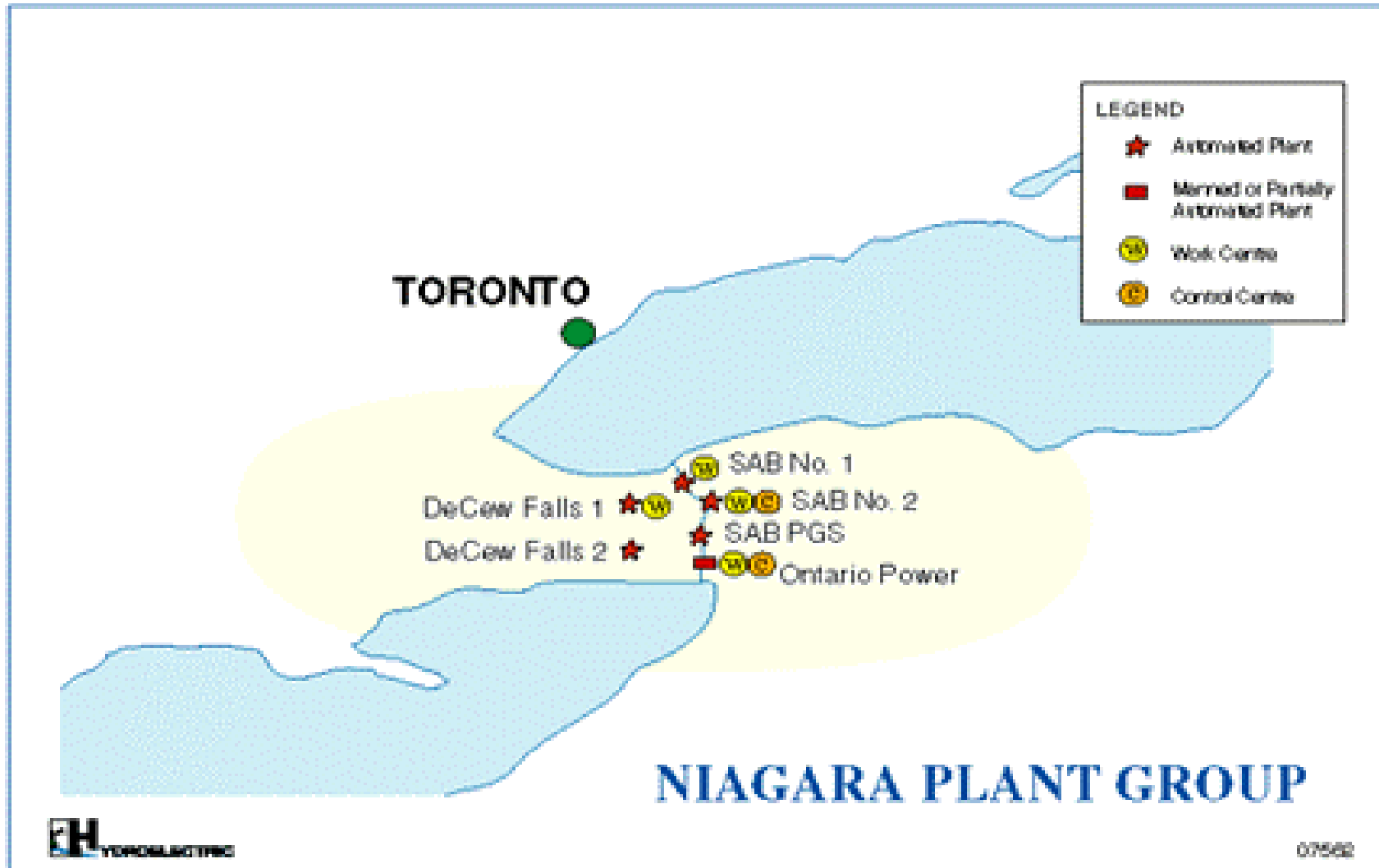




Re-design of the Sodium Hypochlorite Treatment Approach for Zebra Mussels at Niagara Plant Group Generating Stations

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1.0 Niagara Plant Group Location and Facilities



1.0 Niagara Plant Group Location and Facilities



Sir Adam Beck #2



Sir Adam Beck #1



DeCew #2



Pump Generating Station

2.0 Original Treatment Approach 1992-2002

- Chlorination systems were first installed in the early 90's to mitigate the quickly spreading threat from zebra mussels.
- OPG had no previous experience with this type of equipment/operation – A generic system design was employed and rolled out to “at risk” plants
- The typical treatment period was 180 days (June to November) each year
- Various treatment approaches were used, continuous shock at start and end of the year and daily periodic treatment through the remainder of the year in the 2 to 5 ppm concentration range
- There was no system in place to check on effectiveness of treatment other than monitoring chlorine concentration levels

2.0 Original Treatment Approach 1992-2002

Over time, common problems emerged.....

- Leaking PVC piping, piping breakages, pump break downs, dysfunctional automatic operation
- Over time health and safety problems emerged, labour intensive operations (\$\$)
- Fluctuating concentrations and breakdowns resulted in effective treatment
-



Water Cooled Transformer Piping at DeCew in 1999

3.0 Improved Zebra Mussel Management

2001- 2002 A new approach.....

•“Prototype” new system at Decew #2 Plant

•Prototype Philosophy:

- **Redesign from ground up**
- **Get it right on our smallest system-then carry experience to large plants**
- **Satisfy safety, environmental, operational and cost concerns**
- **Clarify accountability for operation and maintenance**
- **Adhere to KISS (NB)**

•Develop “best practices” chlorination strategy and revise permits accordingly to allow for a flexible approach



3.0 Improved Zebra Mussel Management

2003 Moving Forward...

Treatment Strategy

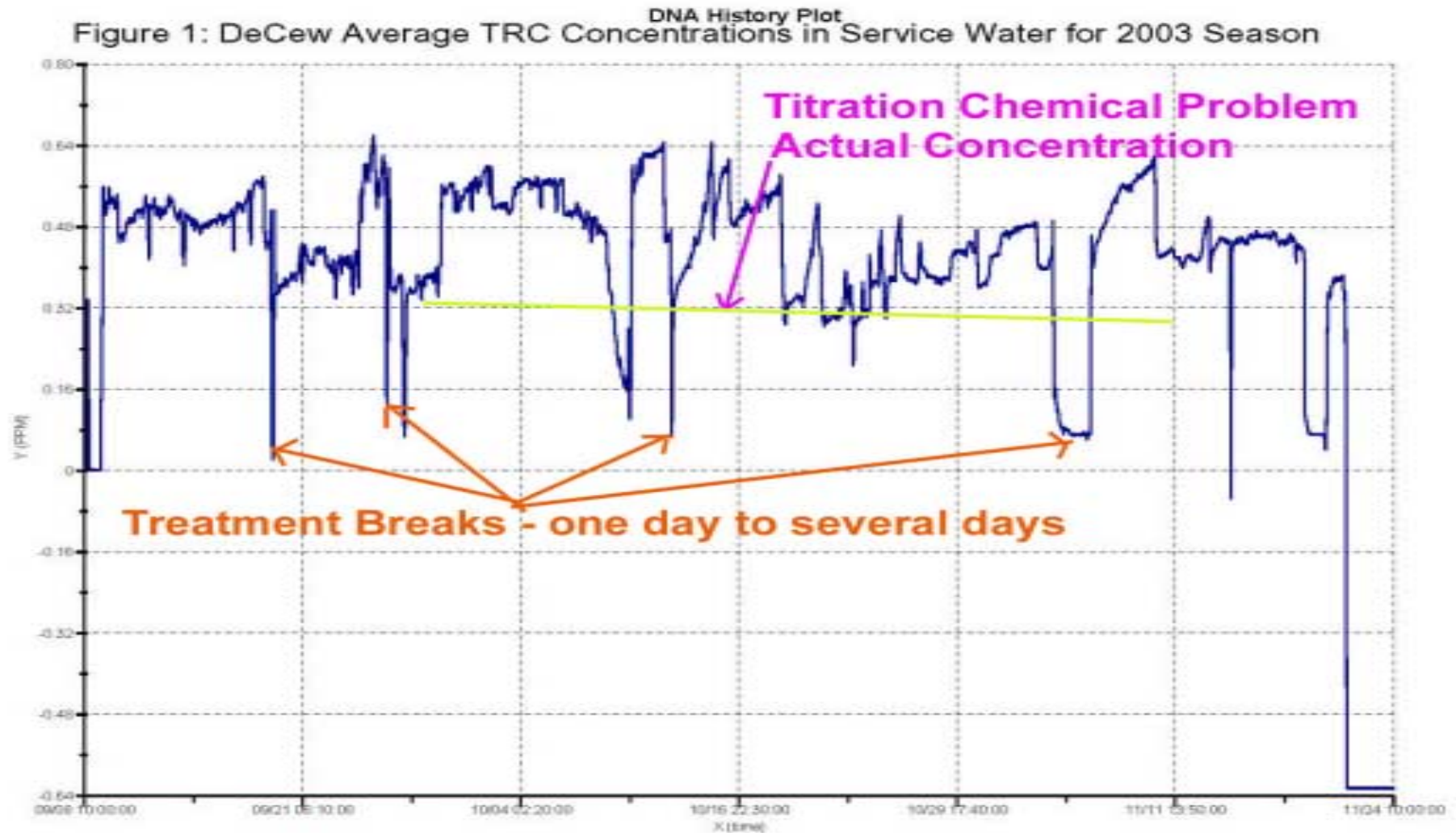


- NPG started to work with ASI Group Ltd. (ASI), a full service engineering and environmental technology company that is recognized as an international industry leader in the research and design of programs for zebra mussel control
- ASI's treatment effectiveness monitoring program showed that the existing treatment equipment and strategy was ineffective (0% mortality of adult mussels in the bioassay @PGS after 59 days of operation)

Chlorination Systems

- Decew prototype operated reliably – system operated for 74 days for from September 9th to November 21st, 2003, however, only 65% mortality of the adult mussels in the bioassay was observed after 74 days of treatment indicating only partial control of infestation was obtained.
- Replacement projects initiated at SAB#1, SAB#2 and Pump GS patterned on the DeCew prototype

3.0 Improved Zebra Mussel Management



3.0 Improved Zebra Mussel Management

New Chlorination Systems-Status

- In 2002 a new treatment system was installed at Decew #2. It operated for the first time in 2003.
- In 2003 a new treatment system was installed at our Sir Adam Beck 1 and Sir Adam Beck 2 plants
- In 2004 a new treatment system was installed at Pump GS
- Extensive negotiations were required with our Ministry of Environment to achieve a flexible, consistent and practical Certificate of Approval that fit planned treatment strategies and equipment and that also met the regulators requirements



3.0 Improved Zebra Mussel Management

2004

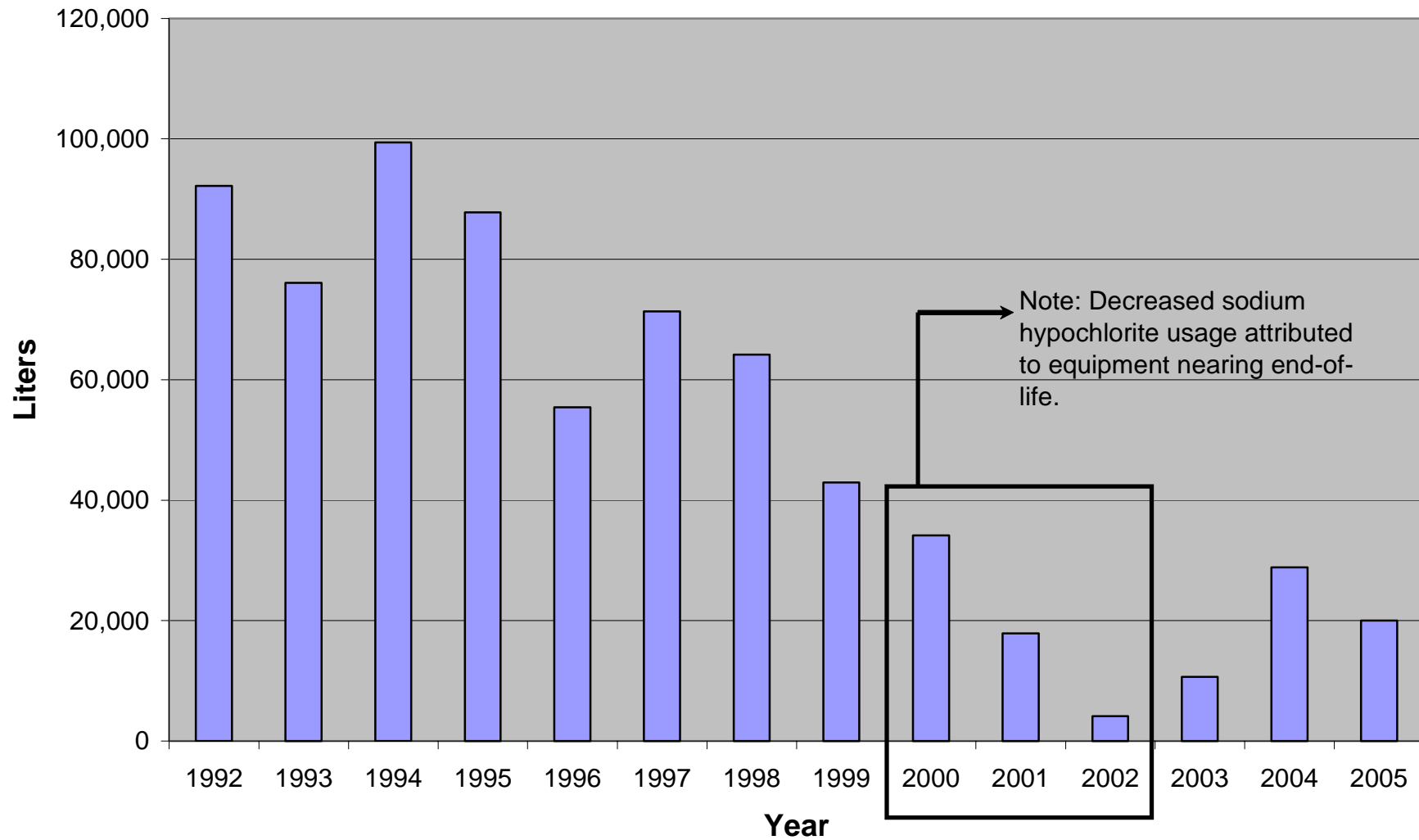
Treatment Strategy– ASI Recommends a New Approach



- 24 hour a day treatment at low concentration (0.4-0.8 ppm) for a short period (10-21 days) with a target concentration average of 0.65 ppm within the system
- chlorine levels must not fall out of this range over the treatment period for more than a few hours
- focussing treatment during warm (>20 C) water temperatures
- targeting August/September so that mussels can not re-establish before winter, and those that do will grow slowly over the winter while water is cold so as to pose minimal risk till next season's treatment
- application of this approach be consistently used at all our plants
- seeding live adult mussels in a container in a biobox to monitor treatment effectiveness in the form of a bioassay with treatment continuing until 100% mortality of the adult mussels in the bioassay is achieved
- Minimum treatment of 10 days to insure complete kill

4.0 Treatment Performance 2004, 2005

Sodium Hypochlorite Usage NPG 1992-2005



4.0 Treatment Performance 2004, 2005

ASI's Mussel Monitoring Program Objectives:

1. Track and determine the seasonal peaks of free-floating larvae (veligers and post veligers) and the infestation rates of settlement stage larvae at the in-plant biobox locations at each facility to help optimize the timing of the treatment program.
2. Evaluate the effectiveness of the treatment programs during each facility treatment by monitoring adult mussel bioassays daily.
3. Monitor chlorine levels at biobox locations daily during the treatments and compare the results to in-line chlorine monitoring system measurements and the performance of portable TRC test equipment to ensure adequate concentrations are maintained within the system.

4.0 Treatment Performance 2004, 2005

2004

Bioassay Results

- DeCew NF23 treatment **12 days** and **100 % mortality** in 8 days
- Pump GS treatment **21 days** and **98 % mortality**
- SAB 1 treatment **22 days** and **98 % mortality**
- SAB 2 treatment **24 days** and **98-100 % mortality**

2005

Bioassay Results

- DeCew NF23 treatment **10 days** and **100% mortality** in 6 days
- Pump GS treatment **7 days** and **100% mortality** in 7 days
- SAB 1 treatment **9 days** and **100% mortality** in 9 days
- SAB 2 treatment **13 days** and **100% mortality** in 11 days



4.0 Treatment Performance 2004, 2005



Dead Zebra Mussels Found in Unit Coolers after 2004 treatment at our Pump GS



4.0 Treatment Performance 2004, 2005

2004 Treatment Results Pump GS Piping

Before



After



4.0 Treatment Performance 2004, 2005

TRC Quality Results 2004 & 2005

•Results revealed that greater control of TRC residuals were obtained within the service water system from 2004 to 2005 with significantly fewer discrepancies between the in-line analyzer and titrator results



Location	2004 # of Analyzer Readings with >5% Discrepancy with Titrator Results	2005 # of Analyzer Readings with >5% Discrepancy with Titrator Results
DeCew NF23	0	0
SAB 1	7	1
SAB 2	27	15
PGS	10	5

4.0 Treatment Performance 2004, 2005

ASI Recommends the following for continued success:

1. Continued monitoring of intake densities of free-floating larvae and in-plant densities of settlement stage larvae.
2. In-plant bioboxes should remain operational throughout the entire year.
3. Continued implementation of treatment programs when water temperatures are above and are expected to remain above 15°C.
4. Treatment duration should occur for a minimum of 10 days.
5. Continue to refine the current procedures for handling, storage and use of titrator chemicals to ensure analyzers are calibrated to true TRC readings



4.0 Treatment Performance 2004, 2005

Summary

1. The integrated approach to controlling mussel infestation the OPG NPG adapted beginning in 2003 has been extremely successful in assisting with the optimization, evaluation and timing of treatment strategies.
2. Adult mussel bioassays used to evaluate the success of the treatments has proved critical in determining the endpoint of each treatment.
3. TRC analysis by ASI as an independent quality check of the functioning of OPG's portable test equipment and in-line monitoring equipment has proven efficient in optimizing residual chlorine levels within the system.



5.0 Problem Encountered and Resolution

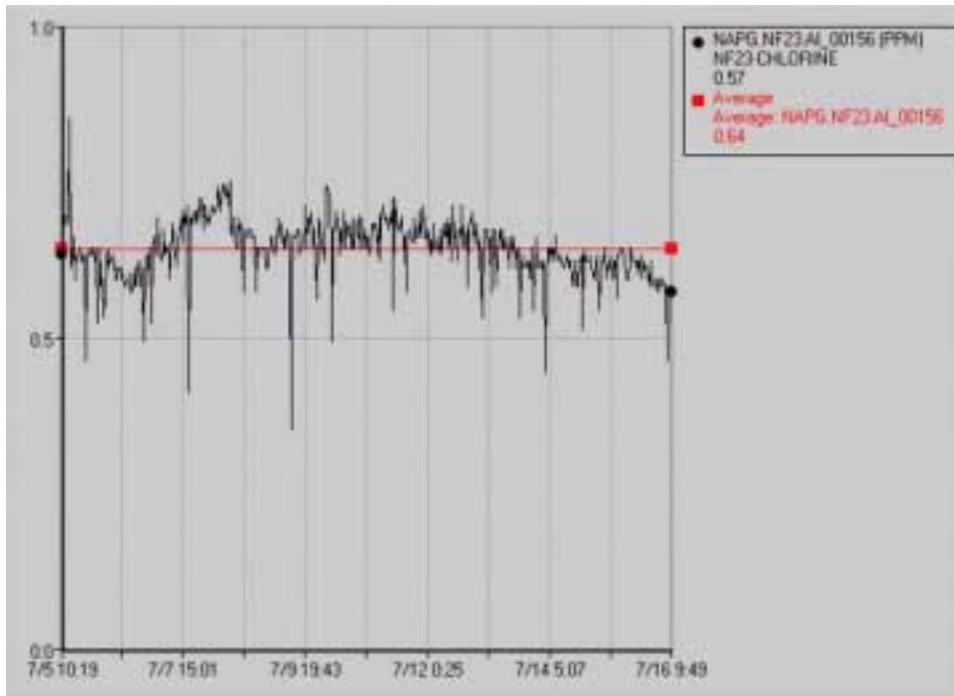
Bad Chemicals Used with Titrations for Calibration

- OPG uses Wallace and Tiernan Titrators to check calibrations of our analyzers
- As part of the titration, phenylarsenoxide (PAO), PH4 buffer and potassium Iodide solutions are used
- Each year over the past 3 years we have discovered through independent quality checks by ASI that one or more of the titration chemicals was suspect resulting in erroneous calibrations and treatment at lower concentrations than was expected
- **Considerations:**
 - Minimize cross contamination of chemicals
 - Store chemicals in amber bottles
 - Keep the chemicals cool, or replace frequently when in use even if well before the expiry date

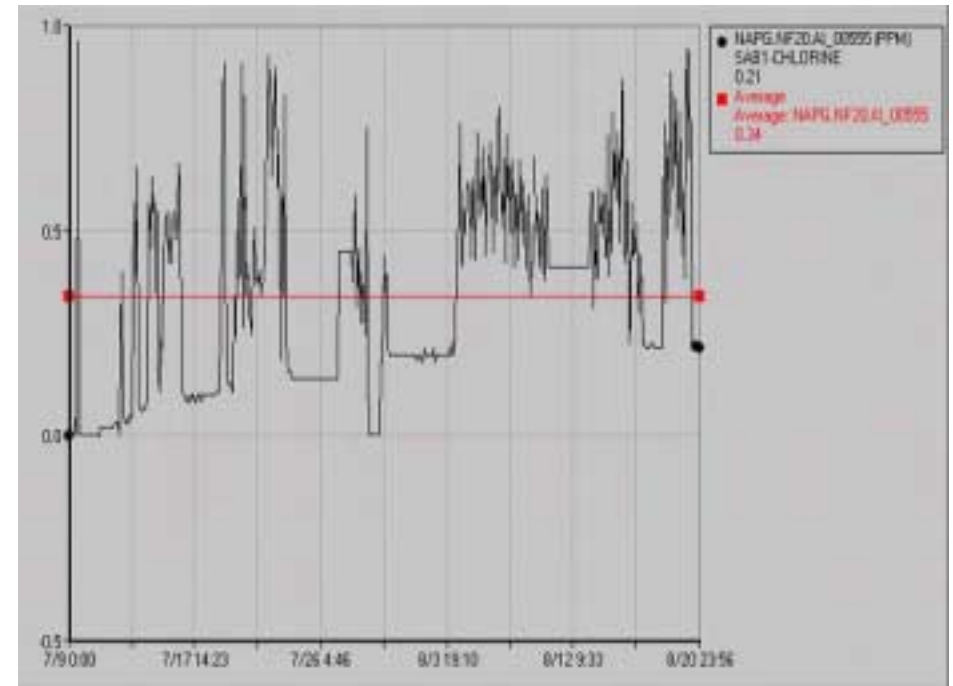


5.0 Problem Encountered and Resolution

Steady vs. Fluctuating Concentrations



DeCew July 2004: 12 Days 100% mortality



SAB 1 July/Aug 2004: 22 days, 98 % Mortality

- Fluctuating concentrations, what ever the cause, can extend the treatment period dramatically

5.0 Problems Encountered and Resolution

Off gassing of Sodium hypochlorite

- At both our SAB 2 and SAB 1 plant, vent lines were incorporated into the design for the sodium hypochlorite tank as well as locations along the length of the sodium hypochlorite supply lines
- In both cases, we experienced some small spills/leaks as a result of gas accumulating in the vent tube and actually pushing the sodium hypochlorite out of the vent. This occurred even though the top of the vent pipe was at least 3 ft above the top elevation of the supply tank and line
- The fix in both cases was to extend the vent piping further and to also expand the diameter of the tubing near the top to break any “bubbles” of chlorine gas that may accumulate



5.0 Problems Encountered and Resolution

Variable concentrations of sodium hypochlorite in treated water

- One of the sources contributing to variation in sodium hypochlorite in service water were our automatic coolers that were using the service water to cool generator units during the summer months
- These units are automated, and came on and off on a frequent basis making it difficult to get a “stable concentrations”

Consideration:

- We opted to remove the automatic setting for our coolers and set them to “full” to eliminate this variable



5.0 Problems Encountered and Resolution

Water Temperature:

- Treatments carried out late in the season, October and November took much longer to achieve a 100 % kill, and often did not achieve a complete kill.

Consideration:

- Carry out treatments in August and early September when water temperatures are high (over 20°C) and metabolic rates of Zebra Mussels are also high
- Treatments in 2005 were almost all completed before or in 10 days and all achieved a 100 % mortality.

5.0 Problems Encountered and Resolution

Sediment and Debris Clogging Analyzer:

- Summer thunderstorms, often bring heavier sediment loads which can foul up analyzer sensors

Consideration:

- During treatment, daily checks of the analyzer including cleaning if required are necessary to insure continued operation without breaks.

6.0 Summary of Results and Conclusions

- **Treatment has been reduced to less than 2 weeks a year from 10 to 25 weeks resulting in:**
 - A huge savings on labour costs (\$200 - \$400 K/yr)
 - A substantial reduction on amount of chlorine released to the environment (20 KI vs. 85 KI)
 - A reduction on chlorine purchase costs (\$ 15 K /yr)
 - A reduced risk of non compliance with the Permits due to reduced treatment time
 - Reduced time of exposure to chlorine hazard by employees by reducing the treatment time and using superior materials that are much more resistant to corrosion
- **Effectiveness of treatment is confirmed through live zebra mussel bioassays which dictate when treatment can be shut down**