Investigations of the Pedro Miguel Fault during Borinquen Dam 1E Construction Panama Canal Expansion

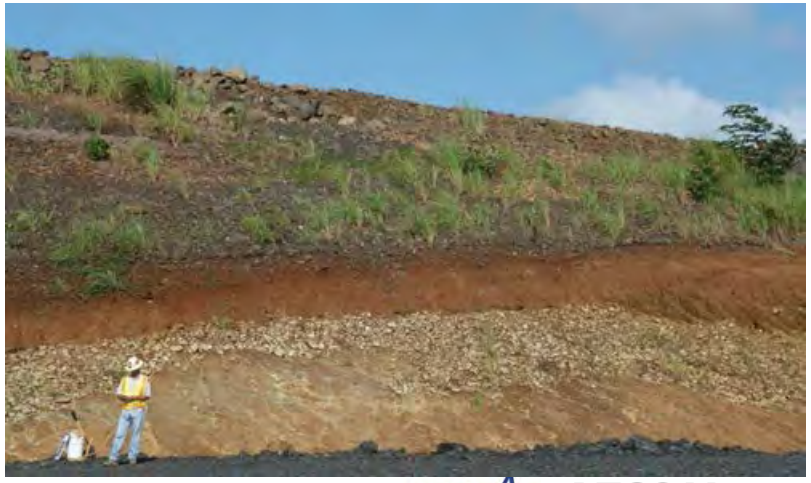
David Schug, Paul Salter, Dan Meier,
Robert Urban, Chris Goetz, AECOM

Derek Irving, Autoridad del Canal Panama (ACP)

AEG September 22, 2016

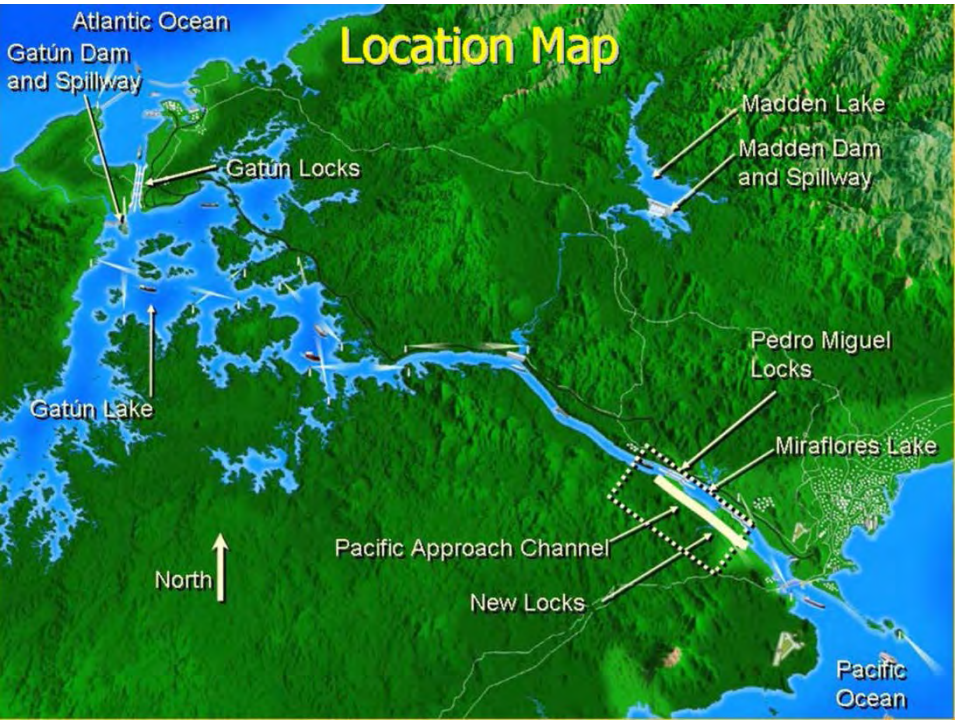
Presentation Outline

- Overview of fault investigations during construction-
  - The Pedro Miguel fault had minor displacement of early Holocene alluvium at Dam 1W
  - The absence of a reported “Main Trace” of the Pedro Miguel fault

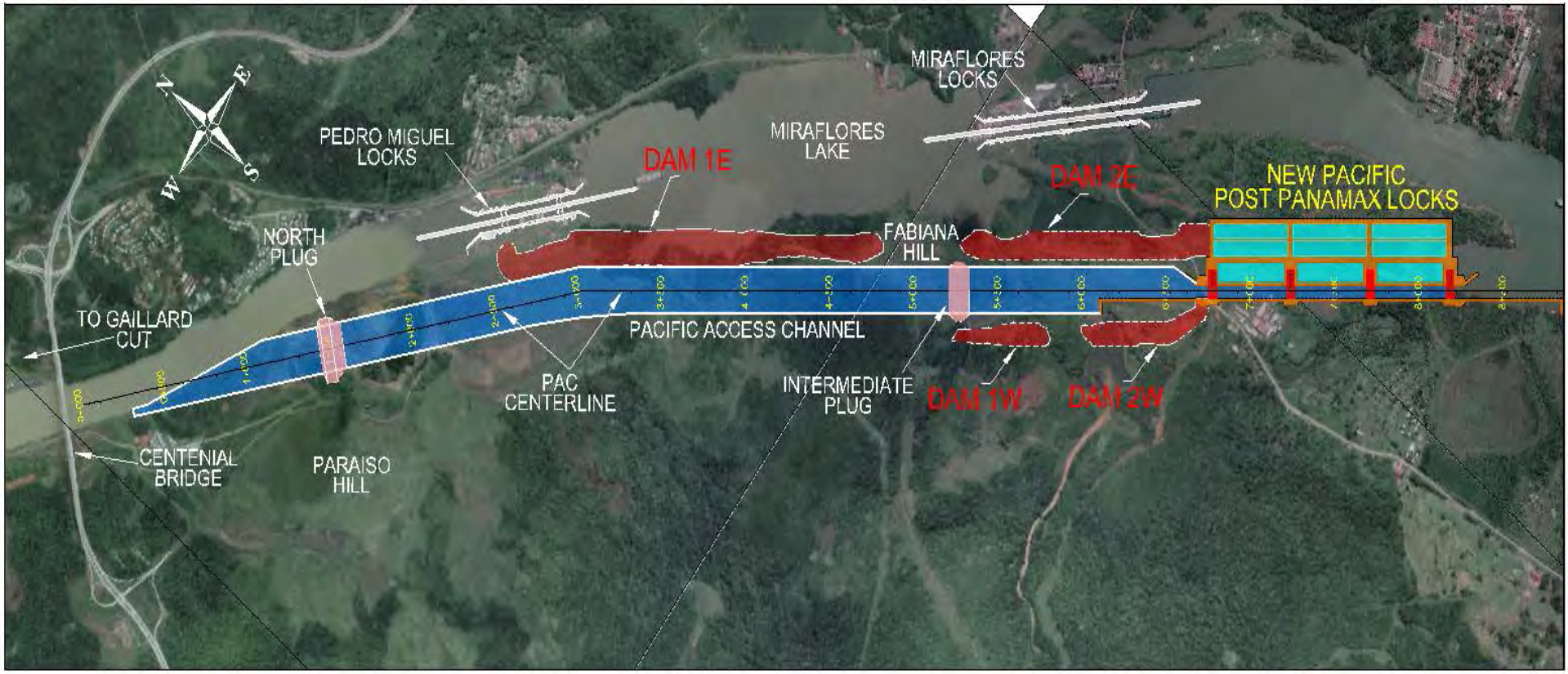


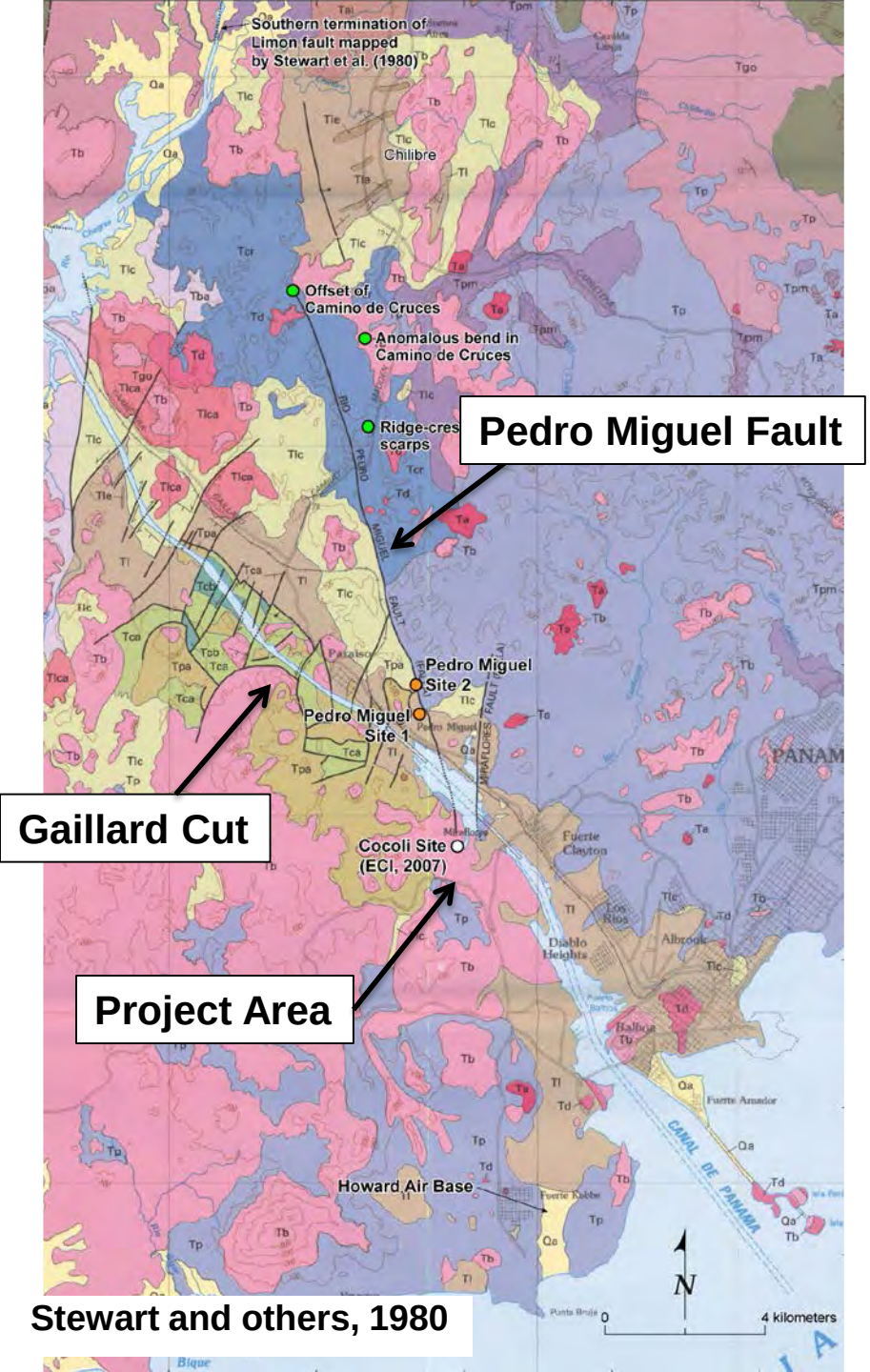
ACP AECOM

Overview of Pacific Approach Channel (PAC)

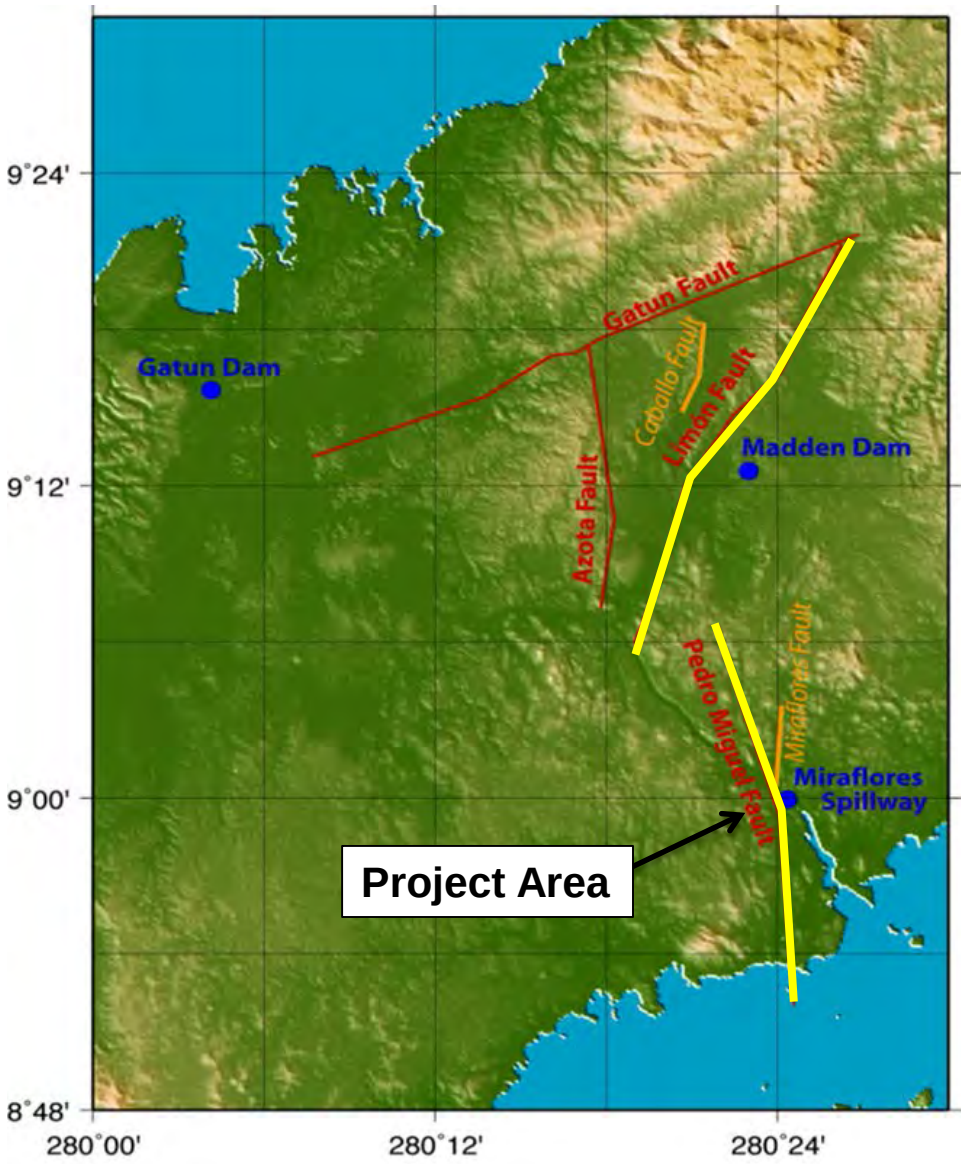


PAC EXPANSION OVERVIEW



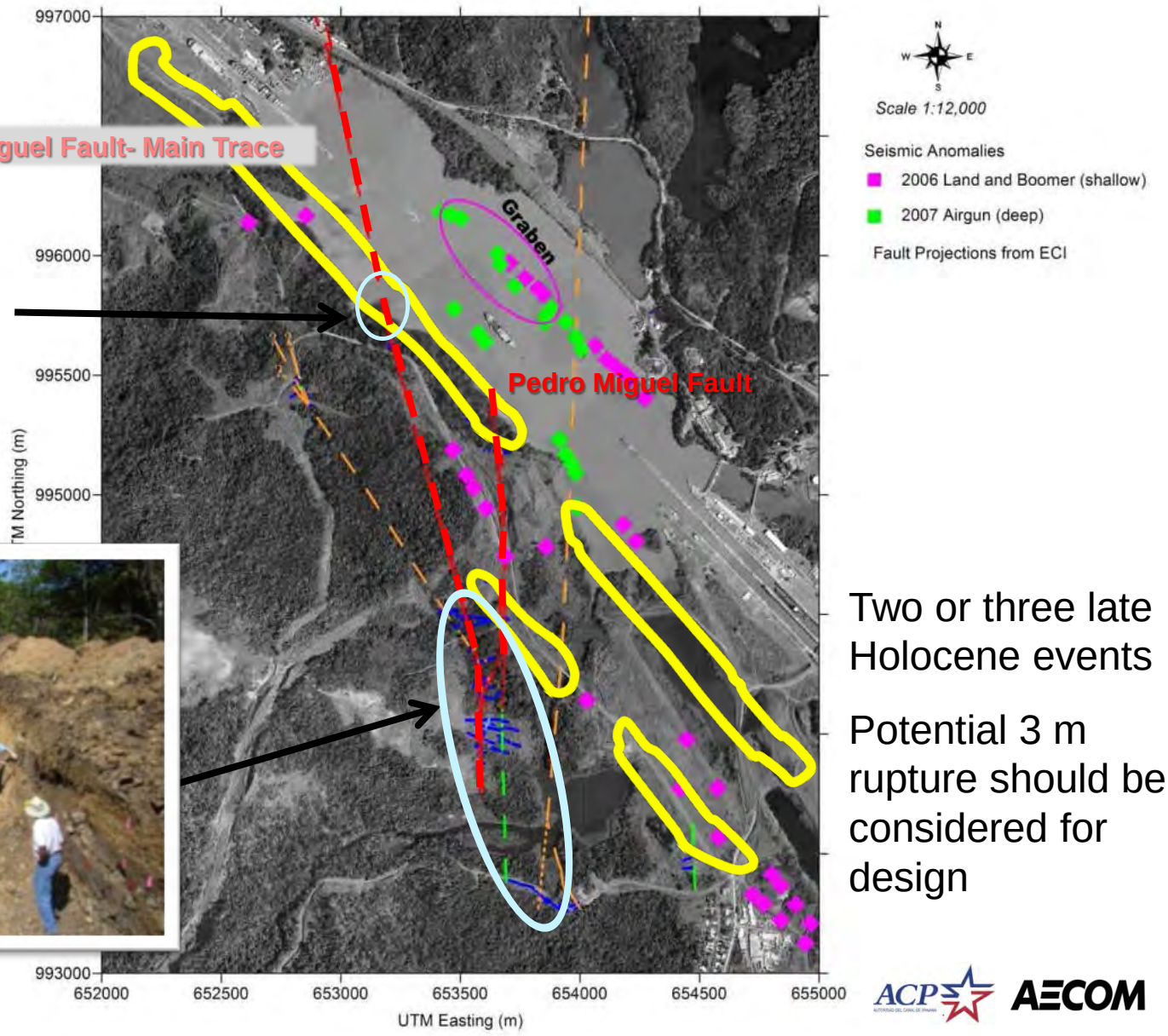


Stewart and others, 1980



ACP AECOM

Active faults mapped at Dams 1E-1W



Multiple Holocene events
Surface rupture
Most recent event 1621 AD

Two or three late Holocene events

Potential 3 m rupture should be considered for design

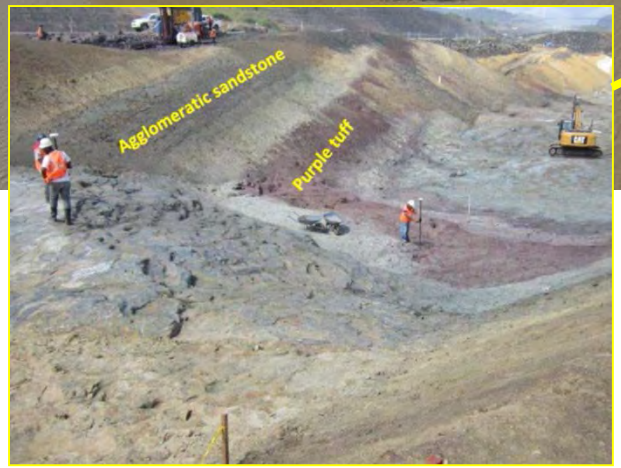
The PAC- World's Deepest Fault Trench

Photo 3-16-10

ACP AECOM

Initial PAC Excavation – Columnar Basalt

Dam 1E- Foundation Excavations & Trenching



AECOM

Pedro Miguel Fault at Dams 1E-1W and the PAC

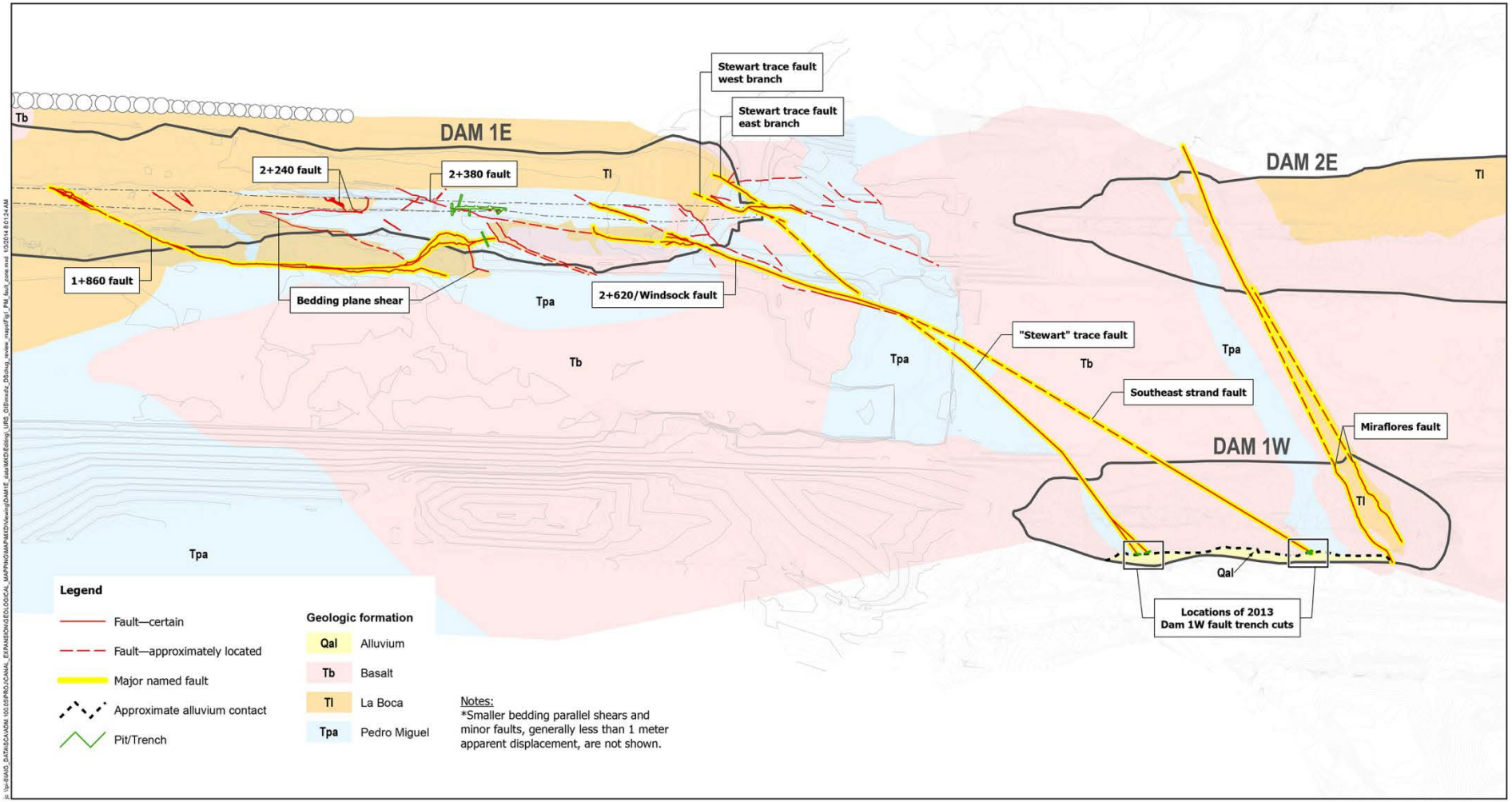


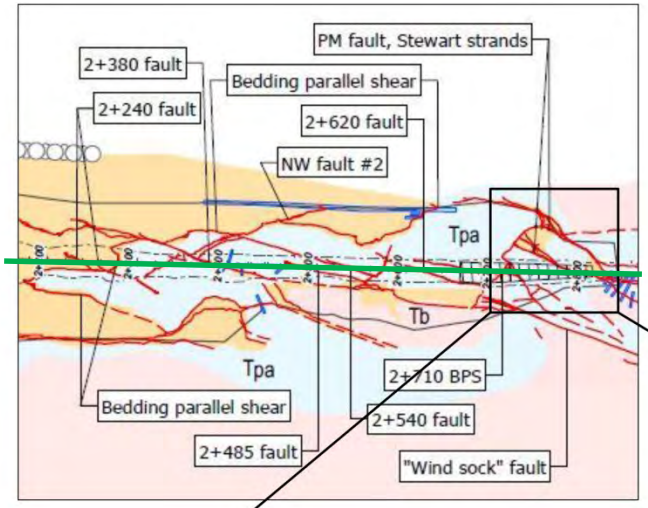
FIGURE 10
PEDRO MIGUEL FAULT ZONE
THROUGH DAMS 1W, 1E AND THE PAC

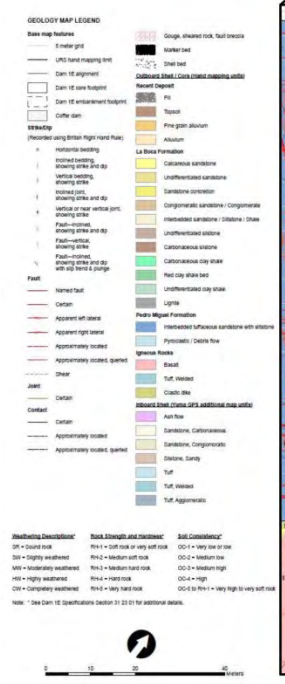
December 2013 Panama Canal Expansion Program
Panama City, Panama

URS CANAL DE PANAMÁ


MIRAFLORES FAULT
DAM 1W CORE
Southeast Strand
Stewart Trace
DAM 2E CORE
View to SW from N end of Dam 2E

Pedro Miguel Fault
South Abutment Dam 1E





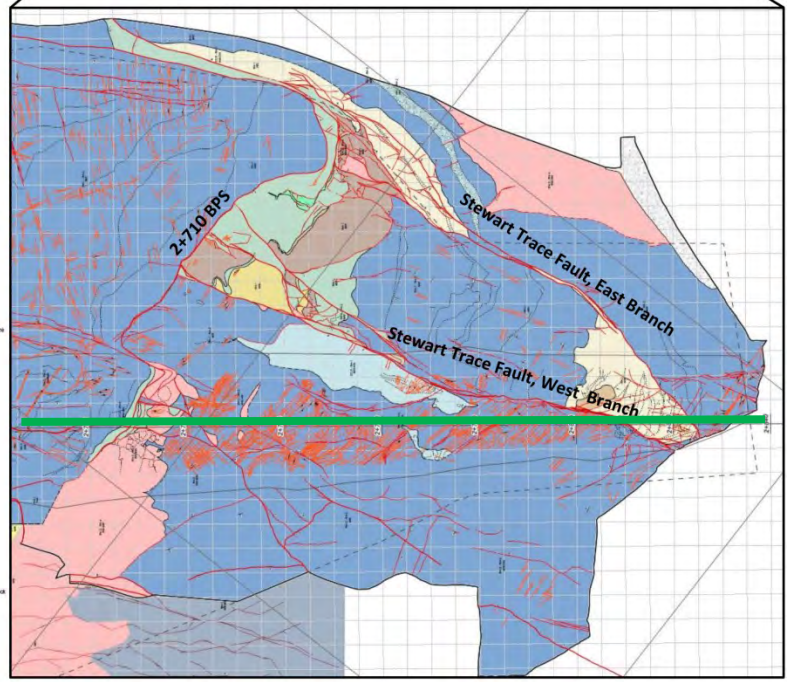
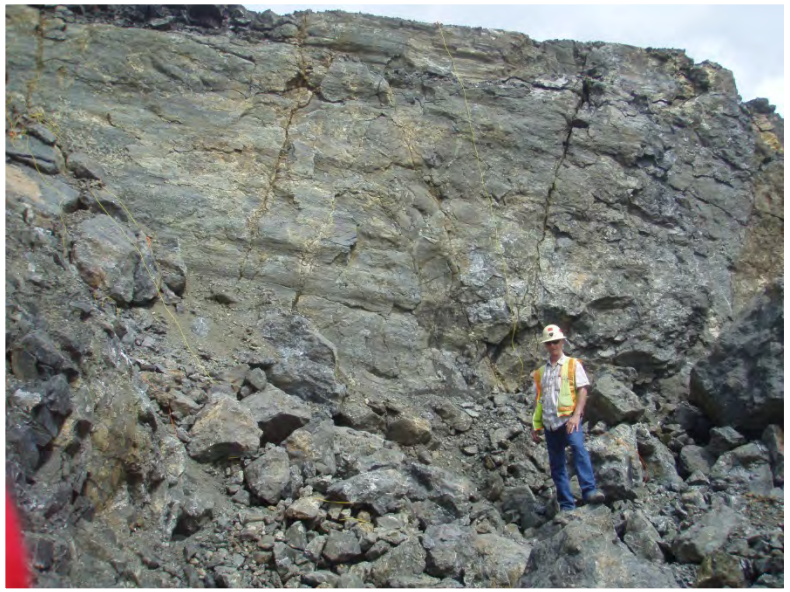


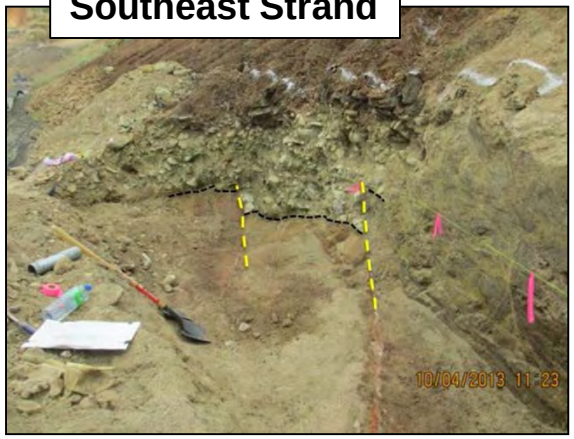
Figure 6: Pedro Miguel Stewart Strands Geology

Pedro Miguel Fault
PAC Centerline

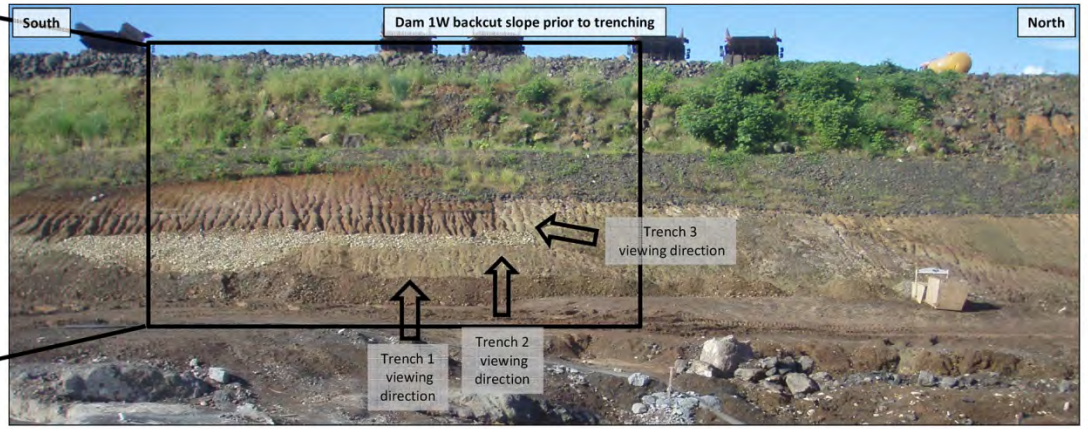


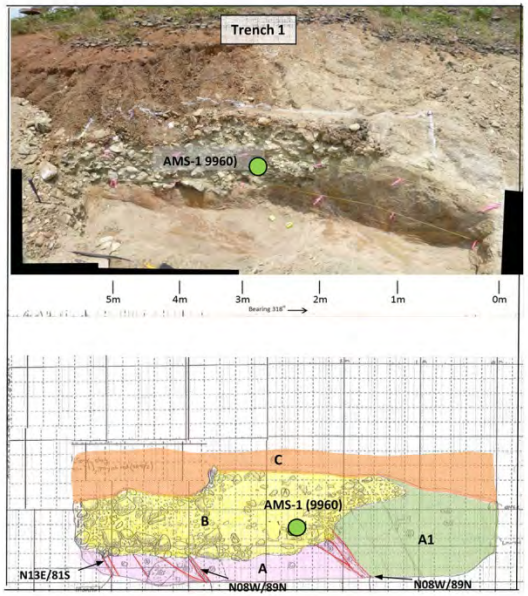
Pedro Miguel Fault
Dam 1W Foundation

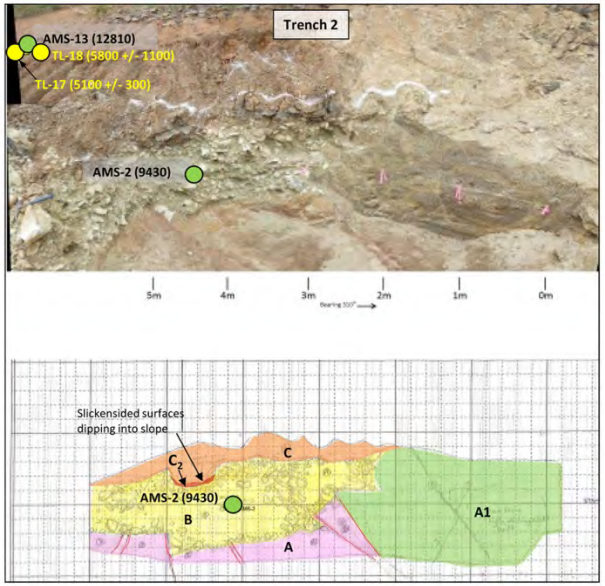
Southeast Strand

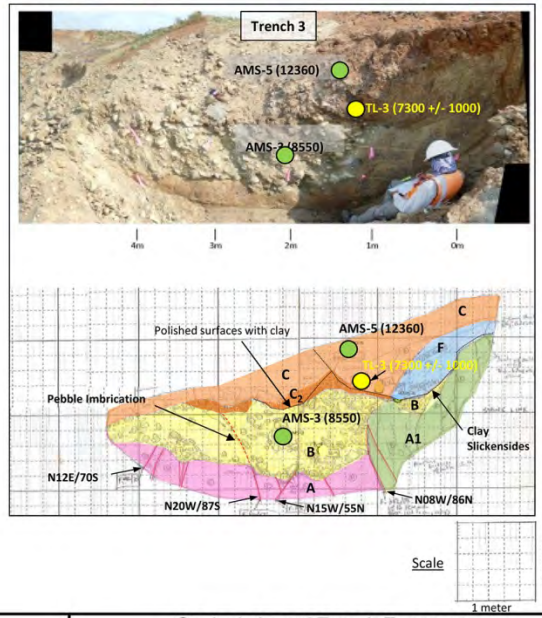


Pedro Miguel "Southeast Strand" Fault Trenching at Dam 1W









Legend

Unit A - Completely Weathered Volcaniclastic Rock (Pedro Miguel Fm)
Unit A1 - Highly Weathered Basalt (Pedro Miguel Fm)
Unit B- Basal Alluvial Gravels
Unit C - Fine-Grained Alluvium
Unit C_2 - Clayey Gravels (at base of Unit C)
Unit F- Silty Clay (Completely Wx Bedrock/Possible Slump)

TL-8 (Age- years before present)
AMS-7 (Age- years before present)
N08W/89N

Shelby Tube Sample
Bulk Sample
Fault Strike/Dip

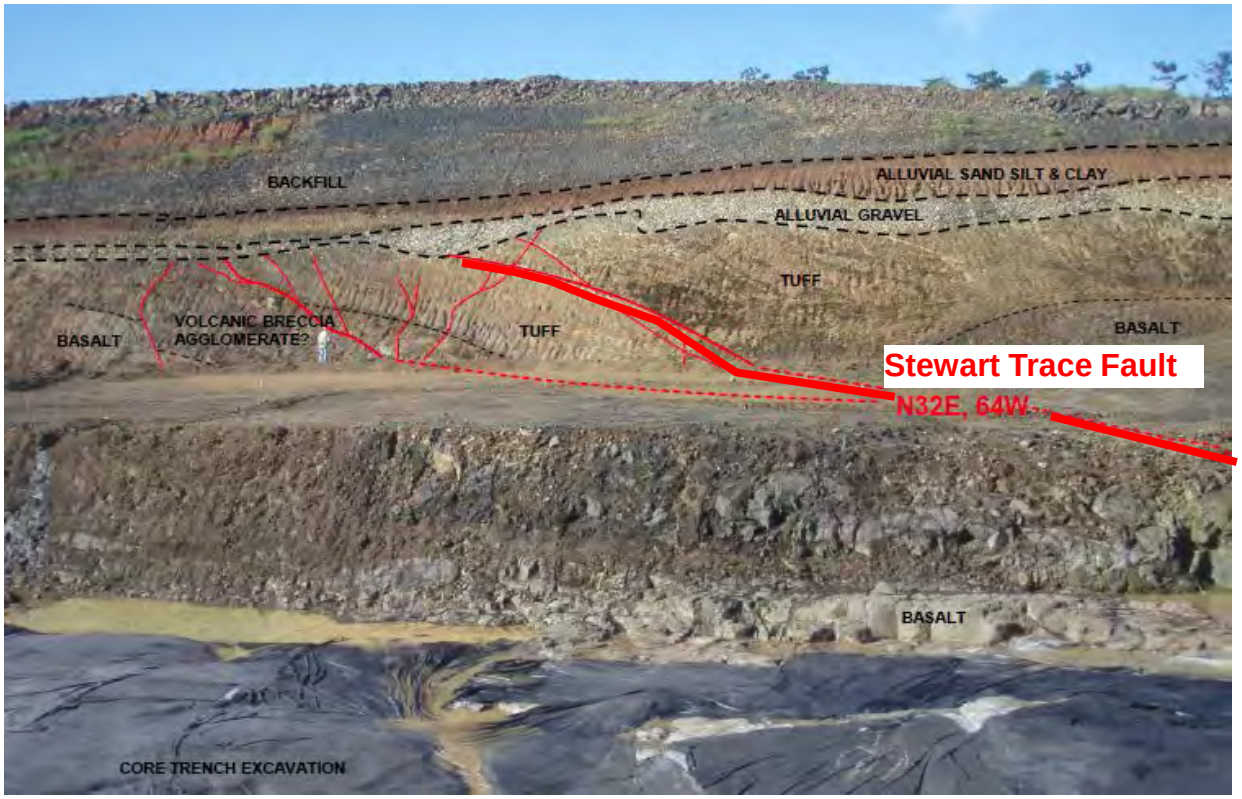
Geologic Log of Trench Exposures
Southeast Strand Fault at Dam 1W

URS | CHECKED BY: DLS | DATE: 1-2-14 | PM: | PROJ. NO.: 26818044.00035 | FIG. NO. 12

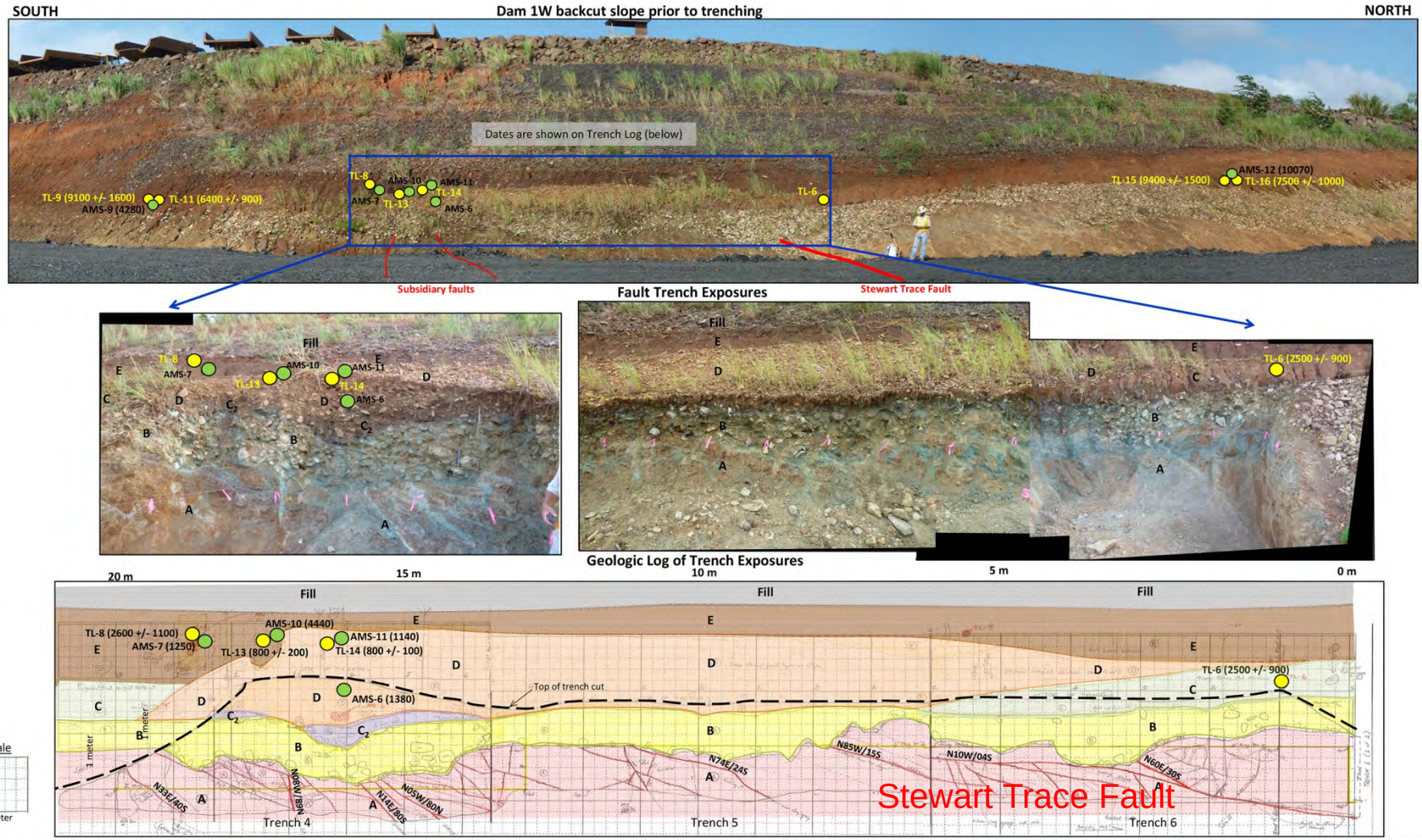
Figure 3 Logs of SE Strand rev 1-2-14

Pedro Miguel Fault at Dam 1W Foundation Dental Treatment

Pedro Miguel Fault at Dam 1W



Pedro Miguel Fault
Trenching at Dam 1W



Legend

Unit A - Moderately to highly weathered tuff (Pedro Miguel Formation)
Unit B - Basal Alluvial Gravels
Unit C - Fine-Grained Alluvium
Unit C_2 - Clayey Gravels (at base of Unit C)
Unit D - Alluvial Gravels
Unit E - Fine-grained Alluvium

TL-8 (Age- years before present) — Shelby Tube Sample
AMS-7 (Age- years before present) — Bulk Sample
N08W/89N — Fault Strike/ Dip

Geologic Log of Trench Exposures
Stewart Trace Fault At Dam 1W

URS | CHECKED BY: DLS | DATE: 12-30-13 | PM: | PROJ. NO.: 26818044.00035 | FIG. NO. 2

Fig 2 Logs of Stewart Strand rev 12-30-13

Key Geologic Findings at Borinquen Dams

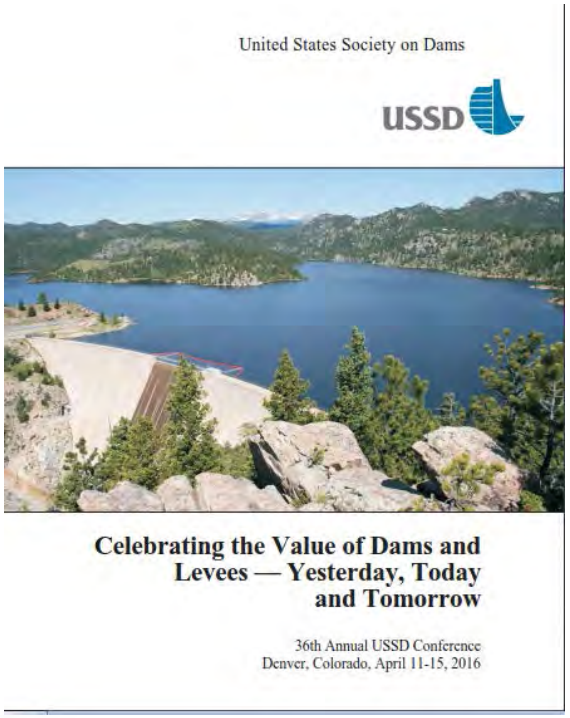
The Pedro Miguel “Stewart Trace” fault does not displace Holocene alluvial gravels at Borinquen Dam 1W

The “Southeast Strand” of the Pedro Miguel fault has produced minor displacement of early Holocene alluvium at Dam 1W

Geologic observations do not provide evidence for multiple late Holocene events with meters of slip per event at Borinquen Dams

The Pedro Miguel “Main Trace” does not exist at the Canal

Thank you



FAULT INVESTIGATIONS DURING BORINQUEN DAM 1E CONSTRUCTION PANAMA CANAL EXPANSION

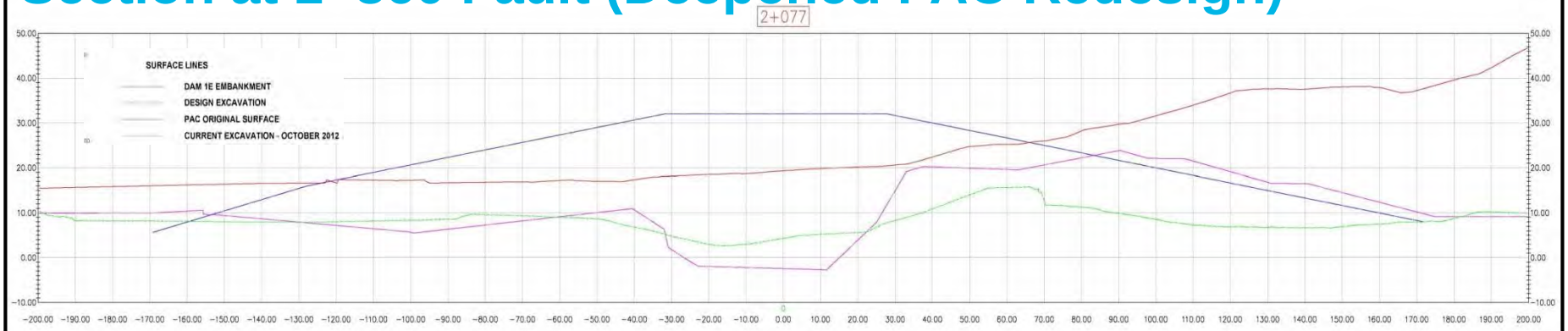
David Schug[1],
Dan Meier[3]
Chris Goetz[5]
James Toose[7]
Pastora Franceschi[9]
Jaime Arrocha[11]

Paul Salter[2]
Robert Urban[4]
Lelio Mejia[6]
Derek Irving[8]
Maximiliano De Puy[10]
Roberto Miranda[12]

[1] Principal Geologist, URS Corporation (merged with AECOM), San Diego, CA, david.schug@aecom.com
[2] Resident Geologist, AECOM, Borinquen Dam 1E Project Panama Canal Expansion Program, Orange, CA, paul.salter@aecom.com
[3] Assistant Resident Geologist, AECOM, Portland, OR, dan.meier@aecom.com
[4] Resident Geologist, AECOM. Santa Maria, CA, robert.urban@aecom.com
[5] Principal Geologist, AECOM, Santa Ana, CA, christopher.goetz@aecom.com
[6] Project Manager, AECOM, Oakland, CA, lelio.mejia@aecom.com
[7] Resident Engineer, AECOM, Borinquen Dam 1E Project Panama Canal Expansion Program, james.toose@aecom.com
[8] Supervisor, Geología, Autoridad del Canal de Panamá, Panama, DIrving@pancanal.com
[9] Supervisor, Geología, Autoridad del Canal de Panamá, Panama, PFranceschi @pancanal.co
[10] Manager, Geotechnical Section, Autoridad del Canal de Panamá, Panama, MDePuy@pancanal.com
[11] Geólogo, Autoridad del Canal de Panamá, Panama, JArrocha@pancanal.com
[12] Geólogo, Autoridad del Canal de Panamá, Panama, RMiranda@pancanal.com

ACP AECOM

Section at 1+860 Fault (Deepened PAC Redesign)



Apparent bedding dip = 5 degrees