ENHANCED NATURAL REMOVAL OF CYANIDE AND AMMONIA IN TAILINGS LAKE AND ZONE 2 PIT LAKE AT COLOMAC, NWT

REMTECH 2006

by

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ALS Environmental

Taiga Environmental

PRESENTATION OVERVIEW

- Treatment Of Mine Water At Colomac
- Description of Monitoring Programs
- Results &Treatment Evaluation for Tailings Lake and Zone 2 Pit

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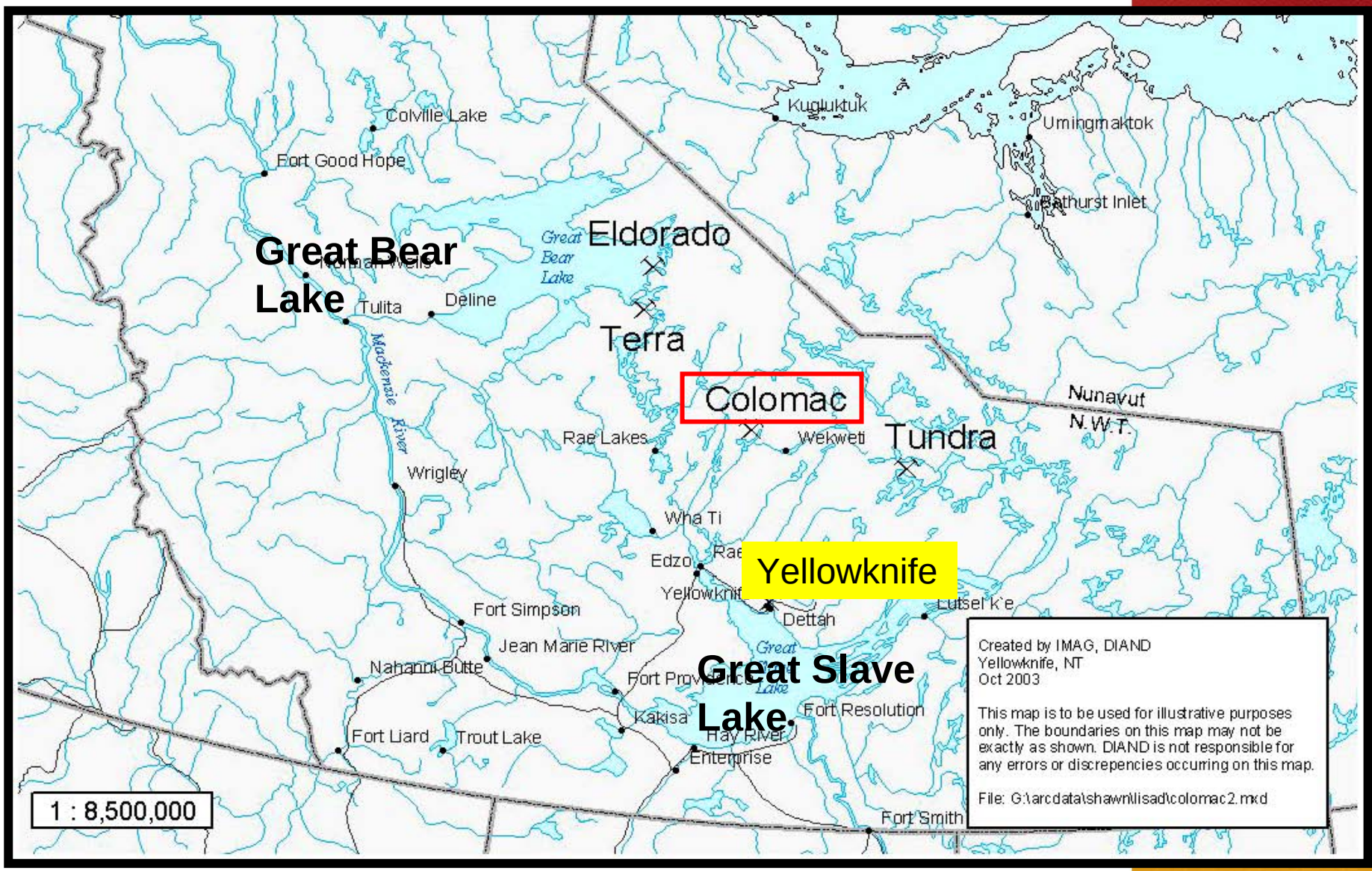
Colomac Mine Site



HISTORY

- 1990 Mine operations begin
- 1997 Ore processing & milling ceases
- 1999 Water transfers begin
- 1999 INAC assumes responsibility of abandoned site
- 2001 Construction of diversion ditches begins
- 2002 Water treatment begins
- 2004 Remediation Plan approved by MWL&W Board

ISSUES

- Water Management

  Tailings Lake expected to exceed licenced freeboard limit by 2006

- Water Quality

  Natural degradation of cyanide and related compounds insufficient

Tailings Lake

WATER TREATMENT & MANAGEMENT PLAN

- Add phosphate for ENR

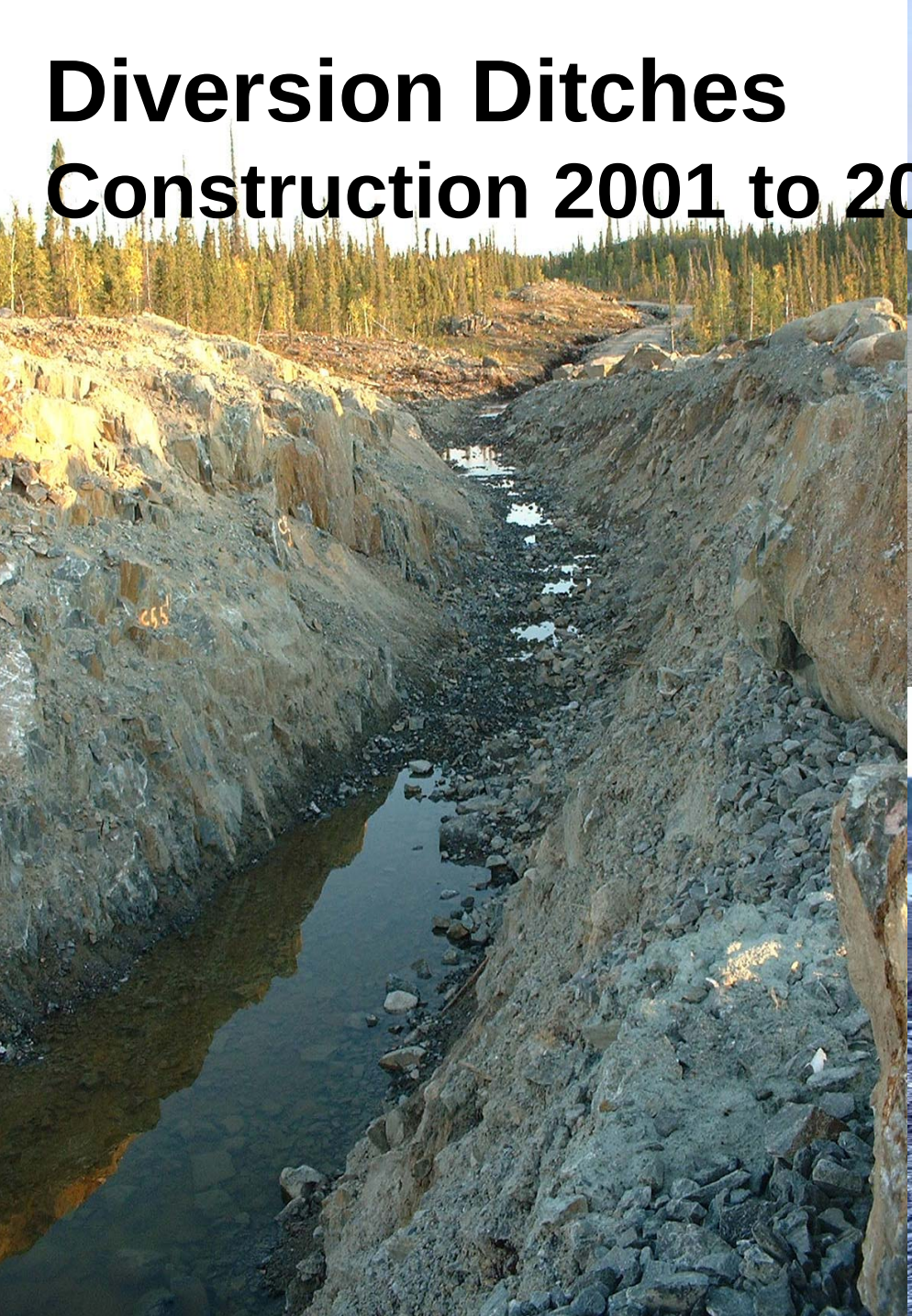
  2002: 11 tonnes of MAP
  2003: 9 tonnes of MAP

- Divert runoff to increase storage time
- Discharge Fuscum Lake annually
- First discharge of TLk via north spillway : 2008 - 2009

WATER TRANSFER 1999 – 2002

3.4 M m3 from TLk to Z2P

Diversion Ditches
Construction 2001 to 2004



WATER TREATMENT OPTIONS

Enhanced Natural Removal (ENR)

- Preferred Option
- Phosphorus Deficient
- Bench Scale Tests

Pilot Plant

- Alkaline Chlorination
- Rotating Biological Contactor

ENR LAB BENCH TEST Oct 2001

MAP fertilizer on melting ice

Staging
of MAP


PHOSPHATE ADDED BY HELICOPTER AT BREAKUP

Zone 2.0 Pit Water Treatment & Management Strategy

- Add phosphate for ENR

  2002: 22 tonnes of MAP
  2003: 9 tonnes of MAP

- If required, induce artificial circulation in 2006
- Reach regulated level in 2011
  Seepage to Baton 2014

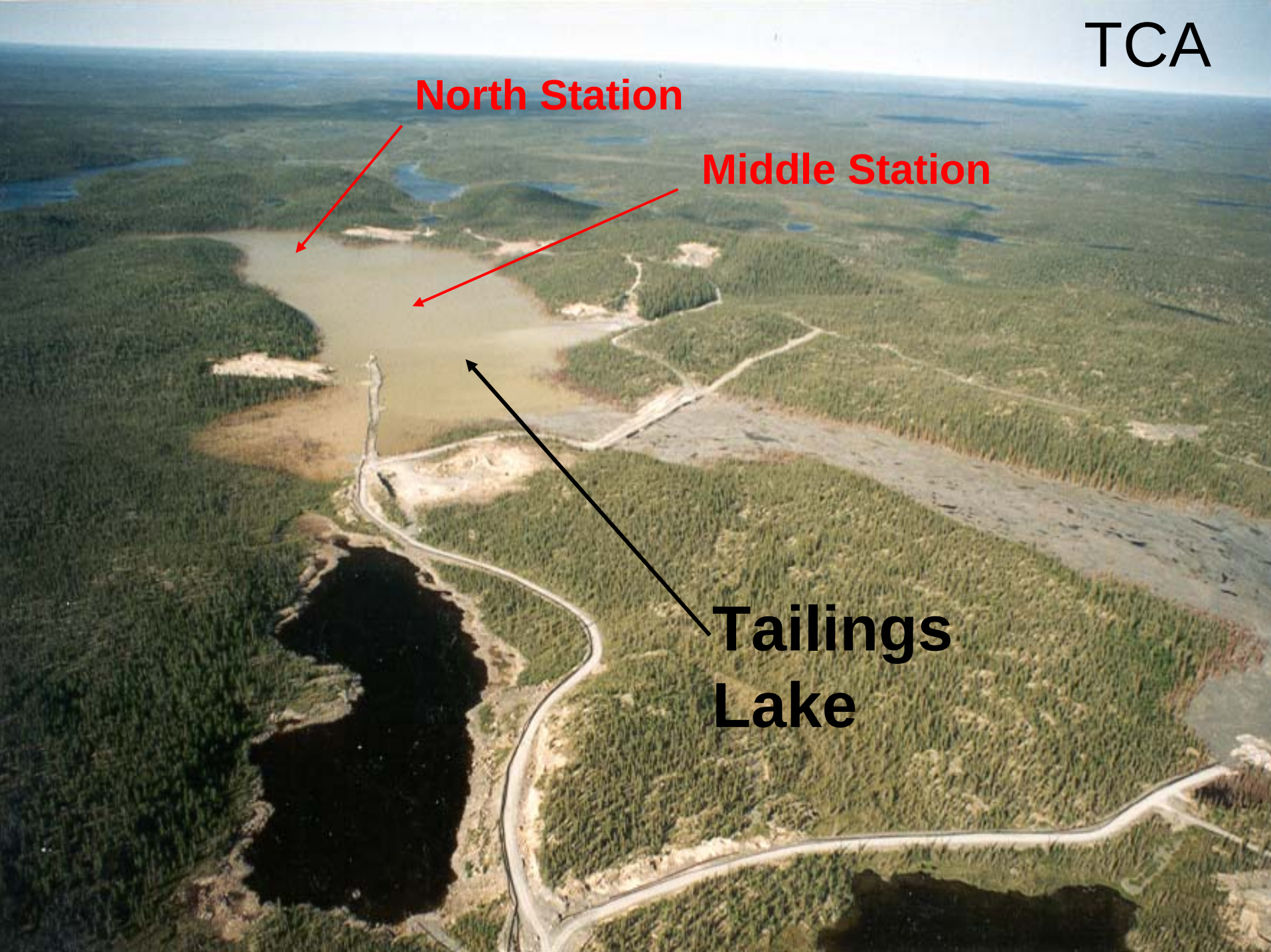
Colomac Technical Advisory Committee

ENR Monitoring Program

- Physical : lake limnology
  (depth profiles – Temp, DO)

- Biological: algae identification, biomass and diversity

- Chemical : major ions, nutrients, metals
  targets: cyanide, ammonia


TCA
North Station
Middle Station
Tailings
Lake

Zone 2 Pit Sample Locations

Z2P-S

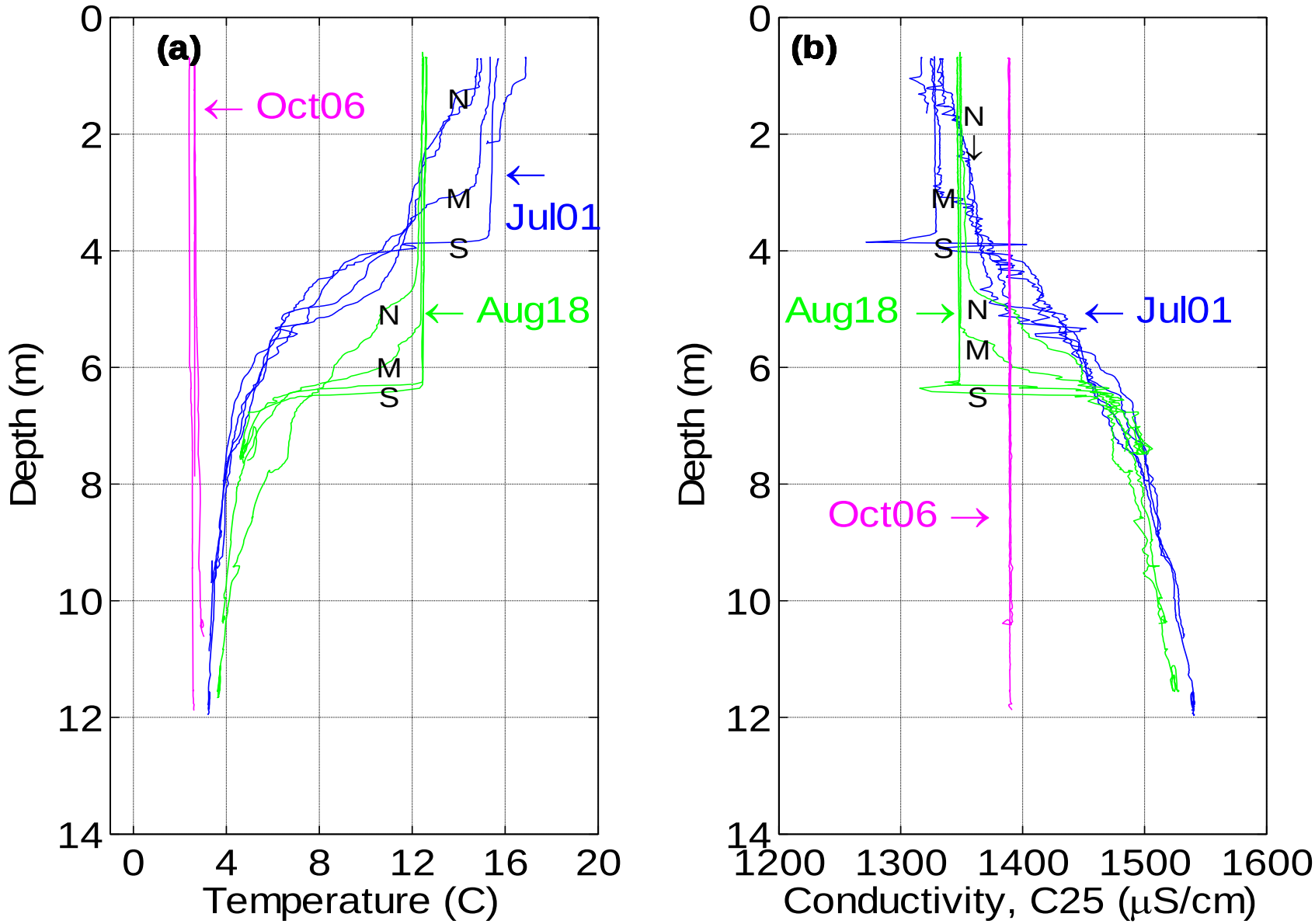
Z2P-NW

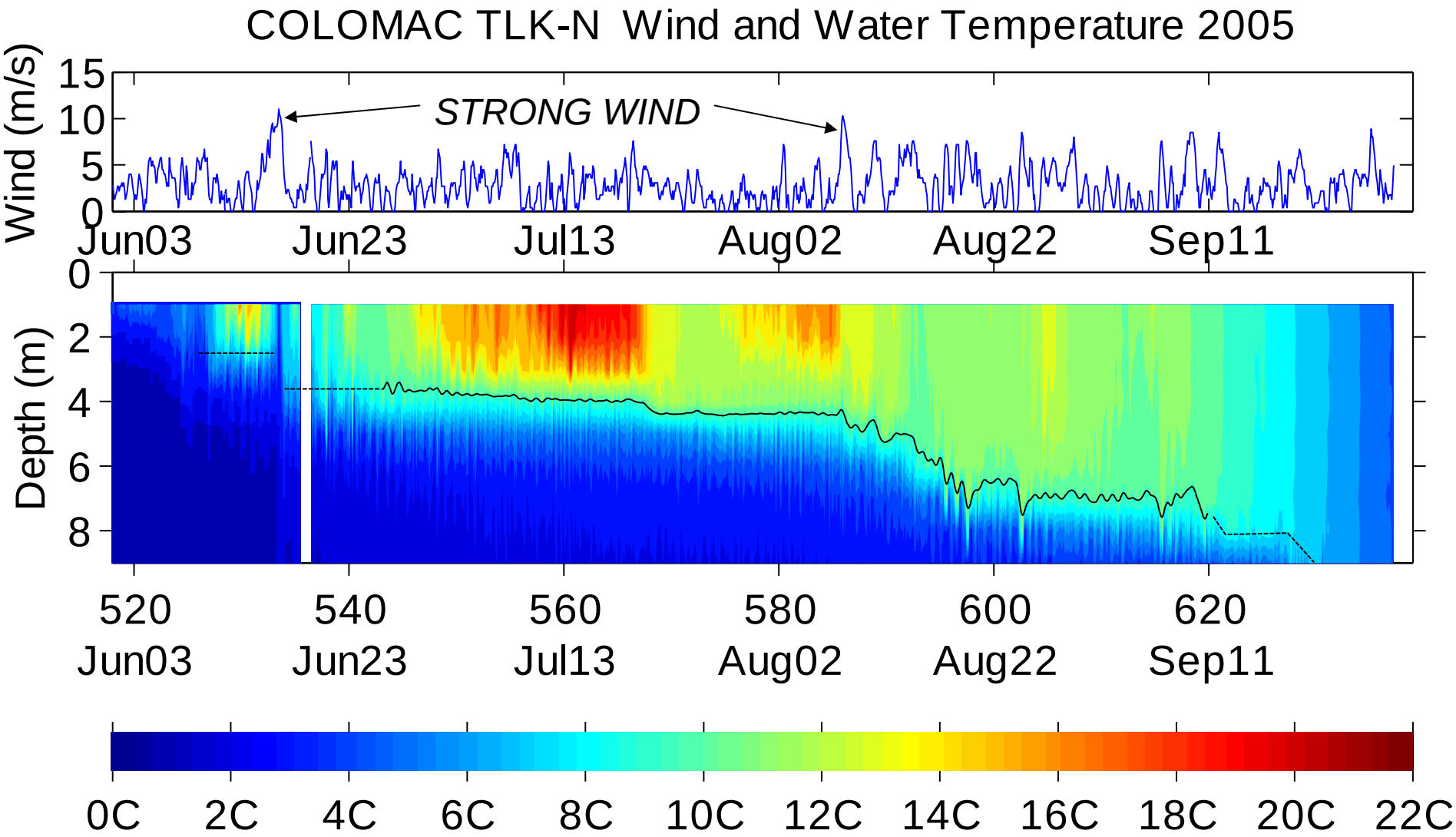
Pieter's Monitoring Raft

Twice under ice

Monthly open water

COLOMAC Tailings Lake - All 2004 Seabird Casts




COLOMAC TLK-N Wind and Water Temperature 2005
Wind (m/s)
15
10
5
0
STRONG WIND
Jun03
Jun23
Jul13
Aug02
Aug22
Sep11
Depth (m)
0
2
4
6
8
520
540
560
580
600
620
Jun03
Jun23
Jul13
Aug02
Aug22
Sep11
0C
2C
4C
6C
8C
10C
12C
14C
16C
18C
20C
22C

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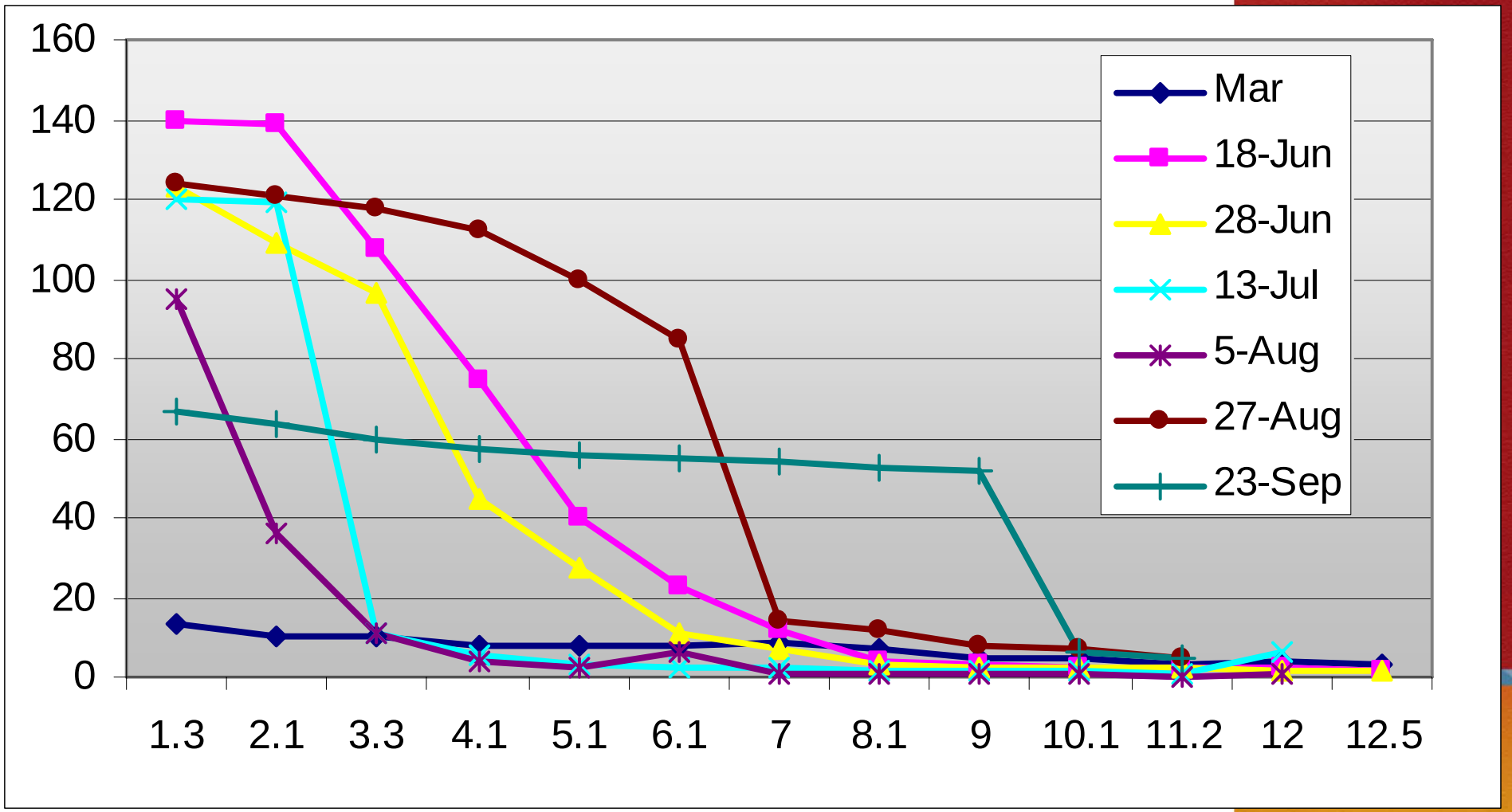
Dissolved Oxygen % vrs Depth TLK 2005



Physical Monitoring indicated :

- lake stratifies in summer

  active, warm, oxygenated epilimnion

  cold, anoxic hypolimnion
- strong wind can overturn or cause mixing
- Mixing is important to supply P to the surface where it is needed for SCN & NH_3-N removal
- lake is anoxic in winter

Biological Monitoring Component

- Physical changes in water – colour, clarity
- Algal productivity levels (biomass)
- Algae identification & diversification

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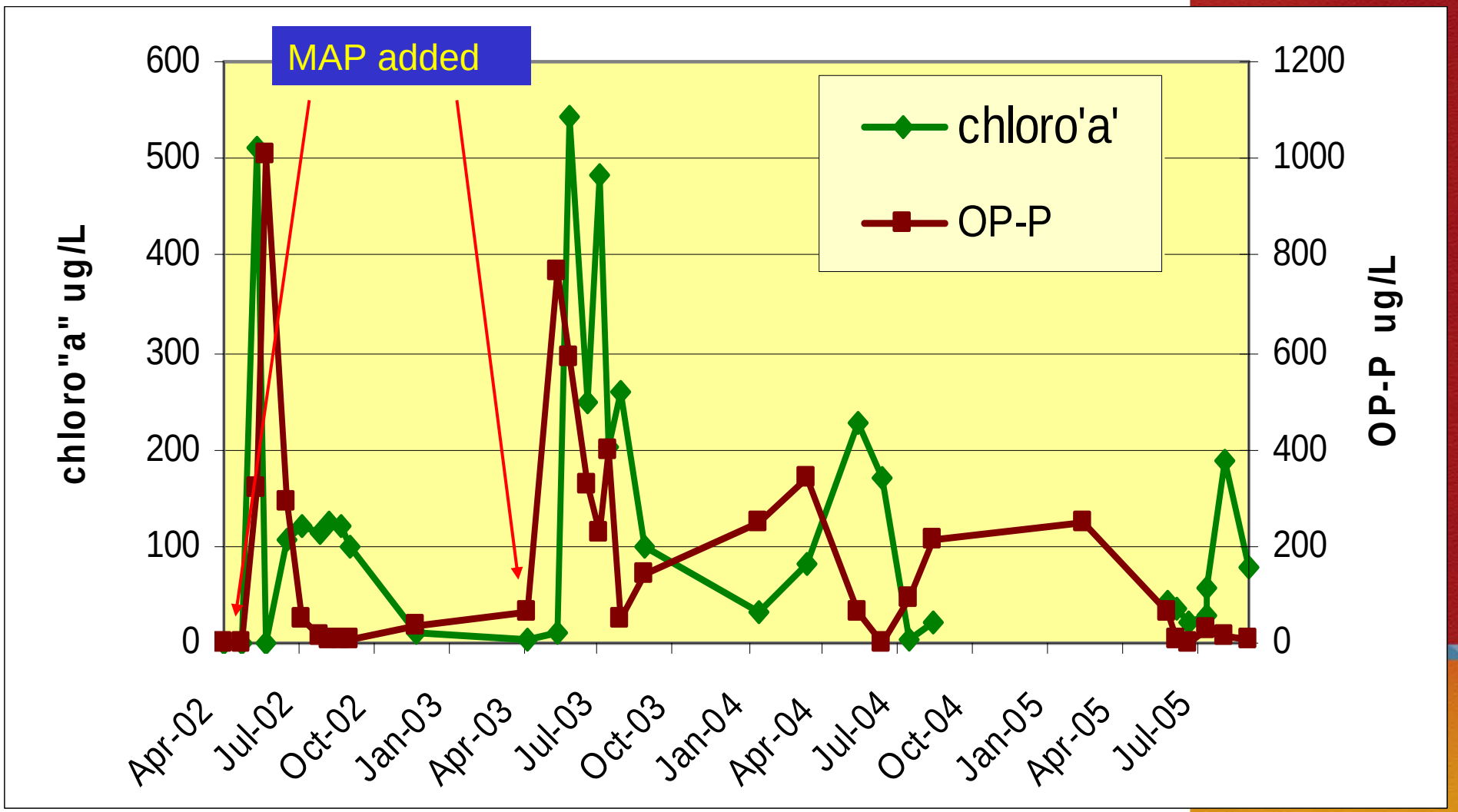
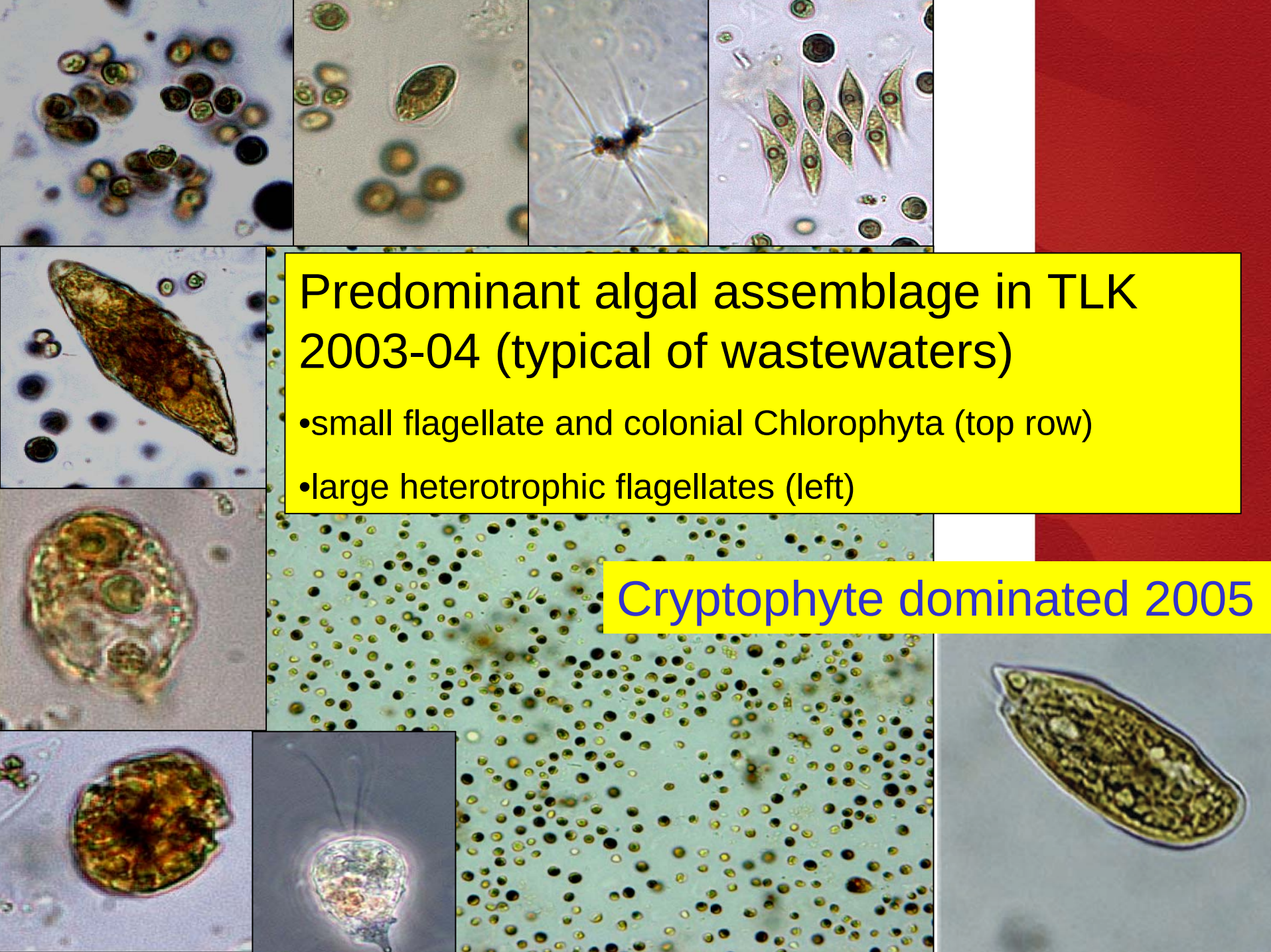
Algae Response to Phosphorus Addition





Predominant algal assemblage in TLK 2003-04 (typical of wastewaters)

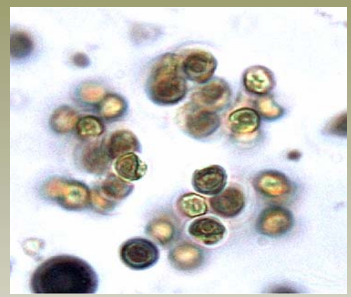
- small flagellate and colonial Chlorophyta (top row)
- large heterotrophic flagellates (left)

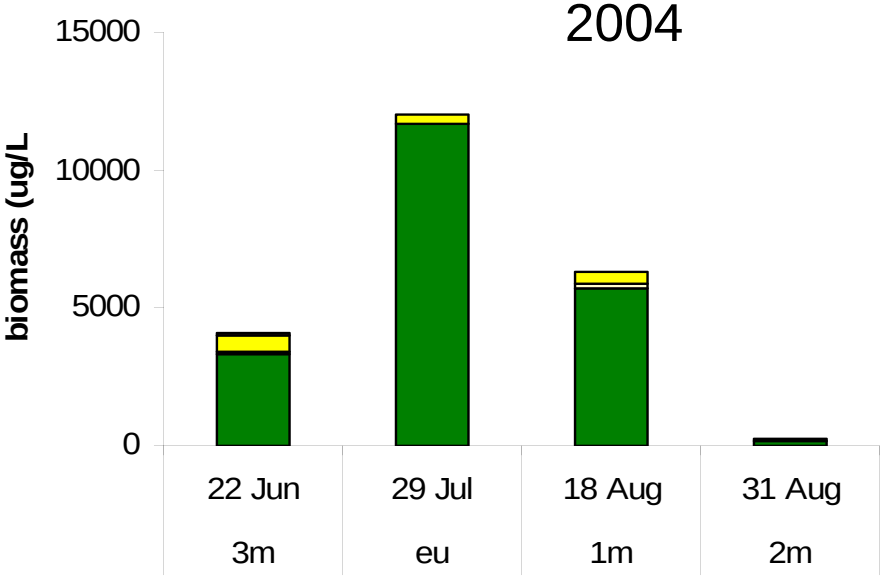
Cryptophyte dominated 2005

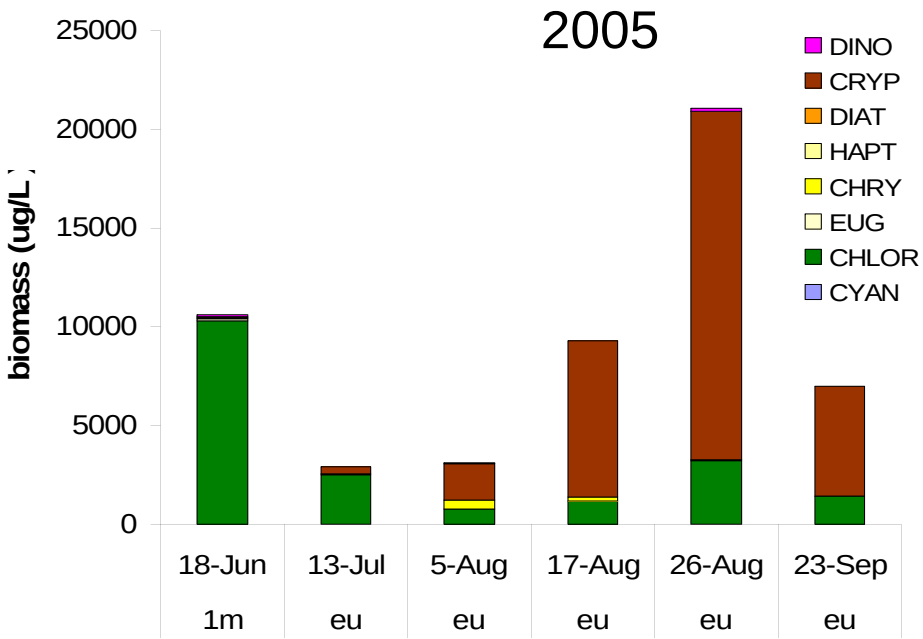
TLK-M

ALGAL BIOMASS &

MAJOR TAXA 2004-2005







Similar biomass range
Predominated by green algae

2005 increase in flagellates (Cryptomonads)

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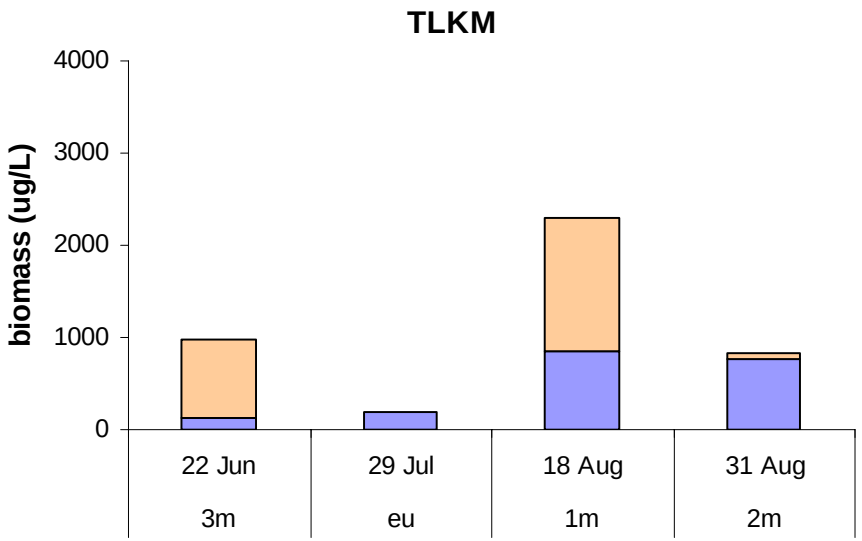
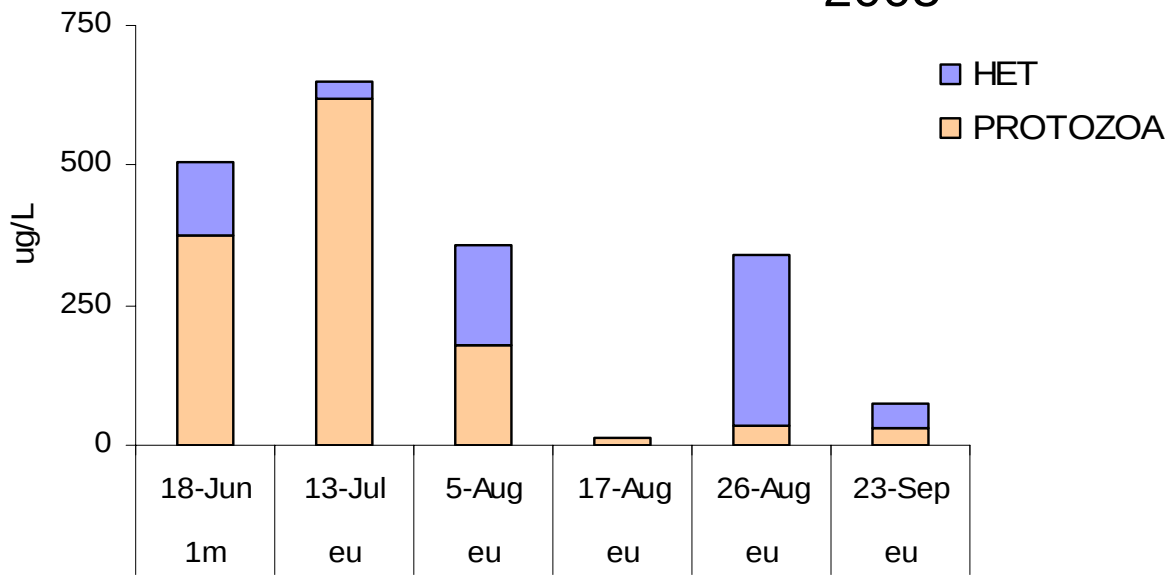
2004

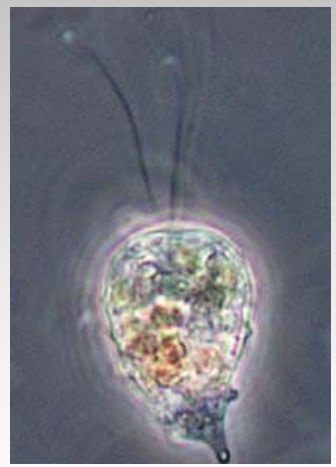


2005



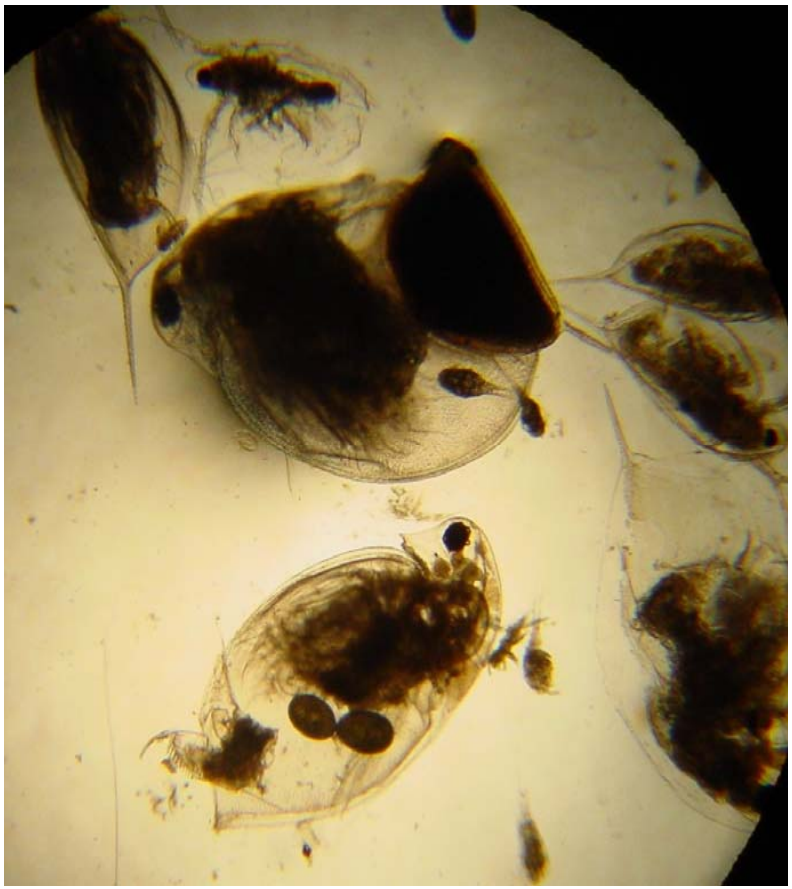
TLK-M

MICROZOOPLANKTON & HETEROTROPHS



→ LOWER ABUNDANCE IN 2005

First Appearance of Macrozooplankton in 2005



Daphnia pulex

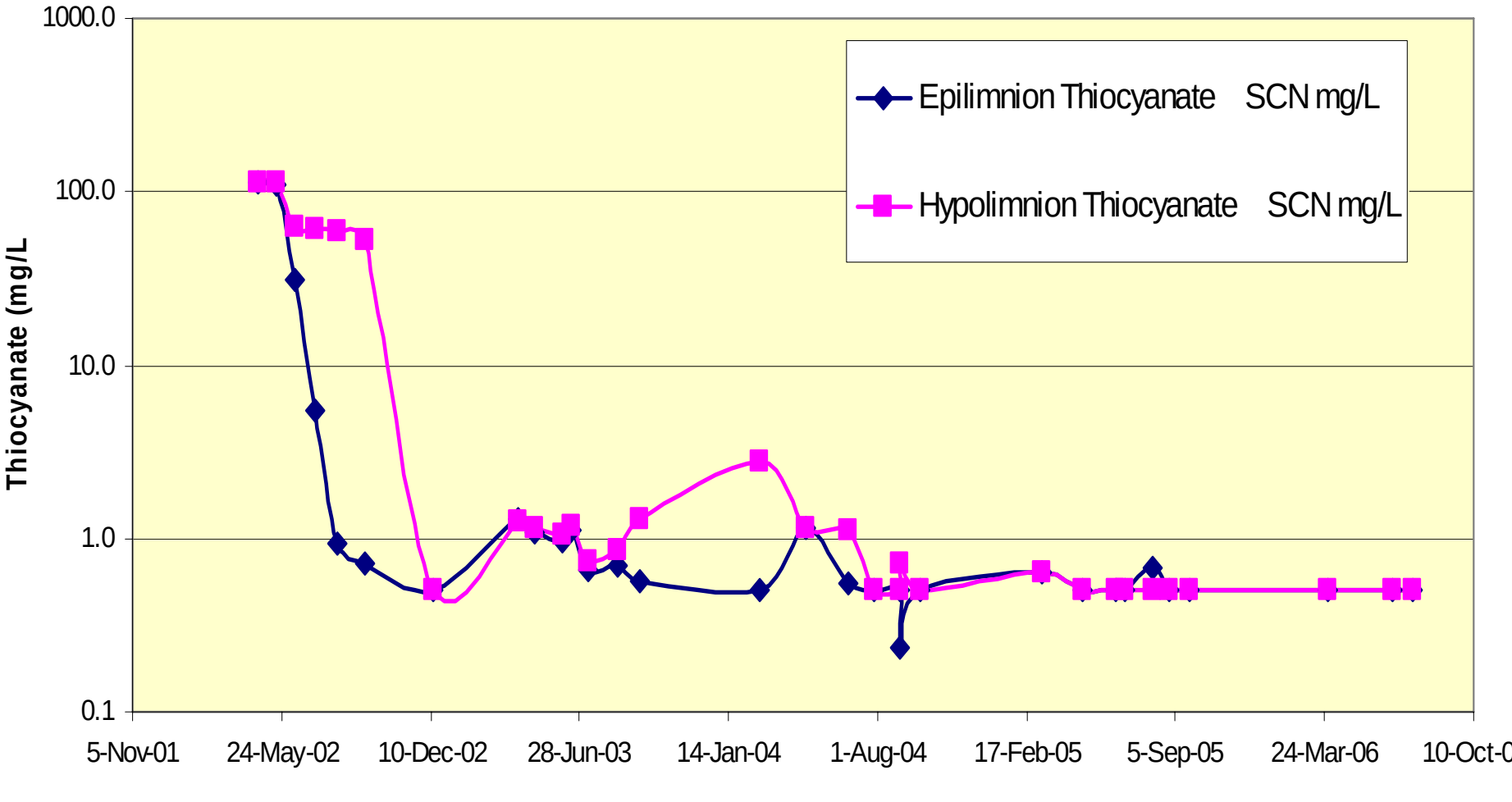
Cyclops vernalis

Monitoring Water Chemistry

Monthly sampling of the water column indicated:

- Trends in contaminant removal from season to season
- Greatest removal rates related to biological activity in the epilimnion (above thermocline layer)

THIOCYANATE REMOVAL in TLK



THIOCYANATE REMOVAL

$$SCN^- + 2H_2O + {}^5/_2\,O_2 \rightarrow SO_4^{-2} + HCO_3^- + NH_3$$

Biological oxidation

Produces ammonia

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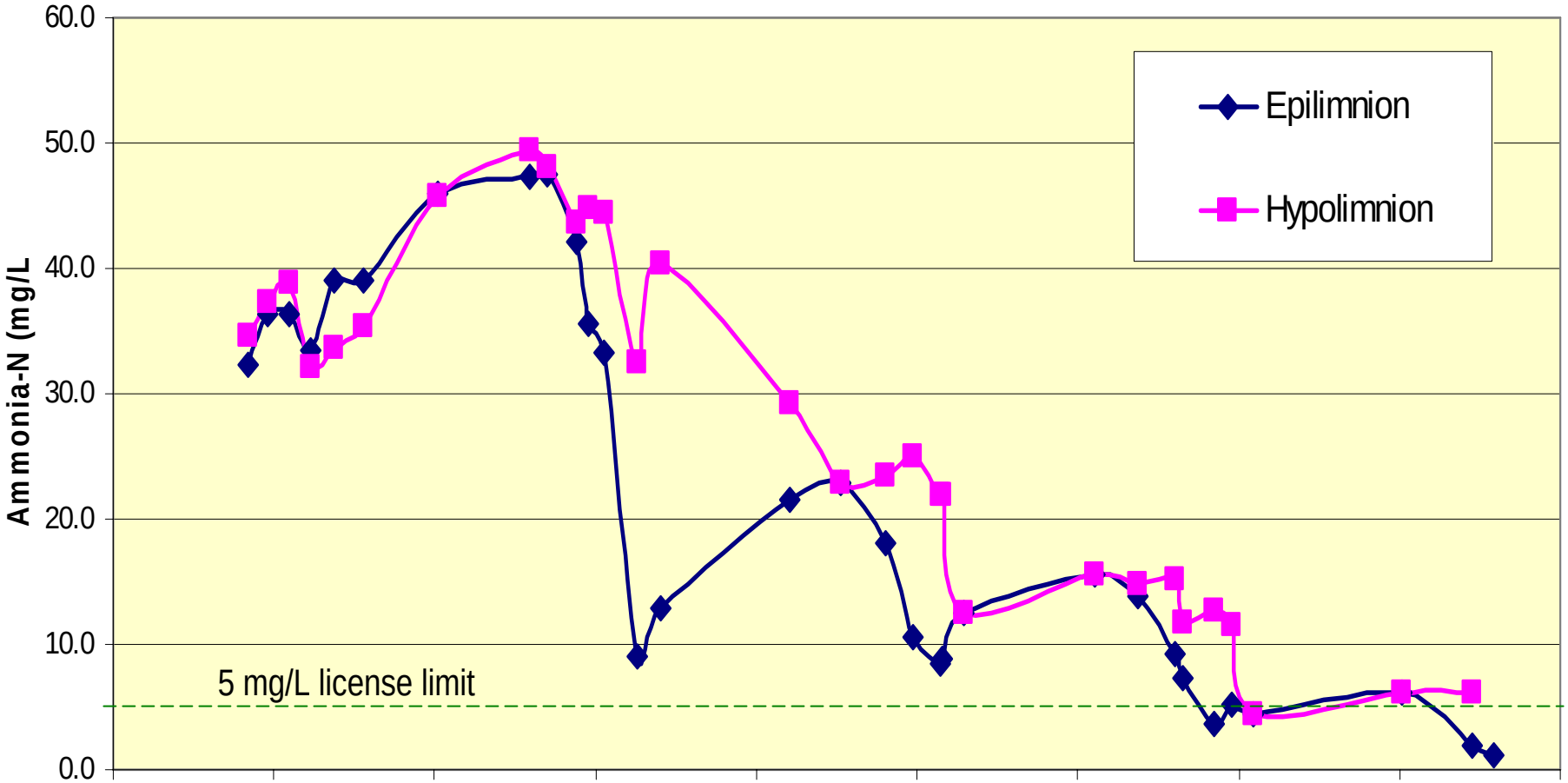
AMMONIA REMOVAL in TLK



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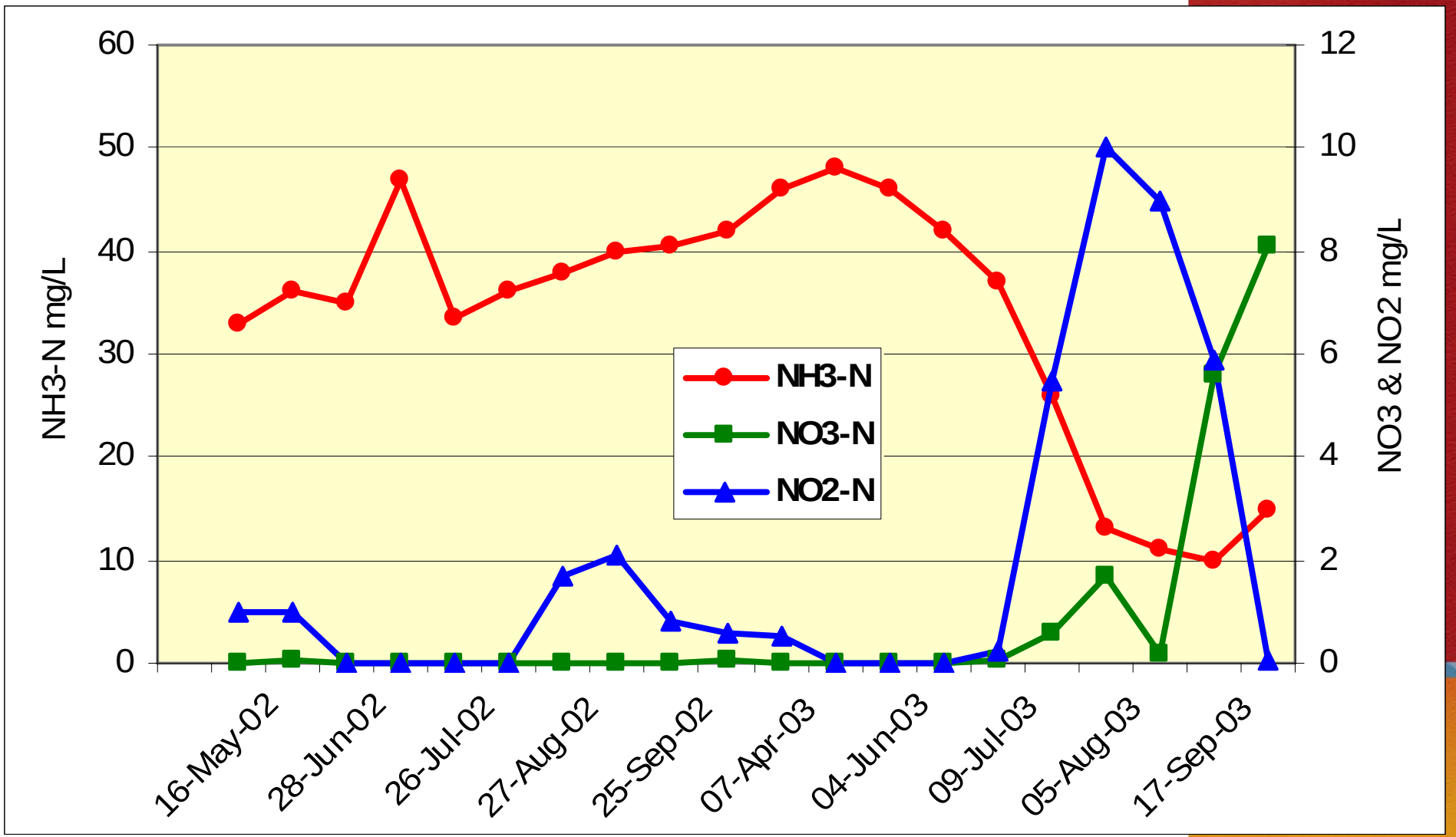
Ammonia–N Removal : TLk Epilimnion 2002 - 2003



AMMONIA-N REMOVAL MECHANISMS

1) DIRECT UPTAKE BY ALGAE

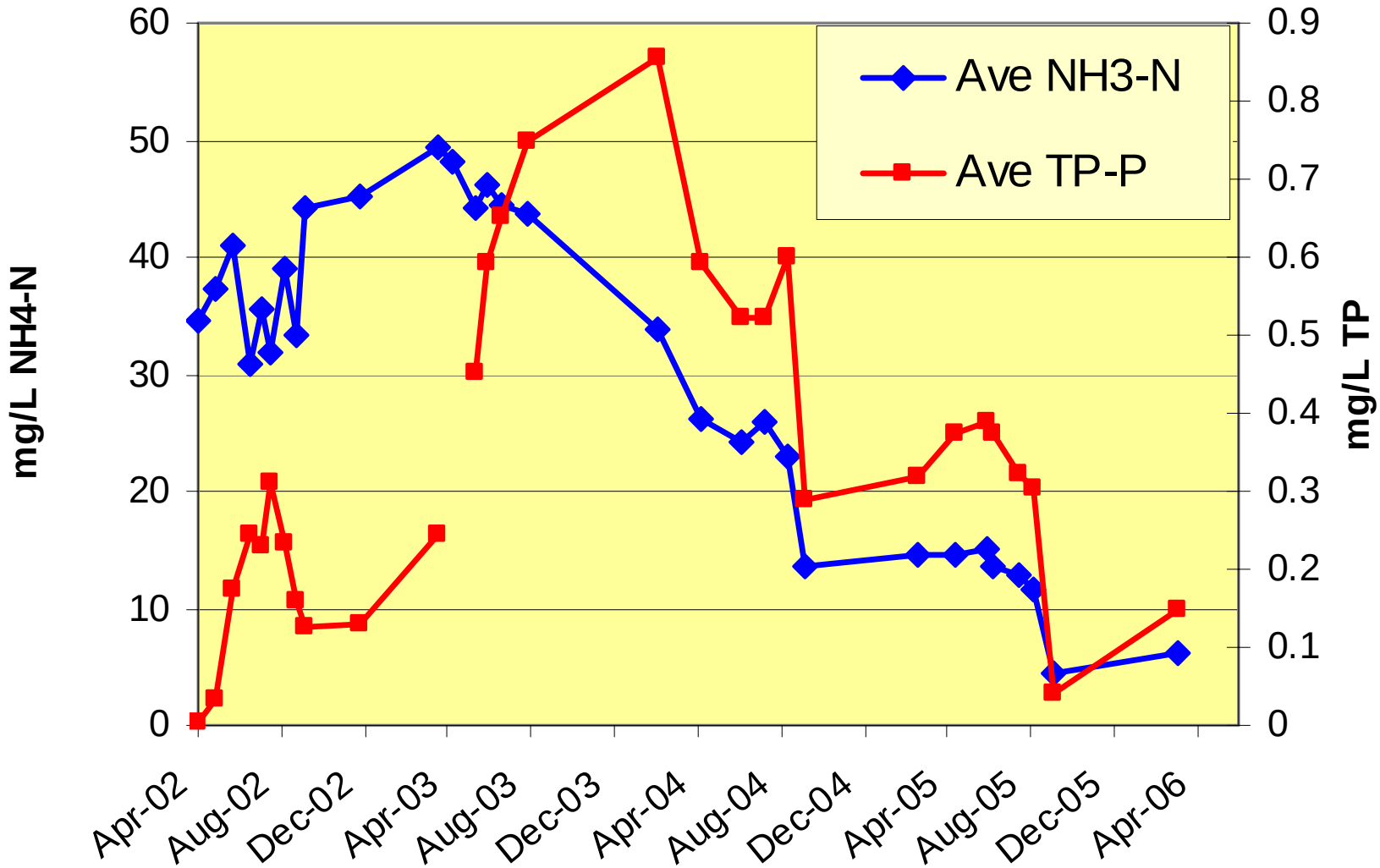
2) MICROBIOLOGICAL NITRIFICATION

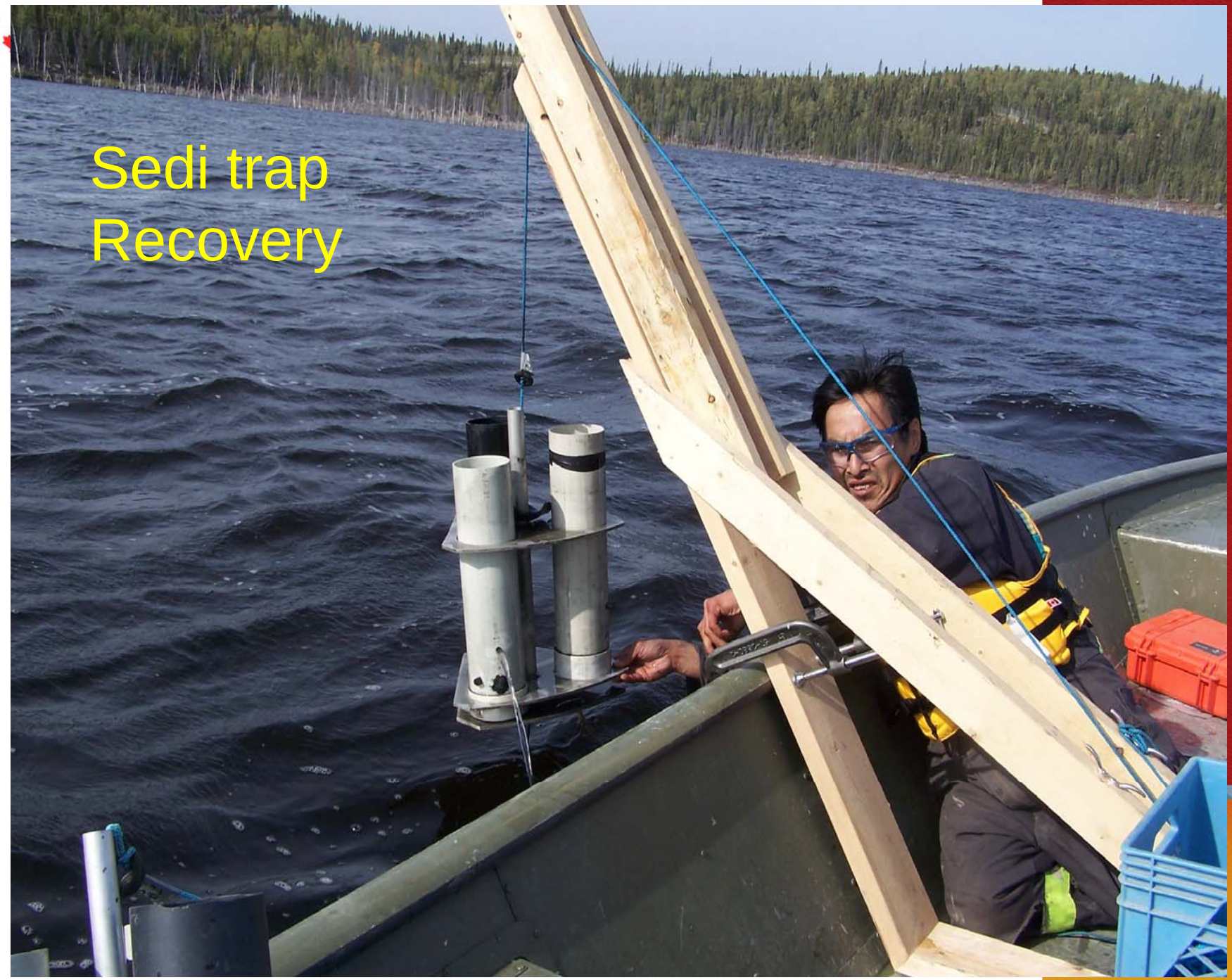
$$NH_4^+ + {}^3/_2\, O_2 \rightarrow 2H^+ + H_2O + NO_2^-$$

$$NO_2^- + ½\, O_2 \rightarrow NO_3^-$$

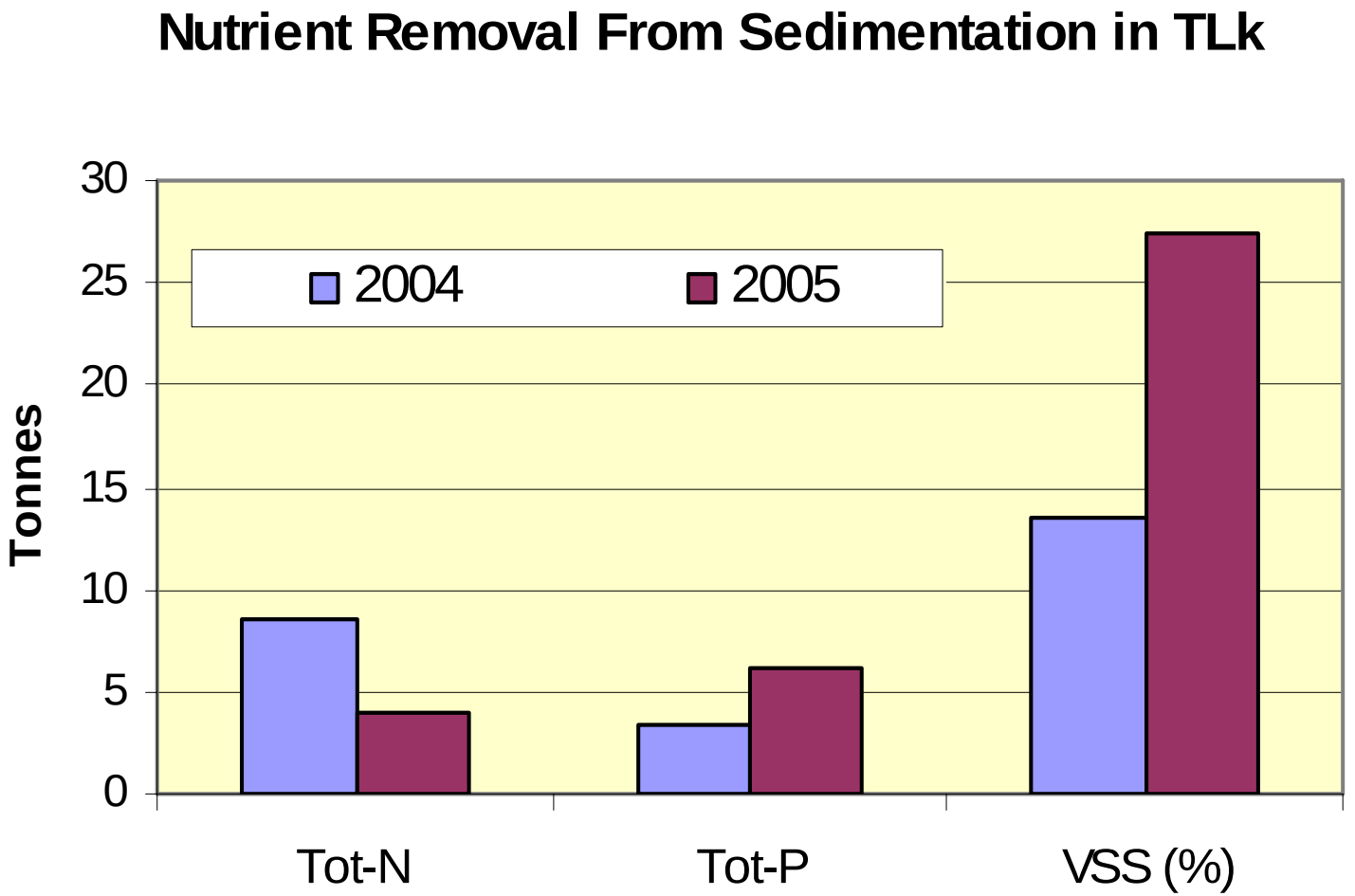
3) MICROBIOLICAL DENITRIFICATION (anoxic)
Nitrate to nitrogen gas

Nutrient Recycling At Bottom 2m of TLk




Sedi trap
Recovery

SEDIMENT TRAP RESULTS



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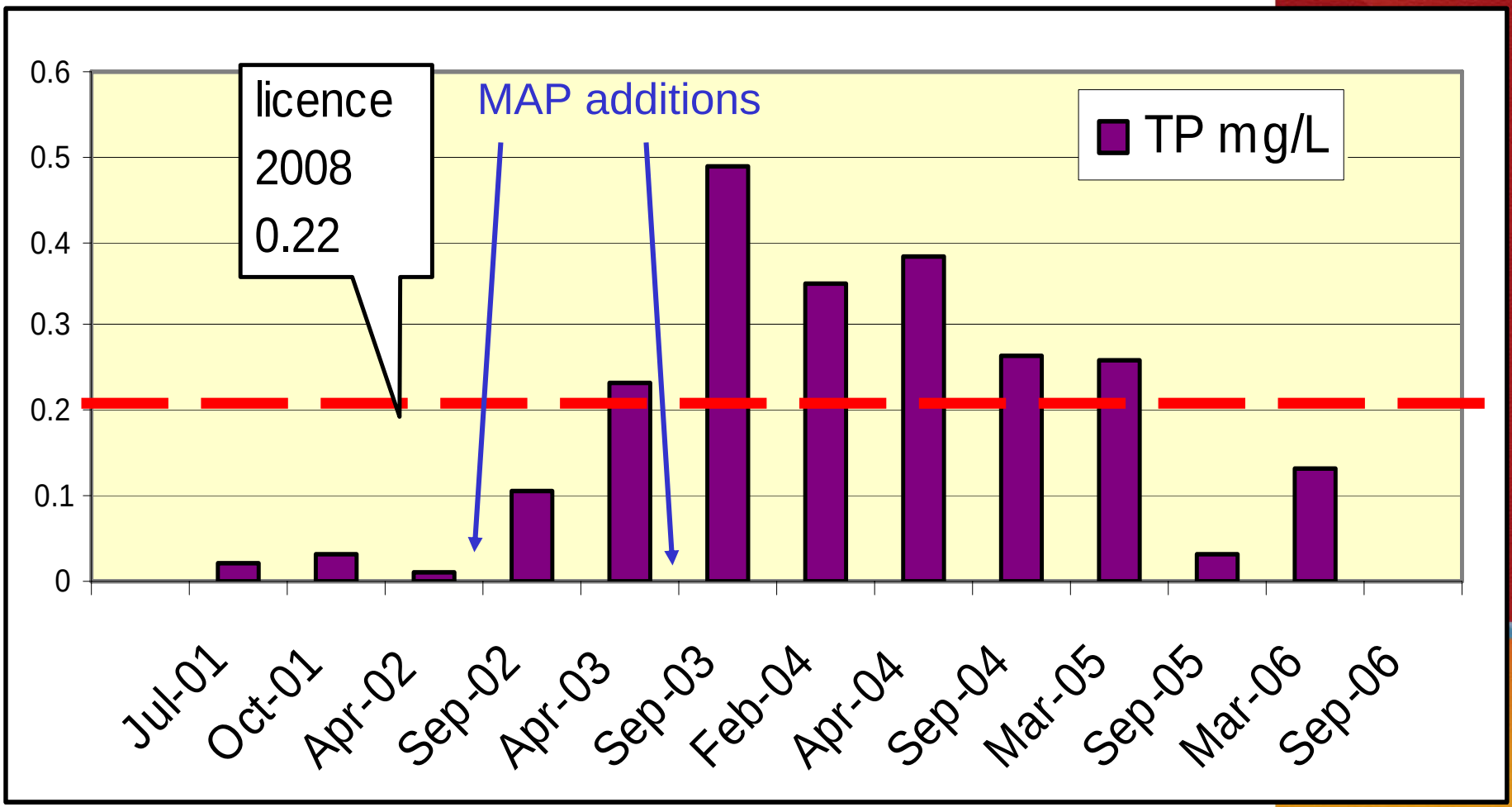
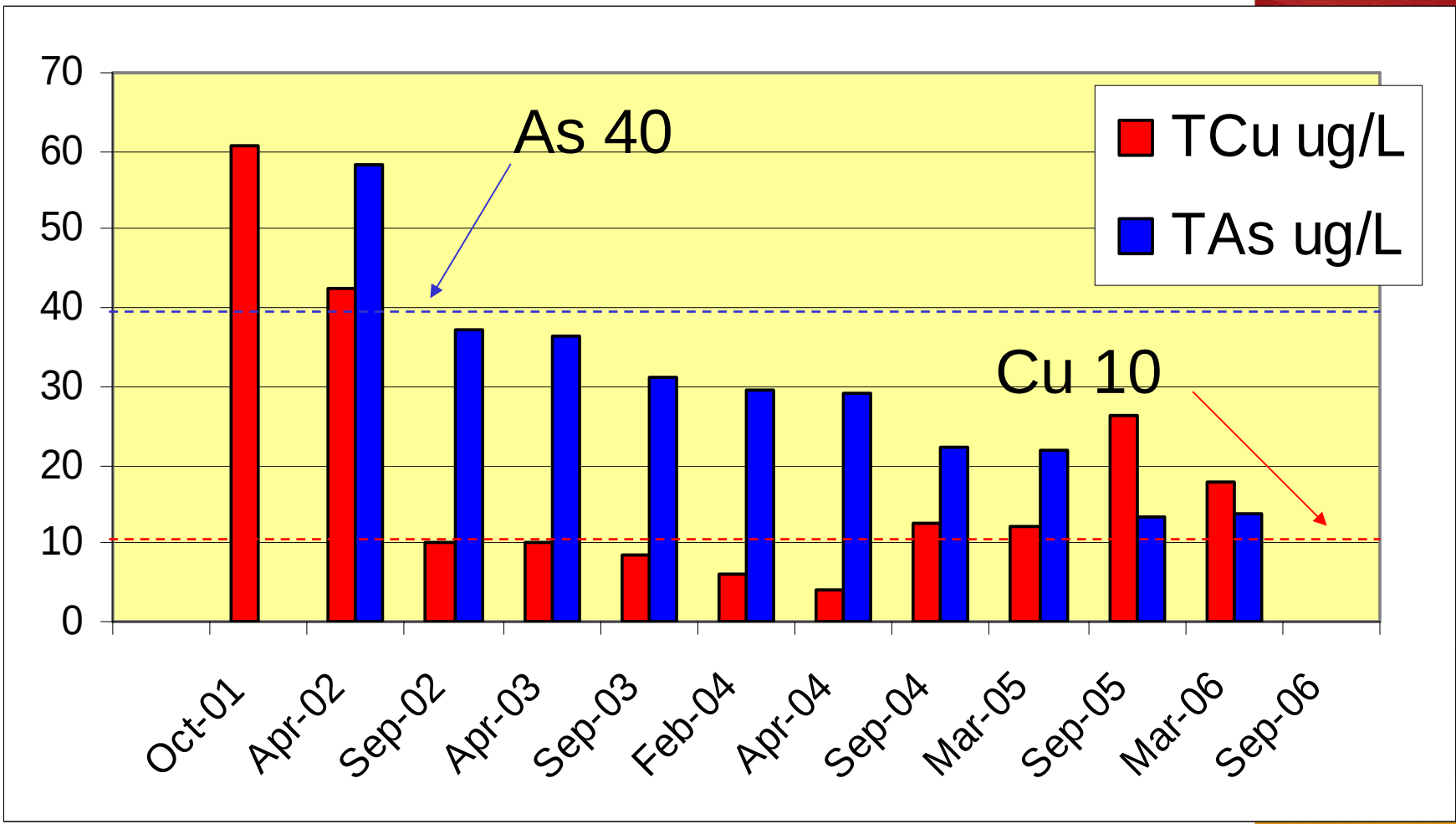
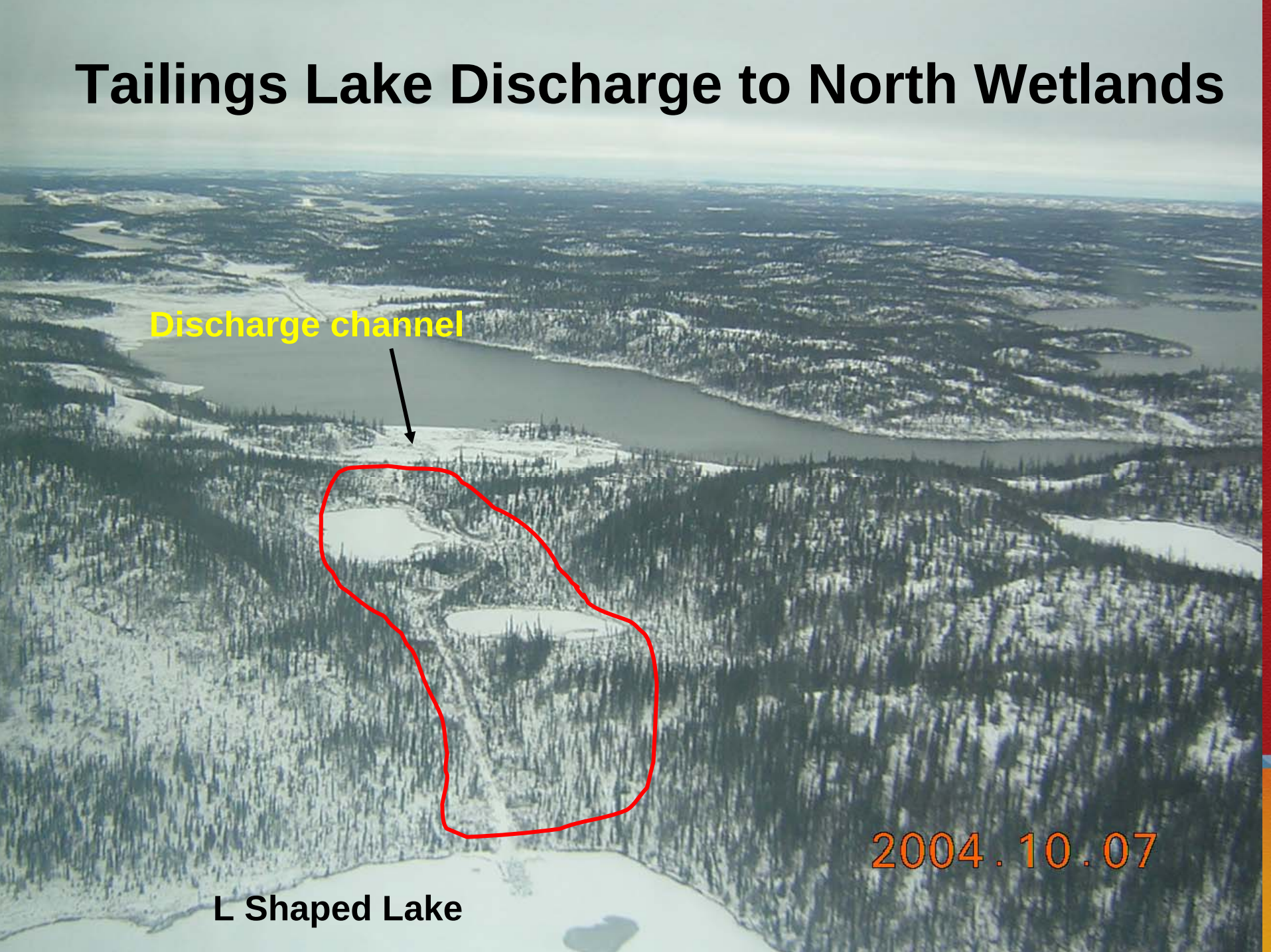
Removal Of Total Phosphorus - TLk



Removal Of Total Metals - TLk



Tailings Lake Discharge to North Wetlands



SUMMARY FOR TAILINGS LAKE

- ENR with P addition + Water Management was an cost effective and low risk treatment

- Water Quality of Tailings Lake has improved to within licence limits established for discharge in 2008/09

NEXT STEPS for TLk

- Continue to monitor ENR process until discharge in 2008/09
- If necessary, supply depleted phosphorus to active algae layer from lake bottom with a pumping system
- Modify the Tailings Lake discharge wetland to optimize wetland treatment and attenuation

Zone 2 Pit - OVERVIEW

ENR process

Zone 2 Pit morphology and limnology

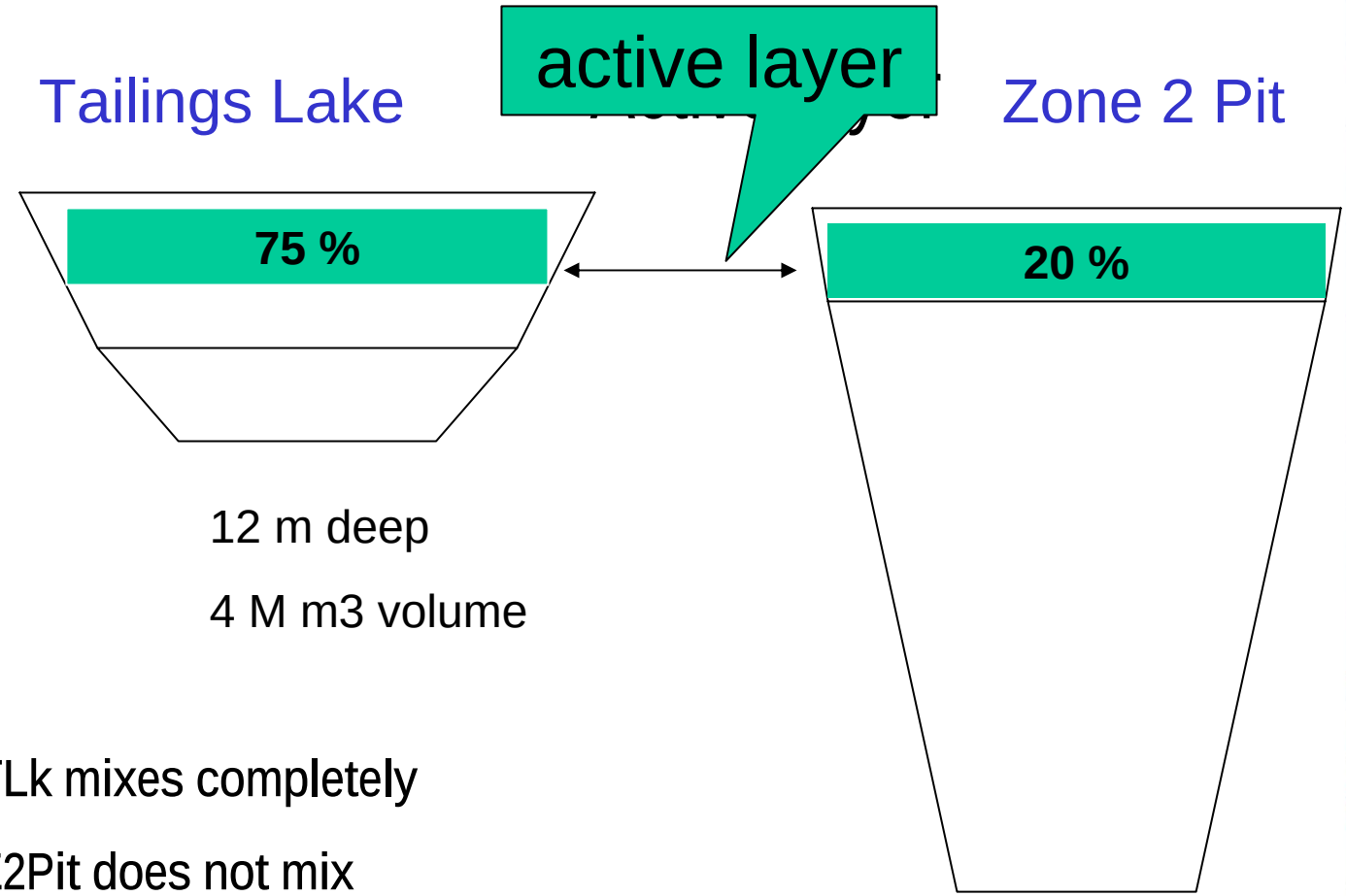
Artificial circulation option

Design of Zone 2 Pit destratification system

Preliminary results

Next steps

COMPARISON OF TREATED LAKES



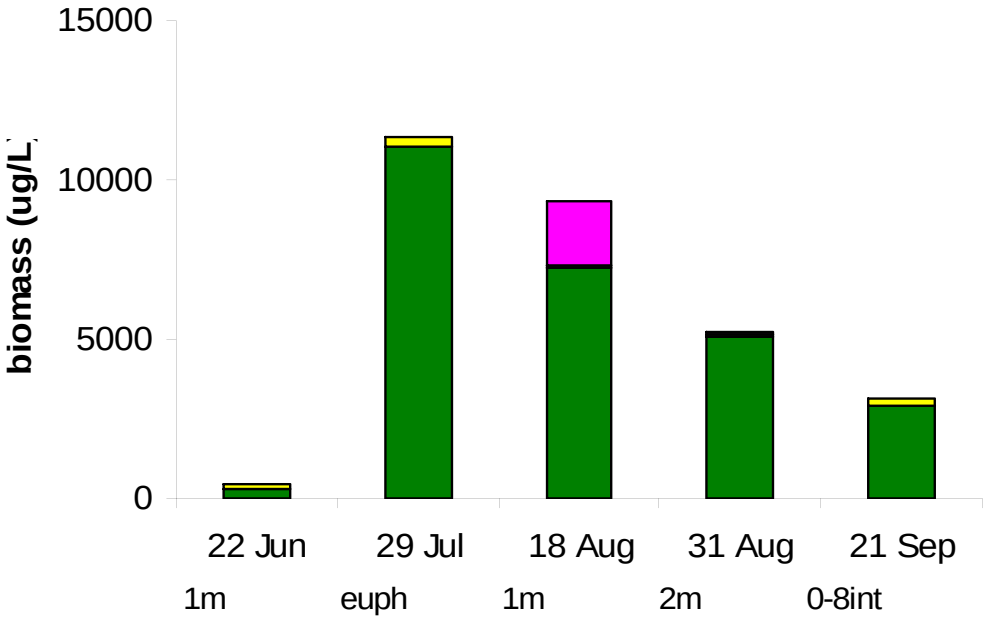
TLk mixes completely

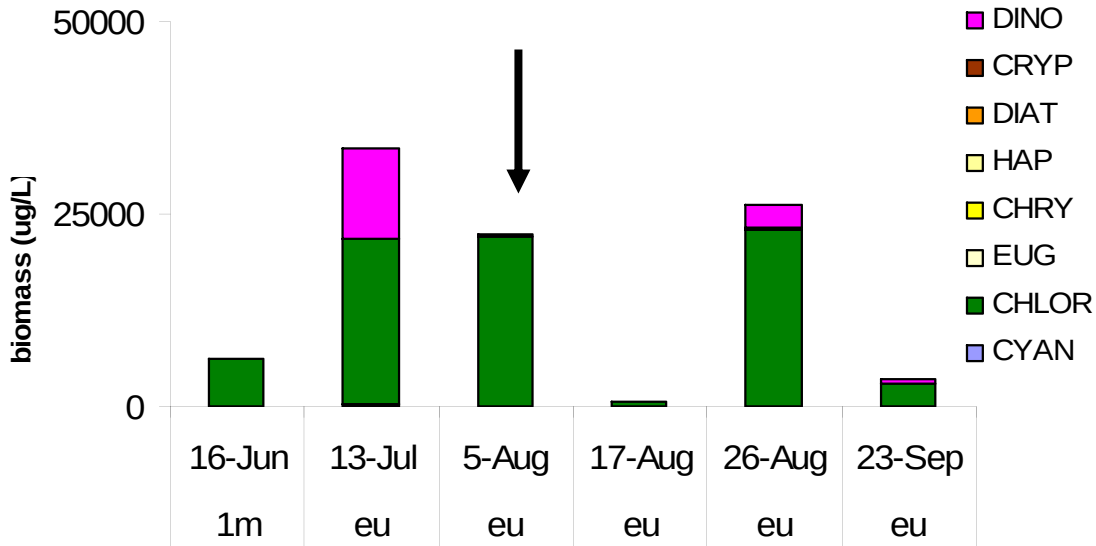
Z2Pit does not mix

SURFACE BLOOM IN ZONE 2 PIT

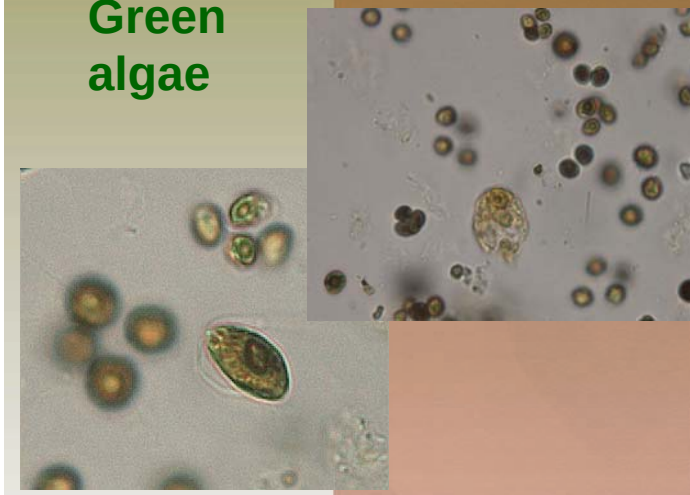
Z2P-N

ALGAL BIOMASS & MAJOR TAXA 2004 -05





Green algae



flagellates (Dinophyta)

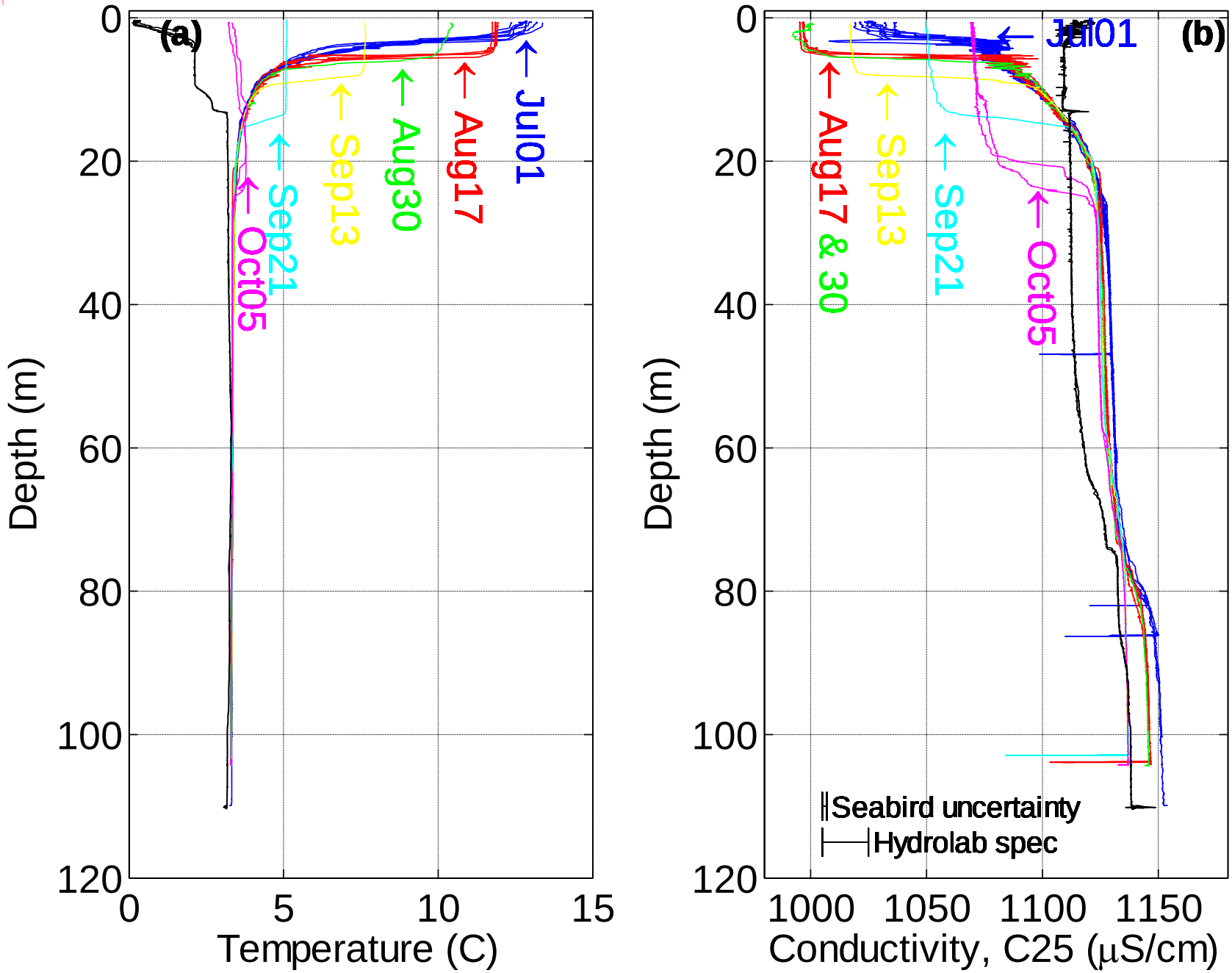
ZONE 2 PIT - ISSUES

- SCN and NH_3-N remain despite ENR
- Z2P water elevation predicted to reach Baton Lake level in 2011
- Action required if water quality not suitable when Z2P reaches 0.5 m within Baton Lake

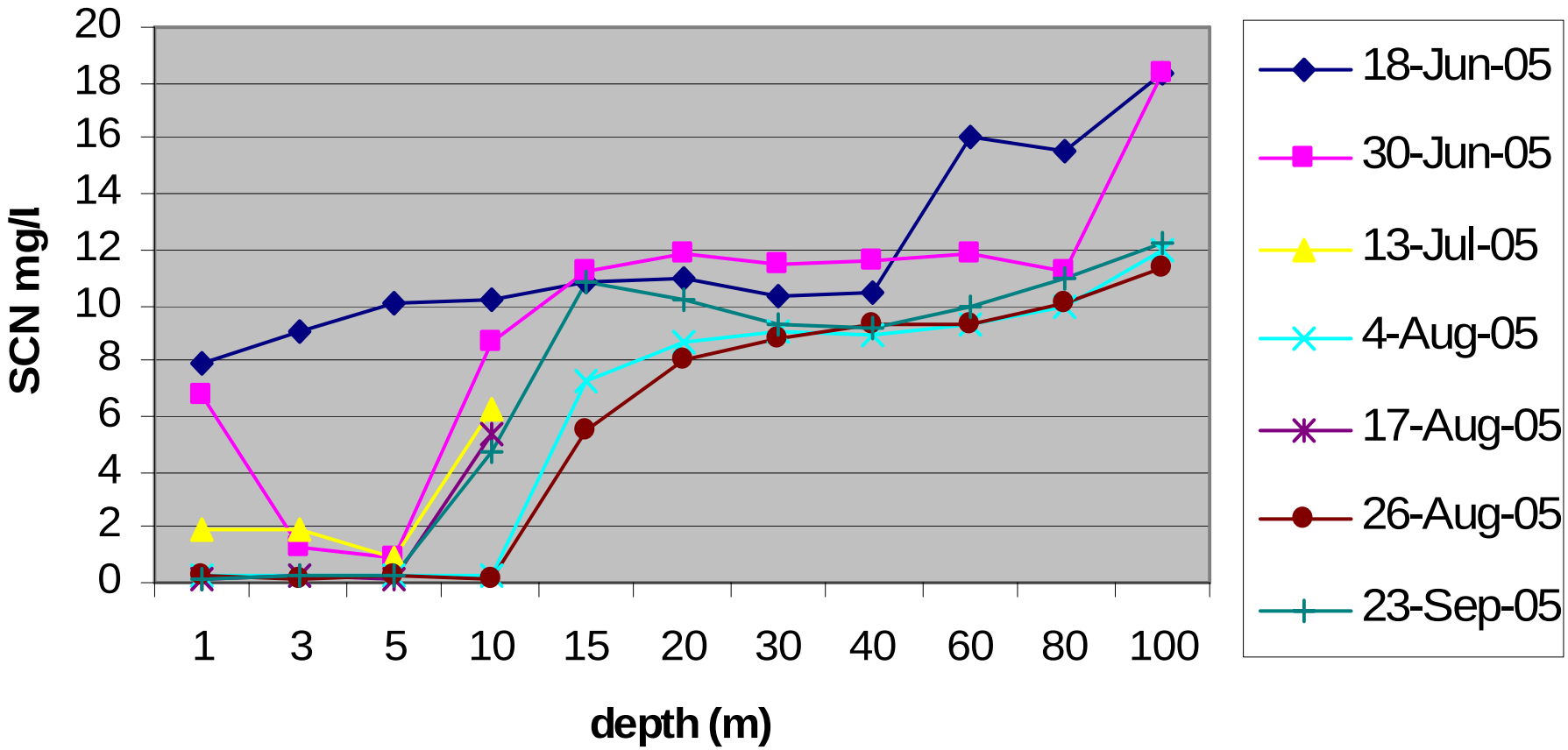
Zone 2 Pit Morphology & Limnology

- high depth to length ratio (15.7 ha)
- occurrence of relatively saline water
- lack of natural outlet (220 years retention time)
- protection from prevailing winds
- sampling data indicate the Pit rarely mixes below 50 m, usually ~ 22 m
- no oxygen in lower layers, high concentrations of ammonia and thiocyanate
- Under-ice circulation driven by salt freeze-out

FIGURE 1. COLOMAC Zone 2 Pit - All 2004 Seabird Casts



Depth profiles of SCN from Z2PNW Stn 2005

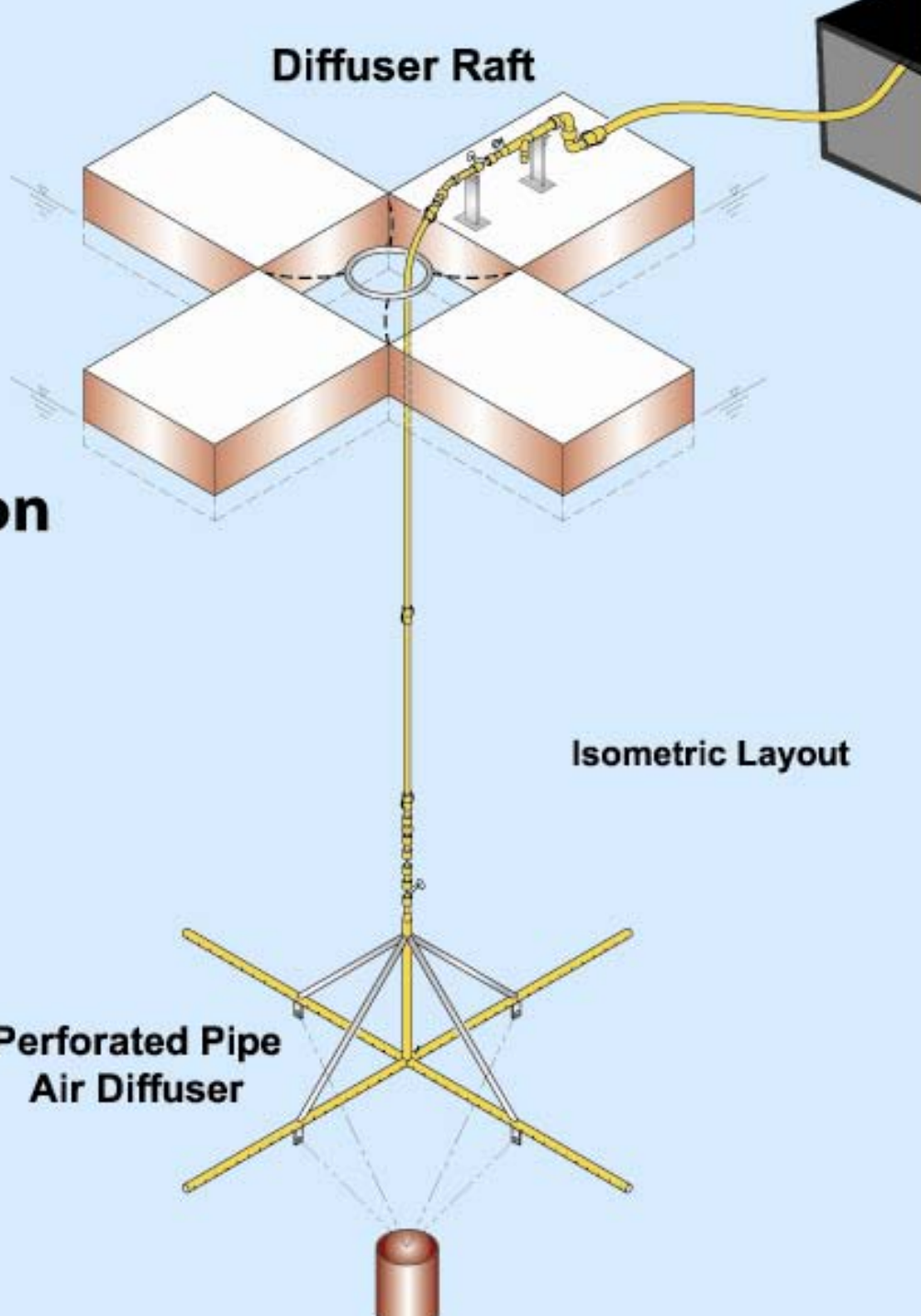


Hardware Of Artificial Circulation System

STAINLESS STEEL DIFFUSER

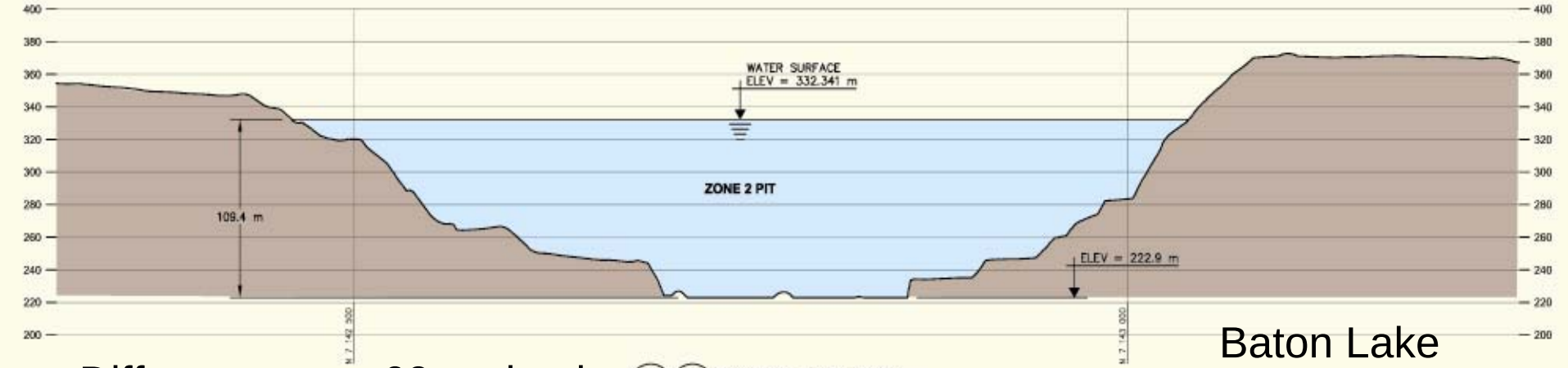
Colomac Zone 2 Pit, NWT Artificial Circulation System for Water Quality Remediation

Compressed Air Destratification System



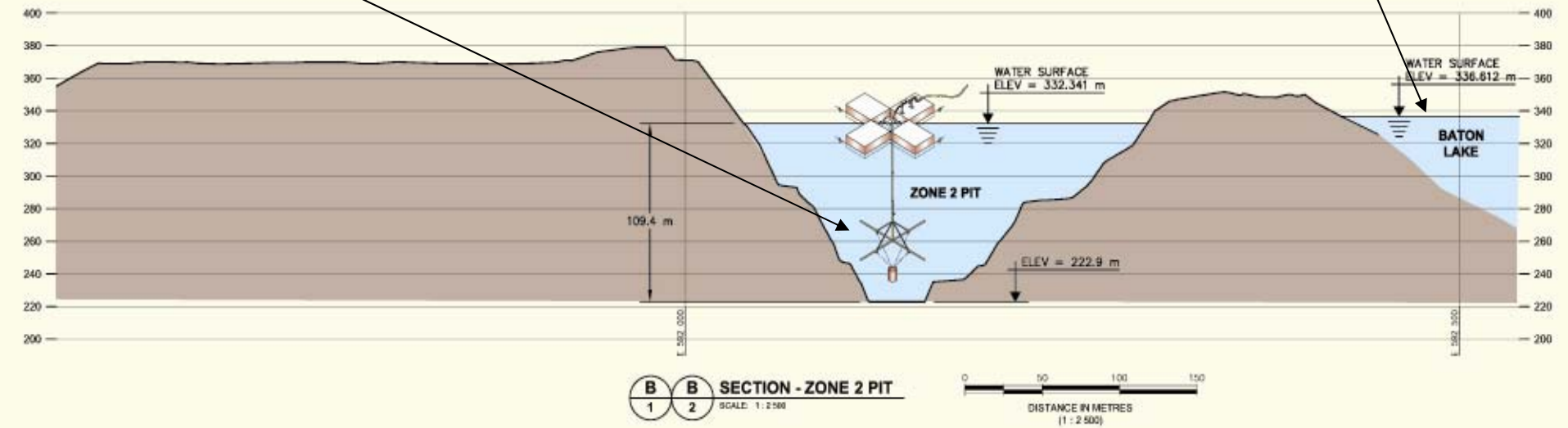
Colomac Zone 2 Pit Remediation

Northwest Territories - Cross Sections



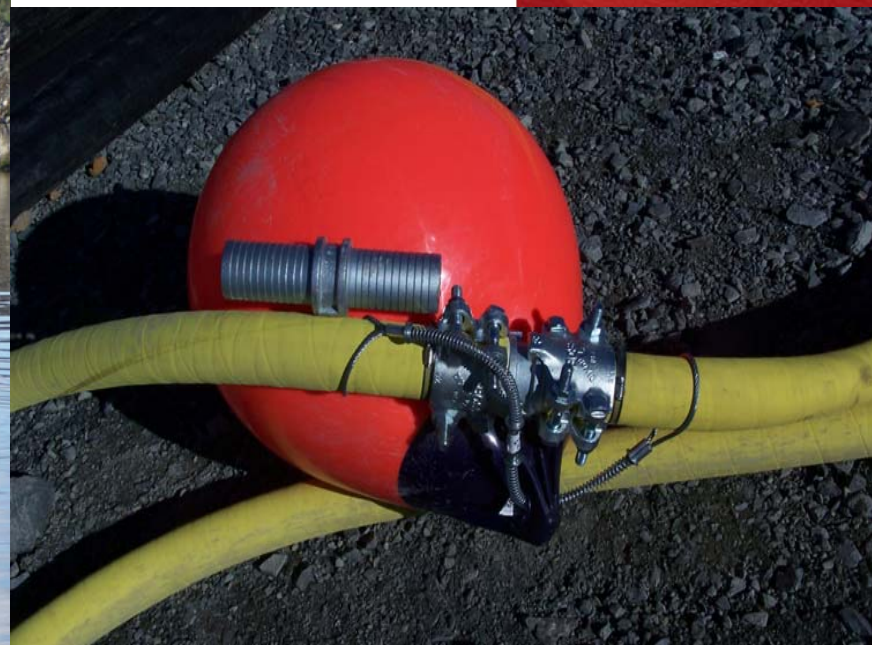
Diffusers set at 60 m depth

Baton Lake

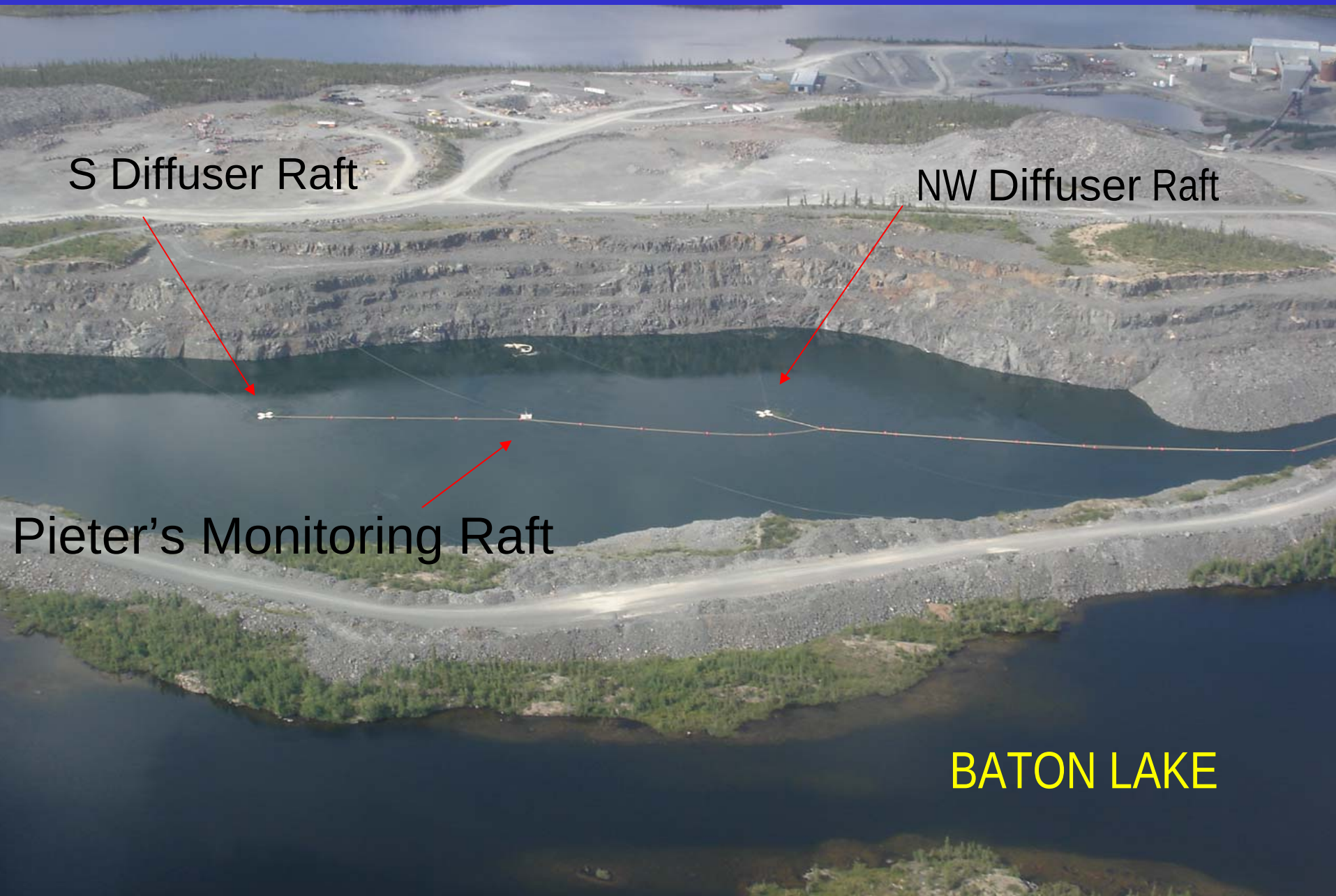


INSTALLATION OF DIFFUSER INTO RAFT

CHECKING FOR LEAKS IN THE HOSE SECTION JOINS



Circulation System in Zone 2 Pit



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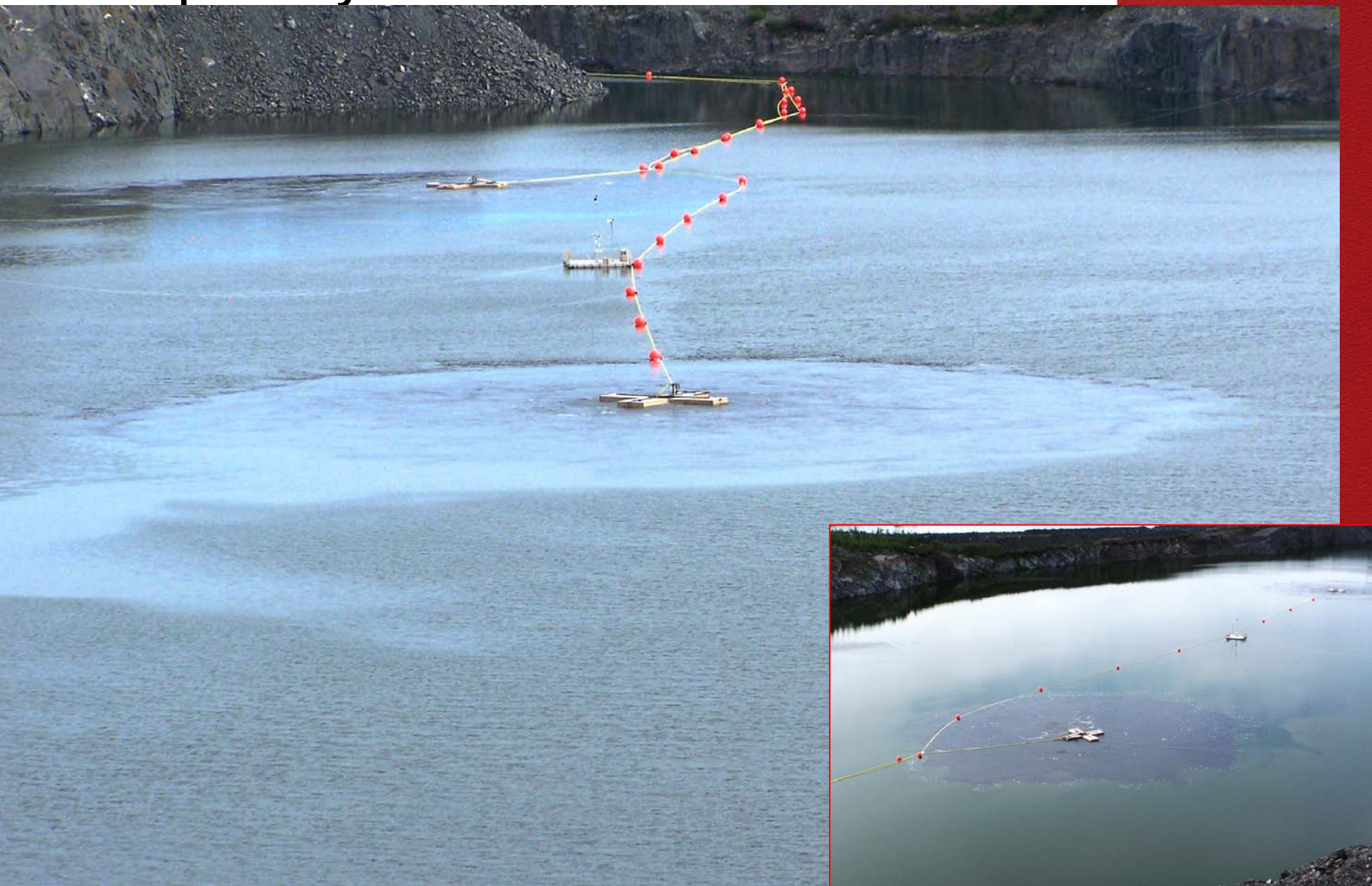
Startup – July 12 – Both Diffusers

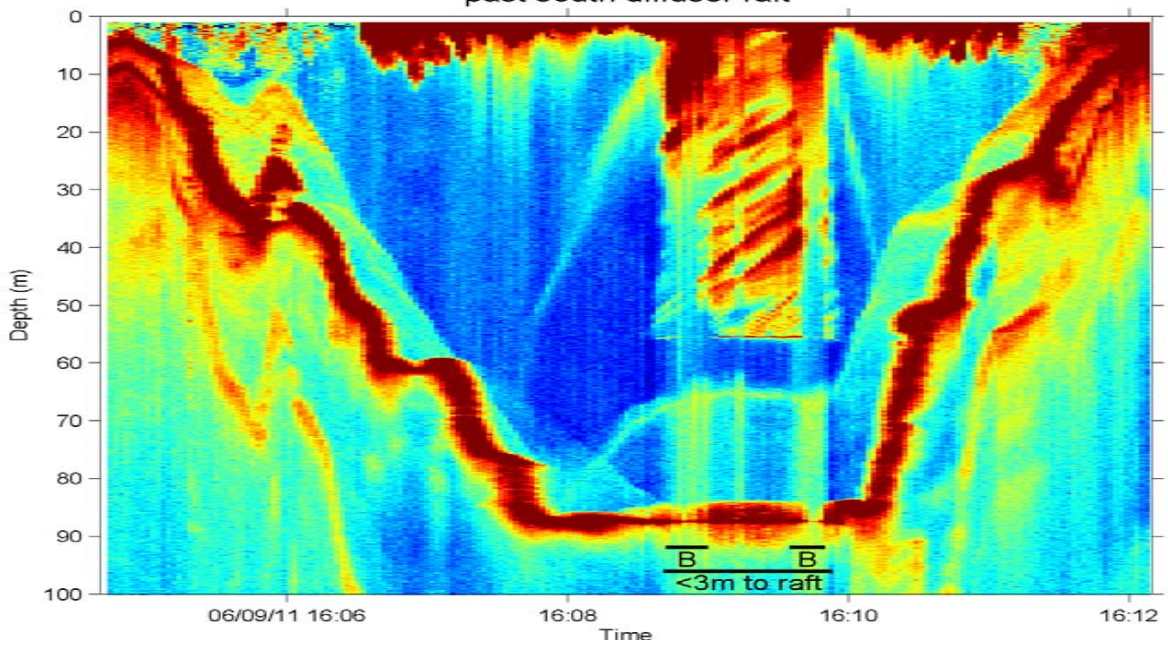


STARTUP PLUME SOUTH DIFFUSER

22 DAYS AFTER STARTUP

Zone 2 Pit Sonar Transect

Figure 6 Raw sounder transect east to west past south diffuser raft



Canada

Preliminary Results

-Temperature

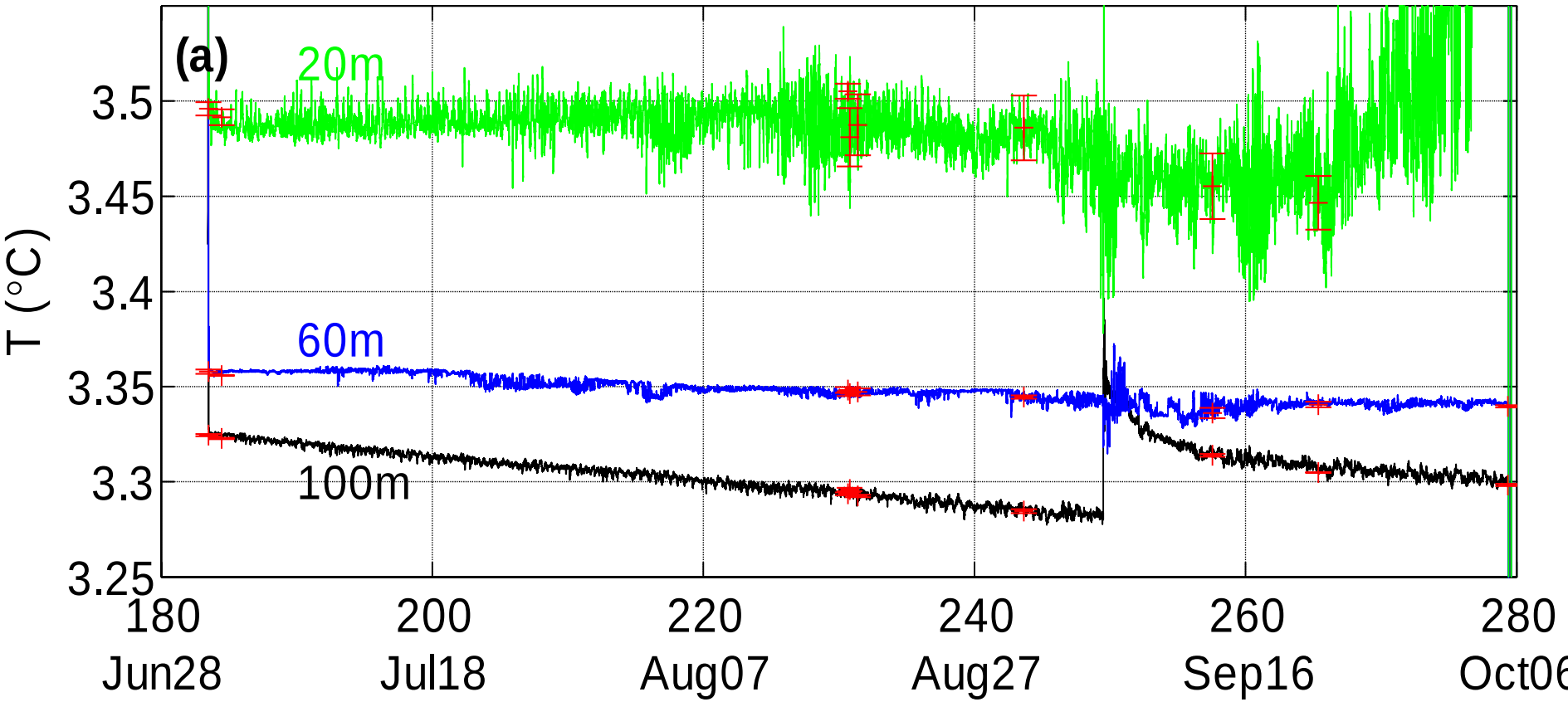
-% Dissolved Oxygen saturation

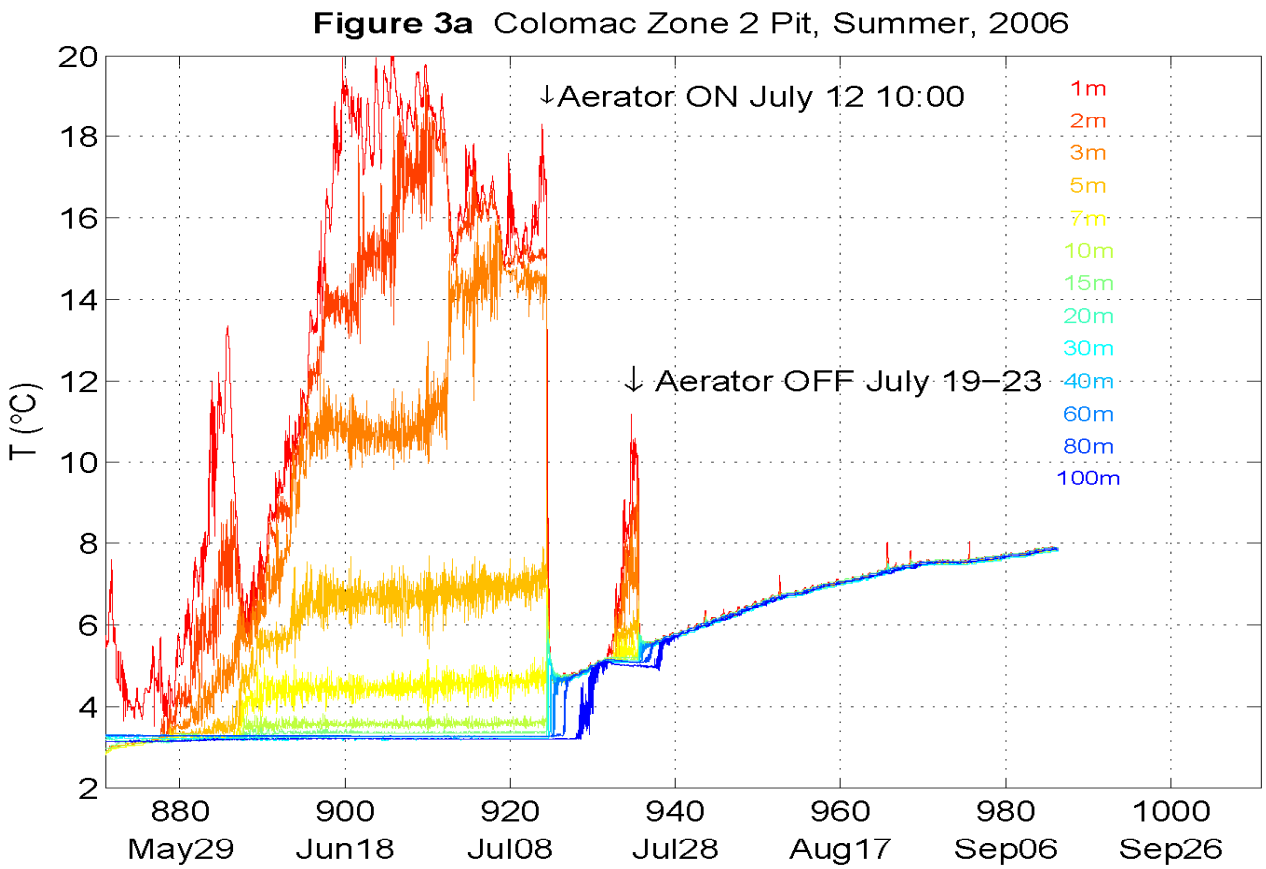
-SCN

-NH_3-N

-$N0_3$-N

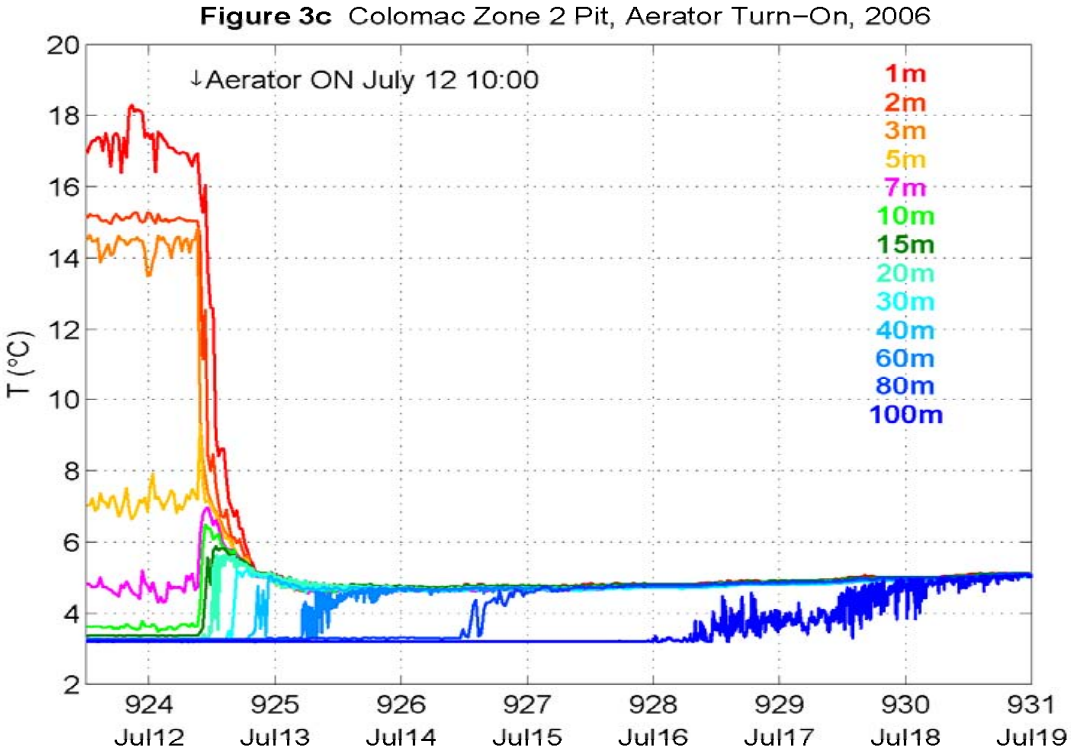
Temperature from dataloggers stationed at Pieters Monitoring Raft 2005





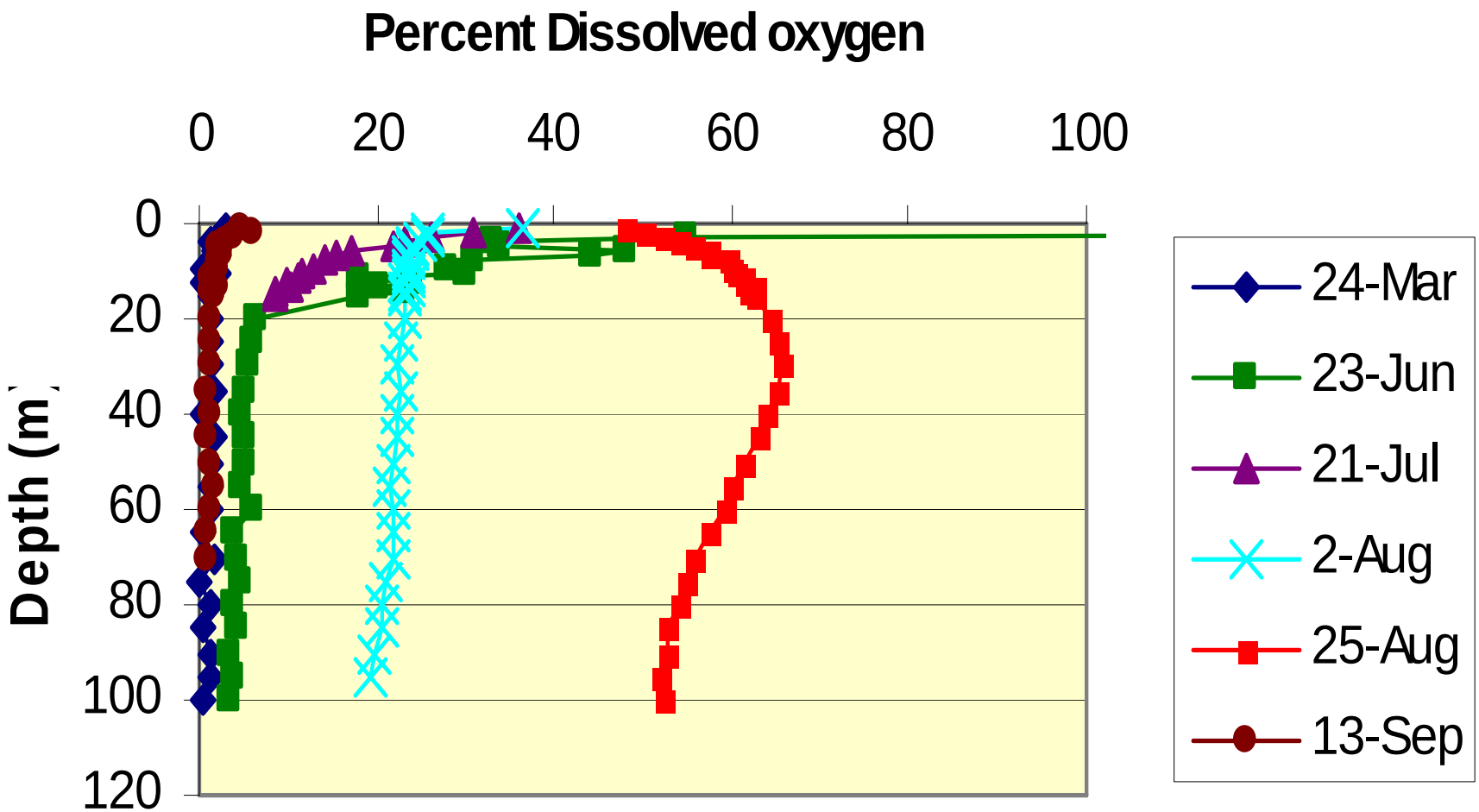
T dataloggers, Pieters raft 2006 (UBC)

Canada

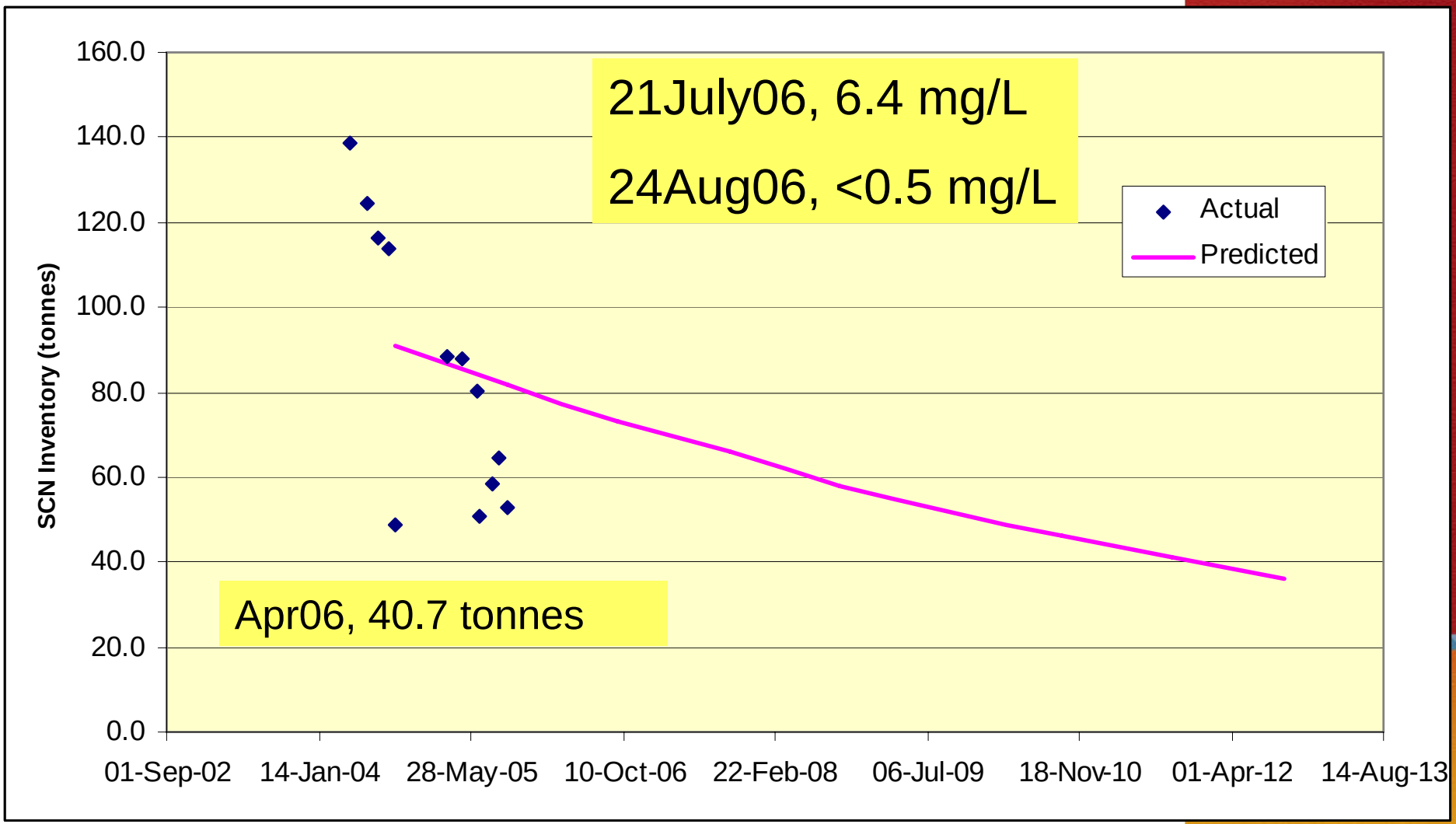


Temp change July 12 – 19, 2006 from Temp dataloggers, Pieters Raft (UBC)

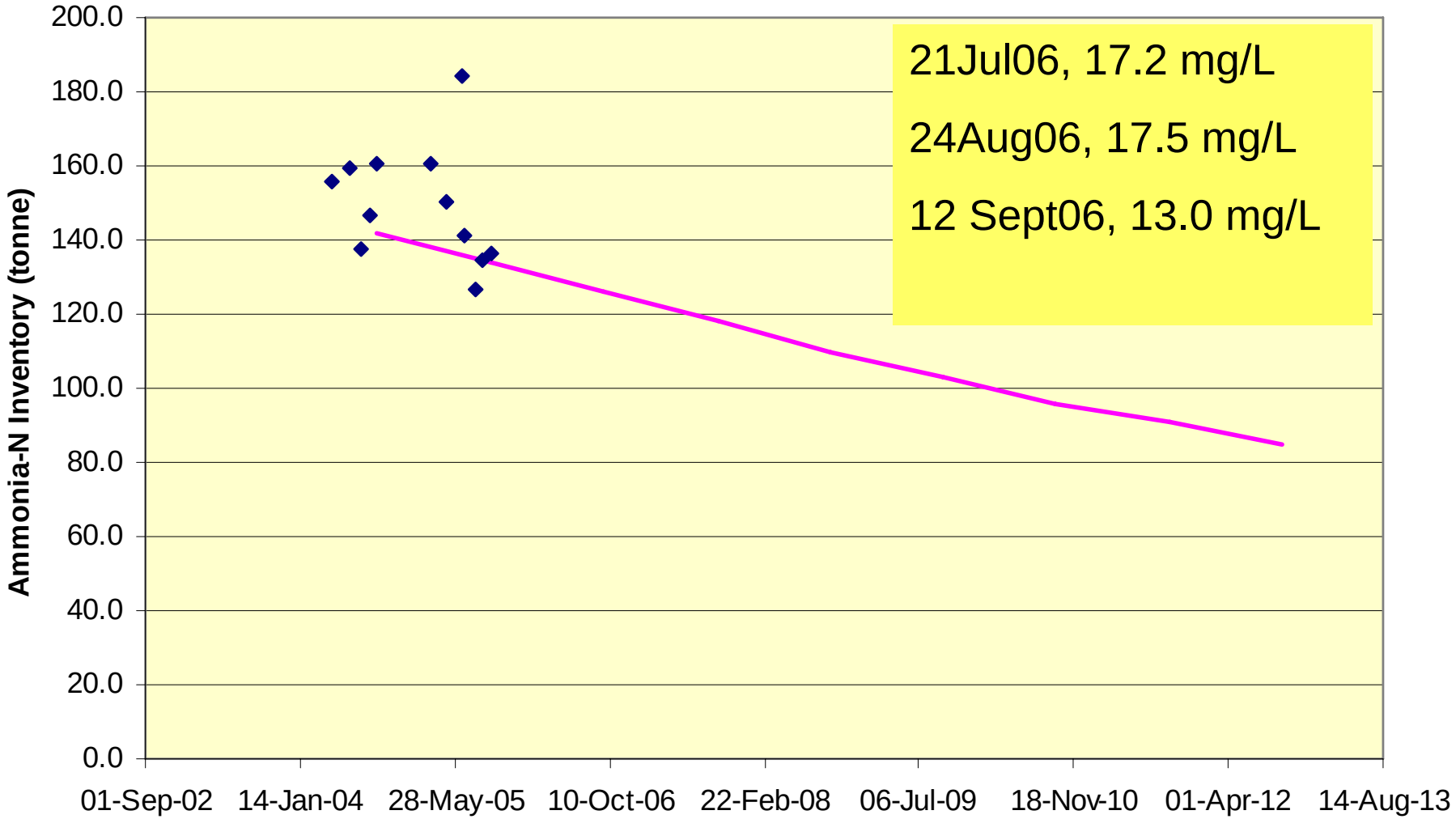
DO Profiles in Zone 2 Pit - 2006



Zone 2 Pit – Thiocyanate Inventory



Zone 2 Pit – Ammonia Inventory



Z2 Pit Results for NO_3-N (mg/L)

Depth (m)	June 23/06	July 21/06	Aug 2/06	Aug 24/06	Sept 12/06
1		0.036		0.51	6.16
10		0.040		0.56	8.2 (15)
20		0.040		0.54	7.7 (30)
40		0.042		0.57	
60		0.042		0.57	
80				0.64	
95		0.043		0.52	

NEXT STEPS for Z2P

- Review and analyze 2006 data
- Conduct under ice sample program for DO and water chemistry
- Meet with ENR Scientific Advisory Committee and decide on 2007 treatment schedule