

# General Excavation Plan Pacific Approach Channel

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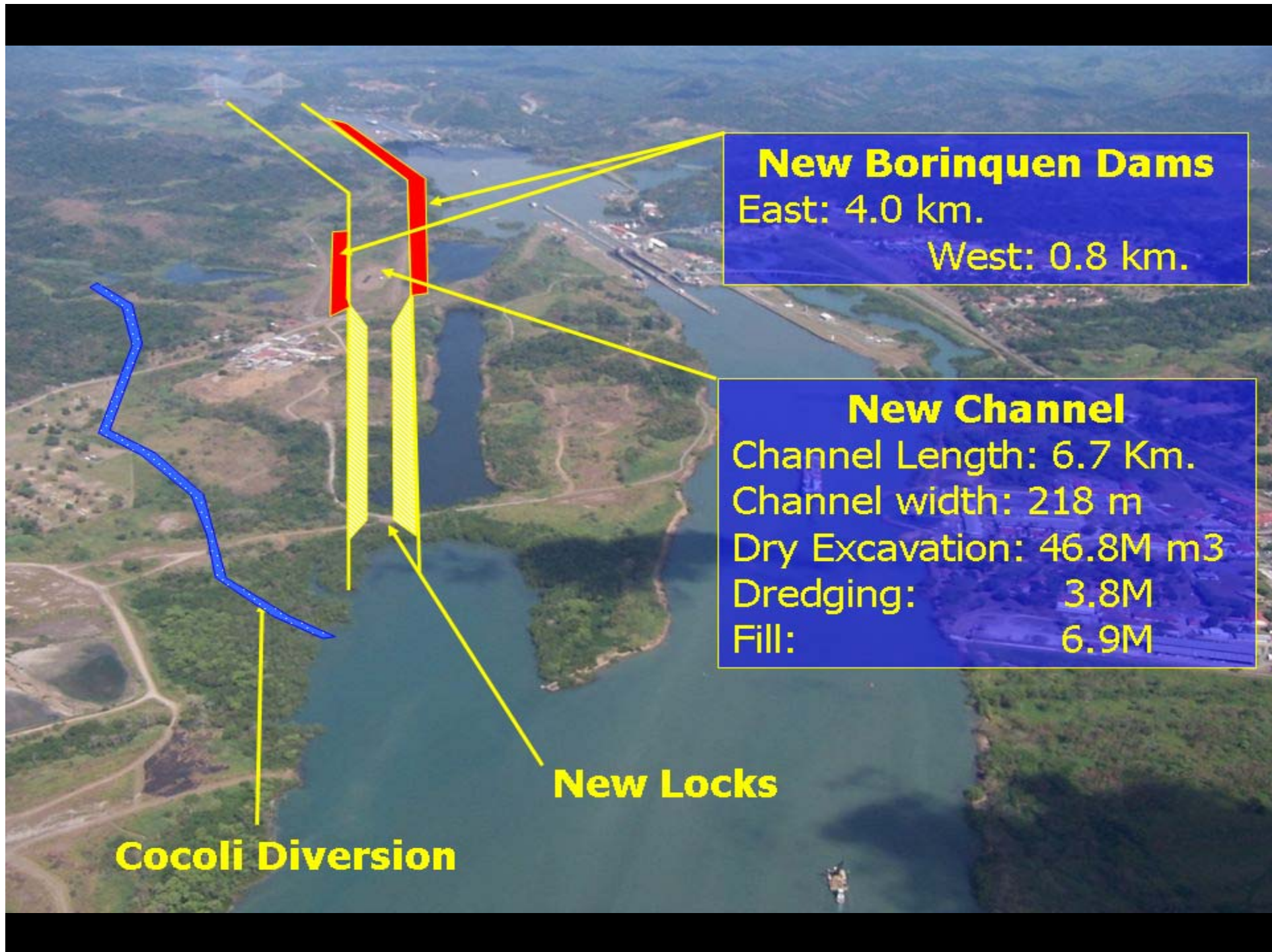
# Location Map





# Objectives and Characteristics

- Excavate a navigation channel that will connect the Gaillard Cut and the Pacific Locks.
- Channel Length: 6.7 Km, (not including the new locks)
- Channel width: 218m
- There will be a series of dams to separate Miraflores Lake (16.45m PLD) from the new channel, which will operate a higher water level (27.13m PLD)
- Geological Formations:
  - Primarily: La Boca, Pedro Miguel Agglomerate and Basalts
  - Secondarily: Cucaracha and Culebra



**New Borinquen Dams**  
East: 4.0 km.  
West: 0.8 km.

**New Channel**  
Channel Length: 6.7 Km.  
Channel width: 218 m  
Dry Excavation: 46.8M m<sup>3</sup>  
Dredging: 3.8M  
Fill: 6.9M

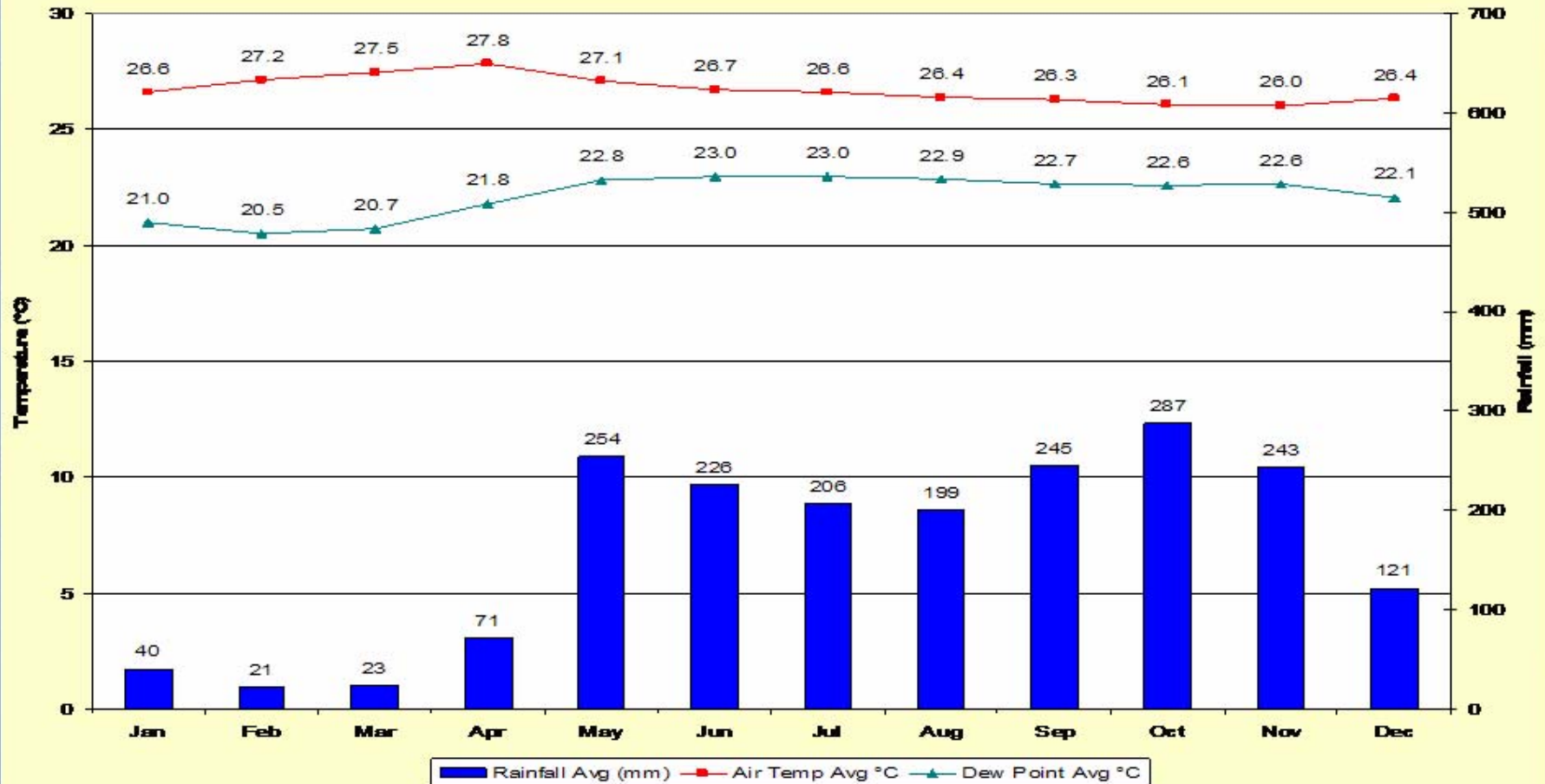
**New Locks**

**Cocoli Diversion**



# Average Annual Climates

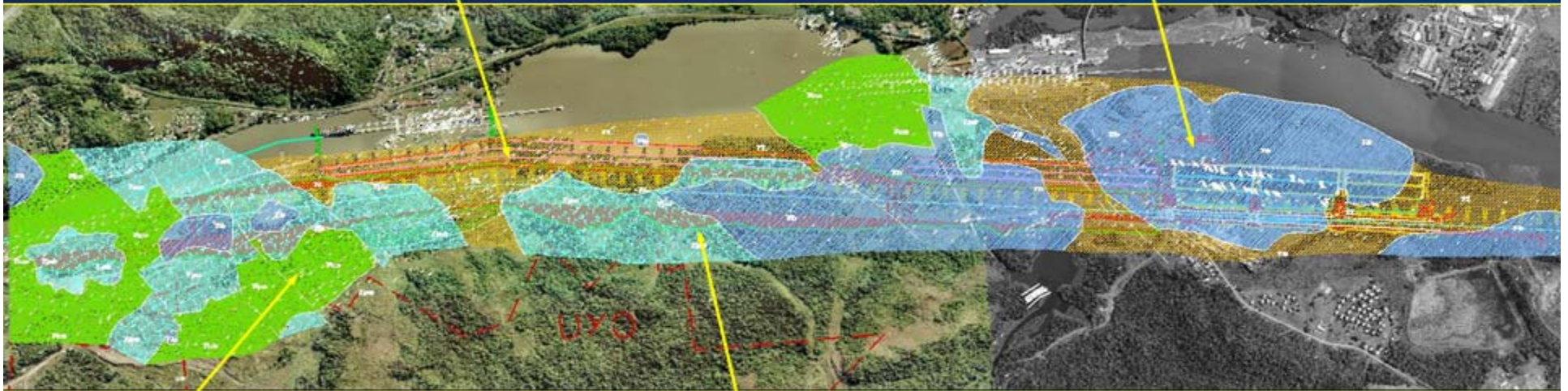
**Balboa FAA**  
**Average Annual Climate**



# Local Geology

La Boca Formation  
(soft rock)

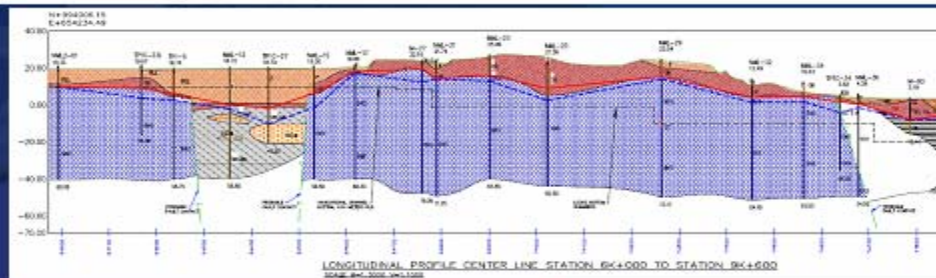
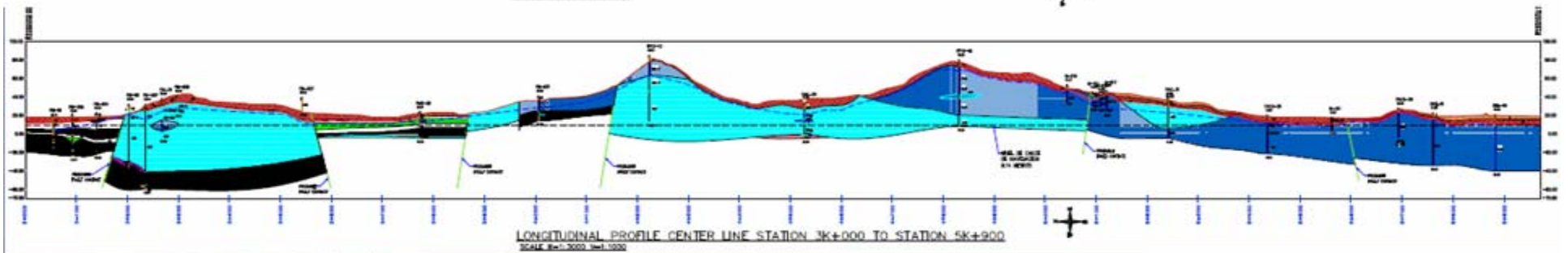
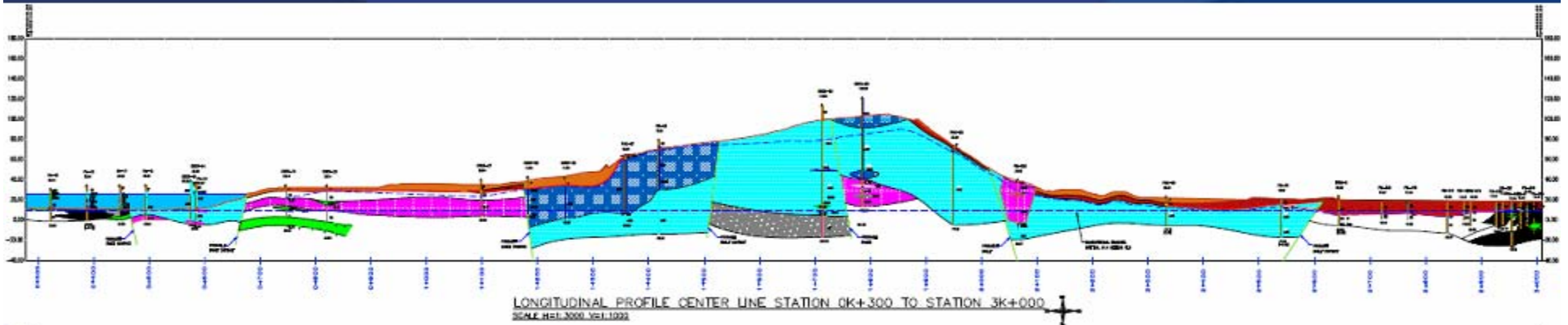
Basalt (hard rock)



Cucaracha Formation  
(soft rock)

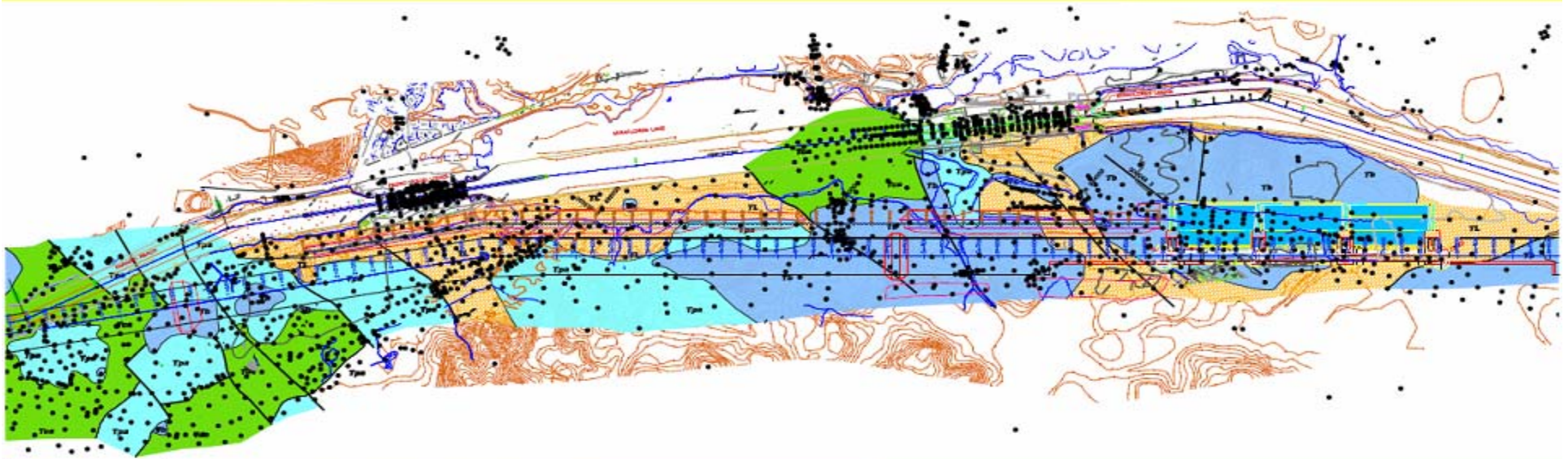
Pedro Miguel  
Agglomerate  
(medium to hard rock)

# Longitudinal Geological Profiles





# Site Investigations & Drilling Programs



Year	Holes ID	Location	Total	Length (m)
1938-1948	PM	Pedro Miguel	504	18,748
	M	Miraflores	495	12,855
2001	TP1/2	Miraflores	68	3,009
2005-2006	NML	Miraflores	65	4,473
	PAC	Paraiso to Miraflores	100	4,556
TOTAL			1,232	43,641

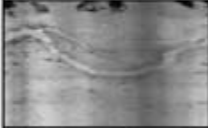



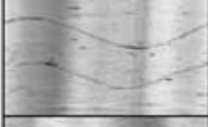

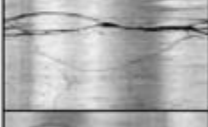







# In-Situ Tests Program

- Permeability tests (Lugeon)
- Resistance and Compressibility tests:
  - Goodman (Borehole) Jack: for hard rock, mainly basalt
  - Pressuremeter: for very soft rock and overburden.
  - Dilatometer: for medium soft to medium hard rocks, mainly Clay Shales, Sandstones, Siltstones, Agglomerates.
- Discontinuity Characteristics
  - Core Orientation:
    - a) CHRISTENSEN HÜGEL 1 in hard Rocks
    - b) Borehole Image Processing System (BIPS)
  - RQD and Core Recovery
- Geophysical Investigation

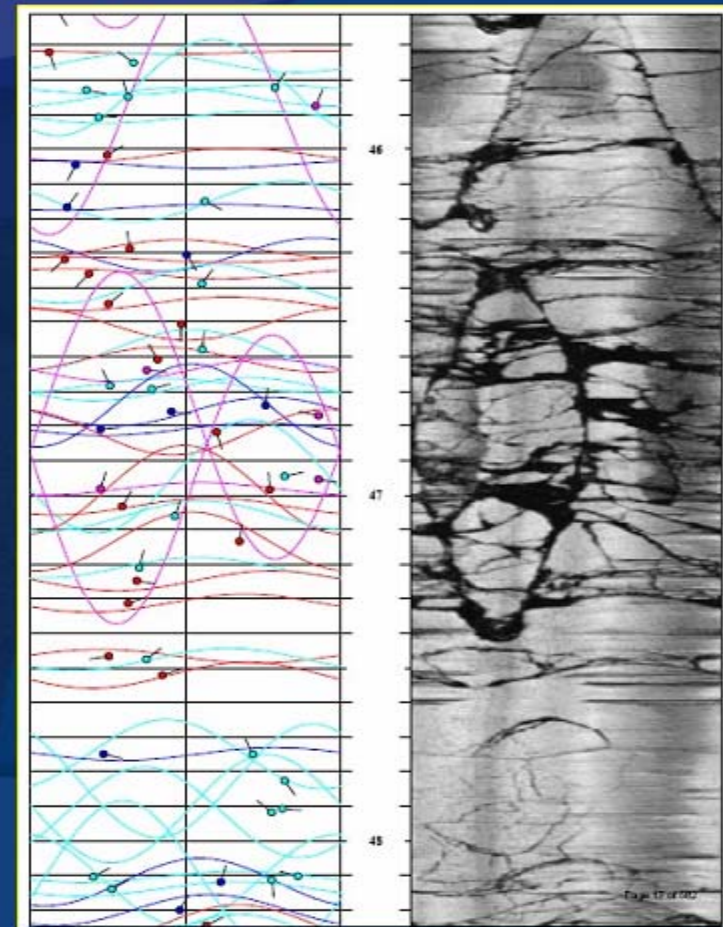
# Borehole Image Processing System (BIPS)

Sistema de Rango por Características Acústicas

	Rango	Color	Observaciones	Escala de Acuerdo al Flujo
	0	Gris 	Característica, sin flujo	Sellado, sin flujo
	1	Cyan 	Característica débil, no continua alrededor del pozo	Fisura, parcialmente abierta
	2	Azul 	Característica clara	Fisura con abertura continua
	3	Rojo 	Característica clara, con abertura aparente	Fisura con abertura mas pronunciada
	4	Magenta 	Fractura muy clara, más abierta y posiblemente interconectada	Fisura con abertura muy pronunciada, o fracturas interconectadas
	5	Verde 	Zona extensa de fracturas, visible en ambas imágenes de amplitud y tiempo	Fractura pronunciada

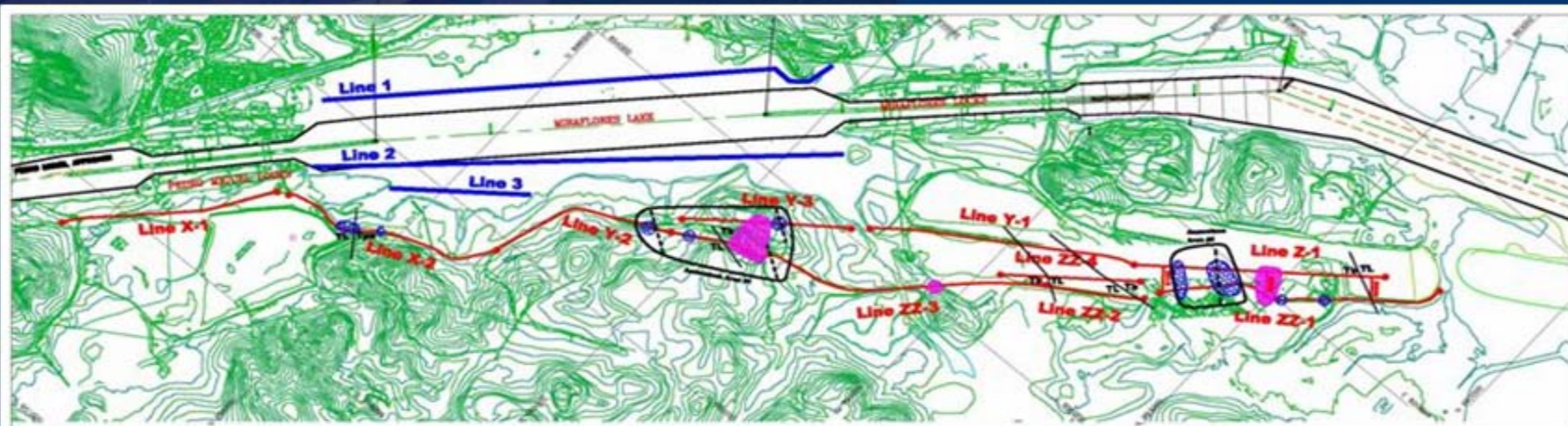
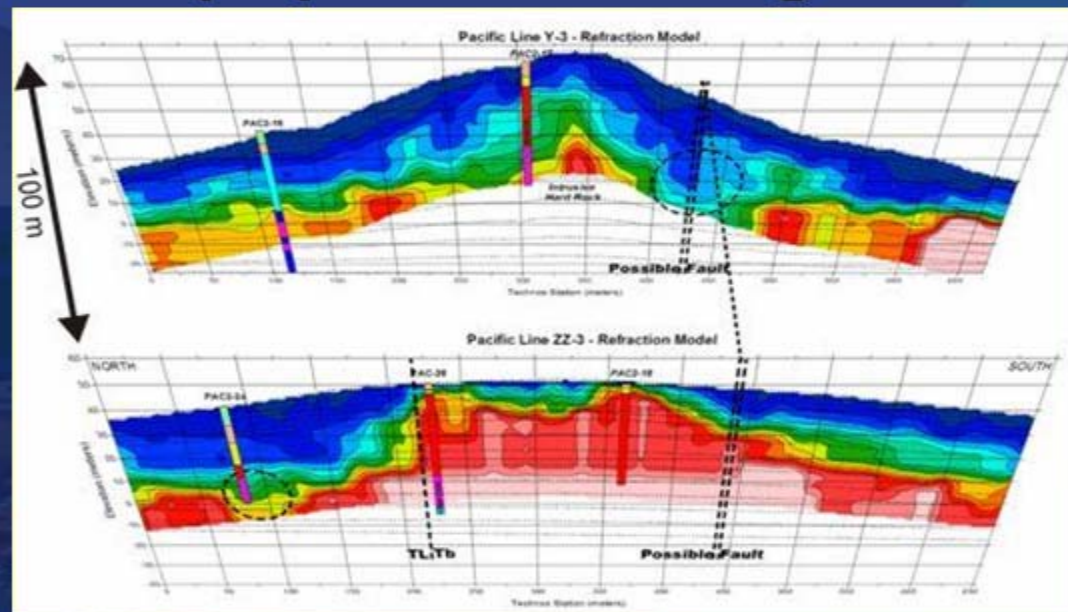


COLOG Division of Layne Christensen





# Geophysical Investigations



Basemap provided by ACP  
Scale 1:20,000

- Land Survey Line
- Marine Survey Line

## Pacific Area Seismic Velocities

<b>Formation</b>	<b>P-wave Velocity (m/s)</b>	<b>S-wave Velocity (m/s)</b>
Fill/Overburden	400-1,600	100-400
Weathered La Boca	1,600-2,000	300-500
Unweathered La Boca	2,000-3,200	500-1,000
Weathered Basalt	2,000-3,200	400-600
Unweathered Basalt	3,200-6,000	600-1,500 Underestimated by MASW method
Pedro Miguel (Tuff/Agglomerate)	2,000-4,000	400-1,200 Underestimated by MASW method



# Laboratory Test Program

- Unconfined Compressive Strength
- Classification
- Engineering Index Properties
- Point Load Test Index
- Slaking Durability Index
- Effective Shear Strength
  - Direct Shear
  - Large Shear Box
  - Bromhead Ring Shear
  - Triaxial Test
    - Soil/Soft Rocks
    - Hard Rocks (Hoek Triaxial Cell)



# Statistical Summary: Unconfined Compressive Strength, Elastic Modulus, Unit Weight and Specific Gravity (Miraflores)

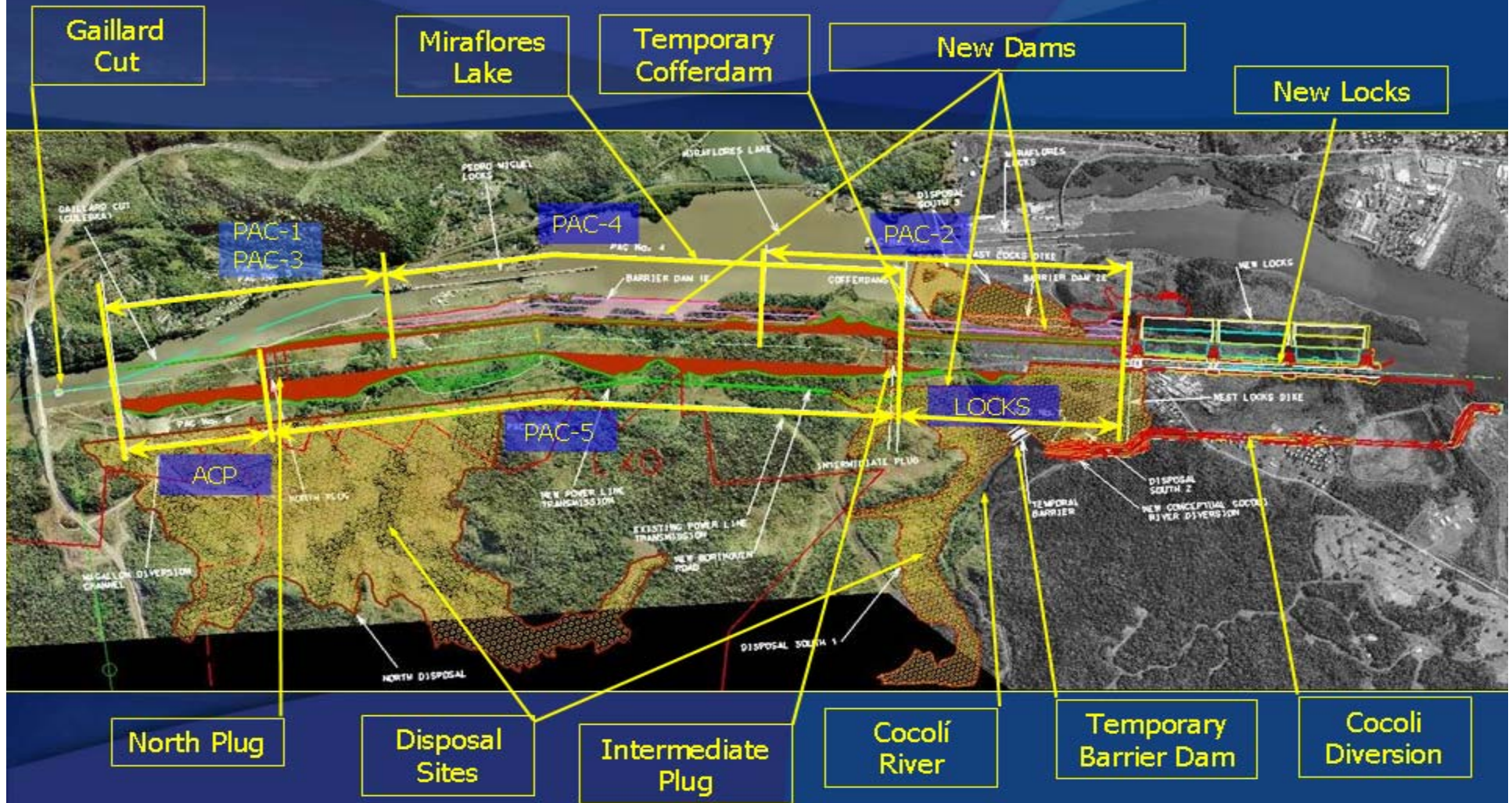
Gs			Unit Weight (Kg/m <sup>3</sup> )			Elastic Modulus E (GPa)			UCS $\sigma_c$ (MPa)			Formation
N	Median	St. Dev.	N	Median	St. Dev.	N	Median	St. Dev.	N	Median	St. Dev.	
	Average			Average			Average			Average		
9	2.2	0.08	9	2,233	89	9	994	1,764	9	5	9	Cucaracha
	2.21			2,224			1,598			8		
163	2.25	0.1	163	2,246	151	139	1,182	4,195	163	7	13	La Boca
	2.26			2,242			3,056			12		
8	2.3	0.09	8	2,269	66	--	--	--	8	20	7	Panama
	2.3			2,265			--			18		
323	2.4	0.06	324	2,371	125	194	6,624	4,170	324	32	12	Pedro Miguel
	2.38			2,383			7,274			30		
312	2.72	0.08	334	2,724	113	288	12,563	6,746	334	54	33	Basalt
	2.72			2,716			13,683			59		



# Definition of Excavation of Unclassified Material

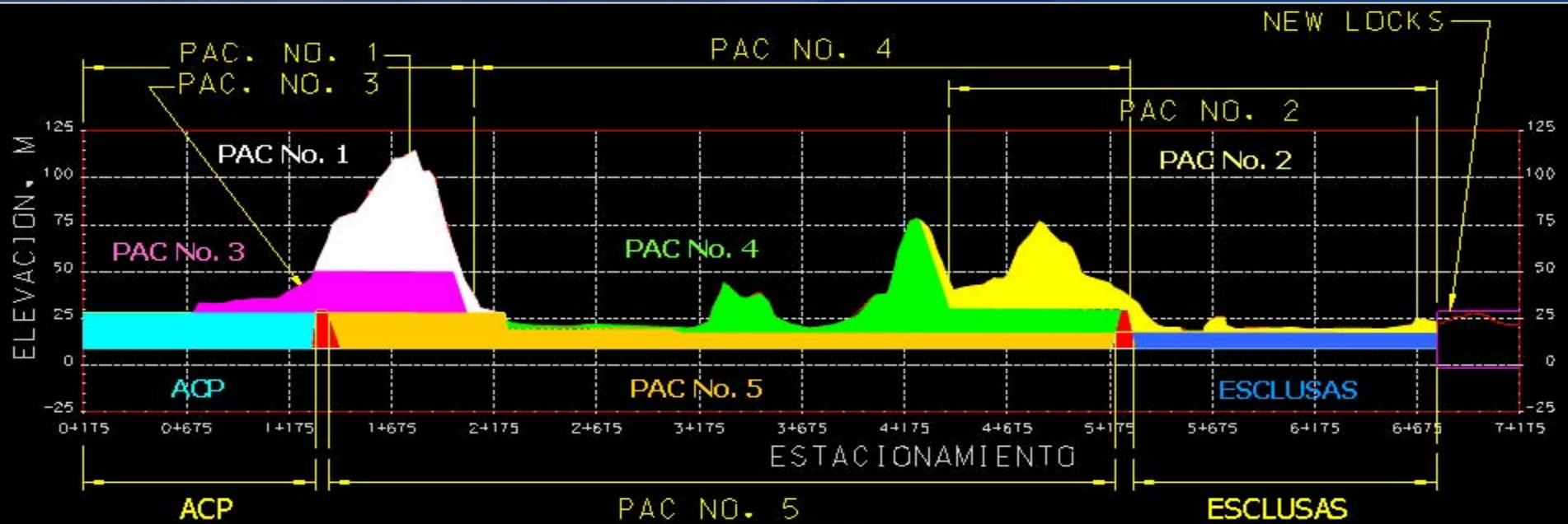
It is the excavation of any combination of topsoil, soil, hard material, rock, and muck. Unclassified excavation shall be carried out to the lines and grades shown on the plans without regard to percentage of moisture and type of material found between the surface and final depth.

# General Excavation Layout

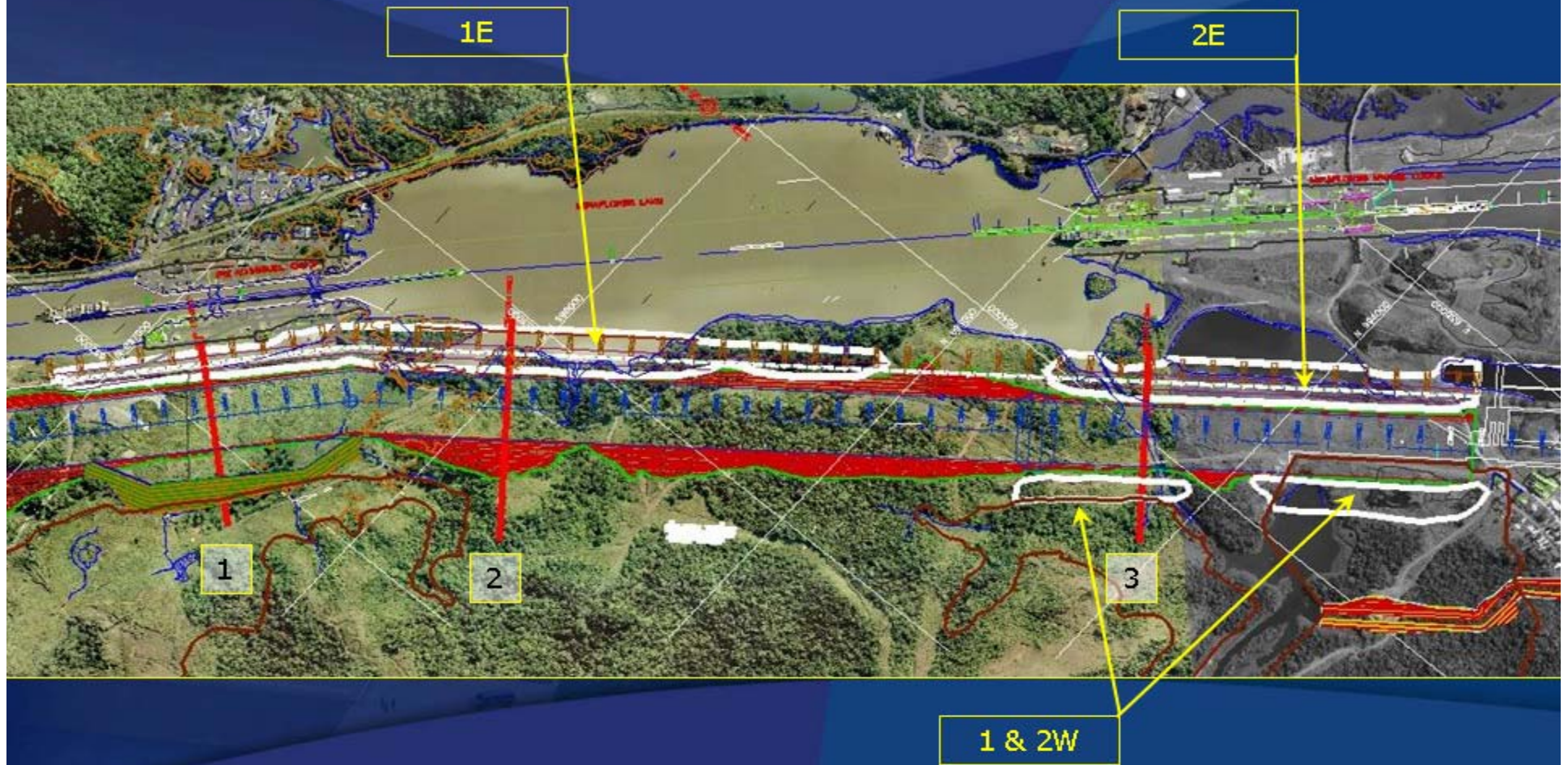




# Project Sequence



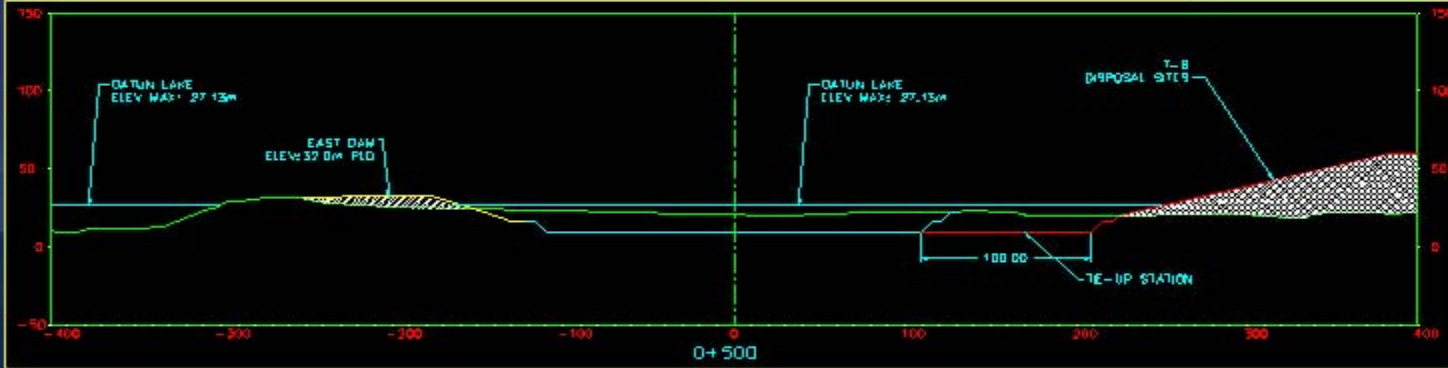
# Borinquen Dams



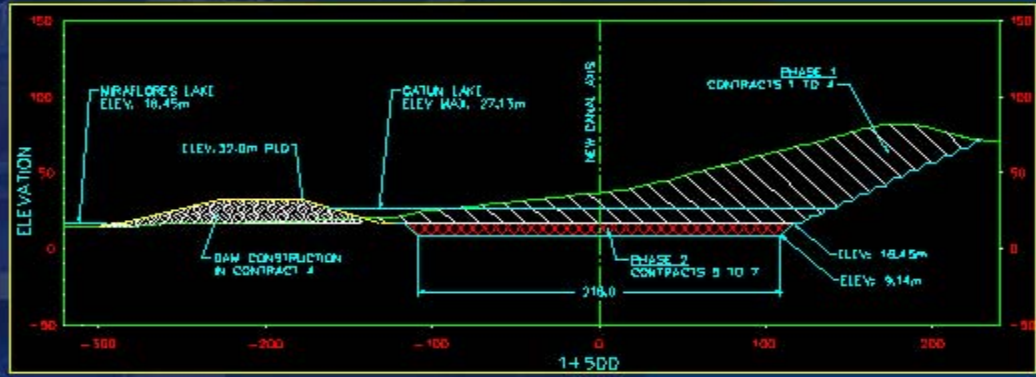


# Sections

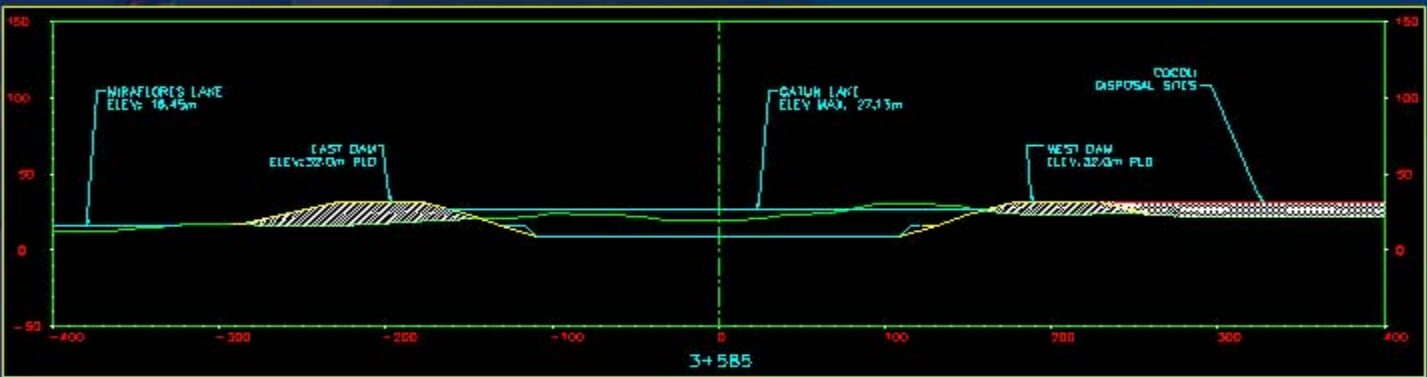
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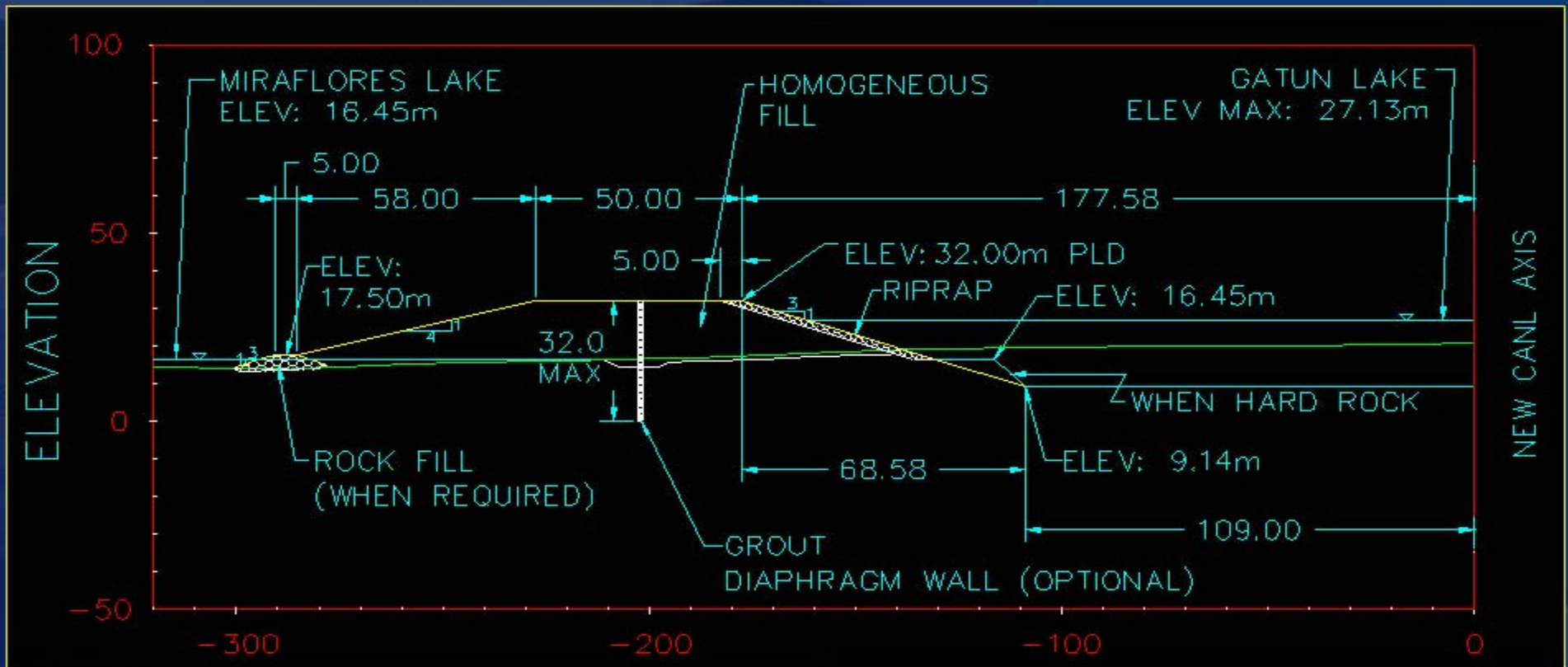
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3

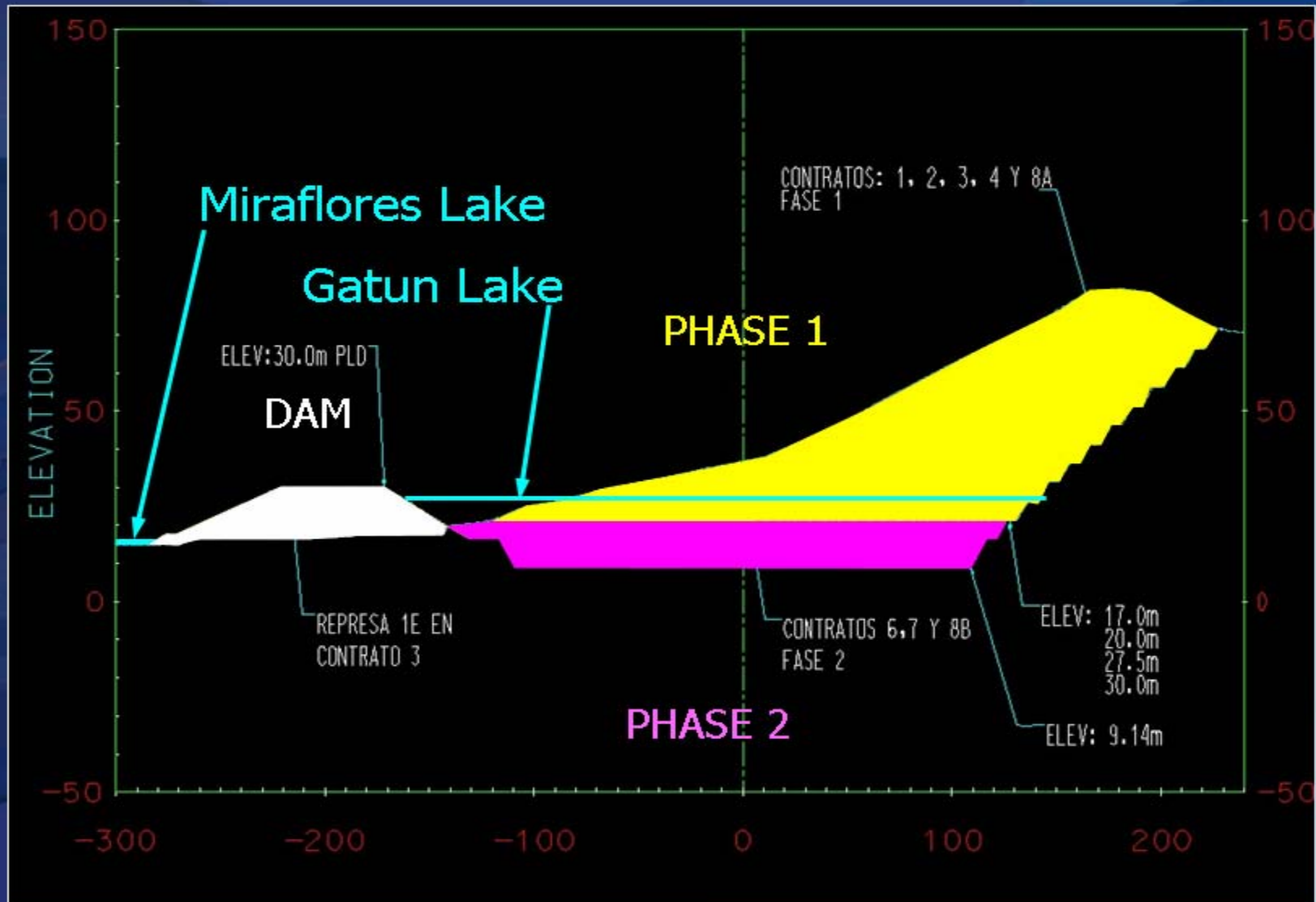


# Typical Dam Section (conceptual)





# Excavation Phases



# Excavation Volumes

CONTRACTS	OBSERVATIONS	STATIONS		Excavation Level (PLD, m)	Dry Excavation (m <sup>3</sup> )	Fill (m <sup>3</sup> )	Dredging (m <sup>3</sup> )
CONT. NO. 1	EXCAVATION	0+000	2+075	46.00	7,400,000		
	BORINQUEN HIGHWAY1				1,300,000	1,300,000	
CONT. NO. 2	EXCAVATION	4+395	5+275	30.00	7,960,000		
		5+275	6+675	17.00			
	BORINQUEN HIGHWAY 2						
	COCOLI						
CONT. NO. 3	EXCAVATION	0+000	2+075	27.50	7,750,000		
CONT. NO. 4	EXCAVATION	2+075	2+225	27.50	12,540,000		
		2+225	3+075	20.00			
		3+075	5+275	17.00			
	EAST BARRIER DAM No. 1E				230,000	2,350,000	
	MAGALLON DIVERSION				200,000		
CONT. NO. 5	EXCAVATION	1+285	5+275	9.14	9,400,000		
<b>Total</b>					<b>46,780,000</b>	<b>3,650,000</b>	<b>-</b>
ACP	DREDGING	0+000	1+285	9.14			2,840,000
ACP	NORTH PLUG	1+285	1+425	9.14			530,000
ACP	INTERMEDIATE PLUG	5+185	5+310	9.14			410,000
LOCKS CONTRACT	EXCAVATION	5+275	8+000	9.14	2,440,000		
	EAST BARRIER DAM No. 2E & 1W				200,000	1,600,000	
	COCOLI RIVER DIVERSION FINAL				800,000	160,000	
	EAST LOCK EMBANKMENT					750,000	
	WEST LOCK EMBANKMENT					750,000	
<b>Total</b>					<b>50,220,000</b>	<b>6,910,000</b>	<b>3,780,000</b>



# Excavation Program



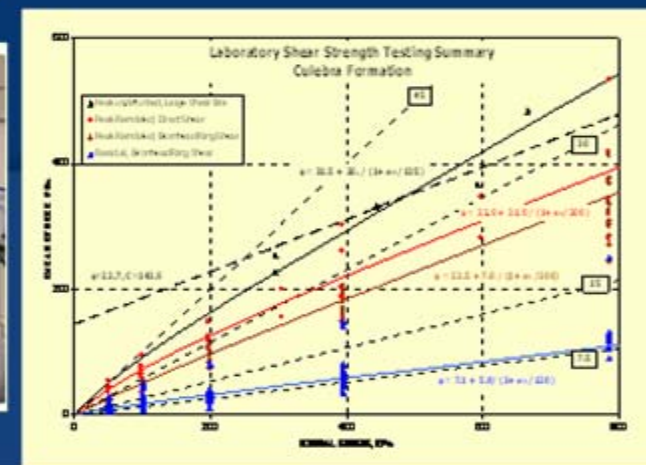
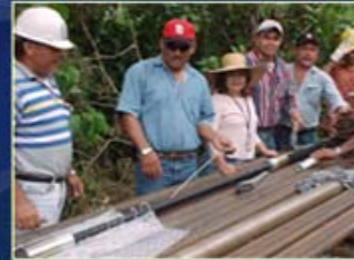
# Excavation Design (1)

Investigation and Geotechnical Characterization



Construction & Surveillance

- Drilling
- Field Mapping
- Laboratory Testing
- Subsurface and surface instrumentation
- Instability History





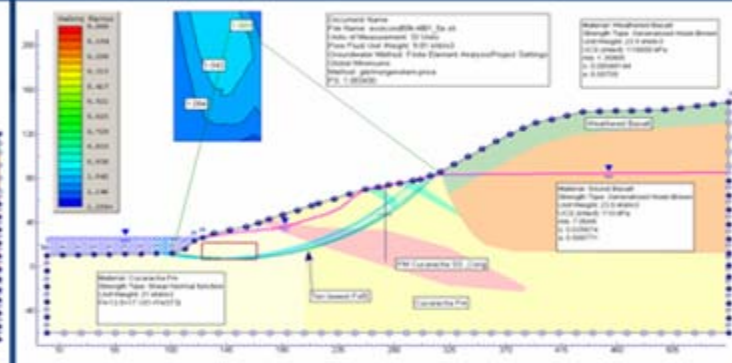
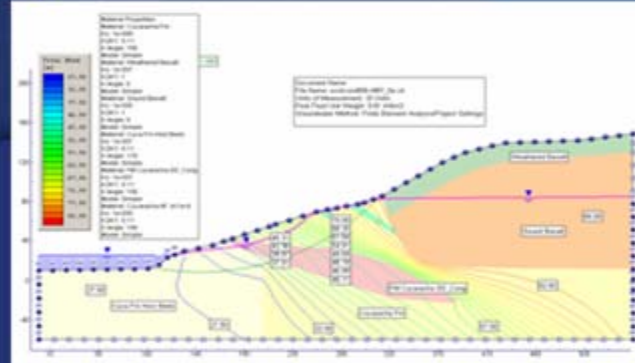
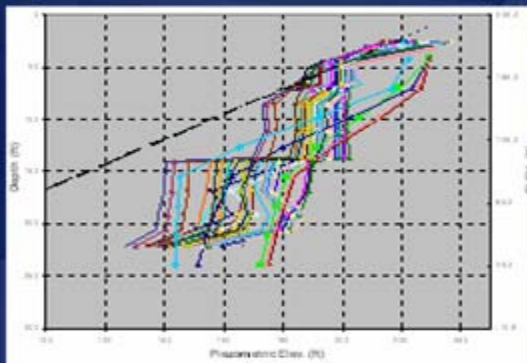
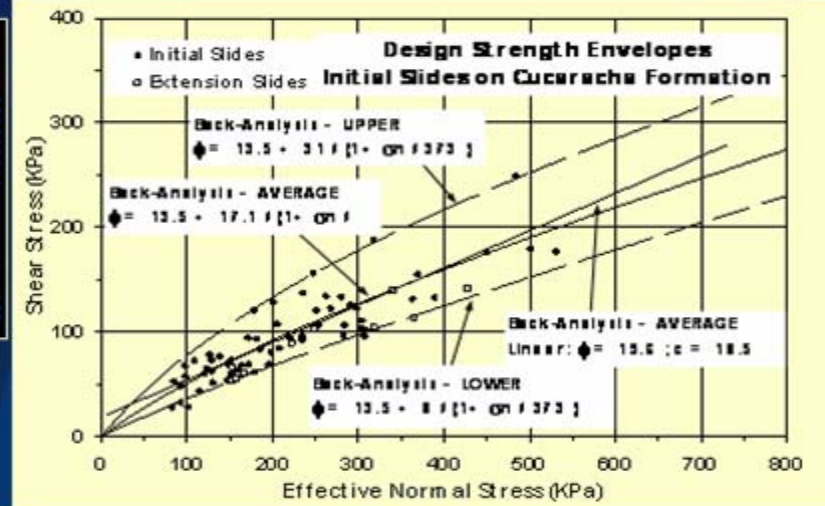
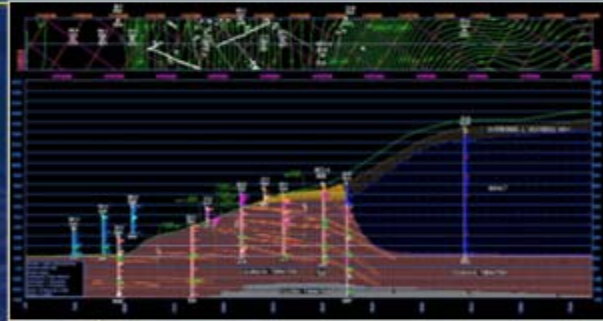
# Excavation Design (2)

Investigation and Geotechnical Characterization



Construction & Surveillance

- Geological Model
- Geotechnical Model
- Stability Analysis
  - Existing
  - Design
- Excavation Optimization
- Drawings, Specifications and budget



# Excavation Design (3)

Investigation and  
Geotechnical  
Characterization

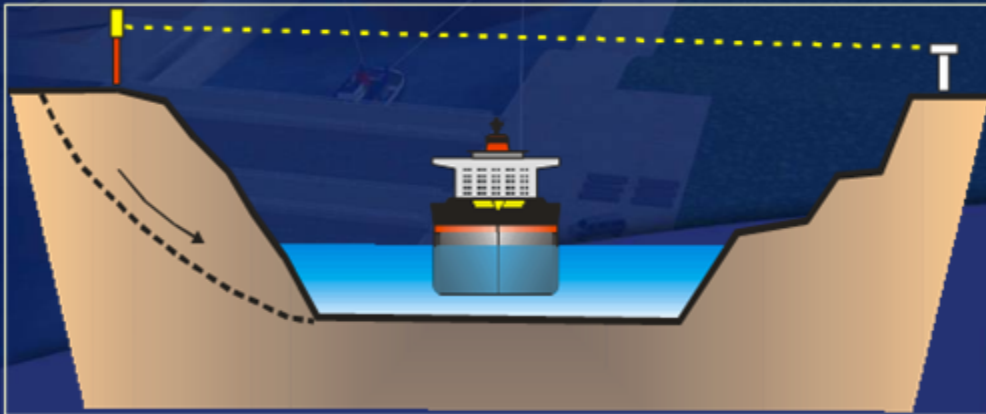
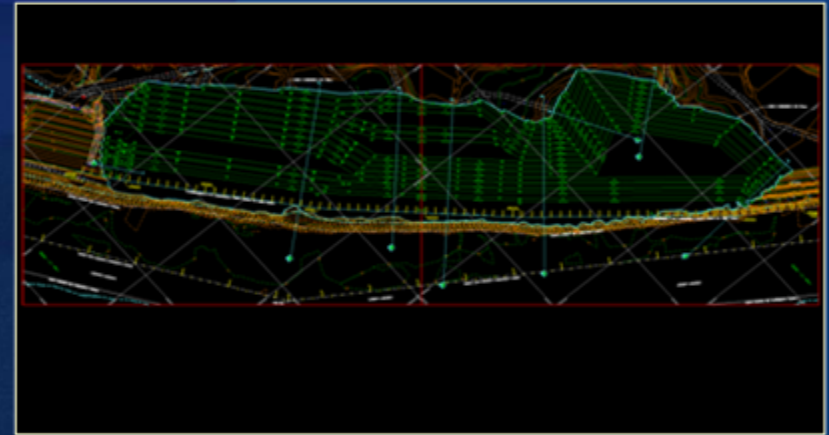


Design



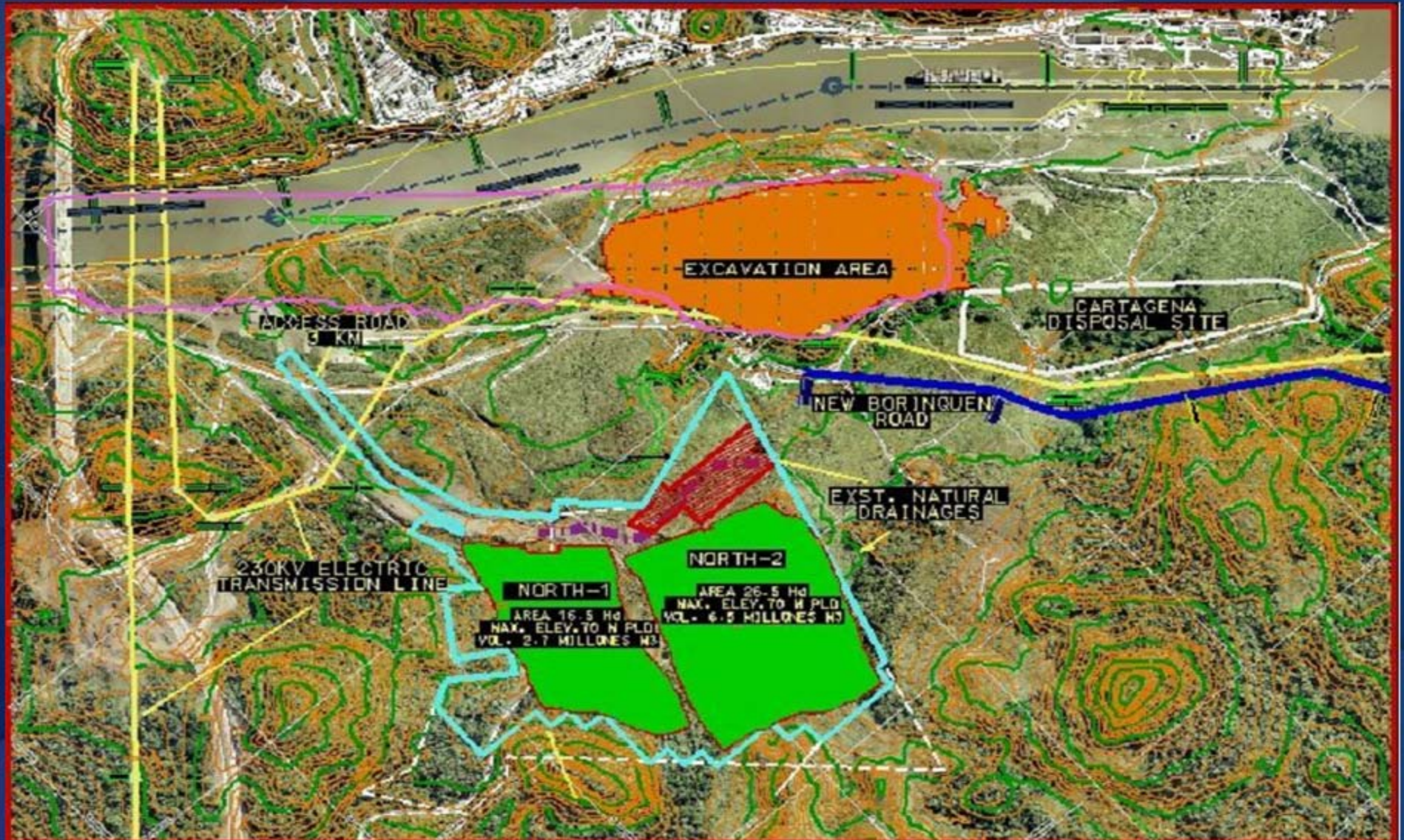
Construction &  
Surveillance

- Inspections and quality assurance
- Program manager
- Changes and re-designs
- Landslide Control on Long-term



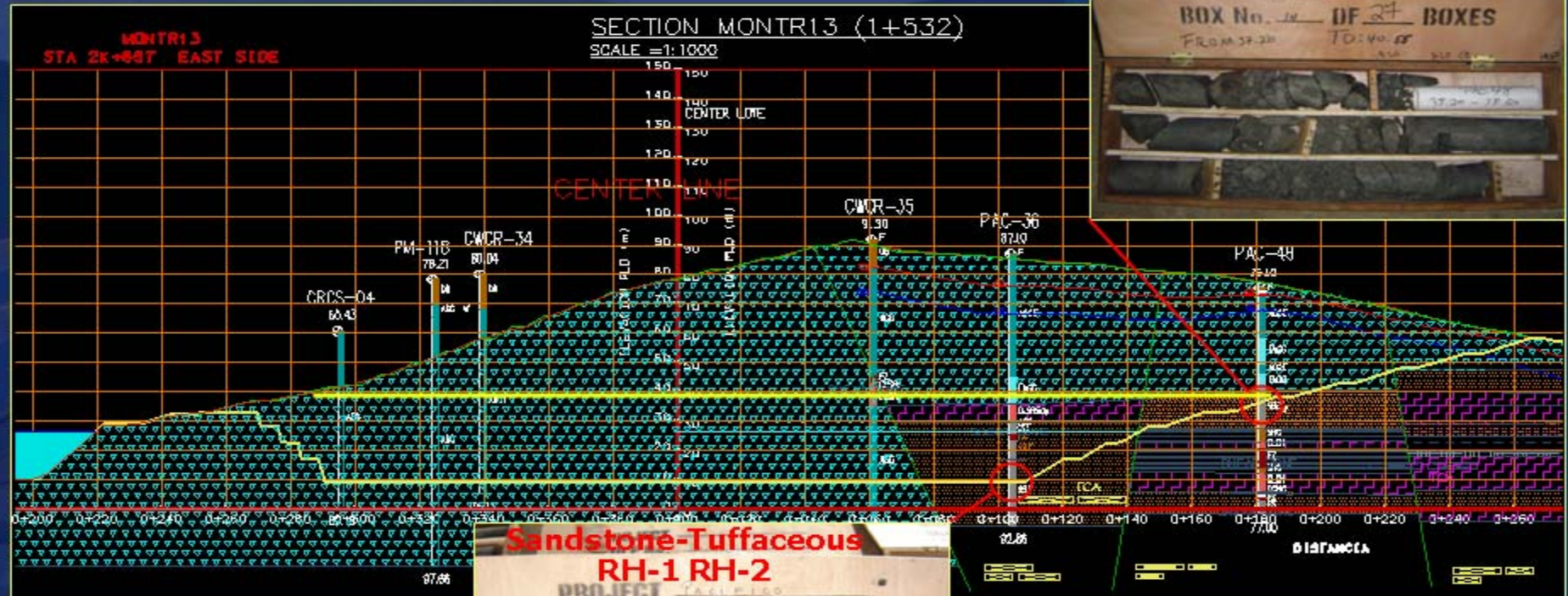


# First Contract (PAC-1)



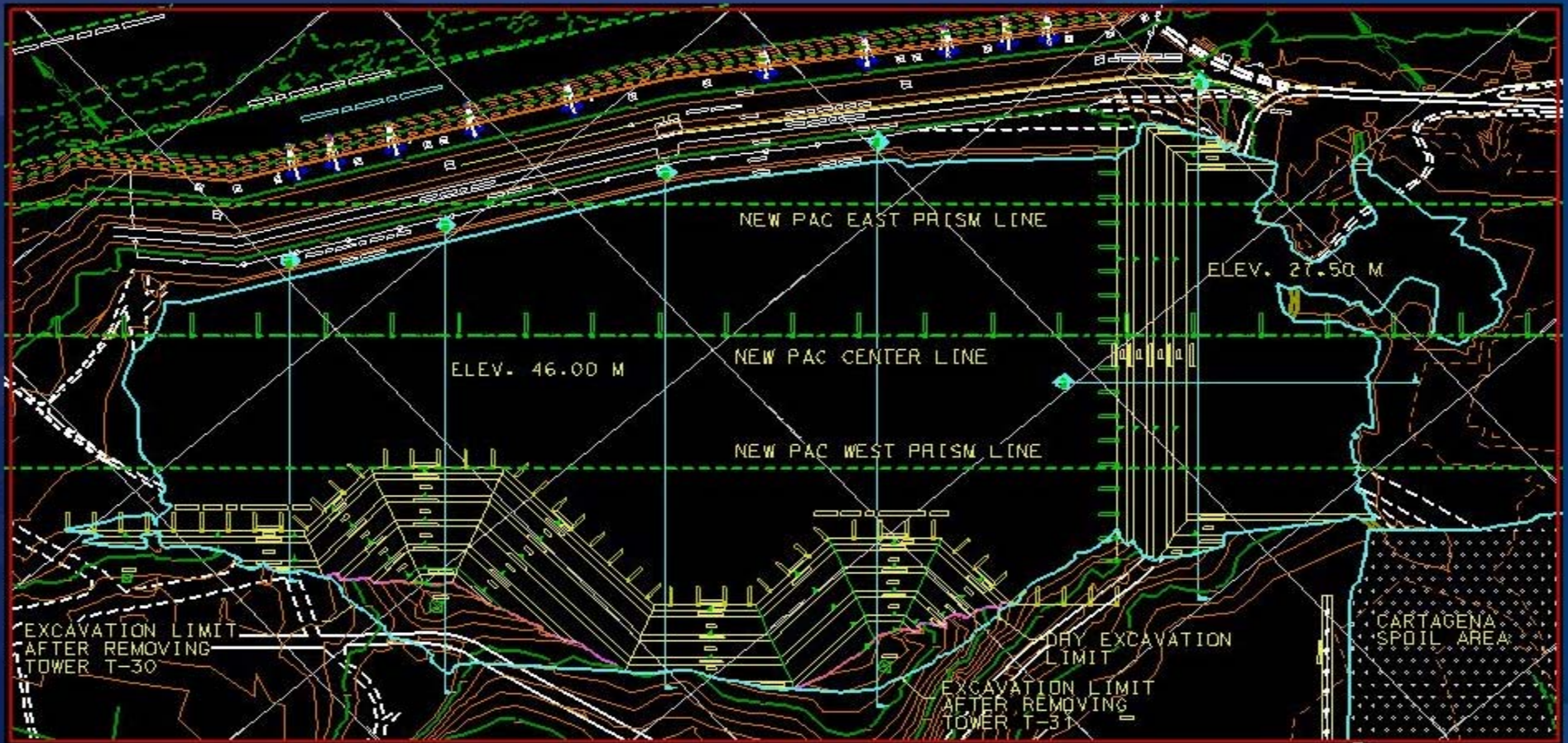


# Typical Excavation Section





# Excavation Layout of First Contract (PAC-1)





# View of PAC-1





# Lookout Point for the PAC





End