COMNAP

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Waste Management in Antarctica

2006 Workshop Proceedings

Proceedings of the 2006 workshop held by the
COMNAP Antarctic Environmental Officers Network (AEON)
on Monday 10 and Tuesday 11 July 2006

The Antarctic Environment Officers Network (AEON) of the Council of Managers of National Antarctic Programs (COMNAP) conducted a two day workshop in Hobart, Australia on Monday 10 and Tuesday 11 July 2006.

The focus on the workshop was practical information sharing on waste management in Antarctica, with Day 1 focusing on current waste management practices in Antarctica, with Day 2 focusing on activities to clean up waste previously deposited in Antarctica.

The following document is the proceedings of the workshop, published with the generous consent of the presenters and / or authors. The proceedings are complied in the following format:

Day 1: How Do we Currently Manage Waste in Antarctica?

Day 2: How are we Cleaning up Old Waste in Antarctica?

Report on AEON Workshop Presented to COMNAP Plenary

AEON Social Function

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DAY ONE:

How do we currently manage waste in Antarctica?

1.0 Formal Welcome and Introductions

Rodolfo Sánchez, AEON Coordinator

Acknowledgements:

- The Australian Antarctic Division for providing the venue for the meeting.
- Veolia Environmental Services for providing daily transport and sponsorship of the social function.
- Participants from National Antarctic Programs and sponsors for contributing presentations.

Welcome and Thanks

It is with pleasure that I welcome all participants to the workshop on practical waste management in Antarctica. Waste management is a key issue in Antarctic operations, due to both its magnitude, in terms of the logistic efforts required to deal with waste, as well as to the environmental implications associated likely impacts of waste on Antarctica's natural values.

This is the first time since the Madrid Protocol (1991) that the issue of Waste Management in Antarctica has been specifically tackled within the Antarctic Treaty System. This is a long-expected opportunity to exchange experiences on a wide range of environmental, operational and cultural issues concerned with waste management in Antarctica. In doing so, this workshop will greatly contribute to the achievement of Council of Managers of National Antarctic Programs *(*COMNAP) primary goal, to improve Antarctic operations.

Input from workshop participants is essential before we can start working on some of the most relevant Antarctic waste management issues. We must aim to increase the information flow on these issues, so that we are in the position of being able to evaluate the experiences of other national operators, and implement new techniques and/or procedures appropriate to waste management in Antarctica.

Historical Background

Concerns about the detrimental impacts of human activities on the Antarctic terrestrial environments and ecosystems were first expressed by the Antarctic Treaty Parties in 1970, through Rec. VI-4. This considered that there was an increasingly urgent need to protect the environment from human interference. Among other things, Scientific Committee on Antarctic Research (SCAR) was invited to propose measures which might be taken to minimize harmful interference. As a result, SCAR prepared a set of recommendations on how to deal with specific operational activities in Antarctica, particularly in relation to waste management. SCAR's "Code of Conduct for Antarctic Expeditions and Station Activities" was agreed through Rec. VIII-11 (Oslo, 1975), as was a number of recommended procedures. Some waste categorization was included in the code, and a further distinction between coastal and inland stations in terms of waste management was also proposed.

Before then, environmental issues in Antarctic operations were generally of secondary consideration, if addressed at all. Waste disposal was haphazard, with rubbish left to accumulate or else dumped into the sea. Disused bases were simply abandoned and left to deteriorate, and accumulated rubbish was not removed. Waste disposal practices and standards differed between national operators, but often involved landfill rubbish tips, dumping offshore onto sea ice, discharging sewage and effluents into either the sea or on the ice, and burning or incineration of combustibles. In summary, a short-term view was generally taken on waste management in Antarctica.

In 1983, the Antarctic Treaty Consultative Meeting (ATCM) recommended to their governments, through Rec XII-4, that they seek the advice of their respective Antarctic operating agencies concerning any problems which had been experienced in implementing the “Code of Conduct for Antarctic Expeditions and Station Activities”,. This action was proposed in order to evaluate the need to conduct a review of the code. The recommendation led to the elaboration of Rec. XIII-4 (Brussels, 1985), through which the Antarctic Treaty parties recommended to their respective Governments that they invite SCAR, through their national Antarctic committees, to undertake a comprehensive review of the waste disposal procedures outlined in the Annex to Recommendations VIII-11, and offer proper advice regarding these issues. Almost a decade had passed since the establishment of SCAR’s Code of Conduct, and the parties were aware that activities in Antarctica had become more complex, resulting in the need for review of the existing framework for waste management.

Shortly after these events, a new forum would give the opportunity to Antarctic Treaty parties to approach Antarctic waste management from a more specific point of view. In 1988, The national Antarctic programs established COMNAP. Its primary function and activities concerned the exchange of practical, operational information, with a view to improving the way all national programs fulfil their various missions, together and independently. This included mutual support in the design, ongoing improvement and operation of Antarctic facilities and transport infrastructure, as well as waste management activities. In 1996, the Antarctic Environmental Officer’s Network (AEON) was created within COMNAP. AEON brings together those officers of the national Antarctic programs who have to deal with the practical and technical environmental aspects of their operations. AEON reports to COMNAP’s Environmental Coordinating Group.

Since its creation, COMNAP, mostly through AEON, has made significant progress in compiling information about waste management activities, principally through the use of surveys among national operators.

As a response of Rec XIII-4, SCAR convened a *Panel of Experts on Waste Disposal***,** whose results and recommendations gave way to the adoption of a set of practices regarding waste management in Antarctica. These practices were included in Rec. XV-3 (Paris, 1989), which also recommended that the parties undertake any necessary measures to ensure compliance with them.

The recommendations stemmed from the SCAR *Panel of Experts*, contained in Rec XV-3, which provided the basis for the elaboration of the Annex III of the Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol) agreed in October, 1991.

(Note: All the above- mentioned recommendations are included as Appendix 1)

Waste management in the Madrid Protocol

Provisions related to waste management in Antarctica in the Madrid Protocol were included in its Annex III: “Waste Disposal and Waste Management”. This annex contains different regulations, mainly associated with the establishment of:

- Priorities for waste management practices (waste reduction as a “priority number one”), and obligations to clean up past and present waste deposits.
- A waste classification scheme, so as to assist with management planning.
- Different methods of dealing with wastes in Antarctica. In order to do that, Annex III takes into account the type of wastes, and the characteristics of the site for waste disposal. Particular provisions are referred to:
    - Removal of wastes from the Antarctic Treaty area;
    - Waste disposal by incineration, including the prohibition of all open burning of waste from the end of the 1998-1999 season;
    - Other waste disposal on land, and disposal of waste in the sea;
    - Development of waste management plans;
    - Storage of waste; and
    - Prohibited products.

In addition, particular recommendations, in terms of circulation and review of waste management plans, and of different management practices, including training, were also incorporated into Annex III. Finally, Annex III foresees a framework for review, cases of emergency and amendments.

Supervision of Waste Management Activities in the Antarctic Treaty

After the Madrid Protocol had been agreed, Antarctic Treaty parties, in an attempt to monitor its success, incorporated environmental issues into the inspection mechanisms contained in Art. VII of the Antarctic Treaty. Resolution 5 (1995) proposed a series of checklists to guide observers when conducting inspections of Antarctic facilities. These checklists focussing on environmental aspects included Permanent Antarctic Stations, Vessels, Abandoned Antarctic Stations, and Waste Disposal Sites. Sections on waste management were included in Checklists A and B, and specific recommendations aimed to promote clean-up operations in Checklist C. Finally, Checklist D was specifically devoted to monitor activities on sites where waste disposal have been undertaken in the past.

Since the adoption of Resolution 5 (1995), the focus of inspections has moved primarily towards monitoring the level of fulfilment of the Madrid Protocol, particularly provisions related to waste management.

The CEP and the implementation of the Madrid Protocol (1998-2006)

The creation of the Committee for Environmental Protection (CEP) gave Antarctic Treaty parties the valuable opportunity to inform other operators on practical implementation of the Madrid Protocol on an annual basis. Review of information exchanged between national programs at CEP meetings between 1998 to 2006 included 36 information papers specifically addressing different aspects of waste management, such as:

- Clean-up of old waste deposits;
- Removal of disused facilities;
- Waste water treatment;
- Waste management plans;
- Waste inventories; and
- Examples of good waste practices.

Activities covered by the first two items included documents from a dozen countries, a clear signal of their commitment towards the environmental recovery of sites of past activities. The fact that no substantial debate on this issue has never arisen within the CEP (given that no working papers had ever addressed waste management activities) could imply that, at least for the time being, implementation of national (and other international) procedures on these issues has proven adequate. However, it has been encouraging to see parties engaged on a regular exchange of information about waste management activities in Antarctica.

Present and Future: AEON Workshop on Waste Management in Antarctica

As briefly described above, national Antarctic operators do currently have quite a comprehensive framework on waste management. However, the practical implementation and coordination of such a framework might, on occasions, have proven insufficient. Therefore, additional tools may be necessary to ensure success. As AEON recognizes the importance of implementing sound waste management procedures, this *Workshop on Waste Management in Antarctica* constitutes a relevant step forward towards increase the flow of information on these issues among national Antarctic operators (what we have done, what we have learned and what we need to undertake in the future). Opportunities to bring those waste management officers together will be created, which will encourage the implementation of alternative, creative and/or likely joint initiatives among Antarctic operators on these matters. Eventually, the results of this workshop and subsequent actions resulting from it, will gradually favour new standards, conditions and scenarios for waste management on the continent. This will surely make a significant contribution towards the enhancement of the Antarctic environment of the future.

Appendix 1

Measures agreed within the Antarctic Treaty System on Waste Management

A) REC. VI-4. TOKYO, 1970: MAN'S IMPACT ON THE ANTARCTIC ENVIRONMENT

The Representatives,

Considering and recognizing that:

1) *In the Antarctic Treaty area, the ecosystem is particularly vulnerable to human interference;*
2) *The Antarctic derives much of its scientific importance from its uncontaminated and undisturbed condition;*
3) *There is an increasingly urgent need to protect the environment from human interference;*
4) *The Consultative Parties should assume responsibility for the protection of the environment and the wise use of the Treaty area;*

Recommend to their Governments that:

1. *They invite the Scientific Committee on Antarctic Research through their National Antarctic Committees:*
   (a) to identify the types and assess the extent of human interference which has occurred in the Treaty area as a result of man's activities;
   (b) to propose measures which might be taken to minimize harmful interference; and
   (c) to consider and recommend scientific programs which will detect and measure changes occurring in the Antarctic environment;
2. *They encourage research on the impact of man on the Antarctic ecosystem;*
3. *They take interim measures to reduce known causes of harmful environmental interference; and*
4. *They consider including on the agenda for the Seventh Antarctic Treaty Consultative Meeting an examination of this matter in the light of any further available information.*

B) REC. VIII-11. OSLO, 1975. CODE OF CONDUCT FOR ANTARCTIC EXPEDITIONS AND STATION ACTIVITIES

The Representatives,

Recalling Recommendations VI-4 and VII-1;

Desiring to minimise the impact of man on the Antarctic environment;

Noting with appreciation the response of the Scientific Committee on Antarctic Research (SCAR) to Recommendation VI-4;

Recommend to their Governments that:

1. *To the greatest extent feasible, they observe the code of conduct annexed to this Recommendation at their stations and for their activities within the Antarctic Treaty area;*
2. *Through their national Antarctic committees, they invite SCAR, in co-operation with the Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions, to continue its interest in the development of scientific programs for detecting and assessing changes occurring in the Antarctic environment.*

Waste disposal

Recommended procedures:

(a) Solid Waste

(i) Non-combustible, including chemicals (except batteries):These materials may be disposed of at sea either in deep water or, if this is not possible, at specified sites in shallow water.

(ii) Batteries should be removed from the Antarctic Treaty area.

(iii) Combustibles:

- *Wood, wood products and paper should be incinerated, the ash being disposed of at sea.*
- *Lubricating oils may be burnt, except those containing harmful additives which should be removed from the Antarctic Treaty area.*
- *Carcasses and materials associated with imported experimental animals should be incinerated.*
- *All plastics and rubber products should be removed from the Antarctic Treaty area.*

(b) Liquid Waste

(i) Human waste, garbage and laundry effluents should, where possible, be macerated and be flushed into the sea.

(ii) Large quantities of photographic liquids should be treated for the recovery of silver and the residue should be flushed into the sea.

(c) The above procedures are recommended for coastal stations. Field sites supported from coastal stations should, where feasible, use the facilities of their supporting station. Inland stations should concentrate all waste in deep pits. Except as stated for inland stations, waste should not be buried.

(d) Waste containing radio-isotopes should be removed from the Antarctic Treaty area.

(e) Every effort should be made to reduce the plastic packaging of products imported into the Antarctic Treaty area.

(f) If possible, the use of leaded fuels, or fuels containing ethylene bromide and ethylene chloride, should be avoided.

(g) When incinerators are used, it is desirable to monitor the effluents.

C) REC. XII-4. CANBERRA, 1983. MAN'S IMPACT ON THE ANTARCTIC ENVIRONMENT: CODE OF CONDUCT FOR ANTARCTIC EXPEDITIONS AND STATION ACTIVITIES.

The Representatives,

Recalling Recommendation VIII-11;

Noting a general increase in awareness amongst Consultative Parties of the potential environmental impacts of the disposal of waste in the Antarctic region;

Noting that the increasing level and degree of complexity of Antarctic operations is likely to introduce into the Antarctic a wider range of potentially environmentally damaging substances than previously;

Noting that improvements in logistics and technology increase the feasibility of on-site treatment of human and other waste, and of the removal of solid waste, residues and noxious substances from the Treaty area;

Recommend to their Governments that they seek the advice of their respective Antarctic operating agencies as to:

(i) Any problems which have been experienced in implementing the Code of Conduct for Antarctic Expeditions and Station Activities contained in the Annex to Recommendation VIII-11; and

(ii) The desirability and feasibility of revising the Code of Conduct in the light of the points noted above, particularly the increased potential for on-site treatment and removal of waste from the Treaty area.

D) REC. XIII-4. BRUSSELS, 1985. MAN'S IMPACT ON THE ANTARCTIC ENVIRONMENT: CODE OF CONDUCT FOR ANTARCTIC EXPEDITIONS AND STATION ACTIVITIES: WASTE DISPOSAL.

The Representatives,

Recalling Recommendations VI-4, VIII-11 and XII-4;

Recognising that Antarctica derives much of its scientific importance from its uncontaminated condition, and the consequent need to reduce to the minimum level practicable, the spread of all potential contaminants introduced into the Antarctic Treaty area by man;

Noting that changes have occurred in the perception of what constitutes pollution and in analytical techniques since Recommendation VIII-11 was approved;

Noting with appreciation the preliminary review by the Scientific Committee on Antarctic Research (SCAR) of the waste disposal aspects of the Annex to Recommendation VIII-11;

Recommend to their respective Governments that through their national Antarctic committees they invite SCAR, using all resources available to it, to undertake a comprehensive review of the waste disposal aspects of the Annex to Recommendations VIII-11 and, giving due consideration to the need to avoid detrimental effects on neighbouring or associated ecosystems outside the Antarctic Treaty area, and to considerations of cost-effectiveness, to offer:

1. *Scientific advice regarding waste disposal procedures and standards that it is desirable to achieve at coastal and inland stations and field camps;*
2. *Advice regarding the logistic feasibility of such procedures, bearing in mind Antarctic operational circumstances, including variation in the numbers of personnel between stations, operational and logistic difficulties, and local circumstances; and*
3. *Such other advice as seems to SCAR to be relevant to waste disposal procedures.*

E) REC. XV-3. PARIS, 1989. HUMAN IMPACT ON THE ANTARCTIC ENVIRONMENT: WASTE DISPOSAL

The Representatives,

Recalling Article II of the Antarctic Treaty and Recommendations VI-4, VIII-11, XII-4, and XIII-4;

Reaffirming the commitment of Consultative Parties to take measures to reduce the amount of wastes generated in Antarctica and to minimize the impact of wastes on the Antarctic environment, giving due consideration to the need to avoid detrimental effects on dependent or associated ecosystems outside the Antarctic Treaty area;

Recognizing that the Antarctic derives much of its scientific importance from its uncontaminated condition;

Recognizing further that the support of science has an impact on the Antarctic environment which it is impractical to eliminate completely, but which, by good management can be limited;

Noting that the increasing level and complexity of Antarctic operations have increased the quantity and variety of wastes produced, but that improvements in logistics and technology have increased the capacity to minimize wastes and their environmental impacts;

Recognizing further that different environments, scales of operation, and logistic infrastructures will require different approaches to waste management, and that further technical developments can be expected to provide new solutions to waste management problems;

Noting with appreciation the work of the Scientific Committee on Antarctic Research (SCAR) in response to Recommendation XIII-4, which invited National Antarctic Committees to undertake a comprehensive review of the waste disposal aspects of the Annex to Recommendation VIII-11, and to offer scientific advice regarding waste disposal procedures and standards that it is desirable and practical to achieve at coastal and inland stations and field camps;

Desiring to revise the waste disposal aspects of the Code of Conduct annexed to Recommendation VIII-11 to take account of the recommendations of SCAR;

Recommend to their Governments that they adopt the following practices and take measures within their competence necessary to ensure compliance with them;

General obligation

1. The amount of wastes produced, or disposed of, in Antarctica shall be reduced to the maximum extent possible so as to minimize impact on the Antarctic environment and minimize interference with scientific research, or other legitimate uses of the Antarctic.

Waste management planning

2. Each Government carrying out Antarctic activities shall establish a waste disposal classification as a basis for recording wastes and to facilitate studies aimed at evaluating the environmental impacts of operational and scientific activity. Wastes produced may be classified as sewage and domestic liquid wastes (Group 1); other liquid wastes and chemicals, including fuels and lubricants (Group 2); solids to be combusted (Group 3); other solid wastes (Group 4); and radioactive materials (Group 5). Source classification codes, which represent individual processes or functions logically associated with points of waste creation, may be used in auditing studies.
3. Each Government carrying out Antarctic activities shall, in respect of those activities, prepare and annually update:

(a) Plans for waste management (including waste reduction, storage and disposal), specifying for each fixed site, for field camps generally, and for each vessel (other than small boats that are part of the operations of fixed sites or of vessels);
(i) Programs for cleaning up existing waste disposal sites and abandoned work sites;
(ii) current and planned waste management arrangements;

(iii) Current and planned arrangements for analysing the environmental effects of Antarctic waste and waste management systems; and

(iv) Other efforts to minimize any environmental effects of wastes and waste management.
(b) an inventory of locations of past activities (such as traverses, fuel depots, field bases, crashed aircraft) as far as is practicable, before the information is lost, so that such locations can be taken into account in planning future scientific programs (e.g. snow chemistry, pollutants in lichens, ice core drilling etc.).

4. Each Government carrying out Antarctic activities shall include the waste management plans referred to in paragraph 3 (a) above in the annual exchanges of information in accordance with Articles III and VII of the Antarctic Treaty and related Recommendations under Article IX of the Treaty. The formats of such exchanges shall be determined by each Government pending development of standardized formats. They shall also exchange the inventories referred to in paragraph 3 (b) above.

5. Each Government carrying out Antarctic activities shall ensure that its national Antarctic operators 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.

6. Those carrying out activities in Antarctica shall ensure that members of their expeditions receive training designed to limit the impact of their operations on the Antarctic environment and to inform them of required practices.

7. Pesticides, polychlorinated biphenols (PCBs), non-sterile soil or polystyrene beads, chips or similar forms of packaging shall not be sent to the Antarctic. The use of poly-vinyl chloride (PVC) products in packaging shall be discouraged.

8. Those carrying out activities in Antarctica shall ensure that their expeditions to Antarctica are advised of any PVC products being provided.

9. Each Government shall establish a long-term program to remove existing abandoned fuel drums and fuel, where such removal is practical. Such programs shall identify for clean up at the first opportunity those drum sites where the transport equipment which delivered the drums is no longer available in the same area.

10. Waste compaction, storage and incineration facilities shall be incorporated in the design and construction of ships engaged in or supporting Antarctic programs.

Waste disposal

11. The following wastes shall be removed from the Antarctic Treaty area:

(a) Radio-active materials;

(b) Electrical batteries (including lead/acid, dry cell and other types);
(c) Fuel, both liquid and solid; and

(d) Wastes containing high levels of heavy metals or harmful persistent compounds.

12. The following wastes shall be removed from the Antarctic Treaty area unless they are incinerated in equipment which neutralizes the harmful emissions that would otherwise be produced:
(a) Poly-vinyl chloride (PVC), polyurethane foam, polystyrene foam, rubber and lubricating oils which contain additives that are widely recognized as products that could produce harmful emissions;
(b) all other plastic wastes, including those of unknown composition.

13. The following wastes shall be removed from the Antarctic Treaty Area to the maximum extent practicable:

(a) Liquid wastes, other than sewage and domestic liquid wastes;

(b) Solid, non-combustible wastes; and

(c) Fuel drums.

14. The following wastes shall be removed from Antarctic Treaty area unless incinerated, autoclaved or otherwise treated to be made sterile: residues of introduced animal carcasses; cultures of micro-organisms; and introduced avian products.

15. Combustible wastes, not removed from the Antarctic Treaty area, shall be burnt in incinerators designed to reduce harmful emissions to the maximum extent practicable.

16. All open burning of wastes shall be phased out. Pending the completion of such phase out, when it is necessary to dispose of wastes by open burning:

(a) 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; and
(b) Wastes to be burnt shall be stored in such as way as to prevent their dispersal by wind, or access and dispersal by scavengers.

17. 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 by wind or access and dispersal by scavengers.

18. Solid non-combustible wastes, which cannot be removed to land disposal sites outside the Antarctic Treaty area and which are to be disposed of at sea, shall only be disposed of at selected dump sites in deep waters, within or outside the Antarctic Treaty area and only in accordance with the international Convention for the Prevention of Marine Pollution by the Dumping of Wastes and other Matter (London Dumping Convention), as well as any other relevant international agreements.

19. Dumping of any other wastes at sea shall be carried out in accordance with the London Dumping Convention.

20. Sewage, chemical wastes and, to the maximum extent practicable, domestic liquid wastes shall not be disposed of onto ice free land. Sewage and domestic liquid wastes may be discharged directly into the ocean, provided that:

(i)Such discharge be located, wherever practicable, where conditions exist for rapid dispersal;

(ii) Large quantities of such wastes (generated by approximately 30 individuals or more), receive at least primary treatment, such as maceration; and

(iii) Consideration be given to the advantages of treating very large quantities through systems, such as Rotating Biological Contractor Systems, to reduce biological oxygen demand (BOD) and suspended solids.

21. Vessels engaged in supporting Antarctic activities that are not fitted with incinerator facilities shall, to the maximum extent practicable, stockpile waste, excluding untreated sewage and domestic effluents, for appropriate disposal at stations, bases, deep waters sites or outside of the Antarctic Treaty area, provided that such wastes may be disposed of at stations or bases in Antarctica only in accordance with these practices, and at sea only in accordance with relevant Antarctic Treaty recommendations, the London Dumping Convention and any other relevant international agreements. Any incineration of shipboard wastes in the Antarctic Treaty area shall be conducted in incinerators of the type which are designed to reduce harmful emissions to the maximum extent practicable.

22. Those carrying out activities in Antarctica shall to the maximum extent practicable clean up the waste disposal sites and abandoned work sites of their Antarctic activities.

23. Wastes generated at inland stations shall be removed from the area of such stations to the maximum extent practicable for disposal in accordance with the practices set out in this Recommendation. Where this is not practicable, such wastes shall be concentrated in deep ice pits. In planning the location of inland stations where deep ice pits are the only practicable alternative, sites on known ice flow lines which terminate at ice-free areas or in areas of high ablation shall be avoided.

24. Wherever practicable, wastes generated at field camps shall be removed to their supporting stations, bases or ships for disposal in accordance with the practices set out in this Recommendation.

Procedures

25. These practices shall be kept under continuing review so as to ensure that they are up-dated as necessary to reflect improvements in waste disposal technology and procedures and to ensure maximum protection of the Antarctic environment. To this end it would be desirable for SCAR and the Managers of National Antarctic Programs to continue to consider problems, prospects and opportunities for cooperation in Antarctic waste management and to provide advice on appropriate steps that may be taken.

26. Governments should ensure that their nationals and vessels are subject to measures governing waste disposal in Antarctica that are no less effective in affording protection of the environment than those applicable to their nationals and vessels outside Antarctica. Further, nothing in these practices shall be interpreted as replacing national environmental standards applicable to Antarctic activities, where such standards are stricter than those contained in these practices; nor shall any provision in these practices be interpreted as limiting governments from adopting stricter standards.

27. These practices shall not be interpreted or implemented in such fashion as to endanger human life.

F) RESOLUTION 5 (1995). ATCM XIX, SEOUL. ANTARCTIC INSPECTION CHECKLISTS

The Representatives,

Considering that inspection checklists are useful as guidelines for those planning and conducting inspections under Article VII of the Antarctic Treaty, and in assessing implementation of the provisions of the Environmental Protocol pending its entry into force;

Noting that inspection checklists are not mandatory and are not to be used as a questionnaire;

Recommend that:

The Consultative Parties should encourage the use of the checklists attached:

Checklist A Permanent Antarctic Stations and Associated Installations;

Checklist B Vessels within the Antarctic Treaty area;

Checklist C Abandoned Antarctic Stations and Associated Installations; and

Checklist D Waste Disposal Sites.

2. Stories about Waste at Dumont d'Urville, on the Traverse and at Concordia Station

Claire Le Calvez, French Polar Institute

Abstract

The paper will describe the different types of waste produced at Dumont d'Urville and Concordia stations as well as on the traverse that links the two stations, and explains the waste management procedures currently in place.

The implemented solutions intend to reduce the amount of waste, to modify storage conditions, to handle waste immediately so that there is no accumulation, and to find adapted treatments both on-site and outside the Treaty area. This must be supported by good staff training and also liaison with suppliers.

However, practices in place are not sufficient, and alternative, or at least additional, solutions need to be found. Some projects under study, and ideas under consideration, will be presented.

Outline:

- Global Scheme.
- Types of Waste.
- Objectives.
- Sewage and Domestic Waste.
- Waste treatment: Solid Combustible.
- Waste Treatment: Gas Effluent.
- Waste Figures from 2005-06.
- Future Developments.

Global Scheme

At DOME C, the goals are as follows:

1. Minimize pollution;
2. Very limited and focused treatment (exhaust gas, water); and
3. No accumulation of waste.

The following diagram displays the global waste management scheme:

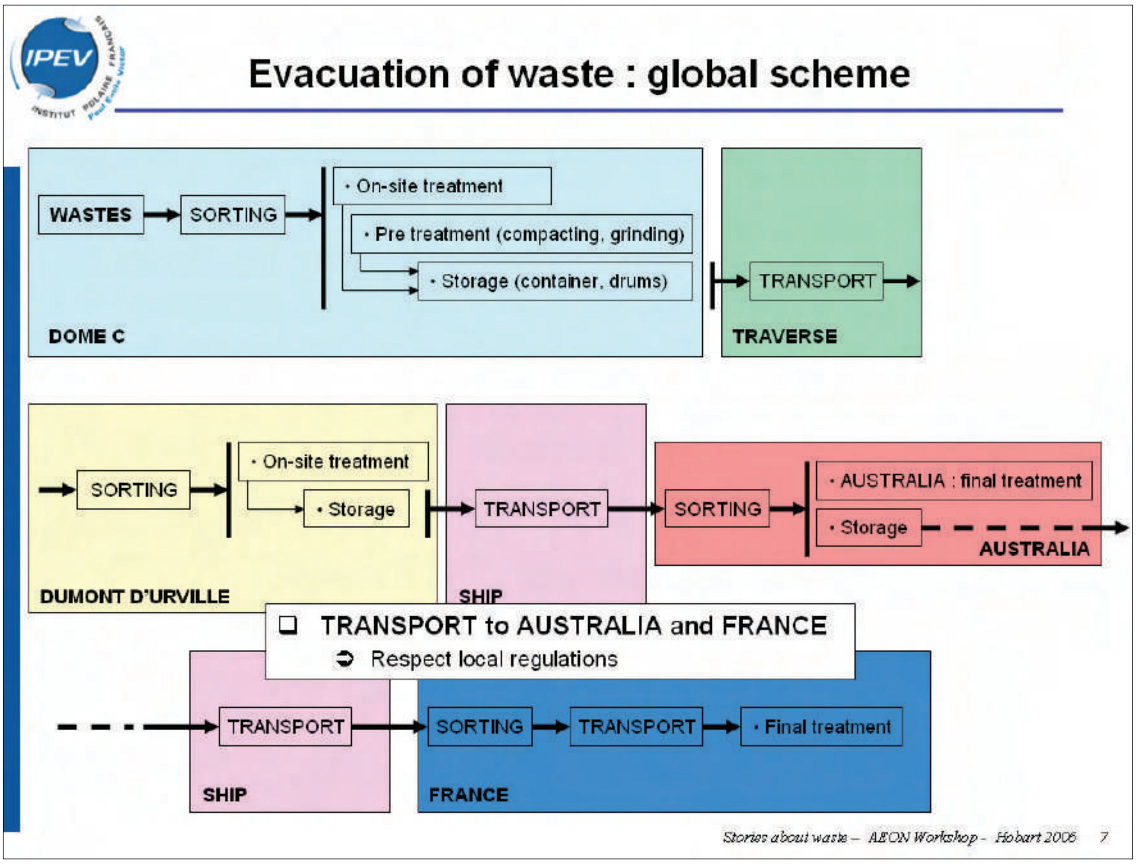

Figure 1: Global Waste Management Scheme

The diagram below displays the length of time it takes to undertake waste evacuation at Dumont d'Urville (DDU) and Dome C.

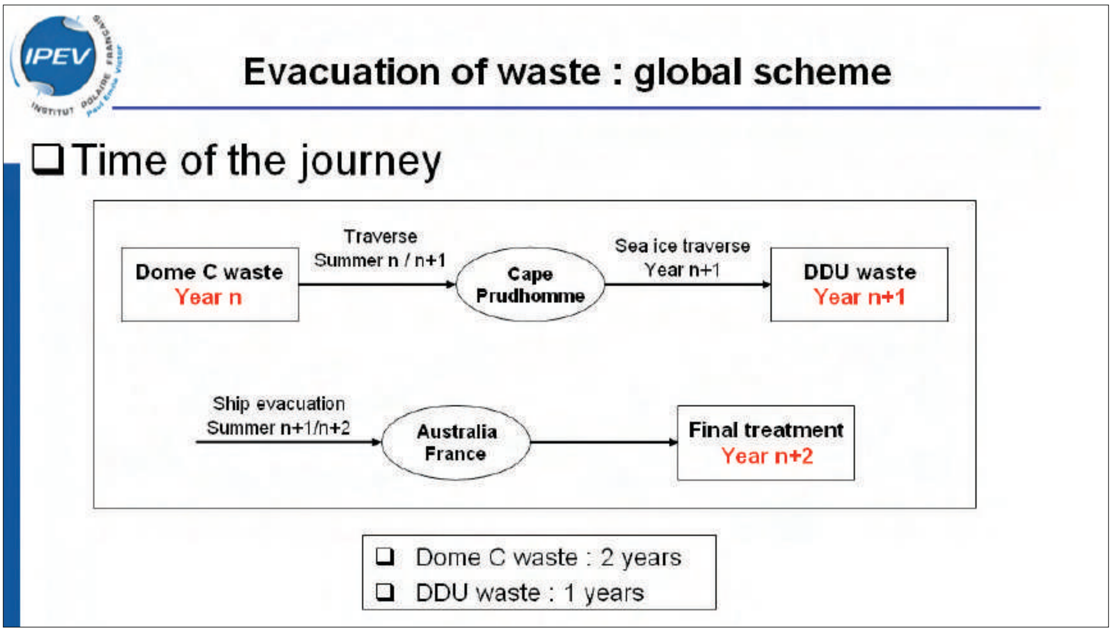

Figure 2: Time of Global Waste Journey

As well as efficient monitoring and transportation of the waste, robust packaging is needed to withstand storage and transportation conditions.

Types of Waste

Types of waste include:

- Sewage and domestic liquid waste;
- Other liquid waste and chemicals;
- Solid non-combustibles;
- Medical waste; and
- Gaseous effluent.

Issues include:

- Disposal into the sea at Dumont d'Urville;
- Incineration at Dumont d'Urville;
- Evacuation of waste from Concordia and Dumont d'Urville to Australia and France; and
- On-site recycling.

Objectives

One of our objectives is to minimise volume. In support of this, our suppliers are asked to limit packaging. Grinders and compactors are used to reduce the volume of stored waste. Another objective is to re-use on-site containers. Empty fuel drums are prepared and re-used for waste storage. In addition, wooden boxes are also re-used. A third goal is to find and use adaptable, robust waste packaging that is easy to store, handle and load. A final objective is to avoid unnecessary sorting: that is, to sort waste correctly at the waste disposal point to avoid the need to re-sort down the line.

Figure 3: Reuse of wooden boxes being used to store cardboard boxes of shredded plastics.

Figure 4: Special containers for specific wastes

Figure 5: techniques to avoid further sorting

Figure 6: Techniques to avoid further sorting

Figure 7: Avoid badly packed containers

Sewage and Domestic Liquid Waste

At Dumont d'Urville Station

Sewage and domestic liquid waste is deposited into the sea, with toilet and food first being ground.

On a traverse

Toilet waste (black water) is incinerated with an electrical toilet.

Domestic liquid waste (grey water) is minimised through the use of pre-prepared food and plastic plates. Only a very small amount of grey water waste is therefore generated, and this is deposited on the ice.

As food is pre-prepared, very little food waste is generated, and this is stored.

At Concordia Station

The diagrams on the following pages show figures relating to the treatment of grey water at Concordia:

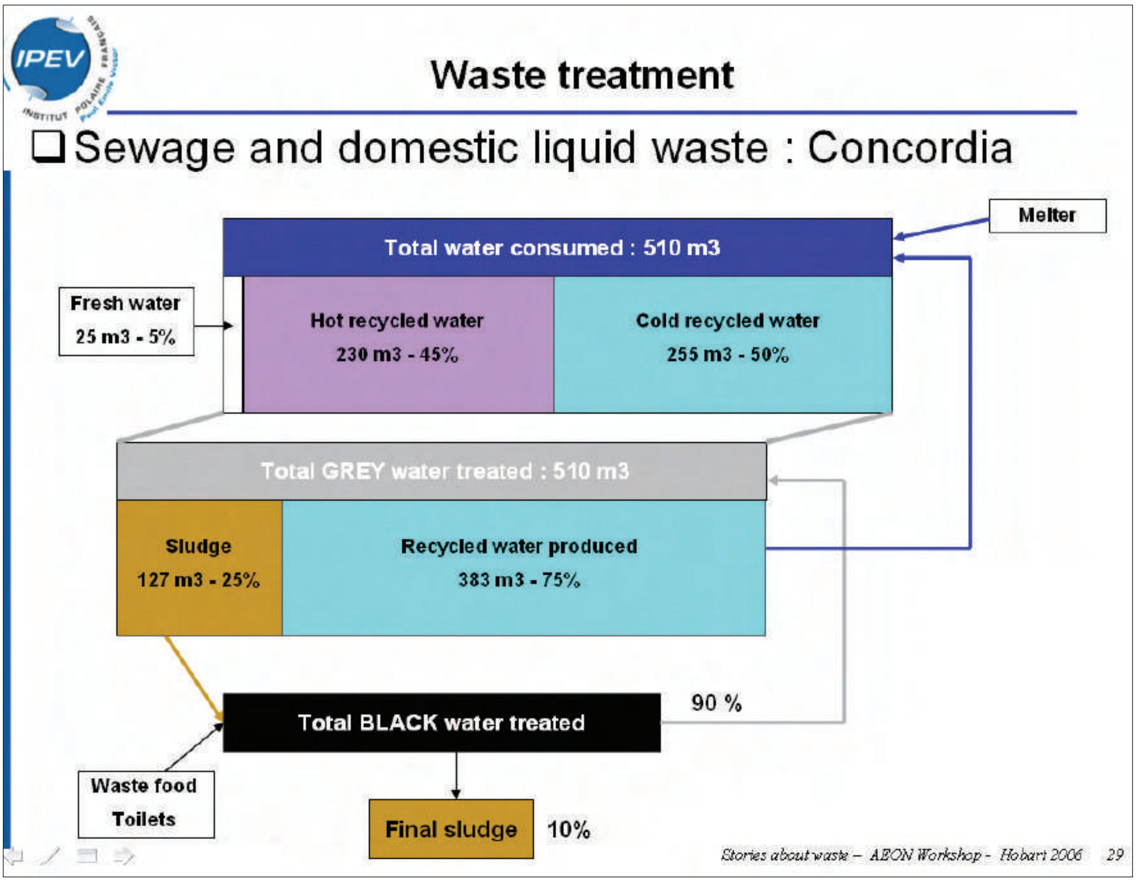

Figure 8: Volumes of Sewage and Domestic Liquid Waste

Toilet waste (black water) is currently incinerated with an electrical toilet. A new treatment unit has been proposed for installation in the 2007-08 season.

Domestic liquid waste (grey water) is recycled, with 76% of this water destined for re-use on the station.

Four stages of treatment are implemented:

1. UV filtration;
2. Nano filtration;

3. Reverse Osmosis Stage 1; and
4. Reverse Osmosis Stage 2.

Sludge from the treatment unit is deposited into a well in the ice.

Waste Treatment: Solid Combustible

At Dumont d'Urville, paper, cardboard and wood is burnt in an incinerator. Ashes are collected and evacuated to France for treatment.

Waste Treatment: Gaseous Effluent

For engine exhaust gases, a cooling system is used to recover heat, which also allows for the condensation of water vapour.

A diesel particulate filter (ceramic) is used at the outlets to reduce oxide and trap particles. In addition, a special fuel additive is used. This is a Ceria-based, fuel-borne catalyst (Eolys Rhodia) which facilitates regeneration of the filter and lowers the ignition temperature of the trapped soot (400 to 450°C).

Waste Figures from 2005-06 Season

Concordia to Cape Prudhomme :	
Paper	5x20'' containers
Plastics	3x20'' containers
Metal / alu / copper / composites	3x20'' containers
Wood	3x20'' containers
Organics	2x20'' containers
Glass bottles	3 wooden boxes
Sump oil	7 drums
Chemical liquids	7 drums (glycol, oil + water)

Dumont d'Urville to France:	
Solids: Plastic	2 tonnes
Solids: Composites	2 tonnes
Liquids:	5 m3
Ashes	4 m3

Dumont d'Urville to Australia:	
Solids: Total	39 tonnes
Solids: Wood	17 tonnes
Solids: Recyclable plastics	4 tonnes
Solids: Non recyclable plastics	8 tonnes
Solids: Steel cans	5 tonnes
Solids: glass from bottles	5 tonnes
Liquids (oil and others)	5 m3

Future Developments

Diesel Particulate Filter with Special Fuel Additives

- Installation on all engines at power station; and
- Installation on engines used on the traverse.

Waste Water Management

Concordia:

- Implement Black Water Treatment Unit; and
- Achieve an overall efficiency of 90%.

Traverse:

- Implement some type of grey water treatment unit.

Dumont d 'Urville

- Implementation of a waste water treatment plant to decrease organic load of effluent.

Waste management

Cape Prudhomme:

- Installation of a paper/cardboard incinerator; and
- Decrease the amount of waste produced.

3. Learning Outcomes from Industry Management of Waste Generated by East Antarctic Activities

John Brennan, Veolia Environmental Services

Abstract

In the long term, how can Antarctic nations contain waste management costs, minimise associated environmental impacts, comply with environmental obligations and meet global social and community responsibilities and expectations?

Factors contributing to success include environmental policy, unfaltering leadership underpinned by appropriate resources, achievable goals and practical procedures. Effectiveness is determined by the people involved, methodologies, records and an appropriate review process. Partnerships with industry specialists can effectively assist the continual improvement process. The latter is especially true if an environmental management system (e.g. ISO14001 or equivalent) is available to drive the process.

Veolia Environmental Services (VES) has managed waste returned from East Antarctic programs for over fifteen years. French and Australian Antarctic programs engage VES to ensure that waste returned from subantarctic and Antarctic activities is managed to meet compliance standards. They also want to ensure that priority is given to examine and segregate waste to minimise waste to landfill/disposal, and promote beneficial re-use/recycling.

The cooperative partnership between the environmental industry specialist, VES, and Antarctic programs demonstrates that continual improvement and sustainable waste management practices can be achieved. The key learning outcomes to share from this presentation will include:

- Management of “waste” as a “resource”;
- Objectives, targets and agreement;
- Measurements of success;
- Communication and reporting of findings;
- Audit, check and review processes; and
- Remaining open to possibilities.

Outline

- What is Veolia Environmental Services (VES)?
- For whom do we provide services?
- Drivers for best practice waste management.
- Case Study – Institut Polaire Francais (IPEV).
- Case Study – Australian Antarctic Division (AAD).
- Learning Outcomes.
- Reporting.
- Contractual Arrangements.
- Conclusion.

What is Veolia Environmental Services?

<u>Veolia Water</u>

As a world leader in water services, Veolia Water specialises in:

- Water and wastewater management for public authorities and industries; and
- Design of technological solutions and construction of facilities required to operate the water services.

<u>Veolia Energy</u>

As a European leader in energy services, Veolia Energy specialises in:

- Energy management, heating and cooling networks;
- Integrated facilities management services;
- Installation and maintenance of power generation and cooling systems; and
- Public lighting systems

<u>Veolia Transport</u>

As public transport specialists, Veolia Transport specialises in:

- Outsourced management of urban and regional public transport systems encompassing all types of vehicles: buses, coaches, trains, subway, tramway, trolleys, boats and taxis.

<u>Veolia Environmental Services</u>:

- Ranks No. 2 in the world for waste management and cleaning services;
- Is active in 34 countries;
- Employs 71,000 employees worldwide;
- Serves 50 million people, including 350,000 industrial and tertiary sector customers;
- Earns $12 billion in revenue (2005);
- Collected 33 million tons of waste; and
- Treated 52 million tons of waste.

Who are Our Clients in Tasmania?

Our Antarctic waste activities are based at the Hobart Wharf in an allocated quarantine area. We have over 15 years experience in dealing with RTA waste and quarantine issues. Our long standing clients include IPEV and AAD, which operate out of Hobart. Antarctic and subantarctic waste returned to Australia (RTA waste) enters the port of Hobart port which has capacity to receive very large ships.

Drivers for Best Practice with Waste Management

- Policy;
- External obligations (Madrid Protocol);
- Internal obligations (organisational);
- Commitment, procedures and processes;
- Environmental management systems (EMS);
- External accreditation (e.g. auditable to ISO14001);
- Prevention of loss;
- Resources such as shipping and station space;
- Financial resources for waste services;
- Time – expeditioners, training;
- Consultation – internal/external; and
- System review for incidents and audit with feedback.

Case Studies: France and Australia

- Veolia/Collex developed standard procedures to streamline approvals, inspections and processing of materials/waste.
- IPEV waste is classed as foreign imported waste.
- Based on Basel Convention, approval is required for the import of hazardous waste.
- On an annual basis, the application is revised and a report submitted.
- Consultation occurs between Veolia/Collex, the shipping agent and IPEV.
- AAD waste is imported under Australian trans-boundary requirements (NEPM).
- The approval process involves Veolia/Collex, AAD and the Tasmanian Environment Division.

Figure 1: Superb port facilities used by Veolia / Collex in Hobart

This successful partnership is based on importation managed through a seamless process involving:

- IPEV or AAD staff;
- The ship;
- Shipping agents;
- Customs;
- Quarantine;
- Ports service;
- Environmental regulators (local and national);
- A competent and well-resourced contractor; and
- Approved methods for reuse/recycling/treatment and disposal.

Generic aspects of the waste management process include:

1. Pre-season approvals and consultation concerning consignment authorizations.
2. Quarantine sorting area and permits.
3. Working within shipping schedule
4. Release of specific manifest of RTA waste.
5. Inspection – quarantine, environmental regulators, client.
6. Release of waste for sorting/grading/processing.
7. Waste is weighed and sorted for:
    a. Reuse;
    b. Recycling;
    c. Treatment and disposal; and
    d. Landfill.
8. Tracking of waste and input of data to specialized database.

Several factors affect seasonal waste composition and diversion rates. These include the following:

Pre-RTA

- weather conditions e.g. helicopters and ice;
- general cargo logistics/priorities;
- availability of containers for waste storage; and
- communication / training / attitude / participation of all involved.

Post-RTA

- contamination;
- foods mixed with recyclables;
- deep burial, resulting in the loss of the resource; and
- the presence of ceramics in glass at a rate of 25 g/tonne.

IPEV Statistics on Recycling and Reuse

IPEV - Stats – Recycling/Reuse	
Season	**Diversion Rate% (weight)**
00 -01	39%
01 -02	71%
02-03	71%
03-04	74%
04-05	78%

Comments:

- Consistent results;
- Commendable;
- Very little contamination;
- Space utilisation is good – use of compaction; and
- Improvement over time.

Note that variability is much less compared to AAD explained by less points of generation (one major station compared to 4) and some IPEV wast is still repatriated to France where as AAD waste is all returned to Tasmania, Australia.

AAD Statistics on Recycling and Reuse

AAD - Statistics – Season Totals	
Season	**Diversion Rate(% by weight)**
99/00	19%
00/01	55%
01/02	36%
02/03	37%
03-04	22%
04-05	31%

Comments:

- Variable results;
- Commendable effort;
- Contamination;
- Space utilisation is good – use of compaction;
- Improvement over time; and
- Greater volumes are handled.

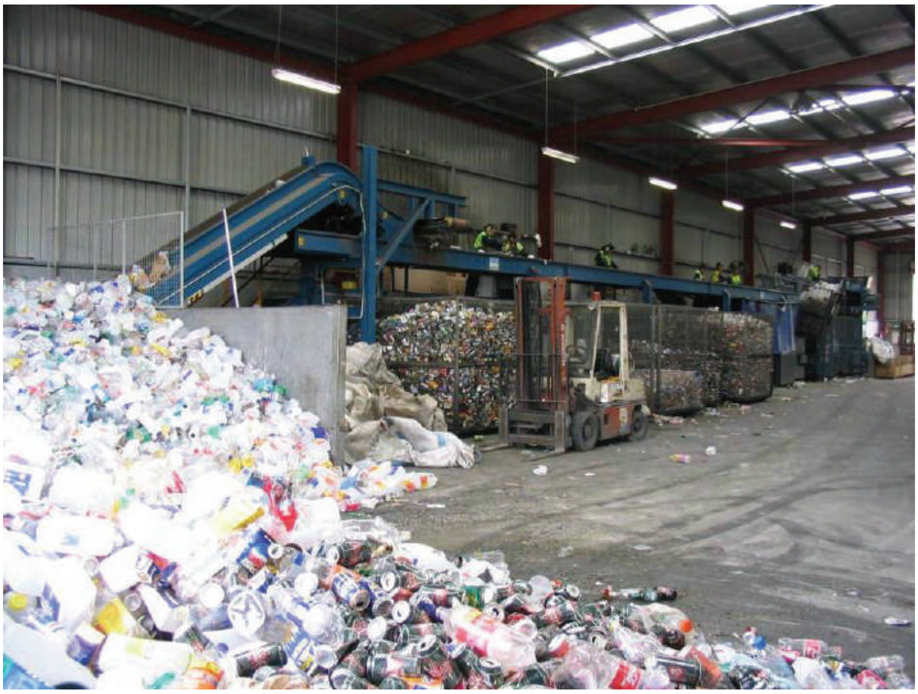

Figure 2: Recyclables can be received co-mingled form Antarctica for sorting in the Collex / Veolia recycling facility in Hobart

Learning Outcomes: General RTA Findings

Decrease contamination. For example, reduce liquid mixing in containers, avoid food residues with recyclables, contain recyclables to avoid non-conforming product due to water/moisture ingress (e.g. rusting of steel cans).

Improve container signage/marking and manifest details.

Improve container utilization. This will lead to an improvement in the containment of waste,

Cover all waste during shipping. This will reduce littering, as well as the likelihood of waterlogging of waste/recyclables, and will assist in the deterrence of illegal salvaging if containers sit at wharves.

Improve quarantine compliance. Pre-clean container fork pockets to reduce the presence of soil or gravel.

Audit on station and during the RTA process to monitor the process.

Improve efficiency. Make the process as easy as possible for expeditioners. (e.g. co-mingled collection: keep unbroken glass together and all plastics together.)

Enforce supplier responsibility through the tender process and quality control measures. Avoid waste at the front end to gain efficiencies. Tighter controls on the types of packaging are warranted, as is the potential for re-usable packaging. Supporting the tendering process with auditing is an ideal mechanism to control this issue.

Reduce cross contamination - a co$tly exercise. (e.g. CCA wood burnt and contaminates ash, fuel slops contaminate other drummed liquids)

Explore the possibilities for resource recovery and re-use. (e.g. sewage sludge for composting or vermiculture.

Case Study: Audit of an AAD Station

In 2000 Veolia/Collex was invited to visit Casey. The purpose of the visit was to;

- Present observations made while visiting Casey;
- Comment on the issues which may place constraints on best practice waste management at Casey;

- Discuss waste and recycling with expeditioners to ascertain their attitudes;
- Comment on the audit of waste and recyclables returned to Tasmania;
- Provide comments and recommendations for improvement; and
- Discuss some issues that effect contaminated sites (old landfills).

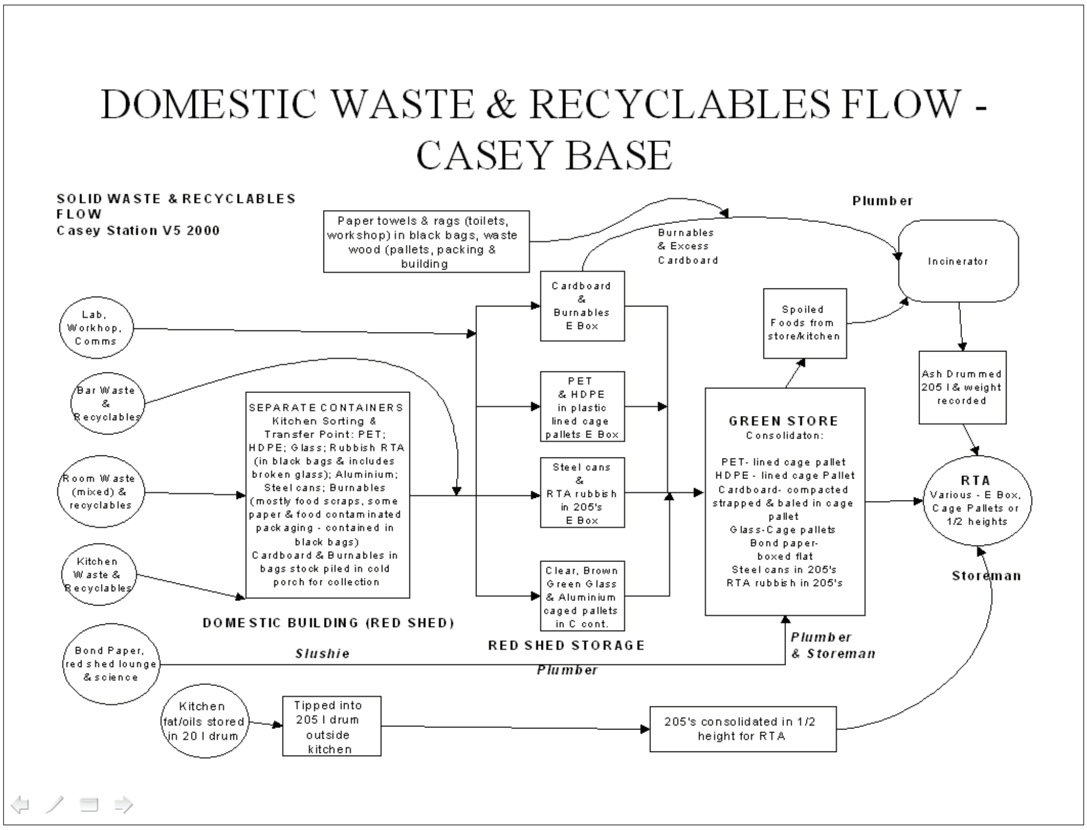

Figure 3: Waste and Recyclables flow at Casey Station

Observations and issues identified included:

There is a need to reduce packaging. Less packaging = less cost (both financial and environmental). The solution is to purchase bulk/concentrated items whenever possible.

Acknowledgement of the existing system: staff and expeditioners are pro-active.

Consultation and feedback: positive feedback to expeditioners is necessary to foster ownership.

Education on waste management should be increased. A considerable effort has been made by management at Kingston and the expeditioners to establish the current system, which could be enhanced further by increasing awareness through educational means.

Redesign and planning: new approaches to management of waste and recyclables will require redesign of the current system in consultation with all stakeholders.

Resourcing infrastructure: new/additional infrastructure, or adaptations to the existing infrastructure, may be required so that waste minimisation and resource recovery can be achieved in a practicable and efficient manner.

Reporting

Written Report from Site Audits:

- Important to action priorities – **A** address in short term; **B** may require longer term planning; and **C** issue(s) require strategic planning for operating in Antarctic regions (e.g. high capital value etc.)

Database

- Tracking costs, waste/resource outcomes, linking to voyages and stations, generation of summary reports including seasonal breakdown

Contractual Arrangements

Drivers for Best Practice

Contract management drives change in line with policy and procedures (mandatory requirements plus a wish list).

- Focus on avoidance of waste as a priority. Use the purchasing system;
- Then focus on:
    - Reducing the amount of waste generated (adopt new technologies/products);
    - Reusing materials before disposal;
    - Recycling by reprocessing or composting; and
    - Disposal by consigning residuals to landfill or treatment plant;
- Have input to waste management review committees and logistics;
- Implement holistic approach audits on station as well as on RTA waste;
- Develop databases to capture information for KPI reporting and to meet environmental obligations (e.g. EMS); and
- Remain flexible.

Management Objectives

1. Develop and accept a set of common objectives for the disposal of waste;
2. Work towards the most efficient and cost effective system;
3. Keep in place reliable monitoring and reporting process;
4. Achieve maximum recycling and reuse, and minimise landfill; and
5. Develop strategies for minimising packaging and thus reduce the creation of waste.

Performance and Benchmarks

AAD contract is a partnership approach. For example:

Service Element	KPI
Diversion from landfill	40% target
OHS compliance	Cooperative incident reporting
Controlled/hazardous wastes	Reported tracking
RTA wharf processing	Achieved within agreed timeframe
Reporting	Database, quarterly and annual including NEPM certificates

Conclusion: Tips to Keep Waste Costs ($) Down!

- Avoid waste creation through purchasing procedures. Front end avoidance is PREVENTION;
- Purchase in bulk/concentrated quantities as this minimises packaging. Whenever possible, reuse or recycle packaging;

- Use accredited contractors with experience, appropriate systems and capacity;
- Adopt an EMS (preferably follow ISO14001);
- Audit your system and have others audit it as well, including your contractors;
- Set up partnerships and avoid a *master: servant* contract. Share the pain and share the gain;
- Communicate within your organisation and with contractors; and
- Set achievable targets and have KPIs.

Acknowledgements

- Station expeditioners (they do the hard work);
- IPEV & *L'Astrolabe* crew;
- AAD;
- Australian Quarantine Service;
- Environment Division – Tasmania;
- Australian Department of Environment and Heritage – Canberra;
- Oceania Shipping;
- P&O Polar (*Aurora Australis*);
- Tasmanian Ports Corporation; and
- AEON/COMNAP

4. Current Waste Management Arrangements in the Australian Antarctic Territory

Leslie Frost, Australian Antarctic Division

Abstract

Under the *Antarctic Treaty (Environment Protection) (Waste Management) Regulations 1994*, Australia is obliged to minimise and manage waste in the Australian Antarctic Territory (AAT) through effective planning controls.

These planning controls include training programs for expeditioners, environmental purchasing guidelines for contractors and provedores, a Station Waste Management Guide and a volunteer Station Waste Management Officer appointed at each station to provide advice and ensure that waste is managed in accordance with guidelines. Specific guidelines for various field locations and activities have been developed, with the aim of returning all wastes to station for disposal or for return to Australia, for recycling or safe disposal.

Labelling, cleaning, reuse and recycling of empty fuel drums continues to be an issue for the AAD. We are keen to hear about any innovations in fuel drum management that have been developed by our colleagues in the Antarctic environmental community.

Outline

- Introduction.
- Current Waste Minimisation Efforts.
- Current Station Solid Waste Management Practices.
- Reporting.
- Current Waste Water Treatment on Stations.
- Management of Waste from the Field.
- Waste Minimisation and Management – the Future.
- Fuel Drums.
- AAD Waste Management Procedures.

Introduction

Protection of the Antarctic environment is one of four Australian Government goals for its activities in Antarctica. The Antarctic Treaty (Environmental Protection) 'Act 1980 is the enabling legislation for the Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol).

Under the Antarctic Treaty (Environment Protection) (Waste Management) Regulations 1994, Australia is obliged to minimise and manage waste in the Australian Antarctic Territory (AAT) through effective policies, planning controls and procedures. Specific waste management procedures have been developed by the Australian Antarctic Division (AAD) for station and field operations to give effect to these legislative and treaty obligations.

Australia operates three permanent year round stations in the AAT at Casey, Davis and Mawson. It also operates a permanent station at Macquarie Island Nature Reserve, where these procedures are undertaken with additional controls provided by the Tasmanian State Government.

The environmental management system (EMS) of the AAD is certified to an international standard (ISO 14001:2004) for all its operations in Tasmania, the subantarctic and the AAT. The EMS ensures high level policy commitment and a systematic means of managing the

AAD's interactions with the environment. It ensures that significant environmental aspects such as waste are identified and managed through:

- environmental training programs for expeditioners;
- environmental purchasing guidelines for contractors and provedores;
- the Station Waste Management Guide;
- appointment of a volunteer Station Waste Management Officer at each station;
- specific waste management guidelines for field activities; and
- procedures for return to Australia (RTA) for recycling or safe disposal in accordance with quarantine requirements and in partnership with our waste management contractors.

Current Waste Minimisation Efforts

Effective waste management begins with waste minimisation. Environmental training programs for expeditioners before leaving Australia emphasise individual responsibility for waste minimisation and management. All expeditioners are asked to minimise packaging and waste materials in their personal and scientific program cargo. Training programs also provide them with information about waste management on station and in the field, and performance assessments include their responsiveness to environmental protection measures.

Prior to departure, a Station Waste Management Officer is appointed and trained to provide advice and guidance for the expeditioners at each station for the year. They are provided with copies of the Station Waste Management Guide and participate in annual station self-audits of waste management activities, which usually result in improvement suggestions for waste management.

The Environmental Purchasing Guide for the AAD requires that waste minimisation must be part of every contract. For example, due to the recent change to concentrated juices, soft drinks and powdered milks, about 25 000 fewer plastic bottles were sent to all stations each year.

Figure 1: removal of excess packaging prior to deployment in the field

Current Station Solid Waste Management Practices

In conjunction with waste minimisation, the aim is to remove as much waste from Antarctica as possible. Most solid waste is securely stored on station and returned to Australia for management by a licensed waste management contractor.

Upon arrival at station, expeditioners are responsible for sorting their own solid waste and delivering it to collection sites as required, whether generated at the station or in the field. Solid waste is incinerated, recycled on station, or returned to Australia for recycling or appropriate safe disposal. The Station Leader has overall responsibility for seeing that waste is handled in accordance with the regulations and the Waste Management Guide. The Station Waste Management Officer is responsible for implementing these requirements.

Supplies, stores and equipment are unpacked indoors if possible, and packing materials are retained for re-use on station or for RTA. Station Leaders ensure that older stores are used first to minimise waste, particularly food waste.

Each station also organises regular station clean-ups in the immediate station vicinity and down-wind from the station. Marine debris collections are undertaken around the coast of Macquarie Island. These clean ups are undertaken enthusiastically and are particularly important during summer as the melt progresses and any wind blown debris is exposed.

Recycling

Aluminium cans, steel cans, glass bottles, plastic bottles, cardboard, paper, recyclable batteries, cooking fats and oils, some fuel drums and some metal wastes can be recycled. By working in partnership with the waste management contractor, recycling of waste from Antarctica has improved from 27% of the waste returned in 2002/03 to 36% in 2003/04, to 44% in 2004/05. The improvement in 2004/05 was partly due to a decrease in volume of waste returned to comply with quarantine restrictions.

Incineration

Some solid wastes are incinerated on station, including kitchen wastes, hydroponics waste, a small amount of medical waste and human faeces returned from the field. Small quantities of untreated wood, cardboard or second grade paper may be included to ensure a good burn. The only plastics which may be burnt are food-soiled LDPE (i.e. thin film) plastics, the bags containing burnables and any containers specifically designed for disposing of medical waste (usually yellow LDPE boxes). Incinerator ash is returned to Australia and tested to ensure that only approved items have been burnt and to evaluate emissions quality.

Reporting

Solid waste volumes and types are recorded and published on the AAD State of the Environment reporting system on the AAD website. These records include:

- volume and types of waste burnt in incinerators at each station;
- volume and types of waste returned to Australia (including recyclables); and
- waste water quality discharged from the waste water treatment plants.

This data is regularly evaluated and reviewed by management.

Current Waste Water Treatment on Stations

Waste water on stations is directed through macerating pumps on each building, treated to a secondary level in a waste water treatment plant (except at Davis) and then discharged into the local marine environment. Sewage sludge is dried and stored in tank pallets for return to Australia.

The former Davis Waste Water Treatment Plant was a closed container design that was inefficient, experienced frequent problems as it aged and was removed in 2005/06. A new plant is expected to be operating at Davis by 2010/11.

Management of Waste from the Field

The aim is to return all waste to stations as far as practicable, to reduce cumulative impacts in frequently visited field locations and to use best practice in waste management in Antarctica. Field training and the *AAD Field Manual* provide guidance for management of rubbish, human waste, urine and grey water in the field. Appropriate equipment and containers are provided and must be used on field trips and expeditions for collection and management of waste.

Scientific fieldwork and field expeditions are subject to environmental assessment. Permits will include conditions that require parties to use best practice techniques to reduce impacts. Waste management practices may be reviewed as part of that process to ensure that wherever possible, waste is returned from the field.

The following table describes the management of human faeces, urine and grey water for various field situations.

Management of Human Faeces, Urine and Grey Water in the Field			
Field Situation	**Human faeces**	**Human urine**	**Grey water**
Intercontinental Airfield, 70 km from Casey Station	Electric toilets. Ash residue to be returned to station. If not working or over capacity, human faeces are to be collected in plastic bags, frozen and returned to Casey Station for incineration.	Electric toilets. Ash residue to be returned to station. If not working or over capacity, urine is to be collected in specific containers and returned to Casey Station for defrosting and trickle feed into treatment plant.	To be collected in specific containers and returned to Casey Station for defrosting and trickle feed into the waste treatment plant. Empty fuel drums are not to be used for collection of urine and grey water due to OHS issues, and the likely contamination of urine and grey water with fuel residue
Intra continental airfield sites at Davis and Mawson (plateau sites)	Human faeces are to be bagged and returned to the nearest station for incineration.	At Mawson human urine and grey water is to be collected in 20L or 50L specific urine / grey water sealable containers and returned to station for disposal in treatment plant. At Davis upon return to station, the containers are to be taken to the 'smelly lab' in the Science Building. Here they can be opened and placed upside down for thawing into the sink and drained into the sewage outfall pipe to the marine environment.	
Antarctic field huts and field locations based out of Davis Station	Human faeces are to be double bagged by visiting party and securely stored at field site for retrieval by helicopter for return to station for incineration.	Due to the current lack of a waste treatment plant at Davis Station, urine and grey water generated in field locations based out of Davis can be disposed of in the following order of preference: 1. Sea 2. Tidal crack 3. Glacial crevasse 4. Ice pit Urine and grey water are not to be released onto ice free land or into lakes.	

<table>
<tr><th colspan="4">Management of Human Faeces, Urine and Grey Water in the Field</th></tr>
<tr><th>Field Situation</th><th>Human faeces</th><th>Human urine</th><th>Grey water</th></tr>
<tr><td>Other Antarctic field huts and field locations based out of Casey or Mawson Stations</td><td>Human faeces are to be double bagged by visiting party and returned to nearest station.

Upon return to station double bagged human waste is to be placed in the correct bin at the incineration building for eventual incineration.</td><td colspan="2">Human urine and grey water is to be collected by visiting party in 20L specific urine / grey water sealable containers and returned to station for disposal in treatment plant.

Upon return to station the containers are to be opened and placed upside down on the racks in the WWTP.

Empty fuel drums are not to be used for collection of urine and grey water due to OHS manual handling issues, and the likely contamination of urine and grey water with fuel residue.</td></tr>
<tr><td>In transit:
• Aircraft
• Quad
• Hagglund
• Utility</td><td>Human faeces are to be bagged by field party and returned by that party to station for incineration.</td><td colspan="2">Human urine and grey water are to be collected in 20L specific urine/grey water sealable containers and returned by that party to station for disposal in treatment plant (except at Davis where it may be disposed of in the smelly lab of the Science Building until a new waste treatment plant is installed).</td></tr>
<tr><td>In transit:
• on foot
• on skis
• in an inflatable rubber boat</td><td>Human faeces are to be bagged by field party and returned by that party to station for incineration.</td><td colspan="2">The following is an order of preference for disposal of urine and grey water in the field:
1. Sea
2. Tidal crack
3. Glacial crevasse
4. Ice pit

Plastic bags are not to be used. Waste is to be collected in buckets and/or paper bags which may be deposited directly into sea/tidal crack. Waste of any kind must not be deposited in an ice free area or lake.</td></tr>
<tr><td>Commonwealth Bay/Cape Denison and other remote field campaigns and traverses</td><td colspan="3">The preference is to return all waste but other conditions may be determined for individual expedition as part of the environmental impact assessment process. Aspects to be considered include:
• the size of the party and the length of their stay;
• what transport (ground, air, water) is used and whether that transport can accommodate collection and return of human waste;
• transport and safety issues due to weather constraints; and
• whether chemical, electrical or gas toilets can be used.

In the event that waste cannot practicably be returned, the less preferred option is to deposit human faeces, urine and grey water in the sea or tidal crack. Plastic bags are not to be used. Waste is to be collected in buckets and/or paper bags which are deposited directly into the sea or tidal crack. Waste of any kind must not be deposited in an ice free area, melt lake or saline lake.</td></tr>
</table>

Management of Human Faeces, Urine and Grey Water in the Field			
Field Situation	**Human faeces**	**Human urine**	**Grey water**
Subantarctic Macquarie Island	Human faeces is to be bagged by field party and returned by that party to station for incineration; or deposited below high water mark on the coast for dispersal in the sea.	Human urine and grey water is to be collected in specific urine/grey water sealable containers and returned to either: • the station for disposal in the waste treatment system; or • the coast for emptying of container in the sea.	
Subantarctic Heard Island	Waste disposal must be in accordance with Section 6.3 of the Heard Island and McDonald Islands Marine Reserve Management Plan.		

All other solid waste is to be returned from the field to stations for management and eventual recycling or disposal. The solid waste is to be sorted into the relevant recyclable / burnable / RTA categories applicable at the station and / or on the ship.

Waste Minimisation and Management – the Future

Two of the current objectives for waste under the AAD's EMS are to replace the Davis Waste Water Treatment Plant and to either replace the aging incinerators on stations or to return all organic waste to Australia.

Another aim is to examine in-situ bioremediation of fuel-contaminated soil from station activities so that soils do not have to be returned to Australia for safe disposal in deep burial sites. A large experiment is underway at Casey using a permeable reactive barrier and heat to activate naturally occurring microbes in hydrocarbons. Small experiments at Davis and at Mawson seem to show that turning contaminated soil in summer can assist in the release of volatile hydrocarbons.

The remediation of the Thala Valley tip site at Casey and the possible removal of the old station at Wilkes near Casey are bigger waste management objectives that will take some years to resolve.

Fuel Drums

While fuel for stations is transferred in bulk, a large number of 200 litre drums are sent south and used for refuelling helicopters and intra-continental aircraft. These drums are stored at station and cached in the field to support science and operational programs. Empty drums are potentially wind-blown rubbish.

Empty fuel drums in good condition must be cleaned thoroughly to ensure that no contamination or possible reaction with fuel residue is possible before they can be used as containers for RTA of waste for disposal or recycling. The use of water for cleaning purposes is energy intensive.

While care is taken to remove all labels from empty drums, re-labelling methods have not been satisfactory. Labelling using spray paint and stencils seems to be the most effective, but can be worn away by weather and ship transport.

Contaminated fuel drums are not crushed on stations. Empty fuel drums are stored in cage pallets and then returned to Australia for cleaning, crushing and recycling as scrap metal.

Improvements in fuel drum management and labelling are of great interest to Australia – any suggestions and ideas from the Antarctic Environmental Officers Network workshop will be seriously considered.

AAD Waste Management Procedures

- Station Waste Management Guide 2005/06.
- Provedore Waste Management Plan.
- Environmental Purchasing Guide.
- Environmental Audit: Self Assessment for Stations: Waste Management.
- Environmental Management System Manual 2005.
- Environmental Code of Conduct.
- Antarctic Environmental Training Manual.

5. Wastewater Treatment in Antarctica: Challenges and Process Improvements

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Cassandra Shenk, *United States Antarctic Program, Raytheon Polar Services Co., Centennial, CO, USA*

Don Van Veldhuizen, *Integrity Environmental, LLC, Woodburn, OR, USA*

Margaret Knuth, *National Science Foundation, Office of Polar Programs, Arlington, VA, USA (presenter of paper)*

Abstract

In 2003, the United States Antarctic Program (USAP) began processing wastewater at McMurdo Station. Prior to this, all wastewater was macerated and released into McMurdo Sound. The wastewater treatment plant (WWTP) is a conventional, activated sludge plant. Its by-products are clean effluent that is discharged to McMurdo Sound, and dewatered sludge that is packaged and removed from the continent. Since activation, the plant has experienced a variety of problems that have prevented the treatment process from reaching its maximum efficiency. In November 2005, a wastewater treatment expert was brought to the station to diagnose problem areas and provide recommendations for improvement.

The sources of several problems in the system have been found and are discussed in the presentation. Some problems stemmed from design issues, while others are caused by the extreme and remote environment. Plant optimization has shown decreased values for total solids, total phosphorous, and alkalinity in the effluent. Continuous process improvements should further decrease these effluent characteristics. The most important lesson learned by the USAP during this process is the need for long term planning and an understanding of the environment. We hope that the issues presented here will help others as they upgrade their waste treatment.

Outline

- Introduction.
- Treatment Process.
- Plant Optimisation Study.
- Anoxic Basin Retrofit and Pilot Study.
- Aeration Basin.
- Wastewater Lift Stations.
- Lessons Learned and Summary.
- References.

Introduction

The United States Antarctic Program (USAP) began processing wastewater produced from McMurdo Station in 2003, following nearly seven years of planning, engineering, and construction. The system is capable of treating 495,900 liters per day (l/day), with a 757,900 l/day peak flow. The wastewater treatment plant (WWTP) uses conventional methods of solids removal (clarification) and denitrification[1] to process domestic wastewater. The by-products are clean (disinfected) effluent, which is discharged to the sound, and settled, de-watered biosolids, which are packaged and removed from the continent.

Though the WWTP has been a great success, unexpected problems have been experienced well into its second year of operation. Denitrification of waste under anoxic conditions was not occurring effectively. Dissolved oxygen levels in the aeration basin were hard to control, especially during periods of peak flow, such as after mealtimes. Extremely small colloidal particles were forming in the aeration basin and contributing to poor settling characteristics. Effluent was not as clear as expected, and solids were being released in the final effluent over clarifier weirs.

In November of 2005, a wastewater treatment expert, independent of USAP and the original contractor, was brought to the station to diagnose problem areas, to experiment with process improvements during a pilot study, and provide recommendations for further improvement. The project was successful. Improvements entailed a mechanical retrofit to the anoxic basin, as well as better use of data collection for process control. Although some problems could be resolved, others will require further process improvements.

Resolutions implemented at McMurdo Station may be of interest to other programs around the continent considering changes to practices for discharging wastewater.

Treatment Process

The McMurdo WWTP consists of four major treatment components: an anoxic zone, an aerobic zone, clarification, and disinfection. These four components constitute one treatment train. The plant is designed to operate with one to three treatment trains online to address fluctuations in loading between winter and summer seasons. Wastewater is piped to the plant from most of the station by gravity feed. It is pumped from lower lying areas by two lift stations. Incoming wastewater first passes through a macerator (grinder), a parshall flume for flow measurement, and then into one of three treatment trains via a splitter box. The treatment trains use a modified "Ludzack-Ettinger" design (Figure 1) and begin with an anoxic basin. In the anoxic basin, the influent is mixed with return activated sludge from the clarifier and mixed liquor[2] from the aeration basin to facilitate denitrification and removal of nitrogen content as N_2 gas. From here, the anoxic basin effluent enters the aeration basin, where oxygen is added by coarse air diffusers. The aeration basin facilitates aerobic digestion, and is the part of the process responsible for removal of organic content, as measured by biochemical oxygen demand (BOD). Dissolved oxygen (DO) is maintained close to 2 mg/L by manually adjusting valves on the air system.

The return activated sludge and the mixed liquor suspended solids in the anoxic and aeration basins provide micro-organisms to treat the wastewater influent. In order to grow, these micro-organisms use the pollutants in the influent as "food." For the wastewater treatment process to work properly, it is important to maintain an appropriate balance between the "food" and the number of micro-organisms present in the system. This balance is referred to as the "food to microbe ratio." An operating strategy is usually needed to monitor the food to microbe ratio, but was not initially implemented with this system.

[1] Denitrification occurs when oxygen is depleted and bacteria turn to nitrate in order to respire organic matter.

[2] Mixed liquor is the combination of partially treated wastewater and activated sludge in suspension in the aeration basin.

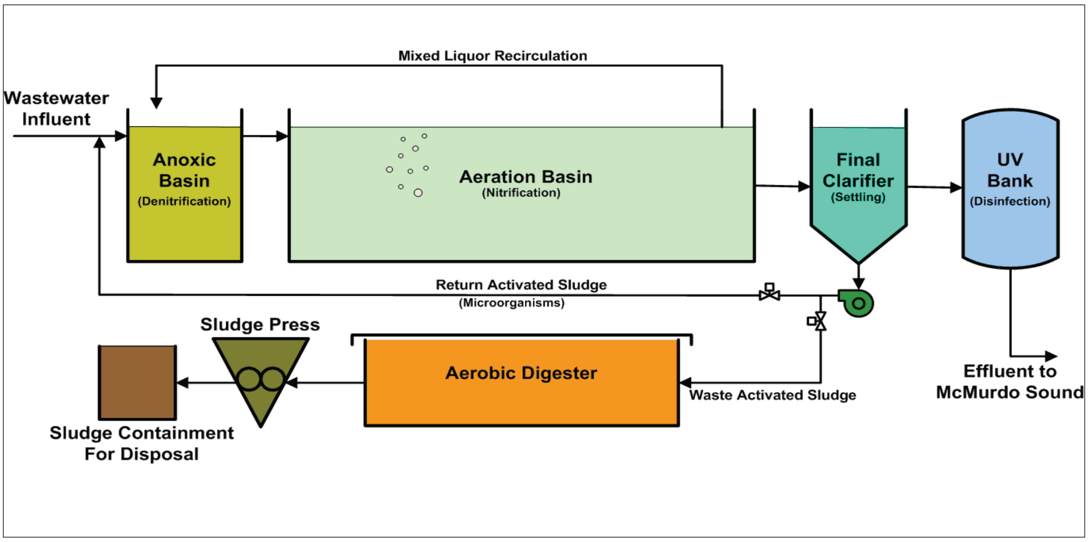

Figure 1: Schematic of the McMurdo Station wastewater treatment process. The four major treatment components of an individual treatment train are an anoxic zone, an aerobic zone, clarification, and disinfection. The plant can simultaneously operate between 1 and 3 trains.

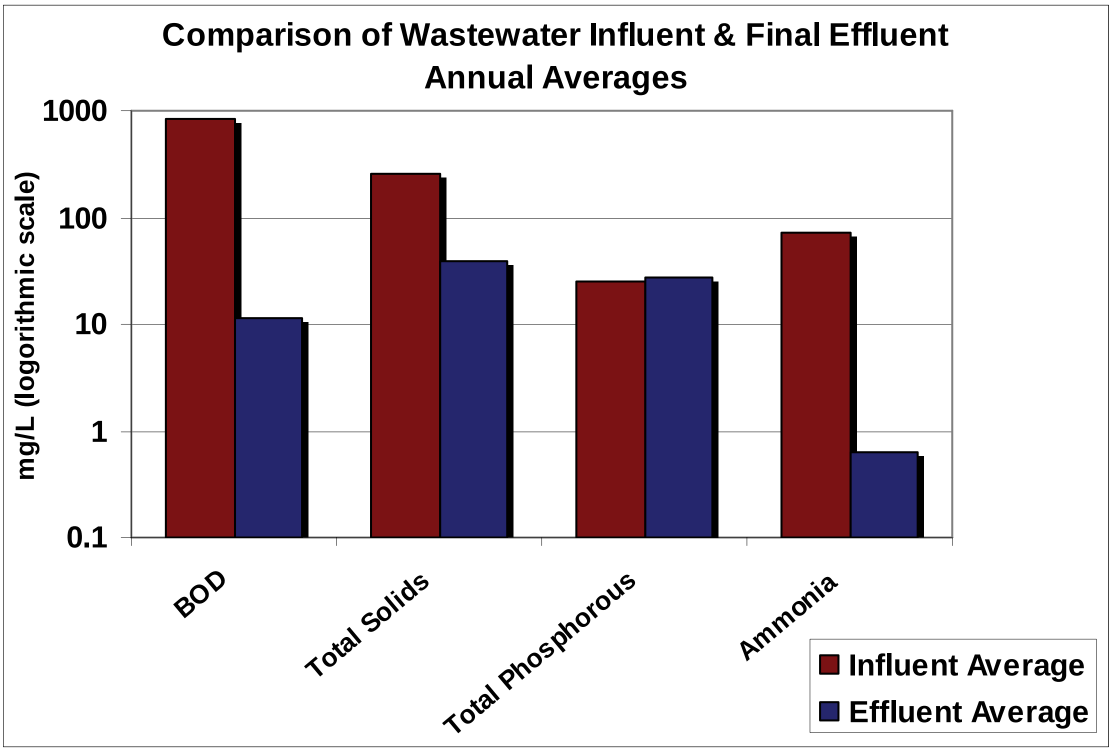

Figure 2: Benefits of wastewater treatment process. Note: Biochemical Oxygen Demand (BOD) is a measurement of organic content in the water that consumes dissolved oxygen.

Downstream of the aeration basin, solids are gravity separated in the clarifiers. Clarified effluent is sent to the disinfection process, and solids (activated sludge) from the bottom of the clarifier, are either returned to the system (the anoxic basin) or wasted, depending on food to microbe ratio. The by-product of treatment is settled sludge, which is digested aerobically and then de-watered into inert “cake.” The cake consists primarily of expired microbes and is removed from the station. During 2005, 46,675 kg of cake was produced, containerized, and retrograded to the U.S. where it was sent to landfill in the state of California.

Clarified effluent is irradiated by a shielded bank of low-pressure 254 nm UV lamps, which effectively removes bacteria and cysts. The treated wastewater exits through a parshall flume, where flow is measured, and finally, discharged to McMurdo Sound. Treatment of wastewater typically reduces faecal coliforms to 1-10 colonies/100 mL, biochemical oxygen demand (BOD_5) to 2-10 mg/L, and total suspended solids to <30 mg/L . The benefits of the WWTP (before optimization) are illustrated in Figure 2.

Plant Optimization Study

The Design-Build-Operate (DBO) concept is now common practice in managing large projects, such as the construction of a WWTP. This delivery method creates a single point of responsibility for design and construction. Special circumstances in USAP restricted the implementation of such a plan, but in hindsight, this would have greatly reduced some of the issues still experienced today. During the plant optimization study, observations of mechanical processes that were problematic were considered, along with design data provided by the original equipment manufacturer. Each area was the subject of pilot testing, as described below. Data collection and the frequency of testing were adjusted to measure the effects of process changes after they were implemented.

Anoxic Basin Retrofit and Pilot Study

Inadequate mixing and a reduced detention time in the anoxic basin were found to contribute to poor sludge settling characteristics occurring downstream in the clarifier. This is attributed to the short distance (1 m) between the influent and effluent, a mixing paddle not large enough to adequately draw water from the surface to the lower depths of the basin, and the absence of baffling. The basin was passing a large percentage of the influent directly to the effluent channel without thorough mixing or time for anaerobic digestion. In addition, the basin was not deprived of oxygen, as designed.

To address the need for better mixing, on-site materials were used as a pilot test. Baffles were constructed from 55-gallon drums. The lid and bottoms were removed from the drums, cut in half lengthwise, and then welded together, forming a 2 meter long half cylinder baffle. The baffle was inserted next to the anoxic basin effluent channel, providing a 2 meter extension to the channel. This promoted more thorough mixing in the basin and increased the detention time. Mixed-liquor suspended solids, which were shut off during the previous season due to alkalinity and pH problems, are now being returned to the anoxic basin, along with return activated sludge.

Initial results demonstrated a 73.5% increase in total solids removal measured after installation. Reductions in ammonia and phosphorous in the final effluent were observed as well. The anoxic basin showed an initial increase in nitrate and nitrite concentrations shortly after the introduction of the mixed liquor suspended solids to the basin. This was probably due to the increase in ammonia loading, or an increase in dissolved oxygen in the aeration basin. As the channel becomes more anaerobic, lower concentrations of total nitrogen are expected due to a reduction in freely available oxygen. The increase of nitrates and nitrites, along with the anaerobic conditions, is necessary in order to have the desired nutrient removal effect. Results from the addition of temporary baffling support the efficacy of a permanent retrofit to the basin.

Aeration Basin

Two major process issues in the aeration basin were identified with the current use of coarse air diffusers:

1. Excessive turbulence; and
2. Difficulty maintaining sufficient dissolved oxygen to the basin during peak BOD loading demands.

Although air supplied by the blowers adequately meets the required volume, it was quickly determined that the use of coarse air diffusion was not allowing enough oxygen to be delivered into solution. In addition, the excessive turbulence was encouraging floc[3] shearing

[3] Floc is the term used for collections of smaller particles (such as silt, organic matter, and microorganisms) that have amalgamated into larger particles that are more likely to settle.

to occur in the aeration basin, and was contributing to the presence of small floc in the final clarifier. It was also exacerbating foaming problems.

Energy efficiency and potential power conservation improvements for the aeration basin were also examined. Currently, the coarse air diffusers are supplied by blowers on manual control. Although these diffusers require less initial investment and minimal maintenance, they waste excessive energy when supplied by a non-adjustable blower. As fine air diffusers require increased maintenance, and have the potential for plugging if not properly maintained, they are often overlooked in original design specifications. However, they do provide much greater efficiency in placing oxygen into solution and contribute to long-term operational cost savings.

When combined with a variable frequency drive control, fine air diffusers become even more energy efficient. Implementation of variable frequency drives wired to online dissolved oxygen analyzers, can allow blowers to run at just enough capacity to deliver the necessary air requirements to the basin. Energy consumption by aeration systems can be as great as 55% of the total energy cost in a normal activated sludge system[4]. A change to this type of configuration would allow significant cost savings over the original investment, especially given the long-term life cycle of the plant. Currently, the addition of variable frequency drives is being considered as energy consumption, and its associated costs are becoming an increasingly important issue.

The original design for the plant recommended the use of single stage centrifugal blowers. This design was later modified within RPSC and is an example of the need for a DBO plan. While the diffusers do create excessive turbulence, corrective action has been taken and currently additional air is blown off into another basin.

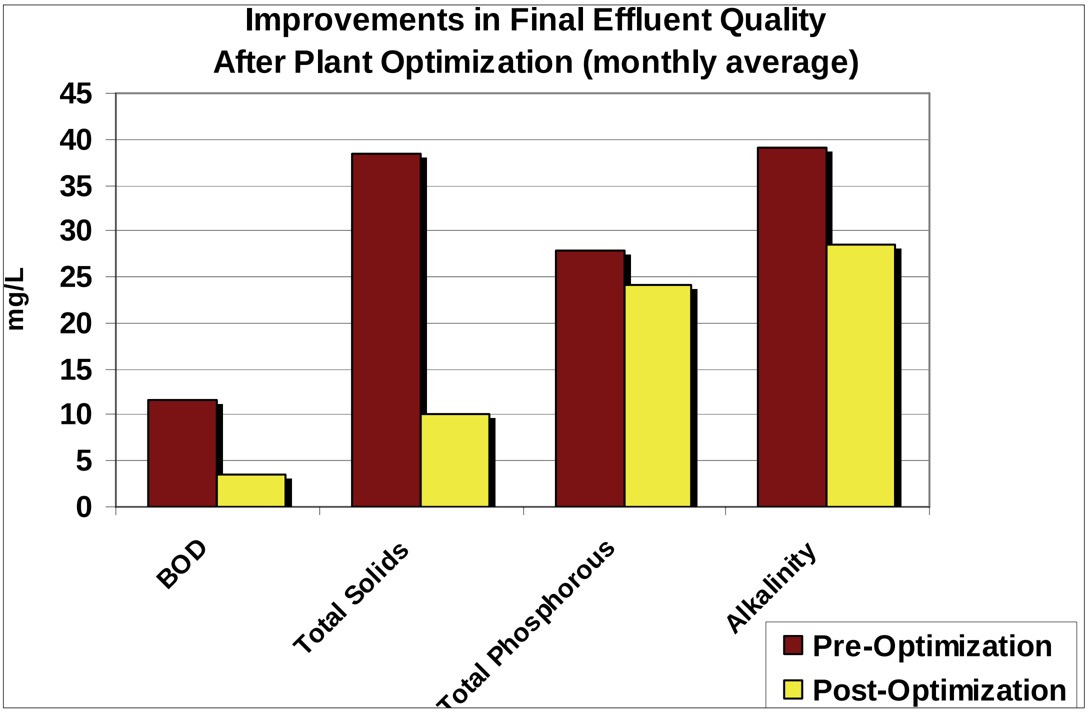

Figure 3: Plant performance improvements from November 2005 (pre-optimization) and December 2005 (post-optimization

Wastewater Lift Stations

Long detention times between automatic pumping cycles in the wastewater lift stations may have periodically afflicted plant stability. Upon inspection, long detention times in areas of low usage around the station were found to cause very septic conditions. This probably

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[4] Figure obtained from *Turblex Incorporated* technical brochure, "*Aeration System Control"*

introduced septic sludges into the system and contributed to a portion of the plant upsets. This problem has been addressed by implementing frequent inspections, manual pumping of the lift stations, and periodic localized disinfection with the addition of calcium hypochlorite to prevent septic conditions from occurring.

All of the corrective actions mentioned above have combined to increase the efficiency of the WWTP (Figure 3). We hope that future work will continue to improve the plant and subsequently, the reduced pollution will aid in the recovery of the benthos in the region of the outfall.

Lessons Learned and Summary

Many of the problems with wastewater treatment at McMurdo Station may have been avoided with a better Design-Build-Operate plan. In addition, ease of operation, maintenance, process control and power consumption should be considered in plant design, as these aspects can be even more important in Antarctica than elsewhere. In retrospect, we recommended that the following issues be considered when developing or effectively evaluating wastewater system design choices:

- Size the plant to accommodate long-term trends in population and flexibility of design to accommodate fluctuating waste loading within and between seasons;
- Power consumption and energy efficiencies; and
- Ease of operation, maintenance, and process control.

Although sequential batch reactors (SBR's) and membrane bioreactors (MBR's) were not fully proven at the time of the McMurdo WWTP project development, both types of bioreactors are now used successfully in small communities throughout the world. They may have many advantages for use in Antarctica. These systems can adapt to changing population and loading characteristics, while maintaining good performance. Both types of systems are usually more stable when treating unexpected shock loads. Furthermore, the systems create a smaller installation footprint than conventional systems, as well as relatively low installation costs. These smaller packaged plants may address more effectively the smaller populations of other national programs.

Challenges in wastewater treatment have always existed, but as new technologies emerge, the nature and extent of issues can be increasingly complex. These issues are compounded in Antarctica by limited operational support, and a lack of nearby technical expertise that would be available in most other areas of the world. The need for DBO strategies is perhaps even more important in this environment. Programs should plan for follow-up technical assistance, pilot tests, and other measures after installation of a new wastewater treatment plant. Competent and knowledgeable operational staff is also important, especially during the first two to five years of operations.

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6. Managing Antarctic Wastes

Rod Downie, British Antarctic Survey

Abstract

The British Antarctic Survey (BAS) Waste Management System is based on the separation of waste at source, compacting it where feasible to reduce its volume for transport, and removing it from Antarctica for reuse, recycling or safe disposal.

BAS is committed to producing less waste, recycling more of its waste, reducing the burden on landfill, and treating sewage where practicable. In 2005-06, we reused or recycled 60 % of all waste (including empty fuel drums) removed from our Antarctic stations.

BAS is developing new and innovative waste management products and techniques. In 2005-06, we undertook successful trials at Rothera Research Station to steam-clean empty fuel drums for packaging recyclable waste. We are working with private sector companies to develop an incinerating toilet which operates on waste fuel, and a light, portable hydraulic drum-crusher.

Outline

- Introduction: BAS Waste Management Strategy.
- Recycling and Sewage Treatment.
- Field Incinerating Toilet.
- Steam-Cleaning Empty Fuel Drums.
- Disposal of Fuel Drums from Remote Field Depots.
- Summary.

Introduction: BAS Waste Management Strategy

The BAS waste management strategy is based on waste minimisation, separation, compaction and removal for reuse, recycling or licensed disposal.

Planning and co-ordination is undertaken by the Environment Office, whilst on-site responsibility rests with Base Commander and Base Assistant.

One of eleven key objectives of the BAS environmental strategy is to minimise the amount of waste sent to landfill and to recycle more.

Fourteen categories of waste are sent for re-use or recycling:

45 gal. fuel drums	cans and food tins	paper
cardboard	glass	some plastics
batteries	fluorescent tubes	Waste Electrical and Electronic Equipment
vermiculite	waste timber	photo-chemicals
scrap metal	printer cartridges	

Sixty percent (60%) of the waste removed from BAS stations in Antarctica was reused or recycled in 2005-06:

- Halley – 388 m3 (84%);
- Rothera – 127 m3 (33%); and

- Signy – 4.3 m3 (31%).

Sewage Treatment in Antarctica

A sewage treatment plant was installed at Rothera Research Station in 2003. It is a submerged biological aeration filter system which treats up to 15m3/day for a maximum of 128 people. Treated and dried sludge will be disposed of in a high temperature incinerator.

Biological and chemical monitoring at the sewage outlet at Rothera has shown that, following the installation of the sewage treatment plant, water quality exceeds EU bathing water standards.

At Halley VI, a containerised marine unit is planned to treat sewage for 16 - 52 people.

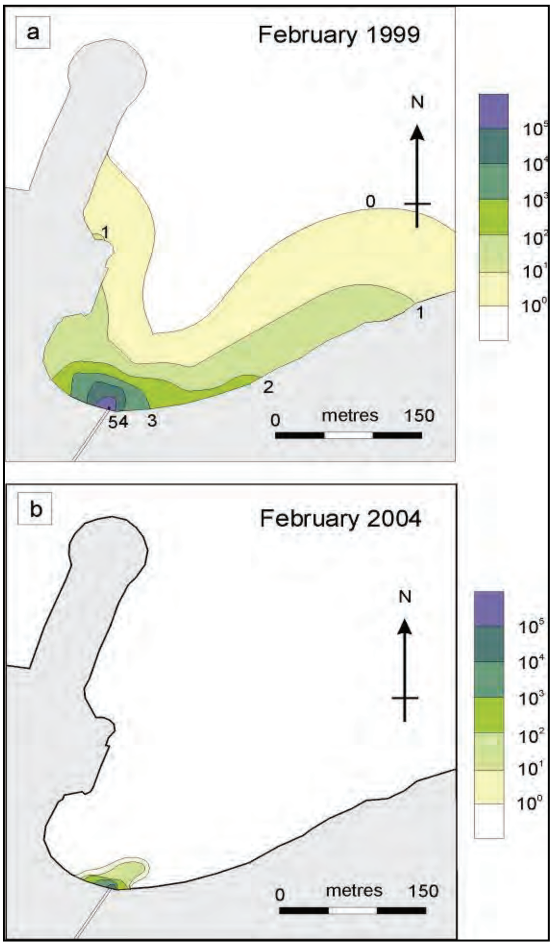

Figure 1: Sewage plume at Rothera Point (a) before and (b) after the installation of the sewage treatment plant

Incinerating Field Toilet

An incinerating field toilet has proven successful at major static field camps for the in-0situ disposal of human waste. It is portable, light-weight and burns waste AVTUR to increase calorific value. The toilet is powered by a small petrol generator, with a one hour burn cycle for up to four uses. A prototype was trialled at Rothera in 2005 and the remote Sky-Blu field camp in 2006.

For more information visit the website Usenburn: www.usenburn.ca

Steam Cleaning Empty Fuel Drums

BAS has an agreement with an island fuel supplier who reuses more than 1000 BAS fuel drums per annum.

During 2006, we held steam cleaning trials to determine whether or not drums could be reused to package recyclable waste – e.g. glass and steel/ aluminium cans.

Under the UK Environment Agency guidelines, drums are classified as non-hazardous if they are free of liquid and vapour, with a residue of less than 0.1 % fuel by weight, including drum (i.e. 20 gram). Trials resulted in 90 good-condition drums topped and cleaned effectively at a rate of 30 drums per person per day.

Steam- cleaning resulting in 4 litres of oil/water/ detergent waste per drum.

Our initial conclusions indicate that steam-cleaning and re-use of drums is very cost effective and good environmental practice.

Disposal of Fuel Drums from Remote Field Sites

BAS maintains seven major, deep-field fuel depots, with approximately 100-200 drums at each site. Removing empty drums from the field intact can result in an increase in flying hours and associated fuel consumption and cost. A Twin Otter aircraft can transport 20 empty drums (by volume) or 50 - 60 if crushed (by weight). For example, to crush and remove 113 drums from our Pine Island depot would save 17,000 litres of AVTUR at a cost of £50,000, compared to removing them intact

BAS has trialled a number of options for reducing the volume of empty drums, to fly them out from the field. In 2006, we worked closely with a local engineering firm to develop a portable, light-weight drum crusher for use at remote field sites. The prototype meets the following specifications:

- A machine that can crush a 45 gal. fuel drum to approx 20 % of original volume;
- Crushed drum must be safe to handle manually and safe for air transport;
- Weight must be less than 200 kg, and it must break down into component parts of less than 80 kg;
- Width must not exceed 1m to fit inside the door of a Twin Otter aircraft;
- The hydraulic power pack must run on a small portable petrol generator;
- The crusher must work at temperatures of –20 °C; and
- Fuel dregs must be captured on crushing to allow for proper disposal.

Figure 2: Drum crusher prototype

Summary

Waste management has developed significantly at BAS over the last 15 years and far exceeds the requirements of Annex III of the Protocol. Prof. Howard Dalton, the Chief Scientific Advisor for the UK Department for the Environment visited Rothera Research Station in 2005/06 and was 'seriously impressed by the BAS waste strategy'. Recycling is now a routine and popular component of the waste management system at BAS stations and the disposal of human waste and empty fuel drums from remote field camps are major challenges To meet these challenges, we are working closely with private sector companies to develop new and innovative waste management products.

7. Report on Recent SANAP Environmental Waste Management Activities, Incidents and Developments over the Past Year

Henry Valentine, South African National Antarctic Program (SANAP)

Abstract

The report provides a brief summary report on recent SANAP environmental waste management activities, incidents and developments over the past year including:

- An environmental audit programme;
- Oil spill contingency planning;
- The establishment of an inventory of past activities; and
- Decommissioning of the Emergency Base (E Base) on the Fimbulisen Ice Shelf.

Outline

- Activities.
- Incidents.
- Developments.

Activities

An annual environmental audit of SANAP activities was undertaken in accordance with its Environmental Health and Safety Management System (EHSMS) during the 2005-6 summer season.

South Africa established an Oil Spill Contingency Plan for the South African National Antarctic Programme's (SANAP) research and supply vessel, the MV *SA Agulhas*, and its Antarctic base, SANAE IV. This was based on the guidelines as set out by the Council of Managers of National Antarctic Programs (COMNAP), which has been effective since 23 October 1996. A review of the plan was undertaken during 2005. The document was updated and expanded. Stakeholders were consulted and re-briefed. Emergency drills in Antarctica are planned for the near future, hopefully during the 2006-7 summer season. This exercise coincided with a comprehensive review of all SANAP's fuel/lubricant and chemical handling systems, procedures and practices.

An inventory of past activities was drafted during 2005 (See **Appendix 1** for a list of these sites). Of the 50 sites identified, only three required clean-up action. Two of the three sites were cleaned-up during the 2005-6 summer season. The last remaining site (SANAE IV) is subject to an annual clean-up at the end of each season. The final phase of the 2005 oil spill clean-up will be completed this coming season.

The Emergency Base, which serviced the old SANAE III Base, was fully decommissioned, dismantled and removed from the Antarctic Treaty area (see **Appendix 2** for a full report on the decommissioning process).

Incidents

A fuel spill at the SANAE IV Base reported on 16 July 2005, initially incorrectly suggested a spill involving approximately 100 000 litres. The cause of the spill (human error) was investigated during the 2005-6 summer season. After thorough calculation, the spill was found to not have exceeded 20 940 litres. A partial (approx. 50%) clean-up of the effected area was undertaken immediately by the over-wintering team during the year. During the past summer season, a dedicated team continued the clean-up effort. A third and final clean-up will be undertaken during the coming season. A comprehensive report on the completed clean-up exercise will be tabled at next year's meeting.

Figure 1: Initial reported fuel spill

Figure 2: trenches being du oin the contaminated area of the spill

Developments

A new component to deal with SANAP environmental issues, both in Antarctica and on the subantarctic Prince Edward Islands has been established within the Department of Environmental Affairs and Tourism. This new Sub-Directorate: Antarctica and Sensitive Environments will allow for independent auditing and review of SANAP activities.

Appendix 1

Antarctic Site Inventory: South African Activities

NO.	SITE	GEOGRAPHIC POSITION	TYPE OF SITE	COMMENTS
1	Norway Station	70° 30' S 002° 32' W	Over-wintering Station	Decommissioned - December 1961 - No clean-up required
2	SANAE I	70° 18' S 002° 21' W	Over-wintering Station	Decommissioned - February 1971 - No clean-up required
3	SANAE II	70° 18' 18"S 002° 21' W	Over-wintering Station	Decommissioned - February 1979 - No clean-up required
4	SANAE III	70° 18.37' (22) S 002° 24.78' (47) W	Over-wintering Station	Constructed 1976 - Decommissioned - 1995 - No clean-up required
5	SANAE IV	70° 17.98 S 002° 51' W	Over-wintering Station	Currently operational - Annual clean-up. - Further clean-up (50%) of 2005 fuel spill required
6	Emergency Base	71° 40' S 002° 25.47 W	Summer Station / Fuel Depot	Decommissioned - February 2006 - No clean-up required
7	Borga	72° 58' S 003° 48' W	Geological Base	Constructed February 1969 and only in use for 1 year - Decommissioned - February 1979 - No clean-up required
8	Grunehogna	72° 02' S 002° 48' W	Geological Base	Constructed March 1971.- Decommissioned January 1976 - No clean-up required
9	Sarie Marais Station	72° 01' 35" S 002° 48' 18" W	Summer Geological Base	Decommissioned February 2002 - No clean-up required
10	Construction Base	71° 40.25' (15) S 002° 49.73' (44) W	Sanae IV Construction Base	Temporary Base - Decommissioned February 1997 - No clean-up required
11	Gavlpiggen	73° 58.75' (45) S	Nunatak	No clean-up required

NO.	SITE	GEOGRAPHIC POSITION	TYPE OF SITE	COMMENTS
		005° 47.37’ (22) W		
12	Drabanten	73° 54.22’ (13) S 005° 54.62’ (37) W	Nunatak	No clean-up required
13	Instind-Halsen	72° 05.00’ (00) S 002° 36.00’ (00) W	Nunatak	No clean-up required
14	Viddalen	72° 13.00’ (00) S 002° 08.00’ (00) W	Nunatak	No clean-up required
15	Nashorn-Kalvane North	72° 17.73’ (44) S 001° 56.52’ (31) W	Nunatak	No clean-up required
16	Tvora	72° 09.00’ (00) S 000° 03.00’ (00) E	Nunatak	No clean-up required
17	Brattskarvet	72° 04.00’ (00) S 001° 08.00’ (00) E	Nunatak	No clean-up required
18	Snarbynuten	72° 00.27’ (44) S 001° 35.00’ (00) E	Nunatak	No clean-up required
19	Stabben	71° 56.00’ (00) S 002° 45.00’ (00) E	Nunatak	No clean-up required
20	Gjelsvikfjella	71° 58.00’ (00) S 003° 20.00’ (00) E	Nunatak	No clean-up required
21	Möteplassen	72° 46.77’ (46) S 003° 05.57’ (34) W	Nunatak	No clean-up required
22	Larsgaddane	71° 53.00’ (00) S 004° 12.00’ (00) E	Nunatak	No clean-up required
23	Hamarskaffet	71° 50.00’ (00) S 004° 56.00’ (00) E	Nunatak	No clean-up required

NO.	SITE	GEOGRAPHIC POSITION	TYPE OF SITE	COMMENTS
24	Svarthamaren	71° 53.00’ (00) S 005° 10.00’ (00) E	Nunatak	No clean-up required
25	Sloret	73° 42.63’ (38) S 004° 15.58’ (35) W	Nunatak	No clean-up required
26	Robertskollen	71° 28.98’ (59) S 003° 05.83’ (50) W	Nunatak	No clean-up required
27	Skappelnabben	73° 42.65’ (39) S 004° 33.95’ (57)W	Camp site	Temporary site - No clean-up required
28	Enden	73° 35.83’ (50) S 004° 14.42’ (25) W	Camp site	Temporary site - No clean-up required
29	Hallgrenskarvet	73° 21.85’ (51) S 003° 25.93’ (56) W	Camp site	Temporary site - No clean-up required
30	Utrinden	73° 50.32’ (19) S 005° 19.47’ (28) W	Camp site	Temporary site - No clean-up required
31	Tverregga	73° 23.83’ (50) S 003° 31.72’ (43) W	Camp site	Temporary site - No clean-up required
32	Utrinden	73° 50.33’ (20) S 005° 19.42’ (25) W	Camp site	Temporary site - No clean-up required
33	Skappelnabben	73° 42.65’ (39) S 004° 33.95’ (57) W	Camp site	Temporary site - No clean-up required
34	Ryvingen	72° 56.25’ (15) S 003° 25.85’ (51) W	Camp site	Temporary site - No clean-up required
35	Flöymannen	73° 08.70’ (42) S 002° 14.60’ (63) W	Camp site	Temporary site - No clean-up required
36	Transglobe	72° 54.65’ (39) S	Field hut	Established by private Trans-Globe Expedition - broke off with ice shelf - No

NO.	SITE	GEOGRAPHIC POSITION	TYPE OF SITE	COMMENTS
		003° 31.98' (59) W		clean-up required
37	Swartbandufsa	73° 28.82' (49) S 003° 50.20' (12) W	Depot site	Temporary Geologist depot site - No clean-up required
38	Hallgrenskarvet	73° 21.98' (59) S 003° 25.13' (08) W	Depot site	Temporary Geologist depot site - No clean-up required
39	Jokulskarvet	72° 39.32' (19) S 003° 17.07' (04) W	VHF repeater mast	Removed after each season - No clean-up required
40	Bleset	73° 38.95' (57) S 003° 57.00' (00) W	Cairn site	No clean-up required
41	Bidisen (Borga)	72° 32.53' (32) S 003° 44.15' (09) W	Metal pole #1	No clean-up required
42	Bidisen (Borga)	73° 32.57' (34) S 003° 43.67' (40) W	Metal pole #2	No clean-up required
43	Bidisen (Borga)	72° 32.77' (46) S 003° 42.70' (42) W	Metal pole #3	No clean-up required
44	Bidisen (Borga)	72° 32.83' (50) S 003° 42.72' (43) W	Metal pole #4	No clean-up required
45	Vesleskarvet	71° 41.53' (32) S 003° 03.92' (55) W	Overland route turning point marker pole	Poles are replanted every year - No clean-up required
46	Repeater Station position	71° 10.669' S 006° 50.192 W	Repeater for summer season only (on heavy vehicle traverse route)	Standard practice to remove system after last traverse of the season
47	Fuel Depots - Logistical and routes to Neumayer	71° 32.390' S 006° 37.320' W	Temporary summer depot for traverse teams	Standard practice to clean up after last traverse
48	Ice Shelf Depots (Neumayer Station) - Atka Bukta	71° 30.80' S	Temporary storage facility for SANAP cargo	No clean-up required

NO.	SITE	GEOGRAPHIC POSITION	TYPE OF SITE	COMMENTS
	one)	008° 11.55' W		
49	Halfway Caboose (SANAE/E-Base)	70° 51.83 S 002° 47.88 W	Overland halfway caboose	Temporary site - Decommissioned 2005/6 season - No clean-up required
50	Halfway Diesel Tanker (SANAE/E-Base)	70° 51.83' S 002° 47.88' W	Temporary summer depot for traverse teams	Standard practice to clean up after last traverse

Appendix 2

Report on Decommissioning of the E-Base in Antarctica

Information Paper
South Africa
Agenda Item: CEP 11 and ATCM 15

REPORT ON THE DECOMMISSIONING OF THE EMERGENCY BASE (E-BASE) IN ANTARCTICA

Department of Environmental Affairs and Tourism
Directorate: Antarctica and Islands
East Pier Building
East Pier Road
V&A Waterfront
Cape Town

Compiled by: Mr. Franz Hoffmann

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1 INTRODUCTION

The Emergency Base (hereafter referred to as E-Base) was constructed and commissioned in January 1985 as a refuge in cases of emergency for the SANAE 3 (decommissioned) over wintering station. E-Base was located at 70˚ 17'80 S; 02˚ 25' 56W on the Fimbulisen ice shelf approximately eleven kilometers inland from the Penguin Bukta. During the summer periods, E-Base was actively used as accommodation for relief voyage and logistical personnel.

The base was constructed on top of steel pillars supporting a floor structure comprising of integrated steel space frames. The main buildings comprised of four modules from North to South orientation respectively:

- Power shack and ablution facilities
- Recreation and kitchen area
- Accommodation and hospital
- Accommodation and communication facilities

Photo of E-Base - year 2000

Photo of E-Base - year 2000

Due to the glacier movement and also taking into account the anticipated life expectancy of E-Base. An EHS Audit was compiled during the 2001/02-relief voyage to determine the feasibility of maintaining E-Base as a logistical platform. The conclusion of above audit was that E-base had suffered structural damage due to glacier movement and that it would not be financial viable for SANAP to maintain E-Base as a platform. Recommendations were made for E-Base to be removed.

After the initial EHS Audit and submission, case studies were completed to explore alternative off-loading sites for SANAP operations. The outcome of the joint venture between the South African National Antarctic Programme (SANAP) and the Alfred Wegner Institute (AWI) was an identified and commissioned traverse route between SANAE IV and Neumayer Station. This new route further enhanced that the old E-Base was no longer required and needed to be decommissioned and removed from the Antarctic Treaty area.

2 BACKGROUND AND TASKING

The South African National Antarctic Programme (SANAP) Manager, Mr. Henry Valentine instructed that E-Base be decommissioned during the 2005/06-relief voyage. A decommissioning Project Manager was appointed to investigate all avenues and further liaise with National Department of Public works (RSA) on decommissioning strategies. A comprehensive decommissioning document was compiled illustrating all logistical requirements and functions e.g. pre season actions and preparations; logistical requirements; containerisation and back loading of the dismantled buildings. Three preliminary decommissioning meetings were held in Cape Town to discuss the removal of infra structures, furniture, lubricants and the rehabilitation of the area.

3 PRE-DECOMMISSIONING ACTION

Three traverses were undertaken by the SANAE 43rd over wintering team to provide a comprehensive report on the conditions of E-Base after the winter period. This information received was integrated into the decommissioning planning and actions prior to departure. Extract from SANAE 43rd over wintering team report dated 5th October 2005:

Large Sastrugis stretch from the western end of all the zones and reach as high as the roof in most areas. There is also substantial accumulation between the buildings e.g. the western side doors are all completely covered.

Photo 3 - year 2005

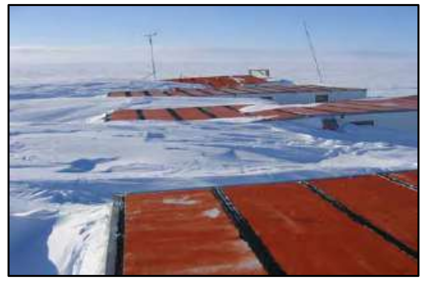


Photo 4 - year 2005

Photo 3 - Illustrates the snow accumulation on the western side of the on Power shack / ablution facilities and Recreation / kitchen area.

Photo 4 - Illustrates the height of the snow build-up on the western side of E-Base.

Photo 5 – year 2005

Photo 6 – year 2005

Both Photo 5 and 6 illustrates sagging and severe structural stresses due to the weight of the snow accumulation on top of the walkways.

4 ON-SITE INVESTIGATION (DECOMMISIONING PERIOD 26TH DECEMBER 2005 TO 05TH JANUARY 2006).

Upon arrival at the *RSA Bukta* (26th December 2005) a team was tasked to inspect E-Base and formulate a plan to systematically decommission and back load E-Base simultaneously onto the *SA Agulhas*. Due to the extent of the damage and the possibility of not being able to use certain of the buildings as temporary accommodation the following was decided respectively:

- The designated decommissioning personnel (twenty persons) were accommodated in the "Accommodation and communication facility" which was the last structure to be removed.
- That the eastern walkway is cleaned / cleared of all ice and the snow accumulation, by Caterpillar vehicle.

- A field kitchen caboose was utilized.
- Two cabooses will be used as temporary accommodation for the driver logistical team (eleven persons).
- Two field toilets tents were erected.
- A third tent was erected for use as a shower and wash facility
- A mobile generator was used.
- Waste disposal (Human waste, glass, plastic waste etc.) containers were placed in strategic points.

The following rules were abided to by the E-Base Decommissioning Team .

- All waste generated at E-Base, excluding grey water, was containerized and returned to a point where it can be included in the main waste stream.

- All afore mentioned waste was contained and marked as follows.

General waste	- paper, plastics, tins, glass etc. (marked with a green circle)
Sewage	- human waste (solid), food scraps (black circle).
Urine	- Grey water waste marked "chemicals".
Construction waste	- Once removed the building material was either containerized and/or packed onto sledges ready for back-loading. No construction waste or part thereof was left on the ice.

- Round (200 liter) seal able containers were provided for general waste generated in the field.

- Round (200 liter) drum lined with a plastic liner was provided for all human waste. Size 500 x 500mm black bags were provided to place over specially manufactured portable toilets for human waste.

- Vehicle teams were responsible for returning the waste to points where it could be entered into the main waste stream.

5 DECOMMISSIONING PROCESS

5.1 Execution of task emanating from paragraph 4 and 5

In preparation for the decommissioning of E-Base the eastern side was levelled to approximately one meter below the steel walk way. This action was necessary for the safer handling of heavy vehicles, cargo, sledges and any other activity in and around E-Base.

Photo 7 – year 2005

Photo 8 – 27th December 2005

Photo 9 – 27th December 2005

<u>27th December 2005</u>

- The Eastern side of E-Base was cleared of ice and snow accumulation to approximately one meter below the walkway (illustration photo 9).
- Access points to the temporary accommodation and communication facilities were cleared.
- A black bag system for human waste was installed.
- General waste drums were placed in strategic positions on top of the walkway.
- The E-Base kitchen was temporary used by the chef to prepare meals.

5.2 First phase of the decommissioning of the accommodation and hospital block C

The dismantling of first of the four building commenced on the 28th December 2005. All the furniture, electrical wiring, hospital equipment and fixtures were packed into dedicated containers. In sequent, the interior walls were removed, the roof and finally the main supporting walls, as illustrated below. The entire decommissioning exercise was concluded on the same day.

Photo 10 – 28th December 2005

Photo 11 – 28th December 2005

Photo 12 – 28th December 2005

Photo 13 – 28th December 2005

<u>28th December 2005</u>

- On the morning of the 28th December 2006 all movable furniture, fixtures, electrics, piping and dry walls were removed from the sleeping accommodation and hospital building (Block C).
- All abovementioned items were packed into 20-foot transport containers (illustrated in photo 10).
- The decommissioning team started removing the insulated roof panels (illustrated in photo 11).
- The team continued by dismantling the walls and remaining support pillars (illustrated in photo 12).
- All the roof and wall building panels were strapped together and weighed ready for back loading (illustrated in photo 13).
- All metal waste (e.g. roof bolts, railings, PVC piping etc) was placed in recycle bins.
- All plastic novilon flooring was removed.
- Only the wooden floor panels and the steel support structures (space frame) remained behind.

5.3 Second phase of the decommissioning of the power shack and ablution facilities (Block A) (commencing period 29th December 2005 to 31st December 2005).

This building was anticipated to be the most difficult of the four buildings to remove. It contained the ablution block, workshop and two 120 KVA generators (power plants). Due to the extent of the slope (angle) of the building and the stresses on the sub structure; the interior, dry walls and the roof had to be removed before the diesel day tanks and the generators could be loaded onto cargo sledges. Two twenty-foot containers were used to store the removed: fixtures, lubricants, engine parts, E-base maintenance tools, batteries and movables! Note: A minor spill (less than ten litres) of polar diesel was reported during the removal of the generators. The spill was contained and cleaned satisfactory!

Photo 14 – 29th December 2005

Above photo
All fixtures and electrical wiring / ducting being removed

Photo 15 – 29th December 2005

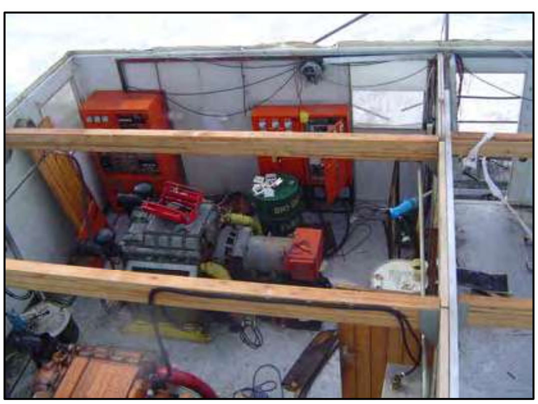
Above photo
Roof being cleared of ice

Photo 16 – 30th December 2005

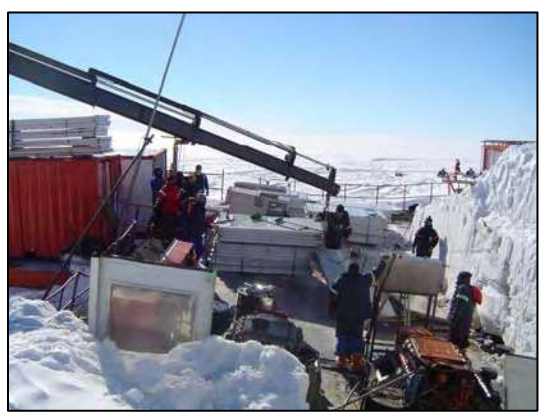
Above photo
Roof being cleared of ice, prior to roof being removed

Photo 17 – 30th December 2005

Above photo
Roof removed



Above photo
View of the power shack with roof removed



Above photo
The walls of Block A being removed

Photo 20 – 31st December 2005

Above photo
The wall panels being strapped ready for loading onto cargo sledges

Photo 21 – 31st December 2005

Above photo
The diesel day tank and generators ready for loading onto cargo sledges

Photo 22 – 30th December 2005

Above photo
The snow smelter was the last item to be removed from the floor platform

5.4 Third and Fourth phase of the decommissioning of the kitchen and communications block respectively. (1st January 2006 to 4th January 2006)

Removal of the living area, kitchen and dining room followed the same sequence of events at the other two modules, namely:

- All movable furniture, stoves, deep freezers, blower ovens, fixtures, electrics, piping and dry walls were removed from the lounge, dining room, pantry and kitchen area.
- All abovementioned items were packed into 20-foot transport containers.
- The decommissioning team started removing the insulated roof panels.
- The team continued by dismantling the walls and remaining support pillars (illustrated in photo 12).
- All metal waste (e.g. roof bolts, railings, PVC piping etc) was placed in recycle bins.
- Only the wooden floor panels and the steel support structures (space frame) remained behind.

Photo 23 – 5th January 2006

<u>Above photo (taken from the South)</u>

Aerial photo of the last structure remaining. The insulated panels were removed by mid afternoon. Prior to the team being moved to the vessel a clean-up effort was held to collect any small debris that might have landed onto the ice or in the operating areas of the vehicles. The entire area was rehabilitated.

Photo 24 – 5th January 2006

Photo 25 – 5th January 2006

<u>Above photo (taken from the West)</u>

All remaining cargo and panels were loaded onto cargo sledges and transported to the Bukta (RSA) ready for back-loading.

Cargo being transported for back loading.

5.5 Back loading onto the *SA Agulhas*

The back-loading was commenced on 13 January 2006. All building material, twenty-foot containers and panels were back loaded through a ramp onto the *SA Agulhas*. All cargo was back loaded and nothing remained depot on sledges.

Photo 26 – approx 17th January 2006

Photo 27 – approx 17th January 2006

The two illustrations above show the back loading through the ramp at the *RSA Bukta*.

6. Conclusion

6.1 All four buildings (wall panels, roof panels, interior fittings and equipment) which comprise the E-Base were completely removed from the Antarctic Treaty area and was returned to South Africa for disposal.

6.2 Due to the structural stress damage to the floor panels and attached integrated space frame platform removal thereof was deemed by the National Department of Public Works (NDPW) on-site Engineer, to be too dangerous to be continued.

7. Acknowledgements

The decommissioning process and the successful decommissioning of E-Base would not been possible without the cooperation received from all National role players and Stakeholders. E-Base was removed in less that half of the projected time of six weeks, under the most extreme conditions of Antarctica. A word of appreciation to Mr. Henry Valentine, Mr. Richard Skinner, Ships Operations Managers and the National Department of Public Works.

ANNEXURE A

Detailed list of all construction material back loaded onto the *SA Agulhas*

20 foot container No.	Dimensions	Volume	Description of items	Quantity
Container no 5	**6.1x2.4x2.6**	**38.06**	Mattress	17
			Meranti doors	7
			Pine shelving	102
			Upright shelve stands	37
			Bed bases	19
			Sliding door rails	5
			Sliding door pelmets	5
			Window blinds	8
			Oak wall units	2
			Bed side cupboards with drawers	10
			Dry room towel rails	15
			Wall heathers	6
			Steel table frame	1
			Steel cabinet	1
			Steel filing cabinet	1
			Waste basket	5
			20 litre plastic drums empty	4
			Hospital steel tables	4
			Chairs	6
			Blankets	3
			Hospital steel basin	1
			Trolley chairs	1
			Medicine cupboards	1
			Green empty drum	1
Container no 6	**6.1x2.4x2.6**	**38.06**	Mattress	17
			Bed bases	16
			Upright shelve stands	22
			Pine shelving	100
			Sliding door	5
			Sliding door rails	5
			Door	1
			Chairs	12
			Pillows	15
			Running carpet	6
			5 meter x 3 meter carpet	1
			Sliding door pelmets	5
			Waste basket	6
			Bed ladders	2
			Blinds	10
			Dust bins	1
			Antenna	1

20 foot container no	Dimensions	Volume	Description of items	Quantity
			Hoist steel bar	1
			Hot water urn	1
			Blankets	17
			Heaters	7
			Office table	1
			Fire extinguishers	4
			Steel scrap	N/a
			Steel brackets	N/a
			Bolts and nuts of beds	N/a
			Wood shelves	N/a
			Tent (scrap)	1
			DB electrical board	1
Container no 7	**6.1x2.4x2.6**	**38.06**	Stand upright fridge - DEAT	1
			Chest freezers - DEAT	2
			Dining room tables	2
			Kitchen cupboards	3
			Antennae	4
			Pipes aluminum	2
			Heavy duty stove	1
			Heavy duty oven	1
			Gas stove	1
			Steel iron frame	1
			Tumble dryers	3
			Top loader washing machine	1
			Gas bottles	3
			Hospital gas bottles	4
			Chairs (dining room)	17
			Electrolux Hoover	1
			Round oven frame shoes	3
			Cigarette ash trays	4
			Duckboard	1
			Compactor	1
			Paper hand towel stands	2
			Mattress	1
			Challenger mattress	1
			Carpet (lounge)	1
			Under felt (lounge)	1
			Kitchen extractor fans	2
			Laminated beams	3
			Floor vinyl (scrap)	1
			Diesel day tank	1
			Diesel day tank frame	1
			Generator vents	2
			20 litre motor oil	N/a
			Steel wash basin	N/a

20 foot container no	Dimensions	Volume	Description of items	Quantity
			Starter motors	N/a
			Caterpillar spares	N/a
			Batteries	4
			Urinal	1
			Wooden shelves	N/a
			Wooden upright stands	N/a
			Electric motor	1
			Timber	N/a
			Geyser	1
			Tools and hardware	N/a
			Beds (single bunks)	4
			Coffee tables	2
			Lounge suite chairs with foam seats	10
			Mattresses	4
			Workshop and generator scraps	N/a
White container	**6.1x2.4x2.6**	**38.06**	Timber (scrap)	N/a
			Cupboards	N/a
			Beds	15
			Pipes (scrap)	N/a
			Steel scrap	N/a
			Hospital chair	1
			Fire extinguisher	16
			Gas cylinder	1
			Light fittings	N/a
			Shower stands	2
			Wooden doors	2
			Laminated beams	4
			Water pumps	2
			Electric cables scraps	N/a
			Generator sliding door rail	1
			One ton Hitachi winch	1
			Hoist frame	1
			Sliding door (Generator room)	1
			Water filters (red)	2
			Generator main boards	3
			Kitchen double sink	1
			Room beam brackets	25
Loose item	6.7x1.6x 1.0	64.23	White wall and roof panels (E-Base)	Approx. 120
Loose item	10x3.0x1.0	80.29	Gensets (Power generators)	2
	200 l drums	N/a	Human waste	21 drums
	200 l drums	N/a	Kitchen food waste (Food)	15 drums
	200 l drums	N/a	Human waste (Urine)	8 drums
	200 l drums	N/a	Glass waste	12 drums
	200 l drums	N/a	Tin waste	

8. Waste Management Approaches in the Brazilian Antarctic Program

Tania Brito, Brazilian Antarctic Program

Abstract

In compliance with Annex III of the Madrid Protocol, the Brazilian Antarctic Program has established a waste management plan, which consists of procedures, guidelines and best practices on managing the waste generated at the Brazilian Antarctic Station “Comandante Ferraz”, as well as in refuges and on board the vessels.

All wastes are separated weekly. Organic combustible wastes are incinerated and filters are used to reduce harmful emissions, which are constantly monitored. The solid residue of such incineration is removed from the Antarctic Treaty area, together with all the other solid wastes, which are compacted and adequately stored for transportation, as well as chemicals and lubricating oils. Sewage and domestic liquid wastes are treated in a secondary sewage plant. The resulting treated liquid is monitored to attest efficiency of the sewage treatment and is discharged into the sea.

The surrounding marine area where the by-product of the sewage treatment is discharged has been monitored for indicators of chemicals from sewage including: persistent organic compounds, heavy metals, nutrients, chlorophyll, pH, alkalinity, dissolved oxygen and partial pressure of CO_2 in the seawater, organic hydrocarbons from petroleum, microbiological indicators of faecal origin, xenobiotic and pathogen-degrading micro-organisms, benthic community structure and marine food web, including multiple controls in the detection of anthropogenic effects through asymmetrical analyses. In addition, toxicity, bio-accumulation and bio-transformation experiments have been conducted to evaluate marine organism responses to anthropogenic contaminants in the field and laboratory.

Special focus is given to the training of staff and scientists, not only in terms of managing waste but also with regard to environmental awareness

Outline

- Brazil in Antarctica
- Solid Waste
- Waste Water
- Monitoring Impacts in Admiralty Bay
- Conclusion

Brazil in Antarctica

The Comandante Ferraz Antarctic Research Station (EACF) is located in Admiralty Bay on King George Island, within an Antarctic Specially Managed Area. The station was established in 1984 on the eastern coast of Keller Peninsula as the base for scientific research and associated logistic operations conducted by the Brazilian Antarctic Program. It started year-round operations in 1986.

The station consists of 64 containers including biological, chemical, meteorological and geophysical laboratories; dormitories with a capacity of 46 berths; storage facilities; a garage for land vehicles, diesel generators etc. The station is equipped with one helicopter pad. Fuel is stored in 17 large double-walled steel tanks with a total capacity of 316,000 liters of diesel, and in a small tank (3,000 L) for gas.

It has a winter and summer population of between:

2 - 27 research staff;

10 station group (Navy); and

1 - ±12 maintenance group

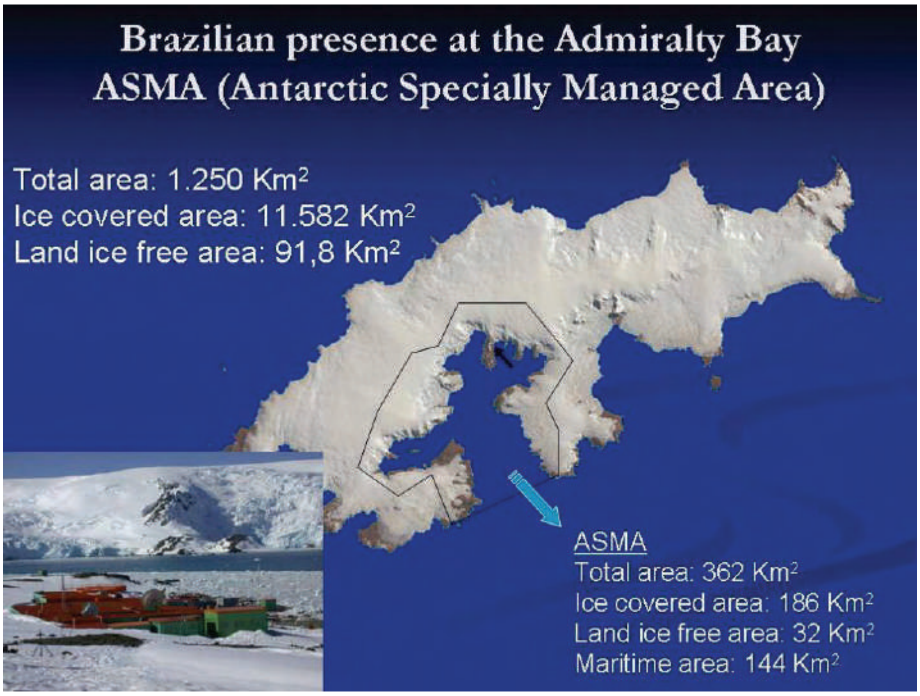


Figure 1: Brazilian Presence in Admiralty Bay

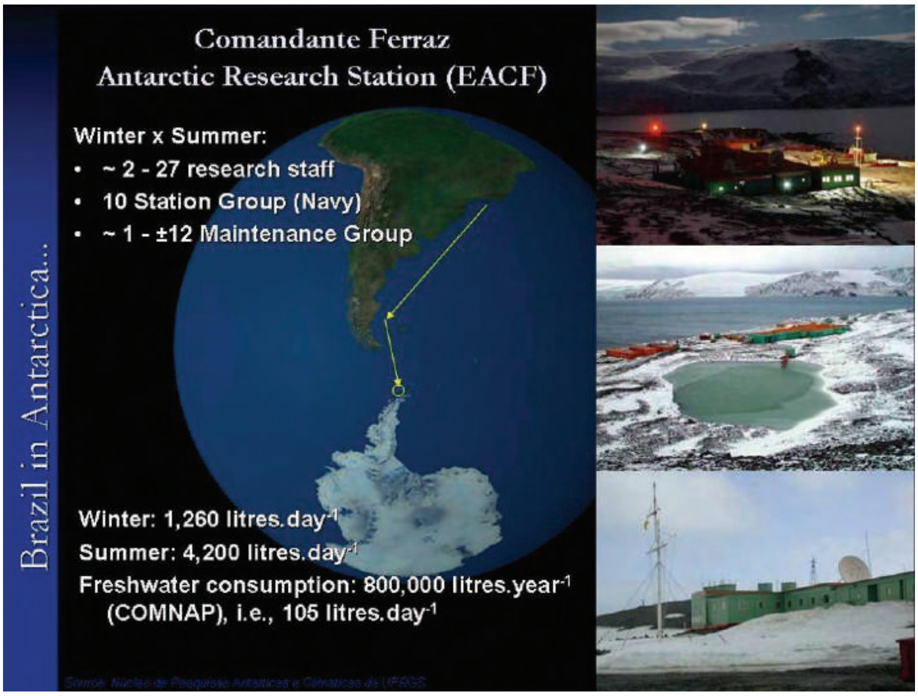


Figure 2: Comandante Ferraz Antarctic Research Station

Solid Waste

PROANTAR has adopted the policy to return all waste generated by the station and ship in the Antarctic Treaty area. This policy is in place since the first Brazilian expedition, in 1983, and reflects PROANTAR's concerns with waste management which is now subject of Annex III of the Madrid Protocol.

The station and the ship have selective waste collection. All wastes are separated weekly. Organic combustible wastes are incinerated and filters are used to reduce harmful emissions, which are constantly monitored. The incinerator operates on diesel and burns to a temperature up to 700° C. Incineration is conducted under low pressure and in temperatures between 400ºand 600º C. This process, known as pyrolysis, inhibits generation of dioxins, halogens and furans and prevents residues of heavy metals from oxidation. The solid residue of such incineration is removed from the Antarctic Treaty area. The ashes and all the other solid wastes, such as plastic, glasses, and papers are compacted and stored for transportation, together with chemicals and lubricating oils and returned to Brazil.

Figure 3: Photographs of waste management activities

All waste apart from food waste, sewage and grey water are removed from Ferraz for recycling or safe disposal in Brazil. Waste is separated at source in the following categories: Waste oil and lubes; paper; glass; metal; plastic; steel/aluminium cans; clothes; fluorescent lamps; and general waste. Waste bins are clearly marked by category.

A study has been undertaken on the main categories of waste. The figure below shows waste generation.

Figure 4: Waste generation

Waste Water

The Station is fitted with an efficient sewage system for up to 6O people. Sewage and grey water is treated in a three-stage passive filtration system. The system has four steel septic tanks, two anaerobic filters, two decanting tanks and two intercepting tanks.

The system treats the sewage water and domestic liquid wastes separately. A serial of septic tanks decants the sewage before reaching the anaerobic filters.

The domestic liquid wastes go to the decanting tanks where all solids and suspended matters are decanted before reaching the anaerobic filters. All the solid wastes from the septic tanks are then retrieved and incinerated. Solids are sent to Brazil for safe disposal.

The water resulting from this process is monitored to attest efficiency of the sewage treatment. Treated effluent is discharged inshore to Martel Inlet below the low tide line. Through chemical analysis, the quality of the discharged waters has been considered within satisfactory levels.

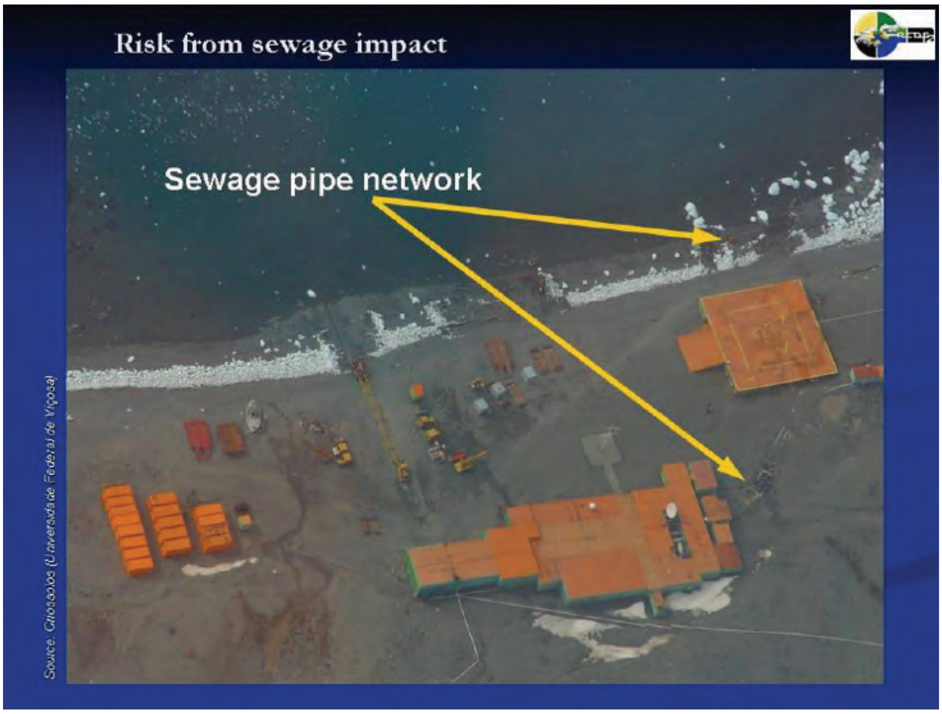


Figure 5: Sewage pipe network

Sewage from toilets (black water) passes through primary treatment, anaerobic filters and filtration boxes prior to sewage outfall.

Sewage from showers, kitchens and sinks (grey water) passes through a solids retention box, anaerobic filters and filtration boxes prior to sewage outfall.

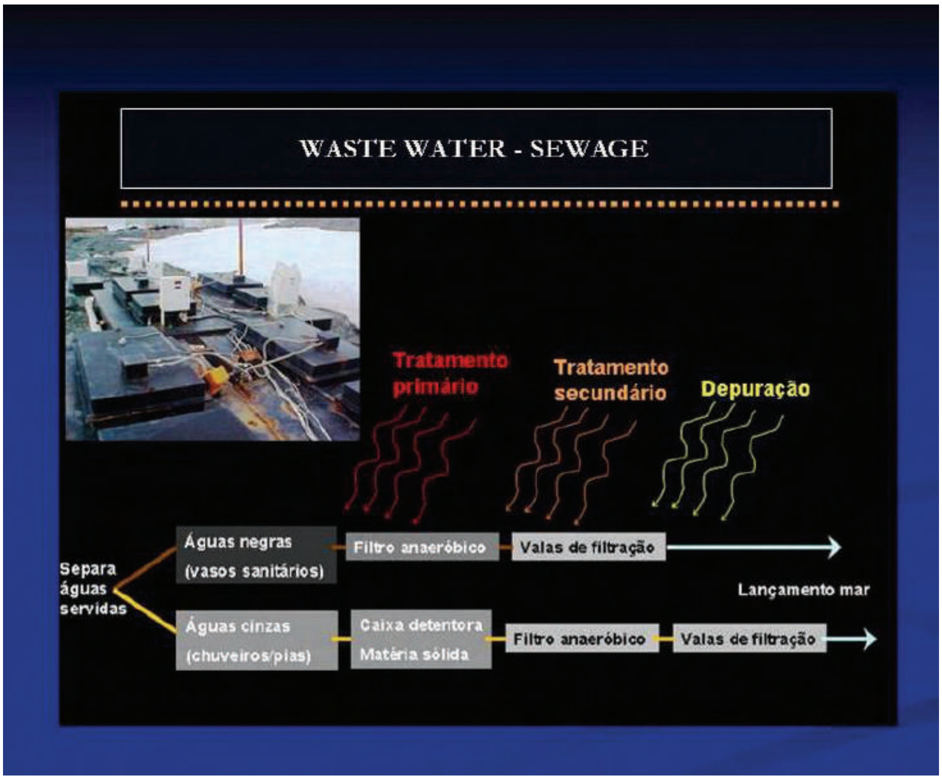


Figure 6: Waste Water Treatment Process

Monitoring Impacts in Admiralty Bay

The surrounding marine area where the by-product of the sewage treatment is discharged has been monitored for chemical indicators of sewage, persistent organic compounds, heavy metals, nutrients, chlorophyll, pH, alkalinity, dissolved oxygen and partial pressure of CO_2 in the seawater, organic hydrocarbons from petroleum, microbiological indicators of faecal origin, xenobiotic and pathogen-degrading micro-organisms, benthic community structure and marine food web, including multiple controls in the detection of anthropogenic effects through asymmetrical analyses.

In addition, toxicity, bio-accumulation and bio-transformation experiments have been conducted to evaluate marine organism responses to anthropogenic contaminants in the field and laboratory.

The following figure displays the framework of the monitoring program.

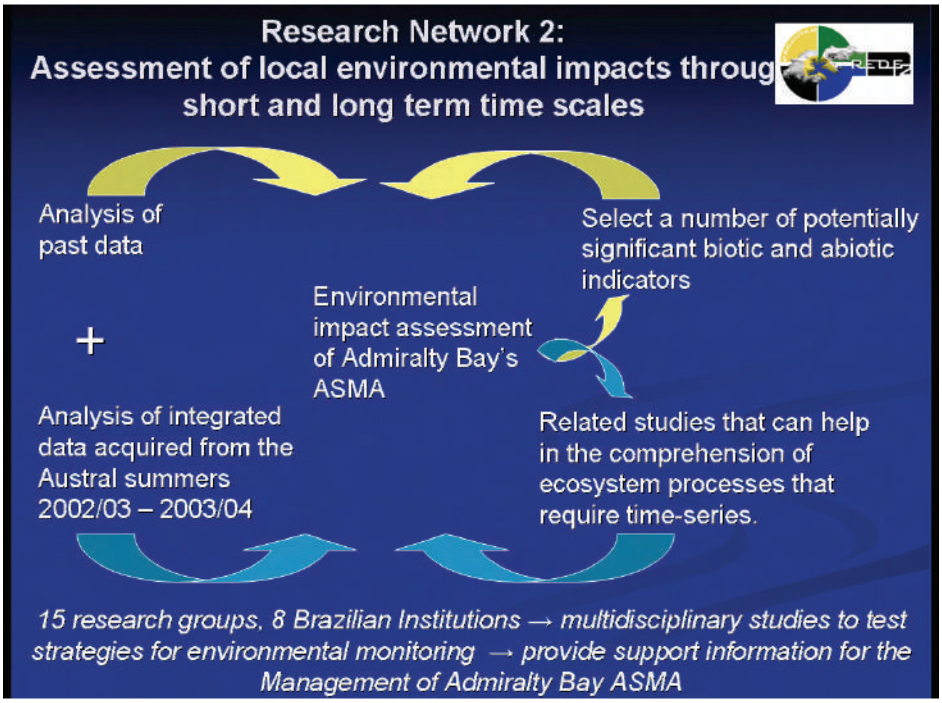


Figure 7: Framework of Monitoring Program

Some of the results from the monitoring program are presented in the following sections of this paper.

RESULTS FROM THE MONITORING PROGRAMME

Abiotic Parameters

The following figure shows the distribution of abiotic parameters in Admiralty Bay

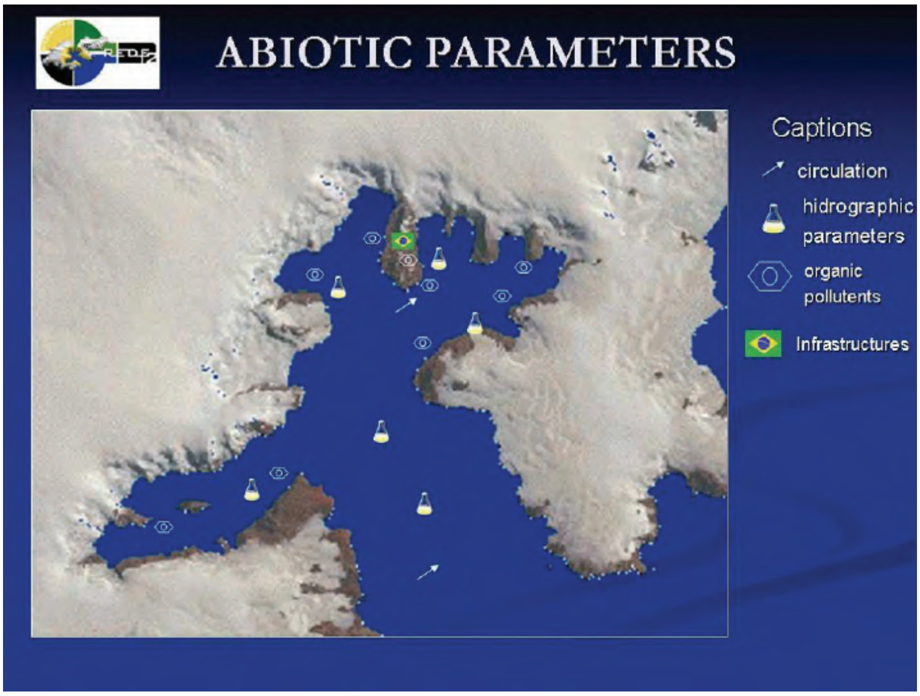


Figure 8: Abiotic Parameters in Admiralty Bay

Biotic Parameters

The following figure shows the distribution of biotic parameters in Admiralty Bay

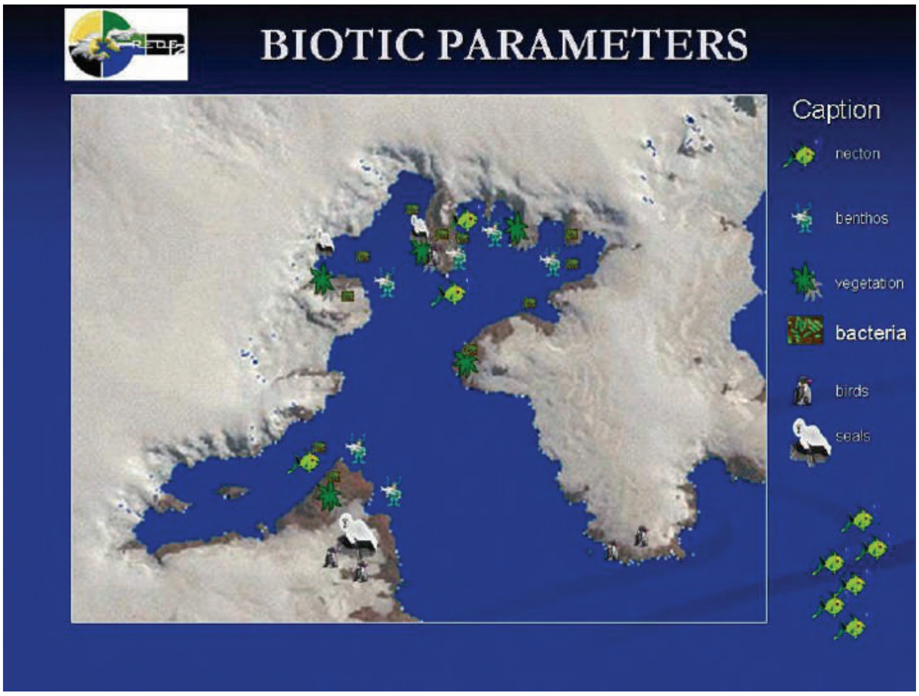


Figure 9: Biotic Parameters in Admiralty Bay

Water Column

Monitoring provided the following data with respect to the water column:

- Typical currents → 0.40m.s-1 (main channel) and 0.02m.s-1 (within inlets), more intense in Martel due to tidal influence in its shallow region;
- Intense mixture processes generated by tides and winds;
- Hydrodynamics forced by bottom topography;
- Water temperatures → -1.6 to 3°C; and
- Salinity → 16 to 34 in the summer.

Distribution of Thermohaline and Nutrients

The following figure shows the distribution of thermohaline and nutrients of abiotic parameters in Admiralty Bay

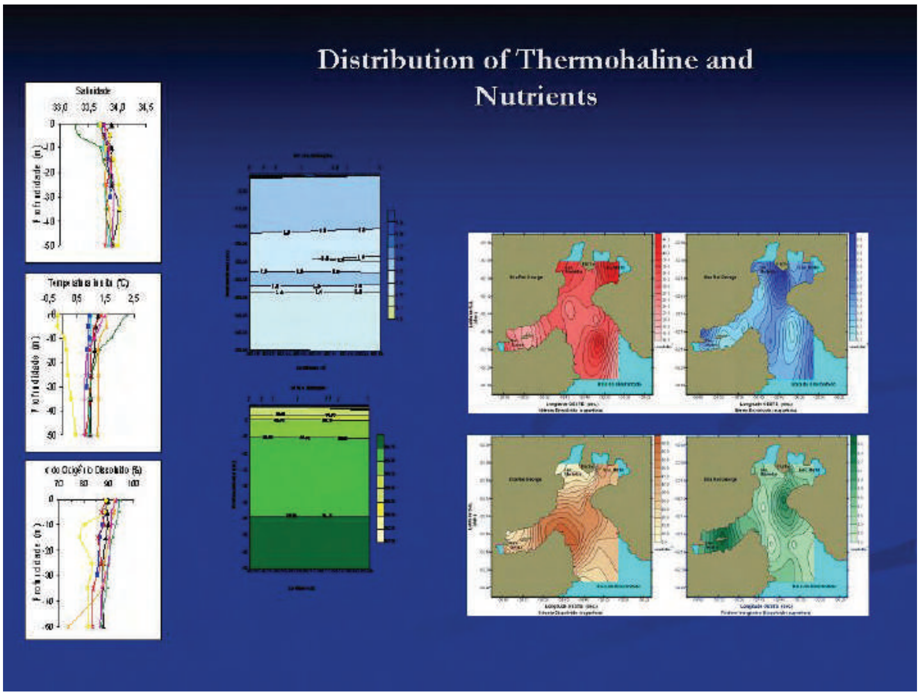


Figure 10: Distribution of Thermohaline and Nutrients

Phytoplankton

Monitoring revealed the following data with respect to phytoplankton:

<u>Early Summer</u>

- Water temperature = -0.4 ± 0.2°C;
- Salinity = 35;
- Dissolved oxygen = 6.4 ± 1.2 mL.L-1;
- Phosphate = 2.6 ± 0.3 µmol.L-1; and
- Lower phytoplankton abundance (6.2 x 102 ± 6.9 x 102 cells L-1) except in specific conditions, e.g. when pennate benthic diatoms have had an abundance increase (>1.5 x 104 cells.L-1), possibly due to sediment re-suspension or melting ice.

<u>Late Summer</u>

- Warmer water = 1.5 ± 0.3°C;
- Salinity = 34 (lower, p=0,00);

- Dissolved oxygen = 2.9 ± 0.1mL.L-1;
- Phosphate = 4.5 ± 2.5 µmol.L-1; and
- Higher phytoplankton abundance (1.5 x 103 ± 1.5 x 103 cells L-1) caused by the contribution of centric diatoms (55%), typical from the Bransfield Strait oceanic waters.

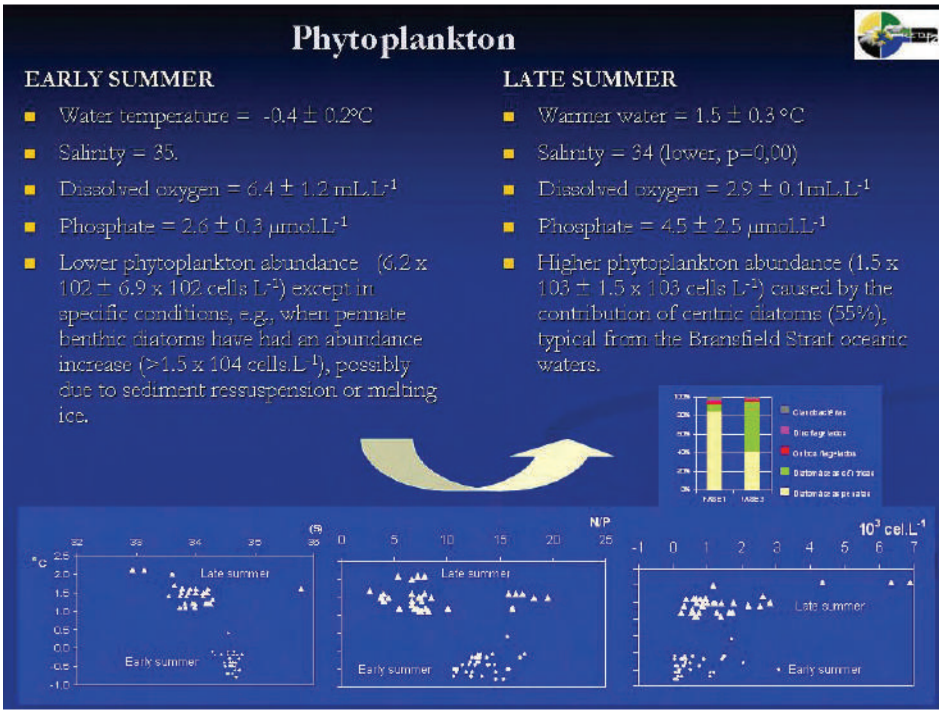


Figure 11: Phytoplankton

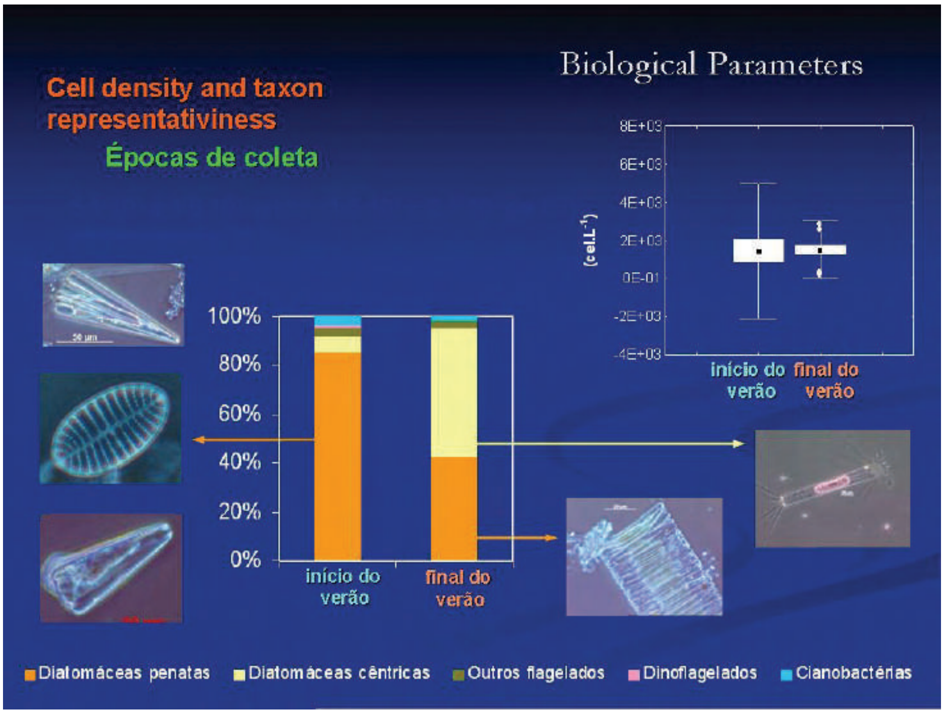


Figure 12: Biological Parameters

Faecal Pollution

Monitoring revealed the following information about faecal sterols in sediments:

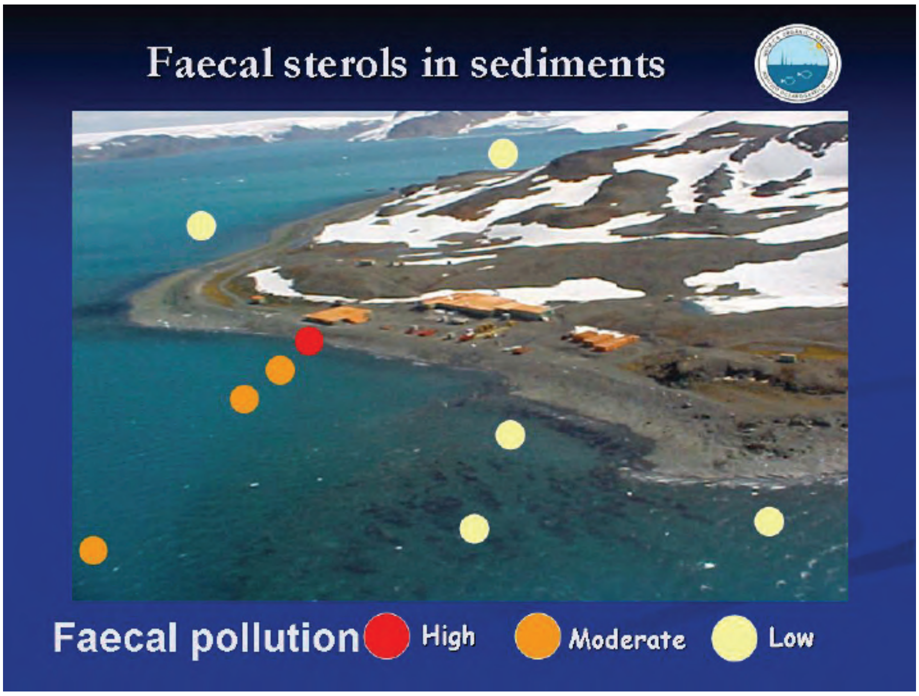


Figure 13: Faecal sterols in sediments

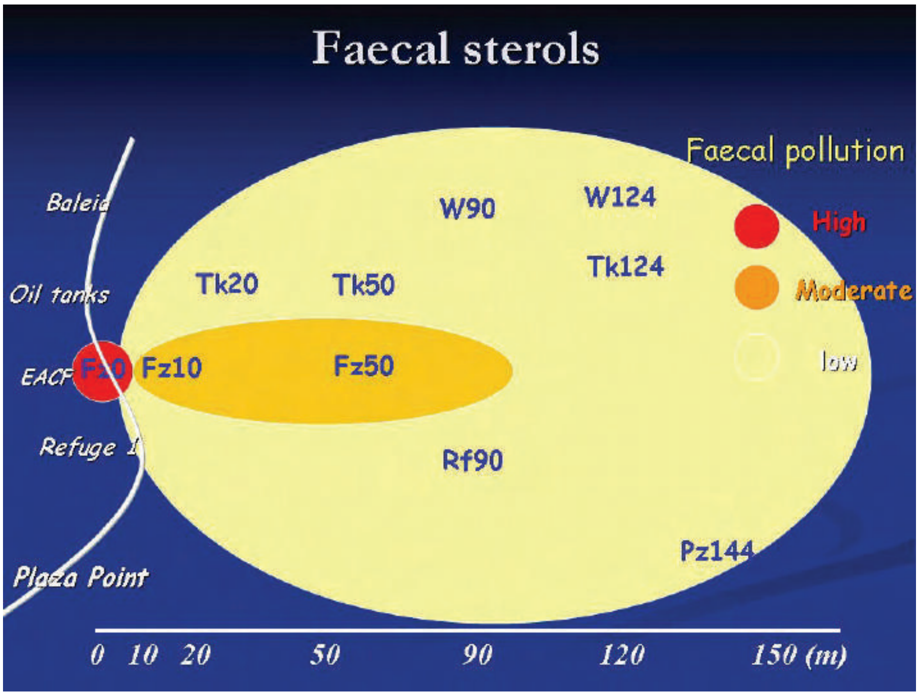


Figure 14: Faecal pollution

Seabed Topography

The bottom topography is similar to a fjord system and is conditioned by volcanic rocks, trenches and glacial erosive processes.

- Depth: 500m (main channel) → 200-300 (inlets confluence);
- Steep bottom topography and irregular with a variety of geomorphic features in the slopes and shallowest zones;

- Bottom features of the bay → seasonal ice behavior (shallowest zones);
- Sediments have varied particle size distribution;
- Pebbles, boulders and sand (shallowest) → silt and clay (increasing depth) *(Sicinski 2004, Schaefer et al 2004)*;
- the processes of ice movement and melting is a process that naturally transports particles, and also generate expressive ice-scours in the Bay *(Mahiques et al 2005)*;
- Biodetritic carbonate 4.5 – 11.0%; and
- Interstitial salinity = 34 -37, more saline in deepest zones *(Rezende et al in prep.*

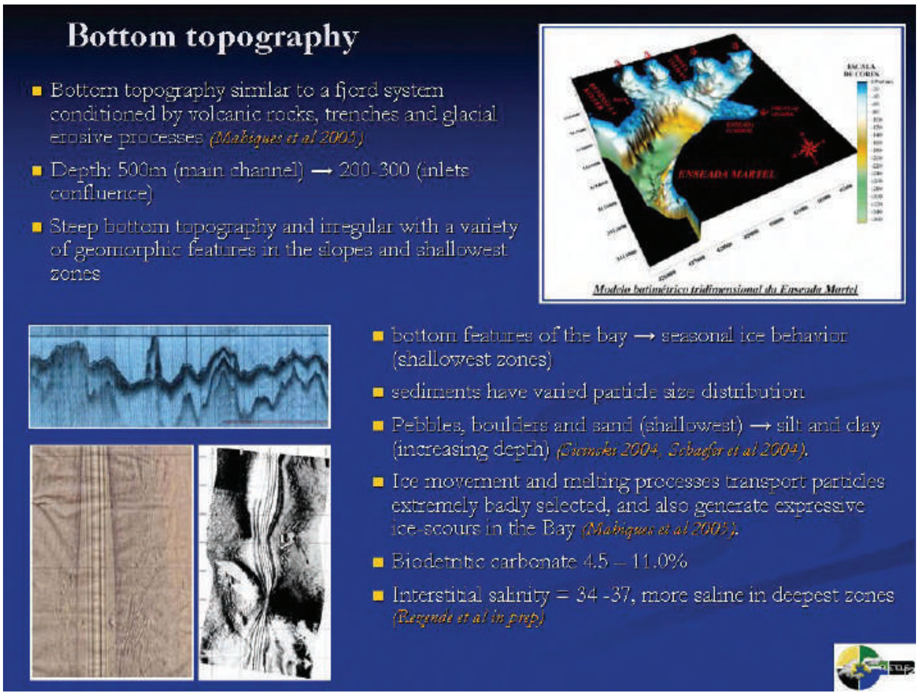


Figure 15: Bottom Topography

Sediment Sampling

A Mini-Box Corer (55Kg) was used, operated from an 8m boat with a winch in Antarctic shallow water.

Beaches were found comprised of rocks, boulders, pebbles rochas and sand.

Sea Bottom:

- pebbles and coarse sand (inter-tidal);
- sand and mud (shallower sub-tidal down to ~ 20m);
- mud at deeper areas (from 20m and deeper, but still pebbles and boulders can still be found).

Results of sediment sampling and analysis of heavy metals and hydrocarbons are shown in the following figures.

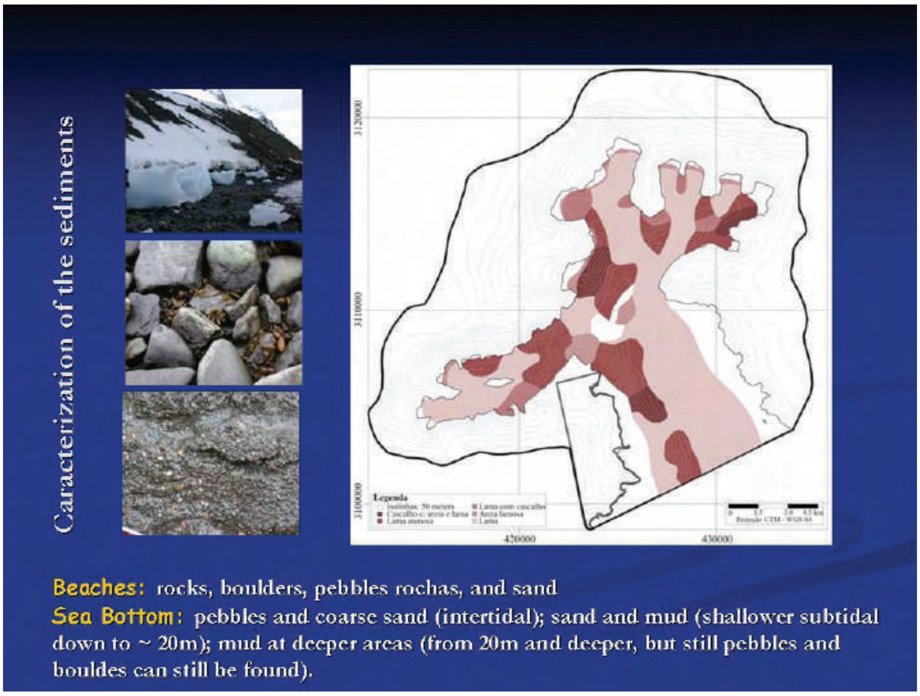


Figure 16: Sediment sampling

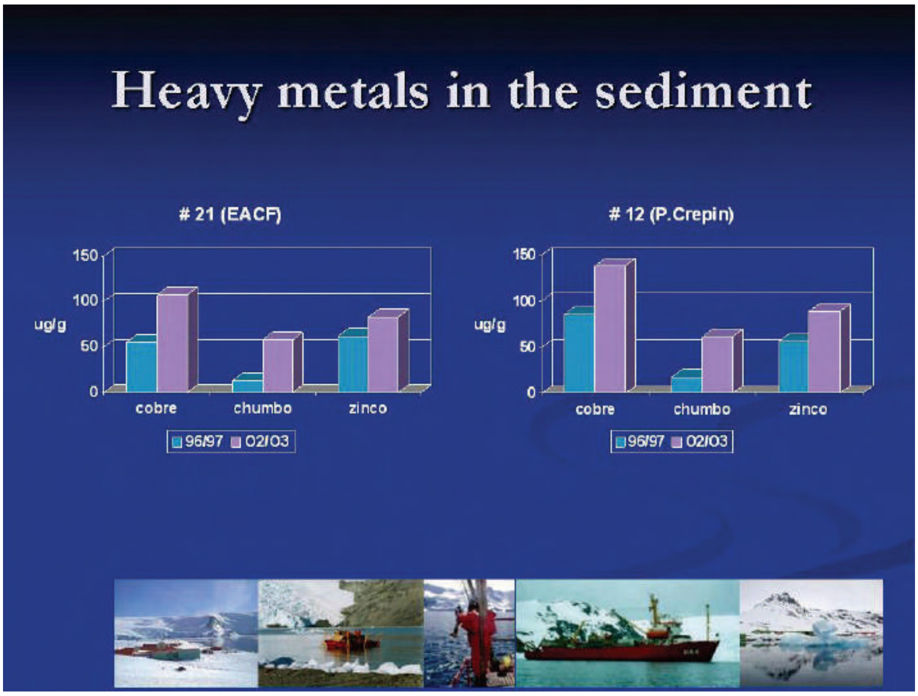


Figure 17: Heavy metals in the sediments

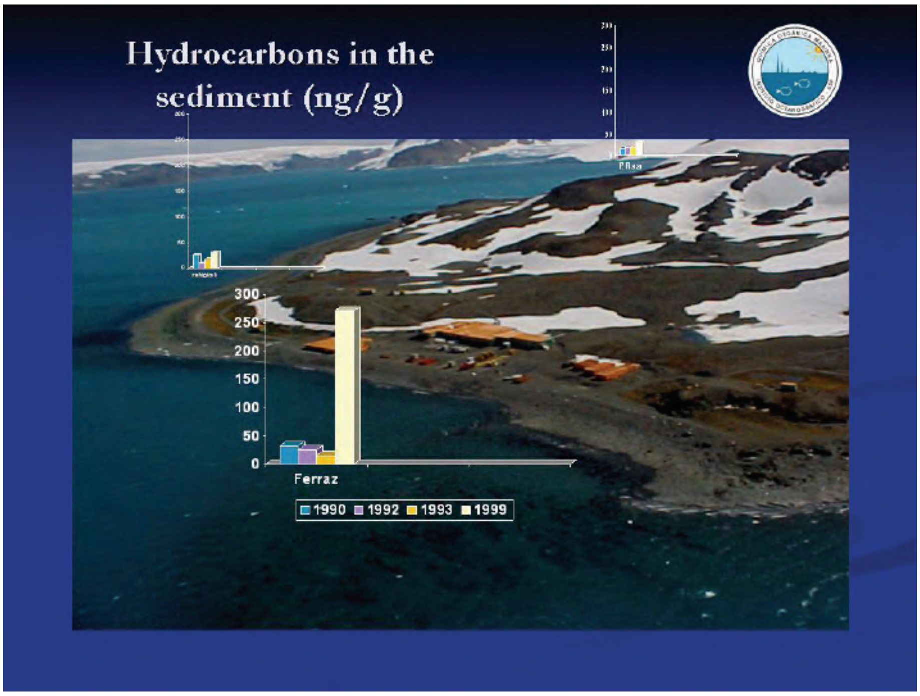


Figure 18: Hydrocarbons in the sediments

Bioaccumulation of Persistent Organic Pollutants (POPs) and Polycyclic Aromatic Hydrocarbons (PAHs)

Analysis of POPs and PAHs in birds displays the following results:

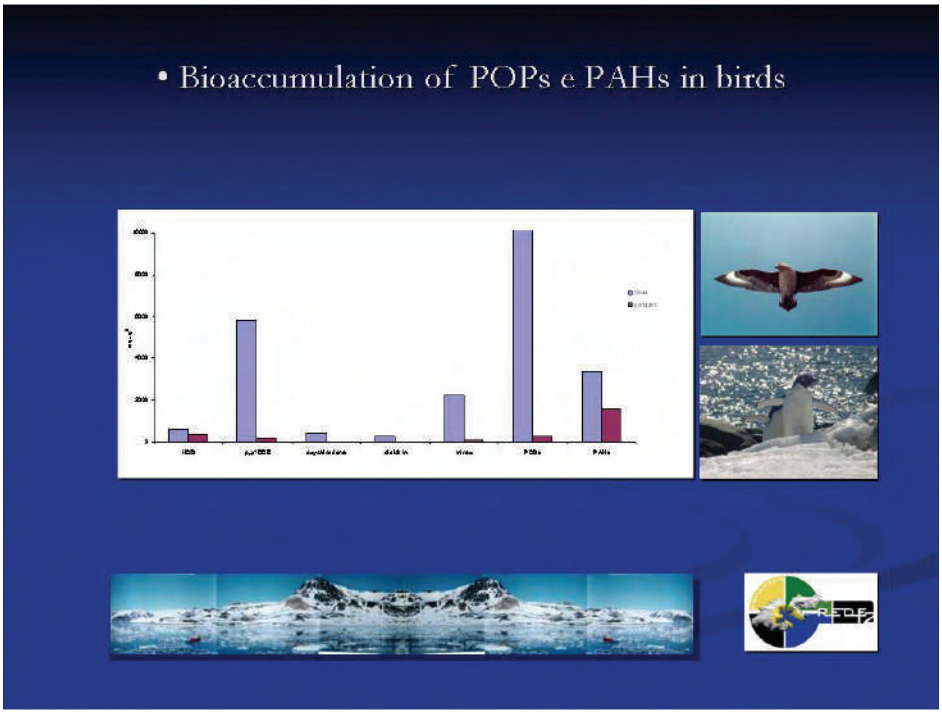


Figure 19: Bioaccumultation of POPs and PAHs

Cellular Biological Markers

Analysis reveals the following information:

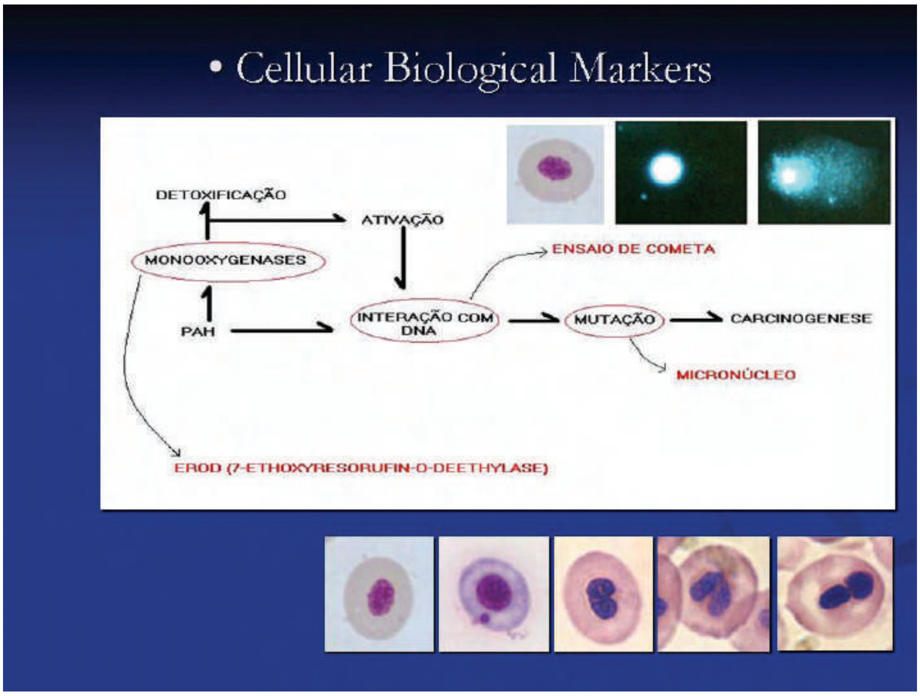
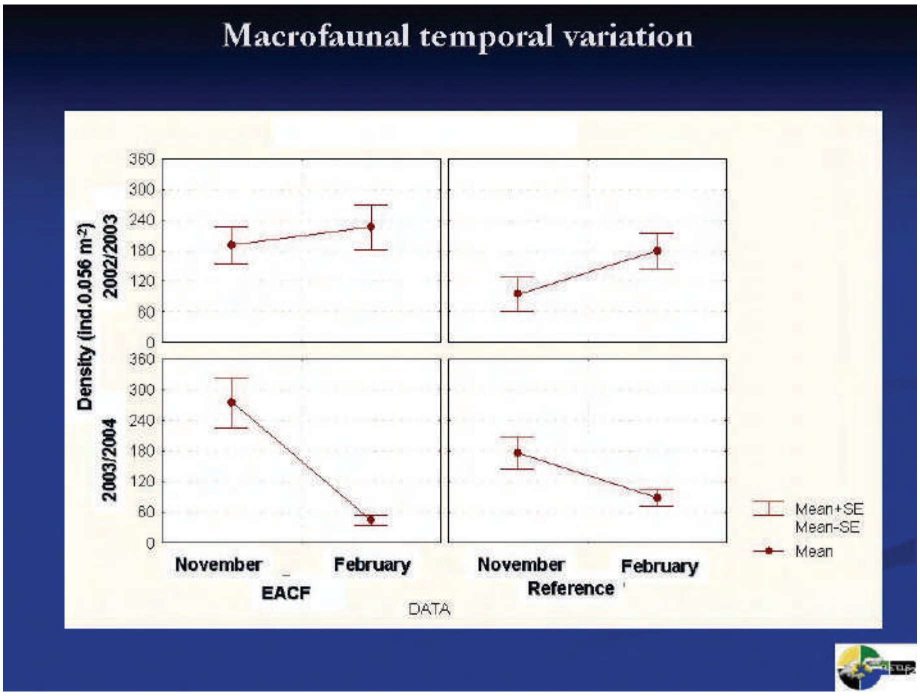
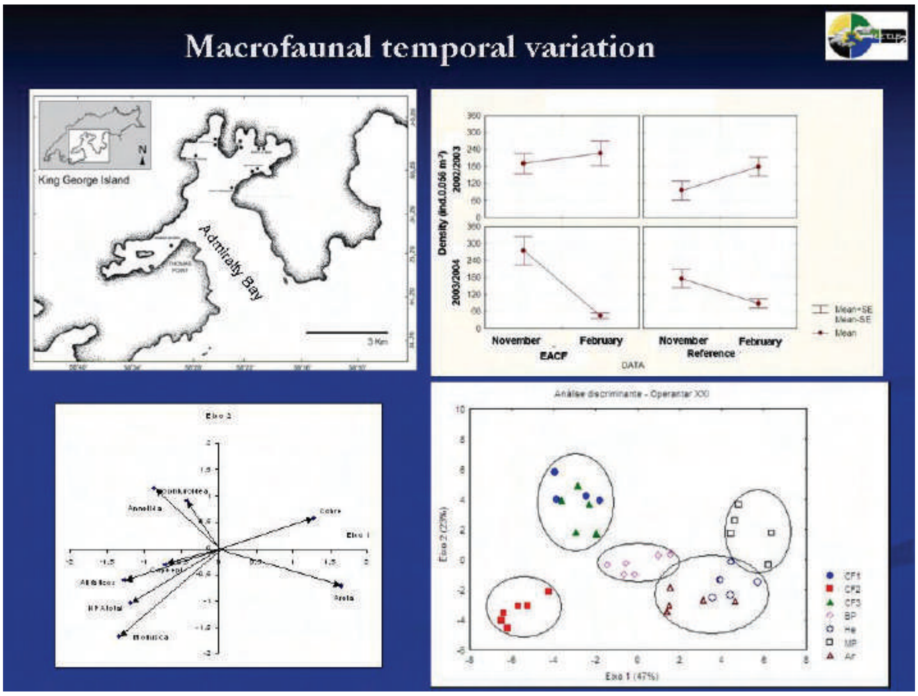


Figure 20: Cellular Biological Markers

Macrofaunal temporal variation

Analysis reveals the following information:





Figures 21 and 22: Macrofaunal temporal variation

Trophic Relationships in the Near Shore near EACF

Analysis reveals the following information:

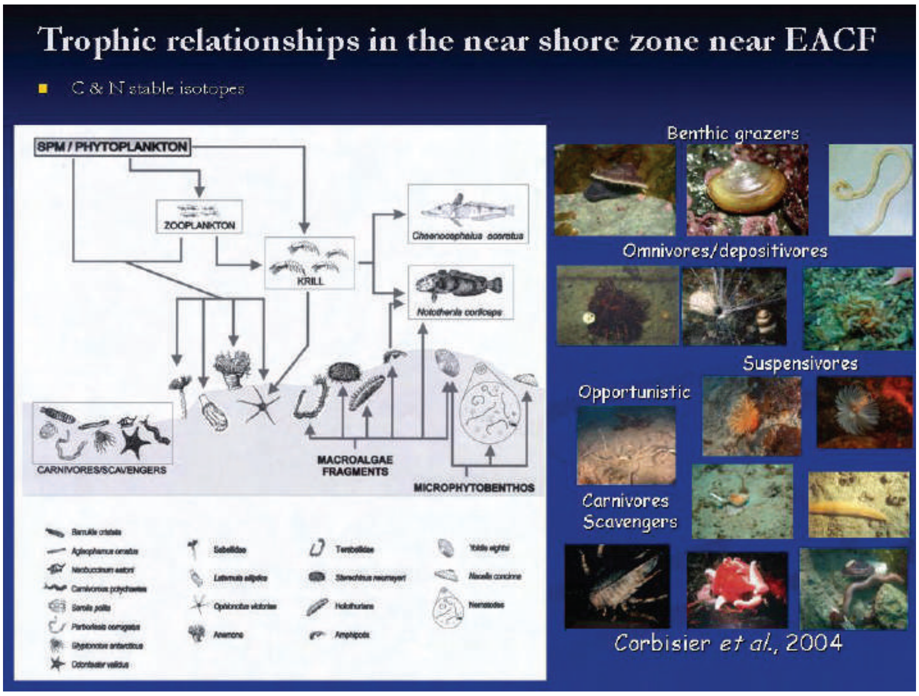


Figure 23: Trophic relationships

Microbial Pollution Indicators

Analysis reveals the following information:

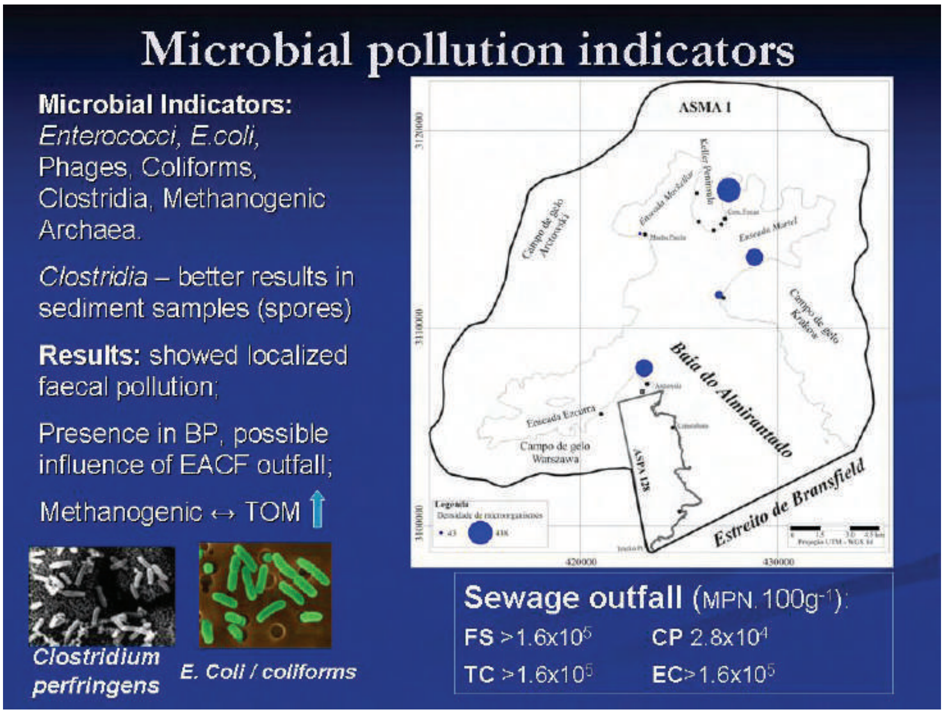


Figure 24: Microbial pollution indicators

Atmospheric Conditions

Analysis reveals the following information:

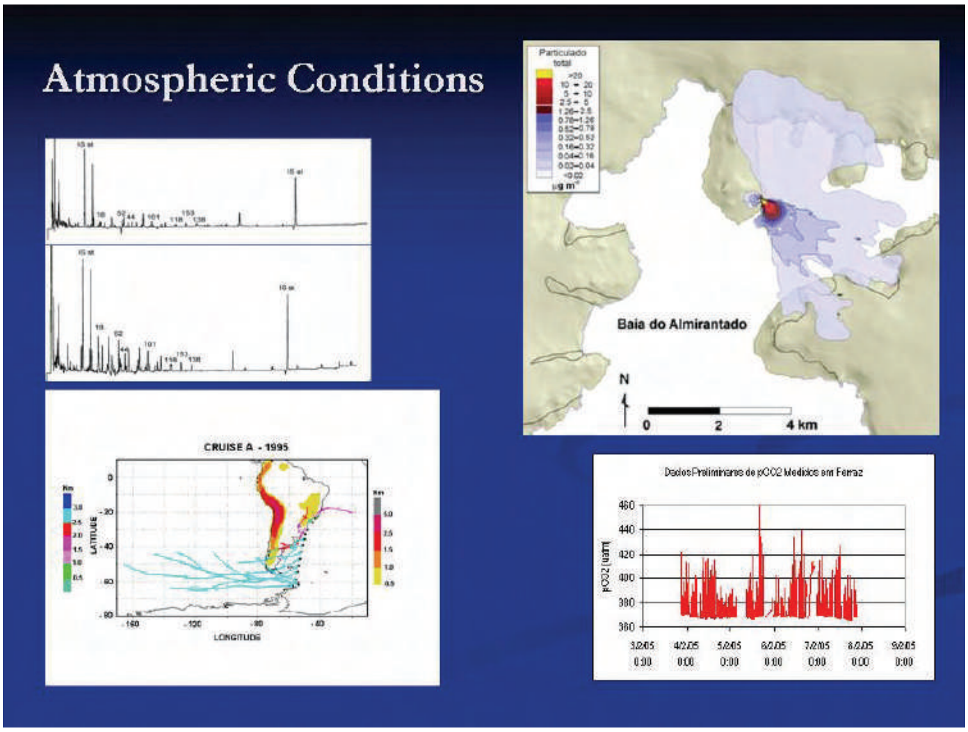


Figure 25: Atmospheric Conditions

Note: All the information acquired in this study is available in a Geographic Information System – GIS.

Conclusion

The sites near EACF have shown some relevant differences from the reference areas when considering the most frequently analysed variables.

This study indicates that a suitable temporal replication within each year in sampling surveys is necessary to avoid confounding effects in long term trends for assessments within Antarctic environmental monitoring programs.

It appears that benthic faunal abundances change in relation to the water column production.

Carbon and Nitrogen stable isotopic analysis has not indicated differences between areas related to organic enrichment in the food web.

Natural rather than anthropogenic processes are the main causes of sedimentary changes.

The effects of the contamination sources are chronic and very restricted in extent (maximum 200m from the shoreline in front of EACF).

DAY TWO:

How are we approaching cleaning up old waste in Antarctica?

9. Cleaning up BAS's Legacy of Abandoned Bases and Worksites in Antarctica

Dr John Shears and Rod Downie, British Antarctic Survey (BAS)

Abstract

The UK is undertaking a major, long-term programme to remove abandoned British bases and worksites from Antarctica. The sites are spread over a wide geographical area, representing a significant logistical challenge.

Major clean-up work achieved so far includes the demolition and removal of an old bulk fuel tank and two large buildings at Signy Research Station (2001-02), the removal of a remote waste dump site at Fossil Bluff (2002-03), and the removal of the abandoned bases at Danco Island and Prospect Point (2003-04). The clean-up was featured in the BBC World TV documentary series 'Secrets of Antarctica' in 2004. In 2006 several field hut on South Georgia were removed.

Planning is underway for the removal of Halley V Research Station, to begin in 2007/08

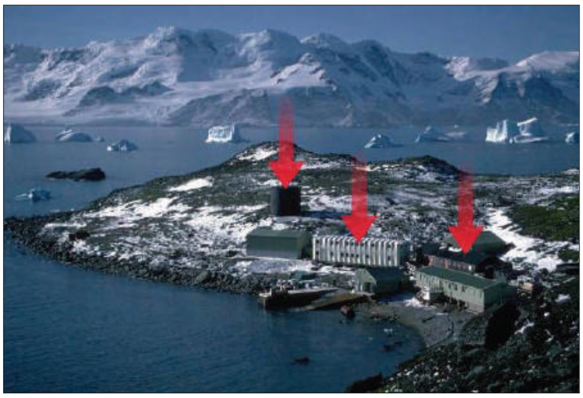
Outline

- Signy Demolition.
- Removal of Fossil Bluff Waste Dump.
- Abandoned Bases Clean-up.
- South Georgia Clean-up.
- Project Management.
- Summary.

Signy Demolition 2001-02

During the Signy demolition clean-up:

- Two disused buildings and the old fuel tank were demolished;
- About 20,000 litres of waste fuel was recovered and used to power station generators; and
- A total of 800 cubic metres of waste was removed.




Figures 1 and 2: Removal of two disused building and fuel tank

Fossil Bluff Waste Dump 2002-03

During the Fossil Bluff clean-up, which resulted in an international "Green Apple" Gold Award in 2003, the following activities were carried out:

- The clean-up and removal of the old rubbish dump;
- The removal of hundreds of empty fuel drums, tins and general rubbish; and
- A total of over 50 tonnes of wastes were flown out.


Figures 3 and 4: Fossil Bluff in Feb 2002 and following clean up in Feb 2003

Abandoned Bases 2003-04

In the clean-up of abandoned British bases, the following activities were carried out:

- The demolition and removal of Danco Island (Base O) and Prospect Point (Base J);
- The removal of waste from Deception Island (Base B);
- A total of 880 cubic metres of waste was removed, including hazards such as asbestos; and
- Historic artefacts were collected and taken to Port Lockroy for display.

Figure 5: The clean-up team offload cargo at Danco Island

Figure 6: Demolition starts at Prospect Point.

Cleaning up BAS's legacy on South Georgia 2005-06

During January - February 2006, the following activities were carried out:

- Demolition of the old Bird Island station and removal of more than 800m3 of waste ;
- Demolition and removal of abandoned BAS huts, reindeer exclosure fences and former work sites on South Georgia. at Carlita Bay, Johnson Beach, Moltke Harbour, Hound Bay, Husvik, Tønsburg Point, Ocean Harbour, Sørling Valley and Schleiper Bay
- Control measures to avoid hard to local wildlife and prevent introduction of non-native species implements; and

- Use of the RRS Ernest Shackleton as the platform for the clean-up, which proved to be an excellent support vessel for environmental operations at remote coastal locations.

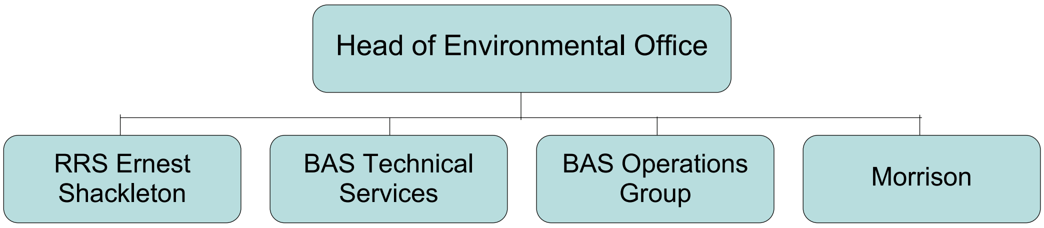
Figure 7: Removal of waste cargo at Bird Island

Project Management

Characteristics of a good management structure for site clean-up include:

- Clear management structure and procedures;
- Ability to facilitate a ‘good fit’ with decision-making between BAS and the clean-up contractors, Morrison; and
- Ability to keep all the key players in the loop.

The structure adopted by BAS which met these requirements is outlined in the diagram below:



Summary

- BAS, in partnership with Morrison, has undertaken a successful and award-winning clean-up programme in Antarctica and South Georgia.
- The total cost of clean-up, including logistic support, is about £2.5 million.
- The partnership agreement has worked well due to the close co-operation between key BAS and Morrison staff by means of dedicated working groups.
- Clean-up will continue with the removal of redundant buildings at Cape Geddes, Rothera and Halley V.

Figure 8: There was a good cultural fit between BAS and private organisation Morrison – critical to achieving good partnership outcomes for projects in remote Antarctica

10. Clean-Up Program at Syowa Station and the Next Stage Challenges

Kenji Ishizawa, National Institute of Polar Research

Abstract

Since 1998, in accordance with the Environmental Protocol to the Antarctic Treaty enforced in 1998, the Japanese Antarctic Program has conducted clean-up and removed old dumps left by earlier expeditions at Syowa Station.

The Japanese Antarctic Program has begun a four-year clean-up campaign at Syowa Station, which is scheduled to continue between 2005 and 2008.

The clean-up program consists of three main activities:

- The clean-up of old dumps;
- Intensive clean-up days; and
- The commencement of a sewage disposal process at Summer Lodge.

The first activity is the removal of the old dumps. We plan to completely remove wastes such as snow vehicles, sleds, building materials, pipes and old fuel drums by 2008. We are planning for a total waste shipment of 200 tons every year.

All of the old dumps, with the exception of landfill, are to be removed completely by 2008.

Treatment for landfill is a significant problem, and is now under consideration.

Asuka Station is an inland station in which wintering activities were conducted for five years. A new clean-up campaign is planned from the 2009-10 season. The total amount of waste to be removed is about 100 tonnes

Each summer season, intensive clean-up activities were carried out by expeditioners and the crew of the ice vessel for two or three days over the whole area of East Ongul Island, where Syowa Station is located. After the completion of the program, we will deal with buried waste at Syowa Station and dumps at inland camps.

A biological sewage treatment system started operation in the winter of 1999.

Outline:

- Waste Management at Syowa Station
- Four-year Clean-Up Program at Syowa Station
- Landfill at Syowa Station
- Clean-up Programs at Inland Stations

Waste Management at Syowa Station

Figure 1: Syowa Station

The 47th Japanese Antarctic Research Expedition had 37 personnel at the station over the winter, and 23 personnel over the summer.

The following graph shows amount of waste generated at the station:

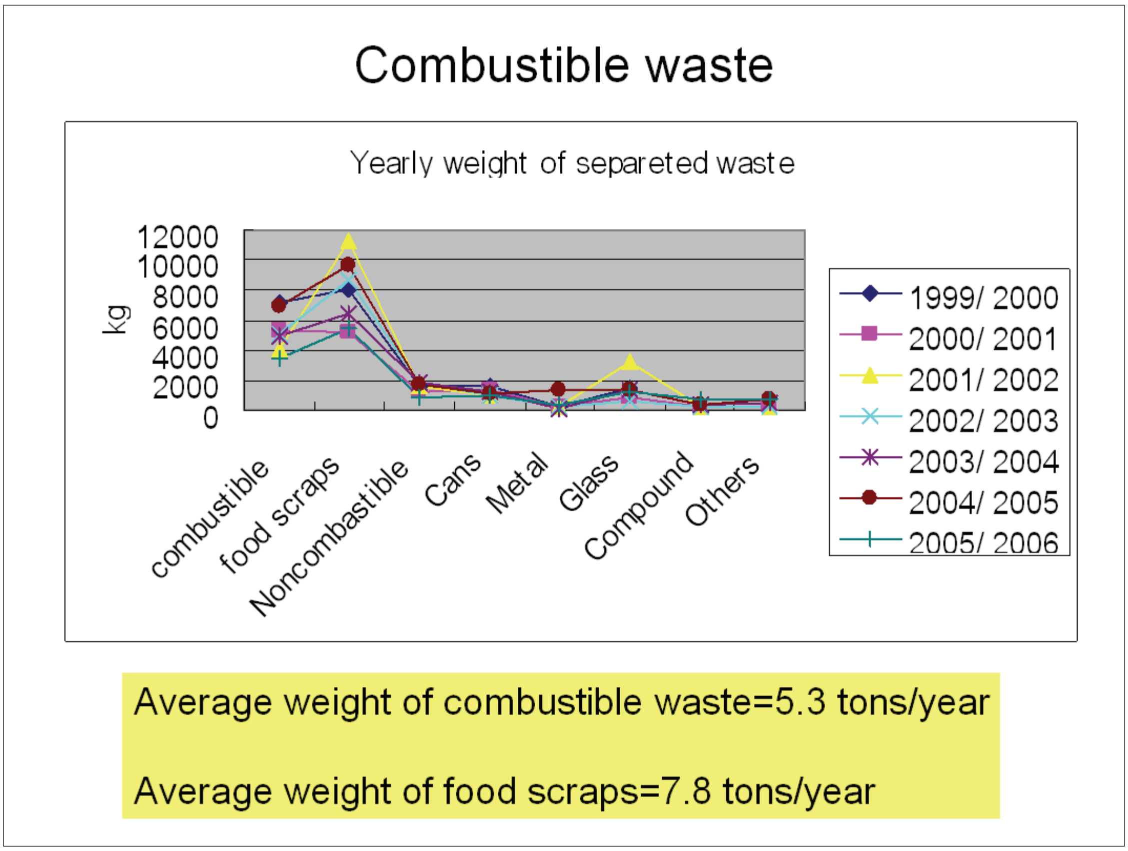


Figure 2: Waste generated at Syowa Station

The average weight of combustible waste is 5.3 tons per year. The average weight of food scraps is 7.8 tons per year

An incinerator and a carbonization unit are used on station.

In the incinerator, the volume of combustion room is 0.5 m^3. The weight of ash is 1/30 the weight of timber. The ash is brought back to Japan and weighs approximately 730 kg.

Prior to the installation of the carbonization instrument, an incinerator with an oil burner was used, but it was impossible to successfully burn a lot of garbage, especially at the end of the winter. Therefore, we decided to introduce a carbonization instrument to deal with food scraps.

The specification for the carbonization instrument is as follows:

Specifications for Carbonization Instrument	
Dimension (mm)	1510×1100×2090
Weight (kg)	1000
Capacity	0.2 m^3/batch
Power supply	3 ϕ 200V AC
Power consumption	1.1kW
Fuel consumption	0.003 ~ 0.004 m^3/h
Calorific value of burner	19,200 kcal/h
Operation time	4 ~ 6h/batch

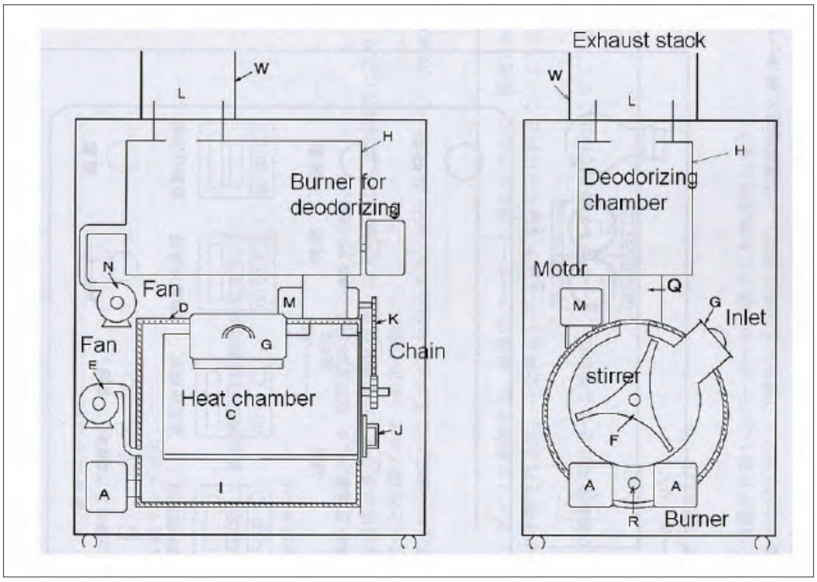


Figure 2: Outline of the carbonization instrument

Figure 3: Carbonized charcoal from outlet

The following graph shows non-combustible waste generated at the station which is returned to Japan:

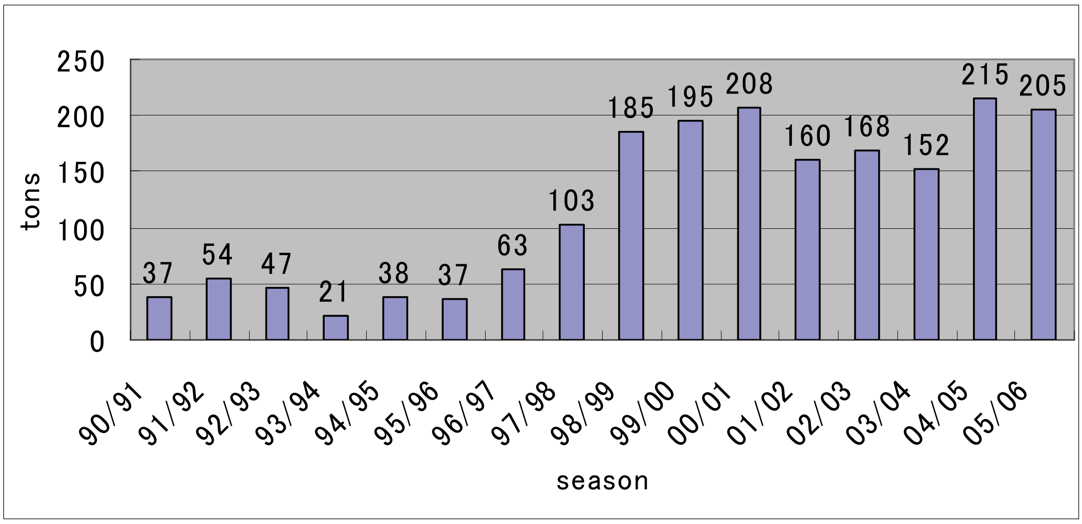


Figure 4: Non-combustible waste returned to Japan

A new sewage treatment building, with an area of 109 m^2, was built in 1997. The facilities in the building were installed in 1997-1998, and the system, using aerobic digestion, operated from the beginning of the 1999 winter. The following table shows performance of the plant:

Performance of Sewage Treatment Plant at Syowa Station		
	Summer time (110 persons)	Winter time (40 persons)
Volume of treated sewage (per day)	13 m^3	6 m^3
BOD	60 ppm	20 ppm
SS (suspended solids)	120 ppm	70 ppm

Four Year Clean-Up Program at Syowa Station

There are three strategic issues informing the clean-up of Japanese activities in Antarctica:

1. Removal of wastes on land: resulting in the clean-up project in 2005-2008;
2. Treatment of landfill: resulting in either removal or containment; and
3. Removal of wastes remaining at inland bases (Asuka Station has160 ton; Mizuho Station has snow vehicles and antennas).

The Syowa Station four year clean-up program for 2005-2008 is focused on two issues:

1. The removal of the accumulated old dumps; and
2. The practice of intensive clean-up days in summer time.

The following table shows volume of remaining waste at Syowa Station:

Items of remaining wastes at Syowa	Weight (ton)
Snow vehicles, trucks, sledges	120
Scrap such as steel pipe	100
Empty fuel drums	12
Building materials	73
Instruments for scientific observation	22
Waste oil （lubricant, antifreeze）in drums (50 cans)	10
Total	337

Figure 4 Waste snow vehicles and sledges around Syowa Station

The plan to return the waste to Japan is as follows:

	46th - 2005	47th - 2006	48th - 2007	49th - 2008	Total
Remaining wastes	113.7	118.1	59.7	0	291.5
New wastes	86.3	81.9	129.2	142.2	439.6
Total	200	200	188.9	142.2	731.1

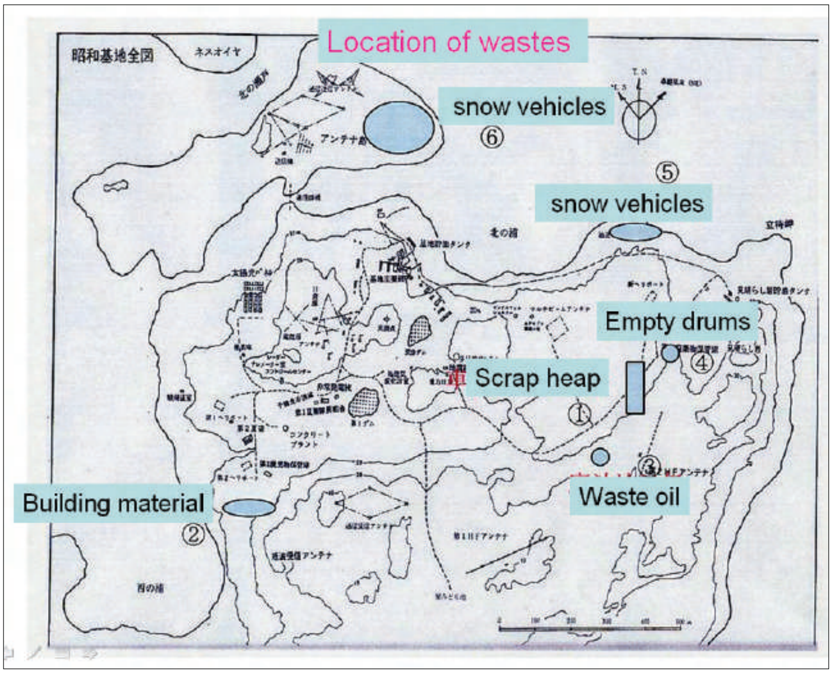


Figure 5: Locations of wastes around Syowa Station

Figure 6: Waste packed for return to Japan

In addition to the removal of waste, intensive clean-up days are undertaken by station personnel over the summer period.

Figure 7: Intensive Clean Up Days

Landfill at Syowa Station

From 2009, we intend to start a clean-up program for the landfill at Syowa Station.

Figure 9: Landfill at Syowa Station

Removal of Wastes at Inland Stations

Waste remains at the inland Asuka Station, which was inhabited by wintering parties over five years from 1987 to 1991. Asuka Station is located at approximately 71.5° South and 24° East. With an altitude of 930m, the annual average air temperature is -18.3°. The annual average wind speed is 12.6 m/s, while the wind direction is East-South-East.

Figures 9 and 10: Waste snow vehicles and fuel drums at Asuka Station

The waste to be removed is as follows:

Waste to be Removed from Asuka Station	
Snow vehicles: SM50×5	6 tons×5=30 tons
Snow vehicles: SM40×4	3.5 tons×4 =14 tons
Mini-bulldozer: 1	2 tons
Snow blower: 1	0.2 ton
Mini-crane with rubber tracks: 1	3 tons
Snow vehicle (mini):15	2.5 tons
Battery, timber, pipes, lubricant oil	30 tons
Empty fuel drums: 350 pieces	10 tons
Total weight	91.7 tons

The proposed clean up program for Asuka Station is proposed to commence in 2009-10, following the commencement of service of the new ship “Shirase”.

11. Progress Report on the Clean-up of the Thala Valley Tip at Casey Station, Australian Antarctic Territory

Leslie Frost, Australian Antarctic Division

Abstract

The Thala Valley waste disposal site at Casey Station operated from 1965 to 1986 as a dumping and incineration site for domestic and construction wastes. It was abandoned in 1986 and since 1988; all solid waste from Casey has been incinerated or returned to Australia for disposal.

A decision was taken to use the site to develop clean-up techniques that have no greater adverse impact on the environment than leaving it *in situ*, and, of course, to meet Australia's obligations under the Madrid Protocol to clean up abandoned waste disposal sites to reduce overall environmental impacts. An Initial Environmental Evaluation (IEE) was produced in early 2003 and clean-up activities commenced in the summer of 2003-04, the first season for a period of ten years. Over the last two seasons, the condition of the resulting environment has been monitored to detect any adverse impacts caused by clean-up activities and to evaluate the effectiveness of mitigation measures.

Outline

- Introduction
- Planning and Preparation
- Excavation and Removal Operations
- The Next Stages
- Conclusion
- Information Sources

Introduction

The *Antarctic Treaty (Environmental Protection) 'Act 1980* is the enabling legislation for the Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol). Annex III to the Protocol deals with waste disposal and waste management for all activities undertaken in the Antarctic Treaty area.

The Environmental Management System (EMS) of the Australian Antarctic Division (AAD) is certified to an international standard (ISO 14001:2004) for all of its sites and activities in Australia, the subantarctic and the Antarctic. To fulfil the intent of AAD's Environmental Policy and the EMS, the AAD establishes, maintains and reviews environmental objectives, targets and management programs to prevent and minimise pollution, waste and other human impacts on the environment. One of those targets is the clean-up, remediation and monitoring of the old Thala Valley tip site.

The Thala Valley waste disposal site at Casey Station operated from 1965 to 1986 as a dumping and incineration site for domestic and construction wastes. It was abandoned in 1986 and since 1988; all solid waste from Casey has been incinerated or returned to Australia for recycling or appropriate disposal.

A decision was taken to use the site to develop clean-up techniques that have no greater adverse impact on the environment than leaving it *in situ*, and, of course, to meet Australia's obligations under the Madrid Protocol to clean up abandoned waste disposal sites to reduce overall environmental impacts. An Initial Environmental Evaluation (IEE) was produced in early 2003 and clean-up activities commenced in the summer of 2003/04, the first season for a period of ten years. Over the last two seasons, the condition of the resulting environment has been monitored to detect any adverse impacts caused by clean-up activities and to evaluate the effectiveness of mitigation measures, before attempting to remove the remaining material from the site.

Planning and Preparation

Thala Valley was selected as a priority for clean-up for two major reasons:

- earlier *ad hoc* attempts at clean up and remediation caused erosion and leaching of contaminants from the tip site into Browns Bay, resulting in lower diversity of marine life compared to nearby inshore marine areas; and
- it was a relatively small site and could be used to develop and test techniques for application on a larger scale, such as the potential clean up of the old Wilkes Station near Casey.

Pre-planning included detailed site assessments, shipping and container design requirements, time-frames and operational requirements. An IEE was prepared in accordance with Annex I to the Madrid Protocol and the project was approved. An Environmental Management Plan was prepared that took into account Australian legal requirements for occupational health and safety, quarantine and contaminated waste disposal.

Risk assessment indicated that the potential for adverse effects arose from the drainage of contaminated meltwater and leachate into Browns Bay, and increasing the footprint of contamination and disturbance through the movement of vehicles on and off-site. Plans to mitigate these risks included the construction of diversion channels for meltwater, holding ponds for leachate and a water treatment plant. The site was designated a controlled area and all vehicles had to be washed down before leaving the site to prevent transport of contaminants off-site.

The monitoring program was designed to test whether removing the waste caused greater adverse impacts than leaving the material *in situ*. Each season, meltwater drains from the plateau through the Thala Valley and the tip site to the accumulating environment of Browns Bay. Short, medium and long-term monitoring programs were designed and implemented to identify any adverse affects on marine life and the sea-bed in Browns Bay from tip site disturbance and subsequent mobilisation of contaminants through meltwater and leachate.

Excavation and Removal Operations

After several years of planning and preparation, excavation work began early in the 2003/04 summer season. Diversion channels were constructed to guide meltwater into Thala Valley around the excavation site. Sediment barriers and holding ponds were made so that water could be treated before being released to Browns Bay. All vehicles went through wash down before leaving the site. The ‘tip team’ wore personal protective equipment and observed safety procedures.

Over 1000 cubic metres of contaminated waste were loaded into special containers and returned to Australia for safe disposal. At least 1000 cubic metres remains stockpiled on the Thala Valley tip site, protected from meltwater by diversion channels, a geofabric/membrane barrier and bunding. Monitoring has been undertaken over the last two seasons to determine the effectiveness of these measures.

Figure 1: Thala Valley tip site from the air

Figure 2: Brown Bay below the Thala Valley tip site

Figure 3: Loading the last container of waste from the tip in 2003-04

Figure 4: Containers at the Hobart wharf used to provide a quarantine enclosure for receiving and treating contaminated waste from Thala Valley

Figure 5: Loading remediated waste for transport to safe disposal site

The Next Stages

The Australian Quarantine and Inspection Service and the AAD are working together to develop further risk assessments for treatment, transport and disposal of the remaining material to other deep burial locations in Australia. Depending upon these risk assessments and the results of monitoring programs, it is planned to return the rest of the stockpile from Antarctica to Australia in coming seasons. Further monitoring of Browns Bay and rehabilitation of the old tip site will hopefully conclude this project within the planned ten year timeframe.

Conclusion

While excavation of the tip site was relatively straightforward, meeting the requirements of the Madrid Protocol and Australian Antarctic legislation greatly increased the complexity. The measurement of environmental performance using monitoring programs is costly and time consuming, especially if undertaken in a comprehensive manner to ensure that any adverse impacts are detected and resolved. Ideally, complete excavation and removal of the site in one season would reduce risks from prolonged exposure of contaminated sites, but this has been shown to be difficult to achieve, even for a relatively small site, and likely to be impossible for a larger site given time and resource limitations.

Information Sources

ATCM XXVII Information Paper for CEP 4(e), submitted by Australia

Various reports on file, audit reports and personal communication with AAD staff

12. Partnerships – Can they Benefit Clean Up Activities in Antarctica

John Brennan, Veolia Environmental Services

Abstract

Corporate philanthropy and collaboration between government agencies, environmental regulators, scientists, tertiary institutes, logisticians, manufacturers, technologists and service providers were the key ingredients for the success of the first stage clean-up of the abandoned landfill located at Thala Valley, Casey Station.

The learning outcomes of the clean-up will be shared.

Outline:

- Who is Veolia Environmental Services (VES)?
- Why Support Antarctic Clean-Up?
- Whom Do We Support?
- Case Study – Thala Valley
- Learning Outcomes
- Water Treatment
- Overall Outcomes
- Conclusion

Veolia Environmental Services

Veolia is No. 2 in the world for waste management and cleaning services and is active in 34 countries. With 71,000 employees worldwide serving 50 million people, Veolia has 350,000 industrial and tertiary sector customers, and collects $12 billion in revenue (2005). In total, 33 million tons of waste is collected by Veolia Environmental Services, and 52 million tons of waste is treated.

Why Support Antarctic Clean-Up?

Antarctica is important to all of us as a global community. Environmental philanthropy is aligned with the business of Veolia Environmental Services.

A goal of Veolia Environmental Services is to provide an international platform for a sustainable solution to assist with:

- Rehabilitating contaminated sites; and
- Reducing human impacts.

Our support is aimed at sharing “know-how” and resources between Veolia Environmental Services and Antarctic nations.

The aim is not just to provide funds - but to use the strengths of Veolia Environmental Services to achieve a truly global outcome (e.g. research and development).

Whom Do We Support?

Our first clean-up initiative commenced in 2000-01 between Veolia Environmental Services and the Australian Government Antarctic Division (AAD) for the Thala Valley project.

Veolia has now signed agreements of philanthropic partnership with:

- Australia;
- France; and
- Chile.

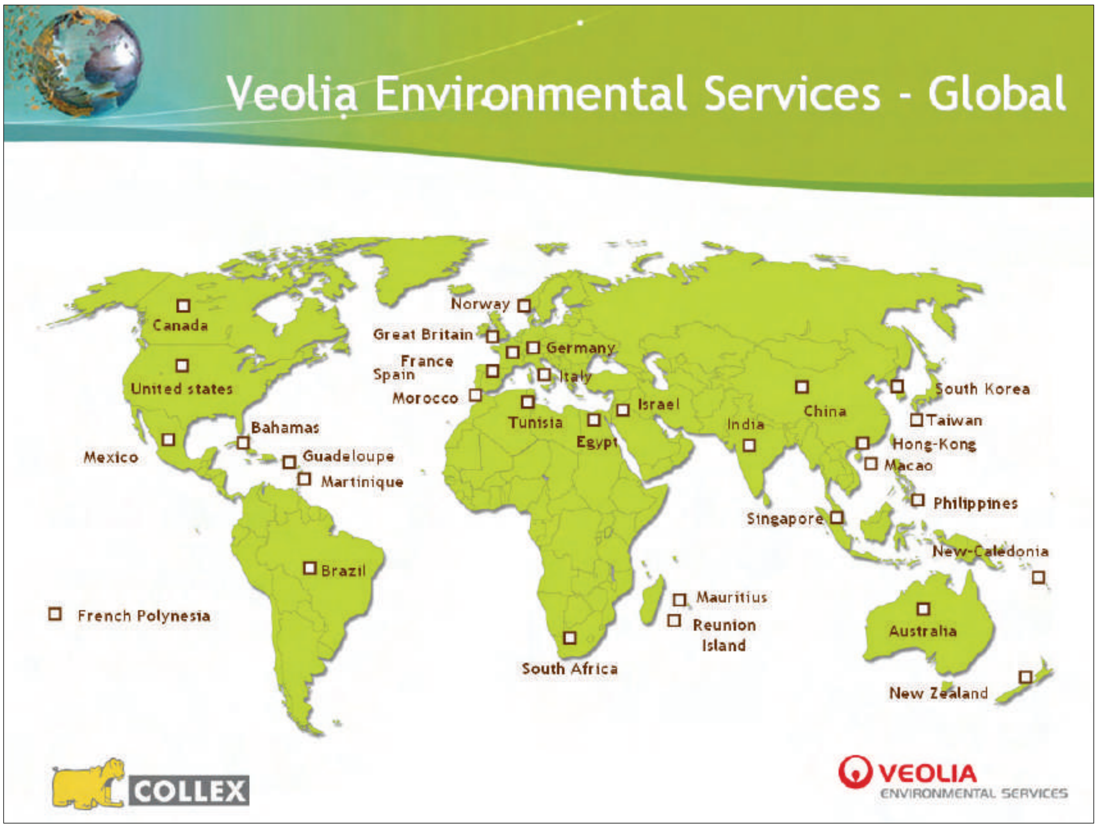


Figure 1: Global locations of Veolia / Collex

Case Study – Thala Valley Clean-Up

The AAD had a project that was ready to commence – remediation of the Thala Valley land fill near Casey Station, Antarctica.

<u>Philosophy</u>

Annex III, Article 1 of the Madrid Protocol stipulates that obligations to clean-up/remove historical waste/contamination are not applicable under the following conditions:

- If heritage value is affected; and/or
- If greater environmental degradation will be caused by the removal of waste than if waste is left in place.

The aim of the Thala Valley clean-up was to reduce contaminant levels in soil to levels as low as practicably possible, and leave the site in a state where the dispersal of residual contaminants will not cause environmental harm.

Figure 2: The site of Thala Valley Landfill, adjacent to Brown Bay, near Casey.

Figure 3: Waste at Thala Valley

Facts and Figures

Casey is located 3422 km from Hobart, on the coastal fringe of the east coast of Antarctica, a most sensitive and ecologically diverse part of Antarctica. Thala Valley is located 500 m NE of Casey.

There is a legacy of historic activity which does not reflect current best practices (RTA) in terms of waste management. This has resulted in heavy metal contamination in Thala Valley soils and the adjacent water of Brown Bay, and its marine benthic sediments and communities.

The Thala Valley site footprint is approximately 0.15-0.30 ha with approximately 1600-2500 m^3 of waste and contaminated soil.

Stakeholders

Stakeholder interests in the project included:

- Science – Human Impacts Program (AAD) & Melbourne University and Macquarie University in Australia;
- Operations – Engineering and Logistics Sections of the AAD;

- Politics/budgets – Australian Government at the federal level;
- Philanthropy – Veolia; and
- Regulators – Environmental and quarantine at the state and federal government levels.

There was real potential for stakeholder conflict due to their different project goals, backgrounds and agendas.

Waste Containers

The main philanthropic commitment from Veolia Environmental Services was the supply of 240 purpose-built waste containers to ship excavated waste back to Australia. The value of this commitment was $2 million AUD.

By arrangement, these bins are available for use by other countries should the need arise.

Figure 4: Waste Containers provided by Veolia Environmental Service for use at Thala Valley

Strategy and Communication

Years of collaborative research and logistical preparation was invested:

- AAD – between internal sections (Human Impacts research & Engineering/Logistics);
- Regulators - with environmental & quarantine services;
- Collaborative research with other institutions – e.g. Melbourne University and Macquarie University; and
- Industry – philanthropy – e.g. containers, technical support and research donated by Veolia Environmental Services.

A holistic approach was developed for waste extraction, which included requirements for the completion of the following:

- Initial Environmental Evaluation (IEE);
- Environmental Management Plan;
- Occupational Health and Safety Plan; and
- The employment of specific clean-up crew, with implications for multidiscipline input, consultation, training etc.

Clean-up options considered by AAD included:

1. Ad hoc/opportunistic extraction;

2. Limited extraction of high risk areas;
3. Complete staged extraction, including progress assessment and the development of procedures for future Antarctic clean-ups; and
4. Clean-up as quickly as possible.

Issues Identified for Risk Control

The major issue identified was off-site migration of contaminants (heavy metals) during excavation.

It was recognized that there was a likely risk of transitory movement of contaminants into Brown Bay from extraction of contaminants in Thala Valley. Risks and mitigation strategies were assessed as follows:

- The short term impact to Brown Bay was considered to be less than *long term* if contaminants/waste were left in-situ. Such a scenario would be monitored.
- Appropriate controls would be adopted to reduce identified impacts; and
- Remain flexible but at the same time develop procedures for future Antarctic and cold climate contaminated site clean-ups.

Learning Outcomes – On the Ground

Specific learning outcomes from excavation activities:

Issue	Learning Outcome
Minimise soil disturbance	Chemical monitoring program to determine excavation boundaries
Mitigate contaminant dispersal	Excavate while frozen – before melt (hydraulic hammer versus ripper) Diversion channel around site – do as early as possible before melt Option for the instillation of impermeable barrier/booms Specialised water treatment plant for particulate/dissolved metals
Minimise air emissions	Excavate frozen or when waste wet and monitor. Covers or wetting
Disturbance to drainage patterns	Acceptable transitory impact to mitigate contaminant migration during extraction and storage
Vehicle usage/waste storage where other aspects identified with a suite of mitigation measures adopted	Allocated vehicle access routes – *stick to the routes* Specialised waste containers – *sealed and covered* Allocated storage sites for waste containers – *store and log*

Learning Outcomes – Chemical Monitoring

Issue	Learning Outcome
Dedicated on-site chemical validation/assessment team to provide strategic response to operations	Critical and successful part of operation: so important for feedback and operational efficiency
Comprehensive documented sampling and analytical strategy	Validation techniques to meet statutory requirements /standards
What contamination levels should be adopted for the clean-up? (No specific clean-up guidelines for the Antarctic region)	Decision to go as low as practicably achievable towards Antarctic background levels, with cut-off levels meeting state government environmental regulator "Clean Fill" requirements.
Adopt a conservative strategy to cater for waste heterogeneity and the "unknowns" – precautionary principal	1 sample (composite of 3) per 5m^3 of soil versus 1 sample per 25 m^3 as required by regulator Examine <2mm fraction for leachable metals versus 9.5 mm fraction as required by USEPA Duplicates forwarded for independent verification
Chain of custody – auditable procedure	Sampling database – track every sample from Antarctica to Australia Waste grading database – donated by Veolia to track waste containers and grade waste against regulatory contaminated soil requirements – "cradle to grave" documentation

Figure 5: View east to Brown Bay from Dump Site October 2003

Figure 6: Excavation of frozen waste from Thala Valley

Figures 7 and 8: Excavation Site and Frozen Wastes in Container

Water Treatment

A partnership was developed with the University of Melbourne and AAD to manage;

- Melt water from within the excavation over the summer melt;
- Snowfalls within the area from blizzards;
- The treatment of mobile contaminants (e.g. lead) attached to suspended particulates; and
- The treatment of melt water pumped from bins.

A mobile plant was installed on site – which included caustic buffering, ferric chloride flocculation and particle separation in a solids separator.

A program was also instigated for monitoring water quality into and out of the plant.

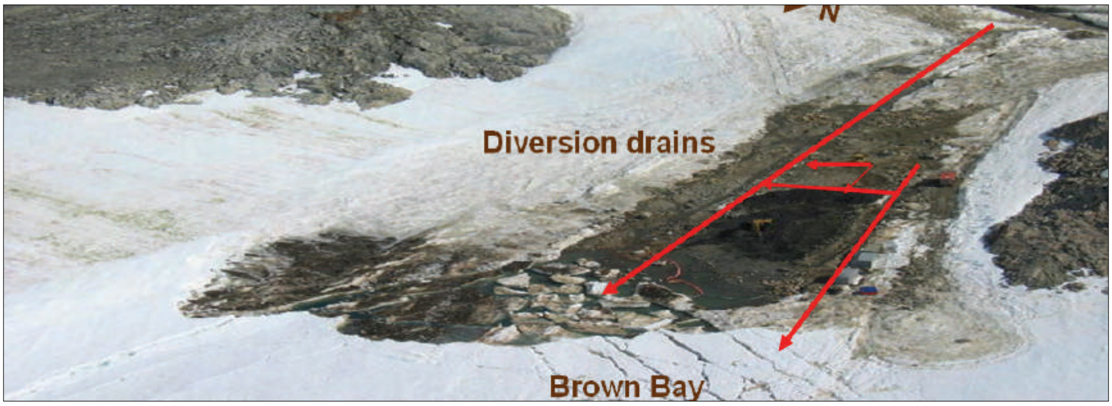


Figure 9: Aerial view of site drainage Feb 2004

Overall Outcomes

Overall outcomes for the project:

1. 235 containers containing approx. 1000 tonnes of waste and contaminated soil returned to Australia for remediation;
2. Approximately 250,000 litres of contaminated water was successfully treated on-site;
3. Approximately 1000 tonnes of soil was excavated and stockpiled - bunded on geofabric / bentonite & covered with plastic for 2004-05 season;
4. Heavy metal validation confirms the successful excavation of contaminants from site as was required by the IEE; and
5. Short, medium and long term biological and physical monitoring was implemented and interpreted successfully to gauge the effectiveness of controls and level of transitory impacts.

Conclusion

The challenges overcome included:

- Competing interests;
- Remoteness/logistical aspects (i.e. excavation/bins/shipping); and
- Limitations of working in a cold climate.

A collaborative approach by many stakeholders was harnessed in the interests of achieving a beneficial outcome. In addition, learning outcomes can be applied to other remote cold climate clean-ups.

Partnerships – can they benefit clean-up activities in Antarctica? ………………….YES

Is there application for future projects? ………..OF COURSE

IT IS possible to build bridges between different stakeholders: Government / Policy / Science / Operations / External Research Organisations /Industry

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Thank you to AEON / COMNAP

13. Cleaning-Up Past Activities at Sites by the Uruguayan Antarctic National Program

Aldo Felici, Uruguayan Antarctic National Program

Abstract

This paper outlines efforts by the Uruguayan Antarctic National Program in accordance with Annex III, Art. 1, par. 5, and Art. 8, par. 2(a), Environmental Protocol.

Figure 1: Uruguayan Helicopter and Logistic Ship removing waste from Antarctica

Seasons 1998 to 2001 – Cleaning-up from Past Activities at Sites at ECARE (Estación Científica Antártica T/N Ruperto Elichiribehety) (Transferred 1997 by U.K.)

Location:

Lat: 63º 24´.1 S

Long: 56º 58´.4 W

Hut Cove, Hope Bay, Antarctic Peninsula

Removed material corresponding to past British Antarctic activities:

- Group 3: Canvas and timber; and
- Group 4: Treated timber, plastics, rubber, metals, glass, and concrete remains.

Cleaning activities:

- Classification, storage and withdrawal of found items in the surrounding area of the station.

Personnel and means involved:

- ECARE crew, supported by helicopter of Uruguayan Air Force and logistic ship of Uruguayan Navy.

Effort:

- Working days, 1000 hours/men, 6 hours of Uruguayan Air Force helicopter flight. 32 m^3 waste removed.

Note:

All items were removed from Antarctic Treaty area by Uruguayan Navy logistic ship *Vanguardia* in two stages: 16 m^3 waste in 2000 and other 16 m^3 in 2001.

Seasons 2000-2001 – Cleaning-up from Past Activities at Sites at Collins Glacier

Location:

Lat: 62º 09´.9 S

Long: 58º 53´.4 W

Collins Glacier, minor dome

Removed material corresponding to Uruguayan investigation activities:

- Group 3: Canvas and timber; and
- Group 4: Pipes and other metallic items.

Removed material corresponding to undetermined origin activities:

- Group 3: Timber and wooden boxes; and
- Group 4: Remains of wooden and metallic sledges.

Cleaning activities:

- Classification and withdrawal of own and (unknown) found items.

Personnel and means involved:

- BCAA crew in collaboration with Great Wall (Chinese base) crew; and
- Helicopter of Uruguayan Air Force and logistic ship of Uruguayan Navy.

Effort:

- working days, 700 hours/men, 5 hours of Uruguayan Air Force helicopter flight, 650 kg weight removed.

Note:

All items were removed from Antarctic Treaty area by Uruguayan Navy logistic ship *Vanguardia* in 2001.

14. Clean Up operations at Marambio Station (Argentina). More than a decade after their start

Rodolfo Sánchez, Dirección Nacional del Antártico (Argentina)

Abstract

After the Madrid Protocol was ratified by Argentina (1993), efforts were initiated to improve the environmental quality of their Antarctic stations. The main focus was directed on Marambio Station, the largest Argentine Antarctic facility. By 1995, an environmental analysis ("Environmental Review of the Argentine Activities at Marambio Station") was prepared. Preliminary results stemming from this study indicated the need for implementing a clean-up program for historic wastes. As a result, a removal plan for historic wastes was initiated in 1995, which included unearthing, classification and evacuation of a very large volume of wastes around Marambio's main facilities. In addition, removal of large accumulations of discarded fuel drums from different areas of Marambio (Seymour) Island also began at that time. The environmental review also promoted the implementation of a monitoring program, which started in 1998 and continued until 2001. Monitoring activities were primarily focused on the identification of water and soil pollution processes.

After more than a decade, the clean-up program at Marambio Station is still active, and more than half of the historic waste deposits identified in 1995 have already been removed. In spite of the success of this clean-up project, a number of economic, operational and institutional issues resulted in certain difficulties which slowed progress. Apart from the removal of old wastes and its positive impact on the environment around Marambio Station, lessons learned from the process have increased environmental awareness among field operators and decision makers, and developed a stronger commitment to environmental concerns. In 2003, this resulted in the ISO 14001 certification of an Environmental Management System for Marambio Station. Given this scenario, and the difficult operational conditions in which this project is being undertaken, it is foreseen that clean-up operations at Marambio Station will still take several years. The clean-up of these sites represents a major logistical challenge for the Argentine Antarctic Program, but a significant step forward in restoring a highly disturbed landscape in Antarctica.

Outline

- The Scenario
    - Geographical Setting
    - Marambio Station
    - Wastes at Marambio Station
    - Impacts Caused by Old Waste
- The Clean-up Program
    - Identification of the Need to Instigate Clean-Up Operations
    - Clean-Up: Criteria for Prioritisation for Evacuation
    - Description of Clean-Up Activities
    - Monitoring Scheme
    - Monitoring Activities
    - Training Activities

- The Future
    - Planned Future Activities
    - Costs
- General Assessment
    - Achievements
    - Problems Found During Clean-Up Operations
    - Lessons Learned

The Scenario

Geographical Setting

Marambio Station is located in the northeast of Marambio Island (Seymour Island, in English literature), which is situated at 64°14' S, 56°39' W. It belongs to the James Ross Islands Group, approximately 100 km to the southeast of the northern tip of the Antarctic Peninsula, in the Weddell Sea. No glaciers and the absence of permanent snow accumulation during summer are outstanding features of the island.

The station lies on a plateau 3 km long and 1 km wide, with its highest point 210m above sea level. The landscape dips gently to the east down to a height of 190m above sea level. Station facilities are situated between 195m and 210m above sea level, covering an area of approximately 0.6 sq km.

Flanks of the plateau, on which Marambio Station is located, are composed of poorly to non-consolidated silts and sands. The top of the plateau is covered with a conglomerate consisting of large boulders (up to $3m^3$) within a matrix of very fine sand and loam, with a maximum thickness of 5 metres or less. The non-consolidated, fine-grained nature of the sediments, in conjunction with the steep slopes found in the island, and its particular weather characteristics, create conditions very conducive to erosion processes. This fact becomes particularly significant when analysing the effects of human activities, which may cause even further degradation.

At Marambio Island, some plant communities are present, although these are not extensive and consist of one or very few species. Fauna is very scarce on the island. While some Weddell seals haul out in summer, birds are restricted to an Adelie penguin rookery, situated 8 km south from Marambio Station, and some scattered nesting seagulls and Antarctic terns. Interaction between fauna and station is negligible.

Marambio Station

Marambio Station was founded on October 29th, 1969, and is run by the Argentine Air Force. Marambio has been the first Antarctic station with a consolidated-ground airstrip, which is currently one of only three gravel runways in the Antarctic Peninsula area, the others being at Rothera Research Station (UK) and Teniente Marsh (Chile). The length of the airstrip, after some enlargements, is 1200m, which allows operation of large cargo flights, like Hercules C-130 aircraft. For the Argentine Antarctic Program, Marambio Station represents the main logistic support centre for scientific activities.

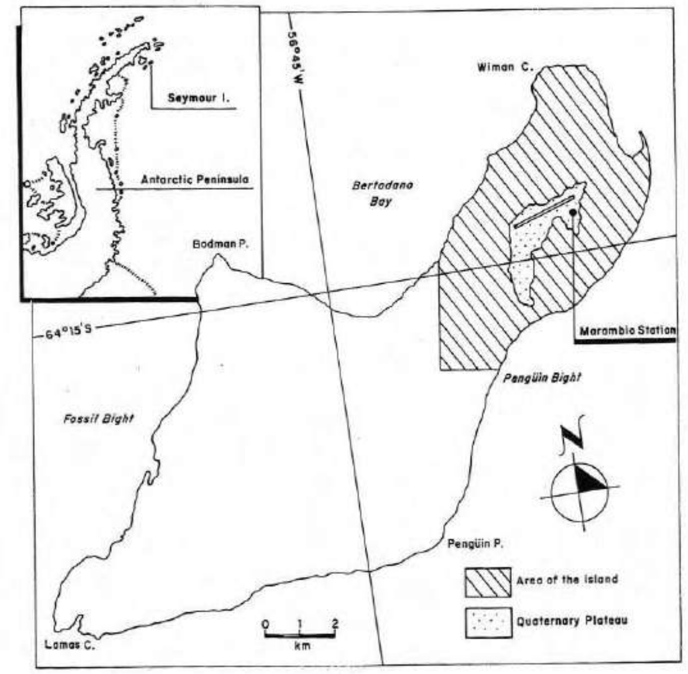

Figure 1: Location of Marambio Station

Over time, Marambio Station has undergone continuous growth. At present, it is composed of some 20 buildings, and a number of metallic, roofless platforms and fuel tanks. Most buildings are elevated on steel supporting piles driven into the permafrost. Buildings and facilities are interconnected by elevated walkways, which are decked with extruded aluminium panels and provided with hand rails. Pipe work and electrical wires are supported beneath these walkways. Vehicle tracks consist of compacted terrain.

The winter population averages 40 people while the summer population is around 120. At Marambio Station, a range of air operations take place. A Twin Otter 200 operates permanently at the station to connect it to other Argentine stations. In summer, two helicopters, Bell 212, also operate at the station, providing logistic support for research activities. Hercules C-130 aircraft are the only means of passenger and cargo transportation, either from Rio Gallegos or Ushuaia to Marambio Station. Flights are usually once a month, but tend to increase in summer.

Wastes at Marambio Station

Since its foundation, intense logistic activities at Marambio Station have generated a significant amount of waste. During the first two decades of operations, wastes were disposed of on-site. Waste accumulated over the surrounding areas, forming large outdoor rubbish tips, resulting in a slow but continuous accumulation of negative effects, mainly on the landscape around Marambio. Some of these wastes, scrap and other residues, accumulated near the station, while others, particularly fuel drums, were transported away from the area of the station by gravity force, hydraulic action and backward erosion. Eventually, some of the drums reached the shoreline, after sliding through valleys and gullies.

Impacts Caused by Old Wastes

A series of environmental impacts were generated by the dispersal of historic wastes, with their effects going beyond station boundaries. A large accumulation of residues may have affected the environment, particularly in terms of aesthetic impacts and the chronic pollution of bodies of water.

Specifically, impacts were observed on the following values:

- Landscape: Historic waste dispersal was the only activity with major potential for landscape deterioration. Due to their slow rate of decomposition, the large number of drums, filled with a variety of different wastes, have become a permanent feature on some slopes of Marambio's plateau. Impacts of wastes on landscape could therefore be considered "permanent" and "general".
- Water bodies: Organic wastes were the main water-contaminating agents, as they contained substances able to modify nutrient levels in the water. Impacts on water bodies are regarded as "localized" and "transitory". Their localized nature permitted the adoption of measures to avoid further dispersion and impact on areas as yet undisturbed.
- Flora: Pollutants derived from waste leaching can be taken up by plants and incorporated into their tissues. Such a situation would be determined as a long time span ("permanent" impact), even after discharges had stopped. However, impacts of waste deposits scattered over the island on vegetation, depends on the distribution and composition of the wastes. Therefore, these wastes should be considered to be on a local scale.

Figure 2: Wastes around Marambio Station

Figure 3: Wastes around Marambio Station

The Clean-up Program

Identification of the Need to Instigate Clean-Up Operations

After the Madrid Protocol was ratified by Argentina (1993), efforts were initiated to improve the environmental quality of their Antarctic stations. The main focus was directed towards Marambio Station, the largest Argentine Antarctic facility. By 1995 an environmental analysis of the human activities in Marambio Station was in preparation.

The "Environmental Review of the Argentine Activities at Marambio Station" (Agraz et al, 1998), presented at CEP I as IP 49, proposed a number of management measures to improve the environmental situation around Marambio Station. In particular, the most relevant proposals were focused on the implementation of a clean-up program for historic wastes. Updates of this work were presented in CEP II (IP 90, Lima 1999) and in CEP VI (IP 43, Madrid, 2003)

Clean-up Activities Undertaken Around Marambio Station - Criteria for Prioritising Evacuation

Before starting clean-up activities of old waste dumps, the following criteria were kept in mind:

1. Priority was given to areas of high-density, scattered wastes, particularly waste deposits.
2. Areas close to water streams were also prioritized, since they were prone to be rapidly washed, and wastes could therefore be incorporated easily into drainage systems. This situation could have worsened during times of thaw.
3. In the long term, organic, non-biodegradable wastes contained in old drums constituted, the most dangerous impact on the environment. Such wastes were therefore prioritized when planning evacuation.
4. Waste deposits were found in different conditions: at the surface, partially buried and completely buried. Priority was given to those deposits at the surface, due to the relative ease of clean-up. As time passes, these wastes would become buried, and so make clean-up operations more difficult.

Description of Clean-up Activities

Clean-up measures have been carried out on waste deposits in the proximity of the station as part of the routine activities of the station staff. On occasions, groups have been commissioned to specifically undertake such tasks.

Once a waste deposit has been identified, clean-up operations consist of manual removal of drums and other wastes from the ground. These wastes are then taken to flat areas, grouped in small clusters, and secured with rope nets to avoid wind dispersion. Wastes are transported by helicopters to the station, from where they are evacuated back to Argentina, either via the icebreaker *Irizar* or on Hercules C-130 flights.

These clean-up tasks involve a range of operational difficulties due to the particular terrain - the presence of steep slopes - and ground conditions of the area. Concerning the latter, the sandy silts of Marambio's slopes are prone to changes in their hydrological states, which, in turn, are controlled by weather conditions. These may vary from year to year, and within a particular season. Hence the conditions differ according to the year/ time of season under consideration. As a consequence, clean-up operations at Marambio Station may pose certain risks to the personnel involved.

Thanks to the clean-up activities, more than 20 waste deposits have been completely removed. This accounts for more than 50% reduction in the volume of old waste deposits around Marambio Station. In addition, waste classification and clustering activities have been undertaken in some other areas to facilitate removal in the future.

Figure 4: Before clustering activity

Figure 5: After clustering activity

Figure 6: Clean Up Activities – on site removal

Figure 7: Wastes ready to be evacuated

Figure 8: Wastes being evacuated

<u>Monitoring Scheme</u>

Monitoring indicators have measured two sources of environmental disturbance in the Marambio Station area: existing and past activities. The fact that the products of these activities may, on occasions, overlap adds certain disturbance when attempting to distinguish between the effects of those management measures taken to deal with existing activities, and those taken to approach past ones, particularly noting that, at that time, environmental concerns were not an issue. However, it is expected that the results of a continuous monitoring program might reflect, over time, a gradual dilution of impacts due to past activities. Therefore, in the future, monitoring would exclusively focus on existing activities.

Past activities relating to waste disposal and fuel management have produced a number of negative, on-going impacts. These effects usually overlap to produce an even greater impact than the same activities do today. In this case, relationships between action, output and its associated impact are not always evident.

Establishing a monitoring plan presented an additional difficulty, due to the absence of baseline information to define an “initial environmental situation” (or undisturbed scenario). This was necessary to compare monitoring results, and thus determine the level of impact of a given activity. Consequently, prior to designing the Environmental Monitoring Program for Marambio Station, baseline information on certain environmental values of the area had to be collected. Studies were conducted in a range of areas, including hydro-geologic system behaviour, plant taxonomy and vegetation inventories, soil mapping, characterization and comparison of drainage micro-basins, as well as estimations of fluvial sediment transport indexes, among others.

Research was also undertaken to determine appropriate methods for fresh water and soil sampling in polar climates, with particular emphasis on monitoring and other hydrological studies.

At the same time, undisturbed sampling sites (i.e., non-exposed sectors), which resembled the original situation, were recognized as sites with potential for comparison. Determination of the magnitude of impact could only be achieved if ascertaining - or at least estimating - ranges of the natural variability of the parameters involved. Therefore, establishing a system of coupled-sampling (disturbed-undisturbed) was deemed appropriate.

Monitoring Activities

During the 1997-98 summer season, a network of 17 monitoring wells was built in the station area, their location selected according to their vulnerability to pollution processes. Three additional monitoring wells were installed in an undisturbed area of the plateau, to be used as a basis for comparison.

The monitoring program started during the 1998-99 summer season, and consisted of the collection and pre-processing of water samples, both from surface and shallow underground systems. Pre-processing consisted of qualitative field analysis. Samples were also sent to laboratory, in order to quantify field data. Analysis determined major ions (chloride, sulphide, alkalinity and hardness), total hydrocarbons and heavy metals. Periodical readings of water depth, water temperature, water conductivity and pH have also been carried out. Geo-electrical profiles were also undertaken, so as to detect the presence of likely past landfills.

Soil samples were taken in different locations over the plateau for leachate analysis.

Training Activities

In addition to the field activities described above, before their departure for Marambio Station, staff members are trained on environmental issues as part of a broader training course. Such activities, which have been undertaken since 1997, are focused on waste management in general, and particularly on the clean-up operations.

The Future

Planned Future Activities

A three-year plan has been designed to prepare and remove an estimated 1600 m^3 of the remaining old wastes from Marambio Station and its surrounds, which would account for most of the identified old waste deposits. However, this plan is subject to the availability of financial and technical resources. A less optimistic scenario would result in a 6 year time frame.

The original plan was developed according to the following schedule of activities:

Planned Schedule		
Year 1	**Year 2**	**Year 3**
1.1. Update inventory of old wastes. Assessment of previous removal activities. Implementation of further management measures.	Assessment of previous removal activities. Implementation of further management measures.	Assessment of previous removal activities. Implementation of further management measures.
1.2. Clustering of 50% of remaining waste deposits on site.	Clustering of 50% of remaining waste deposits on site.	---
1.3. Waste clusters to be transported to Marambio Station with the use of helicopters. First stage:	Waste clusters to be transported to Marambio Station with the use of helicopters. Final stage: estimated 20 hrs	

Planned Schedule		
Year 1	**Year 2**	**Year 3**
estimated 20 hrs		
1.4. Wastes to be compacted, stored and labelled to facilitate access to Hercules C-130 (or icebreaker *Irízar*).	Wastes to be compacted stored and labelled to facilitate access to Hercules C-130 (or icebreaker *Irízar*).	Wastes to be compacted stored and labelled to facilitate access to Hercules C-130 (or icebreaker *Irízar*).
1.5. Air transport Marambio - Argentina (estimated 4-5 flights)	Air transport Marambio - Argentina (estimated 4-5 flights)	Air transport Marambio - Argentina (estimated 4-5 flights)
1.6. Final disposal of old wastes	Final disposal of old wastes	Final disposal of old wastes

Costs

The estimated associated costs for this three-year clean-up plan for Marambio Station are summarized in the following table. Activities shown are linked to the previous table:

Budget (U$S Dollars)				
Activity	Year 1	Year 2	Year 3	Total
1.1	5.000	5.000	5.000	15.000
1.2	10.000	10.000	--	20.000
1.3	30.000	30.000	--	60.000
1.4	5.000	5.000	5.000	15.000
1.5	64.000	64.000	64.000	192.000
1.6	20.000	20.000	20.000	60.000
Total	134.000	134.000	94.000	362.000

General Assessment

Achievements

The whole clean-up process that is currently taking place at Marambio Station and surrounding areas has followed a sequence of events based on a planned, written strategy – the Environmental Review. This document has played a key role and represents a significant step forward, helping decision makers to approach Antarctic logistics in terms of environmental concerns, with increased awareness of the problems. It was the Environmental Review which generated consideration of a certification process for the operations of the whole station. Eventually, in September 2003, an environmental management system for Marambio Station was awarded certification to ISO 14.001. This situation bodes well for the future, particularly with regards to increasing opportunities for external funding for clean-up operations.

The enhancement of the environmental conditions at Marambio Station and its surrounds has been a direct consequence of this clean-up program, and it is the most significant outcome.

In addition, another major achievement was that information on this process was subsequently provided to the ATS. The Environmental Review itself, and its updates, were presented at CEP meetings. Such a connection between field operators and the ATS gave a higher profile to the process, and thus encouraged further work and commitment from the station operators.

Finally, on February 25th 2005, Marambio Station was inspected under the provisions of Article VII of the Antarctic Treaty, by a joint team led by British, Australian and Peruvian inspectors. The inspection report highlighted Marambio Station as an example of best practice in waste management, and in particular, noted the clean-up operations in process.

Problems Found During Clean-Up Operations

In spite of the success of this clean-up project, throughout its development a number of economic, operational and institutional issues hampered progress. Among these, the following were noted:

The deep economic crisis that Argentina faced in December 2001 negatively impacted on the availability of resources for Antarctic operations. Therefore, maintenance operations and research activities were prioritized and clean-up operations were necessarily relegated to second place. As an example, during the following two seasons after the crisis, helicopter operations, a key element in the planned clean-up operations, were severely restricted at Marambio Station.

The nature of the works is largely weather-dependant. Helicopter activities rely on climate and conditions on the ground in which wastes are partially buried. Therefore, achievement of planned goals had much to do with local climatic conditions at the site.

Providing adequate resources to keep monitoring programs in place was difficult at times (regardless of any economic crisis), particularly when these activities were weighed against the need for resources for research and maintenance. However, as noted above, new opportunities have arisen, since the ISO 14001 certification.

There have been difficulties in maintaining active communication channels between the environmental management section and operators in the field. The fact that station operators change annually does not foster on-going, permanent contact with environmental managers. In addition, the broad scope of environmental management concerns prevents a dedicated focus at times on specific programs such as this. However, new alternatives (training courses, creation of dedicated environmental personnel at the station, establishment of working groups) are being implemented in order to tackle these obstacles.

Lessons Learned

A number of lessons have been learned since this program was initiated. The most relevant ones are summarized as follows:

Environmental reviews are crucial, not only as sources of baseline information, but also as starting points for planning, and triggers to generate awareness of the problems. A similar program to that followed in Marambio had been implemented at Esperanza Station (1996), and, although not formally completed, at Jubany Station. As in Marambio's case, both led to a considerable improvement in environmental conditions and included the removal of old waste dumps.

It is important to establish links between the ATS and the operational decision makers as a way to promote deeper commitment to environmental issues. The need to promote guidance on waste management practices by COMNAP/CEP is therefore a very relevant issue.

Finally, the outcomes of inspections under Art. VII of the Antarctic Treaty seem to have played an important role in the decision-making process. Good results stemming from the inspection have kept management measures under permanent review, and prompted more attention on, and a greater commitment to, environmental issues, particularly waste management.

15. Clean-up of Abandoned Cape Hallet Station – New Zealand and United States

Neil Gilbert, Antarctica New Zealand

Abstract

During the summer of 1956-57, New Zealand and the United States established a joint research station in Northern Victoria Land, in order to provide weather data for American aircraft flying between New Zealand and Antarctica, as well as to undertake an IGY research programme covering meteorology, geomagnetism, auroras, ionospherics, and seismology.

Cape Hallett Station was occupied year round between 1957 and 1964. Following the completion of the IGY research programmes, the station continued to undertake meteorological measurements, as well as biological research on the large Adelie penguin rookery on Seabee Spit.

In 1964, a fire destroyed the main scientific laboratory. From that point on, the station was operated as a summer-only research station until 1973, when the station was abandoned. At the time, it was left in place in anticipation of being re-opened again in the future. However, no efforts to reopen the station have ever been made.

Article 1 of Annex III to the Madrid Protocol requires abandoned work sites to be cleaned up unless the site has been designated as an historic site or monument, or the removal of such structures or waste materials would cause greater environmental impact than leaving them in place.

Clean-up operations have been ongoing at Cape Hallett since the early 1980s, but a coordinated effort was made to complete the work between 2003 and 2006.

This presentation will summarise the successful programme undertaken by New Zealand and the United States to clean up the abandoned research station at Cape Hallett, and will identify the lessons learned and future monitoring plans.

Outline:

- Brief History of Cape Hallett Station
- Early Clean-Up Efforts
- Recent Clean-Up: Completing the Job
- Next Steps: How Well Have We Done?

Brief History of Cape Hallet Station

Built by US Navy Engineers (“Seabees”), Cape Hallet Station was established 1956-1957 in order to:

- Provide meteorological information for the United States (US) aircraft flying between New Zealand and McMurdo Station; and
- Undertake a programme of polar geophysical research during the International Geophysical Year of 1957-1958.

When the station was built, several acres of Seabee Hook were fenced off, resulting in the relocation of 7,800 birds, including 3,000 chicks. When the fence blew down, the exercise had to be repeated!

Figure 1: Seebee Hook, Cape Hallet

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U. S. Navy, Official

↑ **Seabees Seize a Beachhead from an Army of Penguins at Cape Hallett**

Black basalt cliffs rise almost straight from the sea at the tip of Victoria Land. Navy construction men detailed to build an IGY station found the narrow pebbled beach already occupied: Adélie penguins nested on virtually every inch of level ground (next two pages). To clear a site, the builders fenced off several acres and removed 7,800 birds. When the last Adélie had been evicted, a storm blew down the fence, and the colony swarmed back. Scientists had to repeat the laborious move before the joint U. S.–New Zealand wintering party could move in.

↓ Station personnel gather squawking chicks in boxes, lead parents in nets, for transport to new homes.

Figure 2: National Geographic Article, 1957

Station operations were conducted as follows:

- 1957-1959: Operated year-round with a focus on geophysical and meteorological research;
- 1960-1964:Operated year-round, with a switch in focus to biological research (penguins and moss);
- 1964: The main laboratory was destroyed by fire;
- 1964-1973: Operated as a summer-only station; and
- 1973: The station was abandoned.

Early Clean-Up Efforts

Early clean-up efforts began in 1984 with joint New Zealand/US site assessment. Between 1984 and 1987, the majority of buildings were dismantled and vehicles were removed. Pollutants were re-drummed and removed between 1993 and 1996.

Figure 3: Early clean up efforts

Figure 4: Early clean up efforts

Recent Clean-Up: Completing the Job

In 2000, all that remained on the site was a cluster of buildings, a bulk fuel tank and several smaller tanks.

When the Madrid Protocol came into force, there was a requirement to clean up abandoned sites, unless they were designated as either historic sites, or the clean-up operations were deemed to cause greater environmental harm than leaving waste in situ.

The historic site option was rejected for the following reasons:

- Earlier clean-ups had significantly modified the site;
- The remote location (away from NZ / US activities) restricts maintenance opportunities;
- It was an opportunity to return the site to the penguins; and
- The site was now protected for its fauna and flora.

In terms of clean-up operations potentially resulting in greater environmental damage, the area has been given Special Protected Area status. A small outcrop of moss resulted in its designation as a specially protected area in 1966. In 2002, the Special Protected Area was expanded to include the whole of Seabee Hook.

Issues considered in deliberation of the proposed clean-up included higher environmental standards set by the Madrid Protocol, and the protected area status of the site.

An environmental impact assessment concluded that a clean-up would not cause greater impact. Key concerns identified included disturbance to breeding birds and the release of pollutants.

These key concerns were addressed through rigorous planning and extensive site characterisation.

Site characteristics (in terms of contaminated ground and groundwater movements) were identified as shown in the following figure:

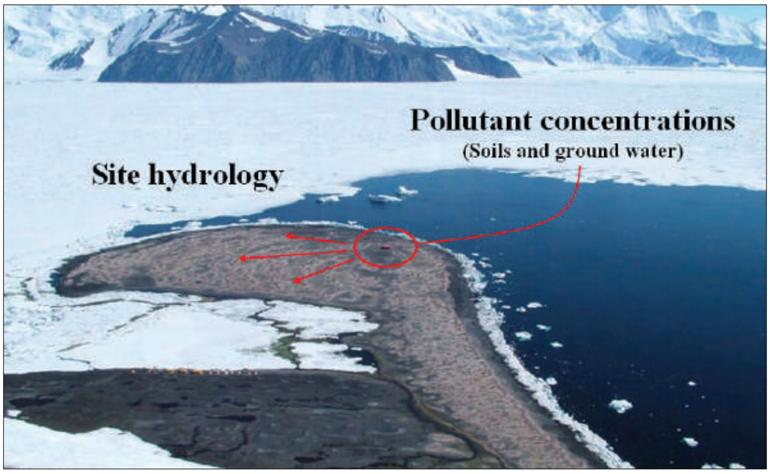

Figure 5: Site characteristics

Serendipitously, a three-season programme of research (part of the New Zealand-led "Latitudinal Gradient Project") was undertaken at Cape Hallett between 2003 and 2006. This research project included a dedicated camp and camp staff. The clean-up operations were therefore able to be undertaken using this infrastructure.

The most significant concern was the remobilisation of contaminants that were known to be in the soils around the fuel tanks. Testing was undertaken to determine the extent of the contamination and assessment of the need for removal to ensure safety of the site.

Figure 6: 2003 / 04 clean up efforts

Figure 7: 2004 / 05 clean up efforts

Figure 8: Tank removal occurred 2005 / 06.

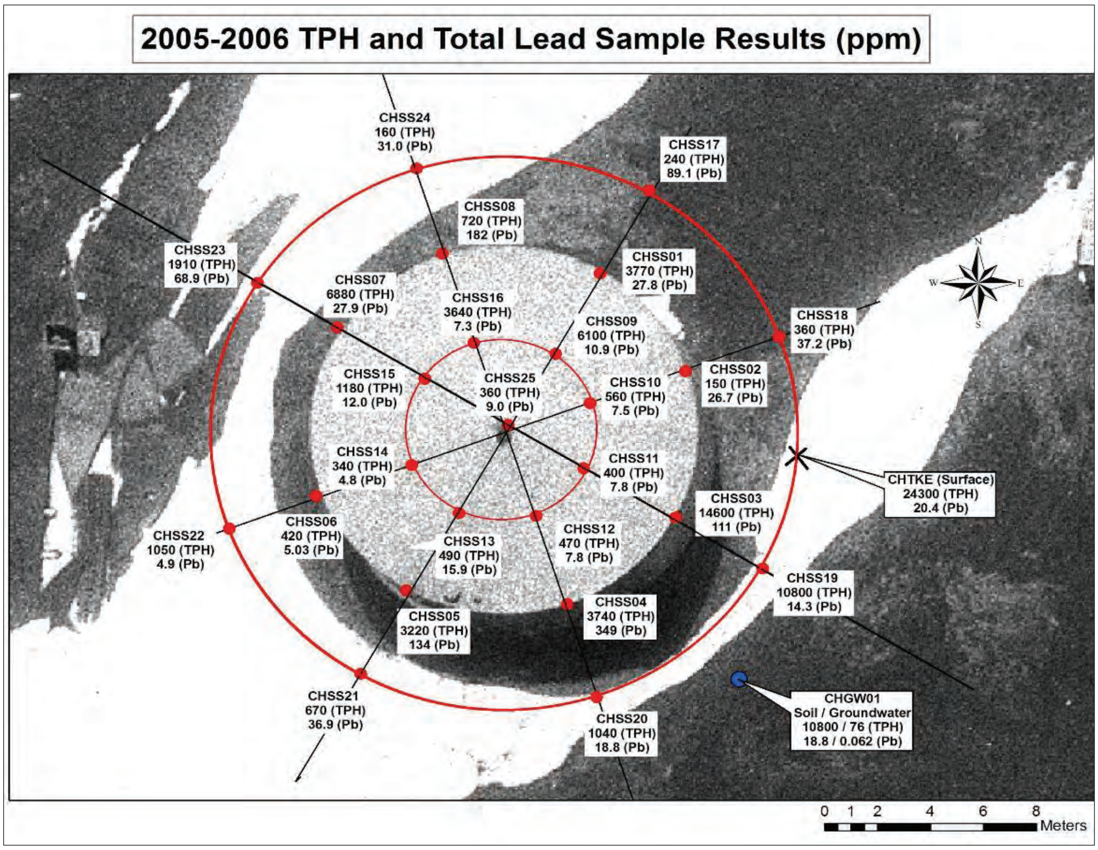

Figure 9: Total lead and TPH sample results from 2005 / 06 (post tank removal) from former 100,000 gallon tank area. All results are presented in ppm, as diesel range organics (C7 to C44) with C30 to C34 removed.

By the end of the 2005 / 2006 season, all buildings, and their contents had been removed from the site; the bulk fuel tank and smaller tanks had been cleaned and dismantled and mostly removed from the site. All that remains on site is 50 tonnes of cleaned steel from the fuel tanks. This will be removed at the earliest opportunity.

Next Steps

Monitoring is essential to assess the success of the clean-up. Monitoring indicators and parameters will include:

- Visible characteristics, measured by disturbance plots and monitoring of debris;
- Penguins: aerial photography will assess the status and trends of the colony; and
- Pollutants, measured by sampling the ground water for TPH.

Acknowledgements

The US and New Zealand programmes wish to express particular thanks and appreciation to the Italian Antarctic Program for invaluable assistance with shipping and logistics – the clean up of Hallett station could not have been completed without their support.

REPORT ON AEON WORKSHOP

Presented to COMNAP Plenary

AEON Antarctic Environmental Officers Network

Report on Information Sharing Workshop: Waste Management in Antarctica

Monday 10 and Tuesday 11 July 2006

Part of COMNAP XVIII, Hobart Tasmania, Australia,

Introduction

On the 10 and 11 July 2006 an Information Sharing Workshop on Waste Management in Antarctica for AEON Members was undertaken as part on COMNAP XVIII in Hobart Australia.

The workshop was intended simply as an information sharing exercise between AEON members, without policy intent. In line with COMNAP's aims and objectives, high priority was given to providing information of practical use to the other National Programs. It was hoped through effective sharing of information on waste management; individual participants could learn information to improve their own waste management efforts.

In the introduction to the Workshop it was noted that it was the first time since the Madrid Protocol was agreed (1991) that an *ad hoc* forum within the Antarctic Treaty System has tackled issues associated to waste management in Antarctica.

Full information about the workshop is available at the AEON Workspace at the COMNAP website at www.comnap.aq.

Attendees & Presentations

The workshop was attended by 21 representatives from 11 COMNAP Members. (see Appendix 1). Experiences on current waste management practices and clean-up operations of old waste deposits were presented by participants from 9 countries and the private sector. In addition, though not in attendance, a paper was submitted by Uruguay for the workshop and distributed to attendees.

Sponsors

The Workshop was partly sponsored by Veolia Environmental Services, a consultancy that assists in the management of Antarctic waste. Their sponsorship extended to providing daily transport to and from the workshop venue, and catering for the AEON social event. John Brennan from Veolia was also extended an invitation to attend and speak at the workshop.

The Australian Antarctic Division also kindly sponsored the workshop, providing a venue at their offices at Kingston near Hobart.

Workshop structure

The workshop was structured in two days, according to the following scheme:

Day 1: How Do we Currently Manage Waste in Antarctica? The Practical Aspects.

Day 1 of the workshop focused on the practical aspects of waste management in Antarctica, with a series of presentations by several nations about their current waste management practices. These presentations were followed by group discussions.

The list of presentation is outlined in the table below:

Formal Welcome and Introductions:	Rodolfo Sánchez, AEON Coordinator
Stories about Waste at Dumont d'Urville, on the Traverse and at Concordia station,	Claire Le Calvez, French Polar Institute
Learning Outcomes from Industry Management of Waste Generated by East Antarctic Activities	John Brennan and Ron Ward Veolia Environmental Services
Current Waste Management Arrangements in the Australian Antarctic Territory Program:	Leslie Frost. Australian Antarctic Division (AAD)
Wastewater Treatment in Antarctica: Challenges and Process Improvements	Margaret Knuth NSF United States Antarctic Program
Managing Antarctic Wastes	Rod Downie British Antarctic Survey (BAS)
Report On Recent SANAP Environmental Waste Management Activities, Incidents And Developments Over The Past Year	Henry Valentine South African National Antarctic Programme (SANAP)

Presentations were interspersed with group discussion. Items of discussion included:

- optimal incineration techniques,
- management of food scraps, in order to enhance efficiency of incinerators
- fuel drums cleaning, reuse and crushing,
- waste categories used in stations,
- waste management in field parties,
- waste management upon return to countries for final disposal,
- benefits from reducing wastes prior to departure to Antarctica,
- ways to minimise wastes,
- auditing waste management practices,
- problems faced and solutions found during the operation of high-scale wastewater plants
- involvement of the private sector on the design of technological solutions for specific problems found in Antarctica

- cultural aspects associated to waste management practices
- problems found in reporting of waste management (particularly incidents) from Antarctic stations
- ways of improving communication connected to waste management, also including other complementary, possibly non-technical, issues.

At the conclusion of the day, the AEON Coordinator led a "wrap-up" session. The following findings were noted:

- there is a need to increase the flow of information at a technical level among those responsible for waste management in Antarctica within National Programs. Participants agreed that the COMNAP website was the most adequate tool to achieve such a goal, and that the AEON workspace should be adjusted to allow an easier flow of information.
- the incorporation of the Environmental Management System (EMS) concept into waste management practices could be a very convenient way to facilitate such activities.
- With respect to incident reporting, there is a need to provide feedback on the information forwarded by operators, as a way to increase confidence on the usefulness of their work and on the reporting system itself.
- Participants agreed that, on the issue of waste management, AEON would benefit from closer links with TRAINET and other COMNAP networks.

Social Function:

A social function was conducted on the evening of Day 1 to allow informal communication and interaction between AEON Members. The social function was a successful event enjoyed by all.

Day 2: How are we Approaching Cleaning Up Old Waste in Antarctica?

Day 2 of the workshop focused on current efforts to clean up old waste in Antarctica that was deposited prior to introduction of the environmental protocols. Again a series of presentations were undertaken by several nations about their current approaches and efforts.

Formal Welcome and Introductions for Day 2	Rodolfo Sánchez, AEON Coordinator
Cleaning Up BAS's legacy of Abandoned Bases and Worksites in Antarctica	Rod Downie British Antarctic Survey (BAS)
Secrets of Antarctica" – Documentary on the clean-up of abandoned British bases	Rod Downie of BAS screened this documentary that was broadcast on BBC World.
Clean Up Program at Syowa Station and the Next Stage Challenges	Kenji Ishizawa National Institute of Polar Research, Japan
Progress Report on the Clean Up of the Thala Valley Tip at Casey Station	Leslie Frost Australian Antarctic Division (AAD)
Partnerships – Can they Benefit Clean Up Activities in Antarctica?	John Brennan and Ron Ward Veolia Environmental Services

Clean-Up Operations at Marambio Station (Argentina): More than a Decade after their Start	Rodolfo A. Sánchez Argentina
Waste Management Approaches in the Brazilian Antarctic Programme	Lucia Siqueiros Brazil
Clean up of abandoned Cape Hallett Station – New Zealand and United States	Neil Gilbert Antarctica New Zealand

As previously discussed a paper prepared by the Uruguayan Antarctic National Program entitled "Cleaning of Past Activities" was also distributed.

Presentations were interspersed with group discussion. Items of discussion included:

- benefits and lessons learned from working with private sector
- problems associated to keep long-term clean up operations, particularly monitoring, active over time
- alternatives used for clean up operations in sensitive areas (ASPAs, presence of wildlife, active stations)
- treatment techniques for contaminated waste
- Occupational health and safety
- assessment of environmental impacts associated to major clean up programs
- benefits from keeping COMNAP Members informed of progress on clean up operations

At the conclusion of the day, the AEON Coordinator led a "wrap-up" session. The following findings were noted:

- the importance of partnership among National Programs, and of the involvement of the private sector when undertaking clean-up operations.
- the need of long-term planning when addressing clean up operations, given the fact that such activities usually involve high costs and human & technical resources. At this respect, participants stressed that clean up operations should be based on reliable site characterizations and that monitoring is a necessary complement of such operations.
- the importance of written strategies to help understand clean-up operations as part of a process, which may include planning, designing, implementing, monitoring and documenting clean-up activities
- the importance of being flexible when undertaking clean-up programs, as they are usually highly dependant on harsh conditions present in Antarctica. Participants noted the importance of being ready for alternative solutions.
- the value of communicating results from clean-up operations, particularly to the general public, as a powerful tool to obtain resources for further progress on such operations.
- the recovery of historical objects can be a positive side effect stemming from clean-up programs.
- the continuing interest of AEON in progress towards the cleaning of old waste deposits and disused facilities in Antarctica.

Publication of Papers and Presentations

Following on from the workshop, it is intended to publish the presentations and papers as an on-line document (on the COMNAP website). It is intended as a useful reference about contemporary waste management practices in Antarctica for AEON Members.

Conclusion

Participants fully agreed that the Workshop was a very fruitful initiative and that further sharing information exercises on these issues should be encouraged within AEON.

AEON thanks COMNAP for its funding for the Workshop, the Australian Antarctic Division for providing the venue and Veolia Environmental Services for sponsorship.

Appendix 1: Attendees at AEON Practical Waste Management Workshop

Claire Le Calvez, French Polar Institute
Henry Valentine, South African National Antarctic Programme (SANAP)
John Brennan, Veolia Environmental Services
Kenji Ishizawa, National Institute of Polar Research, Japan
Leslie Frost, Australian Antarctic Division
Lou Sanson, Antarctica New Zealand
Lucia Siqueiros, Brazilian National Antarctic Program
Margaret Knuth, National Science Foundation, Office of Polar Programs, Arlington, USA
Maxine Wolfe, Australian Antarctic Division
Neil Gilbert, Antarctica New Zealand
Phil Read, Quarantine Tasmania
Rebecca Malcolm, Australian Antarctic Division
Rodolfo Sánchez, Dirección Nacional del Antártico, Argentina (AEON Coordinator)
Rod Downie, British Antarctic Survey
Sandra Potter, Australian Antarctic Division
Shaun Walsh, AEON Project Officer, COMNAP
Sun Yunlong Polar Research Institute of China
Cong Kai, Professor of The First Institute of Oceanography, State Ocean Administration, China
Zhang Yi, Senior Engineer of the Qinghua University, China
Yves Frenot, French Polar Institute
Victor Pomelov, Russian Antarctic Expeditions, Arctic and Antarctic Research Institute

AEON SOCIAL FUNCTION

Photographs of AEON Social Function

11 July, Shane's Fish Punt, Constitution Dock, Hobart


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