WATER AND CITY
Guidelines of local governments for sustainability

CITIES AND NEW TECHNOLOGIES

Management and renewal of urban water infrastructure

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Outline

- ✓ Context – what is the problem?
- ✓ Should large and small diameter pipes be treated the same or differently?
- ✓ Need to collect data – why and what to collect?
- ✓ What can we do with data?
- ✓ How cathodic protection can be effective strategy to manage small diameter mains?

- ✓ 1664 – Versailles, France uses cast iron mains

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- ✓ 1692 – Boston incorporates water works (wood pipe)

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- ✓ 1804 – Philadelphia uses cast iron mains

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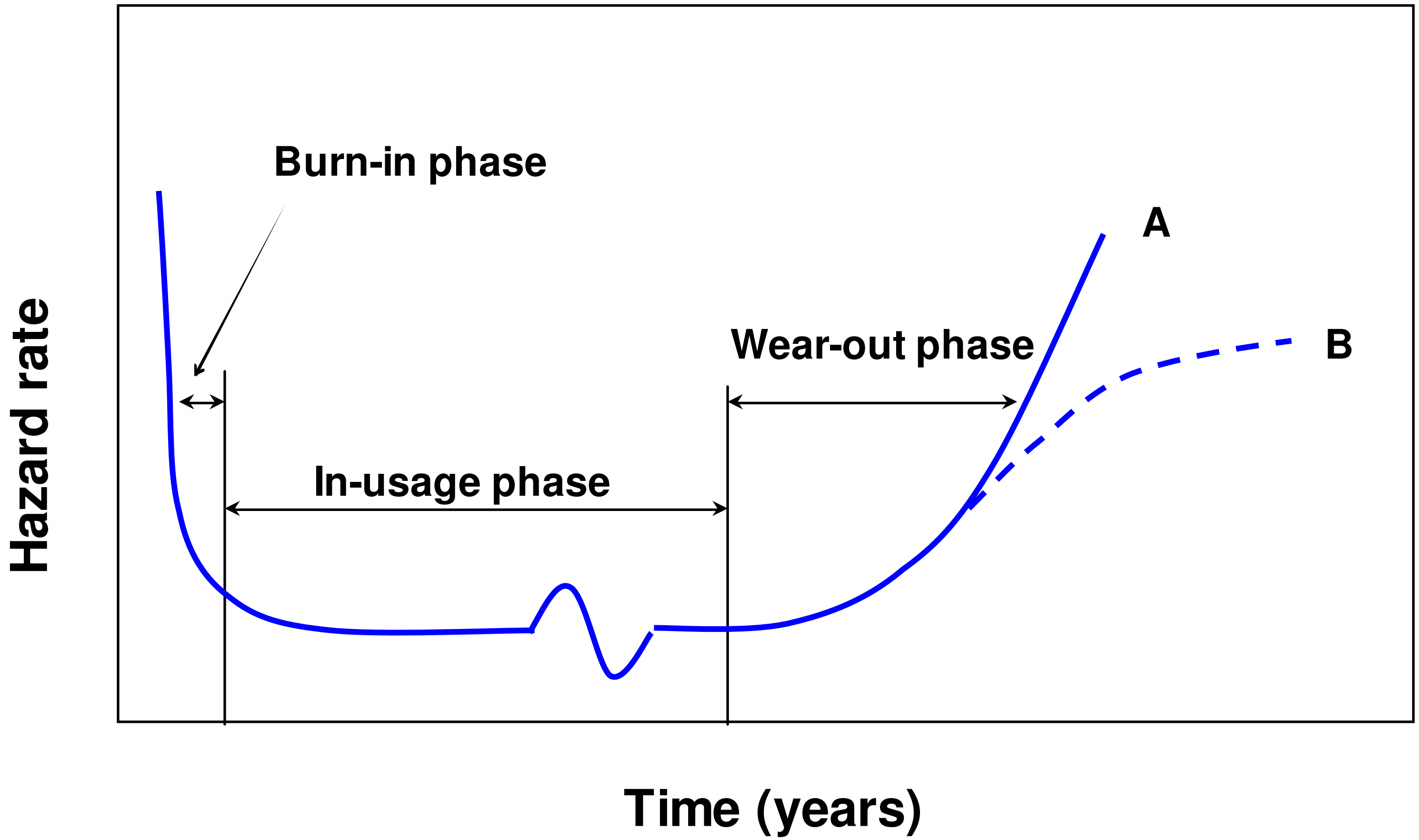
- ✓ 1841 – Toronto has first private water supply system
- ✓ 1842 – NY completes Croton aqueduct for water supply

Bathtub curve of life cycle of buried pipe



Asbestos cement

Source: CSIRO

Combined degradation / structural failure of asbestos cement pipe

Cast iron

After sand blasting

Before sand blasting

125 year-old pipe

Pit-cast pipe sample with casting voids

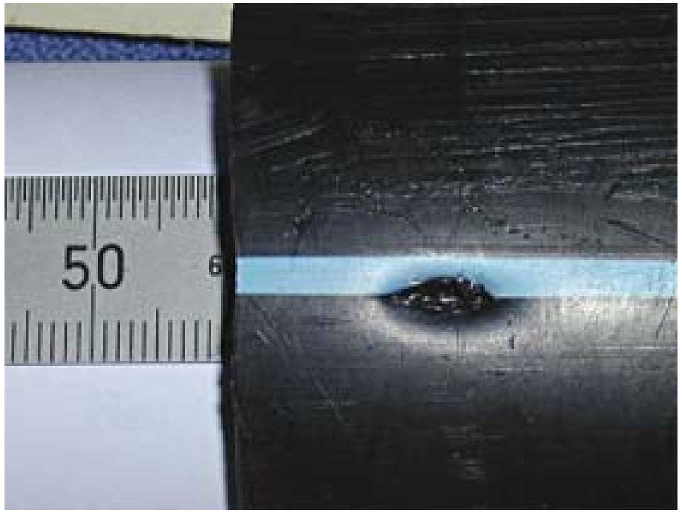
Source: Toronto, 2004

Ductile iron

Source: Toronto, 2004

Brittle fracture of PVC pipe

Polyethylene pipes



Rupture of polyethylene pipe

Large diameter cast iron mains

Cleveland, 1926

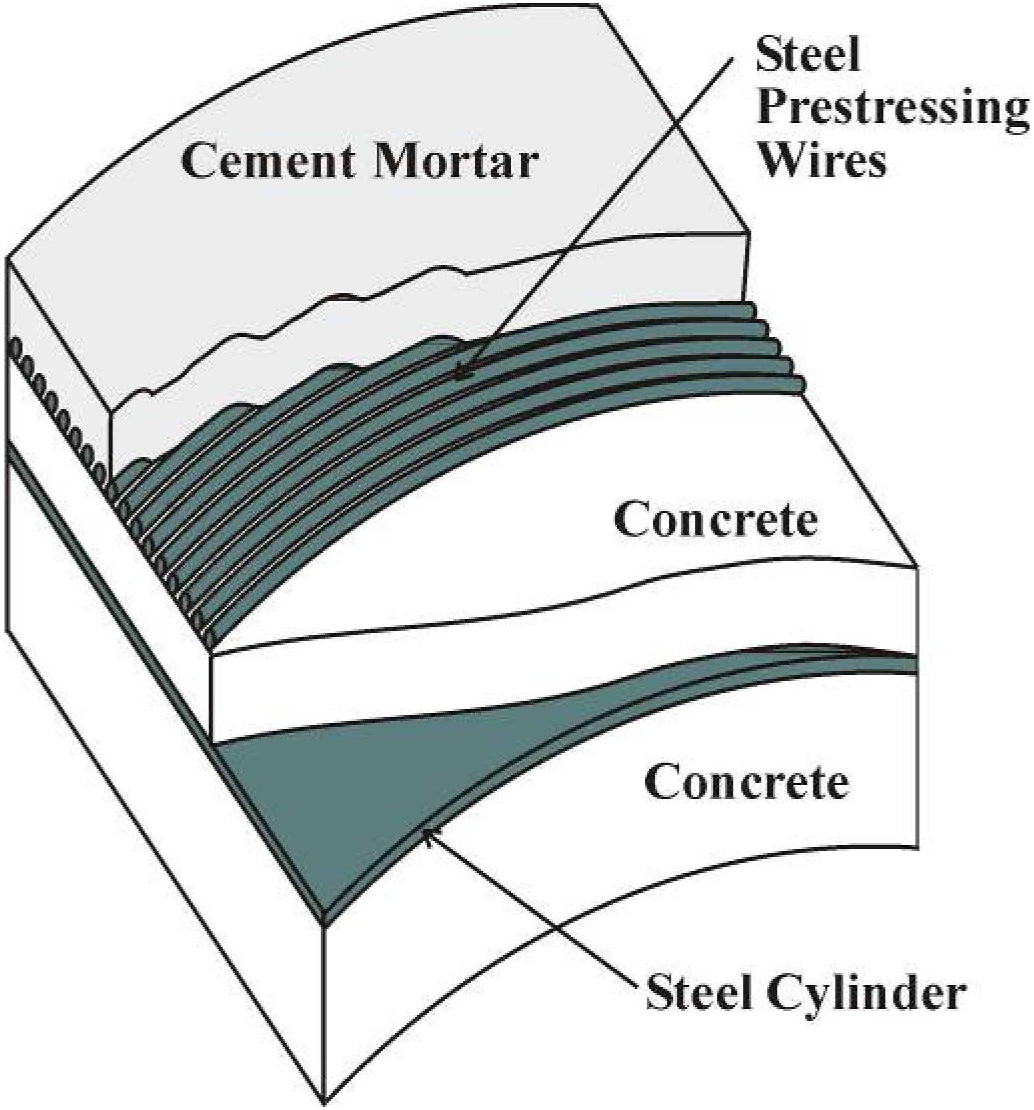
Source: Cleveland, 2002

Hamilton, January 2003

Source: Hamilton, 2003

Large diameter cast iron mains

Large diameter PCCP



Large diameter PCCP

Calgary, Alberta
January, 2004

Temperature –31°C

PCCP 1200 mm

Repair costs: $700 K

No loss of life
No damage
Major arterial road

Source: AWWA Opflow

Fort Lauderdale

PHOTO: CITY OF FORT LAUDERDALE PUBLIC WORKS DEPARTMENT

Financial needs

US

ASCE	US $11 B / year
US EPA	US $83 B over 20 years
AWWA	US $250 B over next 30 years
WIN	US $460 B over next 20 years

Canada

FCM	Can $ 12 B over next 15 years

- ✓ Mains replacement value in North America US$ 400 B
- ✓ Only 0.5% replaced annually (expected life 200 years)

Challenges to manage distribution systems

- ✓ Large majority of mains subject to corrosion
- ✓ Large systems – enormous ‘inertia’ – slow and difficult to change course
- ✓ Owners do not ‘depreciate’ assets
- ✓ Pro-active vs. reactive maintenance
- ✓ Distribution system self insured

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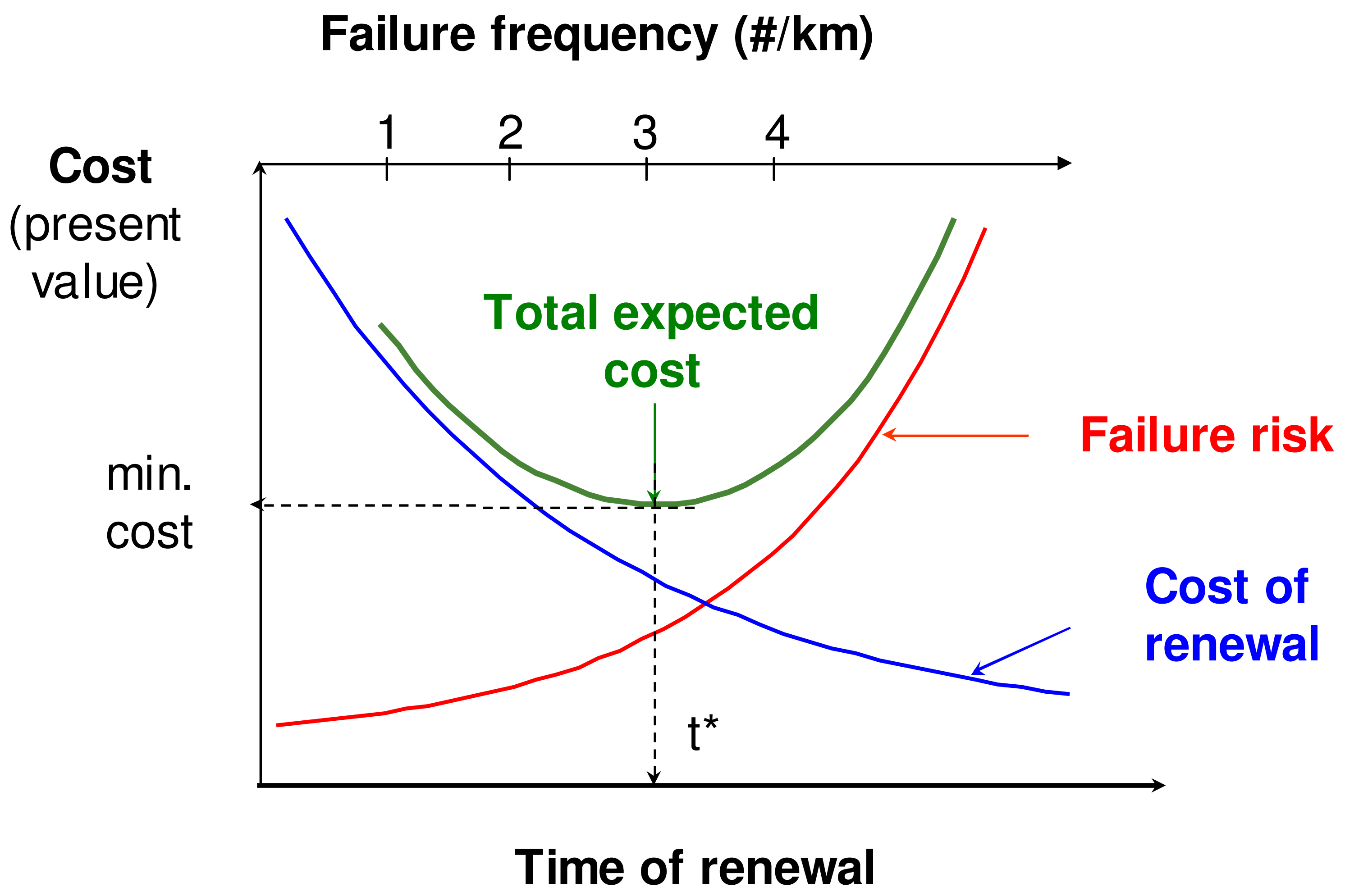
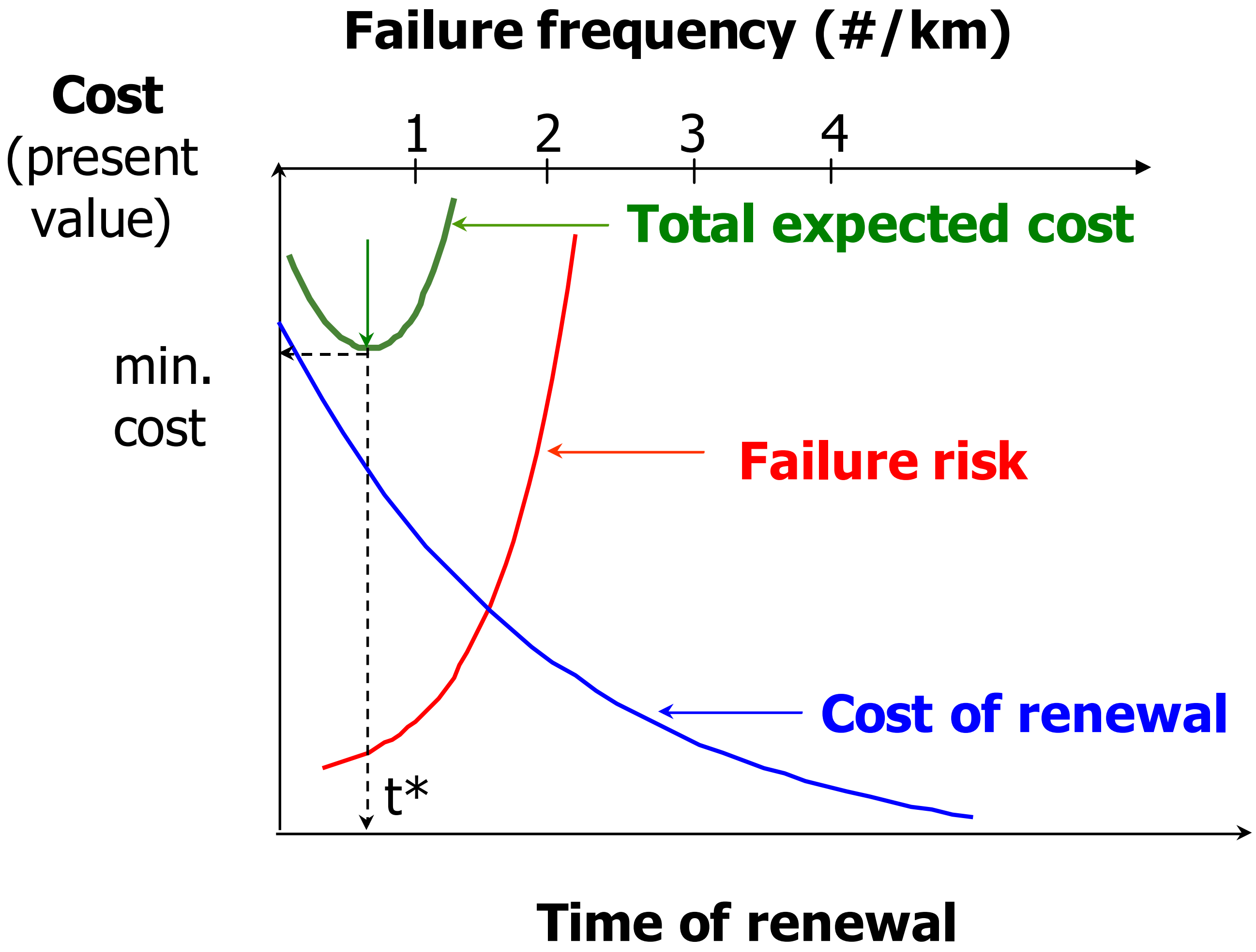
Transmission vs. Distribution Water Mains

Mains	Transmission	Distribution
Material	PCCP, AC, steel,CI, DI	PVC, CI, DI
Pipe size	Large (> 300 mm)	Small (< 300 mm)
Consequences of failure	Severe	Moderate
Risk tolerance	Low	Moderate
Repair / Renewal	Immediate	Risk / life cycle cost
Length in North America	65,000 km	1,500,000 km
Redundancy	Usually none	High
Non-intrusive condition assessment	Inspection of in-service Pipes	Deterioration modeling

Distribution mains (small) – failure management



Transmission mains (large) – failure prevention



Summary: Data requirements

Static

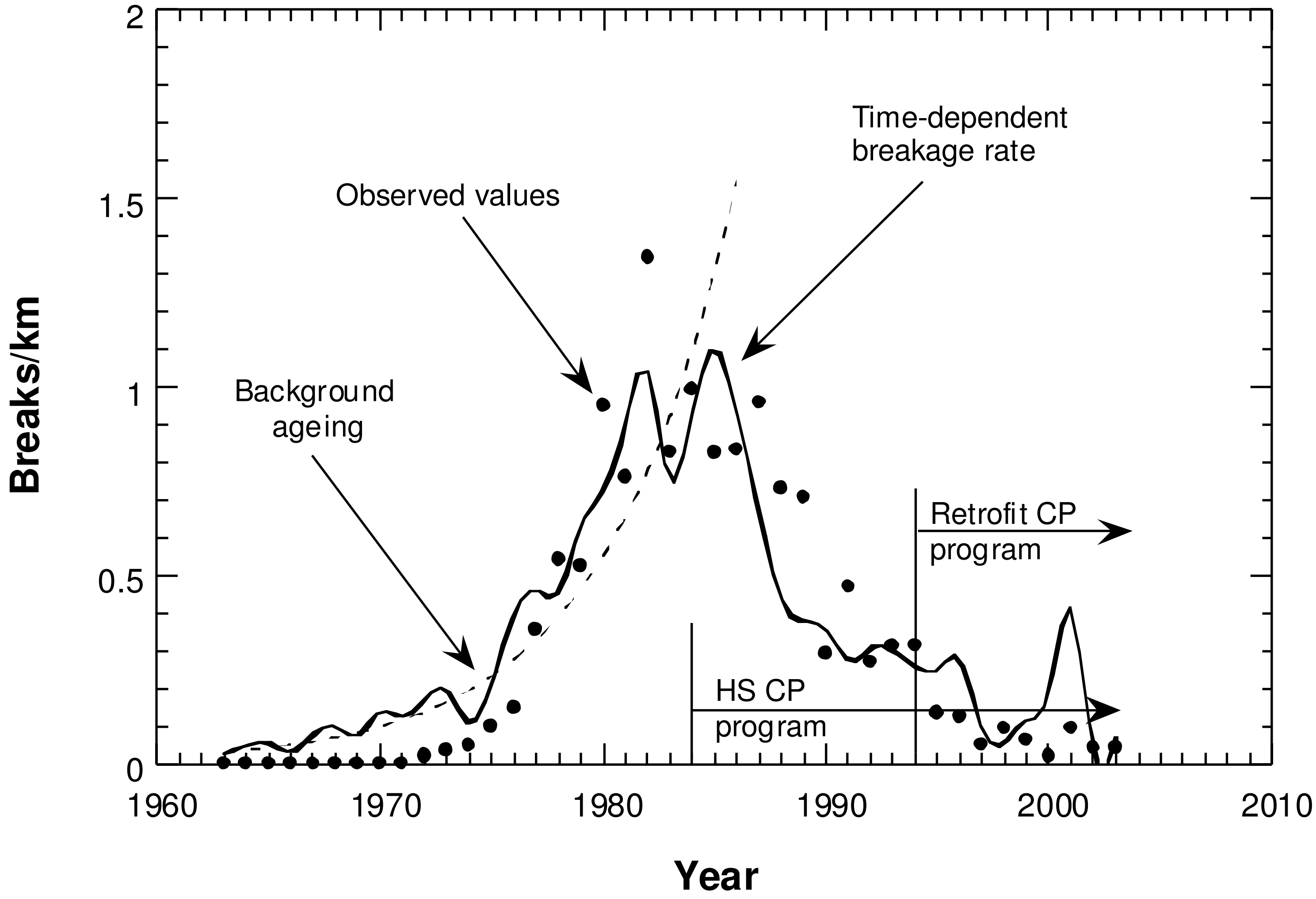
Pipe inventory	Operating conditions
✓ Pipe diameter ✓ Pipe length ✓ Geographical coordinates (start and end nodes) ✓ Pipe installation dates ✓ Pipe material ✓ Service connections ✓ Soil type, soil characteristics	✓ Operating conditions such as pressure ✓ Traffic level ✓ Temperatures (soil, water) ✓ Soil moisture conditions ✓ Cathodic protection

Dynamic

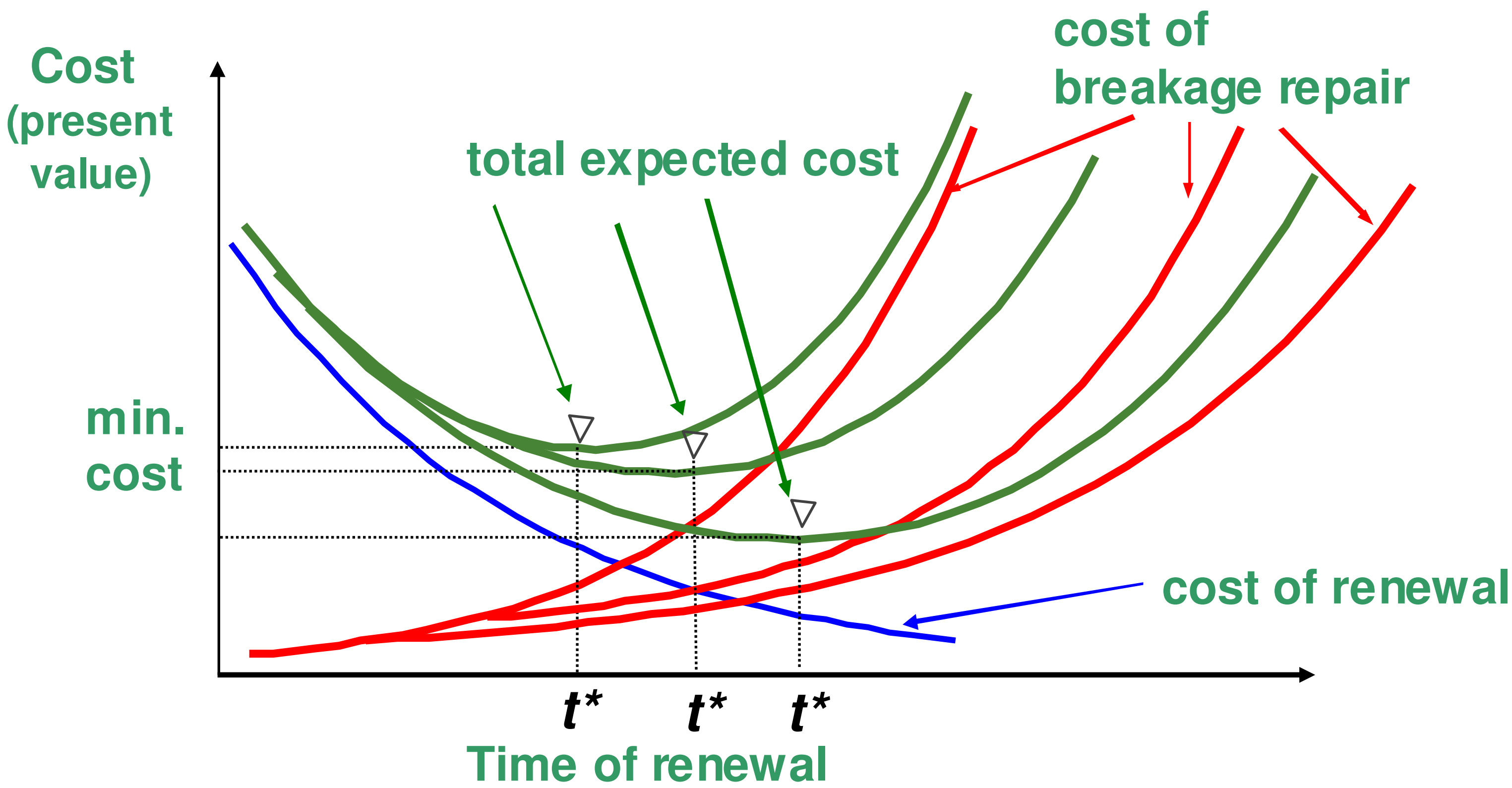
Pipe performance	
✓ Pipe breakage history ✓ Location of failure along pipe length	✓ Failure mode ✓ Pipe "time of death" (end of economic life)

Sacrificial Anode Cathodic Protection

HS and Retrofit Cathodic Protection



Pipe life - economic outcome of life-cycle costs



Final remarks

- ✓ **Treat large and small pipes differently:**
  - ✓ **Large mains: *failure prevention.***
  - ✓ **Small mains: *failure management.***
- ✓ **Collect data but must be good data!**
- ✓ **Without the right data → no analysis possible → rational decisions not possible.**
- ✓ **Use models to foresee possible problems.**
- ✓ **Use decision-making models to argue financial needs.**
- ✓ **Cathodic protection can help reduce performance of water distribution networks.**

Acknowledgements

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URBAN INFRASTRUCTURE

Time line for iron pipe wall thickness ….