Atlas Specialty Steels
Welland, Ontario
and
Environment Canada
Toronto, Ontario

The Full-Scale Welland River Reef Cleanup Project

Project Assessment Report

Technical Reference Document
Volume 1 of 3
Main Report

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Acres International Limited
Niagara Falls, Ontario

Acknowledgments

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Summary

The Welland River Reef Cleanup Project comprised the removal of two contaminated sediment deposits (reef formations) in the Welland River. It was undertaken by Atlas Specialty Steels (Atlas) of Welland, Ontario, a division of Sammi Atlas Inc. The reef formations were located in the Welland River in Welland, close to the Atlas plant and were primarily associated with two specific sewer outfalls, the McMaster Avenue and Atlas 42-in. outfalls. The reef materials consisted of industrial mill scale (granular, metallic particles) and solvent extractable contaminants (oil and grease) released by Atlas and other sources into the river over a period of 50 to 60 years, prior to the 1980s. In total 9833 m^3 of reef materials were removed from the Welland River. The project also included the removal of approximately 1215 m^3 of mixed coarse mill scale and sediments from the floodplain downstream from the Atlas 42-in. outfall.

The background, context, implementation and evaluation of the Welland River Reef Cleanup project is briefly described in a separate Executive Summary document. This Technical Reference Document assembles data gathered during the sediment removal, sediment treatment and environmental and equipment monitoring, and evaluates the effectiveness and cost of the technologies used. Environmental approvals, anticipated impacts and public consultation aspects are described in detail in the Environmental Screening Report (ESR).

The goal of the project was the removal and treatment of the contaminated reef deposits adjacent to the McMaster Avenue and Atlas 42-in. outfalls and the downstream floodplain pocket. Within this overall purpose, the following objectives were also to be realized:

- the project was to be completed using environmentally friendly, innovative technologies and as economically as possible, recognizing the limited funding available

- the project was to be completed in a manner which minimized, as much as possible, the impact on the environment

- the effectiveness of the selected sediment removal and treatment technologies were to be evaluated during a full-scale production orientated remediation project

- the project should not significantly impact on the associated floodplain sediments or wetland, or limit future planning options for these areas.

The Welland River Reef Cleanup Project was a full-scale demonstration that contaminated sediments can be removed from a riverine environment using innovative dredging techniques and without contaminating downstream areas due to resuspended sediment. As one of the projects selected for funding under Environment Canada's Great Lakes 2000 Cleanup Fund, the project utilized innovative technologies for the removal and treatment of contaminated sediments and allowed evaluation of their commercial application both in Canada and internationally.

Due to funding limitations, the tendering process for the Welland River Reef Cleanup Project had to be flexible to achieve the best balance between price and risk to the owner. Separate contracts were awarded for dredging and floodplain protection as follows.

- Contact C1A - Dredging [comprising sediment removal and pumping of dredgeate through a pipeline to Atlas' North Filtration Plant (NFP)]; awarded to Normrock Industries Inc. of Terrebonne, Quebec.

- Contract C1B - Floodplain Protection (comprising site preparation and facilities, sheet piling, granular fill placement and floodplain pocket remediation); awarded to The Ontario Construction Co. Ltd. of Niagara-on-the-Lake, Ontario.

Sediment treatment was carried out by Atlas, using equipment rented from Derrick and operated by Atlas' labor. Only by reducing risk to the contractors and splitting up the project into a number of components (dredging, floodplain protection and sediment treatment) was it possible to reduce the cost of the project to within the limit of funding.

The sediment removal component of the project involved the removal of 9833 m^3 of industrial mill scale and contaminated river sediments from the McMaster Avenue and Atlas 42-in. outfall areas in the Welland River. An Amphibex dredge, a combination mechanical/hydraulic suction dredge, excavated a total of 7613 m^3 of material, while a long-reach, land-based backhoe excavated an estimated 2220 m^3. The material dredged by the Amphibex was pumped up to 1500 m, through a 200-mm diameter pipeline using booster pumps, to Atlas' NFP where a temporary sediment treatment facility had been set up to receive and treat the slurry.

The Amphibex dredge is a combination mechanical-hydraulic suction dredge which requires no cables for anchoring or maneuvering. The forward backhoe-style arm of the dredge can be equipped with various attachments including a pump bucket, an excavating bucket, rake, hammer, etc. The pump bucket attachment was used for dredging the river sediments. The pump bucket, which has a rotating cutter bar mounted inside it, was also capable of removing the floodplain materials which consisted of organic rich sediments, root masses and stalks from aquatic vegetation. The backhoe-style bucket was well suited to handle large or angular objects or debris, such as boulders, pieces of wood, etc.

The innovative Amphibex dredge was easily launched using its 'walking' capabilities. It was also easily positioned in the river without the aid of a cable system, due to the incorporated spud legs, stabilizer arms and rear-mounted propeller.

The Amphibex was capable of dredging the industrial mill scale and contaminated river sediment at overall sustained slurry solids concentrations of between 10% and 20% by weight at flows ranging from approximately 1000 to 1800 USgpm. Average slurry solids content (by weight) ranged from 6% in predominantly mill scale material to 28% in fine-grained sediments. The overall average dredging production rate was 24.9 m^3/h. Average production rates in the various materials encountered ranged from 12.8 m^3/h (McMaster Avenue area) to 16.9 m^3/h (Atlas 42-in. area) in predominantly mill-scale material, and 112.4 m^3/h in the fine-grained sediments (Atlas 42-in. area only).

All dredging by the Amphibex was done within a geotextile silt curtain which helped to minimize the impact of resuspended sediments on downstream water quality during dredging. Turbidity in the vicinity of the pump bucket during dredging was high and it is not considered feasible to dredge with the Amphibex in the conditions and materials encountered during this project (fine sediments and flowing water conditions) without the use of a silt curtain. However, under certain conditions (for example, coarse grained sediments and still water conditions) the use of a silt curtain may not be necessary.

Sediment treatment at Atlas' NFP used equipment and temporary storage basins (TSBs) to separate and dewater the various dredgeate slurry solids. The equipment consisted of a scalping screen, screw classifier, high 'G' dryers, and associated piping and sump pumps. Atlas' NFP was used to receive and treat all water generated during dredging before it was released back to the river.

The scalping screen functioned adequately in separating out coarse particles and river debris. The screw classifier worked well in separating out the sand sized particles, especially the coarse mill scale from the slurry. The high 'G' dryers consisted of a combination of hydrocyclones and a fine vibrating screen. The hydrocyclones separated solids larger than 40 to 50 μm which were eventually removed on the fine screens.

Removing more material than originally anticipated resulted in the TSBs filling up earlier than planned. Despite cleaning out and modification of the TSBs, carryover of fines from TSB No. 2 to Atlas' settling pond, and ultimately the NFP filters, was a recurring problem throughout the latter part of the project. Dredging had to be frequently halted during this period to allow backwashing of the filters. Due to the persistence of this problem, a portion of the overflow from TSB No. 2 was pumped into the regional sewer system for treatment at the RMON sewage treatment plant; this occurred over a total of 36 hours from December 8 to 16.

Solids from the screw classifier consisted primarily of coarse mill scale with some natural sand. Some of this material was recycled with Atlas' process and the remainder was tested and then disposed of in the City of Welland landfill. Solids removed by the scalping screen and high 'G' dryers were used as landfill cover material, after appropriate testing.

It was recognized that, at both the McMaster Avenue and Atlas 42-in. outfall areas, contaminated floodplain sediments would remain at the floodplain/river interface after dredging had been completed. Therefore, to prevent exposure of this material to river flows, possible erosion and subsequent transport of contaminants, protection of the floodplain sediments was required at both areas. At the McMaster Avenue outfall area, the slope in the floodplain sediments was covered by sand fill followed by coarse granular fill to provide long-term erosion protection. At the Atlas 42-in. outfall area, sheetpiling was installed along the floodplain edge prior to dredging. After dredging had been completed adjacent to the sheetpiling, granular fill was placed to cover the sheetpiling and form a riverbed slope along the floodplain.

As part of the project, approximately 1215 m^3 of mixed mill scale and sediments was removed from a 30 m by 15 m irregularly shaped area in the floodplain downstream of the Atlas 42-in. outfall. This was accomplished by installation of sheetpiling to enclose the area, excavation of the floodplain materials within the area using a backhoe, backfilling of the excavation and then removal of the sheetpiling.

The dredging part of the project was originally scheduled over a 6-wk period, with all dredging to be done by the Amphibex. Dredging actually extended over a period of 12.5 weeks. The reasons for the extended dredging period included dredging of approximately 35% more sediment than originally estimated, delays due to impacts from fine sediment on Atlas' NFP, reduced productivity of the Amphibex in the heavy mill scale material and sediment containing debris, and impacts due to cold weather.

The total cost of dredging (excluding standby) was \$426,700, of which \$85,000 was for mobilization and demobilization. The unit cost of dredging was \$20/m^3 excluding mobilization and demobilization, site facilities, pipeline setup and operation, booster pump and other miscellaneous administrative costs. Pumping costs add another \$4/m^3 to the cost of getting the slurry to the treatment facility, giving a total unit cost for dredging and slurry transport of \$24/m^3.

The overall cost of sediment treatment is estimated at \$192/m^3 which is considered unusually high due to costs resulting from delays and necessary modifications and cleanout of the TSBs.

The cost of remediation of the floodplain area containing mixed mill scale and sediment downstream of the Atlas 42-in. outfall was approximately \$150/m^3.

The Welland River Reef Cleanup Project is part of a long-term multistakeholder, multiphase plan to improve the quality of the Welland River and its watershed, which is part of the larger Niagara River Area of Concern (AOC). This project will assist in the eventual delisting of the Niagara River AOC. The completion of this full-scale sediment removal and treatment demonstration marks the end of a successful government/ industry partnership between Environment Canada and Atlas Specialty Steels which focussed on the remediation of contaminated sediments using innovative technologies. Environment Canada and the MOEE will undertake a post-project sediment and biological investigation to evaluate the cleanup of the site and assess any biological effects caused by the contaminated sediments. This work will take place within 5 years of the site cleanup.

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Glossary of Abbreviations

AOC	Area of Concern
DFO	Department of Fisheries and Oceans
ESR	Environmental Screening Report
FTU	Formazin turbidity units
HRT	hydraulic retention time
LOI	loss on ignition
MNR	Ministry of Natural Resources
MOEE	Ministry of Environment and Energy
NFP	North Filtration Plant
NTU	nephelometric turbidity units
PAC	Public Advisory Committee
PCB	polychlorinated biphenlys
PSQG	Provincial Sediment Quality Guidelines
PWQO	Provincial Water Quality Objectives
QCPC	Queenston-Chippawa Power Canal
RAP	Remedial Action Plan
RMON	Regional Municipality of Niagara
RTP	Remediation Technologies Program
SEL	severe effect level
TRC	Technical Review Committee
TSB	temporary storage basin
TSS	total suspended solids
WPCP	Water Pollution Control Plant
WRCC	Welland River Cleanup Committee
WTC	Wastewater Technology Center
WTIC	Water Technology International Corporation
WTP	Water Treatment Plant

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1 Introduction

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1.1 General

The Welland River Reef Cleanup Project comprised the removal of two contaminated sediment deposits (reef formations) in the Welland River. It was undertaken by Atlas Specialty Steels (Atlas) of Welland, Ontario, a division of Sammi Atlas Inc. The reef formations were located in the Welland River in Welland, close to the Atlas plant (Figures 1.1 and 1.2).

During the early 1980s Brock University researchers in conjunction with the MOEE, discovered heavy metal and oil and grease-contaminated sediments in the lower Welland River. Reef like deposits were found adjacent to two sewer outfalls (the McMaster Avenue and Atlas 42-in., Figure 1.3) used over the previous 50 to 60 years by Atlas Specialty Steels and other industrial and municipal dischargers. The reef deposits included industrial mill scale (granular, metallic particles) and solvent extractable contaminants (oil and grease) released by Atlas and other sources into the river over a period of 50 to 60 years, prior to the 1980s. These materials were intermixed with river sediments. The concentrations of contaminants in the reef materials exceeded the Severe Effect Level (SEL) of the Ontario Ministry of the Environment and Energy's (MOEE's) Provincial Sediment Quality Guidelines (PSQG), 1993 for a variety of metals (notably Cu, Cr, Fe, Ni, Mn, Pb and Zn) and had been found to be toxic to sediment dwelling organisms during biological sampling and laboratory testing.

Atlas had implemented wastewater abatement measures during the 1970s. However, in 1987 Atlas acknowledged responsibility for the mill-scale portion of the reef deposits and embarked on site studies. These were undertaken to determine the extent of contamination and to develop remediation plans. A chronology of these and other significant project events is presented in Table 1.1.

The Welland River Reef Cleanup Project is part of a long-term multistakeholder, multiphase plan to improve the quality of the Welland River and its watershed which is part of the larger Niagara River Area of Concern (AOC). It is one of the remedial activities recommended in the Stage 2 Niagara River Remedial Action Plan (RAP) document (Recommendation 16) and as such will assist in the eventual delisting of the Niagara River AOC. Both the RAP Team and the Niagara River RAP Public

Advisory Committee (PAC) endorsed this project. The project also addresses the Canada-Ontario Agreement regarding the cleanup of severely contaminated sediments.

Financial support for the project was provided by Atlas, Environment Canada, the MOEE, the Regional Municipality of Niagara (RMON) and the City of Welland. While Atlas was the major source of funding, significant federal government funding was provided through the Great Lakes 2000 Cleanup Fund under Environment Canada's Remediation Technologies Program (RTP).

Public consultation has been a key element in project development since its inception, and has included two workshops (one before and one after the pilot-scale demonstration), an open house (prior to the pilot-scale project), a public meeting (March 1995, prior to the full-scale demonstration) and the local distribution of newsletters (March and August 1995). In addition, the project development process has been reviewed and guided by the Welland River (Welland) Cleanup Committee (WRCC) and its associated Technical Review Committee (TRC), as well as the Niagara River RAP-PAC. Table 1.2 provides an overview of the initial project participation and review committees as they existed for the 1991 pilot-scale and 1995 full-scale demonstration projects. Efforts have been made throughout the project development process to inform and solicit input from the public and interested parties. Further details on public consultation aspects are provided in the ESR. A partnership approach has been applied throughout the process in terms of funding, project direction and review.

1.2 Pilot-Scale Demonstration Project

A pilot-scale demonstration of an innovative hydraulic suction dredging technology and an associated treatment process was undertaken by Atlas during the fall of 1991 to assess their suitability and feasibility for the full-scale cleanup. That demonstration project concentrated on the removal of a portion (127 m^3) of the industrial mill scale and contaminated clay/silt sediment located in the vicinity of the McMaster Avenue outfall (Figure 1.3). This material was transferred by pipeline to a temporary sediment treatment facility established on Atlas property adjacent to their NFP, at which point solids were separated and dewatered prior to disposal. The solids generated by this process were classified as a nonregisterable, nonhazardous solid industrial waste, suitable for industrial or municipal landfilling. Liquid effluent was blended with Atlas' normal plant effluent and treated at its existing NFP prior to discharge back into the river.

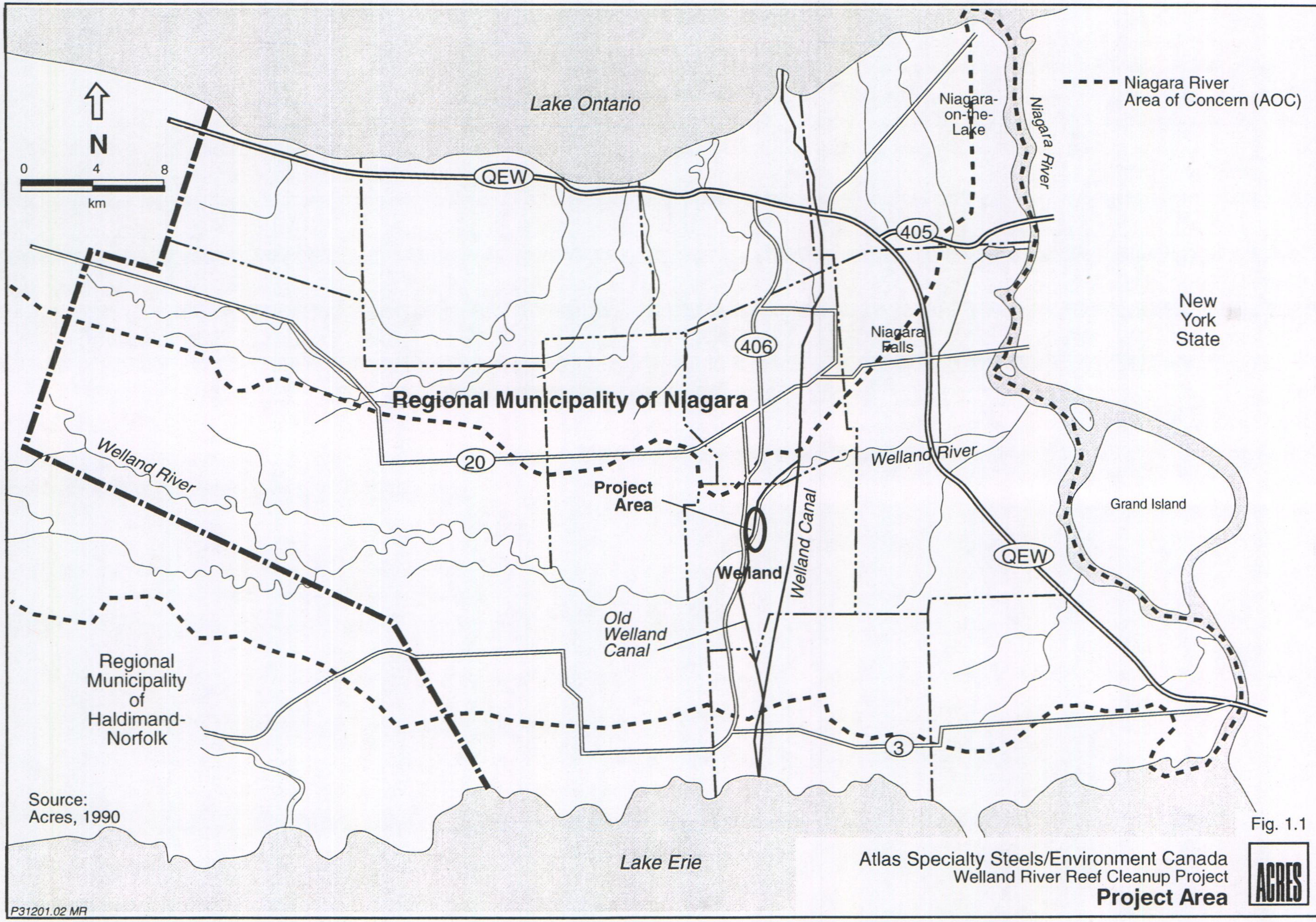

Fig. 1.1

Atlas Specialty Steels/Environment Canada
Welland River Reef Cleanup Project
Project Area

ACRES

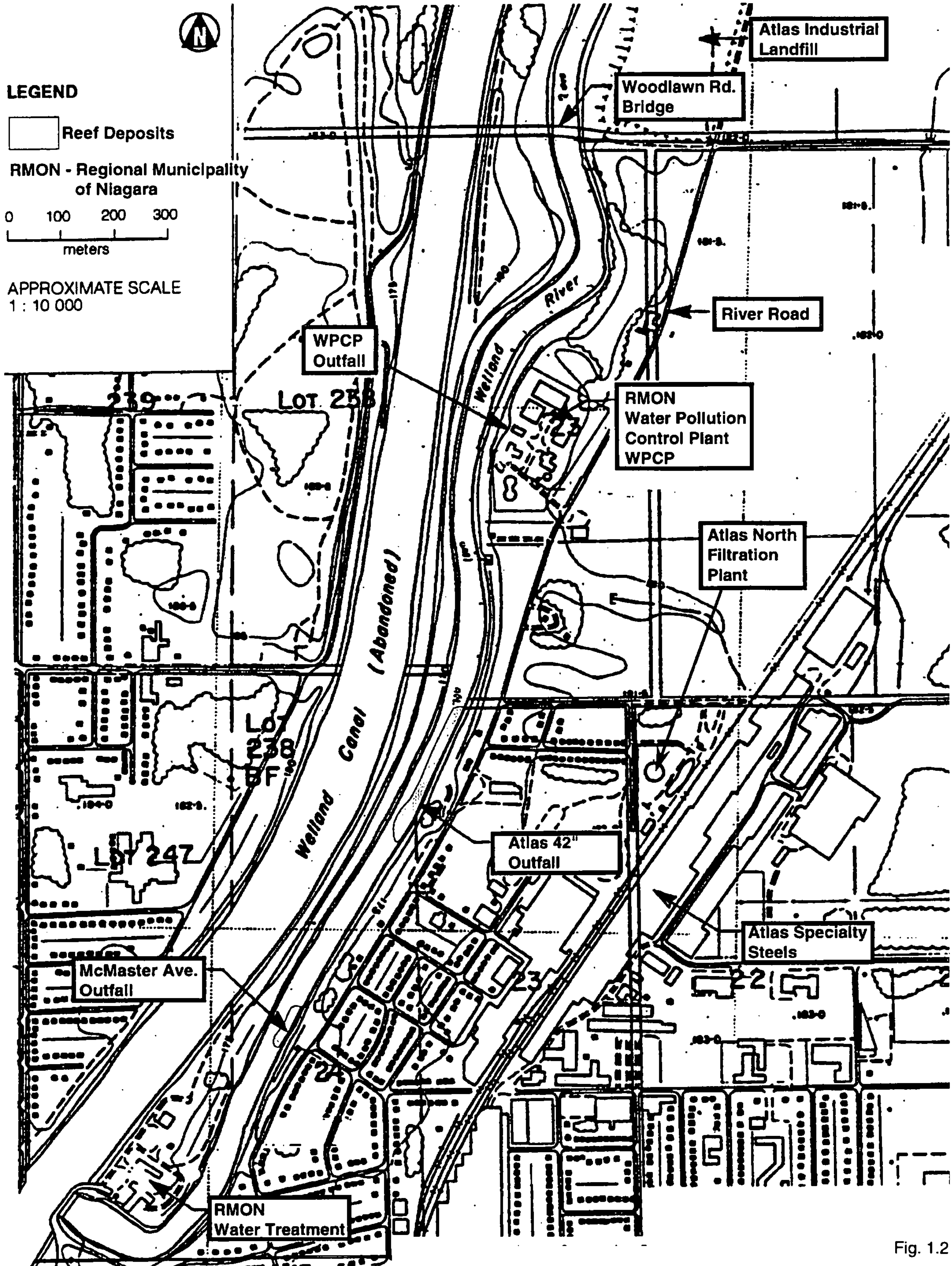

Fig. 1.2

Atlas Specialty Steels/Environment Canada
Welland River Reef Cleanup Project
Project Location

ACRES

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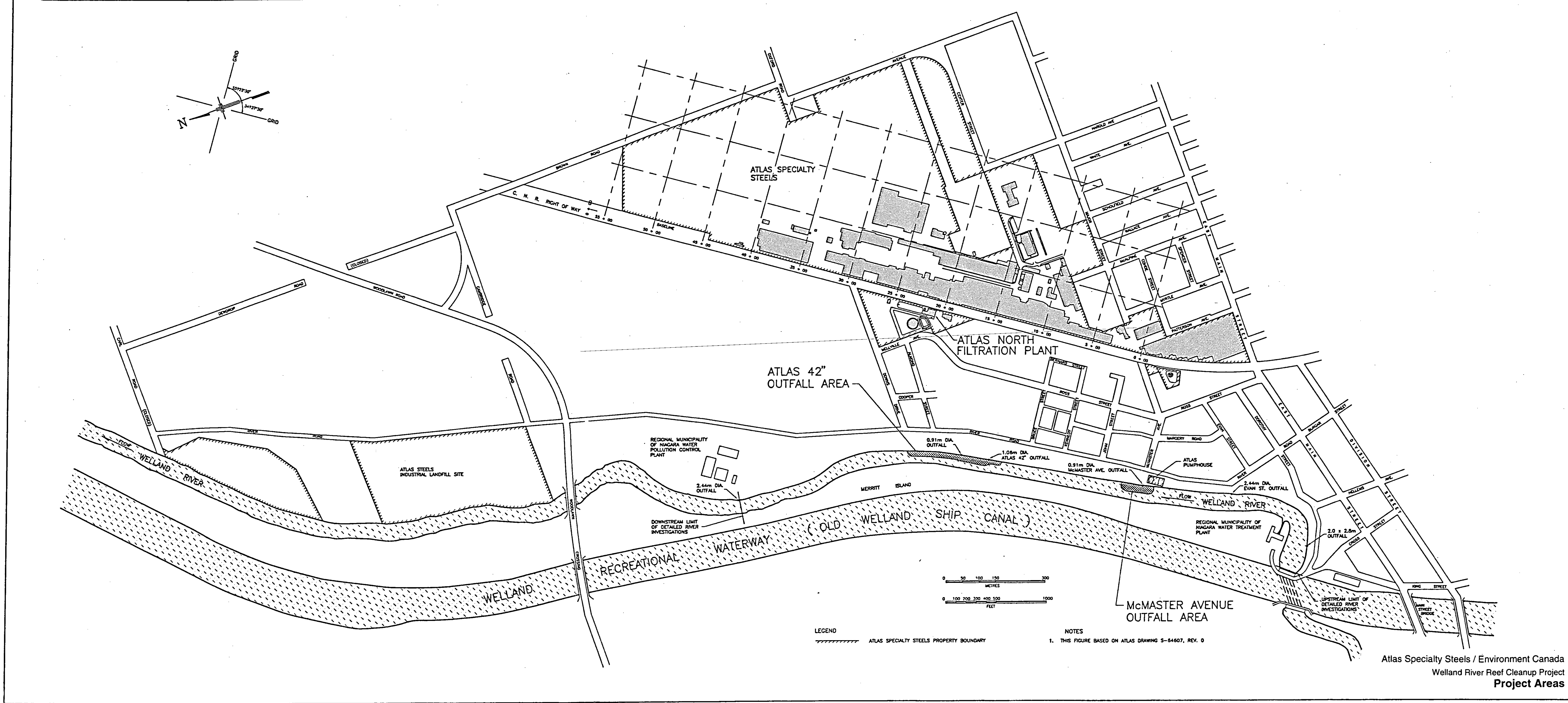


Fig. 1.3

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Project Areas

ACRES

Table 1.1

Project Chronology of Significant Events

Date	Description of Event or Milestone
mid-1980s to present	Brock University researchers study impact of industrial contaminants in Welland River
December 1987	Atlas commits to river cleanup
March 1989	Acres initiates first Welland River sediment study
March 1990	Acres initiates preliminary Welland River Floodplain study
June 1990	First WRCC meeting
November 1990	MOEE Water Resources Branch initiates sediment bioassay study
December 1990	Unsolicited proposal for Welland River Dredging Demonstration submitted to Environment Canada Atlas/Acres presentation of proposed project to RAP-PAC
March 1991	Acres initiates follow up to preliminary floodplain study Environment Canada approves proposal and Welland River Dredging Demonstration Project initiated First Welland River Dredging Demonstration Planning Committee meeting (held monthly) Phase I of project initiated
April 1991	Merger of WRCC and Demonstration Planning Committee
May 1991	Atlas hosts Welland River Dredging Demonstration open house Phase II of project initiated
June 1991	Permitting and approval process initiated

Date	Description of Event or Milestone
July 1991	Unsolicited proposal for bench-scale testing submitted to Environment Canada and Water Technology International Corporation
August 1991	Proposal for bench-scale testing approved by Water Technology International Corporation
September 1991	Final design of treatment facility completed
October 1991	Phase III of project initiated Permits and approvals received from regulatory agencies Dredging in contaminated sediment initiated (October 28)
November 1991	Dredging completed
February 1993	Final Report issued to Welland River Demonstration Planning Committee and Welland Reef Cleanup Committee
April 1993	Agreement in principle by RAP-PAC to planned remediation of contaminated sediments
June 1993	WRCC workshop
April 1994	Special Wetland Working Group formed
June 1994	EC/MOEE sampling over an 8-km stretch of river
October 1994	Establishment of Welland River Reef Technical Review Committee to oversee full-scale dredging demonstration
March 1995	Public meeting
August 1995	Open House
September 1995	Commencement of dredging
December 1995	Dredging completed
January 1996	Fill-placement completed

Table 1.2
Project Participation and Review

	Welland River Reef Cleanup Committee	Dredging Demonstration Planning Committee		Niagara River Remedial Action Plan - Public Advisory Committee (RAP-PAC)
		Pilot	Full Scale	
Ministry of Environment and Energy	•	•	•	•
Ministry of Natural Resources	•	•	•	
Environment Canada	•	•	•	
Water Technology International Corporation	•	•	•	
Public Works Canada		•		
Regional Municipality of Niagara	•	•	•	•
City of Welland (Engineering)	•	•	•	
Regional Niagara Department of Health	•			•
Brock University	•	•		•
RAP-PAC	•	•	•	
Niagara Peninsula Conservation Authority	•			•
Niagara Ecosystems Task Force	•			•
Niagara Falls Nature Club				•
Niagara River Angler Association				•
Local Industry/Tourism				•
Department of Fisheries and Oceans				•
Regional Niagara Council				•
Niagara Falls City Council				•
Public	•		•	•
Operation Clean Niagara				•
Canadians for a Clean Environment				•
Atlas Specialty Steels	•	•	•	•
Acres International Limited	•	•	•	•

That 1991 demonstration concluded that the dredging and treatment technologies utilized were viable and appropriate for a full-scale demonstration, and that the environmental impact of the process could be controlled/mitigated with existing technology(ies). The present full-scale demonstration project built upon the experience gained during the previous pilot-scale demonstration.

1.3 Full-Scale Cleanup (Demonstration) Project

During June 1994, a bioassay program was conducted by Environment Canada and the MOEE. The purpose of this program was to further define the extent and severity of the contamination in the areas surrounding the reef structures and to assess the biological conditions in the Welland River prior to undertaking the cleanup of the reef deposits and associated contaminated sediments.

In August 1994, Atlas submitted a proposal to Environment Canada for a partial funding of a full-scale sediment removal and treatment demonstration project to remove the reef deposits. This proposal was accepted by Environment Canada in the fall of 1994 and partial funding was provided through the Great Lakes 2000 Cleanup Fund.

The goal of the full-scale project was the removal of the remainder of the reef at the McMaster Avenue sewer outfall and the removal of the reef associated with the Atlas 42-in. outfall. Different hydraulic dredging techniques, but similar treatment technologies, to those utilized during the pilot-scale demonstration project were employed taking into account improvements/refinements forthcoming from that demonstration, and the individual comments/suggestions of the numerous agencies associated with the previous project. The specific goals for the rehabilitation of the affected floodplain adjacent to the reef deposits will be established by a subcommittee of the WRCC in consultation with the public and appropriate resource and regulatory agencies [primarily Ontario Ministry of Natural Resources (MNR) and the Federal Department of Fisheries and Oceans (DFO)]. Future planning options for the floodplain and adjacent wetlands should not be restricted by the full-scale cleanup and slope stabilization techniques selected for the project.

The full-scale project was undertaken by Atlas while the project management role was shared by Atlas and Acres International Limited (Acres). Acres also acted as consultant to Atlas and was responsible for project design. Technical assistance was provided by Environment Canada and, as noted previously, technical review was carried out by the TRC, comprising representatives from Environment Canada, MOEE, MNR, RMON, City of Welland, Wastewater Technology Centre (WTC), Niagara River RAP-PAC, and private citizens, as well as Atlas and Acres.

1.4 Report Organization

This Technical Reference Document assembles and assesses data gathered during the sediment removal, sediment treatment, and environmental and equipment monitoring. It also presents an evaluation of the effectiveness and the cost of the technologies. A separate Executive Summary document has been produced which provides an overview of the background, context, implementation and evaluation of the Welland River Reef Cleanup Project. Environmental approvals, anticipated impacts and public consultation aspects are described in detail in the Environmental Screening Report (ESR).

Volume 1 of the Technical Reference Document is organized as follows:

- Section 2 - Project Objectives
- Section 3 - Site Description
- Section 4 - Contractual Considerations, including tendering, contract structure and project schedule
- Section 5 - Sediment Removal including description of the sediment removal technology, and evaluation of dredge performance and impact on river water quality.
- Section 6 - Sediment Treatment, including description and evaluation of the sediment treatment technology.
- Section 7 - Floodplain Activities, including details of the types of floodplain protection utilized and the description of the floodplain pocket remediation.
- Section 8 - Conclusions

Data obtained during the implementation phase of the project are presented in Volume 2 - Appendixes. Volume 2 also contains a description of the overburden materials in the project area, including the contaminated materials removed.

2 Project Objectives

2 Project Objectives

The goal of the Welland River Reef Cleanup Project was the removal and treatment of contaminated reef deposits adjacent to the McMaster Avenue and Atlas 42-in. outfalls. Within this overall purpose, the following objectives were also to be realized:

- the project was to be completed using environmentally friendly, innovative technology and as economically as possible, recognizing the limited funding available

- the project was to be completed in a manner which minimized, as much as possible, the impact on the environment

- the effectiveness of the selected sediment removal and treatment technologies were to be evaluated during a full-scale production orientated remediation project, with particular emphasis on

  - operation and performance
  - cost
  - addressing environmental concerns
  - meeting regulatory requirements
  - applicability to a variety of remediation conditions and situations

- the project should not significantly impact on the associated floodplain sediments or wetland, or limit future planning options for these areas.

During the Welland River Reef Cleanup Project contaminated sediments were removed from a riverine environment using innovative dredging techniques and without contaminating downstream areas due to resuspended sediment. As one of the projects selected for funding under Environment Canada's Great Lakes 2000 Cleanup Fund, the project utilized innovative technologies for the removal and treatment of contaminated sediments and allowed evaluation of their commercial application both in Canada and internationally.

Although it is known that contaminants exist at various concentrations within the floodplain sediments adjacent to and downstream of the reef areas, the evaluation of the risk associated with those sediments and the need for their removal/rehabilitation was not part of this project. However, remediation of a limited area of the floodplain, where a mill scale deposit had been identified, within the sediments was included.

It was initially anticipated that the sediment removal and treatment technologies for this project would be similar to those used in the 1991 pilot-scale demonstration and would build upon the experience gained in that project. However, due to funding and technical considerations (as described in Sections 4 and 5), an alternative type of hydraulic dredge to that used in 1991 was actually utilized. The sediment transport and treatment technologies were similar to those used in 1991.

The Welland River Reef Cleanup Project was structured into five phases, each with specific objectives, to facilitate overall management. The five phases were as follows:

- Phase 1 - Detailed Project Definition
- Phase 2 - Environmental Screening and Regulatory Approvals
- Phase 3 - Detailed Project Design and Contract Documents
- Phase 4 - Demonstration of Technologies and Monitoring
- Phase 5 - Project Assessment.

3 Site Description

3 Site Description

3.1 General

The Welland River Reef Cleanup project is located on the lower reach of the Welland River within the City of Welland, Ontario, as shown in Figure 1.3. On the west side of the river is Merritt Island which was formed during construction of the old Welland Canal. The island is a park owned by Public Works and Government Services Canada (PWGSC). The east shore of the river is mixed residential, industrial and unused open field or woodlot with substantial ownership by the City of Welland.

Topography and bathymetry in the McMaster Avenue and Atlas 42-in. outfall areas as they existed prior to the full-scale cleanup are shown on Tender Drawings 11201-A0-009 and -010, respectively (Appendix A).

A floodplain has developed along both banks of the river in the project area. The width of this floodplain can be up to 25 m. The elevation of the floodplain varies from as low as 170.9 m along the river edge to as high as 171.5 m at the toe of the adjacent slope. At the edges of the floodplain, the ground surface rises relatively steeply, reaching approximately el 178 m on both sides of the river.

The ground surface in the floodplain area can be wet and boggy and access across it is generally poor. The river level can rise above the floodplain and cause seasonal flooding during periods of high flow.

At the dredging sites, the width of the Welland River varies from approximately 40 m to 60 m. River bottom elevations are as low as el 167.7 m and el 167.6 m at the McMaster Avenue and Atlas 42-in. outfall areas, respectively. For a nominal river elevation of 171 m, corresponding maximum water depths are about 3.3 m and 3.4 m. Immediately adjacent to the McMaster Avenue and Atlas 42-in. outfalls, 'reefs' of contaminated deposits had formed. Repeated, but limited exposure of the reef to the atmosphere at the Atlas 42-in. outfall during periods of low water level had formed a hard crust of contaminated material over a relatively small area.

The project area is part of a provincially significant wetland. Aquatic vegetation along the underwater side slope consists primarily of the submerged aquatics, water milfoil (Myriophyllum sp.) and coontail (Ceratophyllum demersum). From the top of the side slope, the floodplain is vegetated mainly by cattails (Typha latifolia), interspersed with arrowhead (Saggitaria sp.), burweed (Sparganium sp.) and sporadic wood species near shore. Clumps of tolerant woody species (willow, dogwood, speckled alder) are present immediately downstream of both the McMaster Avenue and Atlas 42-in. outfalls near the edge of the floodplain. A root mat has formed over and within the upper floodplain sediments and has a thickness of up to approximately 0.5 m.

Significant debris was present either on the riverbed or within the sediments, particularly in the vicinity of the outfalls. Such debris included tires, rock, concrete debris, large branches, large timbers, pieces of metal, waste rubber products, larger household items, miscellaneous refuse, etc.

The location and size of known outfalls and intakes at the McMaster Avenue outfall and Atlas 42-in. outfall areas are shown on Drawings 11201-A0-009 and -010, respectively in Appendix A.

3.2 Overburden Deposits

Within the project area the Welland River is located in a moderately deep channel in the postglacial clay plain which covers much of the Niagara Peninsula. Although its channel is largely natural, the lower 65 km of Welland River has been dredged for navigation purposes in the historical past, during the early days of navigation (Dillon, 1985). In relatively recent times, river conditions have allowed the deposition of generally fine-grained sediments in the river. These have also accumulated along both shorelines to form provincially significant wetlands and floodplains.

Within this section of the Welland River and its floodplain, six overburden types can be recognized as described below. Concentrations of various parameters in these materials were compared to the MOEE's PSQG, 1993, to indicate degree of contamination. Seven metals of concern were identified for this project, namely copper, chromium, iron, lead, manganese, nickel and zinc.

- **Metallic mill scale** - industrial deposits largely restricted to the riverbed adjacent to the McMaster Avenue and Atlas 42-in. outfalls and as rare lenses within the floodplain sediments. In many instances, the mill scale contained concentrations of heavy metals, in oxide form, in excess of the PSQG severe effect levels and relatively high concentrations of oil and grease.

- **River sediments** - present along the length of the river and constituting the underwater slope of the floodplain along the edges. The concentrations of metals and oil and grease in the river sediments vary widely depending on the nature of the sediments and their association with the mill scale. Where they were in close proximity to the mill scale, metal concentrations could be as high or higher than those in the mill scale.

- **Floodplain sediments** - immediately underlying the wetlands on each side of the river. The floodplain sediments adjacent to the reef deposits at the McMaster Avenue and Atlas 42-in. outfall areas typically have concentrations of the metals of concern in excess of the PSQG severe effect levels and have relatively high concentrations of oil and grease.

- **Postglacial sediments** - underlying the river or floodplain sediments and frequently exposed near the center of the river. These sediments generally contain little or no contamination.

- **Glacial till** - underlying the river floodplain or postglacial sediments and occasionally exposed near the center of the river. The glacial till contains little or no contamination below the top few centimetres.

- **Sand and gravel** - isolated thin layers overlying the river sediments, within the floodplain sediments or within the glacial till.

The distribution and geotechnical and chemical characteristics of each overburden type are discussed in more detail in Appendix A.

3.3 Hydrological Data

The section of the Welland River in which the dredging was carried out is situated between two syphon structures which allow the river to flow under the old and new Welland canals. These and other man-made structures have altered the natural flow conditions in this reach of the river.

In addition to allowing the natural river flows to pass under the old Welland Canal, the upstream syphons, located approximately 700 m upstream of the McMaster Avenue outfall, also serve to divert a fairly constant flow of 14.2 m^3/s from the old Welland Canal into the river through holes in the tops of the syphons. Near the upstream syphon structure is the RMON Water Treatment Plant (WTP) which passes up to 7 m^3/s of water from the old Welland Canal on a continuous basis into the Welland River. Approximately 1.25 km downstream from the McMaster Avenue outfall is the RMON Water Pollution Control Plant (WPCP) which also discharges into the river. Several municipal, industrial and residential outfalls of various sizes exist on the east bank of the river between the upstream syphons and the WPCP.

The hydraulic regime in the river is further complicated by a flow diversion offtake located approximately 16 km downstream from the dredging site at the entrance to the Queenston-Chippawa Power Canal (QCPC). The canal, which is located approximately 7 km upstream of the confluence of the Welland and Niagara rivers, serves to divert all of the Welland River flow and a portion of the Niagara River flow to the Sir Adam Beck Generating Station. Total flow in the diversion canal is controlled by manipulating water levels in the Niagara River within a prescribed range and rate of change. Water levels at the dredging site are directly influenced by the downstream level control. Water flow may occasionally reverse due to the operation of the downstream diversion control structure. These reversals tend to be gradual and do not result in significant flow velocities.

A summary of the Welland River monthly hydrology at the dredging site is presented in Table 3.1.

Daily fluctuations in river level during the project were generally less than 0.3 m. During one storm event on November 11, 1995, the river level rose by an estimated 0.8 m.

Water velocities in this length of river ranged between 0.1 and 0.69 m/s during the period of dredging and are detailed in Table 3.2.

Table 3.1

Summary of Welland River Hydrology at Dredging Site

Month	Percent Probability Flow (m^3/s) Will be Equaled or Exceeded											
	1%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
January	98.5	46.2	33.2	21.2	18.4	17.0	15.9	15.2	14.7	14.2	14.2	14.2
February	159.0	82.2	44.6	24.2	19.2	17.1	15.9	15.3	14.8	14.4	14.2	14.2
March	151.0	106.0	82.1	56.3	42.3	31.0	24.6	20.6	17.6	15.9	14.8	14.2
April	143.0	77.5	53.5	36.8	26.8	21.3	18.8	17.4	16.4	14.6	15.0	14.4
May	90.4	36.0	22.8	18.1	16.4	15.7	15.1	14.9	14.6	14.4	14.2	14.2
June	51.5	20.2	16.6	15.1	14.8	14.5	14.2	14.2	14.2	14.2	14.2	14.2
July	29.8	16.5	15.3	14.9	14.5	14.2	14.2	14.2	14.2	14.2	14.2	14.2
August	39.0	18.6	16.3	15.2	14.9	14.6	14.3	14.2	14.2	14.2	14.2	14.2
September	70.1	24.7	17.6	16.2	15.3	14.9	14.5	14.2	14.2	14.2	14.2	14.2
October	69.4	27.9	19.8	17.2	16.3	15.7	15.0	14.7	14.3	14.2	14.2	14.2
November	109.0	52.2	36.5	23.3	19.1	17.4	16.6	15.9	15.2	14.2	14.2	14.2
December	143.0	73.0	47.6	29.6	22.5	18.9	17.1	16.0	15.2	14.7	14.2	14.2

Notes:

- Flow analysis (Acres, July 1991) based on historical daily flow data (from 1957 to 1990) for the Welland River taken from WSC Station 02HA007 (near Caister Corners) and adjusted to following site conditions:
    - Ratio of drainage area at Station 02HA007 to site just upstream of Old Welland Canal syphon 3.35
    - Diversion flow from old Welland Canal into Welland River via ports in syphon equal to 14.2 m^3/s continuous
    - Diversion flow from old Welland Canal into Welland River via Water Treatment Plant is not considered.

Table 3.2

River Velocity Measurements

Date	Velocity (m/s)	
	a.m.	p.m.
September 27, 1995	0.42	
September 28, 1995	0.13	
September 30, 1995	0.3	0.43
October 2, 1995	0.31	0.4
October 3, 1995	0.32	0.42
October 4, 1995	0.35	
October 5, 1995	0.2	0.33
October 10, 1995	0.16	
October 11, 1995	0.19	0.19
October 12, 1995	0.18	0.25
October 13, 1995	0.15	0.21
October 14, 1995	0.18	
October 16, 1995	0.17	0.19
October 17, 1995	0.14	0.25
October 18, 1995	0.25	0.31
October 19, 1995	0.23	0.24
October 20, 1995	0.2	0.22
October 21, 1995	0.16	0.2
October 23, 1995	0.4	
October 24, 1995	0.27	0.35
October 25, 1995	0.21	0.24
October 26, 1995	0.23	0.3
October 27, 1995	0.14	0.35
October 28, 1995		0.25
October 30, 1995	0.17	0.22
October 31, 1995	0.21	0.24
November 1, 1995	0.18	0.23
November 2, 1995	0.26	0.35

Table 3.2
River Velocity Measurements - 2

Date	Velocity (m/s)	
	a.m.	p.m.
November 3, 1995	0.23	
November 4, 1995	0.24	0.29
November 6, 1995	0.2	
November 11, 1995	0.18	
November 14, 1995	0.69	
November 15, 1995	0.6	
November 16, 1995		0.6
November 21, 1995	0.4	0.45
November 22, 1995	0.45	0.49
November 23, 1995	0.46	0.48
November 24, 1995	0.35	
November 27, 1995	0.37	0.42
November 28, 1995	0.38	0.41
November 29, 1995	0.4	
December 1, 1995	0.35	
December 5, 1995	0.32	0.37
December 6, 1995		0.11
December 7, 1995	0.21	
December 8, 1995	0.23	
December 9, 1995	0.1	
December 11, 1995	0.12	
December 12, 1995	0.15	
December 13, 1995	0.21	
December 14, 1995		0.21
December 15, 1995		0.23
December 16, 1995		0.2
December 19, 1995	0.18	
December 20, 1995	0.16	
December 21, 1995	0.16	

4 Contractual Considerations

4 Contractual Considerations

4.1 Tendering Process

Due to funding limitations, the tendering process for the Welland River Reef Cleanup Project had to be flexible to achieve the best balance between price and risk to the owner. Three tender calls were necessary before selecting the final contractors. Key dates during the tendering process are summarized in Table 4.1. The various tender calls are described briefly below.

4.1.1 Contract C1 - Sediment Removal and Treatment (May and June 1995)

It was originally intended that project implementation would be carried out as a single contract (Contract C1) with the selected contractor responsible for all aspects of the site work, including site preparation and facilities, sediment removal, floodplain protection and sediment treatment. This approach was initially desired to ensure coordination by the contractor between the dredging and sediment treatment operations, and therefore minimization of interface problems and schedule delays. Due to Derrick Corporation's involvement with the 1991 demonstration project, Contact C1 specified that Derrick was to be a designated subcontractor for sediment treatment. The tender documents also specified that the dredge should be a horizontal auger, hydraulic suction type dredge, as this was the type of dredge for which performance data was available from the 1991 demonstration. A sophisticated dredge positioning system was required to be installed on the dredge.

All tenders prices received for Contract C1 were significantly above the available funding amount. Discussions with tenderers indicated that this was due to the level of risk they perceived in the project and the cost of dredge modifications.

4.1.2 Proposals from Tenderers (June and July 1995)

In an attempt to deal with some of the concerns raised by the tenderers and therefore facilitate the project, tenderers were asked to submit proposals to carry out the project within an upper cost limit of $1.5 million. It was stressed in the call for proposals that Atlas would be as flexible as possible in considering

Table 4.1

Key Dates During Tendering Period

Date	
May 12, 1995	Tender documents issued for Contract C1, Sediment Removal and Treatment.
June 13, 1995	Tenders for Contract C1 received. All tenders significantly exceeded available funding.
June 20, 1995	Tenderers advised that submitted tender prices exceed available funding, previous tender call cancelled and proposals requested based on upper limit price of $1.5 million.
June 30, 1995	Proposals received.
July 12 to 14, 1995	Tenderers advised that, because of cost and technical concerns, submitted proposals cannot be accepted. Tenderers then invited to submit bids for one or more separate components of the project (dredging, treatment or floodplain protection).
July 17, 1995	Tenderers submitted for split contracts.
August 22, 1995	Award of Contract C1B - Floodplain Protection to The Ontario Construction Co. Ltd
August 23, 1995	Award of Contract C1A - Dredging to Normrock Industries Inc.

appropriate suggestions and alternatives by tenderers. Several relaxations of the specifications of Contract C1 would also be permitted, such as

- the use of hydraulic suction dredges, other than the horizontal auger type, would be permitted

- the use of Derrick Corporation as a designated subcontractor could be relaxed and alternative treatment processes would be considered.

Proposals were submitted by several tenderers, but due to various cost and technical concerns, none could be accepted.

4.1.3 Split Contracts (July and August 1995)

The possibility of splitting up the site work was then investigated. The dredging, sheet piling and sediment treatment components would be carried out as separate contracts under Atlas' management. It was anticipated that this approach would be more cost-effective by reducing risk to the contractor. Tenderers were therefore invited to submit cost estimates for one or more of the three main components of the project (i.e., dredging, floodplain protection and sediment treatment). Tenderers were also advised that Atlas was considering the use of an alternate dredging technology.

Favorable submissions were received from several tenderers and, after clarification and evaluation of submissions, the following contracts were awarded:

- Contact C1A - Dredging (comprising sediment removal and pumping of dredgeate through a pipeline to Atlas' NFP); awarded to Normrock Industries Inc. of Terrebonne, Quebec.

- Contract C1B - Floodplain Protection (comprising site preparation and facilities, sheet piling, granular fill placement and floodplain pocket remediation); awarded to The Ontario Construction Co. Ltd. of Niagara-on-the-Lake, Ontario.

Sediment treatment would be carried out by Atlas, using equipment rented from Derrick and operated by Atlas' labor.

4.2 Site Organization

The site organization during implementation is shown in Figure 4.1. Atlas acted as overall project manager, with Acres supervising dredging and floodplain protection activities on Atlas' behalf.

4.3 Schedule

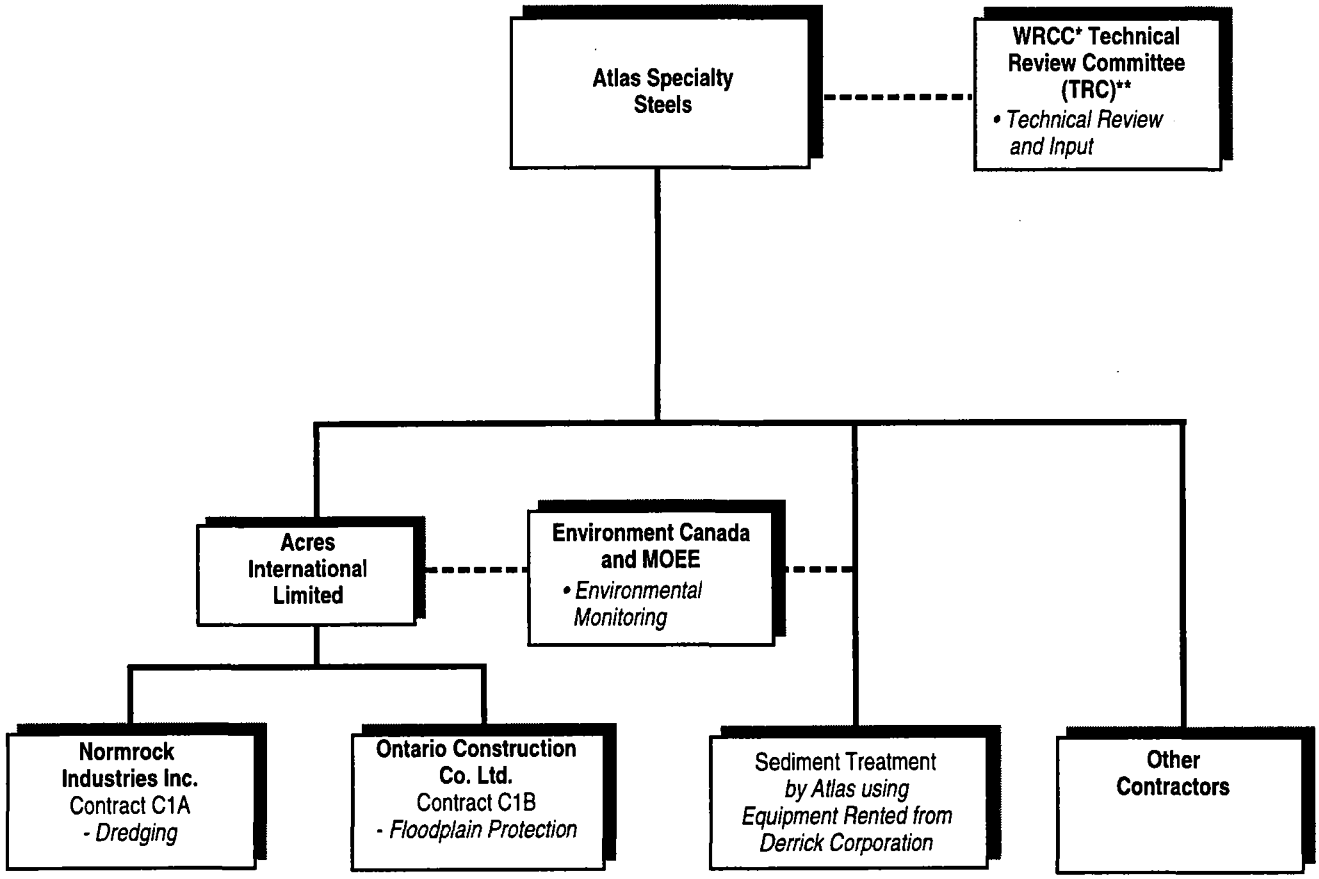
The schedule for site works, as agreed with the contractors at the time of award of Contracts C1A and C1B, is shown in Figure 4.2 as the "baseline" schedule. Also shown in the figure is the actual schedule, along with annotations regarding site activities.

As can be seen from Figure 4.2, baseline and actual completion dates were

	Baseline Completion Date	Actual Completion Date
Dredging	October 28, 1995	December 19, 1995
Floodplain protection	November 15, 1995	January 26, 1996 (Substantial)

The reasons for the significant increase in the duration of the site works are discussed in detail in Sections 5, 6 and 7. However, the major reasons can be summarized as follows:

- reduced dredging rate in heavy mill scale material
- reduce dredging rate due to river debris
- removal of greater volume of contaminated sediment than originally anticipated
- inadequate capacity to handle/store fine sediment fraction of dredgeate
- winter weather conditions.



* WRCC - Welland River Cleanup Committee

** TRC Memberships

- Acres International Limited
- Atlas Specialty Steels
- City of Welland
- Environment Canada
- Members of the Public
- Ministry of Environment and Energy
- Ministry of Natural Resources
- Niagara River RAP-PAC
- Regional Municipality of Niagara
- Water Technology International Corporation

Fig. 4.1

Atlas Specialty Steels/Environment Canada

Welland River Reef Cleanup Project

Site Organization During Implementation

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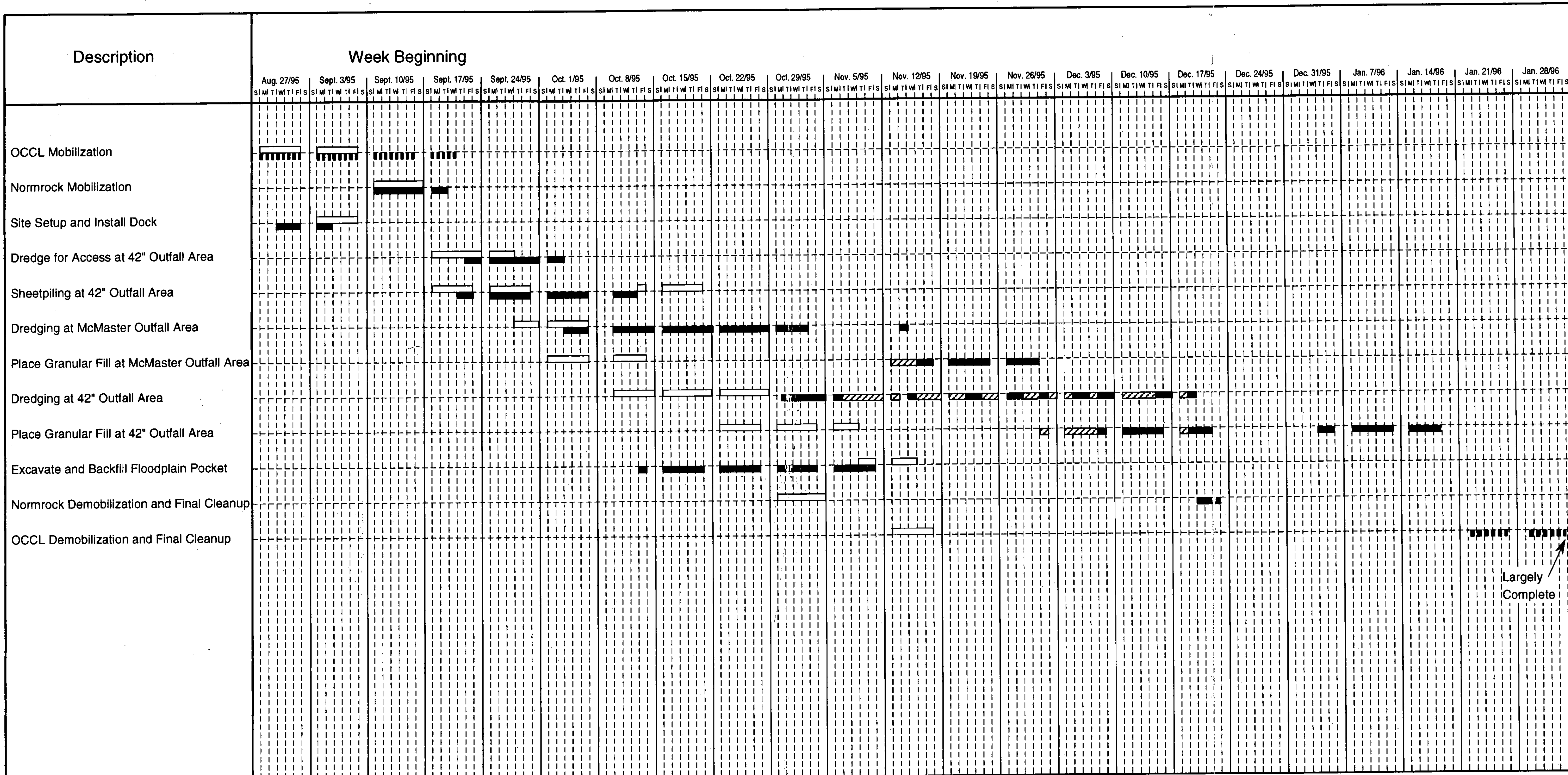

Legend

- Baseline Duration
- Actual Duration
- Standby
- Intermittent

OCCL - The Ontario Construction Co. Ltd.
Normrock - Normrock Industries Inc.

Note:
OCCL schedule based on 5 working days per week
Normrock schedule based on 6 working days per week

Fig. 4.2

Atlas Specialty Steels/Environment Canada
Welland River Reef Cleanup Project
Project Schedule

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5 Sediment Removal

5 Sediment Removal

5.1 General

Dredging of mill scale and contaminated sediments from the Welland River commenced on September 22, 1995 and was completed on December 19, 1995. Dredging was carried out at both the Atlas 42-in. outfall and the McMaster Avenue outfall areas as indicated in As-Built Drawings 11201-A0-004, 005, 006 and 007 (back pocket, Volume 1). In total, a calculated 9833 m^3 of material were removed from the river, with 6783 m^3 coming from the Atlas 42-in. area and the remaining 3050 m^3 from the McMaster Avenue area.

The major part of the dredging (7613 m^3) was carried out using an Amphibex dredge, owned and operated by Normrock Industries Inc. of Terrebonne, Quebec. The remainder (2220 m^3) was removed using a land-based, long-reach backhoe, owned and operated by Livingstone Excavating and Trucking Inc. of Simcoe, Ontario. Due to debris and the high specific gravity of the mill scale, initial dredging rates with the Amphibex at the McMaster Avenue outfall area were insufficient to maintain the schedule. Therefore, the long-reach backhoe was brought to site to assist with removal of mill-scale material at this location. It was subsequently used to remove mill scale material in the immediate vicinity of the Atlas 42-in. outfall.

The material dredged by the Amphibex was pumped as a slurry through a 200-mm diameter polyethylene pipeline, having a length of up to approximately 1.5 km, to Atlas' NFP where a temporary sediment treatment facility had been set up. The river material excavated by the backhoe was hauled by truck to a drying pad located on Atlas property.

The dredging part of the project was originally scheduled over a 6-wk period, with all dredging to be done by the Amphibex. Dredging actually extended over a period of 12.5 weeks. The reasons for the extended dredging period included dredging of approximately 35% more sediment than originally estimated, delays due to impacts from fine sediment on Atlas' NFP, reduced productivity of the Amphibex in the heavy mill scale material and sediment containing debris, and impacts due to cold weather. Two factors contributed to the increase in dredging quantities--the depth and lateral extent of contaminated materials was greater than originally anticipated, and overdredging may have occurred at the McMaster Avenue area.

During the early part of the project, control of dredging depth and extent was carried out by the dredging contractor, Normrock. However, due to concerns regarding possible overdredging and contamination found below intended dredging grade at the McMaster Avenue outfall area, an inspector from Acres was stationed on the dredge during subsequent dredging to monitor depth of sediment removal.

After dredging was considered complete in a section of river, samples of the riverbed material were obtained on a 5-m by 5-m grid. These were first inspected visually and then submitted for analytical testing to ensure that the clean-up criteria (metal concentrations to be below PSQG severe effect levels) had been achieved. In a few isolated areas, this sampling indicated that contaminated material remained after the initial dredging. These areas were then redredged and resampled until it was confirmed that the clean-up criteria had been met.

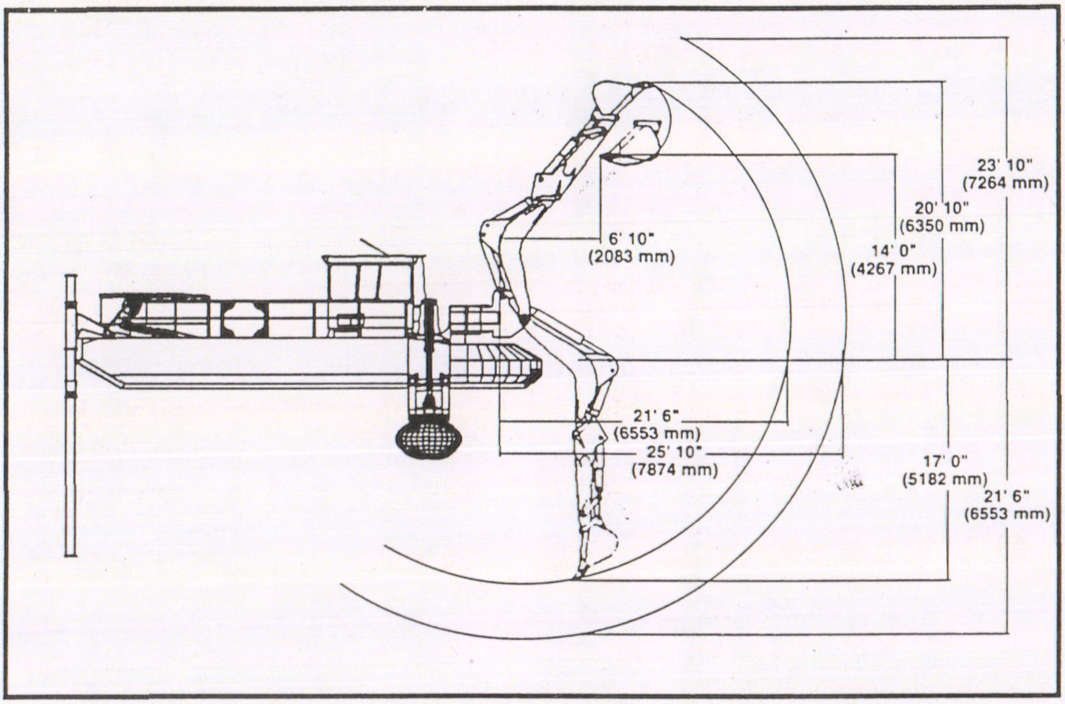
All dredging was performed inside a silt curtain in order to minimize the impact of any resuspended solids on downstream river water quality. A river water quality monitoring program was implemented at the start of the project to monitor environmental compliance with regulatory criteria. This monitoring program and the regulatory criteria are discussed in Section 5.3.2.

An evaluation of the performance of the Amphibex dredge is presented in Section 5.2.

5.2 Description of Sediment Removal Technology

The Amphibex dredge is a combination mechanical-hydraulic suction dredge which requires no cables for anchoring or maneuvering. It has two spud legs at the rear of the dredge, and two stabilizer arms off either side near the front end of the dredge. The spud legs can be tilted, and in combination with the stabilizing arms and the excavating arm, can effect movement of the dredge both in the water and on land. It also has a rear mounted propeller which allows additional maneuvering capabilities in water. Technical features and specifications of the Amphibex are shown in Figure 5.1.

The forward backhoe-style arm of the dredge can be equipped with various attachments including a pump bucket, an excavating bucket, rake, hammer, etc. During operation, the main body of the dredge remains stationary and the attachment is extended over the front of the dredge for use.



TECHNICAL FEATURES
MODEL AE3

Maximum length:
35'8" (10.85 m)

Maximum depth:
21'6" (6.53 m)

Maximum reach:
25'10" (7.86 m)

Approximate working weight:
18 metric tons

Transport length:
42'2" (12.85 m)

Transport width:
11'6" (3.50 m)

Transport height:
10'6" (3.20 m)

Approximate speed on water:
9 knots

Fig. 5.1

Atlas Specialty Steels / Environment Canada
Welland River Reef Cleanup Project
Amphibex Dredge - Features and Specifications

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The pump bucket attachment was used for dredging the river sediments. It features an excavating bucket fitted with a horizontal cutter bar and dual 150-mm suction pumps which collect and transport the excavated material. The two 150-mm discharge lines from the pumps go to two 125-mm pipelines, which then join, on the dredge, to a single 200-mm discharge pipeline. From the dredge the slurry was fed into a single 200-mm diameter polyethylene pipeline and pumped, with the aid of 1 or 2 booster pumps, up to approximately 1.5 km to the sediment treatment facility. Movement of the dredge in the water was achieved by pulling with the spuds and pushing off the river bed with the bucket. The dredge would normally excavate sediment within the sweep radius of the backhoe arm before repositioning itself. While dredging, the Amphibex was firmly anchored on the riverbed using the rear spuds and the side stabilizing arms. The radial sweep capability of the backhoe arm and the articulation provided in the backhoe arm and bucket provided the operator with significant flexibility in positioning the dredge.

The Amphibex, with its rotating cutter bar mounted in the pump bucket, was capable of removing not only the river sediment, but also the floodplain materials which consisted of organic rich sediments, root masses and stalks from aquatic vegetation.

The backhoe-style bucket was well suited to handle large or angular objects or debris, such as boulders, pieces of wood, etc. These were lifted out of the river with the bucket and placed in a separate container for disposal. In areas of excessive debris, the Amphibex was fitted with a rake to clear away debris prior to suction dredging.

The Amphibex offered flexibility in terms of deployment. It can be launched by crane into the water or, as it was done for this project, it can lift itself and 'walk' across the shoreline into the water using the spuds, backhoe bucket and stabilizing arms.

From an environmental perspective, the Amphibex was considered capable of completing the dredging without causing a significant negative impact on downstream water quality. However, some amount of sediment resuspension and turbidity was expected during dredging and to ensure this was contained the dredging was performed within a silt curtain.

5.3 Evaluation

5.3.1 Dredge Performance

An evaluation of the productivity and efficiency of the Amphibex was made possible through the daily records of dredging activities maintained by Normrock and by the installation and use of an electromagnetic flowmeter and a nuclear densitometer installed on the dredge in the 200-mm diameter pipeline. Due to space limitations on the dredge, the nuclear densitometer could not be mounted to measure vertically across the pipeline, and had to be aligned at approximately 60° from the vertical. This may have caused the densitometer to indicate slurry densities lower than the overall density in the pipeline. The flowmeter and densitometer were operating for a limited period between November 29 and December 19, 1995.

Site records, survey data, contractor's daily records of dredging activity, and instrumentation data provided the following information regarding the productivity of the Amphibex dredge during the project. A summary of dredging activity on each day is provided in Appendix C.

Location	**Time Dredging [1] (h)**	**Time Dredging [2] (%)**	**Volume Dredged [3] (m^3)**	**Average Dredging Rate [4] (m^3/h)**	**Range of Flows (USgpm)**
McMaster Avenue Outfall[5] - predominantly mill scale	142.8	57.4	1830	12.8	1000 to 1800
Atlas 42-in Outfall					
- predominantly mill scale	130.5	71.9	2197	16.9	1000 to 1800
- fine grained sediments	31.9	69.2	3586	112.4	1000 to 1800
Overall Performance (in mill scale and sediments)	162.4	71.4	5783	35.6	1000 to 1800
Combined Locations	305.2	64.1	7613	24.9	1000 to 1800

[1] Includes time dredging sediment and excludes time for pumping clean water, flushing the pipeline, clearing debris, repairs and maintenance, delays due to water quality.

[2] Time dredging expressed as a percentage of total available time (excluding major setup time and standby time).

[3] In situ volume.

[4] Based on in situ volume.

[5] At the McMaster Avenue outfall area, the dredged material was predominantly mill scale, but some fine sediment was also dredged. The fine sediment was either interlayered/mixed with the mill scale or was excavated from the adjacent floodplain.

The greatest hourly dredging rate achieved was on December 19, 1995, the last day of dredging. On this day, the dredge removed the remaining downstream 120 m length of contaminated fine-grained sediments at the Atlas 42-in outfall area. The average dredging rate for this day was approximately 195 m^3/h over about 6.5 hours. Further details are provided in Table 5.1.

A typical plot of the flow and densitometer data versus time is shown in Figure 5.2. This and other plots covering several (but not all) dredging periods between November 29 and December 19, 1995, are presented in Appendix C. Times when the dredge was not operating or when data was not being recorded are shown in the plots.

The plots indicate how both the flow (USgpm) and the slurry solids content (by weight) fluctuated considerably during dredging events. This is mainly attributed to the short cycle dredging sequence whereby the dredge pulls the pump bucket through the sediment creating and attempting to maintain a high solids content slurry. During this period the flow fluctuates in response to the solids loading. When the pump bucket has reached its pull limit and is lifted to engage more sediment, the solids content in the slurry drops to very near zero and the flow again fluctuates in response.

Throughout the dredging the flow was observed to range between 1000 and 1800 USgpm. The plots of slurry solids content from densitometer data show frequent peaks in the range of 20 to 60% solids, however, these concentrations are not sustained for long periods of time. From these plots, the average sustained slurry solids content during the period that data was collected is estimated to have been between 10 to 20% by weight. Back calculation of slurry solids content, using average dredging rates, typical in situ densities and material specific gravities, and an average flow rate of 1400 USgpm, gives the following estimates of average solids contents.

Location	**Average Slurry Solids Content** (% by weight)
McMaster Avenue Outfall - predominantly mill scale	6
Atlas 42-in. Outfall	
- predominantly mill scale	8
- fine-grained sediments	28

Table 5.1

Dredging Data
December 19, 1995

Material Dredged:	Fine grained sediments (clay and silt)
In situ bulk densities: (approximate)	Wet bulk density - 1.47 tonne/m^3 Dry bulk density - 0.95 tonne/m^3
Average solids specific gravity:	2.6
Water depth:	0 to 2.8 m
Pumping distance:	800 to 900 m
Pumping head (river level to North Filtration Plant):	11 m
Number of booster pumps:	1
Volume removed	1266 m^3
Dredging time:	6.5 hours approximately
Average dredging rate:	195 m^3/h
Slurry flow rate:	1000 to 1800 USgpm
Average slurry solids content:	43% by weight

This indicates the significant improvement in solids content achieved by the Amphibex when dredging the fine grained sediments.

Toward the latter part of the dredging, when temperatures fell below freezing, problems were experienced with the slurry in the pipeline freezing when there was a pause in dredging. It was then very difficult to thaw or remove the frozen slurry, and measures such as steam hoses were required. This matter was reviewed with the TRC on a number of occasions. Eventually, the most effective solution was complete draining of the slurry pipelines whenever a significant pause in dredging was anticipated.

The total cost of dredging (excluding standby) was $426,700, of which $85,000 was for mobilization and demobilization. The dredging was carried out at a unit rate of $20/m^3 (in situ volume) excluding mobilization and demobilization costs, pipeline setup costs, slurry transport costs (i.e., operation and maintenance of pipeline and booster pumps), site facilities and other miscellaneous costs (e.g., accommodations, administration, etc). Slurry transport costs, which included costs associated with the operation and maintenance of approximately 1500 m of pipeline, with one or two booster pumps, worked out to an additional $4/m^3, giving a total unit cost for dredging and slurry transport of $24/m^3.

5.3.2 Water Quality During Dredging

5.3.2.1 Background and Program Description

A multiparameter, multiple sampler monitoring program was established at the beginning of the dredging project to evaluate the environmental compliance and performance of the dredge in relation to water quality standards of Environment Canada, the MOEE, and the MNR. This program included collection and submission of samples for laboratory analysis; collection of grab and integrated samples for immediate turbidity measurement in the field; and electronic, real time, on-site monitoring of eight specific water quality parameters. The monitoring program was designed to be more intensive during the first 5 days of operation at each reef, and then diminish in intensity as operations became more routine. The field monitoring program work plan is presented in its entirety in Appendix C, while a brief description of, and the rationale for, implementation of each aspect of the overall monitoring program is presented below.

Turbidity was selected as the parameter that would be intensively measured in the field to determine whether the dredge was operating within the established project water quality criteria. Data collected during the 1991 pilot-scale demonstration had been used to develop a relationship between total suspended solids and turbidity for this particular site. The full-scale monitoring program sought to use and build on that data base, so as to provide a reliable, real-time means of monitoring dredge performance and meeting regulatory requirements for the project. Experience from the pilot-scale project had indicated that controlling turbidity would also control the loading of other contaminants, particularly metals, which are generally tightly bound to particulate matter.

For monitoring purposes, the relationship shown on Figure 5.3 of acceptable turbidity downstream of dredging for varying background (upstream) turbidity levels was selected. This relationship was compiled from previous water quality criteria provided by Environment Canada, MNR and MOEE, and was reviewed by these agencies prior to its adoption. Toward the end of the project, a decision was made by Environment Canada, MOEE and MNR to modify the criteria to recognize the effect of high background turbidity levels. The new criteria required mitigative measures to be taken when downstream turbidity readings exceeded upstream levels by 25 NTU, during high periods of background turbidity.

Three primary sampling areas were selected, namely upstream, downstream and within the silt curtain enclosing the dredging operations. Upstream and downstream sampling locations were positioned approximately 25 m from their respective ends of the silt curtain enclosure. The "within curtain" sampling point was positioned immediately inside of the downstream end of the silt curtain.

Samples were collected and submitted for water quality analysis (11 parameters; being turbidity, total suspended solids (TSS), oil and grease, cadmium, chromium, copper, iron, manganese, lead, nickel and zinc) at all three locations from one to two times daily, depending on the daily dredging schedule and/or the duration of dredging during a particular day. Samples were submitted to Acres Analytical Limited (Niagara Falls) during the first 5 days at each location (turnaround time of 2 days specified), and to the MOEE (Toronto) during the remainder of the time at each reef (slower turnaround time acceptable). Results of the first 5 days of sampling were used to verify that the turbidity-based water quality criterion established for the project was acceptable and operating as anticipated.

Two Hydrolab submersible multiprobes (one H_2O Multiprobe and one DataSonde 3 Multiprobe Logger) attached to shore-based Surveyor 3 Display Loggers were deployed at the upstream and downstream monitoring points. These instruments were configured to measure temperature, turbidity, pH, specific conductivity, total dissolved solids, dissolved oxygen (% saturation and mg/L) and depth of probe deployment. Instruments were supplied by, installed, serviced and calibrated by Environment Canada. Probes were deployed approximately 1.5 m below the water surface, and 3 to 4 m from shore, dependant on the width of the reef in that particular area. This position was selected as it provided the greatest potential for loss of suspended sediment from the silt curtain at the intersect of the river bottom and river side slope. Data was downloaded from the data logger to a portable PC on a daily basis, and hourly averages were calculated for each measured parameter.

Grab samples were taken downstream from the silt curtain at various water depths and distances from shore (mid-curtain and outer edge of silt curtain enclosure) to ensure that the silt curtain was providing uniform silt retention along its length, and that the point being monitored by the electronic, real time equipment was representative of water quality in the downstream area. These grab samples were taken twice a day when the dredge was operational, and were immediately analyzed for turbidity in the field trailer. Additionally, hourly integrated samples (four aliquots collected 15 min apart to produce a 1-hour integrated sample) were collected at the sampling points within the silt curtain and downstream of the silt curtain with ISCO samplers. These samples were analyzed for turbidity at the field trailer, and compared to readings produced by the electronic monitors. A selected portion of these samples was retained for the detailed laboratory analysis noted above. A daily integrated sample (consisting of hourly subsamples) was collected upstream from the dredging operation and also analyzed for turbidity and other parameters.

5.3.2.2 External Inputs

A number of inputs extraneous to the actual operation of the dredge were noted at various times throughout the project. The most significant of these were related to storm water runoff and discharge from the Atlas 42-in. outfall and from the 36-in. outfall directly to the north. Any external inputs between the upstream and downstream sampling locations would add TSS and organic and inorganic inputs to the system. These inputs would be in addition to any disturbance caused by dredging activities. The flows from external inputs could also affect the ability of the silt curtain to contain both inputs from these sources and any sediment resuspension caused by dredging.

Stormwater Runoff
For several rain events during the project, large flows into the Welland River were noted from a number of outfalls. Although consideration was given to the selection of sampling locations with respect to external inputs, up to three active outfalls were within the upstream and downstream sampling locations at certain times. Also, outfalls along the river upstream of the project area and river bank erosion combined to significantly alter background TSS levels.

Sewer Discharges
During several days abnormally turbid discharges were noted at the Atlas 42-in. outfall and at the 36-in. outfall. In most cases, the Atlas 42-in. outfall discharge could be traced to filter difficulties at the NFP related to the dredging operation. However, on several days in early December, starting approximately December 6, the turbid discharge was traced to the discharge of post-sediment treatment water to the Regional sewer system. Although the volume being pumped was within the limit set by the Region, the flow was too high for the sewer configuration and resulted in a backflow to the Atlas 42-in. sewer and overflow to the 36-in. sewer. This problem was rectified by lowering the volume of water discharged to the Regional sewer system until flow ceased to the Atlas 42-in. and the 36-in. sewers.

5.3.2.3 Monitoring Results

The results of the water quality monitoring program are presented on a parameter-by-parameter basis in the following section. Concentrations of each parameter upstream from the dredging operation, within the silt curtain and downstream from the silt curtain, are presented graphically in Figures 5.4 to 5.17 (plots of concentration versus time) in comparison with the provincial water quality objective (PWQO) (MOEE, 1995a) for that parameter. In those cases where morning (a.m.) and afternoon (p.m.) samples were taken on the same day, a daily average value is used in the plot. Dredging commenced at the Atlas 42-in. reef on September 22, and continued at that location until October 3, when enough sediment had been removed to allow equipment barges to access the river-shore interface to drive sheet piling. The dredging operation was then moved to the McMaster Avenue reef area from October 4, to November 2, and returned to the Atlas 42-in. reef on November 3, to complete the removal of sediment at that area. Redredging of a limited area of the McMaster Avenue reef was carried out on November 14. Analytical results and data tables upon which the plots are based are presented in Appendix D (Volume 2).

Cadmium

Cadmium concentrations upstream of, within and downstream of the silt curtain, are shown in Figure 5.4 and presented in tabular form in Table D1.1 (Appendix D). The PWQO for cadmium is 0.0002 mg/L. Cadmium concentrations were at or below the PWQO during all initial operations at the Atlas 42-in. reef, and during most of the dredging at the McMaster Avenue reef. There were however, two occasions (October 18 and 21) when upstream levels were greater than the PWQO. On both occasions, the downstream concentrations were twice the upstream concentrations, indicating that the dredging operation was also contributing to the higher downstream levels. On October 18, within curtain and downstream values were the same, indicating that, at that particular time, the silt curtain was ineffective in containing contaminants generated by the dredging operation. On October 21, downstream concentrations were approximately half of those within the silt curtain, indicating that the curtain was providing a reduction in contaminant concentrations.

Upstream concentrations of cadmium exceeded the PWQO for 7 of the 15 days that data are available for the remaining Atlas 42-in. dredging operation (November 4 onward), with values ranging from 2.5 to 25 times the PWQO. Within curtain and downstream concentrations exceeded upstream concentrations on only one occasion (November 28), when downstream values were higher than both the upstream levels and the PWQO. This indicates that, on this day, the very fine particles to which the cadmium was attached were either passing through the curtain, or finding their way under or around the curtain.

Chromium

Chromium concentrations associated with the dredging operations at the two reef areas are presented in Figure 5.5(a) and Table D1.2. The PWQO for chromium is 0.1 mg/L. Downstream concentrations were below the PWQO on all but two occasions (November 11 and 15). On the first date, upstream and within curtain concentrations were both above the PWQO and the downstream values, indicating that the silt curtain was effectively reducing downstream concentrations of chromium. On the second date

(November 15), upstream values were marginally below the PWQO, while downstream values exceeded the PWQO. Samples within the curtain were not taken that day. Apparent high values from November 11 to 14, and on December 5, are the result of high detection limits for those samples.

In order to evaluate the effectiveness of turbidity and TSS as viable indicators of water quality, turbidity (FTU) has been plotted in conjunction with chromium in Figure 5.5(b), while TSS has been plotted with chromium in Figure 5.5(c). Scales have been adjusted to avoid overlap of data points as much as possible in order to reveal any potential correlations or patterns.

The turbidity vs chromium plot indicates that high concentrations of chromium are usually associated with high turbidity levels, but the relationship is not constant nor consistent. In some cases, elevated downstream concentrations of chromium were associated with high turbidity levels (i.e., period from November 4 to 11), while at other times they were not (i.e., November 14 to 16). Further investigation of this inconsistency indicated that it may be related to differences in turbidity measurements obtained by the two labs (Acres and MOEE). Further discussion of this topic is presented in the TSS versus turbidity section.

The TSS versus chromium plot indicates that TSS concentrations followed a similar pattern as chromium concentrations within the water column during most of the dredging operations at the Atlas 42-in. reef, but not at the McMaster Avenue reef. In the latter case, chromium concentrations were consistently low throughout the dredging at McMaster, while TSS concentrations fluctuated from near zero to approximately 300 mg/L.

Copper

Concentrations of copper upstream, within the silt curtain and downstream from the dredging site are shown in Figure 5.6, while analytical results are listed in Table D1.3. The PWQO for copper is 0.005 mg/L. During the initial period of dredging in the vicinity of the Atlas 42-in. outfall, ambient concentrations at the upstream location exceeded the PWQO for 4 out of 10 days, while concentrations at the downstream location exceeded the PWQO on three of seven occasions. On only one occasion (September 29) was there an obvious linkage between high concentrations of copper within the silt curtain and the resultant downstream levels.

Throughout the dredging operation at the McMaster Avenue reef, copper concentrations were very near the PWQO at all three monitoring locations. The highest concentration measured during this period was 0.009 mg/L, which occurred once within the silt curtain on October 19, and once downstream on October 26. The highest upstream level was 0.007 mg/L on October 13.

During the final phase of dredging at the Atlas 42-in. outfall reef, copper concentrations varied widely and were often in excess of the PWQO, both upstream and downstream of the dredging site. This period was characterized by considerably higher river flows and velocities (0.69 m/s measured maximum on November 14) than at this location or at McMaster Avenue outfall (see Table 5.1). Concentrations within the silt curtain exceeded the PWQO on 7 of the 12 days that samples were collected, while downstream concentrations were above the PWQO on 11 of 14 days monitored. Generally, downstream concentrations were marginally lower than those within the silt curtain, although there were two occasions when they were higher. On three of those same 14 days, upstream concentrations were above the PWQO, indicating that the dredging was not the only source of copper to the river.

Iron

Plots of iron concentrations upstream, within the silt curtain and downstream of the dredging sites are shown in Figure 5.7, while measured values are listed in Table D1.4. The PWQO for iron is 0.3 mg/L.

During the initial period of dredging at the Atlas 42-in. outfall, ambient upstream concentrations exceeded the PWQO for 4 of 10 days, while downstream concentrations exceeded the PWQO for 4 of 8 days. A clear correlation was present between high levels within the silt curtain and high downstream levels on two occasions (September 29 and October 3). High values at other times were related to high ambient upstream levels.

During the dredging operation at the McMaster Avenue reef, iron concentrations downstream of the dredging operation exceeded the PWQO for 7 of 16 days, with three of those occasions corresponding to high upstream levels. On all but one occasion (October 25, 0.82 mg/L), downstream levels were only marginally above the provincial objective. Measured values within the silt curtain exceeded the PWQO on 6 of 15 days.

The silt curtain was generally effective in reducing the downstream concentrations of iron to reasonable levels, although there were two occasions at the start of the McMaster dredging period (October 10 and 12) when downstream levels exceeded both the within curtain and upstream levels.

Iron concentrations upstream, within the silt curtain and downstream of the dredging site consistently exceeded the PWQO during the majority of the dredging operation to complete the reef removal at the Atlas 42-in. site. Although downstream concentrations were generally lower than those within the silt curtain, the reduction was often only marginal, indicating that the silt curtain was partially effective in retaining contaminated sediment within its borders during this period. On a number of occasions (November 6, 23, 28, 29, and December 1) the downstream concentration was higher than that measured within the silt curtain, presumably indicating that sediment was escaping from the silt curtain without being detected at the within curtain monitoring location.

Lead

Concentrations of lead measured at the three sampling locations are shown in Figure 5.8 and listed in Table D1.5. The toxicity of lead is dependant on the alkalinity of the water, declining as the alkalinity increases. The PWQO for lead ranges from 0.005 to 0.025 mg/L as alkalinity (measured as $CaCo_3$) increases from 20 to greater than 80 mg/L. Although it was not measured as part of this program, alkalinity has been found to average slightly less than 100 mg/L in the Welland River based on previous sampling (MOEE, 1995b). The applicable PWQO is therefore 0.025 mg/L, which is shown in Figure 5.5.

Upstream lead concentrations were at or marginally above the PWQO during all of the initial dredging operations at the Atlas 42-in. reef location and during the majority of the cleanup at the McMaster Avenue site. There was, however, one occasion (October 26) at the McMaster Avenue location when lead levels were above the PWQO for all three monitoring sites, with higher levels at the within curtain and downstream sampling locations.

During the completion of the dredging at the Atlas 42-in. location, levels at all three monitoring sites were at or near the provincial objective for most days, although there were two occasions (November 11 to 16, and December 5) when levels were significantly higher than the PWQO. The peak downstream level was recorded on November 15, (0.7 mg/L), and occurred in association with high upstream levels (0.5 mg/L), which coincided with peak river flows and current velocities (Table 5.1).

Manganese

Plots of manganese concentrations at the three sampling locations upstream, within the silt curtain and downstream of the dredging site are presented in Figure 5.9, while laboratory analytical data is listed in Table D1.6. Manganese is used in the iron and steel industry, but is also a naturally occurring element in soils, sediments, and metamorphic and sedimentary rocks. As such, no formal water quality criteria for the protection of aquatic life exists for the element, although concentrations in natural surface waters are usually 0.2 mg/L or less, but may reach 1 mg/L (CWQG, 1989). The provincial maximum desirable concentration of 0.05 mg/L related to the aesthetic quality of drinking water is not considered applicable to this work. Hence, the average natural surface water concentration (0.2 mg/L) will be used for comparison.

Concentrations of manganese were at or below 0.2 mg/L at all three monitoring sites during the initial dredging at the Atlas 42-in. reef location and during the cleanup at the McMaster Avenue site. Concentrations were higher and more variable during the final dredging operation at the Atlas 42-in. reef. Concentrations downstream from the silt curtain were generally equivalent to or marginally higher than those within the silt curtain, indicating that the silt curtain was not effective in retaining suspended sediments during this period. The maximum concentration recorded was 0.6 mg/L (November 11), which occurred upstream and within the silt curtain, and was more likely a result of stormwater inflows than releases from the dredging operation. The high values listed on December 5 (0.5 mg/L) are again the result of high detection limits.

Nickel

Nickel concentrations upstream, within the silt curtain and downstream of the dredging operation are shown in Figure 5.10(a), and presented in tabular form in Table D1.7. Figures 5.10(b) and (c) present nickel concentrations in association with turbidity and TSS levels, respectively, measured at the same time in order to provide a comparison and assessment of the usefulness of those parameters for estimating in-water nickel concentrations.

Figure 5.10(a) indicates that nickel concentrations were within or marginally above the PWQO during the dredging operation at the McMaster Avenue reef, but were often above the PWQO during both the initial and the latter dredging period at the Atlas 42-in. reef. On the one occasion during the initial dredging period when within curtain concentrations were high (September 29), downstream levels were significantly reduced by the silt curtain, but were still above the PWQO. During the latter dredging period at the Atlas 42-in. reef, nickel concentrations exceeded the PWQO about half of the time, although a number of the higher values are the result of high detection limits (November 11 and December 5).

Figure 5.10(b) compares the nickel concentrations described above with turbidity measured on samples submitted for water quality analysis. Scales have been adjusted to better visualize similarities and differences between the two data sets. Generally, turbidity and nickel exhibited similar patterns in that low nickel concentrations usually corresponded with low turbidity levels, while high turbidity generally corresponded with high nickel concentrations. The relationship was not, however, consistent for all sampling dates, although large scale changes were similar.

TSS is compared with nickel concentrations in Figure 5.10(c). No clear nor consistent patterns are evident, as high nickel concentrations were sometimes associated with moderate levels of TSS, and low nickel concentrations were associated with both high and low TSS.

Zinc

Plots of zinc concentrations upstream, within the silt curtain and downstream of the dredging site are shown in Figure 5.11, while analytical values are presented in Table D1.8. Zinc levels were at or marginally above the PWQO of 0.03 mg/L throughout most of the monitoring program at all three sites (upstream, within curtain and downstream) at both the Atlas 42-in. reef area and the McMaster reef area, with a few exceptions. Most of the high levels were obtained during the second week of November coincident with high water levels and current flows. The high levels recorded on December 5, were an artifact of an abnormally high (0.1 mg/L) detection limit for those samples.

Oil and Grease
Oil and grease (solvent extractable) concentrations at the three sampling sites are plotted in Figure 5.12 and listed in Table D1.9. Levels were low through the dredging operation at all three sites, with the exception of some higher values recorded near the first part of November and December (up to 3 mg/L). Much of the variation in the lower readings is the result of different detection limits. One anomalous value of 11 mg/L was reported for the downstream site on December 6.

Total Suspended Solids (TSS)
TSS levels upstream, within the silt curtain and downstream from the dredging operation are shown in Figure 5.13, while values are listed in Table D1.10. The plot indicates that there was very little difference between upstream and downstream TSS concentrations throughout the entire project, while ambient TSS levels during that period ranged from less than 10 to over 300 mg/L. Closer examination of the data in Table D1.10 indicates that there were 7 days when downstream levels were 25 mg/L or more above upstream levels. Of those seven periods, only two exceeded upstream levels by more than 50 mg/L, and both occurred during periods of very high ambient concentrations (October 26 and November 29). Three of the five remaining periods were marginally over the 25 mg/L increment above ambient concentrations.

Turbidity
Turbidity levels measured as part of the water quality sampling program are plotted over time in Figure 5.14, and listed in Table D1.11.

Overall levels were low throughout most of the initial dredging activity at the Atlas 42-in. reef area, and during all operations at the McMaster Avenue reef area. Considerably higher values were present during the remainder of the cleanup at the Atlas 42-in. reef.

Turbidity levels downstream of the silt curtain were generally less than the maximum acceptable levels shown in Figure 5.3. However, on over 20 occasions this criteria was exceeded because of silt curtain problems largely caused by high river flows. Measures such as cleaning or weighing down the silt curtain and temporarily halting dredging were taken on such occasions to reduce downstream turbidity to acceptable levels.

TSS Versus Turbidity

Plots of natural and log transformed TSS vs turbidity for all water quality data currently available are presented in Figures 5.15(a) and (b), while values used to generate the plots are listed in Table D1.12. An examination of the plots in Figure 5.15(a) indicates that there are two distinct relationships identified between TSS and turbidity for the samples collected.

In the first case (points grouped closest to the X-axis, refer to as line 1), there is approximately a log linear relationship between the two parameters (see log-log plot) which passes through the origin. This is similar to what was observed in the 1991 pilot-scale demonstration project.

The second group of data points can also be described as a log linear relationship (refer to as line 2); however, it is different from line 1 in that it does not pass through the origin. It also has a significantly different slope and is almost horizontal. This is clearly illustrated in the natural plot [top portion of Figure 5.15(a)] in which relatively high TSS values are associated with low turbidity readings. Interestingly, however, subsequent increases in both parameters are also log linearly related.

The initial assessment of this phenomenon was that there are two different groups of particles present within the water column that are measured in different manners by the two measurement methods. The first group of particles could be considered the very fine materials that stay in suspension. An increased number of particles results in a proportional increase in both measurements (TSS and turbidity). The second group may correspond to larger particles that sink too quickly to be measured accurately by the light penetration methodology employed by turbidity meters. In this case, a particular threshold concentration must be reached before the turbidity meter registers a reading, however, subsequent increases above that level would be noted. The lower concentrations could still be detected by the TSS methodology, which does not consider particle size, but measures the total amount of solids in the sample.

In order to assess whether this phenomenon was related to the dredging operation, data from the three sampling sites (upstream, within curtain and downstream) were plotted separately to determine whether the above noted patterns were specific to any particular site. These plots are shown in Figure 5.15(b) and indicate that the same pattern is present at all three locations, which indicates that the phenomenon is not related to the dredging process.

Closer examination of the data (Table D1.12) indicated that the differences were more closely related to the laboratory that performed the analysis than any other factor. Generally, the line 1 data points were from Acres Analytical data while the line 2 data points were from MOEE data. The differences in the results may be related to the long MOEE holding time prior to analysis, which may have resulted in settling and adhesion/agglomeration of the fine particles. This could account for the lower turbidity measurements associated with the high TSS values.

Other Metals - Aluminum

Samples submitted to the MOEE labs for analysis were also analyzed for aluminum. The results of those analyses are presented in graphical and tabular form in Table D1.13. Most values recorded were in excess of the PWQO Guideline (0.1 mg/L), with the highest levels occurring during late November/early December (1.7 mg/L). Downstream levels were generally similar to upstream levels with the exception of one period near the end of October when dredging was being undertaken at the McMaster Avenue reef.

Comparison of Turbidity Measurements

Results of the daily grab sampling program to verify the placement of the downstream Hydrolab multiprobe are presented in Figures 5.16(a) and (b) for the periods September 25 to October 19, and October 31 to December 6, respectively. Each figure compares the turbidity readings obtained downstream from the silt curtain by the Hydrolab turbidity sensor with readings of turbidity taken from hourly ISCO grab samples at a sampling point 1 to 2 m from the Hydrolab sensor. The ISCO samples were read by a Hach 2100 A benchtop turbidity meter in the field trailer. Also included are the results of morning and afternoon grab samples taken from depths of 0.75 and 1.5 m approximately 1 m from the multiprobe deployment location (called mid-curtain) and from depths of 1.5 and 3 m at the outer edge of the silt curtain approximately 5 to 7 m from the Hydrolab sensor, at the same distance downstream. These grab samples were used in an attempt to ensure that the Hydrolab multiprobe was positioned in the most appropriate location downstream from of the silt curtain. Data used to prepare the plots are presented in Table D1.14, while field data sheets are also presented in Appendix D.

Figure 5.16(a) presents the data for the time period from September 25 to October 19, and indicates that the values recorded by the Hydrolab multiprobe were generally quite similar to those recorded from water samples collected by the ISCO sampler and grab sampling. This provides confirmation that in most cases, the data being recorded by the Hydrolab was representative of the downstream water mass. There were, however, four occasions (September 27 and 29, and October 5 and 12,) when grab samples were substantially higher, although these were the exception rather than the rule.

The period from October 21 to December 6, is shown in Figure 5.16(b), which illustrates a similar pattern of high and low levels between the two measurements, although the Hydrolab readings were consistently higher than those obtained from the ISCO water sample. During the latter part of the project, this difference was significant (50 or more units), indicating that there is less agreement between the two measurement methods at higher turbidity levels.

Comparison of Upstream vs Downstream Turbidity

Plots of hourly turbidity data from the upstream and downstream locations, as measured and recorded by the Hydrolab data loggers, are presented in Figures 5.17(a) and (b) for the periods September 25 to October 31 and November 1 to December 9, respectively. Tables D1.15 (Station 1 - upstream) and D1.16 (Station 3 - downstream) in Appendix D contains the data on which the plots are based, as well as listings of hourly averages for the other parameters measured by the Hydrolab multiprobes.

Examination of Figure 5.17(a) indicates that the silt curtain was fairly effective in reducing downstream turbidity to acceptable levels under most circumstances during the September and October dredging period. However, there were two occasions when downstream turbidity was above the upstream levels, with the first centered around October 12, and the second from October 24 to 30, 1995. The majority of the downstream measurements during these days exceed the operational water quality limit established for the project, which was developed from 1991 water quality data. The largest exceedances occurred during the late October period, and are generally associated with specific periods of relatively high current velocity (greater than 0.25 m/s) and relatively high background turbidity. In each case, upstream concentrations increased during the day and downstream levels rose incrementally with the upstream values. The increase in upstream concentrations each day would appear to indicate that some aspect of the project was affecting those levels, as they were often near the same level at the start of each day. During three of those days (October 26, 27, and 30), the dredge was shut down a number of times as a result of high downstream turbidity levels. Those shut down periods are apparent in the plots, and indicate that this action was successful in reducing downstream levels.

Figure 5.17(b) illustrates upstream and downstream turbidity levels during the remainder of the dredging project (November and December). Background levels were high throughout this period, hence they have been plotted separately from the September and October results. Downstream levels were in excess of upstream values on a number of occasions (November 3, 28 and 29, December 5 and 6), and were above the water quality criteria established for the project. This period was also characterized by more extreme weather than the September/October period, receiving considerably more rainfall which resulted in high river flows and ambient sediment loads due to upstream inputs. The plots clearly indicate that the silt curtain was less effective in reducing downstream turbidity levels under these conditions.

5.3.2.4 Discussion of Results

A review of the results presented above indicates that there are some obvious similarities between the concentrations of a number of the parameters measured, while other parameters exhibit quite different patterns. The elements chromium, copper, iron, manganese, nickel and zinc all exhibited similar high or low concentration patterns, indicating that they were all closely linked within the reef deposits. This is not unexpected, as these elements (with the exception of copper) are all associated with the iron and steel industry, and have been acknowledged to have been present in Atlas' former discharges. During the initial dredging period at the Atlas 42-in. reef, these elements all exhibited a peak within silt curtain concentration at the same time (September 29), and were all effectively reduced to below or marginally above the provincial objective at the downstream monitoring site. Similar patterns were evident during periods in mid-November and early December. Downstream concentrations of copper, iron, manganese and nickel, and to a lesser extent zinc, were often in excess of the provincial objective during much of these high flow conditions. Thus, the silt curtain was less effective during these periods of high water and current velocities than during the low flow conditions.

Other elements measured during the monitoring program exhibited entirely different pattern of peaks and valleys (i.e., cadmium and lead) compared to those exhibited by the group of elements noted above. Cadmium concentrations were high on three distinct occasions (October 18 and 21, and November 28), which did not coincide with peaks of any of the other elements. Both of the initial peaks occurred while dredging at the McMaster Avenue reef. Upstream levels were well above the provincial objective on both of those days, indicating that an upriver source (likely storm sewers) was at least partially responsible for the high levels. Daily monitoring of river currents indicated that flows were moderate on both of those days (0.16 to 0.31 m/s), and no current reversals were noted at any time throughout the dredging project. During the latter concentration peak, within curtain and downstream values were very similar, while upstream values were at the detection limit, suggesting that a specific pocket of Cd contaminated sediment was encountered that day. As with the two previous peaks, there was little or no reduction in downstream concentrations from those measured within the silt curtain; indicating that either the silt curtain was not functioning properly, or that the cadmium was in a dissolved form which would not be captured by the porous curtain.

Lead concentrations in river waters were above the PWQO on only three occasions. The largest peak in lead levels occurred October 26, at the McMaster Avenue reef, and was an isolated event. Upstream levels were also well above the provincial objective, again indicating that an upstream source was partially responsible for these high levels. Turbidity levels were also elevated on this day, but had been the previous day, and continued to be elevated on subsequent days. This isolated occurrence may have been the result of the removal of a pocket of Pb contaminated sediment, or could potentially have been associated with stormwater discharges from the McMaster Avenue and upstream sewers.

Throughout the project, turbidity was used as the day-to-day means of assessing the environmental compliance of the project. Readings were taken minutes apart at upstream and downstream sites with Hydrolab multiprobe meters, while ISCO integrated water samples were collected and read in the field trailer to verify multiprobe operation. Also, grab samples were taken at two depths and locations downstream of the silt curtain to evaluate its operation and determine whether the Hydrolabs were positioned in appropriate locations. These programs generated significant quantities of data, which generally exhibited similar trends, but was not always in complete agreement.

At certain times external inputs raised background turbidity and TSS levels of the river substantially. During storm events, background levels were sufficiently high that variations between sampling locations could not be detected. In these instances, it became difficult to fully evaluate the dredge's impacts on water quality.

The conclusions from these programs is that the use of turbidity to monitor the dredging operation was appropriate and efficient; and played a valuable role in maintaining downstream water quality within reasonable levels. As previously noted, there were a number of periods during the project when various metals exceeded the provincial water quality objective. On many of those occasions, the elevated downstream turbidity levels, as determined by the Hydrolab, were used as the basis for shutting down the dredging operation so as to allow turbidity levels to stabilize before proceeding further. The differences in downstream turbidity levels, as determined by the Hydrolabs and from the ISCO samples, caused some difficulty in data interpretation during the project, as occasionally one of the turbidity levels would exceed the water quality criteria while the other was acceptable. Some high Hydrolab turbidity levels were the result of fouling of the turbidity sensor. In general, the continuous monitoring of turbidity then became a valuable tool for assessing and controlling the performance of the dredging operation.

The additional grab and integrated sampling program was used to verify that the readings obtained by the Hydrolabs were indeed accurate, and to identify when the multiprobes became fouled and required servicing. These readings provided assurance that conditions at the Hydrolab deployment locations were indeed representative of conditions at other locations downstream of the silt curtain, and also serve as a second QA/QC check on samples submitted for laboratory analysis.

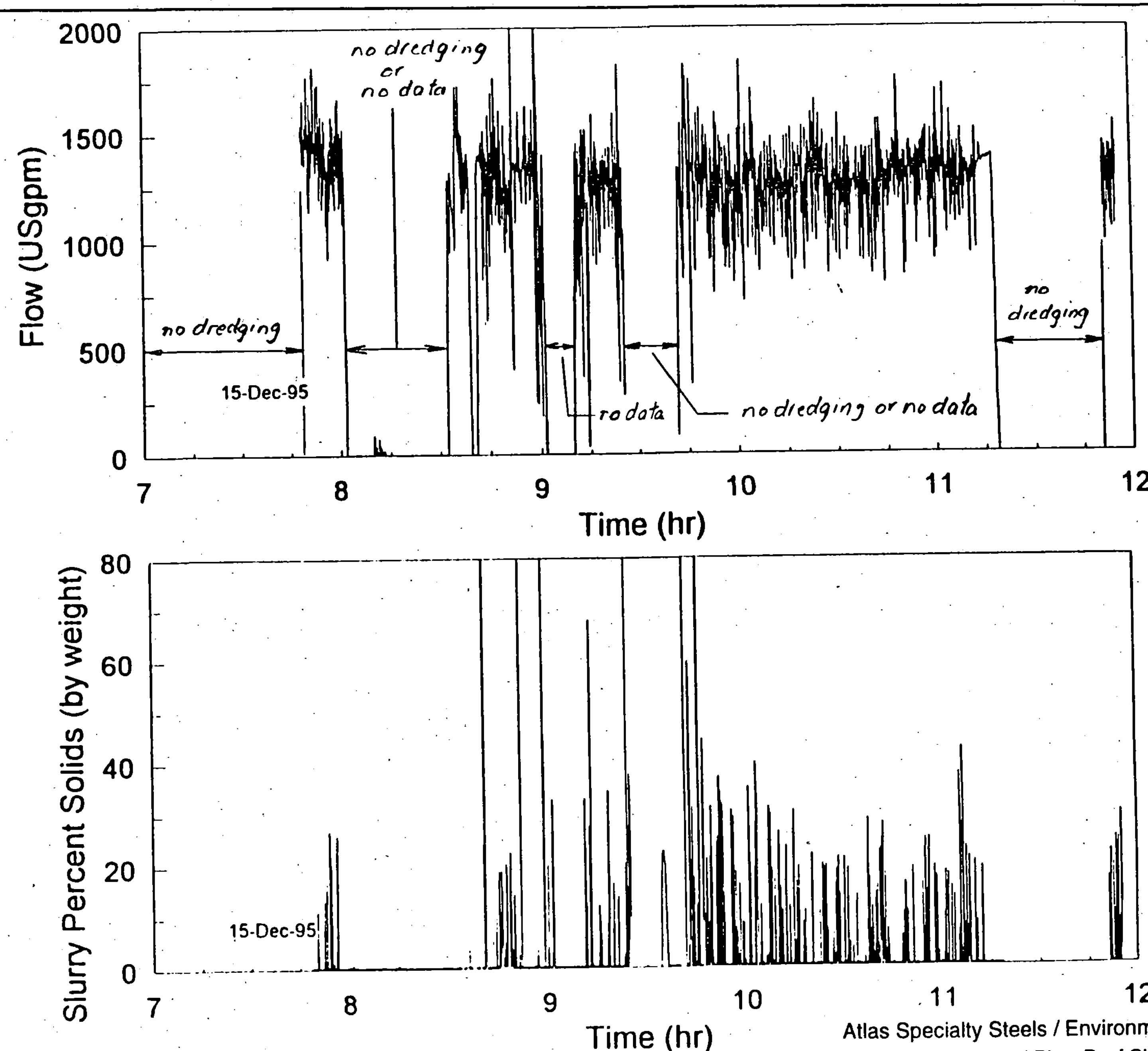

Fig. 5.2

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Typical Plot of Flow Densitometer Data

ACRES

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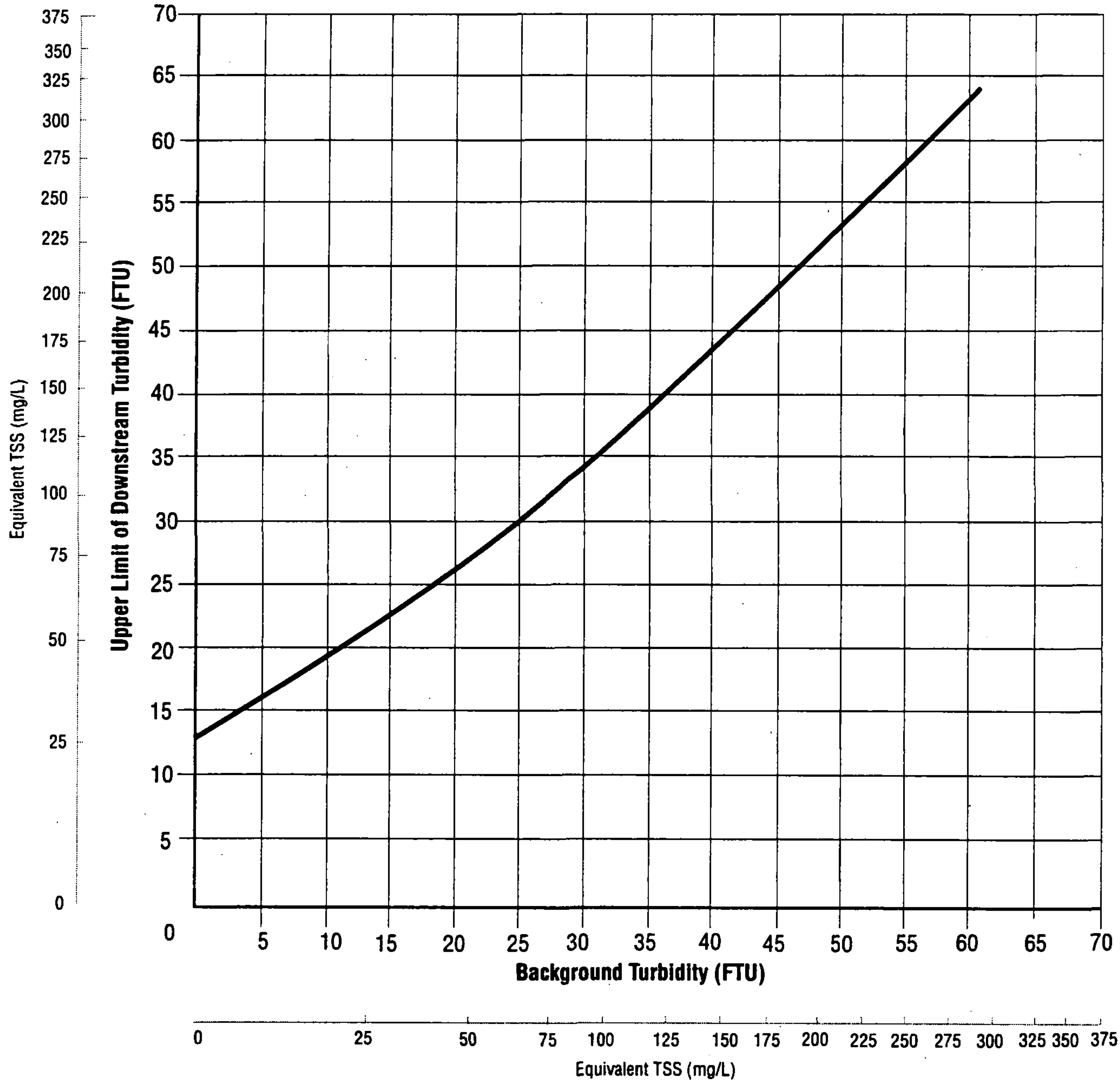


Note:
In the latter part of the project during periods of high background turbidity, the upper limit of the downstream turbidity was set at 25 FTU above background.

Fig. 5.3

Atlas Specialty Steels/Environment Canada
Welland River Reef Cleanup Project
Water Quality Monitoring Criteria

ACRES

P11201.00/rm/w3320156a&a

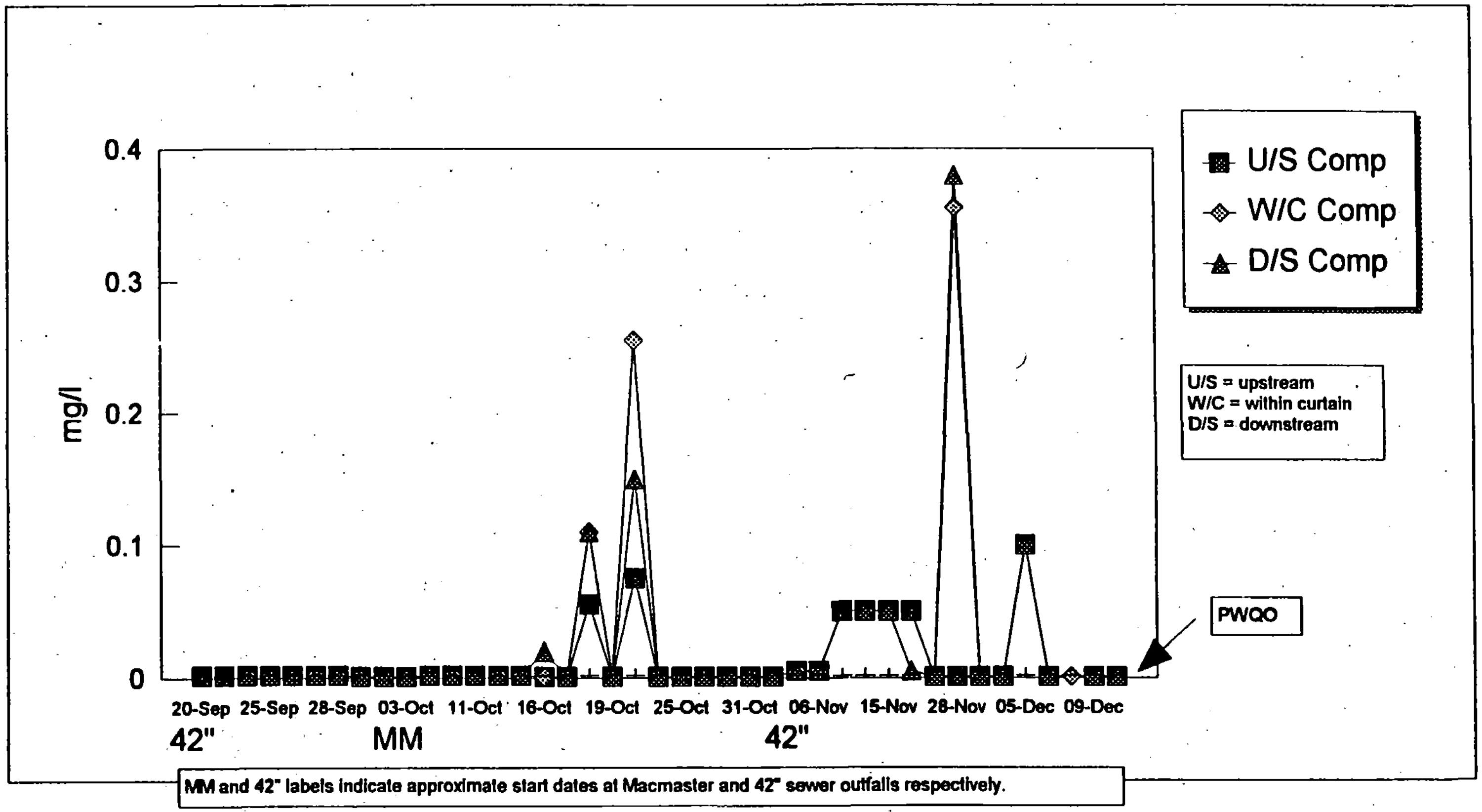


Fig. 5.4

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - Cadmium

ACRES

P31201.02 MR

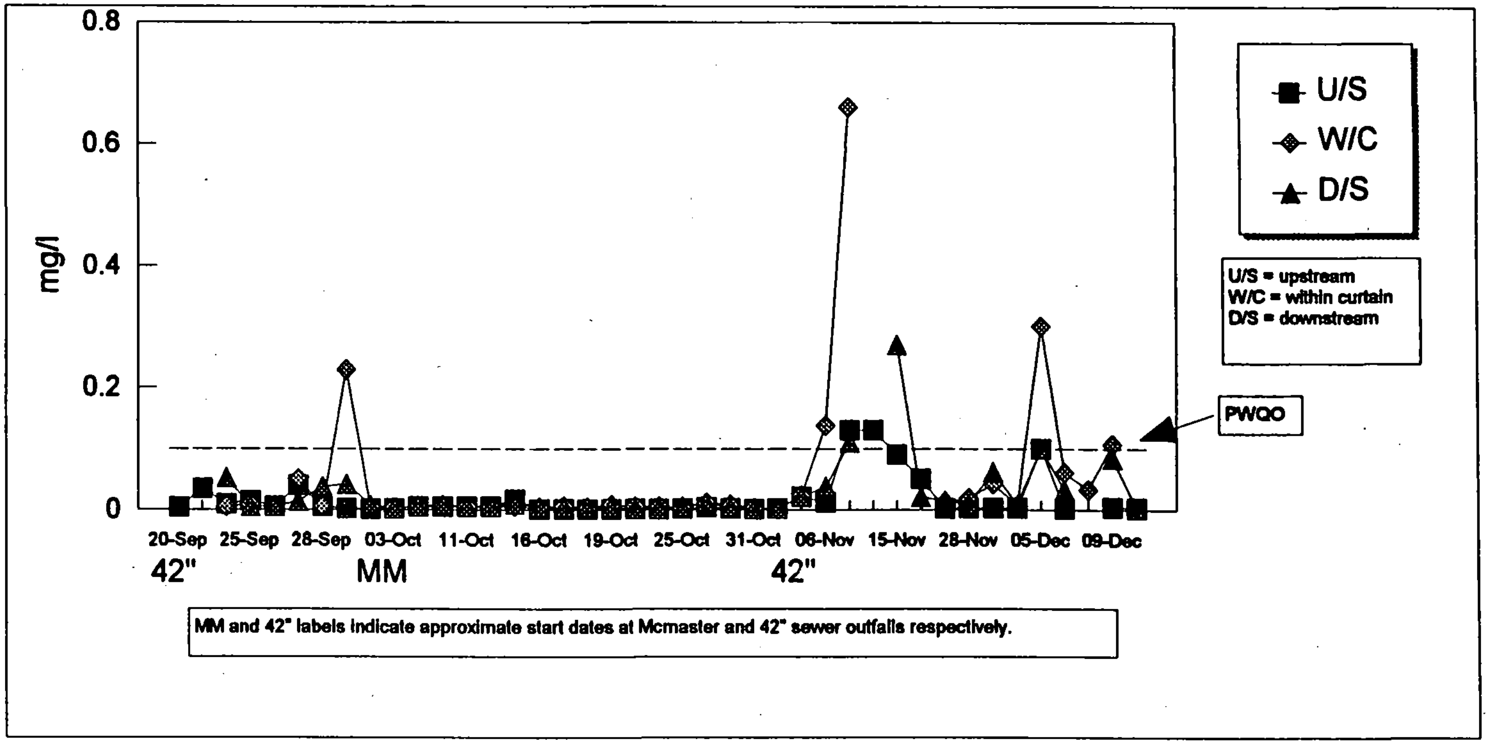


Fig. 5.5 (a)

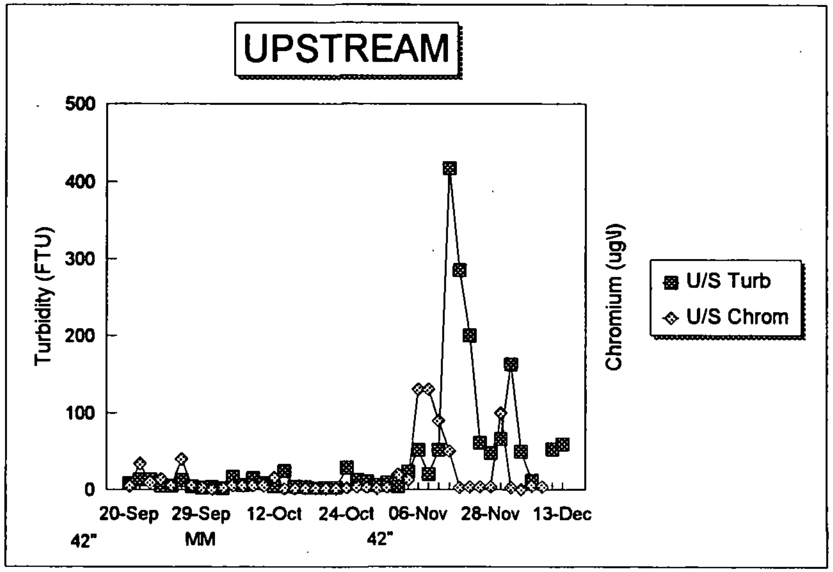
Atlas Specialty Steels / Environment Canada

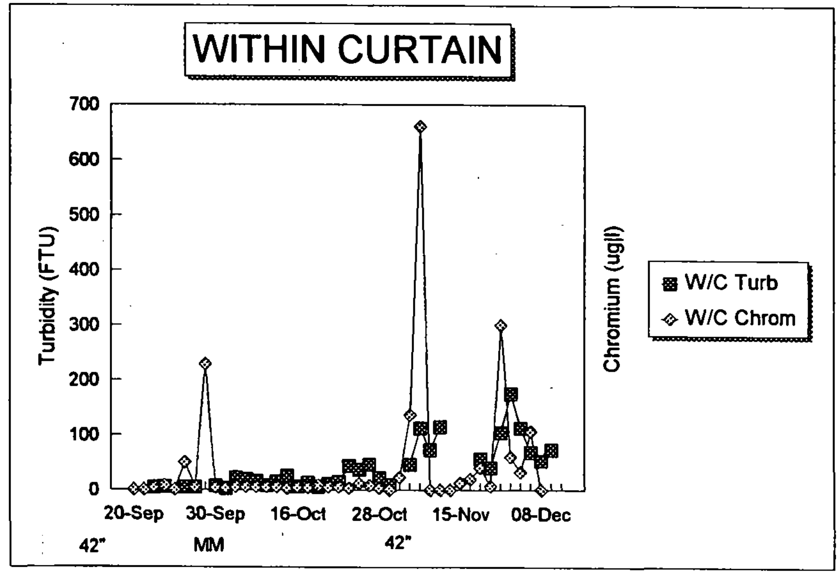
Welland River Reef Cleanup Project

Water Quality Monitoring - Chromium

ACRES

P31201.02 MR





MM and 42" labels indicate approximate start dates at McMaster Avenue and Atlas 42" outfalls respectively.

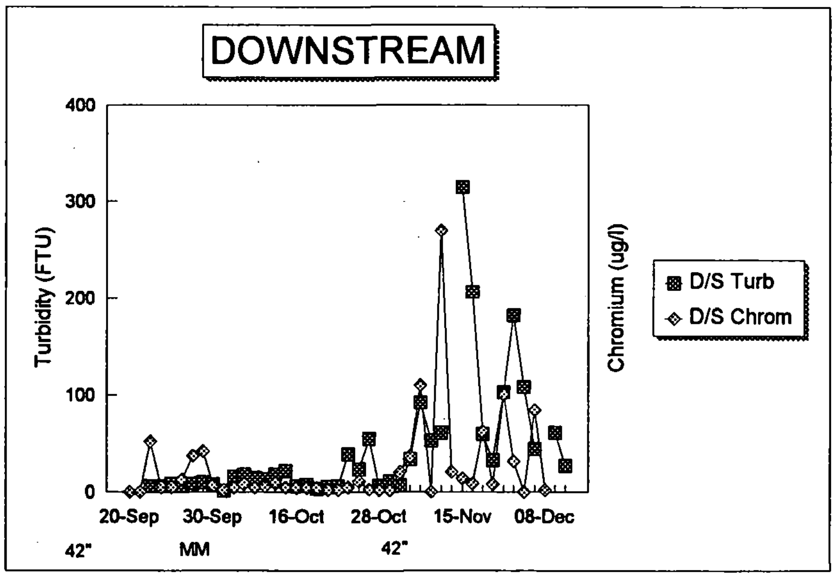


Fig. 5.5 (b)

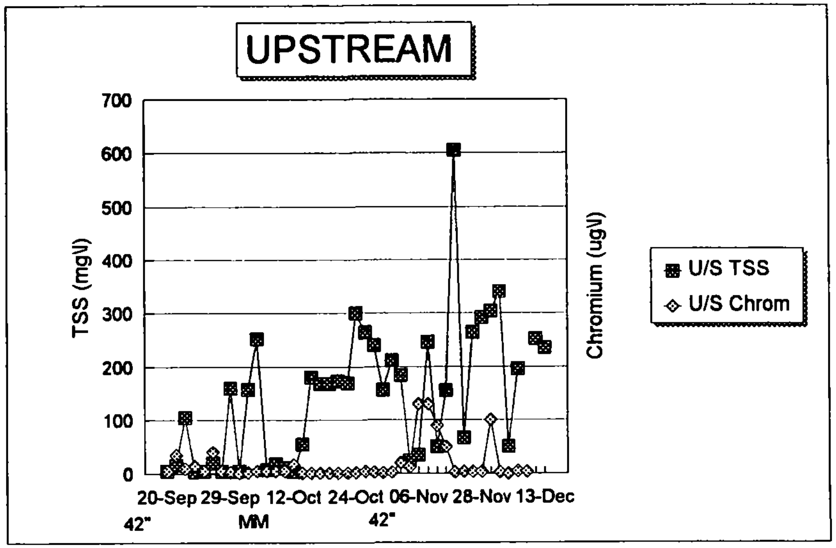
Atlas Specialty Steels / Environment Canada

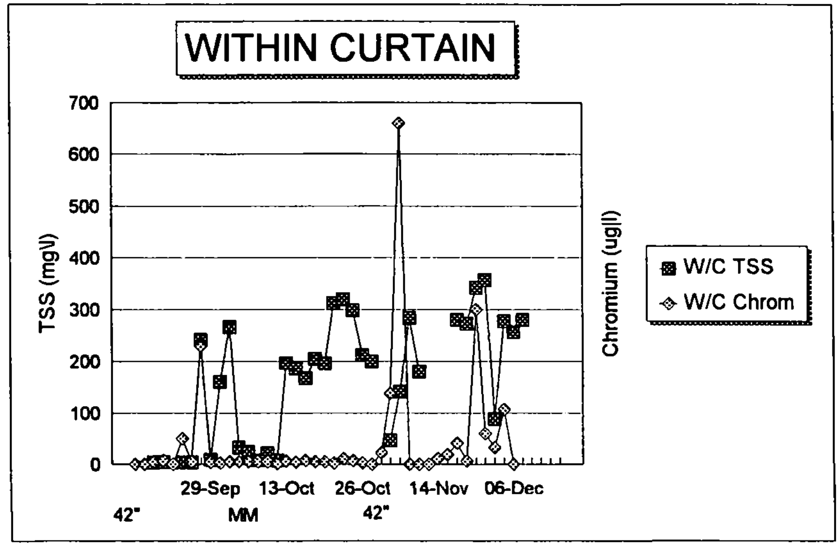
Welland River Reef Cleanup Project

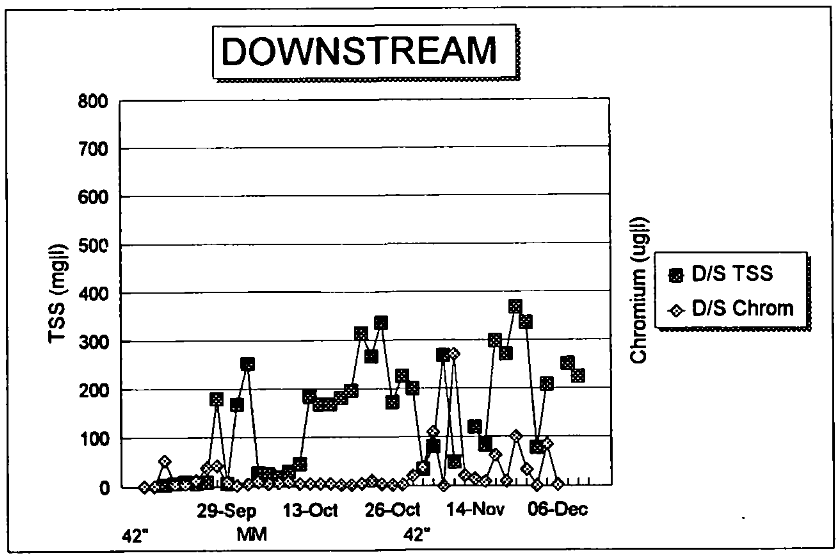
Water Quality Monitoring - Turbidity vs Chromium

ACRES

P31201.02 MR







MM and 42" labels indicate approximate start dates at McMaster Avenue and Atlas 42" outfalls respectively.

Fig. 5.5 (c)

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - TSS vs Chromium

P31201.02 MR

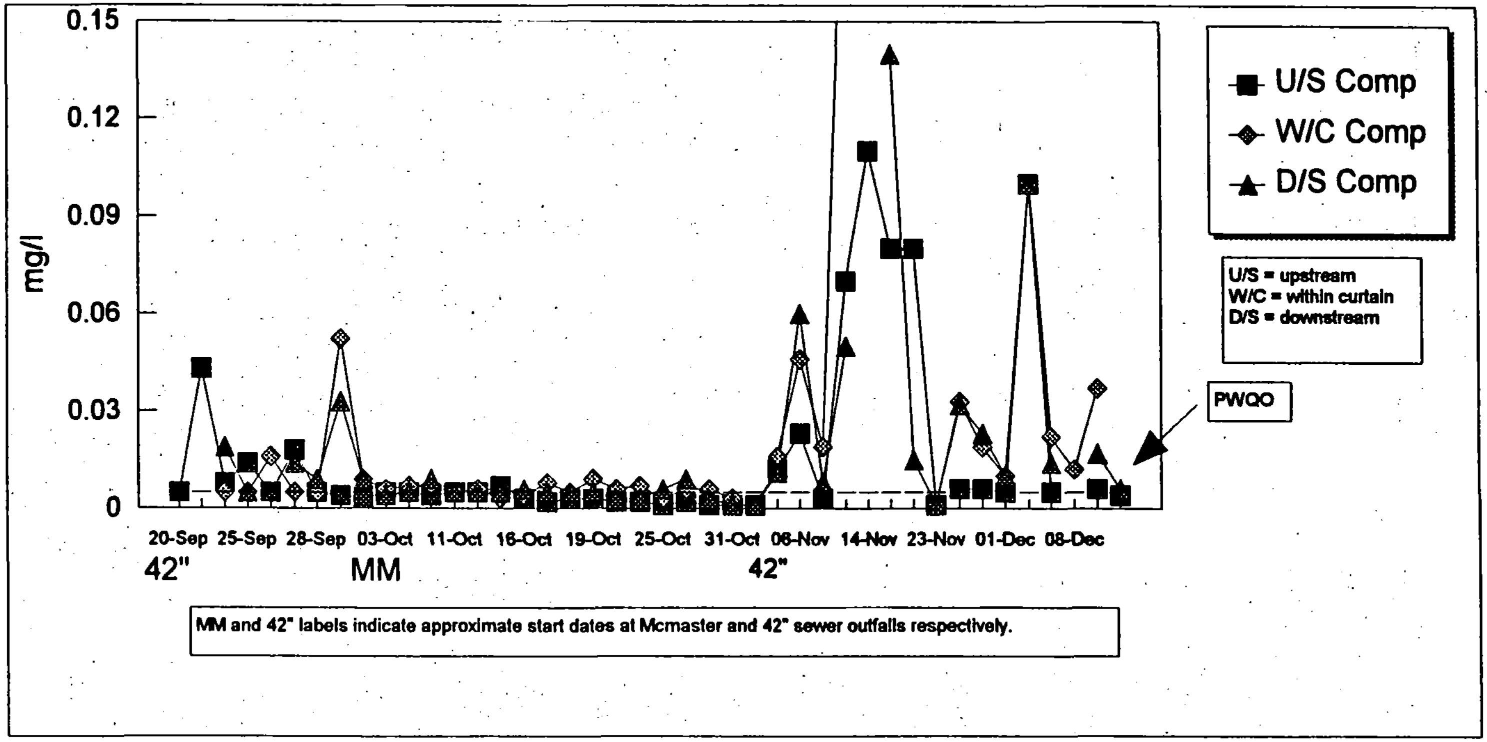


Fig. 5.6

Atlas Specialty Steels / Environment Canada
Welland River Reef Cleanup Project
Water Quality Monitoring - Copper

ACRES

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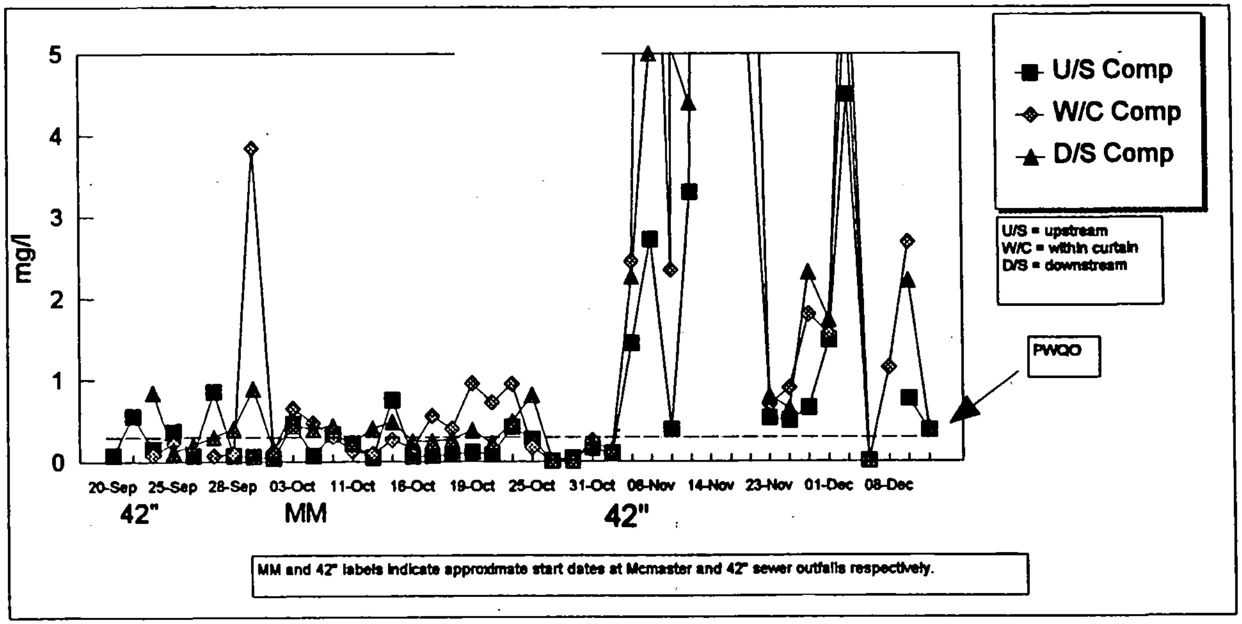

Fig. 5.7

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - Iron

ACRES

P31201.02 MR

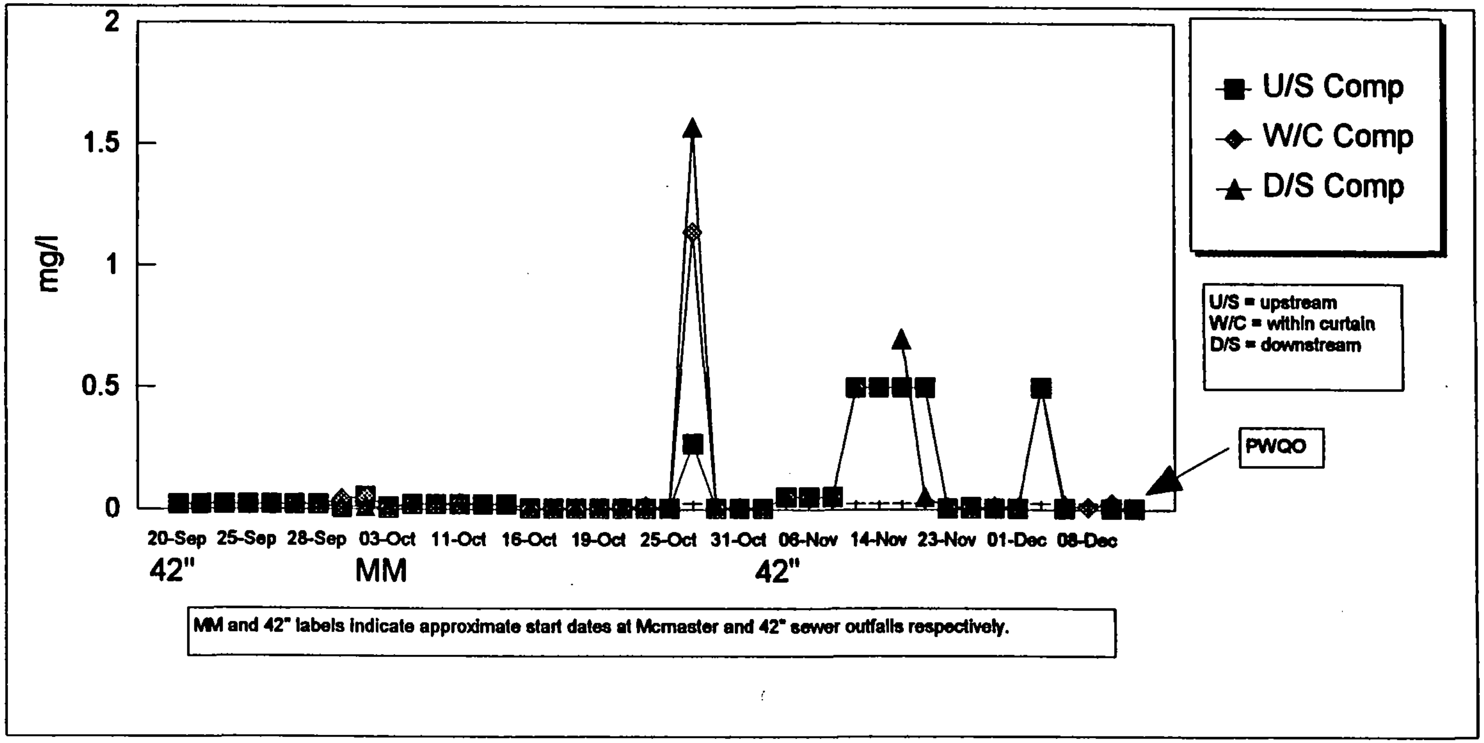

Fig. 5.8

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - Lead

ACRES

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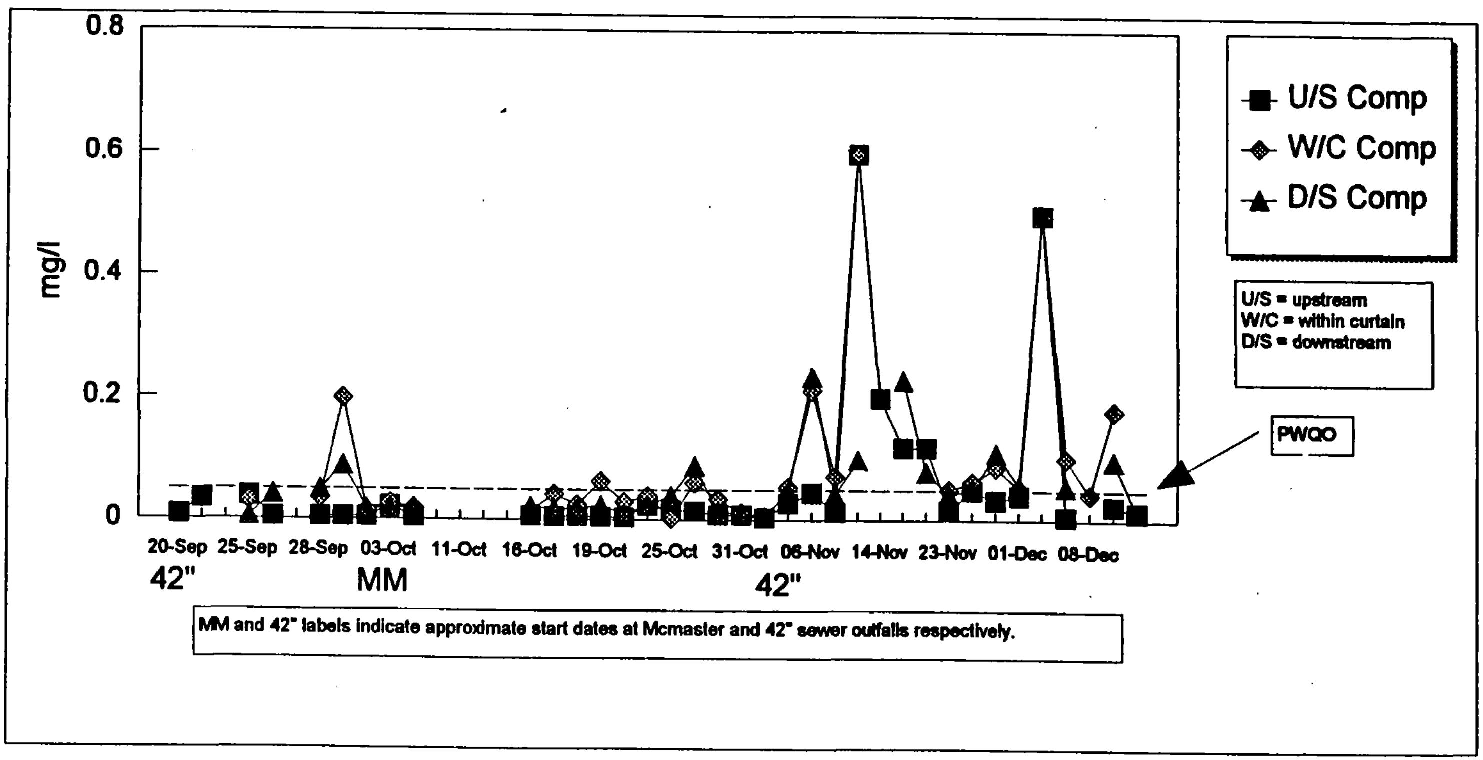


Fig. 5.9

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - Manganese

ACRES

P31201.02 MR

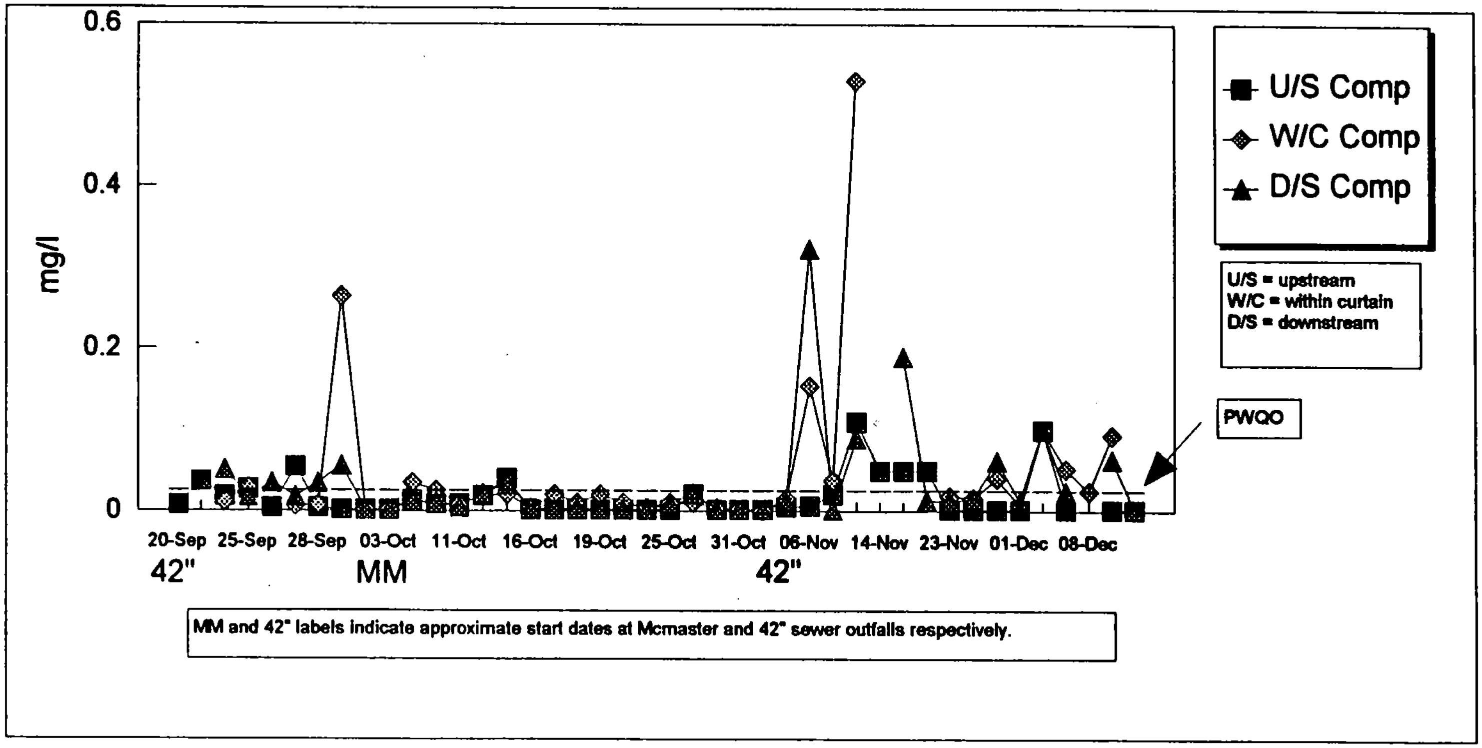


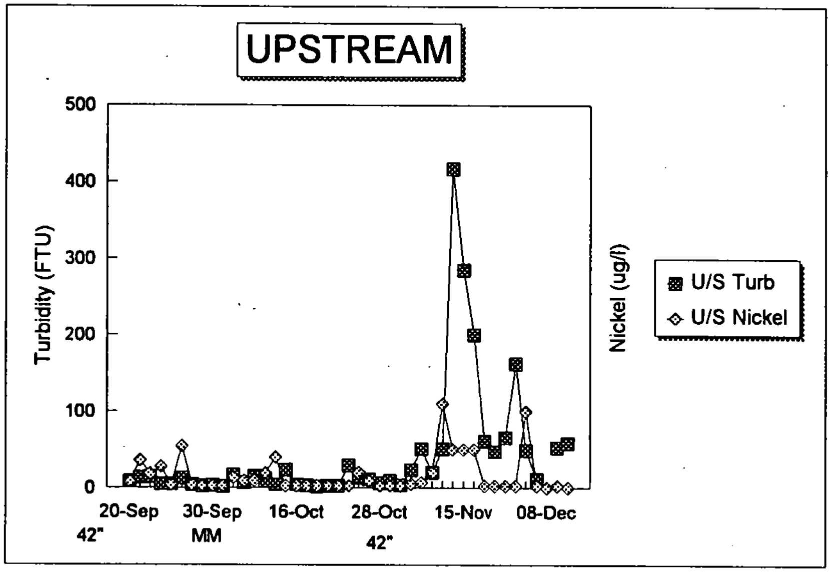
Fig. 5.10 (a)

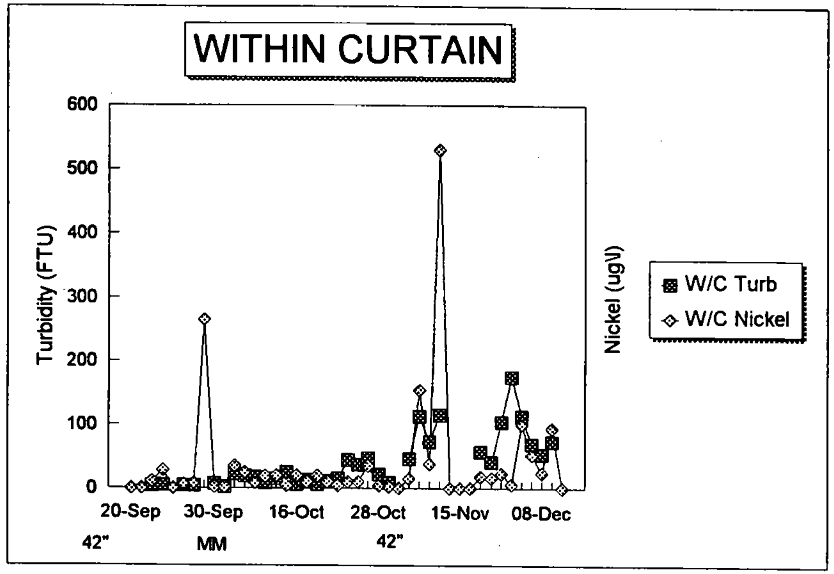
Atlas Specialty Steels / Environment Canada

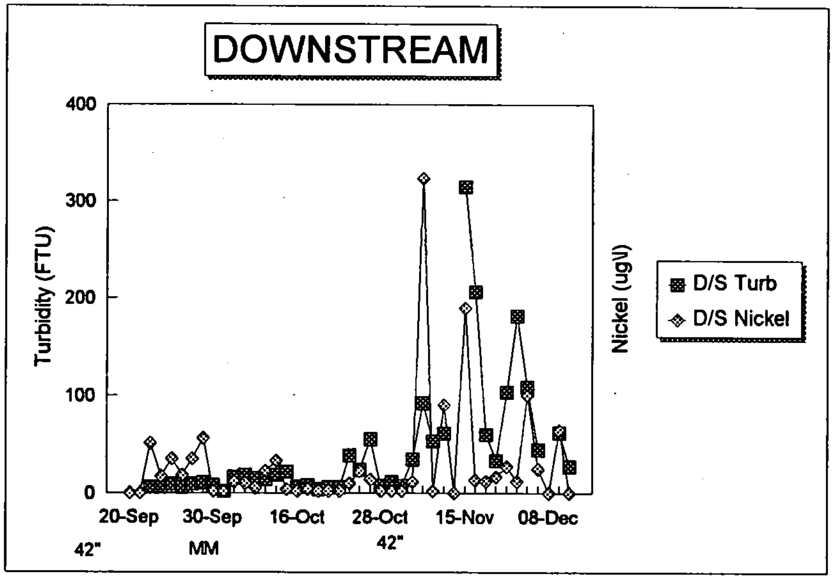
Welland River Reef Cleanup Project

Water Quality Monitoring - Nickel

P31201.02 MR







MM and 42" labels indicate approximate start dates at McMaster Avenue and Atlas 42" outfalls respectively.

Fig. 5.10 (b)

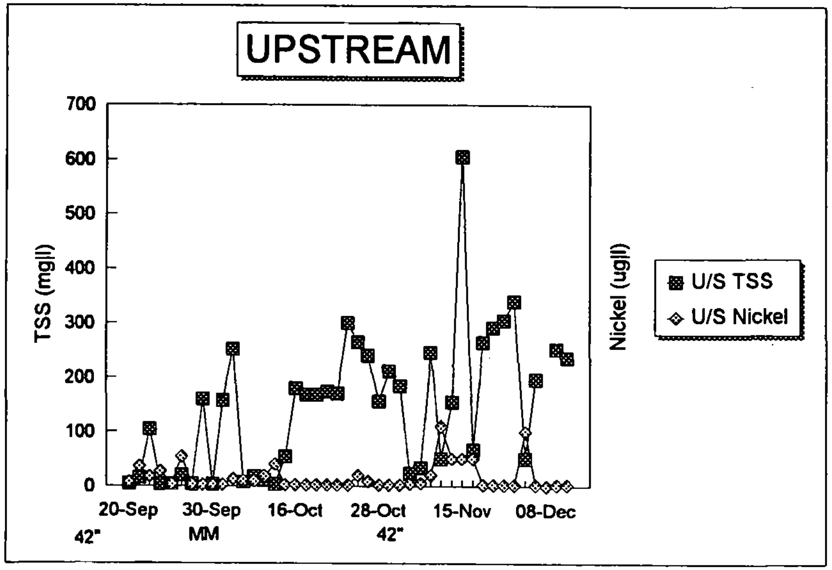
Atlas Specialty Steels / Environment Canada

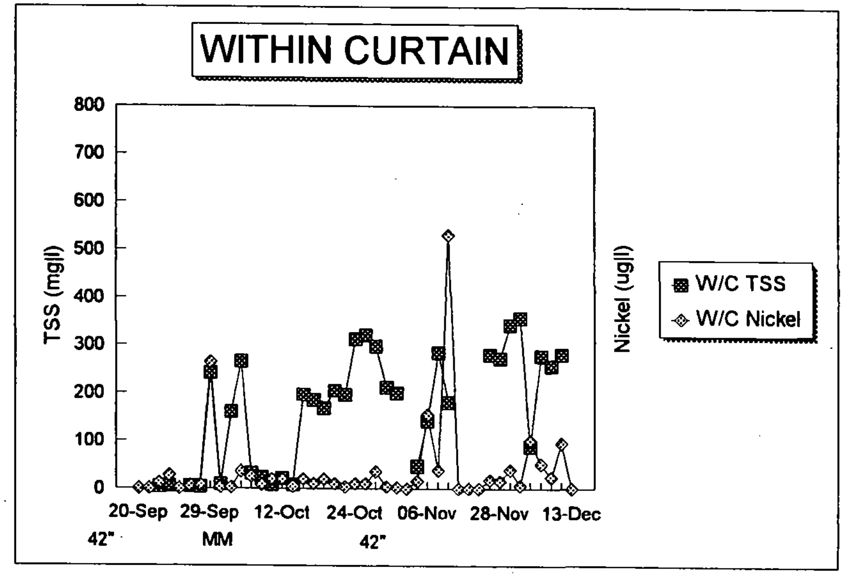
Welland River Reef Cleanup Project

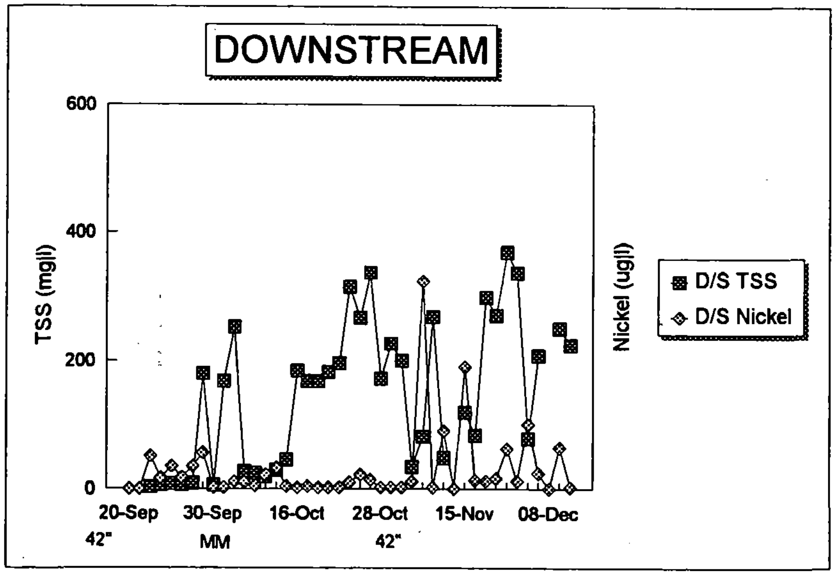
Water Quality Monitoring - Turbidity vs Nickel

ACRES

P31201.02 MR







MM and 42" labels indicate approximate start dates at McMaster Avenue and Atlas 42" outfalls respectively.

Fig. 5.10 (c)

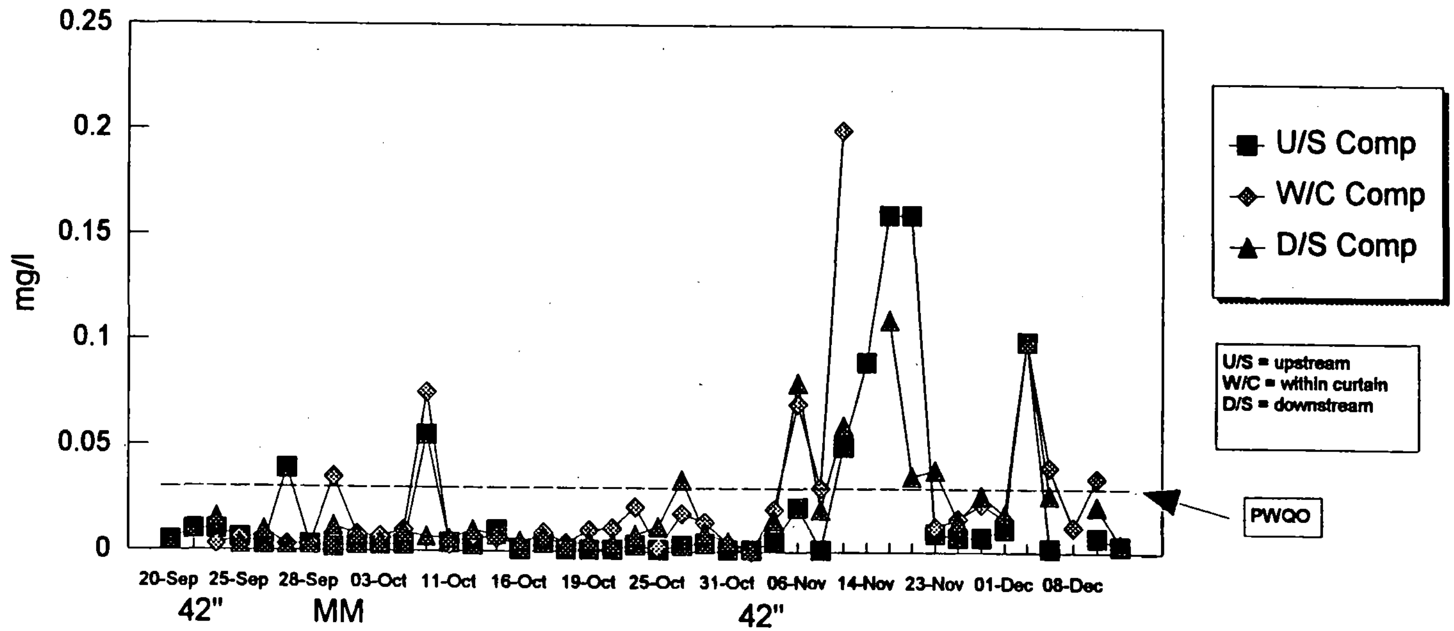
Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - TSS vs Nickel

ACRES

P31201.02 MR



MM and 42" labels indicate approximate start dates at Mcmaster and 42" sewer outfalls respectively.

Fig. 5.11

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - Zinc

ACRES

P31201.02 MR

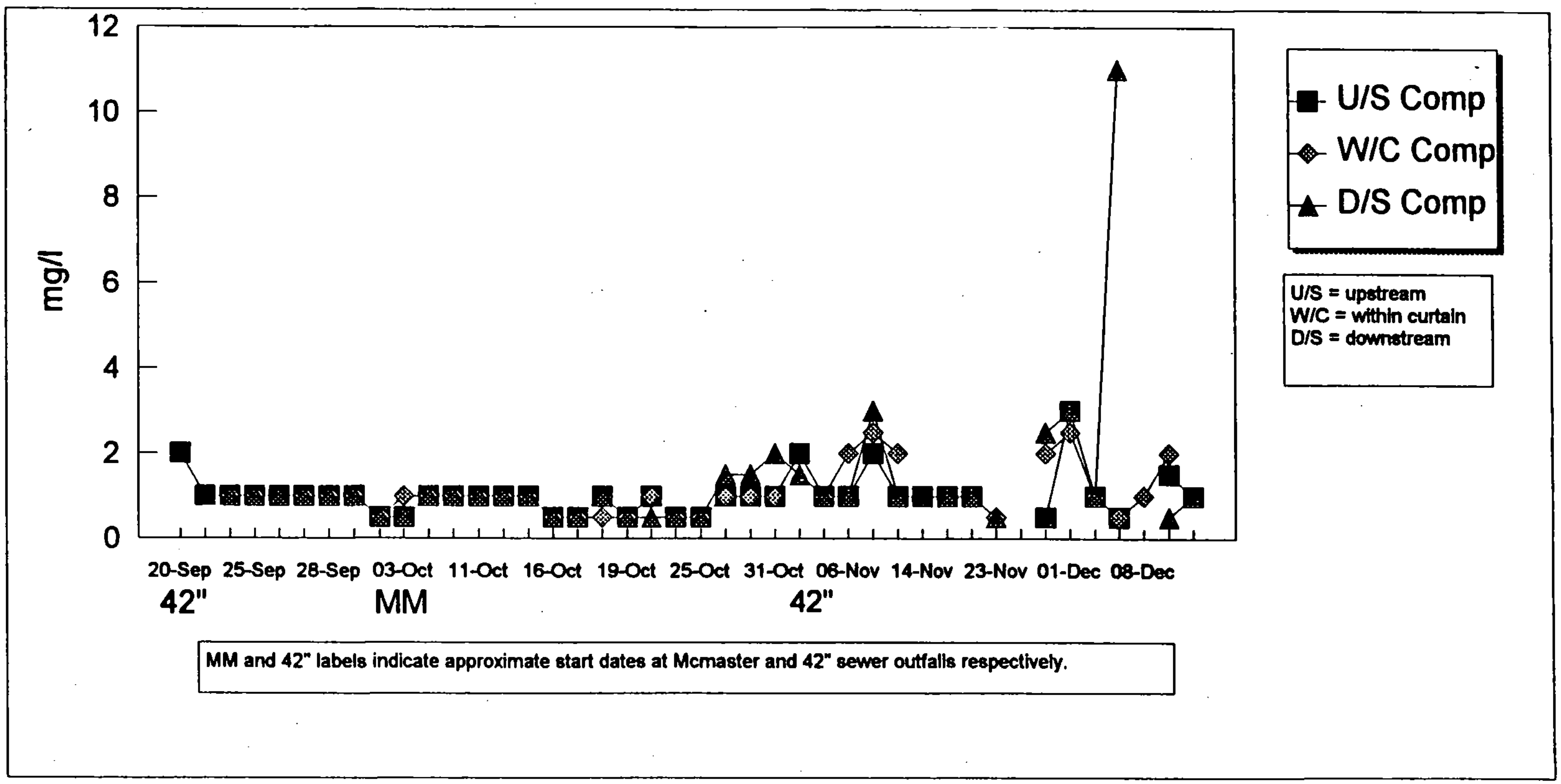


Fig. 5.12

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - Solvent Extractables

ACRES

P31201.02 MR

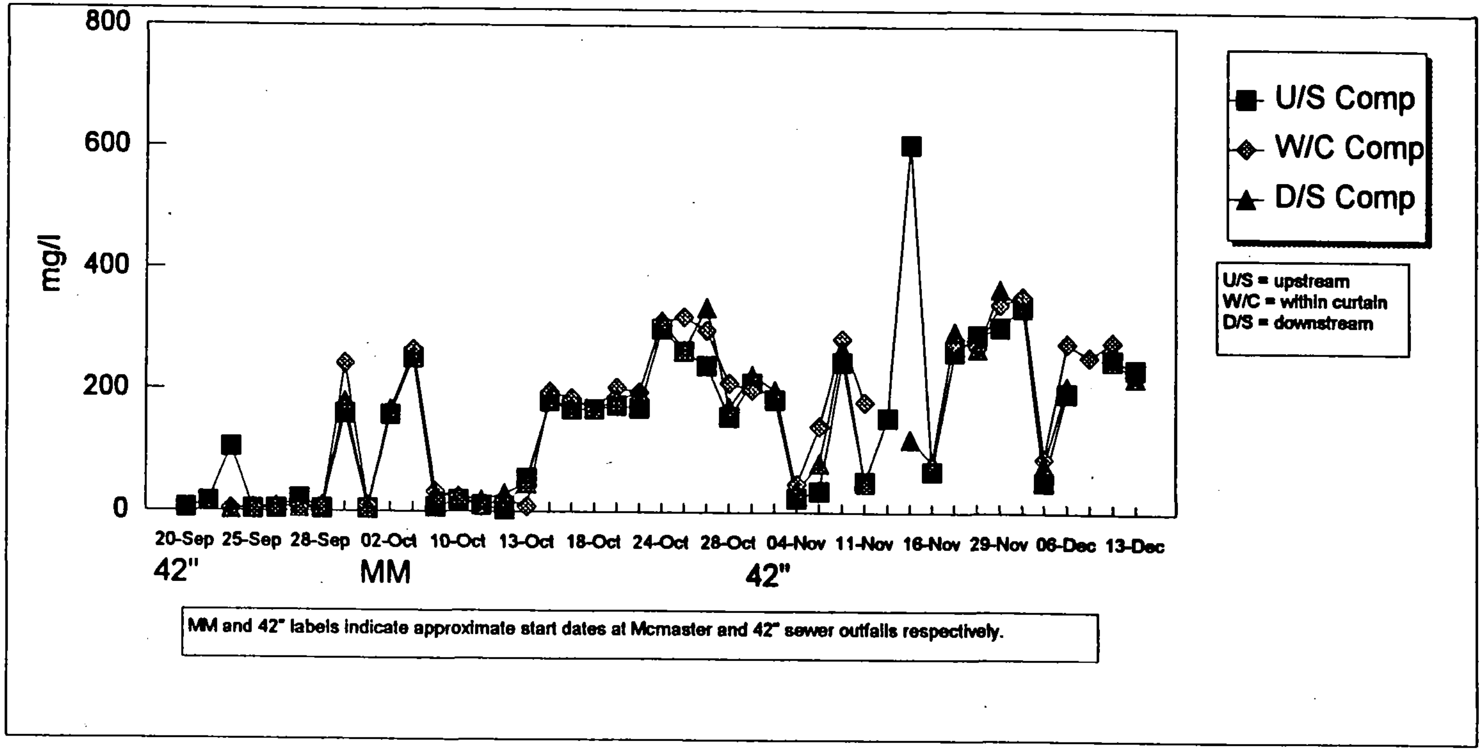


Fig. 5.13

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - TSS

ACRES

P31201.02 MR

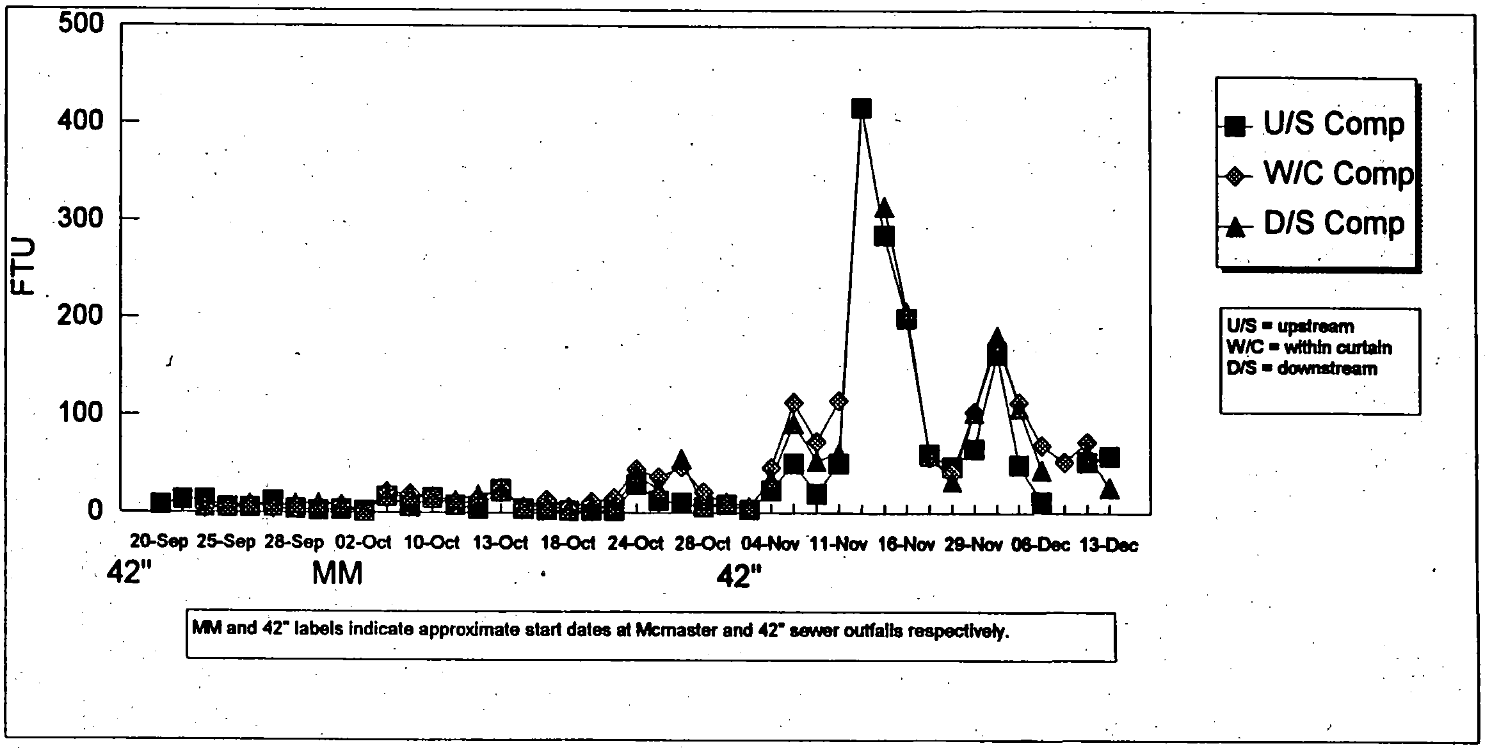


Fig. 5.14

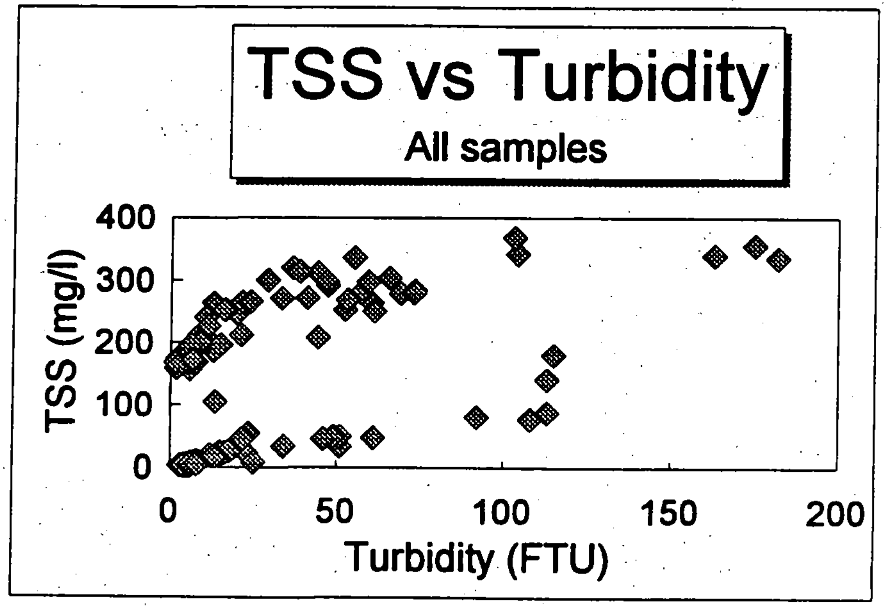
Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - Turbidity

ACRES

P31201.02 MR



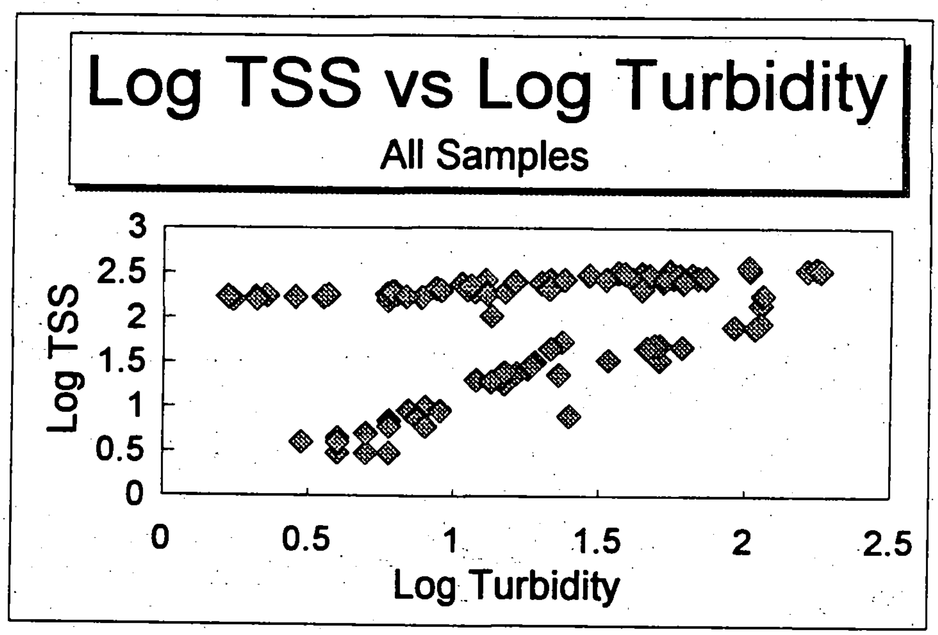


Fig. 5.15 (a)

Atlas Specialty Steels / Environment Canada
Welland River Reef Cleanup Project
Water Quality Monitoring - TSS vs. Turbidity

ACRES

P31201.02 MR

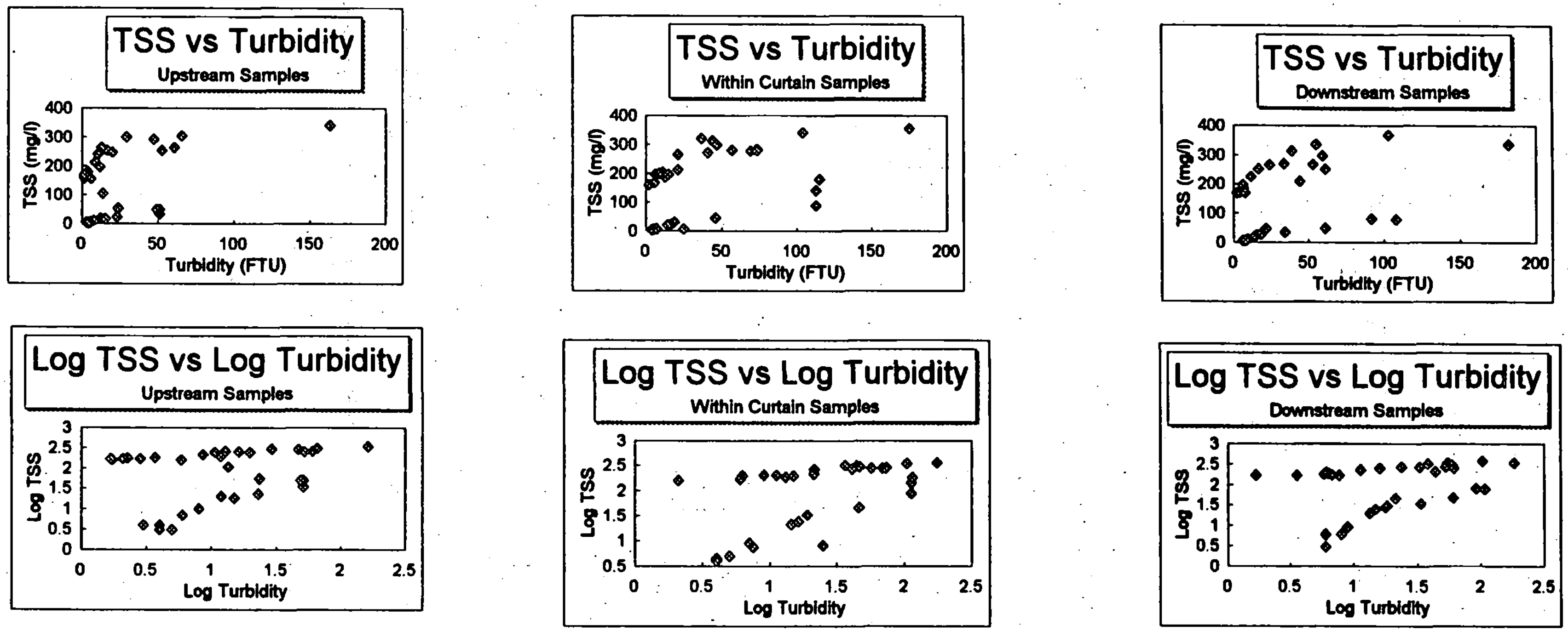


Fig. 5.15 (b)

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Water Quality Monitoring - TSS vs. Turbidity

ACRES

P31201.02 MR

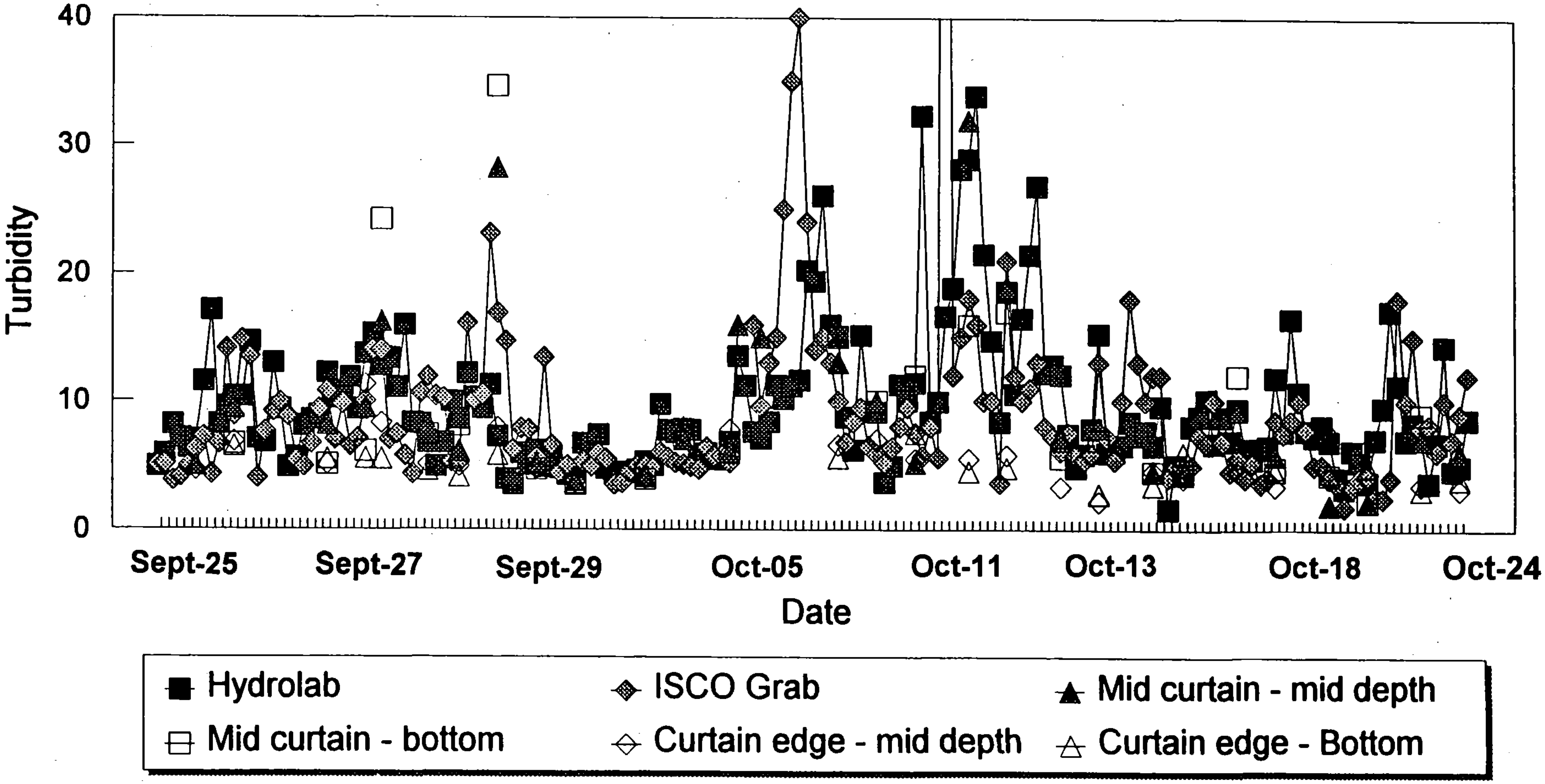


Fig. 5.16 (a)

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Turbidity Measurement Comparison - Sept. 25-Oct. 19, 1995

ACRES

P31201.02 MR

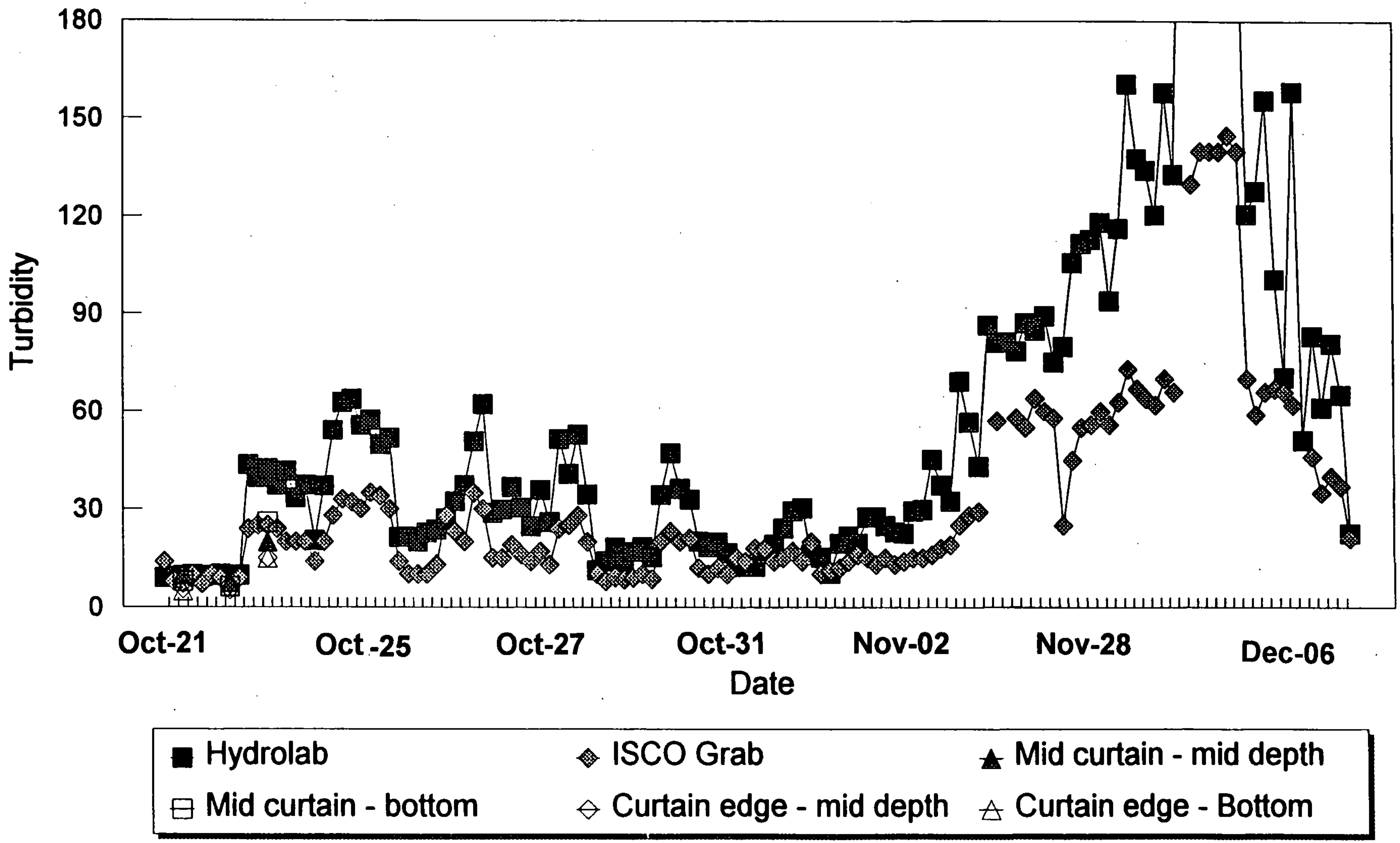


Fig. 5.16 (b)

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Turbidity Measurement Comparison - Oct. 21-Dec. 6, 1995

ACRES

P31201.02 MR

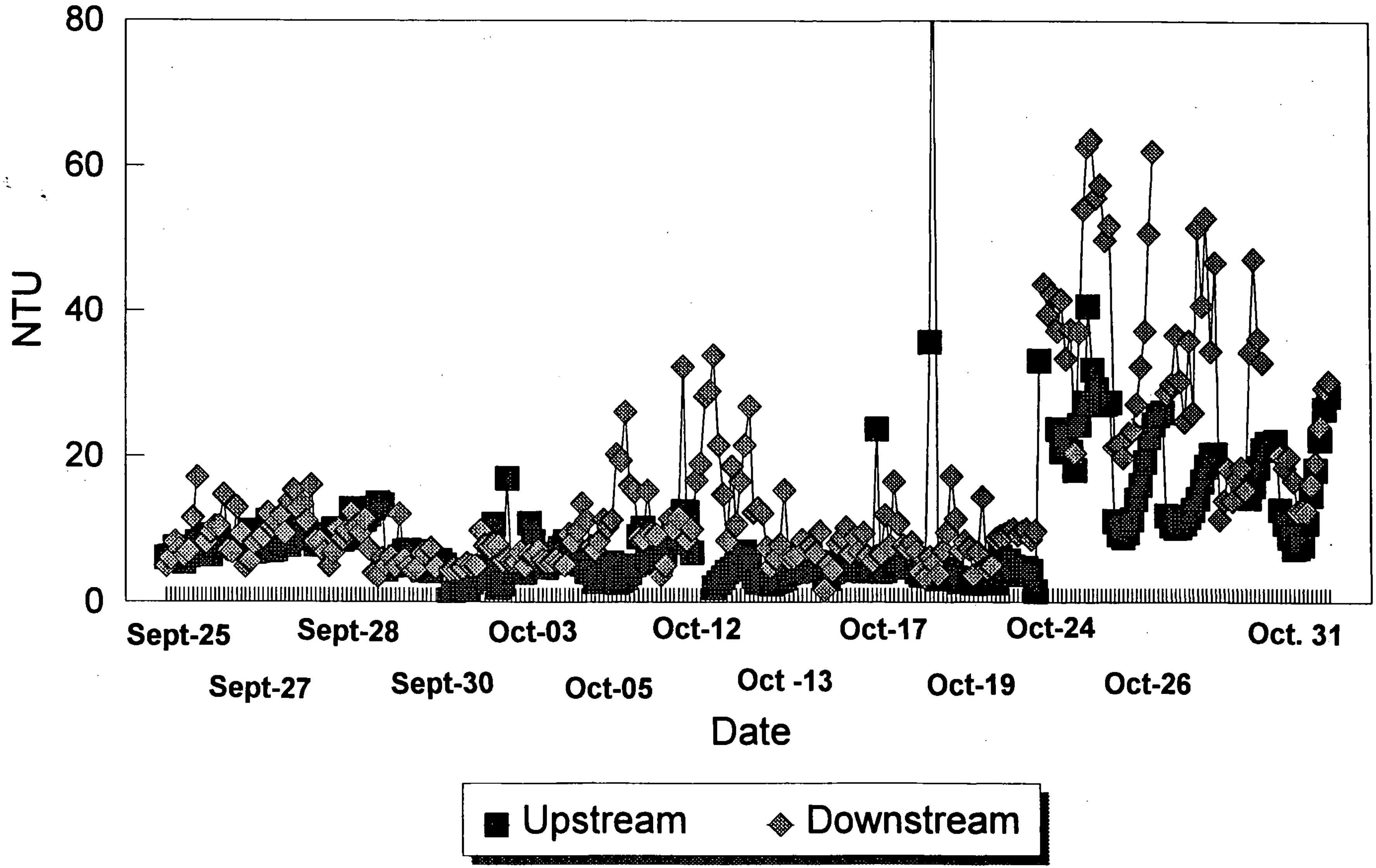


Fig. 5.17 (a)

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Turbidity Comparison - Sept.25-Oct. 21, 1995

ACRES

P31201.02 MR

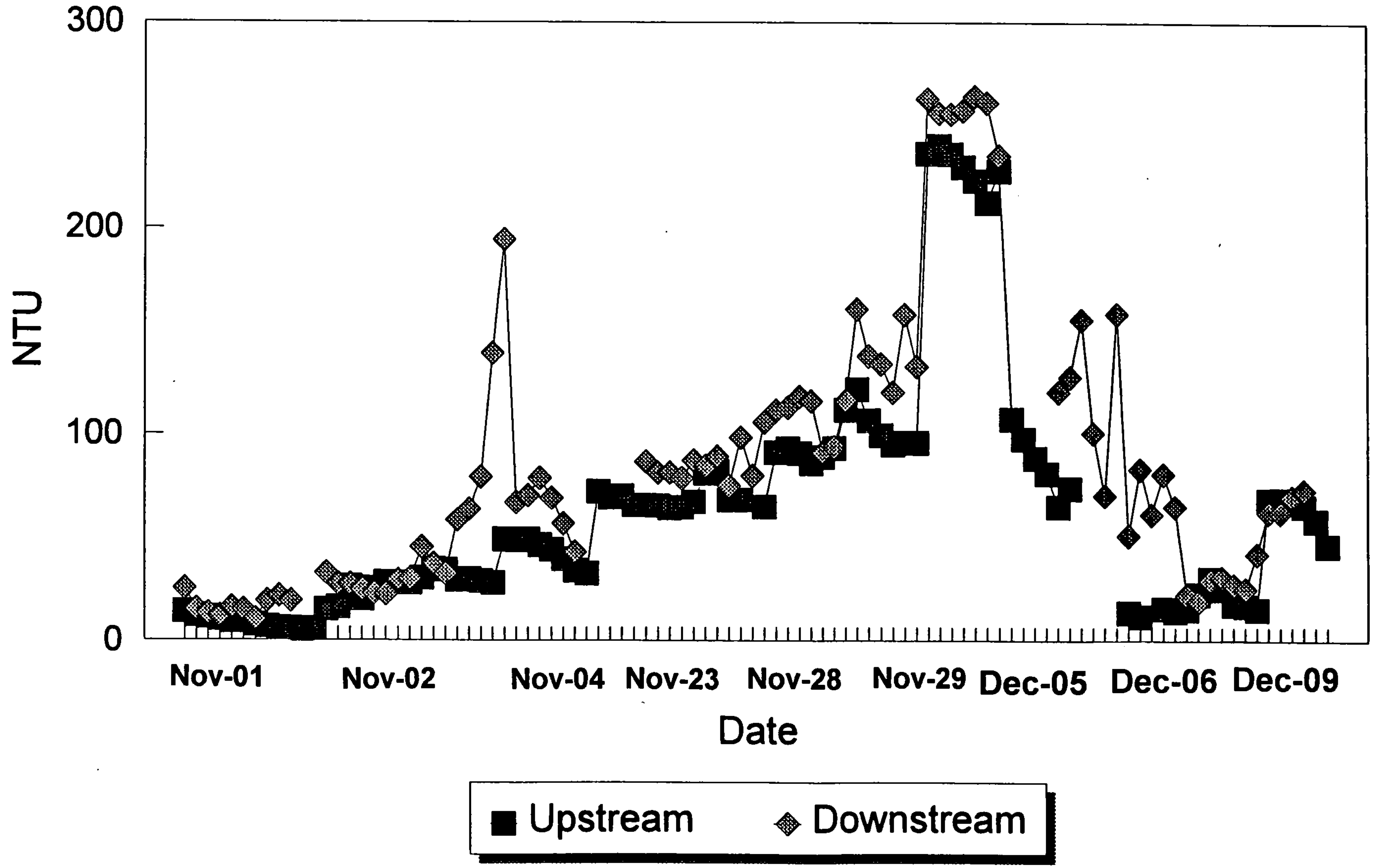


Fig. 5.17 (b)

Atlas Specialty Steels / Environment Canada
Welland River Reef Cleanup Project
Turbidity Comparison - Nov. 1-Dec. 9, 1995

P31201.02 MR

6 Sediment Treatment

6 Sediment Treatment

6.1 Description of Sediment Treatment Technology

The design of the selected sediment treatment technology for the full-scale clean-up project was based on the similar technology which was used to treat the sediment slurry generated during the 1991 pilot-scale demonstration. The technology was based on physical/chemical treatment principles for solid/liquid separation.

The materials removed from the river during the full-scale project were a mixture of predominantly fine to coarse granular, metallic, industrial mill scale and contaminated, clayey silt river sediment. Other river bottom materials including sand and gravel and a wide variety of debris were also encountered. Except for large debris which could not be pumped through the dredging pipeline and material excavated using the long-reach backhoe, all of the dredged material had to handled at the sediment treatment facility.

The design of the treatment facility was based on the following guidelines:

- 2000 USgpm slurry, 10% solids by weight, average river sediment composition (i.e., 1.5 tonnes/m^3 in situ bulk density), corresponding to an excavation rate of approximately 45 m^3/h

- 1800 USgpm slurry, 10% solids by weight, average mill scale composition (i.e., 1.9 tonnes/m^3 in situ bulk density), corresponding to an excavation rate of approximately 30 m^3/h

- 1500 USgpm slurry, 10% solids by weight, heavy/coarse mill scale composition (i.e., 2.8 tonnes/m^3 in situ bulk density), corresponding to an excavation rate of approximately 15 m^3/h

- 1000 USgpm slurry, 20% solids by weight, average or heavy/coarse mill scale composition, corresponding to an excavation rate of approximately 20 m^3/h

As had been done for the 1991 pilot-scale project, the temporary sediment treatment facility for the full-scale cleanup was located on Atlas property adjacent to its NFP approximately 400 m east of the Welland River. This provided the advantage of utilizing Atlas' existing thickener/clarifier, settling basin and filtration system in conjunction with the new temporary treatment facility. The operation of the NFP was such that additional flow capacity was available at the facility to allow the effluent from the temporary sediment treatment facility to be discharged into the existing settling basin and treated with the normal North Plant process water. Atlas' North plant continued its normal operations during the project.

The treatment facility, as originally designed for the full-scale project, consisted of the following main components:

- scalping screen (1)
- screw classifier (1)
- high `G' dryer (2)
- sludge thickener/clarifier (1)
- temporary stórage basins (2)
- Atlas' NFP.

Key features of the selected technology can be summarized as follows:

- provides efficient separation of solid/liquid phases down to 50 μm

- provides efficient separation of the various solid fractions, each having different contaminant characteristics

- compact, modular and portable design allows assembly with relative ease in congested areas

- operates as a continuous process over a wide range of flow rates

- designed to operate at high flow rates matching those generated by the dredging technology

- designed to handle a wide range of solids content

- can accommodate additional treatment modules or 'reactors' as necessary to treat other contaminant types

- low noise level allows operation near residential areas

- relatively low set up and operating costs
- minimal labor requirements for operation.

Except for the clays and some silt which accumulated in the temporary storage basins (TSBs) and which required further dewatering, the dewatered and separated solids generated by the various process were ready for disposal pending identification of contaminant concentrations.

A description of each process component is presented below. Selected photographs included in this volume show the various components of the sediment treatment facility in operation.

An evaluation of the performance of the sediment treatment facility during the project is presented in Section 6.2.

6.1.1 Initial Sediment Treatment

The following is a description of the components and the process for the treatment of the dredged sediment slurry at the beginning of the project. During the course of the project, modifications were made to the process in order to minimize impacts on the operating NFP and to provide additional storage for the fine silts and clays accumulating in the TSBs. The final arrangement of components at the sediment treatment facility are shown in As-Built Drawing 11201-AO-008.

Scalping Screen
The scalping screen was the first component of the sediment treatment facility and was designed to separate out particles greater than 2 mm in size. The unit was manufactured by Derrick Corporation.

The slurry pumped from the river was introduced via the feed box to the vibrating screen surface. The coarse solid fraction was retained on the screen and conveyed by the vibrating action to the end of the screen where it was discharged to the ground surface. The rest of the slurry passed through the screen into a sump below, from which it was pumped to the next piece of equipment.

The screen panels had openings of 2 mm and were constructed of urethane for high abrasion applications. The screen sizing was based on a solids loading of 100 tonne/h and a removal efficiency of 20 tonne/h. The high frequency, low amplitude vibrating action applied to the screens helped to rapidly break fluid-surface tension, promoted close screen/particle contact for fast and accurate separation, and imparted tangential movement to the solids allowing speedy discharge.

Screw Classifier

The screw classifier was the next process unit and received effluent from the scalping screen. The WEMCO screw classifier consisted of an inclined tank enclosing one revolving helix or spiral. The unit was designed to receive sediment slurry at the lower end of the tank (pool). The separation of higher specific gravity sand-sized particles from the slurry occurred by sedimentation within the pool where the coarser and heavier particles tended to settle while the lighter and finer particles tended to remain in suspension. The extent of the separation was controlled by the physical characteristics of the particles, slurry density and viscosity, differential settling rates of the particles, tank dimensions and slope and other factors. The design of the classifier was based on the specific gravity of the heavier particles to be removed (i.e., SG greater than 2.8) and the smallest particles to be removed (0.1 mm).

During operation the spiral revolved slowly and freely within the tank simultaneously draining and conveying heavy accumulated solids up the tank to the discharge point. The classifier overflow conveyed, by gravity, a continuous overflow of water containing fine suspended lower specific gravity particles from the pool to a sump below. The slurry was then pumped from the sump to the next piece of process equipment.

High 'G' Dryer

Two high 'G' dryers were the next units in the treatment process replacing the fine vibrating screens used in the 1991 demonstration. Each unit comprised a circular cluster of 20 hydrocyclones mounted on top of a vibrating fine screen.

The hydrocyclones, which first received the effluent from the screw classifier, were designed to remove particles 40 to 50 μm in size. The underflow (solids) from the cyclones was directed onto the screens which had openings of 0.5 mm, while the overflow (liquid) from the cyclones was routed to Atlas' existing thickener at the NFP. The solids trapped by the screens were discharged to the ground surface. The underflow from the fine screens were pumped back into the tank of the screw classifier.

On initial startup of the treatment process, the cyclone underflow was a dilute slurry which passed directly through the fine screens (0.5-mm openings) and were recirculated back into the screw classifier. After a short period of operation (10 to 20 minutes), the build up of solids in the recirculating flow produced a dense slurry in the cyclone underflow which could be retained and dewatered by the fine screens.

Thickener Unit

The sludge thickener used to receive the liquid effluent from the hydrocyclones was part of Atlas' existing NFP. It consisted of a square concrete tank with a conical bottom and a raking mechanism. While the thickener was not designed to be used for handling silty clay type sediments, it was modified and used for this purpose during the 1991 demonstration and it was also used in the early stages of the full-scale cleanup.

The working volume of the thickener is 180 m^3 with a depth of 4 m and a diameter of 8.2 m. At a maximum slurry flow of 5700 L/min (1500 USgpm) the hydraulic retention time (HRT) in the thickener would be approximately 32 min. This HRT is approximately four times shorter than that required for effective handling of the fine grained sediments.

Because of the limited storage volume available in the thickener it was necessary to pump the thickened sludge (underflow) from the bottom of the thickener to TSB #1 where final thickening was to occur. To maintain flexibility in storing the thickened sludge piping was installed to allow pumping to either TSB #1 or #2.

The overflow from the thickener went into a small sump from which it was pumped to TSB #2. During periods of high flow, overflow from the sump drained by gravity into the upstream end of Atlas' existing settling pond.

Chemical Coagulation and Flocculation

The removal of fine silty clay sediment from the slurry was assisted by a chemical coagulation and flocculation process. The coagulant Polutrol 2000 was introduced into the slurry in the effluent from the screw classifier and served to form pin-flocs (small sludge particles) in the slurry. The agglomeration and settling of the pin-flocs in the thickener and the TSBs was assisted by the addition of a chemical flocculent Midfloc PW 1319E which was introduced into the slurry in the liquid effluent from the high 'G' dryers. Both the coagulant and the flocculent were provided by Rochester Midland Limited.

Solids Handling

Dewatered solids were generated at varying rates by the scalping screen, screw classifier and high 'G' dryers during dredging and treatment facility operation. Stockpiles of each material type were maintained in the vicinity of the treatment facility. Representative samples of the piles were taken and chemical analyses were carried out to determine contaminant concentrations and to provide necessary documentation for proper disposal. A small initial quantity of solids generated by the screw classifier (coarse, mill scale) was placed with a larger Atlas stockpile of similar material for reuse. All other dewatered solids were eventually disposed of at the City of Welland municipal landfill meeting the need for daily cover.

Temporary Storage Basins

Two TSBs were used as part of the treatment process during the full-scale cleanup. TSB #1 was constructed for use during the 1991 demonstration. It had a high density polyethylene liner and a storage capacity of approximately 800 m^3. TSB #2 was constructed prior to the full-scale project to provide additional sludge settling time and additional storage capacity for fine solids. TSB #2 was a clay-lined structure having a storage capacity of approximately 3500 m^3. Overflow from both TSBs was directed by gravity into the upstream end of Atlas' existing settling pond.

6.1.2 Modifications to Sediment Treatment

During the course of the project, modifications were made to the sediment treatment process in order to improve its efficiency and to minimize problems with the NFP. These modifications are described below.

(a) Overflow of Solids from the Thickener

Early in the project it was observed that the thickener was not functioning satisfactorily. Overflow from the thickener, which was being pumped from a sump into TSB #2, contained a high concentration of suspended solids; the overflow from the sump occasionally sent suspended solids directly into Atlas' existing settling pond; and the underflow from the thickener, which was pumped intermittently into TSB #1, was not thickening significantly. While it was known at the outset of the project that the thickener did not provide the correct HRT to allow the fine solids to properly settle out, it was used with the expectation that some degree of thickening of the slurry would occur.

After approximately 1.5 weeks of use, the thickener was removed from the treatment train and the liquid effluent from the high 'G' dryers was sent directly into TSB #1. After a further 2 weeks of operation, and because of the limited size of TSB #1, the effluent from the high 'G' dryers was redirected to TSB #2.

(b) Availability of Thickener for NFP Backwashing

The dual media filtration system at the NFP requires regular backwashing to maintain the integrity of its three filters for normal North Plant operation. The thickener is used during this normal backwashing to contain and clarify the dirty backwash water. At the beginning of the project, when the thickener was used to receive the high 'G' dryer effluent over a daily shift of up to 12 hours, the thickener was unavailable for use in backwashing. This situation put a strain on the NFP during the remaining hours of the afternoon and night shifts and was another factor in the decision to remove the thickener from the treatment train.

(c) Carryover of Fines from TSB #2 into Atlas' Existing Settling Pond

After 5 weeks of receiving discharge from the high 'G' dryers, TSB #2 began to fill with fine solids to the point that solids were being carried over with the overflow water into Atlas' existing settling pond. As a result, the filtration system of the NFP was being affected and required frequent manual backwashing in order to keep it operational for normal plant production use.

To try to minimize the loss of fines from TSB #2 a geotextile silt curtain was placed across the width of the basin. Attempts were also made to improve the performance of the coagulant and flocculent by closely monitoring their dosages and making adjustments as necessary. Approximate dosing rates eventually adopted were as follows:

- coagulant (Polutrol 2000) - 50 to 75 ppm when slurry contained predominantly mill scale; 5000 to 6000 ppm when slurry contained mostly fine grained sediment. Dosing rate was very variable and was dependent on the amount and ratio of mill-scale and fine grained sediments in the slurry. It also appeared that the coagulant was less effective at lower temperatures.

- flocculent (Midflow PW1319E) - 10 to 15 ppm. This dosing rate was relatively constant for both mill-scale and fine grained sediment slurries throughout the project.

While these measures offered some benefits, the NFP continued to be impacted by the carry over of fines and eventually dredging was stopped in order that TSB #1 and #2 could be cleaned out and their configuration modified.

A long-reach backhoe was used to clean out, deepen and enlarge TSB #1. The excavated solids were loaded into sealed trucks for temporary stockpiling at a drying pad on another area of Atlas property. TSB #1 was made into two connected cells having a new total storage capacity estimated at 1200 m^3. Oil booms were placed between cells 1A and 1B. TSB #1 was connected to TSB #2 by two 450-mm diameter overflow pipes allowing flow to travel from TSB #1 into TSB #2.

TSB #2 was also cleaned out and enlarged using the long-reach backhoe. The new storage capacity of TSB #2 was estimated at 4370 m^3.

Other modifications made at this time included redirecting the effluent from the high 'G' dryers back to TSB #1 (Cell 1A).

To minimize the carry over of fines in the overflow water into the Atlas settling pond, two double rows of hay bales were later installed across the middle of TSB #2 separated by approximately 5 m. Also, a geotextile silt curtain (two in total) was placed in front of each double row of hay bales. Increased monitoring of the chemical dosing of the coagulant and flocculent was also initiated, implementing hourly jar tests on the slurry entering TSB #1A. The NFP backwash water, which previously overflowed from the thickener into Atlas' existing settling pond, was redirected to TSB #1A in an attempt to further minimize impact on the

NFP. The backwash water was also dosed with chemicals prior to being discharged into TSB #1A.

In the second week of December, with the NFP continuing to be impacted by fines from TSB #2, it was decided to remove one of the double rows of hay bales and one silt curtain from TSB #2. The bales and silt curtain had shifted and were allowing the soft sludge to be stirred up on the bottom of the basin. In addition, through an agreement with the Regional Municipality of Niagara, Atlas began to pump a portion of the overflow water from TSB #2 into the regional sewer system for treatment at the sewage treatment plant.

The problems with the settling basins and the subsequent modifications were extensively reviewed with the TRC, who provided valuable input and direction.

(d) Sludge Dewatering Using Centrifuges

At the end of the first week in November a Derrick centrifuge was received and put into service dewatering some of the sludge which was accumulating in TSB #2. A second centrifuge was added about 1 week later. Each centrifuge had a flow through capacity of approximately 80 to 100 USgpm. Attempts to provide a uniform thick slurry feed to the centrifuges using different pumping arrangements from TSB #2 were not successful in the cold weather and as a result solids dewatering with centrifuges was slow and inefficient. The centrifuges were taken out of service on about November 20.

(e) Scalping Screen

During periods of high solids content in the dredged slurry, it was occasionally observed that the 2-mm mesh of the scalping screen would become blinded resulting in the discharge of much of the slurry flow onto the ground in front of the screen. To prevent this from occurring the 2-mm mesh screen was replaced with a coarser 9.5-mm mesh which allowed more and larger solids to pass through it. These solids were then removed from the slurry by the screw classifier.

6.2 Sampling and Analysis

Monitoring of the sediment treatment process, to allow evaluation of its performance, was carried out during the course of the project. It consisted of sampling and analyzing both the liquid and solid phases of the dredged slurry at various stations at the treatment facility.

6.2.1 Liquid Phase Sampling and Analysis

Liquid phase sampling was carried out at the following sampling stations at the sediment treatment facility.

1 Influent to scalping screen
2 Influent to screw classifier
3 Influent to high 'G' dryer units
4 Effluent from high 'G' dryer (originally influent to thickener)
5 Influent to TSB #2 (originally thickener overflow)
6 Influent to TSB #1 (originally thickener underflow)
7 Effluent from TSB #2 (to NFP settling basin)
OV = overflow
UN = underdrain
8 Effluent from TSB #1 (to NFP settling basin)
9 Effluent from NFP (final effluent to Welland River)

The sampling and analytical program comprised the following.

Liquid phase samples were collected at the nine sampling stations listed above. Each location, except Station 9, was manually sampled up to four times per day (1 to 2 hours apart, if possible), normally 4 to 6 days/wk unless dredging activity was restricted. Station 9 was being automatically sampled by Atlas as part of its MISA program monitoring. A single 1-d composite sample for each station was created from the individual sampling events.

Laboratory analysis of the one-day composite samples was carried out for

- TSS (all nine stations)
- oil and grease (Stations 1, 4, 5, 7, 8, 9)
- pH (Stations 1, 4, 5, 7, 8, 9)

- Metals (Stations 1, 4, 5, 7, 8, 9)
- TP (Stations 1, 7, 8)
- TKN (Stations 1, 7, 8).

In addition, individual samples from Stations 4, 5, 7 and 8 (effluent from high 'G' dryers, influent to TSB #2, effluent from TSB #2, and effluent from TSB #1) were analyzed for turbidity in the field prior to being combined to form the composite sample.

Frequent analyses for the parameters TSS, oil and grease and pH were carried out over the duration of the project. Analyses for metals, TP and TKN were carried out less frequently and were generally concentrated in the period from September 23 to October 25 and from November 4 to 16.

Samples from the first 2 to 5 days of dredging in each of the coarse mill-scale and fine sediments at the Atlas 42-in. reef, and for 4 days on commencement of dredging at the McMaster Avenue reef were submitted to Acres Analytical Limited for analysis. All other samples were submitted to the MOEE laboratory for analysis.

A summary of the analytical results for the main parameters TSS, oil and grease, chromium, nickel, TKN and TP are presented in Tables 6.1 to 6.6. Complete and certified analytical results are provided in Appendix E.

6.2.2 Solid Phase Sampling and Analysis

Solids removed by the scalping screen consisted of a variable mixture of large particles (very coarse mill scale, gravel and small cobbles, as well as a variety of inorganic and organic debris) that are nonhazardous in nature. No chemical analysis of this waste stream was carried out during the project. These solids were taken to the City of Welland landfill and used as cover material.

Solids from the screw classifier consisted primarily of coarse mill scale with some natural sand. This material was stockpiled on site and sampled and tested in accordance with the MOEE Reg. 347 slump and leachate test (inorganic parameters only) prior to disposal. The results of Reg. 347 leachate tests on screw classifier and other treatment facility solids are presented in Table 6.7. As previously indicated, a small quantity of this mill scale was placed with Atlas' existing stockpile. When quantities of sand made the material too variable for use by Atlas, the screw classifier solids were taken to the City of Welland landfill for use there.

The dewatered solids generated by the high 'G' dryer units consisted of the fine mill scale (approximately 70% silt and clay and 30% fine to medium sand) and inorganic particles [1.5% to 7.5% loss on ignition (LOI)]. This material was also stockpiled on site where it was allowed to drain. Twelve samples of the material were analyzed for pH, oil and grease and metals. These results are presented in Table 6.8. After a sufficient quantity had accumulated, a Reg. 347 slump test and leachate test were carried out to determine its suitability for use in the City of Welland municipal landfill.

Some fine solids which remained in TSBs #1 and #2 at the completion of sediment treatment were removed from the TSBs in August and early September 1996 and deposited at a drying pad on Atlas property. Similar testing as noted above (slump and leachate tests as per MOEE Reg. 347) will be required prior to use as landfill cover.

6.3 Evaluation

6.3.1 Treatment Costs

The total cost of the sediment treatment operation is estimated at $1,462,000. This includes a wide variety of costs related to

- rental of Derrick equipment
- sewer discharge
- Atlas labor and facility operation
- installation and piping
- facility maintenance
- utilities
- provision of Atlas' NFP
- new storage basins
- clean out of storage basins
- city supplied equipment
- chemicals
- miscellaneous items.

The total volume of contaminated material dredged from the river with the Amphibex was 7613 m^3. All of this material was pumped to the sediment treatment facility where it passed through the equipment, storage basins and Atlas' NFP.

The overall unit treatment cost is, therefore, estimated at $192/$m^3$ (in situ volume). This cost is considered unusually high due largely to significant costs associated with delays at the treatment facility and the need to clean out and make modifications to TSBs.

6.3.2 Liquid Phase

An evaluation of the summarized data in Tables 6.1 to 6.6 yields the following information about the performance of the dredge, the temporary sediment treatment facility and Atlas' NFP. Remarks have been added to these tables to identify where the Amphibex dredge was working when the samples were taken. Analytical results on which tables are based are presented in Appendix F.

Total Suspended Solids
Samples were taken from Station 1 (influent to scalping screen) in an attempt to determine the percent solids by weight in the slurry being generated by the Amphibex. Because the slurry contained a large variety of particle types, sizes and shapes, it was recognized that samples taken from Station 1 (25-mm sampling port) would not be completely representative of the slurry; however, they would provide an (under) estimate of slurry percent solids. It is also noted that the variable pipeline flow and the activity at the dredge head are significant factors governing constancy of the slurry solids content.

The range of TSS concentrations in the slurry (expressed as percent solids by weight) at the various sampling stations is summarized below.

Station	Slurry Solids Content (% by weight)	Remarks
1	0.07 to 8.2 0.02 to 11.6 0.03 to 15.3	Dredging at Atlas 42-in., Sept 23 to Oct 3 Dredging at McMaster Avenue, Oct 10 to Nov 2 Dredging at Atlas 42-in., Nov 4 to Dec 16
2	0.09 to 20.2	Range for Sept 23 to Dec 9
3	0.17 to 14.0	Range for Sept 23 to Dec 9
4	0.03 to 13.0	Range for Sept 23 to Dec 9
5	0.01 to 3.2	Range for Sept 23 to Oct 3
6	0.87 to 30.5	Range for Sept 23 to Oct 2
7 OV	0.002 to 6.7	Range for Sept 23 to Dec 16
9	0.0001 to 0.2	Range for Sept 23 to Dec 16

The upper limit of the range in slurry solids content from Station 1 corresponds closely to what was found from the densitometer mounted on the dredge, i.e., that the maximum sustained slurry solids content generated by the Amphibex was in the range of 10% to 20% solids by weight.

The data from Station 9 (MISA control point) indicates that there were 4 days between October 25 and November 29 when the daily plant loading limit (according to MOEE Reg. 214/95) for TSS was exceeded in the NFP final effluent.

The discharge (pumping) of water from TSB #2 into the Regional sewer system commenced on December 8 to reduce the impact of the project on the NFP. The discharges occurred over a total of 36 hours from December 8 to 16, at an estimated discharge rate of 750 gal/min for a total of 1 620 000 gal. The TSS concentrations in the discharge water as determined in daily composite samples ranged form 428 to 600 mg/L and are shown in Table 6.1 under Station 7OV for the dates December 9, 15, and 16.

Other Parameters
The range of concentrations of oil and grease, Cr, Ni, TKN and TP in the slurry at the various sampling points throughout the project is summarized below.

Station	Oil and Grease (mg/L)	Cr (mg/L)	Ni (mg/L)	TKN (mg/L)	TP (mg/L)
1	1 to 2420	0.09 to 243.8	0.13 to 198.1	0.9 to 263	0.7 to 169
2	32 to 2230	na	na	na	na
3	19.5 to 2510	na	na	na	na
4	6 to 2090	0.11 to 197.8	0.11 to 183.2	na	na
5	3 to 1570	0.26 to 151.7	0.45 to 99.95	na	na
6	250.5 to 7000	na	na	na	na
7OV	0.5 to 540	0.03 to 74.6	0.126 to 52.15	0.4 to 37.5	0.02 to 27.2
9	*	0.005 to 0.123	0.02 to 0.206	na	na

* measured as weekly average - no range given
na not analyzed

The data from Station 9 indicates that there was 1 day (November 16) when the daily plant loading limit for Cr was exceeded in the NFP final effluent.

6.3.3 Solid Phase

The equipment used in the full-scale cleanup project to dewater and separate the various size fractions dredged from the river was very similar to that used in the 1991 demonstration project. The main differences were the elimination of the use of the centrifuges and the change from the fine vibrating screens to the high 'G' dryers for the full-scale cleanup. (Note: Two centrifuges were used for a short time during the full-scale cleanup but not in the same manner as in 1991 and not effectively).

Because of the similarities to 1991, an evaluation of the scalping screen was not attempted. The solids generated by the scalping screen were a wide variety of sand and gravel sized particles (including coarse mill scale) as well as assorted debris. No chemical analyses were carried out on this variable material prior to disposal at the City of Welland landfill.

Solids from the screw classifier consisted of sand sized particles of mostly industrial mill scale and some natural river sediment. The high 'G' dryer solids consisted of approximately 70% silt and clay sized particles and 30% fine to medium sand sized. The high 'G' dryer solids were generally black being mostly fine mill scale.

Chemical analyses of 14 assorted samples of solids form the treatment facility, including high 'G' dryer solids (12 samples) centrifuge solids (one sample) and (backhoe) excavator solids (one sample), as shown in Table 6.8, indicate all are high in metals.

The high 'G' dryer solids (TP and HG samples) had oil and grease concentrations ranging from 680 to 28 440 mg/kg. Moisture contents in four other high 'G' dryer solids samples ranged from 22.1% to 32.7%, while organic content ranged from 1.5% to 7.5%.

Six samples of treatment facility solids were analyzed in accordance with the MOEE Reg. 347 leachate test (inorganic components only, as previous testing had indicated that inorganics in the river material were not a leachate concern). Results are shown in Table 6.7. These samples represented the high 'G' dryer solids, the screw classifier solids, the centrifuge solids, the excavator solids sampled from Atlas' drying pad area, and a mixture of all solids which were temporarily stockpiled at the NFP. Results show that the concentrations of listed parameters are no greater than 10 times the MOEE Schedule 4 leachate quality criteria indicating all the solids to be nonregisterable and nonleachate toxic, suitable for municipal landfill use. Analytical results are presented in Appendix G.

Table 6.1

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: TSS
(All units in mg/L)

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7 OV	Station 7 UN	Station 8	Station 9	Remarks
23-Sep	82030	54670	79650	44690	30380	305000	14290		40	1	Dredging at Atlas 42-in
25-Sep	725	1125	2840	1090	90	119260	50			3	Dredging at Atlas 42-in
26-Sep	58520	120190	96110	76450	31690		90		30	1	Dredging at Atlas 42-in
27-Sep	10790	14780	24450	14170	12790		220			16	Dredging at Atlas 42-in
28-Sep	4965	3100	5125	2060	55	73740	30			1	Dredging at Atlas 42-in
29-Sep	1880	2570	15900	1510	288	24700	268	238		1	Dredging at Atlas 42-in
30-Sep	2230	900	1930	795	35	73570	20	20	20	1	Dredging at Atlas 42-in
02-Oct	848	3410	1910	1510	240	8660	200			1	Dredging at Atlas 42-in
03-Oct	3870	1460	9460	4190	204		224			1	Dredging at Atlas 42-in
10-Oct	7685	16965	24915	(1*) 46840	(1*)	(1*)	165				Dredging at McMaster
11-Oct	1760	1630	4510	2780			100			1	Dredging at McMaster
12-Oct	63600	13630	26700	21650			985			1	Dredging at McMaster
13-Oct	5630	9360	16450	9400			105			1	Dredging at McMaster
16-Oct	3540	7830	33200	5950			288			1	Dredging at McMaster
17-Oct	168	7700	12600	9510			258			1	Dredging at McMaster
18-Oct	168	7110	11100	3630			220			1	Dredging at McMaster
19-Oct	20900	12200	10000	4360			244			1	Dredging at McMaster
21-Oct	20000	188000	68200	46800			504			3	Dredging at McMaster
24-Oct	116000	137000	39800	(2*) 17700			548			1	Dredging at McMaster
25-Oct	99300	123000	140000	57900			460			5^	Dredging at McMaster
26-Oct	560	1590	11400	7000			588			2	Dredging at McMaster
27-Oct	4530	14000	1830	11800			418			1	Dredging at McMaster
28-Oct	35700	6660	7480	2700			246			1	Dredging at McMaster
30-Oct	33400	9770	14800	20900			2580			1	Dredging at McMaster
31-Oct	19200	10800	11700	14500			354			1	Dredging at McMaster
01-Nov	15100	5520	7820	1530			1090			1	Dredging at McMaster
02-Nov	11500	14600	69400	73700			364			1	Dredging at McMaster
04-Nov	920		103930	129670			67440			129^	Dredging at Atlas 42-in
06-Nov	153240	57970	114000	113210			22030			1	Dredging at Atlas 42-in
14-Nov	405		5080	320			110			1	ReDredging at McMaster
15-Nov	45150	30020	66390	50930			520			1	Dredging at Atlas 42-in
16-Nov	23960	39200	129280	109830			553			248^	Dredging at Atlas 42-in
23-Nov	21400	8490	1710	6140			400			3	Dredging at Atlas 42-in
27-Nov	14600	31500	41600	20200			306			1	Dredging at Atlas 42-in
28-Nov	9350	13000	11100	8680			434			4	Dredging at Atlas 42-in

Table 6.1

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: TSS
(All units in mg/L)

29-Nov	31600	35500	51300	35600			5410			13^	Dredging at Atlas 42-in
01-Dec	340	43200	36500	18800			10300			2	Dredging at Atlas 42-in
05-Dec	38330	58940	78920	42760			188			2	Dredging at Atlas 42-in
06-Dec							10020			1	Dredging at Atlas 42-in
06-Dec	12600	70000	35400	22500						1	Dredging at Atlas 42-in
08-Dec		24000	26300	45500						2	Dredging at Atlas 42-in
09-Dec		202000	61000	44600			428			1	Dredging at Atlas 42-in
15-Dec							600			2	Dredging at Atlas 42-in
16-Dec							560			10	Dredging at Atlas 42-in
16-Dec		109000	77300	163000						1	Dredging at Atlas 42-in
19-Dec		281000	133000	560000						1	Dredging at Atlas 42-in

Bolded dates indicate samples analyzed by Acres Analytical Limited. All others were analyzed by the MOEE.
OV and UN indicate overflow and underflow, respectively.
Station 9 is a MISA control point for Atlas Steels. The symbol ^ indicates a day when the daily loading limit occurred.
(1*) - Thickener no longer used as part of the temporary sediment treatment facility.
High 'G' dryer rerouted to TSB#1.
(2*) - High 'G' dryer rerouted to TSB#2.

Table 6.2

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: Oil and Grease
(All units in mg/L)

23-Sep	2420	2060	2040	1940	1500	7000	540		1	1	Dredging at Atlas 42-in
25-Sep	30	32	37	27	3	3950	2				Dredging at Atlas 42-in
26-Sep	1760	2230	2510	2090	1570		5		5		Dredging at Atlas 42-in
27-Sep	233	330	513	350	468		4				Dredging at Atlas 42-in
28-Sep	67	52	62	48	2	1890	2				Dredging at Atlas 42-in
29-Sep		53	67.5	13.5	0.5	250.5	0.5				Dredging at Atlas 42-in
30-Sep	56			12	< 1		< 1	< 2			Dredging at Atlas 42-in
02-Oct	32.5	51.5	84.5	20	0.5	293	0.5				Dredging at Atlas 42-in
03-Oct	40.5	54	77.5	56	0.5		2			1	Dredging at Atlas 42-in
10-Oct	81	257	225	(1*) 381	(1*)	(1*)	1				Dredging at McMaster
11-Oct	44	37	64	64			1				Dredging at McMaster
12-Oct	163	55	125	175			4			1	Dredging at McMaster
13-Oct	87	211	115	75			3				Dredging at McMaster
16-Oct	37.5	91	266	25			1.5				Dredging at McMaster
17-Oct	98	72	105	97.5			1.5				Dredging at McMaster
18-Oct	120	143.5	80.5	47			1.5				Dredging at McMaster
19-Oct	126.5	114.5	100.5	64			2			1	Dredging at McMaster
21-Oct	89.5	144.5	168	134			1				Dredging at McMaster
24-Oct	176	188	165	(2*) 78			2				Dredging at McMaster
25-Oct	213	186	195	112.5			2				Dredging at McMaster
26-Oct	15	68	59.5	16.5			3			1	Dredging at McMaster
27-Oct	75										Dredging at McMaster
28-Oct	260	88.5	44.5	11			2				Dredging at McMaster
30-Oct	272	86	58.5	34.5			7				Dredging at McMaster
31-Oct	60.5	94.5	52.5	31.5			2.5				Dredging at McMaster
01-Nov	84	51	60.5	10.5			4			1	Dredging at McMaster
02-Nov	69.5	136	179.5	56.5			2.5				Dredging at McMaster
04-Nov	8		200	230			395				Dredging at Atlas 42-in
06-Nov	1330	405	1005	1055			76				Dredging at Atlas 42-in
14-Nov	< 1		6	6			< 1				Dredging at McMaster
15-Nov	890	177	540	485			< 1				Dredging at Atlas 42-in
16-Nov	400	590	875	1110			3				Dredging at Atlas 42-in
23-Nov											Dredging at Atlas 42-in
28-Nov	112.5	219.5	81.5	119			0.5				Dredging at Atlas 42-in
29-Nov	320	189	179	222.5			72			1	Dredging at Atlas 42-in
01-Dec	17.5	43.5	34	19			20				Dredging at Atlas 42-in
05-Dec	225	525	560	310			3				Dredging at Atlas 42-in
06-Dec							85			1	Dredging at Atlas 42-in
06-Dec	44.5	64.5	90.5	122.5							Dredging at Atlas 42-in
08-Dec		52.5	69.5	122							Dredging at Atlas 42-in

Table 6.2

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: Oil and Grease
(All units in mg/L)

09-Dec		238	19.5	15			1.5				Dredging at Atlas 42-in
15-Dec							14				Dredging at Atlas 42-in
16-Dec							78				Dredging at Atlas 42-in
16-Dec		830	954	1790							Dredging at Atlas 42-in
19-Dec		688	954	874							Dredging at Atlas 42-in

Bolded dates indicate samples analyzed by Acres Analytical Limited. All others were analyzed by the MOEE.
OV and UN indicate overflow and underflow, respectively.
Station 9 is a MISA control point for Atlas Steels.
(1*) - Thickener no longer used as part of the temporary sediment treatment facility.
High 'G' dryer effluent rerouted to TSB#1.
(2*) - High 'G' dryer effluent rerouted to TSB#2.

Table 6.3

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: Chromium
(All units in mg/L)

23-Sep	243.8		171.3	151.7	74.6		0.044	0.005	Dredging at Atlas 42-in
25-Sep	54		7.86	0.66	0.24			0.005	Dredging at Atlas 42-in
26-Sep	107		197.8	104.2	0.15		0.26	0.012	Dredging at Atlas 42-in
27-Sep	35.95		50.4	44.4	0.308			0.034	Dredging at Atlas 42-in
28-Sep	56.55		19.25	0.354	0.126			0.005	Dredging at Atlas 42-in
29-Sep	28		9.85		0.24	0.2		0.006	Dredging at Atlas 42-in
30-Sep									Dredging at Atlas 42-in
02-Oct	9.84		6.86	0.34	0.08			0.005	Dredging at Atlas 42-in
03-Oct	10		10.3	0.26	0.09			0.005	Dredging at Atlas 42-in
10-Oct	6.1		(2*) 18	(1*)	0.09				Dredging at McMaster
11-Oct	3.715		4.245		0.206			0.005	Dredging at McMaster
12-Oct	6.09		5.18		0.18			0.01	Dredging at McMaster
13-Oct	44.65		21.78		0.062			0.12	Dredging at McMaster
16-Oct	28.6		22.8		0.08			0.005	Dredging at McMaster
17-Oct	11.3		15.9		0.03			0.006	Dredging at McMaster
18-Oct	26.3		14.5		0.25			0.005	Dredging at McMaster
19-Oct	45.3		16.6		0.23			0.005	Dredging at McMaster
21-Oct	9.8		23.6		0.06			0.005	Dredging at McMaster
24-Oct	27		(2*) 5.24		0.03			0.005	Dredging at McMaster
25-Oct	20.2		8.89		0.03			0.005	Dredging at McMaster
26-Oct								0.005	Dredging at McMaster
28-Oct								0.005	Dredging at McMaster
30-Oct	41.7		12.6		0.86				Dredging at McMaster
31-Oct								0.005	Dredging at McMaster
01-Nov								0.005	Dredging at McMaster
02-Nov								0.005	Dredging at McMaster
04-Nov	0.114	12.7	12.69		5.88			0.04	Dredging at Atlas 42-in
06-Nov	15.98		11.56		1.29			0.005	Dredging at Atlas 42-in
14-Nov	0.09		0.11		0.13			0.005	ReDredging at McMaster
15-Nov	48.26		18		0.15			0.005	Dredging at Atlas 42-in
16-Nov	65.89		146.4		0.48			0.123^	Dredging at Atlas 42-in
23-Nov								0.005	Dredging at Atlas 42-in
27-Nov	50.2		191	0.13					Dredging at Atlas 42-in
28-Nov								0.005	Dredging at Atlas 42-in
29-Nov								0.008	Dredging at Atlas 42-in
01-Dec	11.2		7.44		2.78			0.016	Dredging at Atlas 42-in

Table 6.3

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: Chromium
(All units in mg/L)

05-Dec	31.2		47.4		0.5			0.013	Dredging at Atlas 42-in
06-Dec					10.6			0.02	Dredging at Atlas 42-in
08-Dec									Dredging at Atlas 42-in
09-Dec			64.4		0.09			0.005	Dredging at Atlas 42-in
15-Dec					0.95			0.008	Dredging at Atlas 42-in
16-Dec					13.62			0.01	Dredging at Atlas 42-in
16-Dec			757						Dredging at Atlas 42-in

Bolded dates indicate samples analyzed by Acres Analytical Limited. All others were analyzed by the MOEE.
OV and UN indicate overflow and underflow, respectively.
Station 9 is a MISA control point for Atlas Steels. The symbol ^ indicates a day when the daily loading limit occurred.
(1*) - Thickener no longer used as part of the temporary sediment treatment facility.
High 'G' dryer rerouted to TSB#1.
(2*) - High 'G' dryer rerouted to TSB#2.

Table 6.4

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: Nickel
(All units in mg/L)

23-Sep	198.1		129.2	99.95	52.15		0.175	0.074	Dredging at Atlas 42-in
25-Sep	71.4		0.11	13.26	0.35			0.071	Dredging at Atlas 42-in
26-Sep	126.3		183.2	86.21	0.044		0.13	0.115	Dredging at Atlas 42-in
27-Sep	37.24		50.55	32.92	0.268			0.093	Dredging at Atlas 42-in
28-Sep	56.55		19.25	0.354	0.126			0.09	Dredging at Atlas 42-in
29-Sep	42.4		16.2		0.4	0.3		0.112	Dredging at Atlas 42-in
30-Sep								0.05	Dredging at Atlas 42-in
02-Oct	23.6		12.7	0.55	0.15			0.02	Dredging at Atlas 42-in
03-Oct	18.9		12	0.45	0.2			0.051	Dredging at Atlas 42-in
10-Oct	7.98		(1*) 19.26	(1*)	0.24			0.146	Dredging at McMaster
11-Oct	3.43		2.68		0.35			0.12	Dredging at McMaster
12-Oct	6.4		5.44		0.4			0.117	Dredging at McMaster
13-Oct	35.29		14.94		0.334			0.108	Dredging at McMaster
16-Oct	18		12		0.5			0.047	Dredging at McMaster
17-Oct	11.6		15.2		0.3			0.085	Dredging at McMaster
18-Oct	15.8		14		0.5			0.134	Dredging at McMaster
19-Oct	39.2		11		0.4			0.206	Dredging at McMaster
21-Oct	10		25.4		0.2			0.004	Dredging at McMaster
24-Oct	21.7		(2*) 6.6		0.05			0.193	Dredging at McMaster
25-Oct	0.13		13.6		0.05			0.088	Dredging at McMaster
26-Oct								0.096	Dredging at McMaster
28-Oct								0.02	Dredging at McMaster
30-Oct	32.1		9.07		0.9				Dredging at McMaster
31-Oct								0.023	Dredging at McMaster
01-Nov								0.142	Dredging at McMaster
02-Nov								0.132	Dredging at McMaster
04-Nov	0.167	13.61	13.28		7.74			0.062	Dredging at Atlas 42-in
06-Nov	32.4		21.12		2.33			0.045	Dredging at Atlas 42-in
14-Nov	0.29		0.13		0.07			0.029	Dredging at McMaster
15-Nov	36.22		13.59		0.16			0.104	Dredging at McMaster
16-Nov	64.21		128.6		0.6			0.141	Dredging at McMaster
23-Nov								0.088	Dredging at McMaster
27-Nov	42.4		153		0.25				Dredging at McMaster
28-Nov								0.08	Dredging at McMaster
29-Nov								0.192	Dredging at McMaster
01-Dec	8.25		5.45		2.2			0.126	Dredging at McMaster

Table 6.4

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: Nickel
(All units in mg/L)

05-Dec	34.4		44.4		0.6			0.135	Dredging at McMaster
06-Dec					6.9			0.132	Dredging at McMaster
08-Dec								0.125	Dredging at McMaster
09-Dec			47.1		0.25			0.111	Dredging at McMaster
15-Dec					0.6			0.135	Dredging at McMaster
16-Dec					9.1			0.131	Dredging at McMaster
16-Dec			657						Dredging at McMaster

Bolded dates indicate samples analyzed by Acres Analytical Limited. All others were analyzed by the MOEE.
OV and UN indicate overflow and underflow, respectively
Station 9 is a MISA control point for Atlas Steels.
(1*) - Thickener no longer used as part of temporary sediment treatment facility.
High 'G' dryer effluent rerouted to TSB#1.
(2*) - High 'G' dryer effluent rerouted to TSB#2.

Table 6.5

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: TKN
(All units in mg/L)

	Station 1	Station 7 OV	Station 7 UN	Station 8	Remarks
23-Sep	30	26		8	Dredging at Atlas 42-in
25-Sep	0.9	3			Dredging at Atlas 42-in
26-Sep	31	2.4		2.6	Dredging at Atlas 42-in
27-Sep	9.6	3.2			Dredging at Atlas 42-in
28-Sep	8	1.4			Dredging at Atlas 42-in
29-Sep	2	1.6	1.75		Dredging at Atlas 42-in
30-Sep					Dredging at Atlas 42-in
02-Oct	1	0.4			Dredging at Atlas 42-in
03-Oct	1.5	0.45			Dredging at Atlas 42-in
10-Oct	3.9	0.5			Dredging at MacMaster
11-Oct	1.8	0.5			Dredging at MacMaster
12-Oct	32	1.3			Dredging at MacMaster
13-Oct	3.3	0.5			Dredging at MacMaster
16-Oct	17.5	1.9			Dredging at MacMaster
17-Oct	31.3	3.85			Dredging at MacMaster
18-Oct	9.5	1.95			Dredging at MacMaster
19-Oct	75	1.8			Dredging at MacMaster
21-Oct	35	7			Dredging at MacMaster
24-Oct	263	4.5			Dredging at MacMaster
25-Oct	250	2.35			Dredging at MacMaster
26-Oct					Dredging at MacMaster
28-Oct					Dredging at MacMaster
30-Oct	77.5	6.25			Dredging at MacMaster
31-Oct					Dredging at MacMaster
01-Nov					Dredging at MacMaster
02-Nov					Dredging at MacMaster
04-Nov	1.4	21			Dredging at Atlas 42-in
06-Nov	26				Dredging at Atlas 42-in
14-Nov	1.8	1			Dredging at MacMaster
15-Nov	32	1.6			Dredging at Atlas 42-in
16-Nov	18.1	0.7			Dredging at Atlas 42-in
23-Nov					Dredging at Atlas 42-in
27-Nov	65	4.2			Dredging at Atlas 42-in
28-Nov					Dredging at Atlas 42-in
29-Nov					Dredging at Atlas 42-in
01-Dec	32.5	37.5			Dredging at Atlas 42-in
05-Dec	31.4	1.6			Dredging at Atlas 42-in
06-Dec					Dredging at Atlas 42-in
06-Dec					Dredging at Atlas 42-in
08-Dec					Dredging at Atlas 42-in
09-Dec		4.75			Dredging at Atlas 42-in
15-Dec		2.1			Dredging at Atlas 42-in
16-Dec		9			Dredging at Atlas 42-in

Bolded dates indicate samples analyzed by Acres Analytical Limited. All others were analyzed by the MOEE.
OV and UN indicate overflow and underflow, respectively.

Table 6.5

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: TKN
(All units in mg/L)

23-Sep	30	26		8	Dredging at Atlas 42-in
25-Sep	0.9	3			Dredging at Atlas 42-in
26-Sep	31	2.4		2.6	Dredging at Atlas 42-in
27-Sep	9.6	3.2			Dredging at Atlas 42-in
28-Sep	8	1.4			Dredging at Atlas 42-in
29-Sep	2	1.6	1.75		Dredging at Atlas 42-in
30-Sep					Dredging at Atlas 42-in
02-Oct	1	0.4			Dredging at Atlas 42-in
03-Oct	1.5	0.45			Dredging at Atlas 42-in
10-Oct	3.9	0.5			Dredging at MacMaster
11-Oct	1.8	0.5			Dredging at MacMaster
12-Oct	32	1.3			Dredging at MacMaster
13-Oct	3.3	0.5			Dredging at MacMaster
16-Oct	17.5	1.9			Dredging at MacMaster
17-Oct	31.3	3.85			Dredging at MacMaster
18-Oct	9.5	1.95			Dredging at MacMaster
19-Oct	75	1.8			Dredging at MacMaster
21-Oct	35	7			Dredging at MacMaster
24-Oct	263	4.5			Dredging at MacMaster
25-Oct	250	2.35			Dredging at MacMaster
26-Oct					Dredging at MacMaster
28-Oct					Dredging at MacMaster
30-Oct	77.5	6.25			Dredging at MacMaster
31-Oct					Dredging at MacMaster
01-Nov					Dredging at MacMaster
02-Nov					Dredging at MacMaster
04-Nov	1.4	21			Dredging at Atlas 42-in
06-Nov	26				Dredging at Atlas 42-in
14-Nov	1.8	1			Dredging at MacMaster
15-Nov	32	1.6			Dredging at Atlas 42-in
16-Nov	18.1	0.7			Dredging at Atlas 42-in
23-Nov					Dredging at Atlas 42-in
27-Nov	65	4.2			Dredging at Atlas 42-in
28-Nov					Dredging at Atlas 42-in
29-Nov					Dredging at Atlas 42-in
01-Dec	32.5	37.5			Dredging at Atlas 42-in
05-Dec	31.4	1.6			Dredging at Atlas 42-in
06-Dec					Dredging at Atlas 42-in
06-Dec					Dredging at Atlas 42-in
08-Dec					Dredging at Atlas 42-in
09-Dec		4.75			Dredging at Atlas 42-in
15-Dec		2.1			Dredging at Atlas 42-in
16-Dec		9			Dredging at Atlas 42-in

Bolded dates indicate samples analyzed by Acres Analytical Limited. All others were analyzed by the MOEE.
OV and UN indicate overflow and underflow, respectively.
Station 9 is a MISA control point for Atlas Steels.
(1*) - Thickener no longer used as part of temporary sediment treatment facility.
High 'G' dryer effluent rerouted to TSB#1.
(2*) - High 'G' dryer effluent rerouted to TSB#2.

Table 6.6

Welland River Reef Cleanup Project - Liquid Phase Analytical Results
Location: Sediment Treatment Facility
Parameter: TP
(All units in mg/L)

	Station 1	Station 7 OV	Station 7 UN	Station 8	Remarks
23-Sep	97.2	27.2		0.26	Dredging at Atlas 42-in
25-Sep	2.4	0.15			Dredging at Atlas 42-in
26-Sep	65.5	0.1		0.1	Dredging at Atlas 42-in
27-Sep	11	0.05			Dredging at Atlas 42-in
28-Sep	3	0.07			Dredging at Atlas 42-in
29-Sep	1	0.06	0.06		Dredging at Atlas 42-in
30-Sep					Dredging at Atlas 42-in
02-Oct	0.7	0.02			Dredging at Atlas 42-in
03-Oct	1	0.06			Dredging at Atlas 42-in
10-Oct	7.5	0.5			Dredging at McMaster
11-Oct	1.75	0.15			Dredging at McMaster
12-Oct	48.5	0.5			Dredging at McMaster
13-Oct	6.5	0.15			Dredging at McMaster
16-Oct	9	0.14			Dredging at McMaster
17-Oct	11.5	0.08			Dredging at McMaster
18-Oct	4.8	0.08			Dredging at McMaster
19-Oct	20	0.06			Dredging at McMaster
21-Oct	14.5	0.44			Dredging at McMaster
24-Oct	75	0.3			Dredging at McMaster
25-Oct	90	0.14			Dredging at McMaster
26-Oct					Dredging at McMaster
28-Oct					Dredging at McMaster
30-Oct	39	2.1			Dredging at McMaster
31-Oct					Dredging at McMaster
01-Nov					Dredging at McMaster
02-Nov					Dredging at McMaster
04-Nov	0.85	6.7			Dredging at Atlas 42-in
06-Nov	169	21.3			Dredging at Atlas 42-in
14-Nov	< 0.5	< 0.5			Dredging at Atlas 42-in
15-Nov	81.3	0.5			Dredging at Atlas 42-in
16-Nov	29.9	1			Dredging at Atlas 42-in
23-Nov					Dredging at Atlas 42-in
27-Nov	42	0.74			Dredging at Atlas 42-in
28-Nov					Dredging at Atlas 42-in
29-Nov					Dredging at Atlas 42-in
01-Dec	30	15			Dredging at Atlas 42-in
05-Dec	36	< 1			Dredging at Atlas 42-in
06-Dec					Dredging at Atlas 42-in
06-Dec					Dredging at Atlas 42-in
08-Dec					Dredging at Atlas 42-in
09-Dec		0.2			Dredging at Atlas 42-in

Bolded dates indicate samples analyzed by Acres Analytical Limited. All others were analyzed by the MOEE.
OV and UN indicate overflow and underflow, respectively.

Table 6.7

Results of Reg. 347 Analyses (Inorganics Only)

(All Units in mg/L except pH)

Parameter	Sample						
	HG 0923-01	TP 0928-11	SC 1107-01	CF 1114-02	EX 1117-01	TPMIX 1209-01	MOEE Schedule 4 Leachate Quality Criteria
pH	8.81	8.90	7.40	7.64	8.99	8.71	-
Ag	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
As	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.05
Ba	<0.01	5.37	0.40	0.76	4.84	3.20	1.0
B	<0.50	<0.50	<0.05	<0.10	<0.10	0.21	5.0
Cd	<0.005	<0.005	<0.002	0.006	<0.002	<0.002	0.005
CN (Free)	<0.002	<0.02	0.005	<0.002	<0.002	<0.02	0.20
Cr	<0.02	0.02	0.02	0.02	<0.005	<0.005	0.05
F	1.30	0.20	<0.10	<0.10	<0.20	0.50	2.40
Hg	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Pb	<0.05	<0.05	0.50	0.13	<0.02	<0.05	0.05
Sc	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
$NO_3 + NO_2$	0.04	0.50	<0.20	<0.20	<0.20	0.30	10.0
NO_2	<0.02	0.04	<0.20	<0.20	<0.20	<0.20	1.0

CF = Centrifuge solids
EX = Excavator solids (sampled at Atlas' drying pad)
HG = High 'G' dryer solids
SC = Screw classifier solids
TPMIX = Mixture of solids from treatment plant
TP = High 'G' dryer solids

Table 6.8

Results of Analyses on Treatment Facility Solids
(All Units in mg/kg Unless Notes Otherwise)

Parameter	Sample																
	TP 0923-10	**TP** 0923-11	**TP** 0927-10	**TP** 0927-11	**TP** 0928-10	**TP** 1011-10	**TP** 1012-10	**TP** 1013-10	**TP** 1014-10	**TP** 1014-11	**HG** 1104-01	**HG** 1106-01	**CF** 1114-01	**HG** 1114-01	**HG** 1115-01	**EX** 1117-01	**HG** 1116-01
pH (s.u.)	7.9	-	8.0	-	8.4	7.4	7.3	7.2	6.9	-	7.2	7.4	7.0	7.0	7.6	7.6	7.8
Cd	57	-	56	-	53	12.0	62.5	20.0	20.0	-	<1	<1	17	18	61	<1	<1
Cr	3810	-	3000	-	3510	780	2952	1145	5490	-	300	321	1414	891	3483	2388	3029
Cu	534	-	570	-	543	157	768	228	478	-	109	93	516	228	767	703	775
Fe	166 400	-	162 800	-	158 100	63 600	221 100	108 910	104 775	-	39 305	42 469	85 680	84 010	199 800	141 462	172 206
Mn	3854	-	3340	-	4015	1120	5475	2011	1472	-	669	693	2570	1494	4436	2881	4556
Pb	108	-	88	-	104	52	126	58	508	-	62	49	137	100	72	105	104
P	-	-	-	-	-	-	-	-	-	-	-	-	1086	641	442	501	435
Ni	4551	-	3790	-	5675	425	1875	777	1528	-	235	225	1300	526	3899	3847	3815
Zn	123	-	112	-	149	78	200	86	677	-	128	100	297	139	110	160	137
Oil & Grease	3045	-	3370	-	4905	1475	1940	2655	28 440	-	2000	680	4955	1890	1570	7350	3075
Moisture (%)	-	22.1	-	24.2	-	-	-	-	-	32.0	32.7	-	-	-	-	-	-
LOI (%)	-	1.5	-	2.2	-	-	-	-	-	6.4	7.5	-	-	-	-	-	-

CF = Centrifuge solids
EX = Excavator solids (sampled at Atlas' drying pad)
HG = High 'G' dryer solids
TP = High 'G' dryer solids
LOI = Loss on ignition

7 Floodplain Activities

7 Floodplain Activities

7.1 Floodplain Protection

Earlier investigations had identified that the floodplain sediments adjacent to the river 'reef' deposits contained metals contamination in a range of concentrations. It was recognized, therefore, at both the McMaster Avenue and Atlas 42-in. outfall areas, that contaminated fine grained sediments would remain at the floodplain/river interface after dredging had been completed. To prevent exposure of this material to river flows, possible erosion and subsequent transport of contaminants, protection of the floodplain sediments was required at both areas. Two different types of floodplain protection were used due to the differing depths of dredging and variations in the consistency of the floodplain materials at the two areas. The measures adopted are discussed separately below.

7.1.1 McMaster Avenue Outfall Area

The depth of dredging along the edge of the floodplain at the McMaster Avenue outfall area was expected to be a maximum of 1 m. Due to this limited depth of dredging and the slightly firmer nature of the floodplain sediments in this area, it was anticipated that a suitable temporary stable slope (2H:1V) could be excavated by the dredge. This slope would then be covered by fine, washed, granular sand fill (Zone 2 fill) followed by a coarser, washed, granular fill (Zone 1 fill) to provide long-term erosion protection. The thickness of both layers was to be 0.6 m. The finished slope of the granular fill was to be 3H:1V. Removal of a limited width of the floodplain (about 2 m) would be required downstream of the McMaster Avenue outfall. Upstream of the outfall, dredging would only extend up to the edge of water and no removal of the steeper bank in this area would be carried out. Provision for sheetpiling along the edge of the floodplain downstream of the outfall was provided in Contract C1B as a contingency measure should slumping or instability of the floodplain sediments occur.

Actual depths of dredging along the edge of the floodplain varied up to almost 3 m, as shown in As-Built Drawing 11201-A0-004 and 006. The width of floodplain requiring removal was approximately 1.8 m. When excavated by the Amphibex, the floodplain slopes experienced some immediate instability (slumping). Dredging of the floodplain sediments from the slope continued until steeper stable slopes developed. Temporary slopes achieved in the floodplain sediments varied from 0.75H:1V to 2.3H:1V. These temporary slopes appeared to be stable with no obvious continuing slumping and sheetpiling was therefore not required. The exposed floodplain sediments were covered with up to 2 m of the Zone 2 granular fill (sand) and then 0.6 m of Zone 1 granular fill (erosion protection), as shown in As-Built Drawing 11201-A0-006. Grain size distributions for these materials are shown in Figure 7.1. Final slopes achieved for the Zone 1 fill ranged from approximately 2.5H:1V to 2.9H:1V while the final slopes for the Zone 2 were approximately 2.6H:1V. The Zone 1 fill was placed to a top elevation of nominally 171 m which is the approximate elevation of the adjacent floodplain surface.

The granular fill was placed using a backhoe mounted on a spud barge with the fill material being transported to it by a material scow. Land based equipment was not utilized during placement. The granular fills were placed after completion of dredging at the McMaster Avenue outfall area and consequently, the floodplain sediments were exposed to river flows for a period of up to approximately 28 days; however, there was no apparent erosion of the sediments. Approximately half of this time was after the silt curtain had been removed from the McMaster Avenue site.

All contaminated sediments overlying and between the abandoned and the existing raw water intake pipes upstream of the McMaster Avenue outfall (see As-Built Drawing 11201-A0-004) could not be removed during the project due to concerns about damaging or disturbing the pipes. As a result, the intake pipes and immediately adjacent areas, a total width of approximately 14 m, were covered with 0.5 m of Zone 1 erosion protection from the shoreline and out into the river to the limit of dredging, in order to prevent the future erosion of the remaining contaminated sediment.

Zone 2 and Zone 1 granular fill was placed on the underwater slope from the downstream side of the intake pipes to the northern limit of dredging. Upstream from the intake pipes, the exposed sediments were found to meet the project cleanup criteria and, therefore, the placement of granular fill on the slope was not necessary.

7.1.2 Atlas 42-in. Outfall Area

The depth of dredging along the edge of the floodplain in this area was anticipated to be 1 to 2.5 m and possibly deeper adjacent to the outfall itself. It was recognized that this depth of excavation could not be achieved, and the requirement for minimal loss of the floodplain satisfied, without the installation of sheetpiling to temporarily support the very soft floodplain sediments. The sequence of construction would be ...

- installation of the sheetpiling along the floodplain's edge, in advance of dredging. It was anticipated that the bottom of the sheetpiling would be driven to between el 165.0 and 167.0 m, and that its top would be a minimum of 0.3 m below the level of the floodplain

- dredging of the reef deposit and contaminated sediments up to the sheetpiling

- placement of Zone 1 granular fill to cover the sheetpiling and form a riverbed slope along the floodplain. The finished slope in the granular fill was to be 2.5H:1V. The top of the fill was to be at nominally el 171 m.

The configuration of the installed sheetpiling is shown in As-Built Drawing 11201-A0-007. L-50 section sheetpiling was used along the entire length to minimize driving problems. Deeper sheetpiling was installed around the Atlas 42-in. outfall to provide support for the outfall during adjacent dredging. Final slopes achieved in the Zone 1 granular fill were between 1.7H:1V and 2.7H:1V, with the lower slopes generally being even flatter as a result of some of the fill moving out toward the center of the river. During and immediately after placement, appreciable settlement or movement of the granular fill occurred which resulted in an increase in quantities. This was likely due to the penetration of granular fill into the underlying soft sediment foundation, some natural compaction of the fill under its own weight, and some movement of the fill down the slope to achieve a stable angle of repose. The Zone 1 fill was placed to a top elevation of up to 171.5 m to allow for some longer term settlement along the edge of the floodplain with the expectation that the top of the fill will end up at nominally el 171 m. A layer of cobbles was placed over the Zone 1 granular fill around the Atlas 42-in. outfall to prevent scour by the continuous discharge.

The sheetpiling was driven using a vibratory hammer supported by a barge mounted crane. No appreciable problems were encountered during sheetpile driving. The granular fill was placed using the same method as utilized at the McMaster Avenue outfall area (i.e., a backhoe mounted on a spud barge). No land-based equipment was used during the floodplain protection works. The granular fill placement operation followed as closely as possible behind the dredging. The period between completion of dredging and start of fill placement at a particular location varied between 4 to 6 weeks.

7.1.3 Water Quality During Fill Placement

Water quality sampling was carried out during fill placement at both the McMaster Avenue and Atlas 42-in. outfall areas. There were two distinct phases--prior to the completion of dredging on December 19, 1995 and after.

Prior to December 19, 1995
Fill placement began at the McMaster Avenue area prior to the completion of dredging at the Atlas 42-in. outfall area. Samples were taken intermittently 25 m upstream and downstream of the fill placement location, due to requirements of the water quality sampling program being carried out for the dredging at the Atlas 42-in. location. During fill placement, the water quality was affected for short periods of time as fines were “washed off” the fill material. This was rectified through better washing of the fill prior to placement. No riverbed material appeared to be disturbed during fill placement.

From observations made during fill placement at the McMaster Avenue area, it was decided that a silt curtain would be used around fill placement activities at the Atlas 42-in. outfall area. Due to the proximity of the fill placement and dredging work areas at the Atlas 42-in. outfall area it was not possible to monitor the fill placement separately. At the start of fill placement in this area, upstream of the dredging, a silt curtain was positioned around the fill placement. Water quality sampling stations were located 25 m upstream of the fill placement and 25 m downstream of the dredging activity. Toward the end of this period, dredging and fill placement were in close proximity at the downstream end of the Atlas 42-in. outfall area. A single silt curtain was used at that location to enclose both activities.

After December 19, 1995
After the completion of dredging, water quality monitoring continued at upstream and downstream sampling locations during fill placement. The water quality remained acceptable throughout this period. Sampling ended with the completion of fill placement on January 18, 1996.

7.1.4 Infilling of Granular Fill

During the planning stages of the project it was noted that the Zones 1 and 2 granular fill, to be used to recreate the underwater side slope in the river after dredging, was different from the existing river bank materials (fine silts and clay), and a concern was raised that the selected material would provide a different type of habitat than would normally be expected in the Welland River system. Following further discussion with the MNR, it was agreed that a program would be initiated after the project was completed to assess the rate and degree of infilling of the granular material over time. The initiation of this program was identified as a responsibility of Atlas' as part of the full-scale clean-up project. The program, as outlined below, involved the installation of sedimentation samplers into the side slope at selected locations downstream from the McMaster Avenue and Atlas 42-in. outfalls. Following retrieval and assessment of the first set of samples (late spring 1996 after the spring flood event), the program would be turned over to the Welland River Wetland Working Group. The long-term goal of the program is to determine the suitability of this type of granular material for similar shoreline applications in the future.

Materials and Installations

Sampling tubes were installed at four locations along the remediated shorelines (two at the McMaster Avenue reef area, downstream from the outfall and two downstream from the Atlas 42-in. outfall as shown in Figures 7.1 and 7.2, Locations MC1, MC2, AT1 and AT2). Each sampler consists of a 30-cm length of 8.3-cm ID clear acrylic tube. The bottom end of the tube is capped, and a marker (section of plastic flagging tape) was attached to the top of each tube to assist in subsequent location of individual tubes.

At each of the four locations, a group of nine tubes was installed approximately half-way down the side slope, such that the tops of the tubes were at or marginally below (approximately 1 cm) the surface of the granular material. The tubes were filled with granular material from the side slope and installed such that they are approximately perpendicular to the surface of the side slope. The group of nine tubes at each area was spaced approximately 50 cm apart, such that they covered 1 m^2. A marker buoy was installed immediately offshore of the installation to facilitate subsequent location and recovery of the samplers (Figure 7.3).

Retrieval and Analysis

Three tubes will be randomly selected from the nine present at each location and will be capped prior to removal. The tubes will be gently removed from the side slope, and the following observations will be made by the retrieving diver:

- depth of fine sediment penetration into granular material
- number of distinct sediment layers
- measured depth of each layer
- other observations related to infilling of the granular material.

The tube will be maintained in a vertical position and returned to the surface with as little disturbance as possible, where it will be photographed. The contents of the tube will then be transferred to a bucket, stirred and agitated, and passed through a 1-mm screen to separate coarse particles from fine sediments. Each portion will be retained, dried and weighed, and the concentration of fine sediment will be expressed as a percentage of the total material in the tube. The fine sediment from the three tubes will be composited, and subjected to particle size analysis (providing sufficient sample is obtained) to determine the distribution of size fractions comprising the fine material.

7.2 Floodplain Pocket Remediation

Previous investigations had identified layers of coarse (sand-sized) mill scale within the floodplain sediments on the east side of the river at two locations; at Borehole AH-8, just downstream of the McMaster Avenue outfall, and at Borehole BH-301, 70 m downstream from the Atlas 42-in. outfall area. As part of the full-scale cleanup project, these two 'pockets' were to be remediated by removal of the mill scale materials.

7.2.1 McMaster Avenue Outfall Area

The mill scale at Borehole AH-8 was found at a depth of 0.4 to 1.0 m and was intermixed with sandy silt. As this location was close to the edge of the floodplain, it was anticipated that dredging would be extended slightly into the floodplain (about 5 m) to include the removal of this material.

Some of the reef deposit adjacent to the McMaster Avenue outfall was excavated by a long-reach backhoe working from the shore. The same piece of equipment was used to remove the mill scale pocket around Borehole AH-8. The actual excavation extended up to 12 m into the floodplain and was up to 2 m deep. The excavation was not backfilled apart from covering the resulting slope with Zones 1 and 2 granular fill, as described in Section 7.1.1.

7.2.2 Atlas 42-in. Outfall Area

During the 1992 investigations, Borehole BH-301, located at the end of a 0.91 m city outfall, encountered mill scale between the depths of 2.06 and 2.62 m. Mill scale was not recovered in any other boreholes in this area at that time. As it was Atlas' intention to remove this mill scale pocket as part of the full-scale cleanup project, it was estimated that excavation of a 10-m by 10-m area and approximately 300 m^3 of floodplain sediments would be adequate for remediation. An additional investigation was recommended prior to the initiation of the full-scale cleanup to confirm the size of the area requiring remediation and this was carried out in August 1995. Boreholes showed thin (0.05 to 0.23 m) lenses, containing a significant amount of mill scale (more than 20%), to be present within the floodplain sediments over a 30-m by 15-m irregularly shaped area. It was decided that, to fulfil the objective of the floodplain pocket remediation, all mill scale identified during the investigation should be removed, requiring excavation of a larger area than initially assumed.

The sequence of work was as follows:

(a) Construction of a temporary road to the floodplain pocket area.

(b) Driving of sheetpiling to enclose the floodplain pocket area as shown in As-Built Drawing 11201-A0-005.

L-50 section piles, 6 m long, were used and the depth of penetration varied from 4.5 m on the southeast side to 5.7 m on the northwest side. In all areas around the perimeter of the pocket, the sheetpiles were driven down through the contaminated sediments into the underlying firm to stiff uncontaminated clayey silt and till. The piles were driven with a vibratory hammer and no significant problems were encountered during driving.

(c) Excavation of the floodplain materials within the sheetpile box using a backhoe.

The depth of excavation ranged from approximately 2 to 3 m. The excavated material totaling approximately 1215 m^3 of combined mill scale and floodplain sediments was loaded into tandem trucks with sealed boxes and then transported to a temporary drying pad area on Atlas' property. Because of the cantilever design of the sheetpiling which eliminated the need for internal bracing, care was taken to maintain the water level in the excavation within 1 m of the external ground level.

(d) Backfilling of the excavation with the backhoe.

Up to 1 m below ground level the excavation was backfilled with sand and gravel and a minor amount of 100 mm minus stone taken from the temporary access road. Above this, only sand and gravel was used. A grain size distribution for the sand and gravel backfill is shown in Figure 7.4. During backfilling, some pumping of groundwater from the excavation was required to improve the access into the area by heavy equipment. A total of 224 000 gal of water was pumped and discharged to the regional sewer system in compliance with a program established by the RMON and in accordance with the provisions of the RMON's Sewer Use By-law. This pumping was carried out in late October and early November and did not contribute to the external inputs from sewer discharges noted in Section 5.3.2.2.

Limited testing prior to discharge indicated that the water would meet the RMON Sewer Use By-law, Schedule 2 requirements. However testing of the water actually discharged showed that it exceeded the TSS limits and very slightly exceeded the limit for polychlorinated biphenyls (PCBs). Digester biosolids from the Region's Welland WPCP will be tested for PCBs four times during 1996 (January, March, June and October) to confirm that there is no measurable presence of these compounds. Analytical results of groundwater discharged to the sewer are summarized in Table 7.1. Complete certified test results and related quality control data sheets are presented in Appendix F.

(e) Removal of the sheetpiling.

Following backfilling of the excavation, the sheetpiling was removed using the same equipment used to install it. The excess access road material was excavated and hauled to the Atlas drying pad area and the floodplain surface was leveled to approximately its original elevation.

The area of the excavation and access road was to be replanted with suitable vegetation in the spring of 1996 following an evaluation of requirements by the WRCC Wetland Working Group.

It should be noted that, although mill scale has been removed from this area of the floodplain, the backfilled area will still retain some degree of contamination. This is due to contaminated floodplain sediments having been unavoidably mixed with the backfill materials and unrestricted groundwater flow from the surrounding contaminated area into the backfill.

The total cost of this part of the work was approximately \$182,000, excluding mobilization and demobilization, giving a unit price for remediation of approximately \$150/m^3.

Table 7.1

Results of Groundwater Analysis
(All Results in mg/L, Unless Noted Otherwise)

Parameter	Sewer-Use By-Law Limit	Sample CC-1102-01
Aluminum	50	4.58
Arsenic	1	0.01
Barium	5	0.46
Cadmium	2	<0.005
Chromium	5	0.26
Copper	5	0.07
Cyanide	1	0.004
Iron	50	15.52
Lead	5	0.07
Mercury	0.1	<0.001
Nickel	5	0.29
Tin	5	<0.05
Zinc	5	0.10
Phenols	1	<0.002
BOD	300	<50
Suspended Solids	350	2525
TKN	100	3.3
NH_3	50	na
NO_2 (Nitrite)	40	<0.02
NO_3 (Nitrite)	40	0.22
PCB	0.003	0.00387
Dioxins/Furans*	0.0001	0.022 ng/L
Solvent Extractables**	100	29

* Reported as total toxic equivalency in ng/L
** Solvent used was dichloromethane
na = not analyzed
Indicates an exceedance of the by-law limits.

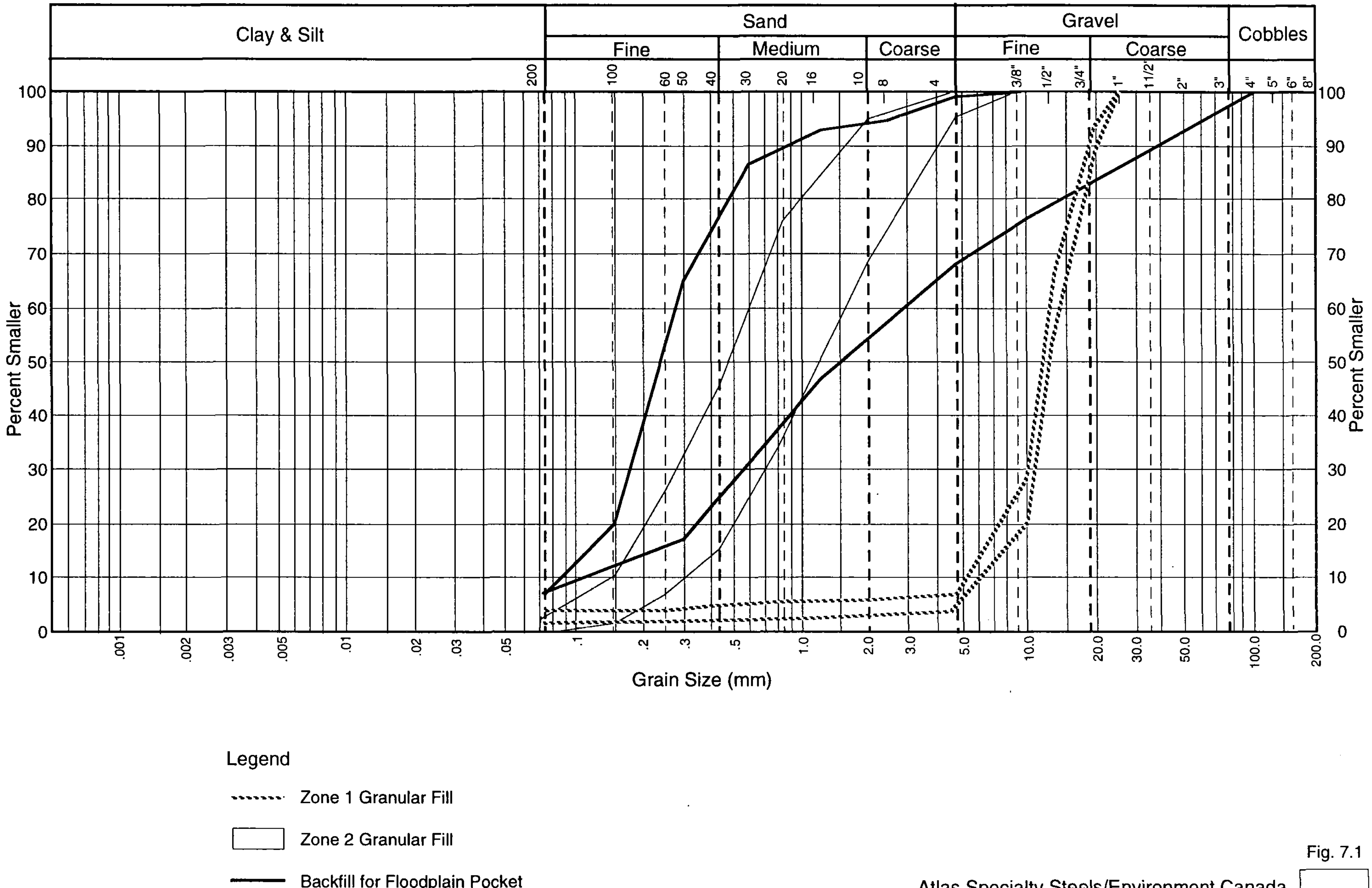


Fig. 7.1

Atlas Specialty Steels/Environment Canada
Welland River Reef Cleanup Project
Granular Fills - Grain Size Distributions

ACRES

P31201.02 MR

Table 6-8

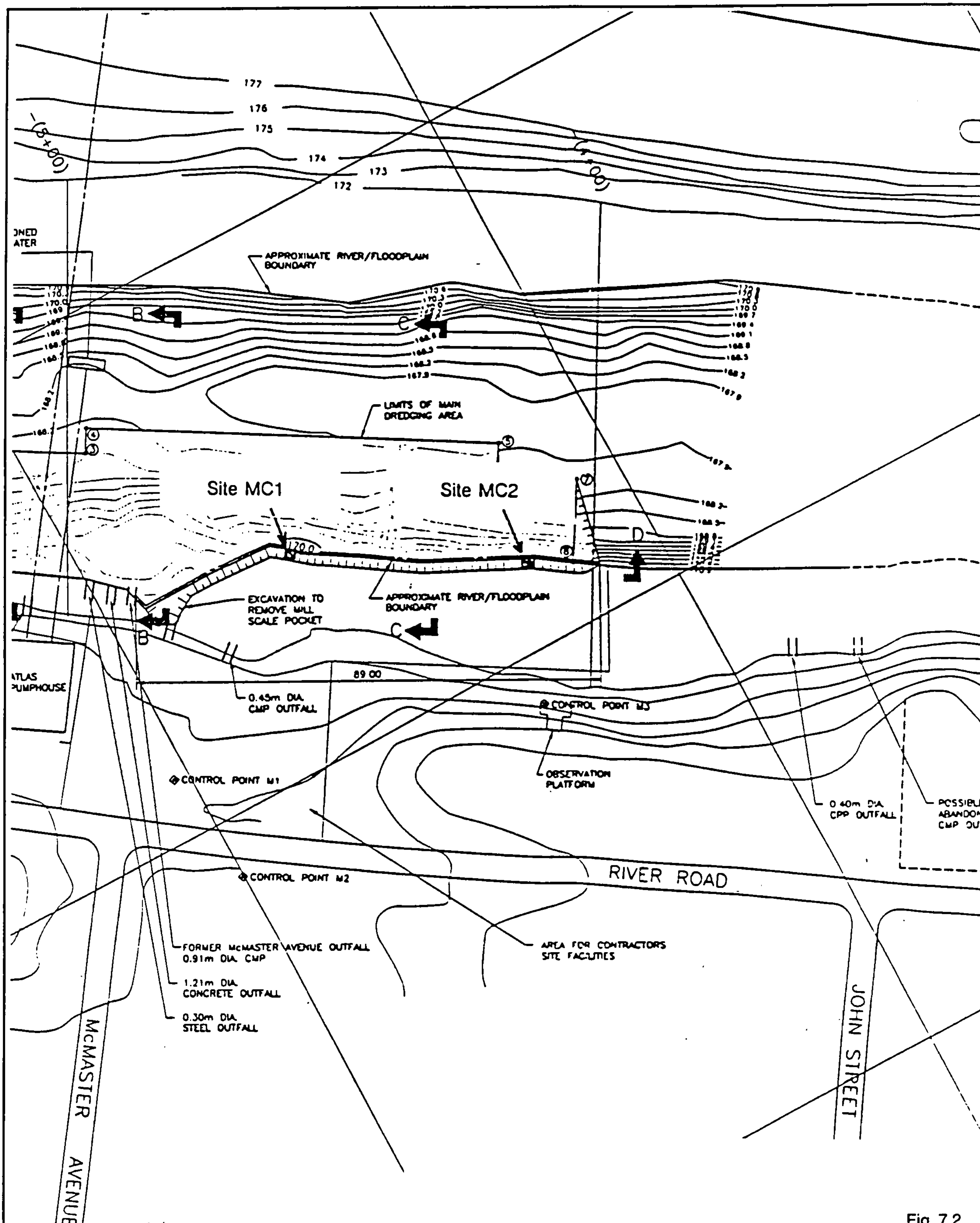


Fig. 7.2

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Sediment Tube Installation Sites at McMaster Avenue Reef Remediation Area

ACRES

Dwg 11201-AO-004

P31201.02 MR

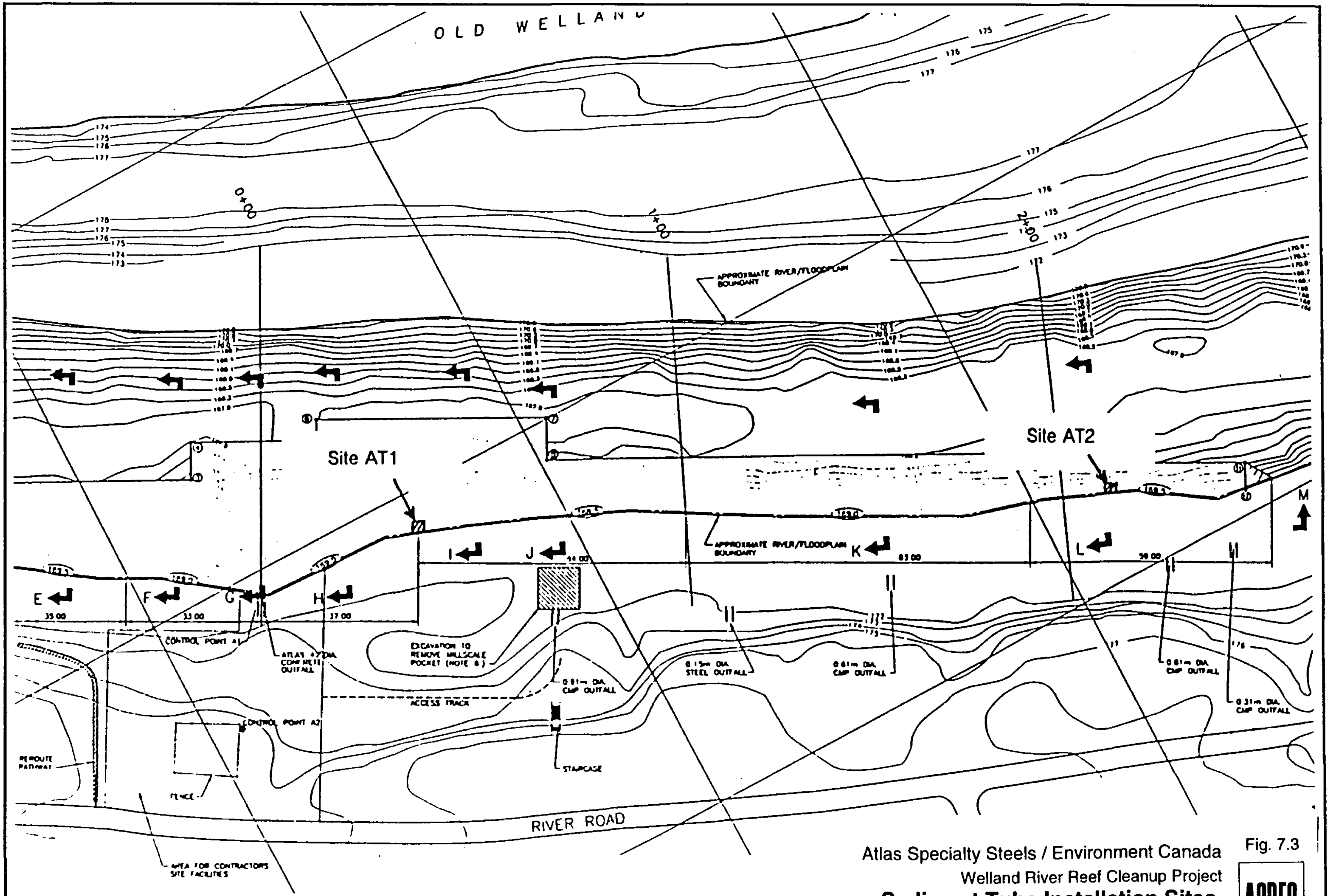


Fig. 7.3

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Sediment Tube Installation Sites at Atlas 42" Reef Remediation Area

ACRES

P31201.02 MR

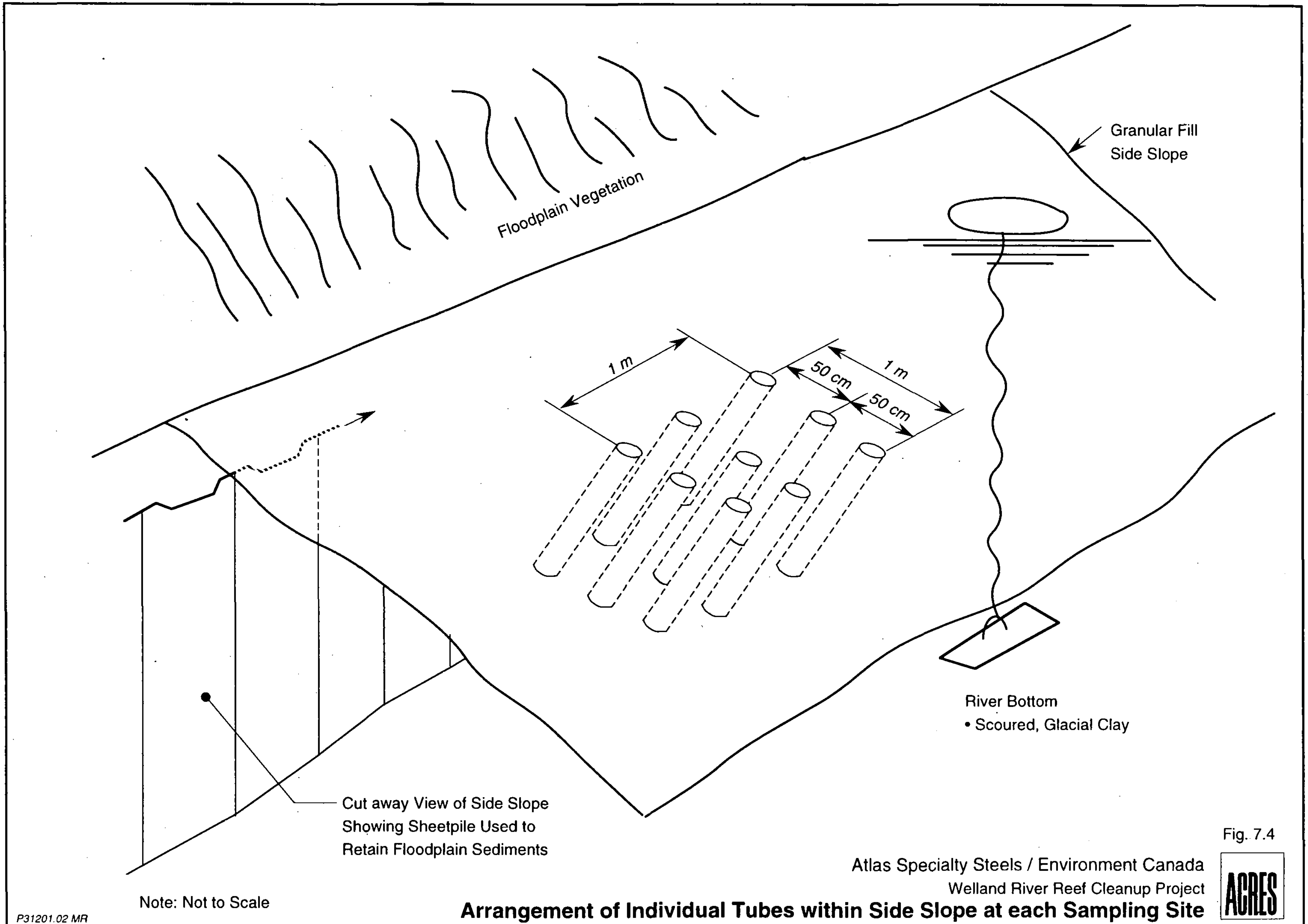


Fig. 7.4

Atlas Specialty Steels / Environment Canada

Welland River Reef Cleanup Project

Arrangement of Individual Tubes within Side Slope at each Sampling Site

8 Conclusions

8 Conclusions

The completion of the full-scale sediment removal and treatment demonstration, known as the Welland River Reef Cleanup, marks the end of a successful government/ industry partnership between Environment Canada and Atlas Specialty Steels which focussed on the remediation of contaminated sediments using innovative technologies.

The project involved the removal of 9833 m^3 of industrial mill scale and contaminated river sediments from the McMaster Avenue and Atlas 42-in. outfall areas in the Welland River. An Amphibex dredge, a combination mechanical/hydraulic suction dredge, excavated a total of 7613 m^3 of material, while a long-reach, land-based backhoe excavated an estimated 2220 m^3. The material dredged by the Amphibex was pumped through a 200-mm diameter pipeline to Atlas' NFP where a temporary sediment treatment facility had been set up to receive and treat the slurry.

The project also included the removal of approximately 1215 m^3 of mixed coarse mill scale and sediments from the floodplain downstream from the Atlas 42-in. outfall using more conventional land-based excavating equipment.

The major conclusions associated with the main sediment removal and treatment components of the project are identified below.

8.1 Sediment Removal

The innovative Amphibex dredge was well suited to the Welland River environment. It was easily launched using its 'walking' capabilities. It was also easily positioned in the river without the aid of a cable system.

The Amphibex was capable of dredging the industrial mill scale and contaminated river sediment at overall sustained slurry solids concentrations of between 10% and 20% by weight at flows ranging from approximately 1000 to 1800 USgpm. Average slurry solids contents varied with the type of material being dredged, ranging from 6% in predominantly mill scale material to 28% in fine-grained sediments (by weight).

The dredging production rates varied from 12.8 m^3/h at the McMaster Avenue outfalls area, to 35.6 m^3/h at the Atlas 42-in. outfall area, with an overall average production rate of 24.9 m^3/h. The highest overall dredging rate was approximately 195 m^3/h, which was achieved in the fine grained sediments over a roughly 6.5-h period on the final day of dredging. Average production rates in the various materials encountered ranged from 12.8 m^3/h (McMaster Avenue area) to 16.9 m^3/h (Atlas 42-in. area) grained sediments (Atlas 42-in. area only).

The Amphibex experienced difficulties with river debris, especially at the McMaster Avenue site, which tended to reduce the dredging rate. The Amphibex can be equipped with various attachments on its backhoe style arm, such as a rake which can be used to remove river debris if significant amounts are anticipated.

All dredging by the Amphibex was done within a geotextile silt curtain which helped to minimize the impact on downstream water quality from resuspended sediments as a result of the dredging.

Turbidity in the vicinity of the pump bucket during dredging was high and it is not considered feasible to dredge with the Amphibex in the conditions and material encountered during this project without the use of a silt curtain. Dredging had to be stopped on a number of occasions due to high turbidity levels downstream from the silt curtain as a result of the dredging activity. This was normally during periods of high river flows which tended to cause difficulties with the positioning and effectiveness of the silt curtain. Under certain conditions (for example, coarse grained sediments and still water conditions) the use of a silt curtain may not be necessary.

The combination of the Amphibex and the long-reach backhoe dredging or excavating within the same silt curtain created considerable turbidity which made it difficult for both pieces of equipment to operate at the same time.

Sediment sampling after dredging was carried out to confirm that the mill scale and contaminated sediment had been removed and remaining sediments had contaminant concentrations below the PSQG severe effect level.

The dredgeate slurry was successfully pumped through a 200-mm diameter polyethylene pipeline a distance of up to approximately 1500 m using one or two booster pumps. The destination of pumped slurry was Atlas' NFP where a temporary sediment treatment facility had been set up. Two booster pumps pumping slurry over the 1500-m length sometimes had difficulty reaching the flows originally expected.

When dredging was suspended during periods of freezing temperatures problems were experienced with freezing of the slurry in the pipeline. It was therefore important that the pipeline be completely drained whenever a significant pause in dredging was anticipated during such conditions.

The total cost of dredging (excluding standby) was $426,700, of which $85,000 was for mobilization and demobilization. The unit cost of dredging was $20/m^3$ excluding mobilization and demobilization, site facilities, pipeline setup and operation, booster pump and other miscellaneous administrative costs. Pumping costs add another $4/m^3$ to the cost of getting the slurry to the treatment facility, giving a total unit cost for dredging and slurry transport of $24/m^3$.

8.2 Sediment Treatment

Sediment treatment at Atlas' NFP consisted of equipment and storage basins designed to separate and dewater a variety of dredgeate slurry solids. The equipment consisted of a scalping screen, screw classifier, high 'G' dryers, and associated piping and sump pumps. Chemical coagulants and flocculants were added to the slurry to assist in settling of fine sediments in the TSBs. Atlas' NFP was used to receive and treat all water generated during dredging before it was released back to the river.

The scalping screen generally functioned adequately in separating out the coarse particles and river debris. Occasionally, when the solids content in the slurry was high, the screens (2-mm opening) on the unit would blind resulting in a sudden discharge of wet slurry to the ground. Toward the latter part of the project the 2-mm screens were replaced by 9.5-mm screens which eliminated the blinding problem.

The screw classifier worked well in separating out the sand sized particles, especially the coarse mill scale from the slurry.

The high 'G' dryers consisted of a combination of hydrocyclones and a fine vibrating screen. The hydrocyclones separated solids larger than 40 to 50 μm which were eventually removed on the fine screens.

Atlas' thickener did not function well at the beginning of the project due to the high solids content of the influent slurry. The slurry did not have sufficient residence time in the thickener to enable the fines to settle out. The thickener was removed from the treatment train after only a short period of use.

The volume of fine sediments (clays and silts) entering the temporary storage basins was greater than originally anticipated (partly due to the increase in quantity and the type of sediment removed from the river) with the result that the basins filled with solids to the point that fines were being carried over into Atlas' existing settling pond which ultimately had a negative impact on the filters of the NFP. The TSBs had to be cleaned out and modified in design to improve their operation. The required coagulant dosing rate was much higher when the slurry largely comprised fine-grained sediment. It also appeared that the coagulant was less effective at lower temperatures. The flocculent dosing rate was relatively constant throughout the project. Carry over of fines from TSB #2 to Atlas' settling pond was a recurring problem throughout the latter part of the project.

The impact of the fine sediment on the filters of the NFP resulted in frequent occasions in the latter half of the project when dredging had to be stopped in order that the filters could be backwashed. Such stoppages put the dredging contractor on 'standby' which delayed the schedule, adding significant costs to the project.

Discharging TSB #2 overflow to the regional sewer system under an approved program with the RMON was partially successful in alleviating the load on the NFP filters. It was difficult to maintain flow to the sewer, however, due to the relatively high solids content in the discharge.

The overall cost of sediment treatment is estimated at \$192/m^3 which is considered unusually high due to costs resulting from delays and necessary modifications and cleanout of the TSBs.

8.3 Floodplain Activities

It was recognized that, at both the McMaster Avenue and Atlas 42-in. outfall areas, contaminated floodplain sediments would remain at the floodplain/river interface after dredging had been completed. Therefore, to prevent exposure of this material to river flows, possible erosion and subsequent transport of contaminants, protection of the floodplain sediments was required at both areas. At the McMaster Avenue outfall area, the slope in the floodplain sediments was covered by sand fill followed by coarse granular fill to provide long-term erosion protection. At the Atlas 42-in. outfall area, sheetpiling was installed along the floodplain edge prior to dredging. After dredging had been completed adjacent to the sheetpiling, granular fill was placed to cover the sheetpiling and form a riverbed slope along the floodplain.

It was found at the McMaster Avenue area that washing of the fill was required prior to placement in order to avoid affecting water quality. A silt curtain was used during fill placement at the Atlas 42-in. outfall area. A separate silt curtain to that containing dredging activities was generally used; however, where dredging and fill placement was in close proximity, a common silt curtain was used.

As part of the project, approximately 1215 m^3 of mixed mill scale and sediments was removed from a 30 m by 15 m irregularly shaped area in the floodplain downstream of the Atlas 42-in. outfall. This was accomplished by installation of sheetpiling to enclose the area, excavation of the floodplain materials within the area using a backhoe, backfilling of the excavation and then removal of the sheetpiling. The cost of remediation of the floodplain area containing mixed mill scale and sediment downstream of the Atlas 42-in. outfall was approximately \$150/m^3.

List of References

List of References

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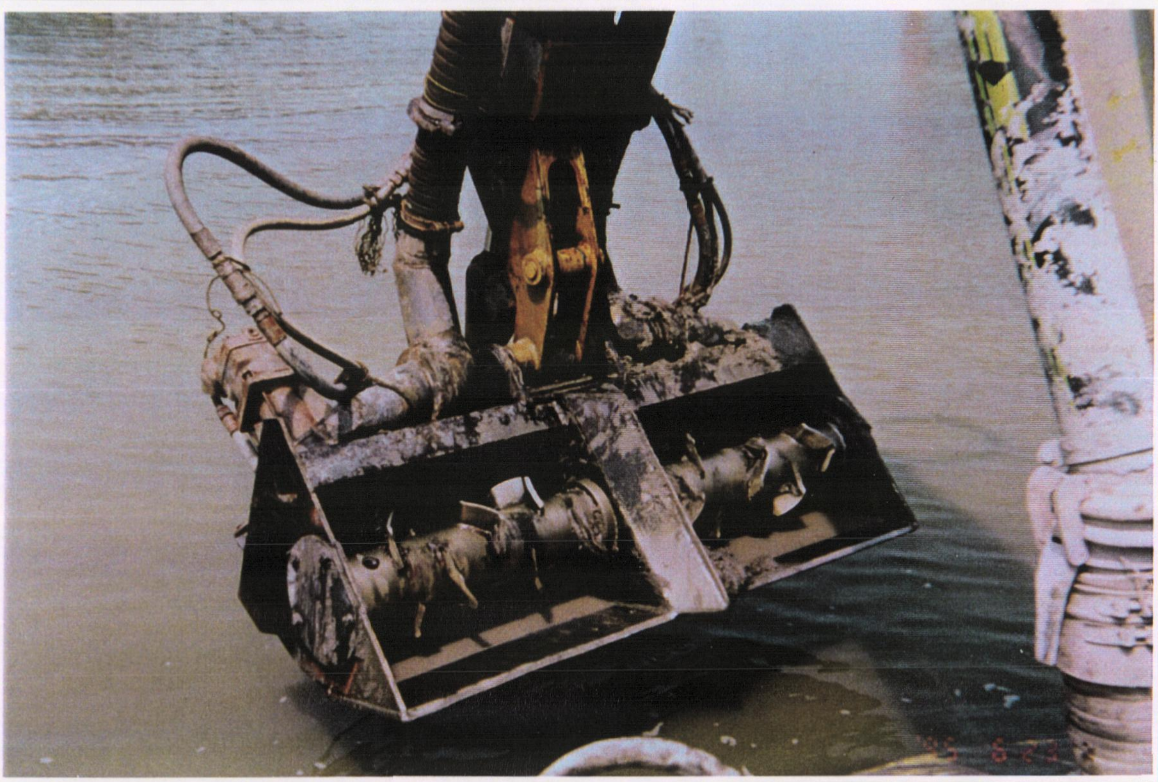
Selected Photographs

Project sign with Amphibex in background arriving by road transport.

Amphibex off-loaded and preparing to enter river, slurry pipeline to right.

Amphibex entering river at McMaster Avenue reef site.



Dredge head showing augers, pumps and split bucket design.

Amphibex deployed in river.

Operator's view of dredge.

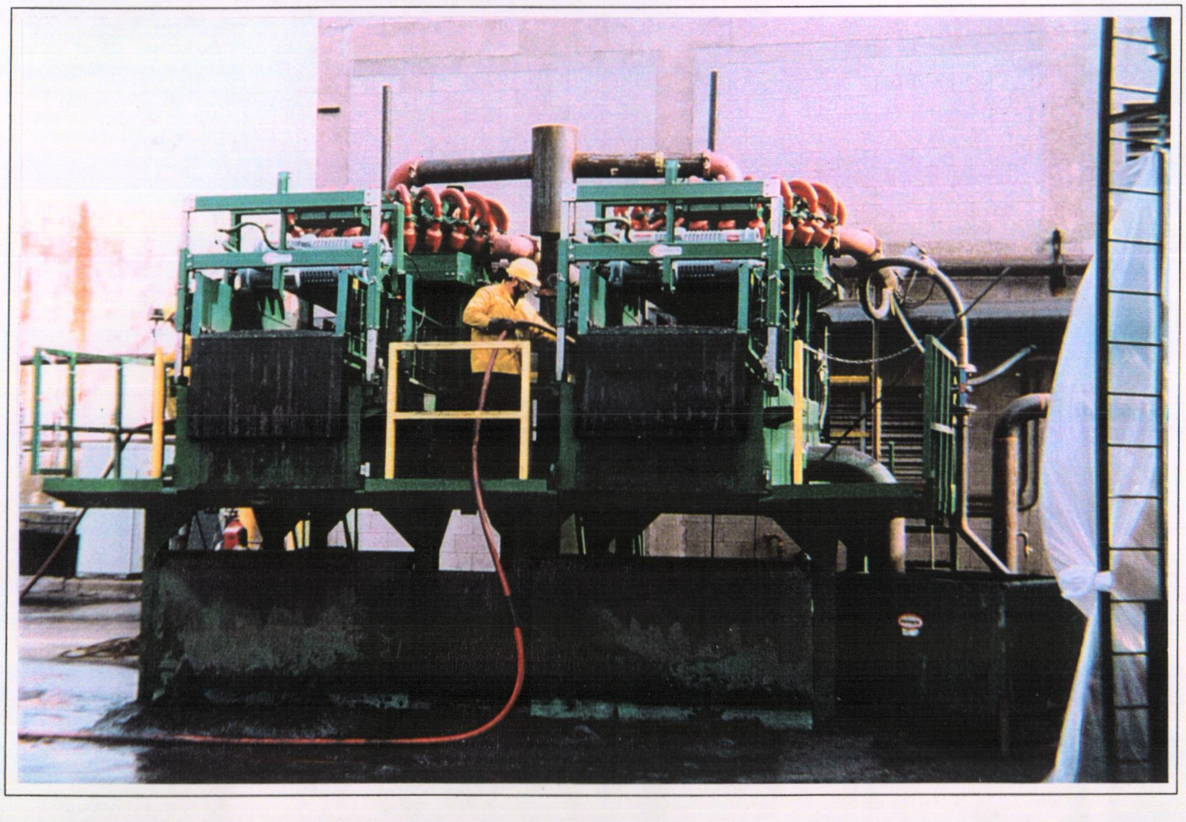
Booster pump located at edge of floodplain, midway between dredging and treatment sites.

Aerial view of screw classifier (foreground) and scalping screen (background).

Front view of scalping screen and separated coarse materials (screw classifier to left).

Front view of screw classifier (left) and scalping screen (right) during cold weather (December 19, 1995) operation.

Aerial view of high 'G' dryers (combination hydrocyclone and fine screens).



Front vie\ of high 'G' dryer: during operation

Cold weather (December 19, 1995) operation of high 'G' dryers.

Separated material removal.

Temporary Storage Basin No. 2 (TSB2) and Atlas North Filtration Plant settling pond (right).

Effluent from physical separation processes entering TSB2.

Temporary dock for river access and material handling equipment.

Backfilling of dredged areas to recreate river side slope using clean granular fill.

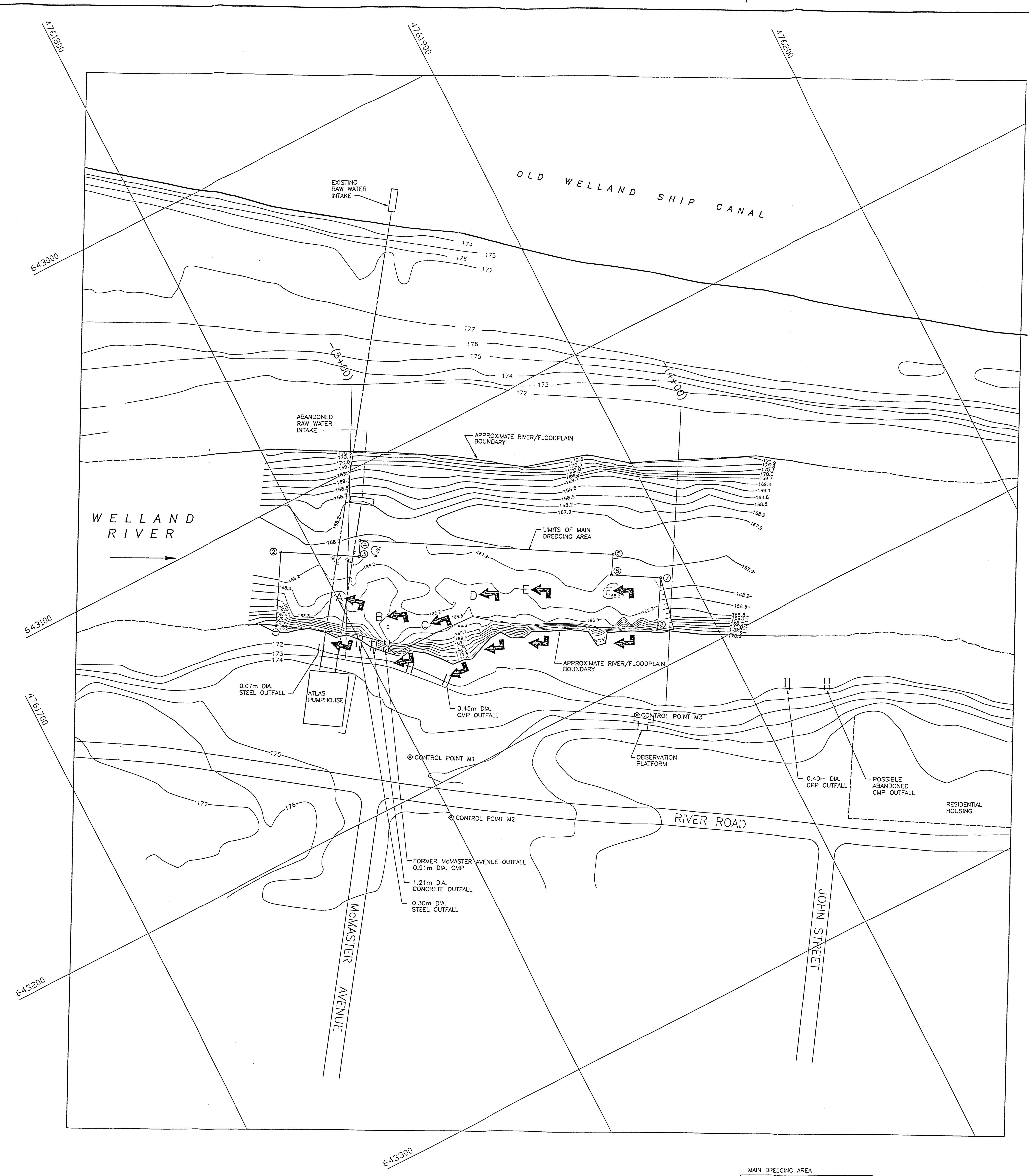
Placement of granular fill along edge of remediated area.

Initial excavation of floodplain millscale pocket north of Atlas 42 in. outfall.

Removal of millscale pocket sediments.

Millscale pocket prior to backfilling with sand and gravel.

Drawings



LEGEND

◈ SURVEY CONTROL POINT

−(4+00) APPROXIMATE CHAINAGE RELATIVE TO ATLAS 42" OUTFALL. NEGATIVE UPSTREAM, POSITIVE DOWNSTREAM

168.2 RIVERBED CONTOUR AFTER DREDGING AND PRIOR TO FILL PLACEMENT

NOTES

1. OUTSIDE MAIN DREDGING AREA, RIVERBED CONTOURS AND APPROXIMATE RIVER/FLOODPLAIN BOUNDARY ARE FROM UPPER CANADA CONSULTANTS. DWG. 5630A, MARCH 8, 1995. RIVERBED SURVEY CARRIED OUT ON FEB. 22 AND 23, 1995. WATER LEVEL DURING SURVEY WAS APPROXIMATELY 170.8m. RIVER/FLOODPLAIN BOUNDARY CORRESPONDS TO THE EDGE OF FLOODPLAIN VEGETATION AND IS APPROXIMATE ONLY.
2. WITHIN MAIN DREDGING AREA, RIVERBED CONTOURS AND RIVER/FLOODPLAIN BOUNDARY ARE FROM MATTHEWS, CAMERON, HEYWOOD DWG. 32622STH.DWG, NOV. 29,1995.

ALL DIMENSIONS AND ELEVATIONS ARE IN METRES

0 10 20 30 40 50 m

CONTROL POINT	DESCRIPTION	NORTHING	EASTING	ELEV.
M1	FIRE HYDRANT, WEST SIDE TOP OF FLANGE BOLT (BENCHMARK)	4761797.18	643188.16	174.807
M2	NAIL IN PATH TO PARK	4761799.72	643211.10	175.121
M3	NAIL ON OBSERVATION PLATFORM, NORTH WEST CORNER	4761865.80	643209.39	176.812

MAIN DREDGING AREA

POINT	NORTHING	EASTING
1	4761779.32	643132.73
2	4761791.04	643113.00
3	4761811.75	643125.29
4	4761814.30	643121.00
5	4761882.00	643161.20
6	4761878.67	643166.80
7	4761891.64	643174.50
8	4761883.39	643188.39

DATE	NO.	REVISIONS	CH.	APP.	APP.
SEPT 11/96	2	AS-BUILT DRAWING			
SEPT 18/95	1	ISSUED FOR CONSTRUCTION – CONTRACTS C1A AND C1B	CSB	CSB	PCM
MAY 12/95	0	ISSUED FOR TENDER – CONTRACT C1	CN	CSB	CSB

ATLAS SPECIALTY STEELS

A DIVISION OF SAMMI ATLAS INC.

WELLAND RIVER REEF CLEAN-UP PROJECT

ACRES INTERNATIONAL LTD

DESIGN — PREPARED: CSB; CHECKED: RRS

DRAWING — PREPARED: M.NASLUND; CHECKED: CSB

DEPARTMENTAL PROJECT ENGINEER: C.S. BODIMEADE

PROJECT ENGINEER: C.S. BODIMEADE

PROJECT MANAGER: P.C. MILES

McMASTER AVENUE OUTFALL AREA – SITE PLAN AND DREDGING LIMITS

SCALE: 1:500

ACRES PROJECT NO.: P1120100

DRAWING NO.: 11201-A0-004

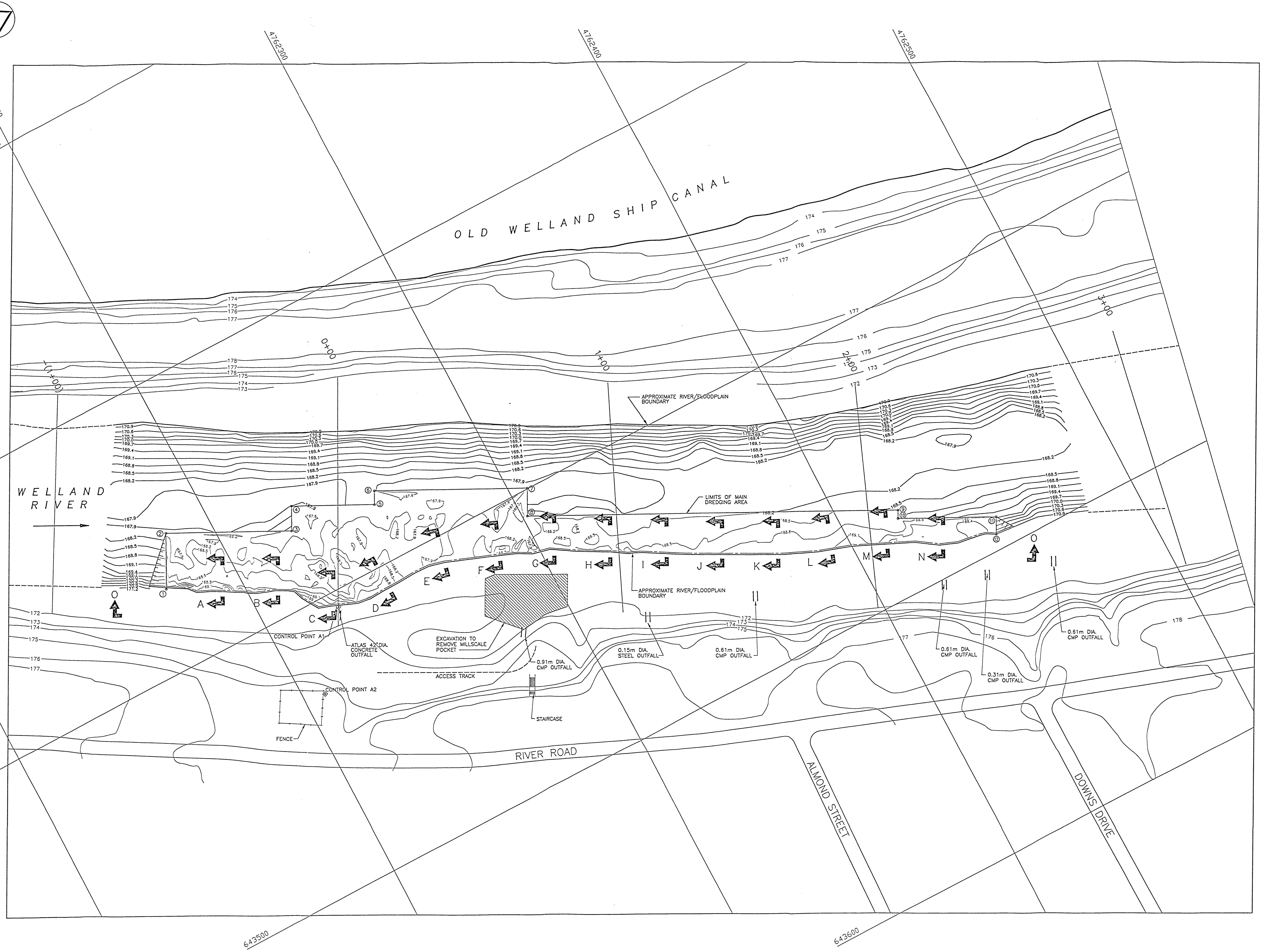
SHEET OF

REVISION: 2

Plot Date SEPT 12, 1996 – 10:29:22

N:\P1120100\CIVIL\11201004.DWG SCALE 1:500

DRAWING No. 11201-A0-004 REV. 2 SHEET OF



MAIN DREDGING AREA

POINT	NORTHING	EASTING
1	4762175.00	643370.72
2	4762184.32	643352.65
3	4762224.32	643373.25
4	4762228.44	643365.25
5	4762255.11	643379.00
6	4762257.40	643374.55
7	4762306.30	643399.73
8	4762301.65	643408.75
9	4762420.78	643470.10
10	4762419.40	643472.77
11	4762450.52	643488.80
12	4762447.64	643494.40

LEGEND

- ◈ SURVEY CONTROL POINT
- −(4+00) APPROXIMATE CHAINAGE RELATIVE TO ATLAS 42" OUTFALL. NEGATIVE UPSTREAM, POSITIVE DOWNSTREAM
- — — — LOCATION OF SHEET PILING
- 168.2 RIVERBED CONTOUR AFTER DREDGING AND PRIOR TO FILL PLACEMENT

NOTES

1. OUTSIDE MAIN DREDGING AREA, RIVERBED CONTOURS AND APPROXIMATE RIVER/FLOODPLAIN BOUNDARY ARE FROM UPPER CANADA CONSULTANTS. DWG. 5630A, MARCH 8, 1995. RIVERBED SURVEY CARRIED OUT ON FEB. 22 AND 23, 1995. WATER LEVEL DURING SURVEY WAS APPROXIMATELY 170.8m. RIVER/FLOODPLAIN BOUNDARY CORRESPONDS TO THE EDGE OF FLOODPLAIN VEGETATION AND IS APPROXIMATE ONLY.
2. WITHIN MAIN DREDGING AREA, RIVERBED CONTOURS AND RIVER/FLOODPLAIN BOUNDARY ARE FROM UPPER CANADA CONSULTANTS, SITE DWG.ZIP, JAN. 24,1996

ALL DIMENSIONS AND ELEVATIONS ARE IN METRES

0 10 20 30 40 50 m

CONTROL POINT	DESCRIPTION	NORTHING	EASTING	ELEV.
A1	CROSS-CUT ON OUTFALL HEADWALL	4762226.53	643405.74	171.928
A2	RIB ADJACENT TO FENCE	4762207.63	643431.39	176.544

DATE	NO.	REVISIONS	CH.	APP.	APP.
SEPT 11/96	2	AS-BUILT DRAWING			
SEPT 18/95	1	ISSUED FOR CONSTRUCTION - CONTRACTS C1A AND C1B	CSB	CSB	PCM
MAY 12/95	0	ISSUED FOR TENDER - CONTRACT C1	CN	CSB	CSB

ACRES

ATLAS SPECIALTY STEELS
A DIVISION OF SAMMI ATLAS INC.
WELLAND RIVER REEF CLEAN-UP PROJECT

ACRES INTERNATIONAL LTD
DESIGN PREPARED CSB
CHECKED RRS
DRAWING PREPARED M.NASLUND
CHECKED CSB
DEPARTMENTAL PROJECT ENGINEER C.S. BODIMEADE
PROJECT ENGINEER C.S. BODIMEADE
PROJECT MANAGER P.C. MILES

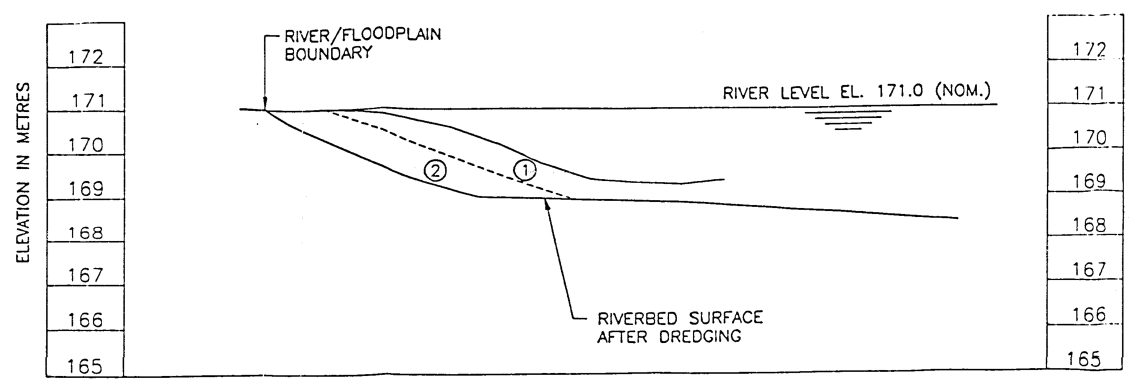
ATLAS 42" OUTFALL AREA - SITE PLAN AND DREDGING LIMITS

SCALE 1:500
ACRES PROJECT NO. P1120100
DRAWING NO. 11201-A0-005
SHEET OF
REVISION 2

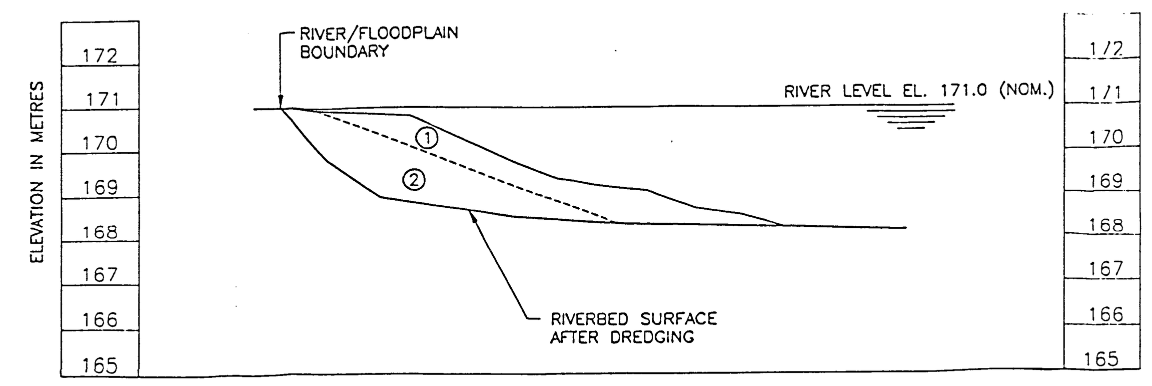
Plot Date SEPT 23, 1996 - 11:27:22

PLOT SCALE 1=500

DRAWING No. 11201-A0-005 REV. 2 SHEET OF



SECTION A-A
(DWG. 11201-A0-004)



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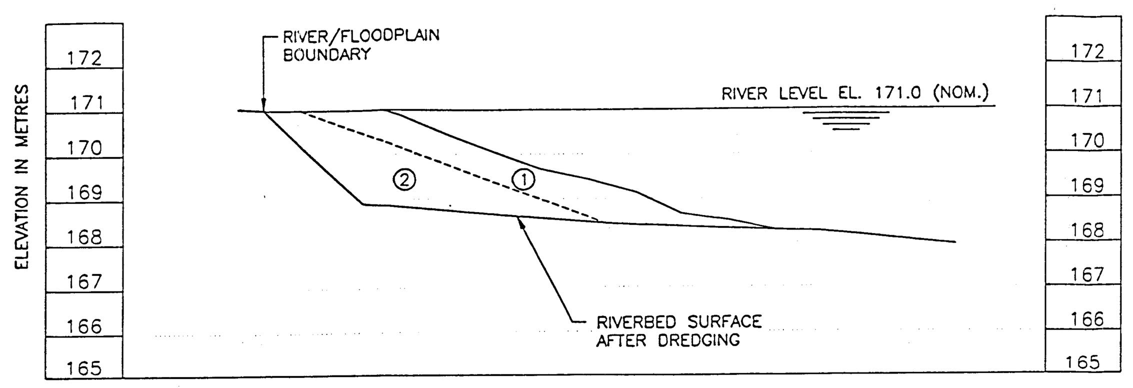
(DWG. 11201-A0-004)



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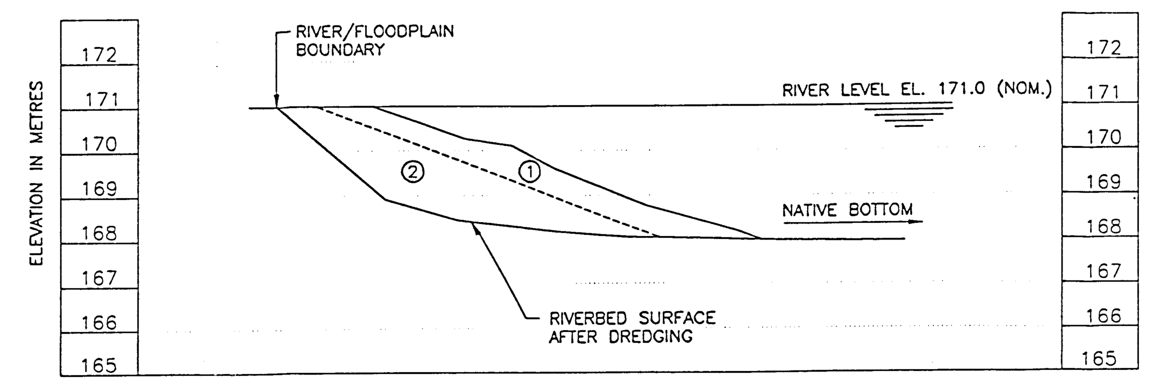
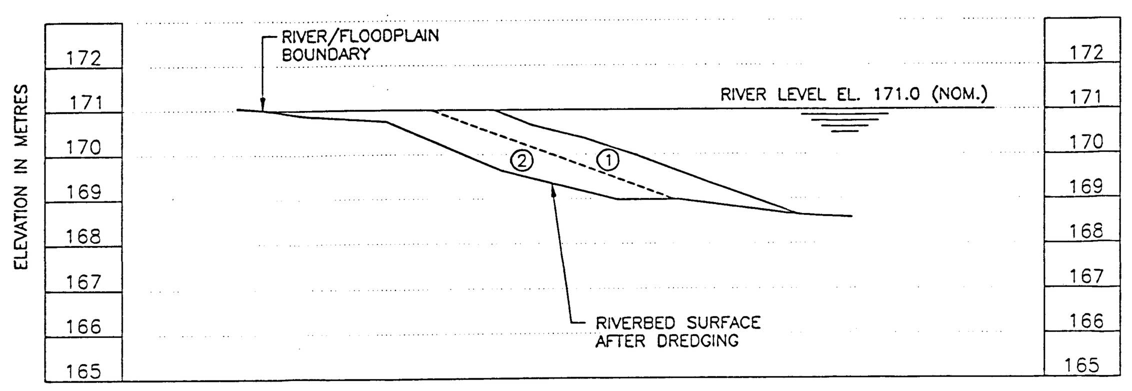
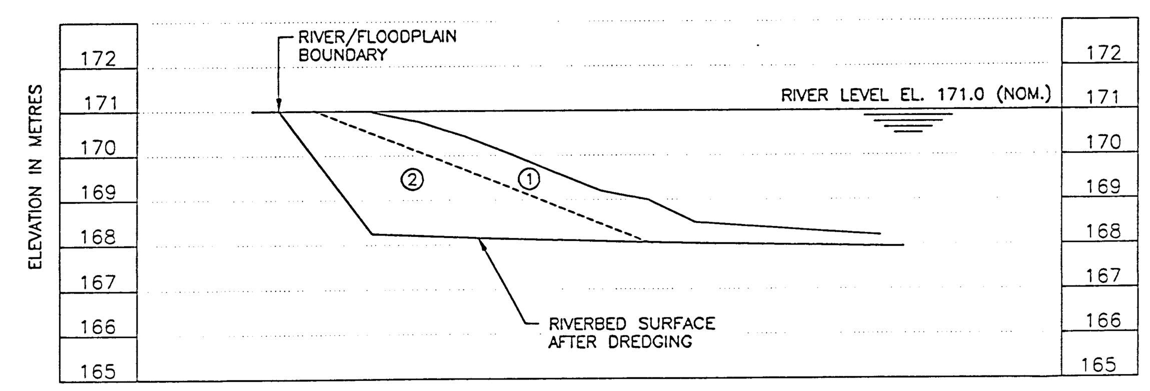
(DWG. 11201-A0-004)



SECTION E-E
(DWG. 11201-A0-004)



SECTION C-C
(DWG. 11201-A0-004)



SECTION F-F
(DWG. 11201-A0-004)

NOTE

1. FOR GENERAL NOTES SEE DWG. 11201-A0-004

LEGEND

① PROCESSED GRANULAR (EROSION PROTECTION)
② PROCESSED GRANULAR (FILTER)

ALL DIMENSIONS AND ELEVATIONS ARE IN METRES

0 2 4 6 8 10 m

DATE	NO.	REVISIONS	CH.	APP.	APP.
SEPT 11/96	2	AS-BUILT DRAWING			
SEPT 18/95	1	ISSUED FOR CONSTRUCTION - CONTRACTS C1A AND C1B	CSB	CSB	PCM
MAY 12/95	0	ISSUED FOR TENDER - CONTRACT C1	CN	CSB	CSB

ACRES

ATLAS SPECIALTY STEELS
A DIVISION OF SAMMI ATLAS INC.
WELLAND RIVER REEF CLEAN-UP PROJECT

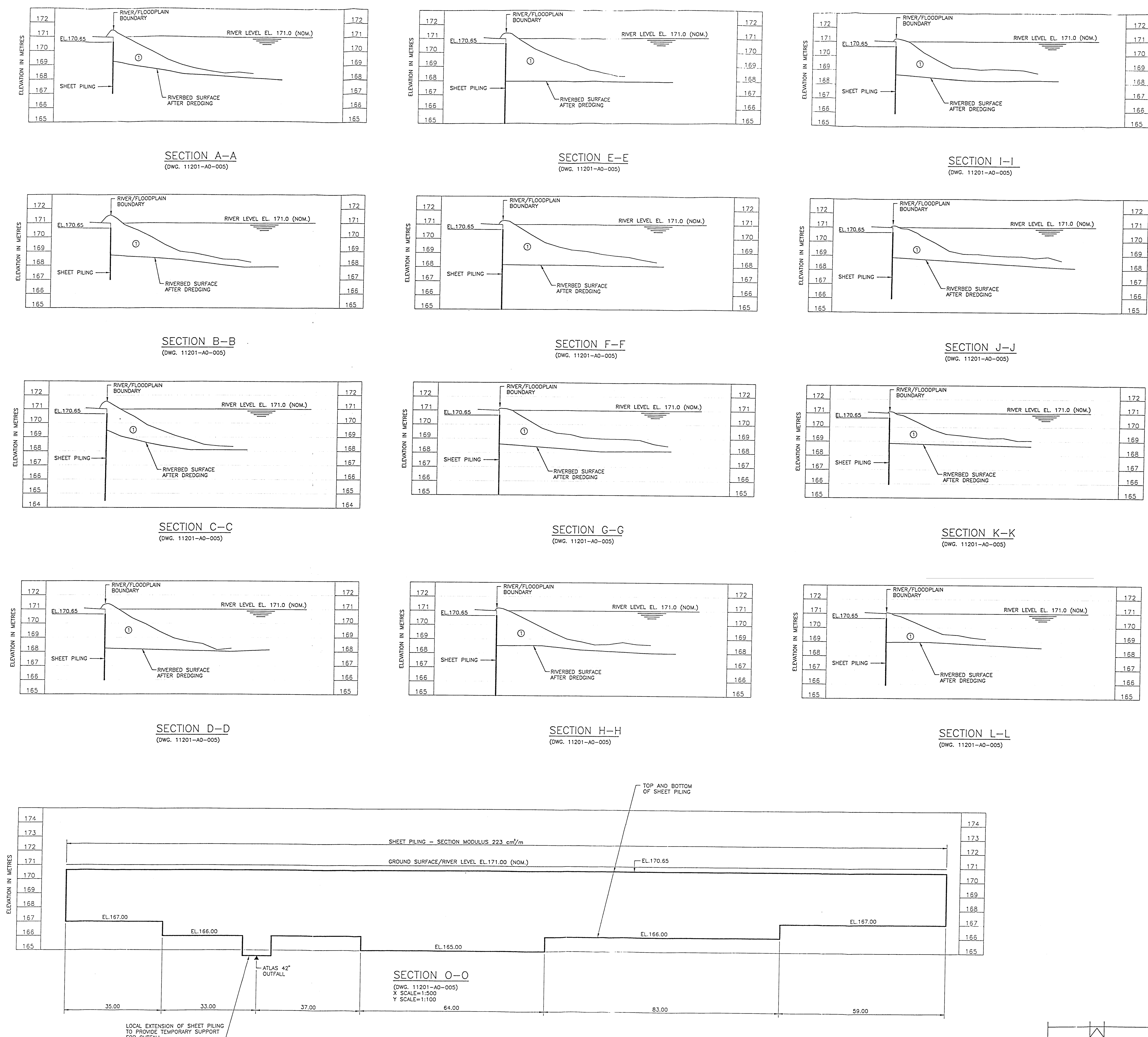
ACRES INTERNATIONAL LTD
DESIGN PREPARED CSB/CN
CHECKED TJB/CSB
DRAWING PREPARED M.NASLUND
CHECKED CSB
DEPARTMENTAL PROJECT ENGINEER C.S. BODIMEADE
PROJECT ENGINEER C.S. BODIMEADE
PROJECT MANAGER P.C. MILES

McMASTER AVENUE OUTFALL AREA - TYPICAL SECTIONS

SCALE 1:100 OR NOTED
ACRES PROJECT NO. P1120100
DRAWING NO. 11201-A0-006
SHEET OF
REVISION 2

DRAWING No. 11201-A0-006 REV. 2
SHEET OF

N:\P1120100\CIVIL\11201006.DWG
PLOT SCALE 1=100
Plot Date SEPT 23, 1996 - 11:29:45



NOTES

1. FOR GENERAL NOTES SEE DWG. 11201–A0–005

LEGEND

① PROCESSED GRANULAR FILL (EROSION PROTECTION)

ALL DIMENSIONS AND ELEVATIONS ARE IN METRES

0 2 4 6 8 10 m

DATE	NO.	REVISIONS	CH.	APP.	APP.
SEPT 11/96	2	AS-BUILT DRAWING			
SEPT 18/95	1	ISSUED FOR CONSTRUCTION – CONTRACTS C1A AND C1B	CSB	CSB	PCM
MAY 12/95	0	ISSUED FOR TENDER – CONTRACT C1	CN	CSB	CSB

ACRES

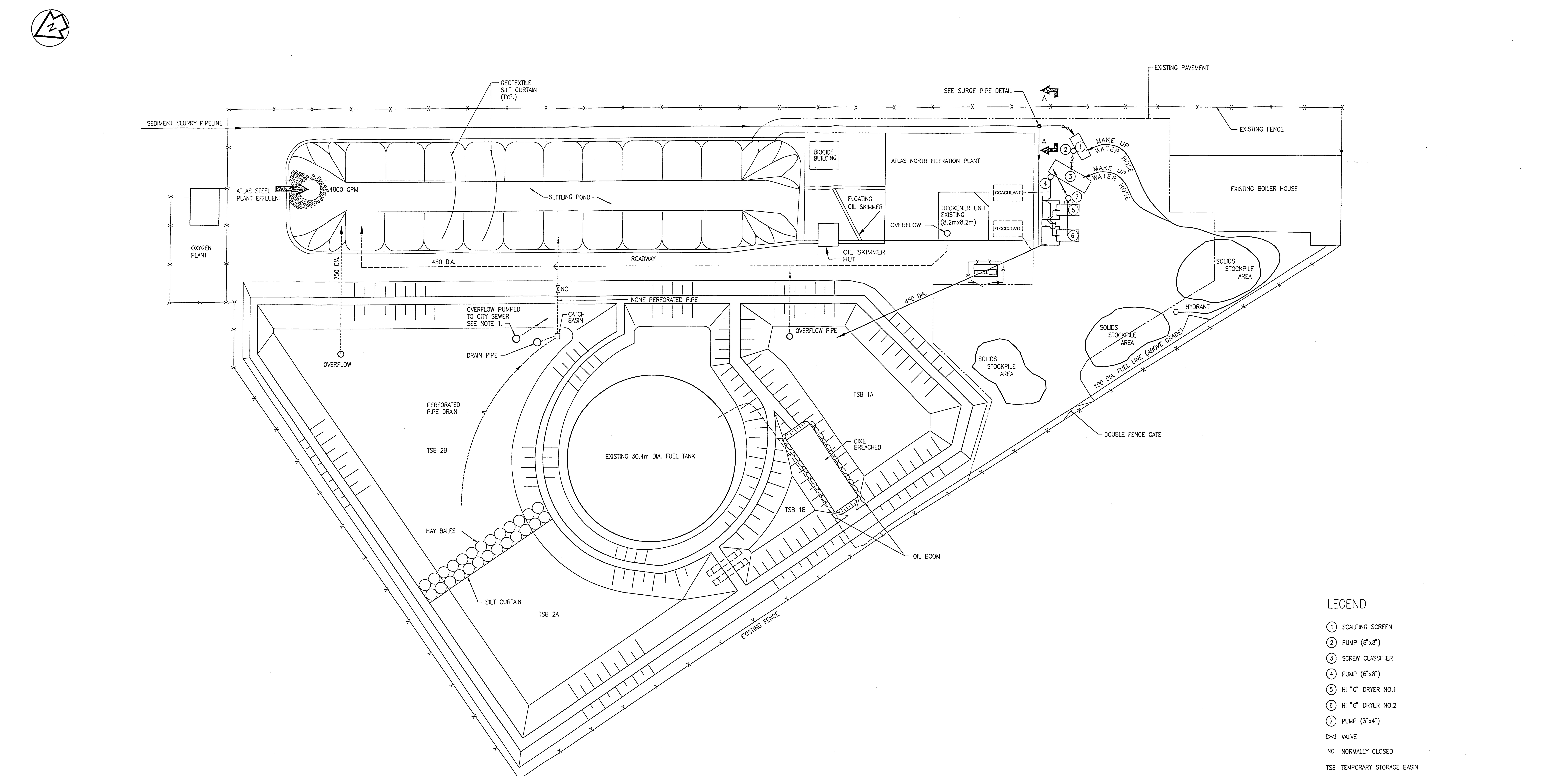
ATLAS SPECIALTY STEELS
A DIVISION OF SAMMI ATLAS INC.
WELLAND RIVER REEF CLEAN-UP PROJECT

ACRES INTERNATIONAL LTD
DESIGN PREPARED CN
CHECKED TJB/CSB
DRAWING PREPARED M.NASLUND
CHECKED CSB
DEPARTMENTAL PROJECT ENGINEER C.S. BOOMEADE
PROJECT ENGINEER C.S. BOOMEADE
PROJECT MANAGER P.C. MILES

ATLAS 42" OUTFALL AREA
TYPICAL SECTIONS

SCALE 1:100 OR NOTED
ACRES PROJECT NO. P1120100
DRAWING NO. 11201–A0–007
REVISION 2

DRAWING No. 11201–A0–007 REV. 2

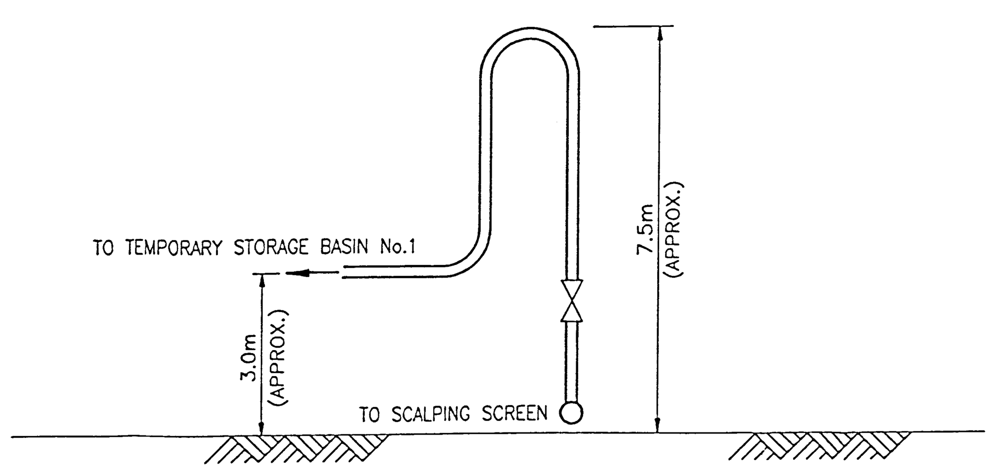


PLAN

NOTE

1. PUMPING FROM TSB 2 TO CITY SEWER OCCURRED INTERMITTENTLY DURING FINAL FOUR DAYS OF DREDGING ONLY.
2. APPROXIMATE TSB VOLUMES

TSB 1A	800 m^3
TSB 1B	400 m^3
TSB 2A	1800 m^3
TSB 2B	2570 m^3



SURGE PIPE DETAIL
SECTION A–A

ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE

0 5 10 15 20 25 m

DATE	NO.	REVISIONS	CH.	APP.	APP.
SEPT 11/96	2	AS-BUILT DRAWING			
SEPT 21/95	1	ISSUED FOR INFORMATION – CONTRACTS C1A AND C1B	CSB	CSB	PCM
MAY 12/95	0	ISSUED FOR TENDER – CONTRACT C1	RRS	RRS	CSB

ACRES

ATLAS SPECIALTY STEELS
A DIVISION OF SAMMI ATLAS INC.

WELLAND RIVER REEF CLEAN-UP PROJECT

ACRES INTERNATIONAL LTD
DESIGN PREPARED MS CHECKED RRS
DRAWING PREPARED C.VALENTINE CHECKED RRS
DEPARTMENTAL PROJECT ENGINEER R. STEAD
PROJECT ENGINEER C.S. BODIMEADE
PROJECT MANAGER P.C. MILES

NORTH FILTRATION PLANT AND SEDIMENT TREATMENT FACILITY – LAYOUT

SCALE 1:250
ACRES PROJECT NO. P1120100
DRAWING NO. 11201-A0-008
SHEET OF
REVISION 2

DRAWING No. 11201-A0-008 REV. 2
SHEET OF

SCALE 1:250
N:\P3120101\CIVIL\11201008.DWG

Plot Date SEPT 13, 1996 – 11:46:44