FINLAND **April 26, 2000**
Ministry of the Environment
Finnish National AMAP Working Group

NATIONAL IMPLEMENTATION PLAN (NIP) FOR THE AMAP TRENDS AND EFFECTS PROGRAMME 1998-2003

PREFACE

The Arctic Monitoring and Assessment Programme, AMAP, is an international organisation established in 1991 to implement the components of the Arctic Environmental Protection Strategy (AEPS). As a part of the programme of the Arctic Council, AMAP 's current objective is "to provide reliable and sufficient information on the status of, and threats to, the Arctic environment, and to provide scientific advice on actions to be taken in order to support Arctic governments in their efforts to take remedial and preventive actions relating to contaminants."

To achieve this, AMAP shall:

- "measure the levels, and assess the effects of anthropogenic pollutants in all compartments of the Arctic environment, including humans;
- document trends of pollution; document sources and pathways of pollutants;
- examine the impact of pollution on Arctic flora and fauna, especially those used by indigenous people;
- report on the state of the Arctic environment, and
- give advice to Ministers on priority actions needed to improve the Arctic condition."

The monitoring work within AMAP is based, as far as possible, on existing national and international monitoring and research programmes. The Finnish National Implementation Plan (NIP) has been prepared in accordance with the principle that the individual environmental research institutes and other relevant bodies include AMAP issues in their own research and monitoring programmes. The existing or planned programmes are being directed to better meet the needs of AMAP.

The Finnish NIP is a comprehensive tentative list of the research and long-term monitoring programmes and other supporting studies that produce data relevant to the AMAP objectives. The environmental research and monitoring programmes are carried out by national research institutes, local authorities and universities, under the auspices of five different ministries. The Finnish NIP is prepared, and will be updated, by the Finnish National AMAP Working Group, which is composed of representatives from the following relevant national bodies:

- Ministry of the Environment
- Finnish Environment Institute
- Lapland Regional Environment Centre
- Finnish Meteorological Institute
- Finnish Forest Research Institute
- Geological Survey of Finland
- National Veterinary and Food Research Institute
- Radiation and Nuclear Safety Authority
- Finnish Game and Fisheries Research Institute

- Finnish Institute of Marine Research
- State Provincial Office of Lapland
- Saami Parliament, Finland

The Finnish NIP includes six sub-programmes, which are described in this report: the atmosphere, terrestrial ecosystems, freshwater ecosystems, human health, radioactivity and marine environment. These sub-programmes are defined in terms of parameters and media to be monitored with respect to the priority contaminants, such as persistent organic contaminants (POPs), heavy metals and radioactivity. Acidification and the effects of pollution on the health of humans living in the Arctic, including the possible effects of increased UV radiation and climate change, are also priorities. Only part of the data (e.g. atmospheric data and freshwater contaminants) will be submitted regularly to the thematic data centres (TDCs). Other data, such as terrestrial data and hydrological data supporting the effects of climate change, will be available for the assessment procedure on request. Additional supporting studies are listed at the end of each sub-programme.

The strategy for further development of the monitoring activities in Finland is to promote the integration of the sub-programmes. This will enable the sub-programmes to utilise data from other media in their assessments. An integrated monitoring station of this sort has been planned for the Pallas atmospheric monitoring site, and there are plans to include terrestrial and freshwater sampling in the future. This station will provide an integral contribution to the monitoring of the Northern Fennoscandian Key area.

The Northern Dimension policy, currently being prepared by the EU, calls for international co-operation in research in northern areas. In order to provide guidelines for Finnish research the Polar Committee, which was set up by the Council of State, prepared Finland's Arctic Research Strategy in 1999. The importance of international co-operation and Finland's contribution to this, including AMAP, is noted in the strategy as follows: "The activity of Finnish researchers will be augmented in research programmes related to the Arctic Council and the Barents Euro-Arctic Council, in addition to the Offshore Technology Working Group and other bilateral joint programmes."

1. ATMOSPHERIC SUB-PROGRAMME

1.1 Objective and structure

The atmospheric monitoring provides data for the future assessment of the state of the Arctic environment, especially temporal and spatial trends in concentrations of heavy metals, POPs and acidifying substances in air and precipitation.

The Finnish monitoring programme consists of measurements performed within the framework of international and national programmes, supplemented by a number of parameter measurements established for the AMAP programme at Pallas.
The international programmes are:

- EMEP (Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Pollutants in Europe) co-ordinated by UN/ECE, WMO/GAW (Global Atmosphere Watch of the World Meteorological Organisation). The purpose and long-term goal is to provide data, scientific assessments and other information on changes in the chemical composition and related physical characteristics of background atmosphere from all parts of the Globe.
- Integrated Monitoring, also co-ordinated by ECE, for estimation of the long-term effects of air pollutants on a complete ecosystem in a restricted catchment area.

1.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/ Examination	Programme and/or responsible institute
Air/aerosol	PAH, HCH, PCB, DDE, DDD, DDT, chlordane, trans-nonachlor	1 week / month	Pallas	AMAP/FMI, IVL
Bulk precipitation	PAH, HCH, PCB, DDE, DDD, DDT, chlordane, trans-nonachlor	1 week / month	Pallas	AMAP/FMI, IVL
Air/aerosol	Cd, Cu, Pb, Zn, Cr, Ni, As, Al, V	Weekly	Pallas	AMAP/FMI
Bulk precipitation	Cd, Cu, Pb, Zn, Cr, Ni, As, Al, V	Monthly	Pallas	AMAP/FMI
Air/aerosol	Hg; particulate	Every other week	Pallas	AMAP/FMI, IVL
Air/aerosol	Hg; gaseous	1 day / week	Pallas	AMAP/FMI, IVL
Bulk precipitation	Hg	Monthly	Pallas	AMAP/FMI, IVL
Air/aerosol	SO_2, SO_4^{2-}, sum NO_3^- + HNO_3, sum NH_3 + NH_4^+	Daily	Pallas	GAW/FMI
Air/aerosol	NO, NO_2, SO_2, O_3, CO_2, condensation nuclei, black carbon, ^{222}Rn	Continuous	Pallas	GAW/FMI
Air/aerosol	VOCs, N_2O, CH_4	2 / week	Pallas	GAW/FMI
Bulk precipitation	SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, K^+, pH, conductivity	Daily	Pallas	EMEP/FMI
	Meteorology, at three sites, 300-760 m a. s. l.	Continuous	Pallas	FMI
Air/aerosol	SO_2, SO_4^{2-}, sum NO_3^- + HNO_3, sum NH_3 + NH_4^+	Daily	Oulanka	EMEP/FMI
Air/aerosol	NO_2, O_3, SO_2	Continuous	Oulanka	EMEP/FMI
Bulk precipitation	SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, K^+, pH, conductivity	Daily	Oulanka	EMEP/FMI
Bulk precipitation	Cd, Cu, Pb, Zn, Cr, Ni, As, Al, V	Monthly	Vuoskojärvi, Pesosjärvi	IM/FMI
Bulk precipitation	SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, K^+, pH, conductivity	Monthly	Vuoskojärvi, Pesosjärvi	IM/FMI
Bulk precipitation	SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, Cl^-, K^+, pH, conductivity	Monthly	Kevo, Sodankylä Värriö	FMI
Air/aerosol	SO_2	Monthly	Kevo, Sodankylä	FMI
Air/aerosol	O_3	Continuous	Sodankylä	GAW/FMI
Air/aerosol	^{210}Pb, ^7Be	Daily	Sodankylä	GAW/FMI

Air/aerosol	^{222}Rn	Continuous	Sodankylä	GAW/FMI
Ozone/UV-B	Upper air soundings	2 / day	Sodankylä	GAW/FMI
Ozone/UV-B	Ozone soundings	1 / week	Sodankylä	GAW/FMI
Ozone/UV-B	Backscatter soundings	5 / winter	Sodankylä	FMI
Ozone/UV-B	Total column ozone (Brewer #037, Saoz)	Continuous	Sodankylä	GAW/FMI
Ozone/UV-B	NO_2 (Saoz)	Continuous	Sodankylä	GAW/FMI
Ozone/UV-B	UV-B (290 - 325 nm); spectral Brewer	Continuous	Sodankylä	GAW/FMI
Ozone/UV-B	CIE-weighted total UV-dose	Continuous	Sodankylä	GAW/FMI
Ozone/UV-B	Solar radiation: global, diffuse, reflected	Continuous	Sodankylä	FMI
Ozone/UV-B	Radiation balance, sunshine hours	Continuous	Sodankylä	FMI
	Meteorology	Continuous	Sodankylä	FMI

AMAP	Arctic Monitoring and Assessment Programme
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
FMI	Finnish Meteorological Institute
GAW	Global Atmosphere Watch of the World Meteorological Organization
IM	Integrated Monitoring
IVL	Swedish Environmental Research Institute

1.3 Supporting studies

In addition to the air monitoring stations mentioned above, the Finnish Meteorological Institute has an air research station at Sevettijärvi, NE Finland, close to the Norwegian and Russian borders. Separate measurement programmes, primarily for aerosol research, have been carried out at Sevettijärvi since 1991. There is also a DOAS instrument continuously measuring NO_x, SO_2 and O_3 concentrations.

A study on the source apportionment of the POP and heavy metal concentrations measured at the Pallas Station is being conducted using statistical multivariate methods and air mass analyses.

Ozone research is based on measurements and models. FMI is collaborating with NCAR in the field of 3-D stratospheric chemistry and dynamics modelling. The ROSE model has been developed further for Arctic and Antarctic ozone simulation purposes. FMI is also collaborating with MPI (Hamburg) in the field of (stratospheric) climate modelling based on ECHAM4 Middle Atmosphere GCM model. The following topics are currently of interest:

- The roles of chemistry and dynamics in the observed ozone depletion at high latitudes
- Interactions between (stratospheric) climate change and ozone chemistry
- Ozone scenarios
- Observed changes in polar vortex behaviour

In addition to carrying out its own UV measurements, FMI is also hosting a European UV database containing spectral UV data from about 30 European stations and ancillary data. The database

consists of single files and an Oracle relational database accessible through www. Methodology on space-born retrieval of UV radiation at the Earth's surface is also being developed as a part of FMI, NASA and IASB collaboration. The following items are being studied:

- The impacts of ozone depletion, snowcover and cloudiness on UV radiation
- UV trends based on different techniques
- Space-born UV retrieval and its validation
- UV scenarios
- UV measurement methodologies and their errors

Satellite activities:

- EUMETSAT Satellite Application Facility on Ozone Monitoring (Ozone SAF)
- ESA ENVISAT-1 Global Ozone Monitoring by Stellar Occultation (GOMOS)

A new UV research centre, Finland's Ultraviolet International Research Centre (FUVIRC), will be established at Sodankylä in the near future. There will be meteorological, biological, ecological and medical research concerning ozone and UV radiation.

In addition, the following Finnish studies are considered relevant for the AMAP Programme:

- Atmospheric emissions of heavy metals in Finland in the 1997-1998 (FEI)
- Developing Consistent Global Change Scenarios for Finland (FINSKEN) (FEI)
- Arctic feed-backs to global warming: a circumpolar assessment (University of Lapland)
- LOUVRE / Long-term Ozone and UV estimates (FMI)
- Aerosols in the atmosphere and cloud formation (University of Oulu, University of Helsinki, University of Kuopio, FMI)

2. TERRESTRIAL ECOSYSTEMS SUB-PROGRAMME

2.1 Objective and structure

The purpose of the terrestrial ecosystems part of the NIP is:

1) to monitor the effects of anthropogenic air pollutants and contaminants on tundra and forest ecosystems,
2) to assess the impact of possible climate change on tundra and forest ecosystems, and
3) to determine the effects of UV-B radiation on tundra and forest ecosystems.

The terrestrial part of the monitoring programme is subdivided into intensive monitoring and regional monitoring.

The intensive monitoring plots include the ICP-Forests (Level II) and ICP-IM plots, which form part of the Pan-European Forest Condition Monitoring Programme, originally instigated under the auspices of the UN/ECE, and now funded by the EU (Finland and Sweden only). There are 13 such plots in Northern Fennoscandia. The purpose of the monitoring and research activity carried out by the Finnish Forest Research Institute within the programme is to investigate the relationships between anthropogenic and abiotic stress factors and the condition and vitality of forest ecosystems. The monitoring includes physical and chemical parameters in the soil and soil solution, as well as biological parameters related to the functioning of the forests.

A number of different organisations are responsible for carrying out monitoring on the regional scale. The Geological Survey of Finland carried out a survey of metals in mosses and soil in 1995, and a new survey will be carried out in the year 2000. The Finnish Forest Research Institute

conducts surveys of forest condition in Northern Fennoscandia, as part of the ICP-Forests programme, on a network of about 120 plots at the so-called Level I. In addition to the annual assessment of parameters relating to forest condition (defoliation, discoloration), needle chemistry surveys are carried out at 2-year intervals. A soil survey was carried out during 1986-89 and 1995, and will be repeated in 2004. A heavy-metal survey was carried out on moss, lichen and bark samples in 1985, 1990 and 1995, and will be repeated in the year 2000.

2.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/ examination	Programme and/or responsible institute
Tree stand	Tree growth	Every 5 years	Sevettijärvi (pine) Kevo (pine) (ex IM)	ICP Forests (UN/ECE/ LRTAP) METLA
	Defoliation	Every year	Pallas (pine) Pallas (spruce)	
	Needle chemistry (N, S, P, B, Ca, Mg, K, Cu, Zn, Mo)	Every 2 years	Sodankylä (pine) Kivalo (pine) Kivalo (spruce)	
Ground vegetation	Species composition	Every 5 years	Oulanka (spruce) (ex IM) Oulanka (pine) Oulanka (spruce)	
Mosses, epiphytic lichens, pine bark	As, Cd, Cr, Cu, Fe, Pb, Ni, V, Zn, S	Every 5 years, next sampling 2000	Ca. 100 plots	METLA
Stand throughfall	pH, Ca, Mg, K, Na, Mn, Cu, Zn, DOC, NH_4, NO_3, SO_4, PO_4	4-week intervals	Sevettijärvi (pine) Pallas (spruce) Kivalo (pine) Kivalo (spruce) Oulanka (spruce) (ex IM)	ICP Forests (UN/ECE/ LRTAP) METLA
Soil solution	pH, Ca, Mg, K, Na, Mn, Cu, Zn, total Al, Al^{3+}, Fe, DOC, NH_4, NO_3, SO_4, PO_4			
Litterfall	Ca, Mg, K, Na, Fe, Cu, Zn			
Snow water	Snow water equivalents mm/m^2	Monthly (winter)	Ca. 40 in Lapland	FEI
Stand climate	**Above stand**			
	Air temperature	Continuous (1 h)	Pallas (spruce) Kivalo (pine) Kivalo (spruce)	ICP Forests (UN/ECE/ LRTAP) METLA
	Wind speed	Continuous (1 h)		
	Wind direction	Continuous (1 h)		
	Solar radiation	Continuous (1 h)		
	PAR	Continuous (1 h)		
	Within stand			
	Relative humidity	Continuous (1 h)		
	Air temperature	Continuous (1 h)		
	Soil temperature	Continuous (1 h)		
	Soil moisture	Continuous (1 h)		
Mosses	Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Tl, U, V, Y, Zn	Sampling in 1995	About 200 sampling points, each point representing 100 km^2 catchment areas	KOLA Ecogeochem-istry Project, Geological Survey of
	Ag, Al, As, B, Ba, Be, Bi, C, Ca, Cd, Co, Cr,			

Organic layer **Mineral soil**	Cu, Fe, H, Hg, K, La, Li, Mg, Mn, Mo, N, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Ti, Tl, U, V, Y, Zn **(upper 5 cm)** Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, Ir, La, Lu, Mo, Na, Nd, Ni, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, U, W, Yb, Zn **B horizon** Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Se, Si, Sr, Te, Th, Ti, V, Y, Zn **C horizon** Ag, Al, As, Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Eu, Fe, Hf, Hg, I, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sm, Sr, Ta, Tb, Te, Th, Ti, U, V, W, Y, Yb, Zn		Norwegian-Russian-Finnish	Finland
Mosses **Organic layer** **Mineral soil**	Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Tl, U, V, Y, Zn Ag, Al, As, B, Ba, Be, Bi, C, Ca, Cd, Co, Cr, Cu, Fe, H, Hg, K, La, Li, Mg, Mn, Mo, N, Na, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sr, Th, Ti, Tl, U, V, Y, Zn **C horizon** Ag, Al, As, Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Eu, Fe, Hf, Hg, I, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Rb, S, Sb, Sc, Se, Si, Sm, Sr, Ta, Tb, Te, Th, Ti, U, V, W, Y, Yb, Zn	Sampling in 2000	About 1500 sampling points, each point representing 100 km^2 catchment areas in the Barents-area Finnish-Russian-Norwegian	BARENTS Ecogeochem-istry Project, Geological Survey of Finland
Reindeer	DDT, PCBs, HCB, chlordane, lindane, Cd, Pb, Hg, Se	Every 2 years	Lapland county	National residue control program, EELA
Elk	Cd, Pb	Every 5 years	Lapland county (whole Finland)	National residue control Program, EELA
Common shrew (Sorex araneus)	PCB, HCH, HCB, Cd, Pb, others	1 to 2 year interval	Kevo, Pallas, Oulanka	National, FEI
Wood ant (Formica sp.)	PCB, HCH, HCB, Cd, Pb, others	1 to 2 year interval	Kevo, Pallas, Oulanka	National, FEI

ICP Forests	International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests
UN/ ECE	United Nations/ Economic Commission for Europe
LRTAP	Long-Range Transboundary Air Pollution

METLA Finnish Forest Research Institute
EELA National Veterinary and Food Research Institute
FEI Finnish Environment Institute

2.3 Supporting studies

A large number of supporting studies are already being carried out, or will be started in the near future, in the arctic region of Finland. These include both studies on topics directly connected to the unique features of the region, and more general studies based on the climatic gradient running through the whole of Finland. Some of the studies are being carried out as joint efforts between Finland, Sweden and Norway. Some of the most important studies are listed in the following:

- Ecology and management of timberline areas, 1994-1998, 1999-2003 (METLA)
- UV radiation stress in plants at the timberline, 1997-2000 (METLA, University of Lapland)
- Climatic effects on pools of organic carbon and nitrogen and fluxes of dissolved carbon and nitrogen in forest soils, 1999-2001 (METLA)
- Paleoclimate studies on antarctic blue ice fields with ground-penetrating radar in Spitzbergen, 1999-2001 (University of Lapland, METLA)
- Global Change in Subarctic Environment: Physiological and Ecological Stress Responses and Recovery of Wild Plants (University of Oulu)
- Factors affecting microbial production of nitrous oxide and nitric oxide in agricultural soils (AGROGAS) (University of Kuopio, Agricultural Research Centre of Finland, FMI, University of Joensuu)
- Dynamics and modelling of the functioning and structure of forest ecosystems with implications for sustainability of the forest production and climate change impact (University of Joensuu)
- Climate-biOspheRE interactions (CORE) (University of Helsinki, University of Kuopio, FMI)
- Modelling past global change - forecasting the future (Geological Survey of Finland)
- The impact of increased UV-B on plant ecosystems (University of Oulu)
- Paleoenvironment and Climate in the North (University of Oulu)

3. FRESHWATER ECOSYSTEMS SUB-PROGRAMME

3.1 Objective and structure

The objective of the freshwater programme is to provide both spatial and temporal monitoring data for the assessment on heavy metals, acidification, and the effects of climate change. Most of the projects have been established for national needs or as part of international activities other than AMAP.

National lake surveys, co-ordinated with respect to lake selection, analytical methods, sampling techniques and sampling period, were conducted in the Northern Europe (Finland, Sweden, Norway, the Kola Peninsula, NW Russian) in 1995. The key objectives were to assess the status of the lakes with respect to overall water quality, and the occurrence and large-scale regional variation of acidification, eutrophication and heavy metal concentrations. Heavy metals have been analysed on a subsample (90 lakes) of the survey. The Geological Survey of Finland has conducted several surveys of a wide set of elements in stream water and stream sediments throughout the country. Monitoring acidification in lakes in Lapland provides regional information about long-term changes in small lakes, as well as empirical data for e.g. critical load calculations. Monitoring at river streamflow stations provides information about trends in overall water quality. The River

Tornionjoki (catchment area north of the Arctic Circle in Sweden and Finland, sampling station near the mouth of the river opening into the Baltic Sea) is included in the GEMS/water - programme, in which heavy metals and some organochlorines are measured twice a year.

A project on contaminants in sediment and fish has reported POP and heavy metal data to the first assessment according to the AMAP Monitoring guidelines. One of the lakes (Pahtajärvi) is now included in the national monitoring network on bioaccumulating compounds in freshwaters.

Several long-term hydrological monitoring programmes provide useful data for assessing the effects of climate change; ice freeze-up and break-up in rivers and lakes, ice cover thickness in lakes, and lake surface temperatures.

3.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/ examination	Programme and/or responsible institute
Lake water	General water chemistry, including major ions, pH, alkalinity, TOC, conductivity, P, N, Cd, Cu, Pb, Zn, Ni, As, Cr, Co, V, Fe, Mn, Al	10 year interval	184 throughout Lapland	North European Lake Survey (FEI)
Lake water	General water chemistry, including major ions, pH, alkalinity, colour, conductivity, N, P	3 year interval	200 throughout Lapland	Regional (LAP)
Lake water	General water chemistry, including major ions, pH, alkalinity, TOC, conductivity, P, N, Cd, Cu, Pb, Zn, Ni, As, Cr, Co, V, Fe, Mn, Al	6 per year	Vasikkajärvi, Sodankylä	(FEI+LAP) ECE/ICP waters
Stream water	General water chemistry, including major ions, pH, alkalinity, TOC, conductivity, P, N	15 per year	Laanioja	National stream network (FEI)
Lake and stream water	General water chemistry, including major ions, pH, alkalinity, TOC, conductivity, P, N, Cd, Cu, Pb, Zn, Ni, As, Cr, Co, V, Fe, Mn, Al	6 per year	Vuoskojärvi	ECE/ICP IM (FEI+LAP)
Lake water	15 congeners PCBs, 4 HCHs, HCB, 3 DDTs, 4 chlordanes	4 per year	River Tornionjoki	GEMS (FEI)
Lake sediment	Heavy metals incl. Cd, Cu, Pb, As, Hg, Ni, PAH, 33 congeners PCBs, DDT/DDD/DDE, PCDD/F	20 year interval	3-5 small lakes in Lapland	AMAP (FEI)
Lake sediment	Diatom inferred acidification and climate change history from sediment cores	20 year interval	3-5 lakes in Northern Lapland	University of Helsinki
Surface temperature	Surface temperature of open waters	Daily	5 lakes north of Arctic circle	FEI
Ice freeze-up and break-up	Ice freeze-up and break-up dates	Yearly	Ca. 10 lakes north of Arctic Circle, River Tornion-joki	FEI

Thickness of ice cover	Thickness of ice cover in lakes	3 /month (winter)	Ca. 11 sampling points in Lapland	FEI
Stream water	(filtered and acidified sample): Ca, Na, Mg, Al, Fe, K, Mn, Ag, As, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Li, Mo, Ni, Pb, Sb, Se, Sr, Th, Tl, U, V Zn (unfiltered sample): pH, Eh, conductivity, $KMnO_4$, colour, alkalinity, SO_4^{2-}, Cl^-, Br^-, NO_3^-, SiO_2, F^-, PO_4^{3-}, chlorophenols	Every 5 years	110 sampling points, each point representing 30-40 km^2 catchment areas	GTK
Stream sediments	Ca, Na, Mg, Al, Fe, K, Mn, Ag, As, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, La, Li, Mo, Ni, P, Pb, Sb, Sc, Se, Sr, Th, Ti, Tl, U, V, Y, Zn and C, H, N, S	Every 5 years	110 sampling points, each point representing 30-40 km^2 catchment areas	GTK
Groundwater	In the field: temperature, pH, conductivity, O and CO^2 In the lab: pH, conductivity, colour, $KMnO_4$, alkalinity (HCO_3^-), SO_4^{2-}, Cl^-, F^-, Br^-, NO_3^-, PO_4^{3-}, Ca, Mg, Sr, Ba, Be, Na, K, Li, Rb, SiO_2 and total hardness, Al, B, Fe, Mn, Cu, Zn, Ni, Co, Cr, Pb, Cd, V, Mo, Se, Ag, Tl, As, Sb, Bi, Rn, U, Th, D , ^{18}O	4 times every year	22 sampling points from 18 catchment areas	GTK
Groundwater	In the field: temperature, pH, conductivity, O and CO^2 In the lab: pH, conductivity, colour, $KMnO_4$, alkalinity (HCO_3^-), SO_4^{2-}, Cl^-, F^-, Br^-, NO_3^-, PO_4^{3-}, Ca, Mg, Sr, Ba, Be, Na, K, Li, Rb, SiO_2 and total hardness, Al, B, Fe, Mn, Cu, Zn, Ni, Co, Cr, Pb, Cd, V, Mo, Se, Ag, Tl, As, Sb, Bi, Rn, U, Th, D , ^{18}O	Once every year	7 sampling points from 7 catchment areas	GTK
Fish	Population trends	5-10 years	10-20 lakes and streams, north-eastern Lapland	RKTL
Fish (muscle)	Hg, 15 cong. PCBs, 4 HCHs, HCB, 3 DDTs, 4 chlordanes	1 to 3 year interval	Pahtajärvi (Arctic char, burbot) Lake Inari (whitefish, pike) Lokka reservoir (whitefish, pike) RiverTornionjoki (whitefish)	AMAP (FEI) National /FEI National /FEI National /FEI
Fish (muscle)	Cd, Pb, DDT, PCBs, HCB, Chlordane, lindane, Hg, Se	2 to 5 year interval	Lapland county Several species	EELA

AMAP	Arctic Monitoring and Assessment Programme
ICP waters	International Co-operative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes
ECE	Economic Commission for Europe (UN)
GEMS	Global Environment Monitoring System (UNEP)
FEI	Finnish Environment Institute
LAP	Lapland Regional Environment Centre
GTK	Geological Survey of Finland
RKTL	Finnish Game and Fisheries Research Institute
EELA	National Veterinary and Food Research Institute

3.3 Supporting studies

A model system for predicting watercourse discharges is being developed by FEI and is operated jointly by FEI and the Lapland Regional Environmental Centre. This system has been used for evaluating hydrological responses to climate change.

A water quality survey of small tributaries of the River Teno (most important salmon river of the area) is planned. This may subsequently lead to a new monitoring programme in northeastern Lapland. Also a survey of benthic invertebrate population trends is planned to investigate acidic pulses in stream water in northern Lapland. A survey of fish populations (gillnets, electrofishing) in small lakes in the NE Lapland is planned as a joint undertaking (Norway and the Kola Peninsula included). Lakes studied in the early 1990's would be re-sampled. Juvenile salmons (*Salmo salar*) are monitored annually in the River Tenojoki and River Tornionjoki. Time series data of ca. 20 years exist, which may be of use in regard of long term environmental changes.

A survey of mercury in fish (pike, whitefish, roach) in lakes is planned for the years 2000-02 by FEI. The number of sites and specimens have not yet been decided. Earlier data (1980-95) and reports could be useful for assessment purposes.

A joint project between Finland, Norway and Russia, "Developing a Joint Environmental Management System for the Paatsjoki River Basin", is planned for 1999-2001. The project will be co-ordinated by the Lapland Regional Environment Centre. The project consists of several studies including:

- Acidification of small streams in the Paatsjoki river basin
- Environmental toxin concentrations in Lake Inari
- Developing a method for monitoring the ecological state of fish stocks in Lake Inari

In addition, the following Finnish studies are considered relevant for the AMAP Programme:

- European Mountain lake Ecosystems: Regionalisation, diaGnostics & socio-economic Evaluation (EMERGE) (2000-2003)" (University of Helsinki, Department of Geography)
- Carbon pathways through Boreal lakes: a multiscale approach (CARBO) (University of Helsinki, FEI)
- Solar UV-B actions on aquatic ecosystems (University of Jyväskylä)

4. HUMAN HEALTH SUB-PROGRAMME

4.1 Objective and structure

The general objective of the human health sub-programme is to protect and promote the health of Arctic peoples, especially children, with respect to exposure to environmental contaminants (anthropogenic contaminants and radionuclides). The sub-programme has the following objectives:

1) To fill the monitoring gaps: The population of Sodankylä (Saami area) and of the area surrounding the steel works at Tornio are also being taken as target population.
2) To continue to monitor maternal blood at 5 year intervals in order to obtain temporal trends.
3) To make better use of existing data bases for estimating the impacts of environmental contaminants on the population.
4) To evaluate the utility of bio-markers as a tool for assessing the impact of contaminants.
5) To harmonise the dietary and demographic survey instruments.
6) To co-ordinate the activities of phase 2 of AMAP within the public health administration.

The concentrations of pollutants in local food stuffs are needed (and still missing) to calculate the external dose of pollutants e.g. in water, milk, berries, potatoes and other vegetables, mushrooms, elk and reindeer meat, birds and fish (Hg, Cd, Pb, Se, Cu, Zn, PCBs, HCH, HCB, DDT/DDE, toxaphene, dioxins).

4.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/ examination	Programme and/or responsible institute
Maternal blood	Cd, Hg, Pb, Se, Toxaphene PCB, DDTgroup HCH, HCB, Chlordan Dieldrin, Toxaphene (PCC) Dioxins/ (PCDD) Dibenzofuran (PCDF)	at 5-year intervals 50 mothers	Enontekiö, Inari Utsjoki, Savukoski Salla, Kemijärvi, Pelkosenniemi, Sodankylä Tornio	State Provincial Office of Lapland
Mothers/ food	Calculating external dose: Hg, Cd, Pb, Se, Cu, Zn, PCBs, HCH, HCB, DDT/DDE, toxaphene, dioxins in food Food questionnaire	at 5-year intervals 100 mothers	9 municipalities above	State Provincial Office of Lapland
Human breast milk	PCB, dioxins	10 mothers	Enontekiö, Salla, Inari	National Institute of Health
Placentas	Enzymes indicating xenobiotic and steroid metabolism in human placenta	at 5-year intervals 40 mothers	The whole target population of 9 municipalities	University of Oulu Department of Pharmacology and Toxicology
Human eyes	Effect of UV radiation		Northern population	University of Oulu, Department of Eye Diseases
Human skin	Effect of UV radiation		Northern population	University of Oulu Department of Skin Diseases

Bio-physical indicators	Epidemiological Effect Markers		Target Population	Programme and/or responsible institute
Health statistics	Morbidity/ Mortality data		Lapland/Finland	State Provincial Office of Lapland
Pregnancy outcome	Abortion Gestational age Sex (single/multiple) Placenta weight, metabolism		Lapland/Finland 9 municipalities	State Provincial Office of Lapland
Developmental anomalities	Maldescent testis Hypospadias Epispadias Cancer incidence		Lapland/Finland	State Provincial Office of Lapland
Immunological effects	Hospitalisation Vaccination response		The whole population of 9 municipalities in Lapland	State Provincial Office of Lapland

4.3 Supporting studies

Human tissues are being analysed for Hg, Cu, Pb, Cd, Ni, PCBs and dioxins at 5-year intervals in nine municipalities by the State Provincial Office of Lapland.

The effect of cold on hormone metabolism in the northern human population is being studied at the Department of Physiology and Institute of Occupational Health, University of Oulu.

The concentrations of heavy metals (Hg, Zn, Cd, Pb) in human blood are being analysed and correlated with human health status within the "Cohort 66" project conducted by the Department of Public Health and General Practice, University of Oulu. Samples collected in 1996 were taken from the whole population of Lapland born in 1966.

5. RADIOACTIVITY SUB-PROGRAMME

5.1 Objective and structure

The aim of the surveillance and research activities of the Radiation and Nuclear Safety Authority (STUK) is to prevent and limit the harmful effects of radiation. The permanent environmental monitoring program (YSV) of STUK includes the continuous monitoring of external radiation at 273 automatic measurement stations, the collection of aerosol samples at nine locations, precipitation at nine stations, surface water in the estuaries of three rivers, and milk from four dairies. In addition, tap water and hospital food baskets are analysed in three towns, and school children measured by whole body counting in two towns. However, these continuous measurements are not relevant for the AMAP program.

The research programs of STUK's Regional Laboratory in Northern Finland include several environmental research projects in which the transport and accumulation of anthropogenic radionuclides in Arctic food chains, and the concentration in locally produced foodstuffs, are studied. The results of these long time series were extensively used in the first phase of the AMAP program.

5.2 Monitoring and effects studies

Target media	Parameters	Frequency	Location of sampling/ examination	Programme and/or responsible institute
External radiation	Dose rate, uSv/h	Continuos	44 stations/Lapland	YSV/STUK
Atmospheric: Air/aerosol	Gammanuclides (^{137}Cs, ^{134}Cs, ^{131}J), Bq/m^3	Weekly	Rovaniemi	YSV/STUK
Atmospheric: Air/aerosol	Gammanuclides (^{137}Cs, ^{134}Cs, ^{131}J), Bq/m^3	Weekly	Sodankylä	YSV/STUK
Atmospheric: Air/aerosol	Gammanuclides (^{137}Cs, ^{134}Cs, ^{131}J), Bq/m^3	Weekly	Ivalo	YSV/STUK
Atmospheric: Precipitation/ fallout	Gammanuclides (^{137}Cs, ^{134}Cs, ^{131}J), ^{90}Sr, Bq/m^2	4 / year	Rovaniemi	YSV/STUK
Atmospheric: Precipitation/ fallout	Gammanuclides (^{137}Cs, ^{134}Cs, ^{131}J), ^{90}Sr, Bq/m^2	4 / year	Sodankylä	YSV/STUK
Atmospheric: Precipitation/ fallout	Gammanuclides (^{137}Cs, ^{134}Cs, ^{131}J), ^{90}Sr, Bq/m^2	4 / year	Ivalo	YSV/STUK
Atmospheric: Precipitation	^{3}H, Bq/m^3	4 / year	Apukka/Rovaniemi rural commune	STUK
Terrestrial: Permanent lichen plots, surface soil	Gammanuclides(^{137}Cs, ^{134}Cs), Bq/kg, Bq/m^2	Every 3-5 years	Utsjoki (Koihkenjavepakti), Inari (Kaamanen airport) Rovaniemi (Apukka) Kittilä (Pahtavuoma)	STUK
Terrestrial: Vascular plants, mosses, surface soil	Gammanuclides(^{137}Cs, ^{134}Cs), Bq/kg, Bq/m^2	Every 3-5 years	Utsjoki (Koihkenjavepakti) Salla (Oulanka) Rovaniemi (Apukka) Kittilä (Pahtavuoma)	STUK
Terrestrial: Reindeer meat	Gammanuclides(^{137}Cs, ^{134}Cs), Bq/kg	Annually	Saami reindeer herding districts in Utsjoki and Inari Kemin-Sompio	STUK
Terrestrial: Willow grouse	Gammanuclides(^{137}Cs, ^{134}Cs), Bq/kg	Every 3 years	Utsjoki	STUK

Terrestrial: Dairy milk	Gammanuclides, ^{90}Sr	6 /year (gamma), 4 / year (Sr)	Rovaniemi dairy (eastern Lapland)	YSV/STUK
Terrestrial: Farm milk	Gammanuclides, ^{90}Sr	Monthly	Vikajärvi	STUK
Terrestrial: Farm milk	Gammanuclides, ^{90}Sr	2 / year	Inari Kittilä	STUK
Terrestrial: Mushrooms	Gammanuclides	Annually	Kivalo	STUK/ METLA
Terrestrial: River water	Gammanuclides	4 / year	Kemijoki	YVS/STUK
Fresh water: Lake water	^{137}Cs, ^{90}Sr, Bq/m^2	Annually	Apukkajärvi Nitsijärvi	
Fresh water: Fish (muscle)	Gammanuclides (^{137}Cs, ^{134}Cs), Bq/kg	Annually	Apukkajärvi (pike, perch, roach) Jerisjärvi (pike, perch,burbot, whitefish, vendace) Äkäsjärvi (pike, perch,burbot, whitefish, vendace) Lake Inari (pike, burbot, whitefish, trout) Nitsijärvi (pike, burbot, whitefish, trout)	STUK
Fresh water: Salmon (muscle) (bone)	Gammanuclides (^{137}Cs, ^{134}Cs), ^{239,240}Pu, ^{90}Sr Bq/kg	Annually	River Kemijoki River Simojoki	STUK/ RKTL ARCTICMAR (1998-2002)
Marine: Salmon (muscle) (bone)	Gammanuclides (^{137}Cs, ^{134}Cs), ^{239,240}Pu, ^{90}Sr Bq/kg	Annually	River Teno	STUK/ RKTL ARCTICMAR (1998-2002)

STUK Radiation and Nuclear Safety Authority
YSV The permanent environmental monitoring program of Radiation and Nuclear Safety Authority
METLA Finnish Forest Research Institute
RKTL Finnish Game and Fisheries Research Institute
ARCTICMAR Radioecological assessment of consequences from radioactive contamination of arctic marine areas

5.3 Supporting studies

Whole-body counting of the Finnish Saami reindeer herders in Utsjoki and Ivalo was an important part of the first phase of the AMAP program. The long measurement series from 1960 to 1997, together with the food consumption data, illustrated the effects of atomic-weapon testing and the Chernobyl accident on the Saami population. Continuation of these measurements was highly recommended by the AMAP expert groups for Radioactivity and Human Health. However, for the present, STUK is not able to continue these expensive measurements without some support from other sources.

6. MARINE SUB-PROGRAMME

Finland has defined the Arctic Circle as the southern limit of the regions participating in co-operation under the Arctic Council. Despite the fact that the Bay of Bothnia, as well as some other parts of the Baltic Sea, are cold and covered at least partly by ice during winter, the Baltic Sea has not been included in the Arctic co-operative programmes. However, Finland has participated in Arctic marine research and could contribute to the AMAP marine sub-programme with selected supporting studies.

The Finnish Institute of Marine Research (FIMR) has participated in studies in the Petshora Sea area within the framework of a co-operation agreement drawn up between FIMR and the Murmansk Marine Biological Institute. During the course of the AMAP Trends and Effects Programme, 1998-2003, the FIMR will participate in publishing basic information about the hydrographical and biological state of this area. FIMR will also, within the framework of AMAP, follow the situation in Arctic waters, participate in relevant programmes and, on request, place the knowledge and expertise of the FIMR about the ecology of polar seas at the disposal of the programme.

In addition, the following Finnish studies are considered relevant for the AMAP Programme:

- Arctic snow, sea-ice and glaciers in a changing climate
  (University of Helsinki, Arctic Centre)
- Sedimentary and geochemical indicators of climatic and environmental change in polar margins (University of Oulu)