

DEAD SEA PARKWAY PROJECT

**REPORT
OF
GROUND SURFACE INVESTIGATION**

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JICA D/D STUDY TEAM

**GEOLOGIST
KUMITA Shoji**

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1.0 Introduction

Upon the request by the Ministry of Public Works and Housing, Jordan(hereinafter called "MPWH"), JICA D/D Study Team(hereinafter called "JST") additionally assigned a geologist to carry out the ground surface investigation for the detailed design of DEAD SEA PARKWAY.

The purpose of this investigation is to determine whether the boring survey for the very steep slope area along the recommended route is required for the detailed design of the DEAD SEA PARKWAY.

2.0 Scope of works

The scope of this study is to provide with full information regarding the existing ground conditions along the recommended route of the Dead Sea Parkway through the execution of the ground surface investigation. This information should be useful for the design to determine the safe foundations and cut slopes and for judgement whether the road should be constructed as designed, and necessity of boring survey for the very steep slope area.

The scope of works are as follows:

- Field work and mapping (ground surface investigation)
- Provision of the geological maps
- Provision of the geological cross sections
- Provision of the geological longitudinal sections
- Determination of soil factor
- Stability analysis
- Determination of cut slope gradient

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3.0 Geomorphology and General Geology

3.1 Geomorphology

The recommended route of the DEAD SEA PARKWAY is mainly divided into two geomorphologic features as follows:

- Steep slope area (Station No. 0-No. 5)
- Upper plateau (Station No. 5-No. 9)

Steep slope area is the section between station No. 0 and No. 5. The lowest elevation at station No.0 (the intersection with the Dead Sea Highway(Route 65)) is -353m and the elevation at station No.5 is 101m. This slope is rugged, intersected by deep vallies. Generally, the slope angle ranges between 30 ° - 45 ° , but it partly shows more steep and occasionally almost vertical cliff. There are three rock fall zones that are close to the recommended route. The unstable exposures which are upward slope generate 1-5m rock falls in diameter. This steep slope area is generally not accessible by the vehicle. However, there is a short path between station No. 0 and around station No. 1+700, such range may be accessible by 4-Wheel Drive Vehicles.

The upper plateau is the section between No. 5 and No. 9. The highest elevation at station No.6+240 is 170.5m. This plateau is almost flat, with partly rises and falls. There are two main wadies crossed by the recommended route where are is Wadi Al Asal located at station No. 6, and Wadi Himara located at station No. 7.

The wadies are generally deep and very steep. The depth and slope angle of these wadies are generally 30-75m and 40 ° -60 ° respectively. It was observed that rock mass slide exists on the slope of the right bank where alignment passes through at Sta.5+930. Therefore it is recommended to shift the alignment to east by at least 10m.

3.2 General geology

The geology of the Dead Sea Parkway site consists of Paleozoic-Mesozoic sediments and Cenozoic sediment and deposits as shown in Table 1. General geology and ground condition of these sediments and deposits are described as follows.

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Besides, the geology is referred to "The geology of Ma'in area map area sheet No. (3153 III), Khaled Shawabekeh (1998)".

「Umm Ishrin formation」 (IN)

This formation mainly consists of red, brown, yellow colored medium-coarse grained sandstone and which is partly intercalated thin siltstone. This formation is the oldest sediment of Cambria age in this site. There are many joint in the rock. The rock is almost hard and compact, however the surfaces of 1-10m in depth are weathered. This formation distributes between station No. 0 and No.1+250 in steep slope area.

The thickness of Umm Ishrin formation is estimated as over 110m.

「Umm Irna formation」 (UI)

This formation mainly consists of gray, red colored fine-coarse grained sandstone and siltstone. This formation is Permian-Triassic age. The rock is almost hard and compact, however the surfaces of 1-10m in depth are weathered. This formation distributes between station No. 1+250 and No. 2+880 in steep slope area.

The thickness of Umm Irna formation is estimated as approximately 160m.

「Ma'in formation」 (MN)

This formation mainly consists of white, brown, yellow colored fine-medium grained sandstone which is intercalated thin siltstone. This formation is Triassic age. The rock is almost hard and compact, however the surfaces of 1-10m in depth are weathered. This formation distributes between station No. 2+880 and No. 3+220 in steep slope area.

The thickness of Ma'in formation is estimated as approximately 40m.

「Dardur formation」 (DR)

This formation mainly consists of brown, yellow, white colored fine-medium grained sandstone intercalated thin siltstone, and which partly consists of dolomitic limestone. This formation is Triassic age. The rock is almost hard and compact, however the surfaces of 1-10m in depth are weathered. This formation distributes between station No. 3+220 and No. 4+150 in steep slope area.

The thickness of Dadur formation is estimated as approximately 40m.

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「Kurnub group」 (KS)

This formation mainly consists of white, yellow, pink colored medium-coarse grained sandstone, and which is partly included sandstone and siltstone alternation. This group is Cretaceous age. The rock almost hard and compact. This formation mainly distributes between station No. 4+150 and No. 9 in upper plateau.

The thickness of Kurnub group is estimated as over 145m.

「Lisan formation」 (Li)

This formation is Quaternary lake deposit. This formation mainly consists of gray, yellowish gray colored sand and marl. Surface of the formation is hardly cemented, however the inside of this may be soil-like condition. This formation mainly distributes between station No. 2+280-No. 2+825 and between station No. 3+900 and No. 4+50 in steep slope area.

The thickness of Lisan formation is estimated as maximum approximately 20m.

「Wadi deposit」 (wd)

This deposit mainly consists of rounded gravel, sand and silt. This deposit is dense. This deposit distributes along the stream in the valley bottom of Wadi Himara.

The thickness of wadi deposit is estimated as maximum approximately 8m.

「Talus deposit」 (dt)

This deposit mainly consists of gravel, sand and silt. This deposit is hardly cemented and dense, so that the deposit forms over 45° angle slope and shows to overhang on the eroded cliff. However, in case that the origins of talus deposit is existed, there is relatively new portion where is loose from the surface to approximately 1.5m in depth. These deposits distribute on slopes and in the valley.

The thickness of talus deposits is estimated as approximately between 0.5m and 5m.

「Rock mass slide」 (Ls)

This is sandstone rock mass limited by join. This rock mass is 10m in width, 20m in height, 5m in depth. The mass has slid downward because sandstone strata is not continuous and also is dropping condition downward.

This rock mass slide located at station No. 5+930.

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3.3 Geological structure

The Paleozoic-Mesozoic sediments have almost flat structure in this site. The structure partly inclines gently toward, westward and eastward 10° - 30° in angle. The dip slope structure is observed between station No. 0+200 and No. 0+980 and between No. 3+200 and No. 3+470, therefore it is necessary to excavate the cut slopes.

Massive faults are not observed, but joints are often observed in Paleozoic-Mesozoic. The strike of joints mainly shows N-S, NNE-SSW, NNW-SSE, and the dip shows 70° - 90° eastward and westward.

3.4 Slope condition

「Steep slope area (Station No. 0-No. 5)」

The slope of steep area is generally rugged, intersected by deep gullies. General slope angle is ranged 30° - 45° , and it partly shows more steep and it is occasionally like vertical cliff, however the landslide and soft ground areas are not observed. There are three rock fall areas close to the recommended route (Station No. 1+600-No. 1+700, station No. 1+780-No.1+900, station No. 3+575-No. 3+675).

At these areas the unstable exposures which are upward slope generate 1-5m rock falls in diameter. The place where are distributing Lisan formation generally shows gentle slope 0° - 15° in angle.

In general, talus deposits are distributed on the slope below ridges cliffs, and in the valley.

「Upper plateau (Station No. 5-No. 9)」

This plateau is almost flat, but it partly rises and falls. There are two main wadies, that Wadi Al Asal is located at station No. 6, and another one is Wadi Himara located at station No. 7. The wadies are generally deep and very steep. The depth and slope angle of these wadies are generally 30-75m and 40° - 60° respectively.

In general, talus deposits are distributed on the slope of wadi side, in the hollow space of flat areas and the valleys.

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4.0 Geology and slope condition along the route

4.1 Description of geology and slope condition along the route

The geology and slope condition along the recommended route are described as follows (refer to Plate 1 to Plate7; these are geological maps):

Besides, representative geological cross sections are shown in Figure 1 (1) to Figure 1 (9) and geological longitudinal section along the recommended route are shown in Figure 2 (1) to Figure 2 (13).

「Station No. 0+000 to No. 1+725」

<Geomorphology and geology>

Geomorphology of this section is generally gentle slope, but it is partly steep slope. There is rock fall zone between station No. 1+600 and No. 1+700 where are distributing Lisan formation which overhanging exposures are upward slope, and rock falls are 1-5m in diameter.

The bed rock in this section is mainly consisted of Umm Ishrin formation and Umm Irna formation. The Lisan formation which are overhanging exposures distributes on the slope around station No. 1+700. The bed rock are almost covered by talus deposits which thickness is between 1m and 3m, but it is occasionally approximately 5m (station No. 1+275-No. 1+520, on the slope around station No. 1+700). The rock of Umm Ishrin formation (almost sandstone) is hard and compact, but is developed joints (fissures). The rock of Umm Irna formation (sandstone, siltstone) is generally hard and compact. The rock of Umm Ishrin formation and Umm Irna formation are estimated to be weathered maximum approximately 10m in depth from the surface, and these are possible to be loose along the joint. The talus deposit mainly consists of gravel, sand and silt. This deposit is generally hardly cemented and dense. However, there is relatively loose portion from the surface to approximately 1.5m in depth on the slope around station No. 1+700, because there is the exposure generated by new talus deposit which slope is upward.

Geological structure shows mainly flat but the strata inclines toward west (toward Dead Sea) between station No. 0 and around No. 1+200, i.e. the cut slope faced to west shows the dip slope structure in this range.

<Main road structure>

Cut slopes

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<Geotechnical notice>

The geological structure shows mainly flat, but the strata inclines toward west (toward Dead Sea) between station No. 0 and around No. 1+200, the cut slope faced to west shows the dip slope structure between station No. 0+200 and No. 0+980, so that this range is required to apply to proper countermeasure such as gentle cut slope gradient in order to stabilize.

There is rock fall zone between station No. 1+600 and No. 1+700 where are distributing Lisan formation which overhanging exposures are upward slope, and rock falls are 1-5m in diameter. It is very danger for the recommended route to go through, so that a cleaning process prior to construction is effective to stabilize.

「Station No. 1+725 to No. 5」

<Geomorphology and geology>

Geomorphology of this section is generally steep slope, and it is partly gentle slope. There is rock fall zone between station No. 1+780 and No. 1+900 where are distributing Lisan formation which overhanging exposures are upward slope, Between station No. 3+575 and No.3+675 where are distributing Kurnub formation which exposures are upward slope. There are rock fall 1-5m in diameter on the slope.

The bed rock in this section are mainly Umm Irna formation, Ma'in formation, Dardur formation and Kurnub group. Lisan formation distributes between station No. 2+280 and No. 2+825 and between station No. 3+900 and No. 4+050 on the bed rock with the gentle slope formed several steps. Talus deposit overlays above bed rock on the slope and in the valley. Thickness of talus deposit is between 1m and 3m, but it is occasionally about 5m (on the slope around station No. 3+600 and on the slope around station No. 4+760). The rock of Umm Irna formation (sandstone, siltstone), Ma'in formation, Dadur formation and Kurnub group are generally hard and compact, but the surface of these rocks are estimated to be weathered maximum approximately 10m in depth from the surface, and these are possible to be loose along the joint. The Lisan formation mainly consists of gray, yellowish gray colored sand and marl. Surface of the formation is hardly cemented, however the inside of this may be soil-like condition. The talus deposit mainly consists of gravel, sand and silt. This deposit is generally hardly cemented and dense. However, there is relatively loose portion from the surface to approximately 1.5m in depth on the slope around station No. 3+600 and on the slope around station No. 4+760, because there is exposure generated by new talus deposit which slope are upward.

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Geological structure shows mainly flat but the strata inclines toward east or west. The cut slope faced to west shows the dip slope structure between station No. 3+200 and No.3+470.

<Main road structure>

Cut slopes, embankments

<Geotechnical notice>

There is rock fall zone between station No. 1+780 and No. 1+900 where are distributing Lisan formation which overhanging exposures are upward slope, and between station No. 3+575 and No. 3+675 where are distributing Kurnub formation which exposures are upward slope. There are rock fall 1-5m in diameter on the slope. Those are very danger for the recommended route to go through, so that a cleaning process prior to construction is effective to stabilize.

The geological structure shows mainly flat, but the strata occasionally inclines toward west where shows the dip slope structure between station No. 3+200 and No. 3+470, so that this range is required to apply to proper countermeasure such as gentle cut slope gradient in order to stabilize.

The recommended route goes through on Lisan formation where is planned to construct the embankment at between station No. 3+880 and 3+980. Surface of Lisan formation is hardly cemented, however the inside of this may be soil-like condition. That is, if the embankment will be filled, it may be possible to occur settlement and/or slip.

「Station No. 5 to No. 9」

<Geomorphology and geology>

Geomorphology is almost flat, but it partly rises and falls. There are two main wadies, that Wadi Himara is located at station No. 7, and another one is Wadi Al Asal located at station No. 6 where are planed to construct the bridges. The wadies are generally deep and very steep. The depth and slope angle of these wadies are generally 30-75m and 40°-60° respectively. It is found out the rock mass slide on the slope of right bank where is planed to construct the abutment at station No. 5+930 of Wadi Al Asal. Talus deposit overlays above bed rock on the slope and in the valley. Thickness of talus deposit is between 0.5m and 3m, and it is occasionally about 5m (on the slope around station No. 6+950; at abutment).

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The bed rock in this section are Kurnub group. The wadi deposit distributes along the stream in the valley bottom of Wadi Himara. In general, talus deposits distributes on the slope of wadi side, and in the hollow space of flat, and the valleys.

The rock of Kurnub group (mainly sandstone) is generally hard and compact, especially it is found out very hard portion from the surface to approximately 2m in depth by metamorphism. There are occasionally many joints where may be loose. The wadi deposit mainly consists of rounded gravel, sand and silt. This deposit is dense. The talus deposit mainly consists of gravel, sand and silt. This deposit is generally hardly cemented and dense. However, there is relatively loose portion from the surface to approximately 1.5m in depth on the slope around station No. 6+950 and on the slope around station No. 4+760, because there is exposure generated by new talus deposit which is upward the slope.

Geological structure shows mainly flat.

<Main road structure>

Cut slopes, bridges

<Geotechnical notice>

There is rock mass slide on the slope of right bank where is planed to construct the abutment at station No. 5+930 of Wadi Al Asal. It is required that the recommended route shall be shifted 10-20m to the North-east.

4.2 Attention areas

According to the geology, geological structure and slope condition, etc., as a result of ground surface investigation, the attention areas extracted are summarized in Table 2. The distribution of attention areas are shown in Figure 3.

5.0 Consideration

5.1 Soil factor

According to the geology and the ground condition, as a result of the ground surface investigation, the soil factors are summarized in Table 3.

The soil factors are decided to refer to Japanese data regarding the Soil Factors of Investigation of Geotechnical Survey.

Due to the ground surface investigation, the soil factors are presumed as safety side.

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Beside, the decision of the soil factor refers to following data.

- Rock classification, Engineering Geology Special Issue (1984), p. 93, p. 95.
- Sekkei Youryou Dai 1 syuu, Japan Highway Public Corporation (1985), p.28.

Table 3 Soil factors for stable analysis

Merial	Weight (γ) tf/m ³	Cohesion (C) tf/m ²	Friction angle (ϕ) ($^{\circ}$)
Talus deposit	1.9	0.5	40
Lisan sand, marl	1.9	1.0	30
Sandstone (Weathered)	1.9	1.0	35
Sandstone	2.0	1.5	40

5.2 Stable analysis

In order to find suitable cut slope gradients, the stable analyses are applied for inputting soil factors. The planned safety factor is assumed on $F_{sp}=1.2$ for calculation.

The stable analyses are applied for each geology (including ground condition, i.e. weathered rock). Examined geological cross sections corresponded to geology are as follows:

- Sandstone : Station No. 5+100; Figure 1 (9)
(Paleozoic-Mesozoic sediments)
- Sandstone (weathered) : Station No. 1+972; Figure 1 (3)
(Paleozoic-Mesozoic sediments)
- Lisan formation : Station No. 2+807; Figure 1 (4)
(Sand, marl)
- Talus deposit : Station No. 3+600; Figure 1 (6)
(Cemented gravel, sand, silt)

Table 5 Concluded cut slope gradient

Material	Slope gradient (V:H)	Remarks
Talus deposit	1:1.0	Better gentle slope gradient in loose talus deposit 1.5m in depth from surface
Lisan sand, marl	1:1.3	
Sandstone (Weathered)	1:1.0	At dip slope structure, better should be gentle slope gradient
Sandstone	1:0.5	

NOTE:

Cut slopes may be adjusted according to the soil conditions prior to the commencement of the construction.

6.0 Conclusions and Recommendations

6.1 Conclusions

The contents observed due to the ground surface investigation are as follows:

1. Geomorphology, geological feature and ground conditions

The geomorphological feature is divided Steep slope area (station No. 0- No. 5) and Upper plateau (station No. 5-No. 9). Steep slope area is rugged, intersected by the deep vallies. Therefore, the steep slope area is generally not accessible by the vehicle, however, there is a short path between station No. 0 and around No. 1+700, therefore, this range may be accessible by the 4-wheel drive vehicles.

The geology of Dead Sea Parkway site consists of Paleozoic-Mesozoic sediments, Cenozoic sediment and deposits as shown Table 1.

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The ground conditions of Paleozoic-Mesozoic sediments is stable in general, however some surfaces are weathered (approximately 1-10m in depth).

In addition, Cenozoic sediment also is stable in general, however there may be loose portion in the Lisan formation and near the surface of talus deposit.

2. Slope condition

In general, landslide and soft ground area are not observed, however, rock fall area at No. 2, 3 and 4 as shown in Figure 1(refer to Table 2). In addition, the dip slope structures are observed at No.1 and No. 7 as shown in Figure 3.

The following solutions are suggested in order to solve the above slope conditions:

- A cleaning process prior to construction is required for the rock fall areas,.
- For the dip slope structure areas, which can be stabilized by applying proper countermeasures such as mild cut slopes.

The rock mass slide is observed in area No.6 as shown in Figure 3.

According to the above, it is confirmed that the recommended alignment of the DEAD SEA PARKWAY has no major problem for construction from geological point of view.

Regarding the necessity of boring survey in steep slope area, the followings are recommended:

- (1) It is not accessible for machines and equipment of boring survey in the steep slope area In such area it is not practical to conduct a boring survey at the present(D/D) stage, considering the excessive construction cost and difficulties of construction of temporary road for the boring survey. Therefore, it is recommended that the detailed design of DEAD SEA PARKWAY in this steep area shall be carried out based on the available data and information without the boring survey.
- (2) It is required that the detailed design of the DEAD SEA PARKWAY in this steep area shall be re-examined prior to the commencement of the construction based on the result of confirmation boring and observation of geological conditions which will be conducted by the contractor during the construction stage.

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6.2 Recommendations

There is a short path between station No.0 and No. around 1+700, so that this stretch is accessible for the 4-wheel drive vehicles in steep slope area. It is therefore recommended that a boring survey shall be carried out at this stage in this accessible area as shown in Figure 3. The recommended locations and specifications of boring are shown in Figure 12 and Table 6 respectively.

In addition to above, it is recommended that seismic prospecting investigations in steep slope area (between station No. 1+700 and No. 5) shall be carried out as shown in Figure 13 and Table 7 respectively.

Even in the accessible area as shown in Figure 3, it is also recommended to carry out the seismic prospecting investigation for some boring holes as shown in Figure 12 and Table 7 respectively in order to obtain more accurate data of the geological conditions.

6.3 Engineer's Consideration

It is evaluated in this report that the disaster such as a land slide may be not occurred due to the Dead Sea Parkway construction especially in the area between the Dead Sea and the plateau, however, such area is partly founded the dip slope structure. It is therefore required in this area that the cut slope shall be gentle such as 1(H): 1(V) and the alignment of road should be allocated to the lower part of this dip slope structure in order to avoid the huge cut of slope.

Some rock fall zones were observed in this area in order to avoid the rock fall. The cleaning process prior to construction should be generally required. And the alignment of the road shall be studied carefully in order to minimize the slope of cut for the safety.

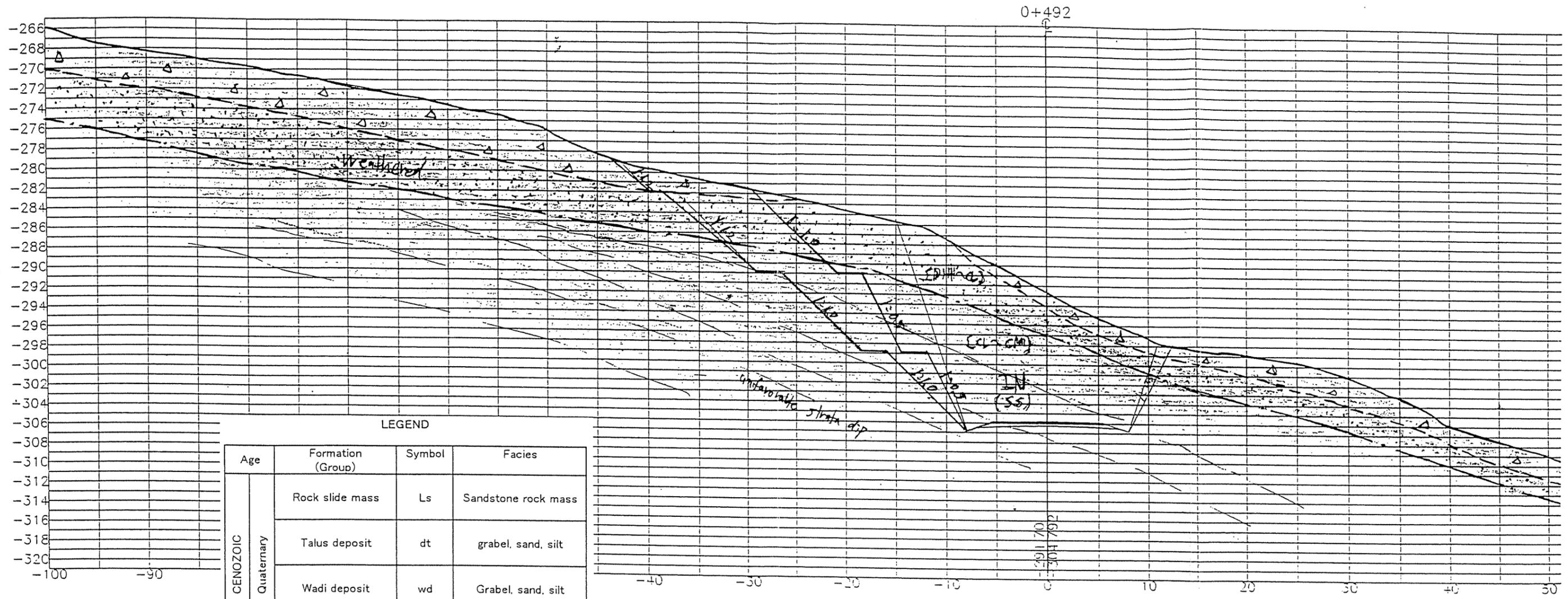
Taking into consideration of the above mentioned, the final recommended alignment of the Dead Sea Parkway was geologically studied and evaluated. It is therefore judged that the final recommended alignment of the Dead Sea parkway does not have any geological problems provided the previously mentioned precautions to be taken.

APPENDIX

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LEGEND

Age	Formation (Group)	Symbol	Facies		
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass	
		Talus deposit	dt	grabel. sand, silt	
		Wadi deposit	wd	Grabel. sand, silt	
		Lisan formation	Li	Sand, marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	
		Triassic	Dardur formation	DR	Sandstone, siltstone
			Ma'in formation	MN	Sandstone
PALAEOLITHIC	Cambrian	Umm Irna formation	UI	Sandstone, siltstone	
		Umm Ishrin formation	IN	Sandstone	

- Geological boundary
- Weathered line
- Weathered zone

Figure 1 (1) Geological cross section (Station No. 0+492)

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone
		Dardur formation	DR	Sandstone, siltstone
	Triassic	Ma'in formation	MN	Sandstone
		Umm Inna formation	UI	Sandstone, siltstone
PALEOZOIC	Cambrian	Umm Ishrin formation	IN	Sandstone

-  Geological boundary
-  Weathered line
-  Weathered zone

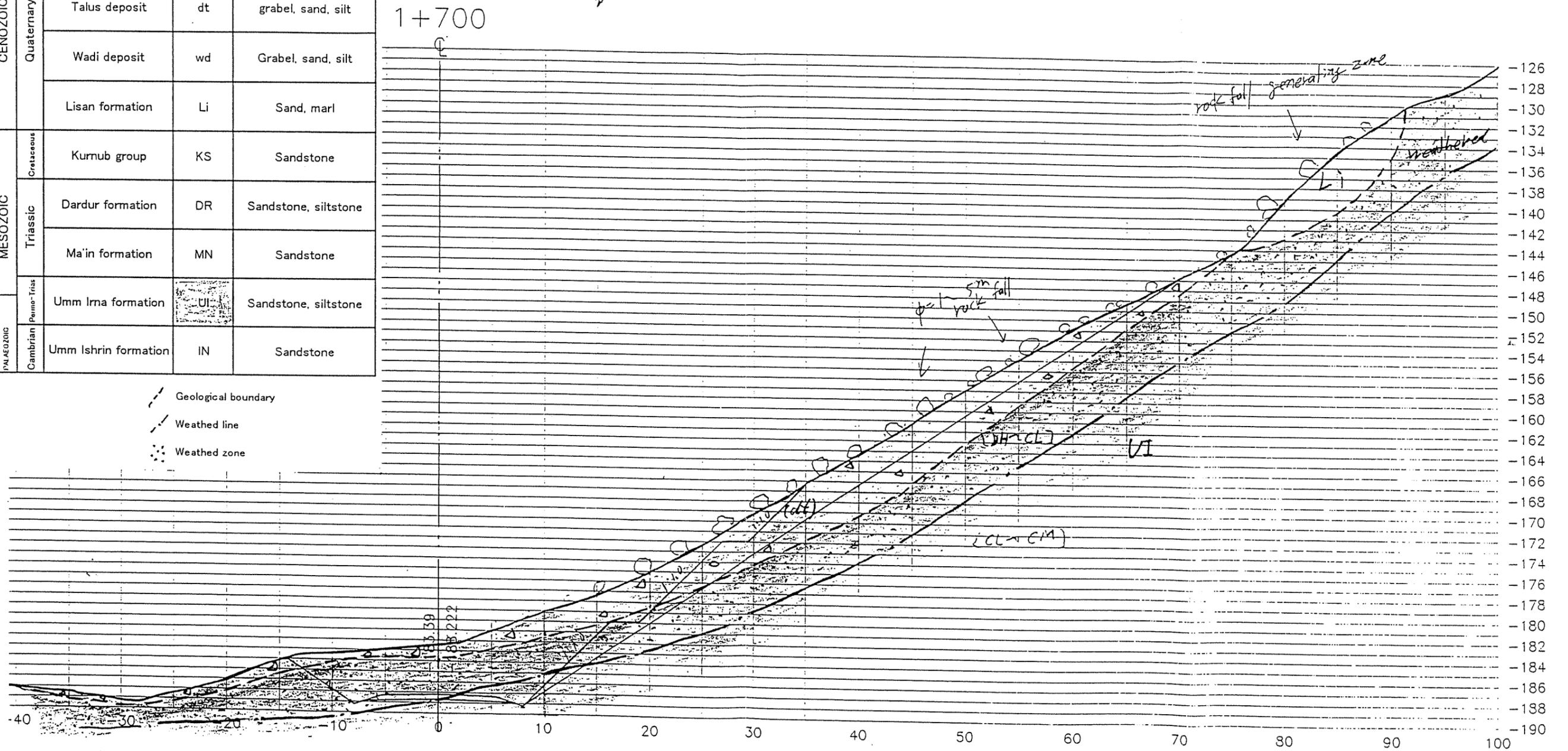
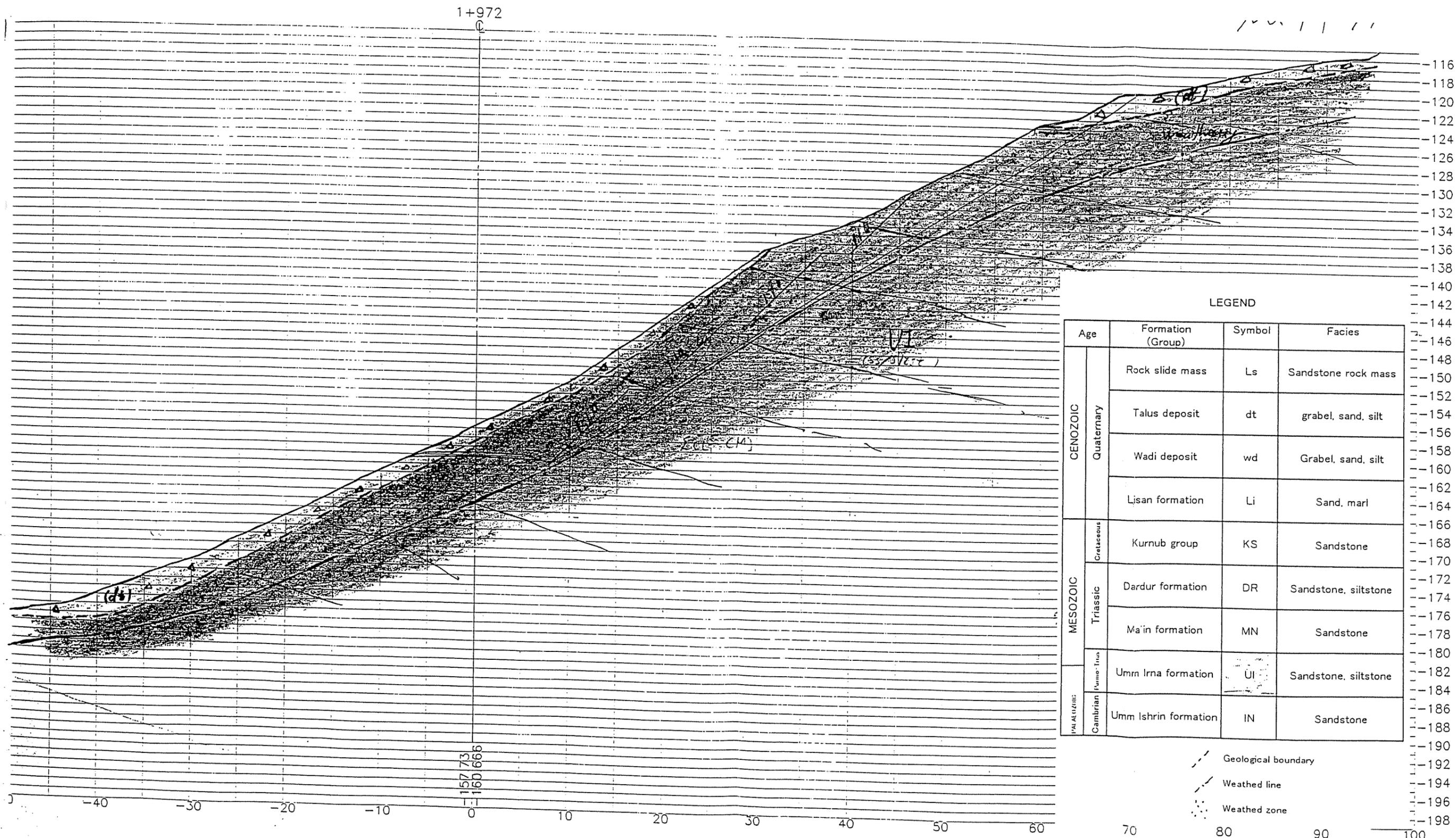


Figure 1 (2) Geological cross section (Station No. 1+700)



LEGEND

Age	Formation (Group)	Symbol	Facies		
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass	
		Talus deposit	dt	grabel, sand, silt	
		Wadi deposit	wd	Grabel, sand, silt	
		Lisan formation	Li	Sand, marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	
		Triassic	Dardur formation	DR	Sandstone, siltstone
			Ma'in formation	MN	Sandstone
			Umm Irna formation	UI	Sandstone, siltstone
PALAEOLITHIC	Cambrian	Umm Ishrin formation	IN	Sandstone	

- Geological boundary
- Weathered line
- Weathered zone

Figure 1 (3) Geological cross section (Station No. 1+972)

NO 2+807

LEGEND

Age	Formation (Group)	Symbol	Facies		
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass	
		Talus deposit	dt	grabel, sand, silt	
		Wadi deposit	wd	Grabel, sand, silt	
		Lisan formation	Li	Sand, marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	
		Triassic	Dardur formation	DR	Sandstone, siltstone
			Ma'in formation	MN	Sandstone
PALAEOZOIC	Permian-Triassic	Umm Irna formation	UI	Sandstone, siltstone	
		Umm Ishrin formation	IN	Sandstone	

-  Geological boundary
-  Weathered line
-  Weathered zone

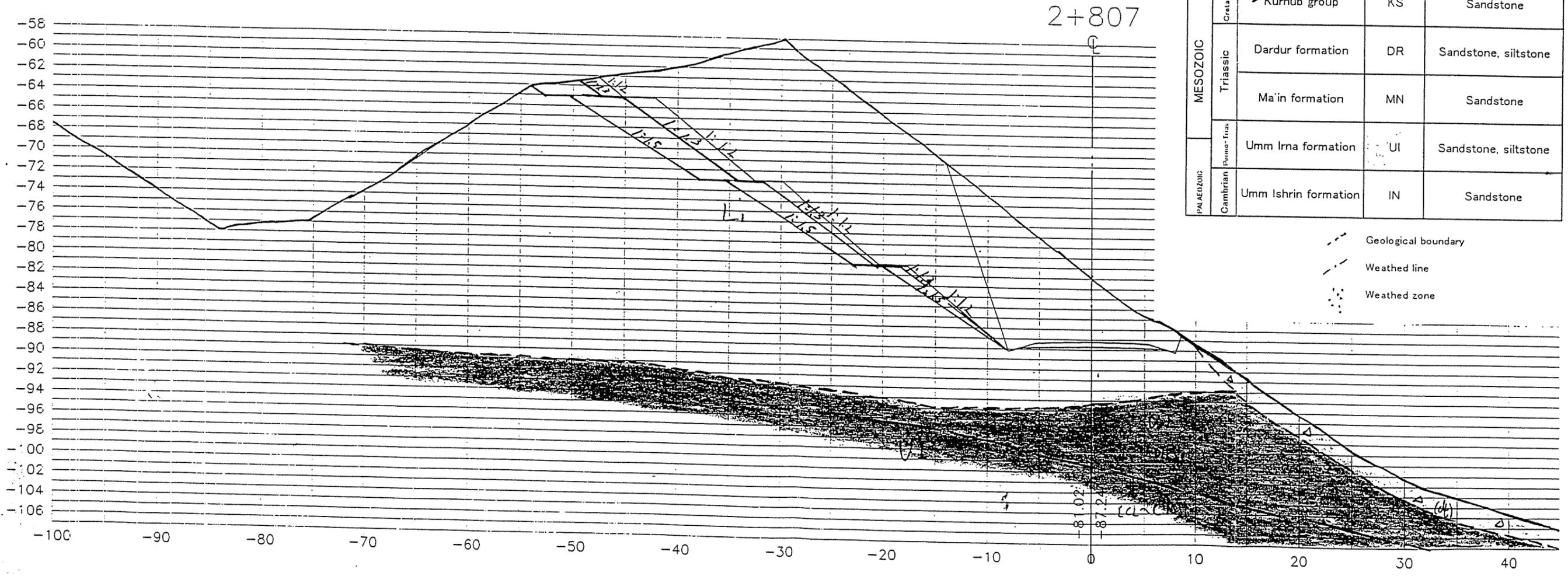


Figure 1 (4) Geological cross section (Station No. 2+807)

NO 3+293

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone
		Dardur formation	DR	Sandstone, siltstone
	Triassic	Ma'in formation	MN	Sandstone
		Umm Irna formation	UI	Sandstone, siltstone
PALAEZOIC	Cambrian	Umm Ishrin formation	IN	Sandstone

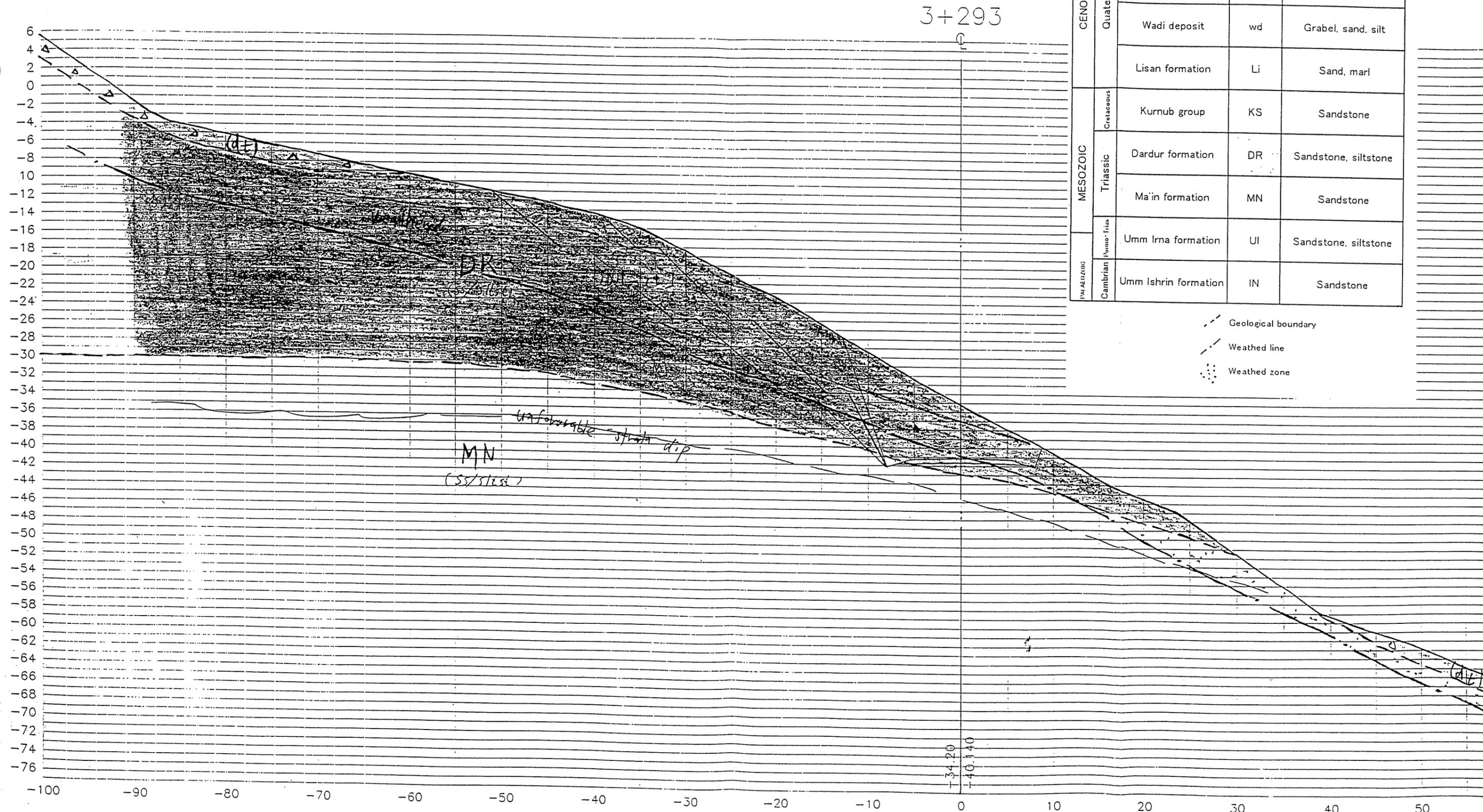
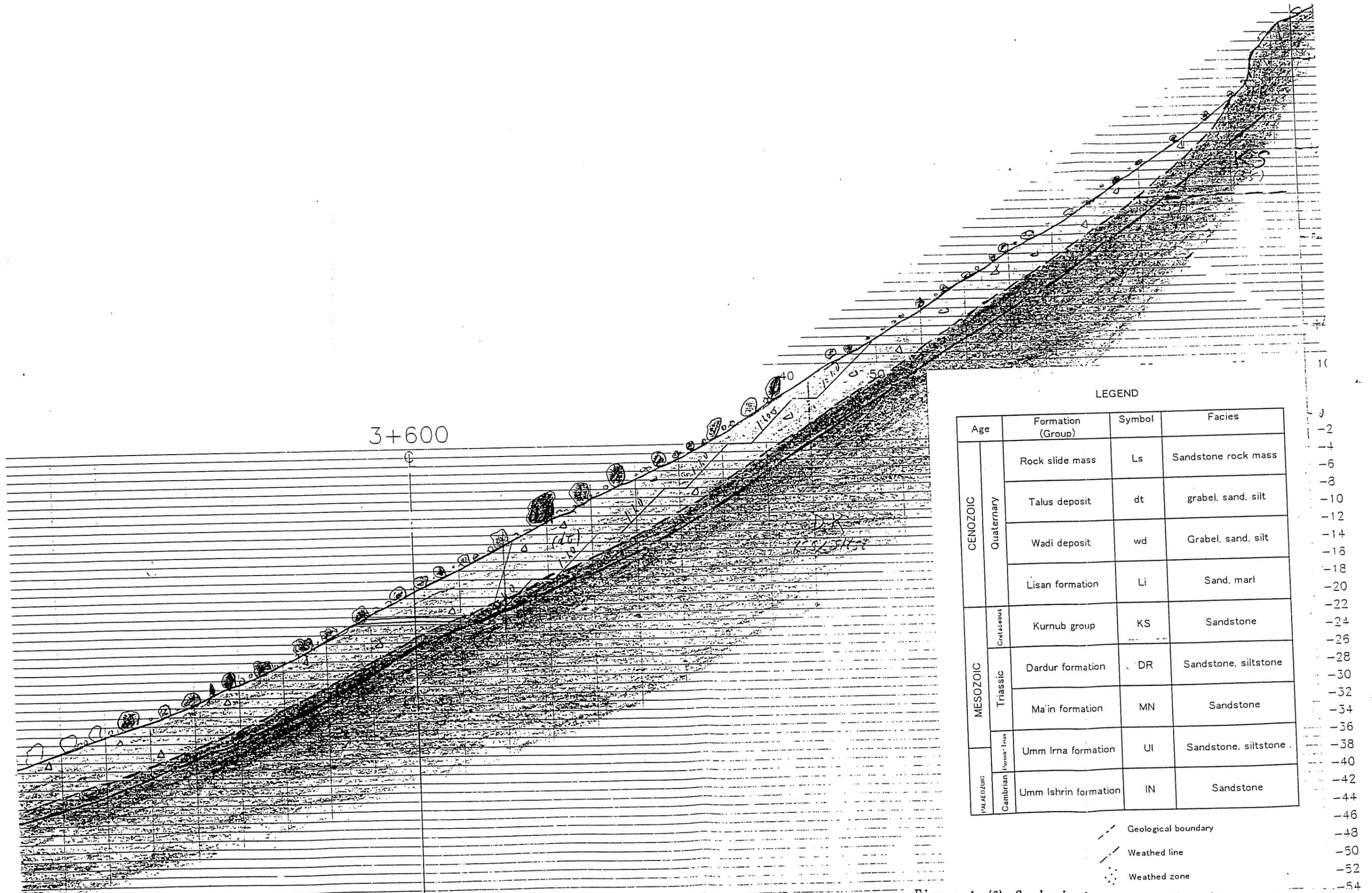


Figure 1 (5) Geological cross section (Station No. 3+293)

NO 3+600



LEGEND

Age	Formation (Group)	Symbol	Facies		
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass	
		Talus deposit	dt	grabel. sand, silt	
		Wadi deposit	wd	Grabel. sand, silt	
		Lisan formation	Li	Sand, marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	
		Triassic	Dardur formation	DR	Sandstone, siltstone
			Ma'in formation	MN	Sandstone
			Umm Irna formation	UI	Sandstone, siltstone
PALAEOZOIC	Cambrian	Umm Ishrin formation	IN	Sandstone	

- - - Geological boundary
- - - Weathered line
- Weathered zone

Figure 1 (6) Geological cross section (Station No. 3+600)

LEGEND

NO 3+940

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone
	Triassic	Dardur formation	DR	Sandstone, siltstone
		Ma'in formation	MN	Sandstone
PALAEOZOIC	Permian-Triassic	Umm Irma formation	UI	Sandstone, siltstone
	Cambrian	Umm Ishrin formation	IN	Sandstone

-  Geological boundary
-  Weathered line
-  Weathered zone

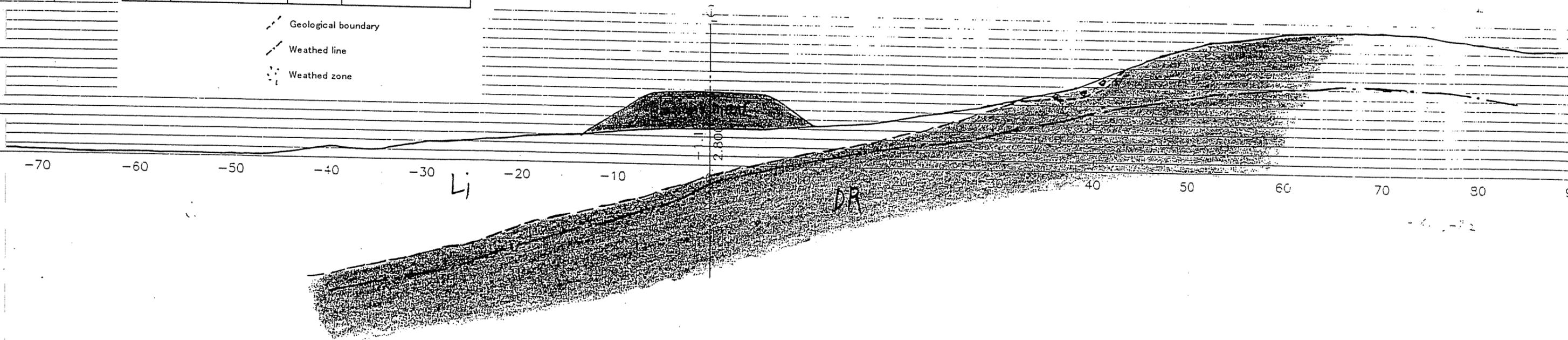


Figure 1 (7) Geological cross section (Station No. 3+940)

NO 4+700

LEGEND

Age	Formation (Group)	Symbol	Facies		
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass	
		Talus deposit	dt	grabel, sand, silt	
		Wadi deposit	wd	Grabel, sand, silt	
		Lisan formation	Li	Sand, marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	
		Triassic	Dardur formation	DR	Sandstone, siltstone
			Ma'in formation	MN	Sandstone
PALAEOZOIC	Permian-Triassic	Umm Irna formation	UI	Sandstone, siltstone	
		Cambrian	Umm Ishrin formation	IN	Sandstone

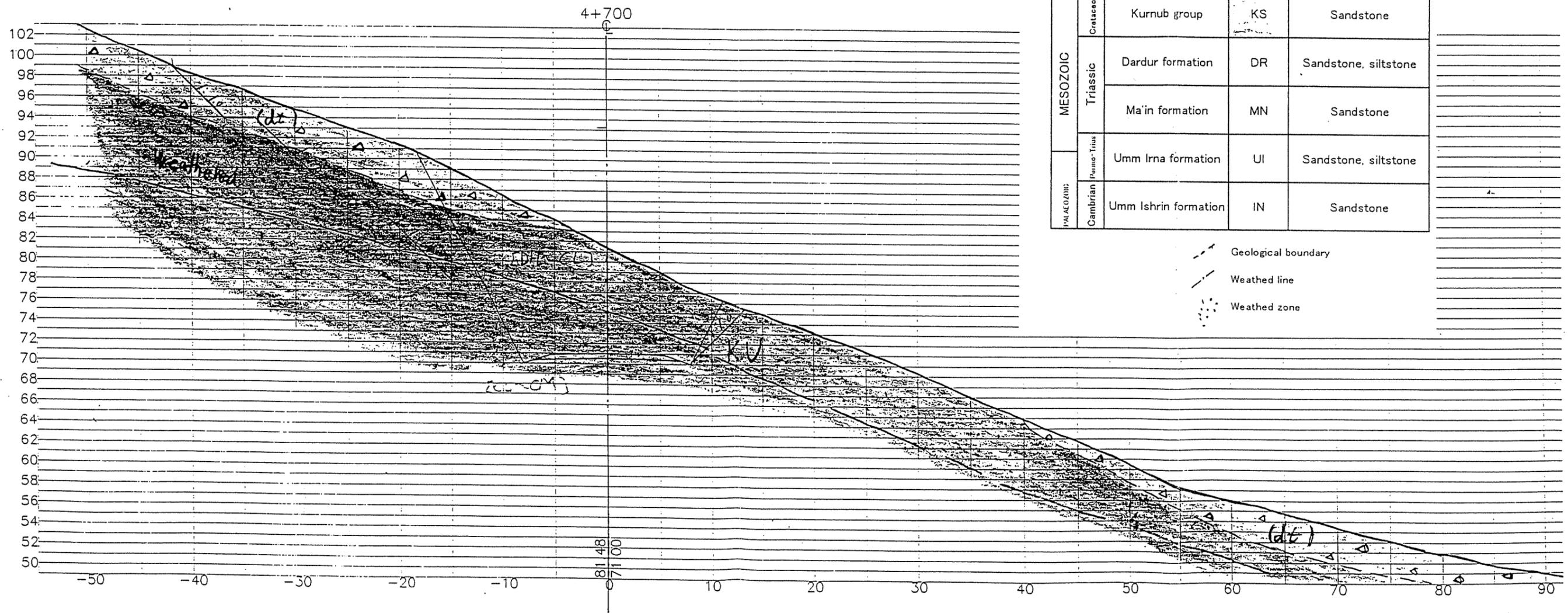


Figure 1 (8) Geological cross section (Station No. 4+700)

LEGEND

Age	Formation (Group)	Symbol	Facies		
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass	
		Talus deposit	dt	grabel. sand, silt	
		Wadi deposit	wd	Grabel. sand, silt	
		Lisan formation	Li	Sand. marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	
		Triassic	Dardur formation	DR	Sandstone, siltstone
			Ma'in formation	MN	Sandstone
PALAEOZOIC	Cambrian / Permian - Trias	Umm Irna formation	UI	Sandstone, siltstone	
		Umm Ishrin formation	IN	Sandstone	

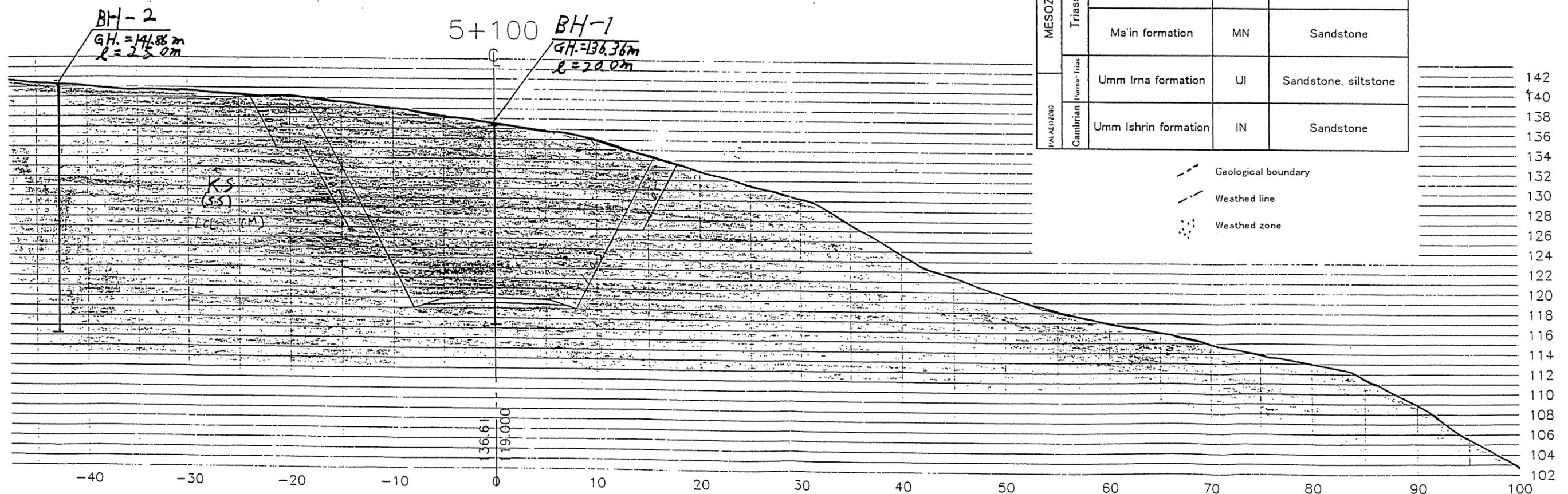


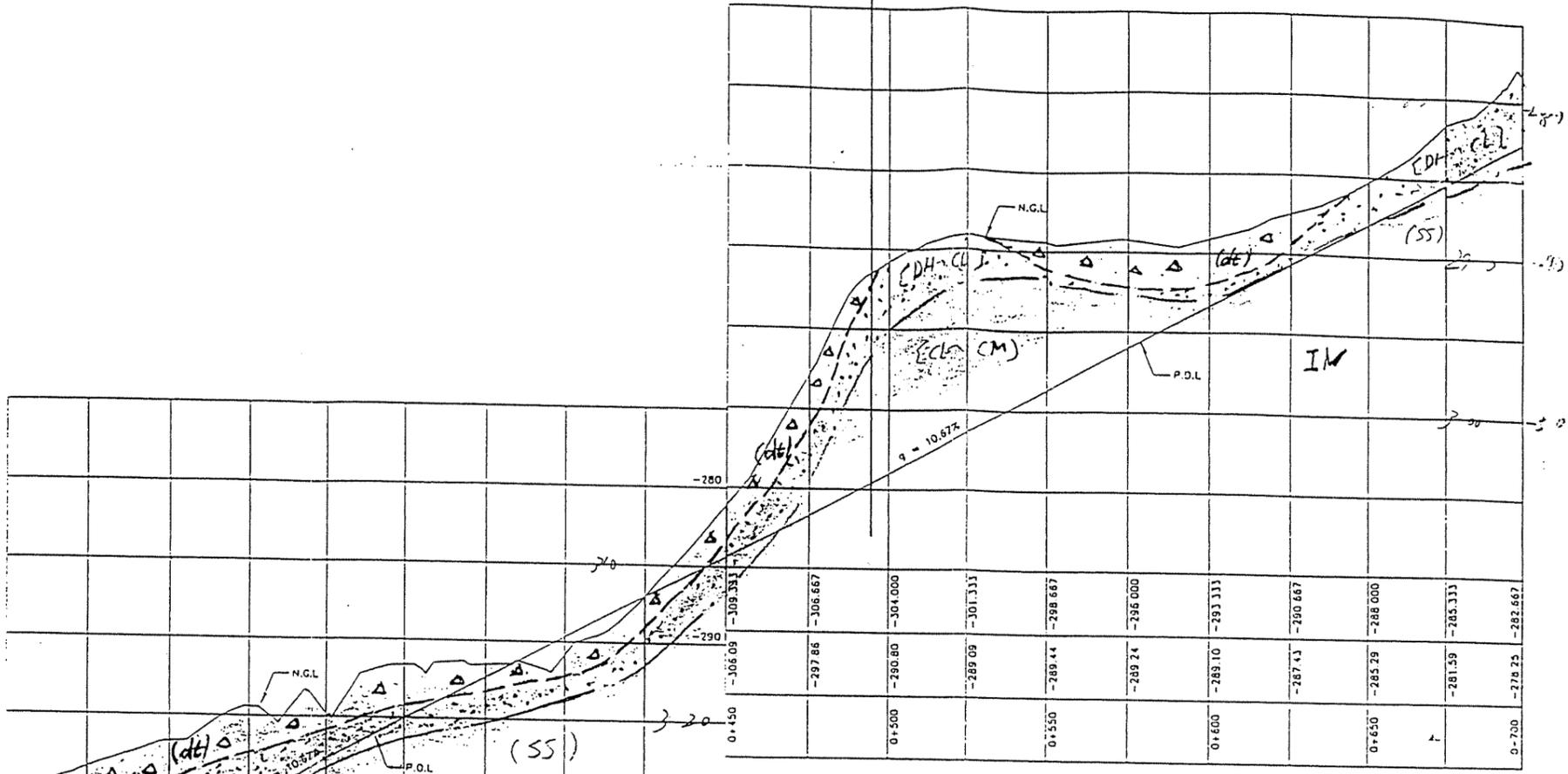
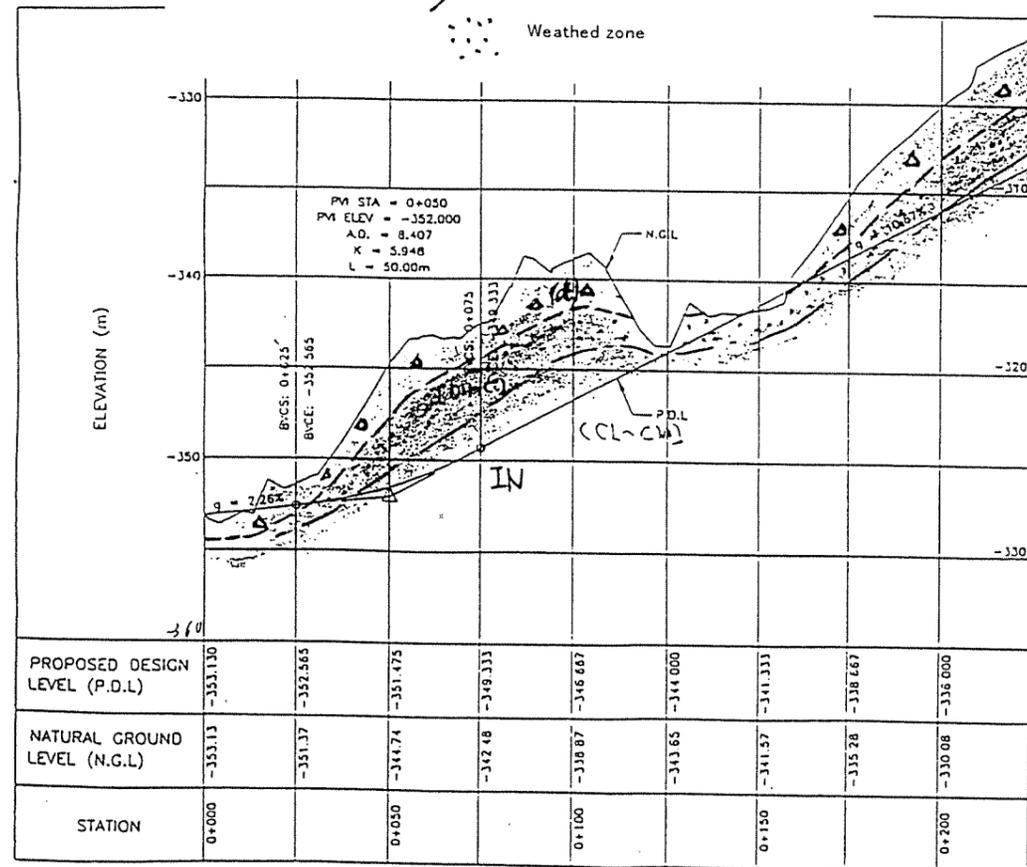
Figure 1 (9) Geological cross section (Station No. 5+100)

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone
		Dardur formation	DR	Sandstone, siltstone
	Triassic	Ma'in formation	MN	Sandstone
		Umm Irma formation	UI	Sandstone, siltstone
PALEOZOIC	Cambrian	Umm Ishrin formation	IN	Sandstone

- Geological boundary
- Weathered line
- Weathered zone

Geological cross section No. 0+492



SCALE	H 1:1000	V 1:200	DATE	AUG. 1999	DESIGNED BY	JICA D/D STUDY TEAM
DRAWING BY				CHECKED BY		
PROJECT	DEAD SEA PARKWAY SUB - PROJECT			STATION	STA.0+000 - STA.0+700	

UNLESS OTHERWISE INDICATED.

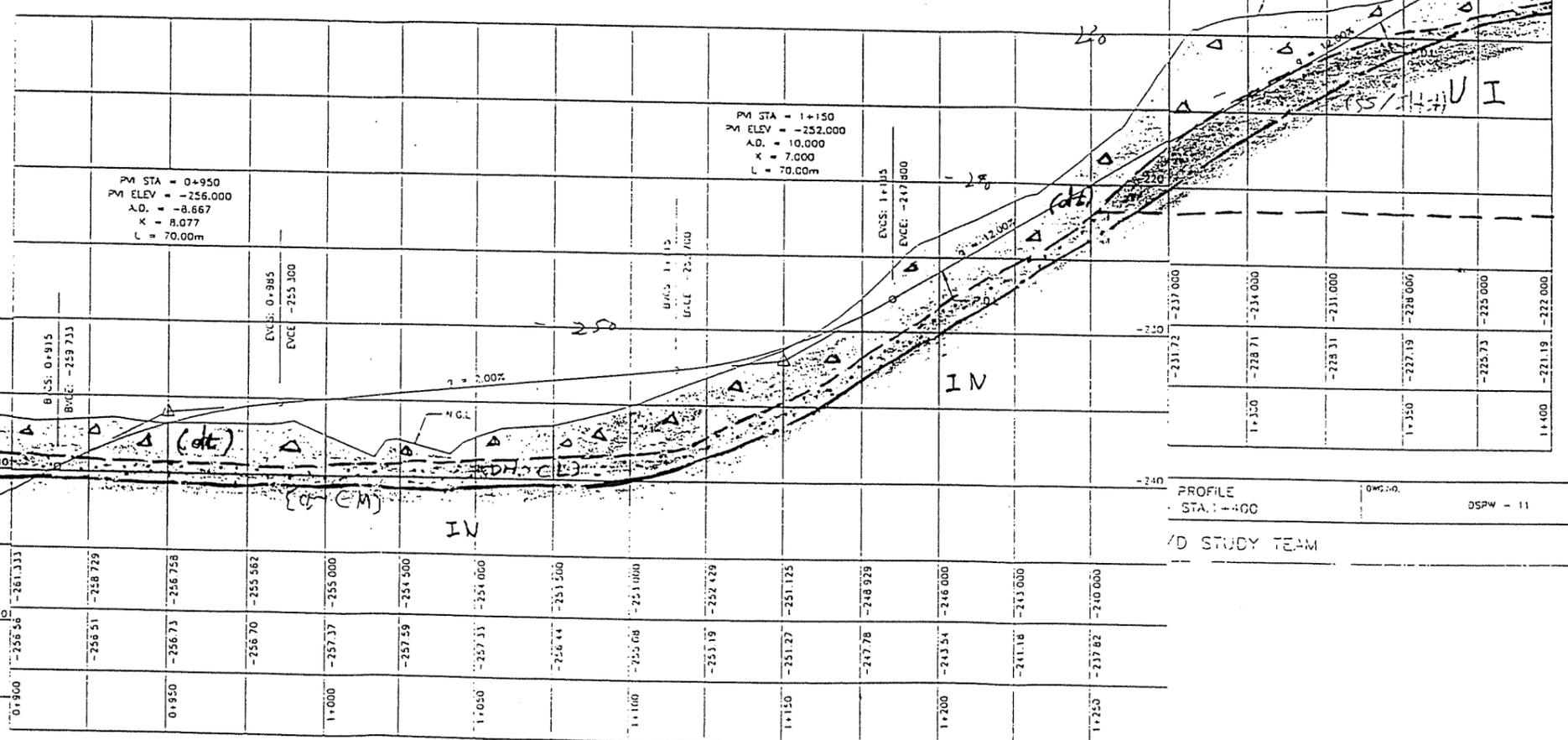
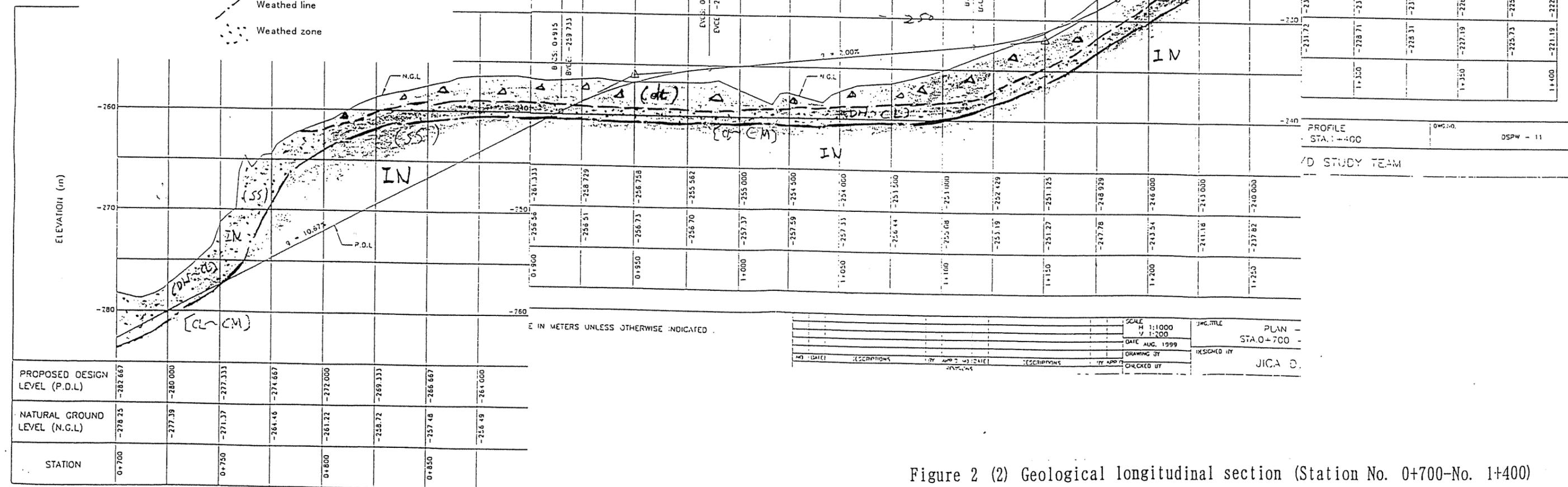
NO.	DATE	DESCRIPTIONS	BY	APP'D	DATE	REVISIONS

Figure 2 (1) Geological longitudinal section (Station No. 0+000-No. 0+700)

LEGEND

Age	Formation (Group)	Symbol	Facies
CENOZOIC	Quaternary	Rock slide mass	Ls Sandstone rock mass
		Talus deposit	dt gabel, sand, silt
		Wadi deposit	wd Grabel, sand, silt
		Lisan formation	Li Sand, marl
MESOZOIC	Cretaceous	Kurnub group	KS Sandstone
		Dardur formation	DR Sandstone, siltstone
	Triassic	Ma'in formation	MN Sandstone
		Umm Irna formation	[Symbol] Sandstone, siltstone
Cambrian	Umm Ishrin formation	IN Sandstone	

- - - Geological boundary
- - - - - Weathered line
- Weathered zone



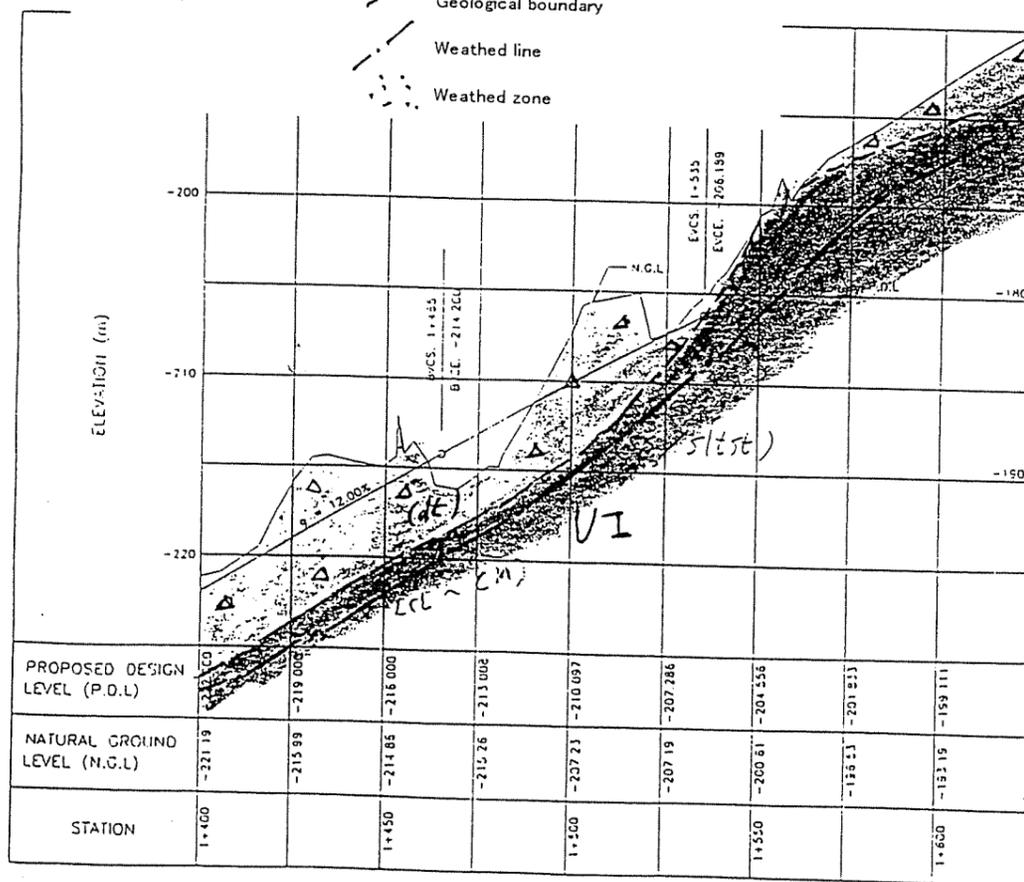
SCALE	H 1:1000	V 1:200
DATE	AUG. 1999	
DRAWING BY	JICA D.	
CHECKED BY	JICA D.	

Figure 2 (2) Geological longitudinal section (Station No. 0+700-No. 1+400)

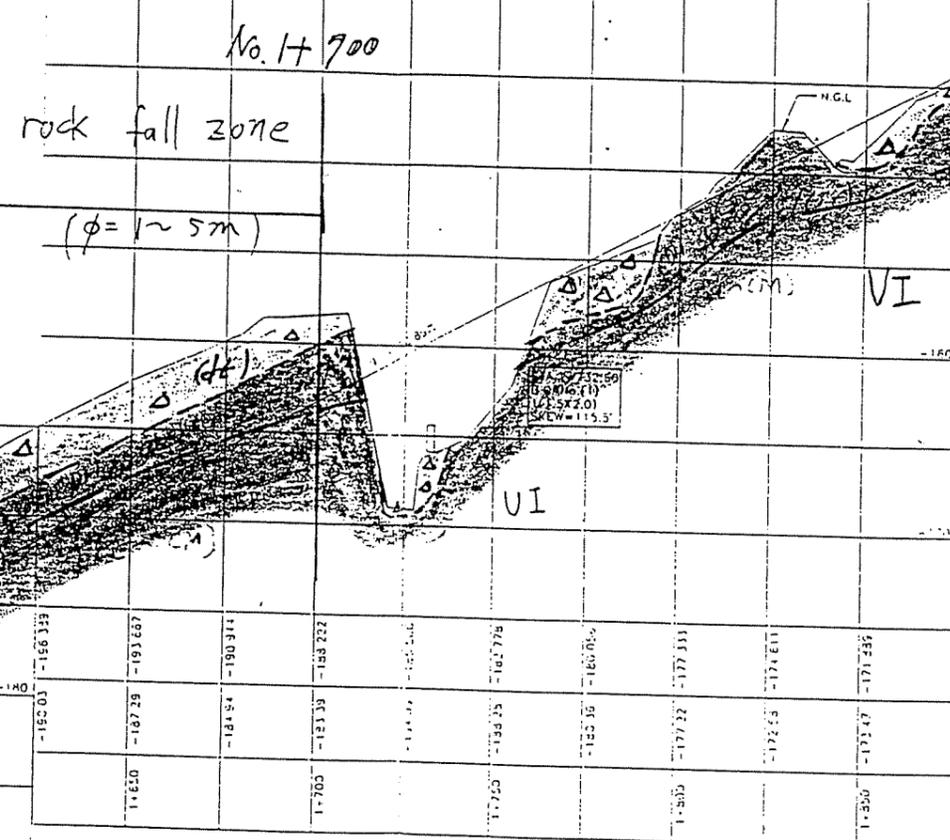
LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone
		Dardur formation	DR	Sandstone, siltstone
	Triassic	Ma'in formation	MN	Sandstone
		Umm Irna formation	UI	Sandstone, siltstone
PALAEZOIC	Cambrian Permian-Triassic	Umm Ishrin formation	IN	Sandstone

- Geological boundary
- Weathered line
- Weathered zone

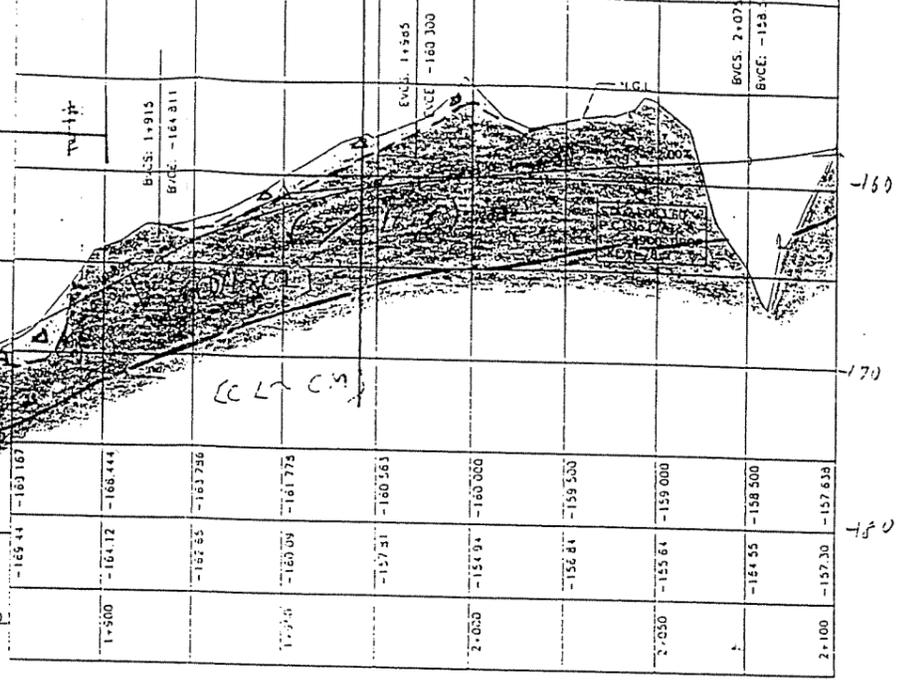


Geological cross section No. 1+700



Geological cross section No. 1+972

PM STA = 1+950
 PM ELEV = -161.000
 A.O. = -1.889
 K = 7.875
 L = 70.00m



SCALE: 1:1000	DATE: AUG 1999	DESIGNED BY: JICA O/D STUDY TEAM
DRAWING NO.	CHECKED BY	ENGINEER: DSPW - 12

UNLESS OTHERWISE INDICATED

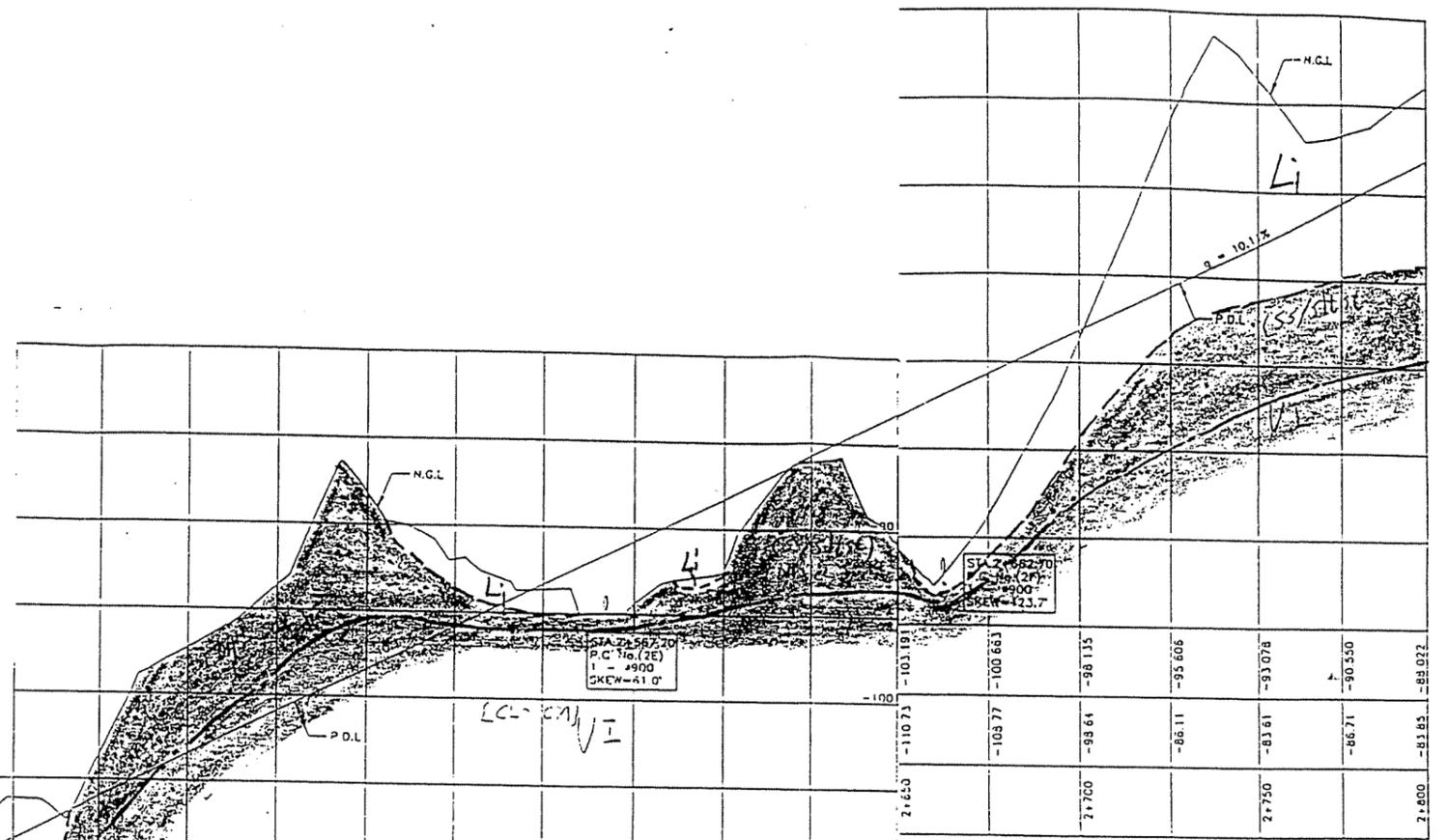
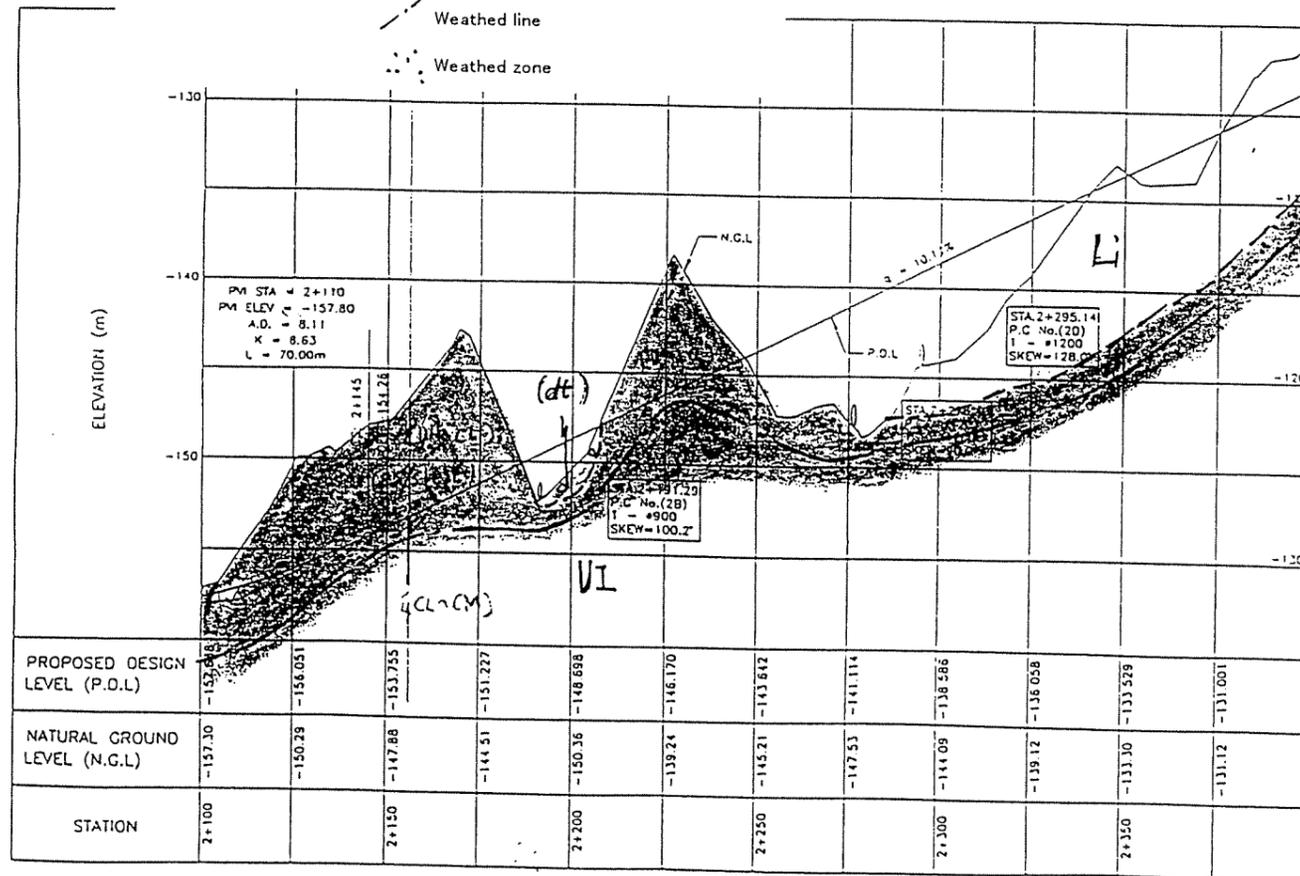
NO.	DATE	DESCRIPTION	BY	APP'D	DATE	REVISIONS

Figure 2 (3) Geological longitudinal section (Station No. 1+400-No. 2+100)

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kumub group	KS	Sandstone
		Dardur formation	DR	Sandstone, siltstone
	Triassic	Ma'in formation	MN	Sandstone
		Umm Irna formation	UI	Sandstone, siltstone
Paleozoic	Cambrian	Umm Ishrin formation	IN	Sandstone

- - - Geological boundary
- - - Weathered line
- ... Weathered zone



PLAN - PROFILE
 STA. 2+100 - STA. 2+800
 DWG. NO. DSPW - 13
 JICA D/O STUDY TEAM

NO.	DATE	DESCRIPTIONS	BY	APP'D. NO.	DATE	DESCRIPTIONS	BY	APP'D.

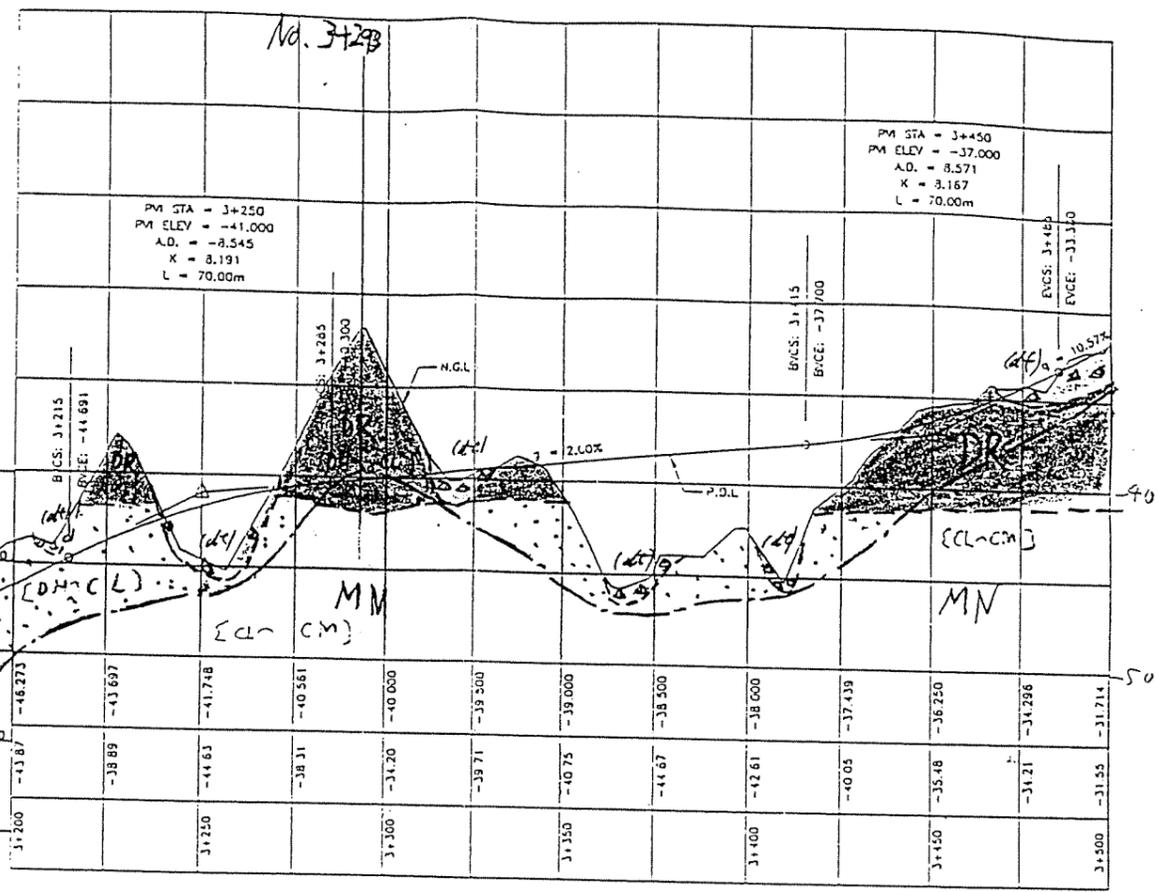
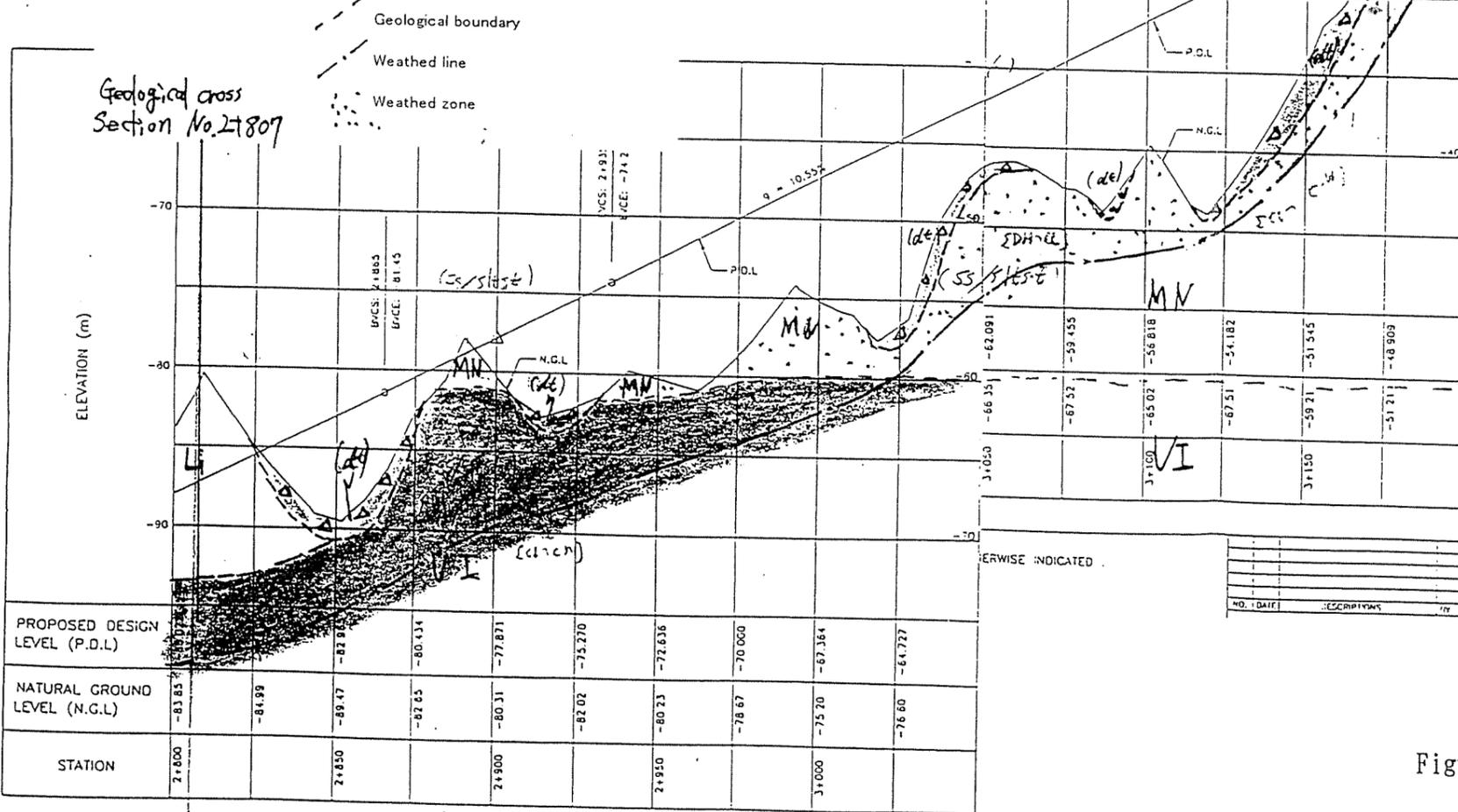
SCALE
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 V 1:200
 DATE AUG. 1999
 DRAWING BY
 CHECKED BY

Figure 2 (4) Geological longitudinal section (Station No. 2+100-No. 2+800)

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel. sand, silt
		Wadi deposit	wd	Grabel. sand, silt
	Lisan formation	Li	Sand, marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone
		Triassic	Dardur formation	DF
	Ma'in formation		MN	Sandstone
	Permian-Triassic	Umm Irna formation	UI	Sandstone, siltstone
Cambrian		Umm Ishrin formation	IN	Sandstone

Geological cross section

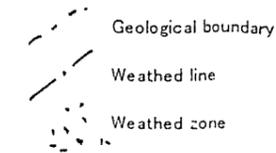


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PROJECT: DEAD SEA PARKWAY SUB - PROJECT	STATIONING: STA. 2+800 - STA. 3+500	DSPW - 14

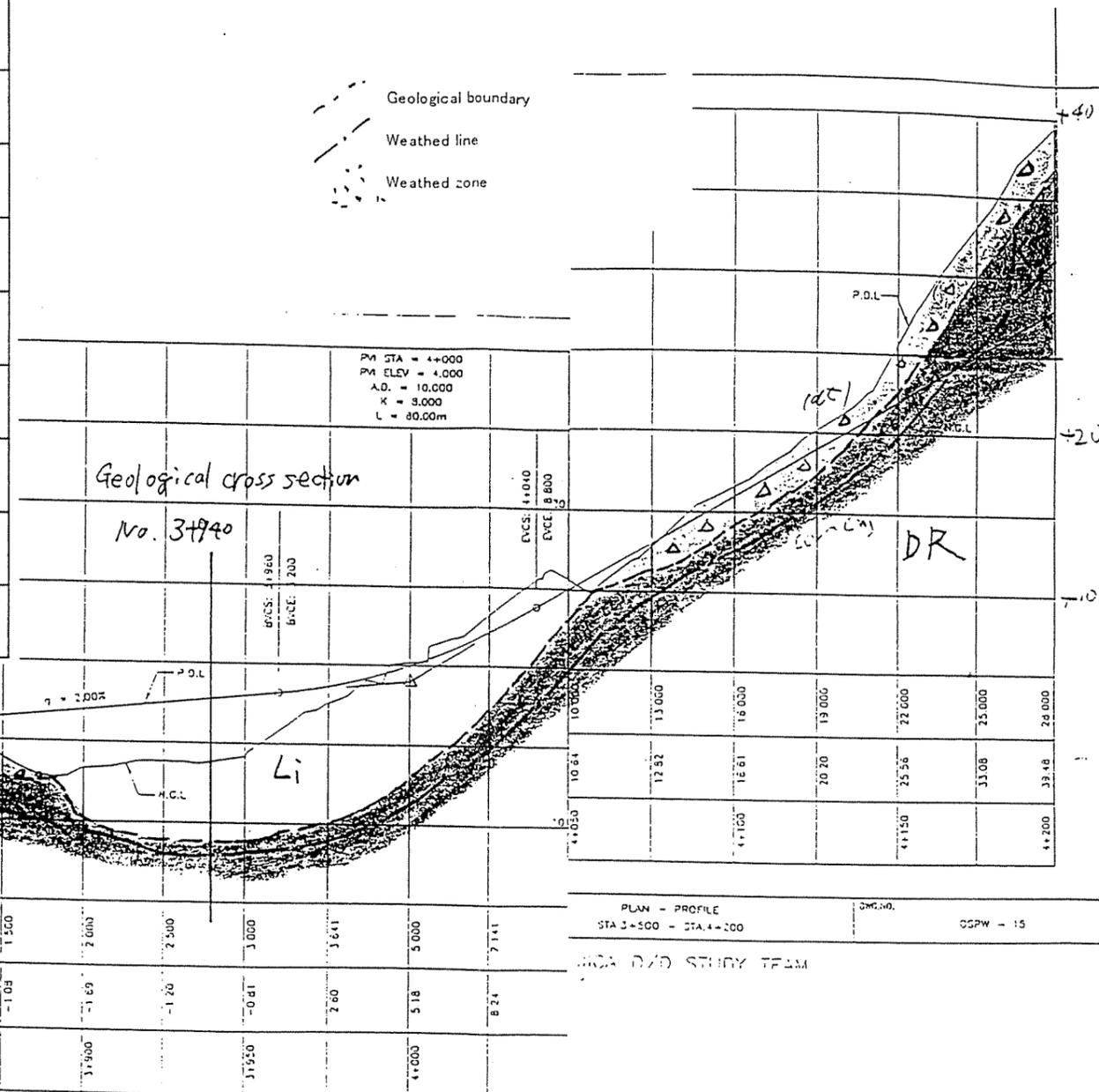
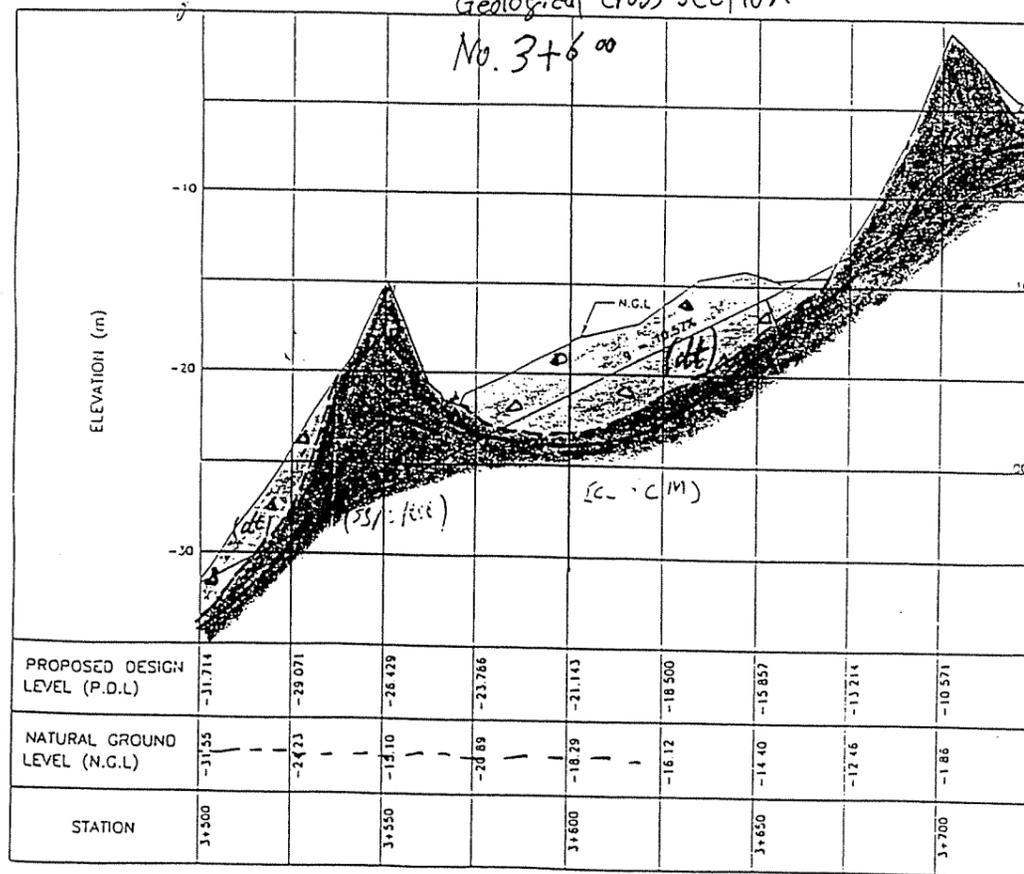
Figure 2 (5) Geological longitudinal section (Station No. 2+800-No. 3+500)

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel. sand, silt
		Wadi deposit	wd	Grabel. sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Triassic	Kurnub group	[Symbol]	Sandstone
		Dardur formation	[Symbol]	Sandstone, siltstone
		Ma'in formation	MN	Sandstone
PALAEOZOIC	Cambrian Permian-Triassic	Umm Irna formation	UI	Sandstone, siltstone
		Umm Ishrin formation	IN	Sandstone



rock fall zone
 $\phi = 125m$
 Geological cross section
 No. 3+600



STATION	3+750	3+800	3+850	3+900	3+950	4+000	4+050	4+100	4+150	4+200
ELEVATION (m)	-1.37	-0.92	0.24	1.01	-2.67	-0.51	-1.04	-1.69	-1.20	-0.41
PROFILES	-7.929	-5.286	-2.704	-0.750	0.439	1.000	1.500	2.000	2.500	3.000
VERTICAL CURVE DATA										
GRADES (%)										
STATIONING										

UNLESS OTHERWISE INDICATED

SCALE	H 1:1000	V 1:200
DATE	AUG. 1999	
DRAWING BY	DECIDED BY	

PLAN - PROFILE
 STA 3+500 - STA 4+200
 ROAD D/D STUDY TEAM
 OSPW - 15

Figure 2 (6) Geological longitudinal section (Station No. 3+500-No. 4+200)

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Triassic	Kurnub group	[Symbol]	Sandstone
		Dardur formation	DR	Sandstone, siltstone
		Ma'in formation	MN	Sandstone
		Umm Irna formation	UI	Sandstone, siltstone
PALAEZOIC	Cambrian	Umm Ishrin formation	IN	Sandstone

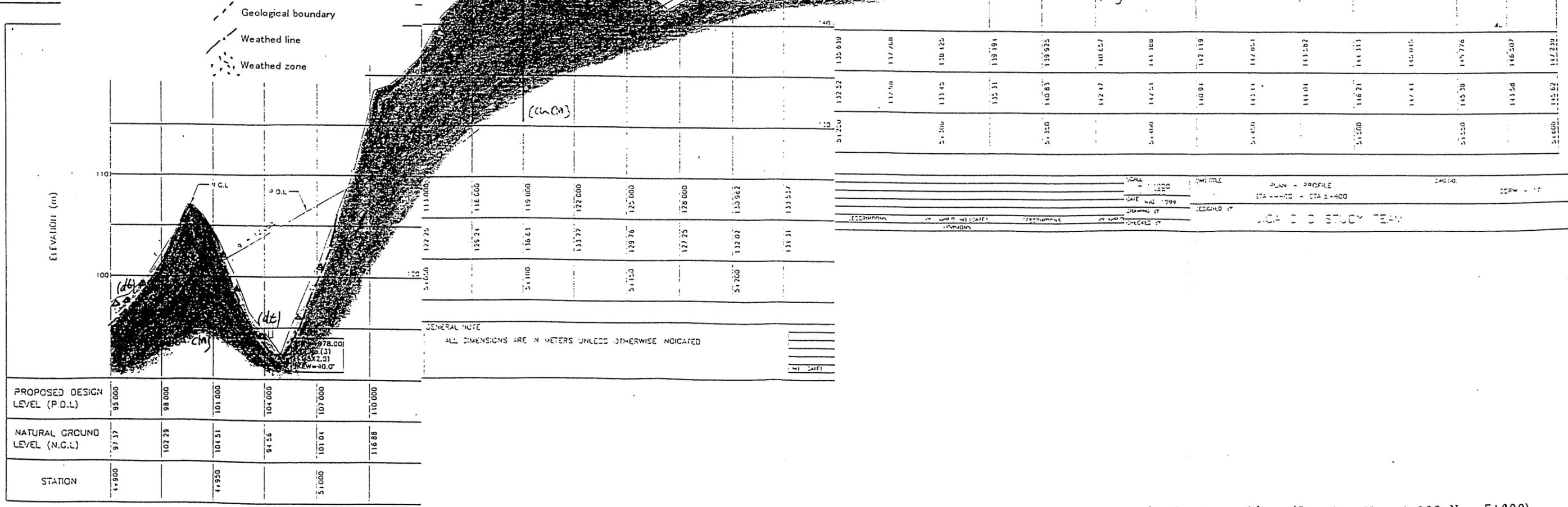
Geological cross section

No. 54100

PM STA = 5+200
PM ELEV = 117.000
A.O. = -9.075
K = 11.224
L = 110.000

Geological boundary
Weathered line
Weathered zone

ELEVATION (m)



GENERAL NOTE
ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE INDICATED

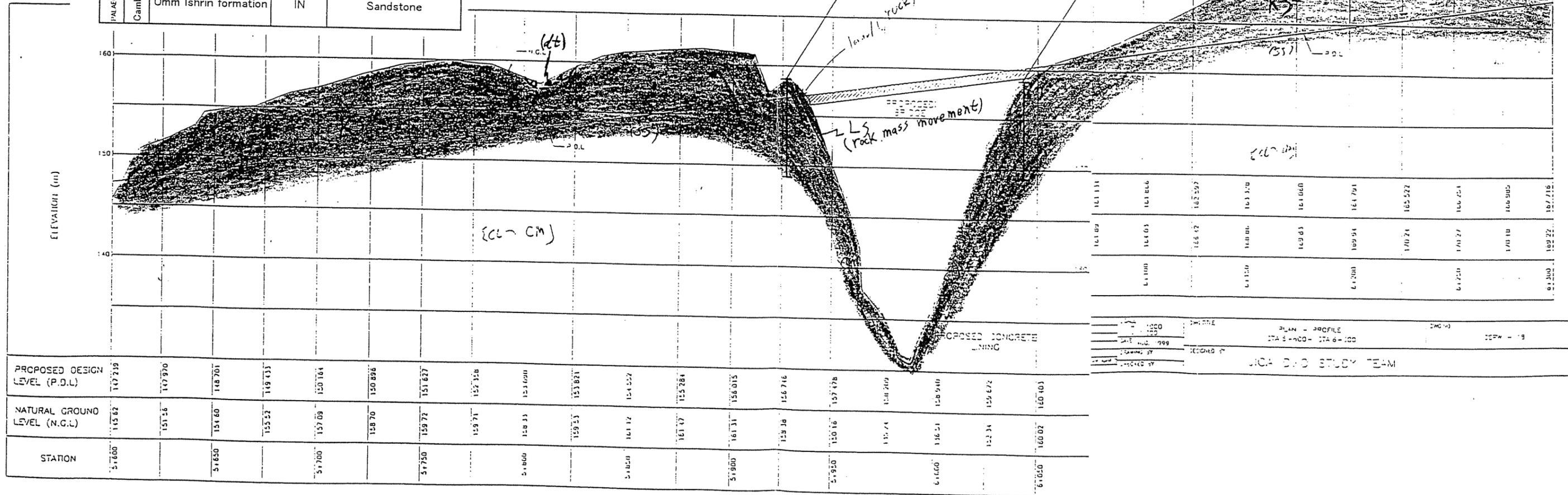
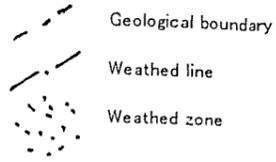
SCALE: 1:1000
DATE: 11/1999
DRAWING BY: [Name]
DESIGNED BY: JOH O O STUDY TEAM

Figure 2 (8) Geological longitudinal section (Station No. 4+900-No. 5+600)

PROJECT
DEAD SEA PARKWAY SUB - PROJECT

LEGEND

Age	Formation (Group)	Symbol	Facies
CENOZOIC	Quaternary	Rock slide mass	Sandstone rock mass
		Talus deposit	grabel, sand, silt
		Wadi deposit	Grabel, sand, silt
		Lisan formation	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	Sandstone
		Dardur formation	Sandstone, siltstone
	Triassic	Ma'in formation	Sandstone
		Umm Irna formation	Sandstone, siltstone
Palaeozoic	Cambrian	Umm Ishrin formation	Sandstone



BH-4
GL = 158.72
L = 10m

BH-3
GL = 151.50m
L = 10m
Sandstone
Siltstone

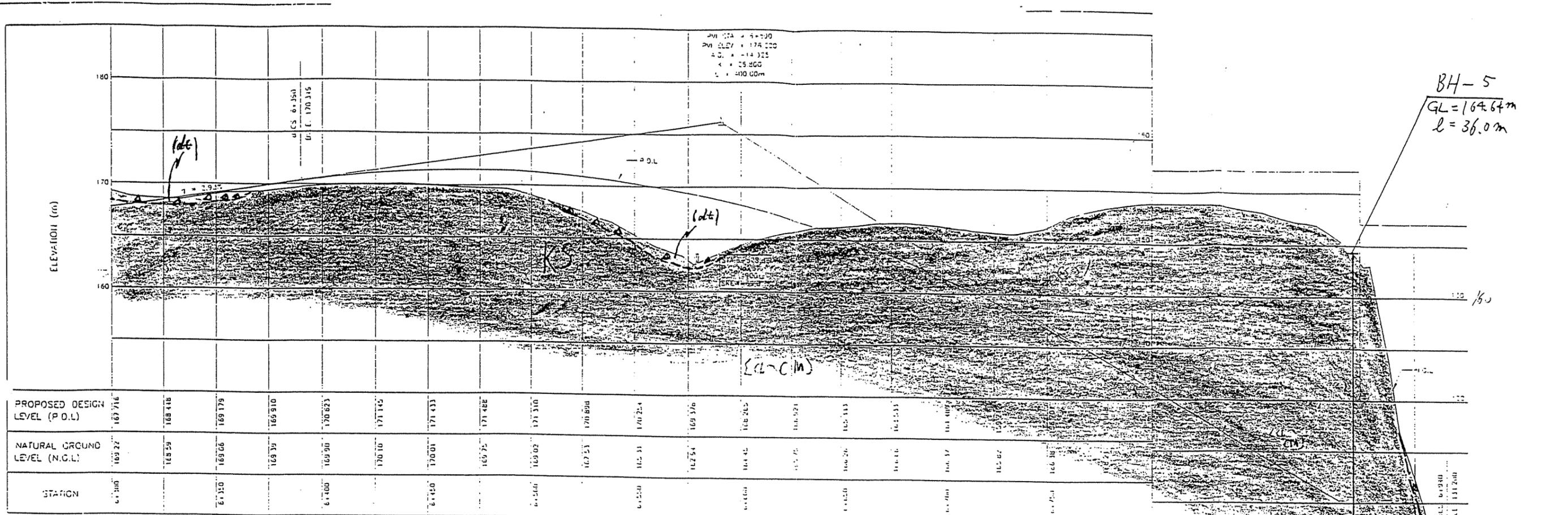
LS (rock mass movement)

DATE: 10/10/99
SCALE: 1:100
PROJECT: DEAD SEA PARKWAY SUB - PROJECT
DRAWN BY: JICA DAD STUDY TEAM

PROJECT: DEAD SEA PARKWAY SUB - PROJECT

GENERAL NOTE: ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE INDICATED

Figure 2 (9) Geological longitudinal section (Station No. 5+600-No. 6+300)



BH-5
 GL = 167.64m
 L = 36.0m

LEGEND

Age	Formation (Group)	Symbol	Facies	
GENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone
		Dardur formation	DR	Sandstone, siltstone
	Triassic	Ma'in formation	MN	Sandstone
		Umm Irna formation	UI	Sandstone, siltstone
Palaeozoic	Cambrian	Umm Ishrin formation	IN	Sandstone

- Geological boundary
- Weathered line
- Weathered zone

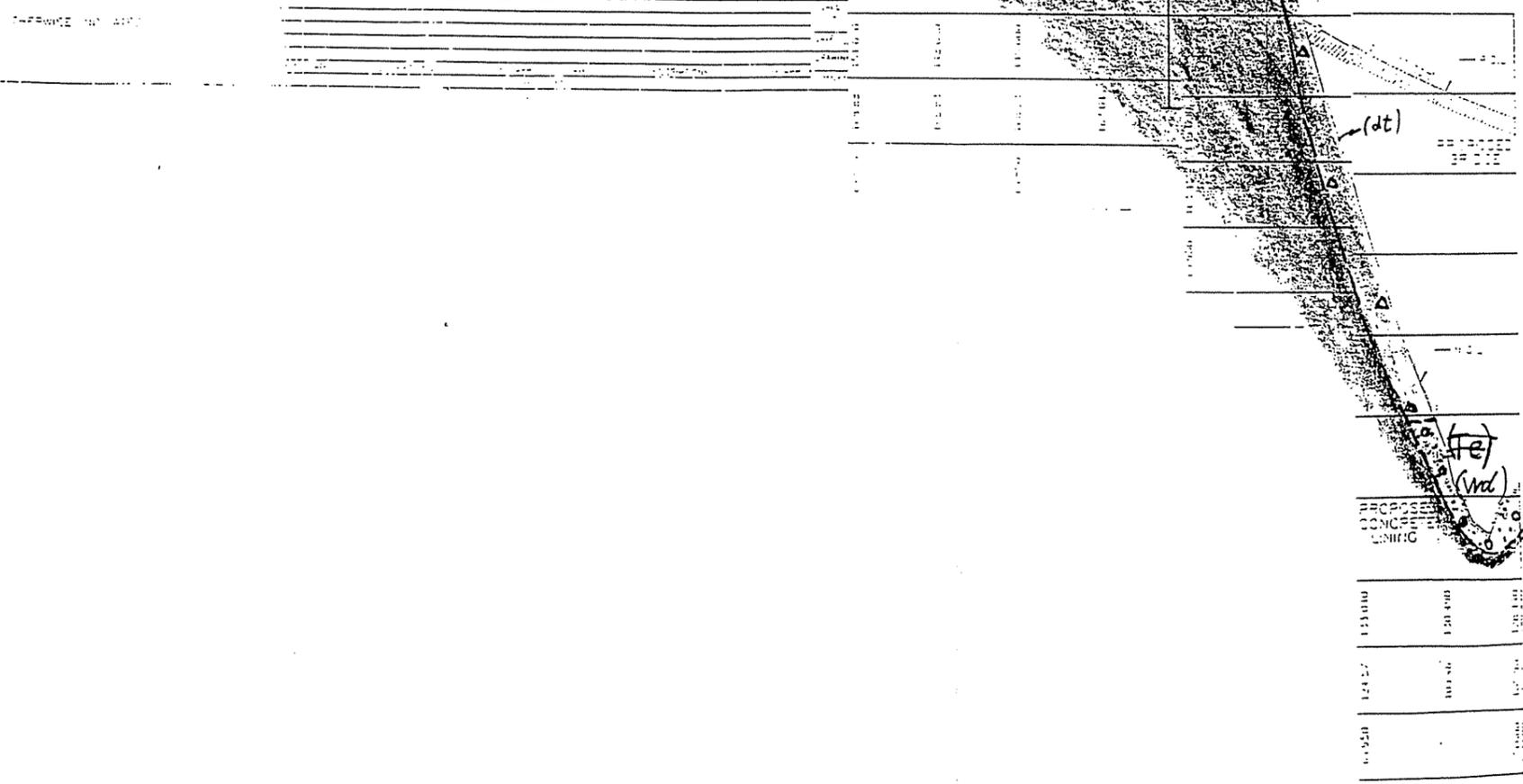
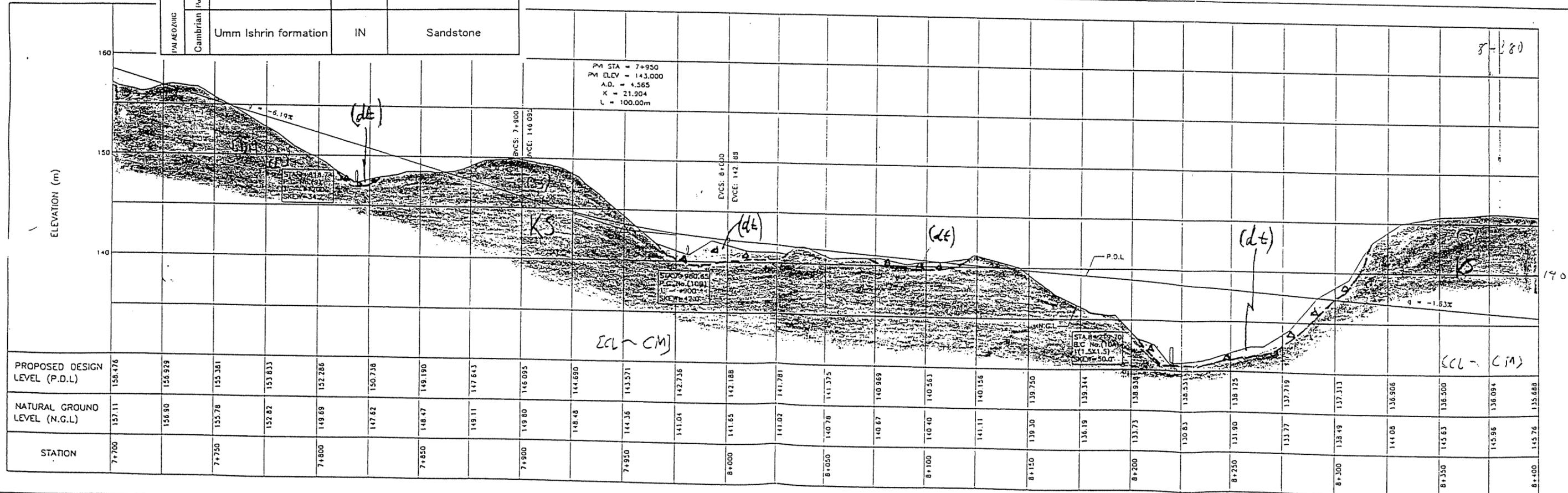


Figure 2 (10) Geological longitudinal section (Station No. 6+300-No. 7+000)

LEGEND

Age	Formation (Group)	Symbol	Facies	
CENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass
		Talus deposit	dt	grabel, sand, silt
		Wadi deposit	wd	Grabel, sand, silt
		Lisan formation	Li	Sand, marl
MESOZOIC	Cretaceous	Kurnub group	[Symbol]	Sandstone
		Dardur formation	DR	Sandstone, siltstone
	Triassic	Ma'in formation	MN	Sandstone
		Umm Irma formation	UI	Sandstone, siltstone
Paleozoic	Cambrian	Umm Ishrin formation	IN	Sandstone

- Geological boundary
- Weathered line
- Weathered zone



PM STA = 7+950
 PM ELEV = 143.000
 A.D. = 4.365
 K = 21.904
 L = 100.00m

STA 7+980.65
 P.C. No. (108)
 P.T. = 900.00
 SKEW = 42.5

STA 8+250.70
 B.C. No. (104)
 P.T. = 841.50
 SKEW = 50.0

PROJECT
 DEAD SEA PARKWAY SUB - PROJECT

GENERAL NOTE
 ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE INDICATED.

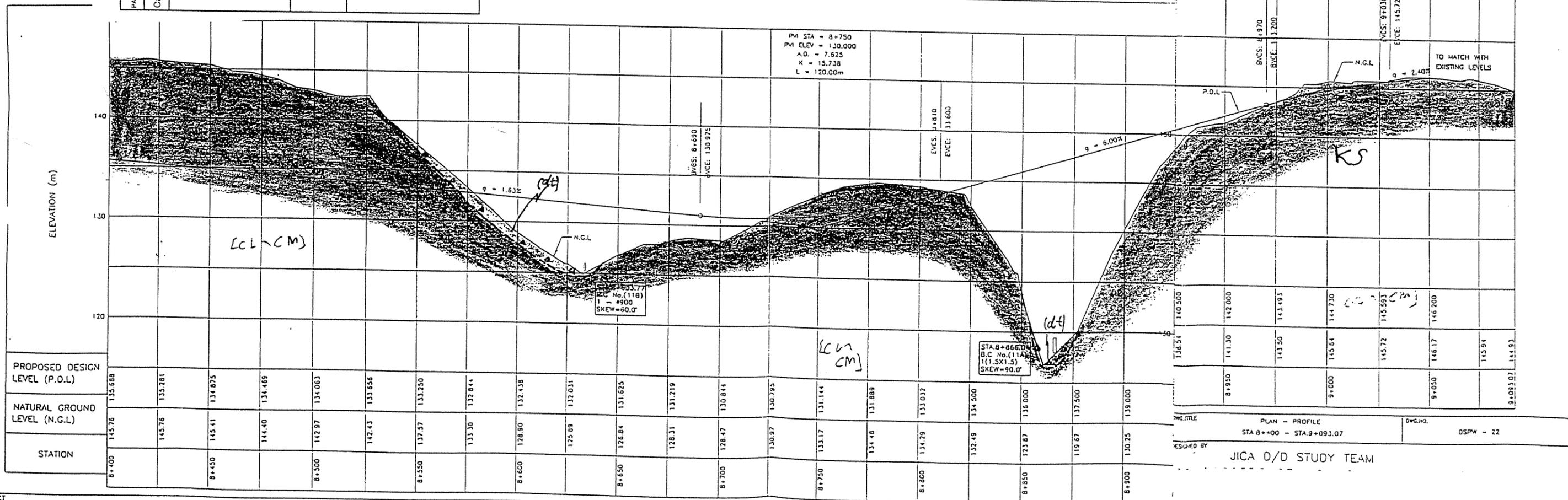
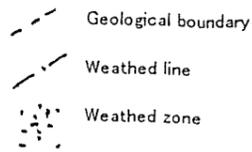
NO.	DATE	DESCRIPTIONS	BY	APP'D	DATE	DESCRIPTIONS	BY	APP'D	DATE

SCALE
 H 1:1000
 V 1:500
 DATE AUG. 1999
 DRAWING BY
 CHECKED BY
 DWG. TITLE
 PLAN - PROFILE
 STA. 7+700 - STA. 8+400
 DWG. NO.
 OSPW - 21
 DESIGNED BY
 JICA D/D STUDY TEAM

Figure 2 (12) Geological longitudinal section (Station No. 7+700-No. 8+400)

LEGEND

Age	Formation (Group)	Symbol	Facies		
GENOZOIC	Quaternary	Rock slide mass	Ls	Sandstone rock mass	
		Talus deposit	dt	grabel. sand, silt	
		Wadi deposit	wd	Grabel. sand, silt	
		Lisan formation	Li	Sand, marl	
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	
		Triassic	Dardur formation	DR	Sandstone, siltstone
			Ma'in formation	MN	Sandstone
PALAEOZOIC	Cambrian	Umm Irna formation	UI	Sandstone, siltstone	
		Umm Ishrin formation	IN	Sandstone	

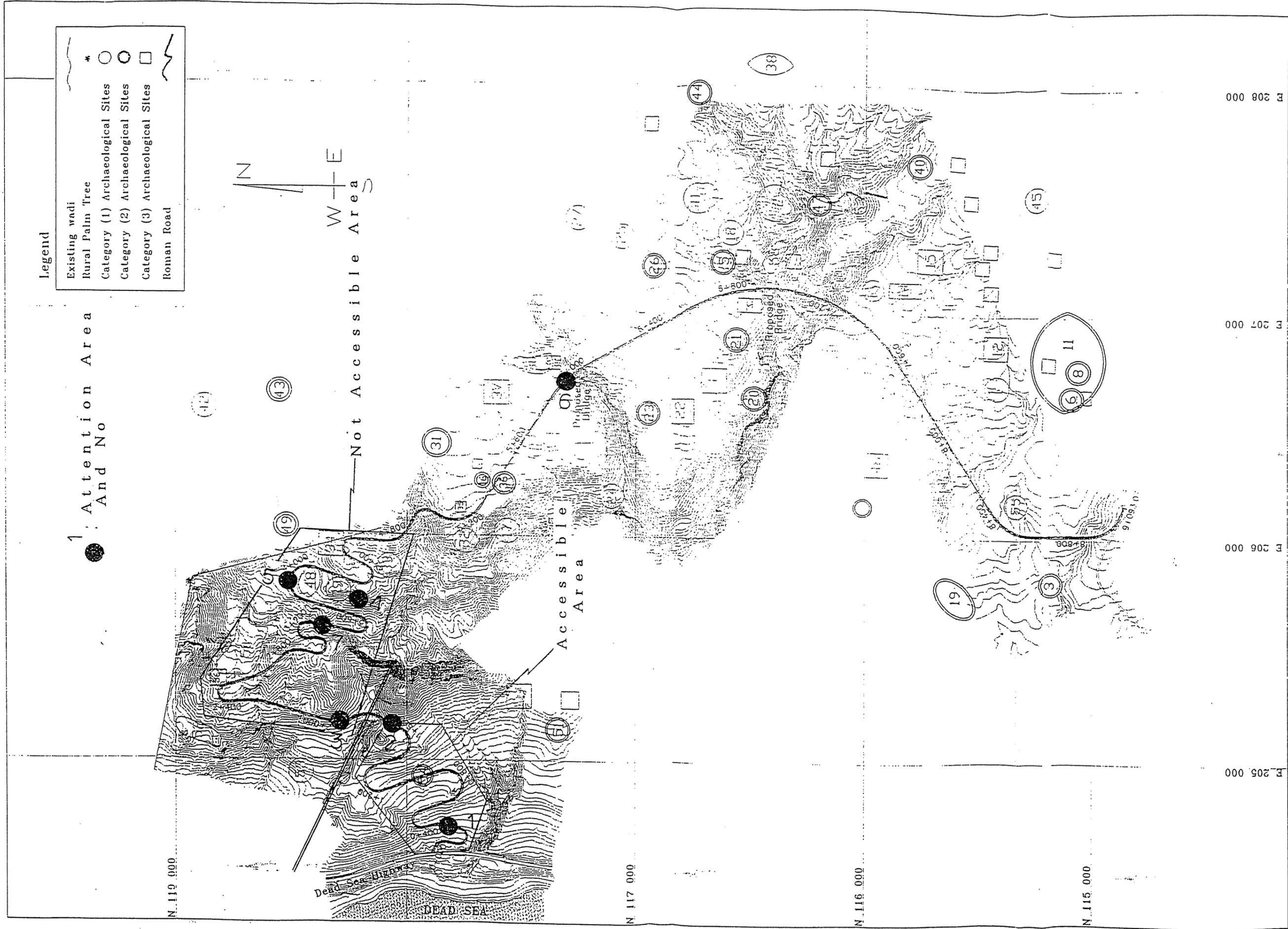


DEAD SEA PARKWAY SUB - PROJECT

GENERAL NOTE
ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE INDICATED.

NO.	DATE	DESCRIPTIONS	BY	APP'D. NO	DATE	DESCRIPTIONS	BY	APP'D.

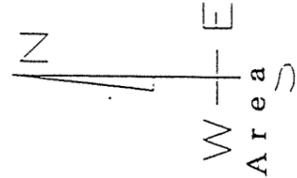
Figure 2 (13) Geological longitudinal section (Station No. 8+400-No. 9+093)



Legend

- Existing wadi
- Rural Palm Tree *
- Category (1) Archaeological Sites
- Category (2) Archaeological Sites
- Category (3) Archaeological Sites
- Roman Road

1 : Attention Area
● And No



Not Accessible Area

Accessible Area

JICA D/D STUDY TEAM	Dead Sea Parkway Sub - Project	REC. ALTERNATIVE (Alternative III Revised)
		NOT TO SCALE

Figure 3 Distribution of attention areas
380

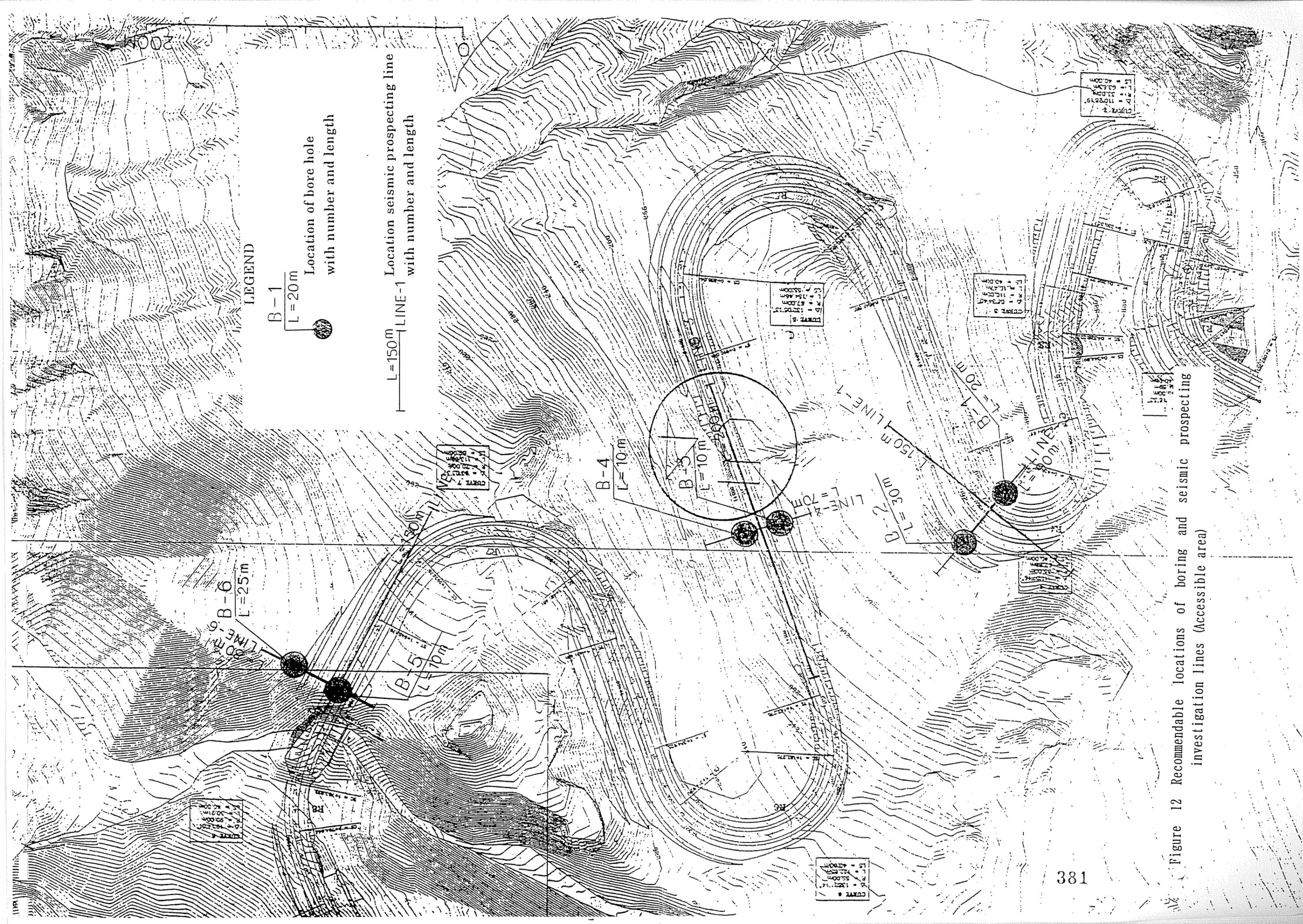


Figure 12 Recommendable locations of boring and seismic prospecting investigation lines (Accessible area)



LEGEND

L=250m — LINE-7 Location seismic prospecting line with number and length

Figure 13 Recommendable locations of seismic prospecting (Not accessible area)

Table 1 Geological composition

Age		Formation (Group)	Symbol	Facies	Remarks
CENOZOIC	Quaternary	Rock mass slide	Ls	Sandstone rock mass	W=10m, H=20m, D=5m, limited by joint. Distributing at No. 5+930 (Bridge abutment)
		Talus deposit	dt	Gravel, sand, silt	Many gravel, cemented hardly(dese). Distributing on the slope , in the valley.
		Wadi deposit	wd	Gravel, sand, silt	Rounded gravel, dense.
		Lisan formation	Li	Sand, marl	Lake deposit. Gray-yellowish grey coloured. Hardly cemented(dense) on surface, soil-like inside. Mainly distributing No. 2+280-No.2+825, No.3+900-No. 4+50.
MESOZOIC	Cretaceous	Kurnub group	KS	Sandstone	White, yellow, pink colored medium-coarse grained sandstone. Partly including sandstone/siltstone alternation. Distributing No. 4+150-No. 9.
	Triassic	Dardur formation	DR	Sandstone, siltstone	Brown, yellow, white colored fine-midium grained sandstone including dolomitic limestone. Distributing No. 3+220-No. 4+150.
		Ma'in formation	MN	Sandstone	White, brown, yellow colored fine-medium grained sandstone including siltstone, carbonate rocks. Distributing No. 2+880-No.3+220.
	Permo-Trias	Umm Irna formation	UI	Sandstone, siltstone	Gray, red colored fine-coarse grained sandstone, siltstone. Distributing No. 1+250-No. 2+880.
PALAEOZOIC	Cambrian	Umm Ishrin formation	IN	Sandstone	Yellow, brown, red colored medium-coarse grained sandstone. Intercalacted thin siltstone. Developing joint(fissure). Distributing No. 0-No. 1+250.

Table 2 Attention Areas

No.	Range (Sta. No.)	Geology	Type of danger	Slope condition	Remarks
1	No. 0+200–No. 0+980	Umm Ishrin sandstone	Dip slope structure	Gentle slope	Cut slope zone. Better gentle cut slope gradient.
2	No. 1+600–No. 1+700	Umm Irna sandstone, Lisan marl	Rock fall	Existing unstable rock fall ($\phi=1-5m$) and exposure with unstable rocks	Cut slope zone. Remove rock falls and clean up slope before cutting.
3	No. 1+780–No. 1+900	Umm Irna sandstone, Lisan marl	Rock fall	Existing unstable rock fall ($\phi=1-5m$) and exposure with unstable rocks	Cut slope zone. Remove rock falls and clean up slope before cutting.
4	No. 3+575–No. 3+675	Dadur sandstone	Rock fall	Existing unstable rock fall ($\phi=1-5m$) and exposure with unstable rocks	Cut slope zone. Remove rock falls and clean up slope before cutting.
5	No. 3+880–No. 3+980	Lisan marl	Settlement, slip	Gentle slope in valley.	Embankment zone. Settlement and/or slip may occur in the embankment.
6	No. 5+930	Kurnub sandstone	Rock mass slide	Abutment	W=10m, H=20m, D=5m rock mass movement limited by joint. Small shift of alignment.
7	No. 3+200–No. 3+470	Dadur sandstone	Dip slope structure	Slope (approximately 35°)	Cut slope zone. Better gentle cut slope gradient.

Table 3 Soil factor at stable analysis

Merial	Weight (γ) tf/m ³	Cohesion (C) tf/m ²	Friction angle (ϕ) ($^{\circ}$)
Talus deposit	1.9	0.5	40
Lisan sand, marl	1.9	1.0	30
Sandstone (Weathered)	1.9	1.0	35
Sandstone	2.0	1.5	40

Table 4 Results of stable analysis

Merial	Cutting slope angle (Minimum stable factor)				
	3:1	1:0.5	1:1.0	1:1.2	1:1.3
Talus deposit (No. 3+600)	-	1.18 ×	1.30 ○	-	-
Lisan sand, marl (No. 2+807)	-	-	-	1.19 ×	1.24 ○
Sandstone (Weathered) (No. 1+972)	1.09 ×	1.04 ×	1.32 ○	-	-
Sandstone	1.12 ×	1.23 ○	-	-	-

○ : $F_s \geq 1.2$

× : $F_s < 1.2$

Table 5 Concluded cut slope gradient

Material	Slope gradient (V:H)	Remarks
Talus deposit	1:1.0	Better gentle slope gradient in loose talus deposit 1.5m in depth from surface
Lisan sand, marl	1:1.3	
Sandstone (Weathered)	1:1.0	At dip slope structure, better should be gentle slope gradient
Sandstone	1:0.5	

NOTE :

Cut slopes may be adjusted according to soil conditions prior to the commencement of the construction.

Table 6 Recommendable borings

No.	Boring No.	Point (Sta. No.)	Geology	Length (m)	Purpose	Remarks
1	B-1	No. 0+492	Umm Ishrin sandstone, talus deposit	20	Confirm cut slope grand condition (condition and thickness of talus deposit, etc.)	Accessible by car (extend road)
2	B-2	No. 0+492	Umm Ishrin sandstone, talus deposit	30	Confirm cut slope grand condition (condition and thickness of talus deposit, etc.)	Accessible by car (extend road)
3	B-3	No. 1+030	Umm Ishrin sandstone, talus deposit	10	Confirm embankment basement (condition and thickness of talus deposit, etc.)	Accessible by car (extend road)
4	B-4	No. 1+030	Umm Ishrin sandstone, talus deposit	10	Confirm embankment basement (condition and thickness of talus deposit, etc.)	Accessible by car (extend road)
5	B-5	No. 1+700	Umm Irna sandstone, talus deposit	10	Confirm cut slope grand condition (condition and thickness of talus deposit, etc.)	Accessible by car (extend road)
6	B-6	No. 1+700	Umm Irna sandstone, talus deposit	25	Confirm cut slope grand condition (condition and thickness of talus deposit, etc.)	Accessible, but difficult to set up machine
			Total	105		

NOTE :

Actually we can not fix length of boring yet before establishing the final design line, i.e final vertical alignment. Hence, the length of boring is better set as : to be about 5m below the final vertical alignment of center line.

**Table 7 Recommendable Seismic
prospecting investigation lines**

The accessible area (No. 1 and 2)

No.	Line No.	Length (m)
1	LINE-1	150
2	LINE-2	90
3	LINE-3	200
4	LINE-4	70
5	LINE-5	150
6	LINE-6	80
	Total	740

The not accessible area (No. 3, 4, 5 and 7)

No.	Line No.	Length (m)
1	LINE-7	250
2	LINE-8	100
3	LINE-9	180
4	LINE-10	70
5	LINE-11	70
6	LINE-12	90
7	LINE-13	50
8	LINE-14	170
9	LINE-15	80
10	LINE-16	300
11	LINE-17	100
12	LINE-18	200
13	LINE-19	90
	Total	1750