From Monitoring to Management: Working Towards Maintaining and Improving Water Quality at Pigeon Lake

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Alberta Environment and Sustainable Resource Development

September 27, 2013

Introduction

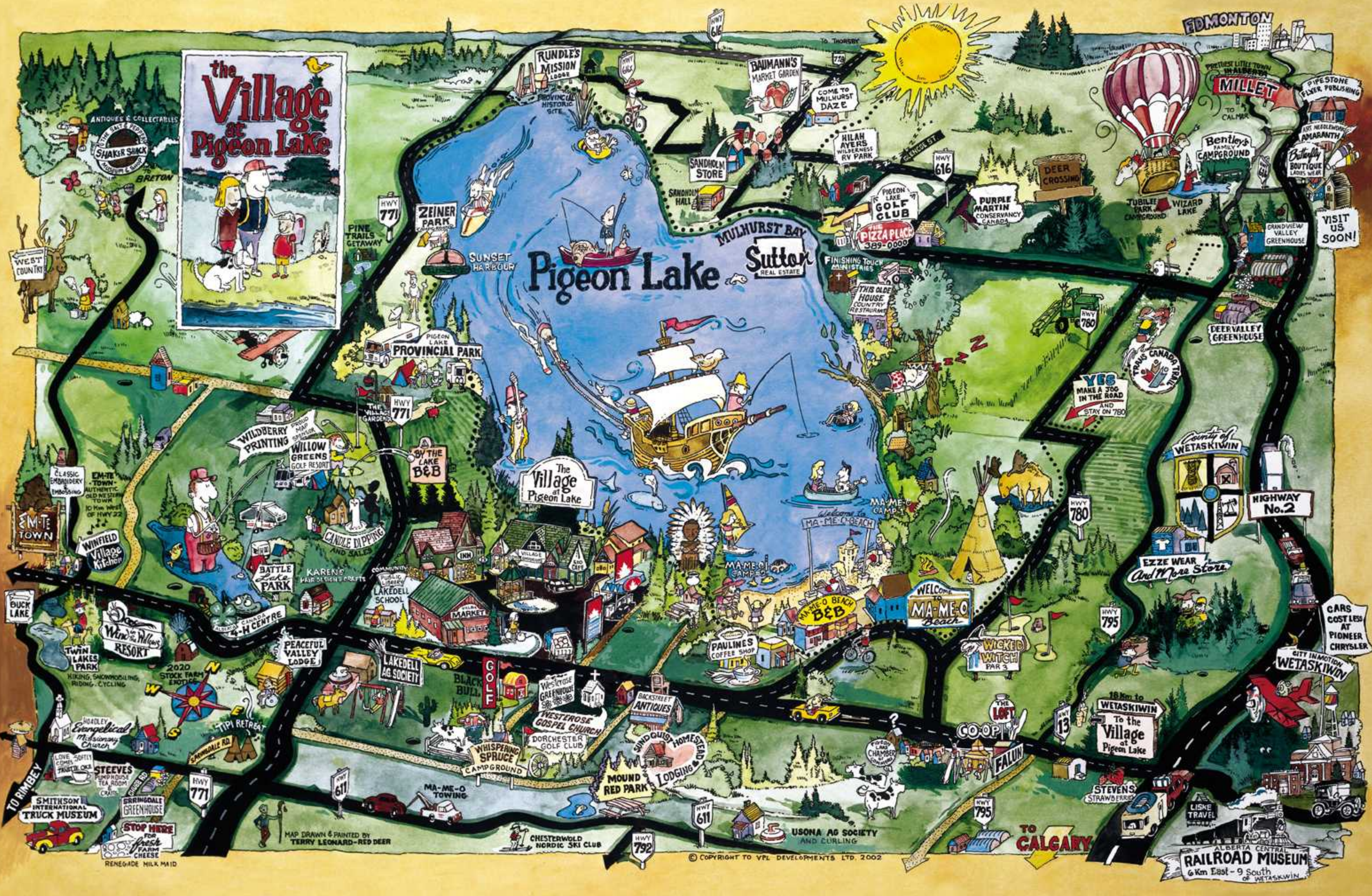
Outline

- Pigeon Lake and Pigeon Lake watershed
- Nuisance blooms and fish kills – issues or indicators?
- Evolution of monitoring and management – past to present
- Where do we go from here?

Pigeon Lake and Pigeon Lake Watershed

Overview and History

- Very popular recreational lake located 60km southwest of Edmonton within Battle River watershed
- Large lake (96.7km^2) with a relatively small watershed (187km^2)
- Relatively shallow (maximum depth of ~10m) with small inflowing streams and single outflow – large fluctuations in water levels
- Development and more intensive use of the watershed and lake beginning in 1850's
- Currently includes 10 summer villages, 2 counties, First Nations reserve, provincial park, agricultural land, and natural areas – lots of varying land-use
- Differing bylaws, land-use strategies, values, etc. – lake is common bond


the Village at Pigeon Lake
Pigeon Lake
EDMONTON
MILLET
TO THORSBY
TO CALMAR
RUNDLE'S MISSION LODGE
PROVINCIAL HISTORIC SITE
BAUMANN'S MARKET GARDEN
COME TO MULHURST DAZE
HILAH AYERS WILDERNESS RV PARK
SANDHOLM STORE
PIGEON LAKE GOLF CLUB
THE PIZZA PLACE
PURPLE MARTIN CONSERVANCY CANADA
DEER CROSSING
Bentley's FAMILY CAMPGROUND
JUBILEE PARK CAMPGROUND
WIZARD LAKE
PIPESTONE FLYER PUBLISHING
AMARANTH
Butterfly BOUTIQUE
VISIT US SOON!
GRANDVIEW VALLEY GREENHOUSE
DEER VALLEY GREENHOUSE
MULHURST BAY
Sutton REAL ESTATE
FINISHING TOUCH
THIS OLDE HOUSE COUNTRY RESTAURANT
ZEINER PARK
SUNSET HARBOUR
PINE TRAILS GETAWAY
HWY 616
HWY 771
HWY 780
HWY 795
HWY 13
HWY 611
HWY 792
PIGEON LAKE PROVINCIAL PARK
TRANS CANADA TRAIL
YES MAKE A ZOO IN THE ROAD AND STAY ON 780
County of WETASKIWIN
HIGHWAY No.2
EZZE WEAR And More Store
ANTIQUES & COLLECTABLES
SHAKER SHACK
BRETON
WEST COUNTRY
WILDBERRY PRINTING
WILLOW GREENS GOLF RESORT
BY THE LAKE B&B
The Village at Pigeon Lake
EM-TE TOWN
WINFIELD Village Kitchen
BATTLE LAKE PARK
CANDLE DIPPING
4-H CENTRE
BUCK LAKE
TWIN LAKES PARK
PEACEFUL VALLEY LODGE
LAKEDELL SCHOOL
LAKEDELL AG SOCIETY
GOLF
2020 STOCK FARM EXOTICS
TIPI RETREAT
Hoadley Evangelical Missionary Church
STEEVES TEA ROOM
TO RIMBEY
SMITHSON INTERNATIONAL TRUCK MUSEUM
STOP HERE FOR fresh FARM CHEESE
RENEGADE MILK MAID
WESTEROSE GOSPEL CHURCH
DORCHESTER GOLF CLUB
BACKSTREET ANTIQUES
WHISPERING SPRUCE CAMPGROUND
MOUND RED PARK
LODGING
MA-ME-O TOWING
MA-ME-O BEACH
MA-ME-O BEACH B&B
WELCOME TO MA-ME-O Beach
PAULINES COFFEE SHOP
WICKED WITCH PAR 3
THE LOFT
CO-OP
FALUN
16 Km to WETASKIWIN
To the Village at Pigeon Lake
WETASKIWIN
CARS COST LESS AT PIONEER CHRYSLER
STEVENS STRAWBERRIES
LISKE TRAVEL
RAILROAD MUSEUM
6 Km East - 9 South of WETASKIWIN
TO CALGARY
USONA AG SOCIETY AND CURLING
CHESTERWOLD NORDIC SKI CLUB
MAP DRAWN & PAINTED BY TERRY LEONARD-RED DEER
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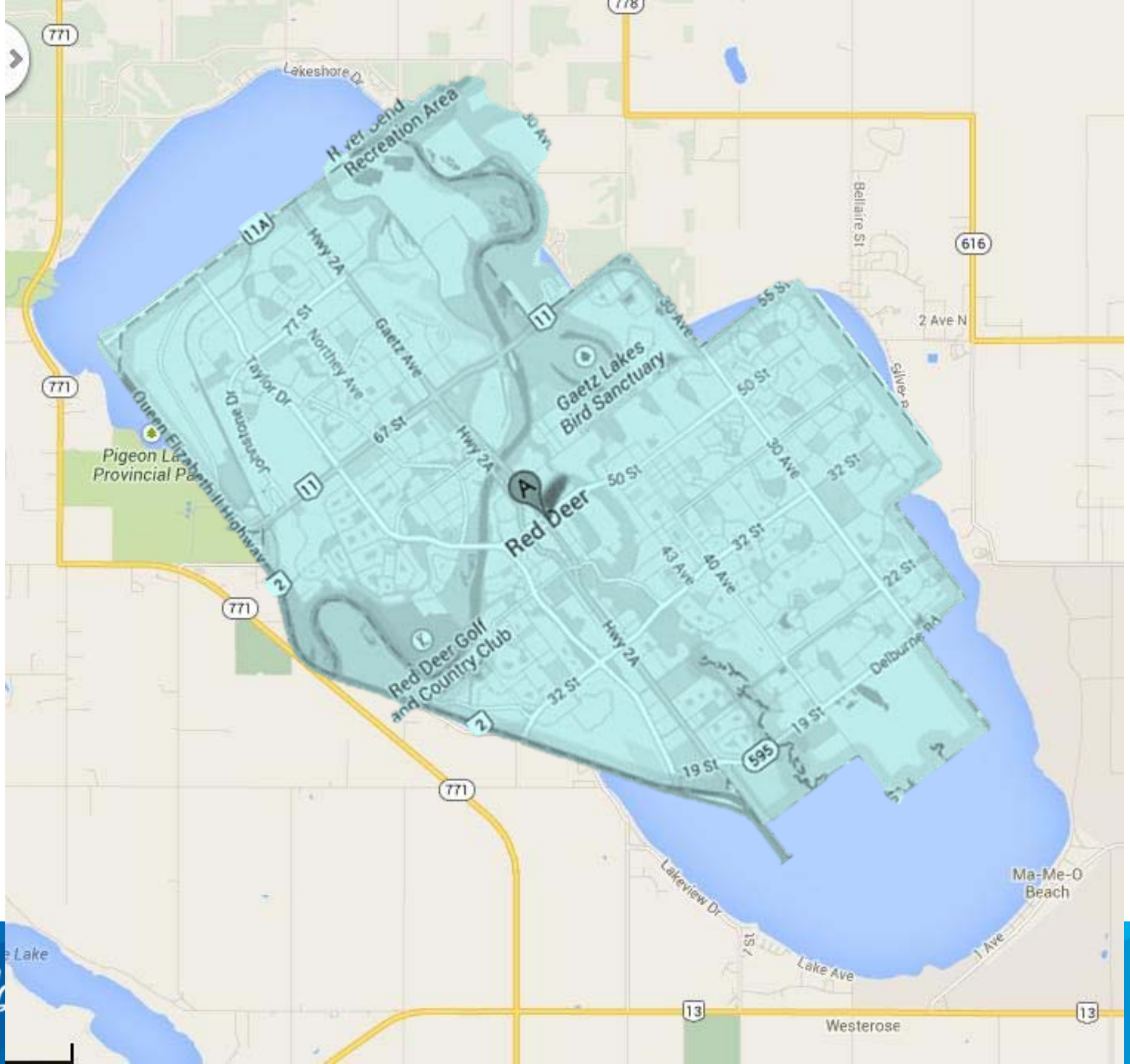
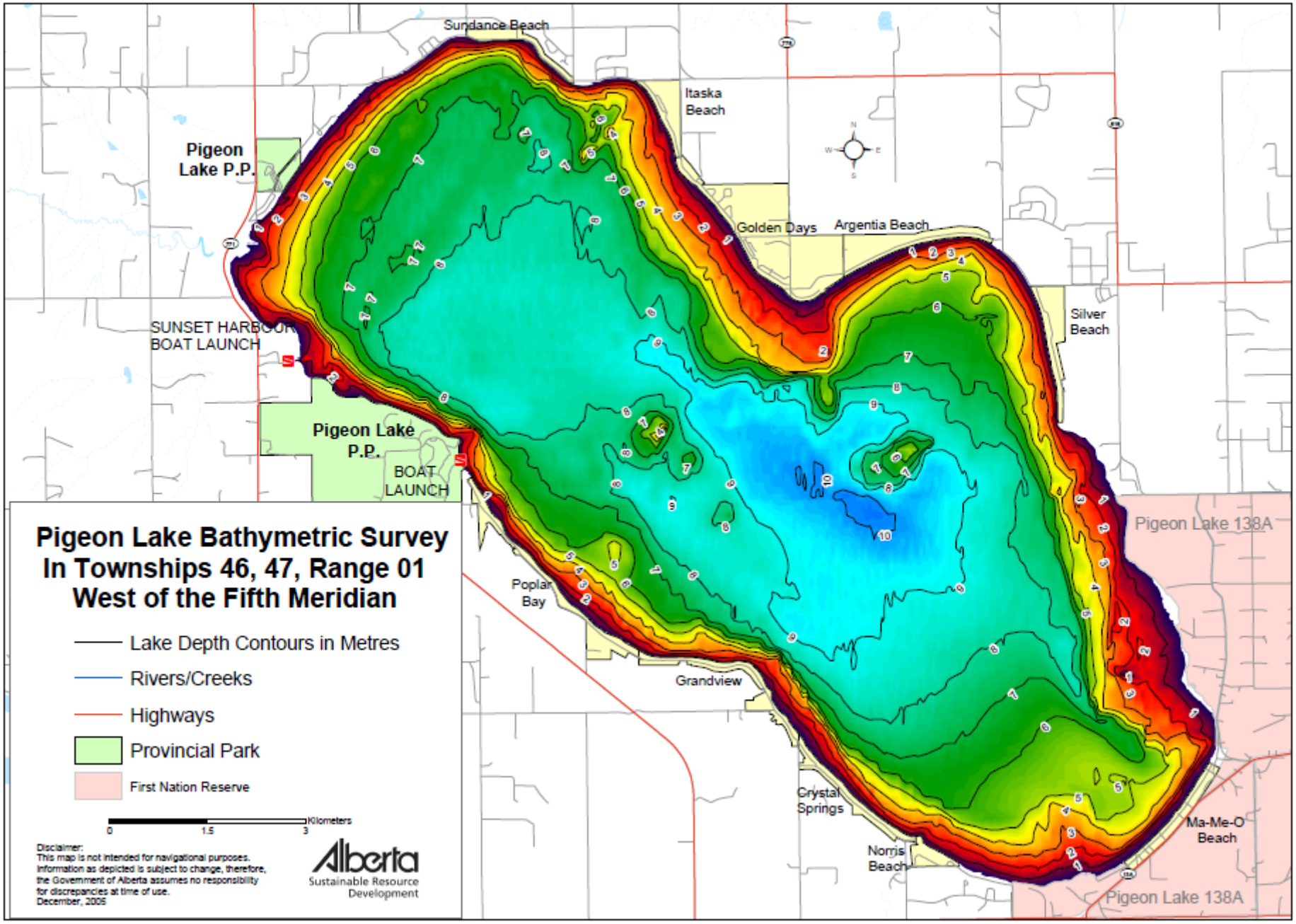
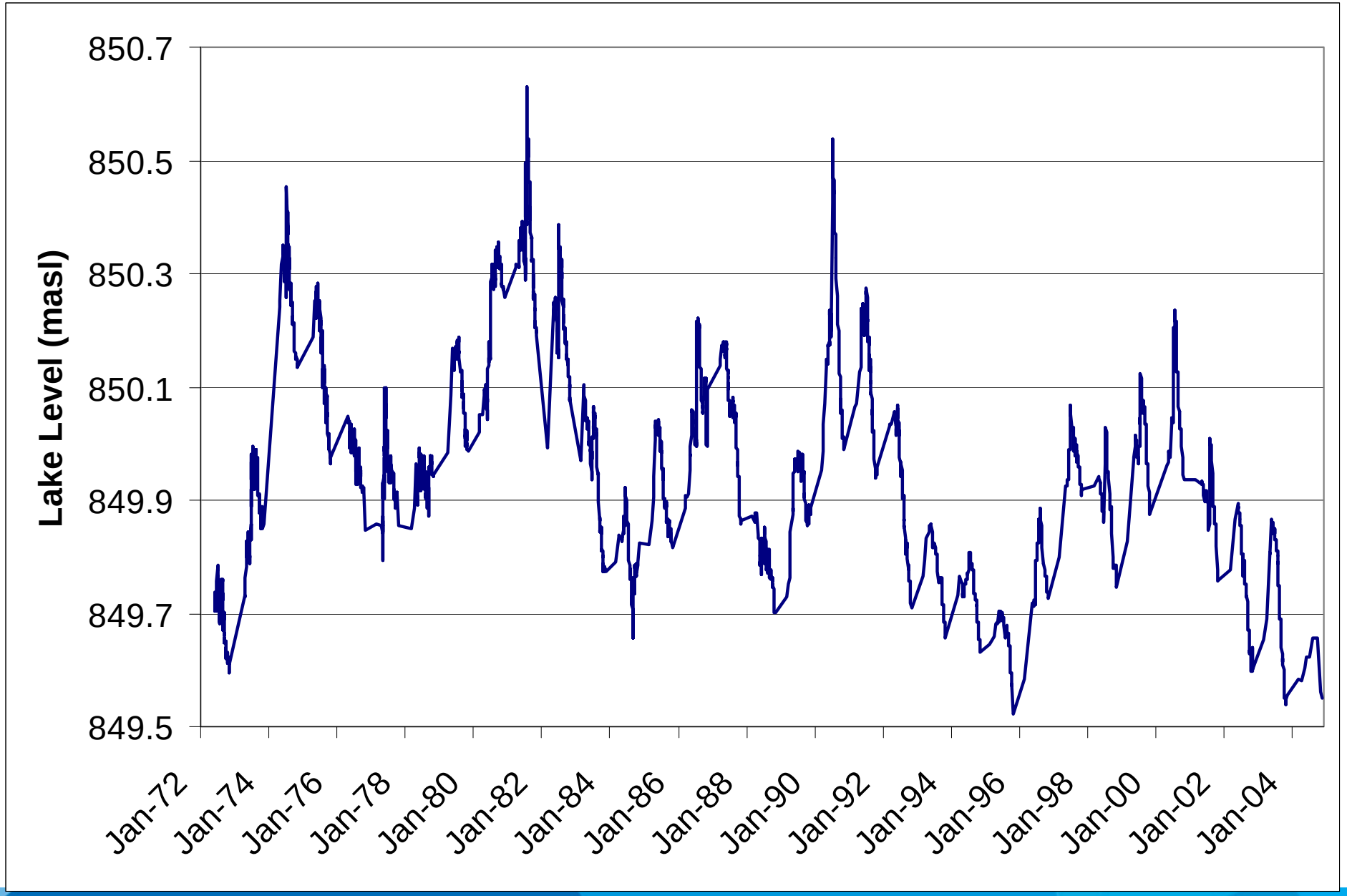
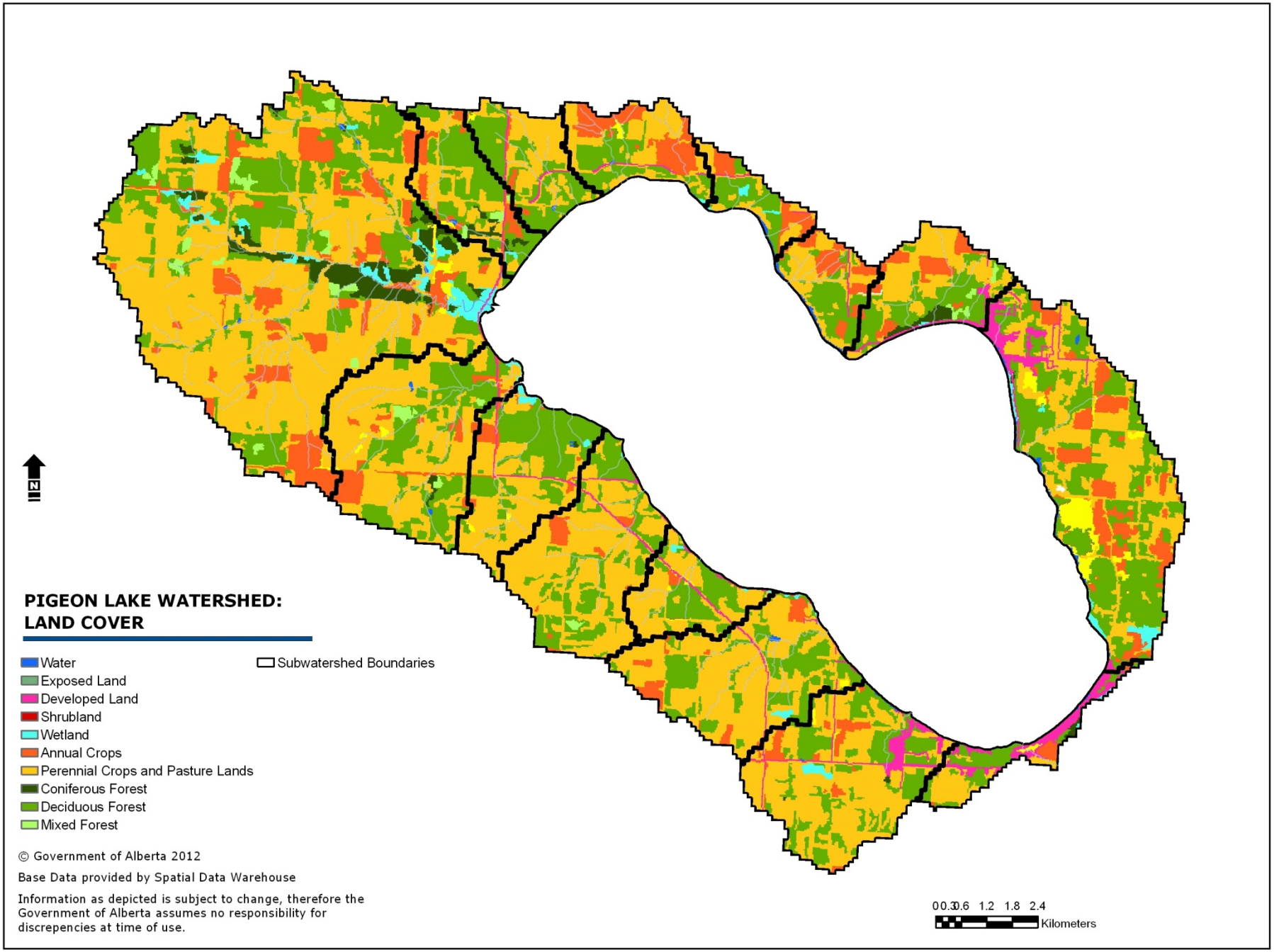
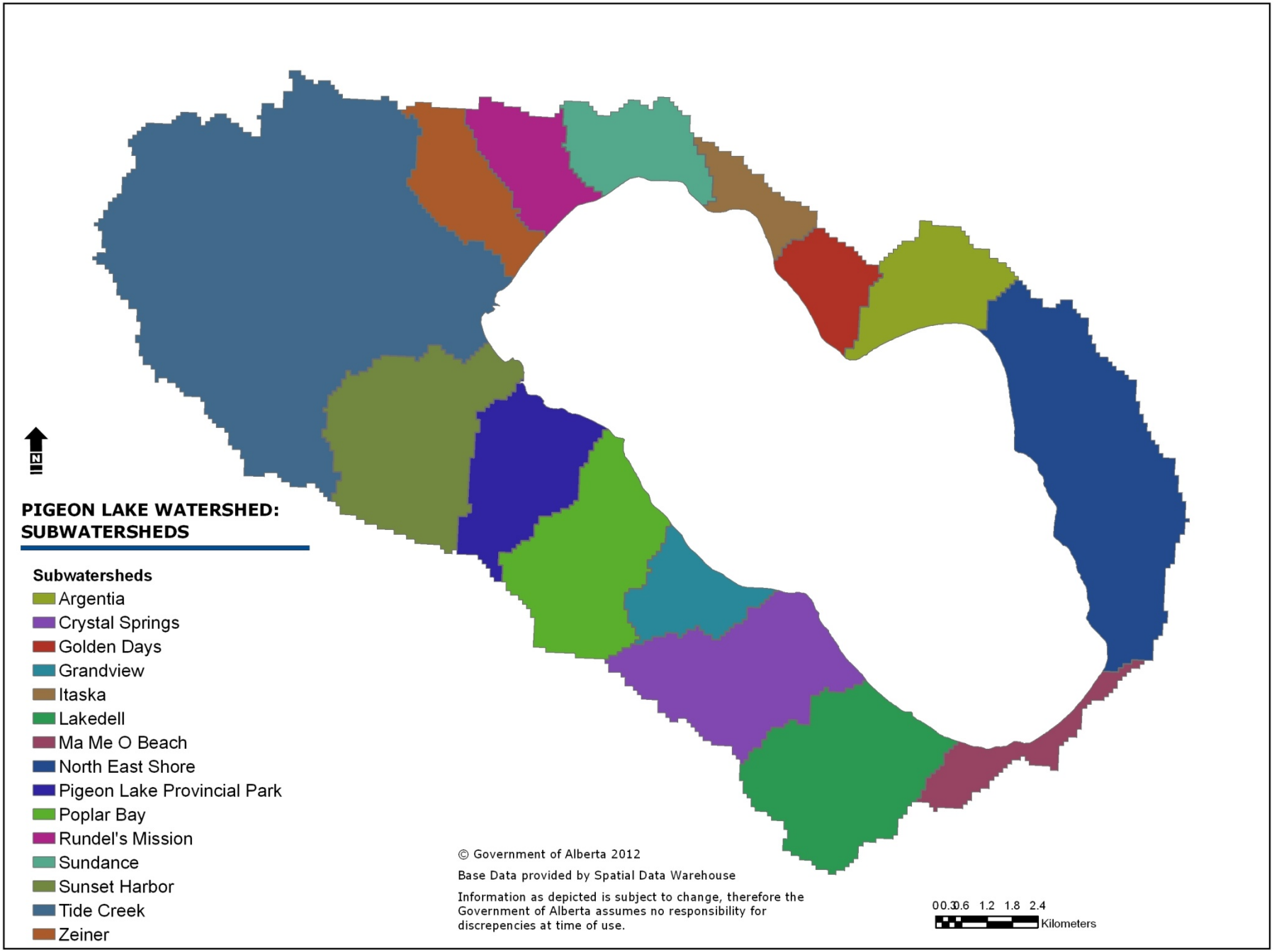
Alberta


Red Deer
Gaetz Lakes Bird Sanctuary
Red Deer Golf and Country Club
Pigeon Lake Provincial Park
Queen Elizabeth II Highway
Lakeshore Dr
Hwy 2A
Gaetz Ave
Northey Ave
77 St
67 St
50 St
32 St
43 Ave
40 Ave
30 Ave
22 St
19 St
Delburne Rd
Bellaire St
2 Ave N
Lakeview Dr
Lake Ave
Ma-Me-O Beach
Westerose
771
11
11A
2
595
616
13


Sundance Beach
Itaska Beach
Pigeon Lake P.P.
Golden Days
Argentia Beach
Silver Beach
SUNSET HARBOUR BOAT LAUNCH
Pigeon Lake P.P.
BOAT LAUNCH
Pigeon Lake 138A
Poplar Bay
Grandview
Crystal Springs
Norris Beach
Ma-Me-O Beach
Pigeon Lake 138A
Pigeon Lake Bathymetric Survey
In Townships 46, 47, Range 01
West of the Fifth Meridian
Lake Depth Contours in Metres
Rivers/Creeks
Highways
Provincial Park
First Nation Reserve
Kilometers
0
1.5
3
Disclaimer:
This map is not intended for navigational purposes. Information as depicted is subject to change, therefore, the Government of Alberta assumes no responsibility for discrepancies at time of use.
December, 2005
Alberta
Sustainable Resource Development


Lake Level (masl)
850.7
850.5
850.3
850.1
849.9
849.7
849.5
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04


N
PIGEON LAKE WATERSHED:
LAND COVER
Water
Exposed Land
Developed Land
Shrubland
Wetland
Annual Crops
Perennial Crops and Pasture Lands
Coniferous Forest
Deciduous Forest
Mixed Forest
Subwatershed Boundaries
© Government of Alberta 2012
Base Data provided by Spatial Data Warehouse
Information as depicted is subject to change, therefore the Government of Alberta assumes no responsibility for discrepencies at time of use.
0 0.3 0.6 1.2 1.8 2.4
Kilometers


PIGEON LAKE WATERSHED:
SUBWATERSHEDS
Subwatersheds
Argentia
Crystal Springs
Golden Days
Grandview
Itaska
Lakedell
Ma Me O Beach
North East Shore
Pigeon Lake Provincial Park
Poplar Bay
Rundel's Mission
Sundance
Sunset Harbor
Tide Creek
Zeiner
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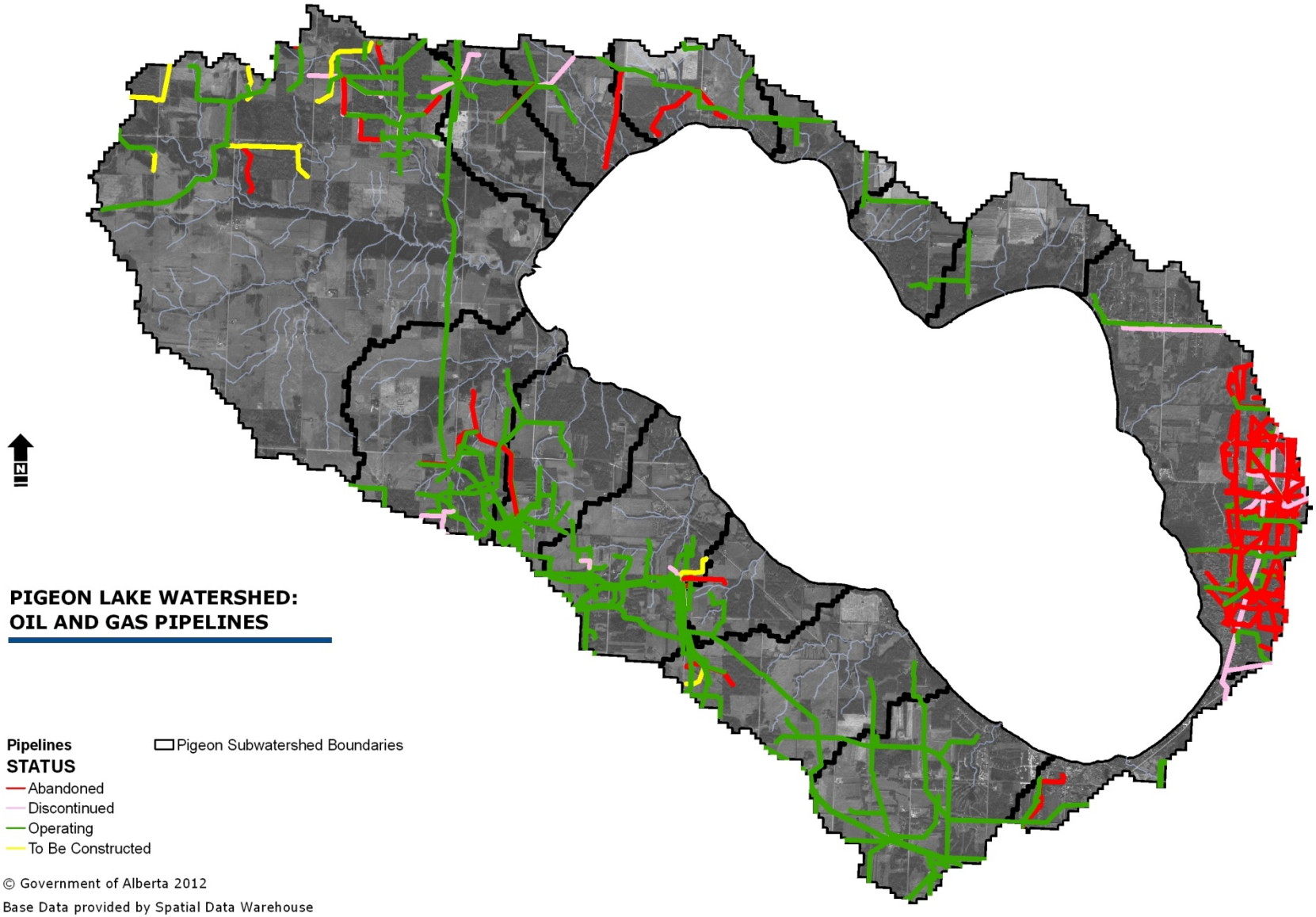
0 0.3 0.6 1.2 1.8 2.4
Kilometers



Base Data provided by Spatial Data Warehouse

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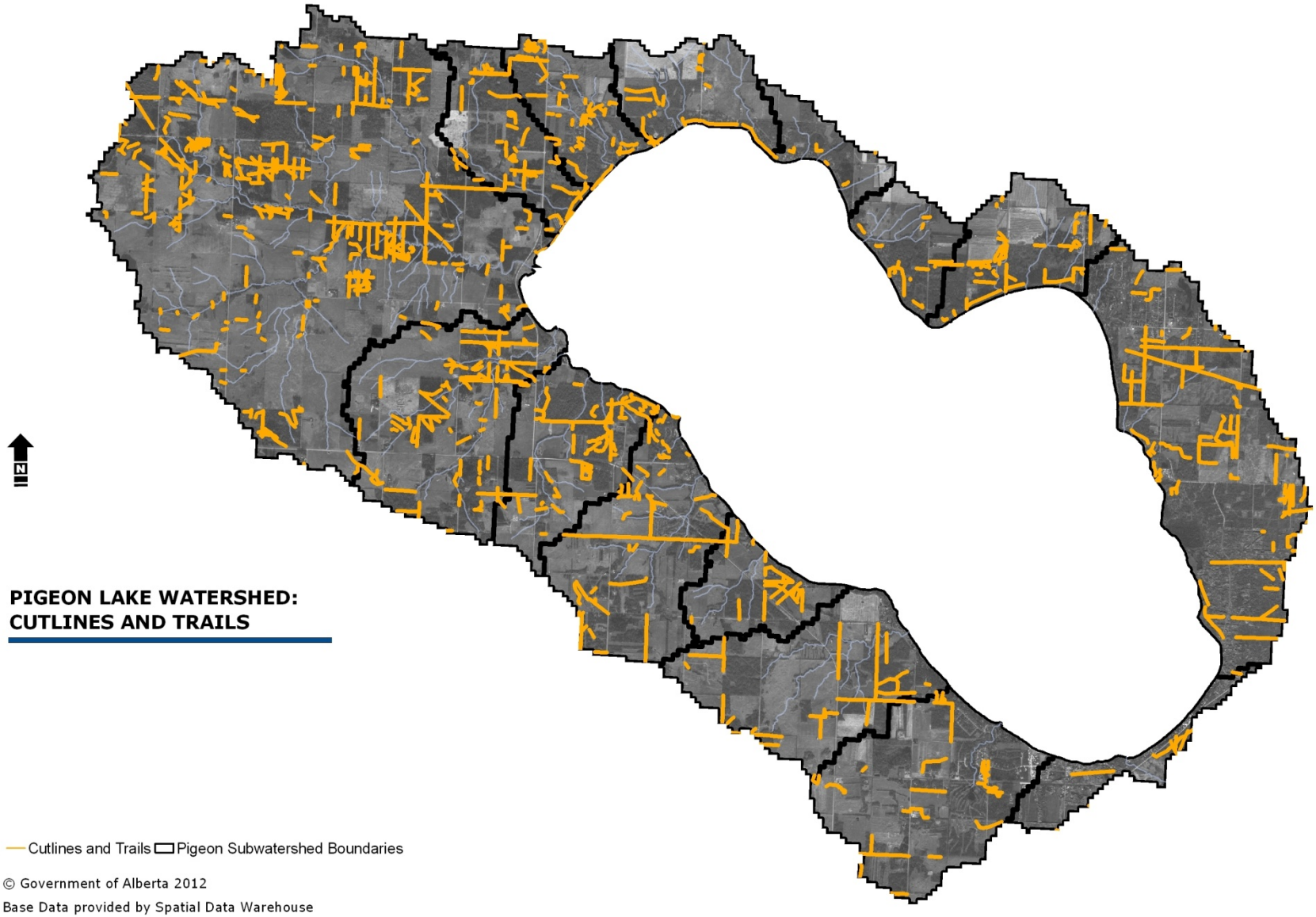
N
PIGEON LAKE WATERSHED:
CUTLINES AND TRAILS
Cutlines and Trails
Pigeon Subwatershed Boundaries
© Government of Alberta 2012
Base Data provided by Spatial Data Warehouse
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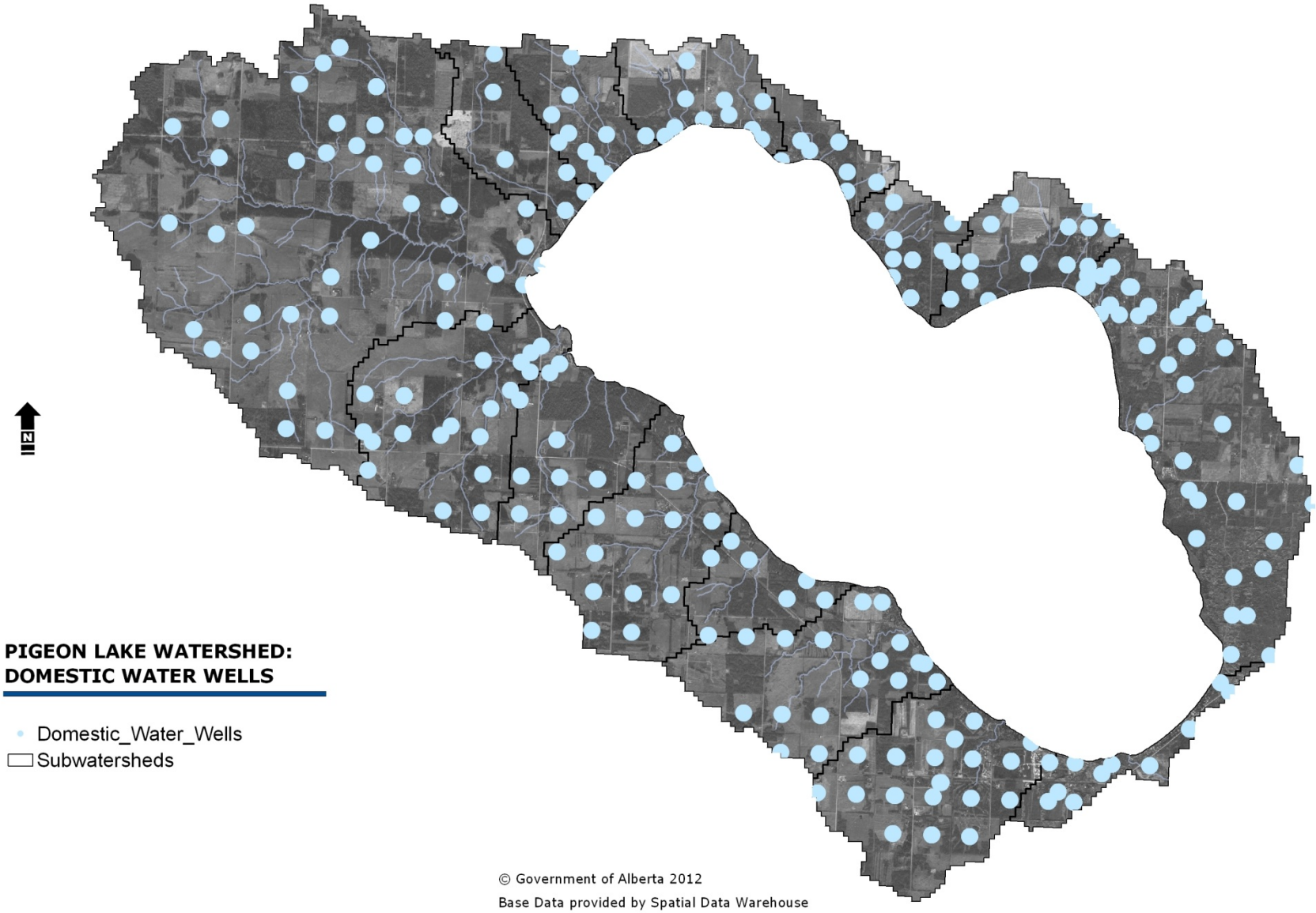
0 0.3 0.6 1.2 1.8 2.4
Kilometers


N
PIGEON LAKE WATERSHED:
DOMESTIC WATER WELLS
Domestic_Water_Wells
Subwatersheds
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0 0.3 0.6 1.2 1.8 2.4
Kilometers

Nuisance Blooms and Fish Kills – Issues or Indicators?

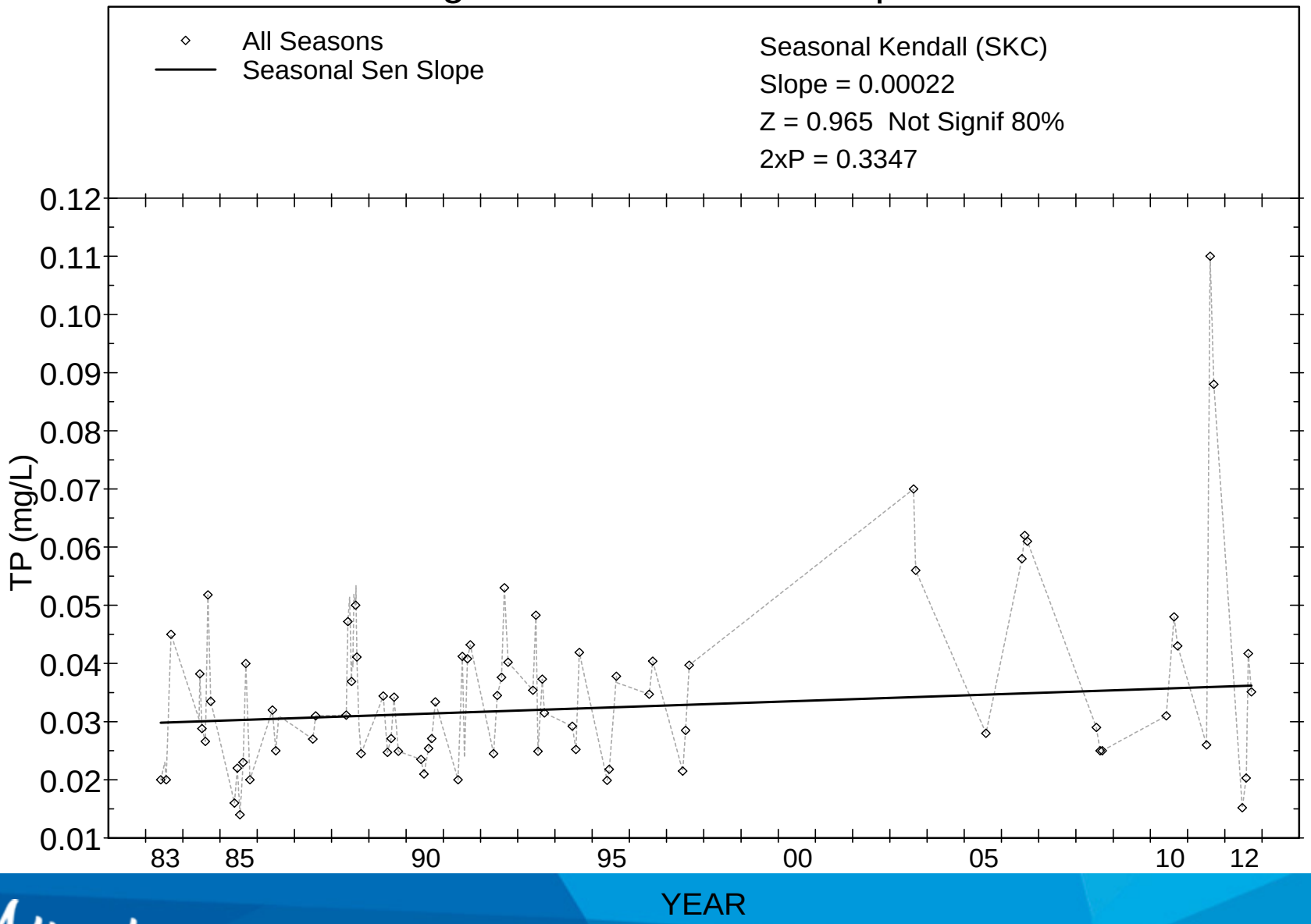
Nuisance Blooms and Fish Kills

- Pigeon Lake has long been a productive lake
  - Mitchell (1986) – Pigeon Lake is “relatively shallow, green with algae in summer…”
  - Mitchell (1996) – Pigeon Lake has “relatively good water quality for much of the summer even though the water may appear green…”
- Classified as eutrophic, similar to many other central Alberta lakes
  - Productive soils = productive lakes
  - Chemical and physical characteristics are ideal for cyanobacteria

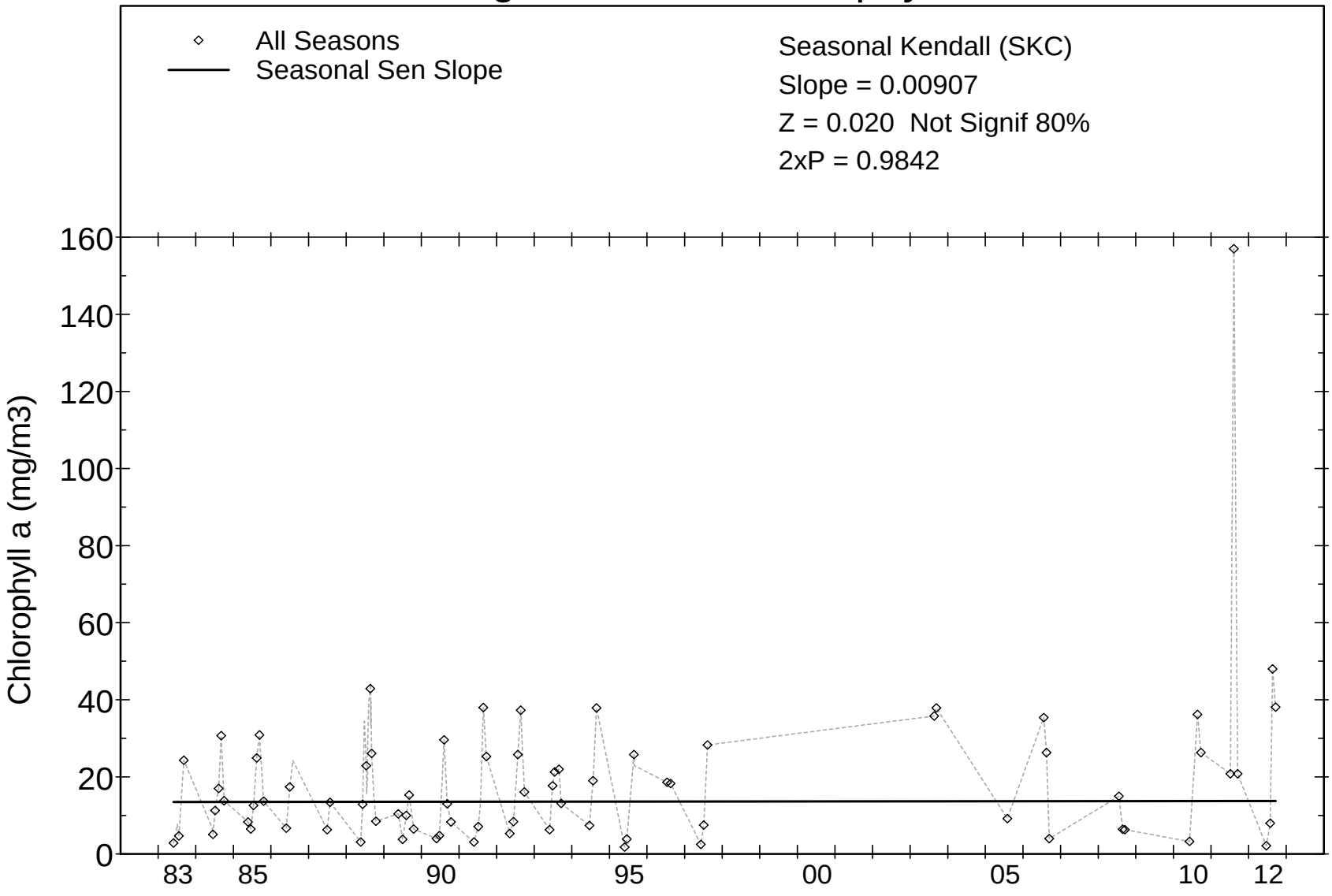
Nuisance Blooms and Fish Kills

- Despite presence of nuisance blooms in recent years, long-term data does not indicate a significant increase in nutrient or chlorophyll-*a* content over time
- Possible explanations?
  - Sample timing and sample gaps
  - Collection of integrated composite samples
  - Variability in dataset
  - Heightened awareness
- Likely that subtle changes over long period of time have lead to favourable conditions for algal blooms – no one major change

Pigeon Lake - Total Phosphorus

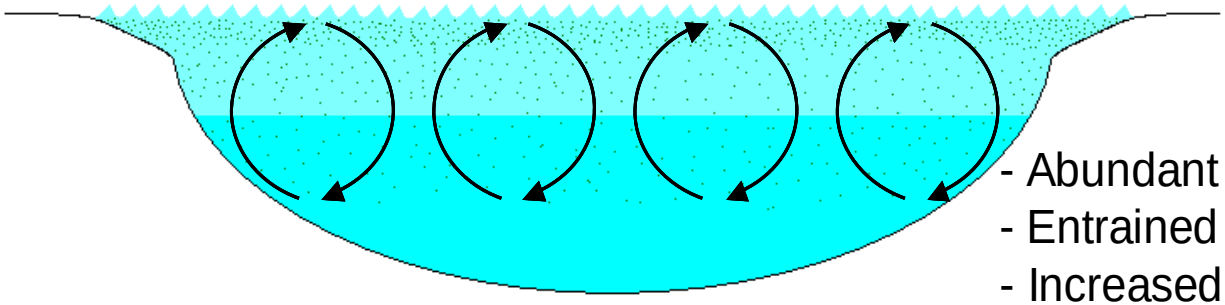


Pigeon Lake - Chlorophyll a



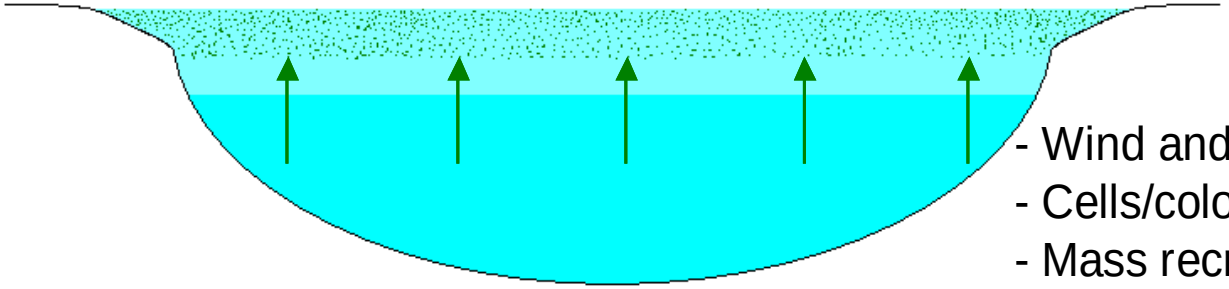
wind

Turbulent Conditions



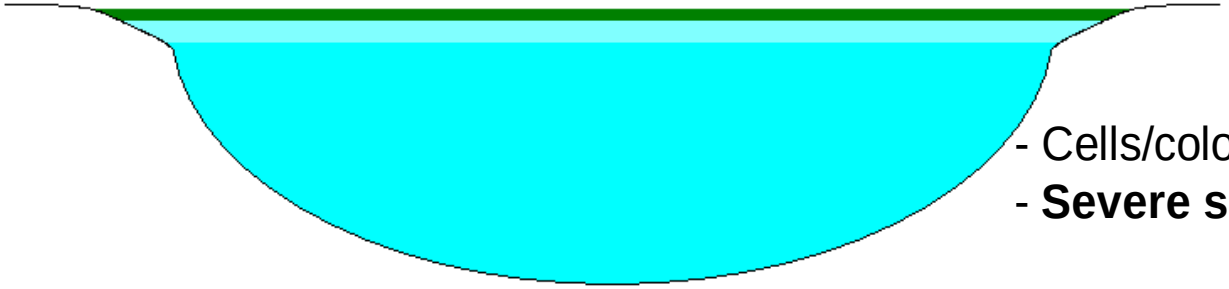
- Abundant ~~existing cells/colonies~~.
- Entrained throughout water column.
- Increased gas vesicle production.

Calm Conditions

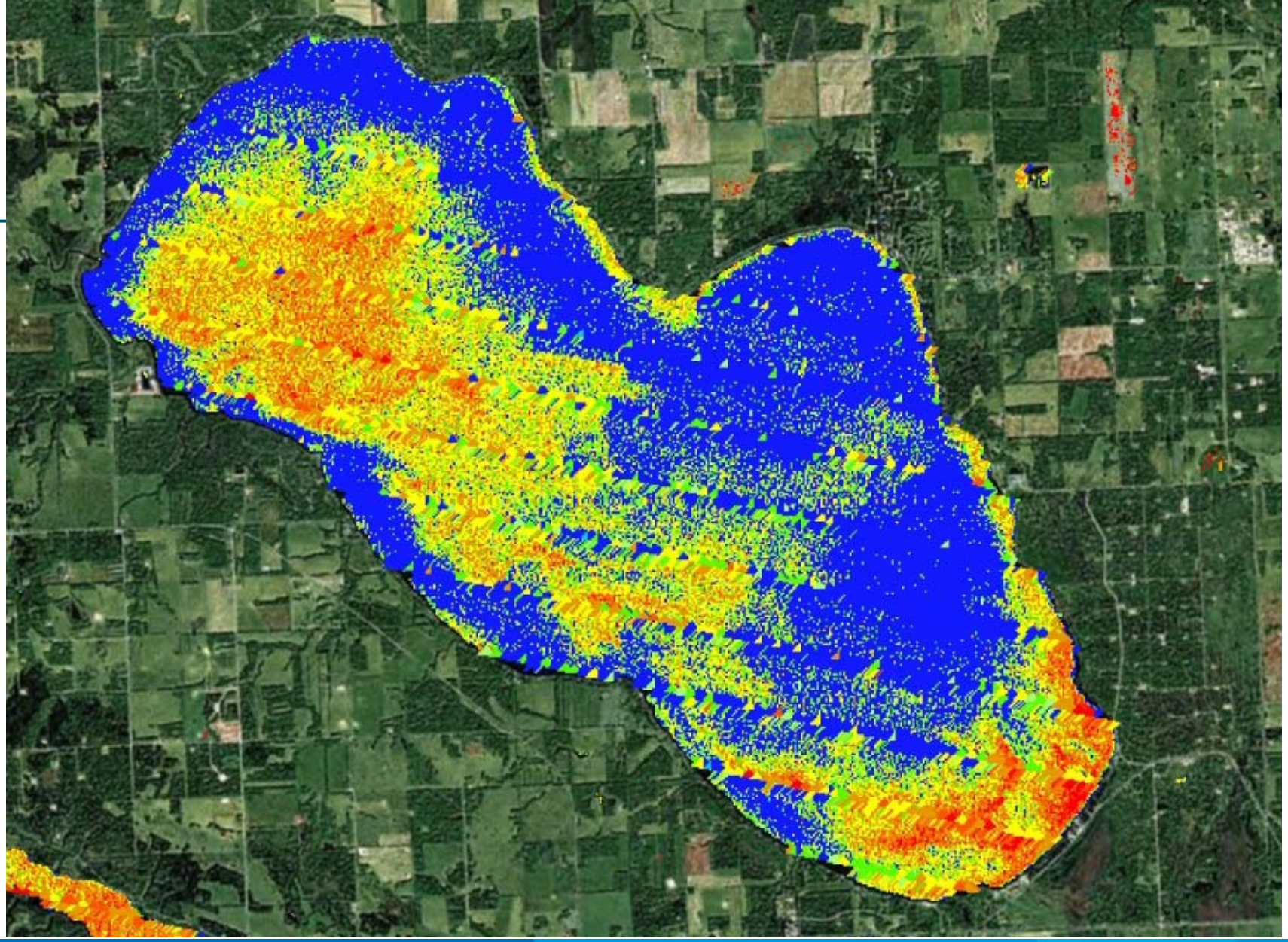


- Wind and wave action cease.
- Cells/colonies over buoyant.
- Mass recruitment towards surface.

Bloom Formation



- Cells/colonies stranded at surface.
- **Severe surface accumulation!**

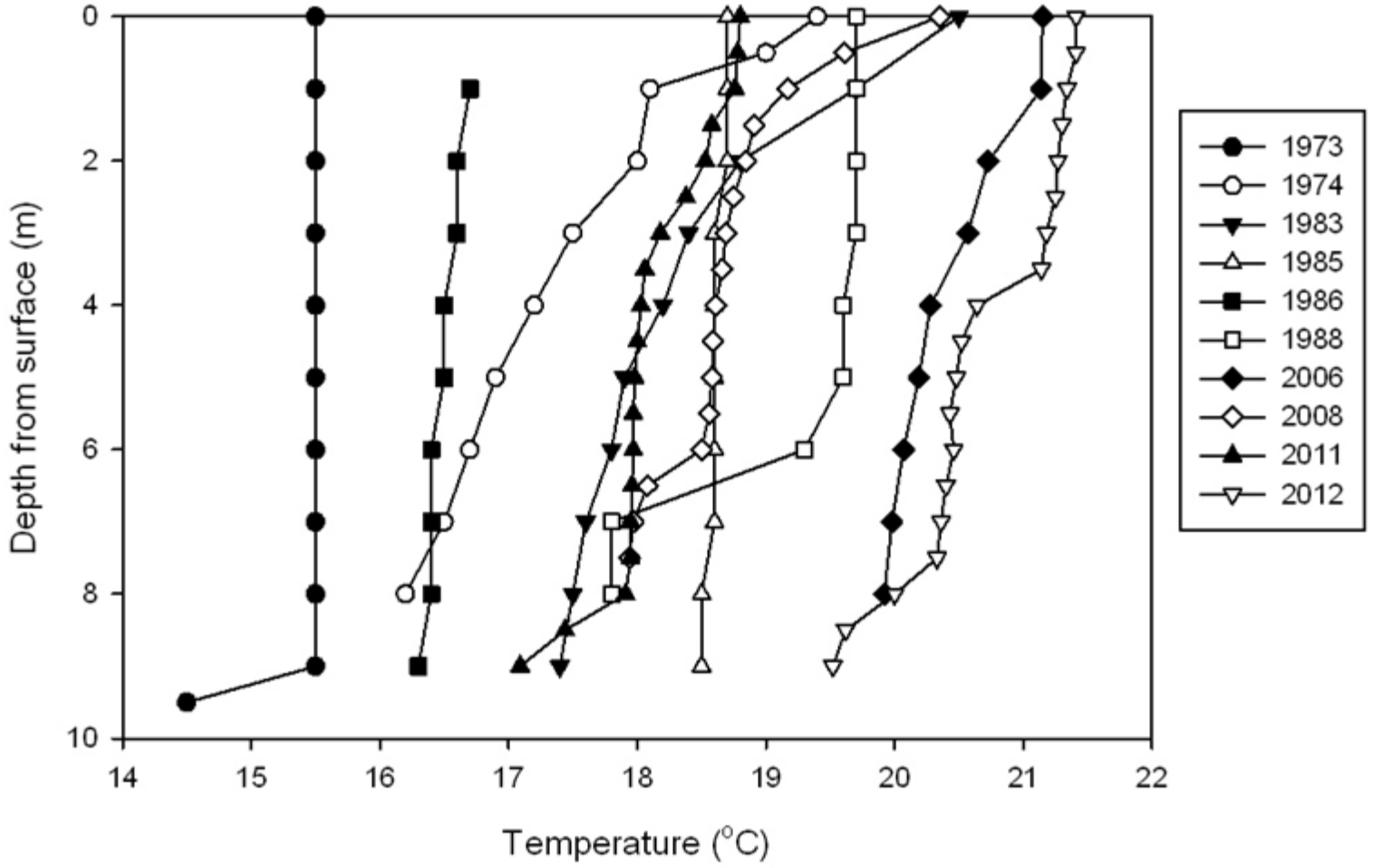


Nuisance Blooms and Fish Kills – Fish Kills

- Similar to cyanobacteria, fish kills have been occurring at Pigeon Lake for many years
- More severe die-offs in 2010 and 2012 and to a smaller extent in 2013
- All similar age and size class lake whitefish
- Several hypotheses, but many assumed algal blooms/toxins responsible
- Issues with this hypothesis:
  - Die-offs in 2012 and 2013 began prior to significant growth of cyanobacteria
  - Testing of fish tissue has revealed virtually no microcystin in muscle tissue
  - Lake water microcystin levels have always been very low in Pigeon Lake

Nuisance Blooms and Fish Kills – Fish Kills

- Plausible theory:
  - Warmer temperatures leading to stress and death of fish
  - Fish die-offs exacerbated by algal bloom collapse (consumes oxygen upon decomposition)
- July 2012 warmest temperature profile on record
- Warmer temperatures may lead to increased fish kills and nuisance blooms


Depth from surface (m)
0
2
4
6
8
10
14
15
16
17
18
19
20
21
22
Temperature (°C)
1973
1974
1983
1985
1986
1988
2006
2008
2011
2012

Nuisance Blooms and Fish Kills - Timeline

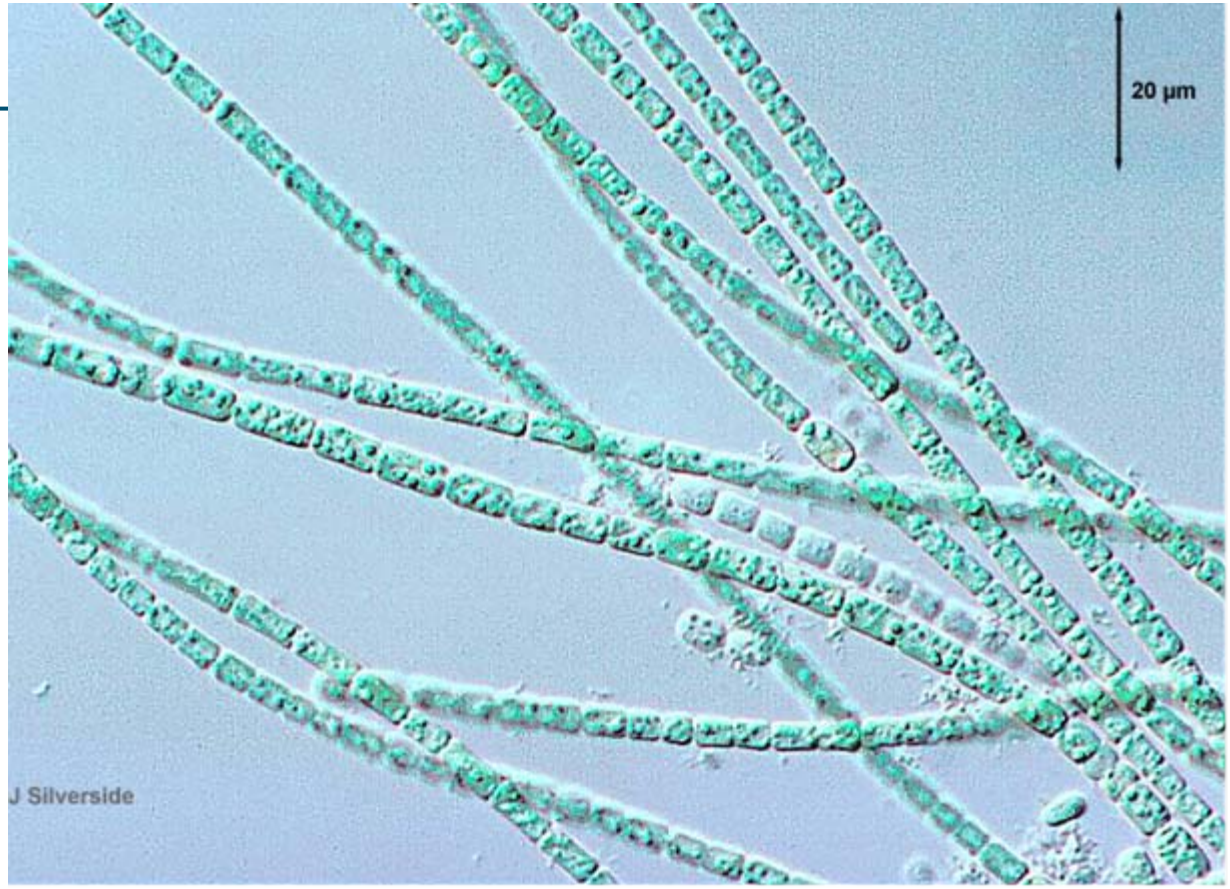
- Whatever the history, frequent and intense blooms along with fish kills have occurred in recent years

- 2006 – severe cyanobacterial bloom occurs
- Dominated by *Lyngbya* along with *Gleoeotrichia*, and *Anabaena*
- Includes die-off of snails and some fish
- Subsequent years blooms of varying intensity occur
- In addition to nuisance blooms large whitefish die-offs occur in 2010 and 2012
- Blooms and fish die-offs can be expected to continue without change
  - Focus is on nutrient controls

Lyngbya spp.

Gloeotrichia spp.

Anabaena spp.



Nuisance Blooms and Fish Kills - Response

- Response to blooms and fish kills has evolved over time
- Initially
  - High need for education and awareness
  - Lots of finger pointing
  - Lots of expectation for government to fix the problem
- Over time
  - Realization of personal responsibility
  - Partnering with municipalities, government, stakeholders to understand and address the issue
  - Initiatives to look at watershed management and in-lake treatment options
  - Moved from panic to education to action mode
- Still evolving

NO DRINKING, SWIMMING, OR OTHER CONTACT WITH THIS WATER

TOXIC ALGAE

HAS BEEN REPORTED AT THIS LOCATION

For Further Information:
1-877-360-6366

Alberta Health Services

Alberta Health Services

PUBLIC HEALTH ADVISORY

Protect Your Health

AHS has identified a blue-green algae bloom and/or toxin in the lake water.

Reduce your risk by not swimming, ingesting or being in contact with the lake water.

The public may wish to limit their consumption of fish.

If contact occurs, wash with clean water as soon as possible.

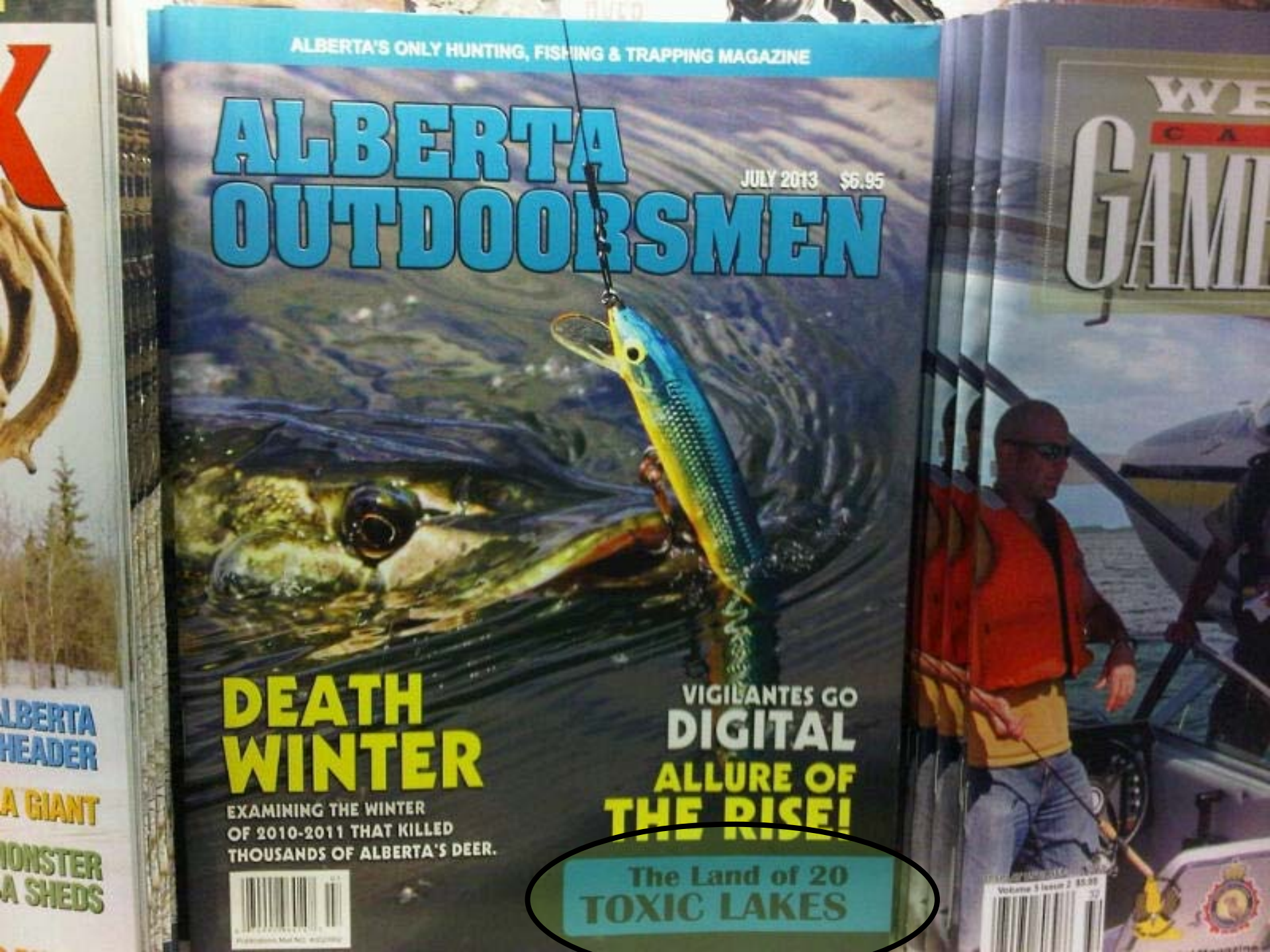
Persons experiencing illness after having contact with lake water are advised to seek medical attention.

Call Toll Free 1-866-408-LINK (5465)

www.albertahealthservices.ca

Nuisance Blooms and Fish Kills - Response

- The Good
  - Working together more effectively to address the current conditions
  - Gaining a much better understanding of the ecology of the lake
  - People want to do the right thing
  - Moving from panic to proactive
- The Bad
  - Lots of negative publicity around the lake, especially during blooms and fish die-offs
  - Decreased property values, business, and recreation
  - “Snake oil” salesmen come out of the woodwork


ALBERTA'S ONLY HUNTING, FISHING & TRAPPING MAGAZINE
ALBERTA OUTDOORSMEN
JULY 2013 $6.95
DEATH WINTER
EXAMINING THE WINTER OF 2010-2011 THAT KILLED THOUSANDS OF ALBERTA'S DEER.
VIGILANTES GO DIGITAL
ALLURE OF
The Land of 20 TOXIC LAKES

EDMONTON JOURNAL

Omar Khadr's lawyer decries government interference

Pigeon Lake the latest to be plagued with blue-green algae

BY ALEXANDRA ZABJEK, EDMONTON JOURNAL AUGUST 14, 2013

But…

EDMONTON JOURNAL

Omar Khadr's lawyer decries government interference

Pigeon Lake lovers battle blue-green algae with education, research, lifestyle changes

"Everyone working together, it all adds up"

BY ALEXANDRA ZABJEK, EDMONTON JOURNAL AUGUST 18, 2013

Nuisance Blooms and Fish Kills – Issues or Indicators?

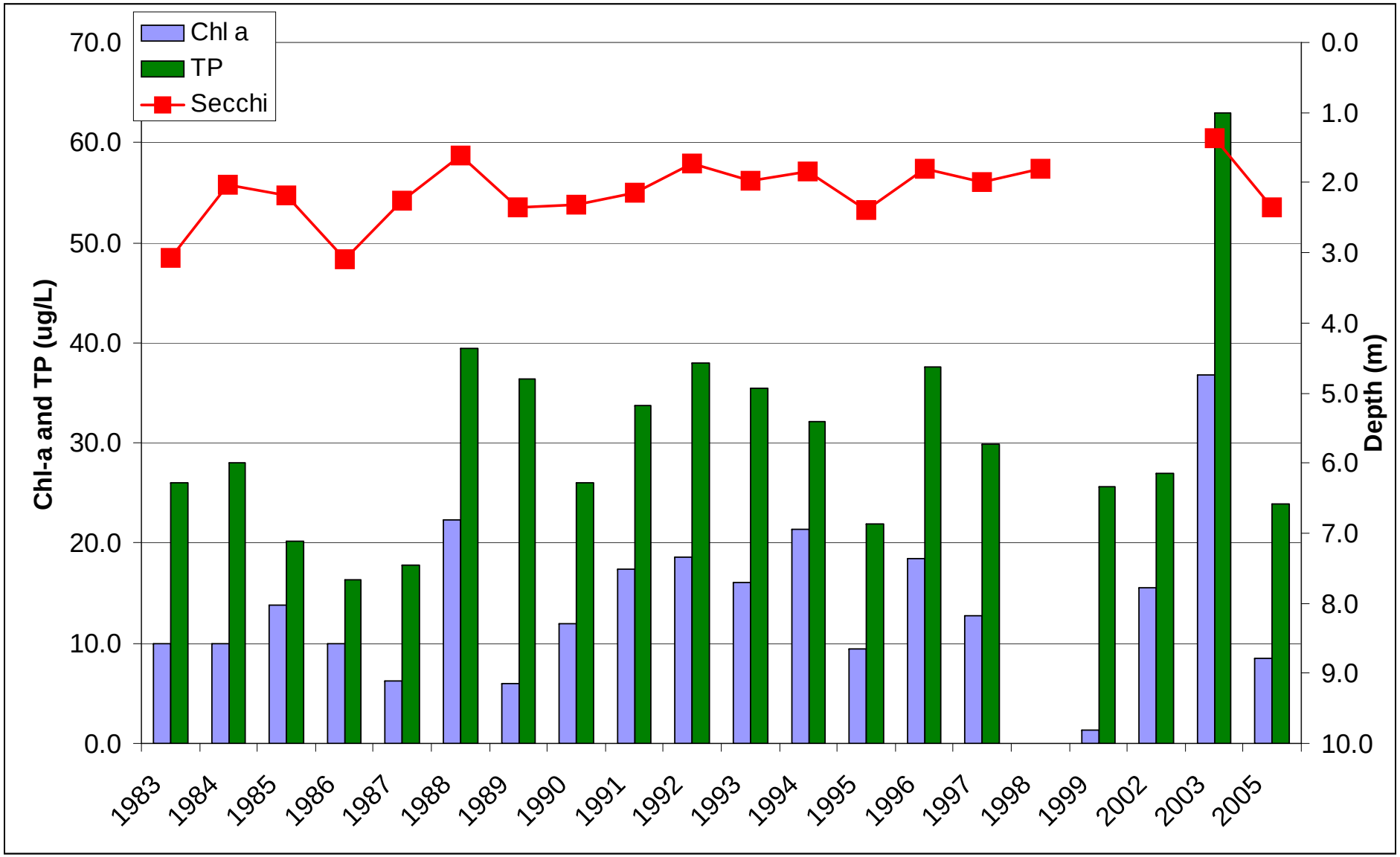
- Remaining question: are nuisance blooms and fish kills issues or indicators?
- Issue
  - If nuisance blooms and fish kills did not occur, unlikely that options to address them would be looked at
  - As blooms and dead fish affect lake values, they are an issue
- Indicator
  - Algal growth relies broadly on light, temperature and nutrient concentration so is an indicator of potential issues (e.g. excess nutrient runoff)
  - As work progresses and measures are taken to reduce severity of blooms and potentially fish kills, the presence of both will serve as an indicator
- Difference needs to be kept in mind when setting management goals for the lake

Evolution of Monitoring and Management – Past to Present

Past – Water Quality

- Prior to movement towards management of nutrients, monitoring focused on characterization of lake only

- Sampled in 1969-1975 by U of A
- Sampled in 1981, 1983-1999, 2002, 2003, 2005, 2006, 2008, 2011-2013 by ESRD
- Sampled in 2001, 2010, 2013 by ALMS
- Predominantly sampled for physical (temperature, pH, dissolved oxygen), nutrient and major ion parameters
- Very little stream monitoring prior to 2012


Chl a
TP
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70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Chl-a and TP (ug/L)
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3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Depth (m)
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1985
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1994
1995
1996
1997
1998
1999
2002
2003
2005

Past – Management

- Impacts to lake water quality primarily managed through approvals

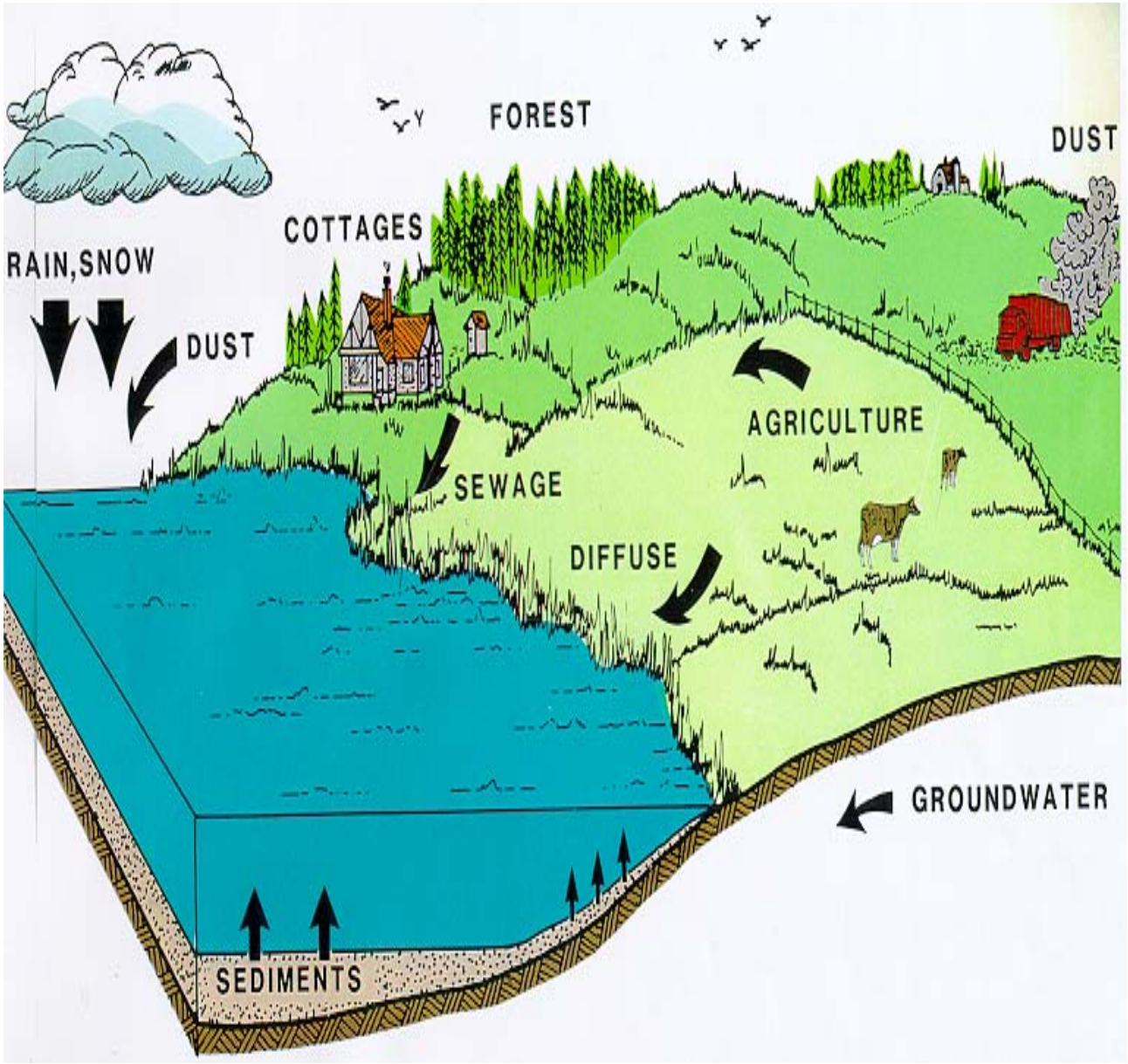
- 2006 land septage spreading discontinued in Pigeon Lake watershed
- Ongoing work to develop regional wastewater line for Pigeon Lake
- Ongoing work to ensure lakeshore developments held to higher standard for wastewater and stormwater treatment

Present – Options Report

- PLWA requested that ESRD present overview of options for control of blue-green algal blooms at Pigeon Lake
- ESRD generated report in 2012 – “Lake and Watershed Management Options for the Control of Nuisance Blue-Green Algae in Pigeon Lake, Alberta”
- Looked at watershed management and in-lake technology options and broadly classified into:
  - Applicable at Pigeon Lake
  - Not applicable at Pigeon Lake - legal or technical reasons
  - Potentially applicable but requiring more study
- PLWA exploring watershed management options and APLM exploring in-lake treatment options in more detail
- Consensus is that watershed management ***must*** happen, in-lake treatments may provide additional benefit

Present – Nutrient Budget

- Need to know where nutrients are coming from
  - Set baseline conditions for future work
  - Identify areas of concern
- 2012 began initial work for nutrient budget
- 2013 more intensive sampling for nutrient budget
- Partnered with ALMS to hire on staff in 2013 dedicated to Pigeon Lake sampling
- Began stream sampling in April, lake sampling in June
- Weekly to bi-weekly stream sampling + storm events
- Weekly sampling of lake with volunteers
- Continued until end of September (lake)/October (streams)

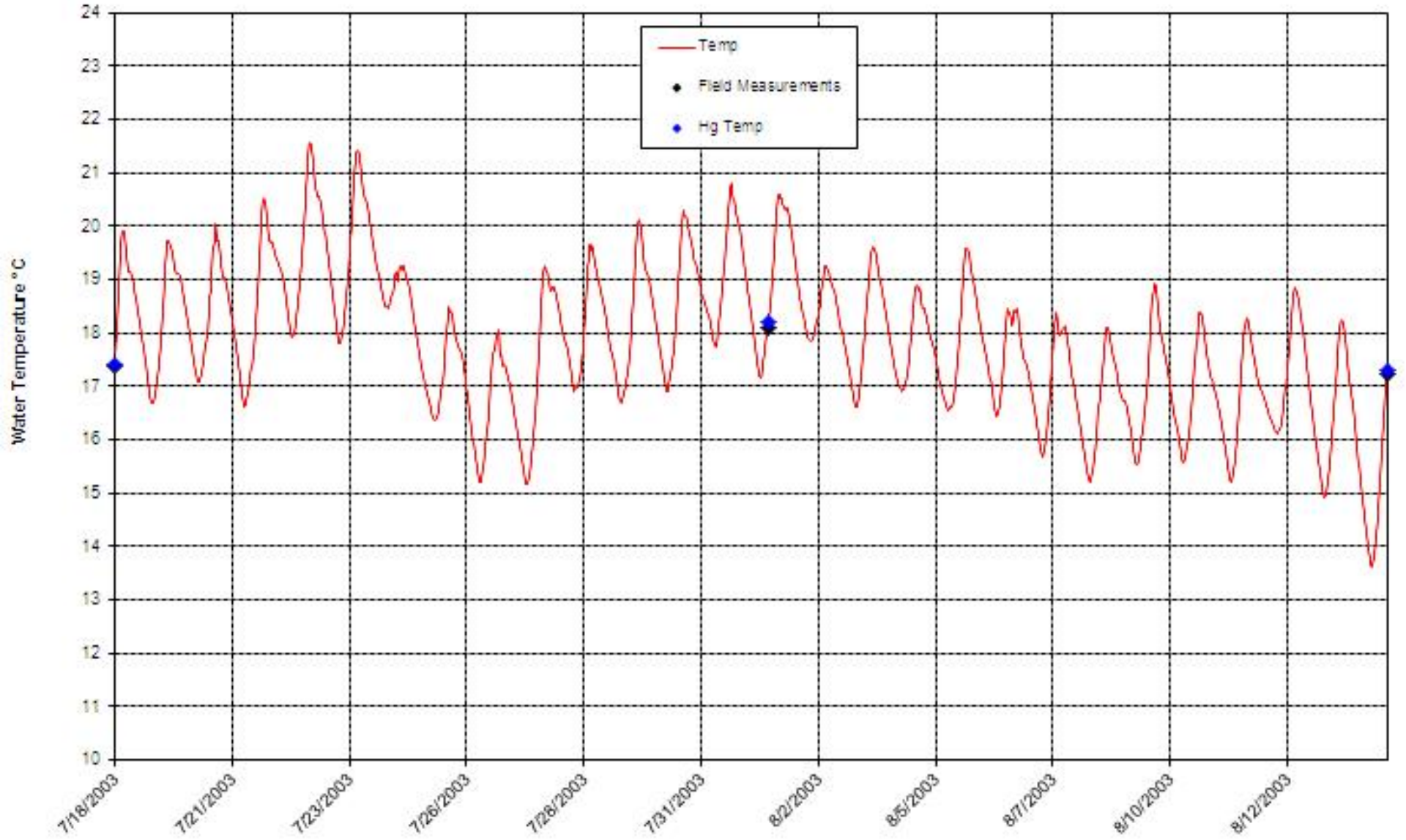

FOREST
DUST
COTTAGES
RAIN,SNOW
DUST
AGRICULTURE
SEWAGE
DIFFUSE
GROUNDWATER
SEDIMENTS

Present – Additional Analyses

- Collected sediment cores in early June for chemical analyses
  - Potential for phosphorus release/adsorption into water column/sediments
  - Providing data for exploration of dredging option
- Collected bloom samples in August for chemistry
  - Data for harvesting option
  - Better understanding of partitioning of nutrients in the water column
- Collected weekly zooplankton and phytoplankton samples for taxonomy
  - Tracking species level changes in the phytoplankton and zooplankton community in response to changing water chemistry

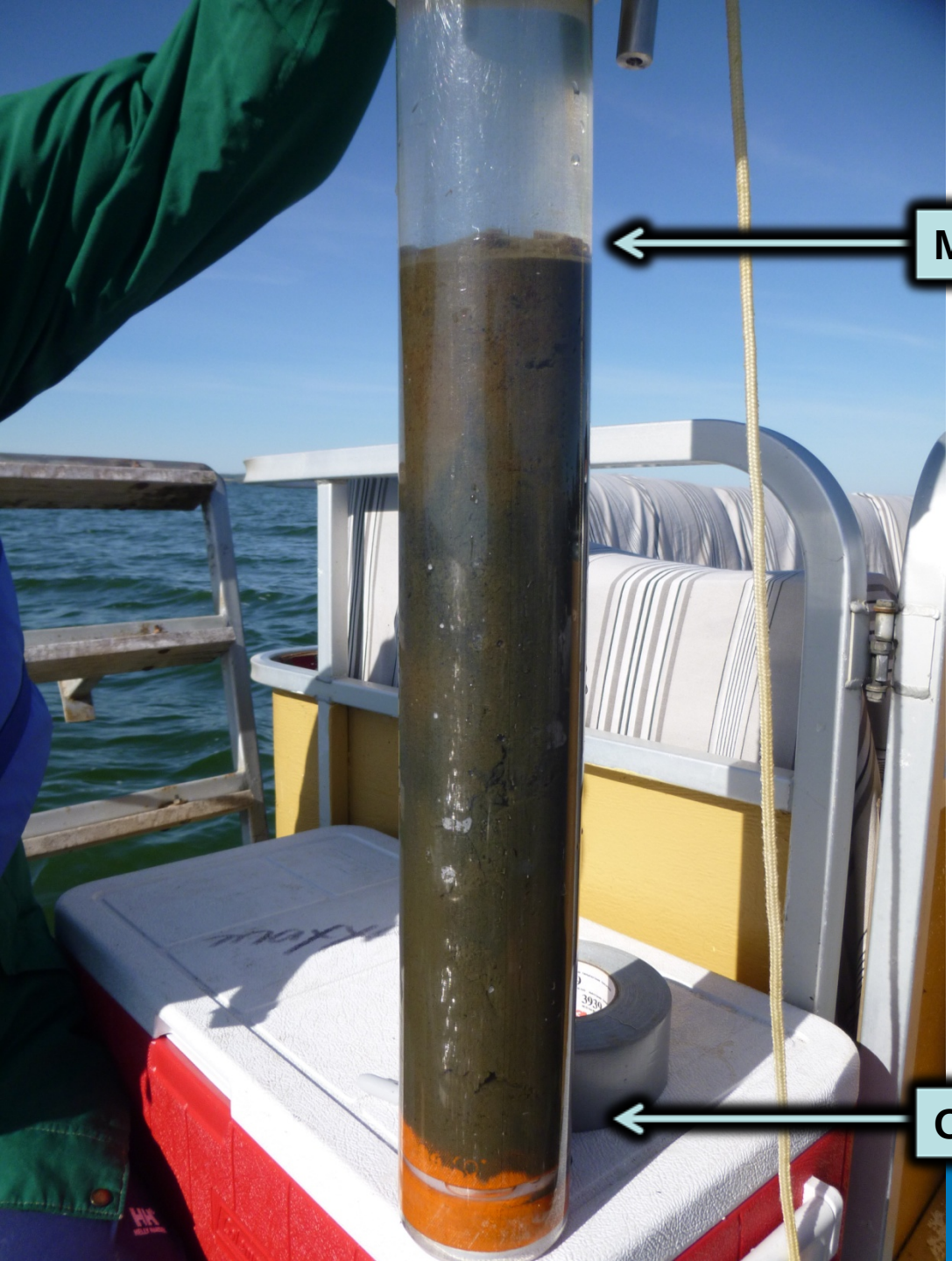
Present – Datasonde monitoring

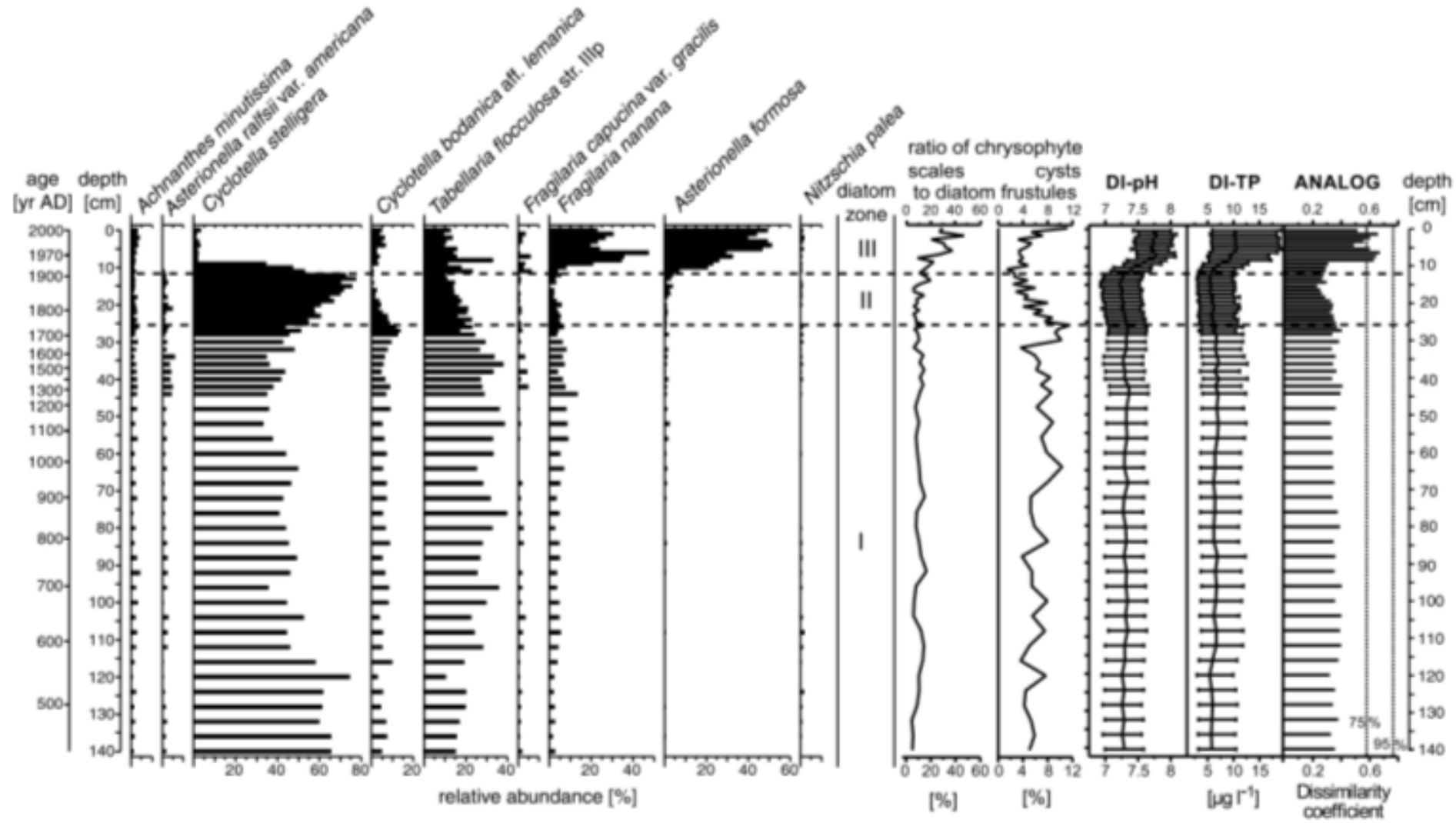
- Fisheries staff deployed two datasondes into Pigeon Lake in 2012 and 2013
- Monitoring for parameters such as temperature and dissolved oxygen on a high frequency basis
- Utilizing data for insight into fish kills


Temp
Field Measurements
Hg Temp
Water Temperature °C
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
7/18/2003
7/21/2003
7/23/2003
7/26/2003
7/28/2003
7/31/2003
8/2/2003
8/5/2003
8/7/2003
8/10/2003
8/12/2003

Present - Paleolimnology

- Paleolimnology contract to Hutchinson Environmental for assessing Wabamun and Pigeon lakes
- Reconstructing trophic status history from pre-European settlement to present
- Provides insight to what the lake looked like prior to available contemporary monitoring data, identifies major changes in trophic status, and potential causes of these changes
- Helps set reasonable management targets for Pigeon Lake


Most recently deposited (2013)
Oldest sediments (~1600)


age [yr AD]
depth [cm]
Achnanthes minutissima
Asterionella ralfsii var. americana
Cyclotella stelligera
Cyclotella bodanica aff. lemanica
Tabellaria flocculosa str. IIIp
Fragilaria capucina var. gracilis
Fragilaria nanana
Asterionella formosa
Nitzschia palea
diatom zone
III
II
I
relative abundance [%]
ratio of chrysophyte scales to diatom frustules
cysts
[%]
[%]
DI-pH
DI-TP
ANALOG
[µg l⁻¹]
75%
95%
Dissimilarity coefficient
depth [cm]

Where do we go from here?

Future

- Looking beyond the surface – groundwater and air monitoring
- Complete nutrient budget and paleolimnology work in 2014
- Complete predictive modelling work for 2014
- Complete water quality overview report for 2014
- Continue work with APLM and PLWA to examine, recommend, monitor and implement measures to maintain and improve water quality of Pigeon Lake based on sound data
  - Work with PLWA to assess watershed management options and support development and implementation of watershed management plan
  - Work with APLM to examine feasibility of in-lake options
- Work with AHS locally and provincially on beach monitoring program
- Ongoing work with other agencies, government branches, and local interest groups

Summary

- Pigeon Lake is a very large lake – presents challenges
- More frequent, intense blooms have lead to evolution of response and management
  - Focus is on reduction of nutrients – watershed management must be done, enhanced by in-lake treatment if feasible
  - Moving from monitoring for characterization to monitoring to support exploration of management options
- Numerous focused studies undertaken to provide answers to management questions
  - Where are the nutrients coming from? How long until a change is expected? What caused the changes observed?
- Next step is to begin implementing management measures and move to monitoring response of lake
  - Patience, patience, patience – management measures will result in small changes and take many years to see change in lake
  - Keep in mind that it has taken many years to arrive at this point

Acknowledgements

- ESRD staff – limnologists, fisheries biologists, field staff, data management, planners, managers and executive
- ALMS staff and volunteers – Arin, Bradley, Elynne and all the Lakewatch volunteers
- PLWA and APLM – countless volunteer hours dedicated to Pigeon Lake

Thanks!