# Study of pH Adjustment Systems in Newfoundland & Labrador

Kasia Piskorz, XCG Consultants Ltd.
Lori Wiseman, AMEC Earth & Environmental

XCG
Environmental Engineers & Scientists

amec

# Introduction

- AMEC Earth & Environmental in association with XCG Consultants Ltd., was retained by the Department of Environment and Conservation to conduct a study on pH adjustment systems in drinking water systems in Newfoundland and Labrador.

amec

XCG
Environmental Engineers & Scientists

# Objectives

- Collection of design information and background data for 45 communities in Labrador and Newfoundland
- Assessment of effectiveness of pH adjustment systems
- Identification of problems and issues with ineffective pH adjustment systems
- Evaluation of common corrosion indices
- Recommendations for Design Guidelines

# Background

- Newfoundland and Labrador surface waters naturally have low pH and alkalinity
- Several communities have installed pH adjustment systems, to raise the pH in the treated water and distribution system
- pH is an important factor in treatment processes such as coagulation, disinfection and corrosion control
- Guidelines for Canadian Drinking Water Quality (GCDWQ) established an operational guideline (OG) range for pH of 6.5 to 8.5

# Background

- Internal corrosion control in drinking water systems changes the water chemistry to make it less corrosive
- Chemicals commonly used for pH and/or alkalinity adjustment
  - Sodium hydroxide, NaOH (caustic soda);
  - Potassium hydroxide, KOH (caustic potash);
  - Calcium hydroxide, $Ca(OH)_2$ (lime);
  - Sodium carbonate, $Na2CO_3$ (soda ash);
  - Potassium carbonate, $K2CO_3$ (potash); or
  - Sodium bicarbonate, $NaHCO_3$.

- Non-chemical addition methods
  - Limestone contactors
  - Aeration

# Collection of Design Information


XCG
Environmental Engineers & Scientists

amec

# Collection of Design Information

- Site visits to collect the following information
  - Point of application of pH adjustment chemicals
  - Point of application of disinfectant chemicals
  - Type of pH adjustment system used
  - Chemical or filter media used
  - Solution tank volume or filter capacity
  - Feed pump capacity
  - On-line pH monitor and location

# Collection of Design Information

- 38 operational pH adjustment systems
  - 28 systems use sodium carbonate (soda ash)
  - 2 systems use sodium hydroxide (caustic soda)
  - 7 systems use calcium hydroxide (lime)
  - 1 systems use calcium hydroxide (lime) and carbon dioxide ($CO_2$)

# Collection of Design Information

- Monitoring of pH using a handheld meter was performed at each site at the following locations
  - Raw water (intake before any treatment)
  - Before and after pH adjustment
  - Before and after disinfection


- Raw water pH ranged from 4.4 - 7.3
- Treated water pH ranged from 4.2 – 10.4


# Assessment of Effectiveness

XCG Environmental Engineers & Scientists

amec

# Assessment of Effectiveness

- Water Quality Review
  - Evaluated the effects of pH adjustment on
    - Disinfection by-products – trihalomethanes (THMs) and haloacetic acids (HAAs)
    - Dissolved organic carbon (DOC)
    - Metals - aluminum, copper, iron, lead and zinc

# Assessment of Effectiveness

- Water Quality Review Results
  - pH adjustment systems have no impact on DBP formation
    - Elevated levels of natural organic matter (NOM) in the water at the point of disinfectant application appears to be the main factor contributing to THM and HAA formation
  - pH adjustment no effect on DOC concentrations
    - Most municipalities have small treatment facilities with no capacity for DOC removal
  - Concentrations of aluminum, copper, iron, lead and zinc were generally found to be within acceptable levels in treated water and in the distribution system

# Assessment of Effectiveness

- The effectiveness of the system was assessed on the basis of:
  - Ability to maintain a treated water pH in the OG range of 6.5 to 8.5 established in the GCDWQ
  - Ability to provide a treated water with a pH that is consistently greater than the raw water pH
  - Effect on distribution system metals concentrations (iron, copper, lead and zinc)
  - Occurrence of watermain and/or service leaks, discoloured water complaints, or other indicators of system corrosion

# Assessment of Effectiveness

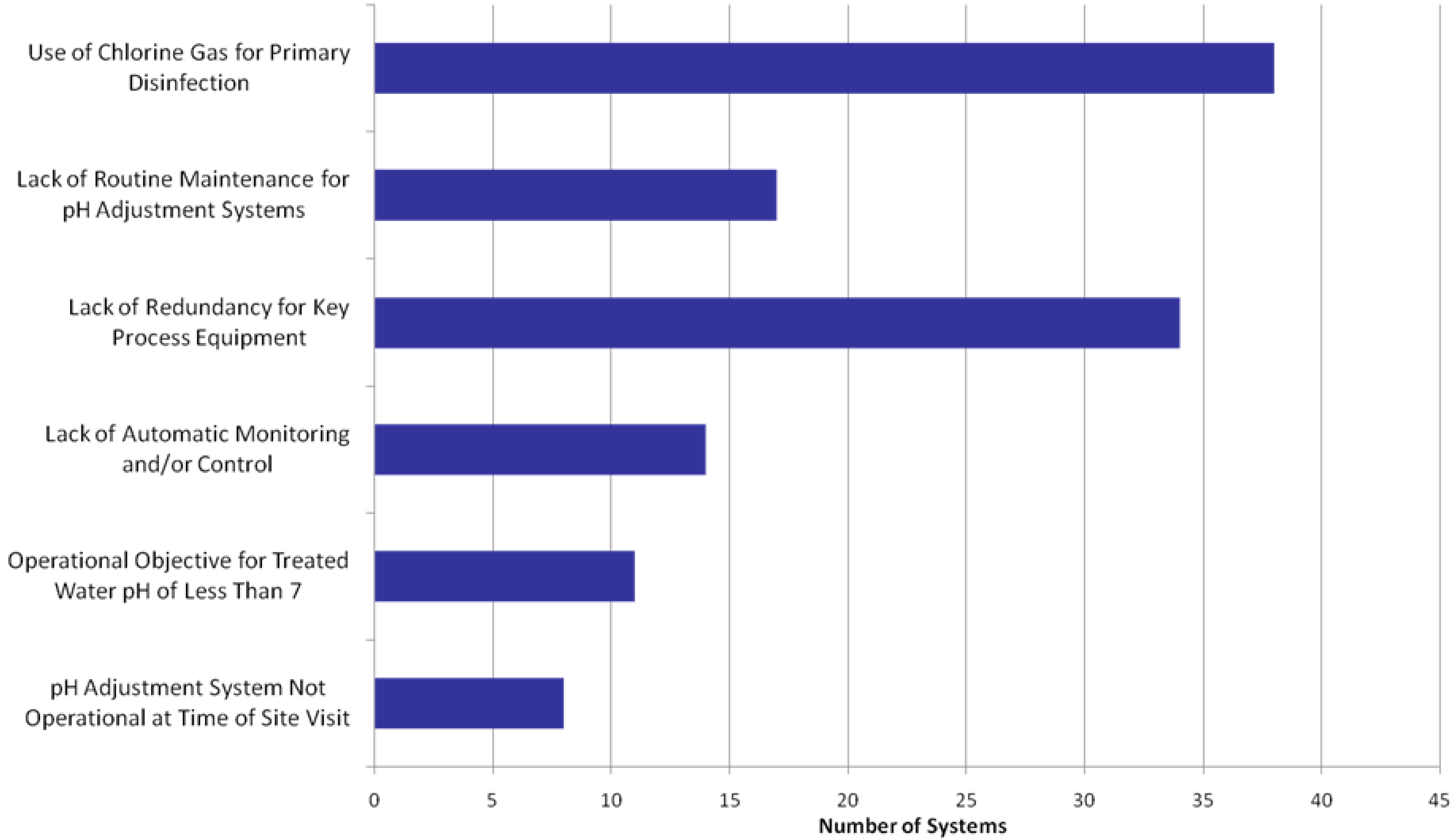
- Evaluation results showed that:
  - 9 systems are performing effectively (20 percent)
    - 5 systems use soda ash
    - 3 systems use lime
    - 1 systems use caustic soda
  - 8 systems are currently not operational (18 percent)
  - 28 systems are not operating effectively (62 percent)

# Identification of Problems and Issues with Ineffective Systems


XCG Environmental Engineers & Scientists

amec

# Identification of Problems and Issues with Ineffective Systems



# Identification of Problems and Issues with Ineffective Systems

- The use of chlorine gas for primary disinfection
  - 38 of the 45 systems use chlorine gas for primary disinfection
  - Chlorine gas decreases alkalinity, which results in a decrease in pH
  - Naturally low levels of alkalinity present in raw waters already
  - A change from chlorine gas to sodium hypochlorite would provide a positive change in alkalinity and pH during disinfection

# Identification of Problems and Issues with Ineffective Systems

- The lack of routine maintenance
  - 17 of the 45 systems had no preventative maintenance program for pH adjustment systems
  - 8 systems were not operational (mainly due to problems with process equipment e.g. process shutdown due to pump failure)
  - Many factors may be contributing to lack of routine or preventative maintenance
    - Lack of spare parts or equipment
    - Chemical feed equipment installed in a location that is difficult to access
    - Lack of operator awareness regarding the importance of maintenance or lack of required skills/training
    - Lack of available resources to implement a preventative maintenance program

# Identification of Problems and Issues with Ineffective Systems

- A lack of redundancy for key process equipment
  - Very few systems have spare pumps and/or parts for chemical addition systems

# Identification of Problems and Issues with Ineffective Systems

- Lack of automatic monitoring or control
  - 14 systems did not have any on-line pH monitoring
  - Smaller systems are unattended facilities (i.e. operators may only visit the site daily or weekly)
  - Changes in flow or raw water quality are often unnoticed
  - Changes in pH adjustment chemical dosage are not made in timely fashion

# Identification of Problems and Issues with Ineffective Systems

- Operating objectives for treated water pH of less than 7.0
  - GCDWQ operating range of 6.5 to 8.5
  - 11 of the systems had a target pH of less than 7.0
    - Too low for effective corrosion control given the low alkalinity of raw water sources
  - Effective systems have treated water pH objective range of 7.0 to 7.8

# Design Issues

- Design/capacity of existing pH adjustment systems not the main performance limiting factor
- Poor performance of pH adjustment system attributed to insufficient dosage of pH adjustment chemicals
- Several systems pH adjustment equipment is not easily accessible

# Review of Existing Design Guidelines


XCG Environmental Engineers & Scientists

amec

# Review of Design Guidance

- Guidelines for Canadian Drinking Water Quality Summary Table and Technical Documents (Health Canada, 2008)
- Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (Ontario Ministry of the Environment, 2006)
- Regulation Respecting the Quality of Drinking Water (Développement Durable, Environnement et Parcs, Québec, 2005)
- Manitoba Drinking Water Quality Standards Regulation (Manitoba Water Stewardship, 2007)
- Alberta Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems
- Saskatchewan Drinking Water Quality Standards and Objectives (Saskatchewan Environment, 2006)

# Review of Design Guidance

- British Columbia Drinking Water Quality Guidelines (BC Ministry of the Environment, 1998)
- World Health Organization Guidelines for Drinking Water Quality (WHO, 2008)
- USEPA List of Drinking Water Contaminants (USEPA, 2009)
- Atlantic Canada Guidelines for the Supply, Treatment, Storage, Distribution and Operation of Drinking Water Supply Systems (ACCWA, 2004)
- Ontario Design Guidelines for Drinking Water Systems (Ontario MOE, 2008)
- Alberta Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems
- Recommended Standards for Water Works (Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2007)
- Newfoundland and Labrador Guidelines for the Design, Construction, and Operation of Water and Sewage Systems (DOEC, 2005)

# Evaluation of Langelier & Ryznar Indices


XCG Environmental Engineers & Scientists

amec

# Evaluation of Corrosion Indices

- Natural scales form on the surface of all metals used for water conduits
- Water treatment processes are used to manage the development of other scales, particularly calcium carbonate ($CaCO_3$)
- Water supersaturated with $CaCO_3$ would develop a protective $CaCO_3$ layer on the inside of the pipe

# Evaluation of Corrosion Indices

- Langelier Saturation Index
  - Most common of the $CaCO_3$ saturation indices used to predict corrosion
  - Evaluates the stability of water to control corrosion and deposition of scales
  - Measure of a water’s pH relative to its pH saturation with $CaCO_3$
- Ryznar Saturation Index
  - Based on the Langelier index
  - Incorporates a correlation between $CaCO_3$ build up and water chemistry observed in municipal water systems

# Study Findings

# Summary of Findings

- Water Quality Review
  - pH adjustment no impact on DBP formation
    - 32 systems exceed GCDWQ maximum acceptable concentration (MAC) of 100 µg/L for THMs
    - 35 systems exceed the GCDWQ MAC of 80 µg/L for HAAs
  - DOC concentration in the raw and treated water are generally the same
  - Concentrations of lead, copper, zinc, aluminum in distribution system are generally within GCDWQ
  - 17 systems have iron concentrations above the aesthetic (AO) of 0.3 mg/L

# Summary of Findings

- Assessment of Effectiveness of pH Adjustment Systems
  - Approximately 9 systems are performing effectively (20 percent)
  - Approximately 8 systems are currently not operational (18 percent)
  - The remaining 28 systems are not operating effectively (62 percent)

# Summary of Findings

- The most common performance limiting factors
  - The use of chlorine gas for primary disinfection
  - The lack of routine maintenance
  - A lack of redundancy for key process equipment
  - A lack of automatic monitoring and/or control of pH adjustment systems
  - Operating objectives for treated water pH of less than 7.0

# Summary of Findings

- Corrosion Indices
  - Not recommended as the primary method for determining the corrosivity of water.
  - Langelier and Ryznar corrosion indices are based on assumption that water will be less corrosive if it has a tendency to deposit a $CaCO_3$ scale on metal surfaces.
  - May not accurately predict whether $CaCO_3$ deposit will form a protective film, how much will form, or how protective the deposit may be.
  - The precipitation of $CaCO_3$ is affected by pH, alkalinity, calcium and carbonate concentrations and many other water quality parameters.

# Study Recommendation


XCG Environmental Engineers & Scientists

amec

# Recommendations

- Operation and Maintenance of pH Adjustment Systems
  - Preventive maintenance programs should be developed for existing pH adjustment systems.
  - Spare parts for key components of the pH adjustment system should be maintained on site.
  - In some cases a servicing agreement with the equipment supplier or an outside contractor for routine maintenance may be a cost effective procedure for maintaining the pH system.
  - Municipalities and water treatment operations personnel are encouraged to establish treated water pH targets that are equal to or greater than 7.2.

# Recommendations

- Operation and Maintenance of pH Adjustment Systems
  - The optimum treated water pH objective should be determined on a site specific basis.
  - The Province should adopt an approach similar to that used by Ontario, Health Canada and the United States Environmental Protection Agency (USEPA) which recommends the development of site specific corrosion control plans.
  - The Province should move away from the use of corrosion indicators, such as the Langelier and Ryznar Indices.

# Recommendations

- Future upgrades or expansions to existing systems
  - Provision of stand-by or spare chemical feed equipment.
  - A change from chlorine gas to sodium hypochlorite, where feasible and appropriate.
  - Installation of raw and treated water on-line pH analyzers, with low and high level alarms for treated water pH.

# Recommendations

- Future upgrades or expansions to existing systems
  - Provision of some degree of automated control (i.e. flow-paced chemical addition) where adequate instrumentation is already in place (i.e. flow and pH meters)
  - Allow for easy access to chemical feed equipment. Where chemical feed pumps are located below grade, stairways should be provided rather than ladders to facilitate safe carrying of parts, tools, etc.

# Recommendations

- Updates or modification to existing *Newfoundland and Labrador Guidelines for the Design, Construction, and Operation of Water and Sewage Systems (DOEC, 2005)* were recommended for sections addressing:
  - Corrosion Control
  - Langelier Index
  - pH Adjustment
  - Automated/ Unattended Operation of Surface Water Treatment Plants
  - Measurement List

# Questions

XCG
Environmental Engineers & Scientists

amec