Recommendations for Monitoring Freshwater Quality to Assess Impact of Development in the Halifax Regional Municipality

Report of the Ad Hoc Committee on Water Quality Parameters
[A sub-committee of the Halifax County/Halifax Mainland Watershed Advisory Board - WAB]

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(i) The Halifax Regional Municipality;
(ii) Dalhousie University;
(iii) SNC Lavalin;
(iv) Environment Canada; and
(v) Nova Scotia Department of Environment.

The opportunity to consider and report on this important issue, as presented by the Halifax County/Halifax Mainland Watershed Advisory Board, is gratefully acknowledged.

DISCLAIMER

The opinions and recommendations expressed in this report represent a response to a request to advise on meaningful and economically realisable monitoring procedures to be incorporated in development agreements within the Halifax Regional Municipality to facilitate protection of water resources which may be adversely impacted by development.

The views and recommendations expressed are generally reflective of the agencies and institutions which are represented by the participants. However, it should be recognized that these recommendations are made in this particular context as minimum monitoring efforts and do not limit liability of individuals undertaking development activities. All requirements and associated liabilities laid out in applicable legislation and regulations remain the responsibility of the developer.

EXECUTIVE SUMMARY

The Halifax County/Halifax Mainland Watershed Advisory Board (WAB), advises Halifax Regional Municipality (HRM) on issues affecting water quantity and quality within a designated area of the HRM. In October, 1998 WAB set up an ad hoc subcommittee (AHS) to recommend on matters pertaining to the monitoring of water quality parameters in development agreements.

This report to WAB represents the consensus deliberations of the AHS which met approximately monthly. The AHS considered the physical, chemical and biological indicators of water quality, the nature, methodology and costs of monitoring for water quality, and the potential users of the resulting data. Approaches taken in other jurisdictions were examined and adopted where considered applicable.

As a result of its deliberations, the AHS recommends the consolidation of water quality monitoring policy throughout HRM, and that an ad hoc Technical Subcommittee (TSC) be constituted to provide scientific and technical advice, on request, to all water advisory groups in HRM.

It is further recommended that any proposed development, arising from a development agreement, be classified into one of three categories in terms of potential impact on fresh water quality in any stream or lake as: (i) substantial, (ii) moderate, or (iii) unlikely to impact to any significant extent.

Where impact of development is potentially substantial it is recommended that initial baseline monitoring be carried out followed by on-going monitoring of a shortlist of key indicator parameters. A base list of parameters is presented for each of these phases, together with a time schedule for the shortlist program.

Where potential for impact is moderate, it is recommended that only the shortlist of key parameters be carried out by trained volunteers under a part-time coordinator. It is suggested that developer and constructor organizations be approached to provide the necessary support funding, in return for which they would have the right to advertise their patronage and to use the results for promotional purposes.

All data must have quality assurance, must be assessed within a reasonable period, and the data and assessment must be readily accessible to all interested parties.

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1. REASON FOR FORMATION OF THE SUBCOMMITTEE

The Halifax County/Halifax Mainland Watershed Advisory Board (WAB) is a volunteer body which advises Halifax Regional Municipality (HRM) on issues which may impact on the quantity and quality of fresh and marine water within its boundary (excluding Dartmouth and Bedford which have separate Advisory Boards). Specifically, as defined in relevant extracts from the "Terms of Reference" (Appendix A), the purpose of WAB is to review development applications submitted to HRM with a focus on protecting the water quantity and quality as well as the quality of life associated with these water resources. In so doing, WAB recognizes that development is both necessary and desirable for the good of the community; however, WAB endeavours to ensure that development occurs in an environmentally responsible manner.

In order to better carry out its mandate, WAB seeks to improve the knowledge base used to formulate its recommendations. The acquisition of baseline, construction and post-construction data provides WAB with information which can be used to improve future recommendations of a similar nature. A specific example of this approach is the case of the Glen Arbour development, presented in summary detail in Appendix B. As may be noted in Table B-1, the list of physical and chemical parameters actually monitored is substantial, all of which were sampled at three-month (seasonal) intervals. Although recommended by WAB (Appendix B), no biological sampling was included in this development agreement.

Following discussion on the nature of monitoring for water quality at the October 21, 1998 meeting of WAB, it was agreed "to form an ad hoc subcommittee to develop a list of parameters of practical importance which water testing studies... should include." The current subcommittee resulted from this decision.

The considerations which follow relate only to development agreements in which the proposed development differs from the area's zoning designation. For "as-of-right" development, in which the proposal conforms to the designated zoning, HRM's Watershed Advisory Boards have no input and therefore cannot recommend on a monitoring scheme.

2. NATURE OF WATER POLLUTION FROM DEVELOPMENT

During the initial construction phase of any project, soil will be exposed and therefore is vulnerable to detachment and transport by runoff from snowmelt and/or rainfall. Potential pollutants are the soil particles themselves and chemicals having a high partition coefficient (strong adherence to colloidal material comprising clay and humus) such as phosphorous and some pesticides (if present from

anthropogenic sources), which w22ill tend to separate in the water environment. Additionally, exposure of pyritic rock can produce highly acid runoff which can dissolve and make toxic metals in rocks biologically available, and movement of partly decomposed vegetative matter to water bodies can deplete the dissolved oxygen. However, the main pollutant from grubbing and clearing of natural forest will be soil particles (mainly SiO_2) which will discolour but not chemically contaminate receiving water, although if in excess, the silt fraction can negatively affect vertebrate and invertebrate organisms (e.g. young fish and molluscs) and, chlorophyll (and thereby oxygen) production by phytoplankton. Additional danger exists from accidental spills of petrochemicals used to run machinery.

Following the clearing phase, residential, road and subsurface utility construction, and establishment of grassed areas (for lawns, playgrounds, sports fields and golf courses) is accompanied by localized soil disturbance and the application of fertilizers and pesticides. Additionally, wetland areas which naturally cleanse polluted runoff may be partially or wholly filled in, or bypassed due to landscaping changes or installation of stormwater drains.

In the mature stage, a developed area produces a range of pollutants from human habitation. These include petroleum products in street runoff, inorganic fertilizers and organic pesticides from grassed areas, faeces from domestic animals and possible outflow from septic tank fields, all of which may flow into and degrade adjacent surface waters.

3. MANDATE

The mandate of the Committee, as addressed in this report, was to use the water quality monitoring program in the Glen Arbour development agreement as a base from which:

(a) To recommend on whether all of the water quality parameters collected were necessary;

(b) To recommend any parameters not collected, which had been recommended, or which should have been included;

(c) To recommend a minimum list of essential parameters;

(d) To recommend on a sampling protocol and frequency; and,

(e) To recommend on a duration of data collection at a particular site.

4. ISSUES

A number of issues revolve around the central objective of preservation of water quality within HRM. These are:

(a) It is generally understood that development can negatively impact water quality even though these impacts can be largely mitigated through use of well-accepted, relatively inexpensive practices during the development phase, proper design practices, and responsible stewardship in the post-development phase. To ensure that development is responsibly undertaken, it is desirable that a quantitative measure, or suite of measures, of water quality be defined. These measures then also may serve to quantify the level of stewardship and warn of potential deterioration in later years.

As set out in the Canadian Environmental Quality Guidelines [3], the quality of water resources is measured in terms of suitability for a given use. These uses are: aesthetic; protection of aquatic life and maintenance of the existing natural biodiversity; drinking purposes by humans or animals; irrigation; or, recreation such as swimming or boating.

Within HRM, since property value is directly linked to 'quality of life' it is clearly in the developer's best interest to ensure the maintenance of the highest possible quality of adjacent water resources during the development phase, and in the interests of the subsequent property owners to ensure continued quality.

(b) The potential users of the data are foreseen to be: HRM, both directly and through mandated Watershed Advisory Boards, such as WAB, for landuse planning and development approval purposes; volunteer groups and other stakeholders to promote stewardship; developers and users of environmental mathematical models in the academic community; and, Nova Scotia Department of Environment (NSDOE), Environment Canada (EC) and Fisheries and Oceans Canada (DFO) in terms of a knowledge base to assess impacts from human activities and the effectiveness of protection programs.

(c) The hydrology of a specific freshwater system impacts the quality of the water in the system at any given time. Streams, and lakes subject to short residence times, evidence more rapid fluctuations in water quality, particularly where surface runoff is a major component in the inflow. For such systems time incremental samples taken at predetermined intervals, without regard to prevailing hydrologic conditions, will most likely provide no information on short duration toxic (to certain biological species) conditions which may exist. However, to acquire discrete samples

during, or immediately following storm events, is not feasible unless expensive (approx. $5,000 plus installation), stage-activated, automatic samplers are used.

(d) The size, scope and time frame of the proposed development will affect both the magnitude of the construction phase effects and the relative feasible cost for monitoring. This continuum ranges from short duration (less than 1-year) clearing and construction of a new subdivision and/or golf course, through construction of a subdivision or development of a golf course in phases over several years, and trailer park enlargement, to single lot alterations.

(e) Monitoring may be contracted out to a qualified third-party agency (or agencies) or may be performed by volunteers. An intermediate model, such as in King's County [1], comprises a paid co-ordinator, answerable to a body such as WAB (through a delegated subcommittee), to oversee a group of trained volunteers for field sample collection. For development within HRM costs could be covered by a fee for service charged to the developer.

To ensure a satisfactory level of data quality for water quality monitoring, rigorous sample collection practices as set out by Environment Canada [5] must be adhered to, and laboratory analyses must be carried out by professionally qualified personnel in an acceptably equipped laboratory which is CAEAL certified or equivalent.

(f) Sets of physical, chemical and biological data exist for many of the lakes within HRM. This data is readily available on the internet (Internet homepage: http://www.ccn.cs.dal.ca/sciences/SWCS/SWCS.html) and in Soil and Water Conservation of Metro Halifax reports such as references [6] through [9], and should be utilized where relevant.

5. HISTORICAL APPROACHES

5.1 Physical and Chemical Parameters

5.1.1 *United States Environmental Protection Agency*

An approach taken by the United States Environment Protection Agency (USEPA) is to classify lakes throughout the USA according to (i) current condition, and (ii) vulnerability to future deterioration. The summary below is a synopsis from the USEPA internet site (http://www.epa.gov/surf/iwi).

Condition indicators, each of which are rated on a points system, are:

(a) That the lake water meets all designated uses.

(b) That there are no restrictions on the edibility of fish or game due to contamination.
(c) Quality of water for human consumption in terms of (i) assessment of the state, (ii) the current treatment practices, and (iii) occurrence of significant levels of chemicals.
(d) Level of contamination of bottom sediments in terms of toxicity and as detected in fish tissue. Such contamination is noted as being a good indicator of the aquatic condition as toxic chemicals in the bottom sediments can harm or kill bottom dwellers and can move up the food chain.
(e) Ambient water quality as measured by a suite of indicator chemicals: Cu, Cr (hexavalent), Ni and Zn, in terms of the percent exceedance of water quality standards over the past 6 years.
(f) Ambient water quality as measured by a suite of 4 conventional chemicals: NH_3, dissolved O_2, TP and pH, in terms of the percent exceedance of water quality standards over the past 6 years.
(g) Loss of wetlands, in terms of percent loss over the period 1870 to 1980 and over the period 1986 to 1996.

According to the sum of the points count, lakes are then categorized in terms of their current condition as: (i) better, (ii) having less serious problems, or (iii) having more serious problems.

In terms of vulnerability to future quality degradation, factors considered are the level of inflow pollutants in excess of permitted levels from urban and agricultural land, and changes in population levels in the watershed. Lakes are categorized as either: (i) highly vulnerable, or (ii) low vulnerability.

The USEPA is currently working on the addition of indices of biological integrity.

5.1.2 *Kings County, NS*

As a result of local concern about the impact of increasing residential (mainly cottage) development on adjacent lake water quality, Kings County, NS, residents and municipal governments hired a consultant to advise on a course of action [1]. The consultant produced a modified version of a phosphorous loading model used in Ontario to predict the effect of increased cottage development on resulting lake trophic status.

In order to verify and improve the "Kings County Planning Model" a structured program of water quality monitoring began in May, 1997. Under this program an Implementation Committee, comprising representatives from local residents, government and academia, sets objectives and facilitates operation. A separate Technical Advisory Committee provides expertise on sampling protocols and on quality control, which comprises the use of blank, split and

duplicate samples. Field work is carried out by volunteers under the direction of a part-time Area Coordinator hired by the Implementation Committee. Composite water samples, taken from the deepest location in each of nine lakes (with two locations in two of the lakes), are collected monthly between May and October of each year and analysed at the QE II Health Sciences Centre Environmental Chemistry Laboratory in Halifax according to one of six packages, each of which is defined in Table 2. Laboratory analysis costs (including HST) as of May, 1997, ranged from $299.86 for Package #1 to $48.59 for Package # 6 [1].

Additionally, volunteers note water and air temperature, and Secchi disk depth.

Initial data has been compiled in report form [10].

5.1.3 *Halifax/Dartmouth Lakes Decadal Surveys*

Water samples were collected and analysed from 51 lakes in the Halifax and Dartmouth area on 14 April, 1980 and again on 16 April, 1991 [12]. The samples were analysed for a number of parameters including trace elements (Table 2). The most dramatic change was the marked increase in conductivity mainly due to increases in Na and Cl. Overall there was little change in pH and nutrients, although nitrates and phosphorous tended to increase.

The intention was to repeat the survey in April, 2000.

5.2 Biological Indicators

On the basis that life forms which continually inhabit a specific water body thereby integrate and evidence the effects of the quality of their surroundings, it is logical that an assay of the biology of a lake will provide the most valid indicator of water quality.

The biological community in any lake is diverse in terms of its habitat (shallow or deep water; littoral (shoreline) or profundal (deep water) sediments); position in the food chain; mobility; and, tolerance to specific physical and chemical conditions.

As previously indicated, phosphorous, as the limiting nutrient, closely correlates with algal production (commonly measured by chlorophyll a). Similarly, chemical analysis of fish tissue provides a measure of spatial as well as temporal integration, together with accumulation at a high level in the food chain.

Another approach is that of quantifying the diversity of the benthic macroinvertebrate population. These organisms inhabit the bottom substrates in fresh water bodies for at least part of their lives, and include insects (which are the most numerous and diverse); true water mites; clams, snails and mussels; crustaceans; worms; and, leeches [7]. Studies [8] to [10], have been carried

out on ten lakes in HRM. These studies have concentrated on the biodiversity of insects which inhabit the sublittoral (1 m depth) zone close to the shoreline.

6. DISCUSSION

Given the diversity of geology which exists across the HRM; scale, time frame and nature of possible development; and, widely varying response of specific receiving water bodies, it is felt that no singular set of parameters can be advocated to cover all cases of development.

The approach recommended below is that of a general framework, within with each individual case is considered firstly for need, and, if deemed necessary, magnitude and nature of monitoring. Where monitoring is advocated, it is strongly recommended that the integrity of the data be paramount and not be compromised by cost considerations.

7. RECOMMENDATIONS

It is recommended that:

(a) WAB approach Dartmouth Lakes Advisory Board (DLAB) and Bedford Waters Advisory Committee (BWAC) with a view to coordinating policy for water quality monitoring recommendations in development agreements throughout the HRM.

(b) That the proponent of any development, which is subject to a development agreement, and which may substantially affect freshwater quality presents a water quality monitoring proposal (based on Table 2) to the appropriate group (WAB, DLAB or BWAC) together with the development proposal. A proponent is expected to ascertain early in the proposal stage as to whether such a condition exists.

(c) That an ad hoc "Technical subcommittee" (TSC) be constituted to provide technical and scientific advice on any proposed monitoring program referred by a water advisory group. It is recommended that the TSC be constituted by, and comprise, representation from the water advisory groups, government and academia (WAB Terms of Reference, Item 3.0 - App.A), with powers to seek outside advice as it deems necessary. Development proposals, together with the proposed monitoring program, referred to any HRM water advisory group, would first be considered by that group. If the group feels it appropriate to seek expert advice, it would then be referred for review by the TSC, and the TSC recommendations on

quantity and quality data collection (recommendations d and e below) would then be referred back to the applicable group for final recommendation. The TSC normally will provide its recommendations to be available at the next scheduled group meeting.

(d) Where development is of a substantive nature and/or where a strong potential for adversely affecting freshwater bodies exists (b, above):

(i) Prior to development, a substantial baseline study based on the parameters recommended in Table 2, with site-specific additions and deletions (which may be recommended by the water advisory group) be carried out.

(ii) The short list of parameters (Tables 1 and 2), with the addition of site-specific additional parameters recommended by the water advisory group, then be sampled during the construction phase on at least a seasonal basis, with monthly sampling for a sub-set of parameters.

(iii) Annual sampling for continuing stewardship of the water resource should continue during the post-development phase using trained volunteers who are preferably from the particular community most directly affected.

(e) Where construction activities are potentially of a lesser impact, only recommendation (d) (ii) be carried out, by trained volunteers. Recommendation (d) (iii) to be encouraged where feasible.

(f) All field sampling and, storage and handling protocols be carried out as set out in reference [5], and that all laboratory analyses be carried out by CAEAL, or equivalent, laboratories.

(g) A copy of the raw data obtained by sampling be passed directly from the laboratory to a designated officer of HRM for interpretation (according to OECD recommendations on trophic status [11] and Canadian Environmental Quality Guidelines [3]) within 2 weeks of receipt and both the data and the interpretation then be made available to the appropriate water advisory group for consideration and comment, following which all data, comments and interpretation will be made available to the public.

(h) Contractor's and developer's organizations be approached for financial support to pay for a part-time co-ordinator, field equipment, and chemical and biological analyses. In return these organizations or individuals should be free to advertise their support and the results of the monitoring program.

(i) An inventory be kept of all data collected for each fresh water body assessed in the HRM. This data to include the date of assessment and the names of the monitoring and laboratory bodies doing the respective assessments.

8. REFERENCES

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TABLE 1. Shortlist of Parameters

Parameter	Justification
Laboratory measurements of samples	
pH	Influence of disturbed pyritic (-) or gypsum (+) bedrock; loss of buffering capacity
Color	Influence of wetland areas; interrelationship with phosphorous and aluminum availability (color tends to bind with P an Al).
Phosphorous (TP)	Potential for changes in trophic status
Coliform and Fecal bacteria	Presence of point or non-point source pollution; presence of wildlife (waterfowl); indicator of conditions that could allow survival of other pathogens
Aluminum	Effects on fish populations (various problems with different age classes); evidence of local or generalised acidification
Turbidity and suspended solids	Turbidity is relatively inexpensive, suspended solids is more expensive. Recommend both. Indicators of eroded soils entering surface water and/or high algal productivity; potential sedimentation in fish spawning areas; smothering of benthic species and/or fish eggs
Conductivity	Indicates level of dissolved solids which may have physiological effects on biological community, corrosion rates, precipitation of minerals; impacts of road salt; impacts of point sources of pollutants
Trace metal	Site dependant heavy metal indicator
Field Measurements	
Water temperature, dissolved oxygen Secchi disk and pH.	All taken at mid-point of 1 m depth increments at deepest location on site.

TABLE 2. Comparison of Glen Arbour, Kings County and Metro Survey Parameters with Suggested Baseline and Shortlist Parameters

Parameter	Unit	Cost ($)	Other Programs			Suggested	
			Glen Arbour	Kings Co.	Metro Survey	Base line	Short list
Physical Parameters							
pH		5	*	1,2,3,4	80,91	R	Y,F,M
Water Temp.	°C		*[5]	F	91	F[2]	F[2],M
Air Temp.	°C			F			
Colour	Hazen	5	*[5]	1,2 4	91	R[2]	Y[2]
Turbidity	NTU	5	*[5]	1,2,3,4		R[2]	Y[2]
Conductivity	µmhos/cm	5	*[5]	1,2,3,4	80,91	R[2]	Y[2]
Solids suspended	mg/L	10		1		X	Y,M
Secchi disk	m		*	F	91	F	F,M
Conventional Chemical Parameters							
Dissolved Oxygen	mg/L		*[5]			F[2]	F,M
Organic carbon	mg/L						
Total	mg/L	8		1,2		R	
Dissolved	mg/L		*	3,4,5	91		
Sodium	mg/L	6	*	1,2	80,91	R	
Potassium	mg/L	6	*	1,2	80,91	R	
Calcium	mg/L	6	*	1,2	80,91	R	
Magnesium	mg/L	6	*	1,2	80,91	R	
Hardness		12	*	1,2		R	
Alkalinity	mg $CaCO_3$/L	7	*	1,2,3,4	80,91	R	
Acidity		10					
Fluorescein Dye		17					
Fluoride		7					
Bicarbonate			*				
Carbonate			*				
Sulphate	mg/L	7	*	1,2	80,91	R	
Chloride	mg/L	7	*	1,2	80,91	R	
Silica	mg/L	7	*	1,2	80,91	R	
Nitrogen total	mg/L	11	*[5]	1,2,3,4	80,91		
NO_3+NO_2 N	mg/L	7	*	3			
NO_3		7		1,2	80,91	R	
NH_4 N	mg/L	7	*	1,2,3	80,91	R	
Kjeldahl		16					
UV, total		11					
Phosphorus Total	µg/L	11(bd)	*[5]	1,2,3,4,5,6	80,91	X[2]	Y[2],M
Ortho-P	µg/L	7	*	1,2,3,4,5,6		R	
Cyanide							
Hydrogen Sulphide		40					

Cation sum	meq/L		*				
Anion sum	meq/L		*				
Ionic Balance	% diff		*				
Saturation pH			*				
Langelier Index 20C			*				

Parameter	Unit	Cost ($)	Other Programs			Suggested	
			Glen Arbour	Kings Co.	Metro Survey	Base line	Short list
Metals							
Aluminum	mg/L	6	*	1	91	X	Y
Arsenic	mg/L	10		1	91		
Antimony	mg/L	6		1			
Barium	mg/L	6		1			
Beryllium	mg/L	6		1			
Boron	mg/L	6		1			
Cadmium	mg/L	6		1	91		
Cerium					91		
Chromium	mg/L	6		1			
Cobalt	mg/L	6		1	91		
Copper	mg/L	6	*	1,2	91	R	
Dysprosium					91		
Erbium					91		
Europium					91		
Gadolinium					91		
Holmium					91		
Indium					91		
Iron	mg/L	6	*	1,2	91	R	
Lanthanum					91		
Lead	mg/L	6		1	91		
Luterium					91		
Manganese	mg/L	6	*	1,2	91	R	
Mercury	mg/L	19.50		1			
Molybdenum	mg/L			1			
Neodymium					91		
Nickel	mg/L	6		1	91		
Paeseodymium					91		
Samarium					91		
Selenium	mg/L	6		1			
Silver	mg/L			1			
Strontium	mg/L			1			
Terbium					91		
Thallium	mg/L			1			
Thulium					91		
Titanium					91		

Tin	mg/L	6		1			
Vanadium	mg/L	6		1	91		
Uranium	mg/L	5		1	91		
Ytterbium					91		
Yttrium					91		
Zinc	mg/L	6	*	1,2	91	R	

Organic

Phenolics

Parameter	Unit	Cost ($)		Other Programs			Suggested	
				Glen Arbour	Kings Co.	Metro Survey	Base line	Short list
Biological Parameters								
Chlorophyll a								
Field filtered	µg/L	22.50					X[2]	
Lab filtered	µg/L	30.50	*[5]	1,2,3,4,5,6		91		
Phaeophytin	µg/L	2.50	*[5]				X[2]	
Tannin & Lignin								
Humic Substances		8						
Colliform Presence		12					X	Y
Total (count)		15						
Fecal (count)		15						
Iron Bacteria		20						
Algae		20						
Fish Tissue								
Biodiversity							X	

Notes:

[2] For lakes, parameter to be evaluated from each of two samples, one to be taken at 0.25m below surface, and second 1 m off bottom. For streams, only one sample required.

[5] Parameter evaluated from five samples taken at depths of lake surface, and 4 equal intervals.

1..6 Package number in Kings Co. study

80 Halifax/Dartmouth Metro Area Lakes Survey 14 April 1980

91 Halifax/Dartmouth Metro Area Lakes Survey 16 April 1991

* Parameters quantified in Glen Arbour monitoring

R RCAP (Table C-1 - $80)

X Parameters, with laboratory analysis, not in RCAP package for baseline

Y Recommended laboratory analysed shortlist + at least one site specific heavy metal (Table 1) - taken seasonally

F Field measurement

M Monthly measurements in mid-April through mid-October

APPENDICES

Appendix A

Relevant Extracts from the Terms of Reference of the Halifax County/Halifax Mainland Watershed Advisory Board (WAB)

"1.0 Purpose

The Halifax County/Halifax Mainland Watershed Advisory Board is established to advise Community Council on all matters related to the management and alteration of the lakes, rivers, waterways, coastal inlets and their watersheds within Halifax Regional Municipality, and to act as an advisory resource in providing Community Council with recommendations on their sustainable use.

Without limiting the generality of the above, the Board shall have the following responsibilities:

(a) To provide leadership, promote public awareness and education, and identify issues and action on matters related to the Municipality's lakes rivers, waterways and coastal inlets (to the citizens of Halifax Regional Municipality);

(b) To provide input to Community Council and the Community Planning Advisory Committees, on all applications for development agreements, rezoning and amendments to any land use by-law with regard to potential impact on the Municipality's lakes, rivers, waterways and coastal inlets;

(c) To monitor studies being conducted and regulations being formulated by various levels of government and comment and provide recommendations to Community Council on these with respect to their impact on the Municipality's lakes, rivers, waterways and coastal inlets;

(d) To cooperate with other similar agencies in addressing issues affecting directly or indirectly the Municipality's lakes, rivers, waterways and coastal inlets;

(e) To liaise with and encourage input from local community based organizations involved in watershed protection and related activities;

(f) To advise on any other matters which Community Council and the Community Planning Advisory Committee deem necessary."

"3.0 Committees

The Board may appoint ad-hoc committees to deal with issues as needed."

"7.0 Relationship to Community Council

The Board shall act only in an advisory manner to Community Council. Any plan, program or proposed development activity within any watershed likely to have an effect on any lake, river, waterway or coastal inlet shall be referred to the Board for its consideration and subsequent recommendations to Community Council."

APPENDIX B

Sample Data Monitoring - Glen Arbour Development

At its meeting of 19 June, 1996, and following a presentation by the proponents of the then proposed new Glen Arbour golf course and subdivision development to the 17 July, 1996 meeting, WAB submitted a memo of recommendations to Northwest Community Council (NWCC) for approval and transmittal to the HRM Planning Services Central Division. The first of these recommendations was:

> "Baseline studies of the three lakes should be conducted involving water quality parameters and characterization of the species of benthos present in each lake which could act as indicator species of environmental degradation. Water quality parameters examined should include: sodium, potassium, calcium, magnesium, hardness, alkalinity, sulphate, chloride, silica, nitrate + nitrite, ammonia, iron, manganese, copper, zinc, TOC, turbidity, conductivity, orthophosphate, colour and pH; these are usually available as a single suite of analyses by most labs and are often referred to as RCAP. Minimal sampling frequency would be during the spring and fall turnover of the water in the lakes. As well total phosphorus (TP), chlorophyll a (Cha) and total nitrogen should be sampled monthly for a full year to monitor seasonal changes of these parameters...We would also recommend that a suitable sedentary organism (freshwater clam, mussel or non-migratory fish) be sampled in each lake for mercury. Given historical use of mercury in pesticide control on golf courses, it could be in the best interests of the developer to obtain such information for future reference."

In subsequent sections of the development agreement, approved by NWCC of HRM on 9 January, 1997, it was agreed as below:

"6.10 The Developer hereby agrees to carry out baseline water quality sampling to determine the existing lake water quality within and immediately upstream of the Property. The sampling program shall be undertaken pursuant to the recommendations of the Centre for Water Resource Studies, Technical University of Nova Scotia [now DalTech, Dalhousie University]. Results of the baseline water quality sampling shall be provided to the Municipality prior to permits being issued for the construction of the Golf Course.

6.11 The Developer hereby agrees to carry out water quality sampling until completion of the construction of the eighteen hole golf course

> and for a one year period after the commencement of operation of the Golf Course. The sampling parameters and on-going monitoring shall be undertaken pursuant to the recommendations of the Centre for Water Resource Studies, Technical University of Nova Scotia..., and shall be provided to the Municipality on a quarterly basis."

It may be noted, in reference to the original recommendation from WAB, that mercury is no longer used in pesticides applied to golf courses.

The parameters, all of which were monitored on a fixed seasonal basis, are given in Table B-1.

TABLE B-1. Parameters Monitored in Glen Arbour Study

Parameter	Unit	Monitored	
		Single sample	At five depths
Physical Parameters			
pH		*	
Temperature	°C		*
Colour	Hazen		*
Turbidity	NTU		*
Conductivity	µmhos/cm		*
Secchi disk		*	
Conventional Chemical Parameters			
Dissolved Oxygen	mg/L		*
Organic carbon			
Dissolved	mg/L	*	
Sodium	mg/L	*	
Potassium	mg/L	*	
Calcium	mg/L	*	
Magnesium	mg/L	*	
Hardness		*	
Alkalinity	mg $CaCO_3$/L	*	
Bicarbonate		*	
Carbonate		*	
Sulphate	mg/L	*	
Chloride	mg/L	*	
Silica	mg/L	*	
Nitrogen total	mg/L		*
NO_3-NO_2 N	mg/L	*	
NH_3 N	mg/L	*	
Phosphorus Total	µg/L		*
Ortho-P	µg/L	*	
Cation sum	meq/L	*	
Anion sum	meq/L	*	
Ionic Balance	% diff	*	
Saturation pH		*	
Langelier Index 20C		*	
Metals			
Aluminum	mg/L	*	
Copper	mg/L	*	
Iron	mg/L	*	
Manganese	mg/L	*	
Zinc	mg/L	*	
Biological Parameters			
Chlorophyll a			*
Phaeophytin	µg/L		*

APPENDIX C

Costs for Laboratory analyses

TABLE C-1. Sample Costs for Laboratory Analyses

Parameter	Package			Cost ($)
	Basic Anal.	RCAP Anal.	Gen. Anal. + Metal Scan	
Physical parameters				
pH	X	X	X	5.00
Colour(TCU)		X	X	5.00
Turbidity		X	X	5.00
Conductivity		X	X	5.00
Solids total				10.00
total fixed or vol.				10.00
total dissolved				10.00
total suspended			X	10.00
fixed or vol. sus.				10.00
Chemical parameters				
Total Organic Carbon		X	X	8.00
Sodium		X	X	6.00
Potassium		X	X	6.00
Calcium	X	X	X	6.00
Magnesium	X	X	X	6.00
Hardness	X	X	X	12.00
Alkalinity	X		X	7.00
Fluorescein Dye				17.00
Fluoride			X	7.00
Sulphate	X	X	X	7.00
Chloride	X	X	X	7.00
Silica - reactive		X	X	7.00
Nitrogen NO_3-NO_2-N				7.00
NO_3	X	X	X	7.00
NH_3 -N	X	X	X	7.00
Kjeldahl				16.00
UV, total				11.00
Phosphorus Ortho		X	X	7.00
total (bd)				16.00
total (UV)				11.00
Acidity				10.00
Alkalinity		X		7.00
Cyanide				By arrang.
Hydrogen Sulphide				40.00

Parameter	Package			Cost ($)
	Basic Anal.	RCAP Anal.	Gen. Anal. + Metal Scan	
Heavy Metals				
Aluminum			X	6.00
Arsenic			X	10.00
Antimony			X	6.00
Barium			X	6.00
Beryllium			X	6.00
Boron			X	6.00
Cadmium-ICP			X	6.00
-HGA			X	11.00
Chromium			X	6.00
Cobalt			X	6.00
Copper		X	X	6.00
Iron	X	X	X	6.00
Lead-HGA			X	11.00
-ICP			X	6.00
Manganese	X	X	X	6.00
Nickel			X	6.00
Selenium			X	6.00
Tin			X	6.00
Vanadium			X	6.00
Uranium				5.00
Zinc		X	X	6.00
Organic				
Phenolics				By arrang.
Biological parameters				
Chl a (field filtered)				22.50
(lab filtered)				30.50
Phaeophytin ("a")				2.50
Tannin & Lignin				By arrang.
Humic Substances				8.00
Colliforms Presence				12.00
Total (count)				15.00
Fecal (count)				15.00
Iron Bacteria				20.00
Algae				20.00
Biodiversity				
Package Cost ($)	50.00	80.00	150.00	

Source: Memorandum of 21 April, 1999 from Kyna MacVicar, Supervisor, Environmental Services, QE II Health Sciences Centre, Halifax, NS.