Tank Mixing: Improve Water Quality and Minimize Ice Damage

August 5, 2015

Dr. Peter S. Fiske
PAX Water Technologies, Inc.


Water storage tanks are an expensive asset ($2-$4 per stored gallon)
Most do NOTHING to help manage water quality…

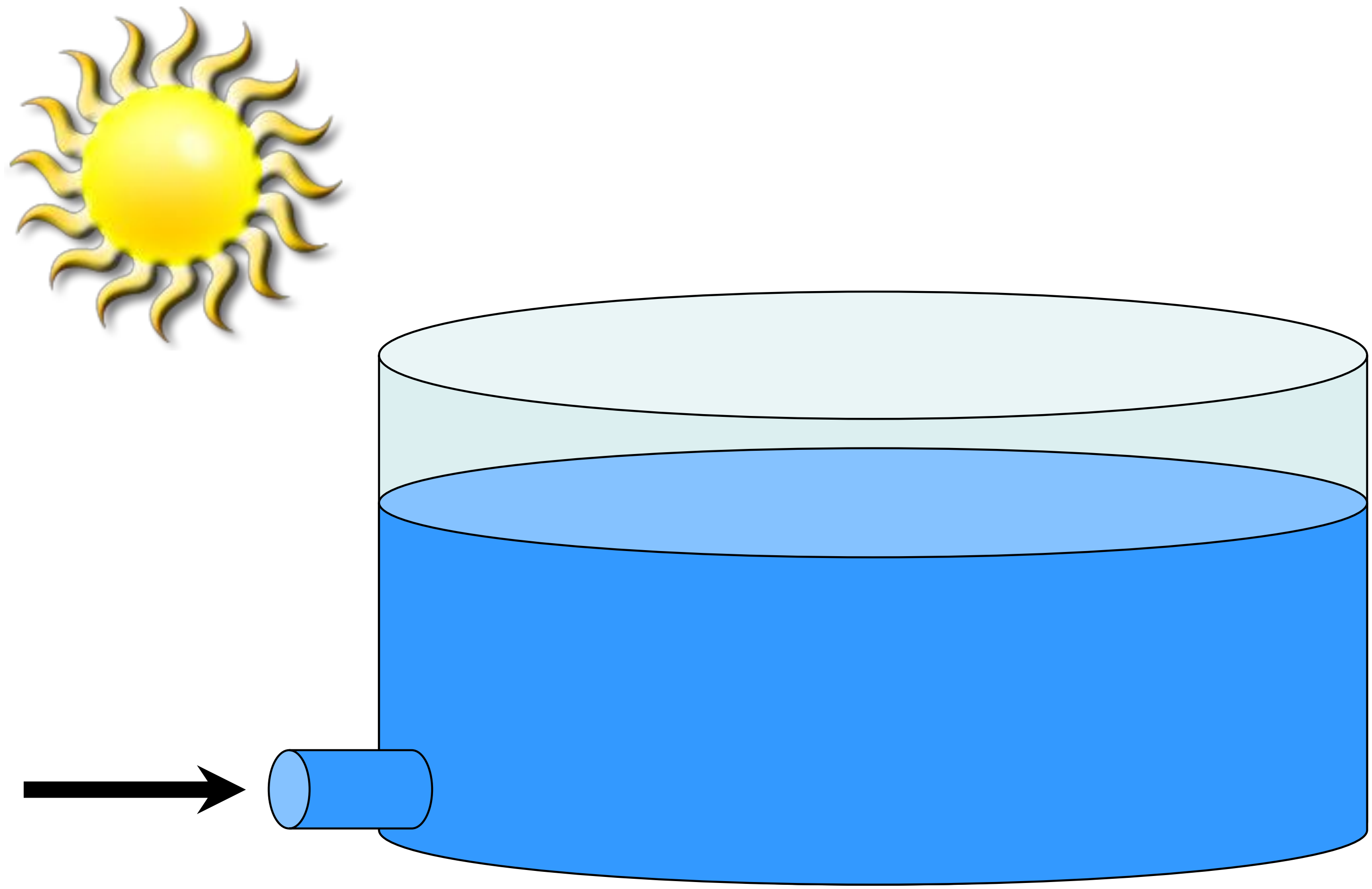
=

As presently operated, water storage tanks are a liability…

- Often too big for optimal distribution system operations
- Create conditions of low velocity – accumulate sediment
- Prone to thermal stratification
  - Residual loss
  - DBP formation (Summer)
  - Ice formation (Winter)

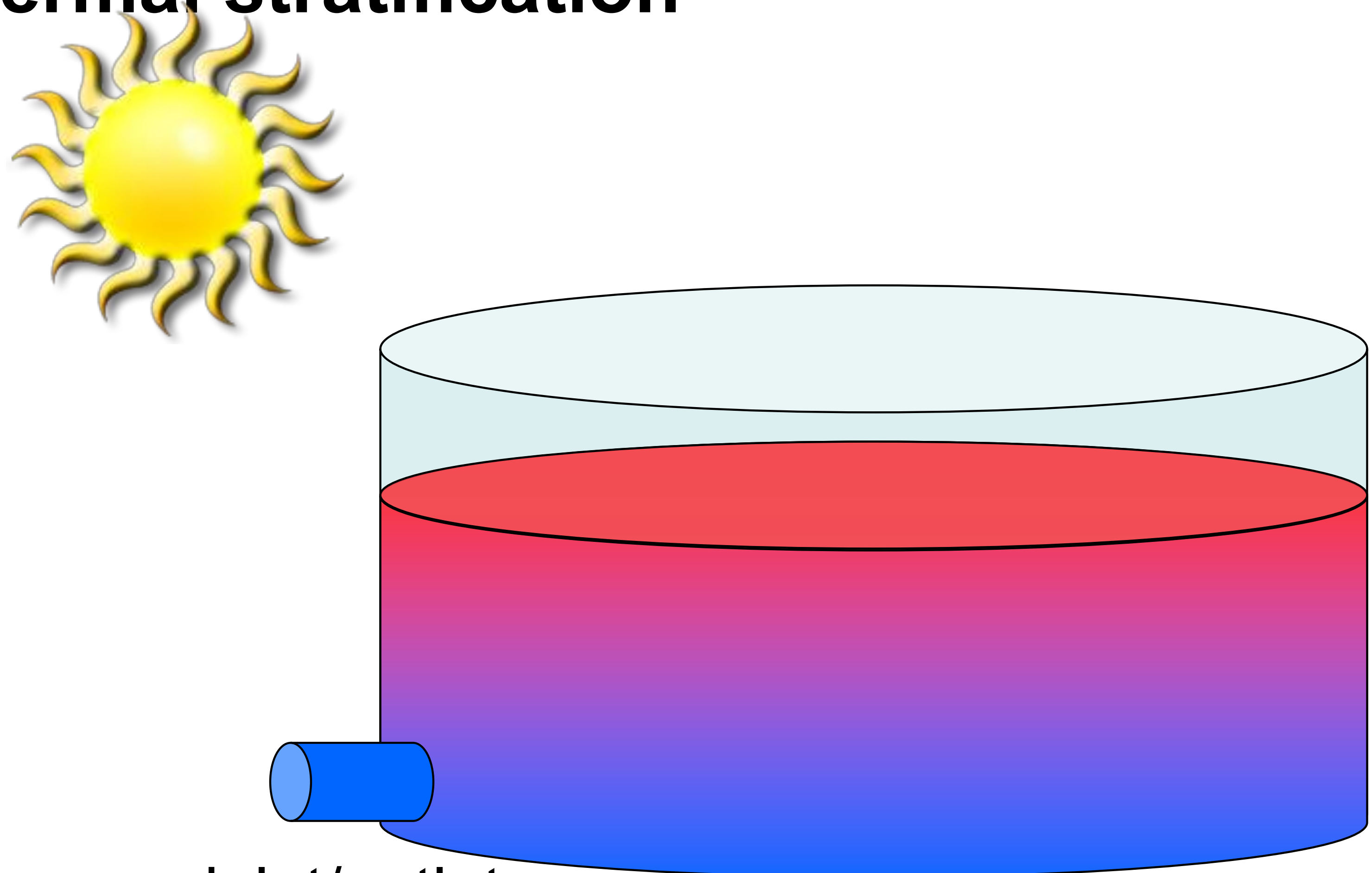
Tank Hydraulics, Active Mixing, and Water Quality

Thermal stratification



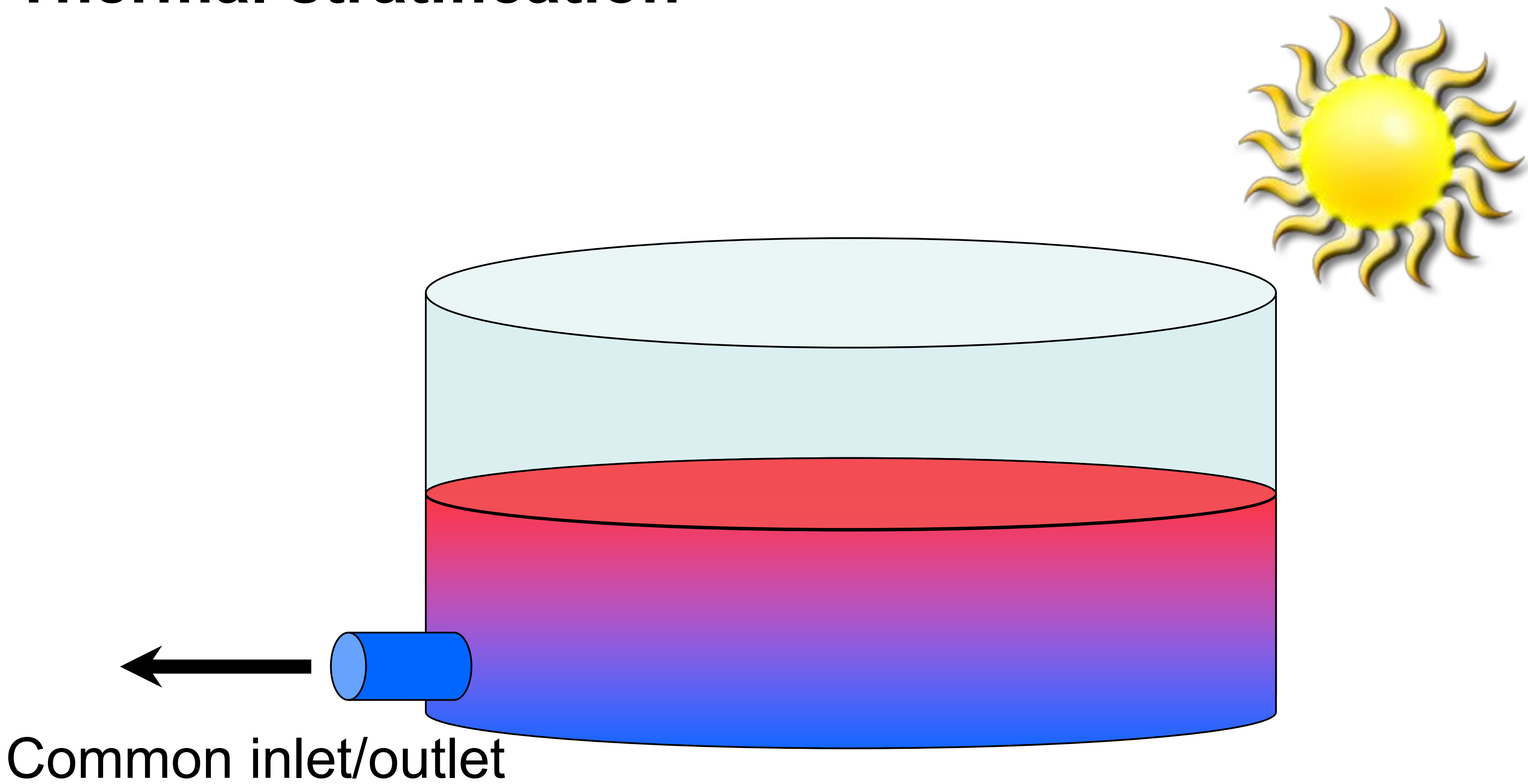
Common inlet/outlet

Thermal stratification

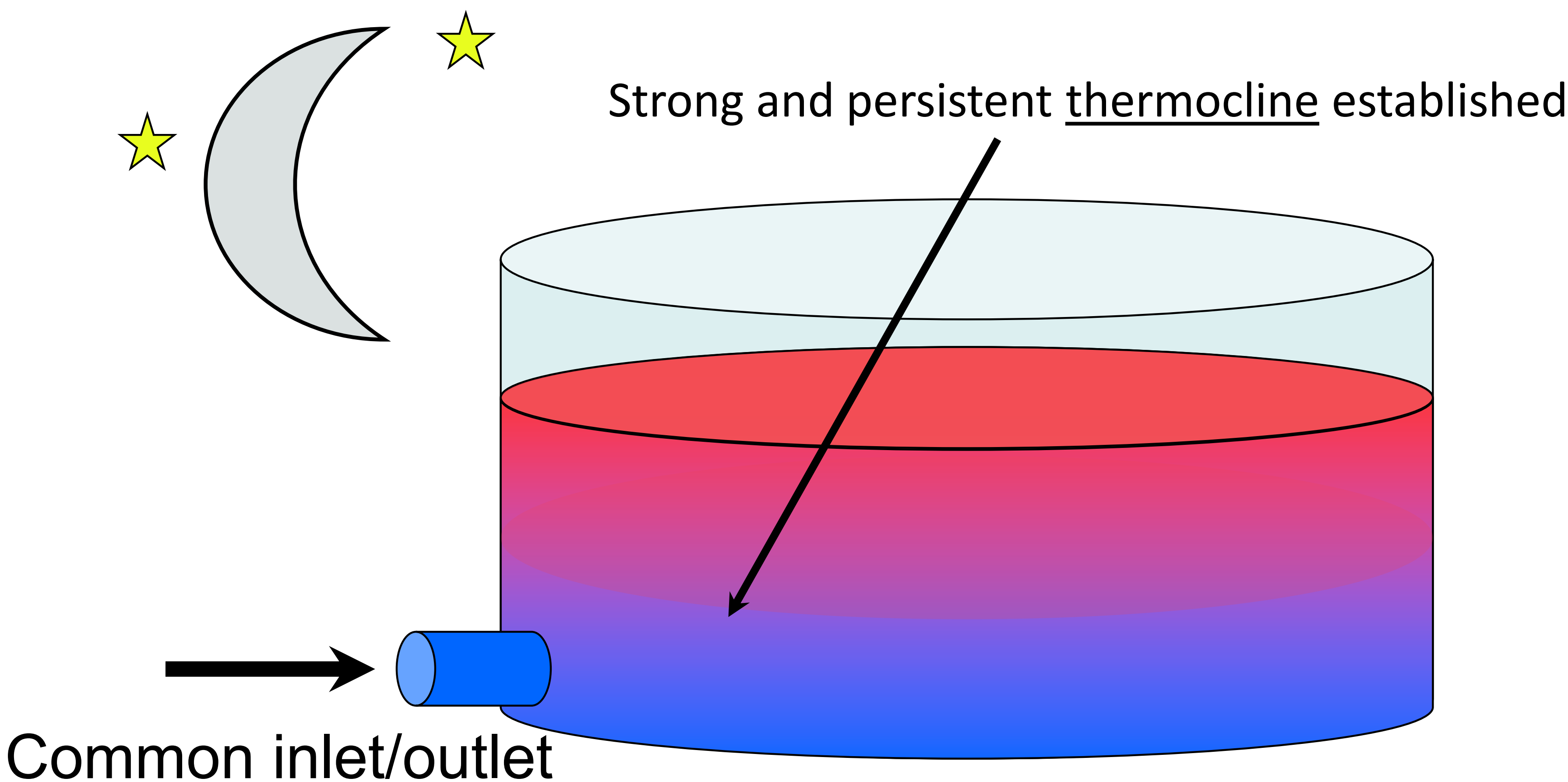


Common inlet/outlet

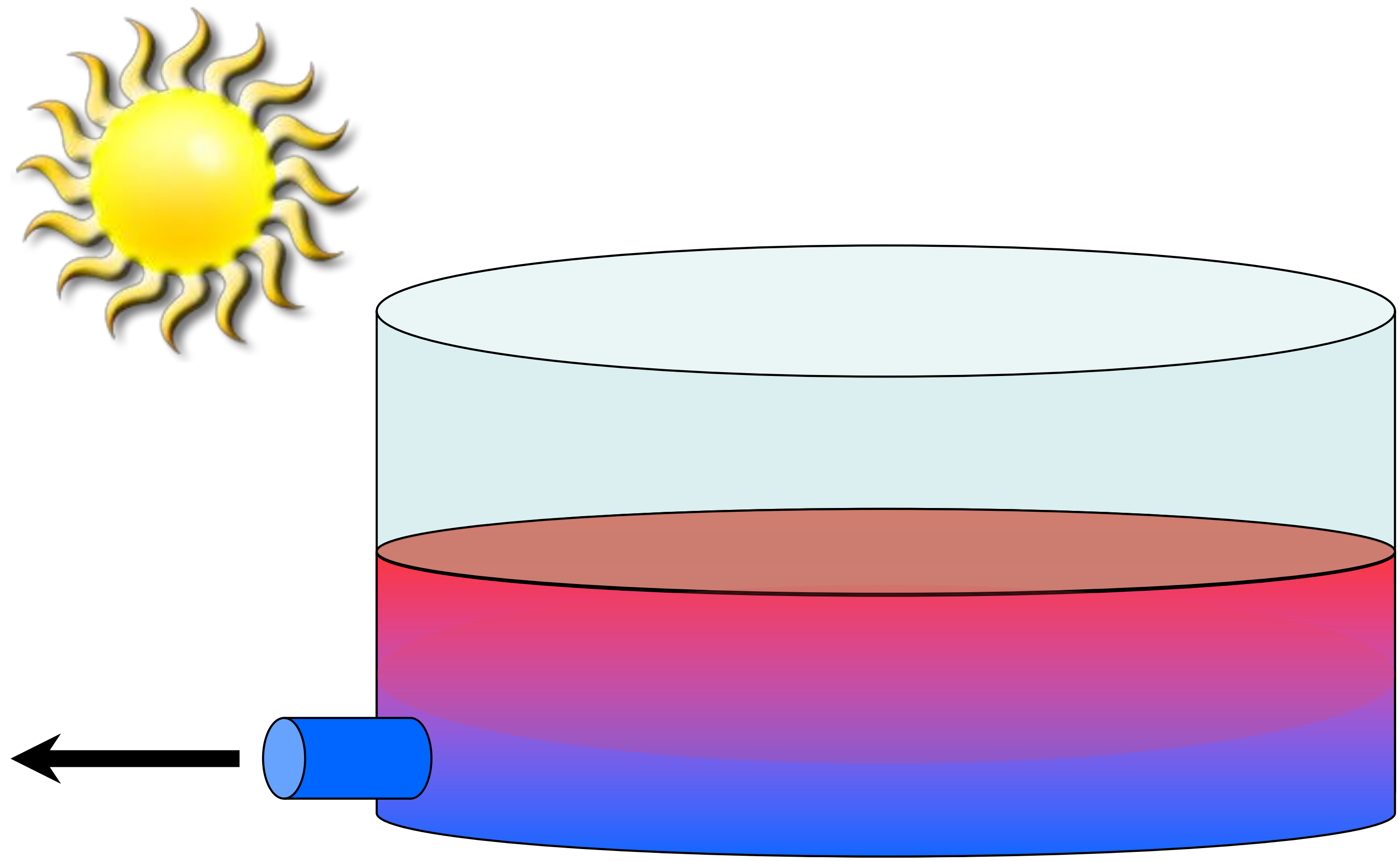
Thermal stratification



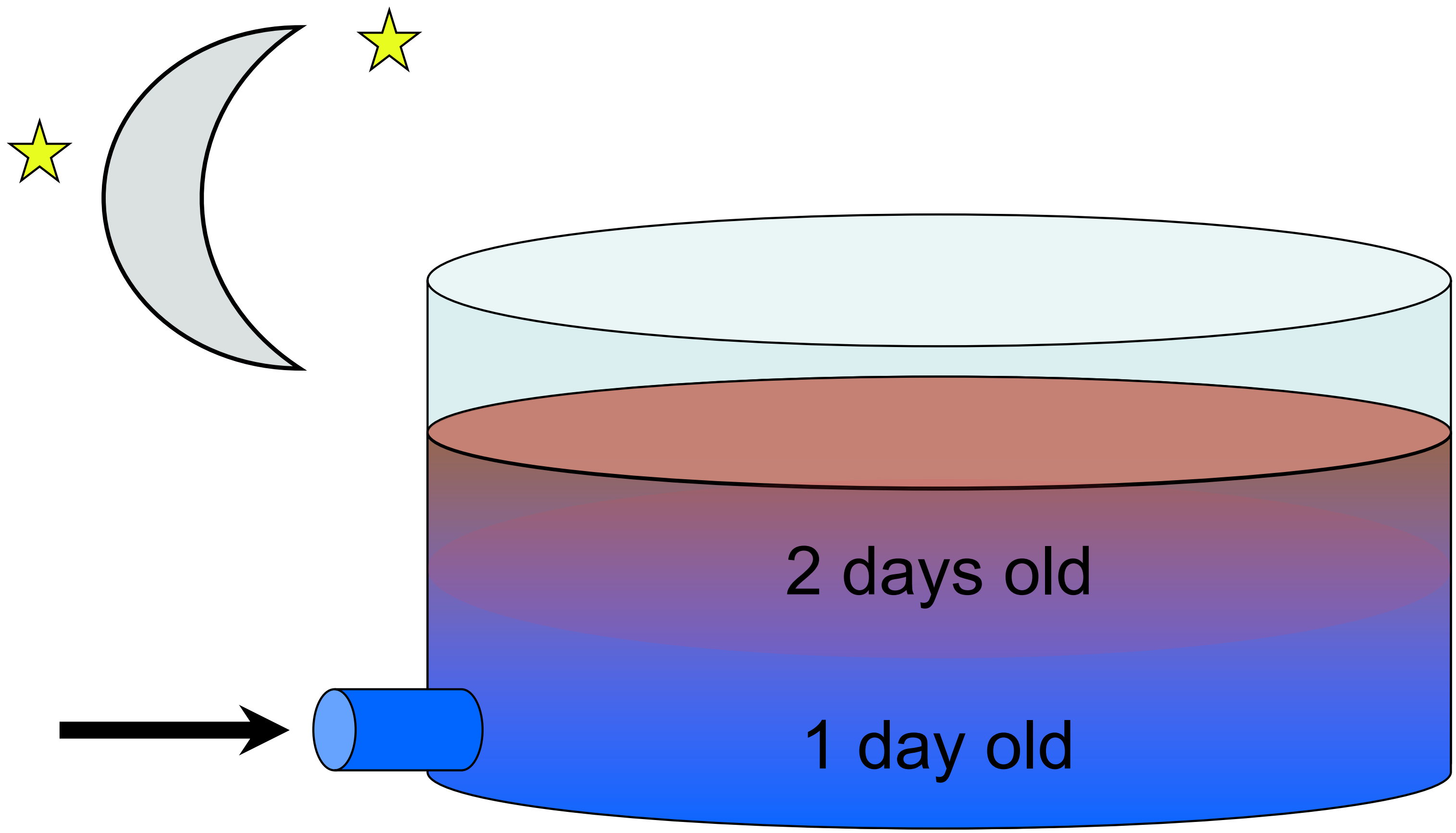
Thermal stratification



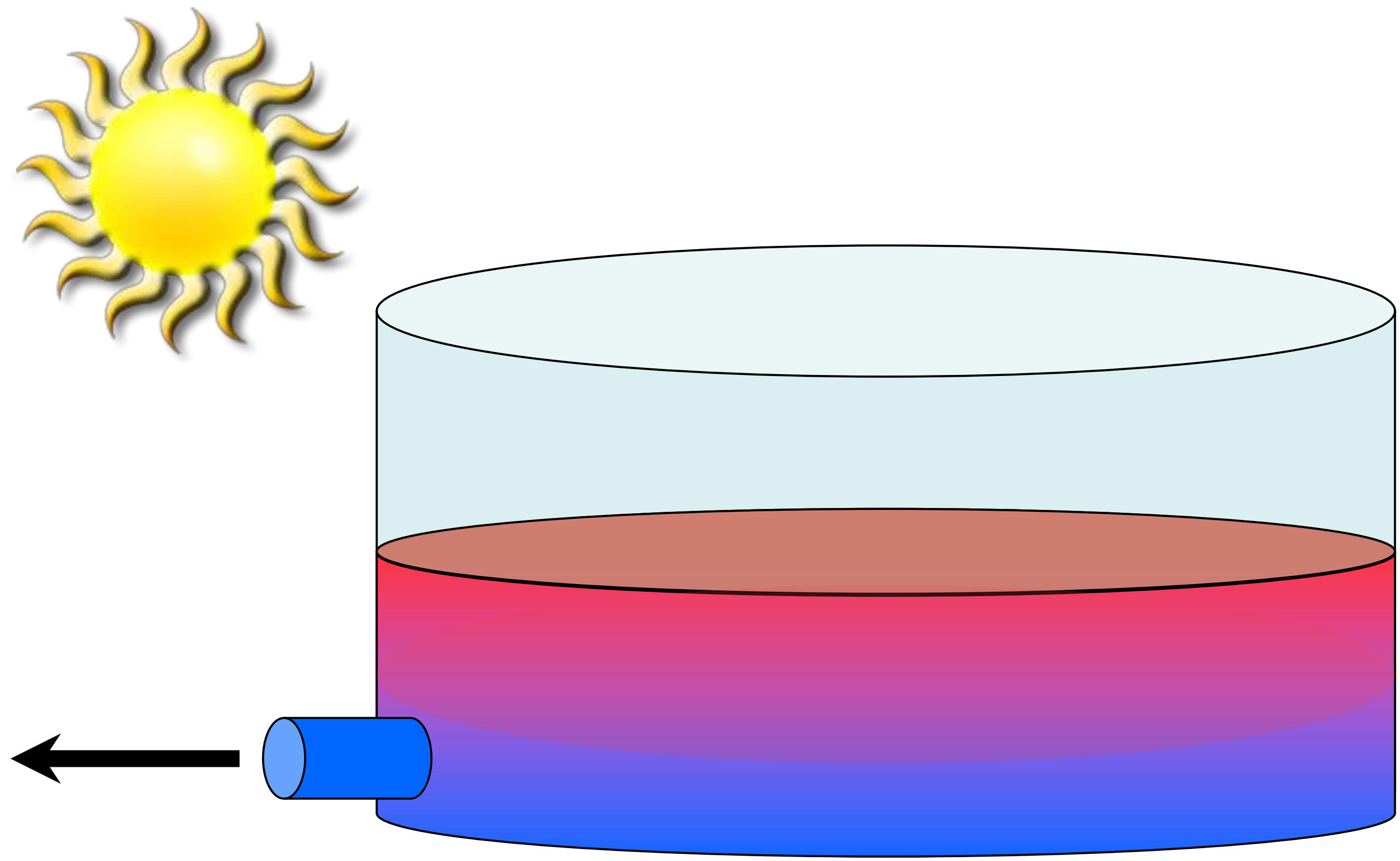
Thermal stratification



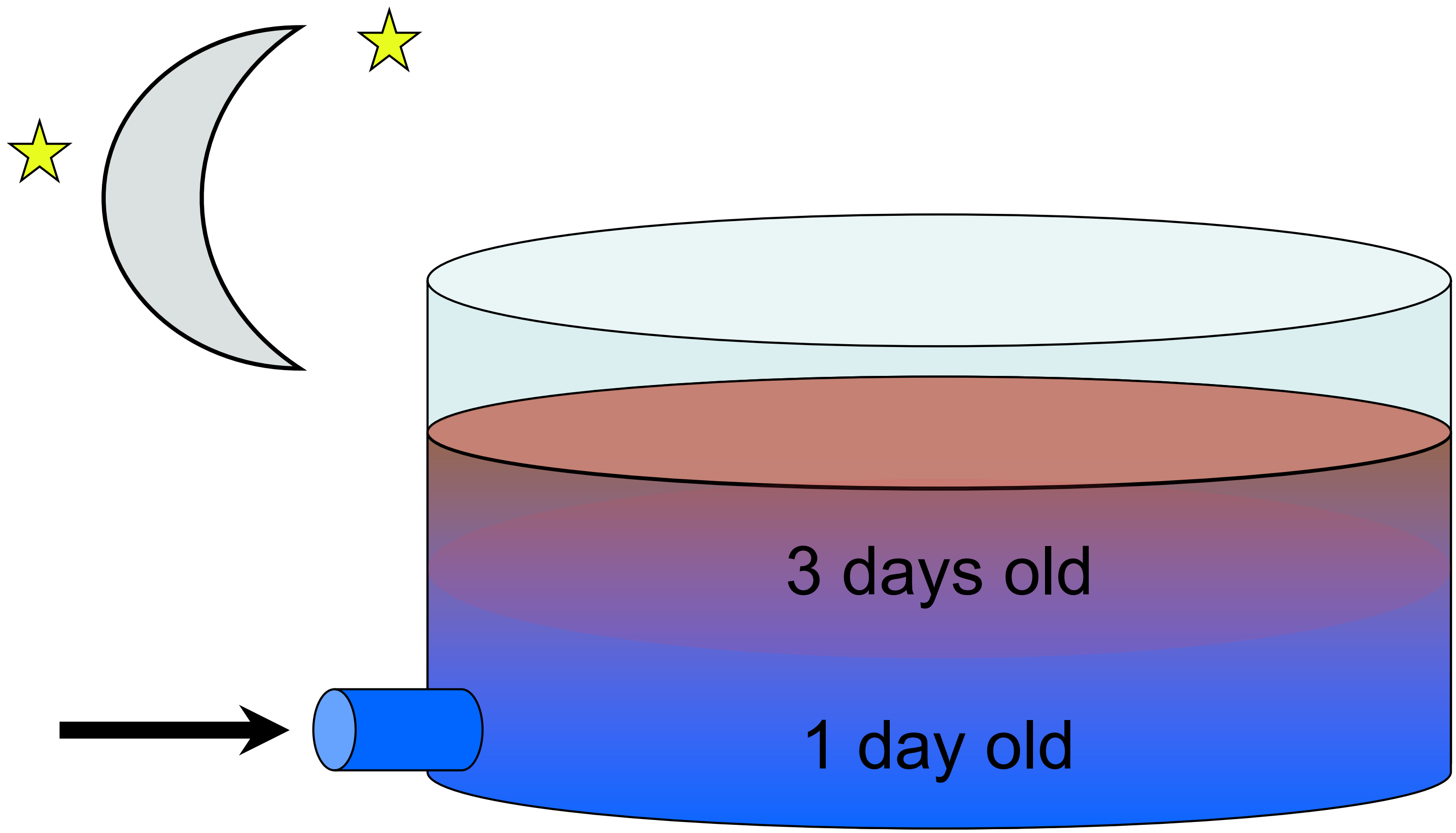
Thermal stratification



Thermal stratification

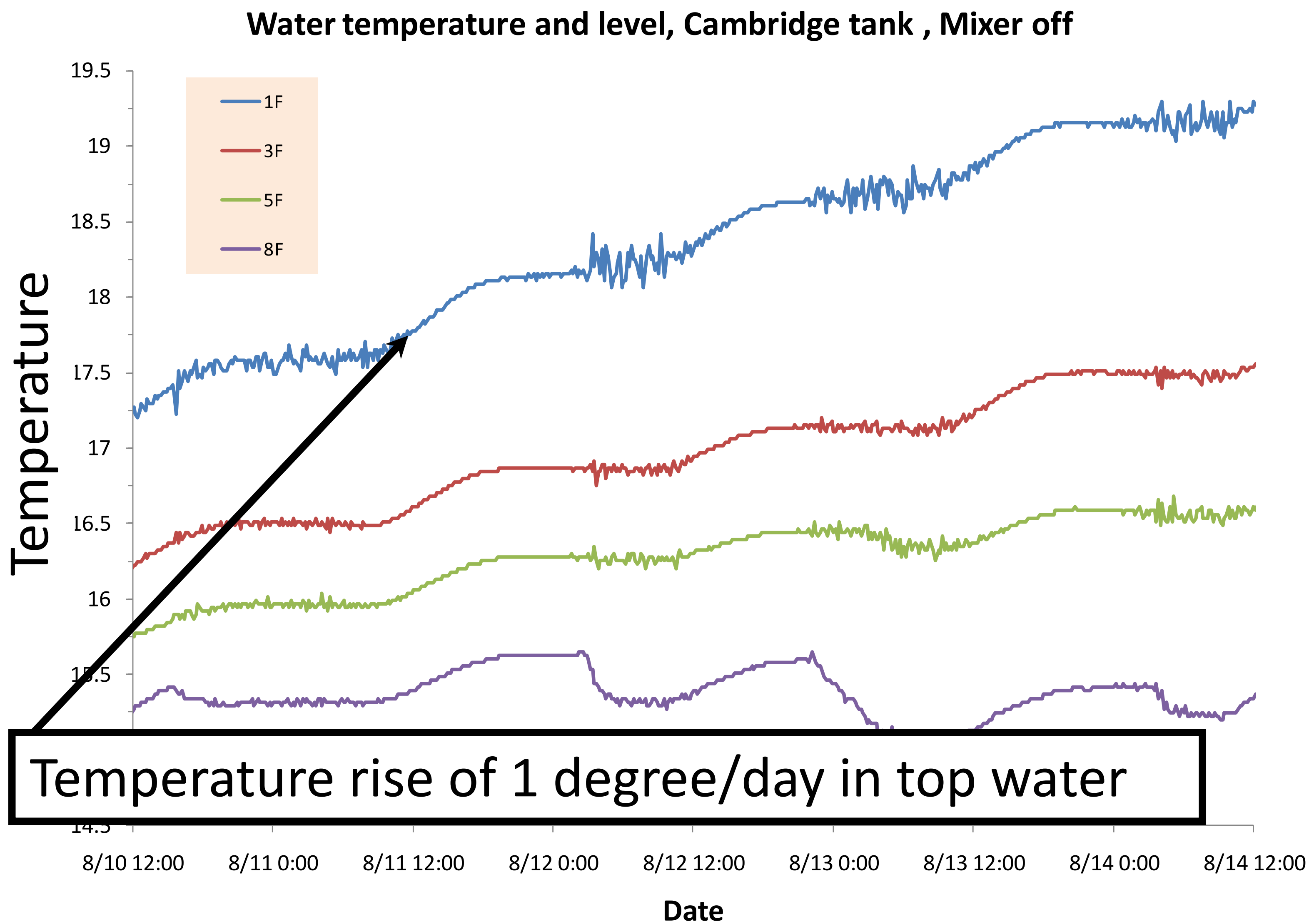


Thermal stratification

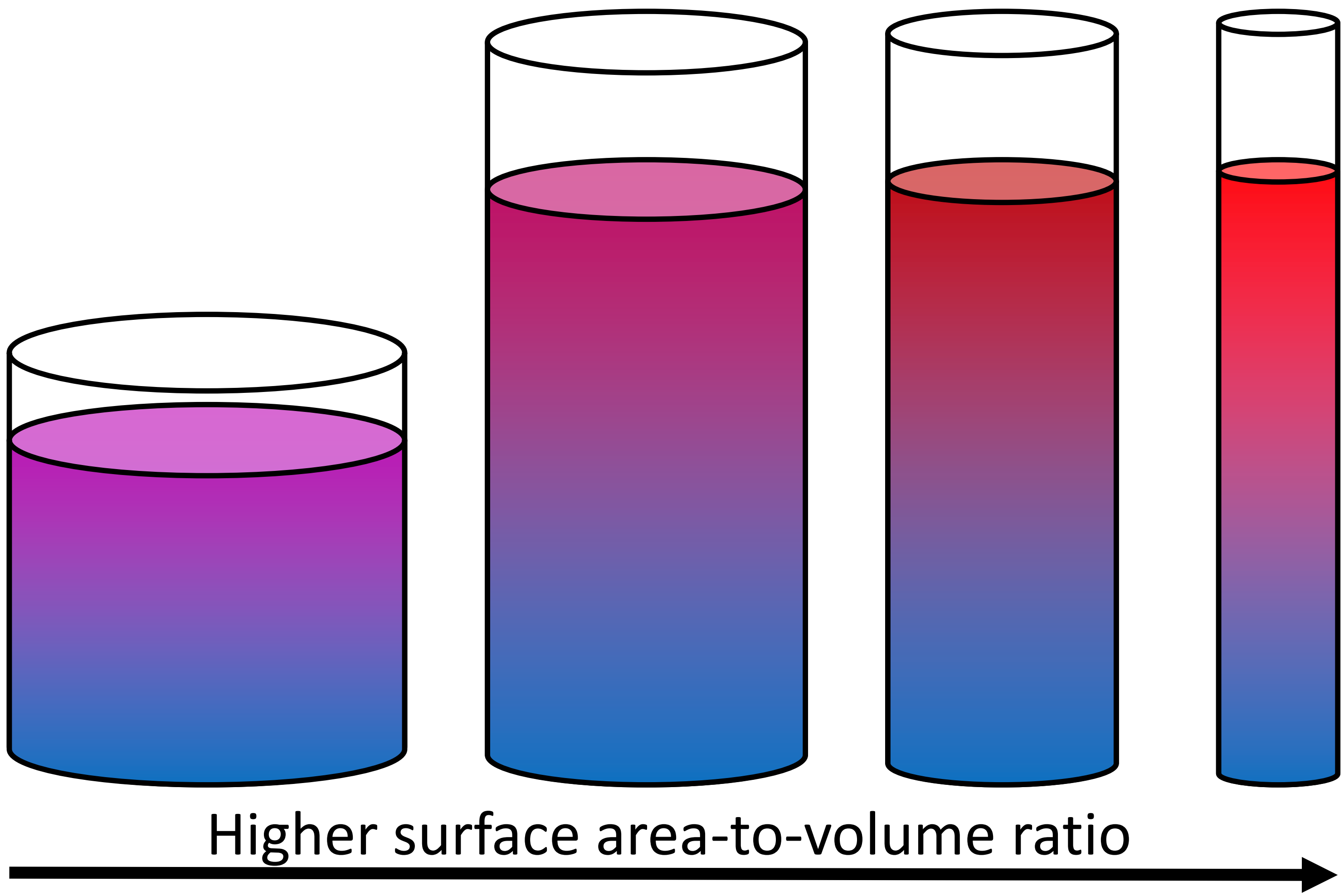


Stratified tanks can have HIGH water age…

Thermal stratification data



Thermal stratification problems get worse, as aspect ratio increases…



How do I know my standpipe needs better mixing?

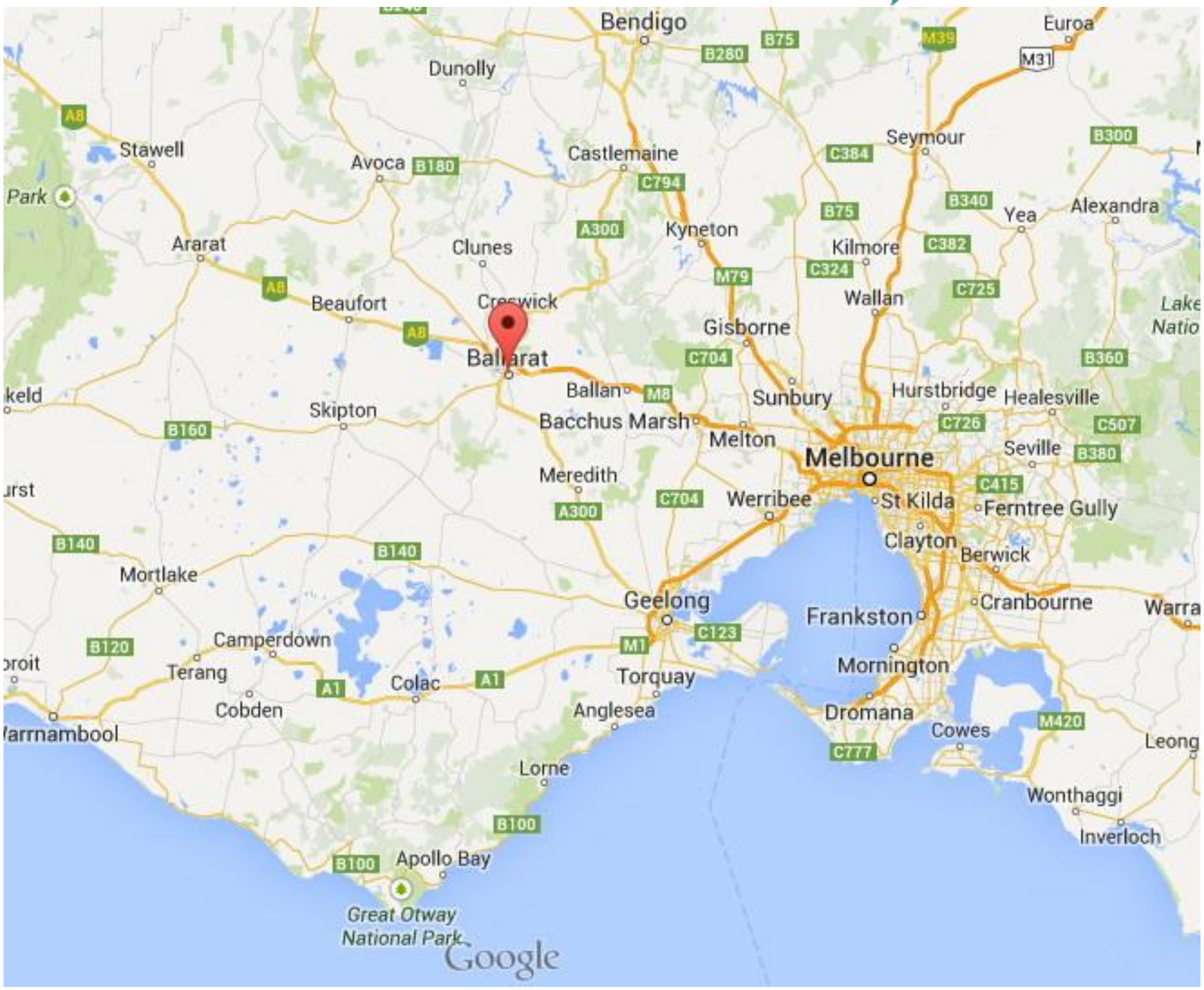
- Lower residual at the top versus the bottom
  - Residual drops as I drain my standpipe
- Higher temperature in the water at the top
- “Sweat mark” midway up the standpipe
  - Thermocline
- Ice formation at the top in winter

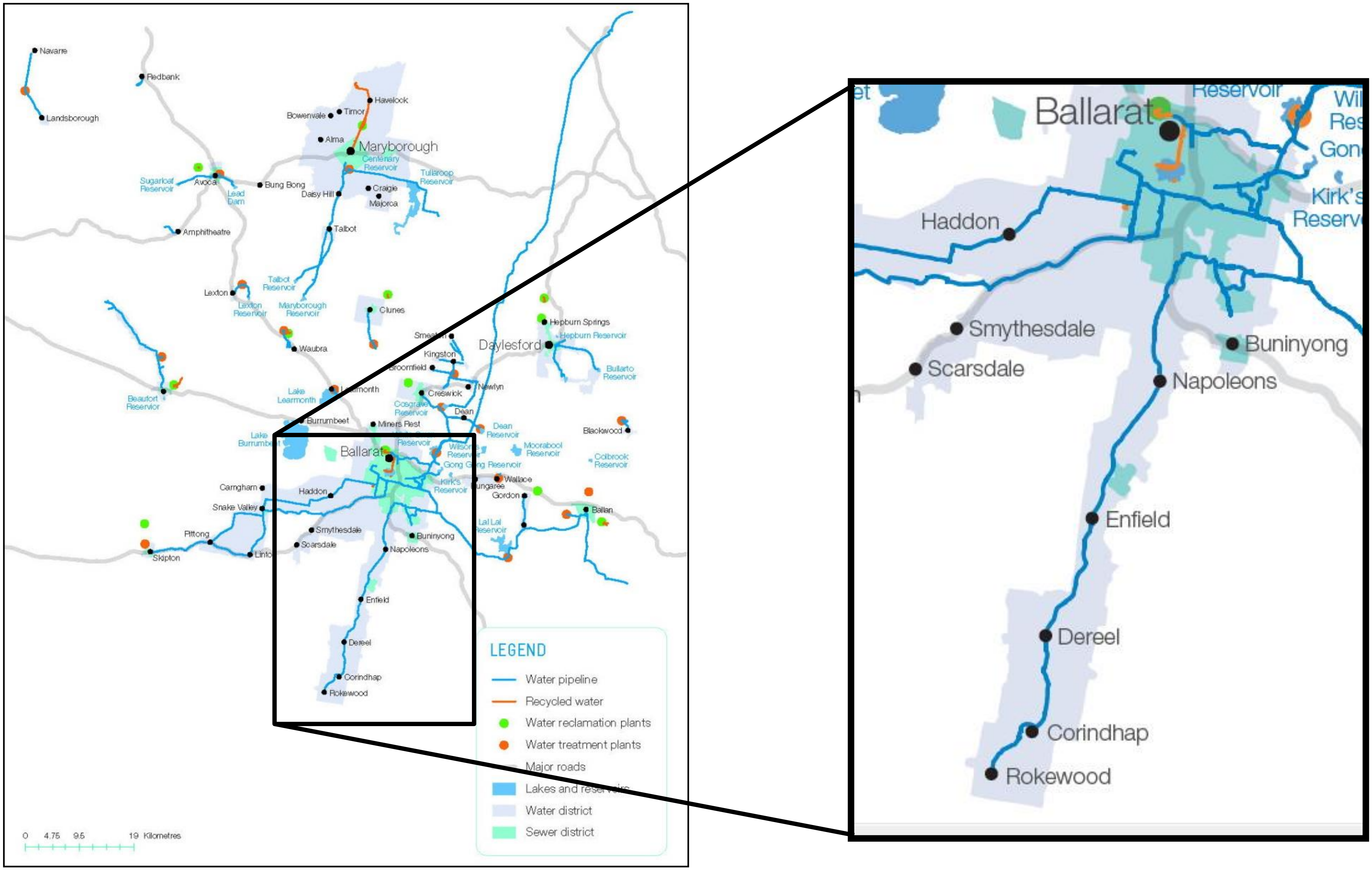
Honestly: we have not found a standpipe that did not show significant stratification at least some of the time

Active Mixing for Water Quality Improvement

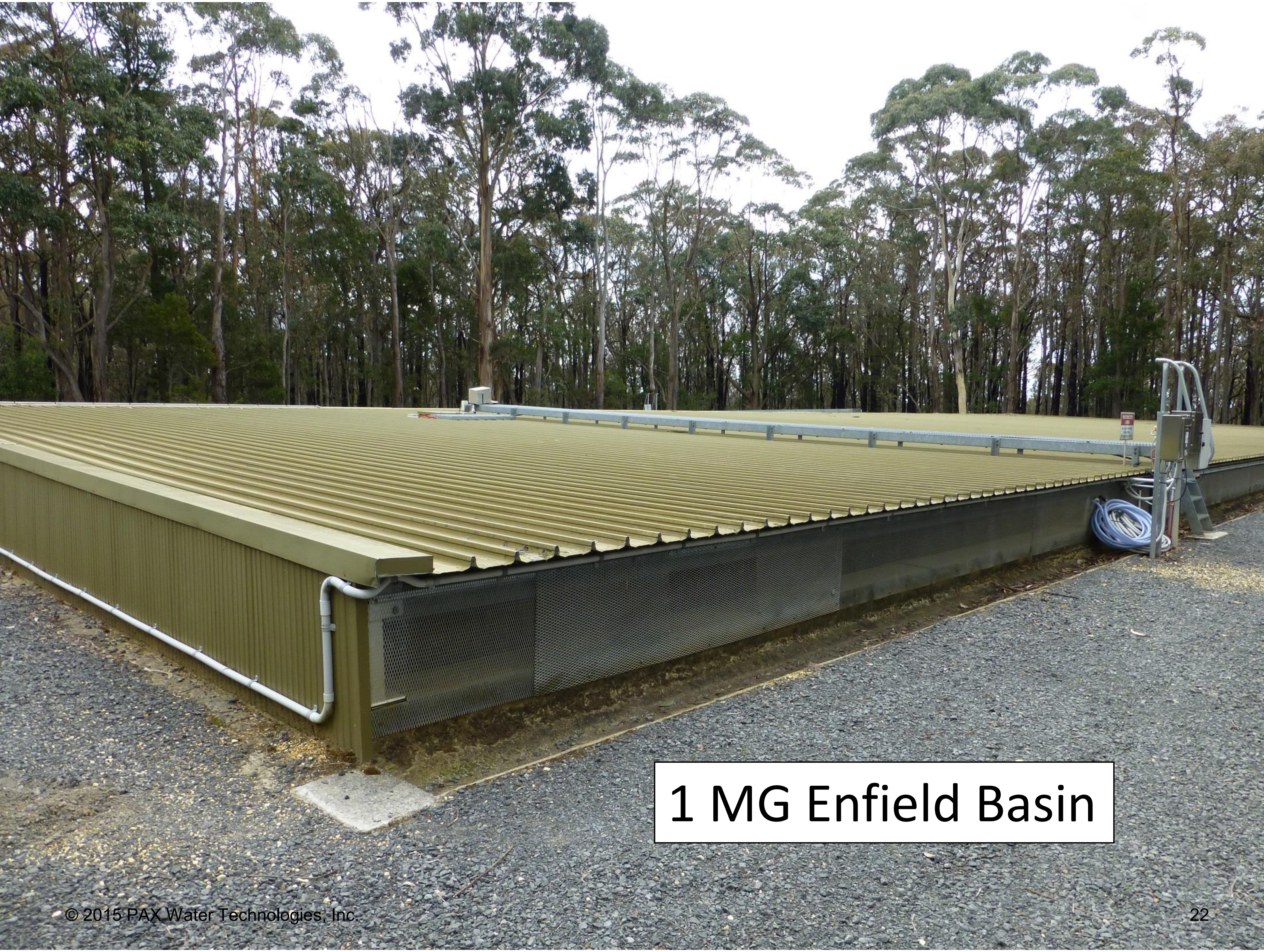
Case Studies

Central Highlands Water



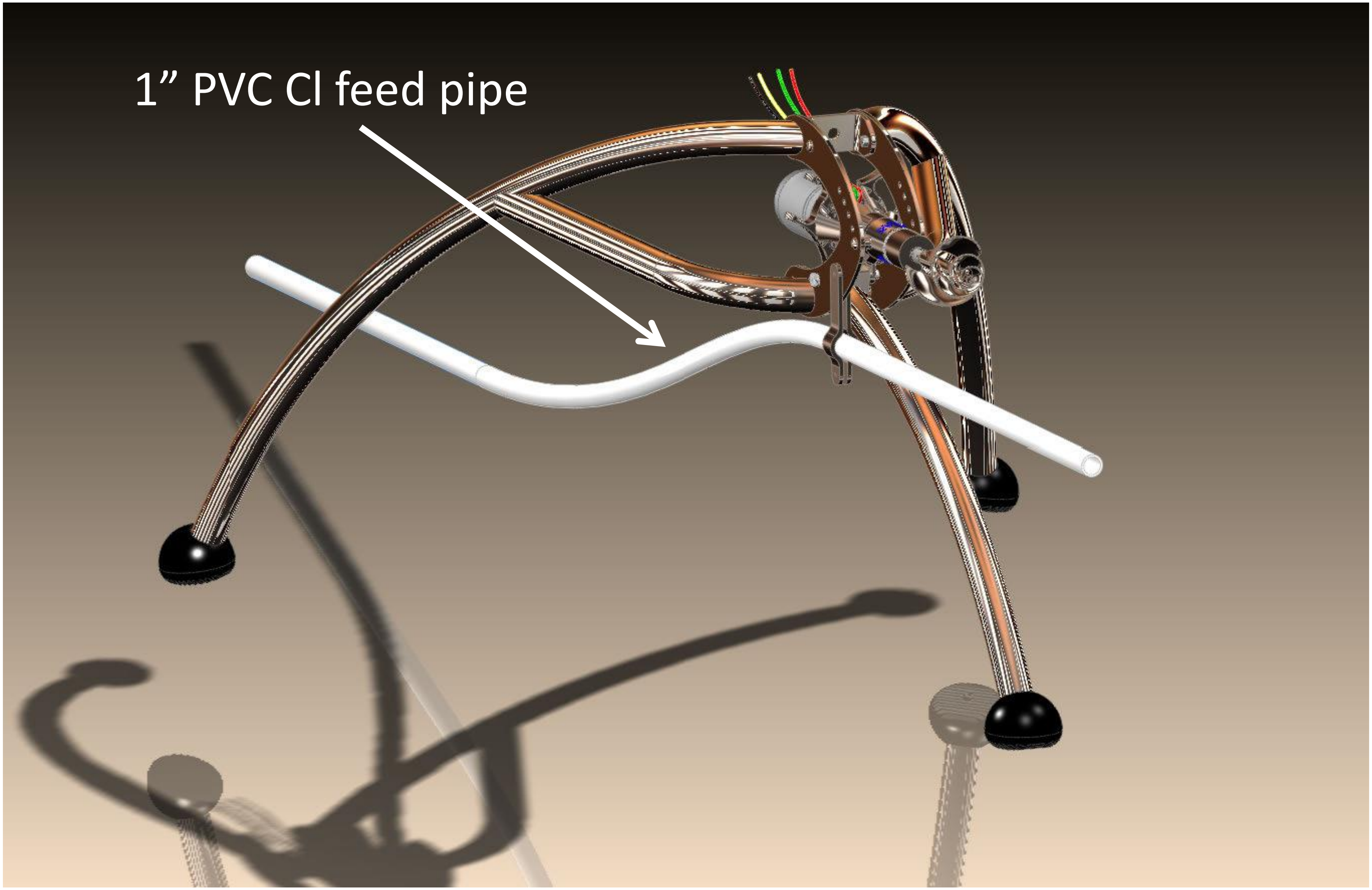

Navarre
Landsborough
Redbank
Havelock
Timor
Bowenvale
Alma
Maryborough
Centenary Reservoir
Tullaroop Reservoir
Sugarloaf Reservoir
Avoca
Lead Dam
Bung Bong
Daisy Hill
Craigie
Majorca
Amphitheatre
Talbot
Talbot Reservoir
Lexton
Lexton Reservoir
Maryborough Reservoir
Clunes
Hepburn Springs
Hepburn Reservoir
Waubra
Daylesford
Bullarto Reservoir
Kingston
Creswick
Newlyn
Beaufort Reservoir
Lake Learmonth
Burrumbeet
Miners Rest
Dean
Dean Reservoir
Blackwood
Lake Burrumbeet
Ballarat
Moorabool Reservoir
Colbrook Reservoir
Gong Gong Reservoir
Wallace
Gordon
Carngham
Haddon
Kirk's Reservoir
Ballan
Snake Valley
Lal Lal Reservoir
Pittong
Smythesdale
Buninyong
Scarsdale
Napoleons
Skipton
Enfield
Dereel
Corindhap
Rokewood
LEGEND
Water pipeline
Recycled water
Water reclamation plants
Water treatment plants
Major roads
Lakes and reservoirs
Water district
Sewer district
0 4.75 9.5 19 Kilometres

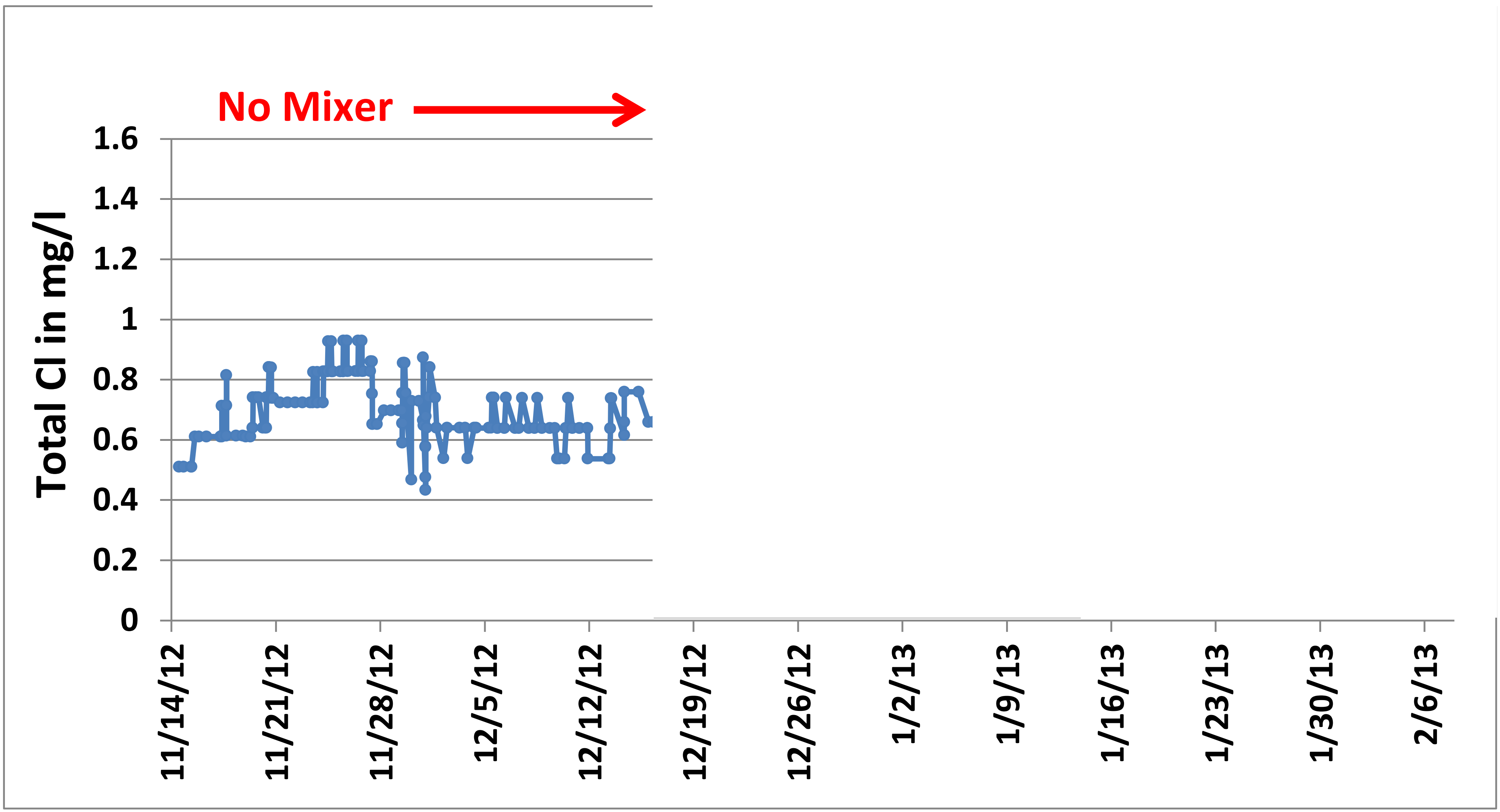

Lake
Wendouree
Alfredton
C805
Ballarat
Redan
Delacombe
Mount Clear
C294
Mount Helen
A300
Buninyong
Enfield State Park
Colac-Ballarat Rd
Colac-Ballarat Rd

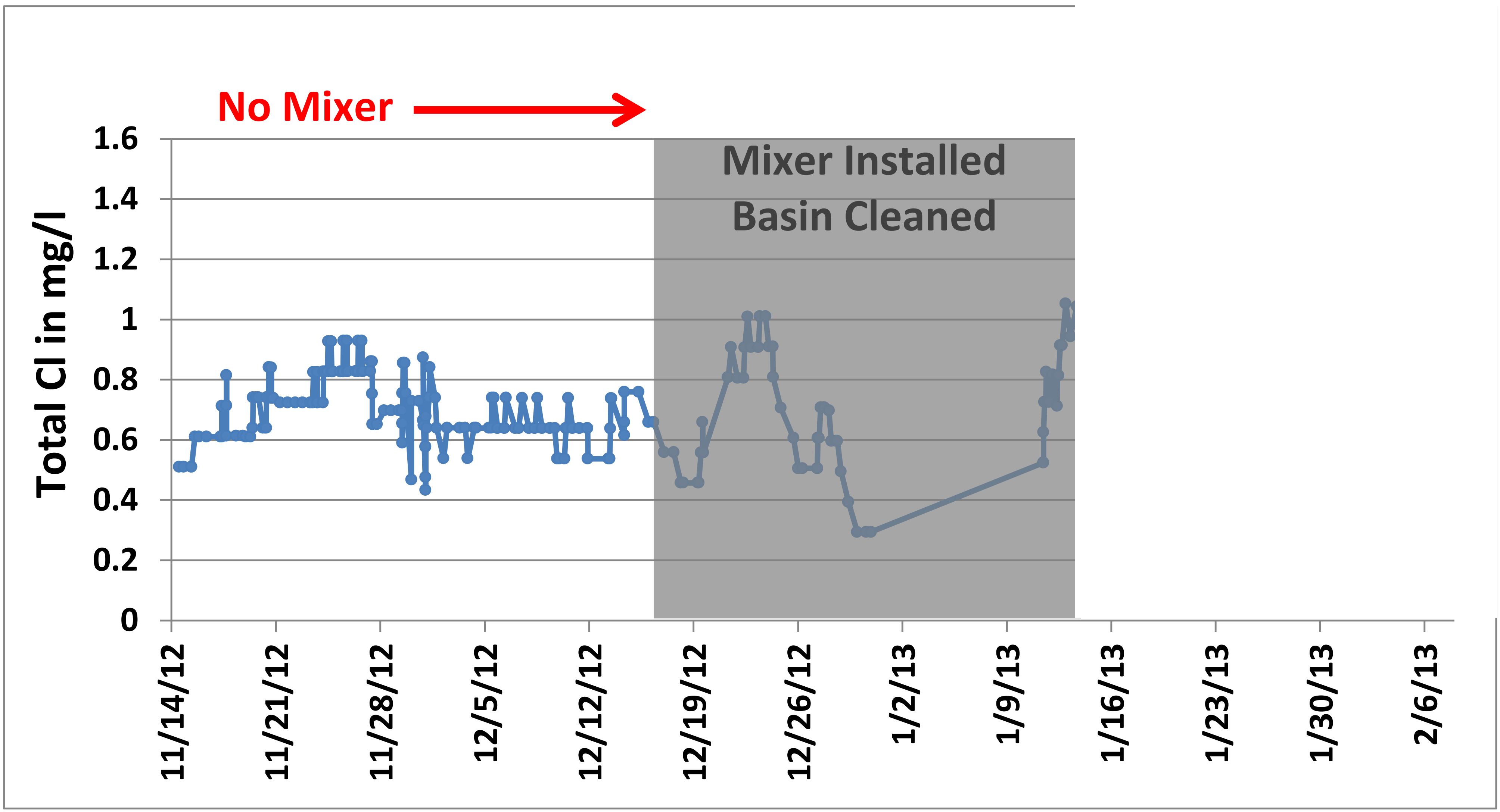


1 MG Enfield Basin

PAX PWM-400 – Horizontal orientation




No Mixer
Total Cl in mg/l
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
11/14/12
11/21/12
11/28/12
12/5/12
12/12/12
12/19/12
12/26/12
1/2/13
1/9/13
1/16/13
1/23/13
1/30/13
2/6/13


Total Cl in mg/l
No Mixer
Mixer Installed
Basin Cleaned
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
11/14/12
11/21/12
11/28/12
12/5/12
12/12/12
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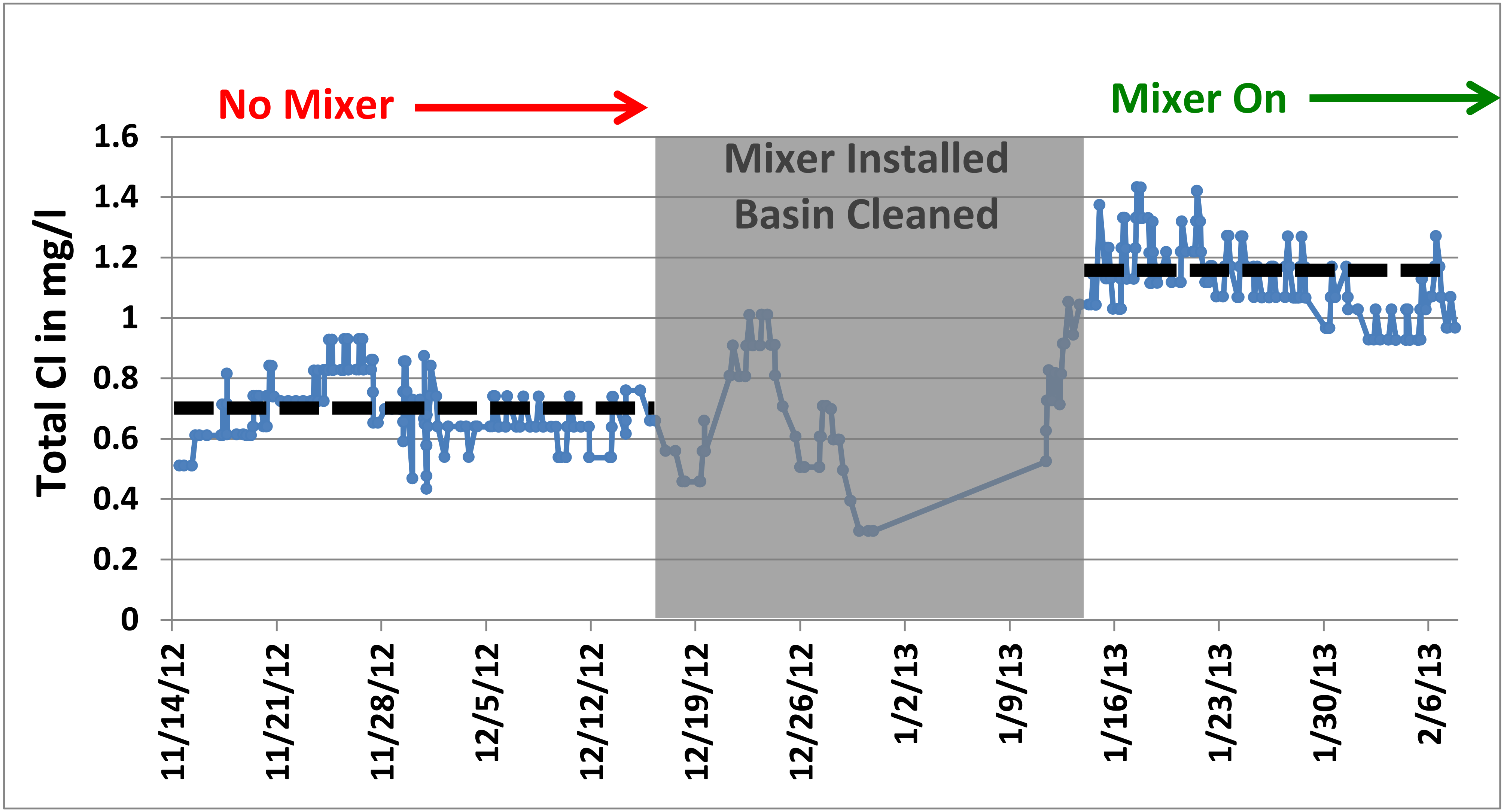
12/26/12
1/2/13
1/9/13
1/16/13
1/23/13
1/30/13
2/6/13



No Mixer
Mixer On
Mixer Installed
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Total Cl in mg/l
1.6
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11/14/12
11/21/12
11/28/12
12/5/12
12/12/12
12/19/12
12/26/12
1/2/13
1/9/13
1/16/13
1/23/13
1/30/13
2/6/13

“Residual levels rose to 1.8 to 2.0 mg/l after 2 months. The Mixer is a great tool that we can add to our water quality management. We now have a lot more control of our system.”

Jon Gooding – Senior Engineer
Central Highlands Water – Ballarat, VIC

Case study published in the Journal of the Australian Water Association – Spring, 2014

Download at www.paxwater.com

WATER QUALITY & MONITORING

108
Technical Papers

HOW MIXING IMPROVES DISINFECTANT RETENTION AND STABILISES WATER QUALITY

A case study involving a Central Highlands Water water treatment plant in Ballarat

P Piske

INTRODUCTION

Maintaining disinfectant residual levels in drinking water reticulation systems is a challenge, even under normal conditions. Water must travel through several kilometres of pipes and is often stored in water tanks and basins before reaching customers.

However, when the distance between the treatment plant and customer is extensive, maintaining adequate disinfectant levels becomes even harder. Further challenges become apparent during times of low water usage as the age of the water within the water reticulation system increases.

Central Highlands Water, west of Melbourne, faced this issue to an extreme. To service the southernmost part of the system, water produced at one of the main treatment plants in Ballarat is pumped and then gravity-fed 68km through a single water main to the town of Rokewood (Figure 1).

At a distance of 42km from the treatment plant, the water passes through the 2.3 ML Enfield Basin, a below-ground, rectangular tank with inlet and outlet at opposite ends.

Maintaining adequate disinfectant residual levels has always been a priority for Central Highlands. However, years of drought and substantial decreases in water use, as a result of changed customer behaviour, made it difficult to keep chlorine residuals at the right level at the end of the system.

Figure 1. Ballarat's water supply network.

DISCUSSION

A common technique for improving disinfectant residual levels at the end of a reticulation system is to flush water. But while flushing is widely practised, and in some utilities is seen as the "price" for maintaining water quality, operators at Central Highlands Water sought ways to improve water quality without the need to regularly flush.

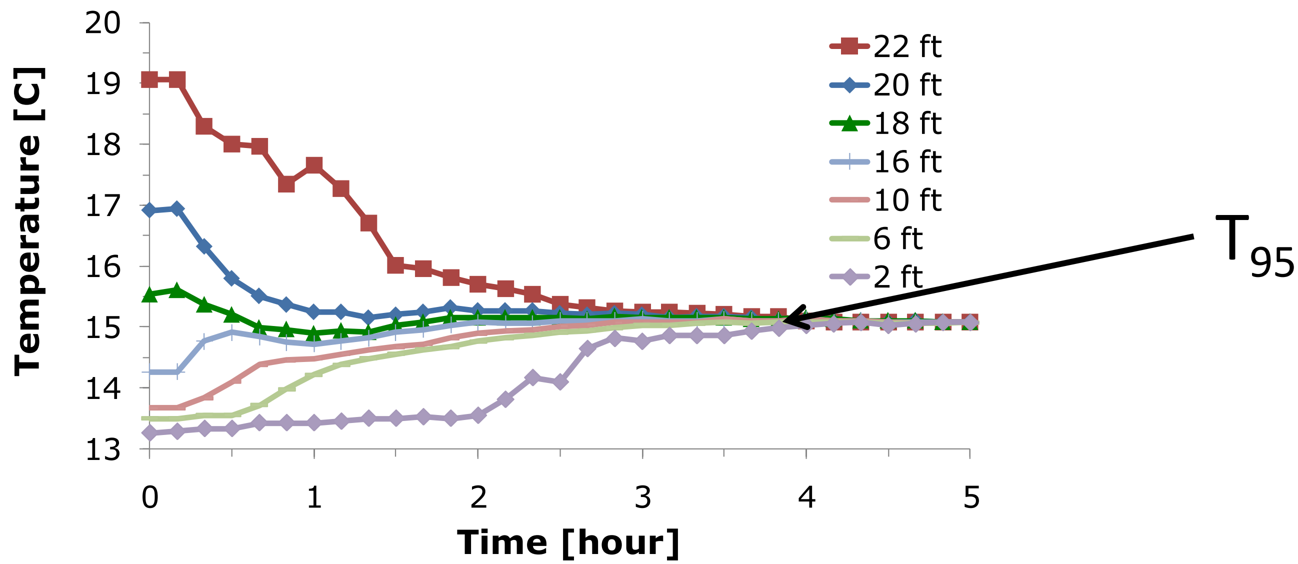
Central Highlands Water started by conducting a dual process that involved high-velocity flushing and air-scouring of the water-main feeding this part of the reticulation system. This approach uses the high velocity of water and the action of air to dislodge sediment and biofilm that accumulate naturally in water pipes.

Figure 2. The 2.3ML Enfield Basin.

Specifying Mixers and Evaluating Mixer Performance

Key Performance Metric: Blend time

- T_B = Blend time
- T_B is the time to blend an initially unmixed tank to a blended condition
  - T_{90} = time to reduce variation to 10% of its initial condition
  - T_{95} = time to reduce variation to 5% of its initial condition



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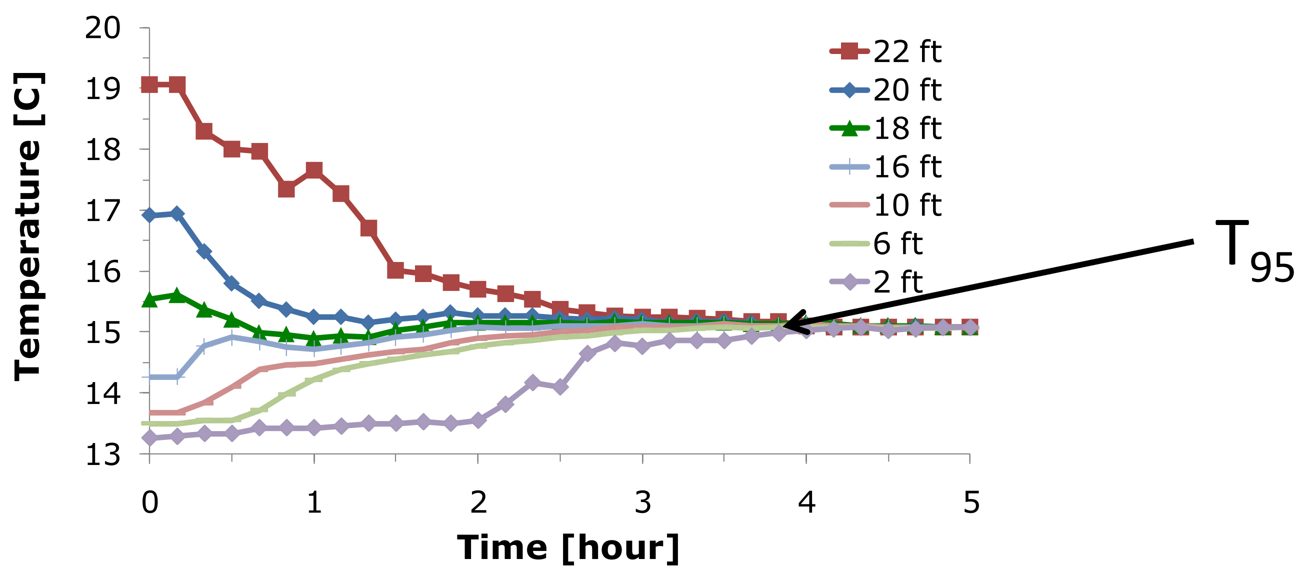
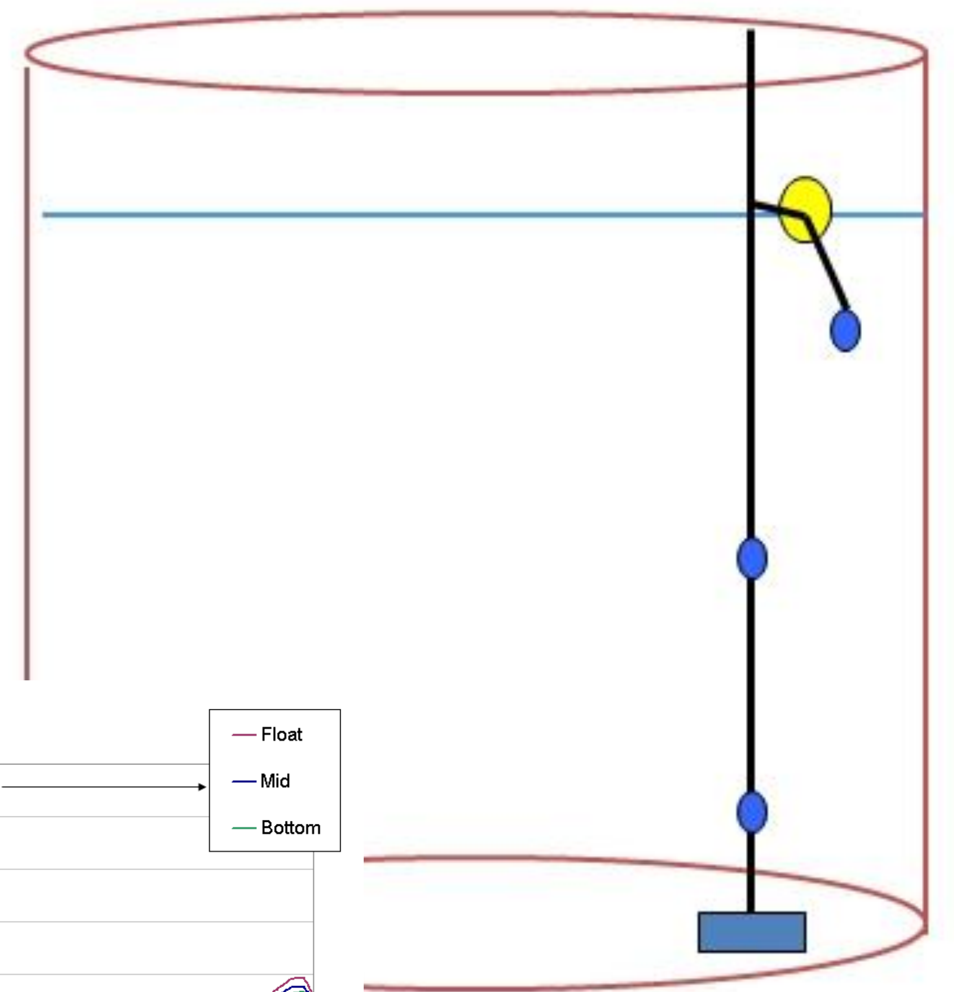
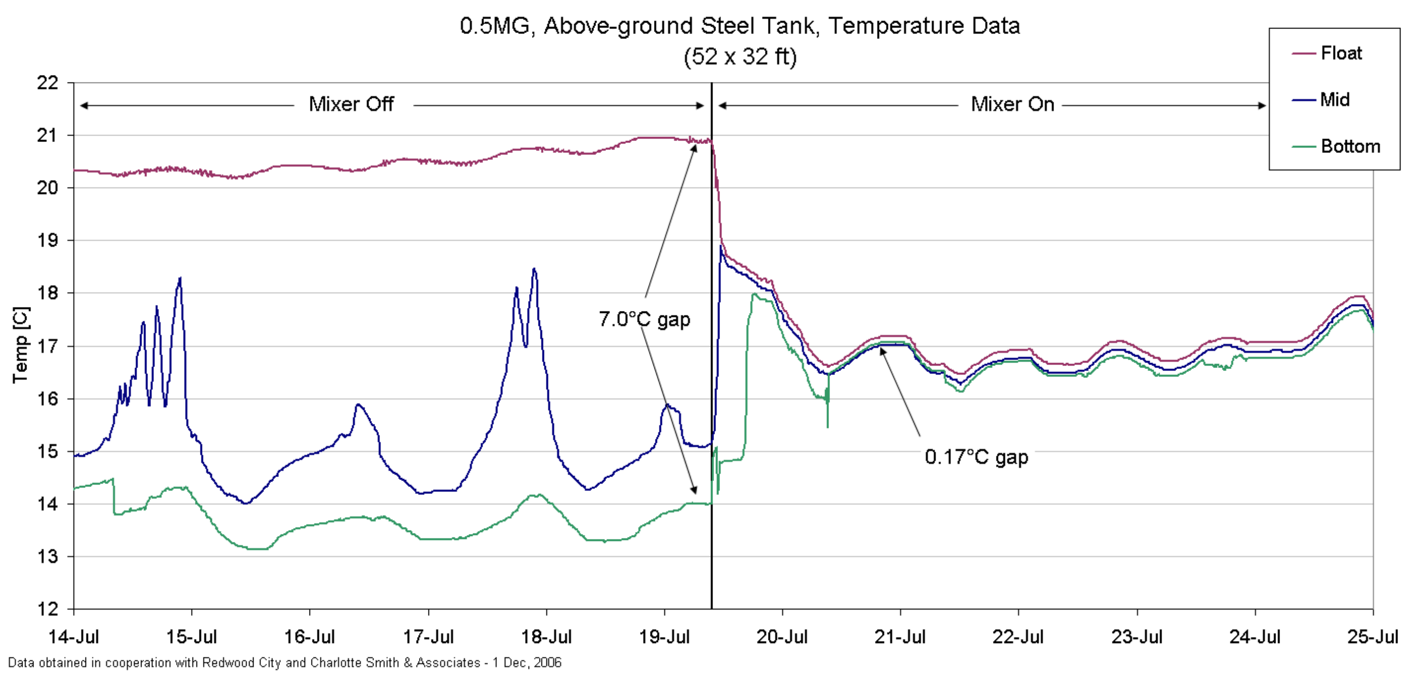


Performance Metrics: Temperature profile

- Temperature profiles easiest to demonstrate complete mix
  - Float fixed below surface
  - Mid-level
  - 2 ft off bottom

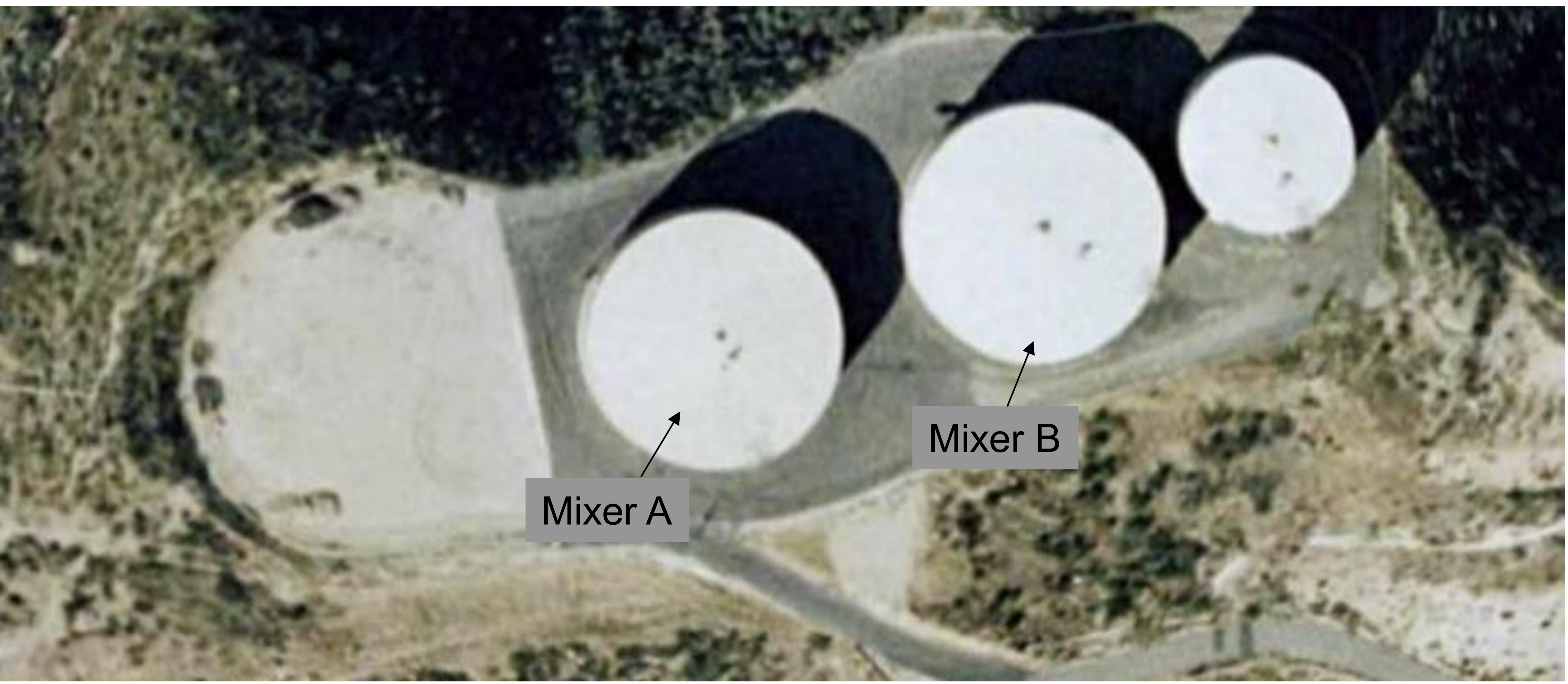
- More data points can be used for increased resolution



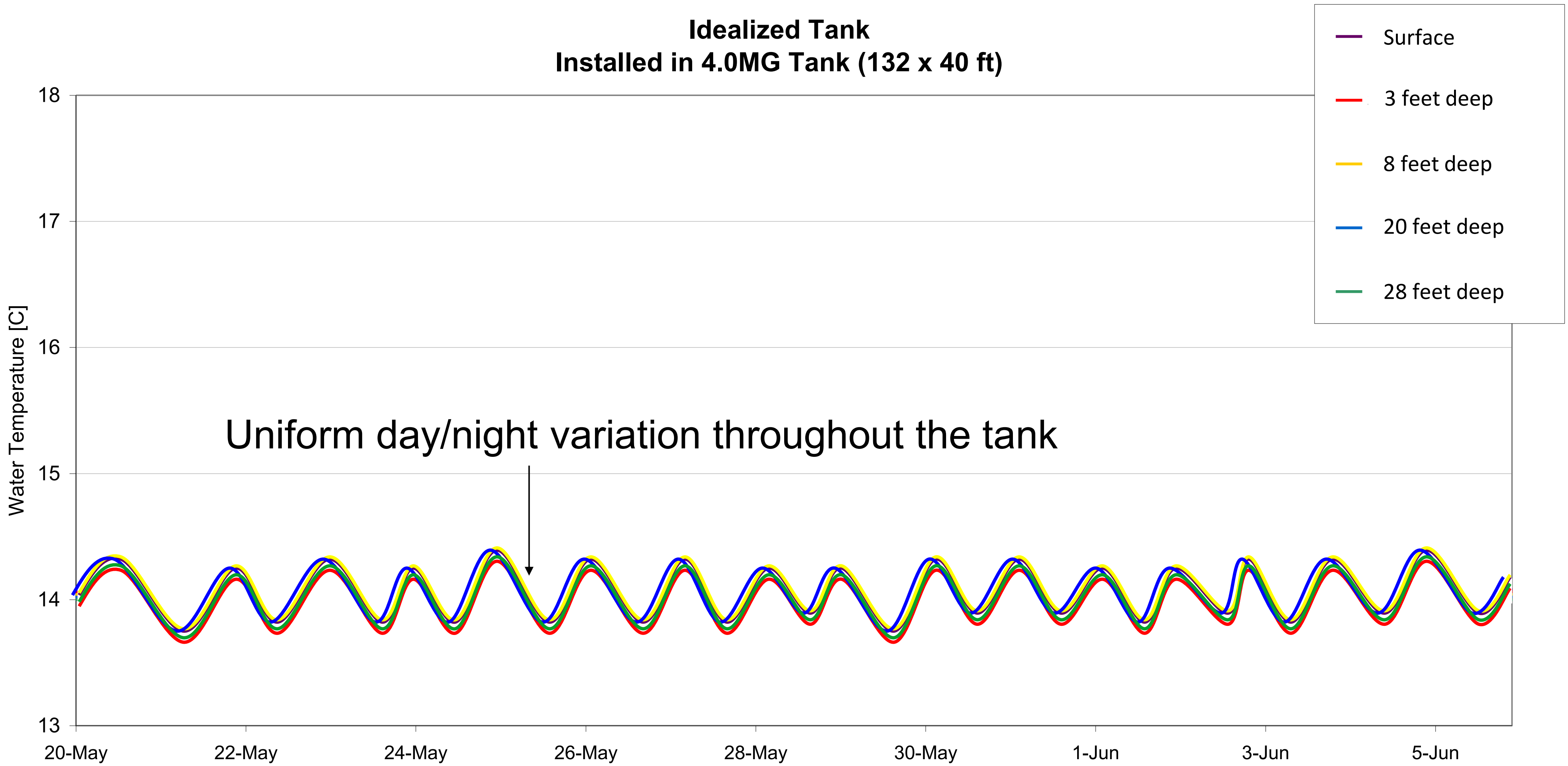


What does adequate vs. inadequate mixing look like: Temperature

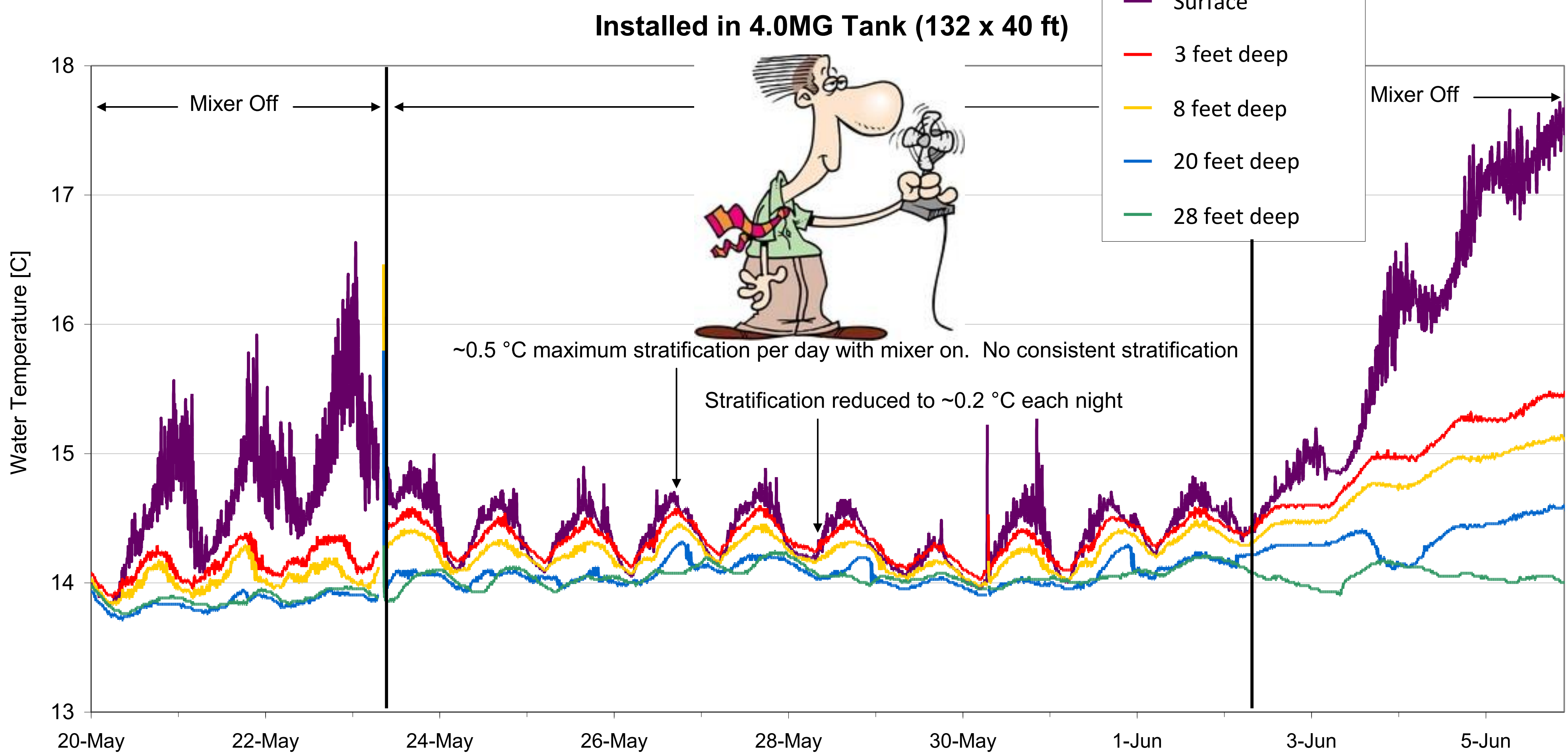
- 4.0MG Tanks, 132 x 40 ft
- Equal sunlight, equal water



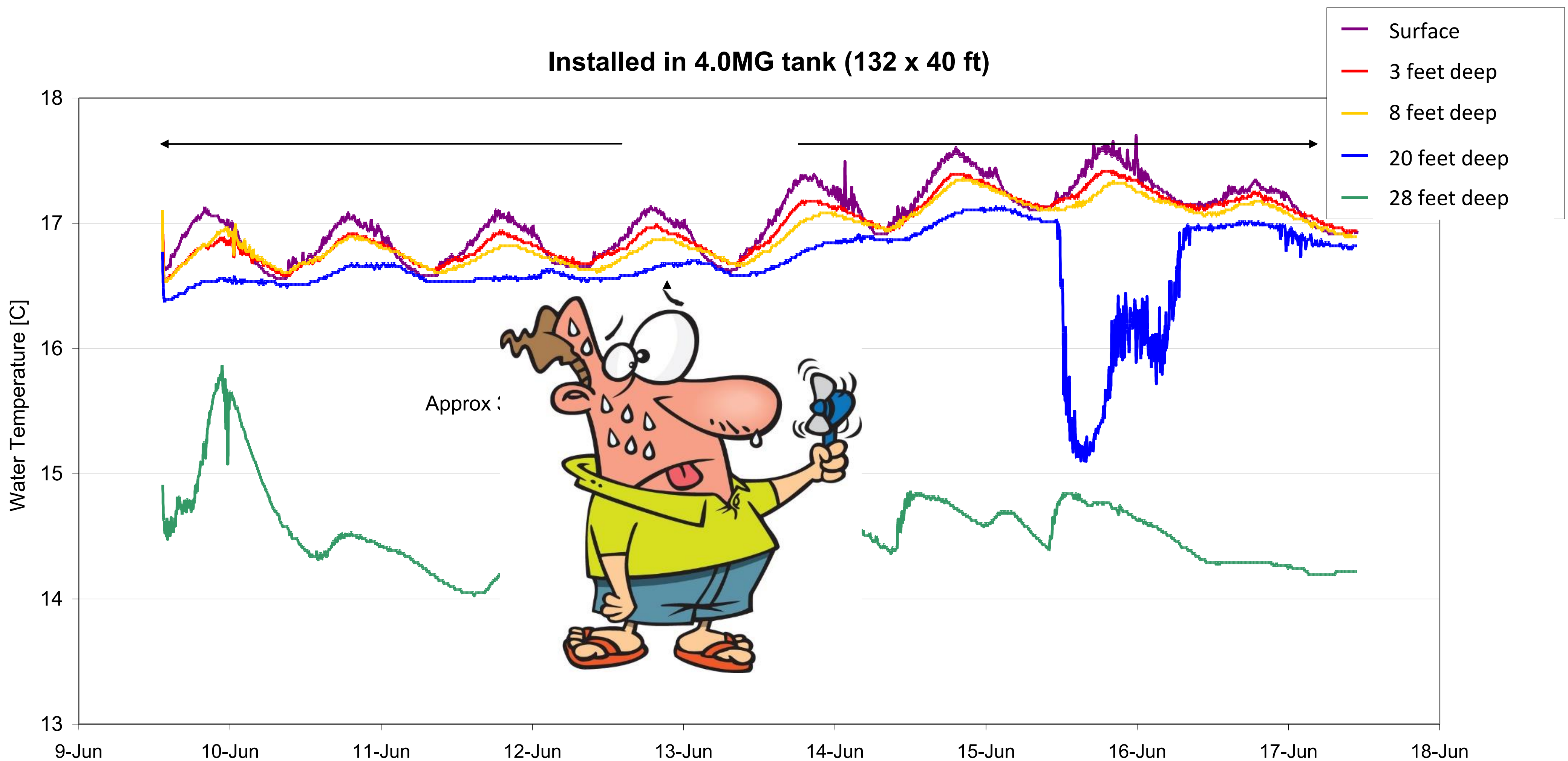
Ideally Mixed Tank

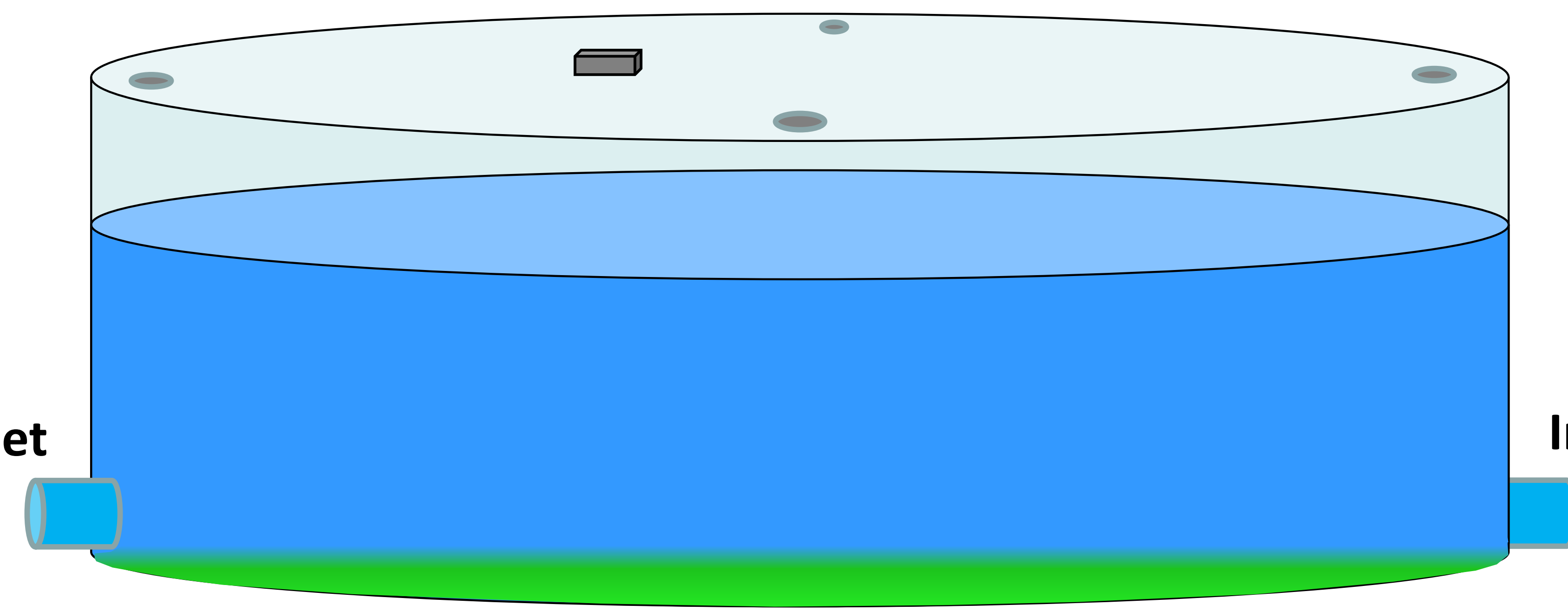


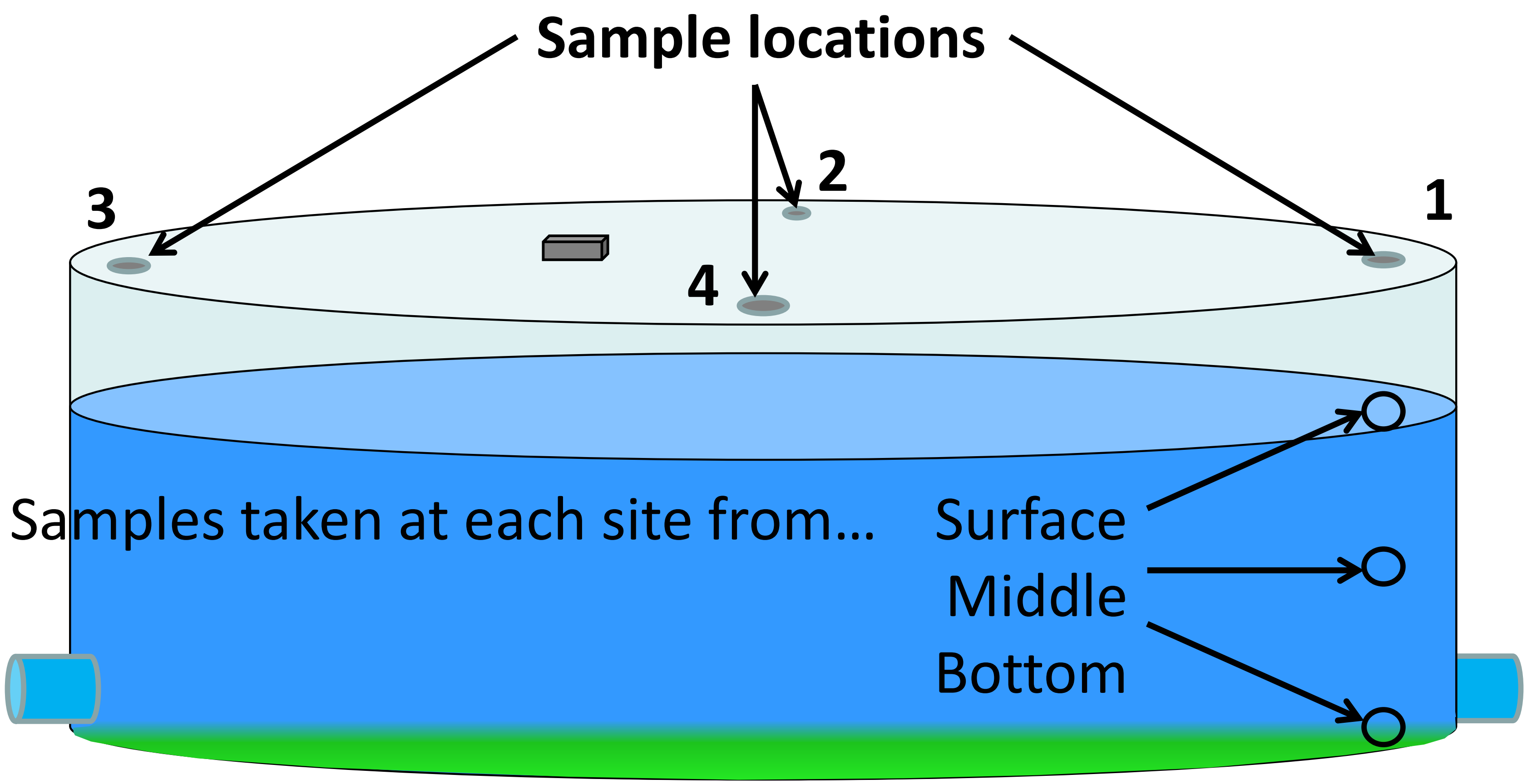
Mixer A Results

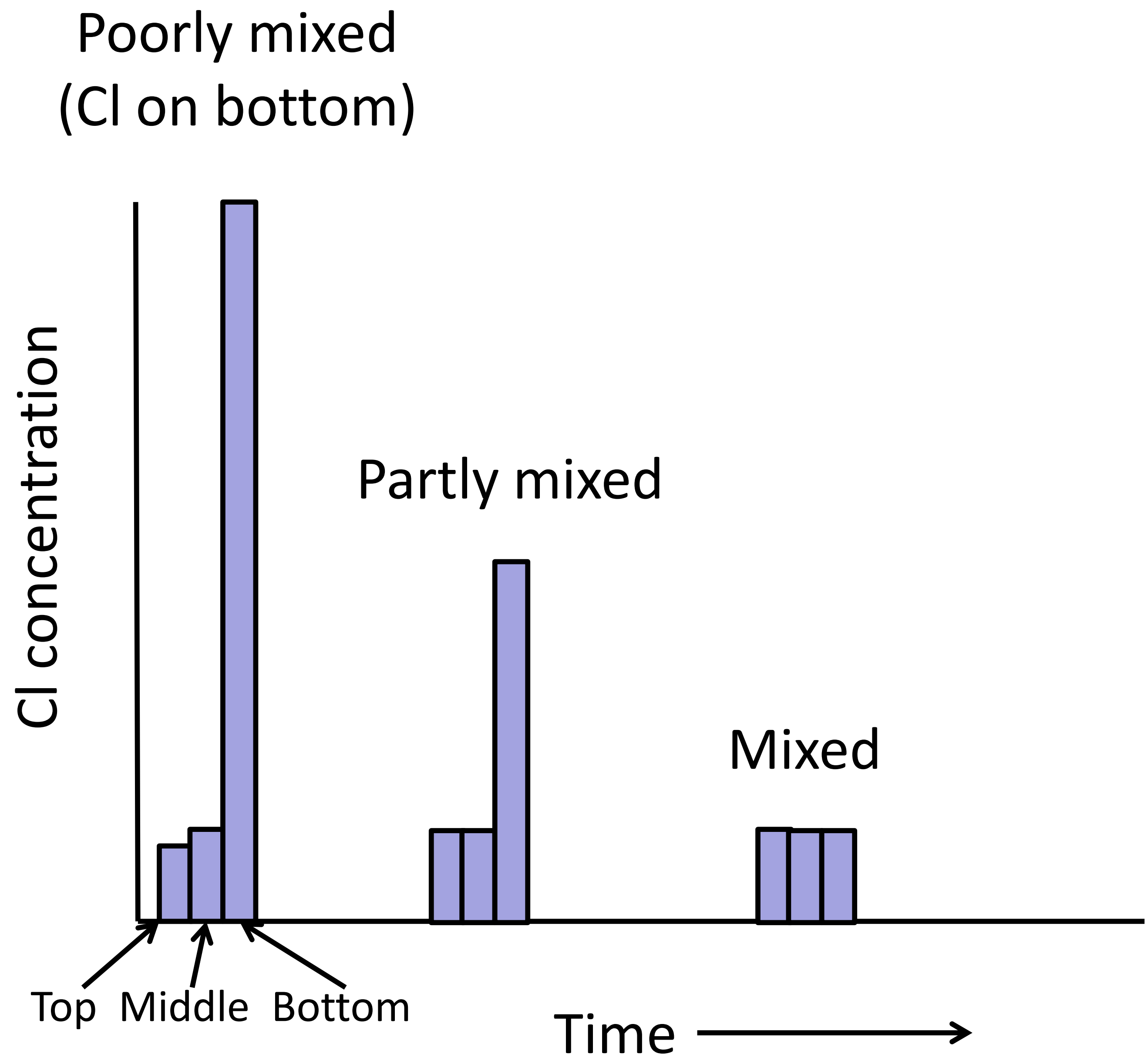


Mixer B Results

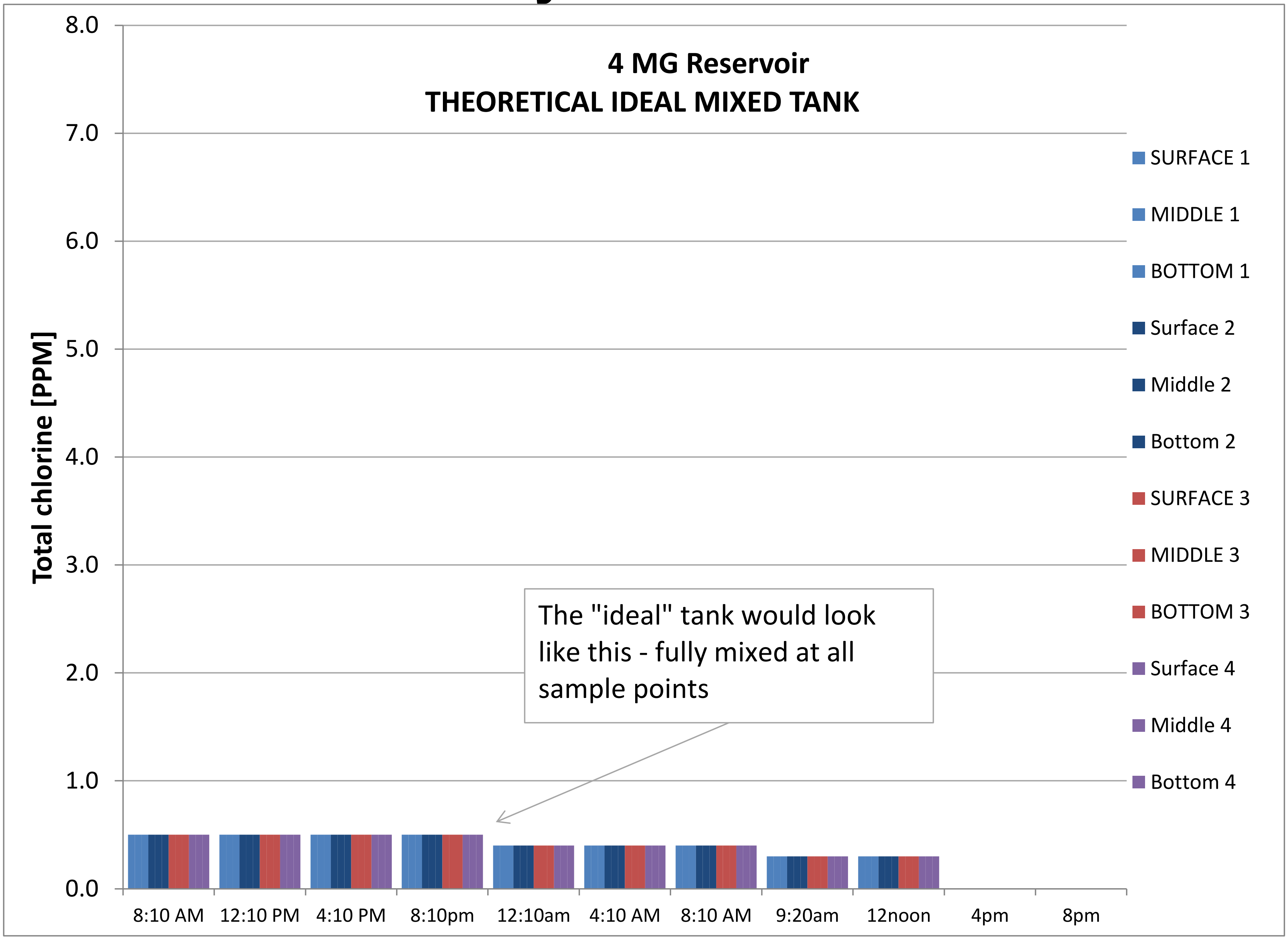



Outlet
Inlet

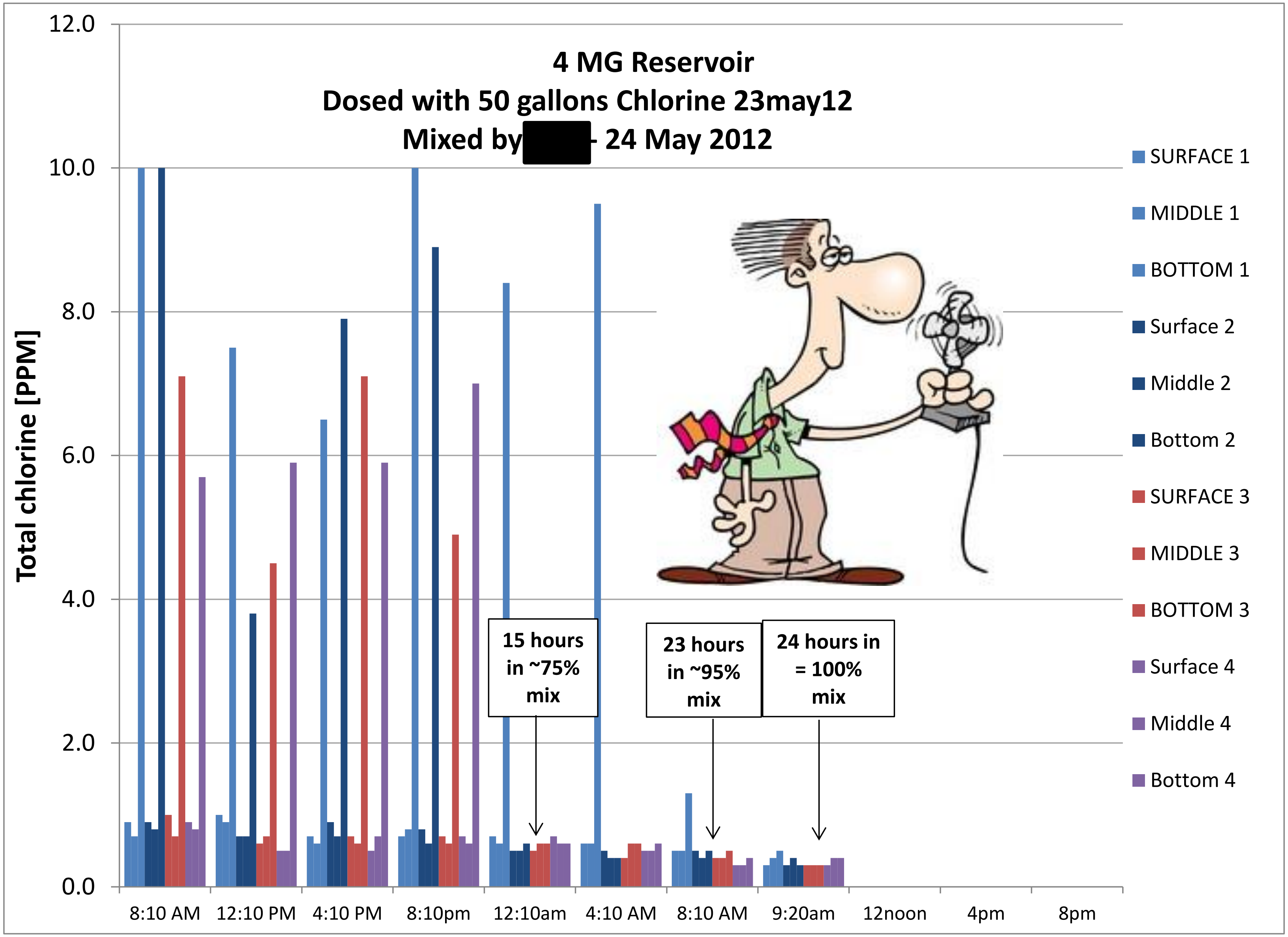

Sample locations
3
2
1
4
Samples taken at each site from…
Surface
Middle
Bottom


Poorly mixed
(Cl on bottom)
Cl concentration
Partly mixed
Mixed
Top Middle Bottom
Time

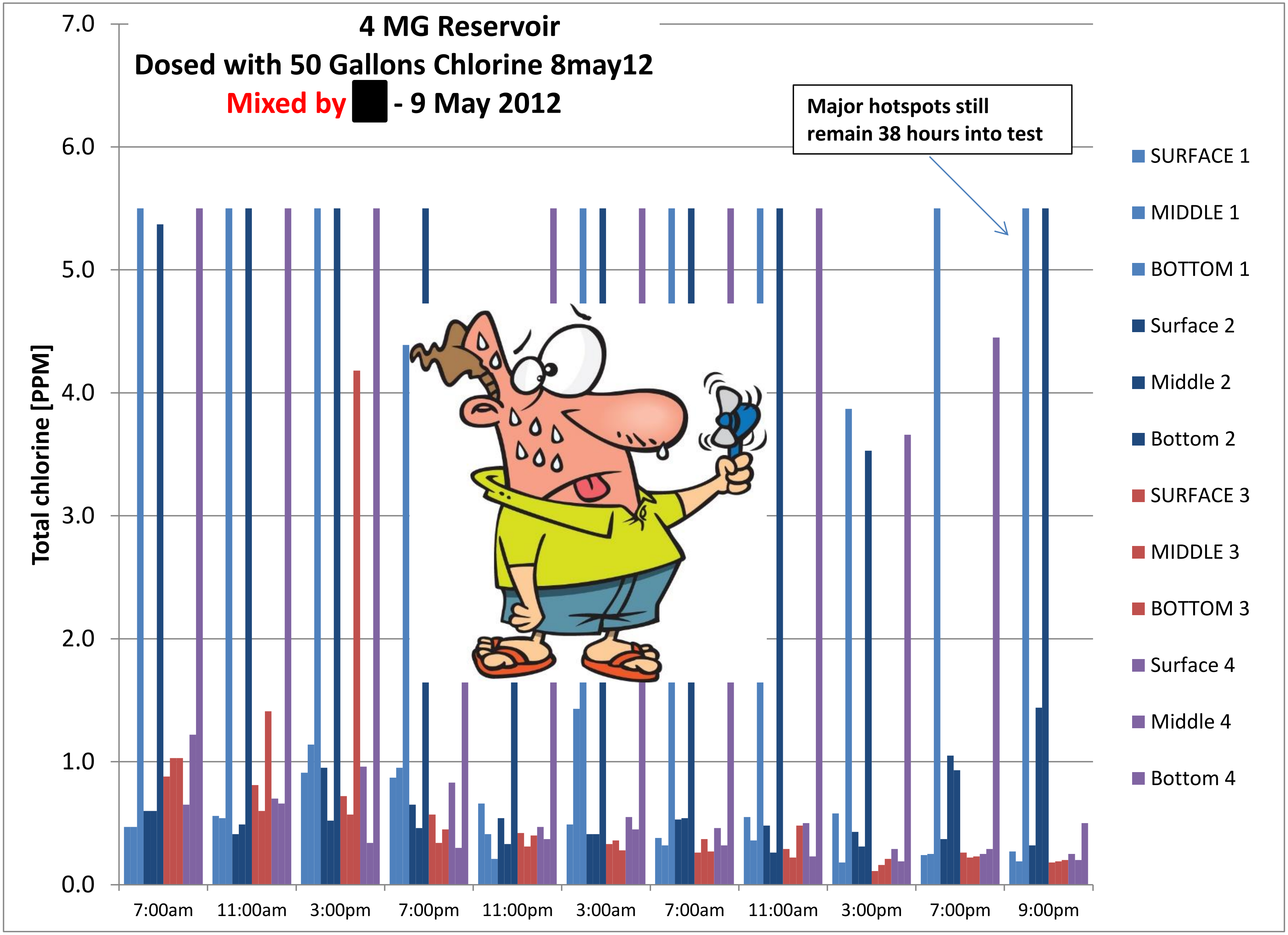
Ideal Scenario – Fully Mixed



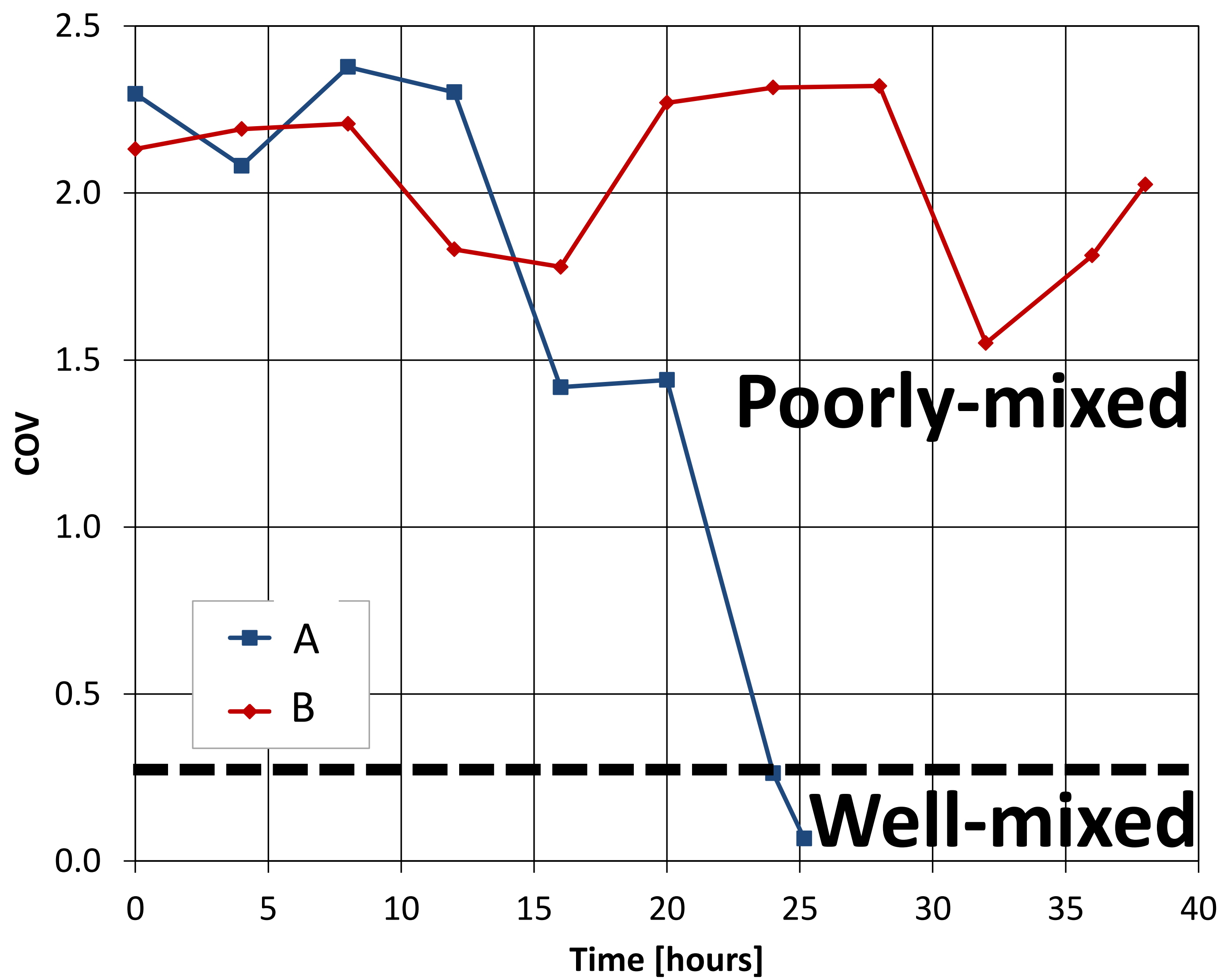
Mixer A – Fully Mixed after 24 hours



Mixer B – Never Mixed



Variance: Statistical measure of uniformity



"The trial clearly showed that plumes of high Cl introduced into the tank were eliminated by the PWM400 within 24 hours and were not eliminated by the GS-12 after 38 hours. **The differences in mixing results were significant.**"

Tom Smith– Superintendent (retired)
City of Camarillo Water Superindendant

New white paper:

How to Select and Specify Mixers for Potable Water Storage Tanks

Download at www.paxwater.com

How to Select and Specify Mixers for Potable Water Storage Tanks

A Resource For Engineers and Operators

Introduction

Mixing in potable water storage tanks is increasingly recognized as an important factor for improving water quality and protecting tank assets. Thorough mixing eliminates thermal stratification and ensures uniform conditions in tanks. This has been shown to lower overall disinfectant residual demand, reduce the risk of nitrification and enable safe, reliable boosting of residual disinfectant. Additionally, mixing can protect and preserve tank assets by preventing the formation of ice (which can scrape tank coatings or puncture tanks), and lowering summertime headspace temperatures (which reduces corrosion rates).

But how much mixing is "enough" for each application? And how do tank size, shape and frequency of fill and drain cycles affect the power needed to completely mix a tank? What are the consequences of selecting a mixing technology that is too weak for a given application?

Relationship Between Tank Volume, Tank Turnover and Mixing Power

The size or volume of a water storage tank is a principal design consideration when considering mixing. Published scaling relationships show that blend time (the time required to take an initially unmixed volume and blend it to a homogeneous condition) scales linearly with the volume of tank.

The rate of turnover in a tank also determines how much mixing power is required to achieve blended conditions. Any mixing system must be able to achieve a fully blended condition in less than the cycle time of the tank. Most water storage tanks have a fill/drain cycle that is 24 hours long. Thus, many mixing systems are specified to achieve fully-blended conditions in less than 24 hours. However, if a tank is cycled at a higher frequency, the required minimum blend time will be shorter, and the required amount of mixing power will be higher.

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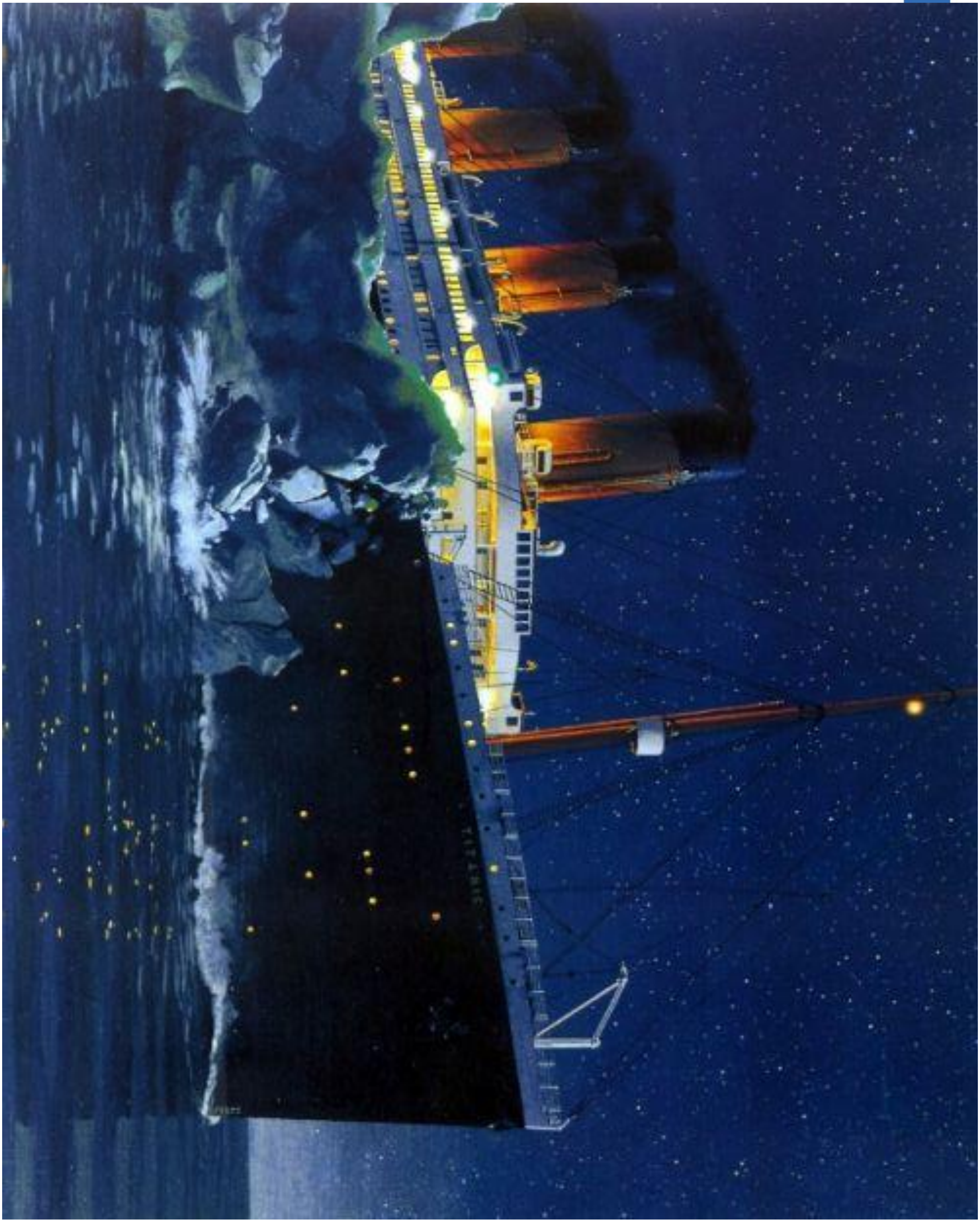
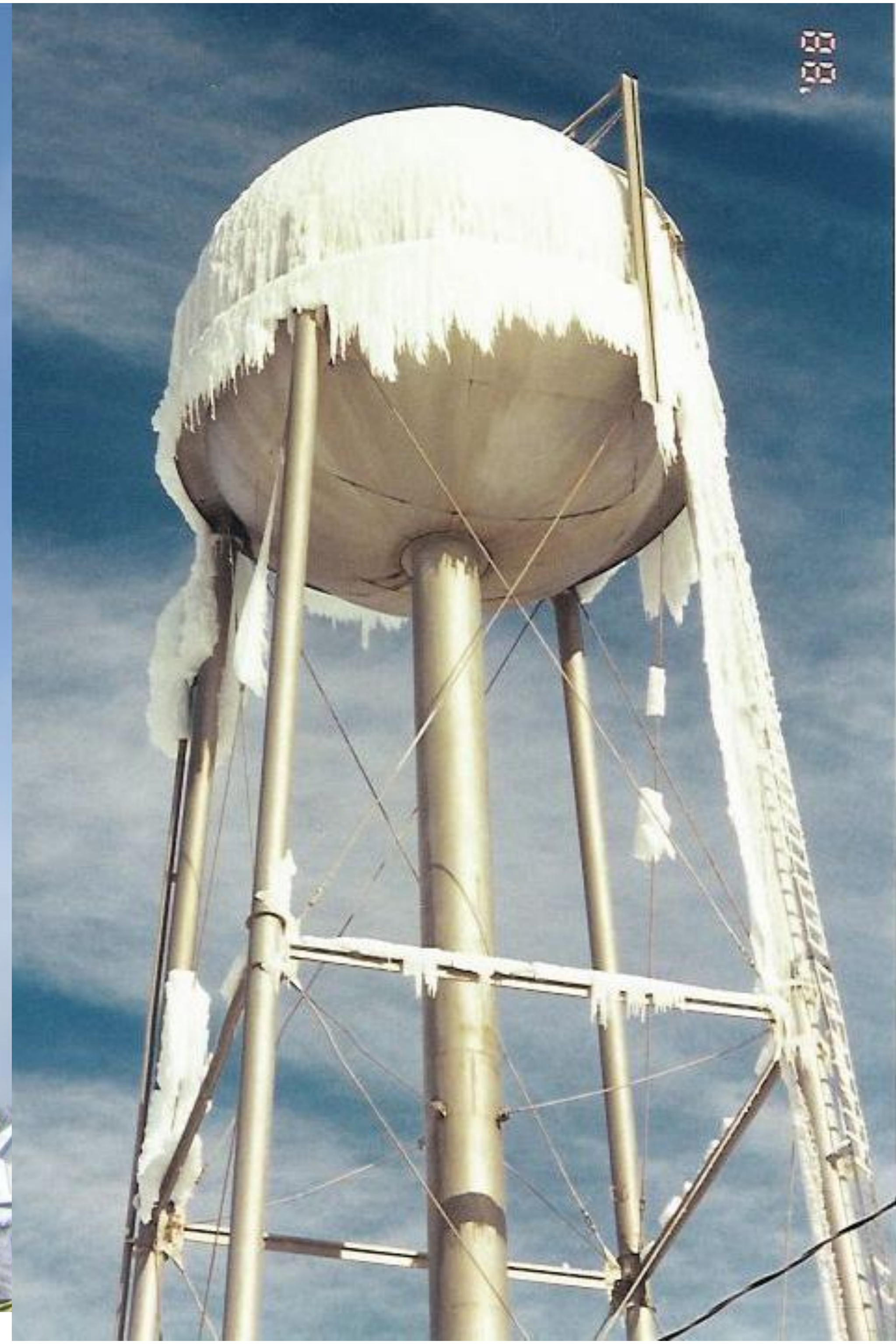


Photo courtesy of Utility Service Co.



$22,000 repair

Photo courtesy of Utility Service Co.

Photo courtesy of Utility Service Co.

PAX WATER TECHNOLOGIES™

Examples of Ice Damage

Photo courtesy of Utility Service Co.

Canada, Feb 2009

Photo courtesy of Utility Service Co.

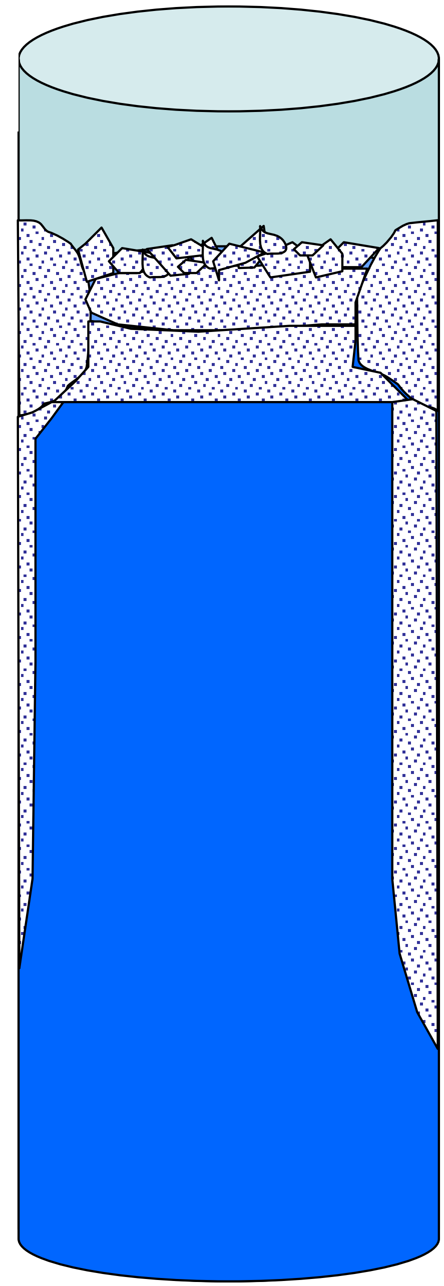
PAX WATER TECHNOLOGIES™

Photo courtesy of Utility Service Co.

Photo courtesy of Utility Service Co.

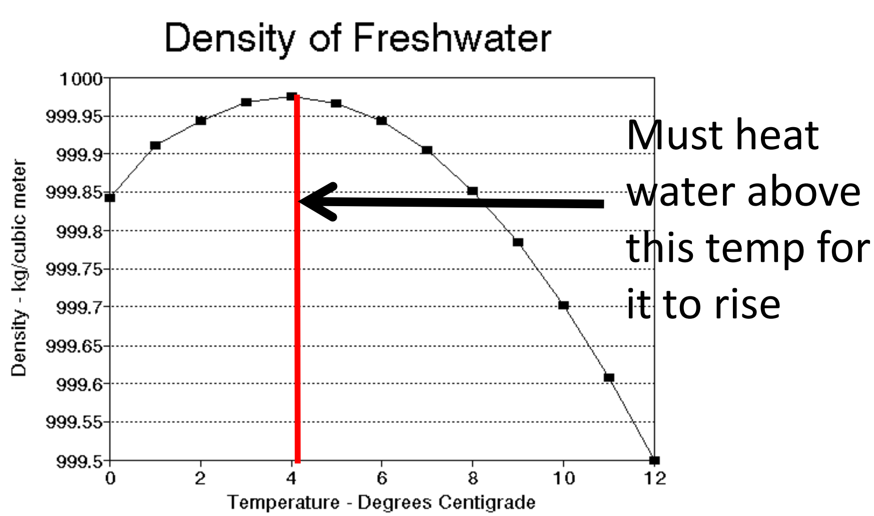
Why do tanks freeze at the top?

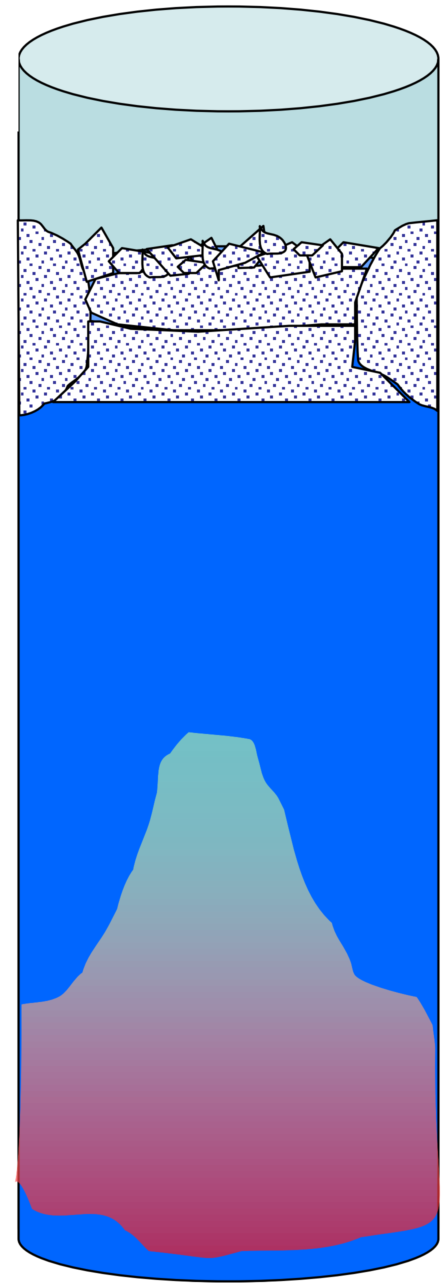
1. Top of the tank is more exposed
2. Ice is unusual: it floats



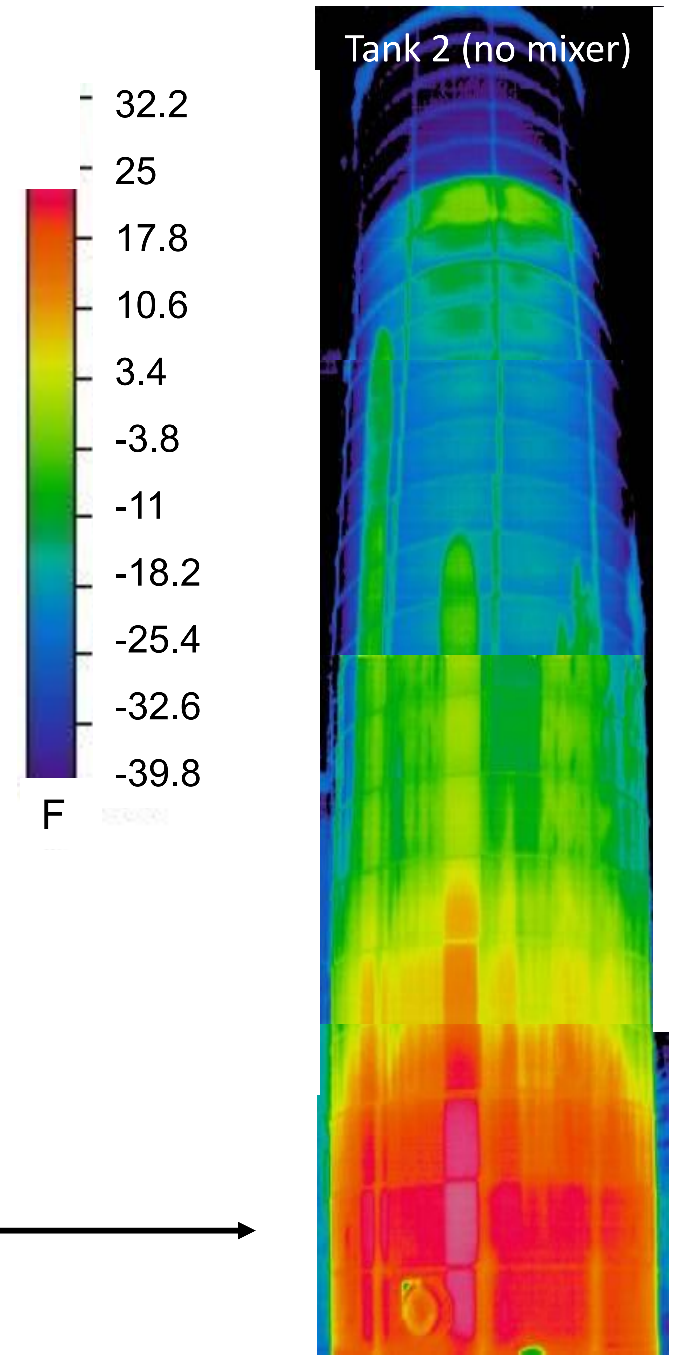
What about warmer water at the bottom of the tank?

1. Warmer water is DENSER: it stays on the bottom
2. In order for water to rise to the top of the tank (free convection) the temperature must be ~40°F (5C)





IR image of a standpipe in winter…



Pocket of warm water at tank bottom

PAX WATER TECHNOLOGIES™

What about heaters?

Heaters must warm the water significantly ABOVE the freezing point for the water to float to the top of the tank

A LOT of extra energy is being wasted just to promote "free convection"

How much?

For a 100,000 gallon tank – 100 kWh

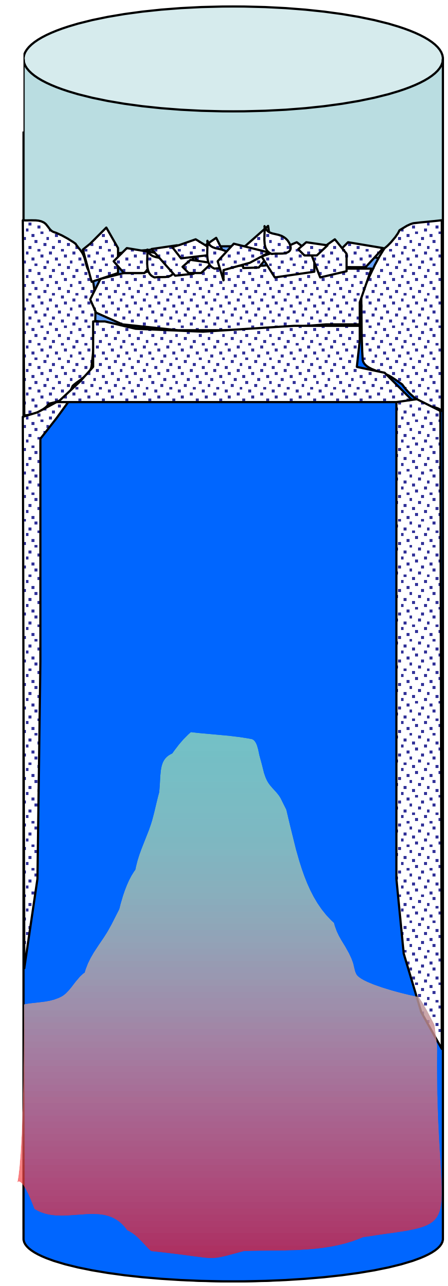


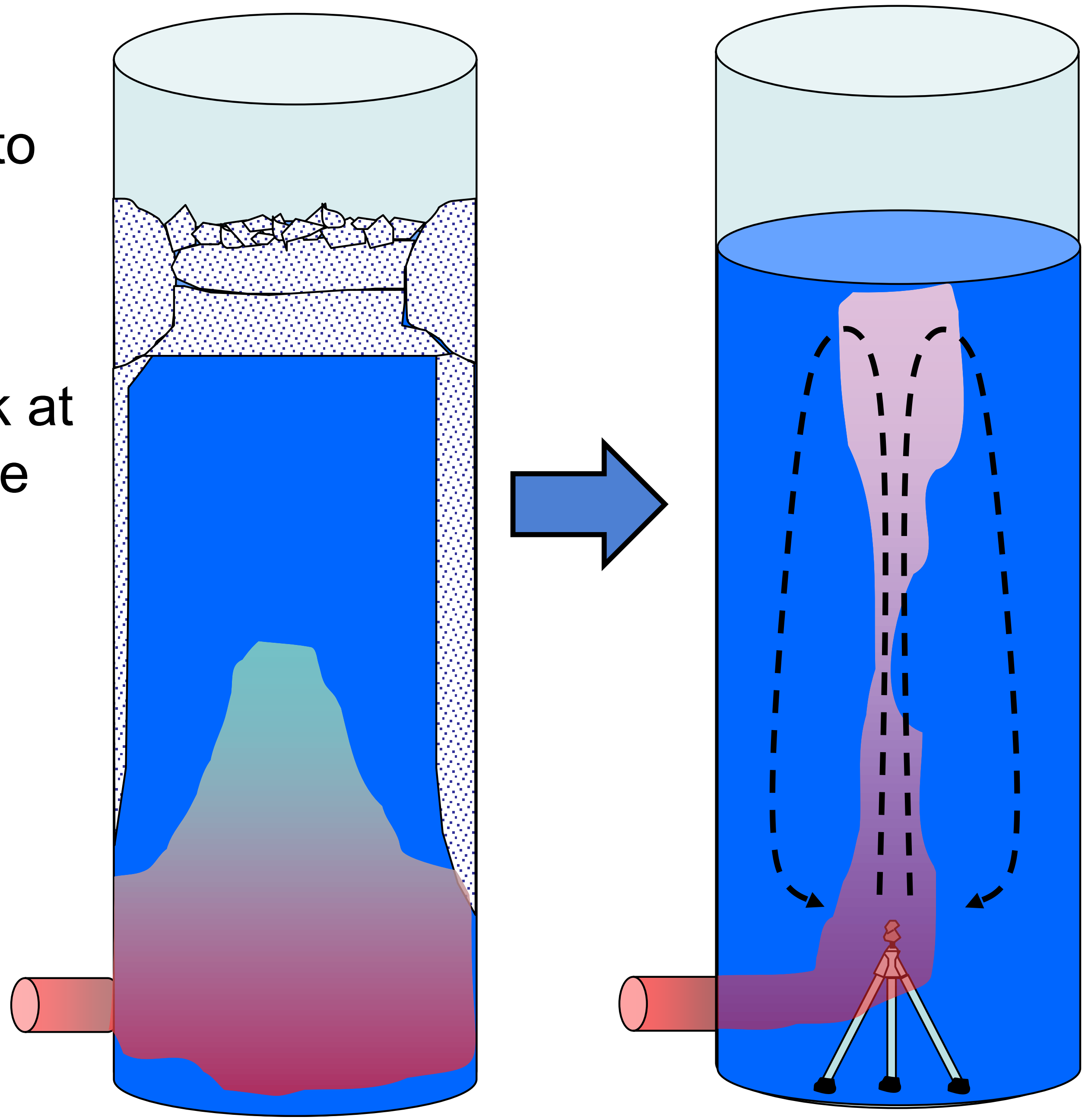
Photo courtesy of Utility Service Co.

Forced convection (active mixing)

Pushes warm water to the top of the tank

Keeps the entire tank at the same temperature

…with a LOT less energy

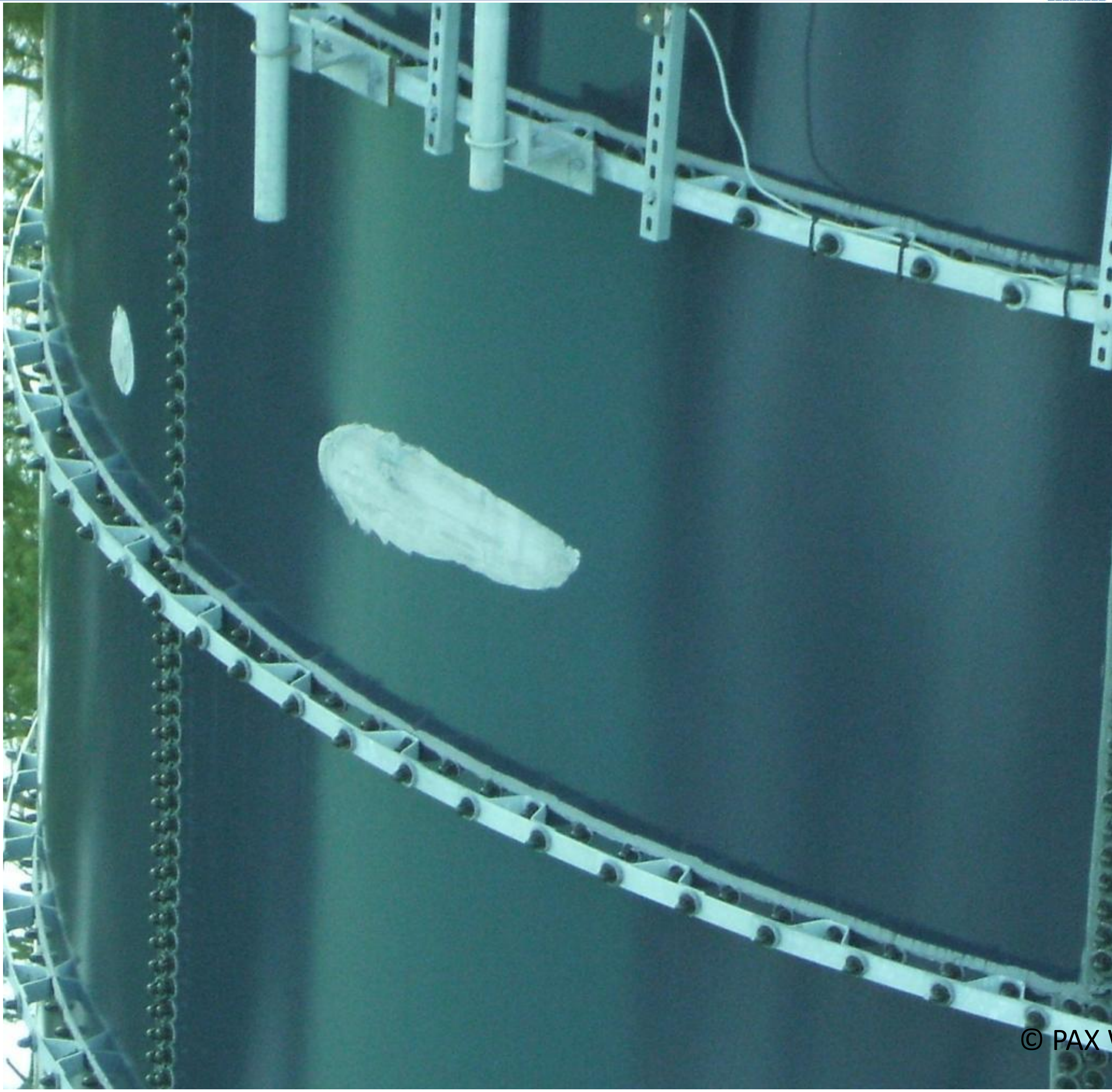


How much mixing do I need to keep my tank ice-free?

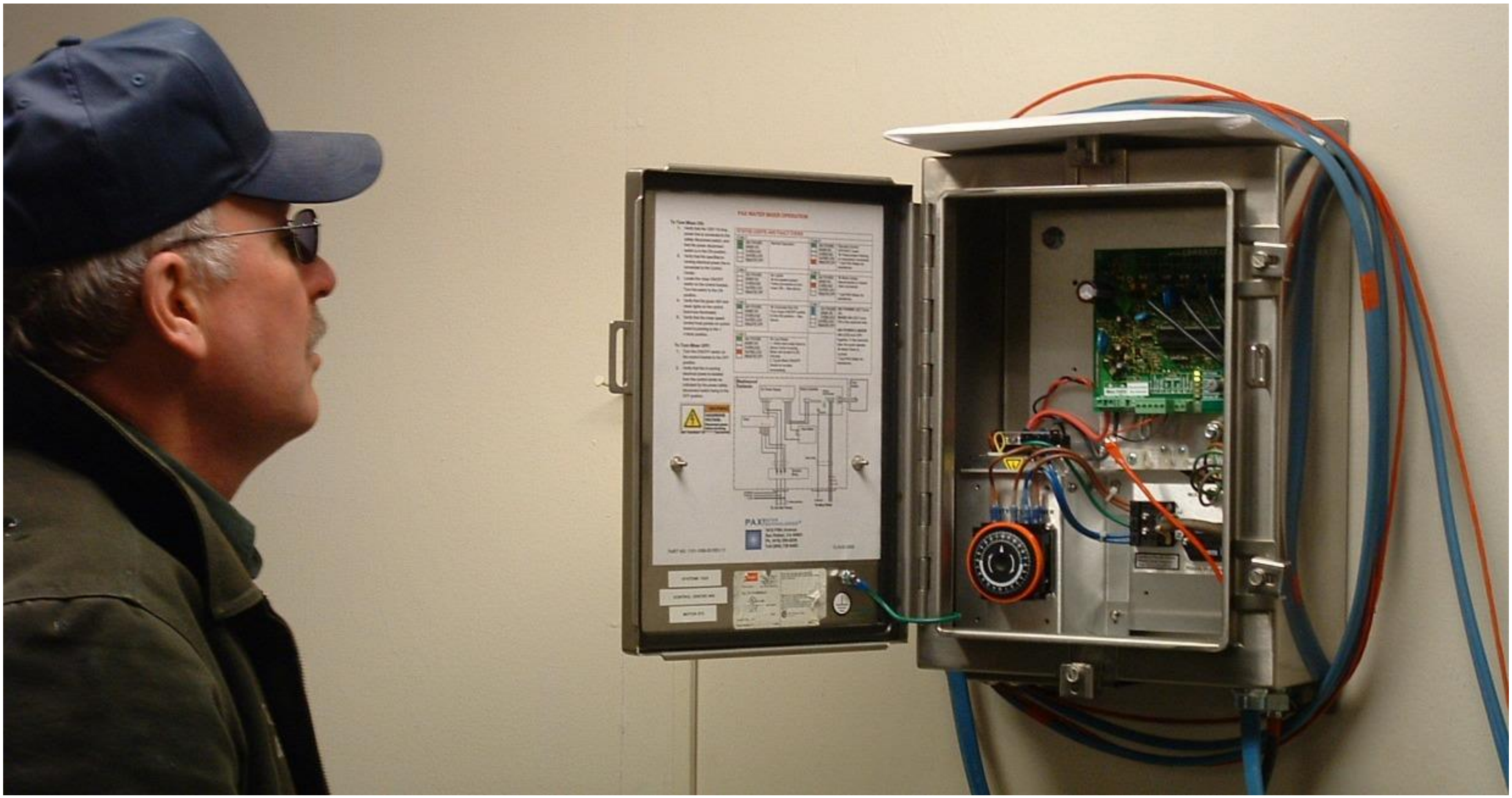
- Depends on the size and shape of the tank
- Depends on the temperature (and sunlight)
- Depends on turn-over
- Depends on the inlet water temperature
- Depends on color of tank
- Depends on tank’s R-value

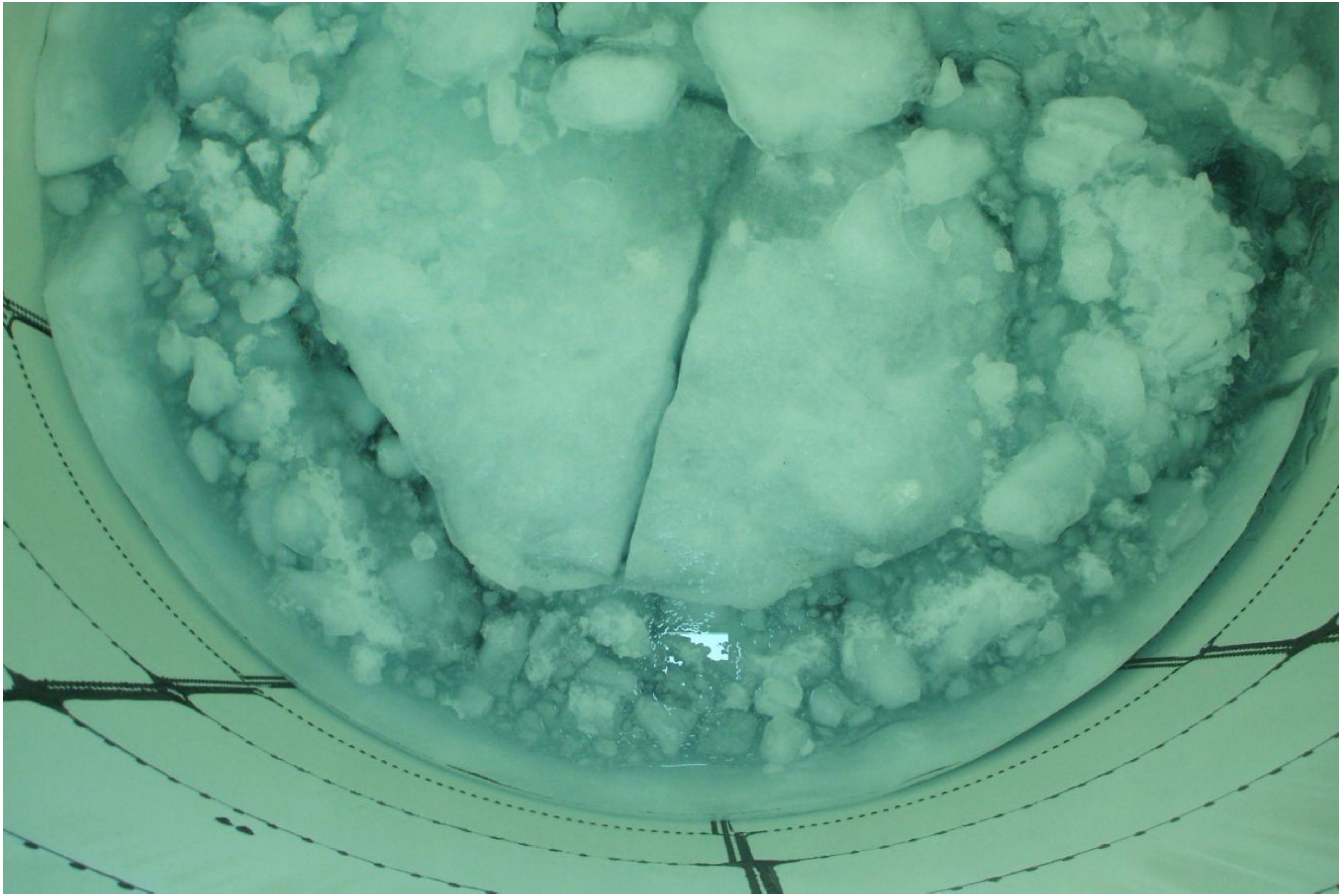
Old Town, ME – Frank Kearney

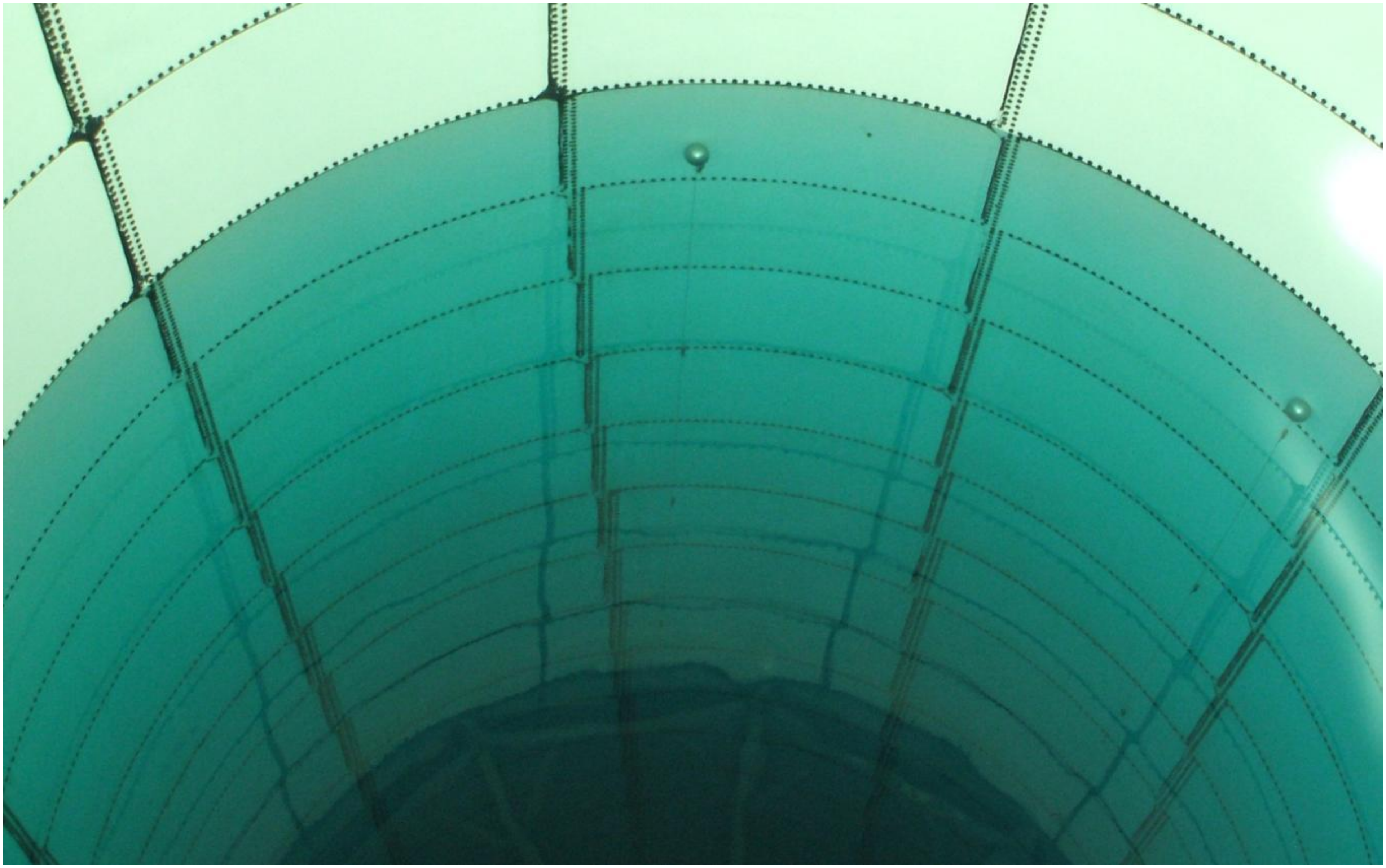
Tanks at Old Town



Installation

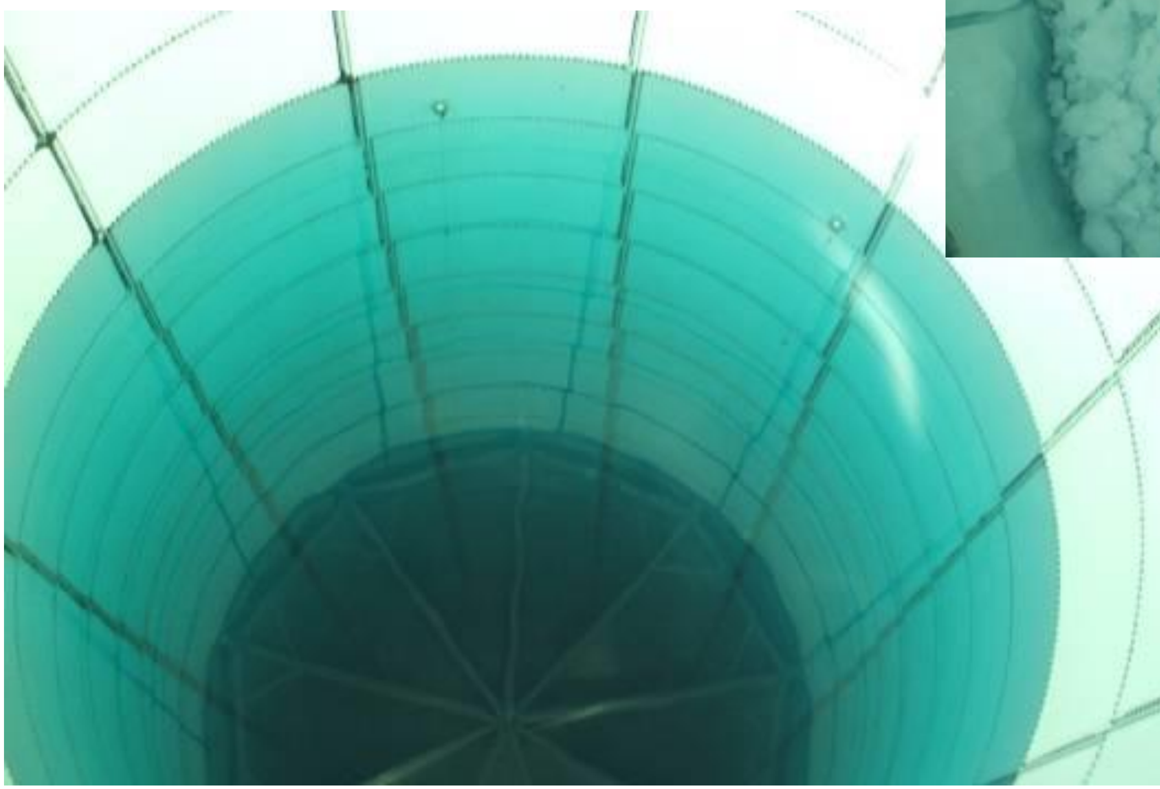






Spring Thaw – 3/25/09

Tank #1 – Mixed by PAX



Tank #2 – not mixed

PWM100 – ideal for ice prevention in small tanks

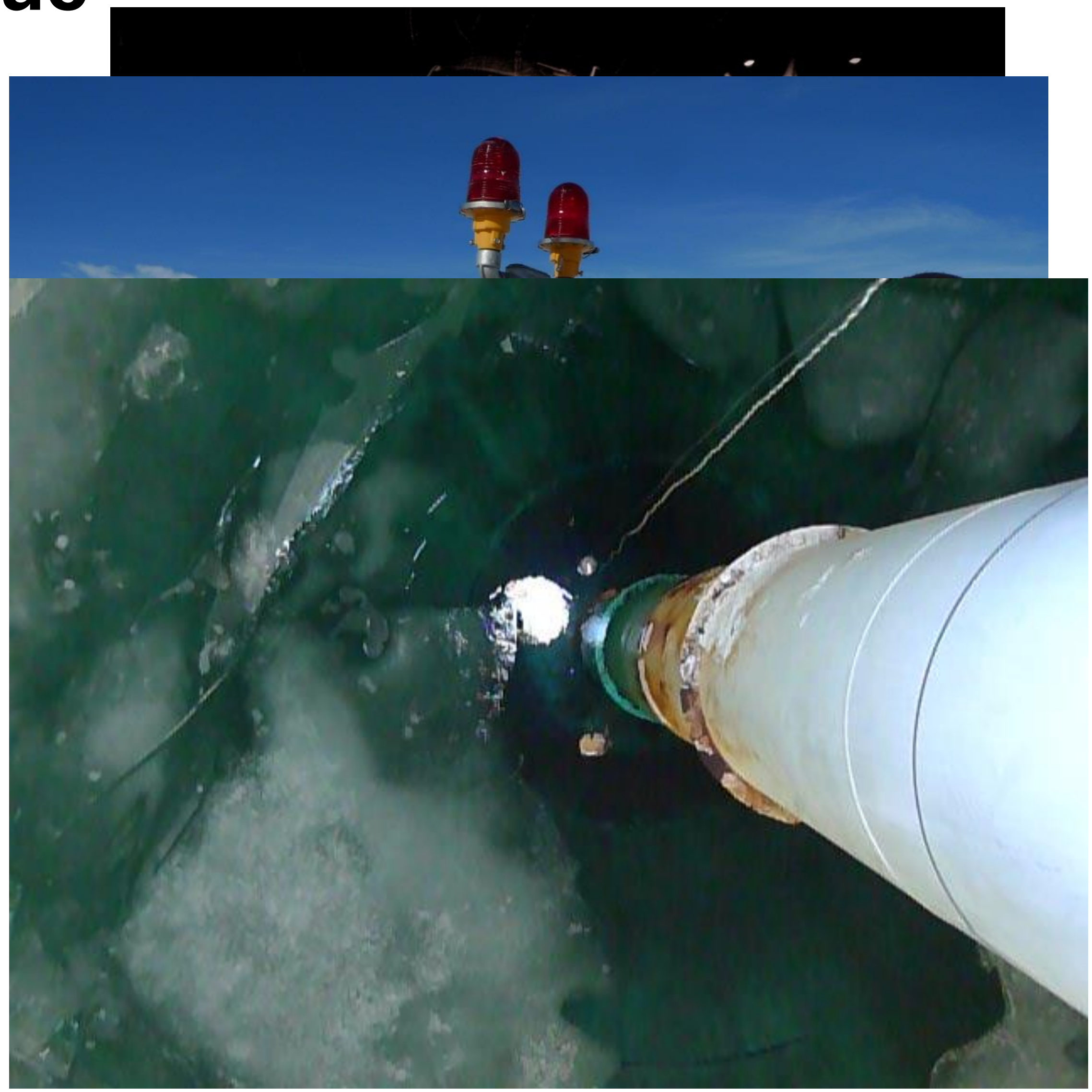
Produces powerful vortex jet: like rifling of a bullet

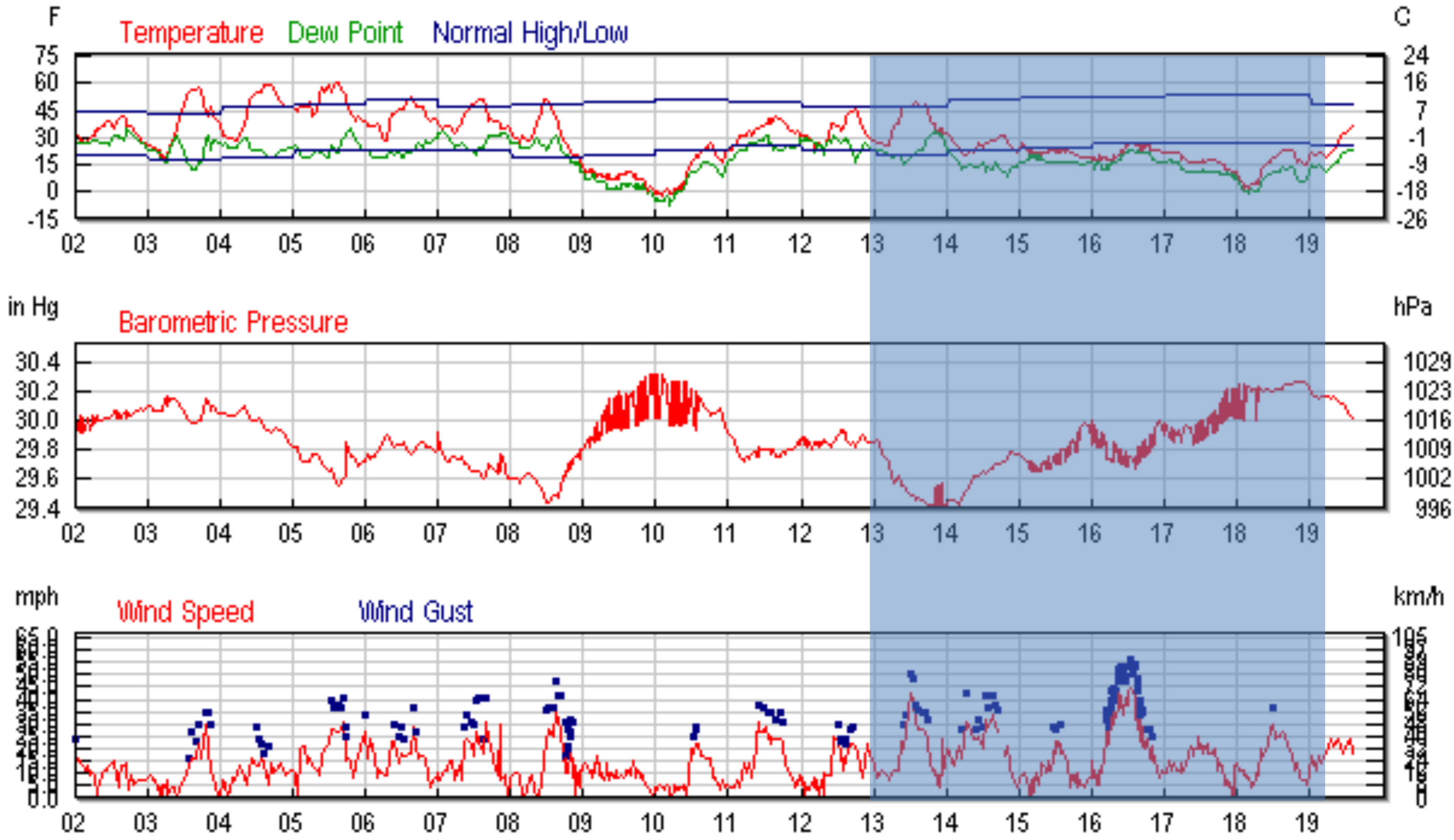
Case Study: Laramie, WY

- 300,000 gallon pedisphere
- Severe ice problems in winter
- Low residual levels in summer

PWM100 to the rescue

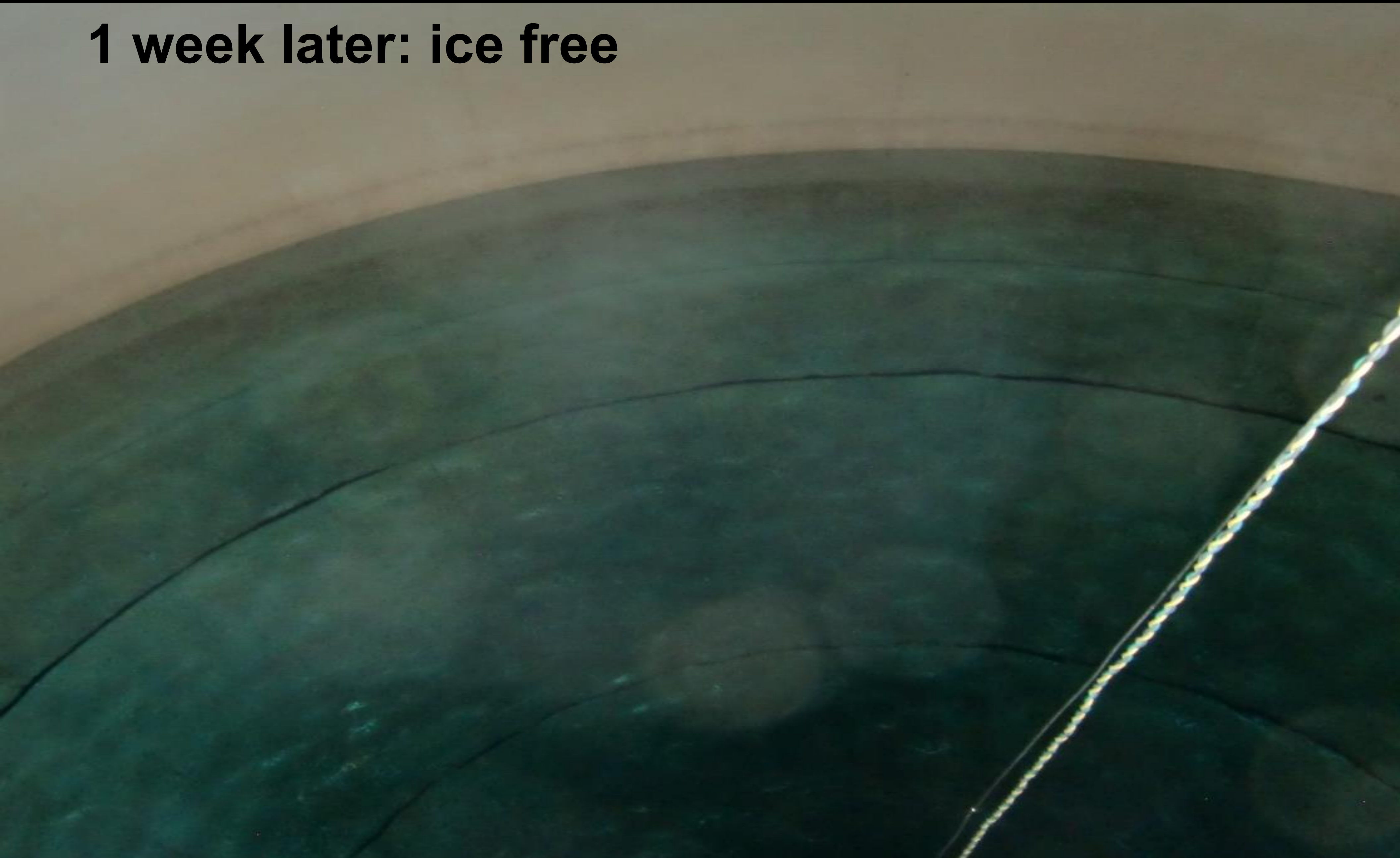
- PAX Service team flew to Laramie
- Powered mixer off airplane light circuit
- Installed mixer into tank w/ temp string




F
Temperature Dew Point Normal High/Low
C
75
60
45
30
15
0
-15
24
16
7
-1
-9
-18
-26
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19
in Hg
Barometric Pressure
hPa
30.4
30.2
30.0
29.8
29.6
29.4
1029
1023
1016
1009
1002
996
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19
mph
Wind Speed
Wind Gust
km/h
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19


Day 0


24 hours later


1 week later: ice free

"We were very impressed with this new technology. [The PWM-100] is ideally suited to a tank and system of our size, and the ability to easily install and remove it ourselves is a big advantage."

Foster White
Operation/ Manager
Laramie, WY

Susanville (Cal Fire) water storage tank

- 84,000 gallons
- Steel-bolted tank
- No insulation
- Sub-freezing conditions

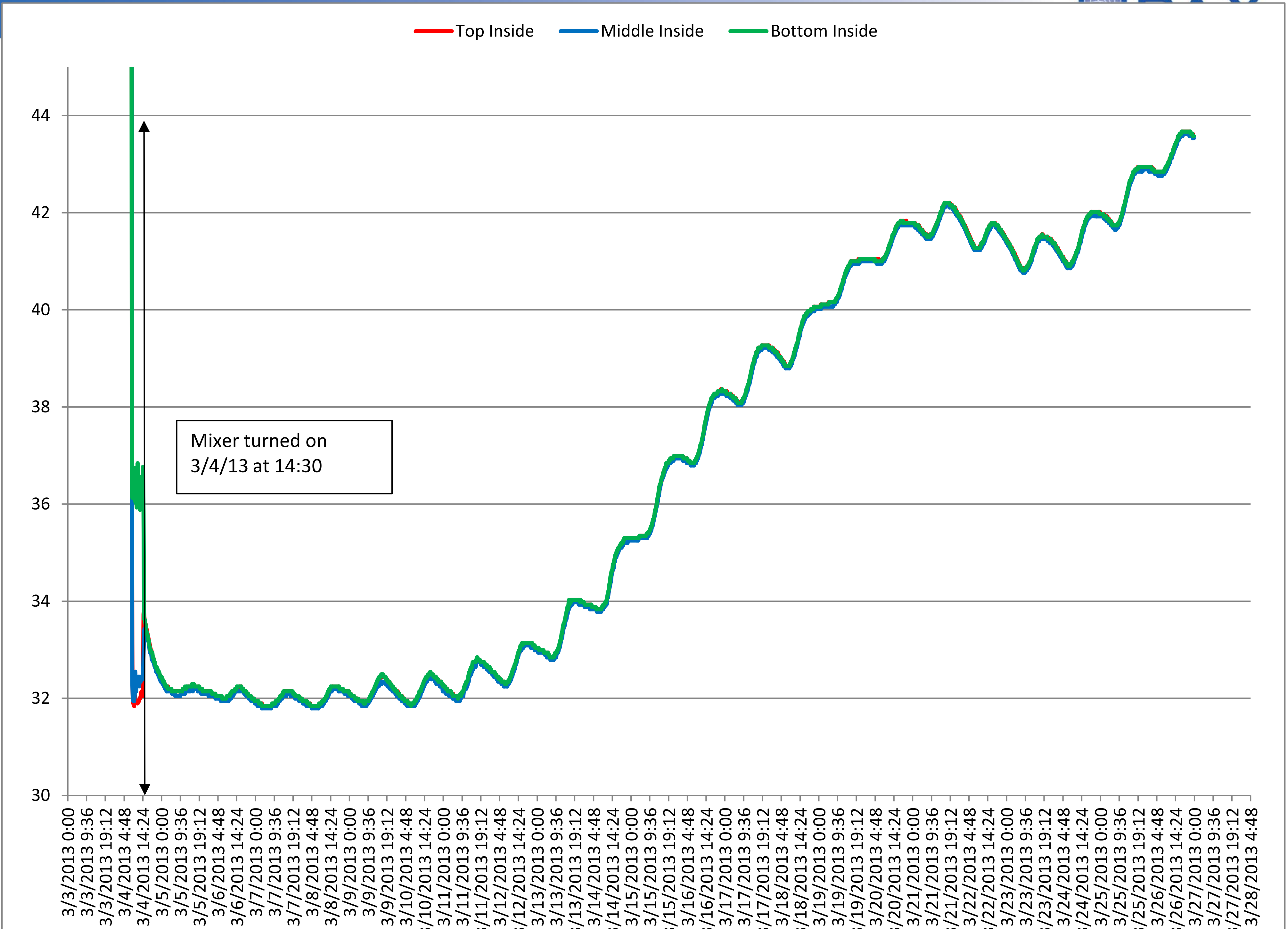

02.26.2013 13:26


03.06.2013 10:20


03.06.2013 10:29


03.27.2013 08:47


03.27.2013 08:48



Top Inside
Middle Inside
Bottom Inside
Mixer turned on
3/4/13 at 14:30
44
42
40
38
36
34
32
30
3/3/2013 0:00
3/3/2013 9:36
3/3/2013 19:12
3/4/2013 4:48
3/4/2013 14:24
3/5/2013 0:00
3/5/2013 9:36
3/5/2013 19:12
3/6/2013 4:48
3/6/2013 14:24
3/7/2013 0:00
3/7/2013 9:36
3/7/2013 19:12
3/8/2013 4:48
3/8/2013 14:24
3/9/2013 0:00
3/9/2013 9:36
3/9/2013 19:12
3/10/2013 4:48
3/10/2013 14:24
3/11/2013 0:00
3/11/2013 9:36
3/11/2013 19:12
3/12/2013 4:48
3/12/2013 14:24
3/13/2013 0:00
3/13/2013 9:36
3/13/2013 19:12
3/14/2013 4:48
3/14/2013 14:24
3/15/2013 0:00
3/15/2013 9:36
3/15/2013 19:12
3/16/2013 4:48
3/16/2013 14:24
3/17/2013 0:00
3/17/2013 9:36
3/17/2013 19:12
3/18/2013 4:48
3/18/2013 14:24
3/19/2013 0:00
3/19/2013 9:36
3/19/2013 19:12
3/20/2013 4:48
3/20/2013 14:24
3/21/2013 0:00
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3/22/2013 4:48
3/22/2013 14:24
3/23/2013 0:00
3/23/2013 9:36
3/23/2013 19:12
3/24/2013 4:48
3/24/2013 14:24
3/25/2013 0:00
3/25/2013 9:36
3/25/2013 19:12
3/26/2013 4:48
3/26/2013 14:24
3/27/2013 0:00
3/27/2013 9:36
3/27/2013 19:12
3/28/2013 4:48

Can a mixer keep my tank ice-free under ALL conditions?

- How much water comes into your tank?
- What is the incoming water’s temperature?
- How cold is it outside?
- How long is it that cold?
- What is the color of the tank?
- What is the R-value of the tank?

Depending on these factors, an additional heat source may be needed

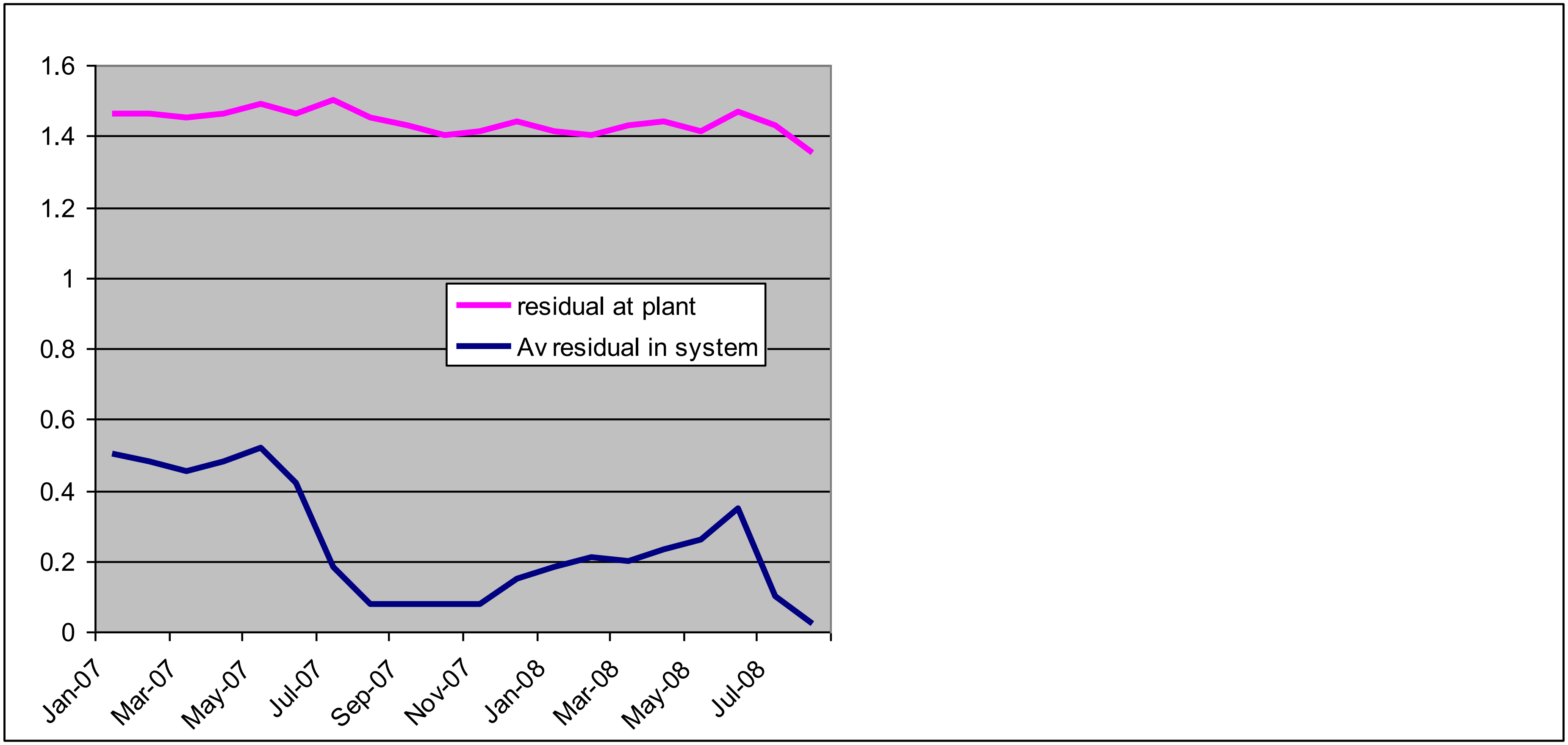
PAX WATER TECHNOLOGIES™

Active Mixing Lowers Residual Demand…

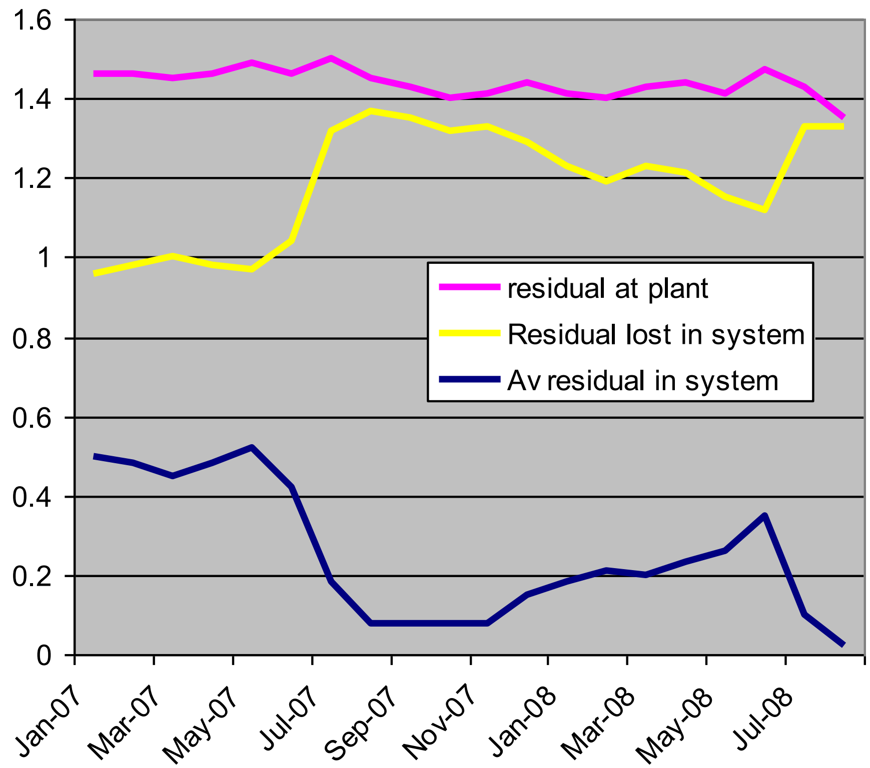
Old Town, Maine

- 2 identical tanks
- History of ice damage in winter
- Problems w/ residual loss in summer

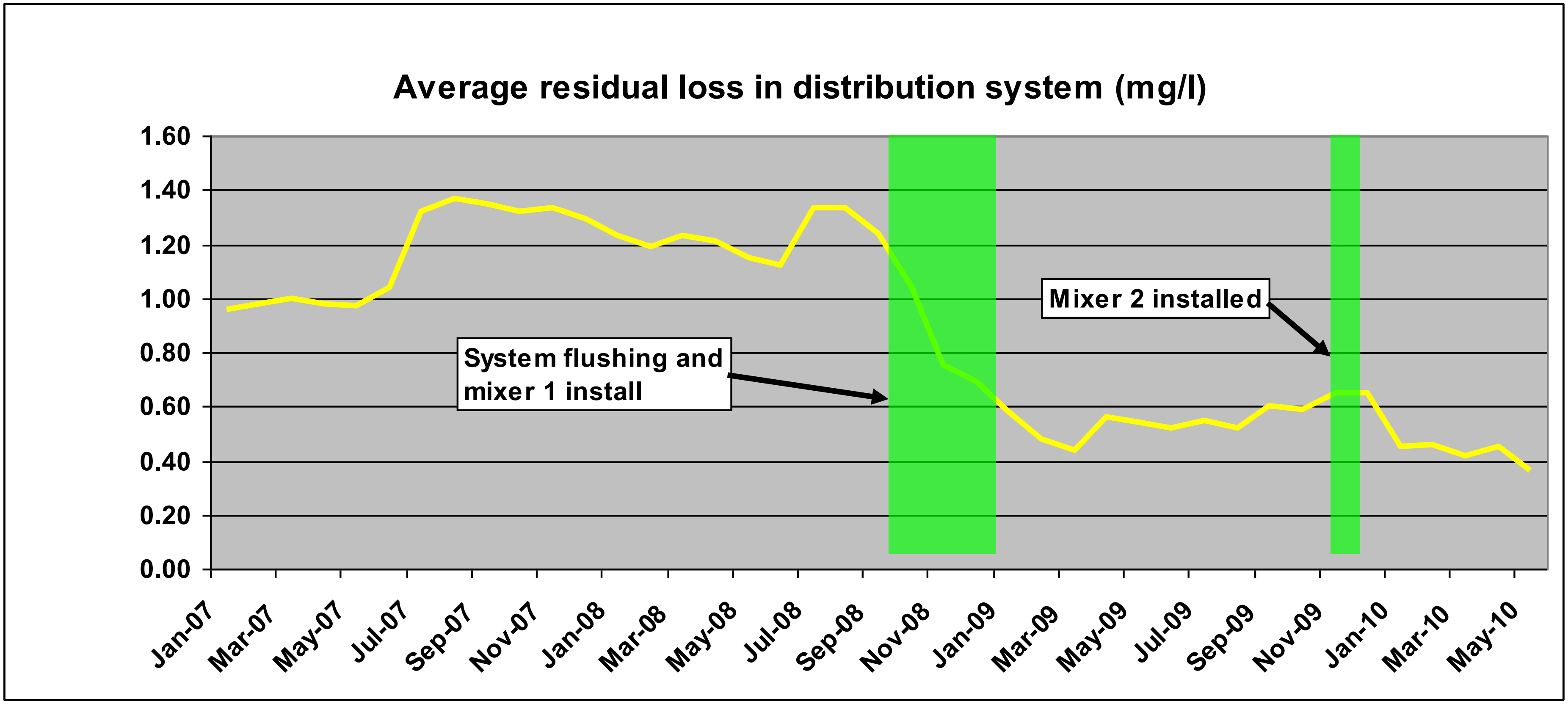
Residual before installing mixers



Residual before installing mixers



Residual after installing mixers



Lower disinfectant consumption = lower DBP production

"*We are able to maintain residual better than before we installed [the] 3 mixers.* The operator told me this morning that he thinks we can dial another .1mg/l out of the dose any day now because of rising residuals. "

Frank Kearney, Superintendent
Old Town, Maine

Download Free Whitepaper

First Name *

Last Name *

Company *

State/Province *

Email (kept private) *

What is your biggest water

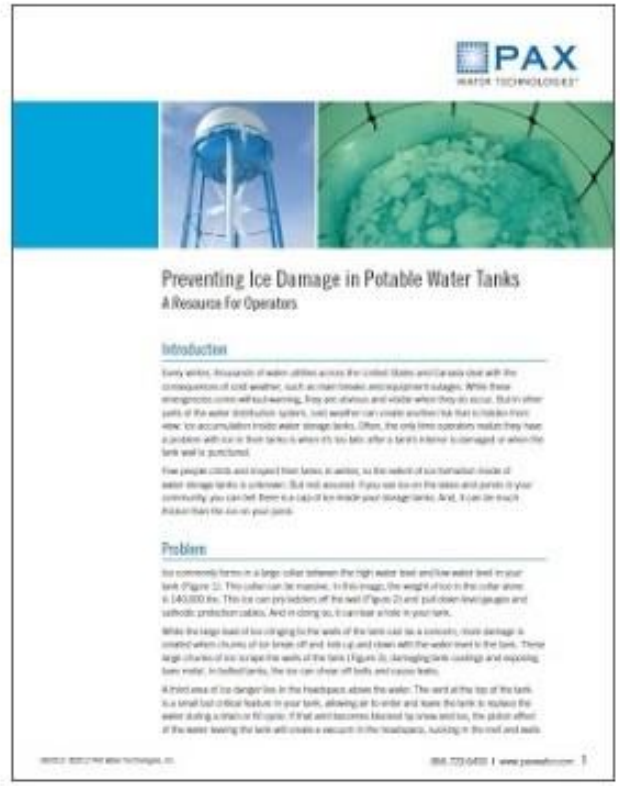
Preventing Ice Damage in Potable Water Tanks

Free Whitepaper for Operators

Every winter, thousands of water utilities across the United States and Canada deal with the consequences of cold weather, such as main breaks and equipment outages. While these emergencies come without warning, they are obvious and visible when they do occur. But in other parts of the water distribution system, cold weather can create another risk that is hidden from view: ice accumulation inside water storage tanks.

This whitepaper provides information on:

- The risks of ice formation in water storage tanks
- Traditional approaches for managing ice
- Active mixing as a new ice prevention tool
- Utility case studies on ice prevention



PAX

Preventing Ice Damage in Potable Water Tanks

A Resource For Operators

Introduction

Problem