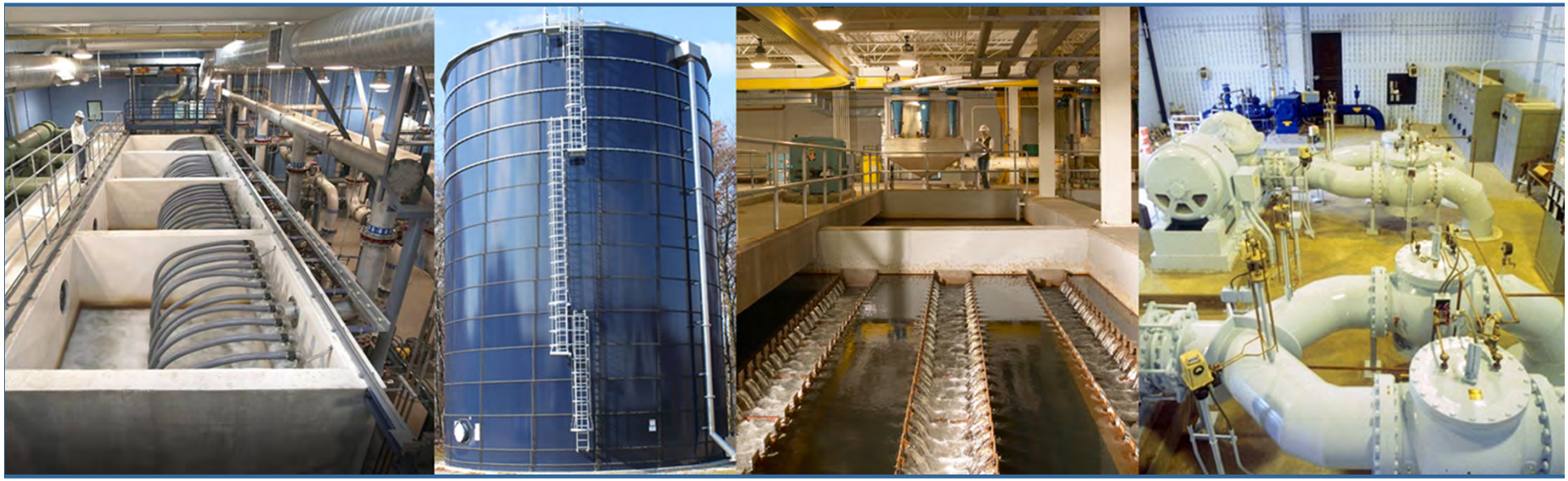
Distribution System Upgrades to Improve Water Quality



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Pennsylvania AWWA
American Water Works Association
www.paawwa.org

PA AWWA Annual Conference
May 6th – 8th, 2014 Bethlehem, PA

Hatch Mott MacDonald

Outline

- Replace Water Lines Project
  - Project Purpose
  - Study Phase
    - Utility Source Evaluation
    - Elevated Storage Tank Evaluation
    - Plumbing System Evaluation
    - Distribution System Evaluation
    - Hydraulic Model
  - Design Phase
  - Construction Phase
  - Conclusions

Project Purpose

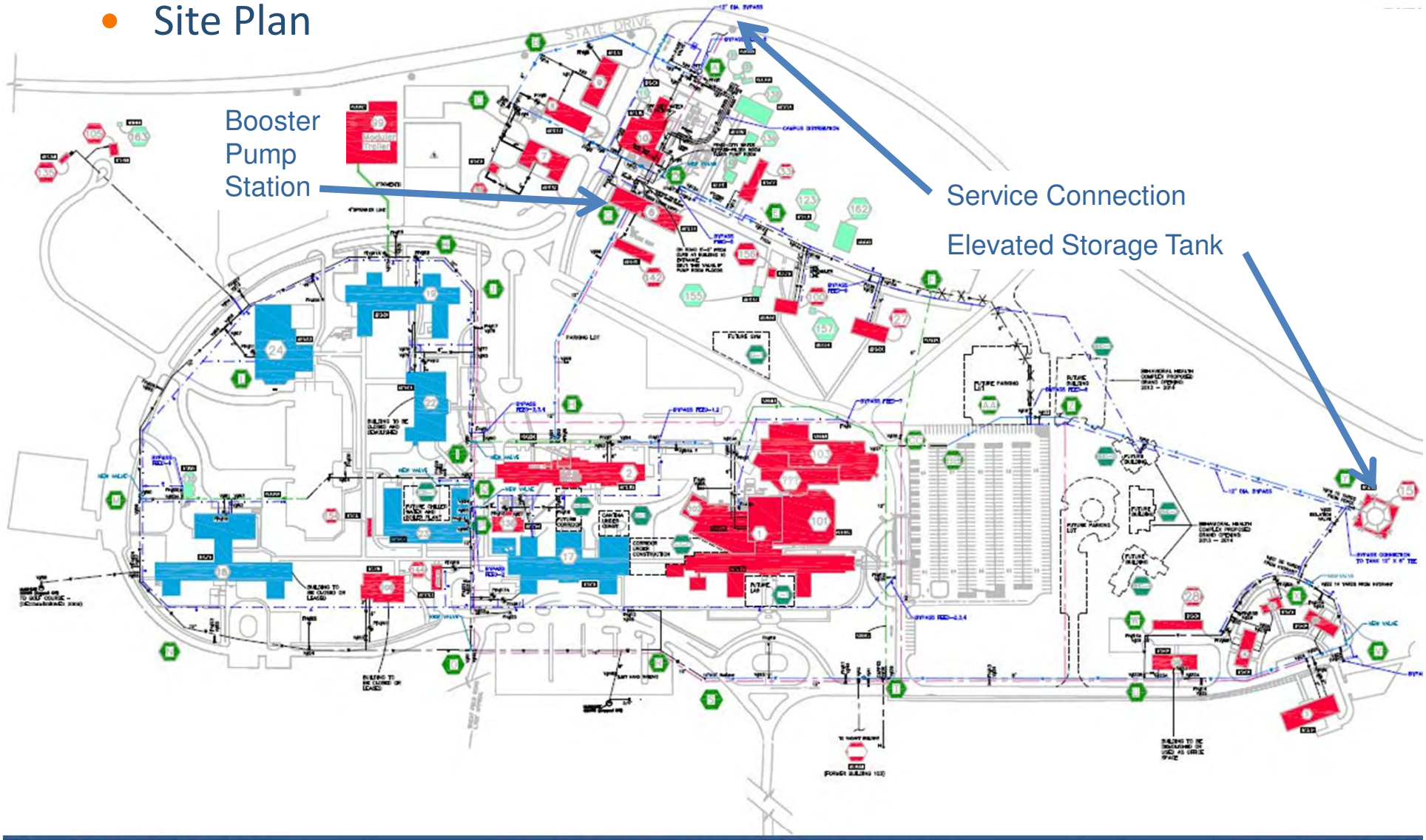
- Harrisburg, Pennsylvania Vicinity
- Project Driver – Brown Water Quality Complaints
  - Consecutive Distribution System
    - Purchase Water From Utility
    - Booster Pump Station / Chlorine Booster Station
    - 250,000 Gallon Elevated Storage Tank
  - Business Campus
    - Established in 1947
    - Business Model Changes - Large Reduction in Water Demand

Project Purpose

- Project Scope
  - 20,040 Linear Feet of Distribution System – Investigate Condition
  - 6 Buildings (18 Stories) - Investigate Plumbing Condition
- Identify Source of Brown Water Quality & Design Upgrade
  - Utility Source Evaluation
  - Elevated Storage Tank Evaluation
  - Distribution System Evaluation
  - Plumbing System Evaluation

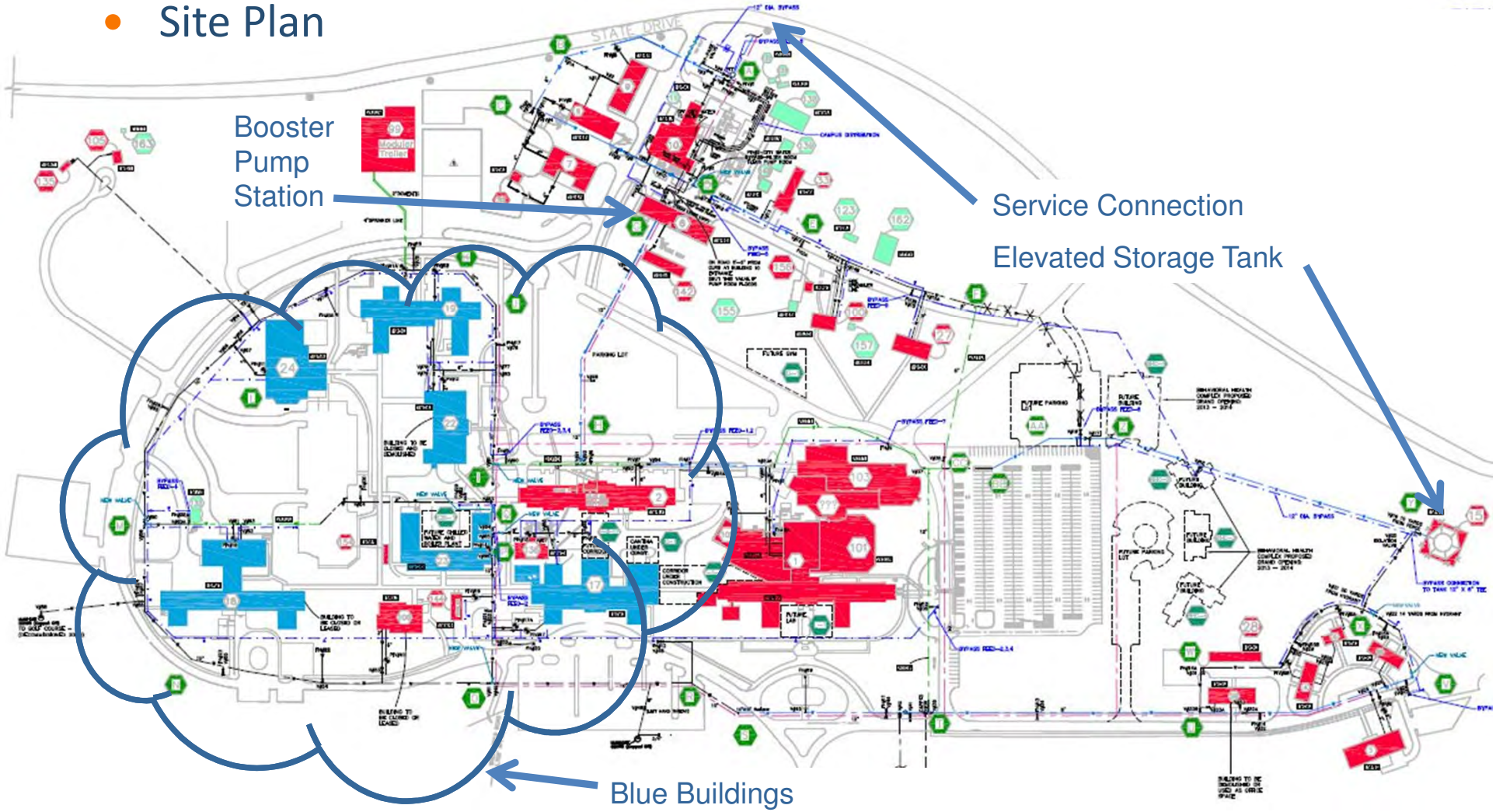
Project Purpose

- Site Plan



Project Purpose

- Site Plan



Study Phase

- Utility Source Evaluation – CCR Primary Contaminants

Contaminant (Unit of measurement)	Violation (Y/N)	Level Detected	Range	MCLG/MRDLG	MCL/ MRDL
Total Coliform Bacteria (Percent of monthly samples positive)	N	0% of samples positive	0	0	5%
Turbidity (NTU)	N	100% of samples <0.1	0.04 to 0.07	n/a	TT = 95% of samples <0.3
Chlorine (Entry Point) (ppm)	N	1.43	1.43 to 1.62	4	4
Chlorine (Distribution System) (ppm)	N	1.51 (a)	1.37 to 1.51 (a)	4	4
Copper (ppm) (2010)	N	0.0097 (b)	(c)	1.3	AL=1.3
Fluoride (ppm)	N	0.99 (d) (f)	0.95 to 1.02 (a) (f)	2 (e)	2 (e)
Haloacetic Acids (HAA5) (ppb)	N	16.1 (g)	11.1 to 25.8 (h)	n/a	60
Lead (ppb) (2010)	N	0.0000 (b)	(c)	0	AL=15
Nitrate (ppm)	N	0.20	n/a	10	10
Arsenic (ppm)	N	0.0000	n/a	n/a	0.010
Total Organic Carbon (ppm)	N	1.3 (g)	0.95 to 2.2 (g)	n/a	TT <2.0
Total Trihalomethanes (TTHMs) (ppb)	N	49.8 (g)	26.1 to 100.0 (h)	n/a	80

- Normal Ranges
- No Apparent Discolored Water Source

Study Phase

- Utility Source Evaluation – CCR Secondary Contaminants

Contaminant (Unit of measurement)	Violation (Y/N)	Level Detected (a)	Range (b)	Recommended Limit (c)
Alkalinity (ppm)	N	24	19 to 32	n/a
Aluminum (ppb)	N	71	60 to 80	200
Hardness (ppm)	N	49	40 to 57	Soft Water < 75 Hard Water >150
Iron (ppb)	N	13	10 to 20	300
Manganese (ppb)	N	8	0 to 10	50
pH	N	9.9 (d)	9.8 to 9.9 (d)	6.5 - 8.5
Sulfate (ppm) (2004)	N	26	n/a	250

(a) Annual average value.
(b) Monthly average values.
(c) Recommended limits on compounds that might be a nuisance to the customer. These compounds affect aesthetic quality (appearance, taste, odor, etc.), but do not pose a health risk.
(d) A higher pH is maintained to help control corrosion in the distribution system mains and is approved by the State Dept of Environmental Protection.

- Fe & Mn Normal Ranges
- pH Abnormally High

Study Phase

- Utility Source Evaluation – Distribution Samples
  - Fe Normal Range – 0.01 to 0.04 ppb
  - Mn Normal Range – 0.00 to 0.04 ppb
- Elevated Storage Tank Evaluation
  - Recent inspection
    - No solids accumulation
    - Interior coating needed replacement
  - Tank not considered source
  - Tank scheduled for replacement

Study Phase

- Water Quality Sampling Event
- Service Connection Samples
  - Fe (Total) – 0.48 ppm
  - Mn – 0.02 ppm
- 10 Sample Locations
  - Plumbing & Distribution System
  - Fe (Total) Range – 0.48 to 4.8 ppm
  - Mn Range – 0.02 to 0.33 ppm

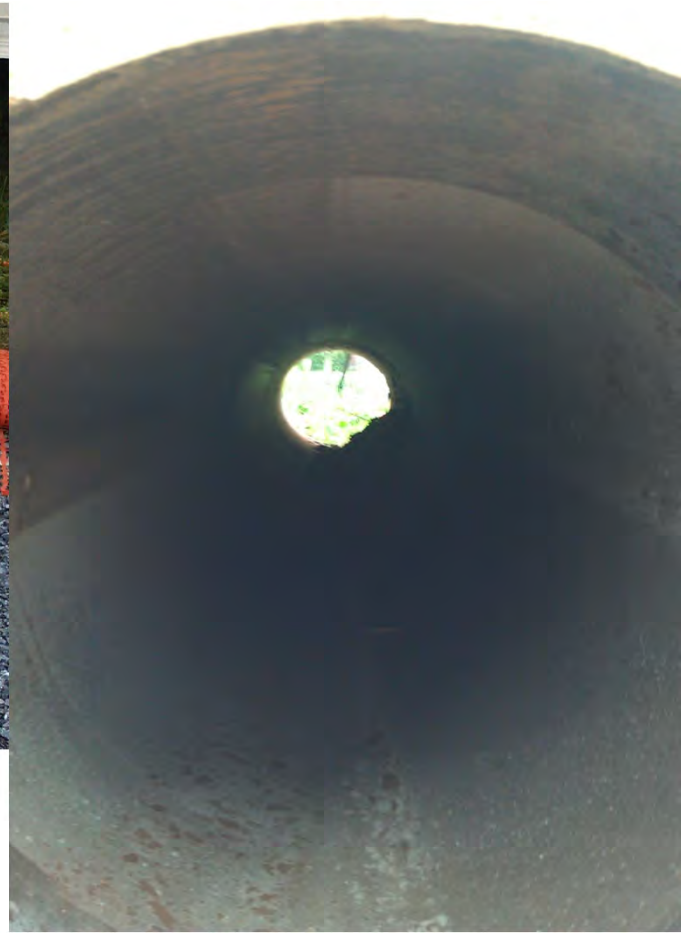
Study Phase

- Plumbing System Evaluation

Galvanized Pipe
- 60 Years of Service

Study Phase

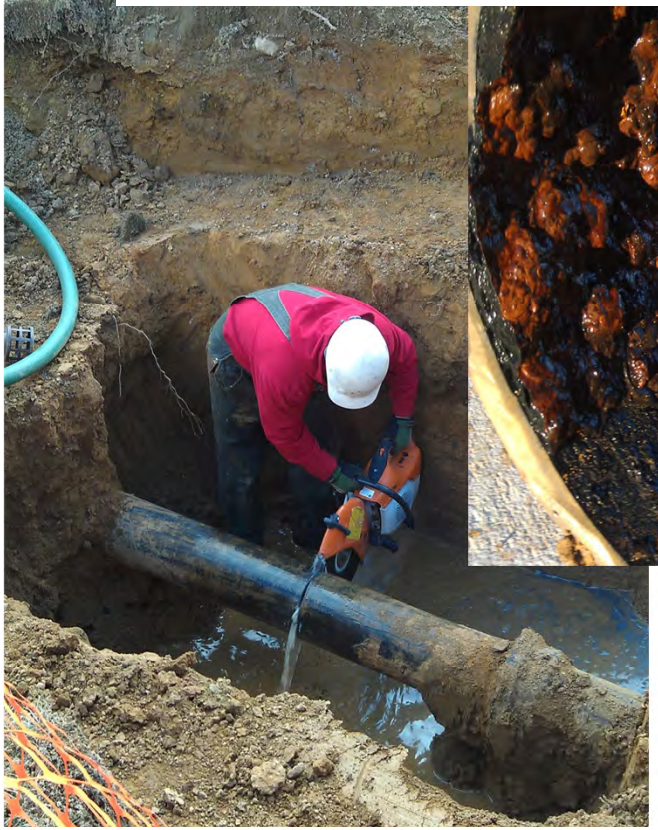
- Distribution System Evaluation – Bone Yard



Transite Pipe - 60 Years of Service

Study Phase

- Distribution System Evaluation



Condition Assessment– Spool Piece

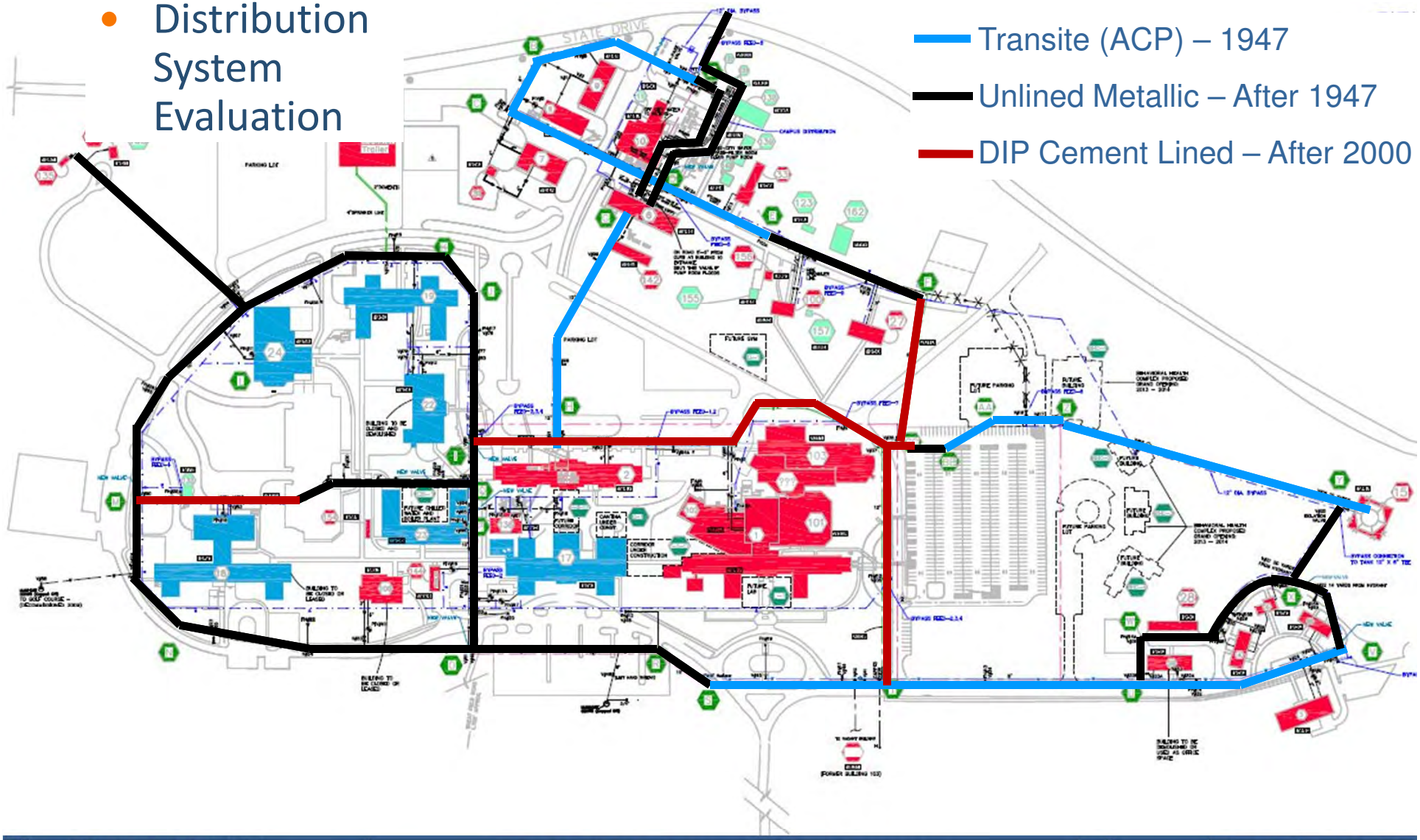
Unlined Cast Iron Pipe - 60 Years of Service

Study Phase

- Distribution System Evaluation
- Limited Distribution System Understanding
  - Pipe Material: Yes
  - Pipe Diameter: Yes
  - Interior Lining: No
  - Exterior Coating: No
  - Pipe Condition: No
  - Year Installed: 30 Year Accuracy
  - Water Quality: No
  - Soil Conditions: No
  - Break History: No
  - Non-Revenue Water: No
  - Renewal Rate: No
- Construct Distribution System Map / GIS Database

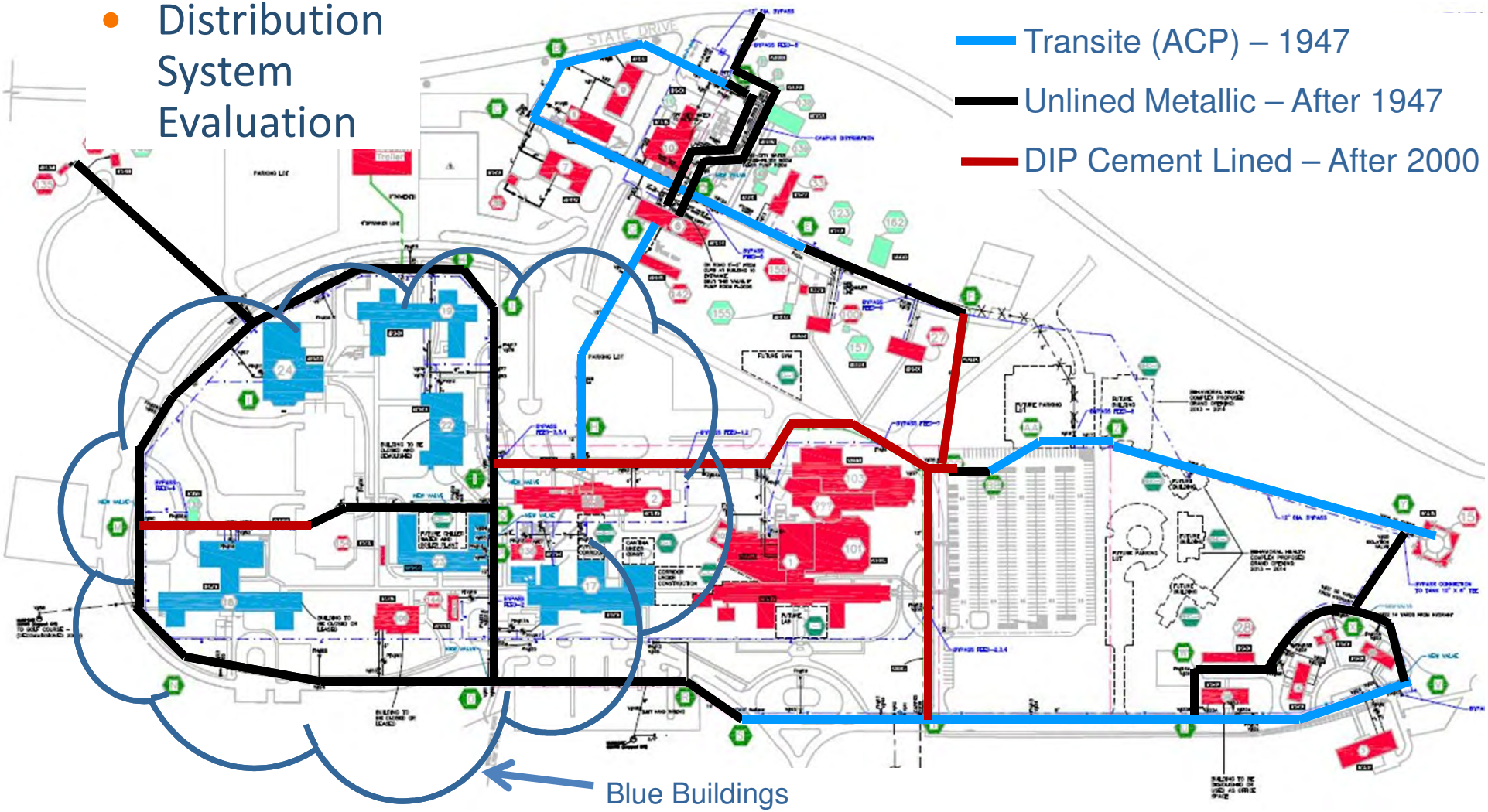
Study Phase

- Distribution System Evaluation



Study Phase

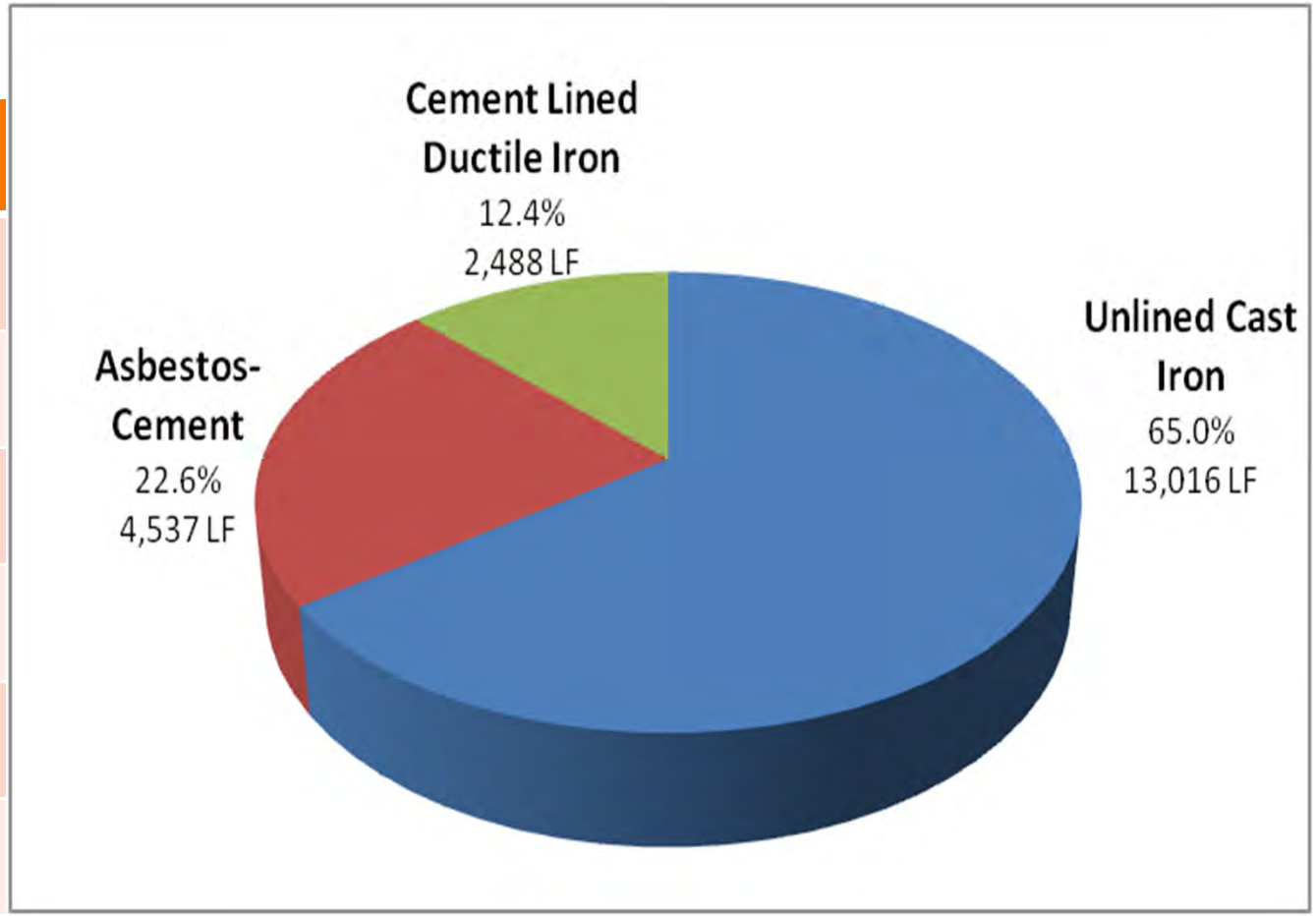
- Distribution System Evaluation



Study Phase

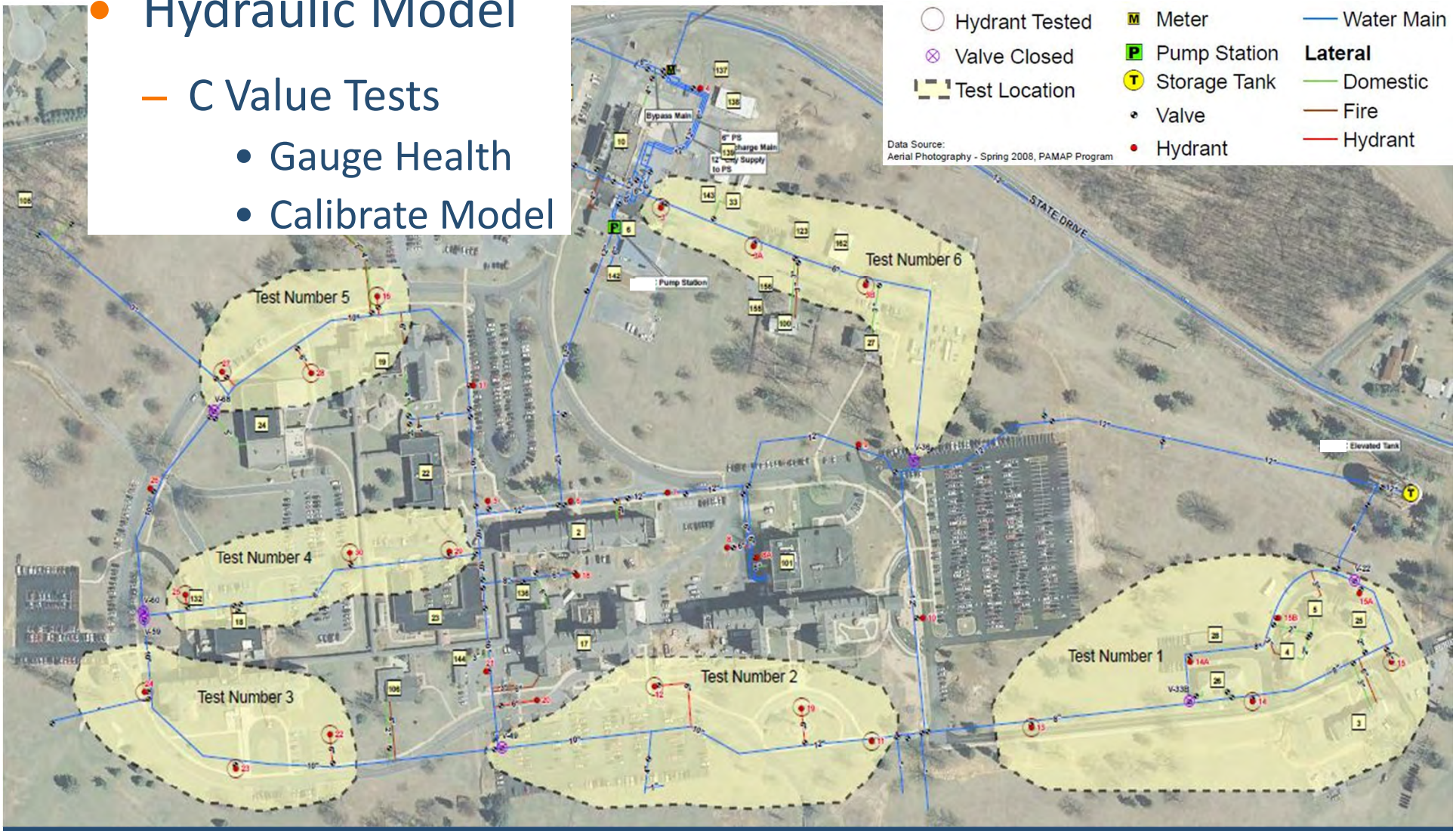
- Hydraulic Model

Diameter	Length (ft)
< = 4"	3,955
6"	4,880
8"	2,915
10"	3,525
12"	4,765
Total Pipe	20,040



Study Phase

- Hydraulic Model
  - C Value Tests
    - Gauge Health
    - Calibrate Model

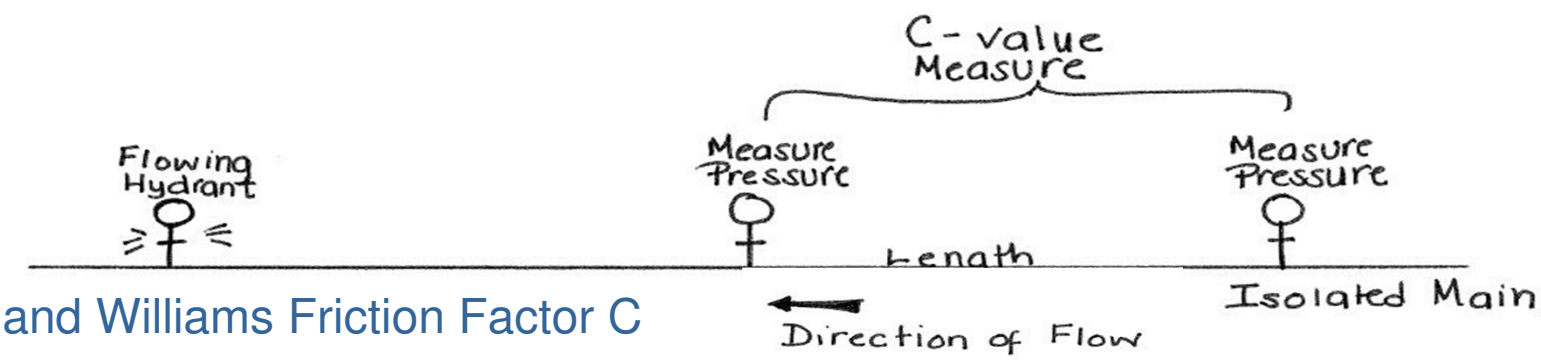


- Hydraulic Model – C Value Tests

Study Phase

- Hydraulic Model – C Value Tests

Test No.	Pipe Material	Pipe Diameter	Calculated C-Value	Design C-Value
1	Asbestos-Cement	8"	126	140
2	Cast Iron	12"	32	100
3	Cast Iron	10"	40	100
4	Cast Iron	8"	53	100
5	Cast Iron	10"	40	100
6	Asbestos-Cement and Cast Iron	6"	83	N/A



Hazen and Williams Friction Factor C

Study Phase

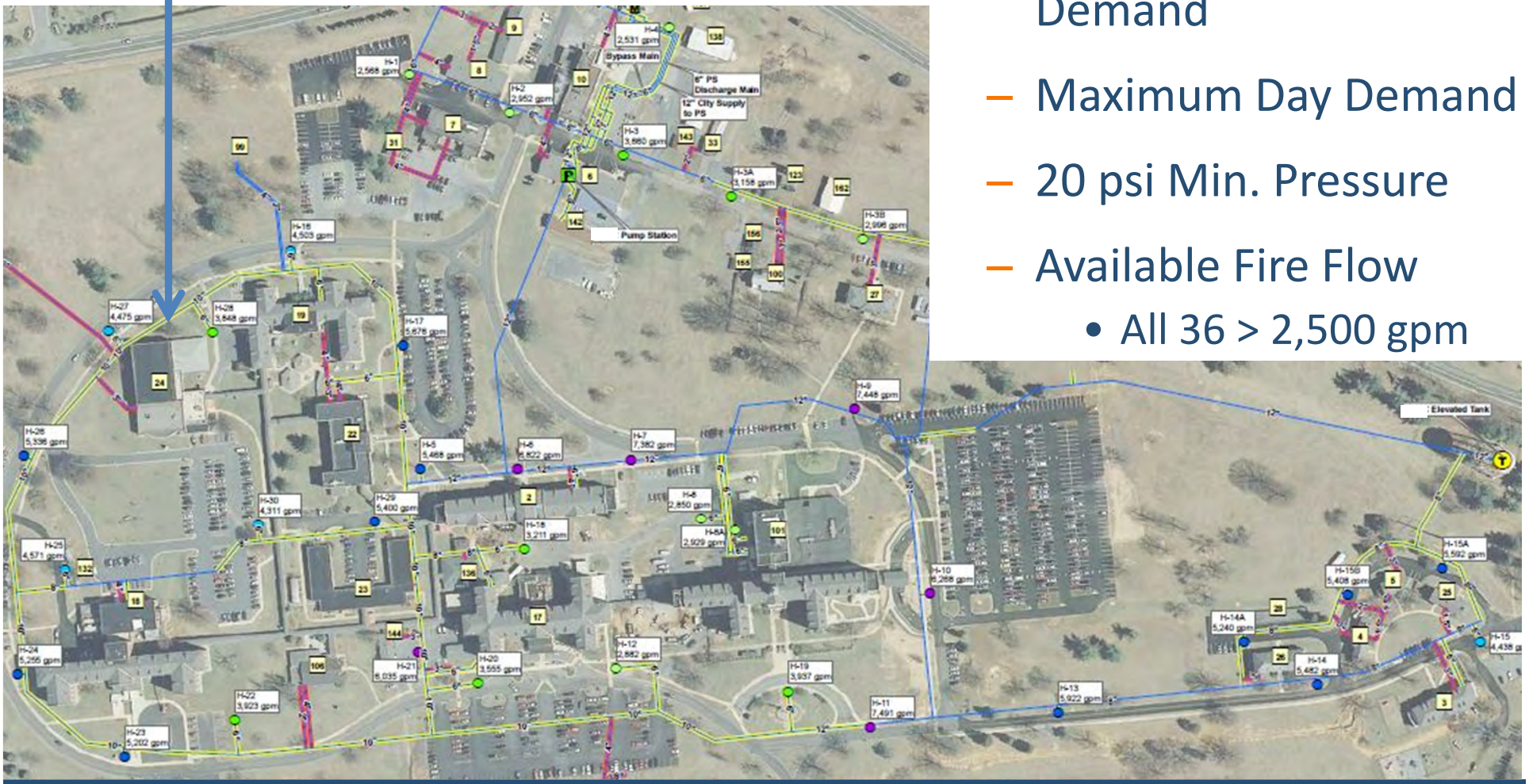
- Hydraulic Model – Existing Available Fire Flow

- Maximum Day Demand
- 20 psi Min. Pressure
- Available Fire Flow
  - 12 of 36 < 1,500 gpm

Study Phase

- Hydraulic Model – Proposed Available Fire Flow

Yellow = Proposed Cleaning & Lining



- Fire Flow > Domestic Demand
- Maximum Day Demand
- 20 psi Min. Pressure
- Available Fire Flow
  - All 36 > 2,500 gpm

Design Phase

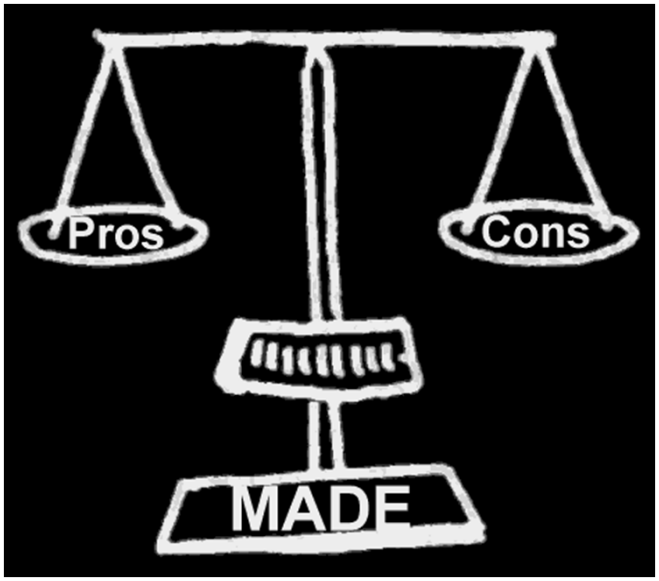
- Recommended a Tiered Approach
  - Tier 1 – Water Quality Monitoring Program
    - Baseline Water Quality
    - Monitor Upgrade Water Quality Improvements
  - Tier 2 – Watermain Upgrades
    - Fire Flow > Domestic Demand
    - Watermains Oversized for Domestic Demands
    - 6-inch Diameter and Larger – Cleaning & Lining
    - 4-inch Diameter and Smaller – Replacement
  - Tier 3 – Building Plumbing Upgrades
    - Select highest priority building

Design Phase

- Why Cleaning and Lining?

Pros

- Cost Savings
- Time Savings
- Less Disruption



Cons

- Risk
- Unknown Subsurface Conditions
- Unknown Pipe Condition

Typically Cheaper to Repair Than Replace Pipe

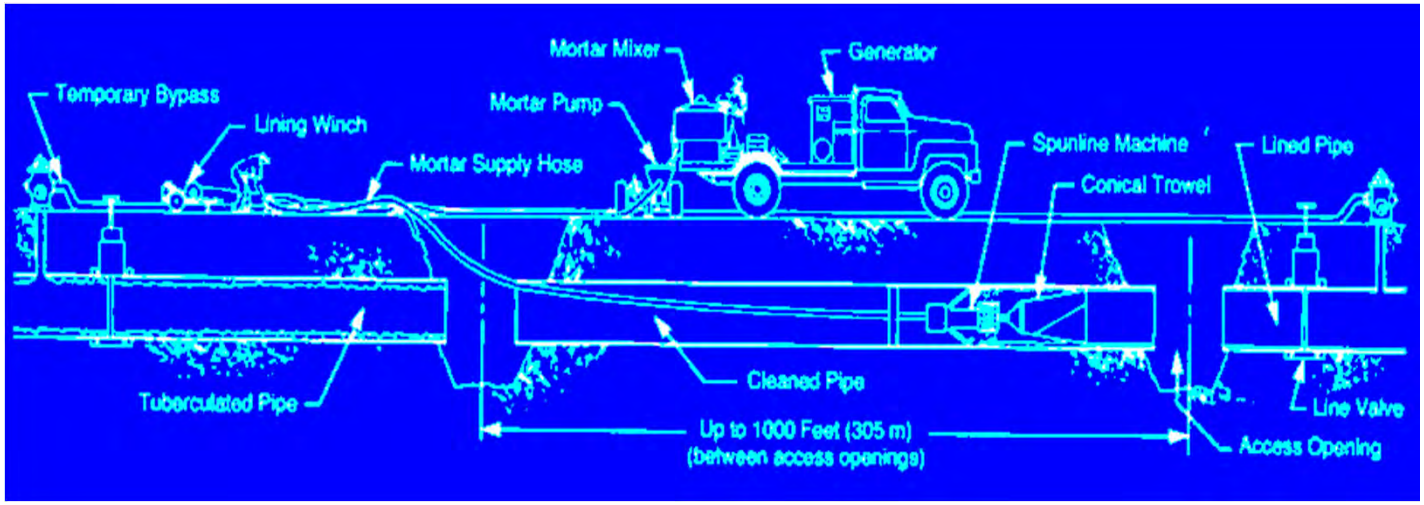
Pipe Diameter Increase – Rehabilitation Cost Savings Increase

Design Phase

- Cleaning & Lining Project Requirements?
- Access Pits – Every 500 to 700 Linear Feet
- Access Pit Typical Locations
  - In Line Valves
  - Side Line Mains
  - Hydrant Laterals
  - Fittings
    - 22 ½ to 90 Degree Elbows
    - Pipe Diameter Change

Design Phase

- Recommendations
  - Phased Construction
    - Rehabilitation by Cleaning and Lining
    - 7,500 linear feet of Cleaning and Cement Mortar Lining
    - 1,200 linear feet of service connection replacement
    - Base Bid
    - Bid Alternates to control contract upper limit



Source: Heitkamp, Inc.

Construction Phase

- Install Bypass Pipe
- Disinfect Bypass Pipe / Bacteria Test
- Install Bypass Service Connections

Bypass Hydrant

Bypass Service Connection

Construction Phase

- Excavate Access Pits
- Isolate Water Main
- Remove Water Main From Service
- Cut Water Main At Access Pits
- Rehabilitate Water Main – **Cleaning & Cement Mortar Lining**

Construction Phase

Cleaning Scrapers

Tuberculation Removal at Access Pit

Construction Phase

- Repair Water Main At Access Pits
- Disinfect Water Main / Bacteria Test
- Restore Water Main Service Connections
- Remove Bypass
- Road Restoration At Access Pits

Conclusions

- Rehabilitation Versus Replacement
  - Project Specific Comparison Recommended
- Cleaning & Cement Mortar Lining
  - Cost Savings
  - Accomplished Client Goals of Reducing Brown Water Quality
  - Extends Watermain Service Life
- Client In Process of Removing Bottled Water Stations

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Questions

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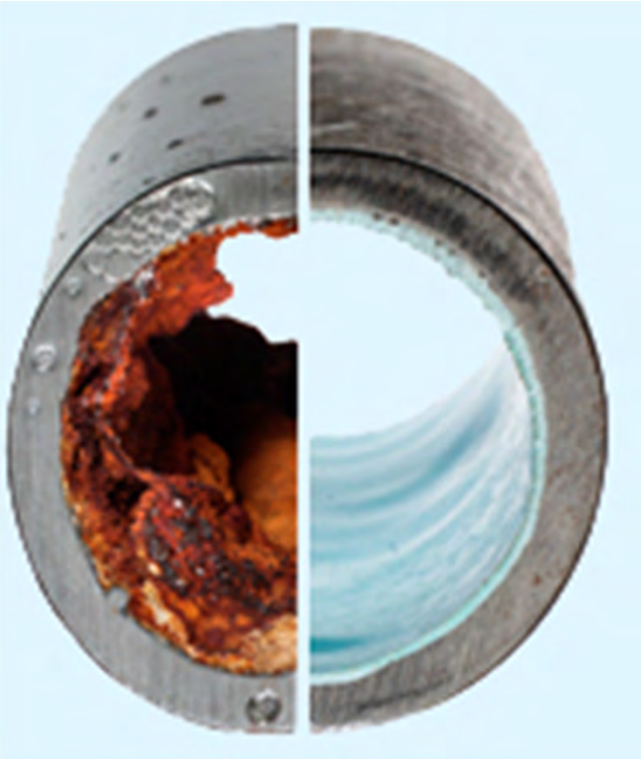
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