3.9 GIS/Database

The purpose is to collect data on which to base the GIS database and slope disaster hazard maps that will be made in the second year. This chapter reports on the following contents:

- Data collection of GIS/Database and information related to the study
- Organizing/preprocessing/compilation of the collected data

The implementation procedure for the above is given below.

- Reviewing existing GIS data, documents and materials, collecting/organizing related information in Japan
- Requesting meetings for investigation and providing related data/information with GIS/DB to the C/P
- Checking the collected data, and organizing, preprocessing for GIS, compilation as a GIS/Database

Table 3.9.1 shows the data collected by the study.

Table 3.9.1 Data collected by the Project

No.	Name	Type	Contents/ Attribute	Scale/ Resolution	Source
1	Populated place	SHP(Point)	Name	1:1,000,000	Digital Chart of the World
2	Major road	SHP (Line)	-	1:1,000,000	Digital Chart of the World
3	Major river	SHP (Line)	-	1:1,000,000	Digital Chart of the World
4	National boundary	SHP (Polygon)	-	1:1,000,000	Digital Chart of the World
5	Administrative boundary	SHP (Polygon)	Level Name	1:1,000,000	Map library
6	Administrative boundary(Region, Zone, Wereda)	SHP (Polygon)	Region name Zone name Wereda name	-	Ministry of Agriculture and Center for Development and Environment (MOA and CDE)
7	Basin	SHP (Polygon)	Basin name Area	-	MOA and CDE
8	River	SHP (Polygon)		-	MOA and CDE
9	Towns	SHP (Point)	Town name Population Rain Elevation	-	MOA and CDE
10	Road	SHP (Line)	Class Length Type	-	MOA and CDE
11	River	SHP (Line)	Name Length Class Type	-	MOA and CDE
12	ASTER-GDEM(Digital Elevation Model)	Satellite (Raster)	Elevation	30m	ASTER-GDEM project website
13	SRTM(Digital Elevation Model)	Satellite (Raster)	Elevation	90m	USGS
14	LANDSAT	Satellite (Raster)		30m	USGS
15	GLS	Satellite (Raster)			USGS
16	Road shapes and benchmarks of Gohatoshion-Dejen	CAD	-	1:2,500	The project for rehabilitation of trunk road phase 3
17	Landslide Area Topography (contour, road	CAD	-	1:2,000	The project for rehabilitation of trunk road phase 3

	shapes, etc)				
18	Contour map	CAD	-	1:500	Ethiopia Road Authority
19	Cross section	CAD	-	1:500	Ethiopia Road Authority
20	Topographical map (250k)	Raster (Hard copy/scanned data)	-	1:250,000	Ethiopia Map Agency
21	Topographical map (50k)	Raster(Hard copy/scanned data)	-	1:50,000	Ethiopia Map Agency
22	Road map	Raster(Hard copy)	-	1:2,000,000	Ethiopia Map Agency
23	Geological map	Raster(Hard copy/scanned data)	-	1:2,000,000	GSE
24	General Geology Reconnaissance map	Raster (Hard copy/scanned data)	-	1:50,000	GSE
25	GEO-EYE	Raster (Satellite)	-	0.5m	Japan Space Imaging co., ltd.
26	Topographical map	CAD/SHP	Transportation Buildings Small objects Water areas Surround Open spaces Vegetation Topographic features Control points Annotation	1:5,000 and 1:10,000	The Project
27	Cross section	CAD		1:200	The Project
28	Drilling & monitoring point	Coordinate values	Drilling point name Monitoring devices	On-site survey	The Project
29	Landslide geomorphological analysis result	SHP (Polygon, line)	Name (ID) Class	On-site survey	The Project
30	Spring water	SHP	Class	On-site survey	The Project
31	Geological map	SHP	Class	On-site survey	The Project
32	Hazard map	SHP	Risk rank by the score Risk rank for roads	On-site survey	The Project
33	Rockfall scarp	SHP	Name (ID)	On-site survey	The Project
34	High risk debris flow streams	SHP	Name (ID) Risk rank by the score Risk rank for roads	On-site survey	The Project
35	Cracks	SHP		On-site survey	The Project
36	Access roads to drilling points	SHP	Name (ID) Length	On-site survey	The Project
37	Streams	SHP	Name (ID) Length	On-site survey	The Project
38	Landslide distribution by elevation	SHP		On-site survey	The Project
39	Landslide distribution by geology	SHP		On-site survey	The Project
40	Catchment area of streams	SHP	Name (ID) Area	On-site survey	The Project
41	Slope	SHP	Class	On-site survey	The Project
42	Rain gauging stations	SHP	Class	On-site survey	The Project
43	Land cover classification result	SHP	Class	1m	The Project

Figure 3.9.1 shows an output example of elevation thematic map using ASTER-GDEM and topographical map (scale 1:5,000 by the Project).

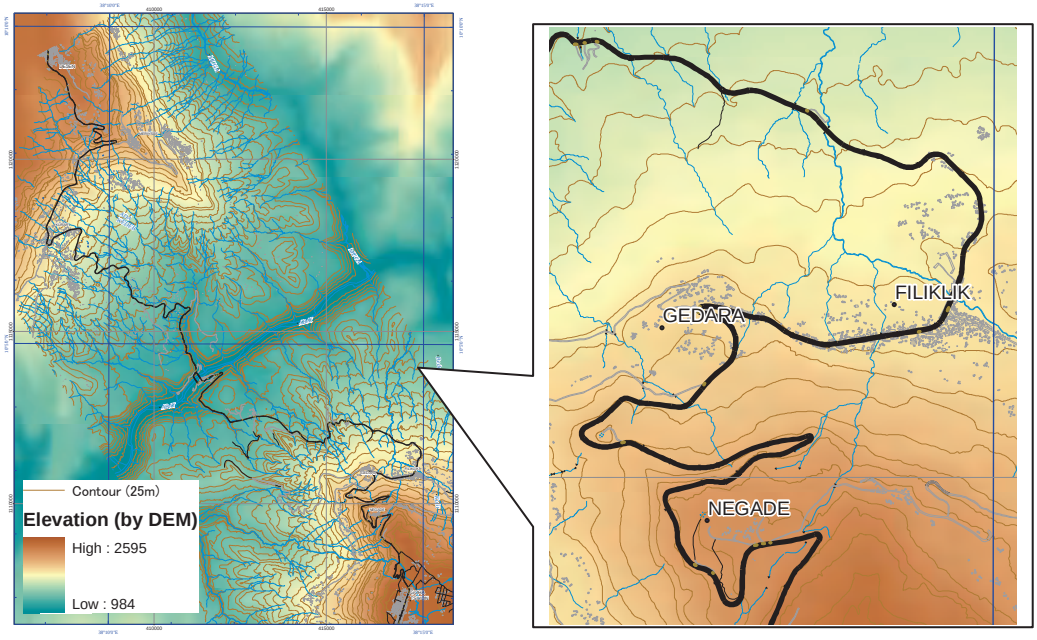


Figure 3.9.1 An output example of elevation data

Figure 3.9.2 is an output example using satellite image of GEO-EYE, administrative boundary, towns, roads, rivers, and so on.

(This figure has only one data which is satellite image; there is nothing of the legend)

Figure 3.9.2 An output example of satellite image GEO-EYE

Figure 3.9.3 is an output example map around L/S 27-28 area, which contains drilling/monitoring points, cracks, landslides, movements, springs and cross section lines.

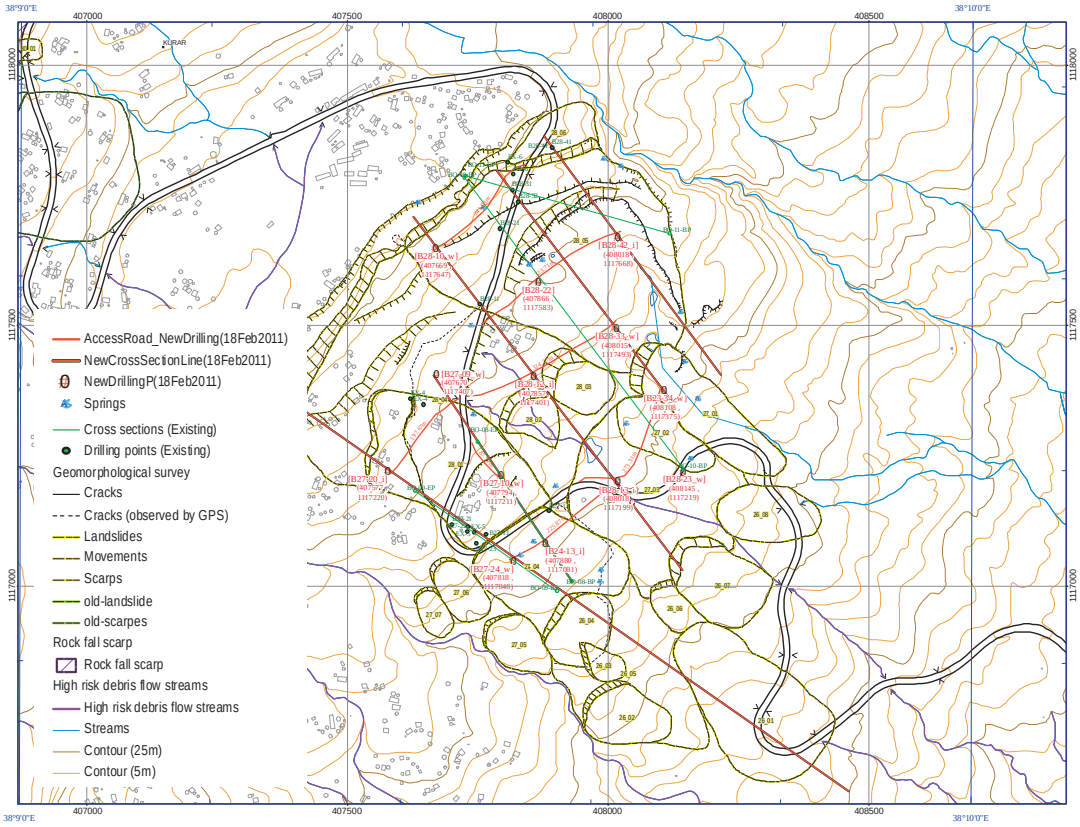


Figure 3.9.3 An output example of collected data by field survey

Figure 3.9.4 is an output example of slope analysis for debris flow risk evaluation, which shows catchment of streams, high risk debris flow streams, slope level (under 15 degree, 15-30 degree, 30-40 degree, over 40 degree).

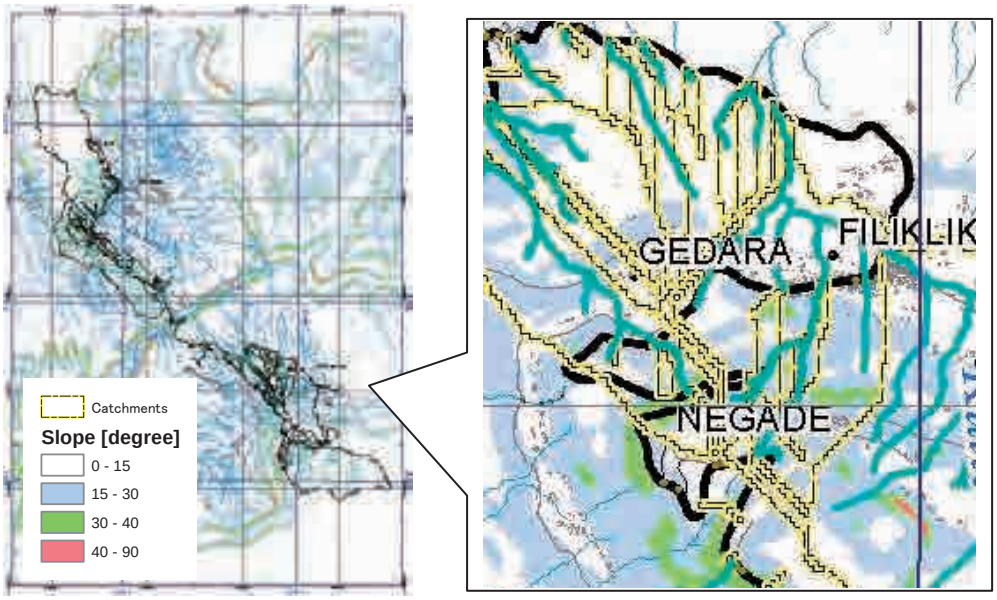


Figure 3.9.4 An output example of slope analysis for debris flow risk evaluation

Figure 3.9.5 is an output example of land cover classification result for debris flow risk evaluation, which shows classified polygon of bush, shrub and grass.

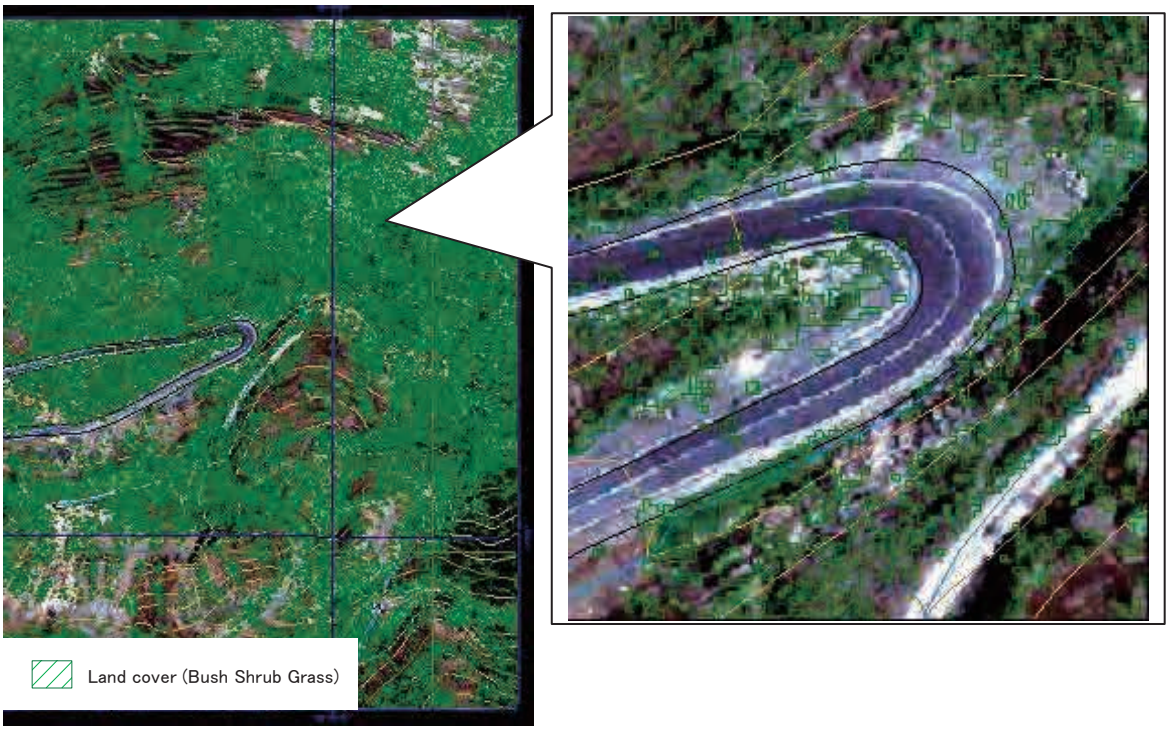


Figure 3.9.5 An output example of land cover classification result

Table 3.9.2 shows the list of the maps which are made to support the survey, study and analysis of this project

Table 3.9.2 Maps made by the Project

No.	Map name	Description
1	Project area location map (scale: 1/100,000,000)	This was made to confirm the location of the project site in whole of Ethiopia.
2	Project area location map (scale: 1/5,000,000)	This was made to confirm the location of the project site in northeast area of Ethiopia.
3	Project area location map (scale: 1/1,000,000)	This was made to confirm the location of the project site in the area of Addis Ababa to the site.
4	Project area location map (scale: 1/250,000)	This was made to confirm the location of the project site in Oromia and Amhara region border area.
5	Project area location map (scale: 1/250,000)	This was made to confirm the location of the project site in Oromia and Amhara region border area, using satellite image.
6	Project area location map (scale: 1/250,000)	This was made to confirm the location of the project site in Oromia and Amhara region border area, expressed in elevation gradation map by digital elevation model data.
7	Project area location map (scale: 1/250,000)	This was made to confirm the location of the project site in Oromia and Amhara region border area, expressed in hill shade map by digital elevation model data.
8	Project area location map (scale: 110,000)	This was made to confirm the location of the project site in Oromia and Amhara region border area, expressed by Topographical map.
9	Preliminary survey map	This map contains the contour lines and road shapes for preliminary survey as a basic information

10	Geomorphological survey result map (8th October 2010 version)	This was made to compile the geomorphological analysis result based on the field survey.
11	Location map of drilling and cross section lines (28th October 2010 version)	This was made to confirm the location of the drilling and cross section lines.
12	Landslide distribution map	This was made to confirm the landslide distribution of whole study area and magnified key areas.
13	Location map of drilling and cross section lines (Progress Report 1 version)	This was made to confirm the location of the drilling and cross section lines.
14	Location map of borehole and extensometer	This was made to confirm the location of the borehole and extensometer.
15	The map of landslide frequency distribution by altitude	This was made to analyze the relationship with landslide distribution and elevation.
16	The map of landslide distribution and geology	This was made to analyze the relationship with landslide distribution and geology.
17	Landslide distribution map whole study area (6th January 2011 version)	This was made to confirm the landslide distribution of whole study area.
18	Landslide distribution map of each part of study area (6th January 2011 version)	This was made to confirm the landslide distribution by each part of study area.
19	The map for catchment analysis of debris flow and rockfall	This was made to generate catchment areas for debris flow and rockfall analysis.
20	Field survey map (7th January 2011 version)	This was made to support the reconnaissance survey on the field.
21	Map for land cover classification	This was made to analyze the land cover classification (Bush/Shrub/Grassland) for debris flow and rockfall analysis. This map made for the preprocessing of the image analysis.
22	The map for the investigation of drilling 2011 location	This was made to assist the field survey for the location of drilling 2011
23	The map for slope analysis for debris flow and rock fall survey	This was made to analyze the slope for classification of hazard and risk of debris flow and rock fall
24	Map for land cover classification	This was made to analyze the land cover classification (Bush/Shrub/Grassland) for debris flow and rockfall analysis
25	Geological map (20th Mar 2011 version)	Geological map
26	Landslide, rockfall and debris flow distribution map (Interim report version)	This was made to confirm the distribution of landslide, rockfall and debris flow in whole study area
27	Landslide, rockfall and debris flow distribution map (Interim report version)	This was made to confirm the distribution of landslide, rockfall and debris flow in each part of the study area.
28	Hazard map ranked by the score whole study area	This map shows the hazard rank of landslide and debris flow by the score whole study area.
29	Hazard map ranked by the score each part of study area	This map shows the hazard rank of landslide and debris flow by the score each part of study area.
30	Hazard map for road ranked by the score whole study area	This map shows the hazard rank of landslide and debris flow by the score whole study area.
31	Hazard map ranked by the score each part of study area	This map shows the hazard rank of landslide and debris flow by the score each part of study area.
32	Elevation map of the whole study area	This map shows elevation with contour and gradation of digital elevation data and
33	Land cover classification map for debris flow and rockfall analysis	This map shows the land cover classification result (bush, shrub and grass) for debris flow and rockfall analysis

34	Slope classification map for debris flow and rockfall analysis	This map shows the slope classification result (under 15, 15-30, 30-40 and over 40 degree) for debris flow and rockfall analysis
35	Spring water points distribution map	This map shows the spring water points distribution
36	Map for cross section position review	This map shows the cross section position to check the drilling points of 2011 fiscal year.
37	Field survey map for new drilling location in 2011	This map made to support field survey for new drilling location investigation in 2011
38	Geological map whole study area	Geological map whole study area which made for printout to A1 size, scale: 1/15,000
39	Risk rank map of landslide and debris flow for roads	Hazard map for road ranked by the score whole study area, which is made for printout to A1 size, scale: 1/15,000.
40	Hazard rank map of landslide and debris flow by the score	Hazard rank map of landslide and debris flow by the score whole study area, which is made for printout to A1 size, scale: 1/15,000.
41	Landslide, rock fall and debris flow distribution map	Landslide, rock fall and debris flow distribution map which is made for printout to A1 size, scale: 1/15,000
42	Drilling location investigation map	This map shows drilling location in 2011
43	Cross section investigation map (3rd October 2011 ver)	This map is made to support the investigation of cross section location.
44	Cross section investigation map (4th October 2011 ver)	This map is made to support the investigation of cross section location.
45	Field survey map for geomorphological analysis (scale: 1/15,000)	This map is made to support field survey for geomorphological analysis, which is scale: 1/15,000.
46	Field survey map for geomorphological analysis (scale: 1/6,000)	This map is made to support field survey for geomorphological analysis, which is scale: 1/6,000.
47	Boreholes location map for groundwater analysis	This map is plotted boreholes which has water level meter to support the groundwater analysis.
48	The map for geomorphological survey result compiling	This map shows the geomorphological survey result (16 October 2011 versino)
49	Boreholes and spring water points location map for groundwater analysis	This map is plotted boreholes which has water level meter and spring water positions to support the groundwater analysis.
50	Field survey map for geomorphological analysis (scale: 1/15,000)	This map is made to support field survey for geomorphological analysis, which is scale: 1/15,000.
51	Field survey map for geomorphological analysis (scale: 1/6,000)	This map is made to support field survey for geomorphological analysis, which is scale: 1/6,000.

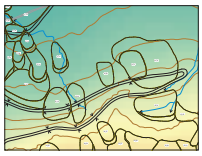
Table 3.9.3 to Table 3.9.8 shows case examples of analysis and mapping from the above map using the collected and compiled data by this project

Table 3.9.3 Mapping example of project area location

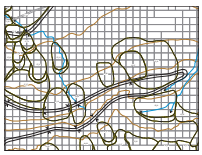
Name	Project area location map
Purpose	To confirm the project site location and the brief condition such as elevation, positional relation of towns and etc.
Data	(a) Project area rectangle shape; polygon (b) Road map by Ethiopian Road Authority; raster
Method (outline)	(1) Make the shape which has the rectangle frame of the project area. (2) Geo-referencing; set the special coordinate information to the hard copy road map. (3) Overlay the above outputs.

Table 3.9.4 Analysis example of the relationship between landslide and elevation

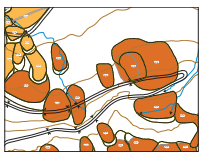
Name	The map of landslide frequency distribution by altitude
Purpose	To analyze the relationship with landslide distribution and elevation.
Data	(a) Digital Elevation Model data (DEM); raster (b) Landslide body; polygon
Method (outline)	(1) Convert DEM data from raster to polygon. (2) Intersect the output (1) by the landslide body polygon (3) Apply the Spatial Join Tool to the above output (2) and landslide body (4) Export the attribute date of output (3)



DEM and Landslide body



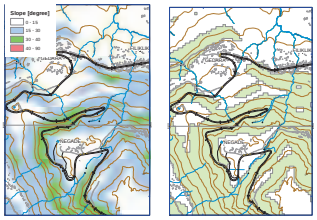
Convert DEM data from raster to polygon



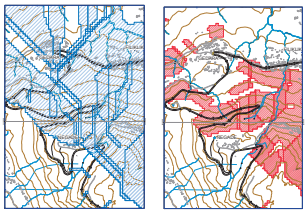
Apply the Spatial Join Tool to the above output (2) and landslide body

Table 3.9.5 Analysis example of the slope for debris flow and rockfall

Name	The map for slope analysis for debris flow and rock fall survey
Purpose	To analyze the slope for classification of hazard and risk of debris flow and rock fall
Data	(a) Digital Elevation Model data (DEM); raster (b) Catchment area; polygon
Method (outline)	(1) Apply the Slope Tool to the DEM data (2) Convert the output (1) to polygon using the Raster to Polygon Tool. (3) Intersect the output (2) by the catchment polygon. (4) Export the attribute date of output (3)



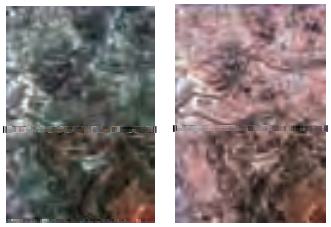
Apply the Slope Tool to the DEM data & Convert the output to polygon



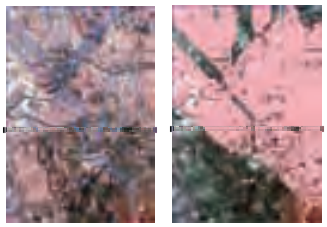
Intersect the output by the catchment polygon & Export the attribute date of output

Table 3.9.6 Analysis example of land cover classification (bush, shrub and grass)

Name	Land cover classification map for debris flow and rockfall analysis
Purpose	To classify the land cover (bush, shrub and grass) for debris flow and rockfall analysis
Data	(a) Satellite image; raster (b) Catchment; polygon
Method (outline)	(1) Make the signature data (2) Apply the Maximum Like-hood Tool to the satellite image using the signature data for land cover classification (3) Convert the output (2) from raster to polygon (4) Intersect the output (3) by the catchment polygon (5) Export the attribute date of output (4)



Satellite image & classification result (The bush, shrub and grassland are colored by pink)

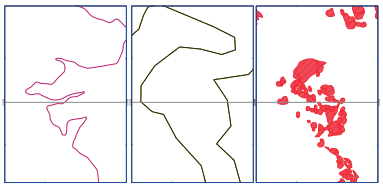


Intersect the classified land cover polygon by the catchment polygon

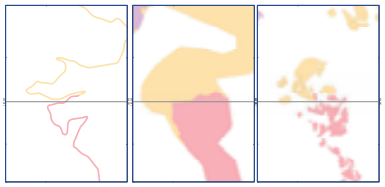
Table 3.9.7 Analysis example of the relationship between landslide and geology

Name	The map of landslide distribution and geology
Purpose	To analyze the relationship with landslide distribution and geology
Data	(a) Geology (polygon) (b) Road center line (line) (c) Subject area (polygon) (d) Landslide body (polygon)
Method (outline)	(1) Intersect the target data (road centerline, subject area and landslide body) by the geology polygon. (2) Export the attribute date of output (1)

Geology (polygon)



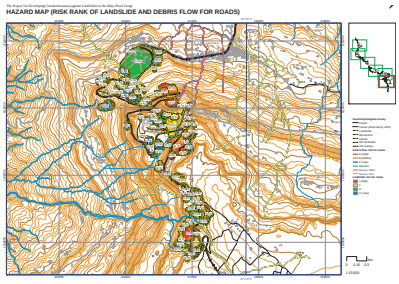
Road center line, subject area and landslide body



Intersected road center line, subject area and landslide body

Table 3.9.8 Mapping example of Hazard map (Risk rank for roads)

Name	Hazard map (Risk rank of landslide and debris flow for roads)
Purpose	To confirm the risk rank of landslide and debris flow for roads
Data	(a) Geomorphological survey result (moving body, scarp and crack); polygon and line (b) Risk rank evaluation result of landslide body: polygon (c) Debris flow risk evaluation result; line (d) Stream; line (e) Topographical map which has road line, contour line, building, river and etc. (f) Map frame for printing; polygon (g) Risk evaluation result table of landslide and debris flow; excel
Method (outline)	(1) Export the attribute data of landslide body and debris flow stream with the feature ID and the landslide ID. (2) Link the output (1) and Risk evaluation result table of landslide and debris flow by the landslide ID using the database software such as the Access (3) Export the table of output (2) with the feature ID (4) Join attributes from the table of output (3) by the feature ID



3.10 Preliminary interpretation for each landslide

In this section, preliminary interpretation was considered based on the results of the above mentioned seismic survey, resistivity survey and monitoring. The interpretation is basic of the further discussion for each landslide blocks. The detailed landslide profile and slip surface will be discussed in next chapter 4 by integrating these preliminary analyses with geological and hydrological interpretation.

3.10.1 Location L/S 00

The result of monitoring and survey indicate the following interpretation for the landslide movement on location L/S00. Figure 3.10.1 summarized the survey results at the site. The circle numbers in the following sentence are area numbers in the figure.

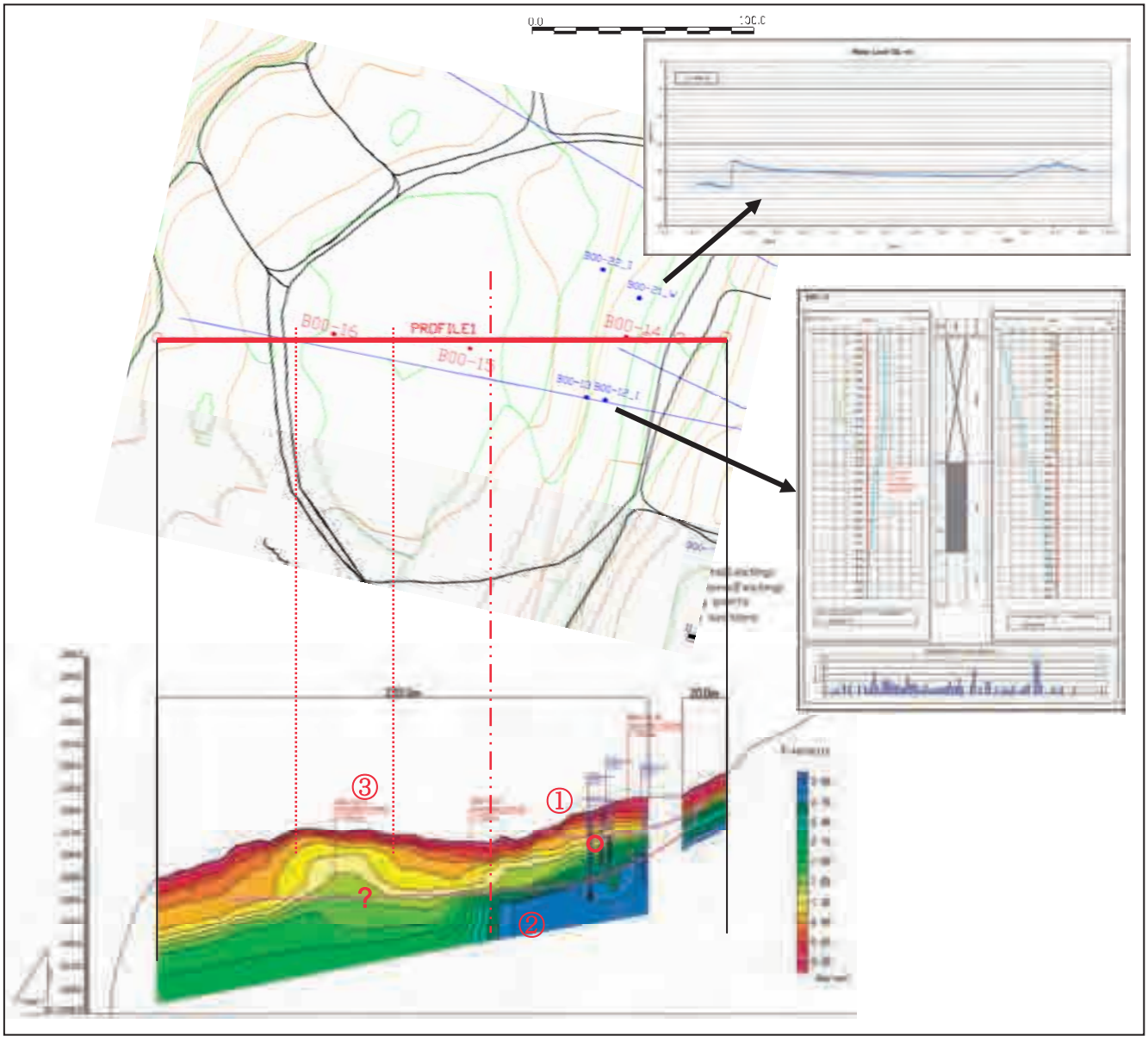


Figure 3.10.1 Integrated figures for preliminary interpretation on L/S00

①: At B00-12 installed casing pipe for borehole inclinometer on the roadside on July 2010, the pipe was broken by the movement of the landslide at 16.2m depth in August 2010. That depth is close to the boundary of embankment (and/or colluvial deposit: these deposits have

no clear boundary) and basaltic lava bedrock. Based on the result of borehole inclinometer monitoring on B00-12, the landslide which have significantly damaged the road is controlled with the deformation of road embankment. However, it is impossible to determine the hydro-geological structure and the landslide mechanism for the entire block at this time because the drilling surveys were conducted only near the road.

②③: The result of the seismic survey indicate two features in the area. One is the discontinuity of seismic velocity around ② area in Figure 3.10.1, which may indicate geological discontinuity. Another is the mount of seismic velocity around ③ area in Figure 3.10.1. The mount means several possibilities; 1) a rising up of toe on the landslide which overlies bedrock, 2) an existence of ground-water-bearing layer, or 3) velocity errors on seismic exploration.

Table 3.10.1 summarized the seismic velocity of colluvial deposit/embankment and the drilling survey in the landslide. However, the results do not cover entire landslide block. Additional drilling surveys and elastic wave explorations are required to understand the interpretation of mechanism for entire landslide.

Table 3.10.1 Comparison of seismic exploration and drilling survey on L/S00

		boundary of seismic velocity (km/sec)			Borehole NO.	existance depth(m)				
						sliding mass				basement layer
		～1	1～3	3～		surface soil	embankment	colluvial dep.		
L/S00	Profile 1	10 – 15m	10 – 30m	25 – 30m	B00-21	–	0.00 – **22.10m**		22.10 –25.50m	25.50 – 30.00m
					B00-12	–	0.00 – 16.60m		16.60 – **31.50m**	31.50 – 35.00m
					B00-22	–	0.00 – 11.30m	11.30 – **21.40m**	–	–
					B00-13	–	0.00 – 5.00m	5.00m – **23.50m**	23.50 – **34.45m**	34.45 – 38.00m
					B00-14	to be continue				
					B00-15	post pone				
					B00-16	post pone				

The boundary of colluvial deposit and sliding mass is considered seismic velocity 2.0km/sec on near road (12-25m depth)

3.10.2 Location L/S 05

The result of monitoring and survey indicate the following interpretation for the landslide movement on location L/S05. Figure 3.10.2 summarized the survey results at the site.

On the upper landslide 05-01, there are two surface extensometers, EX-2 and EX-3. These equipment indicate different trend of movement. EX-2 indicates sharp extension in September, 2010 and then gently compression without relation to the rainfall amount. EX-3 indicates gentle extension trend without relation to the rainfall amount.

According to JICA (2008), the landslide was considered as a colluvial deposit slide and its slip surface is the boundary of the limestone bedrock and the colluvial deposit. In case the interpretation on the report would apply to the area, the movements of two extensometers can indicate landslides shown like cross section at 05-01 in Figure 3.10.2. Namely, Landslide 05-01 is subdivided 3 part (Slide “a”, “b” and “c” from the bottom) and the estimated movement is as follows;

i) Slide “a” and “b” moved on last September when the ground water level was high.
ii) The velocity of slide “b was slowed down by decreasing ground water level on the upper part.
iii) As a result of decreasing counter weight by moving slide “a” and “b” forward, slide “c” starts to move.

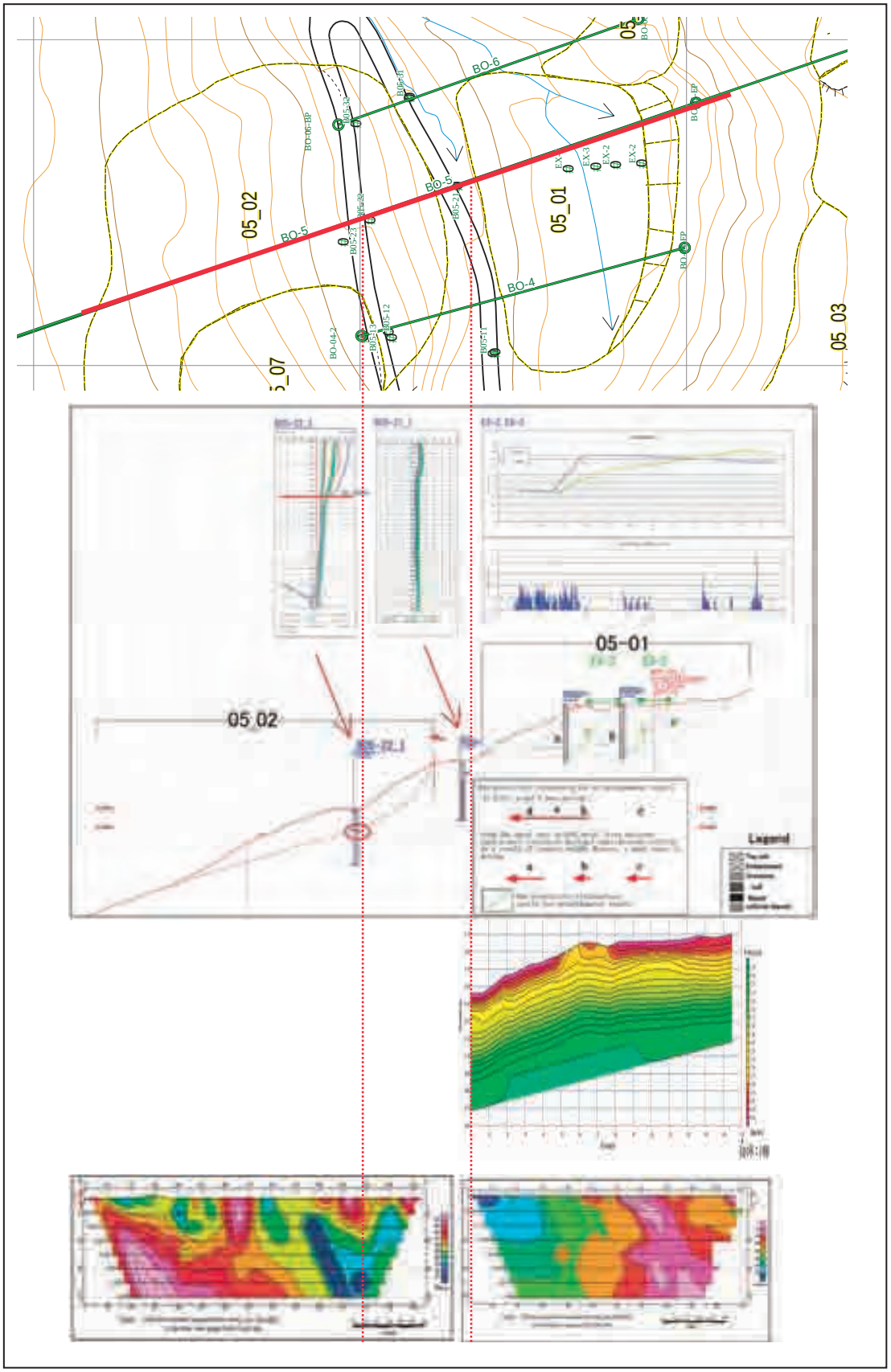


Figure 3.10.2 Integrated figures for preliminary interpretation on L/S05

They are only conjecture for explanation of the extensometer movements, therefore additional drilling surveys and the borehole monitoring in major blocks are required.

On the lower landslide 05-02, one casing pipe for inclinometer and two water level meters were installed. The downward (west part) of the landslide 05-02 is subdivided landslide 05-03. The road have been significantly damaged on the landslide 05-03.

At B05-22 installed casing pipe for borehole inclinometer on the downward roadside, small movement at around 10.6m depth and minute movement at around 28.0m depth were observed. The 10.6m depth is the boundary of limestone and colluvial deposit and had not been active moving point until November 2010. However, sharp movements were seen at the depth with 131.9mm monthly rainfall on March and 155.3mm on May 2011 at Filiklik.

New casing pipe for inclinometer was installed at landslide 05-02, casing pipe for inclinometer and water level meter at landslide 05-03 on July 2011. This additional equipment obtain the behavior of rainy seasons in 2011.

3.10.3 Location L/S 22

The result of monitoring and survey indicate the following interpretation for the landslide movement on location L/S22. Figure 3.10.3 summarized the survey results at the site.

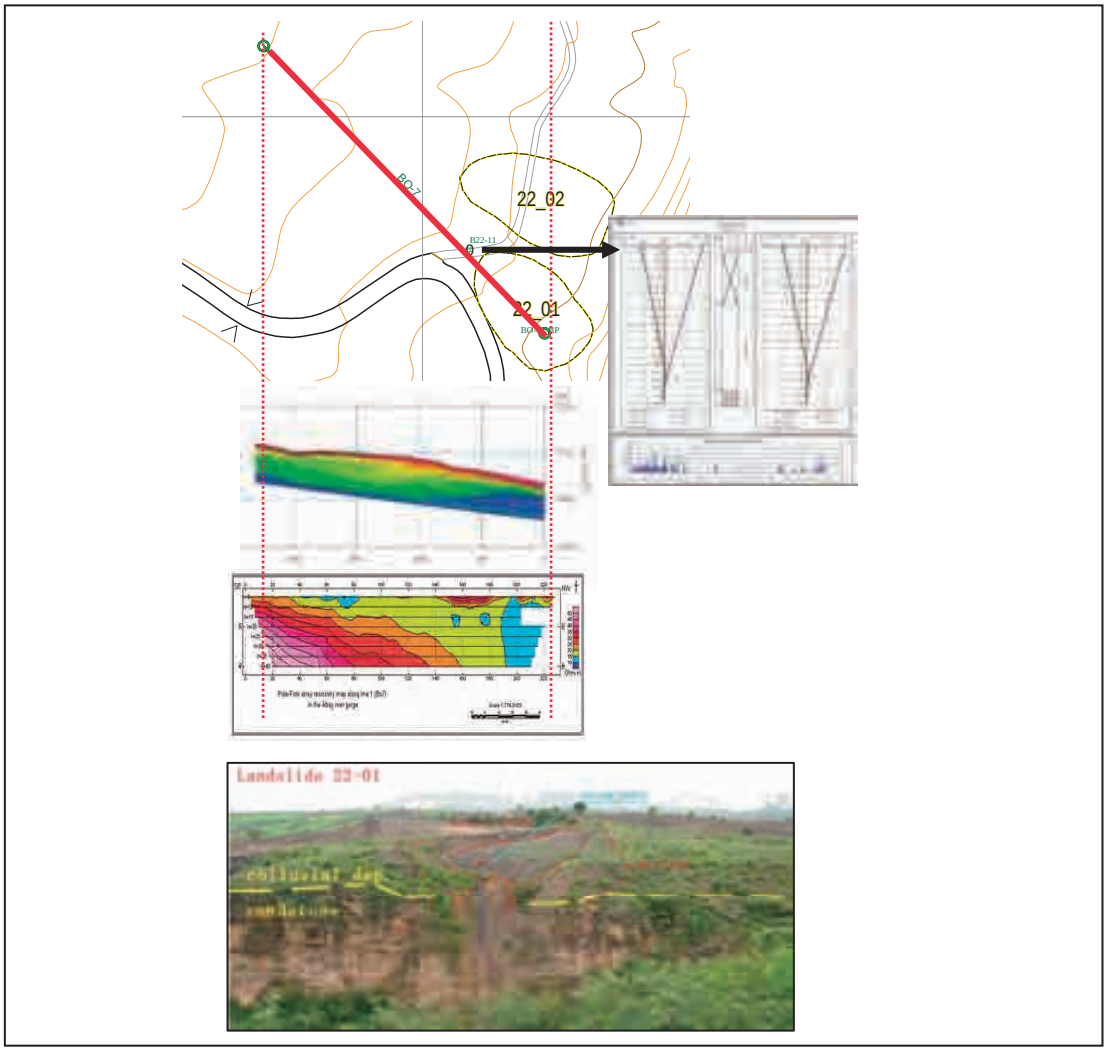


Figure 3.10.3 Integrated figures for preliminary interpretation on L/S22

On landslide 22-01, there is one casing pipe for borehole inclinometer at B22-11 installed on September 2010. At the whole, minute movement at around 5.5m depth is observed, and the bending of pipe occurred at around 18m depth in February 2011.

In the field observation, the area happens to include a large old landslide block. The boundary of sandstone and colluvial deposit is considered as a slip surface. The ground water springs out from the upper part of the slip surface.

The continuous monitoring and the detailed geomorphologic/geological analysis need further discussion.

3.10.4 Location L/S 27

The result of monitoring and survey indicate the following interpretation for the landslide movement on location L/S27. Figure 3.10.4 summarized the survey results at the site.

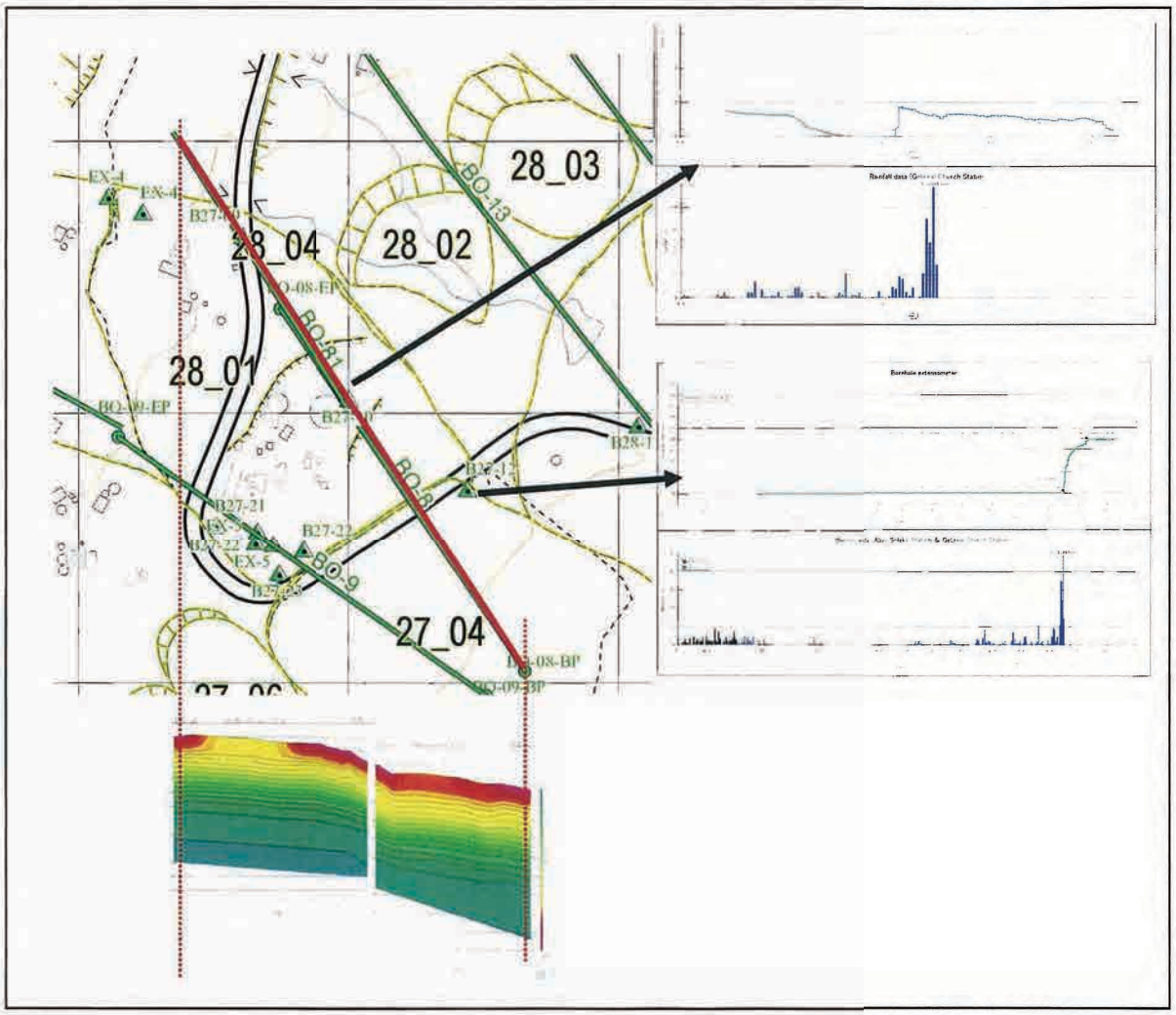


Figure 3.10.4 Integrated figures for preliminary interpretation on L/S27

EX-4 installed the upper slope of the road indicate extension movement during the middle of August to early October 2010 and continues to extend to 61.8mm. EX-5 installed next to a church indicates extension movement from early July until late November 2010 and re-started in January 2011, it reached 201.2mm in the middle of June 2011. It is considered that the landslide intensively activates in the rainy season and is continuously moving even in the dry season.

The movement of landslide was occurred around 7.5m depth at borehole B27-11. A distinct slip surface was confirmed at around 15.0m depth at borehole B27-22. It is considered that there are slip surfaces around these depths accompanying active landslide movement.

However, these are surface movement of the huge landslide, therefore, new traverse lines were planned, and additional drilling and geophysical exploration were planned along the traverse lines for further interpretation of the landslide.

As results of the seismic survey and the drilling survey (Table 3.10.2), it was confirmed accordance between the deposit and the seismic velocity; the depth of colluvial deposit accord with the velocity <1.0km/sec (brown box in the table), and the depth of sliding mass is the velocity 1.0-3.0km/sec (orange box in the table). However, the previous survey does not unveil the information of the deeper slip surface in the area yet. Furthermore the seismic profiles contained several abnormal values. Additional survey and analysis is therefore required to obtain further exact information.

Table 3.10.2 Comparison of seismic exploration and drilling survey on L/S27

		boundary of seismic velocity (km/sec)			Borehole NO.	existance depth(m)				
						sliding mass				basement layer
		～1	1～3	3～		embankment	surface soil	colluvial dep.		
L/S27	Profile 5	10 – 15m	10m – (less than 2km)	–	B27-09	0.00 – 3.90m	–	3.90 – 24.60m	24.60 – 30.00m	30.00 – 50.00m
					B27-10	–	0.00 – 2.20m	2.20 – 13.30m	13.30 – 21.30m	21.30 – 30.00m
					B27-12	–	0.00 – 0.90m	0.90 – 13.40m	13.40 – 25.00m	
	Profile 6	5 – 10m	5– 30m	20 – 35m		–				
	Profile 7	5 – 15m	5m – (less than 2km)	–	B27-20	post pone				
					B27-21	–	0.00 – 0.30m	0.30 – 12.40m	12.40 – 25.00m	–
					B27-22	–	0.00 – 1.70m	1.70 – 15.40m	15.40 – 27.00m	–
					B27-23	–	0.00–9.00m		9.00–25.00m	–
					B27-11	–	0.55 – 8.90m		8.90 – 25.00m	–
					B27-24	post pone				

3.10.5 Location L/S 28

The result of monitoring and survey indicate the following interpretation for the landslide movement on location L/S28. Figure 3.10.5 summarized the survey results at the site.

EX-6 installed on the step of the head of the landslide indicates extension movement from early July to late November 2010. The extension movement during that time was totally 211.8mm. The movement of EX-6 re-started in January 2011, it reached 312.1mm in the middle of June. It is considered that the landslide intensively activates in the rainy season and is continuously moving even in the dry season.

The movement of landslide was occurred around 14.7m depth at borehole B28-11. A distinct slip surface was confirmed at around 13.0m depth at borehole B28-31. At borehole B28-32, the measurement has not been able to be implemented since November 2010 because the bending of pipe occurred at around 24.5m depth. It is considered that there are slip surfaces around these depths accompanying active landslide movement.

However, it shows just a part of the movements on the roadside. L/S 28 block is huge landslide block that contains lots of subdivided small landslides, and each movement are closely related to the movement on neighbor blocks. For considering the countermeasures, e exact information of each landslide relations is needed. Therefore, new traverse lines are planned, and additional drillings and geophysical explorations are planned along the traverse lines.

As results of seismic survey and the drilling survey (Table 3.10.3), it was confirmed accordance between the deposit and the seismic velocity; the depth of colluvial deposit accord with the velocity <1.0km/sec (brown box in the table), and the depth of sliding mass is

the velocity 1.0-3.0km/sec (orange box in the table). However, the previous survey does not unveil the information of the deeper slip surface in the area yet. Furthermore the seismic profiles contained several abnormal values. Additional survey and analysis is therefore required to obtain further exact information.

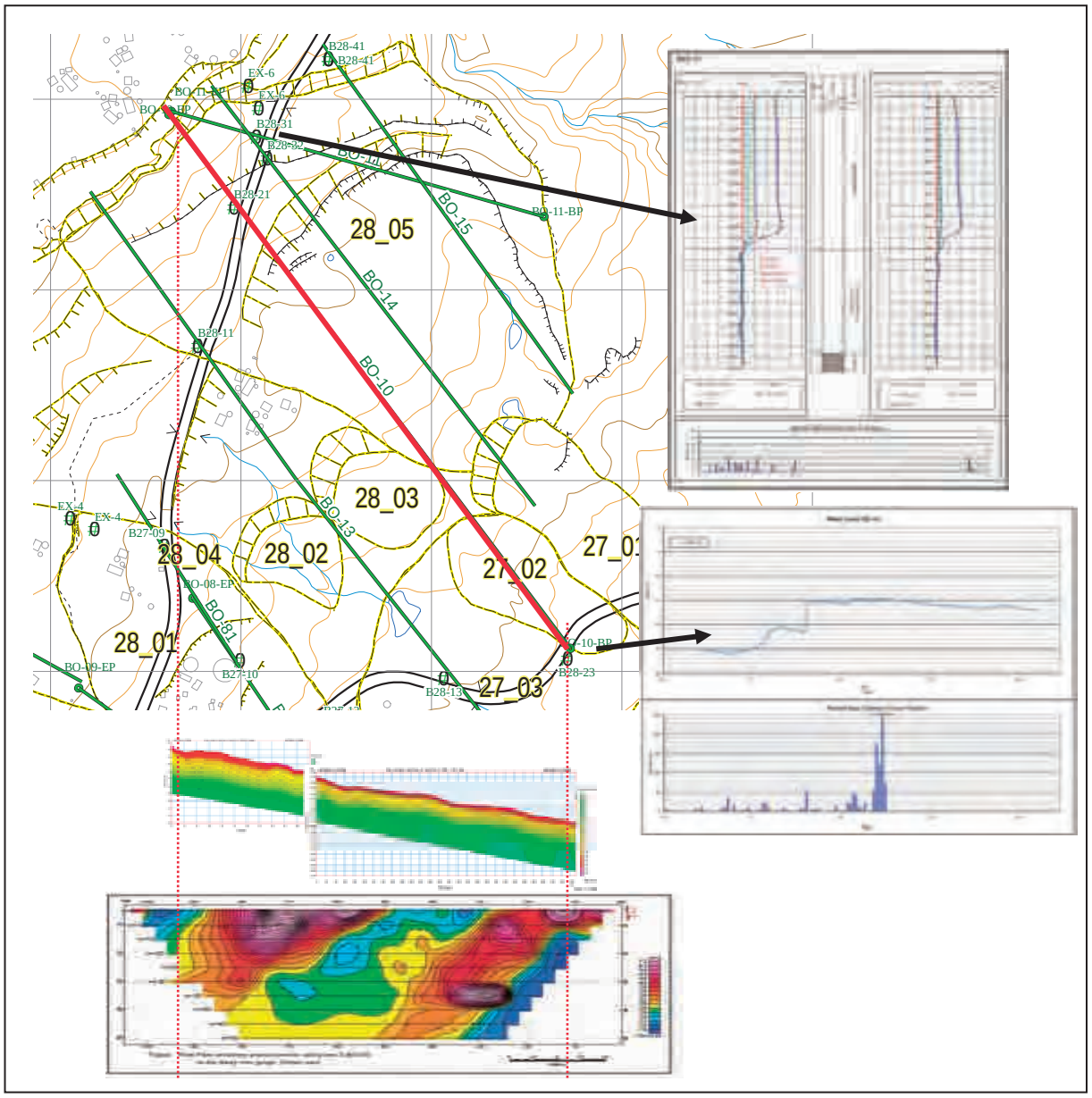


Figure 3.10.5 Integrated figures for preliminary interpretation on L/S28

Table 3.10.3 Comparison of seismic exploration and drilling survey on L/S28

		boundary of seismic velocity (km/sec)			Borehole NO.	existance depth(m)				
						sliding mass				basement layer
		～1	1～3	3～		embankment	surface soil	colluvial dep.		
L/S28	Profile 2	5 – 15m	5 – 45m	30 – 45m	B28-41	0.00 – 5.30m	–	5.30 – 9.80m	9.80 – 34.50m	–
	Profile 3	5 – 20m	5m –	–	B28-31	–	0.00 – 14.00m		14.00 – 25.00m	–
					B28-32	–	0.00 – 0.70m	0.70 – 11.80m	11.80 – 32.05m	32.05 – 40.00
					B28-33	post pone				
					B28-34	post pone				
	Profile 4	5 – 10m	5m –	–	B28-10	post pone				
					B28-11	–	0.00 –0.40m	0.40 –13.95m	13.95 25.00m	–
					B28-12	post pone				
					B28-13	–	0.00 – 23.00m		23.00–26.35m	26.35m–30.00m
					B28-14	post pone				