Impacts of Winter Road Salting on Municipal Groundwater Supplies – Evaluation Tools for Source Water Protection

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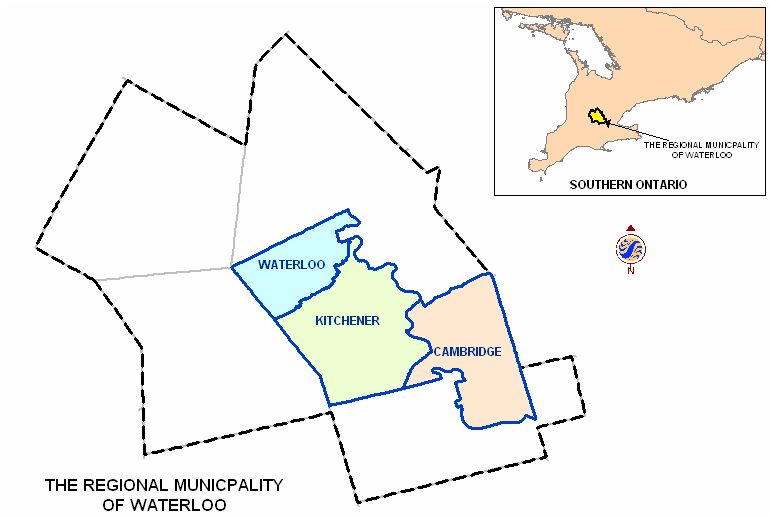
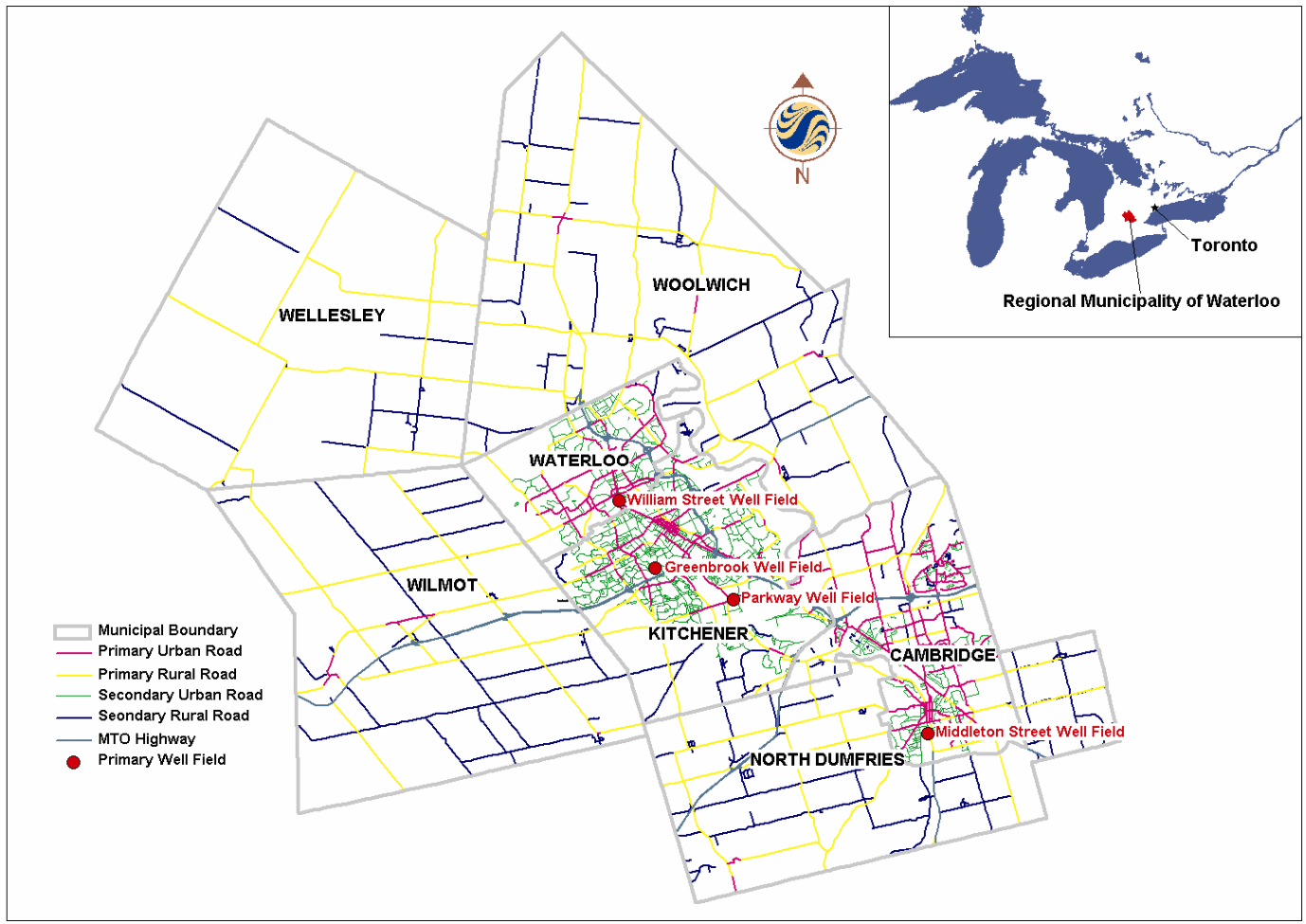
Introduction / Background

- Chloride concentrations have been steadily increasing since the mid-1960s at a number of key urban well fields.
- 5% of the urban supply (6 wells) were above the Ontario Drinking Water Standard (ODWS) for chloride.
- Need to understand if, and when, concentrations would exceed the ODWS.
- To develop long term management options, a technically defensible and cost effective methodology needed to be developed.



Study Area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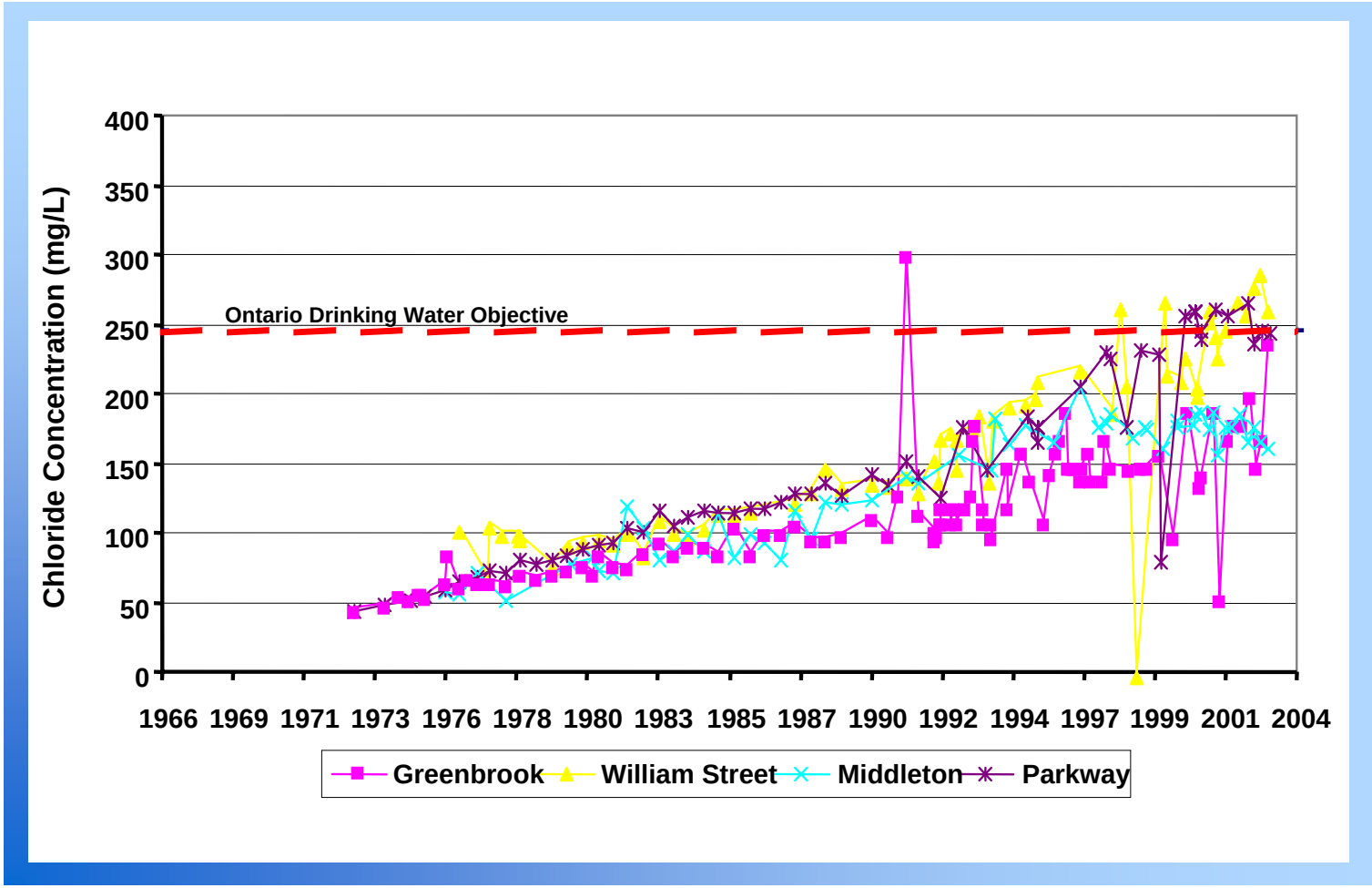
WELLESLEY
WOOLWICH
WATERLOO
WILMOT
KITCHENER
CAMBRIDGE
NORTH DUMFRIES
William Street Well Field
Greenbrook Well Field
Parkway Well Field
Middleton Street Well Field
Municipal Boundary
Primary Urban Road
Primary Rural Road
Secondary Urban Road
Seondary Rural Road
MTO Highway
Primary Well Field
Toronto
Regional Municipality of Waterloo

Chloride Concentrations Trends



Study Approach

- Winter Road Maintenance and Road Salt Application Rates
- Road Salt Impacts to Groundwater Quality
- Determination of Chloride Loading and Distribution
- Model Development and Evaluation
- Evaluation of Management Options

Road Salt Loading Function

Road Network

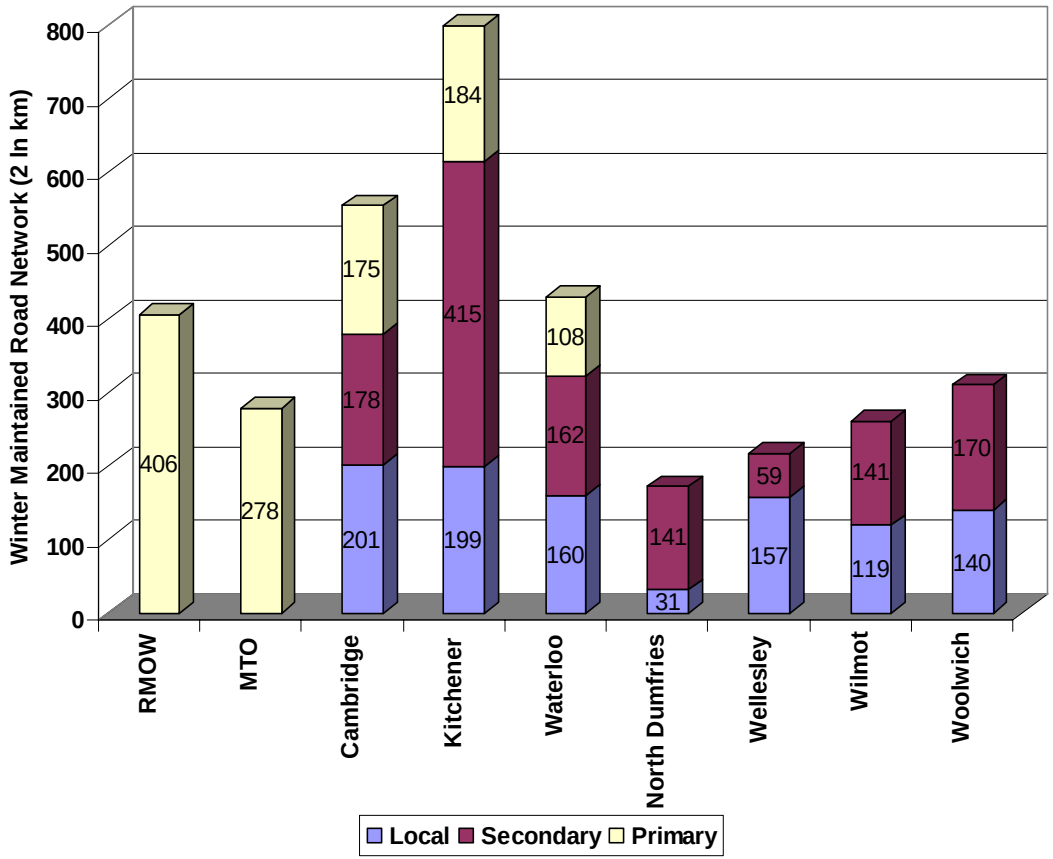
- Difficulty in correlating road network lengths provided with GIS.

Road Salt Application

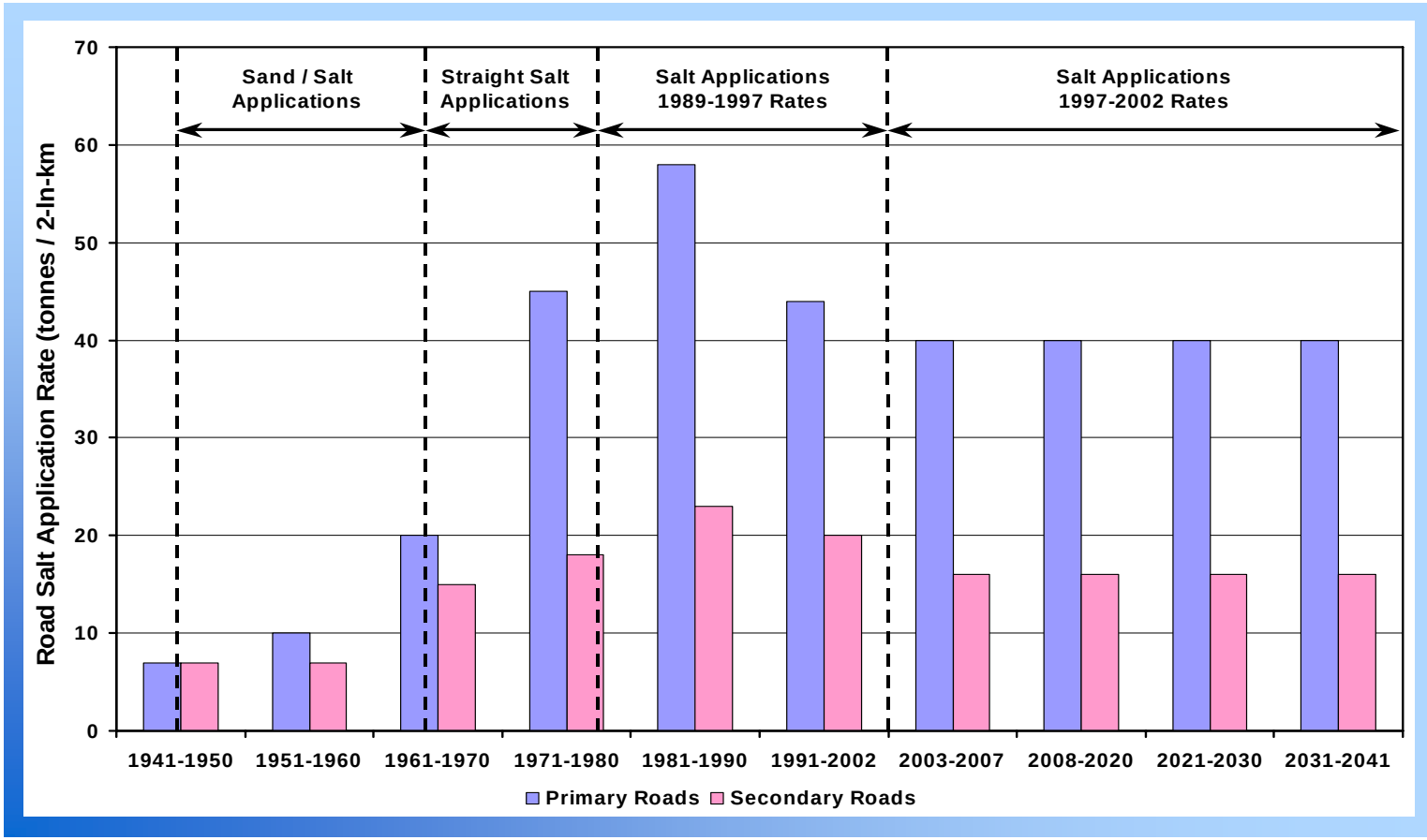
- Records for annual and seasonal purchases, not per season.
- Limited records on other salt uses.
- Limited historical data.

Winter Road Classification

- Primary - provincial, regional, main arterials.
- Secondary - most city streets and township roads.
- Local - minor city streets and gravel roadways.



Road Salt Loading Function

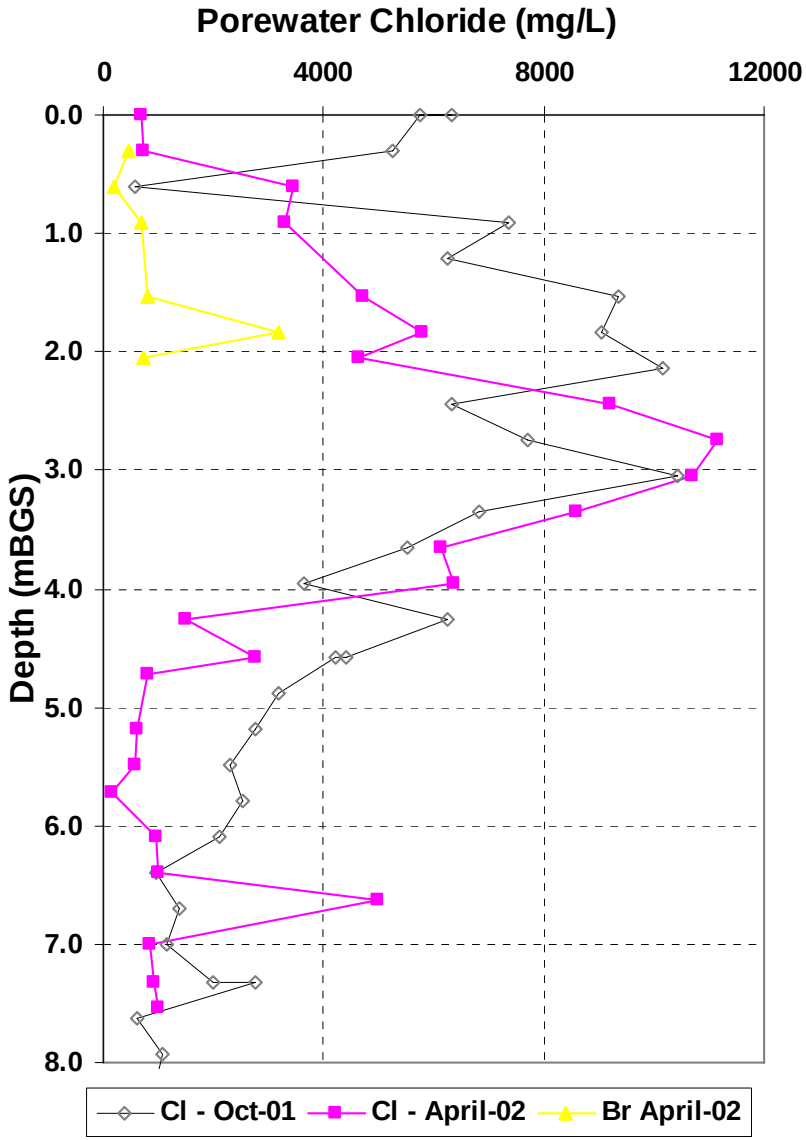


Road Salt Impacts to Groundwater

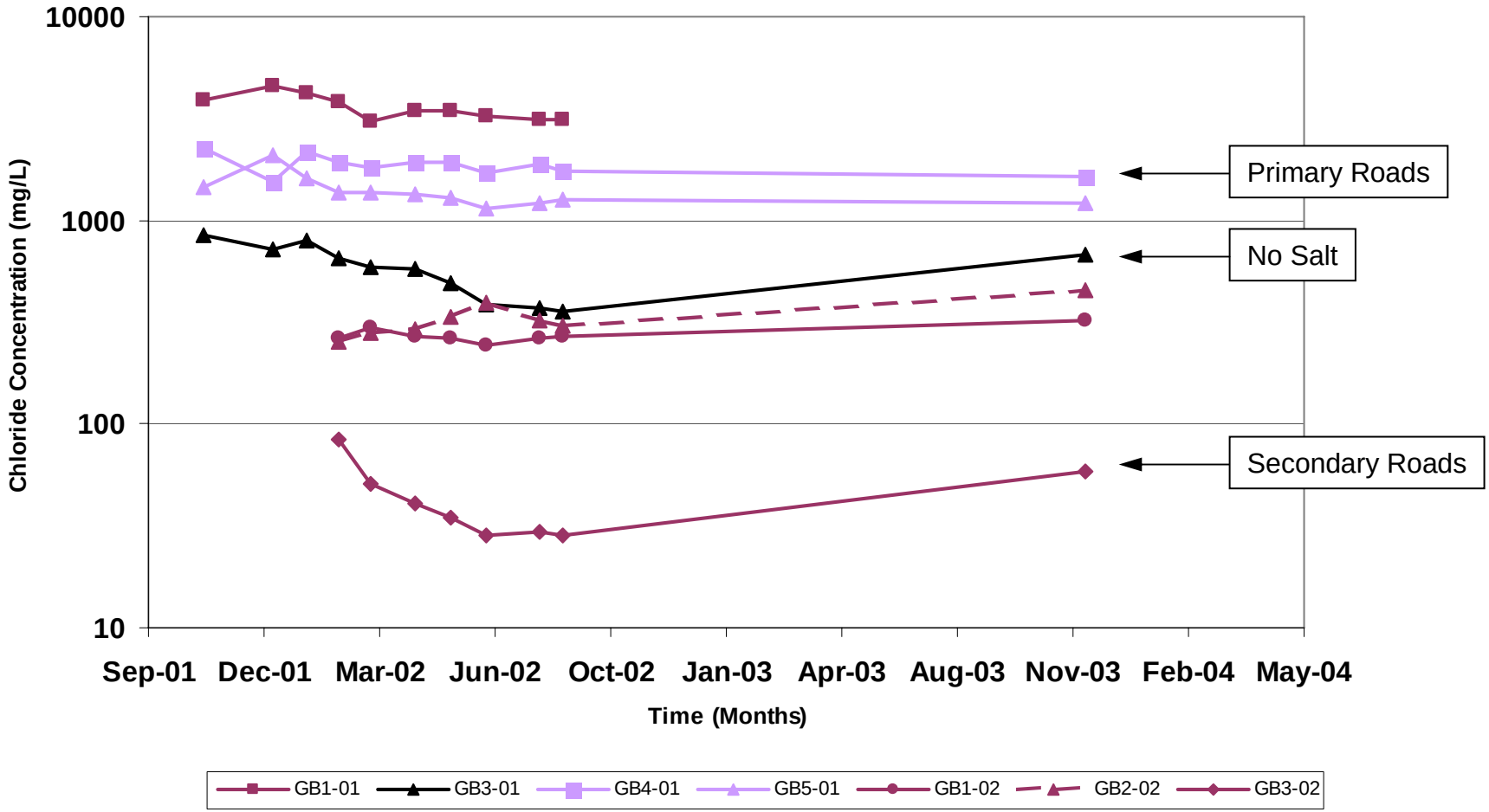
Field Program

- Established 12 field sites with groundwater monitoring wells.
- Completed detailed analyses of soil cores to document chloride concentrations in unsaturated zone.
- Detailed tracer tests completed a 4 locations to determine chloride migration rates and chloride loading.
- Groundwater quality monitored over a 12 month period to determine seasonal impacts.

Unsaturated Zone Profiles



Groundwater Chloride Concentrations



Loading to Groundwater System

- **Unsaturated Zone Data**
  - Primary Roads - Peak chloride porewater concentration 3,800 - 6,900 mg/L.
  - Secondary Roads - Peak chloride porewater concentration 1,000 - 2,300 mg/L.
  - Vertical migration rate of 3 to 4 m/yr.

- **Groundwater Data**
  - Primary Roads – Chloride concentrations 500 - 1,500 mg/L
  - Intersection – Chloride concentrations 4,000 mg/L
  - Secondary Roads – Chloride Concentrations of 50 mg/L – 4,000 mg/L

Modeling Approaches

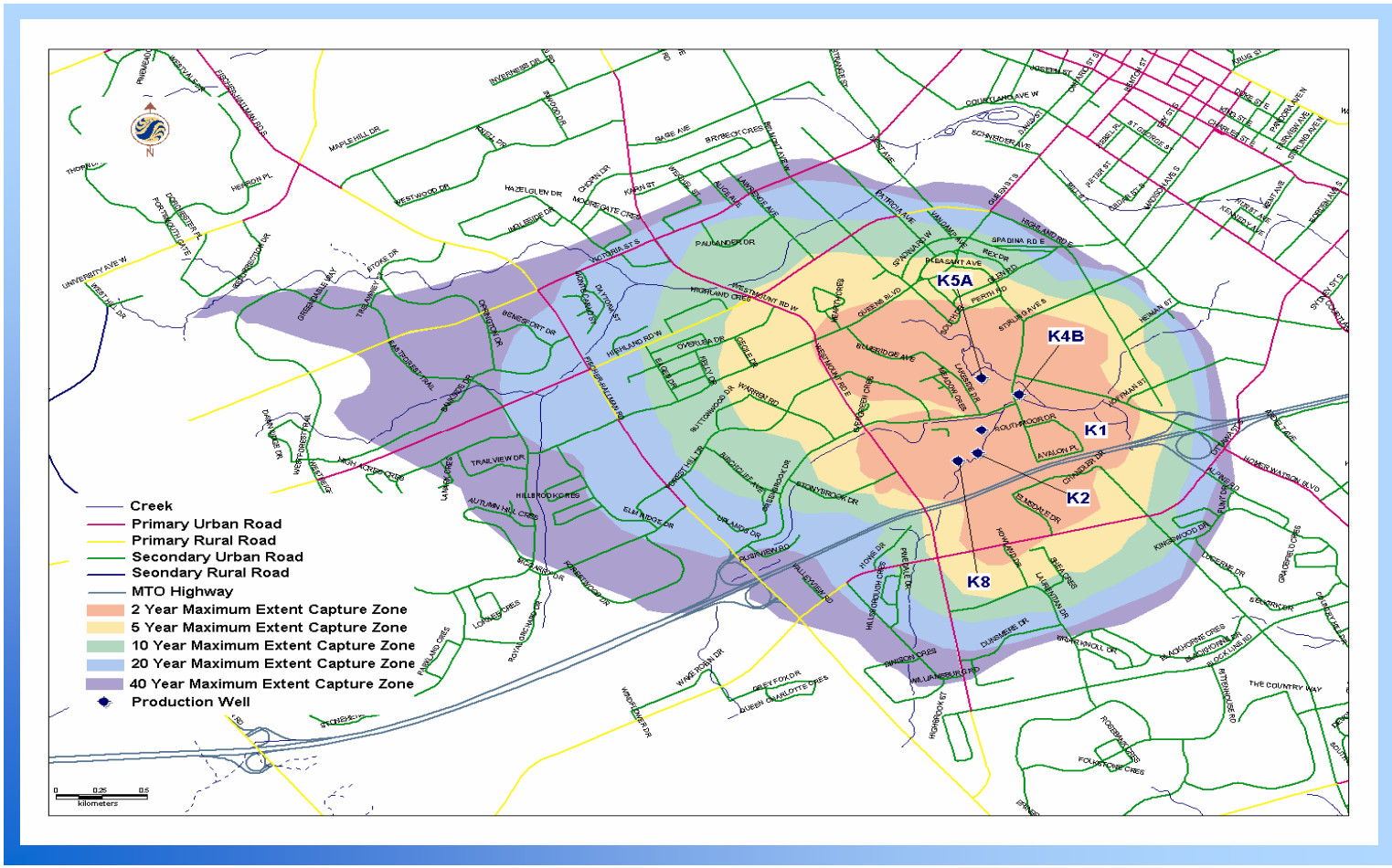
Mass Balance Model

- Specify loading rate for primary and secondary roads.
- Modify percentage infiltration by soil type and recharge.
- Move chloride through system based on unsaturated and saturated travel times from previous modeling.

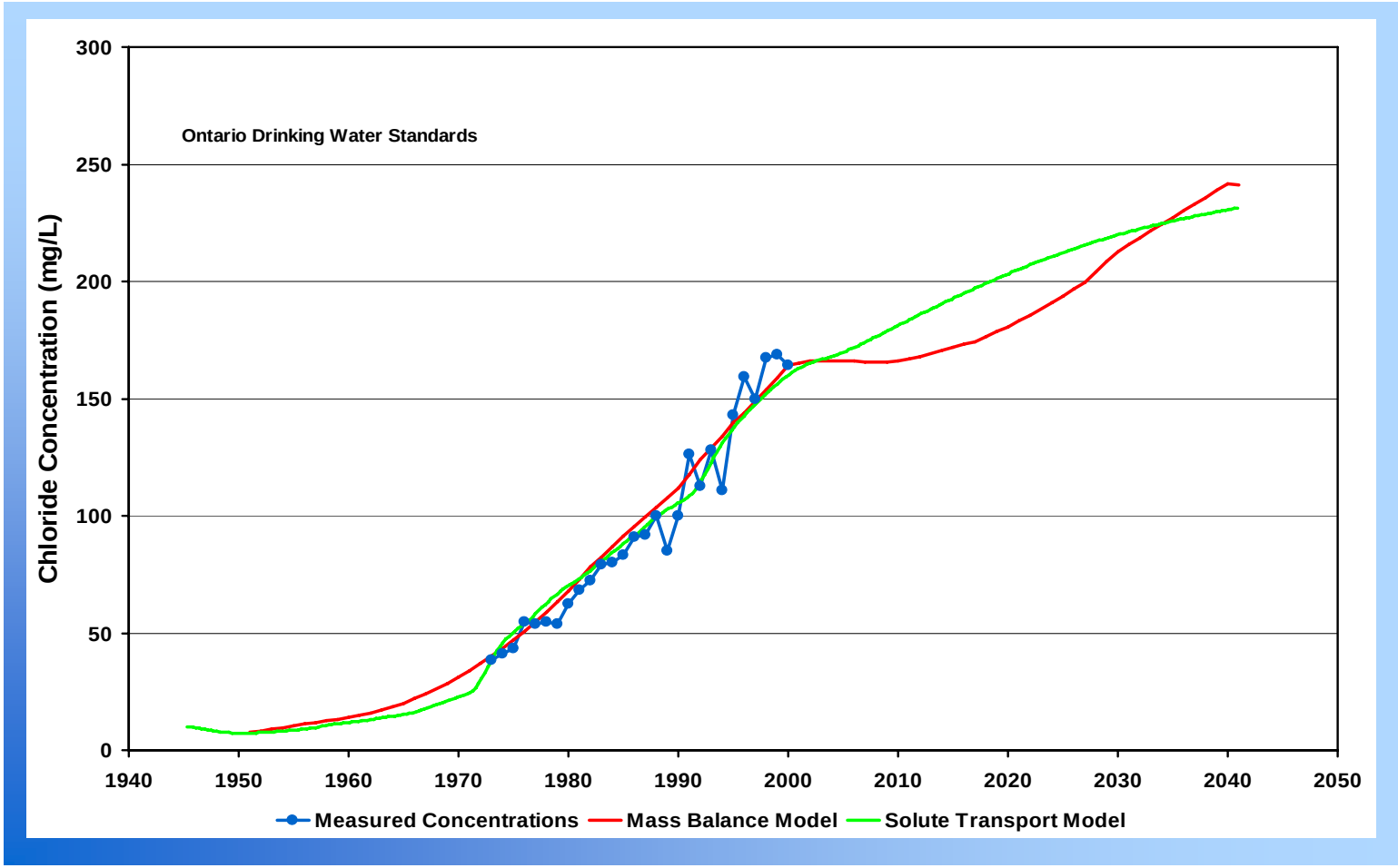
3-D Solute Transport Model

- Specify loading rate for primary and secondary roads.
- Specify percentage infiltration.
- Unsaturated and saturated transport using WATFLOW.

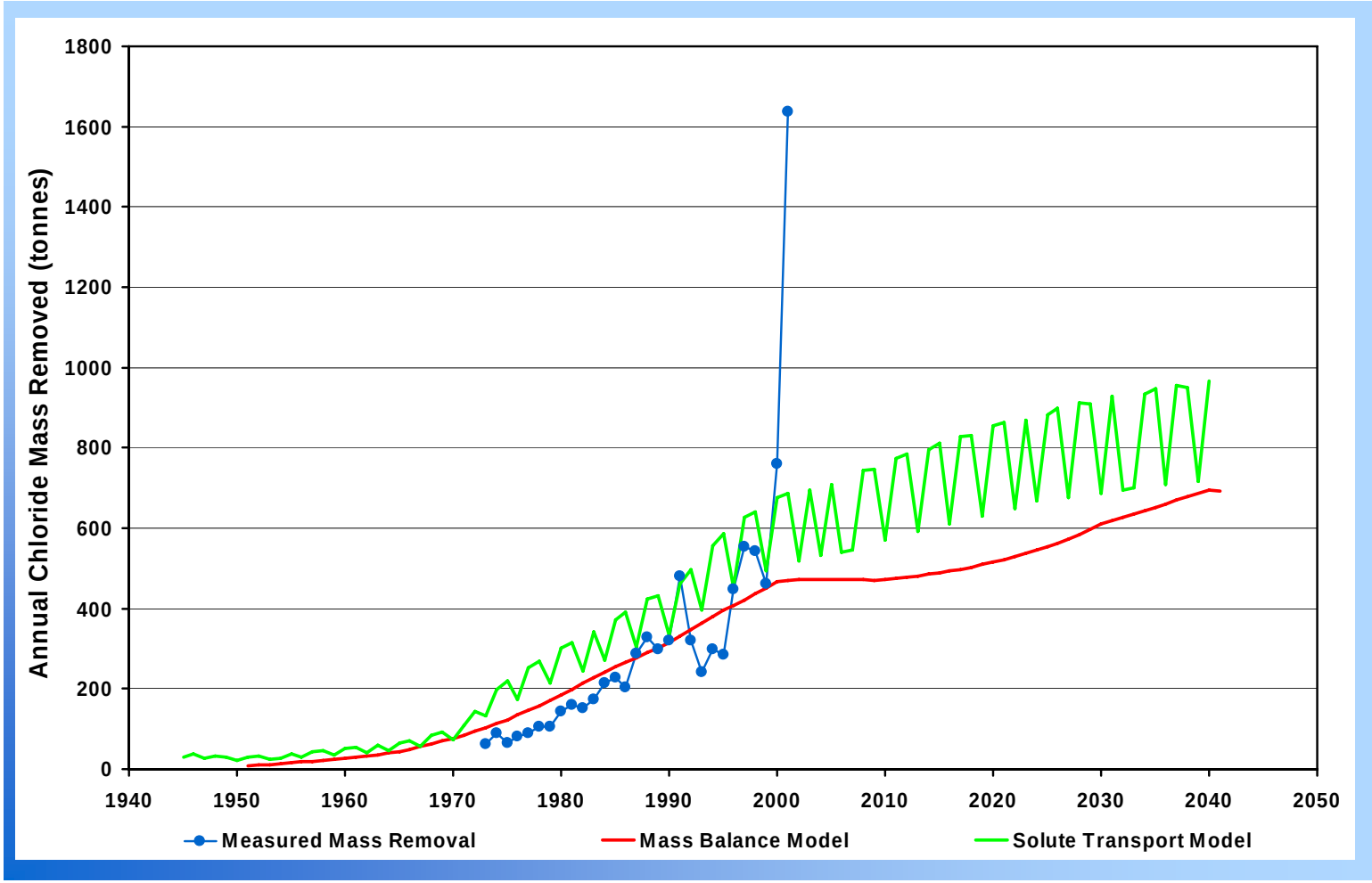
Greenbrook Well Field



Model Calibration - Concentration



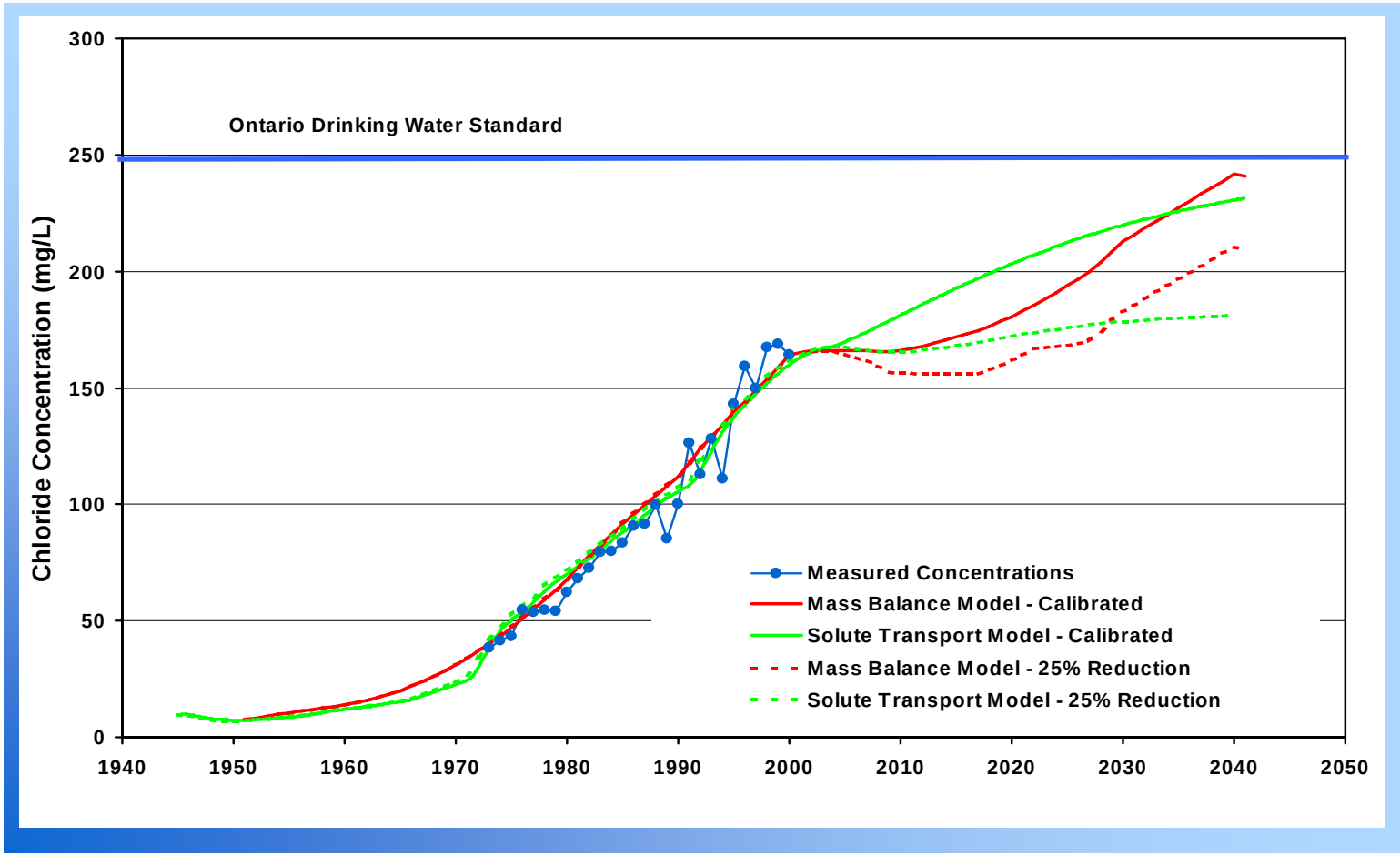
Model Calibration - Mass



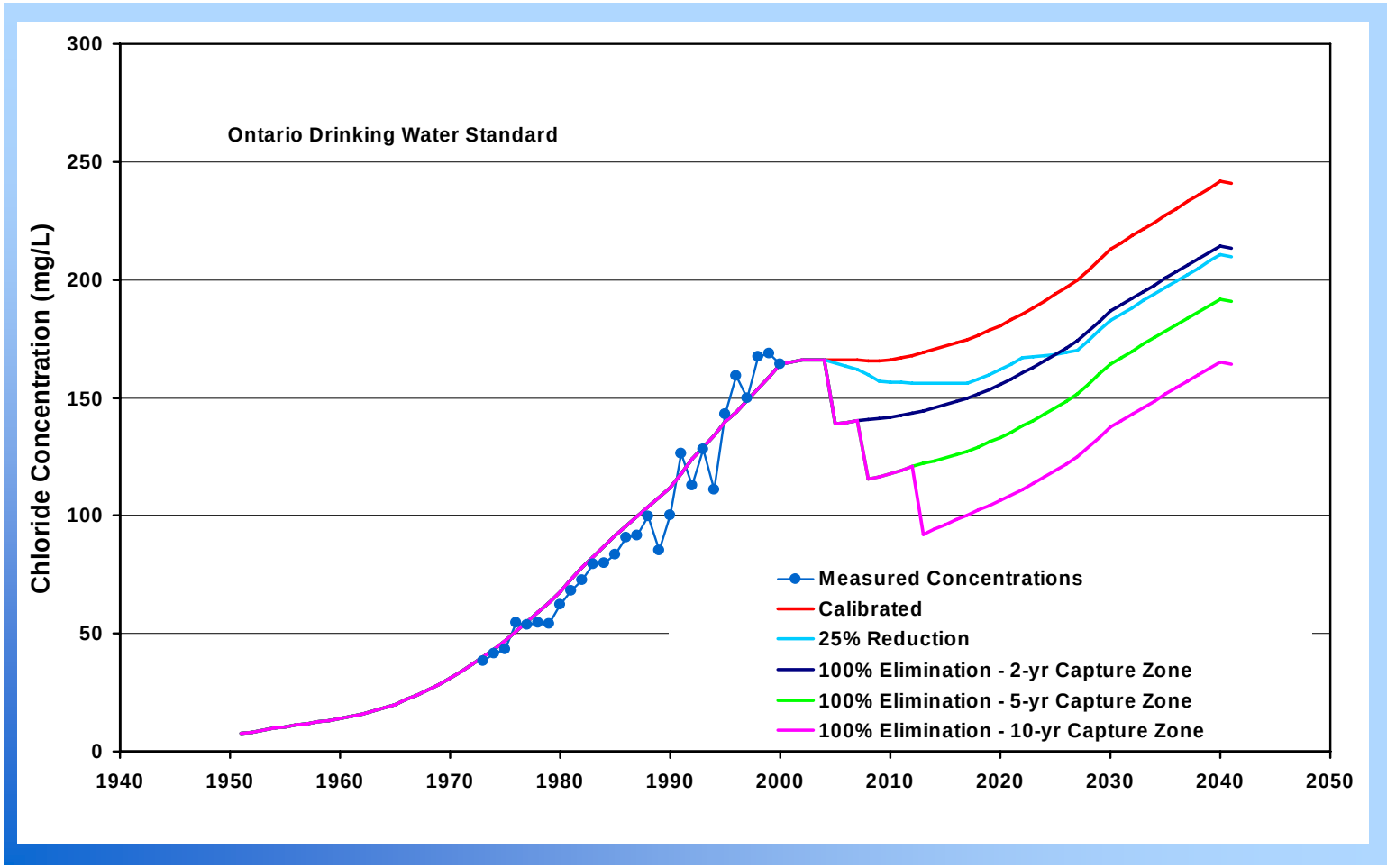
Road Salt Management Options

- Do Nothing.
- 25% road salt reduction over entire capture zone.
- 100% elimination and use of alternative deicing compound (CMA) within
  - 2-Year Capture Zone.
  - 5-Year Capture Zone.
  - 10-Year Capture Zones.
- Treatment of groundwater

25% Reduction in Road Salting



100% Reduction in Road Salt



Model Results

- Mass balance model and solute transport model provide similar results.
- Approximately 27% of the total road salt applied infiltrates to the groundwater table.
- Chloride concentrations at the Greenbrook Well Field will reach 241 mg/L by 2041. A 25% reduction in road salt application rates decreases chloride concentrations to 210 mg/L by 2041.
- Complete elimination of road salt within the 5-year and 10-year capture zones would reduce chloride concentrations to 191 mg/L and 164 mg/L by 2041.

Evaluation of Reduction Options

- Impact on Groundwater / Well Field Concentrations.
- Long Term Security.
- Environmental Impacts.
- Impact on Winter Road Maintenance Operations.
- Public Acceptance.
- Cost.

Cost Evaluation

- Do Nothing $3,060,000
- 25% Road Salt Reduction $2,800,000
- 100% Elimination in 2-Yr Capture Zone $10,500,000
- Treatment $7,800,000

Preferred Option
•25% Reduction in Road Salt Application
•Maximum Chloride Concentration of 211 mg/L

Questions and Answers