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Ductile Iron Pipe
Research Association

THE ABC OF CORROSION CONTROL ON CAST/DUCTILE IRON PIPE

PRESENTED BY: SAM GHOSN, P.Eng
REGIONAL DIRECTOR, CANADA

Strength and **Durability** for **LiFe**®

PRESENTATION OUTLINE

- Introductions: *“Long History of Iron Pipe”*
- Dealing with the facts –*“Nothing Destroys Iron but its Own Corrosion “*
- Defining *Galvanic Corrosion*
- Asset Management Strategies: *“Standing the Test of Time “*
- Decision Making for Existing Pipelines- Repair, Rehab, or Replace?
- Evaluation for new Construction
    - Risk management
    - Selection of corrosion control Method
- Conclusions

OLDEST CAST IRON PIPE IN SERVICE

King Louis XIV Palace of Versailles, France – 1664
15 miles of Cast Iron Pipe Survived the Palace of Versailles, France for +330 years since 1664

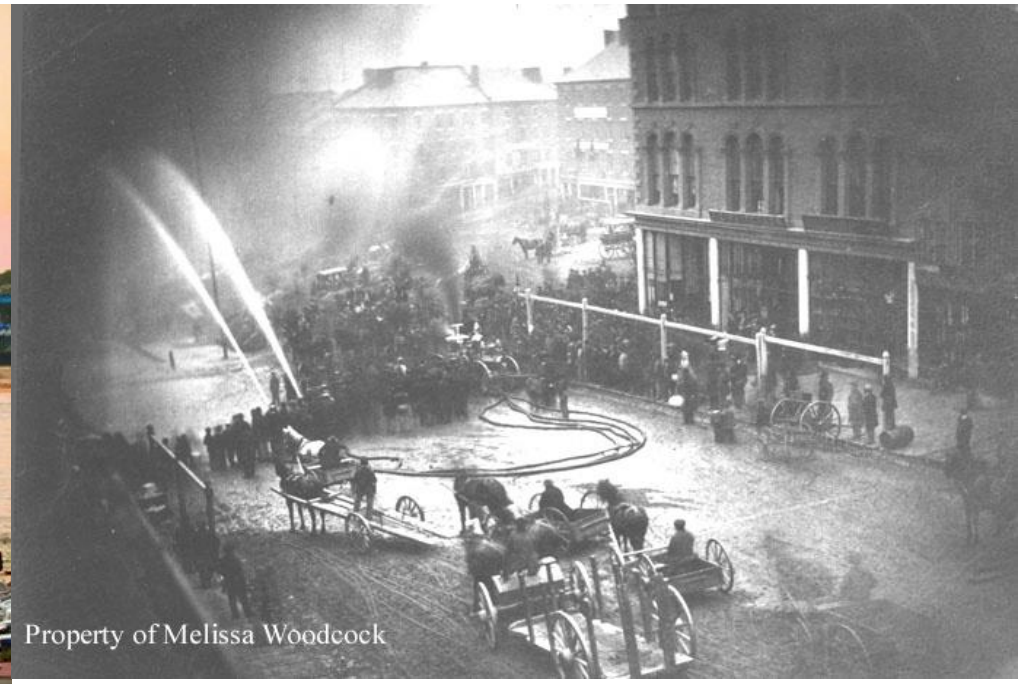
DIPRA CENTURY CLUB MEMBERS

Today, over **500 utilities** in USA and Canada still benefit from Iron Pipes in service for more than 100 years, and **30 utilities** with iron pipes still in service for over 150 years.

CITY OF SAINT JOHN, NEW BRUNSWICK

City of Saint John, New Brunswick : First Incorporated city in what became Canada in 1785

Today, the city of Saint John, NB, celebrates **165 years of continuous service of their Cast Iron water mains**



ISSUES WITH “PROBLEMATIC” IRON PIPES

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Cast Iron Pipe: 1820 – Today..

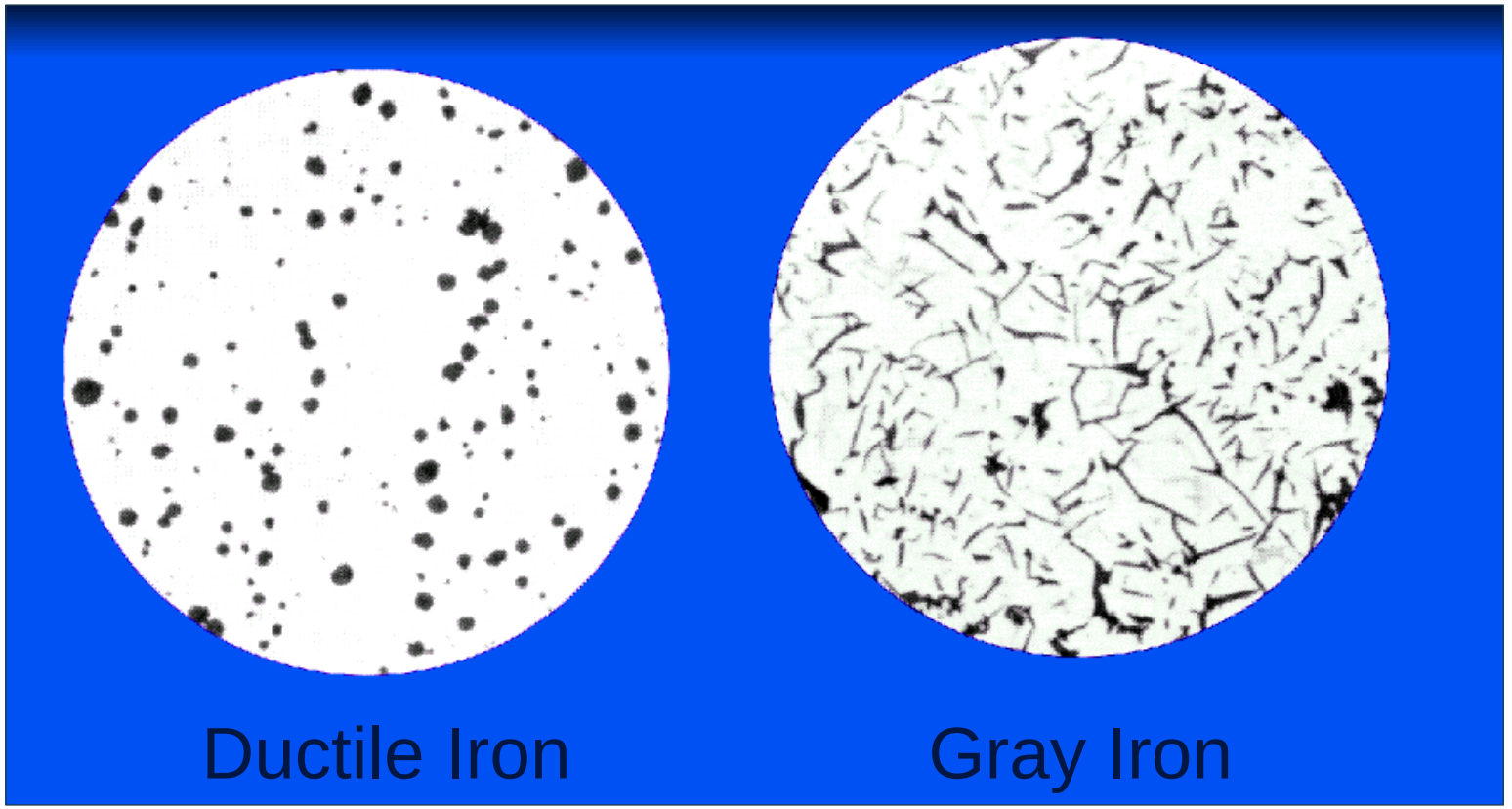
- Internal Corrosion: Tuberculation with Unlined Cast Iron Pipe
- External Corrosion: Galvanic Corrosion in Corrosive Soils
- Mechanical Failures: Barrel/Joint failures - Brittle mechanical properties

Ductile Iron Pipe: 1960’s – Today..

- External Corrosion: DIP galvanic corrosion in aggressive soils without corrosion control/protection

FROM CIP TO DIP– WHAT'S THE DIFFERENCE ?

- Iron:
  Molten at 2,500° F
- Magnesium:
  Vaporizes at 2,050° F



1960'- Today

1850's- 1960's

PIPE MATERIALS COMPARATIVE STRENGTH

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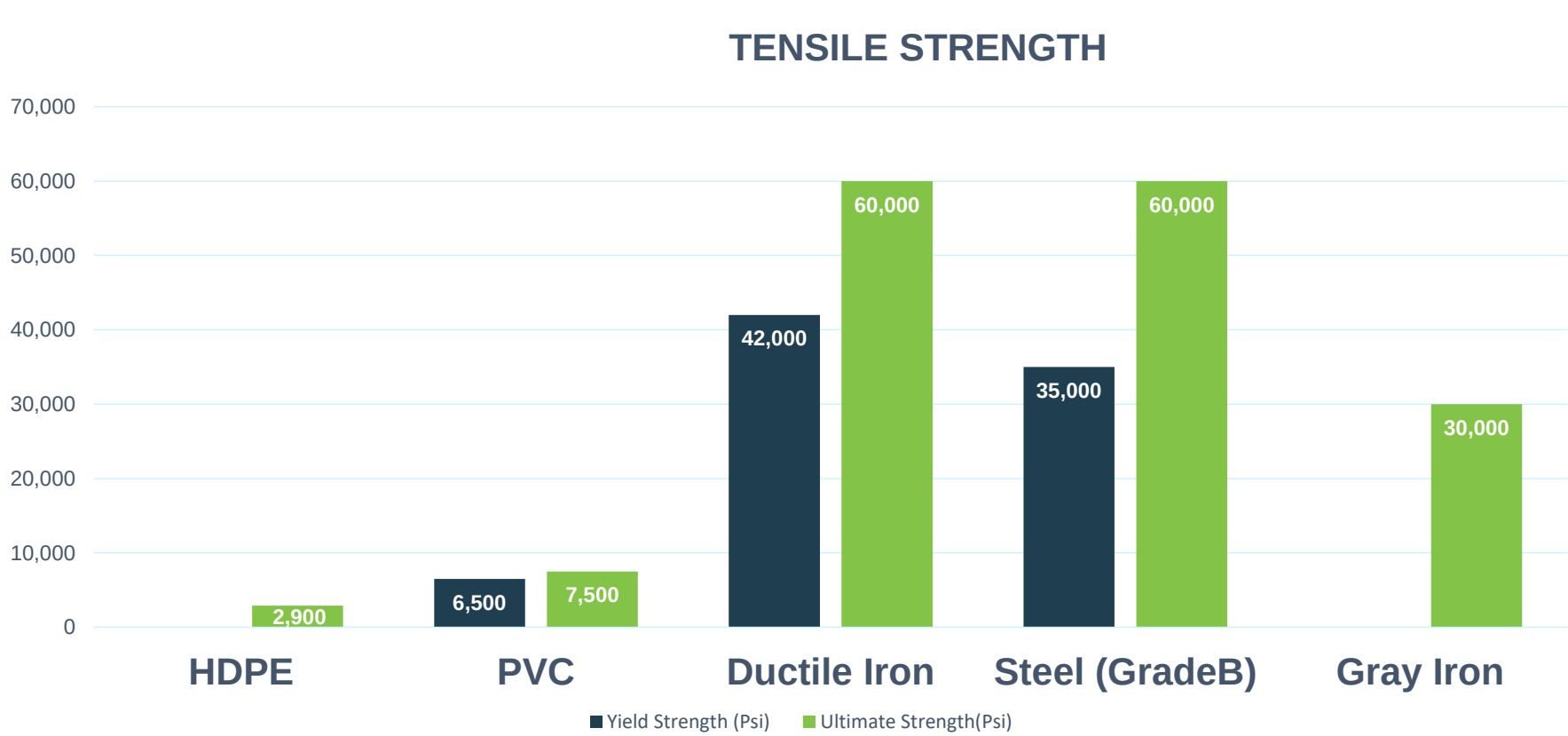
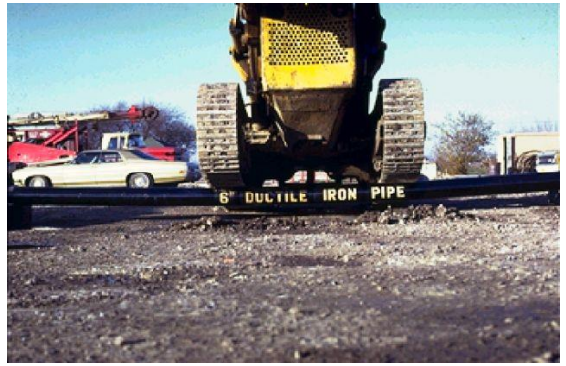
Pipe Mechanical Properties





CORROSION IS :

The deterioration of a material by reaction with its environment

INTERNAL CORROSION – UNLINED IRON PIPES

Historical Problem :

Internal Corrosion (Tuberculation) in Unlined Iron Pipe

Solution:

Cement lining
AWWA
C104 A21.4

Modern
Ductile Iron Pipe

WHEN A SOIL IS CORROSIVE

It will have an effect on …..

- Cast Iron Pipe
- Ductile Iron Pipe
- Steel Pipe
- Concrete Pressure Pipe
- All metallic appurtenances or accessories used with Plastic Pipes (PVC, HDPE)

ONE OF THE EARLIEST DIP INSTALLATIONS PRINCETON, KENTUCKY (1963 – 1964)

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Princeton, Kentucky – 16-Inch Ductile Iron Pipe
Installed: 1963 – 1964
Inspected: 1998 (2003) (2013)

Resistivity: 3,600 – 7,600 ohm-cm

CORROSIVE ENVIRONMENTS

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Common causes:

- Low-resistivity soils
- Anaerobic bacteria
- Dissimilar metals
- Differences in soil composition
- Differential aeration of the soil around the pipe
- Stray current from external sources

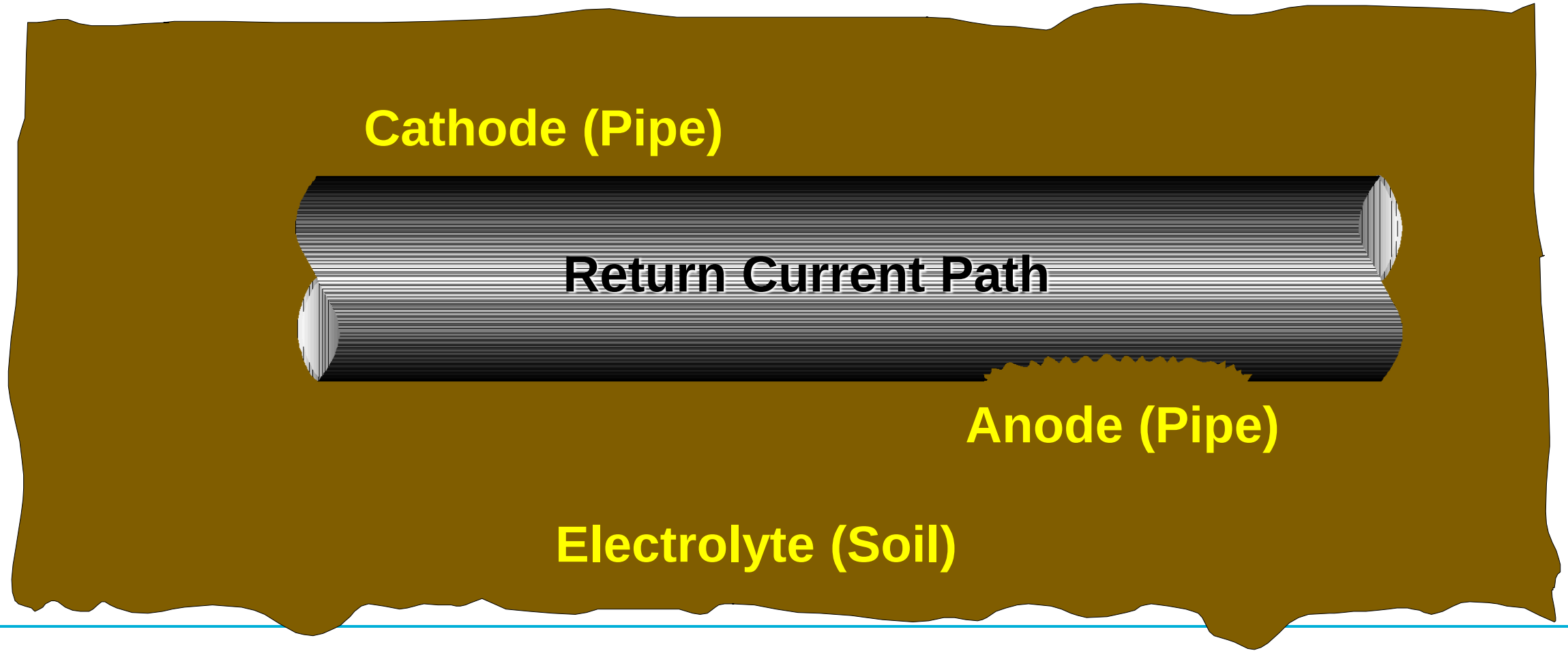
GALVANIC CORROSION

Basic Corrosion Cell Elements

- Anode
- Cathode
- Return Current Path
- Electrolyte

If one of these elements is missing, corrosion will NOT occur.

THE UNDERGROUND PIPE CORROSION CELL…



OHM'S LAW – ELECTRIC CURRENT

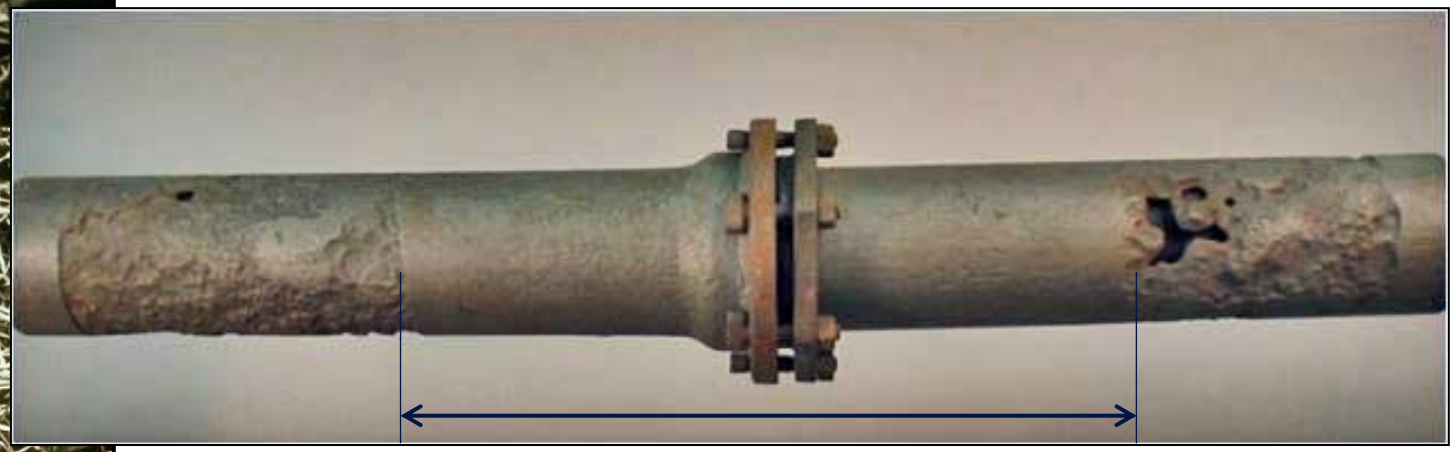
The magnitude of the current is directly proportional to the driving potential and inversely proportional to the circuit resistance.

$$I = \frac{E}{R}$$

$$\text{Current} = \frac{\text{Driving Potential}}{\text{Circuit Resistance}}$$

EVERGLADES TEST SITE – BOLTS STUDY – CIP

Everglades City, FL - 6” Gray Cast iron
18 years exposure

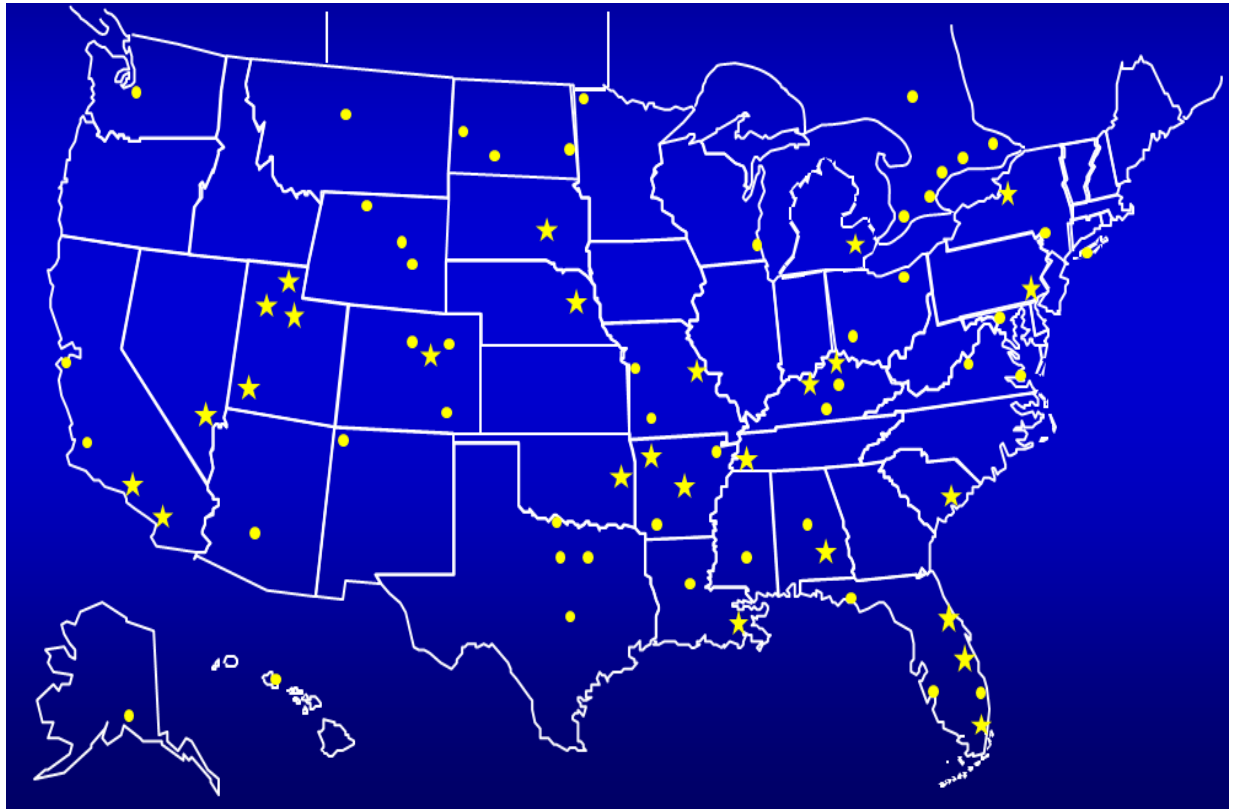


4-mil polyethylene encased

Resistivity:	**400 ohm-cm**
Redox:	**- 35 mV**
pH:	**7.1**
Sulfides:	**Positive**
Soil Moisture:	**Saturated**

SINCE 1951….

DIPRA has conducted **28** research projects and examined over ***1,600*** specimens of pipe related to ***Polyethylene Encasement***



Polyethylene Investigations Across USA

POLYETHYLENE ENCASEMENT - HISTORY OF DEVELOPMENT

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ANSI/AWWA C105/A21.5-18
(Revision of ANSI/AWWA C105/A21.5-10)

American Water Works Association
Dedicated to the World's Most Important Resource®

AWWA Standard

Polyethylene Encasement for Ductile-Iron Pipe Systems

ONLY FOR DUCTILE IRON PIPE ? NO… ALL METALLIC UNDERGROUND APPURTENANCES

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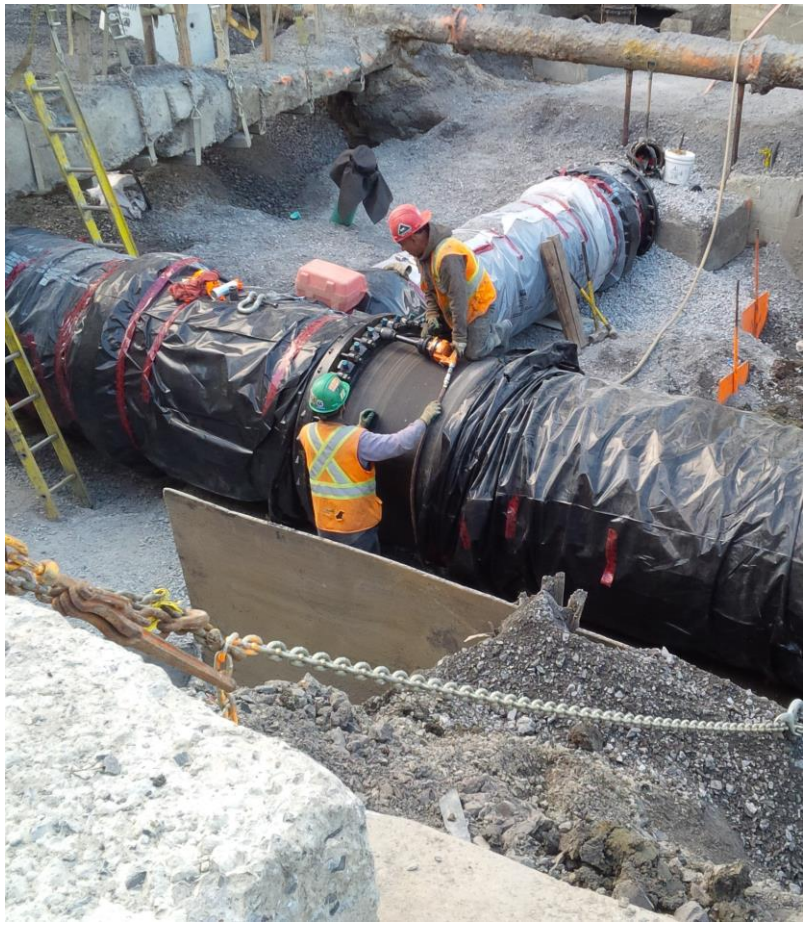
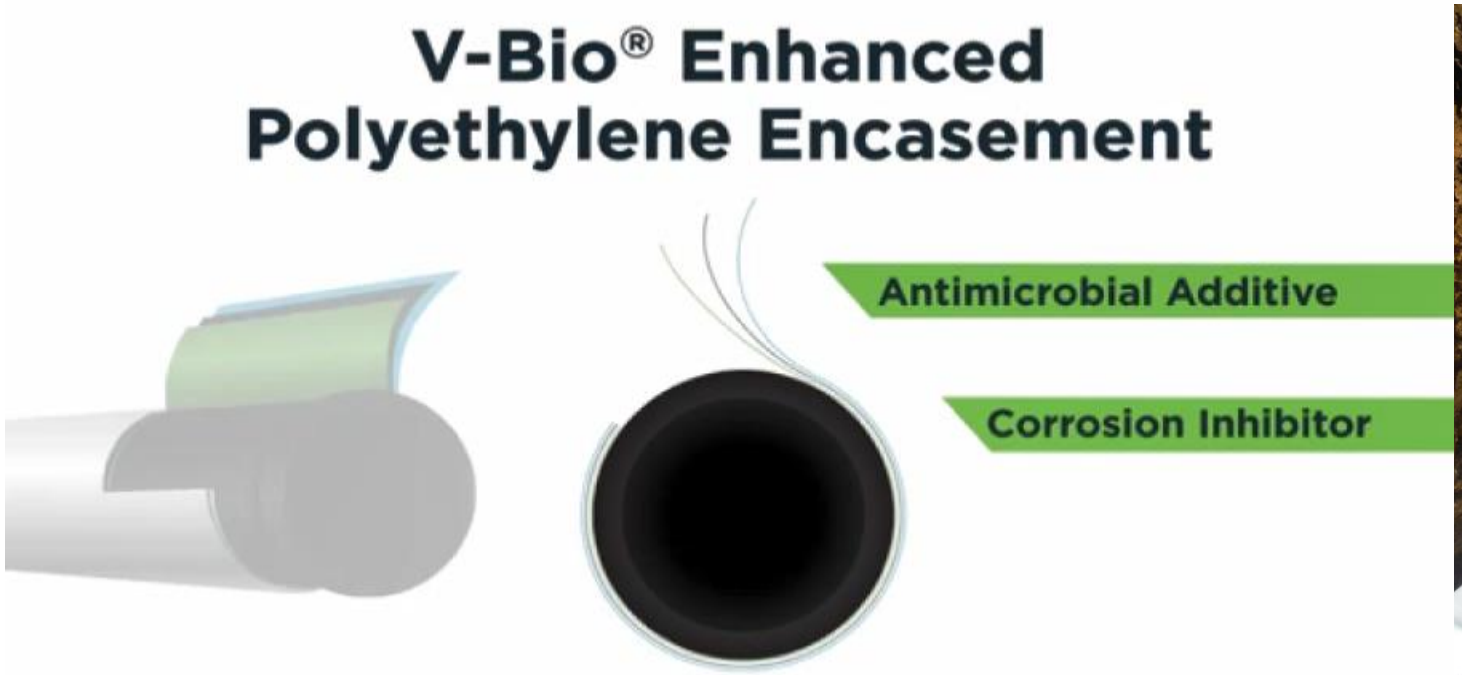


IN 2013, DIPRA INTRODUCED V-BIO® ENHANCED POLYETHYLENE ENCASEMENT V-BIO®



ENHANCED CORROSION CONTROL USING ZINC COATING

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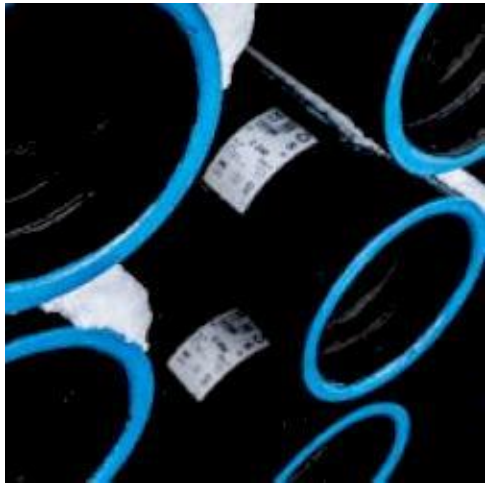
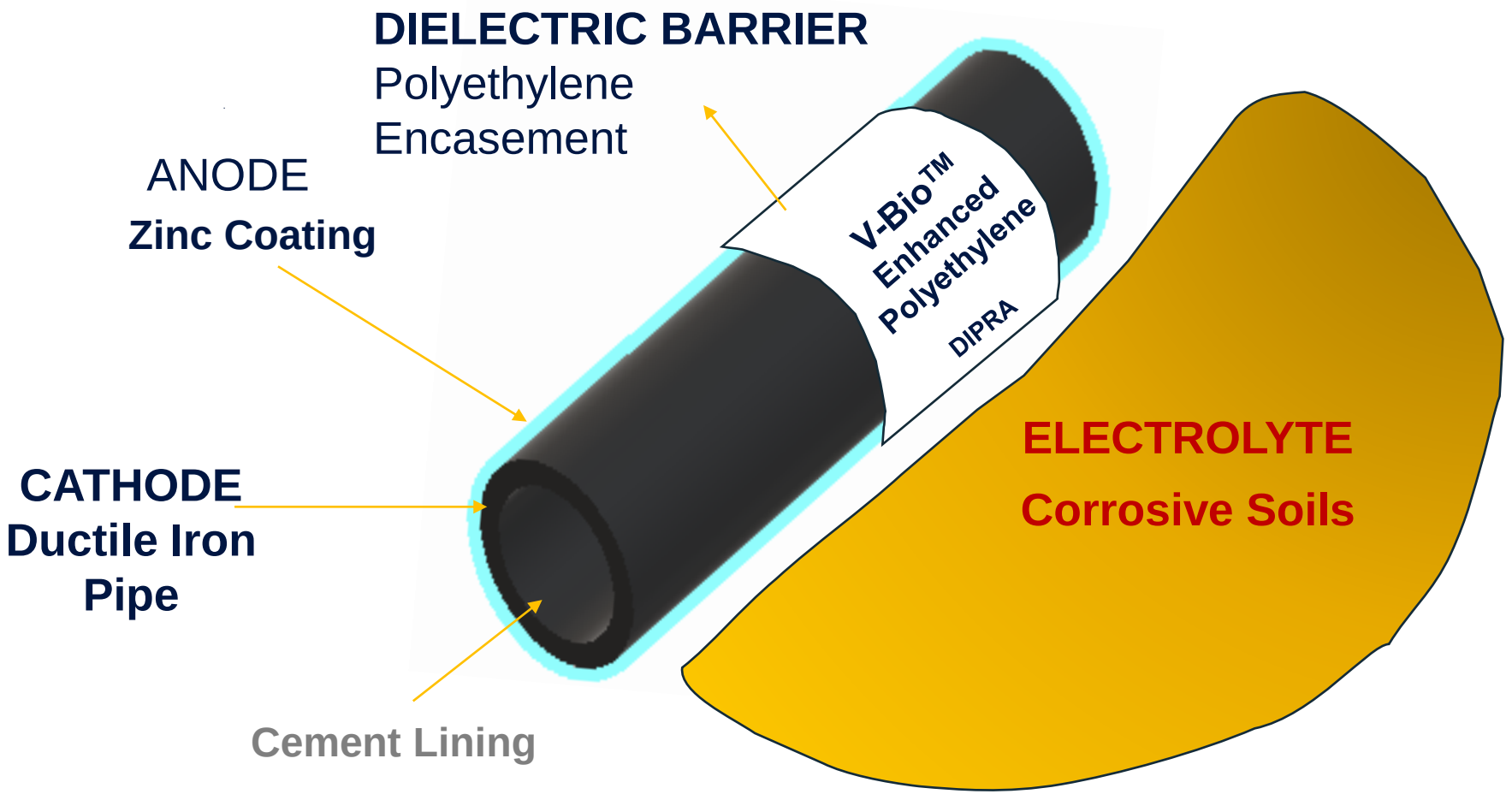


Bell Ring Markings Zinc Coating Blue or Silver

ENHANCED CORROSION CONTROL USING ZINC COATING



SOIL CORROSIVITY SURVEYS

- RESISTIVITY
- CHLORIDES
- MOISTURE
- GROUND WATER
- PH
- SULFIDE
- REDOX POTENTIAL
- BI-METALLIC

DIG-UP INVESTIGATIONS, HIGH CORROSIVE ENVIRONMENTS

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4-Inch
Cast Iron Pipe

Installed in Lafourche Parish, Louisiana

<u>Soil</u>
Resistivity: 320 ohm-cm
pH: 6.9
Redox: - 30 mV
Sulfides: Positive
Saturated

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DIG-UP INVESTIGATIONS, HIGH CORROSIVE ENVIRONMENTS

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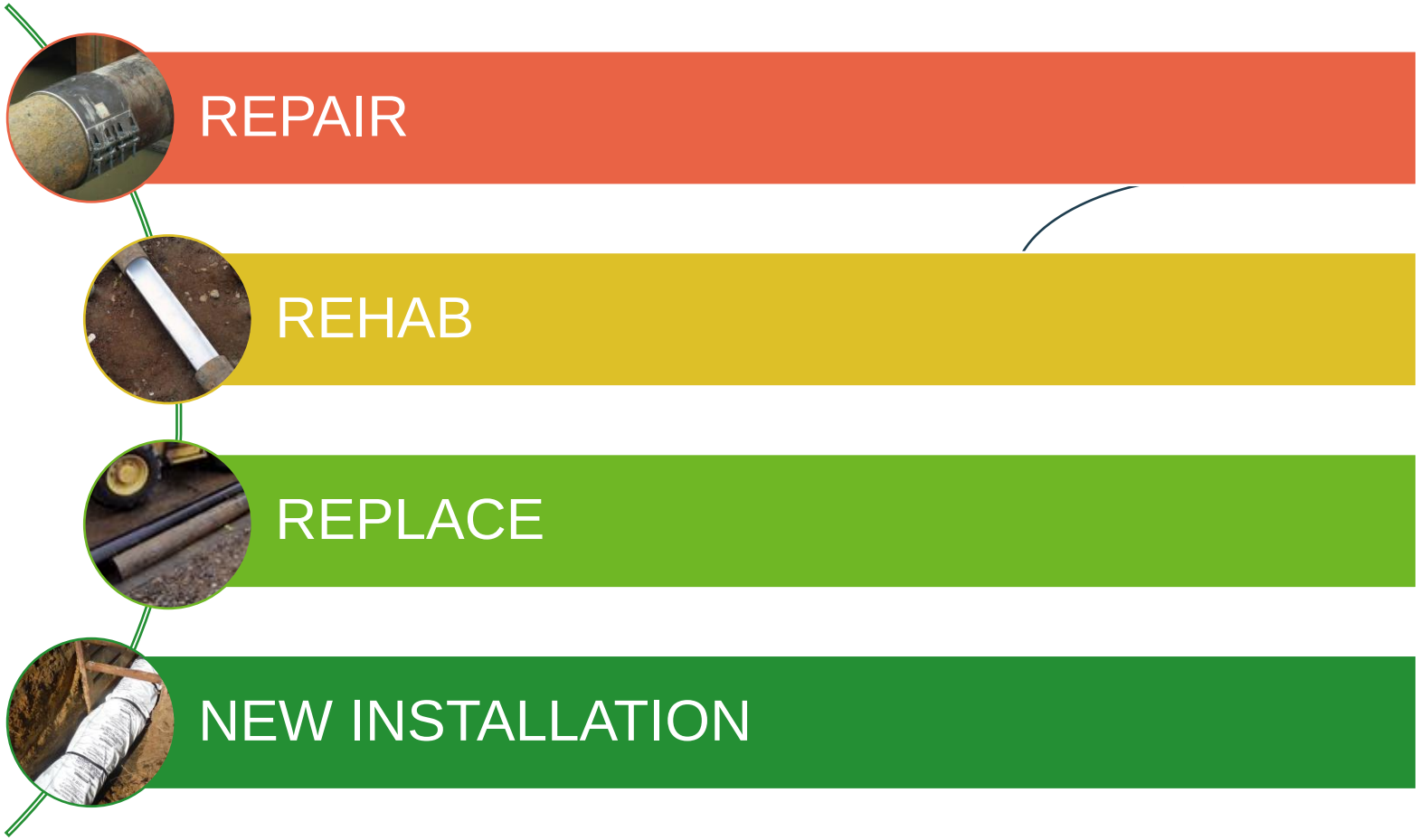
DECISION MAKING :



DECISION MAKING: REPAIR

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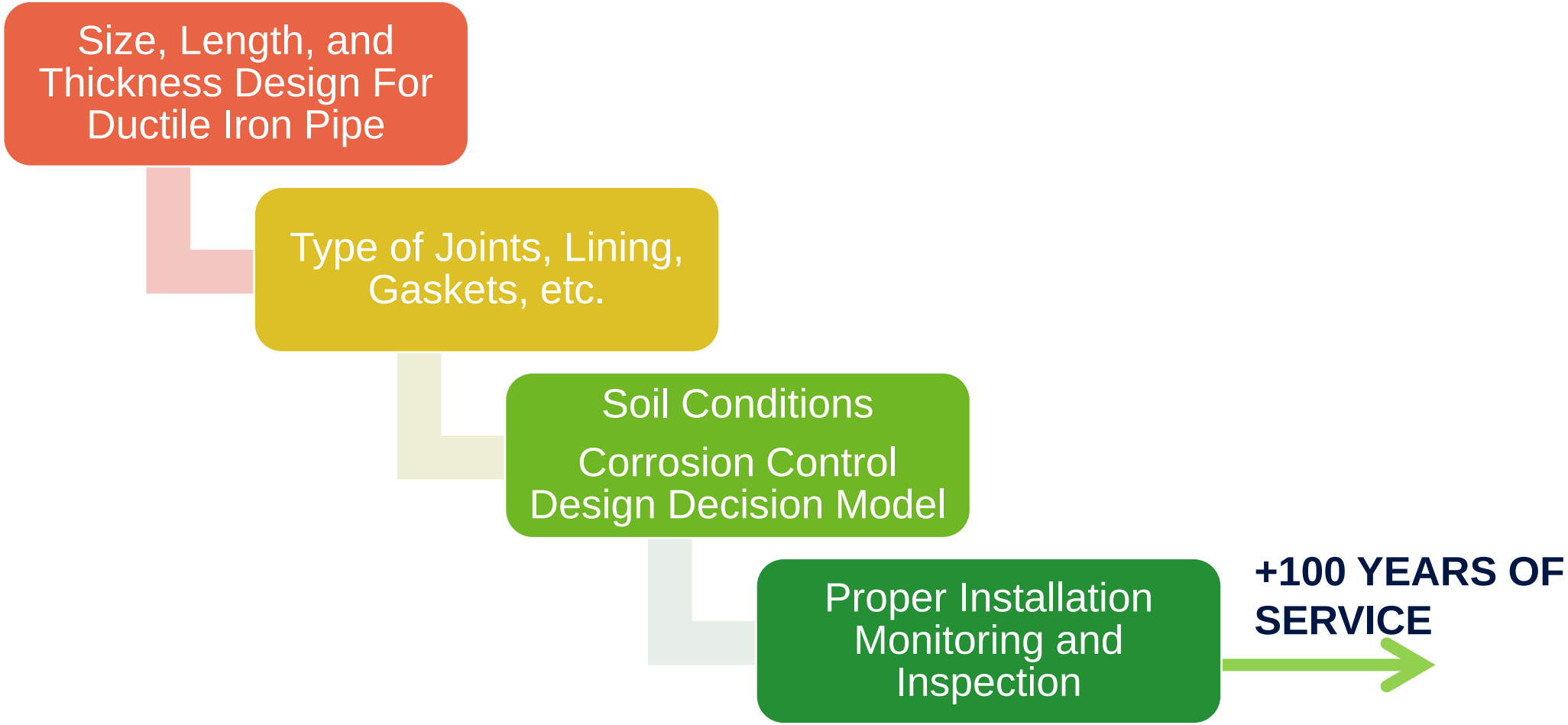
Leak Repair Clamps

Galvanic Anodes

NEW INSTALLATION – DESIGN CONSIDERATIONS



INTERNAL PROTECTION WITH CEMENT MORTAR LINER FOR DUCTILE IRON PIPE

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STANDARD : **AWWA C104 CEMENT-MORTAR LINING FOR DUCTILE-IRON PIPE**
AWWA C602 CEMENT-MORTAR FOR WATER PIPELINES IN PLACE

Lining Thickness Dependant on Pipe Size

1/16-Inch for 3 to 12”

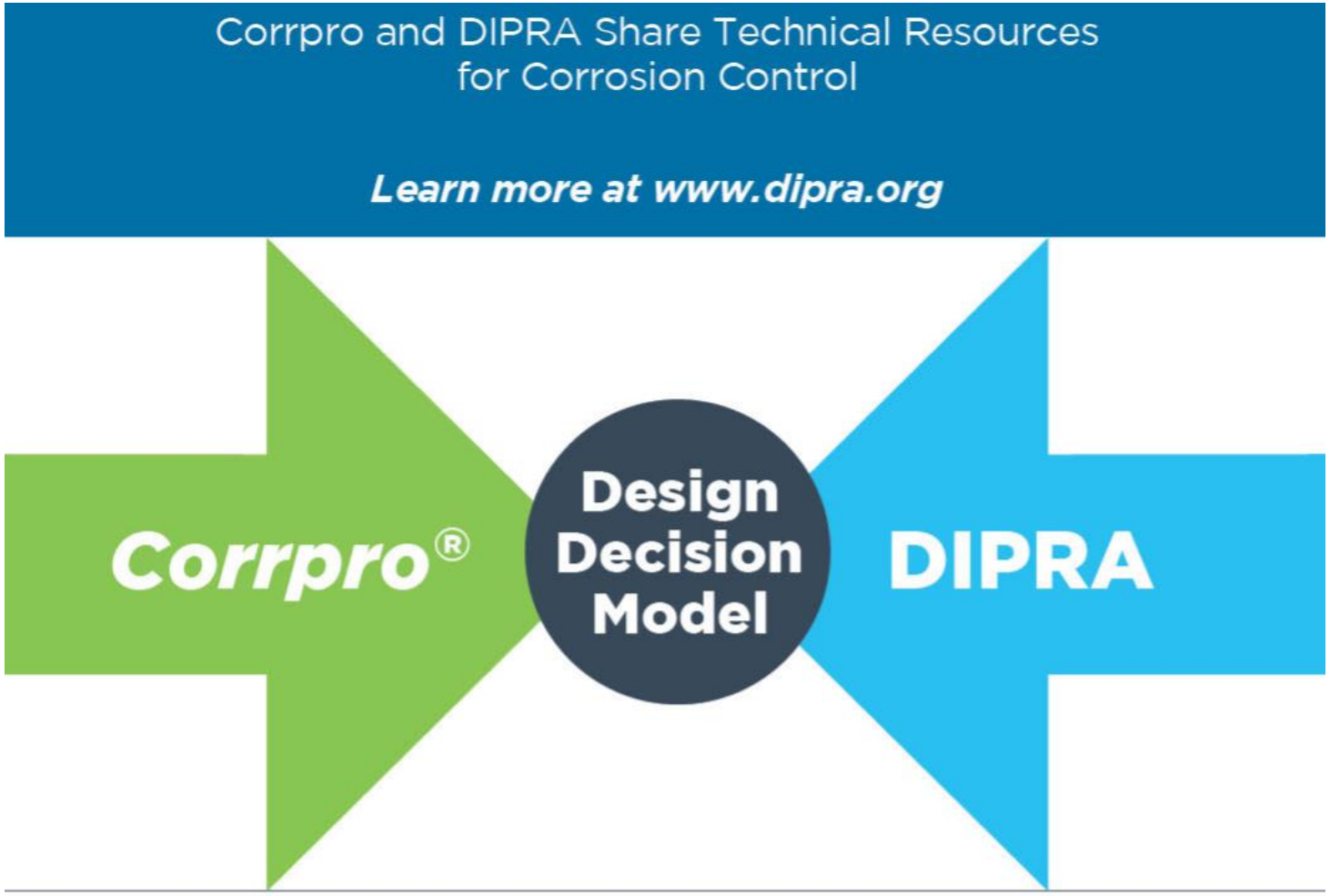
3/32-Inch for 14 to 24”

1/8-Inch for 30 to 64”

DUCTILE IRON PIPE LININGS SELECTION

Description	Max. Service Temp. (°F)	Common Uses
Portland Cement Mortar **with Sealcoat** **without Sealcoat**	**150°** **212°**	**Drinking Water** **Sea Water** **Non-Septic Gravity Sewers** **Sanitary Sewer Force Mains**
Petroleum Asphalt Coating	150°	Air
Fusion-Bonded Epoxy (For fittings only)	120° - 150°	Drinking Water Non-Septic Gravity Sewers Sanitary Sewer Force Mains
Protecto 401™ **Ceramic Quartz Filled** **Amine Cured Novalac Epoxy (1)**	**120° - 150°**	**Septic Sewers** **Acids** **Alkali Waste** **Pickling Brine**

DECISION MAKING : NEW INSTALLATION
DESIGN DECISION MODEL – DDM®



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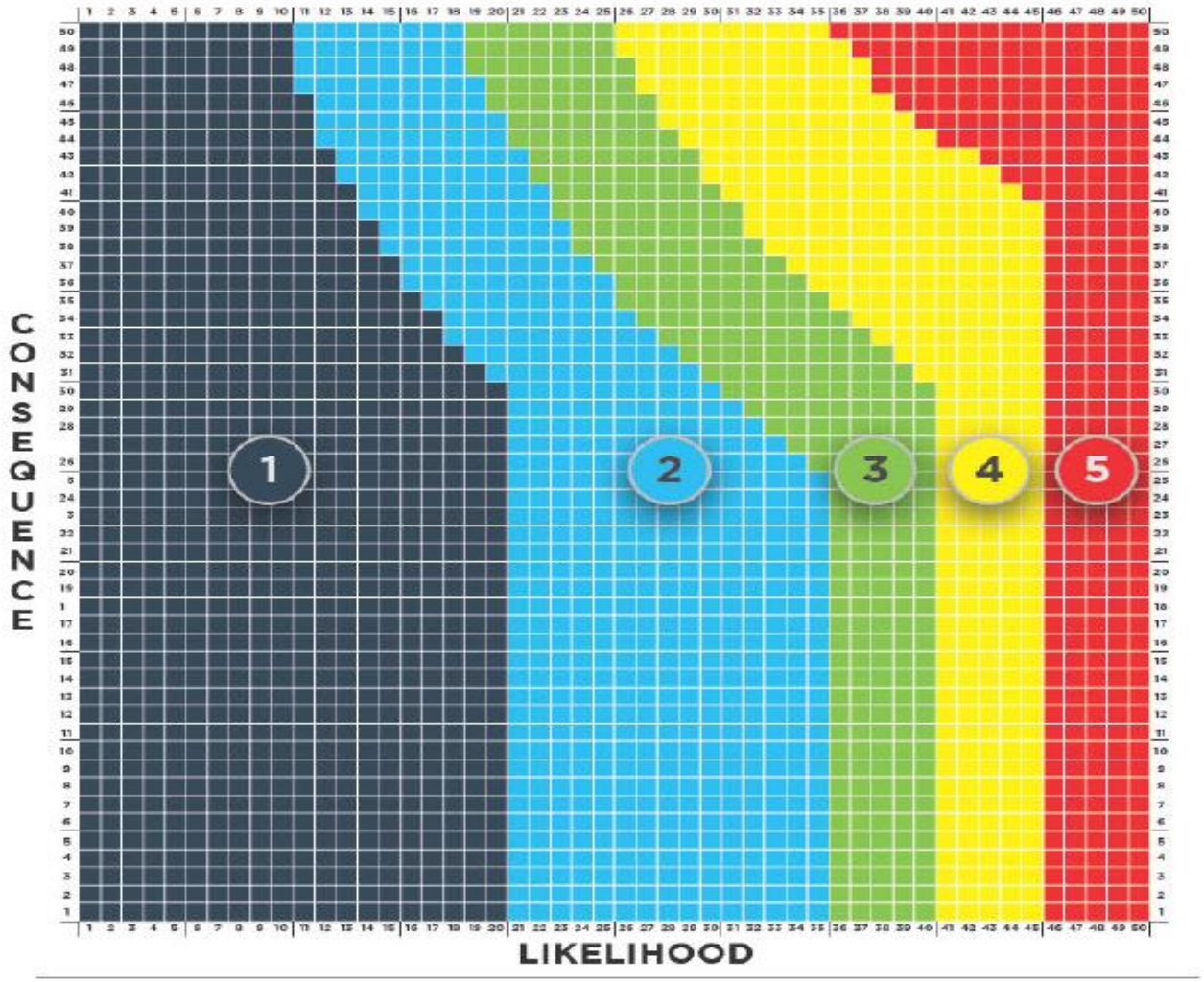
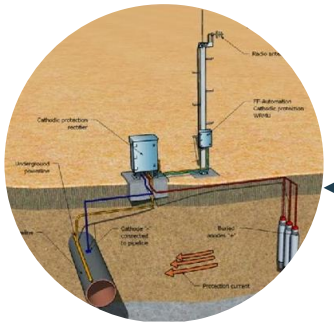


DECISION MAKING:
CORROSION CONTROL SELECTION – DDM®



Recommendations	
1	As Manufactured with Shop Coat
2	V-Bio® Enhanced Polyethylene Encasement
3	V-Bio® Enhanced Polyethylene Encasement, or V-Bio® Enhanced Polyethylene Encasement with Joint Bonds
4	V-Bio® Enhanced Polyethylene Encasement with Metallized Zinc Coating, or V-Bio® Enhanced Polyethylene Encasement with Life Extension Cathodic Protection
5	V-Bio® Enhanced Polyethylene Encasement with Metallized Zinc Coating, or V-Bio® Enhanced Polyethylene Encasement with Cathodic Protection

DECISION MAKING : NEW INSTALLATION
SOIL INVESTIGATION – LIKELIHOOD OF CORROSION

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- RESISTIVITY
- CHLORIDES
- MOISTURE
- GROUND WATER
- PH
- SULFIDE
- REDOX POTENTIAL
- BI-METALLIC

DECISION MAKING : NEW INSTALLATION
SOIL INVESTIGATION – LIKELIHOOD OF CORROSION

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LIKELIHOOD FACTOR		POINTS	MAXIMUM POSSIBLE POINTS
RESISTIVITY	< 500 ohm-cm	30	30
	≥ 500 - 1000 ohm-cm	25	
	> 1000 - 1500 ohm-cm	22	
	> 1500 - 2000 ohm-cm	19	
	> 2000 - 3000 ohm-cm	10	
	> 3000 - 5000 ohm-cm	5	
	> 5000 ohm-cm	0	
CHLORIDES	> 100 ppm = positive	8	8
	50 - 100 ppm = trace	3	
	< 50 ppm = negative	0	
MOISTURE CONTENT	> 15% = Wet	5	5
	5 - 15% = Moist	2.5	
	< 5% = Dry	0	
GROUND WATER INFLUENCE	Pipe below the water table at any time	5	5

LIKELIHOOD FACTOR		POINTS	MAXIMUM POSSIBLE POINTS
pH	pH 0 - 4	4	4
	pH > 4 - 6	1	
	pH 6 - 8, with sulfides and low or negative redox	4	
	pH > 6	0	
SULFIDE IONS	positive (≥1 ppm)	4	4
	trace (> 0 and < 1 ppm)	1.5	
	negative (0 ppm)	0	
REDOX POTENTIAL	= negative	2	2
	= positive 0 - 100 mv	1	
	= positive > 100 mv	0	
BI-METALLIC CONSIDERATIONS	Connected to noble metals (e.g. copper) - yes	2	2
	Connected to noble metals (e.g. copper) - no	0	

	TOTAL POSSIBLE POINTS	60
Known Corrosive Environments	Cinders, Mine Waste, Peat Bog, Landfill, Fly Ash, Coal	21

* Soils with Known Corrosive Environments shall be assigned 21 points or the total of points for Likelihood Factors, whichever is greater.

DECISION MAKING : NEW INSTALLATION
DESIGN DECISION MODEL – DDM®

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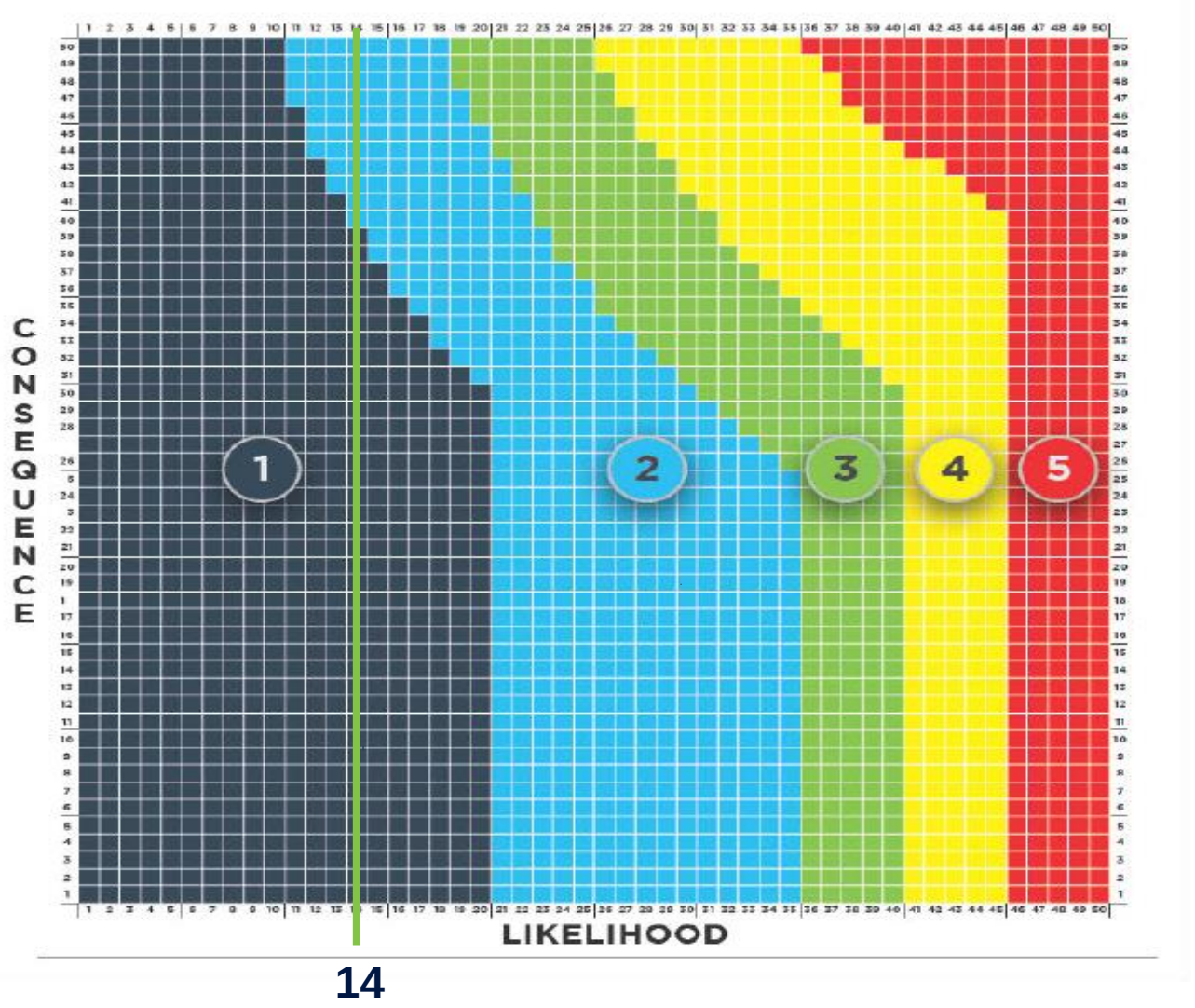

DECISION MAKING : NEW INSTALLATION RISK ASSESSMENT – CONSEQUENCES

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PIPE SIZE :
SMALL, MEDIUM LARGE DIAMETER

CONSTRUCTION – REPAIR CONSIDERATIONS
ROUTINE (Fair to good access, minimal traffic, other utility considerations, etc.)
MODERATE (Typical business, residential areas, some right of way limitations, etc.)
DIFFICULT (Subaqueous crossings, downtown metropolitan business area, multiple utilities congestions, etc.)

DEPTH OF COVER
SHALLLOW / DEEP BURRY ?

ALTERNATIVE WATER SUPPLY
YES / NO ?

DECISION MAKING : NEW INSTALLATION RISK ASSESSMENT – CONSEQUENCES

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CONSEQUENCE FACTOR		POINTS	MAXIMUM POSSIBLE POINTS
PIPE SERVICE	3" to 24"	0	22
	30" to 36"	8	
	42" to 48"	12	
	54" to 64"	22	
LOCATION: Construction-Repair Considerations	Routine (Fair to good access, minimal traffic/other utility consideration, etc.)	0	20
	Moderate (Typical business/ residential areas, some right of way limitations, etc.)	8	
	Difficult (Subaqueous crossings, downtown metropolitan business areas, multiple utilities congestion, swamps, etc.)	20	
DEPTH OF COVER CONSIDERATIONS	0 to 10 feet depth	0	5
	> 10 to 20 feet depth	3	
	> 20 feet depth	5	
ALTERNATE WATER SUPPLY	Alternate supply available - no	3	3
	Alternate supply available - yes	0	
	TOTAL POSSIBLE POINTS		**50**

DECISION MAKING : NEW INSTALLATION
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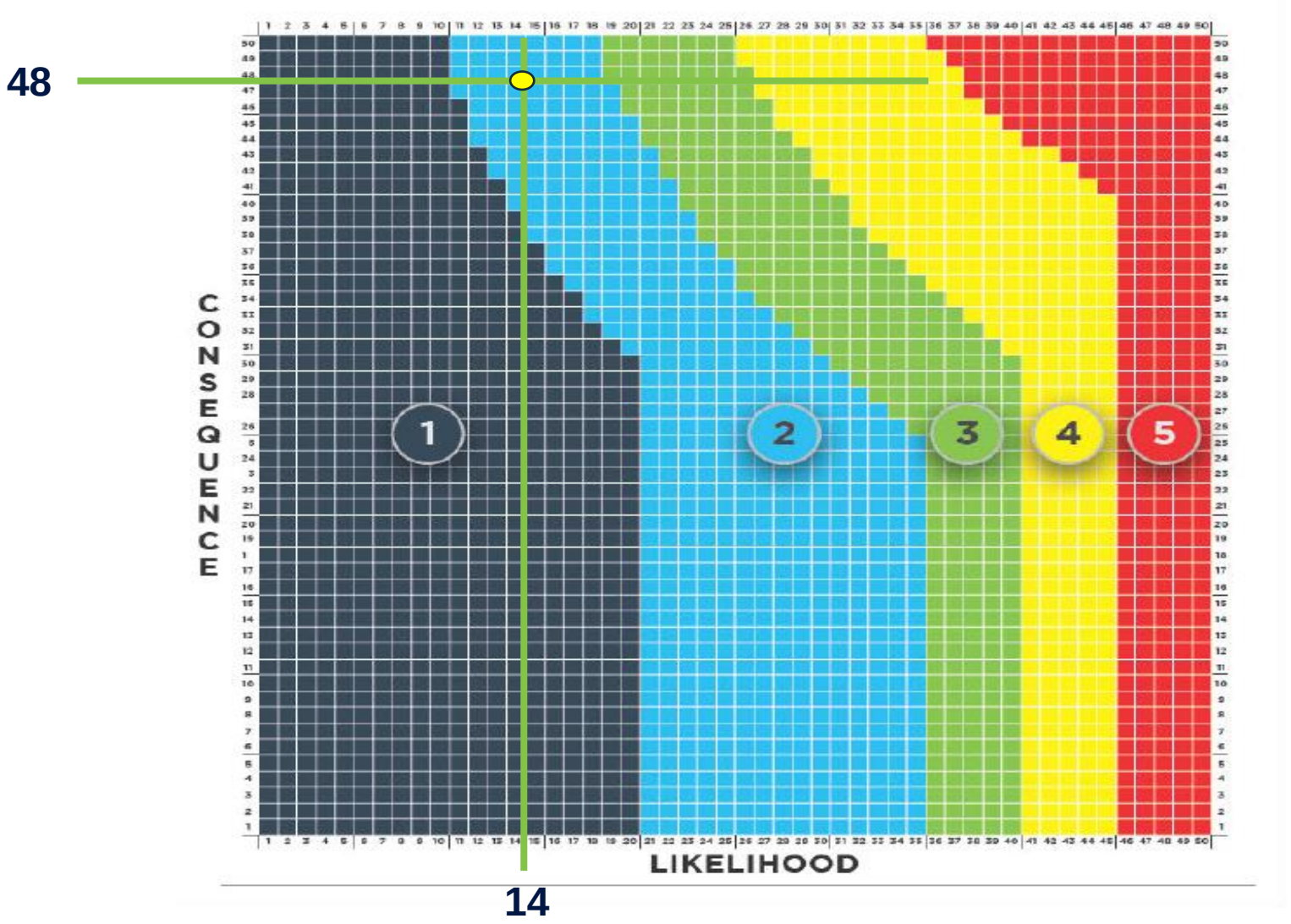

DECISION MAKING: NEW INSTALLATION - SELECTION OF CORROSION PROTECTION METHOD - DDM®

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Recommendations	
1	As Manufactured with Shop Coat
2	V-Bio® Enhanced Polyethylene Encasement
3	V-Bio® Enhanced Polyethylene Encasement, or V-Bio® Enhanced Polyethylene Encasement with Joint Bonds
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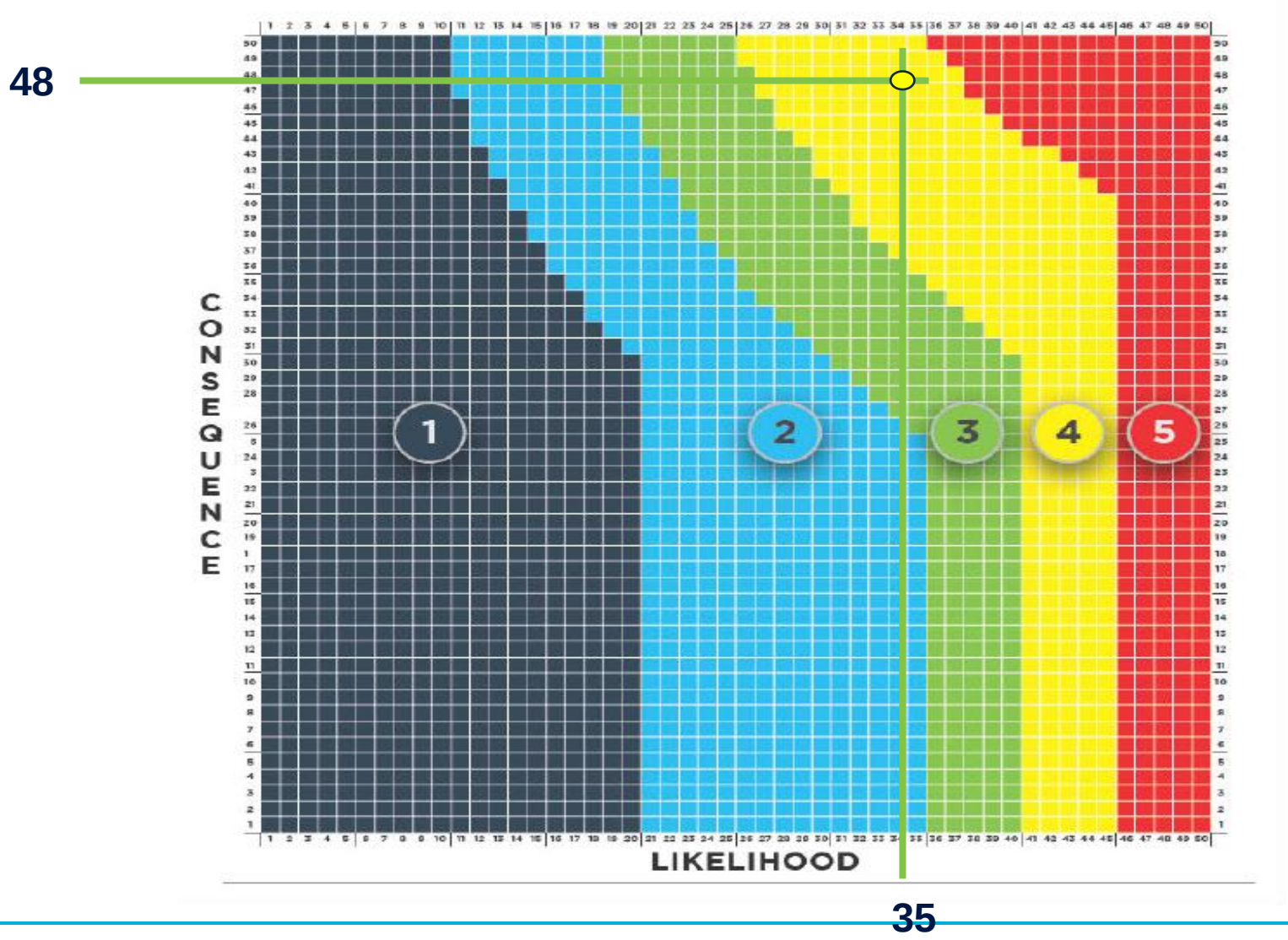

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THANK YOU!

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