OPTIONS FOR THE REMEDIATION OF ENVIRONMENTAL PROBLEMS IN THE NIAGARA RIVER (ONTARIO) AREA OF CONCERN

PHASE I: PRELIMINARY IDENTIFICATION OF REMEDIAL OPTIONS

PHASE II: SCREENING OF REMEDIAL OPTIONS

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PHASE I: PRELIMINARY IDENTIFICATION OF REMEDIAL OPTIONS

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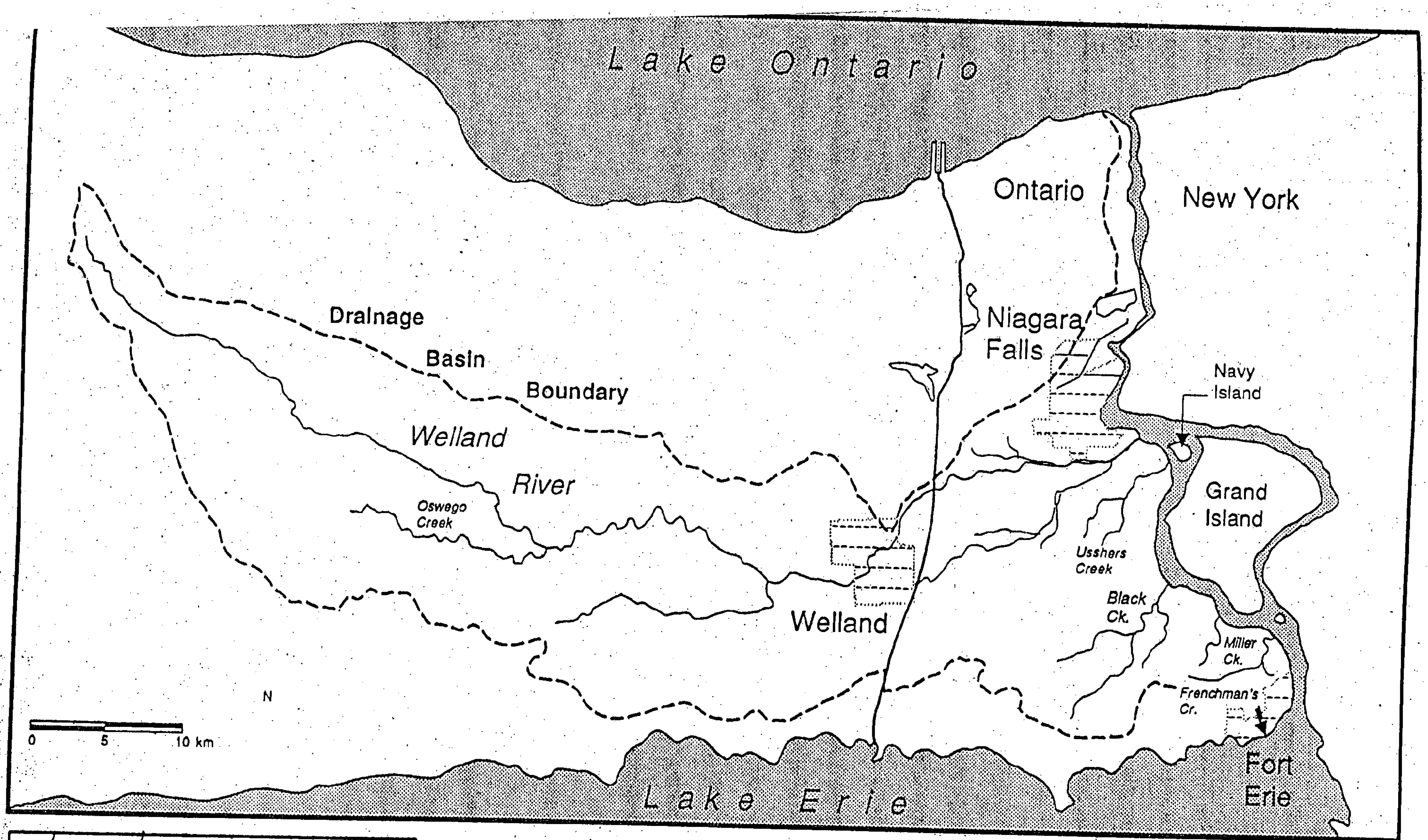
1.0 INTRODUCTION

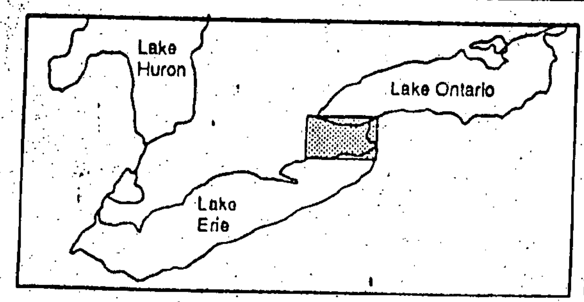
1.1 General Background

The Water Quality Board of the International Joint Commission (IJC) has designated 42 Areas of Concern in the Great Lakes Basin, on the basis of impaired environmental conditions. Five of these involve the Great Lakes interconnecting channels and the St. Lawrence River, and include the Niagara River. In 1986, the Ontario Ministry of the Environment and Natural Resources and the federal Department of the Environment, through the Canada-Ontario Agreement, committed to prepare a series of Remedial Action Plans (RAPs) for each of the 17 Areas of Concern falling within Canadian jurisdictions. Each RAP is coordinated by a RAP team responsible for creating a Remedial Action Plan for presentation to the IJC.

The Niagara River Area of Concern is being addressed by two RAPs - one for Ontario and one for New York State. The Niagara River (Ontario) RAP is coordinated by a team of technical and scientific experts from Canadian and Ontario government agencies, and is advised by the Niagara River Public Advisory Committee (PAC) which consists of volunteers representing academia, industry, environmental groups, local agencies, municipalities and the public at large. The Niagara River (Ontario) Area of Concern encompasses the Ontario portion of the Niagara River, as well as the Welland River which extends some 70 km to the west of the Niagara River. Figure 1.1. depicts the Niagara River (Ontario) area of concern.

Pollution has long been recognized as a problem in the Niagara River and, more recently, serious pollution from persistent toxic substances such as organochlorines and heavy metals has been identified. Seepage of toxic waste from chemical dumps on the New York side has achieved widespread notoriety, although there are over 200 hazardous waste dumps along the river course (Allan et al., 1983). In addition, there are 33 major industrial sources of chemicals to the river out of several hundred industrial plants (Vincent and





Key

FIGURE 1.1
The Niagara River
Area (Ontario) of Concern

Franzen, 1982). The river has also been affected by poorly treated or untreated municipal sewage and stormwater as well as by agricultural runoff, as outlined in the federal-provincial draft Remedial Action Plan (Stage I) report (Ontario Ministry of the Environment *et al.*, 1990). The Welland River is more heavily impacted by erosion-induced siltation and suspended sediment than is the Niagara River, although municipal and industrial sources also cause problems along its course.

In 1986, the Province of Ontario, the State of New York, Canada and the U.S. signed a Declaration of Intent to ensure that a management strategy is adopted to move towards a significant reduction in toxic chemical loadings in the Niagara River. The intent of this initiation, which is developed as the Toxic Management Plan, is to adopt a strategy to achieve a 50% reduction in the loading of persistent toxic chemicals to the Niagara River by 1996, with a long term goal of virtual elimination. Unlike the RAP, this plan is focused exclusively on the toxic problem in the Niagara River. It is anticipated that the Toxic Management Plan will eventually be merged with the RAP for the Niagara River. This merge will take place as portions of the RAP process not covered by the Toxic Management Plan are developed to a similar degree as the Toxic Management Plan.

1.2 Problems and Impaired Uses in the Niagara River (Ontario) AOC

Through the development of the Niagara River RAP, the RAP Team and the PAC have identified and categorized various impaired beneficial uses of the Niagara and Welland Rivers and have identified suspected or known causes of these impairments. These impairments have been categorized into six groups:

- water quality problems;
- aquatic and wildlife problems;
- contaminated sediments;
- impaired industrial, municipal and agricultural uses;
- impaired recreational use; and

- impaired fisheries resource.

Table 1.1 provides a summary of the impaired beneficial uses in the Niagara River, and lists the sources of these problems as identified in the Stage I RAP report. A brief background description of these problems follows:

1.2.1 Water Quality-Related Problems

Water quality in the lower Niagara River is considered unacceptable for human consumption use or industrial use without extensive treatment and is impaired to the degree that it may be deleterious to aquatic life. Furthermore, the occurrence of organic contaminants in potable water, and possibly in the Niagara Falls mist, create the perception or fear of health hazards in Niagara Region residents.

Several chemicals in the river exceed Government water quality guidelines at the mouth of the Niagara River due to sources along the river and upstream. Theses include:

- iron,
- PCBs,
- tetrachloroethylene, and
- various PAHs (benzo (a) anthracene, benzo (b) fluoranthene, chrysene, benzo (a) pyrene and benzo (k) fluoranthene.

Aluminum, cadmium, chromium, copper, lead and silver concentrations exceed guidelines elsewhere in the river. Sources of pollution include municipal, industrial and agricultural point and non-point sources, as well as contaminated sediments.

Environment Canada monitors water quality continuously at Niagara-on-the-Lake and Fort Erie to document long-term trends and net loadings to Lake Ontario from sources along the river. This program will be useful in documenting the cumulative success of efforts to

TABLE 1.1: ENVIRONMENTAL PROBLEMS IN THE NIAGARA RIVER (ONTARIO) AREA OF CONCERN AND THEIR POTENTIAL SOURCES

Problem	Concern	Potential Sources															Comments
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
Water Quality	• Water Quality Impairment	x	x	x	x	x	x	x	x						x	x	• Water quality criteria exceeded for heavy metals and various organic compounds
	• Drinking Water Consumption	x	x	x	x	x	x	x	x		x			x		x	• Concern is presence of toxic contamination
	• Clean Air (Niagara Mist)	x	x	x	x		x			x						x	• Extensive water treatment required • Niagara River shore wells impacted
Impairment of Use by Aquatic Biota and Wildlife	• Aquatic Life	x	x	x	x	x	x	x	x		x	x		x		x	• Concern is persistent toxic contamination
	• Birds and Mammals	x	x	x	x	x	x	x	x		x	x	x			x	• Contaminated sediment has impaired aquatic and terrestrial food chains
	• Sediment Quality	x	x	x	x	x	x	x	x			x			x	x	• Loss and impairment of habitat
Sediment Quality	• Sediment Contamination	x	x	x	x	x		x	x	x	x				x	x	• Includes heavy metals and toxic organic contaminants
	• Downstream transport of suspended sediments					x		x	x		x	x			x	x	•Includes heavy metals and toxic organics; due to adsorption of contaminants to particulates
Impaired Uses, Industrial, Municipal, Agricultural	• Power Generation		x			x								x		x	• Impacted by biological contamination (zebra mussels)
	• Irrigation - Agricultural Use	x	x	x	x	x	x	x	x							x	• Concern is presence of toxic contamination
	• Industrial and Municipal Use	x	x	x		x			x					x			• Impacted by contaminated sediments/siltation
Impaired Recreational Values	• Aesthetics	x	x	x	x	x	x		x		x					x	• Visual impairment
	• Boating and Water Sports	x	x	x	x	x	x	x	x							x	• Poorly planned and administered development • Fluctuating water levels restrict access • Impaired water quality impacts recreational uses
Fishing and Consumption of Fish		x	x	x	x	x	x	x	x							x	• Impacted by toxic contaminants • Fish consumption advisories for a number of sport fish

Sources

A - Municipal Discharges
B - Industrial Discharges
C - Combined Sewer Overflows
D - Stormwater Runoff
E - Agricultural Runoff
F - Landfills
G - Contaminated Sediments (in-place)
H - Industrial/Agricultural Spills
I - Air Pollution
J - Urban Development
K - Construction Activities
L - Recreational Activity
M - Zebra Mussels
N - Upstream Sources
O - US Sources

reduce loadings of contaminants to the river in response to the implementation of remedial actions.

Pre-MISA monitoring under the Ontario Ministry of the Environment Municipal-Industrial Strategy for Abatement program has shown several point sources of wastewater or cooling water to the Welland and Niagara Rivers which are out of compliance at least periodically with their respective Certificates of Approval. The following outlines parameters that have been out of compliance and their sources:

- biochemical oxygen demand (B.F. Goodrich, Fleet, Ford and Washington Mills)
- suspended solids (Atlas Steel, B.F. Goodrich, Fleet, Washington Mills and Stelco Welland Tube Works)
- cadmium (Atlas Steel, Fleet)
- pH (Atlas Steel)
- phosphorus (Welland, Fort Erie, Niagara Falls Sewage Treatment Plants)
- oil and grease (Stelco)
- phenolics (Can-Oxy Durez)

MISA monitoring is underway or completed for seven of fourteen discharges to the Niagara and Welland Rivers, and will provide further information on loadings of contaminants from these sources. The remaining sources are from industrial or municipal sectors not covered under MISA and may be monitored in later MISA programs. All point sources will be routinely monitored under the Niagara River Toxics Management Plan.

Until very recently, the McMaster Avenue and Stanley Avenue combined sewers released untreated municipal and industrial waste to the Welland River and Chippawa Creek respectively, and have resulted in unacceptable bacterial and chemical contamination. These sewers have now been separated although the Stanley Avenue sewer continues to discharge cooling water from Washington Mills directly into Chippawa Creek. Other combined sewers have more recently been identified in Niagara Falls and Welland and efforts are underway to implement separation.

Stormwater runoff from urban and rural areas and from the Mount Hope and Welland airports contributes loadings of heavy metals, petroleum residues, de-icing compounds and pesticides and herbicides to the Niagara system. Combined sewer overflows (CSOs) are also problematic in all municipalities and result in exceedences of PWQOs in receiving waters. CSOs are currently being addressed in Pollution Control Plans under development by the Regional Municipality of Niagara.

Five municipal and industrial landfills on the Ontario side of the river were identified in 1984 by the Niagara River Toxic Committee as having a significant potential to contaminate the river, including:

- the Fort Erie (Bridge Street) municipal landfill;
- the Atlas Steel landfill;
- the CNR (Victoria Avenue) landfill;
- the Cyanamid Welland plant disposal area; and
- the Cyanamid-Niagara Falls plant waste disposal area.

It is difficult to estimate the impacts of these landfills, although some estimates have been recently made in a report prepared by Monenco Engineering for the MOE (MOE, 1991). This report estimated the loadings of 15 inorganic substances and 116 organic chemicals listed in the U.S. EPA Priority Pollutant List from these landfills to the Niagara River. The estimated total loading (all contaminants) is 30.5 kg/day, with the organic portion estimated to be virtually nil. About 88% of the total is cyanide from the Cyanamid Inc. landfills at Niagara Falls. The remainder is primarily metals from the other landfills. The total loading of 30.5 kg/day represents only 10% of the magnitude of the total loading from the

U.S. sites. The U.S. EPA has targeted a 99% reduction in contaminant loadings from hazardous waste landfills on the U.S. side by 1996.

There is a general belief by residents in the Area of Concern that tap water and water from wells along the banks of the river is contaminated and presents a health threat to consumers. Ministry of the Environment testing of treated tap water has uncovered no violations of provincial drinking water objectives; however, the perception of a contamination problem persists.

Some researchers have hypothesized that the mist below the Falls causes volatilization of chemical contaminants from the river into the atmosphere and exposes workers at the Falls to health hazards. The air in the mist and surrounding area have been monitored but no elevated concentrations of contaminants have been found. Occasional spills of wastewater into the river could result in short term air pollution from volatilization; however, this phenomenon has not been directly measured.

1.2.2 Aquatic and Wildlife Problems

Various effects of contamination and other human disturbances have been identified in the fish and wildlife resources of the Niagara River, as identified in the draft Stage I RAP report, including:

- elevated incidences of neoplasms and deformities in fish and benthos in the lower Welland River. Although specific causes are unknown, pollution by mutagenic substances is a candidate cause;
- impaired benthic community in areas of high sediment contaminant levels. Some of these sediments are contaminated to levels in excess of provincial sediment quality guidelines - lowest effect levels and in some cases, in excess of severe effect levels and guidelines for the open water disposal of dredged spoils. In the Niagara River (Ontario)

Area of Concern, these contamination problems occur mainly in the Welland River.

- fish kills and acutely toxic conditions occur sporadically, at some locations in the Welland River and tributaries, in association with spills or other industrial process upsets;
- declines in fish populations from the cumulative impacts of erosion and siltation, the introduction of exotic species, water quality impairment and chronic or acute toxicity, and other human manipulations of aquatic resources (ice booms, hydroelectric generation, etc.);
- loss of fish and wildlife habitat due to human encroachment on streambanks and wetlands, erosion, channelization and eutrophication; and
- contaminant accumulation in aquatic wildlife, most notably birds, including elevated levels of organics in the eggs of herring gulls, terns and black-crowned night herons. Levels of PCBs in some fish exceed the Great Lakes Water Quality Agreement PCB objective for the protection of fish-eating birds.

1.2.3 Contaminated Sediments

Sediments can act as both a sink and a source of contaminants to downstream waters, and sediment contamination has been identified on the Ontario side near the mouth of Frenchman's Creek (p,p'-DDT), at the mouth of Miller Creek (mirex) downstream of Navy Island (mirex), and in the lower Niagara River (Zn, Hg and various organochlorines) (Niagara River Toxic Committee, 1984). Heavy metal contamination also occurs in Ontario Hydro's Sir Adam Beck reservoir and most tributary mouths (Stage I RAP report). Because of extreme turbulence in the Niagara River, sediment accumulation in the river is sparse and much of the sediment load is transported into Lake Ontario (e.g., Kuntz and Warry, 1983). The rapid translocation of sediment causes difficulty in tracing source locations and results in transboundary transport, so that problems on one shore may have origins on the other.

A zone of extensive iron oxide and heavy metal deposition in the Welland River, known as the "Atlas Reef", presents a unique problem. This deposit resulted from historic releases of particulate heavy metals in wastewater from Atlas Steel which, combined with sediment in the river, have formed a hardened metal-rich deposit on the river bottom. The extent of the problem is currently being investigated, although existing information indicates that Provincial Sediment Quality Guidelines - Severe Effect Levels for the protection of aquatic biota and guidelines for the disposal of dredge spoils are exceeded for some metals.

1.2.4 Industrial, Municipal and Agricultural Uses

Environmental impairment of the Niagara and Welland Rivers increases costs incurred by existing or new resource users in several ways:

- industrial and municipal users incur higher water treatment costs to overcome impaired water quality.
- siltation increases costs of dredging and water treatment, impairs shipping and diminish the value of aggregate resources in the Niagara Bar;
- existing pollution diminishes residual assimilative capacity for other waste sources;
- zebra mussel infestation impairs electrical generation and affects water intakes for municipalities and industries;
- the tourist industry is adversely impacted by the perception that the natural beauty of the river is diminished by pollution and flow controls; and
- use of water for irrigation and livestock watering is perceived to cause a build-up of toxins in the human food chain, although the Stage I RAP document has not identified any violations of Provincial Water Quality Objectives for agricultural use (livestock watering).

1.2.5 Recreation

Recreational uses of the river, including general viewing (aesthetics), body contact recreation, access to the river and boating, are impacted by environmental impairment and conflicting water use practices in the basin. The following outline these recreational impairments, as described in the draft Stage I RAP document:

- High concentrations of nutrients have created excessive growths of algae and aquatic macrophytes in slower flowing portions of the Niagara and Welland Rivers. Contributing to this problem are the Fort Erie and Niagara Falls sewage treatment plants which are occasionally out of compliance with their discharges of phosphorus. Other contributing factors are agricultural runoff and erosion of nutrient-rich soils in the Welland River watershed and wastewater discharges from Cyanamid's Welland Plant fertilizer operation.

- Foam and debris, or "scum", collect in the Maid of the Mist Pool below the Falls, creating an aesthetic concern affecting general viewing. Investigations to date show that the foaming agents consist of natural lipids and appear to be unrelated to any pollution problem.

- Bacterial pollution has led to frequent beach closures in the Area of Concern. Provincial Water Quality Objectives for total and fecal coliforms are exceeded in the Chippawa Channel, the lower Niagara River and in portions of the Welland River. The sources of the problem include municipal sewage treatment plants that may provide inadequate disinfection or provide little or no treatment under storm flows, combined sewer overflows, faulty septic systems and sewage lagoons, both within the Area of Concern and along the U.S. shoreline.

- Boating and boat access is adversely affected by fluctuating water levels resulting from hydroelectric regulation by Ontario Hydro and the New York State Electrical Commission.

1.2.6 Fishing

Niagara and Welland River fisheries have been impaired by the bioaccumulation of contaminants resulting in fish consumption advisories and the reduced production of desirable species due to factors such as those discussed in Section 1.2.2.

Consumption advisories are in place for larger size classes of many fish species from the lower Niagara River and Lake Ontario near the river mouth, as well as for larger size classes of white sucker and freshwater drum in the upper river (MNR/MOE, 1990). Consumption advisories are due to contamination in the upper river and mercury, PCBs and mirex in the lower river. Investigations have shown organochlorine contamination through the measurement of contaminants in young-of-the-year spottail shiners along the river (e.g., Suns et al., 1985). These contaminants have impaired both sport and commercial fishing in the Niagara River and Lake Ontario in general.

Although fish tainting substances, primarily phenolic compounds, are found in wastewater discharges and in river water, flavour impairment of fish from the Niagara River has not been directly reported. Industrial and municipal sources of phenolics have been identified and actions are underway to reduce these loadings. Non-compliance discharges of phenolics have occurred to Frenchman Creek by Canadian Oxy Chemicals Limited, although significant abatement has been achieved in recent years.

Over the past decade, populations of emerald shiners in the upper Niagara river have declined, resulting in reduced catches by the bait fish industry. Sources of the decline are unknown but possible causes have been identified as overfishing, the recovery of Lake Erie walleye populations, stocking of salmonids in Lake Erie, lake level manipulation, habitat destruction in tributary streams and reductions in phosphorus levels in Lake Erie.

1.3 Objectives

The draft Stage I document was recently completed by the Niagara River RAP team and Public Advisory Committee. The report identifies six major problem sets or impaired uses and discusses their sources. These problems and sources were summarized in Table 1.1.

The next step in the RAP process is to develop remedial options for each of the identified sources that may be implemented to achieve specific ecosystem goals. This report presents Phase I of this remedial option development, and develops extensive lists of options for remediating each type of problem source and provides a very general overview of each.

Phase II of this program will undertake a screening level feasibility assessment of the various options and will evaluate their general cost ranges as well as the general level of improvement that might be achieved. The options considered include engineered and scientific options, communications options, regulatory options, political options and other "common sense" options that may be applicable to the general types of problem sources identified.

Several source categories have been identified as contributing to the six environmental problems or impaired uses:

- municipal sewage plant discharges
- private sewage treatment systems
- industrial discharges
- deposition of atmospheric pollutants
- urban development
- construction activities
- combined sewer overflows

- stormwater runoff
- agricultural runoff
- landfill leachate
- contaminated sediments
- zebra mussels
- upstream sources
- U.S. sources
- industrial/agricultural spills

The report has been structured such that these sources have been addressed within the following categories:

- Municipal Sewage Treatment Plants (Chapter 2)
- Industrial Discharges (Chapter 3)
- Urban Areas (Chapter 4)
- Agricultural Areas (Chapter 5)
- Landfills (Chapter 6)
- Contaminated Sediments (Chapter 7)
- Atmospheric Pollution (Chapter 8)
- Physical Habitat Disruption (Chapter 9)
- Other Sources (Chapter 10)
- Upstream and United States Sources (Chapter 11)

No specific remedial options are assigned to sources outside of the Niagara River (Ontario) Area of Concern, such as those upstream on the New York State side of the Niagara River. Comments are made where possible, on the degree of source reduction that may be necessary to achieve a degree of improvement within the Area of Concern.

2.0 MUNICIPAL SEWAGE TREATMENT PLANTS

There are six (6) municipal water pollution control plant (WPCP) point source discharges within the Ontario Niagara River drainage basin. The location, capacity, status and the name of the receiving body of water for each are identified in Table 2.1.

The treatment processes used at these treatment plants include:

- activated sludge (2);
- sewage lagoons (2); and
- rotating biological contactors (RBC) (1).

At one of these plants (Welland Water Pollution Control Plant), activated sludge treatment has recently (1989) been expanded to include a tertiary treatment step.

2.1 Potential Contaminants

Potential contaminants discharged from the WPCPs that may affect the water quality in the receiving water include conventional contaminants such as:

- BOD_5,
- suspended solids, and
- nutrients (phosphorus, ammonia),

and varying levels of industrial contaminants such as metals and organics.

BOD_5 is released as a result of insufficient treatment performance in soluble form as well as particulate form as carried-over biological solids.

TABLE 2.1: WATER POLLUTION CONTROL PLANT

Water Pollution Control Plant	Type (Q m³/d)	Status	Receiving Water	Comments
Fort Erie (Anger Avenue) WPCP	MD (16,300)	*	NR	• Activated Sludge Plant (1989) • Wet Weather CSOs and Pumping Station Overflows • Infrastructure I/I problems
Stevensville - Douglastown Lagoons	MD (1,470)		NR	• Sewage lagoons • Continuous of discharge
Welland WPCP	MD (45,460)	*	WR	• Tertiary WPCP (1990)
Port Robinson Lagoons	MD (441)		WR	• Aerated and facultative lagoons • Commissioned 1989
Niagara Falls (Stamford Avenue) WPCP	MD (68,200)	*	QCPC	• Secondary WPCP (1985) (RBC)
Queenston WPCP	MD (500)		NR	• Recently commissioned • Package activated sludge plant

Legend:

MD = Municipal Discharge
ID = Industrial Discharge
WR = Welland River
NR = Niagara River
* = Significant Source (NRTC)

QCPC = Queenston Chippewa Power Canal
RW = Receiving Water
FC = Frenchmens Creek
CC = Chippawa Creek
I/I = Infiltration/Inflow

Suspended solids are discharged in excess if the secondary process unit (final clarification or the biological system) is overloaded. These suspended solids generally carry excess amounts of BOD_5, heavy metals, phosphorus, and many organic contaminants that may be released to the receiving water.

Phosphorus is discharged in a soluble form if the biomass in a biological treatment system cannot utilize all the phosphorus in the plant influent and/or when chemical precipitation is ineffective.

Ammonia is usually oxidized in the biological system to nitrite and nitrate nitrogen. The presence of residual ammonia in treated effluent indicates that the biological system does not have the capacity in terms of sludge age and hydraulic retention time to complete the biochemical oxidation of ammonia to nitrate nitrogen.

2.2 Remedial Action

The following section describes treatment options to improve WPCP effluent quality.

The BOD_5 content of WPCP effluent may be reduced by the following treatment steps:

- source control (e.g., reductions in loadings from industry through pre-treatment, process substitution, chemical substitution, water recycle, regulatory control, etc.)
- CSO - combined sewer separation
- sewer use bylaw changes and/or enforcement
- upstream flow equalization (especially important for combined sanitary/storm sewage);
- improved biological treatment through plant expansion and/or enhancement, incorporating:
  - activated sludge treatment
  - rotating biological contactors

- trickling filter pretreatment,
- effluent polishing ponds, and
- wetland post-treatment;

- improved final clarification performance and/or increased capacity;
- filtration after final clarification;
- wetland polishing treatment; and
- public education (to promote wise use of household water and sewers).

The suspended solids content of WPCP effluent can be reduced by the following treatment processes:

- improved sludge settling through chemical addition (alum, ferric chloride, organic polymers, etc.);
- improved final clarification and/or increased capacity;
- filtration after final clarification; and
- wetland polishing treatment.

Phosphorus can be removed by:

- source control (e.g., further legislated reductions in phosphorus concentrations in detergents, reduced use of phosphate-based detergents through public education, application of sewer use by-laws and enforcement);
- chemical precipitation (soluble phosphorus);
- biological phosphorus removal;
- filtration to remove particulate matter containing phosphorus; and
- wetland treatment.

Ammonia can be removed by:

- air stripping;

- enhanced activated sludge treatment to include nitrification and denitrification processes; and
- wetland treatment.

Heavy metals can be removed from WPCP effluent with suspended solids, as most of the metals are bound to solids particles. Organics are biologically oxidized or adsorbed onto biomass during activated sludge/biological treatment. Thus, treatment for BOD and solids removal provides control for metals and organic contaminants. Other, more specific control options for metals and organic contaminants found in municipal sewers but originating primarily from industrial sources are described in Section 3.0 of this report. Various general alternatives are available to control loadings of contaminants from sewers to the environment:

- **Sewer use surcharges** - increased fees for discharge of heavy metals, toxic organics and conventional contaminants to sewers by industry, for increased source control.
- **Industrial pre-treatment** - enforce sewer use by-laws limiting loadings from industry to sewers, possibly requiring treatment at source.
- **Water Conservation** - reduced hydraulic loadings can improve effluent treatment.
- **Process Substitution** - encourage industry to substitute processes generating toxic effluents with others that are less toxic.
- **Chemical Substitution** - substitute less hazardous chemicals into industrial processes and formulations to reduce toxic loadings. Both in-plant and at WPCPs (e.g., replacements for chlorination such as ultraviolet light, ozonation).
- **Water Recycle** - encourage industry to re-use process water to reduce contaminant loadings.
- **Public Education** - educate the general public on the wise use of water and the value of water conservation and the control of household contaminants.

Sludge treatment options should be reviewed with a view to improvement because waste sludge may contain heavy metals and synthetic organics. Incineration of sludge results in air pollution and creates an ash residue requiring disposal. Sludge composting on farmland is preferred over incineration, but can only be practised if sludge metal concentrations meet provincial guidelines for landspreading of sewage sludge. Control of metal loadings in the sewer system through industrial pre-treatment, process substitution or other means will improve the quality of sewage sludge.

3.0 INDUSTRIAL DISCHARGES

Fifteen (15) industrial point sources in Ontario discharge to the Niagara River drainage basin. Four (4) industrial plants discharge to the Upper Niagara River and Frenchman Creek, seven (7) to the Welland River or Lyons Creek and four (4) to the Chippewa Creek power canal system.

These fifteen (15) industries can be classified based on their production as:

- petrochemical (3);
- metal processing (5);
- food processing (1);
- manufacturing (2);
- aviation industry (1);
- chemical manufacturing (2); and
- hazardous waste transfer station (1).

Table 3.1 summarizes the relevant information on each industrial point source.

3.1 Contaminants

The fifteen (15) industries listed in Table 3.1 discharge effluents with the following contaminants:

- BOD_5,
- pH,
- heavy metals,
- suspended solids,
- oil and grease,
- cyanide,

TABLE 3.1: INDUSTRIAL POINT SOURCES

Industrial Point Sources	Location	Receiving Water	Comments
Upper Niagara River			
Canadian Oxy Chemicals Ltd. (resins and moulding compounds)	Fort Erie	FC	• 140 m^3/d non-contact cooling water discharge • Major contaminant is phenol • Site stormwater directly discharged
Gould Manufacturing of Canada Ltd. (lead acid storage batteries)	Fort Erie	NR	• Process wastewater directed to municipal system (1988) • 1 km drainage ditch remediated • No direct discharge after 1989
Fleet Manufacturing Ltd. (aircraft, radar/sonar and sattelite components)	Fort Erie	FC	• Process wastewaters direct discharged • Treated sanitary wastewater discharged • Trichloroethylene groundwater problem
Holiday Farms Ltd. (food processing)	Niagara	NR	• Treated process and sanitary wastewater now discharged back on-site (spray irrigation) • Treatment via stabilization pond • Wastewater generated at maximum production is 90 m^3/d
Welland Area			
Atlas Specialty Steels Division	Welland	WR	• Identified by NRTC as single largest point source (Canadian) • 85% wastewaters discharged to Atlas 42" sewer • Discharge is 24,700 m^3/d • Cooling water and process water treated prior to discharge with ongoing improvements taking place • Ongoing sewer separation project
Gencorp-Diversitech General (automotive rubber trim and sporting equipment)	Welland	WR	• Two point discharges to McMaster Avenue - municipal sewer and Atlas Steel's 42" sewer

TABLE 3.1: INDUSTRIAL POINT SOURCES

Industrial Point Sources	Location	Receiving Water	Comments
Stelco-Stelpipe Welland Tube Works	Welland	LC-WR	• Process wastewater treated prior to discharge • Treatment via oil/water separator and settling lagoon
Ford Motor Company of Canada	Niagara Falls	WR	• Two point discharges • Raw water treated prior to process distribution • Majority process water is non-contact cooling water • Potential contaminants include SS, BOD, oil/grease, dissolved salts and minor quantities of xylene and silver • Lagoon system for treatment of effluent and removal of sludge from raw water treatment
B.F. Goodrich Inc.	Thorold	WR	• Wastewater treated in aerated lagoon and facultative polishing pond prior to discharge • Average discharge is 2,300 m^3/d • Leachate pond from sludge dewatering batch discharged every one to two months • Ongoing expansion to double capacity
Cyanamid of Canada Limited	Welland	WR	• One effluent discharge into Thompson's Creek • Average discharge is 28,800 m^3/d • Filtration plant backwash direct discharged to Welland River • Significant source of cyanide, heavy metals and nutrients
Laidlaw Environmental Services Facility	Thorold	WR	• No process wastewater generated on-site • On-site stormwater management system

TABLE 3.1: INDUSTRIAL POINT SOURCES

Industrial Point Sources	Location	Receiving Water	Comments
Niagara Falls Area			
Washington Mills - Electro Minerals	Niagara Falls	CC	• Two combined effluent discharges • Cooling water treated via 2 settling lagoons prior to discharge to Pell Creek and Stanley Avenue sewer • Intake water pumped at 30,000 m^3/d
Norton Company of Canada Ltd.	Niagara Falls	CC	• Four effluent discharges • Washwater neutralized and discharged to a settling lagoon to Pell Creek • Intake water pumped at 14,200 m^3/d
Washington Mills Ltd.	Niagara Falls	CC	• One effluent discharge • Intake water pumped at 1,630 m^3/d • Cooling waters collected in cooling pond with overflow to Chippawa Creek
Cyanamid of Canada Ltd.	Niagara Falls	NR	• Intake water pumped at 32,400 m^3/d • One-third direct discharged to Queenston Chippawa Power Canal • Two-thirds overflow from cooling water pond direct to Niagara River • Identified as a significant source of cyanide and heavy metals to the Niagara River by the Niagara River Toxics Committee, although source reductions have been achieved subsequently

Legend:

CC = Chippawa Creek
FC = Frenchmans Creek
QCPC = Queenston Chippawa Power Canal
NR = Niagara River
WR = Welland River
LC = Lyons Creek

- nutrients (ammonia, phosphorus), and
- organic contaminants.

Some of these contaminants are termed conventional pollutants. This includes BOD_5, suspended solids and nutrients. Conventional pollutants are so called because they have traditionally been associated with sanitary sewage. However, these contaminants may also be produced from other than sanitary sources such as during manufacturing operations and discharged together with other non-conventional pollutants as shown in Table 3.2.

In addition, some of the industries may discharge a contaminated surface runoff. Contaminants in runoff from an industrial site can originate from precipitation falling on stored raw material and finished products, or possibly from process spills.

3.2 Remediation Options for Point Source Industrial Discharges

Most of the industries in the Niagara Region have already implemented some degree of effluent treatment. Most often, this includes some form of mechanical, chemical and/or biological process effluent treatment and some degree of non-contact cooling water recycling.

Options applicable for each industrial discharger were reviewed with the objective of improving effluent quality and further reducing the toxic/contaminant load to the receiving water. These options included:

- 4Rs (reduction, recovery, reuse, recycle);
- engineering/technical;
- training; and
- other options.

The options considered for each plant are shown in Table 3.2.

TABLE 3.2: REMEDIAL ALTERNATIVES FOR INDUSTRIAL POINT SOURCES

Industrial Point Source	Potential Contaminants	Source	Engineering/Technical	4Rs	Training	Others
Ford Motor Co. Niagara Falls Glass Plant	• suspended solids • BOD • oil/grease • dissolved salts • xylene • silver	• process effluent	• solids removal by settling • oil/grease separation • ultrafiltration • metal precipitation and settling • chemical and biological oxidation of BOD and xylene • install cooling waters	• recycle cooling water • reuse cooling water as as process water • reuse treated process water	• improve operators training • improve spill control by operators • report/record spills	• continue monitoring program • restricted chemical use • increased effluent quality requirements
B.F. Goodrich Inc.	• suspended solids • BOD • solvents • vinyl chloride	• process effluent	• improve production in the old plant • biological treatment • ultrafiltration • solids removal by settling • polishing pond or wetlands • install cooling towers	• recycle cooling water • reuse cooling water as process water • reuse treated process water • recover solvents and vinyl chloride from plant effluent	• improve operators training • improve spill control by operators • report/record spills	• continue monitoring program • restricted chemical use • increased effluent quality requirements
Cyanamid of Canada Ltd. Welland Plant	• suspended solids • pH • ammonia • phosphorus • cyanide • heavy metals	• process effluent	• improve production in the plant • improved material loss control in the plant • suspended solids removal by settling • pH control • metal precipitation and settling • phosphorus precipitation at source • ammonia stripping at source • chemical oxidation of cyanide at source • install cooling towers	• recycle cooling water • reuse cooling water • recover materials from process flows at source	• improve operators training • improve spill control by operators • report/record spills	• continue monitoring program • restricted chemical use • increased effluent quality requirements

TABLE 3.2: REMEDIAL ALTERNATIVES FOR INDUSTRIAL POINT SOURCES

Industrial Point Source	Potential Contaminants	Source	Engineering/Technical	4Rs	Training	Others
Welland Area						
Atlas Specialty Steels Division	• pH • cadmium • suspended solids • oil/grease • chromium • nickel • iron • zinc • trichloroethylene	• process effluent • surface runoff • cooling water	• magnetic seeding/separation • pH control • metal removal • solids removal by settling • oil and grease removal • filtration • spill control/collection • install cooling tower • storage/equalization • pH adjustment	• recycle cooling water • recycle process water • recover metal hydroxide sludge-waste exchange	• improve operators training • better plant control • spill control by employees • report/record spills	• continue monitoring program • restricted chemical use • increased effluent quality requirements
Gencorp-Diversitech General	• pH • oil/grease • suspended solids • cyanate • BOD • organics	• process effluent	• pH control • oil/grease removal • solids removal by settling • activated carbon treatment • ultrafiltration • chemical oxidation of cyanate and organic contaminants • control of material loss at process areas	• recycle cooling water • reuse cooling water as process water • reuse process water after treatment in less critical process areas • reduce waste introduced to process effluent	• improve operators training • improve spill control by operators • report/record spills	• continue monitoring program • identify sources of contaminants • restricted chemical use • increased effluent quality requirements
Stelco-Stelpipe Welland Tube Works	• oil/grease • trichloroethane • toluene • paints • suspended solids	• process effluent • surface runoff	• oil/grease removal • solids removal by settling • activated carbon treatment • ultrafiltration • chemical oxidation of organics • install cooling tower • redirect contaminated runoffs to treatment plant	• recycle cooling water • reuse cooling water as process water • reuse treated process water	• improve operators training • improve spill control by operators • report/record spills	• continue monitoring program • restricted chemical use • increased effluent quality requirements

TABLE 3.2: REMEDIAL ALTERNATIVES FOR INDUSTRIAL POINT SOURCES

Industrial Point Source	Potential Contaminants	Source	Engineering/Technical	4Rs	Training	Others
Laidlaw Environmental Services Facility	• organics • heavy metals • pH • suspended solids	• runoff	• segregate areas with potential contamination; separate drainage system • storage/equalization of potentially contaminated runoff • pH control • suspended solids removal by settling • pH adjustment for metal precipitation • sand filtration • activated carbon filtration • wetland treatment as a polishing step before discharge		• improved spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • increased effluent quality requirements
Upper Niagara River						
Canadian Oxy Chemicals Ltd.	• phenol • cresol • formaldehyde • furfuryl alcohol	• cooling water	• vacuum evaporation • ultrafiltration • chemical oxidation of organics • install cooling towers for cooling water reuse	• recycle cooling water • reuse cooling water • recover raw material at source of discharge	• improve spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • restricted chemical use • increased effluent quality requirements
Gould Manufacturing of Canada Ltd.	• lead • oil/grease	• process water	• oil/grease removal • pH adjustment • metal precipitation • filtration • ultrafiltration • install cooling towers for cooling water reuse	• recycle cooling water • reuse treated process water • reuse settling water in the process area	• improve spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • increased effluent quality requirements

TABLE 3.2: REMEDIAL ALTERNATIVES FOR INDUSTRIAL POINT SOURCES

Industrial Point Source	Potential Contaminants	Source	Engineering/Technical	4Rs	Training	Others
Fleet Manufacturing Ltd.	• cadmium • chromium • cyanide • organic solvents • pH • suspended solids • TCE • PCE	• process flow	• improved rinse water usage • cyanide oxidation • organic solvent oxidation • pH adjustment • metal precipitation • vacuum evaporation • ion exchange • ultrafiltration • settling	• reuse water after treatment • recycle cooling water	• improve spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • restricted chemical use • increased effluent quality requirements
	• BOD • suspended solids • fecal bacteria	• sanitary sewage	• sand filtration • disinfection • biological treatment			
Holiday Farms Ltd.	• BOD • suspended solids • oil/grease	• combined process and sanitary sewer	• dry cleanup of equipment before washdown • install cooling towers • oil emulsion break-up • oil/grease separation • suspended solids removal • biological treatment • polishing pond • wetland • vacuum evaporator treatment of process flow	• recycle cooling water	• improved spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • increased effluent quality requirements
Niagara Falls Area						
Washington Mills-Electro Minerals	• suspended solids • aluminum • iron • chromium • oil/grease	• process water	• oil/grease removal • solids removal by settling • pH adjustment for metal precipitation followed by settling • sand filtration • phenol oxidation • install cooling towers	• recycle cooling water • reuse treated water • recover metal hydroxyde sludge for reuse.	• improved spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • restricted chemical use • increased effluent quality requirements

TABLE 3.2: REMEDIAL ALTERNATIVES FOR INDUSTRIAL POINT SOURCES

Industrial Point Source	Potential Contaminants	Source	Engineering/Technical	4Rs	Training	Others
Norton Company Canada Ltd.	• suspended solids • oil/grease • heavy metals • pH	• process water	• pH adjustment • metal precipitation and settling • oil and grease removal • solids removal by settling • filtration • install cooling towers	• recycle cooling water • reuse treated water • recover metal sludge from effluent	• improved spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • increased effluent quality requirements
Washington Mills Ltd. (Niagara Falls)	• suspended solids • heavy metals associated with particulate matter • oil/grease	• process flow	• solids removal • oil/grease removal • sand filtration	• recycle treated process water	• improved spill control • report spills • improved plant operation, material stripping and storage	• continue monitoring program • increased effluent quality requirements
Cyanamid of Canada Ltd. (Niagara Falls)	• cyanide • heavy metals • oil/grease	• process/cooling water	• separate process/storage areas with potential material spills • treat waters from this area separately • oil/grease removal • cyanide oxidation at process source • heavy metal removal by pH adjustment and settling • settling • sand filtration • install cooling towers after treatment system	• recycle treated cooling water	• improve spill control and material loss control • improved housekeeping practices • report spills	• continue monitoring program • restricted chemical use • increased effluent quality requirements

3.2.1 Reduction, Recovery, Reuse and Recycle

A distinction must be drawn between conventional pollution abatement, that is, the traditional end-of-pipe treatment technologies and waste recovery technologies. Waste recovery technologies reflect contemporary thinking and the preferred approach.

Conventional pollution abatement comprises end-of-pipe treatment. Typically, in end-of-pipe treatment, the addition of substantial amounts of chemicals and energy are required to bring about the removal of potentially deleterious components from a waste stream. This approach creates sludges (residuals) which, most often, are ultimately deposited in a landfill. Thus, wastes are not eliminated but, rather, a water pollution problem is transformed into a potential land pollution problem. End-of-pipe treatment represents an open-end-type system where resources are used once and waste products (residuals) are discarded.

Contemporary thinking favours waste recovery technologies. These technologies represent closed-loop-type systems where process wastes are recovered and reused repeatedly at the point of generation. Therefore, best environmental management practice suggests that reduction and recovery technologies be applied first followed by treatment and disposal as a last resort.

The objective of waste reduction is to reduce contaminant production at its source so that the generation of contaminants is minimized in an overall sense. Typically, waste reduction involves any one or more of the following aspects:

- an industrial waste audit wherein the quantity and quality of produced wastes are characterized and sources identified;
- product reformulation;
- raw material substitution;
- installation of more efficient production equipment;
- process redesign;

- improved process monitoring/control; and
- waste concentration.

Waste recovery activities follow waste reduction activities. Comprising waste recovery are the following aspects:

- recycling wherein wastes are captured and incorporated back into the original generating process;
- recovery for use by another industry;
- waste segregation;
- inter-industry exchange; and
- combination of specific waste streams.

A number of appropriate approaches, reflecting this contemporary thinking, are discussed in the following sections.

3.2.1.1 Cooling Water

Most of the plants listed in Table 3.1 use large quantities of water for once-through cooling. Some of these flows are non-contact cooling waters but others may be contaminated during the cooling process. Contaminated cooling waters are best treated prior to discharge. Large treatment systems may be required to treat combined process and cooling water effluents. The blending of process and cooling water results in pre-treatment dilution which reduces the efficiency of subsequent treatment.

Cooling water may be recirculated to the plant after a cooling/treatment pond or a cooling tower. Excess cooling water may also be reused as process water make-up.

3.2.1.2 Process Water

Process waters carry most of the contaminants discharged during production. These flows contain contaminants with different concentrations. In many cases, it is possible to recirculate process water after some treatment or reuse a less contaminated process flow as make-up water at other production steps.

The volume of process flow may be significantly reduced by process water reuse and recycle. The application of in-line treatment systems treating recirculated process flows may reduce the amount of contaminants discharged in final effluent. Also, process improvements can serve to reduce the demand for raw water.

3.2.1.3 Material Recovery

Certain contaminants have value such as heavy metals (silver, cadmium, chromium, copper) and solvents. The recovery of these materials is also important in reducing the contaminant load to the receiving water. Recovered materials may be purified and reused or used as a raw material at another operation. The economic benefit of waste material recovery and reuse is a lower cost for end-of-pipe effluent treatment.

Material recovery is most efficient if it is applied to individual process flows at their source and prior mixing with other flows.

3.2.2 Engineering/Technical Options

Engineering options include treatment systems to remove contaminants and technical approaches to facilitate the reuse, recycle, reduction and recovery options.

The amount of contaminants discharged may be reduced by end-of-pipe treatment or the control of material loss/spill control in process areas.

Spill control in both process and materials handling areas can significantly reduce the amount of contaminants discharged and in many cases, reduce end-of-pipe treatment requirements. Spills collected at the source should be treated to recover valuable materials.

3.2.2.1 BOD_5 Removal

BOD_5 is associated with biologically oxidizable organic matter. The discharge of this organic matter may result in oxygen depletion in receiving water. The BOD_5 load to receiving water may be compounded by sanitary sewage or from organic contaminants discharged during production when mixed with process flows.

The amount of organic matter contributing to the BOD_5 load discharged by a plant may be reduced with the following:

- biological treatment system, such as activated sludge, lagoon or RBC;
- ultrafiltration membrane treatment;
- vacuum evaporation;
- filtration as a polishing step after biological treatment; and
- in-plant spill and material loss control.

3.2.2.2 pH Control

The final pH of industrial discharges should be between 6.5 and 8.5 to protect aquatic life in receiving water. In some cases, the pH is adjusted intermediately during treatment to a target value which is different from the allowable discharge limits. This is necessary to facilitate the removal of contaminants such as metals and oil emulsions, or may be required by the process itself for physical/chemical reaction. Following intermediate adjustment, the pH of the effluent has to be readjusted to meet discharge criteria.

The pH of the effluent may be adjusted by the addition of alkali, such as lime, or acid, such as sulphuric acid, addition in a well mixed reactor.

3.2.2.3 Metals Removal

Metals may be removed by the following treatment steps:

- pH adjustment, precipitation, flocculation and settling;
- ion exchange;
- electrolysis;
- vacuum evaporation;
- ultrafiltration membrane treatment;
- filtration after flocculation and settling;
- rinse water reuse in plating operations;
- unit process efficiency improvements; and
- process/equipment improvements.

3.2.2.4 Suspended Solids

Suspended solids may originate from production processes and may contain particles of the raw material or final product. Consequently, suspended solids may carry significant amounts of metals and BOD_5. Suspended solids may also be generated through the creation of sludges in the treatment of raw water for industry or for municipal use. The presence of suspended solids may increase the contaminant load to receiving water.

Suspended solids may be removed by the following treatment steps:

- flocculation and settling;
- settling;
- dissolved air flotation (DAF);

- ultrafiltration membrane treatment; and
- filtration.

Backwashing of filters used in suspended solids removal should not be practised where there is a potential for contamination, since backwashed solids may be discharged to the environment.

3.2.2.5 Oil/Grease Removal

Oil/grease may exist in process water in the form of floating (free) oil or oil in emulsion. Floating (free) oil can be removed by physical means in an oil/water separator or dissolved air flotation (DAF) unit.

Oil in emulsion cannot be separated from process water in this fashion. Chemical treatment, consisting of pH adjustment and metal salt addition, is used to transfer the oil from the emulsion to the free/floating form. The floating oil can then be removed from the water by physical means.

3.2.2.6 Organic Contaminants

Many of the organics lost to process effluent are valuable raw materials or products. The loss and discharge of these materials may be prevented and valuable materials recovered by the following steps:

- modern production procedures; and
- treatment of process effluents at the source, i.e.,
  - ultrafiltration membrane treatment,
  - vacuum evaporation,
  - stripping, and
  - distillation.

In many cases, however, small amounts of organics may be discharged with the process effluent.

Once organics are mixed into large flows, their recovery is technically more difficult. For this reason, end-of-pipe treatment is the option of last resort. Appropriate treatment for the removal of organics includes biological treatment, such as activated sludge and rotating biological contactors, or activated carbon adsorption.

3.2.2.7 Cyanide and Cyanate

These contaminants are frequently associated with metal finishing plant operations or certain chemical production processes. In many cases, cyanide removal is the prerequisite to the removal of heavy metals from process water. It is important to segregate cyanide-bearing wastewaters from other process flows and treat them separately because of the different nature of the required technologies. Cyanide may be removed by the following treatment processes:

- alkaline chlorination (oxidation);
- hydrogen peroxide oxidation;
- SO_2 /air oxidation;
- distillation; and
- ion exchange.

3.2.2.8 Nutrients

Phosphorus and ammonia are nutrients. Ammonia in high concentration may be steam stripped from the process flow and recovered as a fertilizer. In low concentration, it may be oxidized to nitrate in a biological system designed for nitrification.

Phosphorus may be removed by chemical precipitation with ferric or aluminum salts at a specific pH. The precipitated solids can be removed by settling and filtration steps.

3.2.3 Training

A significant portion of the contaminants discharged by an industry originates from improper process operation and material losses or spills.

Better plant operation and consequently, reduced material wastage, can be achieved by increasing the importance of human resources in plant operation through proper training. This aspect of plant operation involves dialogue between management and operators and includes the following aspects:

- enhanced understanding at the operations level of production, sources of material loss and the prevention of these losses;
- more efficient operation of manufacturing and treatment systems; and
- motivation of operators to prevent, report and/or cleanup material and waste spills.

3.2.4 Others

Included under this remedial action are activities not closely associated with plant operation. These activities may involve improved effluent quality and quantity monitoring for target contaminants and possibly more stringent effluent discharge regulations. More stringent effluent quality (and possibly, quantity) regulations may force industry to review its operation, implement best management practices, reuse and recycle process and cooling waters and improve the performance of existing treatment systems.

4.0 URBAN AREAS

Contamination from urban areas is widespread and includes nutrients and pesticides which have been spread on lawns, leaching of heavy metals from motor vehicle emissions and vehicular traffic, petroleum and chemical spills, airborne deposition and bacterial contamination from fecal droppings of animals.

A recent report (BEAK, 1989) defined the various sources of contamination from urban areas as follows:

- storm sewer discharges,
- combined (and sanitary) sewer overflows,
- spills,
- cross-connections between the sanitary and storm sewers,
- snow dumps,
- stream bank erosion,
- construction activity from development sites,

Outlined below are various options which may be used to mitigate the impacts from these sources.

There are various regulatory programs in place which attempt to minimize the impact of urban areas on the environment. These programs include:

- Municipal Strategy for the Abatement of Pollution (MISA), - Ministry of the Environment
- Municipal Sewer Use Bylaw Programs, - Ministry of the Environment, municipalities
- Stormwater Quality Control Guidelines (interim), - Ministry of the Environment, Ministry of Natural Resources

- Combined Sewer Overflow Policy (pending), - Ministry of the Environment
- Erosion and Sediment Control Guidelines, - Ministry of Natural Resources, Conservation Authorities
- Spills Control Programs, - Ministry of the Environment, and
- Public Education Programs.

In addition to the above programs, there are two types of studies which may be carried out to better define the sources of the problem and measures to reduce the impact: Infrastructure Needs Studies (INS) and Pollution Control Plan (PCP) studies.

In the Regional Municipality of Niagara, both Fort Erie and Niagara-on-the-Lake have completed INS which identified problems with combined sewer overflows or sanitary overflows at pumping stations. Both studies recommended combinations of increased storage and pumping capacity, as well as long-term improvements to the sewer infrastructure to control extraneous inputs (inflow and infiltration). Recommended improvements included repair and replacement of leaky sewers and manholes, sewer separation in some locations and disconnection of roof leader downspouts and foundation drains from sanitary sewers.

Niagara Falls and Welland have, based on preliminary field work and monitoring, recognized combined sewer overflow problems. Both are currently negotiating for funding to carry out Infrastructure Needs Studies of their sewer systems. These studies will emphasize data collection to identify sewer system deficiencies, and analysis of control operations as mentioned above. The studies should also look at combined sewer control options such as:

- high rate treatment at overflow locations including solids removal, disinfection and storage;

- wet weather operation of sewage treatment plants to optimize treatment of inflows and stored combined sewage;
- real time control of sewage system storage and treatment elements to maximize storage and minimize releases of untreated sewage, and
- creation of wetlands for treatment of combined sewer overflows.

The remedial options to reduce the impact of urban areas have been divided into the following categories:

- stormwater,
- combined/sanitary sewage, and
- construction activity.

Many of the options as described in Table 4.1 are equally applicable as remediative measures within areas which are already developed or as preventative measures within areas to be developed. Construction activity is provided as a separate category as the problem is quite specific, i.e., increased volume of sediment from areas where vegetative cover has been removed in order to facilitate the construction of houses, commercial or industrial buildings.

TABLE 4.1 PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF URBAN DEVELOPMENT PROBLEM SOURCES

Sources	Remedial Option	Description
Stormwater	Continue Implementation Projects Underway	In many cases, remedial programs (i.e. Pollution Control Plans, Infrastructure Needs Studies) may be underway in the watershed to remedy specific problems.
	Public Education	Establishment of programs to better educate the public in hopes of reducing pollutant loadings. Programs may include pet litter control, general litter control, application of lawn and garden chemicals, management of hazardous household waste and solid waste management/disposal.
	Retrofit Existing Ponds	Retrofitting of existing ponds to improve water quality control or groundwater recharge.
	Wet Ponds	Implementation of wet ponds (permanent pools of water) to provide water quality remediation and habitat benefits in stormwater systems.
	Wetlands	Implementation of artificial wetlands in applicable locations for reduction in nutrient and suspended solids loadings from stormwater; discharge to existing wetlands
	Policy Development & Planning	Recommendation of policies to ensure existing resources are protected.
	Infiltration Trenches/ Basins	Implementation of measures to reduce runoff volumes and enhance groundwater recharge, such as infiltration trenches, porous pavement, grassed swales.
	Porous Pavements	Areas such as parking lots, driveways and local roads are constructed using porous materials to promote groundwater infiltration. This may lead to groundwater contamination.
	Grassed Swales	Application of grassed swales versus traditional curb and gutter drainage systems in applicable developments to reduce runoff volumes and manage the impact of frequent small rainfall events.
	Street Sweeping	Common practice undertaken to clean accumulated sediment and debris from the streets. May be increased in frequency or modified to be more efficient.
	Catch Basin Cleaning	Another common practice whereby grit and leaves are periodically removed from catch basins. May be increased in frequency.

TABLE 4.1 PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF URBAN DEVELOPMENT PROBLEM SOURCES (Cont'd)

Sources	Remedial Option	Description
	Roof Downspout Disconnection	Disconnection of roof downspouts which are directly connected to the storm or sanitary sewer systems. The downspouts would be reconnected such that they discharge to the surface, thereby reducing the potential for infiltration to the sanitary sewer system or volume of runoff to the storm sewer system. Downspouts should discharge to vegetated areas, promoting infiltration to groundwater and uptake by vegetation.
	Land Use Policy	Restriction of specific land uses within a specified area. This alternative would be applicable in areas where a specific land use may result in adverse environmental impacts (eg: an industrial area which uses toxic materials and is located upstream of a resident fishery).
	Land Use Planning	This alternative involves proper planning to ensure that natural features are identified and protected (e.g. the identification and protection of a wetland and adjacent buffer zone). It may also include zoning limitations or limitations as to the maximum permissable level of development within a subcatchment or watershed.
	Natural Drainage Systems	This involves the use of natural drainage systems to convey runoff from residential/commercial or industrial sites (e.g: grassed swales, vegetated strips) and natural materials within watercourses to ensure that environmental resources are protected (eg: soil bioengineering).
	MISA	Provincial program designed to regulate the discharge of various pollutants from specific types of industry.
	Storage and Disinfection of Priority Outfalls	Storage and disinfection of discharges which are identified as priority outfalls.
	Erosion Control Programs	Bank stabilization, provision of buffer strips, sediment control during construction, promote conservation tillage and cultivation methods.
	Spill Control Programs	Implementation of a comprehensive Spills Management and Mitigation Program.
	Oil/Grease Separation Device	Storage facility commonly placed at the property line of an industrial/commercial development. Traps heavy solids and oils/greases during spills. Cleanout and maintenance programs must be enforced.

TABLE 4.1 PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF URBAN DEVELOPMENT PROBLEM SOURCES (Cont'd)

Sources	Remedial Option	Description
	Enforcement of Existing Policies/Regulation Laws	Various policies/regulations/laws exist for the control of pollutants from urban areas. Enforcement of existing policies will assist in reducing the pollutant loading. Enforcement may require the rewriting of a policy or law to provide stronger penalties.
	Sewer Use By-Law	Sewer Use By-Laws are Municipal By-Laws for regulating discharges to sanitary and storm sewers. These By-Laws control the discharge of several parameters including bacteria, solids, nutrients and heavy metals.
	Modify Outfalls or Sewers	Divert sewer systems, relocate outfalls, install diffusers, etc., to achieve better dispersal.
	Bathing Beach Controls	Curtain off and disinfect swimming areas, replace beach sediment, control fecal inputs from birds, pets, etc. Divert discharge away from beach areas and/or improve circulation patterns.
Combined/ Sanitary Sewage	Continue Implementation of Programs Underway	In many cases, remedial programs (i.e., Pollution Control Plans, Infrastructure Needs Studies) may be underway in the watershed to remedy specific problems.
	Build or Expand WPCP's	Provide adequate capacity for existing and planned future populations; add additional treatment technologies.
	Infrastructure Rehabilitation	The primary target for this alternative would be the reduction of infiltration/inflow to the sanitary or combined sewer system. Various alternatives are described below.
	Structural Rehabilitation	Existing sewers may be replaced, relined or grouted to reduce infiltration/inflow. Rehabilitation on public and private property should be carried out.
	System Inspection	Periodic inspection to locate and remove blockage due to tree roots, sediment etc. should be carried out. Inspection of control gates or structures should also be undertaken.
	Inspection of Water Distribution System	Inspect and repair leakage in water distribution system thereby reducing infiltration to storm, sanitary or combined sewer systems.
	Sewer Flushing	Wastewater solids which settle within the combined sewer during dry weather conditions and are then resuspended during wet weather conditions can be reduced with sewer flushing during dry weather conditions.

TABLE 4.1 PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF URBAN DEVELOPMENT PROBLEM SOURCES (Cont'd)

Sources	Remedial Option	Description
	Elimination of Cross Connections between Sanitary and Storm Sewer Systems	Smoke and dye testing may be carried out in conjunction with water quality sampling programs in order to identify and remediate cross connections between the storm and sanitary sewer systems.
	Storage and Treatment	Excess combined or sanitary flows may be stored in underground tanks during periods of heavy rainfall. Increased storage of existing pumping stations may also reduce overflows.
	Sewer Separation	Separation of the domestic and stormwater flows in combined sewer areas will reduce the flows to the plant. Total loadings to the receiving body however, may not decrease.
	Swirl Concentration	A small, compact solids separation device that concentrates foul matter from combined sewers and directs it to the treatment plant.
	Dunkers Flow Balancing System	A storage device which is constructed within an open body of water. The facility, which is comprised of a series of pontoons and curtains stores combined or sanitary overflows during rainfall events and redirects flows to the treatment facility during dry weather periods.
	Water Conservation Practices	Conservation of water may reduce pollutant loadings to the receiving bodies of water. Conservation is of benefit especially during wet weather conditions when treatment facilities are subject to large flow volumes. May be accomplished through increased user rates.
	Reduction at Source	Promote programs and enforce by-laws to reduce contaminant loadings to sewers by industry through reduction, re-use, or treatment at source. This may require increased financial disincentives (sewer discharge fees or fines) for excessive contaminant loadings.
	Improved Household Practices	Educate householders to conserve water, use non-hazardous chemicals in the home; to minimize loadings to sewers (e.g., kitchen garbage disposals with sewer hook-ups); use pesticides, herbicides and fertilizers wisely and less frequently; dispose of hazardous materials such as oil and solvents through municipal collection depots rather than in drains or storm sewers.

TABLE 4.1 PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF URBAN DEVELOPMENT PROBLEM SOURCES (Cont'd)

Sources	Remedial Option	Description
Construction	Rock check dam and other energy dissipators	Rock Check Dams or dams fashioned of strawbales and/or geotextiles are placed within a stream or ditch and slow down flows, thereby reducing erosion and sediment transport.
	Sediment Basin	A temporary pool of water which promotes sedimentation of solids eroded from construction sites.
	Settling Ponds	Install wet ponds to collect runoff and settle eroded material before other land development activities proceed. These should be designed to provide for both siltation control and control of the hydrograph and would remain in place for long-term stormwater management.
	Silt Fences/Straw Bales	Generally used together to trap sediment from overland runoff.
	Mulching/Hydroseeding	Temporary replacement of vegetative cover to reduce soil loss.
	Buffer Strips	Establishment of a setback in which vegetative cover remains in place. Helps trap sediment prior to discharge to receiving body of water.
	Geotextiles	Use geotextiles to cover exposed ground, especially on slopes, to reduce erosion until vegetation can be re-established.
	Improved land-clearing practice	Vegetation should be stripped or soil disturbed no earlier than necessary. Vegetation/soil could be stripped incrementally as required.
	Environmental planning and policy	Establish and enforce regulations for environmental management at construction sites to minimize erosion and siltation of watercourse.

5.0 AGRICULTURAL AREAS

There are various problems associated with agricultural or farming practices. The sources of pollution and associated potential problems are outlined below:

- soil loss due to wind, sheet or rill erosion which results in increased sediment loads in the receiving bodies of water;

- the use of fertilizers, pesticides and herbicides which are detrimental to the aquatic ecosystem if conveyed offsite;

- accidental spills which enter the river directly or through runoff and may result in habitat destruction or eradication of the aquatic community;

- septic tank discharges and septic bed failures which increase nutrient loadings to surface waters and groundwater; and

- general practices (e.g., manure spreading, cleaning of pesticide or herbicide containers, etc.) which may increase bacterial or chemical contamination of surface or groundwaters.

Outlined in Table 5.1 are various remedial options which, if implemented, would reduce the impact of agriculture on the receiving body of water.

TABLE 5.1 PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF AGRICULTURAL PROBLEM SOURCES

Sources	Remedial Option	Description
Agricultural	Public Education	Foster understanding for the need to control non-point source contamination by silt, pesticides and the impact of soil loss to the farming operation and the environment.
	No-tillage	A method of planting crops that involves no seedbed preparation other than opening the soil for the purpose of placing the seed at the intended depth.
	Contour Farming	Conducting field operations, such as plowing, planting, cultivating, and harvesting on the natural field contour.
	Mechanical Cultivation	Use of mechanical weeding devices in order to reduce the need for herbicides.
	Crop Rotation	The growing of different crops in recurring succession on the same land. Rotations offer advantages for erosion, pesticide and nutrient control.
	Streambank Protection	Protection of the streambank may occur by limiting livestock access, providing a riparian buffer strip along the banks or via structural measures.
	Terraces	Embankments or combinations of embankments and channels constructed across a slope to control erosion, and or store surface runoff on high gradient farmland.
	Improve Soil Fertility	Improving soil fertility increases crop yields and reduces soil erosion.
	Eliminate Excess Application of Nutrients or Pesticides	Establish protocol whereby fertilizer rates are based on crop nutrient budgets.
	Conservation Tillage	Promote the further application of soil conservation practices, such as those under development by OMAF and Agriculture Canada, to reduce soil and pesticide loss.
	Restrict Stream Access	Promote the restriction of stream access by livestock to conserve riparian vegetation and reduce erosion, and prevent direct contamination of surface waters and loss of instream habitat.
	Establish Buffer Strips	Encourage farmers to protect stream-side vegetation to stabilize banks and maintain aquatic habitat.
	Construct Control Ponds Wetlands	Installation of sediment traps (ponds, wetlands) along agricultural and drainage systems will reduce downstream siltation and sediment transport.
	Implement watershed management practices in agricultural areas	Measures to protect or enhance fish habitat such as maintenance or establishment of wooded buffer strips, stabilization of eroding stream banks, etc. May require financial incentives to promote implementation.

6.0 LANDFILLS

The draft Stage I RAP report identifies 16 landfills in the Area of Concern (MOE, 1984). Five are currently operating and 11 are closed. Of the 16, five were identified by the Niagara River Toxics Committee (1984) as having significant potential to impact the aquatic environment, although this does not indicate that off-site contamination is occurring. Monenco (MOE, 1991) recently completed an evaluation that indicates a potential loss of 30.5 kg/day of priority pollutants to surface waters from the five landfills, with 88% of the total being cyanide from the Cyanamid landfills at Niagara Falls.

As summarized in the draft Stage I RAP report, these landfills are:

Site	Location	Reasons for Classification
Atlas Landfill	Welland	2,5
Cyanamid Landfill	Welland	1,4
Cyanamid Landfill	Niagara Falls	1,2
Bridge Street Landfill	Fort Erie	3
CNR Landfill	Niagara Falls	2,5

Legend:
1 - contents
2 - proximity to surface water
3 - known contamination
4 - size of site
5 - local topography

Table 6.1 provides a list of approaches available for remediating landfill problems in general, both as related to hazardous wastes and materials and routine (non-hazardous)

TABLE 6.1: LIST OF OPTIONS FOR REMEDIATION OF LANDFILL PROBLEMS

Category of Option	Options	Description
Waste Containment	Watertable adjustment	Lower watertable below landfill by groundwater extraction to reduce groundwater contact with waste
	Contaminant Plume Containment by Groundwater Extraction	To reduce downgradient movement of contaminated groundwater and collect groundwater for treatment
	Reduction of plumes with upgradient Barriers or diversions (slurry walls, grout curtains, sheet piling)	To isolate waste by deflecting aquifer flow away from landfill
	Encircle waste with impermeable material (e.g. slurry walls, grout curtains, sheet piling) and tie into low permeability strata	Provides near complete waste isolation, infiltration of water may cause bathtub effect that may be partially remedied by capping
	Capping with low permeability materials	Greatly reduces infiltration of water from the surface, most often used where landfill is above watertable
	Surface water diversion	Drainage control on the surface may be used to enhance or divert runoff and minimize infiltration
	Liners of impermeable materials (e.g. clay or synthetic liners)	Used to line surface landfills to isolate landfills to isolate leachate from groundwater
Collection and Treatment of Leachate	Leachate collection/extraction and treatment	Includes biological and physical treatment as described below
	Biological treatment	Activated sludge, aerated basins, trickling filters, landspreading, anaerobic digestion to oxidize organic waste
	Chemical treatment	• Chemical precipitation (metals), oxidation (e.g., cyanide, organic compounds using ozone), U.V., H_2O_2, chlorine, etc.) • Reduction (e.g., chromium) • Ion exchange (to remove inorganic salts) • Neutralization (pH adjustment) • Wet air oxidation (high temperature and pressure for oxidizing organic compounds) • Solvent extraction (to remove organic contaminants for further treatment or disposal) • Activated carbon or resin adsorption (removes organic compounds)

TABLE 6.1: LIST OF OPTIONS FOR REMEDIATION OF LANDFILL PROBLEMS

Category of Option	Options	Description
	Physical treatment	• Filtration (to remove suspended solids) • Reverse osmosis (concentrates salts) • Air stripping (to remove volatile compounds) • Flocculation (to enhance settling)
Removal	Excavate all or part of landfill	To permit implementation of better or alternate waste management practices
Incineration (hazardous waste)	Rotary kilns, mobile incinerators, cement kilns, fluid bid reactors, thermal reactors, arc pyrolysis	To destroy toxic organic compounds in solid waste
Solidification/ Stabilization	Cementation, thermoplastic binding, organic polymer binding, surface encapsulation, glassification	To immobilize hazardous waste materials excavated from landfills
In Situ Methods	Biological treatment/bioremediation	• Through enhancement of natural decomposition by aeration/fertilization • Inoculate landfill with organisms selected for degrading waste
	Physical/chemical treatment	• Injection of chemical agents to promote reactions to detoxify or immobilize waste (e.g., reduction of hexavalant chromium with ferrous sulphate and oxidation of cyanide with sodium hypochlorite • Vitrification - in development, involves fusion of waste into stable, glassy matrix
	Solution mining	Introduces a solvent that is subsequently collected and treated. Solvents include water, acids, ammonia, etc., and may contain chelators to improve metal solubility
Waste Reduction/ Reuse/Recycling/ Replacement	Reduction	Reduce loadings of materials to landfills that may cause environmental problems; may include economic incentives to reduce (e.g., increased fees for landfilling)
	Reuse	Maximize reuse of municipal or industrial materials before landfilling (may require economic incentives)
	Recycle	Reprocess materials for further use rather than landfill both in municipal and industrial recycling programs (may require economic incentives)

TABLE 6.1: LIST OF OPTIONS FOR REMEDIATION OF LANDFILL PROBLEMS

Category of Option	Options	Description
	Replace	Substitute less environmentally harmful materials or promote activities to produce less hazardous waste (may require economic incentives)
Communication	Increase public awareness	Foster sound environmental practice at the home to reduce, reuse and recycle household waste and promote use of "environmentally friendly" products; Encourage hazardous waste separation and collection
		Foster sound environmental practice by industry (reduce packaging, reduce use of hazardous materials)
	Public Education	Educate the public on the advantages and disadvantages of various methods of waste disposal including incineration and cogeneration facilities.
Regulatory	Reduction of packaging	Legislate reduction of packaging of consumer products
	Restrict landfill criteria	Reduce numbers of materials permitted for landfilling to force more reuse, reduction, reuse, recycling and to keep hazardous materials from landfills where better management options are available
	Enforcement	Ensure landfilling regulations are enforced
	Develop requirements for better landfill design, leachate control and/or treatment	To reduce leaky landfills or hazardous contaminants from landfills

wastes that may be landfilled. Many of the technical options listed are those described in texts by Ehrenfeld and Bass (1984) and Major and Fitchko (1990).

7.0 CONTAMINATED SEDIMENTS

The draft Stage I RAP report (MOE *et.al.* 1990) identifies several problem areas where sediment contamination exceeds sediment quality guidelines. Bottom sediment accumulation is limited in the Niagara River itself and is confined primarily to tributary mouths and shoreline backwaters. Some of these sediments maybe contaminated with heavy metals or persistent organic compounds.

Welland River sediments are also contaminated with metals, nutrients and other materials. The "Atlas Reef" downstream of the Atlas Steel and McMaster Ave. outfalls represents a severe environmental problem in terms of contamination and physical habitat deterioration. Previous problems relating to coal tar deposits in sediment of the Chippawa Creek portion of the Welland River were largely cleaned-up in 1986 and 1987.

Suspended sediments in the Niagara River are also contaminated with metals and persistent organics. Studies show that the suspended sediment load originates largely from Lake Erie and to a lesser extent from tributaries flowing into the Niagara. Contamination appears to be added to the suspended sediment from sources along the length of the Niagara River.

Table 7.1 identifies of various options for remediating contaminated sediments.

TABLE 7.1: PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF CONTAMINATED SEDIMENTS

Category of Option	Options	Description
Source Control	Reduce or eliminate sources of contaminants that result in sediment contamination	Reduction of loadings from industry, municipalities, landfills, etc. that contributed to sediment contamination using methods identified in other chapters of this report.
Bottom Sediment Removal	Conventional (clam shell) dredging	Involves underwater excavation and surface transport for disposal or treatment
	Suction dredging	Involves pumping of a fluid or slurried sediment to a containment and treatment system
	Siltation controls in dredging	Used in connection with dredging to minimize resuspension and transport of contaminated sediments; involves physical isolation of the dredging operation from surrounding waters
	Excavation in the dry	Involves isolating the sediment with a cofferdam, removing the water and excavating the sediment using traditional earth-moving equipment. This is done most readily where coffer dam can be tied into a shoreline or suitable in-stream structure.
	Hydraulic flushing of contaminated sediments	To disperse contaminated sediments downstream
Disposal of Dredged Sediments	Open water disposal	Disposal at a designated offshore location in the Great Lakes
	Confined Disposal	Disposal in a water-based confined disposal facility (CDF) for sediments not meeting MOE open water disposal guidelines
	Landfilling	Disposal in a conventional or hazardous waste landfill
	Lakefilling	Use of dredged sediments to create land for development along lake shorelines
Treatment of Dredged Sediments	Solvent extraction	To collect organic contaminants for further treatment (incineration, physical or chemical treatment)
	Incineration (e.g., rotary kiln/mobile incinerators)	To destroy toxic organic compounds in contaminated sediments
	Solidifcation/Stabilization (cementation, thermoplastic binding, organic polymer binding, surface encapsulation, glassification)	To immobilize hazardous waste materials in contaminated sediments and then disposal using traditional methods

TABLE 7.1: PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF CONTAMINATED SEDIMENTS

Category of Option	Options	Description
	Biological treatment	Through enhancement of natural decomposition by landfarming or bioremediation
	Physical/chemical treatment	• Injection of chemical agents to promote reactions to detoxify or immobilize waste (e.g., reduction of hexavalent chromium with ferrous sulphate and oxidation of cyanide with sodium hypochlorite) • Vitrification - in development, involves fusion of contaminated sediment into stable, glassy matrix
In-Situ Remediation of Contaminated Sediments	Cover in-place with clay or other low permeablility material	To isolate contaminants from water column biosphere
	Passive covering of sediments	After source removal, allow natural sedimentation to cover contaminated material with cleaner deposits
	In-situ remediation	Introduce chemical or biological agents to immobilize or decompose contaminants
Diversion	Divert river channel	Isolates the river from the contaminated material by diverting around it
Erosion Control	Erosion and sediment control within the AOC watersheds	Reduces the quantity of sediment originating from erosion of soil that may be contaminated; controls to be implemented within municipalities and in agriculture
Communication	Improve public awareness	Foster "environmentally friendlier" practices by all sectors of the community including the public, municipalities, farming community and industry
Regulatory	Tighten regulations	• Reduce quantities of chemical wastes permitted for discharge to the environment • Restrict use and discharge of persistent toxic substances • Increase restrictions on use of pesticides and herbicides that are linked to sediment contamination
	Enforce regulations	Ensure that environmental regulations are enforced, including those outlined individual Certificates of Approval for wastewater discharge and landfill operation.

8.0 ATMOSPHERIC POLLUTION

Air quality impinges on water quality through the wet and dry deposition of airborne contaminants onto the water surface or onto the watershed. Much of the local air pollution in the Niagara River area occurs within the heavily industrialized and populated corridor along the New York State shoreline. These sources are outside of the Niagara River (Ontario) AOC; in fact much of the atmospheric deposition within the AOC originates from sources within a much larger regional airshed. Dry deposition of particulate contaminants generally occurs closer to sources (e.g., stacks, roadways, etc.) than does wet deposition, and to the extent that it occurs may be expected to include a substantial component from within the AOC.

Around the Falls atmospheric pollution may occur from the volatilization of aerosols and volatile contaminants in the mist produced by the Falls; however, monitoring of the mist by the MOE and Environment Canada has failed to show contamination above levels normally experienced in an urban environment.

Remedial options for reducing the impacts of atmospheric pollution on the Niagara River are limited within the Niagara Falls (Ontario) AOC because most of the atmospheric pollutants deposited within the AOC originate from external sources. However, some options exist for controlling atmospheric emissions from within the AOC. A list of these is provided in Table 8.1.

Table 8.2 provides a list of options for reducing concerns related to atmospheric pollution from the Niagara Falls mist.

TABLE 8.1: PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF ATMOSPHERIC DEPOSITION

Category of Option	Options	Description
Source Elimination	Combustion replacement	Replace combustion processes in industry with others that achieve the same objective (e.g. landfilling rather then incineration)
	Contain or Cover with Clean materials	Contain, cap or cover contaminated materials (e.g. soils) that are otherwise subject to wind erosion.
	Close or move sources from the AOC	Remove problem sources from the AOC to less sensitive sites using economic incentive and/or re-zoning of industrial lands
Source Reduction	Collect particulates from stack emissions	Using electrostatic precipitators, filter bags, etc.
	Remove acid gases from emissions	Using scrubbers, etc.
	Dust suppression	To reduce the generation of dust from contaminated soils (e.g., industrial properties)
	Discontinue or reduce waste incineration	Use alternative disposal methods rather than incineration
Combustion Controls	Alternative fuels/feed stocks	Encourage use of cleaner-burning fuels
	Optimize temperatures	Combustion temperatures may be optimized in some facilities to minimize atmospheric emissions of some gases and particulates
Stack Controls	• Increase stack exit velocity • Increase stack height • Increase stack gas temperature	These measures result in greater initial dispersion of gases from point sources, and promote dilution in a larger airshed
Source Grouping	• Grouping of multiple sources at single facilities into fewer stacks	To facilitate better management of emissions by industry and regulatory control by the MOE.
Watershed Remediation	Street sweeping	To remove contaminated dust and other deposition before washing into storm sewers
	Liming of lakes/watersheds	To neutralize acidic conditions caused by acidic precipitation
	Stormwater management (many options, see Section 4.0)	To promote removal of contaminants from airborne sources before discharge to receiving waters
Reduce/Reuse/ Recycle Options	• Reduce waste volumes for incineration • Reduce fuel consumption	To reduce emissions; may include economic incentives to reduce (increased fees/taxes for excessive waste production or fuel consumption)

TABLE 8.1: PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF ATMOSPHERIC DEPOSITION

Category of Option	Options	Description
Communication	Increase public awareness	Foster sound environmental practices by the public and industry to reduce air emissions
Regulatory	Tighten regulations	Reduce allowance of atmospheric loadings of contaminants
	Enforce regulations	Ensure compliance with regulations

TABLE 8.2: PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF NIAGARA MIST CONCERNS

Category of Option	Options	Description
Source Controls	Reduce loadings of contaminants to upper Niagara River	Decrease loadings from municipal, industrial, landfill and other sources using all appropriate and feasible options
Mist Control	Reduce amount of mist	Decrease misting by diverting more flow for power generation
Communication	Increase public awareness	Publicize monitoring results; may require more frequent or extensive monitoring and improved communication
Exposure controls	Reduce opportunities for public exposure	To reduce public exposure to perceived problem
Air Quality Monitoring	Increase frequency of monitoring and number of parameters measured	To provide better definition of any problem and increase the probability of monitoring contamination due to sporadic spill events. If a problem is defined, source control or elimination can be implemented.

9.0 PHYSICAL HABITAT DISRUPTION

Many human activities within the Niagara River AOC directly alter the physical characteristics of fish and wildlife habitat to the detriment of biological communities. Of necessity, urban development and agriculture drastically change the face of the landscape and alter most components of the biological community. However, certain environmental management practices may be used to minimize habitat damage and preserve valued components of the natural ecosystem. Many of the general solutions outlined in the accompanying table (Table 9.1) include measures identified for municipal and stormwater sources. All of these options may be implemented through the adoption of new regulations or planning and approval requirements, economic incentives, and increased public awareness and participation in preservation and restoration activities.

TABLE 9.1: PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF PHYSICAL HABITAT DAMAGE

Problem	Options	Description
Disruption or loss of Streambank Vegetation	Preserve or restore vegetation buffer strips	Loss of streambank vegetation diminishes fish and wildlife habitat values; government funding (e.g. Ministry of Natural Resources Community Fisheries Program (CFIP) may be a funding source for stream revegetation programs
	Restrict or eliminate livestock access to streams	May require incentives to farmers for fencing or provision of alternative water supplies
Loss of Wetlands	Preserve, restore or create wetland habitat	To restore hydrologic functions, provide habitat, possibly to manage stormwater or sewage
Erosion/Siltation of Streams	• Adopt runoff control measures in agriculture, municipalities • Stabilize actively eroding streambanks	To reduce erosion and sedimentation of streams and rivers
Water Level Fluctuations	Use alternatives to hydro power (nuclear, coal)	Water level fluctuations above and below hydro installations disrupt shoreline zones and riparian habitat
	Control fluctuations to protect habitat for spawning, egg incubation of fish	
Loss of Valued Ecosystem Components	Establish more nature preserves	Designate more areas of Natural and Scientific Interest, Environmentally Sensitive Areas, etc. to preserve natural habitat
Stream Flow Fluctuations	Reduce fluctuations in hygrograph Enhance groundwater recharge and reduce direct runoff	Streamflow variation is increased by urban drainage, agriculture, and clearing of land in general, reducing habitat value. Adopting appropriate control measures in agriculture and urban drainage planning will reduce the impact of this problem
In-Stream Alteration	Control and reduce channelization, damming and other alterations to reduce runoff problems that leads to	In-stream changes to habitat reduce values to fish communities and impede fish movements; better landuse management will reduce runoff problems that lead to the need for in-stream engineering to control flooding and erosion
Loss of in-stream cover	Provide in-stream cover in the form of rock, embayments, flow restricting structures, and bank revegetation to diversity in-stream habitat	Widely fluctuating water levels due to rapid runoff from developed land (urban and rural) washes out natural in-stream structures and broadens stream channels. In-stream rehabilitation combined with watershed controls (improved stormwater management) will improve fish habitat. CFIP funding may be available to community volunteers for stream habitat enhancement.

10.0 OTHER PROBLEM SOURCES WITHIN THE AOC

The draft Stage I RAP document identifies several other potential problem sources within the Niagara River (Ontario) Area of Concern, including:

- physical, chemical and biological agents that impair water use (foam, acidity, zebra mussels);
- commercial shipping (dredging, spills);
- water recreation (e.g., grey water, fuel spills); and
- water levels (access problems, power generation problems).

Table 10.1 provides a brief outline of some of the options that may be used to remediate these problem sources.

TABLE 10.1: PRELIMINARY LIST OF OPTIONS FOR REMEDIATION OF OTHER PROBLEM SOURCES WITHIN THE AREA OF CONCERN

Source of Problem	Options	Description
Physical Agents of Impaired Use:		
• Foam (Maid of the Mist Pool)	• No action	No action is required if the foam is of natural origin
	• Defoaming agents	May be applied directly to foam in river to improve aesthetics, but agents may present contamination problem. Water sprays may be effective. If an upstream source of foaming agents is identified, control or eliminate the source.
Chemical Agents of Impaired Use	Source control	Reduce loadings of contaminants from municipal, industrial and other sources
	Treat to improve water quality	Physical or chemical treatment of process or intake water
Zebra Mussels	Biological controls	Introduce predators or pathogenic organisms to control infestations at ecosystem level
	Chemical controls	Used at intake facilities, e.g., chlorine, tri-butyl-tin oxide, copper oxide, paint/copper sulphate, cyanuric acid, ammonium, other toxicants (Mackie et al., 1989)
	Physical controls	Heat, flushing, desiccation, electric fields, acoustic controls, screening, mechanical or manual removal (Mackie et al., 1989)
Commercial Shipping	Improved wastewater and ballast water management	Stricter regulations for waste and ballast water management for shipping in the AOC and Seaway
	Improved spill response capability	Improved training and facilities for cleanup of spills from shipping
	Silt curtains in dredging	To control losses of contaminants from dredged sediments
Recreational Boating and Other	Holding tanks for grey water, improved controls at pump-out stations	To reduce contamination from boating
	Placement of navigation channels	Locate navigation channels away from important habitat areas (e.g., weed beds)
	Greater control on dispensing and storage of marine fuels (e.g. containment around pumps, adsorbents for small spills	To reduce contamination by fuels, especially near docking facilities.
	Limit boating speeds and/or sites	To minimize shoreline erosion and disturbance of riparian habitat
Water Levels	Limit water level fluctuations to improve access for boating	Develop navigation priority water levels during the boating season with hydroelectric facilities

11.0 PROBLEMS FROM SOURCES IN THE U.S. AND UPSTREAM

Many of the environmental problems identified within the Niagara River (Ontario) Area of Concern originate along the U.S. side of the river or upstream in Lake Erie, as outlined in the draft Stage I RAP report. The hazardous waste sites along the U.S. side of the river are widely recognized as the major contributors to the toxic pollution problems of the Niagara. The Buffalo River Area of Concern is also a significant contributor to environmental problems in the Niagara River. Remediation of environmental problems arising outside of the Niagara River (Ontario) Area of Concern will be addressed by RAP activities proceeding for these other AOCs. Nonetheless, actions may be initiated within the Niagara River (Ontario) AOC to influence remediation activities within these other jurisdictions. Some of these actions include:

(i) Review Remedial Plans and Actions

The RAP for the Niagara Falls (New York) AOC is on-going in parallel with the corresponding Ontario RAP. While the programs are co-ordinated intergovernmentally, it will be of interest to the Niagara River (Ontario) PAC and other members of the public to review and comment on the other RAP as it unfolds. This would provide a means of communicating concerns relating to sources on the U.S. side that are causing impairment in Ontario.

(ii) Apply Political or Diplomatic Pressure

If remedial activities for sources in other jurisdictions are inadequate to achieve specific ecosystem goals within the Niagara Falls (Ontario) AOC, political or diplomatic actions may be taken by the government of Ontario or Canada to induce regulatory action in these jurisdictions. Public pressure through municipal governments, elected officials and environmental lobby groups can be effective in initiating diplomatic action. Agreements with the

U.S. government that have been achieved on acid gas emissions are examples of successful diplomatic efforts to reduce transboundary pollution.

(iii) International Agreements

International agreements can be made to reduce or eliminate transboundary pollution and to establish common ecosystem objectives in boundary waters. Examples of existing international agreements include the Great lakes Water Quality Agreement, the Niagara River Toxics Management Plan and the international RAP program. As new ecosystem goals are formulated or new environmental problems identified, these agreements provide a mechanism for establishing common goals and schedules for action.

(iv) Legal Action

Legal action may be considered by Canadians or by government agencies if environmental or regulations are not upheld in other jurisdictions. Legal actions would be appropriate only where diplomatic and political means fail. The public may also press regulatory agencies for enforcement of environmental regulations where violations occur.

(v) Monitoring

Monitoring programs can be continued or expanded to trace responses to remedial efforts in other jurisdictions. Monitoring activities such as the current Niagara-on-the-Lake and Fort Erie water quality program can be used to measure long term trends and evaluate the need for further remedial action. Because monitoring programs tend to be costly, it is important to ensure that objectives are clearly defined and procedures planned before any new programs are implemented. As both Canada and U.S. have interests in achieving remediation, there is scope for joint funding and participation in such programs.

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PHASE II: SCREENING OF REMEDIAL OPTIONS

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1.0 INTRODUCTION

Pollution has long been recognized as a problem in the Niagara River, with serious problems being linked to persistent toxic chemicals in the water and sediments. In 1986, the Province of Ontario, State of New York, Canada and the U.S. signed a Declaration of Intent to ensure the adoption of a management strategy to significantly reduce the toxic chemical loadings in the Niagara River. The Toxic Management Plan is the document expressing this strategy, and it calls for a 50% reduction by 1996 in the loading of many of the 18 persistent toxic chemicals identified in Table 1.1. The long term goal of the Plan is the virtual elimination of loadings of these chemicals into the Niagara River. Sources of these toxic substances include both Ontario and New York state facilities, and are primarily attributed to seepage from hazardous waste dumps; discharges from industrial plants, municipal sewage and stormwater treatment facilities; and runoff from agricultural areas.

Two Remedial Action Plans (RAPs) are being developed for the Niagara River Area of Concern (AOC) - one for Ontario and one for New York state. The Niagara River (Ontario) AOC encompasses the Niagara River, as well as the Welland River which extends some 70 km to the west of the Niagara River (see Figure 1.1). The purpose of RAPs is to clean up, restore and protect AOCs. RAPs should focus on virtual elimination of persistent toxic substances, and should promote measures that are directed at preventing recontamination, rather than strictly focusing on remediation.

Both Niagara River RAPs are intended to outline a strategy and set of specific, remedial measures targeted at preventing the further impairment of water and sediment quality, fish and wildlife habitat, and areas of natural beauty and recreational enjoyment within the Niagara River watershed. The goals of both RAPs extend beyond prevention of further impairment, to include the improvement and rehabilitation of existing natural resources. Follow through and implementation of the RAPs objectives and recommended remedial actions is key to the success of the RAP process.

The RAP process is coordinated by a team of technical and scientific experts from Canadian and Ontario government agencies. The RAP team is advised by the Niagara River Public Advisory Committee (PAC), which consists of volunteers representing academia, industry, environmental groups, local agencies, municipalities and the public.

The RAP process encompasses a number of Stages. Stage I was recently completed by the Niagara River (Ontario) RAP team and PAC, culminating in a report identifying six major problem areas, specific environmental concerns within these areas, and potential sources of the problems and concerns (see Table 1.2). The six major problem areas identified in Table 1.2 are:

- water quality problems;
- aquatic biota and wildlife problems;
- sediment contamination problems;
- impaired industrial, municipal and agricultural uses;

TABLE 1.1: CHEMICALS OF CONCERN IN THE NIAGARA RIVER

Persistent Toxic Chemical	On List for 50% Reduction
Arsenic	
Benz(a)anthracene	X
Benzo(a)pyrene	X
Benzo(b)fluoranthene	X
Benzo(k)fluoranthene	X
Chlordane	
Chrysene	
DDT and Metabolites	
Dieldrin	
Dioxin (2,3,7,8-TCDD)	X
Hexachlorobenzene	X
Lead	
Mercury	X
Mirex	X
Octachlorostyrene	
PCBs (total)	X
Tetrachloroethylene	X
Toxaphene	

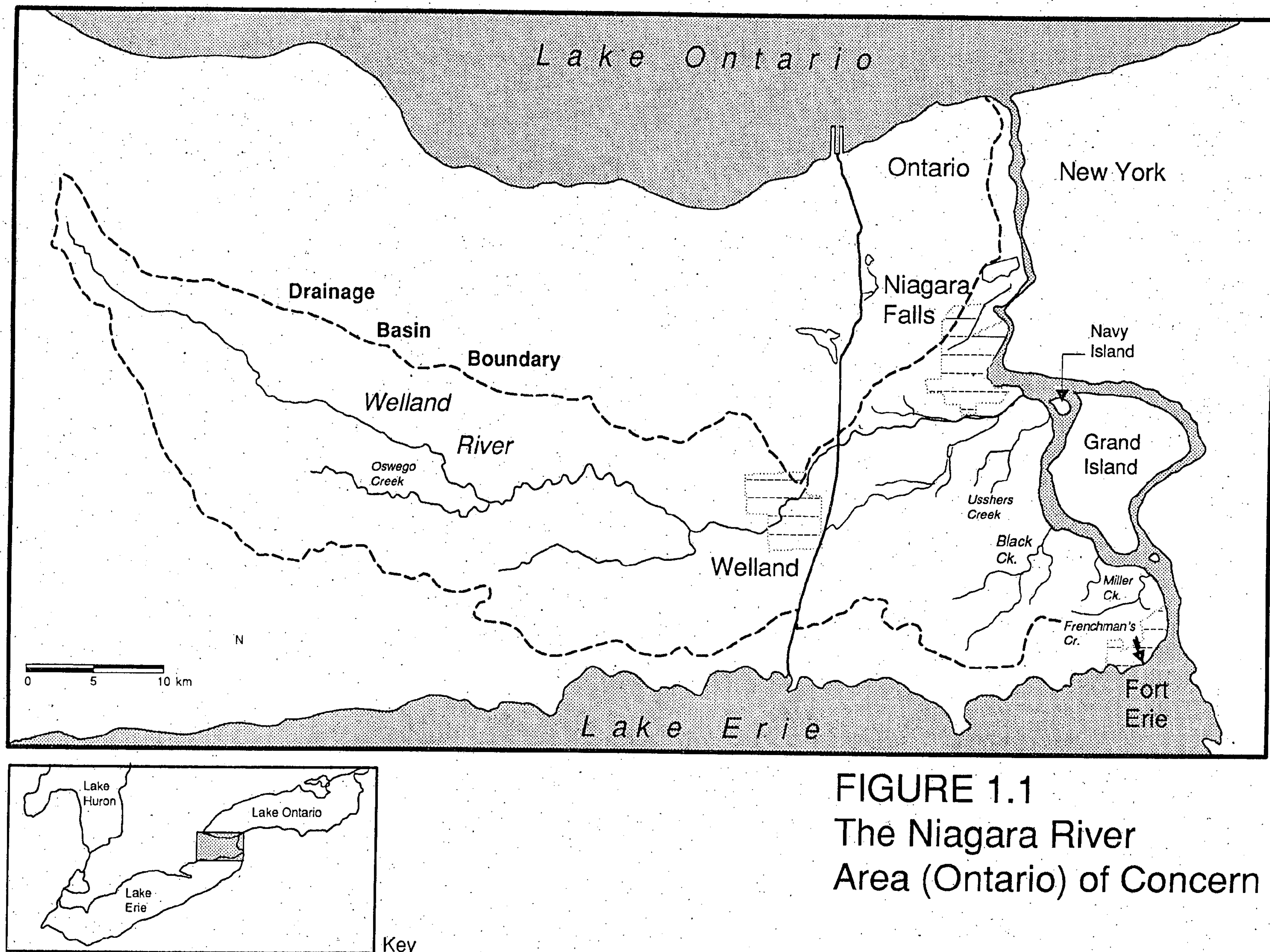


FIGURE 1.1
The Niagara River
Area (Ontario) of Concern

TABLE 1.2: ENVIRONMENTAL PROBLEMS IN THE NIAGARA RIVER (ONTARIO) AREA OF CONCERN AND THEIR POTENTIAL SOURCES

Problem	Concern	Potential Sources															Comments
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
Water Quality	• Water Quality Impairment	x	x	x	x	x	x	x	x						x	x	• Water quality criteria exceeded for heavy metals and various organic compounds
	• Drinking Water Consumption	x	x	x	x	x	x	x	x		x			x		x	• Concern is presence of toxic contamination
	• Clean Air (Niagara Mist)	x	x	x	x		x			x						x	• Extensive water treatment required • Niagara River shore wells impacted
Impairment of Use by Aquatic Biota and Wildlife	• Aquatic Life	x	x	x	x	x	x	x	x		x	x		x		x	• Concern is persistent toxic contamination
	• Birds and Mammals	x	x	x	x	x	x	x	x		x	x	x			x	• Contaminated sediment has impaired aquatic and terrestrial food chains
	• Sediment Quality	x	x	x	x	x	x	x	x			x			x	x	• Loss and impairment of habitat
Sediment Quality	• Sediment Contamination	x	x	x	x	x		x	x	x	x				x	x	• Includes heavy metals and toxic organic contaminants
	• Downstream transport of suspended sediments					x		x	x		x	x			x	x	• Includes heavy metals and toxic organics; due to adsorption of contaminants to particulates
Impaired Uses, Industrial, Municipal, Agricultural	• Power Generation		x			x								x		x	• Impacted by biological contamination (zebra mussels)
	• Irrigation - Agricultural Use	x	x	x	x	x	x	x	x							x	• Concern is presence of toxic contamination
	• Industrial and Municipal Use	x	x	x		x			x					x			• Impacted by contaminated sediments/siltation
Impaired Recreational Values	• Aesthetics	x	x	x	x	x	x		x		x					x	• Visual impairment
	• Boating and Water Sports	x	x	x	x	x	x	x	x							x	• Poorly planned and administered development • Fluctuating water levels restrict access • Impaired water quality impacts recreational uses
Fishing and Consumption of Fish		x	x	x	x	x	x	x	x							x	• Impacted by toxic contaminants • Fish consumption advisories for a number of sport fish

Sources

A - Municipal Discharges
B - Industrial Discharges
C - Combined Sewer Overflows
D - Stormwater Runoff
E - Agricultural Runoff
F - Landfills
G - Contaminated Sediments (in-place)
H - Industrial/Agricultural Spills
I - Air Pollution
J - Urban Development
K - Construction Activities
L - Recreational Activity
M - Zebra Mussels
N - Upstream Sources
O - US Sources

- impaired recreational use; and
- impaired fisheries resources.

The next stage in the RAP process, Stage II, is to develop remedial options for addressing the concerns within each of the above problem areas, by potential source. Beak Consultants Limited (BEAK) has previously contributed to Stage II by releasing a report (BEAK, 1991) identifying and describing a number of options for remediating each type of problem or concern, including scientific, communications, regulatory, political, societal and other "common sense" options. No attempt was made to rate these options in terms of their potential feasibility or effectiveness in remediating specific environmental problems.

This report complements BEAK's previous study by undertaking a screening level feasibility assessment of each of the options. Section 3 of this report describes the results of this screening and evaluation process, and has been structured to address remediation options applicable to the following categories of sources:

- Public Pollution Prevention Measures (Section 3.1);
- Urban Areas (Section 3.2);
- Municipal Sewage Treatment Plants (Section 3.3);
- Industrial Discharges (Section 3.4);
- Rural Areas (Section 3.5);
- Landfills (Section 3.6);
- Contaminated Sediments (Section 3.7);
- Physical Habitat Description (Section 3.8); and
- U.S. and Upstream Sources (Section 3.9).

No specific remedial options are assigned to sources outside the Niagara River (Ontario) AOC, such as those upstream on the New York state side of the Niagara River, since the evaluation and recommendation of these options is within the mandate of the Niagara River (New York) RAP team. However, suggestions concerning potential forms of interaction between the state of New York and the province of Ontario have been made to facilitate communication between the two countries and ensure compatible and complementary courses of action.

2.0 STUDY APPROACH

This Phase II report reviews the problem sources; screens the potential remedial alternatives in terms of potential level of improvement, feasibility, acceptability, cost and potential for conflict; and develops a short list of preferred alternatives for each problem source considered. These alternatives are then developed further in a descriptive sense and, where possible, are presented in terms of the potential degree of improvement that may be expected. For these problem sources where remedial measures are already in place or are planned, descriptions of the measures are given. In cases where the problems are rather widespread and non-point source in nature, such as those under the rural and physical habitat disruption categories, the remedial options identified are accordingly presented in a non site-specific framework. Regulatory aspects, for the most part, are not presented as remedial options per se, but rather are presented later in the context of implementation of the options.

Where possible, approximate costs associated with remedial activities are presented to facilitate cost-benefit comparisons and to aid in planning. The reader is cautioned, however, that these costs are based on information for similar undertakings elsewhere or are simply based on our best judgement, and should not be used for detailed budgeting purposes. In other cases, information on unit costs only is given, as it was impossible to develop a total cost estimate because the nature and extent of the problem sources are not well-defined. For some remedial options, particularly for those that are planned or are in the an implementation stage in industry, the associated costs are confidential. For those problem sources that are in the public domain, however, costing information is highly relevant.

Once the remedial alternatives have been screened and preferred alternatives identified for problem sources, the report attempts to compare the relative magnitude of different source categories in order to provide a focus on sources where remediation is first warranted. This is of particular relevance for different sources of contaminant loadings, where the priority for remediation should be directed towards the largest sources.

The final section of the report provides a general summary and discusses considerations that may be important in implementing some of the key remedial alternatives. Factors discussed here include the use and development of regulatory controls, financial assistance and effective public involvement.

3.0 SCREENING AND EVALUATION OF OPTIONS

3.1 Public's Pollution Prevention Initiatives

3.1.1 Identification of Sources

Various waste generation and handling practices within individual households in the Niagara Region contribute to environmental problems in the Welland River and Niagara River. However, as with rural areas (Section 3.5), the problem sources are non-point in nature and the environmental effects are cumulative. It is difficult to judge the relative significance of specific pollution sources and quantify the effects of particular pollution prevention initiatives. Nonetheless, there is little doubt that collective adoption of pollution prevention initiatives by members of the public will contribute to the achievement of the Niagara River RAP's objectives. The approach used in this Section is to identify pollution prevention initiatives that are appropriate for use by the public in addressing household wastes as a broad category, and to screen and evaluate these initiatives in a general sense. Initiatives open to the public to encourage good environmental practice by other members of the public and other actors, such as industry, are also considered.

There are a number of pollution prevention initiatives that can be undertaken by the public to protect and enhance the Niagara River AOC. These initiatives fall into three main categories:

- actions that individuals can undertake to reduce the generation of household wastes;
- actions that individuals can undertake to reduce the use and potential disturbance of significant public resources and sensitive areas; and
- participation of individuals on committees and working groups to advise other actors concerning pollution prevention measures and coordinate various initiatives.

Table 3.1 provides a screening and rating of pollution prevention initiatives within each of these main categories, and the following subsections further describe and evaluate each of the initiatives. Screening is based on a qualitative and subjective analysis, since the evaluation and recommendation of particular initiatives would require reference to a specific case, such as the waste generation and management practices in place at a given household.

3.1.2 Screening of Pollution Prevention Initiatives

Table 3.1 provides a summary comparison and evaluation of each of the pollution prevention initiatives open to the public. Initiatives given an 'A' rating are recommended for implementation and those given a 'B' rating are recommended for further consideration on a case-by-case basis.

TABLE 3.1: COMPARISON AND EVALUATION OF PUBLIC POLLUTION PREVENTION MEASURES

Control Option	Level of Improvement	Technical Feasibility	Government Acceptance	Public Acceptance	Cost[1]	Conflict Potential	Operation & Maintenance	Policy Considerations	Overall Rating[2]	Additional Comments
I. Household Measures										
1. Conserve Water	⊖	⊖	⊖	⊖	$$	x	⊖	⊖	A	aggressive action would require metering, monitoring and rate increases
2. Reduce Use of Toxic/ Hazardous Chemicals	⊖	●	●	●	$$		○	○	A	public education important, consistent with primary goals of RAP and GLQA
3. Precycle	○	●	●	●	$$		○	○	A	public education important, indirect benefit to water quality
4. Toxic/Hazardous Chemicals Use and Disposal	⊖	●	●	●	$$		⊖	○	A	public education and municipal, direct water quality benefits
5. Non-Toxic Waste Disposal	○	●	⊖	●	$$		⊖	○	A	particularly beneficial in shoreline areas, public education and government support often important
6. Reuse	○	●	●	●	$$		○	○	A	public education important, indirect benefit to water quality
7. Composting	○	⊖	⊖	⊖	$$		○	○	B	public education important, legislation may be forthcoming, technical investigations ongoing
8. Septic Tank System Maintenance	○	●	●	●	$$		○	○	A	low-volume toilets may represent a more cost-effective solution
9. Control Pets	○	●	●	●	$$		○	○	A	government support and monitoring would be helpful
10. Reduce Atmospheric Emissions	○	●	●	●	$$		○	○	B	indirect impact on water quality through good environmental practice generally
II. Use of Sensitive/ Significant Public Resources	⊖	●	⊖	⊖	$$/ $$$	x	⊖	⊖	B	• government regulation, monitoring required to ensure optimal use of sensitive resources • additional government control may result in poor public perception

TABLE 3.1: COMPARISON AND EVALUATION OF PUBLIC POLLUTION PREVENTION MEASURES

Control Option	Level of Improvement	Technical Feasibility	Government Acceptance	Public Acceptance	Cost[1]	Conflict Potential	Operation & Maintenance	Policy Considerations	Overall Rating[2]	Additional Comments
III. Public Involvement										
1. Lobby Government Officials	●	●	⊖	⊖	$$	x	⊖	⊖	A	government support important for success of many other options
2. Participate on Advisory Committees, Working Groups	⊖	●	●	●	$$	x	○	○	A	industry and government support important
3. Public Education	⊖	●	●	●	$$		○	○	A	initiate on an ongoing basis, important for success of other options
4. Agreements between Communities & Industry	⊖	●	●	●	$$	x	⊖	○	A	legal and government support required for developing agreements and monitoring compliance
5. Reforestation, Tree Planting, Revegetation	○	●	●	●	$$		○	○	B	beneficial only on a very large scale

[1] Cost Categories: $ - relatively low cost (<$100,000); $$ - moderate cost ($100,000 to $1,000,000); $$$ - relatively high cost (>$1,000,000).

[2] Rating: A - Recommended for implementation; B - Recommended for consideration on a case-by-case basis.

Rankings:

- ● high or good ranking
- ⊖ fair or modest ranking
- ○ poor or low ranking

In addition to these initiatives, it should be emphasized that one of the ultimate goals of the RAP is the virtual elimination of toxic contaminants. To this end, the public must both encourage toxics elimination and practise toxics elimination in the household and at the work place.

Most of the pollution prevention initiatives open to the public were assigned an 'A' rating. The potential improvement to the environment resulting from each of these initiatives is typically 'low' or 'modest', primarily reflecting the extent to which the initiative **directly** contributes to Niagara River RAP water quality objectives (versus good environmental practice more generally). Examples of initiatives that are more likely to directly impact the Niagara River RAP objectives include conserving water, and properly using and disposing of products containing toxic chemicals. Examples of initiatives that are less likely to directly impact water quality include energy conservation, home insulation, car pooling, and reduced use of automobiles.

Despite most public initiatives resulting in a low or modest potential improvement to the environment, there is little doubt that measurable improvements will be seen if the initiatives are collectively adopted by the public. Also, most of the initiatives complement one another and are more likely to have a noticeable impact if they are adopted as a set of compatible activities. Most initiatives are low cost, low maintenance, technically feasible and unlikely to result in conflict. They do not differ significantly from one another in terms of efficacy, and the effects of most initiatives are non-quantifiable. However, once the public has developed an environmentally conscious philosophy, or 'mindset', they are likely to look for many different ways to achieve their environmental objectives and adopt actions that are consistent with the overall philosophy. Therefore, they are likely to adopt daily routines and practices that encompass many of the initiatives, rather than only one or two.

Three of the initiatives in Table 3.1 were assigned a 'B' rating: composting, controlling public use of sensitive resources, and reforestation and tree-planting. This rating reflects a number of factors, including: the relative lower efficacy of the initiative in achieving the Niagara River RAP objectives, the need for additional education and instruction, and the need for supporting government regulation and the resulting implications on public perception. For example, while composting can reduce the municipal waste stream by up to 15 or 20 percent, it requires additional effort and education relative to many of the other initiatives. Also, there are uncertainties concerning the technology and the disposition of the resulting humus-like material, and composting may be subject to government regulation in future. Controlling public use of sensitive resources is another initiative that will require government regulation and monitoring to enforce the controls. Reforestation, tree-planting and revegetation are only likely to have a significant impact if many people participate in the activities. Also, these types of practices may be better left with regional or municipal governments to ensure that priority areas are addressed first (e.g., drainage ditches, erosion prone areas) and regular follow-up and maintenance practices are adopted. Also, if these initiatives are not targeted at specific areas where erosion and runoff are particularly acute, they are more likely to contribute to global environmental objectives, rather than those specific to the Niagara River RAP.

3.1.3 Evaluation of Pollution Prevention Initiatives

3.1.3.1 Household Pollution Prevention Initiatives

Conserve Water

Reduced water use would result in a lower volume of waste water entering treatment plants and septic disposal systems, thereby reducing the strain on these facilities. Methods of conserving water include:

- reducing outdoor water use for washing driveways, cars and watering lawns. An alternative source of water for outdoor use is from the eavestrough: disconnect the eavestrough downspout and drain it to the lawn or driveway. There are also modern approaches to landscaping such as 'xeriscaping', which emphasize water conservation principles such as drip irrigation, heavy mulching of planting beds and organic soil improvements for better water absorption and retention;
- reducing indoor water use by introducing measures such as:
- waiting until there is a full load of laundry before using the washing machine;
- substituting a basin of water for a running tap when brushing teeth, shaving and washing dishes;
- reducing the amount of water used in flushing toilets by installing displacement devices (bags, bottles, dams) in toilet tanks or purchasing low-volume, 'ultra-low flush' toilets (see Section 3.5.3.8); and
- using water-conserving fixtures in new homes and retrofitting such devices in older homes. An example of such a device is a 'low-flow' aerator for kitchen and bathroom faucets and shower heads;
- extending water metering programs to all homes within a community; and
- promoting the establishment of water rates that more closely reflect the true costs of water.

Water conservation measures are likely to result in modest environmental improvements, with more aggressive action such as metering and increasing water rates potentially resulting in dramatic reductions in water use.

Reduce Use of Toxic/Hazardous Chemicals

In the Great Lakes Water Quality Agreement, the U.S. and Canadian governments agreed that the only long-term answer to the problem of poisoning the Great Lakes by toxic chemicals is **Zero Discharge** - the virtual elimination of all inputs of persistent toxic chemicals. Persistent toxic chemicals are contained in such common household products as: household cleaners, pool chemicals, paint, solvents, pesticides and herbicides, fertilizers, wood preservatives, metal and furniture polishes, some medications, chemicals in pet collars and insect sprays/powders, photographic chemicals, antifreeze, batteries and used motor oil.

The key actions that the public can take regarding these and other products containing toxic chemicals are:

- use less of the products;
- use reusable products (e.g., rechargeable batteries); and
- use substitute products that contain fewer or no toxic chemicals. The following table provides a list of alternatives to certain common household products.

The public can also be guided in the purchase of toxic-free or 'environmentally friendly' products by looking for authorized labels, such as the **'Ecologo'** label authorized by the Canadian federal government.

Reducing the use of products containing toxic chemicals is consistent with the guiding philosophy of the Great Lakes Water Quality Agreement and the primary goals of RAPs - preventing contamination and recontamination by virtually eliminating the use of toxic substances. This initiative is highly recommended for this reason, and would benefit considerably if backed up by a continuous public education campaign.

Precycle to Reduce the Amount of Waste Generated

Recycling is based on the concept of properly disposing of products **after** they have been purchased to minimize the waste generated. Precycling is based on the concept of reducing the waste **before** you buy products by considering the product's production process, usage, disposal and packaging. Examples of precycling include:

- purchasing products that are packaged using recycled material (e.g., eggs in recycled cardboard rather than styrofoam, beverages in glass or aluminum containers);
- purchasing products in bulk to reduce the amount of packaging; and
- purchasing vegetables loose rather than in plastic bags.

Precycling is a good environmental practice generally, though its contribution to improving water quality and achieving the Niagara River RAP objectives is indirect relative to some of the other initiatives.

Use and Dispose of Toxic Wastes Properly

To the extent that toxic chemicals are used in the home, they should be used and disposed of properly. For example, the following actions should be taken:

- products containing toxic chemicals should be used according to the instructions on the product's label;
- toxic chemicals should not be poured down sinks or drains. They will end up in sanitary sewers and sewage treatment plants, thereby contaminating sewage sludge and potentially being discharged into lakes and streams.

ALTERNATIVE PRODUCTS LIST

(Source: Canadian Institute for Environmental Law and Policy, 1991)

The following alternatives to common household products are cheaper and safer for you, your family, your pets and the environment.

Product	Hazardous Ingredients	Alternatives
Silver polishes	acidified thiourea	Soak in 1 quart of warm water with 1 tsp of baking soda and a small piece of aluminum.
Oven cleaners	potassium or sodium hydroxide, ammonia	Use baking soda and water for scouring.
Toilet cleaners	muriatic (hydrochloric) or oxalic acid, paradichlorobenzene	Scrub with toilet brush and baking soda or mild detergent.
Disinfectants	diethylene or methylene glycol; phenols	Use 1/2 cup borax in 1 gallon water.
Drain cleaners	sodium or potassium acid, petroleum distillates	Use plunger, flusher with boiling water, 1/4 cup baking soda and 2 oz vinegar.
Rug and upholstery cleaners	naphthalene, perchloroethylene, oxalic acid	Sprinkle dry cornstarch on the rug and vacuum.
Floor and furniture polish	diethylene glycol, petroleum distallates, nitrobenzene	Use 1 part lemon juice, 2 parts olive oil or vegetable oil.
Mothballs	naphthalene, paradichlorobenzene	Use lavender flowers.
Ammonia-based cleaners	ammonia ethanol	Use vinegar, salt and water or baking soda and water.
Abrasive cleaners or powders	trisodium phosphate, ammonia ethanol	Rub the area with 1/2 lemon dipped in borax. Rinse and dry.
Paint thinner, turpentine	n-butyl alcohol, acetone, methylisobutyl ketone, petroleum distillates	Use water with water-based paints.
Furniture strippers	acetone, methyl ethyl ketone alcohols, xylene, toluene, methylene chloride	Use sandpaper or a heat gun.
Wood preservatives	chlorinated phenols, copper or zinc naphthenate creosote	Use naturally rot-resistant wood.

Product	Hazardous Ingredients	Alternatives
Pesticides		
Fungicides	captan, folpet, anilazine, zinc. copper compounds	Do not overwater. Keep areas clean and dry.
House plant insecticide	methoprene malathion tetramethrin carbaryl	Spray a mixture of bar soap and water or dishwater on the leaves and rinse.
Flea collars and sprays	carbamate pyrethrins organophosphates	Use herbal collars or ointment citronella and put brewers yeast in pet's food.
Roach and ant killer	organophosphates, carbamate, pyrethrins	Roaches: use traps or a baking soda and powdered sugar mix. Ants: sprinkle chili powder to hinder entry.
Rat and mouse poisons	brodifacoum coumarins strychnine	Use live traps. Remove food supply.
Herbicides	2,4-D glyphosate prometon	Pull weeds by hand.

They may also end up in a septic tank; if the tank's capacity constraints for holding liquid waste are exceeded, chemicals can leach through the soil and into the groundwater;

- toxic chemicals should not be poured into storm sewers. They will end up in lakes, rivers and streams, and they may end up in the drinking water;
- toxic chemicals should not be put in the trash. They will end up in a landfill, which may leak and potentially leach toxic chemicals into groundwater and surface water systems. They may also end up in an incinerator, which is known to be a source of dioxins in addition to numerous metals including zinc, cadmium, nickel, chromium and copper; and
- toxic chemicals should be recycled by taking them to a municipal/regional reclamation centre or transfer station. Most municipalities offer household hazardous waste collection programs. Consideration should be given to increasing the frequency of collection days, though this will require support from municipal and regional governments.

The proper use and disposal of products containing toxic chemicals offers direct benefits in terms of improvements to the water quality of the Niagara River.

Dispose of Non-Toxic Wastes Properly

There are a number of products that are not toxic, but nonetheless contribute to the accumulation of waste in landfills or represent unnecessary environmental hazards. Methods that the public can undertake to reduce the environmental impact of disposing of ordinary household wastes include:

- recycling materials such as newspapers, glass bottles and jars and aluminum cans. It may also be possible to recycle other materials such as telephone books, corrugated cardboard, tin cans, plastic soda bottles and milk cartons;
- disposing of six-pack rings in the trash, after snipping the rings. Six-pack rings should not be disposed of in storm sewers or left lying on beaches or shorelines; and
- placing waste in waste containers rather than littering along sidewalks, roadways or in ditches. Waste that is not properly disposed of often ends up in storm drains and eventually in the lakes, rivers and streams.

While the proper disposal of non-toxic wastes is good environmental practice generally, it is unlikely to offer direct water quality benefits relative to some of the other initiatives.

Reuse Non-Biodegradable Products

In addition to properly disposing of waste products, other measures can be taken to minimize the amount of certain materials accumulating in landfills or ending up in lakes, rivers and streams. For example, efforts directed at reducing the accumulation of waste in landfills can focus on encouraging the use of reusable products or biodegradable products, rather than disposables or non-biodegradable products. Examples of measures that can be taken in the home include:

- reusing glass, plastic and metal containers rather than disposing of them in the trash. Examples include reusing plastic shopping bags or reusing glass containers to store left over food items;
- using reusable containers or biodegradable products (e.g., wax paper, freezer bags) to wrap food instead of aluminum foil, plastic wrap or plastic bags; and
- using cloth rather than disposable diapers.

As with a number of other initiatives, there is an indirect linkage of 'reuse' philosophies with water quality improvements. Nonetheless, reuse initiatives represent good environmental practice.

Compost Household Organic Wastes

Again, in the interests of minimizing the amount of certain materials accumulating in landfills or ending up in lakes, rivers and streams, the public should consider composting organic household wastes. Options include making use of community composting programs, commercial composters or establishing a home composting system. Household materials that are good candidates for composting include: grass clippings, leaves, food waste, paper and wood. In addition to reducing the congestion of organic materials in landfills and elsewhere, the resulting humus-like substance is a source of natural, rich fertilizer.

Relative to other pollution prevention initiatives open to the public, composting requires more public education, effort and care. The technology is also under investigation and there is the possibility that composting may become regulated in the future. Essentially, the technique is most appropriate for the 'converted', or those members of the public that are willing to thoroughly investigate the technology and ensure its proper and safe use.

Check and Maintain Septic Tank Systems

Malfunctioning septic tank and tile disposal systems contribute to surface and groundwater pollution. Therefore, the public should inspect and clean out septic systems regularly and ensure that tile fields are replaced as required to minimize contamination from this source.

As discussed in Section 3.5.3.8, septic systems are a particular problem in rural areas of the Welland River watershed, due to physical limitations of the heavy clay soil which limits infiltration rates from tile fields and results in more surface runoff. In these cases, replacing or expanding tile fields may not address the problem, and a more appropriate and cost-effective solution might be the purchase of low-volume toilets.

Control Pets

Pet feces are a major source of bacterial contamination in urban waterways. Therefore, the public should adopt the 'Stoop and Scoop' practice. While many municipalities already have by-laws in place requiring that this practice be adhered to, the problem still exists suggesting the need for increased government support and enforcement effort.

Reduce Atmospheric Emissions

While atmospheric emissions are not believed to directly or significantly impact the water quality of the Niagara River AOC, there are measures that the public can undertake that represent good environmental practice generally, and if collectively adopted, may result in measurable improvements to water quality. These measures include:

- adopting energy conservation measures within the home. Adequate home insulation, and marginal reductions in water heater and household temperatures are some of the more common energy conservation measures; and
- reducing automobile emissions by increasing the use of car pools and public transit, or by using other means of travel for shorter distances (e.g., walking, bicycling). Another possibility is to convert automobiles to natural gas, though this can lead to costly capital and operating expenses.

3.1.3.2 Public's Use of Significant, Sensitive Resources

The public's use of the Niagara River and its associated shoreline is critical to the preservation and conservation of the Niagara River Area of Concern. In particular, the following two issues appear to be important:

- control of the public's access to the walking trails and surrounding areas running along the Niagara Gorge. The Gorge is particularly sensitive and susceptible to disruption due to congestion and disregard/misuse of the natural resources; and
- boating and water skiing in shallow waters, such as the Welland River or Chippawa Creek. Excessive boating in these waters is disruptive, causing turbidity and soil erosion.

It is important to realize that both of the above issues are likely to require government support and enforcement because of the inherent difficulties in motivating individuals to use public resources in a manner beneficial to all of society.

3.1.3.3 Become Involved in Programs to Protect, Enhance and Restore Resource Areas

Lobby Government Officials for Support of Environmental Issues

A number of Niagara River PAC members stressed the importance of government support in a number of areas, particularly financial, regulatory and monitoring/enforcement (personal communication).
Funding and government support are often key to ensuring public involvement and the efficacy of that involvement. Funding is important to encourage the public to participate in working groups and sit on committees, and is also required to support other initiatives such as public education and information programs. Government support in the form of regulation and monitoring is also a prerequisite for ensuring that other actors, such as industry, satisfy the public's demands and comply with standards and legislation enacted to protect the public's interest.

The public should lobby all levels of government, but particularly the federal and provincial governments because these levels effectively determine municipal government funding amounts and environmental regulation. Lobbying efforts include direct contacts (telephone calls, meetings) with government officials as well as writing letters to Members of Parliament and Ministers of the Environment, Natural Resources, Energy etc.

Participate on Advisory Committees and Working Groups

The public can also become involved by participating in environmental advisory committees, working groups and environmental interest groups. One example is the continued involvement of public representatives on the Niagara River Public Advisory Committee to oversee implementation of the Niagara River RAP. Another example is to elect public representatives (having specific environmental interests and expertise) to industry Boards of Directors or corporate Environmental Advisory Committees to advise management concerning environmental matters of relevance to the company and surrounding community.

Promote Public Education and Information Programs

A prerequisite to effective, widespread public participation and involvement is a public that has been educated in environmental issues, problems and potential solutions. In most communities there remains a silent majority, many of which remain silent because they do not understand the significance of the environmental issues facing their community or do not see how these issues relate to the welfare of their families. Therefore, it is important that public education and information programs continue to expand to address the information needs of the public and stimulate their interest in environmental issues. Once they have gained an understanding and developed a concern about the environment, they will be more willing to become involved in developing pollution prevention policies, stimulating the development and use of non-toxic products and lobbying for stronger pollution controls and institutional support for safe disposal practices and programs (e.g., community hazardous waste collection days).

Perhaps more important than adult education campaigns are education efforts targeted at children. While it remains difficult to change the long-established habits and values of adults, children are more receptive to change and their values and actions are typically not deeply rooted or irreversible. Children also have a particular interest and fondness for nature and the environment. Therefore, educational efforts within the primary school system should be emphasized to establish preservation and conservation values in children that will guide them throughout their adult lives.

Develop Agreements Between Communities and Industry

A formal method that communities can undertake to secure the cooperation of other actors, such as industry, is to enter into formal agreements with them. Examples of such agreements include the 'Good Neighbour' agreements established between a number of communities and industries in the states of New Jersey and Massachusetts. Good Neighbour Agreements can be negotiated around a number of issues and often include provisions to:

- study and reduce toxic chemical use and waste generation;
- establish a comprehensive accident prevention program;
- provide funds for residents to hire their own technical experts to review a firm's activities;
- permit residents the right to periodically review a firm's activities; and
- grant residents the right to participate in corporate health and safety committees.

Agreements can cover many different issues, but their primary purpose is to outline the environmental objectives important to the surrounding community and the specific actions that industry will undertake to ensure that those objectives are satisfied.

With limited staff and resources, and many polluting facilities within their jurisdictions, it is almost impossible for government environmental agencies to deal effectively with all the toxic pollution entering the ecosystems they are charged with protecting. Agreements such as the good neighbour agreements, along with an active citizenry, can complement government environmental protection efforts. The vested self-interest that communities have in both jobs and the environment increases the likelihood that mutually satisfactory agreements can be reached between industry and local communities.

Participate in Reforestation and Tree-Planting Programs

Reforestation, tree-planting and revegetation programs are important in addressing the environmental problems specific to the Niagara River as well as more global atmospheric and energy related concerns. For example, planting trees along the Niagara River will assist in stabilizing streambanks, slowing runoff and minimizing erosion. If this activity is undertaken collectively by many communities and jurisdictions, it also produces global benefits in terms of reducing CO_2 emissions and reducing energy consumption.

Funding to assist with reforestation and revegetation efforts is available from OMNR's Community Fisheries Involvement Program and Community Wildlife Involvement Program. These programs provide money and technical expertise to community groups wishing to remediate problems and rehabilitate habitat. It is also important to note that the reforesting of private lands over 5 acres is eligible for reforestation agreements under the Woodlands Improvement Act.

To ensure success with reforestation and revegetation efforts, it is important that qualified professionals be consulted for planning, designing, preparing sites, planting and maintaining sites. The need for professional assistance suggests that funding assistance is a prerequisite to the adoption of these measures on a large scale. It also suggests the need for municipal, regional and provincial government involvement and direction. Perhaps it is more appropriate for reforestation and revegetation efforts to be initiated by governments and environmental agencies, who would then be responsible for securing voluntary assistance from the public and funding public involvement.

Section 3.8 contains a more comprehensive discussion and comparison of revegetation efforts, including buffer strips, riparian plantings, and streambank stabilization techniques. Section 3.8 also contains a more detailed analysis of the associated cost of each of these measures.

3.2 Urban Areas

3.2.1 Introduction

The Region of Niagara includes four municipalities which ultimately discharge to the Niagara River. These are:

- Fort Erie,
- Welland,
- Niagara Falls, and
- Niagara-on-the-Lake.

Contamination from urban areas is widespread and includes nutrients and pesticides which are spread on lawns, leaching of heavy metals from automobiles and vehicular traffic, sediment from construction sites, petroleum and chemical spills in industrial areas and bacterial contamination from fecal droppings of birds and dogs.

For the purposes of this document, the various sources of contamination from urban areas have been grouped as follows:

- overflows, and
- urban stormwater discharges.

Overflows include sanitary and combined sewage overflows within the system, as well as pumping station overflows.

Urban stormwater discharges include flows not only during wet weather, but also during dry weather owing to sanitary overflows, interconnections and infiltration inflows. Municipal water pollution control plant and industrial sources within an urban setting are dealt with elsewhere in this document.

3.2.2 Background

All four municipalities and the Region of Niagara are aware of the potential impact of overflows within their respective systems, and have capital works programs to reduce the impact. The works have generally taken the form of structural works (e.g., sewer separation) or non-structural works (e.g., TV inspection, smoke and dye testing).

In addition to the capital works programs, all municipalities are currently carrying out or have completed studies to better define the carrying capacity of the system, types and sources of problems, potential solutions and, in some cases, estimated costs of proposed works.

The two types of studies are:

- Infrastructure Needs Studies (INS), and
- Pollution Control Plans (PCPs).

Infrastructure Needs Studies, in general, look at the condition of the infrastructure and define ways to rehabilitate or improve the system. This may include works such as grouting or relining a sewer, or methods to reduce extraneous infiltration/inflow, or capacity upgrade.

Pollution Control Plans generally involve defining the water quality problem and environmental issues, such as pollutant loadings and pollutant sources from municipal, industrial, agricultural or rural tributaries. In general, the PCPs carried out within the Region of Niagara have lacked the detail required to calculate storage volumes, overflow frequency, etc. to abate the problem. Additional works within the INS is usually required in order to quantify the flows in the system, and to allow for the design and implementation of the proposed works.

Outlined below is a summary of the types of studies in which each municipality has participated:

- Niagara Falls - INS (Chippewa only)
- Welland - PCP (in progress)
- Niagara-on-the-Lake - INS
- Fort Erie - INS and PCP

In summary, a majority of the capital works programs and associated studies have focussed on:

- upgrading the structural integrity of the existing sewer system;
- reducing extraneous sources of infiltration/inflow; and
- reducing combined and sanitary overflows and the associated environmental impacts.

The programs have included both pollution control works and source control measures on both private and public property. The existing programs have generally not considered the potential impact of storm sewer effluents and, as such, measures have not been recommended for reducing the impacts associated with the effluents. The approach, as outlined below, will attempt to address the impact of all urban sources of pollution.

3.2.3 Resource Management Strategy

Past practices for many municipalities have focused on preventing or reducing problems associated with flooding and erosion. As a result of these narrowly focused practices the diversity and quality of the environmental resources (e.g., wetlands, fishery or groundwater quality) have been significantly reduced in many parts of southern Ontario.

More recently, the focus has been shifted toward providing an integrated approach to resource management. This approach, commonly referred to as the "ecosystem approach" includes the consideration of the biological, physical and chemical environment in which the given communities live.

In developing resource management strategies to maintain or improve the environment, it is important to remember that an ecosystem approach (Crombie, 1991) mandates that:

- everything is connected to everything else;
- human beings are part of nature and not separate from it;
- human beings are responsible for their actions and associated impacts; and
- economic health and environmental health are mutually exclusive.

In general terms, there are four general approaches to remediation of urban environmental problems in the Niagara River system. These include:

- pollution prevention,
- pollution control,
- regulatory control, and
- land use policy/planning.

3.2.3.1 Pollution Prevention

Pollution prevention is an umbrella term for a wide range of source pollution reduction activities. These may include:

- public education - e.g., educate urban consumers on household hazardous wastes and lawn management practices; educate farmers on land management
- source control - e.g., Sewer Use Bylaw Enforcement, spill prevention and management
- inspection - e.g., regulatory inspection of erosion/sediment control devices
- alternative substance/material usage - e.g. replacing or substituting non-hazardous for hazardous materials in processes

3.2.3.2 Pollution Control

Pollution control generally involves the implementation of technical solutions to reduce/minimize the impact of a given source. Prime examples include the construction of a Water Pollution Control Plant to treat sanitary sewage or the installation of a storage facility to reduce treatment plant bypasses or to store stormwater for later treatment, thereby reducing pollutant loading.

3.2.3.3 Regulatory Control

Regulatory control may be applied in one of many ways. For example, the Ministry of the Environment has various programs (e.g. Municipal Industrial Strategy for Abatement of Pollution (MISA)) which set standards for the discharge of pollutants from various municipal and industrial plants. Furthermore, regulatory control may be applied in conjunction with pollution control alternatives. This approach is used in the Region of Ottawa Carleton where proposed stormwater management facilities which discharge flows to the Rideau River must have effluent levels of fecal coliform less than 100 per 100 millilitres.

3.2.3.4 Land Use Policy/Planning

Develop an integrated land use - watershed planning strategy which duly respects the linkages between land uses, water and the environment and ensures that the environmental features are protected or enhanced. In cases where it cannot be clearly demonstrated that the desired goals/objectives can be met or exceeded policies which restrict specific land uses (e.g., landfills, aggregate extraction) may be enforced. Alternatively the level of future land use changes may be limited.

3.2.4 Source Control

Outlined below is an overview of several alternatives which could be applied within this study area. The measures are summarized in Table 3.2.

TABLE 3.2: COMPARISON AND RECOMMENDATION OF ALTERNATIVES

Pollution Prevention/ Source Control	Potential Level of Improvement	Technical Feasibility	Municipal/ Public Acceptance	Cost Effectiveness	Conflict Potential	Overall Rating	Comments
1. Public Education Programs	⊖	●	●	$	○	A	Initiate on an ongoing basis
2. Spill Prevention and Management	⊖	●	●	$	○	A	Tie in existing programs with Public Education
3. Street Sweeping and Catch Basin Cleaning	○	⊖	⊖	$$	⊖	-	Not cost-effective
4. Sewer Use By-Law Enforcement	⊖	●	●	$	○	A	Continue existing by-law enforcement program
5. Water Conservation	⊖	●	⊖	$	○	A	Help reduce overflows and improve treatment efficiency
6. Residential Programs	⊖	⊖	⊖	$	○	A	Should be carried out where feasible
7. Sediment Control Construction Sites	●	●	⊖	$	○	A	Sediment loads from construction sites may significantly impact the environment

● high or good ranking
⊖ fair or modest ranking
○ poor or low ranking

$ - relatively low cost
$$ - moderate cost

A - recommended for implementation

3.2.4.1 Public Education Programs

Public education or awareness programs involve preparation and dissemination of information regarding practices that can be undertaken to improve overall water quality. Information on specific practices can be passed on to the public through brochures, information booths/centres, advertisement in the local media, and special public information events. Typical issues addressed include:

- water conservation;
- pet litter control;
- general litter control;
- application of lawn and garden chemicals;
- spill prevention and management;
- management of hazardous household waste;
- solid waste management/disposal; and
- removal of roof drains, foundation drains, sump pumps from sewer connections.

Public education programs are relatively low cost, easy to implement, and keep the public actively involved in the commitment to improve water quality.

The primary benefit of public eduction programs is the creation of an awareness of water quality issues and enhancement initiatives. Additional long-term benefits include potential reduction of nutrient and chemical loadings associated with lawn care/gardens, and reduction in spill of contaminants (i.e., automotive fluids, paints, and solvents) to receiving waters via the storm sewer system. Further information pertaining to public education programs is provided in Section 3.1.

3.2.4.2 Spill Prevention and Management

Spill prevention and management provides both a means of attempting to minimize potential for spills and an efficient manner of addressing incidents when they occur. Currently, the Ministry of the Environment has in place a Spills Response Program. The Ministry of Environment under the Environmental Protection Act (Part IX) is the regulatory agency for enforcing duties on persons responsible for spills, recommending cleanup procedures, and evaluating the adequacy of cleanup and disposal efforts. This program addresses "shock" loadings of pollutants to receiving waters. The Ministry of the Environment is also involved in prevention through its Spills Reduction Strategy which is implemented with industry.

Measures to minimize the impact of accidental spills of contaminants that may enter storm sewers include provision of underground oil/grit separators at commercial and industrial developments, and buffer strips between storm sewer outfalls and receiving waters. Oil/grit separators are commercially available or can be modified reinforced precast concrete vaults. In addition, stormwater control ponds can be fitted with spills control devices. To be effective, they should be a functioning component of the storm sewer system and be located at the property line of development sites to allow for inspection and maintenance by municipal staff. Buffer strips between storm sewer outfalls and receiving waters provide a containment area for accidental spills.

3.2.4.3 Sewer Use By-Law Enforcement

The Regional Municipality of Niagara has had a Sewer Use By-Law in place since 1983 (Sewer Use By-Law No. 3308-83). Discussions with Regional staff suggest that the Ministry of the Environment Sewer Use By-Law will be adopted in 1993.

Sewer Use by-laws are municipal by-laws for regulating discharges to sanitary and storm sewers. These by-laws control the discharge of several pollutants which include bacteria, nutrients, solids, and heavy metals. A key factor is that sewer use by-laws govern the parameters of the discharge to and not from either sanitary or storm sewers. In general, violation of sewer use by-laws are primarily from industrial sources and impact dry weather conditions. In order for the program to be effective sampling during dry weather conditions is required.

The existing Sewer Use By-Law program has, through a recent monitoring program, identified 27 industries which discharge pollutants in excess of the current by-law.

3.2.4.4 Street Sweeping and Catchbasin Cleaning

Street sweeping and catchbasin cleaning are municipal practices undertaken to clean accumulated sediment and debris from streets and catchbasin sumps. Typical methods of street cleaning are manual clean-up, mechanical broom sweepers, vacuum sweepers, and street flushing. The assumed benefit of these practices is that contaminant accumulation is reduced thereby reducing pollutant loadings to receiving waters.

Results from the Toronto Area Watershed Management Strategy (TAWMS 1986) and U.S. National Urban Runoff Program (U.S. EPA 1983) suggested that options such as street sweeping and catchbasin cleaning are generally ineffective in both reducing bacterial loadings and improving overall quality of urban runoff. In typical municipal programs with sweeping or catch basin cleaning frequencies of once or twice per month, the removal efficiency for suspended solids is less than 5 percent. However, there may be special cases in which vacuum sweepers could be applied at specific locations and times of the year to provide an improvement in water quality. These cases would include areas which discharge to/or immediately upstream of beaches and/or areas with a significant buildup of sediment and debris, and periods following snowmelt or leaf accumulation in the fall.

3.2.4.5 Residential Programs

Results from the Infrastructure Needs Studies suggests that significant quantities of extraneous infiltration/inflow to the sanitary or combined sewer system originates from private property. The extraneous infiltration/inflow tends to overload the infrastructure during rainfall events, thereby resulting in overflows within the sewer system or at the Water Pollution Control Plant (WPCP).

Various programs to reduce infiltration/inflow may be carried out. These include:

- lot grading programs,
- roof downspout disconnection programs, and
- disconnection of the weeping tiles which presently discharge directly to sanitary or combined sewers.

Several of these programs have been considered by the municipalities. For example, the City of Niagara Falls will pay for the disconnection of the weeping tile from the sanitary sewer (a sump pump is installed). Fort Erie staff check the condition of the lateral during a house transaction (Town By-Law No. 90-87). If the connection is not found to be proper, then the existing owner must pay to have it corrected.

These programs are beneficial in that the reduction of infiltration/inflow to the sanitary or combined sewer system reduces the potential for overflows within the system during rainfall events. Furthermore, treatment costs are reduced at the WPCP.

3.2.4.6 Water Conservation

Water conservation programs are beneficial from the perspective that they reduce flows to the WPCP. This may permit the plant to operate more effectively during dry weather conditions, and should also reduce overflows within the system during rainfall conditions. Several bylaws are in place within the Region (e.g., Niagara Falls) which promote conservation practices (e.g., reducing industrial cooling water demands, tips for homeowners). Further information is provided in Section 3.1.

3.2.4.7 Sediment Control on Construction Sites

Sediment loadings to the receiving body of water impact the environment in many ways, including:

- degrading the aesthetic value of the watercourse;
- reducing the hydraulic capacity;
- increasing in-stream erosion (significant quantities of sediment are generated to transport incoming sediment);
- providing a sink for additional pollutants; and
- damaging aquatic habitat.

Various methods for limiting the impacts of sediment during construction exist (e.g., silt fences, rock check dams, etc.). However, many municipalities have had difficulty ensuring that the works are installed, and are maintained. Several municipalities have overcome this problem of enforcement by establishing by-laws (e.g., City of Mississauga, Towns of

Ancaster and Aurora). The by-laws outline limits as to the amount of land that may be stripped and the duration. Furthermore, considerable fines for exceeding the limits are enforced.

3.2.5 Pollution Control Measures

Outlined below are several alternatives for controlling the impact of urbanization. The alternatives are summarized in Table 3.3.

3.2.5.1 Sewer Separation

The separation of combined sewers is a practice that is commonly used throughout Canada. The potential benefits include reduction in overflows (both within the sewer system and at the WPCP) and a lower frequency in basement flooding.

The recent trend, however, has been to move away from sewer separation programs for the following reasons:

- cost,
- time required to complete the programs,
- effectiveness, and
- impact on water quality.

Recent studies carried out in Metropolitan Toronto, Sarnia, Windsor and Thunder Bay have shown that other alternatives are more cost-effective than sewer separation. Furthermore, remedial alternatives such as end of the line storage facilities can be constructed relatively quickly as compared to storm trunk sewers and the associated lateral sewers along local streets.

Lastly, the impact on water quality, due to separation programs, has been defined in recent studies (TAWMS, 1986; MOE, 1989). The results of these studies show that separation programs generally provide only a marginal reduction in pollutant loading. In some cases, the loadings of some water quality parameters actually increased.

All of the municipalities within the region are undertaking, or are considering, separation programs.

3.2.5.2 Storage and Treatment

Storage and treatment of combined or sanitary flows involves the construction of facilities within the sewer system or at the WPCP. Storage may be provided directly within the sewer system, i.e., by increasing the diameter of the sewer, or off-line, i.e., by constructing an underground tank. Storage facilities to control extraneous infiltration/inflow within the sanitary sewer system have been constructed in Niagara Falls, and are being considered elsewhere within the Region.

TABLE 3.3: COMPARISON AND RECOMMENDATION OF ALTERNATIVES

Pollution Control	Potential Level of Improvement	Technical Feasibility	Municipal/ Public Acceptance	Cost Effectiveness	Conflict Potential	Overall Rating	Comments
1. Sewer Separation	○	●	⊖	$$$	●	C	May increase pollutant loadings
2. Storage-Treatment	●	●	●	$$	○	A	Cost-effective, environmental compatible
3. Infrastructure Rehabilitation	●	●	●	$$$	○	A	Minimizes extraneous flows to plants
4. Upgrading of Infrastructure	⊖	●	●	$$$	○	B	Beneficial in specific locations to reduce overflows
5. Alternative Technologies (RTC, Swirls, Dunkers)	⊖	⊖	⊖	$$	○	B	Feasibility to be defined in future studies
6. Best Management Practices (existing and proposed developments, see Table 3.3.3)	●	●	⊖	$$	○	A	Beneficial in improving long-term environmental health

● high or good ranking
⊖ fair or modest ranking
○ poor or low ranking

$ - relatively low cost
$$ - moderate cost
$$$ - relatively high cost

A - recommended for implementation
B - recommended for consideration on a case-by-case basis
C - not recommended as effective

Storage and treatment of combined sewer flows has generally found to be advantageous as compared to sewer separation, for the following reasons:

- capital cost, and
- reduction of pollutant loading to the receiving body of water.

Potential limitations include:

- available capacity at the WPCP, and
- land availability.

3.2.5.3 Infrastructure Rehabilitation

Contamination of storm sewer flows may occur due to the following:

- cross connections of sanitary and storm sewers;
- direct residential, commercial and industrial sanitary connections; and
- indirect connections between the sanitary and storm sewers due to deteriorated infrastructure

The net result is that, should any of the above occur, then raw sewage is discharged to the receiving streams and rivers.

The primary objectives of infrastructure rehabilitation programs are to improve the structural integrity of the sewer system and to reduce infiltration/inflow. Reduction of infiltration/inflow would, in turn, reduce the volume of flow to be treated at the WPCP.

All four municipalities have ongoing programs to rehabilitate the sewer systems. As was stated previously (see Residential Programs section), the programs are aimed at reducing infiltration/inflow on both public and private property.

3.2.5.4 Upgrading of Infrastructure

Upgrading of the existing sewer infrastructure may involve many tasks, including the construction of sanitary forcemains or increased storage and pumping capacity at a pumping station. Programs to upgrade the system differ from rehabilitation programs in that the intent is to minimize or eliminate a capacity constraint within the system.

All four municipalities have ongoing programs to upgrade the sewer systems. The upgrading may be carried out either to correct an existing constraint or to provide capacity for future development.

3.2.5.5 Alternative Technologies

In recent years, several technologies have been used within Europe and North America to better utilize the existing sewer system, or to provide alternative forms of treatment. Three technologies which may be applicable to the Region of Niagara include:

- Real Time Control,
- Swirl Concentrators, and
- Dunkers Flow Balancing System.

A brief description of each is provided below. Further evaluation of each technology would be required before the feasibility for this study area could be confirmed.

Real Time Control

A Real Time Control (RTC) system involves the collection and dissemination of data in order to better utilize the storage and conveyance capabilities within the existing sewer system. The major components of an RTC system include a monitoring network and telemetry system, a computer controller for the monitoring network and for the control structures within the sewer system.

By using real time data, an operator can better monitor the flows and capacity constraints within the system, thereby reducing overflows and associated environmental impacts.

Swirl Concentrators

The swirl concentrator is a small, compact solids separation device which may be used to partially treat combined sewer overflows. During periods of high inflow, the outflow from the facility is throttled. This results in the facility filling up, and to self-induce a swirling vortex-like operation. In theory, the concentrated foul matter is intercepted for treatment, while the cleaner, treated flow discharges to the receiving body of water.

There are many swirl concentrators in Germany, England and the United States. The primary advantage is the cost-effectiveness, while the primary disadvantage is low treatment efficiency.

Dunkers Flow Balancing System

The Dunkers Flow Balancing System (DFBS) is comprised of a series of pontoons and curtains and a pumping system which is installed in a body of water. During rainfall events, the water from the receiving body of water is displaced by either runoff from the storm sewers or overflows from combined sewers. After the rainfall event has subsided, the storm or combined flows are pumped back to the sewer system to be treated.

There are several DFBS in Sweden. The primary advantage of the system is cost. A suitable location for the facility must, however, be found.

3.2.5.6 Best Management Practices

The potential impact of urbanization on the environment is significant. In summary, the impacts include:

- water quality degradation,
- increased flooding and erosion,
- sediment accumulation,
- degradation of natural features,
- groundwater contamination, and
- destruction of aquatic and terrestrial habitats.

Table 3.4 lists the various measures which may be used to protect or enhance the environment as development occurs or redevelopment takes place. As illustrated, the table includes both prevention measures (e.g., site planning) and control measures (e.g., detention ponds).

Many of the measures which will be listed are applied to proposed developments. They may, however, be used in a retrofit situation as redevelopment occurs. A description of the measures are not provided herein as they are clearly defined in several texts, including the Ministry of the Environment's Best Management Practices Manual (MOE, 1991).

3.2.6 Recommended Approach

All four major municipalities have ongoing works programs for rehabilitating and/or upgrading their infrastructure. Furthermore, various studies dealing with the infrastructure and the associated constraints are ongoing, or have been completed. The intent of this document is not to question the approach taken by each municipality, but to point out how ongoing and proposed programs would fit into an overall program for reducing toxic loadings from urban areas to the receiving bodies of water.

The major types of work being carried out or proposed by the municipalities may be grouped as follows:

- structural rehabilitation programs;
- infiltration/inflow reduction programs;
- sewer system upgrading to eliminate existing constraints, or accommodate future development; and
- reduction of combined or sanitary overflows by providing storage and treatment, increasing pumping capacity or separating combined sewers.

TABLE 3.4: ALTERNATIVE BEST MANAGEMENT PRACTICES

Soft BMPs

- Site Planning
- Fisheries and Wildlife Habitat Protection
- Wetlands Creation
- Groundwater and Baseflow Protection
- Reforestation
- Urban Retrofitting
- Natural Channel Design
- Erosion and Sediment Control Techniques During Construction
- Conservation Measures
- Vegetative Measures

Hard BMPs

- Detention/Retention Ponds
- infiltration Facilities
- Oil/Grit Separators
- Filter Strips
- Vegetated Swales

In summary, the focus of the ongoing programs has been to reduce constraints or environmental impacts associated with the combined or sanitary systems. Furthermore, a majority of the proposed programs involve the construction of works to control the impact as opposed to preventing the problem (several municipalities are, however, implementing pilot source control programs).

Consistent with the approach throughout this document, the overall approach should include both prevention and control measures. Furthermore, based on the findings of several other studies recently completed in Ontario, considerable emphasis must be placed on reducing pollutant loadings associated with stormwater runoff. The importance of reducing stormwater runoff loadings may be demonstrated by comparing the concentrations as provided in Table 3.5.

The average concentrations for storm sewer effluents, combined sewer overflows and WPCP effluents for various constituents are provided. The WPCP effluent concentrations, as provided, are averages from the Region of Niagara plants and the Ashbridges Bay plant in the City of Toronto. The storm sewer effluent and combined sewer overflow values are averages from a number of monitoring locations within Metropolitan Toronto. The following conclusions may be drawn from this table:

- effluent concentrations from combined sewers are similar to those from storm sewers; and
- effluents from combined and storm sewers generally, for various parameters, exceed those from WPCP effluents.

When flow volumes are also considered, the importance of storm sewer effluents become more evident as:

- storm sewer discharge volumes generally exceed, by at least an order of magnitude, combined or sanitary overflows; and
- storm sewer discharges are similar in magnitude to WPCP effluent discharges (assuming equal servicing areas).

The above comparisons are illustrative in nature. The general intent of the conclusions have, however, been shown in other studies (TAWMS, 1986; St. Catharines PCP; MOE, 1989) and would strongly suggest that pollutant loadings from storm sewers may well be the single largest source of a majority of the pollutants to the receiving body of water.

3.2.7 Recommended Strategy and Approximate Costs

Defining a recommended strategy and associated costs will require considerably more information and analysis. The information provided herein should, therefore, be taken in its proper context, i.e., preliminary, based on a limited database with emphasis on the findings of other studies external to the Niagara Region and the authors' own experiences.

TABLE 3.5: COMPARISON OF CONCENTRATIONS FOR STORM SEWER EFFLUENTS, CSOs AND WPCP EFFLUENTS

Parameter	PWQO Aquatic Life (Drinking Water)	Observed Concentration Storm Sewer Effluents	Observed Concentration CSOs	Observed Concentration WPCP Effluent
Fecal Coliforms (CNT/dL)	-	10,000-16E6	30,000-10E6	10-10E5
Suspended Solids (mg/L)	25*	87-188	85-156	13-19
Total Phosphorus (mg/L)	0.03	0.3-0.7	0.4-0.8	0.48-0.75
Total Iron (mg/L)	0.3	2.7-7.2	3.1-7.6	1.7-2.4
Nitrate (mg/L)	(10)	1.1-2.1	0.16-1.7	0.35-0.39
Aluminum (mg/L)	-	1.2-2.5	1.1-1.9	0.098-0.41
Arsenic (mg/L)	0.1	0.001	0.001	<0.001
Benzo(a)anthracene (ng/L)	-	249	261	<1.0
Benzo(a)pyrene (ng/L)	-	320	277	-
Benzo(b)fluoranthene (ng/L)	-	553	557	-
Benzo(k)fluoranthene (ng/L)	-	570	334	-
Alphachlordane (ng/L)	60	0.68	0.49	-
Chrysene (ng/L)	-	333	482	3.0
DDT and Metabolites (ng/L)	3.0	1.09	1.11	-
Dieldrin (ng/L)	1.0	0.80	0.57	-
Hexachlorobenzene (ng/L)	6.5	0.32	0.36	4.0
Lead (mg/L)	0.025**	0.046	0.063	0.019
Mercury (μg/L)	0.2	0.05	0.081	0.1

* RAP suggested value.

** For high alkalinity water.

The recommended strategy is provided in Table 3.6. An overview of the strategy and the assumptions which were made is given below.

The pollution prevention-source control measures (Item 1) apply to all urban sources, and include source control measures on private property. The estimates were obtained, in part, from discussions with various municipal staff members from the Region and from other documents (North Bay, Hamilton and Toronto PCPs).

The pollution control measures - Municipal Infrastructure (Item 2) - include measures defined in existing documents produced for the municipalities, as well as those described by municipal representatives for areas where studies have not been completed (i.e., Niagara Falls and Welland). In cases where studies were not complete, ballpark estimates based on conversations with staff were obtained.

The pollution control measures - WPCP (Item 3) - include proposed works at the WPCP which are required to store and treat flows that, as a result of upgrading the municipal infrastructure (sewer system or WPCP), will significantly reduce overflows. The estimate is based on the following:

- reduction of overflows to two per year;
- WPCP expansion costs of $5 million per mgd;
- an estimate, based on existing studies and data, of overflow volumes within the sewer system and at the WPCPs.

The pollution prevention and control - Existing Areas (Item 4) - assumes that the measures as described in Table 3.4, would be carried out. It is assumed that the proposed measures would be implemented as redevelopment occurs or as infrastructure is replaced. It should be acknowledged that this time frame is considerable (i.e., 50 to 100 years). A unit cost of $150,000 per hectare of urban area was used to establish the estimate. This value was based on one previous study (MOE, 1989) and an ongoing demonstration project within the Town of Markham.

It should be emphasized that the feasibility of successfully implementing Best Management Practices as redevelopment occurs or in a retrofit situation has not been proven.

Item 5 - Pollution Prevention and Control Measures for Future Urban Areas - is similar to Item 4, with the exception that it has been assumed that the cost would be the responsibility of the land developer group.

TABLE 3.6: RECOMMENDED STRATEGY

Item	Description	Cost (millions)
Pollution Prevention-Source Control - General	Includes public education, spill prevention and water conservation, residential programs	5
Pollution Control - Municipal Infrastructure	Includes programs to reduce infiltration/ inflow, upgrade existing system, reduce overflows	300
Pollution Control WPCP Storage - Treatment	Additional cost required at the treatment plant to store and treat flows as a result of upgraded infrastructure	50
Pollution Prevention and Control - Existing Urban Areas	Long-term measures as described in Table 3.3.3, as redevelopment occurs	300
Pollution Prevention and Control - Future Urban Areas	Measures as described in Item 6, Table 3.3.2, as redevelopment occurs	NC

NC = Not costed as it is assumed cost would be the responsibility of the developers.

3.2.8 Conclusions

Based on the information provided for this section, the following conclusions may be drawn:

- the recommended strategy, as presented, should be considered to be preliminary in nature, and is intended to provide direction as to the approach that may be taken to reduce toxic and other pollutant loadings to the receiving bodies of water;
- the major source of toxic loadings is likely to be stormwater runoff (as opposed to combined or sanitary overflows);
- a majority of the efforts by the municipalities to date has been focused on reducing infiltration/inflow, minimizing combined and sanitary overflows, limiting the frequency and severity of basement flooding, and removing capacity constraints within the system;
- the recommended strategy, as outlined in this document, includes both pollution prevention and control measures, and addresses storm sewer discharges, as well as combined and sanitary overflows; and
- the cost estimates, as provided, should, as a whole, be considered to be ballpark estimates. The total estimated cost is $600 million.

3.3 Municipal Water Pollution Control Plants

3.3.1 Identification of Sources

There are six (6) municipal water pollution control plant (WPCP) point source discharges within the Ontario Niagara River drainage basin. These were identified previously in the Phase I Report (Options for the Remediation of Environmental Problems in the Niagara River (Ontario) Area of Concern - Phase I: Preliminary Identification of Remedial Options, dated August 1991) and elsewhere and are summarized briefly in Table 3.7.

The purpose of municipal WPCPs is to provide end-of-pipe treatment of sewage in order to protect the water quality of receiving bodies of water. These facilities provide a high level of treatment of the conventional wastewater characteristics which include suspended solids (SS), oil and grease (O&G) and other biodegradable compounds as measured by the five-day biochemical oxygen demand (BOD_5). As such, WPCPs are not the source of contaminant discharges to the Niagara River Area (Ontario) of Concern but rather the conduit through which contaminants recalcitrant to treatment (assuming they do not bypass secondary treatment at the plant) from numerous sources throughout the various collection systems are discharged to the environment.

The regionally owned and operated WPCPs have been designed and constructed primarily to meet the wastewater disposal needs of the public. As shown in Table 3.7, treatment capacity is distributed according to population. The total rated treatment capacity of the WPCPs listed in the table is approximately 150,000 m^3/d. This capacity serves a residential

TABLE 3.7: WATER POLLUTION CONTROL PLANTS

WPCP	Treatment Capacity m³/d	Treatment Capacity % Total	Flow: Record of Flow[4] (1991 Maximum Month) Average m³/d	Flow: Record of Flow[4] (1991 Maximum Month) Maximum m³/d	Record[4] of Plant By-Pass (1991)	Est. 1990[5] Population Served	Est. 1990[5] Per Capita Flow (Lpcpd)	Estimated Priority Pollutant Discharges[3] (1981-1989 excluding 1985) kg	Estimated Priority Pollutant Discharges[3] (1981-1989 excluding 1985) %	Toxics Discharges
Fort Erie	24,500	16.4	17,770	44,205	No	13,765	1,110	±25,500	42.8	Significant
Stevensville-Douglastown Lagoons	1,470	1.0	1,041	N/A	No	1,500	560	N/A	-	Unknown (non-significant)
Welland	54,550	36.4	47,739	114,956	No	47,205	830	±12,000	20.2	Significant
Port Robinson Lagoons	441	0.3	289	359	No	N/A	N/A	N/A	-	Unknown
Niagara Falls	68,200	45.6	56,950[1]	159,110[2]	Yes	67,835	950	±22,000	37.0	Significant
Queenston	500	0.3	259	722	No	N/A	N/A	N/A	-	Unknown

[1] Based on annual average day (also see Note 4).
[2] Based on maximum day of the year (also see Note 4).
[3] MOE Update Report, Reduction of Toxic Chemicals from Ontario Point Sources Discharging to the Niagara River, 1988, December 1989.
[4] Based on 1991 UMIS data sheets.
[5] Based on draft report on the 1990 Discharges from Municipal Sewage Treatment Plants in Ontario, Vol. II, December 1991.
N/A - Data not available.

population of approximately 130,300 (excluding the Port Robinson and Queenston WPCP service areas).

To a lesser extent, municipal WPCPs provide a predefined level of service to other wastewater generators (e.g., industrial, commercial, institutional, etc.) of measurable importance. The level of service has in the more recent past, been tied to the existing Sewer Use By-Law (3308-83) and related agreements between the Region and various "dischargers" which define "allowable" discharges.

3.3.1.1 Evidence of Toxic Substances in WPCP Effluents

The rankings under the Toxics Discharges column of Table 3.7 categorize the various discharges by their relative importance as defined in the Niagara River Toxics Management Plan (NRTMP) reviews of discharges from the early to mid 1980's and as updated in the Draft Stage I Report (Remedial Action Plan For The Niagara River (Ontario) Area of Concern - Draft 09, dated 13 January 1992). This ranking identifies three of the WPCPs as "Significant" contributors to toxics discharges. The remaining three are categorized as either "Non-significant" or "Unknown" where there are insufficient data. More current data are being compiled and are not available for review at this time.

The existing database of information compiled on the characteristics of municipal sewage in the Niagara region has clearly shown the presence of toxic substances in the effluents of local municipal WPCPs (Update Report, Reduction of Toxic Chemicals from Ontario Point Sources Discharging to the Niagara River, 1988, December 1989). These public owned facilities were originally designed to treat wastewater containing conventional contaminants. This is not a problem unique to the Niagara region.

The work carried out and in progress by the NRTMP to quantify toxics loadings to the Niagara River has demonstrated qualitatively that relative loadings (discharges to the environment) from the municipal WPCPs have declined through the 1980s. Unfortunately, more recent data from ongoing intensive monitoring by the MOE are not currently available for review. In any event, a declining trend is very encouraging as it may be used to infer that public awareness of environmental issues has increased. In this context, domestic sanitary contributions of toxic materials to the sewer can be measurably significant and may play a key role in the evaluation of site specific remedial actions at facilities where industrial discharges to sewer are insignificant.

Wastewater discharges to municipal sewer systems from industrial activity plays a significant role in the presence of specific toxic substances conveyed to the municipal WPCP, regardless of how vigilant the existing monitoring program may be. Any reduction in industrial activity or changes in discharge practices within the sewer-sheds of the municipal systems within the study area may have contributed to the apparent reductions or increases of toxic contaminant discharges observed over the past decade of monitoring.

3.3.2 Review of Sources

This subsection describes in brief the existing municipal WPCPs, recent plant performance information, comments regarding current MOE Certificate of Approval (C of A) and presents remarks on toxic discharges.

3.3.2.1 Fort Erie WPCP

The Fort Erie (Anger Ave) WPCP provides extended aeration activated sludge wastewater treatment since modifications at the plant were completed December 1989. The modified plant has a rated secondary treatment capacity of 24,500 m^3/d and a peak hydraulic capacity of 49,000 m^3/d.

During extreme storm water flows, the old plant (pre-1989) can be brought into service to provide supplemental primary treatment (e.g., screening and sedimentation followed by chlorination) for flow in excess of 49,000 m^3/d. In theory, this configuration provides at a very minimum secondary treated effluent with some primary treated WPCP effluent of "lower" quality during operating periods of extreme flows. The use of the old plant facility is at the discretion of operating staff.

The operating objective is to meet the current MOE C of A limits (C of A No. 3-2140-87-886 dated January 1988). The limits are as follows:

Effluent Parameters	Effluent Objective	Non-Compliance Concentration Limits	Loadings at Capacity (2)
BOD_5	15 mg/L	25 mg/L	367.5 kg/d
Suspended Solids	15 mg/L	25 mg/L	367.5 kg/d
Total Phosphorus	1.0 mg/L	1.0 mg/L	24.5 kg/d
Chlorine Residual (1)	0.5 mg/L	-	12.25 kg/d
Faecal Coliform (1)	200 org/100 mL	-	-

(1) During chlorination season only.
(2) Based on effluent objectives; loadings not included in C of A.

According to the 1991 Municipal Utility Monitoring Program (UMIS) data, the plant was in compliance with the C of A.

Supplemental analyses of composite samples for total ammonium-nitrogen, total Kjeldhal nitrogen, alkalinity and pH is also required by the C of A. The sample composites (24-hour) are to be collected daily. However, not all samples are analyzed daily for the above noted parameters. Monitoring for other contaminants (e.g., priority pollutants, 18 contaminants of concern, etc.) is not part of the plant monitoring and reporting stipulated by the C of A.

The design capacity of the plant and hence its treatment potential is not expected to be realized until the Parkway pumping station is modified to increase pumping capacity. As shown in Table 3.7, based on 1991 UMIS data sheets, the average daily flow to the plant during the maximum flow month of 1991 was 17,770 m^3/d. The maximum day for the same month was 44,205 m^3/d, approximately 90 percent of the peak hydraulic capacity of the modified plant. According to operating records for the same period, the old plant was not brought into service. There was no record of plant by-pass in the UMIS data.

The currently available database of priority pollutant loadings (discharges) to the Niagara River from this plant predate the 1989 modification of the plant to secondary treatment and may no longer be representative of current effluent discharges. According to MOE records for the period 1986-1989, contaminants of concern were detected in the plant effluent including: chlordane, DDT and metabolites, dieldrin, hexachlorobenzene, lead, mercury and tetrachloroethylene. With the exception of the period 1986-1988, the relative loadings (discharges from this facility) have shown a general decline during the period of monitoring from 1981-1989.

3.3.2.2 Stevensville-Douglastown Lagoons

The Stevensville-Douglastown Lagoons were put into service in 1983. The treatment facility consists of two unaerated facultative stabilization ponds covering an area of approximately 9.7 hectares. Space is available at the site for future expansion of the facility to accommodate growth in the service area. The lagoons have a rated treatment capacity of 1,470 m^3/d and a peak hydraulic capacity of 2,940 m^3/d.

The operating objective is to meet the current MOE Certificate of Approval (C of A) limits. The limits identified in the draft 1990 UMIS report summary (Report on the 1990 Discharges from Municipal Sewage Treatment Plants in Ontario, Volume 2, December 1991, Draft) are as follows:

Effluent Parameters	Non-Compliance Concentration Limits	Loadings at Capacity (1)
BOD_5	30 mg/L	44.1 kg/d
Suspended Solids	40 mg/L	58.8 kg/d
Total Phosphorus	N.A.	-
Chlorine Residual	-	-
Faecal Coliform	-	-

(1) Loadings not included in C of A.

According to the 1991 UMIS data, the facility was in compliance with the C of A.

Monitoring for other contaminants (e.g., priority pollutants, 18 contaminants of concern, etc.) is not part of the plant monitoring and reporting stipulated by the C of A.

As shown in Table 3.7, based on 1991 UMIS data sheets, the average daily flow to the lagoons during the maximum flow month of 1991 was 1,041 m^3/d. This is approximately 35 percent of the peak hydraulic capacity of the lagoons. The maximum day for the same month was not recorded probably because the facility is not monitored on a daily basis.

According to the Draft Stage I RAP report (January 1992), this facility is not considered a significant point source to the Niagara River if NRTMP criteria are applied. However, according to MOE records for the period 1986-1989, contaminants of concern were detected in the lagoon effluent including: arsenic, chlordane, DDT and metabolites, lead and mercury. It is not known whether relative loadings (discharges from this facility) have shown a general decline during the period of monitoring from 1986-1989.

3.3.2.3 Welland WPCP

The Welland WPCP provides the most advanced level of wastewater treatment of the municipal facilities currently operating in the study area. Treatment consists of conventional activated sludge treatment including nitrification capability followed by effluent filtration (tertiary treatment). The current plant configuration has been operating since modifications at the plant were completed and brought on-line December 1990.

The plant has a rated secondary treatment capacity of 54,550 m^3/d and a peak hydraulic capacity of approximately 136,200 m^3/d. Flows in excess of 54,550 m^3/d and up to approximately 68,000 m^3/d receive primary treatment followed by effluent filtration. Flow in excess of approximately 68,000 m^3/d receive primary treatment only. In theory, this configuration provides at a very minimum a blend of secondary treated effluent with some primary treated filtered effluent and some primary treated unfiltered effluent of "lower" quality during operating periods of extreme flows.

The operating objective is to meet or exceed the current MOE C of A limits (C of A No. 3-1932-86-887 dated February 1988). The limits are as follows:

Effluent Parameters	Non-Compliance Concentration Limits	Loadings at Capacity (2)
BOD_5	25 mg/L	1,364 kg/d
Suspended Solids	25 mg/L	1,364 kg/d
Total Phosphorus	1.0 mg/L	55 kg/d
Total Ammonium-Nitrogen	varies with flow and month (8 to 25 mg/L)	-
Total Kjeldhal-N	varies with flow and month (13 to 30 mg/L)	-
Chlorine Residual (1)	0.5 mg/L	27 kg/d
Faecal Coliform (1)	200 org/100 mL	-

(1) During chlorination season only.
(2) Loadings not included in C of A.

According to the 1991 UMIS data, the plant may have exceeded total ammonium nitrogen limits as set in the C of A during at least one month of operation.

Supplemental analyses of composite samples for nitrite and nitrate nitrogen, alkalinity and pH is also required by the C of A. The C of A does not specify the daily collection of sample composites (24-hour). Samples are routinely collected by plant operating staff to ensure adequate data is acquired to operate the plant. However, not all samples are analyzed daily for the previously noted parameters. Monitoring for other contaminants (e.g., priority pollutants, 18 contaminants of concern, etc.) is not part of the plant monitoring and reporting stipulated by the C of A.

As shown in Table 3.7, based on 1991 UMIS data sheets, the average daily flow to the plant during the maximum flow month of 1991 was 47,739 m^3/d. The maximum day for the same month was 114,956 m^3/d, approximately 84 percent of the peak hydraulic capacity of the plant. There was no record of plant by-pass in the UMIS data.

The currently available database of priority pollutant loadings (discharges) to the Welland River from this plant predate the 1989/1990 modification of the plant to improve primary treatment and provide effluent filtration and may no longer be representative of current effluent discharges. According to MOE records for the period 1986-1989, contaminants of concern were detected in the plant effluent including: hexachlorobenzene, lead, mercury and tetrachloroethylene. The relative loadings (discharges from this facility) have not shown a general decline during the period of monitoring from 1981-1989, particularly from 1984 to 1989.

3.3.2.4 Port Robinson Lagoons

The Port Robinson Lagoons were put into service in 1989. The treatment facility consists of a single aerated (using two floating mechanically aspirated aerators) lagoon with a volume of 2,384 m^3 followed by two unaerated facultative stabilization ponds covering an area of approximately 2.5 hectares. There appears to be additional land at the site for future expansion of the facility. The lagoons have a rated treatment capacity of 441 m^3/d and a peak hydraulic capacity of 710 m^3/d (based on the capacity of one of two sewage pumps in the raw sewage pumping station).

The operating objective is to meet the current MOE C of A limits (C of A No. 3-0347-88-006 dated May 1988). The limits are as follows:

Effluent Parameters	Non-Compliance Concentration Limits Monthly Average (four samples)	Monthly Average (single sample)	Loadings at Capacity (1)
BOD_5	25 mg/L	40 mg/L	11 kg/d
Suspended Solids	25 mg/L	40 mg/L	11 kg/d
Total Phosphorus	N.A.	-	-
Chlorine Residual	-	-	-
Faecal Coliform	-	-	-

(1) Based on monthly average; loadings not included in C of A.

According to the 1991 UMIS data, the facility was in compliance with the C of A.

Monitoring for other contaminants (e.g., priority pollutants, 18 contaminants of concern, etc.) is not part of the plant monitoring and reporting stipulated by the C of A.

As shown in Table 3.7, based on 1991 UMIS data sheets, the average daily flow to the lagoons during the maximum flow month of 1991 was 289 m^3/d. This is approximately 66 percent of the rated treatment capacity of the aerated lagoon. The maximum day for the same month was 359 m^3/d.

According to the Draft Stage I report (January 1992), this facility is not expected to be a significant point source to the Niagara River if NRTC criteria are applied. At the present time, the MOE is compiling information to determine if contaminants of concern are present in the treated lagoon effluent. This data is not currently available for review.

3.3.2.5 Niagara Falls WPCP

The Niagara Falls (Stamford) WPCP is the largest municipal facility within the study area. The current plant configuration has been in operation since 1985 and consists of primary (screening and sedimentation) treatment followed by secondary treatment (35 rotating biological contactors - RBCs). According to the Draft Stage I report (January 1992), the RBC system was not designed to provide complete secondary treatment for the entire waste stream for the whole operating year.

The RBC secondary treatment system has a rated hydraulic capacity of approximately 100,000 m^3/d. The peak hydraulic capacity of the plant is approximately 136,000 m^3/d. While different operating schemes for secondary treatment are used to deal with flow variations and bypassing during the year, flow in excess of approximately 68,200 m^3/d receives primary treatment only. In theory, this configuration provides at a very minimum a blend of secondary treated effluent with some primary treated effluent of "lower" quality during operating periods of extreme flows.

The operating objective is to meet the current MOE C of A limits (C of A No. 3-0089-84-006 dated May 1984). The limits are as follows:

Effluent Parameters	Effluent Concentration	Loadings at Capacity (2)
BOD_5	40 mg/L	2730 kg/d
Suspended Solids	30 mg/L	2050 kg/d
Total Phosphorus	1.0 mg/L	68 kg/d
Chlorine Residual (1)	Not stated	-
Faecal Coliform (1)	Not stated	-

(1) During chlorination season only.
(2) Based on secondary treatment capacity of 68,200 m^3/d.

According to the 1991 UMIS data, the plant was in compliance with the C of A.

Supplemental analyses of composite samples for total ammonium-nitrogen, total Kjeldhal nitrogen, alkalinity and pH is also carried out but not stipulated in the above mentioned C of A. Sample composites (24-hour) are collected daily. However, not all samples are analyzed daily for the above noted parameters. Monitoring for other contaminants (e.g., priority pollutants, 18 contaminants of concern, etc.) is not part of the plant monitoring and reporting stipulated by the C of A.

As shown in Table 3.7, based on 1991 UMIS data sheets, the annual average daily flow to the plant during 1991 was 56,950 m^3/d. The maximum day for the same year was 159,110 m^3/d, greater than the approximate peak hydraulic capacity of the plant. There was record of both plant by-passes (untreated raw sewage) and in-plant secondary by-passes in the UMIS data sheets.

Some of the currently available database of priority pollutant loadings (discharges) to the Queenston-Chippawa Power Canal from this plant predate the 1984/1985 modification of the plant to increase primary treatment capability and provide secondary effluent treatment for most flows. Therefore, data compiled prior to 1985 may no longer be representative of current effluent discharges. According to MOE records for the period 1986-1989, contaminants of concern were detected in the plant effluent including: dieldrin, hexachlorobenzene, mercury, PCB and tetrachloroethylene. The relative loadings (discharges from this facility) have shown a general decline during the period of monitoring from 1981-1989, particularly from 1986 to 1989 after secondary treatment was brought on-line.

3.3.2.6 Queenston WPCP

The Queenston WPCP provides extended aeration activated sludge treatment. The facility was recently commissioned. The plant has a rated secondary treatment capacity of 500 m^3/d and a peak hydraulic capacity of approximately 1,700 m^3/d.

The operating objective is to meet the current MOE Certificate of Approval (C of A) limits (C of A No. 3-1524-87-896 dated May 1989). The limits are as follows:

Effluent Parameters	Effluent Objective	Non-Compliance Concentration Limits	Loadings at Capacity (2)
BOD_5	15 mg/L	25 mg/L	7.5 kg/d
Suspended Solids	15 mg/L	25 mg/L	7.5 kg/d
Total Phosphorus	N.A.	-	-
Chlorine Residual (1)	Not stated	-	-
Faecal Coliform (1)	200 org/100 mL	-	-

(1) During chlorination season only.
(2) Loadings not included in C of A.

According to the 1991 UMIS data, the plant was in compliance with the C of A.

Supplemental analyses of composite samples for total ammonium-nitrogen, total Kjeldhal nitrogen, total phosphorus, nitrite and nitrate nitrogen, alkalinity, chlorides and conductivity is also required by the C of A. The sample composites (24-hour) must be collected on a weekly basis. Additional weekly grab samples are collected for the determination of total coliforms and faecal coliforms. Monitoring for other contaminants (e.g., priority pollutants, 18 contaminants of concern, etc.) is not part of the plant monitoring and reporting stipulated by the C of A.

As shown in Table 3.7, based on 1991 UMIS data sheets, the average daily flow to the plant during the maximum flow month of 1991 was 259 m^3/d. The maximum day for the same month was 722 m^3/d, approximately 42 percent of the peak hydraulic capacity of the modified plant. There was no record of plant by-pass in the UMIS data.

According to the Draft Stage I report (January 1992), this facility is not expected to be a significant point source to the Niagara River if NRTC criteria are applied. At the present time, the MOE is compiling information to determine if contaminants of concern are present in the treated effluent. This data is not currently available for review.

3.3.2.7 Relative Importance of Sources

The relative importance of WPCP sources of loadings to the environment can be assessed from the perspective of total loadings. While Table 3.7 lists estimates of the total quantities of priority pollutants or toxics from each of the major plants, these estimates are probably not representative of present-day loadings from the Welland and Fort Erie plants due to recent plant expansions and improvements that have been made. Since the Niagara Falls plant has not been upgraded, the estimates shown can be considered reasonably representative of existing conditions, and this plant is now probably the most significant source of toxic loadings from WPCPs within the AOC. The Niagara Falls plant is also the most significant WPCP source of conventional contaminants, based on the size of the population served and on the fact that plant by-passes of untreated or partially treated sewage occur at some frequency. Therefore, from the standpoint of total contaminant loadings, improvements in sewage treatment are most needed at the Niagara Falls plant within the AOC.

The Welland WPCP discharges to the Welland River, while the other two larger plants discharge to the Niagara River. The Niagara River is much larger than the Welland and is more able to assimilate waste discharges without significant water quality impairment. This is particularly true for conventional contaminants (nutrients, BOD, TSS, etc.) which are non-persistent and relatively non-toxic. Thus, poor performance by the Welland plant is more likely to result in significant impacts than is poor performance by the Fort Erie or Niagara Falls plants. The fact that incomplete treatment occurs from time-to-time, depending on flows, indicates that further improvements at the plant or within the infrastructure may be required to cope with higher flow conditions.

3.3.3 MOE Certificates of Approval

3.3.3.1 Compliance

As summarized in the previous review of the municipal WPCPs, all facilities were observed to be in compliance with limits established in existing C of As for the majority of the year. This is based on a review of the draft 1991 UMIS reports.

The C of As of the municipal WPCPs do not place limits on discharge of toxins of concern. Compliance is based solely on conventional parameters including biochemical oxygen demand, suspended solids, phosphorus and nitrogen. Further qualification of the limits established by the C of As is related to the age and complexity of the plant and the dilution capacity of the receiving body of water.

3.3.3.2 Monitoring for Compliance

The monitoring for C of A compliance is carried out regularly by Regional Municipality of Niagara operating staff at each treatment facility in accordance with the C of A. Routine sample analyses (not inclusive of all parameters stipulated in the C of A) are carried out at most but not all WPCPs, the Niagara Regional laboratory and the MOE laboratory. Sample splitting and verification of results are common practice. The results of these analyses are at times subject to careful review between Niagara Region and MOE staff.

As noted in the previous review of the municipal WPCPs, existing C of As do not require analyses of plant effluent samples for parameters stipulated in the C of A on a daily basis. This represents a weakness in ascertaining the "actual" compliance of the WPCP. To illustrate this point, based on the 1991 UMIS data sheets, the Niagara Falls WPCP reported average monthly final effluent BOD_5 concentrations from a total of 131 samples for the entire year (1991). This represents less than 40 percent of the operating year. Considering the documented frequency of bypasses at this plant, it would seem that more frequent performance "excursions" would be reported if effluent sample selection was not at the discretion of the operating staff.

The Municipal Utility Monitoring Program (UMIS) requires all facilities to report total flows, bypass flows, raw sewage and final effluent parameters and disinfection. The reports are submitted on a monthly basis. These reports are reviewed by MOE staff during the operating year to verify facility compliance with the C of A. In addition, the C of A specifies that an annual report be prepared and submitted to the MOE covering 12 months of facility operation. The combined information is used to assess facility compliance.

3.3.4 Screening of Options

There are two major areas which impact on the operation of the WPCPs and thus on the types of remedial actions which may be proven to be beneficial. These are defined as those factors which are either external or internal to the WPCP.

The external factors, discussed in more detail in supplementary sections, can generally be classified as follows:

- sewer inflow/infiltration (I/I) as a result of infrastructure deficiencies;
- implementation, compliance monitoring and enforcement of Sewer Use and applicable By-laws;
- sources of industrial wastewater and level of pretreatment (if applicable);
- combined sewerage; and
- municipal maintenance practices.

The internal factors which are addressed in some detail in this and the following subsection, can generally be classified as follows:

- facility operation;
  - facility reserve capacity
  - flow by-passing
  - operating philosophy
  - performance objectives
  - sampling and analysis
  - operating contingencies
  - budgets

- operating staff; and
    - training
    - technology transfer
    - continuing education
    - number of staff
    - budgets

- facility maintenance;
    - maintenance program
    - equipment
    - housekeeping
    - scheduling
    - budgets

In the review of the six municipal WPCPs, considerable work has been carried out over the past few years to improve the quality of effluent discharges to the Niagara River, particularly at the Fort Erie and Welland WPCPs. Unfortunately, the gains realized with these improvements are being compromised due to documented infrastructure deficiencies which are implicated as the major cause of sewer infiltration/inflow (I/I) and the resulting large percapita flows, shown in Table 3.7, being experienced at the larger WPCPs. These WPCPs were not designed to provide an adequate level of secondary and tertiary treatment to accomodate historical wet-weather flows and frequently must by-pass treatment to pass the excess inflows. From both a pollution prevention and pollution control perspective, this inadequacy is undesirable.

In the context of dealing with toxic contaminants (priority pollutants), considerable knowledge and experience has been accumulated over the past several years clearly demonstrating effectual treatment of toxic substances using biological treatment processes. Biological treatment systems, primarily activated sludge systems, have been proven to be adaptable in the treatment of toxic organic substances and can generally be shown to have economic advantage over other forms of treatment (Gaudy et. al., 1988). In general, this research has shown that biological systems are capable of degrading many of the toxic organic compounds found in municipal sewage which are usually, but not exclusively attributed to industrial discharges to sewer. Most recent research suggests that many toxicants can be metabolized after prolonged acclimatization of the treatment system. The acclimatization process is not necessarily achieved without cost in that there may continue to be some biological inhibition resulting in sub-optimal treatment of conventional contaminants.

Operational problems at WPCP not designed to accommodate and treat wet-weather flows due to I/I can often disrupt the biological activity of the WPCP and theoretically upset the process. Acclimatization may under extreme conditions be adversely affected.

In all practicality, it is virtually impossible to eliminate undesirable fugitive discharges to the municipal collection system(s), particularly from the urban population in general and

TABLE 3.8: SCREENING OF PRELIMINARY OPTIONS FOR MUNICIPAL WPCPs

		Evaluation-Considerations					
Category	Option	Level of Improvement	Feasibility	Cost	Operation and Maintenance Effort	Overall Rating	Comments/Specifics
GENERAL							
	Process Automation	⊖	●	$$	⊖	A	Computerize control systems.
	Operator Training	⊖	●	$	○	A	Improve operator training and knowledge.
	Process Optimization	⊖	●	$	⊖	B	Assess chemical aids, operating modes and practises; improvements can be substantial if plant capacities not limiting.
	Certificate of Approval	⊖	●	$	○	A	Revise existing C of As.
	Monitoring	○	●	$$	○	A	Develop improved monitoring program; not a solution in itself but used to identify need for remediation.
	Communication	⊖	●	$	○	A	Improve reporting/communications between Region and MOE.
	Sewer-use By-law Enforcement	⊖	●	$$	⊖	A	Ensure discharges comply with permitted loadings. Can significantly reduce loadings if violations frequently occur.
PHYSICAL/CHEMICAL TREATMENT							
	Primary Treatment Expansion	⊖	⊖	$$	○	B	Improve screening, degritting, sedimentation where required.
	Equalization Storage	●	⊖	$$	⊖	A	Install on or off-site storage for peak flow equalization. May be the cheapest option for dealing with excess flows.
	Disinfection	⊖	●	$$	⊖	B	Substitute chlorine based disinfection with UV, ozone, etc.
BIOLOGICAL TREATMENT							
	Secondary Treatment Expansion	●	●	$$$	●	A	Activated sludge treatment, other forms of biological treatment.
	Process Modification	○	○	$$	⊖	B	Site specific modifications to existing biological treatment systems.
TERTIARY TREATMENT							
	Tertiary Treatment Expansion	●	●	$$$	●	B	Filtration, adsorption and other forms of advanced treatment; most effective once secondary capacity meets demands.

● high or good ranking
⊖ fair or modest ranking
○ poor or low ranking
A recommended for implementation
B recommended for consideration if additional remediation is needed.
NA not applicable

$ relatively low cost
$$ moderate cost
$$$ relatively high cost

from the many small unregulated commercial dischargers. This is especially critical since most contaminants of concern are present at such low concentrations, the only practical approach to deal with these discharges is to stop them at source (pollution prevention).

Table 3.8 provides a screening of the general remedial option available for the three WPCPs identified as "Significant" contributors of toxic discharges. Options considered include those that are already in place, though they may be inadequate, as well as those which may be considered in the future. Specific controls and recommendations for retrofitting these WPCPs require additional study beyond the scope of this work.

The priority for remediation of WPCP sources is judged to be at the Niagara Falls plant in terms of toxics loadings and the Welland plant in terms of capacity improvements to reduce secondary by-passes. These options can be achieved by increased WPCP capacity, provision for storage of excess sewage at high flow or improvements in infrastructure.

3.3.5 Evaluation of Alternatives

Site specific plant modifications will most likely be designed on the basis that WPCP hydraulic and thus treatment capacity must be increased. This is usually the dominant criteria in assessing the need for plant expansion to provide improved treatment performance and reliability. Historically, the low organic concentration of municipal sewage in the Niagara area as measured by raw sewage BOD_5 in combination with high per capita flows (as shown in Table 3.7) are indicative of significant I/I.

Since WPCPs provide only end-of-pipe treatment, they are not the source of contaminants of concern but rather the conduit through which these and other contaminants are discharged to the Niagara River. The sewer use by-laws by themselves will not reliably lower the level of contaminants in sewage unless steps are taken to enforce the by-law through vigilant and costly monitoring. Monitoring for specific substances at strategic locations in the sewage collection system is in most cases necessary to detect the source(s) of most undesirable contaminants. The practice of allowing sewage haulers to discharge "uncharacterized" sewage at individual WPCPs should be carefully examined.

A thorough review of plant operations with the focus on operating staff, is a possible approach to deal with plant performance inadequecies in the medium term. WPCP operation and performance will ultimately depend on these skilled individuals. A coordinated effort between MOE and the Regional Municipality of Niagara would be considered a prudent step in the development of a plan to examine this important issue.

Process optimization can usually provide improved WPCP performance and may yield operational cost savings. However, this approach may not yield satisfactory results if WPCP operations are plagued by physical plant limitations or operator difficulties.

Process modification and automation are viable alternatives in the short to medium term. In terms of the physical plant, this may involve the replacement or modification of existing WPCP unit operations with newer technology. The most notable technological advance currently gaining more acceptance in Ontario involves the replacement of effluent chlorination with ultraviolet irradiation. UV disinfection virtually eliminates the formation of chlorinated organics, most notably trihalomethanes, commonly associated with the chlorination of effluents containing trace organics. From the perspective of operator and local resident safety, UV disinfection offers many advantages over disinfection using chlorine gas.

The exiting plant C of As need to be upgraded to deal more specifically with sampling and compliance objectives. Further reductions in allowable limits for conventional parameters will put the onus on the Region to improve treatment performance at the plants. Process monitoring for compliance should be improved to ensure true compliance is being realized. A potential spin-off of this process is further reductions of priority pollutants in the effluents of existing and "upgraded" plants. Improved reporting requirements and communications, increased automated data collection and expedited availability of lab testing results would go a long way to improving current facility operations.

In the assessment of urban areas in Section 3.2, it was recommended that existing combined sewerage systems should not be separated and that ultimately all CSO flows would be controlled and essentially routed back to the WPCPs. Since the existing infrastructures of most of the areas associated with the Fort Erie, Welland and Niagara Falls WPCPs contribute flows in excess of their respective capacities, and in order to meet the long term objective of the Plan of "virtual elimination of toxic discharges", it may be necessary to expand these treatment facilities. The specifics of plant expansion is beyond the scope of this study.

The cost to upgrade the Fort Erie, Welland and Niagara Falls WPCPs to achieve full secondary and tertiary treatment of controlled wet-weather flows would probably be in between $50-150 million. The cost to upgrade the other three WPCPs would be significantly less as they represent less than two percent of the combined treatment capacity of the six WPCPs reviewed in this report.

3.4 Industrial Direct Discharges

3.4.1 Identification of Sources

Historically there have been 15 industrial facilities which discharge effluents directly within the Ontario Niagara River drainage basin. These were identified previously in the Phase I Report (August 1991) and elsewhere and are summarized briefly in Table 3.9. Industrial discharges to sanitary sewer were briefly discussed in the previous section of the report since they are not considered direct dischargers. It is appropriate to note that several of the industries identified in Table 3.9 have sanitary sewer connections to some of the WPCPs identified in the previous section.

TABLE 3.9: INDUSTRIES IDENTIFIED AS DIRECT DISCHARGERS

Area	Toxics Discharges
Upper Niagara & Frenchman Creek	
- Canadian Oxy-Chemicals Ltd.	Minor
- GNB Manufacturing of Cananda Ltd.	Minor[1]
- Fleet Manufacturing	Significant
- Diner's Delite	Minor[1]
Welland River & Lyons Creek	
- Atlas Specialty Steels Division	Significant
- Gencorp-Diversetech General	Unknown
- Stelco-Stelpipe Welland Tube Works	Non-significant
- Ford - Niagara Falls Glass Plant	Non-significant
- B.F. Goodrich Inc.	Minor
- Cyanamid of Canada Limited, Welland Plant	Significant
Chippawa Creek/Power Canal (Niagara Falls Area)	
- Washington Mills-Electro Minerals	Minor
- Norton Company of Canada Ltd.	Minor
- Washington Mills	Non-significant
- Cyanamid of Canada Limited, Niagara Falls (ceased operation in April 1992)	Significant

[1] No longer direct discharger.

3.4.1.1 Evidence of Toxic Substances in Industrial Effluents

The rankings under the Toxics Discharges column of Table 3.9 categorize the various discharges by their relative importance as defined by the NRTC reviews of discharges from the early to mid 1980's and as updated in the Draft Stage I Report (Remedial Action Plan For The Niagara River (Ontario) Area of Concern - Draft 09, dated 13 January 1992). This ranking identifies four of the facilities as "Significant" contributors of toxics discharges and a further six as "Minor" contributors. The remaining five are categorized as either "Non-significant" or "Unknown" where there are insufficient data.

3.4.2 Review of Sources

In undertaking the following evaluations, it must be recognized that the study team is unfamiliar with the engineering and operational intricacies of the individual industries considered. Also, in most cases, the industries are in the planning or implementation stages of new pollution reduction measures, either as required by the Ministry of the Environment or under their own initiatives. Therefore, our approach to these evaluations is to focus on those solutions that appear to be most feasible and cost-effective based on discussion with knowledgeable technical staff at the more significant industrial source facilities. To use a more generic approach and identify other options that may appear feasible on the surface could ignore the remedial actions or feasibility work that have already been implemented. Public input to remedial action planning by industry is more effective in the setting of environmental performance standards for industry than in the selection of remedial alternatives for any specific facility, particularly since engineering feasibility work is generally required. If remedial actions are ineffective in achieving objectives, as indicated in effluent monitoring results, further action would then be appropriate.

In general, most of the industries have implemented good control over releases of conventional contaminants such as biochemical oxygen demand, oil and grease, nutrients and suspended solids; therefore, this section focuses primarily on remedial options that would decrease toxics discharges.

As a general option for all industrial direct dischargers, it is recommended that effluents be periodically monitored for the priority toxics targeted in the Niagara River Toxics Management Plan. Results of this monitoring will identify the need for any further actions and serve to track reductions in toxics loadings. All of the direct discharges with certificates of approval will be covered by MISA, so that monitoring should focus on those toxics and conventional contaminants typically associated with each of the relevant industrial sectors.

3.4.2.1 Canadian-Oxy Chemicals Ltd.

Discharges & Evidence of Toxics:

Canadian Oxy-Chemicals purchases approximately 330 m^3/d of water from the Region in the Town of Fort Erie. About 140 m^3/d is non-contact cooling water which is discharged to Frenchman Creek while the balance is contact process water and this is discharged to the sanitary sewer leading to the Fort Erie (Anger Avenue) WPCP.

The plant manufactures phenol-formaldehyde resins, furfuryl alcohol-formaldehyde resins and ethylene bis-stearamide wax. Monitoring of the cooling water flow has shown that phenolics (4AAP) can be present, but may be related to subsurface input rather than a process source.

Certificate of Approval

The plant was built in 1970 and there is no C of A required for the cooling water discharge.

Toxics Reduction Approaches:

The flaker operation is reported to be the major source of cooling water use in the plant. The non-contact water is used to solidify molten product. It is probable that once-through cooling could be replaced with a double circuit, recycle system relying on an evaporative cooling tower or a closed glycol cooling loop. A double circuit system would continue to use water for primary cooling. This would be cooled by the fluid in the secondary loop (e.g., either water or glycol) in a heat exchanger and recycled. The small, intermittent quantities of blowdown (spent water) from such a system that could contain traces of phenol could be discharged to the sanitary sewer by arrangement with the Region.

The cost to introduce a closed cycle cooling system for the cooling flow at this plant would be greater than $100,000 and less than $1,000,000. There would probably be a significant annual operating cost savings based on reduced water purchase from the Region.

The company is concerned that fugitive phenol emissions are primarily responsible for difficulties in maintaining phenol concentration at acceptable levels during wet weather. BEAK was informed that during dry weather flows, phenol concentration in the non-contact cooling water discharge is at or near detection limits. Considering the large quantities of phenols which are used in production at the plant, the company has made considerable progress in eliminating phenol discharges to the environment. Considerable effort has been made to improve housekeeping and promote employee awareness of the need to protect the environment. The company is currently examining alternatives to contain and treated storm water runoff in the vicinity of the processing areas and other areas where products are handled and stored.

3.4.2.2 GNB Manufacturing of Canada Ltd.

Discharges and Evidence of Toxics

GNB Manufacturing was identified as a minor source of toxics because of a direct discharge of about 120 m^3/d of cooling and process water to a 1 km ditch which flowed ultimately to the Niagara River. The plant manufactured lead acid batteries and lead was the primary contaminant associated with the settled and pH adjusted effluent which was discharged to the ditch.

Recent Changes

During the last several years, direct discharge was eliminated and effluent was diverted to the sanitary sewer leading to the Fort Erie WPCP. A remediation program was completed in order to remove the lead contaminated sediment from the ditch.

Current Status

Cooling and process effluents are pre-treated and discharged to the sanitary sewer. BEAK was informed that process effluent is monitored for lead, copper and pH on a weekly basis and that Regional Sewer Use By-Law limits are being met most of the time with few exceptions.

3.4.2.3 Fleet Manufacturing

Discharges and Evidence of Toxics

The chromium content of the combined treated process effluent and cooling water flow entering Frenchman Creek was the cause of Fleet Manufacturing being identified as a significant toxics source by the NRTC data reviews between 1981 and 1984. The effluent also contained solvents such as trichloroethylene and other contaminants including cyanide, nitrates and cadmium.

The contaminant sources were from a variety of anodizing, plating, degreasing, bonding, machining and primer finishing operations for the various aerospace components which are produced at the plant.

Recent Changes

Treated sanitary and process flows have been segregated from non-contact cooling water and diverted to the sanitary sewer leading to the Fort Erie WPCP. Furthermore, cadmium plating operations were discontinued several years ago which effectively eliminated cadmium and cyanide contamination of the process effluent.

Non-contact cooling water now comprises the entire 350 m^3/d of flow discharged to Frenchman Creek. As a result of these changes, the contaminant loads to the Creek have decreased dramatically.

Certificate of Approval

Fleet Manufacturing does not have a C of A for direct discharge of non-contact cooling water.

Toxics Reduction Approaches

The cooling water discharge comes primarily from cooling loops for autoclaves and air compressors. These could be converted to glycol based and/or evaporative cooling tower recycle systems to eliminate direct discharge of non-contact cooling water altogether.

Fleet has been considering this as a potential capital project as the savings in purchased water cost would afford a positive payback. The capital involved in the installation of a cooling water recycle system would probably be greater than $100,000 and less than $1,000,000.

3.4.2.4 Diner's Delite

Discharges and Evidence of Toxics

This plant (formerly Holiday Farms Ltd.) produces frozen dinners and was identified as a "Minor" source of toxics in the early 1980's at a time when both treated sanitary and process effluent from the plant was discharged to Chippawa Channel connected to the Niagara River. Contaminants were mainly oil & grease, suspended solids and BOD_5.

Recent Changes

Diner's Delite has been classified as a zero discharge facility since it constructed a new stabilization pond for effluent treatment and implemented spray irrigation.

3.4.2.5 Atlas Speciality Steels Division

Discharges and Evidence of Toxics

Atlas Steels discharges 20,000 to 25,000 m^3/d of mainly contact and non-contact cooling water from its specialty steel mill to the Welland River through a 42 inch diameter discharge sewer. The facility was described as a "Significant" source of toxics during the NRTC reviews because of the presence of heavy metals including chromium, nickel, zinc, lead and cadmium. Trichloroethylene and tetrachloroethane were also observed.

Atlas Steels produced 200,000 tonnes of carbon, stainless, low and high alloy steel in 1987. The plant uses electric arc furnaces to melt recycled scrap metal. The various processing operations include continuous casting, hot forming, forging and several finishing processes.

Certificate of Approval

The plant has an old C of A which is currently being re-negotiated.

Toxic Reduction Approaches

The large majority of effluent currently discharged after sand filtration is combined contact/non-contact cooling water. The flow is equivalent to about 30 m^3/tonne of steel production based on the 1987 production data which suggests that more effluent is potentially recyclable. Fifty percent or more of the treated effluent is already recycled to process and temperature build-up is probably limiting further recycle opportunities.

Many steel and casting plants have been able to reduce their net effluent discharges to less than 5 m^3/tonne by installing cooling ponds or evaporative cooling towers on the water recycle systems. A small net blowdown is still required to control the build-up of total dissolved solids in the cooling loops but this type of flow reduction will significantly reduce the net discharge of metals and trace organics.

Concentrations of metals and organics in the small blowdown flow may increase above the present values. This introduces the possibility that a final clarification step using hydroxide (e.g., alum or lime) and polymer to enhance treatment may afford a higher degree of treatment.

Treated effluent from the finishing operations is already high in dissolved solids concentration and should probably be excluded from the recycle process. There may be potential for improvement to the treatment processes for the rinses and waste acids from the finishing operations.

The cost of a state-of-the-art cooling and recycle upgrade for the volume of total flow present at Atlas would probably be in between $1,000,000 and $10,000,000. There are insufficient data to comment on the potential costs for upgrades to finishing effluent treatment processes.

3.4.2.6 B. F. Goodrich Inc.

Discharges and Evidence of Toxics

This plant manufactures polyvinyl chloride and polyvinyl acetate resins. Until recently the plant used two different production processes; the older of which was an emulsion process which produced the majority of the 2,300 m^3/d of wastewater flow.

The emulsion process effluent received activated sludge treatment before combining with all remaining flows which entered aerated and facultative basins before discharge.

Recent Changes

A totally new effluent treatment facility was constructed between 1989 and 1991 as part of a plant modernization and expansion program. The old Geon South Plant with its emulsion process was shut down and demolished as part of this upgrade which included the construction of the new Geon West Plant.

The new effluent treatment system incorporates several significant improvements compared to the old system. All tanks and vessels are above grade and replace inground tanks and basins that were part of the old plant. This reduces the risks of unmonitored leakage that might contaminate soils or groundwater. The treatment train comprises equalization, flow controlled pumping to the new primary clarifier; activated sludge treatment; sludge storage and mechanical dewatering; and final effluent filtration through a sand filter.

Certificate of Approval

The new C of A at this facility regulates maximum flow, BOD_5, suspended solids, total phosphorus and vinyl chloride. The maximum month concentration allowable for BOD_5 and suspended solids is 15 mg/L. The monthly total phosphorous limit is 1 mg/L and vinyl chloride is limited to 0.7 mg/L.

The plant is consistently in compliance with its C of A with a few infrequent exceedances for suspended solids, usually during wet weather.

The flow is presently approximately 3,000 m^3/d which is a 20 percent increase compared to pre-expansion operation. There is little opportunity for reducing cooling water use as extensive recycle is already practised in the plant.

Mercury was one of the few toxics which was detected regularly in monitoring by the MOE from 1987 to 1989. BEAK was informed that mercury was not detected in the more recent MISA Regulation Monitoring.

Toxic Reduction Approaches

The use of an activated carbon adsorption process would be a logical add-on effluent treatment unit for installation after the filters if traces of vinyl chloride remain in the effluent but are under the C of A limit of 0.7 mg/L. BEAK was informed by plant personnel that recent outside laboratory results indicate vinyl chloride concentration in the treated effluent to be at or below detection limits (e.g., less than 2 $\mu g/L$). This would make carbon adsorption redundant.

3.4.2.7 Cyanamid of Canada, Welland Plant

Discharges and Evidence of Toxics

Cyanamid of Canada's Welland plant was identified as one of the four "Significant" contributors of toxics in the Ontario portion of the Niagara River drainage basin through the NRTC reviews based on effluent data in the early 1980's. Heavy metals were the major source of "toxics" cited at the time but the effluent also contained cyanides, ammonia, phosphorous, BOD_5 and suspended solids.

The plant's classification as a "Significant" toxics contributor occurred at a time when the facility was still producing a wide range of inorganic chemicals including ammonia, ammonium nitrate, nitric acid, calcium phosphate, urea, phosphine and dicyandiamide.

Recent Changes

By 1990 the ammonia plant was closed reducing production to mainly phosphine and dicyandiamide. This change in production greatly reduced the discharge of toxics. It is reported in Draft Stage I Report (January 1992) that most of the former sources of heavy metal contamination in the effluent were eliminated as a result of the reduction in production activities.

Cyanamid discharges 20,000-25,000 m^3/d of cooling and process effluent to the Welland River via Thompson's (Miller) Creek. The majority of the flow comprises boiler and cooling tower blowdown, once-through cooling and barometric condenser flows. Process effluents represent a relatively small percent of the total flow.

Certificate of Approval

Cyanamid's current C of A was issued in 1988 and requires that the total effluent be non-acutely lethal (meaning that full strength effluent must not be lethal to more than 50% of test fish in a 96-hour toxicity test). The plant has had some difficulty recently in achieving this consistently and there is a study in progress addressing this situation.

Toxics Reduction Approaches

There were insufficient data available from this plant for BEAK to comment on further toxics reduction.

3.4.2.8 Washington Mills - Electro Minerals

Discharges and Evidence of Toxics

Washington Mills - Electro Minerals discharges approximately 30,000 m^3/d of mainly cooling water to Chippawa Creek via two outfall.

The plant produces abrasives through the blending of various raw materials such as bauxite, coke, iron, white alumina, chromic oxide and magnetite. The raw material blends are fused into rods in furnaces and then crushed/ground into the final products. Most of the water used is for contact and non-contact cooling purposes. The contact water is cooled and recycled.

The cooling water is sent to two settling basins for removing suspended solids and oil & grease before being discharged.

Certificate of Approval

The plant effluent is meeting C of A compliance limits for total phosphorus, BOD_5, oil & grease and suspended solids according to the most recent published MOE data (Report on the 1989 Industrial Direct Discharges in Ontario, June 1991). The effluents are routinely non-acutely lethal and there has been little evidence of any of the 18 contaminants of concern based on compiled information from periodic MOE monitoring up to 1989.

3.4.2.9 Norton Company of Canada

Discharges and Evidence of Toxics

This plant uses approximately 14,000 m^3/d of water and discharges it through four outfall into Chippawa Creek.

The plant manufactures abrasives based on aluminum oxide, alumina-zirconia and chromic oxide. Most of the water is used in indirect cooling of the melting furnaces, power transformers and cooling moulds. There is a small flow of contact wash water from the aluminum oxide process which is neutralized and sent to a settling lagoon prior to final discharge.

Certificate of Approval

The effluents from Norton Company are routinely in compliance with control order limits for suspended solids, oil & grease and pH. The effluent was found to be non-acutely lethal during MISA Monitoring in 1989.

This plant has had little evidence of the presence of toxics in recent years.

3.4.2.10 Cyanamid of Canada Limited, Niagara Falls Plant

Discharges and Evidence of Toxics

Cyanamid's plant in Niagara Falls produces calcium carbide, calcium cyanide, calcium cyanamide and desulphurization reagents. It was identified as one of the four "significant" sources of toxics discharges on the Canadian side of the Niagara River in the early 1980s owing to the presence of cyanide and heavy metals entering the Chippawa Power Canal and the Niagara River.

Current Status

Process discharges have ceased since April 1992. It is BEAK's understanding that Cyanamid's intentions at present are to demolish the structures on the site but to retain ownership.

3.5 Rural Areas

3.5.1 Identification of Sources

The draft Stage I RAP report (MOE *et al.*, 1992) discusses rural non-point source runoff as it relates to the problems of siltation and suspended solids, eutrophication and pesticide contamination in the Welland River and Niagara River. Non-point pollution has generally focussed on the erosion of soils and associated contaminants and nutrients during runoff events, particularly in disturbed soils where vegetative cover is limited. Older or over-loaded septic systems can also contribute to agricultural pollution, particularly in clay soils where infiltration from septic beds may be inhibited.

Various land use practices contribute to environmental problems in the Welland River and Niagara River. However, because the problem sources are non-point in nature and the environmental effects are cumulative, it is difficult to identify the relative importance of specific rural sources. Indeed, the relative contribution of rural versus urban sources to contamination problems is unknown.

Rural sources of contamination include not only agricultural sources, but also include road surfaces, roadside drainage ditch maintenance activities (e.g., vegetation removal without revegetation), and rural housing development. Without information on the relative importance of these various sources, it is not possible to identify the degree of improvement that would be realized by any specific remedial action. Nonetheless, it is possible to identify sources where remedial activities are appropriate to address problems relating to water quality, aquatic life and fish habitat.

The incentive for good management practice in agriculture is obvious for the case where the landowner is also the farmer. In this situation, the farmer has a clear vested interest in minimizing soil loss through erosion or water pollution from pesticides and fertilizers. Where the land is leased to a tenant farmer who is often not resident on the land, there may be an inclination to overlook sound management practice when the goal is short-term economic return. Thus, non-farming landowners who lease their land for farming may be unwillingly contributing to environmental problems. Observations made by members of the local Farm Pollution Advisory Committee appear to support this conclusion.

The severing of small parcels of land for rural estate and housing development also contributes to rural environmental problems, due to increased densities of septic systems, to runoff and erosion during construction and to the use of pesticides and herbicides on the landscape. While farmers are generally concerned about minimizing soil loss, are trained and certified in pesticide application and for economic reasons are unlikely to apply fertilizers at excessive rates or at the incorrect time, these do not apply to rural land developers or non-farming rural residents. There is a general belief that rural land development activities collectively represent a significant source of siltation and nutrient enrichment of watercourses in the Niagara River AOC.

3.5.2 Screening of Options

While various types of remedial options are available for consideration, as discussed in the Phase I report (BEAK, 1991), it is difficult to set priorities and select a subset of these options to implement since the community of farmers and other rural residents, as well as local and regional governments and land developers, represent a diversity of interests, opinions and land use activities. Each of these groups typically acts independently and yet cumulatively to impact the natural environment.

In terms of agricultural sources, various financial incentive programs are available to assist farmers in dealing with environmental problems. Because of low marginal profits in farming nowadays, many farmers are unwilling or unable to participate in these programs where the assistance is insufficient to justify the expense associated with specific initiatives. Nonetheless, good environmental practice is generally consistent with maintaining the long-term viability of farming operation. Some specific incentives available to farmers include the CURB (Clean Up Rural Beaches) program which provides funding for remediation of rural sources of water quality problems found at swimming beaches. The Welland River watershed contains one reservoir, the Binbrook Reservoir near Mount Hope, which is impacted by siltation, high bacterial counts and phosphorus from its 10,000-acre watershed. CURB funding may be used in the Binbrook watershed. The National Soil Conservation Program (federally funded) and the Land Stewardship Program (provincially funded) provide funding for the implementation of environmental improvements on farms. In most cases, however, these programs provide only partial (generally 50% or less) for specific remedial works, so that the farmer is required to fund the balance.

A need for identification, evaluation and prioritization of specific problem sources in the Welland River watershed has been recently identified by the Niagara Peninsula Conservation Authority. This would involve an extensive field assessment of problems such as excessive soil erosion, siltation of stream habitat and loss of riparian vegetation due to flooding, crop cultivation along river banks, livestock watering, etc. A study of this nature recently received preliminary approval, but was not initiated at the time due to funding constraints. The preliminary field evaluation component of the study that was proposed could be funded for about $10,000.00 using student labour and should be eligible for funding assistance from the Ontario Ministry of Agriculture and Food. The results of this study would be used to target remedial activities to specific problem sources. Without this information, remedial options can only be screened and evaluated in a general sense.

Table 3.10 provides a screening and rating of remedial options available for controlling rural sources. Screening is done on a qualitative and subjective basis, particularly since the evaluation consideration applied may be expected to vary from location to location and, indeed, from farm to farm. The alternatives are described further in the following subsection, as they are judged to be appropriate for rural areas of the Niagara River AOC.

3.5.3 Evaluation of Alternatives

3.5.3.1 Public Education

There is an ongoing need to inform the rural and agricultural community of best management practices available, as well as the approach to implementation of these practices. Such initiatives may be available through agencies such as the local Ontario Ministry of Agriculture and Food (OMAF). A draft report by the Ontario Federation of Agriculture, entitled "An Environmental Agenda for Ontario Agriculture", outlines the development of a network for communication among farming groups and government, and promotes the development of environmental plans for individual farms. There is also a need for communication on the results of research on integrative pest management, on the economic incentives available, and on environmental regulations that apply to farm operations. Courses on environmental management in agriculture should be developed for presentation at the local level on a continual basis.

3.5.3.2 No Tillage

The "no tillage" alternative involves disturbance of soil only to the degree necessary to plant seeds. In no tillage operations, the vegetative cover and organic matter remain largely undisturbed so that runoff is slowed and little soil is exposed to erosion that could lead to siltation.

No tillage operations require special mechanized equipment such as no till planters or seed drills which may be costly (typically about $20,000.00). Conservation authorities sometimes have such equipment available for use by individual farmers. Operating costs for no till practices are less than conventional tillage costs, as all planting and cultivation is done at once, without the need for separate cultivation.

Crop yields may be affected positively or negatively by alternate cultivation methods, and requirements for chemical application may increase. Farmers are advised to consult with their local OMAF representative for advice.

TABLE 3.10: SCREENING OF PRELIMINARY OPTIONS FOR RURAL AREAS

	Evaluation Considerations						
Options	Level of Improvement	Technical Feasibility	Cost Effectiveness	Public Acceptance	Conflict Potential	Overall Rating	Comments
Public Education	⊖	●	⊖	●		A	Initiate through public (farming) groups
Farming Practice							
No Tillage	●	⊖	⊖	⊖		A	Consider for erosion-prone slopes
Contour Farming	⊖	⊖	●	⊖		B	Consider on erosion-prone slopes
Mechanical Cultivation	⊖	○	○	⊖		B	To reduce herbicide use
Conservation Tillage	⊖	⊖	⊖	⊖		A	Consider for erosion-prone areas
Crop Rotation	⊖	●	●	⊖		A	Good farming practices
Establish Buffer Strips	●	●	⊖	●		A	To prevent streambank and fields from erosion
Reduce Water Use	⊖	●	●	●		A	To reduce water load to septics (e.g., low volume toilets)
Improved Manure Storage	●	●	⊖	⊖	X	A	Set back from streams, sufficient storage for optional application
Control Manure Spreading	●	●	●	⊖	X	A	Avoid spreading on frozen ground
Reduce Pesticide Use	⊖	⊖	⊖	●		B	Feasible if yields not reduced
Spring Tillage	●	⊖	●	●		A	To minimize period of soil exposure
Land Use Controls							
Limit Land Development	●	●	○	⊖	X	A	Control severances for development; may not be cost-effective

TABLE 3.10: SCREENING OF PRELIMINARY OPTIONS FOR RURAL AREAS

	Evaluation Considerations						
Options	Level of Improvement	Technical Feasibility	Cost Effectiveness	Public Acceptance	Conflict Potential	Overall Rating	Comments
Structural Measures							
Control Ponds	⊖	⊖	⊖	⊖		B	May be used at development sites for stormwater control
Wetlands	⊖	⊖	●	●		A	Allow to re-establish in drainage areas
Fencing (to limit livestock access)	●	●	●	⊖		A	Prevent livestock access to streams
Revegetation	●	●	⊖	●		A	Revegetate roadside ditches after clearing, development sites, agricultural drains

● high or good ranking
⊖ fair or modest ranking
○ poor or low ranking

A - recommended for implementation
B - recommended for consideration on a case-by-case basis

3.5.3.3 Contour Farming

Contour ploughing involves cultivating perpendicular to the landslope. In this way, runoff is slowed by the ridges separating the furrows so that erosion is impeded. On longer slopes, this method is more effective if used in combination with grassed strips. Because of the relatively flat topography of rural areas in the Niagara River AOC, this approach is not generally applicable.

3.5.3.4 Mechanical Cultivation

This involves periodic cultivation of land between crop rows to remove weed growth and minimize the requirement for herbicides. Ridge tillage is a form of mechanical cultivation. The practice is not widely followed due to the difficulty in working in fields with growing crops and the expense and additional effort required.

3.5.3.5 Conservation Tillage

This term generally applies to any cultivation technique designed to minimize soil loss. A common means of conservation tillage in Ontario is chisel ploughing. A chisel plough may be purchased for about $5,000.00 to $7,000.00, and is generally fitted onto existing farm machinery. Chisel ploughing leaves more organic residue on the soil surface than does conventional tillage, thereby slowing the rate of runoff and minimizing erosion.

Crop yields may be affected positively or negatively by alternate cultivation methods. Farmers are advised to consult with their local OMAF representative for advice.

3.5.3.6 Crop Rotation

This practice involves rotating the crops on individual fields on a regular and routine basis. Crop rotation is a good farming practice that tends to reduce the need for fertilizers and pesticides and can also reduce soil erosion. The rotation of crops minimizes the incidence and severity of pest and disease problems which otherwise build up with continual planting of the same crop, thereby reducing the need for pesticides. Rotation with leguminous crops will replenish soil nitrogen levels and reduce the need for fertilizer, while the use of a forage crop in rotation will reduce soil losses.

3.5.3.7 Establish Buffer Strips

Buffer strips of natural vegetation should be left along natural stream courses. A typical rule of thumb is that the width of the buffer zone from the wasters edge in metres should be 20 m plus 1.5 times the slope gradient (%). Farmers may obtain specific advice from Conservation Authority representatives. The buffer zone should not be subject to uncontrolled access by livestock, and fencing may be required.

The cost of lost production from these buffer strips should, in the long-term, be compensated by the loss of land and soil to erosion.

3.5.3.8 Reduce Water Use

It is the opinion of individuals at the Niagara Region Conservation Authority that rural septic systems in the Welland River watershed tend to function poorly due to physical limitations of the heavy clay soil. Infiltration rates from tile fields tend to be low, resulting in more surface runoff and contamination of streams by bacteria and phosphorus. A reduction in hydraulic loadings to septic systems would reduce this problem and also reduce the potential for contamination of water sources.

A specific initiative suggested by the Authority is the replacement of standard toilets in rural homes with low-volume (6-litre) toilets. It is estimated that this would reduce household water use and loadings to septic systems by about 28%. The cost of these toilets is about $250.00. For houses in the Binbrook Reservoir watershed, the initiative would probably be eligible for 50% funding through the CURB program. The expense of this measure is much less than the cost of replacing or expanding septic tile beds.

3.5.3.9 Improved Manure Storage

Manure should not be stored on the ground surface in proximity to a watercourse without proper containment. Indeed, direct pollution of surface water by manure is an offence under the Environmental Protection Act and the federal Fisheries Act. Subsidies are available to livestock farmers for the construction of proper manure storage facilities (e.g., pits, concrete berms). Local OMAF representatives should be contacted in this regard.

3.5.3.10 Control Manure Spreading

To minimize water pollution and maximize benefits to soil fertility, manure should not be spread on frozen ground or close to drainage ditches or streams. Direct contamination of surface water by manure is an offence under the Environmental Protection Act. Local OMAF representatives should be contacted for more specific advice.

3.5.3.11 Reduce Pesticide Use

Pesticides generally represent a significant expense to farmers (typically $25.00 to $50.00/acre annually). Persistent pesticides that accumulate in the food chain have largely been replaced with more biodegradable substitutes. Nonetheless, further reductions and replacement should be encouraged as safer products are developed. Communication with OMAF is the key to informing the farming public on these matters.

Pesticide use by non-farming residents for landscape maintenance should be minimized. Public information programs should be used to encourage this reduction.

Vegetation control measures used by local and regional governments, railways, hydro transmission authorities and public companies should be closely examined by the licensing agency (Ontario Ministry of the Environment) to ensure that herbicides are used only when and if necessary. Alternate control measures should be developed where possible.

3.5.3.12 Spring Tillage

Ploughing in spring minimizes the time that fields are not covered by crops or organic matter, thereby reducing erosion of soil by wind and runoff. Spring ploughing also reduces nutrient losses resulting from runoff of nutrients during the snowmelt period. Fall ploughing is the conventional practice since wet conditions that prevent tilling are more likely to be experienced in spring.

3.5.3.13 Land Use Limitation

Limiting the severance of agricultural land for rural housing development can reduce the deleterious effects of construction runoff and unnecessary pesticide use. Also, the problem of inefficient septic systems noted in the Welland River watershed could be minimized by reducing approvals for lot severances. Unfortunately, economic pressures to sever land for development in the Niagara region are high.

3.5.3.14 Control Ponds

Control ponds are detention ponds used to collect stormwater runoff and control the rate of discharge downstream. Wet ponds (as compared to dry ponds) also allow for some removal of solids, thereby reducing downstream siltation. Control ponds are described further in Section 3.2 on urban areas.

In general, the construction and maintenance of control ponds is not practised on farmland, as they remove land from production and may be somewhat costly to construct and maintain. They should be considered (or be required) for controlling runoff from proposed rural estate developments.

3.5.3.15 Wetlands

Natural wetlands may act like control ponds in promoting the removal of solids and control of runoff in rural areas. They also tend to be efficient in removing nutrients and pesticides from runoff. Maintenance costs are negligible. Wetlands also provide valuable habitat for fish and wildlife. Incentives may be available from the Ontario Ministry of Natural Resources to remove wetland areas from production.

Although not widely practised in agricultural settings, artificial wetlands have been used to treat runoff in large, intensive livestock operations (e.g., Costello, 1991).

3.5.3.16 Fencing

Livestock should not be permitted uncontrolled access to watercourses, they trample or consume riparian vegetation, cause streambank erosion, and pollute the water directly. Streams should be fenced to protect riparian buffer strips, and alternate methods used to provide livestock drinking water.

3.5.3.17 Revegetation

Soils devoid of vegetative cover are subject to erosion. Where possible, drainage ditches or swayles should be grassed to slow the runoff and minimize erosion. The practice of roadside ditch cleaning by the Region should include revegetation (e.g., hydroseeding) to minimize erosion.

3.5.3.18 Funding of Remediation

According to District representatives of OMAF, the demand for agricultural subsidies for environmental improvements is very high within the region,and as soon as subsidies become available, they are spent. The need for improvements remains very large, but progress is extremely slow due to funding shortages. The need for identifying means of improving the affordability of environmental improvements on farms is obvious and pressing.

3.6 Landfills

3.6.1 Identification Sources

Sixteen landfill sites have been identified within the Niagara River AOC (MOE *et al.*, 1992). Of these, the Niagara River Toxics Committee (NRTC) identified five as having significant potential to impact water quality (NRTC, 1984). The others were identified to be non-hazardous, or to be located where contaminant migration through surface water or groundwater was unlikely. Available data indicate that no surface water or groundwater impacts have occurred at these other landfills.

Monenco (1991) assessed the potential contaminant loadings from the five potentially significant landfill sources. The five sites and the reasons for their classifications are as follows:

Site	Location	Reasons for Classification*
Atlas Landfill	Welland	2, 5
Cyanamid Landfill	Welland	1, 4
Cyanamid Landfill	Niagara Falls	1, 2
Bridge Street Landfill	Fort Erie	3
CNR Landfill	Niagara Falls	2, 5

* 1 - chemical contents (cyanide)
2 - proximity to surface waters
3 - known migration of minor amounts of leachate from landfill
4 - size of site
5 - local topography

Monenco used the same approach used by Gradient Corp. and Geotrans Inc. in their 1988 report to estimate potential losses of U.S. Environmental Protection Agency priority pollutants from sites on the New York side of the Niagara River. Estimated loadings from each are as follows:

	Estimate[1] (kg/d)	Principal Contaminants
Atlas Landfill	1.1	Inorganic (mainly Sr, Mn, Al)
Cyanamid Landfill (Welland)	0.03	Cyanide
Cyanamid Landfill (Niagara Falls)	26.9	Cyanide
Bridge Street Landfill	0.5	Metals
CN Landfill	2.0	Metals
TOTAL	30.5 kg/d	

[1] Best estimate given by Monenco (1991).

None of the chemicals of concern identified by the NRTC for 50% reduction (see Table 1.1) were predicted to be lost from the five landfill sites. The principal contaminant identified is cyanide. Cyanide is a reactive substance that is readily decomposed by natural processes (photolysis, biodegradation, etc.), so that it is not likely that significant quantities would reach the Niagara River.

The Monenco analysis indicates that known environmental problems associated with these five landfills in the Niagara River AOC are minor and localized, and are not contributing contaminants of concern to the Niagara River or Welland River.

Of the five potential problem landfill sites, the CN landfill and the Cyanamid-Niagara Falls landfill are inactive, and remedial options suitable for operating landfills, such as those within the waste reduction/reuse/recycle/replacement category, do not apply. The Bridge Street Landfill operating permit issued by the MOE expires in May 1992, although it is reasonable to expect that continued operation may be required after that date. The Atlas Steel and the Cyanamid-Welland landfills remain in operation, but sections are being closed as they become inactive.

Some of the other 11 landfills within the Niagara River AOC remain in operation for disposal of municipal, commercial and industrial waste, but are not recognized as potentially contributing to significant off-site environmental problems (MOE *et al.*, 1992).

One of these 11 landfills, the Niagara Falls-Mountain Road landfill, has a leachate collection system that discharges to a sanitary sewer (Industrial Waste Supervisor, Region of Niagara, pers. comm.). Monitoring data are available for this leachate, but the data have apparently not been evaluated by the Niagara RAP team to assess the occurrence and loadings of toxic contaminants.

3.6.2 Screening of Alternatives

Because landfills are not believed to be presently contributing to significant environmental problems within the Niagara River AOC, no requirement for major remedial action is identified. Many of these sites have been "remediated" already to the point where good environmental control is achieved.

The following table (Table 3.11) provides a screening of the general remedial option categories identified in the Phase I report (BEAK, 1991) for the five landfills noted as potential problems. Options considered include those that are already in place, as well as those which may be considered in the future. In addition to these options and landfills, all operating landfills within the AOC will benefit from waste reduction, reuse and recycling options in terms of extending their operating lives, reducing the consumption on natural resources, and reducing the incidental disposal of toxic or otherwise hazardous wastes that should be managed by licensed facilities. Those general environmentally sound practices that do not specifically apply to any of the problems identified at the five landfills of potential concern are described further in Section 3.1 of this report (Public PollutionPrevention Initiatives).

3.6.3 Evaluation of Alternatives

As there are no identified major sources of environmental problems at AOC landfill sites, including no identified loss of toxic chemicals targeted by the RAP, a detailed evaluation of alternative solutions is not required. For the most part, the remedial measures appropriate for controlling or eliminating problems at these sites have been implemented or are planned for implementation. A brief description of feasible remedial options, especially those underway or in place at each landfill, is provided in Table 3.12.

Waste reduction, reuse and recycling options, such as those described in Section 3.1 of this report, are encouraged for all operating landfill sites within the AOC. Of particular importance here is the diversion of potentially toxic waste materials from landfill sites to

TABLE 3.11: SCREENING OF PRELIMINARY OPTIONS FOR LANDFILL SOURCES

Landfill	Magnitude of Problem	Category of Option	Evaluation-Considerations: Level of Improvement	Feasibility	Public Acceptance	Cost	Conflict Potential	Overall Rating	Comments
Atlas	Low	Waste Containment	⊖	●	●	$$		A	Currently practised as sections are closed
		Leachate Collection/ Treatment	⊖	●	●	$		A	Currently done
		Removal	⊖	⊖	●	$$$		B	• Acid waste already removed • Consider if problems arise
		Incineration	○	○	○	-		-	Non-combustible
		Solidification	●	●	●	$$		A	Current practice
		In Situ Methods	○	○	●	$$		-	
		Reduce/Reuse/ Recycle/Replace	○	?	●	?		B	Problems from historic rather than current practice
		Communication	●	●	●	$		A	Employee education
		Monitor	⊖	●	●	$$		A	Current practice
Cyanamid-Welland	Low	Waste Containment	⊖	⊖	●	$$		A	Clay caps used
		Leachate Collection/ Treatment	○	⊖	●	$$		B	Consider if problems arise
		Removal	○	⊖	●	$$$	X	A	Some removal now complete
		Incineration	○	●	○	-	X	-	Little combustible waste
		Solidification	⊖	⊖	●	$$$		A	Practised to some degree
		In Situ Methods	○	⊖	●	$$		-	
		Reduce/Reuse/ Recycle/Replace	⊖	●	●	$		A	Current practice
		Communication	○	○	●	$		A	Employee education
		Monitor	⊖	●	●	$$		A	Current practice

TABLE 3.11: SCREENING OF PRELIMINARY OPTIONS FOR LANDFILL SOURCES

			Evaluation-Considerations						
Landfill	Magnitude of Problem	Category of Option	Level of Improvement	Feasibility	Public Acceptance	Cost	Conflict Potential	Overall Rating	Comments
Cyanamid-Niagara Falls	Moderate	Waste Containment	●	●	●	$$		A	Planned for implementation
		Leachate Collection/ Treatment	⊖	⊖	●	$$		B	consider if unforeseen problems arise
		Removal	⊖	⊖	●	$$$	X	B	Consider if unforeseen problems arise
		Incineration	○	○	○	-	X	-	
		Solidification	○	○	●	-		-	
		In Situ Methods	○	⊖	●	$$		-	
		Reduce/Reuse/ Recycle/Replace	○	○	●	-		-	
		Communication	○	○	●	$		A	To assure public of adequate control
		Monitor	⊖	●	●	$$		A	Current practice
Bridge Street	Low	Waste Containment	⊖	●	●	$$		A	Recommendation made to implement
		Leachate Collection/ Treatment	⊖	●	●	$$		A	Recommendation made to implement
		Removal	⊖	○	⊖	$$$	X	-	
		Incineration	○	○	●	-	X	B	Only as alternate to landfilling
		Solidification	○	○	○	$$$		-	
		In Situ Methods	○	○	○	$$		-	
		Reduce/Reuse/ Recycle/Replace	⊖	●	●	$		A	To reduce waste, eliminate toxics
		Communication	⊖	●	●	$		A	Public education on 4 Rs
		Monitor	⊖	●	●	$$		A	Current practice

TABLE 3.11: SCREENING OF PRELIMINARY OPTIONS FOR LANDFILL SOURCES

Landfill	Magnitude of Problem	Category of Option	Evaluation-Considerations: Level of Improvement	Feasibility	Public Acceptance	Cost	Conflict Potential	Overall Rating	Comments
CNR	Low	Waste Containment	⊖	●	●	$$		A	Site has been capped
		Leachate Collection/ Treatment	⊖	●	●	$$		B	Consider if monitoring identifies new problems
		Removal	⊖	⊖	○	$$$	X	B	Consider if problems arise
		Incineration	○	○	○	-		-	NA
		Solidification	○	○	●	-		-	NA
		In Situ Methods	⊖	⊖	●	$$		B	Consider if off-site migration of chlorinated organics occurs
		Reduce/Revise/ Recycle/Replace	○	○	●	-		-	
		Communication	○	○	●	-		-	
		Monitor	⊖	●	●	$$		A	Periodic monitoring appropriate

● high or good ranking
⊖ fair or modest ranking
○ poor or low ranking
A recommended for implementation
B recommended for consideration if additional remediation is needed.
NA not applicable

$ - relatively low cost
$$ - moderate cost
$$$ - relatively high cost

TABLE 3.12: DESCRIPTIONS OF RECOMMENDED OPTIONS FOR REMEDIATION OF LANDFILL PROBLEMS

Landfill	Problem Description	Remedial Options	Comments
Atlas Steel	Minor losses of metals, mainly due to earlier disposal practices	Waste Containment	Capping of closed portions with clay is practised.
		Leachate Collection/ Treatment	Seepage is collected in a ditch and pond system intended to reduce metal loadings. Elevated metals remain in the final decant to the Welland (Cu, Cr, Mo, Al) and are monitored.
		Solidification	Waste acid is now solidified before disposal and metals immobilized with alkaline slag.
		Communication	Atlas personnel should be encouraged to identify means of reducing waste volumes and toxics that may go to landfill.
		Monitor	Monitoring of leachate quality is practised on an ongoing basis.
Cyanamid-Welland	Very minor losses of cyanide, ammonia, fluoride, sulphate and chromium	Waste Containment	Clay berms used to contain some wastes. All closed areas have been capped with clay and revegetated. Surface drainage from landfills are diverted off the surface to minimize leachate.
		Removal	Some waste material was removed from West Dump in 1982. No need for further removal identified.
		Solidification	Process wastes are disposed of as solids (sludges).
		Waste Reduction	Sludge is re-used in plant processes, so landfilling is reduced.
		Communication	Employee training and communication to promote further waste minimization and ensure control measures are observed.
		Monitor	Test wells in place for monitoring. Surface drainage monitored routinely. No problems identified.

TABLE 3.12: DESCRIPTIONS OF RECOMMENDED OPTIONS FOR REMEDIATION OF LANDFILL PROBLEMS

Landfill	Problem Description	Remedial Options	Comments
Cyanamid-Niagara Falls	Site is not actively used. Some surface seepage and groundwater losses of CN and other nitrogen species. Buried pesticide is not migrating from site and is of low persistence. Surface water seepage may be accessible to local wildlife, although specific problems associated with this are not identified. No measurable effect on Niagara River.	Waste Containment	Plans have been submitted for MOE approval to cap and grade landfill surface. This is intended to eliminate any surface water contamination at site and to reduce losses to groundwater by about half.
		Communication	Cyanamid should publicize their plans and the effectiveness of their program (monitoring results) to minimize public concern.
		Monitor	To ensure detection of problems and track the effectiveness of containment measures.
Bridge Street	No significant effect on Miller Creek identified.	Waste Containment	Recommendations have been made on surface contouring and covering to protect groundwater. These should be implemented upon closure of areas.
		Leachate Collection/ Treatment	Recommendations have been made to prepare contingency systems (french drains) for leachate collection if contaminant migration occurs.
		Reduce/Reuse/Recycle and Public Communication	Public initiatives such as identified in Section .... should be encouraged to reduce or eliminate incidental toxic materials going to landfill, reduce resource consumption and extend landfill life.
		Monitor	Detailed hydrogeologic monitoring has been completed. Additional monitoring has been recommended.
CNR	No evidence of contamination by chlorinated hydrocarbons or phenoxys. Site is closed.	Containment	Site has been closed and capped as designated by Environment Canada. Additional need for remediation not indicated.
		Monitor	Periodic surface drainage monitoring should be carried out to identify any problems that may arise and assure that surface water is safe due to potential for human exposure.

facilities where environmentally sound and authorized management practices for such waste are in place so that future problems in terms of contaminant migration do not occur.

Leachates from the Niagara Falls-Mountain Road landfill that are discharged to municipal sewers should be assessed to confirm that there are no significant loadings of toxics that may reach surface waters via water pollution control plants. This may be done using existing data (some data are available) or through additional monitoring, if appropriate. If toxics are present, some of the options identified in Section 3.6.2 should be considered to remediate these problems.

3.7 Contaminated Sediments

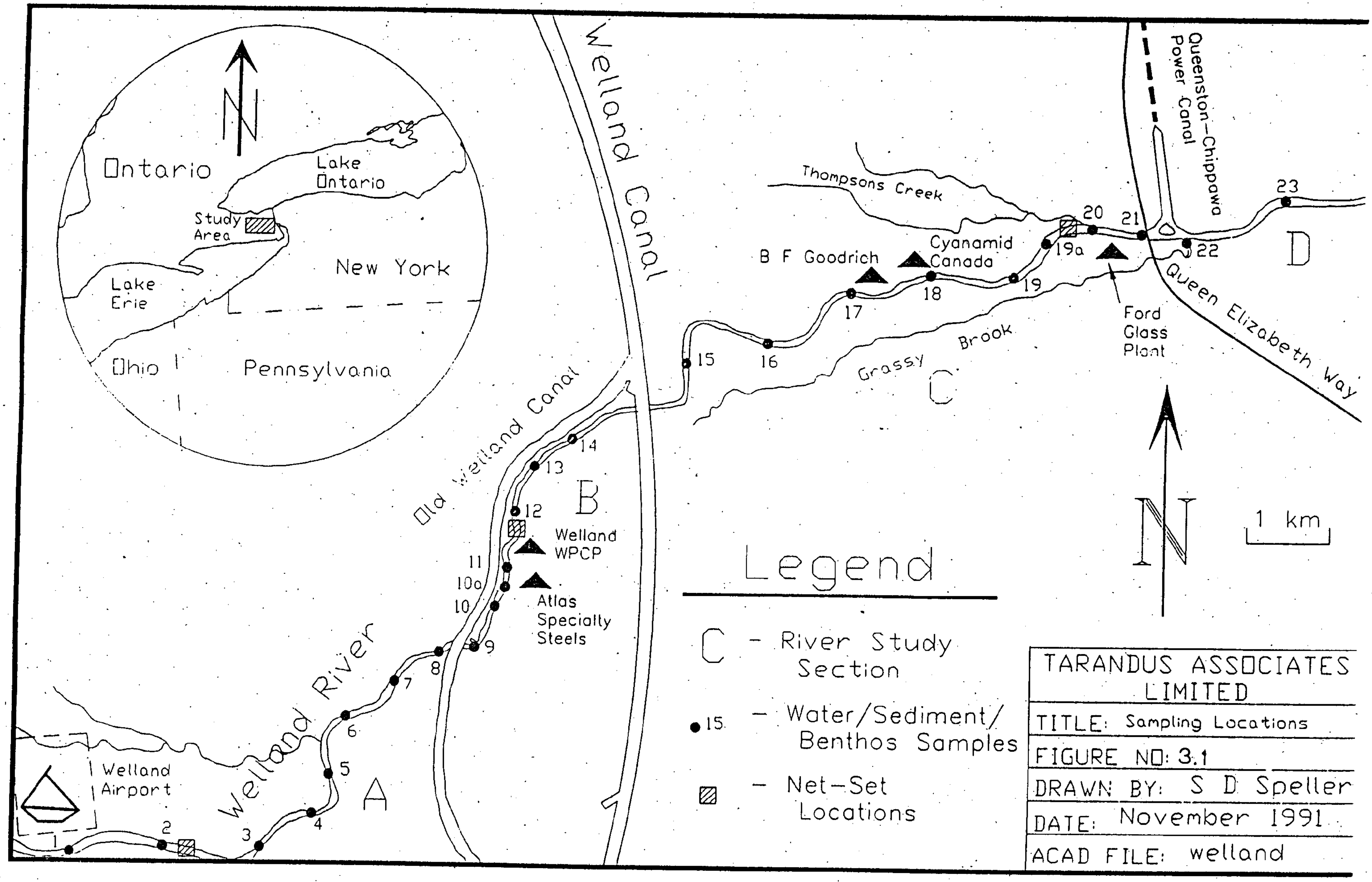
3.7.1 Identification of Sources

Sediments act as both a sink and a source of contaminants to downstream waters. The Niagara River Toxics Committee (1984) identified sediment contamination at various locations on the Ontario side of the Niagara River, including the mouth of Frenchman Creek (p,p-DDT), near the mouth of Miller Creek (mirex), downstream of Navy Island (mirex), and locations in the lower Niagara River (Zn, Hg, various organochlorines). Other contaminated sites include Ontario Hydro's Sir Adam Beck reservoir and the mouths of most of its tributaries (MOE *et al.*, 1992). In general, the extent of sediment contamination in the Niagara River is limited to the mouths of some tributaries and some shoreline backwaters since turbulence and high flow velocities throughout most of the river prevent deposition. The rapid and turbulent transport of sediments in the river causes difficulty in tracing source locations, and it is recognized that problems on one side of the river may have origins on the other.

A zone of extensive iron oxide and heavy metal deposition, known as the "Atlas Reef", occurs in the Welland River downstream of Atlas Steel. This deposit results from historic releases of particulate heavy metals in the Atlas Steel wastewater which, combined with sediments in the river, have formed a metal-rich hardened surface on the river bottom. Existing information indicates that Provincial Sediment Quality Guidelines (Severe Effect Levels) are exceeded in this deposit for some metals.

A very recent study completed by Tarandus Associates for the West-Central Region of the MOE shows widespread problems of sediment contamination in the lower Welland River with the worst area located at Station 9 just downstream of the Old Welland Canal (Tarandus Associates, 1992; see Figure 3.1). The contaminants identified include various polycyclic aromatic hydrocarbons (PAHs), mercury and PCBs, and dioxins and furans (principally the less toxic hexa and octa congeners). There is some relationship suggested between high contaminant levels and sources such as storm sewer outfalls. The PAH contamination may originate from a former foundry in Welland.

Contaminated sediments are not sources of environmental problems; rather, contamination occurs as a result of sources upstream in the watershed. If contamination sources


Ontario
Lake Ontario
Study Area
New York
Lake Erie
Ohio
Pennsylvania
Welland Canal
Queenston-Chippawa Power Canal
Thompsons Creek
B F Goodrich
Cyanamid Canada
Ford Glass Plant
Queen Elizabeth Way
Grassy Brook
Old Welland Canal
Welland WPCP
Atlas Specialty Steels
Welland River
Welland Airport
A
B
C
D
1
2
3
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5
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18
19
19a
20
21
22
23
1 km
Legend
C - River Study Section
15 - Water/Sediment/Benthos Samples
- Net-Set Locations
TARANDUS ASSOCIATES LIMITED
TITLE: Sampling Locations
FIGURE NO: 3.1
DRAWN BY: S D Speller
DATE: November 1991
ACAD FILE: welland

themselves have not been identified and either eliminated or significantly reduced, it is generally unreasonable to consider remedial actions directed toward the sediment. Exceptions may occur if the contaminated sediment is known to be a significant secondary source of water contamination, there is evidence that the sediments are acutely toxic to aquatic life, or that the contamination presents a direct health threat to members of the public who are exposed through body contact. However, in this case, sediment remediation may be an ongoing and costly activity.

Some of the sources of sediment contamination within the AOC are recognized. The source of the Atlas Reef is acknowledged to be Atlas Steel and it is also recognized that the source of contamination that led to the problem has been remedied. The only known source of mirex to the Niagara is on the New York side, so that source control must be implemented outside of the Ontario AOC. Sources of sediment contamination in the Welland River, with the exception of Atlas Steel, are as yet generally unidentified.

3.7.2 Screening of Alternatives

Several options for sediment remediation were identified in the Phase I report. As identified in the Stage I RAP document (MOE *et al.*, 1992), contaminated sediments accumulate only in very localized areas of the Niagara River due to the high flows and turbulence, and most sediments are deposited in Lake Ontario in the Niagara Bar. The need for direct remediation of the Niagara Bar has not been indicated in the RAP document, other than the obvious need for reduction and eventual elimination of persistent toxics to reduce future problems.

Table 3.13 provides a screening of alternatives for remediation of contaminated sediments within the Niagara River (Ontario) AOC. Options screened as suitable for the Atlas Reef remediation reflect the specific option which has been developed and, to some extent, implemented.

3.7.3 Evaluation of Alternatives

3.7.3.1 Atlas Reef

Atlas Steel is currently conducting feasibility studies and trials on the use of a suction-dredge type technology to remove the hardened, heavy-metal contaminated scale that forms the Atlas Reef from the Welland River bottom. The company and the MOE feel that the source of the problem in the form of particulate heavy metal losses in wastewater has been sufficiently remedied, so that the cleanup can proceed with minimal likelihood of the problem recurring.

The specific technology being used in this case is called a "modified Mud Cat" environmental dredge. The dredge essentially loosens the scale from the river bottom and pumps the dredgate into a pipeline for land-based treatment and disposal. The nature of the intake minimizes any losses of suspended particulates downstream. Further feasibility trials

TABLE 3.13: SCREENING OF PRELIMINARY OPTIONS FOR REMEDIATION OF CONTAMINATED SEDIMENTS

Landfill	Magnitude of Problem	Category of Option	Evaluation-Considerations: Level of Improvement	Feasibility	Public Acceptance	Cost	Conflict Potential	Overall Rating	Comments
Atlas Reef	Heavy Metal Deposits	Source Control	●	●	●	$$		A	Already implemented
		Sediment Removal:							
		• suction dredging	●	●	●	$$$		A	Preliminary trial complete
		• clam shell	●	⊖	●	$$$		B	
		• in-the-dry	●	⊖	⊖	$$$	X	-	Not suitable for large areas
		• hydraulic flushing	○	○	○	$$	X	-	Exports problem downstream; scale not easily loosened
		• siltation controls	●	●	●	$	○	A	To control downstream impacts
		Treatment of Sediments	○	○	●	$$$	○	-	
		Diversion	●	○	○	$$$	X	-	
		In Situ Remediation	⊖	○	⊖	$$	X	-	
		Erosion Control	○	⊖	●	$$$		-	Should be implemented for other reasons
		Communication	○	●	●	$		A	Inform public on progress and improvements
		Monitor	⊖	●	●	$$		A	To confirm effectiveness
Welland River (general)	Metals/ Organics	Source Control	●	?	●	?		A	Sources not identified
		Sediment Removal	●	?	●	$$$		A	Consider once sources controlled
		Treatment of Sediments	○	?	●	?		B	
		Diversion	●	○	○	$$$	X	-	Not generally suitable in large rivers. May be suitable for small areas
		In Situ Remediation	⊖	?	⊖	?		-	
		Erosion Control	⊖	⊖	●	$$$		-	Implement for other reasons
		Communication	⊖	●	●	$		A	Communication may be key to source identification
		Monitor	●	●	●	$$		-	To identify sources, evaluate extent

TABLE 3.13: SCREENING OF PRELIMINARY OPTIONS FOR REMEDIATION OF CONTAMINATED SEDIMENTS

			Evaluation-Considerations						
Landfill	Magnitude of Problem	Category of Option	Level of Improvement	Feasibility	Public Acceptance	Cost	Conflict Potential	Overall Rating	Comments
Niagara River	Metals/ Organics	Source Control	●	⊖	●	$$$	●	A	Multitudes of sources implicated, not all identified
		Sediment Removal	⊖	⊖	●	$$$	○	B	Consider as sources controlled
		Treatment of Sediments	○	○	●	$$$	○	B	If required for safe disposal
		Diversion	○	○	○	$$$	●	-	
		In Situ Remediation	⊖	⊖	●	$$	●	B	May be feasible in Sir Adam Beck reservoir
		Erosion Control	○	⊖	●	$$$	⊖	-	Implement for other reasons
		Communication	⊖	●	●	$	○	-	May be key to source identification

● high or good ranking
⊖ fair or modest ranking
○ poor or low ranking
A recommended for implementation
B recommended for consideration if additional remediation is needed.
not applicable

$ - relatively low cost
$$ - moderate cost
$$$ - relatively high cost

are being carried out this year (1992) to evaluate effectiveness and to monitor environmental recovery of areas previously remediated. The dredgate is not classified as hazardous, and leachate trials are being undertaken to determine waste classification so that it is managed and disposed of in accordance with regulatory requirements.

3.7.3.2 Welland River

a) **Source Control**

In order to develop a more specific remedial plan for contaminated sediments in the Welland River (outside of the Atlas Reef area), it is first necessary to identify the sources of the contamination and to develop specific plans for source control. The Tarandus Associates (1992) report makes several specific recommendations relating to characterization of sediment contaminant sources. They are listed below. Figure 3.1 shows the station locations specifically referenced in the Tarandus Associates report.

Recommendations (from Tarandus Associates Limited, 1992)

1. Elevated mercury levels were found in water samples collected during the summer survey at the upstream-most stations in the Lower Welland River study area. The mercury concentrations in this part of the river were also found to decrease continuously from Stations 1 to 5. It is suspected that this situation may be the result of bacterial methylation of mercury in a reservoir upstream of the study area. It is recommended, therefore, that further investigations be completed to determine the source and significance of mercury in this part of the Welland River.

2. Although PAHs were detected in sediments at various stations in the study area, particularly high levels of several PAHs were found at Station 9, located near the Welland water treatment plant. A stormwater discharge is also located at this site. It is recommended that additional studies be completed to determine the origin(s) of the PAHs at this location and to evaluate remediation options if necessary.

3. In addition to the high concentrations of PAHs noted above, Station 9 was found to have elevated sediment levels of several metals, nutrients, oil and grease, and PCBs. Due to the apparent magnitude and relative significance of this location as a problem site, it is recommended that a detailed investigation of this area be completed to determine the source(s) of these contaminants and to evaluate remediation options if necessary.

4. Elevated concentrations of PCBs were found in Welland River sediments at Stations 7, 8, 9, 15 and 21. A stormwater discharge was noted during the field studies at Station 7; Station 15 is located a short distance downstream of the Port Robinson syphon; and Station 21 is situated downstream of the Ford Glass plant, the Cyanamid Canada plant, and the BF Goodrich plant. It is recommended that additional studies be undertaken to determine the source(s) of PCBs at these locations and to evaluate remediation options.

5. Polychlorinated dioxins and furans were found in the sediments at Stations 9, 15 and 21. Given the environmental concerns regarding these contaminants, it is recommended that further work be completed to confirm sample results, and to determine the significance of the concentrations of various dioxin and furan congeners at these locations.

If the PAH problem can be traced to a subsurface contamination problem, as may occur with coal-tar, a hydrogeological study of the contaminant pathway may be appropriate.

b) **Sediment Removal**

Once source controls have been implemented, sediment removal should be considered. If problems of a potential direct health concern are identified, sediment removal should be considered even if source control is not in place as a preliminary remedial measure. The possible concern here relates to the PAH-contaminated sites, which could represent a situation similar to the coal tar problem identified and remediated previously in Chippawa Creek.

The specific technique(s) that might be used in sediment removal cannot be identified without evaluating the extent and nature of the problem, and site accessibility. Suction dredging has been applied elsewhere to remediate surface sediment contamination problems using conventional vacuum truck technology, as recently carried out to remove creosote-contaminated sediments in Thunder Bay Harbour. If carried out carefully, suction-dredging techniques are less likely to cause sediment resuspension and downstream transport than are clam shell dredging methods, and are probably most suitable for river cleanup situations. A recent report entitled "Approaches to Cleanup of Contaminated Sediments in Ontario - Compendium of Past Practices" prepared by the MOE noted that suction techniques have been generally preferred when contaminant mobilization is a concern (BEAK, 1991). The report also noted that cleanup operations typically incorporate measures such as flow diversion, as well as silt curtains, bottom traps and surface booms to minimize contaminant migration.

Costs associated with sediment removal would depend on the technology selected, the volume of contaminated sediment and site logistics. By way of example, conventional Great Lakes harbour dredging costs, including transport to a confined disposal facility or a shore-based off-loading site, was estimated at \$15.00 to \$20.00 per cubic metre in 1988 using available Department of Public Works facilities and equipment (BEAK, 1988). Costs associated with working within the confines of a silt curtain were given as additional. Thus, the cost of clam shell dredging of 10,000 m^3 would be in the order of \$200,000 or more. Conventional harbour dredging equipment may be impractical for use in the Welland River.

Costing information developed by BEAK (1988) on suction dredging options identified a cost range of \$50,000 to \$150,000 for a one-month cleanup operation.

c) **Sediment Treatment/Disposal**

The management of contaminated dredgate after disposal will depend on the volume of material and its waste classification. A dewatering and water treatment operation would probably be required to separate the excavated sediments for disposal. If a simple settling pond and decanting facility is all that is required, costs may be minimized, although the operation would probably be subject to permitting as a sewage works by the MOE.

Wastes may be acceptable for disposal in a conventional landfill if they are classified as unregistered waste. Otherwise, disposal may need to be in a landfill approved for receiving registered non-hazardous waste or, in cases of extreme contamination, disposal may need to be directed to a registered, hazardous waste facility where it may require immobilization or other treatment before disposal. Typical disposal costs for contaminated soils are in the order of $20.00 to $50.00 per ten-tonne load to a rate of about $550.00/tonne for registered hazardous waste. Tipping fees for registered, non-hazardous material are in the order of $80.00/tonne. Waste transportation costs for management and disposal of a contaminated sediment may be significantly greater than the costs of excavation if the material is unsuitable for disposal in a conventional landfill.

d) **Communication**

If the need for remediation is identified, it would be appropriate to establish a public liaison committee by the agency responsible for cleanup coordination. In this way, information can be more readily exchanged on the nature and source of the problem, and the need for further information or data identified. A wider public forum may be more useful in uncovering information on historical industrial operations that may have been the cause of existing problems.

3.7.3.3 Niagara River

The general remedial measures described above for the Welland River may also be applied to the Niagara River. However, because the sources of sediment contamination in the Niagara River are, for the most part, widespread and often not well-defined, because contamination is not extensive and is patchy in distribution, and because the degree of contamination is not severe (that is, the "lowest effect level" guidelines are sometimes exceeded but "severe effect levels" are rarely exceeded); removal of contaminated sediments from the Ontario side of the river is not recommended at present as a means of remediation of contamination problems.

Contaminated sediments have been identified by the MOE in the headpond reservoir of Ontario Hydro's Sir Adam Beck Generating Station. Ontario Hydro now takes special precautions in undertaking construction activities and in reservoir operation to prevent resuspension and mobilization of these contaminated sediments. The need for further remediation is not identified at this time, but should be considered if contaminant remobilization becomes a problem. Because the reservoir bottom represents an artificial aquatic habitat, and turbulence in the reservoir is generally less than in the Niagara River itself, the potential for immobilizing the reservoir sediments *in situ* (e.g., clay cover) should be considered as an alternative to removal in the event that remediation becomes desirable in the future. Remediation would be considered in the event that contaminant mobility increases.

3.8 Physical Habitat Disruption Along Watercourses

As outlined in the Stage I RAP report (MOE *et al.*, 1992), the majority of physical riverine habitat disruptions in the region can be attributed to various combinations of the following problems:

- disruption/loss of riparian habitat;
- streambank erosion and consequent siltation;
- in-stream alterations; and
- loss of wetlands.

An array of measures are available to address these problems. Buffer strips, streambank stabilization techniques, wetland construction and creation of in-stream structures are general examples of the available measures.

Depending on site-specific information, particularly the type and magnitude of the problem, it may be possible to employ volunteer effort and natural materials to implement the appropriate measure(s). Programs such as the OMNR's Community Fisheries Involvement Program (CFIP) and Community Wildlife Involvement Program (CWIP) can provide funding and expertise to local community groups wishing to remediate problems and rehabilitate habitat. Many CFIP and CWIP projects have proven to be a cost-effective means of habitat rehabilitation. Other restoration or protection measures such as fencing against livestock access and maintenance of buffer strips on farms may be eligible for funding through provincial and federal agricultural agencies (Section 3.5).

Stewardship programs are another means of addressing habitat damage problems. Typically, stewardship programs involve a community organization which assumes responsibility for the maintenance and improvement of a local watercourse or reach, e.g., "adopt a stream" groups, such as the Speed River Project and Friends of the Don. The Conservation Authority may wish to implement programs which encourage the establishment of such groups.

In some cases, the Conservation Authority may wish to consider programs to assist landowners in the implementation of riparian-focused measures, such as streamside fencing, cattle crossings, armouring, etc. At other sites, engineering constraints, requirements for heavy machinery, high material costs or the shear magnitude of the operation may preclude the use of volunteers. These projects are more costly, but not necessarily more effective than a number of small-scale volunteer/stewardship programs.

There are many measures which may potentially be implemented to address damage of the riverine habitats. The majority of well-documented techniques are coldwater designs not particularly suitable for warmwater applications; however, a variety of the coldwater designs can be transferred to warmwater situations. These techniques are described in Appendix 1. Although the majority of warmwater habitat techniques have originated in the United States and Europe, many of these are readily transferable to Niagara Region watercourses. These techniques are of particular relevance to watercourses in the Welland River watershed and small watersheds draining directly into the Niagara River, and are of minimal relevance to the Niagara River itself due to its extreme turbulence. Some of these techniques are also described in Appendix 1. Details of these techniques, such as applicability, design and implementation considerations, advantages, disadvantages and factors influencing costs, are presented in Table A1.1.

3.8.1 Techniques for Streambank Stabilization

Urban and rural streambanks of watercourses within the Area of Concern have been affected by removal of vegetation and high storm flows resulting from land use practices. This has resulted in reductions in the stability of streambanks and active erosion of soils into the river. Fish habitat is damaged both by the effects of siltation and by the loss of riparian cover.

There are many approaches to streambank stabilization. The most common technique is the placement of rock rip rap. Other techniques and materials used to stabilize streambanks include log walls, timber cribs and tree revetments. Bioengineering approaches such as live soft gabions and live crib walls represent relatively recent techniques which show great potential. Numerous manuals describing these techniques are available, e.g., Schectl (1980), Binns (1986), Alberta Environment (1986) and Adams and Whyte (1990). The following descriptions of the techniques are adapted from this literature. Sources are noted where appropriate.

3.8.1.1 Rock Rip Rap

Proper installation of rock rip rap along a bank will effectively halt erosion. Fish of various sizes can find living space in the crevices and eddies formed by the rip rap. Figure A1.1 shows a typical riprap installation. The submerged rock will provide substrate for the macrobenthic community. Applicability of rock rip rap, design and implementation guidelines, advantages and disadvantages and cost factors are presented in Table A1.1.

3.8.1.2 Log/Timber Walls and Cribs

These techniques employ relatively simple devices constructed from logs/timber, rock and fill soil. These solid structures are resistant to hydraulic effects, and provide cost-effective bank stabilization. Log/timber walls may be constructed along actively eroding low banks. Cribs are placed immediately upstream to deflect water away from erodible banks.

Examples of log/timber walls and cribs are presented in Figure A1.2. Other details for these techniques are presented in Table A1.1.

3.8.1.3 Tree Revetments

Tree revetments are structures used to halt bank erosion on the outside curves of small to medium size rivers. Tree revetments are composed of trees anchored in the bank and combined with rock rip rap. A typical tree revetment is shown in Figure A1.3. Where high silt loads are present, tree revetments act as sediment traps which become vegetated and creates even more stable banks. The rock rip rap adds stability and prevents possible bank scour behind the trees. The branches of the trees provide fish habitat in the form of cover. Pools habitats often develop along the face of tree revetment structures. Details of the revetment techniques are presented in Table A1.1.

3.8.1.4 Live Soft Gabion and Cribs

These techniques are part of a large body of approaches known as bioengineering. Bioengineering solutions for eroding banks are commonly referred to as biotechnical bank stabilization. Live soft gabions and cribs are similar structures to their "hard" counterparts, except that less rock and more live woody materials are used. Typical materials include dogwood, willow and alder. These species create riparian vegetation with dense root systems in moist soils.

Live soft gabions and cribs become living structures which are broadly applicable, very durable, natural in appearance and self-repairing. In addition, these structures provide a dense riparian buffer which protects the stream and enhances the fish habitat. Live soft gabion is particularly useful for high, steep banks. An example of a live soft gabion and live crib are presented in Figure A1.4. Details on application, design, installation and cost factors are presented in Table A1.1.

3.8.1.5 Riparian Plantings

Vegetation within the riparian zone is widely regarded as a major determinant of fish habitat quality in streams. The riparian community influences stream temperature, erosion and sediment loadings, cover and food for fish. Disruption of riparian communities is known to induce degradation of stream habitats. In these cases, it may be appropriate to conduct riparian plantings to restore habitat.

It is highly recommended that qualified professionals be consulted in the planning, design and implementation of riparian plantings. The Niagara Peninsula Conservation Authority and the Niagara District Office of the Ministry of Natural Resources (Fonthill) can assist in this regard. Riparian planting techniques include seeding, sods, stakes, wattles, transplants and nursery stock. These techniques are generally manual in nature, and can be accomplished using volunteer labour. Site preparation is critical to the success of riparian plantings. The degree of preparation required (and the cost) will vary with the techniques used and the soils which are present in the area. Machinery may be required in some instances.

Costs are also highly dependent on the planting materials used. Seeds, hydroseeding, mulches and cuttings (stakes) are less expensive than sods or nursery stock. Adams and Whyte (1990) provide excellent advice on the details of these riparian planting methods. Some of these details are presented on Table A1.1.

3.8.1.6 Streambank Fencing and Crossings

Streambank fences are simple structures which address livestock-related impacts in and adjacent to streams. Even periodic exposure to livestock is considered to be detrimental to stream habitats. Streambank fences function to exclude livestock from both the stream and riparian zone.

Fences are typically constructed from barbed wire or page wire material. Wooden fences may be required for horses. Fences should be set back from the top of the bank to allow establishment of a riparian zone and lateral stream movement. Fence designs and construction specifications are shown on Figure A1.5.

Watering and crossing points must be constructed so as to exclude livestock from the fenced-off area. Fences or swing gates (to provide for variable flows) can be built across most streams to achieve this objective. An example of a swing gate for livestock crossings is presented in Figure A1.6.

Livestock watering and crossing areas require protection against sedimentation. Entry and exit ramps should have gentle gradients and be constructed of stable granular material. Coarse gravel should be placed to protect the streambed and banks in the accessible area. Additional details regarding streambank fencing and crossings are presented in Table A1.1.

3.8.2 Techniques for In-stream Habitat Creation

As for streambank stabilization, there is a wide selection of techniques used to provide in-stream cover for fish. These techniques involve the installation of various rocks and/or wood structures within the stream channel. Examples are weirs, ramps, deflectors, boulder groups, large organic debris, submerged half logs and log bank cover structures. In some instances, it is possible to create spawning beds or spawning channels for warmwater species such as walleye. Much of the information summarized in the following section is available from a variety of manuals describing these techniques (OMNR, 1984; Alberta Environment, 1986; Adams and Whyte, 1990). The following descriptions of these techniques are adopted from this literature. Sources are noted where appropriate.

The installation of in-stream structures requires that they be able to withstand hydraulic forces. Such structures must be secured to the streambed or to large immobile objects such as trees or bedrock. Improper installation may result in overall habitat loss if the structure is dislodged and causes damage further downstream.

3.8.2.1 Weirs and Ramps

These are termed full-spanning structures which extend across the stream channel and are keyed into both banks. Both techniques are used to create or enhance pool habitat in streams of moderate to high gradient.

Weirs are constructed with either large rocks, logs or both. Weirs may span the channel perpendicularly or diagonally. Variations of diagonal weirs include the "V" and "Y" designs which provide more diverse habitats. Examples of rock weirs showing pool development and scour and depositional patterns are presented in Figures A1.7 and A1.8, respectively.

Ramps are a second type of full-spanning structure constructed of logs, planks and rock. They are ideally suited to small streams with stable flows. An example of a Hewlitt type ramp is presented in Figure A1.9.

Details of full-spanning structures such as application, design and implementation considerations, advantages, disadvantages and costs are included in Table A1.1.

3.8.2.2 Flow Deflectors and Boulder Groups

Flow deflectors are in-stream structures which function to redirect or concentrate flow in order to scour the streambed. Deflectors may be constructed of rock and/or log. The size of rock required is a function of peak flow velocity and stream gradient. Wing deflectors are the most common type employed in southern Ontario. These deflectors may be installed in pairs or as a series of single structures alternating from bank to bank. Such a series of deflectors can be installed along a stream to enhance the natural meander pattern of the watercourse. An example of a rock wing deflector is shown in Figure A1.9.

Flow deflectors are often used in conjunction with boulder groups to create or enhance in-stream structure. Bolder groups typically consist of large rocks arranged in triangular or diamond-shaped configurations.. Such boulder groups often accumulate organic debris (logs, trees, root-wads) which increases the amount of total stream cover. Bolder groups should be placed in or near the thalweg, at the downstream end of riffles or at the upstream end of pools and runs. An example of in-stream habitat creation using boulder groups in conjunction with paired wing deflectors is presented in Figure A1.10.

Details of flow deflector and boulder group structures, such as application, design and implementation, etc., are presented in Table A1.1.

3.8.2.3 Large Organic Debris and Log Cover Structures

Root-wads, trash bundles and trees can be used to increase submerged and overhead cover in streams. Coniferous trees such as cedar are preferred as these will resist rot. Debris should be securely attached to immobilize objects, and should be located in pools or runs along outside curves. These structures are particularly useful in improving rearing habitats in streams. Figure A1.11 shows several techniques for placing and securing large organic debris in streams.

Log cover structures include submerged half logs and log bank cover. These structures are also very useful in improving rearing habitat in small to medium size streams with stable flow. Submerged half log structures consist of logs which are cut in half lengthwise with spacers about 10 cm wide attached at each end of the log on the flat surface. The half log structure is attached to the streambed with rebar inserted through drilled holes in the log and pounded down into the substrate. Figure A1.12 shows a submerged half log installation.

Log bank cover structures are designed to simulate natural cutbank habitats. These structures typically consist of a series of parallel logs that are bound together and anchored at two points along a sharply curving outside bank. Filter fabric is placed over the logs, topped with soil, then vegetated. Log bank cover structures are suitable for small streams. An example of a log bank cover structure is presented in Figure A1.12.

Details on the application, design, implementation, advantages, disadvantages and cost factors for these structures are presented in Table A1.1.

3.8.2.4 Spawning Beds

Artificial spawning beds (for warmwater species such as walleye) have been constructed from rock materials which are placed in-stream. In Ontario, the substrate of choice appears to be limestone rip rap. This material has been used to create spawning habitat where none previously existed. Limestone rip rap has been placed on streambeds to enlarge existing spawning beds. In general, these structures have been successful in attracting spawning fish, particularly walleye but also white sucker.

Care must be taken to avoid downstream movement of the substrate during peak flow conditions. In some situations, excessive siltation may necessitate periodic cleaning of spawning beds.

Details on the application, design, implementation, advantages, disadvantages and cost factors are presented in Table A1.1.

3.8.3 Techniques for Wetland Creation and Enhancement

Wetland creation and enhancement techniques are useful means of restoring spawning, nursery and rearing habitats for many warmwater fish species. Esocids, such as pike, muskellunge and the regionally rare grass pickerel, utilize the flooded marsh vegetation along the margins of rivers in the Welland River watershed and tributaries to the Niagara River. The mid to lower Welland River contains Class I wetlands; however, some tributaries have lost wetlands due to urbanization, agriculture, channelization, etc. These situations are candidates for wetland creation and enhancement projects.

Numerous methods have been employed to construct wetlands for fish habitat. In some instances, it should be possible to combined constructed wetlands for the combined purposes of fish habitat and stormwater (urban and rural) quality enhancement (see Section 3.4.3.15).

Wetlands for fish habitat have been created by damming up the mouths of inflowing tributaries. Earthen dykes with fish passage facilities allow control of water levels and fish access to the created habitat.

In urban stormwater systems, on-line wet ponds can be used as fish habitat, if proper provision is made for fish passage and maintenance of water levels. For channelized reaches or where littoral zone area is limiting, it may be possible to construct wetland embayments which provide excellent fish habitat and recreational opportunities.

Primary considerations in the design of constructed wetlands are grade, water levels and vegetation. Establishing suitable grades and water level regimes are critical for success. Both of these factors are major determinants of vegetation patterns and utilization of the habitat by fish and wildlife.

Suitable spawning substrates are flood-resistant, slender emergent vegetation such as grasses, sedges and spikerush. The preferred vegetation may be introduced to the wetlands by a variety of methods, e.g., natural succession, broadcast seeding, propagate plantings, transplanting, vegetation control, etc.

As for any riparian preparation and plantings, it is highly recommended that qualified professionals be consulted in the planning and implementation of riparian plantings. The Niagara Peninsula Conservation Authority and the Niagara District Office (Fonthill) of the OMNR can assist in this regard.

3.9 Upstream and United States Sources: State-Provincial Relations

3.9.1 Introduction

Many of the environmental problems identified within the Niagara River (Ontario) AOC originate along the U.S. side of the river or upstream in Lake Erie, as outlined in the draft Stage I report. While it is within the mandate of the Niagara River (New York) RAP to recommend remediation measures appropriate for U.S. sources, actions can be initiated by the Niagara River (Ontario) AOC to generate interest in remediation, influence remediation activities, and ensure consistency in addressing cross border environmental problems. This Section briefly outlines some of these types of measures, which generally fall into three broad categories:

- contacts between state and provincial officials;
- agreements between states and provinces; and
- international agreements.

The remainder of this Section will discuss the initiatives within each of these categories. Unlike with other subsections of Section 3 (e.g., rural areas, landfills, urban areas), the initiatives described in this Section will not be screened or evaluated. In the case of different types of agreements, the initiatives cannot be effectively screened in the absence of a specific environmental problem to which they would be addressed. With respect to the different types of contacts, all forms should likely be considered and collectively adopted.

The discussion that follows is based primarily on an excellent study of State/Provincial environmental relations sponsored by the William H. Donner Foundation (Environmental Mediation International, 1985).

3.9.2 Contacts Between State and Provincial Officials

There are a number of different forms of contact that can take place, including:

- informal contacts;
- liaison; and
- official contacts.

These forms of contact constitute different diplomatic methods of influencing the decisions and actions of states and provinces.

Informal Contacts

Officials on both sides of the border have frequently developed informal contacts with their counterparts. Often, board meetings of the International Joint Commission (IJC) serve as the initial focus for these contacts. Informal contacts and IJC meetings provide the opportunity for officials to get to know one another and establish a mechanism to remain in contact. A number of officials have indicated the importance of these contacts because their counterparts represent a familiar face that is 'only a phone call away'.

Informal contacts between officials in similar ministries and agencies are common and have been found to be among the most useful kinds of interactions. These types of contacts work particularly well where the purpose is information exchange or where legislation/regulation exists to back up a request or position. Communication in this case should occur among key individuals in the Ministry of the Environment, the New York State Department of Environmental Conservation, Environment Canada and the Environmental Protection Agency.

There are a few groups or agencies in the U.S. that should be considered when establishing a network of informal contacts. The following list, though not intended to be comprehensive, includes some of these key agencies; (personal communication with Great Lakes United representative):

- Citizen's Environment Coalition (a state-wide environmental interest group based in Albany, New York);
- Great Lakes United in Buffalo, New York; and
- New York State Environmental Coalition (a consortium of over 100 activitists and organizations).

Liaison

These types of contacts are somewhat more formal than informal contacts, often characterized by an officially designated, liaison officer, office or group. An example exists in the state of Maine, where two Canadian Affairs Coordinators have been appointed to handle cross border issues. While the coordinators do not have the authority to resolve cross-border issues, they have the mandate and resources to facilitate decision-making, by assisting in the acquisition and dissemination of information and hosting meetings that bring relevant parties together to discuss and resolve issues.

In Canada, Ministries of Intergovernmental Affairs or similar offices have also begun to handle cross border as well as interprovincial issues. As with informal contacts, liaison-based contacts work best when the purpose is information exchange or when there is a legislation/regulatory basis to back up the request or position. Difficulties arise when there is no jurisdictional mandate to resolve an issue, or when new problems emerge.

Official Contacts

The most formal category of contacts include officially designated Advisory Committees, Working Groups, and ad hoc or permanent Technical Boards. The Niagara River RAP team is such an example. Official groups are generally provided with a terms of reference and specific mandate, and are often justified when there are a significant number of cross border issues that arise. To ensure the effectiveness of committees and working groups, they need to be assigned staff that are dedicated, knowledgeable, and as a group, able to represent the variety of interests relevant to the resolution of cross border environmental issues.

3.9.3 Agreements Between States and Provinces

The Constitutional Setting

It is important to understand the constitutional setting that governs the nature and extent to which states and provinces can enter agreements with foreign entities. In the U.S., the states can enter agreements and contracts with other states and foreign entities, *providing* there is no attempt to increase the power of the state vis a vis the federal government. In Canada, provinces cannot enter into agreements *intended to be binding under international law*, but may enter into arrangements and private contracts that fall short of that prohibition.

Therefore, the constitutional framework of both countries affords considerable latitude to states and provinces to enter agreements with foreign entities. The main limitation is that such agreements cannot encroach on the powers of the federal government or enter the sphere of international law. The agreements, though not binding to government authorities in the strict sense understood in international law, are valid, enforceable contracts under state and provincial laws. As such, they constitute legal methods of influencing and controlling the actions taken by states and provinces.

Types of State-Provincial Agreements

There are essentially four cateogories of operational, State-Provincial, environmental agreements:

- informational agreements;
- managerial agreements;
- commercial agreements; and
- other, miscellaneous arrangements.

Each of these types of agreements can address local or regional environmental problems, and with the exception of informational agreements, frequently incorporate dispute settlement clauses to handle specific types of disputes that may arise under the agreement. Some of these agreements involve federal governments because their 'blessing' is needed to ensure the viability of the agreement, and others involve federal institutions or the IJC because of the nature of the environmental problem.

Informational Agreements

Informational agreements provide for sharing scientific data, joint monitoring of pollution problems, coordinating scientific studies and conducting joint studies. These studies can then be useful in making a political statement to influence federal policymaking, though they are typically not undertaken with this intention.

One example of an information agreement is the Quebec-New York agreement on acid rain, which coordinates the efforts of the two governments to increase their understanding of acid precipitation through joint studies, data sharing and standardized testing. Other examples of informational agreements include the International Michigan-Ontario Air Pollution Board and the Michigan-Ontario Transboundary Air Pollution Committee, where the primary purpose of these bodies is to monitor pollution problems.

Dispute settlement provisions common in managerial and commercial agreements are relatively uncommon in informational agreements, likely because they incorporate non-contentious methods used to address cross border environmental problems.

Managerial Agreements

Managerial agreements provide for cooperative effort to maintain, manage or use a common resource or facility in a manner beneficial to the parties of the agreement. These types of agreements typically focus on developing a practical solution to a mutual problem.

One example of a managerial agreement is the Derby Line-Rock Island agreement between Vermont and Quebec and the federal and provincial environmental agencies. This agreement provides for the construction and operation of a sewage treatment facility shared by the two communities. Another example of a managerial agreement is the Lake Memphremagog Water Quality Management Plan involving Vermont and Quebec, which requires the establishment of a Committee to set compatible water quality objectives, standards and pollution abatement programs.

Managerial agreements differ from informational agreements in that many incorporate a dispute settlement provision. Such provisions often designate a Committee to administer the agreement and resolve disputes. The provisions also include methods of handling unresolved disputes, often requiring submissions to binding arbitration.

Commercial Agreements

Commercial agreements provide for exchange or sale of goods and promotion of travel or trade. Usually economic incentives are impetus for these types of agreements, though additional benefits often include increased services, capacity or convenience.

Examples of commercial agreements include the energy contracts between Hydro-Quebec and the Power Authority of the State of New York and between Ontario Hydro and the Power Authority, which provide the option of buying and selling surplus power to each other. The arrangement allows the power facilities to benefit from excess capacity and to meet peak demands. Another example of a commercial agreement (with a managerial component) is the agreement between Quebec and Vermont regarding the hydroelectric project on the Missisquoi River at North Troy, Vermont.. This agreement relates to the construction and operation of a hydroelectric facility, and its purpose is to minimize the negative environmental effects of the construction and operation of the power project.

As with managerial agreements, commercial agreements generally contain dispute settlement mechanisms because of their contractual nature.

Other, Miscellaneous Arrangements

There are a number of other arrangements between states and provinces that do not fit the above mentioned categories (informational, managerial, commercial). Examples include:

- an agreement between the Public Health Departments of Maine and New Brunswick providing for a contingency plan to coordinate emergency efforts of the agencies in the event of an accident at the Point Lepreau nuclear plant;

- the managerial/commercial agreement concerning the Skagit River and the level of the High Ross Dam;
- the managerial agreement known as The Northeastern Forest Fire Protection Commission, involving New Brunswick, Quebec, Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont. This agreement requires the parties to offer assistance in an emergency and to integrate their fire-fighting programs; and
- managerial agreements between multiple parties, such as the variety of arrangements between the Great Lake states and provinces.

3.9.4 International Agreements

As discussed in Section 3.9.3, states and provinces are restricted from entering international agreements (i.e., agreements binding in international law). However, federal governments can enter into such agreements, and these might represent the most effective means of reducing or eliminating transboundary pollution problems. Examples of international agreements include the Great Lakes Water Quality Agreement and the Niagara River Toxics Management Plan, which provide a mechanism for establishing common goals and schedules of activities, and a legal means of enforcing the actions and activities required of the parties to the agreement.

4.0 RECOMMENDED REMEDIAL OPTIONS AND IMPLEMENTATION CONSIDERATIONS

4.1 Introduction

Section 3.0 identified, evaluated and recommended a number of remedial options for each pollution source. This Section summarizes the options that have been recommended, provides an overview of the basis upon which the recommendation has been made, and addresses some of the key implementation considerations. Remedial options applicable to *landfills* have not been included in this Section because no options have been recommended beyond those already in place, or planned for implementation, at the five landfills of concern within the Niagara River (Ontario) AOC. Table 3.12 summarizes the remedial options in place (or planned) for the landfills of concern. Remedial options applicable to *atmospheric* sources have also been excluded from this Section since many of the air quality concerns originate from much larger regional airsheds and occur within heavily industrialized and populated corridors in New York state. Also, air pollution is not believed to significantly contribute to the Niagara River water quality problems. Beak's Phase I report provides an overview of remedial options for reducing environmental impacts caused by atmospheric sources, including those relating to the Niagara Falls mist (Beak, 1991).

Remedial options are recommended and discussed in this section for each of the other pollution sources. The establishment of priorities among the various options within each source has been attempted, where possible, though no attempt has been made to establish priorities between broad source categories (e.g., urban, rural, public). The determination of priorities is inherently limited by the lack of information on the relative magnitude of contamination caused by specific sources. For example, the relative magnitude of contaminant loadings from urban versus rural sources is unknown. Furthermore, within rural sources, the relative magnitudes of contaminant loadings from rural estates versus agricultural operations is unknown. Without this information, and assuming limited resources, one cannot recommend that urban remedial options be implemented ahead of rural ones, or that septic systems in rural estates be addressed before modifications to agricultural practices. Essentially, these uncertainties make it difficult to recommend or establish priorities among options, both within and between broad source categories.

In order [illegible]ifying priorities, it will be necessary to quantify loadings of toxics in waste streams. For example, for each of the 18 priority pollutants, it will be necessary to identify mass loadings from all potentially significant sources (e.g., stormwater, CSOs, industries, agricultural operations). Once loadings have been estimated, an implementation program focussing on waste minimization/elimination for the priority pollutants can be developed.

4.2 Public Sources

As with many of the other sources, it is difficult to judge the significance of pollution sources and quantify effects, since the problem sources are non-point and their relative contributions are unknown. Though it is expected that the total contribution of individual public sources to the water quality problems of the Niagara River (Ontario) AOC is relatively small, most of the recommended alternatives are cost effective, complement one another, and are likely to yield measurable benefits if adopted collectively. Table 4.1 identifies each of the remedial options recommended for adoption by the public.

Regarding implementation, efforts should focus on elimination and reduction alternatives as a first priority, and control or treatment alternatives as a second priority. This overall strategy is consistent with the ultimate goal of virtual elimination, and embodies the principle of source control to prevent recontamination and continued pollution.

In many cases, public initiatives require support from the government, including funding for ongoing public education programs, and institutional support such as increasing the number of hazardous waste disposal days/depots. Educational programs are key to generating and sustaining public interest, as well as the initiation of remedial options by other sources, such as industry and the agricultural community.

4.3 Urban Sources

The environmental problems within the broad category of urban sources are those principally associated with sanitary sewage and sewage treatment and general stormwater runoff. These problems contribute to various environmental impairments but principally the following:

- water quality impairment by conventional pollutants (nutrients, biochemical oxygen demand, suspended solids/silt, bacteria). This, in turn, can result in impairment of aquatic life through habitat degradation, impairment of recreation uses due to bacterial contamination, and contamination of sediments;
- water quality impairment by toxics found in WPCP effluent, WPCP by-passes, combined sewer overflows and stormwater runoff;
- aquatic habitat impairment through damage or destruction of riparian stream habitat; and
- impaired industrial, municipal and agricultural uses of water resulting from deterioration of the quality of water supplies.

These impairments are not unlike the impairments caused by rural sources within Area of Concern watersheds.

Table 4.2 lists the various urban sources, the alternatives preferred for remediation of these sources, and provides information on rationale, implementation and costing.

TABLE 4.1: RECOMMENDED RE[illegible]L OPTIONS FOR PUBLIC SOURCES

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Household Measures	Conserve water	Water quality	• will result in minor improvements in treatment efficiency and reductions in CSO volumes	• public education important to stimulate and sustain action • indoor water conservation devices, such as low volume toilets, particularly important in rural households • to obtain significant improvements should consider metering and rate increases, though policy implications exist	Moderate
	Reduce use of toxic/hazardous chemicals	• Water quality • Contaminated sediments • Aquatic/biota life	• directly addresses persistent toxics problem • preferred to alternatives directed at proper disposition of toxics	• public education important to increase awareness and advise re: substitute products • promote products having authoritative labelling such as the federal government's 'Ecologo' when purchasing consumer products	Negligible
	Precycle	• Water quality (indirectly)	• indirectly affects water quality by reducing landfill waste volumes • good environmental practice • preferred to alternatives directed at proper disposition of waste	• public education important to increase knowledge of preferable products and packaging alternatives • promote products having authoritative labelling to guide purchasing of consumer products	Negligible
	Toxic/Hazardous Chemicals Use and Disposal	• Water quality	• directly addresses persistent toxics problem • good environmental practice	• public education important • requires institutional support from Region (e.g., increasing the frequency of hazardous waste drop off days)	Negligible

TABLE 4.1: RECOMMENDED REMEDIAL OPTIONS FOR PUBLIC SOURCES (cont'd)

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Household Measures Cont'd	Non-toxic Waste Disposal	• Water quality (indirectly)	• indirectly affects water quality by reducing landfill waste volumes • good environmental practice	• public education important • requires institutional support from Region (e.g., availability/accessibility of recycling facilities and proper waste disposal facilities)	Negligible
	Reuse	• Water quality (indirectly)	• indirectly affects water quality by reducing landfill waste volumes • good environmental practice	• public education important	Negligible
	Septic Tank System Maintenance	• Water quality (bacteria, nutrients)	• minimizes water pollution from conventional contaminants	• low volume toilets and other water conservation techniques may represent more cost-effective solutions because clay soils limit septic system infiltration	Moderate
	Control Pets	• Water quality (bacteria)	• minimizes water pollution from bacterial sources	• public education important • to obtain significant improvements, government support in the form of developing regulation (by-laws) and enforcing compliance should be considered	Negligible
Public Involvement	Lobby government officials	• All impairments (indirectly)	• government support key to the success of many of the remedial options (public, industrial, rural etc.) • would strengthen public's influence over other actors (e.g., industry) and other members of the public	• government support includes many dimensions: financial, regulatory, compliance monitoring, administrative • begin by writing letters, initiating telephone conversations or informal meetings with MP's • emphasize <u>positive</u> forms of government support, such as economic incentives, rather than negative forms such as increased regulation or punitive measures	Modest

TABLE 4.1: RECOMMENDED REMEDIAL OPTIONS FOR PUBLIC SOURCES (cont'd)

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Public Involvement (Cont'd)	Participate on Advisory Committees, Working Groups etc.	• All impairments (indirectly)	• proactive approach that enables the public to assist in finding/implementing solutions • ensures that the public directly protects their own interests	• government support may be helpful to attract/sustain public participation • contact industry and government officials to determine existence of environmental committees, eligibility, application requirements, responsibilities of membership, etc.	Modest
	Public Education	• All impairments (indirectly)	• education is one of the key components to ensure that the public is on an equal footing with other actors and to maximize their ability to influence others • key to the success of many other remedial options (e.g., industrial, rural, etc.)	• on-going program important • funding to develop and offer educational programs available from a number of sources (e.g., Great Lakes Protection fund, Green Plan) • important to obtain information on success stories in all sectors, to focus the public's efforts and discussions and to sustain interest in solving environmental problems • important to consult with Boards of Education to ensure public school curricula reflect environmental values and promote good environmental practice	Moderate
	Agreements between communities and industry	• All impairments (indirectly)	• formalizes relationships and documents commitment from industry • documents expectations from the community	• refer to 'Good Neighbour' agreements in U.S. for guidance concerning content and respective commitments of industry and community members • should seek legal/government advice in order to prepare agreements • include monitoring program and responsibilities of both parties	Negligible

TABLE 4.2: RECOMMENDED REMEDIAL OPTIONS FOR URBAN SOURCES

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Urban Sources					
Household Source (various)	see Table 4.1				
Spills	Spill prevention planning, spill response planning	Variable, potentially any beneficial use may be impaired by spills	Required in handling of hazardous chemicals, wastewaters, to minimize water quality impacts, sewage plant impacts	• MOE has spills response program in place • spills prevention plans should be developed by industry where needed	low
Industrial/Commercial Dischargers (to sewer)	Sewer use by-law enforcement	Water quality, aquatic biota/fishing problems, contaminated sediments	Results in source reduction-elimination	• Ensure toxics are included • More intensive monitoring may be required • Need for stricter by-laws may be identified by monitoring at WPCPs	moderate
Construction Sites	Sediment controls (vegetation, detention ponds, filter strips, etc.)	Water quality, aquatic biota (siltation)	Construction sites are localized, significant sources. A priority source for control	May require limits on extent and duration of stripping soil, use of various erosion control and sediment control	low
Combined Sewer Overflows, Bypasses at WPCPs	Storage and treatment	Water quality recreation, fisheries, sediment quality	• For handling large waste volumes and providing adequate treatment • Provide for treatment of stormwater as well as sanitary overflow	Requires construction of storage capacity at WPCPs or elsewhere	~$50M
Municipal Infrastructure	Rehabilitation, upgrading	Water quality, recreation, fisheries, sediment quality	To reduce infiltration/inflow into sanitary sewers; to increase capacity where necessary	Costly pollution control measures, optimize with storage/treatment and WPCP expansion options	~$300M
Urban Runoff	Various measures to reduce storm runoff rates and improve stormwater quality including wetlands creation, reforestation, urban retrofitting, natural chemical design, erosion and sediment control, detention/retention ponds, infiltration facilities, oil/grit separators, filter strips, vegetated swales, etc.	Water quality, recreation, aquatic life/fisheries, sediment quality	To reduce impacts of stormwater-stormwater impacts in terms of pollutant, and toxic loadings are typically ten times greater than CSO impacts	Done gradually, requires an array of practices	~$300M for existing areas; costs born by developers for new development

TABLE 4.2: RECOMMENDED REMEDIAL OPTIONS FOR URBAN SOURCES (cont'd)

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Water Pollution Control Plants	General operational options - process automation, operator training, C of A revision, monitoring, communication	Water quality, recreation, aquatic life/fisheries, sediment quality	To streamline existing plant operation and identify, monitor toxics loadings	Programs can be developed in cooperation with MOE	low
	Expanded monitoring for NRTMP targeted toxics in influent/effluent	Water quality, aquatic life/fisheries sediment quality	To monitor toxics loading and identify need for source control	Integrate with routine monitoring programs	low
	Engineering options - expanded secondary treatment capacity	Water quality, recreation	To provide full treatment of wet weather flows	Optimize with storage/treatment options and infrastructure rehabilitation/upgrade option	$50-$150M

At present, it is not possible to identify the degree of environmental improvement that will result from the implementation of any specific remedial option. This is because the relative magnitude of urban versus rural sources and the relative magnitudes of the various urban sources in terms of pollutant loadings have not been identified. Because of the high cost of implementation of some of the engineered remedial alternatives appropriate for urban settings, it is strongly recommended that watershed management plans first be developed for the Welland River and for the Ontario portion of the Niagara River before proceeding with major engineering initiatives. The watershed management plans would include the identification of:

- the relative magnitudes of loadings of suspended solids, nutrients and toxics from various sources;
- remediation of specific sources on a priority basis;
- specific policies for the protection or enhancement of natural features (wetlands, buffer strips) that are protective of aquatic resources;
- more specific controls on land development for minimizing environmental impacts; and
- more refined estimates of the costs of implementing specific remedial options.

Watershed plans are currently being undertaken within many regions in Ontario. The studies are generally carried out at a tributary level (e.g., Lyons Creek, Chippewa Creek), and will assist in identifying specific problems, concerns and solutions within the study area. The watershed plans would probably cost about $250,000 per study.

As noted above, an effort should be made to construct a mass balance for toxic contaminants discharged to the environment within the Area of Concern. This would entail a compilation and review of all existing monitoring data on concentrations and flows, particularly in combined sewer overflows (CSOs), storm sewers and sewage treatment plants. Additional monitoring may then be required to quantify or confirm these loadings sufficiently so that remedial actions can be effectively directed towards the most significant and the most controllable sources. As shown in Section 3.0, the concentrations of conventional pollutants and toxics in stormwater and CSOs are generally similar, at least in other municipalities, so that the relative loadings from the two sources are equally proportional to flow. However, because stormwater flows are typically much greater than CSOs, it is likely that loadings of pollutants can be more effectively reduced by remediation of stormwater runoff than by remediation of combined sewer overflows.

In terms of implementation, it is recommended that all of the alternatives identified as "low" or "moderate" in cost be commenced in the near future. Where necessary, this will require some degree of planning control, particularly where municipal-level approvals processes control new development. The most important aspects here are stormwater management and control in all new development or redevelopment projects.

For the more costly pollution control options, it appears that storage and treatment options should be developed in detail for the management of CSOs, as this alternative has generally been found to be more cost-effective and environmentally compatible than sewer separation. Further work will, however, be required to define the impact on the WPCPs due to the increased flow volumes associated with storage of combined sewage.

4.4 Industrial Sources

Remedial options for industry addressed in this report focus on a subset of the 15 industrial facilities recognized as toxic dischargers by the NRTC. As noted in Section 3.4.2, the review and evaluation of options focuses on facilities identified as 'Significant' and 'Minor' contributors of toxics discharges. Table 4.3 identifies recommended remedial options for five of the fifteen industrial facilities. The preferred alternative to reduce toxics discharges for three of the five facilities is a glycol-based and/or evaporative water recycle system for cooling water used in the plants. While the capital cost of this alternative ranges from $100,000 to $1,000,000, operating cost savings are expected to result from a reduction in purchased water.

For two of the plants, studies are currently being undertaken to determine why C of A requirements are not being met (Cyanamid, Welland) and to determine the effectiveness of various alternatives for containing and treating nearby storm water runoff (Canadian-Oxy). The results of these studies will likely suggest further remedial options.

In addition to the above options, it is recommended that industrial effluent be monitored for toxic contaminants targeted for reduction and eventual elimination in the Niagara River Toxics Management Plan.

With respect to the Laidlaw Environmental Services Facility, which the NRTC has identified as an 'Unknown' toxics discharger, no remedial options are recommended. Also, further study is unnecessary to clarify the uncertainty, as the likelihood of toxics discharge to the Niagara River AOC is minimal; the facility is a waste transfer station without any process waste streams.

While this study focused on options applicable to toxics dischargers, the evaluation and monitoring of non-toxic discharges and other waste management practices for all industrial facilities within the Niagara River (Ontario) AOC should also be undertaken. To the extent that such discharges and practices have a detrimental impact on water quality within the AOC, remedial options should be identified and evaluated to address these sources. The severity of impacts and the costs and effectiveness of remedial options will have to be compared with the impacts and options that have already been identified for toxic discharge sources, with the intent on determining overall priorities.

TABLE 4.3: RECOMMENDED REMEDIAL OPTIONS FOR INDUSTRIAL SOURCES

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Fleet Manufacturing	Glycol-based and/or Evaporative cooling tower recycle systems	Water quality (toxics, solvents)	• would eliminate remaining direct discharge concern regarding non-contact cooling water • would yield cost savings due to reduction in purchased water • currently being considered as a potential capital project	• convert cooling loops for autoclaves and air compressors	\$100,000 - \$1,000,000
Atlas Specialty Steels Division	Cooling ponds or evaporative cooling tower recycle systems	Water quality (heavy metals, solvents)	• current effluent flow volumes suggest recycling potential	• should attempt to reduce effluent discharges to less than 5 m^3/tonne of steel production (currently: 30 m^3/tonne) • a small net blowdown is still required to control build-up of total dissolved solids in cooling loops • a final clarification step using hydroxide and polymer may enhance treatment • recycling process should likely exclude treated effluent from finishing operations given high concentrations of dissolved solids	\$1,000,000 - \$10,000,000
Cyanamid of Canada, Welland Plant	?	Water quality (heavy metals)	• plant has had recent difficulty achieving the non-acutely lethal effluent discharges required under the C of A	• current study is in progress to determine why C of A requirements are not being met • more data from this plant are required in order to determine most cost-effective methods for toxics reduction	?
Cyanamide of Canada, Niagara Falls Plant	–	Water quality (cyanide, heavy metals)	• Cyanamid announced in early 1992 that this plant would cease operations before the end of the year	• consider required decommissioning and site remediation activities	–

TABLE 4.3: RECOMMENDED REMEDIAL OPTIONS FOR INDUSTRIAL SOURCES (cont'd)

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Canadian-Oxy Chemicals Limited	Double circuit closed glycol loop and/or evaporative cooling tower recycle system	water quality (phenols)	• would eliminate direct discharge concern regarding non-contact cooling water • would likely yield cost savings due to reduction in purchased water	• replace once-through cooling system used in the flaker operation (major source of cooling water use in the plant) • blowdown (spent water) may contain traces of phenol hence consider discharging to the sanitary sewer	$100,000 - 1,000,000
	Contain and treat stormwater runoff (in vicinity of processing areas and product handling/storage areas)	water quality (phenols)	• company continues to have difficulty maintaining phenol concentrations at acceptable levels during wet and dry weather • company currently examining alternatives	• current study of alternatives in progress • more data required in order to determine the need, cost and effectiveness of alternatives	?

4.5 Rural Sources

Rural sources of contamination concentrate on non-point source runoff as it relates to problems of siltation and suspended solids, eutrophication and pesticide contamination. While a number of remedial options have been recommended (see Table 4.4), it is difficult to establish priorities given the lack of information on the relative significance of specific rural sources.

For a number of the remedial options identified in Table 4.4, the costs are likely to be minimal, particularly when benefits have been taken into account. Examples of some of the benefits include reducing the use of pesticides due to minimization of pest and disease problems, reducing the number of agricultural operations, and eliminating exposure to EPA penalties/charges. In other cases, equipment and expertise may be available from the Conservation Authority, or subsidies may be available from a variety of sources. Unfortunately, the demand for agricultural subsidies to assist in making progress towards environmental objectives far exceeds the supply of available funds. The current narrow profit margins in farming often encourage short run thinking (rather than sustainable, long run farming practices) and create incentives to sever and sell agricultural property to developers.

Realistically, implementation of most remedial options to address the environmental problems in rural areas will require financial support and government assistance. Prior to the commitment of significant funds, a study should be undertaken to identify, evaluate and priorize specific problem sources and remedial options. The need for such a study has already been identified by the Niagara Peninsula Conservation Authority. Though funding constraints have prevented the study from being undertaken, funding of approximately $10,000.00 have been estimated to be sufficient to complete the preliminary field reconnaissance component of such a study, and the results are a prerequisite to targeting remedial activities and ensuring that scarce agricultural resources are put to their best use.

4.6 Contaminated Sediment Sources

The primary difficulty in addressing environmental problems relating to contaminated sediments is that the sources are largely unknown. This is primarily true for both the Welland and Niagara River watersheds, though initial efforts should concentrate on the Welland River where contaminated sediment is more widespread.

As identified in Table 4.5, further study is recommended as the first priority for addressing contaminated sediments in the Welland River watershed. This study, and any remedial options for source control suggested by the study, should be implemented prior to considering sediment removal or disposal/treatment (unless health concerns exist). The focus should be on the one highly-contaminated area recently identified in an MOE-sponsored study. Regarding sediment removal, suction dredging techniques are generally preferred because they minimize contaminant migration. A suction dredge operation is

TABLE 4.4: RECOMMENDED REMEDIAL OPTIONS FOR RURAL SOURCES

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Household and Agricultural	Public Education	• siltation and suspended solids • eutrophication • pesticide contamination of water and sediment	• relatively inexpensive method of developing an understanding and awareness of pollution problems, solutions and funding sources • potential funding sources include: CURB, National Soil Conservation, Land Stewardship, Green Plan Programs	• needs to be ongoing • OMAF assistance important • supports/reinforces a number of other options recommended for rural and other sectors • should be accompanied by study which identifies, evaluates and priorizes sources	moderate
Farming Practice	No tillage	• soil erosion and siltation	• slows runoff and soil erosion by preserving vegetative cover and organic matter • operating costs less than conventional tillage as planting and cultivation combined	• consult OMAF for determination of impact on crop yields • equipment may be available on loan from Conservation Authorities	$20,000 (equipment)
	Conservation tillage	• soil erosion and siltation	• relatively inexpensive method of minimizing soil loss	• consult OMAF for determination of impact on crop yields • chisel plough most commonly used and fits onto existing farm machinery	$5,000 - $7,000 (equipment)
	Crop Rotation	• soil erosion and siltation • pesticide contamination of water and sediment	• good farming practice that minimizes pest and disease problems, replenishes soil nitrogen levels, reduces soil losses	• consult OMAF for determination of crops which will replenish soil nitrogen levels, reduce soil losses	negligible given benefits
	Establish Buffer Strips	• soil erosion and siltation	• slows runoff and soil erosion by establishing a natural vegetative barrier	• consult with Conservation Authority to determine appropriate width of buffer zone • buffer zone requires protection from uncontrolled access by livestock (consider fencing)	negligible given benefits
	Reduce water use	• water quality (bacterial, phosphorus)	• it is well known that rural septic systems in the Welland River watershed promote surface water runoff and contamination due to low infiltration rates (clay soil) • relatively inexpensive solution that will reduce hydraulic loading by 28%	• replacement of standard toilets with low-volume toilets • houses in Binbrook Reservoir watershed may be eligible for 50% funding through CURB program	$250 (6-litre toilets)

TABLE 4.4: RECOMMENDED REMEDIAL OPTIONS FOR RURAL SOURCES (cont'd)

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Farming Practice (cont'd)	Improved Manure Storage	• water quality (bacteria)	• direct pollution of surface water by manure is an EPA offence • subsidies available	• consult OMAF to determine availability of subsidies to construct proper storage facilities (e.g., pits, concrete berms) • setback from streams to minimize contamination potential	moderate
	Control manure spreading	• water quality (bacteria)	• direct pollution of surface water by manure is an EPA offence	• consult OMAF for specific advice • general advice is to not spread manure on frozen ground, or close to drainage ditches, streams	negligible
	Spring tillage	• soil erosion and siltation	• slows runoff and soil erosion by minimizing time that fields are not covered by crops or organic matter • reduces nutrient losses resulting from runoff during snowmelt period	• plough in spring rather than fall	negligible
Land Use Controls	Limit land development	• soil erosion and siltation • pesticide contamination of water and sediment • water quality	• would contribute to environmental improvements by reducing construction runoff, unnecessary pesticide use, inefficient septic systems • may be difficult to justify under current economic pressures	• establish policy for limiting severences and sale of agricultural land to developers • consult with regional/local planning departments to determine policy alternatives	moderate - high
	Re-establish floodplain integrity	• soil/streambank erosion • water quality • fish and wildlife habitat	• floodplain system provides natural bank stability/erosion control, removes nutrients and pollutants, enhances habitat values	• similar to buffer strip option, may be more expensive	slight-moderate
Structural Measures	Wetlands	• aquatic, biota, wildlife, • water quality	• cost effective method if use/ maintain natural wetlands • can remove solids, control runoff, remove nutrients and pesticides	• consult with MNR to determine incentives to remove wetlands from production • artificial wetlands may be used to treat runoff for large, intensive livestock operations	negligible (natural wetlands maintenance)
	Fencing	• vegetation • soil/streambank erosion • water quality	• direction pollution of surface water by manure is an EPA offence	• livestock should be prevented access to streams and riparian buffer strips	moderate
	Revegetation	• soil erosion and sedimentation	• support available from regional authorities	• consult with the Region and Conservation Authorities to target revegetation efforts towards erosion - prone areas • maintenance important • roadside ditch cleaning by the Region and and grassing drainage ditches or swayles should be considered	moderate

TABLE 4.4: RECOMMENDED REMEDIAL OPTIONS FOR RURAL SOURCES (cont'd)

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Structural Measures (cont'd)	Upgrade drainage ditches	• soil/streambank erosion • water quality	• eroding ditches can be significant sources of siltation	• bioengineered banks, application of fluvial geomorphological principles	moderate

TABLE 4.5: RECOMMENDED REMEDIAL OPTIONS FOR CONTAMINATED SEDIMENT SOURCES

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Atlas Steel - Atlas Reef	Source Control, Suction - Dredge technology, siltation controls	• Sediment contamination • Water quality	• known point source • source control already in place • preliminary trials already completed with acceptable results re: losses of suspended particulates and treatment/disposal of dredged material	• Atlas Steel has already remedied the source of the problem (particulate heavy metal losses in wastewater) • Intake methods should be designed to minimize losses of suspended particulate downstream • continued testing of technology required, as well as leachate trials to determine classification/ treatment of dredgate	Moderate
	Communication	• Sediment contamination • Water quality	• facilitates the exchange of information on remediation progress and the need for further information/data • may assist in uncovering historical information useful in analyzing current pollution problems	• program should be ongoing • requires liaison between agency responsible for cleanup coordination, industry, the public, and those undertaking studies to identify pollution sources or source control measures	Low
	Monitor	• Sediment contamination • Water quality	• Key component to monitor progress and target further remedial efforts	• focus on measures of effects (e.g., improvements to water quality and sediment contamination) and efforts (e.g., completion of studies, installation of pollution abatement equipment)	Low-moderate
Welland River	Source Control	• Sediment contamination • Water quality	• generally this is the first step in a remediation plan	• supporting study required to identify the sources of contamination and to develop specific control plans • detailed investigations particularly warranted for sampling station 9 (see Tarandus study) and other locations close to storm sewer outfalls	Moderate - high

TABLE 4.5: RECOMMENDED REMEDIAL OPTIONS FOR CONTAMINATED SEDIMENT SOURCES (cont'd)

Problem Sources	Preferred Alternatives	Impairments Addressed	Rationale	Implementation	Cost
Welland River (Cont'd)	Sediment removal	• Sediment contamination • Water quality	• necessary component of remediation strategy	• consider once source controls have been implemented, unless potential direct health concerns are identified (e.g., PAH - contaminated sites) • through specific techniques depend on extent and nature of problem, generally suction dredging preferred to other methods because it minimizes contaminant migration • cleanup operations should include siltation controls such as silt curtains, bottom traps and surface booms	$50,000 - 150,000 per month (suction-dredging)
Niagara River	Source control	• Sediment contamination • Water quality	• generally this is the first step in a remediation plan	• supporting study required to identify the sources of contamination and to develop specific controls • a number of sources have been implicated from previous studies • contaminated sediments in headpond reservoir of Ontario Hydro's Sir Adam Beck Generating Station have been identified and sources controlled; continued monitoring required to detect contaminant mobility (which would then justify further remediation)	moderate - high

estimated to cost between $50,000 and $150,000 per month, excluding the costs of siltation controls.

Historic wastewater discharges from Atlas Steel are responsible for the 'Atlas Reef' in the Welland River. Source control has already been implemented at the plant to eliminate the particulate heavy metal losses in wastewater. Suction-dredging technology, combined with siltation controls, is currently being tested by Atlas Steel to remove the sediment. Studies of the classification of the resulting dredgate are also underway.

Regarding the Niagara River watershed, further study is also required to identify sources of sediment contamination. A number of sources have already been implicated, but prior to taking any remedial action, sources should be confirmed and options identified appropriate for each source. Contaminated sediments do not generally accumulate in the Niagara River due to the strong currents, so that sediment cleanup is not specifically recommended at this time.

4.7 Physical Habitat Disruption

Fish habitat within the Area of Concern has been impaired by disruption or loss of riparian habitat, streambank erosion and siltation, in-stream alterations and loss of wetlands. As noted in Chapter 3.0, many options are available for remediating such problems, and the specific approach to a damaged area must be selected on a site-by-site basis. Because many of these options can be implemented at low cost by public volunteer groups and are known to be very effective at improving fish habitat, it is recommended that such measures be implemented broadly within the watersheds draining into the Niagara River, and particularly in the Welland River.

Prior to commencing a physical habitat remediation program, it is recommended that problem areas in terms of riparian zone disruption be identified and prioritized by severity and extent. This can be done in consultation with the Niagara Peninsula Conservation Authority. In terms of in-stream enhancement, either or both the Conservation Authority and the Niagara District office of the Ministry of Natural Resources should be consulted. Consultation with these authorities is also recommended to secure the appropriate engineering and scientific expertise required to undertake many of the measures, and to obtain access to available financial support.

Funding for such projects may be available from the Ontario Ministry of Natural Resources through their Community Fisheries Involvement Program or Community Wildlife Involvement Program. In agricultural areas, funding may be available to the farming community through the provincial and federal funding programs noted in Section 3.0 for initiatives such as fencing to prevent livestock access to streambank areas. On industrial land located along stream and river banks, industries may sponsor public activities in rehabilitating damaged areas, providing safety and security concerns can be met.

4.8 Upstream and United States Sources

While it is known that the majority of the environmental problems within the Niagara River (Ontario) AOC originate along the U.S. side of the river or upstream in Lake Erie, the identification and evaluation of remedial options appropriate for these sources is not within the mandate of the Niagara River (Ontario) RAP. Furthermore, there is little evidence to suggest that transboundary environmental problems have been effectively addressed by aggressive legal or diplomatic action. The two, practical options available to the Niagara River (Ontario) RAP are:

- to set an example in Ontario by implementing remedial options targeted at Ontario sources; and
- to develop and maintain informal and formal relations with counterpart agencies and organizations in the U.S.

Adoption of the remedial measures recommended elsewhere in Sections 3 and 4 of this document address the first option. The second option requires time and commitment, and is likely to go through a series of steps ending in the development of a formal agreement between a state and province. Such a formal agreement is premature until viable options are identified that can be undertaken by each jurisdiction to address their respective problem sources. It is recommended that at this time, informal communications begin (or continue) between New York and Ontario officials and members of the public.

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APPENDIX 1

Detailed Comparison of Remedial/Rehabilitative Measures for Damaged Riverine Systems

TABLE A1.1: DETAILED COMPARISON OF REMEDIAL/REHABILITATIVE MEASURES FOR DAMAGED RIVERINE SYSTEMS

Technique	Application	Design and Implementation Considerations	Advantages	Disadvantages	Cost Factors
Bank Stabilization:					
• Rock Rip Rap	• bank slope not greater than 1.5:1 • maximum water velocity not to exceed 4.0 m/s • manual installation possible only on small projects • machinery often essential for largest rocks	• size, shape and type of rock • slope, thickness and alignment of riprap layer • rock must be hard, angular and of varying sizes • largest rocks placed at toe of bank • determine appropriate rip rap size based on maximum flow velocity	• stable at almost all flow levels • very durable • simple to install • provides fish habitat	• usually requires heavy machinery for some construction phases • potential for unnatural appearance • high material cost	• as high as $60.00/m² • proximity and availability of suitable rock • accessibility of site • amount of site preparation • amount of work requiring heavy machinery
• Log/Timber Walls and Crib	• suitable for low banks requiring temporary stabilization • not applicable to streams with spring ice movement • limited to streams <6 m wide with firm bottoms • volunteer effort can be used	• coniferous trees or pressure-treated timber only • logs must be trimmed and debarked before use • armouring may be required to protect the structure • structure must be anchored into the bank • design may also include overhanging planing which provides cover for fish • cribs may be used in combination with rock rip rap to provide additional bank protection • lifespan will vary greatly; therefore, maintenance may be required • pressure-treated timber more costly, but is considered more durable	• excellent potential for volunteer labour • good application for small watercourses • provides fish habitat • low cost	• only moderately durable • relatively complex to install • maintenance required • potential for unnatural appearance	• as little as $10.00 per linear metre • use of native material versus timber for construction • degree of volunteer labour which can be utilized
• Tree Revetments	• low banks • medium to small streams • outside curves • ideal for volunteer installation	• do not trim branches • conifers are preferred • use green bushy trees • install trees snug against bank and anchor using cables and deadman • use adequate size and amount of rock rip rap	• excellent projects for volunteer organizations • actively stabilizes bank • provides fish habitat • low cost • relatively simple installation • semi-natural appearance	• less durable than other structures • maintenance requirements may be high • may require use of backhoe	• cost $5.00 to $10.00 per linear metre of bank • height of structure • native materials versus brought in
• Live Soft Gabions and Cribs	• slope may be 1:1 • very broad applicability from large to small streams • smaller project can use volunteer labour • larger work requires heavy machinery and are also labour-intensive	• timing of construction and preparation of cuttings • works must be isolated from flow during construction • large projects may require geotechnical and engineering studies during design phase • structures will be self-repairing • rock material should be used to provide stable base • short-term protection may be necessary during establishment phase	• very durable • excellent projects for volunteer organizations • some materials are low cost • very natural appearance • self-repairing	• some construction phases may require heavy machinery • some materials are high cost • some expertise is required	• $50.00 to $150.00 per linear metre of bank • height of bank to be stabilized • slope of bank - steep gabions more expensive • availability and proximity of materials

TABLE A1.1: DETAILED COMPARISON OF REMEDIAL/REHABILITATIVE MEASURES FOR DAMAGED RIVERINE SYSTEMS (cont'd)

Technique	Application	Design and Implementation Considerations	Advantages	Disadvantages	Cost Factors
Riparian Plantings: • Seed, Hydroseed, Mulch • Sods • Stakes/Wattles • Nursery Stock • Transplants	• where fish habitat is limited by loss of riparian vegetation • low to moderate gradient streams with stable channel • slopes < 1.5:1 are ideal; steeper slope will require stabilization • seeds, sods, stakes and wattles for steeper slopes • nursery stock and transplants on more gentle slopes	• site preparation essential for success • unstable streambanks must be stabilized prior to plantings • topsoil may have to be brought to site • in-stream sediment controls may be required during slope manipulation • timing of plantings will vary depending on technique employed • seeding and sod applications usually occur during spring • work with cuttings and transplants occur during dormant season	• Seeding: - simple - effective on some slopes in conjunction with mulch or mats - hydroseeding is also effective	• Seeding: - no immediate stability is achieved - vulnerable to drought - erosion may wash seed away prior to germination	• approximate costs vary from \$2.00 to \$5.00/m^2 depending on method • amount of site preparation required
			• Sod: - immediate protection of exposed soil - can be transplanted from native stock - volunteer labour may be used	• Sod: - commercial sod expensive - heavy machinery required to transplant sod	• approximately \$1.50 to \$2.00/m^2 • amount of site preparation • availability of native material
			• Cuttings: - high success rates - material may be readily obtainable from native stock - volunteer labour may be used	• Cuttings: - summer cuttings exhibit shock - large projects will require location of numerous donor sites	• \$1.00 to \$10.00/m^2 depending on method • amount of volunteer labour required • availability and proximity of materials
			• Transplants: - large specimens provide immediate overhang - native stock may be readily available - volunteer labour may be used	• Transplants: - heavy machinery may be required - large projects will require location of numerous donor sites	• typical project costs vary widely depending on methods and proximity and availability of materials • generally \$2.00 to \$5.00/m^2
			• Nursery Stock: - large specimens provide immediate overhang - nursery stock easily handled - volunteer labour may be used	• Nursery Stock: - availability of some species not consistent - materials costly	• high costs for some materials • amount of site preparation • utilization of volunteer labour
• Streambank Fencing and Crossings	• where livestock have degraded short reaches of stream habitat • on streams with low to moderate gradient • minimal lateral shifting • avoid fencing on streams subject to debris-laden floods	• landowner cooperation is essential • fencing materials will vary depending on livestock and landowner requirements • allow sufficient setback from top of bank • straight fence line is desirable • exclusion of livestock and protection of bank at crossing/watering locations • suitable access ramps • use of pressure-treated wood is desirable	• desirable, low maintenance • very effective while allowing access for livestock • natural succession will ensure riparian recovery • buffer strips provide wildlife habitat	• high cost for material and installation • crossing/watering locations may require expensive protection works • natural recovery may be slow	• high material and installation costs • \$5.00 to \$10.00 per linear metre of fencing • \$10.00 to \$15.00 per metre at crossings • costs depending on type of fence and number of bends

TABLE A1.1: DETAILED COMPARISON OF REMEDIAL/REHABILITATIVE MEASURES FOR DAMAGED RIVERINE SYSTEMS (cont'd)

Technique	Application	Design and Implementation Considerations	Advantages	Disadvantages	Cost Factors
In-Stream Cover: • Weirs • Ramps • Flow Deflectors • Boulder Groups • Organic Debris • Log Cover Structures	• streams in which in-stream cover and pools are limiting habitat quality • streams with gradients between 0.5 to 3.0% • low banks • small to large streams	• full-spanning structures built at some angle to direction of flow • proximity of plunge pool to weir is dependent on slope of weir face • sloped weirs create pools further downstream from weir than vertical weir faces • weir must be keyed into both banks for stability • in-stream work should take place during the late summer, low flow period • ramps suitable only for small streams	• suitable for volunteer labour • low maintenance requirements • large organic debris may accumulate on structures • if native material is available, costs will be low • many secondary benefits for aquatic ecosystem	• labour and material costs may be high • placement of large boulder is expensive • moderate durability • construction may require in-stream use of heavy machinery • detrimental hydraulic effects, e.g., erosion may be induced by poorly installed structures	• typical costs $10.00 to $15.00 per structure depending on method • accessibility • heavy machinery requirements • amount of volunteer labour used
• Spawning Beds	• in streams where spawning habitat is limited by lack of suitable substrate • moderate stream gradients	• rip rap size dependent on hydraulic conditions • limestone rip rap is preferred • rip rap must be angular • spawning substrate must be secure from movement during peak flow conditions • flow deflectors may be used to scour spawning substrate after installation • periodic cleaning may be required • consult Habitat Suitability Index models for target species	• often suitable for volunteer labour • relatively durable • if native material available, material costs will be low • provides key habitat for fisheries restoration	• large project requires heavy machinery • material costs may be high • peak flow conditions may damage structure • may require periodic maintenance	• costs $10.00 to $60.00/m² • accessibility • heavy machinery requirements • engineering requirements
Wetland Creation/ Restoration	• streams which have lost wetlands • low gradient streams • good projects for volunteer groups	• grade, water levels and vegetation • wetlands may be dual function, i.e., both fish habitat and stormwater treatment • often suitable for volunteer labour	• low maintenance • low cost unless heavy machinery is required	• some phases may require in-stream work with heavy machinery	• costs vary from $10.00 to $40.00/m² • increased costs if heavy machinery required • increased cost if revegetation does not occur naturally • cost of water level control structure and/or fishway

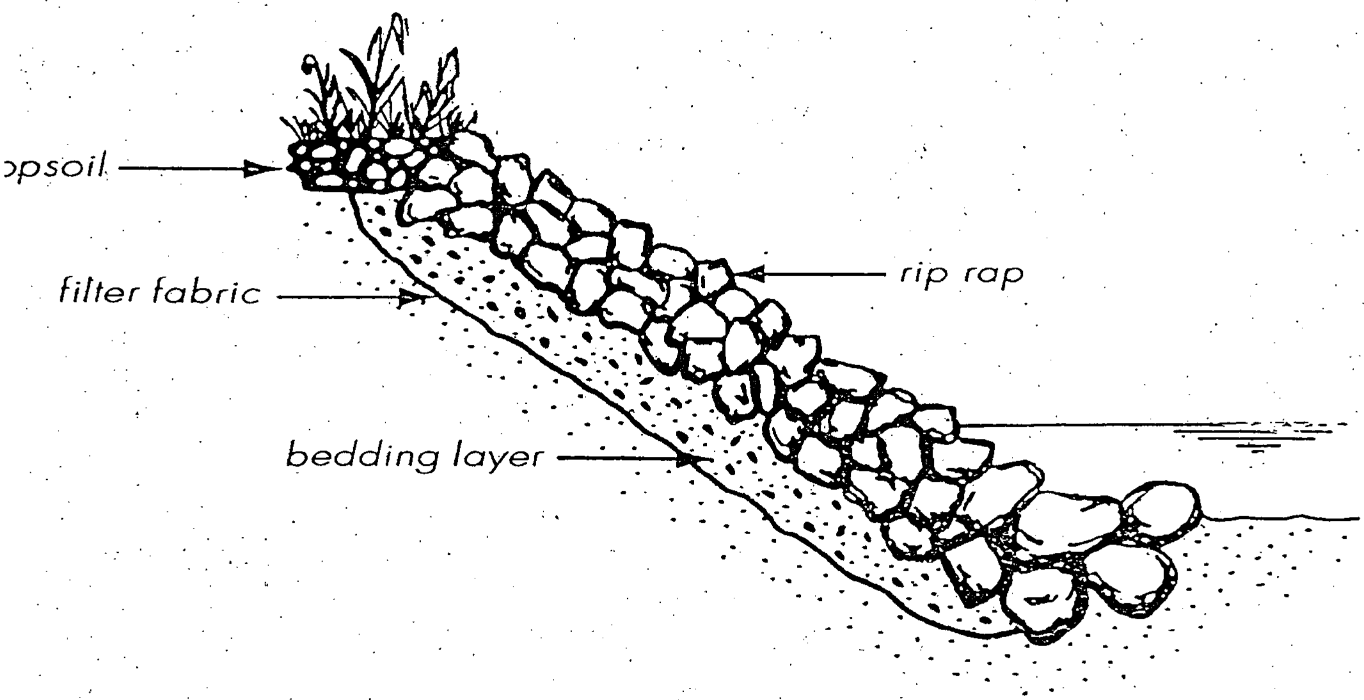

Figure A.1.1: Example of rock rip rap installation. (Source: Adams and Whyte 1990)

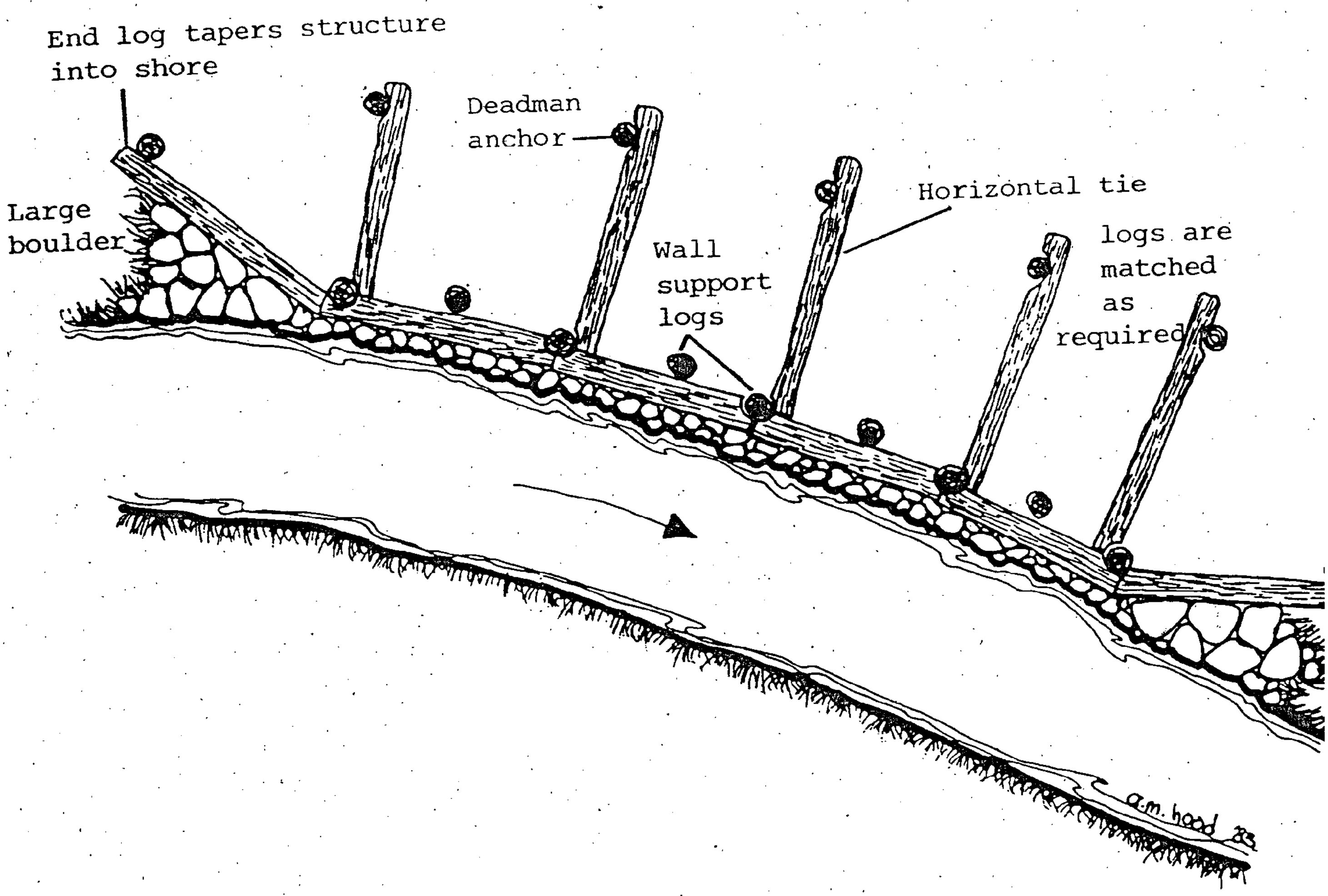

Figure A.1.2: Plan view of exposed log wall structure. (Source: OMNR 1984)

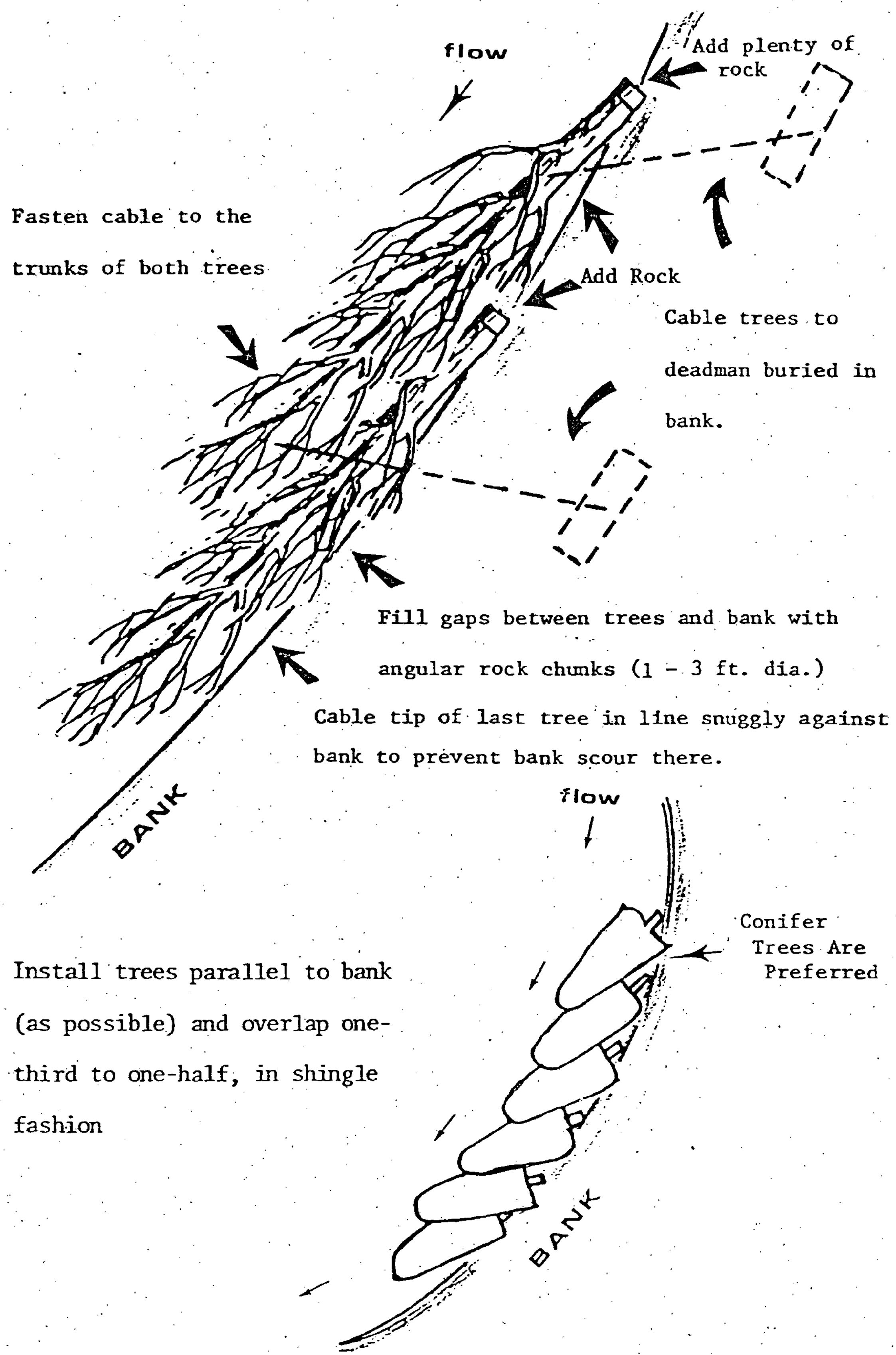

Figure A.1.3: Diagram of a tree revetment structure. (Source: Binns 1986)

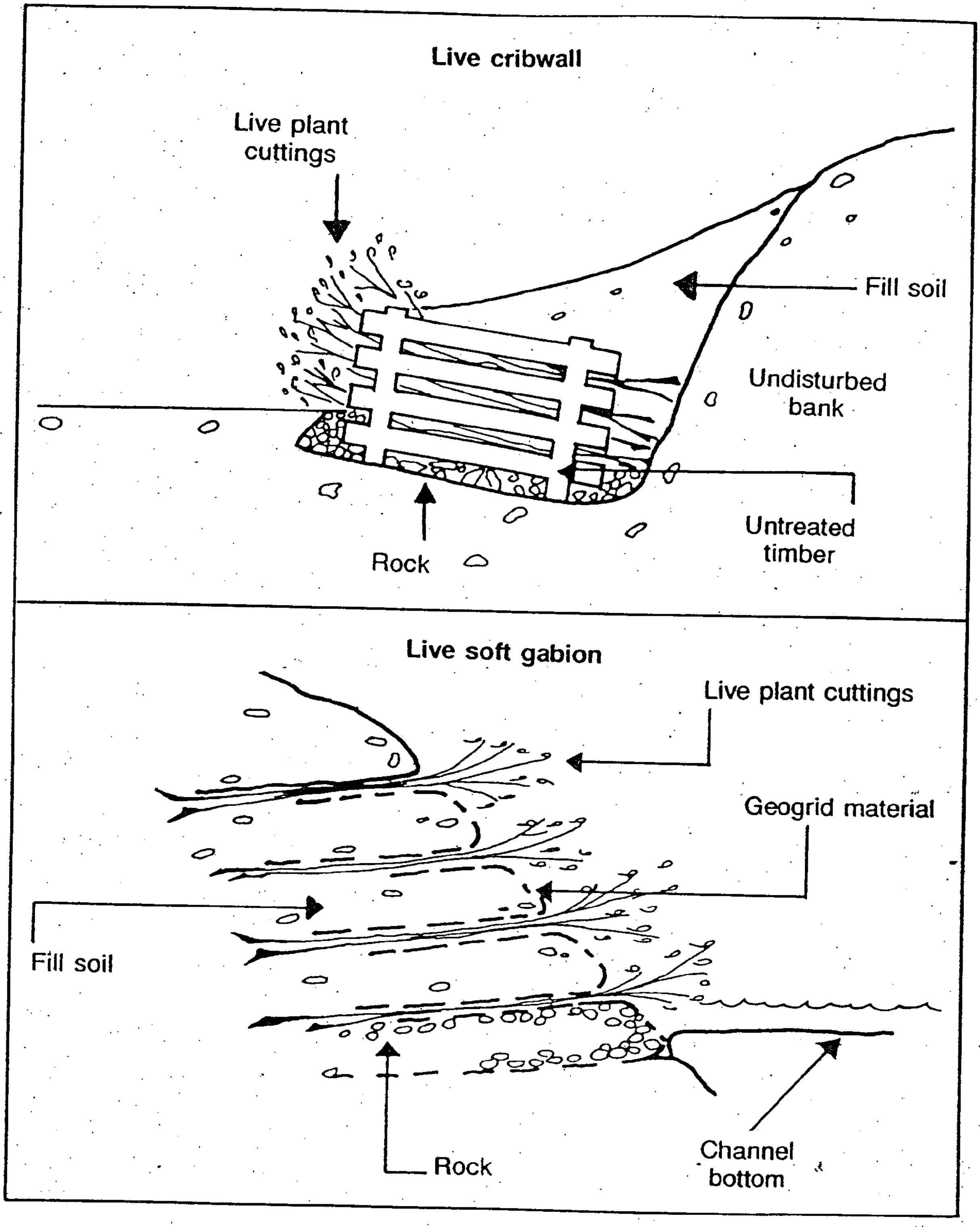

Figure A.1.4: Diagrams of live cribwall and live soft gabion. (Source: Kohnke and Boller 1989)

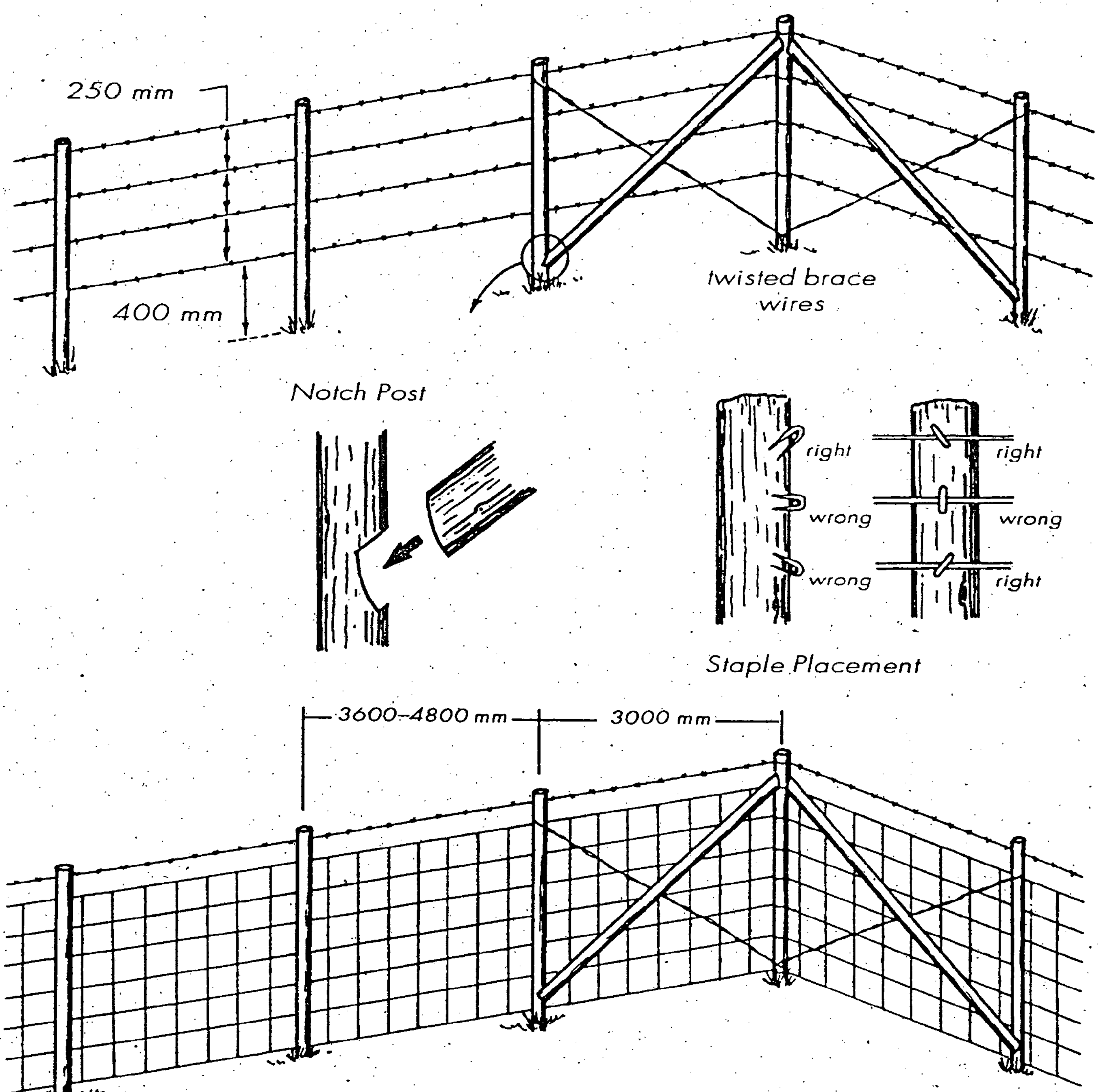

Figure A.1.5: Construction specifications for barbed wire fences (top) and page wire fences (bottom). (Source: Adams and Whyte 1990)

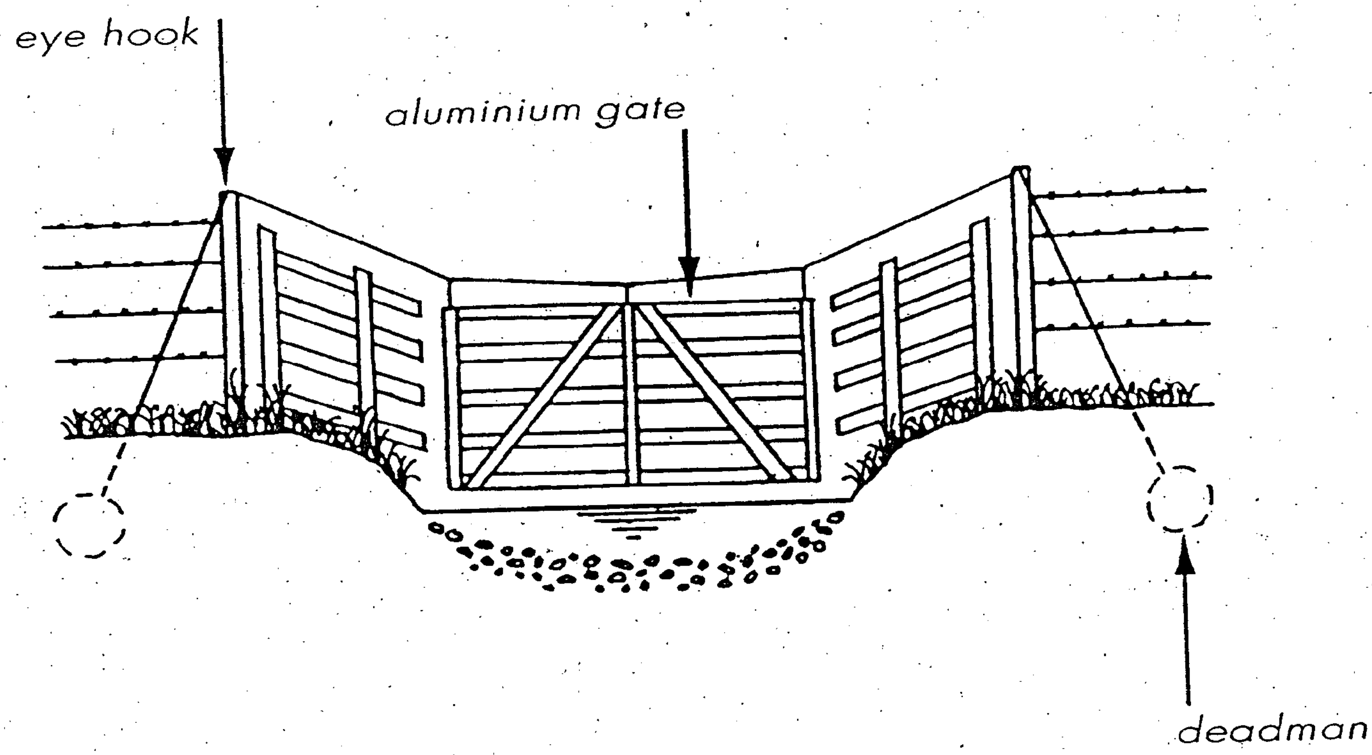

Figure A.1.6: Adjustable swing gate used at livestock crossings and watering locations. (Source: Adams and Whyte 1990)

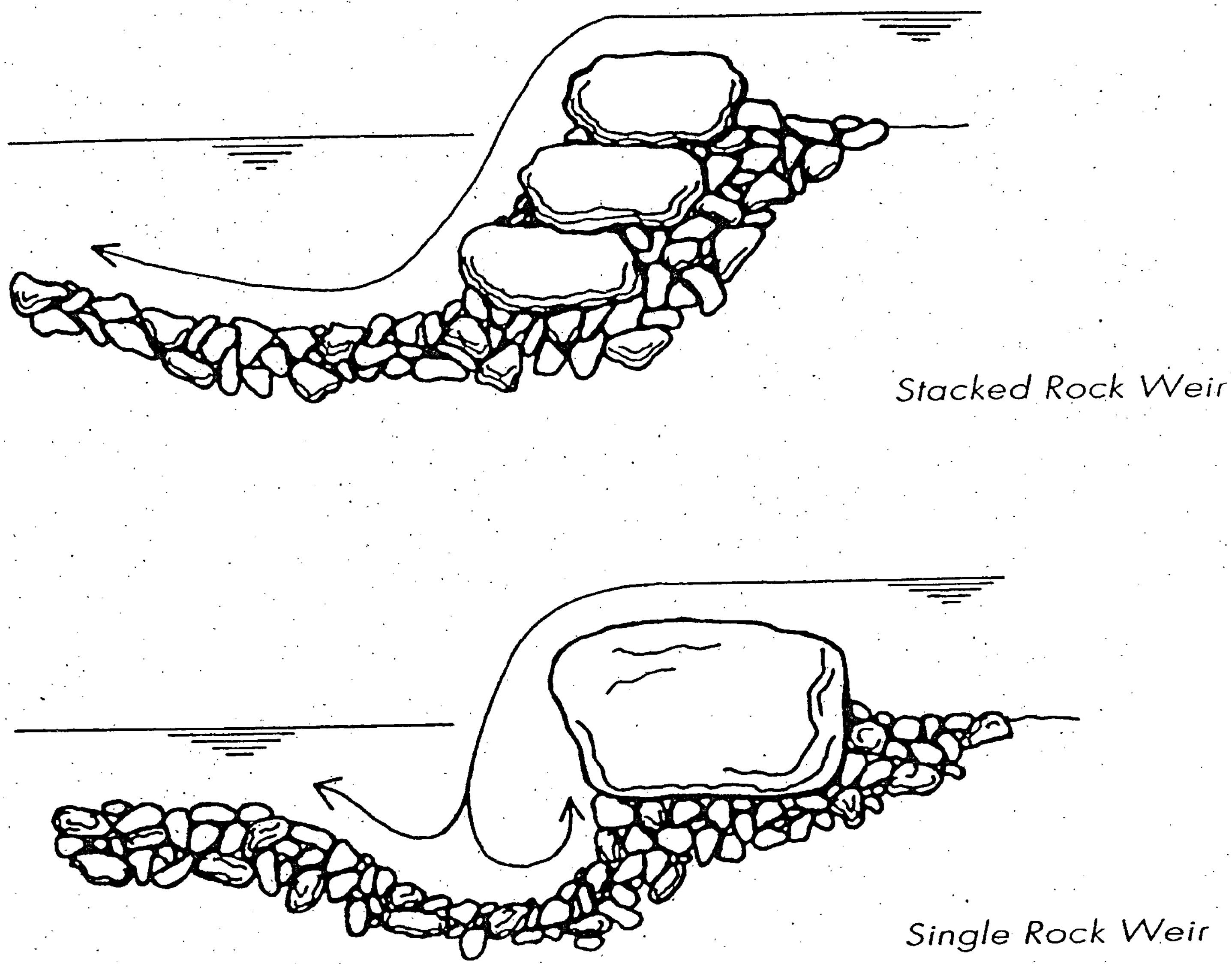

Figure A.1.7: Pool development below rock weirs. (Source: Adams and Whyte 1990)

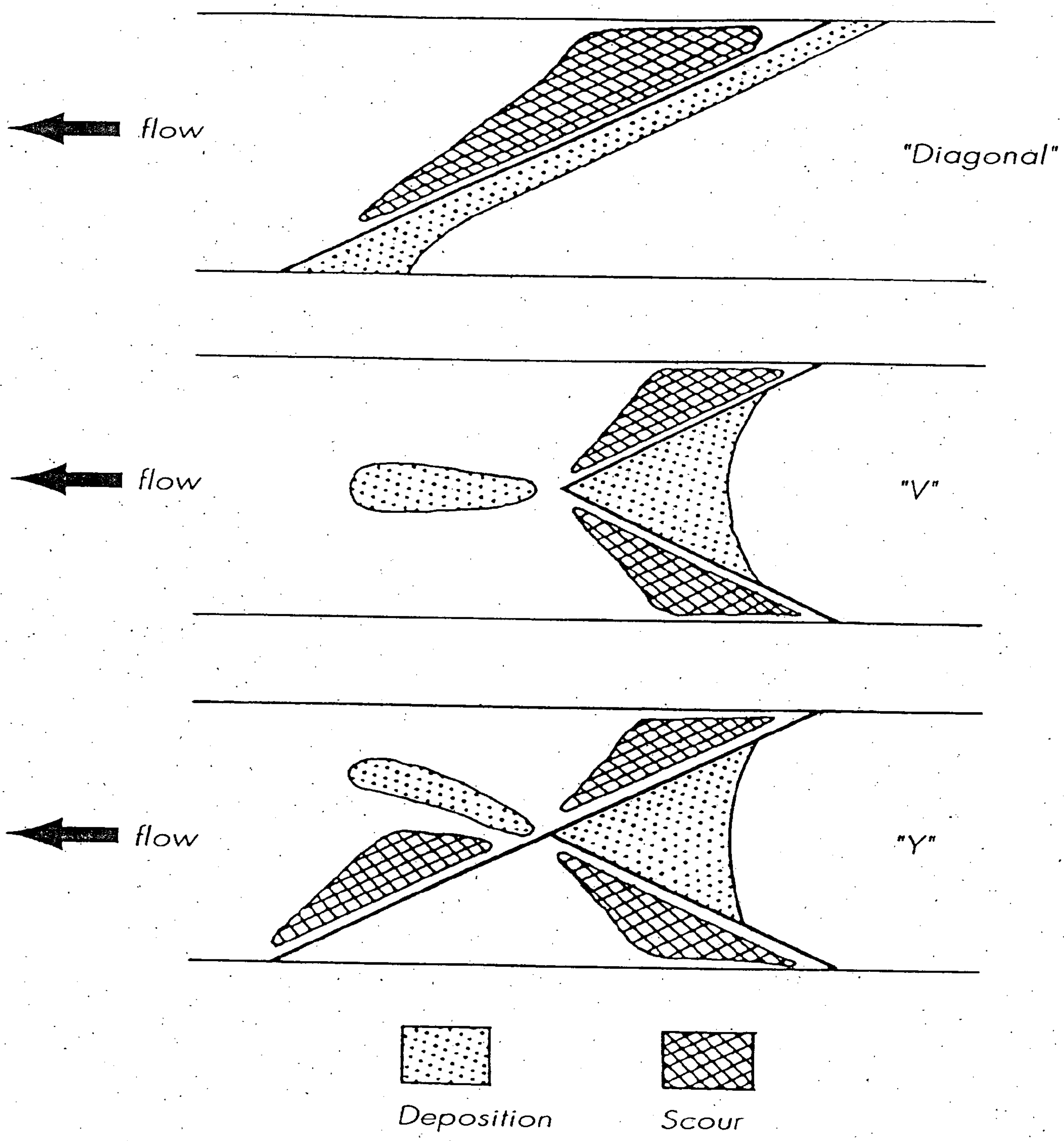

Figure A.1.8: Scour and depositional patterns associated with full spanning weirs. (Source: Adams and Whyte 1990)

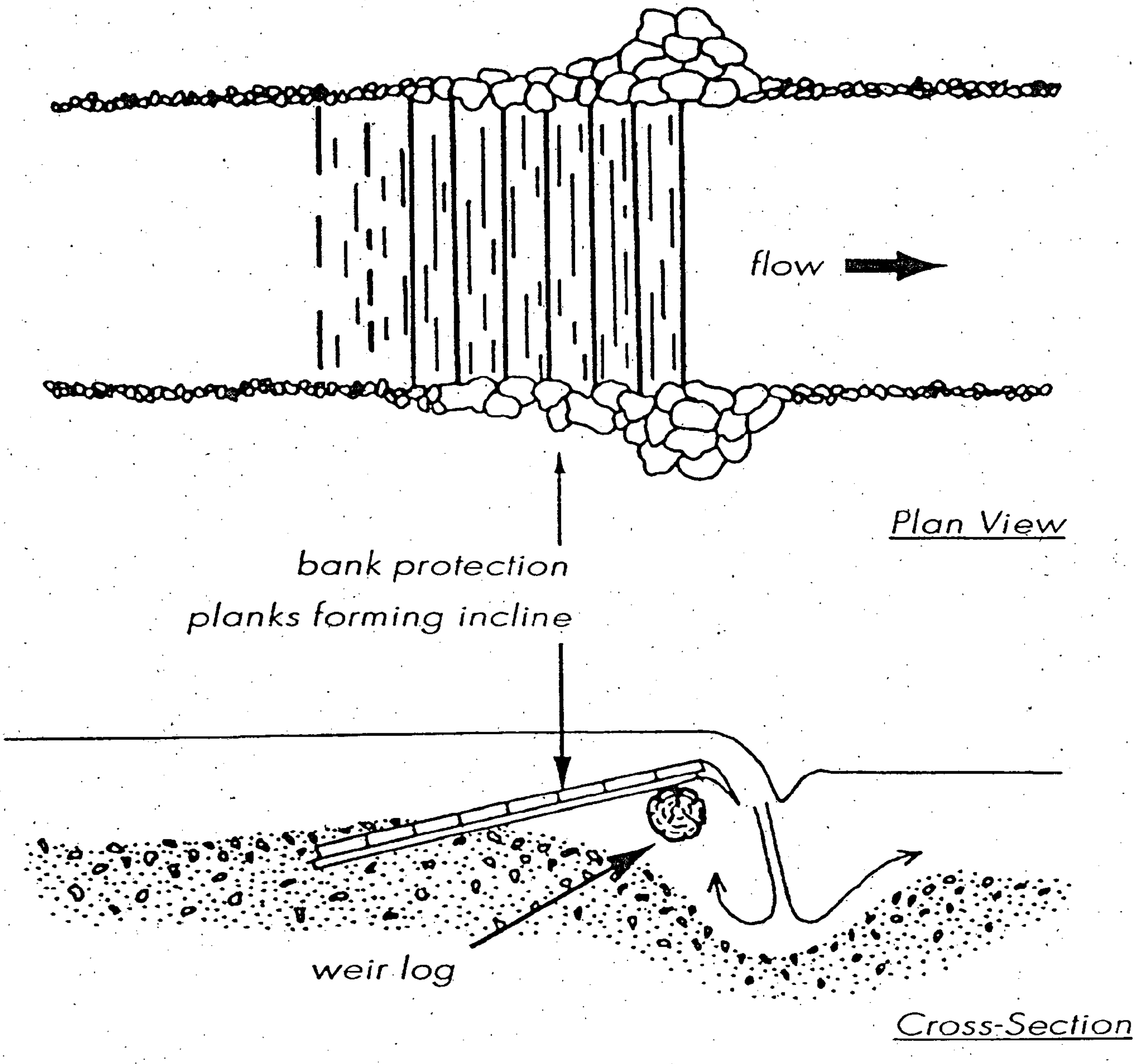

Figure A.1.9: Example of a Hewlitt ramp structure. (Source: Adams and Whyte 1990)

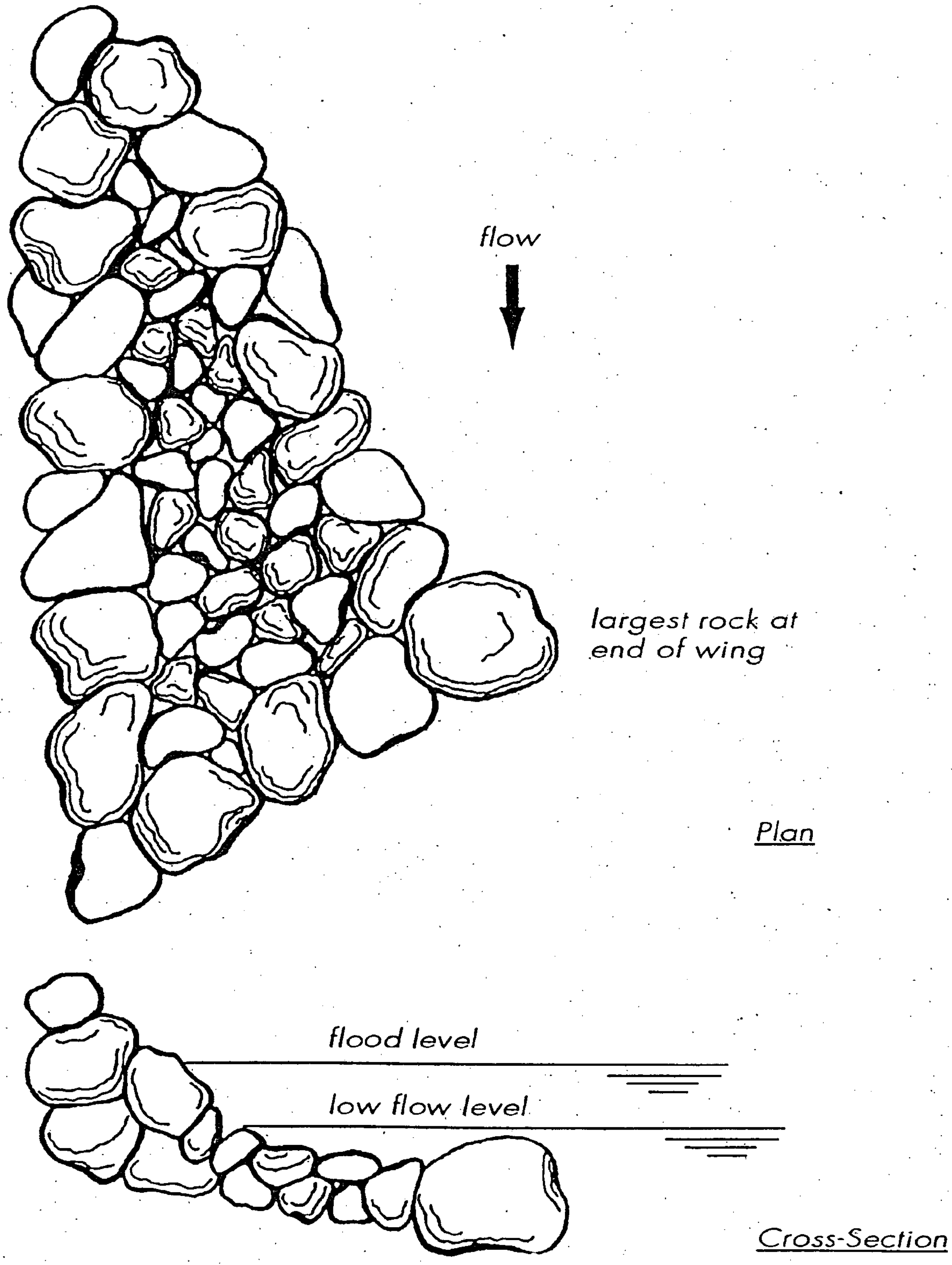

Figure A.1.10: Example of a triangular wing deflector. (Source: Adams and Whyte 1990)

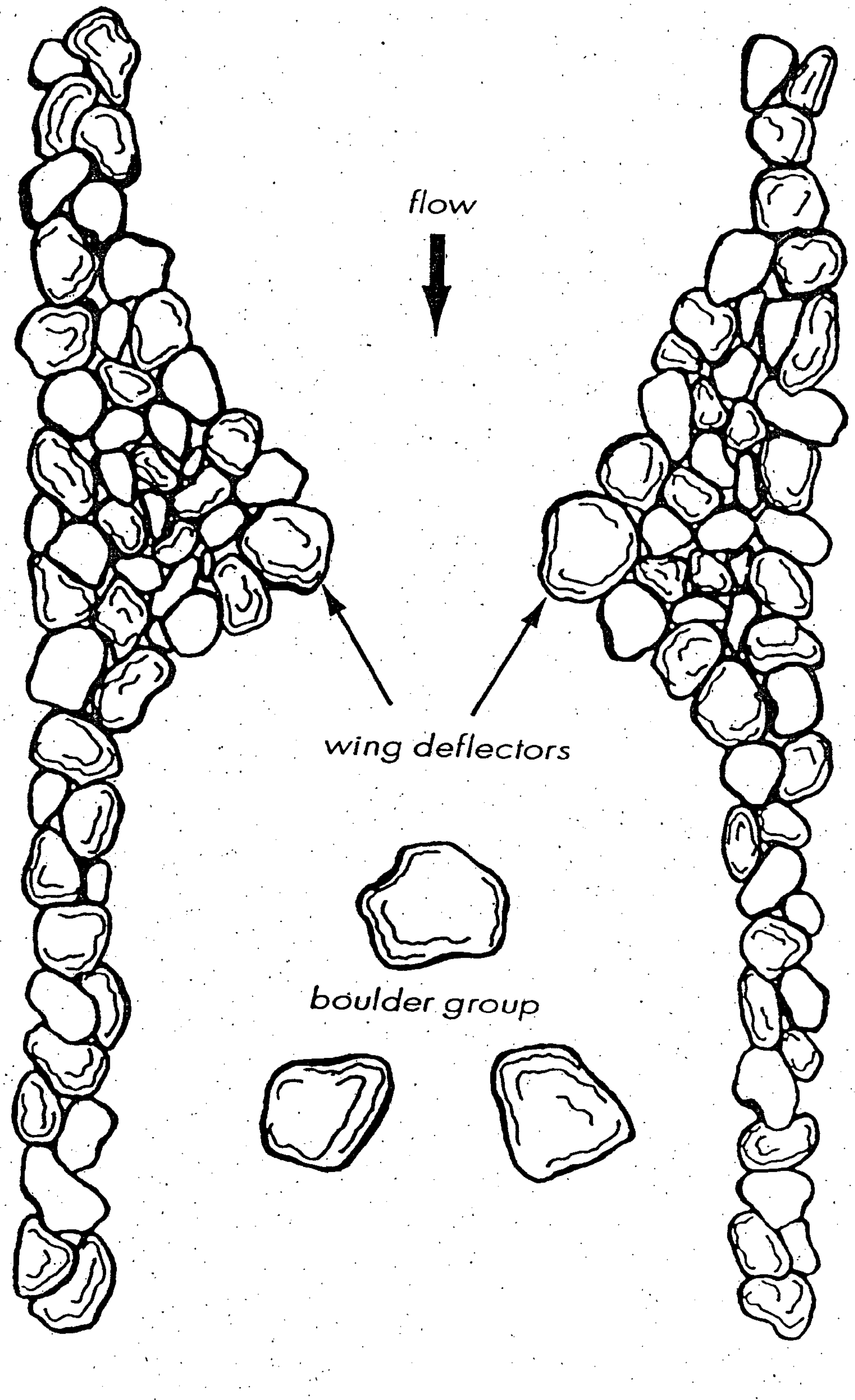

Figure A.1.11: Combined use of paired wing deflectors and boulder group. (Source: Adams and Whyte 1990)

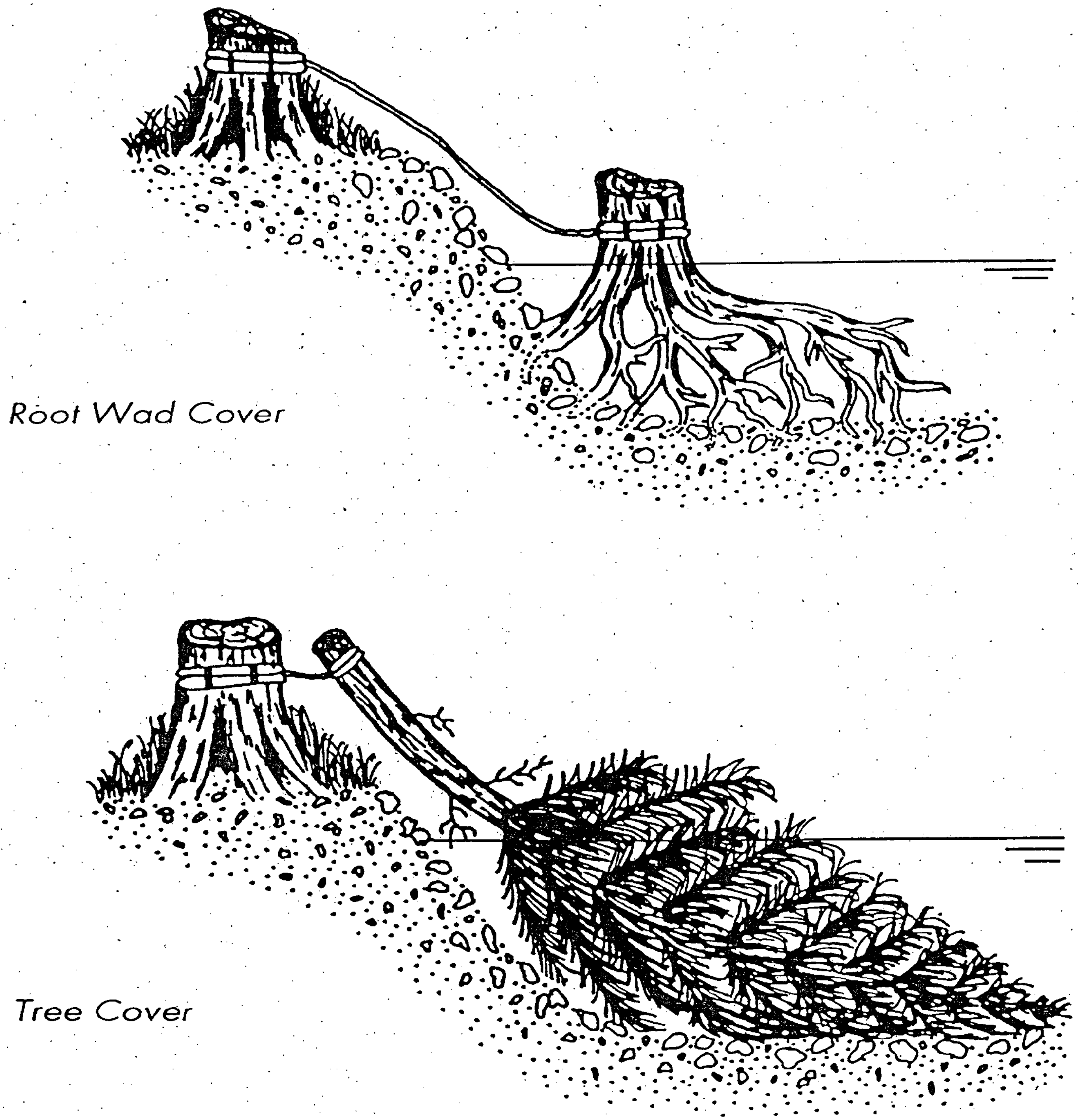

Figure A.1.12: Attachment of large organic debris in streams. (Source: Adams and Whyte 1990)

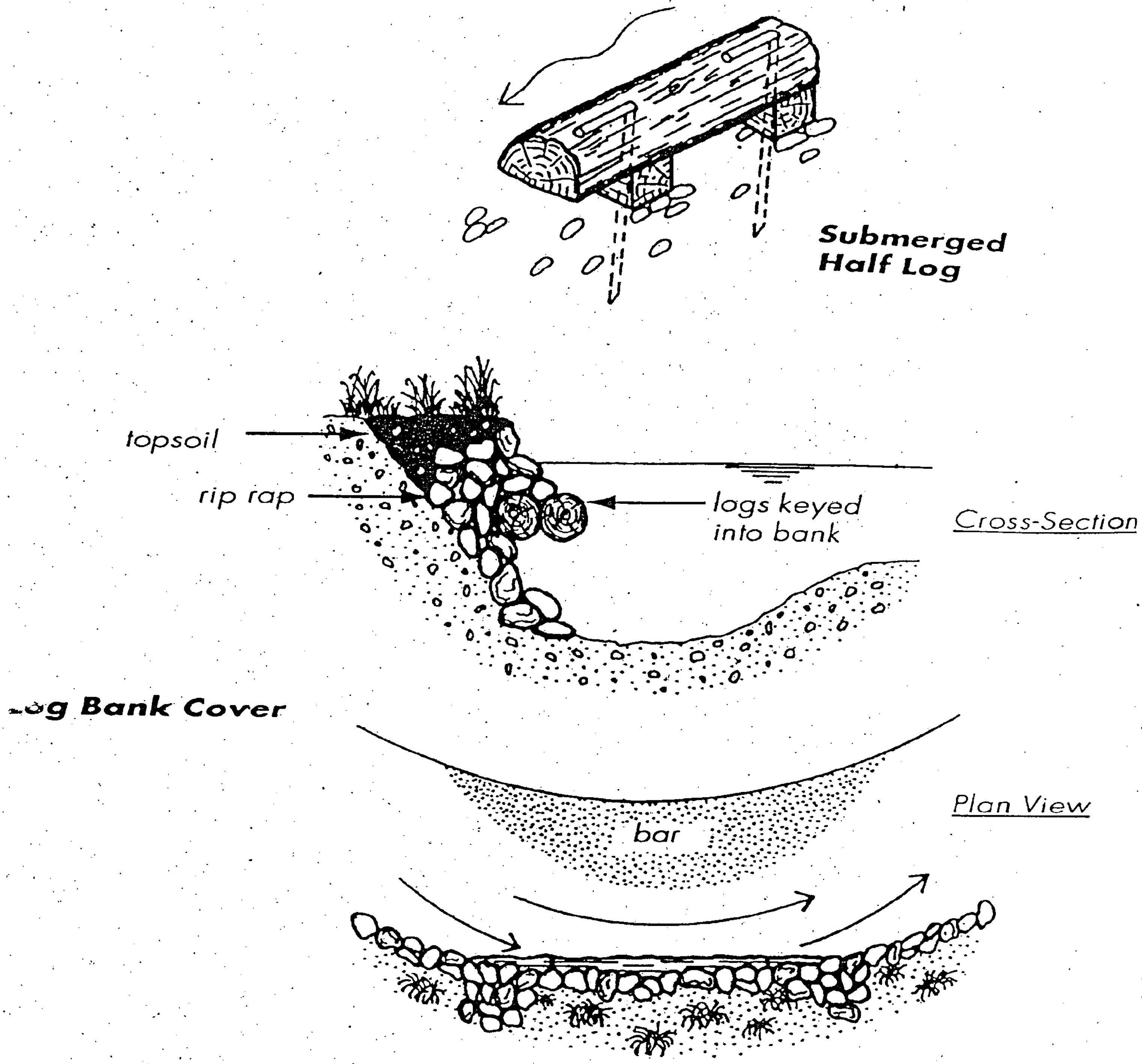

Figure A.1.13: Typical submerged half log and log bank cover structures. (Source: Adams and Whyte 1990)