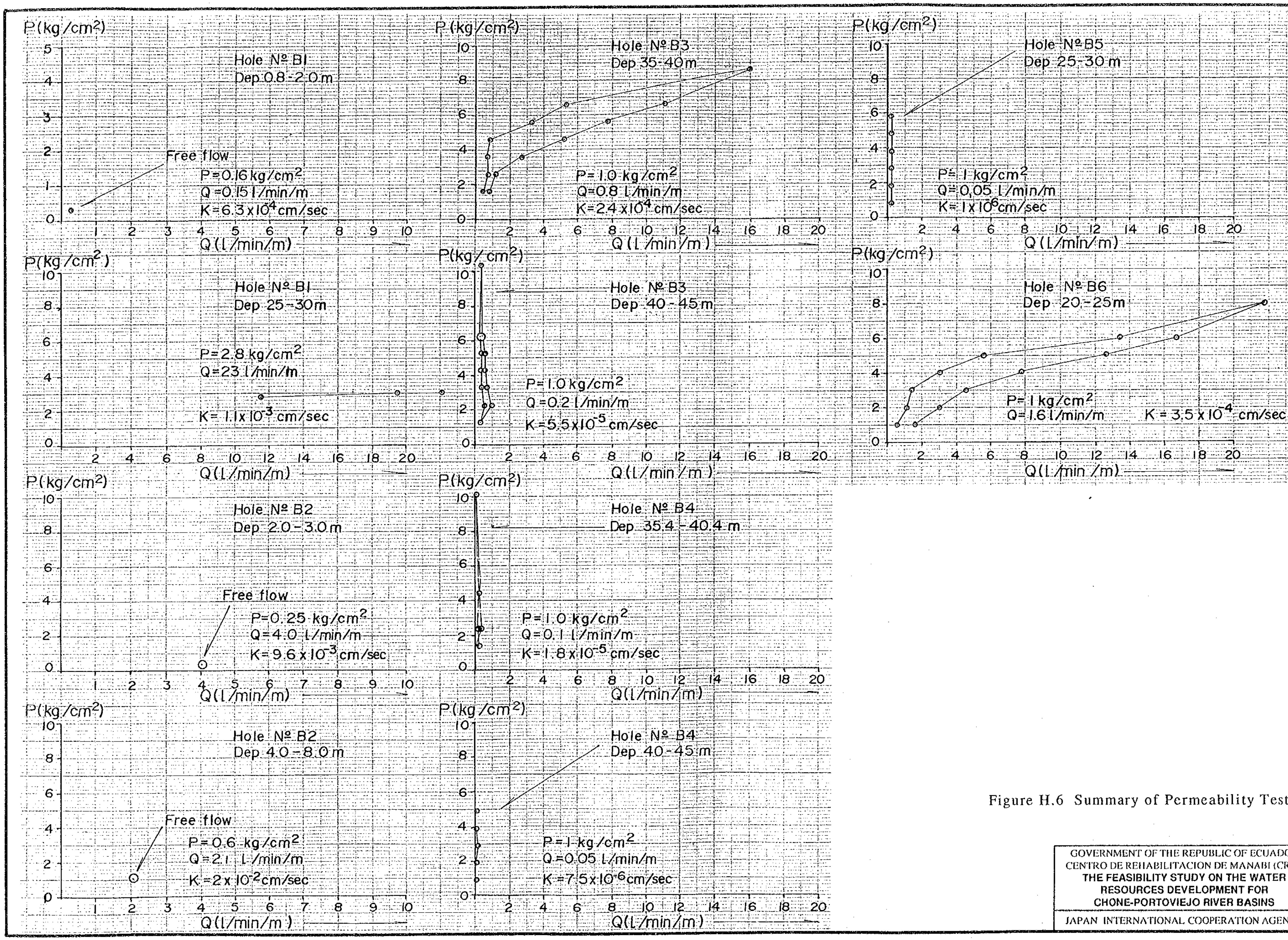
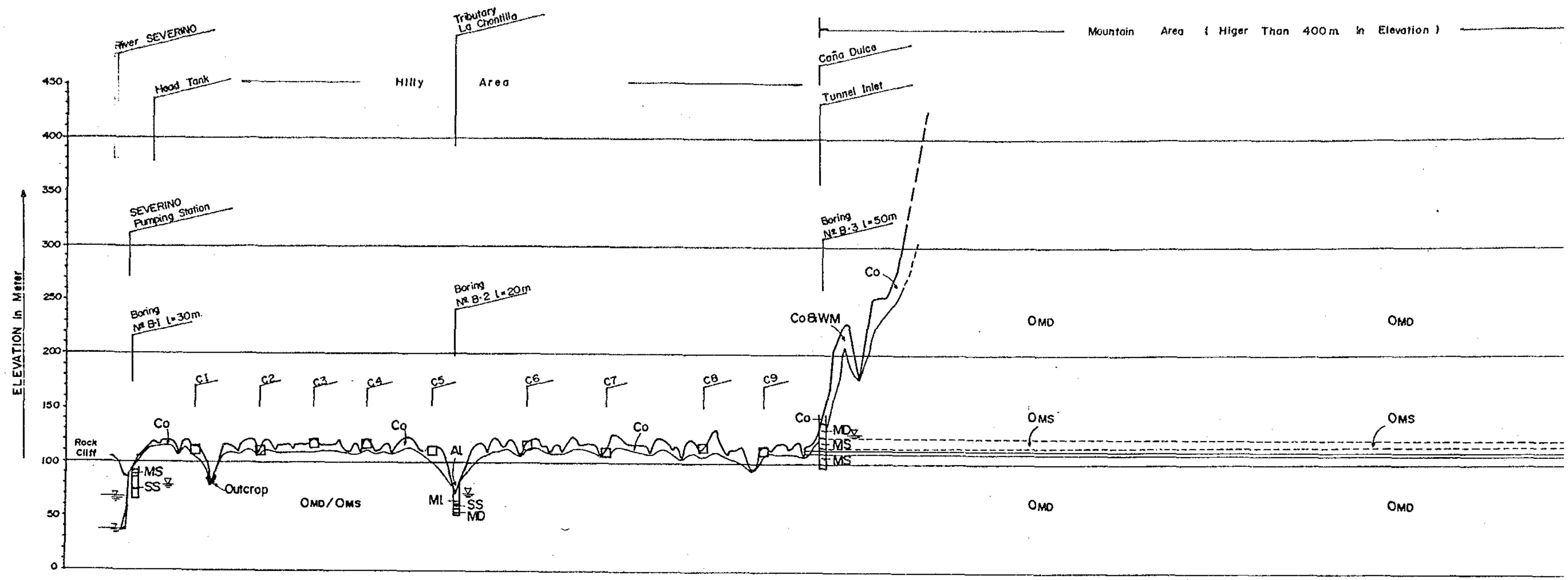


Figure H.6 Summary of Permeability Test

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS

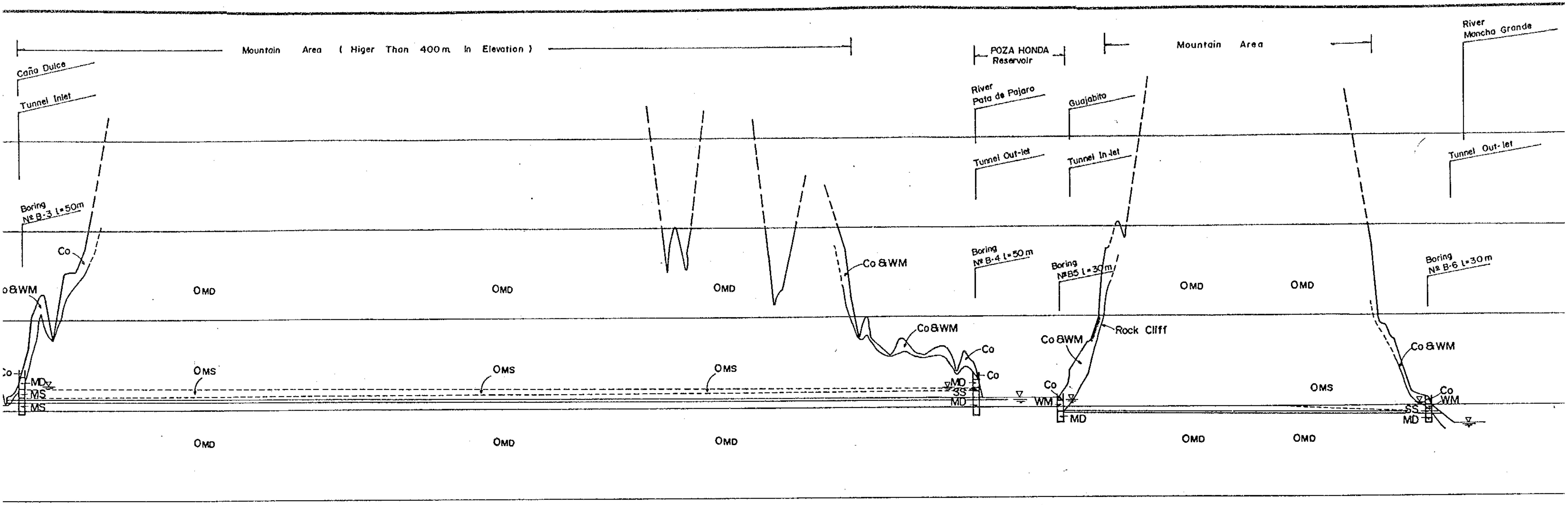
JAPAN INTERNATIONAL COOPERATION AGENCY



OPEN CHANNEL — TUNNEL

Syphone — Syphone — Syphone — Syphone

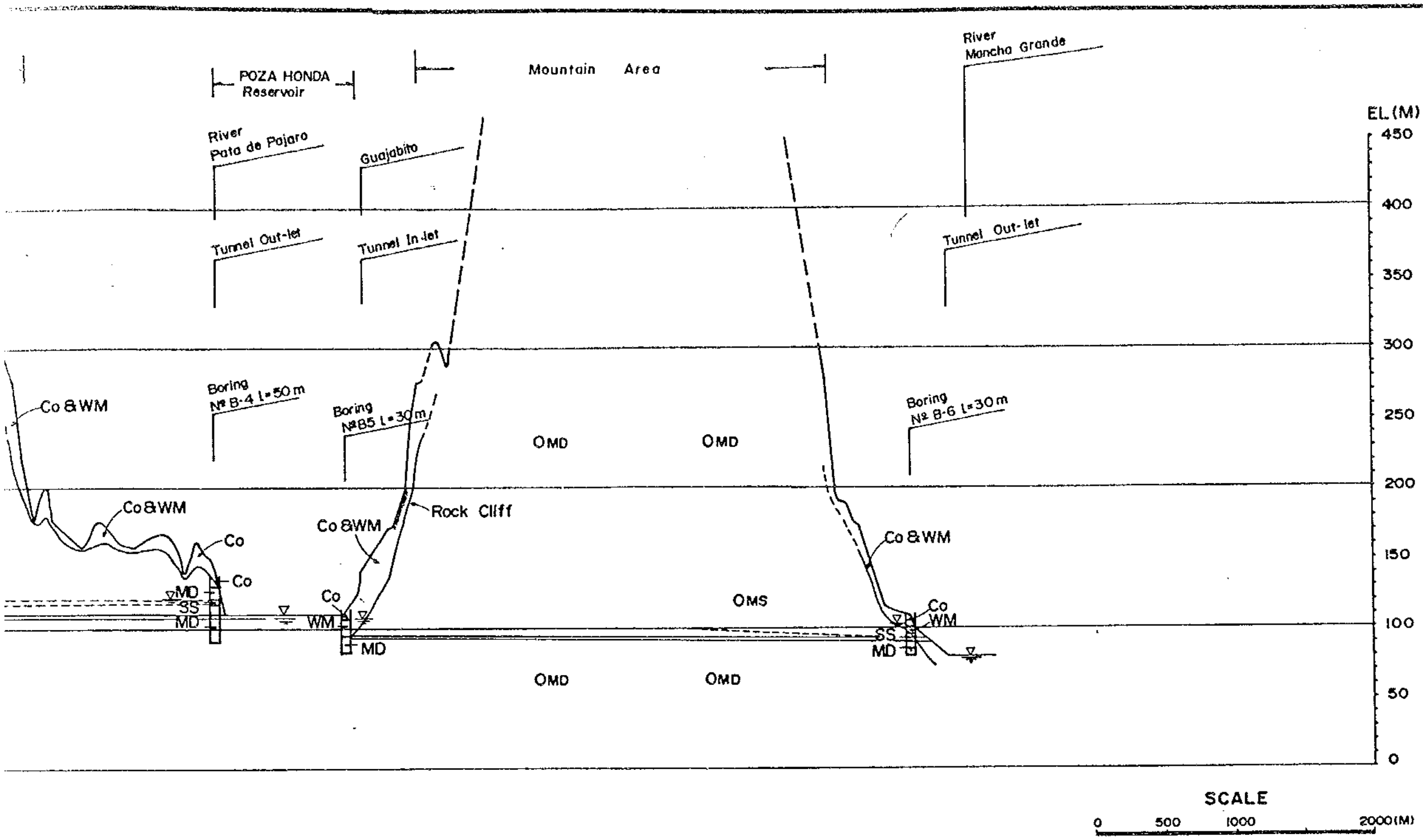
DISTANCE		0.000	1.000 – 2.000	3.000	4.000 – 6.000		7.000	8.000 – 13.000
ROCK TYPE		OM & OMS	Co (Decomposed Rock) Clay	AL Sand Gravel	Co (Decomposed Rock) Clay	Co & WM	OMD Mudstone	OMD Mudstone
ROCK CLASS	(1)	CL CM				D	CL	CL-CM
	(2)	CII				DII	CII	CI
	(3)	III IV				V	IV	IV-III
(4) qu/rh							45/1.7x30 45/1.9x100	100/2.0x400
P wave VELOCITY			2.3 km/sec.				1.8km/sec 2.0km/sec	2.3 km/sec
UNCONFINED COMPRESSIVE STGTH			70 kg/cm²				10kg/cm² 45	100kg/cm²
STATIC ELASTIC MODULUS			15000 kg/cm²				2000kg/cm² 10.000	15.000kg/cm²
GROUND WATER							Alittle Alittle	Alittle
PERMEABILITY							1x10⁻⁴ 1x10⁻⁴ cm/sec	1x10⁻⁵ cm/sec
STEEL SUPPORT							H125 @=1.0 H125 @=1.2	H125 @=1.5
REMARKS								



T U N N E L — (POZA HONDA RESERVIOR) — T U N N E L

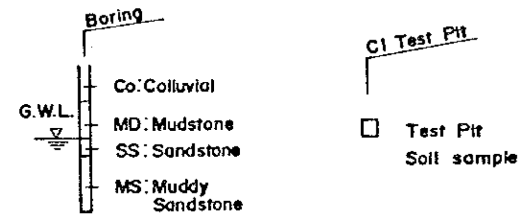
DISTANCE: 7.000, 8.000, 9.000, 10.000, 11.000, 12.000, 13.000, 14.000, 15.000, 16.000, 17.000 (POZA HONDA RESERVIOR) 0.000, 1.000, 2.000, 3.000, 4.000

Co & WM	OMD Mudstone	OMD Mudstone	OMD Mudstone	Co & M	Co & WM	OMD Mud-stone	OMD Mudstone	OMD Mudstone	Co & WM	ROCK TYPE
D	CL	CL-CM	CL	D	D	CL-D	CL-CM	CL	D	(1) ROCK CLASS
DII	CII	CI	CII	DII	DII	CII	CI	CII	DII	(2)
V	IV	IV-III	IV	V	V	IV	IV-III	IV	V	(3)
	45/1.7x30 45/1.9x100	100/2.0x400	45/1.9x200	10/1.7x30	10/1.7x30	30/1.9x50	60-100/2.0x400	30/1.9x50	10/1.7x30	(4) qu/rh
	1.8km/sec 2.0km/sec	2.3 km/sec	2.0km/sec	1.5km/sec	1.5 km/sec	2km/sec	2.2km/sec	2.0km/sec	1.5km/sec	P WAVE VELOCITY
	10kg/cm² 45	100kg/cm²	45kg/cm	10kg/cm²	10kg/cm²	30kg/cm²	60-100kg/cm²	30kg/cm²	10kg/cm²	UNCONFINED COMPRESSIVE STR
	2000kg/cm² 10.000	15.000kg/cm²	10.000kg/cm²	2.000kg/cm²	2.000kg/cm²	10.000kg/cm²	15.000kg/cm²	10.000kg/cm²	2.000kg/cm²	STATIC ELASTIC MODULU
	Alittle Alittle	Alittle	Alittle	Alittle	Alittle	Alittle	Alittle	Alittle	Alittle	GROUND WATER
	$1x10^{-4}$ $1x10^{-4}$ cm/sec	$1x10^{-5}$ cm/sec	$1x10^{-5}$ cm/sec	$1x10^{-4}$ cm/sec	$1x10^{-4}$ cm/sec	$1x10^{-4}$ cm/sec	$1x10^{-5}$ cm/sec	$1x10^{-4}$ cm/sec	$1x10^{-4}$	PERMEABILITY
	H125 @=1.0 H125 @=1.2	H125 @=1.5	H125 @=1.2	H125 @=100	H125 @=100	H125 @=100	H125 @=120	H125 @=100	H125 @=100	STEEL SUPPORT
										REMARKS



LEGEND

MARK	GEO-TIME FORMATION				ROCK TIPE	PROPERTIES
Al	Quaternary		Alluvial		Sand Gravels	River and tributary deposit with boulders
Co	Quaternary		Colluvial		Clay	Talus deposit. Decomposed Soil from mudstone origin.
WM	Neogene	Tertiary	Onsole Formation		Clayey Soil	Weathered mudstone Decomposed into soil
OMD	Neogene	Tertiary	Onsole Formation		Mudstone	Massive silty Mudstone Soft Rock. Homogenious. Partly fractured
OMS	Neogene	Tertiary	Onsole Formation		Sandstone	Muddy sandstone Partly interbedded with fine sandstone. Massive. Soft rock

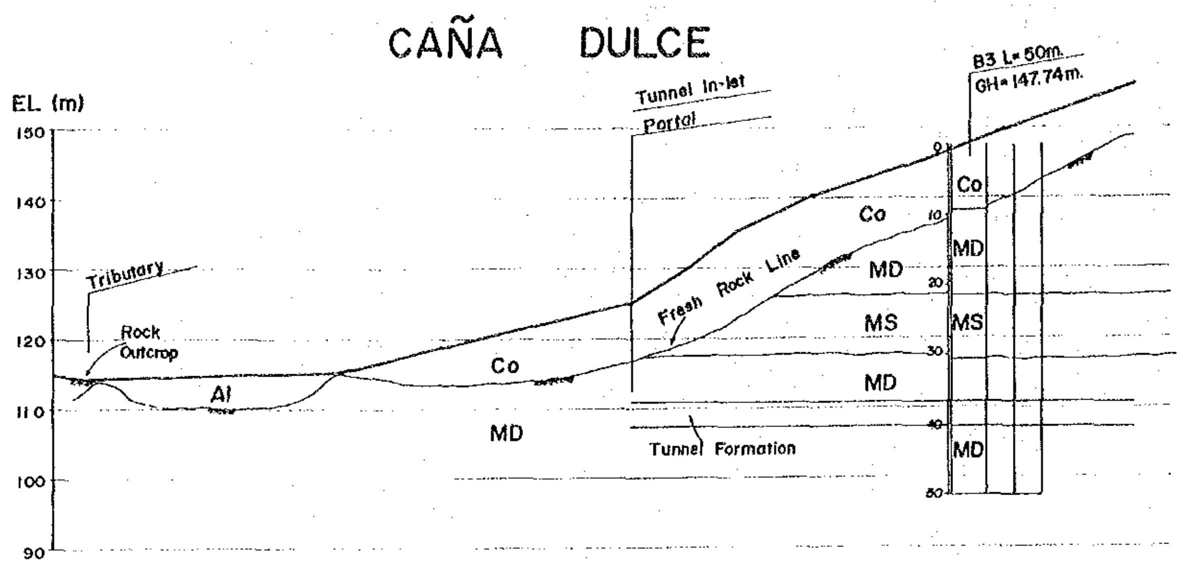


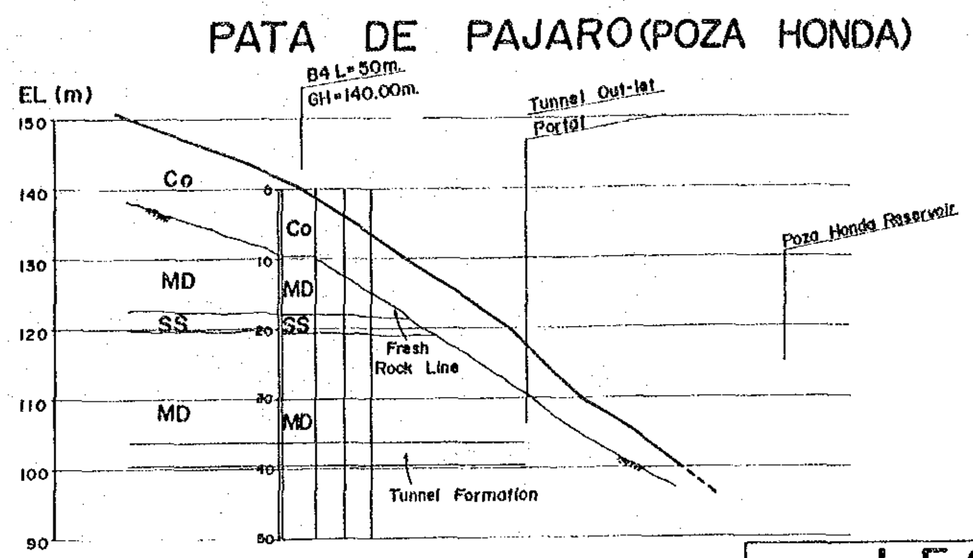
	(POZA HONDA RESERVIOR)		TUNNEL				
	16.000 – 17.000	17.000 – 0.000		1.000 – 2.000 – 3.000		4.000	DISTANCE
	Co & M	Co & WM	OMD Mudstone	OMD Mudstone	OMD Mudstone	Co & WM	ROCK TYPE
	D	D	CL-D	CL-CM	CL	D	(1) ROCK CLASS
	DII	DII	CII	CI	CII	DII	(2) ROCK CLASS
	V	V	IV	IV-III	IV	V	(3) ROCK CLASS
o	10/1.7x30	10/1.7x30	30/1.9x50	60-100/2.0x400	30/1.9x50	10/1.7x30	(4) qu/rh
ec	1.5km/sec	1.5km/sec	2km/sec	2.2km/sec	2.0km/sec	1.5km/sec	P WAVE VELOCITY
n	10kg/cm²	10kg/cm²	30kg/cm²	60-100kg/cm²	30kg/cm²	10kg/cm²	UNCONFINED COMPRESSIVE STRENGTH
/cm²	2.000kg/cm²	2.000kg/cm²	10.000kg/cm²	15.000kg/cm²	10.000kg/cm²	2.000kg/cm²	STATIC ELASTIC MODULUS
	Alittle	Alittle	Alittle	Alittle	Alittle	Alittle	GROUND WATER
/sec	1x10⁻⁴ cm/sec	1x10⁻⁴ cm/sec	1x10⁻⁴ cm/sec	1x10⁻⁵ cm/sec	1x10⁻⁴ cm/sec	1x10⁻⁴	PERMEABILITY
	H125 @=100	H125 @=100	H125 @=100	H125 @=120	H125 @=100	H125 @=100	STEEL SUPPORT
							REMARKS

Figure H.7 Open Channel & Tunnel from Severino, Cana Dulce to Poza Honda, to Mancha Grande Geological Profile

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS

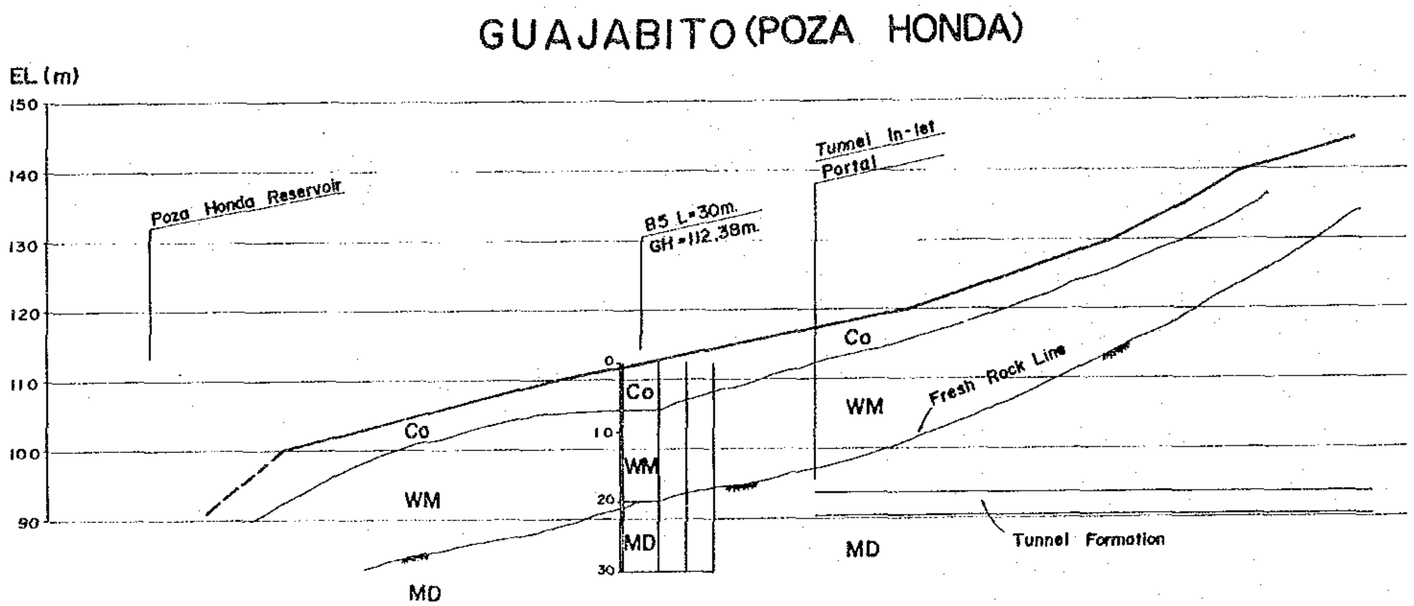
JAPAN INTERNATIONAL COOPERATION AGENCY

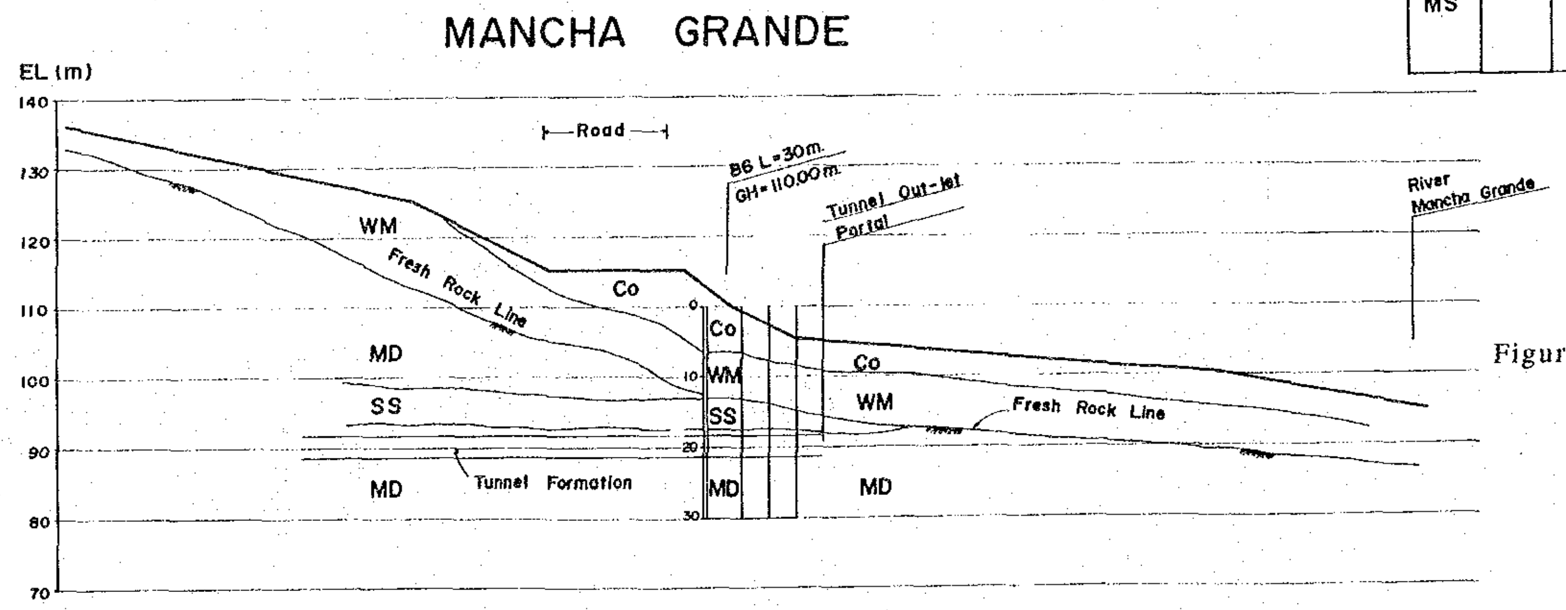




LEGEND

MARK	GEO-TIME FORMATION			ROCK TYPE	PROPERTIES
Al	Quaternary	Alluvial		Sand Gravel	River and Tributary deposit with boulders.
Co	Quaternary	Colluvial		Fine Soil	Talus Deposit Mainly Clay. Soft, Loose.
WM	Neogene Tertiary	Onsole Formation		Clayey Soil	Weathered Mudstone Decomposed into soil.
MD	Neogene Tertiary	Onsole Formation		Mudstone	Massive, silty Mudstone. Soft Rock. partly fractured qu = 45 kg/cm²
SS	Neogene Tertiary	Onsole Formation		Sandstone	Massive, very fine Sandstone Relatively stiff. qu = 70 kg/cm²
MS	Neogene Tertiary	Onsole Formation		Mudstone and Sandstone	Alternation of Mud and Sandstone Soft Rock. qu = 45 kg/cm²





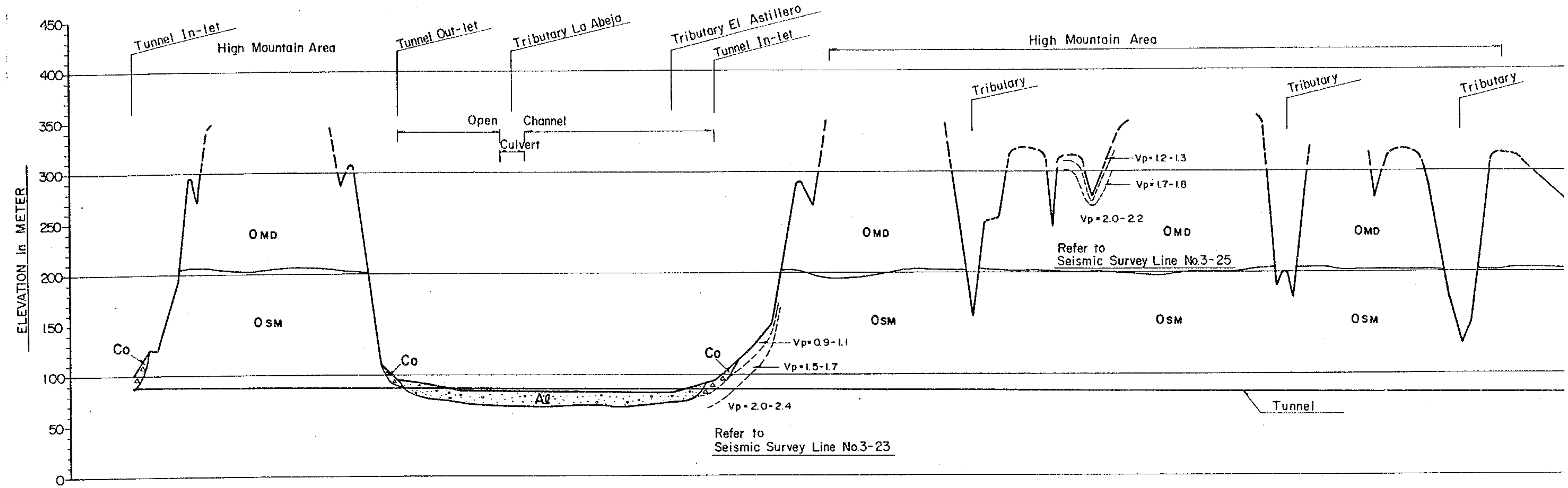
SCALE

0 10 20 30 40 50 (M)

Figure H.8 Tunnel In-let & Out-let from Cana Dulce to Poza Honda and from Poza Honda to Mancha Grande Geological Profile

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS

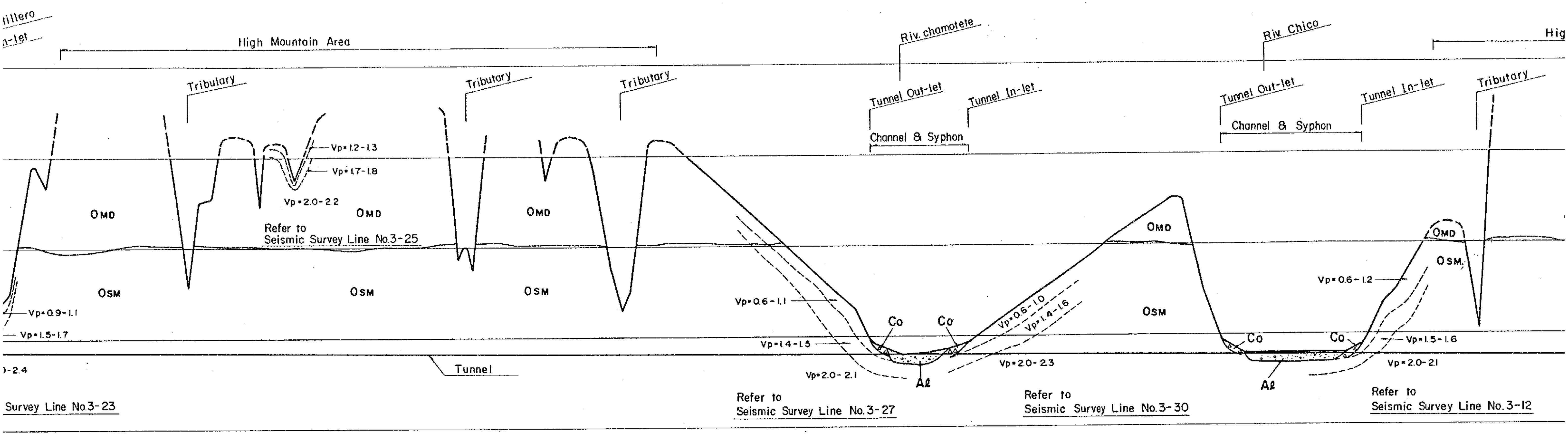
JAPAN INTERNATIONAL COOPERATION AGENCY



		Tunnel		Open Channel		Tunnel	
DISTANCE		0.000 – 200	200 – 1.000 – 2.000 – 400	400 – 560	560 – 3.000 – 4.000 – 5.000 – 660	660 – 900	900 – 6.000 – 7.000 – 8.000 – 9.000 – 10.000 – 11.000 – 12.000 – 13.000 – 14.00
ROCK TYPE		Co & WSM	Colluvium & Weathered Mudstone ← / OSM Mudstone	Co & WSM	Colluvium & Weathered Mudstone ← / Aℓ, Co & WSM Alluvium Colluvium and Weathered Mudstone	Co & WSM	Colluvium & Weathered Mudstone ← / OSM Sandy Mudstone
ROCK CLASS	(1)	D	CL	D	Soil	D	CL
	(2)	DI	CII	DII	Soil	DI	CI
	(3)	V	II - IV	V	I - IV	V	II - IV
(4) qu/rh		←	100/1.7x20 / 1,000/2.0x 300	←	100/1.7x20 / —	←	100/1.7x20 / 1,000/2.0x250
PWAVE VELOCITY		←	1.5 km/sec / 2.3 km/sec	←	1.5km/sec / 0.8 km/sec	←	1.5km/sec / 2.3km/sec
UNCONFINED COMPRESSIVE STRENGTH		←	10kg/cm² / 100 kg/cm²	←	10kg/cm² / 2 - 5 kg/cm²	←	10kg/cm² / 100 kg/cm²
STATIC ELASTIC MODULUS		←	2,000kg/cm² / 12,000 kg/cm²	←	2,000kg/cm² / 200 kg/cm²	←	2,000kg/cm² / 12,000 kg/cm²
GROUND WATER		No	A Little	No	Much (River Plane)	No	A Little
PERMEABILITY		Low	Low	←	Low / High	Low	Low
STEEL SUPPORT		←	H125 @100 / H125 @150	←	H125 @100	←	H125 @100 / H125 @150
REMARKS			Fine grain size. Sandy Mudstone Partly Siltstone.		River deposit and Weathered rock Silty soil dominant.		Partly fine sandstone interlaid

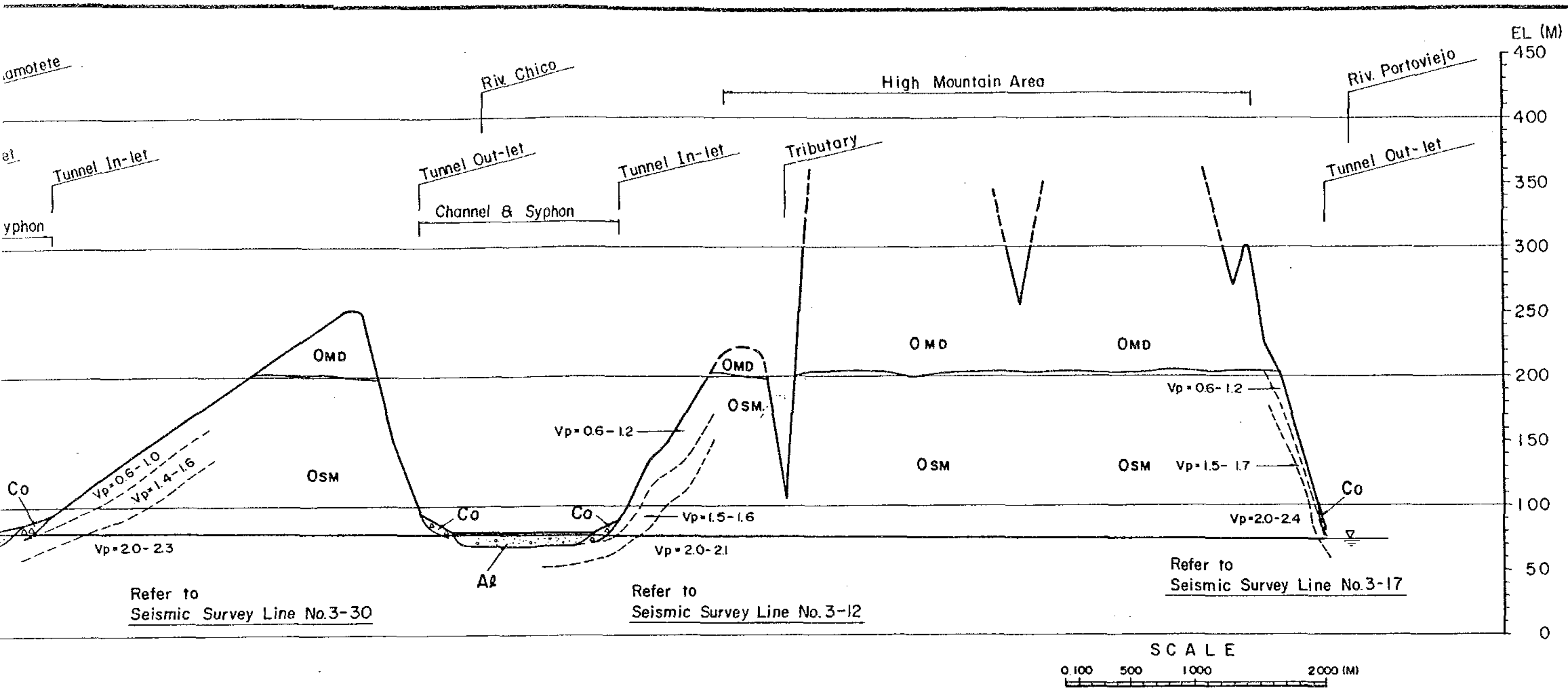
Note: Rock Classification (1) Japanese Standard. (2) Based on the seismic wave velocity (3) Bieniawski's Classification

(4) qu/rh : qu = Unconfined Compressive Strength, rh = Weight of Overburden.



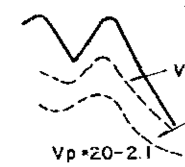
	Tunnel		Channel Syphon		Tunnel		Channel & Syphon		Tu
	7,000 8,000 9,000 10,000 11,000 12,000 13,000 14000 15,000	580 750	16000	840 17,000 200	18000 19,000	660	20000 21,000	22,000 100	22,000 23,000
olluvium & eathered udstone	OSM Sandy Mudstone	Colluvium & Weathered Mudstone Co & WSM	Al, Co & WSM Alluvium Colluvium Weathered Mudstone	Co & WSM	OSM Sandy Mudstone	Co & WSM	Al, Co & WSM Alluvium Colluvium Weathered Mudstone	Co & WSM	OSM Sandy
	CL	D	Soil	D	CL	D	Soil	D	CL
	CI	DI	Soil	DI	CI	DII	Soil	DI	CI
	III - IV	V		V	II - IV	V		V	II - IV
0/1.7x20	1,000/2.0x250	100/1.7x20	–	100/1.7x20	1,000/20x100	100/1.7x20	–	100/1.7x20	1,000/2
5km/sec	2.3km/sec	1.5km/sec	0.8 km/sec	1.5km/sec	2.3km/sec	1.5 km/cec	0.8km/sec	1.5km/sec	2.3 km/
kg/cm^2	100 kg/cm^2	10 kg/cm^2	2-5kg/cm^2	10kg/cm^2	100kg/cm^2	10kg/cm^2	2-5kg/cm^2	10 kg/cm^2	100 kg/c
000kg/cm^2	12,000 kg/cm^2	2,000kg/cm^2	200-500kg/cm^2	2,000 kg/cm^2	12,000kg/cm^2	2,000kg/cm^2	200-500 kg/cm^2	2,000kg/cm^2	12,000
	A Little	No	Much	No	A Little	No	Much	No	A Littl
	Low	Low	High	Low	Low	Low	High	Low	Low
125 100	H125 Φ150	H125 Φ100	–	H125 Φ100	H125 Φ150	H125 Φ100	–	H125 Φ100	H125 Φ150
	Partly fine sandstone interlaid		Silty soil in majority				Fine Soil Major grain Silt.		

assification



LEGEND

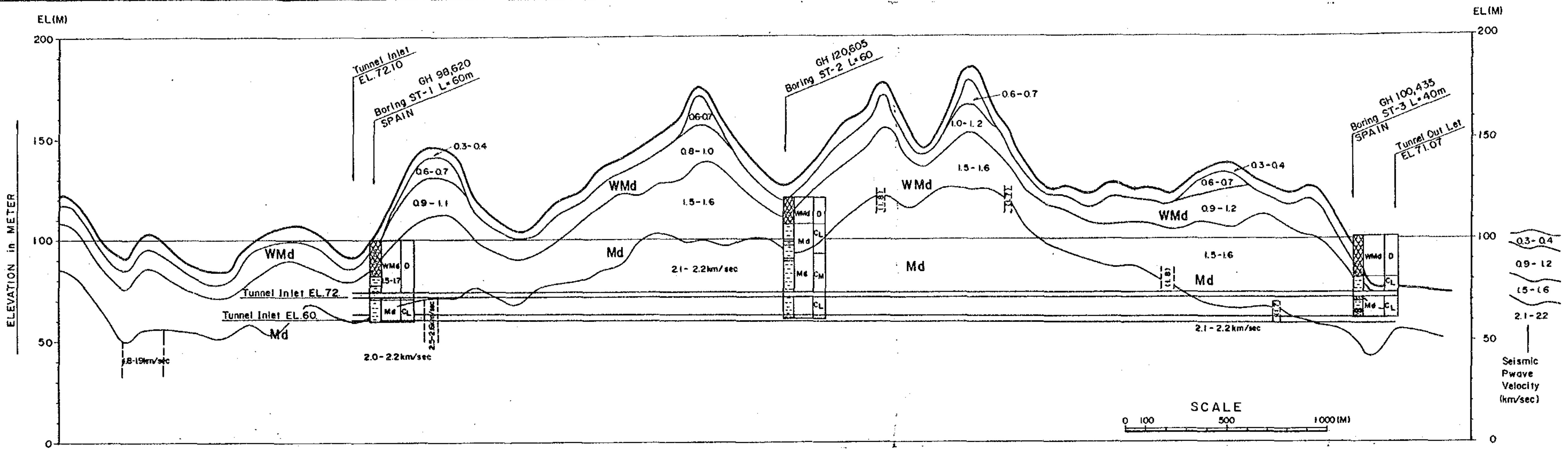
MARK	GEO TIME FORMATION			ROCK TYPE	PROPERTIES
Al	Quaternary	Alluvial		Fine Soil	River and tributary deposit. Silty soil with some gravels.
Co		Colluvial		Fine Soil	Talus deposit. Silty soil with a little amount of boulders.
OMD	Neogene Tertiary	Onsole Formation		Mudstone	Mainly Mudstone. Stratified with very fine sandstone. Horizontal bedding. Soft rock.
OSM				Sandy Mudstone	Mainly Sandy Mudstone. Interlaid with fine sandstone. Soft rock



...nel ...on	16840–17200	Tunnel		Channel & Syphon			Tunnel			
	840 / 17,000 / 200	18000	19,000	660	20000	21,000 / 22,000 / 100	22,000	23,000 / 24,000 / 25,000	26000	500 / 26600
WSM ...xlstone	Co & WSM	OSM Sandy Mudstone		Co & WSM	Al, Co & WSM Alluvium Colluvium Weathered Mudstone	Co & WSM		OSM Sandy Mudstone		Co & WSM
	D	CL		D	Soil	D		CL		D
	DII	CI	DII		Soil		DI	CII	DI	
	V	III - IV		V		V		III - IV	V	
	100/1.7x20	1,000/20x100	100/1.7x20		–		100/1.7x20	1,000/20x300	100/1.7x20	
/sec	1.5km/sec	2.3km/sec	1.5 km/cec		0.8km/sec		1.5km/sec	2.3 km/sec	1.5km/sec	
...²	10kg/cm²	100kg/cm²	10kg/cm²		2-5kg/cm²		10 kg/cm²	100 kg/cm²	10kg/cm²	
.../cm²	2,000 kg/cm²	12,000kg/cm²	2,000kg/cm²		200-500kg/cm²		2,000kg/cm²	12,000 kg/cm²	2,000kg/cm²	
	No	A Little	No		Much		No	A Little	No	
	Low	Low	Low		High		Low	Low	Low	
	H125 @100	H125 @150	H125 @100		–		H125 @100	H125 @150	H125 @100	
...ty					Fine Soil Major grain Silt					

...gure H.9 Diversion Tunnel from Altamira to Portoviejo River. Geological Profile

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

MARK		GEO TIME FORMATION			ROCK TYPE	P WAVE VELOCITY	PROPERTIES
	Al	Quaternary	Alluvial		Fine Soil	0.3-0.4km/sec	Top soil. River and tributary deposit. Silty clay.
	Co	Quaternary	Colluvial		Fine Soil	0.3-0.4km/sec	Talus deposit. Silty clay with angular gravels.
	WMd	Neogene Tertiary		Tosagua	Weathered Mudstone (Fine Soil)	0.6-1.2km/sec	Heavily weathered, decomposed into silty clay. Gypsum stripes are contained. Montmorillonitization.
	Md	Neogene Tertiary		Tosagua	Mudstone	1.5-1.6km/sec	Upper part. Slightly loosened due to slaking action.
						2.1-2.5km/sec	Homogeneous calcalious mudstone. Soft rock.

DISTANCE		0 – 300	300 – 650	650 – 900	900 – 3950 (1000, 1500, 2000, 2500, 3000, 3500)	3950 – 4900 (4000, 4500)	4900 – 5100 (5000)
ROCK TYPE		WMd & Md Weathered Mudstone	Md Mudstone	Md Mudstone	Md Mudstone	Md Mudstone	WMd
ROCK CLASSIFICATION	(1) Japanese Standard	D	CL - CM	CL - D	CL ~ CM	CL	D
	(2) Based on the seismic wave velocity	DI	CI	DII	CI	CI - CII	DII
	(3) Bieniawski's Classification	V	III - IV	V	III ~ IV	IV	V
qu/γh : Compressive strength/ overburden weight		100/1.7x30	600/2.0x60	300/2.0x30	600/ 2.0 x 100	600/ 2.0x50	100/1.7x20
SEISMIC PWAVE VELOCITY		Vp=0.9 - 1.5	Vp = 2.3 - 2.5	Vp = 1.5	Vp = 2.2 km/sec	Vp = 1.6	Vp = 0.9 - 1.2
UNCONFINED COMPRESSIVE STRENGTH		10kg/cm^2	60kg/cm^2	30kg/cm^2	60kg/cm^2	60kg/cm^2	10kg/cm^2
STATIC ELASTIC MODULUS		2,000	12,000kg/cm^2	5,000kg/cm^2	12,000kg/cm^2	10,000kg/cm^2	2,000
GROUND WATER		None	None	None	None	None	None
PERMEABILITY		10^{-5}cm/sec	10^{-5} cm/sec	10^{-5}cm/sec	10^{-5}cm/sec	10^{-5} cm/sec	10^{-5}cm/sec
STEEL SUPPORT		H125 @ 1.0m	H125 @ 1.2m	H125 @ 1.0m	H125 @ 1.5 m	H125 @ 1.2m	H125 @ 1.0m
REMARKS		Loose in the portal		Relatively weathered Loosened		Slightly loose.	Loose

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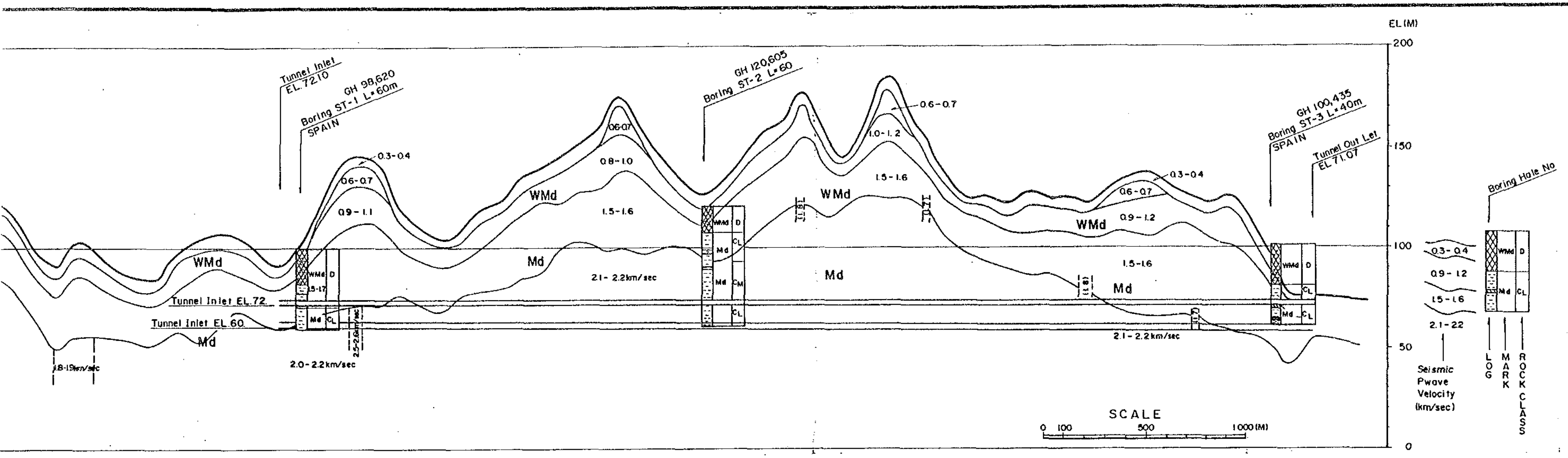


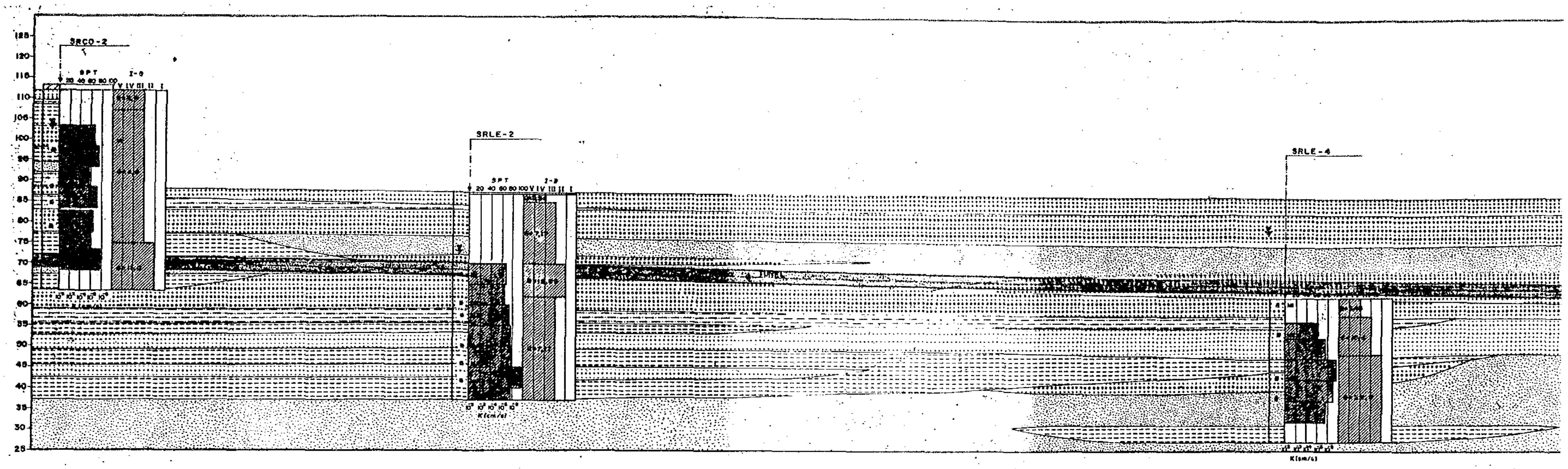
LEGEND

MARK	GEO TIME FORMATION		ROCK TYPE	P WAVE VELOCITY	PROPERTIES
Al	Quaternary	Alluvial	Fine Soil	0.3-0.4km/sec	Top soil. River and tributary deposit. Silty clay.
Co	Quaternary	Colluvial	Fine Soil	0.3-0.4km/sec	Talus deposit. Silty clay with angular gravels.
WMd	Neogene Tertiary	Tosagua	Weathered Mudstone (Fine Soil)	0.6-1.2km/sec	Heavily weathered, decomposed into silty clay. Gypsum stripes are contained. Montmorillonitization.
Md	Neogene Tertiary	Tosagua	Mudstone	1.5-1.6km/sec	Upper part. Slightly loosened due to slaking action.
				2.1-2.5km/sec	Homogeneous calcalious mudstone. Soft rock.

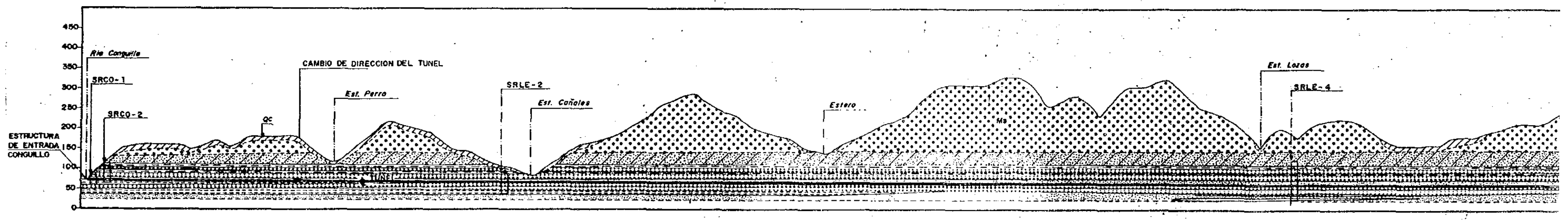
DISTANCE		0 – 300 – 500 – 650	650 – 900	900 – 1000 – 1500 – 2000 – 2500 – 3000 – 3500 – 3950	3950 – 4000 – 4500 – 4900	4900 – 5000 – 5100
ROCK TYPE		WMd & Md Weathered Mudstone	Md Mudstone	Md Mudstone	Md Mudstone	Md Mudstone	WMd
CK ASSIFICATION	(1) Japanese Standard	D	CL - CM	CL - D	CL - CM	CL	D
	(2) Based on the seismic wave velocity	DII	CI	DII	CI	CI - CII	DII
	(3) Bieniawski's Classification	V	III - IV	V	III - IV	IV	V
/rh : Compressive strength/ overburden weight		100/1.7x30	600/2.0x60	300/2.0x30	600/ 2.0 x 100	600/2.0x50	100/1.7x20
ISMIC P WAVE VELOCITY		Vp=0.9-1.5	Vp=2.3-2.5	Vp=1.5	Vp=2.2 km/sec	Vp=1.6	Vp=0.9-1.2
CONFINED COMPRESSIVE STRENGTH		10kg/cm²	60kg/cm²	30kg/cm²	60kg/cm²	60kg/cm²	10kg/cm²
ATIC ELASTIC MODULUS		2,000	12,000kg/cm²	5,000kg/cm²	12,000kg/cm²	10,000kg/cm²	2,000
GROUND WATER		None	None	None	None	None	None
PERMEABILITY		10^{-5}cm/sec	10^{-5} cm/sec	10^{-5}cm/sec	10^{-5}cm/sec	10^{-5} cm/sec	10^{-5}cm/sec
STEEL SUPPORT		H125 @ 1.0m	H125 @ 1.2m	H125 @ 1.0m	H125 @ 1.5m	H125 @ 1.2m	H125 @ 1.0m
REMARKS		Loose in the portal		Relatively weathered Loosened		Slightly loose.	Loose

Figure H.10
Diversion Tunnel in Guarango.
Geological Profile.

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



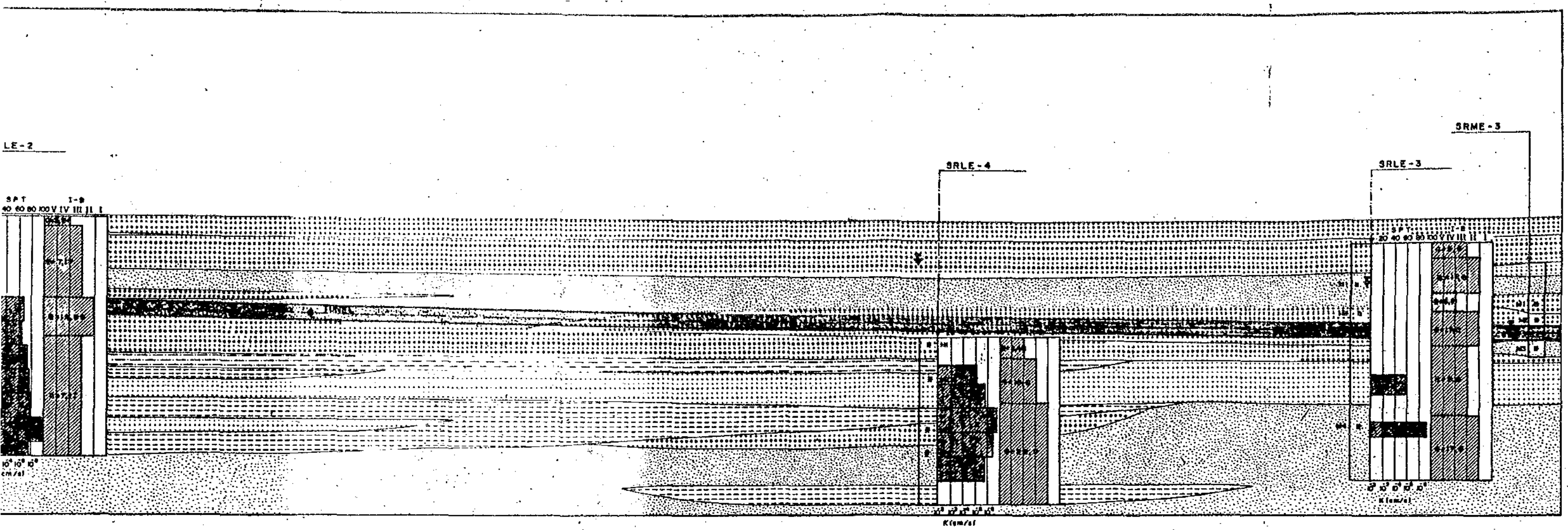
CORRELACION ESTRATIGRAFICA DE LOS SONDEOS
(PROYECTADO A LO LARGO DEL EJE DEL TUNEL)
ESCALAS: HORIZONTAL 1:10 000
VERTICAL 1:500



PERFIL A-A'
(A LO LARGO DEL EJE DEL TUNEL)
ESCALAS HORIZONTAL 1:10 000
VERTICAL 1:5000

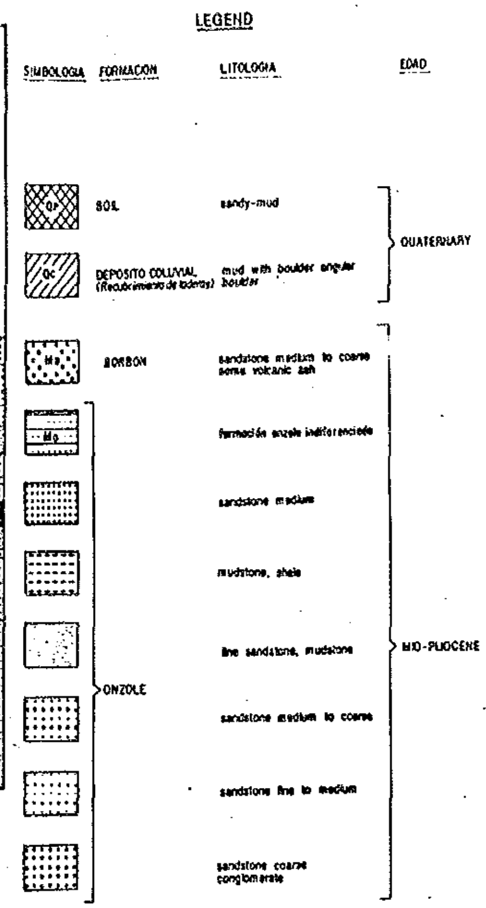
FORMACION GEOLOGICA		O N Z O L E			
LITOLOGIA		Lutita arenosa color gris verdosa existen Niveles de lutita color gris	Intercalación de arenisca de grano fino a muy fino de color gris plomo con clastos milimétricos de roca volcánica	Arenisca de grano medio color gris verdosa	
ESTRUCTURA		Estratificación sub-horizontal de las capas, no existen evidencias de fallas geológicas			
		Existen sistemas de diaclasas: las principales tienen rumbo (N 45° E) y las secundarias (N 140° W) y de la posición vertical con una frecuencia de 5 diaclasas por c/m.	Las juntas tienen una inclinación entre 40° - 45°	Las juntas están inclinadas entre 45° - 60°	Las diaclasas se presentan sub
CLASIFICACION GEOTECNICA		R Q D = 75 % (media a buena)	R Q D = 95 % (excelente)	R Q D = 70 % (media a buena)	RQD
CALIDAD MACIZO ROCOSO	I-B	II (buena)	II (buena)	II (buena)	
	Q	11 (buena)	7 (media)	10 (media-buena)	
PERMEABILIDAD K (cm/s)		1.46×10^{5}	9.13×10^{-5}	9.08×10^{-5}	
REVESTIMIENTO INICIAL					

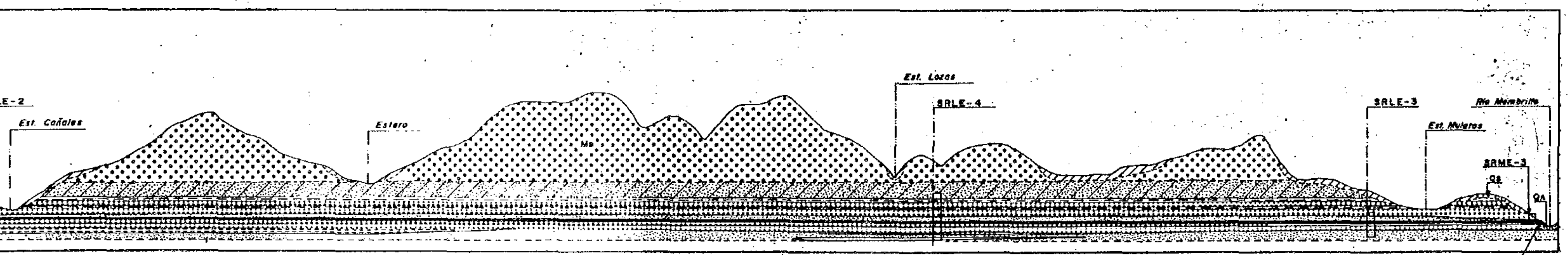
RESUMEN DE CARACTERISTICAS GEOLOGICO-GEOTECNICAS
(A LO LARGO DEL EJE DEL TUNEL)



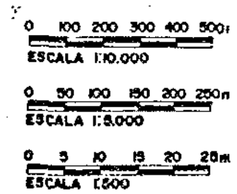
CORRELACION ESTRATIGRAFICA DE LOS SONDEOS
(PROYECTADO A LO LARGO DEL EJE DEL TUNEL)
ESCALAS: HORIZONTAL 1:10.000 VERTICAL 1:500

PERFIL





PERFIL A-A'
(A LO LARGO DEL EJE DEL TUNEL)
ESCALAS HORIZONTAL 1:10 000 VERTICAL 1:5000



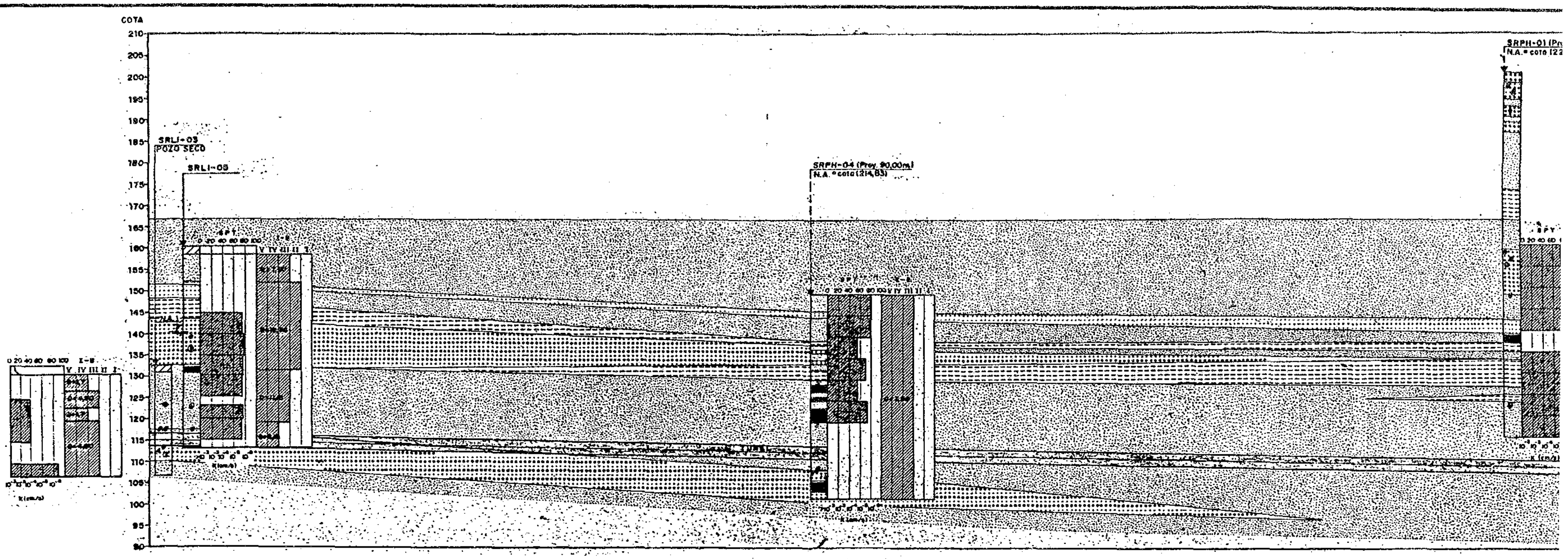
O N Z O L E			
... fino a muy fino de color gris plomo con clastos milimétricos de roca volcánica	Arenisca de grano medio color gris verdosa		Intercalación de arenisca de grano fino a medio
Estratificación sub-horizontal de las capas, no existen evidencias de fallas geológicas			
Las juntas tienen una inclinación entre 40° - 45°	Las juntas están inclinadas entre 45° - 60°	Las diaclasas se presentan sub-verticales	Dos sistemas de diaclasas N85°E N40°W-frecuencia de 7 diaclasas c/10m
RQD = 95% (excelente)	RQD = 70% (media a buena)	RQD = 97% (excelente)	RQD = 77% (media-buena)
(buena)	II (buena)	II (buena)	III (Regular)
(media)	10 (media-buena)	17 (buena)	5.8 (media)
13 x 10^{-5}	9.06 x 10^{-5}	1.5 x 10^{-4}	2 x 10^{-8}

RESUMEN DE CARACTERISTICAS GEOLOGICO-GEOTECNICAS
(A LO LARGO DEL EJE DEL TUNEL)

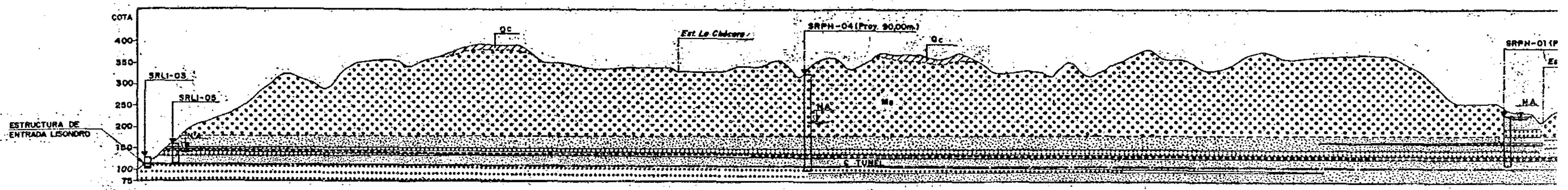
Figure H.11
Diversion Tunnel from
Daule-Peripa to La Esperanza
Geological Profile

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY



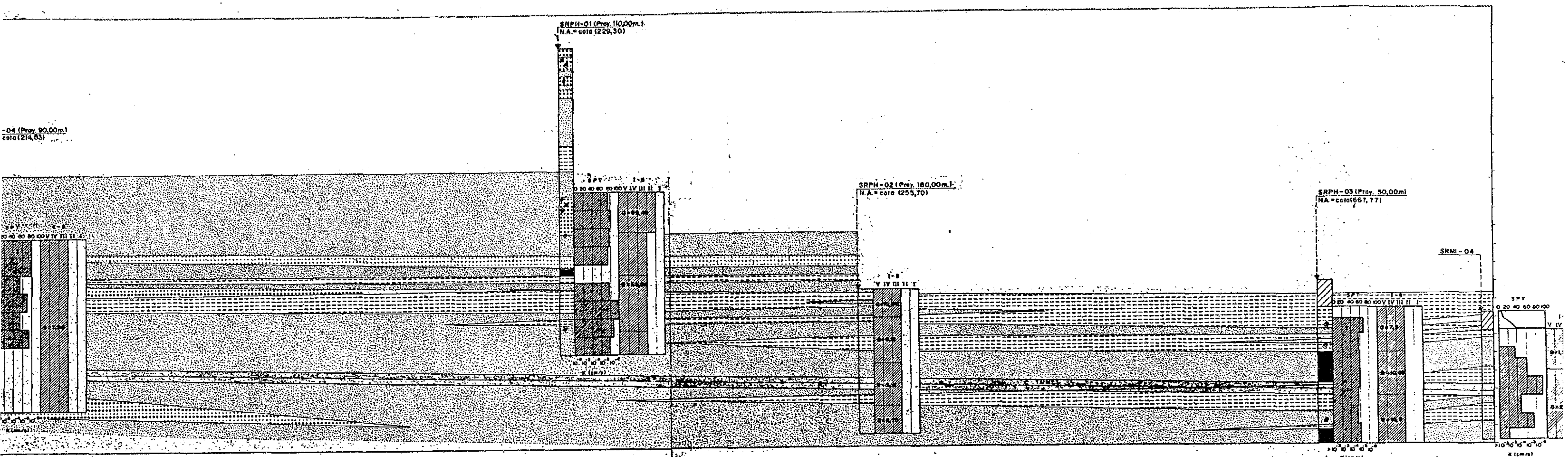
CORRELACION ESTRATIGRAFICA DE LOS SONDEOS
(PROYECTADO A LO LARGO DEL EJE DEL TUNEL)
ESCALAS: HORIZONTAL 1:10.000
VERTICAL 1:500



PERFIL A - A'
(A LO LARGO DEL EJE DEL TUNEL)
ESCALAS: HORIZONTAL 1:10.000
VERTICAL 1:5.000

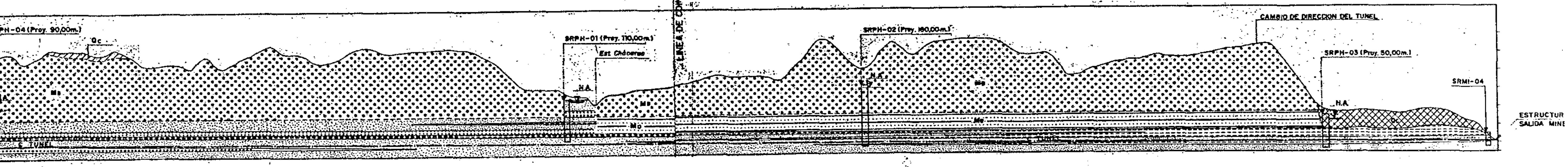
GEO FORMATION	FORMACION GEOLOGICA			ONZOLE	
ROCK TYPE	LITOLOGIA		Arenisca de grano medio a grueso con niveles milimétricos de limolita y lutita y restos de conchas (fósiles) mudy sandstone	Arenisca de grano fino, gris green con fragmentos lithic (de roca volcánica y con niveles fosilíferos Fine sandstone,partly volcanic frequents) (litarenita volcánica fina)	
STRUCTURE	ESTRUCTURA			Stratified layer sub-horizontal de las layer, no existen evidencias de fault geológicas stratified, No fault	a little predominant inclination
			Las juntas están inclinadas entre 30° - 45°	Escasas, predominan las inclinaciones 40° a 65°	Escasos, predominan las inclinac
ROCK CLASS	CLASIFICACION GEOTECNICA		RQD = 60 % (mala-media) poor to medium	80% (buena) good	55% (medi
ROCK QUALITY	CALIDAD MACIZO ROCOSO	I-B	IV (mala) poor III (regular)	III (regular)	III (regul
		Q	4 - 6 (roca media) medium	7-6 (media) medium	35 (buer
PERMEABILITY	PERMEABILIDAD K (cm/seg.)		$2,36 \times 10^{-5}$	10^{-5} (promedio) average	10^{-5} (p
FIRST LINING	REVESTIMIENTO INICIAL				

SUMMARY OF CHARECTERISTIC OF GEOLOGY
(A LO LARGO DEL EJE DEL TUNEL)



GRAFICA DE LOS SONDEOS
RGO DEL EJE DEL TUNEL)
ZONTAL 1:10.000
TICAL 1:500

CORRELACION ESTRATIGRAFICA DE LOS SONDEOS
(PROYECTADO A LO LARGO DEL EJE DEL TUNEL)
ESCALAS: HORIZONTAL 1:10.000
VERTICAL 1:500



– A'
TUNEL)
10.000
5.000

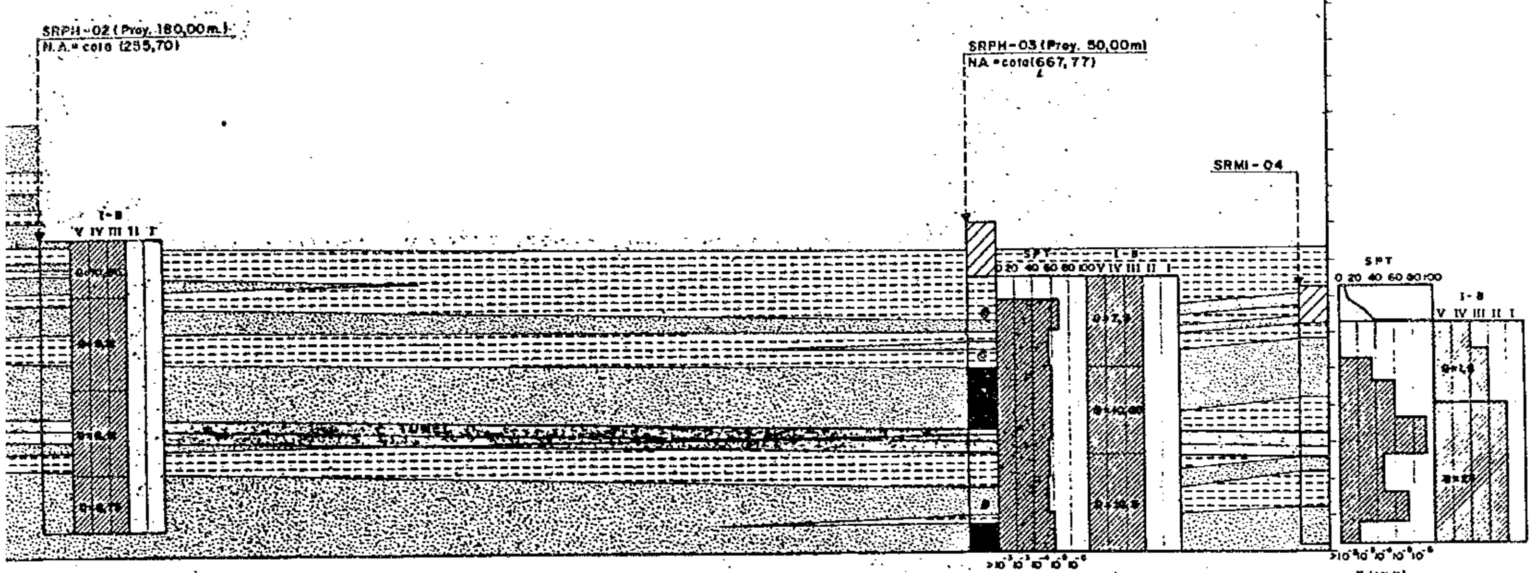
PERFIL A' – A''
(A LO LARGO DEL EJE DEL TUNEL)
ESCALAS: HORIZONTAL 1:10.000
VERTICAL 1:5000

E		O N Z O L E		
...mentos lithic (de rocas volcánicas y con niveles fosilíferos Fine sandstone,partly volcanic frequents) ...lcánicos fine)			mudstone	Limolita subcuarzosa, fosilífera color verdosa
...o existen evidencias de fault geológicas stratified, No fault	a little predominant inclination	Estratificación sub-horizontal de las capas no existe evidencias de fallas geológicas		
...s inclinaciones 40° a 65°	Escasas, predominan las inclinaciones de 45° a 75°	...as de 45° a 75° Escasas, predominan las inclinaciones de 60° y 90°	Escasas, predominan las inclinaciones de 60° y 90°	Escasas, predominan las inclinaciones mayores a 70°
...ena) good	55% (medio) medium	75% (buena) good	80% (buena) good	90% (buena) good
	III (regular)	III (regular)	III (regular)	II (buena) good
...) medium	35 (buena) good			24 (buena)
...edio) average	10^{-5} (promedio) average		10^{-5} (promedio)	10^{-5} (promedio)

...ECTERISTIC OF GEOLOGY
...O LARGO DEL EJE DEL TUNEL)

SUMMARY OF CHARECTERISTIC OF GEOLOGY
(A LO LARGO DEL EJE DEL TUNEL)

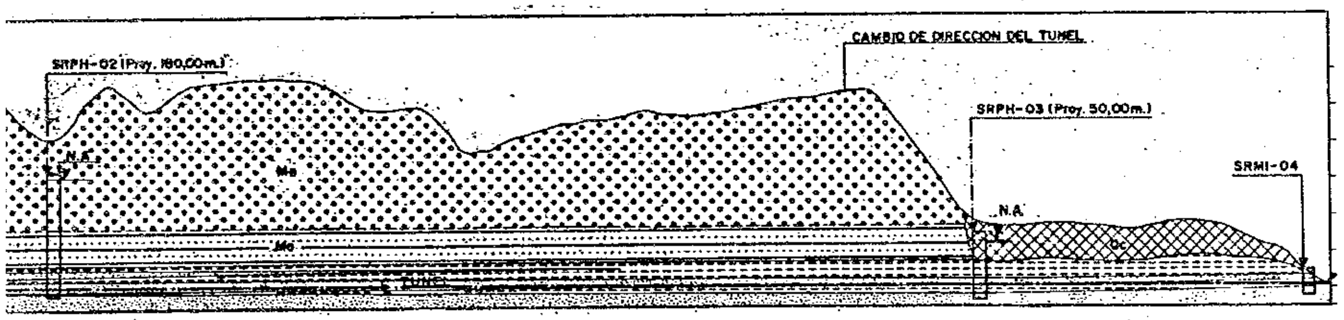
Figure H



CORRELACION ESTRATIGRAFICA DE LOS SONDEOS

(PROYECTADO A LO LARGO DEL EJE DEL TUNEL)

ESCALAS: HORIZONTAL 1:10.000 · VERTICAL 1:500



PERFIL A'-A''

(A LO LARGO DEL EJE DEL TUNEL)

ESCALAS: HORIZONTAL 1:10.000 · VERTICAL 1:5000

ONZOLE		
	mudstone	Limolita subcuarzosa, fosilifera color verdosa
Estratificación sub-horizontal de las capas no existe evidencias de fallas geológicas		
...cosas, predominan las inclinaciones de 60° y 90°	Escasas, predominan las inclinaciones de 60° y 90°	Escasas, predominan las inclinaciones mayores a 70°
75% (buena) good	80% (buena) good	90% (buena) good
III (regular)	III (regular)	II (buena) good
		24 (buena)
	10^{-6} (promedio)	10^{-5} (promedio)

...UMMARY OF CHARECTERISTIC OF GEOLOGY

(A LO LARGO DEL EJE DEL TUNEL)

PERFIL

LEGEND
LEYENDA

SIMBOLOGIA	FORMACION	LITOLOGIA	EDAD
Qp	SOIL	sandy-mud	QUATERNARY
Qc	DEPOSITO COLUVIAL (Recubrimiento de laderas)	mud with boulder angular boulder	QUATERNARY
Ma	BORBON	sandstone medium to coarse some volcanic ash	MIO-PLIOCENE
Mo	ONZOLE	formación onzole indiferenciado	MIO-PLIOCENE
	ONZOLE	sandstone medium	MIO-PLIOCENE
	ONZOLE	mudstone, shale	MIO-PLIOCENE
	ONZOLE	fine sandstone, mudstone	MIO-PLIOCENE
	ONZOLE	sandstone medium to coarse	MIO-PLIOCENE
	ONZOLE	sandstone fine to medium	MIO-PLIOCENE
	ONZOLE	sandstone coarse conglomerate	MIO-PLIOCENE

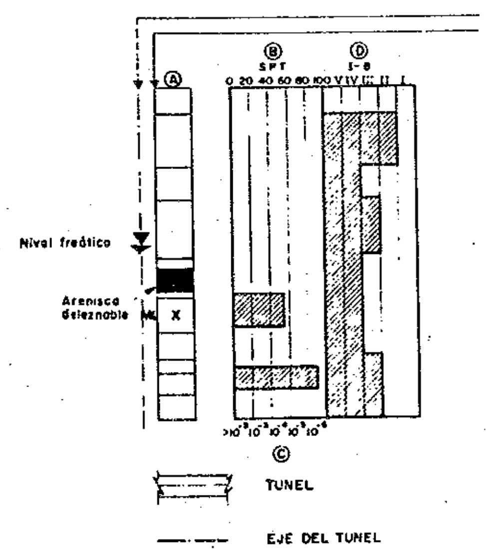
SIMBOLOGIA

——— Contacto geológico comprobado

– – – Contacto geológico inferido

Eje del sondeo proyectado

Eje del sondeo



(A) Litologia (Ver símbolos)

(B) Ensayos SPT (números de golpes)

(C) Ensayos de permeabilidad (K en cm/s)

(D) Clasificación geomecánica de rocas según Bieniawsky I-B
- Clase V – Suelo y roca descompuesta
- Clase IV – Roca con alteración alta y media
- Clase III.– Roca con alteración media
- Clase II – Roca sana
- Clase I – Roca muy sana (excelente)

(Q) Indice de calidad geomecánica de rocas según Barton

Cambio probable de características geológicas geotécnicas

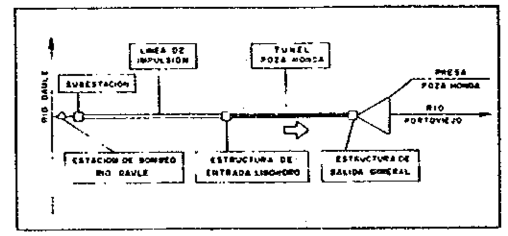
M1 TOMA DE MUESTRAS

NOTAS:

1- DIMENSIONES Y COTAS EN METROS
2- LA CORRELACION DE LOS ESTRATOS SON INDICATIVOS, BASADOS EN LO DATOS DE SONDEOS PRESENTADOS.
3- LOS NIVELES FREATICOS SON DATOS DE SEPTIEMBRE DE 1986.

PLANOS AFINES:

TRAZADO GEOMETRICO RLOIC-GL3-301
GEOLOGIA PLANTA RLOIC-GL3-302
GEOLOGIA PERFIL RLOIC-GL3-303



PLANTA CLAVE
SIN ESCALA

Nº	REVISADO	POR	APROB	APROB	FECHA
0	EMISION INICIAL				9/86

MODIFICACIONES

APROBADO		
APROBADO		9/86
COMPROBADO		9/86
PROYECTADO		9/86
DIBUJADO	FTBS	9/86
APROBACIONES		FECHA

CONSORCIO ECUATORIANO - BRASILEÑO

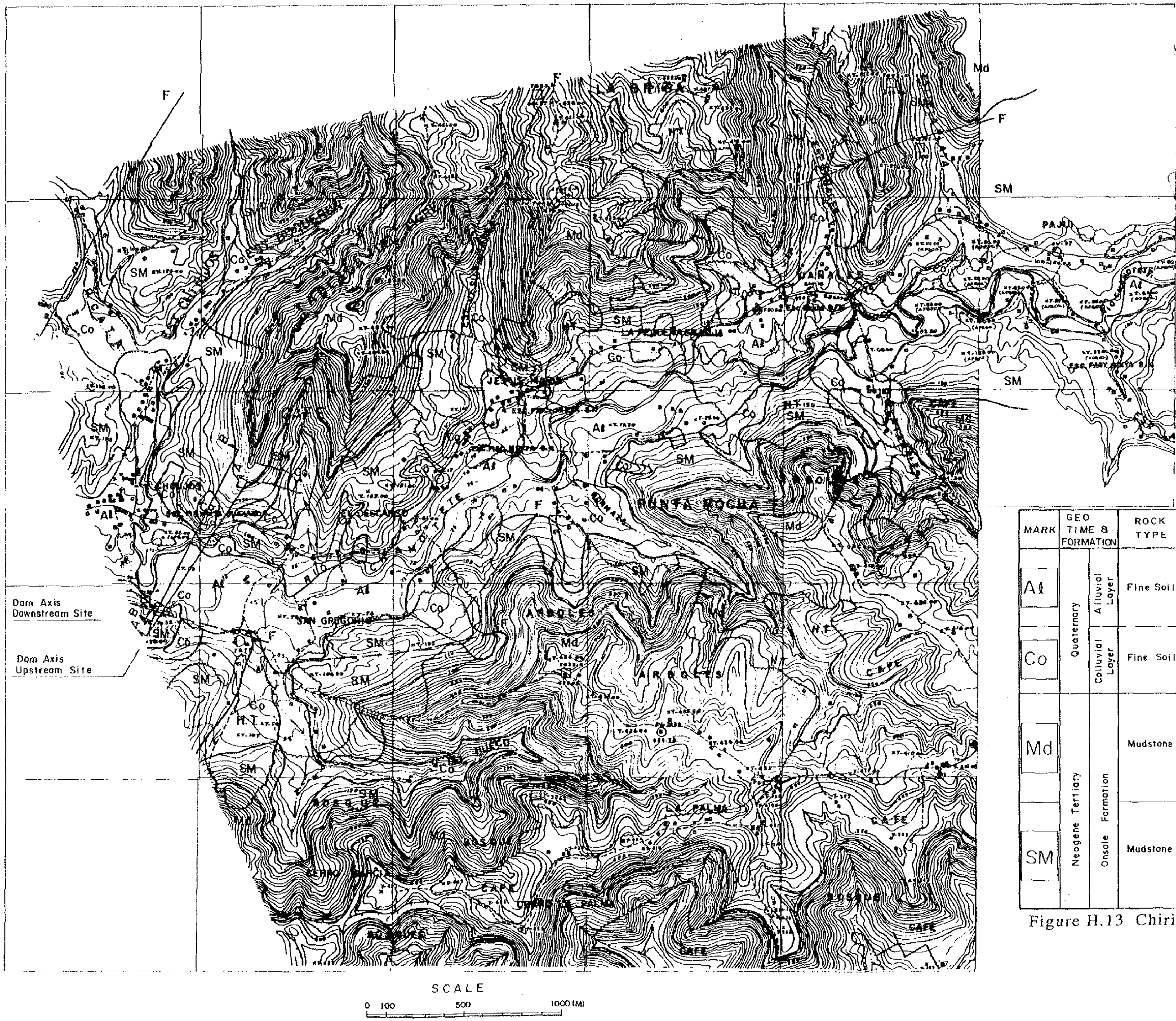
REPUBLICA DEL ECUADOR
MINISTERIO DE AGRICULTURA Y GANADERIA
CRM
CENTRO DE REHABILITACION DE MANABI

TRASVASE DEL RIO DAULE A LOS EMBALSES DE POZA HONDA Y LA ESPERANZA

Figure H.12 Diversion Tunnel from Downstream of Daule-Peripa to Poza Honda.
Geological Profile

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

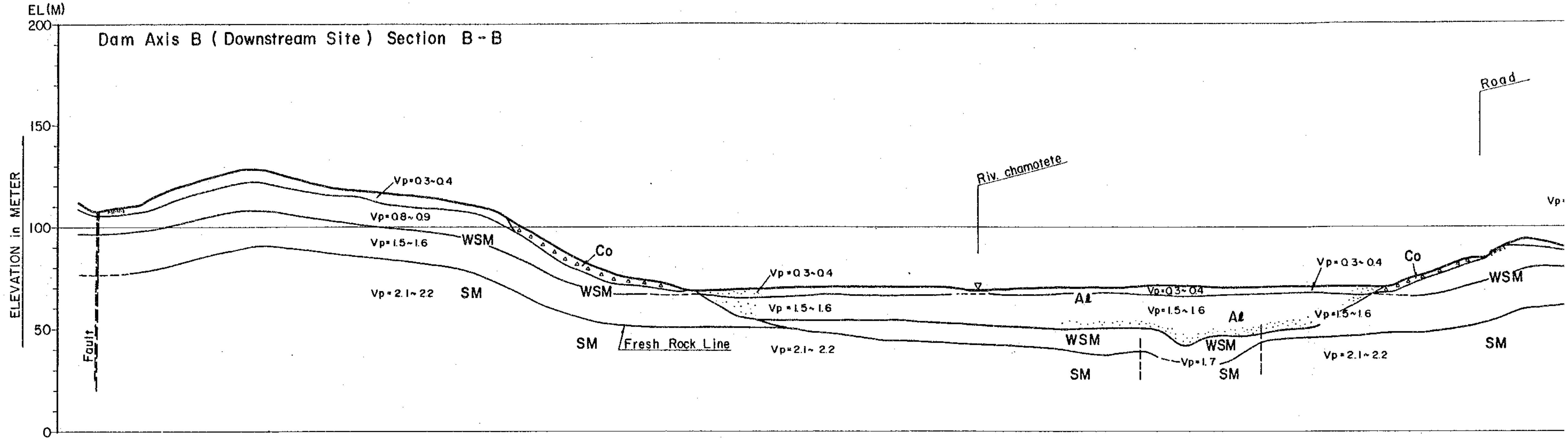
Cliff and Collarpsible Slope

F — Lineament, Fault

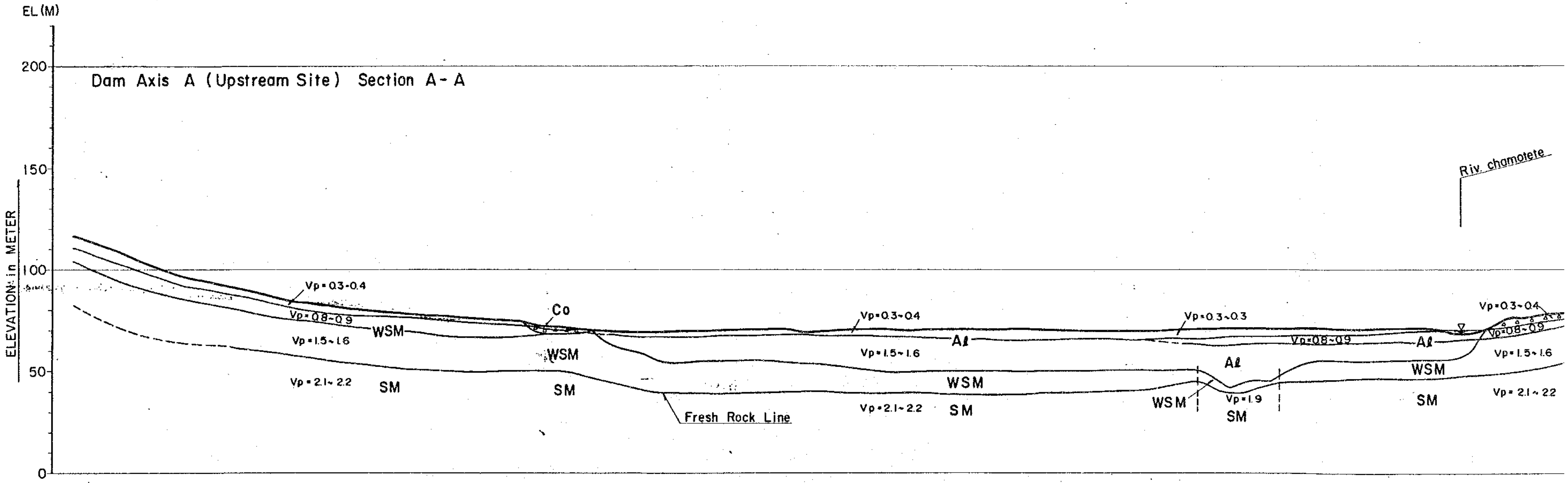
MARK	GEO TIME & FORMATION		ROCK TYPE	CLASS	PROPERTIES
Al	Quaternary	Alluvial Layer	Fine Soil	Soil	River deposit. Terrace deposit. and/or Debri of Tributary. Main composition is silty clay. Sand and gravel are a little.
Co	Quaternary	Colluvial Layer	Fine Soil	Soil	Talus deposit. Silty soil is main composition. Accompanied with angular boulders.
Md	Neogene Tertiary	Onsole Formation	Mudstone	CL	Mudstone and Siltstone. Stratified structure. Soft rock. qu = 60~100kg/cm² Es = 10,000kg/cm² K = 1 x 10⁻⁵ cm/sec.
SM	Neogene Tertiary	Onsole Formation	Mudstone	CL	Sandy Mudstone. Partly fine sandstone is interlaid. Soft rock qu = 100kg/cm² ±. Es = 12,000kg/cm² K = 1 x 10⁻⁴ ~ 1 x 10⁻⁵ cm/sec

Figure H.13 Chirijos Dam Site. Geological Plan.

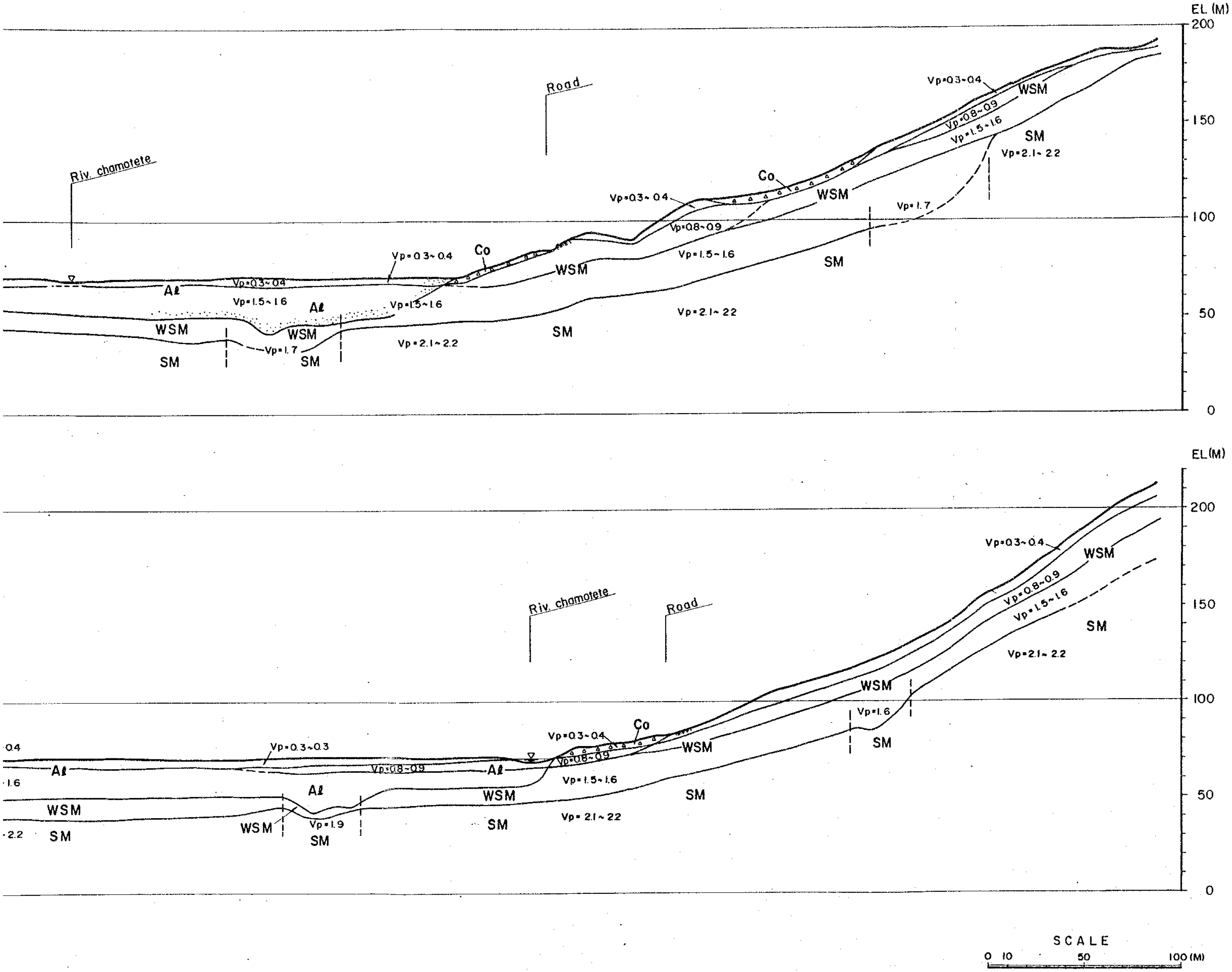
GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY



EL(M)
200
150
100
50
0
ELEVATION in METER
Dam Axis B (Downstream Site) Section B - B
Road
Riv. chamotete
Vp=0.3~0.4
Vp=0.8~0.9
Vp=1.5~1.6
WSM
Co
Vp=2.1~2.2
SM
Fault
Fresh Rock Line
Vp=0.3~0.4
Vp=1.5~1.6
Vp=2.1~2.2
Aℓ
WSM
Vp=1.7
Vp=2.1~2.2



EL(M)
200
150
100
50
0
ELEVATION in METER
Dam Axis A (Upstream Site) Section A - A
Riv. chamotete
Vp=0.3~0.4
Vp=0.8~0.9
Vp=1.5~1.6
WSM
Co
Vp=2.1~2.2
SM
Fresh Rock Line
Aℓ
Vp=0.3~0.3
Vp=0.8~0.9
Vp=1.9
Vp=2.1~22



LEGEND

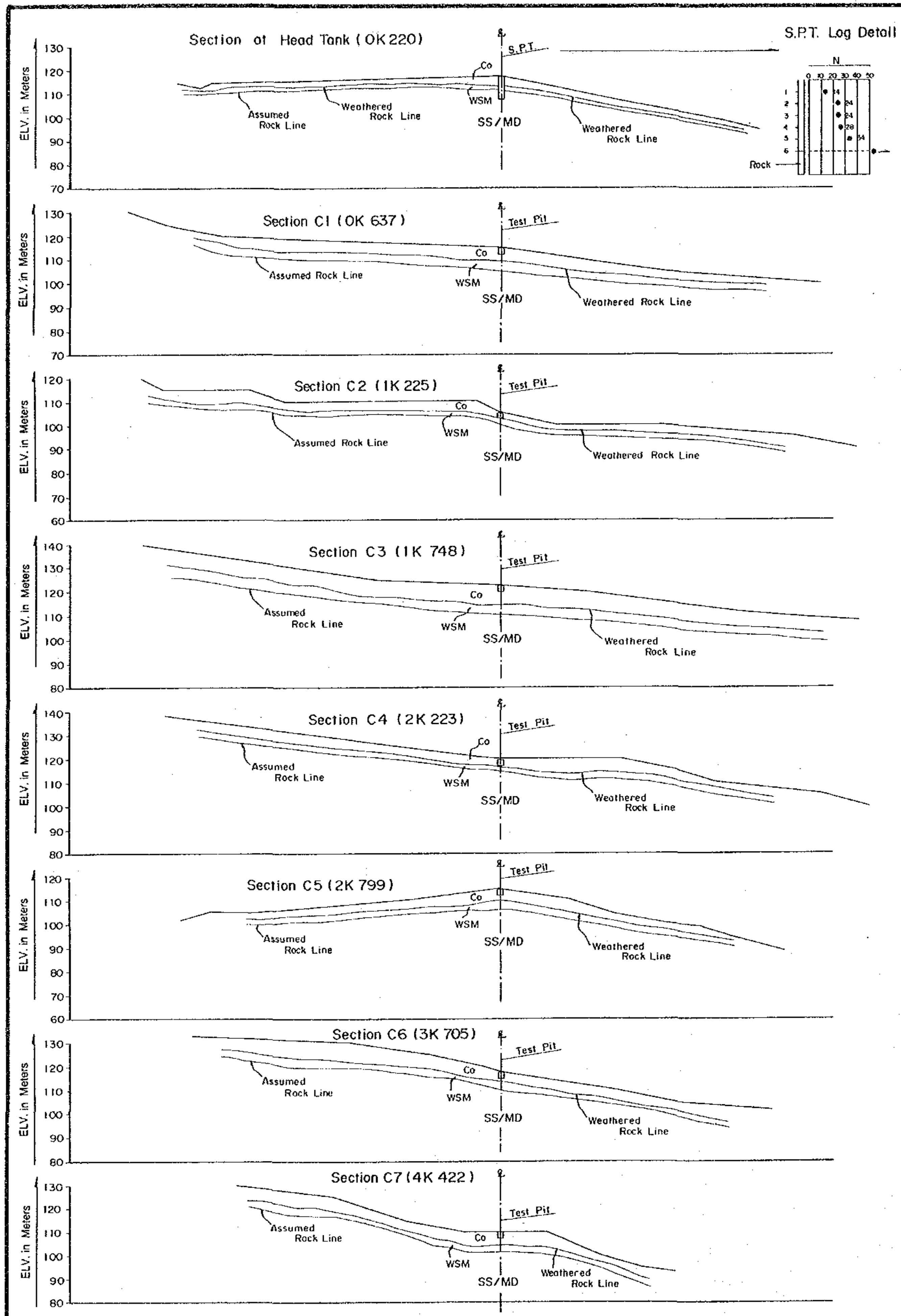
MARK	GEO TIME	FORMATION	ROCK TYPE	CLASS	PROPERTIES
Aℓ	Quaternary	Alluvium	Fine Soil		River deposit. Silty clay in majority. 15~20m in thickness.
Co	Quaternary	Colluvials	Fine Soil		Talus deposit. Silty clay with a little amount of boulders.
WSM	Neogene Tertiary	Onsole Formation	Weathered Mudstone	D	Weathered sandy mudstone. Loose and soft. qu=10~20kg/cm² K=1x10⁻⁴cm/sec
SM	Neogene Tertiary	Onsole Formation	Mudstone	CL	Sandy mudstone. Partly fine sandstone is interlaid. Soft rock. qu=60~100kg/cm² Es=11,000kg/cm² K=1x10⁻⁴cm/sec

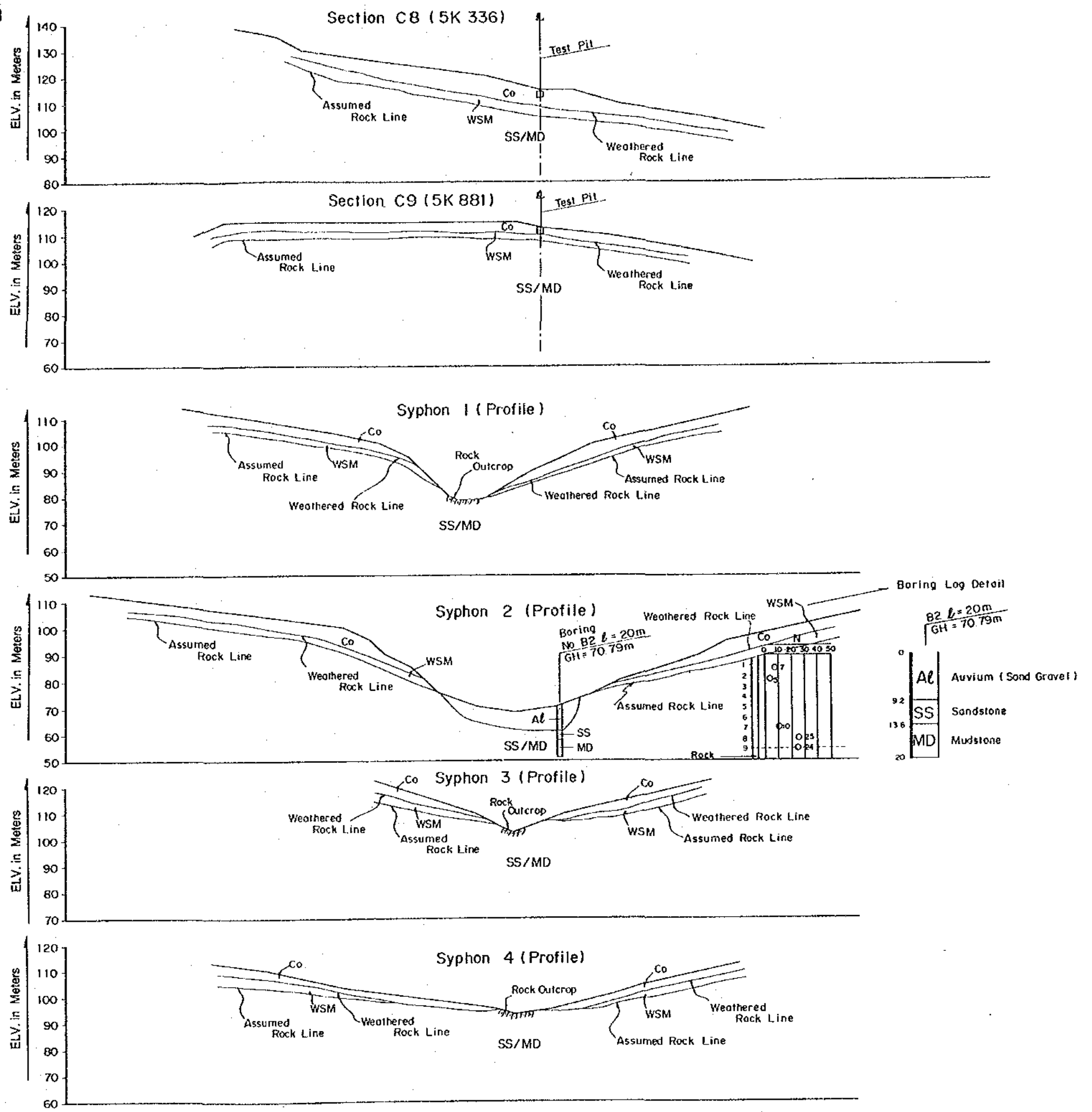
Vp=0.3~0.4
Vp=0.8~0.9
Vp=1.5~1.6
Vp=2.1~2.2

Velocity of seismic P wave (km/sec)

Figure H.14 Chirijos Dam Site. Geological Profile.

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY





LEGEND

Aℓ	Alluvium Sand, Gravel, Boulder.
Co	Colluviam Clayey Soil
WSM	Weathered Rock (Sandstone Mudstone)
SS/MD	Base Rock Sandstone and / or Mudstone.

Section C1 (1K 225)
Distance

SCALE

0 10 50 100 (M)

Figure H.15 Open Channel & Syphon from Severino to Cana Dulce. Geological Section

GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE FEASIBILITY STUDY ON THE WATER RESOURCES DEVELOPMENT FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

Annex I

HYDRAULICS AND STRUCTURAL DESIGN

ANNEX I HYDRAULICS AND STRUCTURAL DESIGN

TABLE OF CONTENTS

List of Tables

List of Figures

1. INTRODUCTION

In the Phase I Study, six (6) alternatives of the water transbasin plan were studied and Alternative-5 was selected as a most promising plan through the cost comparative study.

Afterwards, the route of water transbasin for Alternative-5 was reviewed and Alternative-5a was chosen as a most economical plan in the former part of Phase II Study. Bedsides, more detailed water balance study, and additional investigation and tests were carried out to provide the technical data and information necessary for the basic design. Based on such technical data and information above, the basic design of Alternative-5a was prepared. The study items undertaken in the Phase I and Phase II Studies are presented as follows:

(1) Study items in the Phase I Study

<u>Former part in Ecuador</u>
(from the beginning of November to the end of November in 1991)
- Data collection and review
- Field investigation
- Preliminary study of water transbasin schemes
- Study on criteria for the preliminary design

<u>Latter Part in Japan</u>
(from the beginning of December in 1991 to the end of February in 1992)
- Layout plan study
- Study on hydraulic calculation
- Preliminary design
- Estimate of work quantities of the structures

(2) Study items in the Phase II Study

<u>Former part in Ecuador</u>
(from the beginning of July to the middle of August in 1992)
- Field investigation
- Revise of water transbasin route and type
- Study on criteria for basic design
- Hydraulic design

Latter part in Japan

(from the middle of August to the middle of October in 1992)

- Basic design
- Estimate of work quantities of the structures

General features of the selected Alternative-5a is listed as follows:

(1) Daule Peripa-Esperanza dam water transbasin scheme

- Tunnel ($Q = 18\ m^3/s$)
  L = 8.3 km
  D = 3.7 m (Standard horse-shoe (2R) section, free flow type)

(2) Esperanza dam (Severino) - Poza Honda dam water transbasin scheme

- Pumping station

Total discharge	:	$16.0\ m^3/s$
Total head (Max.)	:	76.0 m
Nos. of pump planned	:	5
Nos. of standby pump	:	1
Discharge of 1 pump	:	$192\ m^3/min$ ($3.2\ m^3/s$)
Type	:	Double suction volute type
Length of pipeline	:	250 m
Lane	:	2 lanes
Diameter of pipeline	:	2,100 mm

- Head tank
  B = 12 m
  L = 18 m

- Open channel ($Q = 16.0\ m^3/s$)
  L = 5.4 km (I = 1/3,000)
  Trapezoidal, B = h = 2.2 m

- Syphon (Q = 16.0 m^3/s)

L1 = 62 m ,	hp = 13 m	(B = H = 2.9m, Concrete box culvert)
L2 =225 m ,	hp = 38 m	(D = 3,200 mm concrete pipe)
L3 = 325 m ,	hp = 47 m	(- do -)
L4 = 55 m ,	hp = 7 m	(B = H = 2.9 m, Concrete box culvert)
L5 = 50 m ,	hp = 10 m	(- do -)
L6 =189 m ,	hp = 20 m	(- do -)

- Tunnel (Q = 16.0 m^3/s)
  L = 10.7 km (I = 1/1,500)
  D = 3.5 m (Standard horse-shoe (2R) section, free flow type)

(3) Poza Honda-Mancha Grande river water transbasin scheme

- Tunnel (Q = 4.0 m^3/s)
  L = 3.9 km
  D = 2.5 m (Standard horse-shoe (2R) section, free flow type)

2. PRELIMINARY DESIGN IN THE PHASE I STUDY

2.1 Data Collection and Review

Data collection was conducted related to the preliminary design from INERHI, CRM and other agencies concerned. Reports and engineering drawings of the structures on water transbasin projects were reviewed as presented in Table I. 1.

2.2 Field Investigation

2.2.1 Structures identified

The field investigations were undertaken to identify the conditions of existing and planned structures as listed below. General features of major dam projects are summarized in Table I. 2.

(1) Dam (existing, under construction, and planned)

- (a) Daule Peripa (existing)
- (b) Esperanza (under construction, started in May 1992)
- (c) Poza Honda (existing)
- (d) Chirijos (planned in Alternatives-1,2 and 4)

(2) Intake and Pumping Station (planned)

- (a) Esperanza - Poza Honda (9 m^3/sec for Alt.-1 and 10 m^3/sec for Alt.-5)
- (b) Esperanza - Rio Portoviejo (12 m^3/sec for Alt.-3)
- (c) Amarillos - Guarango
  (5 m^3/sec for Alt.-1,2,3,5 and 6, and 15 m^3/sec for Alt.-4)
- (d) Rio Daule - Poza Honda (9 m^3/sec for Alt.-2 and 10 m^3/sec for Alt.-6)

(3) Tunnel (including head tank, planned)

- (a) Daule Peripa - Esperanza (8.3 km for Alt.-1,2,3,4,5 and 6)
- (b) Rio Daule - Poza Honda (11.2 km for Alt-2 and 6)
- (c) Esperanza(Severino) - Poza Honda (10.7 km for Alt.-1 and 5)
- (d) Esperanza(Altamira) - Rio Portoviejo (21.0 km for Alt.-3)
- (e) Amarillos - Guarango (6.6 km for Alt.-1,2,3,4,5 and 6)
- (f) Poza Honda- Rio Mancha (4.0 km for Alt.-5 and 6)

(4) Open Channel and Syphon (planned)

(a) Esperanza - Poza Honda Scheme (for Alt.-1 and 5)

(b) Esperanza - Rio Portoviejo Scheme (for Alt.-3)

(c) Esperanza - Guarango Scheme (for Alt.-1,2,3,4,5 and 6)

(d) Guarango - Rocafuerte - Portoviejo Scheme (for Alt.-4)

Of these, site conditions of the planned structures from the view points of topography, geology and others to be considered for the preliminary design were investigated.

2.2.2 Site conditions

(1) Access to the sites

There are three (3) national highways and several provincial roads in the project area. The highways of "Manta-Portoviejo-Quito", "Manta-Quevedo" and "Manta-Guayaquil" are major trunk routes for inland transportation towards the north, east and south, while the provincial roads connect with the major cities and towns such as Portoviejo, Santa Ana, Rocafuerte, Calceta , Tosagua, Chone, etc.. These major road networks were constructed and are being maintained by the Ministry of Public Works. The maintenance conditions of these roads seem to be fair with paving.

(2) Topography

Hilly area with an elevation of around 400 - 600 m runs between the south and north in the central zone of the Province of Manabi and makes boundary of the west and east areas.

The project area located in the central west area of the Province of Manabi covers the Chone and Portoviejo river basins, having the areas of 2,811 km^2 and 2,060 km^2.

(3) Geology

The project area is geomorphologically classified into four(4) areas. They are (1) plain and moderate hilly areas formed in Quaternary era, (2) sedimentary area composed of Onzole, Borbon and Balzar formations, (3) gentle dipping area having a folding formation such as Tertiary Tosagua formation, and (4) steep dipping area of Cretaceous Pinon formation.

The hilly area, in which the major water transbasin facilities are planned such as dam, tunnel, pumping station and open channel, is geologically composed of mud stone and sand stone of Tertiary Onzole and Borbon formations except Amarillos - Guarango tunnel route, where mud stone of Tertiary Tosagua formation is distributed.

(4) Construction materials

Major construction materials required for the construction works are cement, steel, explosives, fuel, concrete aggregate and earth. Mostly, the sufficient quantity and quality of these materials are available from the domestic market and the project area. Of these, concrete aggregate is obtainable in the vicinity of Portoviejo city and earth materials in the upstream mountain area of the Chirijos damsite planned.

2.3 Preliminary Design of the Structures Planned

2.3.1 Layout plan of water transbasin scheme

Layout plan of water transbasin schemes for six(6) alternatives were made based on the available topographic maps, results of various studies and field investigations as shown in Fig. I.1 to Fig. I.6.

(1) Topographic maps available

All the study area is covered by the topographic maps of 1:50,000 in scale prepared by IGM. Besides, more detailed topographic maps in relation with its development projects were prepared by CRM as shown as follows:

	Scale and Contour Interval	Coverage	Related project
(1)	1:10,000 6m	Route of Alternative-4	Carrizal-Chone Multipurpose Project
(2)	Various	Route of Alternative-2 (Daule river-La Esperanza) (Daule river-Poza Honda)	Water Transbasin Project from Daule-Peripa to Manabi
(3)	1:10,000 6m	Route of Alternative-4 (Guarango-Rocafuerte-Portoviejo)	Poza Honda Multipurpose Project
(4)	1:250 1m	Inlet site of Daule-Peripa to La Esperanza tunnel (Conguillo site)	Water Transbasin Project from Daule-Peripa to Manabi
(5)	1:100 1m	Outlet site of Daule-Peripa to La Esperanza tunnel (Membrillo site)	Water Transbasin Project from Daule Peripa to Manabi

In addition to these above, the following topographic maps were newly prepared in this study.

	Scale and Contour Interval	Coverage
(1)	1:5,000 5 m	Route of Alternative-1 and 5 (La Esperanza-Poza Honda, Poza Honda-Chico river)
(2)	1:5,000 5 m	Route of Alternative-3 (La Esperanza-Chico river-Portoviejo river)
(3)	1:5,000 5 m	Chirijos dam and reservoir site
(4)	1:1,000 1 m	Severino Pumping Station site for Alternative-1 and 5
(5)	1:1,000 1 m	Altamira Pumping Station site for Alternative-3
(6)	1:1,000 1 m	Amarillos Pumping Station site for Alternative-4
(7)	1:1,000 1 m	Chirijos damsite

(2) Results of various studies and field investigations

From the results of various studies and field investigations, the following findings on the major structures such as dam, open channel, tunnel and pumping station were taken into consideration for the layout plan

(a) Chirijos damsite

Riverbed portion is wide at the damsite. Slopes of both banks are about 30 degrees. Base rock is mudstone which is thickly covered with decomposed soil in both abutments (about 20 m thick) and alluvial soil in the riverbed (15 to 20 m thick). The surface of the mudstone is weathered with the thickness of 10 to 20 m.

Judging from the strength of fresh mudstone, only fill-type dam is technically feasible. The bearing capacity of the weathered mudstone is sufficient as the dam foundation, but water tightness is not enough. Since ordinary grouting is not effective in the weathered mudstone, cut-off wall with core material, cement-bentonite slurry or concrete reaching the fresh mudstone or blanket method to the upstream side of the core will have to be considered.

As for the dam construction materials, mudstone near the damsite is suitable for impervious core material as well as for random material. Rock and sand material is not available near the damsite. Rock material will have to be supplied from Picoaza quarry about 40 km far from the damsite. Filter material as well as concrete aggregates should be produced by crushing the Picoaza rock.

(b) Open Channel (For all Alternatives)

Some technical remarks from engineering geologies related to the open channel construction are summarized below according to the geomorphological conditions; alluvial area and mountain side colluvial area.

In the alluvial area, open channels are constructed on the alluvial soil layer, which is assumed to consist of silty clay. Since the surface is loose, settlement may take place in some places, and compaction of the foundation or replacement with good soils may be required after channel excavation.

In the mountain side colluvial area, on the other hand, open channels are constructed on the colluvial soil, decomposed soil or weathered rock layer. Slope stability will be a major problem when the open channel is constructed in colluvial soil or decomposed soil. At places where the channel crosses small rivers, protection work against debris flows should be considered.

(c) Tunnel

(i) Severino - Poza Honda route (Alternatives-1 and 5)

The tunnel route was selected in the mountainous area of 200 m to 400 m in elevation. Referring to the seismic survey results, rock type in tunnel formation level will be composed of sandy mudstone except for portal portions where rock type is colluvial deposits.

Rock classification and main engineering properties are as follows.

		Portal position	Inside part of tunnel
Rock type		Colluvial	Sandy mudstone
Rock class		D (soil)	CL (soft rock)
P wave velocity	Vp (km/sec)	1.5	2.1 - 2.3
Unit weight	γ (g/cm^3)	1.7	2.1
Unconfined *compressive strength*	qu (kgf/cm^2)	10 - 20	60 - 100
Static elastic modulus	Es (kgf/cm^2)	2,000	10,000 - 12,000
Permeability coefficient	K (cm/sec)	1×10^{-3} - 1×10^{-4}	1×10^{-5}

Sandy mudstone is soft in solidity but massive and rarely cracked. Large scale fractured zone is not found through the tunnel route. Seepage water quantity will not be much during tunnel excavation. Since the rock is soft, steel support is required. Closer arrangement of support will be needed in the portal portion where the rock is colluvial.

(ii) Altamira - Portoviejo river route (Alternative-3)

The tunnel route was selected in the mountainous area of 200 m to 400 m in elevation. Geological composition or rock type along the tunnel formation level is divided into two groups; one is colluvial or weathered sandy mudstone in tunnel portal portions and the other is sandy mudstone inside part of the tunnel.

Rock classification and engineering properties are as follows.

		Portal position	Inside part of tunnel
Rock type		Colluvial Weathered rock	Sandy mudstone
Rock class		D	CL
P wave velocity	Vp (km/sec)	1.5	2.1 - 2.3
Unit weight	γ (g/cm^3)	1.7	2.1
Unconfined compressive strength	qu (kgf/cm^2)	10 - 20	60 - 100
Static elastic modulus	Es (kgf/cm^2)	2,000	10,000 - 12,000
Permeability coefficient	K (cm/sec)	$1 x 10^{-4}$	$1 x 10^{-5}$

Similar to the geology along the tunnel from Severino to Poza Honda, sandy mudstone shows crackles feature and no large scale fractured zone is expected. Steel support will be required in the sandy mudstone layer. Closer arrangement of support will be needed in the portal portion where the rock is colluvial or weathered sandy mudstone.

(iii) Amarillos - Guarango route (Alternative-4)

The tunnel was selected in the gentle hill of 100 m to 150 m in elevation. In this area, weathering is so heavy and deep that no outcrops of rock are found. Rock type is calcareous mudstone according to the boring result carried out for the study on the Carrizal-Chone multipurpose project. This rock belongs to the Tosagua formation. Clay minerals of gypsum, anhydrite and montmorillonite, which are subject to swelling when stress is released, are included in the rock. Laboratory rock tests carried out in this time indicate that the rate of content of these swelling minerals is about 1% in the weathered zone while it is negligible in the fresh mudstone zone.

Referring to the seismic survey, rock type along the tunnel formation level are divided into three groups; (i) weathered mudstone with much swelling minerals assumed in portal positions, (ii) mudstone slightly weathered with moderate swelling minerals at the upstream side of tunnel, and (iii) fresh mudstone with a little swelling minerals.

Rock classification and engineering properties are as follows.

Rock type	(1) Weathered mudstone with swell mineral	(2) Mudstone slightly weathered with swell mineral	(3) Fresh mudstone
Rock class	E (soil)	D (very soft)	CL (soft)
Vp (km/sec)	0.9 - 1.5	1.5	2.1 - 2.5
γ (g/cm³)	1.6	1.7	2.1
Qu (kgf/cm²)	10	30	60
Es (kgf/cm²)	1,000 - 2,000	5,000	10,000 - 12,000
K (cm/sec)	$1x10^{-4}$	$1x10^{-4}$	$1x10^{-5}$

Tunnel construction through the weathered mudstone with swelling minerals will be difficult and costly, and a careful supporting system will be needed. No serious geological problems will, on the other hand, take place in the fresh mudstone zone.

(iv) Poza Honda - Mancha Grande river route (Alternative-5 and 6)

Geological condition of this tunnel route is nearly the same as the tunnel from Altamira to Portoviejo river. Rock classification and engineering properties are as follows.

Rock type	Mudstone	Colluvial
Rock class	CL	D
Vp (km/sec)	2.1 - 2.3	1.5
γ (g/cm³)	2.1	1.7
Qu (kgf/cm²)	60 - 100	10-20
Es (kgf/cm²)	10,000 - 12,000	2,000
K (cm/sec)	1×10^{-5}	1×10^{-4}

The tunnel can be excavated with ordinary steel support in the inside part (sandy mudstone layer), but in the portal positions (colluvial layer) closer arrangement of support will be required. Judging from deep groundwater table and low permeability of rock, seepage water quantity during tunnel excavation will be small.

(v) Daule-Peripa - La Esperanza route (For all Alternatives)

Geological investigations along this tunnel route were carried out for the study on the Water Transbasin project from Daule-Peripa to Manabi. Rock types along the tunnel formation level is fine sandstone and mudstone. The rock is classified into medium rock from the viewpoint of R.Q.D and grade IV - III on the basis of Beniawski's rock classification and into the rock of CL to CM in Japanese criteria for rock classification. Engineering properties are as follows:

Unit weight	γ = 2.1 g/cm^3
Unconfined compressive strength	qu = 60 - 100 kg/cm^2
Static elastic modulus	Es = 10,000 - 12,000 kg/cm^2
Permeability coefficient	K = 1 x 10^{-4} - 1x10^{-5} cm/sec

Existing boring cores and rock outcrops in the field suggest that the rock is massive and crackless without serious fractured zones.

Judging from the solidity of rock, steel support will be required for tunnel construction. The tunnel is expected to pass mostly the fresh rock layer, but in the portal position of the tunnel, rock is weathered and loosened (D class in classification) where closer arrangement of support will be needed.

(vi) Daule River - Poza Honda route (Alternative-2 and 6)

Geological investigations along this tunnel route were also executed for the study on the Water Transbasin project from Daule-Peripa to Manabi.

The tunnel passes the very fine sandstone and/or sandy mudstone of the Onzole formation. This rock is classified into CL to CM in solidity and its engineering properties are nearly the same as those in the tunnel route from Daule-Peripa to La Esperanza.

Large scale fractured zones are not expected. Seepage water quantity during tunnel construction will be small. Steel support will, however, be required because the rock is soft in solidity.

(d) Pumping Station Sites

There are four(4) pumping station sites investigated under the study, (i) Severino pumping station for Alternatives-1 and 5, (ii) Altamira pumping station for Alternative-3, (iii) Amarillos pumping station for Alternative-4, and (iv) Daule pumping station for Alternatives-2 and 6.

Geological compositions in the Severino site consist of (i) decomposed soil layer of about 5 m deep from the ground surface, (ii) weathered sandy mudstone of 5 to 15 m deep under the decomposed soil layer, and)iii) fresh sandy mudstone under the weathered sandy mudstone. The weathered sandy mudstone is considered to be firm enough for the foundation of the pumping station.

At the Altamira site, weathering is wide and deep. Geological compositions are similar to those of the Severino site and evaluated as follows as well as the engineering properties.

Geological composition	Depth	P wave velocity	Rock class
Decomposed soil (Slightly clay)	0 - 15 m	0.3 - 0.8 km/sec	-
Weathered rock (Mudstone)	15 - 30 m	1.1 - 1.5 km/sec	D
Fresh rock (Mudstone)	30 m below	2.1 - 2.3 km/sec	CL

Engineering properties		Decomposed soil	Weathered mudstone	Fresh mudstone
Unit weight	γ (g/cm^3)	1.6	1.7	2.1
Cohesion	C (kgf/cm^2)	0.1	1.0	5.0
Internal frictional angle	ϕ (degree)	15	25	30
Unconfined compressive strength	qu (kgf/cm^2)	1.0	10.0	60
Static elastic modulus	Es (kgf/cm^2)	200	2,000	12,000

The Altamira pumping station will be founded on the decomposed soil layer. Some foundation treatments may be needed subject to further investigation on the bearing capacity of the layer.

Geological conditions at Amarillos pumping site are nearly equal to those of the Altamira site, Daule site and the Severino site.

2.3.2 Hydraulic studies

Hydraulic studies were made based on the layout plan of the water transbasin schemes. Manning formula was adopted for open channel and tunnel, and Darcy - Weisbach equation combined with Hazen-Williams formula for pressure steel pipe and syphon as shown below.

Manning formula

$$Q = A \times V = A \frac{1}{n} R^{2/3} I^{1/2}$$

where,
- Q : discharge (m^3/s)
- A : flow area (m^2)
- V : flow velocity (m/s)
- n : Manning's coefficient
- R : hydraulic radius (m)
- I : channel slope

Darcy - Weisbach and Hazen-Williams formula

$$hf = f \times L/D \times V^2/(2g)$$
$$f = 134/C^{1.85} \times 1/(D^{1/6} \times V^{0.15})$$

where,
- hf : head loss (m)
- f : coefficient of head loss
- L : length (m)
- D : diameter (m)
- V : flow velocity (m/s)
- g : gravity (m/sec^2)
- C : parameter

Results of hydraulic calculations for Severino - Poza Honda, Altamira - Rio Portoviejo, Esperanza dam outlet - Guarango, Esperanza dam outlet - Guarango - Portoviejo and Guarango - Rocafuerte schemes are shown in Table I. 3 to Table I. 7. More detailed hydraulic calculation will be made for the selected water transbasin scheme in the next stage.

2.3.3 Preliminary design

Preliminary design of the structures for water transbasin plan such as Chirijos dam, open channel, tunnel and pumping station was conducted (See Fig.7 to Fig. 23).

(1) Chirijos dam

1) River diversion works

One(1) diversion tunnel and two(2) cofferdams in the up and downstream were provided for the purpose of diverting riverflow during the period of the construction works of the main dam. The diversion tunnel was designed on the right abutment, considering the river morphology and topographic condition.

A 25-year probable flood with a peak discharge of 190 m3/sec was adopted as a design flood discharge for the diversion scheme and the downstream outlet water level was set at El.

70.00 m based on the flow capacity of downstream river channel. In designing the diversion tunnel, the maximum velocity should be restricted to less than 15 m/sec for the tunnels lined with reinforced concrete.

The diameter of the diversion tunnel was determined in consideration of the upstream reservoir water level and flow velocity in tunnel. The reservoir water level was calculated by the following equations :

R.W.L = O.W.L + he

$he = (1.0+fe+fsr)\ V^2/(2\ g)$

where,

R.W.L:	Reservoir water level (El. m)
O.W.L:	Outlet water level (assumed at El. 70.00 m)
he	: Loss head in tunnel (m)
fe	: Coefficient of entrance loss (= 0.2)
fsr	: Coefficient of friction loss ($= f\ L/D = 124.5\ n^2\ L/D^{4/3}$)

where,

n	: Manning's coefficient (= 0.018)
L	: Tunnel length (m)
D	: Tunnel diameter (m)

Dimensions of river diversion scheme determined are as follows:

- Diameter of diversion tunnel	: D = 5.90 m (Max. V = 6.9 m/sec)
- Elevation of cofferdam	: El. 78.00 m (Freeboard = 1.0 m)

2) Main dam

(a) Dam axis

Alignment of axis of the Chirijos dam planned was studied and prospective dam axis was determined based on the topographic and geologic studies as presented in Annex-H.

(b) Dam type

Construction of a fill type dam was geologically considered to be feasible for the Chirijos dam. Among various fill types, an earthfill type was judged economically superior to rockfill type, because earthfill materials were found available near the damsite, while rockfill materials are not available in the vicinity of the damsite. Rock quarry site is only available in the vicinity of Portoviejo city, located far at about 40 km west from the damsite.

Concrete gravity and concrete arch types were considered inapplicable to this damsite due to the geological conditions. Both bank ridges and foundation are mainly composed of Tertiary mud stone, of which the unit weight is around 2.0 t/m^3, and unconfined uniaxial stress strength is assumed to be about 50 kgf/cm^2 based on the results of the geological studies previously conducted in the project area. These values of physical and mechanical properties, which are lower than those of concrete were judged incompetent for construction of a concrete gravity and concrete arch types.

(c) Dam freeboard and crest elevation

A dam crest elevation was determined by providing required design freeboard above the high water level or design flood water level. The design freeboard shall satisfy both the following requirements.

$$Hn = Hw + Hi + He$$
$$Hf = Hw + Hi$$

where,
- Hn : freeboard above high water level to dam crest (m)
- Hf : freeboard above flood water level to dam crest (m)
- Hw : wave height due to wind (=1 m, estimated by combined S.M.B and Saville method)
- Hi : allowance to fill type dam for overtopping (=1 m)
- He : wave height due to earthquake (=1 m), but design flood and earthquake are assumed not to occur concurrently.

(d) Foundation Treatment

The foundation for the embankment zones, which consists of poor material properties with a depth of about 15 m below the existing riverbed are excavated and replace to suitable embarkment materials up to the weathered rock line as a result of dam stability analysis.

In the foundation of impervious core zone, cut off trench with a width of 6 m and a depth of about 10 m up to the hard rock line was designed, which was confirmed economically feasible than another foundation treatment works such as blanket and continuous wall "soletancy type".

(e) Zoning

The dam cross section is zoned by four(4) different embankment materials. The features of each zone are detailed below :

Impervious core zone

The impervious core material would be clay soil, being obtained from the borrow area located in the upstream area of the damsite. The core zone has a width of 5.0 m at the top and is sloping by 1 : 1 both for the upstream and downstream.

Shell zone

The shell zone is divided into two(2) zones, i.e., random zone and riprap zone, from the viewpoint of dam slope stability, economy and availability of embankment materials. The random material is obtained from the borrow area in the upstream of the damsite, while the riprap material is only available in the vicinity area of Portoviejo city far from the damsite. This riprap zone is arranged both in the upstream and downstream slopes with 5 m in thickness to ensure the surface slope stability and for the prevention of weathering of the inner random zone.

Filter zone

Between the core and the random zones, an inclined drain is provided to regulate the seepage flow. The material is produced by crushing and processing quarried rocks. The drain is designed at 3 m in thickness at the top and with a slope of 1: 1 in the downstream side.

Below the downstream random zone, 3 m-thick horizontal drain is provided in due consideration of the low permeability of the embankment materials and the seepage line in the downstream zone for the slope stability. Drain materials are the same as the filter zone. The dam embankment volumes based on the proposed design are as summarized below:

Zone	Volume(m^3)	Materials
(1) Main dam		
- Core	1,219,000	Clay soil
- Vertical drain	27,000	Crushed and processed rocks
- Horizontal drain	27,000	Crushed and processed rocks
- Random	1,600,000	Selected sandy clay materials
- Riprap	1,081,000	Quarried rock
Subtotal	3,954,000	
(2) Cofferdam	76,100	Clay soil
- Core	108,000	Selected sandy clay materials
- Random	136,000	Quarried rock
- Riprap		
Subtotal	320,100	
Total	4,274,100	

(f) Stability Analysis

Safety of the dam was examined in terms of slope stability using the slip circle method and plane failure surface method. Design values used for the analysis are as tabulated below:

Items	Unit	Riprap	Core	Random	River deposit	Weathered rock
Unit weight, dry	ton/cu.m	1.90	1.80	1.70	1.60	1.80
Unit weight, saturated	ton/cu.m	2.10	2.00	1.90	1.90	2.00
Internal friction angle	degree	40.00	31.00	32.00	20.00	25.00
Cohesion	ton/sq.m	0.00	2.00	0.00	1.00	5.00

Plane failure surface method

Safety factor against surface sliding was calculated by the following equation . Horizontal seismic coefficient of 0.12 was adopted based on the Japanese Standard.

$$SF = (m - k \times g) / (1 + k \times g \times m) \times \tan(a)$$

where,

SF : Safety factor (> 1.2)

m : Slope gradient

k : Horizontal seismic coefficient (= 0.12) g : Saturated density / submerged density for submerged slope and 1.0 for slope which is not submerged

a : Internal friction angle of riprap

Slip circle method

Safety factors against slip circle were analyzed through a trial and error of the upstream and downstream slopes of dam body with a minimum required safety factor of 1.2. Consequently, the upstream and downstream slopes of dam were determined to be 1 to 3.8 and 1 to 3.3, respectively.

Cases	Seismic	Static Condition		Seismic Condition	
	Coeff.	U/S slope	D/S slope	U/S slope	D/S slope
HWL	0.12	2.421	1.952	1.202	1.204
FWL	0.00	2.496	1.797	-	-
Rapid Drawdown	0.06	1.630	1.782	1.212	1.387

3) Spillway

As a discharge carrier of spillway, either an open chuteway type or a tunnel type is conceivable for the earthfill dam. Since the tunnel type spillway has some disadvantage comparing with the open chuteway type in its hydraulic function, it can be adopted only when it is economical enough to offset this disadvantage. As for the type of spillway for the Chirijos dam, the open chuteway type was adopted because it was judged economically superior to the tunnel type in addition to the hydraulic advantage.

A layout of spillway consisting of overflow weir, chuteway and stilling basin was determined based on the topographic and hydraulic conditions. From this view point, the open chuteway type of spillway was planned on the right bank of the Chirijos dam.

The spillway was designed to discharge a 10,000-year probable flood (inflow peak to the reservoir is 560 m^3/sec) with a retarding effect of reservoir or 1.2 times of a 200-year probable flood (360 m^3/sec) without the retarding effect (Japanese Standard). For the sake of simple operation and maintenance, it was predetermined to be non-gated spillway type located on the right abutment due to the topographic condition It consists of non-gated overflow weir, open chuteway and stilling basin with horizontal apron.

The non-gated spillway was designed to have a length of 35 m to safely release the flood peak discharge of 1.2 times of a 200-year probable flood, which is critical than a 10,000-year probable flood with a retarding effect of reservoir. The chuteway was designed to have a slope of 1 : 6.0 taking into account the topographic conditions and the width was determined at 15 m derived from the non-uniform flow hydraulic analysis.

A 100-year probable flood with a peak discharge of 275 m^3/sec was applied for the design of energy dissipator. A stilling basin type was adopted from the hydraulic viewpoint because there are several houses downstream of the energy dissipator. It consists of a 60 m long horizontal apron with 10 m high wall.

The preliminary design of the plan for the river diversion works, main dam and spillway, and the profile and cross section for the main dam are presented in Fig. 7.

(2) Open channel and syphon

1) Layout of open channel

Layout of open channel was designed based on the field investigations, topographic maps with the scale of 1 to 5,000 newly prepared in this study, the maps with the scale of 1 to 5,000 made by the Portoviejo and Chico Irrigation Project (1972), and the maps with the scale of 1 to 10,000 made by the "Transbasin Project from Daule-Peripa to La Esperanza and Poza Honda(1987)" and "Carrizal - Chone Multipurpose Project (1989)".

2) Type of open channel and syphon

Following types of open channel and syphon were taken in consideration of the site conditions.

(a) Open channel with concrete lining and/or flume type
(b) Box culvert (RC)
(c) Steel pipe (SP) and/or reinforced concrete pipe (RCP)

In the alluvial area, open channels are constructed on the alluvial soil layer, which is assumed to consist of silty clay. Since the surface is loose, settlement may take place in some places, and compaction of the foundation or replacement with good soils may be required after channel excavation.

In the mountain side colluvial area, on the other hand, open channels are constructed on the colluvial soil, decomposed soil or weathered rock layer. Slope stability will be a major problem when the open channel is constructed in colluvial soil or decomposed soil. At places where the channel crosses small rivers, protection work against debris flows should be considered.

(3) Tunnel

1) Layout of tunnel

Following items were taken up as the design criteria.

(a) Alignment of tunnel is straight as much as possible in consideration of geology, hydraulic conditions, construction method and economic efficiency.

(b) Minimum radius of bending portion is as follows:

$R \geq 10\,D$

where, R : radius of bending portion (m)

D : diameter of tunnel (m)

2) Type of tunnel

Free flow type of tunnel is basically planned, while pressure type is employed where hydraulic conditions will not allow free flow. Following items were taken up as the design criteria.

(a) Type of tunnel is as follows:

Free flow type : Standard horse-shoe section

Pressure flow type : Circle section

(b) Minimum diameter of tunnel is as follows:

$D \geq 2.5$ m

where, D : diameter of tunnel (m)

(c) Thickness of concrete lining, quantities of steel support and rockbolt are determined based on the geological investigation results.

(d) Slope of tunnel is determined taking into account the hydraulic gradient, construction method and economic efficiency.

(4) Intake facilities and pumping station

1) Intake facilities

Design of intake facilities for the pumping station close to Rio Daule was made based on the detailed design carried out by the Brazilian consultant in 1986. Topographically, the diversion intake was planned to be situated close to a stream course where an aggradation and degradation of riverbed, and change of river course will not be expected in the future.

As for the intake facilities of Amarillos pumping station, the following items were taken up as the design criteria of silting basin .

(a) Storage capacity of silting basin is to be 10 to 20 minutes volume of design intake discharge.
(b) Mean velocity in silting basin is to be 0.02 to 0.07 m/sec.
(c) High water level in silting basin is lower than low water level in channel.
(d) Freeboard of silting basin is to be 1.0 m.
(e) Effective water depth in silting basin is to be 4.0 m. and sediment depth is to be 1.0 m.

Intake facilities for pumping stations at Severino and Altamira were designed equipped with two trashracks and gates.

2) Pumping station

Following items were taken as the basic considerations.

(a) Appropriate number and type of pump are determined by the pumping discharge and lifting head.
(b) One(1) standby pump is installed to facilitate operation and maintenance.
(c) Capacity of each pump is proposed to be same as the others.
(d) Power source of the pump is taken from Daule-Peripa hydropower.

A pump is generally classified into three(3) types depending on the streamline inside the pump impeller, i.e., volute(centrifugal) type, mixed flow type and axial flow type. The axial flow type is normally employed in case that the discharge head is less than 4 m, and hence it is not conceivable for the project.

The remaining two(2) types are further classified into vertical shaft and horizontal shaft types. In consideration of large amount of discharge and head in this project, horizontal shaft type was judged superior to others.

General features of pumps preliminary determined are summarized in Table I.8. However, number and types of pump will be revised based on the study results of intake discharge patterns in the next stage .

2.3.4 Estimate of work quantities

Project features of the water transbasin schemes are summarized below. Work quantities of the major structures for the above water transbasin schemes were estimated based on the preliminary design.

(1) Daule Peripa - Esperanza dam water transbasin scheme

- Tunnel	L = 8.3 km
	D = 3.7 m (Q = 18 m^3/s)
	D = 2.7 m (Q = 9 m^3/s)

(2) Rio Daule - Poza Honda dam water transbasin scheme

- Pressure pipeline	L = 13.3 km
	D = 1,500 mm (Q = 9 m^3/s)
	D = 1,600 mm (Q = 10 m^3/s)
- Tunnel	L = 11.2 km
	D = 2.7 m (Q = 9 m^3/s)
	D = 2.9 m (Q = 10 m^3/s)

(3) Esperanza dam (Severino) - Poza Honda dam water transbasin scheme

- Pressure pipeline	L = 250 m
	D = 1,800 mm , 2 Lanes (Q = 9 m^3/s)
	D = 1,900 mm , 2 Lanes (Q = 10 m^3/s)
- Open channel	L = 6.9 km
	Trapezoidal , B = h = 1.7 m (Q = 9 m^3/s)
	Trapezoidal , B = h = 1.8 m (Q = 10 m^3/s)
- Syphon	L= 640 m
	D = 2,600 mm (Q = 9 m^3/s)
	D = 2,700 mm (Q = 10 m^3/s)
- Tunnel	L = 10.7 km

D = 2.7 m (Q = 9 m^3/s)
D = 2.9 m (Q = 10 m^3/s)

(4) Esperanza (Altamira) - Rio Portoviejo water transbasin scheme

- Pressure pipeline	L = 220 m
	D = 2,000 mm , 2 Lanes (Q = 12 m^3/s)
- Open channel	L = 6.52 km (Q = 12 m^3/s)
	L = 2.37 km (Q = 6 m^3/s)
	Trapezoidal , B = h = 1.9 m (Q = 12 m^3/s)
	Trapezoidal , B = h = 1.5 m (Q = 6 m^3/s)
- Syphon	L= 1,360 m , D = 2,900 mm (Q = 12 m^3/s)
	L= 670 m , D = 2,100 mm (Q = 6 m^3/s)
- Tunnel	L = 13.0 km, D = 3.1 m (Q = 12 m^3/s)
	L = 8.0 km, D = 2.5 m (Q = 6 m^3/s)

(5) Poza Honda dam - Rio Mancha Grande water transbasin scheme

- Tunnel	L = 4.1 km
	D = 2.5 m (Q = 4 m^3/s)

(6) Esperanza - Guarango water transbasin scheme

- Open channel	Rectangular, L = 10.1 km (Q = 22 m^3/s)
	Trapezoidal, L = 5.4 km (Q = 13 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 12.5 m^3/s)
	Trapezoidal, L = 4.4 km (Q = 11 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 9.5 m^3/s)
	Trapezoidal, L = 4.6 km (Q = 8.8 m^3/s)
	Trapezoidal, L = 1.8 km (Q = 5.5 m^3/s)
	Trapezoidal, L = 6.0 km (Q = 5.3 m^3/s)
	Trapezoidal, L = 1.6 km (Q = 6.8 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 6.3 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 5.8 m^3s)
	Trapezoidal, L = 0.5 km (Q = 5.5 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 5.3 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 5.0 m^3/s)
- Syphon	L= 350 m , D = 2,100 mm x 2 Lanes (Q = 13 m^3/s)
	L= 900 m , D = 2,100 mm x 2 Lanes (Q = 12.5 m^3/s)
	L= 550 m , D = 2,000 mm (Q = 5.3 m^3/s)
	L= 500 m , D = 2,000 mm (Q = 6.5 m^3/s)
	L= 540 m , D = 2,000 mm (Q = 6.0 m^3/s)
	L= 430 m , D = 2,000 mm (Q = 5.5 m^3/s)
- Regulation pond	DI-2 , Guarango (2 sites)
- Pressure pipeline	L = 300 m
	D = 1,400 mm , 2 Lanes (Q = 5 m^3/s)
- Tunnel	L = 6.6 km
	D = 2.6 m (Q = 5 m^3/s)

(7) Esperanza - Guarango - Portoviejo water transbasin scheme

- Open channel	Rectangular, L = 10.1 km (Q = 32 m^3/s)
	Trapezoidal, L = 5.4 km (Q = 23 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 22.5 m^3/s)
	Trapezoidal, L = 4.4 km (Q = 21 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 19.5 m^3/s)
	Trapezoidal, L = 4.6 km (Q = 18.8 m^3/s)
	Trapezoidal, L = 1.8 km (Q = 15.5 m^3/s)
	Trapezoidal, L = 6.0 km (Q = 15.3 m^3/s)
	Trapezoidal, L = 1.6 km (Q = 16.8 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 16.3 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 15.8 m^3/s)
	Trapezoidal, L = 0.5 km (Q = 15.5 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 15.3 m^3/s)
	Trapezoidal, L = 1.0 km (Q = 15.0 m^3/s)
	Trapezoidal, L = 2.1 km (Q = 9.9 m^3/s)
	Trapezoidal, L = 5.7 km (Q = 5.6 m^3/s)
	Trapezoidal, L = 7.6 km (Q = 5.2 m^3/s)
	Trapezoidal, L = 7.0 km (Q = 3.3 m^3/s)
- Syphon	L= 350 m , D = 2,900 mm x 2 Lanes (Q = 23 m^3/s)
	L= 900 m , D = 2,900 mm x 2 Lanes (Q = 22.5 m^3/s)
	L= 550 m , D = 3,300 mm (Q = 16.3 m^3/s)
	L= 500 m , D = 3,400 mm (Q = 16.5 m^3/s)
	L= 540 m , D = 2,900 mm (Q = 16.0 m^3/s)
	L= 430 m , D = 3,300 mm (Q = 16.5 m^3/s)
	L= 3,140 m , D = 2,900 mm (Q = 9.9 m^3/s)
	L= 600 m , D = 2,000 mm (Q = 5.6 m^3/s)
	L= 2,080 m , D = 2,000 mm (Q = 5.2 m^3/s)
- Culvert	L=330 m , B=2.5 m , H=2.0 m
- Regulation pond	DI-2 , Guarango (2 sites)
- Pressure pipeline	L = 300 m
	D = 2,100 mm , 2 Lanes (Q = 15 m^3/s)
- Tunnel	L = 6.6 km
	D = 3.4 m (Q = 15 m^3/s)

(8) Chirijos dam

Hydrology

Catchment area	80 km^2
Annual Mean rainfall	1,220 mm
Annual Mean inflow	41 MCM (520 mm)
Runoff coefficient	0.43
Probable flood (1/10,000)	560 m^3/s

Reservoir

Gross storage capacity	46 MCM
Dead storage	10 MCM
Effective storage	36 MCM
Flood water level	EL. 101.0 m
Normal high water level	EL. 98.0 m
Low water level	EL. 78.0 m
Riverbed elevation	EL. 68.0 m
Reservoir area at HWL	3.8 km^2

Dam

Type	Zoned earthfill
Height from foundation	60 m
Crest elevation	EL. 103.0 m
Crest length	517 m

Spillway

Type, Control structure	Non-gated overflow weir
Water conveyance	Open chuteway
Energy dissipator	Stilling basin
Length of overflow weir	35 m
Overflow weir level	EL. 98.0 m
Outflow peak discharge	360 m^3/s (1.2 times of 200-Yr flood)

Intake and Outlet m

Intake level	EL. 78.0 m
Outlet capacity	2 m^3/s

3. BASIC DESIGN IN THE PHASE II STUDY

3.1 Revise of Water Transbasin Route and Type

3.1.1 Selected water transbasin route

In the previous stage, Alternative-5 was selected as a most promising plan. Afterwards, the route of water transbasin for Alternative-5 was reviewed, and Alternative-5a was finally chosen as a most economical plan. General features of the Alternative-5a is listed as follows:

(1) Daule Peripa-Esperanza dam water transbasin scheme

- Tunnel ($Q = 18\ m^3/s$)
  L = 8.3 km
  D = 3.7 m (Standard horse-shoe (2R) section, free flow type)

(2) Esperanza dam (Severino) - Poza Honda dam water transbasin scheme

- Pumping station

Total discharge	:	$16.0\ m^3/s$
Total head (Max.)	:	76.0 m
Nos of pump planned	:	5
Nos of standby pump	:	1
Discharge of 1 pump	:	$192\ m^3/min$ ($3.2\ m^3/s$)
Type	:	Double suction volute type
Length of pipeline	:	250 m
Lane	:	2 lanes
Diameter of pipeline	:	2,100 mm

- Head tank
  B = 12 m
  L = 18 m

- Open channel ($Q = 16.0\ m^3/s$)
  L = 5.4 km (I = 1/3,000)
  Trapezoidal, B = h = 2.2 m