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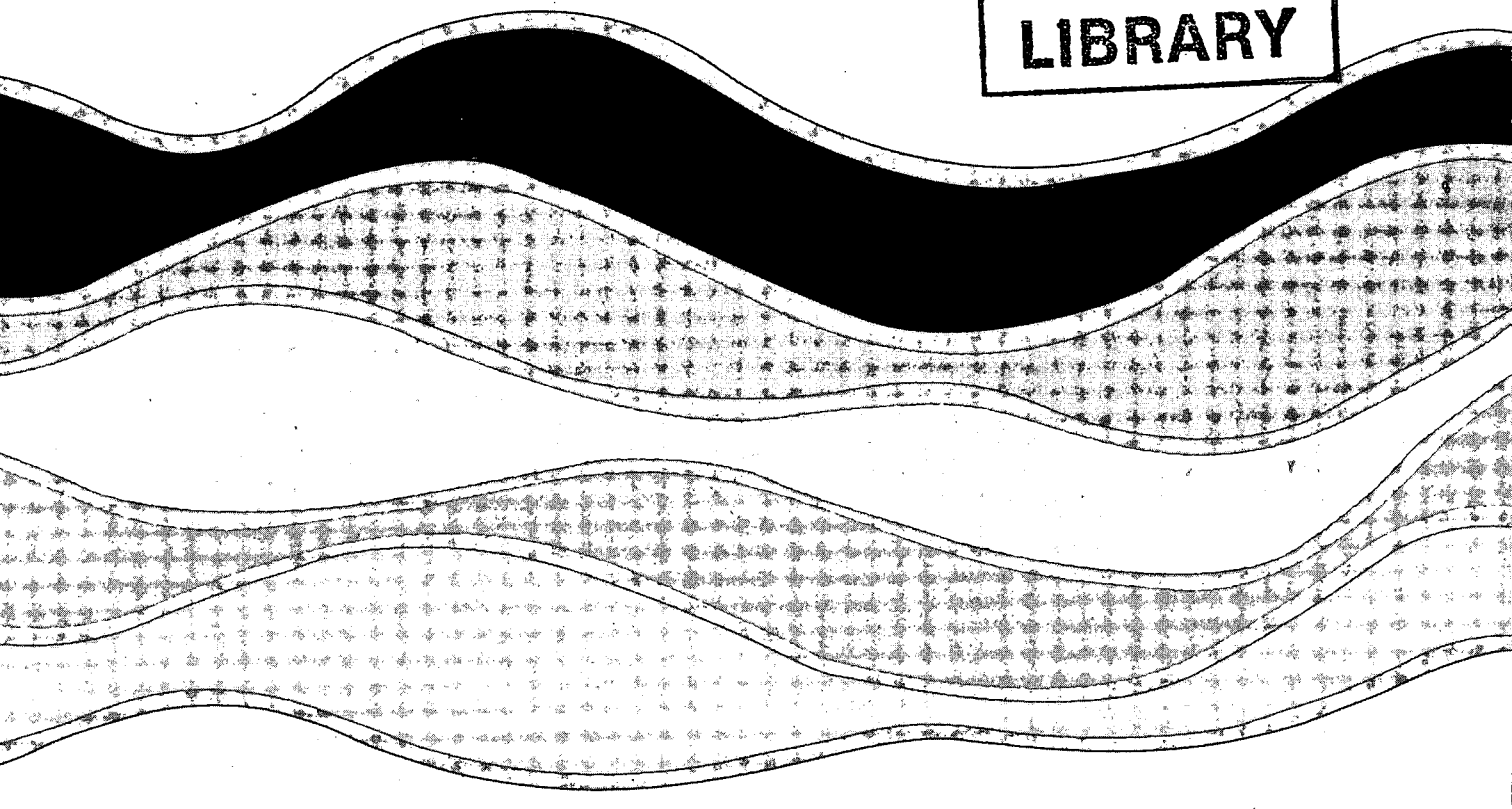

TOXIC SUBSTANCES SCIENCE IN C&P

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EXECUTIVE SUMMARY

A preliminary framework for the development of C&P Toxic Substances Science in support of CEPA is presented.

The purpose of this document is to articulate the science and technology (S&T) required to support the implementation of CEPA. The S&T requirements are categorized as short-term and long-term information and research needs. The short-term needs address primarily the immediate assessment and related decision-making needs for substances on the PSL. The long-term needs are more generic and apply mainly to the post-assessment regulatory, enforcement and control activities of CEPA.

Dr. J. Lawrence
Director
Research and Applications

RÉSUMÉ À L'INTENTION DE L'ADMINISTRATION

On présente un cadre de travail préliminaire en vue de l'élaboration d'un réseau sur les substances C et P toxiques qui servira de référence pour la LCPE.

Le but du présent document est de coordonner les travaux de science et technologie (S et T) nécessaires à l'application de la LCPE. Les exigences relatives à la S et T se divisent en plusieurs catégories : information et recherche à court terme et à long terme. Les besoins à court terme portent principalement sur l'évaluation et les prises de décision immédiates en ce qui concerne les substances de la LSP. Les besoins à long terme sont plus généraux et s'appliquent principalement aux activités de réglementation, d'application et de contrôle liées à la LCPE, qui auront lieu après l'évaluation.

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ABSTRACT

This document provides the framework for the orderly and systematic aquisition of information for credible decision-making with regard to the assessment and control of the harmful impacts of toxic substances. The underlying purpose is to help enummerate the short- and long-term science requirements of CEPA. The appendices provide a preliminary listing of the short-term and long-term informational and research needs based on input provided by managers of C&P programs which have a toxic substance component, Assessment Task Group Leaders and those to be involved in post-assessment control options.

RÉSUMÉ

On a évalué de manière préliminaire la faisabilité d'établir un réseau scientifique sur les substances C et P toxiques pour aider à satisfaire les exigences scientifiques de la LCPE. L'idée d'un réseau scientifique sur les substances toxiques est née de l'analyse du compte rendu du forum scientifique sur la LCPE et de discussions avec des représentants du gouvernement, d'universités, de l'industrie et d'organismes non gouvernementaux. Les résultats de l'évaluation montrent qu'il serait possible de mettre sur pied un réseau scientifique multidisciplinaire basé sur la "meilleure expertise disponible" au Canada, à condition que les exigences scientifiques soient bien définies, que l'on dispose de fonds suffisants et qu'une procédure administrative appropriée soit mise en place. On donne en appendice une liste des divers répertoires et inventaires qui pourraient se révéler utiles pour identifier l'expertise scientifique canadienne pertinente et sa capacité de recherche.

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TOXIC SUBSTANCES SCIENCE IN C&P

I. INTRODUCTION

The Toxic Substances Program of Environment Canada's Conservation and Protection (C&P) Service is primarily in support of the Canadian Environmental Protection Act (CEPA). The objective of this document is to provide the framework for the orderly and systematic acquisition of information, knowledge and advice for credible decision-making with regard to assessing and controlling the harmful impacts of toxic substances under CEPA. The framework will be used to influence both government and non-government organizations to focus their research to the requirements of the Act. This approach is closely linked to the C&P Results Definition Model (Effects Statement C12) and is in keeping with the C&P Integrated Management Framework for Controlling Toxic Substances under CEPA.

The scope of this document is limited to toxic substances which fall into the following categories:

- chemical hazards, including specific atomic and molecular substances, complex mixtures, effluents and emissions;
- microbial hazards, including pathogens and genetically engineered materials;
- inanimate particulates, including mineral fibers such as asbestos, suspended sediments and air particles.

The following are excluded from the scope of the document:

- pesticides and radionuclides which are covered by separate legislation distinct from CEPA;
- exotic microbials and agents of higher disease such as parasites;
- physical energy phenomena such as the radiation from hydro transmission wires.

The underlying purpose of the framework is to help articulate the short- and long-term science requirements of CEPA. The short-term needs are mainly those required for the completion of the assessment reports for substances on the Priority Substance List (PSL) of CEPA, and the priorities must match the substances and timetable set for the PSL. On the longer term, the science needs go beyond the assessment reports and include post-assessment regulatory, enforcement and control activities, as well as pre- and post-control monitoring which is required to evaluate the level of compliance and the success of the regulatory measures implemented. The science needs go beyond those of Part II of the Act and the current PSL, and include the requirements for the second generation PSL and the fast track control chemicals.

For the assessment process, existing relevant information from all possible sources must be utilized, including existing Environmental Quality Guidelines. The CEPA Science Forum held in Burlington, February 22nd & 23rd, 1989, recognized the breadth of the ecosystem science requirements and recommended that effort should be focused on 'need to know' research such as; (i) new multidisciplinary approaches in support of control aspects of the act; and (ii) effects that are particularly relevant to Canadian ecosystems, while drawing on and contributing to, the wealth of knowledge that is developing internationally. The ecosystem framework of CEPA brings together the health, environmental and social aspects of science.

Provision of an adequate science base for CEPA requires maintenance of a strong toxic chemicals program within the Federal Government in addition to specific pieces of knowledge required for assessments and regulatory control under the Act. The government must give priority to ongoing toxic chemical programs in the aquatic, atmospheric, terrestrial, wildlife and health sciences. This will ensure that the long-term (>5 years) needs of CEPA can be met. Such programs must include identification of sources, pathways and transformation of toxics in the environment; the selection and use of wildlife and other biota as biological indicators; analytical methods development; quality assurance (chemical and biological); and effects and impact research (both environmental and health) and monitoring studies.

II. C&P PROGRAMS WITH A TOXIC SUBSTANCES COMPONENT

Many C&P programs have a toxic substances component and are hence relevant to CEPA Science. These programs are itemized in Table 1.

Toxic substances science is required not only by those managers making decisions on the need for the regulation and control of toxic substances, but also by those supporting the regulatory measures. Thus, an attempt has been made to categorize these programs as either assessment related, regulatory related or assessment and regulatory related.

The assessment category is broad and encompasses research, monitoring and pre-regulatory and post-regulatory assessment. The regulatory category includes only the development and implementation of control measures.

TABLE 1 C&P PROGRAMS WITH A TOXIC SUBSTANCES COMPONENT

ASSESSMENT	ASSESSMENT & REGULATORY	REGULATORY
MARINE ENVIRONMENTAL QUALITY	INDUSTRIAL	OCEAN DUMPING CONTROL
WATER QUALITY	WASTE	
PESTICIDE	COMMERCIAL CHEMICALS	
NUCLEAR	ACID RAIN	
EMERGENCY RESPONSE	CLIMATE CHANGE	
WILDLIFE	GREAT LAKES	
LONG RANGE TRANSPORT-ATION OF AIR POLLUTANTS (LRTAP)	ST. LAWRENCE RIVER	
AIR TOXICS	ARCTIC	
ENVIRONMENTAL IMPACT ASSESSMENT	FRASER RIVER	

III. SCIENCE AND TECHNOLOGY NEEDS FOR THE IMPLEMENTATION OF CEPA

CEPA is divided into nine parts, with the first seven containing provisions which could call for the development of new scientific knowledge or technology. The following paragraphs provide an overview of the Act to highlight and illustrate, in general terms, the type of science or technology needs that can be anticipated.

Part I of CEPA contains the mandate for the gathering of information through monitoring and research activities and for the development of environmental quality guidelines, objectives and codes of practice. The implementation of the provisions contained in this part will undoubtedly call for science needs focused on environmental monitoring studies, including early warning approaches and on the fate and effects of substances of concern entering into the environment. The development of codes of practice will provide opportunities to identify areas in need of technology development to improve or minimize the environmental impact of particular industrial activities.

Part II of the Act contains the provisions underlying major governmental programs focused on the assessment and regulatory control of existing substances, particularly those identified on the PSL, and new substances. The implementation of these programs can be expected to create the largest portion of the CEPA science and technology needs because of their broad scope. Data from monitoring, fate, effect, and toxicity studies will need to be developed in support of the assessment of whether particular substances are to be considered toxic as defined in the Act. Studies will be needed to further develop more reliable predictive techniques for the health and environmental assessment of existing and new substances, particularly when the available data on these substances are incomplete. New technology will be needed to assist in the development of the most appropriate control strategies for substances requiring regulation under the Act.

Part IV of the Act incorporates provisions meant to ensure that uniform levels of environmental protection can be achieved across the country in areas or matters not covered specifically under the mandate of the Ministers. Technology development opportunities can be expected to arise in support of the regulatory activities linked to this part. Various science needs can be anticipated to ensure the development and maintenance of a minimal knowledge base for the appropriate implementation of this part within Environment Canada and Health and Welfare Canada.

Part VI of the act contains the provisions for the implementation of the DOE Ocean Dumping program. While the regulatory aspects of this program can be expected to create most of the demands for technology development, numerous science studies in the area of monitoring, fate and effect will need to be undertaken to support assessment work on the environmental impact of particular ocean disposal practices.

Parts III (nutrients), V (international air pollution) and VII (general, enforcement and compliance) of the Act are to a large extent focused on regulatory matters. Opportunities for technology development can be expected to arise in support of the implementation of the various provisions found in these parts of the Act.

IV TOXIC SUBSTANCES SCIENCE AND TECHNOLOGY REQUIREMENTS

The Appendices to this document contain an enumeration of specific toxic substances science and technology (S&T) requirements, which have been categorized as short-term or long-term needs. The initial identification of the science needs listed to date has been provided by managers of C&P programs which have a toxic substances component, Assessment Task Group Leaders and those to be involved in post-assessment control options. It is anticipated that the lists will be further developed as more information is available on the Green Plan and as the science requirements for CEPA become better formulated.

The short-term needs (Appendix I) are driven mainly by the PSL and address the immediate assessment and related decision-making needs of primarily Part II of CEPA (Toxics). This list identifies the need for studies on the presence, fate, effects and toxicity of specific substances on the PSL, as well as the technology and testing procedures/protocols for the implementation of Part II of CEPA. It should be noted that for a number of substances on the PSL, the evaluation of existing information in the literature has not been completed and therefore the short-term list should not be considered comprehensive.

The long-term needs (Appendix II) have been compiled based on information provided by Environment Canada managers who are charged with toxic substance related operational programs from which S&T needs are likely to arise. These long-term needs are more generic in nature and apply to the requirements for the implementation of CEPA in general, including the needs related to the post-assessment, regulatory, enforcement, control and post-control monitoring aspects of the Act. This list will be supplemented and/or made more specific as work progresses under the various CEPA related activities.

The identified needs in the Appendices could provide the operational focus for a Toxic Sciences Network, a national network proposed to link the science needs to the best available expertise in Canada. Through such a network, this document would stimulate the preparation of specific research proposals to address priority needs and bring new perspectives to government research.

APPENDIX I

Short-Term Informational & Research Needs

i) **Canadian Presence/Distribution**

- tri/tetra chloroethylene in groundwater in provinces other than Ontario
- chlorinated paraffins in the aquatic environment and data on their commercial use and production
- dioxins/furans (2,3,7,8-TCDD/TCDF) origins and mechanisms of formation
- PCB congeners in the aquatic environment
- PCB congeners, arsenic and PAHs in St. Lawrence River water, suspended and bottom sediments and selected biotic compartments

- PAHs in emissions from incinerators, wood stoves, teepee burners, aluminum plants, dredging activities and petroleum spills; in groundwater from landfill leachates and in side stream cigarette smoke
- PAHs and metabolites in biota, including invertebrates and the more relevant PAH compounds in ambient city air
- alkylated and heterocyclic aromatic compounds in freshwater sediments and marine sediments
- creosote residue levels in in-use and out-of-use creosote impregnated materials
- methyl methacrylate in the environment

- benzene, toluene, styrenes and xylenes in food (Market Basket Studies)
- benzene, toluene, perchlorethylene and other VOC emissions from industrial sectors including gasoline terminals

- VOC fugitive emissions from refineries and chemical plants
- VOC emissions from waste water treatment plant aeration tanks
- NO_x inventory of sources and emissions (combustion turbines industrial boilers & process heaters, electric power plants,reciprocating natural gas compressors)

- non-pesticidal organotin in sewage treatment plant influents and effluents; landfill leachates; and as a result of the degradation of organotin pesticides
- arsenic, cadmium, nickel, chromium and effluents of kraft pulp mills distribution in wildlife.
- arsenic in all its natural forms and in commerical use
- nickel, commercial use and production data
- copper and mercury in Canadian gold mills
- metals (cadmium, copper, iron, lead, nickel, zinc, etc.) available from scrap

- industrial effluents and toxics generation data base (St. Lawrence River)
- toxic substance (chemical) inventory of industrial waste streams and waste disposal sites
- toxic substance (chemical) characterization of industrial effluent streams
- toxic substances in mixed refuse municipal compost

- microbial ecological profile of organisms already targeted for wide Scale environmental release (Biotechnology)
- microbial characterization and quantification of emission streams from biology-base manufacturing facilities (Biotechnology)

ii) <u>Canadian Environmental Fate & Behaviour</u>

- chlorinated ethanes fate and behaviour in the aquatic environment (removal processes, degradation products and persistence)

- trichloroethane bioaccumulation (two chronic studies with a fish species plus one chronic study with an aquatic invertebrate)
- tetrachloroethane bioaccumulation (one acute study with an aquatic invertebrate and an algal species, plus one chronic study with a fish species)
- ethylene dichloride bioaccumulation (one acute study with an aquatic invertebrate and an algal species)
- trichloroethylene bioaccumulation and depuration (at least one chronic study with an aquatic invertebrate, preferably a life-cycle measurement)
- PCB fate and persistence for congeners of toxicological importance
- dioxins/furans (2,3,7,8-TCDD/TCDF) trends of sediment/biota contamination in fisheries closure areas
- PCB, dioxin and furan congeners bioaccumulation in different trophic levels and persistance (in sediment, algae, fish, mussels)
- PCB identification and ranking of congeners of biological importance

- PASL (Plan d'Action St. Laurent) target compounds (PCB congeners, arsenic and PAHs) fate and persistence
- PAH, PCDD, PCDF, PCB congeners, mercury, chlorophenols, chlorobenzenes, arsenic and cadmium movement and bioaccumulation in animals, particularly birds

- PAHs fate and persistence (more longitudinal studies of controlled exposure to develop a database for estimating persistence and bioaccumulation), including transformation and transport
- heterocyclic N and O containing aromatics bioavailability to members of the marine community
- creosote and its constituents and degradation products fate and effects

- plume modelling for suspended marine sediments and other substances
- contaminants transport in geologic environments (glacial tills)

- stability and transfer frequency of introduced genetic material in the intra- and extra cellular environment (Biotechnology)
- factors regulating survival and growth of microorganisms in the environment (Biotechnology)
- predictive models for transport of microorganisms from the point of application or release to other locations (Biotechnology)

iii) Toxicity

- toluene, wildlife toxicology and ecotoxicity data
- methyl methacrylate, toxicity data for assessing carcinogenicity (long-term and short-term carcinogenic studies)
- waste crankcase oils, toxicity data for all aspects of the assessment
- heterocyclic N and O containing aromatics toxicity to marine sediment dwellers and bioavailability to other members of the community
- PAH exposure data (for mixture) and wildlife toxicology

- PAH, PCDD, PCDF, PCB congeners, mercury, chlorophenols, chlorobenzenes, arsenic and cadmium ecotoxicologic effects on animals, particularly birds
- PCB dioxin & furan congeners and PAHs effects on health and chronic effects at the ecosystem level

- pulp mill effluent chronic effect with and without toxic chlorinated organics
- pulp and paper effluents effects on aquatic ecosystems

- arsenic, cadmium, nickel, chromium and effluents at kraft pulp mills toxicity to wildlife
- arsenic, health effects of organic species if such compounds are of significant occurrence in Canada
- cadmium, nickel and chromium wildlife toxicology and ecotoxicology data for Canada

- contaminated marine sediment cause and effects studies (i.e. correlation of sediment contaminants with tumorigenesis)
- "model" harbour sediments dose-response relationships with flatfish
- marginally contaminated marine sediment in Tuktoyaktuk Harbour resuspension effects study

- determination and changes of effects on non-target organisms from the introduction of microorganisms (Biotechnology)

iv) **Technology**

- disposal method for creosote impregnated materials (e.g. railroad ties, telephone poles, etc.)

- CFC phase-out (destruction) technologies assessment
- PCB solids destruction technology assessment and development
- detoxification/recycling of solid waste contaminated with chlorinated hydrocarbons
- better understanding of industry's practices of managing dioxin/furan containing wastes

- in-stack continuous monitoring of dioxins/furans and particulates (metals)
- in-stack real-time monitoring of organic compounds, particularly chlorinated organics (e.g. dioxins, furans, PCBs) and PAH compounds
- recycling or elimination of contaminated (fluoride, cyanide, PAHs, heavy metals) spent cathodes in aluminum plants

- effective removal of metal contaminants from used oil
- recovery of metals or stabilizion of mining industry sludges to prevent metal releases

- assessment of new combustion turbine engines and NO_x control techniques

- assessment and demonstration of best available control technologies for NO_x from reciprocating natural gas compressors, steam electric power plants, industrial boilers and process heaters
- assessment of available NO_x measuring equipment for monitoring combustion turbine engines and compare with more expensive/cumbersome standard reference methods
- evaluation and demonstration of low-cost NO_x monitoring equipment for industrial/commerical boilers
- demonstration of best available NO_x monitoring systems for steam electric power plants
- assessment of new developments in coal-oil use with low SO_2 emissions for fossil fueled power plants
- assessment and demonstration of control methods for benzene and VOCs from gasoline terminals
- evaluation and development of technologies and approaches for preventing and eliminating benzene and VOC leaks from fugitive sources at refineries and petrochemical plants
- evaluation and assessment of state-of-the-art technologies, techniques and approaches (including substitution and recycling) to prevent, eliminate and/or reduce emissions of benzene toluene, perchlorethylene and other VOCs from industrial sectors

- assessment and promotion of best available control measures for toxic industrial contaminants
- determination of the control efficiency of FLARE systems (chemical/petrochemical plants and petroleum refineries) and establishment of the operating parameters to optimize efficiency for different substances on the PSL
- data base on emerging pollution abatement technologies and identification of areas of research for proper development of technologies needed for the treatment and elimination of hazardous waste as well as the decontamination and restoration of soils
- data base on emerging dredging equipment and decontamination techniques for sediments, and identification and prioritization of the technology development needs for dredging and detoxification of contaminated sediments, as well as for sites restoration

- development of various tools (guides, maps, data base) for users in dredging activities

- methodology to assess the ongoing performance of incineration processes
- disinfection of biomedical waste (including anatomical)

- abiotic and biotic procedures for site decontamination/rehabilitation and termination of experiments (Biotechnology)
- adequacy of existing pollution control devices in treating biological constituents of emission streams (Biotechnology)

v) **Testing Procedures & Protocols**

- a simple acceptable reference method for vinyl chloride
- standard reference methods for the analysis of dioxins/furans and asbestos (mineral fibers) in water and especially air samples

- methods for the analysis of creosote (its constituents and degradation products) in environmental matrices
- methods and interlaboratory calibration for measurement of alkylated and heterocyclic aromatic compounds in sediment
- testing and analytical protocols for substituted PAH compounds (e.g. alkylated nitrosated PAHs) in ambient air, stack samples, drinking and surface water, soil and sediment

- evaluation of existing sampling and standard reference methods for typical compounds found at contaminated sites
- development of reference methods for priority substances released by metal casting operations (i.e. arsenic, nickel, cadmium, chromium, PAHs, VOCs and sediments)
- analytical methods for organo-sulphur compounds in refinery emissions and pulp & paper effluents

- sampling methods for fuels and hazardous wastes from trucks at border crossings
- extraction procedure for testing leachable toxic wastes (including volatile organics)
- improved sampling equipment and methodology to optimize the collection and analysis of wet atmospheric deposition samples for toxic substances
- evaluation and development of field analytical kits for screening toxic and priority list substances
- a solid/liquid determination test

- a toxicity testing protocol to classify hazardous waste based on acute and chronic toxicities for at least six species using five tests
- toxicity techniques for assessing contaminated marine sediments
- evaluation of suitable macro- or micro-organism bioassays for determining acute and chronic toxicity effects from putatively contaminated sediments
- protocols and test organisms, including indigenous Arctic species for bioassays to aid in the assessment of ocean dumping applications
- evaluation of standard sediment bioassay tests for the Arctic marine environment and development of appropriate sediment bioassay test organisms and procedures for the Arctic
- selection of indicator species i.e. research to develop standardized protocols for Canadian species sensitivity (amphipods, sand dollars, sea urchins, mysids, lobster and flounder or bottom fish) for purposes of marine aquatic and sediment toxicity testing (acute and chronic)
- selection of animal species which can serve as good bioindicators of environmental contamination
- field evaluation of suitable sublethal biomontors to supplement analytical data and bioassay results used by regulatory agencies
- bioindicator protocols for marine and freshwater receiving environments for pulp mills and metal mines

- standardized protocols for ambient effects monitoring and for in-situ caged exposure in support of effluent regulation
- development and application of a ready-reckoner scale of the potential ecotoxicological effects from bioassay results obtained from routine "end of the pipe monitoring"
- QA/QC standards and protocols for schedule III, Part I & II substances and for bioassays and marine sediment analysis

- methods for the detection and enumeration of novel microorganisms, extracellular material and product metabolites in complex environmental samples (Biotechnology)
- method for the detection of adverse environmental response (e.g. ecological effect and toxicity) resulting from the introduction of microorganisms (Biotechnology)
- method for recovery and sampling of bacteria from deep subsurface locations (Biotechnology)

vi) Criteria

- development of criteria for chronic toxicity testing
- development of criteria to designate low level radioactive waste as hazardous
- establishment of criteria for selecting and assessing remediation technologies for contaminated sites
- assessment of current remediation criteria for contaminated sites
- development of a classification system for establishing priority for contaminated sites
- development of codes, guidelines or regulations for priority substances released by metal casting operations (i.e. arsenic, nickel, cadmium, chromium, PAHs, VOCs & solvents)
- studies to relate assessment results to organochlorine effluent control requirements for specific organochlorines released by pulp mills

- studies to ensure that ocean disposal sites are selected on the basis of sound site - specific information
- scientific advice on regulated limits for all scheduled substances, including toxic equivalency, normalization to particle size and total organic carbon, etc.
- prioritization of detoxification interventions (St. Lawrence R.) and ensure easier follow-up and easier dissemination of information
- development of means of identifying cause to effect mechanisms (St. Lawrence R.) and adequate monitoring and treatability studies and tools
- contingency planning for accidental release of microorganisms (Biotechnology)

APPENDIX II

LONG-TERM INFORMATIONAL & RESEARCH NEEDS

i) Presence/Distribution

- evaluation of potential for dioxin/furan releases in pulp mill air emissions and need for control
- better understanding of origins of dioxins in pulp mill effluents
- inventory and characterization of sources of VOC pollutants in the industrial sectors
- continued updating of inventory of sources and emissions of benzene/VOCs from gasoline terminals, refineries and chemical/petrochemical plants
- continued updating of NO_x source/emission inventories for combustion turbines, industrial boiler & process heaters, steam electric power plants and reciprocating natural gas compressors

- continued assessment of releases of priority and toxic substances in wastes from metal casting operations
- establishment of an all encompassing database of information pertaining to ocean dumping projects
- continued updating of inventory of toxic industrial contaminants/releases in solid and aqueous media and sources

- identification of sites of industrial contamination hazardous to wildlife
- monitoring of toxic substances in wildlife to assess health effects, risks and overall environmental quality
- chemical and biological monitoring data (Canadian distribution/presence) for substances which may be increasing in the environment and which may have the potential to be on future PSL

ii) **Pathway/Fate & Effects**

- food chain transfer of contaminants in general and specifically from aquatic systems to birds
- development of computer models of contaminant bioaccummulation in wildlife
- determination of pathways of exposure and measurement of effects on wildlife due to impounded water, smelters, hazardous dump sites and sediment disposal
- transportation of priority substances (especially PCBs) in migratory animals (mass balance)
- validation of dioxin toxic equivalency factors for birds
- research into fate, bioavailability and bioaccumulation in aquatic ecosystems of contaminants in pulp & paper mill effluents, including effects of effluents on wildlife

- knowledge on the stability/persistence of dioxins/furans in aquatic environment and on the transfer mechanisms from contaminated sediments to biota and bioaccumulation in the food chain (including effects on biota)
- determination of the fate and effects of creosote, its constituents and degradation products

- continued assessment of exposure and releases of priority and toxic substances in wastes from metal casting operations and non-ferrous smelting/refining operations
- toxicity of contaminants in orphan contaminated sites
- development and validation of prediction models for soil and groundwater contamination from orphan contaminated sites
- knowledge of movement and degradation of contaminants in groundwater
- analysis of contaminant potential from sump operations in the Arctic (groundwater/seepage), permafrost degradation and abandonment/reclamation
- pathways, transport, sinks & fate of mercury, cyanide, arsenic, lead and cadmium contamination from abandoned Arctic waste sites

- fate, effects, biodegradation and biophysics of oil and oil sludge disposal on Arctic terrain
- environmental effects of oil based drilling muds in onshore/offshore environment including toxicity, pathways, fate and treatment
- knowledge on the interactions between substances in wastes and the receptor medium
- knowledge on the stability of sludges in the receptor medium (soil or water)

- knowledge on atmospheric reactions between various components of transportation sector emissions among themselves and with other gases and chemicals in the air
- transport mechanisms of toxics in multiple phases (water, active and inactive sediments, biota) in Mackenzie River system and delta region) as well as fate & effects of toxic components
- cumulative impacts of development activities in a water basin (e.g. Peace, Athabasca, Slave)
- development of models for use in assessing water basin fate and effects for multiple industries
- monitoring of development proposals (e.g. Beaufort Sea, Mackenzie Valley pipeline)

- ecotoxicology of petroleum hydrocarbons in north temperate and Arctic waters
- literature review of known impacts of ocean dredging and ocean dumping
- acute effects of fish offal on benthic communities at designated ocean dump sites.
- chronic effects of dredged spoils on marine benthic communities
- study into behavioural responses of beluga and bowhead whales to dredging operations
- bioassessment of toxicity, carcinogenicity, mutagenicity, and teratogenicity of contamined marine sediments and development of new methods
- relationships between marine sediment contamination and human health risks

- effects of untreated sewage disposal to the marine environment
- basic research into the fate and effects of priority pollutants (e.g. PAHs, dioxins/furans) that will eventually be regulated under CEPA Part VI
- development of new mathematical models or refinement of existing models to integrate laboratory bioassays, microcosm investigations, field studies and case studies for a more comprehensive, yet realistic approach to ecosystem impact predictions
- sediment-water, sediment-biota, and water-biota chemical inter-actions in perturbed marine systems
- influence of ocean circulation and chemistry on dispersion and fate of contaminants
- food-chain transfer of marine contaminants at the water-sediment interface

iii) **Bioindicators & Bioassays**

- development and application of bioassays (both lethal and sublethal)suitable as early warning indicators of effects of toxic substances on wildlife
- establishment of bioindicators and biomarkers, as well as indices of organism health, at the aquatic ecosystem, community, species, biochemical and pathological levels for exposition to multiple substances
- development of toxicity screening methods using avian tissue culture techniques
- development and validation of cost-efficient and integrated ecotoxicological schemes capable of identifying diffuse and point sources of toxic pollutants and eventually diagnosing the state of health of the aquatic receiving environment
- development and standardization of ecotoxicological tools to rapidly reveal the in situ sublethal effects of toxic substances

- development of tools and methods for the assessment of risk associated with the discharge of toxic chemicals in the St. Lawrence River as a results of accidental or regular discharges due to industrial activities
- bioindicator tests and protocols for marine and freshwater receiving environments for pulp mills and metal mines
- evaluation of the biomonitoring potential of various organisms/fish for heavy metals, SO_2 and organic contaminants in the Arctic
- development of quantifiable sublethal indicators (e.g blood biochemicals, detoxification enzymes, pathological lesions, DNA adducts) that may be useful scientific screening critieria in the administration process of CEPA Part VI (i.e. both for permit issuance and surveillance monitoring)
- development of standardized in situ biological tests for ocean dumping (caged organisms)
- protocols for environmental effects monitoring of ocean dumping projects (dredge and dump sites)

- development of methods to evaluate environmental fate and toxicity of biotechnology products.

iv) **Sampling & Analysis Techniques**

- development of a PCB field test that is accurate to the interim order regulated limits
- development of analytical methods for PCB, furan and dioxin congeners with lower minimum detection levels
- development of analytical techniques/procedures/field test kits for CFC analysis, phosphorus in fuels, lead in fuels and PCBs in liquids and soils

- sampling and analytical protocols for soil, air, groundwater and surface water contamination from orphan contaminated sites
- development of contaminant monitoring techniques and tests for routine ocean dumping applications

- further development of marine sediment and biological sampling and storage protocols (refer to Schedule III, Part III).

- development of toxic substance analytical kits which can be used for screening samples in the field
- development of new and improved sampling and analytical techniques to identify the presence of substances in point and ambient sources, as well as in organisms
- practical and precise methods of sampling and analysis for monitoring and enforcement
- development of statistical and pattern recognition techniques for quantitative and qualitative interpretation of monitoring data
- development of efficient routine analytical techniques to measure previously undetermined substances in wildlife (e.g. analytical methods to detect levels of substances from pulp mill effluents in wildlife)
- development of practical, validated standard reference methods for PSL substances
- development of better and more reference materials for environmental analysis of trace organic contaminants (e.g. dioxins in biological material)

v) <u>Waste Management Techniques</u>

- continued assessment of industrial toxic waste disposal techniques
- development of waste management techniques for the reduction, reclamation and recycling of toxic substances
- scientific justification/verification of the safety of waste management techniques
- comparison of CEPA leachate test results to actual field leachate concentrations
- development and expansion of the use of municipal composting

- evaluation of pulp mill sludge management practices for the control of dioxins/furans.

- development of alternative practices for handling and managing Arctic sump constituents
- development of alternatives to the ocean dumping of scrap metal in the Arctic, or fish waste dumping on the east coast (e.g recycling or new uses for materials disposed of at sea)

vi) **Control and Alternative Technologies**

- evaluation of existing treatment/control technologies for the removal of substances
- development of technology to reduce harmful emissions
- development of inexpensive on-line monitoring techniques to be applied to point sources
- encourage the implementation of cost-effective technologies for the reduction or elimination at source of toxics, for recycling and reuse, for process control and monitoring and for alternate production methods and processes
- development of alternative industrial processes which are less polluting
- investigation of techniques, technologies and programs that prevent pollution from industrial sectors, focussing on product reformulation, process modification, recovery and reuse, environmental management techniques, as well as loss and spill prevention programs
- ongoing development of measurement/monitoring techniques for industrial toxic contaminant releases in solid and aqueous media
- development of technology for removing toxic substances or the detoxification of industrial effluents (chemical and petroleum refineries, pulp & paper mills, and metal smelting, refining & plating plants)

- demonstration and validation of new technologies and equipment for dredging contaminated sediments and techniques for restoration of habitats using dredged material in the St. Lawrence River

- development and demonstration of remedial technologies for soil, groundwater and surface water contamination from orphan contaminated sites
- demonstration and validation of new technologies or new applications of existing technologies in the fields of hazardous waste and soil restoration
- development of non-incineration technologies for the destruction of hazardous wastes

- development of methods to stabilize mining industry treatment plant sludges or to remove metals (arsenic, copper, cadmium, lead, nickel and zinc).
- development of methods to remove copper and mercury from gold mill effluents
- development of technology to more fully and economically recover metals (e.g. cadmium, copper, iron, lead, nickel, zinc) from scrap

- development of technologies for material and energy recovered from used tires

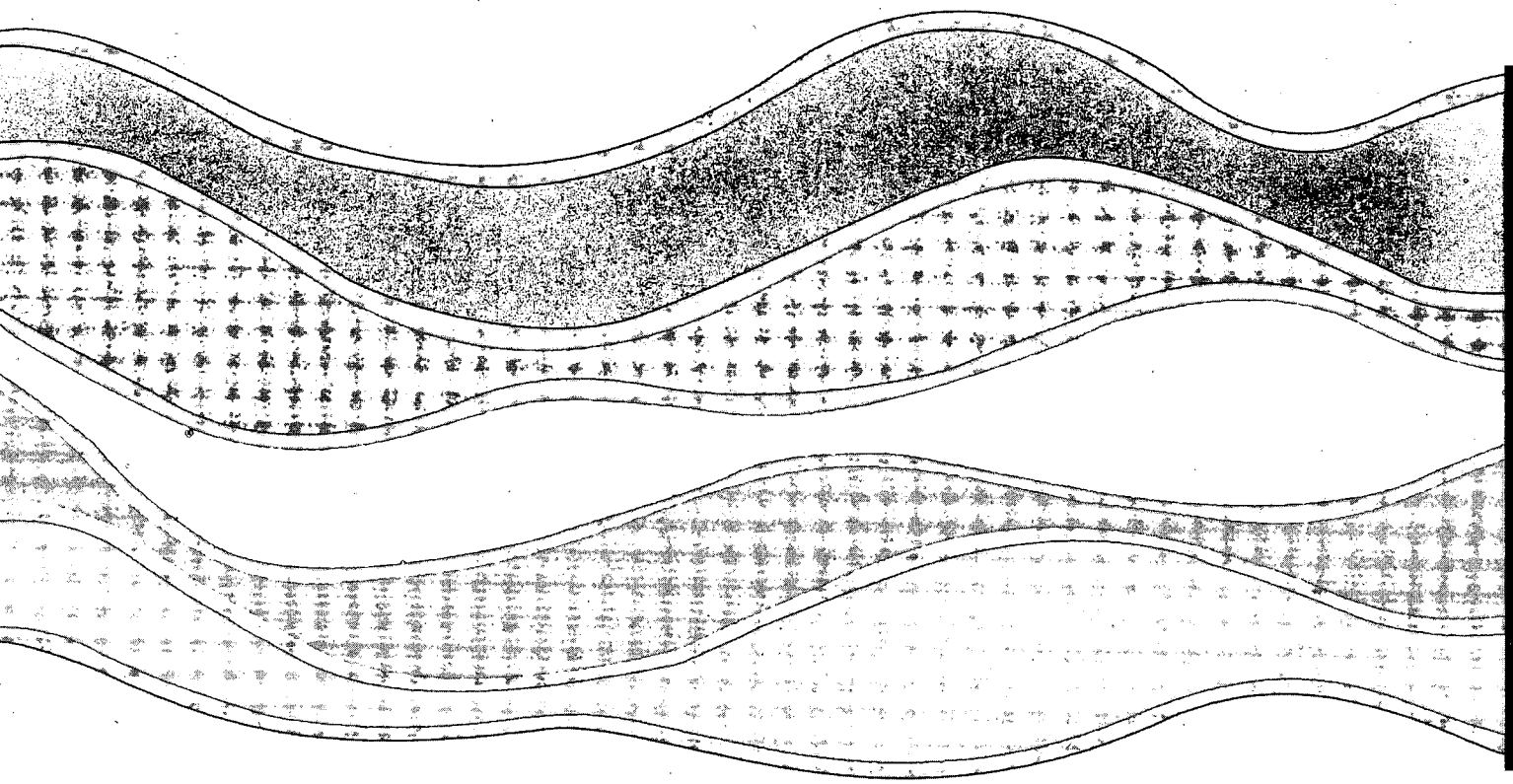
- development of technology to reduce the cost of solar energy and hydrogen fuel
- development of new technologies for the control, substitution and reduction of greenhouse gases in areas which are not addressed by EMR

- continued assessment of new/emerging technologies for the control and elimination of SO_2 from fossil fueled power plants
- continued development/assessment/demonstration of new NOx control technologies for combustion turbines, industrial boilers and process heaters steam electric power plants and reciprocating natural gas compressor
- continued development and assessment of equipment for monitoring NO_x emissions from combustion turbine engines, industrial/commercial boilers and steam electric power plants
- evaluation of new control techniques and technologies, including leak detection equipment, for benzene/VOCs from gasoline terminals

- evaluation and assessment of state-of-the-art control for VOCs from volatile liquid storage tanks, chemical processes, plastic processing, pulp & paper sulphate process, commerical & industrial paint application, commerical & industrial degreasing and dry cleaning

vii) Criteria

- improved and more comprehensive water quality criteria and guidelines for use in assessment of environmental problems, EIAs etc.
- development of remediation criteria for (orphan) contaminated sites that are based on human and environmental health
- criteria development for designating hazardous waste
- establishment of quality criteria for the protection of aquatic life for PCBs dioxins/furans in fresh waters
- development of criteria for assessing the quality of St. Lawrence River sediments
- development of integrated indicators of the state of the St. Lawrence River (management) to evaluate the impacts of various remediation measures
- establishment of critical levels for PSL substances in order to determine the controls.



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