CONSTRUCTION INSPECTION AND DEMONSTRATION PROJECT FOR SEDIMENT MONITORING ON THE STILLWATER – ELLERSHOUSE SECTION OF THE HIGHWAY 101 TWINNING PROJECT, JULY – OCTOBER, 2002

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EXECUTIVE SUMMARY

A generic protocol for water quality monitoring examining erosion and sediment control on highway construction sites was developed in collaboration with federal and provincial departments, including Transportation and Public Works (TPW), Environment and Labour (NSEL), Fisheries and Oceans (DFO) and the Urban Development Institute (UDI). This protocol was used as the basis of a site-specific protocol for the section of the Highway 101 twinning project between Stillwater and Ellershouse, and that is the subject of this report.

DEMONSTRATION PROJECT SITE AND STUDY DURATION

The 5.5km section of the Highway 101 twinning project between Stillwater and Ellershouse was the focus of this study. The area of the drainage basin under review was 27.4 km^2 of which approximately 0.165km^2 was affected by the construction.

Grubbing operations began on July 12, 2002. The collection of field data for the project occurred between July 12 and October 28, 2002.

Review of the Construction Approval Process

This report discusses the various approvals required and plans submitted by TPW for this section of highway. Specific approvals include those associated with the Canada Environmental Assessment Act (CEAA) and NSEL Water Approvals.

Accompanying documentation discussed includes the Environmental Protection Plan (EPP), the Environmental Control Plan (ECP), and the Culvert Mitigation Plan (CMP).

WATER QUALITY ISSUES

The bulk of the work carried out during this study dealt with the impact of construction activities on receiving water quality. Three primary and 20 secondary water quality monitoring sites were established to document total suspended solids (TSS) and turbidity levels at various times prior to, during, and after rain events. Eleven events measuring between 3.4 and 107.4mm were monitored. A total of 668 (564 by CWRS and 104 by TPW) water samples were collected and analyzed.

In addition to water quality testing, precipitation and stream flow were measured.

The water quality program used in this study and the data collected have resulted in the generation of valuable information that can be used, not only to evaluate the effectiveness of erosion and sediment controls applied to this section of highway, but to assist in the development of a water quality monitoring protocol for future highway projects.

During the study, it was observed that the operation of one of the borrow pits and the installation of a stream diversion channel were major sources of significant TSS load to the receiving waters of Dawson Brook and Bog Brook. Several recommendations have been made regarding both of these activities.

For all of the eleven rain events monitored, TSS peaks occurred prior to peaks in streamflow. The timing of these peaks were between 4.5 and 24 hours after the start of the event, a characteristic which has serious implications regarding the timing and method of water sample collection. It would be difficult at best to match these times (TSS peak and sample collection) using the grab sample method specified in the TPW monitoring protocol. It was shown during this study that for more accurate representation of receiving water quality during rain events, an automated method of water sample collection should be adopted.

RECOMMENDATIONS

1) Water Quality Monitoring Protocol

It is recommended that:

a) A start up date be added and referenced to a specified construction activity.
b) Rain events less than 10mm not be monitored; all events between 10 and 20mm be considered for water quality monitoring; and that all those above 20mm be monitored.
c) If the purpose of water quality monitoring is to generate information that accurately represents the impact of construction activity on receiving waters, then the program should employ techniques that ensure temporal coverage of a precipitation event. Grab samples are a common and satisfactory means of acquiring data, provided the frequency and distribution of sample collection is adequate. Ideally, it is recommended that the collection system be automated and triggered by streamflow.
d) The protocol should indicate the location of sample collection in the water body itself. That is mid-stream and at mid-depth. For all downstream, sampling should take place below the point of complete mixing.
e) All water sampling sites must be marked to ensure that sampling is consistent throughout the monitoring program.
f) Water samples must be delivered to a laboratory for processing within an appropriate amount of time. Delivery times are contingent on the specific tests being carried out. For certain tests, this means within hours. For example, Standard Methods (Clesceri et al. 1998) recommends holding times for pH of less than 2 hours, turbidity 24 hours (48h for regulatory purposes) and TSS 7 days, provided the sample has been refrigerated up until the time it is analyzed. *In situ* measurement of pH by meter is preferred if holding times are expected to exceed the 2-hour limit.

2) Field Notes

a) It is recommended that exact collection times for individual water samples retrieved by TPW staff be routinely recorded. On occasion, only a single time was seen to be recorded for a series of samples.

3) Diversion Channels

It is recommended that the design and sequencing of steps for the installation of diversion channels be reviewed. Specifically:

a) Alignment of upstream barrier (i.e. sheet-piling, sand bags) should be angled to stream flow to reduce the turbulence generated by the presence of the dam structure. It should not be installed perpendicular to flow.
b) The upstream barrier should extend to form the first 2 to 3 metres of the channel wall, overlapping the liner material of the channel. Under no circumstances should soil material making up the walls of the channel be exposed to erosional forces of the brook water.
c) A cofferdam should be constructed such that the removal of the streambank plug at the upstream end of the diversion channel is done in the dry. In this way, the channel liner could be extended in to the existing stream channel without having to deal with flowing water, in turn reducing the potential for siltation.

4) Borrow Pits

The process by which regulatory agencies are notified of borrow pit activity should be consolidated to enhance the exchange of information between parties, as both sections of NSEL (Environment and Labour) require notification of borrow pit activity.

5) Fish Rescues

DFO responsibilities:

a) Produce an information pamphlet that describes the program, and the responsibilities of individuals using the program.
b) Consider the issuance of permits that would apply to all areas of a region for a specific period of time, similar to that of a federal fishing licence.
c) Publish a list of individuals/groups authorized to carry out fish rescues.

TPW responsibilities:

a) Incorporate the above contact list somewhere in contract documentation that contains the names of individuals/groups that are/have been certified through DFO to carry out fish rescues.

6) Erosion and Sediment Control Course

It is recommended that the TPW Inspectors attend the ESC course to ensure effective communication between the contractor and TPW inspectors when making decisions regarding ESC issues or adaptive management measures.

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1.0 INTRODUCTION

Concerns about effective implementation of measures for control of erosion and sediment from construction sites in Nova Scotia led to preparation of a report, "Construction Sediment: Effects in the Freshwater Environment, and Responses for Government Agencies", which was completed in July of 2001 (Waller et al. 2001).

Concerns that prompted the 2001 report were based on recognition that:

- it is not always possible, due to soil and weather conditions in Eastern Canada, to consistently maintain sediment concentrations, in water leaving a construction site or in a receiving watercourse, that meet current regulatory requirements, and
- since most regulatory requirements are based on concerns about fish habitat, it is important to understand, as clearly as possible, how fish habitat is affected by sediment characteristics.

The objective of the project was to produce a resource document that would:

- address issues of concern to all of the constituencies concerned with impacts of construction sediment, including contractors, developers, planners, designers, regulators, scientists, and environmental groups, and
- offer conclusions and recommendations aimed at improving the effectiveness of the institutional, management, and regulatory system that is concerned about and responsible for reducing the impact of construction sediment on fish habitat and other uses of aquatic environment.

Financial support was provided by sponsors, including developers, private sector companies, and provincial and federal agencies.

The project began with an extensive review of the scientific literature related to effects of sediment in the aquatic environment, in particular on fish and fish habit. A report was prepared that identified more than 250 references, and included abstracts for most. Over half of these references, including those considered to be directly relevant to this project, were acquired and reviewed as background to the current report.

The report provides an overview of impacts of sediment on fish and fish habitat, introduces issues and problems related to effective control of erosion and sediment, and jurisdictional issues, and regulatory and institutional options. It also discusses the effectiveness of ESC measures, appropriate sampling regimes, and mitigation measures based on water quality standards.

Waller et al (2001) concludes that:

> *Regulatory measures based on sampling of water leaving a construction site, although they may be useful in identifying a sediment source or poor construction practices, are not an appropriate basis for judgement about the effects of construction practices on fish habitat.*

Additionally, it recommends to those who regulate, manage, plan, or implement measures to control erosion and sediment from construction sites, that:

1. *If sediment concentrations are to be used effectively as a regulatory instrument: judgements should be based on samples from the water column of streams, taken upstream and downstream of a constructions site; the number and timing of samples should be sufficient to define both the concentration and duration of elevated solids levels, and should consider watershed size, site area, and storm duration; and it should be recognized that any limit may be exceeded in an extreme event, and that definition of a regulatory design storm frequency may be appropriate.*
2. *Regulatory measures that should be considered to supplement or replace stream sampling are:*

- *requirements for submission, review, and approval of erosion and sediment control plans, and for adherence to those plans*
- *provision of, and requirements for adherence to, standards and guidelines for the content of plans, including contingency measures*
- *requirements that a properly qualified member of a contractors staff be present on a site and be responsible for the implementation of erosion and sediment control measures, whether they are applied in conformity with an erosion and sediment control plan or in accordance with recognized good construction practice.*
- *audit of construction sites by experienced staff of a regulatory agency, to assure compliance with plans.*
- *development controls, to assure that the rate of development in a watershed does not produce sediment effects in excess of those that any reasonable control measures can prevent.*

3. *Non-regulatory measures that should be undertaken and/or promoted include:*

- *development of model ordinances that could be enacted and applied by other levels of government*
- *provision of training courses for staff of government agencies, designers, and contractors*
- *preparation and dissemination of educational materials, and*
- ***development of and participation in a pilot project to evaluate the regulatory and non regulatory options identified above.***

When the report was delivered to interested and supporting government departments attention was drawn to the final recommendation.

TPW responded to this recommendation by agreeing to fund preparation of a "generic" monitoring protocol, and to conduct a pilot project at a TPW highway construction site in the Summer of 2002. The UDI also endorsed the project, and is helping to identify an urban project site.

The generic protocol, included here as Appendix I, was developed by CWRS with input from TPW, NSEL, DFO, and UDI representatives, and reviewed by the CWRS Advisory Panel on ESC.

The generic protocol was subsequently used as the basis of a site-specific protocol for the TPW site that is the subject of this report, and will be the basis of a protocol for an urban development site when one is selected.

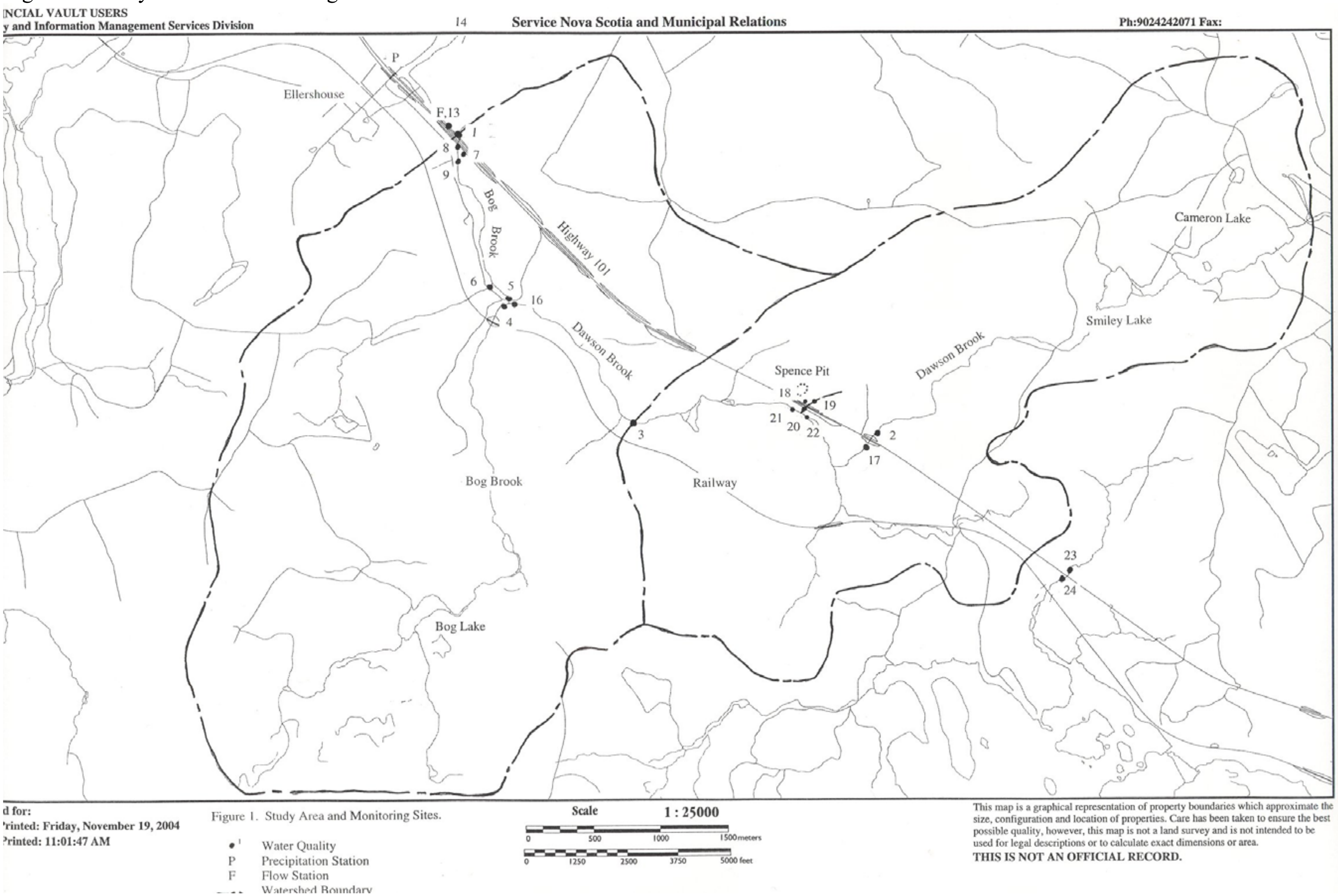
2.0 DEMONSTRATION PROJECT SITE DESCRIPTION

Following consultation with TPW staff, the Stillwater to Ellershouse section of the Highway 101 twinning project between Mount Uniacke (Exit 3) and Ellershouse (Exit 4) was selected as the site for this demonstration project. Approximately 5.5km in length, the highway section is located roughly 50km from Halifax and 13km from Windsor. Water quality sampling locations are summarized in Figure 1. Soil types found along the linear development include Halifax, Rawdon, and Elmsdale. All three types are considered well-drained sandy loams, with very to excessive stoniness. Topography of the area is gentle (2-5%) to moderately (6-9%) sloping (Cann et al. 1954).

The area of land disturbed during construction for this section of highway was estimated to be 0.16km^2, or approximately 0.6 percent of the 27.4 km^2 gauged watershed.

Grubbing operations for this section of highway began on July 12, 2002. The collection of field data for the project occurred between July 12 and October 28, 2002.

Figure 1. Study area and monitoring sites.



3.0 HIGHWAY CONSTRUCTION PROJECT PLANNING

The first step with any TPW highway construction project is a Preliminary Environmental Screening, typically carried out in house during the planning stage. The process investigates and documents the flora, fauna, archeology and a number of other constraints within the affected area of a proposed roadway. The main product of the screening is constraint mapping, which is subsequently used to assist with highway alignment. The screening report is submitted to DFO for comment. This is then used by TPW as a provincial environmental registration document, and/or a federal CEAA "Project Description", as required.

4.0 HIGHWAY 101 CONSTRUCTION APPROVAL PROCESS

The existing section of Highway 101 between Mount Uniacke and Ellershouse, which includes that section used for the CWRS demonstration project (Stillwater to Ellershouse), underwent an Environmental Assessment (EA) Review in the early 1990's as part of requirements under the federal environmental legislation, at that time known as the Environmental Assessment Review Process (EARP). This federal review was required as the project was eligible for federal funding**.** However, changes to federal legislation (EARP became the Canadian Environmental Assessment Act (CEAA)) meant that additional information would be necessary for the Application to obtain CEAA Approval from Transport Canada (TC) for the twinning. This additional work was done in the late 1990's.

Not all highway construction projects undergo a review under CEAA. The need for a review is determined by so-called "triggers" within the approval process. CEAA triggers include funding, a project on federal lands, or lands turned over by the federal government. An EA can also be triggered through requirements for approvals under the Navigable Waters Protection Act (NWPA) and the Fisheries Act.

Information items relevant to the CWRS project included in the TPW CEAA application were mitigation recommendations pertaining to erosion and sediment control (ESC) and culvert installation. As part of TC's review process, Conditions of Release (CoR) for the project were established. Typically, these conditions are simply those identified in the application, as specified by TPW. However, they can go beyond those identified, to include such things as additional monitoring and specific mitigation identified by the reviewers (i.e. prepare a site specific plan for the disposal of acid generating bedrock with Environment Canada and NSEL, after testing is undertaken in the field during the construction phase to determine the extent of the bedrock).

Subsequent to TC's CEAA Approval, an EPP was developed by TPW. It is standard procedure for TPW to prepare an EPP for all its 100 Series Highways. The Plan is a means of communicating TPW policy to its contractors. Regulators look at it as a commitment of the Department's intent to address environmental concerns.

For the twinning of Highway 101 between Mount Uniacke and Ellershouse, Section 1 of the EPP states:

"This protection plan is a compilation of environmental procedures and controls to be used by TPW and its contractors to ensure highway construction minimizes its potential adverse effects on the environment. The EPP has been developed to:

a) Provide regulatory agencies with a generic and, where required, specific description to the procedures and controls that TPW follows during highway construction to ensure environmental protection;

b) Provide TPW and its Contractors with a comprehensive review of environmental concerns and clear, concise guidance on the methods to be used to address these concerns in the construction of a highway; and
c) Facilitate acquisition of approvals and permits required by federal and provincial legislation.

ESP and CMP are also developed for all TPW highway construction projects. Although the completeness of both plans is not measured according to an established protocol, the designs of individual control measures used are. The selection and location of individual control measures on a plan is not governed by a standard protocol, but rather by a designer's expertise. Reference material available includes the NSEL's Erosion and Sediment Control Handbook and Environmental Construction Practice Specifications, Chapter 7 "Environmental Protection" of the TPW Standard Specification Manual, and the new Transportation Association of Canada (TAC) 2004 report, "National Guide to Erosion and Sediment Control on Roadway Projects". These documents act as guides in the selection, design and construction of selected control measures. TPW highway construction contracts indicate that control measures installed are in accordance with specifications outlined in Chapter 7 of their Standard Specification Manual.

Both the ECP and CMP serve as supporting documentation when TPW submits an Application for a Water Approval (WA) to NSEL. These plans are typically produced in house. However, on occasion, they are generated outside the Department and reviewed by TPW staff prior to application submission.

NSEL approvals obtained for this project included:
1. Winter clearing at Dawson Brook
2. All wetlands (individual wetlands areas were not specified in the approval)
3. Each fish bearing stream (13+700, 17+500, 18+500)
4. Culverts not requiring fish passage (11 in total)
5. Dawson Book Wall (16+800 to 16+920).

The written contract between TPW and Contractor is one of the mechanisms through which details of the EPP and Contractor responsibilities are communicated to the Contractor.

One of the conditions to contractors bidding on grading work is that they have on site a foreman/supervisor that has completed the "Erosion and Sediment Control for Construction Sites" course offered through the CWRS. This has been a requirement since the beginning of 2000. The course is intended to provide an understanding of:
- the regulatory systems and the responsibilities of owners and contractors,
- basic principles of erosion and sediment control,
- application of these principles,
- effective implementation of erosion and sediment controls in interpretation of plans and specifications and in response to changing site conditions,
- slope stability, and
- vegetative strategies to prevent erosion and control sedimentation.

For the Highway 101 twinning project Alva Construction Limited was the lead contractor. Three Alva employees on this job attended the course.

During the construction phase of the project, the primary responsibility for implementing the EPP rests with the Contractor. However, TPW is ultimately liable for environmental damage.

Typically, the Project Engineer (PE) and Site Inspectors work with the Contractor to implement measures identified in the EPP, ECP or CMP. At times during a project, environmental protection issues arise that require advice from DFO and/or NSEL.

If at any time during a project TPW believes that ESC measures are not satisfactory, construction activities can be stopped until such time that those concerns are addressed. Additionally, TPW has the power to hire an outside contractor carry out work and in turn bill the principal Contractor for that work.

Following the awarding of a contract and prior to the start-up of construction, a boardroom meeting of all stakeholders (Contractor, TPW, DFO, NSEL, EC, Truckers Association) was convened on July 4, 2002 to discuss issues concerning water quality (WQ) and fish habitat. For projects in which in stream work was planned, such as crossings or culvert installations, a site meeting of selective stakeholders (Contractor, TPW, DFO and NSEL) was held to examine specific site conditions and to ensure that the work was planned in a manner that was satisfactory to all parties. A site meeting for the Stillwater/Ellershouse section of the twinning of Highway 101 took place on July 15, 2002 to review and discuss two culvert extensions and a section of retaining wall (Contractor, TPW, DFO, and CWRS were in attendance). Another meeting took place on September 16, 2002 to discuss concerns associated with the Spence borrow pit (Contractor, TPW and DFO were in attendance).

ESC measures identified in the ECP and CMP were not necessarily installed exactly as shown due to varying site conditions. However, adaptive management ensured that additional ESC measures could be implemented at the discretion of the contractor and/or TPW.

5.0 WATER QUALITY (WQ) ISSUES

The WQ monitoring program for the Highway 101 project, although not a legal requirement for any phase of the approval process (unless a project is to employ a new technology or technique etc.), was recommended by TPW in the screening report and subsequently in its application for TC approval. TC adopted this program in its Conditions of Release for the highway project.

The WQ monitoring program proposed by TPW and subsequently adopted in the Conditions of Release and the EPP, serves as a self-regulatory environmental compliance monitoring (ECM), addressing commitments contained in TC's CoR, the EPP, and NSEL Approvals. A second form of ECM is one that involves regulatory environmental surveillance carried out by NSEL, DFO, EC and/or TC. Monitoring focuses on verifying compliance with applicable legislation and conditions of regulatory authorizations. This form of monitoring was not required for this project.

The WQ monitoring protocol in the EPP included a listing of targeted water bodies, and definitions of event selection and frequency of sampling. The exact locations of individual water quality monitoring stations on each of the target streams, although not specified in the EPP, were identified prior to the start of grubbing operations. Event selection was based on a >25mm rainfall amount. According to the EPP, sampling during these events would consist of upstream and downstream (of the highway crossing) stream samples collected approximately 2-4 hours following the start of an event depending on the intensity. If the rain event continues for over 12 hours, a set of samples should be collected approximately 12 hours after the start of the event. Another set would also be collected approximately 2-4 hours following the rain event. Samples were to be tested for total suspended solids (TSS).

The sampling program carried out by TPW staff deviated slightly from that outlined in the EPP in the following ways:

1. Event selection did not follow the >25mm trigger. The events monitored ranged from 0-94mm. Only one of the twelve events sampled between July 24 and October 17, 2002 was greater than 25mm (6 between 0-10mm; 5 between 10-25mm; 1 greater than 25mm);
2. A single set of rain event samples was usually collected at the start of the working day and not necessarily during the 2-4 hour window after the start of the particular event. Timing of sample collection seemed to be based more on convenience than EPP guidelines;
3. Dawson (Stations 2 and 17) and Bog (Stations 1 and 9) brooks were the two water courses identified in the EPP for monitoring for this section of the twinning project. Samples were to have been collected upstream and downstream of the highway on both brooks, presumably in the vicinity of the two largest culvert extensions. The EPP did not specify distances from the crossings at which stations were to be established. The program was amended by TPW to include four additional locations. These sites included upstream and downstream locations for a culvert installed at 18+540 (Stations 23 and 24) and two sites to monitor the impact of the Spence borrow pit (runoff from the pit (Station 18) and Dawson Brook approximately 85m downstream of the discharge point (16+990) of pit drainage (Station 21)) (see Figure 1);
4. The EPP did not identify a startup trigger for the water quality monitoring program in relation to construction activity. Grubbing operations began July 12, 2002 and the first rain event (29.6mm) occurred on July 19, 2002. The first set of TPW event samples was collected on July 24, 2002.

6.0 DEMONSTRATION PROJECT OBSERVATIONS

6.1 TPW Field Notes

A standard form was used by TPW staff to record water sampling date, time, weather conditions at time of sampling, erosion control measures in place, and general comments. A Chain-of-Custody form was used by staff when submitting water samples for analysis. This form did not contain a line for time of collection.

It is critical, especially for the examination of running (lotic) waters, that the exact collection times for individual water samples be recorded. The intent of event sampling is to be able to review the timed response of a particular water body to anthropogenic influences (i.e. highway construction). WQ data with only a reference to date significantly reduces the usefulness of that data. For this project, reporting of times by TPW staff varied.

6.2 Box Culvert

The diversion channel was installed on August 29, 2002 and operational until October 15, 2002, a total of 48 days. Appendix B of the EPP contains sequencing details of a diversion channel construction. The drawings show the dam in the upstream end of the existing stream channel to be perpendicular to streamflow (as was the case for the box culvert diversion channel). Water turbulence generated at the sheet-pile wall during the September 11, 2002 rain event, was likely the leading factor in the erosion of a section of the diversion's retaining wall. It is also questionable whether the diversion structure would have been capable of containing the event's peak flow even if the diversion structure had not been compromised.

The area encompassing the diversion and culvert extension excavation was flooded during the September 11, 2002 rain event (refer to Figures 2 and 3). The alignment (perpendicular to the flow) and width of the sheet-piling barrier, installed at the upper end of the stream channel to divert flow into the diversion channel, played important roles in the failure of the diversion structure. The diversion channel wall nearest the sheet pile barrier was eroded during the event, permitting access of flow to the dry area under construction. The sheet-piling was installed perpendicular to the direction of flow, with one wall of the diversion channel extending upstream of the piling barrier. This extension of the diversion channel wall was exposed to turbulent flow caused by the presence of the sheet-pile barrier during periods of high water, as was the case during the September 11-12 event (refer to Figure 4).

Figure 2. Installation of diversion trench for box culvert @ 13+700. Upper end. The sheet-piling was installed perpendicular to the direction of flow. As well, the channel wall extended upstream of the piling barrier. Doing so exposed the exterior side of the wall to water turbulence generated when the sandbag cofferdam was breached during the higher flows experienced during the September 11-12 event.

Figure 3a. Area of box culvert installation before and …

Figure 3b. … during the September 11-12 rain event.

Figure 4. Washout of diversion trench sidewall during September 11-12 rain event. View is looking downstream.

Receding water levels revealed that sections of the plastic liner had been dislodged and the underlying material eroded (see Figures 5a and 5b). The exact cause of the displacement is unknown. It is recommended that the design of these structures be reviewed.

Figure 5a. Diversion channel days before the September 11-12 rain event.

Figure 5b. The same section of the channel days after the same event. Note the displacement of the channel liner along a section of the east bank and stream channel at lower riffle.

The Nova Scotia Watercourse Alteration Specifications (1997) does not specify how flow is to be managed during the transition between the original stream channel and the new diversion channel when the upstream plug is removed. For this project, Bog Brook was dammed immediately upstream of the planned entrance to the diversion channel and backwater pumped to a vegetated area away from the site. The pumping was carried out for the majority of the diversion construction period (12+ hours). Doing so permitted removal of the upstream streambank plug between the existing stream channel and the diversion channel in the dry. However, this technique resulted in the elimination of flow to that section of Bog Brook between the temporary dam and the culvert that directed runoff from the vegetated area used for the pumping operation back to Bog Brook. Additionally, the flow did not meet the maintenance flow requirements (Jim Leadbetter (DFO) personal communication). The affected length of stream was approximately 100 metres.

The technique applied to the Bog Brook diversion was that presented in Appendix B of the EPP with the following assumptions. The procedure recommends that flow be maintained in the existing stream channel throughout the operation. However, after allowing flow through the diversion the existing stream channel becomes dammed, and the EPP does not describe the way in which the liner of the diversion channel should be extended through to the existing stream channel. The sheet-piling barrier at the upstream end of the diversion channel was extended by approximately 10 panels, and a plastic barrier was also added to the barrier to reduce seepage (refer to Figures 6a and 6b).

Figure 6a. The sheet-piling barrier at the upstream end of the diversion channel was extended by approximately 10 panels. A plastic barrier was also added to the barrier to reduce seepage.

Figure 6b. Backside of the sheet pile structure following the addition of additional panels. The sand bag in center of photo indicates where the original section ended and the extended section began.

6.3 Borrow Pits

There is no formal permitting process for TPW or contractors of TPW for pits developed specifically for highway construction projects. The only formal requirement under Section 182 of the Occupational General Safety Regulations is contractor notification of the Director of Occupational Health and Safety at NSEL (Labour Division) two weeks prior to commencement of any planned borrow pit activity. Alva provided the NSEL (Dave Walsh) written details of the borrow pits in a letter dated July 16, 2002, (Reg Tramble, Alva. pers. communication). At that time, descriptions of specific ESC measures, on an ECP for pits, were not required. As noted in the EPP, the contractor was supposed to control stromwater runoff to ensure TSS were less than 25mg/L.

The Spence borrow pit was a major source of total suspended solids observed in Dawson and Bog Brooks (refer to Figure 7a and 7b). Seventeen grab water samples were collected between July 24 and November 12, 2002 from the highway ditch draining the borrow pit. total suspended solids concentrations ranged from <1.8 to 5200 mg/L, with an approximate mean value of 500 mg/L. Development of this pit did not include any preventative ESC measures. Attempts to control runoff leaving the pit while it was operational appeared to be relatively unsuccessful. Flow checks were placed in the highway ditch that drained to Dawson Brook. However, there were no diversion ditches installed above the pit to "keep clean water clean". With the exception of a single flow check (Figure 7b), there were also no measures installed to restrict the flow of water out of the pit area, a significant omission in that the entire working area of the pit sloped toward the highway and Dawson Brook.

Figures 7a and 7b. North (looking toward entrance) and south (at entrance looking into pit) entrances to Spence Borrow Pit.

6.5 Inspections

According to TPW's Work Progression Schedule, all grading work and final slope protection for a given work area was supposed to be complete within 30 days (see Generic EPP). However, it was the opinion of the Project Engineer, because of the nature of the material (mostly rock), that the time limit be extended.

A TPW inspector was on site on a daily basis throughout the construction phase and thus carried out inspections at that frequency. The WQ data was frequently submitted to the Environmental Services group which provided an indication of control performance.

6.7 Fish Rescue

One of the Terms and Conditions accompanying the NSEL Water Approval was that approvals be obtained from DFO for fish rescue efforts associated with the two major culvert extensions (13+700 and 17+500). The environmental consultant, Jacques Whitford Environment Limited (JWEL), carried out fish rescues at 17+500 on August 14, 2003 and at 13+700 on August 30, 2003 at the request of Alva Construction Ltd.. Species recorded in TPW logs were 150 trout and 4 eels, and 82 brown trout, 4 mud suckers, and 6 eels, respectively.

DFO now issues "blanket permits" to qualified individuals both within the department and from the private sector as a means of improving the administrative process. Permit holders are required to submit a formal application which subsequently goes through an internal review process. The one requirement of a permit is that a record of activity is forwarded to DFO annually. The record is to include such information as rescue location and numbers by species. This type of permit provides a client, in this case Alva, with the ability to schedule activities with a much shorter lead up time.

It appears, following discussions with staff of Alva, TPW, DFO, and JWEL, that the fish rescue program administered by DFO might be more effective if they:

a) produce an information pamphlet that describes the program, and the responsibilities of individuals using the program;

b) consider the issuance of permits that would apply to all areas of a region for a specific period of time, similar to that of a federal fishing licence. This would reduce the program's administration and/or benefit a Contractor by providing them with a pool of individuals that have already gone through the permitting process;
c) publish a list of individuals/groups authorized to carry out fish rescues;
d) provide the above contact list somewhere in TPW contract documentation that contains the names of individuals/groups that are/have been certified through DFO to carry out fish rescues.

6.8 Erosion and Sediment Control (ESC) Measures Used

The various ESC measures specified on the ECP were not all installed as shown on the Plan. For example, all culverts on the Plan called for silt fencing to border the excavation area. However, fencing was installed at only the twin circular and box culvert sites. In other situations, the Contractor used 'adaptive management' and varied components of the Plan or added new components, to achieve the Project goals. The following subsections summarize our observations in two portions of the twinning project.

6.8.1 Highway Section 16+100 to 18+000

Erosion and sediment control measures identified in the ESC Plan focused on activities involving several small diameter culverts, a twin round culvert extension at 17+500, a retaining wall (located between 16+800 and 16+900), and sloped sections of the highway.

The ESC Plan called for silt fencing to be installed at each of the smaller diameter culvert sites. However, this was not carried out at any of these sites. For the less than 5 installations observed in both this highway section and 13+700 to 16+100 (see Report Section 6.8.2), it is unclear whether or not the presence of fencing would have reduced the amount of sediment in runoff flowing through these temporary excavations. For most, the areas on either side of the trench sloped away from the trench, limiting access of any precipitation event runoff to the trench. These culvert extensions were being installed to carry intermittent flows, and therefore, the contractor did not have to deal with flowing water, as was the case for the two larger culvert extensions. It was observed that during times when flow from the culvert sections of the existing highway was present and allowed to flow through the excavations, water ocasionally became turbid. The impact, if any, on the water quality on the two main receiving waters, Dawson and Bog Brooks, was not investigated.

Work on the twin culverts began on August 14, 2002. The process involved diverting the flow in Dawson Brook from one culvert to the other to allow for the pouring of the footing and subsequent laying of culvert sections for each of the two culvert extensions. A silt fence was used to delineate the working area, and the culverts were installed by August 29, 2002. During this period, a water sample was collected for TSS testing (TPW staff on August 23) at a location 10 metres downstream of the outfall. The TSS concentration was 4.5 mg/L. For comparison, the concentration upstream (Station 2) of the site was <2.3 mg/L. Ten additional samples were collected between August 29 and November 12, 2002 with TSS concentrations ranging from <1.8 to 23 mg/L (mean 4.8 mg/L). TSS levels were measured both upstream (2.3 mg/L - Station 2) and downstream (22.7 mg/L – Station 17) of the culvert site on September 16, 2002, and indicated that the disturbed areas for the new highway (including that of the new twinned culvert) was a source of TSS.

There were no additional forms of ESC employed at the site during the installation and construction of the retaining wall at 16+840 using sheet-piling to separate the main channel of Dawson Brook from the area in which the wall was to be erected (refer to Figure 8).

Figure 8. Retaining wall @ 16+840 showing sheet-piling barrier between construction area and Dawson Brook.

For sloped sections of the new highway, flow checks and a sedimentation pond were used. The flow checks were constructed using straw bale and 4 to 6 inch clear stone. The sedimentation pond, initially installed at 17+560 and later relocated to 17+600, was constructed using 4 to 6 inch clear stone. At the time of its installation, the basin was not considered useful since the slope of the area of highway, for which the structure was intended, was away from the pond. The intended benefit of the pond would have only come into play near the end of the project's completion, when final grading work would have directed highway runoff to the pond.

Mechanical sweeping was used to clear the various access points of soil that had been tracked on to the existing sections of paved highway. This was performed as needed.

In the absence of specific directions for ESC in the ECP for the Spence borrow pit, the effort to reduce the TSS load in runoff from the pit was limited to the use of flow checks. The flow checks were installed in the highway ditch draining the site using 4 to 6 inch clear stone, and an additional flow check was installed in the pit area near the exit of one of the pit's access roads. These structures did not appear to result in any significant decrease in suspended solid levels in runoff leaving the pit. However, there was a reduction in TSS concentration downstream due to the dilution effects of tributary streams and Dawson Brook itself. Prior to emptying into Dawson Brook, runoff from the pit mixes with a small feeder stream, and as a result, TSS concentrations were reduced by 40 to 90 percent. Subsequently, these levels were further reduced after this combined flow joined with Dawson Brook. TSS concentrations in Dawson Brook at Station 21: 16+990-D, which is located approximately 85m downstream of the point of discharge, were lowered by 40 to 85 percent.

SS testing on samples collected at Station 3 on Dawson Brook, located approximately 1.4 km downstream of borrow pit culvert outfall, revealed that concentrations at this location during four separate rain events were similar to those measured at Station 21. This suggests that either the impact zone of the Spence borrow pit outfall is at least 1.4 km in length, or that the TSS levels recorded at Station 3 are actually a reflection of the combination of the borrow pit load (less losses due to settling) plus additional sources of TSS contained in runoff between the two stations. Data from Station 3 on Dawson Brook enables us to compare the level of impact on water quality of construction activities draining to this station as well as that draining to Station 1 on Bog Brook.

6.8.2 Highway Section 13+700 to 16+100

Silt fencing, median flow checks, and a berm were installed in this section of highway. As with the previous highway section, silt fence was not used for any of the smaller culvert installations. It was used along the toe of the slope for the larger fill sections, and it was used extensively at the box culvert extension location (13+700) as per the ECP. TPW records indicate that a total of 450m was installed between 13+730 and 15+760. The monitoring program did not allow for a comparison of upstream/downstream water quality for individual control measures.

The flow checks, installed in the median along sloped sections of the highway, were constructed using straw bales and 4 to 6 inch clear stone as per the ESP. For the most part, the spacing of flow checks satisfied the requirement that the toe of the upstream flow check was at the same elevation of the notch in the flow check immediately down gradient. On occasion, the depth and width of the flow checks appeared to be greater than necessary.

During the construction phase of the box culvert (@13+700) when the diversion channel was operational, a berm was built across the width of the new section of highway to intercept runoff up-gradient of the diversion channel. Straw was used to stabilize the slope between the berm and the silt fence protecting the diversion channel (Figure 9). The berm was installed shortly after a 100+mm rainfall event of September 11-12, 2002. Prior to slope reconstruction and stabilization, there was evidence of rill erosion. A follow-up site inspection was not carried out, therefore, it is not possible to comment on the effectiveness of the treatments on the reduction of soil erosion at this particular location.

Figure 9. Construction zone in the area of the box culvert and stream diversion channel. A temporary berm was constructed to contain and divert runoff from the new section of highway away from the channel. The area down-gradient of the berm was stabilized with straw.

6.9 All-Terrain Vehicle Traffic and Water Quality (WQ)

The occurrence of all-terrain vehicle (ATV) traffic along sections of the new highway was observed to contribute to the erosion and subsequent suspension of soil in receiving watercourses. This was especially apparent in the highway ditch immediately downstream of the Spence Borrow Pit, where the growth of vegetation in the ditch was hampered by ATV movement.

6.10 Contractor Certification

Since 2000, TPW has made it a requirement that for all highway grading work, a contractor is to have at least one person on site that has attended the ESC Course for Construction Sites administered by CWRS.

For this project, Alva Construction Ltd. had three individuals (Site Foreman and two employees) in addition to the TPW Project Engineer on site that attended the course. However, TPW Inspectors responsible for daily site operations had not taken and this lead to conflicting opinions and questionable decisions in some instances.

7.0 CWRS FIELD MONITORING PROGRAM

The following section describes the field work that was carried out by CWRS, in addition to that performed by TPW Inspectors. The generic protocol for the demonstration project and that contained in the EPP for the Project can be found in Appendicies I and II, respectively. Appendix III presents a complete record of the WQ and streamflow data collected by both agencies. Time plots of flow and total suspended solids concentrations recorded for eleven rain events are contained in Appendix IV. Appendix V is a chronology of notable events recorded by TPW and CWRS staff, and participant comments can be found in Appendix VI.

7.1 Watershed Mapping

Topographic 1:10,000 scale maps sheets 10 44 9000 63 900 and 10 44 9000 64 000 (obtained form Service Nova Scotia – Land Information Centre/Registry of Deeds) were used to delineate watershed boundaries, calculate areas, and locate water sampling locations. The total area draining to the hydrometric station established by CWRS on Bog Brook was determined to be 27.4 km^2.

It should be noted that Dawson Brook is tributary to Bog Brook, and because of this some portion of TSS measured in the Dawson Brook watershed will contribute to that observed at selected Bog Brook locations. Refer to Figure 10, Dawson Brook (cloudy) entering Bog Brook (smaller channel).

Figure 10. The confluence of Dawson Brook (cloudy body of water to left of picture) and Bog Brook (smaller channel entering from right side).

7.2 Streamflow

A stream stage recording station was established on Bog Brook approximately 250 metres downstream of the box culvert outfall (13+700) (see Figure 1). The recording station consisted of a steel outer chamber bolted to a concrete pad through which a 2-inch diameter ABS stilling well extended. Water level in the well was measured using a Shape Instrument Model SH3500 pressure transducer, and a Campbell Scientific Inc. CR10 datalogger was used to record the water level at 15-minute intervals. The data recorded by the logger is actually a measurement of electrical voltage.

Converting the voltage readings to streamflow involved two steps, requiring two mathematical relationships, transducer output voltage versus stage, and stage versus flow.

Bog Brook flows were recorded between July 12 and October 28, 2002. Figure 11 illustrates the stage recording site where a metal box mounted to a concrete pad was used to house the data logger and pressure transducer, and a staff gauge fastened to the tree was used to measure stage for pressure transducer calibration.

Figure 11. Bog Brook stage recording site. A metal box mounted to a concrete pad was used to house the data logger and pressure transducer. A staff gauge fastened to the tree was used to measure stage for pressure transducer calibration.

7.3 Rainfall

A rainfall recording station was established adjacent the Highway 101 Ellershouse overpass on the property of Mr. Nathaniel Spence (refer to Figures 1 and 12).

Figure 12. Tipping bucket and standard rain gauge were located on the property of Nathaniel Spence bordering Highway 101 on the northeast side of the Ellershouse highway overpass.

A tipping-bucket rainfall gauge was connected to a CR10 datalogger and was programmed to record bucket tips occurring at 1-minute intervals (each tip is equivalent to 0.2mm of rainfall). The instrument was installed on July 16, 2002, and a standard rain gauge was installed at the site on July 19 for data cross-referencing purposes. For this project, an event is defined as one with a minimum of 0.2mm total rainfall falling over a 24 hour period and discrete events separated by a period of at least 24 hours with no measurable (<0.2mm) rainfall. The number of rain events occurring during the study period of July 19 to October 28, 2002 was 43 (34 events between 0.2-10mm, 7 between 10-25mm, and 6 greater than 25mm).

7.4 CWRS/TPW Water Quality Monitoring Program

Although the CWRS and TPW programs were run independently, several water sampling sites were common to both programs. These included the upstream and downstream stations for the two larger culvert extensions, and the Spence borrow pit stations (station numbers are 1, 3, 9, 17, 18 and 21. See Figure 1).

Water samples for the CWRS program were collected using both automated and manual grab sampling methods. The majority of water samples were retrieved using two Isco Inc. portable samplers (Models 3700 and 6712). Three stations within the watershed were identified for automatic monitoring, including Dawson Brook above the construction impact zone, Dawson Brook at the approximate mid-point of the construction zone, and Bog Brook at the lower end of the impact zone. In addition to the 3 sites identified for automatic sampling, numerous locations within the watershed were selected for grab sample collection. These sites were used to document the ability of various control measures (silt fence, flow checks, compaction of exposed surfaces) to reduce the impact on water quality of specific construction activities (borrow pits, stream diversion, culvert installation, sub-grade development). The TPW program utilized the grab method for all its water sample collection.

In total, 668 samples were collected during the study. Analyses performed included turbidity (561 tests) and total suspended solids (SS)(592 tests) testing. Of the 668 samples, 104 were collected by TPW staff for TSS analysis through a private laboratory as part of the Water Quality Monitoring Program outlined in the EPP.

Eleven of the 29 rain events recorded during the study (3 events between 0.2-10mm, 4 between 10-25mm, and 4 greater than 25mm) were selected for multiple sample collection using the Isco samplers.

8.0 CWRS MONITORING PROGRAM RESULTS

Water quantity and quality data collected by CWRS during this project are summarized in the following section.

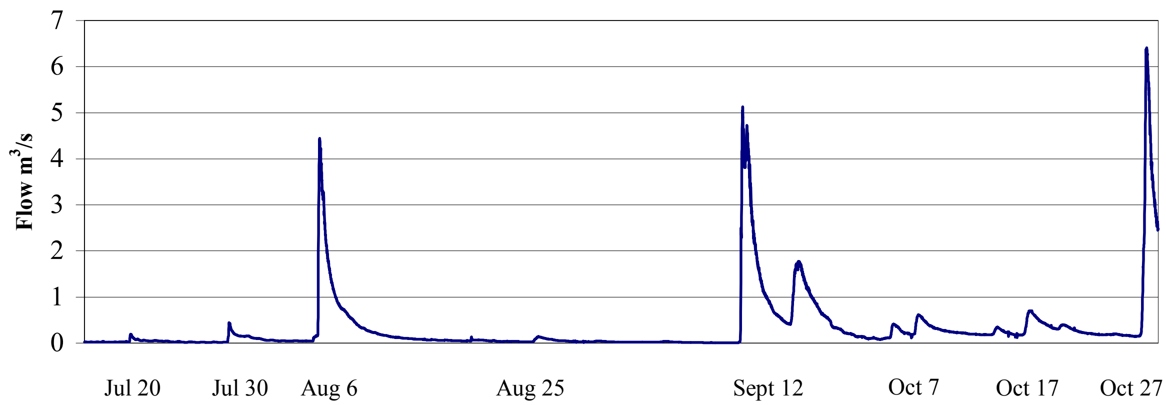
8.1 Streamflow and Rainfall

Streamflow in Bog Brook ranged from 0.004 to 5.435 m^3/s. In the absence of historical records, it is difficult to comment on the flows witnessed during the study. However, given the measured rainfall for the study period, it is likely that the volume discharged was above normal.

Total rainfall for the period between July 12 and October 28, 2002 was 451.0mm, highlighted by three significant rainfall events each contributing more than 50mm to that total (August 6 – 59.6mm; September 11 – 107.4mm; October 26 – 57.0mm). When compared with average monthly records from climate stations at Windsor/Martock and Summerville (operated by Environment Canada), the amount of precipitation experienced during the study was above normal (refer to Table 1).

Differences can be accounted for in September's rainfall alone, which was seen to be more than 75mm above 30-year normals (1971-00) for both EC stations. It is interesting to note that the September 11 event surpassed the extreme rainfall in a 24-hour period for the month of September by 79.6mm (September 2, 1996) for Windsor/Martock and 70.0mm (September 1, 2001) for Summerville. A total of 105.4mm fell in 24 hours at the CWRS Ellershouse site. Figure 13 illustrates the flow measured for the study period.

Figure 13. Bog Brook hydrograph for the period July 12 to October 28, 2002.



8.2 Water Quality (WQ)

The WQ program used in this study and the data collected from twenty-four sites have resulted in the generation of valuable information that can be used not only to evaluate the effectiveness of ESCs applied to this section of highway, but that can be also used to assist in the development of a WQ monitoring protocol for future highway projects.

A total of eleven rain events were monitored for total suspended solids and turbidity analyses. The data is summarized in Table 2.

Selecting sampling stations on both Dawson Brook and Bog Brook essentially split the receiving watershed into three zones (top, middle and base), making it possible to examine the cumulative effects of each zone on water quality. Data gathered from the top station, Station 2 (Dawson Brook), represents background water quality conditions, the middle station, Station 3 (Dawson Brook), represents the impacts due to construction activity between 18+000 and approximately 16+100, and the base station, Station 1 (Bog Brook), represents the net impact of the entire activity as well as that between 16+100 and 13+600.

Extreme levels of TSS were recorded on two occasions during the study. The first occurred during the rain event of August 6, 2002, the second during the September 11, 2002 event.

Flow in Dawson and Bog brooks leading up to the August 6th event were extremely low at 0.01 and 0.04 m^3/s, respectively. It was noted during TSS testing by CWRS that the bulk of the material making up the filterable particulate matter in samples collected from Dawson Brook WQ Station 1 (background water quality station for the project) was dark in appearance and its texture coarse. This material was presumed to be organic debris that was flushed from the system as a result of the higher

Table 1. Comparative rainfall information.

	CWRS 2002 Station	Windsor/Martock[1]	Summerville[1]
Latitude	45° 07'N	44° 56'N	44° 57'N
Longitude	64° 11'W	64° 10'W	64° 00'W
Elevation, m	65.0	38.1	38.1
Distance, km, from CWRS study station	-	12	20
30 Year Normals - Rainfall, mm, for Month of:			
July	49.2[2] (actual for month)	86.6	73.7
August	106.4 (actual for month)	75.3	72.1
September	179.6 (actual for month)	101.8	93.0
October	115.8 (actual for month)	108.5	92.6
Totals	451.0	372.2	331.4

Days with rainfall greater than or equal to:	July[2]	August	Sept	October	July	August	Sept	October	July	August	Sept	October
0.2mm	4	10	16	17	11.0	9.7	10.7	12.4	8.5	7.9	8.6	9.5
5mm	2	5	6	6	4.7	4.4	5	5.5	4.4	4.4	5.2	5.4
10mm	1	4	4	3	2.6	2.7	3.4	3.8	2.2	2.3	3.1	3.0
25mm	0	1	3	1	0.81	0.76	1.2	1.2	0.75	0.63	1	0.86

[1] Source - http://www.msc.ec.gc.ca/climate/climate_normals/index_e.cfm

[2] for the period July 19-31

Table 2. Rain event summary for the period August 6 – October 26, 2002 documenting rainfall, flow, and total suspended solids.

Event	Date	Rainfall					Flow		Suspended Solids (SS), mg/L				
	2002	Start	End	Total mm	Duration hrs	Average Intensity mm/hr	Min-Max1 m^3/S	Flow Peak hrs after start of event	Location	Range	Duration > 25 mg/L hrs	Mean Conc. for period >25 mg/L # samples in ( )	Peak hrs after start of event
1	6-Aug	Aug 6 @ 0533	Aug 7 @ 0252	59.6	21:24	2.8	0.041-4.920	13.7	Bog Brook	1-1890	6	520 (6)	13
									Dawson Station 1	1.5-150	2	108 (2)	11.0
									Dawson Station 2	-	-	-	-
2	25-Aug	Aug 25 @ 0005	Aug 25 @ 1736	16.4	17:31	0.9	0.029-0.140	11.7	Bog Brook	0.9-15	0	-	9.0
									Dawson Station 1	0.3-2.7	0	-	7.0
									Dawson Station 2	-	-	-	-
3	4-Sep	Sept 4 @ 1850	Sept 5 @ 0328	5.4	8:38	0.6	0.021-0.035	11.7	Bog Brook	0.3-16	0	-	*
									Dawson Station 1	0.5-1.4	0	-	8.5
									Dawson Station 2	-	-	-	-
4	11-Sep	Sept 11 @ 1154	Sept 12 @ 1317	107.4	25:23	4.2	0.006-5.127	13.8	Bog Brook	1.1-3180	17	450 (17)	11.0
									Dawson Station 1	1.0-45	3	37(3)	10.0
									Dawson Station 2	-	-	-	-
5	15-Sep	Sept 15 @ 1339	Sept 16 @ 2120	35.0	31:34	1.1	0.409-1.779	31.1	Bog Brook	1.2-90	8	56 (8)	19.5
									Dawson Station 1	1.7-2.4	0	-	14.5
									Dawson Station 2	-	-	-	-
6	23-Sep	Sept 23 @ 2228	Sept 24 @ 0912	3.4	10:44	0.3	0.078-0.121	12.3	Bog Brook	1.1-5.0	0	-	*
									Dawson Station 1	-	-	-	-
									Dawson Station 2	1.1-1.4	0	-	*

Table 2 continued,

Event	Date 2002	Rainfall Start	Rainfall End	Total mm	Duration hrs	Average Intensity mm/hr	Flow Min-Max[1] m^3/S	Flow Peak hrs after start of event	Suspended Solids (SS), mg/L Location	Range	Duration > 25 mg/L hrs	Mean Conc. for period >25 mg/L # samples in ( )	Peak hrs after start of event
7	27-Sep	Sept 27 @ 1253	Sept 28 @ 1109	20.0	22:16	0.9	-	-	Bog Brook	0.8-225	5	116 (5)	24.0
									Dawson Station 1	-	-	-	-
									Dawson Station 2	0.5-22	0	-	21.0
8	3-Oct	Oct 3 @ 0425	Oct 3 @ 1118	9.6	6:53	1.4	-	-	Bog Brook	0.8-3.6	0	-	*
									Dawson Station 1	-	-	-	-
									Dawson Station 2	1.0-2.0	0	-	4.5
9	7-Oct	Oct 7 @ 1346	Oct 7 @ 1928	11.8	5:42	2.1	0.186-0.616	10.0	Bog Brook	0.3-34	2	33.5 (2)	7.0
									Dawson Station 1	-	-	-	-
									Dawson Station 2	0.9-11	0	-	4.5
10	16-Oct	Oct 16 @ 2021	Oct 17 @ 0809	15.8	11:48	1.3	0.177-0.705	18.4	Bog Brook	1.2-15	0	-	10.5
									Dawson Station 1	-	-	-	-
									Dawson Station 2	0.8-9.6	0	-	9.5
11	26-Oct	Oct 26 @ 2132	Oct 27 @ 1045	57.0	13:13	4.3	0.154-6.41	15.0	Bog Brook	0.4-130	13	78 (13)	8.0
									Dawson Station 1	-	-	-	-
									Dawson Station 2	0.4-50	9	40(9)	7.5

[1] min = flow 2 hours before start of event; max = peak flow for the period 2 hours before start of event and 24 hrs after rainfall ceased

* no defined TSS trend

flows. TSS levels at Station 1/Bog Brook ranged from 1 to 1890 mg/L. Observations by TPW staff indicated that sources of "dirty water" were the borrow pits developed in the vicinity of 14+000.

The September 11-12, 2002 event was characterized by rainfall amounts of 107.4mm in just over 25 hours. As previously mentioned, the diversion channel installed at 13+700 as part of the box culvert extension failed, resulting in the flooding of the working area and displacement of sections of the diversion channel liner. During this event TSS levels reached 3180 mg/L at Bog Brook Station 1. It is likely that eroded soil from this area was a significant contributor to the elevated TSS concentrations recorded downstream.

As expected, the concentration and duration of elevated levels of TSS in receiving waters were related to the amount of rainfall in an event (i.e., the greater the amount of rainfall, the higher the level of TSS). For monitored rain events of less than 10mm, although TSS levels did rise, at no time did concentrations at Station 1/Bog Brook exceed 25 mg/L. For rain events between 10 and 20mm, TSS levels rose above the 25 mg/L guideline for up to 5 hours during a single event. For more than 20mm of rainfall, this time increased to between 6 and 17 hours.

The response time for TSS peaks ranged from 4.5 to 14.5 hours after the start of an event for Station 2/Dawson Brook, 4.5 to 21 hours for Station 3/Dawson Brook, and 7 to 24 hours for Station 1/Bog Brook. This information is extremely important when considering event selection and timing of sample collection when establishing a monitoring protocol. Given the wide range in response times, automated sample collection techniques provide better estimates of sediment concentration and loads.

8.2.1 Sediment Loads

Water quality and quantity data collected during the study was used to estimate TSS loads generated in specific sub-watersheds of Dawson and Bog Brooks during individual rain events. Water quality data from Station 3/Dawson Brook and Station 1/Bog Brook, and flow data from the hydrometric station, were used for the calculations.

Sediment load is a product of flow and concentration. The TSS load for Bog Brook, representing the load for the entire watershed (including that estimated for the Dawson Brook sub-watershed) was calculated by applying streamflow records directly to TSS data for Bog Brook (Station 1). The estimate for the Dawson Brook sub-watershed, was subsequently calculated using the same Bog Brook flow record, but adjusted based on drainage area. Construction activity taking place between 16+100 and 18+000 appeared to have the greatest impact on water quality in the Dawson Brook sub-watershed, while the same was true for the area bounded by 13+700 and 16+100 in the Bog Brook sub-watershed.

Both WQ monitoring stations were operated during the period between September 16 to October 28, 2002, allowing a comparison of loads generated in each of the two basins. Four rain events were monitored and TSS loads estimated. Results are contained in Table 3.

Table 3. Suspended solid load estimates for 2 sub-watersheds in the Bog Brook watershed.

	Dawson Brook @ WQ Stn 3	Bog Brook @ WQ Stn 1	Total
Drainage Area, km^2	12.4	15.0	27.4
Length of twinned highway section, km	3.0	2.5	5.5
Disturbed Area, km^2 (assumed 30m width)	0.09	0.075	0.165
Drainage Area:Disturbed Area, percent	0.7	0.5	0.6

Rain Event From	Rain Event To	Amount mm	Total Suspended Solids Load for the period specified, kg: Dawson Brook @ WQ Stn 3	Bog Brook @ WQ Stn 1	Total
Sept 23 2000	Sept 24 1630	3.4	5	10	15
Oct 7 1430	Oct 8 1200	11.8	65	200	265
Oct 16 0915	Oct 17 1530	16.0	70	600	670
Oct 26 1830	Oct 27 1830	57.0	2850	10900	13750

It is clear from estimates presented in Table 3 that for the rain events monitored, the greater portion of the TSS load, approximately 80%, came from the Bog Brook sub-watershed, even though the Dawson Brook sub-watershed contained a slightly longer section of highway under construction (3.0 km versus 2.5 km). Factors that may have played a role in the load differential include:

a) The stage of construction during the monitoring period. At the time of monitoring the section of highway in the Dawson Brook sub-watershed was at a stage where coarser material was in use, which would have been less likely to erode than fine material;
b) The slope (i.e. The greater the slope, the greater the potential for erosion). The slope of the Dawson Brook highway section was considerably less than that of the Bog Brook section;
c) The travel distance. Runoff from the highway section in the Dawson Brook sub-watershed had a longer distance to travel before reaching the main channel of the brook. Several of the highway culverts carrying the sediment laden highway runoff drain via intermittent stream channels to vegetated areas, which enhances the sediment removal process. Also, an increased travel distance also increases the time available for suspended particles to settle; and
d) Point sources. Operation of the Spence borrow pit, a major source of TSS to Dawson Brook while active had ceased, and a earth berm stabilized with straw was installed to seal off one of the entrances on September 27, 2002.

9.0 COMPARISON OF GENERIC AND EPP WATER QUALITY MONITORING PROTOCOLS

As earlier stated, the generic protocol was developed by CWRS to assess recommendations of the report "Construction Sediment: Effects in the Freshwater Environment and Responses for Government Agencies". Comparisons of the main components of the CWRS generic protocol developed for this study and the TPW monitoring protocol developed for the Highway 101 twinning project (TPW 2001) are listed in Table 4.

Table 4. Listing of component descriptions for protocols developed by TPW and CWRS

Component	TPW EPP Protocol	CWRS Generic Protocol
Start Date of Monitoring Program	Not specified	Commencement of grubbing operations
Timing/Frequency of Sample Collection	Rain Events >25mm 2-4 hrs after start of event If event >12 hrs, 2nd set to be collected 12 hrs after start + 3rd set 2-4 hrs after end of event	Rain events >5mm considered Hourly sampling frequency First sample to be collected 30-60 min after start of event Final sample set collected 24 hrs after end of event
Location	Upstream/Downstream	Upstream/Downstream within 100m of construction zone boundary Ideally, at mid-stream and at mid-depth For downstream sites: below point of complete mixing
Station Identification	None specified	Sites to be marked using shoreline stakes and/or flagging
Technique	Manual grab	Manual/Automatic grab
Sample Collection	Rinse bottle 3 times Sample facing upstream Avoid collecting surface debris or stir up sediment	Rinse bottle 3 times with min. 50 mL of water to be sampled Sample facing upstream Avoid collecting surface debris or stir up sediment
Sample Bottle Labeling	Date, Time, Location, Analyses	Date, Time, Location
Sample Handling	Chilled to 4^{o}C Submitted to lab when practical	Chilled Manual grab samples delivered to lab within 3 hrs of collection Automatic grab samples delivered within 12 hrs of collection
Forms	Lab Chain-of-Custody	Lab Chain-of-Custody
Reporting	Not Specified	To designated departments when TSS >25 mg/L, otherwise monthly
Field Notes	Yes	Yes

10.0 RECOMMENDATIONS

There were challenges associated with the monitoring requirements detailed in the EPP. As such, the following recommendations are made:

1) A start up date should be referenced to a specific construction activity.
2) WQ monitoring be limited to events greater than 10mm, as TSS levels in receiving waters did not exceed 25 mg/L during rain events of less than 10mm falling in a 12 hour period. For the four events monitored with rainfall amounts between 10 and 20mm in 24 hours, TSS concentrations exceeded 25 mg/L for periods up to 5 hours, with levels approaching 35 mg/L. Prolonged periods of elevated TSS concentrations were recorded during events exceeding 20mm total rainfall.
3) Whether the purpose of the monitoring program is to quantify sediment loading or simply to report peak TSS concentrations, and given the wide range of response times observed during this project, an automated grab sampling technique should be considered in order to ensure adequate temporal coverage of stream water quality during individual precipitation events.
4) Automated sampling runs should commence 1-2 hours after the start of the rain event to record pre-event conditions and continue for 24 hours, collecting samples hourly. A final sample should be collected approximately 24 hours after the end of the event.
5) Samples should indicate the location of sample collection in the water body itself. (i.e., surface or mid-depth, and mid-stream or near shore, etc.).
6) All water sampling sites should be marked to ensure that sampling is consistent throughout the monitoring program.
7) Water samples must be delivered to a laboratory for processing within an appropriate amount of time. For example, pH measurements should be analysed within 2 hours, turbidity in 24 hours and total suspended solids 7 days, provided the sample has been refrigerated.

The following recommendations arose from observations made in the field and from informal discussions with TPW and Alva staff.

7) **Field Notes -** It is recommended that TPW staff performing water quality sample collection duties record sample retrieval times for each sample location. On occasion, only a single time representing several sampling sites in a sampling run was available.

8) **Diversion Channels -** It is recommended that the design and sequencing of steps for the installation of diversion channels be reviewed. Three points in particular:
   a) Alignment of upstream barrier (i.e. sheet-piling, sand bags) should be angled to stream flow to reduce the turbulence generated by the presence of the dam structure.
   b) The upstream barrier should extend to form the first 2-3 metres of the channel wall, overlapping the liner material of the channel. Under no circumstances should soil material making up the walls of the channel be exposed to erosional forces of the brook water.
   c) A cofferdam should be constructed such that the removal of the streambank plug at the upstream end of the diversion channel is done in the dry. In this way, the channel liner could be extended in to the existing stream channel without being exposed to flowing water and, in turn reducing the potential for siltation.

9) **Borrow Pits** –The process by which regulatory agencies are notified of borrow pit activity should be consolidated to enhance the exchange of information between parties, as both sections of NSEL (Environment and Labour) require notification of borrow pit activity.

10) Fish Rescues –

DFO responsibilities:

d) Produce an information pamphlet that describes the program, and the responsibilities of individuals using the program.
e) Consider the issuance of permits that would apply to all areas of a region for a specific period of time, similar to that of a federal fishing licence.
f) Publish a list of individuals/groups authorized to carry out fish rescues.

TPW responsibilities:

a) Incorporate the above contact list somewhere in contract documentation that contains the names of individuals/groups that are/have been certified through DFO to carry out fish rescues.

11) Erosion and Sediment Control Course

It is recommended that the TPW Inspectors attend the ESC course to ensure effective communication between the contractor and TPW inspectors when making decisions regarding ESC issues or adaptive management measures.

11.0 REFERENCES

Cann, D.B., J.D. Hilchey, and G.R. Smith. 1954. Soil Survey of Hants County Nova Scotia. Report No. 5, Nova Scotia Soil Survey. N.S. Canada Department of Agriculture, Truro, N.S..

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Clesceri, L.S., A.E. Greenberg & A.D. Eaton, eds. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health Assoc., American Water Works Assoc., & Water Environment Fed., Washington, D.C.

Nova Scotia Department of Transportation and Public Works. 2001. Highway 101 Environmental Protection Plan, Water Quality Monitoring Protocol. August.

APPENDIX I

GENERIC PROTOCOL

AI.1.0 Objective

This protocol describes measures that are be undertaken in a pilot/demonstration project to address the issues presented in Waller et al. (2001). It is understood that the information obtained and recorded, and any associated performance assessment, is not intended to be used for regulatory purposes, i.e., that any assessment for regulatory purposes should be carried out in parallel with, but independently of, this project.

AI.2.0 Pre-job Activities

Pre-job meetings will be held with the developer, consultants, contractor, and regulators, in order to:
1. Review the project and project objectives.
2. Determine and record their respective understandings of the anticipated responsibilities of each party related to the pilot/demonstration project.
3. Identify whether one or more of the contractor's staff have received special training in erosion and sediment control, and determine and record their expected role(s) in conduct of the project.
4. Review the erosion and sediment control plan.
5. Determine and record whether the plan was based on any specific requirements, guidelines, standards or references.
6. Determine and record requirements for submission, review and approval of the plan.

AI.3.0 Site-Based Records

Information to be obtained and recorded during and following the project will include, with copies of relevant documents where appropriate:
1. Erosion and sediment control measures undertaken in conformity with the plan
2. Contingency measures undertaken to in response to site or weather conditions.
3. Erosion and sediment control related activities of the staffs of the developer, consultant(s), contractor, and regulators.

It is anticipated that this information shall be obtained with the collaboration and cooperation of the staff of the developer, consultant(s), contractor, and regulators.

AI.4.0 Water Quality Sampling

AI.4.1 Objectives

The field sampling program recognizes the following objectives:

(a) Judgements should be based on analyses of samples from the water column of streams (for total suspended solids, possibly supported by turbidity measurements), taken upstream and downstream of a constructions site; the number and timing of samples should be sufficient to define both the concentration and duration of elevated solids levels, and should consider watershed size, site area, and storm duration.

(b) The water quality monitoring program should recognize that:

- Sampling of effluent leaving a construction site may help to identify the source, but in the absence of flow measurement cannot assess the magnitude of sediment loads entering a receiving water.

  - Any sediment in drainage from a construction site in dry weather should be considered as potential evidence of poor erosion and sediment control practices.

(c) If numerical limits on sediment concentrations are applied, they should be applied to samples from the water columns of streams that are recognized as fish habitat, or where limits are established for another water use.

(d) Numerical limits should be based on permitted increases in concentrations of total suspended solids, possibly supported by turbidity measurements, compared with background concentrations in samples collected upstream of the construction site, and should be defined in terms of the magnitude and duration of increased concentrations.

(e) Numerical limits for total suspended solids in streams in Canada, cited in Section 4 of Waller et al. (2001), are increases, above background concentrations, of up to 25 mg/L or 10 percent of background values.

(f) If numerical limits are applied they should recognize:
  - that the number and frequency of samples should be sufficient to define both the concentration and duration of elevated total suspended solids levels, and should take into account the relative size of the site and the stream watershed, and the storm duration; and
  - that any limits that are applied may be exceeded in exceptional storm events, and that it may be appropriate to define a "design storm" to which the limits apply.

This protocol is not designed to cover situations where construction site runoff discharges to large river systems or lakes where the mixing zone is extremely large or if the objective of a monitoring program is to delineate the impact zone below a point of discharge. Amendments to the protocol would need to be made in these cases.

AI.4.2 Sampling Locations

Background levels of parameters being tested will be measured from a site upstream of the impact zone. The site can typically be identified within 100m of the construction zone boundary.

If possible, a water sample station will be established to monitor the quality of water leaving the site before entering the receiving water. Being able to do this will depend on the configuration of the construction site and whether runoff from the site enters a receiving water via point source discharge or overland flow.

Downstream samples will be collected at a point nearest the lower boundary of the construction site at which runoff from the site has mixed with the receiving water.

To ensure that the site of sample collection is a reasonable representation of the cross-sectional flow at the time of collection, eddies and nearshore sites will be avoided. Due to reduced flow velocities, suspended particulate tends to concentrate in these areas. Water should be taken from mid-stream at mid-depth. For situations where safety is an issue, a suitable alternative to the mid-stream location should be used.

Shoreline locations will be marked using stakes or flagging to identify sampling sites.

AI.4.3 Sample Containers and Labeling

It is imperative that proper size and type of sample container be used in the sampling process and that proper sample handling steps be followed. Use sample bottles supplied by the laboratory performing the analyses. Labeling on all sample containers should be done in indelible ink and include, at a minimum, the following information:

- site code and/or name and location
- project #/name
- date and time of collection

Clear plastic tape applied to the completed label will provide added protection against damage and possible loss of information.

AI.4.4 Field Notes

Field logbooks will be used to maintain a written record of all water samples collected and submitted for analysis and site observations. Information that should be included is:

- site identification code and/or name
- location
- date, time and name of collector
- sample type (grab, automatic)
- weather conditions (including air and water temperature)
- site observations
- record of any photographs taken. Photographs of all sampling locations should be taken. Random photographs should also be taken to document progression of construction activity. Each photograph should be documented in the field logbook and on the back of the photograph with the following items: date, time, photographer, site name, code or picture number for cataloguing purposes
- sketches made
- sequencing of construction activity (useful when comparing activity with water quality results)

AI.4.5 Water Sampling Procedures

For logistical (timing of sample collection and cost) reasons, both manual and automatic sampling techniques will be considered. For both sampling techniques, special attention will be given to the exclusion of bedload sediment (comprised of sediment present prior to a specific event as well as that being deposited to during that event) from water being collected for analysis. Elimination of the bedload component from the process is intended to suppress potential masking effects that could influence the interpretation of erosion control efficacy.

The manual grab sampling technique will be used for non-event sampling runs, events where automatic sampling equipment is not available, and the occasional final sample set for event sampling where automatic samplers are used. Automatic grab sampling will be employed during the majority of precipitation events.

AI.4.5.1 Grab Samples

The following steps will be carried out during grab sample collection. Each sampling run will start at the downstream location, moving to the upstream location. In this way, disturbance related to the sampling procedure will not affect samples on the upstream side. For the same reason, individual samples will be collected while facing upstream.

Step 1. Before immersing sample bottle in water, the appropriate information in a field logbook and on the bottle label will be recorded.

Step 2. Sample bottles will be rinsed three times with at least 50 mL of stream water from intended sampling location. In stream sampling will occur at mid-stream and at mid-depth, conditions permitting. In the event that streamflow and water depth result in unsafe water sampling conditions, the water will be collected from a suitable alternative. No interior surface of the sample container will be touched during the rinsing or collection process. When water levels are low, and the likelihood of disturbing streambed material during the sampling process high, withdrawal of water at mid-depth may not be practical. In these situations, a sample will be collected from the water surface. In all sampling circumstances, floating debris should be avoided.

Step 3. The sample bottle with cap in place will be submerged to mid-depth at mid-stream. Filling of the bottle will be regulated using the cap. When full, the bottle will be recapped while submerged.

Step 4. After collection and during transport from site to laboratory, all water samples will be kept upright in a chilled cooler.

AI.4.5.2 Automatic Sample Collection

Automated liquid samplers introduce considerable flexibility and cost savings to a monitoring program. When compared to a manual water quality monitoring program, manpower requirements and travel costs are significantly reduced. Exposure of field staff to extreme weather and likely hazardous working conditions (darkness, wet, slippery footing) is also reduced when automatic samplers are employed.

Automatic liquid samplers are equipped with a microprocessor control and storage for one or more sample containers (typically 375 mL – 9.45 L capacity). Sampling frequency and sample volume are easily programmable. Contrary to the grab method of sample collection, sample bottles will not be pre-rinsed with sample water. Only the transmission tubing will undergo this operation as part of the sample line purging process.

Reinforcing bar will be used to position the intake of the sample retrieval hose in the stream at each automated sampling site. The transmission tubing will be anchored on the streambed using larger stream substrate. The instrument will be programmed prior to each event being monitored. Within 12 hours of the completion of each sampling run, samples will be retrieved, transferred to appropriately labeled laboratory supplied sample bottles and transported to the laboratory for processing. When samplers are operated in temperatures above $4^{o}C$, collected samples will be kept cool during individual runs using ice placed in the built-in storage compartment in the sampling unit.

It may be necessary to protect equipment in the field from theft and acts of vandalism. In the event that security is an issue, sampling equipment will be housed in vandal-resistant enclosures situated on the streambank.

AI.4.6 Sample Handling

Following the collection of water samples in the field, their transport to the laboratory for analysis will entail:

1. placement of samples upright in chilled coolers. Blocked or cubed ice, or freezer packs will be used to generate chilled conditions.
2. delivery of samples to the laboratory within 3 hours of collection, in the case of manual grab samples, or 12 hours following the completion of an automated sampling run.
3. all samples submitted for analysis should be accompanied by chain-of-custody forms supplied by the laboratory.

AI.4.7 Monitoring Program Startup and Sampling Collection Timing and Frequency

AI.4.7.1 Pre-Construction, Construction, Wintertime Closures and Post-Construction Periods

AI.4.7.1.1 Pre-Construction Period

It is assumed that the water quality data at upstream locations will be representative of background conditions and that observed differences in water quality between the upstream and downstream locations is attributable to the construction activity. Therefore, no pre-construction water quality data collection will take place.

AI.4.7.1.2 Construction Period
The monitoring program will be implemented when grubbing operations commence.

AI.4.7.1.2.1 Non-Event Sampling Component
Manual grab water samples will be collected from all upstream and downstream sampling locations once during each calendar week for the entire construction period. The day of week and time of day will vary. A 24 hour period of no precipitation shall precede every sampling run in this category.

AI.4.7.1.2.2 Rain Event Sampling Component
All rain events with forecast amounts in excess of 5mm over a 24-hour period will be considered for monitoring. For these events, automatic grabs will be collected at hourly intervals for the first 24 hours of rain event, ideally starting within 30 minutes and no more than 60 minutes beyond the onset of runoff. If a particular event extends beyond the 24-hour period, the decision to continue sample collection and at what sampling frequency will be made at that time. Each event series will conclude with an upstream and a downstream manual grab sample taken approximately 24 hours after rainfall has stopped.

During each monitored event, occasional grab samples will be collected from sampling stations established for the purpose of characterizing construction site drainage. These samples are different than the upstream/downstream samples in that they represent point sources.

AI.4.7.1.3 Wintertime Closures
If construction activities are incomplete and subsequently postponed over the wintertime period, water quality will be tested at all sampling sites monthly.

AI.4.7.1.4 Post-Construction Period
A modified monitoring program will be carried out for one year following the completion of the project. The program should consist of bi-monthly grab samples from all upstream and downstream water quality stations. At least half of the samples collected will be representative of precipitation event conditions.

AI.4.8 Field and Laboratory Analyses
Water temperature will be recorded for all manual grab samples. All water samples collected will be tested for turbidity and total suspended solids. Turbidity shall be measured using a nephelometric method, while total suspended solids shall be determined gravimetrically using suitable glass fibre filters, as described in Standard Methods, 20th Edition (1998).

AI.4.9 Precipitation Monitoring
The amount of rain falling during a monitored event will be recorded using a standard rain gauge. It is beneficial to have available data that can be used to calculate rainfall intensity. The automated equipment used for this purpose will, at a minimum, be able to record cumulative rainfall at 5-minute intervals.

AI.4.10 Streamflow Metering
Collection of streamflow data is paramount to the determination of total suspended solids loads. It is also critical in the examination of watershed responses to anthropogenic influences such as highway construction. A continuous flow record is necessary to adequately address both topics. Therefore, automated equipment used for this purpose will be capable of recording stream stage at a minimum of

15-minute intervals. A streamflow gauging will be established according to Environment Canada guidelines (see Environment Canada website in Reference Section).

AI.4.10 Reporting

During the construction phase, field and water quality reports will be forwarded to designated Department(s) on a monthly basis and on a quarterly basis during the wintertime closure and post-construction periods. In the event that total suspended solids levels exceed 25 mg/L above background levels, results will be forwarded immediately.

AI.5.0 References

Waller, D.H., R.S. Scott, P. Saunders, and M. House. 2001. Construction Sediment. Effects in the Freshwater Environment and Responses for Government Departments. Centre for Water Resources Studies, Dalhousie University, Faculty of Engineering, Internal Report No. 01-5.

Clesceri, L.S., A.E. Greenberg & A.D. Eaton, eds. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health Assoc., American Water Works Assoc., & Water Environment Fed., Washington, D.C.

Environment Canada Website - http://www.msc.ec.gc.ca/wsc/CDP/index_ie_e.htm

APPENDIX II

TPW Water Quality Monitoring Protocol (from the Highway 101 EPP; August 2001)

AII.4.0 Monitoring

AII.4.3.5 Water Quality

AII.4.3.5.1 Baseline Water Quality

Baseline water quality information has been collected for several of the water courses along the alignment (Appendix F of EPP, not included here). Additional water quality information will be collected immediately prior to construction to ensure that water quality are fully documented at that time.

The pre- and post-construction water quality samples shall e collected at upstream and downstream sites at the following locations:

- Inlet to Lacey Lake
- Lacey Lake
- Duck Pond Brook
- West Lake Outlet
- Five Mile Lake
- Dawson Brook
- Outlet from Five Island Lake
- Bog Brook

(Note: Dawson and Bog Brooks are the only 2 watercourses located in the demonstration project's watershed).

Parameters to be tested shall include: pH, general chemistry, total suspended solids, and metals. Pre-construction and post-construction samples shall be collected at the same time of year but high and low flow periods shall be avoided. Samples shall be obtained from the same upstream and downstream locations. Samples shall be collected upstream and downstream of the highway in laboratory supplied sample bottles using the following procedure. Water samples must be analysed immediately following collection and shall not be frozen for future analysis.

Enough samples should be taken in the pre-construction phase to ensure background levels are truly representative. If post-construction water deteriorates from pre-construction, the source of the pollution will be determined and corrective action taken immediately. Work in that area may have to be terminated if the remediation required is substantial.

The sampling procedure shall be as follows:

- Label the sample bottles indicating: date, time, sample location and required analysis.
- Sample facing upstream to avoid collecting sediment that may have been stirred up by gaining access to the watercourse.
- Rinse the appropriate sample bottle 3 times with water to be sampled (note: the laboratory will provide separate bottles for metals and general chemistry). Completely fill the bottle being careful not to collect any surface debris or stir up sediment.

- Place bottles upright in a cooler with ice or ice packs. Samples shall be kept at 4°C during sampling and shipment.
- Complete the laboratory supplied chain-of-custody form, include in the cooler and ship the cooler as soon as practical following sampling.

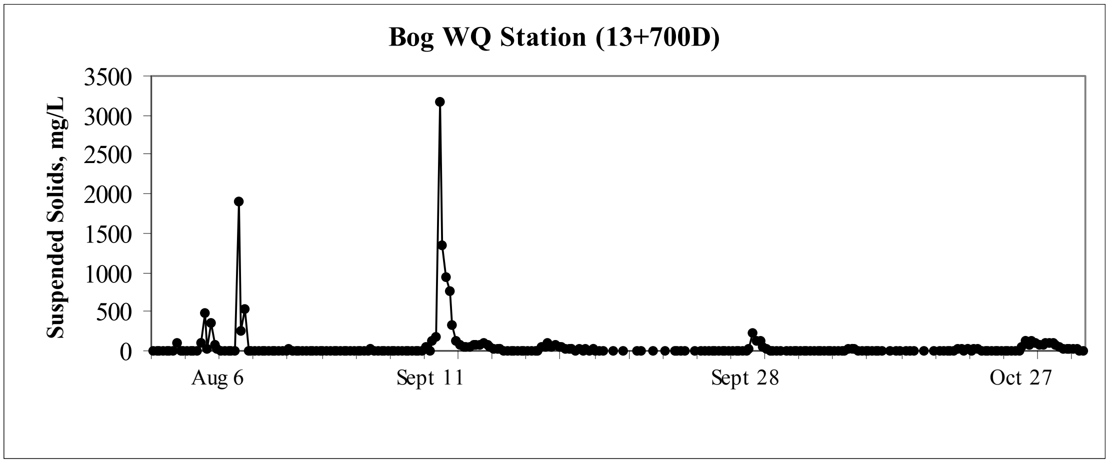
AII.4.3.5.2 Sampling During Rain/Snowmelt Events

In addition to the pre- and post-construction samples, TPW will also carry out sampling during and following rain (>25mm) or snowmelt (equivalent to >25mm rainfall) events for total suspended solids. In general, sampling during rain events would consist of upstream and downstream samples collected approximately 2-4 hours following the start of the event depending on intensity. If the rain event continues for over 12 hours, a set of samples shall be collected approximately 12 hours after the start of the event. Another set would also be collected approximately 2-4 hours following the rain event. If sediment is observed in the watercourse, TPW shall note when the watercourse recovers to its pre-rain conditions.

APPENDIX III

Water Quality Data (see Figure 1 for Station locations)

Bog Brook (13+700-D)(Station 1)



Date	Time	Turbidity NTU	SS mg/L		Date	Time	Turbidity NTU	SS mg/L	
10-Jul	1440	0.64	1.7		6-Aug	1730	380	255	
16-Jul	2005	0.49	1.2		6-Aug	1830	950	545	
17-Jul	205	0.55	0.8		7-Aug	1030	3.8	3.4	
17-Jul	805	0.36	0.4		9-Aug	1705	1.2	1.5	
17-Jul	1235	0.8	<0.3		14-Aug	1530	0.73	0.6	
19-Jul	1630	0.35	<0.3		23-Aug	645		<2.3	*
25-Jul		0.45	<0.3		24-Aug	1000	0.66	0.7	
30-Jul	610		114	*	25-Aug	0	0.82	1.1	
30-Jul			<9	*	25-Aug	100	1	1.3	
30-Jul	1430	4.6	2.6		25-Aug	200	1.25	2	
30-Jul	1915	3.1	1.7		25-Aug	300	2.6	2.2	
5-Aug	2230	0.33	1.4		25-Aug	400	2.64	4	
6-Aug	430	0.27	0.9		25-Aug	500	3.02	3.6	
6-Aug	530	0.32	1		25-Aug	600	3.14	3.2	
6-Aug	630	70	105		25-Aug	700	19.9	14.7	
6-Aug	700		472	*	25-Aug	800	14.5	11.2	
6-Aug	730	14	14		25-Aug	900	9	7.6	
6-Aug	830	750	345		25-Aug	1000	7.07	6	
6-Aug	930	140	70		25-Aug	1100	4.57	4.3	
6-Aug	1030	50	27		25-Aug	1200	3.47	3	
6-Aug	1130	20	12		25-Aug	1300	2.3	2.2	
6-Aug	1230	9	6.8		25-Aug	1400	2.02	1.6	
6-Aug	1330	6.7	5		25-Aug	1500	1.71	1.3	
6-Aug	1430	5.5	4.2		25-Aug	1600	1.82	1.2	
6-Aug	1530	5.8	6		25-Aug	1700	2.2	1.5	
6-Aug	1630	3100	1900		25-Aug	1800	2.03	1.4	

Date	Time	Turbidity NTU	SS mg/L	
25-Aug	1900	2.09	1.5	
25-Aug	2000	1.9	0.9	
25-Aug	2100	2.21	1.7	
25-Aug	2200	2.29	1.8	
26-Aug	810	0.94	0.6	
3-Sep			<1.8	*
4-Sep	2030	1.05	<0.3	
4-Sep	2300	1.05	2.1	
5-Sep	0	6.2	8.6	
5-Sep	100	1.55	2.2	
5-Sep	200	1.66	1.7	
5-Sep	300	1.29	2.2	
5-Sep	400	12.2	16.1	
5-Sep	500	1.85	3	
5-Sep	600	1.42	2	
5-Sep	700	1.46	2	
5-Sep	800	2.34	1.9	
5-Sep	900	2.17	2.2	
5-Sep	1000	1.64	1.8	
5-Sep	1100	1.53	1.7	
5-Sep	1200	1.65	2	
9-Sep	945		4	*
11-Sep	1200	1.39	2.7	
11-Sep	1300	1.28	2.6	
11-Sep	1400	0.54	1.1	
11-Sep	1500	0.57	1.3	
11-Sep	1600	0.83	1.3	
11-Sep	1700	2.34	2.6	
11-Sep	1800	54	63	
11-Sep	1900	8.33	11	
11-Sep	2000	79.4	120	
11-Sep	2100	125	188	
11-Sep	2200	4770	3180	
11-Sep	2300	1940	1340	
12-Sep	0	1340	950	
12-Sep	100	1100	760	
12-Sep	200	470	335	
12-Sep	300	152	135	
12-Sep	400	106	80	
12-Sep	500	66	53	
12-Sep	600	45	41	
12-Sep	700	71	61	
12-Sep	705		70	*
12-Sep	800	96	76	
12-Sep	900	101	78	
12-Sep	1000	121	89	
12-Sep	1100	83	66	
12-Sep	1200	70	52	

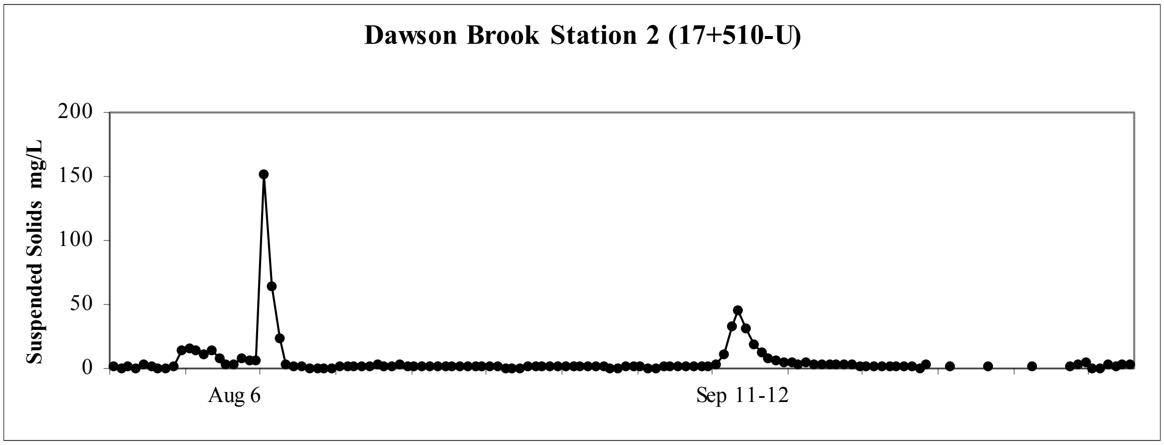
Date	Time	Turbidity NTU	SS mg/L	
12-Sep	1800	21.5	21	
13-Sep	0	15.2	18	
13-Sep	900	11.5	14	
15-Sep	1315	2	2.5	
15-Sep	1500	2.89	2	
15-Sep	1700	2.43	1.5	
15-Sep	1900	1.82	1.3	
15-Sep	2100	2.04	1.4	
15-Sep	2300	2.27	1.5	
16-Sep	100	2.18	1.6	
16-Sep	300	1.97	1.2	
16-Sep	500	2.34	1.9	
16-Sep	600	4.4	3.1	
16-Sep	700	21	12.2	
16-Sep	705		47	*
16-Sep	800	83	51	
16-Sep	900		90	
16-Sep	1000		57	
16-Sep	1100		68	
16-Sep	1200	84	59	
16-Sep	1300	88	59	
16-Sep	1400	41.4	32	
16-Sep	1500	40.1	31	
16-Sep	1600	21.9	22	
16-Sep	1700	12.4	11.3	
16-Sep	1800	15.1	16	
16-Sep	1900	12.7	11.8	
16-Sep	2000	15.3	12.7	
16-Sep	2100	12.7	11.6	
16-Sep	2200	17.8	15.5	
16-Sep	2300	10.6	9.4	
17-Sep	0	7.7	8.1	
17-Sep	100	5.7	5.6	
17-Sep	200	5.1		
17-Sep	300	4.9		
17-Sep	400	5.6	6.3	
17-Sep	500	4.24		
17-Sep	600	4.22		
17-Sep	700	3.76	3.7	
17-Sep	800	3.65		
17-Sep	900	3.13		
17-Sep	1000	4.15		
17-Sep	1100	4.96	4.3	
23-Sep	2000	1.17	5	
23-Sep	2300	1.05		
24-Sep	100	1.09		
24-Sep	200	1.32		
24-Sep	300	1.3	1.6	

Date	Time	Turbidity NTU	SS mg/L		Date	Time	Turbidity NTU	SS mg/L	
24-Sep	400	1.17			3-Oct	1500	2.93	2.9	
24-Sep	500	1.12			3-Oct	1600	2.57	2	
24-Sep	700	1.21	1.4		3-Oct	1700	2.13	1.4	
24-Sep	900	1.09			3-Oct	1800	1.73	1.1	
24-Sep	1100	1.04			3-Oct	1900	1.58	1	
24-Sep	1300	1.05	1.1		7-Oct	1500	0.92	0.3	
24-Sep			<1.8	*	7-Oct	1600	1.29	0.4	
27-Sep	1000	0.87	0.8		7-Oct	1700	8.09	10.5	
27-Sep	1400	0.91	1.2		7-Oct	1800	45	34	
27-Sep	1500	0.8			7-Oct	1900	55	33	
27-Sep	1600	0.94			7-Oct	2000	25.3	14.7	
27-Sep	1700	0.98	1.1		7-Oct	2100	18.9	12.1	
27-Sep	1800	0.91			7-Oct	2200	14.6	9.5	
27-Sep	1900	1.09	0.9		7-Oct	2300	13.8	8.2	
27-Sep	2000	1.61	1.4		8-Oct	0	12.9	7.4	
27-Sep	2100	2.07	1		8-Oct	100	9.9	5.7	
27-Sep	2200	5.14	4.2		8-Oct	200	7.3	3.8	
27-Sep	2300	4.55	3.2		8-Oct	300	5.15	2.8	
28-Sep	0	3.18	2.4		8-Oct	400	3.75	2	
28-Sep	100	2.16	1.8		8-Oct	500	3.21		
28-Sep	200	2.01	1.7		8-Oct	600	2.81	1.5	
28-Sep	300	2.83	2.1		8-Oct	700	2.42		
28-Sep	400	3.99	2.8		8-Oct	800	2.27	0.9	
28-Sep	500	3.22	2.2		8-Oct	805		<1.8	*
28-Sep	600	2.51	2		8-Oct	900	1.83		
28-Sep	700	1.88	1.6		8-Oct	1000	1.85	0.5	
28-Sep	800	1.79	1.8		16-Oct	1130	3.96	3.5	
28-Sep	900	16	34.3		16-Oct	1600	0.81	1.2	
28-Sep	1000	340	223		16-Oct	1700	1.12		
28-Sep	1100	206	139		16-Oct	1800	1.31		
28-Sep	1200	211	131		16-Oct	1900	1.68	1.8	
28-Sep	1300	82	52.4		16-Oct	2000	1.94		
28-Sep	1500	29.1	19.2		16-Oct	2100	1.7		
28-Sep	1700	10.6	8.1		16-Oct	2200	1.41	1.2	
29-Sep	1230	1.74	1.3		16-Oct	2300	1.74		
1-Oct			<1.8	*	17-Oct	0	2.15	2.6	
3-Oct	300	1.51	0.8		17-Oct	100	1.78	2	
3-Oct	400	1.67			17-Oct	200	2.61	3.1	
3-Oct	500	1.63	1.4		17-Oct	300	3.45	4	
3-Oct	600	2.25	2.1		17-Oct	400	8.48	8.8	
3-Oct	700	2.9	2.4		17-Oct	500	15.4	14.6	
3-Oct	800	4.93	3.4		17-Oct	600	15.7	14.7	
3-Oct	900	5.98	3.6		17-Oct	700	10.9	11.9	
3-Oct	1000	6	3.3		17-Oct	705		16	*
3-Oct	1100	5.1	2.9		17-Oct	800	10.3	10.1	
3-Oct	1200	3.67	1.7		17-Oct	900	14.6	14.3	
3-Oct	1300	2.88	1.4		17-Oct	1000	16.3	14	
3-Oct	1400	2.37	1.6		17-Oct	1100	11.6	9.8	

Date	Time	Turbidity NTU	SS mg/L	
17-Oct	1200	8.43	7.5	
17-Oct	1300	8.06	7	
17-Oct	1400	6.16	6.1	
17-Oct	1500	4.69	4.2	
26-Oct	1900	0.92	1.7	
26-Oct	2000	0.76	0.7	
26-Oct	2100	0.78	1.1	
26-Oct	2200	0.94	0.4	
26-Oct	2300	0.9	3.4	
27-Oct	0	1.32	1.2	
27-Oct	100	2.78	2.8	
27-Oct	200	56	51	
27-Oct	300	208	120	
27-Oct	400	85.5	64	
27-Oct	500	190	131	
27-Oct	600	136	103	
27-Oct	700	97	74	
27-Oct	800	65	80	
27-Oct	900	89.5	96	
27-Oct	1000	105	100	
27-Oct	1100	98.5	91	
27-Oct	1200	74.7	78	
27-Oct	1300	41	46	
27-Oct	1400	28.3	35	
27-Oct	1500	19.9	27	
27-Oct	1600	13.5	18.5	
27-Oct	1700	12.1	15.5	
27-Oct	1800	11.8	14.1	*
28-Oct	1030	4.46	5	
12-Nov			3	

* TPW Data

Dawson Brook (17+510-U)(Station 2)

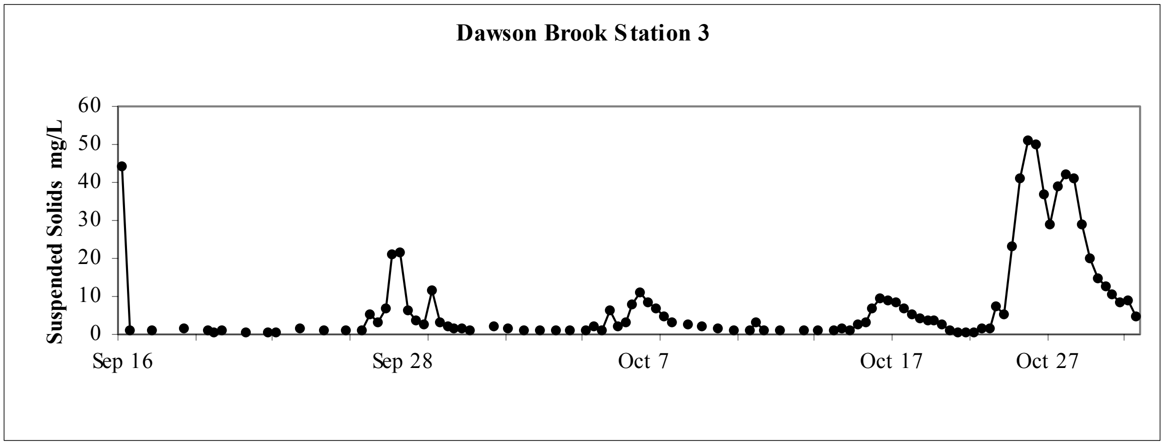


Date	Time	Turbidity NTU	SS mg/L	
10-Jul	1530	0.22	1.3	
19-Jul	1645	0.19	<0.3	
24-Jul	720		2	*
25-Jul		0.26	<0.3	
30-Jul	630		3	*
30-Jul	1505	0.86	2.2	
5-Aug	2230	0.16	0.7	
6-Aug	430	0.96	0.6	
6-Aug	530	1.1	1.5	
6-Aug	630	5	13.8	
6-Aug	7		16	*
6-Aug	730	6.2	14.1	
6-Aug	830	5.3	11.2	
6-Aug	930	16	13.8	
6-Aug	1030	9	7.3	
6-Aug	1130	3.9	3.4	
6-Aug	1230	4.6	3.8	
6-Aug	1330	15	8	
6-Aug	1430	11	5.9	
6-Aug	1530	7	5.9	
6-Aug	1630	60	152	
6-Aug	1730	55	64	
6-Aug	1830	17	23	
7-Aug	1000	2.7	2.9	
9-Aug	1920	1.6	1.9	
14-Aug	1730	0.3	0.9	
23-Aug	615		<2.3	*
24-Aug	930	0.06	<0.3	
24-Aug	2300	0.24	0.3	
25-Aug	0	0.17	<0.3	
25-Aug	100	0.36	1	
25-Aug	200	0.34	1.8	
25-Aug	300	1.14	1.1	
25-Aug	400	0.7	1.6	
25-Aug	500	0.7	1.8	
25-Aug	600	1.7	2.6	
25-Aug	700	1.32	1.8	
25-Aug	800	1.26	1.2	
25-Aug	900	2.71	2.7	
25-Aug	1000	2.12	2.2	
25-Aug	1100	1.4	1.7	
25-Aug	1200	1.35	1.8	
25-Aug	1300	1.26	1.5	
25-Aug	1400	0.81	1.4	
25-Aug	1500	0.71	1.3	
25-Aug	1600	0.68	1.4	
25-Aug	1700	0.63	1.2	
25-Aug	1800	0.8	1.2	
25-Aug	1900	0.89	1.3	
25-Aug	2000	0.88	1.1	
25-Aug	2100	0.45	1.1	
25-Aug	2200	0.71	1.2	
26-Aug	730	0.57	0.6	
3-Sep			<1.8	*
4-Sep	2000	0.2	<0.3	
4-Sep	2300	0.13	1.2	
5-Sep	0	0.22	1.4	
5-Sep	100	0.19	1	
5-Sep	200	0.46	1.2	
5-Sep	300	0.18	0.9	

Date	Time	Turbidity NTU	SS mg/L	
5-Sep	400	0.26	1.3	
5-Sep	500	0.32	1	
5-Sep	600	0.29	1	
5-Sep	700	0.28	1	
5-Sep	800	0.23	1	
5-Sep	900	0.4	0.9	
5-Sep	1000	0.18	0.5	
5-Sep	1100	0.25	0.6	
5-Sep	1200	0.3	0.9	
5-Sep	1300	0.26	1	
5-Sep	1400	0.38	1	
9-Sep	945		<1.8	*
11-Sep	1100	0.3	0.7	
11-Sep	1300	0.37	1.6	
11-Sep	1400	0.69	1	
11-Sep	1500	0.69	1	
11-Sep	1600	1.31	1.2	
11-Sep	1700	0.6	1.6	
11-Sep	1800	1	1.5	
11-Sep	1900	0.6	2	
11-Sep	2000	1.16	2.8	
11-Sep	2100	3.93	10.9	
11-Sep	2200	14.2	33	
11-Sep	2300	38.7	45	
12-Sep	0	22	32	
12-Sep	100	12.5	18	
12-Sep	200	7.95	12	
12-Sep	300	5.12	7.6	
12-Sep	400	4.26	5.7	
12-Sep	500	4.06	4.7	
12-Sep	600	3.39	4.4	
12-Sep	700	3.05	3.8	
12-Sep	705		4	*
12-Sep	800	2.95	3.2	
12-Sep	900	2.85	3.3	
12-Sep	1000	3.37	3.6	
12-Sep	1100	2.93	3.4	
12-Sep	1200	2.48	2.8	
12-Sep	1600	2.96	3	
15-Sep	1700	2.74	2	
15-Sep	1900	2.65	1.8	
15-Sep	2100	3.17	1.7	
15-Sep	2300	2.82	2.1	
16-Sep	100	2.89	1.7	
16-Sep	300	2.64	1.8	
16-Sep	500	2.65	1.9	
16-Sep	700	2.58	1.8	
16-Sep	705		<1.8	*
16-Sep	900	3.42	2.4	
16-Sep	1100	2.7		
16-Sep	1230	3.17		
16-Sep	1400	2.49	2.2	
16-Sep	1530	2.26		
16-Sep	1700	2.16		
16-Sep	1830	2.12		
16-Sep	2000	2.14		
16-Sep	2130	2.05	1.6	
16-Sep	2300	2.17		
17-Sep	30	2.09		
17-Sep	200	2.1		
17-Sep	330	1.91		
17-Sep	500	2.27		
17-Sep	630	1.86	1.4	
17-Sep	800	1.84		
17-Sep	930	1.82		
17-Sep	1100	1.81		
17-Sep	1230	1.66		
17-Sep	1400	1.71	1	
24-Sep			3	*
28-Sep	1145	5.46	5.1	
1-Oct	700		<1.8	*
8-Oct	800		<1.8	*
17-Oct	945	1.48	2.4	
17-Oct			2	*
28-Oct	1000	4.32	2.5	
12-Nov			3	*

* TPW Data

Dawson Brook Station 3 (Station 3)



Date	Time	Turbidity NTU	SS mg/L	Date	Time	Turbidity NTU	SS mg/L
16-Sep	1125	52.6	44	28-Sep	600	1.18	1.2
23-Sep	2000	0.77	1.3	28-Sep	700	1.41	
23-Sep	2200	0.8		28-Sep	800	1.13	0.9
24-Sep	0	1.22		28-Sep	900	3.11	5.4
24-Sep	200	0.9	1.1	28-Sep	1000	2.42	2.9
24-Sep	400	1.1		28-Sep	1100	8.51	7
24-Sep	600	0.75		28-Sep	1200	31.2	20.8
24-Sep	800	0.89		28-Sep	1300	33.2	21.8
24-Sep	1000	0.8	1.4	28-Sep	1500	8.38	6.3
24-Sep	1200	1.19		28-Sep	1700	4.94	3.8
24-Sep	1300	1.24		28-Sep	1900	3.71	2.6
24-Sep	1400	1.47	1.1	28-Sep	2100	20.6	11.4
27-Sep	1030	0.67	0.5	28-Sep	2300	5.41	3.4
27-Sep	1400	0.62	0.9	29-Sep	100	2.85	1.9
27-Sep	1500	0.68		29-Sep	300	2.3	1.6
27-Sep	1600	0.64		29-Sep	500	1.79	1.4
27-Sep	1700	0.6	0.6	3-Oct	300	0.74	1
27-Sep	1800	0.63		3-Oct	400	0.76	
27-Sep	1900	0.75		3-Oct	500	0.67	
27-Sep	2000	0.79	0.6	3-Oct	600	1.8	2
27-Sep	2100	0.82	0.5	3-Oct	700	1	
27-Sep	2200	1.12		3-Oct	800	1.28	1.4
27-Sep	2300	0.96		3-Oct	900	1.2	
28-Sep	0	1.73	1.4	3-Oct	1000	1.17	1.2
28-Sep	100	1.25		3-Oct	1100	1.26	
28-Sep	200	1.48		3-Oct	1200	1.53	1.2
28-Sep	300	1.2	1.3	3-Oct	1300	1.68	
28-Sep	400	1.33		3-Oct	1400	1.67	1.3
28-Sep	500	1.3		3-Oct	1500	1.46	

Date	Time	Turbidity NTU	SS mg/L
3-Oct	1600	1.35	1.1
3-Oct	1700	1.36	
3-Oct	1800	1.27	1.1
7-Oct	1500	0.61	2.1
7-Oct	1600	0.71	1.1
7-Oct	1700	5.31	6.2
7-Oct	1800	1.85	2.3
7-Oct	1900	2.54	3
7-Oct	2000	12.4	7.7
7-Oct	2100	16.3	11
7-Oct	2200	13.9	8.5
7-Oct	2300	9.67	6.9
8-Oct	0	6.46	5
8-Oct	100	4.43	3.4
8-Oct	200	3.45	
8-Oct	300	3.01	2.4
8-Oct	400	2.39	
8-Oct	500	2.25	2.1
8-Oct	600	1.97	
8-Oct	700	1.58	1.7
8-Oct	800	1.49	
8-Oct	900	1.29	0.9
8-Oct	1000	1.19	
8-Oct	1100	1.29	1.3
16-Oct	1200	4.7	3.2
16-Oct	1600	1.12	1.3
16-Oct	1700	0.88	
16-Oct	1800	0.77	1.2
16-Oct	1900	0.68	
16-Oct	2000	0.7	
16-Oct	2100	0.6	0.8
16-Oct	2200	0.66	
16-Oct	2300	0.72	1.3
17-Oct	0	0.78	
17-Oct	100	0.67	1.3
17-Oct	200	1.09	1.8
17-Oct	300	1	1.3
17-Oct	400	1.47	2.5
17-Oct	500	2.35	3.3
17-Oct	600	7.56	6.6
17-Oct	700	14.8	9.6
17-Oct	800	13.6	8.9
17-Oct	900	12	8.2
17-Oct	1000	9.44	6.7
17-Oct	1100	7.08	5.3
17-Oct	1200	5.69	4.4
17-Oct	1300	4.24	3.8

Date	Time	Turbidity NTU	SS mg/L
17-Oct	1400	4.38	3.8
17-Oct	1500	3.51	2.6
26-Oct	1930	1	1.1
26-Oct	2030	0.86	0.4
26-Oct	2130	0.95	0.4
26-Oct	2230	0.8	0.4
26-Oct	2330	1.67	1.7
27-Oct	30	2.15	1.8
27-Oct	130	5.37	7.2
27-Oct	230	4.28	5.4
27-Oct	330	39.3	23
27-Oct	430	66.6	41
27-Oct	530	74	51
27-Oct	630	64	50
27-Oct	730	38.6	37
27-Oct	830	25.7	29
27-Oct	930	37.3	39
27-Oct	1030	41.8	42
27-Oct	1130	44.7	41
27-Oct	1230	28.2	29
27-Oct	1330	21.4	20
27-Oct	1430	15.8	15
27-Oct	1530	15.5	12.8
27-Oct	1630	14	10.5
27-Oct	1730	11.5	8.4
27-Oct	1830	11	8.8
28-Oct	1200	7.48	4.8

Figure 1 Station #	**Miscellaneous Stations**	Date	Time	Turbidity NTU	SS mg/L	
4	Bog Brook 20 m above Dawson Brook Confluence	10-Jul	1410	0.92	2.3	
		19-Jul	1600	0.67	0.3	
		30-Jul	1350	0.95	1.6	
		6-Aug	1215	0.77	1.8	
		12-Sep	1505	1.92	4.6	
		17-Oct	1103	1.7	1.3	
5	Bog Brook 50m below Dawson Brook Confluence	30-Jul	1358	4.7	3.6	
		6-Aug	1220	4.5	3.4	
		17-Oct	1107	9.06	7.7	
6	Stream draining to Bog Brook below Bog/Dawson Confluence (at Williams Road crossing)	6-Aug	1230	0.92	0.7	
	NTS 4 977 150 5 539 900	12-Sep	1508	12.4	24	
		17-Oct	1058	0.96	1.5	
7	Runoff to Bog Brook 10m above Box culvert	12-Sep	1410	7.8	7.5	
		16-Sep	1157	293	170	
		28-Sep	1250	90	56	
8	Discharge to Bog Brook 2m below 7	16-Sep	1155	1860	992	
		28-Sep	1247	1152	693	
9	Bog Brook 20m above Box culvert (13+700-U)	24-Jul	620		4	*
		30-Jul	550		64	*
		6-Aug	700		502	*
		23-Aug	645		<2.3	*
		3-Sep			6	*
		9-Sep	945		4	*
		12-Sep	700		64	*
		16-Sep	700		92	*
		24-Sep			12	*
		1-Oct	700		2	*
		8-Oct	800		<1.8	*
		17-Oct			13	*
		12-Nov			<1.8	*
10[1]	Culvert between Bog Brook WQ Stn and flow station	29-Aug	1505	33.5	29	
		29-Aug	1800	5.77	5.2	
11[1]	Box Culvert 6"hose (Bog Bk behind cofferdam)	29-Aug	1600	0.8	0.5	
12[1]	Box Culvert 3"hose (water from excavation)	29-Aug	1610	7250	9000	
13	Bog Brook at flow metering station	29-Aug	1510	41.2	25	

Figure 1 Station #	Station	Date	Time	Turbidity NTU	SS mg/L	
14	Bog Brook @ Dawson Rd	6-Aug	1315	22	13.3	
		29-Aug	1525	14.1	6.8	
15[1]	Culvert outfall @ 14+600	16-Sep	1215	33	41	
16	Dawson Brook 20m above Bog Brook confluence	10-Jul	1405	0.13	0.5	
		30-Jul	1355	6.4	3.3	
		6-Aug	1212	4.6	3.3	
		12-Sep	1500	17.5	13.1	
		17-Oct	1105	12.7	9.4	
17	Dawson 10m below outfall of twin circular culverts (17+510-D)	24-Jul	720		<1.8	*
		30-Jul	630		2	*
		6-Aug	700		8	*
		23-Aug	615		4.5	*
		3-Sep			<1.8	*
		9-Sep	945		<1.8	*
		12-Sep	700		6	*
		16-Sep	700		5	*
		16-Sep	1100	18.9	22.7	
		24-Sep			<1.8	*
		1-Oct	700		<1.8	*
		8-Oct	800		<1.8	*
		17-Oct			2	*
		12-Nov			2	*
18	Spence Borrow Pit Runoff (16+990-U)	24-Jul	710		<1.8	*
		30-Jul	600		276	*
		6-Aug	700		5200	*
		23-Aug	620		41	*
		3-Sep			5	*
		9-Sep	945		8	*
		12-Sep	700		280	*
		12-Sep	1348	447	256	
		16-Sep	700		950	*
		16-Sep	1110	825	499	
		24-Sep			2	*
		28-Sep	1155	835	435	
		1-Oct	700		53	*
		8-Oct	800		8	*
		17-Oct			44	*
		17-Oct	1000	84	47	
		12-Nov			6	*
19	Stream to which Spence borrow pit runoff drains	6-Aug	700		4	
	(North side of Hwy – upstream of confluence)					
		16-Sep	1112	1.89	2.3	
		28-Sep	1155	2.63	2.1	

Figure 1 Station #	Station	Date	Time	Turbidity NTU	SS mg/L	
19	continued	17-Oct	1003	0.94	0.9	
20	Culvert Outfall for 18/19 - 5m upstream of Dawson Brook	12-Sep	1350	115	76	
		16-Sep	1115	318	202	
		28-Sep	1200	242	43	
		17-Oct	1007	32.3	27	
21	85m below 20 on Dawson Brook (16+990-D)	24-Jul	710		12	*
		30-Jul	630		106	*
		6-Aug	700		324	*
		23-Aug	620		<2.3	*
		3-Sep			6	*
		9-Sep	945		2	*
		12-Sep	700		278	*
		12-Sep	1355	13.8	10.9	
		16-Sep	700		598	*
		16-Sep	1120	41.6	37	
		24-Sep			3	*
		28-Sep	1202	39	25	
		1-Oct	700		4	*
		8-Oct	800		8	*
		17-Oct			18	*
		17-Oct	1010	4.54	7.5	
		12-Nov			4	*
22	30m upstream of 20 outfall on Dawson Brook	17-Oct	1015	1.8	5	
23	Stillwater Rd Brook @ 18+540-U	24-Jul	740		3	*
		30-Jul	700		3	*
		6-Aug	700		7	*
		23-Aug			248	*
		3-Sep			<1.8	*
		9-Sep			2	*
		12-Sep			<1.8	*
		16-Sep			<1.8	*
		24-Sep			5	*
		1-Oct	700		<1.8	*
		8-Oct	800		<1.8	*
		17-Oct			<1.8	*
		12-Nov			5	*

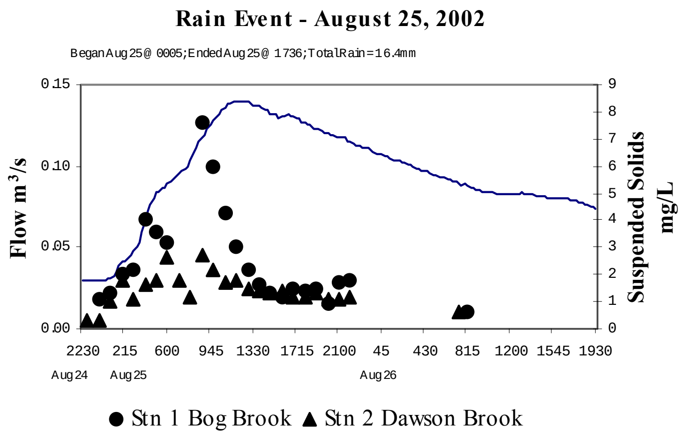
Figure 1 Station #	Station	Date	Time	Turbidity NTU	SS mg/L	
24	Stillwater Rd Brook @ 18+540-D	24-Jul	740		5	*
		30-Jul	700		4	*
		6-Aug	700		<1.8	*
		23-Aug			132	*
		3-Sep			<1.8	*
		9-Sep			<1.8	*
		12-Sep			3	*
		16-Sep			<1.8	*
		24-Sep			2	*
		1-Oct	700		<1.8	*
		8-Oct	800		<1.8	*
		17-Oct			2	*
		12-Nov			4	*

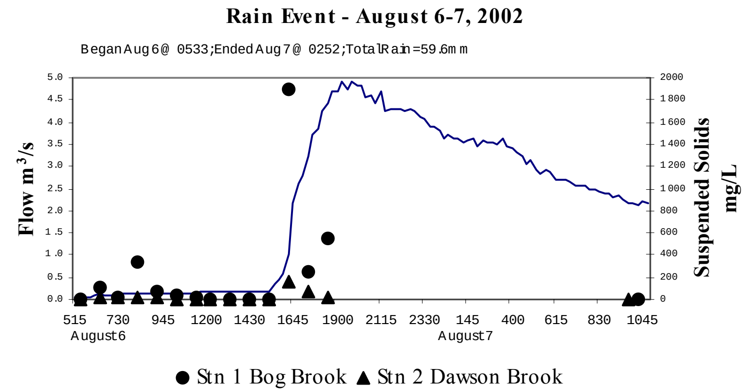
* TPW Data
[1] not shown in Figure

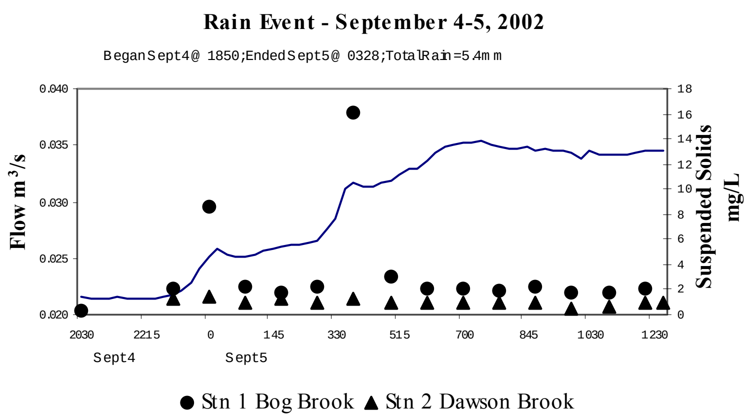
APPENDIX IV

Time Series Plots of Total Suspended Solids Versus Flow

Table IV.1 Rain event summary plots.







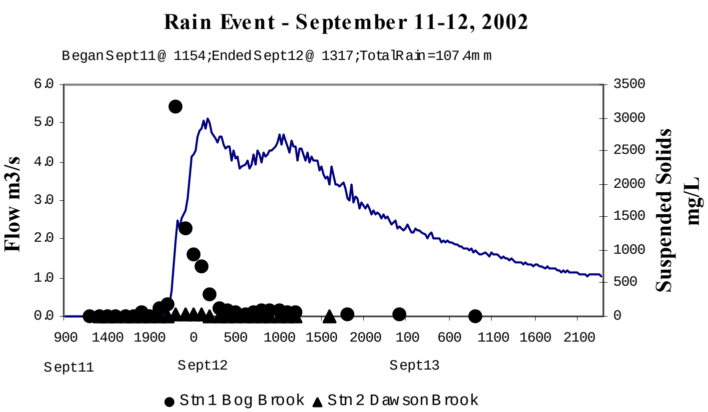
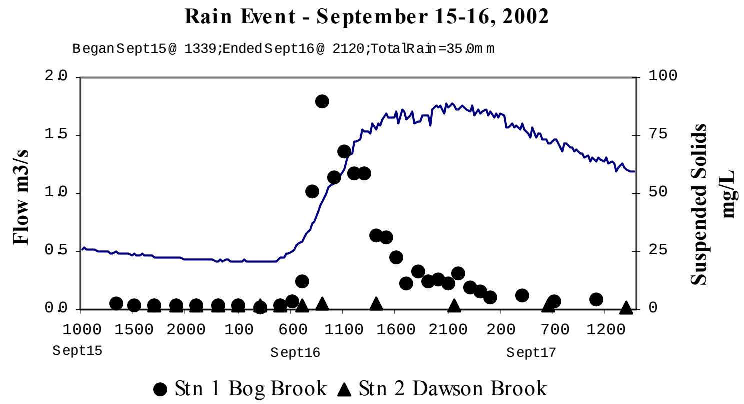
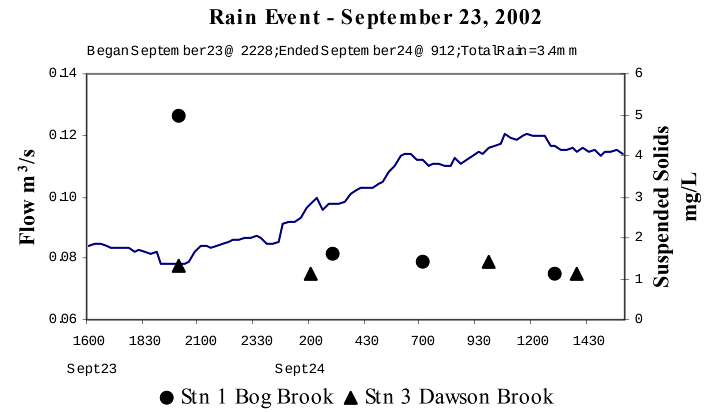
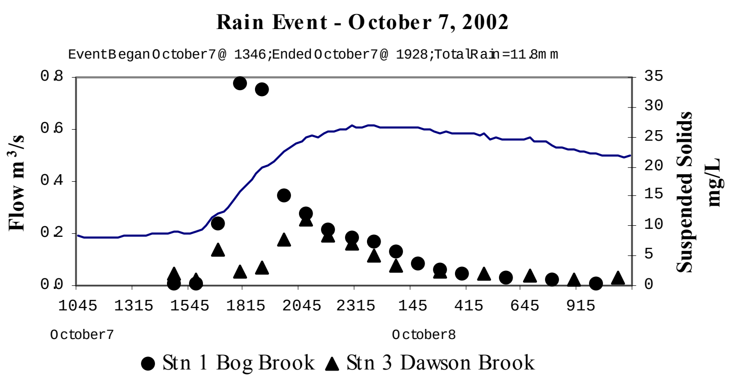


Table IV.1, continued







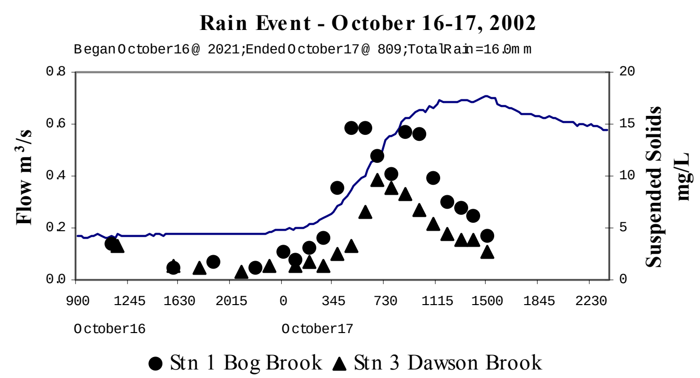
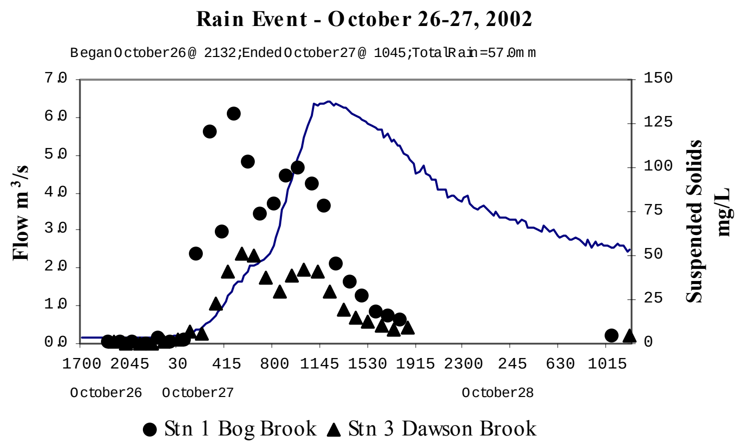


Table IV.1, continued



APPENDIX V

Chronology of Events

July 12, 2003	Installed stage recorder Grubbing began on top of Ellershouse Hill
July 15	Site Meeting – Attended by TPW, ALVA, DFO, CWRS Discussed and visited sites of 2 main culvert installations Discussed retaining wall Information exchanged was related to approaches to be used for each installation and the environmental considerations
July 16	Tipping bucket rain gauge installed on the property of Mr. Nathaniel Spence
July 19	Standard rain gauge installed next to tipping bucket Grubbing 14+000 – 14+200; 14+500 – 14+540
July 22	Slab poured 16+400 Working area 15+480 – 15+660 fill (clay) Grubbing 15+080 – 15+360
July 23	Culvert installations @ 16+400, 15+780, 14+700 Grubbing 16+040 – 16+200
July 25	Began work on borrow pits @ 15+300 and 16+100
July 29	Hauling from borrow pit 14+400 and 13+800 Pit closed down because of improper site distance (min distance required for 100 series truck crossing) - Found a good site distance @ 16+590 - Side borrow pit @ 14+820
July 30	Instructed to install coffer dams 50m then every 100m to culvert @ 16+990 Looked for source of dirty water
July 31	12 sections of pipe installed @ 16+400
August 1	Grubbing 16+620 – 16+580; 16+520 – 16+420; 16+360 – 16+620 Shale put on ramps of haul road from pit @ 16+580
August 5	Discussed with ALVA need to install some mechanism to catch water from borrow pit (the name of pit referred to in notes was not identified by name or location)
August 6	Work on pits to reduce flow of dirty water to creek Borrow pit identified as active source of dirty water to Bog Brook (14+000 – 14+200). Steps taken to stop or at least slow it down Silt fence installed @ 16+990 (11m)
August 7	End of culvert @ 16+990 fixed Reinforced check dams with 4-6 inch stone Installed larger pit in Spence Pit driveway
August 8	Discussed removal of mud on highway by shovel/rake Decided to use broom truck
August 9	Silt fence installed @ 13+730 parallel to Bog Brook, 52 m
August 12	Silt fence installed @ 13+900 – 14+080 (180m); 16+760 – 17+100 (340m)
August 13	Silt fence installed 15+600 – 15+760 (160m); 60m @ 17+500 Grubbing 17+280 – 17+460
August 14	Work began on Dawson Brook twin culverts Borrow pit suspected as source of TSS to Dawson Brook Hay bales placed in borrow pit highway ditch were ineffective – flow topped barrier Electrofish @ 17+500 (Jacques Whitford) (150 trout, 4 eels)
August 15	Plunge pool installed @ 17+500

August 16	Grubbing 17+660 – 17+900
August 17	Water used for dust control (7000gal)
August 19	Grubbing 17+920 – 18+320 2000gal dust control Bog Brook dirty – sources: subgrade @ 13+800 - 14+500 + ditches on Williams Rd
August 21	Culvert @ 17+500 installed (10 lengths of pipe) TPW Inspector and Project Engineer discussed need to protect Bog Brook from subgrade runoff (notes did not specify area of concern)
August 22	Silt fence reinstalled @ 17+500 – removed during installation of culverts Silt fence installed @ 13+790 – 13+900 (110m) Movement of trucks across road stopped due to amount of soil being deposited on road from tires
August 23	Installed sediment pond @ 17+560 Berm and subgrade leveled @ 13+740 - 13+900 to restrict runoff
August 27	Construction of diversion ditch @ box culvert Silt fence installed at diversion ditch (40m)
August 28	Berm constructed @ 13+740 Sheet piles installed @ 13+700 Sediment pond installed @ 17+600 (3.5m wide x 8m long x 1m deep) using 4-6 inch clear stone 8 flow checks installed between 13+830 – 14+540 (hay bale and 4-6 inch clear stone) 8 flow checks installed between 16+500 – 16+970 (hay bales and 4-6 inch clear stone) Plunge pool installed @ 17+500 (7m wide x 3m long x 2m deep) using 4-6 inch clear stone
August 29	Diversion ditch for box culvert installed Upstream flow was pumped to grassy area on Ellershouse side of brook. Runoff drains to culvert which empties to Bog Brook approx. 100m below box culvert outfall. Began pumping at 0700, stopped at 1830 Silt fence installed at diversion ditch (50m)
August 30	Electrofish @ box culvert (82 brown trout, 4 mud suckers, 6 eels)
September 4	Framing for box culvert started
September 9	Grubbing 13+740 – 13+980; 13+200 – 13+360; 14+220 – 14+240; 14+560 – 15+060; 16+220 – 16+340
September 10	Grubbing 15+640 – 17+640
September 11	Prepared site for rain
September 12 - 13	Site closed Excavator working on flooding problems
September 15	Slope up-gradient of 13+700 is retained behind a swale installed to divert runoff from box culvert excavation. Overflow drains to a wet area before being discharged to Bog Brook, approx. 10m above entrance to diversion trench.
September 16	Extra sections of sheet-piling was added to the existing wall at the Bog Brook diversion structure in an attempt to maintain flow through diversion trench. The width of the original wall was insufficient to redirect the flows experienced during the Spetember 11th rain event which dropped over 100mm of rainfall. The result was that a 5-7m section of to redirect flow to the diversion trench. resulting in the wash-out of the streambank margin between the end of the sheet-pile wall and the subsequent flooding of area for extension of existing box culvert. Meeting between DFO (J. Leadbetter), TPW and ALVA re Spence Borrow Pit

September 17	Sheet pile extended @ box culvert Repaired some coffer dams
September 23	Flow checks installed @ 13+780 and 14+200 8 flow checks between 13+780 and 14+980 (hay bales and 4-6 inch clear stone)
September 27	Eastern entrance to borrow pit has been sealed off with an earth berm that has been covered with straw Vegetative cover in highway ditch downstream of borrow pit has been disturbed by ATV traffic leaving bare soil in tracks. Exposed soil in ATV tracks is subsequently eroding Approx. a 15m section of diversion ditch liner at the box culvert extension site has been dislodged, exposing bank and ditch bed. It appears that sections of this exposed area have subsequently been eroded Hay spread on berm by box culvert diversion ditch (15m x 30m) Hay sprayed on Williams Pit
September 30	10 flow checks installed between 13+840 and 14+730 (hay bales and 4-6 inch clear stone) Hay sprayed on Williams Pit
October 1	Data logger at stream gauging site went off-line at 1045 for repairs
October 7	Data logger returned to service at 1030
October 8	Hope to have Bog Brook flowing through box culvert by weekend
October 15	The upper (Sackville side) access road to the Spence borrow pit was sealed off and the entrance landscaped. Pit no longer in use. Sheet pile removed @ 13+700 flooding culvert making it impossible for concrete contractor to work inside
October 16	Sheet pile removed @ 13+700
October 18	Retaining wall @ 16+840 started
October 24	Sheet pile removed from Dawson Brook retaining wall site (16+840)

APPENDIX VI

Regulator Comments

Fisheries and Oceans (provided by Jim Leadbetter)

1. DFO enforces the Fisheries Act and performs an advisory role with NSDEL during the permitting process. The same role applies with proponents of the permits granted (in this case TPW and Alva Construction).
2. DFO staff visited the site 5 to 6 times during various phases of the project. The reasons for these visits included attendance of pre-construction boardroom and pre-construction site meetings, regular sites visits, concerns re the Spence borrow pit (September 16, 2002), and DFO staff alerts.
3. The decision by the TPW Inspector (at the objection of Alva's site foreman) to pump Bog Brook flow and excavation water to a vegetated area above the box culvert during construction of the diversion channel, was made without DFO input. Runoff from this area drained to a culvert that emptied into Bog Brook approximately 100m below the outlet of the existing box culvert. Jim had indicted to me that he would not have allowed what was done if it meant that a section of Bog Brook was without a sufficient maintenance flow. Pumping lasted for a period of at least 12 hours.

Nova Scotia Department of Environment and Labour (provided by Norma Bennett)

1. Activities Designation Regulations made under the NS Environment Act list activities requiring the issuance of approvals. The twinning project involved two culvert extensions and a number of non-fish bearing culverts; all required Water Approvals. The fish and non-fish bearing culverts were treated separately. Terms and Conditions are issued with all Approvals.
2. The Environmental Construction Practice Specifications were replaced in 1997 by the Watercourse Alteration Specifications.
3. Borrow pits developed by TPW or Contractor of TPW specifically for highway construction needs do not need a DEL permit nor does DEL need to be notified. Pits greater than 1 ha developed by others for other uses do. Those developed for this project did not require permits.
4. DEL does not routinely include specific ESC measures in their Water Approvals because of the liability issue. Generalize instead.
5. Approvals are not necessary for culvert installations performed between June 1 and Sept 30 for specific maximum dimensions
   a) 1.8 m in diameter
   b) 3.0 m in span in the case of an arch or open bottom box culvert
   c) 18.3 m in length in all cases
6. All DEL Water Approvals are referred to DFO for comment. DEL must complete review within 60 days. Typically, for highway projects, TPW, DFO and DEL review project prior to submission of Application for Approval to facilitate the process.