Chapter 2

Contents of the Project

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The original request from the Ethiopian Government consisted of reconstruction of three bridges, Gogecha, Modjo and Awash Bridges. However, the Governments of Japan and Ethiopia agreed to exclude Gogecha and Modjo Bridges from the request because of the budgetary constraint on the Japanese side and project implementation by the Ethiopian side.

Therefore, the main text of this summary describes only matters concerning Awash Bridge and matters concerning Gogecha and Modjo Bridges are described in the attachment.

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Goal

2-1-1-1 Ethiopian Road Development Plan

The Ethiopian government, in order to improve the road development status of the country, established RSDP (1997-2007) (Road Sector Development Program) and started to implement RSDPI, the Phase 1 of this program, in July 1997 with the completion targeted for June 2002. RSDP is a comprehensive road development plan including policies and improvement of implementing organizations and is used by all the other donors and aid organizations to examine the methods for assistance because it is the only overall goal for all the road development plans in Ethiopia. Therefore, the road development plans in Ethiopia are to be implemented in accordance with RSDP. The target roads under the jurisdiction of the federal government in this Program are Trunk Roads and Link Roads/Main Access Roads, and the plan implementing organization is the Ethiopian Roads Authority (ERA).

Note that bridges are covered in the Bridge Rehabilitation Program (BRP), a sub-program of RSDP. The bridges included in the request in this project are also the target bridges in BRP.

2-1-1-2 Overall Goal and Project Goal

The overall goal of this project and the project goal are as follows:

・ Overall goal

A1 Trunk Road, the most important trunk road in Ethiopia and an international trunk road, shall be improved to promote economic development of the country.

・ Project goal

Ethiopia is an inland country surrounded by Djibouti, Eritrea, Sudan, Kenya, and Somalia, with 95% of its traffic and transportation available via roads. Therefore, international trunk roads are the most important means of transportation for physical distribution and human exchange with the surrounding countries. Among them, A1 Trunk Road ranks as the most important route with a total distance of 853 km, connecting the capital Addis Ababa and the Port of Djibouti in the neighbor country to handle 90% of import and export of Ethiopia.

Awash Bridge, an indispensable bridge for going further north than this bridge, was built 40 years ago and is frequented by a heavy traffic of large vehicles, causing a problem in the load bearing ability.

This has resulted in a traffic restriction that allows only one vehicle/one way, and prompt construction of a new bridge is requested.
The goal of this project is to build a new bridge and an access road in parallel to the existing Awash Bridge in order to eliminate the traffic bottlenecks and also invigorate international physical distribution, improve traffic access for local residents, promote economic growth and poverty reduction in the surrounding areas.

2-1-2 Project Overview

To attain the goals described above, this grant-aid project shall build a new bridge and an access road in parallel to the existing Awash Bridge over the Awash River. The direct outputs from the implementation of this project are elimination of traffic bottleneck on Awash Bridge due to abolishment of a traffic restriction that allows only one vehicle/one way and securing of safety due to pedestrian-vehicle separation by using this existing bridge as a footbridge, consequently promoting international physical distribution, invigorating local economy, improving the standard of living, and reducing poverty, etc.

2-2 Outline Design of the Requested Japanese Assistance

2-2-1 Design Policies

Regarding the bridge located on A1 Trunk Road, Awash Bridge has become a traffic bottleneck due to traffic restriction of one vehicle/one way due to an insufficient load bearing capacity. To solve these problems, this project constructs a new Awash bridge and access roads in order to promote traffic and exchange between Ethiopia and neighboring countries, implement functions of an international trunk road, and contribute to the development of local economy. The project shall be planned based on the Ethiopian government's request, field reconnaissance, and consultation results in accordance with the policies described hereafter.

2-2-1-1 Basic Policies

The design policies for the outline design shall be as follows:

(1) Scope of cooperation

A formal request for grant aid cooperation regarding this project was submitted by Ethiopia to the Japanese Embassy in 2008.
Although this preparatory survey was implemented to reconfirm the content of the request and confirm mainly the bridge positions, access roads, bridge and access road longitudinal profile plan, width configuration, Bridge types, environment-related procedures, natural conditions, demining, etc. As a result of consultation with Ethiopia, the principal content of the request for grant aid cooperation of Japan was finally confirmed to be as follows:

- Construction of Awash Bridge (two lanes without sidewalks) (parallel construction)
- Construction of access road (Awash Bridge)

(2) Bridge construction positions and access roads

The existing Awash Bridge shall not be removed because there is no detour to this bridge and therefore the existing bridge is to be used as an emergency detour. Therefore, a new Awash Bridge shall be constructed in parallel to the existing one. As the bridge position of the new Awash Bridge, the following three alternatives shall be compared to select the most appropriate one.

- Alternative 1 (100 m downstream shift): Shift by about 100 meters to the downstream side (north side) of the current bridge.
- Alternative 2 (80 m downstream shift): Shift by about 80 meters to the downstream side (north side) of the current bridge.
- Alternative 2 (40 m downstream shift): Shift by about 40 meters to the downstream side (north side) of the current bridge.

(3) Scale, etc.

1) Awash Bridge longitudinal profile plan

At present, the access roads before and after Awash Bridge have a longitudinal gradient of 7% at the maximum. As a longitudinal profile plan to alleviate this steep incline, the following three alternatives shall be compared to select the most appropriate one.

- Alternative 1: The longitudinal gradient of the access road on the Addis Ababa side and the bridge section shall be changed to 3.28%.
- Alternative 2: The longitudinal gradient of the access road on the Addis Ababa side and the bridge section shall be changed to 2.60%.
- Alternative 3: The longitudinal gradient of the access road on the Addis Ababa side and the bridge section shall be changed to 0.5%.

2) Span length

The span length can be obtained using the following formula:

Span length L＝20+0.005Q＝20+0.005×1200m3/sec

where Q is a design flood discharge.

3) Scope of cooperation for access roads

For Awash Bridge to be constructed in parallel to the existing bridge, a new access road is needed for the section connecting the new bridge to the current road.

These access roads shall be constructed by grant aid cooperation of Japan.

(4) Request content and consultation/check items

The outline design shall be promoted under the conditions mutually checked by the two countries and the survey team. Table 2-2-1 shows the request content and consultation and check items in the preparatory survey.

Table 2-2-1 Request content and consultation/check items

Item		Request content	Consultation/check items
Target bridge		Construction of new Awash Bridge	Construction of a new Awash Bridge
Construction position		Construction in parallel to the existing bridge	The following three alternatives shall be compared to select the most appropriate one. ・Alternative 1: 100 m downstream shift ・Alternative 1: 80 m downstream shift ・Alternative 1: 40 m downstream shift
Bridge type and length		PC 3-span continuous Gerber-girder bridge (L=21.0+67.0+21.0 =109.0m) (Existing bridge)	The following three alternatives shall be compared to select the most appropriate one. ・Alternative 1: PC 3-span continuous box-girder bridge ・Alternative 2: Concrete arch bridge ・Alternative 3: Concrete angle-brace rigid-frame bridge
Width	Effective width	7.32m (Existing bridge)	9.3m
	Carriageway	3.66m×2=7.32m (Existing bridge)	3.65m×2=7.3m
	Shoulder	None (Existing bridge)	1.0m×2=2.0m
	Sidewalk	None (Existing bridge)	None
Number of lanes		2 lanes (Existing bridge)	2 lanes
Design speed		Not specified	85km/h
Design live load		As above	Load increased by 25% from HS20 in AASHTO Standard
Access road		As above	Section connecting the new bridge to the current road (Both at the start and end points)
Bank protection work			None

2-2-1-2 Policies on Natural Environmental Conditions

(1) Meteorology

1) Temperature, wind speed, and humidity

In the vicinity of Awash Bridge, the maximum temperature is the highest at 37℃ in June, and the minimum temperature in November is about 18℃ on the average of 11 years. The average temperature throughout the year is 25℃. The wind speed throughout the year is 2.0 m/s to 3.0 m/s, showing no great difference between the rainy and dry seasons. The year-round average wind speed is 2.5 m/s. In the vicinity of Awash Bridge, the humidity is the highest at 64% in August in the rainy season, and is the lowest at 47% in November in the dry season. The year-round average humidity is about 54%.

In this area, the humidity is not particularly high, but it becomes fairly hot and humid at the construction point in the rainy season. Therefore, utmost attention must be paid to temperature changes of structural members during designing and to casting and curing of concrete during construction. It must be remembered that a steel bridge has a problem of corrosion in a hot and humid area and that this has the largest impact on future maintenance and management.

2) Precipitations and rainfall patterns

The annual precipitation at this point is 510 mm on the average of five years, and ranges from around 443 mm at the lowest to around 578 mm at the highest, showing a small difference between years. The precipitation in August is the highest throughout the year and falls to nearly zero in November to February. For Awash Bridge, there is no restriction resulting from the rainy season because there is no construction work in the river.

(2) Scouring and substructure installation depth

The height of the bridge pier foundation shall be determined in consideration of scouring by the bridge piers. The Japanese standards specify securing of a scouring depth of 2.0 m or more from the design riverbed or the deepest riverbed, whichever is lower. In this project, however, the bridge pier footing shall have a setting depth of 2.0 m or more from the deepest riverbed or set in the bedrock. As for the bridge abutment in the case of spread foundation, the footing base shall be set to a sufficient depth in a good bearing layer such as the bedrock, mudstone, and gravel. As required, embedment work shall be installed.

(3) Seismic design

In the central part of Ethiopia, the African Great Rift Valley runs from the northeast to the southwest and is a high volcanic activity area. In Ethiopia, volcanic activities started about 40 million years ago, leaving fresh volcanic features in the Valley, and still continue up to the present. This area is characterized by diverse rocks, eruption patterns, and eruption-level activities in different geological ages, tensile stress fields, and frequent occurrence of seismic activities. The Rift Valley is a normal fault with a width of 35 to 100 km and a total extension of 7,000 km, dotted everywhere with earth fissures and bluffs with a drop of more than 100 m.

The bridge design standards of Ethiopia specify the seismic horizontal coefficient to be adopted in a seismic design for each of the areas and structural characteristics. Since the target bridges in this project are located on the Rift Valley, the design horizontal seismic coefficient shall be calculated and a seismic design shall be made in consideration of structural characteristics.

2-2-1-3 Policies on Traffic Volumes

(1) Basic policies on traffic demand forecasting

In 2005, Africon implemented F/S on the Addis-Adama Expressway and conducted a traffic demand forecasting in it. Then, in 2007, Scott Willson of the U.K. reviewed this F/S, re-examined detailed conditions, and conducted the latest traffic demand forecasting as of the present time. According to the hearing survey on ERA, no toll system has been finalized yet. The future traffic volume of A1 Trunk Road, the target road in this project that runs in parallel to the Expressway, will largely depend on the road improvement cases and toll settings of the latter.

In this report, future traffic volumes in the vicinity of the target bridges shall be set based on the latest version of data available at the time of field reconnaissance. However, it is advisable to update

the design traffic volumes in accordance with the latest information available in the detailed design phase.

Demand forecasting period

2010 to 2030

Toll charging scheme

- Scheme 1: Tolls charged from the start of service
- Scheme 2: Toll-free initially and tolls charged later in consideration of influences

Road improvement cases under examination

- Scenario 1: Only the first stage with an extremely high traffic volume at present, from Addis Ababa to the southern side of Debre Zeyit, shall be improved.
- Scenario 2: All the route from Addis Ababa to Adama (all of the first to third stages) shall be open to traffic at once.

Toll setting

- Free: No toll is collected.
- Option 1 Low toll setting: The toll is about half the normal setting.
- Option 2 Normal setting: The toll to be collected is set in accordance with willingness-to-pay analysis.

The future traffic volume setting for the target section shall be set appropriately in view of future trends of the expressway plan while paying considerations to securing of redundancy.

(2) Overview of traffic volumes

- Overview of traffic volumes of pedestrians and bicycles

  There is little pedestrian traffic demand at present for Awash Bridge.

- Cross-section (both-way) traffic volume

  The daily traffic volume of Awash Bridge is 2,000 vehicles on a weekday and 2,200 vehicles on a holiday.

- Large vehicle mixing ratio

  The large vehicle mixing ratio is outstandingly high for Awash Bridge, as high as 60% in the daytime of a holiday. The mixing ratio is higher on a holiday than on a weekday.

- Ratio of daily traffic to daytime traffic

  Awash Bridge's ratio that is a little higher than the other two indicates that it has a high volume of long-distance transportation traffic, when considered in combination with the aforementioned high large vehicle mixing ratio.

(3) Future traffic volume estimate

For Awash Bridge that does not run directly in parallel with the Addis-Adama Expressway, the design traffic volume shall be calculated from the existing road traffic volume using the annual growth rates. As these growth rates, it has been decided to use the Modjo - Nazret growth rates shown in Addis-Adama Expressway F/S Report.

There is no major city between Nazret and Awash Bridge, and there is no equivalent road that can be used as a detour. Therefore, there must be no big difference between the Modjo-Nazret growth rate and the future traffic growth near Awash Bridge. The following tables show the growth rates of future traffic volumes and the results of traffic volume estimation.

Table 2-2-2 Growth rates of traffic volumes

	cars	buses	trucks
2007-2010	3.5	3.9	4.6
2011-2013	4.6	5.2	6.1
2014-2020	5.8	6.5	7.6
2021-2030	3.5	3.9	4.6

Table 2-2-3 Future traffic volume estimates

Annual	Year	traffic growth rates			Number of traffic (AADT1)								Total
		cars %	buses %	trucks %	Car	S.Wagon & Pickup	S/Bus [<27 seat]	L/Bus [>27 seat]	S/Truck [< 30 Qt]	M/Truck [30-70 Qt]	H/Truck [>70 Qt]	T & T	
Present	2010	3.5	3.9	4.6	53	288	320	31	242	84	70	1,132	2,220
1	2011	4.6	5.2	6.1	55	298	332	32	253	88	73	1,184	2,316
2	2012	4.6	5.2	6.1	57	312	350	34	269	93	78	1,256	2,449
3	2013	4.6	5.2	6.1	60	326	368	36	285	99	82	1,333	2,589
4	2014	5.8	6.5	7.6	63	341	387	37	302	105	87	1,414	2,737
5	2015	5.8	6.5	7.6	66	361	412	40	325	113	94	1,522	2,934
6	2016	5.8	6.5	7.6	70	382	439	43	350	122	101	1,637	3,144
7	2017	5.8	6.5	7.6	74	404	468	45	377	131	109	1,762	3,369
8	2018	5.8	6.5	7.6	79	427	498	48	405	141	117	1,896	3,611
9	2019	5.8	6.5	7.6	83	452	530	51	436	151	126	2,040	3,871
10	2020	5.8	6.5	7.6	88	478	565	55	469	163	136	2,195	4,149
11	2021	3.5	3.9	4.6	93	506	602	58	505	175	146	2,362	4,447
12	2022	3.5	3.9	4.6	96	524	625	61	528	183	153	2,470	4,640
13	2023	3.5	3.9	4.6	100	542	649	63	552	192	160	2,584	4,842
14	2024	3.5	3.9	4.6	103	561	675	65	578	201	167	2,703	5,053
15	2025	3.5	3.9	4.6	107	581	701	68	604	210	175	2,827	5,273
16	2026	3.5	3.9	4.6	111	601	728	71	632	219	183	2,957	5,502
17	2027	3.5	3.9	4.6	115	622	757	73	661	230	191	3,093	5,742
18	2028	3.5	3.9	4.6	119	644	786	76	692	240	200	3,235	5,992
19	2029	3.5	3.9	4.6	123	667	817	79	723	251	209	3,384	6,253
20	2030	3.5	3.9	4.6	127	690	849	82	757	263	219	3,540	6,526

(4) Road standard

From the above design traffic volumes, the standard of roads near the target bridges under survey shall be set as shown below.

The road standard shall be set in accordance with the Ethiopian manual, "Geometric Design Manual 2002 (ERA)."

Table 2-1: Design Standards vs. Road Classification and AADT

Road Functional Classification	Design Standard	Design Traffic Flow (AADT)*	Surface Type	Width (m)		Design Speed (km/hr)				Urban/Peri-Urban
				Carriageway	Shoulder	Flat	Rolling	Mountainous	Escarpment	
TRUNK	DS1	10000–**15000	Paved	***Dual 2 x 7.3	See T.2-2	120	100	85	70	50
LINK	DS2	5000–10000	Paved	7.3	See T.2-2	120	100	85	70	50
MAIN ACCESS	DS3	1000–5000	Paved	7.0	See T.2-2	100	85	70	60	50
COLECTORS	DS4	200–1000	Paved	6.7	See T.2-2	85	70	60	50	50
	DS5	100– 200	Unpaved	7.0	See T.2 -2	70	60	50	40	50
FEEDER	DS6	50–100	Unpaved	6.0	See T.2-2	60	50	40	30	50
	DS7	30–75	Unpaved	4.0	See T.2-2	60	50	40	30	50
	DS8	25–50	Unpaved	4.0	See T.2-2	60	50	40	30	50
	DS9	0–25	Unpaved	4.0	See T.2-2	60	40	30	20	40
	DS10	0–15	Unpaved	3.3	See T.2-2	60	40	30	20	40

From the above, the roads before and after the bridge including the bridge shall be designed in accordance with the road standard shown below.

Table 2-2-4 Road standard

Sites	Road standard	Topographical type	Design speed
Awash Bridge	DS2	Mountainous	85km/h

2-2-1-4 Policies on Bridge and Road Widths

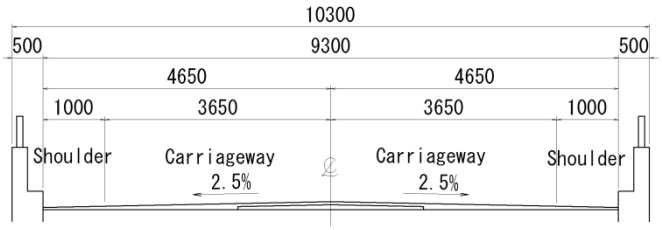
The bridge and access bridge widths shall also be set in accordance with the standard widths by road standards stipulated in "Geometric Design Manual 2002 (ERA)" shown below.

Table 2-2-5 Shoulder widths by road standards

Design Standard	Rural Terrain/Shoulder Width (m)				Town Section Widths (m)			
	Flat	Rolling	Mountainous	Escarpment	Shoulder	Parking Lane***	Foot way	Median[!]
DS1	3.0	3.0	0.5 – 2.5	0.5 – 2.5	n/a	3.5	2.5 (min)	5.0 (min)
DS2	3.0	3.0	0.5 – 2.5	0.5 – 2.5	n/a	3.5	2.5	Barrier[!]
DS3	1.5 - 3.0++	1.5 - 3.0++	0.5 – 1.5	0.5 – 1.5	n/a	3.5	2.5	n/a
DS4	1.5	1.5	0.5	0.5	n/a	3.5	2.5	n/a
DS5*	0.0	0.0	0.0	0.0	n/a	3.5+++	2.5	n/a
DS6**	0.0	0.0	0.0	0.0	n/a	3.5+++	2.5	n/a
DS7	1.0 (earth)	1.0 (earth)	1.0 (earth)	1.0 (earth)	n/a	n/a +	n/a +	n/a
DS8**	0.0	0.0	0.0	0.0	n/a	n/a +	n/a +	n/a
DS9**	0.0	0.0	0.0	0.0	n/a	n/a +	n/a +	n/a
DS10**	0.0	0.0	0.0	0.0	n/a	n/a +	n/a +	n/a

- Carriageway: The section falls into either DS2 standard, the carriageway width shall be 7.3/2 = 3.65 m.
- Shoulder: For Awash Bridge, the topographical type is "Mountainous" with a specified width of 0.5 to 2.5 m, and the shoulder width of 2.5 m shall be secured because relatively large cutting will be made in the access roads and the consistency with the road sections before and after the bridge need to be maintained.
- Sidewalk: No sidewalk shall be basically constructed on Awash Bridge because there is little pedestrian traffic demand and the existing bridge shall be retained.

Awash Bridge



Access roads

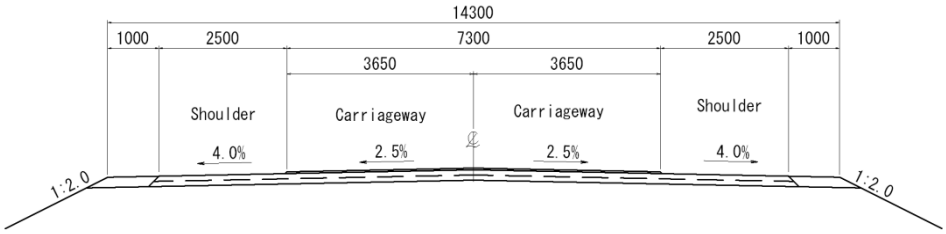


Figure 2-2-1 Widths of bridge and access roads

2-2-1-5 Policies on Design Live Loads

In Ethiopia, Bridge Design Manual:2002, a bridge design standard based on the American Association of State Highway and Transportation Officials (AASHTO) standard, has been established. This Ethiopian standard specifies that HS20 (total weight of 32.6 tons) shall be applied as the design live load of a bridge on a principal trunk road. Actually, however, heavy vehicles exceeding the design live load HS20 are running on the principal trunk roads of Ethiopia. Therefore, a load increased by 25% from this design live load HS20 (total weight of 40.8 tons) shall be applied to the design of bridges in this project.

The following figure shows the load of HS20.

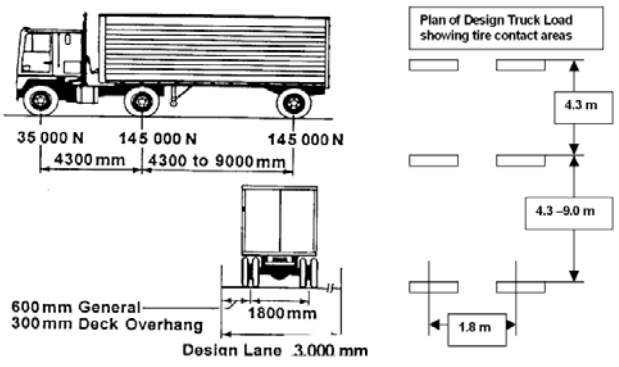


Figure 3-4 Characteristics of the Design Truck

Figure 2-2-2 Live load (HS20)

2-2-1-6 Policies on Socio-economic Conditions

The consideration items and countermeasures needed in planning, design, and construction of the target bridges in the cooperation project are as follows:

① Emission of dust during construction: Countermeasures against dust such as water spray shall be taken.
② Emission of noise and vibration during construction: A construction method with as little noise and vibration as possible shall be adopted.
③ Discharge of contaminants (such as spillage of oil, etc.): Measures against discharge of contaminants shall be taken.
④ Soil runoff and river pollution: Measures against soil runoff and river water pollution shall be taken.
⑤ Obstruction to general traffic: Safety education shall be provided to construction vehicle drivers.
⑥ Measures required for borrow pits and stone pits: As a borrow pit, a place with little environmental load shall be selected. As a stone pit, an existing stone pit shall be used whenever possible to avoid collecting aggregate from a new place.
⑦ Occurrence of accidents: Safety and health education to construction personnel shall be ensured to prevent occurrence of accidents.

It has been confirmed that no resettlement of residents is needed in the scope of this project.

2-2-1-7 Policies on Construction Circumstances

(1) Labor status

In Ethiopia, there are construction companies, technicians, and workers with experience in bridge construction in grant aid cooperation, but they are few in number and have few track records. In paticular, there are very few persons with construction technologies and experiences in prestressed concrete (PC) bridge construction. Therefore, the basic policy shall be as follows: The work types that require advanced technology and the work types for which there are few track records shall be assigned to engineers dispatched from Japan, and for other work types, the local technical capabilities and labor forces shall be utilized wherever possible.
As in the past grant aid projects, workers can be procured in Ethiopia. However, most of the skilled workers belong to construction companies, each of which has its own specialty field. Therefore, it is important to check out and select appropriate ones.

(2) Material procurement status

1) Reinforcing bars, steel products, pre-stressed concrete steel

Although reinforcing bars are manufactured in Ethiopia, they have problems in quality. In consideration of the importance of the structures to build, reinforcing bars shall be procured from Japan or a third country such as South Africa and Egypt. During design or procurement, due

attention must be paid to the diameters and lug geometries of reinforcing bars because there are difference in them between Ethiopia and Japan.
Steel products such as steel plates and shapes shall be procured from Japan or a third country such as South Africa and Egypt because none of them is manufactured in Ethiopia. PC steel materials can hardly be procured on the general market, and there is no facility with a reliable technology to process such products in Ethiopia. Therefore, import from Japan shall be considered for PC steel materials to be used in this project by ordering them to specified import sources and manufacturers, i.e., taking a measure enabling quality check.

2) Bridge accessories

As in the past grant aid projects, it is advisable to procure bridge accessories from Japan because, although some of them can be procured from neighboring countries, they have a problem in quality, etc.

3) Cement

Cement shall be purchased from Ethiopian manufacturers because it is prohibited to import cement into Ethiopia. At present, Mugher and Messebo are two oligopolistic companies with a total share of about 90% of the domestic market, and there is no choice but to purchase cement from them. In the hearing survey, it was learned that the products of these two companies do not have a difference in quality.
Although a full-fledged cement plant with Chinese capital funds is near completion, it has not reached a production or sales stage yet.

4) Asphalt concrete

No specialized manufacturer that owns an asphalt plant is found in the vicinity of the project sites. In Ethiopia, a paving contractor, under a contract with a building contractor, relocates a simple asphalt plant to near the site and produces asphalt while construction is in progress.

5) Aggregate

In the suburbs of Addis Ababa, stationary plants owned by several aggregate producers are in operation. For Awash Bridge, there is a stone pit in Awash Arba (about 10 km to the north of Awash Bridge), and an aggregate plant shall be constructed to produce aggregate.

6) Banking material

Appropriation of materials excavated on each of the sites as banking materials shall be considered first.

(3) Construction machinery procurement status

Although general construction machinery to be used for road repair, etc. are owned by ERA local offices and construction companies, procurement from Japan shall be considered for large cranes and

cantilever erection machines, construction machines such as mixer trucks and concrete pump trucks for concrete casting, asphalt plants, concrete plants, and crusher plants for aggregate production.
Rental construction machinery can be rented from several companies in Addis Ababa, but no such company was found in the nearest city, Nazret, or near the sites. Regarding each of the rentable models, not so many machines are owned, and many users come to rent them at the start of the dry season. Nevertheless, procurement through renting shall be considered for such highly versatile machines as bulldozers, backhoes, and dump trucks.
There are asphalt cement plants and concrete plants owned by a major construction company in Addis Ababa, which also sells asphalt mixtures and ready-mixed concrete. However, the plants are not rented or leased.
Some crusher plants owned by several aggregate producers were found to be in operation near Addis Ababa but they are the stationary type for the companies' own use, and no plant that can be used for our procurement was found.

(4) Design and construction standards for roads and bridge

1) Road design and construction standards

Road design shall comply with the standards established in Ethiopia and, where there is insufficiency, comply with the Japanese standards. Therefore, the following design standards shall be used for road design:

- Geometric Design Manual 2002 (ERA)
- Drainage Design Manual 2002 (ERA)
- Pavement Design Manual 2002 (ERA)
- Standard Detail Drawings 2002 (ERA)
- Road Structure Standard 2004 (explanation and application of road structure regulations) (JAPAN)

2) Bridge design and construction standards

The following design standards shall be applied to bridge design.

- Bridge Design Manual - 2002 (ERA)
- Specifications for Highway Bridges (Japan Road Association)
- Standard Specifications for Concrete Structures (Japan Society of Civil Engineers)
- Government Ordinance for Structural Standard for River Administration Facilities (Japan River Association)

The design live load on a bridge shall be set as a load increased by 25% from HS20 specified in the Ethiopian standard (Bridge Design Manual: 2002) based on AASHTO. However, the structural members of a bridge shall be designed using the allowable stress design method of Japan.

2-2-1-8 Policies on Hiring of Local Contractors

An interview survey on the local contractors and building contractors in the surrounding countries found that the contractors in Ethiopia form a joint venture to participate as a subcontractor in the construction of bridge with long spans. A hearing survey on the local consultants revealed that they have a low technical level and perform a limited range of operations such as land survey, geological survey, traffic volume survey, and environmental survey.

2-2-1-9 Policies on Handling of Operation and Maintenance Abilities of Implementing Agencies

The road administration related to trunk roads in Ethiopia is under the charge of ERA, with its responsibilities and authorities legally stipulated. The former organization of ERA is the Imperial Highway Authority established in 1951. ERA was founded in 1978. The organizational reform in 1997 established its current organizational structure (See Figure 2-1 1, "ERA organization chart").
ERA's number of personnel is 18,372 (as of May 2010), including 2,942 working at the headquarters, 6,765 at local offices, and 8,665 in projects.
As for the organizational structure, ERA has three major departments: the Operation Department, the Engineering and Regulatory Department, and the Human Resource and Financial Department. The division of operations between these departments are as follows: The Operation Department implements construction work and maintenance/repair with ERA's own funds (ERA directly conducts 50% of periodical repair and 100% of daily maintenance/repair); the Engineering and Regulatory Department implements planning, design, and bid contracts and repair, construction, and maintenance management (mainly via outsourcing to the private sector); and the Human Resource and Financial Department is in charge of administrative operations, finance, and human affairs.
Since this project concerns reconstruction of the existing bridges, the requester was ERA's road and bridge maintenance/management department (Road Network Management Division of the Engineering and Regulatory Department). According to ERA, the project is handled by above Road Network Management Division in the JICA preparatory survey phase, and will be handled by the Engineering Service Procurement and Design Division in the contractor tendering phase, and the maintenance/management after construction will be handled by the Road Network Management Division.

2-2-1-10 Policies on facility grade setting

The target bridge in this project is a very important bridge because it is located on A1 Trunk Road, a principal road that runs through Ethiopia, as well as on an international trunk road that supports import and export between the capital Addis Abba of this inland country Ethiopia and the neighboring country Djibouti with an international port. The following grades shall be adopted.

① Design standards

- Road design: Shall comply with the Ethiopian design standards and, where there is insufficiency, comply with the Japanese standards.

- Bridge design: When local materials are used, the design strength for them shall comply with the Ethiopian design standards. The design method shall comply with the Japanese standards.

② Design live load

The design live load on a bridge shall be set as a load increased by 25% from HS20 specified in the Ethiopian standard (Bridge Design Manual: 2002) based on AASHTO.

③ Width

i) Bridge

Carriageway width 3.65m×2=7.3m, Shoulder 1.0m×2=2.0m Total 9.3 m (Effective width)

ii) Access road

Carriageway 3.65m×2=7.3m, Shoulder 2.5m×2=5.0m Total 12.3 m (Effective width)

④ Road type

Trunk road (national road) DS2

⑤ Design speed

85 km/h

2-2-1-11 Policies on Construction Methods and Construction Periods

(1) Policies on construction methods

Since the bridge piers of Awash Bridge shall be constructed at a high altitude, there is no possibility of influence from a flood during construction. However, it is advisable to avoid work near the river in the rainy season because both of the river banks are exceedingly steep.

(2) Policies on Construction Periods

As described above, the conditions differ between sites. Therefore, appropriate construction periods shall be determined to carry out construction in safety in comprehensive consideration of the Ethiopian natural environment with a distinct rainy season, work type, overall flow of construction, etc.

2-2-2 Basic Plan

2-2-2-1 Workflow of Basic Plan

In the basic plan, examination required for implementation of this project shall be conducted, such as a present state survey, selection of a bridge construction position, examination of a bridge longitudinal profile plan, setting of a bridge scale, and examination of bridge types in order to decide on an optimal bridge type. The following figure shows the workflow of the basic plan.

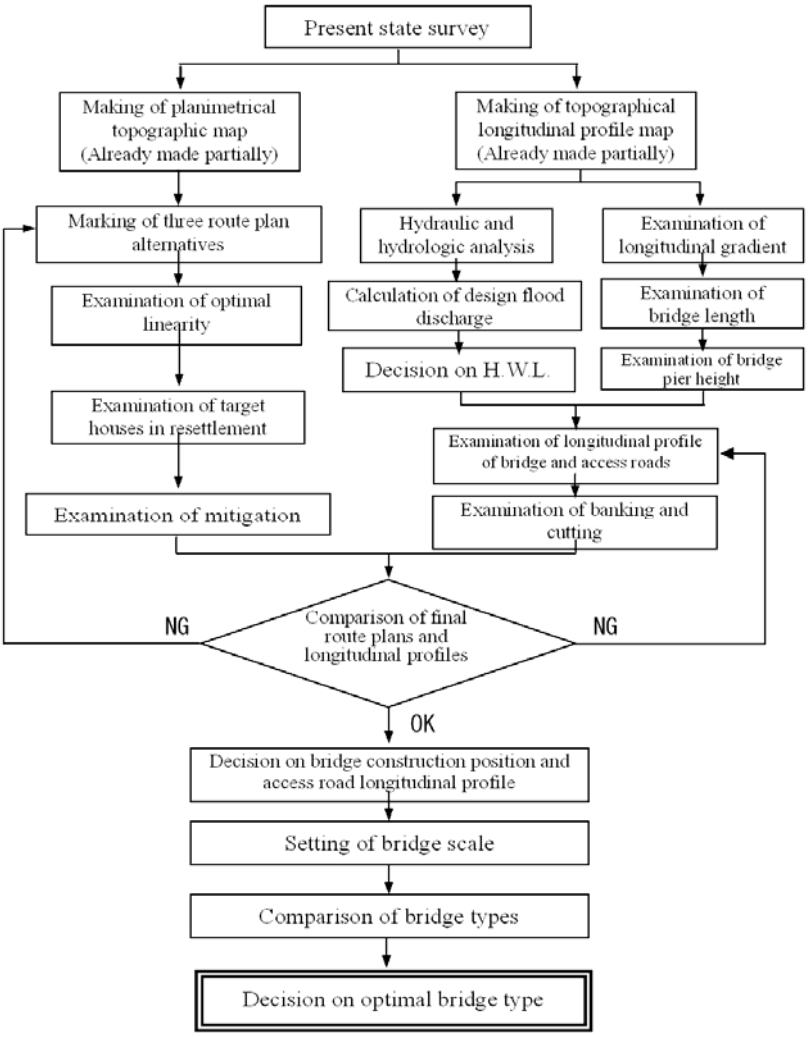


Figure 2-2-3 Basic plan workflow

2-2-2-2 Status Quo of Bridge Construction Position

The prompt construction of Awash Bridge on A1 Trunk Road, the most important route in Ethiopia, is requested because this indispensable bridge for going further north than this bridge was built 41 years ago and is frequented by a heavy traffic of large vehicles, causing a problem in the load bearing ability. Figure 2-2-4 shows the results of present state survey in the vicinity of the existing bridge.

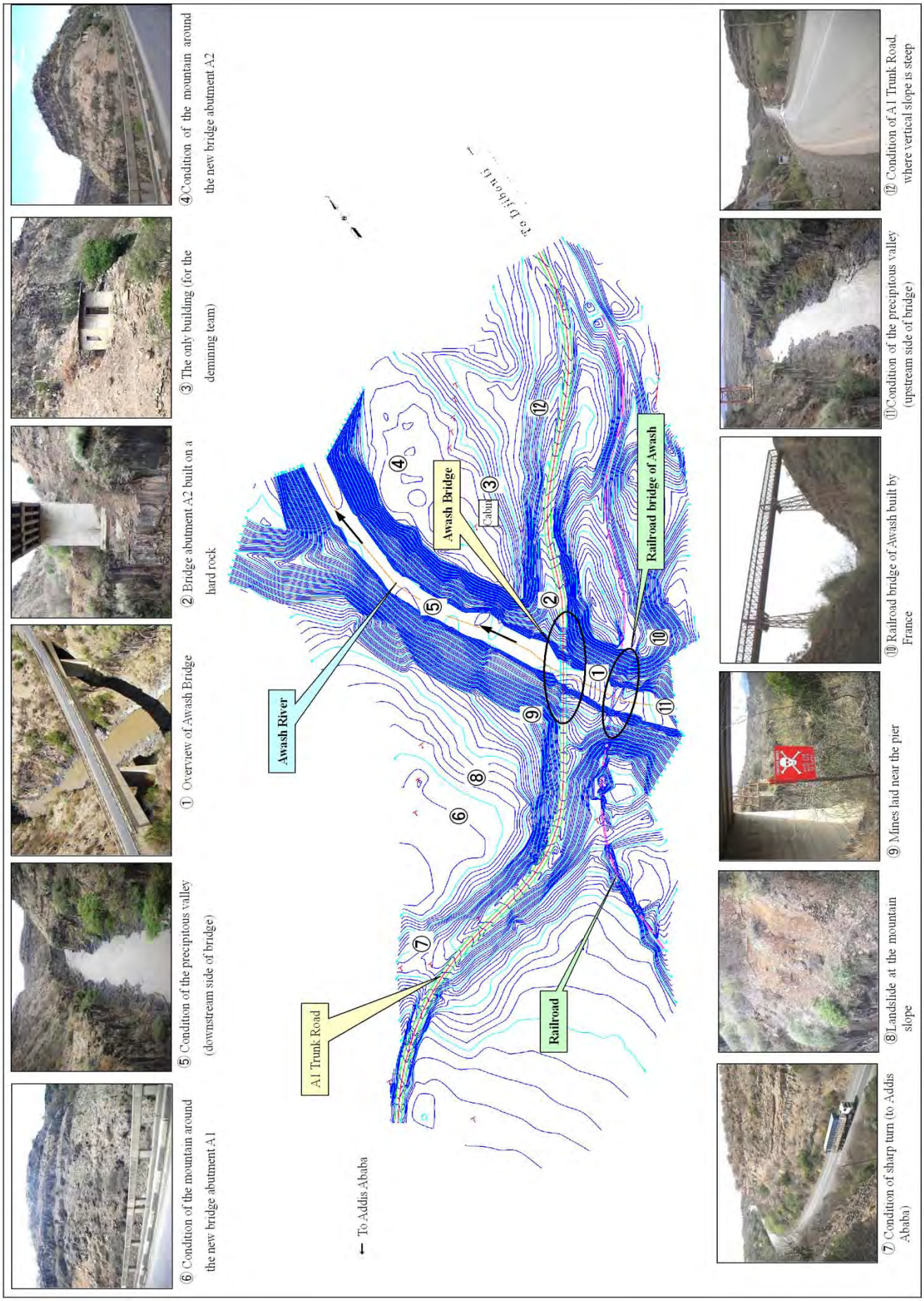


Figure 2-2-4 Map of circumstances around the existing Awash Bridge

2-2-2-3 Evaluation and Verification of Existing Bridge

The existing Awash Bridge is a 3-span continuous PC Gerber-girder bridge built in 1971. This bridge, having been use for about 39 years since opening to traffic, is significantly corroded and damaged, has an insufficient load bearing ability, and is currently under a traffic restriction that allows only one vehicle/one way. Table 2-2-6 and Figure 2-2-5 show the results of survey on the health of the existing Awash Bridge.

Table 2-2-6 Existing Awash Bridge health survey results

Bridge name			Awash Bridge		
Specifications	Year of construction		1971	Position	40°11'01" east longitude, 09°01'35" north latitude
	Daily average traffic volume		2,441 (vehicles per day)	Altitude	831 m
	Large vehicle mixing ratio		89 %	Distance	227km from the capital Addis Ababa
	Width		7.32m (carriageway) + 0.8m (wheel guard) × 2 = 8.92m (total width)		
	Design live load		32 t		
	Superstructure	Bridge type	3-span continuous PC Gerber-girder bridge		
		Bridge length	21.0+67.0+21.0=109.0m		
	Substructure		Bridge abutment: RC structure		Bridge pier: RC structure
Survey results	Functionality (role) in traffic		・ A1 Trunk Road is the most important route connecting Addis Ababa and Djibouti and has an extremely high functionality (role) in traffic as an international physical distribution route and an intra-region traffic route. ・ With a daily average traffic volume at 2,441 vehicles and, due to the lack of an alternative route, the functionality in traffic is extremely high. ・ The lack of sidewalk requires pedestrians to walk in the carriageway, putting them in a dangerous state.		
	Health (Damage level)		・ The hinge section of the Gerber-girder tends to become a weakness and is likely to be causing problems in functionality. ・ The side-span substantial cross-section is significantly corroded. ・ The monument has dropped due to a collision of a vehicle. ・ There are cracks in the main girder. ・ Rainwater remains in the unevenness on the bridge surface.		
	Structural performance (Stability)		・ The main girder flange width is so small that it seems to exceed the allowable stress. ・ The hinge section of the Gerber-girder seems to be dysfunctional, and there seems to be a structural problem. ・ Every time a large vehicle passes, the bridge vibrates significantly, which is a problem in terms of the structure and load bearing ability.		
Considerations			・ In 38 years after construction, the Gerber hinge section seems to be dysfunctional and in a dangerous state. ・ This bridge is in an extremely dangerous state in view of vibrations of the bridge when a large vehicle passes. ・ This bridge appears to be in good condition, compared with Gogecha and Modjo Bridges, but shows signs of structural danger and there is no alternative route so that the construction of a new bridge is necessary in consideration of the importance of A1 Trunk Road.		

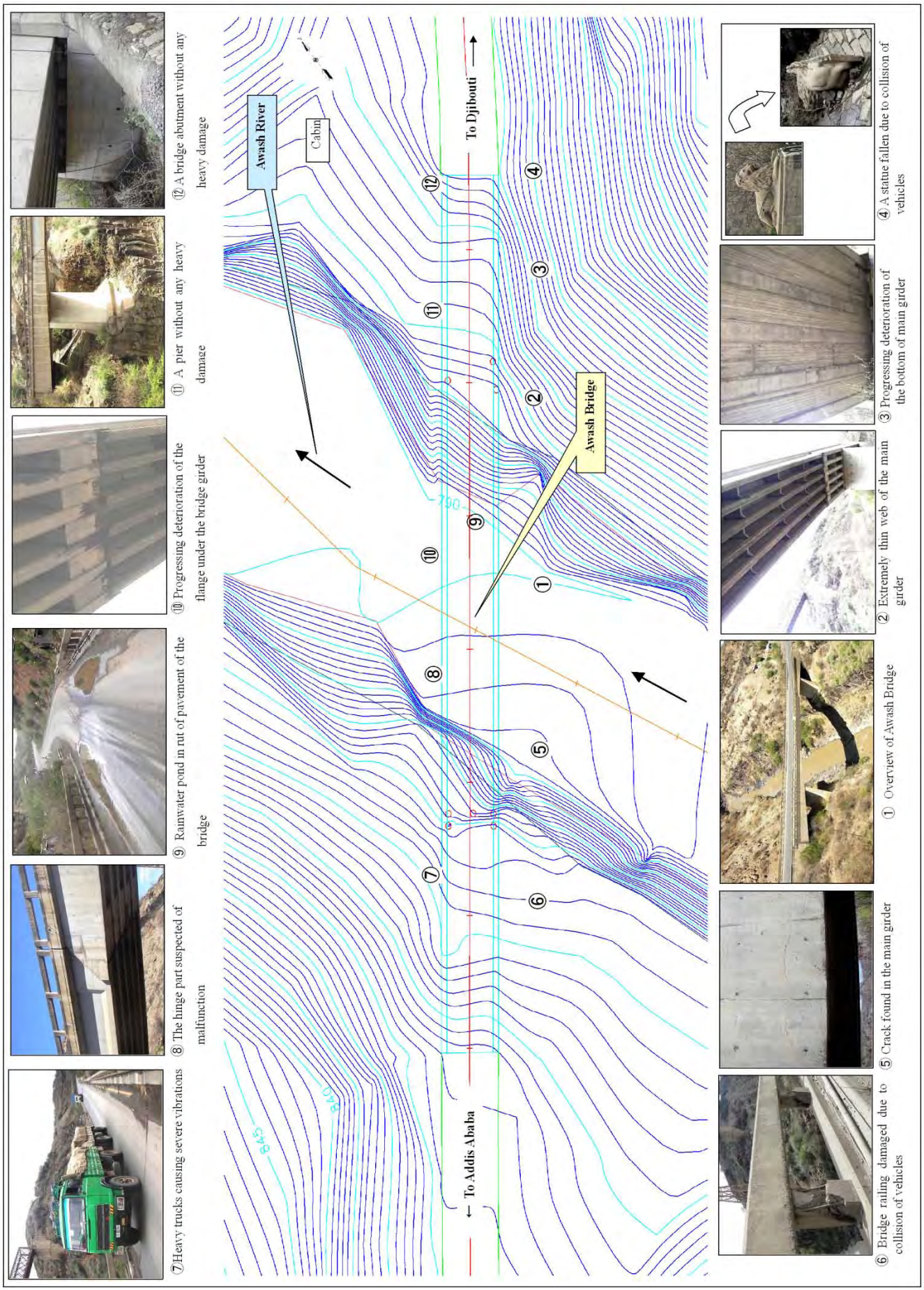


Figure 2-2-5 Existing Awash Bridge health survey results

2-2-2-4 Figure Examination of the Bridge Position

From the result of the comparison among the three alternatives, Alternative 1 (shifting 100 m downstream), Alternative 2 (shifting 80 m downstream) and Alternative 3 (shifting 40 m downstream), the survey team selected the Alternative 1 (shifting 100 m downstream) as the best alternative for the following reasons.

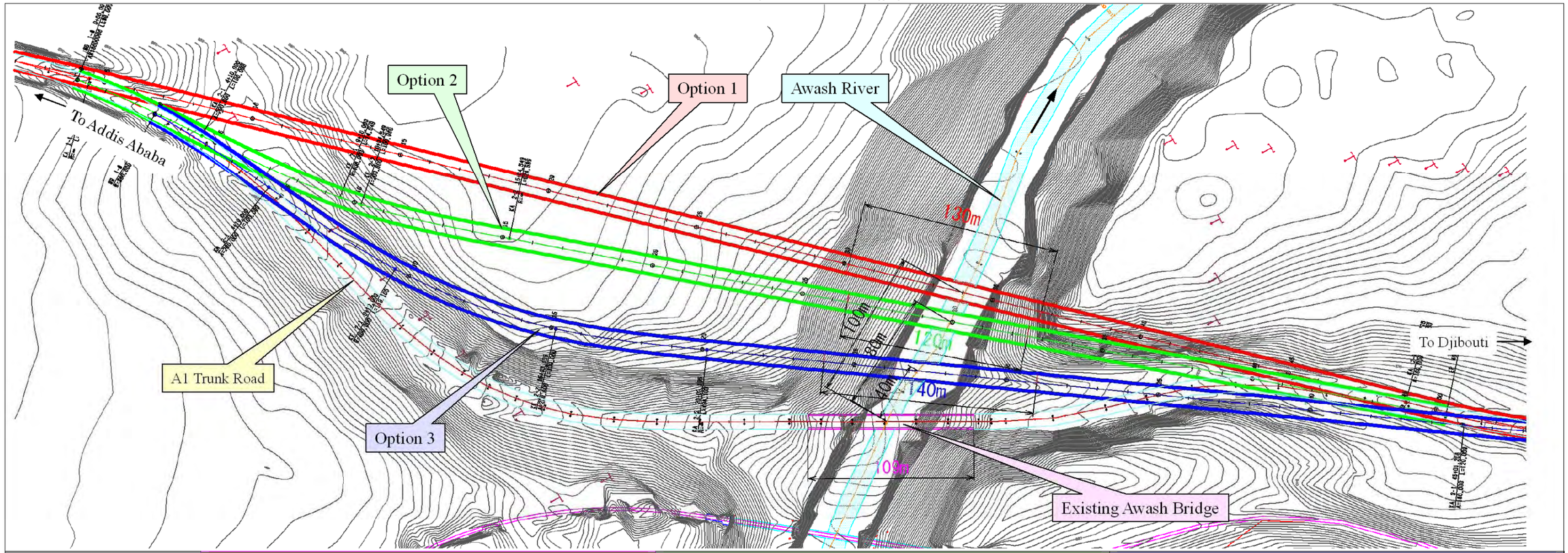
① The access road to the existing bridge has an S-shaped curve on either side of the bridge (R = 360 m on the Addis Ababa side and R = 270 m on the Djibouti side). The Alternative 1 has the best road linearity because the access road on both side of the bridge will be straight.

② The length of the bridge (L = 130 m, second longest among the three alternatives) is not so long.

③ Since the amount of cutting is intermediate (second among the three), it will have moderate impact on the environment.

Table 2-2-7 and Figure 2-2-6 show the comparison of the bridge positions and the linearity diagrams of the three alternatives.

Table 2-2-7 Comparison of the bridge position



Option		Option 1 (Shift 100m downstream)	Option 2 (Shift 80m downstream)	Option 3 (Shift 40m downstream)
Outline		・The plan is to connect the two curves on the Addis Ababa side and Djibouti side with a straight line.	・The plan is to maximum utilize the linearity of the existing road, and shorten the new access road length.	・The plan is to minimize cut earth found in the mountains of the Addis Ababa side.
Evaluation	Usability of the current bridge	・The Gerber hinge of the existing bridge is suspected of malfunction, and the bridge vibrates more when large-sized vehicles pass, however, the deterioration and damage conditions are not as bad as Gogecha Bridge and Modjo Bridge. Therefore, the existing bridge shall not be demolished, and can be utilized for an evacuation route for emergencies (a detour).		
	Linearity of access road	・Linearity is optimum due to a straight new access road.	・Two S-curves in the existing road. The new linearity is planned for 1 S-curve, thus linearity is improved.	・Same as shown on left.
	Length of new bridge	・The bridge length is the second of the 3 options. (130m)	・The bridge length is the shortest of the 3 options. (120m)	・The bridge length is the longest of the 3 options. (140m)
	Necessity for detours	A detour is not required since the new bridge is shift to downstream, and the existing bridge and road can be utilized.		
	Environmental and social considerations	・There are no other buildings in this area, therefore problems concerning relocation of residents or demolition of buildings shall not occur. However, expropriation of land is necessary.		
		・The amounts of cutting (205, 000m3), banking (21,000m3) and surplus soil (184,000m3) are the second of the 3 options, thus this option has the second environmental impact.	・The amounts of cutting (266,000m3) and surplus soil (258,000m3) are the largest of the 3 options (the amount of banking is 8,000m3), thus this option has the largest environmental impact.	・The amounts of cutting (172,000m3) and surplus soil (155,000m3) are the smallest of the 3 options (the amount of banking is 17,000m3), thus this option has the smallest environmental impact.
	Workability	・The impact to the existing road is relatively lower than the other options, and since the new access road is straight, the workability is at high level.	・Bridge length is the shortest, and the existing road is utilized at its most, therefore the range of impact is small, and workability is at high level.	・The bridge length is the longest, and the impact to the existing road at the end side is large, therefore the workability is the lowest.
	Construction works to be included (Ratio to the estimated cost)	・Construction of a new bridge, development of a new access road (1,100m) (Ratio to the estimated cost: 1.0)	・Construction of a new bridge, development of a new access road (930m) (Ratio to the estimated cost: 1.0)	・Construction of a new bridge, development of a new access road (1,020m) (Ratio to the estimated cost: 1.0)
	Overall evaluation	・Major improvement of linearity due to the straight access road. ・Demolition/relocation of buildings is not required, but expropriation of land required. ・Since the amount of cutting is middle rank, the environmental impact is also at mid-level. ○	・Linearity will be improved due to S-curve reduced to only one point. ・Demolition/relocation of buildings is not required, but expropriation of land required. ・Since there are very many amounts of cutting, the environmental impact is the greatest. ×	・Linearity will be improved due to S-curve reduced to only one point. ・Demolition/relocation of buildings is not required, but expropriation of land required. ・Since there are few amounts of cutting, the environmental impact is small. △

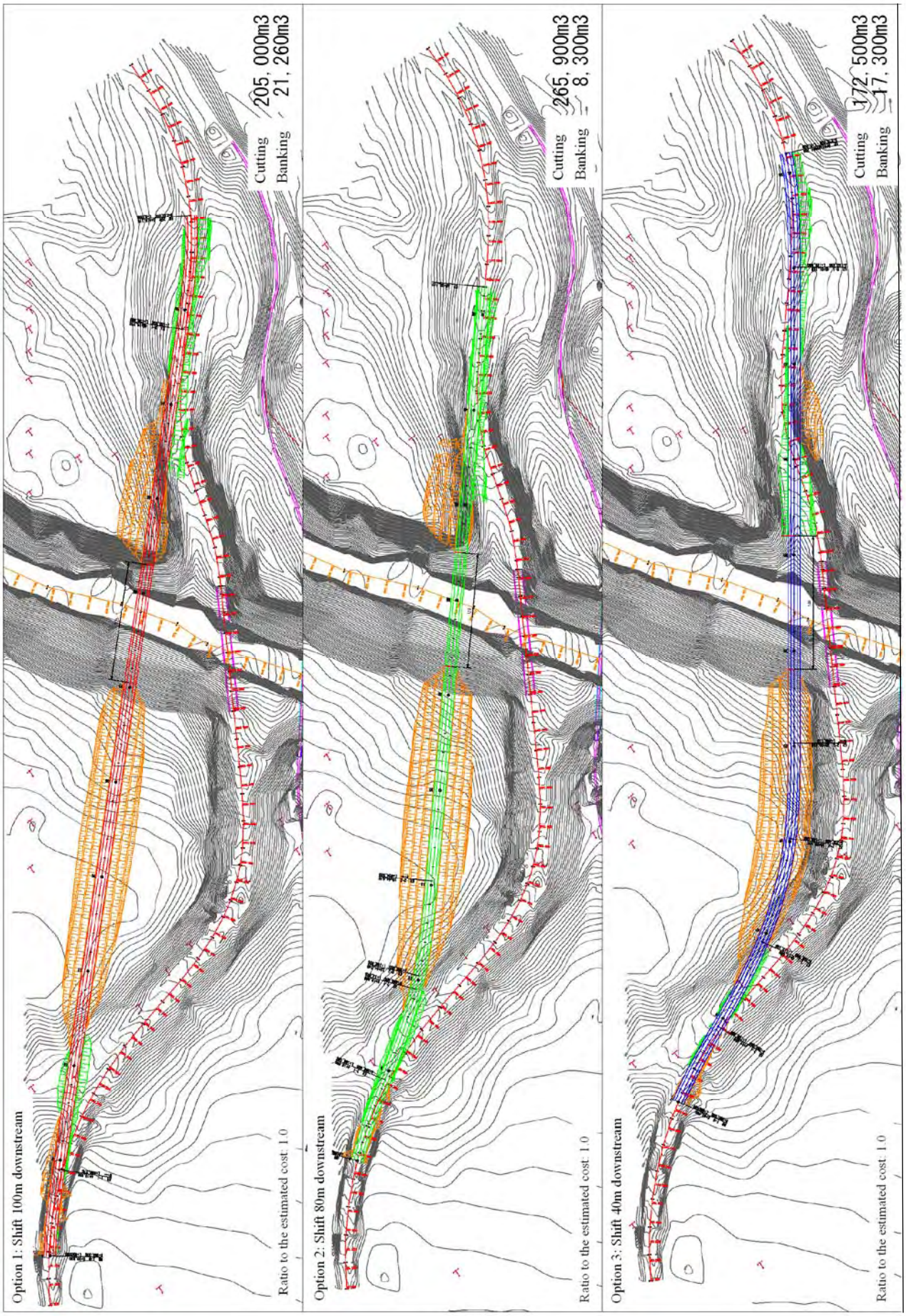


Figure 2-2-6 Linearity diagrams of the three alternatives