Experiences of landslide prevention works in Vietnam

Introduction of Landslide Disaster in Vietnam
and Application of the Japanese Technology of Landslide countermeasures

Kawasaki Geological Engineering Co., Ltd

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1. ***Introduction***
   ベトナムにおける防災対策の現状

2. ***Introduction Landslide countermeasure works in Vietnam***
   ベトナムで行った主な地すべり対策の紹介
   ① ***Landslide control work***
   - *Mon-Seng bridge Landslide, Lao Cai in mountainous areas*
   - *Da Lat city Landslides ,Lam Dong occurred in urban area*

   ② ***Landslide prevention work***
   - *Bai Chai Landslides ,Quan Ninh occurred along the road*

3. ***CONCLUSION***
   まとめ

Introduction

■ In recent years, increase in various natural disasters as landslide, ***due to climate changes on a global scale*** , becomes the serious social problems.

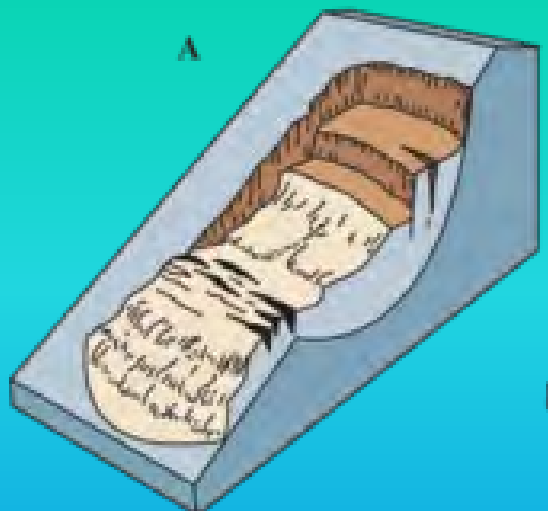
近年気候変動に伴う地すべり災害多発、社会問題化

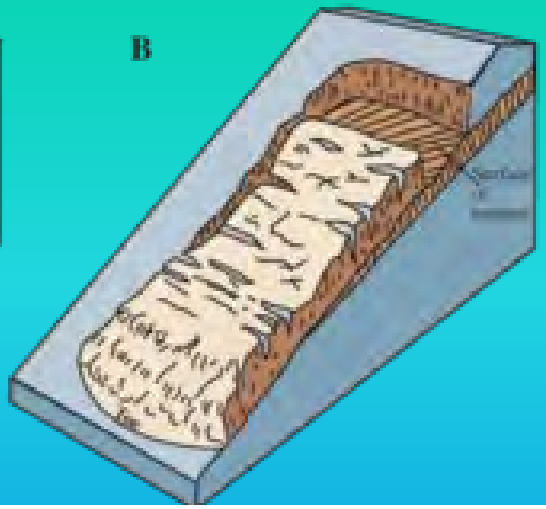
■In Vietnam, the ***serious physical and human damages has been occurring frequently by landslide disasters and it's debris flow*** which caused by torrential rain.

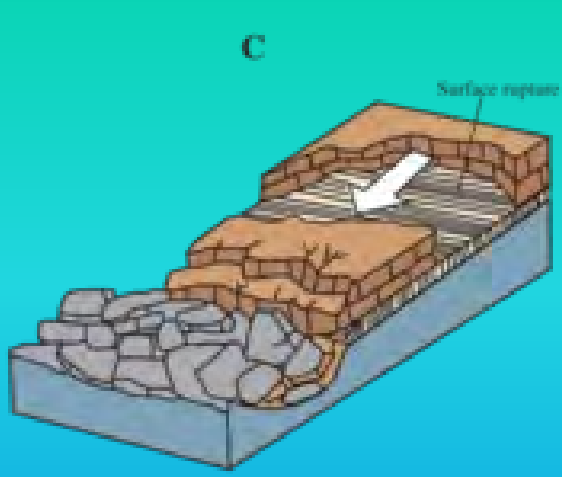
ベトナムにおいても豪雨に伴い発生した地すべり災害によって申告な人的・物理的な被害が発生している。

Example of the slope disasters and the countermeasures for landslides .

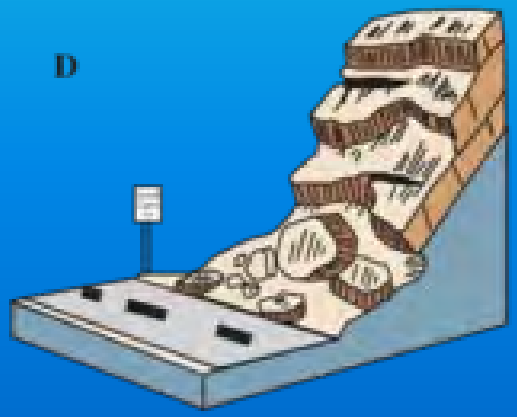
Classification of Landslides Type

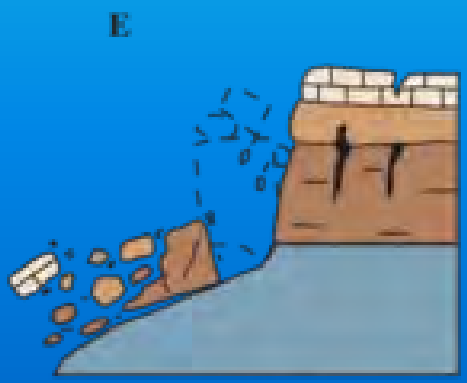


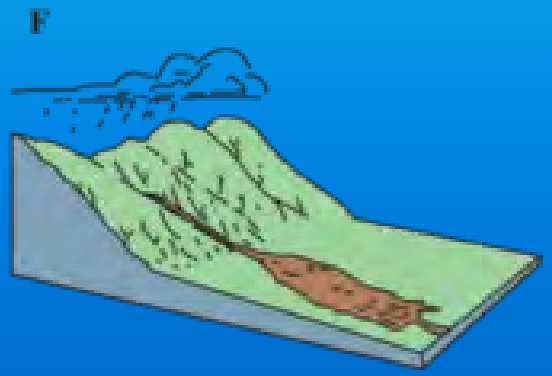




Rotational landslide ***Translational landslide*** ***Block slide***

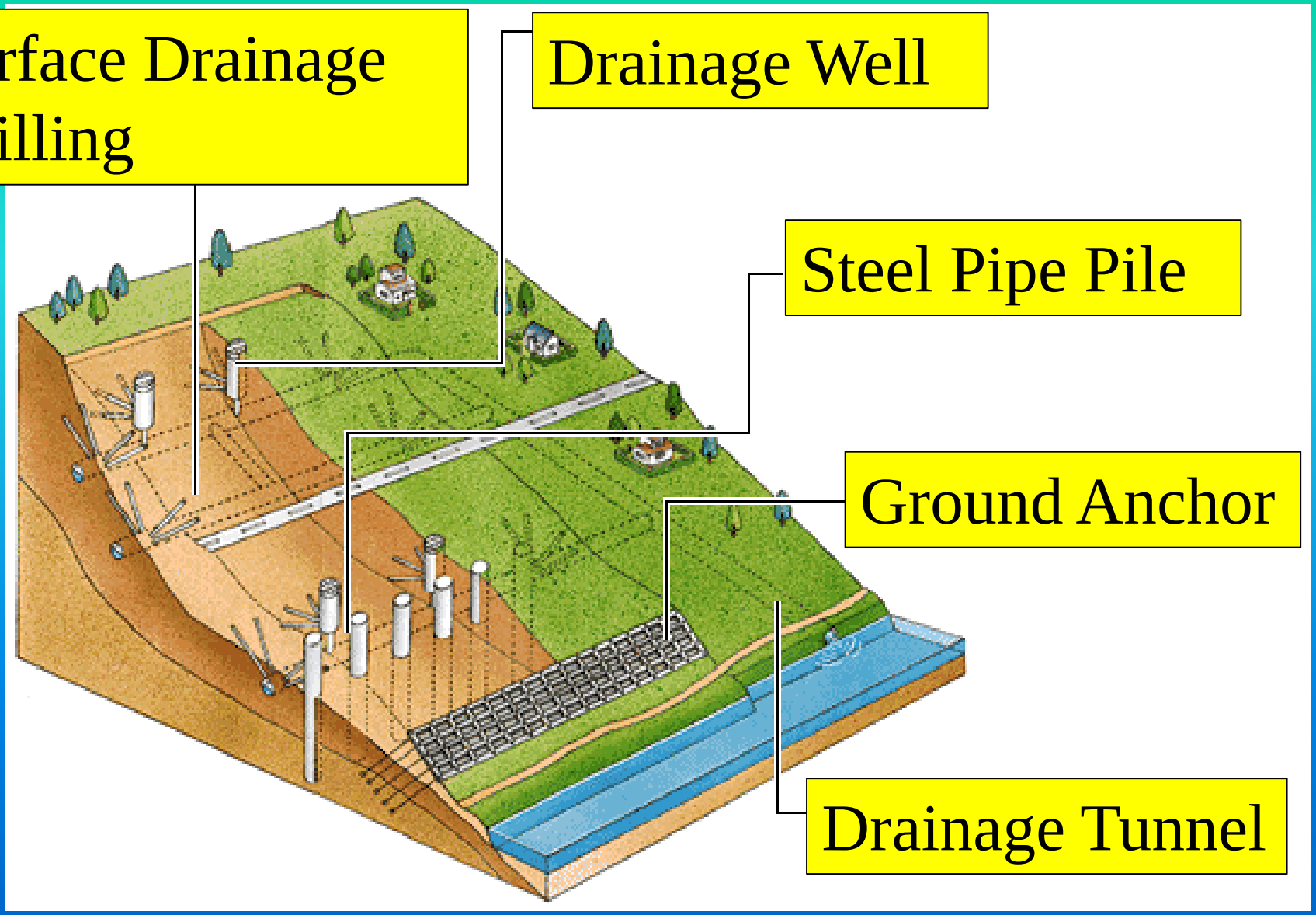






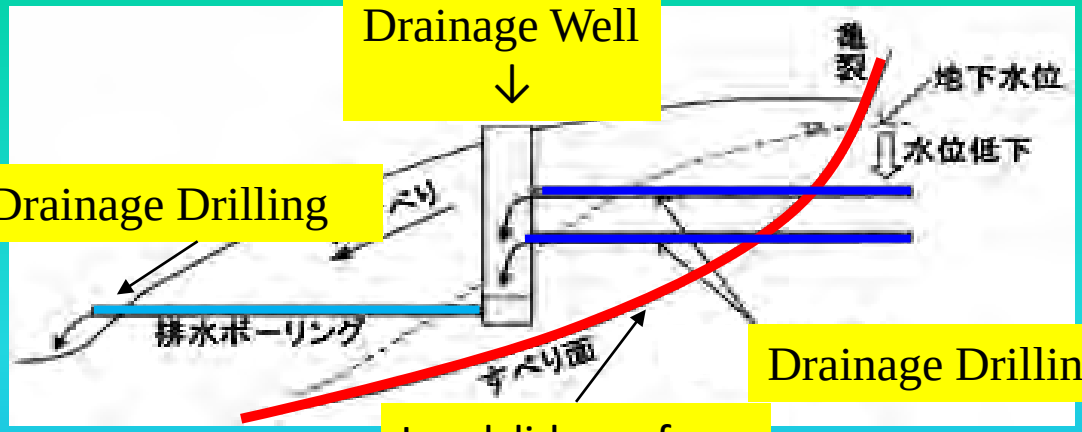
Rock fall ***Topple*** ***Debris flow***

Countermeasure construction of landslide



http://www.ktr.mlit.go.jp/river/bousai/river_bousai00000021.html

Drainage Well



Drainage Drilling

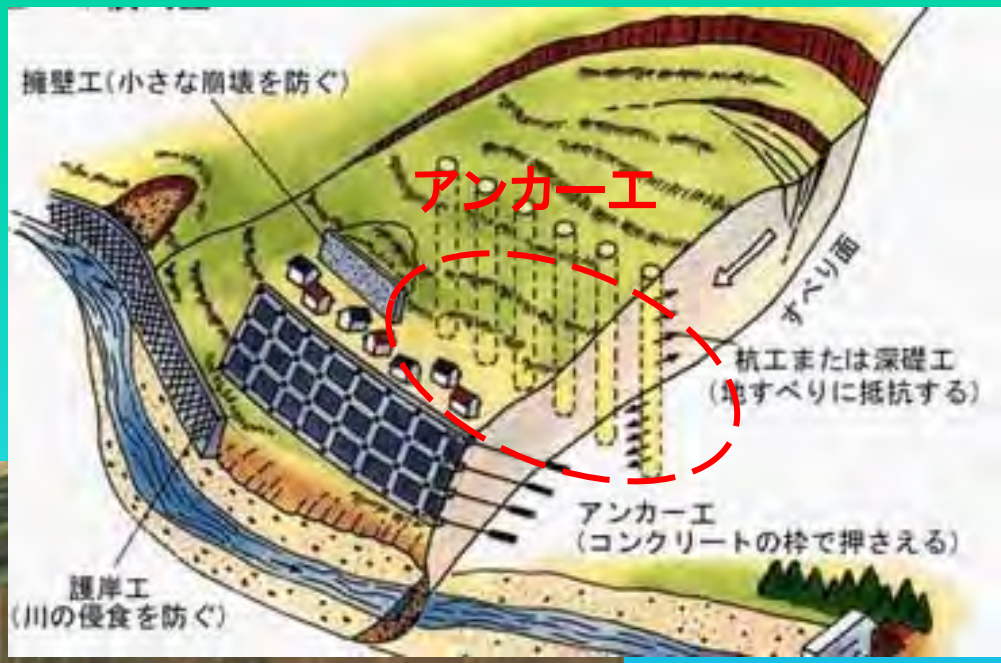
http://www.maff.go.jp/tohoku/nouson/kokuei/shonai-sahi/shintyoku.html

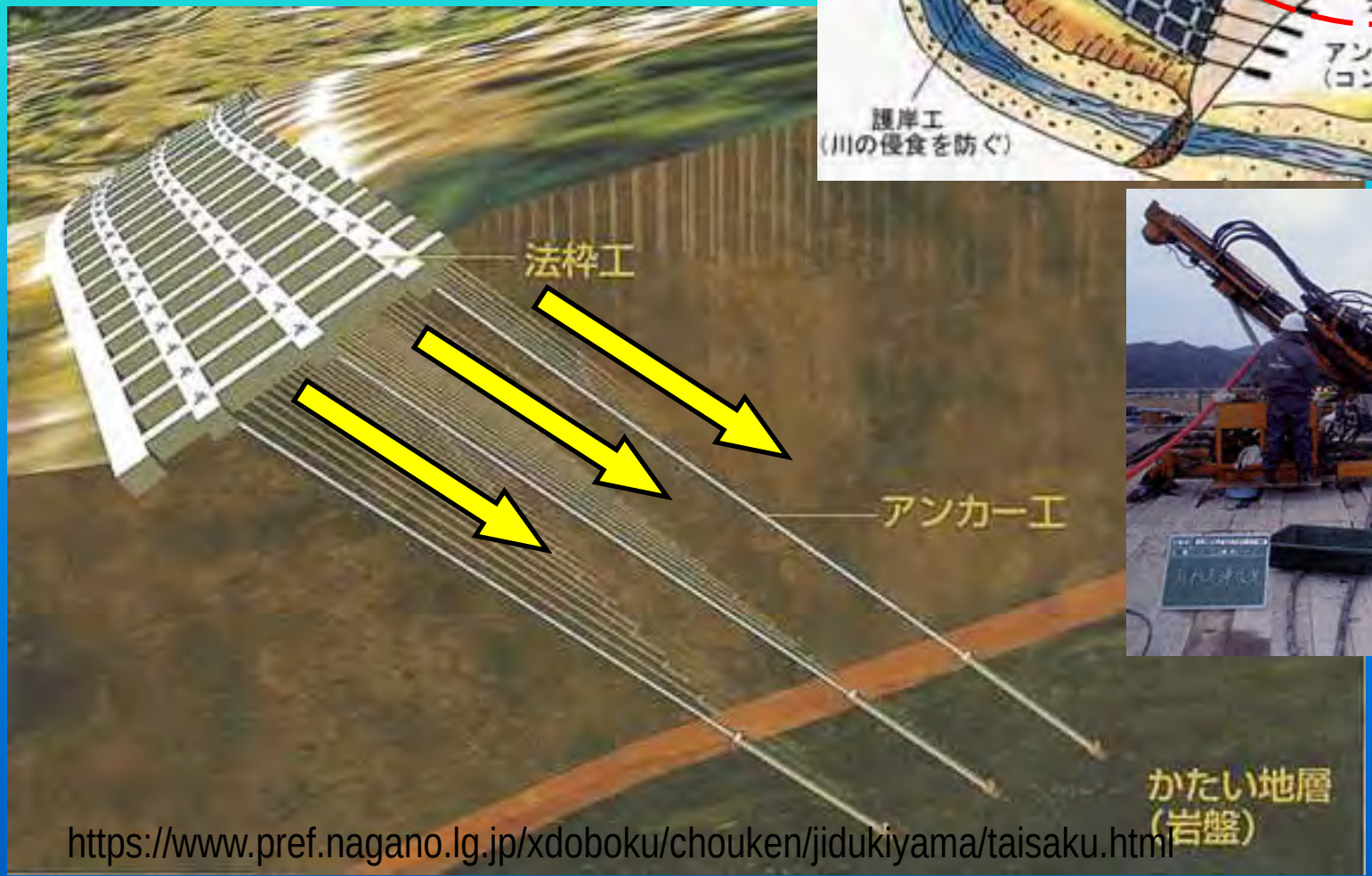
Drainage Drilling on the ground

Lightweight Fill (EPS : foamed styrol)

Embankment to the head of landslide

Ground Anchorage





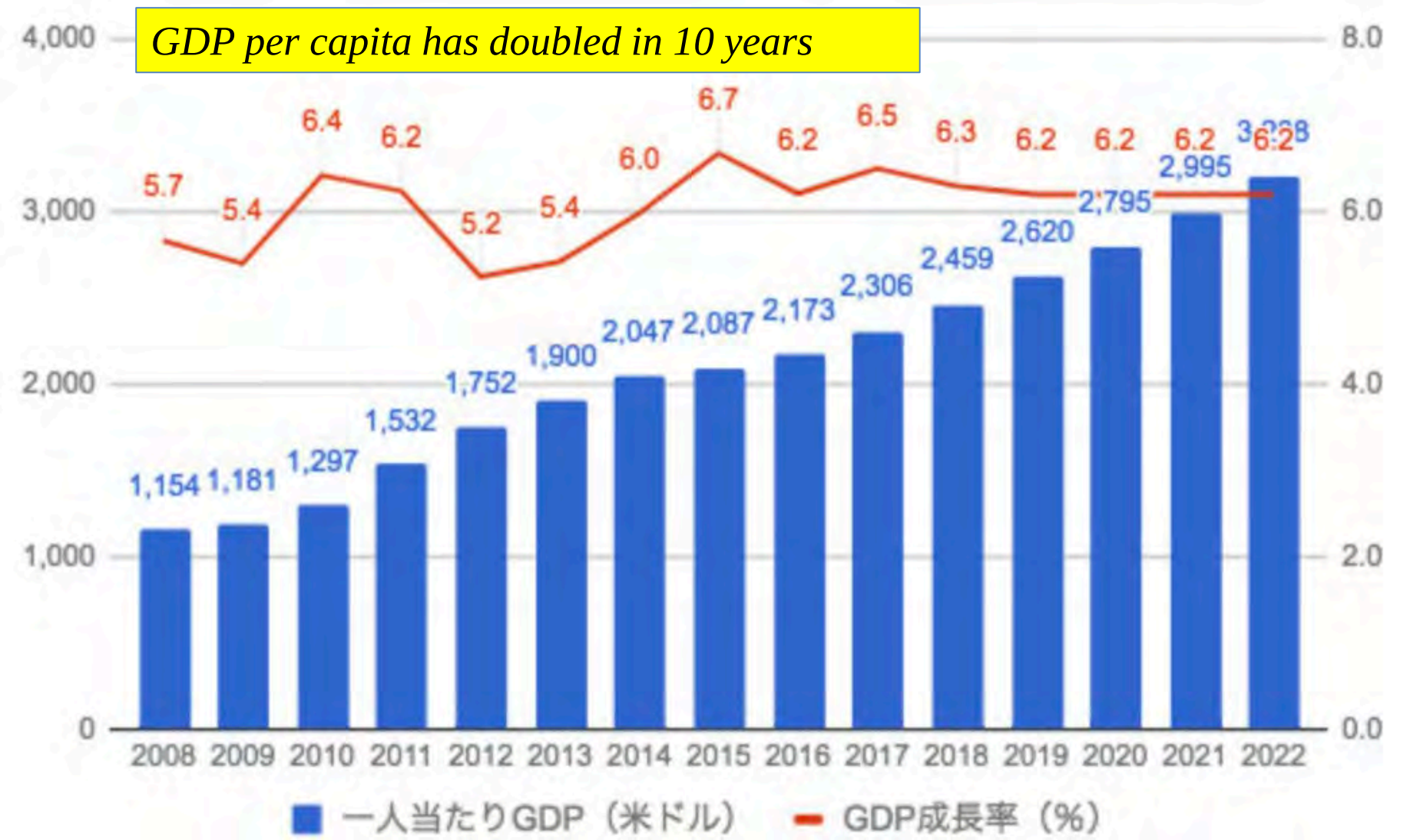
https://www.pref.nagano.lg.jp/xdoboku/chouken/jidukiyama/taisaku.html

Comparison of disaster prevention budgets between Lao Cai province and Shimane pref

	Lao Cai province in Vietnam	Shimane Prefecture in Japan	Ratio
Area	6,357 km²	6,707 km²	
Population	565,700	705,893	
Total Budget	25.3 billion	527.7 billion	1/21
Disaster Prevention Budget	1.3 billion	39.6 billion	1/31
The Ratio of Disaster Prevention Budget/Total Budget	5.00%	7.50%	

The ratio of disaster prevention expenses to the total budget, which is almost the same ratio. However, the total budget in Lao Cai province is 25.3 billion yen in terms of Japanese yen, and 527.7 billion yen in Shimane prefecture. The total budget for Lao Cai province is only about 1/20 or less of Shimane

GDP per capita trends in Vietnam



Case Studies

Mon-Seng Bredge

Landslide

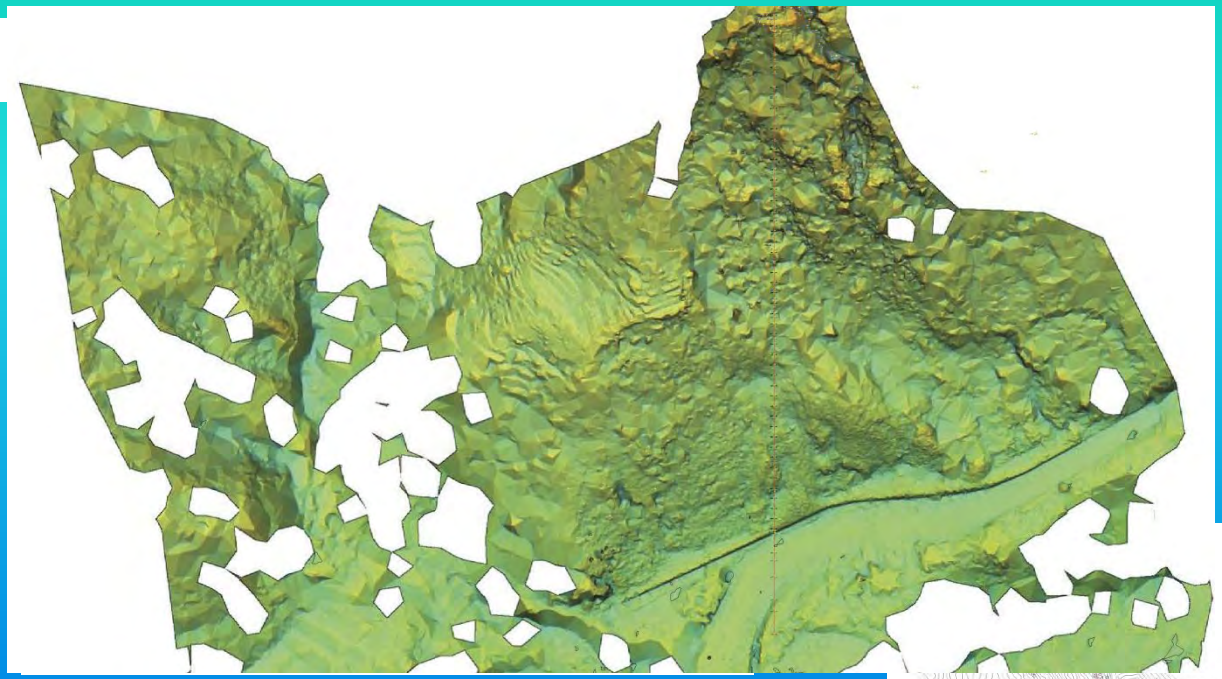
One of the most highest risk of the landslides along the National Road Route 4

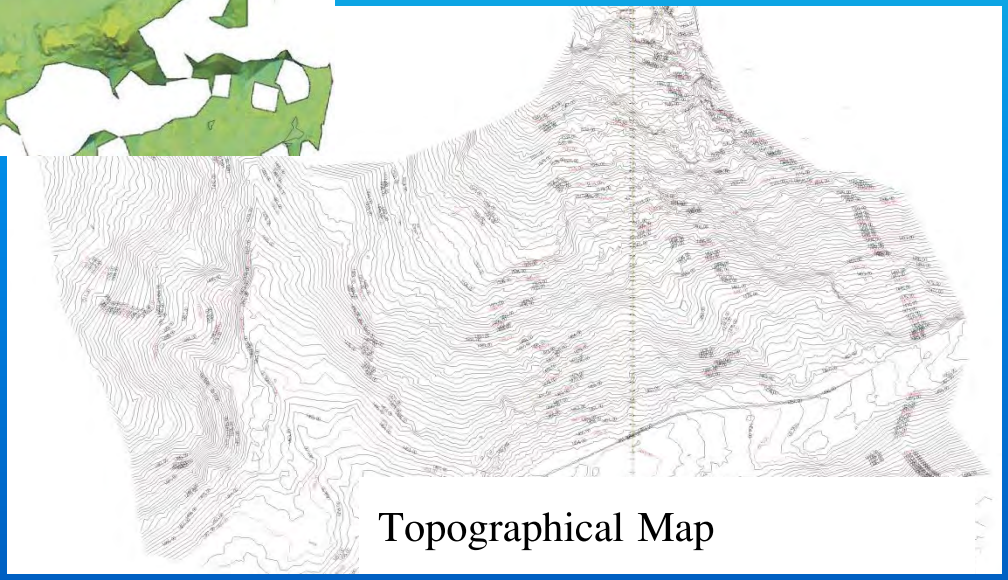
Location Map of the Survey Area

Design Work of Landslide Countermeasures

History of the Mon-Sen landslide

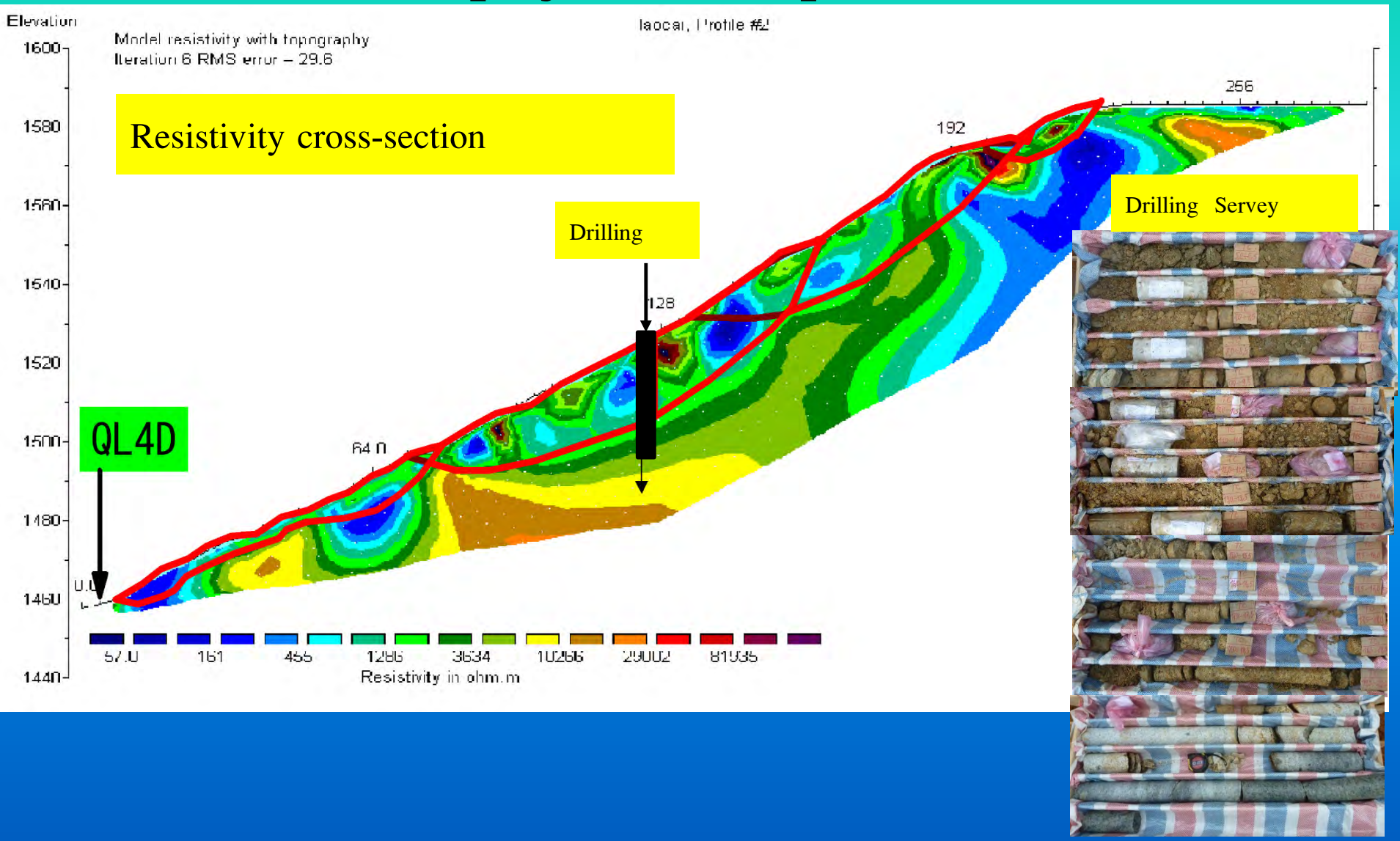
Analysis of Topographic Features of Landslides by Terrestrial LiDAR





Topographical Map

Preliminary Results of High Density Geophysical Exploration



Design Work of Landslide Countermeasures

Drainage drilling work

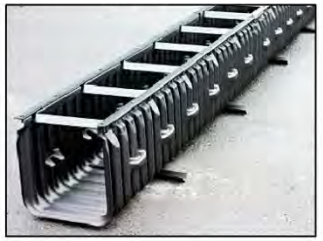
Landslide-slope surface protection by log fence

LEGEND

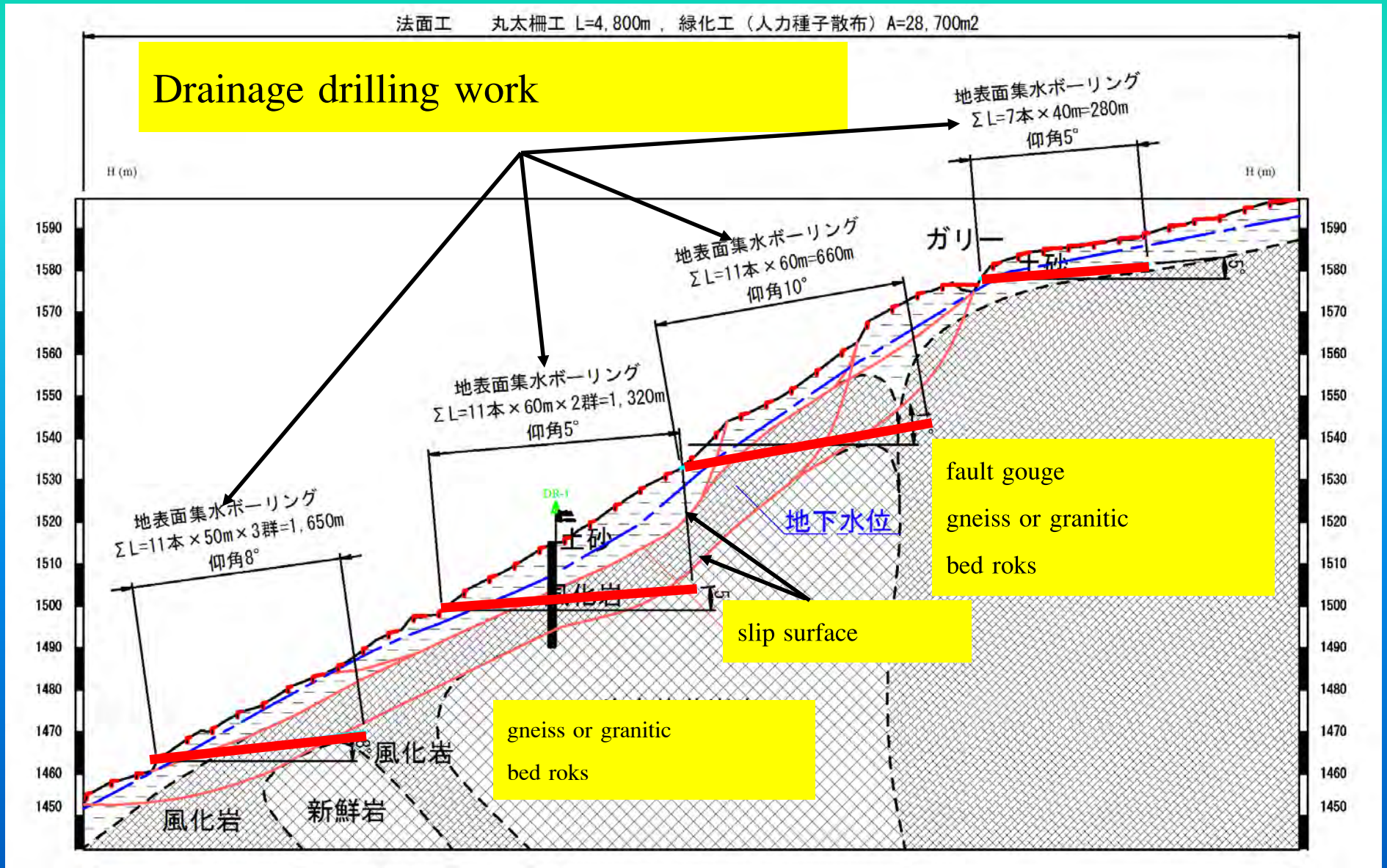
- Drainage drilling
- Ground surface drainage
- Scarp, Knick line

0 10 30 60 100m

Ground surface drainage



Design Work of landslide countermeasures



Case Study

Landslides occurred at urban area in Da Lat city ,April 2017

Drainage Well Construction in Vietnam

Kawasaki Geological Engineering Co.,Ltd

T.Kanno PE(Civil).JP/Ph.D

Situation near the top of the landslide immediately after the landslide in April 2017

Bên trong nhà, vết nứt chạy dọc theo chân tường và trong khu vực bếp

Sụt lún đất ở trung tâm TP.Đà Lạt: Chuyên gia Nhật Bản khảo sát thực địa

05:41 PM - 27/04/2017 | Thanh Niên Online

Chuyên gia Nhật Bản khảo sát thực tế vụ sụt lún đất

Mời chuyên gia xác định nguyên nhân nứt tường, sụt lún nhiều nhà dân tại Đà Lạt

Thứ Năm, 27/04/2017, 14:12:25 | Font Size: − | + | Print

Nhân Dân

Khu vực xảy ra tình trạng nứt đất trên đường Nguyễn Văn Trỗi.

tuổi trẻ online

CHÍNH TRỊ - XÃ HỘI | THẾ GIỚI | PHÁP LUẬT | KINH TẾ | SỐNG KHỎE | GIÁO DỤC | TUYỂN SINH | TH

Chính trị - Xã hội | Thời sự - Suy nghĩ | Phóng sự - Ký sự | Môi trường | Chuy

Trận đấu lớn nhất mùa giải của Mourinho

Nước ngầm gây nứt đất ở trung tâm Đà Lạt

27/04/2017 20:55 GMT+7

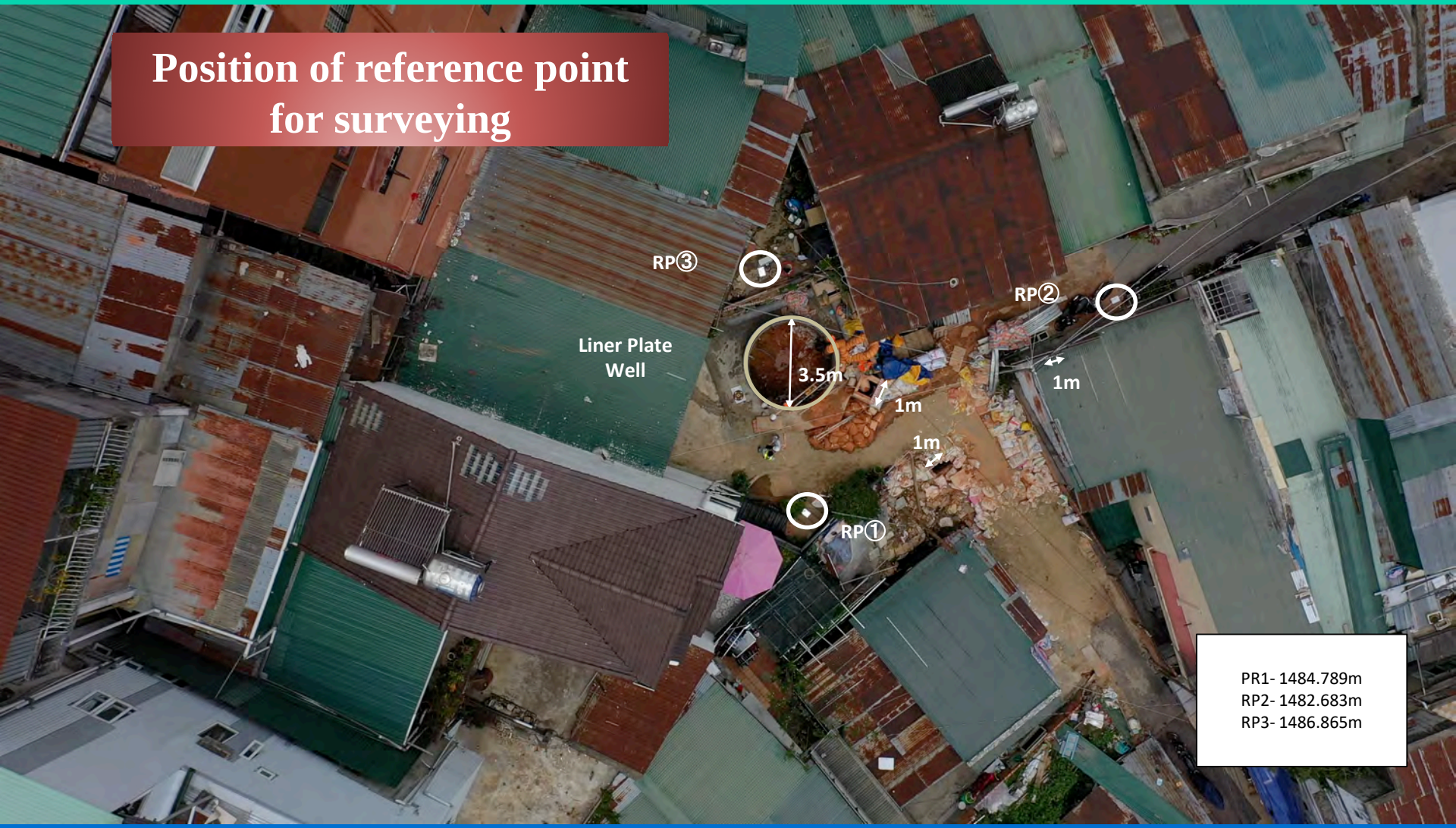
TTO - Các chuyên gia địa chất của Đại học Bách khoa TP.HCM, Viện Hàn lâm khoa học Việt Nam và Công ty Kawasaki (Nhật) đánh giá nước ngầm và mưa lớn là tác nhân quan trọng gây nứt đất tại Đà Lạt.

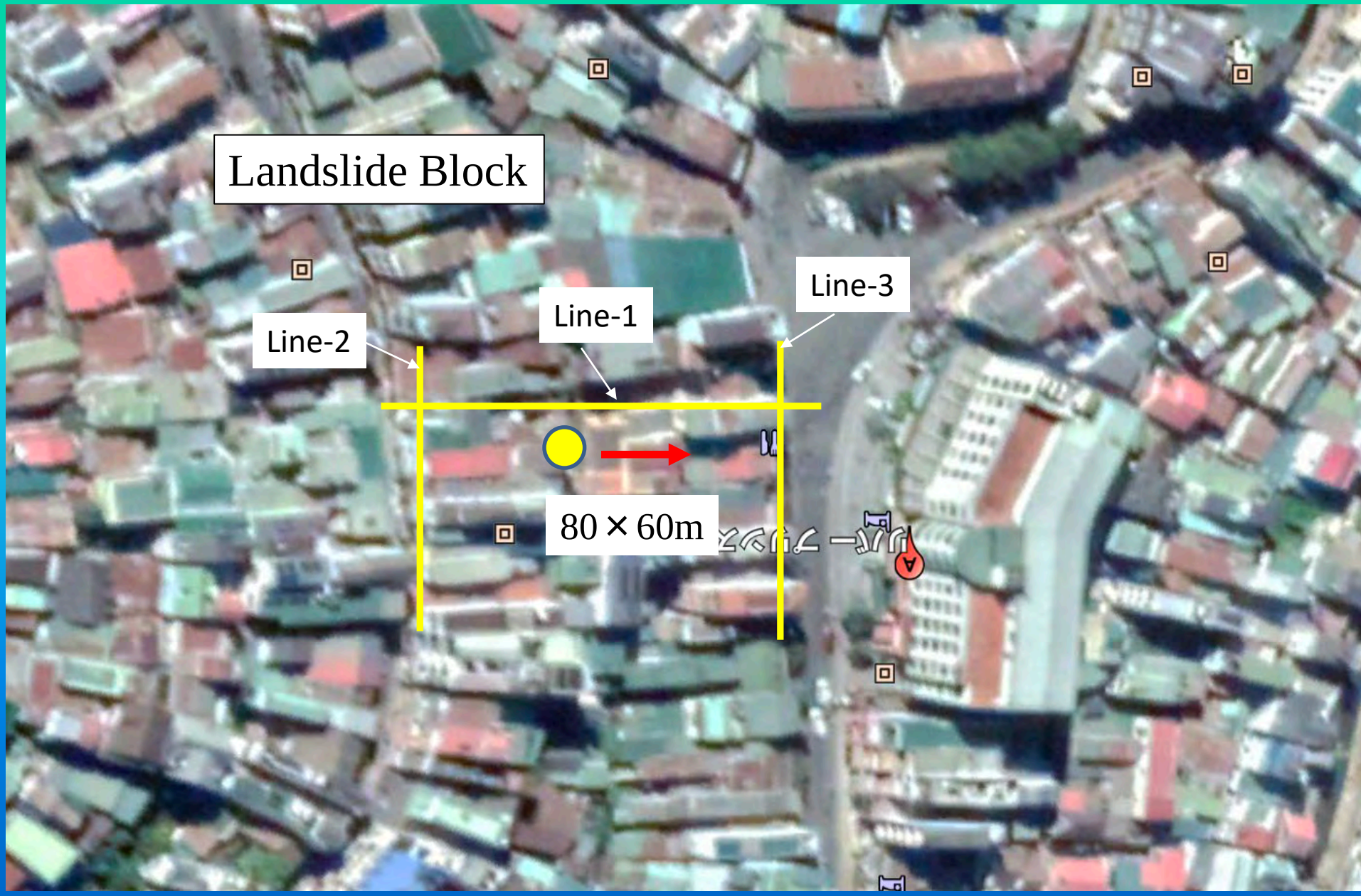
Vết nứt ngang tường tại một căn nhà trên đường Nguyễn Văn Trỗi - Ảnh: M.Vinh

UBND tỉnh Lâm Đồng họp bàn tìm nguyên nhân

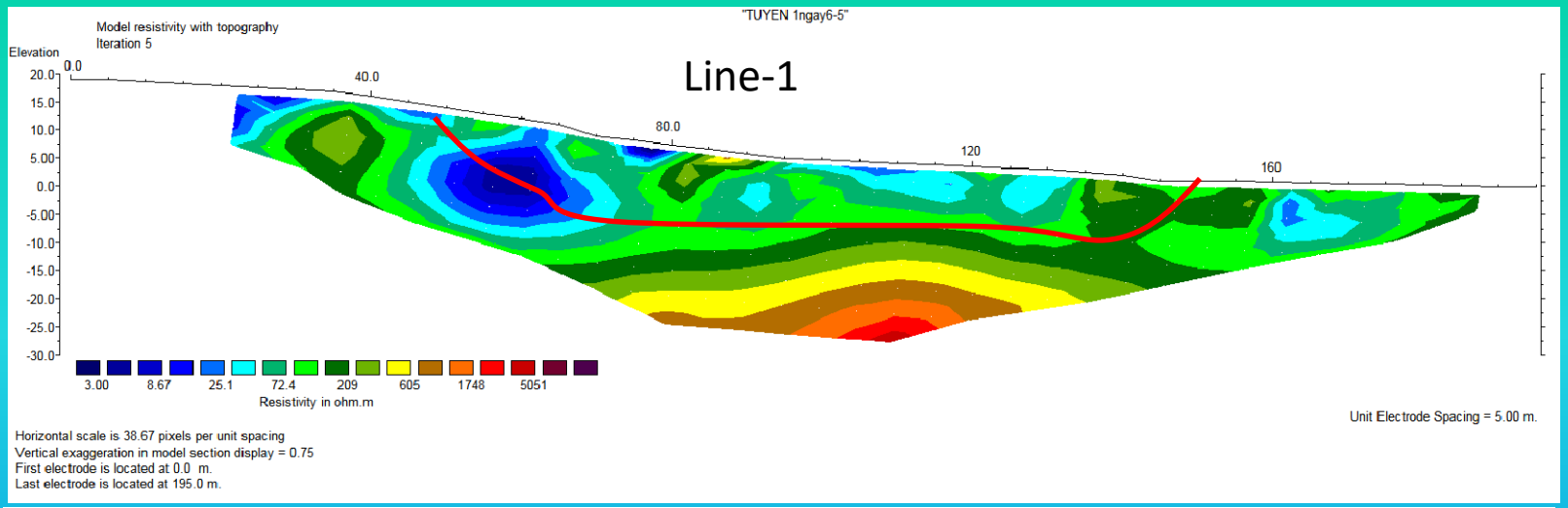
Press

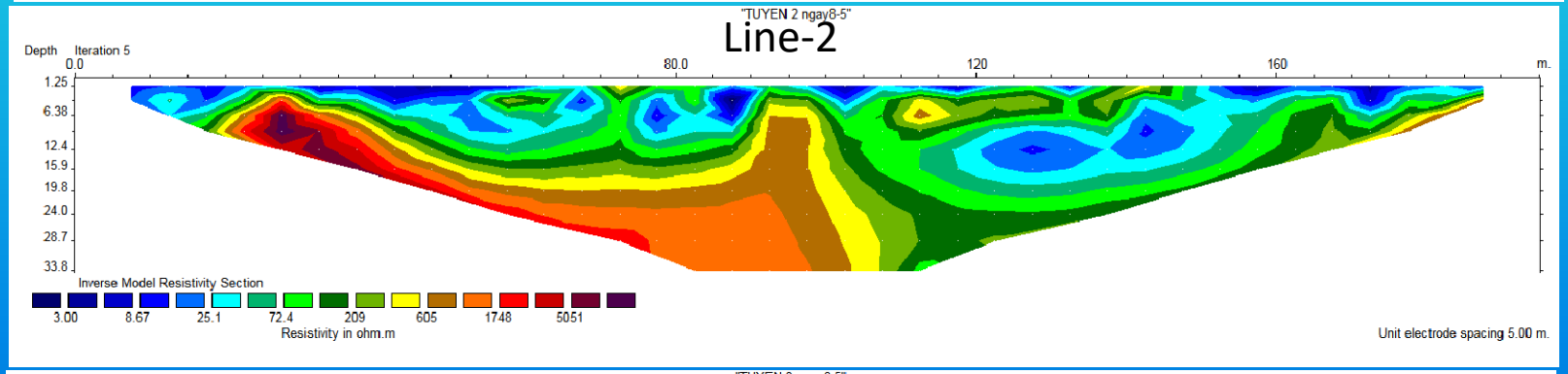
Position of reference point for surveying

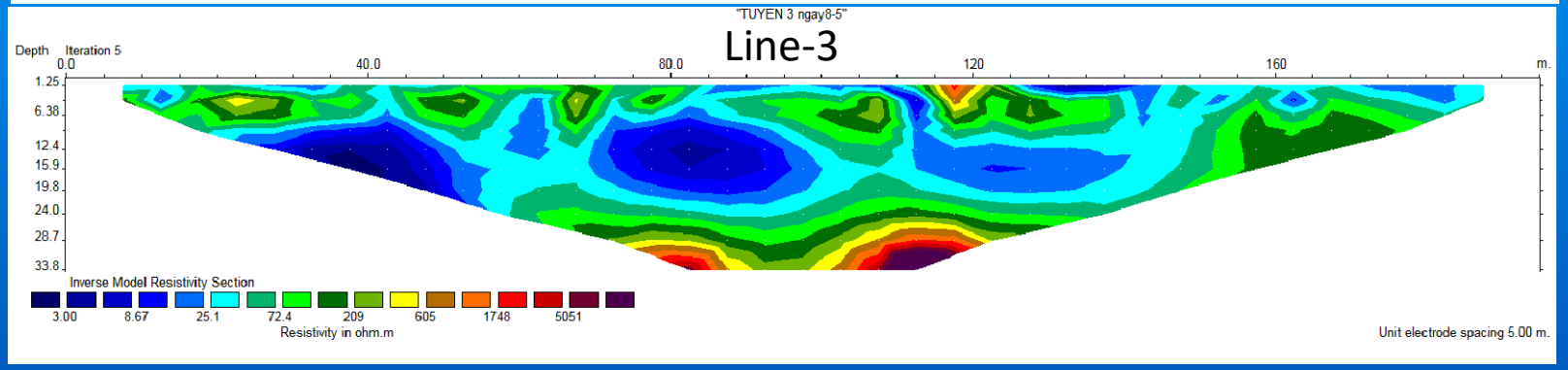



Landslide Block
Line-2
Line-1
Line-3
80 × 60m

High-Density Electrical Prospecting Results



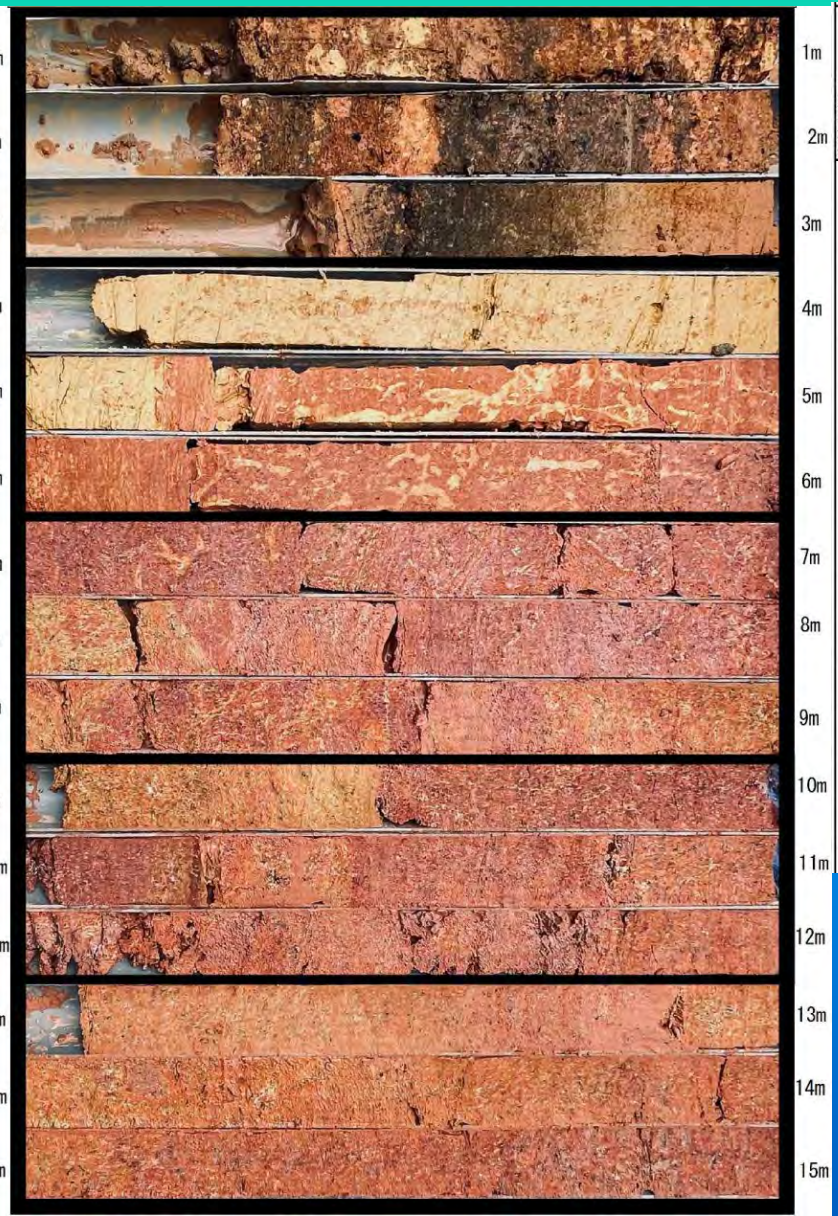




Landslide monitoring with ground extensometer

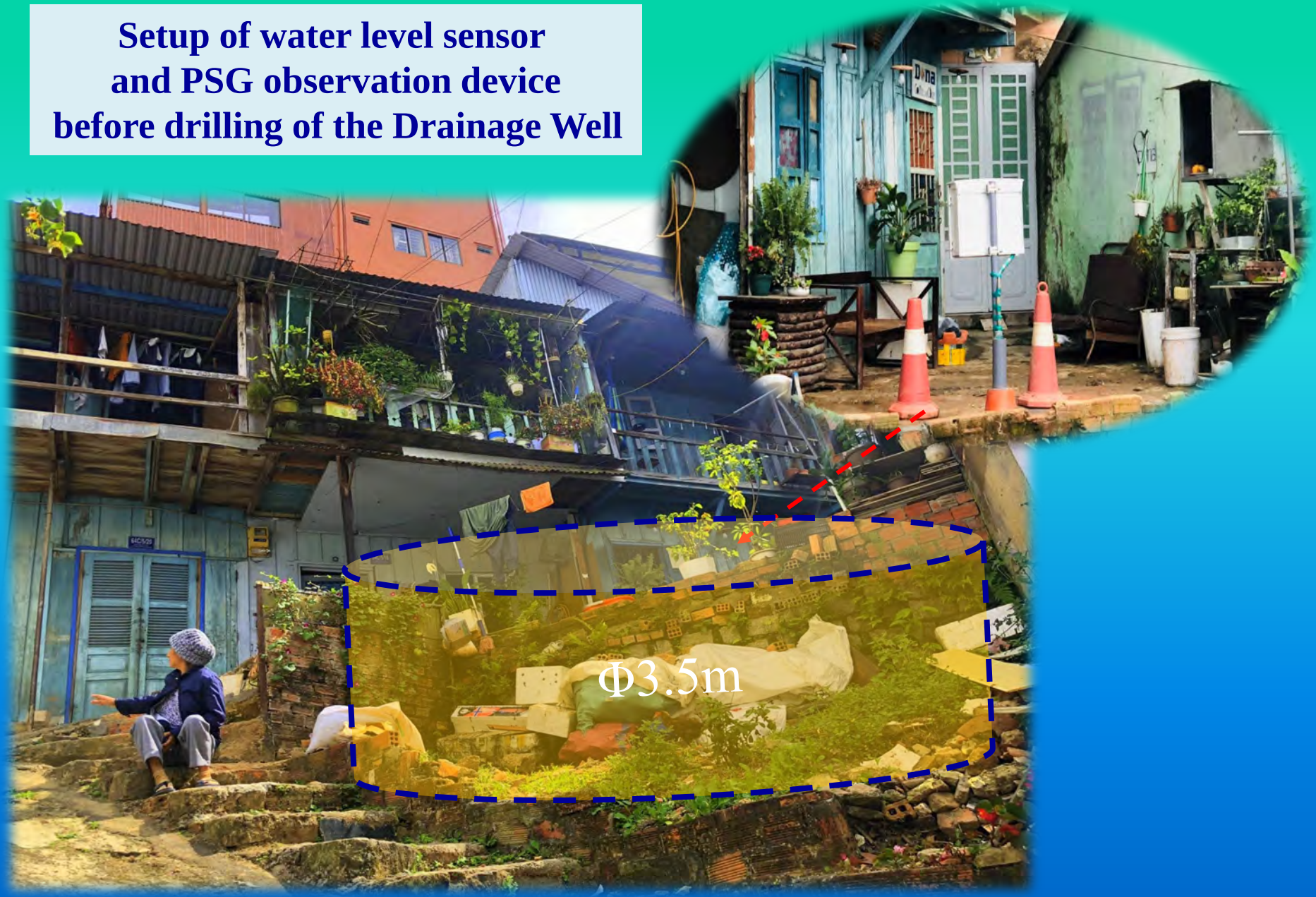
Drilling survey and set-up PSG just before the Drainage Well construction in 2020

Drilling results in 2020

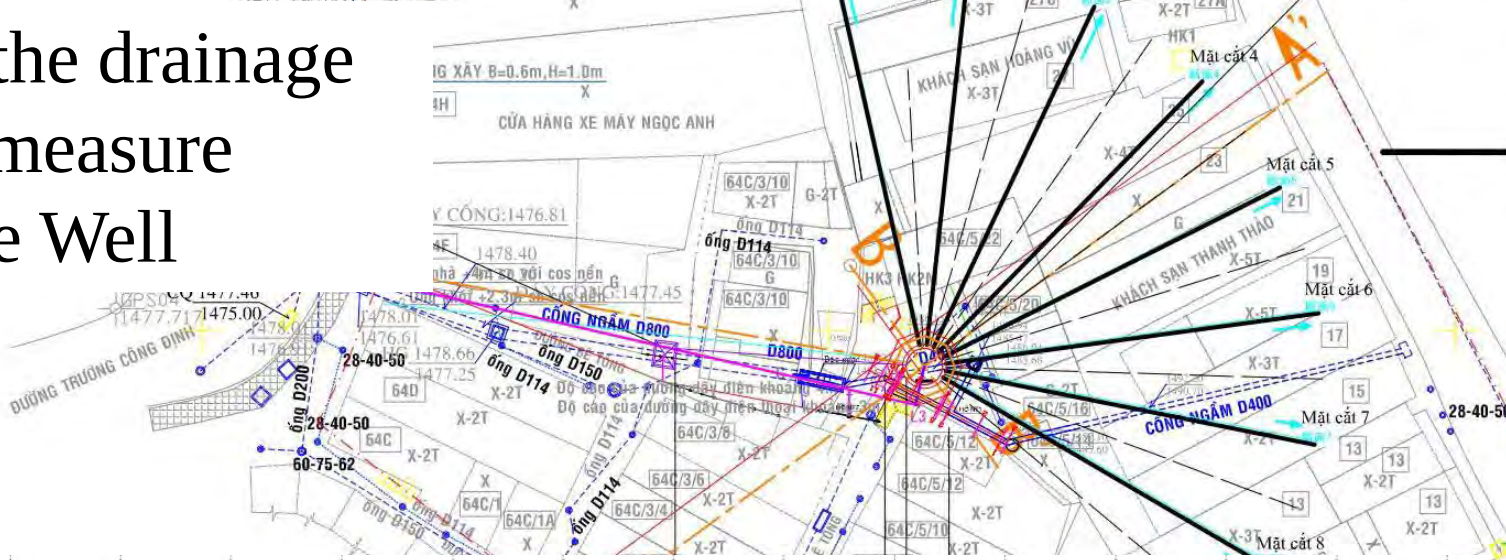


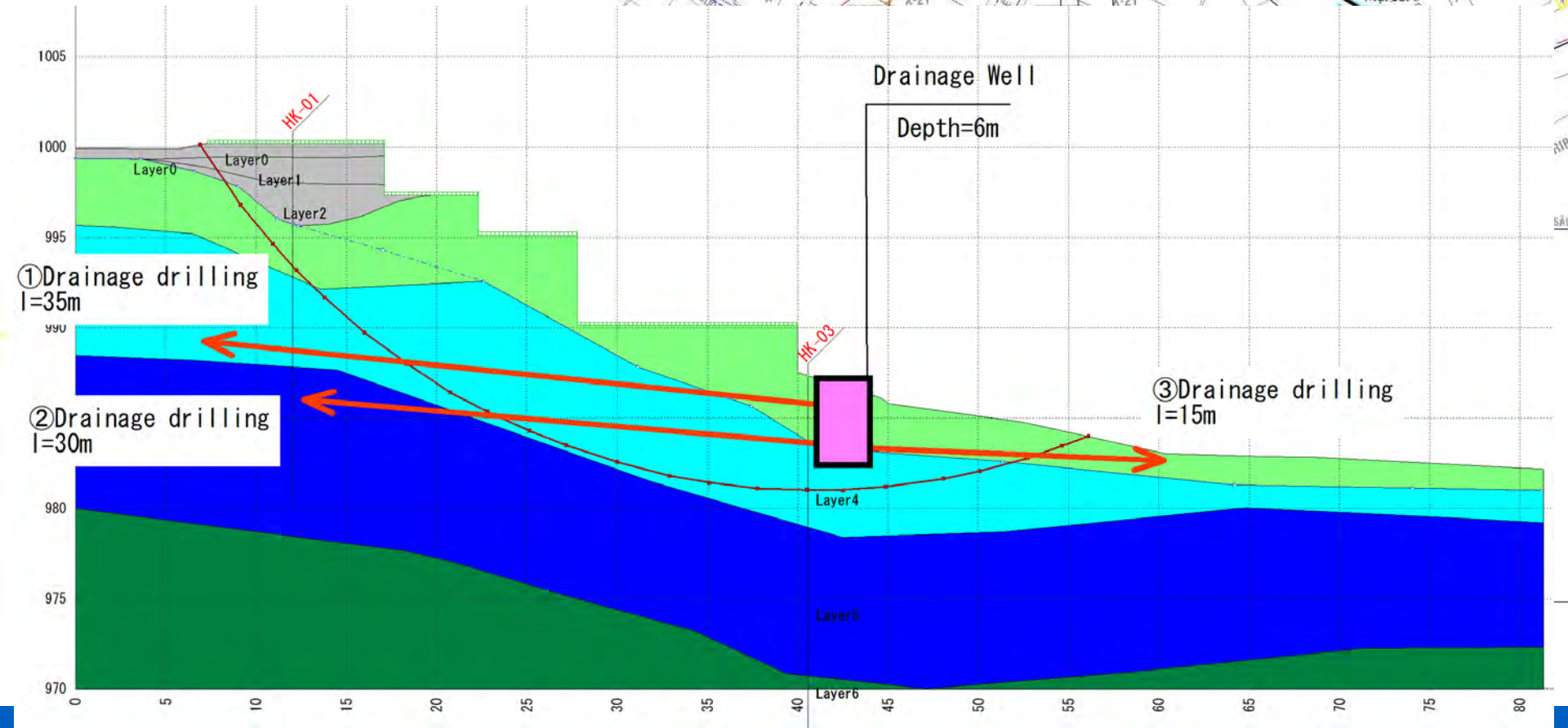
SCALE (m) TỶ LỆ	ELEVATION (m) CAO ĐỘ	DEPTH (m) ĐỘ SÂU	THICKNESS (m) BỀ DÀY	STRATIGRAPHIC KH ĐỊA TẦNG	DESCRIPTION MÔ TẢ	STANDARD PENETRATION TEST THÍ NGHIỆM XUYÊN TIÊU CHUẨN						SAMPLES MẪU		
						SPT No. Số SPT	Depth (m) Độ sâu	Blows/ 15cm Số búa/ 15cm N1	N2	N3	N Value	N value chart/ Biểu đồ giá trị N 10 20 30 40 50	Sample No. Số hiệu mẫu	Depth (m) Độ sâu	Recovery (cm) Chiều dài mẫu
0	1486.9	0.00													
1			2.70	F	Filling materials, reddish brown *Vật liệu đất san lấp, dăm sạn, vụn gạch, sét xen lẫn, màu nâu đỏ.*	1	0.50 ÷ 0.95	1	2	3	5				
2						2	1.00 ÷ 1.45	1	2	2	4				
	1484.1	2.80			*Á sét, màu nâu đỏ, nâu đen lẫn thực vật . Trạng thái dẻo mềm.*	3	2.00 ÷ 2.45	1	2	2	4				
3			1.20	1a	Silty CLAY, reddish brown, yellowish brown, mottled, firm. Some places mixed sand.	4	3.00 ÷ 3.45	1	2	2	4				
4	1482.9	4.00			*Á sét, nâu đỏ, nâu vàng, xám vàng trắng loang lổ, kẻ đường vân. Trạng thái dẻo mềm.*								UD1	4.00 ÷ 4.60	60
5						5	5.00 ÷ 5.45	2	3	4	7				
6			5.00	1b	Silty CLAY, reddish brown, yellowish brown, mottled, firm. *Á sét, nâu đỏ, nâu vàng, xám vàng trắng loang lổ, kẻ đường vân. Trạng thái dẻo mềm.*	6	6.00 ÷ 6.45	2	4	4	8		UD2	5.50 ÷ 6.00	50
7						7	7.00 ÷ 7.45	2	3	3	6				
8													UD3	8.00 ÷ 8.60	60
9	1477.9	9.00				8	9.00 ÷ 9.45	2	4	5	9				
10						9	10.00 ÷ 10.45	2	4	6	10				
11						10	11.00 ÷ 11.45	2	4	7	11				
12			6.50	1c	Silty CLAY, reddish brown, dark yellow, yellow-white grey, mottled, stiff *Á sét, nâu đỏ, vàng sẫm, xám vàng trắng loang lổ, tổn đốm. Trạng thái dẻo cứng.*										
13						11	13.00 ÷ 13.45	2	4	6	10				
14						12	14.00 ÷ 14.45	2	4	7	11				
15	1471.4	15.50				13	15.00 ÷ 15.45	2	4	7	11				

Setup of water level sensor and PSG observation device before drilling of the Drainage Well



Concept of the drainage countermeasure in the Well





Ground leveling work before excavation of Drainage Well(20 March 2021)

Before placing the concrete top plate

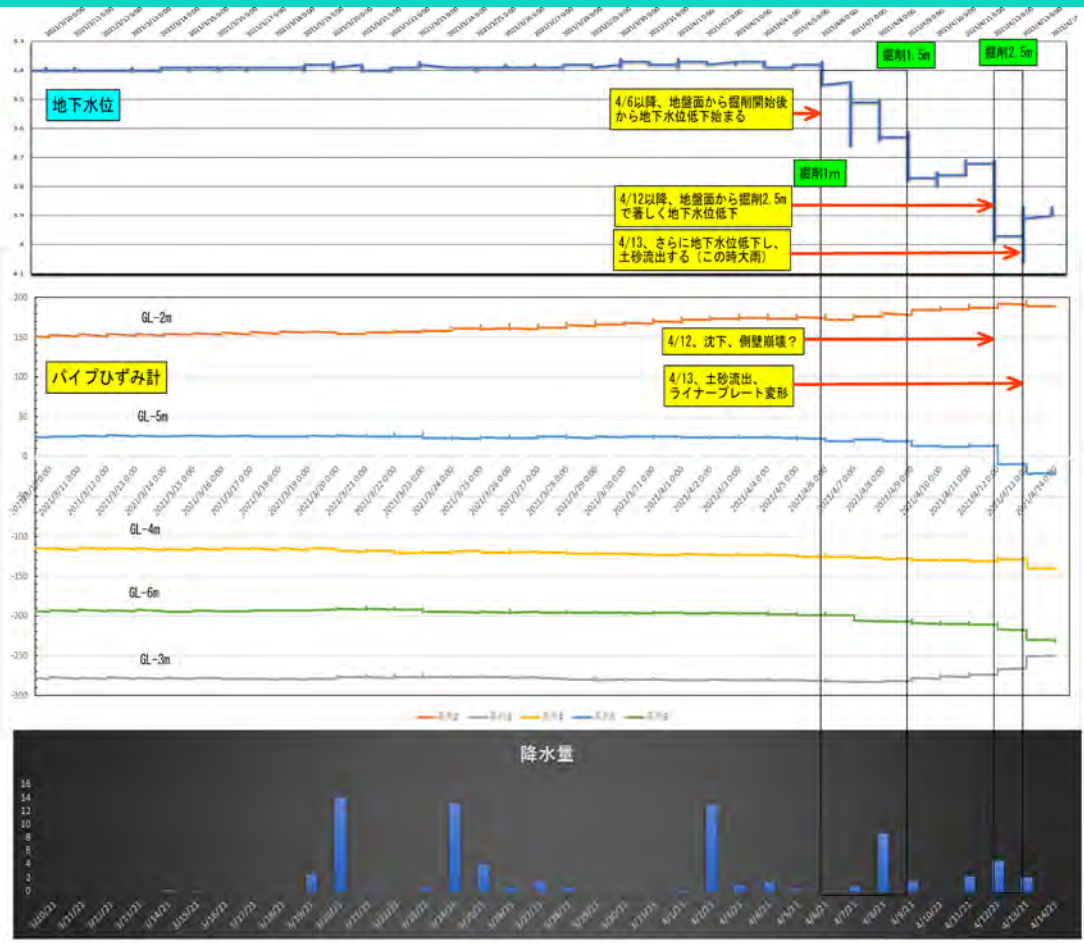
Placement of concrete top plate

Remove the formwork after placing the concrete top plate


EZVIZ
04-01-2021 09:02:42

14 April 2021　Sediment runoff behind the sidewall of the drainage well by heavy rain (beginning of heaving)

土砂流出状況




23 April


23 April


23 April


23 April

As a countermeasure against heaving, grouting was carried out around the hollowed out Drainage Well.

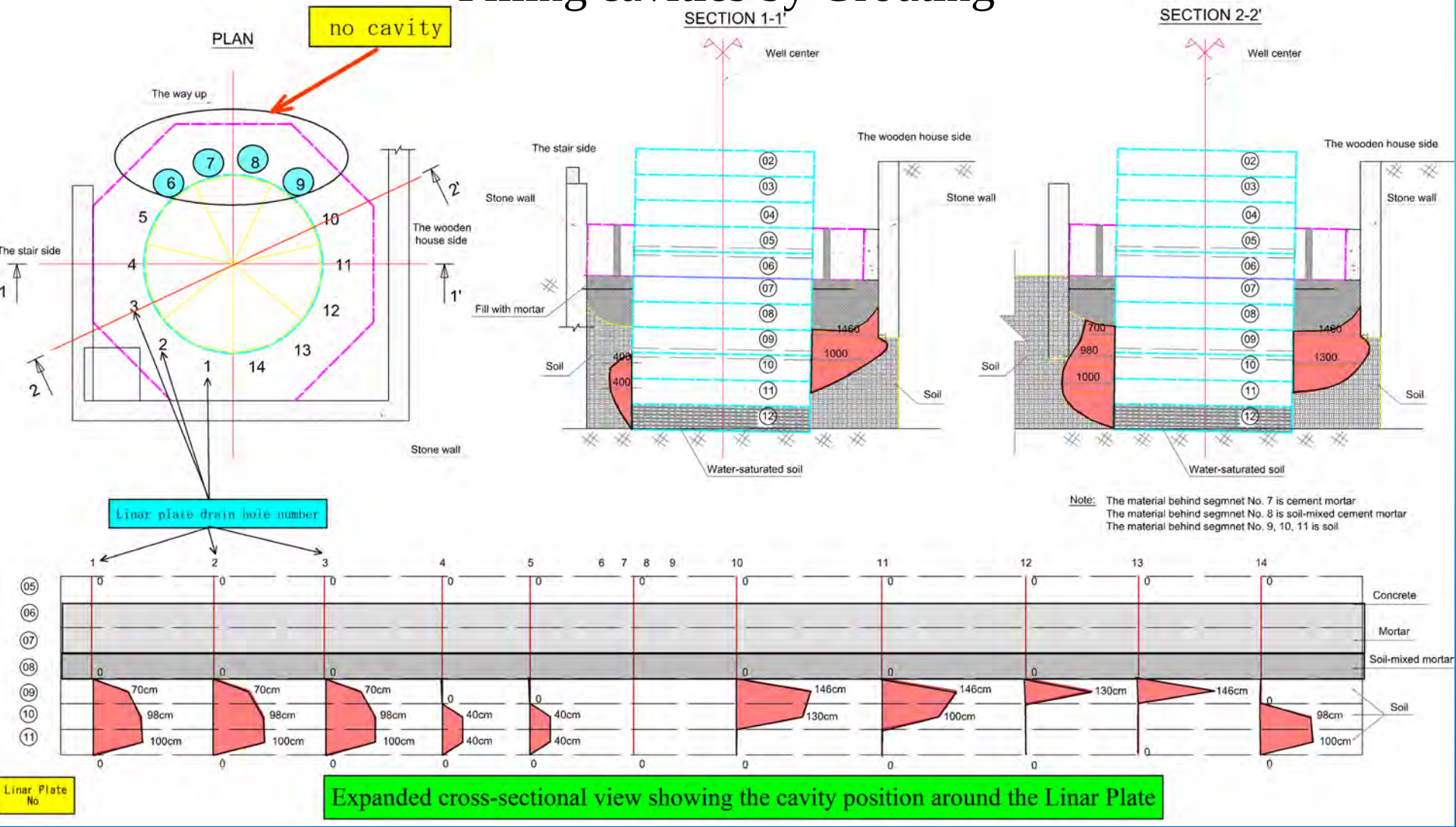


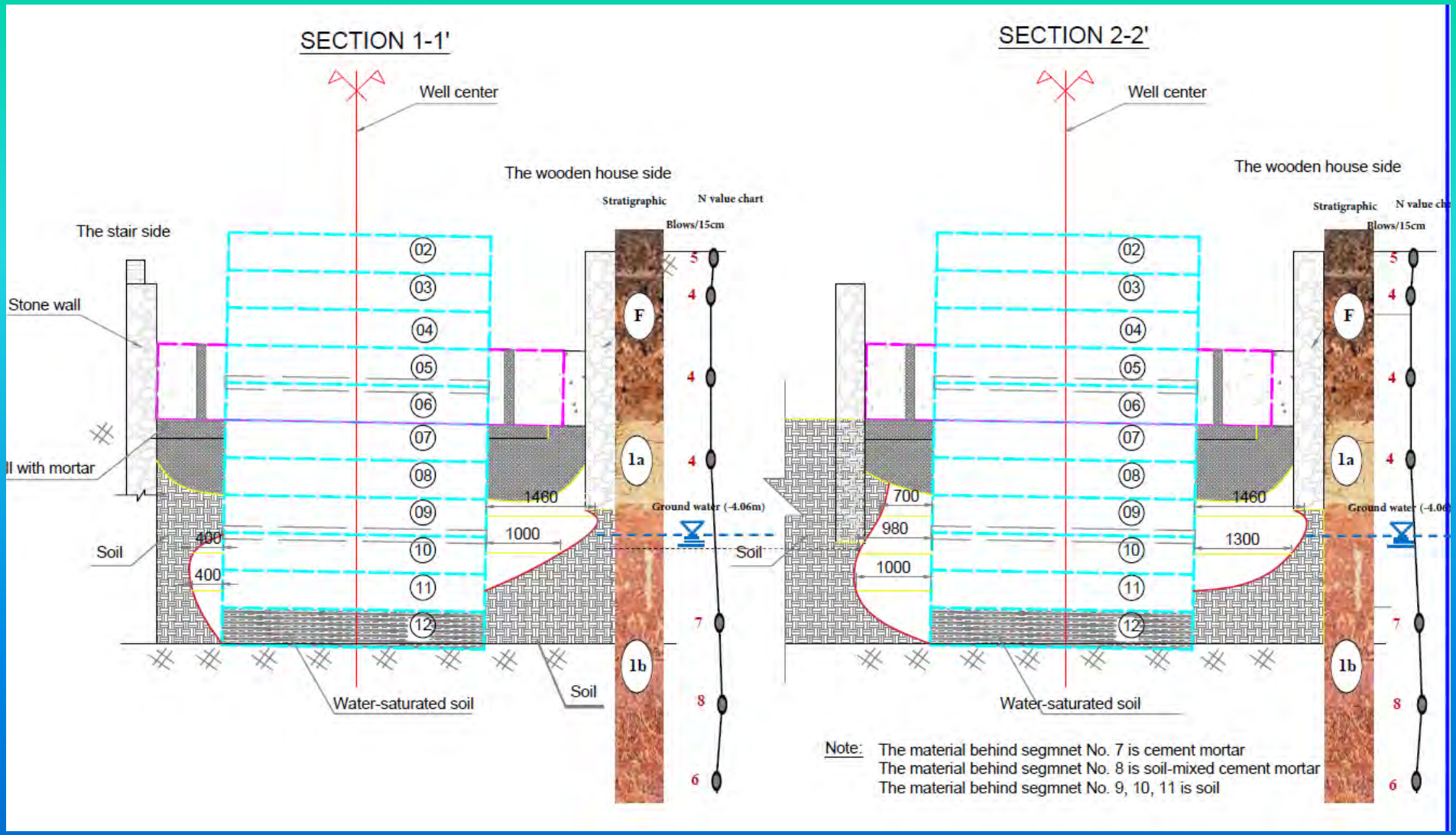



Survey results of the cavity on the back of the liner plate

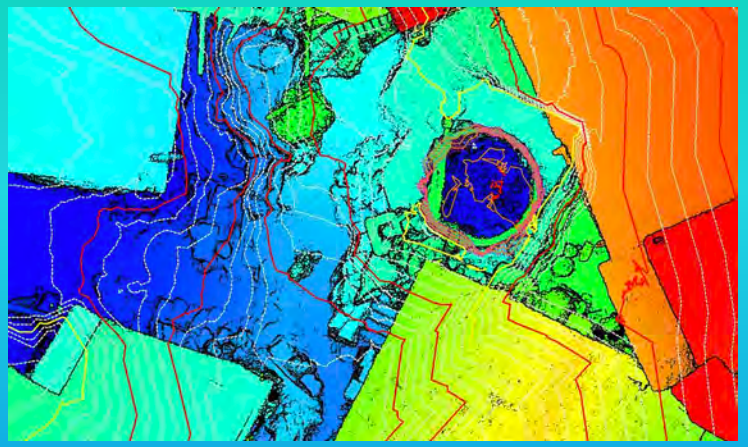
CURRENT STATUS (1/2)

Filling cavities by Grouting



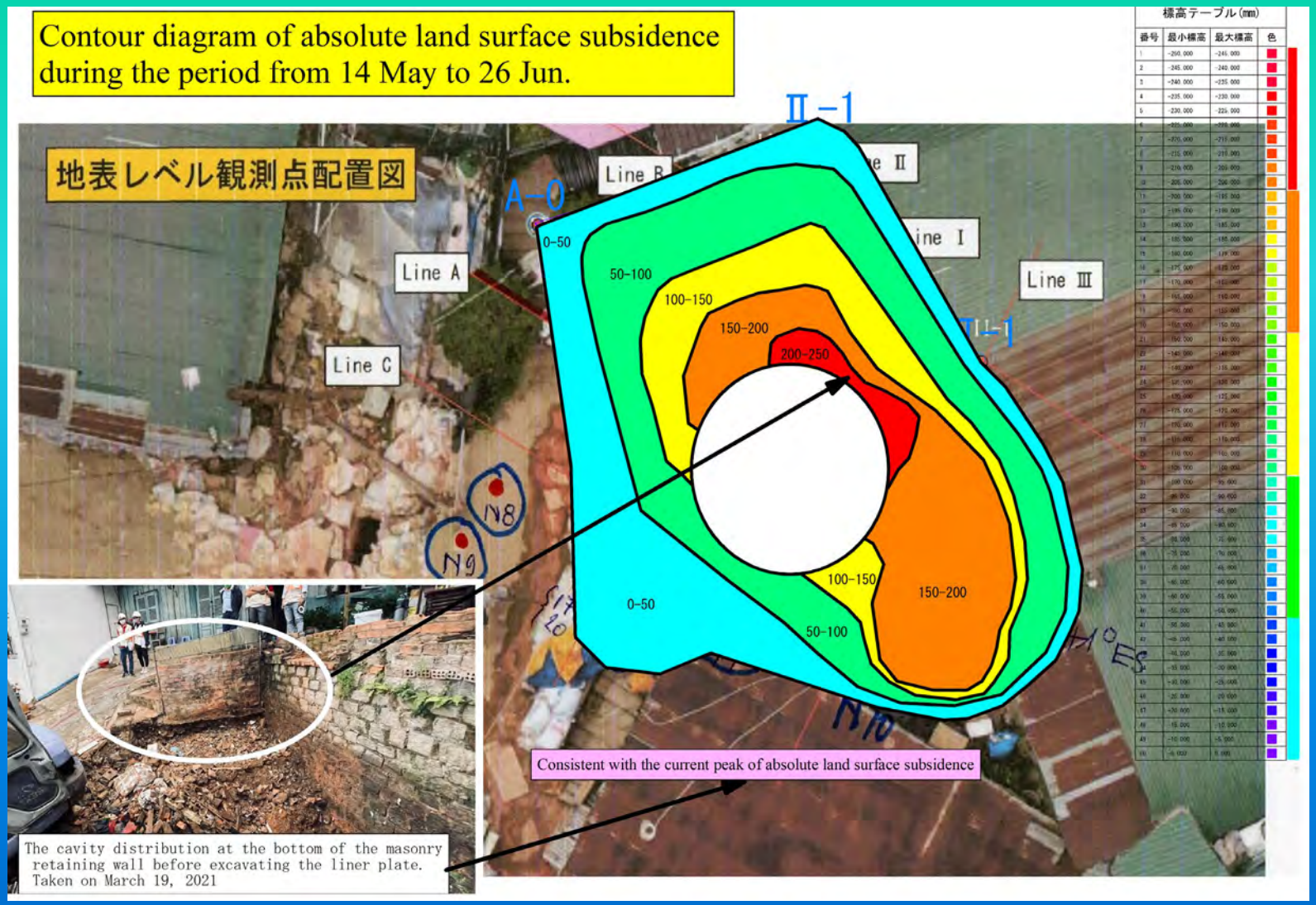

SECTION 1-1'
Well center
The wooden house side
The stair side
Stratigraphic
N value chart
Blows/15cm
Stone wall
l with mortar
Soil
400
400
1460
1000
Ground water (-4.06m)
Soil
Soil
Water-saturated soil
02
03
04
05
06
07
08
09
10
11
12
F
1a
1b
5
4
4
4
7
8
6
SECTION 2-2'
Well center
The wooden house side
700
980
1000
1460
1300
Soil
Water-saturated soil
Note: The material behind segmnet No. 7 is cement mortar
The material behind segmnet No. 8 is soil-mixed cement mortar
The material behind segmnet No. 9, 10, 11 is soil

Identification of the heaving area using orthoimages and topographical contour maps created by aerial drone photography



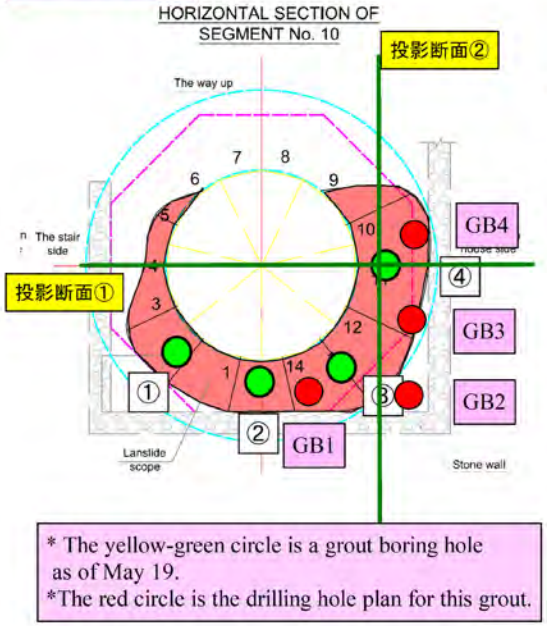
Aerial photography: Kawasaki Geological Co., Ltd.
Image processing: Nakanihon Air Service

Contour diagram of absolute land surface subsidence during the period from 14 May to 26 Jun.



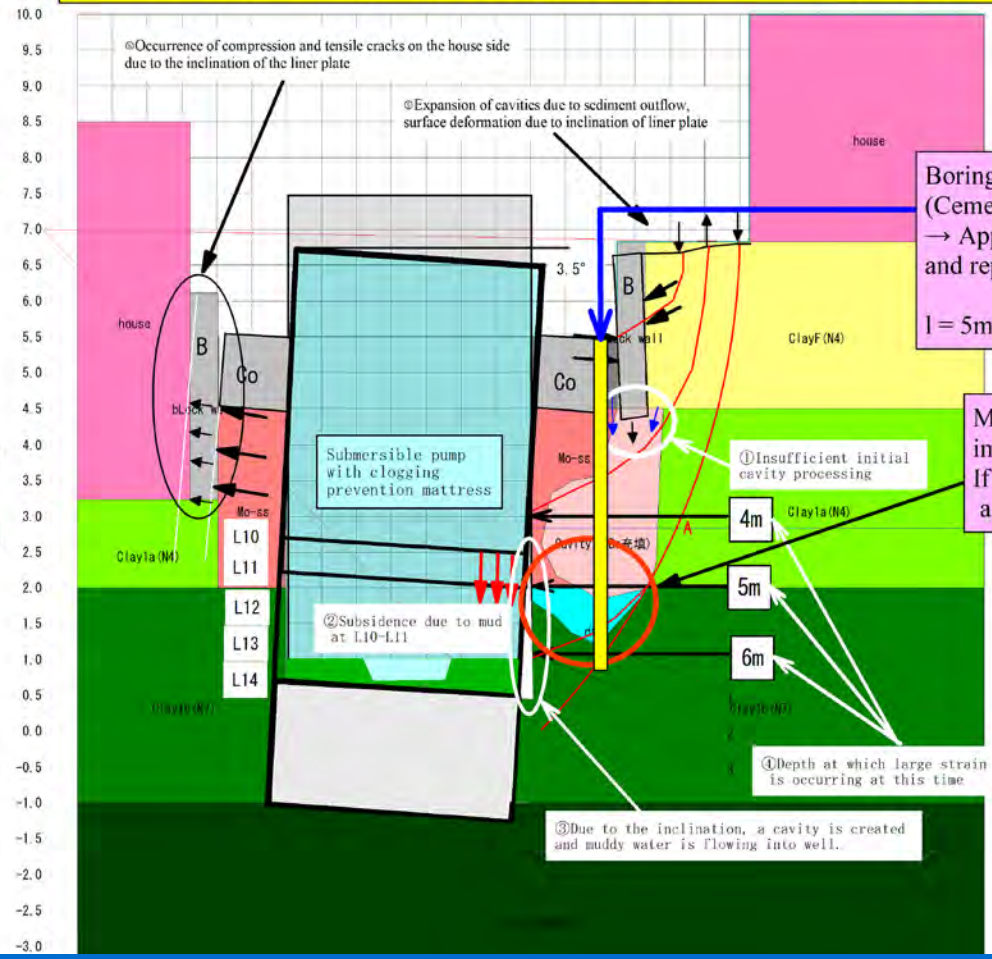
Soil Improvement cross section by Grouting

210708 Docu①

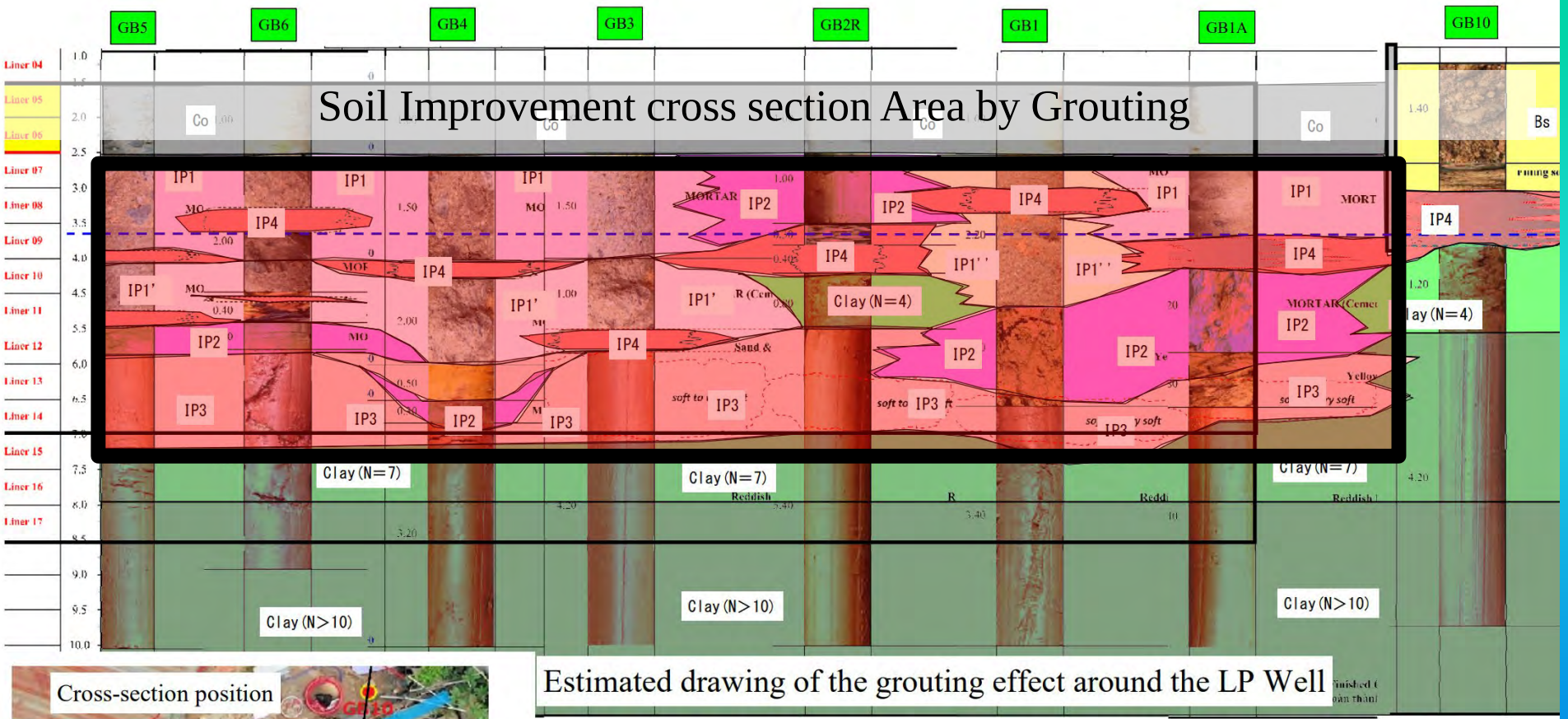


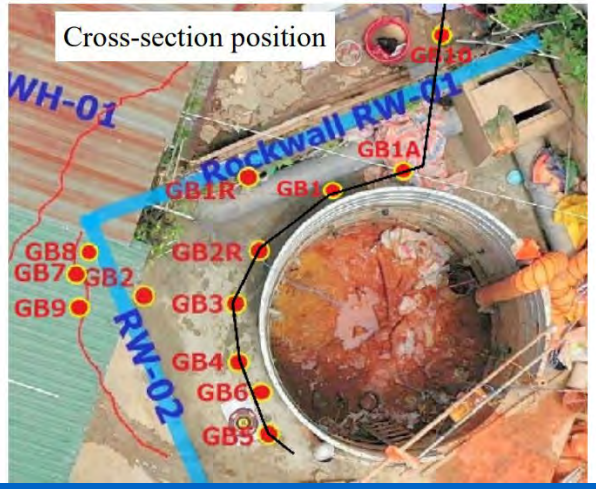
* The yellow-green circle is a grout boring hole as of May 19.
*The red circle is the drilling hole plan for this grout.

210707 Additional Emargency Grouting Method (Cement - Bentonite improvement, replacement, filling)



Soil Improvement cross section Area by Grouting





Estimated drawing of the grouting effect around the LP Well

Legend of Grouting improvement and injection

IP1,IP1',IP1'':Filling by mortar injection
- IP1:Hard enough
- IP1':Slightly inhomogeneous (soft)
- IP1``:Weak consolidation

IP3,IP4:Filling by cement-bentoniter injection or Improvement
- IP2: Stage 1 emergency measures
- IP3::Stage 2 emergency measures(This time)
- IP3::Stage 3 emergency measures(This time)

Legend

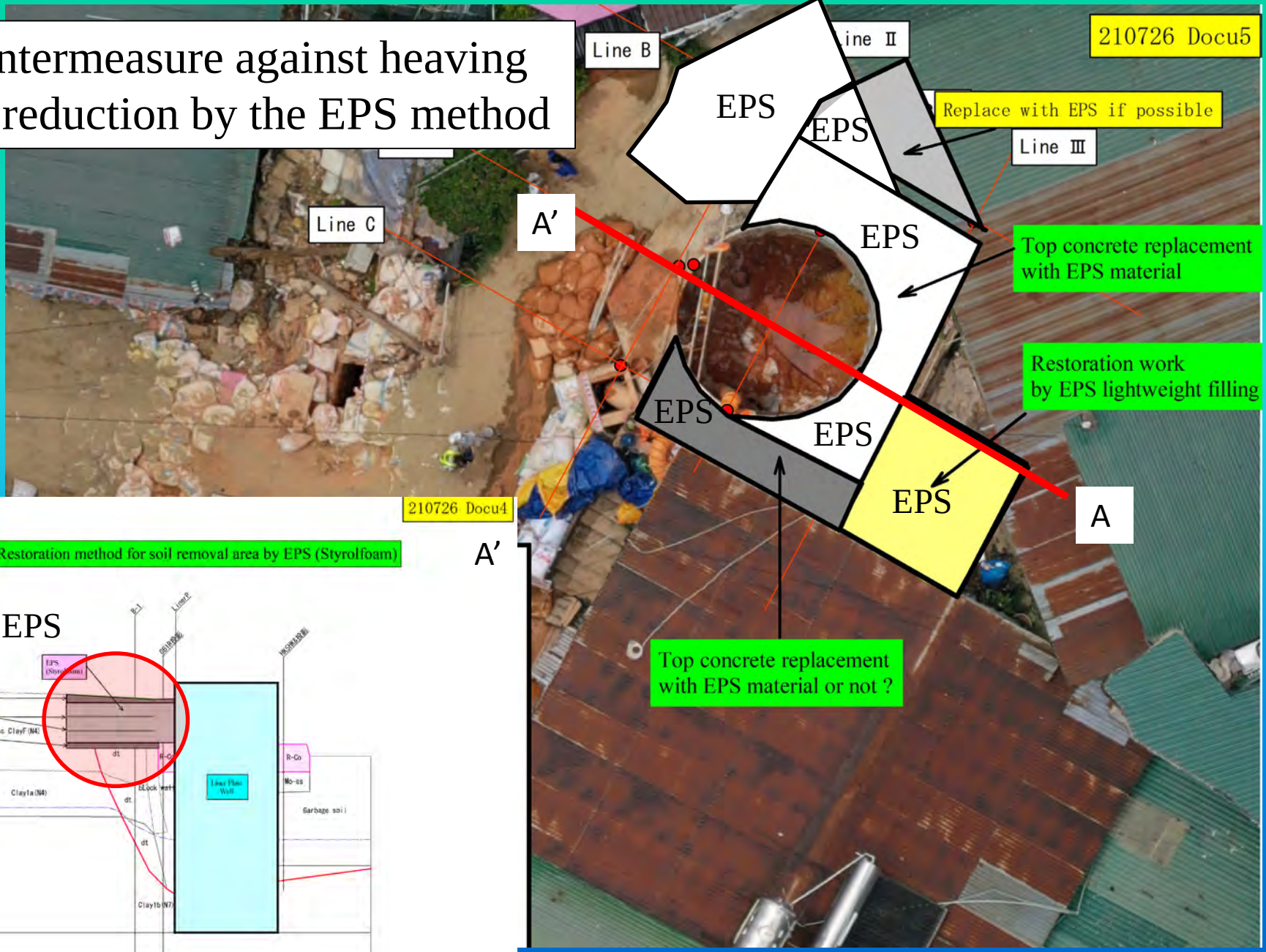
Bs:Filled soil

Co:Top concrete around the LP Well

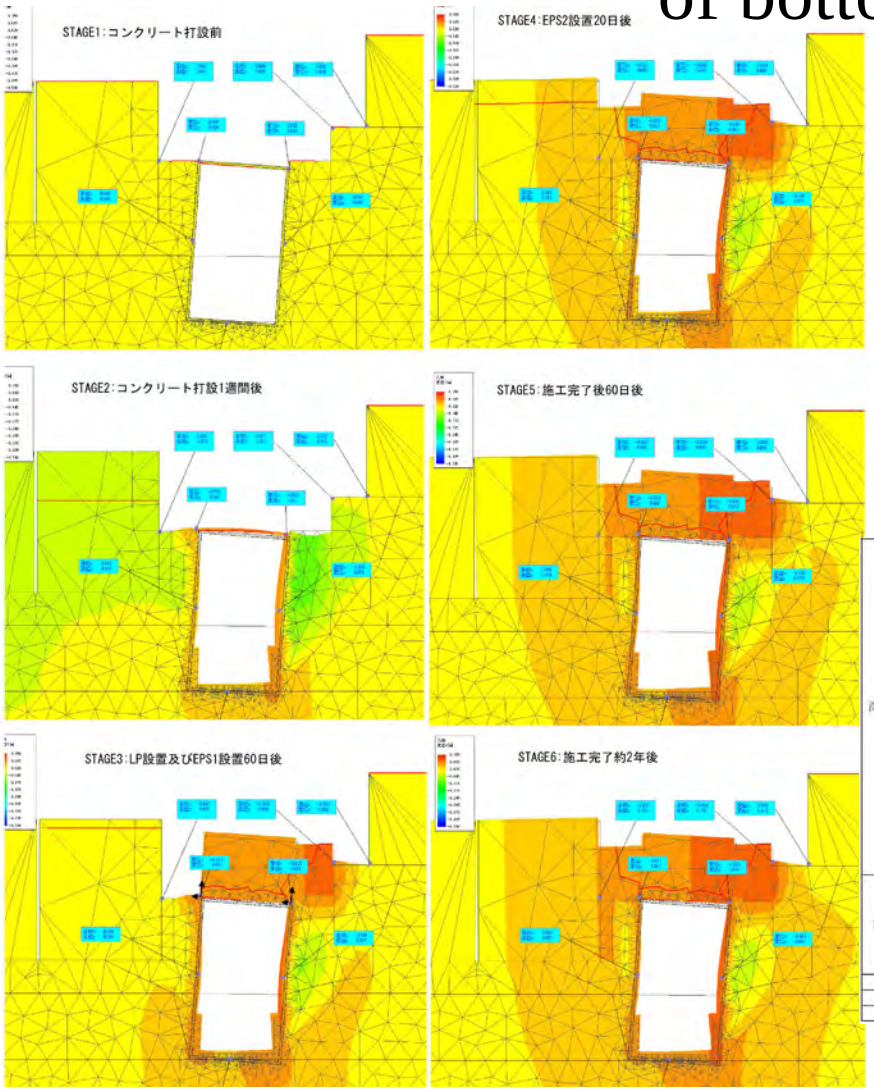
Geology
- Clay (N=4)
- Clay (N=7)
- Clay (N>10)

Groundwater level

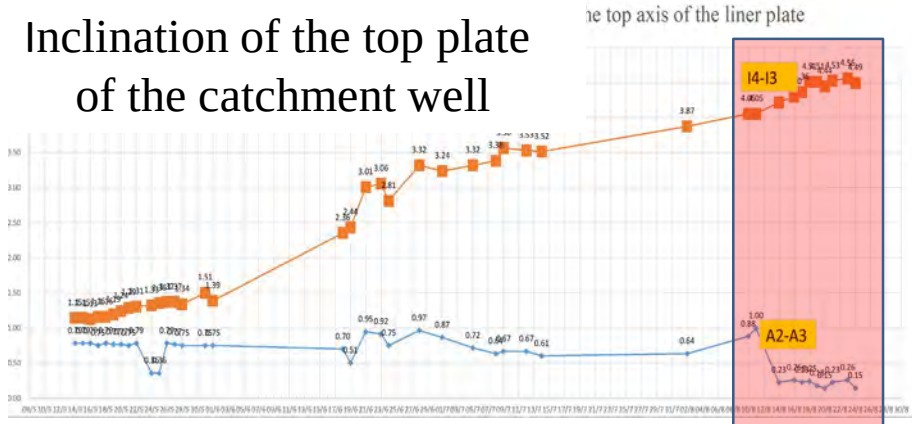
Countermeasure against heaving
Load reduction by the EPS method



Displacement prediction of drainage well after installation of bottom concrete



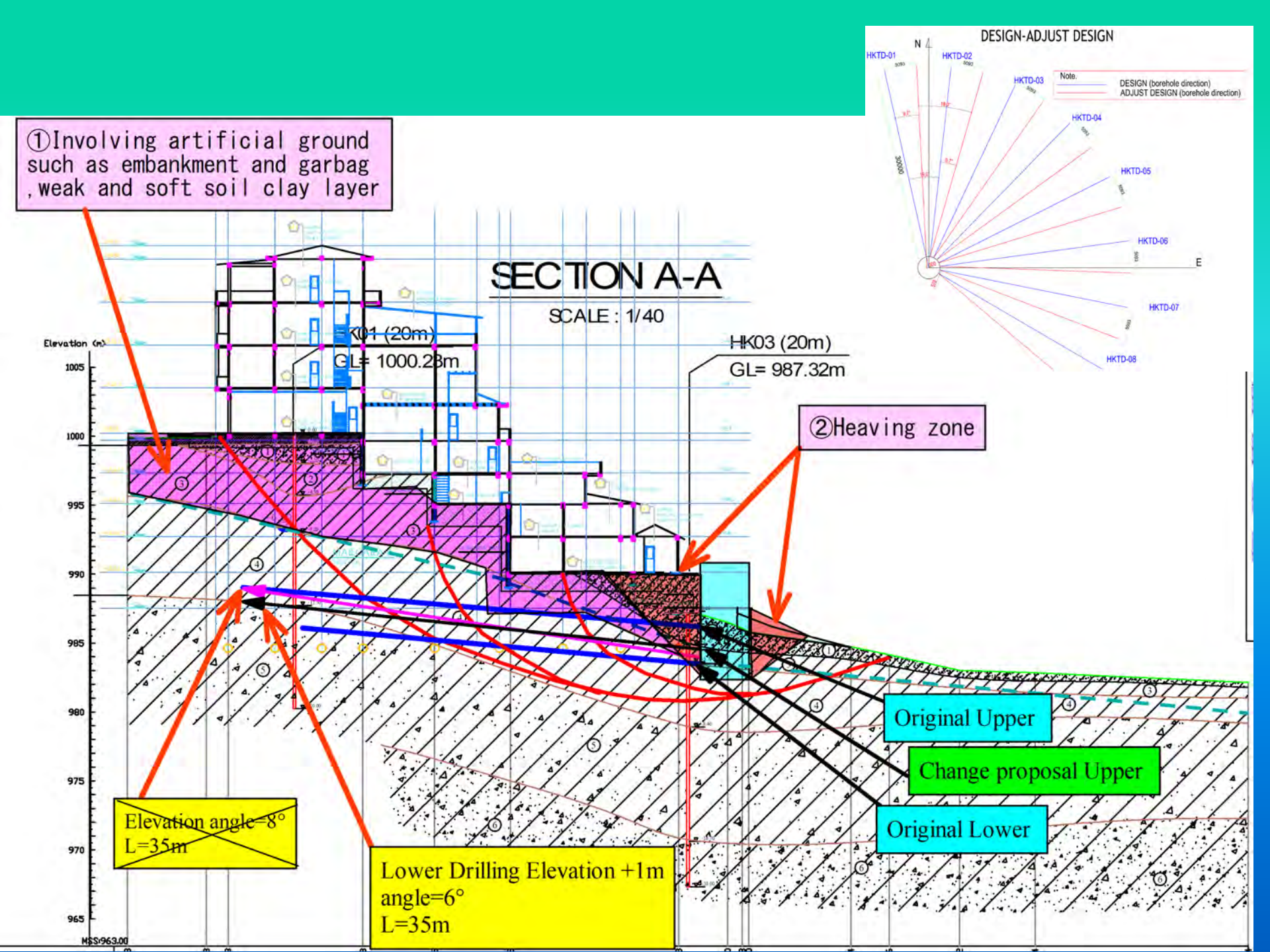
Inclination of the top plate of the catchment well



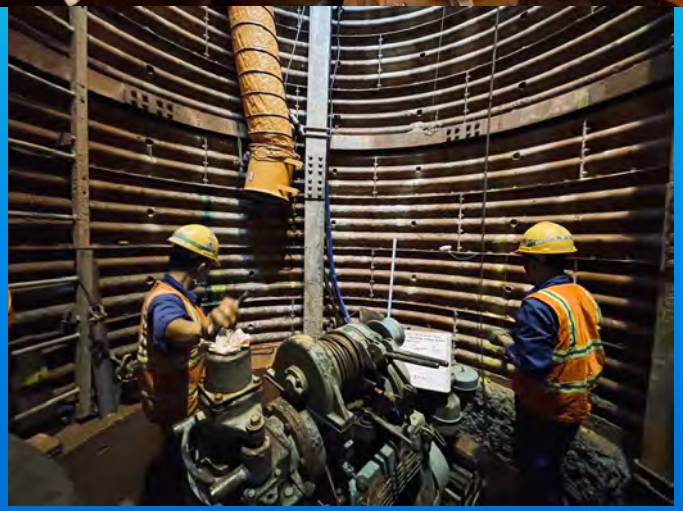
PSG

Displacement stop after installation of bottom concrete

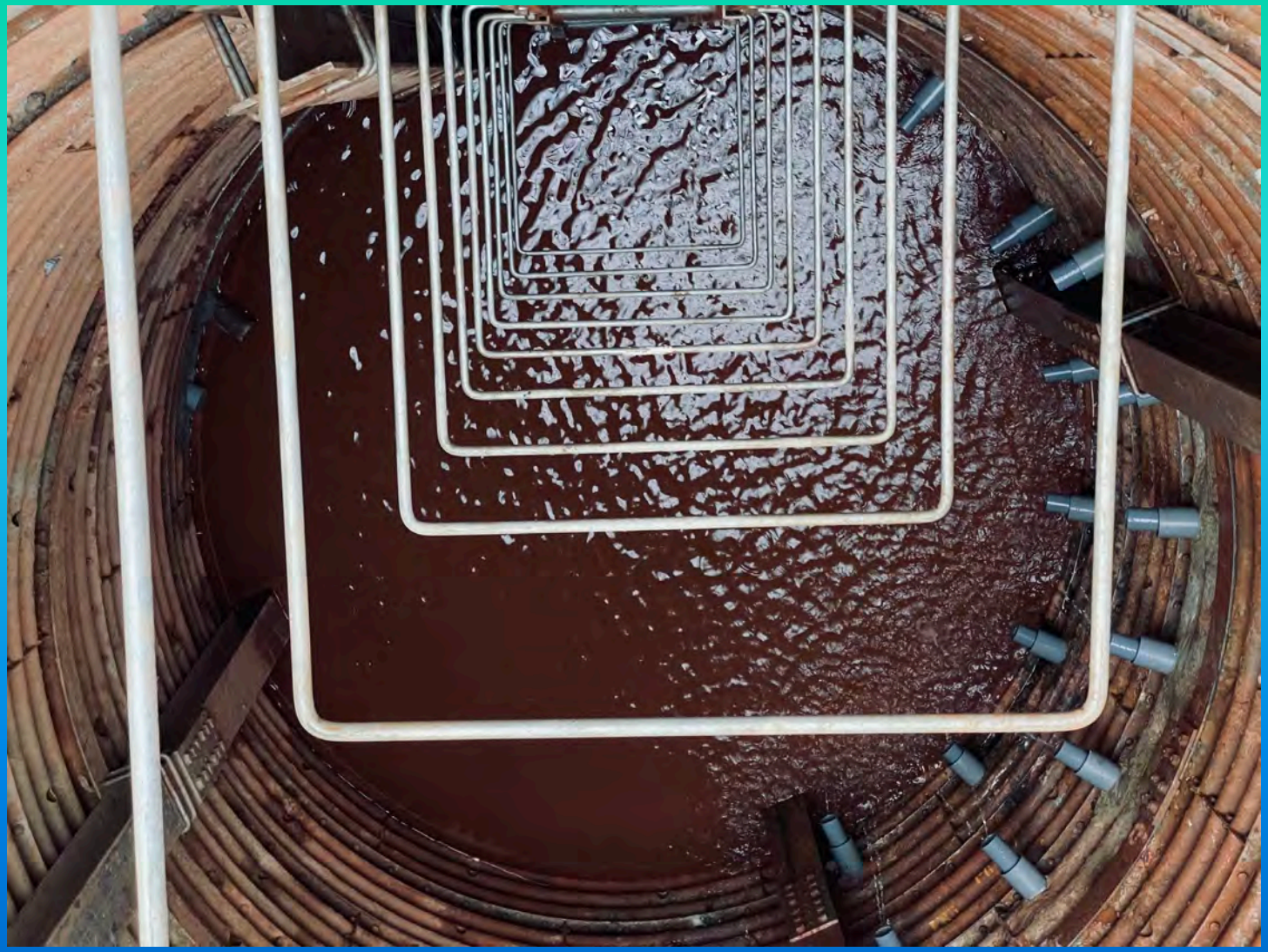
2021.9.27　Drainage Drilling


①Involving artificial ground such as embankment and garbag ,weak and soft soil clay layer
SECTION A-A
SCALE : 1/40
HK01 (20m)
GL= 1000.28m
HK03 (20m)
GL= 987.32m
Elevation (m)
1005
1000
995
990
985
980
975
970
965
②Heaving zone
Original Upper
Change proposal Upper
Original Lower
Elevation angle=8°
L=35m
Lower Drilling Elevation +1m
angle=6°
L=35m
DESIGN-ADJUST DESIGN
N
E
HKTD-01
HKTD-02
HKTD-03
HKTD-04
HKTD-05
HKTD-06
HKTD-07
HKTD-08
Note.
DESIGN (borehole direction)
ADJUST DESIGN (borehole direction)


DỰ ÁN: XỬ LÝ HIỆN TƯỢNG TRƯỢT
ĐƯỜNG NGUYỄN VĂN TRỖI VÀ TRƯỜNG
PHƯỜNG 2, TP ĐÀ LẠT
HANG MK:
Hố khoan:
Nội dung:
Ghi chú:
Ngày:

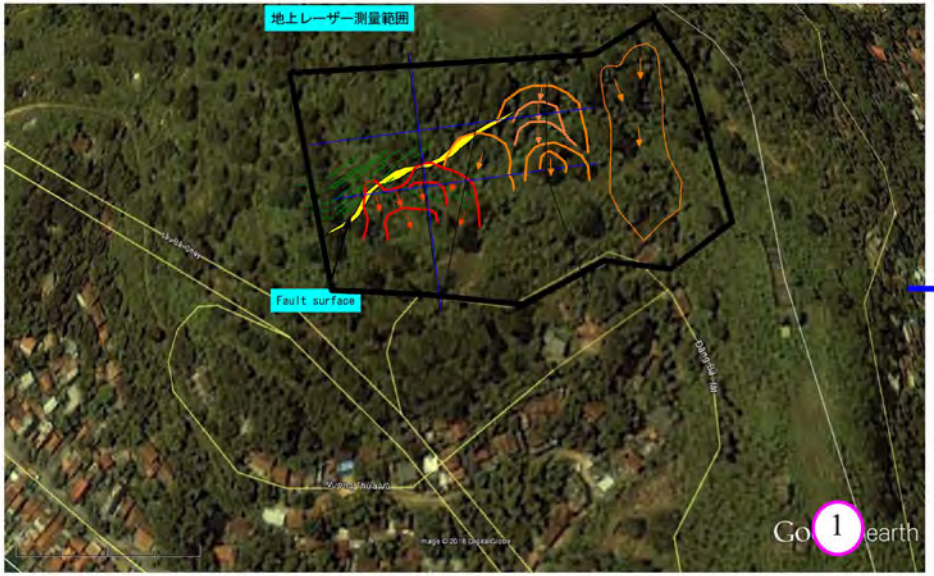



SPEC F
SON NU

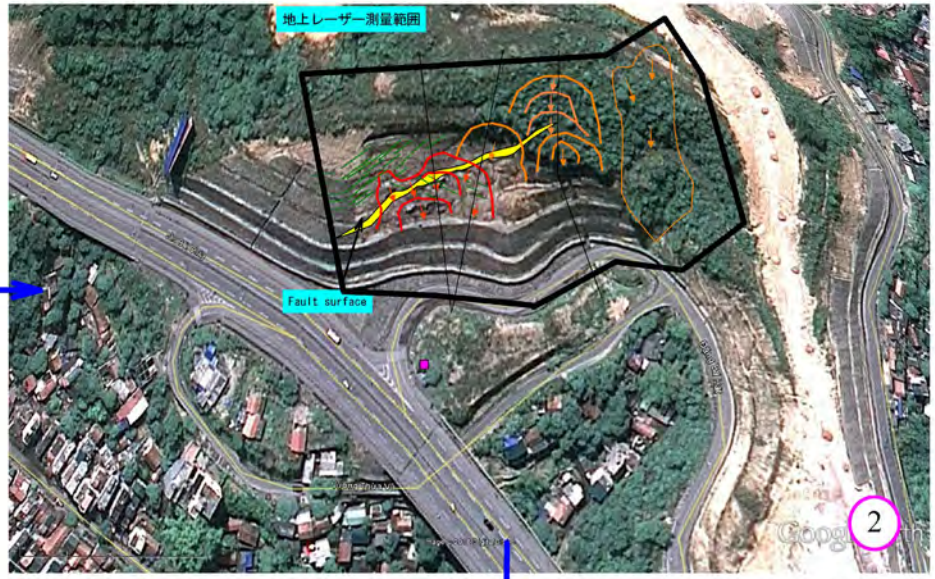


Case Studies
Bai Chai district ,Quan Ninh
Landslides occurred along the road

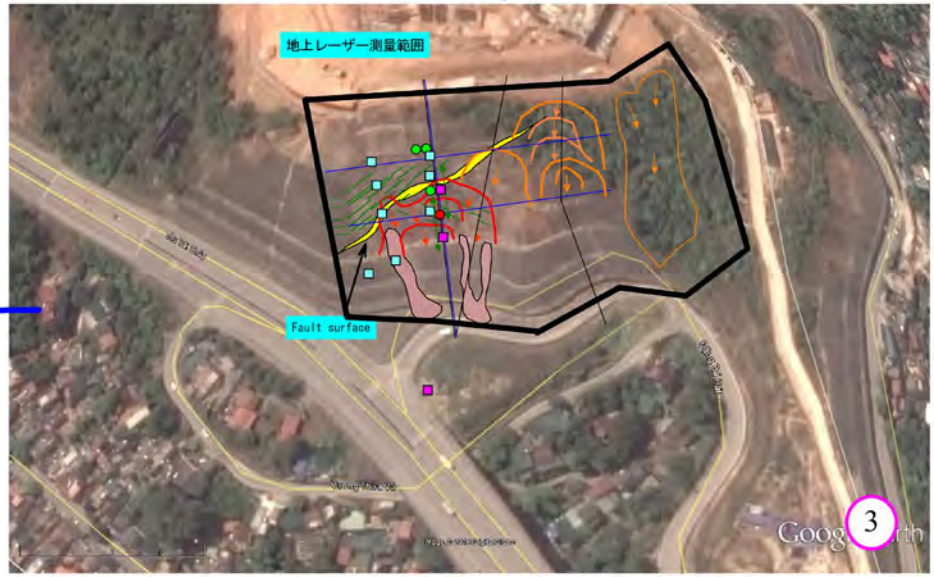
The status of the area of approach road to Bai Chay bridge, Quang Ninh through the years (2001 - 2016)



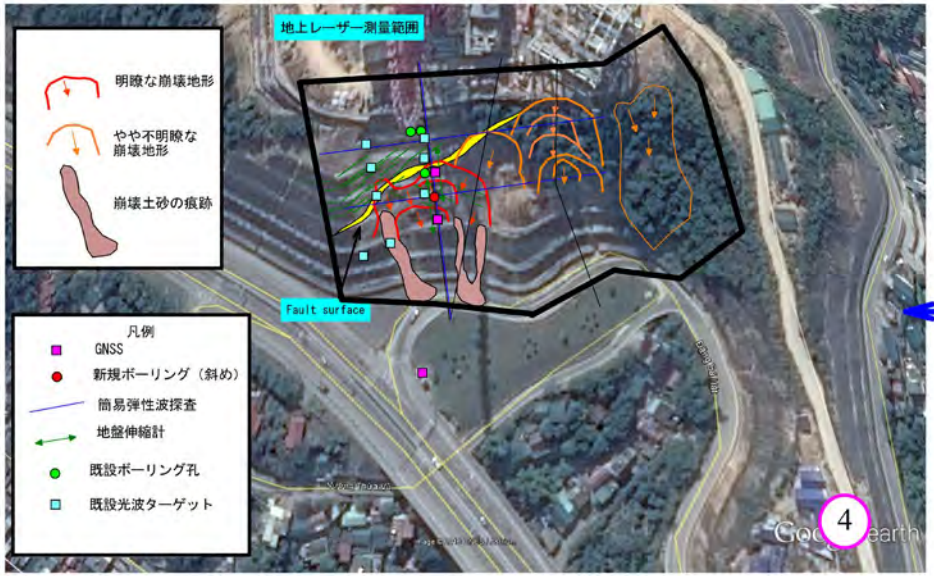
08/17/2001 (in the past)



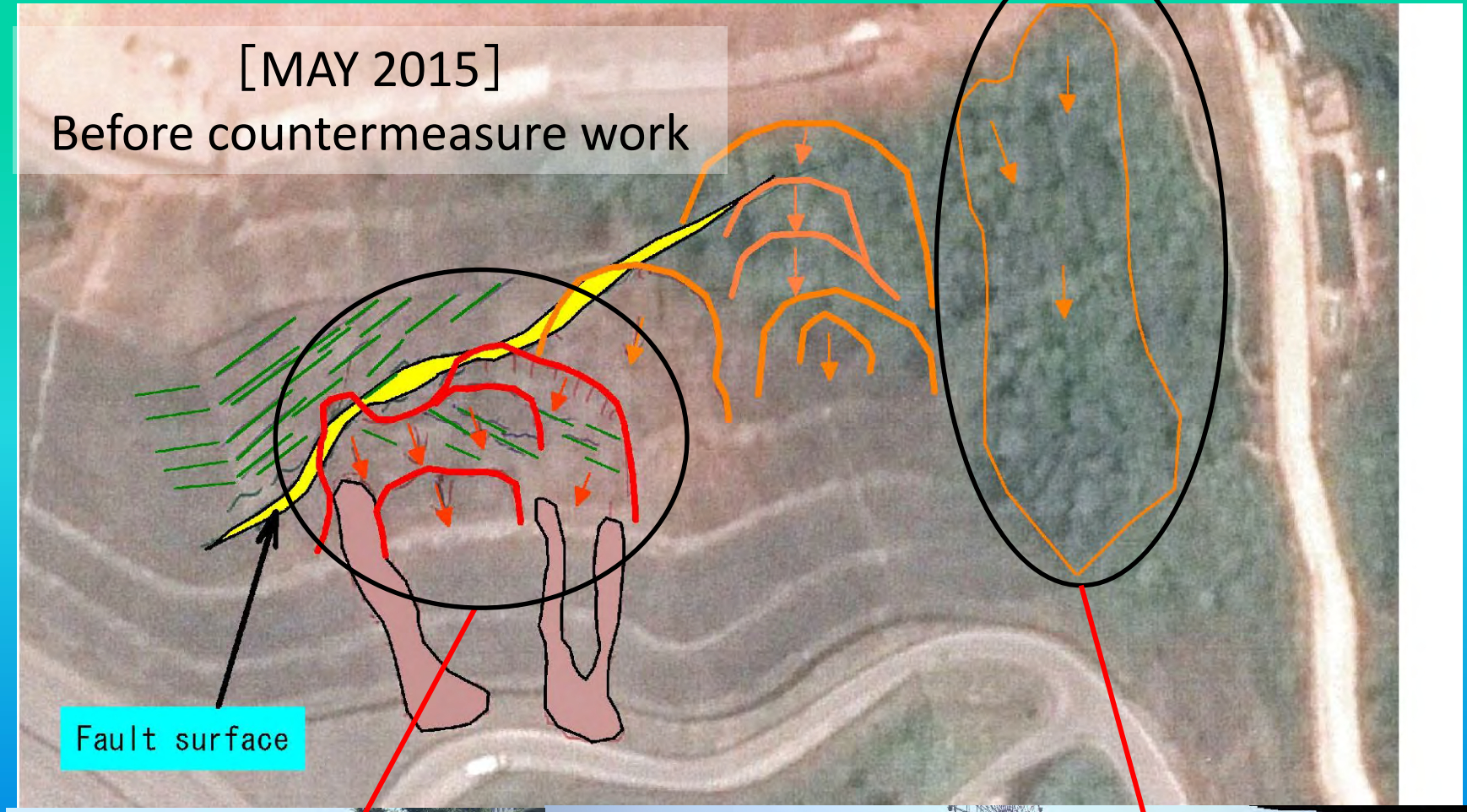
02/25/2010 (after road construction)



05/10/2015 (under the construction on the top)



02/06/2016 (currently)


［MAY 2015］
Before countermeasure work
Fault surface


［AUG 2019］
AAfter countermeasure work


20


①
②
③

写真 3.写真 1 の①の拡大

写真 4.写真 1 の②、③の拡大

写真 5.写真 4 の③近接写真

写真 6.写真 4 の③地すべり性崩壊頂部

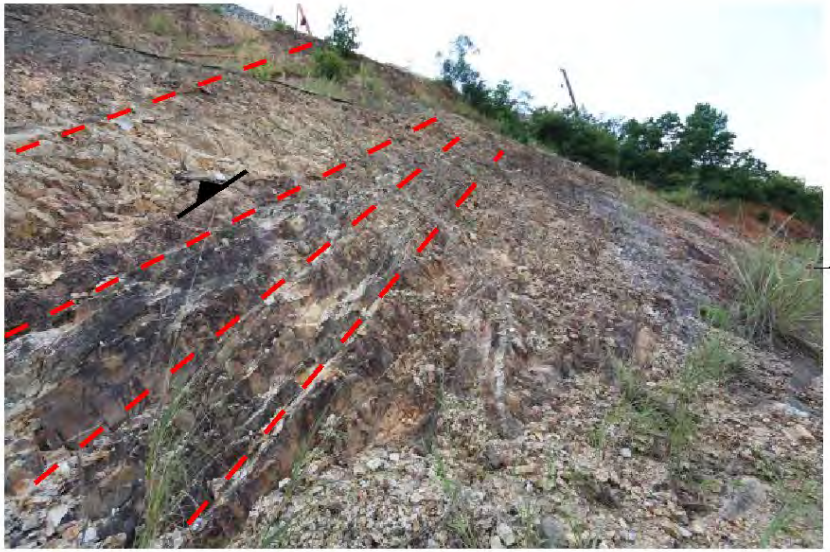


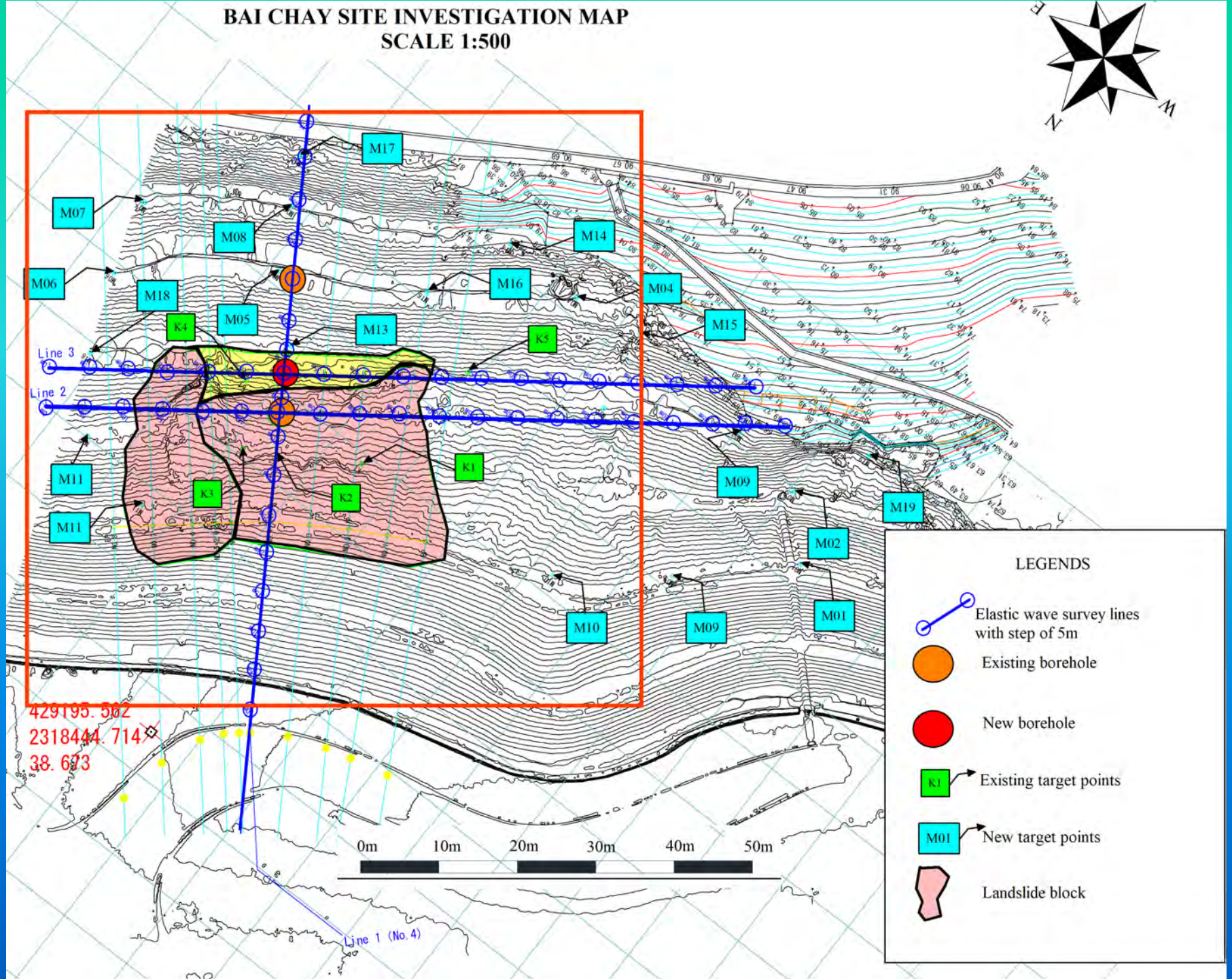
写真 7.断層上の受け盤構造の地層

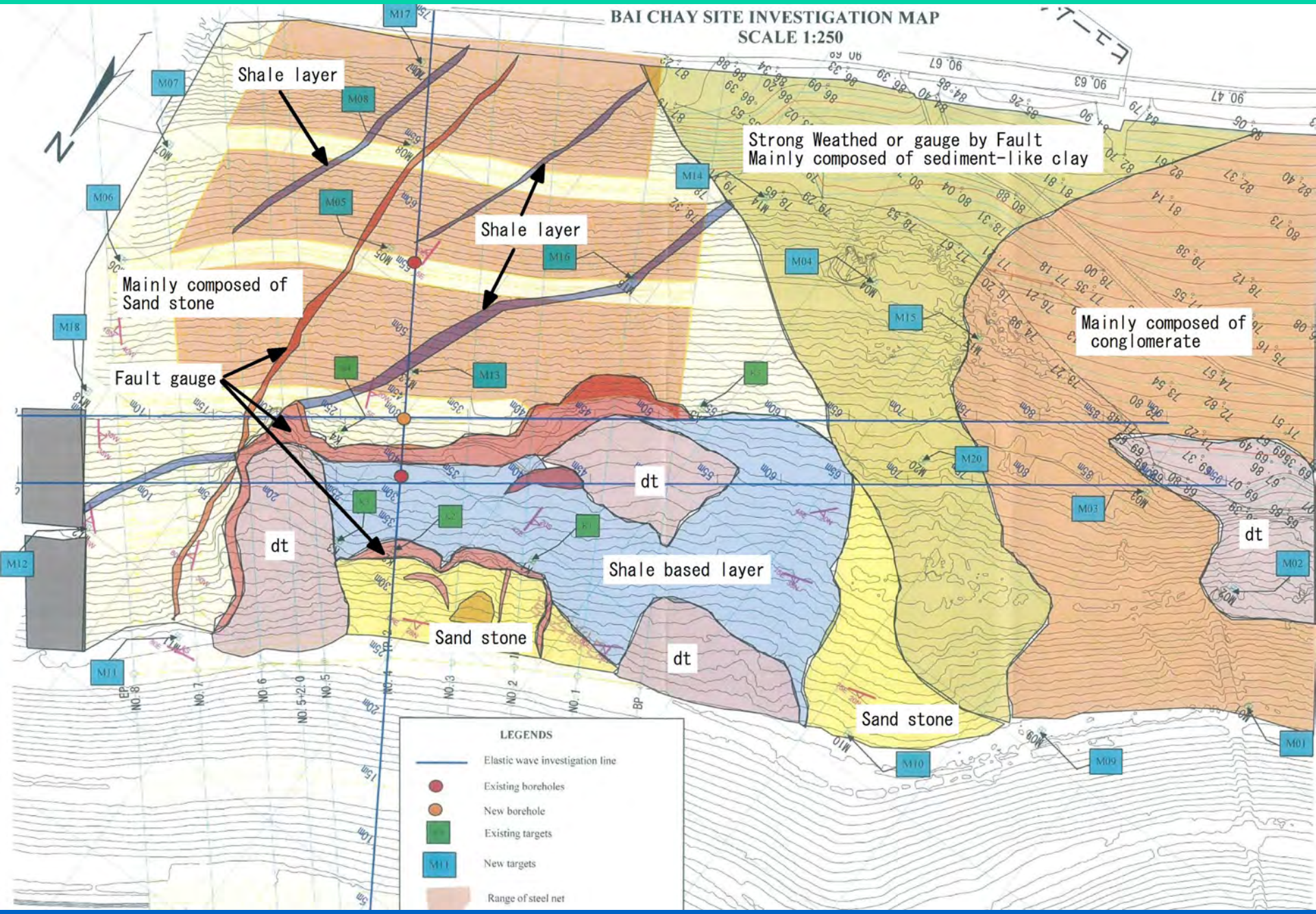
写真 8.断層下の流れ盤構造の地層

写真 9.断層ガウジを伴う破砕帯

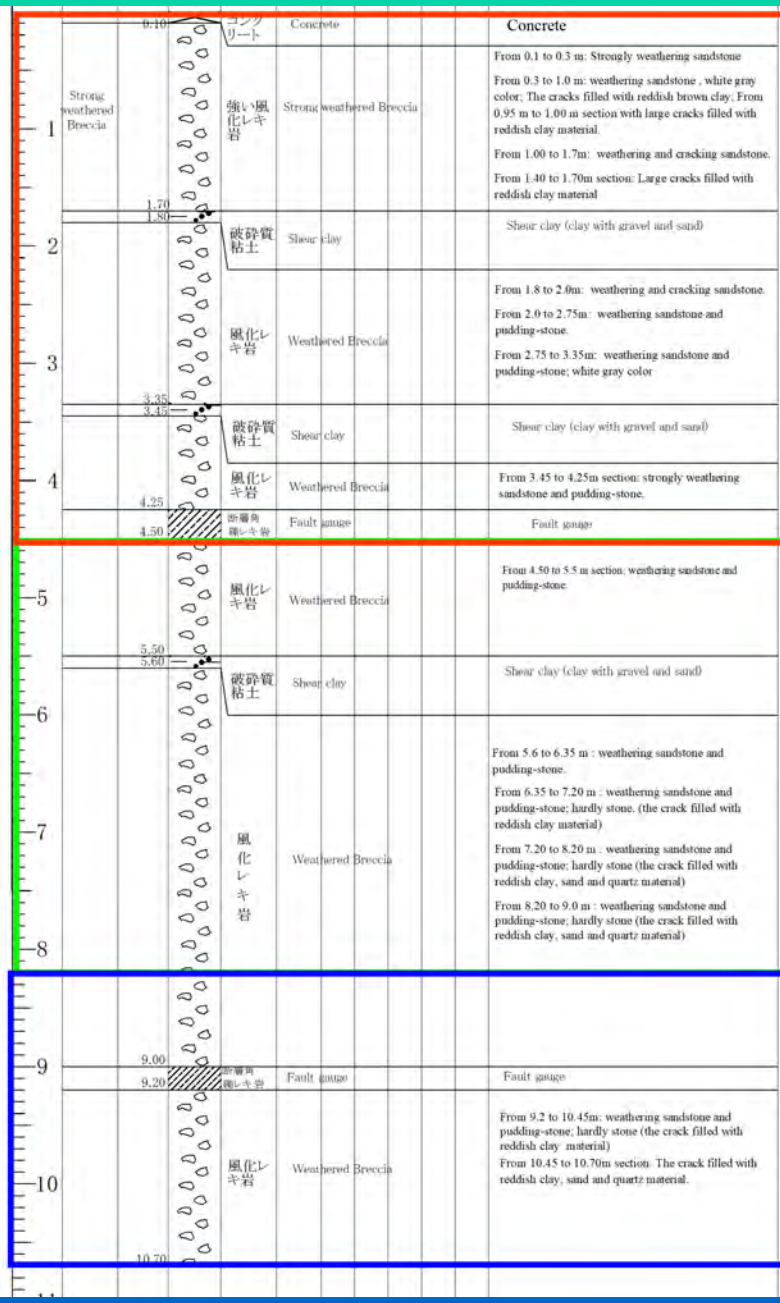
写真 10.断層下に面的に分布する破砕帯

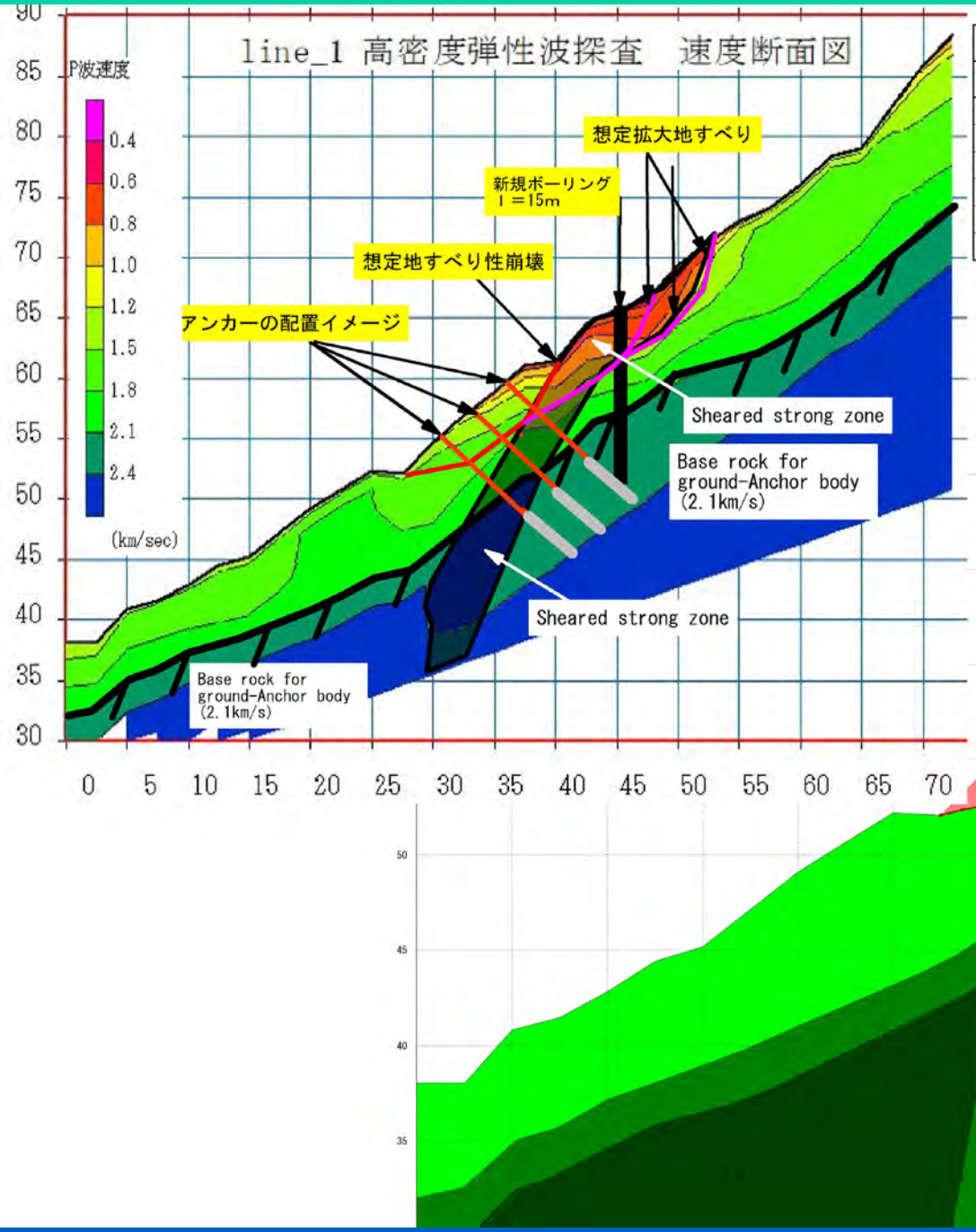

2017/05/16


BAI CHAY SITE INVESTIGATION MAP
SCALE 1:500
E
N
W
M17
M07
M08
M14
M06
M18
M16
M04
M05
M15
K4
M13
K5
Line 3
Line 2
M11
K1
K3
K2
M09
M19
M11
M02
M10
M09
M01
429195.582
2318444.714
38.673
0m
10m
20m
30m
40m
50m
Line 1 (No.4)
LEGENDS
Elastic wave survey lines with step of 5m
Existing borehole
New borehole
K1
Existing target points
M01
New target points
Landslide block


BAI CHAY SITE INVESTIGATION MAP
SCALE 1:250
Shale layer
Shale layer
Strong Weathed or gauge by Fault
Mainly composed of sediment-like clay
Mainly composed of Sand stone
Mainly composed of conglomerate
Fault gauge
dt
dt
dt
Shale based layer
Sand stone
Sand stone
LEGENDS
Elastic wave investigation line
Existing boreholes
New borehole
Existing targets
New targets
Range of steel net

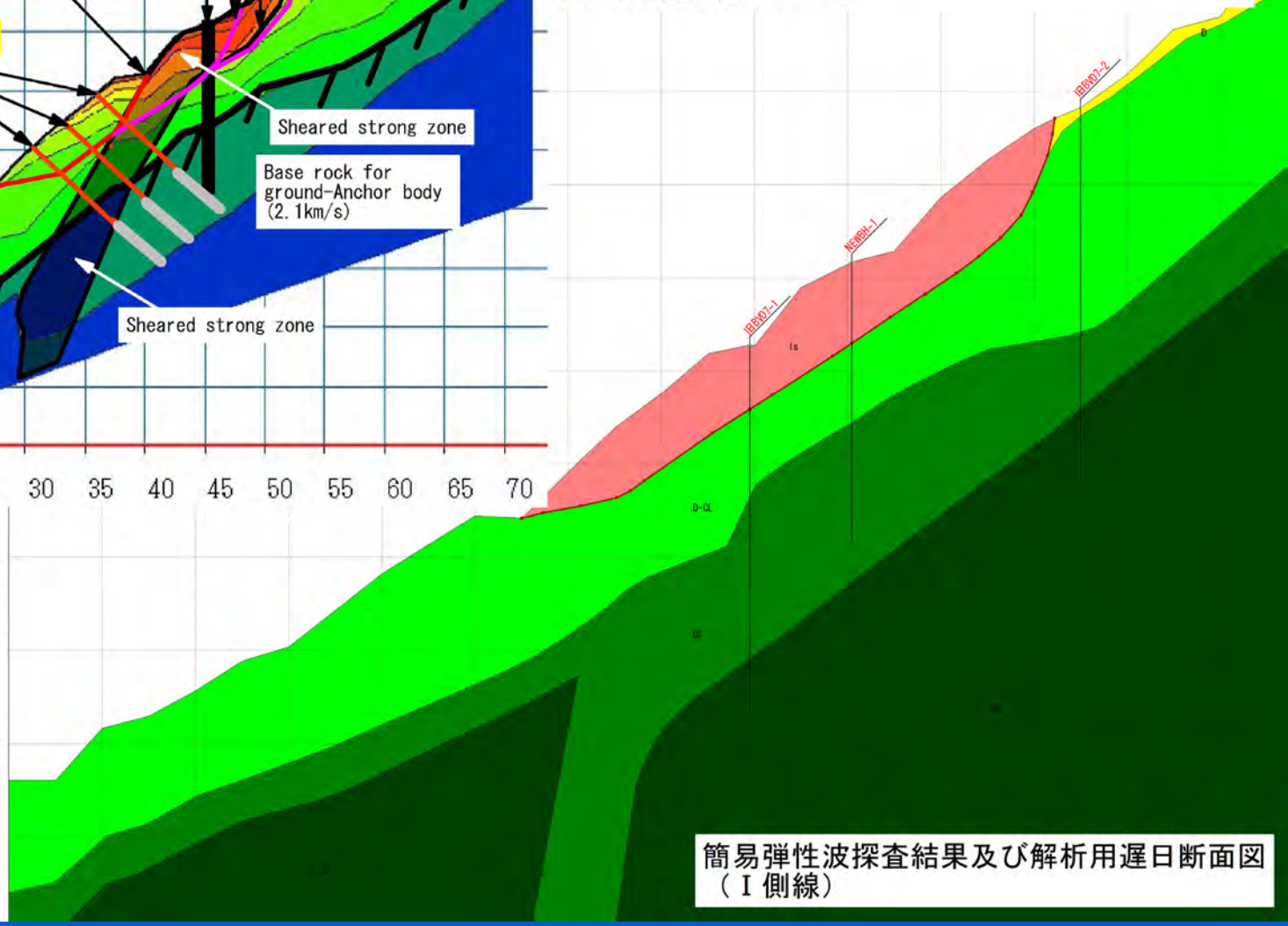

Weatherd strong
Land slide Block
Fault gauge(Land slide surfaace)
Weatherd CL-D rock
Fault gauge
Weatherd CL rock


Strong weathered Breccia
0.10
コンクリート
Concrete
Concrete
強い風化レキ岩
Strong weathered Breccia
From 0.1 to 0.3 m: Strongly weathering sandstone
From 0.3 to 1.0 m: weathering sandstone , white gray color; The cracks filled with reddish brown clay; From 0.95 m to 1.00 m section with large cracks filled with reddish clay material.
From 1.00 to 1.7m: weathering and cracking sandstone.
From 1.40 to 1.70m section: Large cracks filled with reddish clay material
1.70
1.80
破砕質粘土
Shear clay
Shear clay (clay with gravel and sand)
風化レキ岩
Weathered Breccia
From 1.8 to 2.0m: weathering and cracking sandstone.
From 2.0 to 2.75m: weathering sandstone and pudding-stone.
From 2.75 to 3.35m: weathering sandstone and pudding-stone; white gray color
3.35
3.45
破砕質粘土
Shear clay
Shear clay (clay with gravel and sand)
風化レキ岩
Weathered Breccia
From 3.45 to 4.25m section: strongly weathering sandstone and pudding-stone.
4.25
4.50
断層角礫レキ岩
Fault gauge
Fault gauge
風化レキ岩
Weathered Breccia
From 4.50 to 5.5 m section: weathering sandstone and pudding-stone
5.50
5.60
破砕質粘土
Shear clay
Shear clay (clay with gravel and sand)
風化レキ岩
Weathered Breccia
From 5.6 to 6.35 m : weathering sandstone and pudding-stone.
From 6.35 to 7.20 m : weathering sandstone and pudding-stone; hardly stone. (the crack filled with reddish clay material)
From 7.20 to 8.20 m : weathering sandstone and pudding-stone; hardly stone (the crack filled with reddish clay, sand and quartz material)
From 8.20 to 9.0 m : weathering sandstone and pudding-stone; hardly stone (the crack filled with reddish clay, sand and quartz material)
9.00
9.20
断層角礫レキ岩
Fault gauge
Fault gauge
風化レキ岩
Weathered Breccia
From 9.2 to 10.45m: weathering sandstone and pudding-stone; hardly stone (the crack filled with reddish clay material)
From 10.45 to 10.70m section. The crack filled with reddish clay, sand and quartz material.
10.70



土質定数							
No.	地層	地質	湿潤重量 γ_t (kN/m³)	飽和重量 γ_{sat} (kN/m³)	粘着力 C (kN/m²)	内部摩擦角 φ (°)	tanφ
1	D		26.00	26.00	50.00	38.0000	0.781285
2	Is		26.00	26.00	50.00	38.0000	0.781285
3	D-CL		26.00	26.00	50.00	38.0000	0.781285
4	CL		26.00	26.00	100.00	38.0000	0.781285
5	CM		26.00	26.00	200.00	40.0000	0.839099
6	CM		26.00	26.00	200.00	40.0000	0.839099

※ 水の単位体積重量　γ_w ： 10.000 (kN/m³)



簡易弾性波探査結果及び解析用遅日断面図
（Ⅰ側線）

Conclusion

■***Suggest the importance of disaster prevention and mitigation, that should take some measures before the serious damages will occur (ex:hazard map).***

防災・減災に重要なのは、被害を受ける前に事前に手を打っておくこと(ハザードマップ)

■***An important point for Japanese companies doing business in Vietnam is to be able to deploy as many solutions as possible.***

日本の会社がベトナムで業務を行うためには、できるだけ多くのソリューションを有していること。

■***It is also important to provide technical solutions that allow us to obtain a large amount of geological information that will serve as the basis for construction before construction.***

そして、施工前に施工に必要な多くの地質情報を得るための技術ソリューションを提供できること。

■**And last , it is important have enthusiasm and the ability to complete the project.**

最後に重要なのは熱意とプロジェクトをやりとげる実行力です。

Thank you for listening !