Appendix VII – Impact on P - Lake and Wetland Treatment

Basically, due to the lack of available calibrated models, it is difficult to come to a definite conclusion. Dillon reviewed the issue few ways:

1. The volume of P-Lake is estimated to be 11,667 m^3. The volume of the lagoon discharge is estimated to be 59829 m^3 in 2006, increasing to 96047 m^3 in 2026. The volume of water from the lagoon will more than displace the water in P-Lake. Assuming all water in P-Lake is displaced by lagoon water, the BOD_5 concentration of the entire lake will vary between 9 mg/L and 46 mg/L (high and low estimates based on predictions in the feasibility report). The water has one year to treat itself, before another volume of lagoon water will be discharged. Concentration of BOD_5 is assumed to decrease, based on first order kinetics. Examining a best and worst case scenario:

   - Best case:
   C_i = 9 mg/L
   K = 0.047 d-1 (high value from feasibility report)
   t = 90 d (max from feasibility report)

   Using these values, and substituting into equation, C_e = 0.131 mg/L

   - Worst case:
   C_i = 46 mg/L
   K = 0.037 d^{-1} (low value from feasibility report)
   t = 70 d (max from feasibility report)

   Using these values, and substituting into equation, C_e = 3.45 mg/L

   These values could be compared to baseline BOD_5 concentrations of P-Lake, to indicate a potential problem.

2. For a healthy system, the BOD_5 concentrations must be limited such that the oxygen demand of the wastewater does not exceed the oxygen transfer capacity of the lake. For wetlands, it is recommended that the design BOD_u (ultimate BOD) loading rate should not exceed half of the oxygen transfer rate. The ratio of BOD_u:BOD_5 can be estimated as 1.5. For the lagoon effluent in Cape Dorset, BOD_u is predicted to vary between 16.2 and 69 mg/L. P-Lake loading rates would then range from 69 kg/d and 473 kg/d.

   The oxygen transfer rate can be calculated by the following equation:

$$V \frac{dO}{dt} = K_l A_s (O_s - O)$$

and

$$K_l = 0.864 U_w$$

Where: V = Volume of P Lake (11,667 m^3)
A_s = Surface are of P- Lake (13,000 m^2)
O = Oxygen concentration in water
K_l = Oxygen mass transfer coefficient (md^{-1})
O_s = Saturation concentration of oxygen
U_w = Wind speed 10 m above water surface (in m/s, value of 16.9 km/h in Cape Dorset)

O_s can be determined from literature, but O needs to be measured at the surface of the lake. Both depend on temperature, pressure and altitude.

Fecal Coliform Reduction In Wetland

The reduction of fecal coliforms (FC) can also be predicted using **Table 6.3**. The average generation of FC in domestic sewage is $2x10^9$ FC per person per day[1]. Using this value and the predicted sewage volume generation from **Table 2.1**, the average fecal coliform concentration in the P Lake Lagoon system was determined in **Table 6.4.**

[1] Metcalf and Eddy, Inc. (1991). *Wastewater Engineering: Treatment, Disposal and Reuse, 3rd Edition.* Toronto : McGraw-Hill Inc.

Table Error! No text of specified style in document.**.1: Reduction of Fecal Coliform from Lagoon Treatment System**

Year	Population	Fecal Coliorm		Sewage Volume	Fecal Coliform			
					Raw Influent	Annual Lagoon Effluent (99.9% Reduction)	P Lake Lagoon Effluent (40% Reduction)	P Lake Lagoon Effluent
		(FC/p/d)	(FC/d)	(L/d)	(FC/L)	(FC/L)	(FC/L)	(FC/100mL)
2006	1382	2.0E+09	2.8E+12	1.6E+05	1.7E+07	1.7E+04	3.4E+03	3.4E+02
2007	1412	2.0E+09	2.8E+12	1.7E+05	1.7E+07	1.7E+04	3.4E+03	3.4E+02
2008	1441	2.0E+09	2.9E+12	1.7E+05	1.7E+07	1.7E+04	3.3E+03	3.3E+02
2009	1471	2.0E+09	2.9E+12	1.8E+05	1.7E+07	1.7E+04	3.3E+03	3.3E+02
2010	1501	2.0E+09	3.0E+12	1.8E+05	1.7E+07	1.7E+04	3.3E+03	3.3E+02
2011	1536	2.0E+09	3.1E+12	1.9E+05	1.6E+07	1.6E+04	3.3E+03	3.3E+02
2012	1570	2.0E+09	3.1E+12	1.9E+05	1.6E+07	1.6E+04	3.3E+03	3.3E+02
2013	1600	2.0E+09	3.2E+12	2.0E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2014	1632	2.0E+09	3.3E+12	2.0E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2015	1662	2.0E+09	3.3E+12	2.1E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2016	1692	2.0E+09	3.4E+12	2.1E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2017	1726	2.0E+09	3.5E+12	2.2E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2018	1757	2.0E+09	3.5E+12	2.2E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2019	1793	2.0E+09	3.6E+12	2.3E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2020	1829	2.0E+09	3.7E+12	2.3E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2021	1848	2.0E+09	3.7E+12	2.4E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2022	1879	2.0E+09	3.8E+12	2.4E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2023	1910	2.0E+09	3.8E+12	2.5E+05	1.5E+07	1.5E+04	3.1E+03	3.1E+02
2024	1941	2.0E+09	3.9E+12	2.5E+05	1.5E+07	1.5E+04	3.1E+03	3.1E+02
2025	1971	2.0E+09	3.9E+12	2.6E+05	1.5E+07	1.5E+04	3.1E+03	3.1E+02
2026	2002	2.0E+09	4.0E+12	2.6E+05	1.5E+07	1.5E+04	3.0E+03	3.0E+02

The predicted concentration of FC/100mL of P Lake Lagoon effluent is far beneath the design criteria of 10^4 FC/100mL.

Wetland Sewage Treatment - Nutrient Removal

Lagoon treatment systems often have difficultly reducing nutrients (nitrogen and phosphorus) to regulated levels. The effluent from the P Lake lagoon will be discharged to a wetlands area. Northern lagoon systems that run into wetlands areas can generally meet nutrient levels. Wetlands remove nutrients by a variety of natural processes: plant uptake, filtration, sorption, flocculation, sedimentation and biological degradation.