

**Activity 4b:
Reducing uncertainty in the use of non-destructive,
indirect measurement with LPR**

Activity researchers : Tony Wells (UoN) and Sarath Kodagoda (UTS)

In collaboration with: Phil Ferguson of PCA Echologics



Plan of today's talk

Discussion of Activity 4b

- **Objectives**
- **Progress (UoN)**
- **Progress (UTS)**

Activity 4.

Activity 4a. Enhanced reliability of condition assessment of buried large diameter water mains

Activity 4b. Reducing uncertainty in the use of LPR

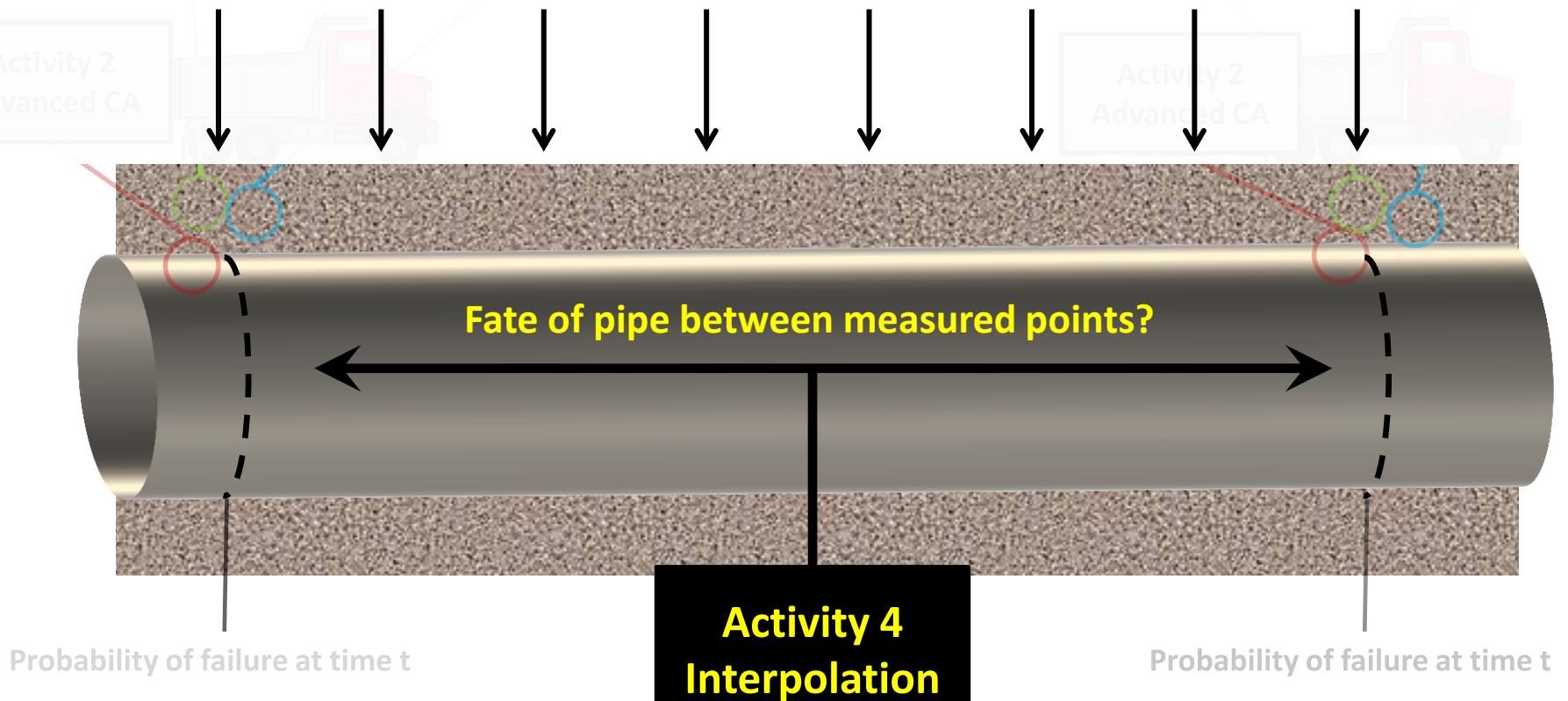
Activity 4c. Enhanced ability to predict the likelihood of pipe corrosion along the length of a pipe

Activity 4d. Enhanced reliability of emerging technologies not yet incorporated into current project

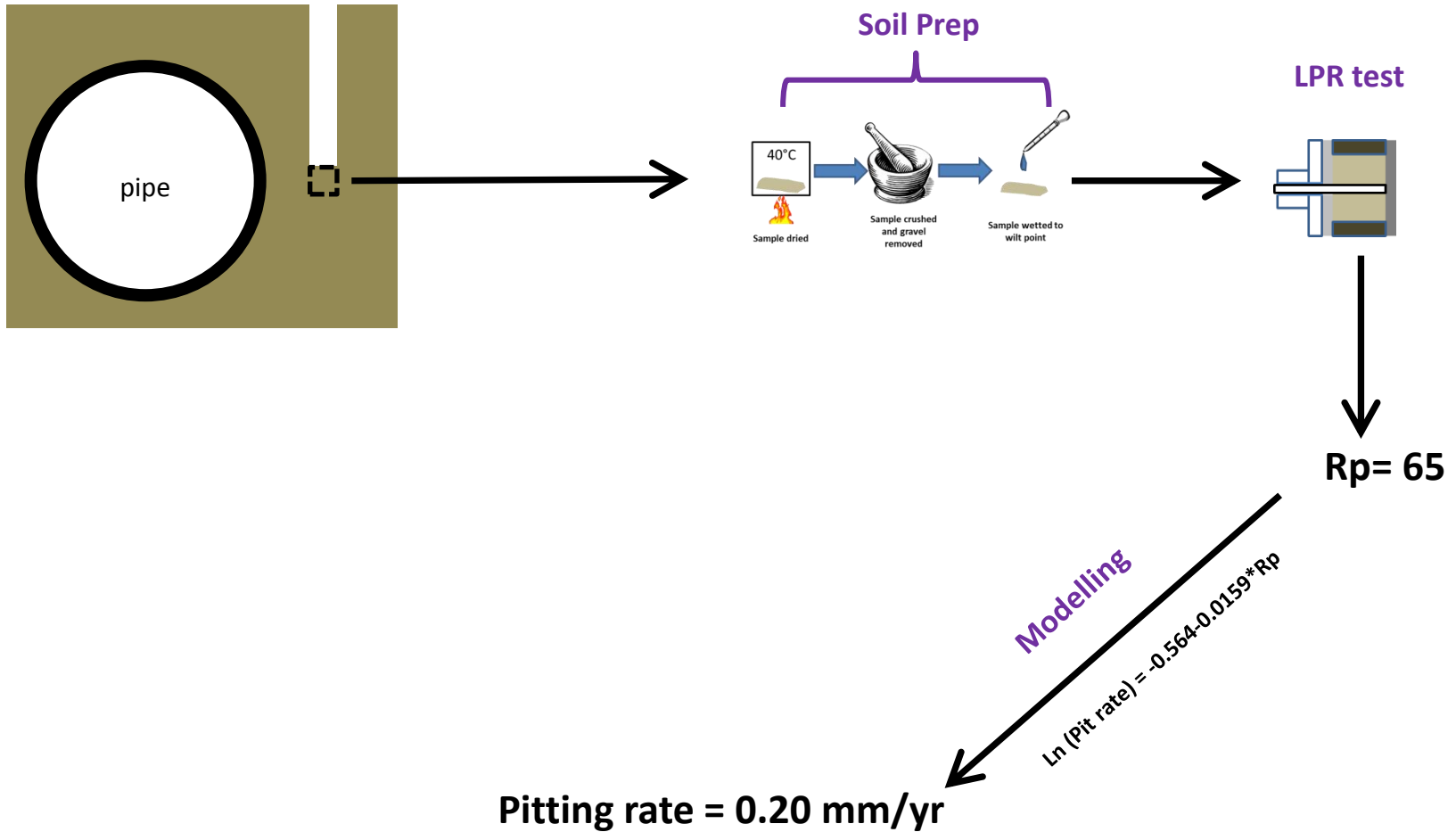
Activity 4e. Enhanced ability to predict failure probability

Why are we looking at LPR in Activity 4?

LPR – cheap, easy, shown to correlate well with corrosion



Activity 4b. Reducing uncertainty in the use of LPR



PCA No.	Texture	Colour	Section No.	LPR Ohms/10sqcm	Pit Rate* mm/yr
PCA047437	LOAM	BLACK	1	41	0.30
PCA047438	LOAM	BLACK	1	37	0.32
PCA047439	CLAY LOAM	VERY DARK BROWN	1	49	0.26
PCA047440	CLAY LOAM	VERY DARK BROWN	1	65	0.20

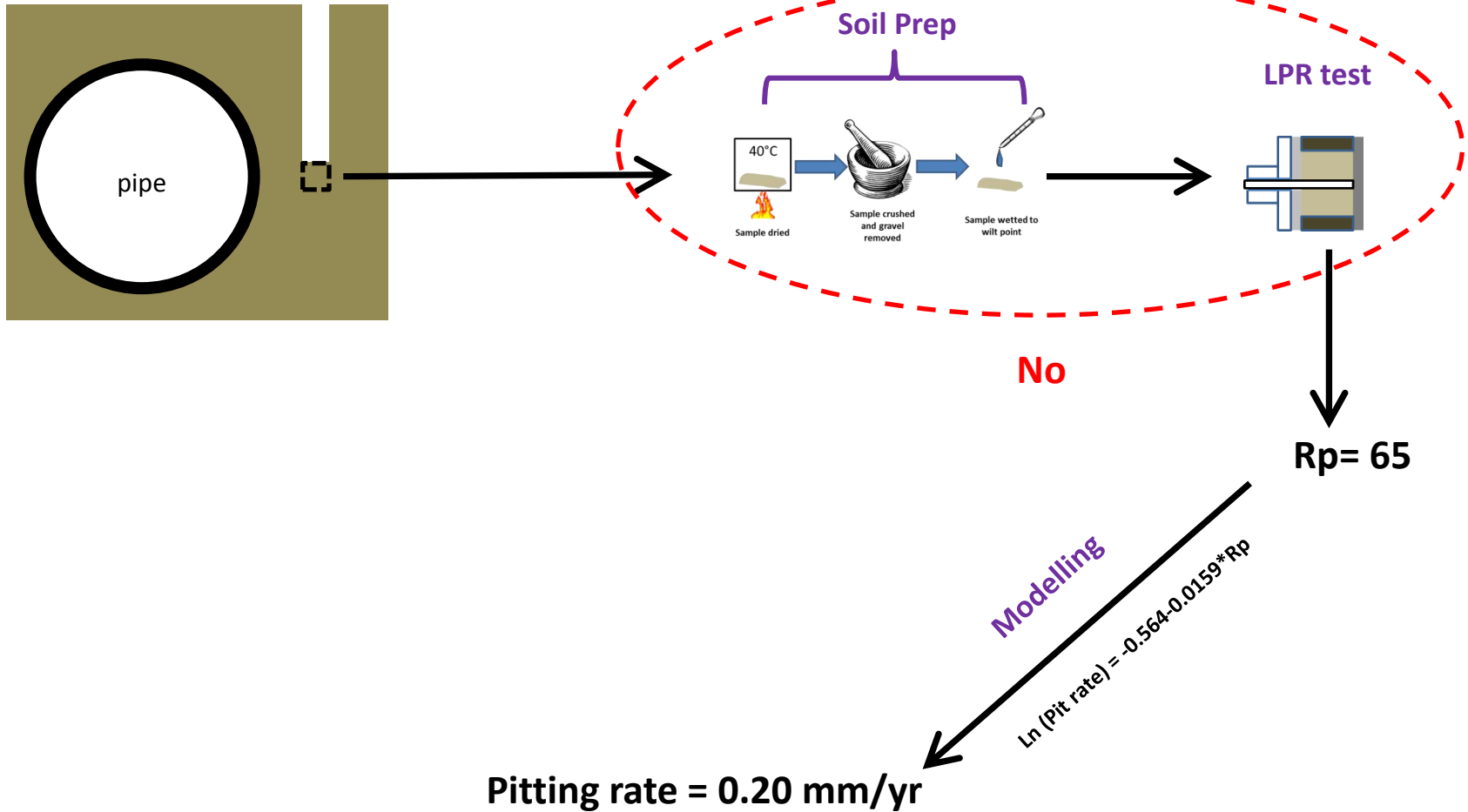
CR=0.20 mm/yr +/-

??

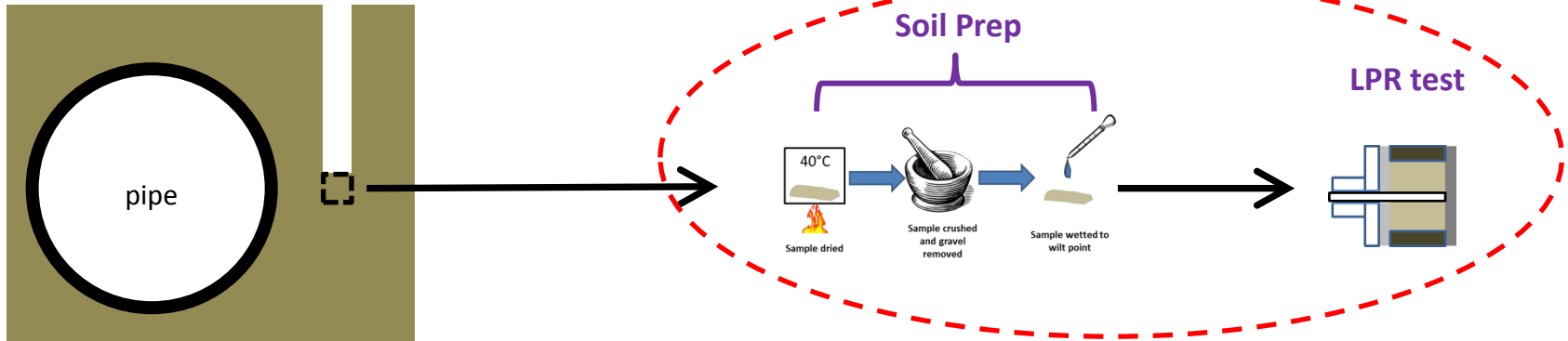
What is the level of uncertainty?

What additional information can we include to reduce prediction uncertainty and improve corrosion predictions?

Activity 4b. Reducing uncertainty in the use of LPR



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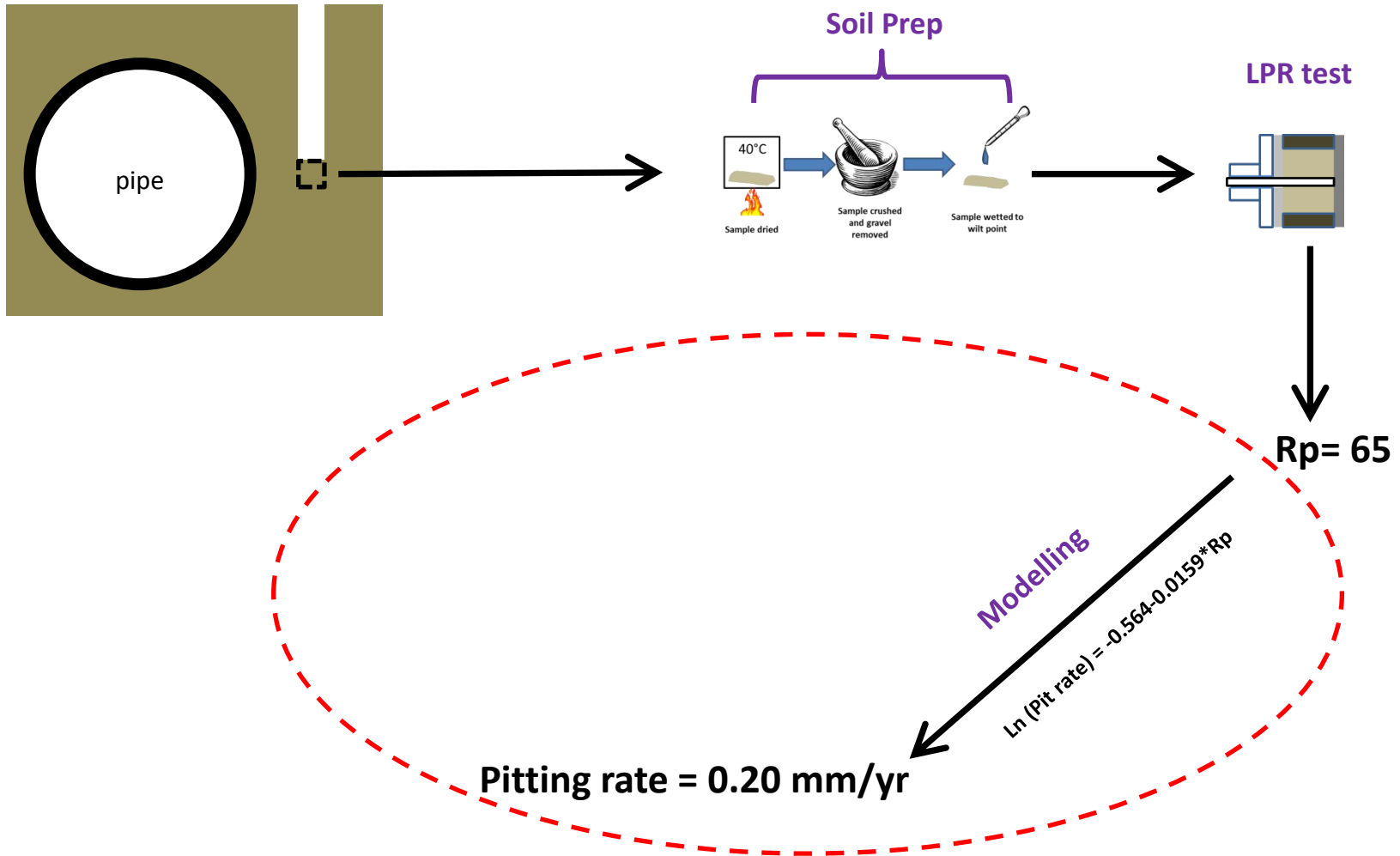
Changes here – No!

Not part of the research plan.

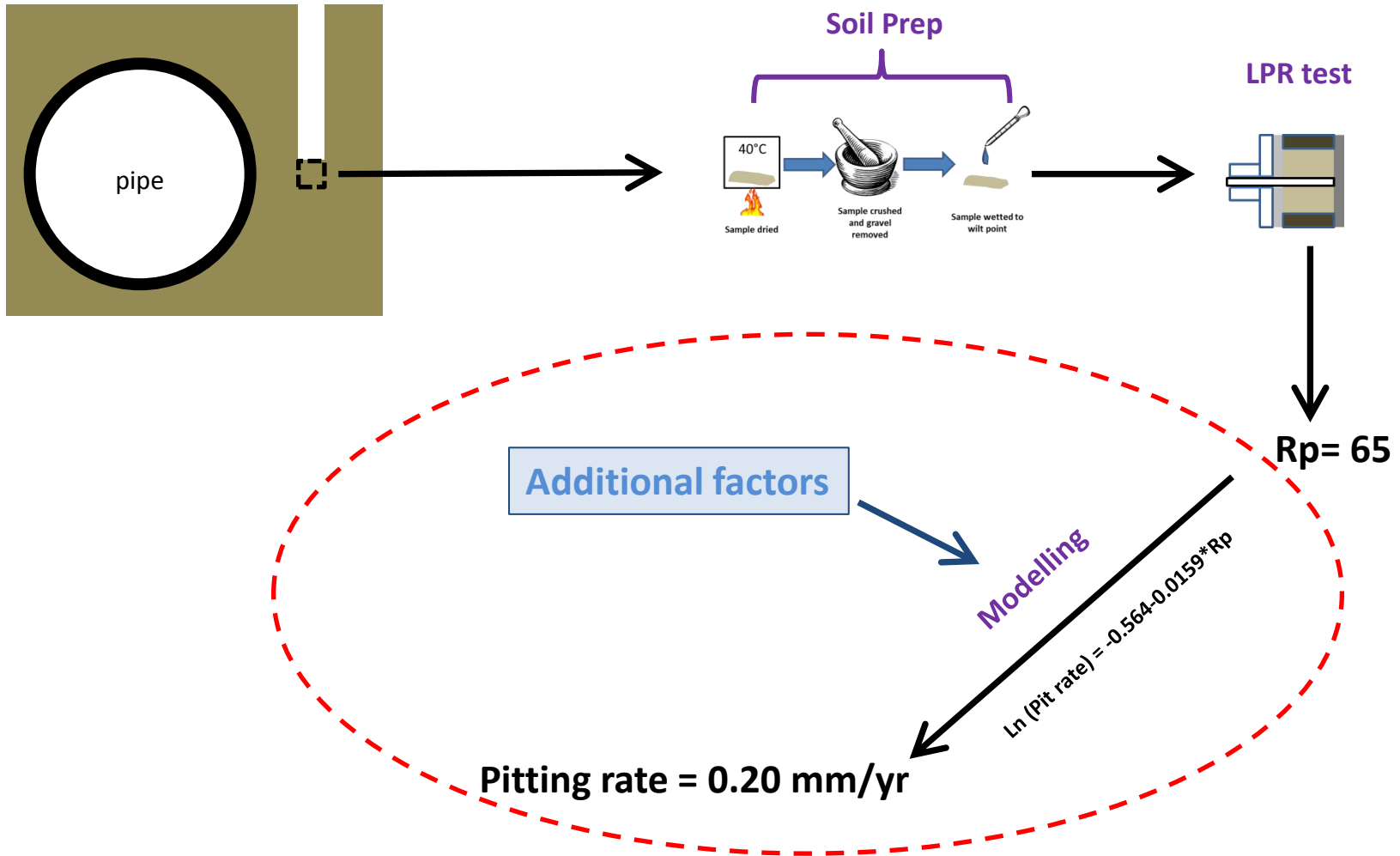
Why not?

1. Not feasible in time frame (results can't be tested on historical data)
2. Different companies – different methods anyway
3. Recent work shows that main areas for improvement of process are not in methodology but rather interpretation of results

Activity 4b. Reducing uncertainty in the use of LPR



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Activity 4b. Reducing uncertainty in the use of LPR

Sub activities:

1. Identify possible factors that we could include in $R_p \rightarrow$ pitting rate model to improve results
 - a) Examine from a theoretical point of view (UoN)
 - b) Examine from a practical point of view (UoN)
2. Round up appropriate data
3. Investigation of machine learning for reducing uncertainty (UTS)

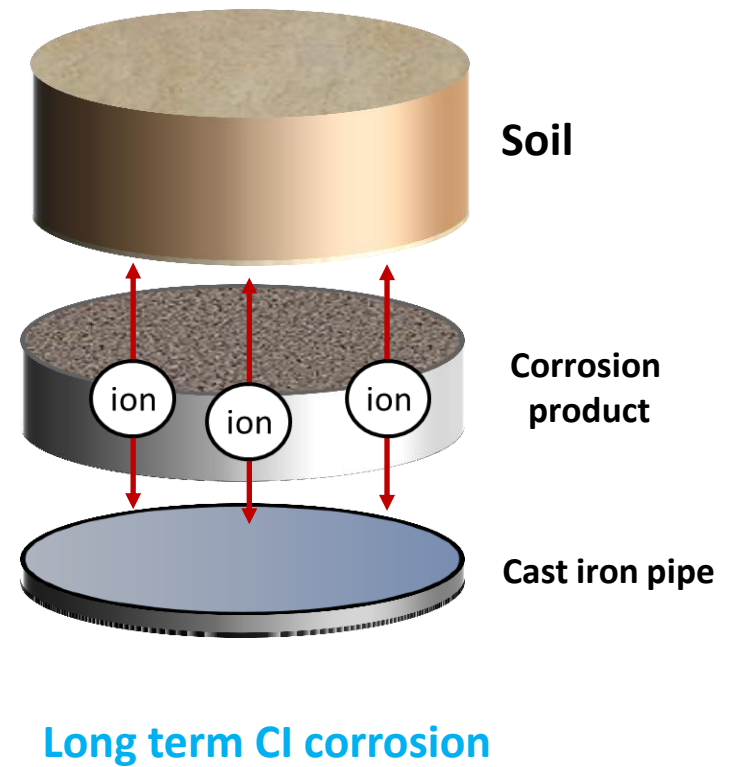
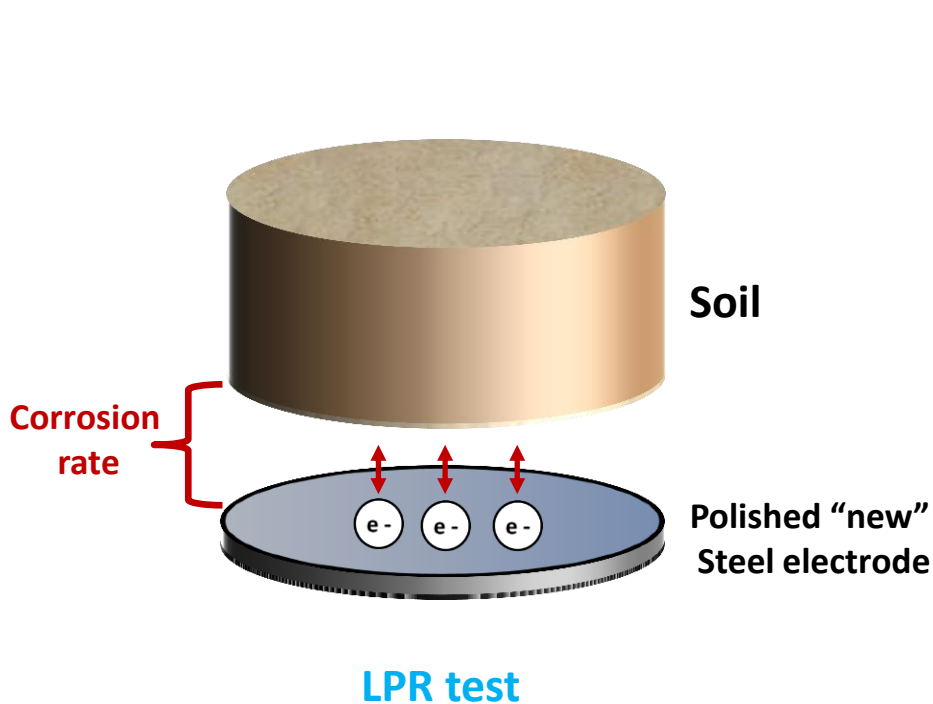
Activity 4b. Reducing uncertainty in the use of LPR

Sub activities:

1. Identify possible factors that we could include in Rp->pitting rate model to improve results
 - a) Examine from a theoretical point of view
 - i. Lit review – done
 - ii. Data base of relevant literature – done
 - iii. Report on findings – done
 - b) Examine from a practical point of view
 - i. Lit review – done
 - ii. Data base of relevant literature – done
 - iii. Report on findings – written, discussed, revised, passed onto PCA
2. Round up appropriate data – ongoing (Ben Wright SW, test bed data, original PCA data??, other field data)
3. Investigation of machine learning for reducing uncertainty – ongoing

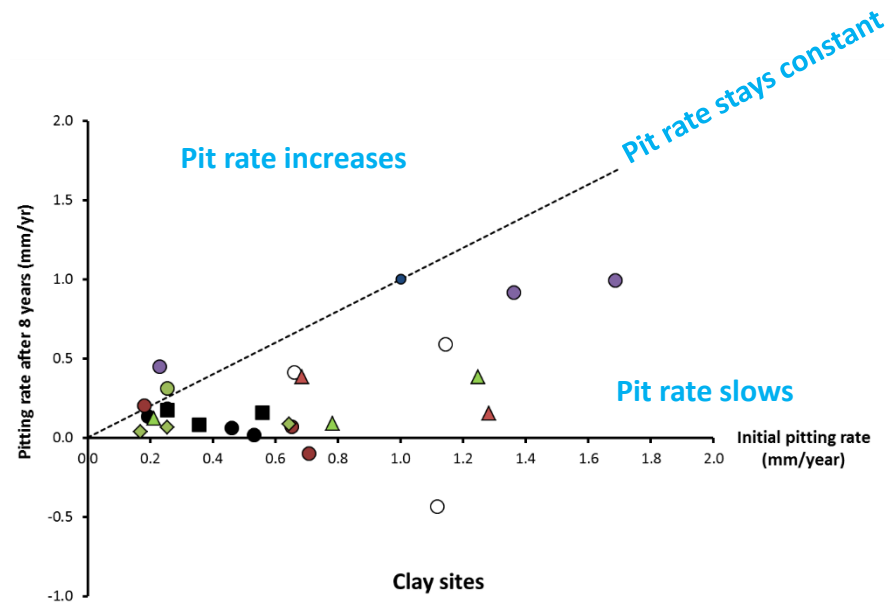
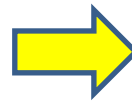
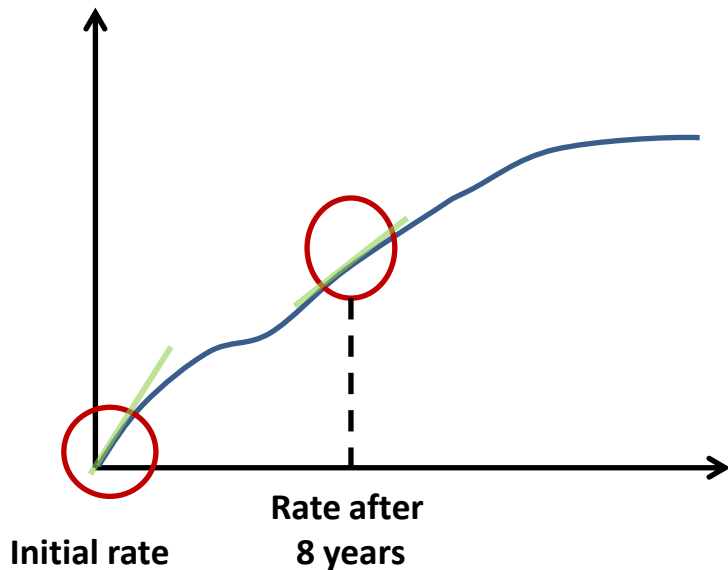
Additional factors that might improve prediction

1. Age of the pipe



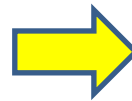
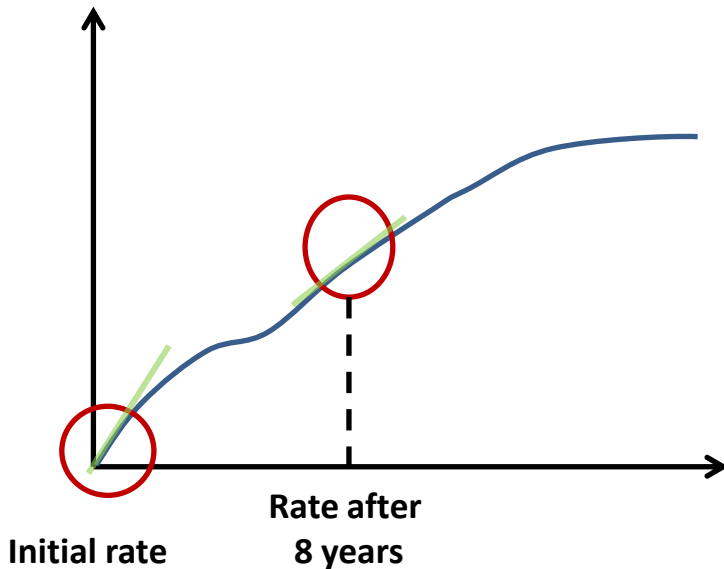
Additional factors that might improve prediction

1. Age of the pipe

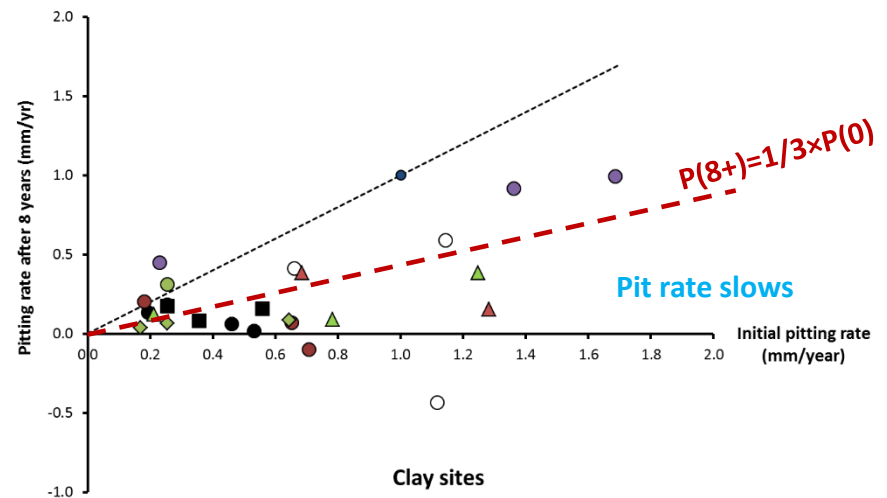


Additional factors that might improve prediction

1. Age of the pipe



Long term pitting rates < initial



Additional factors that might improve prediction

1. Age of the pipe

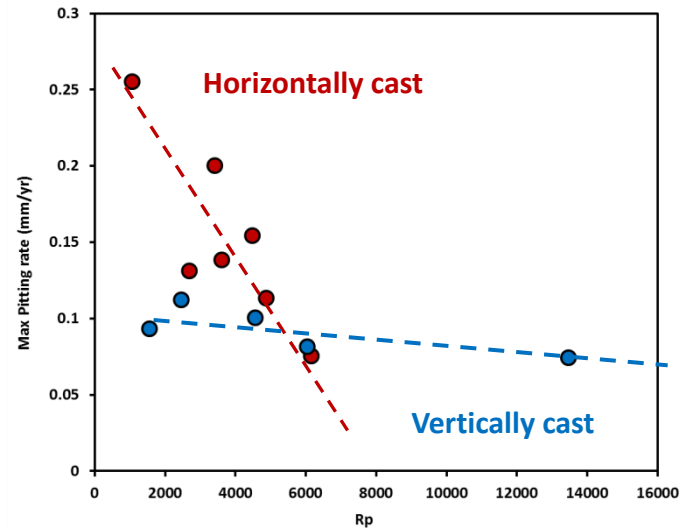
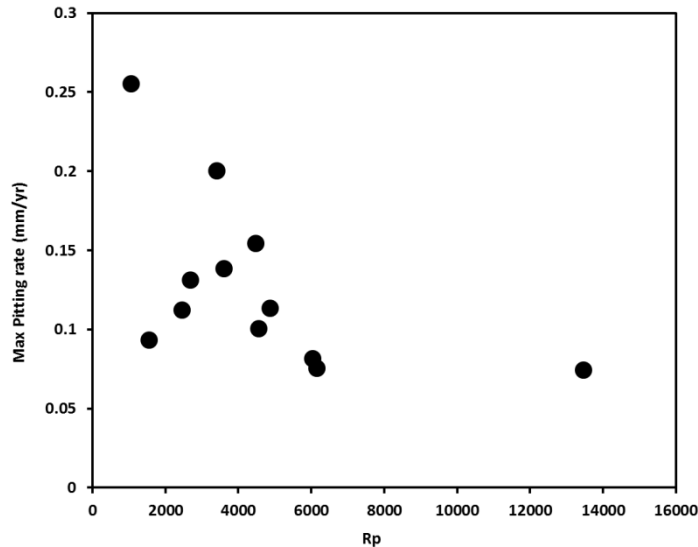
Complicating factors.

- changing method of pipe manufacture (coatings, microstructure)
- changing backfill methods (manual vs mechanical)
- (good) data to determine slowdown of pit rate
 - reliable
 - can't tell from "snapshots"

Additional factors that might improve prediction

2. Method of manufacture

Metal microstructure/coating affects rate of corrosion

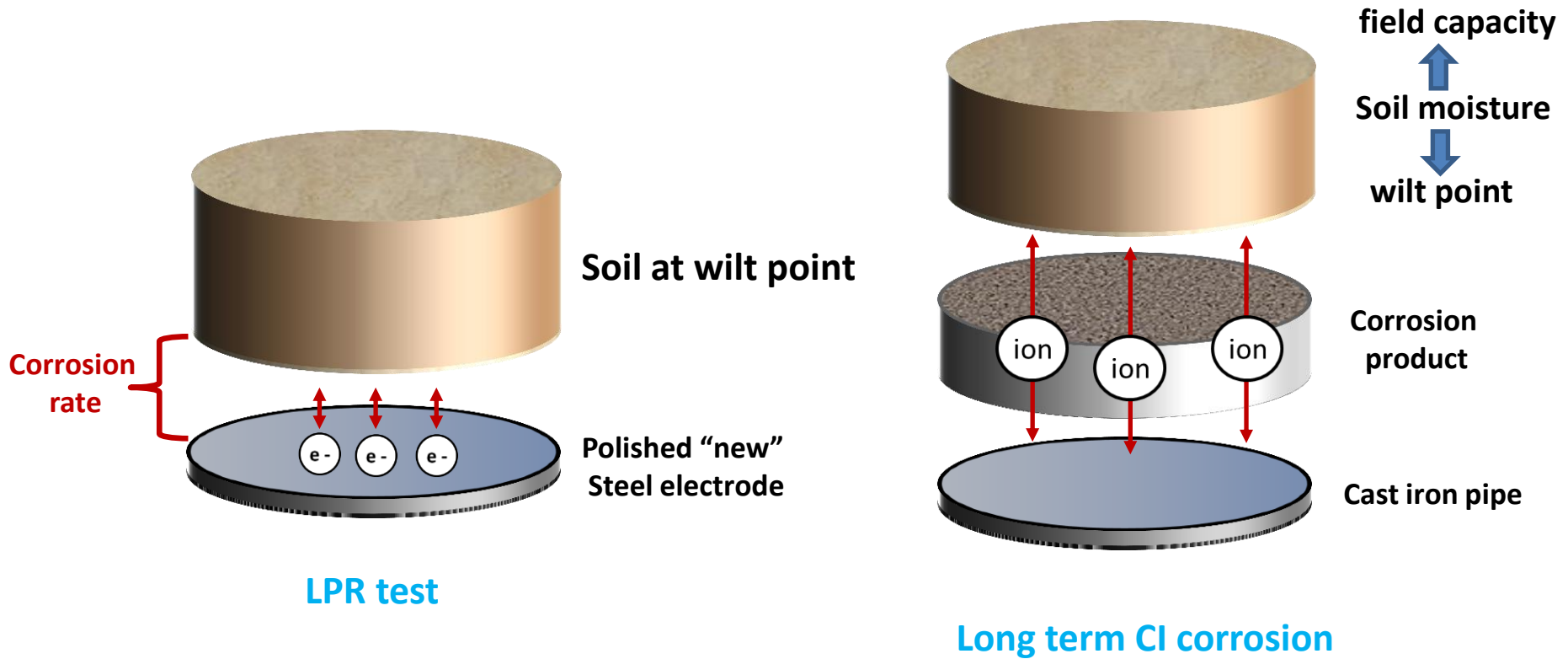


Cast iron pipe corrosion in native soils

Data: M. Dafter, Using LPR to predict underground corrosion of cast iron water mains. Paper 051, in: ACA 2014 conference November 2014, Darwin, 2014.

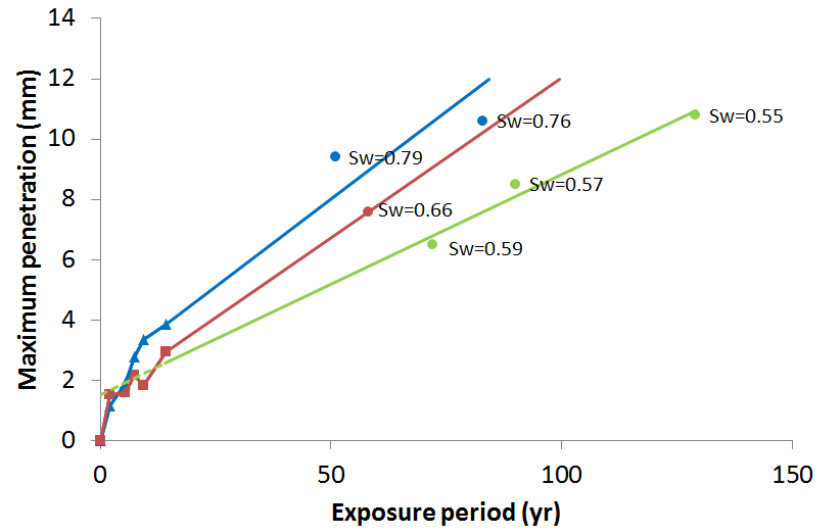
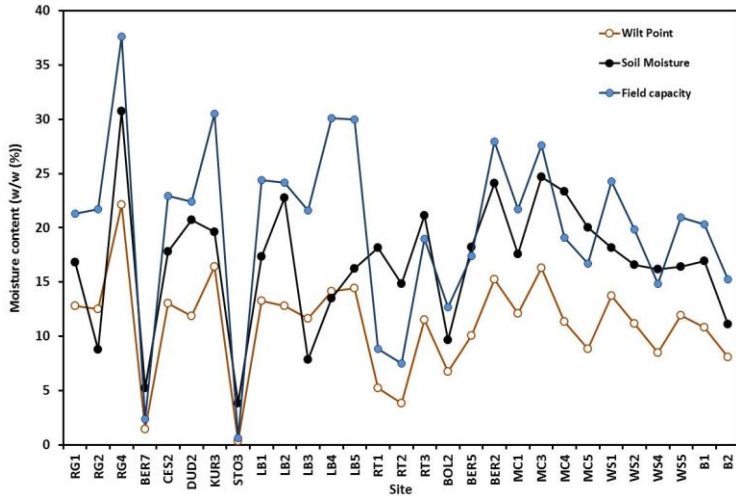
Additional factors that might improve prediction

3. Soil Moisture



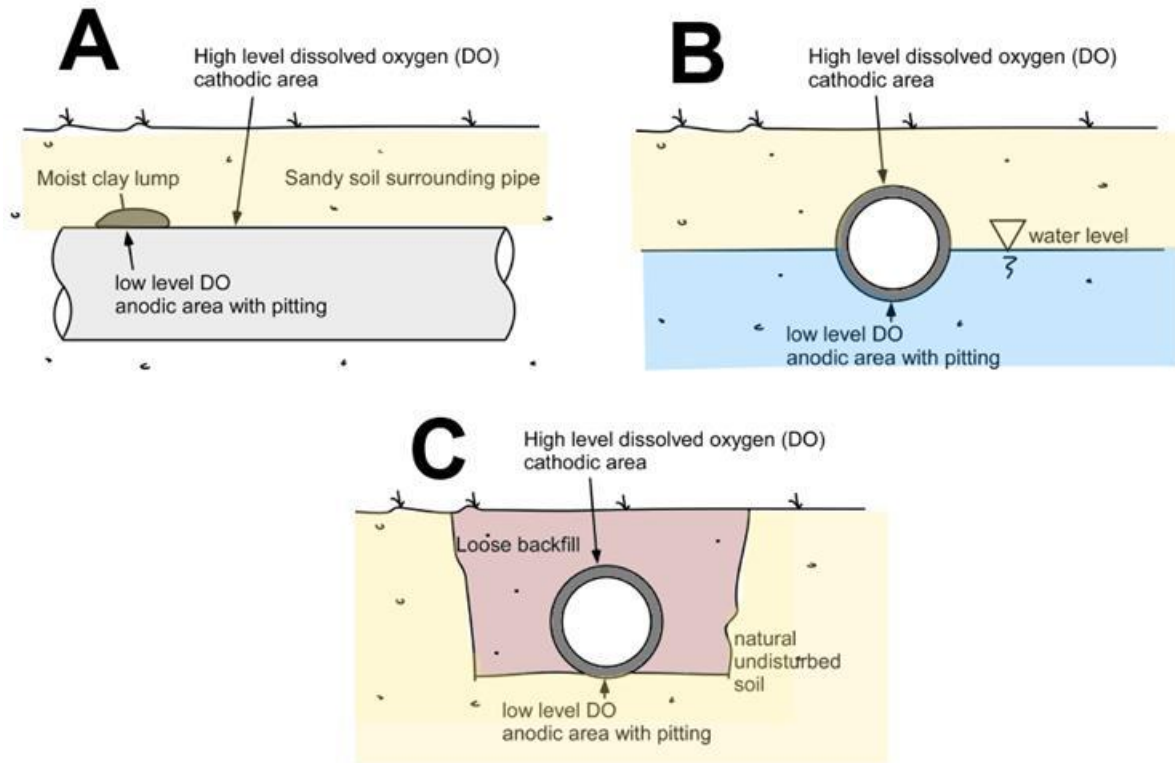
Additional factors that might improve prediction

3. Soil Moisture (saturation)



Additional factors that might improve prediction

4. Nature of fill





Additional factors that might improve prediction

4. Fill type

Complicating factors.

- how to characterise this effect?
 - very localised? (not according to PCA)
 - a simple adjustment factor for type of backfill?
 - how does fill type interact with other factors (e.g. soil moisture)



Strategy for model improvement

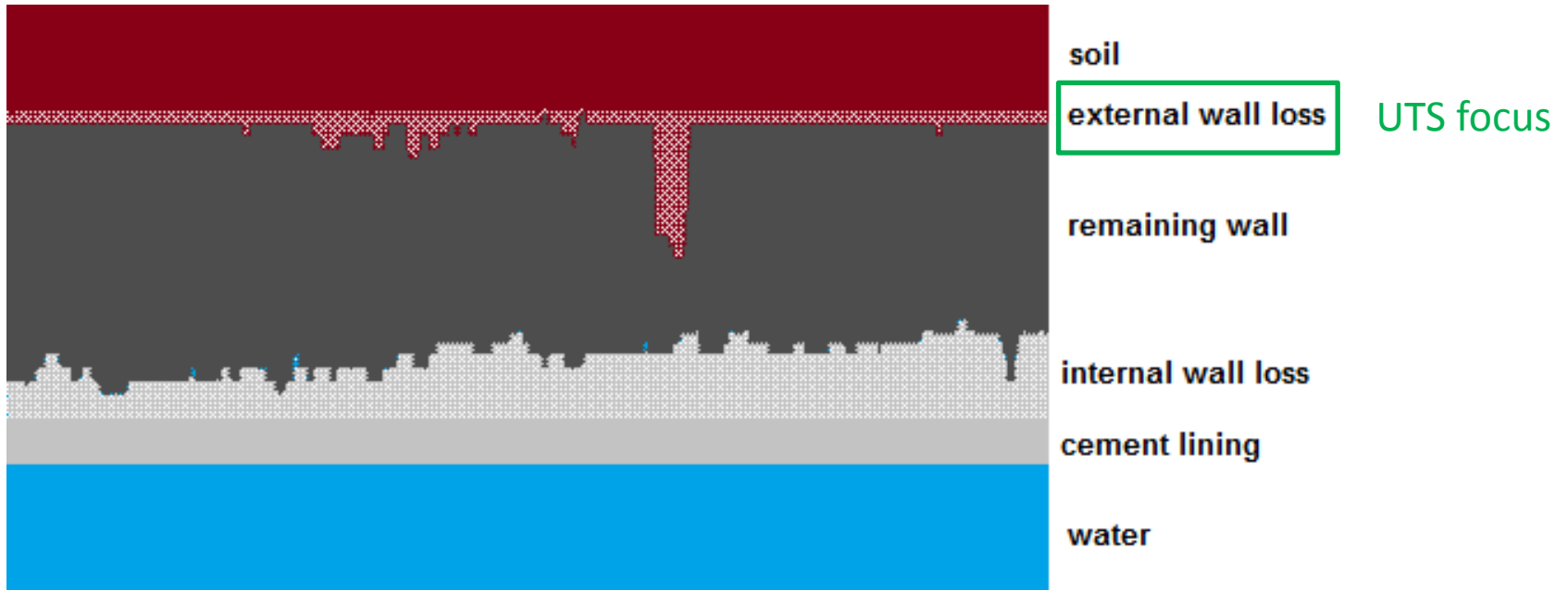
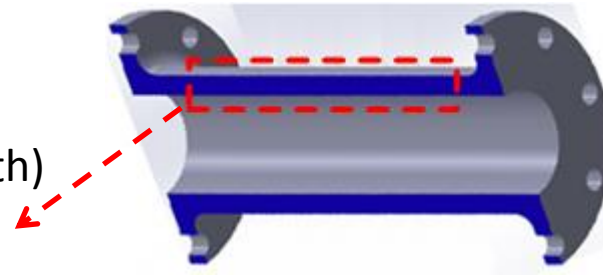
1. Gather data :

LPR (PCA) + soil moisture + fill type + age and how pipe manufactured

2. Conduct ML analysis of data to see if incorporation of new factors improves the corrosion rate prediction.

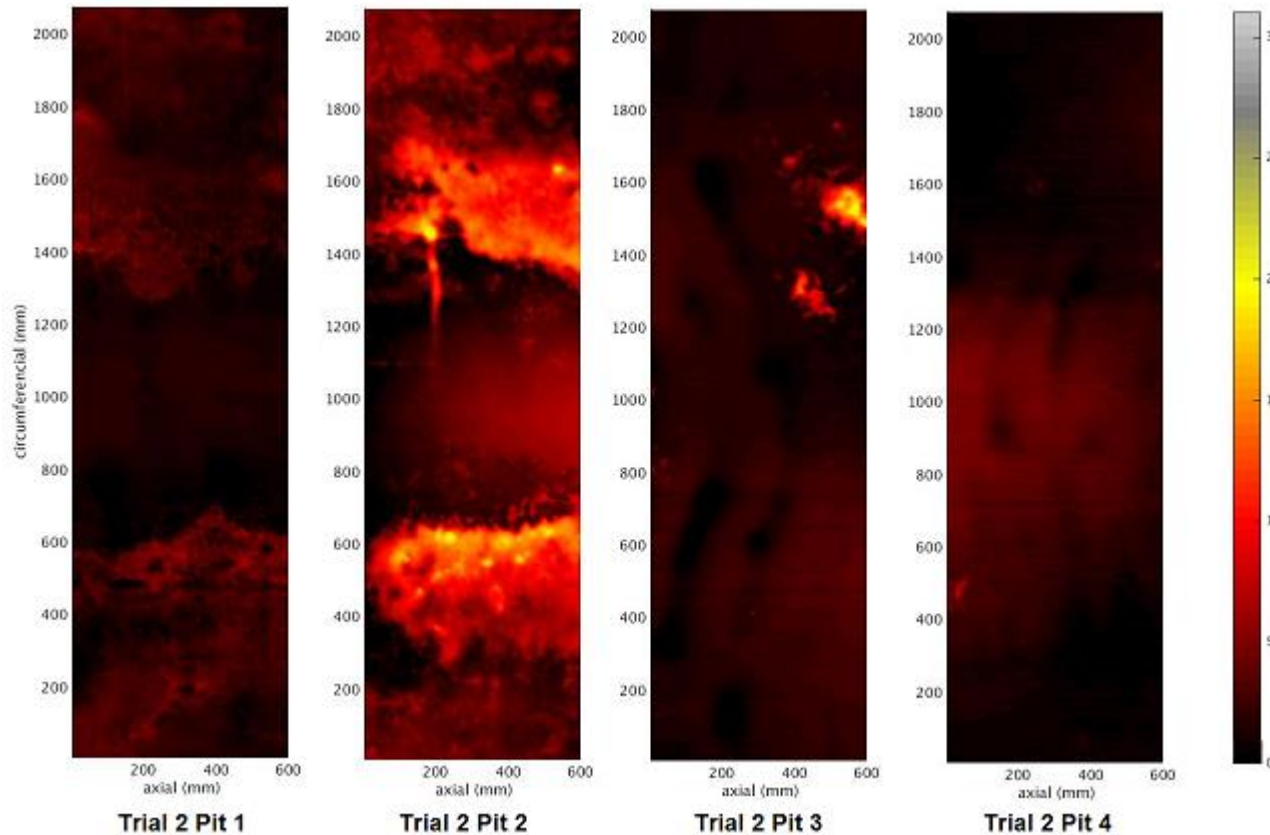
Strategy for model improvement

External Wall Loss Map
(‘cylinder fitting’ estimate from Ground Truth)



Strategy for model improvement

Ground Truth: External Wall Loss Map (examples)

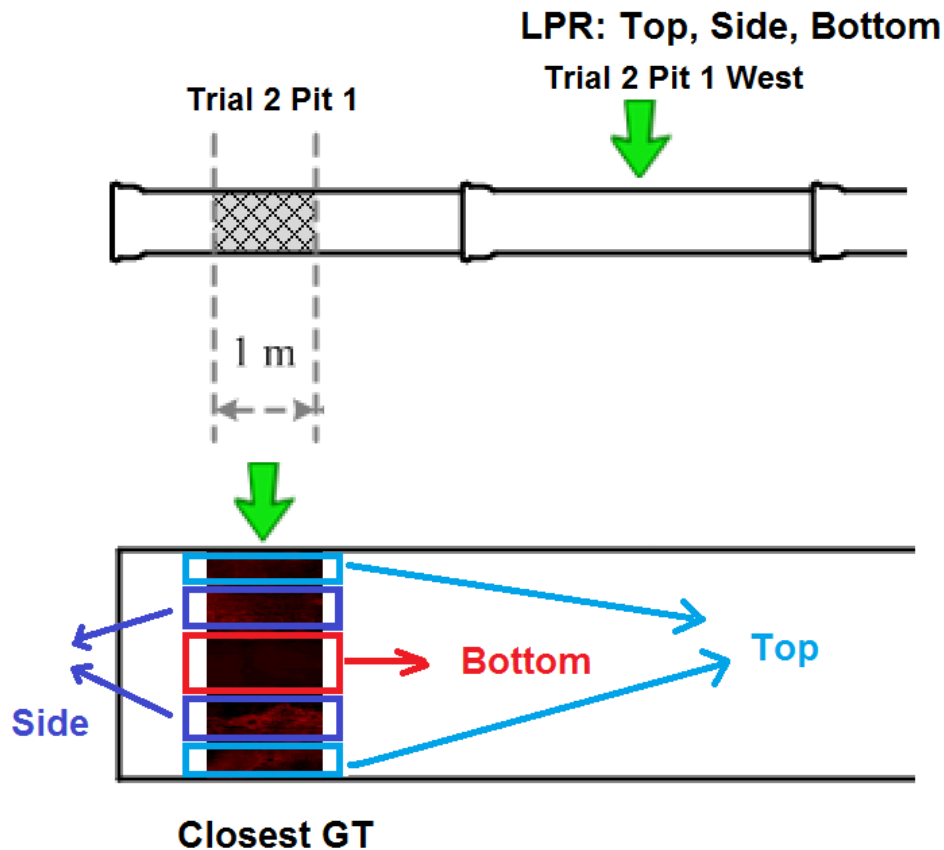


A number of parameters/statistics can be estimated, e.g.:

- Maximum single point wall loss (maximum pitting?)
- Average pitting
- Average wall loss

Strategy for model improvement

How we match GT with data: closest pipe section



Strategy for model improvement

Preliminary Results: it's hard to validate the relationship between LPR and the statistical value (s) representing wall loss. More data required.

