

# Corrosion Control of Buried Piping



**Presented By:**

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**<http://www.corrpro.com>**

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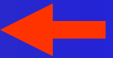


# Corrosion





# Temporary Fix ?



# Corrosion - A Natural Process

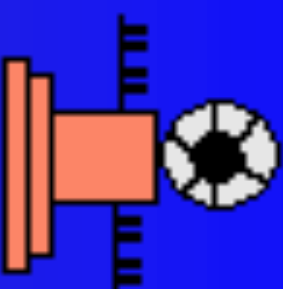


IRON OXIDE +



REFINING

+



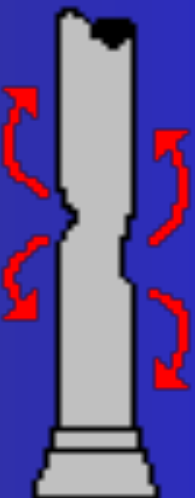
MILLING

=



IRON, STEEL, PCCP

+



CORROSION

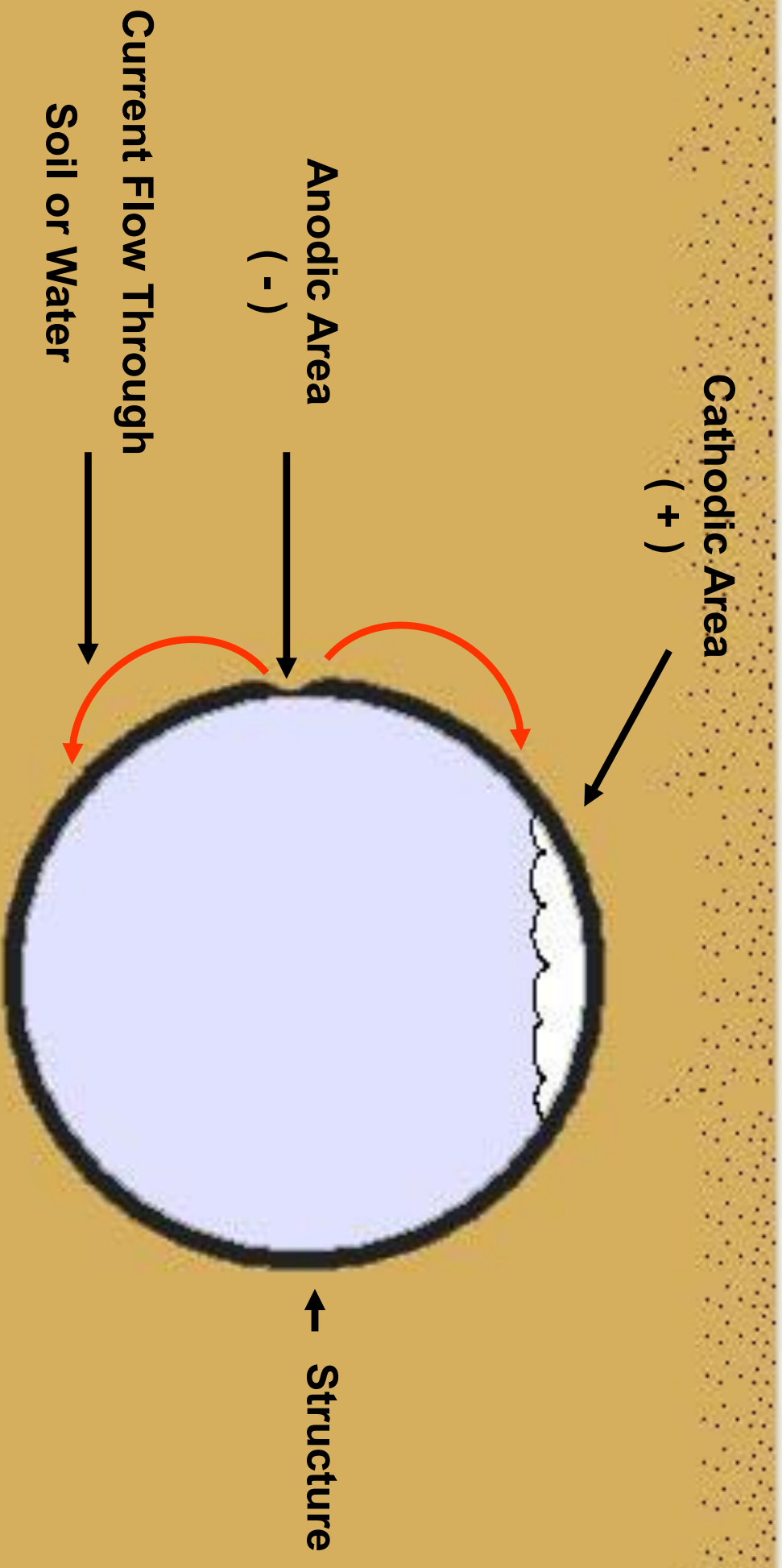
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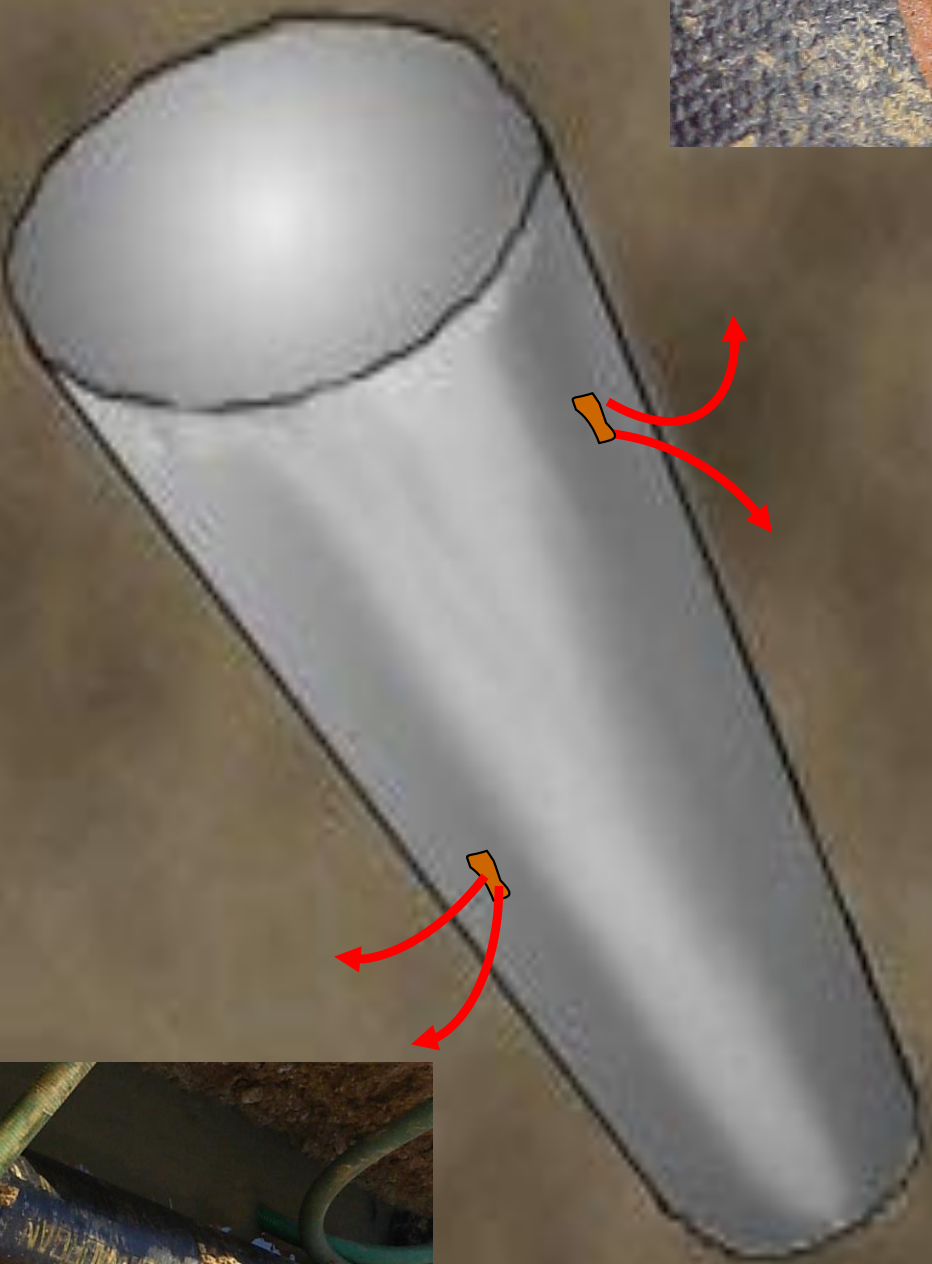
IRON OXIDE



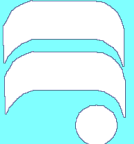
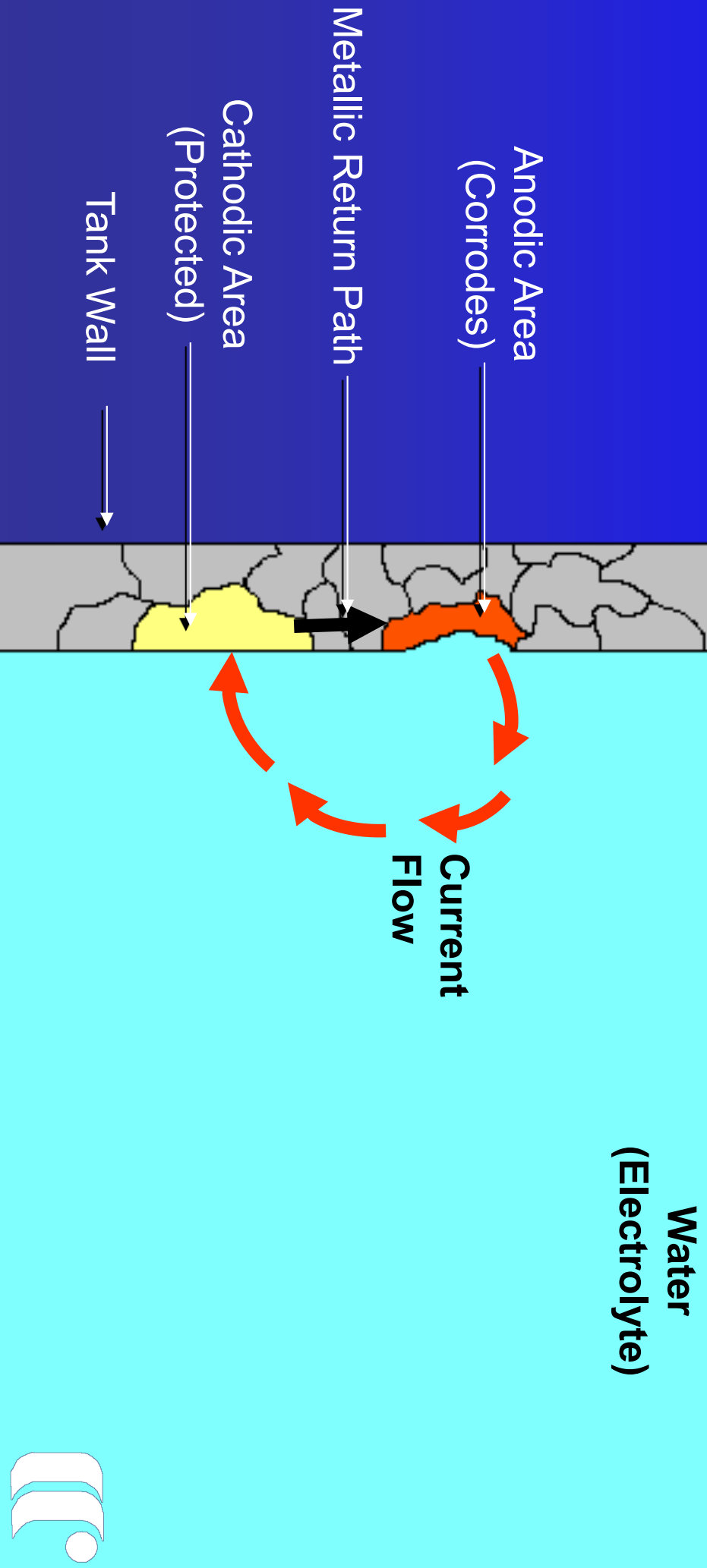
# Corrosion Cell on Buried Piping



# Corrosion of Metallic Structure











# History of Iron Pipe

## Cast Iron

- Introduced to North America during the 1800's and installed till the 1970's.
- Early on, statically cast process produced a thick walled, heavy pipe.
- No longer produced in North America.

## Ductile Iron

- Introduced in 1955 as an improvement to cast iron.
- Centrifugal casting process produces a thinner walled, lighter pipe which is stronger and more ductile than cast iron.



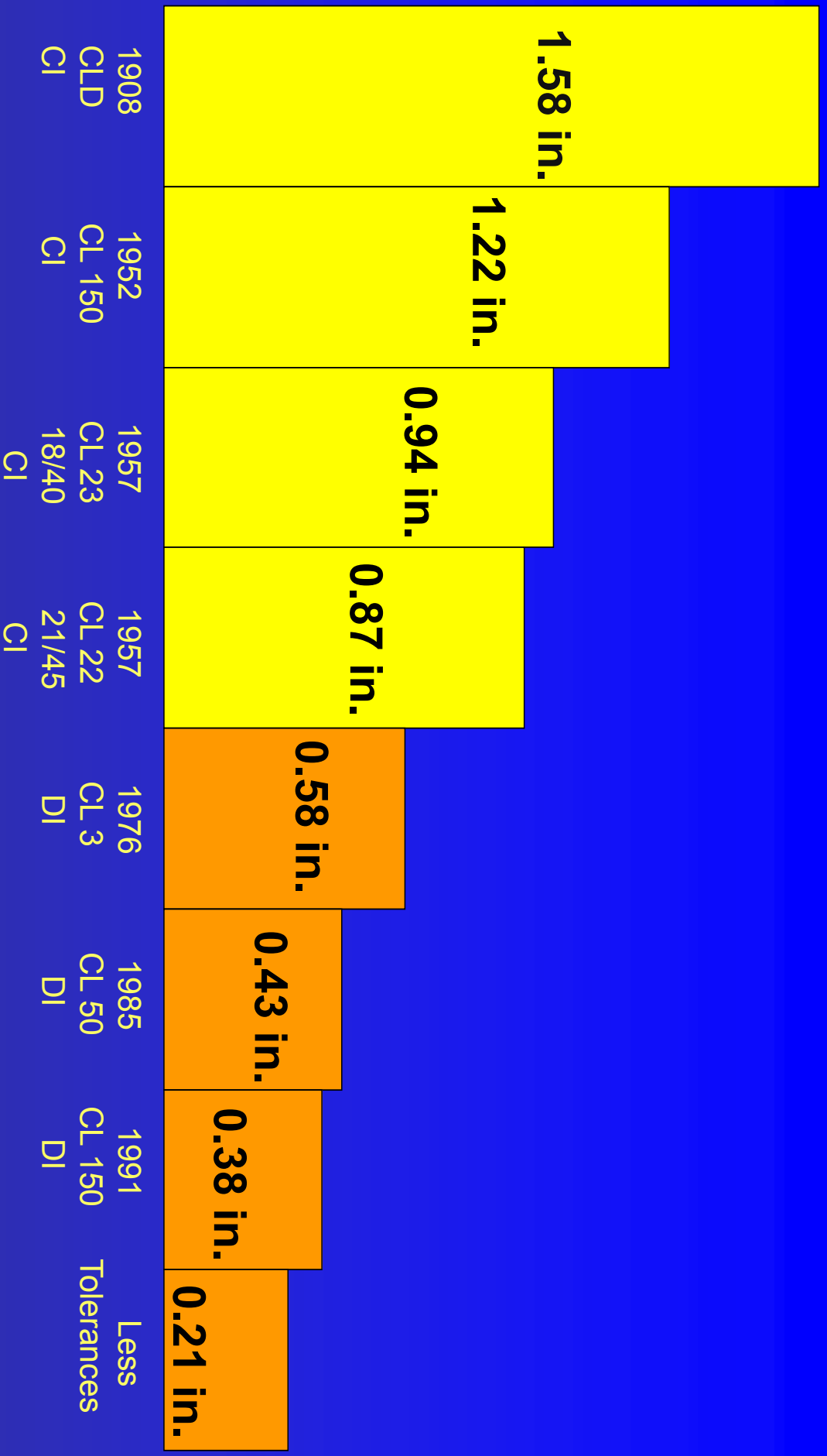


## Cast (Grey) Iron Failures



Graphitization leaves pipe brittle and weakened.





Actual size of AWWA Specification Thickness Reductions for 36-inch Diameter Cast and Ductile Iron Pipe - 1908 to Present (150 PSI Operating pressure)

# Ductile Iron



Pitting (concentrated)  
corrosion attack on ductile iron  
pipe.



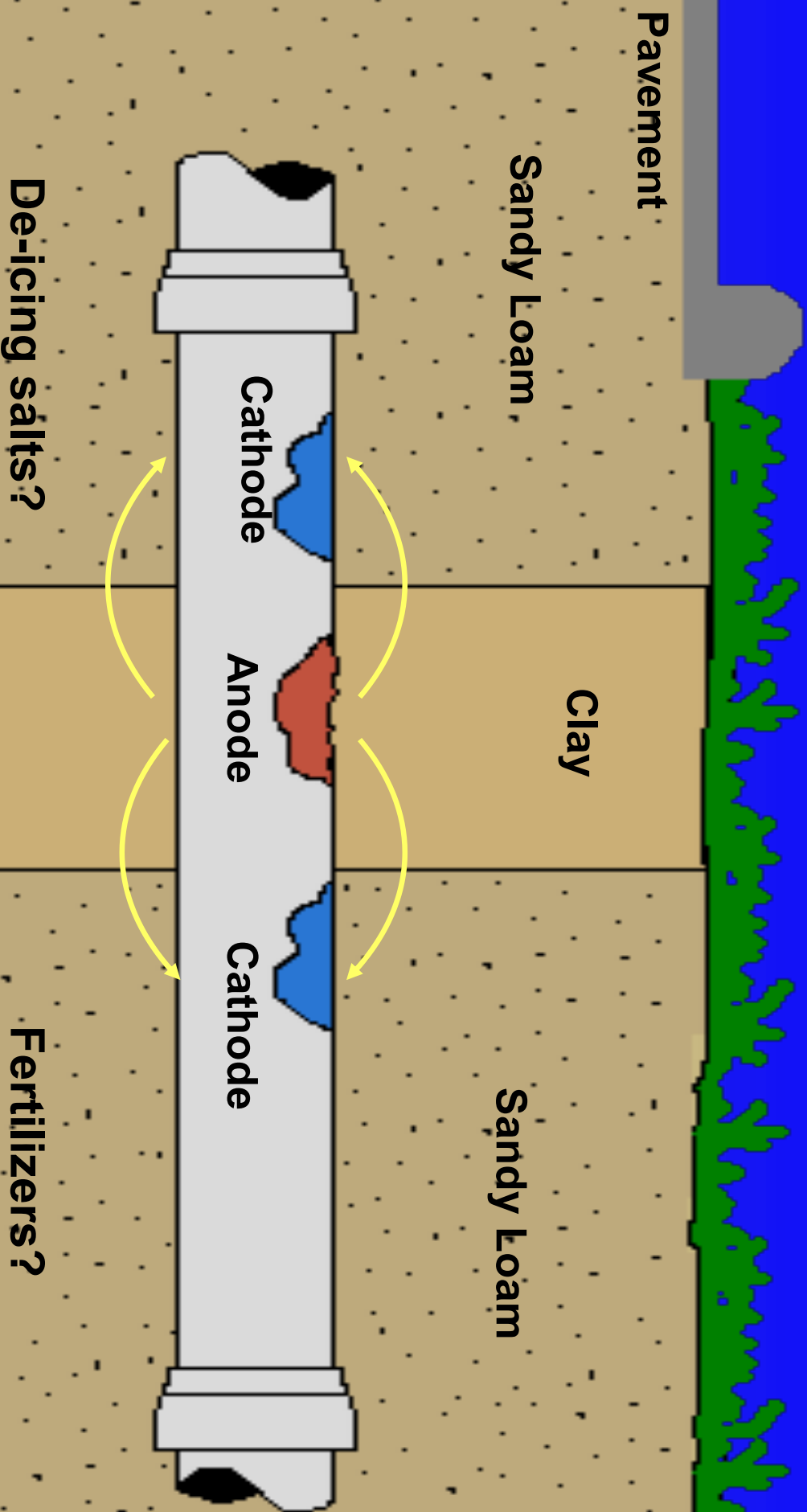


# Adverse Conditions for Metallic Pipe

- High Chlorides
- Low Soil/Water Resistivity
- High Sulfates
- Acidic Soils
- Wet/Dry Fluctuations
- Bimetallic Couplings
- Stray Current Interference

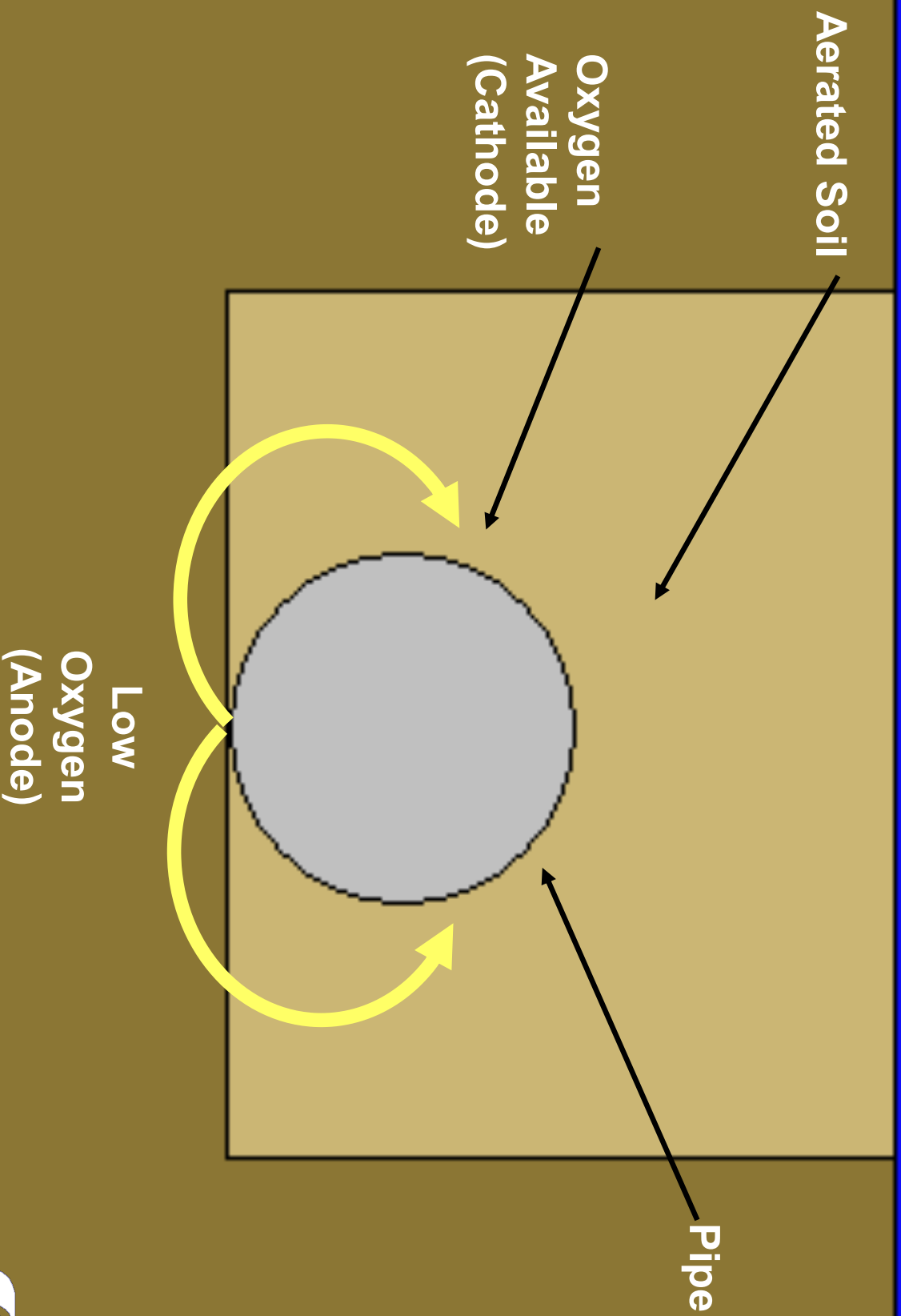


# Dissimilar Soils

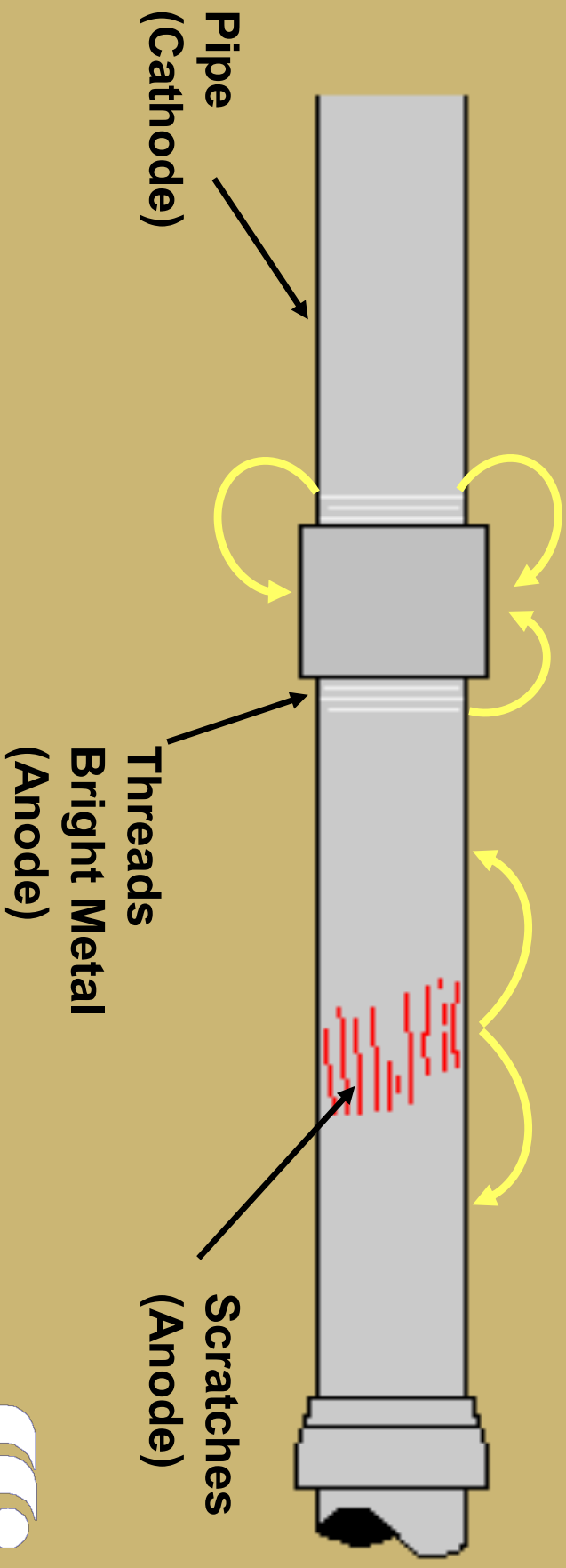




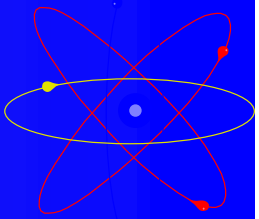
# Corrosion Caused by Differential Aeration



# Dissimilar Surface Conditions







# PRACTICAL GALVANIC SERIES

Material	Potential*
Pure Magnesium	-1.75
Zinc	-1.10
Aluminum Alloy	-1.00
Cadmium	-0.80
Mild Steel (New)	-0.70
Mild Steel (Old)	-0.50
Cast/Ductile Iron	-0.50
Stainless Steel	-0.50 to + 0.10
Copper, Brass, Bronze	-0.20
Gold	+0.20
Carbon, Graphite, Coke	+0.30

\* Potentials With Respect to Saturated Cu-CuSO<sub>4</sub> Electrode

# Coupling to Dissimilar Metals

**Metallic  
Connection**

**Copper service (Cathode)  
- 300mV**



**Iron pipe (Anode)  
- 500mV**



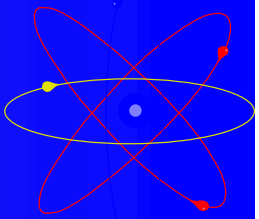
# Proper Handling & Installation of Polyethylene Ductile Iron Pipe



# Polyethylene Encasement of Ductile Iron Pipe



- Follow DIPRA installation procedures
- Clean pipe before installing polywrap
- Repair tears or damage to encasement
- Engage an inspector to oversee installation



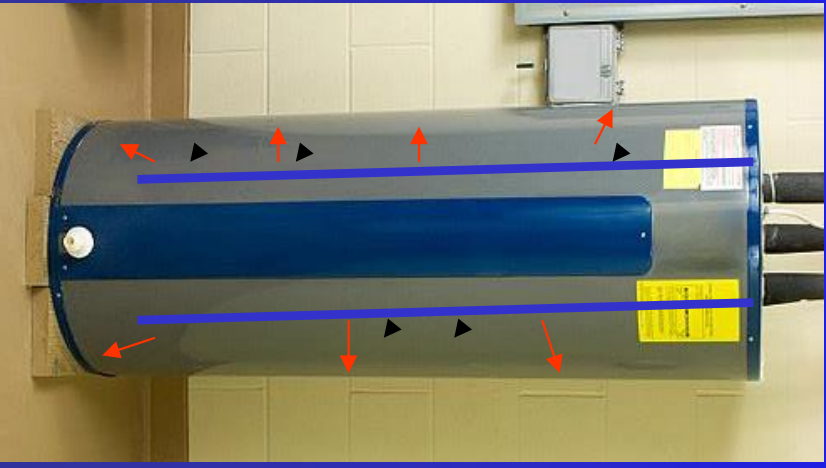
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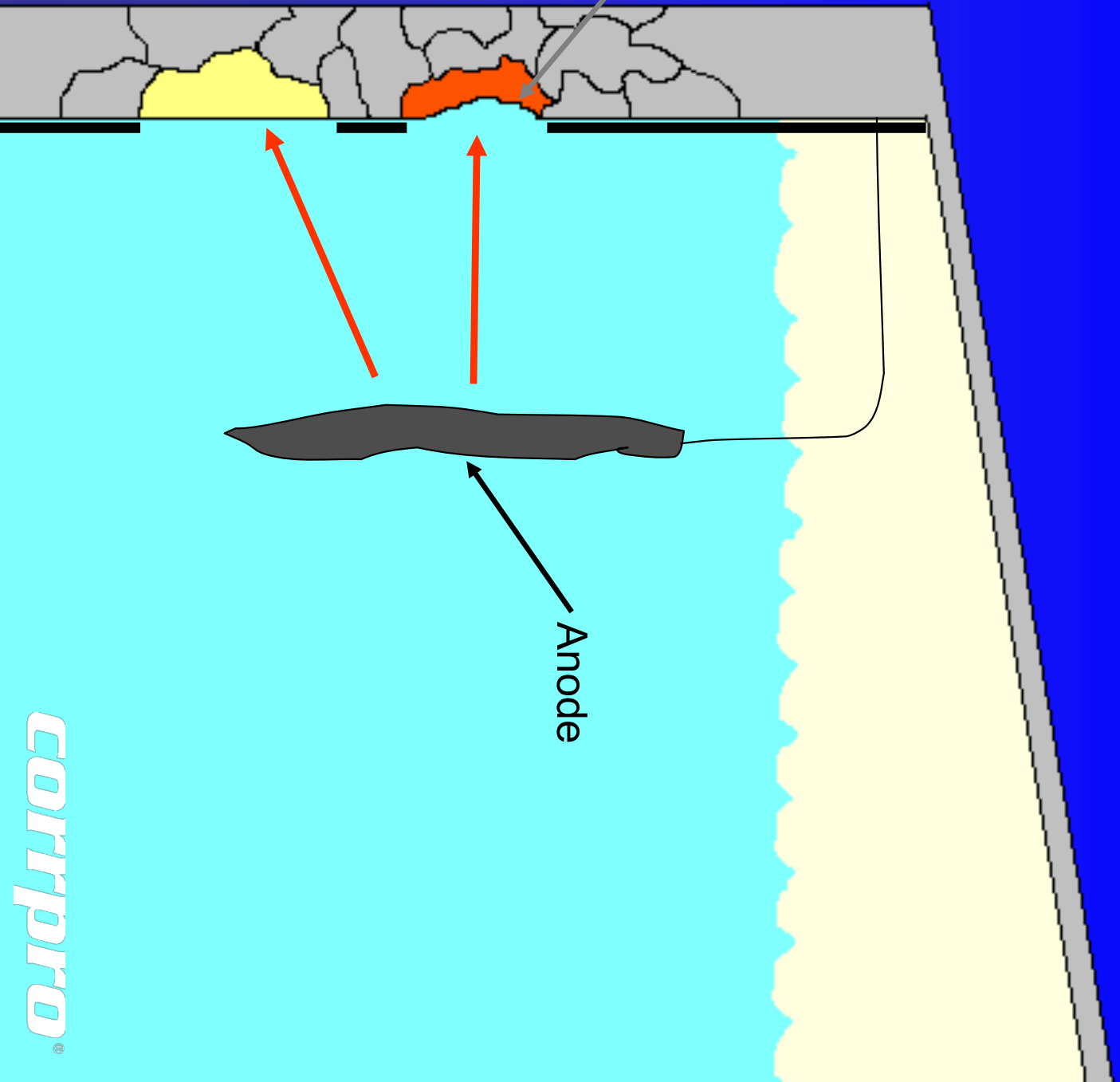


\* Potentials With Respect to Saturated  $\text{Cu-CuSO}_4$  Electrode



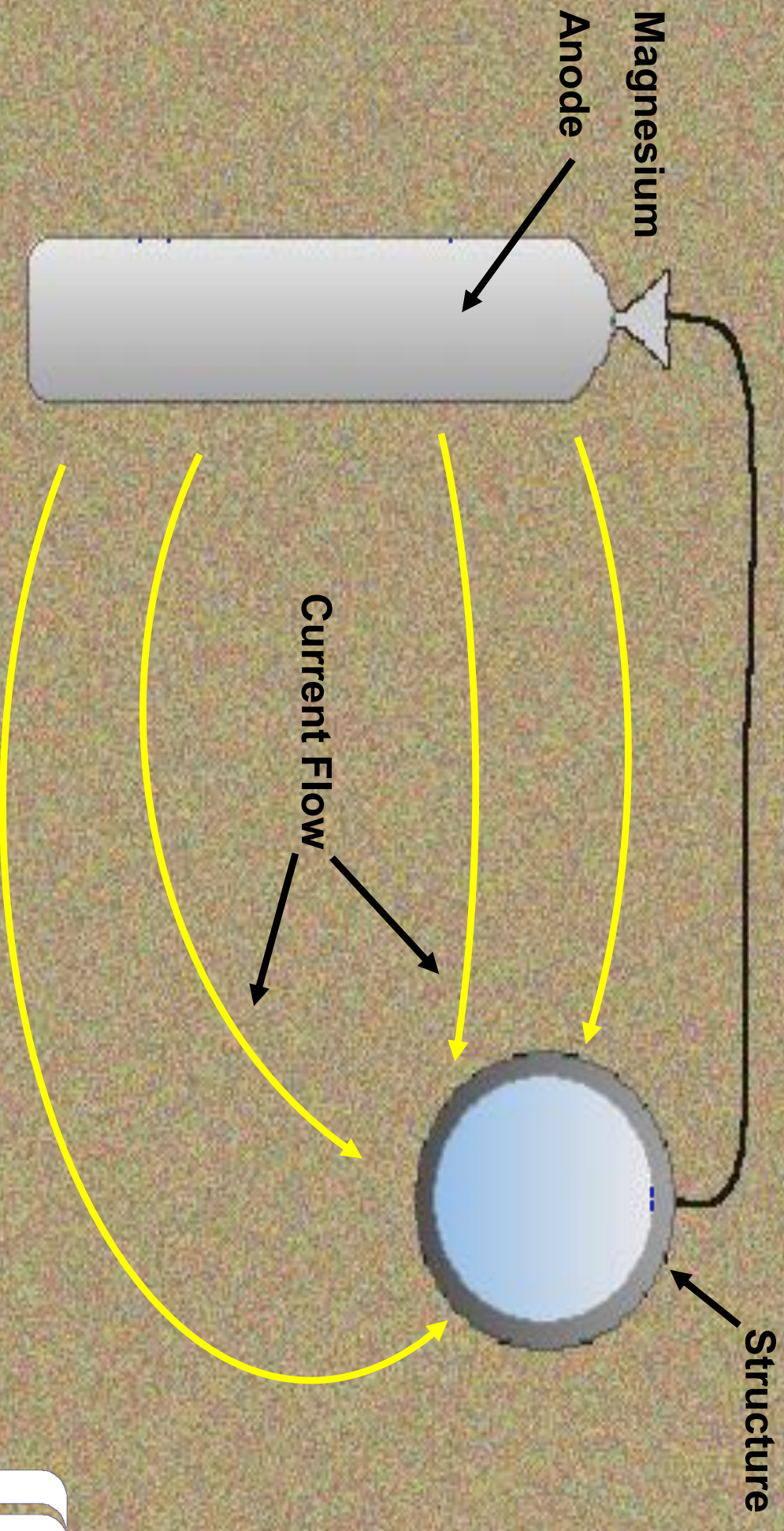


Cathode  
(Protected)



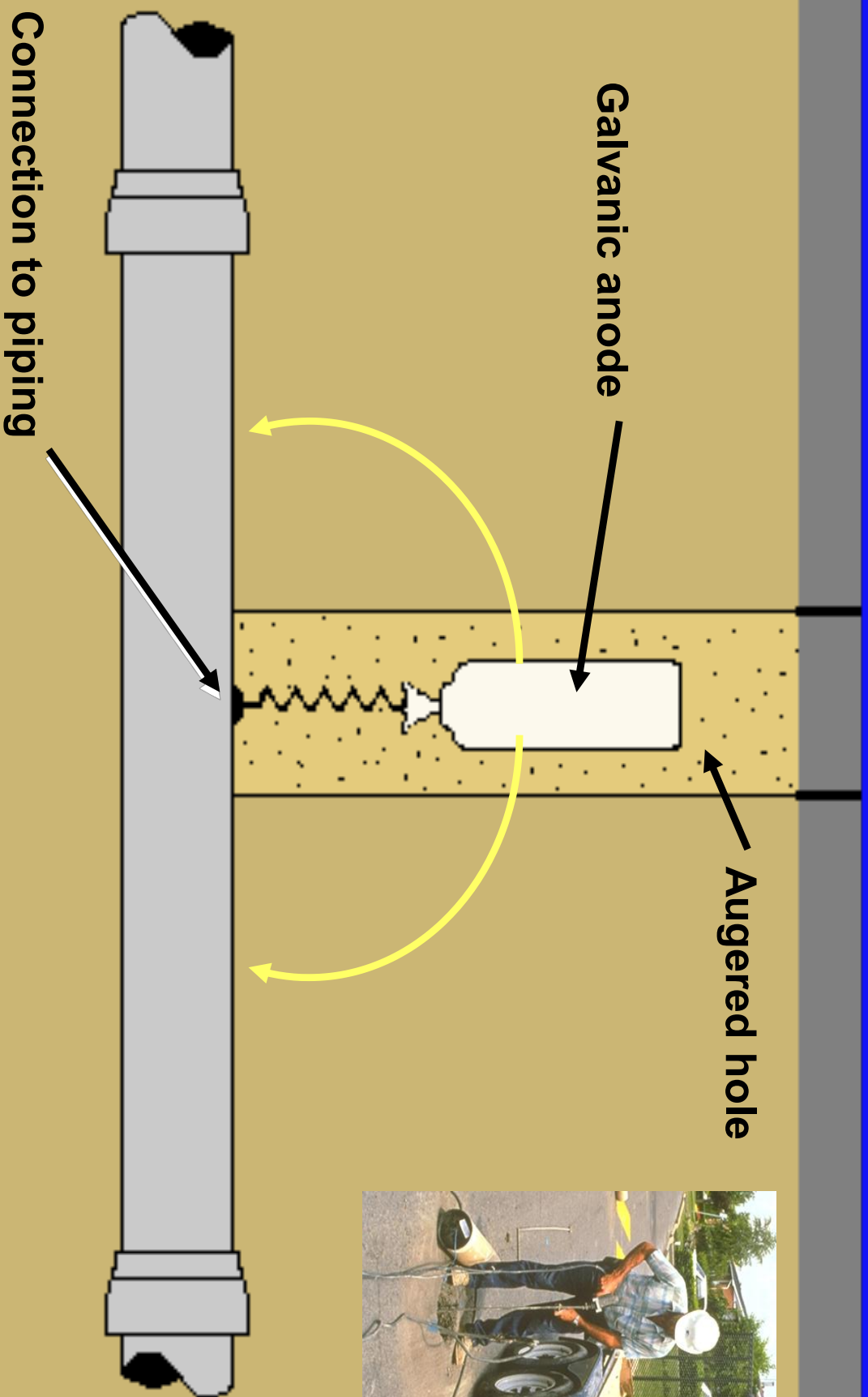
*corrpro*

# Galvanic Anode



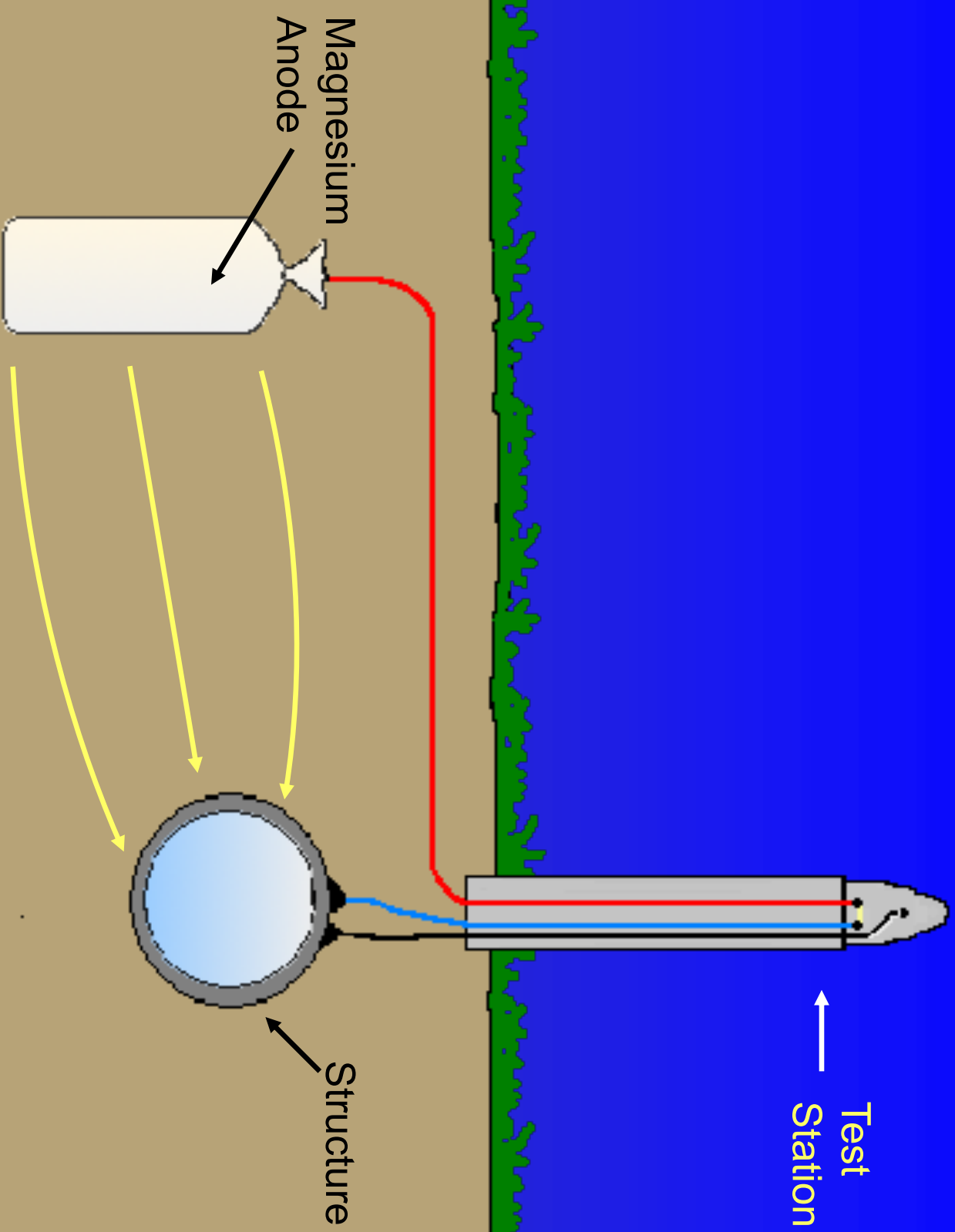


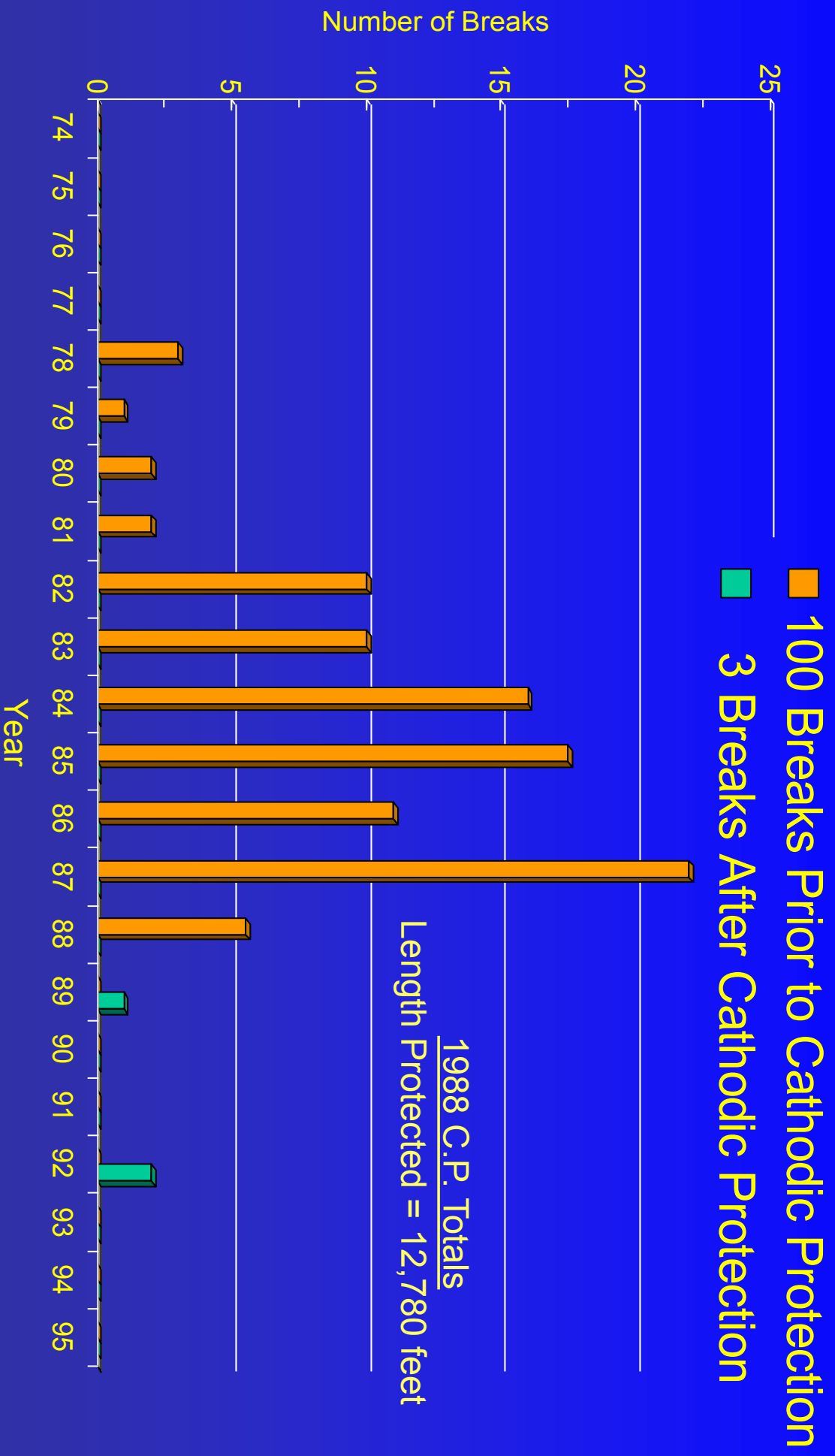
# Anode Installation



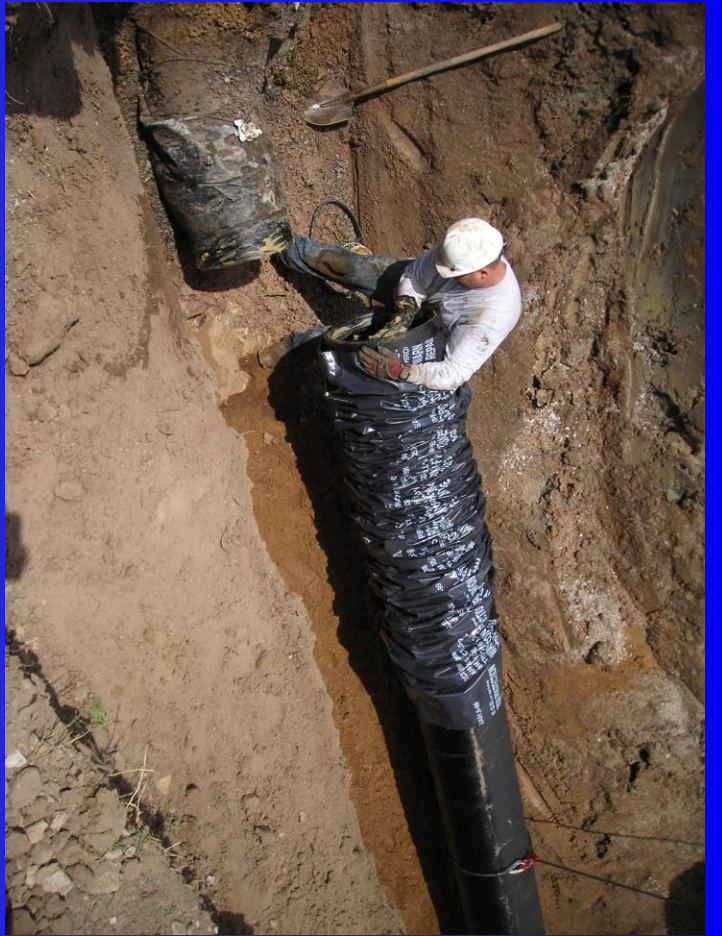


# Cathodic Protection Test Station



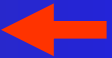


# Break Records for Water Mains Cathodically Protected in 1988





# Temporary Fix ?



# Repair of Break Should Include Anode Installation

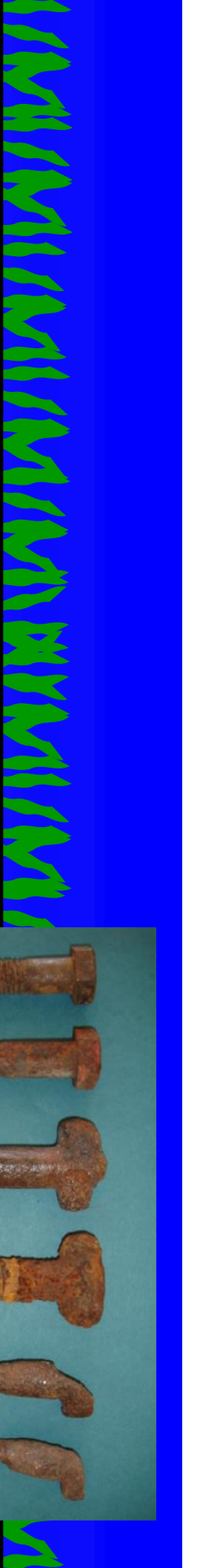


**Incomplete**

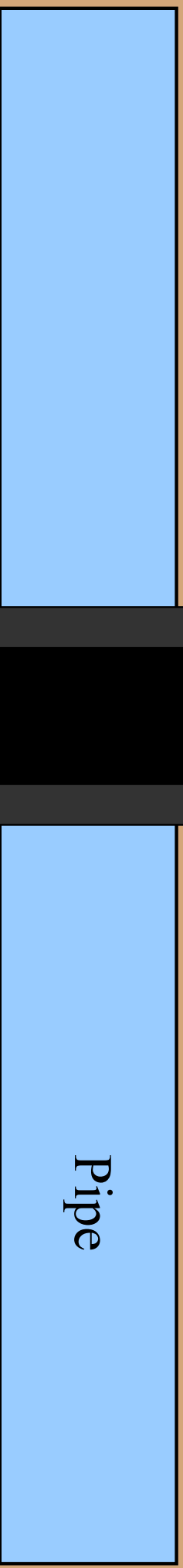


**Complete**





Lower Stress Area  
(Cathode)



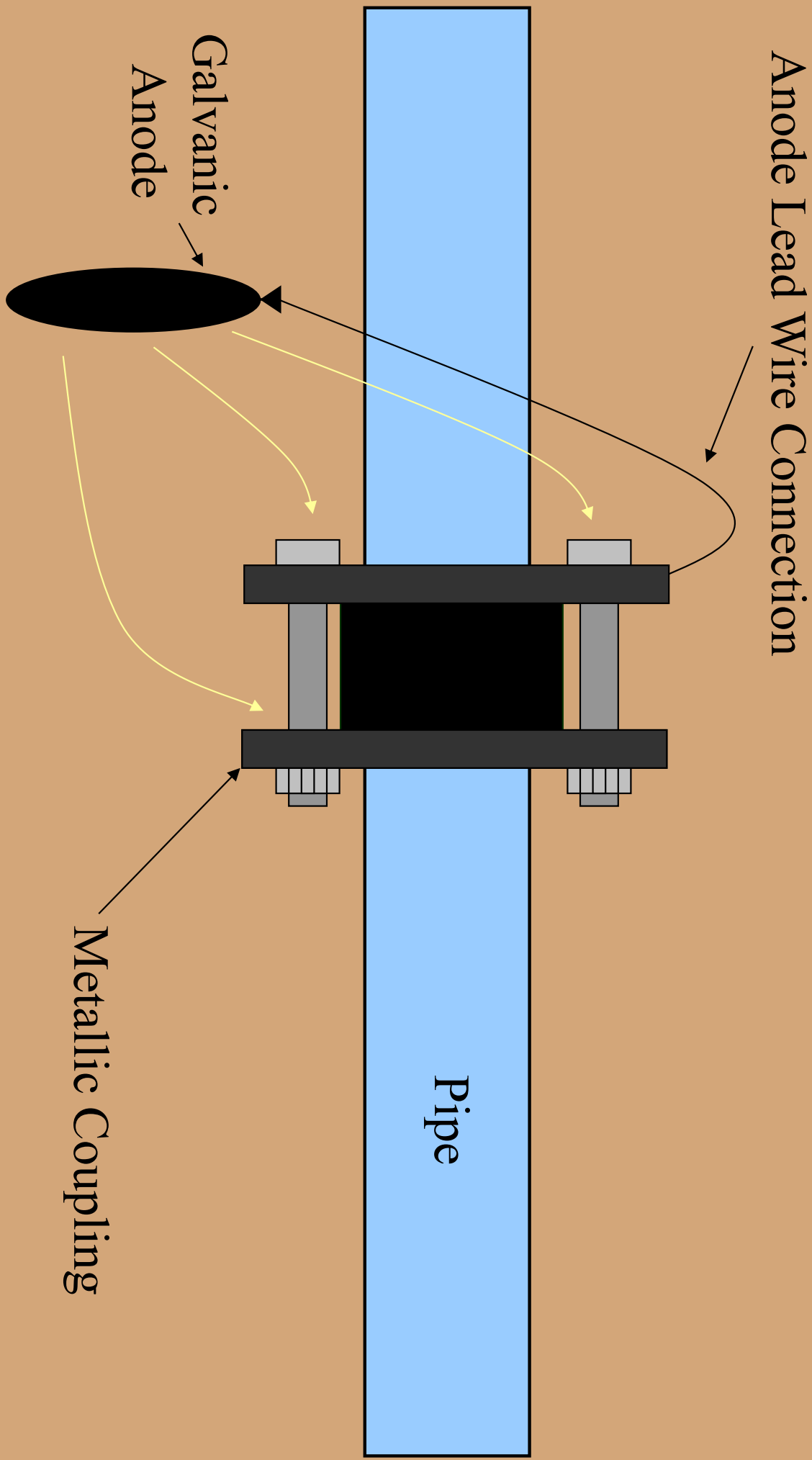
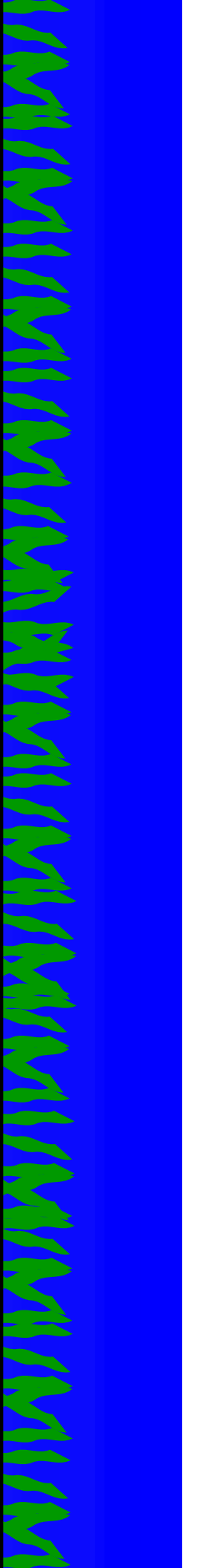
Threaded Bolt  
Higher Stress Area  
(Anode)

Stress Corrosion

Metallic Coupling

Pipe





Cathodic Protection of Metallic Fitting

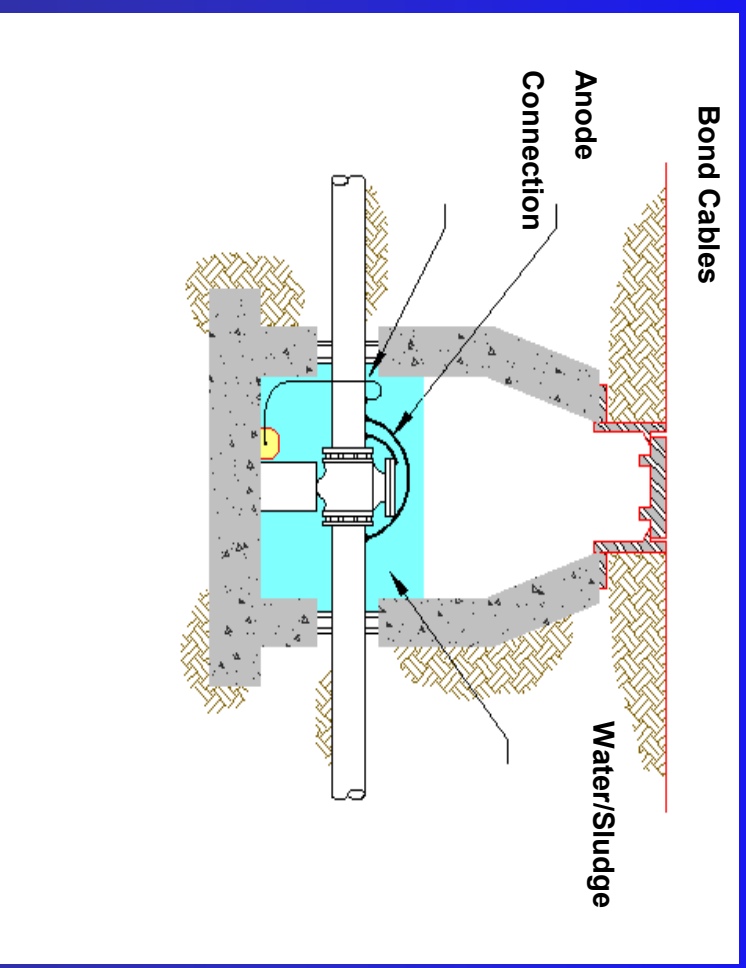
# Anode Installed on Metallic Fitting







Meter Vault Corrosion



Meter Vault with Anode



# Gate Valve Corrosion



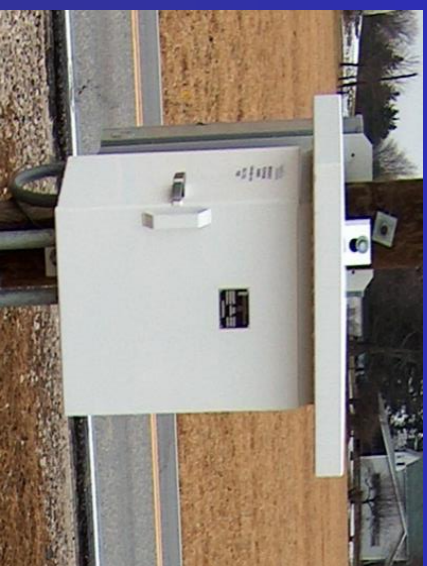
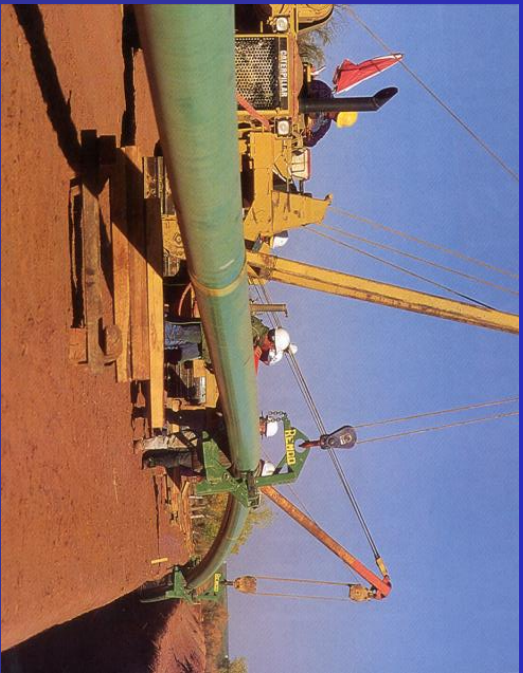


# Stainless Steel Corrosion

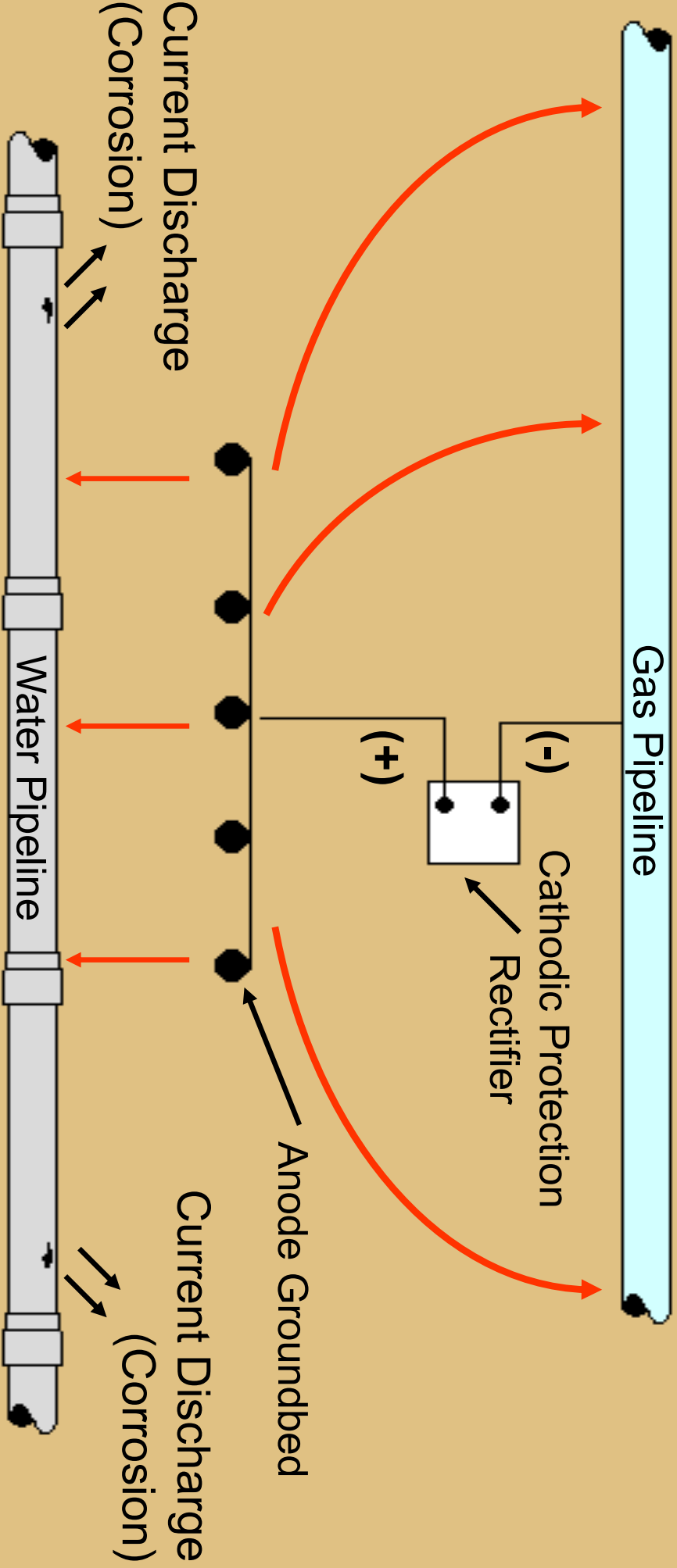




# Stray Current







# Stray Current Due to Impressed Current Cathodic Protection System





# Impressed Current CP System on Oil/Gas Lines can Create Stray Current Problem on Water Lines



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Company



# AC Mitigation



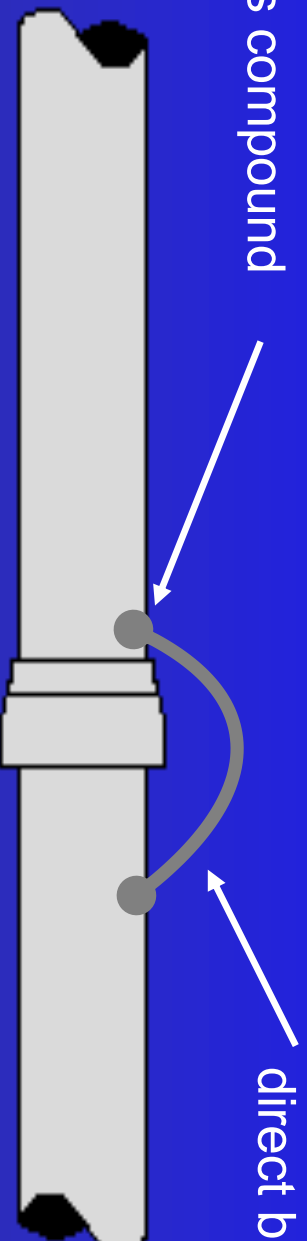


# Bonding Across a Bell and Spigot or Slip-joint

Thermite brazed  
connection coated with  
bitumous compound



Copper wire with  
direct burial insulation



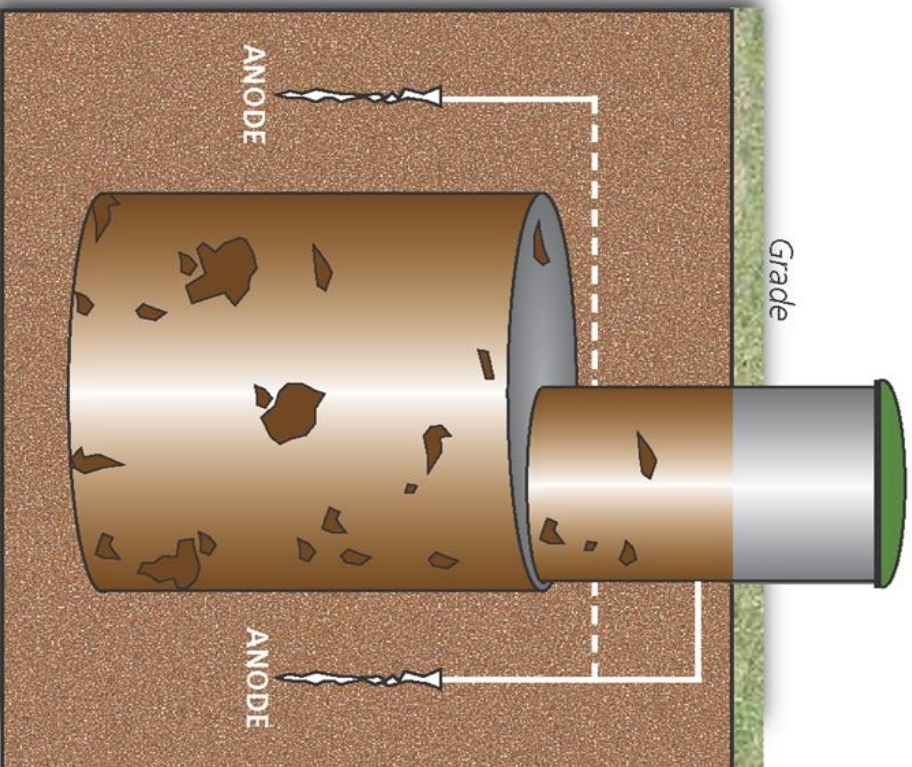


# Pumping Stations

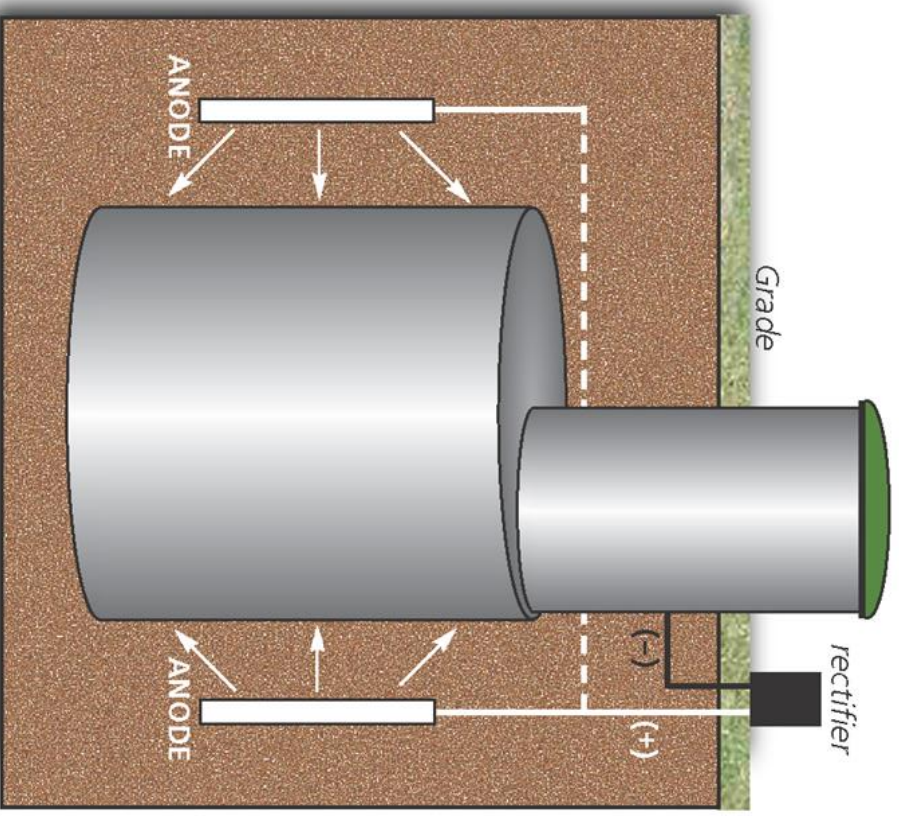




# Depleted & Refurbished Cathodic Protection for Lift Stations



Depleted cathodic protection system allows corrosion to occur.



Effective cathodic protection system prevents corrosion and extends life of lift station.





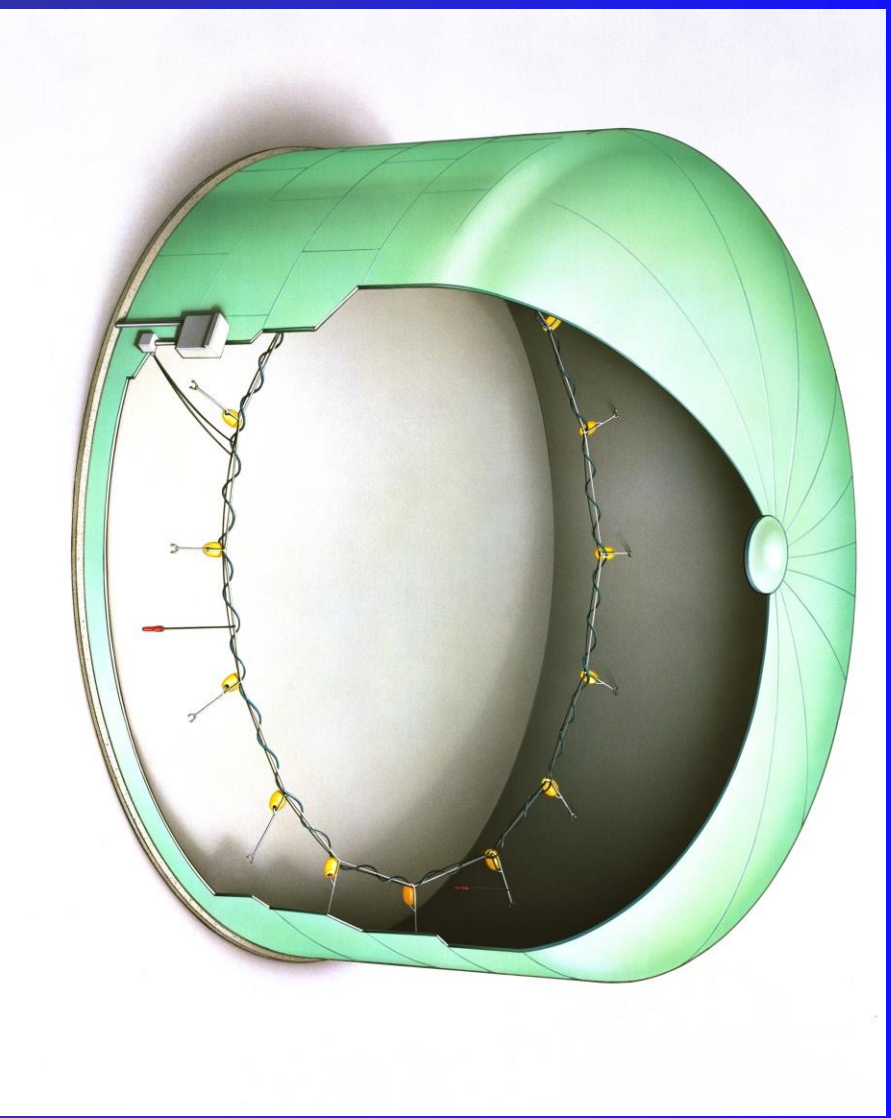
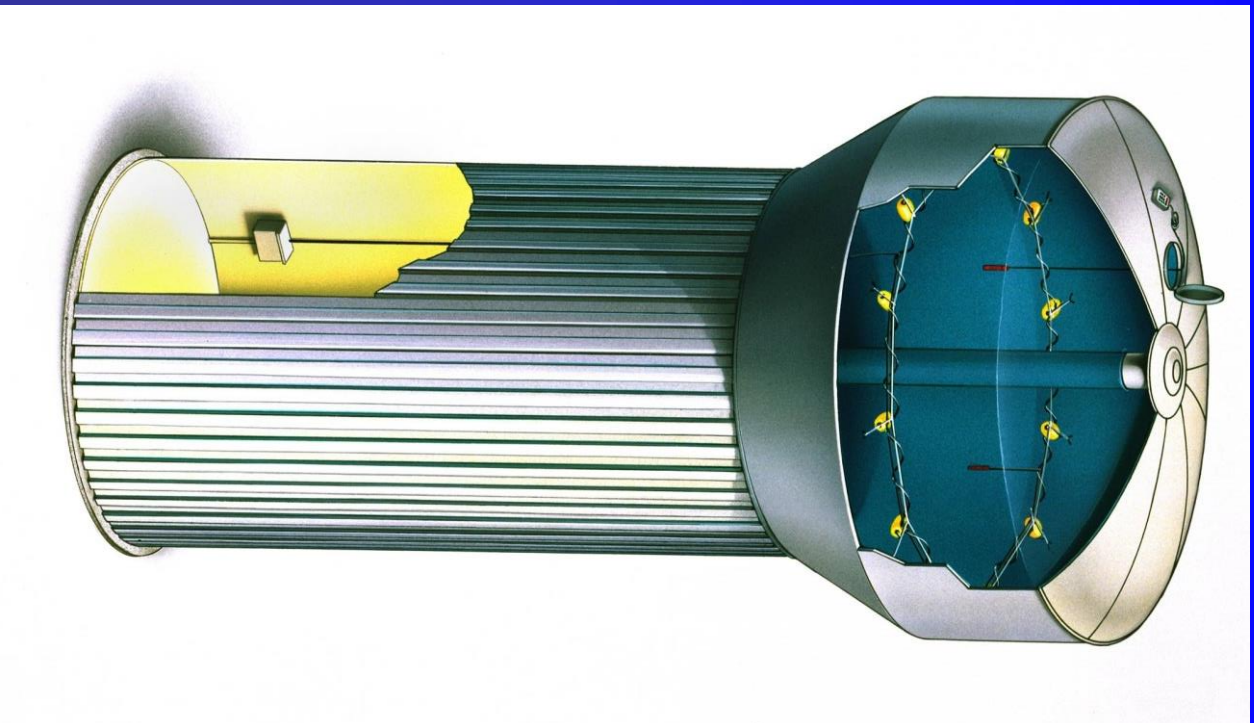


# For New or Refurbished Tanks



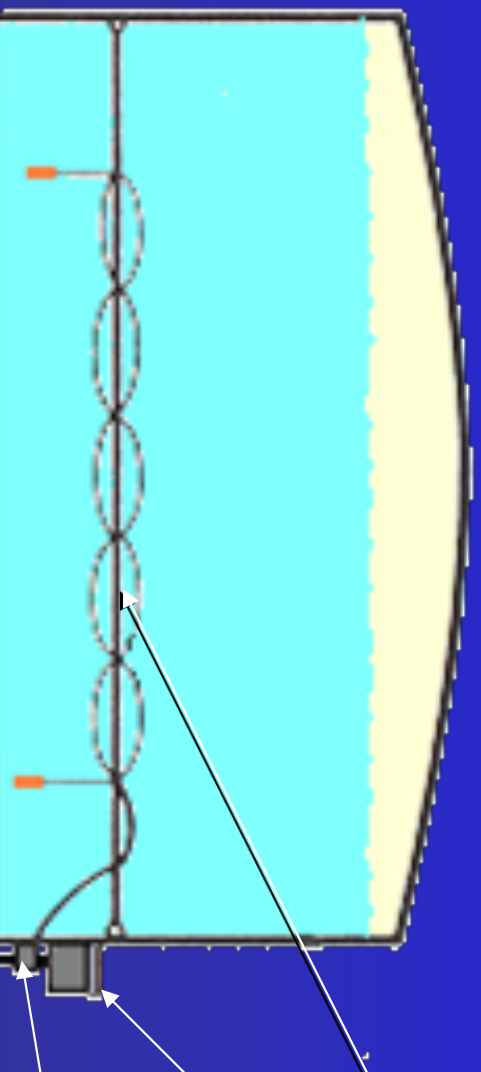
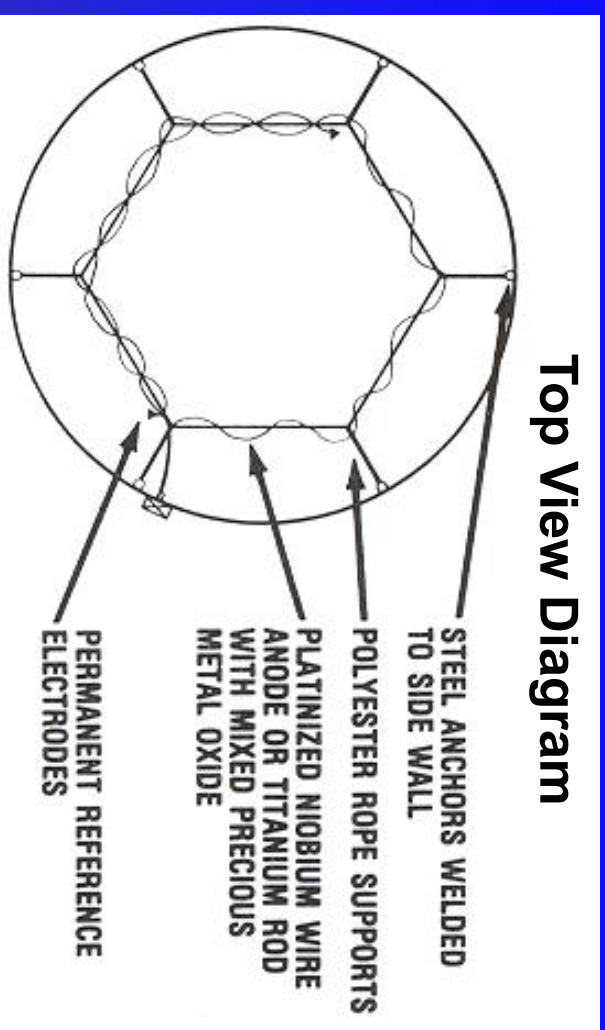
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- CP Benefits:**
- Triple life of coating
  - Reduce maintenance cost

# Suspended Horizontal Anode System



- Submerged Anode Support System
- Automatic Potential Control Rectifier
- Pressure Entrance Fitting





# Corrosion of Clarifier Center Well



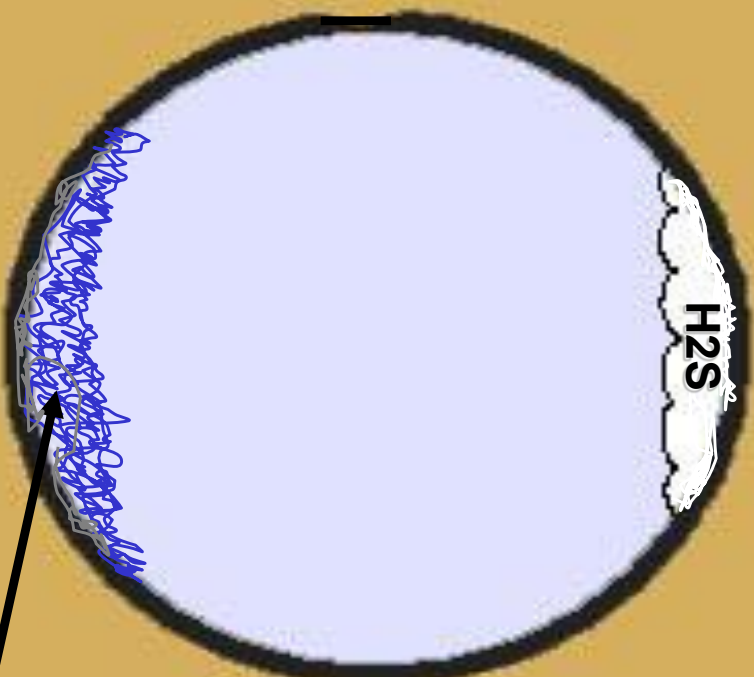


# Annual Maintenance

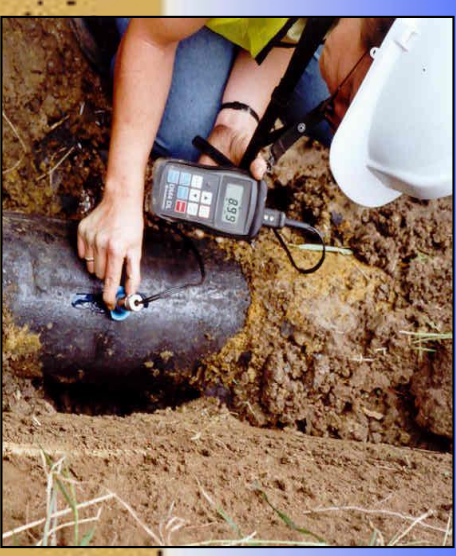




# Internal Corrosion of Force Mains....

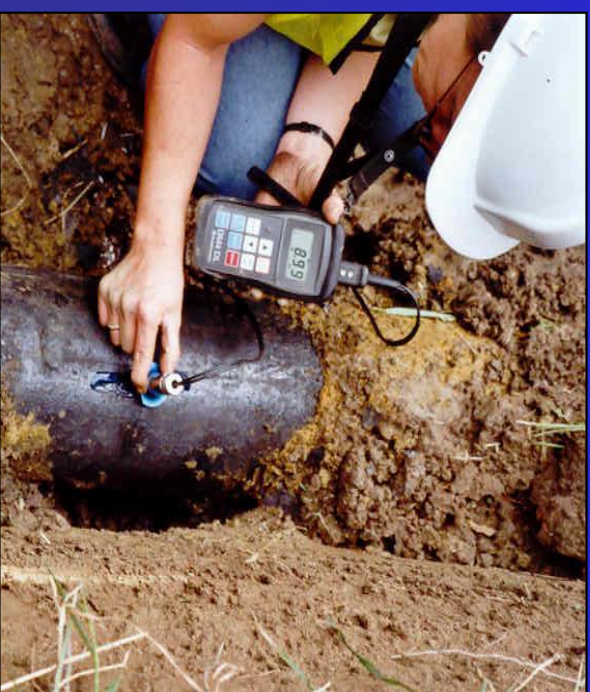


**Solids  
Buildup**





# Force Main Inspections





# 36" Above Ground Crossing

- Failure of force main at above ground crossing
- Crown of pipe attacked by hydrogen sulfide gas



# 24" Ductile Iron Force Main



- Internal failure following loss of internal mortar lining
- Failure was along top of pipe due to formation of hydrogen sulfide gas



# Dual 26" Force Mains



- Internal failures at bottom of pipe
- Failure following loss of internal mortar lining
- Failures concentrated at low areas (dips) in pipeline alignment
- Cause is corrosion under accumulated solids

# Rehabilitation Options





# Investigative Structure (Existing)

## Corrosion Assessment

- Review of General Characteristics of Water System
  - Age
  - Material Type
  - Wall Thickness
  - Construction Practices
- Review Break / Leak History
- Field Survey
  - Soil Conditions (Resistivity, Moisture Content, Chemical Analysis)
  - Electrical Test
- Data Analysis & Risk Management
- Priority Index (Identification of Opportunities to Reduce Replacement / Repair Costs)



# New Piping

## PHASE I

- Obtain drawings of proposed route
- Conduct independent field investigation:
  - a) Soil resistivity study
  - b) Identify foreign pipeline crossing
  - d) Identify AC potential influence
  - e) Collect soil samples (moisture content, chlorides, pH, sulfate ions concentration, conductivity)
- Stray current investigation





# **Corrosion Protection Design Phase II**

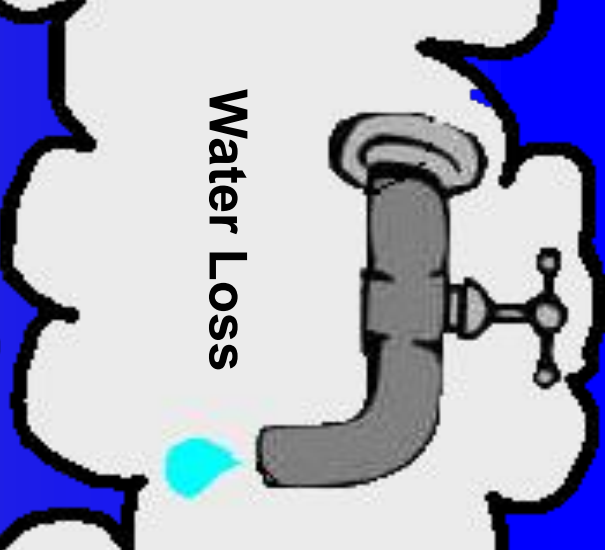
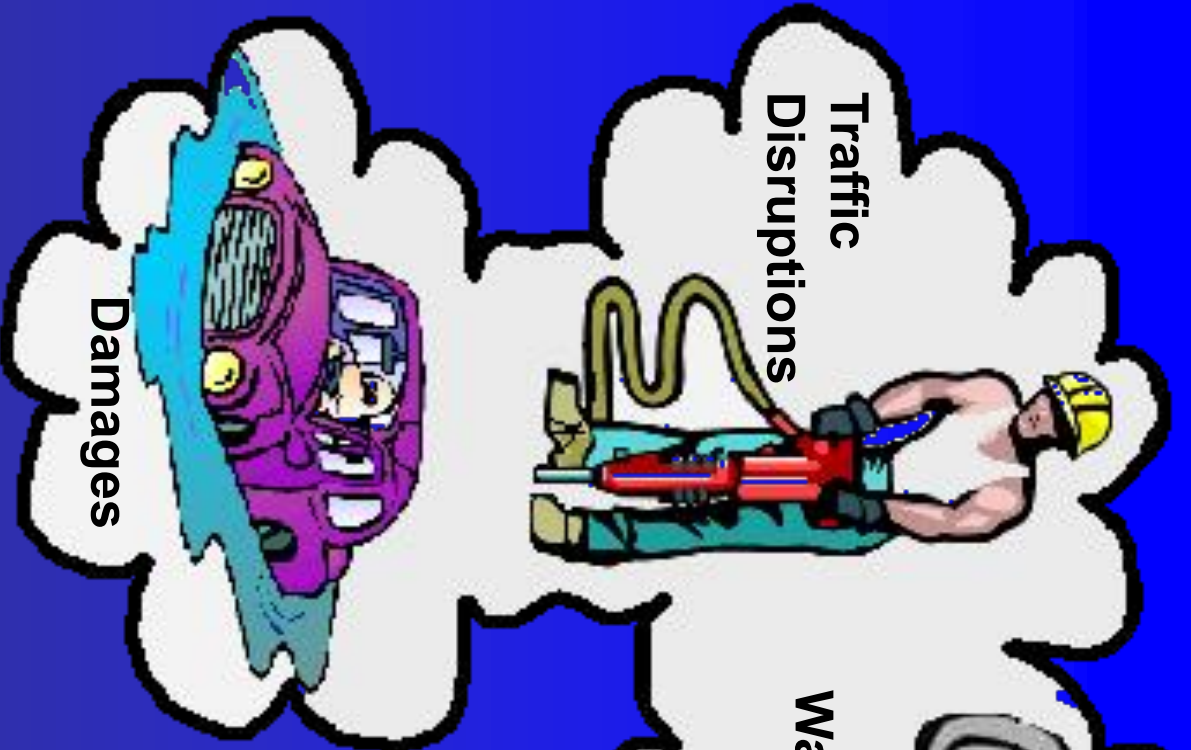
## **Prepare Bid Quality Specifications for:**

- Coatings or Polyethylene Encasement**
  - Test Stations (Monitor Corrosion Rates)**
  - Bonded Joints**
  - Stray DC/AC Mitigation**
  - Cathodic Protection**
  - Combination of Multiple Items**
- 
- Review Submittals/Onsite Periodic Inspection**

# Summary

- ◆ **Reducing corrosion rates on existing water distribution piping will result in a reduction of the number of breaks and also extend the operational life.**
- ◆ **Corrosion control measures should be considered during the design stage for any new metallic piping and storage tank installations.**





# QUESTIONS ?

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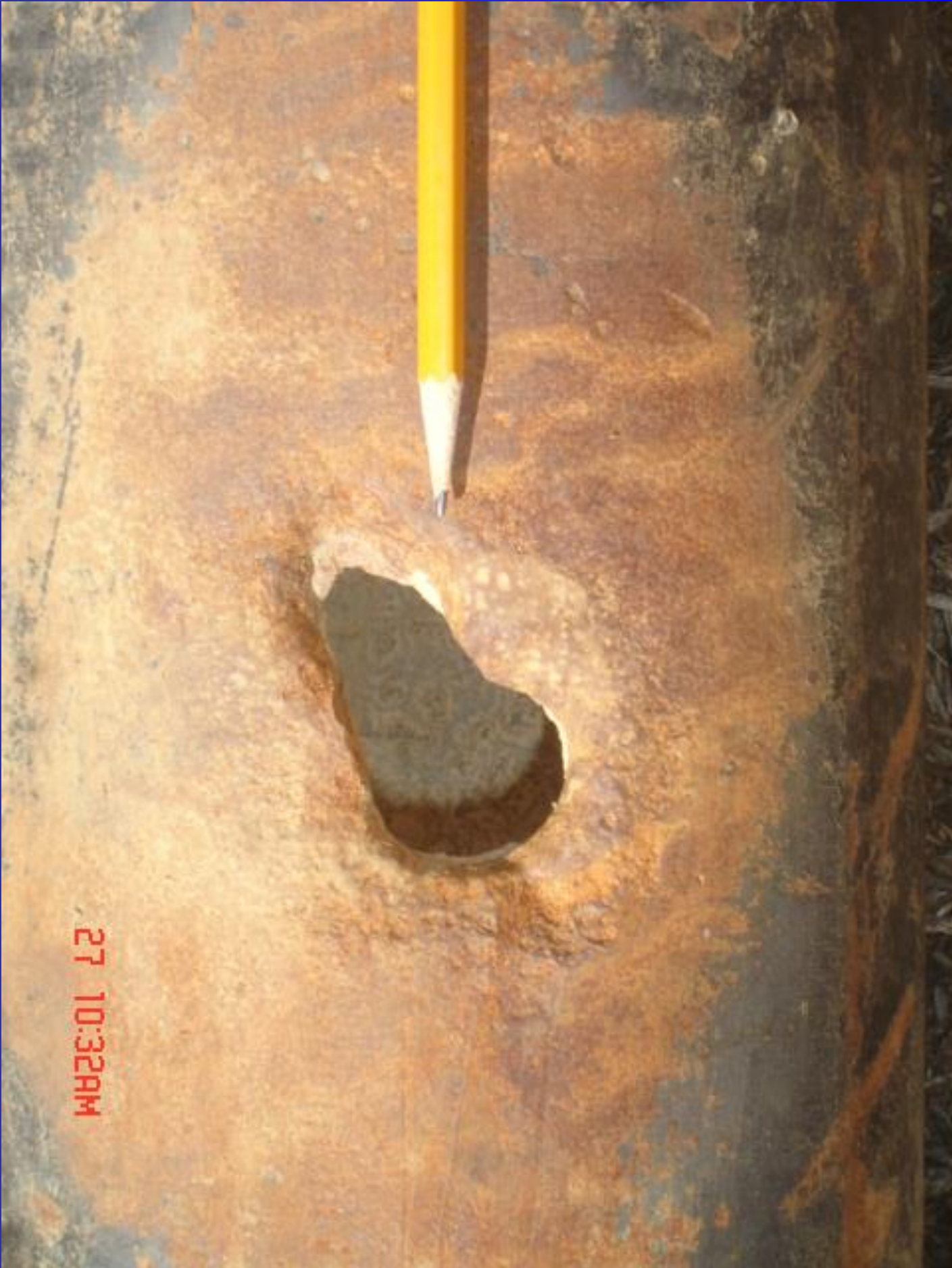
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# Impressed Current CP System on Oil/Gas Lines can Create Stray Current Problem on Water Lines







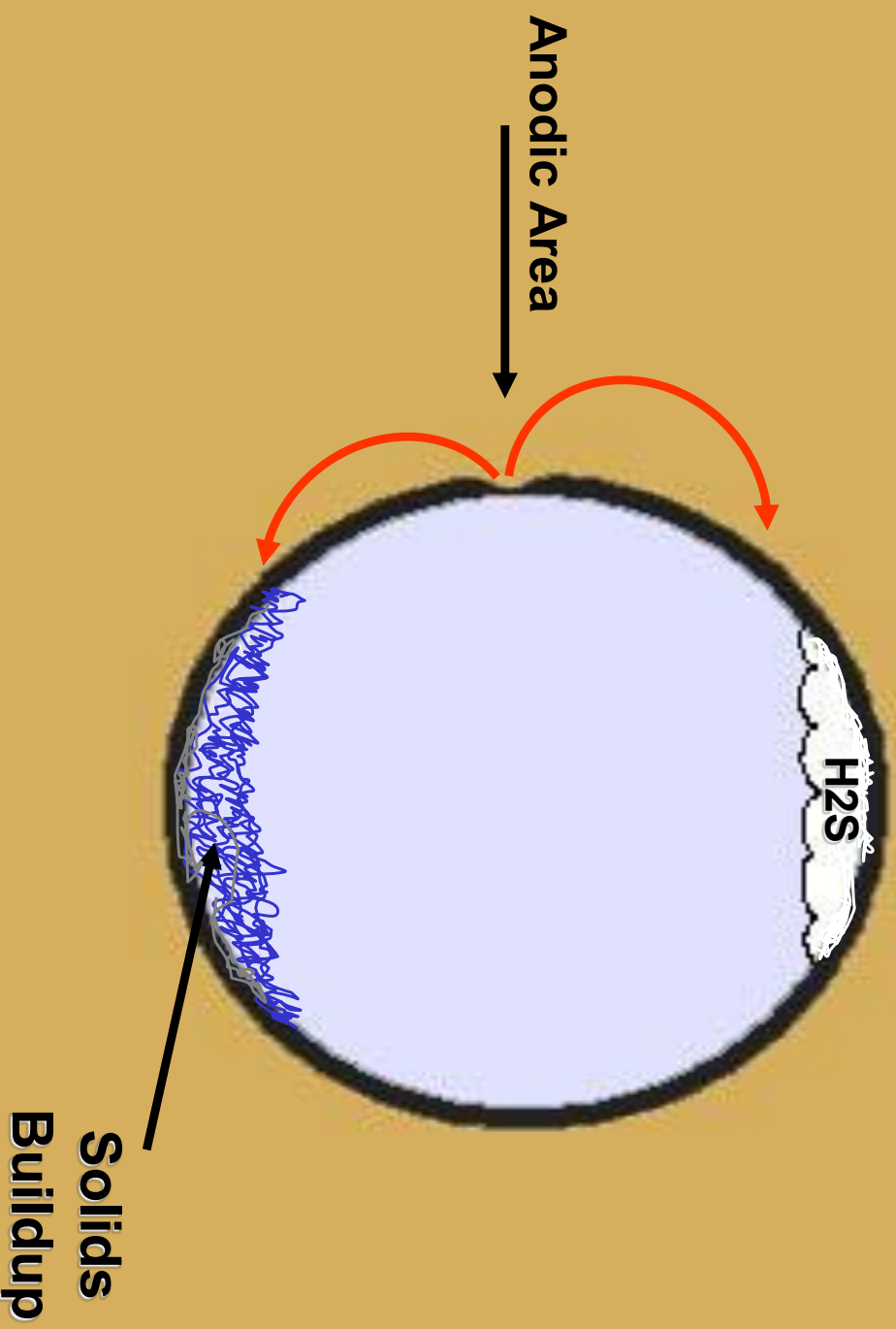
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**Transformer Rectifier**



# *Internal & External Corrosion of Force Mains.....*



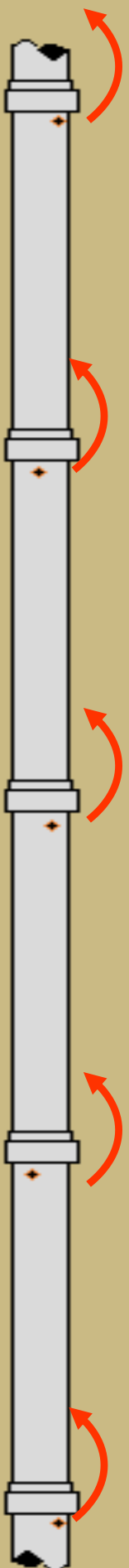


# 36" Above Ground Crossing

- Failure of force main at above ground crossing
- Crown of pipe attacked by hydrogen sulfide gas



# Stray Current





# Computerized Potential Logging Survey



Test Station

Backpack  
Computer Unit  
Chainer/Wire  
Dispenser &  
Counter

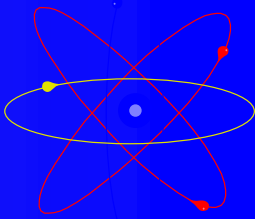
Reference  
Cells

Bonded  
Joints

Polywrap

Pipeline





# PRACTICAL GALVANIC SERIES

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Zinc	-1.10
Aluminum Alloy	-1.00
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\* Potentials With Respect to Saturated Cu-CuSO<sub>4</sub> Electrode



# Thermit Weld to Pipe

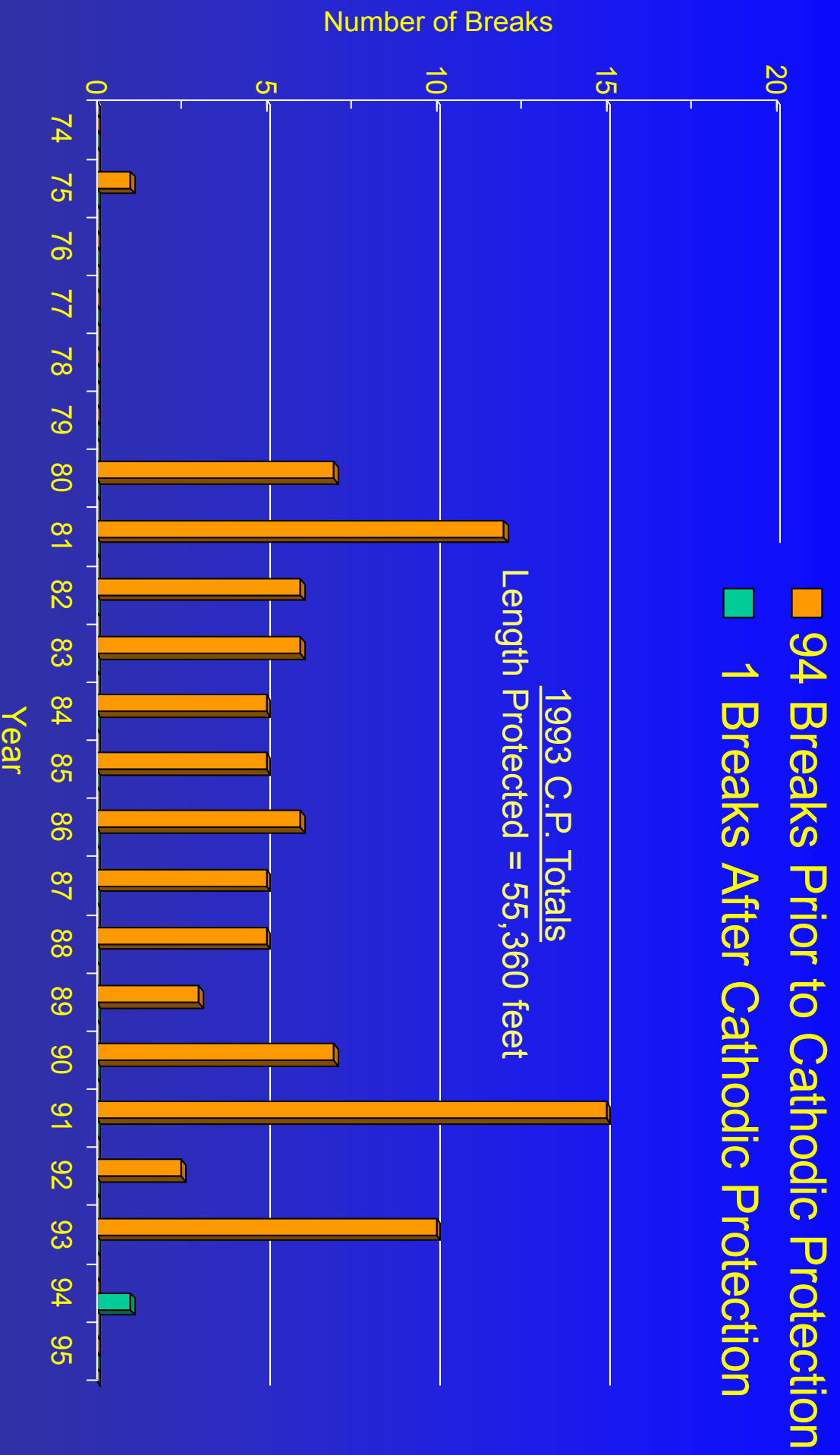






# Access to Pipe





## Break Records for Water Mains Cathodically Protected in 1993

# Water Leak Repair Kit

*Includes:*

**Installation instructions.**

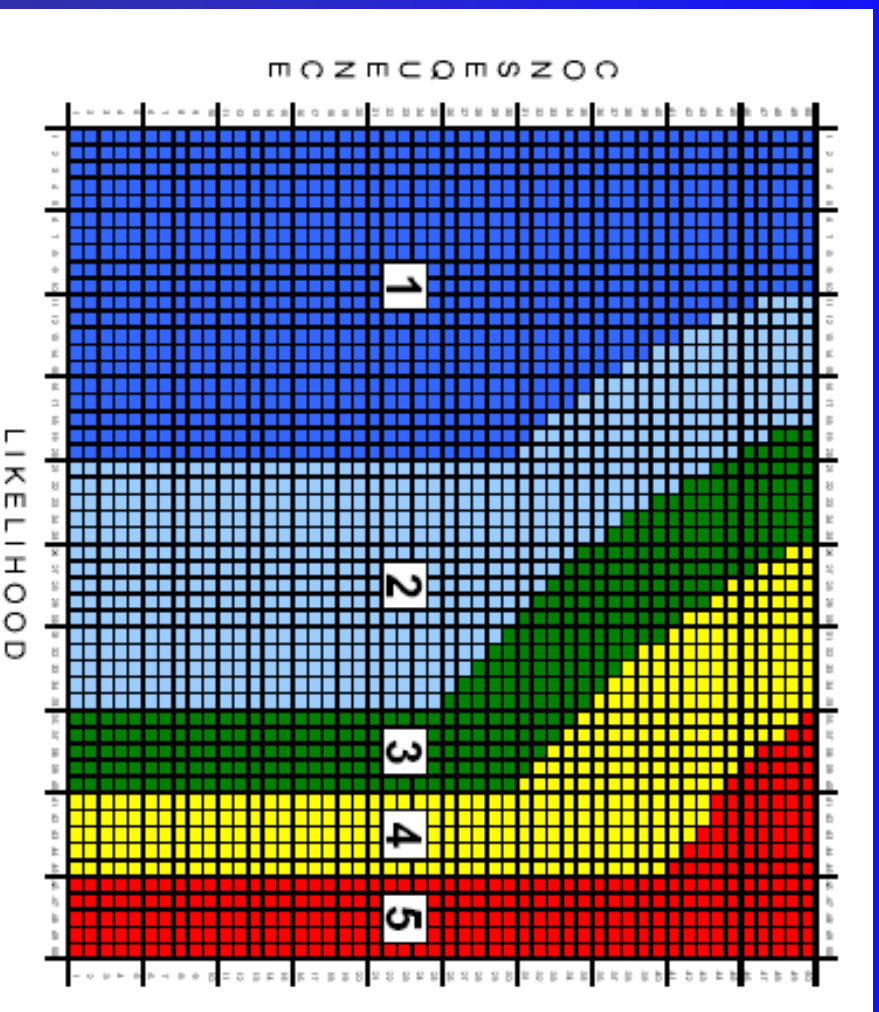
**One day onsite technical assistance.**

**Cathodic protection components/connection materials suitable for 10 repairs.**





# Design Decision Model

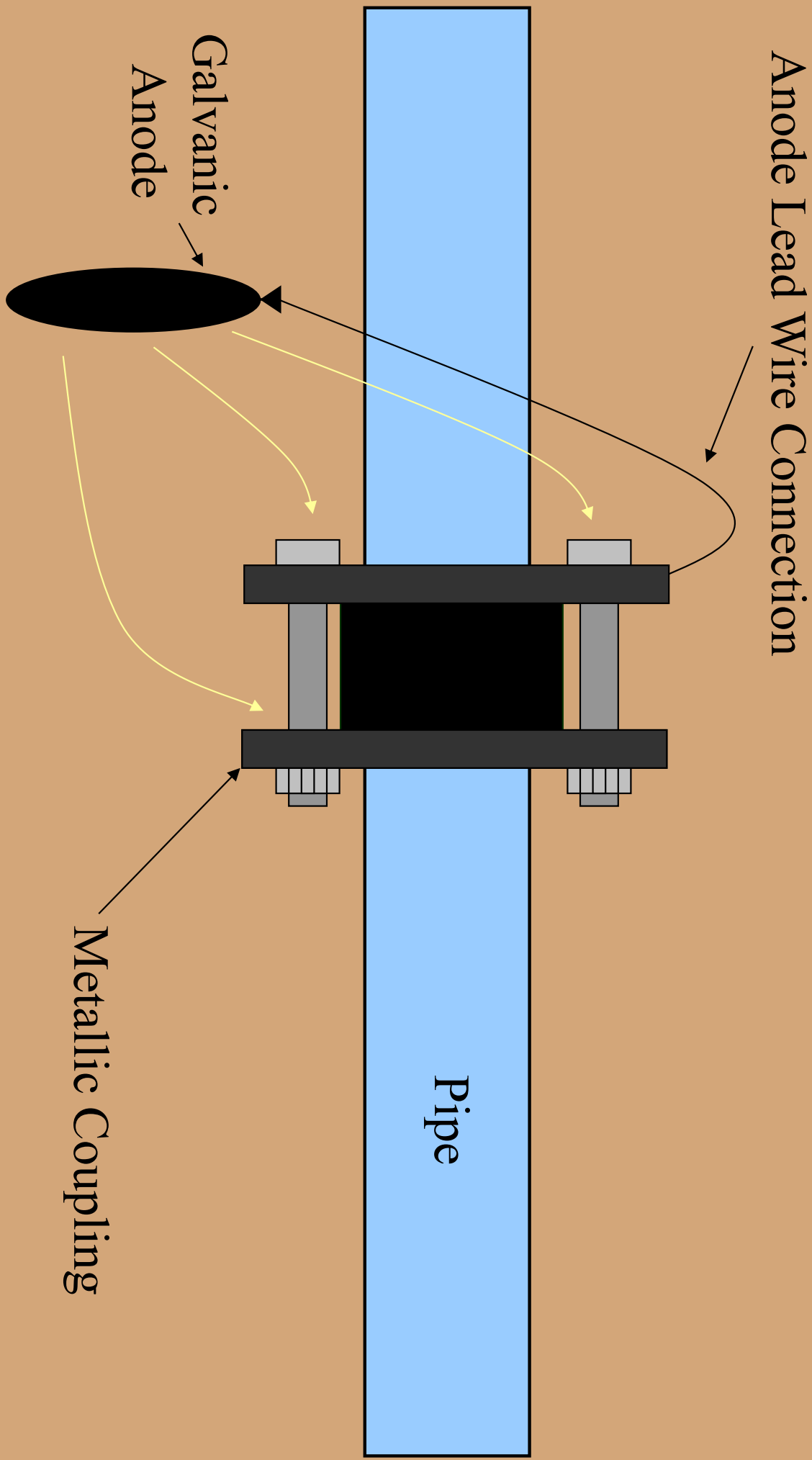
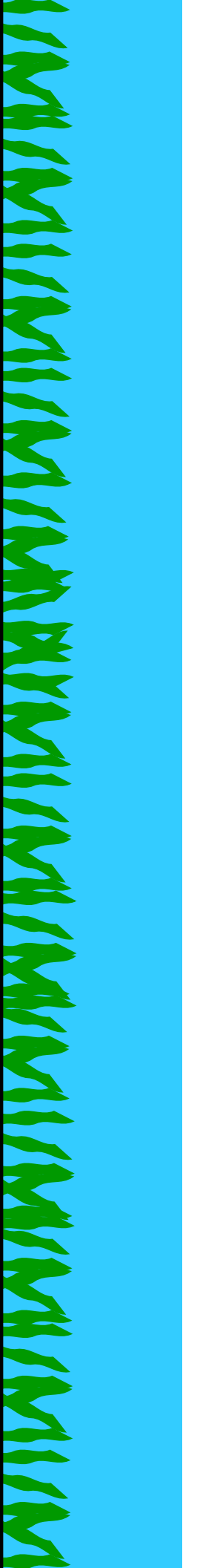


*For Ductile Iron Pipe*

# Insituform







# Cathodic Protection of Metallic Fitting

# Computerized Potential Logging Survey



Test Station

Backpack Computer Unit

Chainer/Wire Dispenser & Counter

Reference Cells



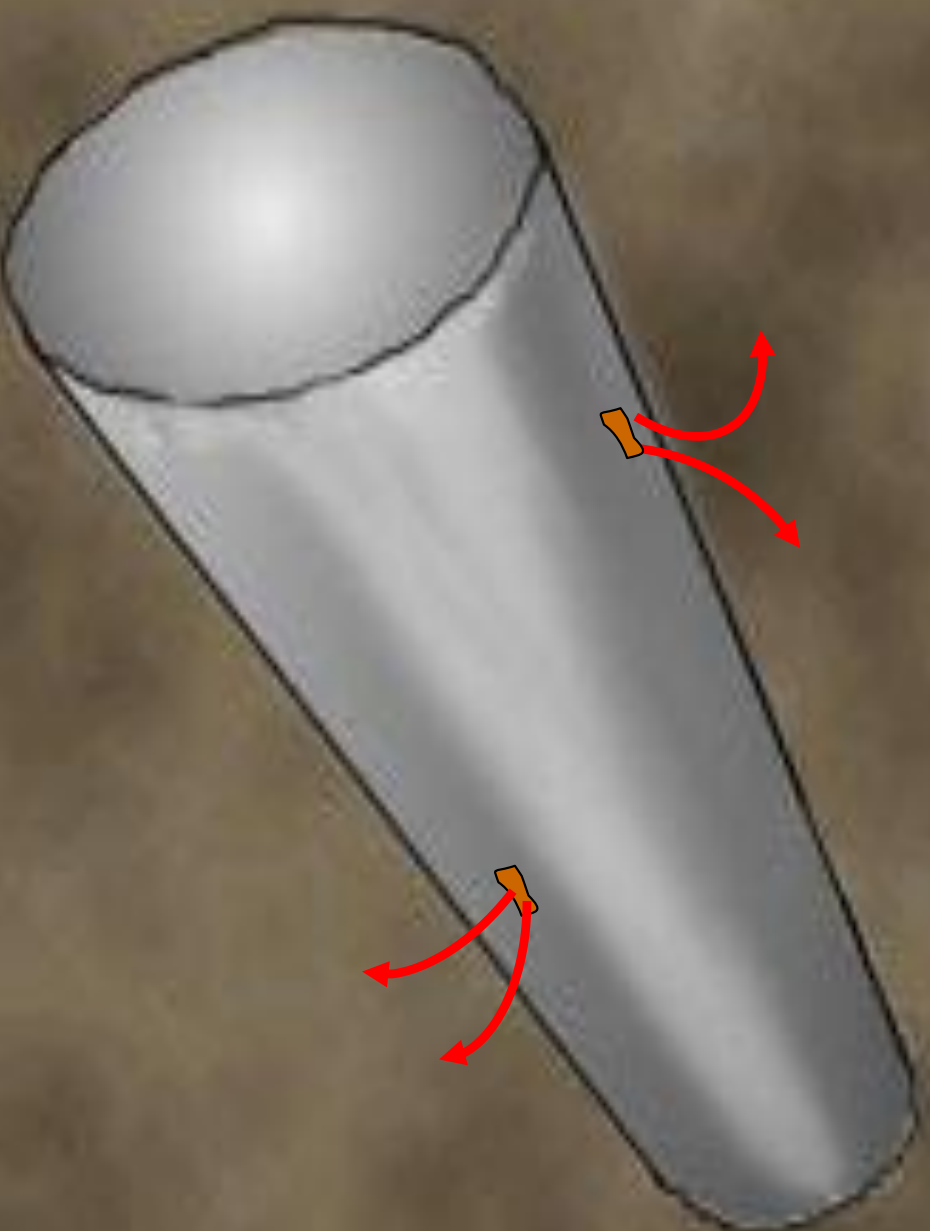
Bonded Joints

Pipeline

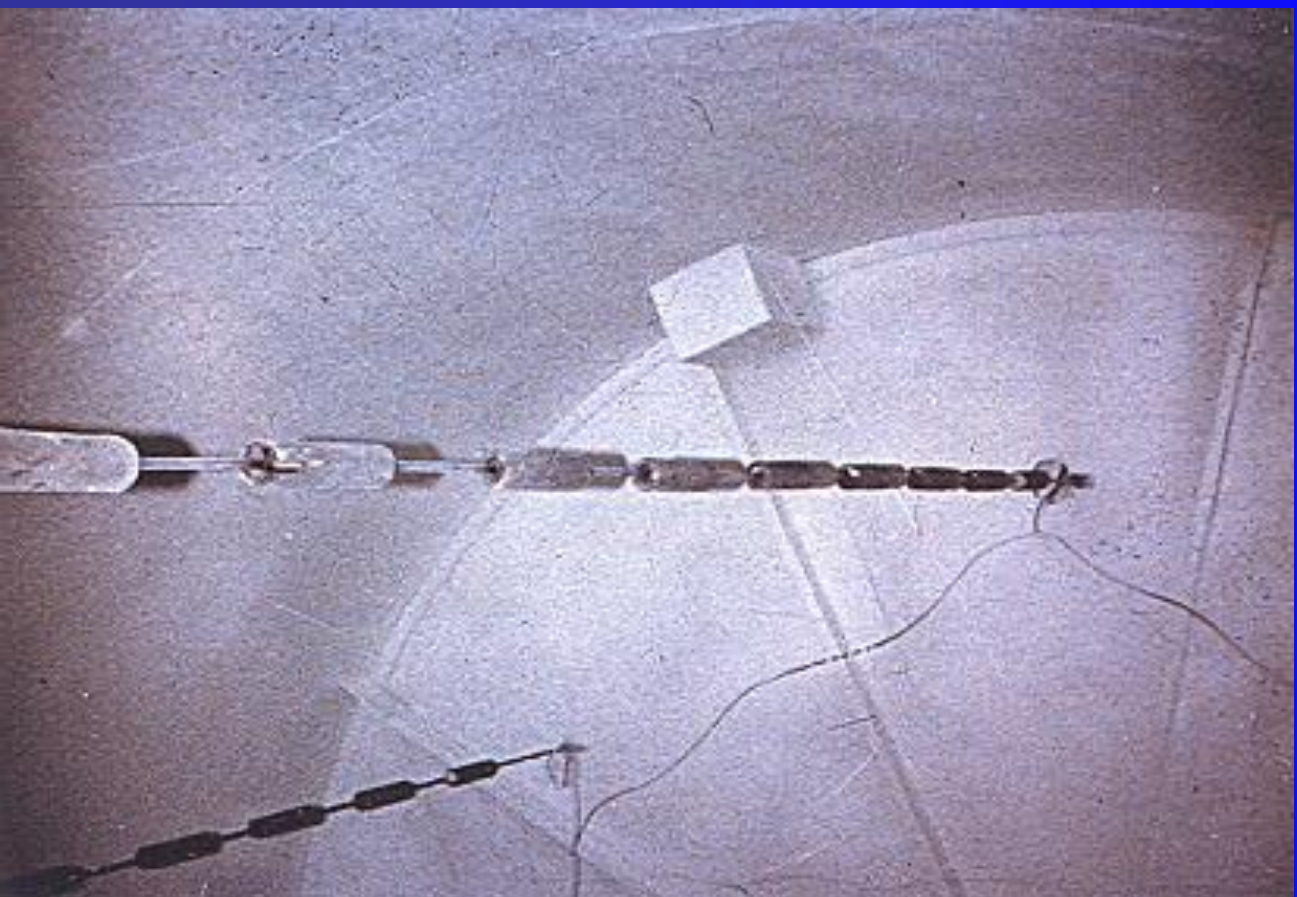




# Corrosion of Metallic Structure

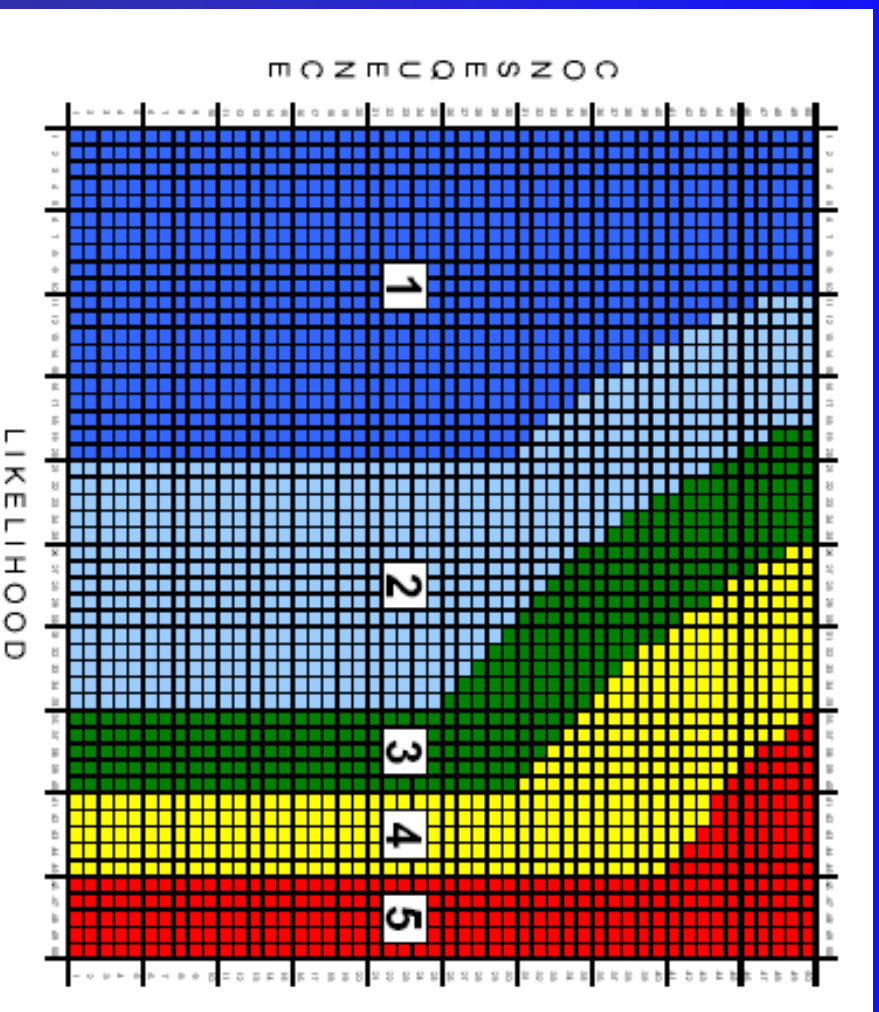


# Vertically Suspended High Silicon Cast Iron Anode String





# Design Decision Model



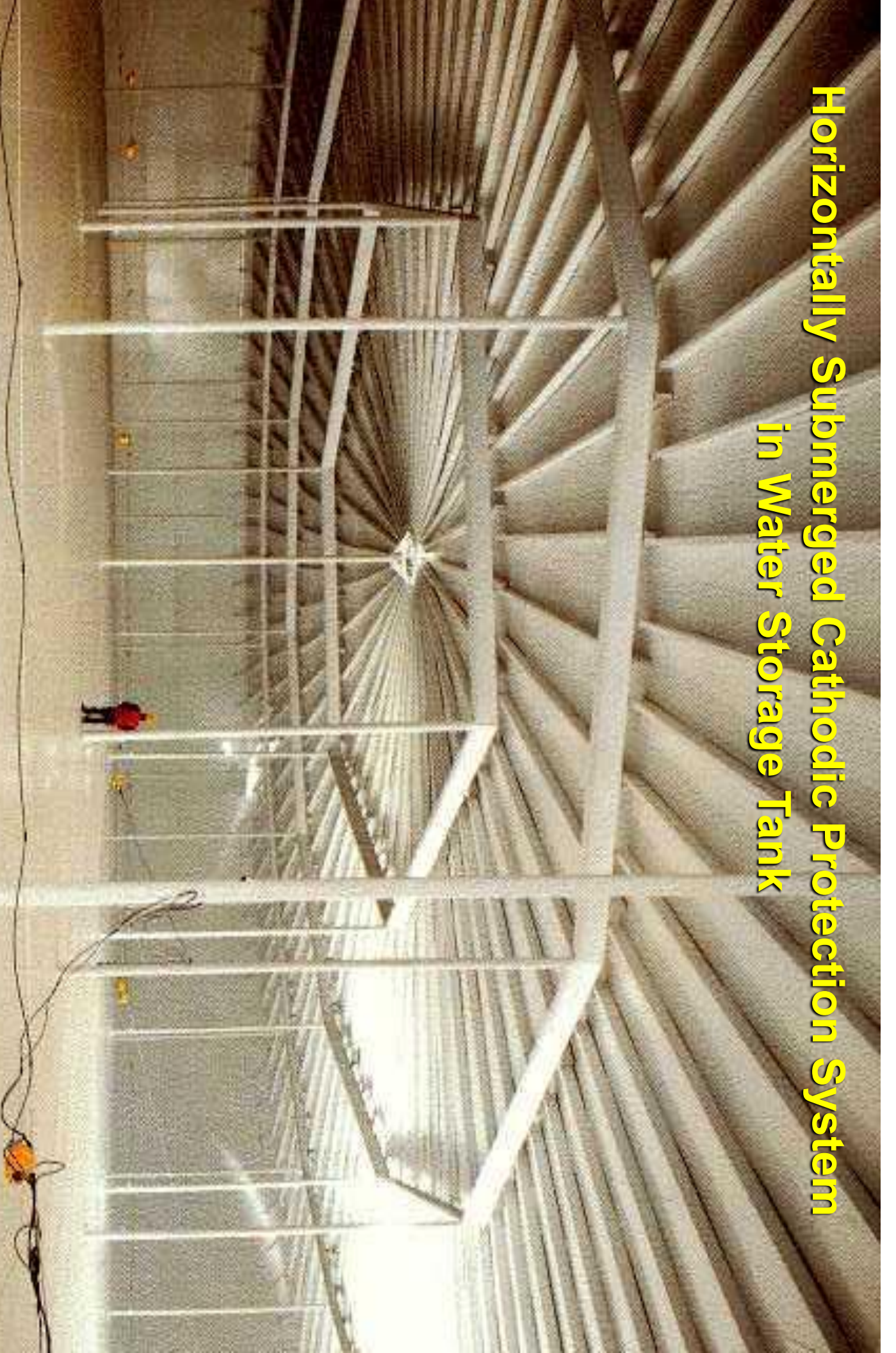
*For Ductile Iron Pipe*

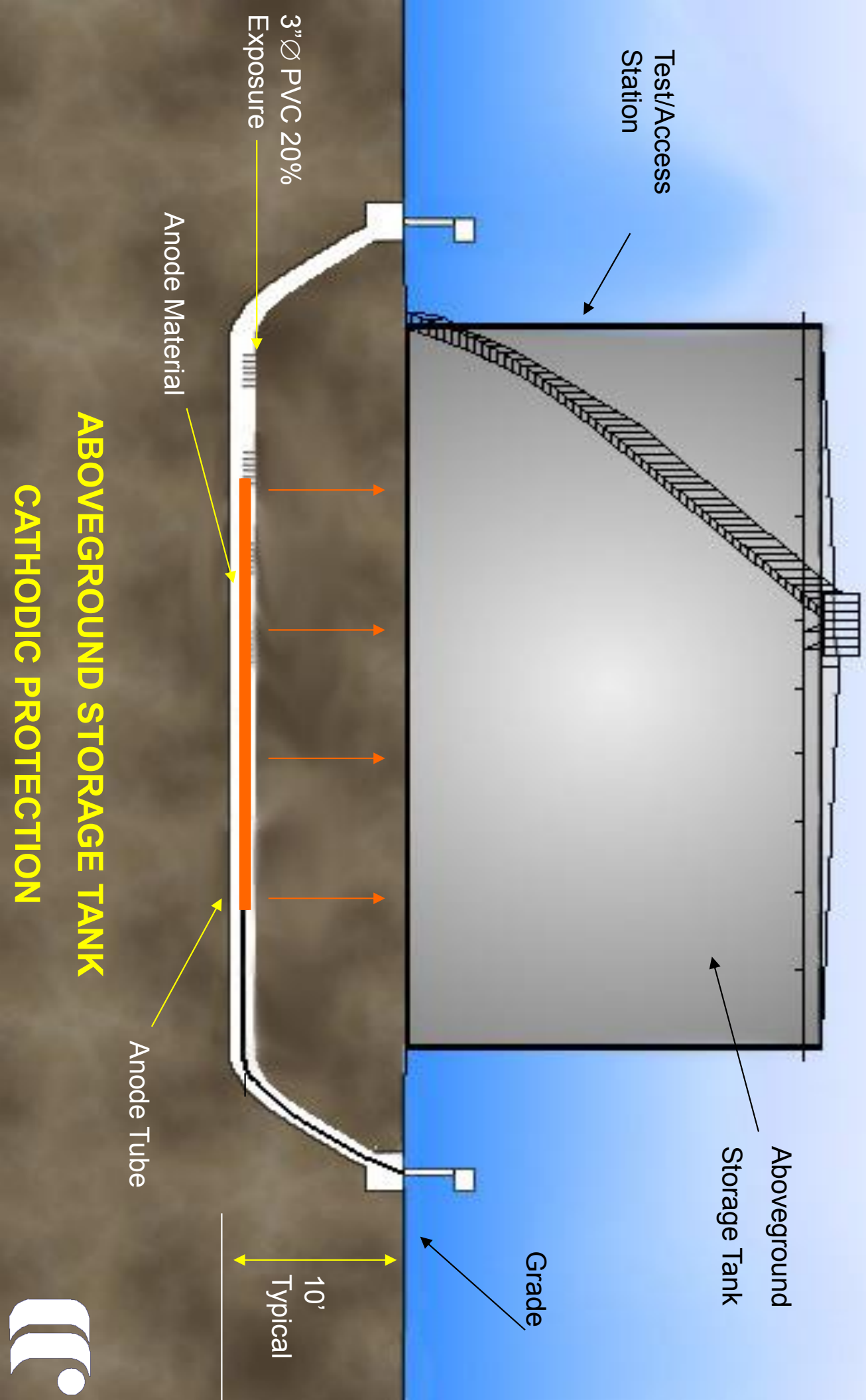


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# Horizontally Submerged Cathodic Protection System in Water Storage Tank





**ABOVEGROUND STORAGE TANK  
CATHODIC PROTECTION**





The estimated annual cost to repair  
water piping breaks in North  
America alone is estimated to be\*:

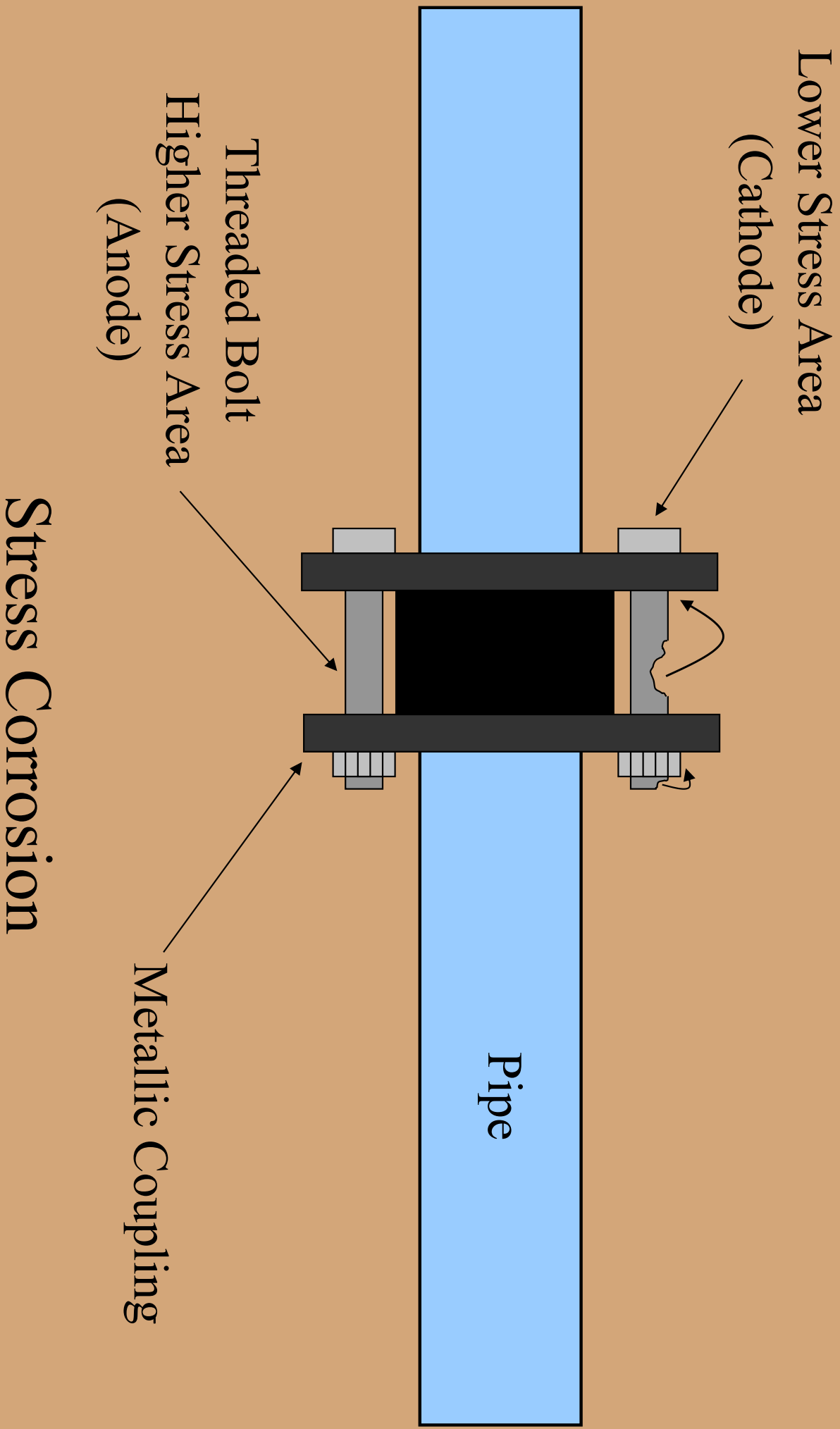
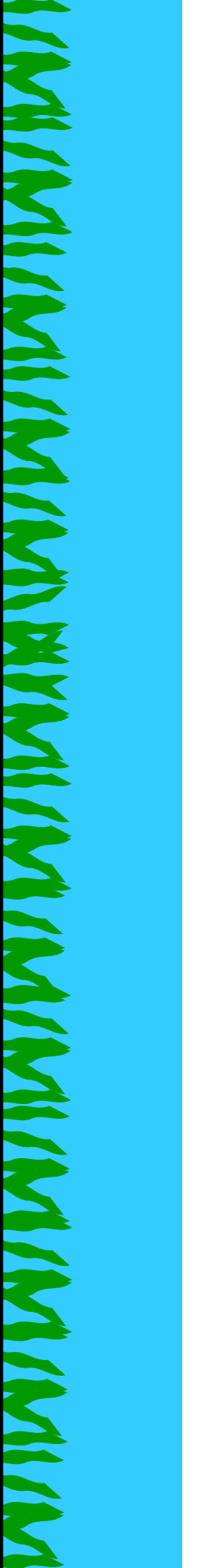
**\$1.5 Billion**

\*based on 250,000 breaks at a repair cost of \$5,875.00 U.S.D. each

**Budget Estimate for Complete  
Cathodic Protection System for  
1MMG Water Tank**

**\$12,000**





# Insituform





# Corrosion Can be Defined as Either:

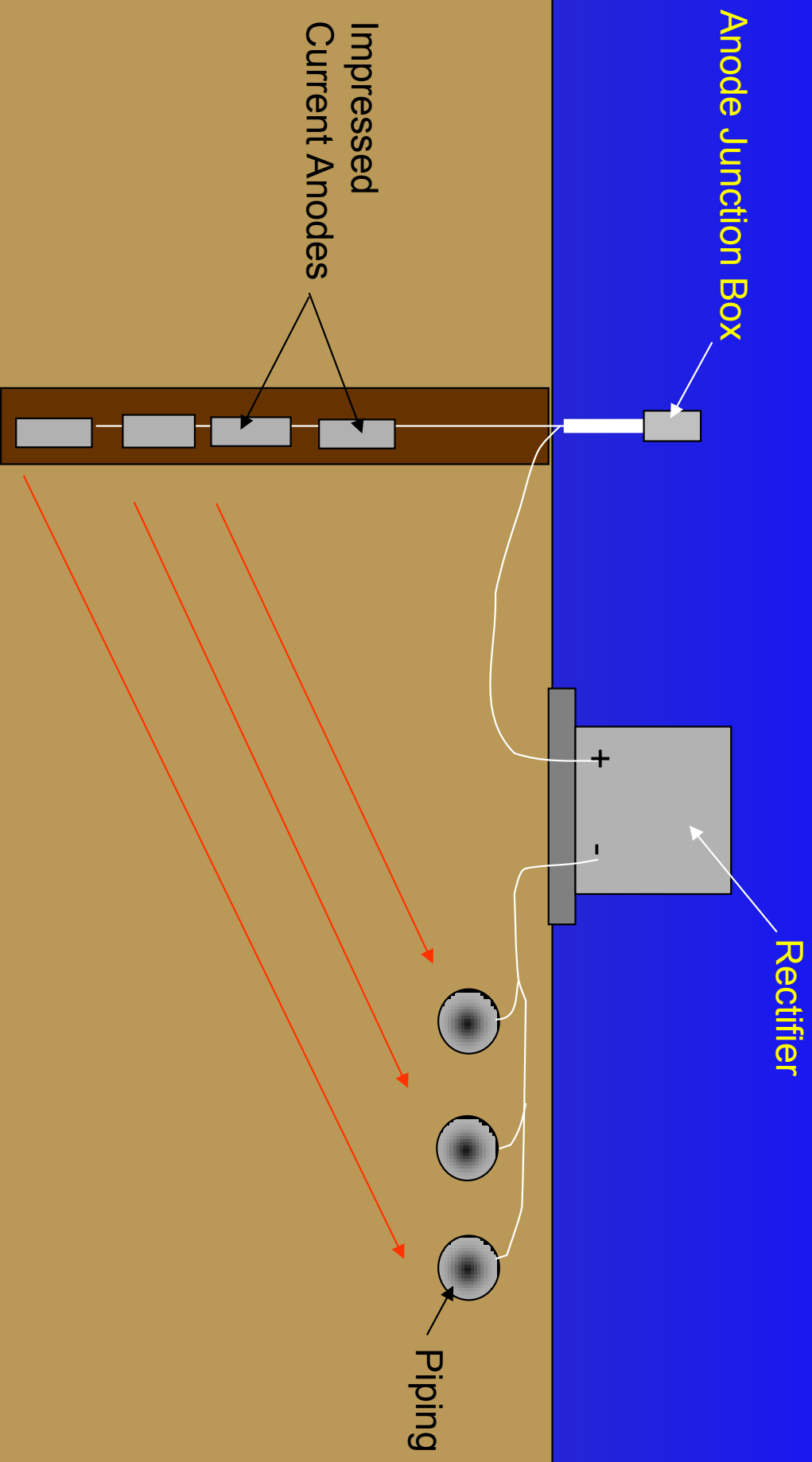
## ▶ **Practical**

Tendency of a Metal to Revert  
to its Native State

## ▶ **Scientific**

Electrochemical Degradation  
of Metal as a Result of a Reaction  
with its Environment

# Yard Piping Deep Anode Groundbed Impressed Current System









# Factory Installed Cathodic Protection Systems



# Bi-Metallic Corrosion Between Carbon Steel Tank & Stainless Steel Ladder



# *Corrosion Control for Water System Piping Results in Reduction of Water Loss*

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*<http://www.corrpro.com>*





# Repair of Break Should Include Anode Installation



**Incomplete**



**Complete**



## Annual Cathodic Protection Survey





# ***Corrosion Control for Water & Wastewater Systems***

***Presented By:***

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***<http://www.corrpro.com>***





Corrosion is the leading contributor to cast and ductile iron water system breaks!





# Bolt & Nut Corrosion

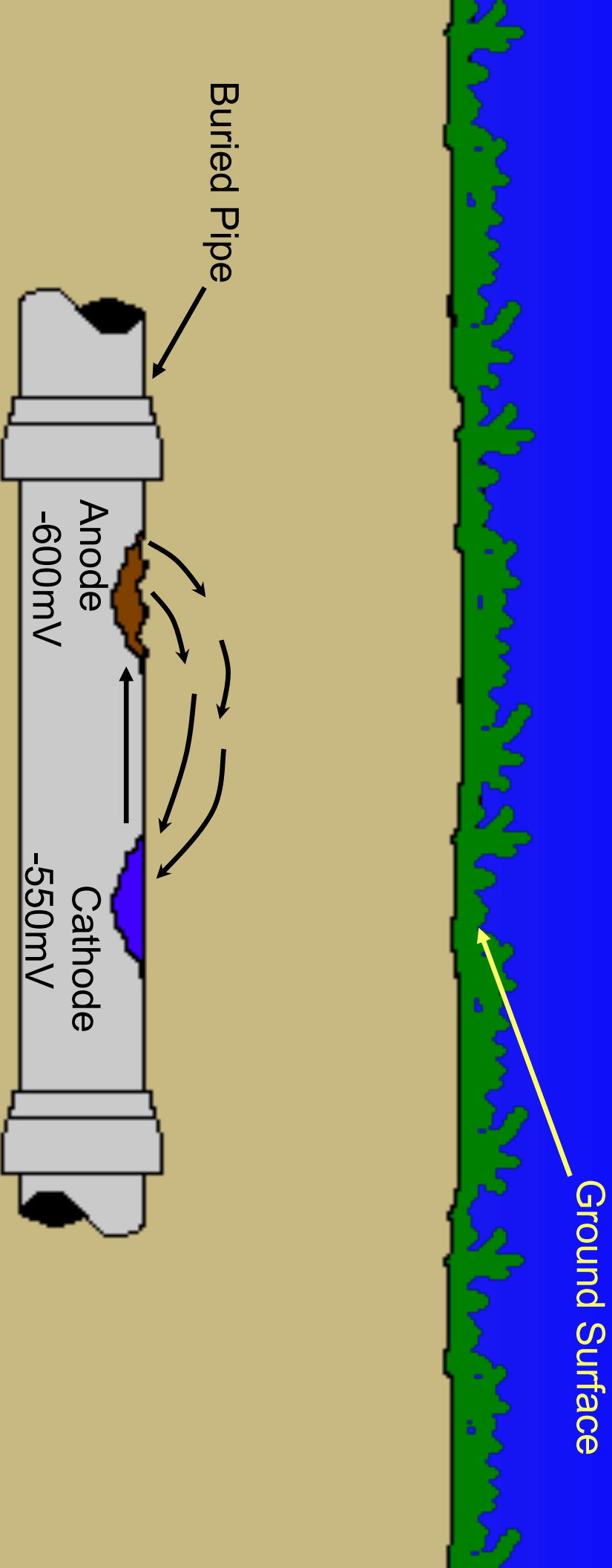


# Inspection of CP System





# Basic Corrosion Cell



- 1) Anode
- 2) Cathode
- 3) Electrolyte
- 4) Electrical Connection

# Structures

- *Piping (Distribution/Transmission)*
- *Metallic Fittings*
- *Water Storage Tanks*
- *Clarifier Units*
- *Lift Stations*



# Corrosion Can be Defined as Either:

## ▶ **Practical**

Tendency of a Metal to Revert  
to its Native State

## ▶ **Scientific**

Electrochemical Degradation  
of Metal as a Result of a Reaction  
with its Environment





# Copper Service Connections





# Anode Installation Prevents Corrosion on Copper Service Line

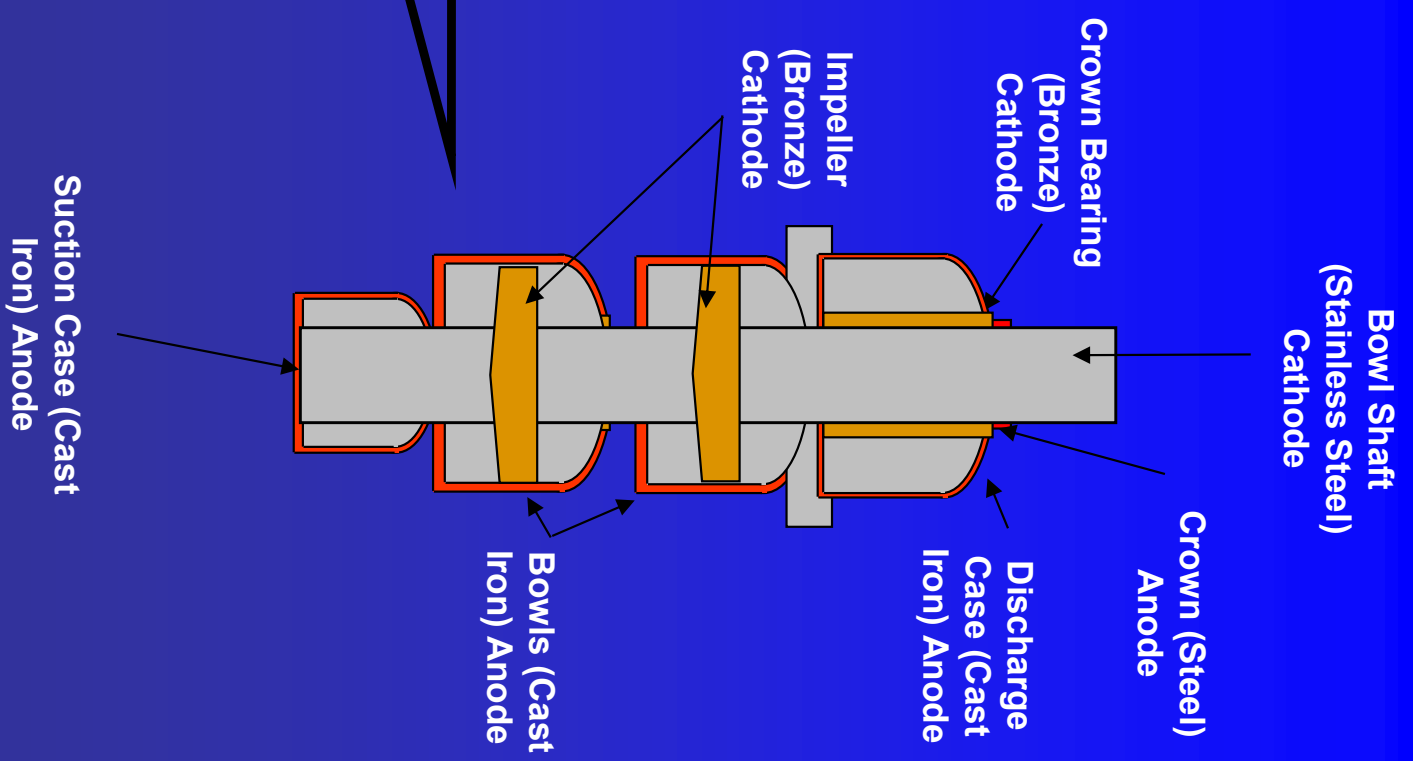
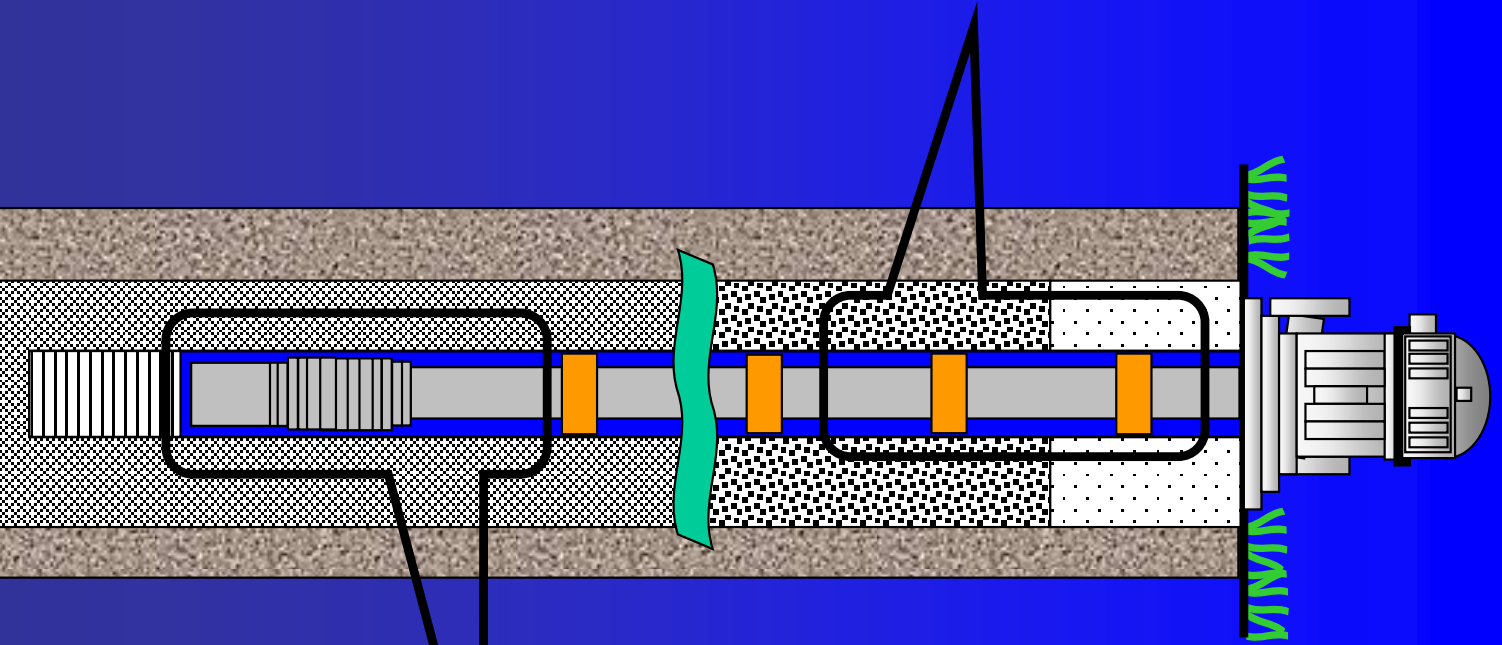
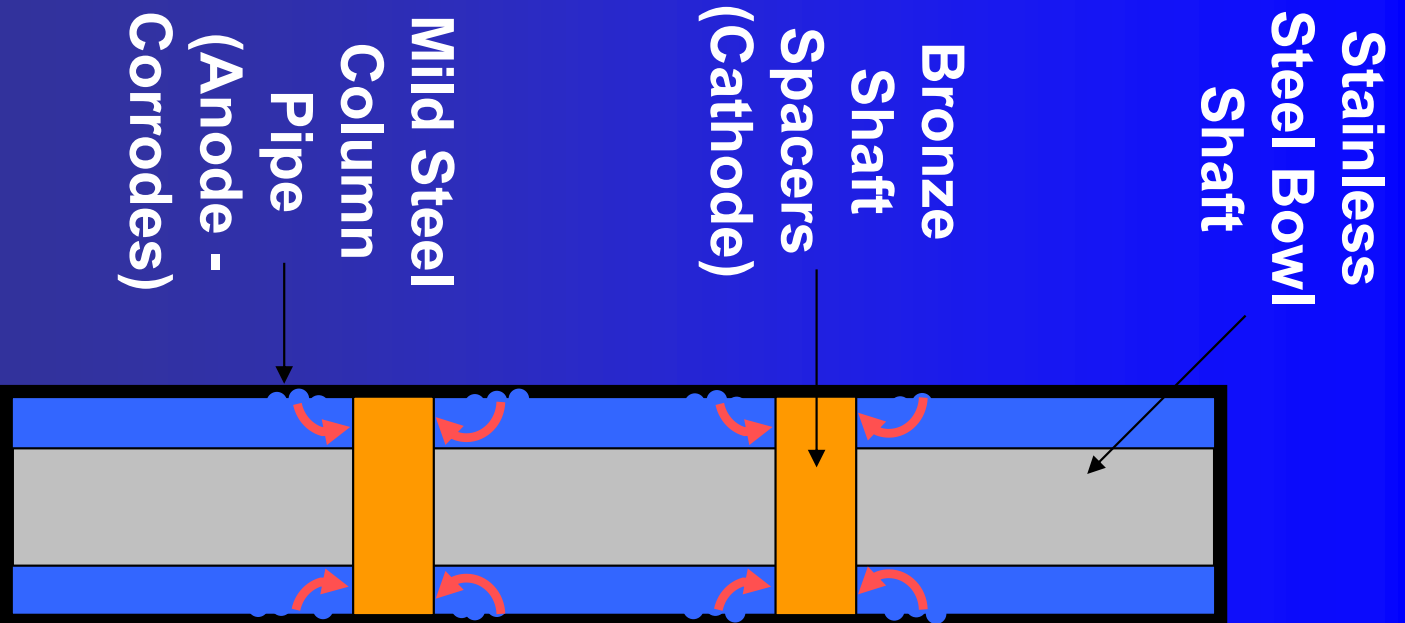
Non metallic or  
Polyethylene Encased  
Ductile Iron Main

Anode Connection to Line

Anode







# Water Wells



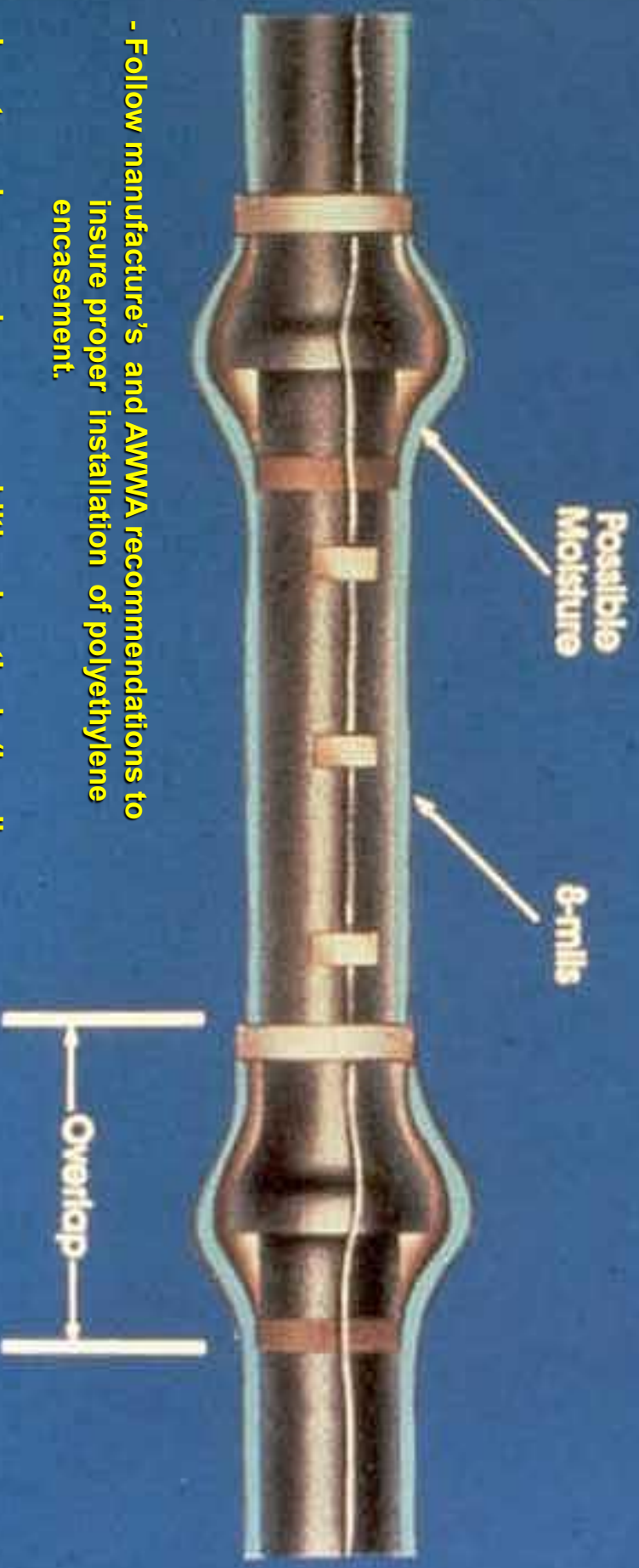


# Stainless Steel Corrosion





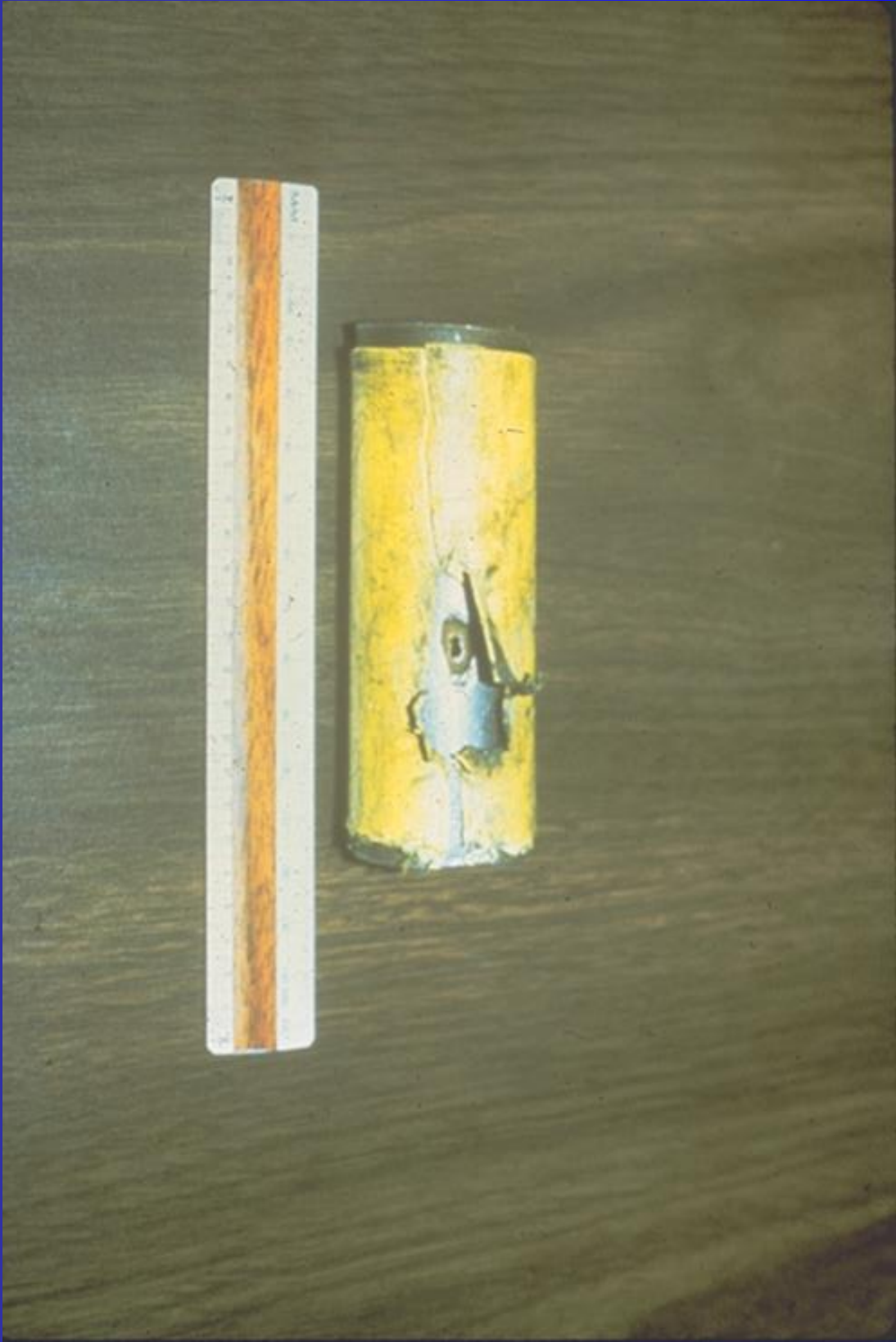
# Polyethylene Encasement



- Follow manufacturer's and AWWA recommendations to insure proper installation of polyethylene encasement.

- In extremely corrosive areas, additional methods (bonding of joints, cathodic protection, may be required).









# History of Iron Pipe

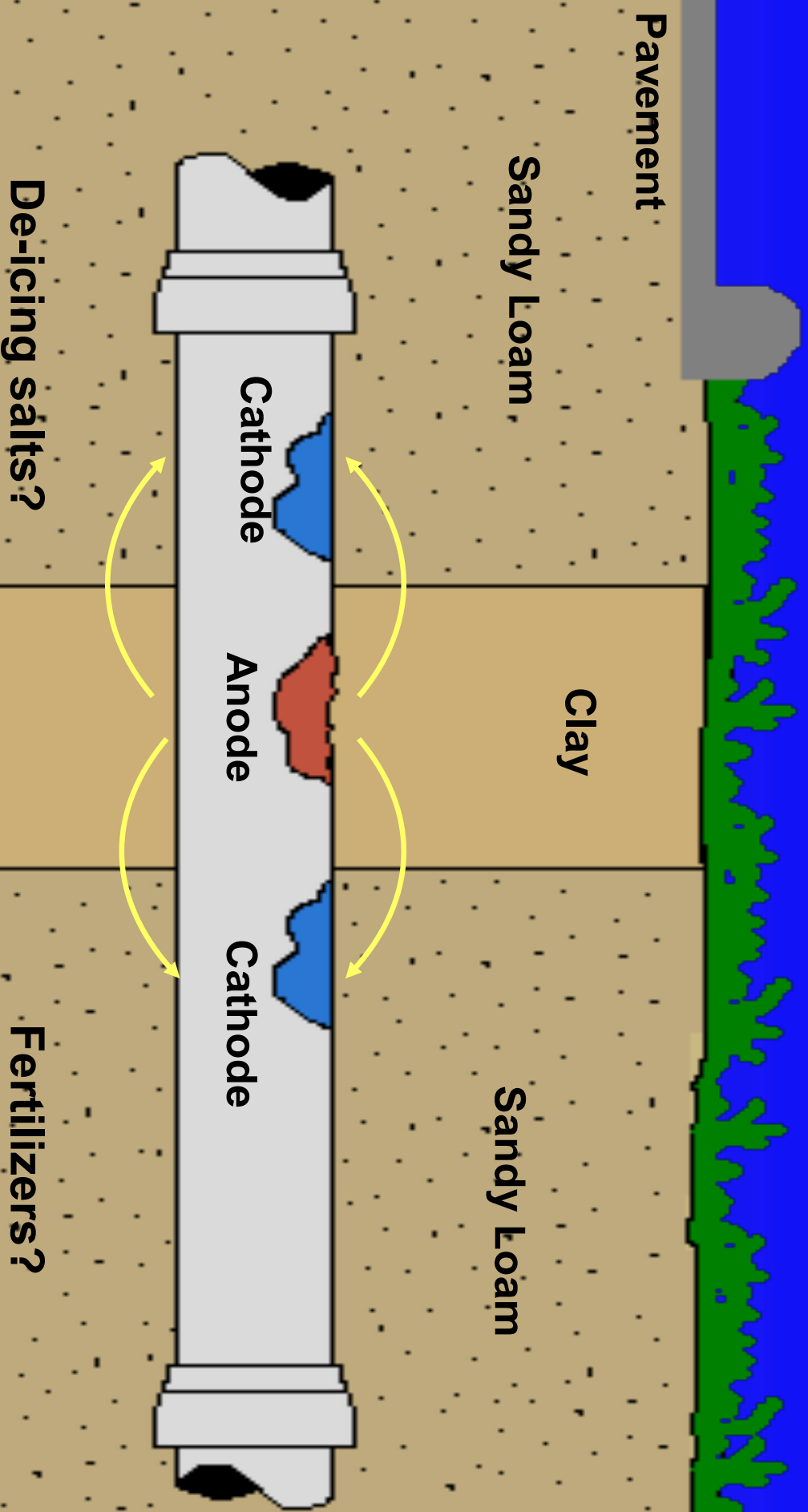
## Cast Iron

- Introduced to North America during the 1800's and installed till the 1970's.
- Early on, statically cast process produced a thick walled, heavy pipe.
- No longer produced in North America.

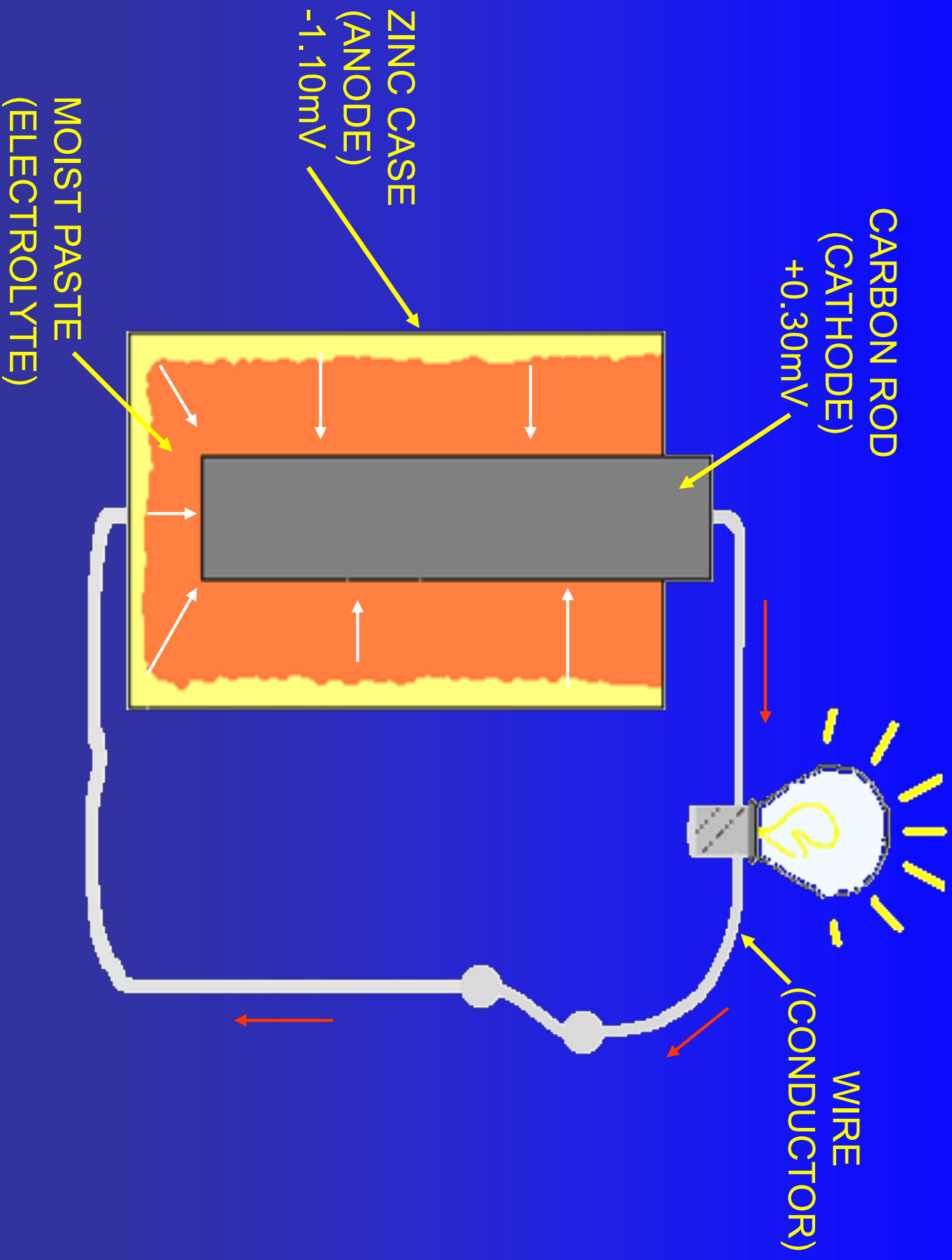
## Ductile Iron

- Introduced in 1955 as an improvement to cast iron.
- Centrifugal casting process produces a thinner walled, lighter pipe which is stronger and more ductile than cast iron.

# Dissimilar Soils









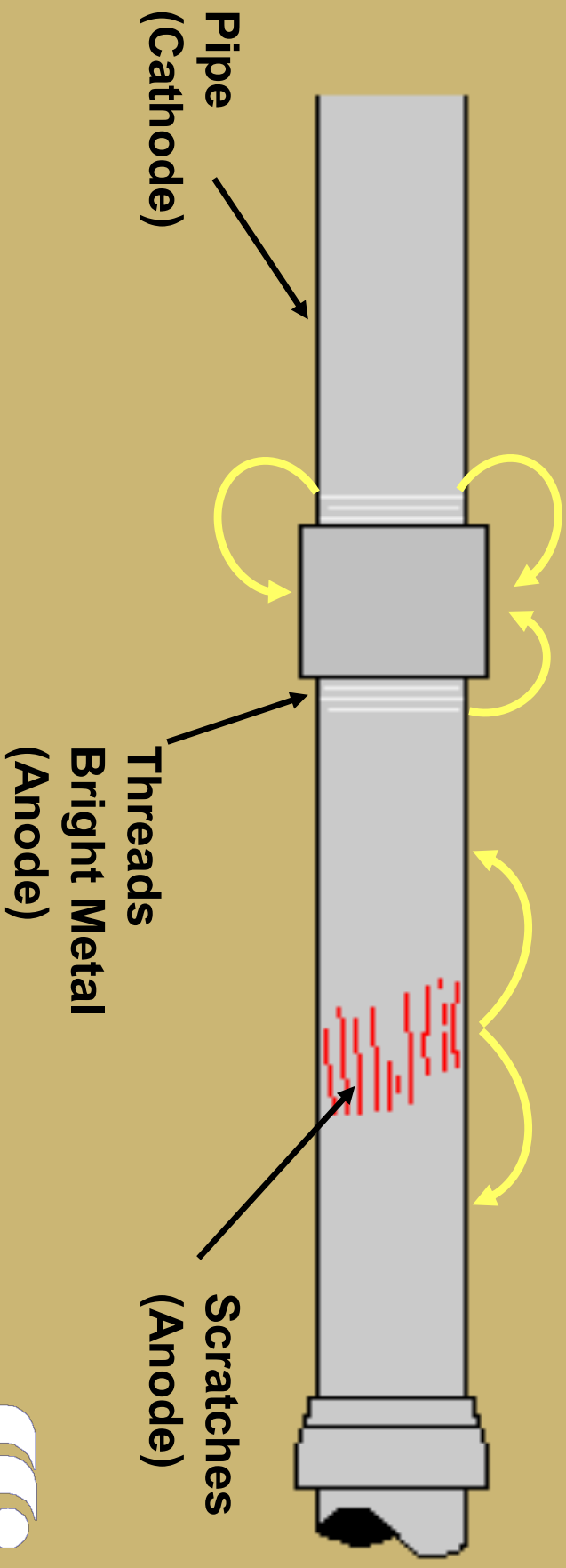
Corrosion of iron when coupled to copper service line.



# Corrosion Pitting

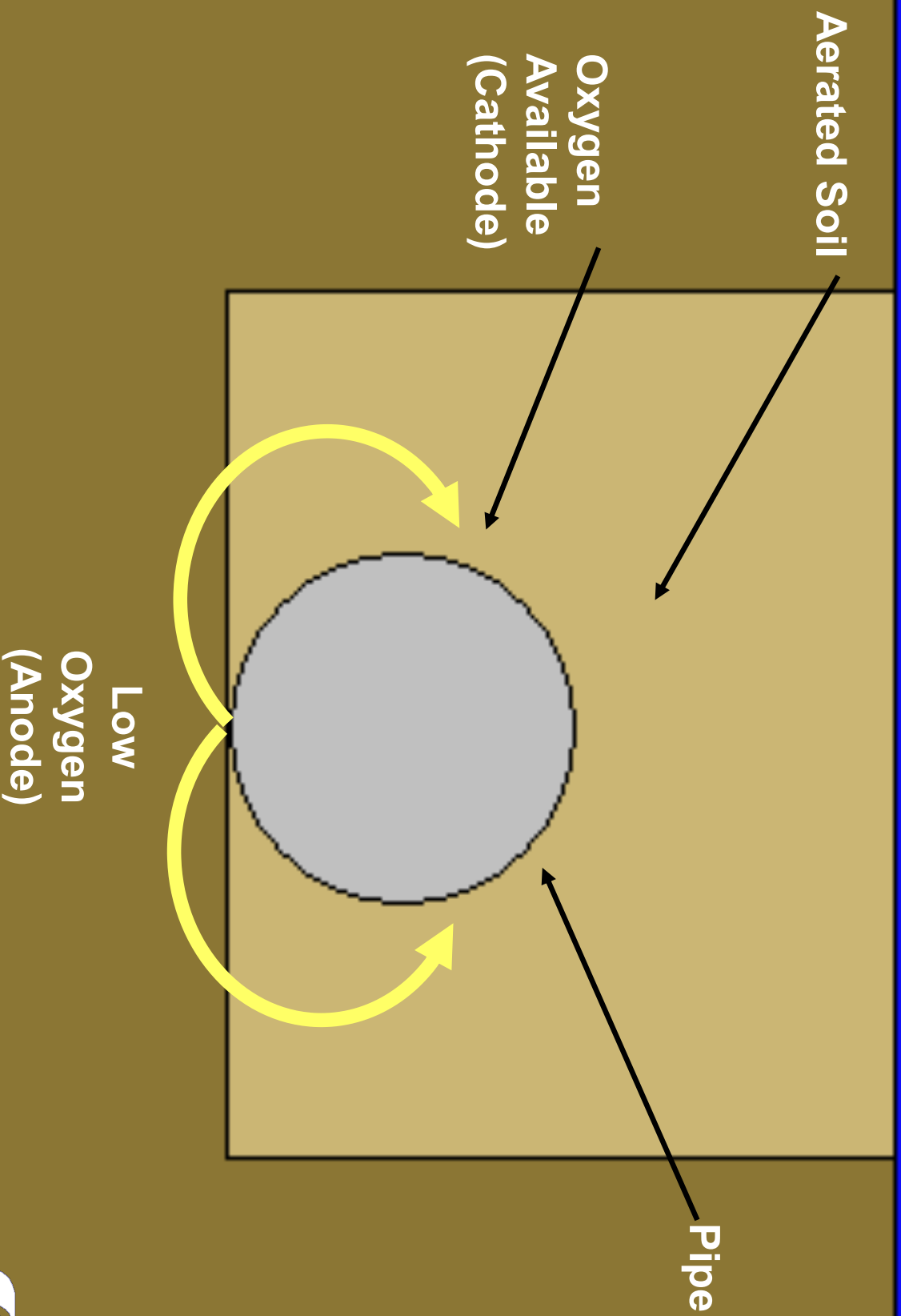


# Dissimilar Surface Conditions



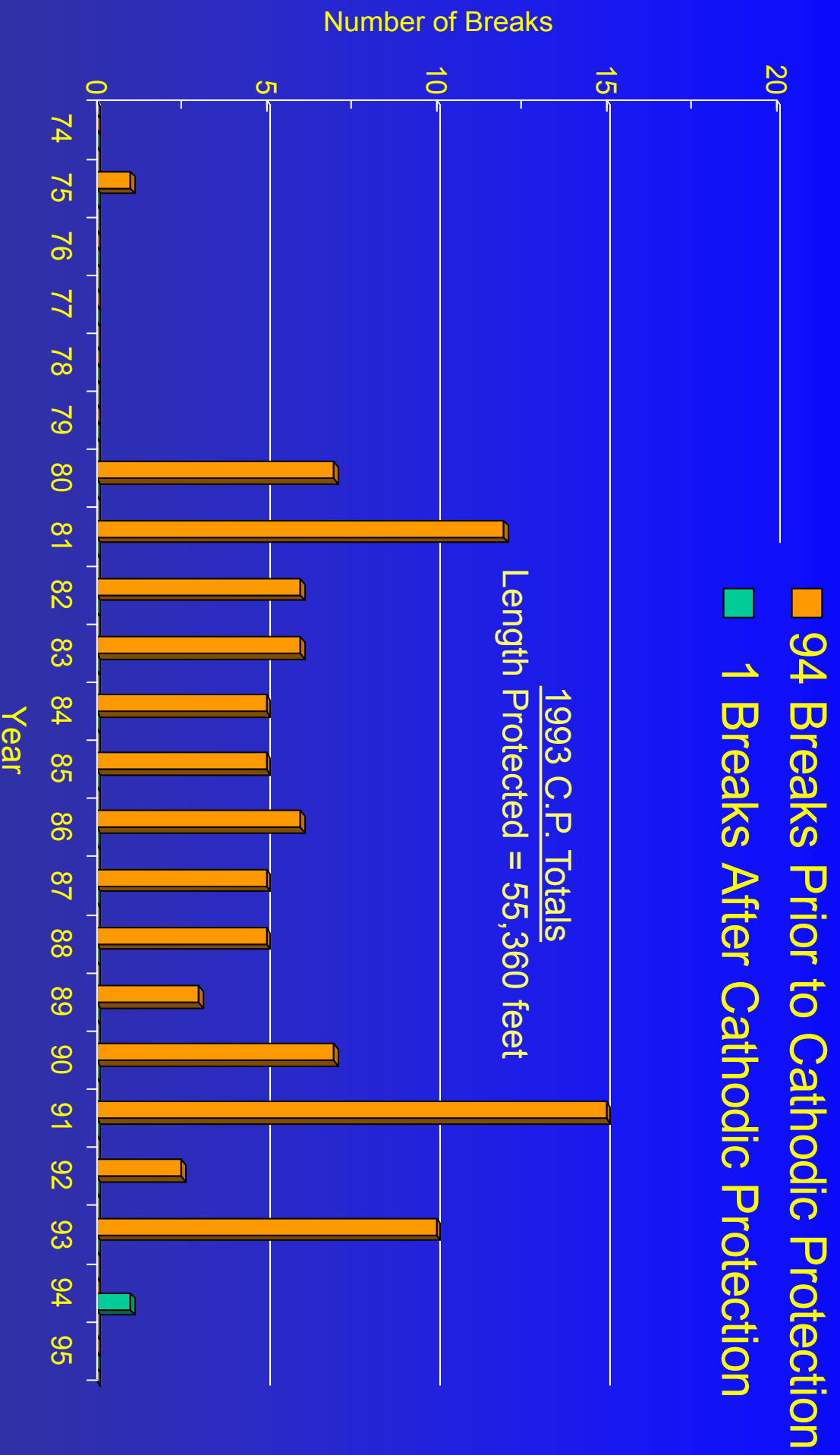


# Corrosion Caused by Differential Aeration

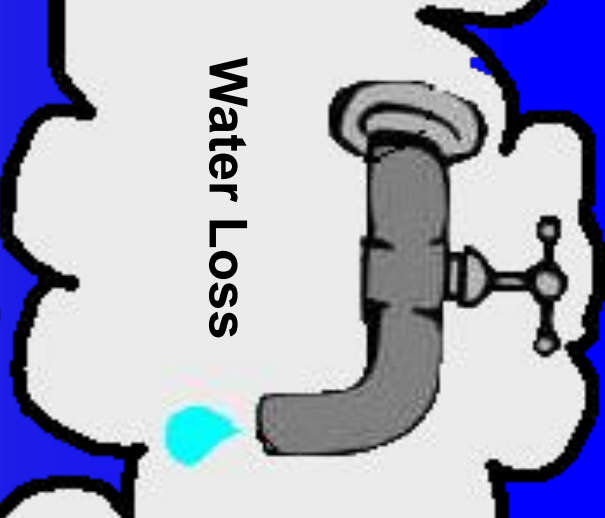
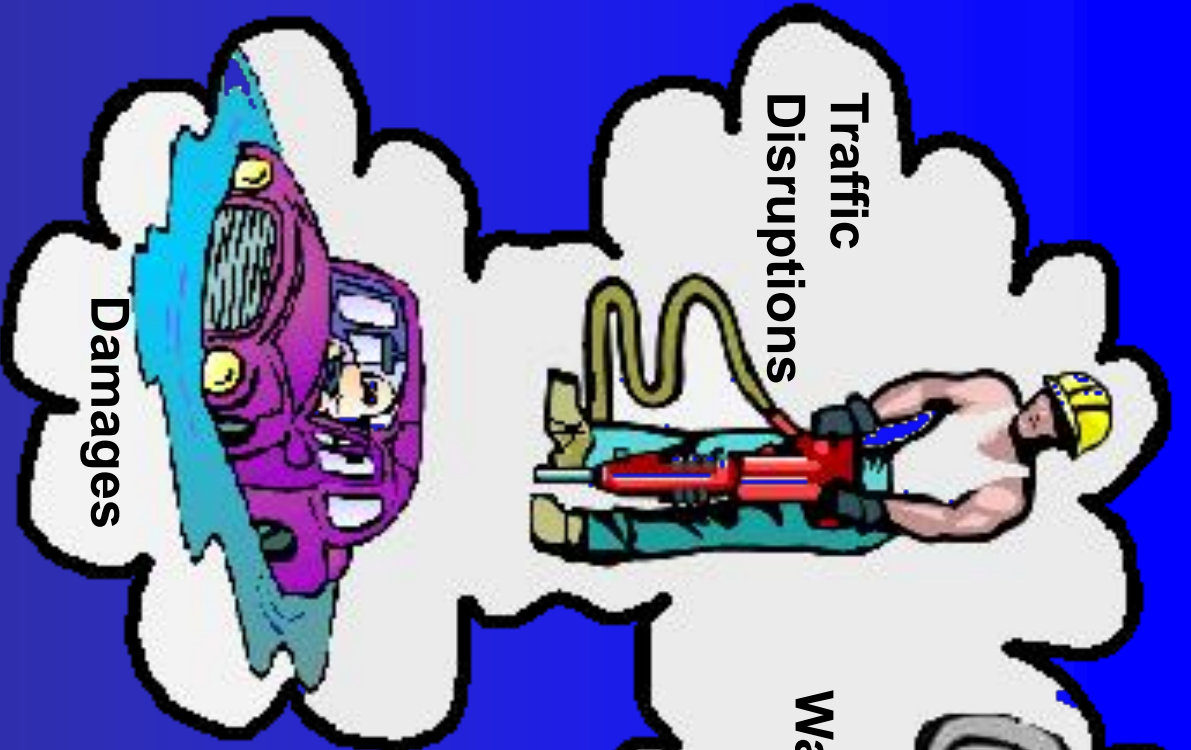








## Break Records for Water Mains Cathodically Protected in 1993





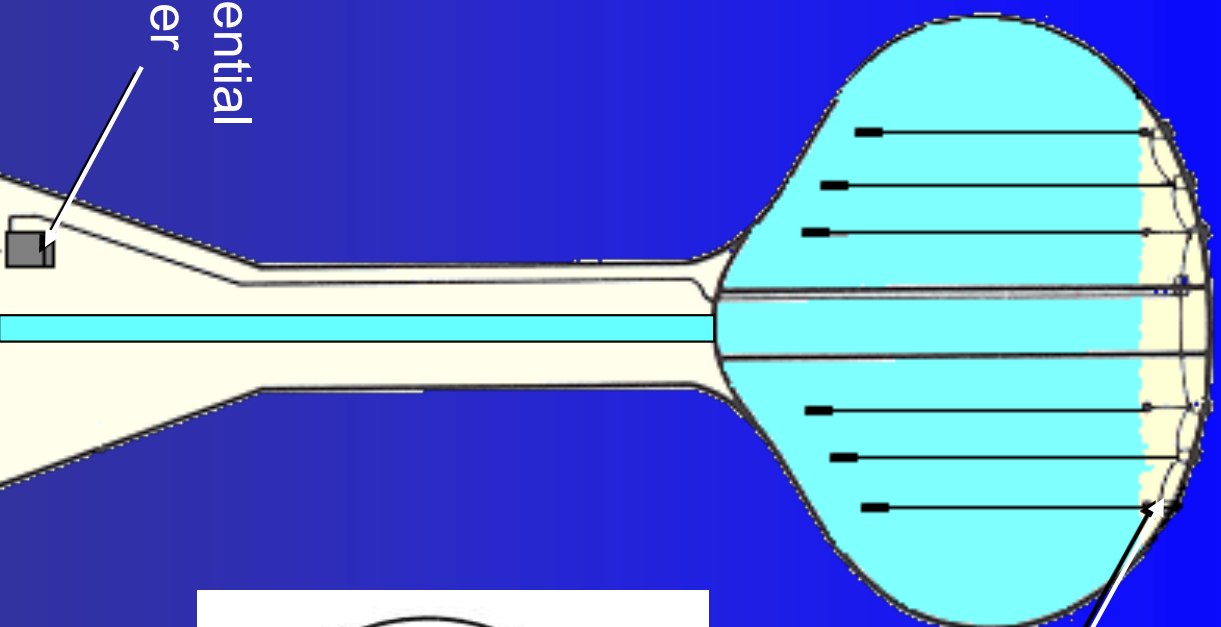


Corrosion on damaged polyethylene encased pipe.

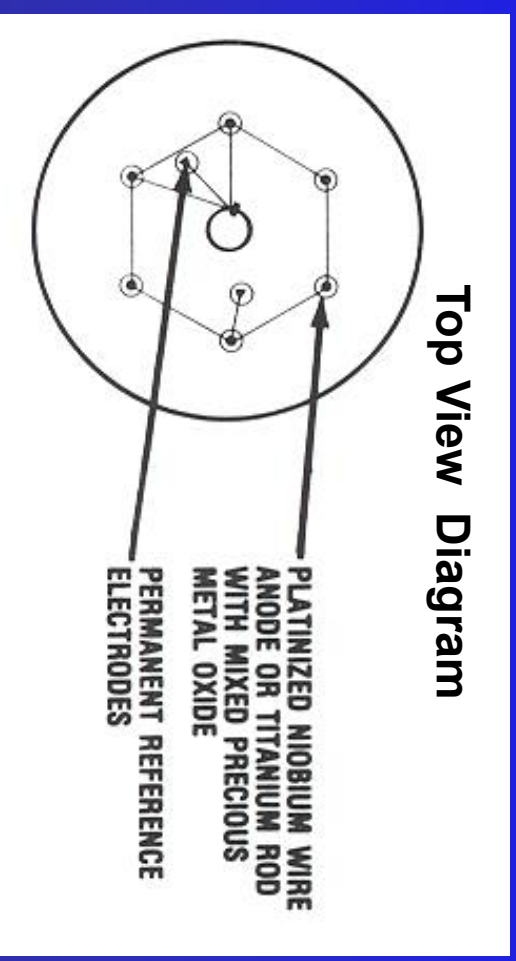


Corrosion of pre-stressed concrete cylinder pipe (P.C.C.P.).

# Suspended Vertical Anode System



Support System Bolted to Roof for Bowl Anodes and Reference Electrodes



Automatic Potential Control Rectifier









# Corrosion



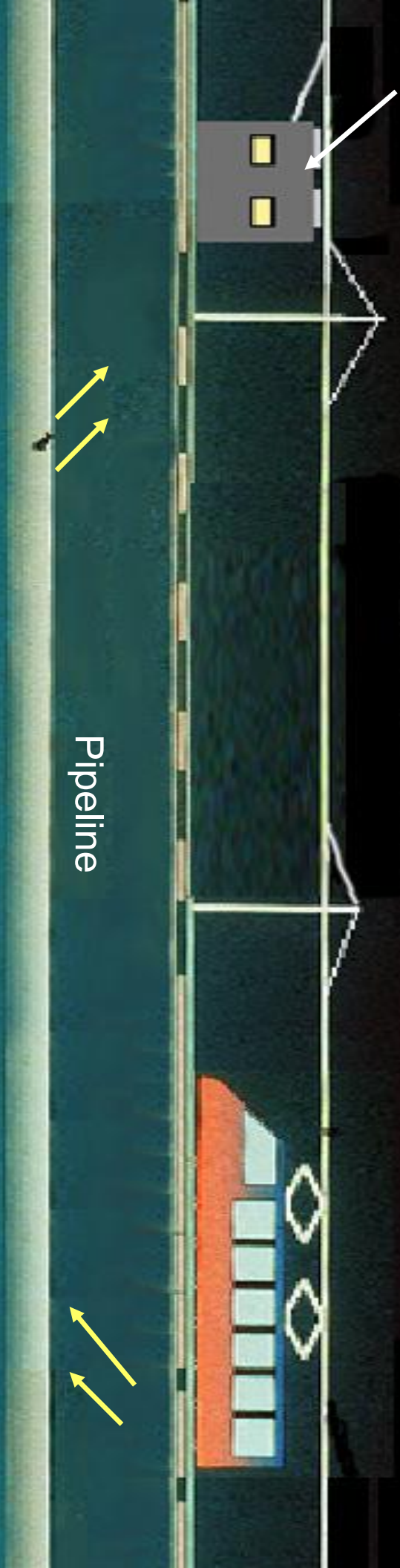
# PCCP Failure





# Stray Current by DC Operated Transit Systems

Power  
Station



Pipeline

Current exit (Anode)

Current entrance (Cathode)







Pre-stressed Concrete Cylinder Pipe (PCCP)



# *Give Me a Break* *Fundamentals of Pipeline Corrosion*



*Presented By:*

*James T Lary*

*Corrpro*

*1090 Enterprise Dr.*

*Medina, OH 44256*

*Tel. 330-723-5082 (x1215)*

*email: [jlary@corrpro.com](mailto:jlary@corrpro.com)*

*<http://www.corrpro.com>*

# **CORRPRO®**



# *Corrosion Control & Cathodic Protection of Water & Wastewater Systems*



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*James T Lary*

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*Medina, OH 44256*

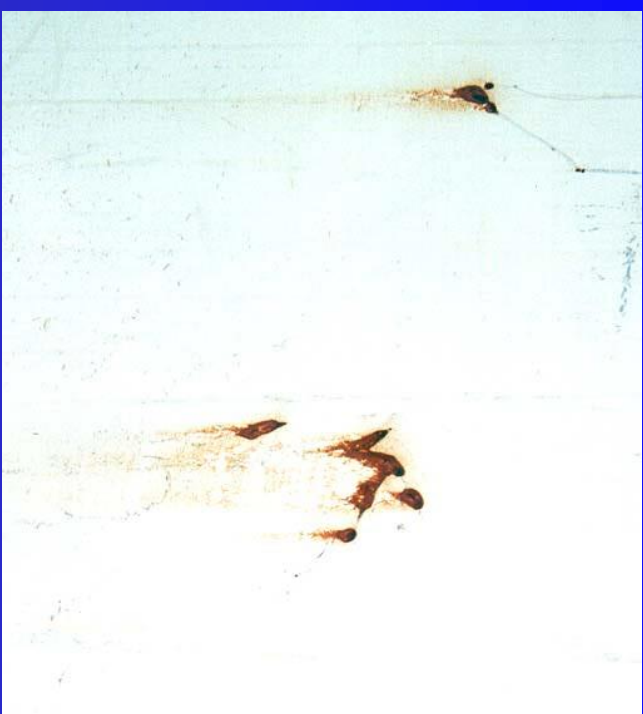
*Tel. 330-723-5082 (x1215)*

*email: [jlary@corrpro.com](mailto:jlary@corrpro.com)*

*<http://www.corrpro.com>*



# Coating Flaws (Holidays)





# Pipeline Inspection Report

Inspector name \_\_\_\_\_ Date \_\_\_\_\_ Address of pipeline inspection \_\_\_\_\_ Leak? Yes \_\_\_ No \_\_\_ File Number: \_\_\_\_\_

1) Type of Pipe: cast iron \_\_\_ ductile iron \_\_\_ carbon steel \_\_\_ copper \_\_\_ carbon steel \_\_\_ non metallic \_\_\_ other \_\_\_

2) Diameter of pipe \_\_\_\_\_ Pipeline Name \_\_\_\_\_ Service Type: Water \_\_\_ Wastewater \_\_\_ Estimated date of pipe installation \_\_\_\_\_ Depth of pipe \_\_\_\_\_

3) Type of Pipe: Distribution \_\_\_ Transmission \_\_\_ Service \_\_\_ Hydrant \_\_\_ Mechanical joint \_\_\_ Fasteners \_\_\_ Other \_\_\_ Unknown \_\_\_

4) Type of Coating: Polyethylene Encased \_\_\_ Shop applied coating \_\_\_ No Coating \_\_\_ Tape Wrap \_\_\_ Unable to determine \_\_\_

5) External Pipe Condition: Very Good \_\_\_ Good \_\_\_ Poor \_\_\_ comments: \_\_\_\_\_

6) Is corrosion pitting evident? Yes \_\_\_ No \_\_\_ Number of Pits \_\_\_\_\_ Typical Size of Pits \_\_\_\_\_ Quantity of pits: \_\_\_\_\_

7) Is graphitization evident (longitudinal or circumferential breaks) Yes \_\_\_ No \_\_\_ Residential area \_\_\_ Rural area \_\_\_ Near street or road \_\_\_

8) Is the pipe installed in (check off appropriate items): Industrial area \_\_\_ Residential area \_\_\_ Rural area \_\_\_ Near street or road \_\_\_  
Near creek or waterway \_\_\_ In reclaimed land \_\_\_ Near oil or gas pipelines \_\_\_ Near high voltage lines \_\_\_

8) Describe soil conditions where inspection occurred: wet \_\_\_ dry \_\_\_ clay soil \_\_\_ rocky soil \_\_\_ cinders \_\_\_ other \_\_\_\_\_

9) Where soil samples obtained, sealed and analyzed for chlorides, moisture content, pH, sulfides, resistivity? If yes results were: \_\_\_\_\_

10) Were previous repairs made on the pipeline (leak clamps, etc) Yes \_\_\_ No \_\_\_ Was new pipe installed Yes \_\_\_ No \_\_\_

11) Was a repair clamp installed on the pipe during inspection Yes \_\_\_ No \_\_\_

12) Was a galvanic anode installed as part of the inspection process? Yes \_\_\_ No, if yes size and quantity \_\_\_\_\_

13) Please relay additional comments: \_\_\_\_\_

14) Plan of Action \_\_\_\_\_

15) Insert digital photos below:

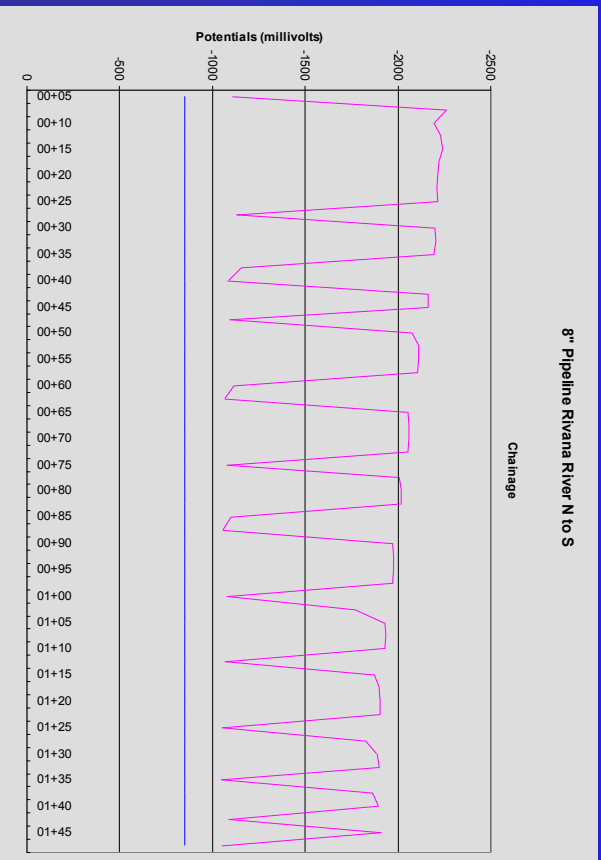




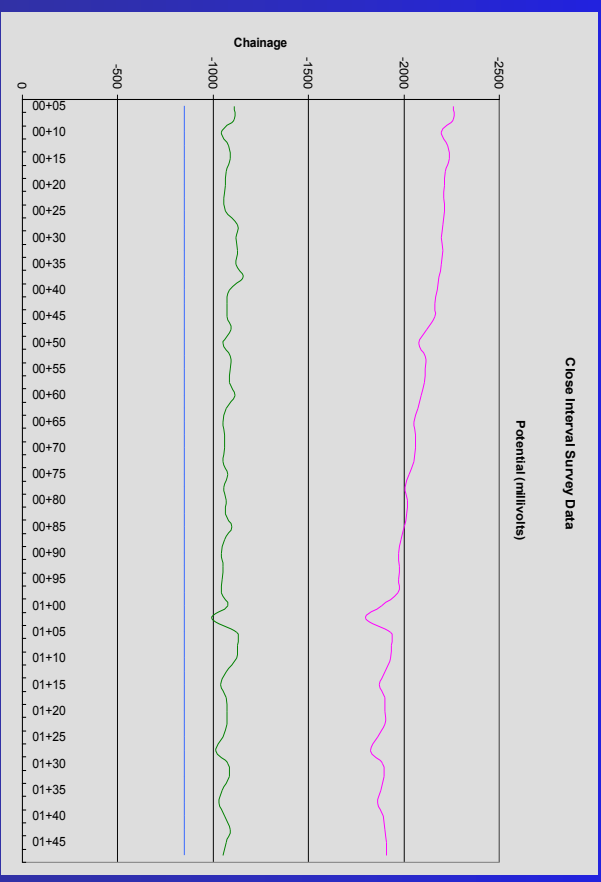
# CIS Survey



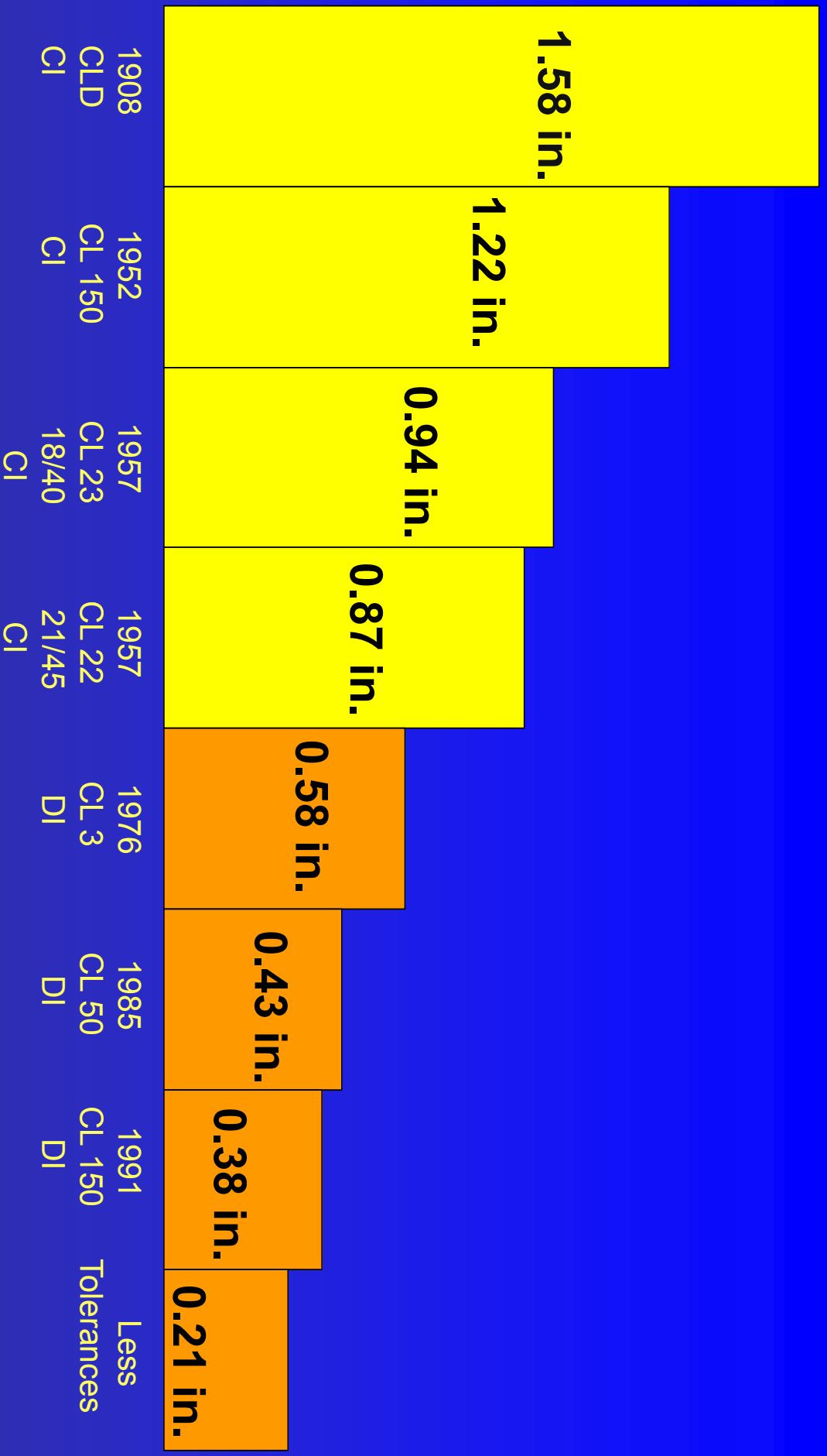
8" Pipeline Rivana River N to S



Close Interval Data  
Interrupted Survey

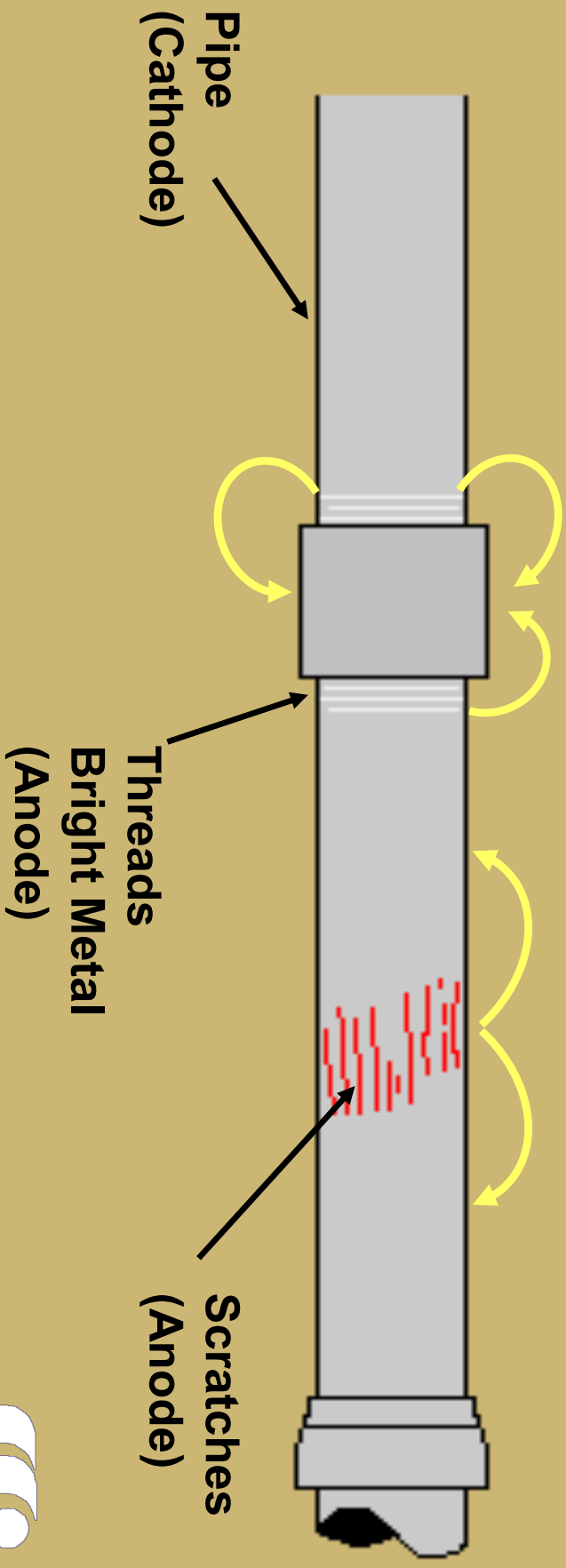


Close Interval Data  
PG/WFA Survey



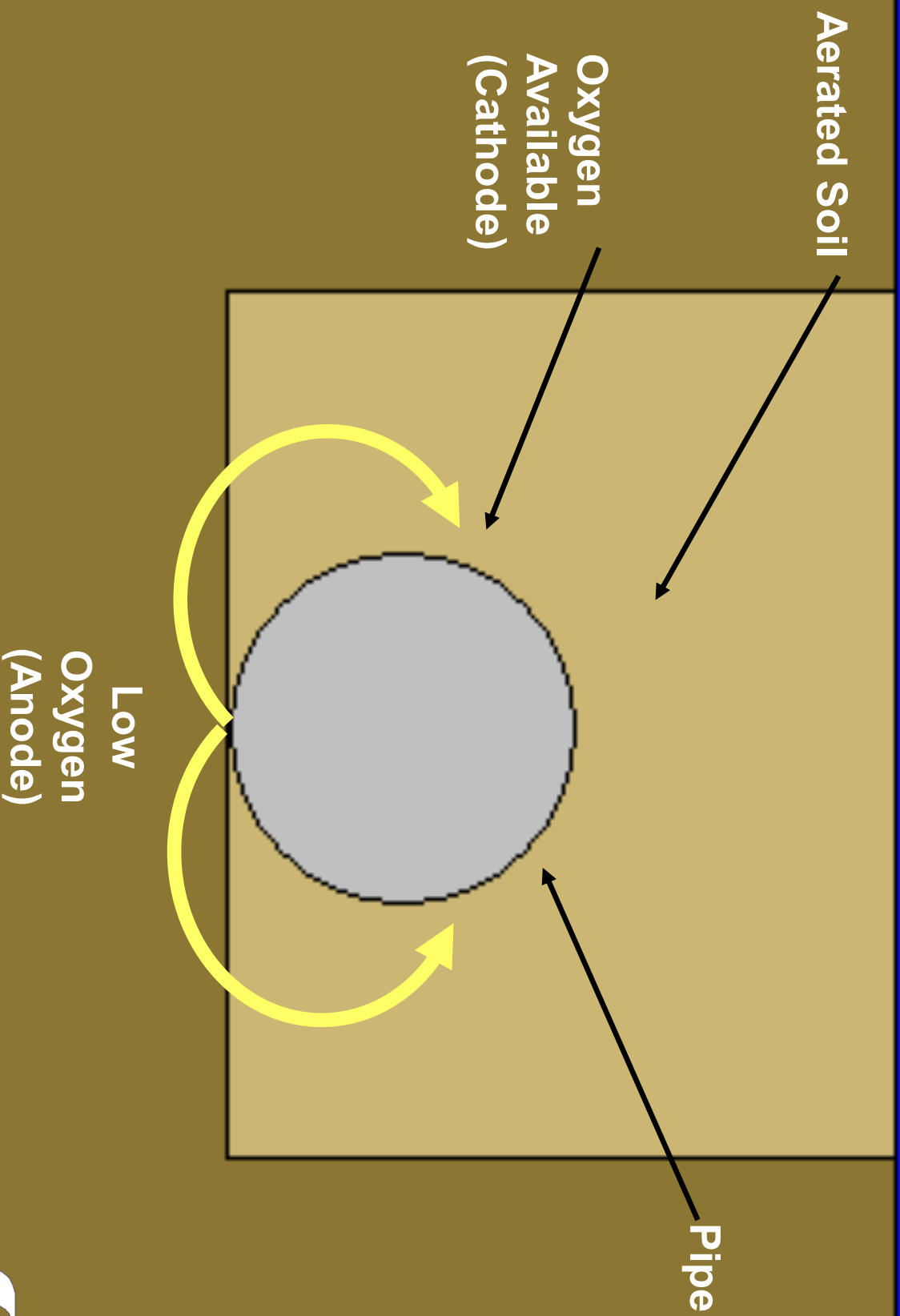
Actual size of AWWA Specification Thickness Reductions for 36-inch Diameter Cast and Ductile Iron Pipe - 1908 to Present (150 PSI Operating pressure)

# Dissimilar Surface Conditions





# Corrosion Caused by Differential Aeration



# Coating Flaws (Holidays)



# Meter Vaults



*(Keep dry if possible)*



# Water Wells



# Galvanic Anode on Polyethylene Encased Ductile Iron Pipe

