What if Flint, MI Water Crisis hits Home?

WATER SOLUTIONS UNLIMITED

WATER SOLUTIONS UNLIMITED

WSU History

Focus on Municipal Drinking Water For last 29 years

1987

1996

2002

2016

Timeline for Flint Water Calamity

Timeline for Flint Michigan Water Crisis

- 2011
  - Emergency City Manager appointed. 1st of 4 over the next 6 years
- 2012
  - December
    - Flint officials meet to discuss water options
      - 1- Stay with Detroit Water System
      - 2- Switch to Karegnondi Water Authority

Timeline for Flint Michigan Water Crisis

- 2013
  - March
    - Flint City Council votes to join K.W.A. but this water will not be available for around 2 years
  - April
    - Detroit Water System notifies Flint that their water purchasing contract will end in a year. K.W.A. will not be finished before the contract ends.
  - June
    - Emergency City Manager hires engineering firm to plan to switch to treating water from the Flint River until K.W.A. is complete

Timeline for Flint Michigan Water Crisis

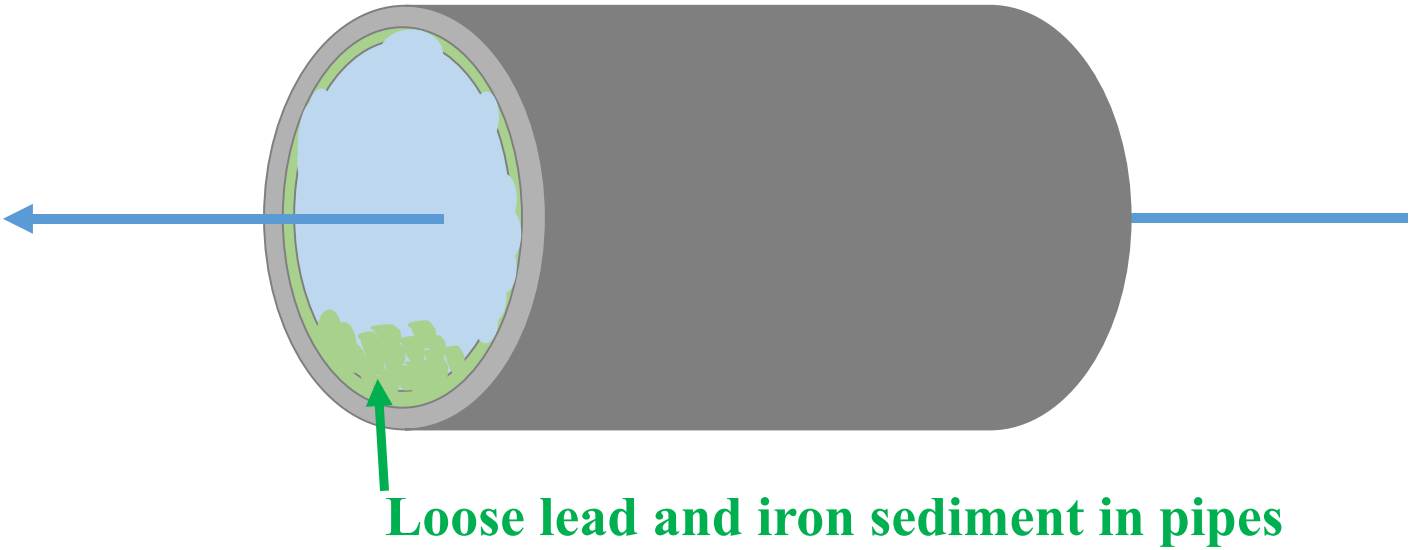
- 2014
  - March
    - Flint City Manager turns down an offer from Detroit to continue to buy their water.
  - April
    - The city opted out of Detroit's water supply and began drawing water from the Flint River , part of a cost-saving move.
    - State Environmental Regulators (MDEQ) approve permits to switch to Flint River, making the switch at the end of the month.
    - Professor Marc Edwards of Virginia Tech, a leading researcher on municipal drinking water, has confirmed that "there is nine times more chloride, which is the key ingredient in the corrosive water. . . in the Flint River than in Lake Huron water."

Timeline for Flint Michigan Water Crisis

- 2014
  - June
    - Numerous complaints from customers of bad smell, bad taste and water discoloration. Many claim the water is making them sick.
  - August
    - Flint Water samples test positive for E.coli. 2 days later several boil orders are issued. To kill the bacteria, the chlorine levels are raised.

Water from Flint River disrupted developed scales and biofilms

Flushing at low flow will clean lead deposits very slowly: Maybe months to years



Water from Flint River disrupted developed scales and biofilms

Flush pipes clean:

Remove lead and iron deposits in weeks

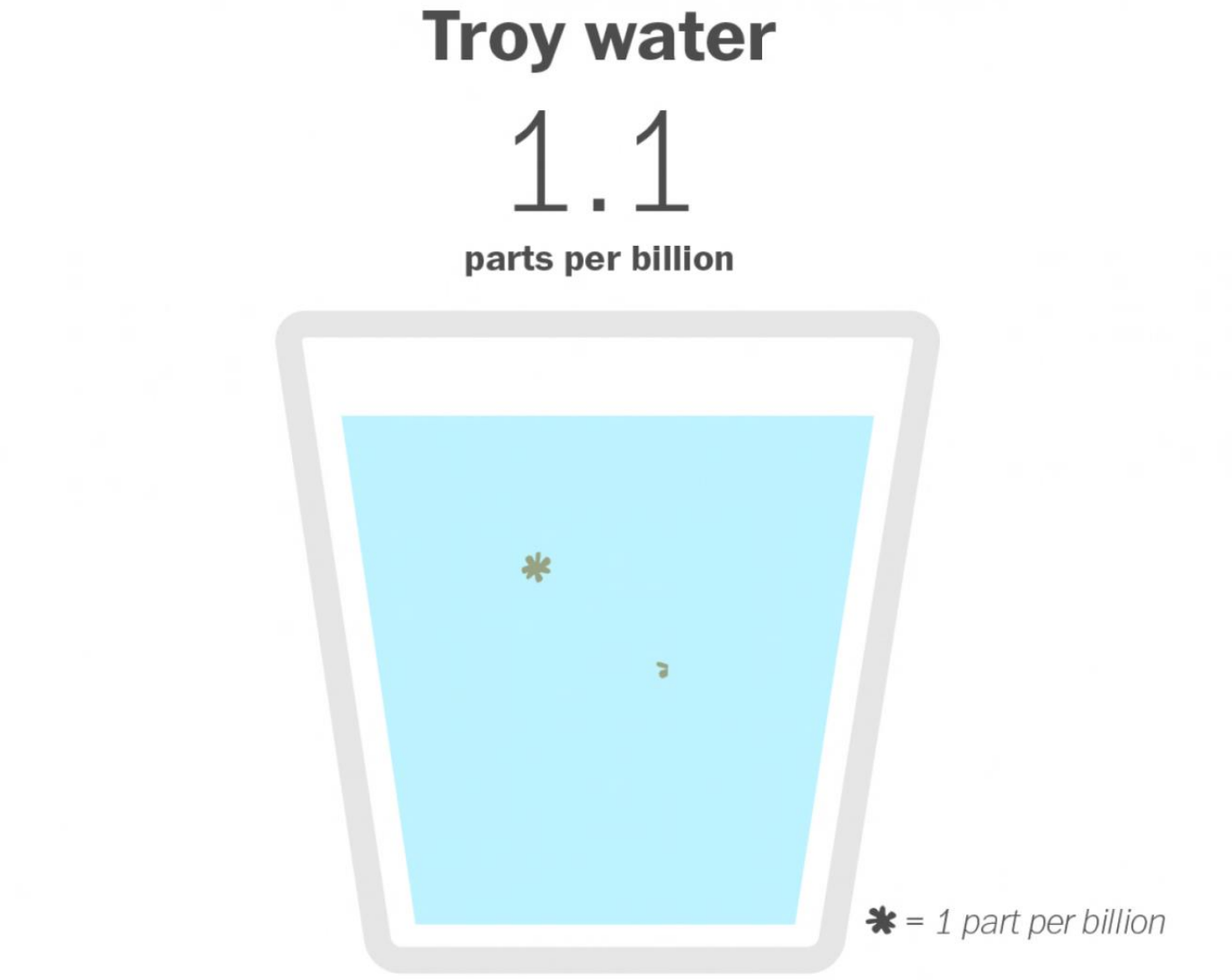
Timeline for Flint Michigan Water Crisis

- 2015
  - January
    - Due to the high amount of CL2 in the water, Flint is now in violation of the Safe Drinking Water Act. The water has unacceptable levels of TTHM's, which is a known carcinogen.
    - The Detroit water system offered to reconnect Flint including waiving a $4 million connection fee, which was declined by emergency manager Jerry Ambrose.
  - February
    - Water tests is certain parts of the city have a lead content of 104 parts per billion and up. The EPA limit is 15ppb.
  - March
    - Flint City Council votes 7-1 to connect back with Detroit.

Timeline for Flint Michigan Water Crisis

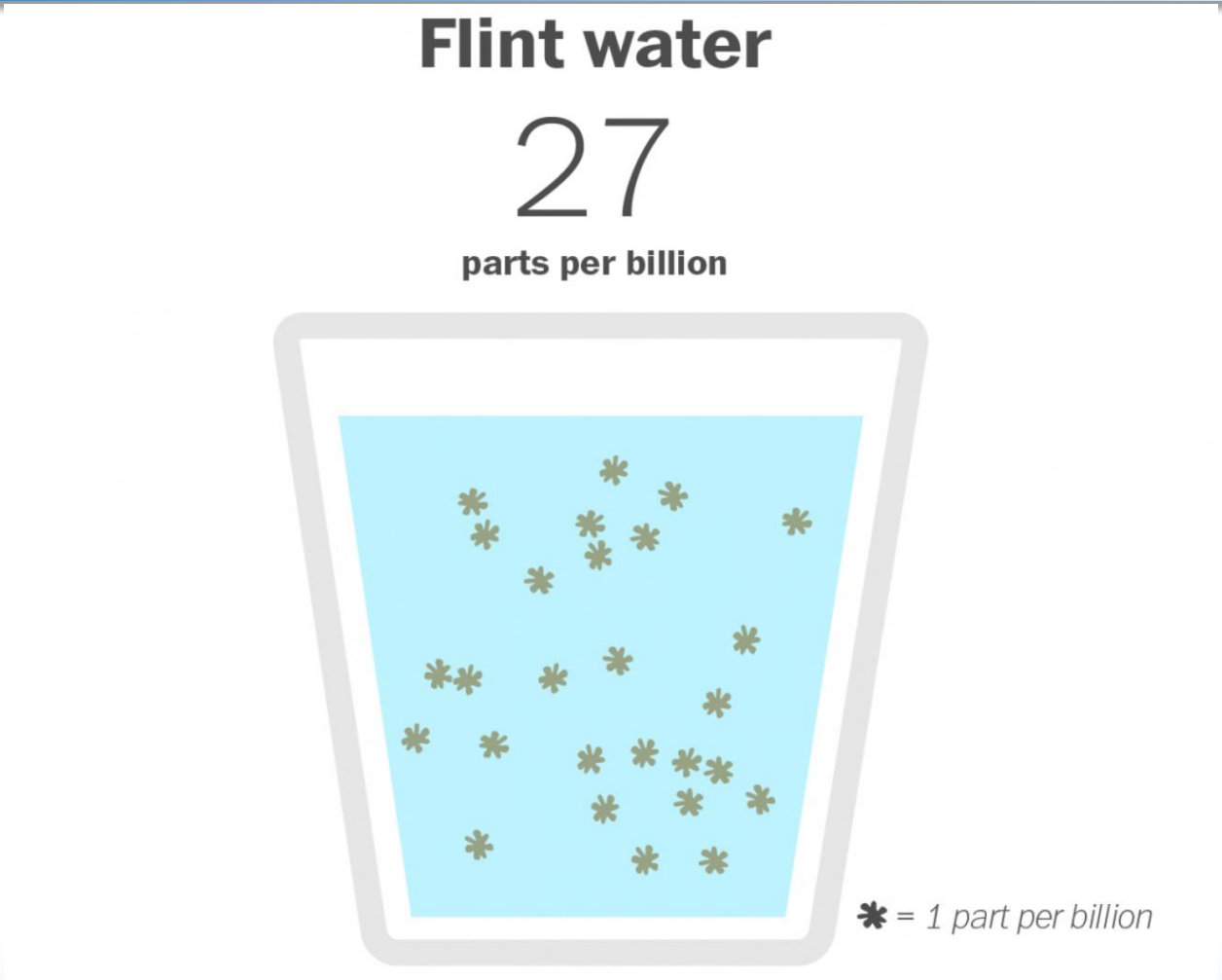
- 2015
  - September
    - Virginia Tech conducts a water study of 300 homes. One sample contain over 13,000 ppb. Anything above 5,000 is considered hazardous waste according to EPA.
  - October
    - County declares State of Emergency. Michigan Governor announces Flint is switching back to Detroit at a cost of around $12 million dollars.

90th percentile level for lead in 2013 was 1.1 parts per billion

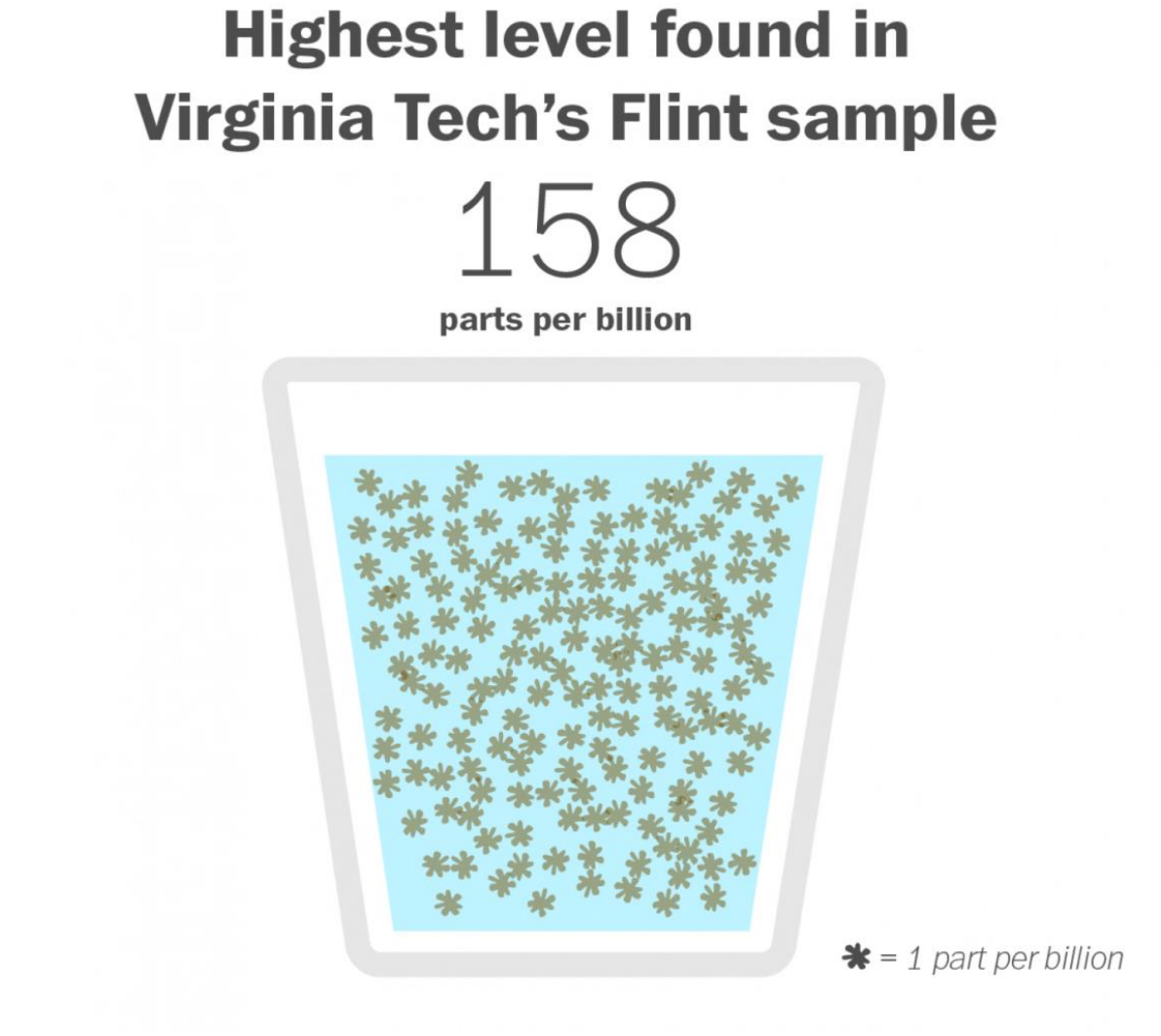


90th percentile reading was 2.3 parts per billion -- still highly acceptable

90th percentile reading among the 271 Flint homes tested in the summer of 2014



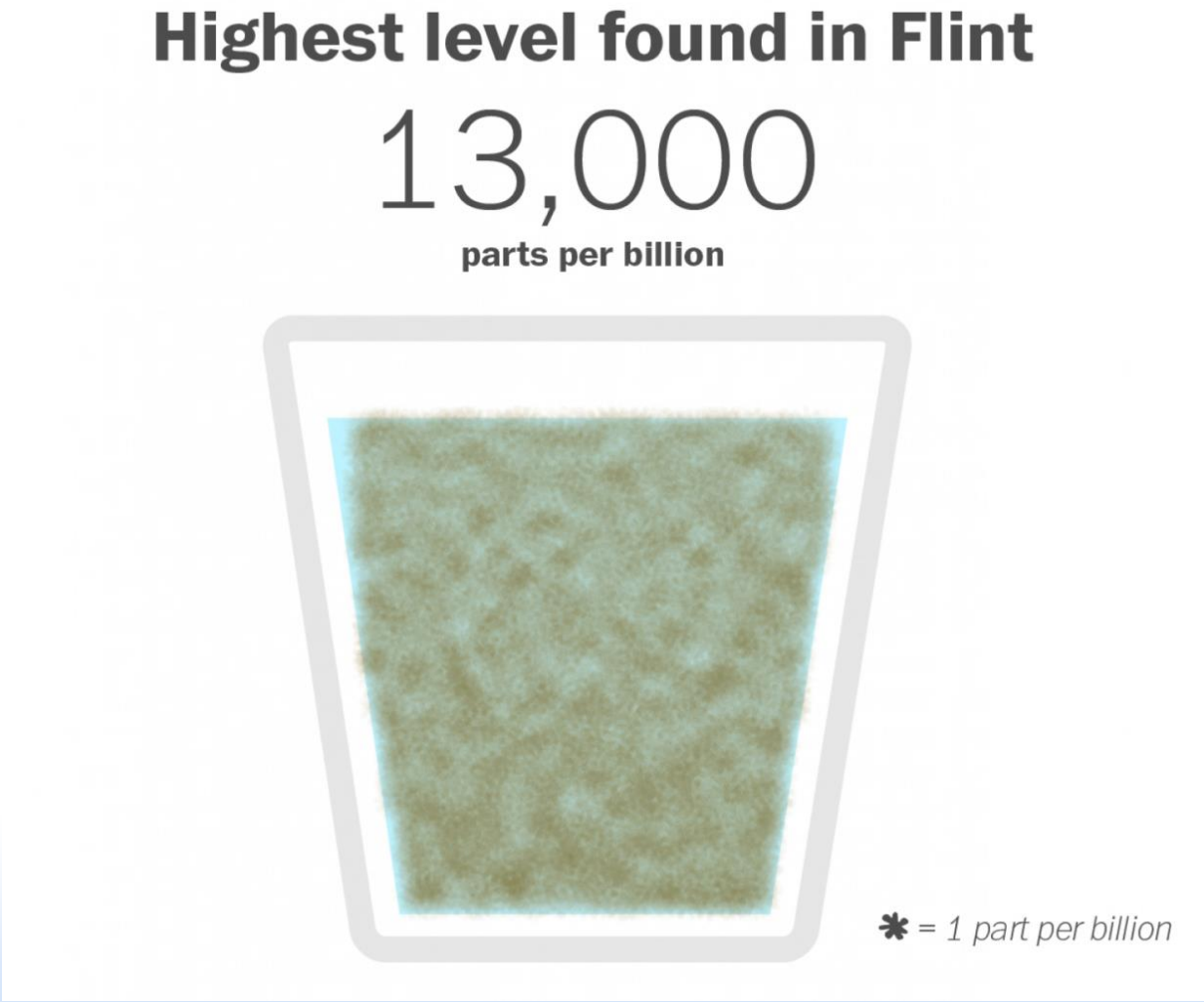
Here's the highest lead reading in the testing during that sample



LeeAnne Walters, mother of 4. One of her 4-year-old sons was diagnosed with lead poisoning

- Spring of 2015, had her line tested at 397 ppb.
- Virginia Tech re-sampled her service line 30 more times. The service line was flushed at different time intervals, then sampled.
- Lowest was 200 ppb. (15 ppb fails)
- More than half the tests were over 1,000 ppb.
- Some above 5,000 ppb (considered Toxic Waste)
- And 1 sample came back at……

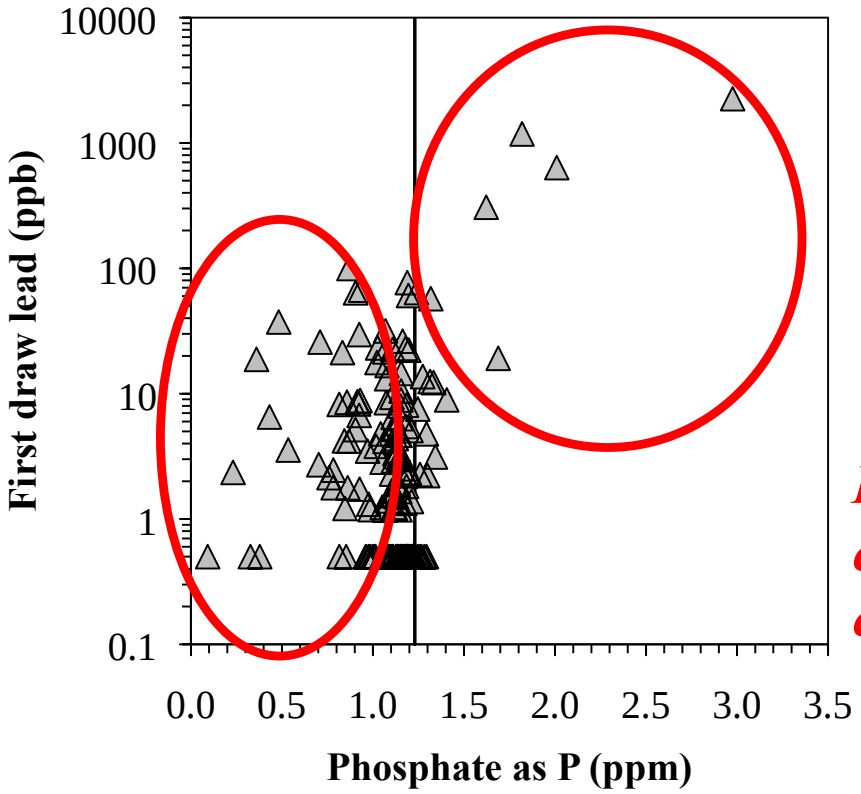
LeeAnne Walters' service line



Municipality Waters

- Federal Law mandates that all public water lines be treated for corrosion.
- **Note:** ***How is it possible, that Flint "passed" the official EPA Lead and Copper Rule sampling overseen by MDEQ?***
- Most facilities started adding Orthophosphates if they had corrosion issues.
- Pb & Cu testing is preformed every 3 years. Testing ranges from 10 to 30 approved sample sites, depending on the system's population.
- EPA action level for lead is 15ppb or .015 ppm.
- EPA action level for copper is 1.3 ppm
- Dirty water can be a factor in corrosion control.

Phosphate levels in 2016



Detachment of leaded scale

Inadequate levels of corrosion control chemicals

22&

Many Flint residents are using very little water

Two homes with persistent elevated lead problem only using ***20-45% of typical monthly volume***

1. Trying to reduce water bills
2. Showering only once per week (<5 min) to reduce the likelihood of rashes or exposure
3. Using bottled water for baths, washing dishes and other uses

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Conclusions

1. Flint is not yet meeting the 90%'ile lead action level

2. Lead levels are lower than in August 2015

3. Iron levels (and red water complaints) are decreasing

4. To speed up recovery of the system, residents will need to use more water

New Reason – "The Analyst" 3-31-16

- Equipment Costs
- Told by Engineering Group Needed a plant upgrade to feed chemical
- Plant upgrade $8 million
- Not sure how much of that all for feeding corrosion –
  - Included in 6,000 gal bulk storage tank. Transfer pumps, 120 gal day tank, and chemical metering pumps

Sampling Process for Lead and Copper

- Investigate:
- Check for new copper plumbing, as it can leach during it's break-in period.
- Make sure they haven't installed a water softener or have softened water on the line to be tested.
- Give your customer an instruction sheet.
- Water must not be used for 6-8 hours. First draw in the morning or when customer returns from work.
- Normal stream of water from the faucet.

What if Flint, MI Water Crisis hits Home?

- Call the Newspaper?
- See if you made the 6 O' Clock News?
- Beg for Mercy from the Mayor?
- Fire Everyone who built, worked, or managed the water plant?
- ……

#1 Option

Replace all Lead Lines

Up $8700 a line

Really Tough to do –
6.5 – 10 miliion homes

Relax – Focus – Do the right thing- Be honest

1. Usually, can be fixed
2. Often, a Simple Solution
3. OH EPA is your Friend
4. Let others help you

What is Corrosion?

Corrosion in water systems is defined as the electrochemical interaction between a metal surface such as pipe wall or solder and water. During this interaction, metal is oxidized and transferred to the water or to another location on the surface as a metal ion. Depending on the material there are many forms of corrosion, but usually the most important for drinking water are:

What Are Signs of Potential Trouble?

Poor Chlorine Residuals

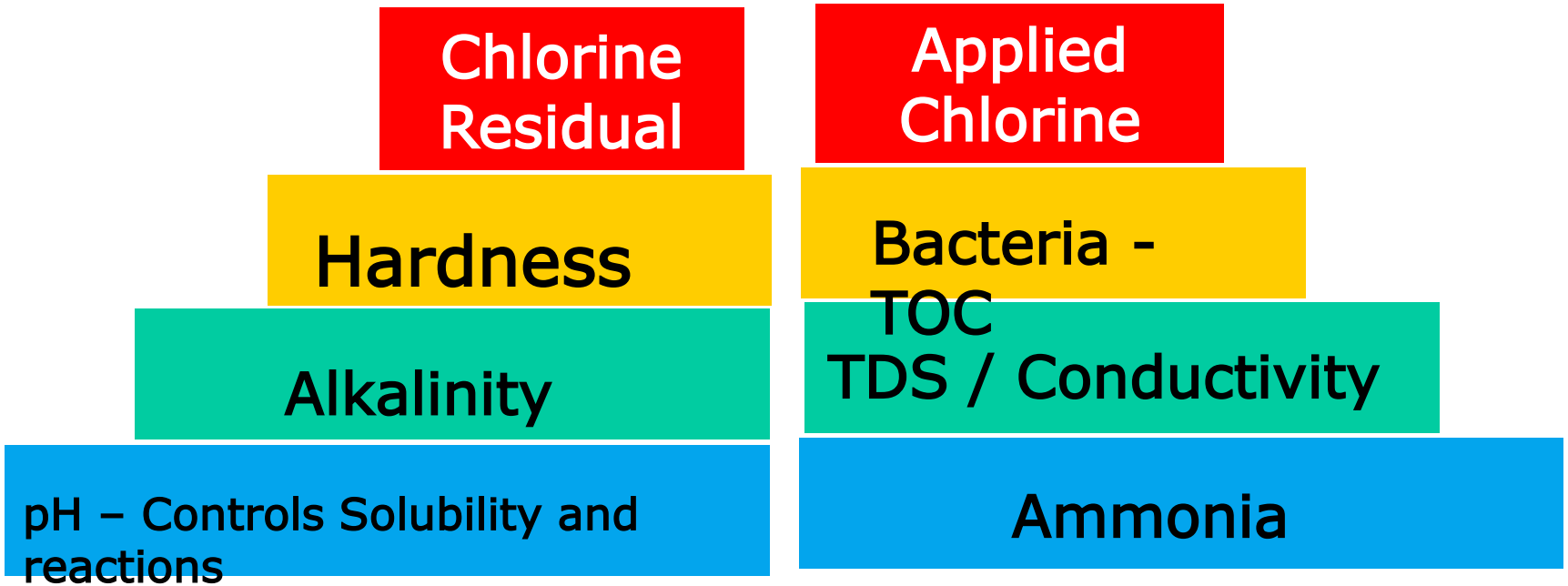
Do you have ammonia?

Discolored Water

Extra Soft Water

Equipment Repair

Building Blocks of Corrosion



Tools To Use

Langelier Index

Larson-Skold Index

CSI-Calcium Saturation Index

Ryznar

Coupons

Revised Larson-Consideration for Conductivity, Temperature, Sulfate, and Chlorides, Water Aging

What does langelier index tell?

- Developed in 1936 to show relationship between chemicals and galvanized pipe or iron
- Also called calcium carbonate saturation index or Saturation Index
- LI predicts if calcium carbonate will precipitate, dissolve, or be in equilibrium with sold calcium carbonate
  - If Precipitates – forms scale
  - If Dissolves – previous scale will be removed and expose pipe

Langelier Index - Interpretation

- LI>0 – H2O is supersaturated with solid calcium carbonate and form scale
- LI=0 H20 at equilibrium
- LI<0 – H20 is under saturated and scale will be removed from pipes

Types of Corrosion

1. General / Uniform
2. Galvanic
3. Erosion
4. Concentration cell & Pitting
5. Leaching of lead and copper

#1 – General Uniform

- electrochemical interaction occurs along the pipe wall, resulting in a relatively uniform loss of metal across the entire surface
- Caused by low pH conditions
- As pH increases, corrosion decreases
- Surface has slight granular feeling like the surface of a basketball, but smaller pebbles
- Pipe can go anodic to cathodic from instant to instant

#1A – Non- Uniform

where metal is lost from a localized point, causing pitting and mounding in some cases

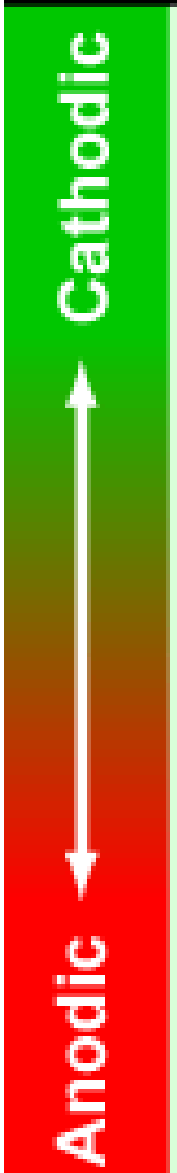
Pitting

MOUNDING

#2 - Galvanic

- Occurs when two dissimilar metals are coupled together and exposed to the same environment (water).
- The further apart the metals are in the electromotive series, the faster the corrosion of the least noble metal (anode)

Table 1- The Galvanic Series of Metals



Least Active High Potential	Platinum
	Gold
	Carbon (graphite)
	Titanium
	Type 316 or 304 stainless steel (passive)
	Monel metal (70% nickel, 30% copper)
	Silver
	Nickel
	Lead
	Bronze, Copper, Brass
	Tin
	Lead/Tin solder
	Type 316 or 304 stainless steel (active)
	Cast Iron/Mild Steel
	Cadmium
	Aluminium
Most Active Low Potential	Zinc
	Magnesium

DISIMILAR METALS

#3 - Erosion

- The natural wearing away of metal surfaces due to friction, abrasion, etc.

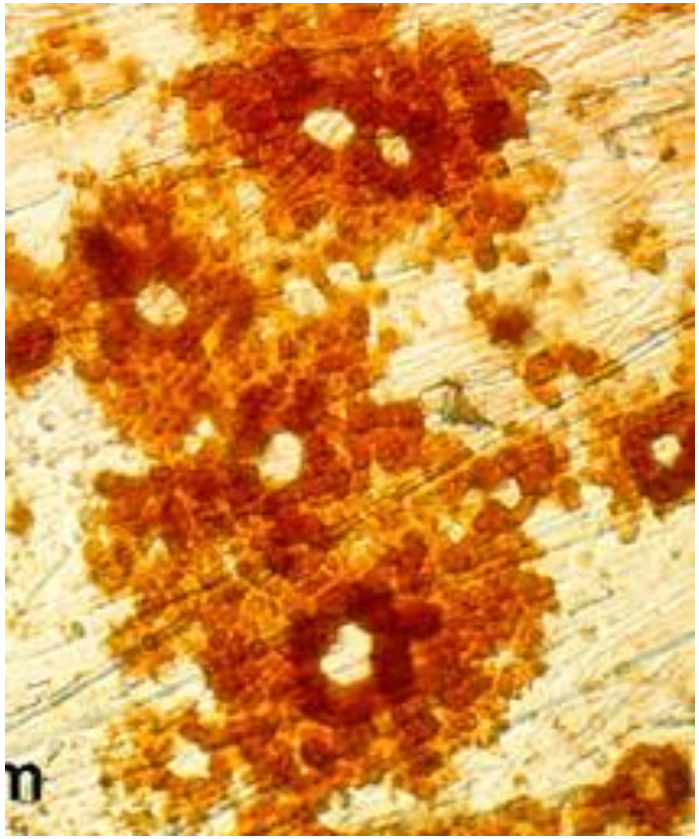
#4 – Concentration Cell and Pitting

- Generally in areas of deposition
- A difference in potential forms when less oxygen forms under the deposit compared to the oxygen around the deposit.
- The area under the deposit becomes anodic compared to the area next to the deposit
- Very rapid corrosion takes place under the deposit forming a pit

Pitting of Pipe

Luxury Home for Biofilm

- Stainless Steel and Copper
- Microorganisms modify disposition of metals
- Detach individually or in clumps
- Aeration of cell, leads to localized changes in oxygen concentration
- Migrate across surfaces
- 10 fold more biofilm on metals vs. plastic



#5 – Selective Leaching of Lead & Copper

- Copper limit 1.3 mg / l
  - 3 mg / l can cause nausea, vomiting, & abdominal pain
- Lead limited to 15 ppb
  - Can lead to fetus development issues, brain, kidney, nervous system in adults

Homeowners

- City water is great – what's happening?
- Over soften
- Take out all hardness
- Go all RO
- Water Heaters too high

The Issues

- Older homes have:
  - Old plumbing fixtures
- Phosphates react with lead, copper and hardness ions to form an insoluble coating on the internal surfaces
- Once coating is formed, lead and copper levels drop rapidly

Does my system look like this?

Does my system look like the pipe on the right?

Realistic, quick, proven options

Silicates	pH Adjustment	Phosphates
• Not commonly used • Will “coat” lines • High feed rates often needed • Can be combined with phosphates • Low hardness water	• Usually with Caustic • Hazardous Chemical • Can clog lines • Inexpensive on a per lb. basis – per application? • Known to work well	• Tried and True • Usually low feed rate • Higher cost per lb. – per application? • Not all phosphates blends the same • Not Haz / except Zinc

WATER SOLUTIONS UNLIMITED

Control by pH

- Use Caustic to increase pH and build a layer to protect from corrosion
- Can lead to blockage in pipes
- Dangerous to work with
- Though to be inexpensive –

Norwalk, OH - Rick Schaffer

"The results of the polyphosphates trial have been overwhelmingly positive. Further checks of the inside of the line between the filter effluent and the plant clearwell confirm that the build-up has stopped. Testing indicates the water in the distribution system is even less corrosive than before the trial, when caustic soda was being used for pH adjustment.

As a side benefit, our chemical expenditures for polyphosphates will be lower than it was under the caustic soda/pH adjustment program. "

CORROSION CONTROL MECHANISM

“Barrier Protection”
How do Phosphates work?

20th Century Uses of Phosphates in Water Treatment

- First Use- 1887, First use of scale & Corrosion Inhibitors
- Threshold Treatment- 1930, small dosage of hexameta to control $CaCO_3$
- Blended Phosphates- 1960’s
- Zinc-orthophosphate- 1970’s
- Lead & Copper Control- 1990’s

Anodes and Cathodes

- Every metal surface is covered with innumerable anode and cathode sites
- Anodes are negatively charged compared to positively charged cathodes
- Sites are extremely small

TYPES OF CORROSION INHIBITORS

- ANODIC INHIBITORS – Stifle anodic reaction by forming a barrier oxide film
  - Orthophosphates
- CATHODIC INHIBITORS – Due to the formation of hydroxyl ions (OH-) at the cathode, this increases the pH, which promotes the precipitation of a thin coating or barrier. This prevents the flow of electrons for the reduction of oxygen
  - Polyphosphates

How Anode and Cathode Sites Develop

- Surface irregularities from forming, extruding and other metal working activities
- Stresses from welding or forming
- Compositional differences at the metal surface

Corrosion Methods

- Phosphates control the corrosion reactions by stifling either the cathode or anode reaction, or both reactions

Anodic and Cathodic protection

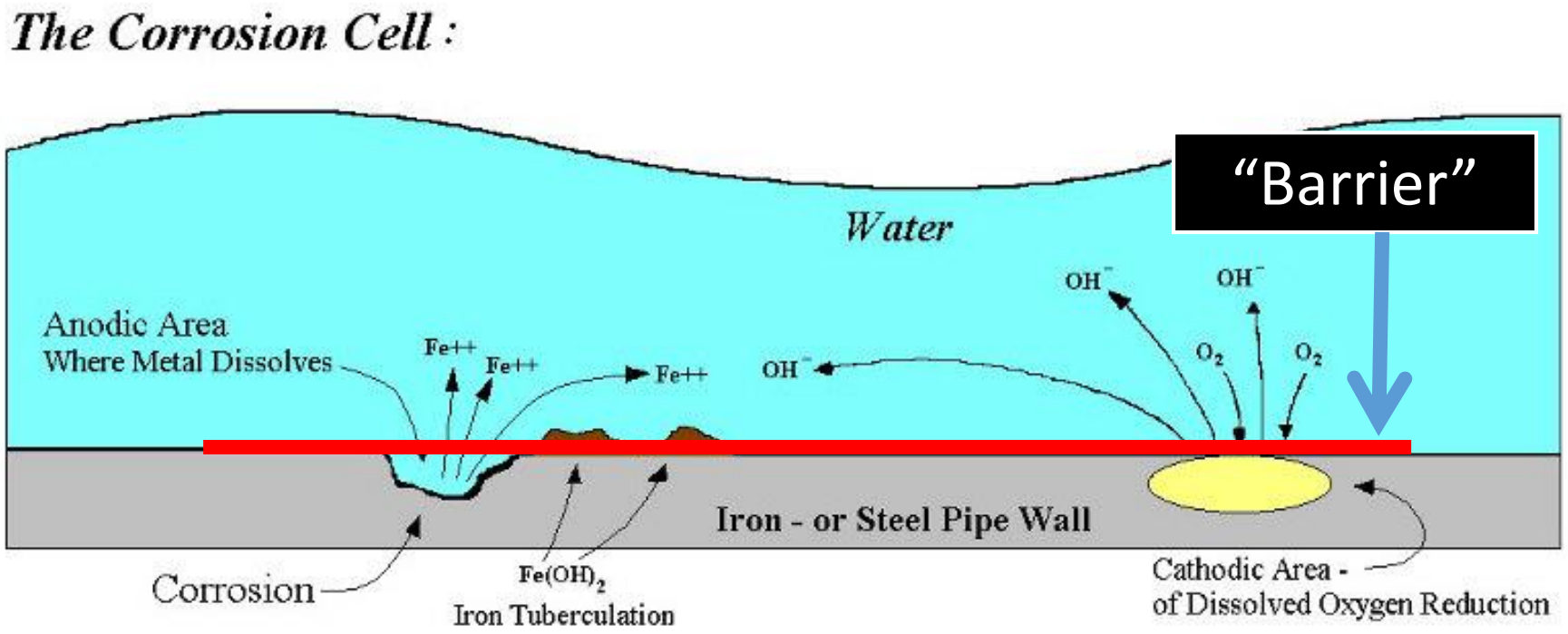
Anodic "Phosphate"

- Corrosive "situation" occurs
- Iron Fe +++ begins its transformation
- Phosphate "Blocks" Fe from leaching into water
- Corrosion stopped

Cathodic "Phosphate"

- Corrosive "situation" occurs
- Oxygen tries to penetrate into pipe wall
- Phosphate "Blocks" Oxygen from getting to pipe to continue the corrosion process

What Happens when a Phosphate is Added?



A "Coating" is laid down to shut down the process. Some phosphates are better at Anodic Corrosion and others better at Cathodic

Keys for a good Barrier

pH

Best under 8 – like closer to 7

Hardness

Calcium Hardness Key

Clean up?

Is there Iron that needs tied up too?

What's Your Target

Copper, Steel, Lead?

Which Phosphate "Blend" is for my system?

- Some better for Steel vs. Copper vs. Lead
- Some very good for Anodic, some better for cathodic corrosion
- Most places need both
  - Good Anodic coverage with poor cathodic coverage often leads to dirty water
- What is the main culprit causing the problem
- Phosphate application is more of an "Art" than a science.

Ortho – Poly Blends

- Provide Sequestering and Corrosion Control
- Effective over a broad pH
- Good Copper control in high hardness waters
- Modest galvanic control

Advantage of Blend

- Ortho and Polyphosphates compliment each other
- Can often use lower dose of blend
- Phosphoric Acid for Corrosion control
  - May dose 2-4 ppm
  - Blend usually .5 -1.5 ppm

Is one better than another – New England Towns

Town A	Town B	Town C
Phosphoric Acid	Zinc / Orthophosphate	Poly / Ortho Blend 65/35
pH - 7.9	pH - 7 - 8	pH - 7.1 – 7.4
Hardness as $CaCO_3$ -13	Hardness as $CaCO_3$ -14	Hardness as $CaCO_3$ -16
Alkalinity- 19	Alkalinity- 16	Alkalinity- 18
Dose - 4.6	**Dose - 1.5 – 2.1**	**Dose - 0.6 – 0.8 ppm**
First Draw Metal	First Draw Metal	First Draw Metal
Lead - 7 ppb	Lead - 12.5 ppb	Lead - 3 ppb
Copper - 0.118 ppm	Copper - 0.147 ppm	Copper - 0.11 ppm

How Do You Measure Success?

Sequestering Application

- ”Cleaner” Water
- Better Flushes
- No breakdown of Phosphate
  - No increase in ortho reading

Corrosion Application

- Better Coupon results
- Better Flushes
- Few line breaks
- Fewer pinhole copper leaks

Actual Coupons

Before Program

After Program


C1010
C1010
A77650
C1010
A77647
C1010
A72426

Highland, IL - Corrosion Coupon Record

2/6/2007

Steel

Coupon Serial No.	Date Installed	Date Removed	Original Weight (g)	Final Weight (g)	Exposure	Weight Loss (g)	Exposure (hours)	Mils per Year 45 days	60 days	90 days	120 days
W 8999	1-Jun-06	17-Jul-06	11.931	10.862	46 days	1.069	1104	19.51			
W 9000	1-Jun-06	30-Aug-06	11.993	10.796	90 days	1.197	2160			11.17	
X 3130	17-Jul-06	30-Aug-06	10.657	9.473	44 days	1.184	1056	22.59			
A 59376	30-Aug-06	17-Oct-06	10.500	9.688	48 days	0.812	1152	14.20			
A 59382	17-Oct-06	4-Dec-06	10.536	10.360	48 days	0.176	1152	3.08			
A 59386	4-Dec-06	18-Jan-07	10.514	10.485	45 days	0.029	1080	0.54			

FEED RATE as PO4

0.3 mg/L

0.3 mg/L

0.3 mg/L

0.6 mg/L

0.9 mg/L

1.1 mg/L

Highland IL 2-2-07Steel

Phosphate Production

- MSP – Monosodium Phosphate
- DSP – Disodium Phosphate
- TSP – Trisodium Phosphate
- SAPP – Sodium Acid Pyrophosphate
- TSPP – Tetrasodium Pyrophosphate
- TKPP – Tetrapotassium Pyrophosphate
- STPP – Sodium Tripolyphosphate
- SHMP – Sodium Hexametaphosphate

How do I choose Blend?

- Are you Groundwater or Surface Water?
- Primary need for phosphate?
  - Corrosion?
    - Copper, Steel, or Lead?
  - Sequester?
    - Iron – Manganese?
- Which ranks higher?
- Do you have filter plant?
- Water Characteristics?

US EPA Potential Recommendations

Improved Optimal Corrosion Control Requirements

Household Action Level

Point of Use Filters

Clarify and Strengthen Sampling Requirements

Eliminate practice of flushing after 6-8 hour stagnation period

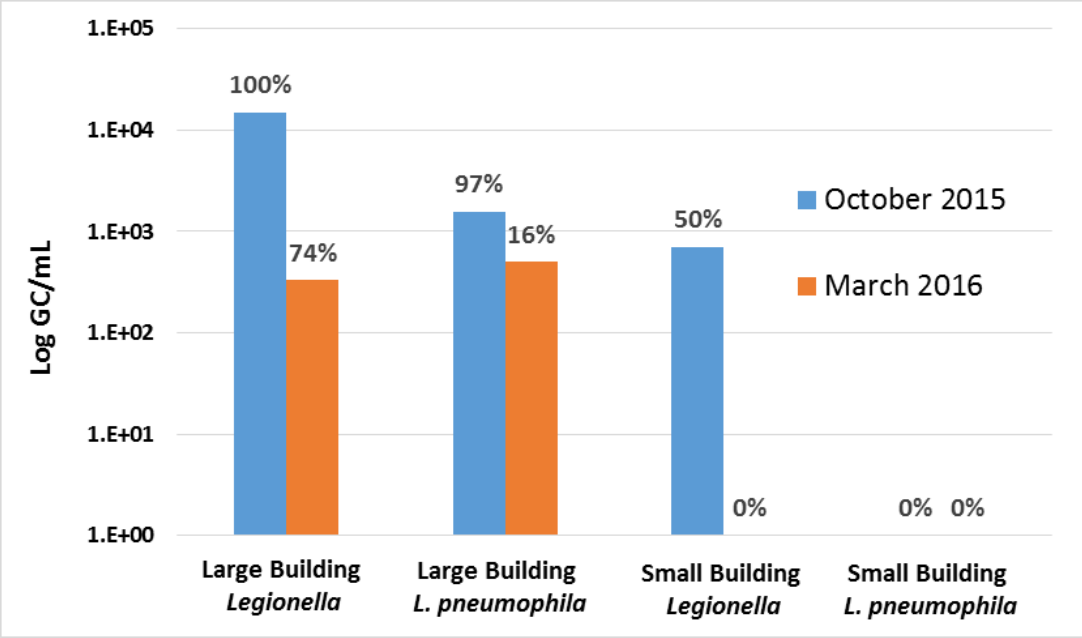
Make sure faucet aerators not removed

Encourage wide mouth bottles79

Bottom - Line

- **Many Issues can be readily solved**
- **Don’t be afraid to ask for help**
- **Fixes are not as expensive and difficult as often believed**

*Legionella)*numbers(decreased(from(October(to(March



Legionella – Quick Review

What Can Happen?

- Lung Infection
- Pneumonia
- Small Droplets of water normal cause
- Hospital Visit
- 1 in 10 die

Incidence

- 5,000 people diagnosed last year
- 20 serious outbreaks

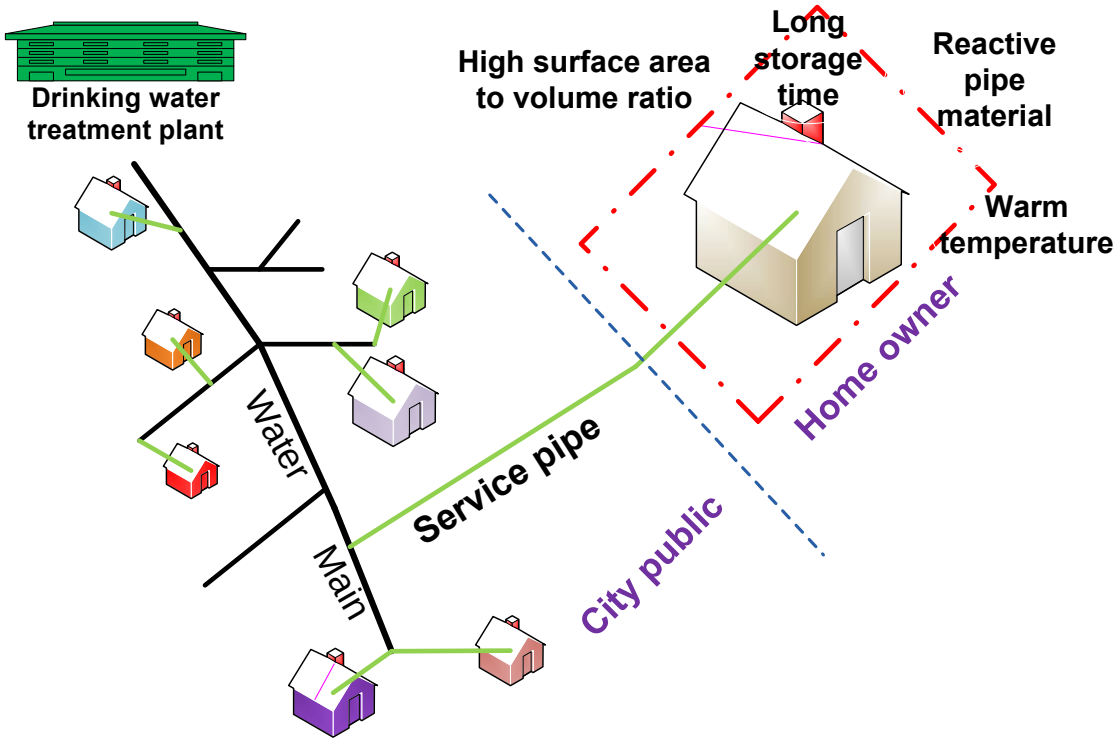
Where does Legionella Grow?

Drinking Water 56% of cases

7% of cases

22% of cases

Influence of City Drinking Water Quality on *Legionella* in Tap Water



How to keep *Legionella* numbers down

- Avoid stagnation of water
  - Normal flushing of the system is helpful
  - Flushing will help stop corrosion and better
- Control Biofilms
- In[illegible] 40°F
- Continued monitoring and vigilance
- EPA working to improve water quality and Health Department is monitoring and reporting illness

All Done – Questions?

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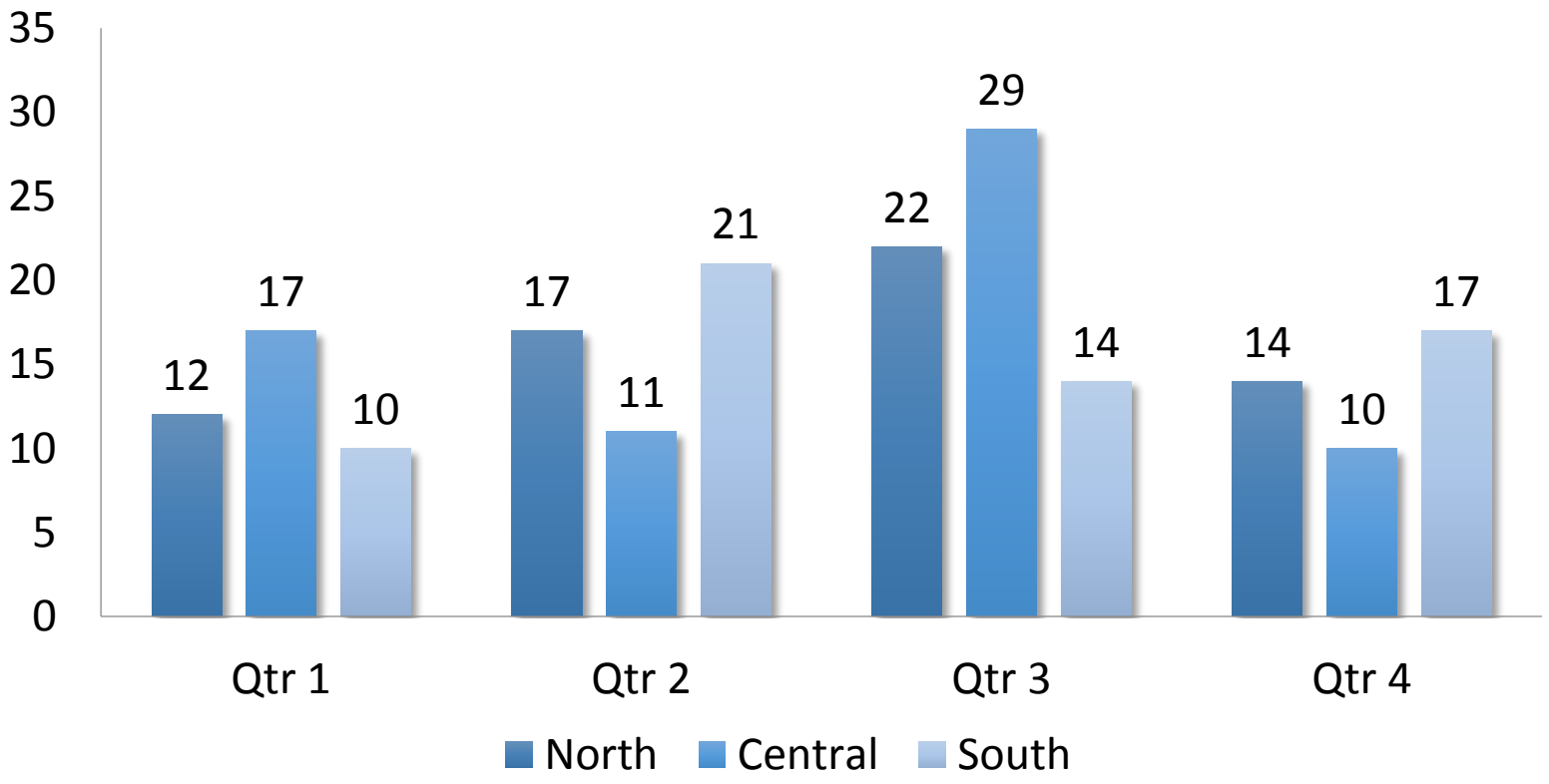

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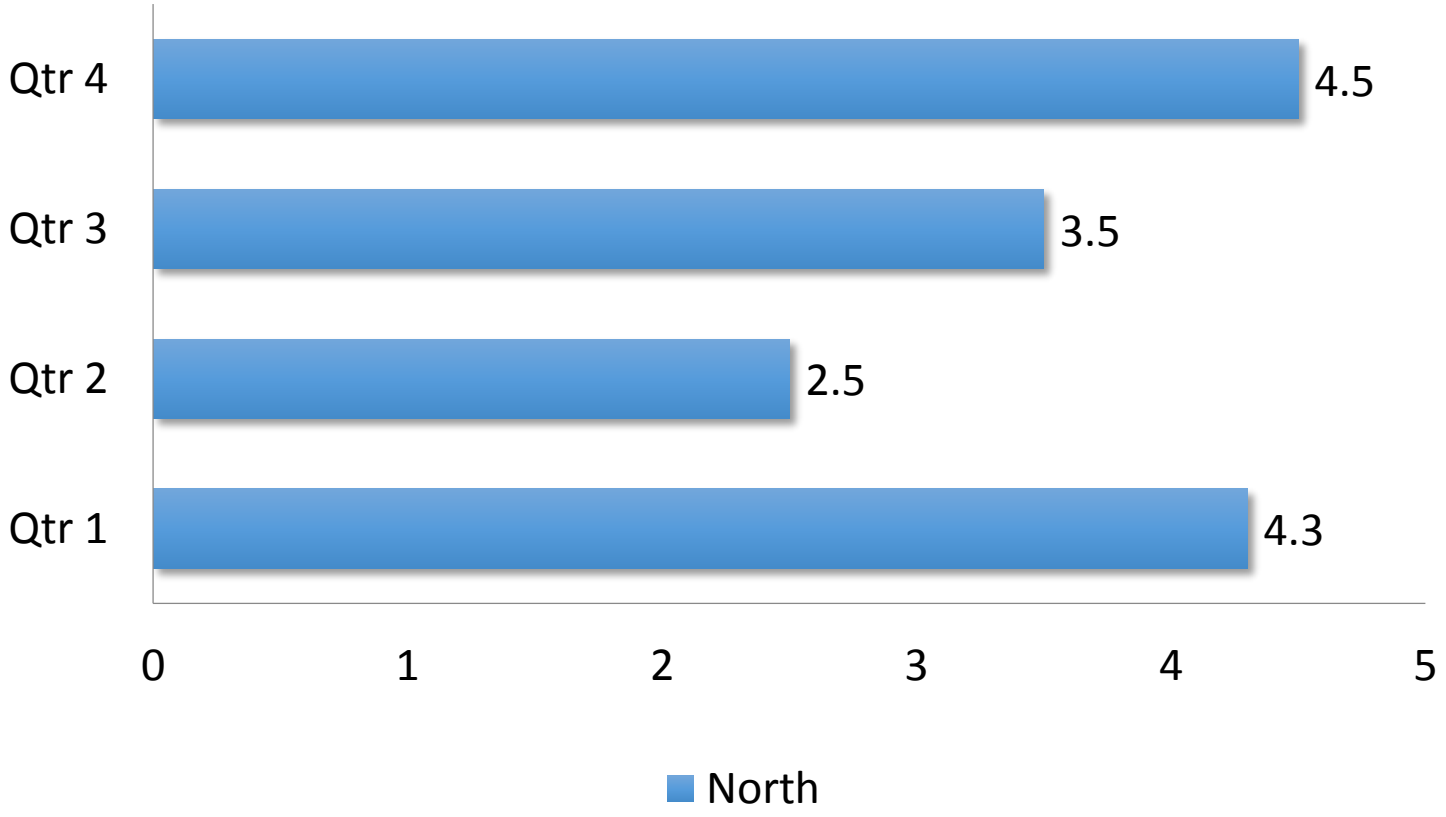

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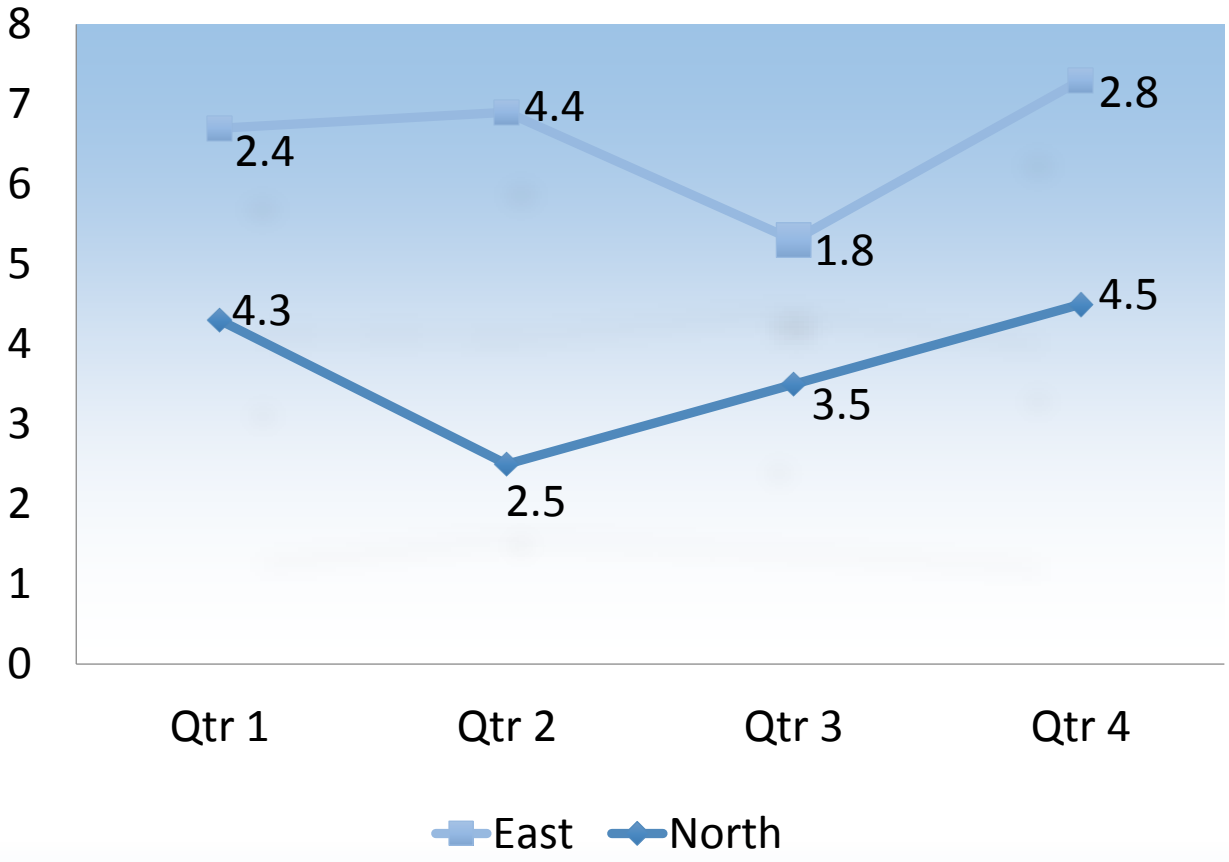

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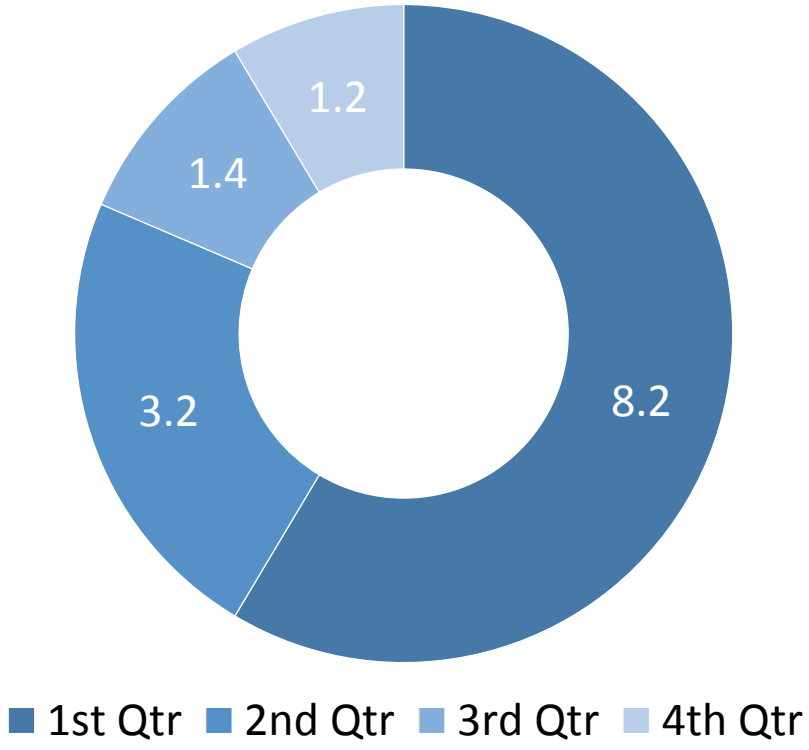

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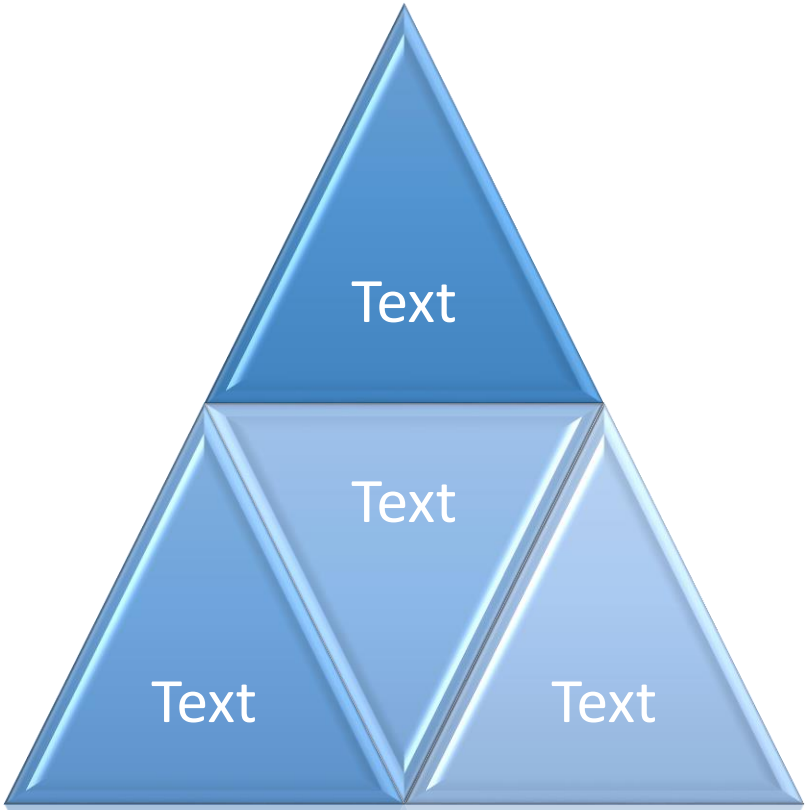

PLACE YOUR TEXT HERE

- This is just a sample text to give you an idea of what it will look like when you place your text
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PLACE YOUR PRESENTATION TITLE HERE

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PLACE YOUR TEXT HERE	TEXT	TEXT	TEXT
Sample text 1	5.5	8.4	6.8
Sample text 2	10.5	5.5	9.8
Sample text 3	7.4	6.2	5.9
Sample text 4	6.8	4.9	8.4
Sample text 5	4.3	3.7	6.9
Sample text 6	9.5	5.8	4.7
Sample text 7	7.4	9.7	3.8
Total	51.4	44.2	46.3

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Sample text 1	5.5	8.4	6.8
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Sample text 3	7.4	6.2	5.9
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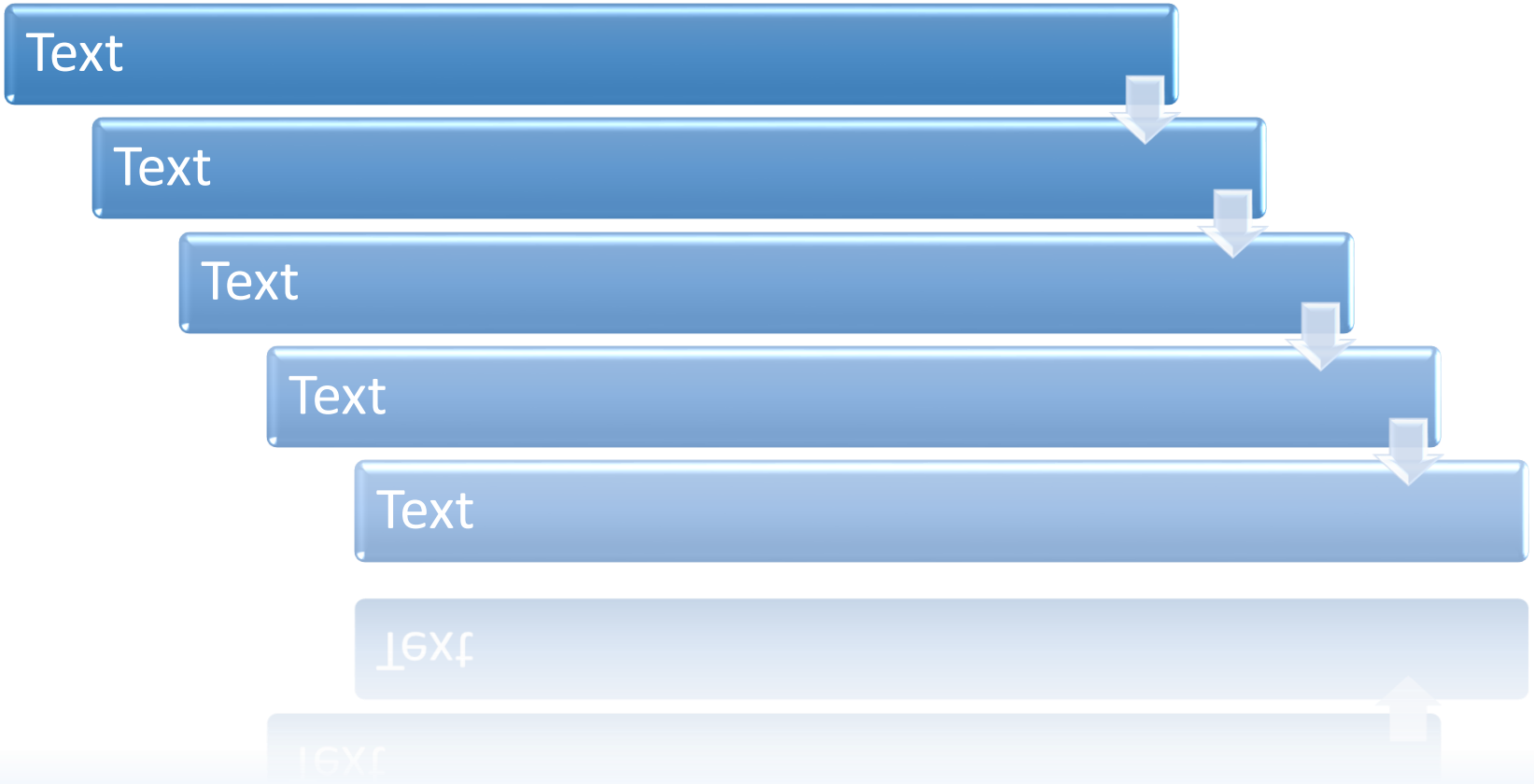

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PLACE YOUR TEXT HERE

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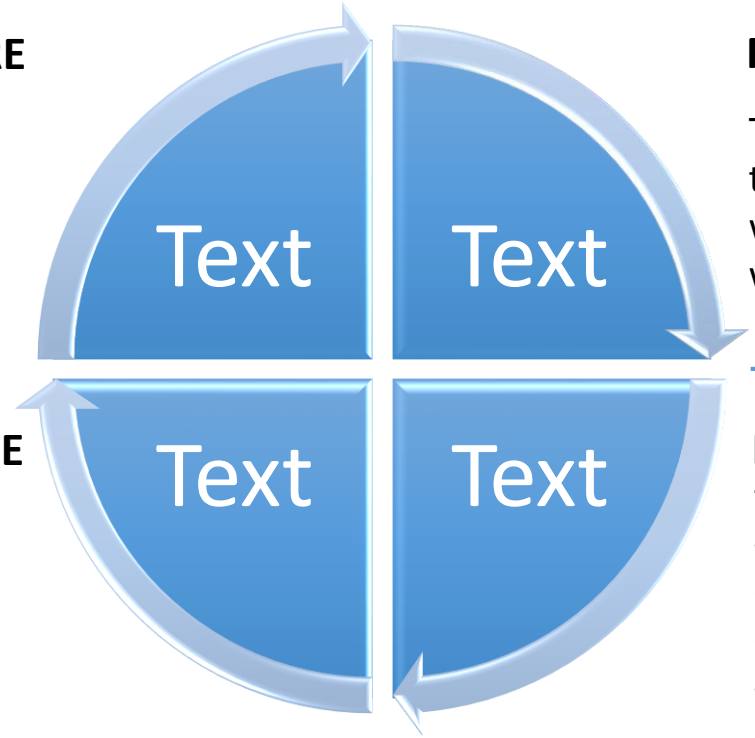

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"This is just a sample text to give you an idea of what it will look like when you place your text. Please feel free to change it to your own text."

-Author's Name

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