Making a Critical Investment:

Data-driven Analysis of Pipeline System Performance and Service Life Estimates

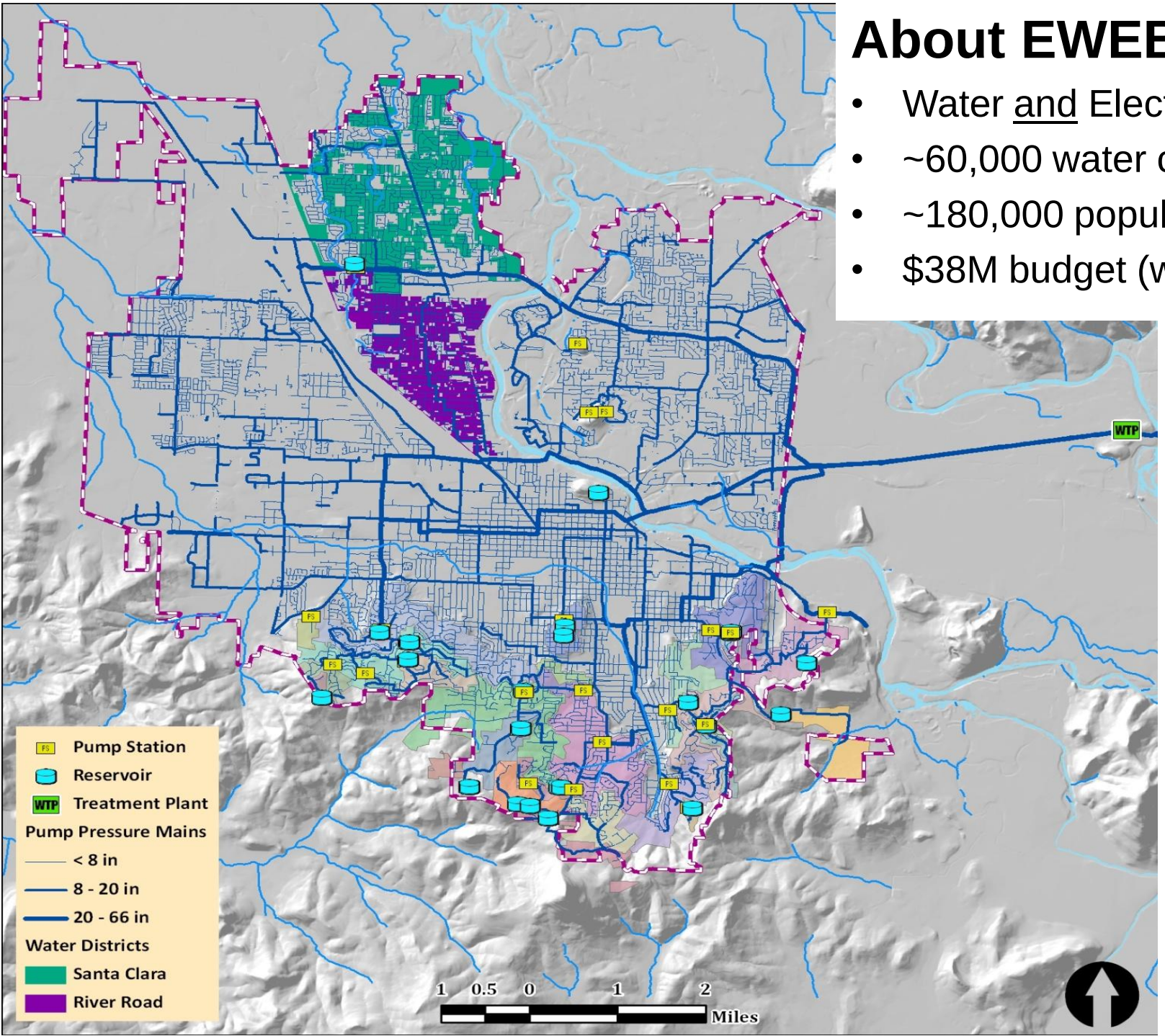
PNWS AWWA Conference
May 10, 2013

Presentation Outline

- Purpose of Study – EWEB capital planning
- Available data for system performance
- Service life analysis techniques
- GIS model to update analysis
- Limitations and improvements
- Conclusions

Purpose of Initial Study

- Understand the long-term replacement program investment needed for ***water mains*** to meet service level goals
  - ***Condition-based deficiencies***
  - *Hydraulic deficiencies*
  - Growth



About EWEB:

- Water <u>and</u> Electric utility
- ~60,000 water customers
- ~180,000 population
- $38M budget (water)

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EWEB's Current Circumstances

- Aging infrastructure
- Declining water revenues
- Pending implementation of enterprise work and asset management system
- Evolving relationship with Water Districts

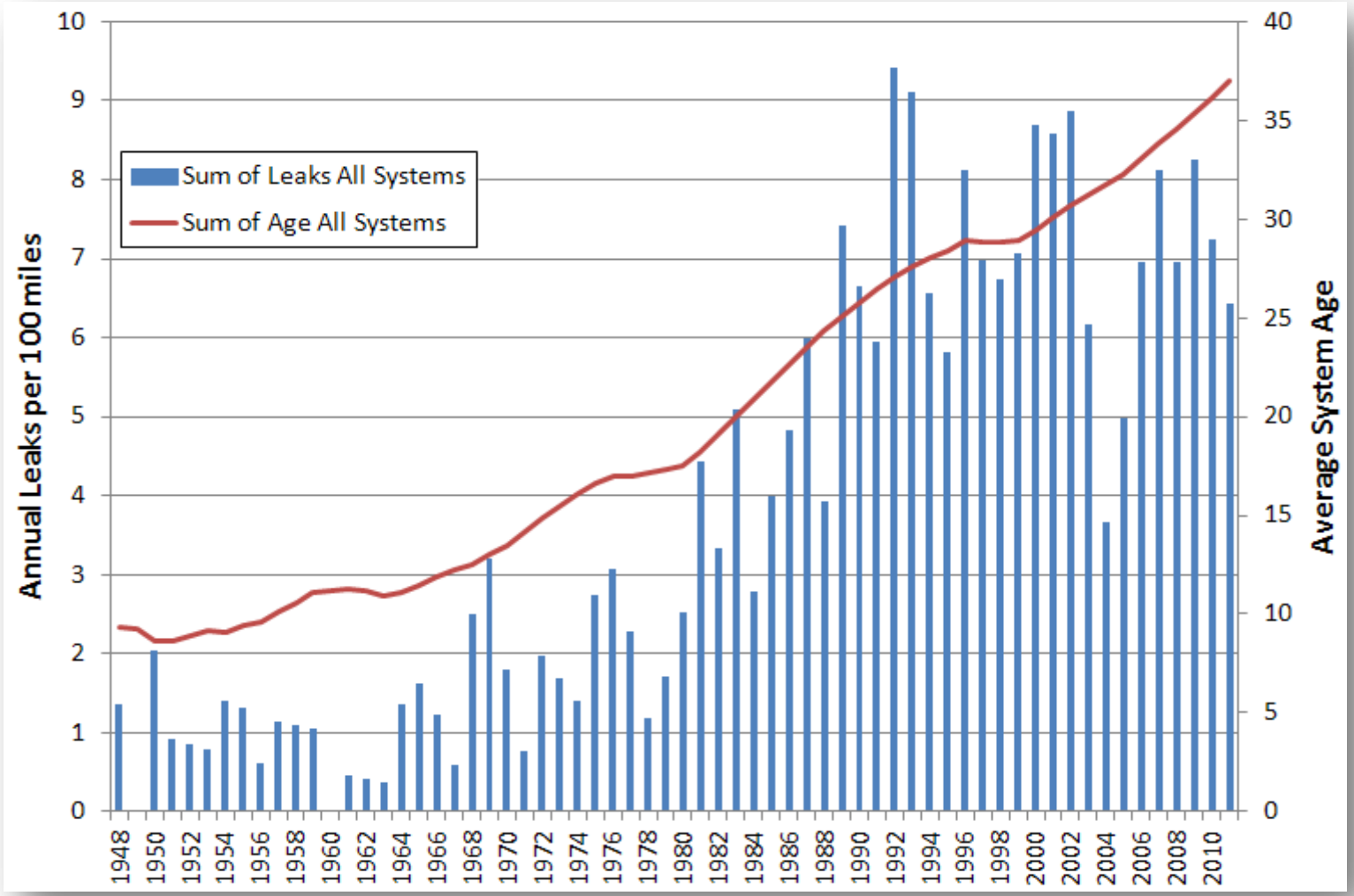
EWEB's Capital Planning

- Investment to make EWEB's water system more reliable (supply, transmissions, distribution)
- Develop a basis for understanding service life of infrastructure
- Understand improvements needed by Districts and other retail/wholesale customers

Data Opportunities/Challenges

- Pipeline asset registry
- Customer assessments
- Leak history
  - EWEB practice to repair all leaks and document
  - EWEB vs. Districts
- Defining asset classes

System-wide Leak History



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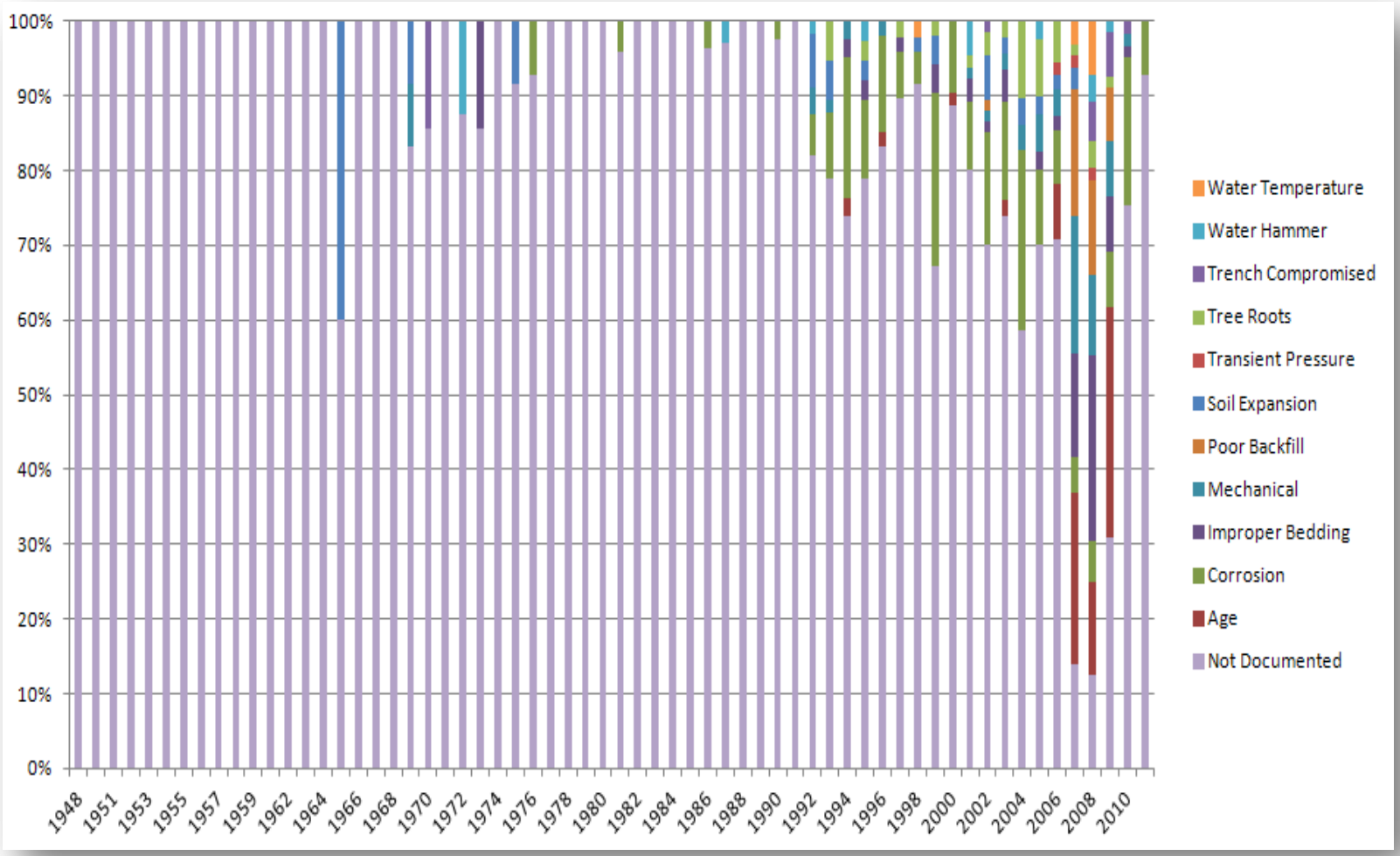
Cause of Leaks (system-wide)

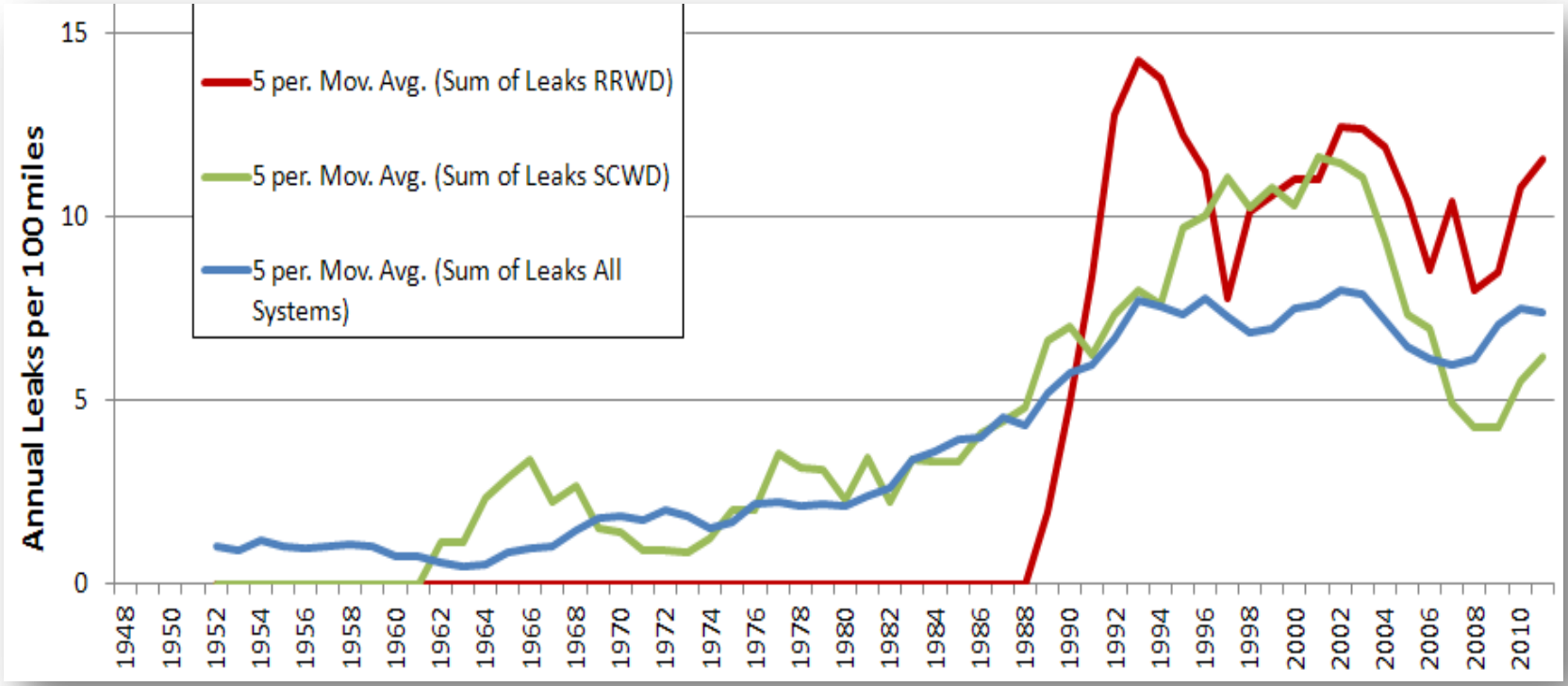


System Performance

- Leak – defined as the structural failure of the water main
- Leak rate – common measure of pipeline system integrity
- Leak rate = annual number of repaired leaks / per 100 miles of pipe
  - US average (EPA/AWWA) = 23 to 27
  - Reasonable goal (WRF) = 25 to 30

Summary of Performance

Systems are performing better than national average



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Performance vs. Pipe Characteristics

- Useful life of pipes can vary by numerous factors
  - Diameter
  - Age
  - Material
  - Not evaluated:
    - Pipe pressure (not enough variation)
    - Soil type (not enough data)
- In PNW: smaller, older pipe, and CI and AC pipe are more likely to leak

Service Life Assessment

- Asset Class Performance Analysis
- Weibull Distribution Analysis
- Informal Regional Utility Survey

Asset Class Performance

- Performance Trend Analysis:
  - Historic performance trend over time by asset class
  - No discernible trend for DI class (relatively new)
  - Low leak rate for large diameter class
  - Exponential trend best fit data

Asset Class Performance

- Define Acceptable Performance:
  - Industry accepted leak rate: 25 per 100 miles
  - Customer level of acceptance
  - Consequence of failure (larger vs. smaller pipes)
- By asset classes:
  - Less than 4 inches => 30 – 60 annual leaks per 100 miles
  - 4-6 inch Cast Iron => 20 – 40
  - 8-12 inch Cast Iron => 15 – 30

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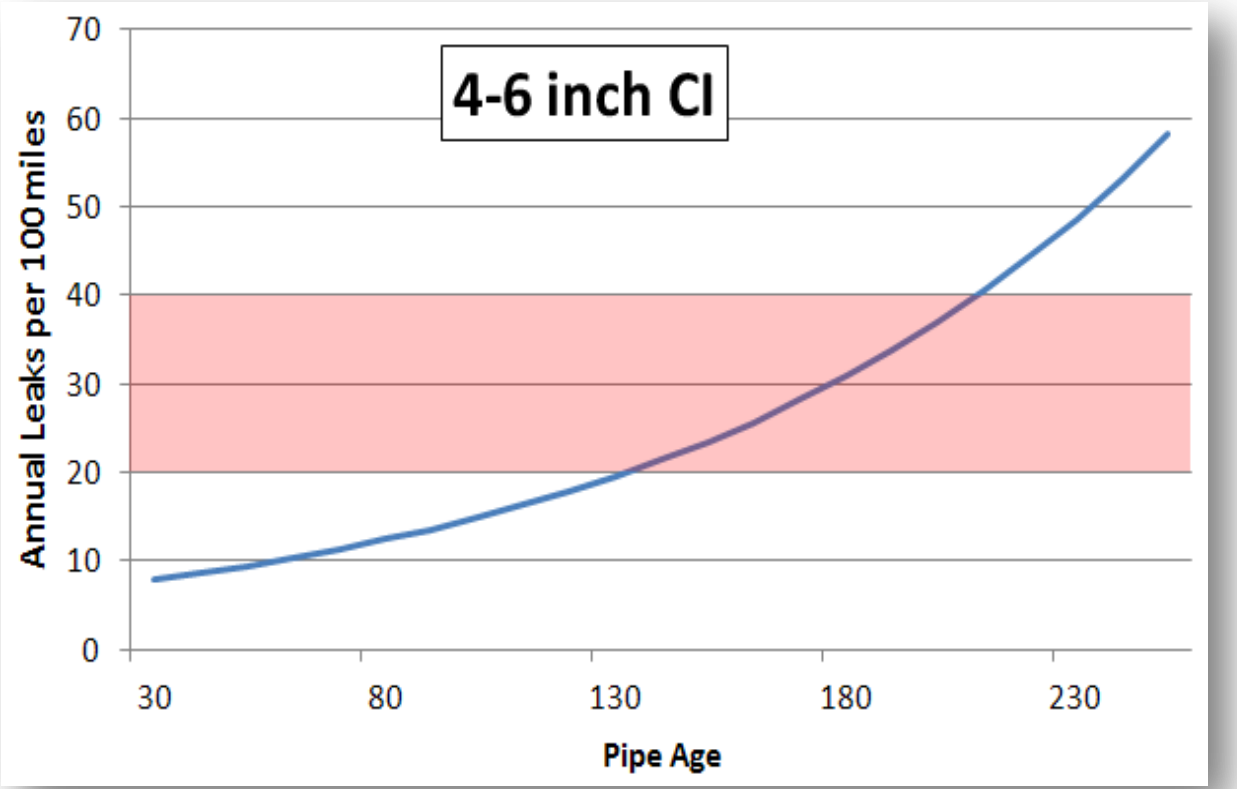
Asset Class Performance

Range of Service life (years):

- < 4”: 90-150
- 4-6” CI: 130-210
- 8-12”CI: 155-215

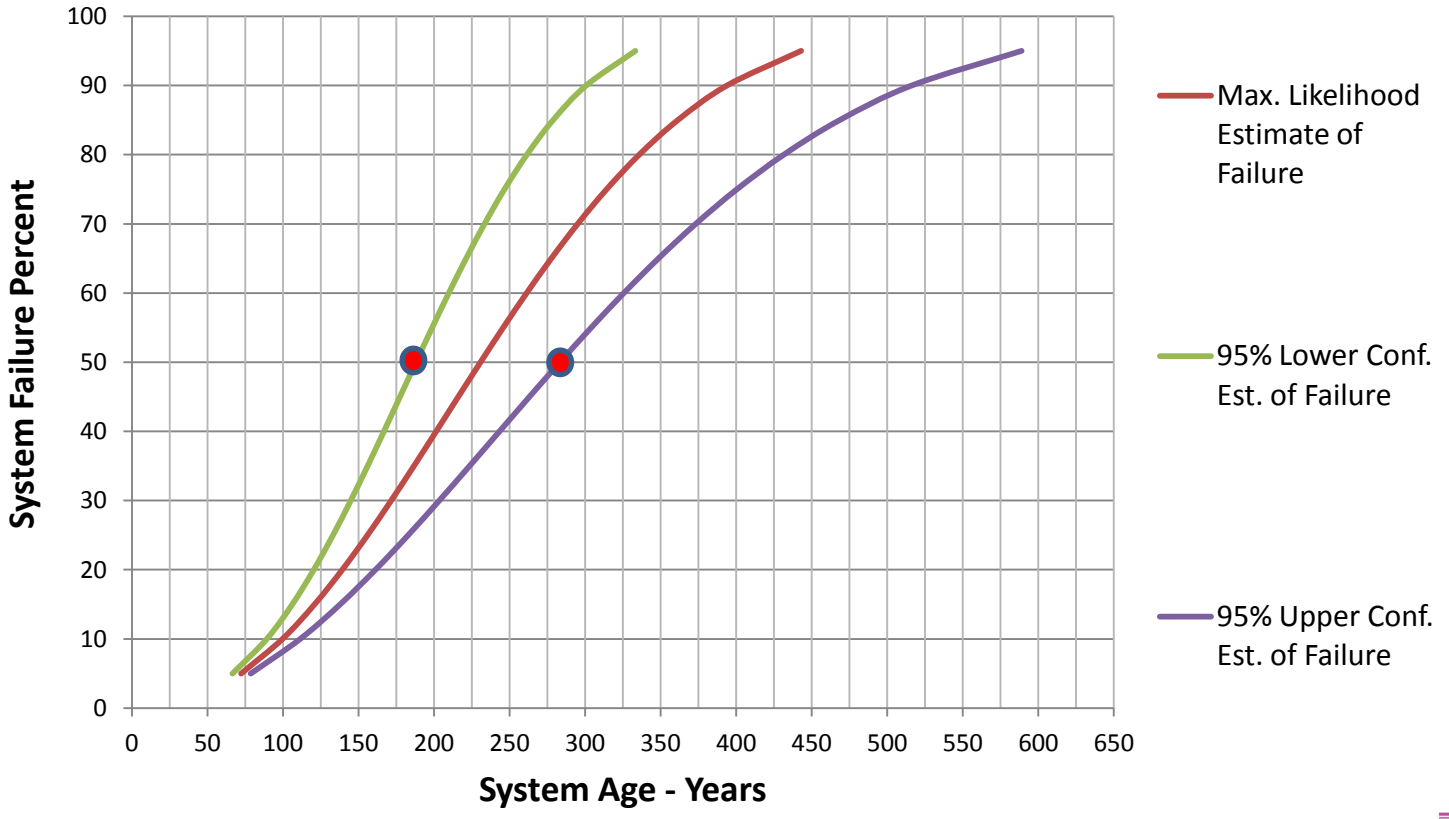


Weibull Distribution Analysis

- Pipe failure definition:
  - Two or more leaks occurring in pipes of length 100 to 1,000 feet
  - Three or more leaks in pipes of length greater than 1,000 feet.
  - Insufficient data to include time component, e.g. pipe has experienced three breaks in the last 10 years

Weibull Distribution Analysis

- Model estimates the median time of failure of the system is in the range of 188 to 283 years with 95 percent confidence



Limitations and Improvements

- Opinion of service life is not meant to be applied to individual pipelines
- Underlying assumptions is that historic performance trends will continue in the future
- Data limitations: e.g. construction quality, groundwater elevations, soil maps, and condition assessment were not readily available
- Time frame for leak occurrence was not included in the definition of failure (Weibull analysis)
- Study should be updated once every five to ten years

GIS Model to Update Analysis

- Water distribution system data in GIS
- Engineering focus on data updates (installation year, material)
- Goal set to re-run process annually
- Built model in ArcGIS to save time

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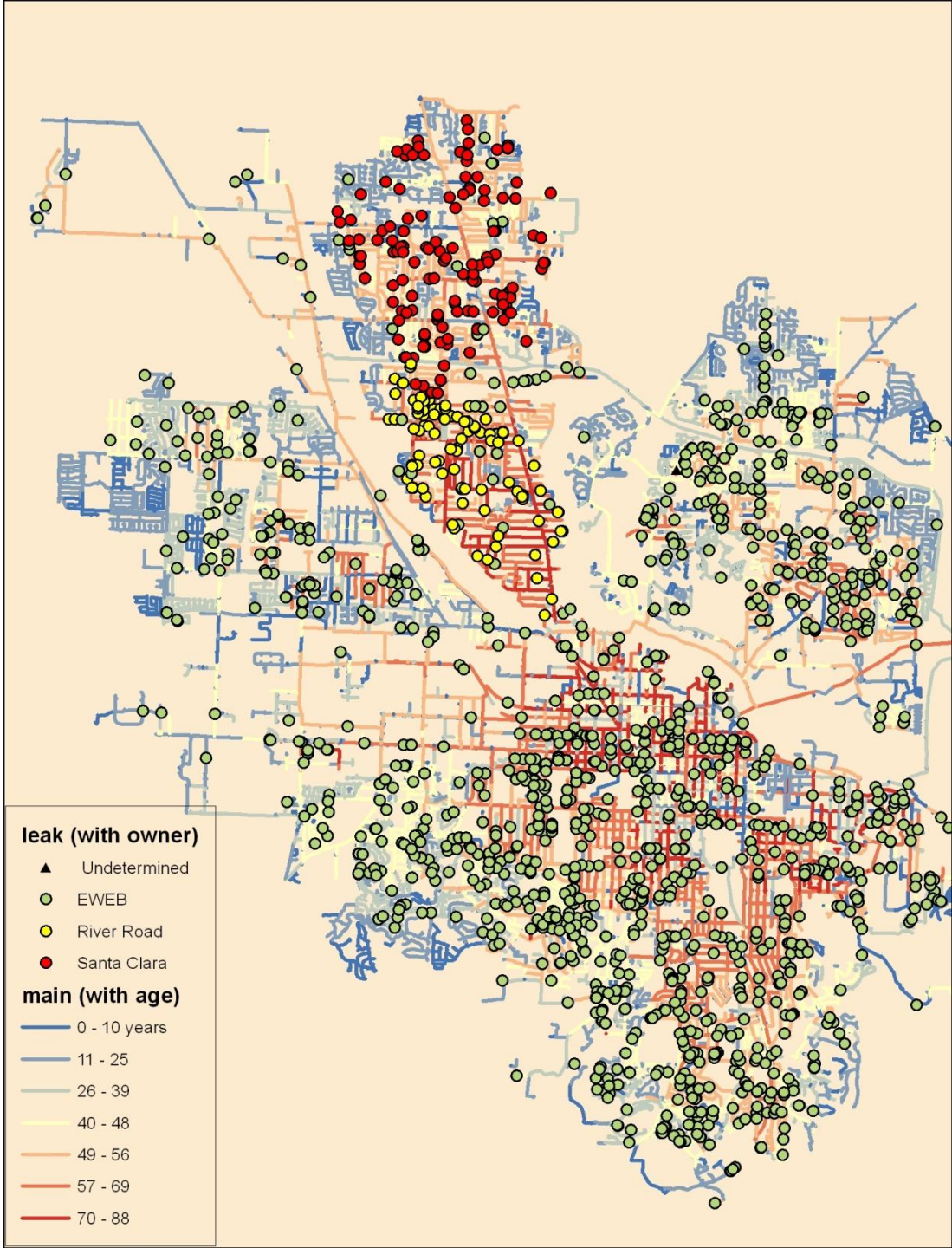
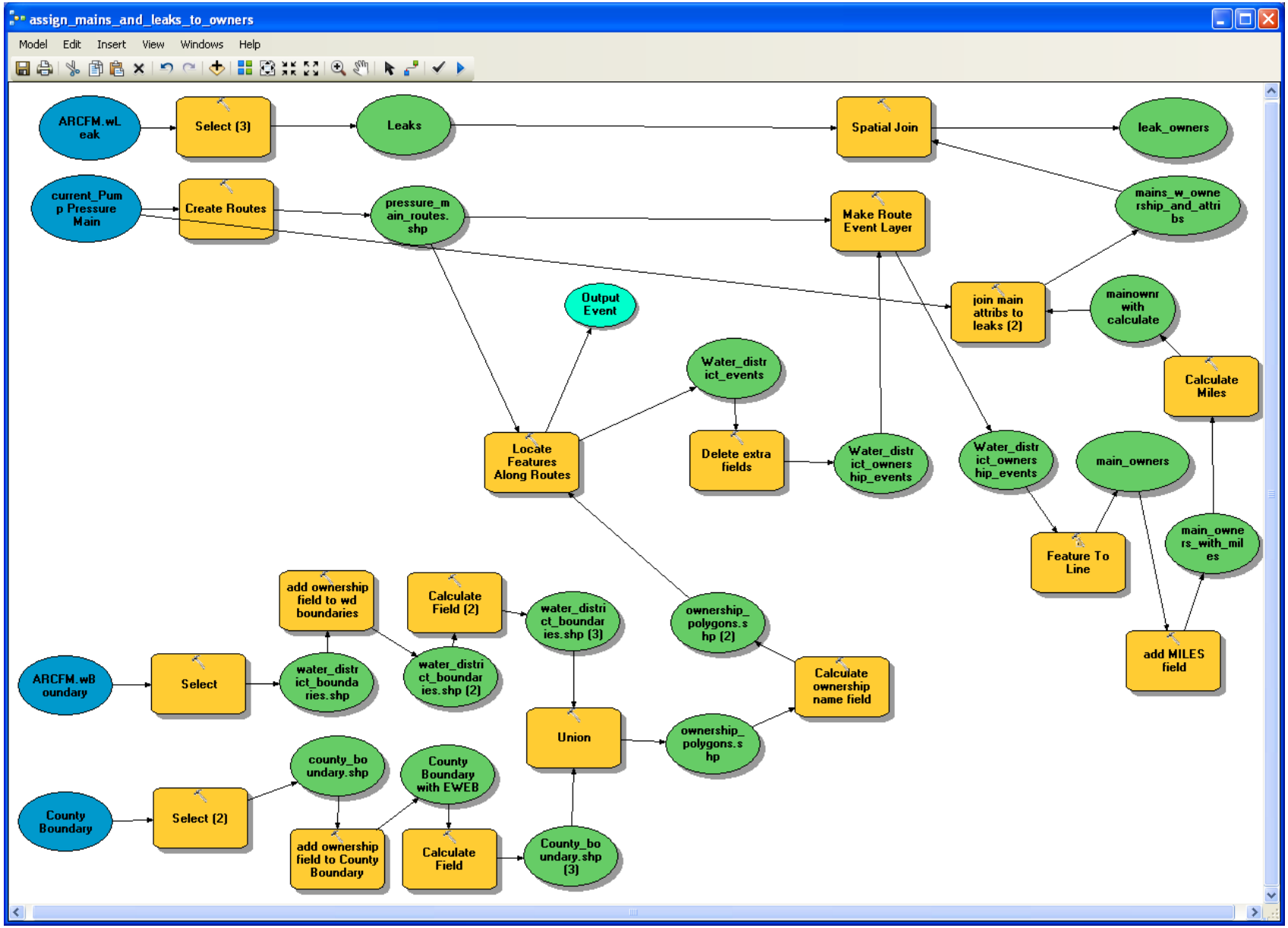
Data extract process:

- Select leaks and mains
- Remove unneeded attributes
- Assign ownership (linear referencing)
- Add attributes and calculate values
- Export tabular data to condition model (Excel)





Model builder model in ArcGIS

Data Recommendations

- Develop a process and policy for defining a failure for a pipe asset
- Develop practices for post replacement condition assessment activities
- Track the impact of leaks to better support decision making
- Update and collect leak cause code data that can be discerned by leak response crews
- Reduce the number of assets managed in GIS

Conclusions

- Use the condition-based CIP to size the investment in water pipeline infrastructure to meet future level of service goals
- Build a reserve for future infrastructure renewal, including field condition assessment.
- Continue to monitor for failure rates and maintain detailed records of failure rates and related data

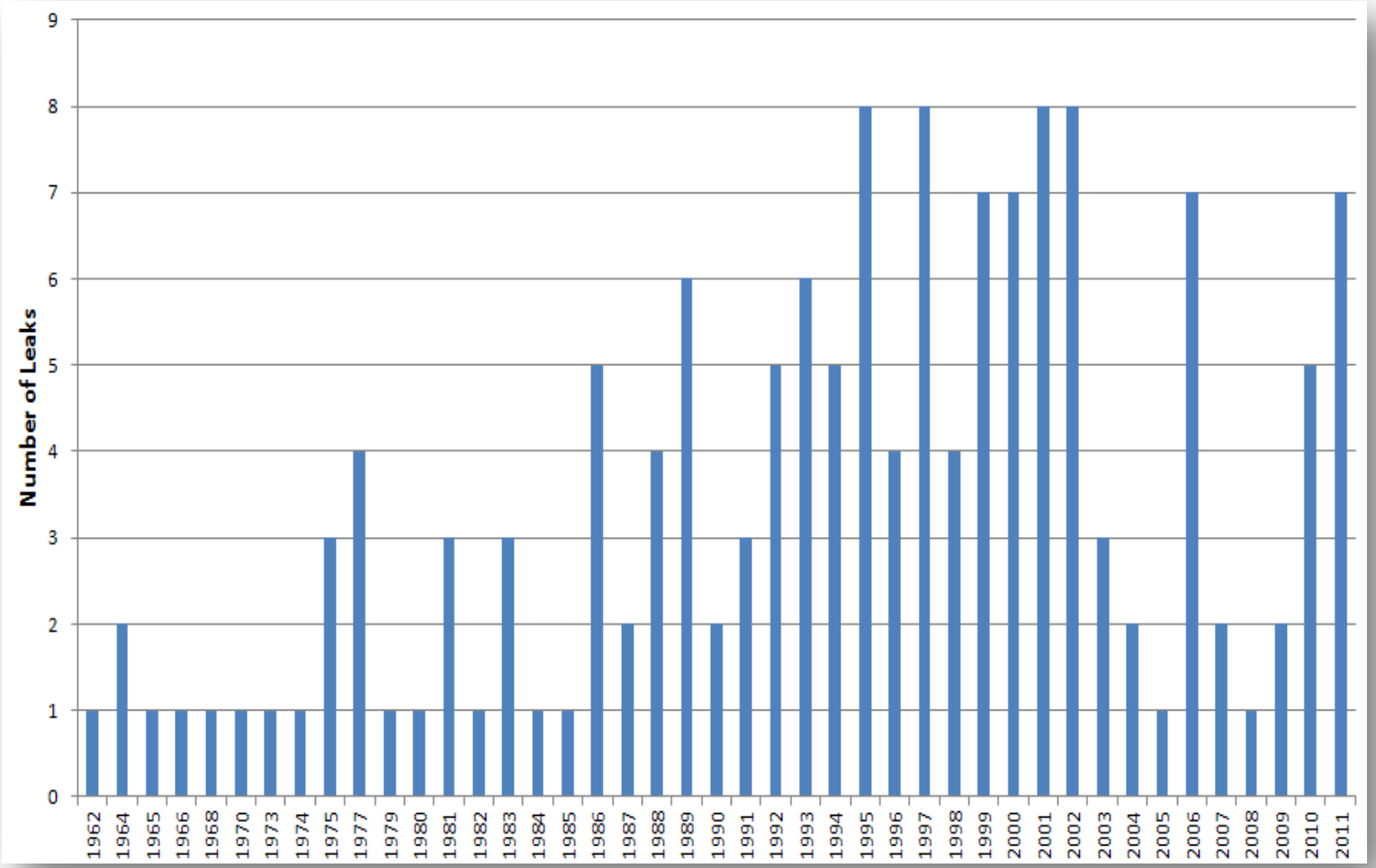
Thank You! … Questions?

Ronan Igloria, PE
Ronan.Igloria@hdrinc.com

Bob Denouden
Bob.Denouden@EWEB.ORG

Extra Support Slides

District Leak History



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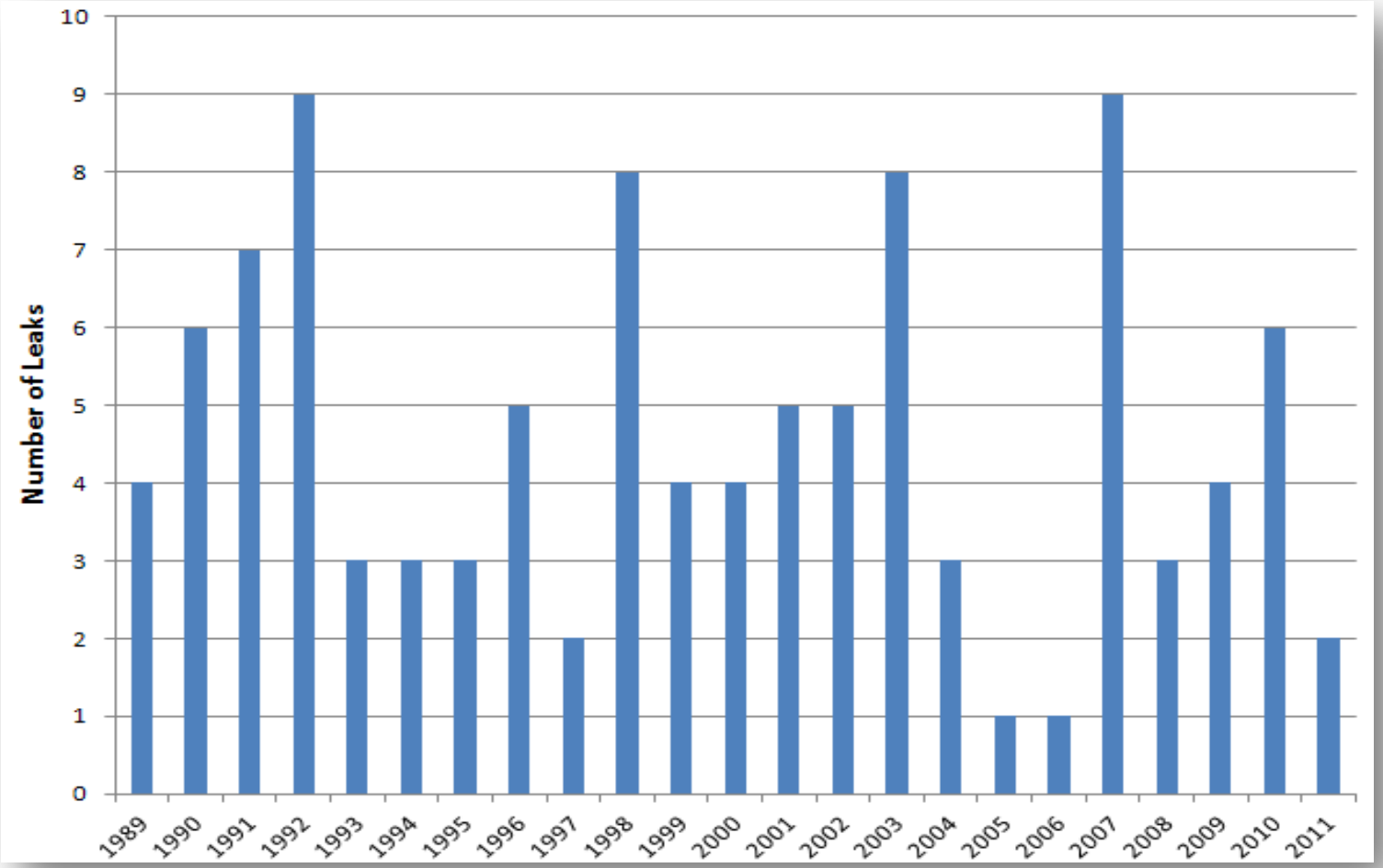
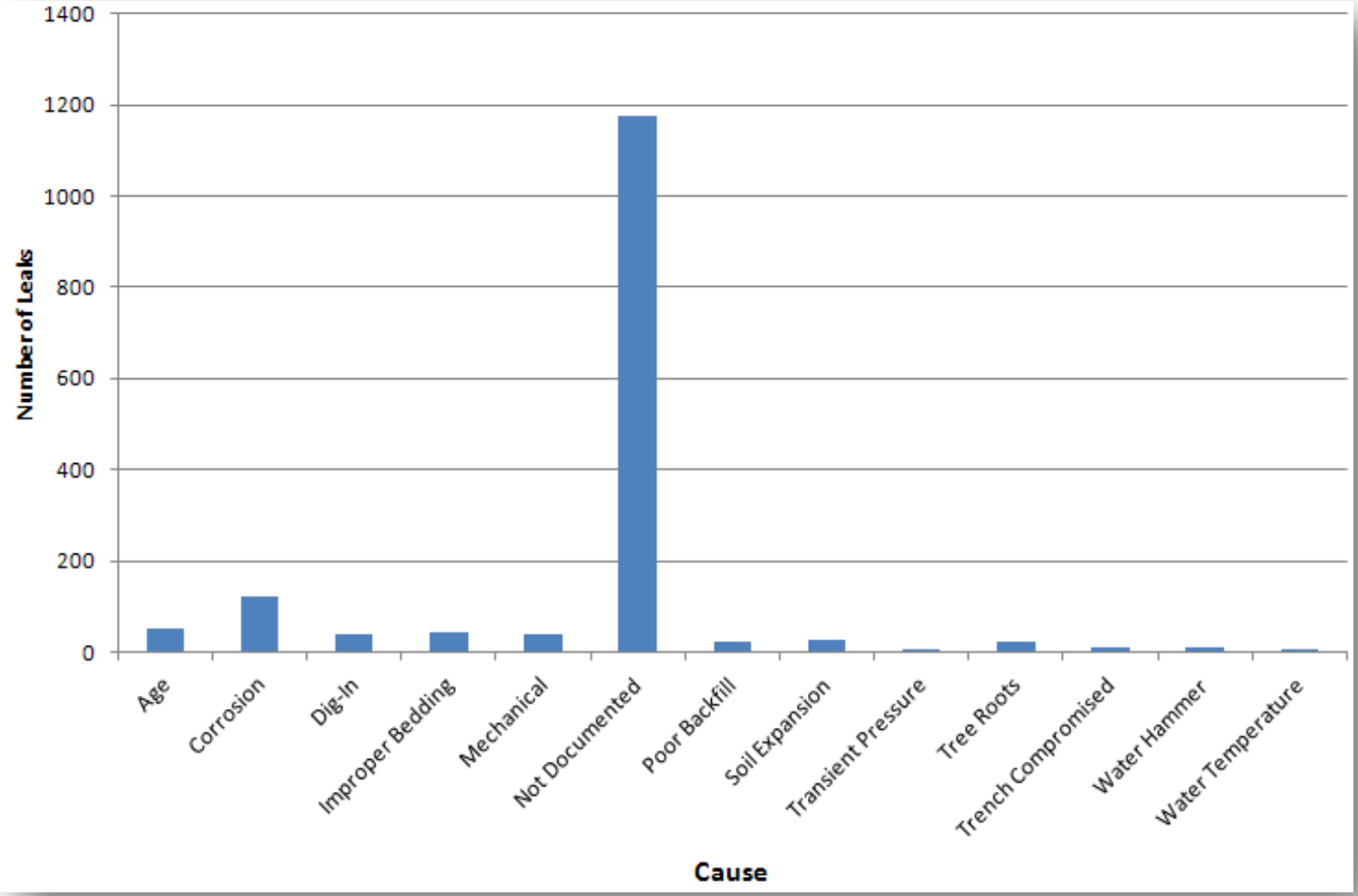
District Leak History

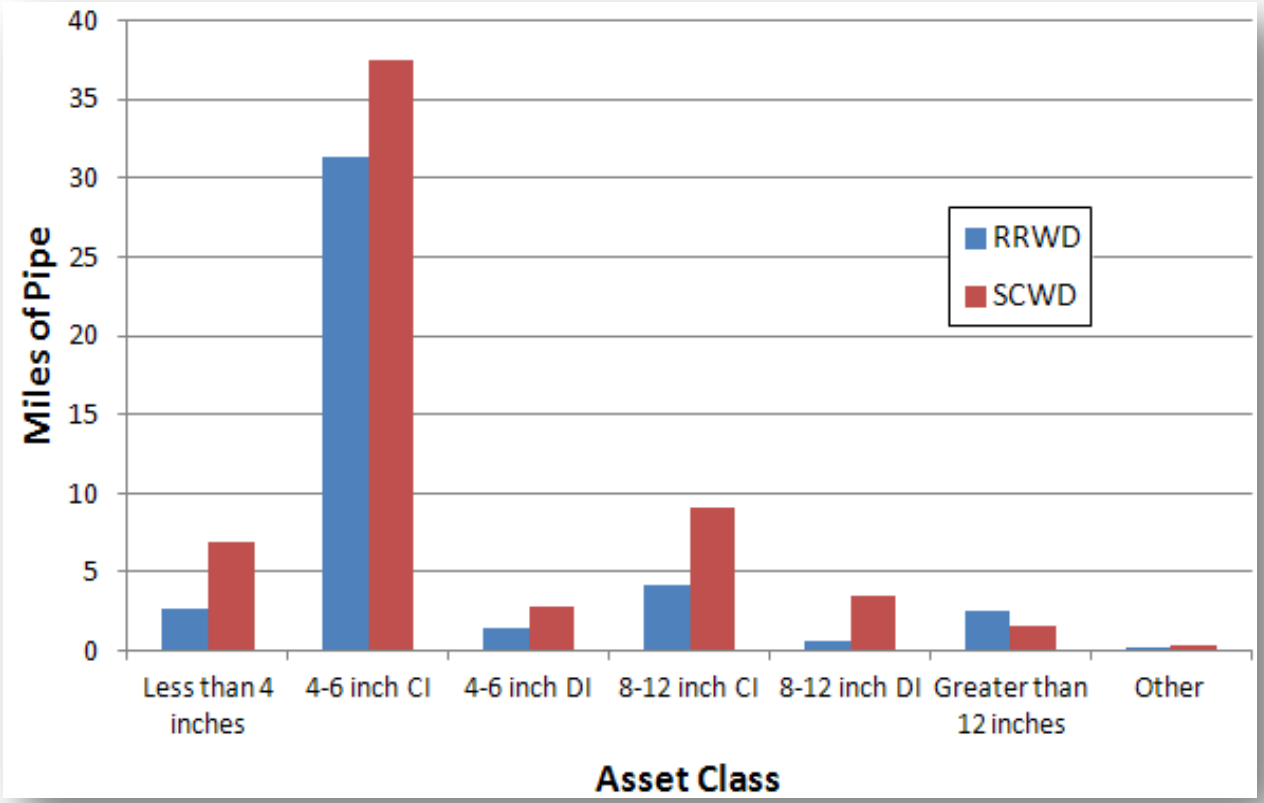


Cause of Leaks (system-wide)

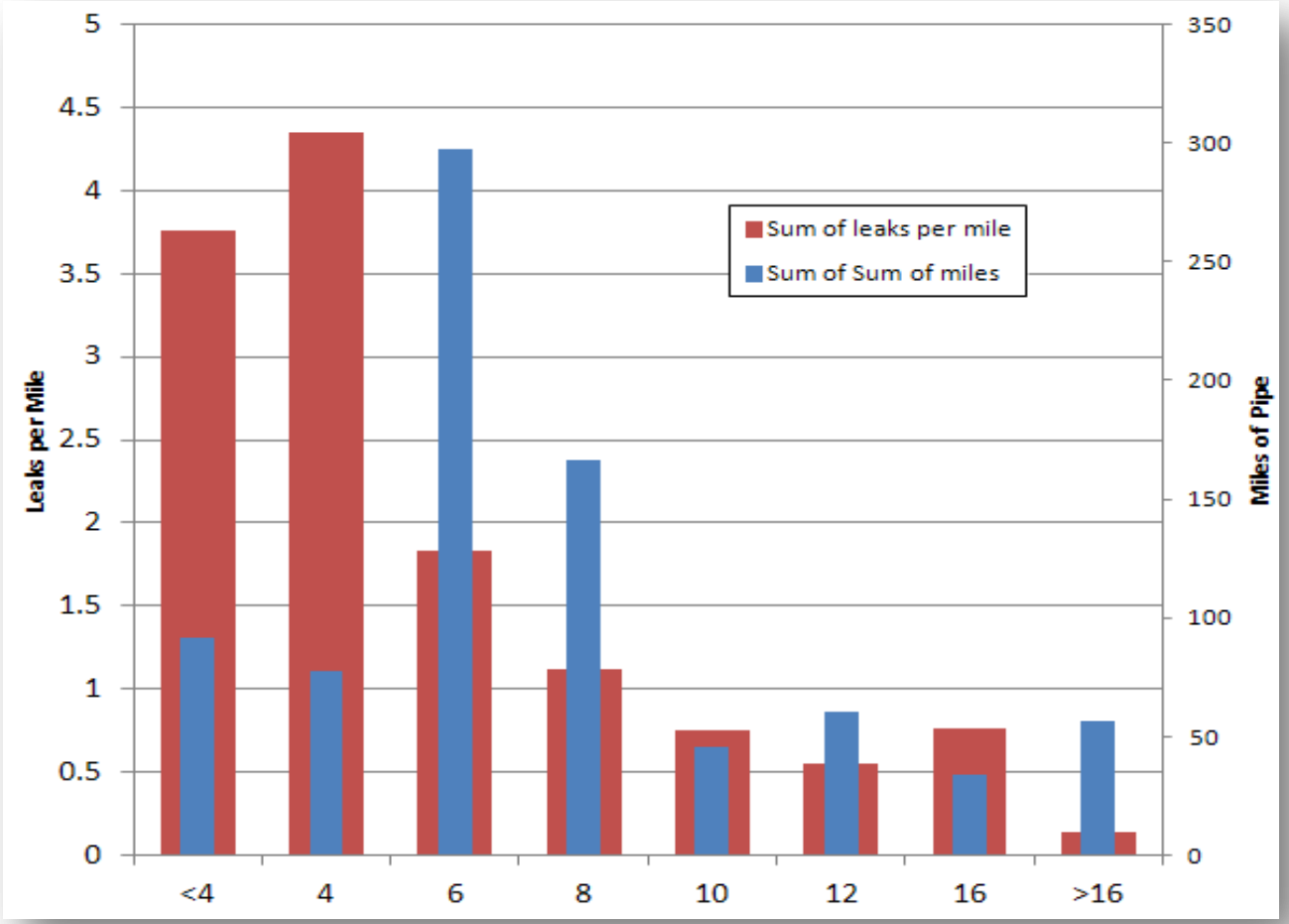


Asset Class Performance

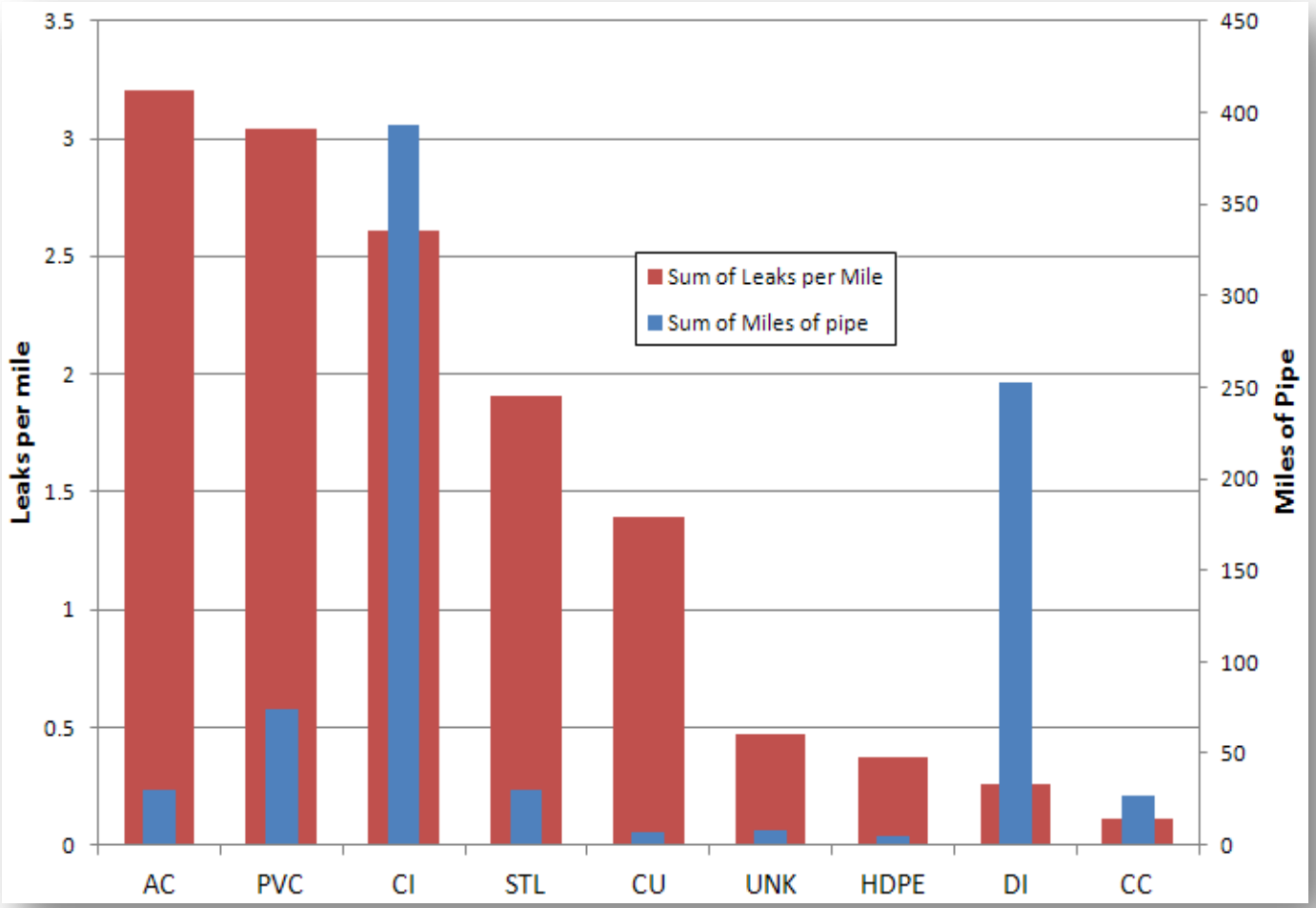
- In PNW: smaller, older pipe, and CI and AC pipe are more likely to leak than other pipes



Leak rate vs. Pipe Diameter



Leak rate vs. Material



Weibull Distribution Analysis

- Weibull analysis is often used in industrial fields to predict time to failure
  - Fits a distribution curve to model the underlying distribution that best explains observed failures

$$f(t|B,C,D) = \frac{B}{C}\left(\frac{t-D}{C}\right)^{(B-1)} e^{-\left(\frac{t-D}{C}\right)^{B}}$$

$$B > 0, C > 0, -\infty < D < \infty, t > D.$$

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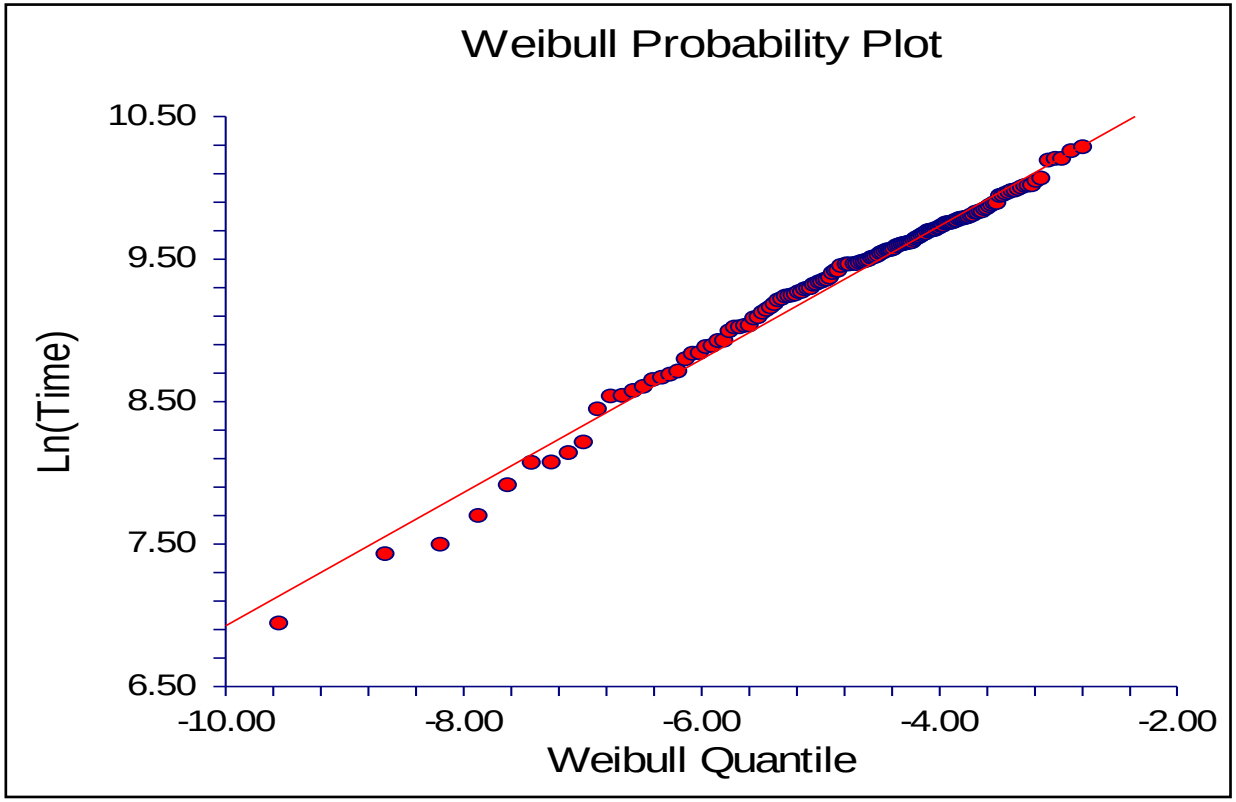
Weibull Distribution Analysis

- Plot of observed transformed failure times against the Weibull quantiles falls on a straight line. This result suggests that the Weibull model explains the pipe failure times well.



Capital Investment