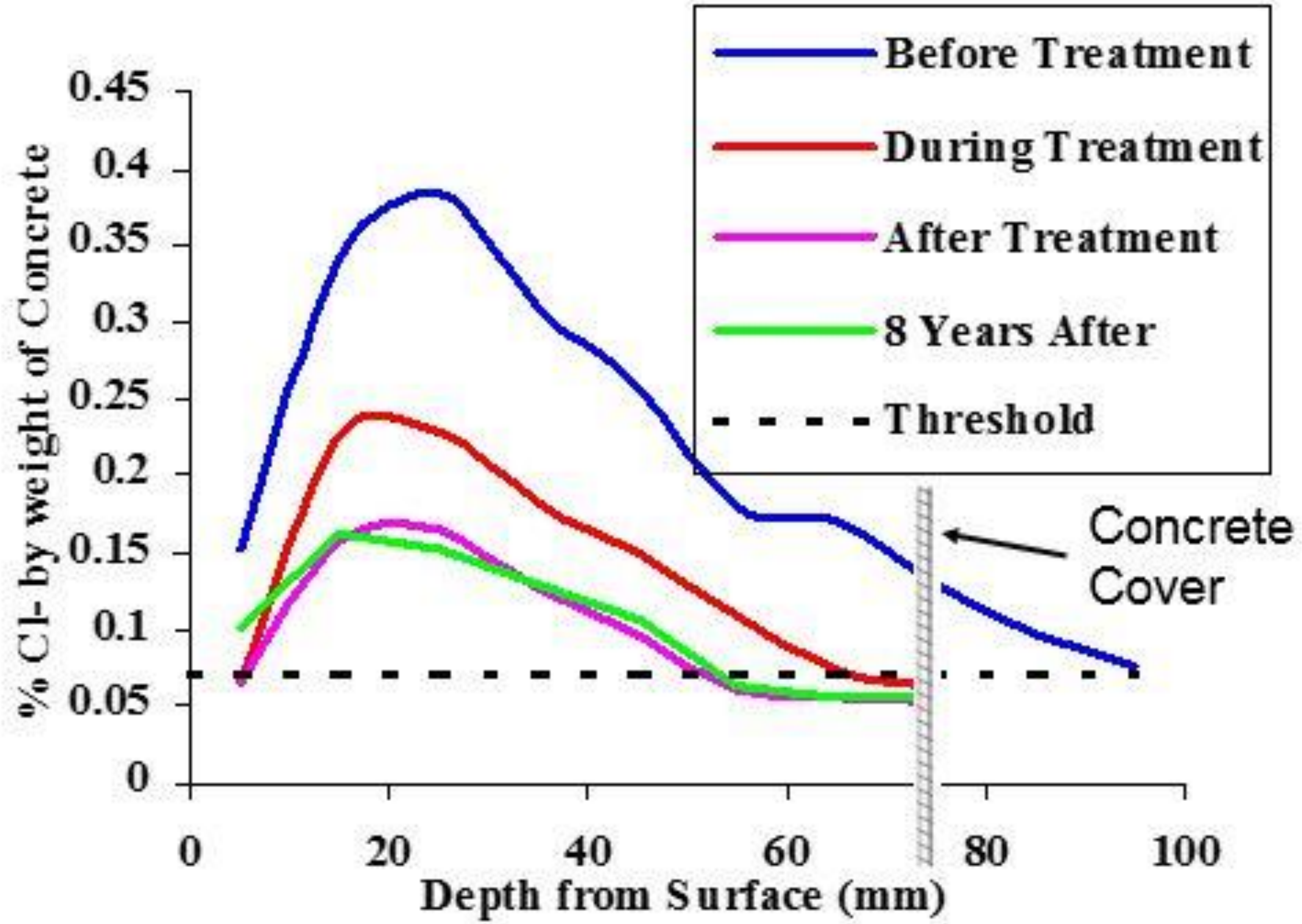
Carolyn Hansson: Contribution to Electrochemical Chloride Extraction, Etc.

Dave Whitmore
Vector Corrosion Technologies

Burlington Skyway
Ontario Ministry of Transportation
Burlington, ON Canada

1989: First Application of Electrochemical Chloride Extraction

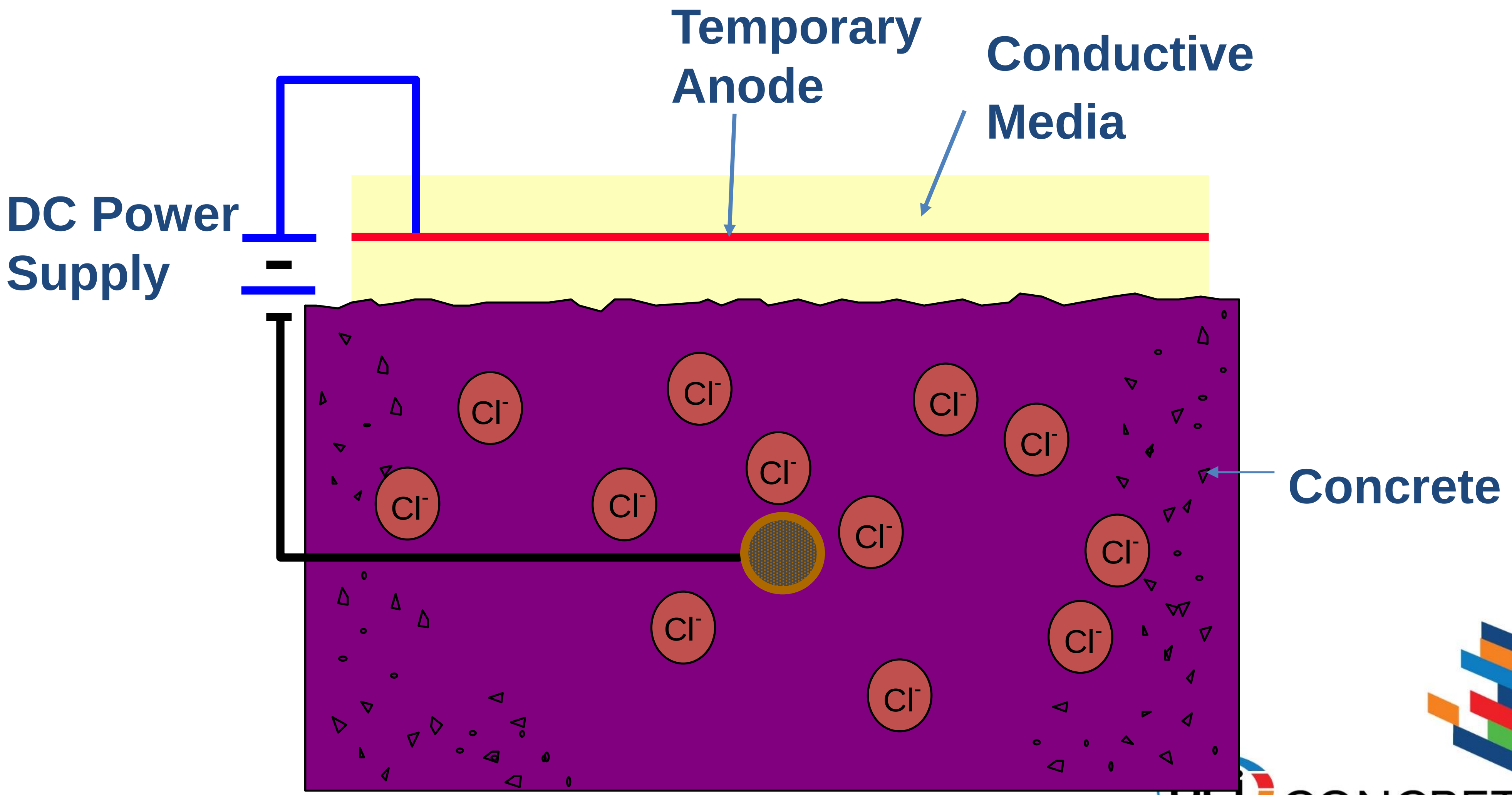
Chloride Test Results for Pier S-19



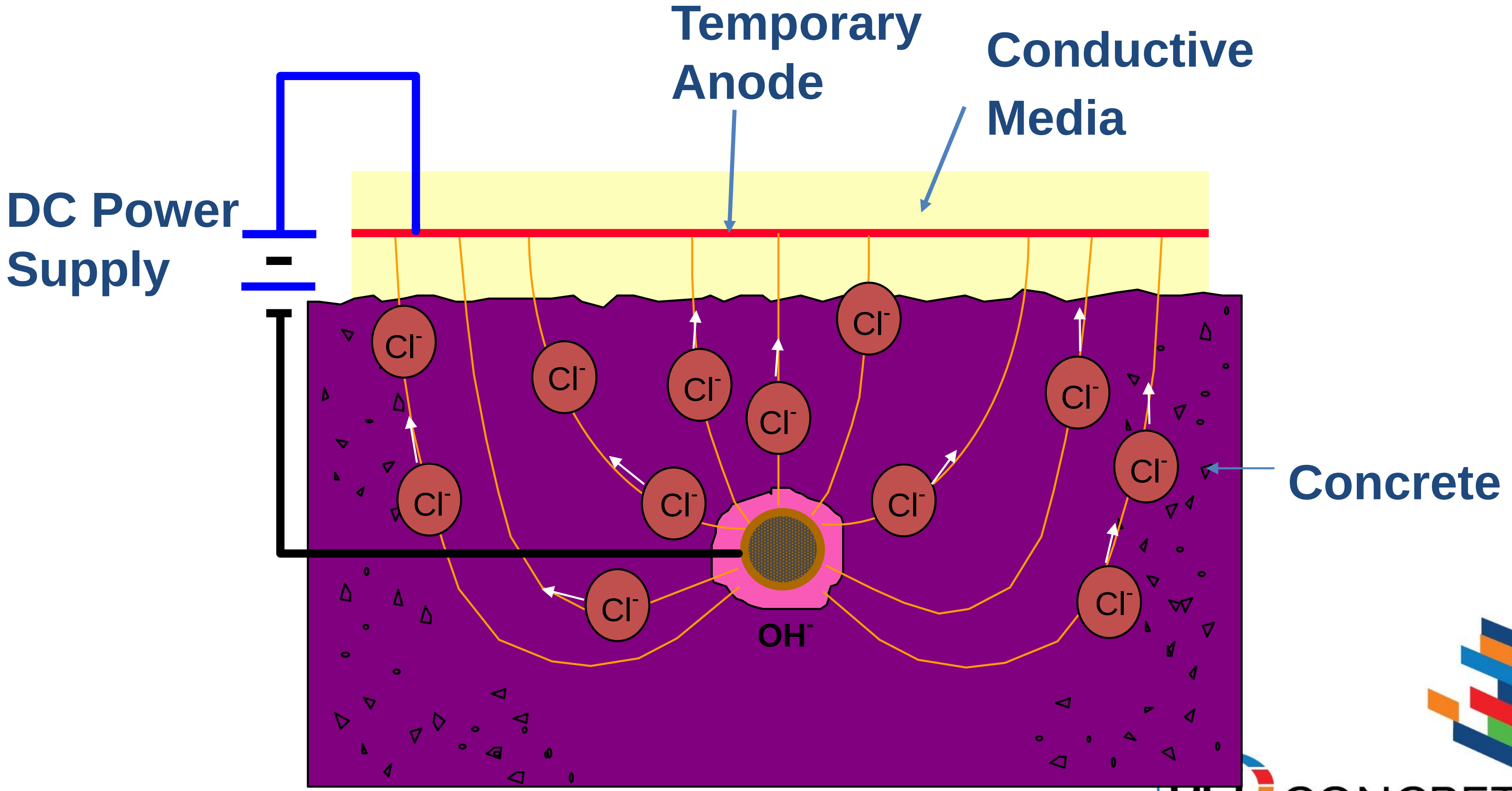
Electrochemical Chloride Extraction (ECE)

- Treatment process to reduce corrosion in chloride-contaminated concrete structures
- DC voltage applied between reinforcing steel and a temporary anode applied on the concrete surface
- Chlorides migrate from the reinforcing steel toward the temporary anode (outside the concrete)
- Hydroxyl ions (OH-) are generated on the steel surface
- Chloride to Hydroxyl Ratio is reduced
- Steel passivates and remains in passive condition

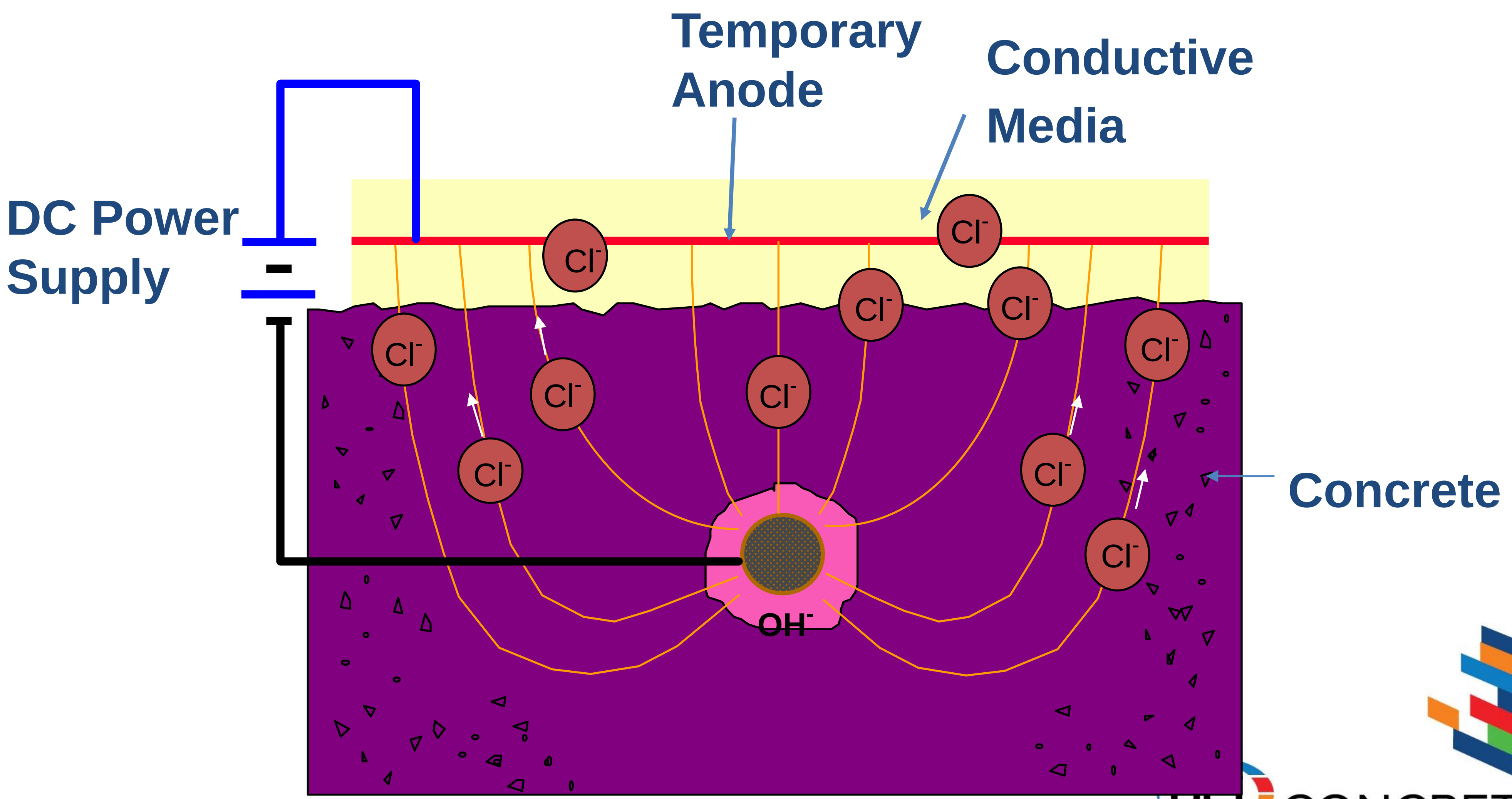
Electrochemical Chloride Extraction Process



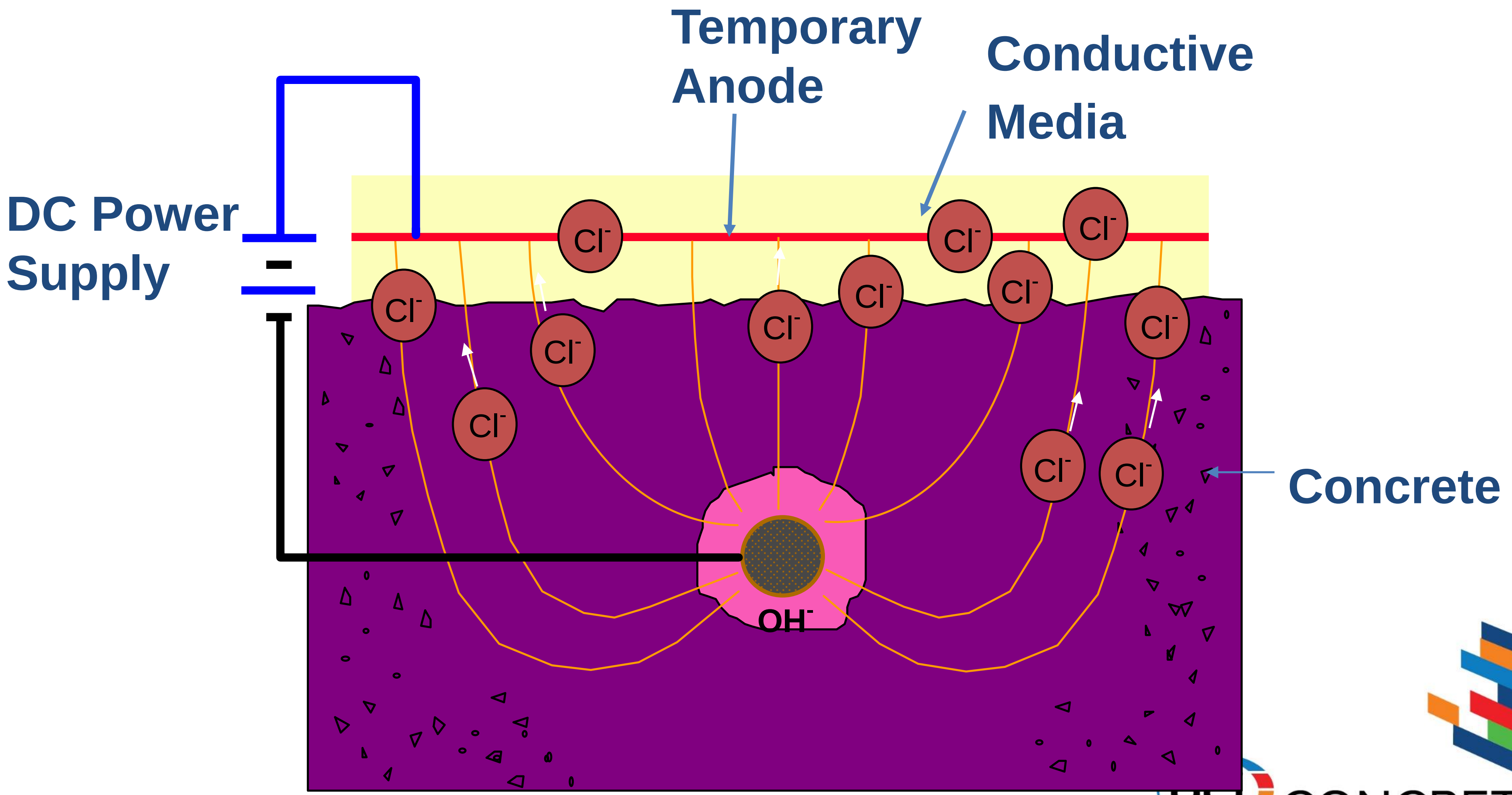
Electrochemical Chloride Extraction Process



Electrochemical Chloride Extraction Process



Electrochemical Chloride Extraction Process



What Aspects of ECE did Carolyn Research?

- Effectiveness with admixed and surface applied chlorides.
- Effectiveness with different steel configurations.
- Changes to concrete interface and bond.
- Changes to corrosion rates and potentials after treatment.
- Data with different electrolyte.

- This research provided laboratory data to define parameters and guide specifications and standards which have been developed over the last 30 years.

Corrosion Potential Data over 20 Years

Percentage of Readings	North Face (Untreated)			South Face (Electrochemical Chloride Extraction Treated)		
	> -200 mV	-200 to -350	<-350	> -200 mV	-200 to -350	<-350
Pre-Treatment	0	85	15	0	96	4
1 Yr. After	41	59	0	100	0	0
2 Yr. After	41	59	0	100	0	0
3 Yr. After	26	74	0	96	4	0
4 Yr. After	26	70	4	96	4	0
5 Yr. After	19	74	7	96	4	0
6 Yr. After	26	59	15	93	7	0
7 Yr. After	30	63	7	96	4	0
8 Yr. After	11	78	11	93	7	0
15 Yr. After	0	74	26	100	0	0
20 Yr. After	25	75	0	100	0	0

Corrosion Rate Data over 20 Years

Average Corrosion Rate (uA/cm2)	North Face (Untreated)	South Face (Electrochemical Chloride Extraction Treated)
Pre-Treatment	1.24	1.61
1 Yr. After	1.24	0.18
2 Yr. After	0.75	0.08
3 Yr. After	0.57	0.06
4 Yr. After	0.54	0.04
5 Yr. After	1.49	0.17
6 Yr. After	1.69	0.18
7 Yr. After	1.01	0.15
8 Yr. After	1.64	0.17
15 Yr. After	0.93	0.37
20 Yr. After	0.30	0.04

Permeability and Resistivity

	Permeability kT ($10^{-16} m^2$)	Electrical Resistance (ohm)
South Abutment		
Pre-Treatment	0.58	42,200
Post-ECE	0.26	Dielectric
Pier S34		
Pre-Treatment	0.54	86,200
Post-ECE	0.09	Dielectric

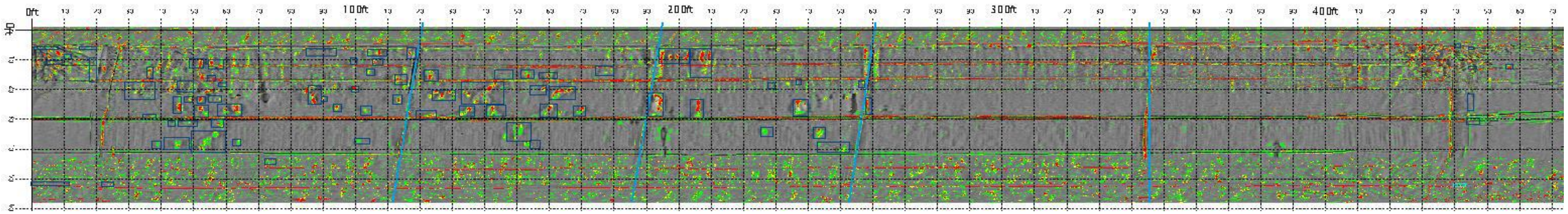
Annual Inspections then 15, 20 and 30 Years After ECE

- No Change in Appearance
- No Delaminations
- No Spalled Concrete
- Low Corrosion Potentials
- Low Corrosion Rate Measurements
- Visual Inspection at 30 Years

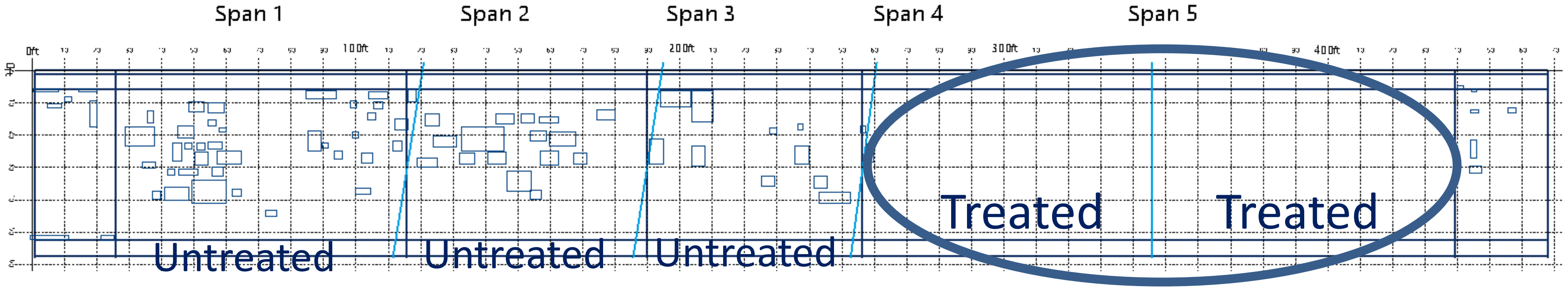
VDOT 34th St. Over I-395 Deck ECE (1995)

VDOT I-395 Over I-395 (Arlington) Bridge Deck

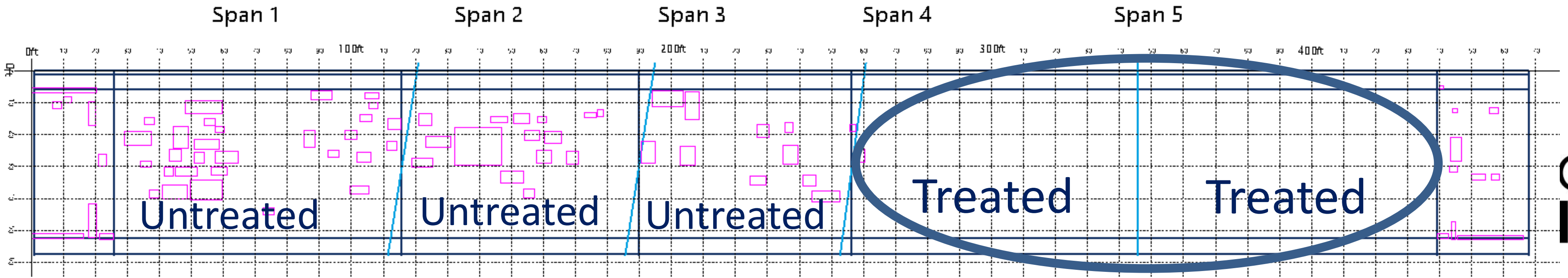
- Infrared Thermography (2021) (Raw Data)



- Delaminations Identified by Infrared Thermography (2021)



- Delaminations Identified by Sounding (2021)



- IR Survey by Nexco West
- IR Thermography produced similar results to manual sounding
- Substantial difference in deterioration of the ECE Treated and Untreated Spans

TH

CRETE
ITION

Winnipeg, Manitoba: Highway 75/100 Substructure

- Bridge Built in 1959
- Chloride Contamination due to Leaking Joints
- Concrete Repairs to All Three Piers in 1998
- 1998 ECE Pilot (Pier 2)
- 2002 ICCP Pilot (Pier 3)
- Pier 4 Maintained as Control

Concrete Repairs Required when Deck was Replaced in 2013

Pier	Quantity of Repairs in 2013
• Control Pier	250.0 m^2 (2,690 ft^2)
• ICCP Pier (2002)	71.2 m^2 (766 ft^2)
• ECE Pier (1998)	9.5 m^2 (102 ft^2)

96% Reduction in Repairs completed on
ECE Treated Pier vs the Control Pier

Conclusions

- ECE is an electrochemical treatment process which can increase the alkalinity and reduce the chloride concentration around the steel.
- ECE can provide long term corrosion benefits.
- ECE is not applicable in all situations
- Research has helped to define parameters and guide specifications and standards which have been developed over the last 30 years.

Thank You

?

We Save Structures