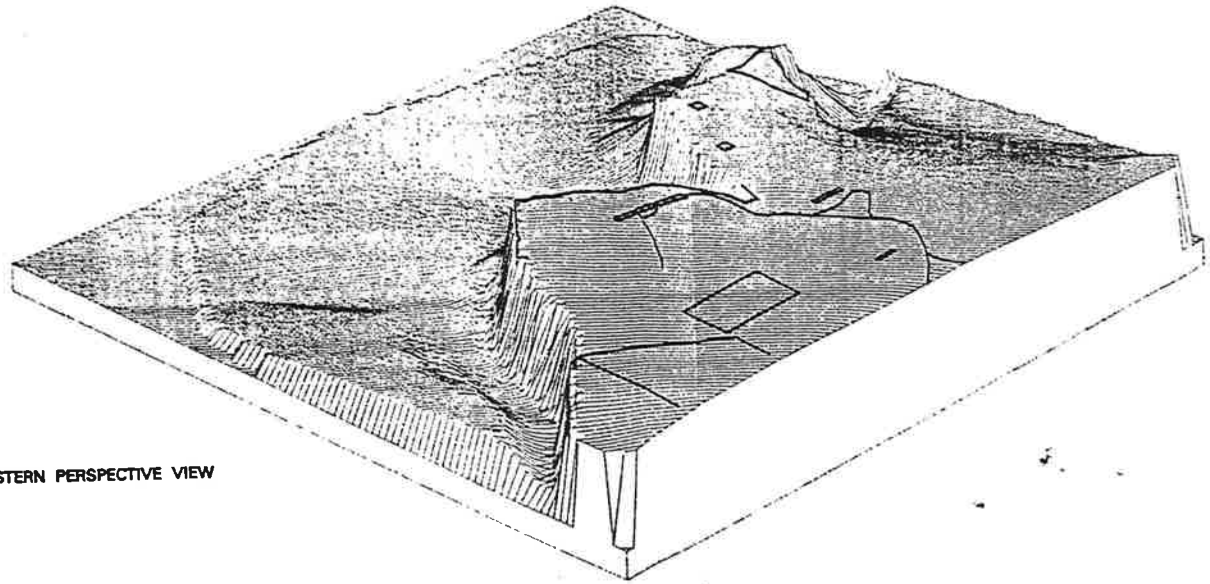
VESLESKARVET SITE PLAN

SANAE IV

COMPREHENSIVE ENVIRONMENTAL EVALUATION



NORTH WESTERN PERSPECTIVE VIEW



SOUTH EASTERN PERSPECTIVE VIEW

GisLAB

Figure 8

VESLESKARVET PERSPECTIVE VIEWS

SANAE IV

COMPREHENSIVE ENVIRONMENTAL EVALUATION

SANAE IV

APPENDIX 3

PLATES

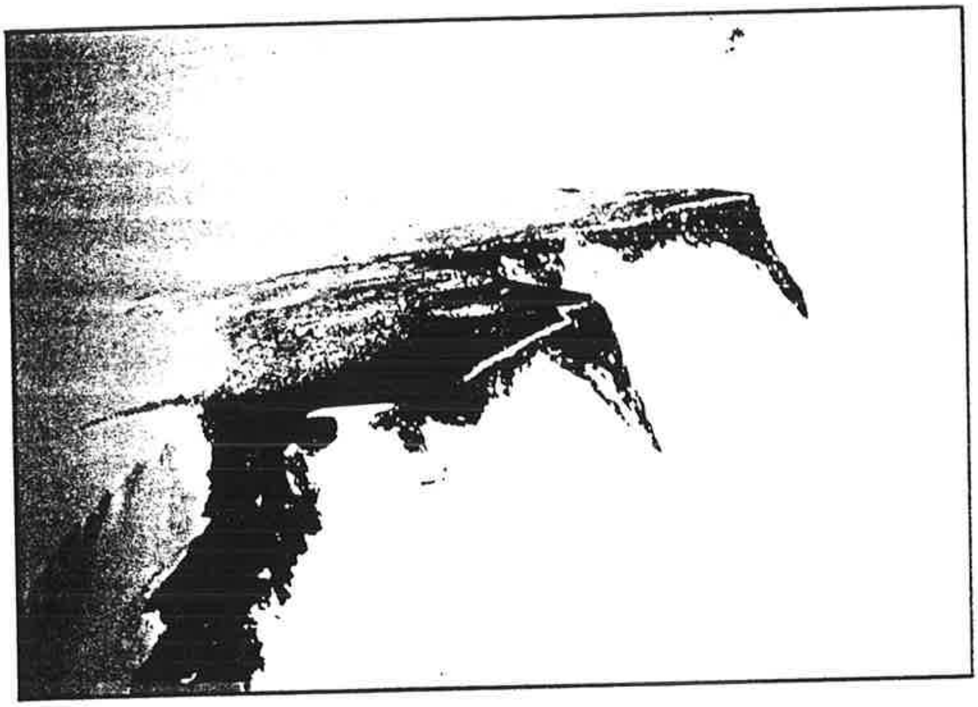


PLATE A: VESLESKARVET

PLATE B: KRYLEN

PLATE C: VALKEN

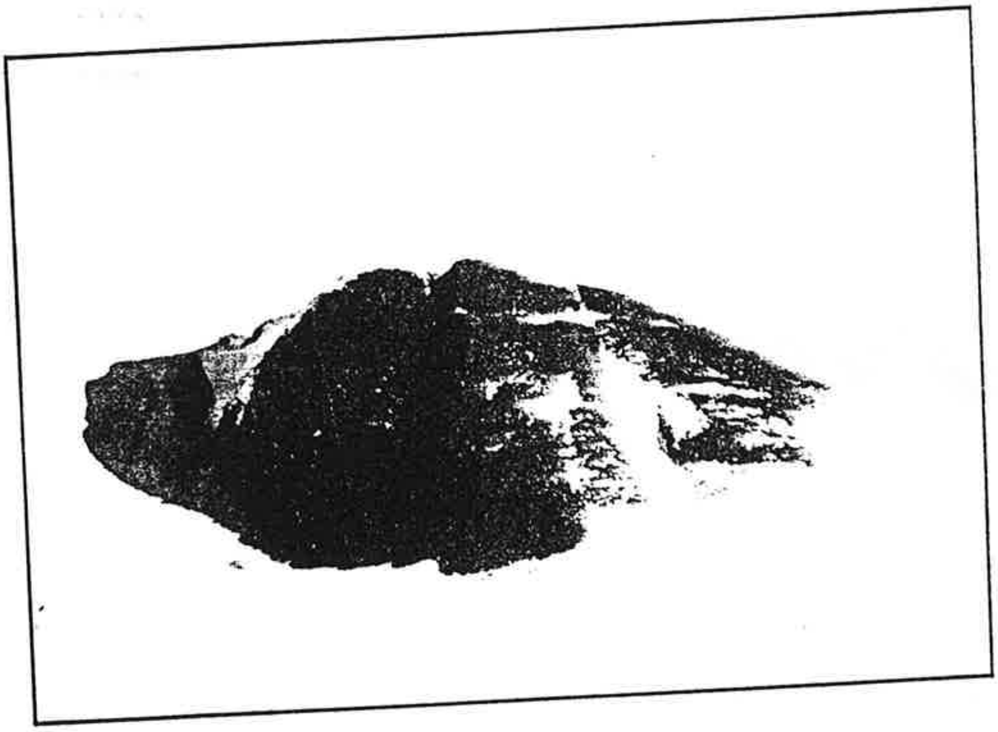


PLATE D: MARSTEINEN

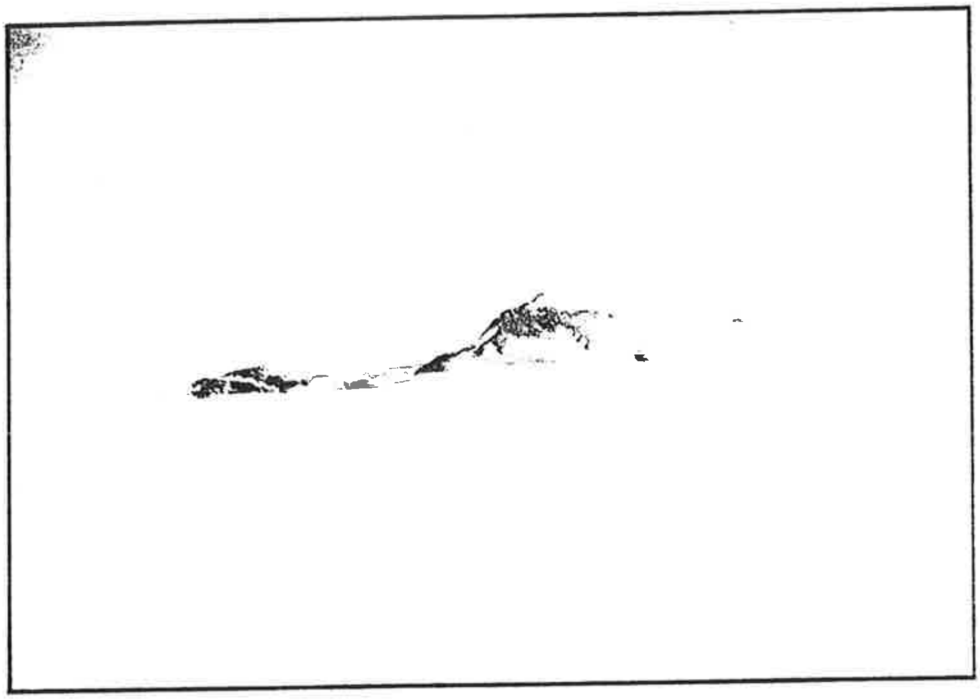


PLATE E: LORENTZENPIGGEN

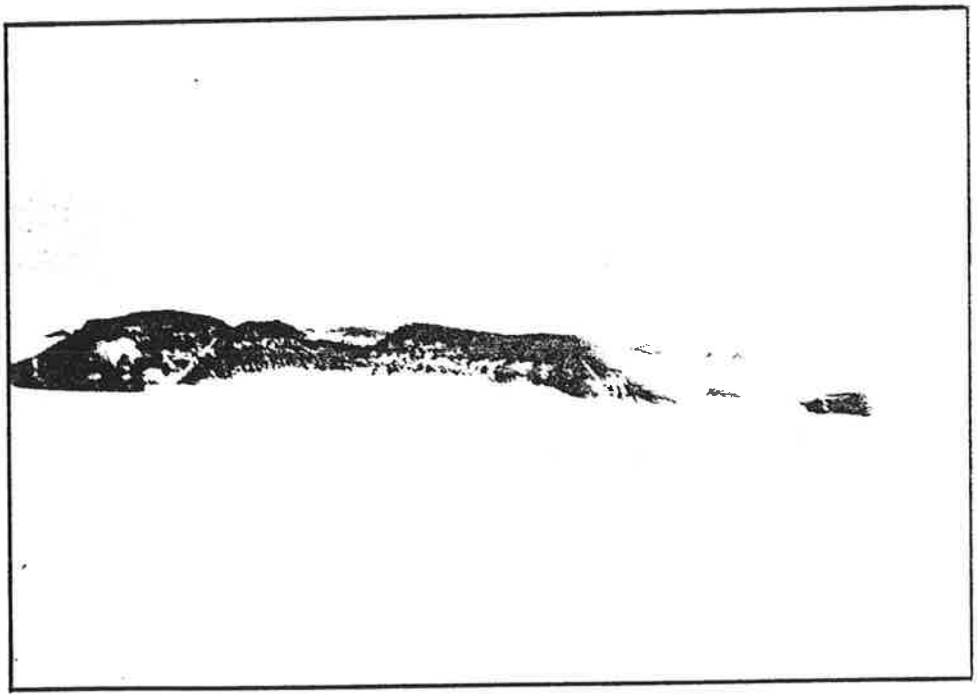


PLATE F: SCHUMACHERSFJELLET

APPENDIX 4

PROTOCOL ON ENVIRONMENTAL PROTECTION

(Only the sections that are relevant to this study are given)

APPENDIX 4:

PROTOCOL ON ENVIRONMENTAL PROTECTION UNDER THE ANTARCTIC TREATY

(MADRID, October 4, 1991)

ARTICLE 3

ENVIRONMENTAL PRINCIPLES

1. The protection of the Antarctic environment and dependent and associated ecosystems and the intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area.

2. To this end:

(a) Activities in the Antarctic Treaty area shall be planned and conducted so as to limit adverse impacts on the Antarctic environment and dependent and associated ecosystems;

(b) activities in the Antarctic Treaty area shall be planned and conducted so as to avoid:

(i) adverse effects on climate or weather patterns;

(ii) significant adverse effects on air or water quality;

(iii) significant changes in the atmospheric, terrestrial (including aquatic), glacial or marine environments;

(iv) detrimental changes in the distribution, abundance or productivity of species or populations of species of fauna and flora;

(v) degradation of, or substantial risk to, areas of biological, scientific, historic, aesthetic or wilderness significance;

(c) activities in the Antarctic Treaty area shall be planned and conducted on the basis of information sufficient to allow prior assessments of, and informed judgements about, their possible impacts on the Antarctic environment and dependent and associated ecosystems and on the value of Antarctica for the conduct of scientific research; such judgements shall take full account of:

(i) the scope of the activity, including its area, duration and intensity;

(ii) the cumulative impacts of the activity, both by itself and in combination with other activities in the Antarctic Treaty area;

(iii) whether the activity will detrimentally affect any other activity in the Antarctic Treaty area;

(iv) whether technology and procedures are available to provide for environmentally safe operations;

(v) whether there exists the capacity to monitor key environmental parameters and ecosystem components so as to identify and provide early warning of any adverse effects of the activity and to provide for such modification of operating procedures as may be necessary in the light of the results of monitoring or increasing knowledge of the Antarctic environment and dependent and associated ecosystems; and

(vi) whether there exists the capacity to respond promptly and effectively to accidents, particularly those with potential environmental effects;

(d) regular and effective monitoring shall take place to allow assessment of the impacts of ongoing activities,including the verification of predicted impacts;

(e) regular and effective monitoring shall take place to facilitate early detection of the possible unforeseen effects of activities carried on both within and outside the Antarctic Treaty area on the Antarctic environment and dependent and associated ecosystems.

3. Activities shall be planned and conducted in the Antarctic Treaty area so as to accord priority to scientific research and to preserve the value of Antarctica as an area for the conduct of such research, including research essential to understanding the global environment.

4. Activities undertaken in the Antarctic Treaty area pursuant to scientific research programmes, tourism and all other governmental and non-governmental activities in the Antarctic Treaty area for which advance notice is required in accordance with Article VII (5) of the Antarctic Treaty, including associated logistical support activities, shall:

(a) take place in a manner consistent with the principles of this Article; and

(b) be modified, suspended or cancelled if they result in or threaten to result in impacts upon the Antarctic environment or dependent or associated ecosystems inconsistent with those principles.

ARTICLE 8

ENVIRONMENTAL IMPACT ASSESSMENT

1. Proposed activities referred to in paragraph 2 below shall be subject to the procedures set out in Annex I for prior assessment of the impacts of those activities on the Antarctic environment or on dependent or associated ecosystems according to whether those activities are identified as having:

(a) less than a minor or transitory impact;

(b) a minor or transitory impact; or

(c) more than a minor or transitory impact.

2. Each Party shall ensure that the assessment procedures set out in Annex I are applied in the planning processes leading to decisions about any activities undertaken in the Antarctic Treaty area pursuant to scientific research programmes, tourism and all other governmental and non-governmental activities in the Antarctic Treaty area for which advance notice is required under Article VII (5) of the Antarctic Treaty, including associated logistic support activities.

3. The assessment procedures set out in Annex I shall apply to any change in an activity whether the change arises from an increase or decrease in the intensity of an existing activity, from the addition of an activity, the de-commissioning of a facility, or otherwise.

4. Where activities are planned jointly by more than one Party, the Parties involved shall nominate one of their number to coordinate the implementation of the environmental impact assessment procedures set out in Annex I.

ARTICLE 14

INSPECTION

1. In order to promote the protection of the Antarctic environment and dependent and associated ecosystems, and to ensure compliance with this Protocol, the Antarctic Treaty Consultative Parties shall arrange, individually or collectively, for inspections by observers´to be made in accordance Article VII of the Antarctic Treaty.

2. Observers are:

(a) observers designated by any Antarctic Treaty Consultative Party who shall be nationals of that Party and;

(b) any observers designated at Antarctic Treaty Consultative Meetings to carry out inspections under procedures to be established by an Antarctic Treaty Consultative Meeting.

3. Parties shall cooperate fully with observers undertaking inspections, and shall ensure that during inspections, observers are

given access to all parts of stations, installations equipment, ships and aircraft open to inspection under Article VII (3) of the Antarctic Treaty, as well as to all records maintained thereon which are called for pursuant to this Protocol.

4. Reports of inspections shall be sent to the Parties whose stations, installations, equipment, ships and aircraft are covered by the reports. After those Parties have been given the opportunity to comment, the reports and any comments thereon shall be circulated to all the Parties and to the Committee, considered at the next Antarctic Treaty Consultative Meeting, and thereafter made publicly available.

ARTICLE 15

EMERGENCY RESPONSE ACTION

1. In order to respond to environmental emergencies in the Antarctic Treaty area, each Party agrees to:

(a) provide for prompt and effective response action to such emergencies which might arise in the performance of scientific research programmes, tourism and all other governmental and non-governmental activities in the Antarctic Treaty area for which advance notice is required under Article VII (5) of the Antarctic Treaty, including associated logistic support activities.

(b) establish contingency plans for response to incidents with potential adverse effects on the Antarctic environment or dependent and associated ecosystems.

2. To this end, the Parties shall:

(a) cooperate in the formulation and implementation of such contingency plans; and

(b) establish procedures for immediate notification of, and cooperative response to, environmental emergencies.

3. In the implementation of this Article, the Parties shall draw upon the advice of the appropriate international organisations.

ARTICLE 17

ANNUAL REPORT BY PARTIES

1. Each Party shall report annually on the steps taken to implement this Protocol. Such reports shall include notifications made in accordance with Article 13 (3), contingency plans established in accordance with Article 15 and other notifications and information called for pursuant to this Protocol for which there is no other provision concerning the circulation and exchange of information.

2. Reports made in accordance with paragraph 1 above shall be circulated to all Parties and to the Committee, considered at the next Antarctic Treaty Consultative Meeting, and made publicly available.

MADRID October 4, 1991

ANNEX 1 TO THE PROTOCOL ON ENVIRONMENTAL PROTECTION TO THE ANTARCTIC TREATY

ENVIRONMENTAL IMPACT ASSESSMENT

ARTICLE 1

PRELIMINARY STAGE

1. The environmental impacts of proposed activities referred to in Article 8 of the Protocol shall, before their commencement, be considered in accordance with appropriate national procedures.

2. If an activity is determined as having less than a minor or transitory impact, the activity may proceed forthwith.

ARTICLE 2

INITIAL ENVIRONMENTAL EVALUATION

1. Unless it has been determined that an activity will have less than a minor or transitory impact, or unless a Comprehensive Environmental Evaluation is being prepared in accordance with Article 3, an Initial Environmental Evaluation shall be prepared. It shall contain sufficient detail to assess whether a proposed activity may have more than a minor or transitory impact and shall include:

(a) a description of the proposed activity, including its purpose, location, duration, and intensity; and

(b) consideration of alternatives to the proposed activity and any impacts that the activity may have, including consideration of cumulative impacts in the light of existing and known planned activities.

2. If an Initial Environmental Evaluation indicates that a proposed activity is likely to have no more than a minor or transitory impact, the activity may proceed, provided that appropriate procedures, which may include monitoring, are put in place to assess and verify the impact of the activity.

ARTICLE 3

COMPREHENSIVE ENVIRONMENTAL EVALUATION

1. If an Initial Environmental Evaluation indicates or if it is otherwise determined that a proposed activity is likely to have more than a minor or transitory impact, a Comprehensive Environmental Evaluation shall be prepared.

2. A Comprehensive Environmental Evaluation shall include:

(a) a description of the proposed activity including itspurpose, location duration and intensity, and possible alternatives to the activity, including the alternative of not proceeding, and the consequences of those alternatives;

(b) a description of the initial environmental reference state with which predicted changes are to be compared and a prediction of the future environmental reference state in the absence of the proposed activity;

(c) a description of the methods and data used to forecast the impacts of the proposed activity;

(d) estimation of the nature, extent, duration and intensity of the likely direct impacts of the proposed activity;

(e) consideration of possible indirect or second order impacts of the proposed activity;

(f) consideration of cumulative impacts of the proposed activity in the light of existing activities and other known planned activities;

(g) identification of measures, including monitoring programmes, that could be taken to minimize or mitigate impacts of the proposed activity and to detect unforeseen impacts and that could provide early-warning of any adverse effects of the activity as well as to deal promptly and effectively with accidents;

(h) identification of unavoidable impacts of the proposed activity;

(i) consideration of the effects of the proposed activity on the conduct of scientific research and on other existing uses and values;

(j) an identification of gaps in knowledge and uncertainties encountered in compiling the information required under this paragraph; and

(k) a non-technical summary of the information provided under this paragraph; and

(l) the name and address of the person or organization which prepared the Comprehensive Environmental Evaluation and the address to which comments thereon should be directed.

3. The draft Comprehensive Environmental Evaluation shall be made publicly available and shall be circulated to all Parties, which shall also make it publicly available, for comment. A period of 90 days shall be allowed for the receipt of comments.

4, The draft Comprehensive Environmental Evaluation shall be forwarded to the Committee at the same time as it is circulated to the Parties, and at least 120 days before the next Antarctic Treaty Consultative Meeting, for consideration as appropriate.

5. No final decision shall be taken to proceed with the proposed activity in the Antarctic Treaty area unless there has been an opportunity for consideration of the draft Comprehensive Environmental Evaluation by the Antarctic Treaty Consultative Meeting on the advice of the Committee, provided that no decision to proceed with a proposed activity shall be delayed through the operation of this paragraph for longer than 15 months from the date of circulation of the draft Comprehensive Environmental Evaluation.

6. A final Comprehensive Environmental Evaluation shall address and shall include or summarize comments received on the draft Comprehensive Environmental Evaluation. The final Comprehensive Environmental Evaluation, notice of any decisions relating thereto, and any evaluation of the significance of the predicted impacts in relation to the advantages of the proposed activity shall be circulated to all Parties, which shall also make them publicly available, at least 60 days before the commencement of the proposed activity in the Antarctic Treaty area.

ARTICLE 4

DECISIONS TO BE BASED ON COMPREHENSIVE ENVIRONMENTAL EVALUATIONS

Any decision on whether a proposed activity, to which Article 3 applies, should proceed, and, if so, whether in its original or in a modified form, shall be based on the Comprehensive Environmental Evaluation as well as other relevant considerations.

ARTICLE 5

MONITORING

1. Procedures shall be put in place, including appropriate monitoring of key environmental indicators, to assess and verify the impact of any activity that proceeds following the completion of a Comprehensive Environmental Evaluation.

2. The procedures referred to in paragraph 1 above and in Article 2 (2) shall be designed to provide a regular and verifiable record of the impacts of the activity in order, inter alia, to:

(a) enable assessment to be made of the extent to which such impacts, are consistent with this Protocol; and

(b) provide information useful for minimising or mitigating impacts, and, where appropriate, information on the need for suspension, cancellation or modification of the activity.

ARTICLE 6

CIRCULATION OF INFORMATION

1. The following information shall be circulated to the Parties, forwarded to the Committee and made publicly available:

(a) a description of the procedures referred to in Article 1;

(b) an annual list of any Initial Environmental Evalua tions prepared in accordance with Article 2 and any decisions taken in consequence thereof;

(c) significant information obtained, and any action taken in consequence thereof, from procedures put in place in accordance with Article 2 (2) and 5;

(d) information referred to in Article 3 (6).

2. Any Initial Environmental Evaluation prepared in accordance with Article 2 shall be made available on request.

ARTICLE 7

CASES OF EMERGENCY

1. This Annex shall not apply in cases of emergency relating to the safety of human life or of ships, aircraft, or equipment and facilities of high value, or the protection of the environment, which require an activity to be undertaken without completion of the

procedures set out in this Annex.

2. Notice of activities undertaken in cases of emergency, which would otherwise have required preparation of a comprehensive Environmental Evaluation, shall be circulated immediately to the Parties and forwarded to the committee and a full explanation of the activities carried out shall be provided within 90 days of those activities.

ARTICLE 8

AMENDMENT OR MODIFICATION

1. This Annex may be amended or modified by a measure adopted in accordance with Article IX (1) of the Antarctic Treaty. Unless the measure specifies otherwise, the amendment or modification shall be deemed to have been approved, and shall become effective, one year after the close of the Antarctic Treaty Consultative Meeting at which it was adopted, unless one or more of the Antarctic Treaty Consultative Parties notifies the Depositary, within that time period, that it wishes an extension of that period or that it is unable to approve the measure.

2. Any amendment or modification of this Annex which becomes effective in accordance with paragraph 1 above shall thereafter become effective as to any other Party when notice of approval by it has been received by the Depositary.

MADRID October 4, 1991

ANNEX II TO THE PROTOCOL ON ENVIRONMENTAL PROTECTION TO

THE ANTARCTIC TREATY

CONSERVATION OF ANTARCTIC FAUNA AND FLORA

ARTICLE 1

DEFINITIONS

For the purpose of this Annex:

(a) "native mammal" means any member of any species belonging to the Class Mammalia, indigenous to the Antarctic Treaty area or occurring there seasonally through natural migrations;

(b) "native bird" means any member, at any stage of its life cycle (including eggs), of any species of the Class Aves indigenous to the Antarctic Treaty area or occurring there seasonally through natural migrations;

(c) "native plant" means any terrestrial or freshwater vegetation, including bryophytes, lichens, fungi and algae, at any stage of its life cycle (including seeds and other propagules), indigenous to the Antarctic Treaty area;

(d) "native invertebrate" means any terrestrial or fresh-water invertebrate, at any stage of its life cycle, indigenous to the Antarctic Treaty area;

(e) "appropriate authority" means any person or agency authorized by a Party to issue permits under this Annex'

(f) "permit" means a formal permission in writing issued by an appropriate authority'

(g) "take" or "taking" means to kill, injure, capture, handle or molest, a native mammal or bird, or to remove or damage such quantities of native plants that their local distribution or abundance would be significantly affected;

h) "harmful interference" means:

(i) flying or landing helicopters or other aircraft in a manner that disturbs concentrations of birds and seals;

(ii) using vehicles or vessels, including hovercraft and small boats, in a manner that disturbs concentrations of birds and seals;

(iii) using explosives or firearms in a manner that disturbs concentrations of birds and seals;

(iv) wilfully disturbing breeding or moulting birds or concentrations of birds and seals by persons on foot;

(v) significantly damaging concentration of native terrestrial plants by landing aircraft, driving vehicles, or walking on them, or by other means;

(vi) any activity that results in the significant adverse modification of habitats of any species or population of native mammal, bird, plant or invertebrate; and

(vii) "International Convention for Regulation of Whaling" means the Convention done at Washington on 2 December 1946.

ARTICLE 2

CASES OF EMERGENCY

1. The provisions of this Annex shall not apply in cases of emergency involving safety of human life or of ships, aircraft, or equipment and facilities of high value, or environmental protection.

2. Notice of activities undertaken in cases of emergency shall be circulated promptly to all Parties.

ARTICLE 3

PROTECTION OF NATIVE FAUNA AND FLORA

1. Taking or harmful interference shall be prohibited, except in accordance with a permit.

2. Such permits shall specify the authorized activity, including when, where and by whom it is to be conducted and shall be issued only in the following circumstances:

(a) to provide specimens for scientific study or scientific information;

(b) to provide specimens for museums, herbaria, zoological and botanical gardens, or other educational or cultural institutions or uses; and

(c) to provide for unavoidable consequences of scientific activities not otherwise authorized under sub-paragraph a or b above, or of the construction and operation of scientific support facilities.

3. The issue of such permits shall be limited so as to ensure that:

(a) no more native mammals, birds, or plants are taken than are strictly necessary to meet the purposes set forth in paragraph 2 above;

(b) only small numbers of native mammals or birds are killed and in no case more native mammals or birds are killed from local populations than can, in combination with other permitted takings, normally be replaced by natural reproduction in the following season; and

(c) the diversity of species, as well as the habitats essential to their existence, and the balance of the ecological systems existing within the Antarctic Treaty area are maintained.

4. Any species of native mammals, birds and plants listed in Appendix A to this Annex shall be designated "Specially Protected Species", and shall be accorded special protection by the Parties.

5. A permit shall not be issued to take a Specially Protected Species unless the taking:

(a) is for a compelling scientific purpose;

(b) will not jeopardize the survival or recovery of that species or local population; and

(c) uses non-lethal techniques where appropriate.

6. All taking of native mammals and birds shall be done in the manner that involves the least degree of pain and suffering practicable.

ARTICLE 4

INTRODUCTION OF NON-NATIVE SPECIES, PARASITES AND DISEASES

1. No species or animal or plant not native to the Antarctic Treaty area shall be introduced onto land or ice shelves, or into water in the Antarctic Treaty area except in accordance with a permit.

2. Dogs shall not be introduced onto land or ice shelves and dogs currently in those areas shall be removed by April 1, 1994.

3. Permits under paragraph 1 above shall be issued to allow the importation only of the animals and plants listed in Appendix B to this Annex and shall specify the species, numbers and, if appropriate, age and sex and precautions to be taken to prevent escape or contact with native fauna and flora.

4. Any plant or animal for which a permit has been issued in accordance with paragraphs 1 and 3 above, shall, prior to expiration of the permit, be removed from the Antarctic Treaty area or be disposed of by incineration or equally effective means that eliminates risk to native fauna or flora. The permit shall specify this obligation. Any other plant or animal introduced into the Antarctic Treaty area not native to that area, including any progeny, shall be removed or disposed of, by incineration or by equally effective means, so as to be rendered sterile, unless it is determined that they pose no risk to native flora or fauna.

5. Nothing in this Article shall apply to the importation of food into the Antarctic Treaty area provided that no live animals are imported for this purpose and all plant and animal parts and products are kept under carefully controlled conditions and disposed of in accordance with Annex III to the Protocol and Appendix C to this Annex.

6. Each Party shall require that precautions, including those listed in Appendix C to this Annex, be taken to prevent the introduction of micro-organisms (e.g., viruses, bacteria, parasites, yeasts, fungi) not present in the native fauna and flora.

ARTICLE 5

INFORMATION

Each Party shall prepare and make available information setting forth, in particular, prohibited activities and providing lists of Specially Protected Species and relevant Protected Areas to all those persons present in or intending to enter the Antarctic Treaty area with a view to ensuring that such persons understand and observe the provisions of this Annex.

ARTICLE 6

EXCHANGE OF INFORMATION

1. The Parties shall make arrangements for:

(a) collecting and exchanging records (including records of permits) and statistics concerning the numbers or quantities of each species of native mammal, bird or plant taken annually in the Antarctic Treaty area;

(b) obtaining and exchanged information as to the status of native mammals, birds, plants, and invertebrates in the Antarctic Treaty area, and the extent to which any species or population needs protection;

(c) establishing a common form in which this information shall be submitted by Parties in accordance with paragraph 2 below.

2. Each Party shall inform the other Parties as well as the Committee before the end of November of each year of any step taken pursuant to paragraph 1 above and of the number and nature of permits issued under this Annex in the preceding period of 1st July to 30th June.

ARTICLE 7

RELATIONSHIP WITH OTHER AGREEMENTS OUTSIDE THE ANTARCTIC TREATY SYSTEM

Nothing in this Annex shall derogate from the rights and obligations of Parties under the International Convention for the Regulation of Whaling.

ARTICLE 8

REVIEW

The Parties shall keep under continuing review measures for the Conservation of Antarctic fauna and flora, taking into account any recommendations from the Committee.

ARTICLE 9

AMENDMENT OR MODIFICATION

1. This Annex may be amended or modified by a measure adopted in accordance with Article IX (1) of the Antarctic Treaty. Unless the measure specifies otherwise, the amendment or modification shall be deemed to have been approved, and shall become effective, one year after the close of the Antarctic Treaty Consultative Meeting at which it was adopted, unless one or more of the Antarctic Treaty Consultative Parties notifies the Depositary, within that time period, that it wishes an extension of that period of time or that it is unable to approve the measure.

2. Any amendment or modification of this Annex which becomes effective in accordance with paragraph 1 above shall thereafter become effective as to any other Party when notice of approval by it has been received by the Depositary.

APPENDICES TO THE ANNEX

APPENDIX A:

SPECIALLY PROTECTED SPECIES

All species of the genus Arctocephalus, Fur Seals, Ommatophoca rossii, Ross Seal.

APPENDIX B:

IMPORTATION OF ANIMALS AND PLANTS

The following animals and plants may be imported into the Antarctic Treaty area in accordance with permits issued under Article 4 of this Annex:

(a) domestic plants; and

(b) laboratory animals and plants including viruses, bacteria, yeasts and fungi.

APPENDIX C:

PRECAUTIONS TO PREVENT INTRODUCTION OF MICRO-ORGANISMS

1. Poultry. No live poultry or other living birds shall be brought into the Antarctic Treaty area. Before dressed poultry is packaged for shipment to the Antarctic Treaty area, it shall be inspected for evidence of disease, such as Newcastle Disease, tuberculosis, and yeast infection. Any poultry or parts not consumed shall be removed from the Antarctic Treaty area or disposed of by incineration or equivalent means that eliminates risks to native flora and fauna.

2. The importation of non-sterile soil shall be avoided to maximum extent practicable.

MADRID October 4, 1991

ANNEX III TO THE PROTOCOL ON ENVIRONMENTAL PROTECTION TO THE ANTARCTIC TREATY

WASTE DISPOSAL AND WASTE MANAGEMENT

ARTICLE 1

GENERAL OBLIGATIONS

1. This Annex shall apply to activities undertaken in the Antarctic Treaty areas pursuant to scientific research programmes, tourism and all other governmental and non-governmental activities in the Antarctic Treaty area for which advance notice is required under Article VII 95) of the Antarctic Treaty, including associated logistic support activities.

2. The amount of waste produced or disposed of in the Antarctic Treaty area shall be reduced as far as practicable so as to minimise impact on the Antarctic environment and to minimise interference with the nature values of Antarctica, with scientific research and with other uses of Antarctica which are consistent with the Antarctic Treaty.

3. Waste storage, disposal and removal from the Antarctic Treaty area, as well as recycling and source reduction, shall be essential considerations in the planning and conduct of activities in the Antarctic Treaty area.

4. Waste removed from the Antarctic Treaty area shall, to the maximum extent practicable, be returned to the country from which the activities generating the waste were organized or to any other country in which arrangements have been made for the disposal of such wastes in accordance with relevant international agreements.

5. Past and present waste disposal sites on land and abandoned work sites of Antarctica-based activities shall be cleaned up by the generator of such waste and the user of such sites. This obligation shall not be interpreted as requiring:

(a) the removal of any structure designated as a historic site or monument; or

(b) the removal of any structure or waste material in circumstances where the removal by any practical option would result in greater adverse environmental impact than leaving the structure or waste material in its existing location.

ARTICLE 2

WASTE DISPOSAL BY REMOVAL FROM THE ANTARCTIC TREATY AREA

1. The following wastes, if generated after entry into force to this Annex, shall be removed from the Antarctic Treaty area by the generator of such wastes:

(a) radio-active materials;

(b) electrical batteries;

(c) fuel, both liquid and solid;

(d) wastes containing harmful levels of heavy metals or acutely toxic or harmful persistent compounds;

(e) poly-vinyl chloride (PVC), polyurethane foam, polystyrene foam, rubber and lubricating oils, treated timbers and other products which contain additives that could produce harmful emissions if incinerated;

(f) all other plastic wastes, except low density polyethylene containers (such as bags for storing wastes), provided that such containers shall be incinerated in accordance with Article 3 (1);

(g) fuel drums; and

(h) other solid, non-combustible wastes;

provided that the obligation to remove drums and solid non-combustible wastes contained in sub-paragraphs (g) and (h) above shall not apply in circumstances where the removal of such wastes by any practical option would result in greater adverse environmental impact than leaving them in their existing locations.

2. Liquid wastes which are not covered by paragraph 1 above and sewage and domestic liquid wastes, shall, to the maximum extent practicable, be removed from the Antarctic Treaty area by the generator of such wastes.

3. The following wastes shall be removed from the Antarctic Treaty area by the generator of such wastes, unless incinerated, autoclaved or otherwise treated to be made sterile:

(a) residues of carcasses of imported animals;

(b) laboratory culture of micro-organisms and plant pathogens; and

(c) introduced avian products.

ARTICLE 3

WASTE DISPOSAL BY INCINERATION

1. Subject to paragraph 2 below, combustible wastes, other than those referred to in Article 2 (1), which are not removed from the Antarctic Treaty area shall be burnt in incinerators which to the maximum extent practicable reduce harmful emissions. Any emission standards and equipment guidelines which may be recommended by, inter alia, the Committee and the Scientific Committee on Antarctic Research shall be taken into account. The solid residue of such incineration shall be removed from the Antarctic Treaty area.

2. All open burning of wastes shall be phased out as soon as practicable, but not later than the end of the 1998/1999 season. Pending the completion of such phase-out, when it is necessary to dispose of wastes by open burning, allowance shall be made for the wind direction and speed and the type of wastes to be burnt to limit particulate disposition and to avoid such deposition over areas of special biological, scientific, historic, aesthetic or wilderness significance including, in particular, areas protected under the Antarctic Treaty.

ARTICLE 4

OTHER WASTE DISPOSAL ON LAND

1. Wastes not removed or disposed of in accordance with Articles 2 and 3 shall not be disposed of onto ice-free areas or into fresh water systems.

2. Sewage, domestic liquid wastes and other liquid wastes not removed from the Antarctic Treaty area in accordance with Article 2, shall, to the maximum extent practicable, not be disposed of into sea ice, ice shelves or the grounded ice-sheet, provided that such wastes which are generated by stations located inland on ice shelves or on the grounded ice-sheet may be disposed of in deep ice pits where such disposal is the only practicable option. Such pits shall not be located on known ice-flow lines which terminate at ice-free areas or in areas of high ablation.

3. Wastes generated at field camps shall, to the maximum extent practicable, be removed by the generator of such wastes to supporting stations or ships for disposal in accordance with this Annex.

ARTICLE 5

DISPOSAL OF WASTE IN THE SEA

1. Sewage and domestic liquid wastes may be discharged directly into the sea, taking into account the assimilative capacity of the receiving marine environment and provided that;

(a) such discharge is located, wherever practicable, where conditions exist for initial dilution and rapid dispersal; and

(b) large quantities of such wastes (generated in a station where the average weekly occupancy over the austral summer is approximately 30 individuals or more) shall be treated at least by maceration.

2. The by-product of sewage treatment by the Rotary Biological Contacter process or similar processes may be disposed of into the sea provided that such disposal does not adversely affect the local environment, and provided also that any such disposal at sea shall be in accordance with Annex IV to the Protocol.

ARTICLE 6

STORAGE OF WASTE

All wastes to be removed from the Antarctic Treaty area, or otherwise disposed of, shall be stored in such a way as to prevent their dispersal into the environment.

ARTICLE 7

PROHIBITED PRODUCTS

No polychlorinated biphenyls (PCBS), non-sterile soil, polystyrene beads, chips or similar forms of packaging, or pesticides (other than those required for scientific, medical or hygiene purposes) shall be introduced onto land or ice shelves or into water in the Antarctic Treaty area.

ARTICLE 8

WASTE MANAGEMENT PLANNING

1. Each Party which itself conducts activities in the Antarctic Treaty area shall, in respect of those activities, establish a waste disposal classification system as a basis for recording wastes and to facilitate studies aimed at evaluating the environmental impacts of scientific activity and associated logistic support. To that end, waste produced shall be classified as:

(a) sewage and domestic liquid wastes (Group 1);

(b) other liquid wastes and chemicals, including fuels and lubricants (Group 2);

(c) solids to be combusted (Group 3);

(d) other solid wastes (Group 4);

(e) radio-active material (Group 5);.

2. In order to reduce further the impact of waste on the Antarctic environment, each such Party shall prepare and annually review and update its waste management plans (including waste reduction, storage and disposal), specifying for each fixed site, for field camps generally, and for each ship (other than small boats that are part of the operations of fixed sites or of ships and taking into account existing management plans for ships):

(a) programmes for cleaning up existing waste disposal sites and abandoned work sites;

(b) current and planned waste management arrangements, including final disposal;

(c) current and planned arrangements for analysing the environmental effects of waste and waste management; and

3. Each such Party shall, as far as it practicable, also prepare an inventory of locations of past activities (such as traverses, fuel depots, field bases, crashed aircraft) before the information is lost, so that such locations can be taken into account in planning future scientific programmes (such as snow chemistry, pollutants in lichens or ice-core drilling).

ARTICLE 9

CIRCULATION AND REVIEW OF WASTE MANAGEMENT PLANS

1. The waste management plans prepared in accordance with Article 8, reports on their implementation, and the inventories referred to in Article 8 (3), shall be included in the annual exchanges of information in accordance with Articles III and VIII of the Antarctic Treaty and related Recommendations under Article IX of the Antarctic Treaty.

2. Each Party shall send copies of its waste management plans, and reports on their implementation and review, to the Committee.

3. The Committee may review waste management plans, and reports thereon and may offer comments, including suggestions for minimising impacts and modifications and improvement to the plans, for the consideration of the Parties.

4. The Parties may exchange information and provide advice on, inter alia, available low waste technologies, reconversion of existing installations, special requirements for effluents, and appropriate disposal and discharge methods.

ARTICLE 10

MANAGEMENT PRACTICES

Each Party shall:

(a) designate a waste management official to develop and monitor waste management plans; in the field, this responsibility shall be delegated to an appropriate person at each site;

(b) ensure that members of its expeditions receives training designed to limit the impact of its operations on the Antarctic environment and to inform them of requirements of this Annex; and

(c) discourage the use of poly-vinyl chloride (PVC) products and ensure that its expeditions to the Antarctic Treaty area are advised of any PVC products they may introduce in the Antarctic Treaty area in order that they may be removed subsequently in accordance with this Annex.

ARTICLE 11

REVIEW

This Annex shall be subject to regular review in order to ensure that it is updated to reflect improvement in waste disposal technology and procedures and to ensure thereby maximum protection on the Antarctic environment.

ARTICLE 12

CASES OF EMERGENCY

1. This Annex shall not apply in cases of emergency relating to the safety of human life or of ships, aircraft or other equipment and facilities of high value.

2. Notice of activities undertaken in cases of emergency shall be circulated promptly to all Parties.

ARTICLE 13

AMENDMENT OR MODIFICATION

1. This Annex may be amended or modified by a measure adopted in accordance with Article IX (1) of the Antarctic Treaty. Unless the measure specifies otherwise, such amendment or modification shall be deemed to have been approved, and shall become effective, one year after the close of the Antarctic Treaty Consultative Meeting at which it was adopted, unless one or more of the Antarctic Treaty Consultative Parties notifies the Depositary, within that time period, that it wishes an extension of that period of time or that it is unable to approve the amendment.

2. Any amendment or modification of this Annex which becomes effective in accordance with paragraph 1 above shall thereafter become effective as to any other Party when notice of approval by it has been received by the Depositary.

APPENDIX 5

CLIMATIC TABLES

TABLE 1: WIND - AVERAGE DIRECTION AND SPEED

SANAE 70°18'S 02°21'W ^{n} = 62 metres

	N		NNE		NE		ENE		E		ESE		SE		SSE		S	
	n	v	n	v	n	v	n	v	n	v	n	v	n	v	n	v	n	v
Jan	0,9	3,7	0,9	4,3	4,3	7,7	8,3	9,0	20,1	9,6	10,7	6,3	10,8	5,8	5,8	5,0	5,5	4,6
Feb	0,2	5,1	0,4	4,6	1,3	9,9	6,7	13,7	20,5	10,7	16,3	8,5	16,3	7,2	9,1	5,3	8,5	5,2
Mar	0,2	4,4	0,4	5,5	2,0	8,6	6,0	11,0	19,2	13,5	15,5	10,6	19,1	8,6	12,5	7,5	8,3	6,8
Apr	0,5	8,4	1,6	12,6	3,2	12,9	8,9	16,0	12,4	13,6	13,2	11,3	16,7	9,0	12,0	7,5	10,8	6,8
May	0,7	6,1	0,9	6,8	3,7	12,0	9,4	15,9	18,3	16,0	14,5	11,5	15,5	9,9	10,7	8,1	8,5	6,4
Jun	0,2	5,3	0,3	6,0	2,5	14,1	9,3	8,9	14,2	15,4	15,3	11,6	13,9	7,9	10,2	6,7	9,2	6,2
Jul	1,2	6,7	1,1	10,5	3,8	11,2	6,2	13,5	11,9	13,7	15,6	12,1	15,3	7,8	12,3	6,8	11,0	6,2
Aug	0,6	7,5	0,3	6,9	1,2	11,1	5,2	15,1	13,0	15,4	13,2	10,3	18,6	8,4	12,7	6,7	11,2	6,2
Sep	0,6	7,1	0,2	6,2	2,4	13,6	6,5	13,0	15,4	14,6	15,6	10,3	15,3	7,9	9,8	6,8	9,8	6,2
Oct	0,3	5,9	0,4	5,5	2,2	12,7	6,7	14,0	16,1	14,6	16,2	12,1	14,4	8,3	10,0	6,1	9,8	5,6
Nov	0,5	5,1	0,7	6,5	2,5	9,0	6,0	12,0	16,7	11,8	18,0	9,7	16,5	7,9	9,5	5,7	7,2	6,0
Dec	0,3	3,4	0,7	5,1	3,8	8,6	8,6	11,1	21,3	10,6	17,2	8,5	11,0	6,7	7,0	5,1	5,2	4,3
	0,5	**6,0**	**0,7**	**7,7**	**2,7**	**9,8**	**7,3**	**12,7**	**16,6**	**13,0**	**15,1**	**10,3**	**15,3**	**8,1**	**10,1**	**6,6**	**8,8**	**6,0**

	SSW		SW		WSW		W		WNW		NW		NNW		Calm	Mean Speed
	n	v	n	v	n	v	n	v	n	v	n	v	n	v	n	v
Jan	3,7	4,3	2,7	4,5	1,9	5,0	4,3	5,3	3,1	4,7	1,9	4,1	0,6	3,3	14,5	5,8
Feb	4,3	4,7	2,5	4,8	1,7	6,9	2,3	7,3	1,5	5,6	0,6	4,2	0,2	3,5	7,6	7,5
Mar	4,6	6,6	2,9	6,5	1,1	7,8	1,7	8,0	0,8	5,4	0,7	7,1	0,3	2,5	4,7	9,1
Apr	6,1	6,1	3,9	6,0	1,6	5,4	1,4	5,7	0,9	6,9	0,6	6,1	0,3	4,7	5,9	9,3
May	5,1	5,9	1,6	6,0	1,4	6,8	1,2	6,7	1,3	6,9	0,7	6,6	0,5	6,8	6,0	10,3
Jun	5,0	6,8	2,7	13,8	1,8	12,3	1,1	7,1	1,6	6,9	1,1	8,3	0,4	8,0	11,2	8,8
Jul	4,4	5,9	1,9	6,1	1,4	8,3	2,0	7,4	1,7	8,2	0,7	6,1	0,3	5,5	9,2	8,5
Aug	5,3	6,5	3,7	8,2	2,7	7,8	2,8	7,1	1,5	6,3	0,7	6,1	0,2	4,9	7,1	8,7
Sep	5,2	6,5	3,2	6,8	1,8	6,5	2,7	6,8	2,1	7,2	1,2	6,5	0,5	6,0	7,7	8,7
Oct	4,8	5,7	3,3	6,6	1,9	6,9	2,3	6,6	1,8	7,2	1,2	6,3	0,4	4,6	8,2	8,9
Nov	4,2	5,2	2,7	5,3	1,8	6,4	1,8	6,2	1,8	5,4	1,4	4,8	0,6	5,1	8,1	7,8
Dec	4,1	4,1	2,4	4,2	1,7	4,2	2,4	5,9	2,0	4,9	1,1	4,2	0,6	4,2	10,6	7,0
	4,7	**5,8**	**2,8**	**6,7**	**1,7**	**7,0**	**2,2**	**6,6**	**1,7**	**6,2**	**1,0**	**5,7**	**0,4**	**5,0**	**8,4**	**8,4**

n = average direction frequency (%) v = average speed (metres per second)

TABLE 2: CLIMATIC AVERAGES

CLIMATE AVERAGES SANAE 70°18'S 02°21'E h = 62 m									
Month	Sea Level Pressure (pHa) 1963-1980	Average Temp (°C) 1963-1980	Daily Max Temp Temp (°C) 1963-1990	Daily Min Temp Temp (°C) 1963-1990	Extreme Highest 1963-1990	Extreme Lowest 1963-1990	Relative Humidity (%) 1963-1990	No. of Sunshine Hours 1963-1990	Daily Cloud Cover (oktas) 1963-1990
Jan	993	- 3,6	- 0,5	- 7,9	+7,3	-19,9	82	234	5,7
Feb	991	- 8,7	- 4,9	-13,9	+3,7	-29,3	83	157	5,4
Mar	987	-13,0	- 9,3	-17,5	+2,0	-35,5	86	122	5,3
Apr	988	-18,9	-14,5	-24,0	-0,1	-42,8	84	70	4,8
May	989	-21,2	-16,7	-25,7	+3,6	-51,0	87	13	4,8
Jun	990	-23,5	-18,8	-28,3	-1,2	-47,9	84	0	4,9
Jul	989	-27,7	-22,6	-32,8	-5,5	-50,0	82	0	4,3
Aug	988	-27,6	-22,7	-32,4	-3,8	-50,0	82	46	4,2
Sep	985	-25,0	-20,4	-30,5	-1,9	-48,3	82	107	4,8
Oct	985	-18,7	-14,4	-24,3	-1,3	-41,7	83	193	5,0
Nov	988	-10,7	- 6,7	-16,4	+3,1	-33,0	86	265	5,3
Dec	993	- 4,6	-1,2	- 9,2	+7,0	-21,2	82	256	5,8
	989	**-16,9**	**-12,7**	**-21,9**	**+7,3**	**-51,0**	**84**	**1 463**	**5,0**

TABLE 3 : SUNRISE AND SUNSET AT SANAE, LAT -70.30 LONG -2.35, MEAN YEAR

MTH	01	03	05	07	09	11	13	15	17	19	21	23	25	27	29	31
Jan Jan	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	0106 2325	0133 2303	0153 2246
Feb Feb	0202 2238	0218 2223	0232 2209	0246 2156	0259 2144	0311 2132	0322 2121	0333 2110	0344 2059	0355 2048	0405 2038	0414 2028	0424 2018	0434 2008		
Mar Mar	0443 1958	0452 1948	0501 1938	0510 1929	0518 1919	0527 1909	0536 1900	0544 1850	0552 1841	0601 1831	0609 1822	0617 1813	0625 1803	0634 1754	0642 1745	0650 1735
Apr Apr	0654 1731	0702 1721	0711 1712	0719 1702	0727 1653	0736 1643	0744 1634	0753 1624	0802 1615	0810 1605	0819 1555	0829 1545	0838 1536	0847 1526	0857 1515	
May May	0907 1505	0917 1454	0927 1444	0938 1432	0950 1421	1001 1409	1014 1356	1028 1343	1043 1328	1100 1311	1122 1249	1155 1217	DARK DARK	DARK DARK	DARK DARK	DARK DARK
Jun Jun	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	
Jul Jul	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	1154 1238	1123 1309	1104 1329	1048 1345	1033 1359	1020 1412
Aug Aug	1014 1418	1002 1430	0951 1441	0940 1452	0929 1502	0918 1512	0908 1522	0858 1532	0848 1541	0838 1550	0828 1559	0818 1608	0808 1616	0759 1625	0749 1633	0740 1642
Sept Sept	0735 1646	0726 1654	0716 1702	0707 1710	0657 1718	0648 1726	0639 1734	0629 1742	0620 1750	0611 1758	0601 1806	0552 1814	0542 1822	0533 1830	0524 1838	
Oct Oct	0514 1847	0505 1855	0455 1903	0445 1912	0436 1920	0426 1929	0416 1938	0406 1947	0356 1956	0346 2006	0336 2016	0325 2026	0315 2036	0304 2046	0253 2057	0242 2109
Nov Nov	0236 2115	0224 2127	0211 2140	0158 2154	0143 2209	0127 2227	0109 2247	0046 2316	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	
Dec Dec	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT

TABLE 4 : SUNRISE AND SUNSET AT VESLESKARVET, LAT -71.67 LONG -2.33, MEAN YEAR

MTH	01	03	05	07	09	11	13	15	17	19	21	23	25	27	29	31
Jan Jan	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	0036 2341
Feb Feb	0107 2324	0137 2259	0159 2240	0218 2223	0234 2207	0249 2153	0303 2139	0316 2127	0328 2114	0340 2102	0352 2050	0403 2039	0413 2028	0424 2017		
Mar Mar	0434 2006	0444 1955	0454 1945	0504 1934	0513 1924	0523 1913	0532 1903	0541 1853	0550 1843	0559 1832	0608 1822	0617 1812	0626 1802	0635 1752	0644 1742	0653 1732
Apr Apr	0657 1727	0706 1717	0716 1707	0725 1656	0734 1646	0743 1636	0753 1625	0802 1615	0812 1604	0822 1554	0832 1543	0842 1532	0853 1521	0903 1509	0915 1457	
May May	0926 1445	0939 1433	0951 1419	1005 1405	1020 1350	1037 1333	1057 1313	1125 1245	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK
Jun Jun	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	
Jul Jul	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	DARK DARK	1124 1309	1100 1332
Aug Aug	1051 1342	1034 1359	1018 1414	1004 1427	0951 1440	0938 1452	0926 1504	0914 1515	0903 1526	0851 1536	0840 1546	0829 1556	0819 1606	0808 1615	0758 1625	0747 1634
Sept Sept	0742 1638	0732 1647	0722 1656	0712 1705	0701 1714	0651 1723	0641 1731	0631 1740	0621 1749	0611 1757	0601 1806	0551 1815	0541 1824	0531 1832	0521 1841	
Oct Oct	0510 1850	0500 1859	0450 1909	0439 1918	0429 1927	0418 1937	0408 1947	0357 1957	0346 2007	0334 2018	0323 2029	0311 2040	0259 2052	0247 2104	0234 2117	0220 2131
Nov Nov	0213 2139	0158 2154	0141 2212	0123 2232	0100 2259	0026 LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	
Dec Dec	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT	LGHT LGHT

TABLE 5 : WIND DIRECTION AND SPEED

PERIOD : 1960 -1970

Average Direction Frequency per thousand (n) and Average Speed (v = m/s, i.e. metres per second) for each of the eight main directions

	N		NE		E		SE		S		SW		W		NW	
	n	v	n	v	n	v	n	v	n	v	n	v	n	v	n	v
Jan	14	4,1	121	7,1	305	8,6	185	5,1	68	4,1	55	4,2	60	5,5	23	4,3
Feb	10	4,7	79	10,2	370	9,0	279	5,9	112	4,5	39	4,2	23	5,4	4	3,1
Mar	12	4,7	64	8,5	301	10,6	293	6,1	123	4,8	55	5,0	40	5,9	12	4,1
Apr	11	9,7	65	11,9	275	11,7	249	7,2	150	5,9	89	5,4	47	6,7	14	5,2
May	14	5,9	61	12,8	249	12,0	277	7,3	171	5,7	67	5,0	40	6,1	15	5,9
Jun	7	7,8	71	13,1	346	11,9	296	7,2	97	5,4	50	4,8	35	6,1	14	5,6
Jul	4	6,5	61	12,5	242	10,2	306	5,9	134	5,0	57	4,9	43	6,2	9	6,3
Aug	5	3,9	51	12,3	236	11,4	277	6,3	153	5,4	68	5,3	68	6,4	10	4,6
Sept	7	4,1	50	10,6	251	10,6	282	6,6	149	5,2	87	5,8	67	6,9	19	5,6
Oct	8	4,8	90	13,4	312	11,9	264	6,7	106	4,7	69	5,9	54	6,5	7	4,1
Nov	13	5,6	89	9,9	355	10,9	237	6,6	108	4,4	54	5,0	45	5,3	13	3,8
Dec	13	3,6	133	7,8	359	9,0	159	5,3	74	3,1	58	4,0	66	5,3	18	4,2
A	10	5,4	78	10,5	300	10,6	259	6,4	120	5,1	62	5,1	49	6,0	13	4,9

A /619 *SANAE 70°19'S; 02°21'W

TABLE 6 : WIND DIRECTION AND SPEED

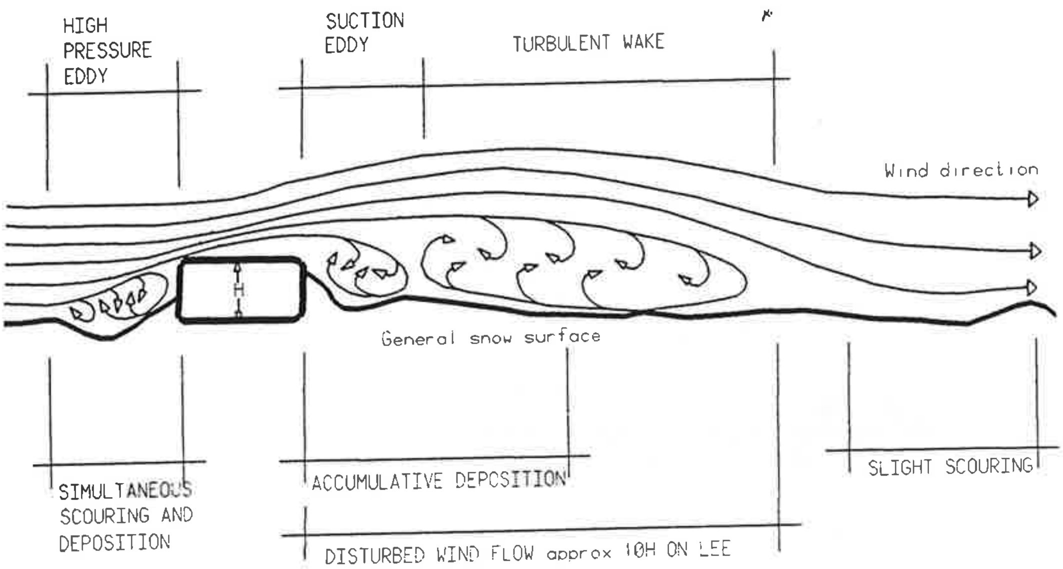
Average Frequency per thousand for the Given Speed Intervals in m/s

	0,0-1,0	1,1-1,5	1,6-3,3	3,4-5,4	5,5-7,9	8,0-10,7	10,8-13,8	13,9-17,1	17,2-20,7	20,8-24,4	24,5-28,4	28,5-32,6	32,6	Ave Speed (m/s)
PERIOD:				10 years										
Jan	170	16	108	210	255	104	72	34	20	9	3	0	0	5,4
Feb	84	10	89	177	299	150	98	43	19	20	6	3	2	6,6
Mar	100	14	71	169	306	141	94	39	37	20	4	3	2	6,7
Apr	100	12	67	132	276	140	99	69	58	24	11	5	7	7,6
May	106	9	84	154	278	106	83	59	52	37	21	8	3	7,5
Jun	35	10	61	139	249	140	113	67	58	42	26	9	2	8,3
Jul	143	13	83	186	288	112	68	41	27	16	8	7	7	6,3
Aug	132	11	70	179	269	130	82	51	30	22	16	5	3	6,7
Sept	87	10	70	181	303	135	94	50	32	18	9	7	3	7,0
Oct	89	10	77	196	223	123	82	68	56	39	17	14	5	8,0
Nov	87	16	81	179	237	136	95	74	46	23	18	5	4	7,4
Dec	120	17	105	202	246	130	86	47	25	14	8	0	0	6,0
A	109	12	30	175	269	129	89	53	39	24	12	6	3	7,0

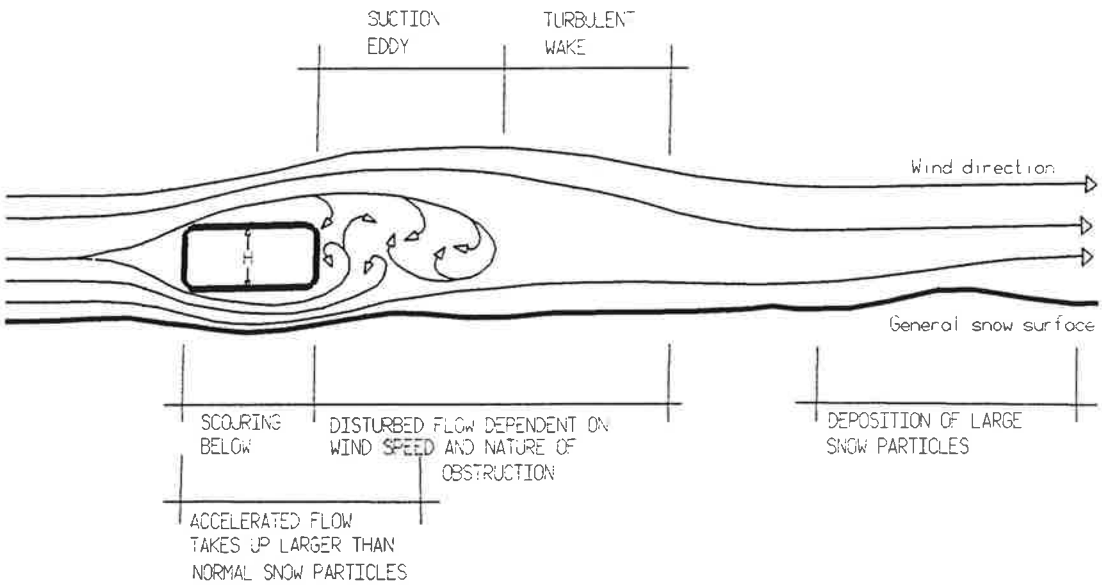
H = 52 m; ha = 10 m

APPENDIX 6

DIAGRAMS

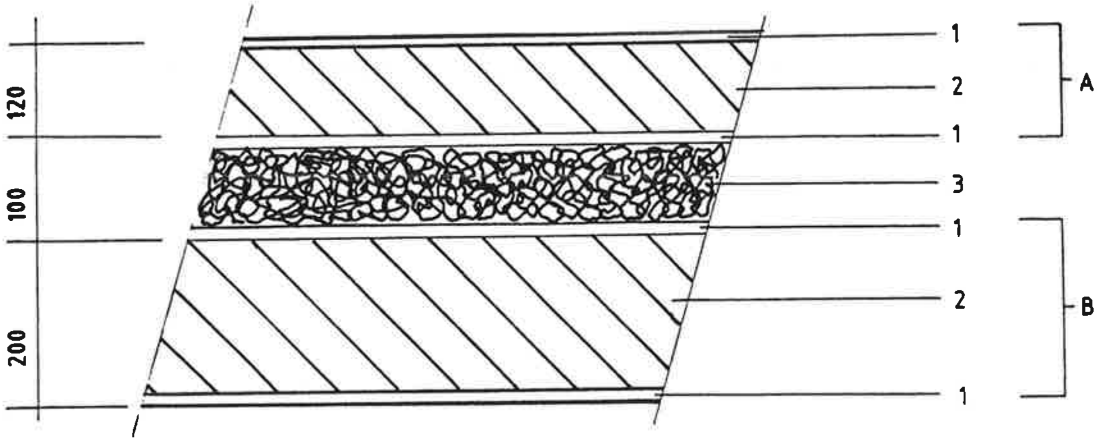


WIND FLOW MODEL - ON-GRADE OBSTRUCTION



WIND FLOW MODEL - OFF-GRADE OBSTRUCTION

DIAGRAM A: WIND FLOW MODELS



1 GLASS-FIBRE REINFORCED POLYESTER RESIN SKIN
2 CFC-FREE POLYCOCYANURATE FOAM
3 CAVITY FILLED WITH GLASS-FIBRE INSULATION

A OUTER PANEL
B INNER PANEL

DIAGRAM B: SECTION THROUGH WALL

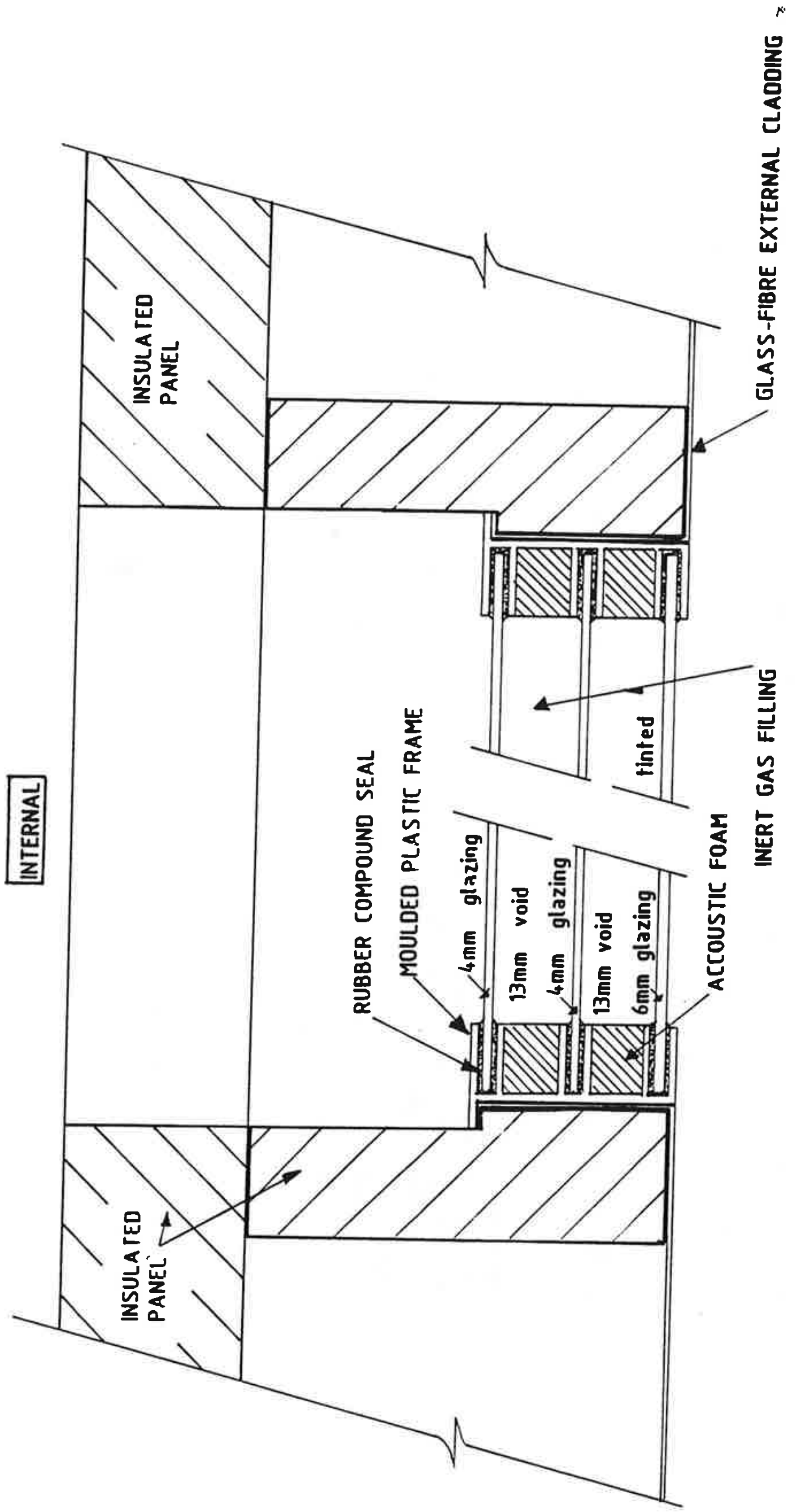
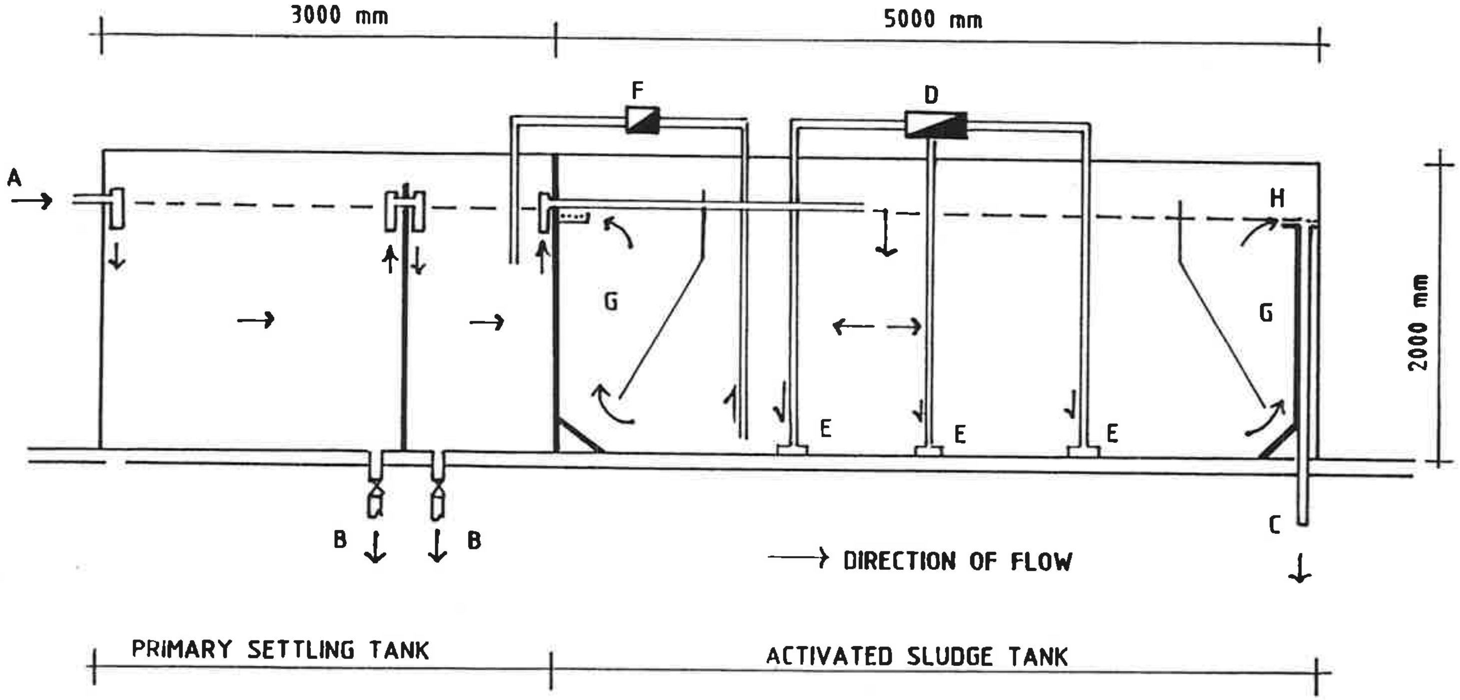


DIAGRAM C: SECTION THROUGH WINDOW



A INCOMING SEWERAGE FROM PUMPSTATION
B OUTLET PIPE BY WHICH SLUDGE IS ABSTRACTED YEARLY
C OUTLET PIPE FOR PURIFIED SEWERAGE WATER WHICH IS DISCHARGED OVER THE EDGE OF THE CLIFF
D COMPRESSORS FOR THE AERATORS
E AERATORS
F PUMP THAT PUMPS ENDOGENIC SLUDGE
G UPWARD FLOW -SETTLING TANK
H OVERFLOW OFPURIFIED SEWERAGE WATER

DIAGRAM D: WASTE PROCESSING PLANT

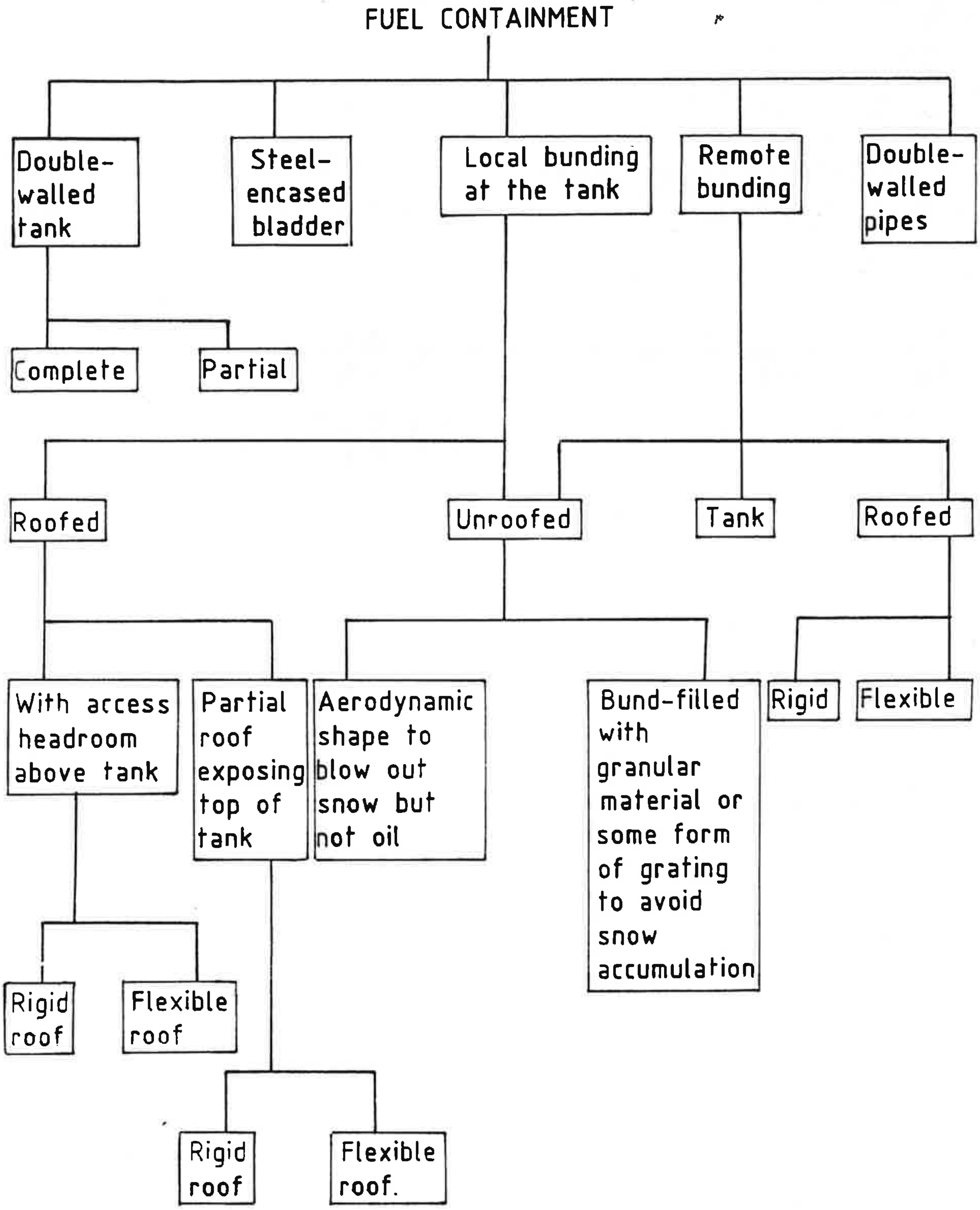


DIAGRAM E: FUEL CONTAINMENT OPTIONS

APPENDIX 7

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APPENDIX 8

COMMENTS RECEIVED ON IEE

SANAE IV CEE

APPENDIX 8:

COMMENTS RECEIVED REGARDING IEE

NATIONAL ENVIRONMENT RESEARCH COUNCIL - BRITISH ANTARCTIC SURVEY (CAMBRIDGE) - DR D J DREWRY

We congratulate South Africa in attempting to put together a very useful IEE which documents clearly the need for a CEE. If the Department of Environment Affairs wishes to receive realistic comment on the CEE which can be fed back into your decision-making process, the documentation should be available, in our opinion, by April or May 1992. This may assist the Department in controlling and monitoring the construction side of the project.

Unfortunately the IEE documents and the invitation to comment upon it (dated 21 November 1992) was receive on 27 January. The deadline for comments, 17 January 1992, was thus impossible to meet.

However, in the presumption that the Department of Environment Affairs is genuinely seeking comment on this IEE, staff of the British Antarctic Survey, in particular, Dr D W H Walton (Head of Terrestrial and Freshwater Life Science Division), have gone to considerable trouble to provide useful comments by examining the EIA in a period of less than 10 working days. I trust that the Department will note this effort and ensure that in any future exercise particularly with the CEE, documentation is mailed so as to arrive with sufficient time for constructive comment. The British Antarctic Survey would certainly wish to provide comment on any CEE produced at a later date.

Specific comments are set out below.

1. In some respects, this document is much less valuable than it could have been. The object of the exercise should surely have been to obtain comments on the IEE before the party was sent in in the 1991/92 season to do ground survey. As it is, the document is still incomplete (it does not contain the c.v.'s of the various contributors) and it was not issued until after the party had already departed for survey work.

2. The inclusion of at least one overseas member in the Review Committee could have assisted in obtaining a realistic assessment of the project. To have half of the Review Committee from the same Department as the assessment team could be seen to pose conflicts of interest.

3. Page 7 notes that planning and budgeting for a replacement base started in 1989. If that was the case, why is this document issued so late in the planning cycle? It may not now be possible to conform to the Protocol in terms of timing.

4. Page 9 and 10 note the criteria that were evaluated for each of the nunataks. There is no information on how this evaluation was conducted in the 1990/91 season - either who conducted it, how long was spent on it, how the groups travelled to the areas and undertook the survey work, etc.

5. On page 18 the accommodation requirements are outlined. Nowhere is there any breakdown or justification for the summer numbers of 80 people and winter numbers of 18.

6. Page 40. The estimates of waste production are not useful, since they are based on mean urban characteristics. It is now well established that Antarctic bases do not conform to this. With sufficient time in hand to plan for this, why couldn't some assessment have been made for current output at Sanae 3?

7. Whilst it is true that the Antarctic Treaty requests that no waste shall be disposed of onto ice-free areas or into freshwater systems, it is possible to dispose of wastes for inland stations into deep ice pits. Since the nunataks is 220 km from the coast, this could be considered to constitute "inland" and since it is surrounded by ice, disposal by that route would be acceptable under the Treaty.

8. Page 51. It does not say why double-walled tanks cannot be used. It is assumed this is because of weight, but that

should be made clear.

9. Page 52. Surely bladder tanks on sledges have the same advantage as steel tanks - that they can be used for removal of liquid wastes from the base?

10. We congratulate the compilers of the IEE on the pages 60-64 as being, for an IEE, a good list of the potential impacts and possible mitigation procedures.

11. Page 63, section 4.3.2a. It is difficult to believe that no adequate sterilisation of construction materials could be conducted to ensure no importation of alien organisms.

4.3.2h. Surely mitigation from base lights is possible. All windows can be fitted with blinds, there would be only a limited need for outside lighting in summer when the birds are most likely to be around and the lighting proposed for the fuel farm could be switched on only when required. Part of the problem (but undisclosed) here is the possible need to run outside lighting to maintain na continuous load on the generator, to keep the phases in balance.

12. Page 64., 4.3.2i. We have yet to hear of anybody successfully implementing penalties for souvenir collection!

4.4.2b. Given the current state of knowledge about Antarctic microbiology, it would be interesting to know how the detailed biological sampling survey was to be conducted.

13. Page 65. 4.4.2i. How is snow accumulation and ice build-up to be estimated, when the area is apparently free of snow and only one short visit in summer is to be made?

4.4.2l. What is an appraisal of the "general ecological sensitivity of the area between the coast and the nunatak"? BAS experts are not sure what those words mean.

14. There are a few general points that do not seem to be addressed. There is no consideration of actually flying fuel in, as is done at the U.S. South Pole Station. this is not suggested as a reasonable option, but since it is already done elsewhere, it might have been considered. There is not suggestion of the establishment on monitoring systems, to convert the period between the visit this summer and the start of construction next summer. There are no clear indication that an assessment is to be made of the effects of the survey team this summer.

Finally, there is no mention of inviting an independent observer to assess whether or not the predictions that are going to be made in the CEE are actually borne out in activities on the ground. In the BAS experience this has been a most valuable means of diffusing un-informed criticism and has been positive for public relations. We would comment that you consider this seriously for the next phase.

COUNCIL OF MANAGERS OF NATIONAL ANTARCTIC PROGRAMS (WASHINGTON, D.C.) - ALFRED N. FOWLER

My first general comment is to commend you and your organization for undertaking the environmental evaluation aspects of your new base in Antarctica in such a detailed and comprehensive manner. I also agree with your efforts toward international and non-governmental circulation of your reports shown by the list in your Appendix 4.

Obviously, during the second half of 1991, you faced a time flow problem with respect to satisfying the newly emerging requirements being created in the form of the Protocol to the Antarctic Treaty. In my case the IEE document has first become available at a time when the period for site preparation has already passed. As stated in your summary on page 2, the decision making process has gone beyond a possible assessment of "no more than a minor or transitory impact." Your intended procedure, summarized on page 4, is to proceed with the SANAE 4 project based on the processing of a CEE in accordance with Article 3 of Annex 1 to the Protocol. As the first such project your efforts will surely attract a lot of attention.

1. You should anticipate and encourage more extensive distribution of your CEE than as shown in your current Appendix 4, especially in the international and "public" directions.

The progress that has been made by COMNAP and SCALOP in the several areas relating to facilities engineering as well as environmental protection should be drawn upon and referred to in the process and documentation of your project. For example:

2. The reports and proceedings of the several Symposia on Antarctic Logistics and Operations, especially the Fourth Symposium in Brazil 1990, contain pertinent reference papers.

3. The Antarctic Environmental Assessment Process - Practical Guidelines as developed at the Workshop and adopted by COMNAP in Bologna, 1991 should be cited in your document; and the suggested procedures, as applicable, followed.

4. SCALOP has developed draft guidelines on

- Oil spill contingency planning
- Design of fuel storage facilities
- Transfer of fuel oil at stations and bases.

Although these are still in the review stage, and I have no reason to think they have been overlooked, I suggest they specifically be included and cited in your process and documentation.

There was an International Conference on Development and Commercial Utilization of Technologies in Polar Regions (POLARTECH '92) held in Montreal, Canada, January 21-24, 1992. I have recently read a copy of a paper presented there on the potential application of direct fuel cell technology to stations in Antarctica.

Obviously, SANAE 4 must be developed using proven off-the-shelf power and water systems. However, there appears to be a real possibility that totally non-polluting direct fuel cell plants producing heat and pure water as well as direct current electric power may be available and cost effective in the foreseeable future. If this proves to be true, the technology would be most applicable to a new installation. There is even the possibility that a new facility to be equipped with a diesel plant should include a design suited to possible future conversion. I have asked the co-author of the paper to send you a copy.

Finally, I offer two minor comments. The material printed in figure 3 is somewhat unreadable. While I haven't spent but a couple hours reading your document, I remain unclear on exactly what is "Penguin Backta". From the context, I assume it is an embayment at ice shelf front, but it isn't shown in figure 2.

NATIONAL SCIENCE FOUNDATION, DIVISION OF POLAR PROGRAMS, (WASHINGTON, D.C.) - PETER E WILKNISS

Cognizant members of the Divisions' staff have inspected and commented on the subject IEE. Purportedly, the IEE assesses environmental as well as health and safety considerations associated with building and operating this station. On the surface, the IEE provides information that we were encouraged to see. For example, the IEE discusses:

- current and perceived program needs;
- consideration of relevant issues to be addressed;
- identification of alternatives;
- the site selection process;
- delineation of the environmental reference state of the selected site;
- identification of impact and pollution potentials at selected site;
- identification of mitigation opportunities;
- initial visits to proposed sites; and proposed inspection of selected site during 1991-1992 to verify conclusions of the IEE; and
- decision to develop station management approaches based on information collected for the IEE and the CEE.

Despite these encouragements, we believe that the IEE does not succeed in being a true environmental assessment document. It appears to be more of a statement of goals for station operation coupled with a set of operation procedures to be adhered to in building and operating the new station.

Overall, we have the following comments and concerns.

- the terms of reference provided to the assessment team did not include recommendation to utilize guidance contained in "Antarctic Environmental Assessment Process: Practical Guidelines" developed by the Council of Managers of National Antarctic Programs in 1991.
- there is need for greater consideration of potential impacts associated with the decommissioning of SANAE 3;
- At page 9, d., (i)-(ix): does the order of these site selection criteria reflect their priority or weighting in the site selection

process? That is, are environmental considerations (ix) given least weight?

- At Page 10 to Page 29: it does not appear that environmental concerns have been factored explicitly into the consideration of the criteria given on Page 9.

- At Page 30 it appears that the "environment" has been addressed only in the descriptive sense, without an attempt to link the various criteria shown on Page 9 with environmental components that may be impacted by such activities as site preparation, potable water and waste-water production, or fuels management.

- At Page 40, and 47, issues discussed seem more relevant to a station operations manual rather that to an environmental assessment.

- At Page 46 c. and d., the discussion of the potential impacts of diesel combustion and incineration is superficial and warrants more indepth consideration and assessment, even at this relatively early stage of planning;

- At page 60, under "Key Issues" it is unrealistic to expect that, "... there (will be) no aspect of the physical and biological environments ... that will be destroyed or damaged ... constructing or operating the new base." Location of the base will change snow drifting patterns; transport to, from and around the station will lead to changes in substrate character as well as levels of atmospheric contaminants; disposal of treated waste-water; and, albeit minor, there may well be some instances of accident relating to fuel or chemical substance loss.

  This whole section sound like a statement of goals rather than an assessment of the likelihood of potential impacts on specific components of the environment.

Overall, we believe that this assessment serves as a guidance and operational planning document for future activities leading to the new station. It provides little assessment, in the environmental sense, of the anticipated impacts of the proposed activity on the environment in question. This is not to say that the IEE will not serve a good purpose in helping to clarify the environmental considerations that will be part of the conduct of the more rigorous Comprehensive Environmental Evaluation on the proposed station.

I hope that these comments prove useful to your continuing efforts to adequately anticipate the potential environmental impacts associated with construction, operation and decommissioning of the proposed station.

PERCY FITZPATRICK INSTITUTE - PROF. WR SIEGFRIED

1. The comment has been distilled from SANARP members of the institute staff. Please note, however, that two members, Dr WK Steele and Mr D Balfour, are currently on the Antarctic continent and therefore have not been able to add their opinions to this report. Comments are in no particular order of importance.

2. Use of windows as fire escapes will presumably need some external structure to gain access to ground level safely, given the height above ground of some of the windows.

3. Waste water should be as clean as possible. Photo lab chemicals should be returned to South Africa, and detergents, etc. should be carefully chosen to minimize pollution. Monitoring for environmental changes at the waste water disposal site should commence prior to operation.

4. Use of wind or solar energy for power will presumable require batteries for storage of generated power. Importation, storage and removal of such batteries could have adverse effects. Solar power will presumably need large banks of panels, whose impact would need to be assessed, as would those of wind generators.

5. Methods for the sterilization of imported materials to combat the risk of alien introductions is problematical. Such a requirement would have to be extended to personal clothing and effects, etc. for complete coverage. Our experience is that propagules, and even living animals, are most likely to be imported in unprepared food stuffs, in packing material and on large construction items presumable stored in the open prior to shipping. Vigilance will be needed in this matter. It is quite clear that several groups (primarily supply and construction) engaged in SANAP activities are not yet fully aware of the problem (e.g. importation of live Helix snails in Cauliflowers and Port Jackson Willow Acacia Saligna Flowers on construction material to Gough Island in 1990, attempted importation of a pine tree to SANAE 3 in 1992, etc.).

6. Long term monitoring programmes should be set up at sensitive sites, such as waste water disposal point(s), prior to

the commencement of construction to obtain baseline levels. Involvement of biologists will be essential for this, which will require funding in addition to that for SANAP biological research. Year-round sampling will need to be made an official duty of members of the SANAE 4 overwintering teams, but will need to be under the supervision of qualified biologists. The medical doctor would seem to be the ideal person to be put in charge of a sampling programme in the field.

7. The report, although fully understandable, requires attention to poor use of grammar and expression in places. Because it has been circulated to a number of non-english speaking nations it is important that no ambiguities due to writing style, etc. exist. The comprehensive document should be carefully checked for style, spelling and grammar.

8. Lastly, this institute is certain to have more detailed comments once its members of the EIA team return and are able to contribute to the discussion. This could conceivably alter some of the above points, as well as adding to them.

UNIVERSITY OF THE WITWATERSRAND (JOHANNESBURG) - PROF B CORNER

p9 A brief description of "the several scientific advantages" would be valuable in justifying the presence of SANAE 4 inland.

p14 For the sake of completion, the mission should also include a directive toward scientific excellence.

p14 The objectives should include a comment on the need for automated data acquisition equipment (e.g. for the meteorological, seismic and geomagnetic observations) in order to reduce the number of essential staff and hence to potentially reduce the output of base waste products.

p4 "sacred protection of the principles and spirit of the treaty..." A point of principle could arise with this statement in that we should be sure that we in fact have acted as we claim, eg. I do not believe that SA, in signing the minerals convention, sacredly adhered to the spirit of environmental protection since this convention is potentially damaging to the environment. Did Foreign Affairs in fact consult our Antarctic scientific community when the convention was signed or was this done unilaterally?

p13 1.3.1a. "... was identified and formulated by the DEA", together with scientific personnel and specialists active in SANAP (the addition underlined here would be more appropriate).

p31 2.1.4, first line ...comprises entirely mafic... (delete of)
second line Borgmassivet is incorrectly spelt

p32 2.1.6 The powers of 10 for k= have been left out - see my original submission.

p51 An additional disadvantage (3.2.2.ii) is the high wind profile of the tanks which would require them to be stored on very high platforms in order to prevent snow accumulation.

p68 "The DEA must issue a comprehensive policy statement, in collaboration with its appointed science management committees that ... in its Antarctic involvements". The addition of the section underlined here would be more appropriate.

General Some discussion needs to be directed toward the location of berthing of the ship during annual servicing of the base. The currently used bukta is not the safest of locations in view of the high ice shelf. Accidents (such as happened this year) can not only lead to loss of life but also to environmental damage (eg. oil or diesel spillages from tanks or bladders). Options such as the Neumayer base or Admiral bay need to be addressed in this regard.

DEPARTMENT OF ENVIRONMENT AFFAIRS - DJ VAN SCHALKWYK

1. REVIEW OF THE REPORT

With reference to review team, I would like to make the following comments:

1.1 After reading through the initial environmental evaluation it is my opinion that the type of review that must be undertaken should involve people with a solid knowledge of the Antarctic, and that we need a critical evaluation which will stand up to international scientific review.

In this regard I would like to recommend that the Department approach Dr John Shear from the British Anarctic Survey and Dr Nigel Bonner, Chairman of Goseac, with the request that they form part of the review team.

2. SUMMARY: PG 1

In the introduction and summary an effort is made to show that the Department of Environment Affairs and the Department of Public Works and Land Affairs adopted a policy of excellence, and to fulfil our Treaty obligations. But as one reads it, it becomes clear that a full evaluation, in the Treaty terms were not done. I would suggest that the wording be changed to accommodate this wrong impression. The report also refers to a comprehensive set of criteria, what is this comprehensive set of criteria?

Chapter 1

(a) See suggested rephrasing in text.

(b) I would suggest that paragraph 7 on page 6 be deleted, seeing that this might give the wrong impression. We are there for science, although the status is a by-product.

(c) On page 10, it is mentioned that each site was evaluated in terms of a few items one of which environmental considerations. The question is, what were these environmental considerations. The report touched on this phrase quite often, but it is not explained.

(d) Fig 3 - This figure is not referred to in the text and the quality of the figure is not god.

(e) Page 14 - The mission should also include the environment.

(f) Objectives -What is meant by environmentally safe? Does it protect the inhabitants from the harsh environment or a site which has a low or insignificant impact on the environment.

(g) Page 16 -Only the maintenance side was addressed, 1.3.4(b) what about changes to the environment.

(c) - With reference to the last sentence "normally the environment was continually monitored." They were considered in the design, not monitored. Please expand on the environmental consequences.

(h) Page 24 -The terms such as appropriate safety measures 1.4.6 (b) should be explained in more detail, so that an evaluator can say that it is adequate.

Chapter 2

Paragraph 2.1.3- For reference purposes refer to figure 2 in text.

Fig.7, 8 and 9 - This figures does not mean anything, no reference is made to them - Do we need to include them.

Page 36 - No graph in Appendix 2.

Page 37 - 2.7 - I don't think we need this detail description of the Depletion of the Ozone layer, being a country that just started a project on the ozone. A statement with the contents of the last paragraph might be sufficient.

GENERAL REMARKS

The logistical operations are inadequately addressed eg. cleaning, repairing of engines and cleaning of buildings etc.

THE DOLPHIN ACTION AND PROTECTION GROUP - (FISH HOEK) - NAN RICE

I have read through the Initial Environmental Evaluation Report which was enclosed and have sent the document to Greenpeace Int in the Netherlands for comment.

While, on paper, those who have put this initial Report together have certainly done a thorough job, hopefully in practice the same situation will prevail.

One thing I would like to comment upon is the following: Since the Department of Transport held their DOTGARB meeting in 1989 we have been urging it to promulgate regulations under MARPOL ANNEX V. We were told that these regulations would be passed this year and so far they have not. While I do know that the various research vessels which travel to Antarctica from our country (South African vessels) hopefully are complying already with ARPOL ANNEX V, it would do no harm if your Department backed us up and urged to DOT to get a move on.

<u>DEPARTMENT OF ENVIRONMENT AFFAIRS - MEV EMD SWART</u>

ALGEMENE KOMMENTAAR:

1. Die Engelse bewoording is eenvoudig en effektief. Dit lees baie maklik.

2. 'n Baie goeie verslag waar daar daadwerklik 'n poging aangewend is om die voorwaardes van die Madrid Protokol met betrekking tot omgewingsinvloedverslae te inkorporeer sowel as die basiese beginsels van GOB.

3. Die feite is op 'n interessante wyse weergegee.

4. <u>Voorstel</u>: Al die terminologie en afkortings kan moontlik in 'n "glossary" omskryf word.

SPESIFIEKE KOMMENTAAR:

1. **Bladsy 1 (i) Summary**: "...Department of Public Works and Land Affairs..." moet lees "...Department of Public Works..."

2. **Bladsy 1 (i) Summary**: "...inland nunutak..." en "SANAE"

   Dit is altyd belangrik dat alle terminologie en afkortings verklaar word. In hierdie geval met behulp van voetnotas of daar kan selfs aan 'n "glossary" gedink word.

3. **Bladsy 1 (i) Summary laaste par.** Voeg verwysing by, want "Annex en Appendix" is verwarrend.

   "...to articles 1 and 2 of Annex 1 of the Protocol that deal with Environmental Impact Assessment (refer to Appendix 1 page 6 of the report).

4. **Bladsy 2 par 1 Summary**: "...large number of interested and affected parties (Appendix 4) for their information with a specific request for comment and inputs."

   In die lig hiervan moet daar kortliks verduidelik word hoe die I&AP's geïdentifiseer is of daar moet ook na bladsy 59 verwys word.

5. **Bladsy 4 (ii) Introduction par 3 and 4**: "...IEM procedure.."

   Die GOB-prosedure sal kortliks omskryf moet word in 'n voetnota of "Glossary", veral ter wille van die talle oorsese belangegroepe wat die verslag moet lees.

6. **Bladsy 4 (ii) Introduction par 3**: "...Environmental impact assessment..." moet lees "...environmental impact assessment..."

7. **Bladsy 5 Procedure**: Uit die "Summary", "Introduction" en die verslag is dit duidelik dat die Vesleskarvet-alternatief voorlopig geïdentifiseer is as die mees geskikte basis. Ek verwys ook na bladsy 67 par 5.1.4 van die verslag. 'n Verandering in die prosedure word dus voorgestel:

Dieselfde

initial environmental evaluation

preliminary site selection

------------------------I&AP's and reviewers

site visit (December 1991)

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final site selection- --record of decision
--conditions for pre- con-
struction phase

Dieselfde

8. FIG 1, 3, 4, 5, 6 (kaarte): Nie duidelik leesbaar nie. Miskien kan dit toegeskryf word aan die feit dat die afdrukke nie vanaf die oorspronklike gemaak is nie.

9. Bladsy 7 par 1.1.2 b: "Problems with and a slow collapse of the structure..." Hoekom gee die struktuur mee?

   Die hoofopskrif is "Motivation for the replacement of the present base" en daarom moet daar in een kort sin genoem word hoekom die struktuur meegee.

10. Bladsy 8 par 1.2.2 b: "...ice-shelf above seal-level..." moet lees "... ice-shelf above sea-level..."

11. Bladsy 11 * Foundation Potential par 1: "boulders ranging from about 300 x 300 x 300 mm and smaller, to 500 x 1000 x 1 500 mm."

   Dit is effens verwarrend en sal beter lees as volg:
   "boulders ranging from about 500 x 1 000 x 1 500 mm to 300 x 300 x 300 mm and smaller."

12. Bladsy 21 par 1.4.3 en bladsy 23 par 1.4.4: "Sub-surface structures" en "Surface structures".

   Die voor- en nadele is meer vergelykbaar in tabelvorm.

13. Bladsy 23 par 1.4.5 "Preferred option". Herhaling van opskrif op bladsy 24.

14. Bladsy 32 par b: "...formation is is relatively..." moet leer "...formation is relatively..."

15. Bladsye 54, 55, 56 en 57: Die voor- en nadele is meer vergelykbaar in tabelvorm.

16. Bladsy 59 par 4.1: "...article 3 of annex 1..." Gebruik deurgaans die Annex 1 met 'n hoofletter.

OMSKRYWING VAN NUNATAK

1. An isolated mountain peak/hill projecting like an island, from the mass of snow and ice near the margin of an ice sheet. The term was borrowed from the Eskimo language. The nunataks become more numerous towards the extreme edge of the ice sheet, for there the ice is thinnest. (Moore, W.G. 1968. A Dictionary of Geography. Penguin Reference Books.)

2. A rock peak sticking out above the surface of an ice sheet. In many instances their peaks were formerly ice covered and only subsequent reduction in the extent of ice in cover has brought about their emergence. (Stiegeler, Stella E. (Ed). 1976. A Dictionary of Earth Sciences. Pan Books.)

APPENDIX 9

BIBLIOGRAPHY

BIBLIOGRAPHY

Antarctic Treaty Consultative Meeting. 1991. *Annex I to the Protocol on Environmental Protection to the Antarctic Treaty.*

Antarctic Treaty Consultative Meeting. 1991. *Annex II to the Protocol on Environmental Protection to the Antarctic Treaty.*

Antarctic Treaty Consultative Meeting. 1991. *Annex III to the Protocol on Environmental Protection to the Antarctic Treaty.*

British Standards Institute. 1992. BS 7750: 1992 *Specification for Environmental management systems.*

Council of Managers of National Antarctic Programmes. 1992. *Guidelines for oil spill contingency planning.*

Council of Managers of National Antarctic Programmes. 1991. *The Antarctic Environmental Assessment Process: Practical Guidelines.*

Department of Environment Affairs, 1992. *The Integrated Environmental Management Procedure.*

Department of Environment Affairs, 1992. *Guidelines for Scoping.*

Department of Environment Affairs, 1992. *Guidelines for Report Requirements.*

Department of Environment Affairs, 1992. *Guidelines for Review.*

Department of Environment Affairs, 1992. *Checklist of Environmental Characteristics.*

Department of Environment Affairs, 1992. *Glossary of Terms used in Integrated Environmental Management.*

Fuggle, RF. & Rabie, MA. 1983. *Environmental Concerns in South Africa: Technical and legal Perspectives.* Cape Town: Juta & Co, Ltd.

Greenpeace International. 1990. *Expedition Report: Greenpeace Antarctic Expedition 1989/90.*

Heap, J (editor). 1990. *Handbook of the Antarctic Treaty System. Part 1: General Measures.* seventh edition

Heap, J (editor). 1990. *Handbook of the Antarctic Treaty System. Part 2: The Antarctic Environment.* seventh edition

Heap, J (editor). 1990. *Handbook of the Antarctic Treaty System. Part 3: The Antarctic Protected Area System.* seventh edition

Heap, J (editor). 1990. *Handbook of the Antarctic Treaty System. Part 4: Other components.* seventh edition

Heymann, G. et al. 1987. *Report to the Minister of Environment Affairs on an environmental impact assessment of a proposed emergency landing facility on Marion Island.* South African National Scientific Programmes report no 140. Pretoria. CSIR.

Kerry, G. 1990. Micro-organisms colonizing plants and soil subjected to different degrees of human activity, including petroleum contamination, in the Vestfold hills and MacRobertson Land, Antarctica. *Polar Biol.* 10: 423-430.

Kohnen, H., Teixeira, AJ. & Fowler, AN. (editors). 1990. *Proceedings of the Fourth Symposium on Antarctic Logistics and Operations*. Brasilia: Grafica e Editora Ideal Ltda.

Krynauw, JR., Allen, AR., Auret, SH. & von Brunn, V. 1983. A note on the breeding sites of Snow Petrels (*Pagodroma nivea*) at Robrteskollen, Boreas and Passat nunataks and Johnsbrotet, western Dronning Maud Land, Antarctica. *South African Journal of Antarctic Research*.13: 51-53.

Ryan, PG. & Watkins, BP. 1988. Birds of the inland mountains of western Dronning Maud Land, Antarctica. *Cormorant* 16: 34-40.

Ryan, PG. and & Watkins, BP. 1988. Snow Petrel breeding biology at an inland site in continental Antartica. *Colon. Waterbirds* 12: 176-184.

Ryan, PG., Watkins, BP., Lewis Smith, RI., Dastych, H., Eicker, A., Foissner, W., Heatwole, H., Miller, WR. & Thompson, G. 1989. Biological survey of Robertskollen, western Dronning Maud Land: area description and preliminary species lists. *South African Journal of Antarctic Research* 19: 10-20.

Schaefer, TG. 1973. Radio echo sounding in western Dronning Maud Land, 1971. *South African Journal of Antarctic Research* 3: 45-52.

Schonfield, SG. & van Zyl, CZ. 1974. Geophysical traverses in the Ahlmannryggen, western Dronning Maud Land, 1973. *South African Journal of Antarctic Research* 4: 50-57.

Smith, RIL. 1987. Biological monitoring and impact studies in the vicinity of research stations. In: *SCAR Report on United Kingdom Antarctic Research*. London: The Royal Society, British Committee on Antarctic Research.

Swart, R. 1989. Observations of birds at nunataks in western Dronning Maud Land, Antarctica, 1988-1989. *Cormorant* 17: 84-85.

Toyoda, S., Enokido, M., Matsumae, M. & Aso, M. 1985. Microbiological investigation of the human pollution at Syowa Station in Antarctica with special reference to the specimens collected by the 23rd Japanese Antarctic Research Expedition. *Journal of Anitbacterial and Antifungal Agents* 13: 541-546.

Toyoda, S., Matsumae, M., Ghoda, A. & Aso, M. 1986. Total number of bacteria and fungi as an index for human pollution at Syowa Station in Antarctica: with special reference to the specimens collected by the 18th Japanese Antarctic research Expedition. *Japanese Journal of Bacteriology* 41: 527-534.

Standing Committee on Antarctic Logisics and Operators (SCALOP) sub-group on Oil Spill Prevention and Response. 1992. *Guidelines for oil spill contingency planning.*

Vincent, WF., 1988. Microbes and humans in Antarctica. In: *Microbial ecosystems of Antarctica*. New York: Cambridge University Press.