

# SHIFTING SANDS

REVOLUTIONIZING SOIL LIQUEFACTION ASSESSMENT  
THROUGH MACHINE LEARNING MODELS

LEARNING TEAM 1

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## Liquefaction in Dagupan, Pangasinan 1990



# SOIL LIQUEFACTION

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# THE EMPIRICAL METHOD

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IDRISS AND BOULANGER (2010)

$$FS = \frac{CRR}{CSR}$$

# THE EMPIRICAL METHOD

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IDRISS AND BOULANGER (2010)

$$CSR = 0.65 \frac{\sigma_v}{\sigma_v'} \frac{a_{max}}{g} r_d$$

$$C_\sigma = \frac{1}{18.9 - 2.55 \sqrt{(N_1)_{60cs}}} \leq 0.3$$

$$r_d = e^{[\alpha(z) + \beta(z)M]}$$

$$FS = \frac{CRR}{CSR}$$

$$K_\sigma = 1 - C_\sigma \ln \left( \frac{\sigma_v'}{P_a} \right) \leq 1.1$$

$$\alpha(z) = -1.012 - 1.126 \sin \left( \frac{z}{11.73} + 5.133 \right)$$

$$N_{1-60cs} = N_{1-60} + e^{\left( 1.63 + \frac{9.7}{FC+0.01} - \frac{15.7}{FC+0.01}^2 \right)}$$

$$\beta(z) = 0.106 + 0.118 \sin \left( \frac{z}{11.28} + 5.142 \right)$$

$$CRR = e^{\left( \frac{N_{1-60cs}}{14.1} + \frac{N_{1-60cs}}{126}^2 - \frac{N_{1-60cs}}{23.6}^3 + \frac{N_{1-60cs}}{25.4}^4 - 2.8 \right)}$$

$$MSF = 6.9e^{\frac{-M}{4}} - 0.058 \leq 1.8$$

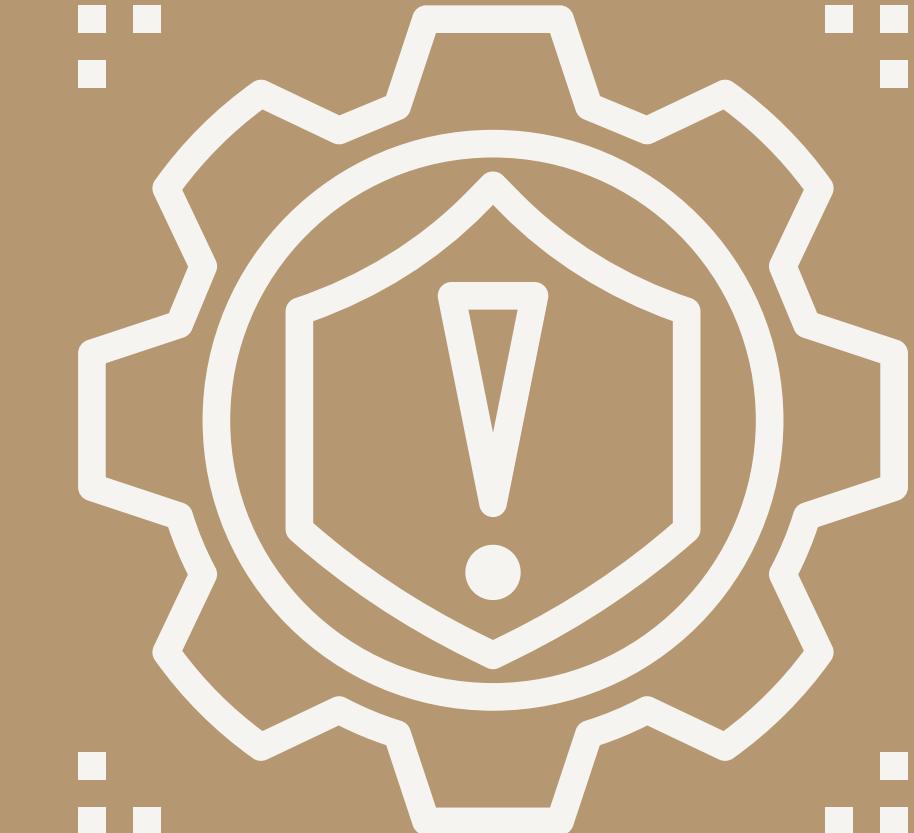
# OBJECTIVE

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## MACHINE LEARNING MODEL



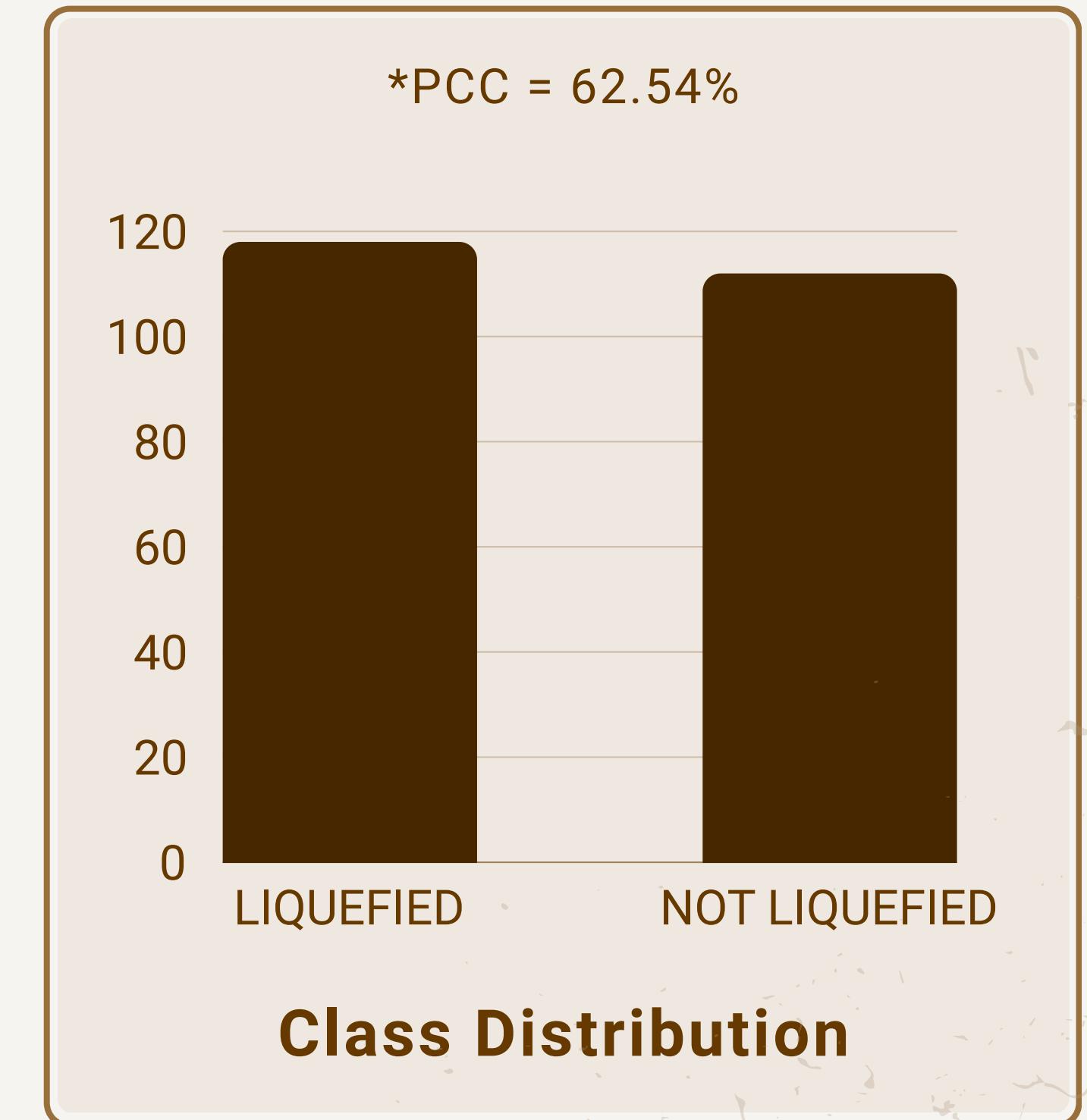
PREDICT



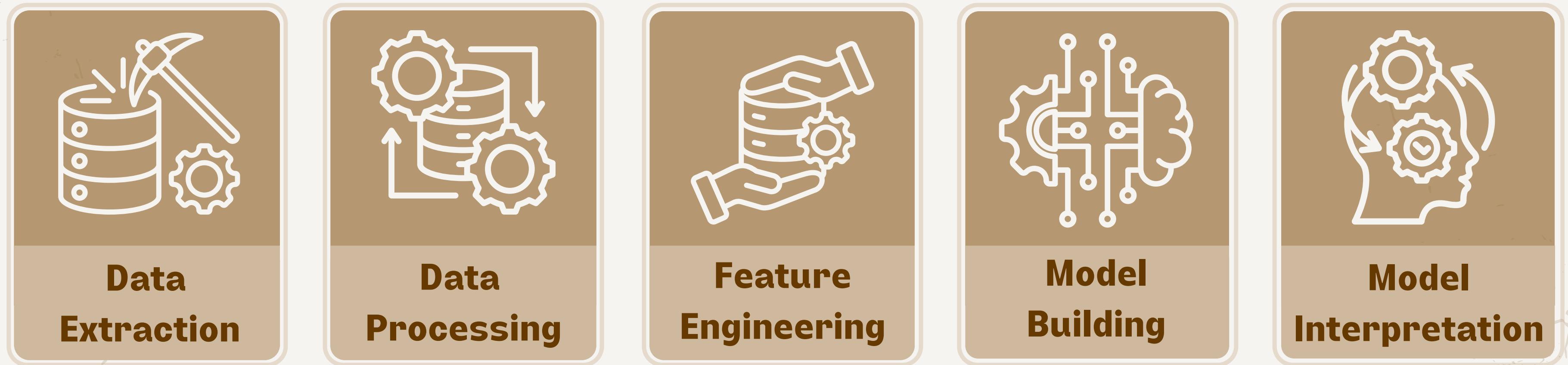
MITIGATE

# DATASET

- 254 Data Points (Case Histories)
- Identified Critical Layers
- Features:
  - Magnitude
  - Peak Ground Acceleration
  - Average Depth
  - Ground Water Depth
  - Porewater Pressure
  - SPT N-Value ( $N_{1-60}$ )
  - %Fines Content
  - Total Vertical Stress
  - Effective Vertical Stress
  - $K_\sigma$
  - Magnitude Scaling Factor
  - Cyclic Stress Ratio
  - Cyclic Resistance Ratio
  - Shear Stress Reduction Factor



# METHODOLOGY



KNN, Logistic Regression, SVC, Decision Tree, Random Forest, GBM, XGBoost

# MODEL PERFORMANCE

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**XGBoost Classifier      Accuracy**

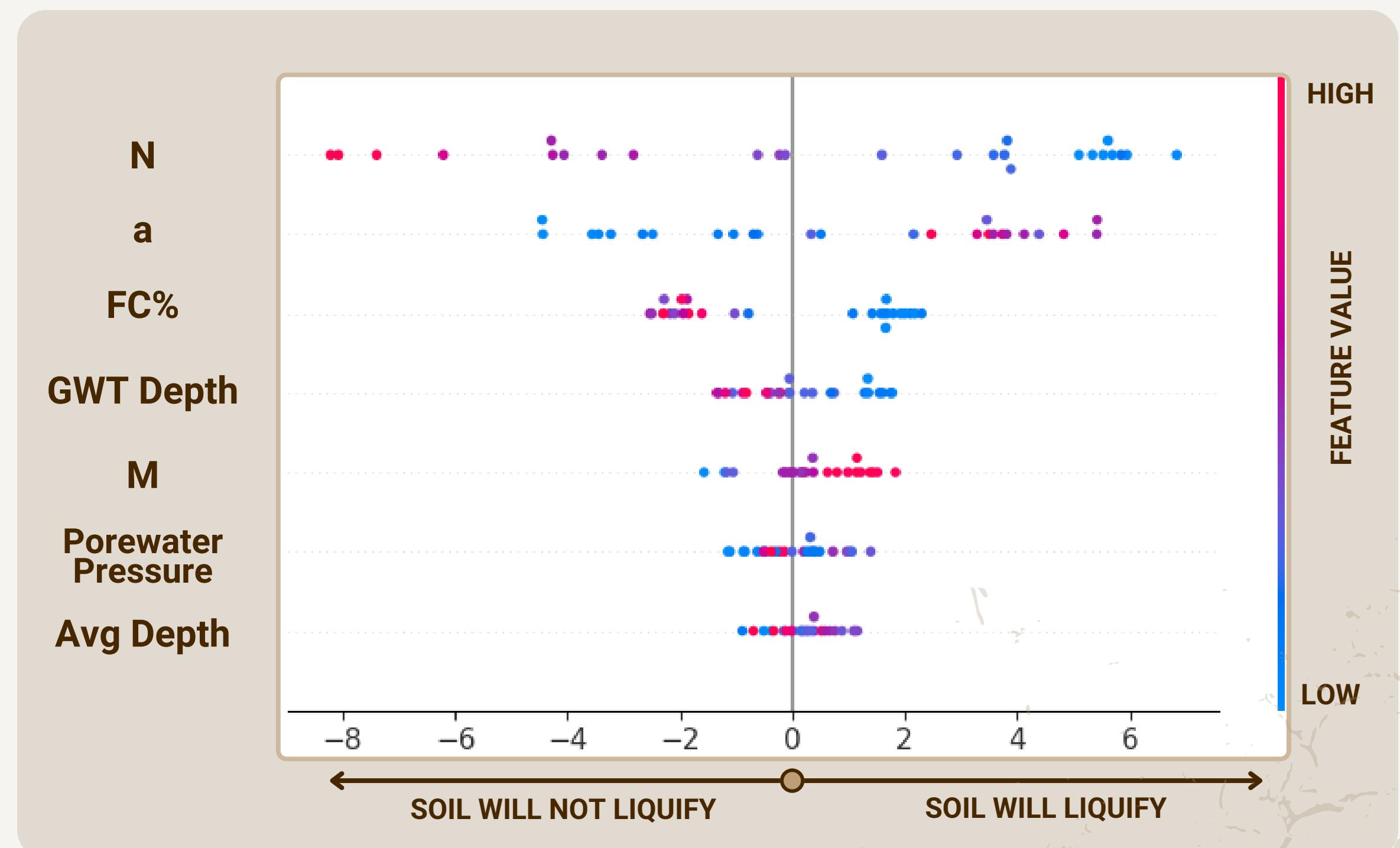
**TRAIN**                  **99.95%**

**TEST**                  **84.69%**

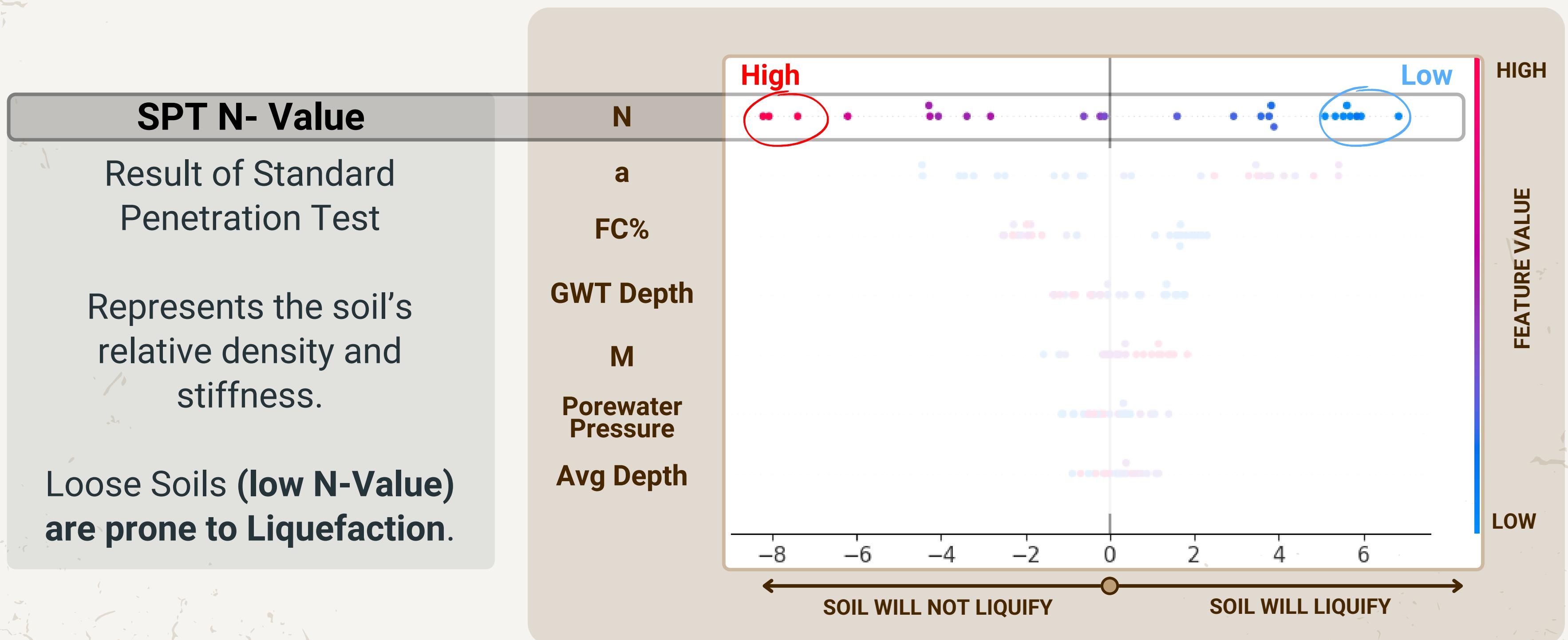
**Empirical Method      Accuracy**

**TEST**                  **83.00%**

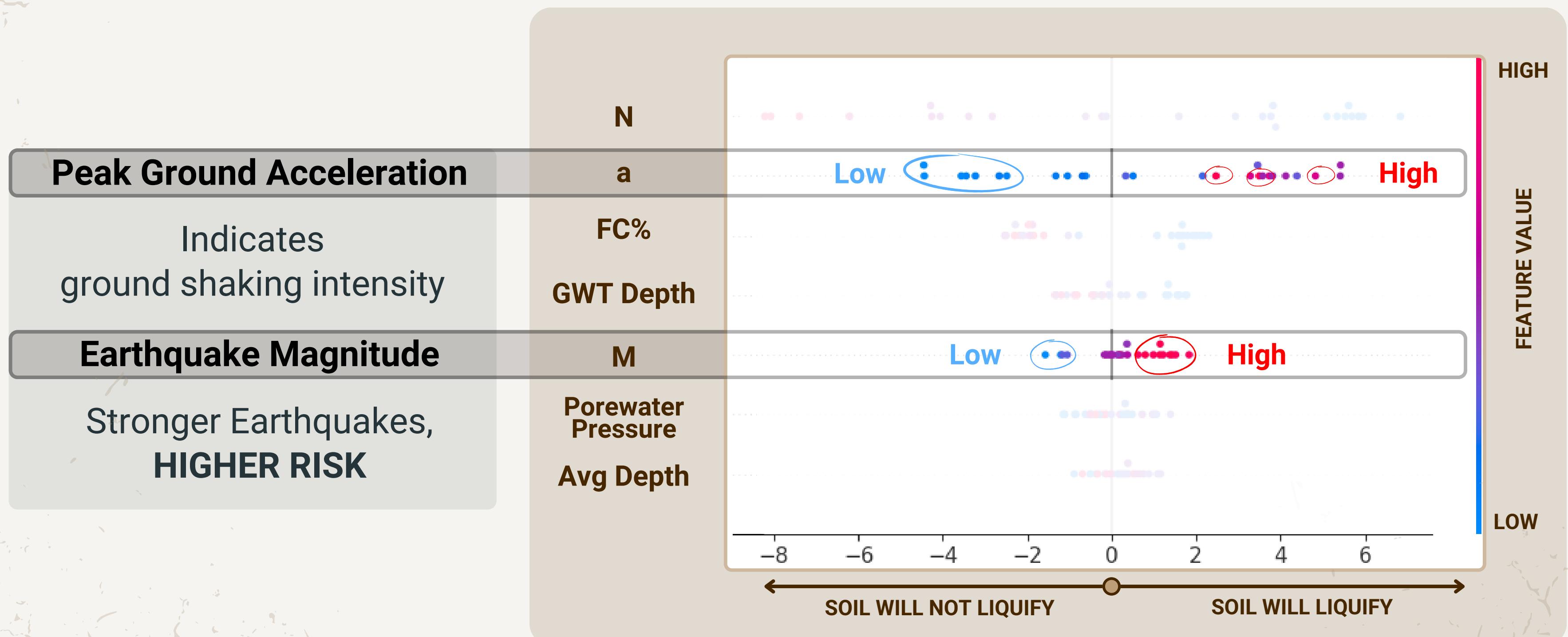
# DOES THE MODEL MAKE SENSE?



# MODEL INTERPRETATION



# MODEL INTERPRETATION



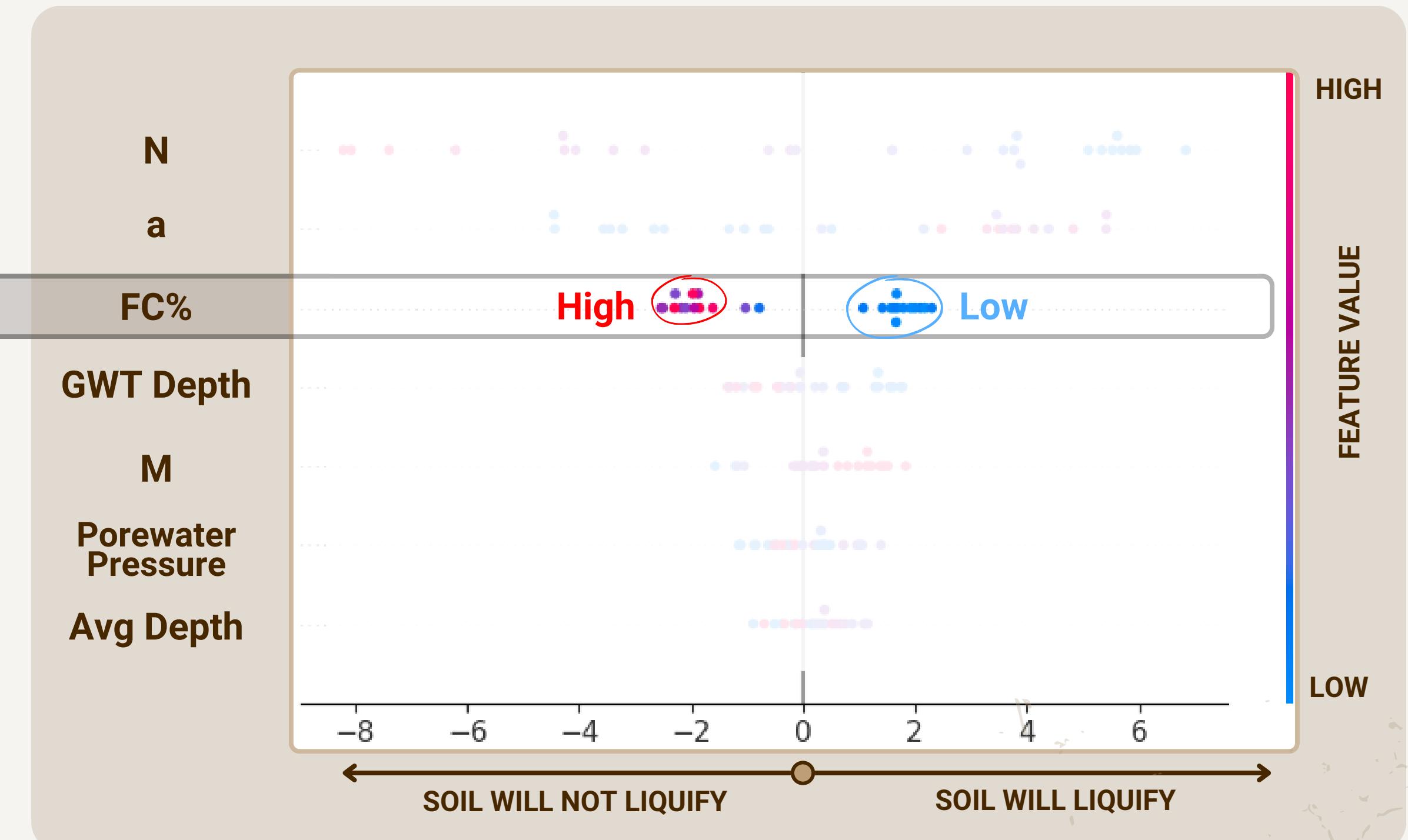
# MODEL INTERPRETATION

HIGH FC% - more silt and clay

**Percentage of Fines Content**

Clay provides **COHESION**.

**COHESION RESISTS  
LIQUEFACTION**



# IMPLEMENTATION

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# CASE HISTORY

## LOMA PRIETA, CALIFORNIA (1989)



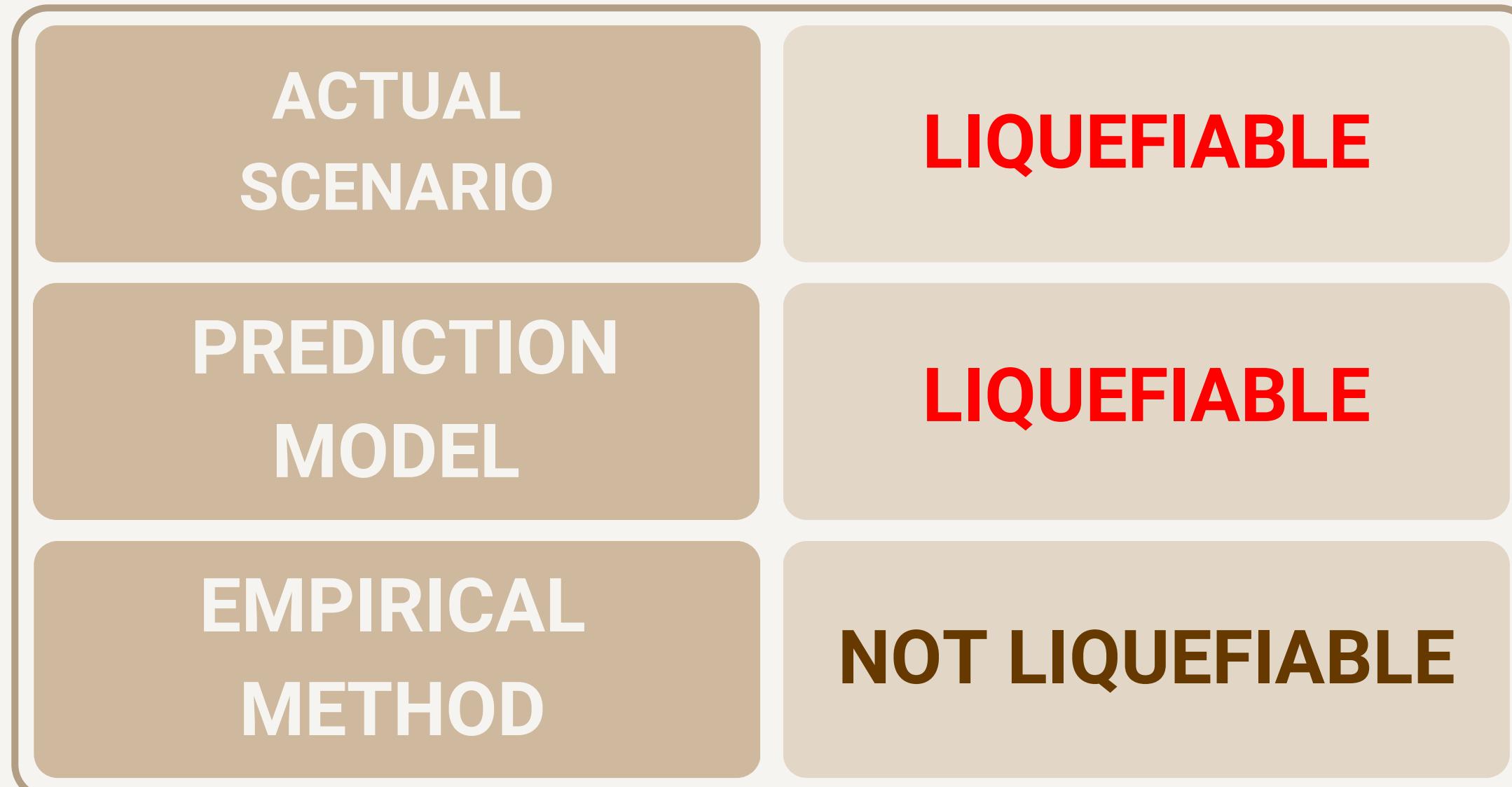
# IMPLEMENTATION

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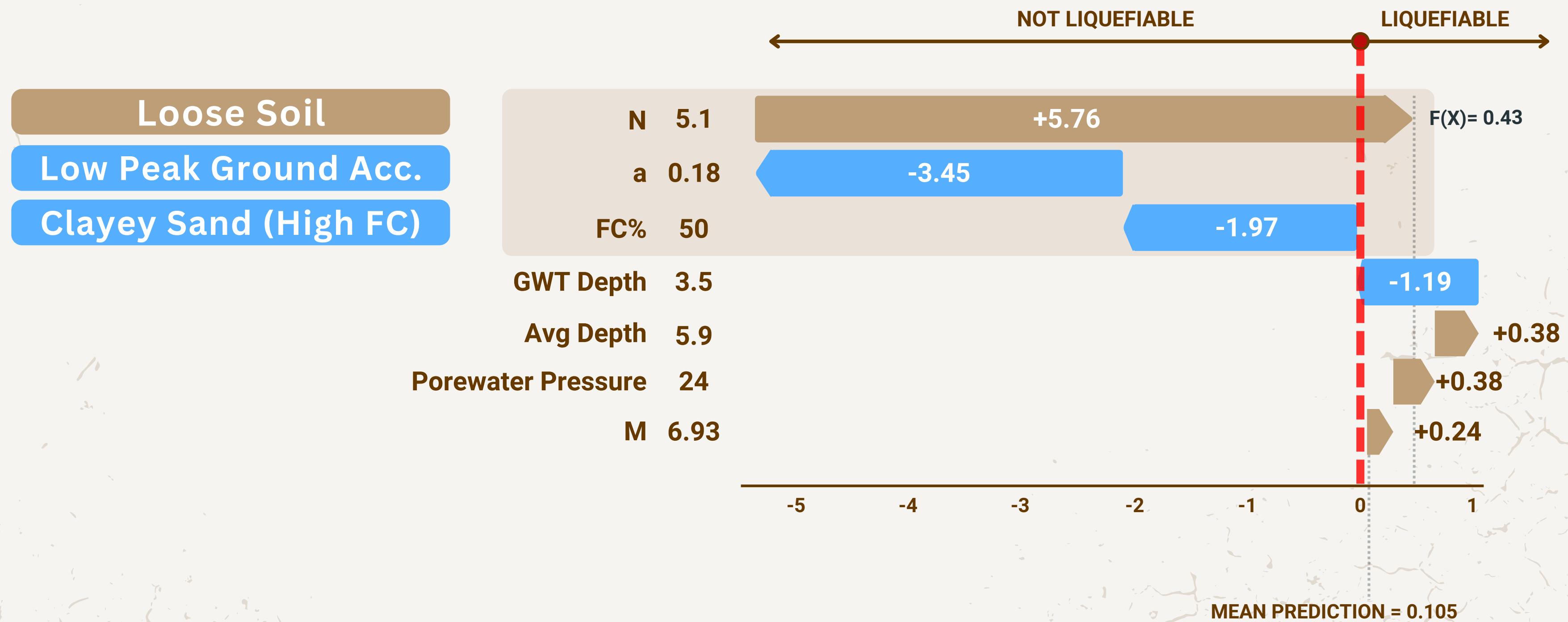
N	5.1	—	<i>stiffness of soil</i>
a	0.18	—	<i>ground shaking intensity</i>
M	6.93	—	
FC%	50	—	<i>presence of silt and clay</i>
GWT Depth	3.5		
Avg Depth	5.9		
Porewater Pressure	24		

# CASE HISTORY

N	5.1
a	0.18
FC%	50
GWT Depth	3.5
Avg Depth	5.9
Stress Diff	24
M	6.93



# PREDICTION EXPLANATION



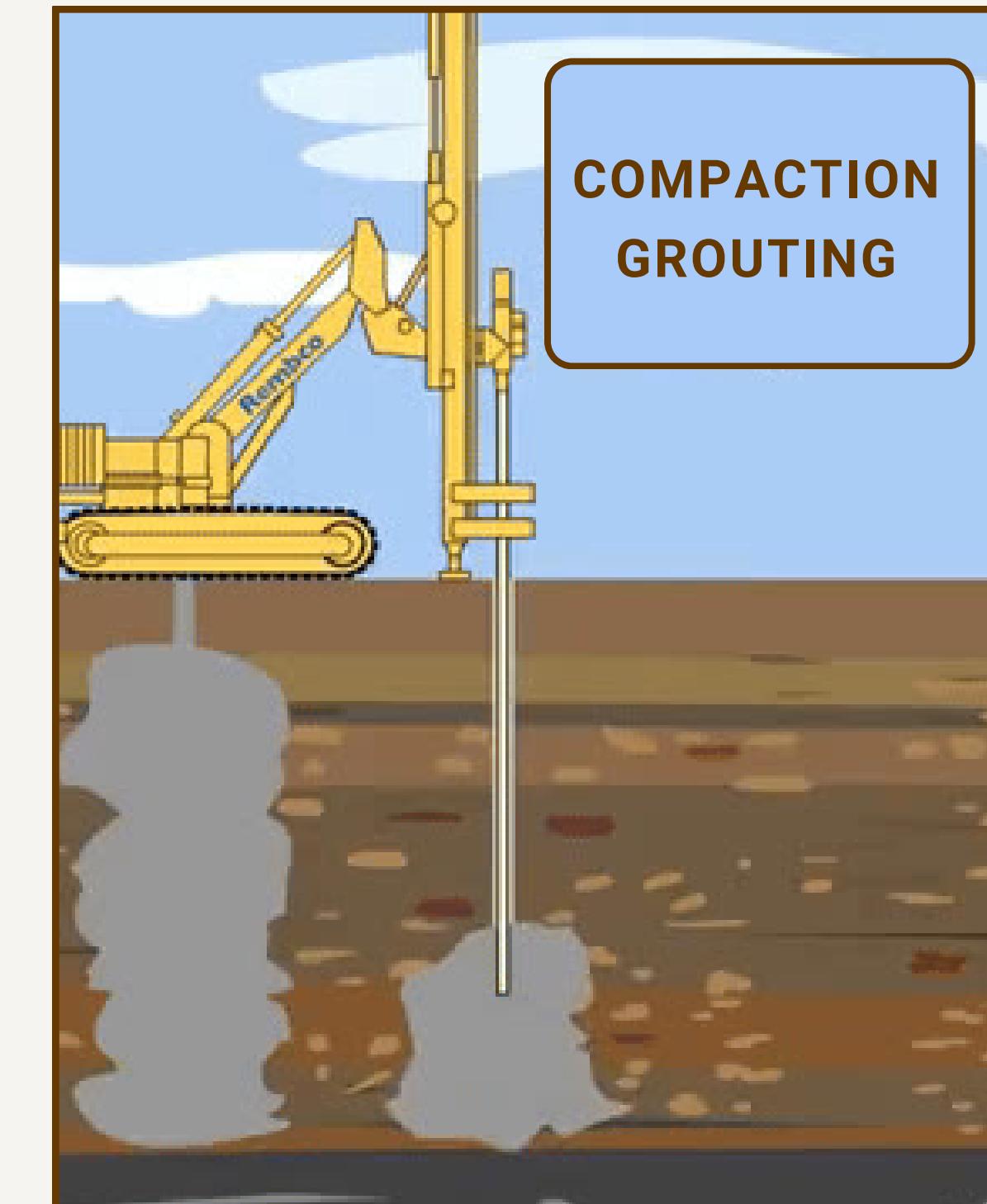
# COUNTERFACTUALS

N	5.1	→	13.3
a	0.18	→	0.18
FC%	50	→	50
GWT Depth	3.5	→	3.5
Avg Depth	5.9	→	5.9
Porewater Pressure	24	→	24
M	6.93	→	6.93
LIQUEFIABLE	→	NOT LIQUEFIABLE	

INCREASE SOIL  
STIFFNESS

# COUNTERFACTUALS

N	5.1	→	13.3
a	0.18	→	0.18
FC%	50	→	50
GWT Depth	3.5	→	3.5
Avg Depth	5.9	→	5.9
Porewater Pressure	24	→	24
M	6.93	→	6.93
LIQUEFIABLE		→	NOT LIQUEFIABLE



# CASE HISTORIES



## DAMAGE

\$ 8,584,000\*



## CASUALTIES

3 Dead\*

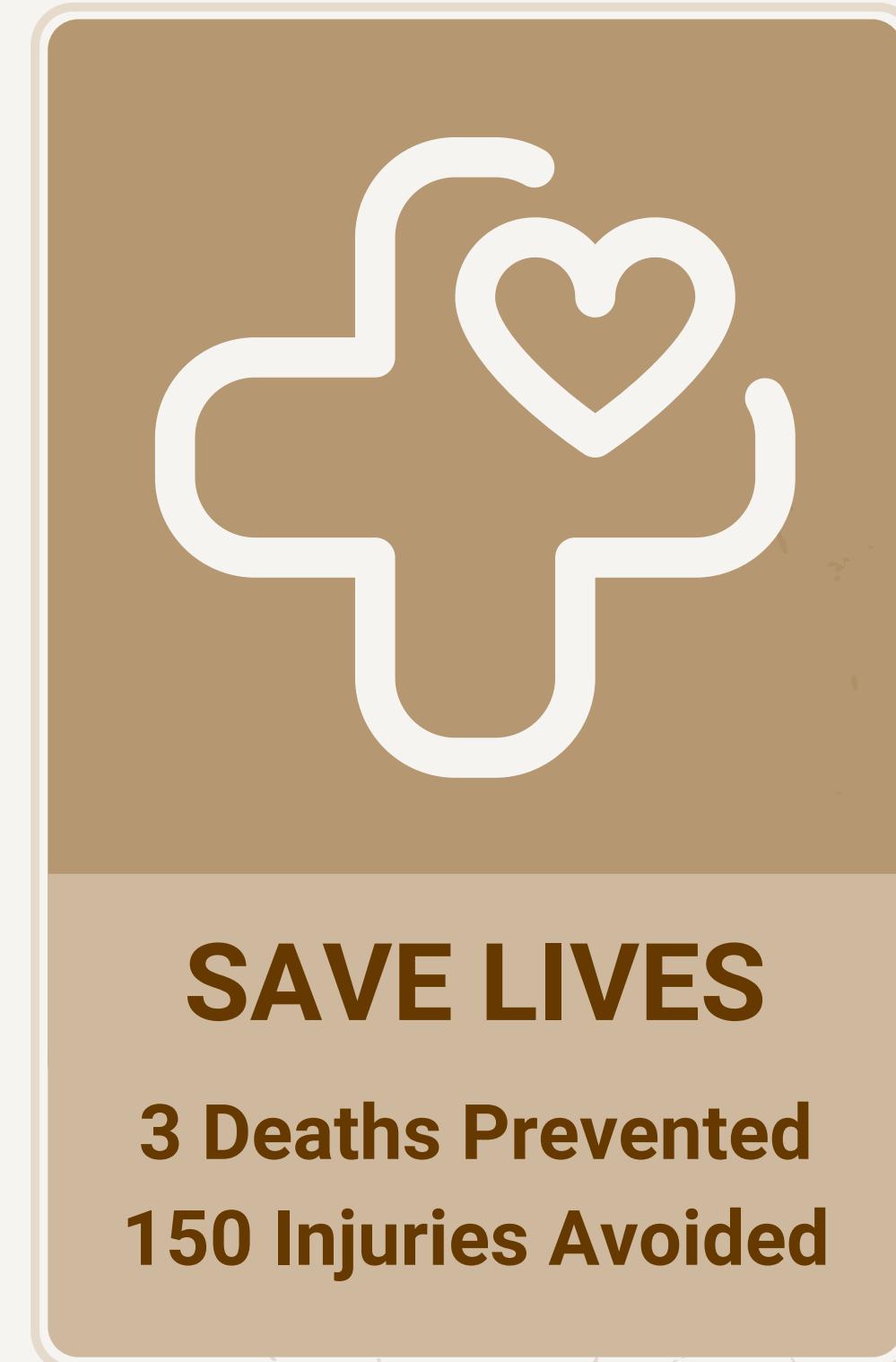
150 Injured\*

# SIGNIFICANCE OF 1.69% INCREASE



DAMAGE  
PREVENTED

\$ 8,584,000\*



SAVE LIVES

3 Deaths Prevented  
150 Injuries Avoided

# MEET THE TEAM



**Chu, Riel**



**Mercado, Gabriel**



**Servañez, Gian**



**Ymson, Arvin**



**Zabala, James**

