PHMSA Research Project

DTPH56-08-T-000012

IMPROVEMENTS TO THE ECDA PROCESS:

Severity Ranking of ECDA Indirect Inspection Indications

PHMSA Advisory Committee Meeting – Dec. 10, 2009

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Severity Ranking of ECDA Indirect Inspection Indications

- **Goal**
  - Determine the inconsistencies in current severity ranking process
  - Identify possible improvements
  - Develop new severity ranking methodology
  - Implement and verify the new severity ranking methodology

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Severity Ranking of ECDA Indirect Inspection Indications

- **Primary Research Activities**
  - Investigate the present industry practices
    - Conduct literature search
    - Evaluate available operator specifications
  - Identify industry "best practices"
  - Develop improved severity ranking methodology
  - Confirm the new methodology with direct examination and inline tool inspections results, including:
    - Previously conducted ECDA projects
    - New ECDA projects
  - Develop procedures and guidelines
  - Final Report

- **Recent Presentations on Research:**
  - Approved paper for presentation at NACE International in 3/10

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Milestones

Task#	Activity/Deliverable	Completion Months
1	Undertake literature search	3
2	Perform data integration and analysis	6
3	Identify emerging trends	9
	Participate in peer review by webinar	9
4	Determine the ease of use of existing table	12
5	Develop of improved severity table	15
6	Implement and verify new methodology	18
	"Go"/"No Go" point/write procedure	18
7	Prepare and submit draft of final report	21
	Participate in peer review by webinar	21
	Present paper at NACECorrosion2010	21
8	Submit final report	24
	Draft recommendations for industry standard	24
	Conduct web-based workshop	TBD

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ECDA Basis for Improvement: Classification and Prioritization of Indirect Inspection Indications

Data

- 5 Operators – Transmission and LDC
- ~200 miles of Close Interval Survey (CIS) with GPS
- ~100 miles of DC Voltage Gradient (DCVG) Survey with GPS
- ~150 miles of AC Current Attenuation (ACCA) Survey with GPS
- Direct Examinations
  - ~400 excavations with soil analyses
    - ~200 with measurable external corrosion
- Inline Tool Inspections (where CIS and ACCA performed)
  - ~100 miles of pipeline
    - ~14,000 joints
      - ~4,000 joints with measurable external corrosion
      - ~100 excavations
- Input from ~10 qualified and experienced personnel (operators & service providers)
  - Over 300 years combined experience

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NACE SP0502-2008:
Table 3 – Example Severity Classification of Indirect Inspections

Tool/Environment	Minor	Moderate	Severe
CIS, aerated moist soil	Small dips with on and off potentials above CP criteria	Medium dips or off potentials below CP criteria	Large dips or on and off potentials below CP criteria
DCVG survey, similar conditions	Low voltage drop; cathodic conditions at indication when CP is on and off	Medium voltage drop or neutral conditions at indication when CP is off	High voltage drop or anodic conditions when CP is on or off
ACVG or Pearson' survey, similar conditions	Low voltage drop	Medium voltage drop	High voltage drop
Electromagnetic	Low signal loss	Medium signal loss	Large signal loss
AC current attenuation surveys	Small increase in attenuation per unit length	Moderate increase in attenuation per unit length	Large increase in attenuation per unit length

- **Meant as general not absolute criteria**
- **Operator must consider specific conditions when defining classification criteria**

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NACE SP0502-2008:
Table 4 – Example Prioritization of Indirect Inspection Indications

Immediate Action Required	Scheduled Action Required	Suitable for Monitoring
• Severe indications in close proximity regardless of prior corrosion. • Individual severe indications or groups of moderate indications in regions of moderate prior corrosion. • Moderate indications in regions of severe prior corrosion.	• All remaining severe indications. • All remaining moderate indications in regions of moderate prior corrosion. • Groups of minor indications in regions of severe prior corrosion.	• All remaining indications.

- **Different criteria may be required for different regions**
- **Criteria should be defined as a function of specific conditions**

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An Operator Example : Severity Classification of Indirect Inspections

Tool/ Environment	Minor	Moderate	Severe
Close Interval Survey (aerated, moist soil)	• Small depression in potential profile • "On" and "Off" potentials are both more negative than -850 mV	• Medium depression in potential profile • "On" potentials are more negative than -850 mV • "Off" potentials are not more negative than -600 mV	• Large depression in potential profile • "Off" potentials are not more negative than -600 mV
DCVG Survey (aerated, moist soil)	• < 36% IR • Cathodic both "On" and "Off"	• 36% to 60% IR • Cathodic "On" • Anodic or Neutral "Off"	• > 60% IR • Anodic both "On" and "Off"
AC Current Attenuation survey (Pipeline Current Mapper or C-Scan)	• -9 to -30 mdB/ft	• -31 to -60 mdB/ft	• > -60 mdB/ft

- **Specific numerical criteria**
- **Objective measurable criteria**
- **Specific definable conditions considered**

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An Operator Example :
Direct Examination Prioritization of Indirect Inspections

		Close Interval Survey			
		Severe	**Moderate**	**Minor**	**No Indication**
DCVG	Severe	Immediate	Scheduled	Scheduled	Monitored
	Moderate	Immediate	Scheduled	Monitored	No Action
	Minor	Immediate	Scheduled	Monitored	No Action
	No Indication	Immediate	Scheduled	Monitored	No Action
ACCA	Severe	Immediate	Scheduled	Scheduled	Monitored
	Moderate	Immediate	Scheduled	Monitored	No Action
	Minor	Immediate	Scheduled	Monitored	No Action
	No Indication	Immediate	Scheduled	Monitored	No Action

- **Specific**
- **Objective**
- **Defined as function of specific conditions**

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Improved Severity Classifications of Indirect Inspections

Measure	Indirect Inspection Severity Classification		
	Minor	Moderate	Severe
TOOL = Close Interval Potential Survey (CIS)			
A = OFF (Polarized) Potential [mV]	-950 mV < **A** < -850 mV	-850 mV < **A** < -650 mV	-650 mV < **A**
	OR	OR	AND
B = ON Potential [mV]	-1000 mV < **B** < -950 mV	-950 mV < **B** < -850 mV	-850 mV < **B**
	AND	AND	AND
C = ON/OFF Convergence [mV]	50 mV < **C** < 70 mV	30 mV < **C** < 10 mV	10 mV < **C**
	OR	OR	AND
D = ON and/or OFF Profile Depression within 100ft span [mV/span]	50 mV/span < **D** < 100 mV/span	100 mV/span < **D** < 200 mV/span	200 mV/span < **D**
TOOL = AC Current Attenuation Survey (ACCA)			
E = Current 98 Hz Frequency Signal **Loss(-)** [mdB(mA)/ft]	7 mdb(mA)/ft < **E** < 3 mdb/ft	12 mdb(mA)/ft < **E** < 7 mdb(mA)/ft	12 mdb(mA)/ft < **E**
	AND/OR	AND/OR	AND/OR
F = Current 4 Hz Frequency Signal **Loss(-)** [mdB(mA)/ft]	20 mdb(mA)/ft < **F** < 40 mdb(mA)/ft	40 mdb(mA)/ft < **F** < 60 mdb(mA)/ft	60 mdb(mA)/ft < **F**
	AND	AND	OR
CP Level Modifier	Adequate CP Level	Adequate to Marginal CP Level	ALL indications with Inadequate CP Level
TOOL = AC Voltage Gradient Survey (ACVG)			
G = Voltage Signal Loss(-) [dB(mV)]	44 dB(mV) < **G** < 60 dB(mV)	60 dB(mV) < **G** < 78 dB(mV)	78 dB(mV) < **G**
	AND	AND	OR
CP Level Modifier	Adequate CP	Adequate to Marginal CP Level	ALL indications with Inadequate CP
TOOL = DC Voltage Gradient Survey (DCVG)			
H = Coating Defect Size [%IR]	5%IR < **H** < 20%IR	20%IR < **H** < 50%IR	50%IR < **H**
	AND	OR	OR
I = Corrosion State Assessment (Normal Operating Conditions)	**I** = Cathodic/Cathodic or Cathodic/Neutral	All Indications 5%IR < **H** < 50%IR where **I** = Cathodic/Anodic	All indications where **I** = Anodic/Anodic
	AND	AND	OR
CP Level Modifier	Adequate CP	Adequate to Marginal CP Level	ALL indications with Inadequate CP

- **More specific numerical criteria**
- **Objective measurable criteria**
- **Several operators**
- **Wide range of specific conditions**
- **Specific definable conditions considered**
- **Supported by data and experience**
- **Sound engineering judgment and practice**

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Improved Indirect Inspection Indication Direct Examination Prioritizations

Direct Examination Prioritization				
Two Tools		1st Indirect Inspection Tool		
		Severe	Moderate	Minor
2nd Indirect Inspection Tool	Severe	Immediate	Immediate	Scheduled
	Moderate	Immediate	Scheduled	Monitored
	Minor	Scheduled	Monitored	Monitored

- **Specific**
- **Objective**
- **Wide range of specific conditions**
- **Defined as function of specific conditions**
- **Supported by data and experience**
- **Sound engineering judgment and practice**

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Further Improvement of Severity Classification and Prioritization: Incorporating USDA Soils Data

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Web Soil Survey

- Freely available data online via web
  - http://websoilsurvey.nrcs.usda.gov
- Geospatially based
- Wide coverage of continental United States
- Detail database of physical and chemical soil properties and characteristics

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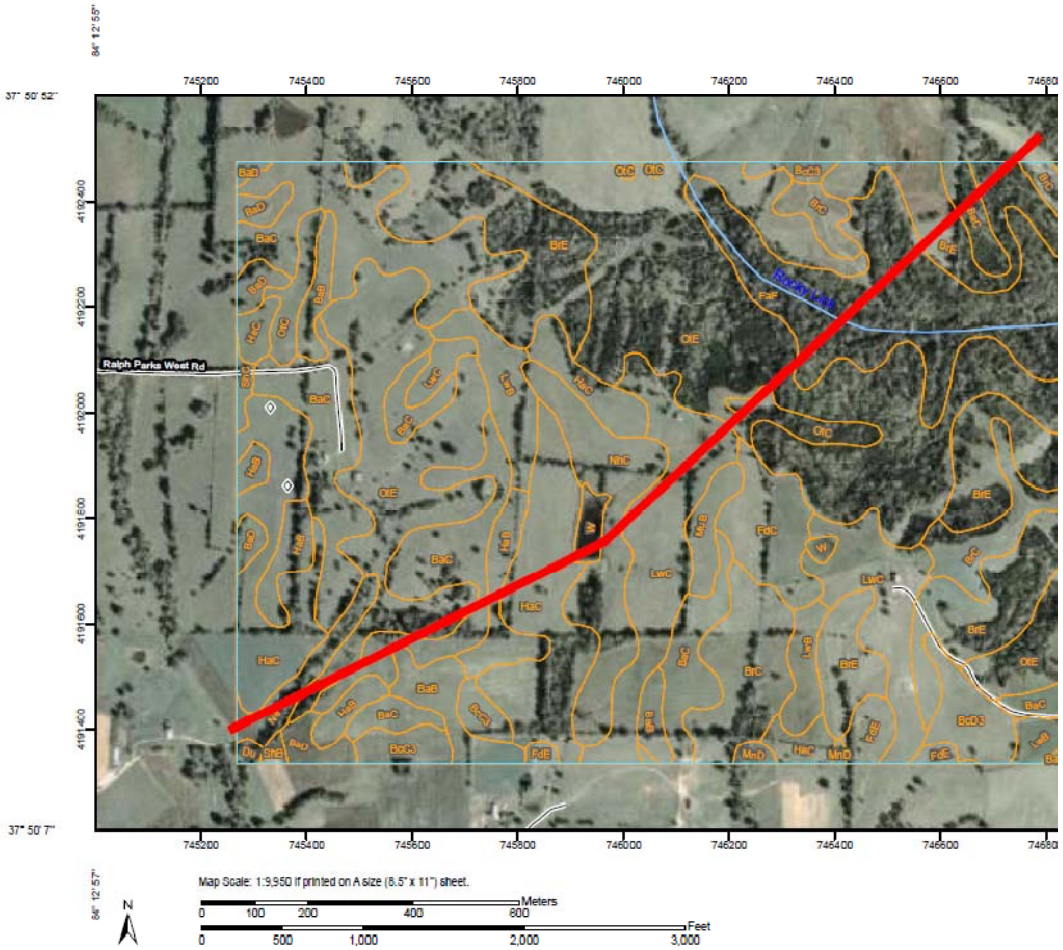
USDA Soil Survey: Example of Detailed Soil Map

Soil Map—Madison County, Kentucky
(24" Pipeline)



Map Unit Symbol	Map Unit Name
BaB	Beasley silt loam, 2 to 6 percent slopes
BaC	Beasley silt loam, 6 to 12 percent slopes
BaD	Beasley silt loam, 12 to 20 percent slopes
BcC3	Beasley silty clay loam, 6 to 12 percent slopes, severely eroded
BcD3	Beasley silty clay loam, 12 to 20 percent slopes, severely eroded
BrC	Brassfield silt loam, 6 to 12 percent slopes
BrE	Brassfield silt loam, 12 to 30 percent slopes
Du	Dunning silty clay loam
FaF	Fairmount-Rock outcrop complex, 30 to 60 percent slopes
FdC	Faywood silt loam, 6 to 12 percent slopes
FdE	Faywood silt loam, 12 to 30 percent slopes
HaB	Hagerstown silt loam, 2 to 6 percent slopes
HaC	Hagerstown silt loam, 6 to 12 percent slopes
LwB	Lowell silt loam, 2 to 6 percent slopes
LwC	Lowell silt loam, 6 to 12 percent slopes
MnD	McAfee silt loam, 12 to 20 percent slopes
MuB	Mercer silt loam, 2 to 6 percent slopes
Ne	Newark silt loam
NhC	Nicholson silt loam, 6 to 12 percent slopes
OtC	Otway silty clay, 6 to 12 percent slopes (shrouts)
OtE	Otway silty clay, 12 to 30 percent slopes (shrouts)
ShB	Shelbyville silt loam, 2 to 6 percent slopes
ShC	Shelbyville silt loam, 6 to 12 percent slopes
W	Water

USDA Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

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USDA Soil Survey: Example of Detailed Database

- Engineering Proprieties

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Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number–				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
BaB:												
Beasley	0-6	Silt loam	CL-ML, ML	A-4	0	0-5	90-100	85-100	80-100	75-100	25-35	4-10
	6-36	Clay, silty clay	CH, CL	A-7	0	0-5	90-100	85-100	85-100	75-100	45-70	20-40
	36-54	Clay, clay loam, gravelly silty clay, silty clay	CH, CL	A-7	0	0-10	70-100	55-100	50-100	50-95	35-65	15-35
	54-60	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

- Chemical Proprieties

Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbon-ate	Gypsum	Salinity	Sodium adsorption ratio
	In	*meq/100 g*	*meq/100 g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
BaB:								
Beasley	0-6	15-30	---	4.5 - 7.3	0-1	0	0.0	0
	6-36	10-30	---	4.5 - 7.3	0-8	0	0.0	0
	36-54	5.0-25	---	6.6 - 8.4	3-21	0	0.0	0
	54-60	---	---	---	---	---	---	---

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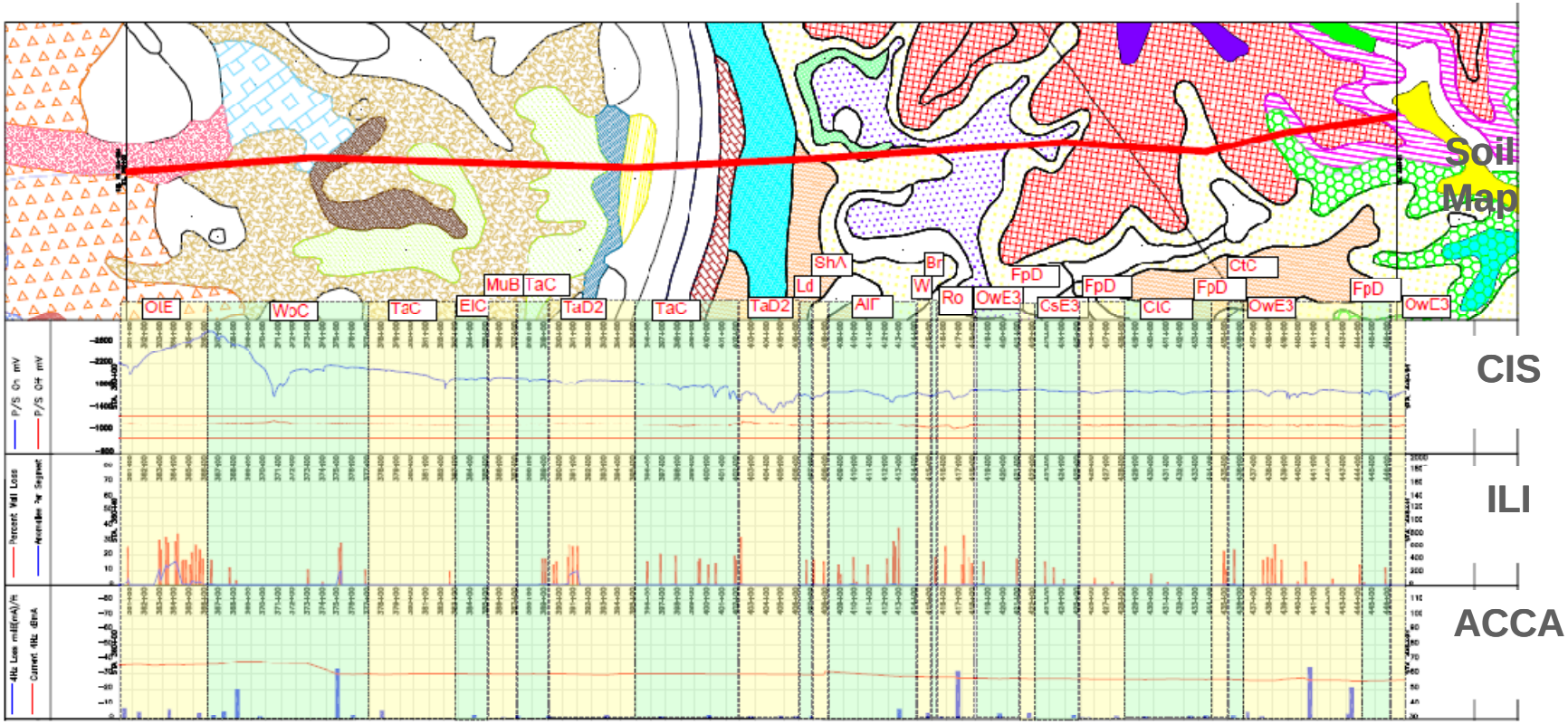
Comparison of Soils, Indirect Inspections and Inline Tool Inspection



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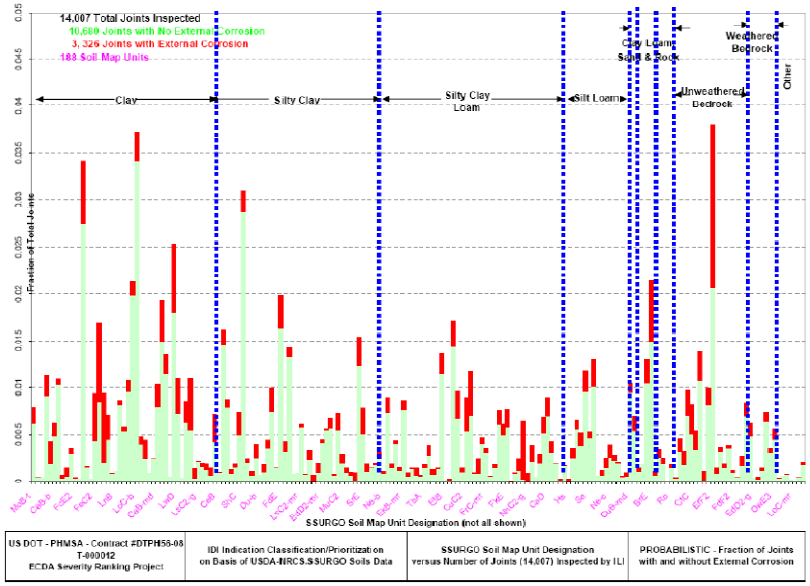
Soils – Joints with and without External Corrosion



- **14,000 joints**
  - **10,000 without External Corrosion**
  - **4,000 with External Corrosion**
- **188 Soil Types**
  - **14 Soil Textures**
- **Correlation between Soil Type Texture and presence of External Corrosion**

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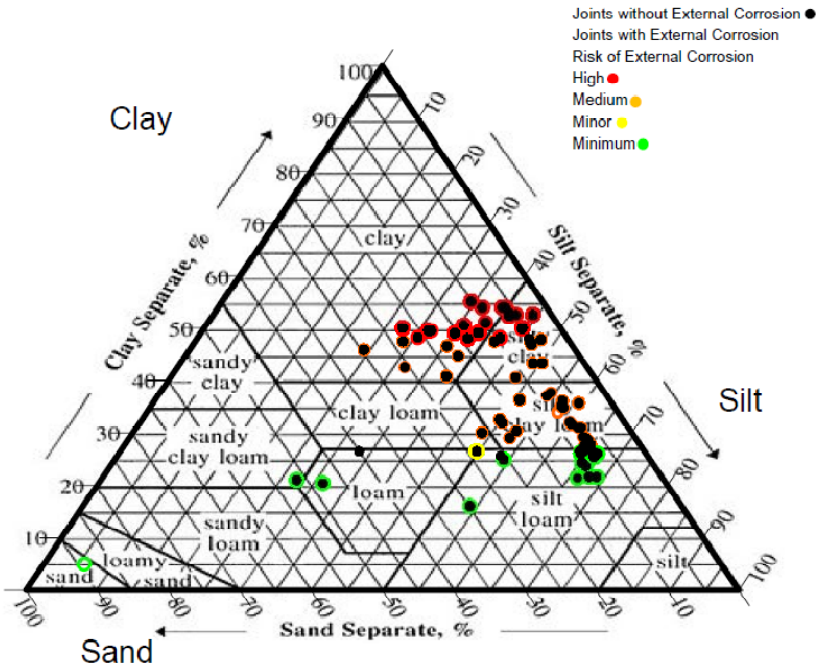
Influence of soils texture on external corrosion



- **14,000 joints**
  - **10,000 without External Corrosion**
  - **4,000 with External Corrosion**
- **188 Soil Types**
  - **12 Soil Textures**
- **Correlation between Soil Texture and severity of External Corrosion**

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External Corrosion Threat Hazards: Rupture & Leak

- The greatest measurable external corrosion defect is substantially more of a threat (orders of magnitudes) to the operational integrity of a pipeline than the least measureable external corrosion defect
  - On the basis of RPR the external corrosion ranges from the greatest rupture threat (RPR=0.8) to the least rupture threat (RPR=1.2) and
    - Depends on stress level and operating pressure
  - On the basis of %WL the external corrosion ranges from the greatest leak threat (%WL=70%) to the least leak threat (%WL=10%)
    - Independent of stress level and operating pressure

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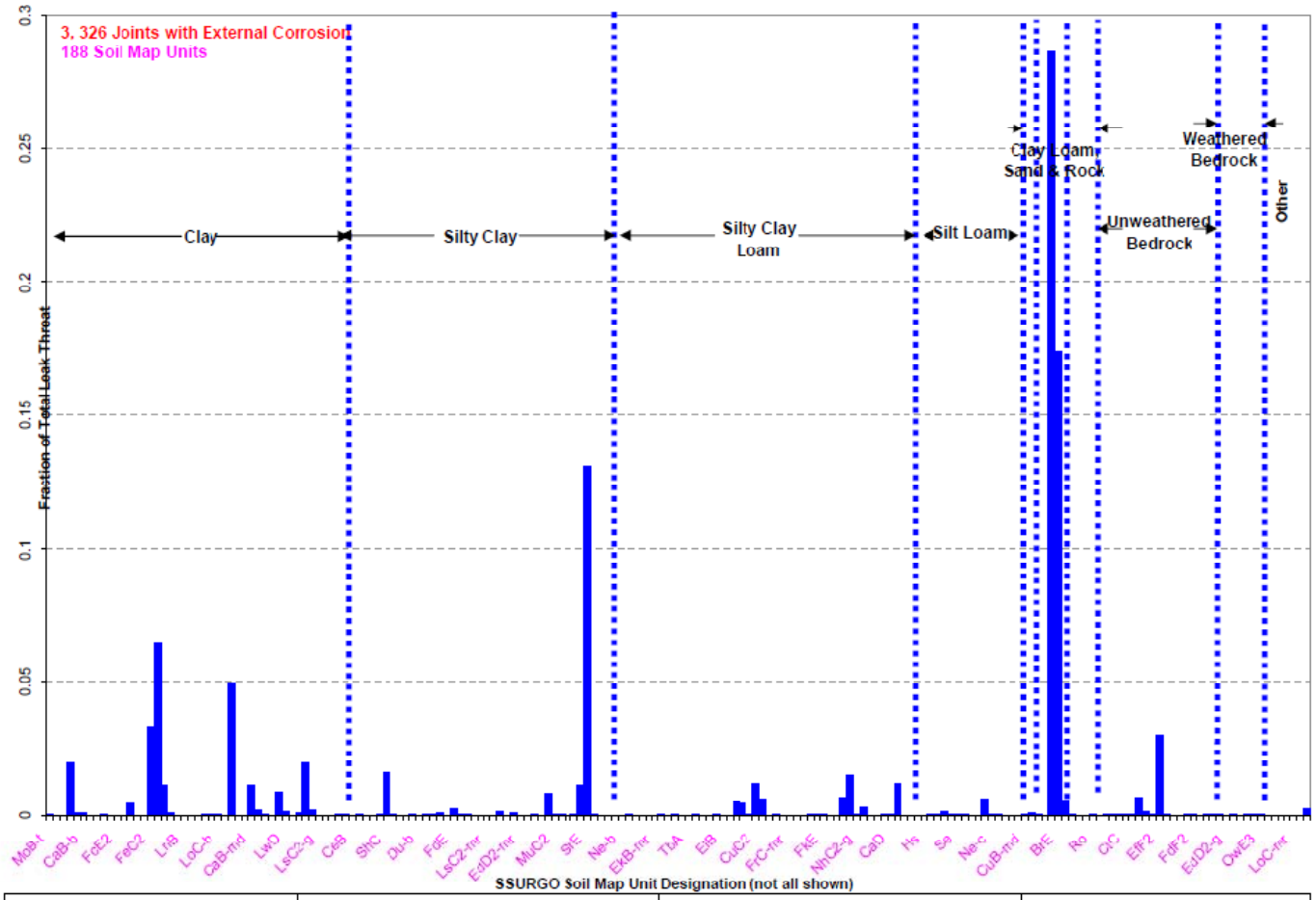
External Corrosion – Leak Threat vs. Soil Type



US DOT - PHMSA - Contract #DTPH56-08 T-000012 ECDA Severity Ranking Project	IDI Indication Classification/Prioritization on Basis of USDA-NRCS.SSURGO Soils Data	SSURGO Soil Map Unit Designation versus Number of Joints with External Corrosion by Leak Threat (3,326) Inspected by ILI	PROBABILISTIC - Fraction of Total Leak Threat

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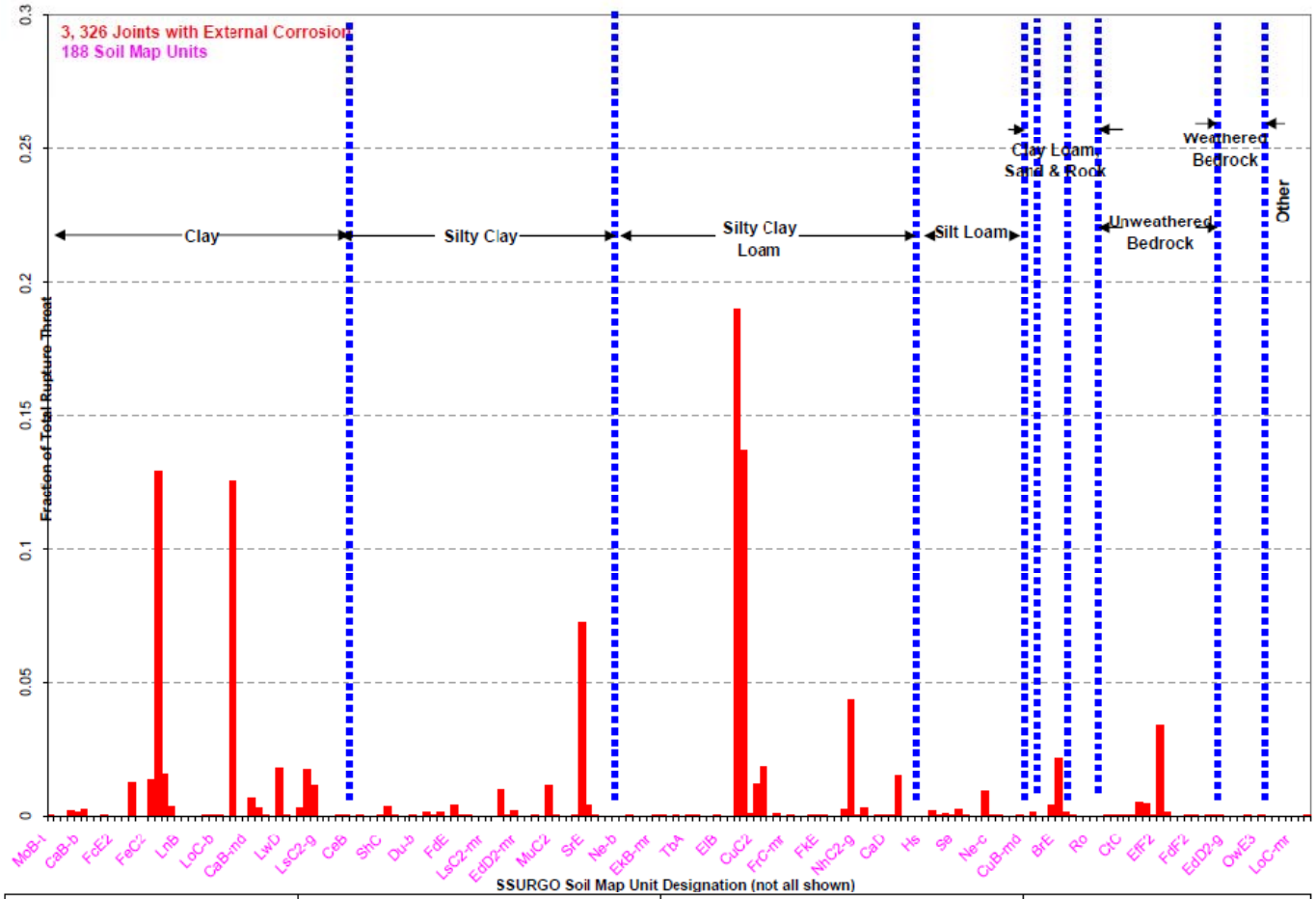
External Corrosion – Rupture Threat vs. Soil Type



US DOT - PHMSA - Contract #DTPH56-08 T-000012 ECDA Severity Ranking Project	IDI Indication Classification/Prioritization on Basis of USDA-NRCS.SSURGO Soils Data	SSURGO Soil Map Unit Designation versus Number of Joints with External Corrosion by Rupture Threat (3,326) Inspected by ILI	PRODADILISTIC - Fraction of Total Rupture Threat

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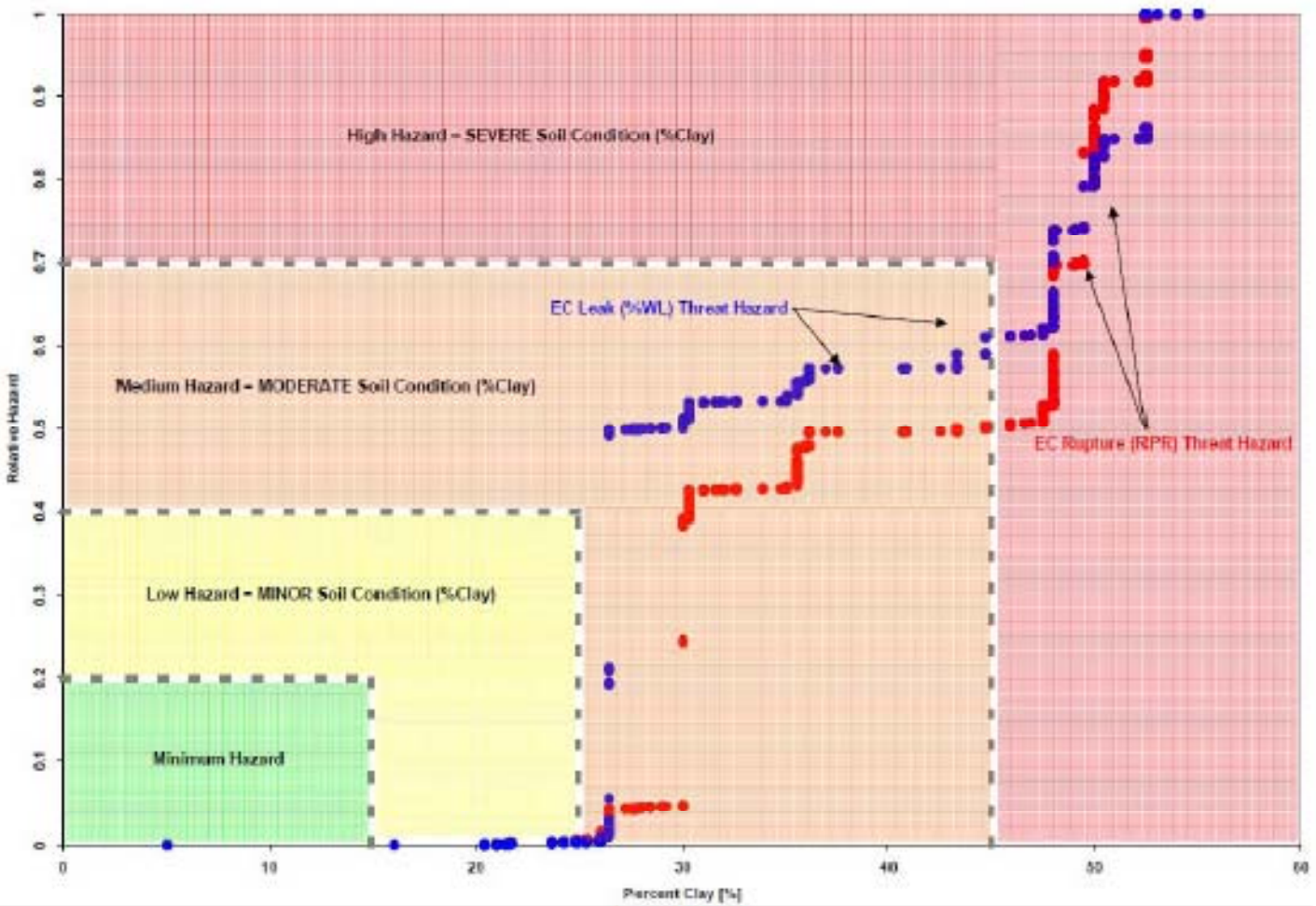
External Corrosion Threat Hazards Vs. Clay Content



US DOT - PHMSA - Contract #DTPH56-08-T-000012 ECDA Severity Ranking Project	IDI Indication Classification/Prioritization on Basis of USDA-NRCS SSURGO Soils Data	SSURGO Soil Texture %Clay ~2700 ILI Data Points	Relative External Corrosion Threat Hazards

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Improved Severity Classification of Indirect Inspections with Soil Texture Modifier

Measure	Indirect Inspection Severity Classification		
	Minor	Moderate	Severe
TOOL = Close Interval Potential Survey (CIS)			
A = OFF (Polarized) Potential [mV]	-950 mV < **A** < -850 mV	-850 mV < **A** < -650 mV	-650 mV < **A**
	OR	OR	AND
B = ON Potential [mV]	-1000 mV < **B** < -950 mV	-950 mV < **B** < -850 mV	-850 mV < **B**
	AND	AND	AND
C = ON/OFF Convergence [mV]	50 mV < **C** < 70 mV	30 mV < **C** < 10 mV	10 mV < **C**
	OR	OR	AND
D = ON and/or OFF Profile Depression within 100ft span [mV/span]	50 mV/span < **D** < 100 mV/span	100 mV/span < **D** < 200 mV/span	200 mV/span < **D**
TOOL = AC Current Attenuation Survey (ACCA)			
E = Current 98 Hz Frequency Signal **Loss(-)** [mdB(mA)/ft]	7 mdb(mA)/ft < **E** < 3 mdb/ft	12 mdb(mA)/ft < **E** < 7 mdb(mA)/ft	12 mdb(mA)/ft < **E**
	AND/OR	AND/OR	AND/OR
F = Current 4 Hz Frequency Signal **Loss(-)** [mdB(mA)/ft]	20 mdb(mA)/ft < **F** < 40 mdb(mA)/ft	40 mdb(mA)/ft < **F** < 60 mdb(mA)/ft	60 mdb(mA)/ft < **F**
	AND	AND	OR
CP Level Modifier	Adequate CP Level	Adequate to Marginal CP Level	ALL indications with Inadequate CP Level
TOOL = AC Voltage Gradient Survey (ACVG)			
G = Voltage Signal Loss(-) [dB(mV)]	44 dB(mV) < **G** < 60 dB(mV)	60 dB(mV) < **G** < 78 dB(mV)	78 dB(mV) < **G**
	AND	AND	OR
CP Level Modifier	Adequate CP	Adequate to Marginal CP Level	ALL indications with Inadequate CP
TOOL = DC Voltage Gradient Survey (DCVG)			
H = Coating Defect Size [%IR]	5%IR < **H** < 20%IR	20%IR < **H** < 50%IR	50%IR < **H**
	AND	OR	OR
I = Corrosion State Assessment (Normal Operating Conditions)	**I** = Cathodic/Cathodic or Cathodic/Neutral	All Indications 5%IR < **H** < 50%IR where **I** = Cathodic/Anodic	All indications where **I** = Anodic/Anodic
	AND	AND	OR
CP Level Modifier	Adequate CP	Adequate to Marginal CP Level	ALL indications with Inadequate CP
TOOL MODIFIER - USDA Soils Data - Soil Texture Designation (Not an independent TOOL)			
J = USDA Soil Texture Designation (12 types)	**J** = Sand, Loamy Sand, Sandy Loam, Loam, Silt Loam or Silt	**J** = Sandy Clay Loam, Sandy Clay, Clay Loam, Silty Clay Loam	**J** = Clay and Silty Clay
	AND	AND	OR
CP Level Modifier	Adequate CP	Adequate to Marginal CP Level	ALL areas with Inadequate CP

- **More specific numerical criteria**
- **Objective measurable criteria**
- **Wide range of specific conditions**
- **Specific definable conditions considered**
- **Supported by data and experience**
- **Sound engineering judgment and practice**
- **Soils data incorporated**

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Improved Indirect Inspection Indication Direct Examination Prioritization with Soil Texture Modifier

Direct Examination Prioritization					
USDA Soil Texture Modifier	Two Tools with Soil Modifier		1st Indirect Inspection Tool		
			Severe	Moderate	Minor
Severe	2nd Indirect Inspection Tool	Severe	Immediate	Immediate	Scheduled
		Moderate	Immediate	Scheduled	Scheduled
		Minor	Scheduled	Scheduled	Scheduled
Moderate		Severe	Immediate	Scheduled	Scheduled
		Moderate	Immediate	Scheduled	Monitored
		Minor	Scheduled	Scheduled	Monitored
Minor		Severe	Immediate	Scheduled	Scheduled
		Moderate	Scheduled	Monitored	Monitored
		Minor	Scheduled	Monitored	Monitored

- **Specific**
- **Objective**
- **Wide range of specific conditions**
- **Defined as function of specific conditions**
- **Supported by data and experience**
- **Sound engineering judgment and practice**
- **Modified on basis of soil texture**

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Accomplishments and Conclusions

- Developed improved ECDA severity classification and prioritization methodologies
  - Enable operators to efficiently/effectively manage external corrosion threats
  - Provide more consistent assessments of the external corrosion threat
- Methodologies developed represent an enhancement of NACE SP0502-2008
  - Quantification of IDI data
  - Introduction of soil texture modifier
  - Effective utilization of available soils data
  - Soil maps used available in the public domain
- The methodologies quantified, qualified, and verified industry knowledge and experience
  - Supported by the data
  - Sound engineering judgment
- The methodologies have significant implications for
  - public safety
  - environmental protection
  - operational reliability
- The methodologies are consistent with other PHMSA's stated goals
  - collaborative development of technology
  - the strengthening of industry consensus standards
  - generation and promotion of new knowledge

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Thank you

We will be pleased to answer your questions.

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