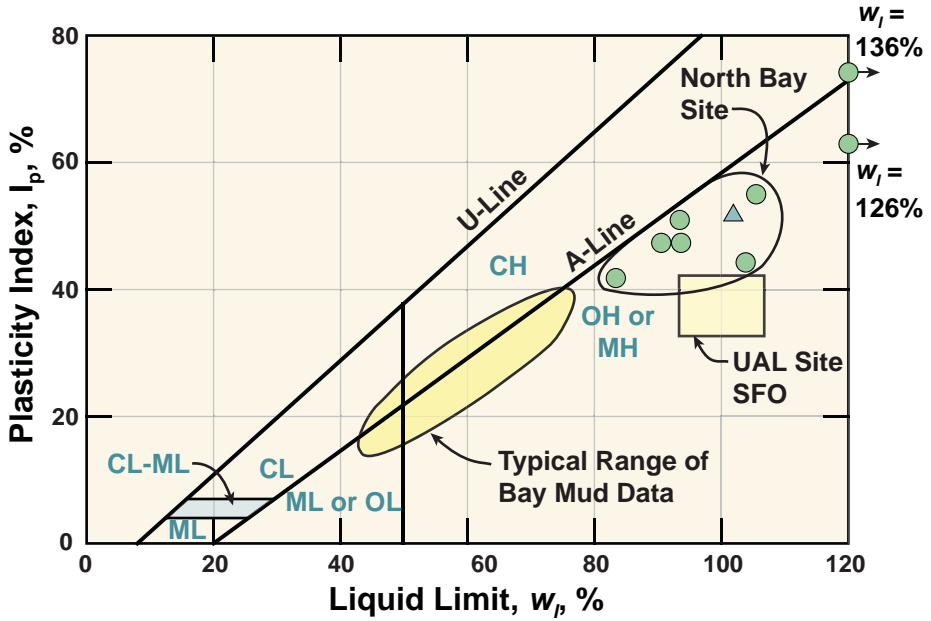
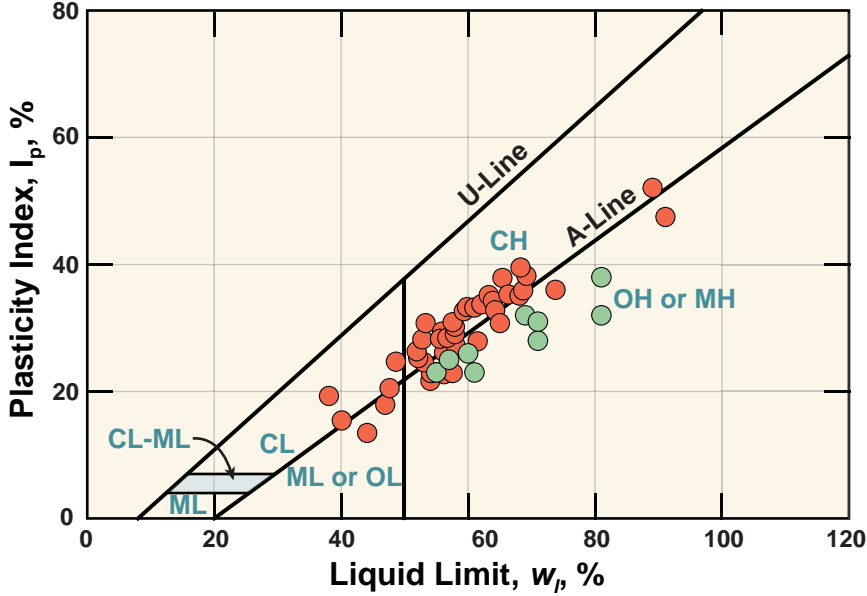


# Bay Mud

**FIG\_18: Title**

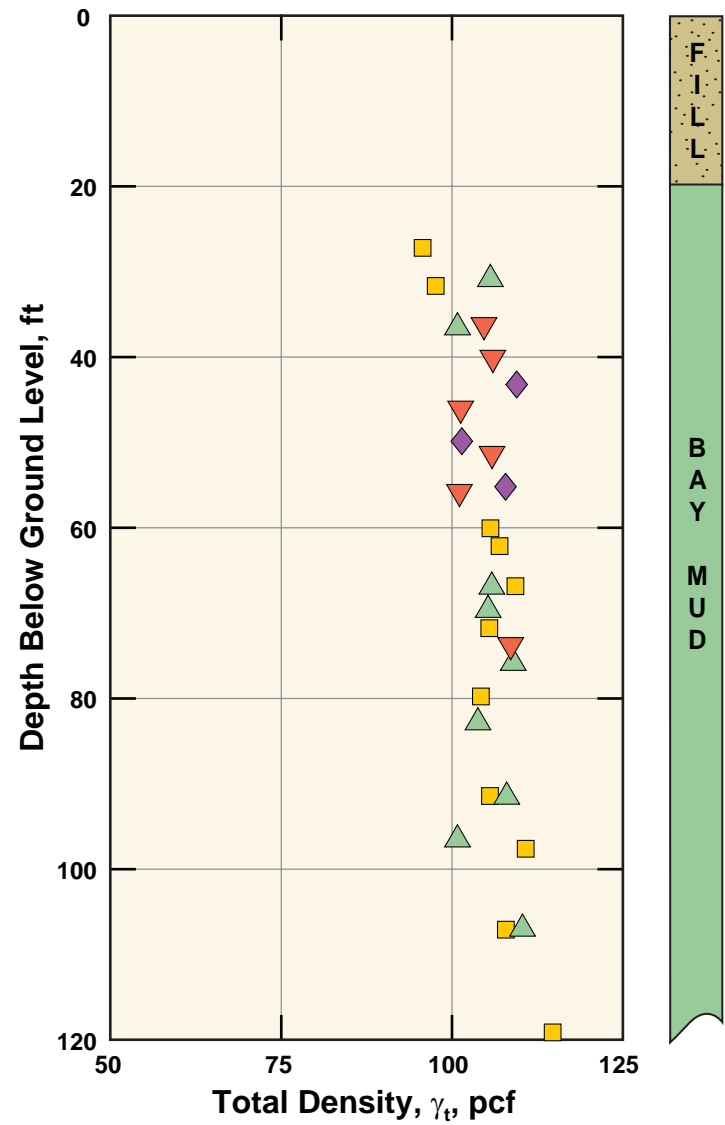
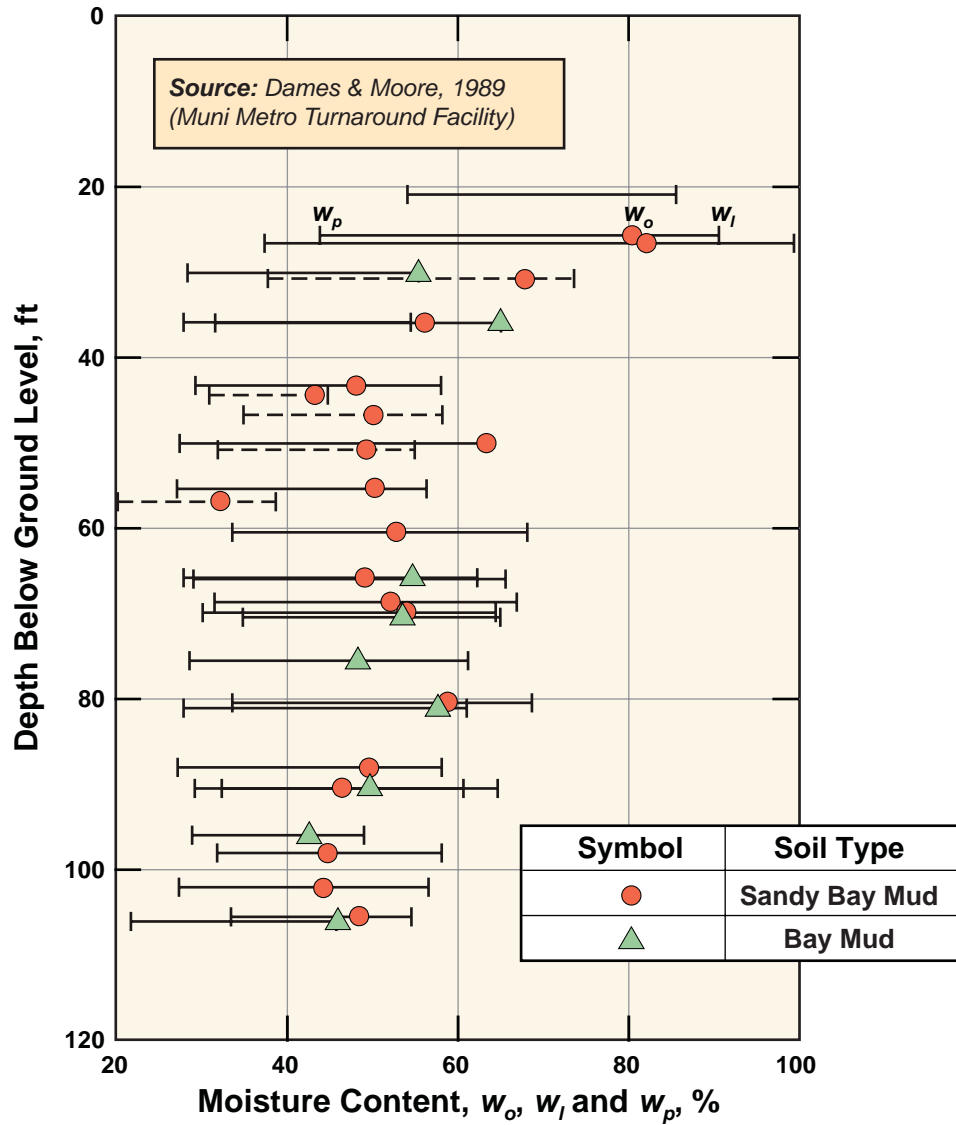
**Bay Mud**

Symbol	Source
● (Green)	DTX Project
● (Red)	Other San Francisco Projects

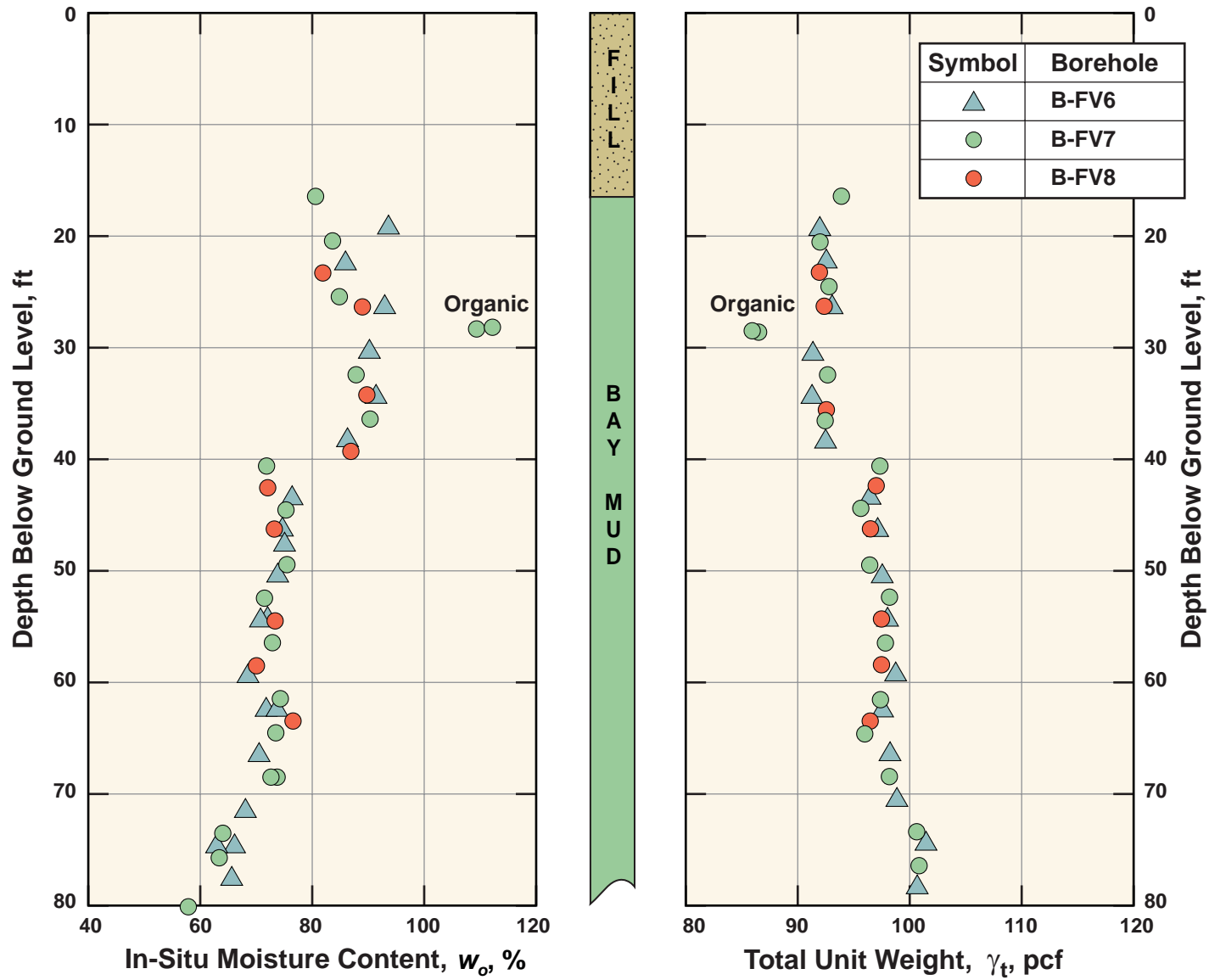


FIG\_18A: Atterberg Limits of Bay Mud

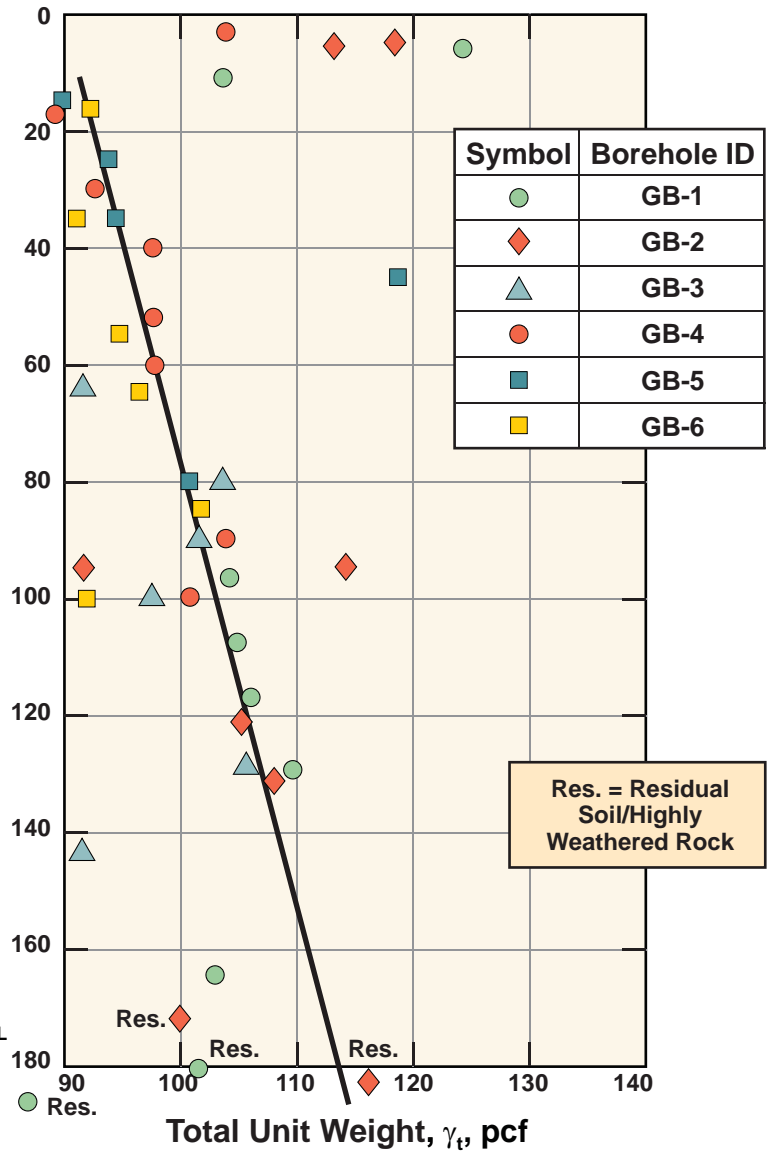
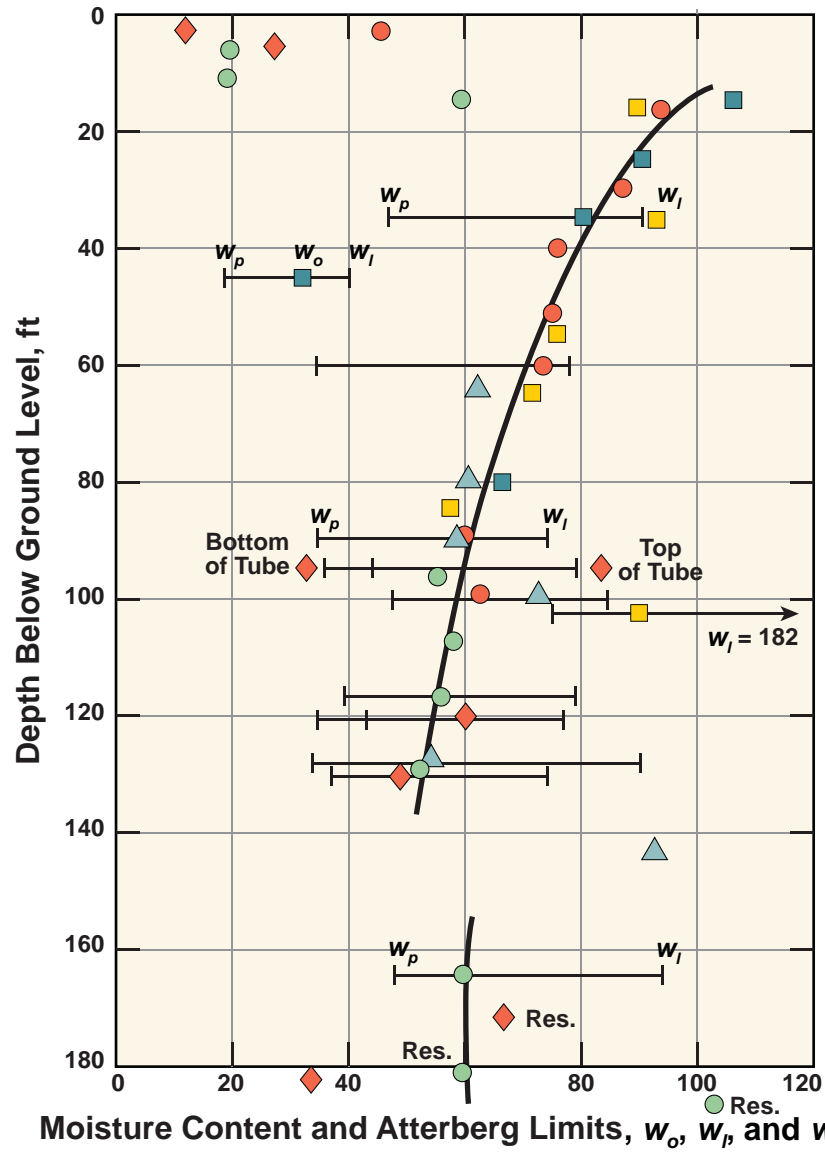
W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Plates\03 BAY MUD (18-78)\FIG\_18A



FIG\_19: IVariation of Index Properties with Depth Muni Metro Turnback Site (Embarcadero Waterfront)

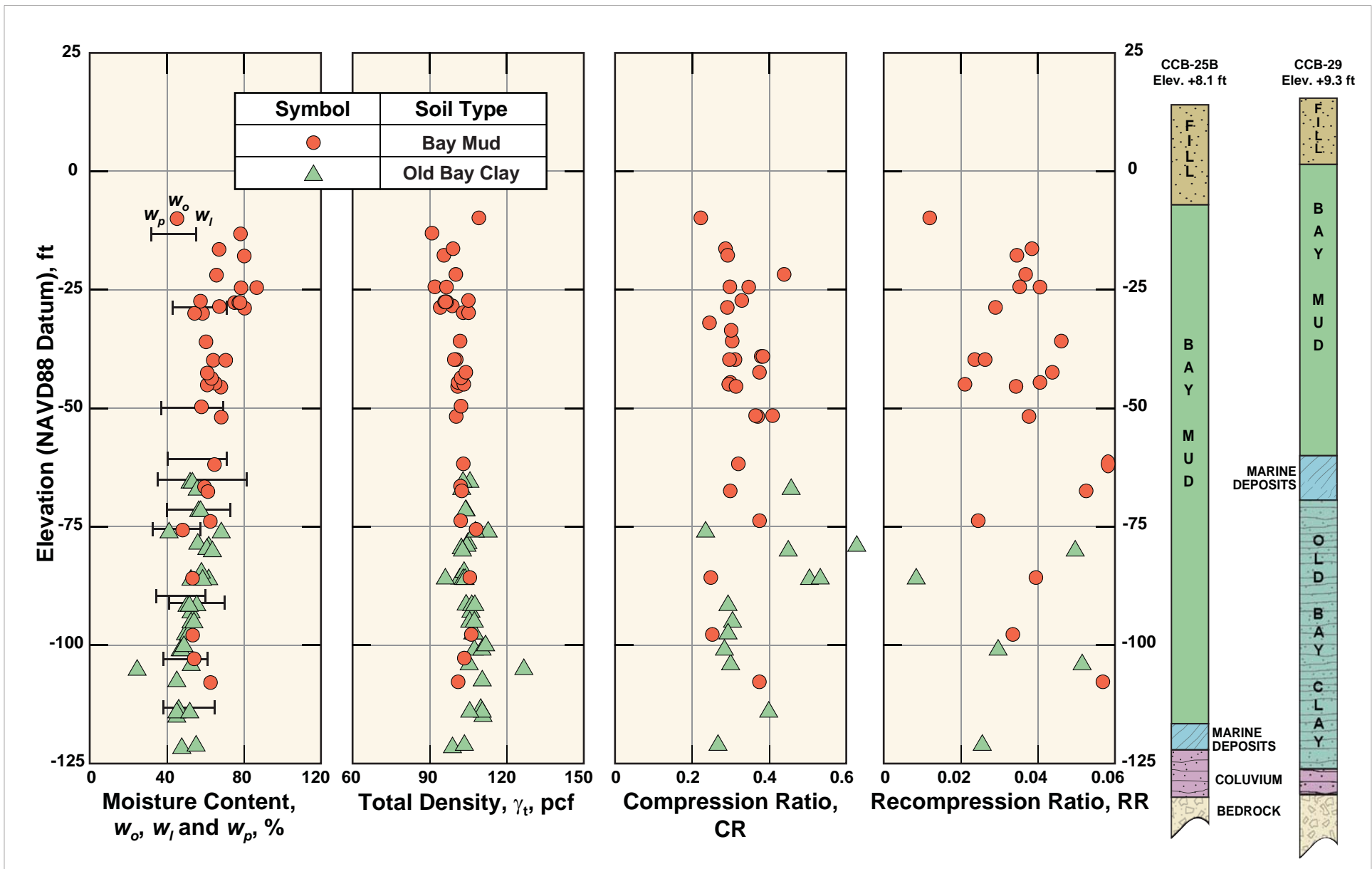


FIG\_20: Index Properties of Bay Mud Islais Creek Area Marshlands (Contract C Alignment)

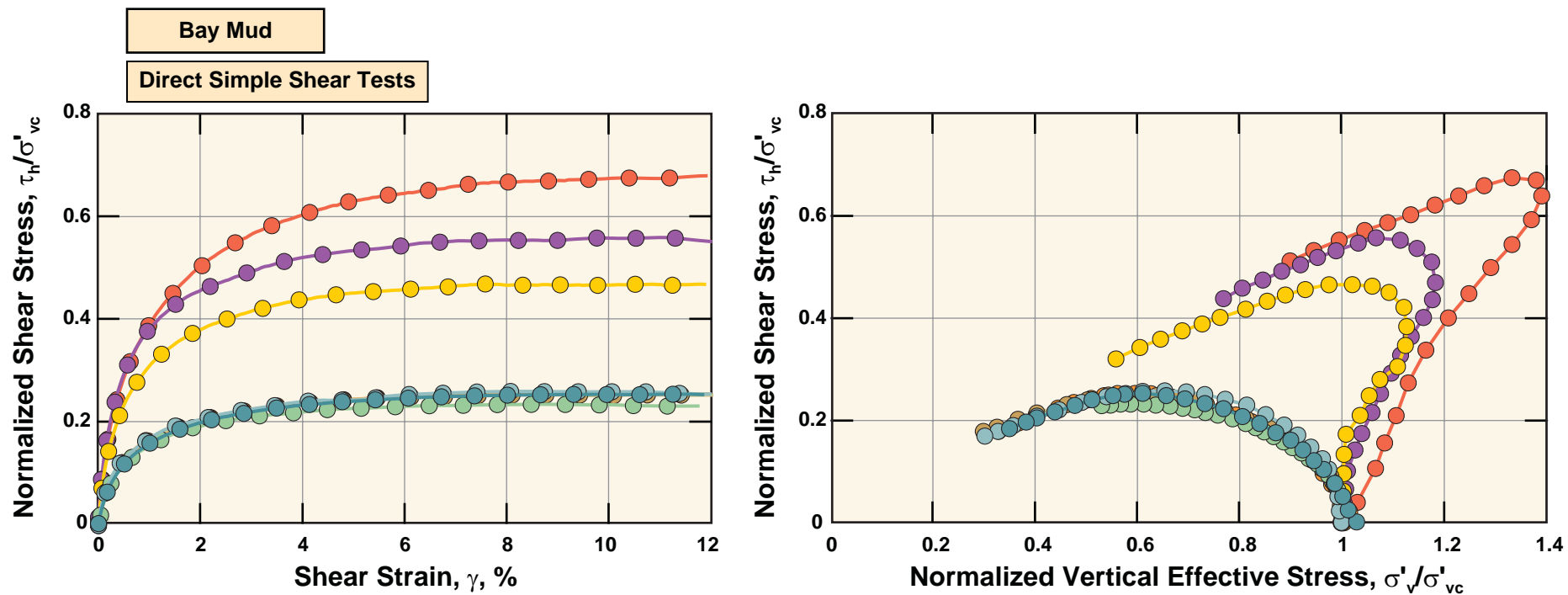


FIG\_21: Index Properties of Bay Mud Islais Creek Channel Area (Digesters Project)

W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Figures\03 BAY MUD (18-78)\FIG\_21

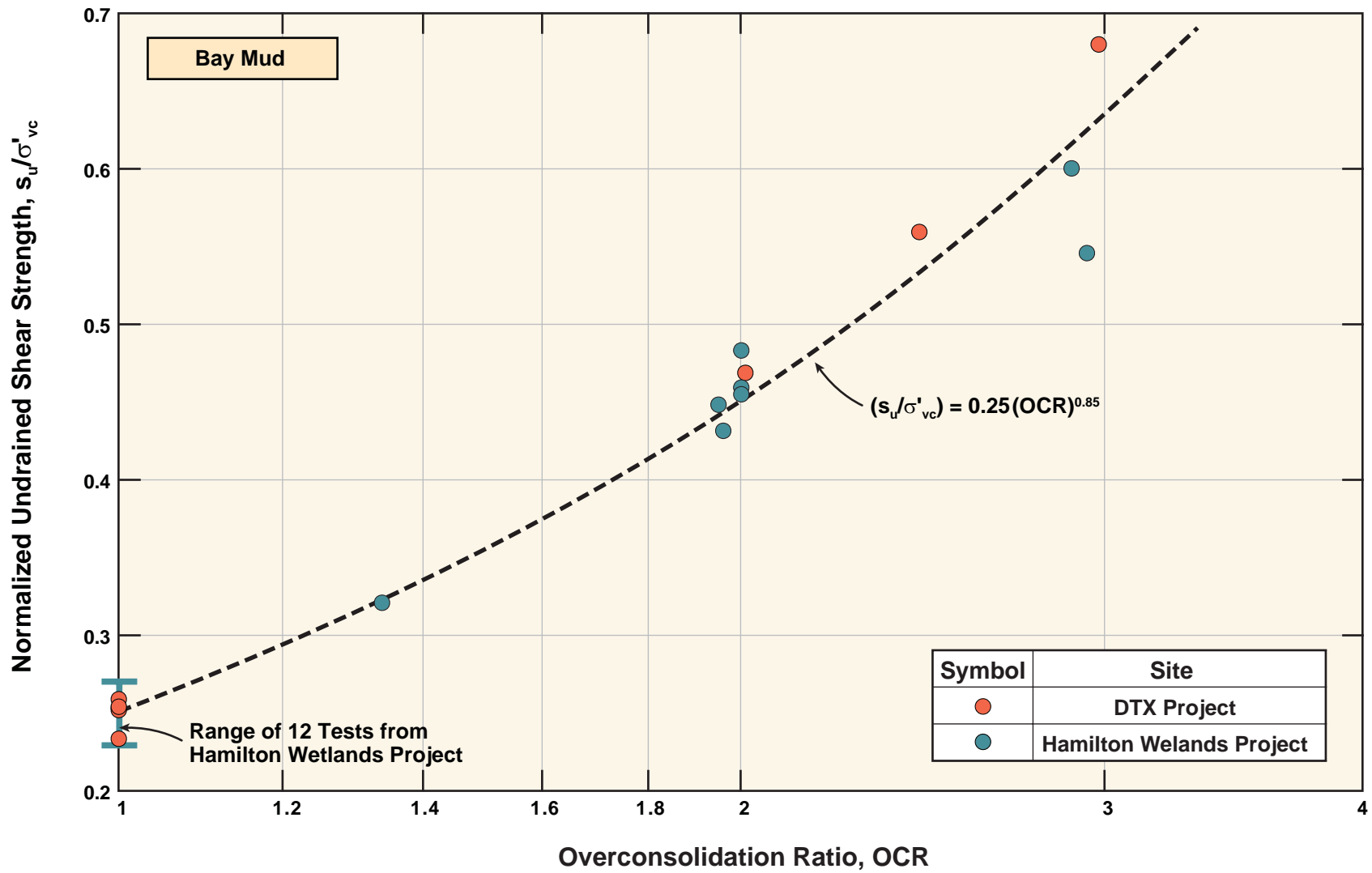


FIG\_22: Index Properties of Bay Mud DTX Segment Along Townsend Street (Mission Bay Area)



Symbol	OCR	$\sigma'_{vc}$ (psf)	$\tau_{h,max}/\sigma'_{vc}$	$\gamma$ (%)
	1.0	8,169	0.25	11.4
		2,716	0.26	8.4
		5,016	0.23	8.7
		5,411	0.25	8.3
		5,378	0.25	8.6
	2.0	2,728	0.47	7.5
	2.4	1,780	0.56	11.0
	3.0	1,894	0.68	11.9

FIG\_23: Normalized Undrained Strength Behavior of Bay Mud DSS Tests



FIG\_24: Variation of Normalized Strength Ratios with Overconsolidation Ratio



**1 Undrained Shear Strength**

$$s_u = \sigma'_v \mathbf{S}(\text{OCR})^m, \text{ where } \mathbf{S} = (s_u/\sigma'_v)_{\text{NC}}$$

**2 Overconsolidation Ratio, OCR**

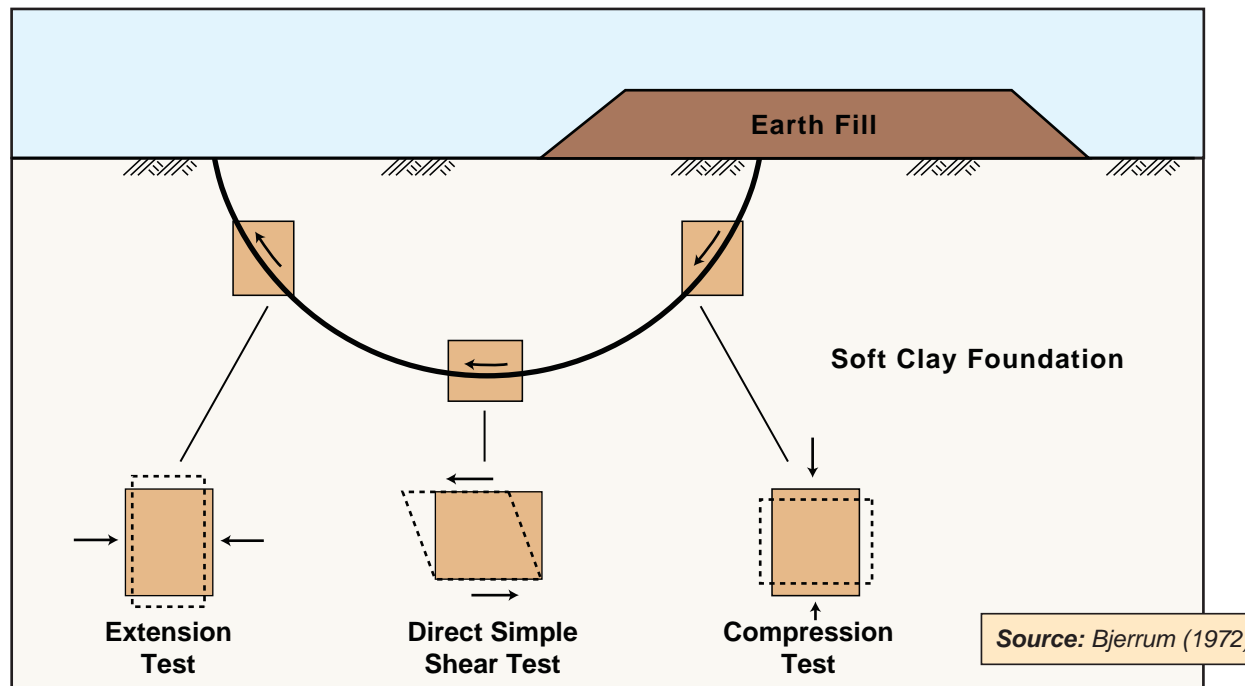
$$\text{OCR} = \frac{\sigma'_p}{\sigma'_{vo}} = \left[ \frac{s_u/\sigma'_{vo}}{\mathbf{S}} \right]^{1/m}$$

**3 Maximum Past Pressure,  $\sigma'_p$ , from Field Vane Shear Tests**

$$\sigma'_p = \sigma'_{vo} \left[ \mu \frac{(s_u)_{\text{FV}}/\sigma'_{vo}}{\mathbf{S}_{\text{DSS}}} \right]^{1/m}, \quad \text{where, } \mathbf{S}_{\text{DSS}} = (s_u/\sigma'_{vc})_{\text{NC}} \text{ from Direct Simple Shear Tests}$$

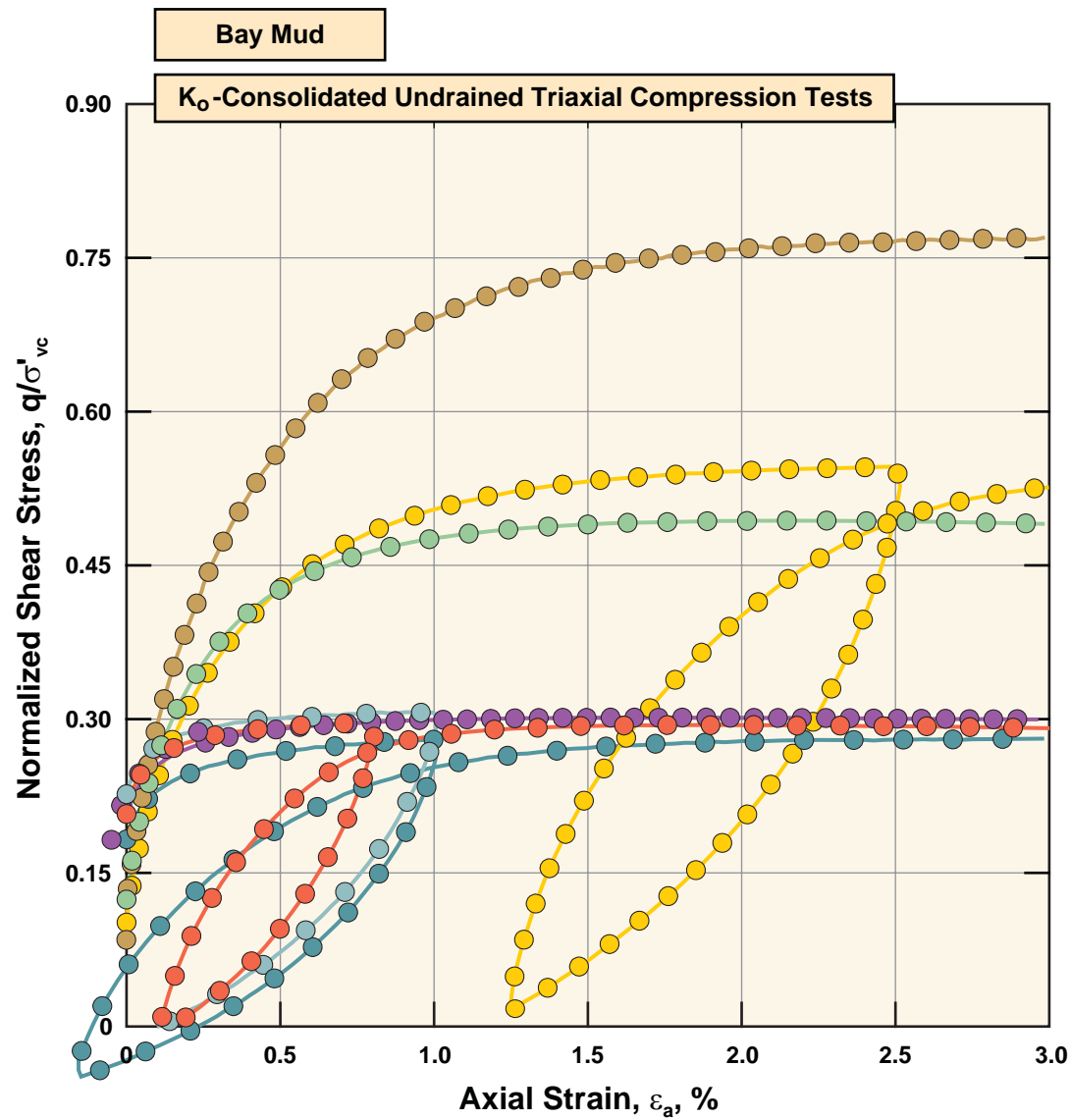
$\mu = \text{Field Shear Vane Correction Factor}$

FIG\_25: SHANSEP Principles of Normalized Undrained Strength Behavior



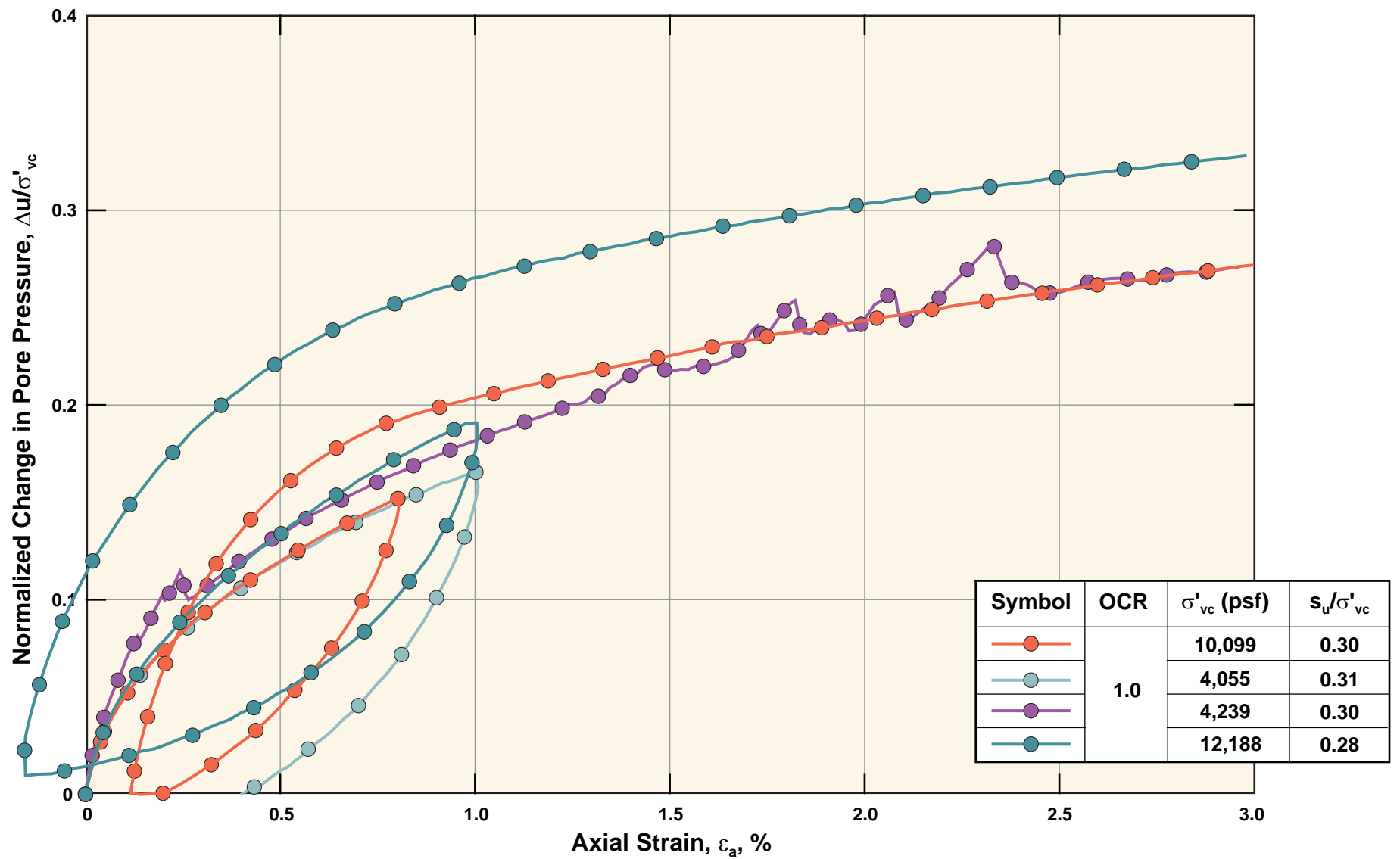
Type of Soil	Index Properties %				Triaxial Tests $\tau/p_o$		Simple Shear Tests	Vane Tests $S_u/p_o$	
	w	w <sub>L</sub>	w <sub>p</sub>	I <sub>p</sub>	Compres.	Extension	$\tau_h/p_o$	Observed	Corrected for Rate
Bangkok Clay	140	150	65	85	0.70	0.40	0.41	0.59	0.47
Matagami Clay	90	85	38	47	0.61	0.45	0.39	0.46	0.40
Drammen Plastic Clay	52	61	32	29	0.40	0.15	0.30	0.36	0.30
Vaterland Clay	35	42	26	16	0.32	0.09	0.26	0.22	0.20
Studenterlunden	31	43	25	18	0.31	0.10	0.19	0.18	0.16
Drammen Lean Clay	30	33	22	11	0.34	0.09	0.22	0.24	0.21

FIG\_26: Anisotropic Behavior of Soft Clays

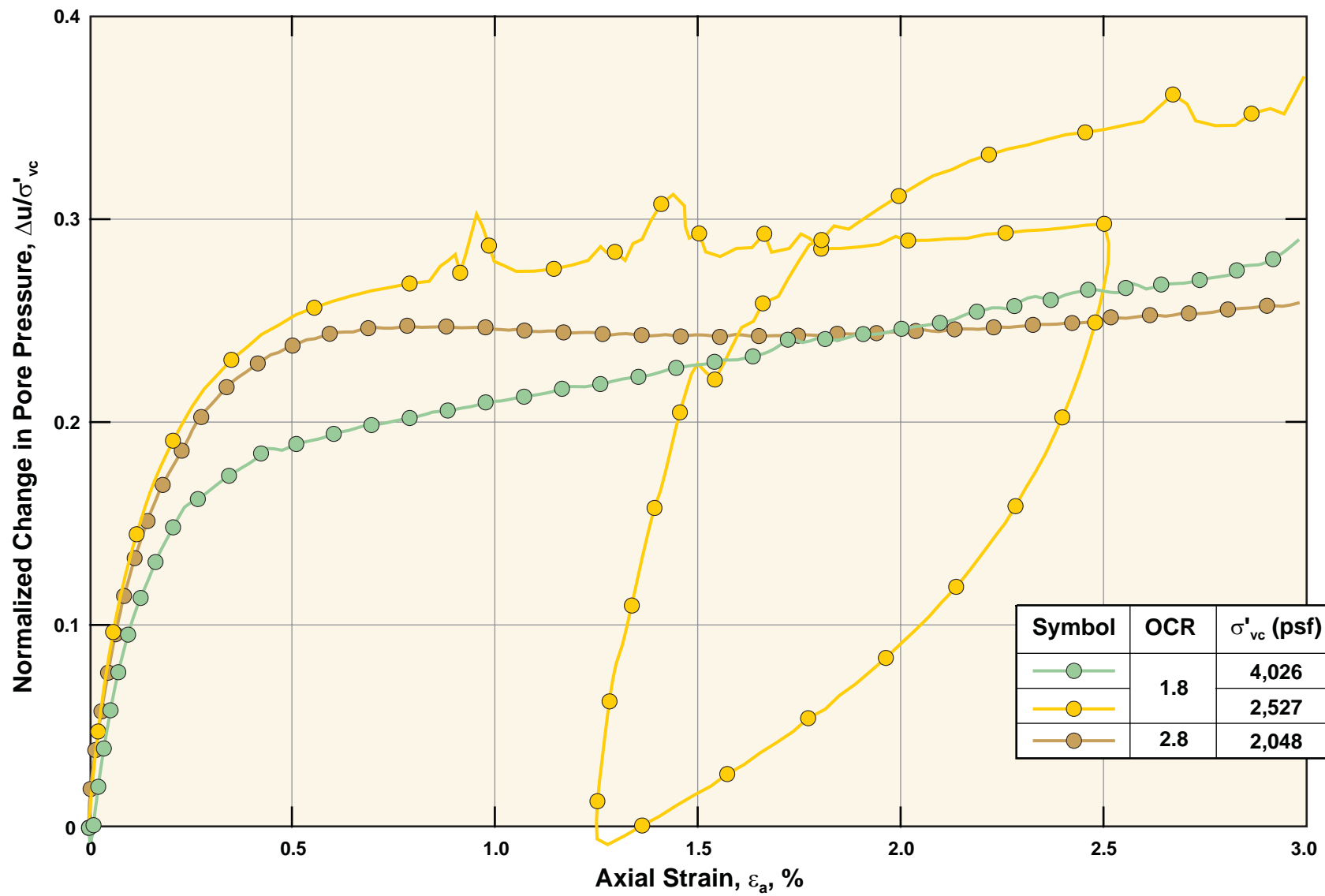


Symbol	OCR	$\sigma'_{vc}$ (psf)	$s_u/\sigma'_{vc}$	$\epsilon_a$ (%)
—●—	1.0	10,099	0.30	0.8
—●—		4,055	0.31	1.0
—●—		4,239	0.30	1.6
—●—		12,188	0.28	3.2
—●—	1.8	4,026	0.49	2.2
—●—		2,527	0.55	2.5
—●—	2.8	2,048	0.77	3.6

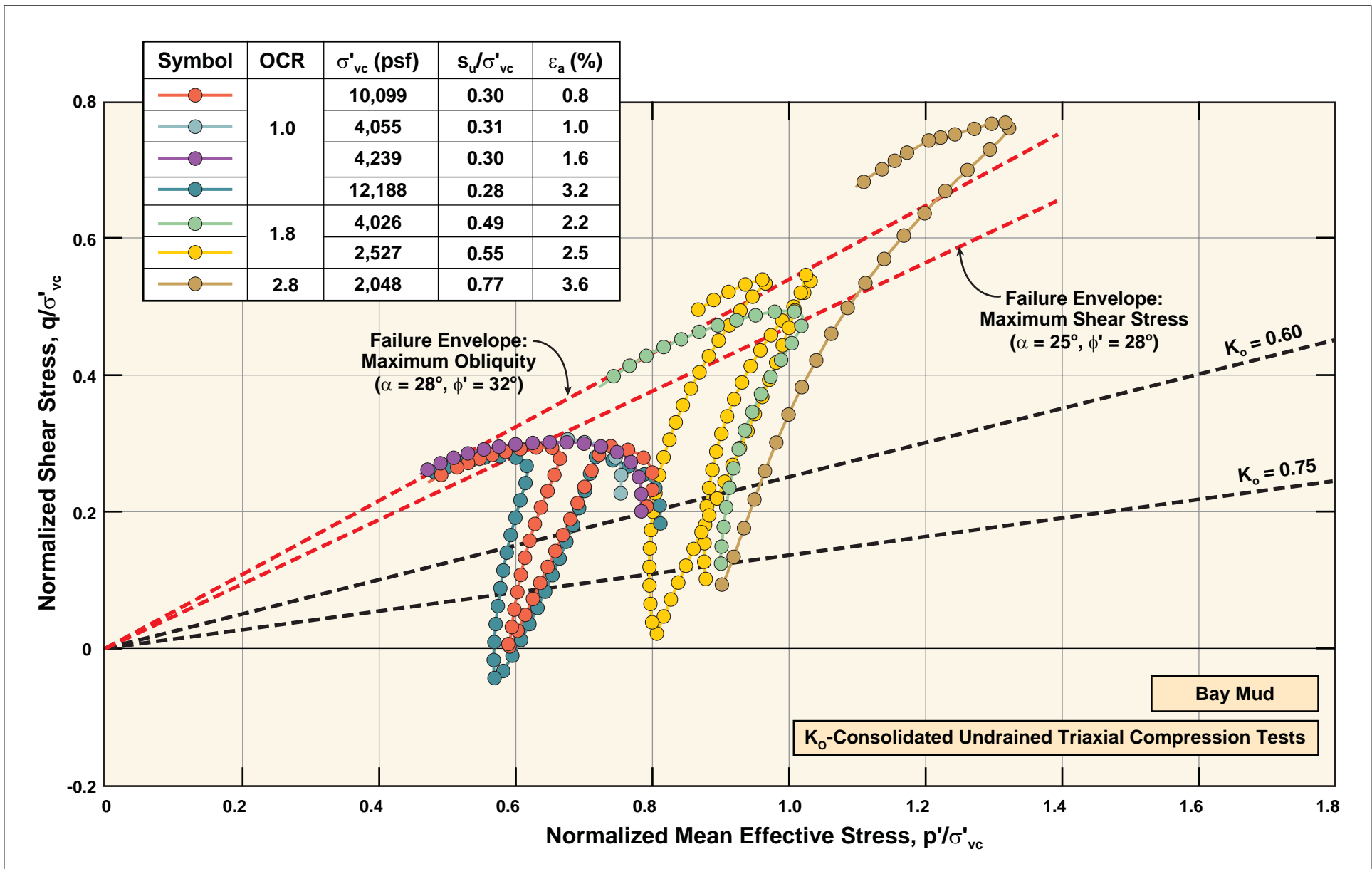
**FIG\_27: Normalized Strength-Strain Behavior from Undrained Ko-Triaxial Compression Tests**



FIG\_28: Pore Pressure Behavior from Ko-Triaxial Compression Tests

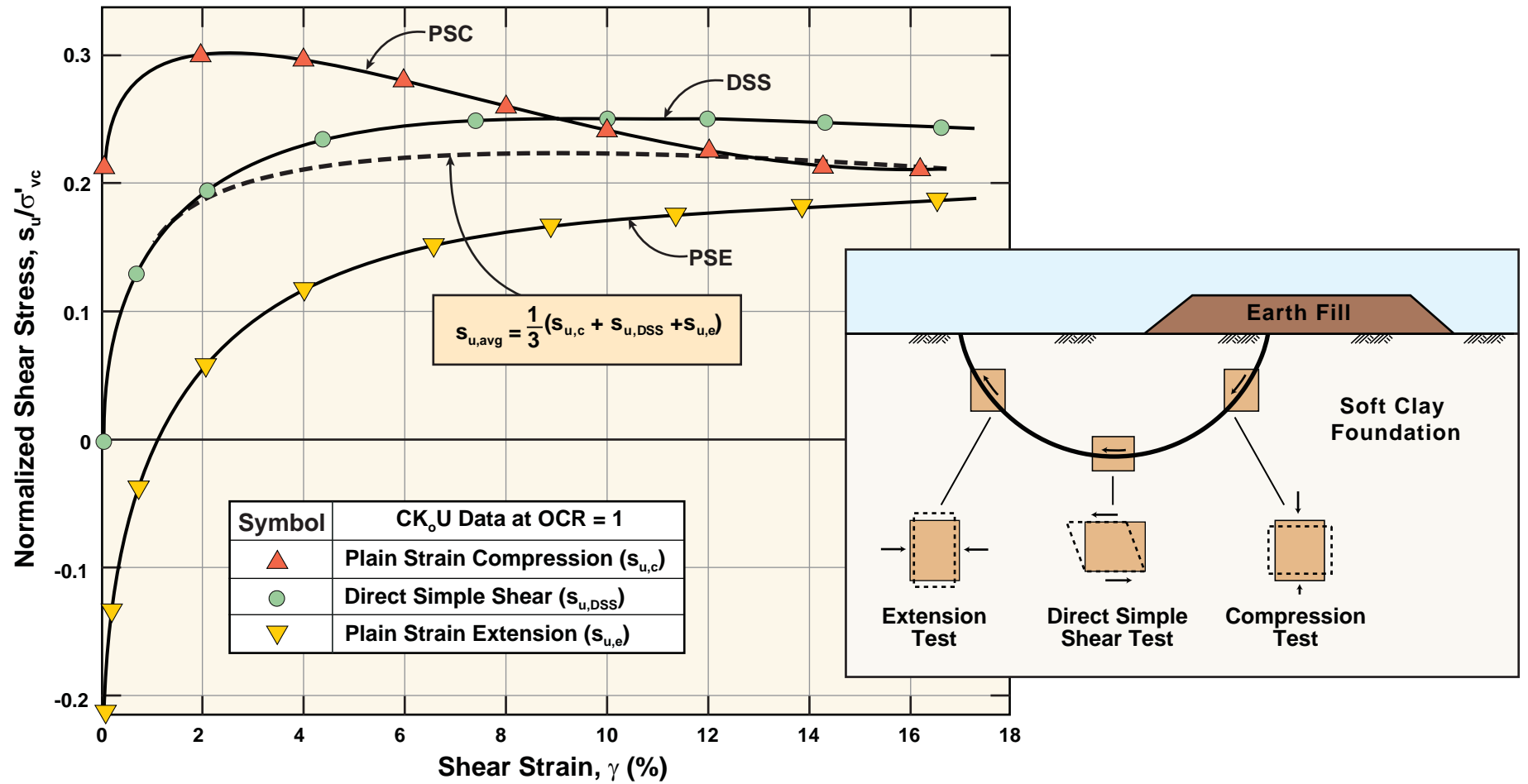


FIG\_28A: Pore Pressure Behavior from Ko-Triaxial Compression Tests

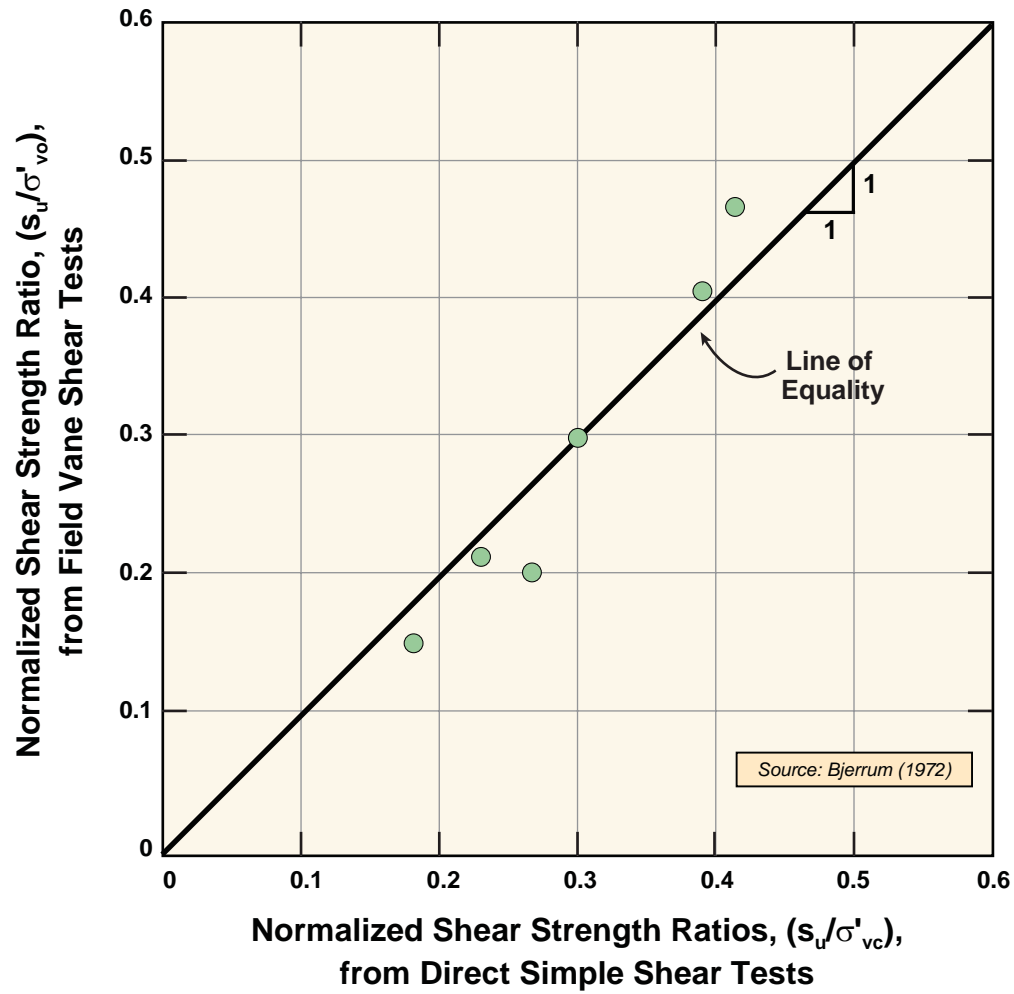


FIG\_29: Effective Stress Paths from  $K_o$ -Triaxial Compression Tests

W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Plates\03 BAY MUD (18-78)\FIG\_29.ai



FIG\_30: Anisotropy and Strain Compatibility Considerations



FIG\_31: Correlation of Normalized Strength Ratios from DSS and Vane Shear Tests



### ① Undrained Shear Strength

$$s_u = \sigma'_v \mathbf{S}(\text{OCR})^m, \text{ where } \mathbf{S} = (s_u/\sigma'_v)_{\text{NC}}$$

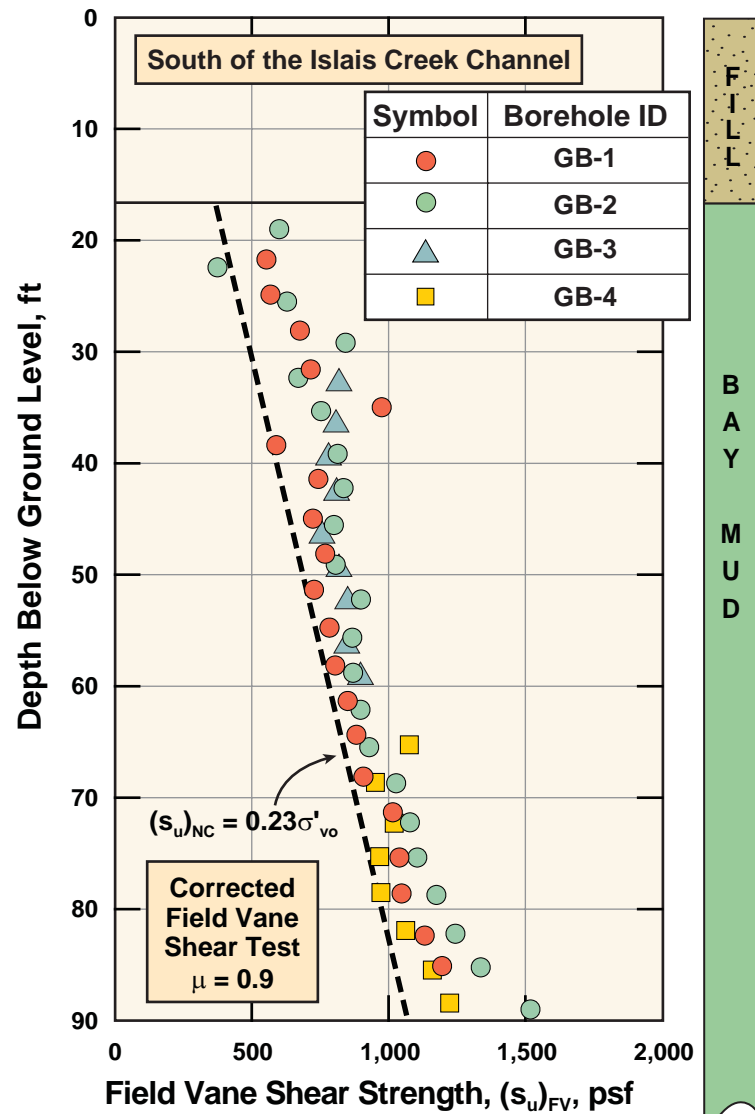
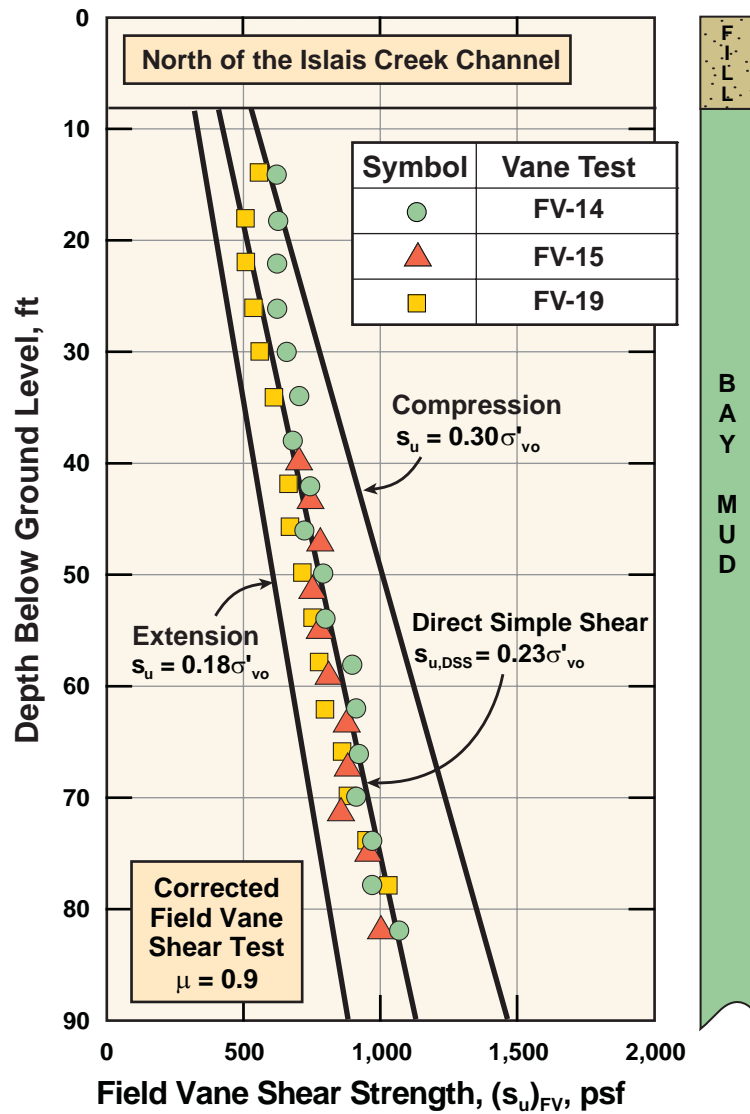
### ② Overconsolidation Ratio, OCR

$$\text{OCR} = \frac{\sigma'_p}{\sigma'_{vo}} = \left[ \frac{s_u/\sigma'_{vo}}{\mathbf{S}} \right]^{1/m}$$

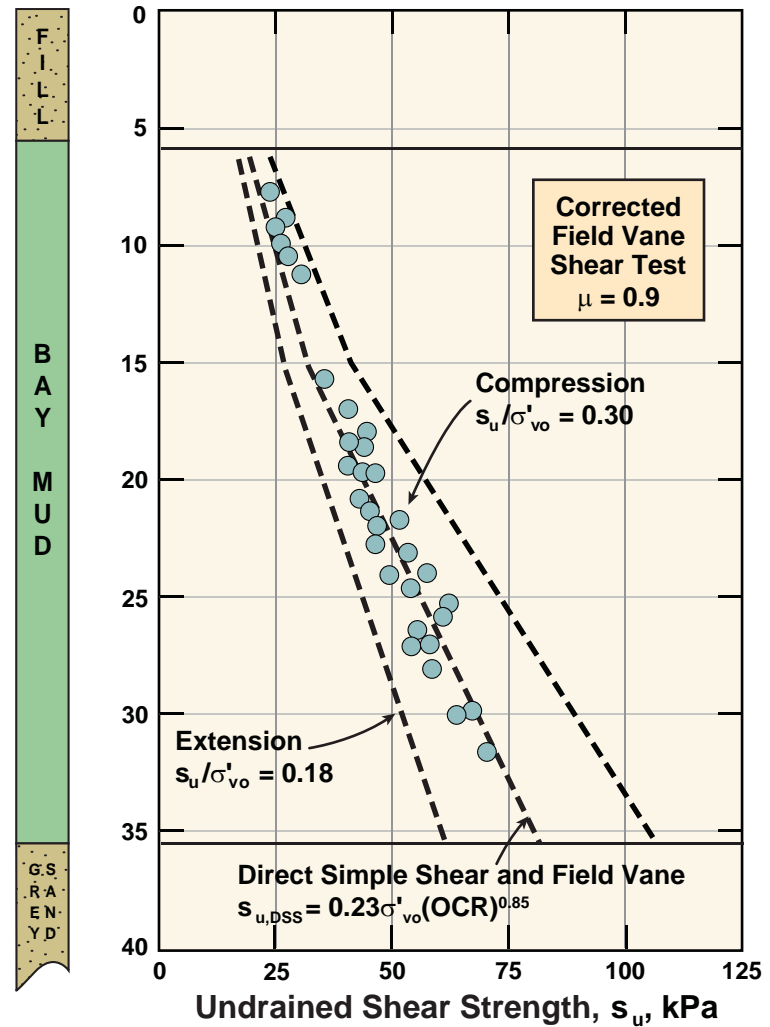
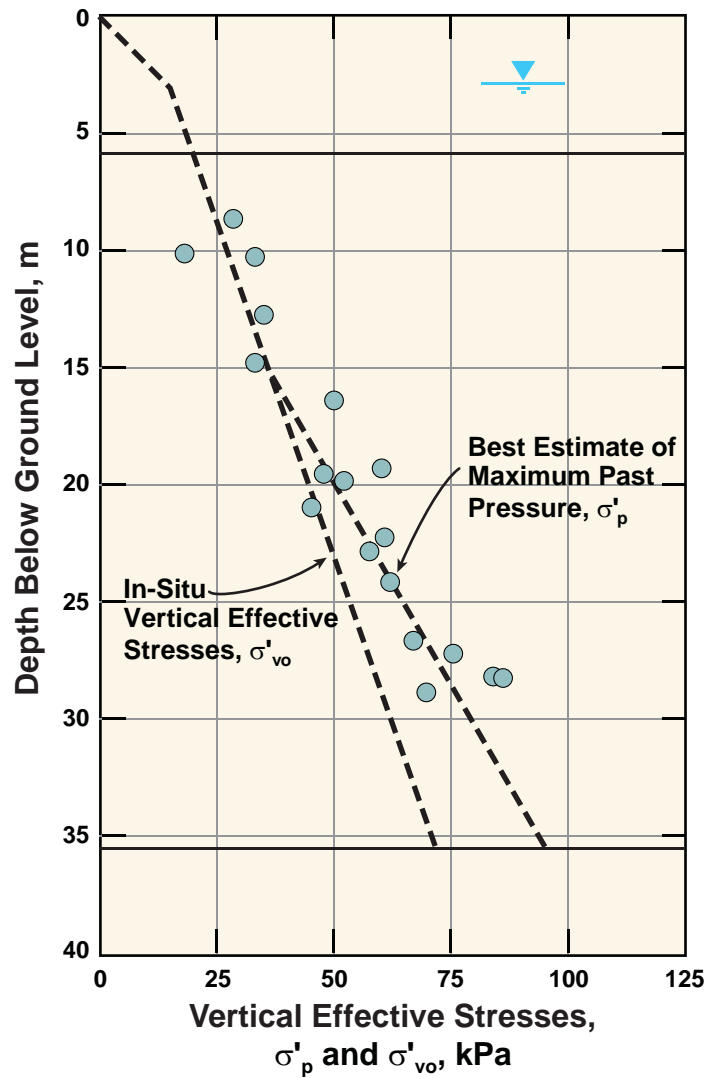
### ③ Maximum Past Pressure, $\sigma'_p$ , from Field Vane Shear Tests

$$\sigma'_p = \sigma'_{vo} \left[ \mu \frac{(s_u)_{\text{FV}}/\sigma'_{vo}}{\mathbf{S}_{\text{DSS}}} \right]^{1/m}, \quad \text{where, } \mathbf{S}_{\text{DSS}} = (s_u/\sigma'_{vc})_{\text{NC}} \text{ from Direct Simple Shear Tests}$$

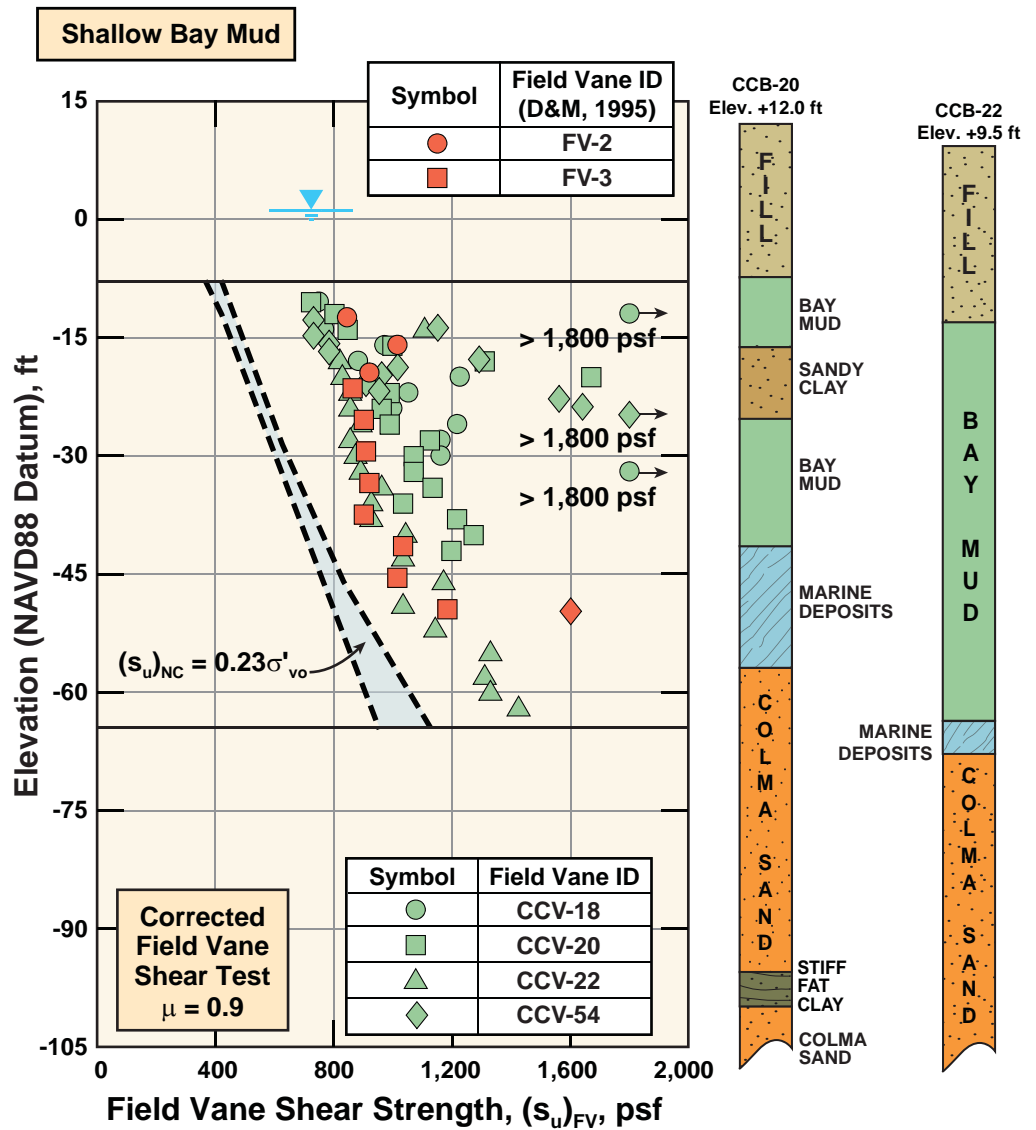
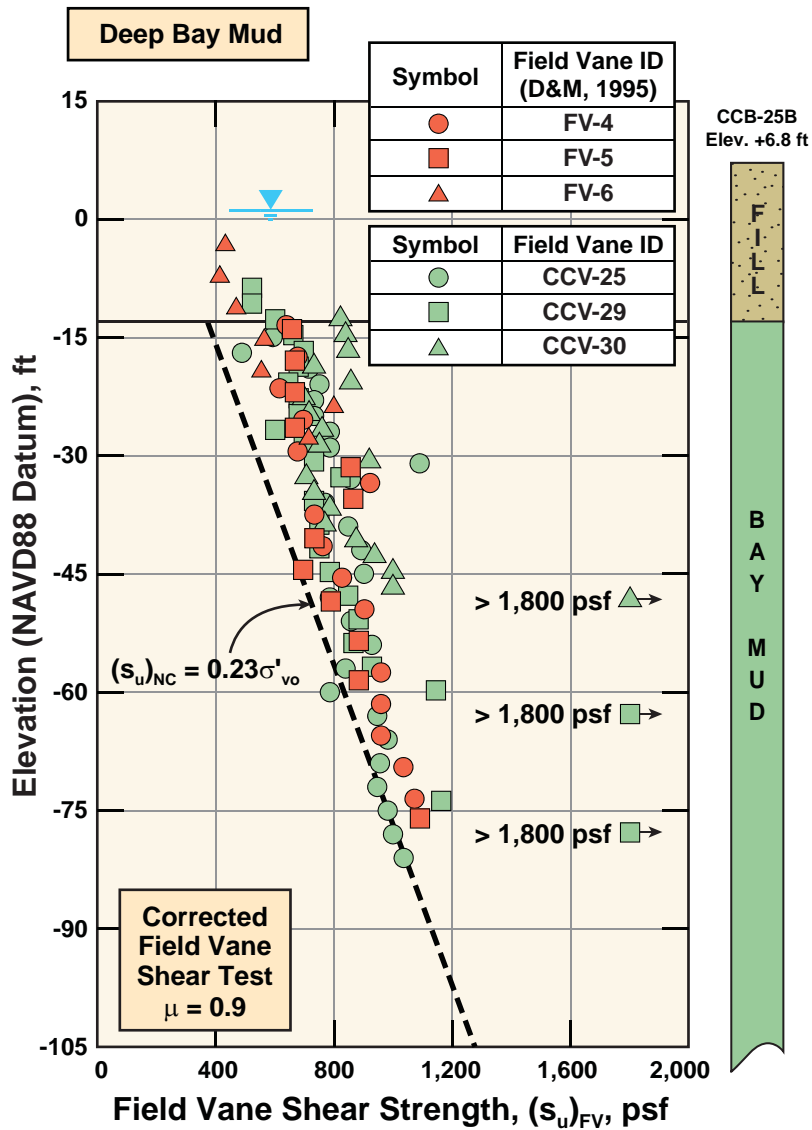
$\mu$  = Field Shear Vane Correction Factor



FIG\_33: Undrained Shear Strengths from Vane Shear Tests Islais Creek T/S Project (Contract D)

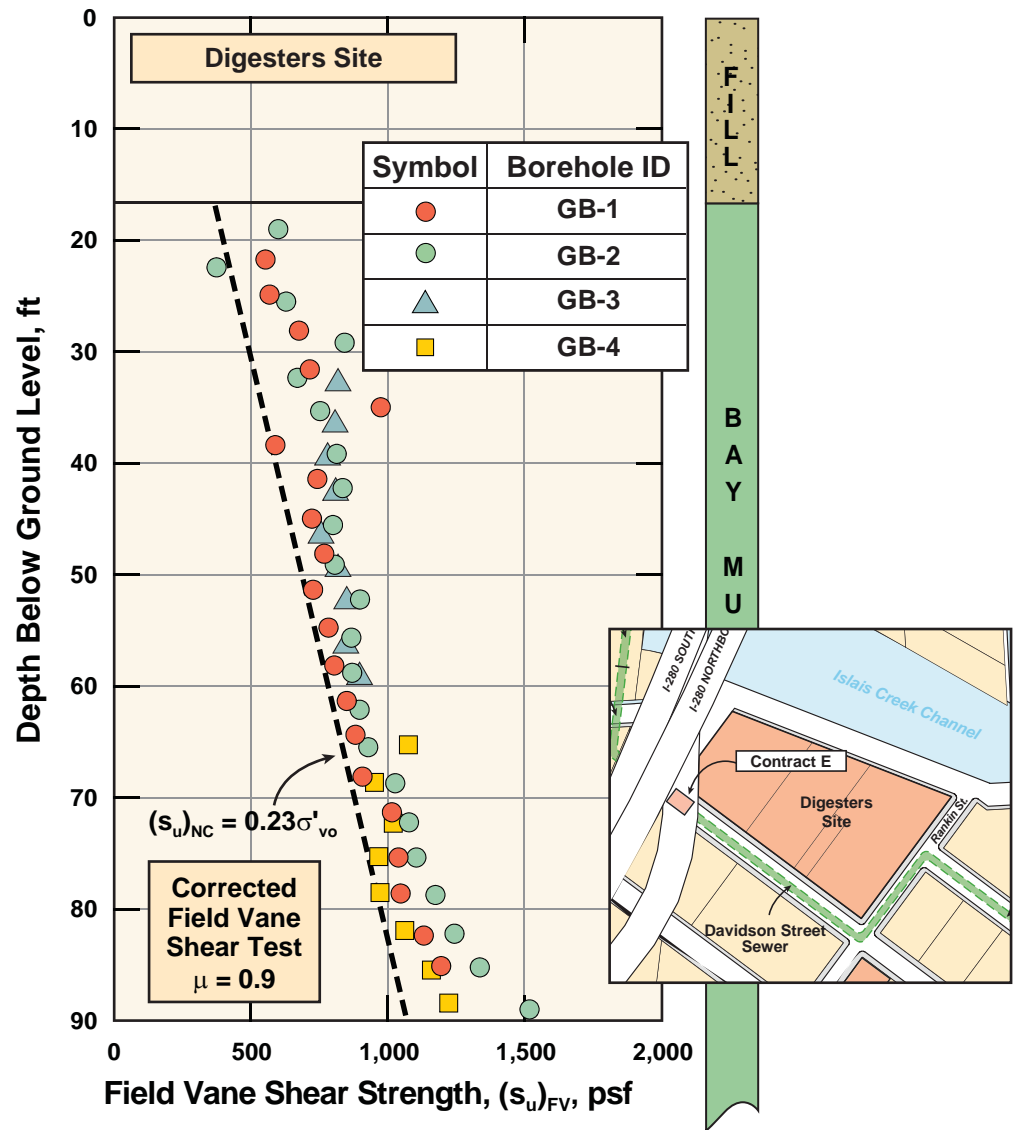
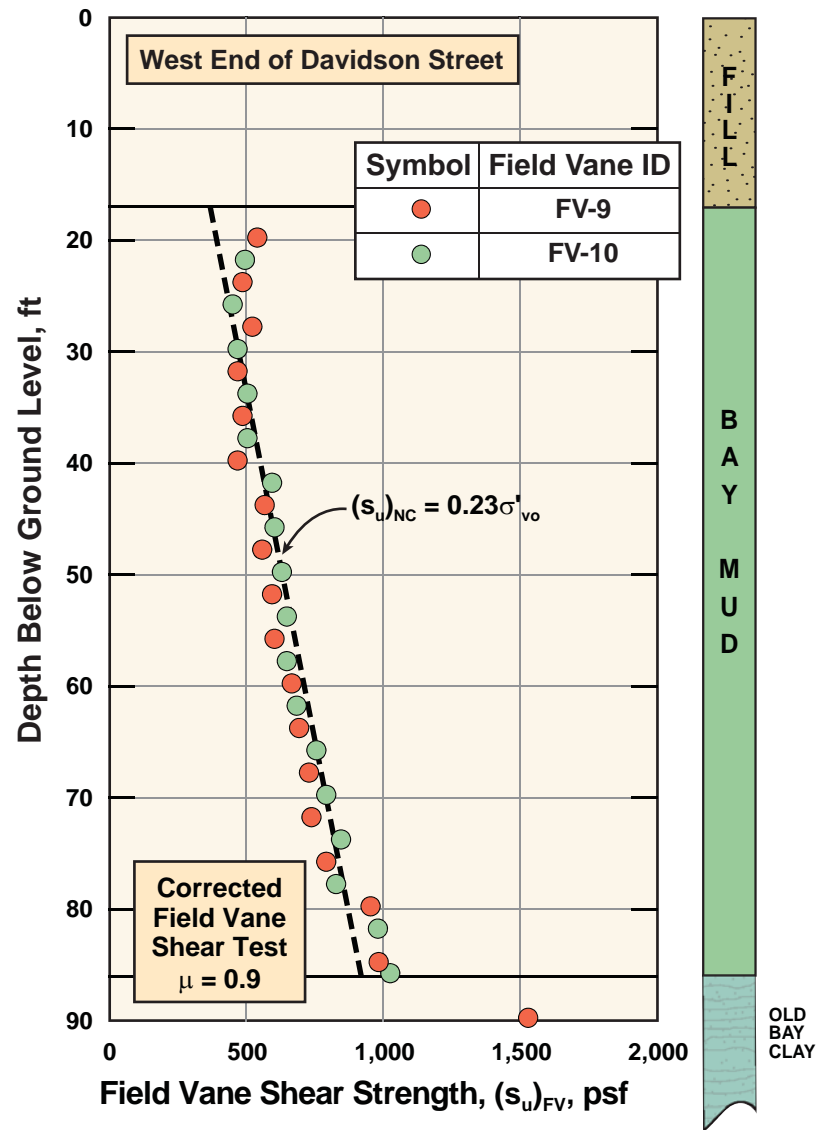


FIG\_34: Stress History and Vane Shear Strengths Muni Metro Turnback Site

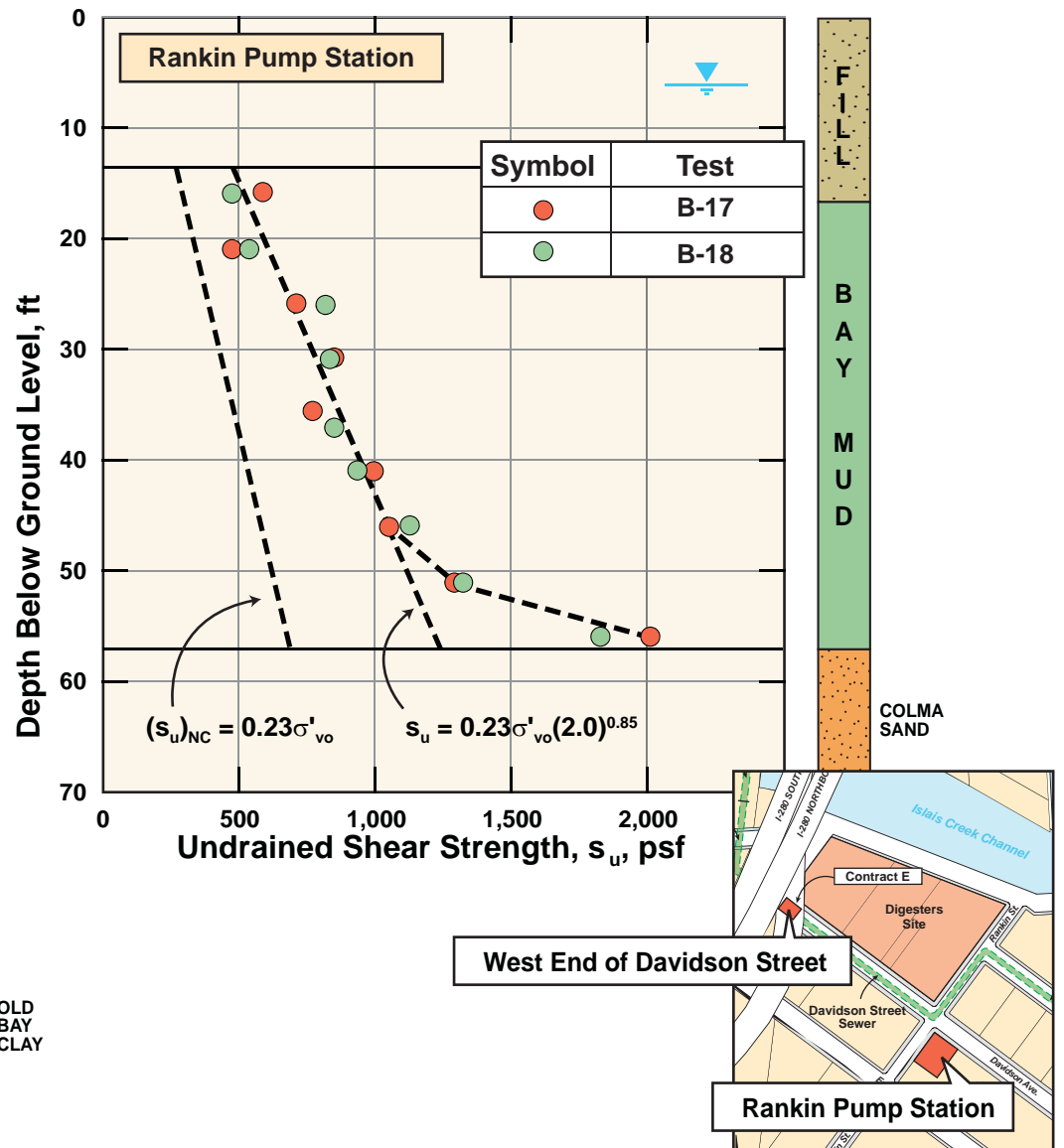
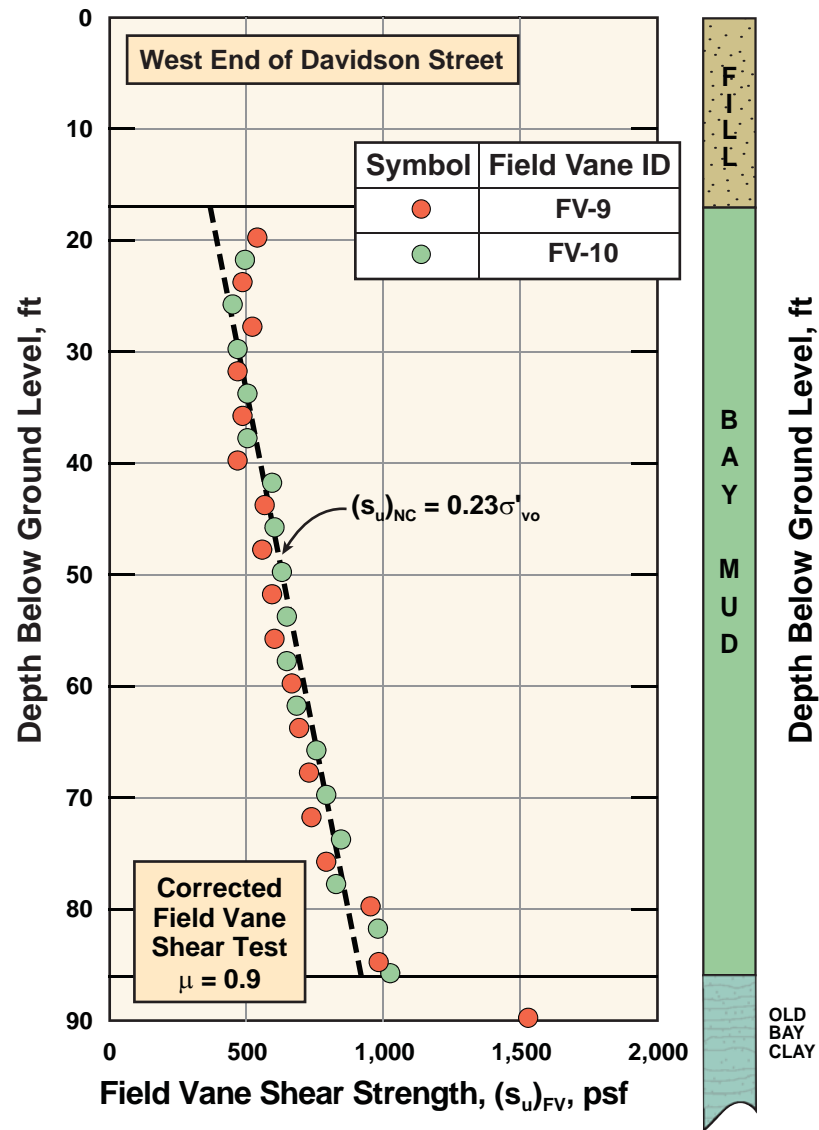


FIG\_35: Undrained Shear Strengths from Vane Shear Tests DTX Alignment Along Townsend Street

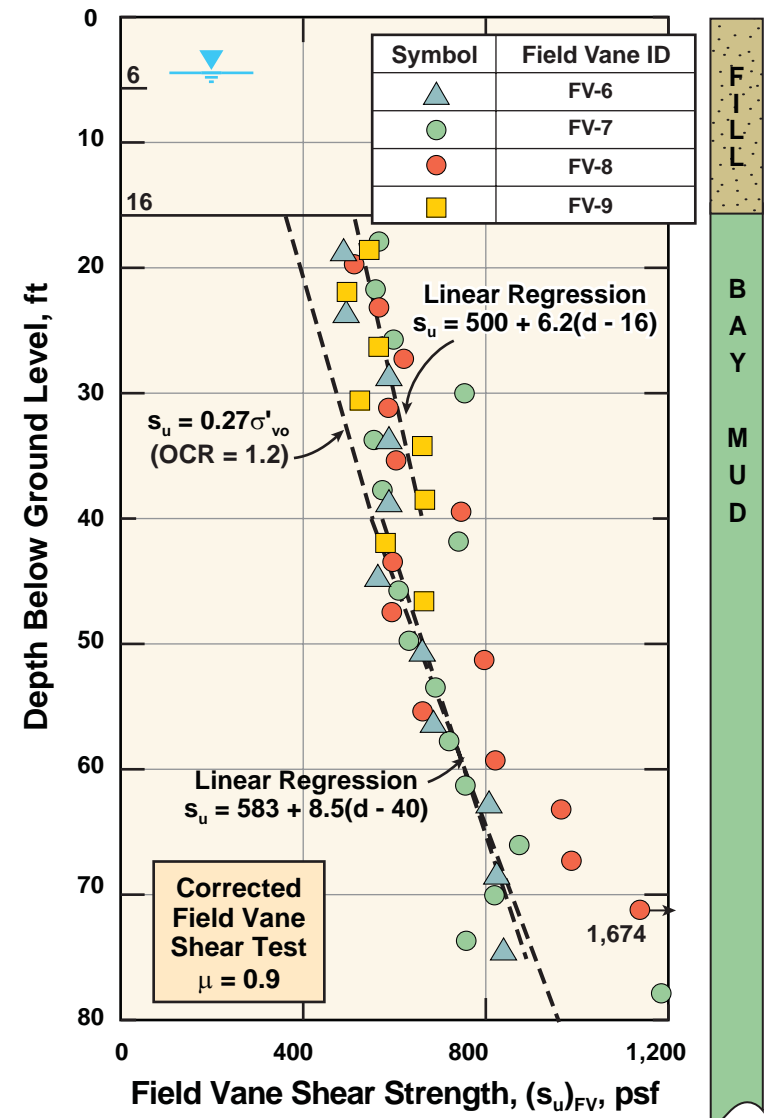
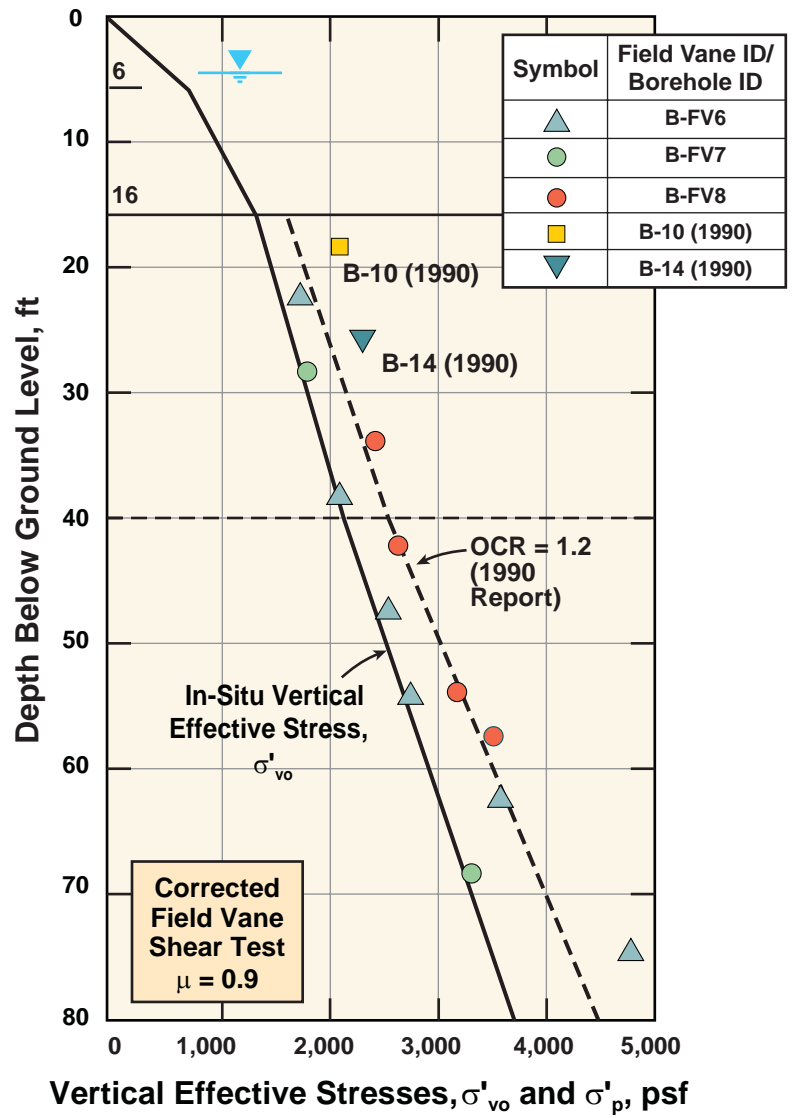
W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Plates\03 BAY MUD (18-78)\FIG\_35



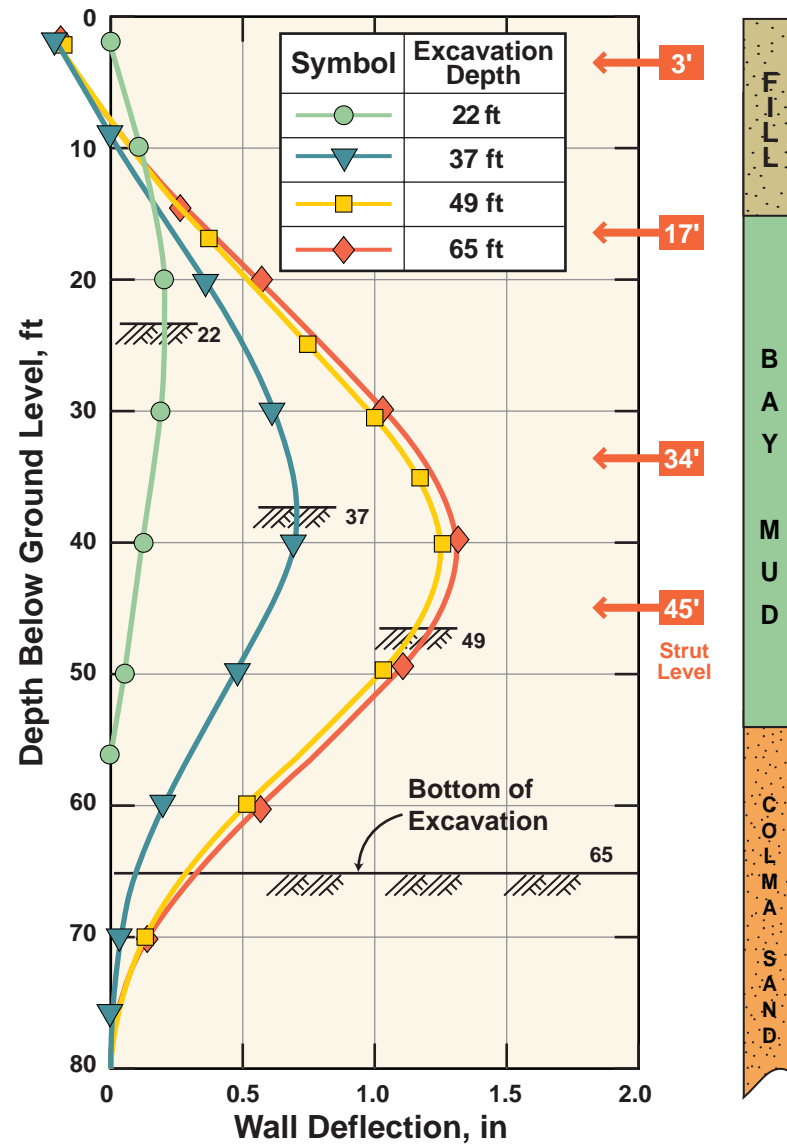
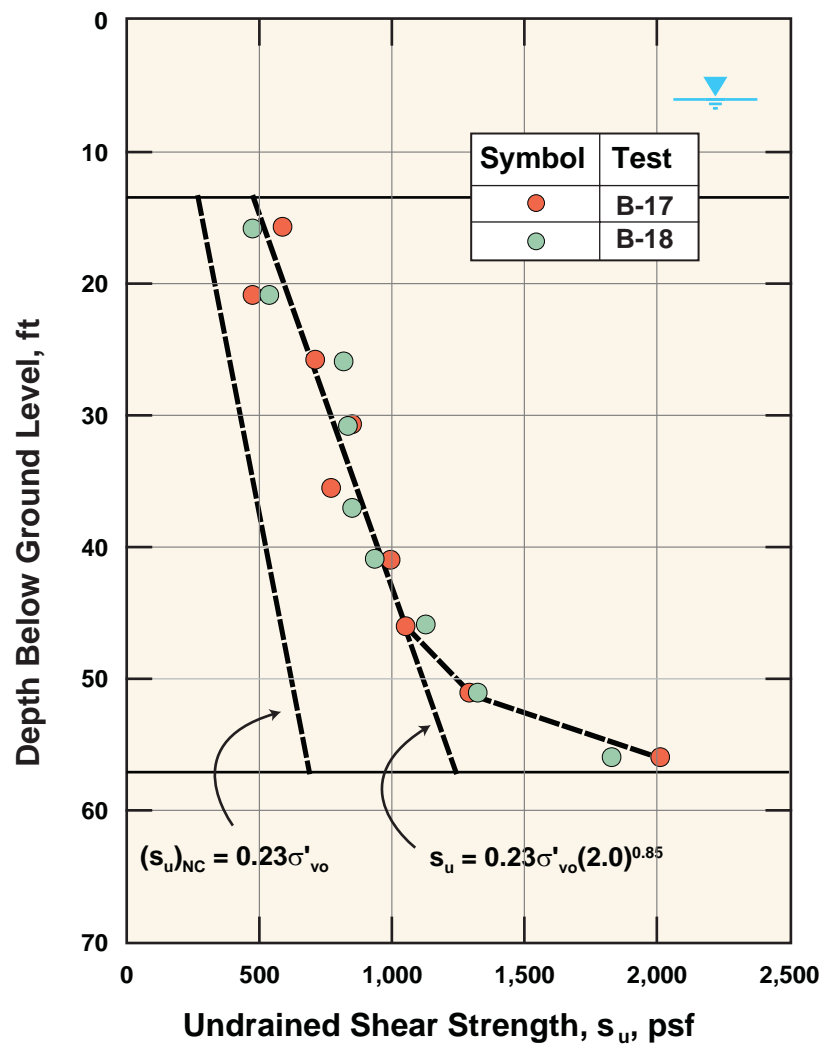
FIG\_36: Undrained Shear Strengths from Vane Shear Tests Islais Creek Area Along Davidson Street



FIG\_36A: Undrained Shear Strengths from Vane Shear Tests Davidson Street: South of Islais Creek Channel

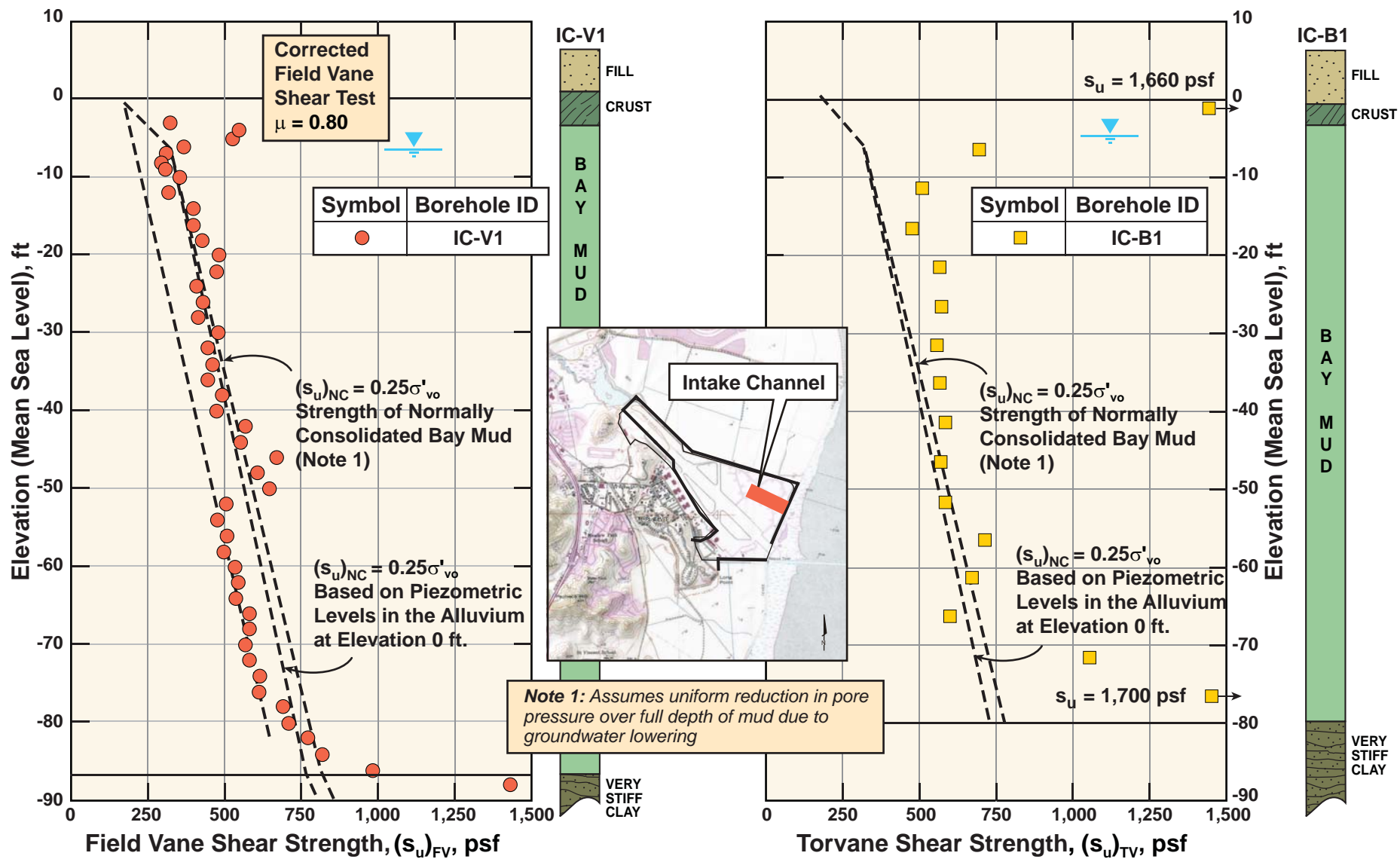


FIG\_37: Stress History and Undrained Strengths from Vane Shear and UU Tests Islais Creek (Contract C)

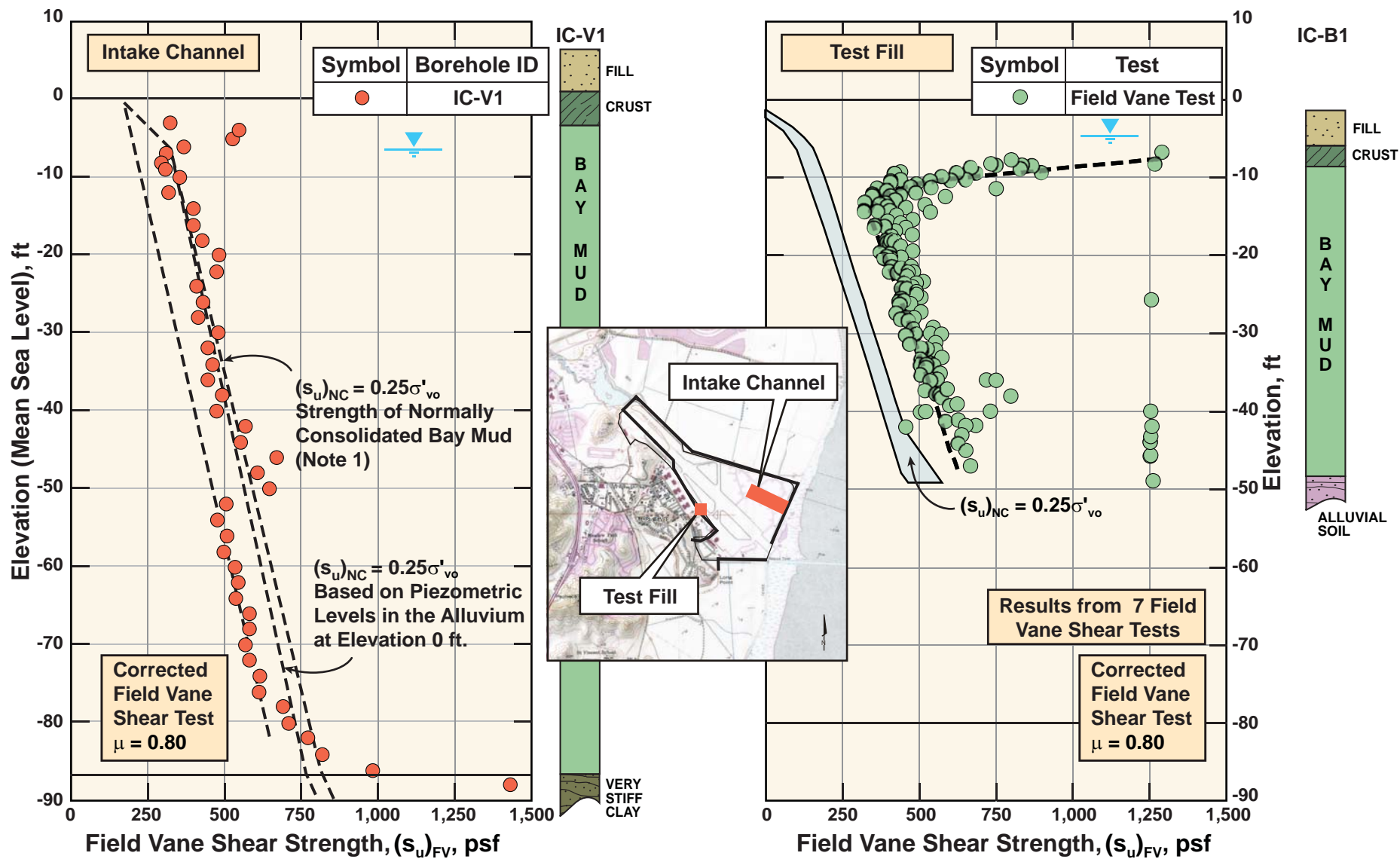


FIG\_37A: Undrained Shear Strengths from Vane Shear Tests Rankin Pump Station Site: Islais Creek Estuary

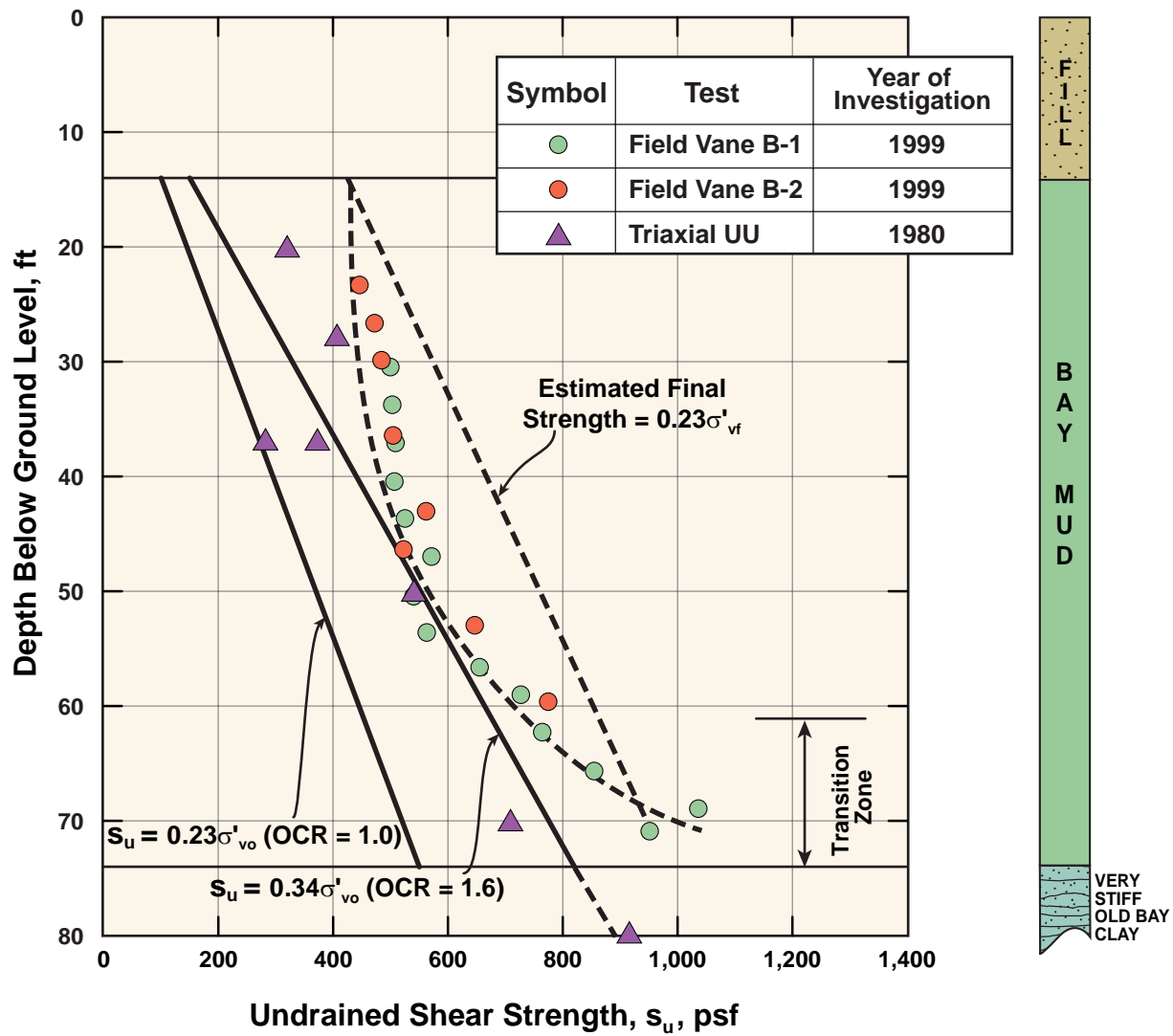




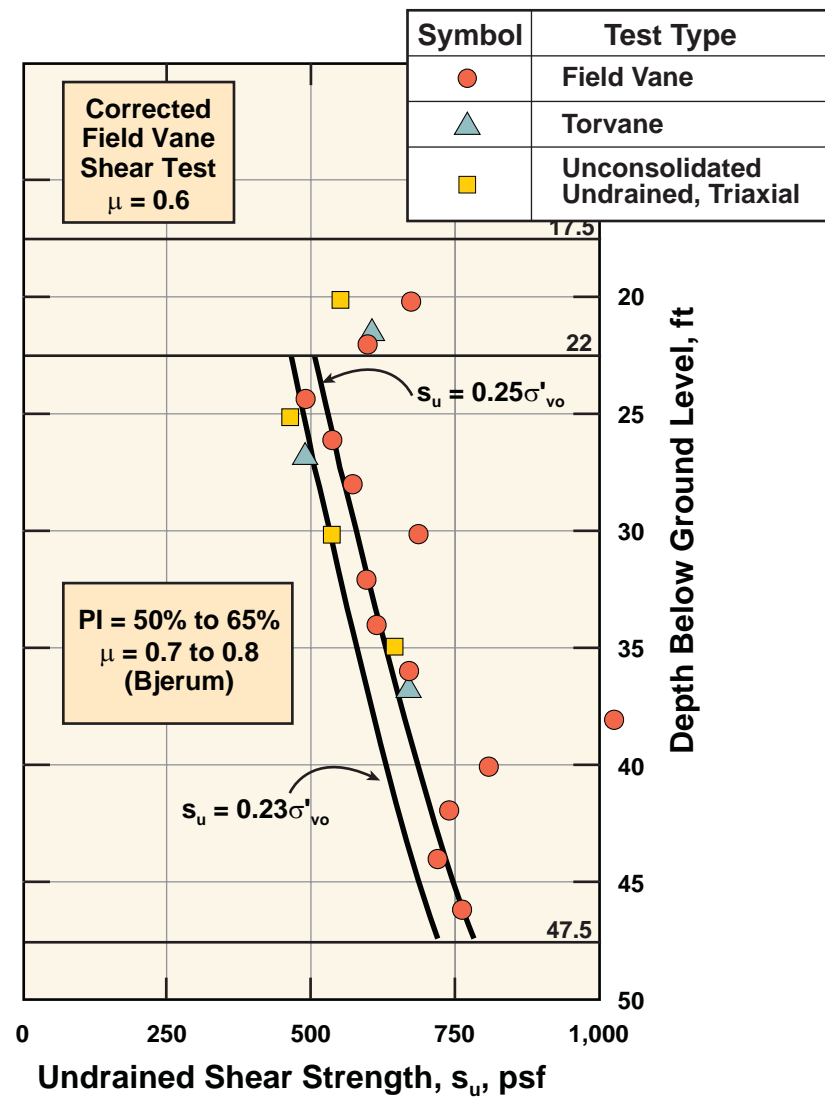
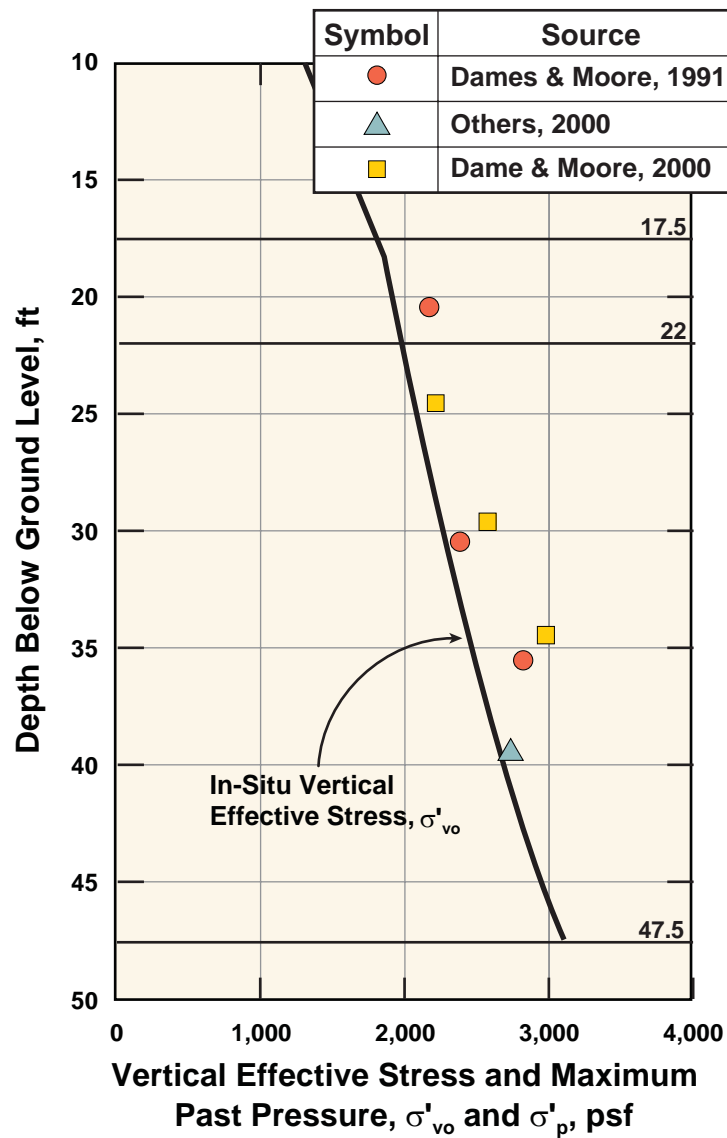
FIG\_38: Undrained Shear Strengths From Vane Shear and Torvane Tests Hamilton Field: Deep Mud Area



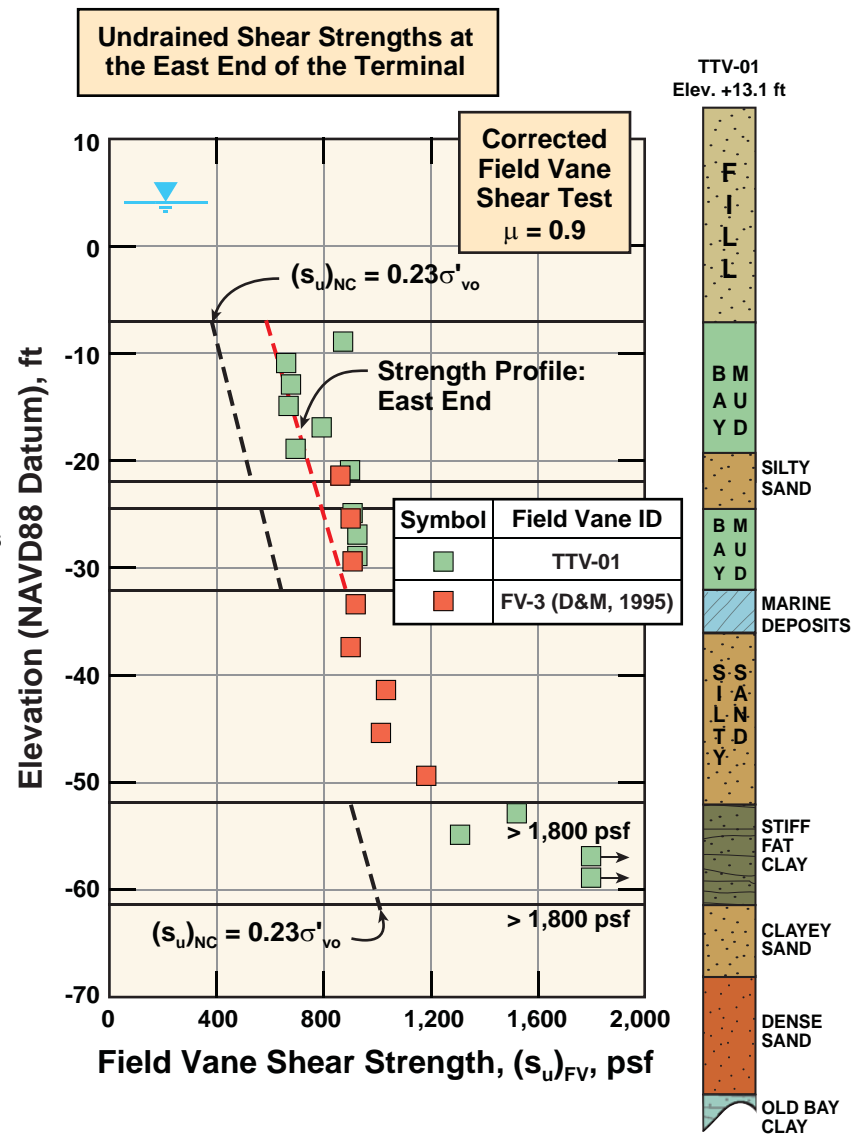
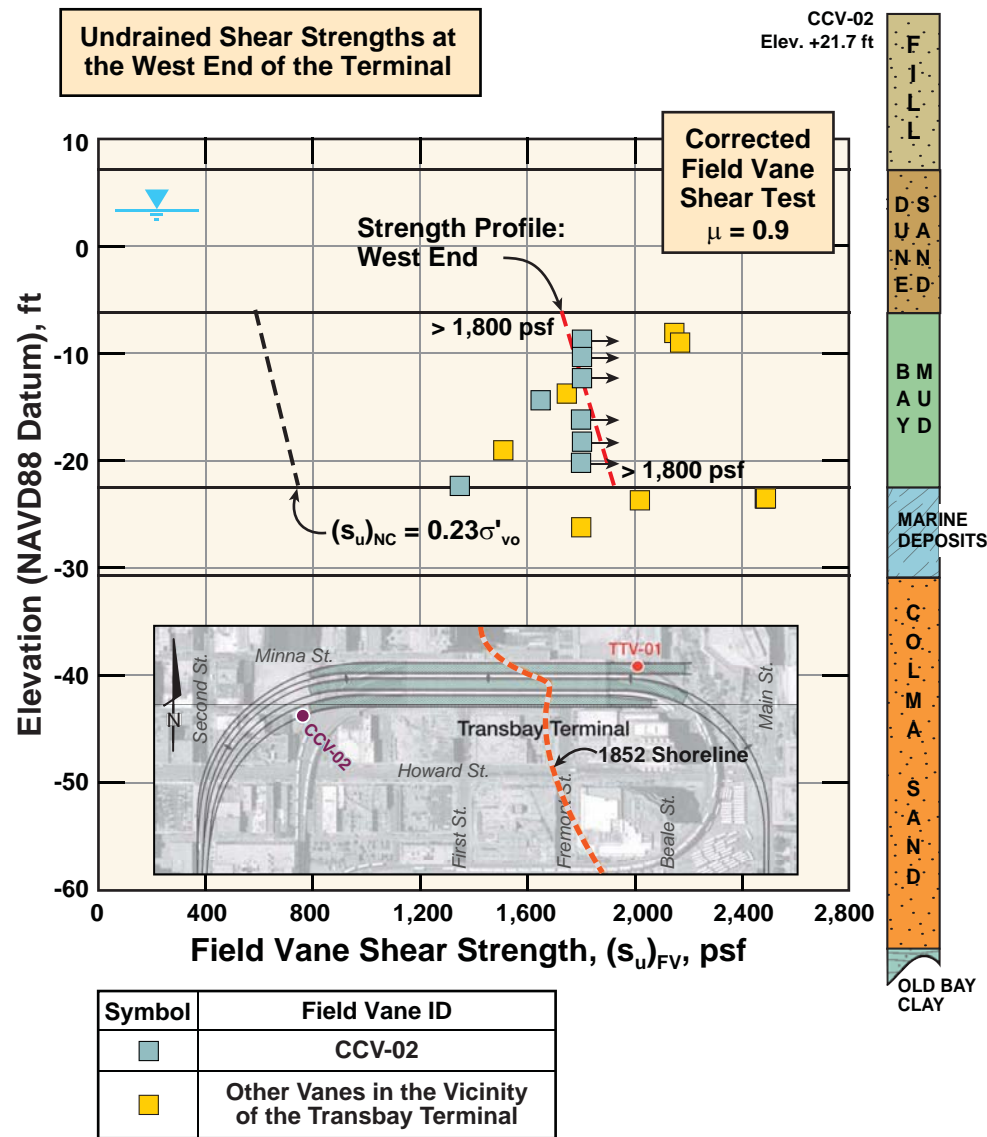
FIG\_38A: Undrained Shear Strengths From Field Vane Shear Tests Hamilton Field



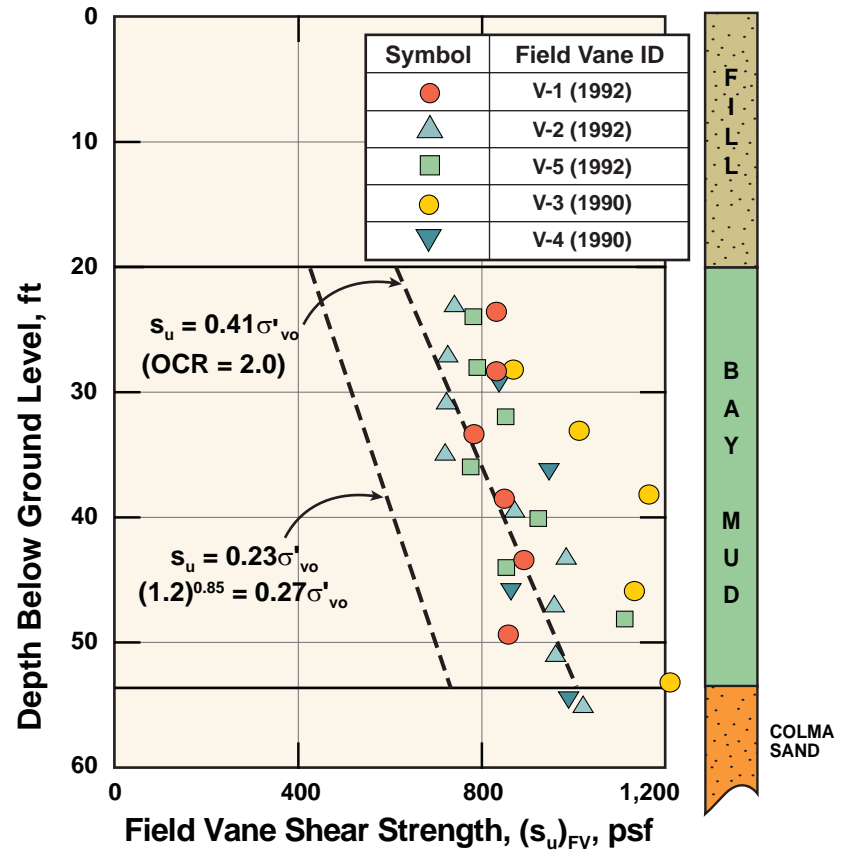
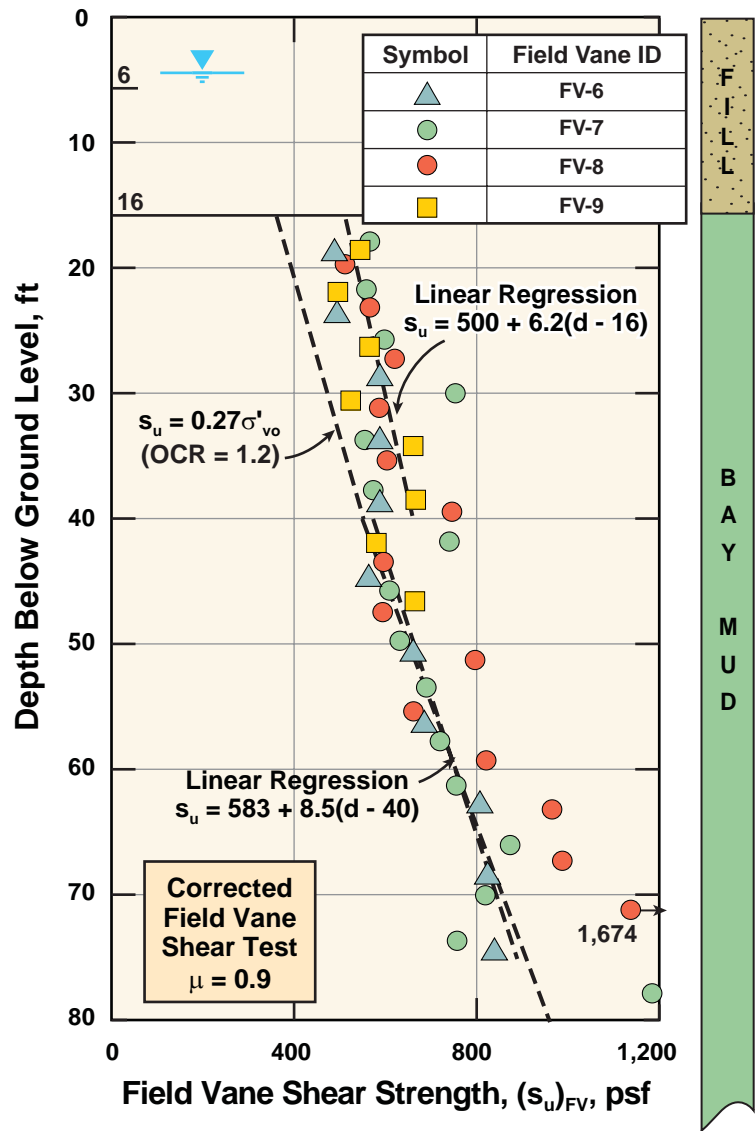
FIG\_39: Undrained Shear Strength of a Site Undergoing Consolidation Under "Recent" Reclamation Fill



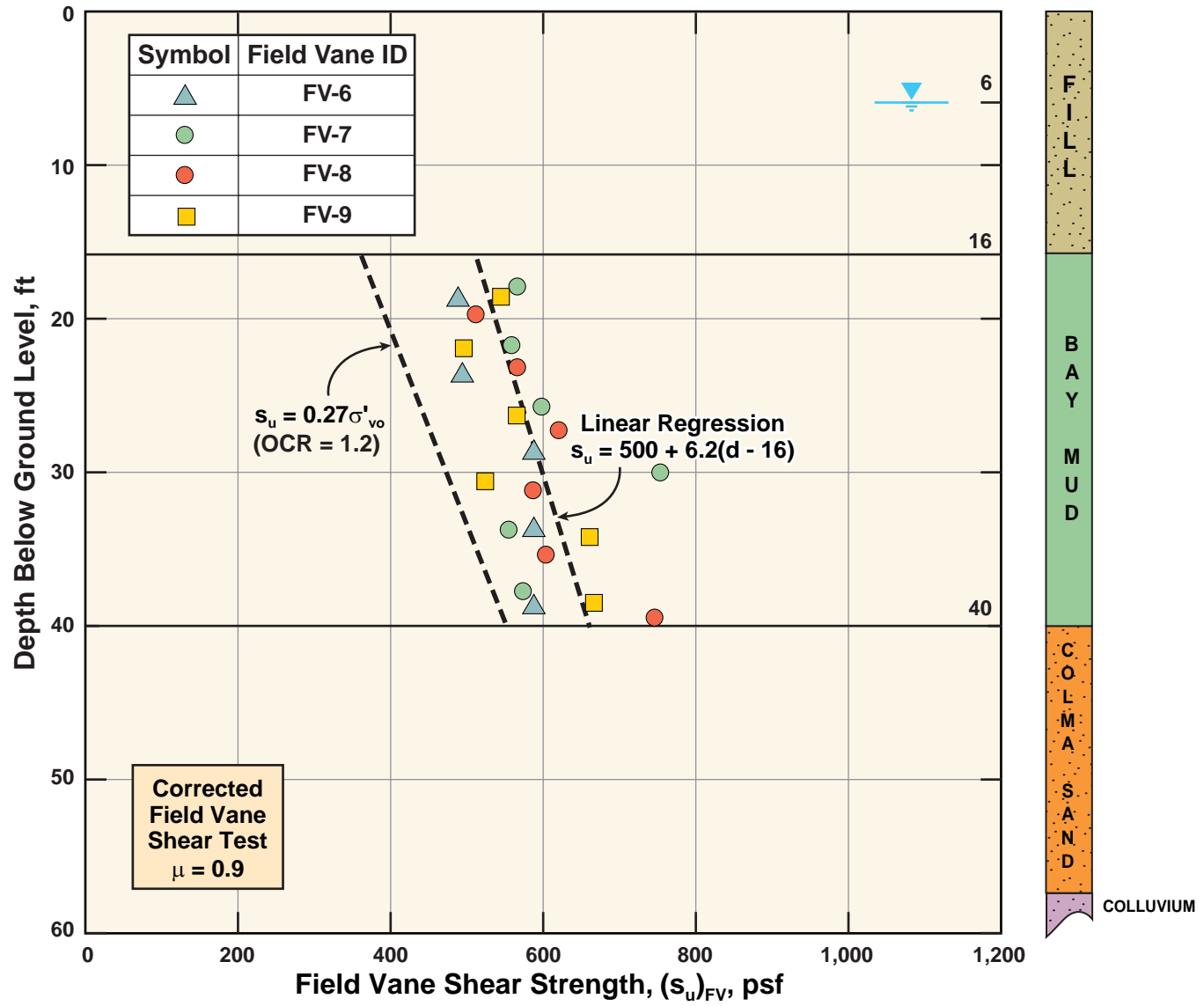
FIG\_40: Stress History and Undrained Vane Shear Strengths of Organic Bay Mud at a Recently Reclaimed Site



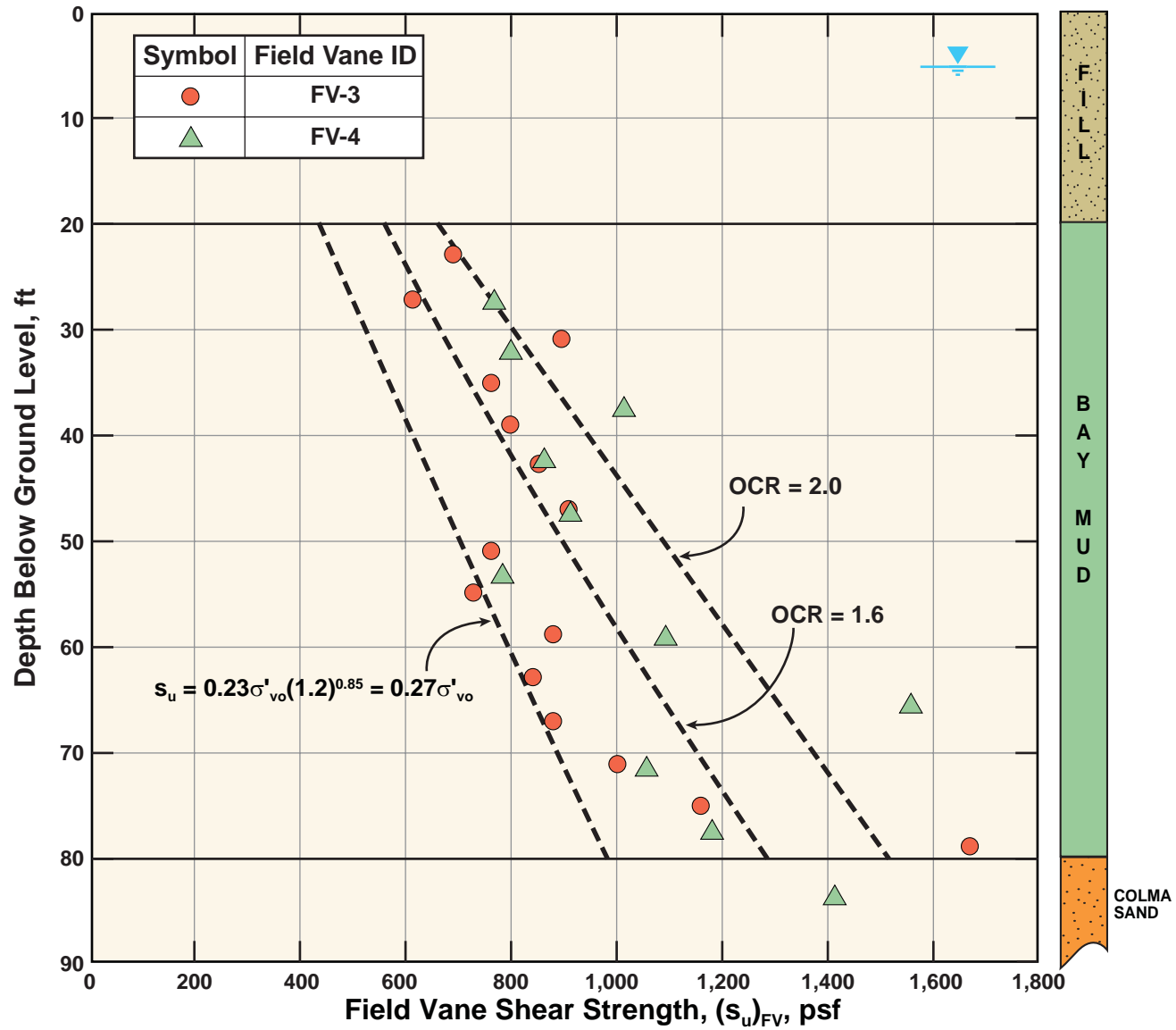
FIG\_41: Undrained Shear Strengths from Vane Tests Variations Between Offshore and Onshore Sites



FIG\_42: Field Vane Tests Marshland Area of Islais Creek (Contract C Site)

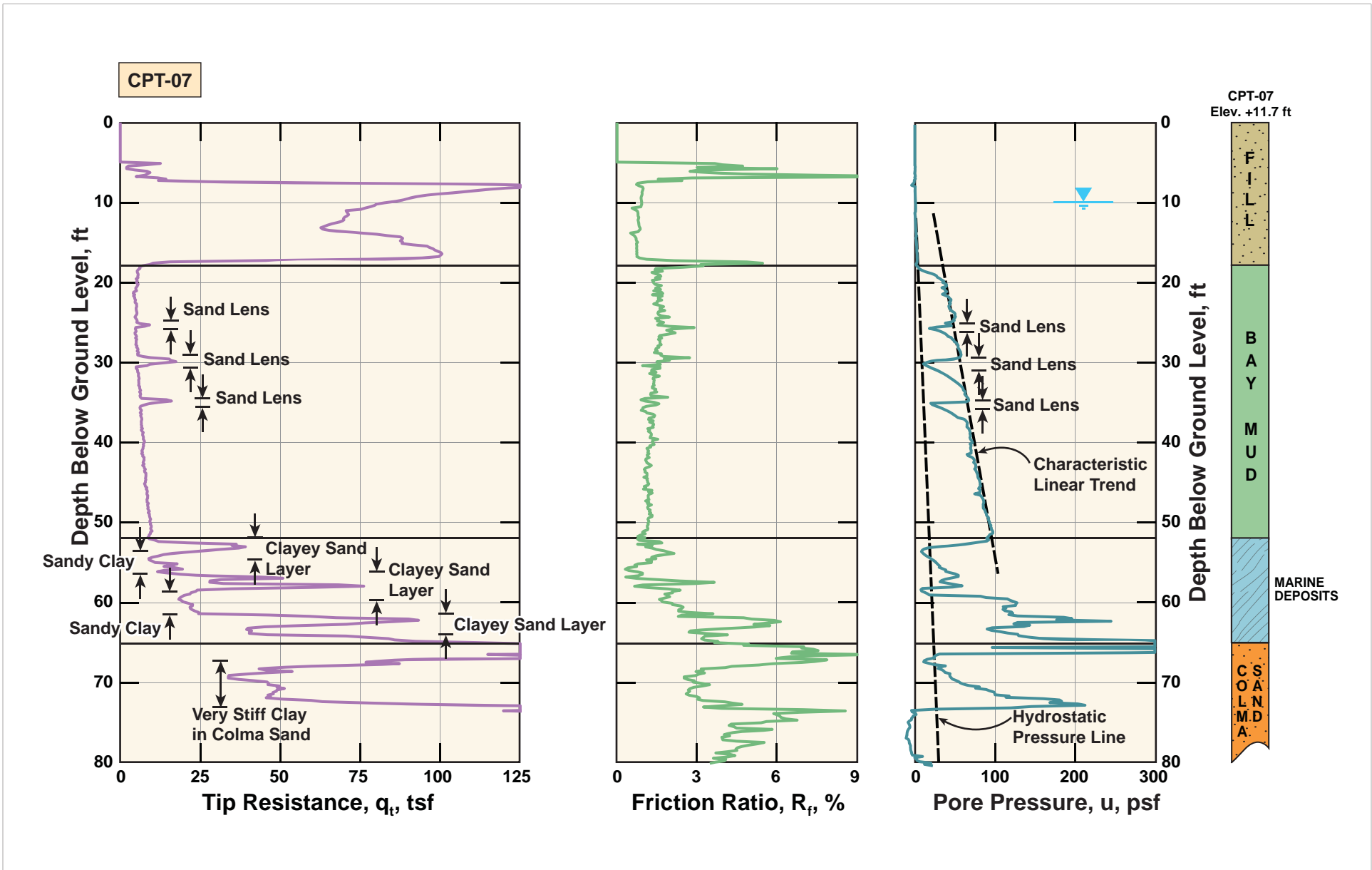


FIG\_43: Comparison of Field Vane Shear Strength with Geotechnical Report Recommendations



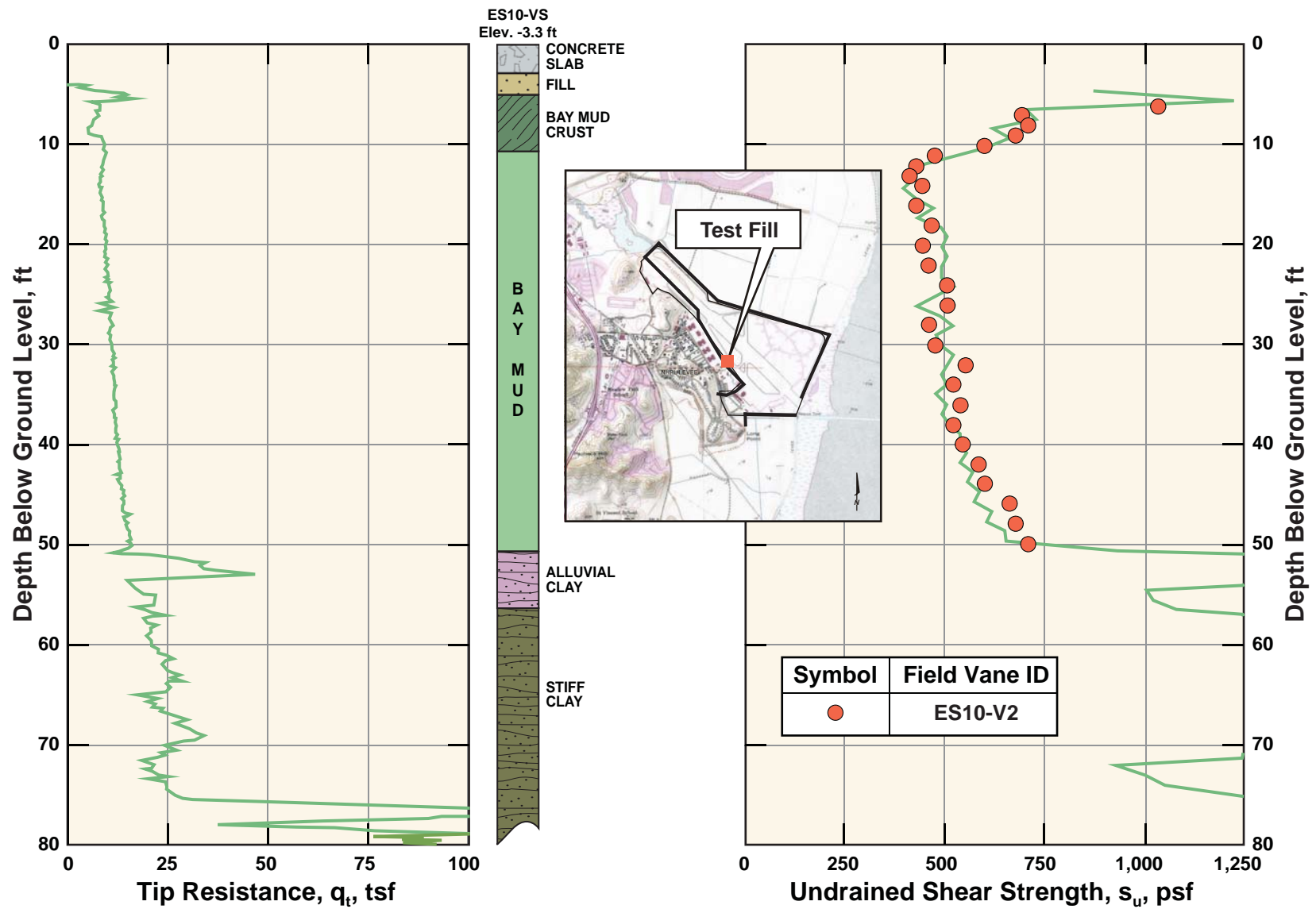
FIG\_44: Variations of Shear Strength Behavior Islais Creek Marshlands – Contract C Near McKinnon Street (Deeper Mud)



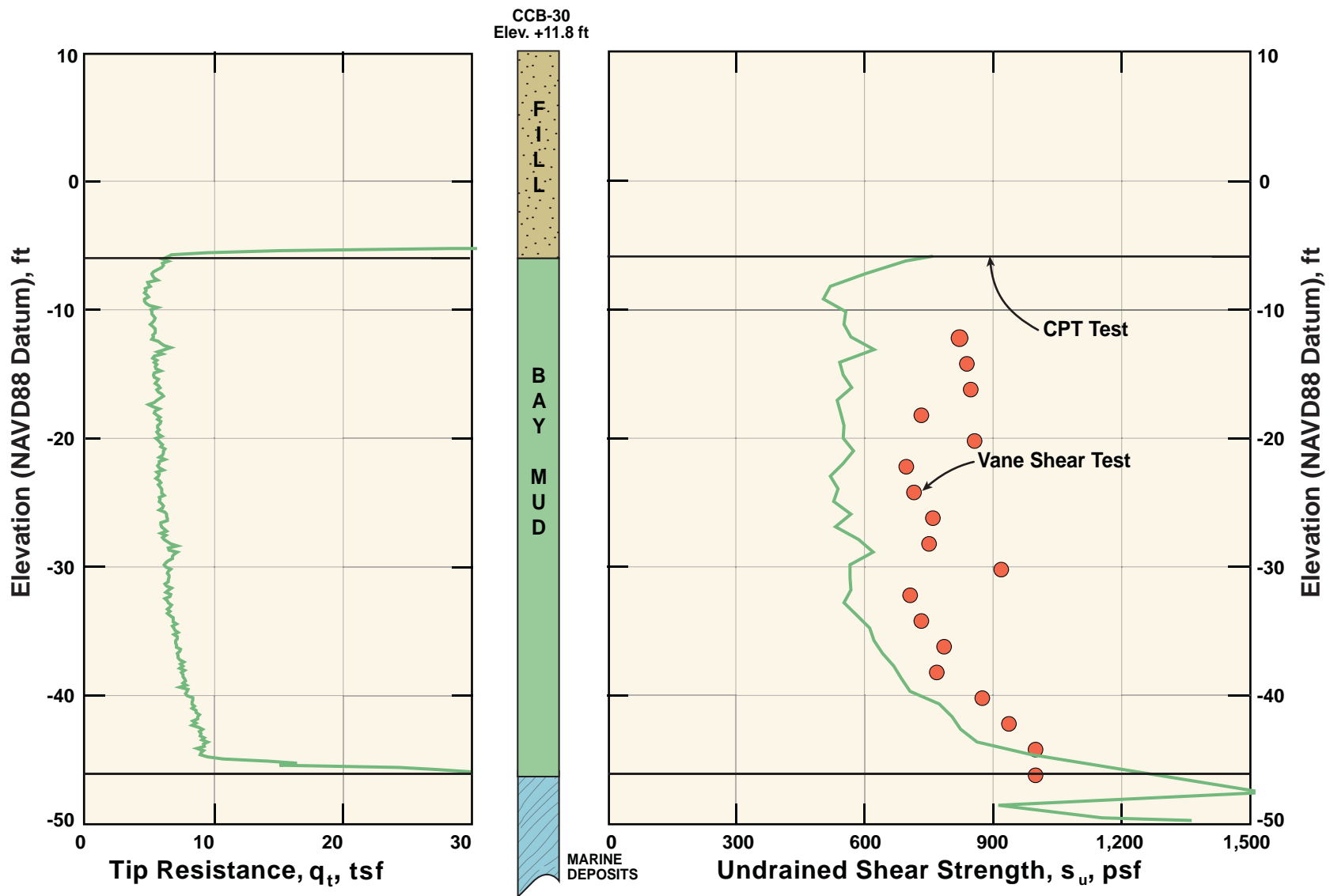


FIG\_45: Typical Results of CPT Tests in Bay Mud

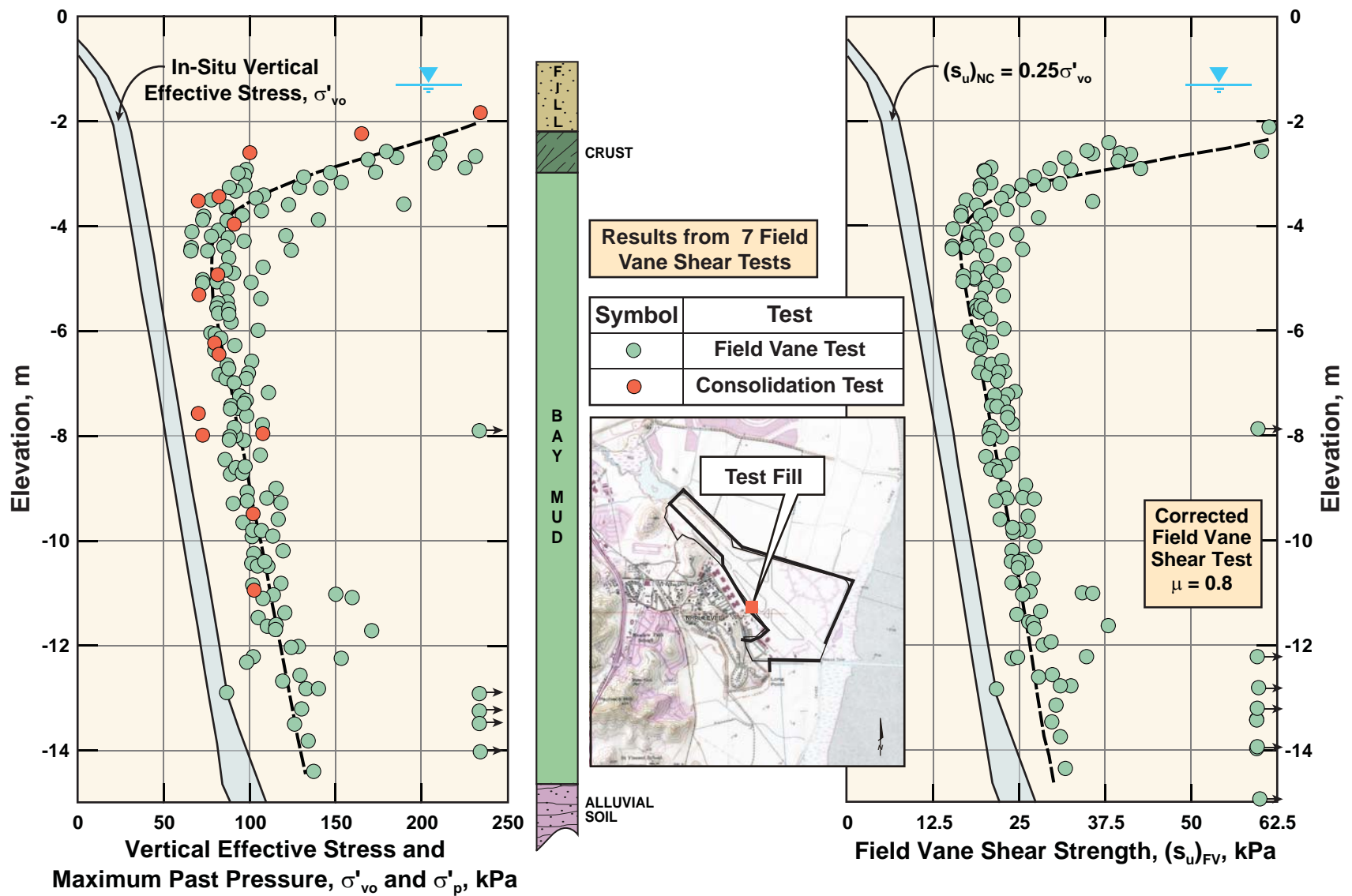
W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Plates\03 BAY MUD (18-78)\FIG\_45



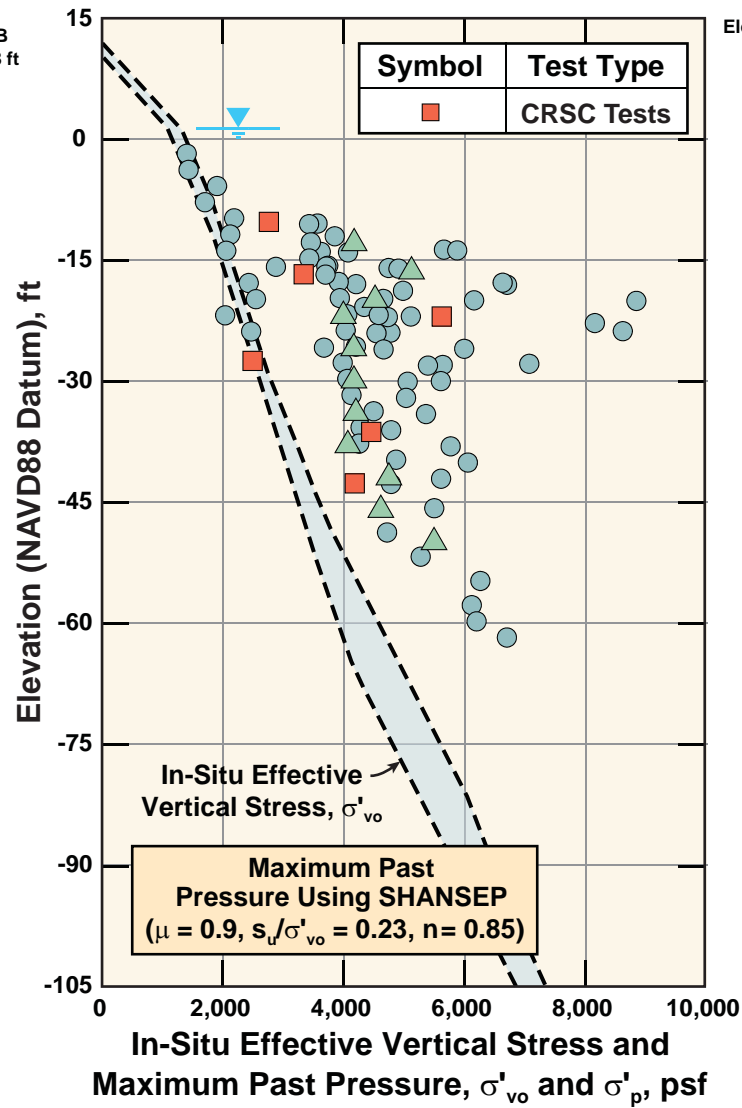
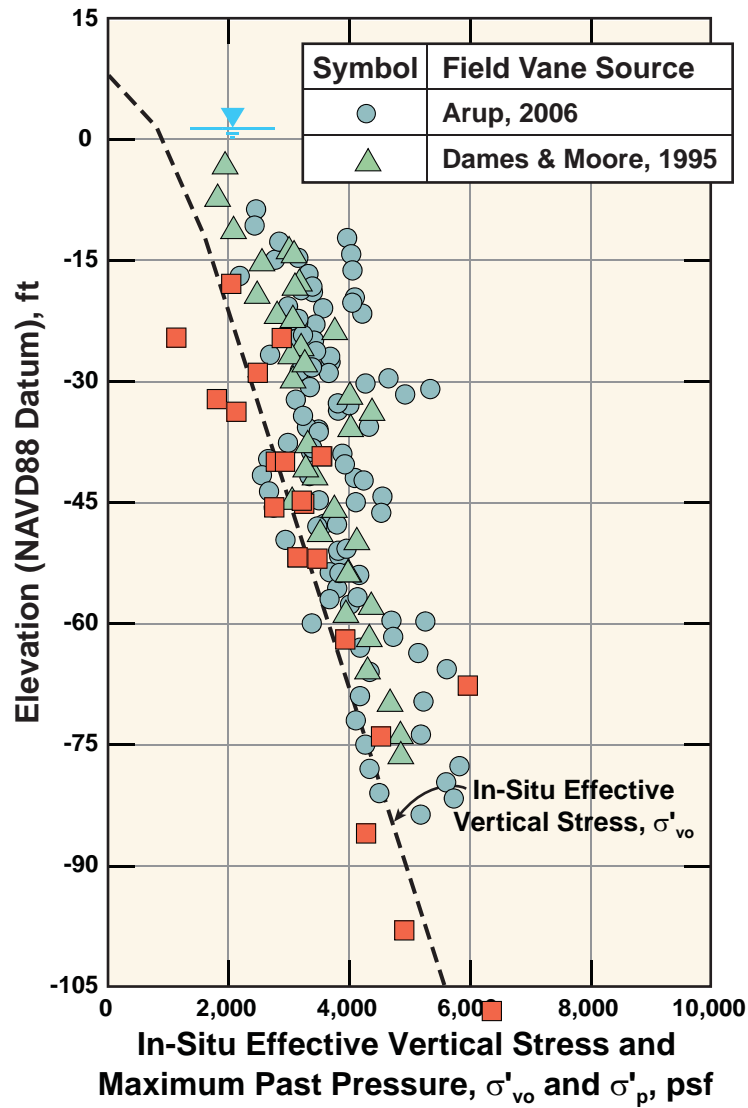
FIG\_46: Correlation of Undrained Strengths from CPT and Vane Shear Tests Hamilton Field Site



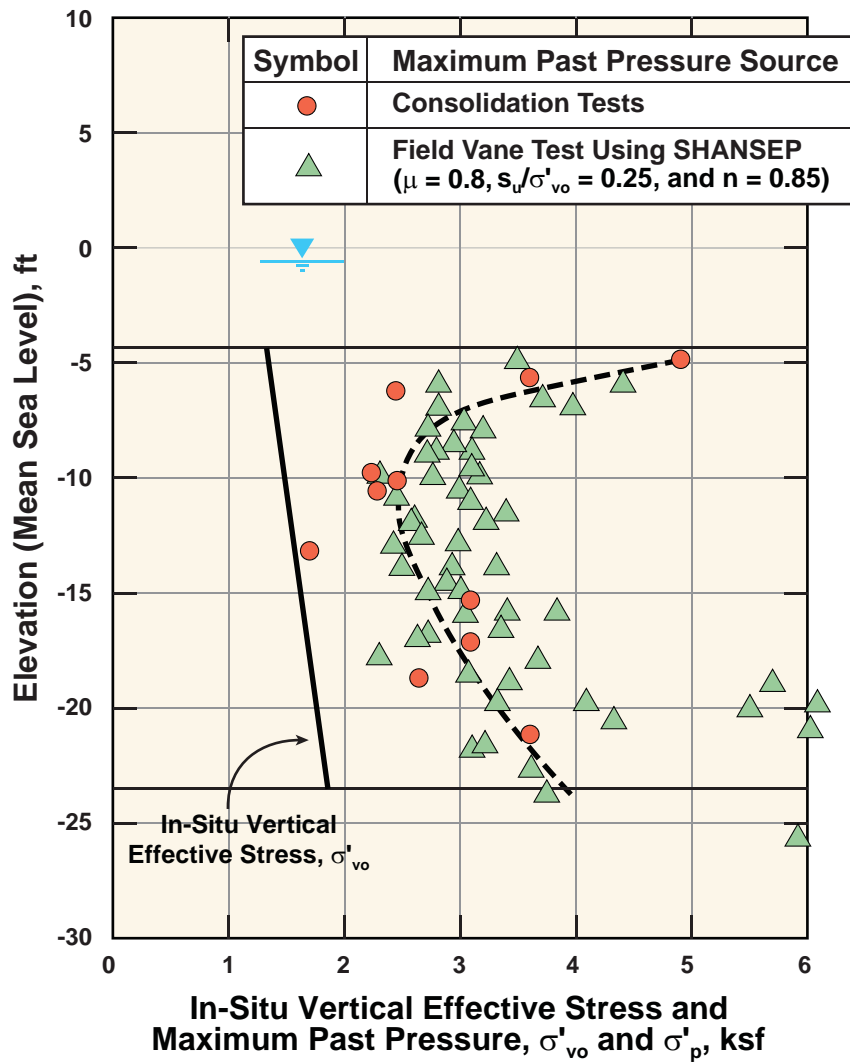
**FIG\_47: Correlation of Undrained Strengths from CPT and Vane Shear Tests Mission Bay Site Along Townsend Street**



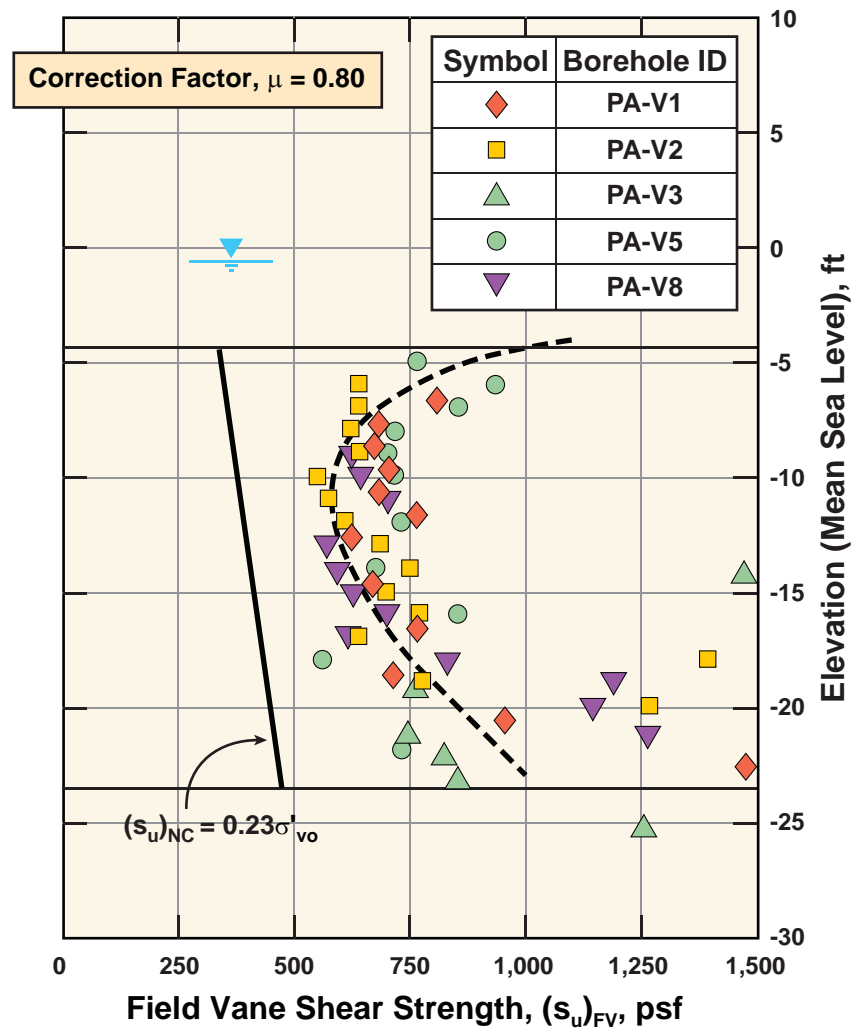
FIG\_48: Estimation of Maximum Past Pressures from Vane Shear Tests Hamilton Field Site



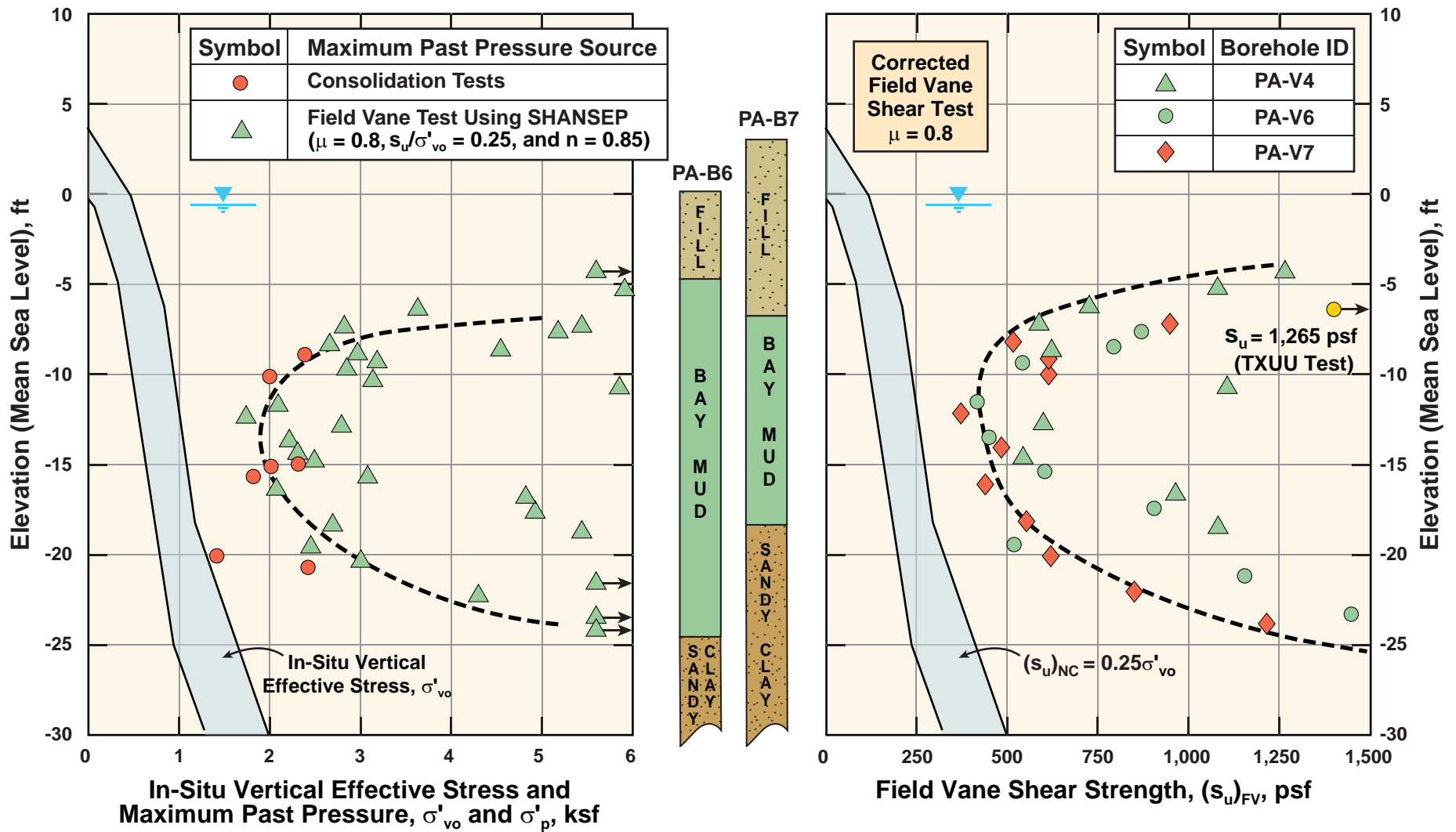
FIG\_49: Stress History of Bay Mud (Maximum Past Pressures)



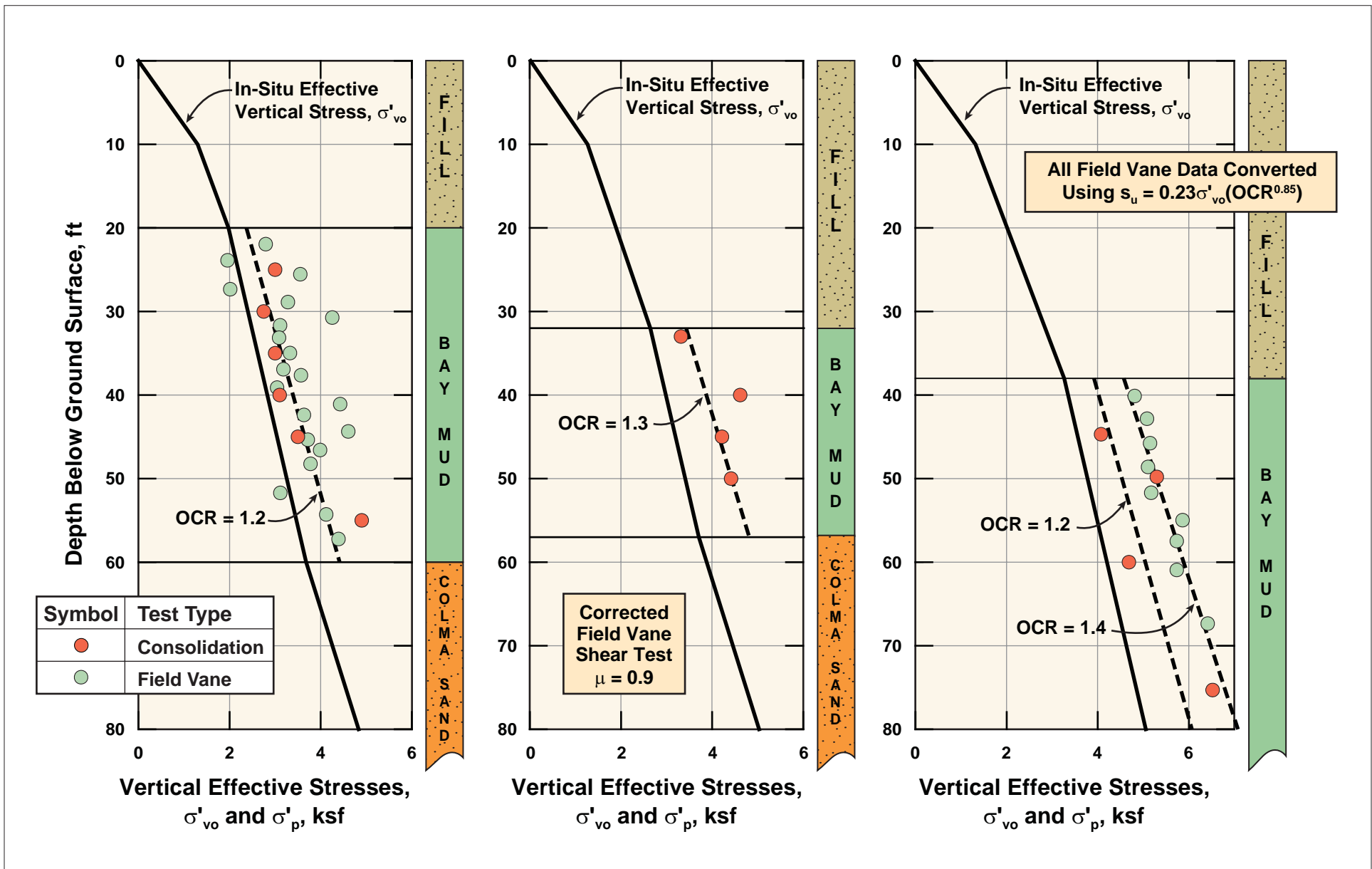
PA-B3



FIG\_50: Estimation of Maximum Past Pressures from Vane Shear Tests Hamilton Field Site: Shallow Mud Area Under Existing Levees

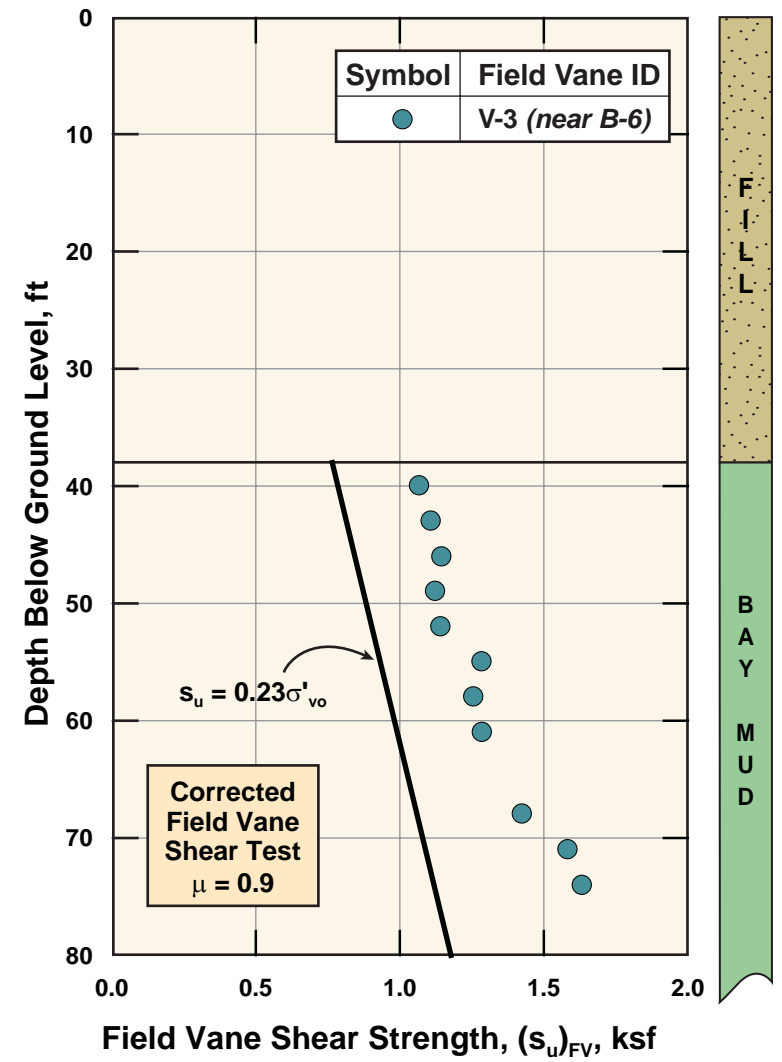
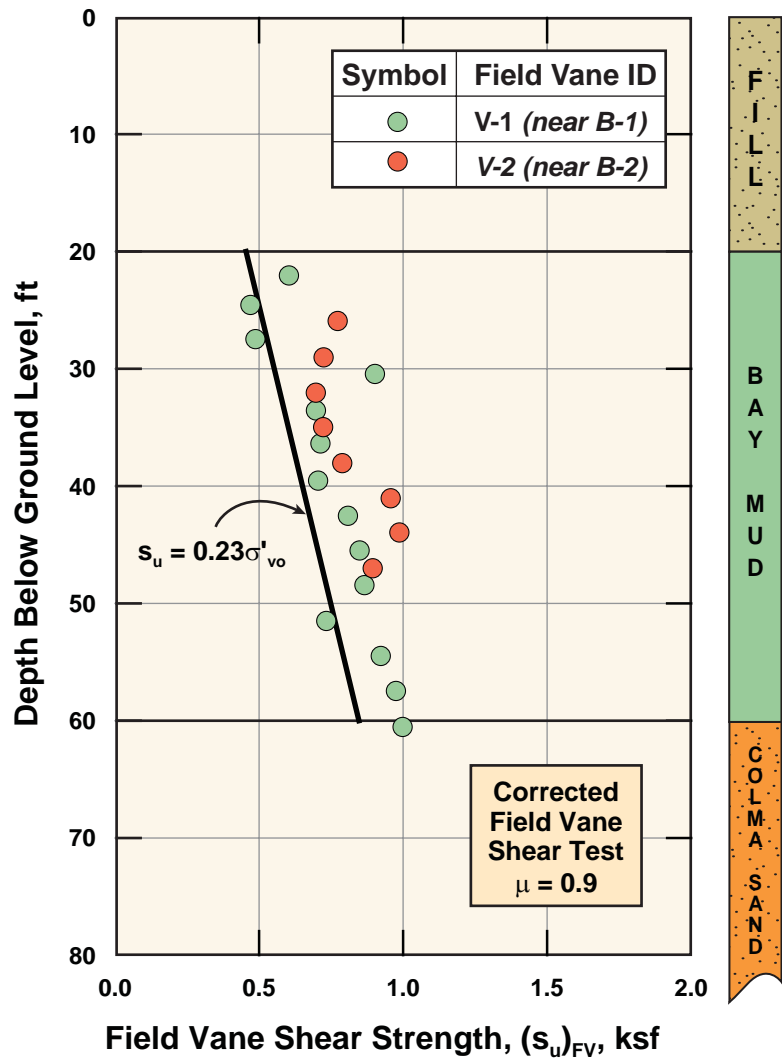


FIG\_51: Estimation of Maximum Past Pressures from Vane Shear Tests Shallow Mud – Free Field Area (HW)

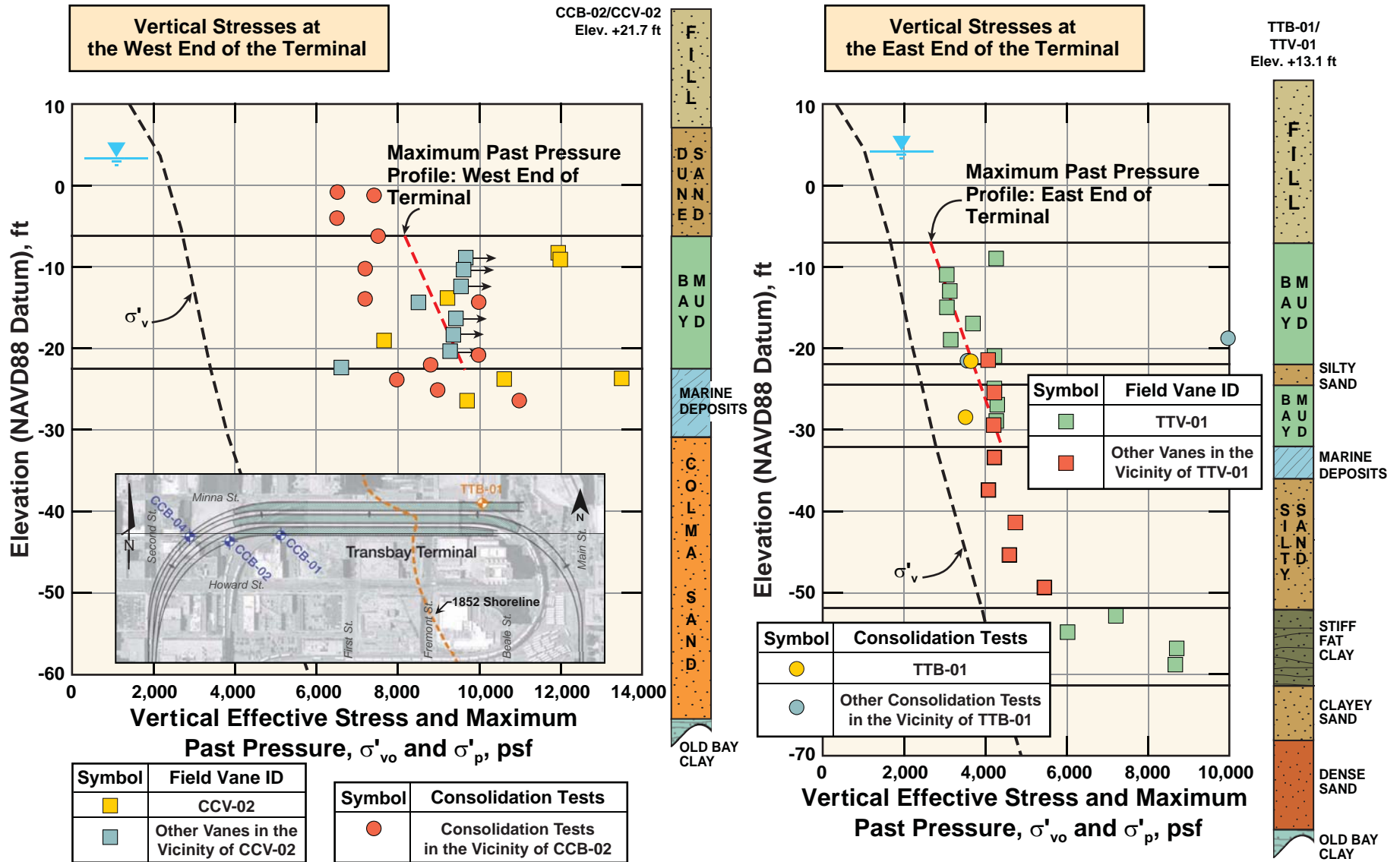


FIG\_52: Stress History for Bay Mud: Muni Metro East

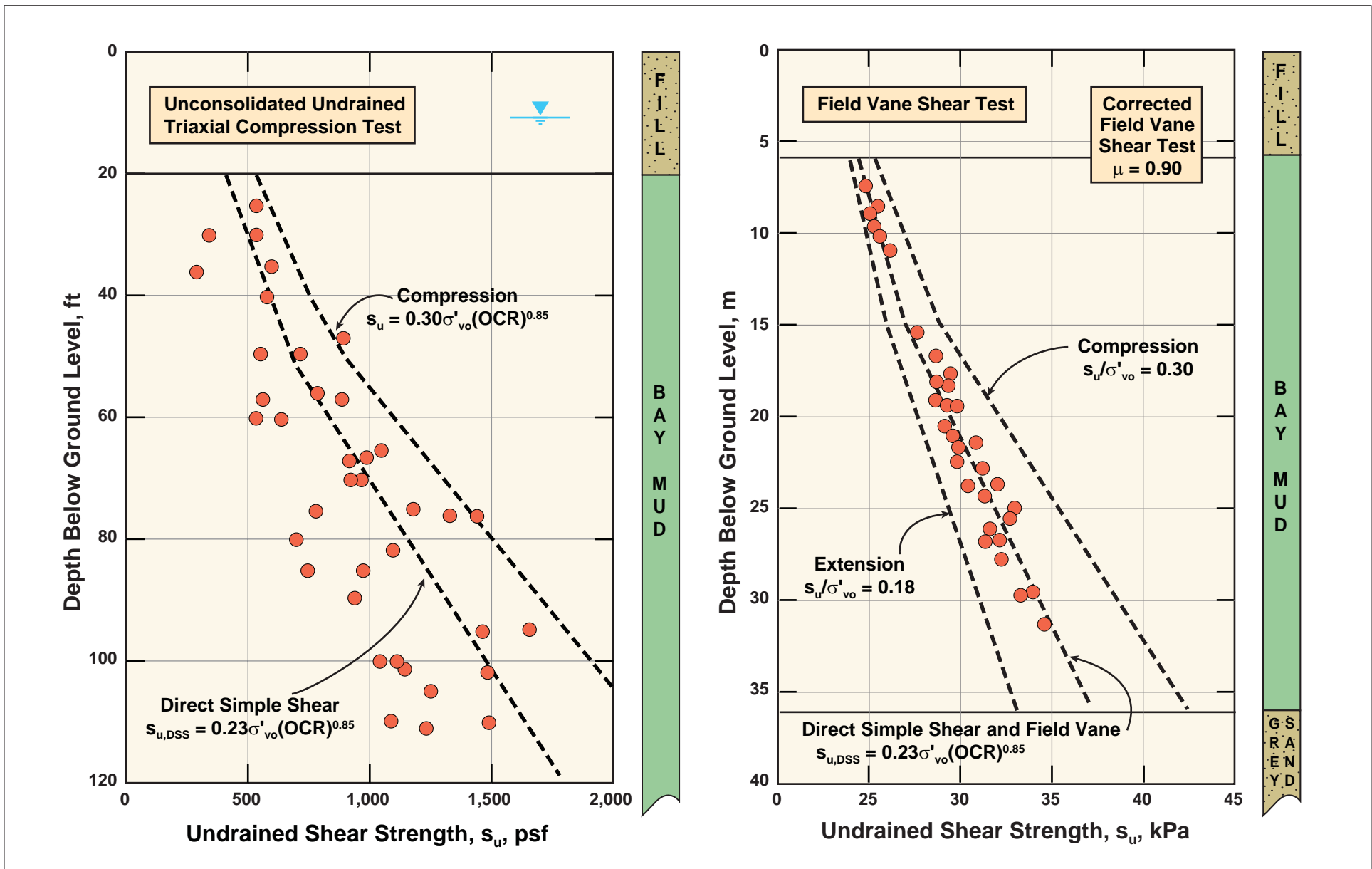




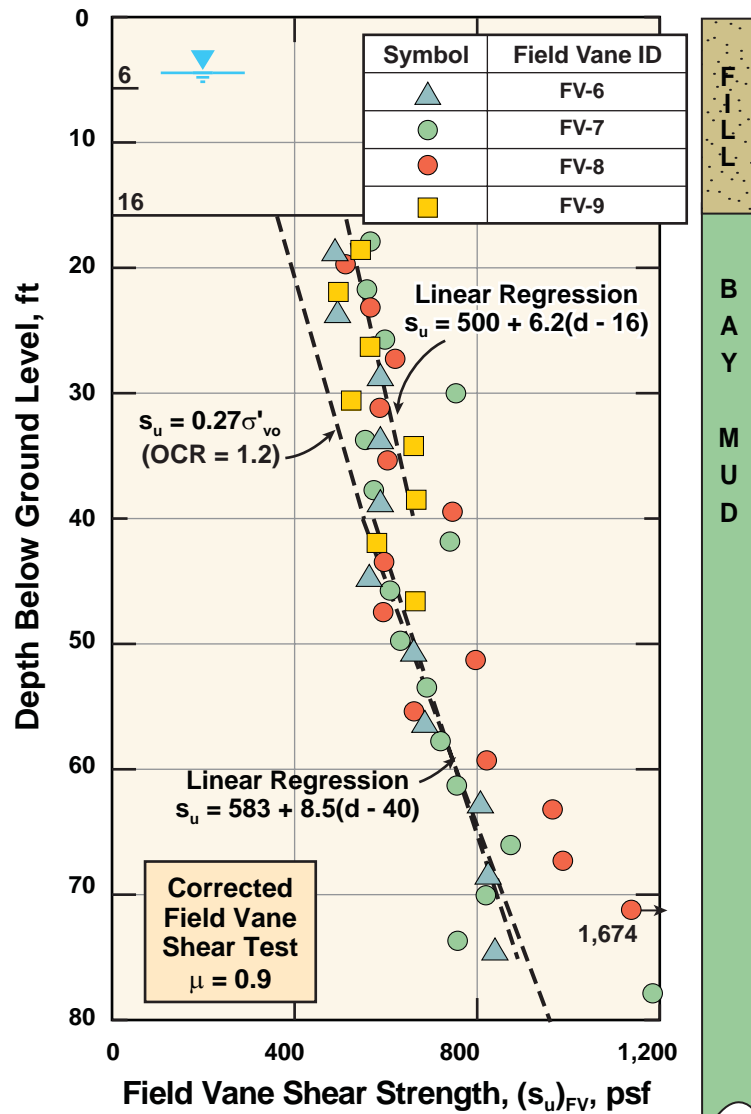
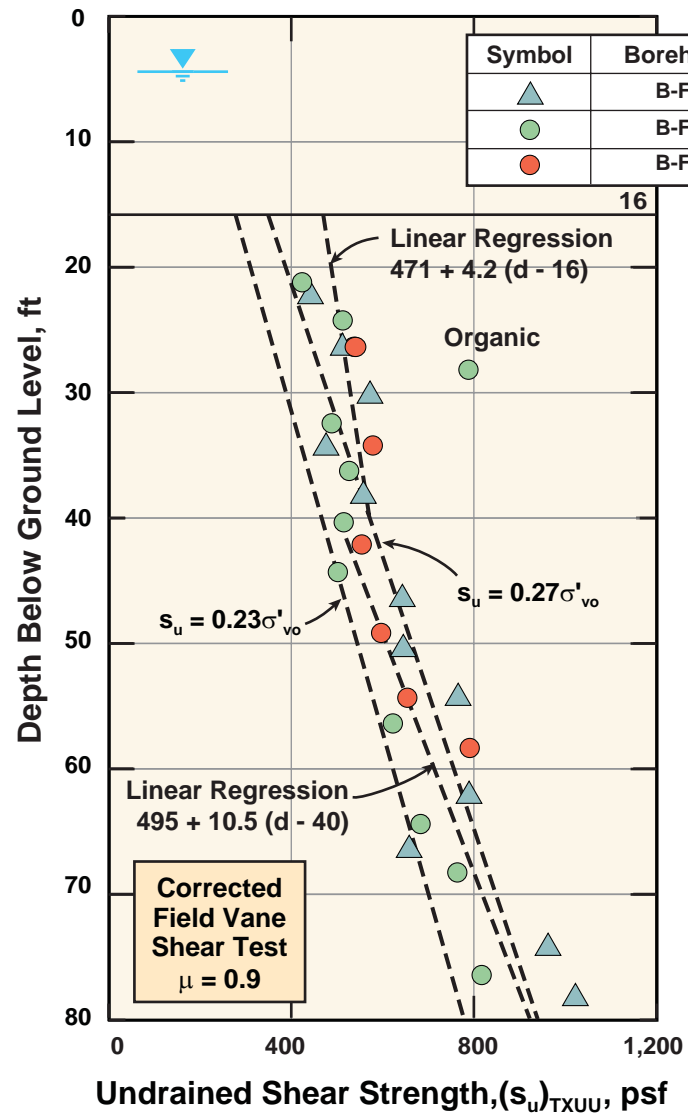
FIG\_52A: Title



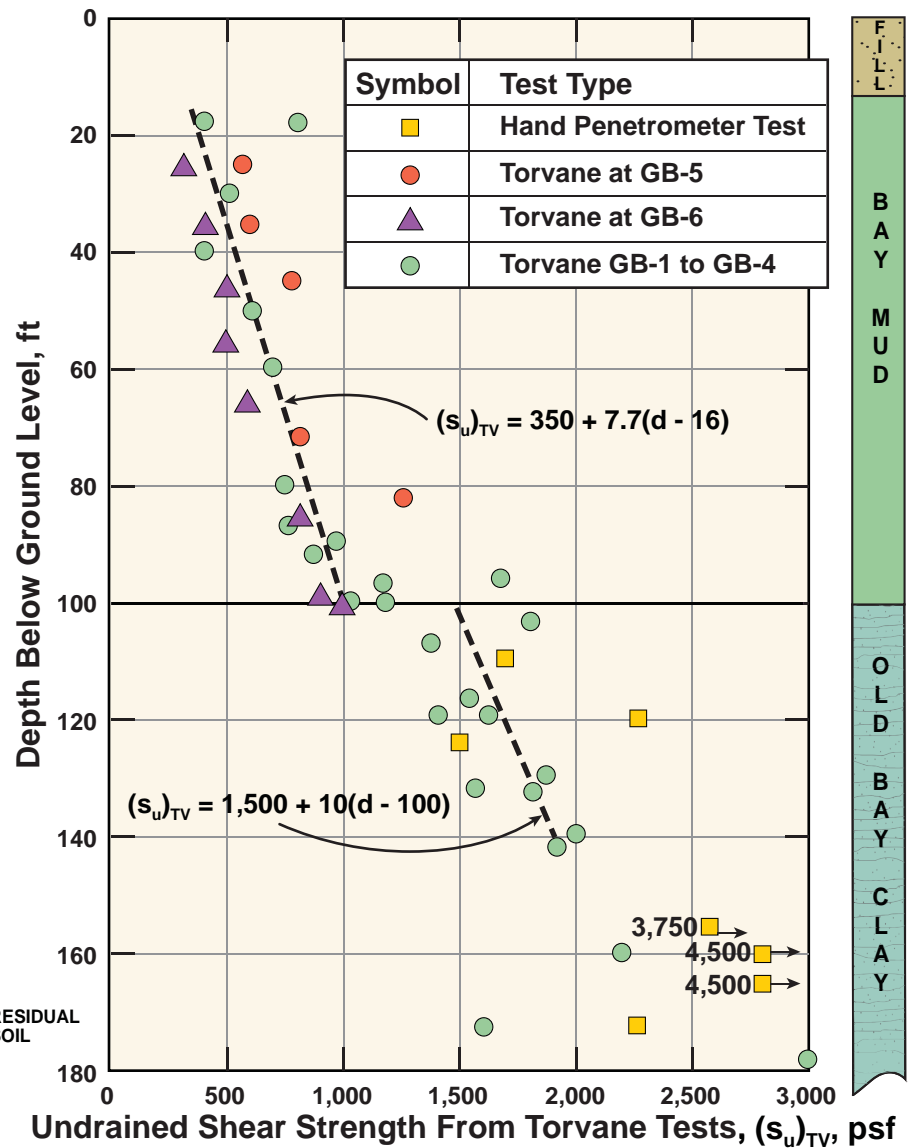
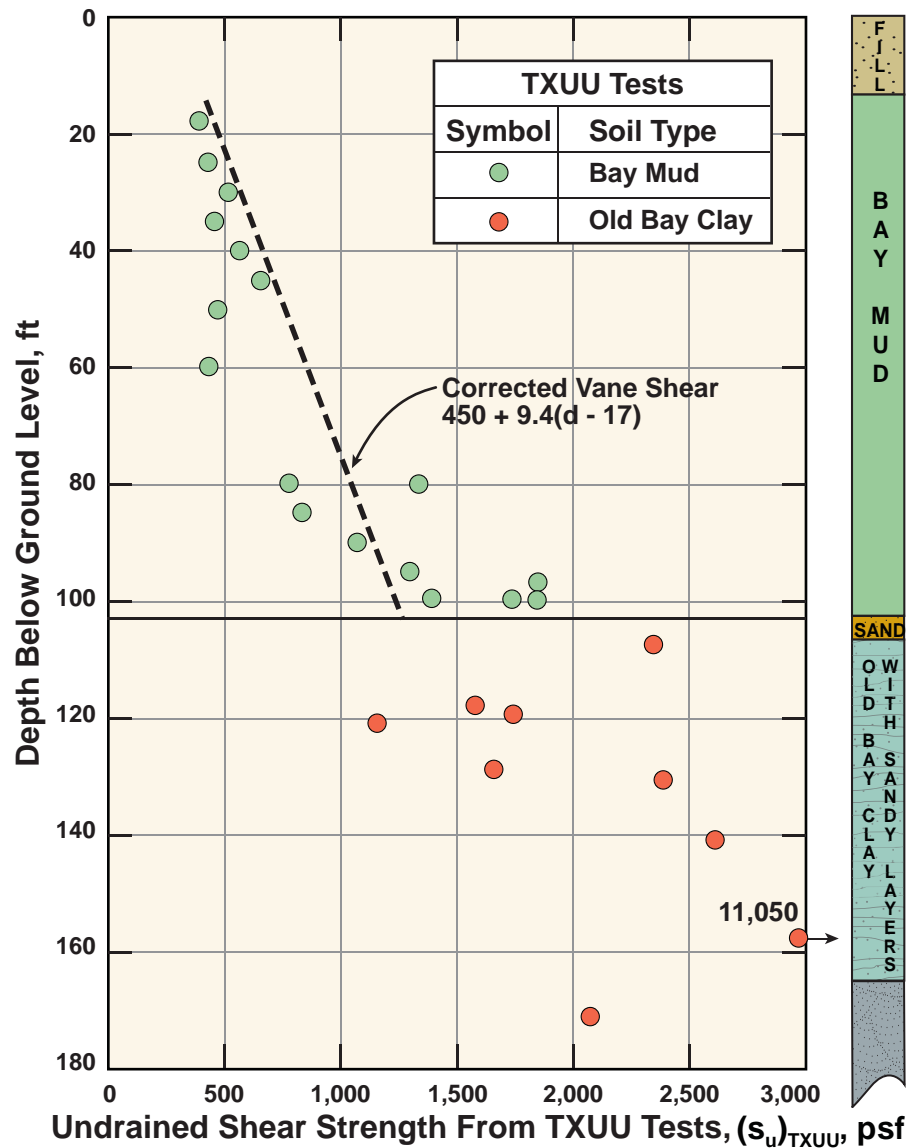
FIG\_53: Estimation of Maximum Past Pressures from Vane Shear Tests Transbay Terminal Site



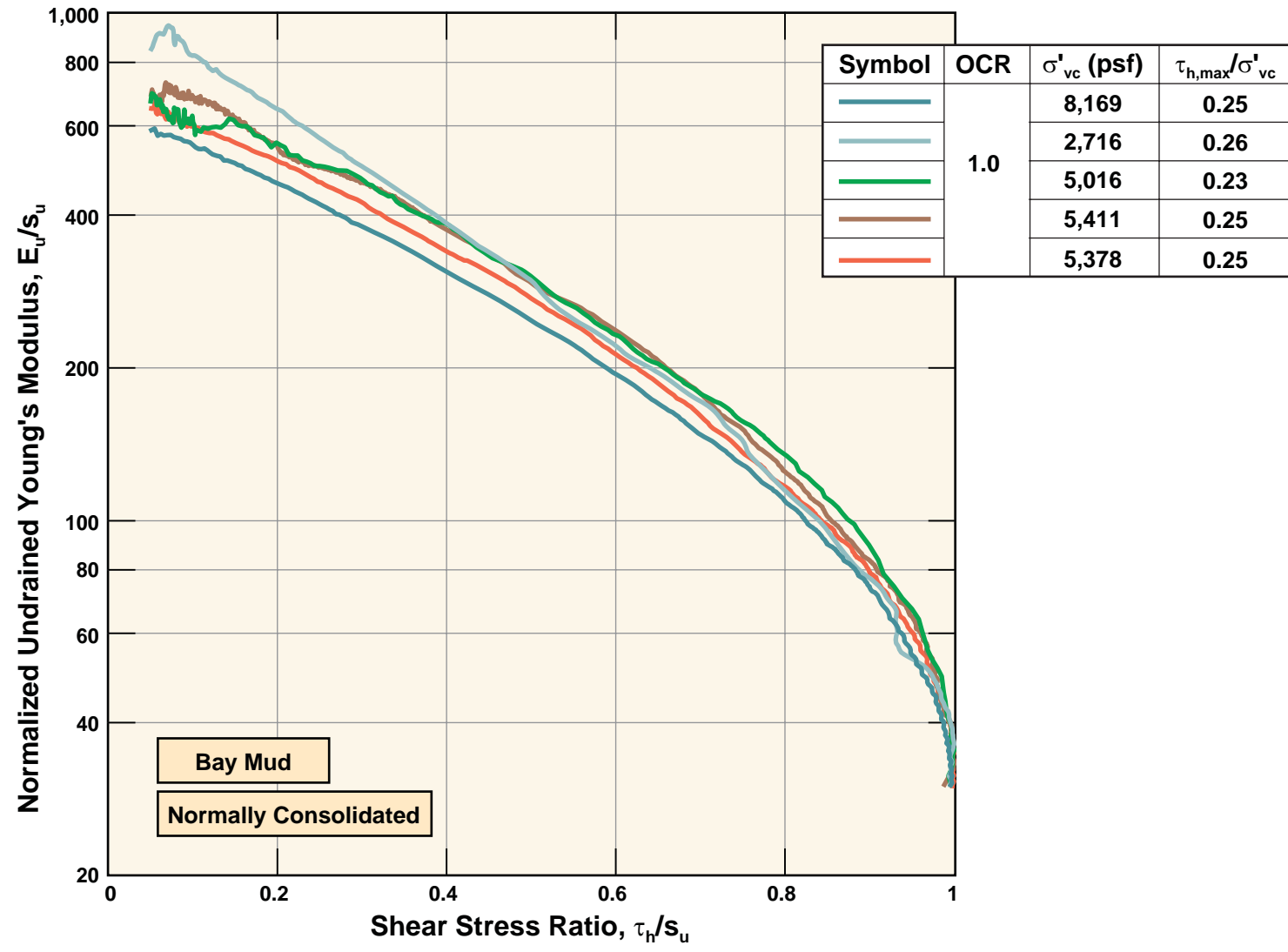
FIG\_54: Undrained Shear Strengths from In-Situ Vane Shear and UU Laboratory Tests Muni Metro Turnback Site



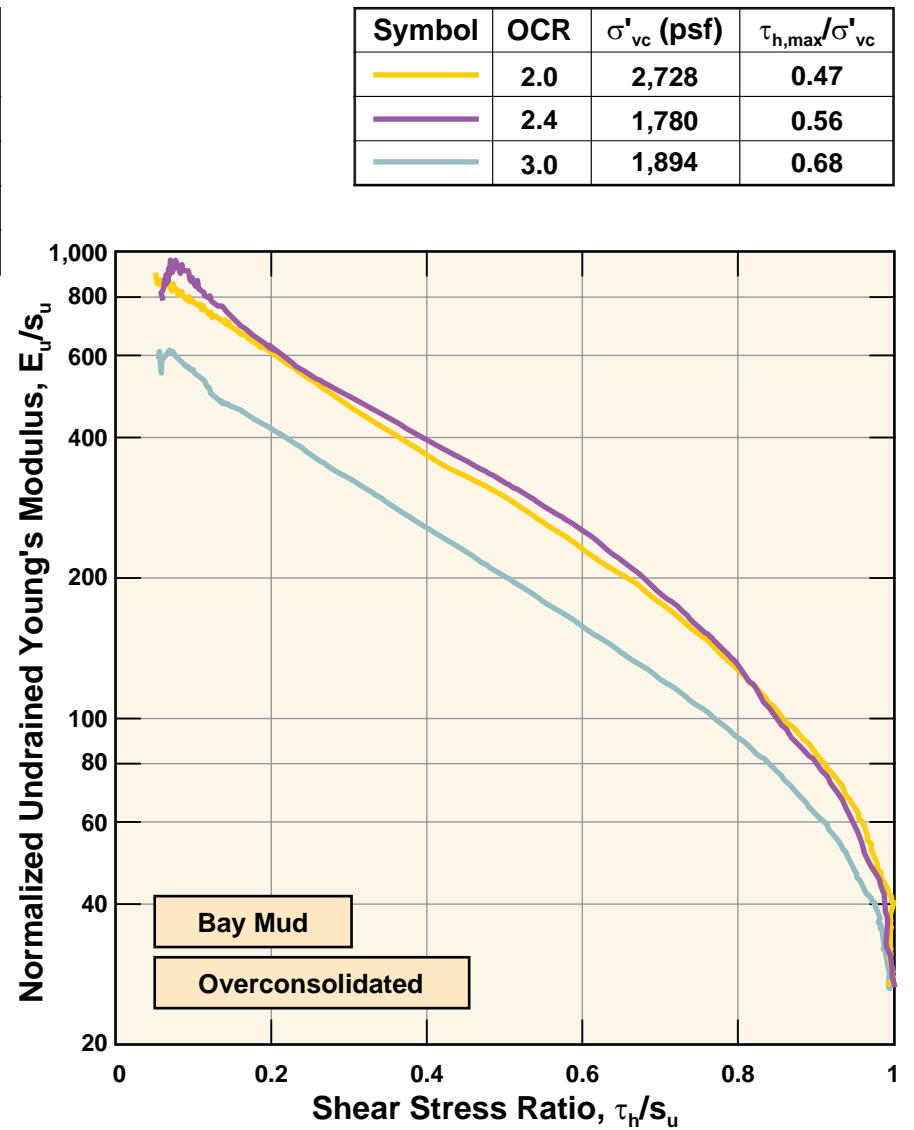
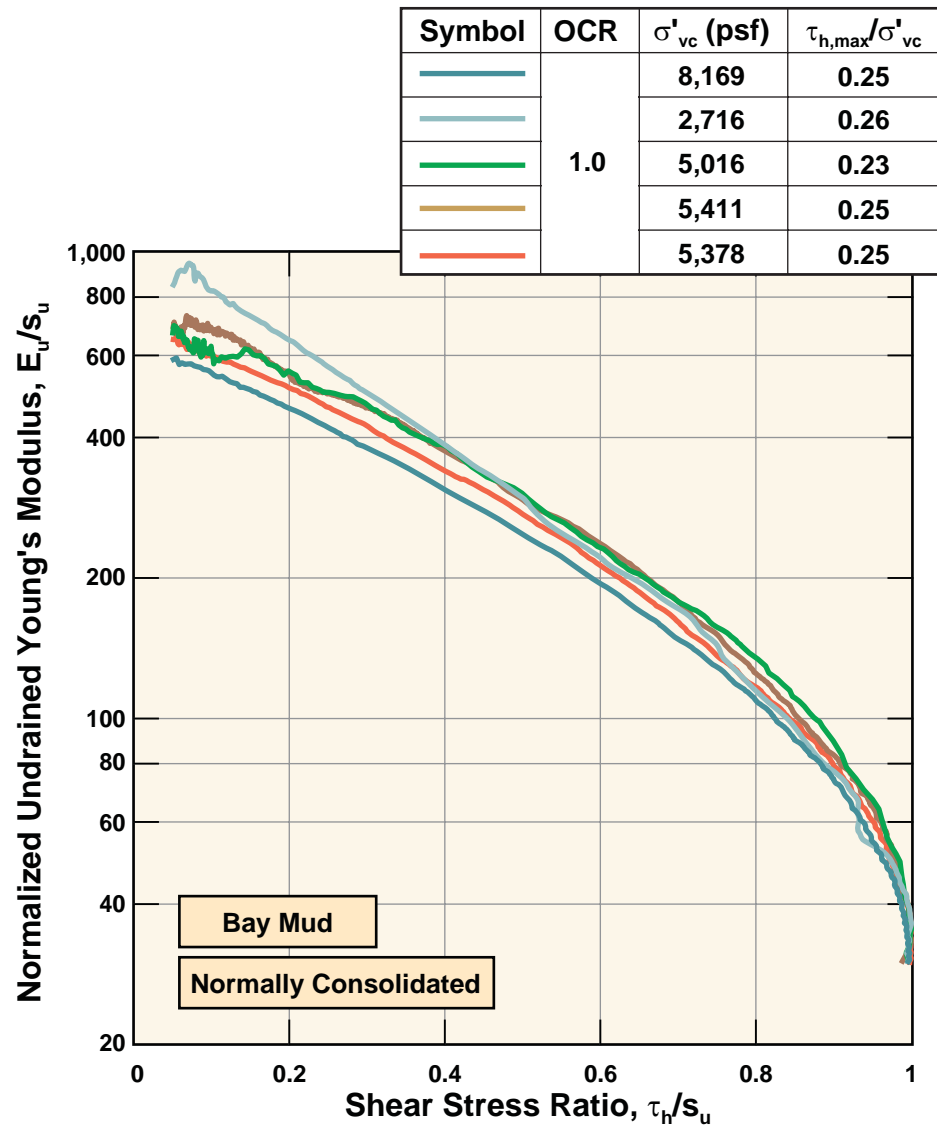
FIG\_54A: Title



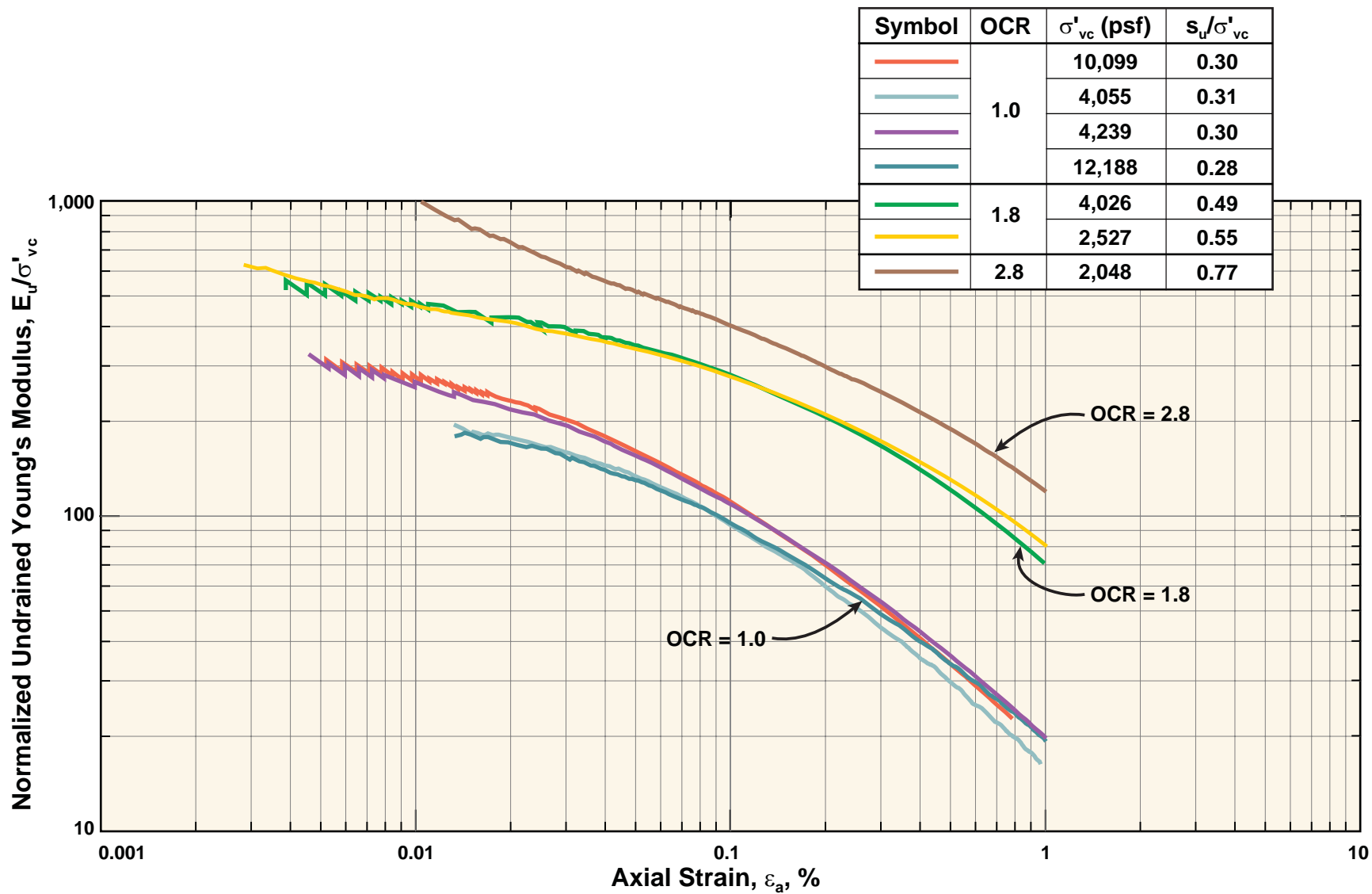
FIG\_55: Undrained Strengths from Vane Shear, UU, and Torvane Tests Digesters Site – Islais Creek Estuary



FIG\_56: Variation of Normalized Undrained Modulus with Shear Stress Level DSS Tests on Normally Consolidated Bay Mud

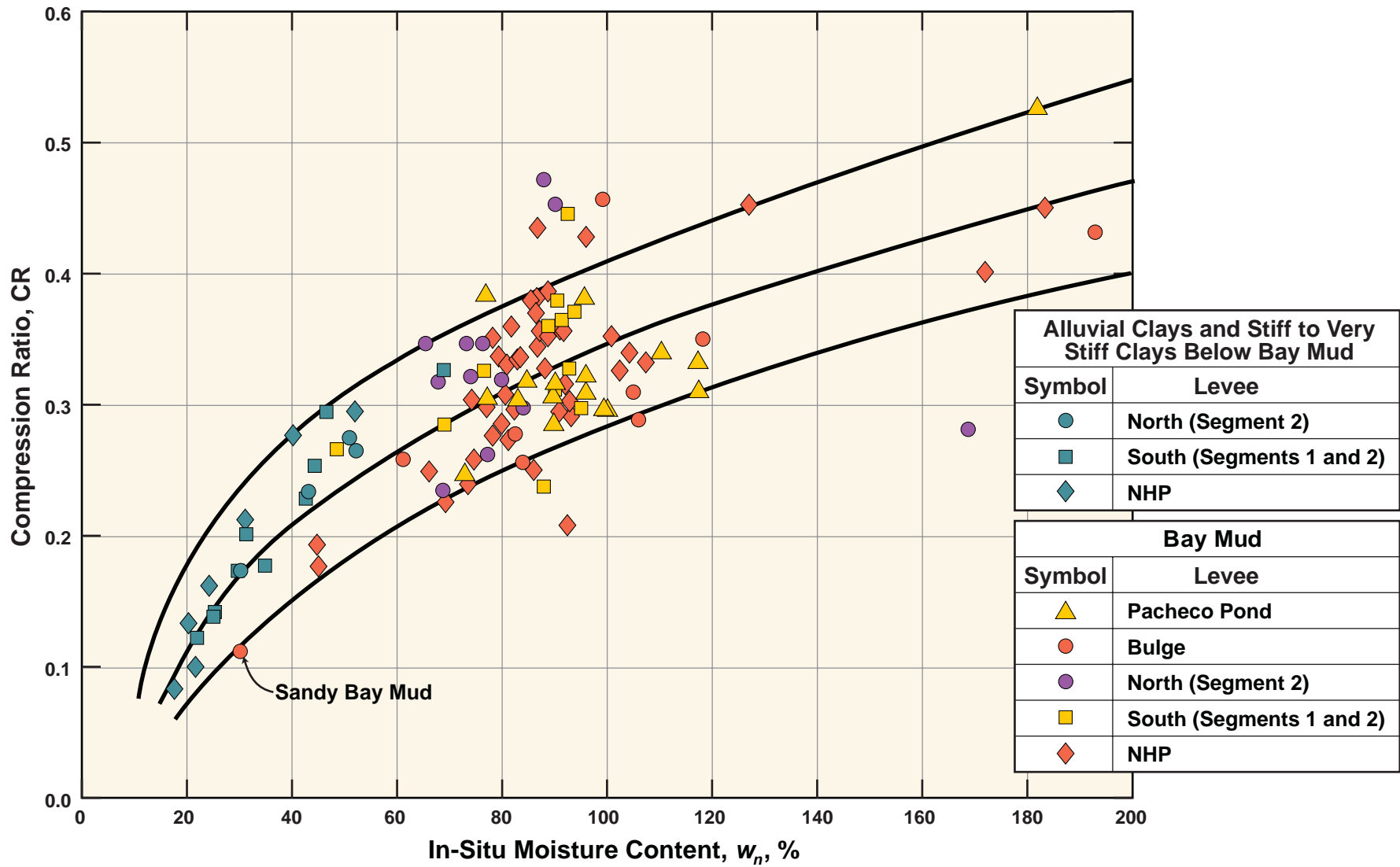


FIG\_57: Normalized Undrained Modulus from DSS Tests Normally and Overconsolidated Bay Mud

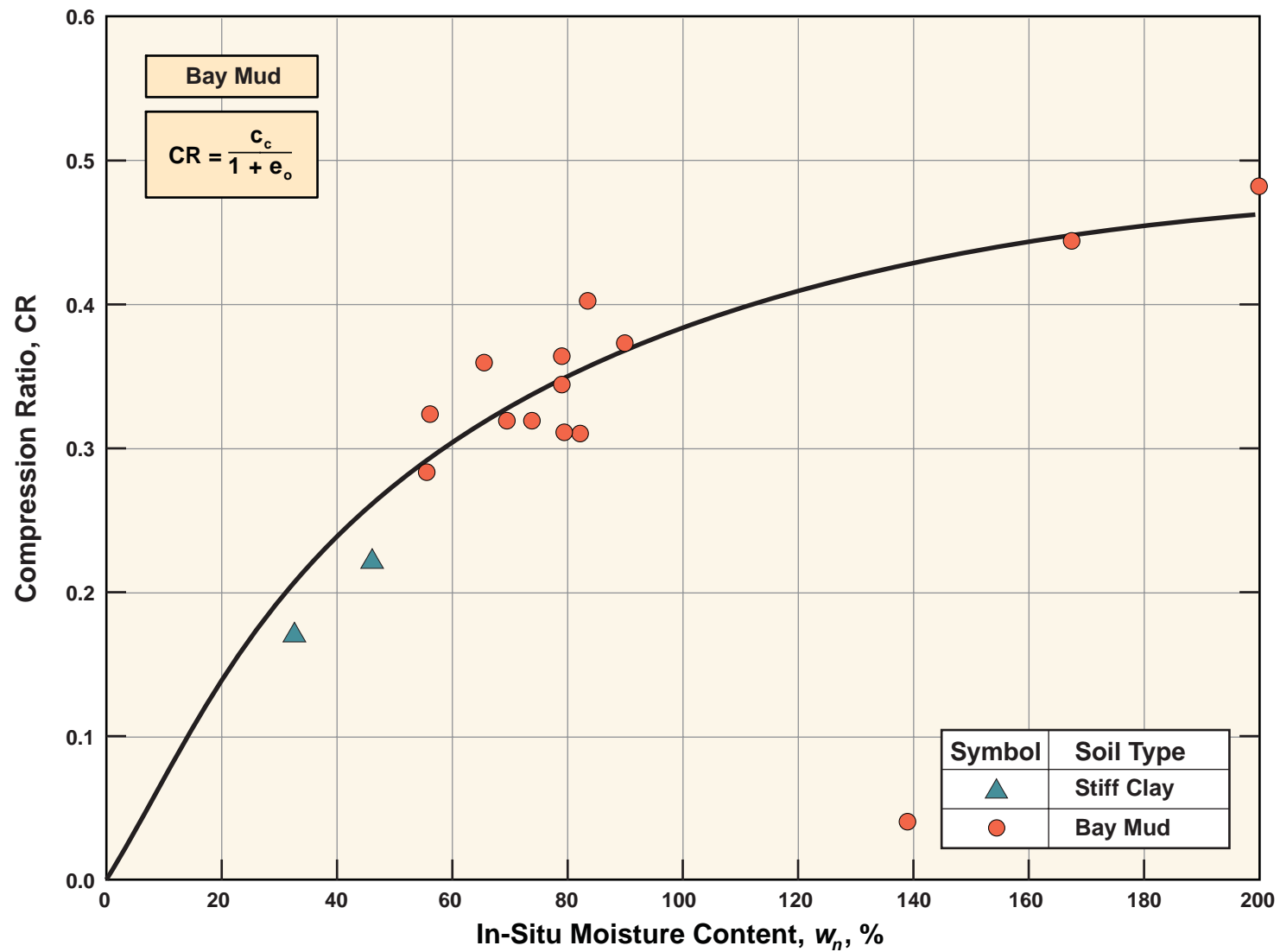


FIG\_58: Variation of Normalized Undrained Modulus with Strain Level From Ko-Triaxial Compression Tests

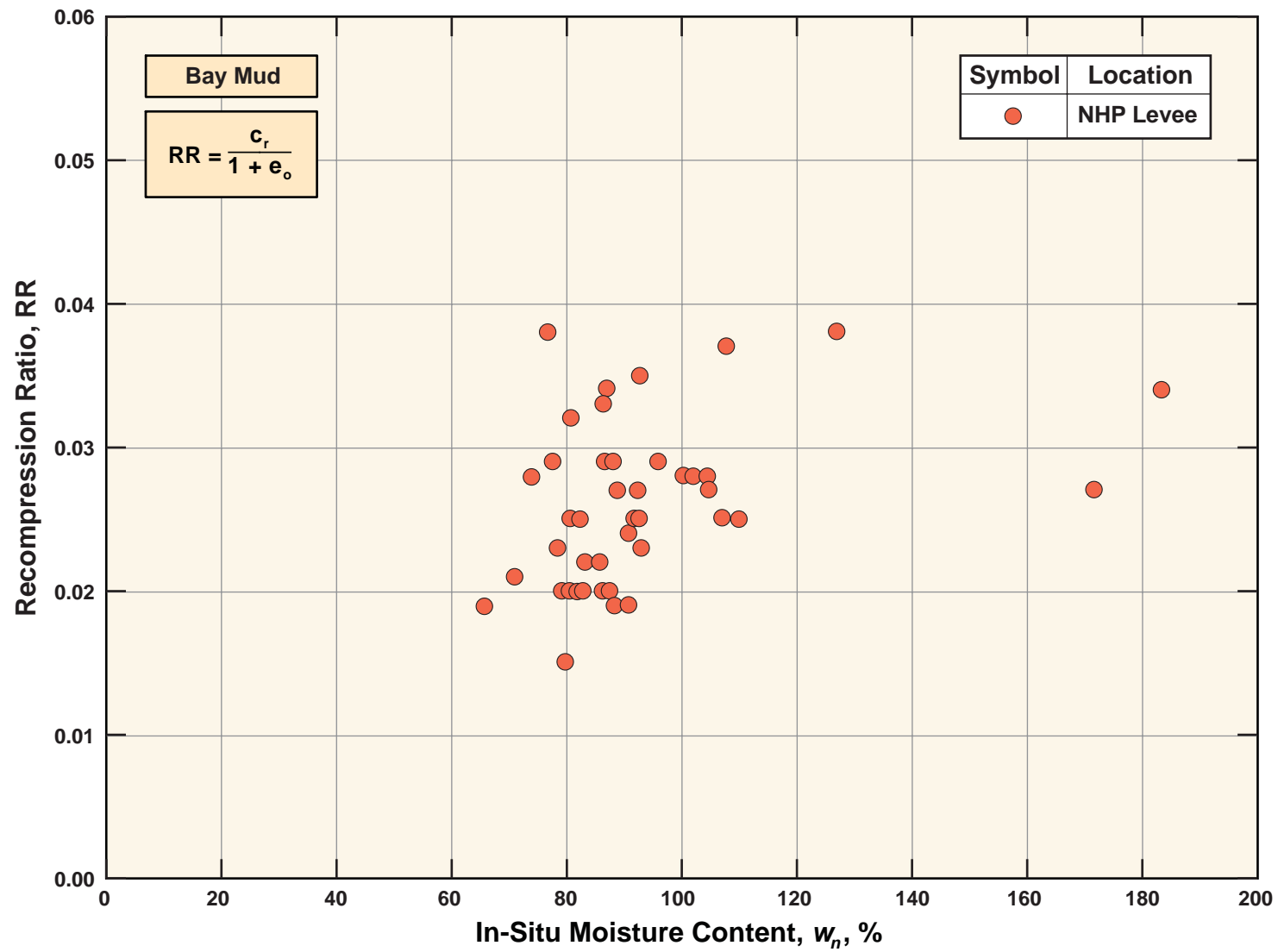




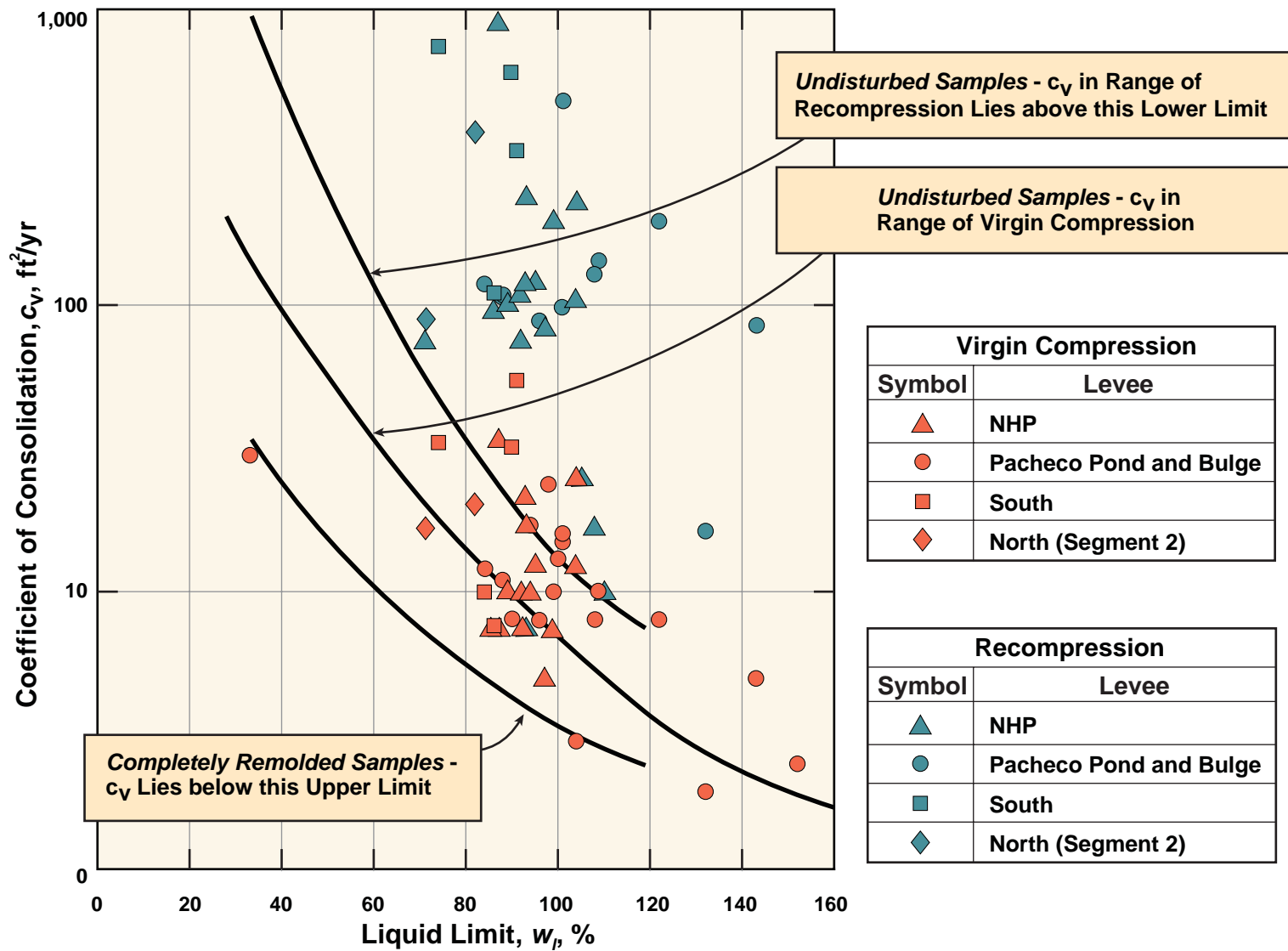
FIG\_59: Variation of Compression Ratio with Moisture Content: Bay Mud and Stiff Clays Hamilton F



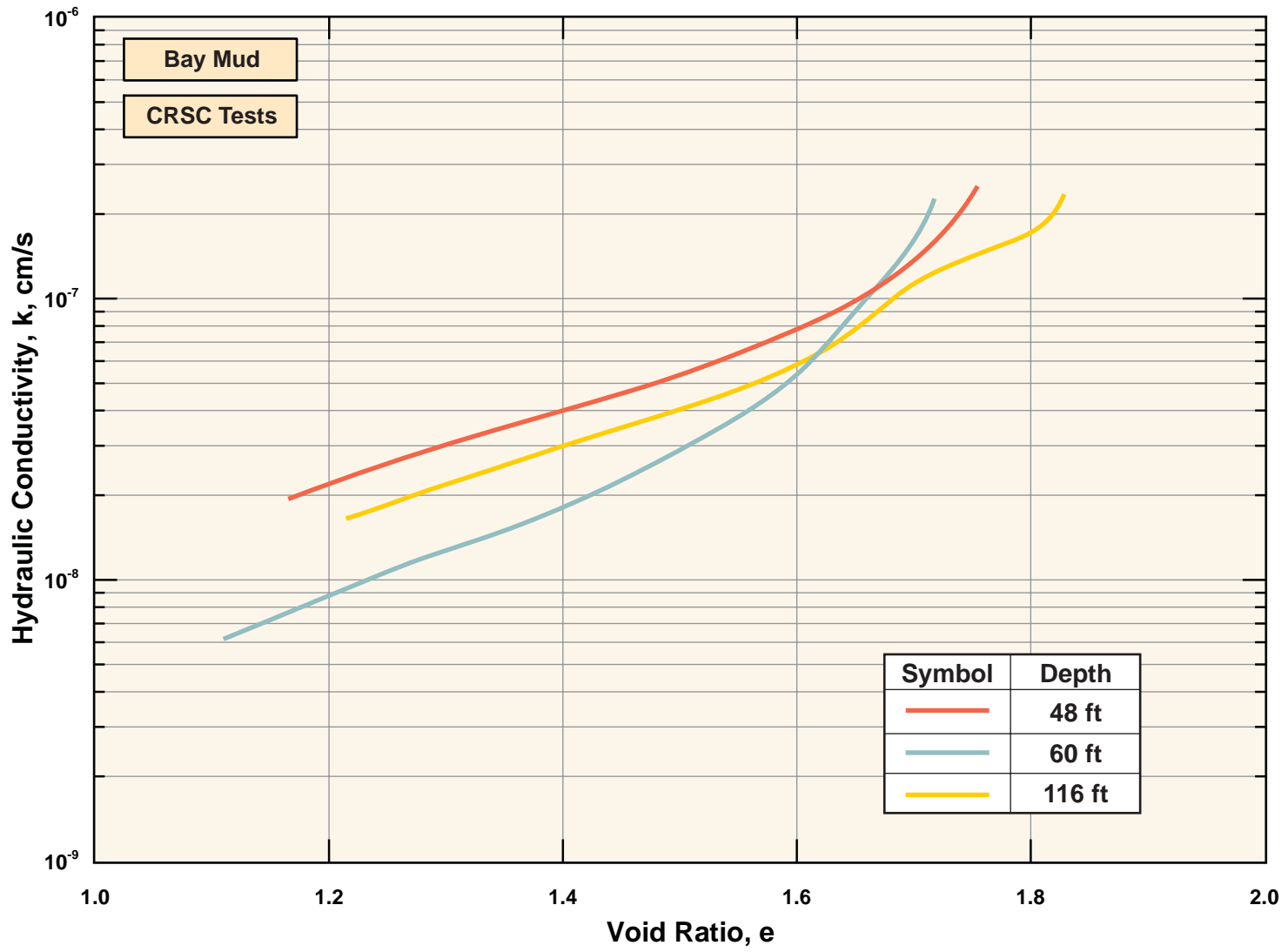
FIG\_60: Variation of Compression Ratio with Moisture Content North Bay Site



FIG\_61: Variation of Recompression Ratio with Moisture Content

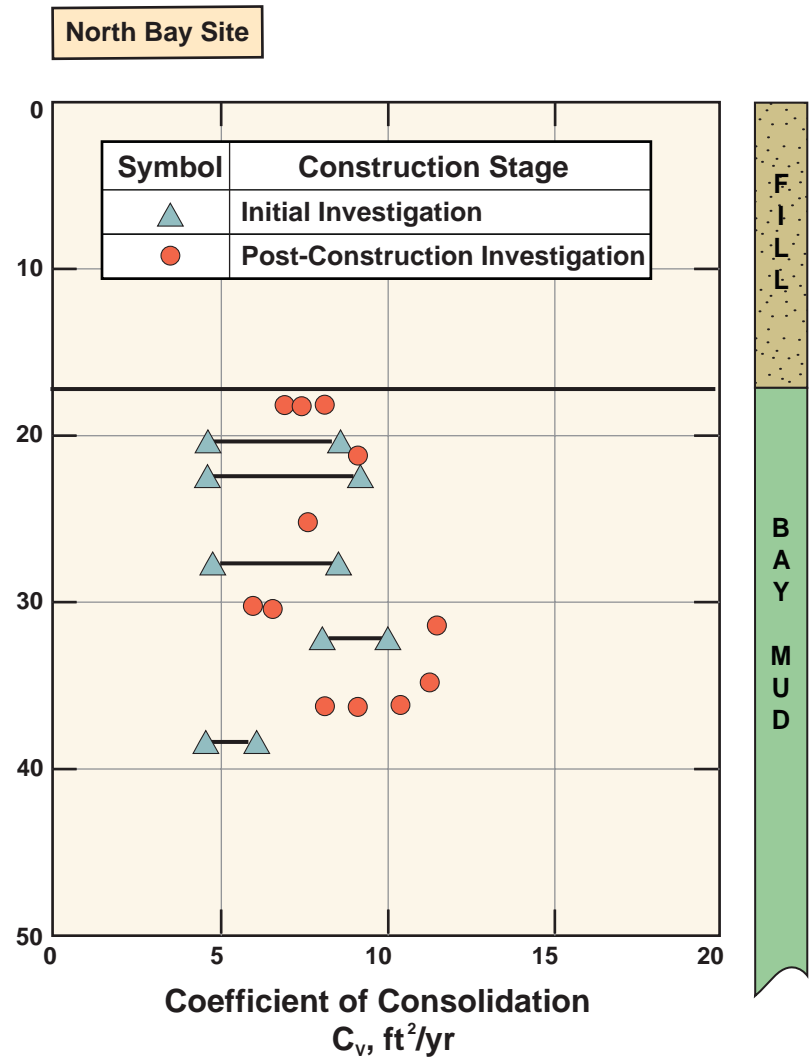
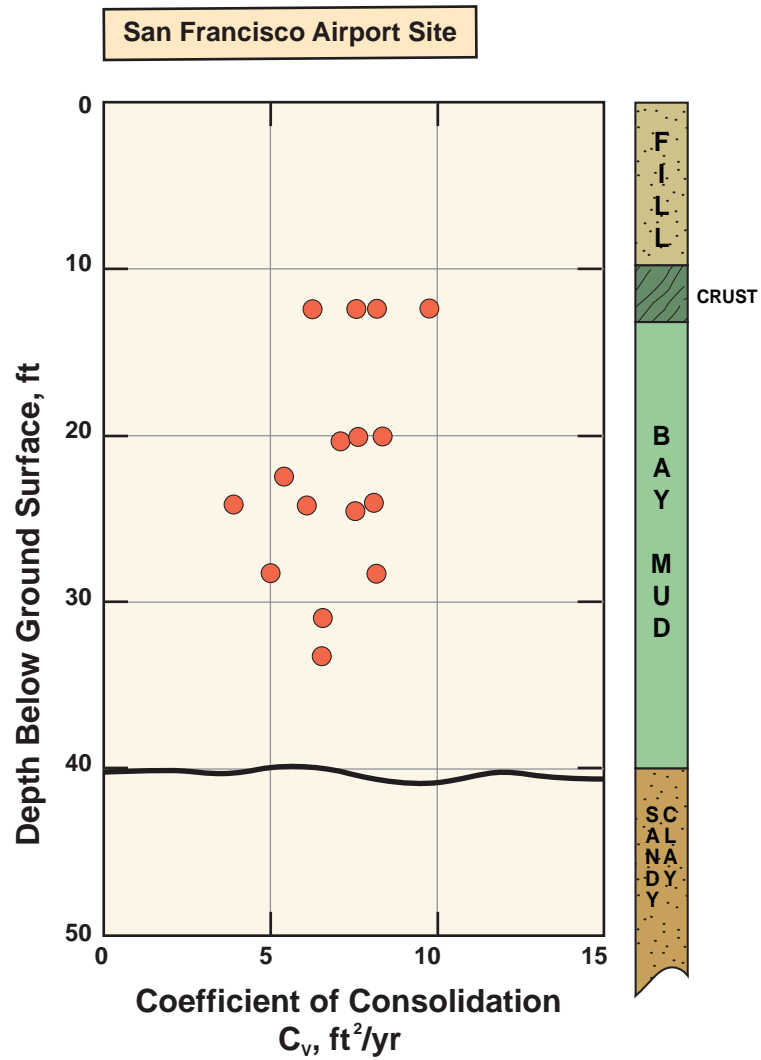


FIG\_62: Variation of Coefficients of Vertical Consolidation with Liquid Limit

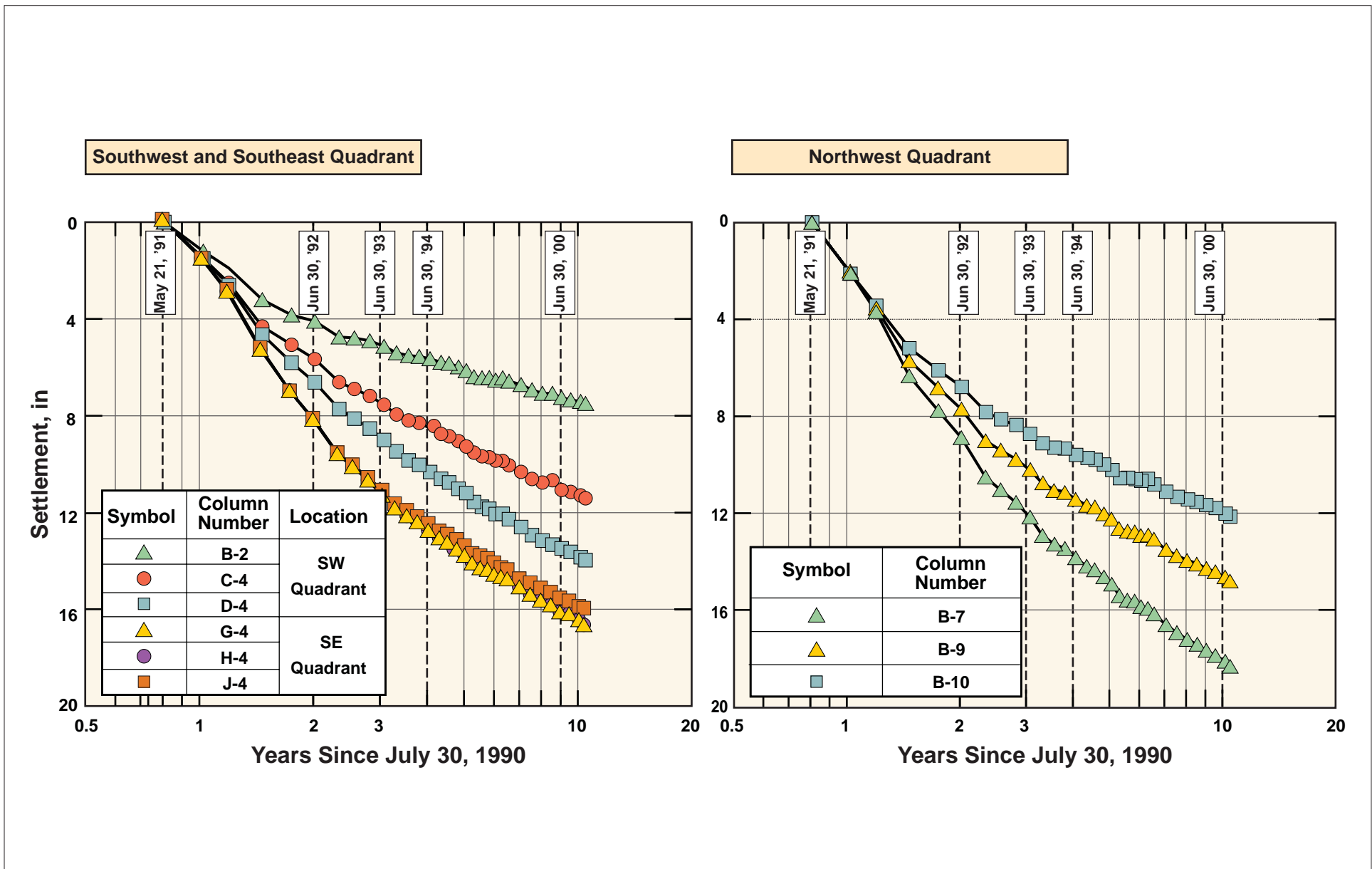


FIG\_62A: Variation of Hydraulic Conductivity with Void Ratio

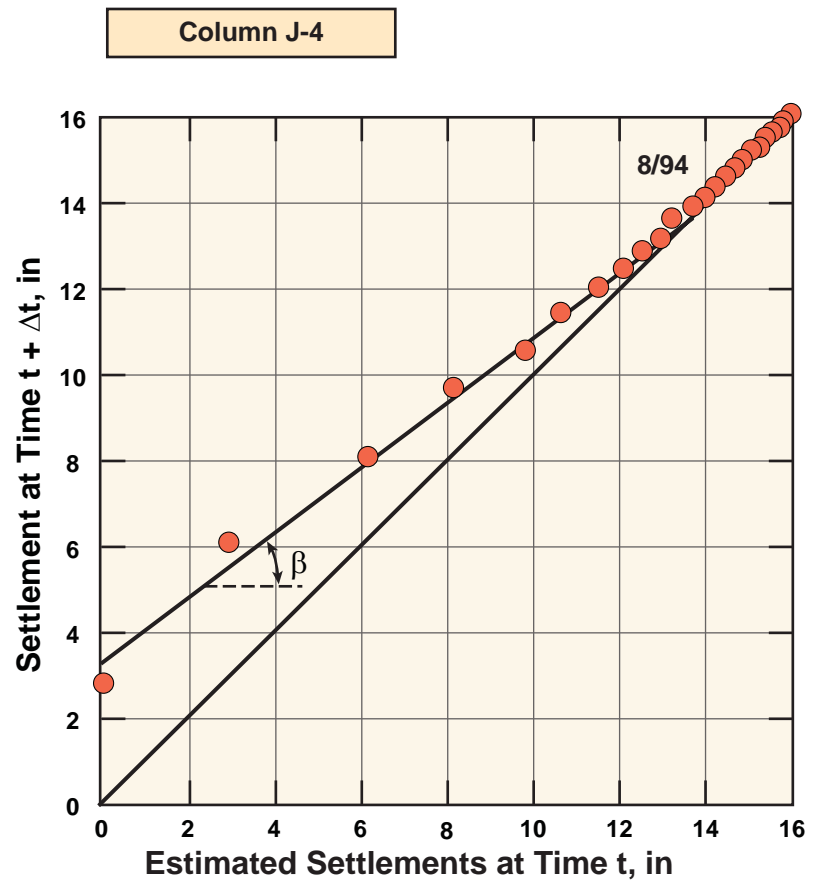
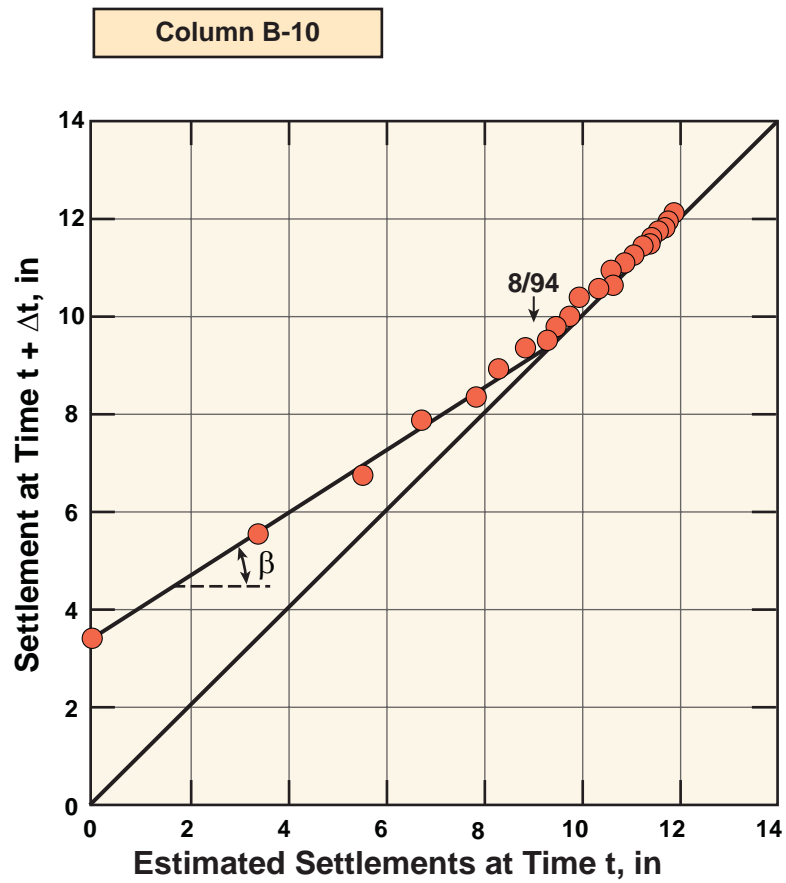
W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Figures\03 BAY MUD (18-78)\FIG\_62A



FIG\_63: Coefficient of Vertical Consolidation of Organic Bay Mud



FIG\_64: Post-Construction Settlements at a Preloaded Site North Bay Site

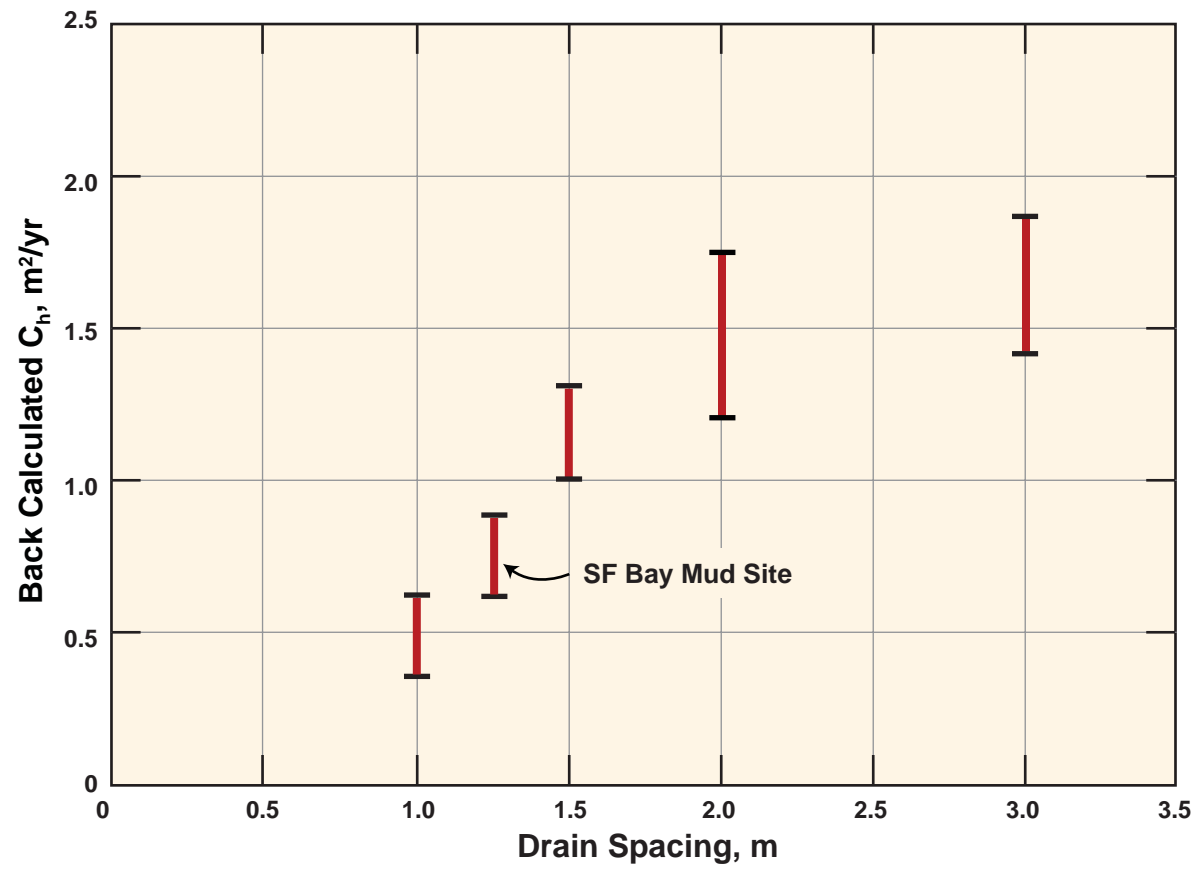


**FIG\_65: Asaoka Method for Estimation of Coefficients of Consolidation and End of Primary Consolidation**

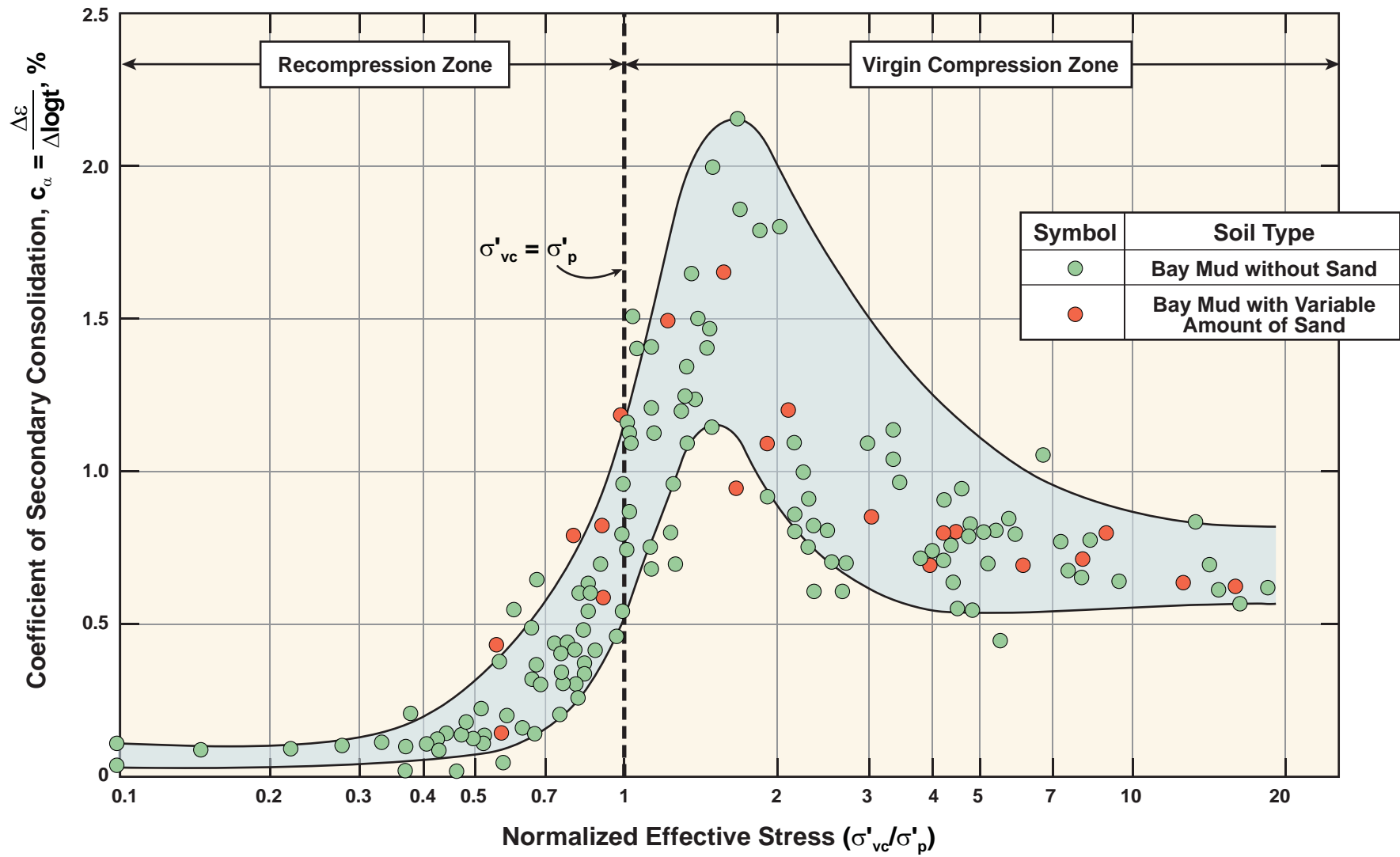


$c_h = \frac{-D e^2 F(n) \ln \beta_1}{8 \Delta t}; \quad D e^2 = 4.4 \text{ ft} \quad F(n) = 2.29$			
Marker ID	$\beta_1$	$\Delta t$ (yr)	$c_h$ (ft <sup>2</sup> /yr)
SM-8	0.904	0.100	5.60
	0.743	0.200	8.20 (6.90)
SM-15	0.935	0.050	7.40
	0.860	0.100	8.30 (7.90)
SM-16	0.901	0.050	11.50
	0.836	0.100	9.90 (10.70)
SM-17	0.913	0.050	10.10
	0.837	0.100	9.90 (6.30)
SM-18	0.946	0.050	6.20
	0.892	0.100	6.40 (10.30)
D-21	0.740	0.110	14.75
D-23	0.820	0.110	9.70
D-25	0.860	0.110	7.60
PAD V	0.800	0.140	9.00
Post-Preload Measurements 12 Columns	0.743	0.273	6.20
Average During Preload Period			8.80

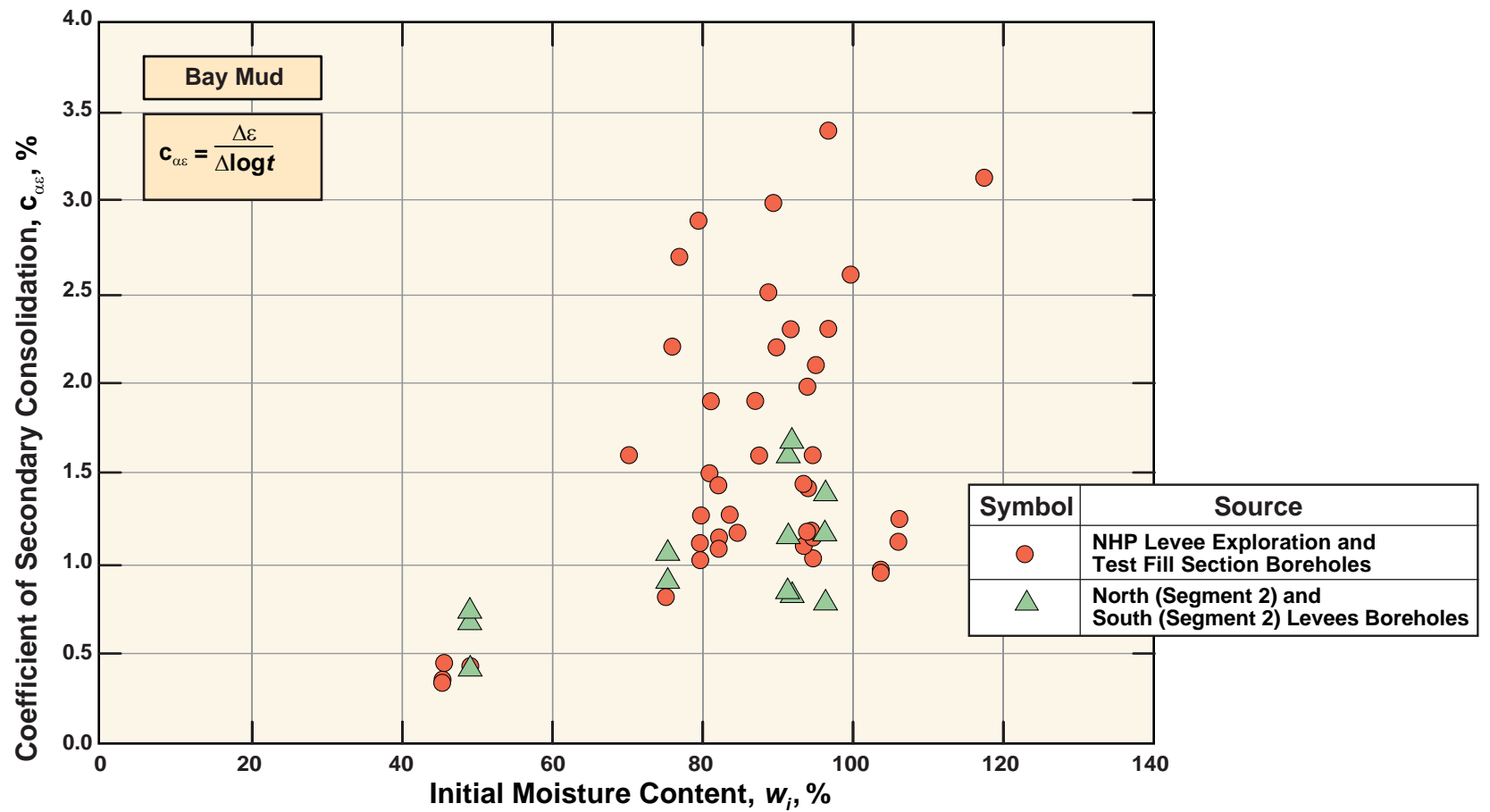
FIG\_66: Estimates of coefficients of Horizontal Consolidation Using the Asaoka Method (Jamialkowski, et al., 1995)



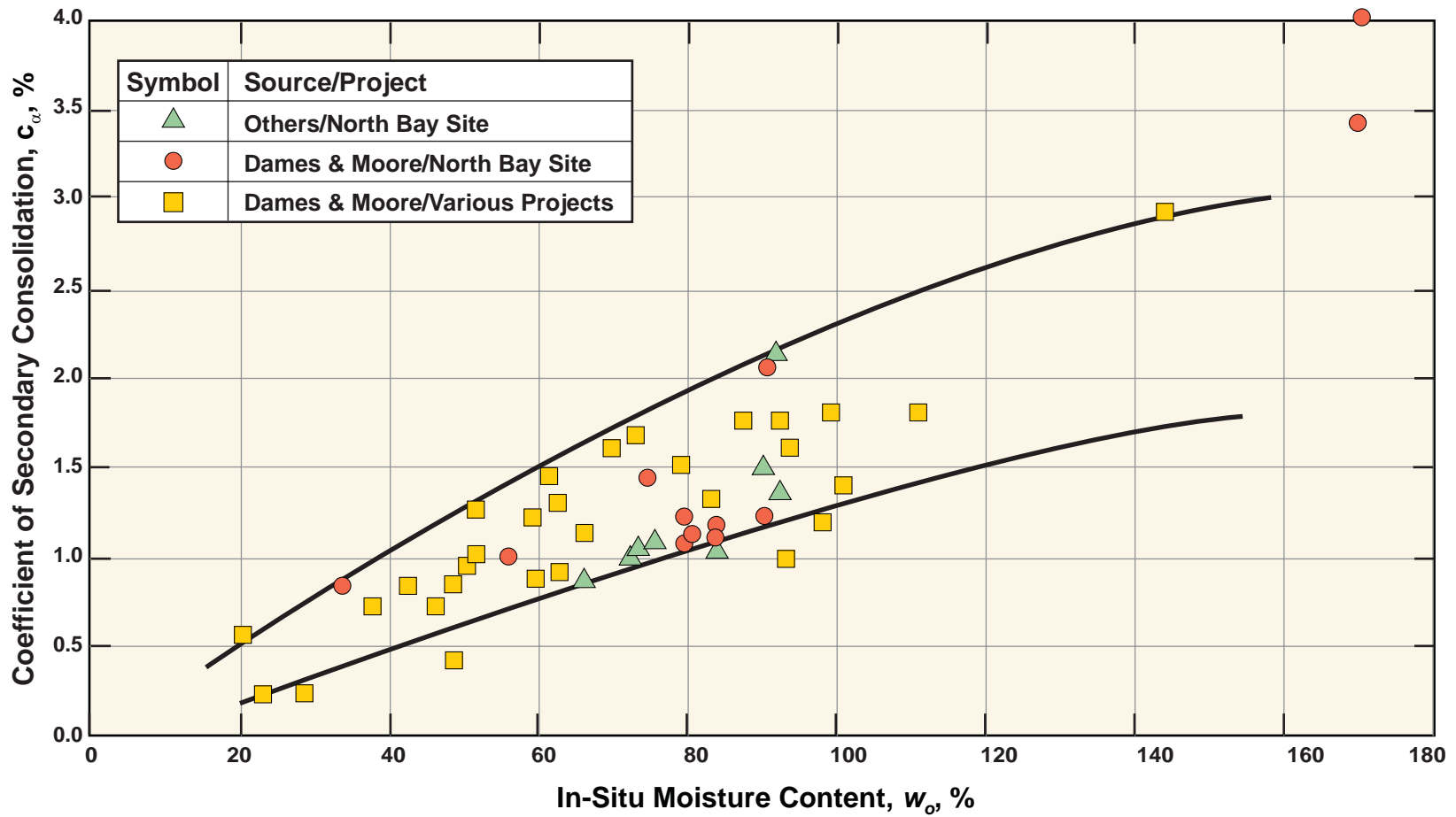
**FIG\_67: Variation of  $C_h$  with Drain Spacing**



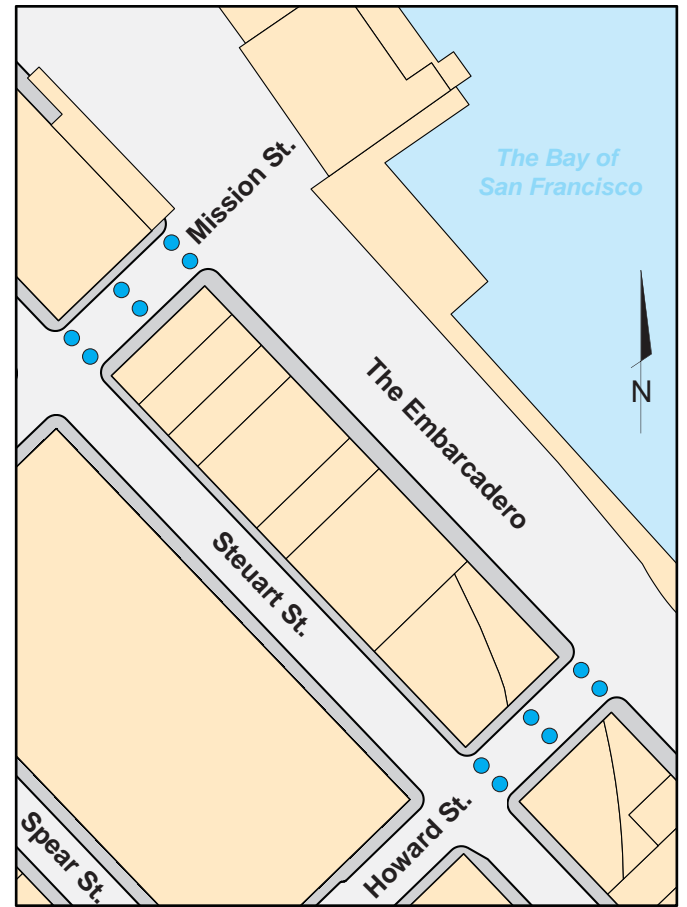
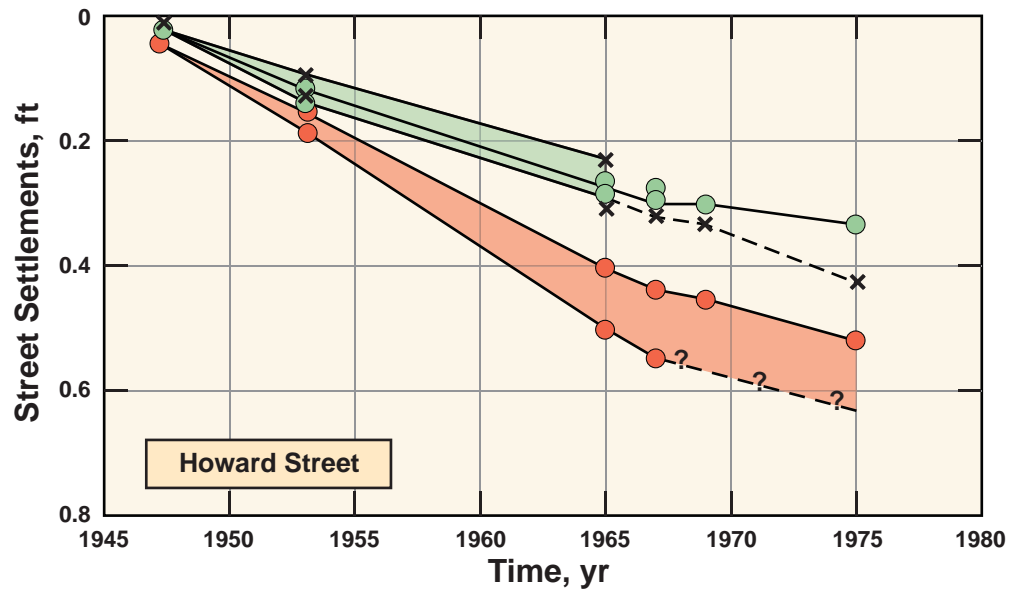
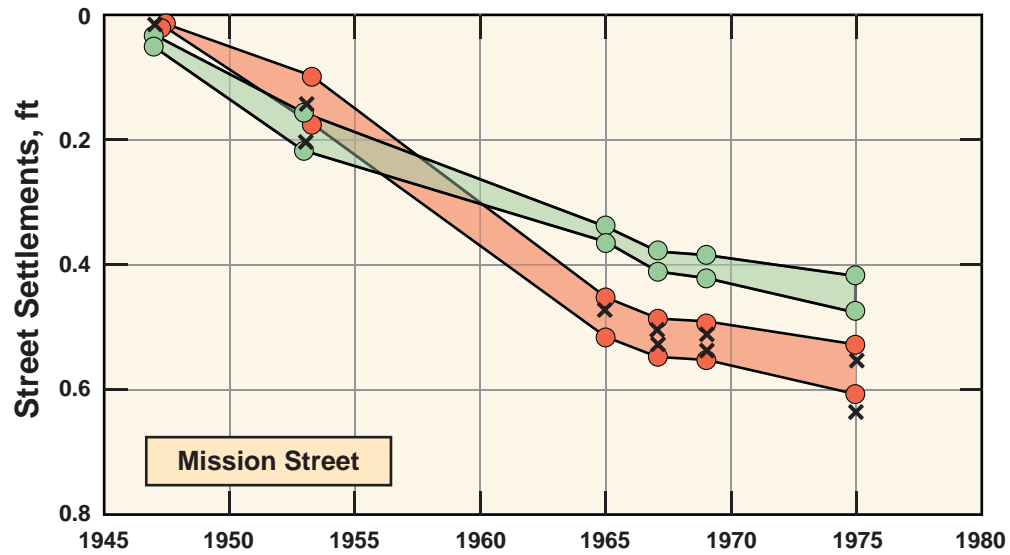
FIG\_68: Variation of Coefficients of Secondary Consolidation with Consolidation Stress



FIG\_69: Variation of Coefficient of Secondary Consolidation with Moisture Content



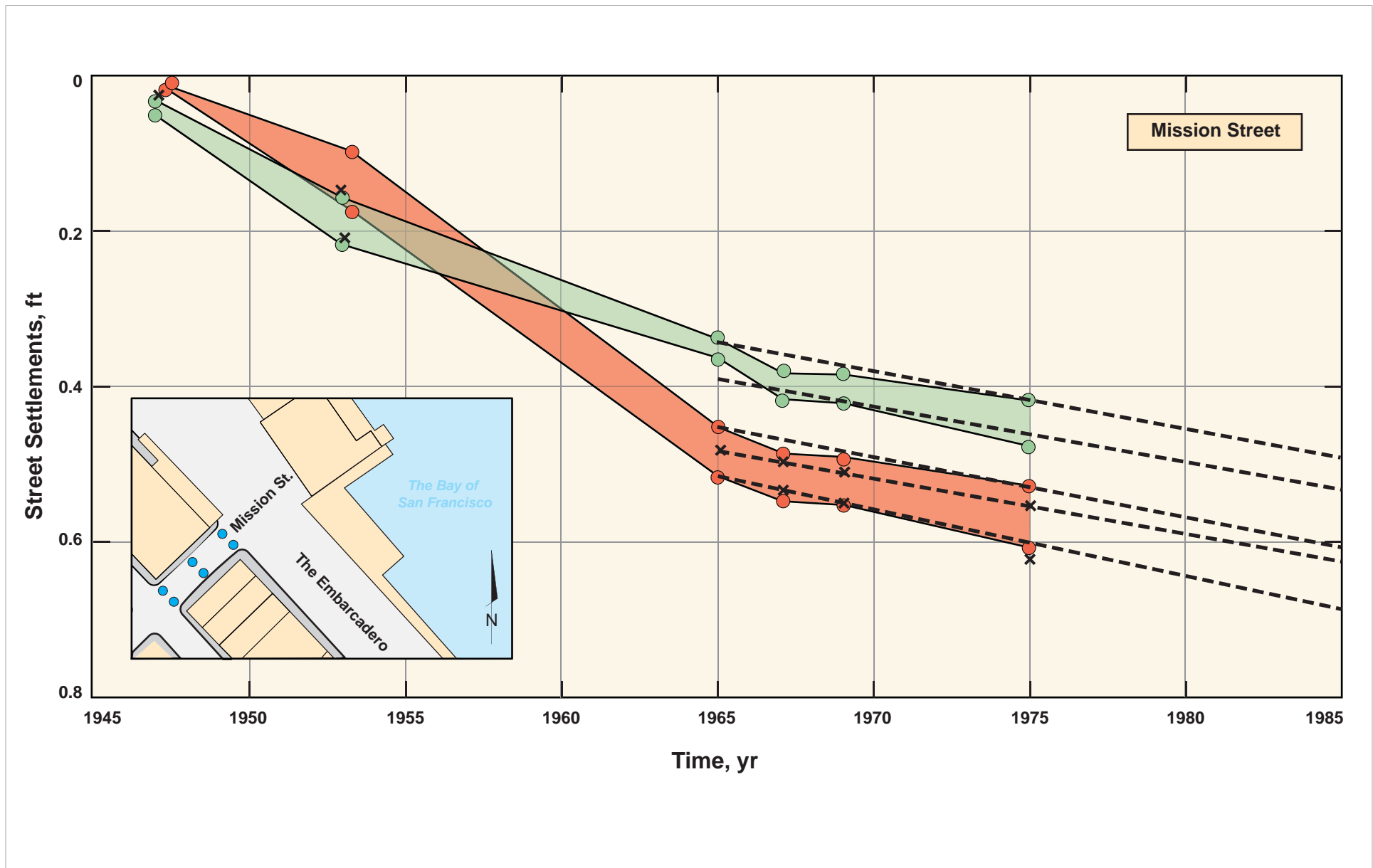
FIG\_70: Variation of  $C_{\alpha}$  with Moisture Content



0 100 200 ft  
Source: DPW files

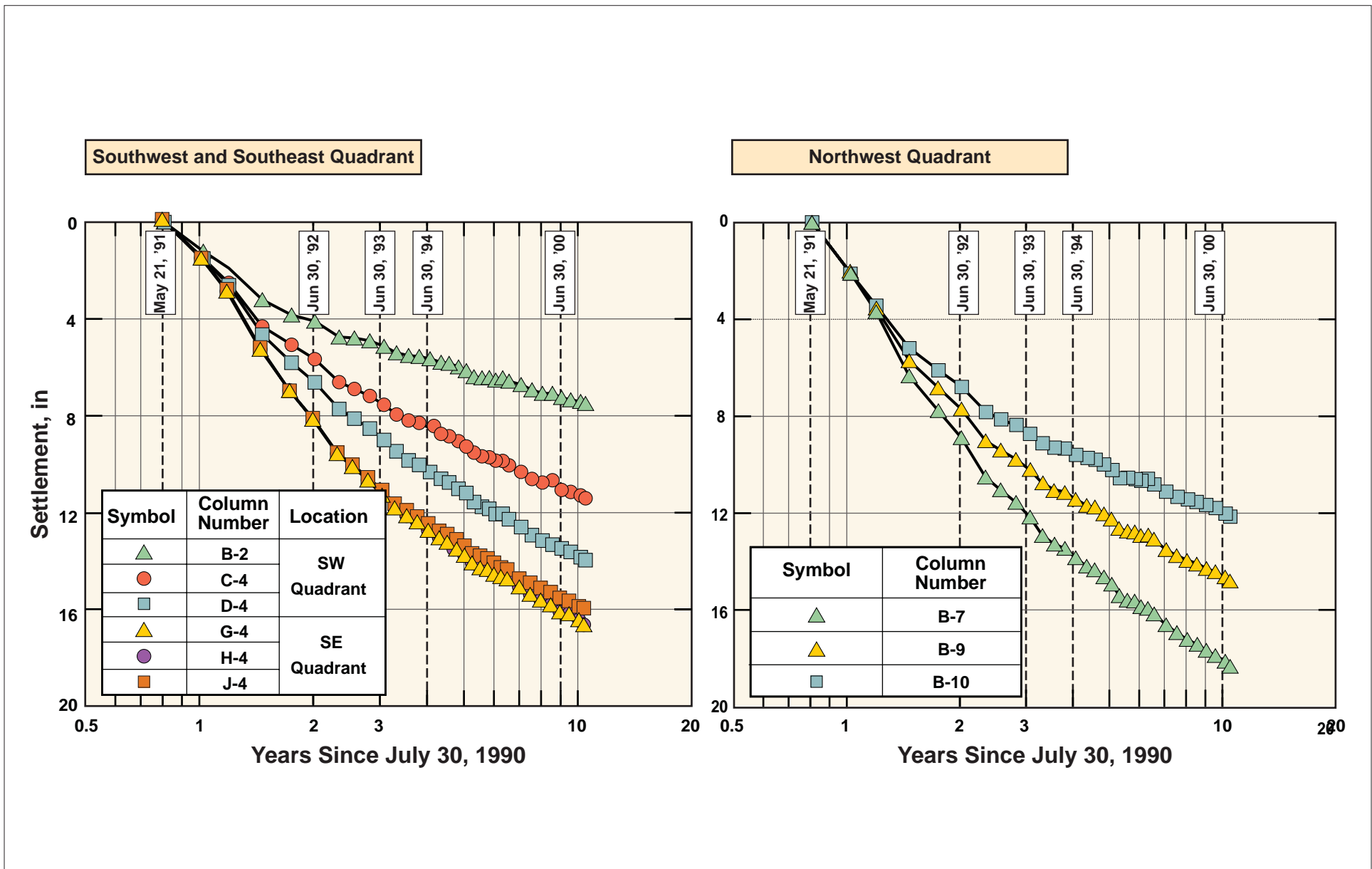
FIG\_71: Long-Term Settlements at Mission and Howard Streets

W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Plates\FIG\_71



FIG\_72: Extrapolation of Settlement Data at Mission Street For Secondary Compression

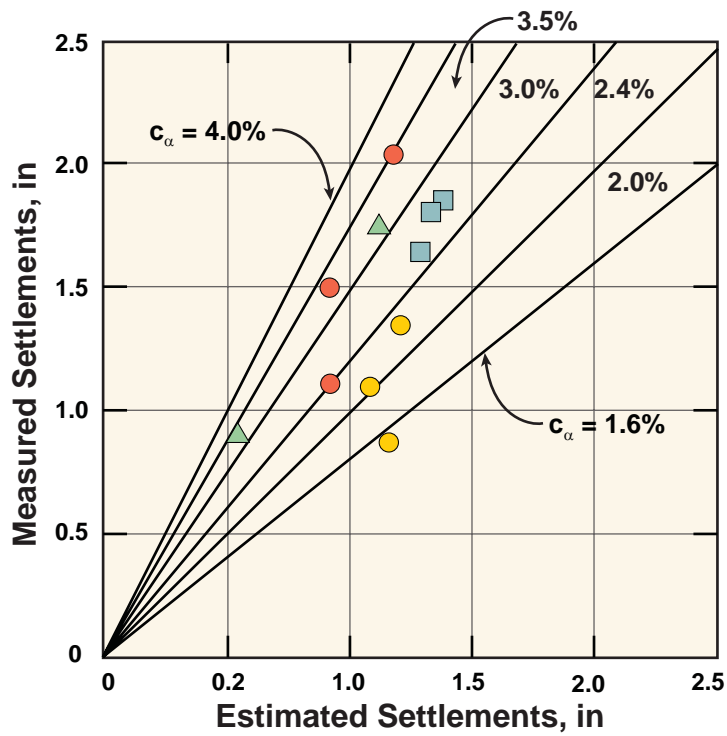
W:\Infrastructure\Geotech\UC Berkeley 2008 Seminar\Final Plates\FIG\_72



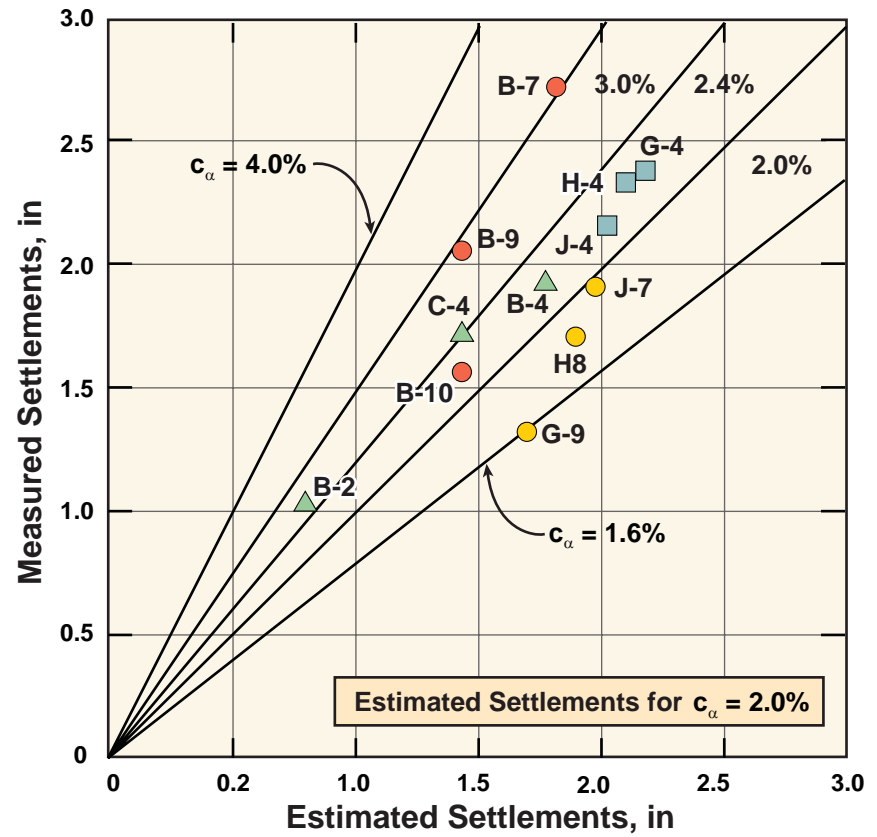
FIG\_73: Estimation of Coefficients of Secondary Consolidation from Long-Term Settlement Data



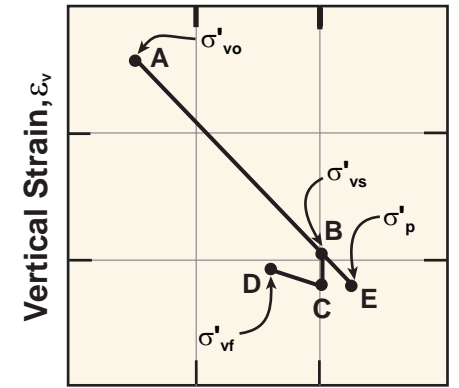
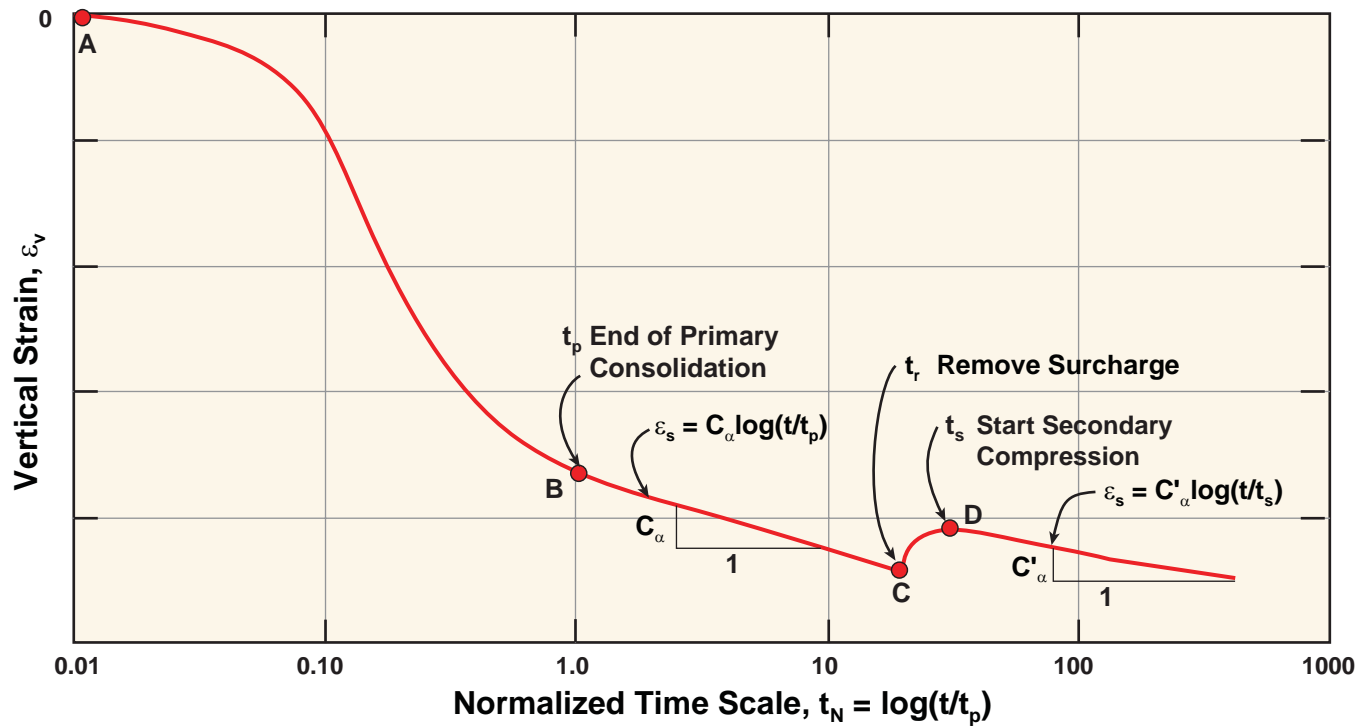
Two-Year Interval:  
August 24, 1994 - August 21, 1996



Five-Year Interval:  
February 27, 1996 - January 18, 2001



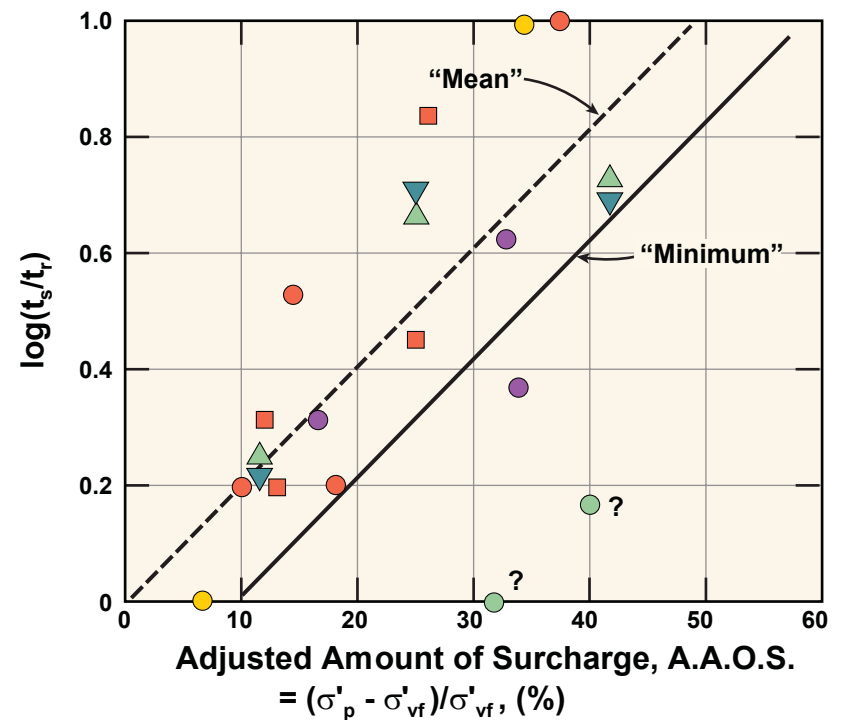
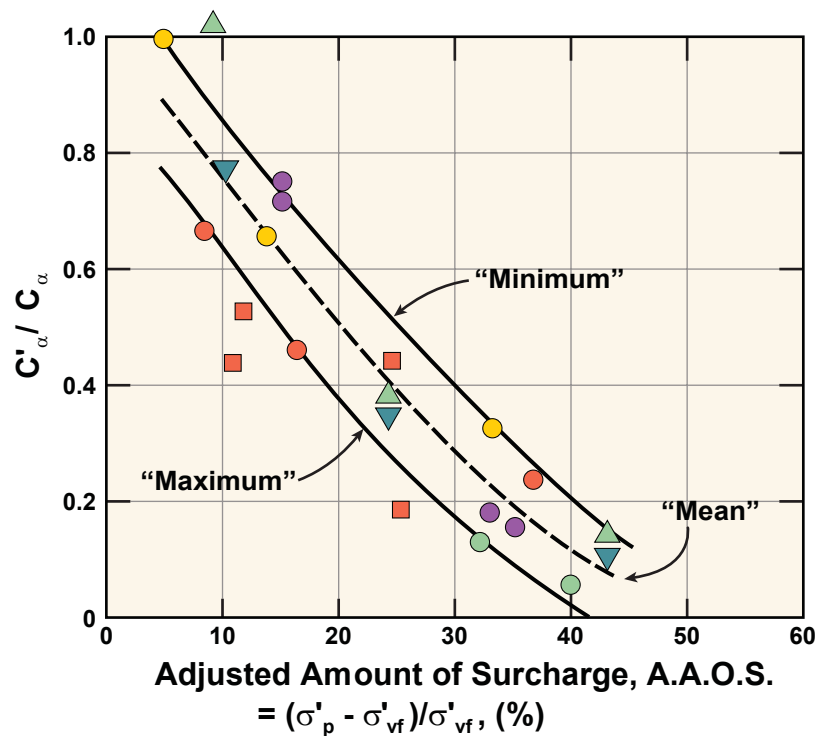
FIG\_74: Estimation of Coefficients of Secondary Consolidation from Settlement Data North Bay Site



Consolidation Stress Log Scale

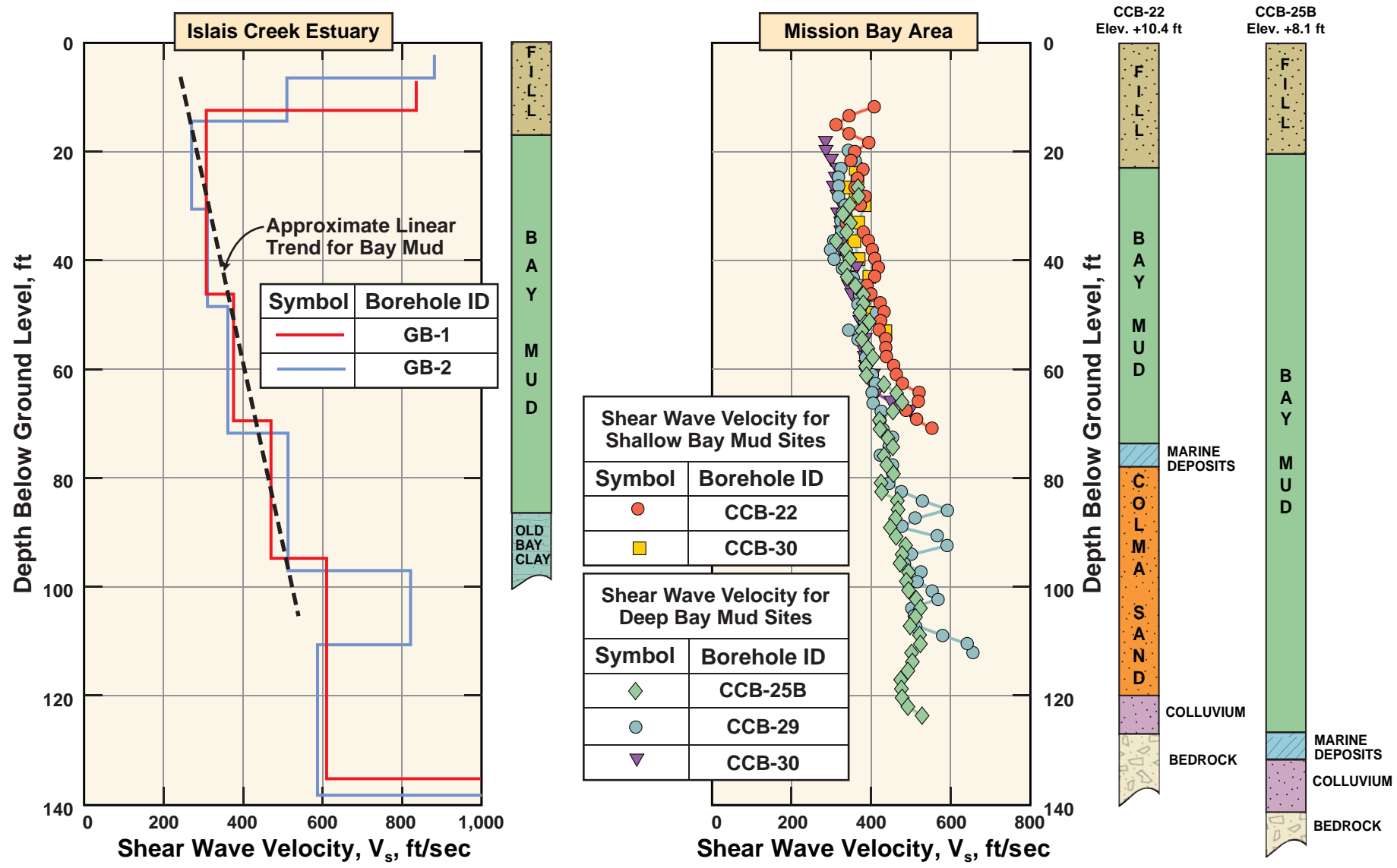
$\text{A.O.S.} = \frac{\sigma'_{vs} - \sigma'_{vf}}{\sigma'_{vf}}$	Amount of Surcharge
$\text{A.A.O.S.} = \frac{\sigma'_p - \sigma'_{vf}}{\sigma'_{vf}}$	Adjusted Amount of Surcharge

FIG\_75: Effects of Surcharge on Secondary Compression (Ladd, 1989)

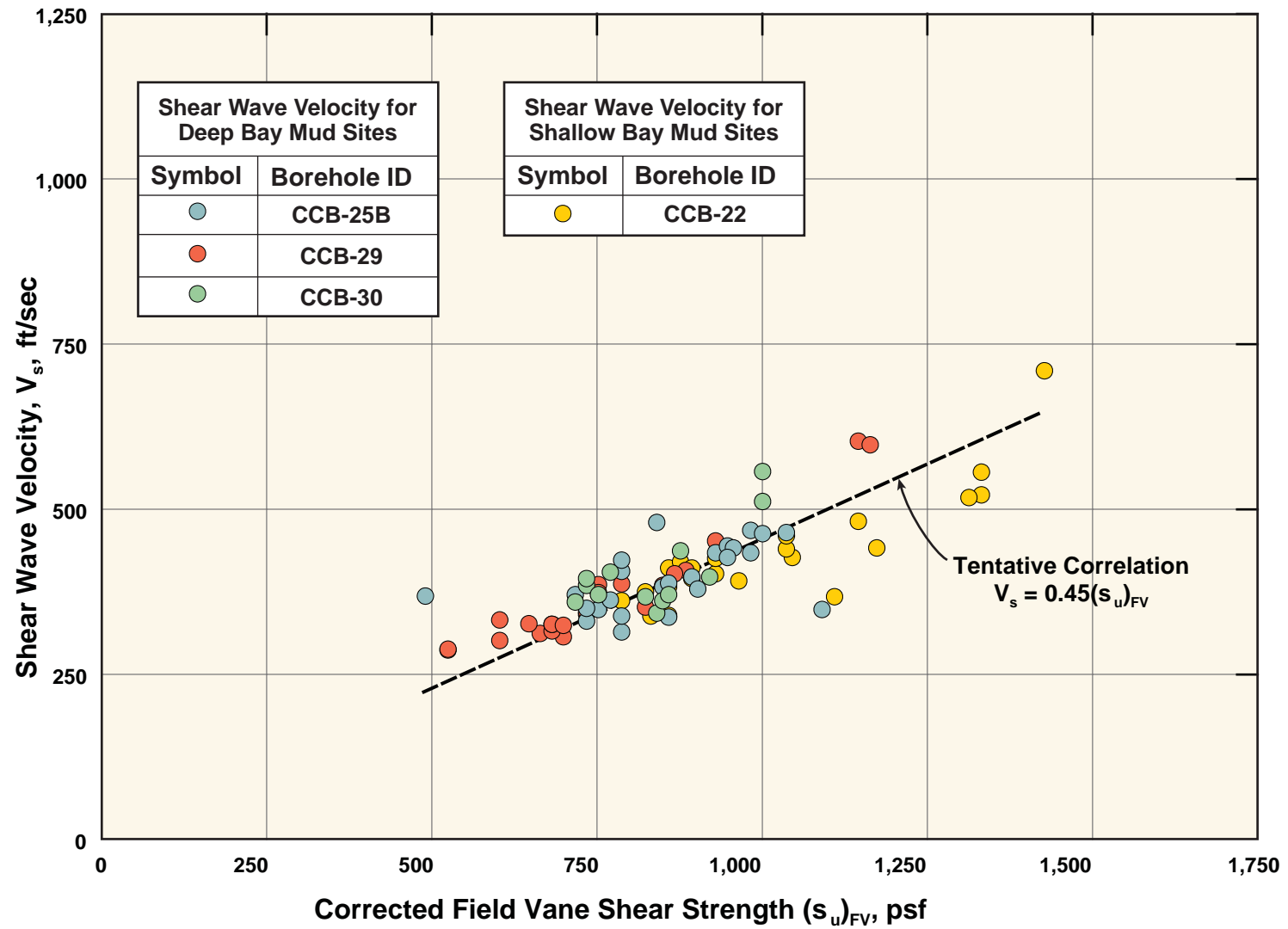


Reference (Location)	Soil	$\frac{c_\alpha}{CR}$	$\frac{t_r}{t_p}$	Symbol
Koutsoftas et al. (1987) (Hong Kong)	Upper Marine CH $I_p \sim 55\%$	0.027 $\pm 0.001$	$\leq 1.0$	$\blacktriangle$ $\blacktriangledown$
Simons (1965) (Fornebu, Norway)	Marine CH $I_p \sim 30\%$	Est. 0.04	1.0 2.0	$\bullet$ $\bullet$
Haley & Aldrich (1987) (Hartford, Conn.)	Varved Clay $w_o = 64 \pm 5\%$	0.02- 0.025	1.0 - 1.8	$\blacksquare$
GZA (1988) (Sommerville, Ma.)	Organic Silt $w_l = 95\%$ , $I_p \sim 54\%$	0.046 $\pm 0.003$	3.5 $\pm 0.5$	$\bullet$
MRCE (1989) (Syracuse, N.Y.)	Varved Clay $w_o = 46\%$	0.041 $\pm 0.003$	21 $\pm 5$	$\bullet$

FIG\_76: Reduction of Coefficient of Secondary Consolidation Due to Surcharge (Ladd, 1989)



FIG\_77: Shear Wave Velocities of Bay Mud



FIG\_78: Tentative Correlation of Shear Wave Velocity with Undrained Shear Strength of Bay Mud