

# A SUSTAINABLE INTEGRATED WATER PIPELINE INTEGRITY MANAGEMENT SYSTEM



*Every Drop Counts*

*Presented by:*

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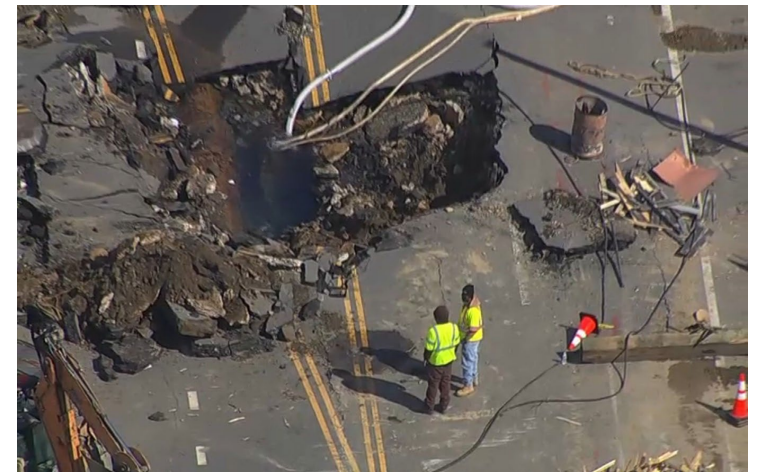
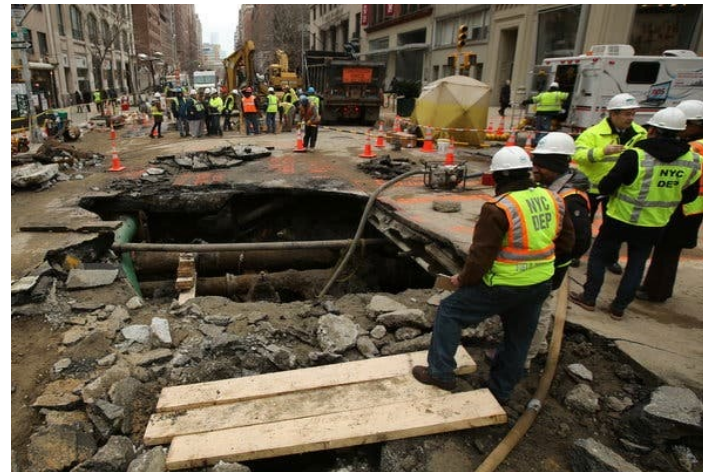
*Pipeline Integrity Consulting Engineers Pte Ltd*

# What is Pipeline Integrity Management?

Pipeline Integrity Management (PIM) may be defined as a systematically planned and comprehensively documented, integrated management program encompassing design, engineering, operations, inspection, maintenance, life optimization and corporate governance policies for operating a pipeline system safely, reliably and in a sustainable manner.

It is a holistic program that should be continually updated and regularly improved to protect the communities and environment along and around the pipeline system.

In a nutshell, it is “The Licence To Operate” Certificate.



# Why Pipelines?

## SAFETY

History and experience have proven that Pipelines are the **SAFEST** mode for conveying water

## ECONOMICS

Pipelines are the **MOST COST EFFECTIVE** mode for conveying water

## RELIABILITY

Pipelines are also the **MOST RELIABLE** water conveying system

## ENVIRONMENT

Lastly, they are also the **MOST ENVIRONMENTALLY FRIENDLY** and **SUSTAINABLE** water conveying system

# Types of Water Pipes

## PRESSURE PIPES

Rely on applied pressure heads induced by water pumps to generate flow

### METAL PIPES

- **Cast Iron** – Original metal water pipes. Very brittle and prone to cracking and structural breakage.
- **Ductile Iron** – Stronger and less brittle than cast iron. Interior walls often lined with cement mortar.
- **Steel** – More costly, lighter and stronger than ductile iron. Welded joints ensure overall strength.
- All metal pipes are susceptible to corrosion.

### CLAY and CONCRETE PIPES

- **Vitrified Clay** – Oldest sewer and water pipes made from clay fired in a kiln. To avoid crushing, fracturing and leakage they are made of thick walls.
- **Reinforced Concrete** – Normally reinforced with steel bars and mesh to enhance strength in both compression and tension
- **Asbestos Cement** – Consists of Portland cement and medium-grade chrysotile asbestos fibres which act as reinforcing materials. Hazardous.

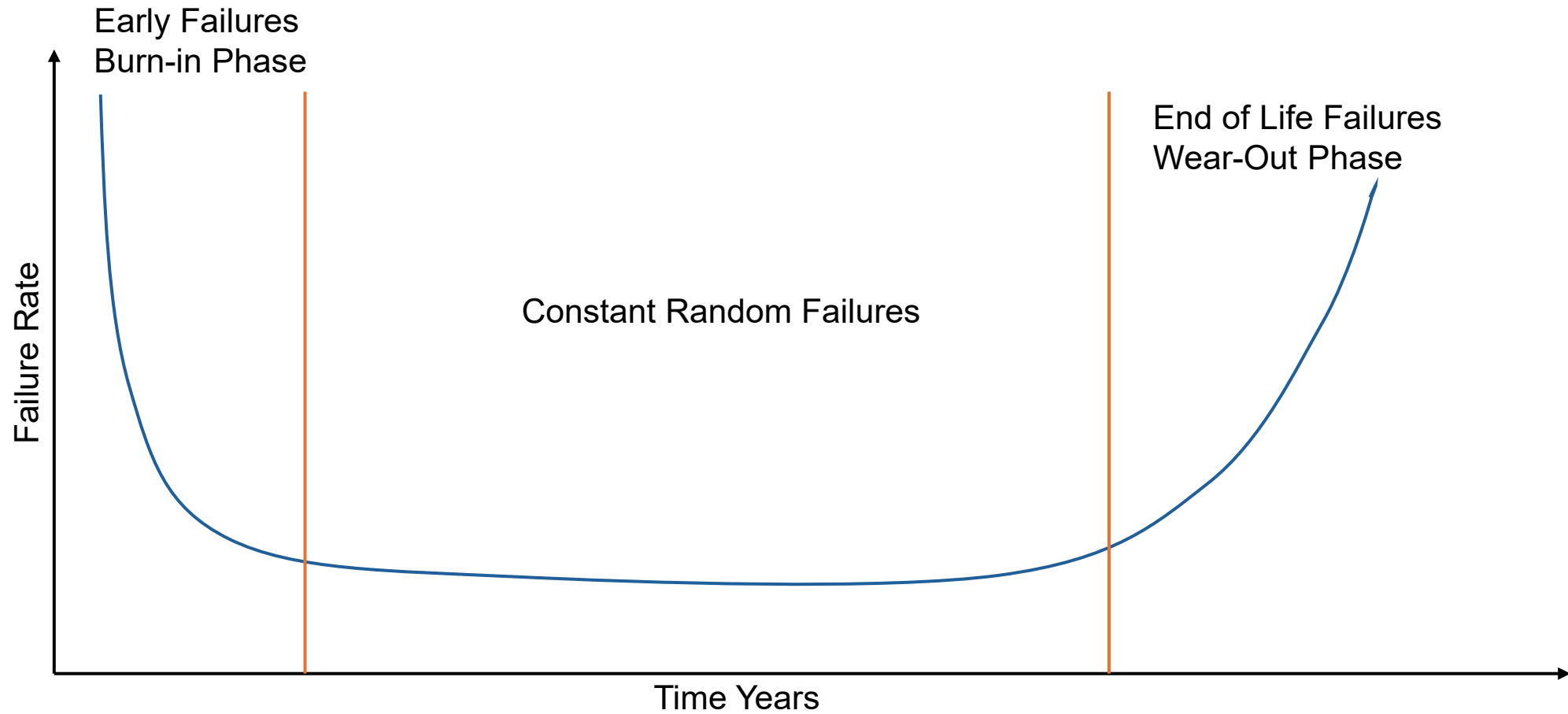
## GRAVITY PIPES

Rely on gravity due to elevation difference for water flow

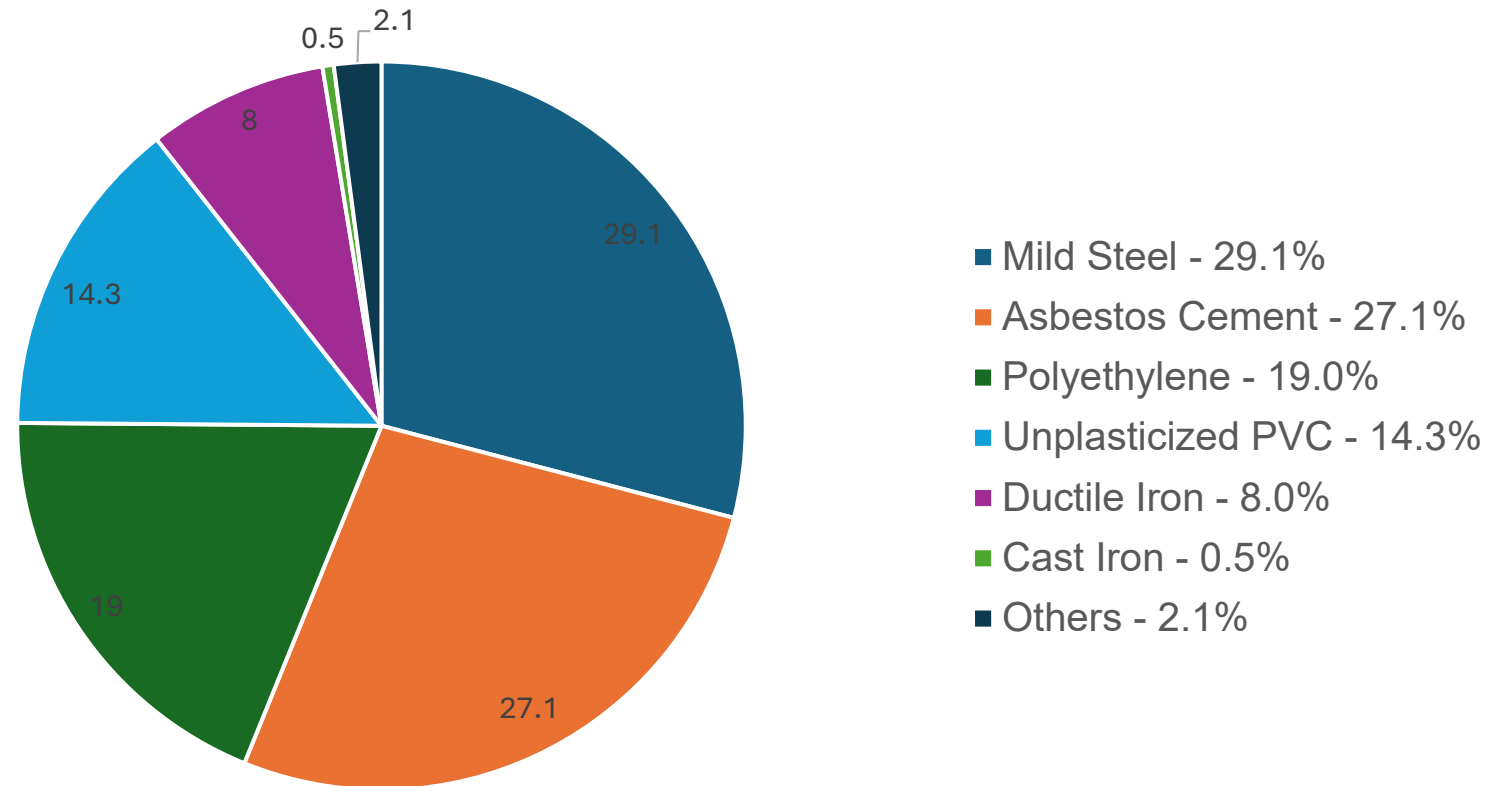
### PLASTIC PIPES

- **HDPE** – Flexible and available in corrugated and solid wall. Joined by applied heat and pressure butt-fusing and allows for trenchless installation.
- **PVC** – Rigid, inexpensive and lightweight. Brittle, prone to cracking and overbending can lead to failure.
- **Fiberglass** – Manufactured by winding process that combines epoxy resins with self-reinforcing continuous glass filaments. Inherently strong and withstands high pressure.

# The “BATHTUB” Curve of Buried Pipes

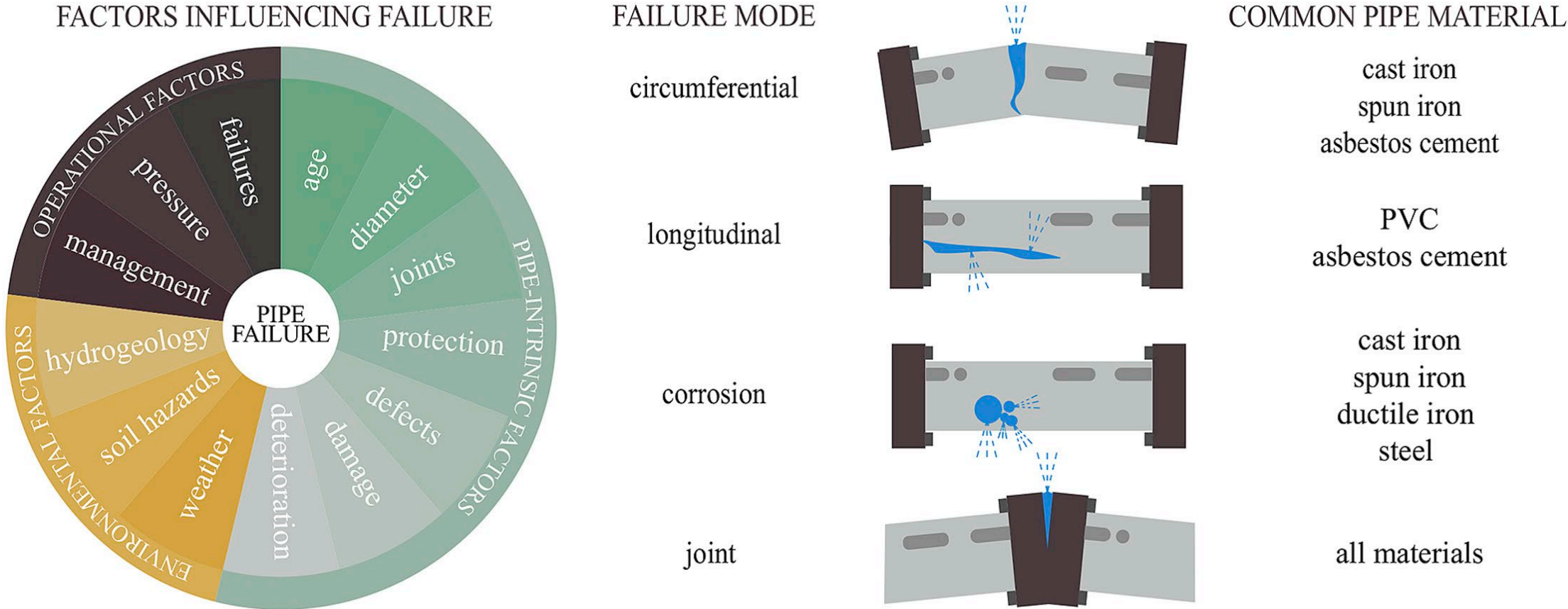


# Water Pipeline Materials in Malaysian Piping System



Source: The Malaysian Water Association (MWA). Malaysian Water Industry Guide 2018

# Factors Influencing Water Pipeline Failures



Source: Barton NA, Farewell TS, Hallett SH, Acland TF. Improving pipe failure predictions: Factors affecting pipe failure in drinking water networks. Water Res. 2019 Nov

# Factors Causing Water Pipeline Deterioration

Al-Barqawi and Zayed (2006), classified the cumulative detrimental effects on piping into Physical, Environmental and Operational categories:

## PHYSICAL FACTORS

- Age & Material
- Wall Thickness
- Diameter
- Joint Type
- Lining and Coating
- Dissimilar Metals
- Installation
- Manufacture

## ENVIRONMENTAL FACTORS

- Bedding
- Trench Backfill
- Soil Type
- Ground Water
- Climate
- Pipe Location
- Disturbances
- Stray Electric Currents

## OPERATIONAL FACTORS

- Internal Water Pressure
- Leakage
- Water Quality
- Flow Velocity
- Backflow Potential
- Operation & Maintenance Practices



# Know Your Pipe (KYP)

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**All buried pipelines operate anonymously. As Water Pipelines are made of different materials, they will require different integrity assessment techniques and programs to be implemented. Always work on the presumption that “no two pipelines are the same”.**

**Desktop Study** – Collate ALL available data. Categorise them into pipeline attributes data, operations and maintenance records, repair and retrofitting reports and more. Identify the gaps and agree on potential alternatives or the need for any additional inspection to fill the data gaps. This can and will be the most daunting task as getting accurate, reliable and meaningful data can be challenging.

**Risk Assessment** – Based on the above collected and agreed data set, carry out a risk assessment to identify all the potential threats, probability of failures and their consequences. Rank the pipeline sections according to their criticality.

**Indirect Condition Assessment** – Establish and carry out the appropriate non-invasive field proven inspection techniques to determine the prevailing condition of the pipeline section.

**Direct Condition Assessment** – This will include in-pipe inspections techniques to yield detailed pipeline anomalies to determine their fitness-for-purpose and probable remaining life.

# Indirect Condition Assessment

Assessments based strictly on failure history, type of pipe, age, size, leak and break frequency, flow testing may lead to **SUB-OPTIMAL DECISIONS**. The following indirect condition assessment techniques are non-invasive, field proven and applicable to metal and reinforced concrete pipes.

## SOIL CORROSIVITY

Soil Resistivity  
Degree of Aeration

- Oxygen Levels
- Redox Potential

Chemical Constituents

- Chlorides, Carbonates,
- Sulfates Nitrates

Acidity / Alkalinity  
Moisture Content  
Soil Classification  
Particle Distribution  
Mechanical Properties

- Bulk Density
- Hydraulic Conductivity

## ULTRASONIC TESTING

Ultrasonic Testing measures the thickness of a material by sending sound waves through it and measuring how long it takes for the sound to return. It measures the metal loss caused by corrosion, erosion or any other damage.

## PIPE TO SOIL POTENTIAL

Pipe-to-Soil Potential is a measurement of the potential of a buried metallic pipeline at a specific location relative to a reference electrode in the soil. It indicates the effectiveness of the cathodic corrosion protection system and the prevailing corrosion status.

# Indirect Condition Assessment

## ELECTRICAL CONTINUITY SURVEY

The Electrical Continuity Survey for a buried pipeline refers to its ability to conduct electrical current along its entire length without interruption or significant resistance. This continuity is important for effective cathodic corrosion protection systems and corrosion monitoring.

## ELECTRICAL ISOLATION SURVEY

The Electrical Isolation Survey for a buried pipeline refers to the safe electrical isolation of the buried pipeline sections from other adjoining foreign structures. This isolation is important for effective cathodic corrosion protection systems and corrosion monitoring.

## CLOSE INTERVAL PIPE TO SOIL (CIPS) SURVEY

Close Interval Pipe-to-Soil (CIPS) Potential Survey is a measurement of the potential of a buried metallic pipeline at close intervals along the full length of the buried pipeline relative to a reference electrode in the soil. It indicates the total effectiveness of the cathodic corrosion protection system and the prevailing corrosion status.

# Indirect Condition Assessment

## **DIRECT CURRENT VOLTAGE GRADIENT (DCVG) SURVEY**

The Direct Current Voltage Gradient (DCVG) Survey is an aboveground inspection technique to determine the prevailing status of the effectiveness of the external coating systems on the buried pipeline. It is intended to identify all coating anomalies.

## **ALTERNATING CURRENT VOLTAGE GRADIENT (ACVG) SURVEY**

The Alternating Current Voltage Gradient (ACVG) Survey measures the leakage current in the vicinity of the pipeline to assess the effectiveness of the external coating systems on the buried pipeline. It is intended to identify coating anomalies.

## **CURRENT ATTENUATION TESTING (CAT) SURVEY**

The Current Attenuation Testing (CAT) Survey measures the attenuation of the transmitted 4Hz signal to establish the pattern of current loss along the buried pipeline to establish the external coating condition, locating faults and shorts caused by contact with other metallic objects.

# Direct Condition Assessment

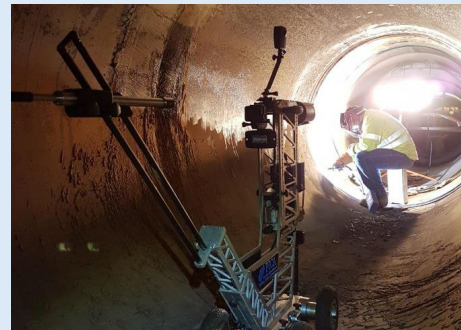
## ACOUSTIC SPHERE INSPECTION

In Line Inspection using  
Multi-Sensor Acoustic  
Sphere Technologies  
Acoustic, Accelerometer,  
Magnetometer, Pressure  
Sensors



## CLOSE CIRCUIT TELEVISION (CCTV) INSPECTION

In Line Inspection using  
CCTV, Laser & Lidar  
Technologies.



## NEAR FIELD EDDY CURRENT (NFT) INSPECTION

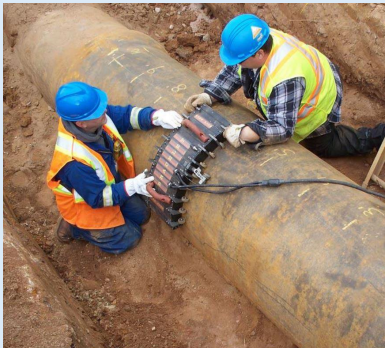
In Line Inspection using  
Near Field Eddy Current  
Electromagnetic Testing  
(NFT) Technology



# Direct Condition Assessment

## INTERMEDIATE NDT INSPECTION

Handheld using Pitch-Catch/Low Frequency Eddy Current & Ultrasonic Electromagnetic, Bracelet Probe CUI Inspection



## ADVANCE NDT INSPECTION

In Line Inspection using Remote Field Eddy Current Electromagnetic Testing (RFT) Technology



## ADVANCE NDT INSPECTION OF PCCP

In Line Inspection can detect both broken wires and cylinder corrosion within PCCP



# Consequences of Water Pipeline Failures

The potential **CONSEQUENCES OF FAILURE** and **LOSS IN REVENUE** are the important factors in determining the level and effort that is invested into a pipeline integrity management program.

## DIRECT COST

- Cost of Breakage Repair
- Cost of Water Lost
- Cost of Direct Damage to Property
- Cost of Liabilities Resulting from a Related Accident

## INDIRECT COST

- Loss of Production in a Plant
- Accelerated Deterioration of nearby Utilities
- Loss due to Fire that could not be effectively extinguished or diminished hydraulic capacity

## SOCIAL COST

- Adverse effects due to intrusion of contaminants
- Increased likelihood of backflow
- Intrusion of debris through broken pipe
- Cost due to service disruption to critical services

# Water Pipeline Retrofitting Technologies

Retrofitting technology selection for the **EXTERNAL PIPELINE SURFACE** is usually customised to the prevailing condition of the pipeline. Here are some common methods:

## **EXTERNAL PROTECTIVE COATINGS**

External surface cleaning followed by multi-layer protective coating applications or tape wrappings.

## **SACRIFICIAL ANODE CATHODIC PROTECTION**

Design and install sacrificial magnesium or zinc anode cathodic protection systems along buried pipeline.

## **IMPRESSED CURRENT CATHODIC PROTECTION**

Design and install impressed current anode cathodic protection systems along buried pipeline.

## **RIGHT OF WAY (ROW) PROTECTION**

Install ROW protection and monitoring systems from 3<sup>rd</sup> Party and environmental interferences.



# Water Pipeline Retrofitting Technologies

Retrofitting technology selection for the **INTERNAL PIPELINE SURFACE** is usually customised to the prevailing condition of the pipeline. Here are some common methods:

## **SPRAY APPLIED LINERS**

Mechanical surface cleaning followed by spray-applied Polyurethane, Polyurea, Epoxy, Polymeric liners.

## **CEMENT MORTAR LINING**

Mechanical surface cleaning followed by spray-applied cement mortar.

## **SPIRAL WOUND LINING**

Strips of PVC are spun inside an existing pipe to form a new pipe within the old pipe

## **PIPE BURSTING**

Existing pipe can be upsized with new pipe installation.

# Water Pipeline Integrity Management System

## Plan Development

- Corporate Mission Statement
- Identification of Threats
- Data Gathering and Integration
- Developing Baseline Integrity Assessment Plan
- Perform Inspection and/or Mitigation

## Program Evaluation

- Evaluate the program annually
- Were the program objectives accomplished?
- Have pipeline integrity, safety and reliability improved?

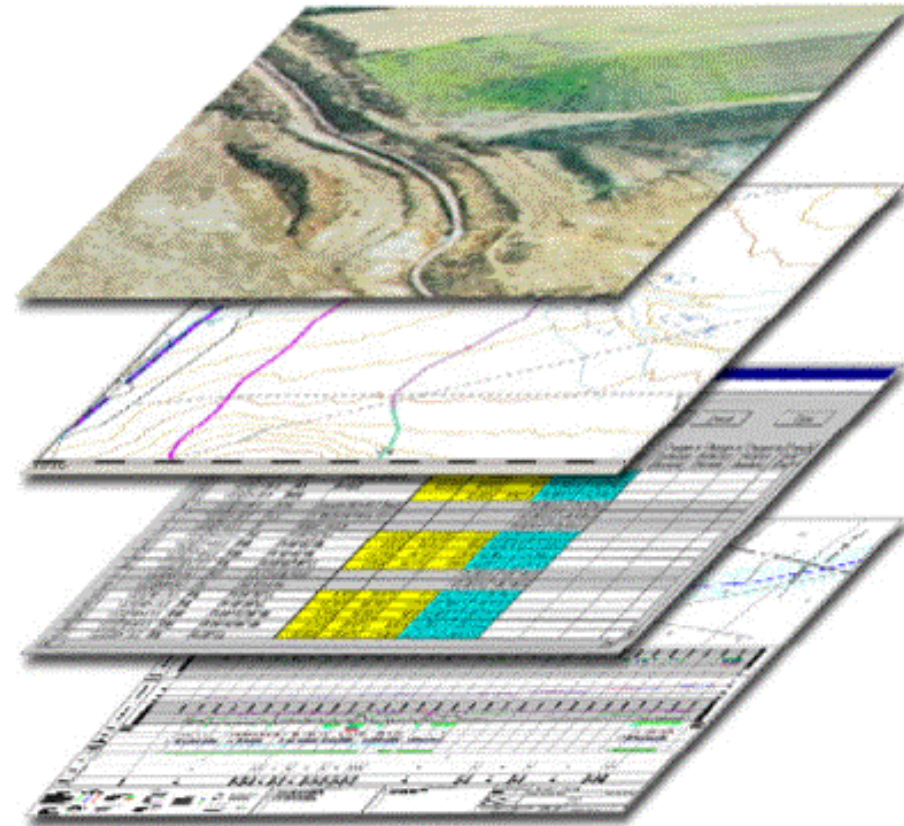
## Performance Measures

- Process or Activity measures
- Operational measures
- Direct Integrity measures

# Pipeline Integrity Data Management

**Pipeline Integrity Management is a data intensive program. Managing the enormous amount data can be challenging.**

**A Geographic Information System (GIS) is probably the preferred tool for storing, managing and analysing these vast quantum of data**



# Why Do You Require Pipeline Integrity Management?

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## WHY?

- 1. REDUCE NON-REVENUE WATER (NRW) REAL LOSSES**
- 2. PROACTIVE PREVENTION OF PIPELINE FAILURES**
- 3. LEAK PREVENTION SHOULD BE THE PRIMARY OBJECTIVE**
- 4. PRIORITISING PIPELINE RENEWAL WORKS**
- 5. SOUND ENGINEERING DECISIONS FOR BETTER ALLOCATION OF LIMITED RESOURCES**
- 6. IMPROVED APPRECIATION OF PIPELINE DETERIORATION AND FAILURE PROCESS**
- 7. LEAK IS NOT AN OPTION**

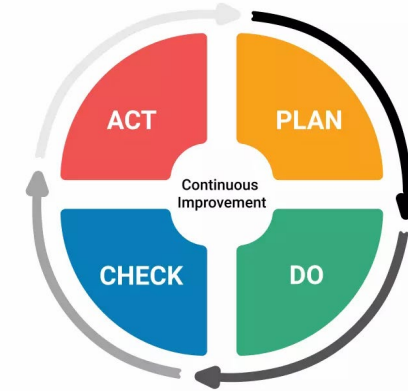
# Water Pipeline Integrity Data Management Program

## About Us

We are Pipeline Integrity, a Specialist Technical Consulting firm within the GreenScience Group of Companies. We provide innovative, state-of-the-art Asset Integrity Management Engineering Solutions throughout an asset life cycle, from concept to decommissioning, in compliance with international codes, standards and the latest industry best practices.

Established more than 3 decades ago, our greatest assets are our Scientists, Engineers and Technologies, whose diversity, unparalleled experience and global expertise, are second to none.

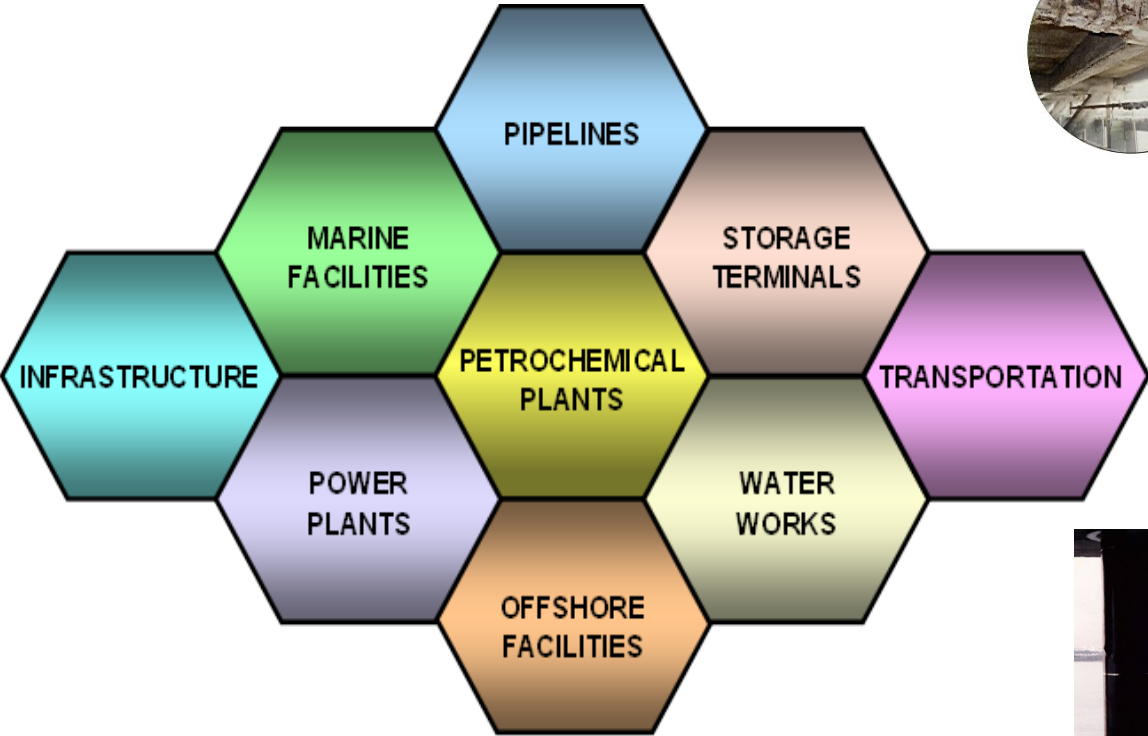
We partner regulators, owners, operators and consultants to develop client specific Responsive, Innovative, Quality, Cost-Effective and Sustainable Integrated Asset Integrity Management Programs.



- CONSULTING
- DATA ANALYTICS
- TRAINING
- JIP R&D
- PIM365.COM

# Water Pipeline Integrity Data Management Program

## Industries We Serve



**We thank you for this opportunity to present our expertise and capabilities and look forward to receiving your valuable enquiries and input.**

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