Designing for Permanence

Material Choices for Real Sustainability

NCPI
National Clay Pipe Institute

Presenters

Michael VanDine, PE – President, NCPI

Joe Parker, PMP – VP of Technical Services, NCPI

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Asset Management & Economics Services
Seattle Public Utilities

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Welcome

NCPI is actively involved in field, university and other contract research designed to improve the manufacture and installation of Vitrified Clay Pipe (VCP) systems.

NCPI provides technical information and support to those involved in the design, construction and maintenance of VCP sanitary sewer systems.

www.ncpi.org

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Poll Question #1

How influential is the Sustainability of a pipe material in your material selection process?

1. It is critical. I'd be willing to pay a 10% premium.
2. It is important. I'd be willing to spend up to 5% more.
3. It is important but I'm working with a very limited budget.
4. It is influential, but there are many other considerations.
5. It's really not that important to me.

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SUSTAINABILITY IN INFRASTRUCTURE

Michael VanDine, PE - National Clay Pipe Institute

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Sustainability and Infrastructure

In the early 1900's water and wastewater systems were buried and forgotten.

Out of sight, . . .
. . . Out of mind.

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Stepping Stones

CMOM - Geared towards operations and elimination of SSO's

GASB 34 – Focused on financial evaluation of operations and its impact on system integrity.

Asset Management – Began to drive proactive, long-term decision making processes into the public works arena.

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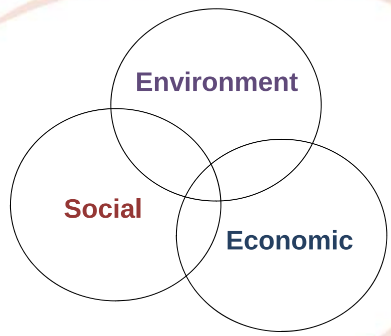
Sustainable Design

The Triple Bottom Line

Balancing social, environmental and economic impacts



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Environmental Issues – Raw Materials

VCP – Clays, shales and water.
Naturally occurring and abundant.

Concrete – Aggregate, sand and cement.

DIP - Recycled metals

Thermoplastic Pipe – Polymers derived primarily from fossil fuels.

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Environmental Issues – Energy Use

Embodied Energy - the energy required to produce and use a product from acquisition of raw materials to end of life.

European Study (Fuegres Export and Scientific Group)

- Clay – 85 MJ/meter
- PVC – 162 MJ/meter

USA Study (IIT/Bechtel Labs)

- Clay – 77,685 BTU/Ft
- Concrete – 72,960 BTU/ft
- PVC – 146,160 BTU/Ft
- DIP – 523,000 BTU/Ft

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Environmental Issues – Longevity

"Once a system is installed, all pipe materials change over time –

Except for Vitrified Clay Pipe."

-Professor Sunil Sinha, Virginia Tech
International No-Dig Show, Toronto, 2009

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Environmental Issues – Longevity

"Inherent corrosion resistance often provides an extended pipe life resulting in the following benefits:

• No liners or coatings to inspect, maintain, refurbish or replace;

• No rehabilitation costs because of corrosion deterioration;

• Hydraulic characteristics are unchanged delaying relief line construction costs;

• Costs for premature replacement are avoided completely."

Source: *CE News* ,"Life Cycle Cost Considerations for Sewer Pipe" August 2001

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Environmental Issues – Longevity

"The main feature of plastics and polymer composites is that their physical, mechanical, thermal and chemical properties are strongly time and temperature dependent."

Source: Dr. Mehdi Farshad: "Plastic Pipe Systems: Failure Investigation and Diagnosis" 2006

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Environmental Issues – Longevity

" Clay Pipe is perhaps the most inert of the common pipe materials in terms of corrosion, and it is very resistant to abrasion.

A 100-year service life may be *assumed* for most clay pipe installations."

After 2,500 years of service as wastewater pipe, this pipe was returned to service as stormwater pipe and is still in service today.

Source: "Life Cycle Cost for Drainage Structures"
US Army Corps of Engineers, 1988

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Environmental Issues

The Three Keys

- Raw Materials
- Energy Consumption
- Longevity

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Poll Question #2

Do you have a current Asset Management or Sustainability program?

1. We have a current, formalized Asset Management program.
2. We have a general directive to be sustainable or green.
3. We are exploring a formalized Asset Management program.
4. We have a general interested in sustainable products.
5. We don’t have either and aren’t looking at developing one.

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ECONOMICS OF LONGEVITY

Joe Parker, PMP - National Clay Pipe Institute

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What is Life Cycle Cost Modeling?

"Life Cycle Cost (Net Present Value) modeling is an economic analysis used in the selection of alternatives that impact both present and future costs"

Considerations

- Long Term strategy to performance
- Long term project value
- Most efficient use of resources
- Material Service Life
- Project Life Cycle
- Project *RISK*

Project Risk

"Risk is the modifier of opportunity"

- The proper identification, qualification and quantification of related risks help control project costs.
- Generally if you have cost issues with a project you have three choices
  - Reduce Scope
  - Reduce Quality
  - Reduce Risk

Source: Project Management Institute, www.pmi.org

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Present & Future Costs

Present Costs analyzed using "Net Present Value" (NPV)

Future Total Costs analyzed using "Parity"

Identified Risk - The appropriate role of risk in both present and future cost calculations

Resources available from NCPI at www.ncpi.org

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Net Present Value

- Total project cost including:
  1. Specified work
  2. Specified material
  3. Lifecycle maintenance costs
  4. Risk Contingency
- Average interest per year
- Average inflation per year
- Designed lifecycle
- Verified Material service life

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Verified Service Life

" About forty percent of our piped sewer system is clay, installed between the time of the fire (1889) and 1940.
. . . . Based on the way these pipes look though, it appears that the majority of them could **easily last 200-years or even longer**."

Source: Terry Martin – Seattle Public Utilities

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Case Study: City of Tyler Texas

US 69/ I-20 Wastewater System Improvements
March 29, 2011

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Case Study: Tyler Texas

- VCP Project Cost: (P)$5,391,727.20:
  Service Life: 100
- PVC Project Cost: (P)$5,205,468.93:
  Service Life: 50
- Difference = $186,258.27 or 3.7% more for VCP

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Case Study: Tyler Texas

Inflation/Interest Rate Factor: 0.9771

NPV_{PVC} = P {1+[(1+I) / (1+i)]^n}

NPV_{PVC} = $5,205,468.93 [1 + (.9771)^{50}]

NPV_{PVC} = $5,205,468.93 (1.31)

NPV_{PVC} = ***$6,819,164.30***

$6,819,164 - $5,205,468 = $1,613,696

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Least Cost Analysis

- If PVC pipe was selected for this project $1,613,695 must be invested today to fund replacement at year 51.
- Planning for sustainability includes a careful evaluation of the difference between the initial project cost and the life cycle cost

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Parity Cost

- ***Parity Cost*** is the cost at which competing materials are at value equilibrium.
- In order for PVC to reach value equilibrium with clay, it has to be replaced at least once
- NPV = P $\{1+[(1+I)/(1+i)]^{n}+[(1+I)/(1+i)]^{mn}\}$

Price Parity Calculation

NPV_{PVC} = \$5,205,468.93 $[1+(.9771)^{50} +(.9771)^{1}]$

NPV_{PVC} = \$5,205,468.93 (2.29)

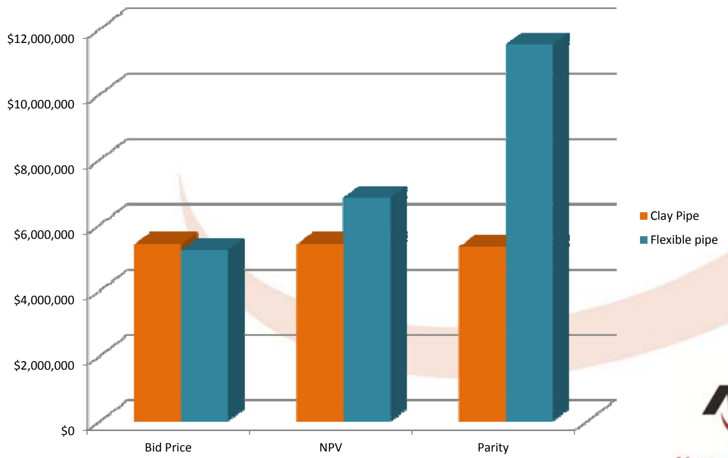
NPV_{PVC} = ***\$11,920,521***

➢ Total Parity cost for the investment

\$11,920,521- \$5,205,468 = ***\$6,715,053***

Economic Analysis

Least Cost vs. Net Present Value & Parity



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Cost Analysis for Sustainability

Includes:
- Long term investment strategy
- Project cost
- Verified material service life
- Risk analysis

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A PRACTICAL ANALYSIS

Terry Martin, PE - Seattle Public Utilities
Acting Director Asset Management & Economic Services

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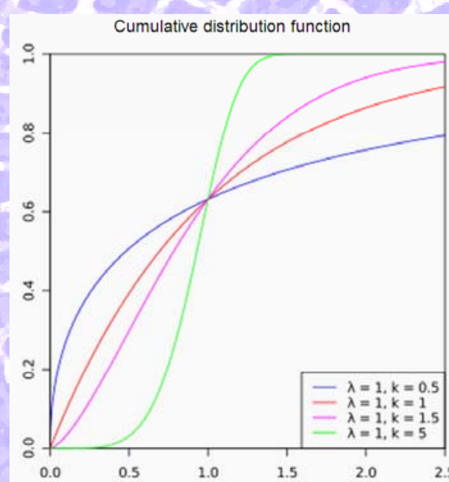
Predictive Failure Curves

- The Likelihood of Failure of a Sewer Pipe is Typically a Function of the Material and the Age of the Pipe
- As the Pipe Ages the Likelihood that it will Fail in a Given Year Usually Increases
- Predictive Failure Curves Play a Crucial Role in Developing Accurate Risk Modeling



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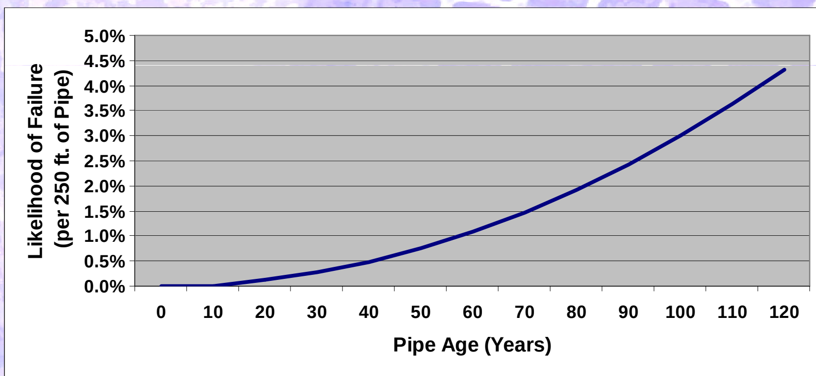
SPU Previously Used "Industry Standard" Weibull Curves for Predicting the Likelihood of Future Sewer Pipe Failure



Curve for Pipe with Avg. Time to First Fail of 100 Years

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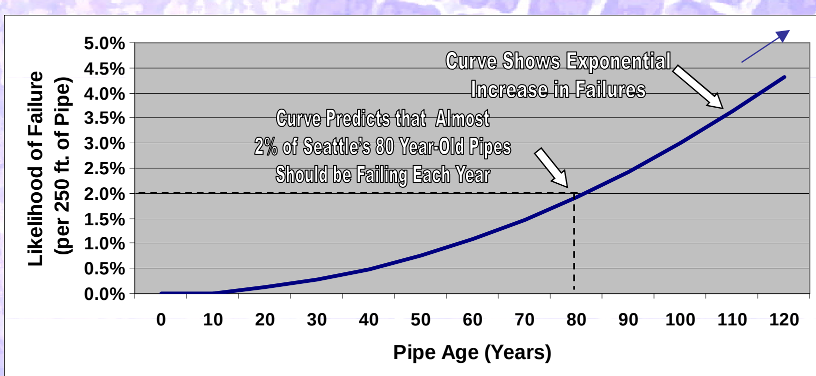
But Was SPU Facing a Greatly Accelerated Increase of Sewer Pipe Failures in the Near Future as this Curve would Suggest?



According to the "Industry Standard" Curves SPU Should Expect to Experience Approximately:

- 400 Material-Related Failures in the Current Year
- 550 per Year by the Year 2020

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The Issue: SPU's Predictive Failure Curves for Sewer Pipe Needed to be Truth-Tested…

1) Were They Correctly Estimating the Number of Pipe Failures in Seattle's System?
2) Were the Trends that They Predicted (a Large Near-Term Exponential Increase in Sewer Pipe Failures) Beginning and/or Likely to Happen?

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An Approach: Analyze the Number of Actual Historical Sewer Pipe Failures and Create New Customized Predictive Failure Curves Based on Experience

- Approximately 2,600 Sewer Pipe Point Repairs were Performed in Seattle's Sewer System from 1989-2004
- A Total of 809 Point Repairs were Selected to be in this Study

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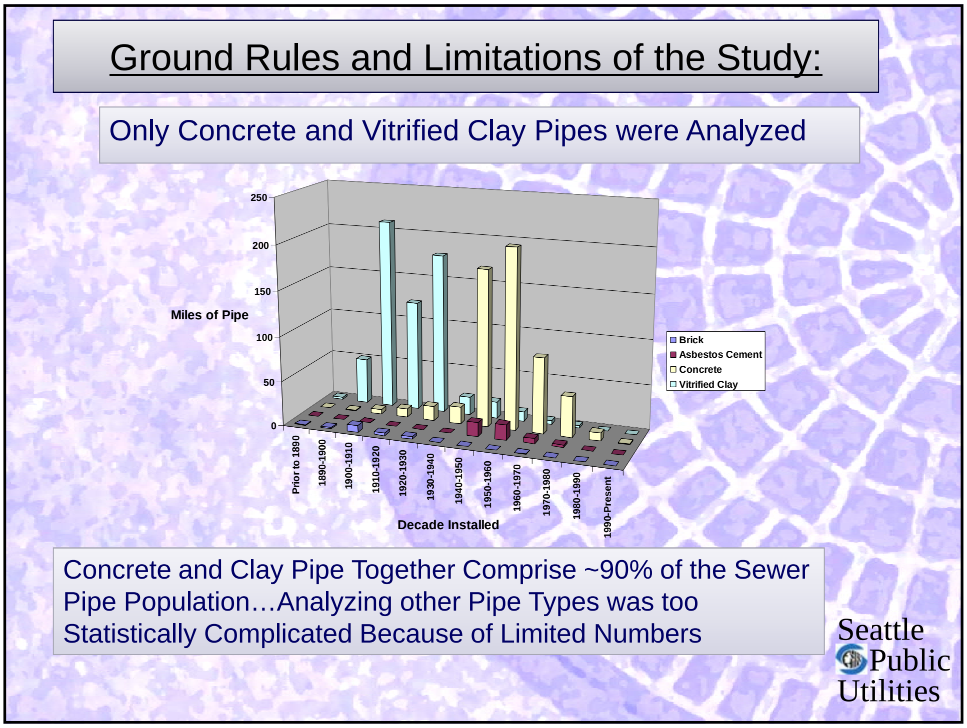
Ground Rules and Limitations of the Study:
Only Concrete and Vitrified Clay Pipes were Analyzed
Miles of Pipe
250
200
150
100
50
0
Prior to 1890
1890-1900
1900-1910
1910-1920
1920-1930
1930-1940
1940-1950
1950-1960
1960-1970
1970-1980
1980-1990
1990-Present
Decade Installed
Brick
Asbestos Cement
Concrete
Vitrified Clay
Concrete and Clay Pipe Together Comprise ~90% of the Sewer Pipe Population…Analyzing other Pipe Types was too Statistically Complicated Because of Limited Numbers
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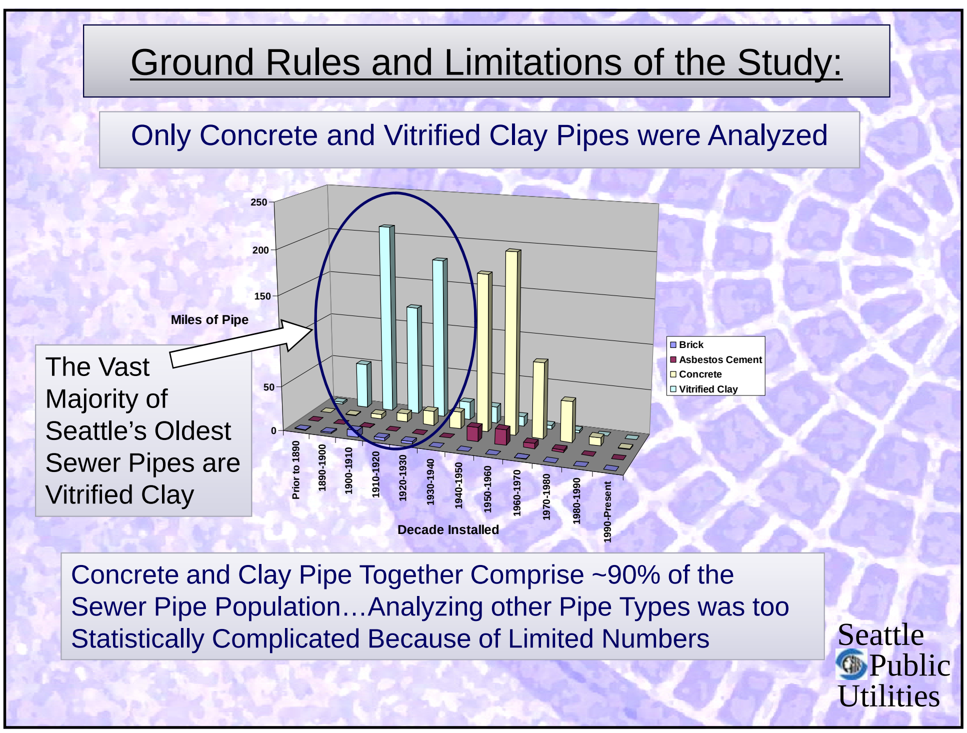
Ground Rules and Limitations of the Study:
Only Concrete and Vitrified Clay Pipes were Analyzed
The Vast Majority of Seattle's Oldest Sewer Pipes are Vitrified Clay
Miles of Pipe
250
200
150
50
0
Prior to 1890
1890-1900
1900-1910
1910-1920
1920-1930
1930-1940
1940-1950
1950-1960
1960-1970
1970-1980
1980-1990
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Concrete and Clay Pipe Together Comprise ~90% of the Sewer Pipe Population…Analyzing other Pipe Types was too Statistically Complicated Because of Limited Numbers
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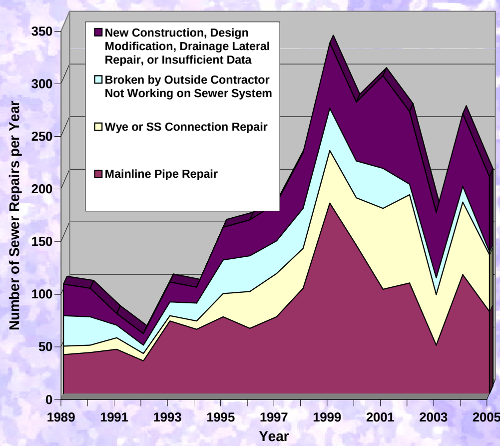
Ground Rules and Limitations (Continued):

Number of City of Seattle Pipe Repairs by Year and Cause (1989-2005)



- Examined only Repairs where Material Breakdown was the Primary Repair Cause (Over 50% of the Repairs Occurring During this Time Period were Due to other Causes such as Dropped Side Sewers, 3rd Party Damage, New Construction, etc.)
- Repairs Containing Incomplete Data (~20%) were also Excluded from the Study

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Ground Rules and Limitations (Continued):

- **Less Than 40% of Sewer Pipes were Video Inspected During the 15 Year Study Period…Results Needed to be Projected Onto the Entire Pipe Population** (Maximum Likelihood Estimation (MLE) Statistical Methodology was Used).
- Pipe Re-Line Data could not be used from this Time Period because it was of Poor Quality. **It was assumed that All Pipe Re-Linings Occurring During the Study Time Period Involved Point Repairs and were Therefore Included in the Data Set.**

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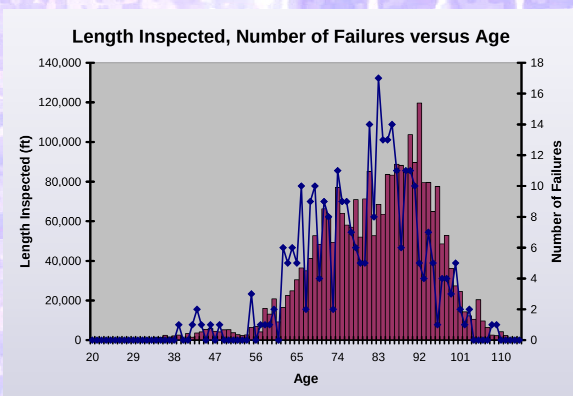
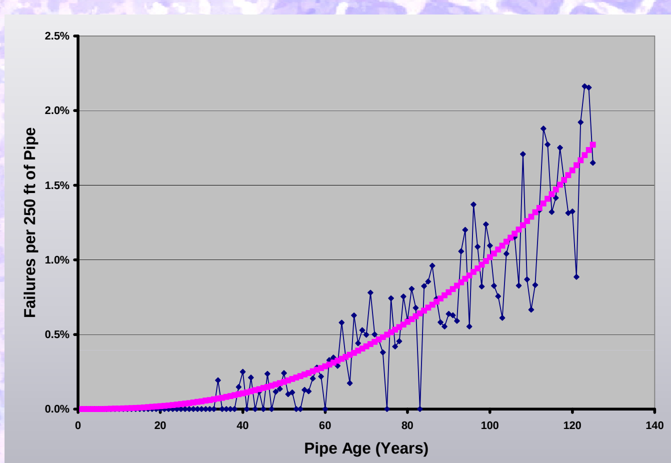
Inspection and Repair During the Study Period (1989-2004)

Video Inspection:
- ~ 11,000 Vitrified Clay Pipes were CCTV Inspected (1.8 Million Ft.)
- ~ 13,700 Concrete Pipes were CCTV Inspected (2.3 Million Ft.)



Repairs
- 561 Vitrified Clay Pipes that had Experienced Material Failure were Repaired
- 248 Concrete Pipes that had Experienced Material Failure were Repaired

Sample Predictive Curve Creation



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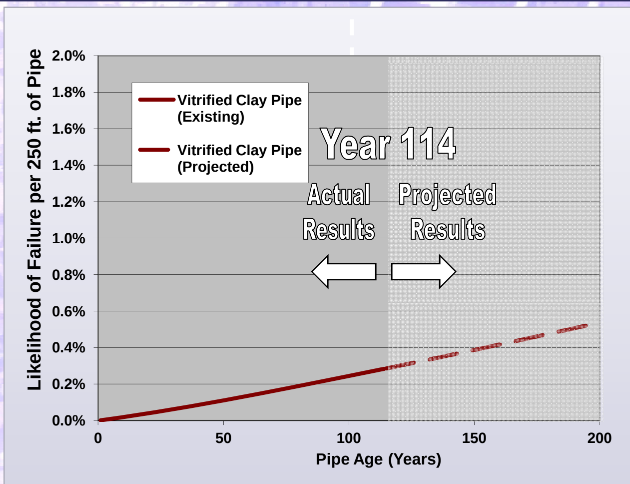
Custom Weibull Curves Derived from Actual Seattle Sewer Pipe Repair Records (1989-2004)



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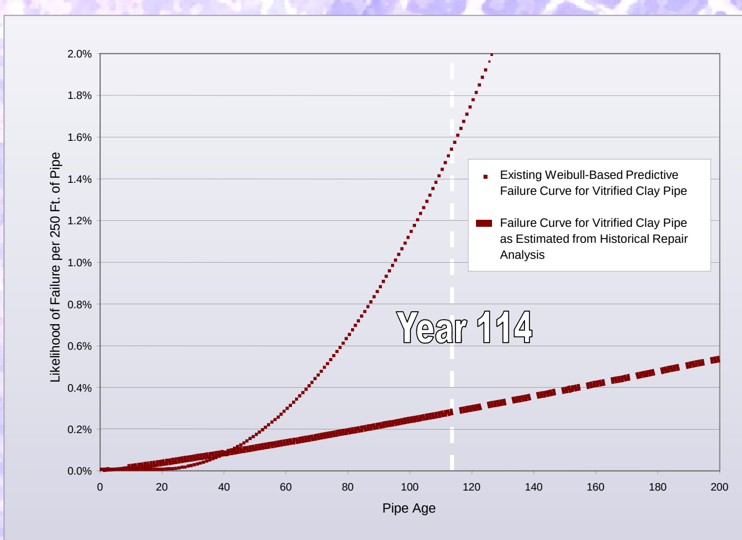
Existing "Industry Standard" Curve vs. Custom 1989-2004 Seattle Weibull Curve for Vitrified Clay Pipe



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This Failure Analysis Study Showed That…

- SPU Does Not Appear to Be Facing a Looming Crisis Regarding Sewer Pipe Failure as the "Industry Standard" Weibull Curves Suggest
- SPU's Sewer Pipes, and Vitrified Clay Sewer Pipes in Particular, Appear to be Experiencing Structural Failure at a much Lower Rate than Originally Predicted
- The Failure Pattern is Different than Originally Assumed…it is Flatter and not Exponential

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CONCLUSION

Michael VanDine, PE - National Clay Pipe Institute

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Sustainability in Infrastructure

Are the methods sustainable?

Are the materials sustainable?

- Cradle to grave impact
- Embodied Energy analysis

What is the long-term impact?

- Environmentally
- Economically
- Socially

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Sustainability in Infrastructure

What metrics should be used?

There is a great deal of confusion about “green” claims.

- Self Certification
- Third Party Review
- Third Party Audited

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SMaRT Certification System

Developed by

The Institute for Market Transformation to Sustainability (MTS)

MTS developed the **SMaRT Standard** to address the market-wide need for transparent, consensus-based and multi-attribute sustainability analysis. MTS dedicates its entire operation to raising awareness of the positive impact that manufacturing, promoting, and purchasing sustainable product choices has on every aspect of our daily lives.

Mike Italiano, CEO of MTS

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SMaRT Certification

Multivariable analysis,

1. Consensus-based and transparent
2. Requires an ISO 14020 compliant Life Cycle Assessment
3. Renewable energy use and conventional energy reduction are specified and encouraged
4. Environmental, social and economic performance criteria are defined & quantified
5. Materials performance criteria
6. Reuse performance criteria

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SMaRT Certification

NCPI member companies have recently been awarded a

SMaRT Gold/EPP Certification!

This certification covers

- Vitrified Clay Pipe
- Roof Tile
- Architectural Terracotta
- Flue Liners
- Wall Coping

For more information visit www.ncpi.org

SMART certified

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Questions?

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Thank You!

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