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Dartmouth Lakes Advisory Board
May 31, 2006

TO: Chair and Members, Dartmouth Lakes Advisory Board

SUBMITTED BY: Paul Dunphy, Director, Planning & Development

DATE: May 26, 2006

SUBJECT: **Russell Lake Phosphorus Threshold**

ORIGIN

Morris-Russell Lake Secondary Planning Strategy (SPS); Russell Lake West Development Agreement

RECOMMENDATION

It is recommended that :

DLAB approve a phosphorus threshold value for Russell Lake of 15 micrograms (μg) per liter (L).

BACKGROUND

Lakes may be classified into three basic categories, based upon their biological productivity. These categories (trophic classes) are determined largely by total phosphorus (TP) concentration:

Oligotrophic: Low TP, low productivity, low chlorophyll, un-impacted
Mesotrophic: Medium TP, moderate productivity, medium chlorophyll, some impact
Eutrophic: High TP, high productivity, high chlorophyll, noticeable impact

In their natural state, lakes with undisturbed drainage basins tend to become gradually enriched over century time-scales with nutrients and organic material carried into the lakes with runoff. This natural process, termed "eutrophication", makes lakes more biologically productive. In an undisturbed state, the productivity of a lake is limited by the nutrients which plants and ultimately the invertebrates and fish require for growth. In most freshwater systems, phosphorus is the most limiting nutrient, and as phosphorus concentrations increase through enrichment, the lake becomes more eutrophic. Water quality changes from very clear to more cloudy due to increased growth of unicellular algae floating in the water column, more growth of aquatic plants occurs in the shallower areas, more organic matter and sediment builds up on the lake bottom. Oxygen concentrations in the water may be reduced by decomposition, and fish communities tend to change from those preferring cold, clear waters to other species more tolerant of enriched conditions.

When human activity disturbs part of a drainage basin or watershed, increased concentrations of nutrients are carried into the lake both in suspended particles and in solution. This causes an acceleration of the eutrophication process as a result of the human disturbance of soils and organic materials in the watershed, and through increased runoff of nutrients and organic material from sewers, lawn and paved areas. This is termed "cultural eutrophication" and can occur on a relatively short timescale of years. The lake may not be as desirable for swimming, there may be fewer game fish, increased growth of macrophytes (plants), and algal blooms may cause surface scum and odour.

Phosphorus Thresholds

A phosphorus threshold level is a management tool, which sets a limit for phosphorus beyond which further assessment is needed. The Morris-Russell Lake area SPS requires eutrophication (TP) threshold levels to be set for these lakes (Attachments A, B). Watershed management controls and development potential are to be revisited if the threshold is exceeded, existing plan policies are to be reviewed, and an appropriate course of action determined regarding watershed management and future land use.

The Canadian Council of Ministers of Environment (CCME) has created a Phosphorus Guideline as part of the Canadian Environmental Quality Guidelines. The Guideline is based on the Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems (Environment Canada, 2004).

The steps in the CCME Framework are as follows:

- Set Ecosystem Goals and Objectives: Goals and objectives for lake water quality may be set based on inherent lake value, and on the value of human uses of the lake.

- Define Reference Conditions: Reference condition refers to the lake's phosphorus concentration under natural conditions prior to any human development of the watershed. Various methods may be used in determining reference conditions:

  - Phosphorus modelling
    - TP export from varying land uses
    - Reset watershed to undeveloped state
    - Backcast of Background TP
  - Use historical data when available
  - Compare to similar undeveloped watersheds/lakes
  - Paleolimnology
    - Sediment fossil diatom assemblages
  - Regional TP Background
  - Ecoregion/ecozone approach
  - 25th percentile method

- Select Trigger Ranges: The trigger range encompasses the lower and upper limits of the trophic category (Attachment C) within which the lake's reference condition would fall, based on total phosphorus reference level as determined above.

- Determine Current Phosphorus Concentration: TP is used as a measurement of phosphorus, either from a single measurement at spring turnover, or from seasonal average over the year.

- Compare Current or Predicted Concentration to Trigger Range: If current or predicted concentration exceeds the trigger range, then there is a risk of impact, and further assessment is recommended.

- Compare Current or Predicted Concentration to Baseline Condition: If the trigger range is not exceeded, then an increase in TP of over 50% above the baseline (reference) condition indicates a risk of impact, and further assessment is recommended.

- Management Decisions: Compare the measured or predicted TP concentration to the original goals, and the trigger values, and decide if the degree of change is acceptable. Consider short and long term strategies. Management actions may include: No action; Reduction in Phosphorus Input; Remediation and Conservation.

DISCUSSION

Goals and Objectives: Russell Lake is a valued community resource, and is used for a variety of recreational activities including contact recreation. As such, it is desirable to at least maintain the lake in its current state, and prevent forcing the lake from its present trophic category into a higher category. The current state of water quality in Russell Lake is better than it has been in the past (mesotrophic vs eutrophic). This is a small lake with an urbanised watershed, and so preservation of the current mesotrophic status is a reasonable objective.

Define Reference Conditions: The phosphorus modelling report provided by Clayton Development suggests using a comparison with three nearby lakes (Topsail, Lamont and Major) which have similar geology, and relatively undeveloped watersheds (as drinking water supply protected watersheds). Due to some limited development, as well as long-range influences, these lakes are indicative but not truly pristine. This approach is consistent with one of the CCME options for determining reference conditions (compare to similar undeveloped lakes), and based on 1980 data give a suggested reference level of 7 micrograms (μg) per liter (L).

Phosphorus modelling uses derived or estimated phosphorus transport coefficients for differing land cover/uses to model the amount of phosphorus transported to a lake via runoff. Phosphorus models supplied to HRM by Mr. S. Mandaville may also be used to estimate a reference TP level, by setting the watershed area to an undisturbed condition (ie. using a phosphorus export coefficient suitable for undisturbed forest). Using a coefficient for forested land of 0.054 kgP/ha/yr, this model gives a reference lake TP level of 4 μg/L. The Clayton model uses a higher coefficient of 0.1 kgP/ha/yr for forested land (estimated by calibrating the model to give TP levels similar to Topsail, Lamont and Major 1980 levels). Using a coefficient of 0.1 in the Mandaville model gives a reference TP level of 6.4 μg/L. A rough preliminary calculation using the standard phosphorus model developed by NSDEL for use in Nova Scotia provides a reference TP level of 4.5 μg/L.

Historical data which is available indicates that Russell Lake has in the past experienced much higher TP levels than are currently measured, so historical data presents a mixed picture. TP values well into the eutrophic range (>35 μg/L) have been measured by NSDoE (1975-1977). Likely sources of historic phosphorus were agricultural operations within the watershed, principally a pig farm on the western side of the lake. Levels since the mid-1980s have been typically within the mesotrophic range (with occasional eutrophic levels), indicating an improvement in trophic status.

Thus, the CCME Reference Condition for Russell Lake would be in the 4-7 μg/L range.

Select Trigger Range: The trigger range, using a strict application of the CCME framework, would be the limits of the oligotrophic category, 4-10 μg/L TP. This would give a phosphorus threshold of 10 μg/L TP. The management objective of maintaining the lake within the mesotrophic category could allow a higher threshold of 15 μg/L TP (mid-range of the mesotrophic category) and still allow for appropriate action should the lake exceed the threshold.

Determine Current Phosphorus Concentration: Recent sample data between April 2005 and March 2006 for the deep station has yielded TP values between 4 and 25 μg/L TP, with a mean of 13.5 which is within the mesotrophic category. Spring 2005 level was 4 μg/L, and spring 2006 level was 15 μg/L. A more recent sample by HRM (May 2006) showed a level below 2 μg/L, but this needs confirmation as it appears excessively low.

Compare Current or Predicted Concentration to Trigger Range and Baseline: Current TP levels exceed the CCME trigger range upper limit (10 μg/L), and also exceed a level 50% above the baseline (calculated as 6-10 μg/L, depending on baseline value selected). Current levels are within the mid range (15 μg/L) of the mesotrophic category. Single sample results are not always indicative of the longer-term status of a lake, and so part of the assessment may involve an analysis of the frequency of levels exceeding the threshold. Annual averages may be more indicative.

Management Decisions: Watershed management controls and development potential are to be revisited if the threshold is exceeded. Depending on the threshold value chosen, current values are above or near the threshold value, suggesting the need for further assessment. If the management goal is to preserve the lake within the current trophic category, then ongoing efforts should seek to ensure that the TP level does not exceed 20 μg/L (the mesotrophic-eutrophic boundary). Modelling provided by Clayton Developments predicts that the planned Russell Lake West development will cause an increment in lake TP levels of about 1.5 μg/L. This would put the lake at the mid range of the mesotrophic category (15 μg/L), and above a TP threshold established using the CCME Framework. This level remains well below the lower limit of the next higher trophic category, which is 20 μg/L (meso-eutrophic).

Colour and depth can affect a lake's response to phosphorus, and may result in misleading classification of a lake based only on the deep-water TP level. Highly coloured lakes may have high TP but lower productivity than predicted ("dystrophic" lakes). Shallow lakes may have much of their production in the form of submerged or emergent microphytes in the shallows, and so may actually be in a higher category than the deep-water TP would indicate. Recent colour readings in Russell Lake are relatively low (although they have been higher in the past), so this should not be a factor. Parts of Russell Lake are shallow (mean depth 3.7 M, maximum depth 9 M), but there is a deep area which can stratify in summer. When a lake stratifies, the deep water is isolated form the surface, and can become anoxic in summer as decomposition uses up oxygen. Under these conditions, phosphorus may be released from the sediments, and redistributed within the lake during fall turnover ("internal loading"). It is possible that this is a source of part of the phosphorus load in Russell Lake, given its history of high TP inputs.

HRM has investigated a possible source of phosphorus entering the south end of Russell Lake, and will continue to assess the situation in an attempt to clearly identify, and if possible remediate or correct the situation. Possible sources include a sewage pumping station at Gaston Road, additional sewage effluent from further upstream through leaks or cross-connections, or drainage water pumped from the Clayton Development construction site.

CONCLUSION

Russell Lake prior to any development within its watershed was very likely an oligotrophic lake. During its history, it has at times been well within the eutrophic category due to various land uses within the watershed. Currently, Russell Lake seems to be within the mesotrophic category. A management goal should be to prevent Russell Lake transitioning to the next category of meso-eutrophic, which would reduce its aesthetic and recreational appeal. A TP threshold in the 10-15 μg/L range would be suitable to prevent this, assuming that strict controls are applied to any activity which is likely to increase the TP level beyond this threshold.

Strict application of the CCME Framework protocol yields a phosphorus threshold of 10 μg/L TP. It is recommended, based on the management objective for the lake, that a phosphorus threshold level of 15 μg/L TP be adopted for Russell Lake. This threshold will allow for appropriate action before the lake reaches the mesotrophic/meso-eutrophic boundary of 20 μg/L TP. Recent data from 2005-2006 indicate that the lake is near or at the threshold level of 15 μg/L presently, and so further assessment is warranted.

Watershed management controls and development potential are to be revisited if the threshold is exceeded. Ongoing monitoring will be important to assess any changes. Further investigation of an apparent source or sources of phosphorus in the Gaston Road area, entering the lake through the south-west inlet, is warranted.

BUDGET IMPLICATIONS

N/A

FINANCIAL MANAGEMENT POLICIES / BUSINESS PLAN

This report complies with the Municipality's Multi-Year Financial Strategy, the approved Operating, Capital and Reserve budgets, policies and procedures regarding withdrawals from the utilization of Capital and Operating reserves, as well as any relevant legislation.

ALTERNATIVES

None recommended.

ATTACHMENTS

A. SPS Water Quality Policy
B. Russell Lake West Development Agreement, Water Quality Policy
C. Trophic Category Limits for Canadian Lakes/Rivers

A copy of this report can be obtained by contacting the Office of the Municipal Clerk at 490-4210, or Fax 490-4208.

Report Prepared by:

Manager, Environmental Performance

ATTACHMENTS

A. SPS Water Quality Policy

Morris Russell Lake Secondary Planning Strategy

Monitoring

The eutrophication process is gradual and takes place over many years. Its progress will be seen in extension of vegetation in shallow areas and the seasonal occurrence of algae. In the Morris Lake Watershed Study a Phosphorus Loading Model was used to determine the relationship of the lake phosphorus inputs to trophic status.

The model determined that Morris Lake is currently mesotrophic and is within 10 to 15 percent of the eutrophic boundary. Thus, the amount of land developed within the watershed should be controlled to prevent Morris Lake from reaching a borderline eutrophic state. The actual amount of land that can be developed can only be determined by undertaking a well designed lake monitoring program and adopting a preset maximum permissible limit for total phosphorus. If the results indicate that Total Phosphorus continues to increase, the watershed management plan will have to be revised and development controls strengthened.

ML-30 A water quality monitoring program shall be undertaken for Morris and Russell Lakes to track the eutrophication process. The program is to be designed and undertaken by qualified persons financed in whole or part by developers within the secondary plan area. Specifics of the program are to be negotiated under the terms of a development agreement in consultation with the Dartmouth Lakes Advisory Board.
The monitoring program shall:

(a) specify the duration of monitoring for the pre-construction, construction and post-construction phases of the development;

(b) Specify the physical and chemical water quality indicators to be measured, the location and frequency of testing and the format of submissions to the Municipality in each phase referenced under clause (a);

(c) Establish eutrophication threshold levels for the lakes which would be used as a basis for reevaluating watershed management controls and future development potential within the area;

(d) Conform with all water quality policies, specifications, protocols and review and approval procedures approved by Regional Council.

ML-31 Pursuant to policy ML-30, in the event the critical water quality threshold for Morris or Russell Lakes are reached, it shall be the intention of Council to immediately undertake a review of existing plan policies contained herein and determine an appropriate course of action respecting watershed management and future land use development in this area. Critical water quality thresholds shall be made available to the public.

B. Russell Lake West Development Agreement, Water Quality Policy

PART 3: SUBDIVISION OF THE LANDS

3.1 Environmental Protection

(a) The terms and conditions of a water quality monitoring program for Russell Lake as prepared by a person deemed qualified by the Municipality have been agreed to by the Municipality. All costs associated with the program are to be assumed by the Developer. The Development Officer shall refer the proposed monitoring program to the Dartmouth Lakes Advisory Board and the Community Council for an opinion regarding it's acceptability and may seek the advice of any person deemed qualified within the Municipality or the Province.

(i) specify the duration of monitoring for the pre-construction, construction, and post-construction phases of development.

(ii) specify the physical and chemical water quality indicators to be measured, the location and frequency of testing and the format of submissions to the Municipality in each phase referenced under Clause (i); and

(iii) establish eutrophication threshold levels for the lake which would be used as a basis for reevaluating watershed management controls and future development potential within the area;

The Development Officer shall refer the proposed monitoring program to the Dartmouth Lakes Advisory Board for an opinion regarding it's acceptability and may seek the advice of any person deemed qualified within the Municipality of the Province.

3.3 The Developer agrees that the monitoring program, approved under clause 3.1 (a) of this agreement, is to be undertaken by a person deemed qualified by the Municipality and the findings are to be submitted to a person designated by the Municipality. The Municipality may require that a security, in a form and amount acceptable to the Municipality, be provided to ensure performance of all work required by the approved monitoring program. The Developer agrees to present the findings of the monitoring program to the Dartmouth Lakes Advisory Board and the Community Council on an annual basis until such time as all obligations under the monitoring program have been completed.

C. Trophic Category Limits for Canadian Lakes/Rivers (CCME Canadian Environmental Quality Guidelines)

Trigger Ranges based on Environment Canada (2004 - Table 1.1)	
TP (μg/L)	Trophic state
0-4	Ultra-oligotrophic
4-10	Oligotrophic
10-20	Mesotrophic
20-35	Meso-eutrophic
35-100	Eutrophic
100+	Hypereutrophic