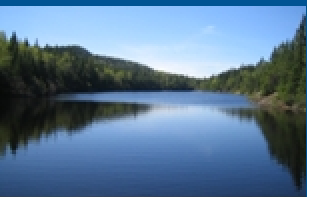
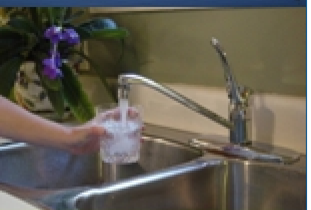


Water Storage Tanks in Newfoundland and Labrador: Blessing or Curse?

Paula Dawe, P.Eng.
Drinking Water Safety Workshop- Gander
March 23, 2010
pauladawe@gov.nl.ca

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Overview of Presentation

- Characteristics of Tanks in NL
- Tank Design and Components
- Tank Condition and Economic Considerations
- Operation of Tanks
- Tanks and Water Quality
- How to Correct Tank Issues?

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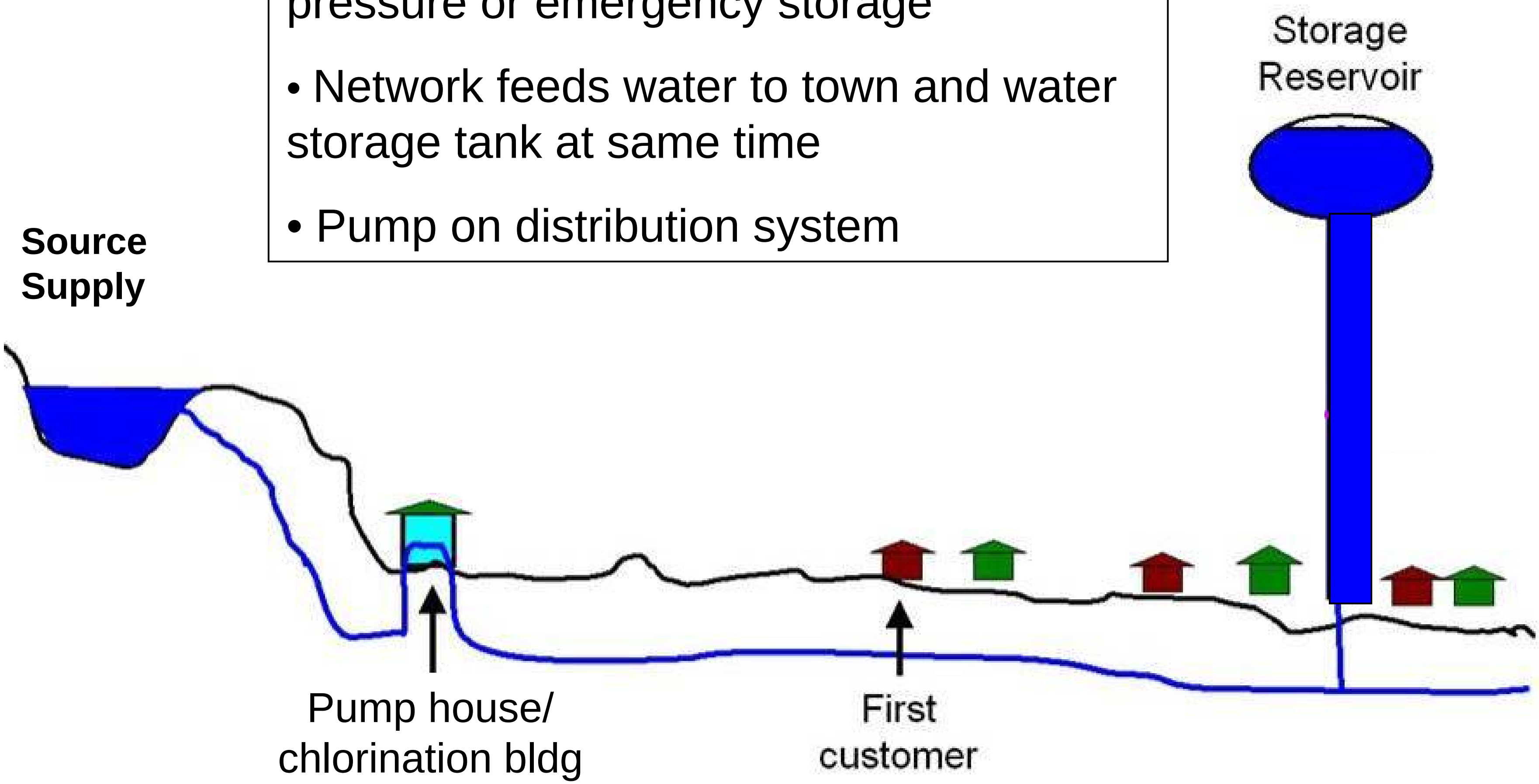
Typical Water System with a Tank

- Tank is there to provide fire flow, pressure or emergency storage
- Network feeds water to town and water storage tank at same time
- Pump on distribution system



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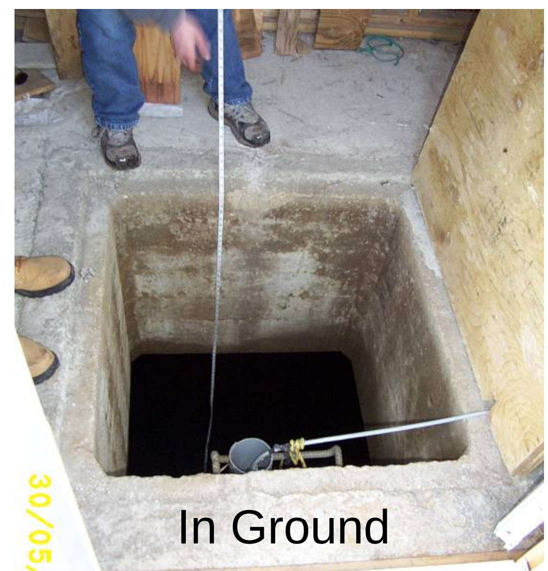
Types of Tanks in NL

Elevated

Standpipe

Reservoir



In Ground

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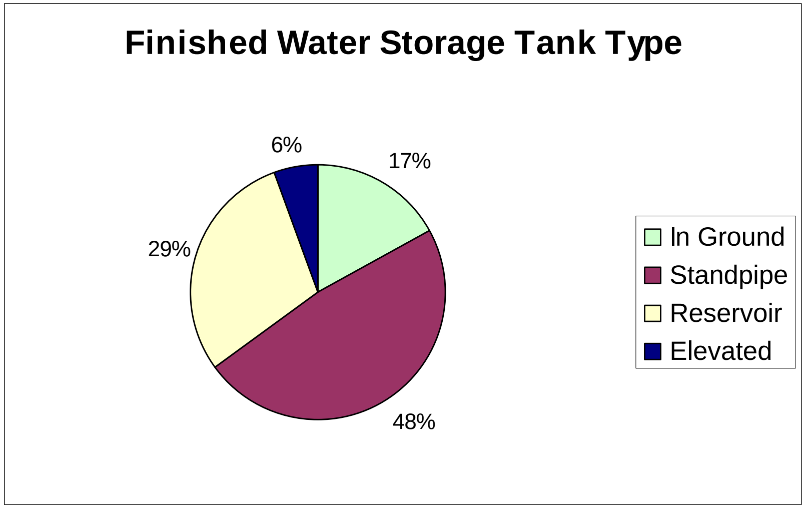
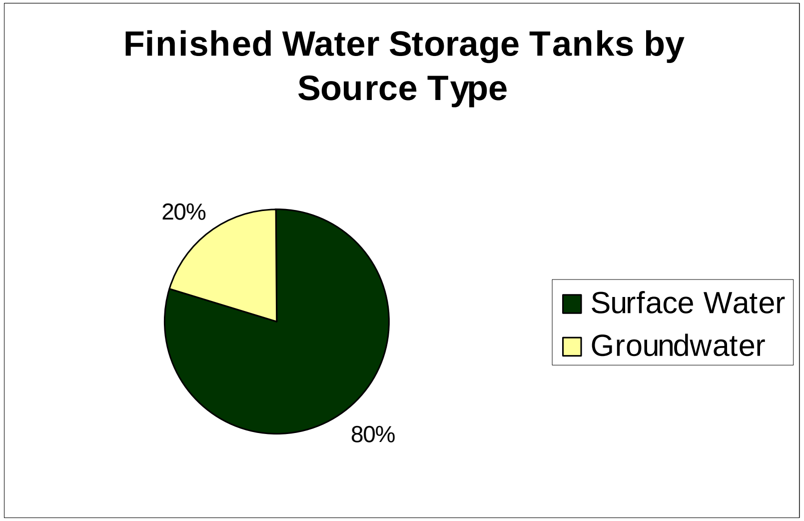
Tank Characteristics in NL





- 123 water storage tanks in province
- 48% are standpipe tanks
- Tanks are fairly evenly distributed across regions:
  - Most in Eastern
  - Fewest in Labrador
- 80% of tanks are on systems with a surface water source

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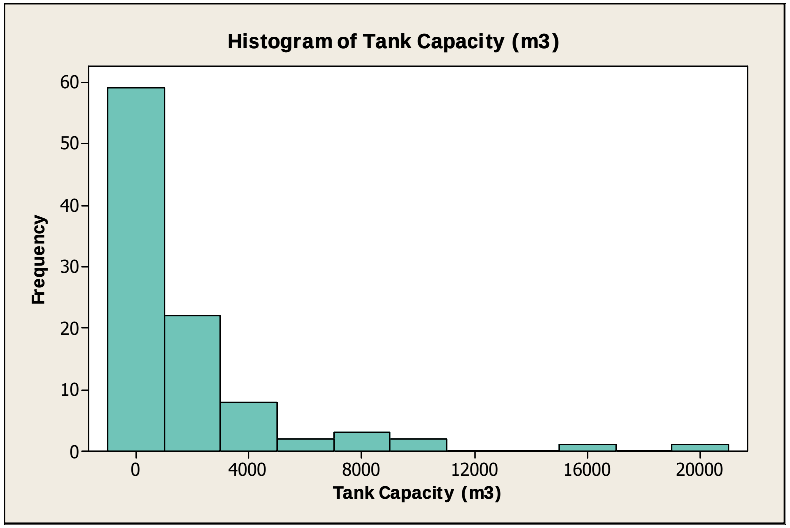
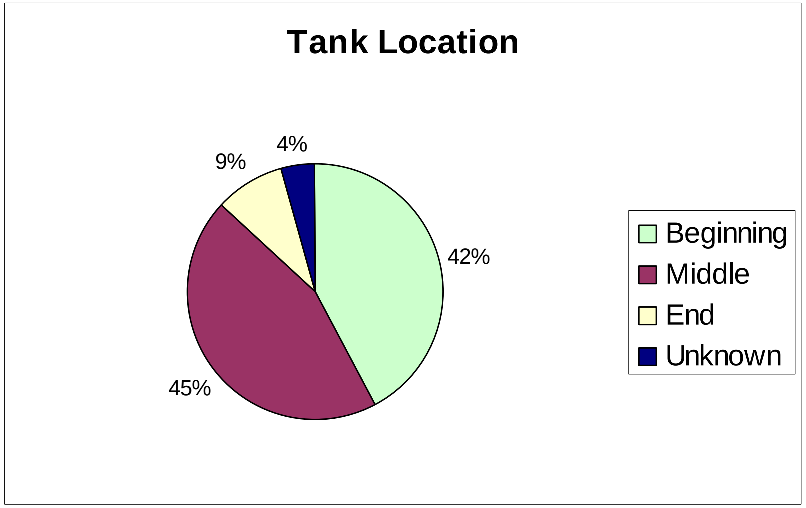
Tank Characteristics in NL

- Tank capacity ranges from 10-20,000 m^3
- Most tanks in NL around 325 m^3
- Even distribution of:
  - Concrete tanks
  - Welded steel tanks
  - Bolted steel tanks
- 42% of tanks located at beginning of system, 45% in the middle





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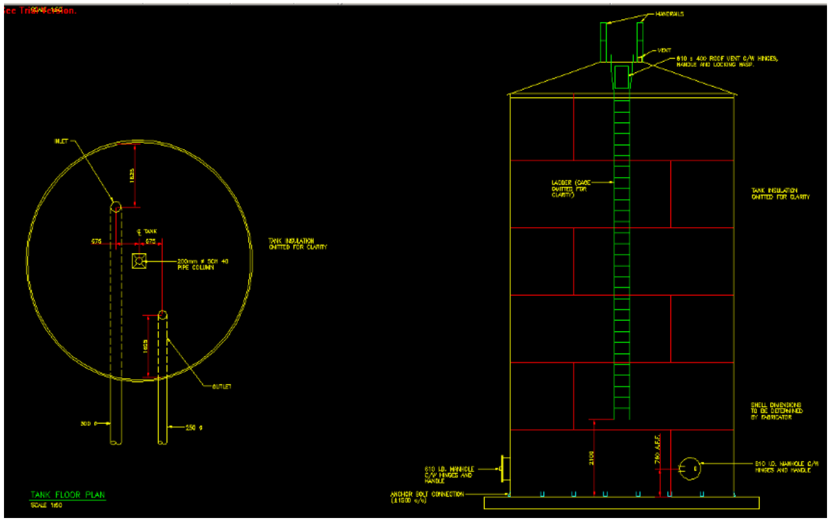
Design of Tanks

- Design of storage tanks changed over years
  - Since 2000 more glass-lined steel-bolted tanks
- Type of tank must suit design need
- Tank design must meet:
  - Guidelines for the Design, Construction and Operation of Water and Sewerage Systems
  - AWWA Standards
- Operation of tank not necessarily looked at in the design



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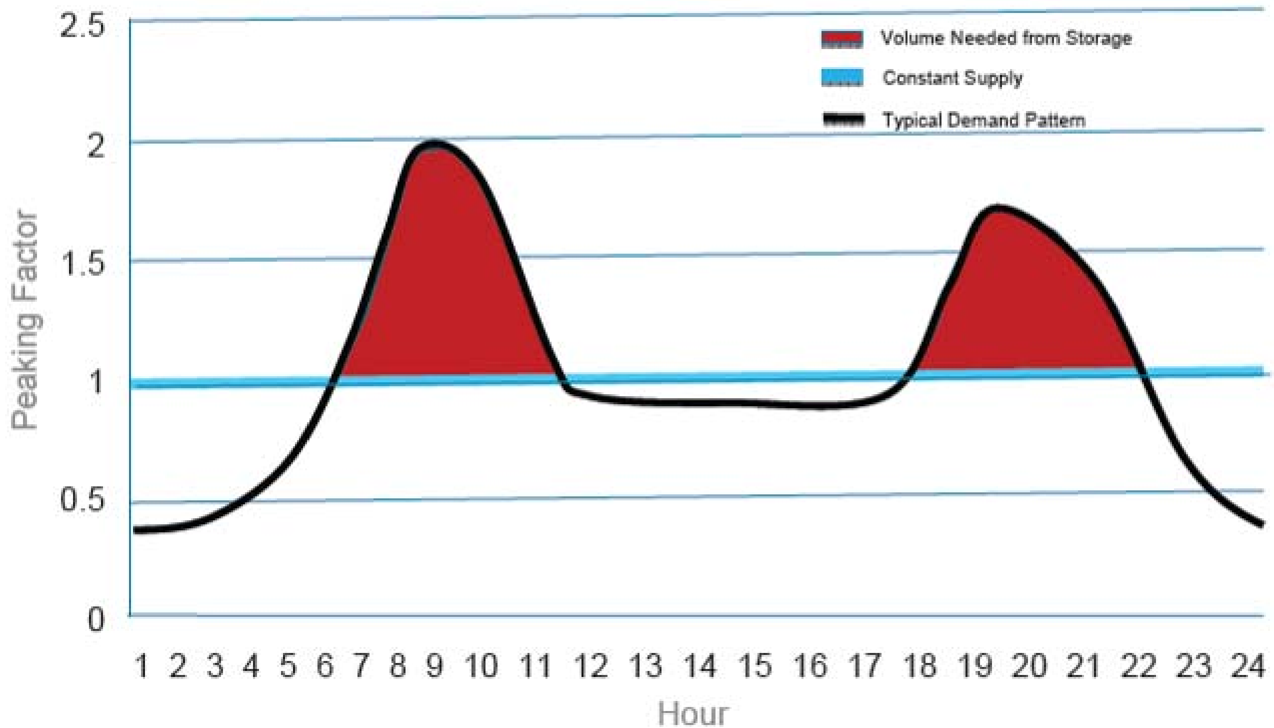
Daily Water Demand



- Demand peaks in morning and evening
- Tank used to store water to meet these peak demands
- Tank fills when demand drops

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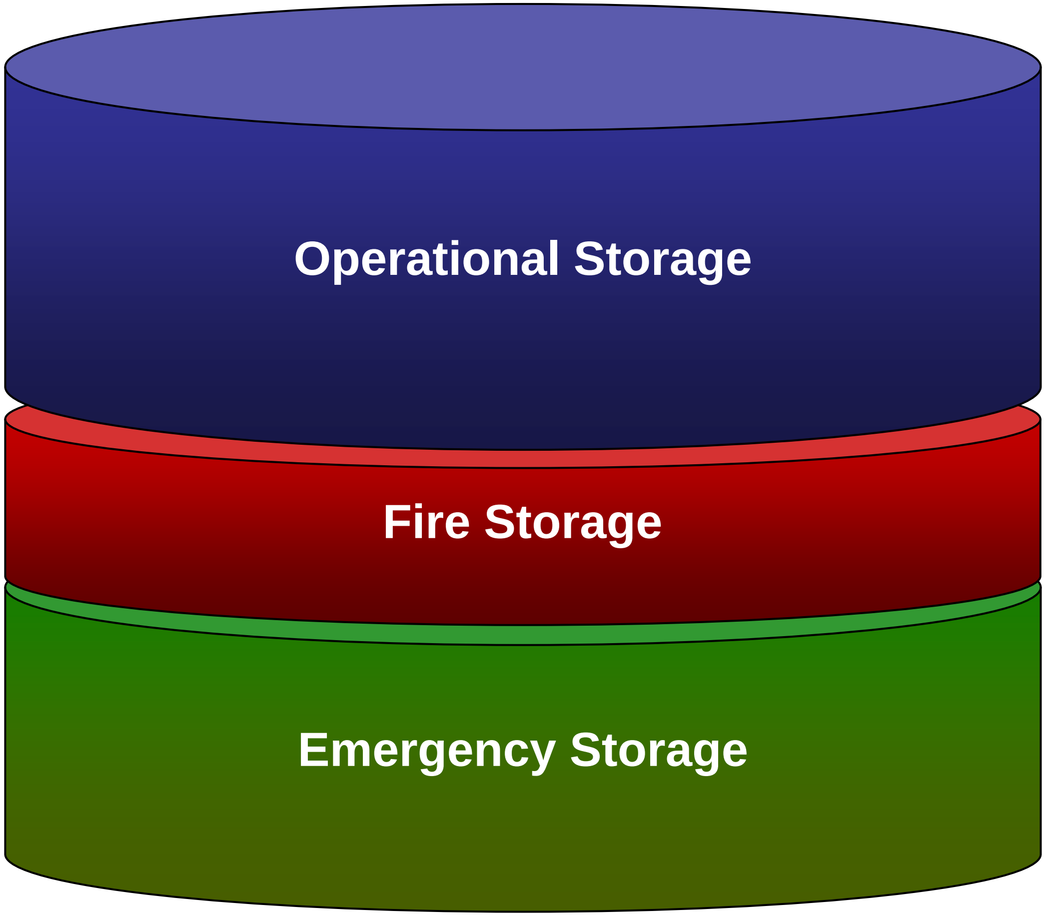
Components of Storage



- 25% of maximum day demand
- Established by Insurance Advisory Organisation
- 25% of Operational and Fire Storage

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Fire Storage

- Based on building type and density

Very Low Density Residential (0-2 DU/acre)	1,000 gpm	2 hrs
Low Density Residential (2-4.5 DU/acre)	1,250 gpm	2 hrs
Medium Density Residential (4.5-15 DU/acre)	2,000 gpm	2 hrs
High Density Residential (15-30 DU/acre)	3,500 gpm	3 hrs
Commercial	3,000 gpm	3 hrs
Industrial	4,000 gpm	4 hrs

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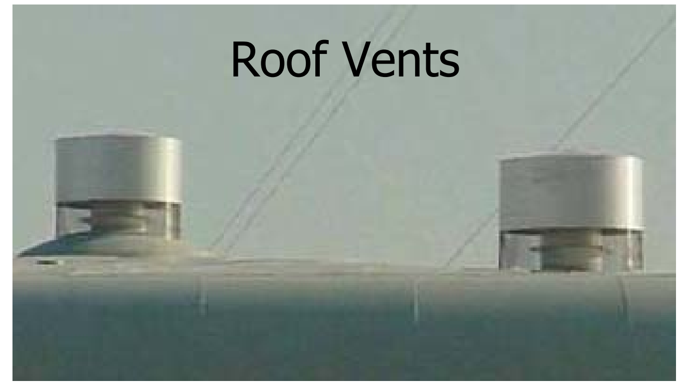
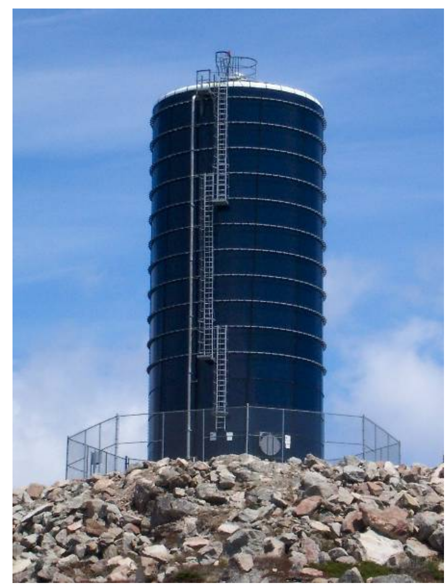
Tank Components





Ladders & Safety Rails

Security Fencing & Locks

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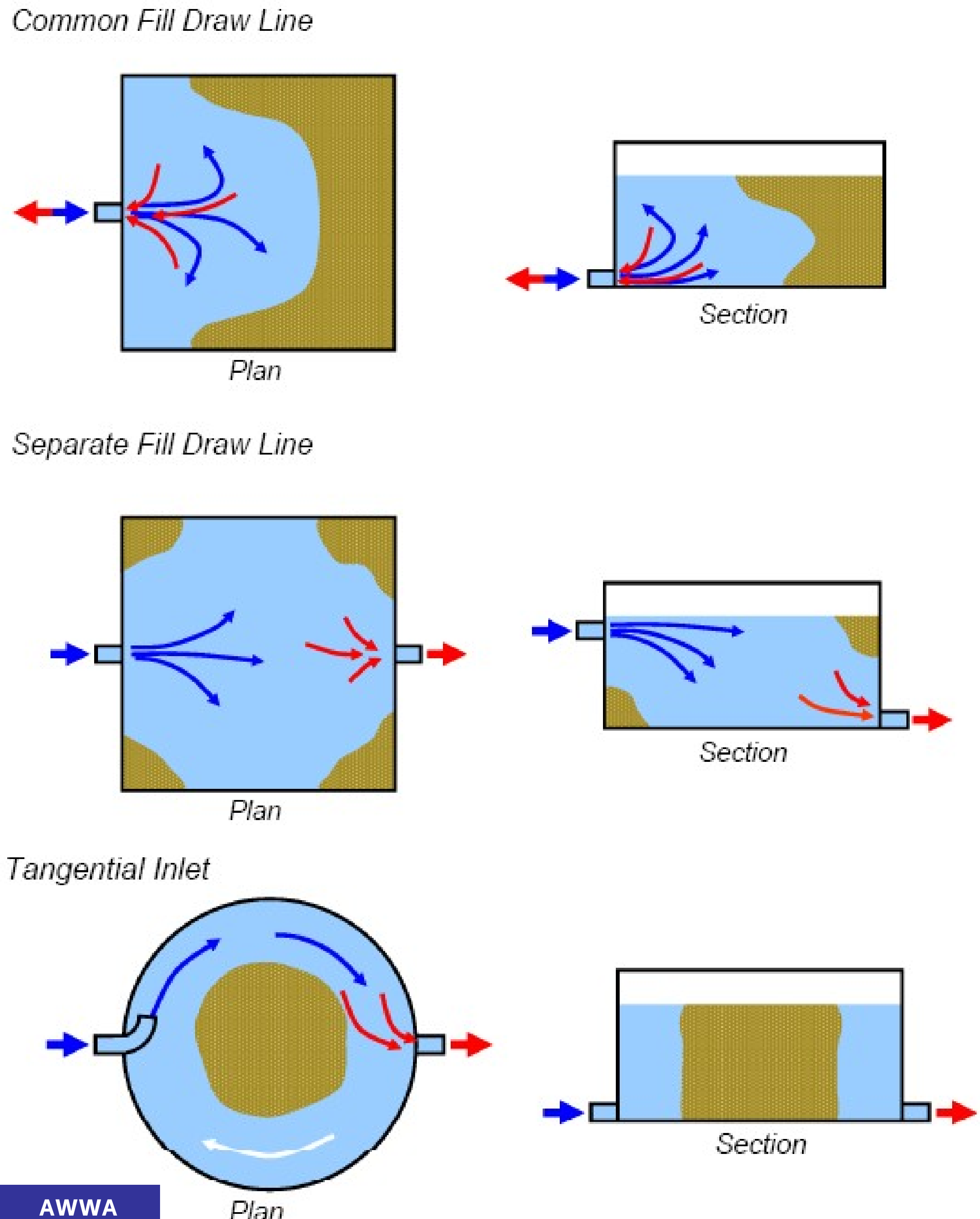
Inlet and Outlet Configuration Considerations



- Common or separate inlet/outlet
- Inlet and outlet location
- Vertical and horizontal separation of inlet/outlet
- Orientation of the inlet
- Inlet and outlet diameter

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Water Level Controls

- Used to regulate water level so tank doesn't overflow or drain completely
- Integrated with pumping system- tell pump when to cut in and off
- Common types:
  - Float operated
  - Altitude valves
  - Hydrostatic types
  - Ultrasonic types

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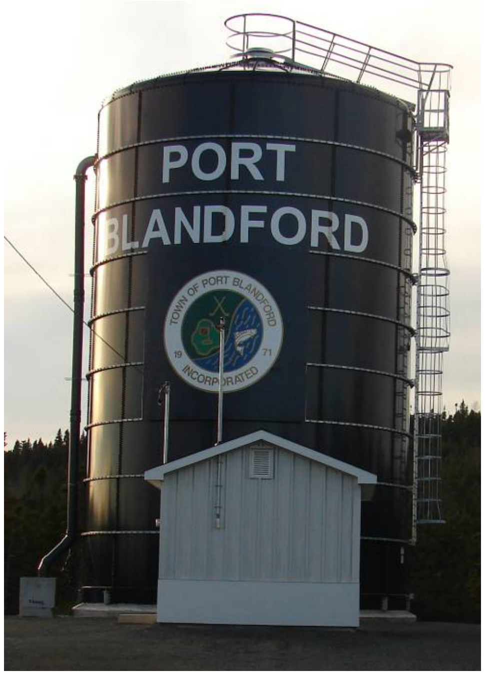
Condition of Tanks in NL



- Approximately 25% of tanks in province installed since 2000

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Capital Cost of Tanks

Town	Year	Capacity (m3)	Cost ($)
CBS	2003	2 x 2835	1,698,898
Paradise	2003	8000	1,925,923
St. John's	2000	16,000	1,239,045
Rigolet	2009	1220	1,200,000
Wabana	2009	1134	745,800
Reidville	2002	345	580,513
Winterland	2000	286	274,275

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Condition of Tanks in NL

- Tanks should have a useful life of 25-100 years depending on the tank material

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Tank Inspections

- Routine inspection- daily or weekly
- Periodic inspection- quarterly or annual
- Comprehensive inspection- every 3 to 5 years

- Sanitary conditions
  - Inspect openings that can allow fauna (birds, squirrels, insects, etc.) into the tank– roof openings, access hatches, low spots on roof plates, vents, overflows
- Structural conditions
  - Inspect anchor bolts, foundations and grouting, wind rods, metal loss in steel plates, roof trusses
- Safety conditions
  - Inspect ladders (inside and outside), fall prevention devices, handrails, access hatches
- Coatings conditions
  - Evaluate general condition, approximated percentage and type of failure, thickness, adhesion, extent of pitting damage, heavy metal presence, bubbling, alligatoring, ice scraping
- Security conditions
  - Inspect fences, locks, barricades, lighting, ladder guards, alarm systems, water monitors (residual chlorine analyzer), control systems

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Cost of Tank Maintenance and Repair

Town	Cost ($)	Year	Description
St. Bernard-Jacques Fontaine	18,630	2000	Tank cleaning and painting
New-Wes-Valley	67,160	1999	Reservoir painting
Lumsden	57,132	2000	Reservoir painting
Burin	111,145	2007	Exterior painting
Rose Blanche	393,300	2009	Tank reconstruction
Wabush	167,900	2004	Tank painting and cleaning
Whitbourne	268,187	2010	Tank repainting

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Tank Operation

- Tank is a like a black box on the distribution system
- How is tank actually operating?
- Need to consider:
  - Turnover rates in water tanks
  - Tank mixing
  - Maintaining optimal water quality in tanks
  - Tank security and access

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Tank Operation

- Operator should have some awareness of:
  - Tank dimensions
  - Tank volume
  - Inlet diameter
  - Flow rate into tank
  - Water level in tank
  - Free chlorine residuals in tank
  - Water temperature in tank
  - Rate of sediment accumulation in tank
  - Max and min water levels set for tank
  - Residence time of water in tank
  - % turnover per day
  - Tank filling and emptying time

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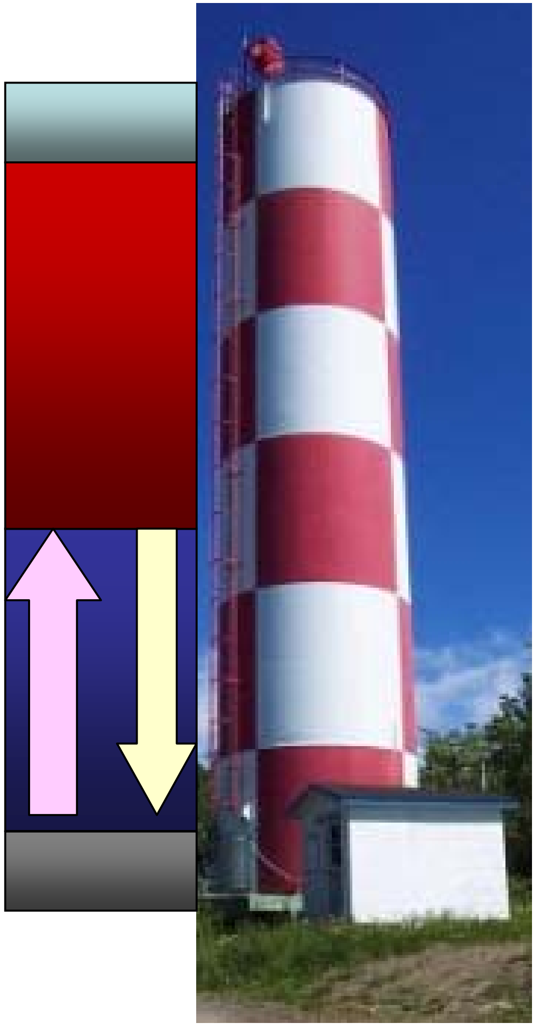
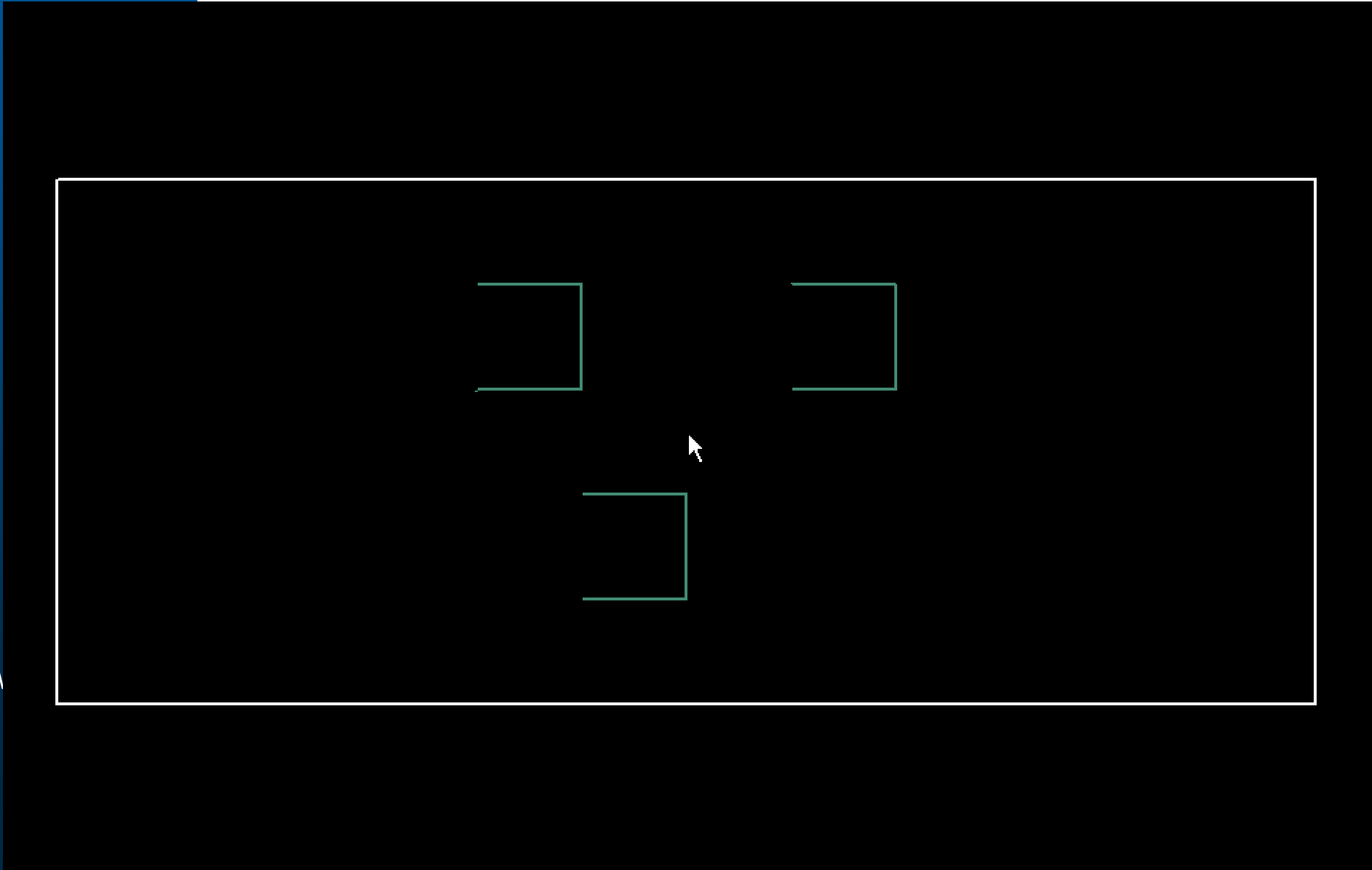
Tank Volume Breakdown

- Dead volume of air at top of tank (5-30%)
- Inactive volume of tank for fire and emergency storage (0-60%)
- Active volume of tank (15-85%)
- Dead volume of water at bottom of tank below outlet riser (15-40%)



CFD Model- St. Paul's Tank



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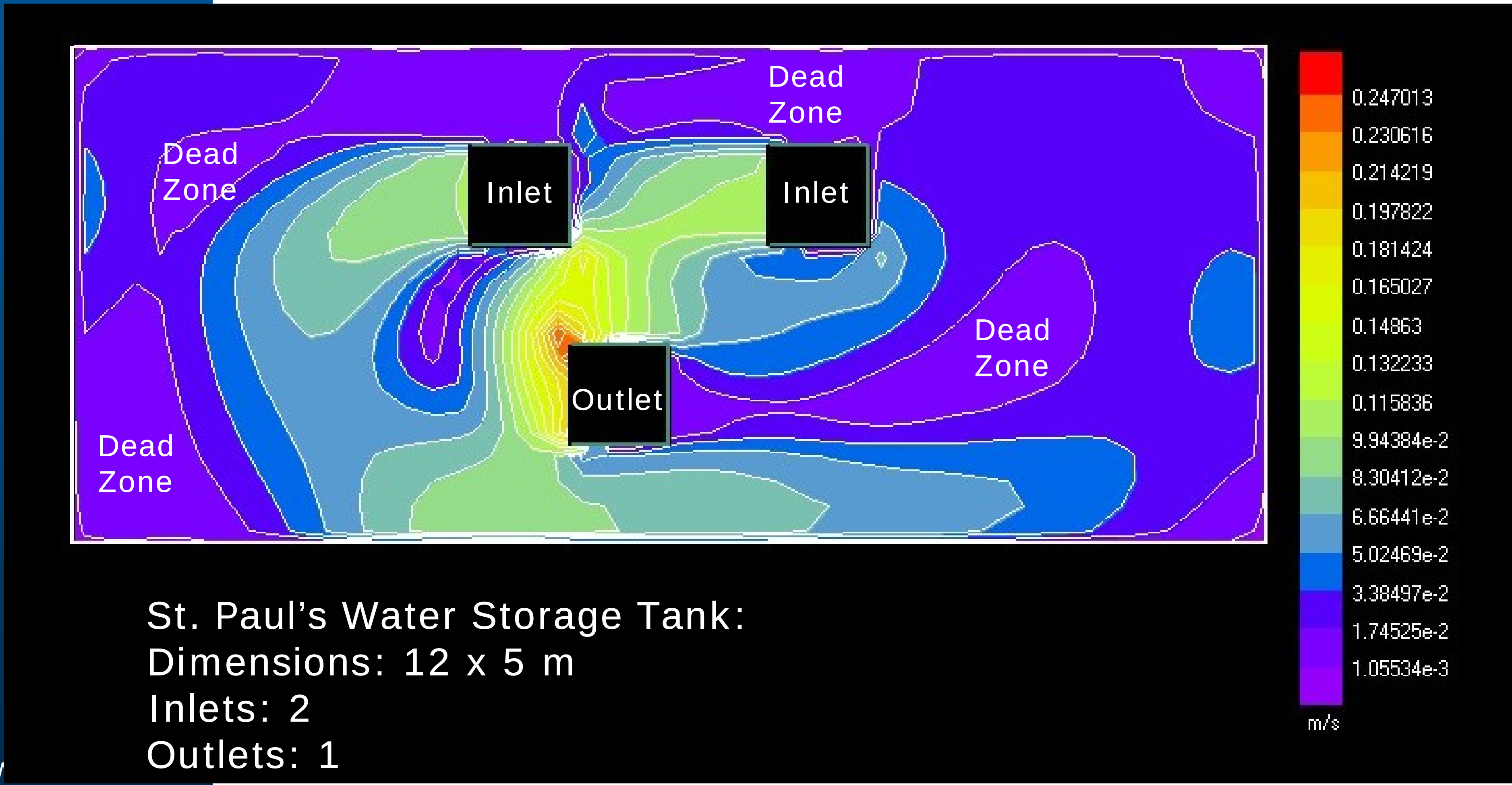
CFD Model- St. Paul's



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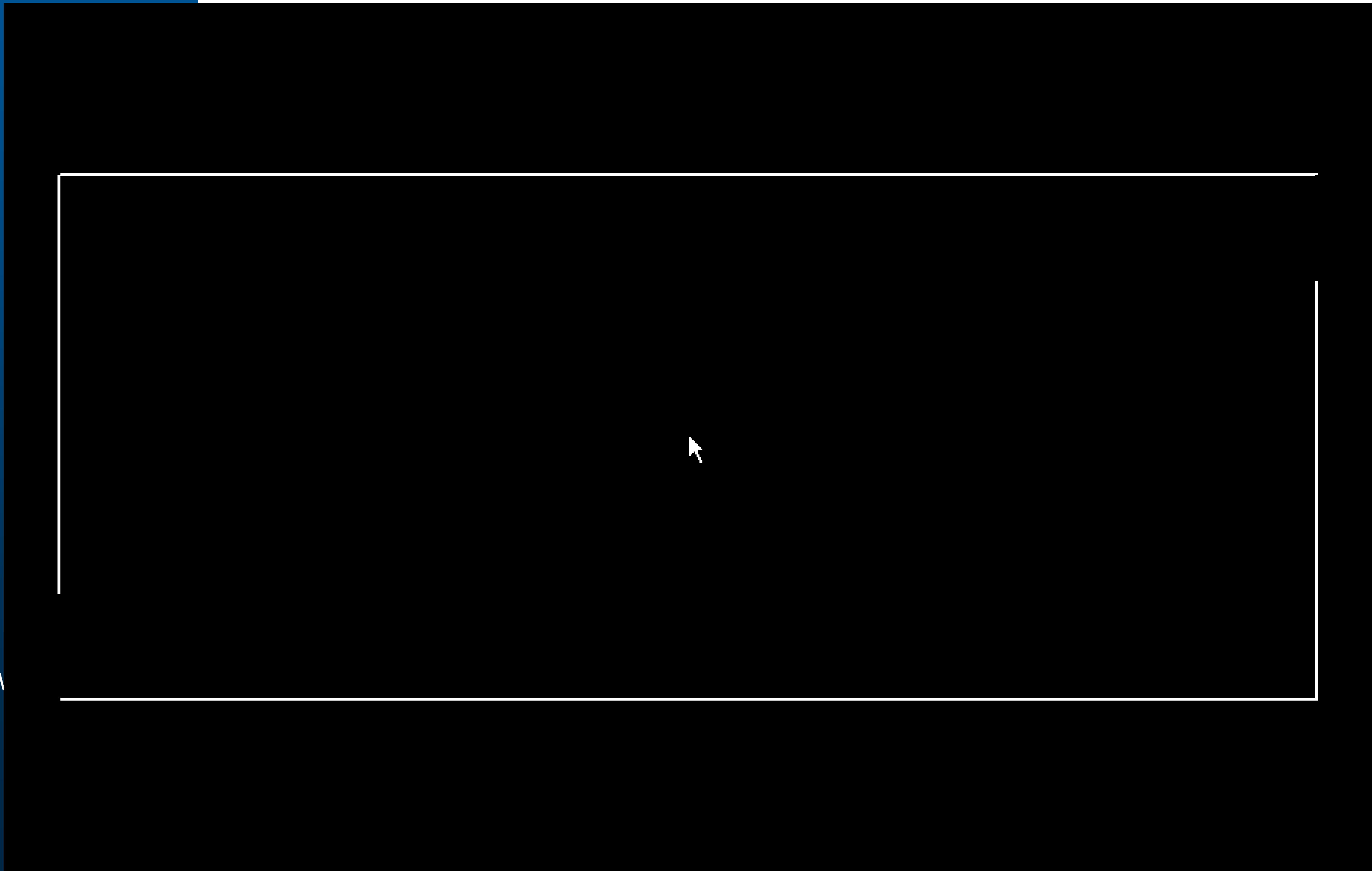
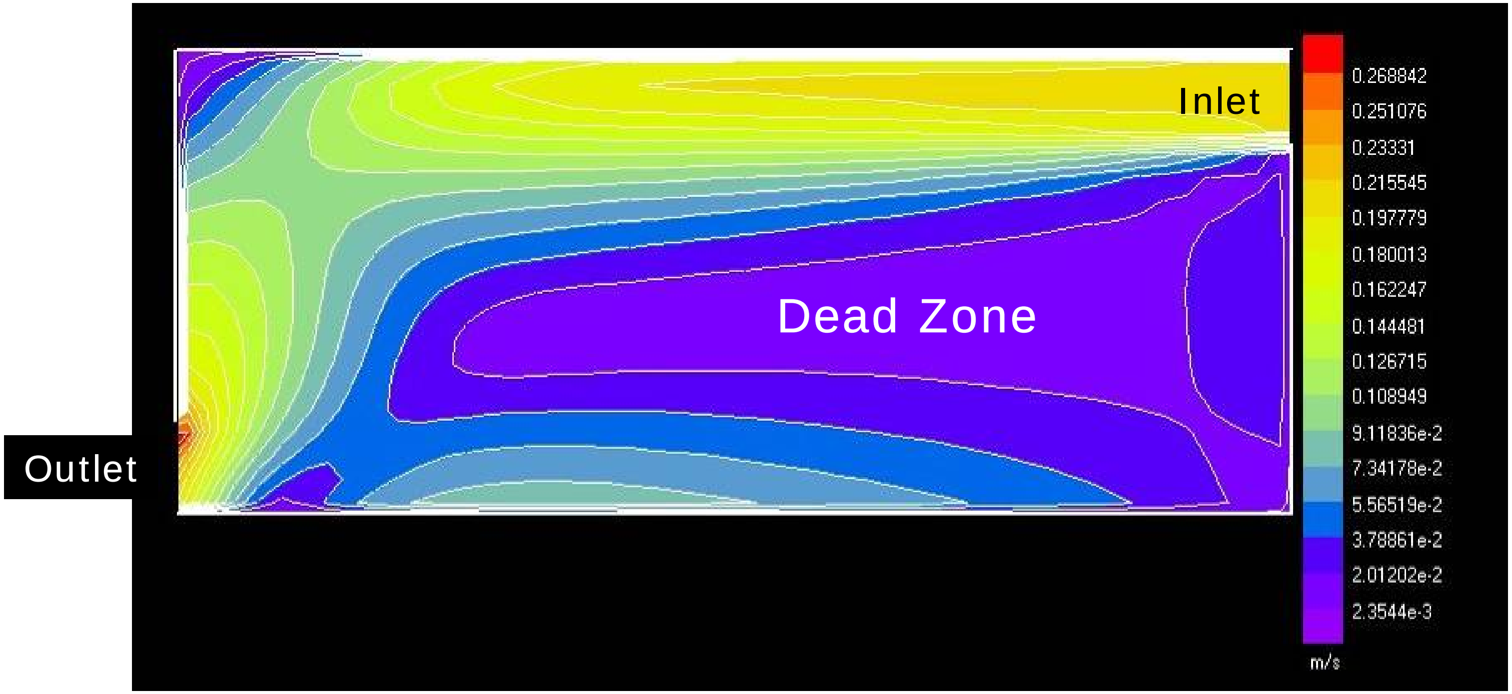
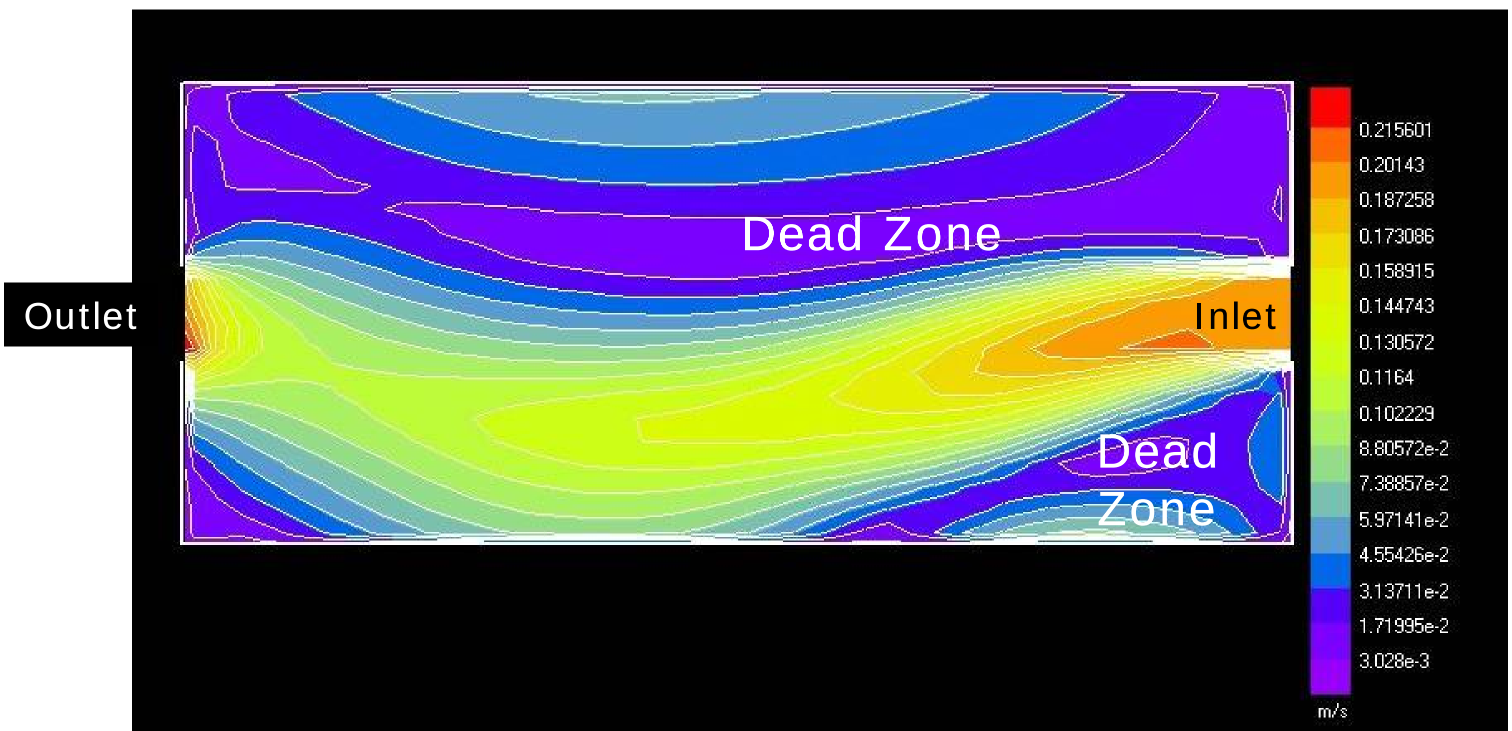
- Using EasyCFD modeling software

CDF Model- Tank with Inlet & Outlet on Opposite Sides







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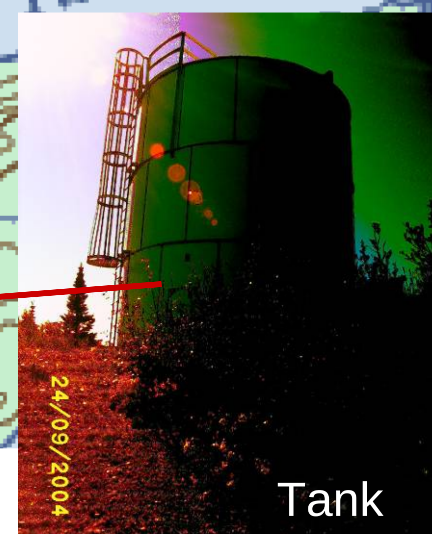
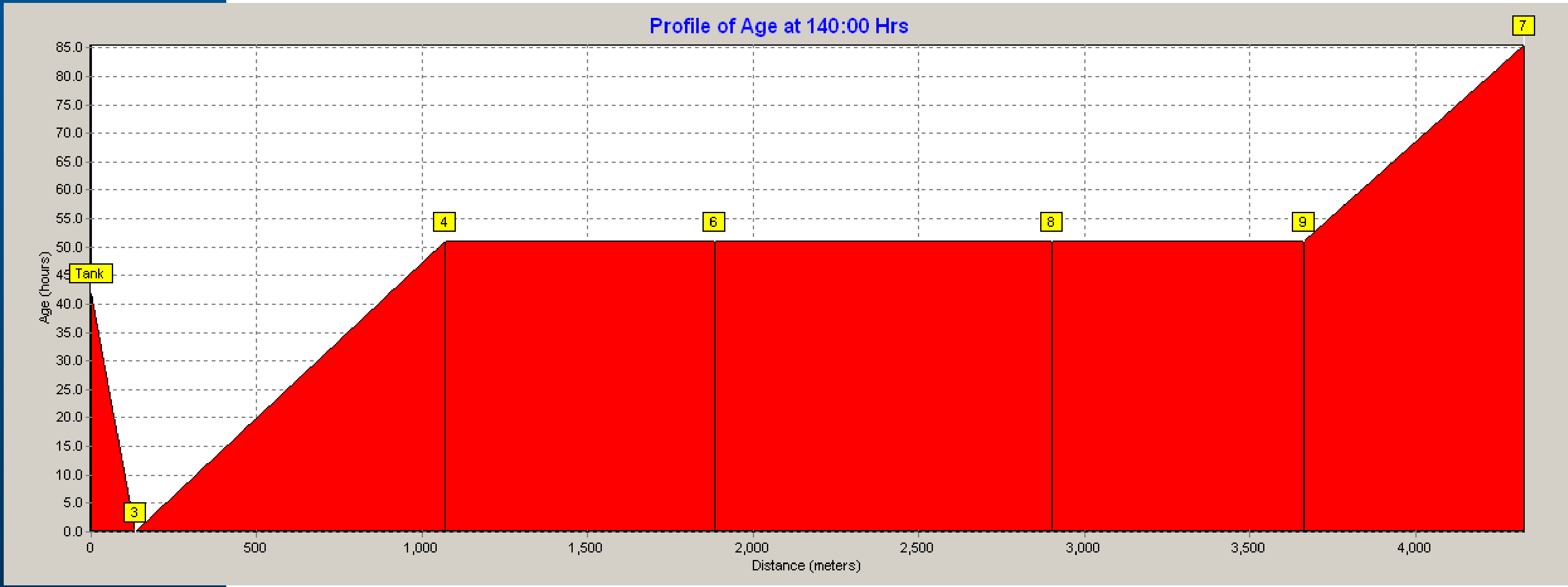
Brighton Distribution System Model



Water Age Profile from Tank to End of Distribution System- Brighton



- Using EPANET water distribution system model
- Younger water also means higher chlorine residuals and lower DBPs

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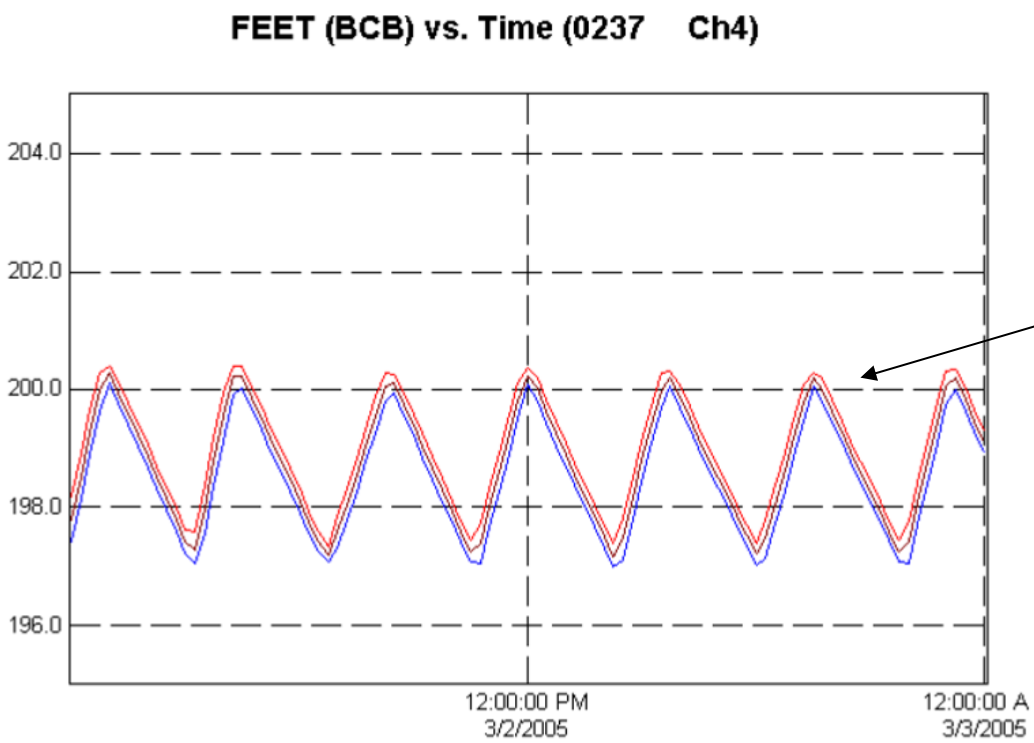
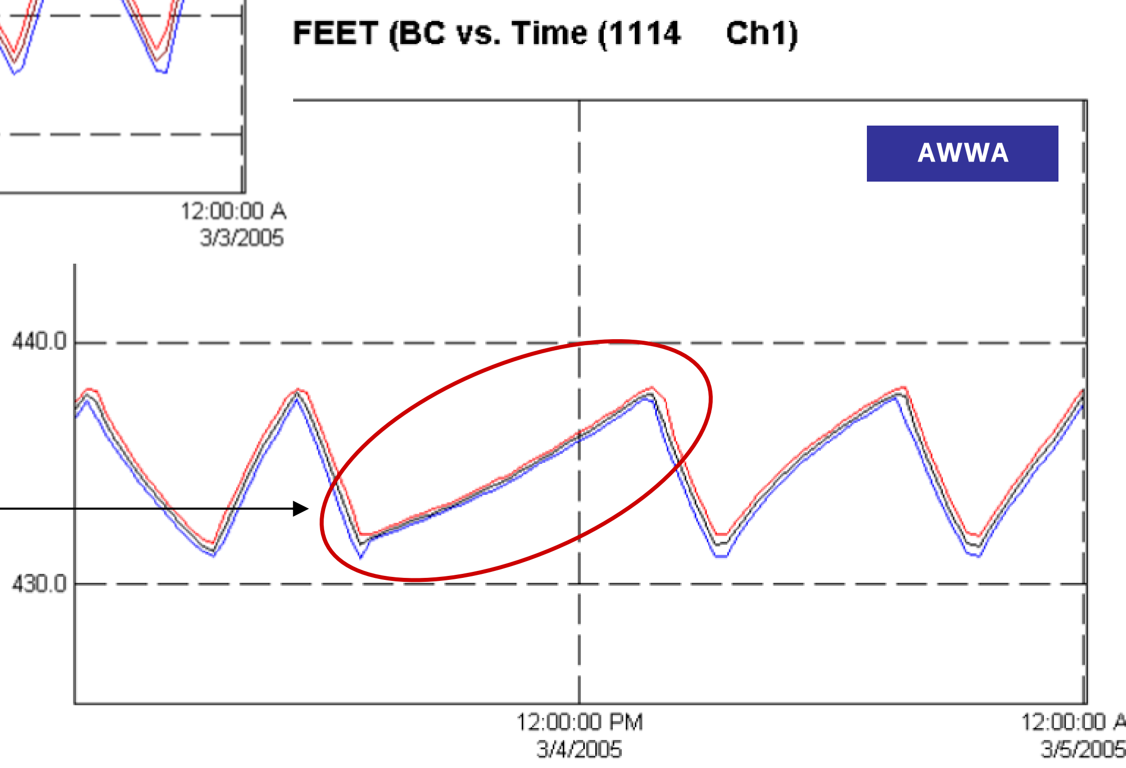
Measuring Water Level in Tanks

- Water level in tanks should be monitored daily

Water Level Monitoring



Normal operation



Leak in distribution system

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Water Quality Issues with Tanks

- Physical issues
  - Water temperature, turbidity from sediment build-up
- Microbiological issues
  - Pathogenic contamination, bio-films
- Chemical issues
  - Leaching of chemicals from tank linings or coatings, loss of chlorine residual, DBP growth, precipitates

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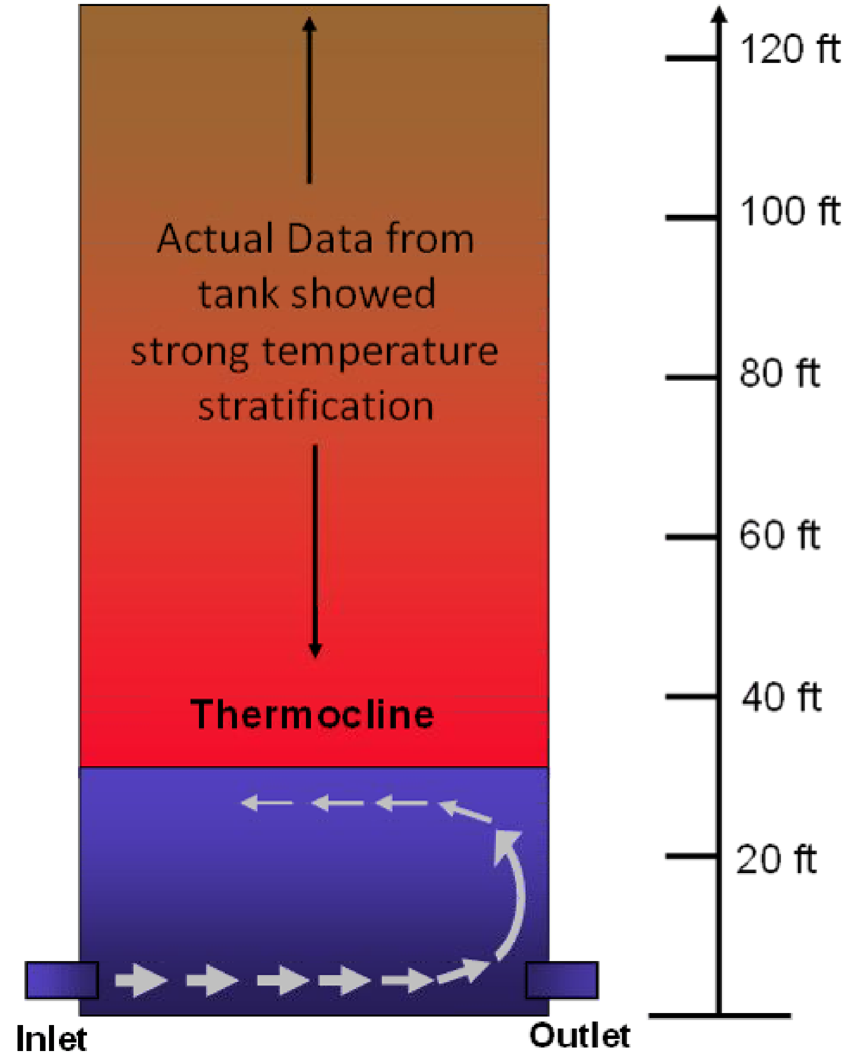
Water Temperature Stratification

PAX Water Technologies



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Ice Formation in Tank

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Sediment Build up in Tanks

- A tank should be drained and cleaned every 3-5 years depending on the rate of sediment deposition in the tank

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Biofilm on Tank Wall

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Contamination of Tanks

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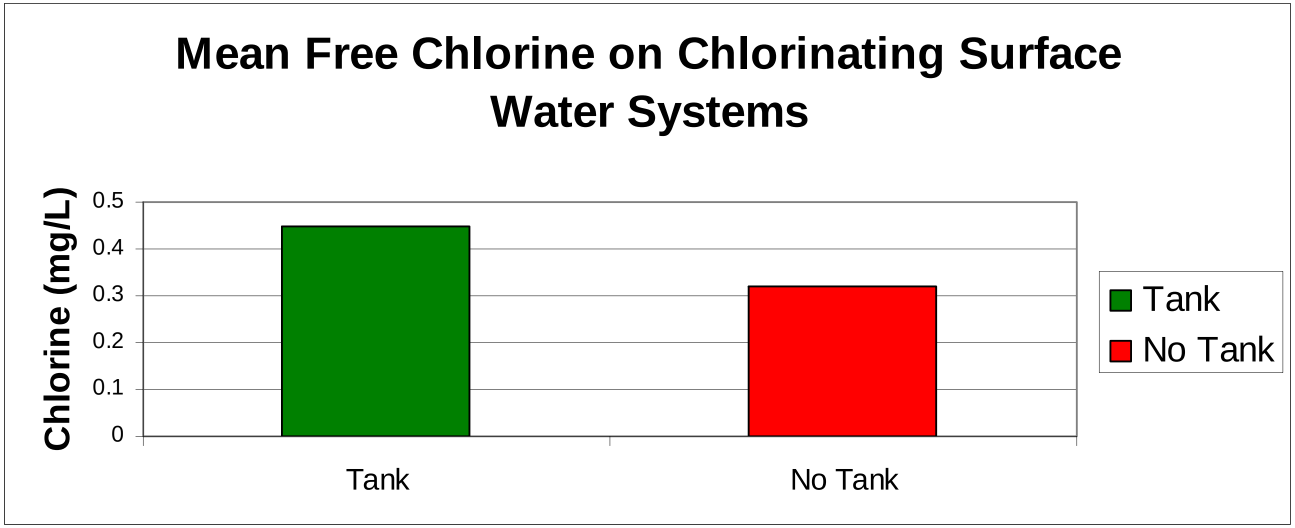
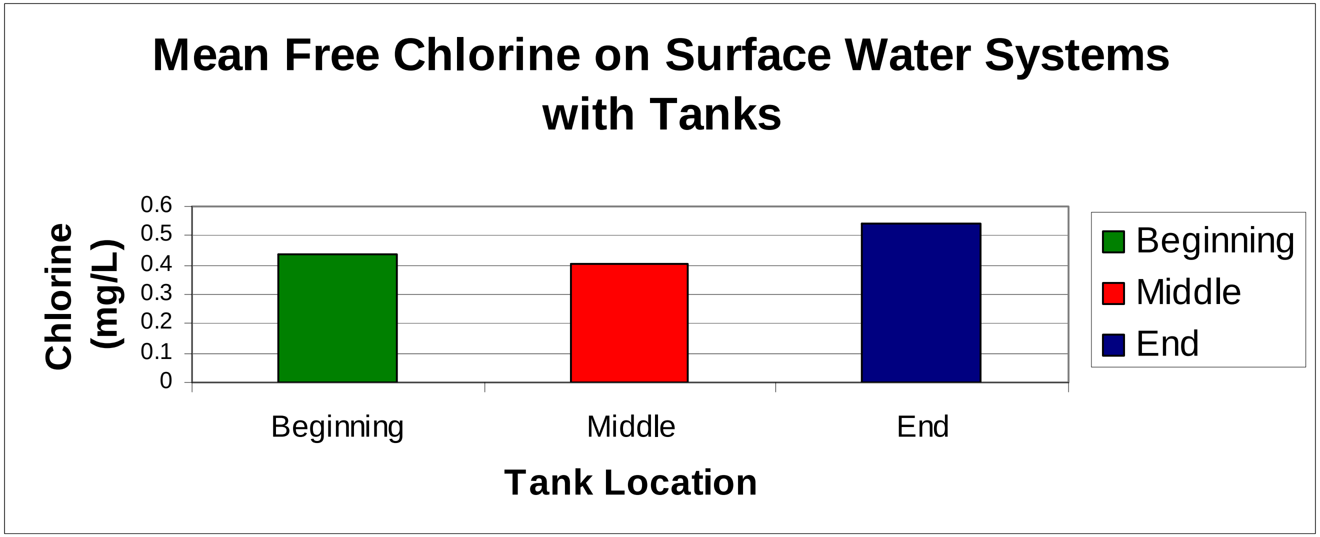
How Tanks Affect Free Chlorine in Distribution Systems in NL





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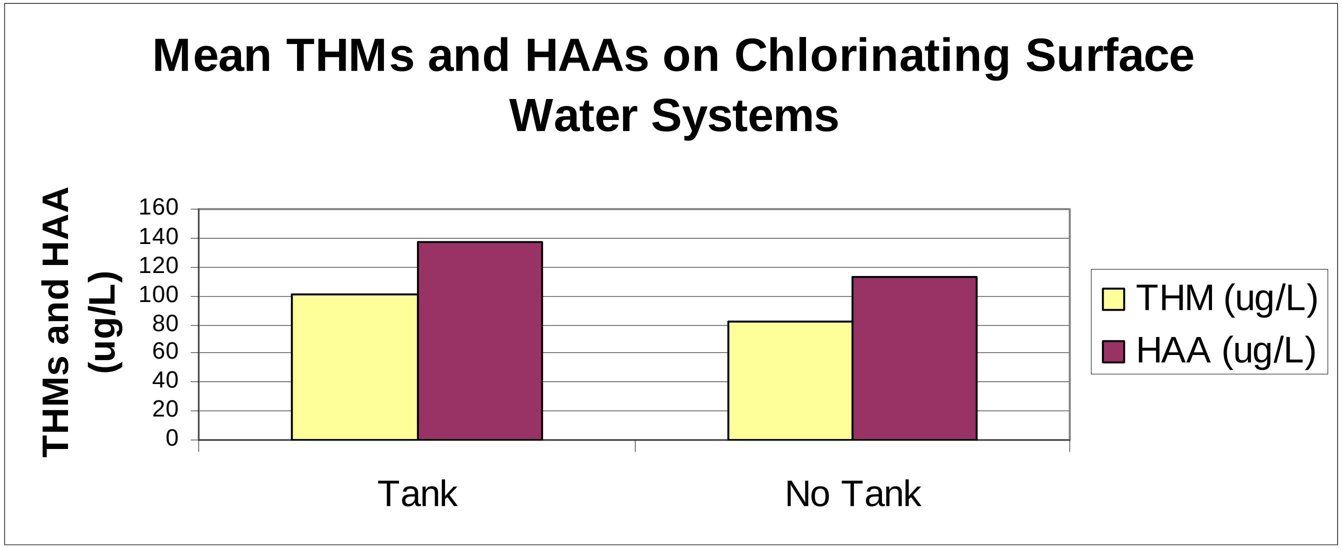
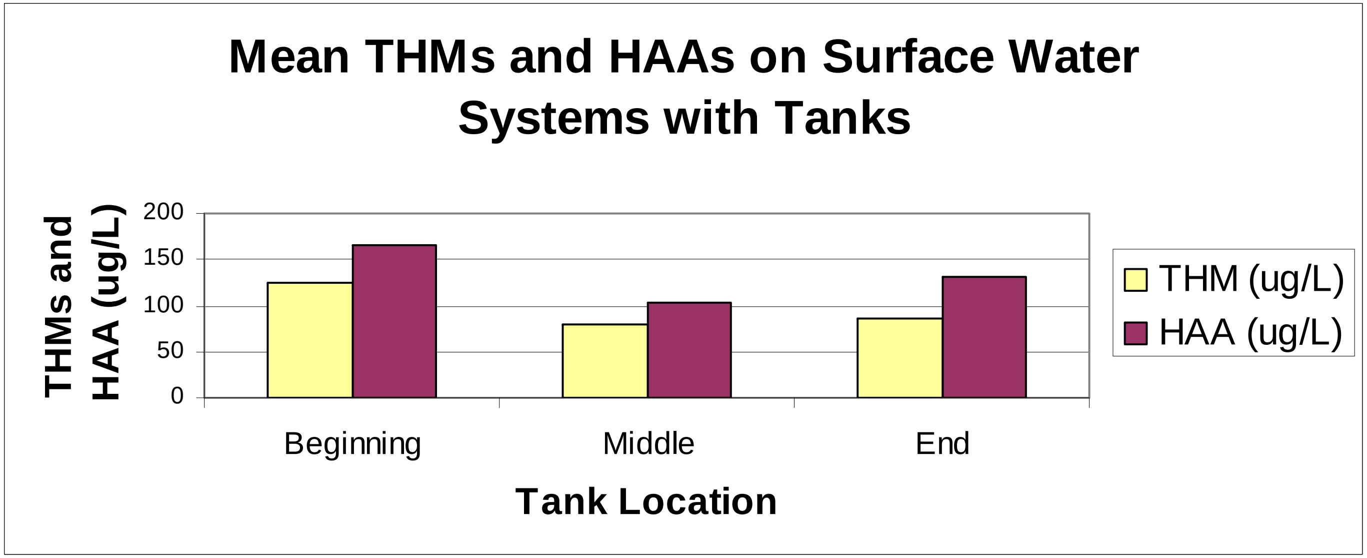
How Tanks Affect DPBs in Distribution Systems in NL





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Issues With Tanks in NL

Town	Issue
Bird Cove	Town put on BWA due to loss of free chlorine and long residence time in tank
Lawn	Water level controls malfunctioning
Cook's Harbour	Ice formed in tank caused walls to collapse
Glenwood	Trouble maintaining chlorine residuals
Lourdes	Tank at end of system, have to super-chlorinate, high DBPs
Port Blandford	Wide variation in free chlorine in system, DBPs, BWAs
Port aux Choix	Tank in very poor condition
Ramea	Leaks in tank
Reidville	Tank taken off-line due to concerns maintaining free chlorine, DBPs
St. Alban's	Leaks on system, hard to keep tank filled
St. Paul's	Large volume of tank inactive, DBPs

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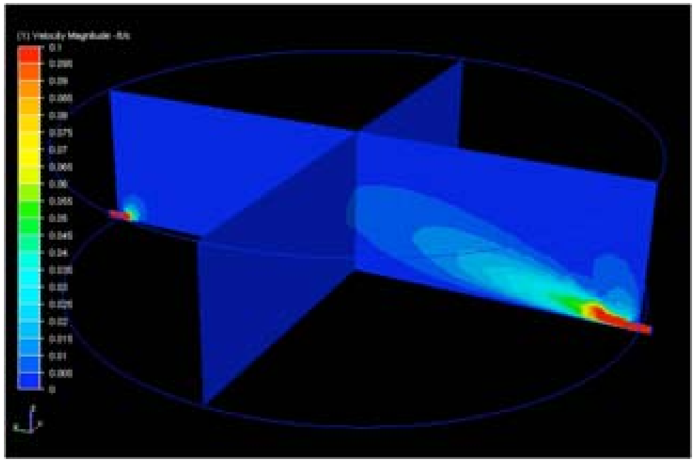
Corrective Measure- Using Models in Design of Tanks

- Water Distribution System Models
  - All elements of the water distribution system are modeled
  - Outputs include hydraulic and water quality behavior
  - Used to evaluate tank performance and operation with respect to the rest of the distribution network
- Computational Fluid Dynamics Models
  - Only the tank is modeled
  - Outputs include behavior of fluid in the tank
  - Used to evaluate tank mixing



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Corrective Measure- Promoting Mixing in Tanks

- Passive mixing:
  - Baffles, walls, obstructions
  - Inlet/outlet methods
    - Reducing diameter of inlet
    - Duckbill valve
    - Separating
  - Force turnover of water in tank
- Active mixing:
  - Adjusting pump operation
  - Install paddle or impellor device
  - Tank aeration or re-circulation

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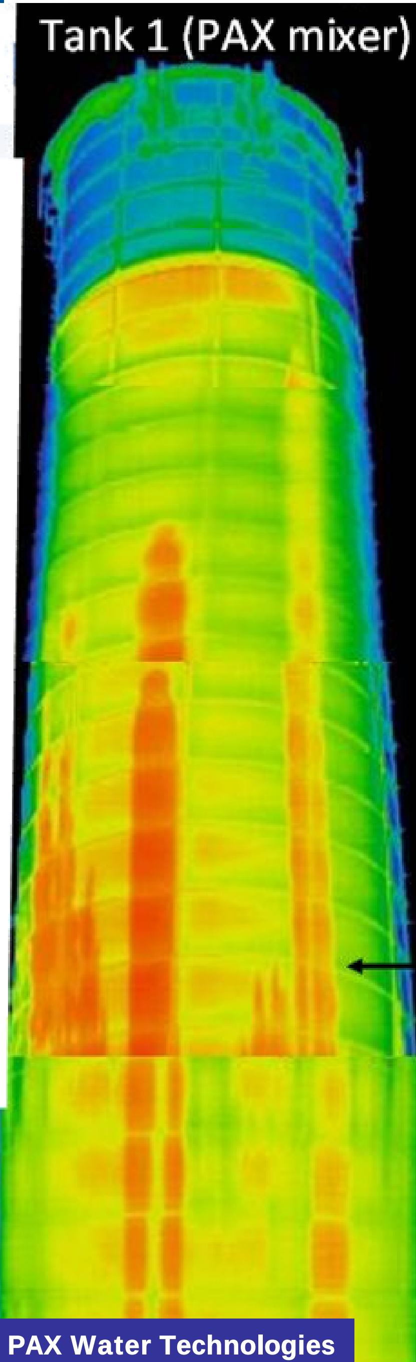

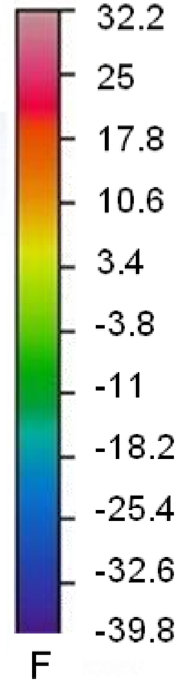

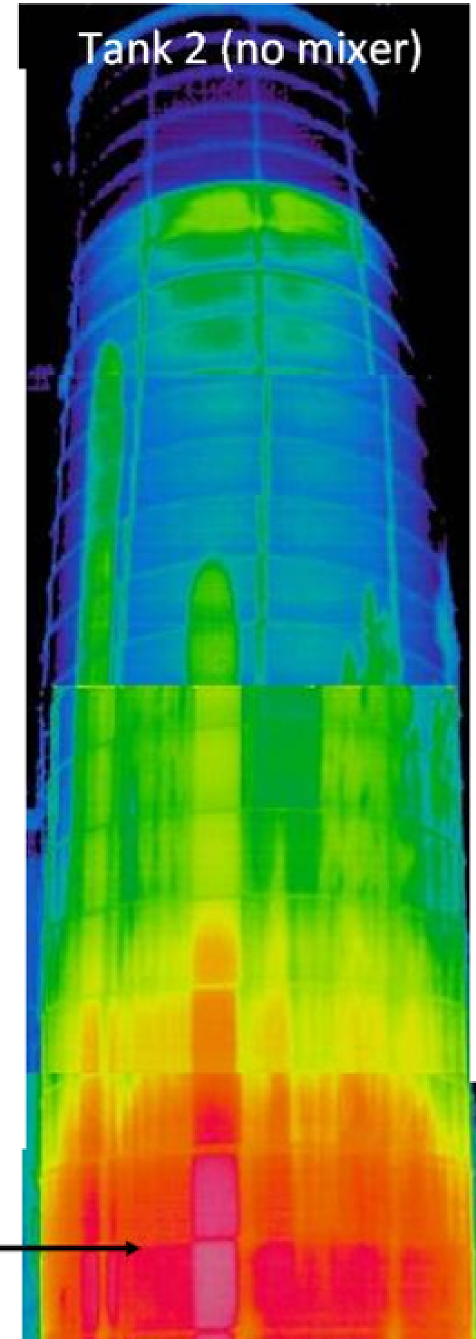

Evenly mixed/ homogeneous water all the way up to top of tank (PAX Mixer)

Pocket of warm water at tank bottom (no mixer)

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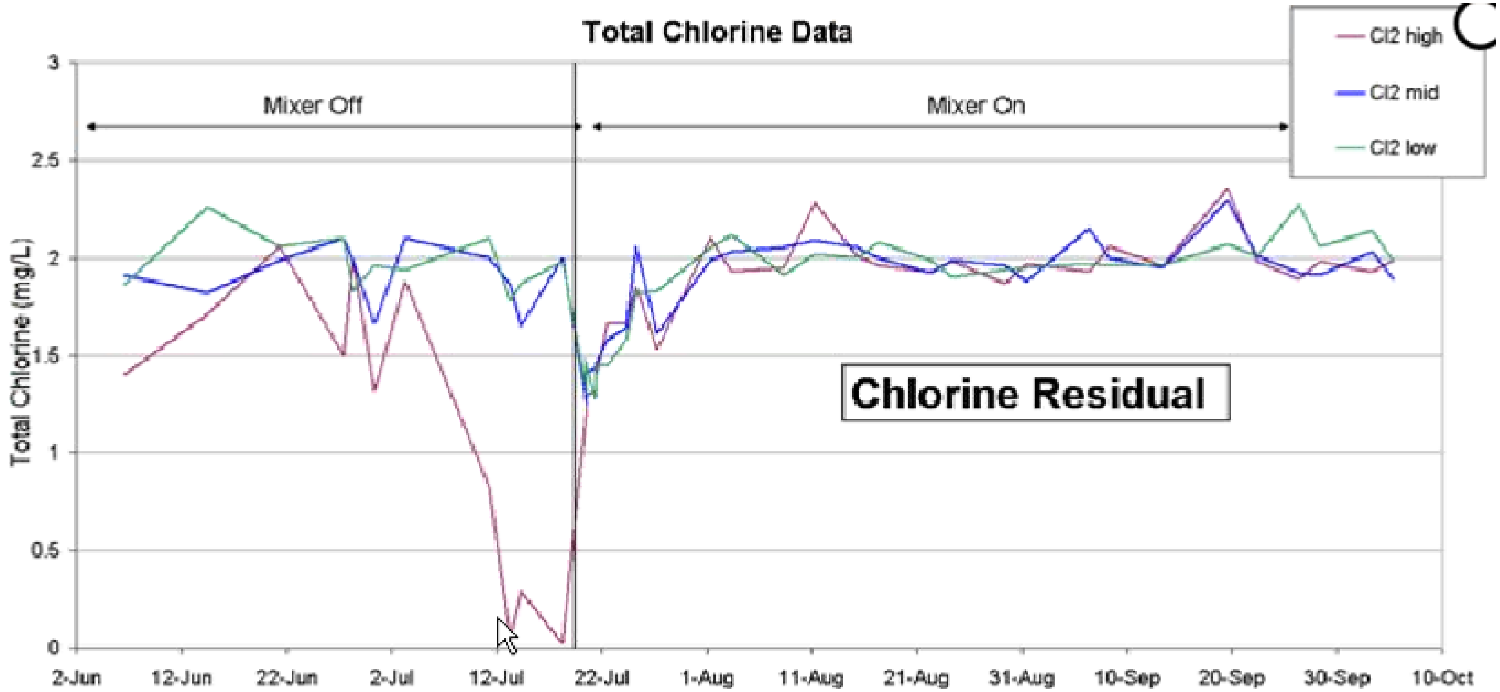

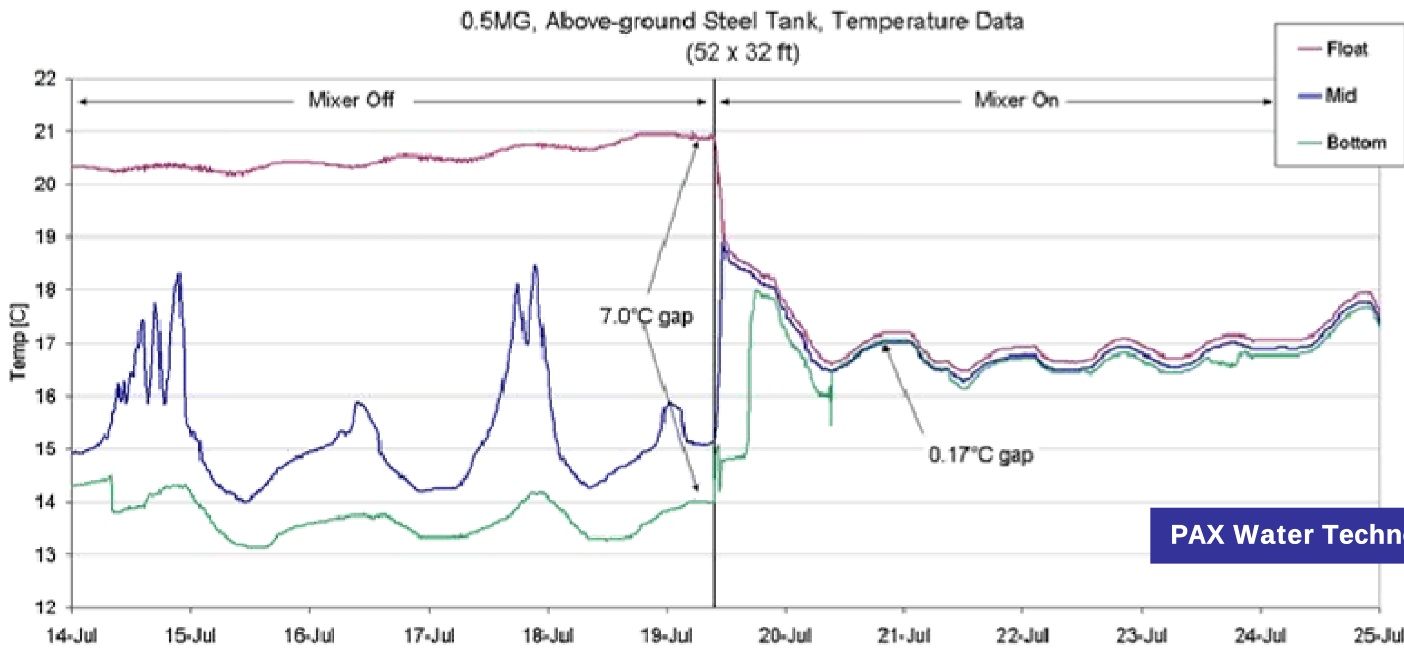

PAX Water Technologies

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Corrective Measure- Regulatory Control of Design & Operation of Tanks

- Consideration of water quality in tank design
- Performance specifications for tanks
  - Inlet location relative to tank geometry
  - Inlet momentum
  - Volume turnover
  - Fill time
  - Residence time
- Operator education and training on tank inspection and maintenance of altitude valves
- Promotion of Retention Time Management (RTM):
  - Optimize tank location and type
  - Optimize pump schedule
  - Reduce storage capacity
- Tank maintenance requirements are stipulated in Permits to Operate for water distribution systems
- Monitoring of tank operation:
  - Water level
  - Chlorine residual
  - Water temperature

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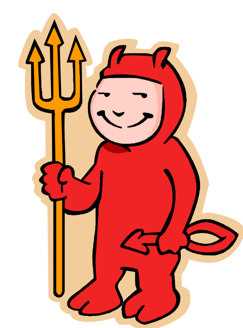
Blessing or Curse

- Equalize supply and demand of water
- To supply water during emergencies such as fire flow, power outages, and loss of pumping capacity
- To minimize pressure variation during periods of high consumption
- To reduce pump size and energy costs
- To increase pressure in the distribution system
- Surge protection
- Blending of water sources
- Providing contact time for disinfectants to inactivate pathogens
- To provide water for industrial demands

- Water quality deterioration
- Poor mixing, inadequate water turnover, dead zones
- DBP formation
- Loss of free chlorine residual
- Wide variation in chlorine residuals
- Mismatch between tank size and water demand
- Water stratification and stagnation
- Failure to meet GCDWQ
- Excessive use of disinfection chemicals
- Something other than water gets in tank



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Summary

- Water storage tank is the most visible asset in your water distribution system
- Make sure your water storage tank remains an asset and not a liability

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