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Response to XXIII ATCM Resolution 5 (1999)

Paper submitted jointly by SCAR and COMNAP

Note for the Secretariat of XXIV ATCM

Resolution 5 (1999) requests COMNAP and SCAR to provide advice in a joint Working Paper to the XXIV ATCM. However, the Resolution also notes the desirability of receiving comments from the CEP on the joint COMNAP/SCAR Working Paper.

COMNAP and SCAR request, therefore, that this paper be also made available to CEP IV.

Contents

Response to Resolution 5 (1999)

A paper prepared jointly by COMNAP and SCAR

The Resolution sought advice from COMNAP and SCAR on aspects of the liability discussions. This paper deals with the questions posed by ATCM XIII from the perspective of the impacts of incidents, not of planned or ongoing activities.

The paper initiates discussion on these issues. If the ATCM considers it valuable to take this discussion further, SCAR/COMNAP consider a workshop involving legal, operational and scientific expertise would be of value. It is also noted that CCAMLR and IUCN, among others, have useful experience that would contribute to determining what levels of impact may be judged to cause “harm” and to developing a set or sets of guidelines that may be used to assist in making such judgements.

SCAR considers that there are no agreed scientific definitions for any of the terms listed in the Resolution since all of them have been developed to deal with cultural or legal acceptability rather than scientific proof of a hypothesis. It is perfectly possible to use scientific data and methods to define criteria or levels of change, the potential for repair and the degree of linkage or association between ecosystems. This should provide the basis for the development of international guidelines linking the science with practical management. SCAR recognizes that this paper makes no attempt to address changes to aesthetic and wilderness values. At the current time, there are no accepted definitions that can be used.

The specific questions raised are answered below.

A) what criteria could be used to determine whether an impact caused harm to the environment?

The terms “harm” and “damage” are not scientific concepts but cultural and legal concepts. They can and have been applied to scientific and environmental problems but, because of their origins, they have not been applied in an objective way. In other words, each application has required a subjective interpretation of the term within a particular context. In the context of the liability discussions it is suggested that general usage would assume that “harm” is caused by a change in the state of the environment brought about by human actions. Interpretation of scientific data for selected criteria to determine whether or not "harm" has been done is subjective. The impact can be primary (e.g. effect of an oil spill on survival of limpets) or secondary (e.g. poisoning of birds by eating limpets polluted with hydrocarbons). In both cases the human induced impact can be said to have caused change to the environment but there still remains the question of whether or not that change results in harm. It makes no difference to the concept of “harm” whether the impact is accidental or planned.

On this basis many, or even most, human activities in the Antarctic cause some change to the environment. For the purposes of liability or regulation the criteria required are those that will provide an indication of the degree of change so that what constitutes “harm” can be determined. For the Antarctic there are at present no agreed criteria to distinguish degrees of change other than those derived by CCAMLR to control the impacts of fishing. In this instance the over-riding requirements are to “Maintain the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources" and "To prevent or minimize the risk of changes [by fishing] in the marine ecosystem which are not potentially reversible over two or three decades". Thus the Convention contains requirements to limit impacts to a particular level that will not cause long-term change to the marine ecosystem. It implements this through setting catch limits for individual species and monitoring the functioning of specific aspects of the marine food web.

There is clearly a need to derive generic scientific guidelines for degrees of change resulting from impacts on terrestrial and freshwater systems. A useful basis on which to develop such considerations is the form of agreement already reached to define which species have populations that are threatened or whose long-term survival is endangered by environmental impacts. In developing such criteria for birds it has proved necessary to define population size and spread, normal natality and mortality, life cycle reproductive characteristics and susceptibility to particular forms of impact.

This paper does not list specific criteria that need to be taken into account although the examples given provide an indication. Useful lists of criteria may be found in Abbott, S B and Benninghoff, W S. 1990. Orientation of environmental change studies to the conservation of Antarctic ecosystems. *In* Kerry, K R *and* Hempel, G *(ed) Antarctic ecosystems: ecological change and conservation.* Berlin, etc, Springer-Verlag, 394–403 and an extract is attached to this paper as Appendix 1.

B) what is the scientific meaning of "dependent and associated ecosystems"?

An ecosystem is a community of plants and animals viewed within its physical environment or habitat. It is a concept and thus can be applied equally well to an individual pond or to the whole world – the key differences being only those of size and complexity. Since all the units of all sizes are connected within the global system all ecosystems are associated in some way, whilst some units are primarily dependent on other units for their effective functioning. Again, the requirement from a scientific viewpoint is to establish the degree of association or dependence between units and to consider what is likely to happen if such relationships are damaged by specific types of impact.

Dependence can be because transfers between two ecosystems are crucial to the long term functioning of one or both. For example, without continuing nutrient transfers by birds from the marine ecosystem to land ecosystems in coastal continental Antarctica most terrestrial communities could not persist. This is a high degree of dependence. A lesser degree is shown by wandering albatrosses that feed on the coastal shelf of Brazil. Whilst for those individuals that choose to feed there we can assume a high degree of dependence on a specific locality, for the species as a whole it can only be a low degree of dependence as many individuals feed elsewhere.

If used scientifically "association" has also to be qualified. Specifically it is necessary to define what the association or linkage is (e.g. shared species or communities, transfers of nutrients or energy) so that some estimate of the significance of the association can be made. For example, the ecosystem in the winter sea ice in the Bellinghausen Sea is clearly associated with the continental shelf ecosystem around South Georgia through the continuing provision of a population of krill in the shelf waters around the island.

C) What in the circumstances of Antarctica, are incidents that could cause environmental harm, distinguishing immediate from gradual or cumulative harm?

COMNAP analyzed the question in two parts:

1. What types of incidents could cause environmental harm:
2. How would operators distinguish between immediate from gradual or cumulative harm?

The following definitions were adopted in this analysis:

Incident:	A time limited unplanned event that results from human activity that becomes apparent at a specific point in time.
Environmental Harm:	An adverse impact to the natural environment, which is significant and lasting.
Immediate Harm:	Environmental harm that commences instantly and/or inevitably from an incident.
Gradual / Cumulative Harm:	Environmental harm that results from continuous or repetitive impact of an incident(s).

The compilation and assessment of types of unplanned incidents that could occur in Antarctica from the operation of facilities and the support of research are shown in Table 1. Examples, with possible response action are given in Appendix 2.

Table 1 shows the environments in and around Antarctica in which scientific and station operations occur, the transport methods, facility operations, and activities that are undertaken to accomplish the objectives of national programs. The matrix illustrates the interrelationship among 132 scenarios that could be encountered during the conduct of activities in the course of implementing a national program.

For example, under Transport Systems, aircraft/helicopters are operated in each of the location categories, as are vehicles with the exception the vehicles are not operated in the Open Sea. Similarly under Facilities, installation and operation of utilities (power and water lines) are limited to Bases/Facilities, whereas the production of sewage/waste water occurs at all locations.

These responses do not include consideration of tourist activities; the introduction of diseases or foreign organisms; space debris, malicious acts, or global pollutants

Having identified systems, facilities,and activities that make up the range of national program activity in Antarctica, the next step is assessing the potential for negative impacts on the environment.

Table 1. Activities that can result in incidents with potential harm to the environment

Location:	Bases/ Facilities	Polar Plateau	Ice Shelf	Coastal Zone	Ice Free Inland	Open Sea
Function						
Transport Systems						
Aircraft	p/n	n/n	n/n	p/p	n/p	n/n
Vehicles	l/n	p/n	p/n	p/n	n/p	na
Ships	p/l	na	Na	p/vl	na	n/n
Facilities						
Piers and Wharves	n/n	na	Na	na	na	na
Fuel Storage	l/p	p/n	p/n	p/p	p/n	na
Water /Power Prod	n/n	n/n	n/n	n/n	n/n	na
Utilities Dist	n/n	na	Na	na	na	na
Airfields	n/n	n/n	n/n	na	na	na
Roads within Facilities	n/n	na	Na	na	na	na
Accommodation	n/n	p/n	p/n	p/n	n/n	na
Warehousing/depot	n/n	n/n	p/n	p/n	p/n	na
Sewage/waste water	p/p	p/n	p/n	p/n	n/n	p/n
Waste Disposal	p/p	n/n	n/n	n/n	n/n	na
Laboratories	p/n	p/n	p/n	p/n	p/n	p/n
Communication	n/n	n/n	n/n	n/n	n/n	n/n
Abandoned Facilities	p/p	n/n	n/n	Na	na	na
Activities						
Transporting material	l/n	p/n	p/n	p/p	p/n	na
Cargo Handling	l/n	n/n	n/n	n/n	n/n	na
Fuel Handling	vl/p	l/n	l/n	p/n	p/l	p/n
Construction	n/n	na	na	Na	n/n	na
Operation of Facilities	p/n	n/n	n/n	n/n	n/n	na
Scientific Activities	p/n	p/n	p/n	p/n	p/p	p/n

Possibility of an incident/environmental harm
na=not applicable; n=negligible; p=possible; l=likely; vl=very likely

Determining Transport Systems, Facilities, and Activities that can result in incidents with the potential for negative impacts on the environment:

As an initial task, we identified the Systems/Facilities/Activities that could result in incidents and assessed the potential to produce a negative impact on the environment. To determine that potential, each Systems/Facilities/Activities was assessed on the likelihood that in the course of conducting the work 1) whether an incident could occur, and 2) if an incident were to occur, whether that the incident could result in environmental harm.

This assessment was done based on a qualitative scale of likelihood as follows: negligible (n); possible (p); likely (l); very likely (vl). As a result each scenario is described by two estimates of likelihood, one for occurrence and the other for environmental harm. The likelihood of an incident occurring is compared to the likelihood that the incident could result in environmental harm, or:

Possibility of an incident/Possibility of environmental harm

The assessment of the likelihood of an incident occurring and the possibility of that incident causing environmental harm is subjective, and was based on the collective experience and judgement of COMNAP/SCALOP members in addition to the 10 years incident reporting of the Antarctic operators evaluated by COMNAP in working paper 16 submitted to the ATCM XXIII.

Thus conclusions of qualitative likelihood can be summarized as follows:

- There is virtually no environmental harm resulting from ground or air transport incidents or fires. These events appear to occur infrequently and when they do the magnitude of the environmental impact is insignificant.
- The most common incidents with the potential to cause the greatest environmental harm are fuel spills.
- Most fuel spills in Antarctica are likely to be small and confined to a station or base or the adjoining waters and are unlikely to threaten significant concentrations of wildlife.
- Fuel spills in the marine environment have a low probability of occurrence but pose a greater magnitude of risk to wildlife than terrestrial or ice sheet spills. Marine spills in the vicinity of rookeries, breeding grounds or primary habitats for marine mammals or birds pose a higher risk than marine spills in the open sea or less sensitive areas.

The judgement of likelihood of causing environmental harm consequently presumes that spill prevention strategies followed by emergency preparedness and spill response are performed according to the COMNAP guidelines.

Determining whether an incident could result in environmental harm:

COMNAP/SCALOP members agreed that an incident could result in environmental harm when the incident has a possibility of causing a significant and lasting impact Any incident that exceeded that threshold is considered having the possibility of resulting in environmental harm. Fourteen scenarios meet or exceed this threshold.

For example, aircraft operating in the coastal zone, the possibility of an incident occurring is considered to be possible (light aircraft and helicopters), and should an incident occur, it is possible that it could result in some environmental harm. This likelihood is shown as p/p in the matrix.

In another example, ships operating in the coastal zone, because of the threat posed by ice bergs and uncharted sea mounts, it is possible that an incident could occur (grounding; sinking, etc.), and as a consequence, the possibility that the accident could result in significant and lasting impact is considered to be very likely. This likelihood would be described as p/vl in the matrix.

On the other hand, for aircraft operating in the Ice Free Inland areas, the possibility of an incident occurring is negligible, but should an accident nevertheless occur, it is possible that environmental harm could result. This likelihood is described as n/p in the matrix.

The scenarios meeting or exceeding the threshold are summarized in Table 2.

Table 2: Locations and Functions that could result in environmental harm

n = negligible; p = possible; l = likely; vl = very likely

Location:	Bases and Facilities	Coastal Zone	Ice Free Inland
Function			
Transport Systems			
Aircraft		p/p	n/p
Vehicles			n/p
Ships	p/l	p/vl	
Facilities			
Fuel Storage	l/p	p/p	
Sewage/waste water	p/p		
Waste Disposal	p/p		
Abandoned Facilities	p/p		
Activities			
Transporting Material		p/p	
Fuel Handling	vl/p		p/l
Scientific Activities			p/p

Distinguishing immediate from gradual or cumulative harm:

If an incident results in immediate harm, further monitoring would be required to determine whether the incident results in gradual or cumulative harm. Of the 14 scenarios that could result in environmental harm each is evaluated on whether or not the incident could result in gradual, or cumulative harm.

For example, fuel storage at bases and facilities could result in gradual/cumulative harm, if for example a leak in storage facilities were undetected or there were a number of repetitive leaks until there was environmental harm.

In the example for scientific activities, the likelihood of gradual/cumulative harm is not applicable at bases, and facilities because incidents are likely to be contained within facilities. Incidents are also not likely to occur in the coastal zone because of the safety precautions taken in travel. While science activities could result in an incident in the ice free inland areas where temporary laboratories are established, immediate harm is possible, but gradual/cumulative harm is not because an incident would be highly localized, and containment measures should be readily available.

The summary of this evaluation is shown in Table 3. It is important to note that of the 14 systems/facilities/activities that could result in environmental harm, only 11 could result in gradual/cumulative harm.

Table 3 Locations and Functions that could result in gradual/cumulative environmental harm

Location	Bases and Facilities	Coastal Zone	Ice Free Inland
Functions			
Transport Systems			
Aircraft		YGC	YGC
Vehicles			NGC
Ships	YGC	YGC	
Facilities			
Fuel Storage	YGC	YGC	
Sewage/waste water	YGC		
Waste Disposal	NGC		
Abandoned Facilities	YGC		
Activities			
Transporting Material		YGC	
Fuel Handling	YGC		YGC
Scientific Activities			NGC

* NGC = NO, not likely to result in gradual/cumulative harm
YGC = YES, could result in gradual/cumulative harm

Summary:

It must be understood, that this approach is a first order attempt to organize operational functions in a way that identifies functions that could result in environmental harm. Tables 1 – 3 is a stepwise compilation of systems/ facilities/ activities and an assessment based on experience, on the possibility of incurring an incident, and how an incident could impact the environment.

The development of the matrixes lead to the identification of systems/facilities/ activities that have the possibility of resulting in some environmental harm IF an incident were to occur. This in turn allows the operator to further analyze those activities to identify preventive measures and contingency response plans. With preventive measures and contingency response plans in place that have been tailored to activities that have the possibility of generating incidents, both the possibility of an incident and the possibility of inflicting immediate or gradual/cumulative environmental harm is significantly reduced.

D) Whether, and under what circumstances, would it be possible and/or practicable to take containment, mitigation or clean up action, and whether, and under what circumstances, would it be possible to restore the environment?

Definition of terms in the question are noted as follows:

Containment:	To prevent additional risk of harm to the environment by preventing the spread of harmful materials as a result of an incident.
Mitigation:	To decrease the potential of environmental harm through containment, recovery, or protection of the environment from harmful materials.
Clean up:	Removal and recovery of released materials resulting from an incident.
Restore the Environment:	Return the environment to the condition it was in prior to an incident.

Containment and mitigation are considered to be the primary actions that could be taken immediately after an incident occurs. However, before the initiation of any action, there must be assessments, first of the risk to safety and life, and second to the practicality of any intervention under existing conditions of weather, and environment.

Clean-up and restoration of the environment are considered to be follow-up actions, in that these should follow an assessment of whether such action is feasible, cost effective, appreciably affect the natural rate of recovery, or will cause more harm than the impact of the incident.

There are several very significant qualifications to the ability to take action. They are:

- that there are no risks to safety or life;
- that weather conditions are suitable for operations;
- that the event is not catastrophic; and
- that material and resources are available.

Reference is made to the table of incidents that could cause environmental harm (Table 2). Each incident that could result in environmental harm was assessed to judge under what circumstance containment, mitigation, clean up, or restoration of the environment could be undertaken. For example, in an incident involving a ship at a base or facility, it is likely that a resultant spill could be contained, that mitigation measures could be undertaken to minimize potential harm, and that clean-up activities could be initiated (contain/mitigate/clean-up). This should be possible at bases and facilities because materials and expertise should be available as a consequence of the preparation of contingency plans for that type of incident, and that bases and facilities generally have the capacity to store and maintain a level of response action.

On the other hand, a fuel storage incident in the coastal zone is problematic because containment materials, and response to mitigate an incident are not likely to be readily available, or timely. However, once the incident is detected, clean up to some extent is likely to be possible (clean up).

Appendix 2 is a summary table of each incident that could result in environmental harm and what are the possible response actions. These are examples of the types of incidents that could occur and are used for purposes of illustration. They are not comprehensive.

Summary:

Each operator should construct their own matrixes to reflect their types of activities, environments and situations, so that an understanding of the kinds of incidents that can occur are identified. By anticipating potential incidents, appropriate preventive measures can be put into place and contingency plans can be developed. Prior preparations will not only significantly reduce the possibility of an incident but should an incident occur, the ability to contain and mitigate environmental impact will also be enhanced.

In all instances where clean up is reasonable, and taking into account possible adverse environmental impacts of clean-up activities themselves, an assessment must be made before proceeding with restoration. Consideration would be made on many factors, including feasibility/desirability to conduct restoration considering further potential adverse impacts, and consideration of natural rates of recovery and cost effectiveness. In many instances, restoration may not be possible in the circumstances presented in Antarctica.

E) is there an operational or scientific definition of the term “irreparable” and, if so, what criteria could be used to determine if harm is “irreparable”

There is no agreed scientific definition of the term “irreparable” since what can be repaired and with what degree of success changes as science and technology develops. In the context of the liability discussions and present scientific knowledge we can at present say three things:

1. death of an individual animal or plant must be considered irreparable
2. destruction of a community must be considered irreparable if repair requires the reconstitution of an identical community; if on the other hand repair requires the restitution of a similar community then the damage may not be irreparable.
3. destruction of a habitat must be considered irreparable if repair requires the reconstitution of an identical habitat; if the restitution of a similar habitat is acceptable the damage may not be irreparable.

As with previous terms the important practical feature of this approach is the provision of agreed criteria on repair; these need to define how closely the repair must match the original and over what time-scale a particular level of achievement must be reached. For example, is it adequate to replace one moss community dominated by three species with another moss community dominated by a single species? Or should a relocated colony of burrowing petrels achieve the mean annual reproductive level typical of the species within the first five years after relocation or within the first 10 years? Setting criteria for both for repair and for determination of success is clearly dependent on the extent of scientific knowledge in each case but what constitutes success is a subjective value judgement.

Please note that the individual responses to the five questions asked in Resolution 5 (1999) were prepared separately by SCAR and COMNAP.

The responses to questions A, B and E were prepared by SCAR.

The responses to questions C and D were prepared by COMNAP.

Appendix 1

The following two tables are extracted from Abbott, S B and Benninghoff, W S. 1990. Orientation of environmental change studies to the conservation of Antarctic ecosystems. *In* Kerry, K R *and* Hempel, G *(ed) Antarctic ecosystems: ecological change and conservation.* Berlin, etc, Springer-Verlag, 394–403.

Table 1. Illustrative relationships among objectives, ecological levels, and spatial and temporal scales of environmental monitoring programs (page 398)

Objective	*Ecological level*	*Spatial scale*	*Time scale*
Detect change in flux rates of elements and ecosystem components	Several. e.g., atmospheric, terrestrial, and marine systems	Global, continental, ocean	Decades to centuries
Detect mesoscale change in marine environment	Large marine ecosystems	Regional	One or several decades
Detect changes in levels of contaminants in environment	Ecosystem (chemical and organismal sampling)	Global, regional, or local	Years, months, days
Detect effects of sewage outfall from coastal stations on benthic communities	Community	Local	Year, season
Detect changes in species diversity, trophic pathways and flux rates	Community	Local or regional	Decades, years ,or months
Detect ranges of natural variability in biota	Populations – distribution – biomass – age structure – sex ratio – vital rates	Regional or local	Decades, years, months, days
Detect changes in animal movements or behavior	Species/populations – behavioral	Regional or local	Years, months, days
Detect early signs of biological effects of environmental pollution	Physiological ecology – respiration rate – thermoregulation	Local	Months, days
Detect introduced species of microbes	Microbiological/ aerobiological	Local or regional (ships' hulls, footprints, aerial samples)	Opportunistic

Table 2. Activities, resources of special concern, and areas of special importance to Antarctic monitoring (page 401)

Examples of logistic and scientific activities that could have significant effects	*Resources of special concern*	*Areas of special importance*
Construction	Particularly vulnerable species and communities (e.g., grass, moss and lichen communities, and associated invertebrates	Existing scientific stations and field camps
Stations		
Airstrips		Designated Sites of Special Scientific Interest (SSSIs)
Harbors		
Roads		
Field camps	Pollution-free air, water, and ice	Designated Specially Protected Areas (SPAs)
Routine operations	Marine living resources	
Stations	Phytoplankton	Designated historic sites and monuments
Ships	Antarctic krill and other zooplankton	
Helicopters		Bird and seal breeding sites
Fixed-wing aircraft	Finfish	
Trucks	Squid	Coastal ice-free (possible station/ industrial sites)
All-terrain vehicles	Penguins and flying birds	
Power generators	Marine mammals	
Heating		Continental shelf (fish/krill breeding areas and fishing)
Water desalinization	Snow algae	
Waste Disposal		
	Meteorites	Victoria Land Dry Valleys
Science activities		
Collection of birds, seals, and other biota	Ventifacts	Ice-free mountain area (e.g., Dufek Massif)
Experimental harvesting/ perturbation	Fossils	
		Sheltered bays (possible anchorages/ station sites)
Offshore drilling/ ice coring	Fresh water sources (snow/ice in the vicinity of stations)	
Use of explosives		Fresh water lakes, ponds, and subsurface waters
Seismic surveys	Ice-free coasts with sheltered anchorages	
Collection of meteorites/ rock samples, fossils, etc		Glaciers
Use of chemicals, acids, radioactive isotopes, etc.	Mineral deposits	
		Ice shelves
	Mountain and other areas with particular recreational and aesthetic value	
Accidents		Sites of particular tourist interest
Ship/aircraft/vehicles		
Fuel Leaks		
Fires		
Introduction of alien species		

Appendix 2: Examples of Incidents that could cause Environmental Harm

Function	Location	Incident (examples)	Response
1) Aircraft Operations	Flying over the coastal zone (ice covered; or ice free)	Crash involving spillage of fuel which can approach 20K liters	Only likely response is **clean-up**. Initial action will be search and rescue. Because of time involved in initial recovery operations, containment; and mitigation measures will not be possible.
2) Aircraft Operations	Flying over ice free inland locations	Crash of small aircraft or helicopters with spill <1000 liters	Only likely response is clean-up. Initial action will be search and rescue. Because of time involved in initial recovery operations, containment; and mitigation measures will not be possible.
3) Ship Operations	Loading or unloading fuel at the base or facility	Fuel hose ruptures	Base operations should be able to contain,mitigate, and clean-up the spill. Contingency plans should identify this possibility, erect containment booms or have response teams at the ready during this operation.
4) Ship Operations	Enroute to a base or facility along the coast	Ship going aground or impacting ice away from the station	The ship should have some response capability that would enable them to contain a spill in a limited fashion. Mitigation, and clean-up would likely have to be done with outside assistance.
5) Vehicle Operations	Operating in an ice -free inland area	Vehicle overturns or otherwise spills fuel	The only likely response is clean-up, although some mitigation may be possible if the spill is small (<10liters). Other response capability is not likely to be available.
6) Fuel Storage	Fuel Storage tanks located on bases or facilities	Rupture of a storage tank	Preventive measures and contingency plans should enable containment, mitigation, and clean-up. Storage tanks should be double walled or bermed to contain fuel should the tank rupture. If mitigative measures are needed, the station response team should be able to handle contingencies, and clean-up should follow.
7) Fuel storage	Fuel caches located away from bases or facilities	Leakage of unattended drums or storage containers	The only likely response is clean-up. Fuel caches are typically unattended and in 200 l. drums. Leaks are not likely to be noted until the cache is visited and therefore the remedy for leakage is clean-up. Preventive measures are relatively simple, and would minimize leaks to the environment.
8) Sewage/ waste water	Waste utility lines at bases and facilities	Failed lines resulting in leaks or dumping from the sewage system onto ice or ice free land	Preventive measures and contingency plans should enable containment, mitigation, and clean-up. Sewage and waste water lines should be valved so they may be closed and repaired and mitigation and clean-up initiated.
9) Waste Disposal	Trash and debris at bases and facilities	Improper handling of waste resulting in material being dispersed by the wind	This can be readily prevented through containment. Mitigation and clean-up would be more difficult since materials would be very widely dispersed.

Appendix 2: continued

Function	Location	Incident (examples)	Response
10) Abandoned Bases and Facilities	Varied. Can be coastal, or inland	Melt water through abandoned tips (landfills), and leaks from abandoned fuel tanks	Because these facilities are abandoned, assessments will have to be made on potential risks, and costs. Mitigation and clean-up would the the possible responses, since containment may no longer be possible.
11) Transport	In the coastal zone on the sea-ice	Vehicles working on or transitting across the sea ice	Fuel and chemicals that may be aboard the vehicle pose the risk to the environment. If significant,

		and falls through	efforts could be made to recover the vehicle and cargo to mitigate and clean-up the spil.
12) Fuel Handling	Fuel tanks and distribution lines at stations and bases	Spills resulting from over-filling of tanks; failure in pipe connections; punctured storage drums	At bases and facilities, is likely that preventive measures, materials, and personnel are available and in place to enable containment, mitigation, and clean-up
13) Fuel Handling away from bases and facilities	Fuel drums and small storage tanks at remote field sites	Spills resulting from sloppy fuel transfers and leaking drums	Since these facilities are typically manned and preventive measures and contingency plans should have been adopted for the operation of these sites, containment, mitigation and clean-up should be possible.
14) Scien-tific Activities	Laboratories and field sites in ice free inland locations	Chemical and other hazardous material spills	Since these facilities are typically manned and preventive measures and contingency plans should have been adopted for the operation of these sites, containment, mitigation and clean-up should be possible.