Appendix B

Phosphorous and Algal Growth in the Yukon

The CCME guideline recommends that, in situations where there is a lack of original data or "reference condition"[3] , one can select reference sites to which the system being studied can be compared. Over the past three years, IWL has sampled over 29 sites throughout the Yukon and done a more detailed study of 10 of these sites.

Through water quality testing and photographic record of these sites, IWL has found varying degrees of TP with no correlation to algal growth. For instance, there are:

- water bodies with exceptionally high TP readings and negligible algae growth,

Example: Klondike Highway, GPS coordinates 08V 451819 6837836, August 8th 2007, TP 129ug/l and according to CCME, Hypereutrophic

[3] Canadian Council of Ministers of the Environment Ecosystem Health, Science Based Solutions, Canadian Guidance Framework for the Management of Phosphorous in Freshwater Systems, page 4

and

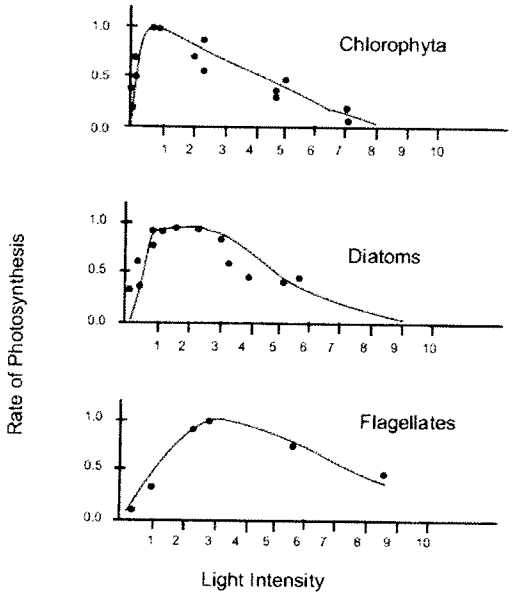
- water bodies with very low TP readings and extensive algae growth.

Example: Fish Lake Marsh[4], September 28th, 2007, TP=0, yet visibly significant algal growth and according to CCME, Ultra Oligotrophic

[4] Fish Lake Marsh GPS location: 08V 486723 6723706. This is the marshy area behind the berm flowing directly into MacIntyre Creek.

Clearly, TP is not the defining factor in algal growth. According to the USEPA Technical Guidance Manual for Performing Wasteload Allocations, EPA-823-13-97-002, there are three requirements for algal growth: light, heat and nutrient (phosphorous) concentration.

THE EFFECT OF LIGHT ON ALGAL GROWTH[5]:



EFFECT OF LIGHT INTENSITY ON ALGAL GROWTH
(After Ryther, 1956)

With increasing light intensity, the rate of algal photosynthesis (growth) increases, until a species specific maximum is reached, and then further increases in light intensity inhibit growth. Light is required for photosynthesis. However, at a certain level, very bright light can slow algal growth.

Given the considerable daylight during the growing season, is could be argued that light is not the limiting factor on algal growth.

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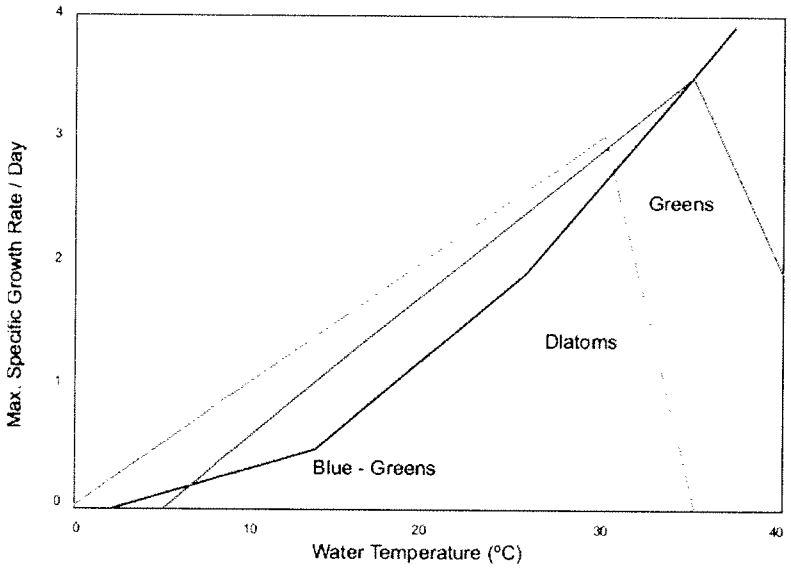
[5] USEPA Technical Guidance Manual for Performing Wasteload Allocations, EPA-823-13-97-002, Figure 2-7., p. 2-16.

THE EFFECT OF HEAT (WATER TEMPERATURE) ON ALGAL GROWTH[6]:

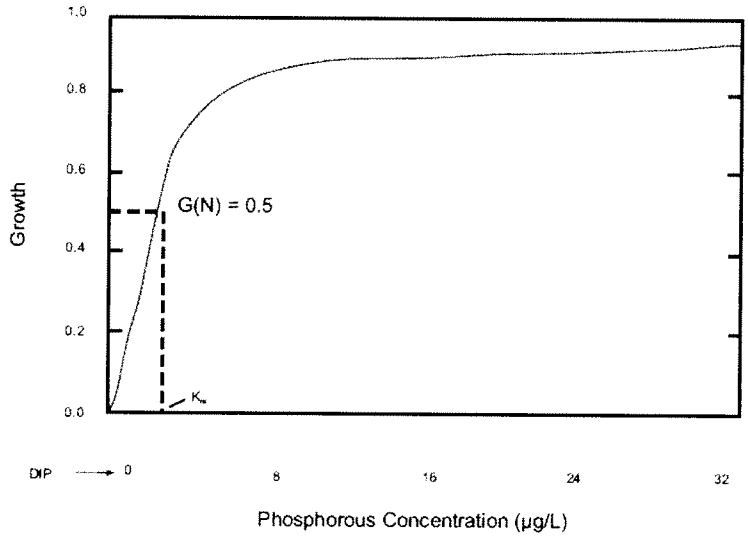


SPECIFIC ALGAL GROWTH RATE AS A FUNCTION OF TEMPERATURE
(After Canale and Vogel, 1974)

Depending on the type of algae, water temperature is a contributing factor to at least 30 C.

Since water temperatures in the Yukon never reach this lowest maximum, this is an unlimited factor for algae. Basically, the warmer the water, the faster the algae will grow.

THE EFFECT OF NUTRIENT CONCENTRATION (PHOSPHOROUS) ON ALGAL GROWTH[7]:



EFFECT OF PHOSPHOROUS ON ALGAL GROWTH
(After Ambrose et al., 1993a)

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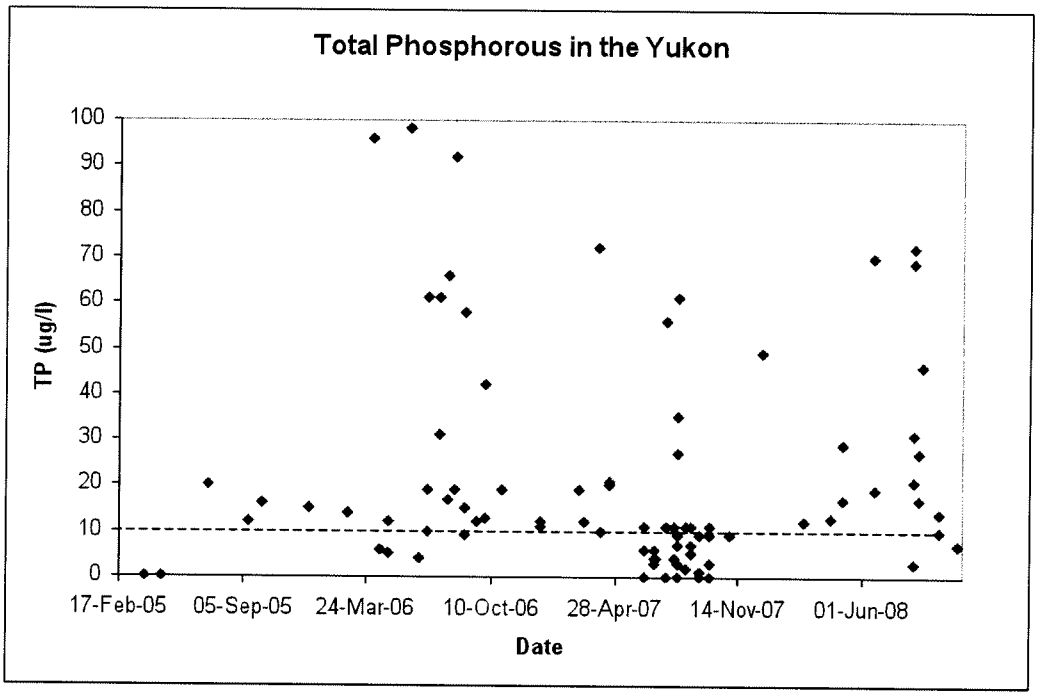
[6] USEPA Technical Guidance Manual for Performing Wasteload Allocations, EPA-823-13-97-002, Figure 2-6., p. 2-16.

[7] USEPA Technical Guidance Manual for Performing Wasteload Allocations, EPA-823-13-97-002, Figure 2-8., p. 2-17.

Increasing phosphorous does not lead to ever-increasing algal growth. Algal growth rate increases linearly with phosphorous concentration until between 8 and 12 ug/l[8]. After this point, algal growth is maximized: the algae cannot use any more phosphorous, with any excess over flowing through the system.

This is the same as any lawn: adding more and more fertilizer to it will eventually not make the grass grow any faster. At some point, the grass has reached its maximum growth rate and adding more fertilizer will not have any effect. The excess fertilizer is not used by the grass to make more grass, but leaches out of, or runs off, the soil.

TP[9] naturally occurring in the Yukon is often higher than that required to maximize algae growth (approximately 10 ug/l). Consider the scatter plot of TP of the 29 sites sampled throughout the Yukon between 2006 and 2008 (85 data points in total):



On 67 % of the sampling occasions (70 of 104 instances), TP was higher than the maximum concentration (as indicated by the dotted line above).

Therefore, additional TP is often not a contributory factor to algal growth in the Yukon.

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[8] For the purposes of this discussion, 10 ug/l will be referenced as the maximum phosphorous load with respect to algal growth.

[9] The USEPA references DIP, which is a variable component of TP. DIP can be any fraction (or all) of TP. Given this variability, IWL is following the CCME recommendation that Total Phosphorous be utilized for "meaningful measurement" (CCME abstract, page 1). Thus, the assumption is that DIP = 100% in these measures.