Republic of Fiji
Ministry of Infrastructure and Transport
Fiji Electricity Authority (FEA)

THE PROJECT FOR THE EFFECTIVE AND EFFICIENT USE OF RENEWABLE ENERGY RESOURCES IN POWER SUPPLY IN REPUBLIC OF FIJI

FINAL REPORT

VOL. III APPENDIX

FEBRUARY 2015

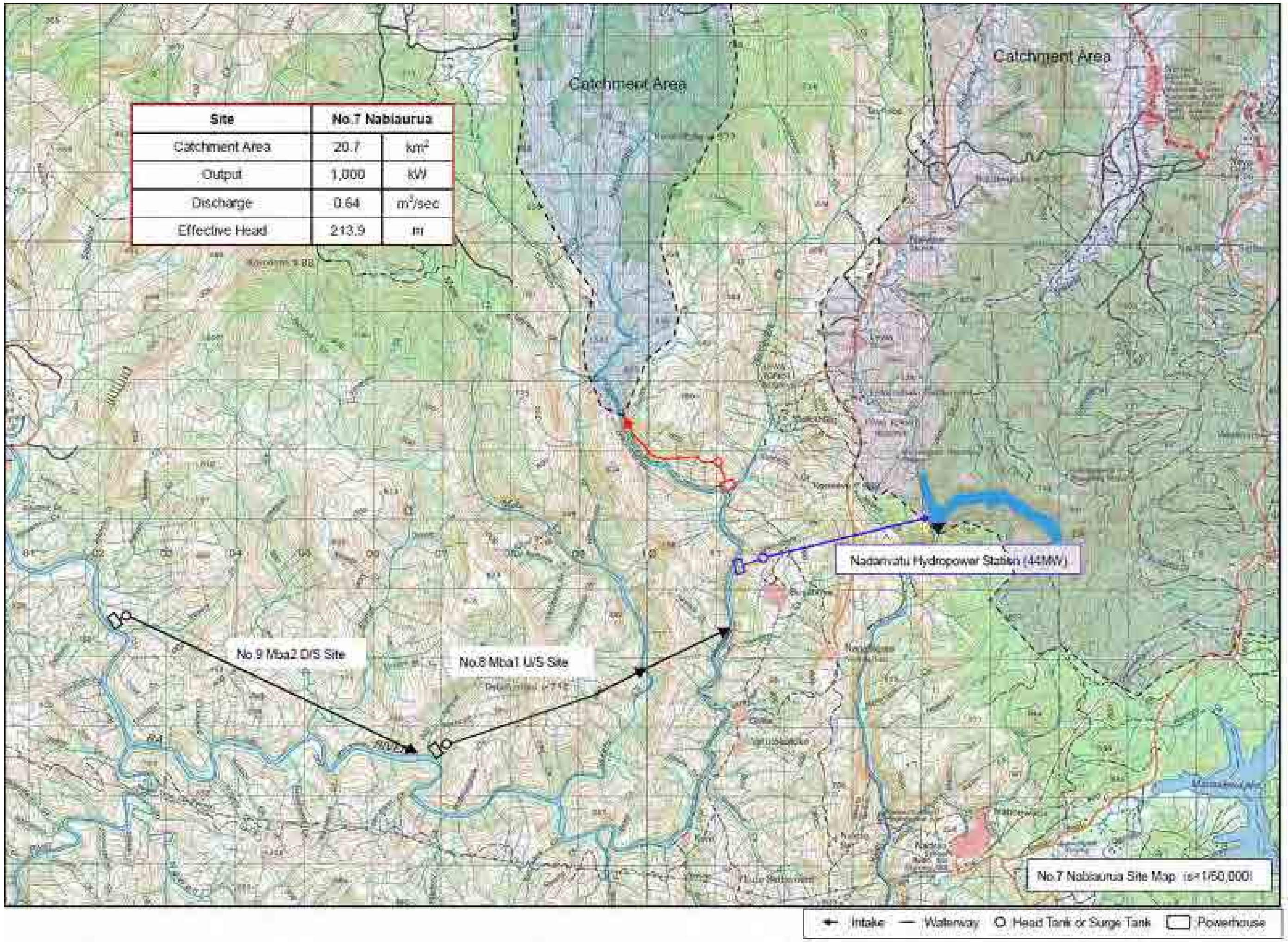
Japan International Cooperation Agency
Tokyo Electric Power Services Company, Ltd.

Appendix List

Appendix 5-2

Site Maps of

Nine (9) Hydropower Potential Sites



Site	No.7 Nabiaurua	
Catchment Area	20.7	km^2
Output	1,000	kW
Discharge	0.64	m^3/sec
Effective Head	213.9	m

Figure 5-2.1 No.7 Nabiaurua Site Map

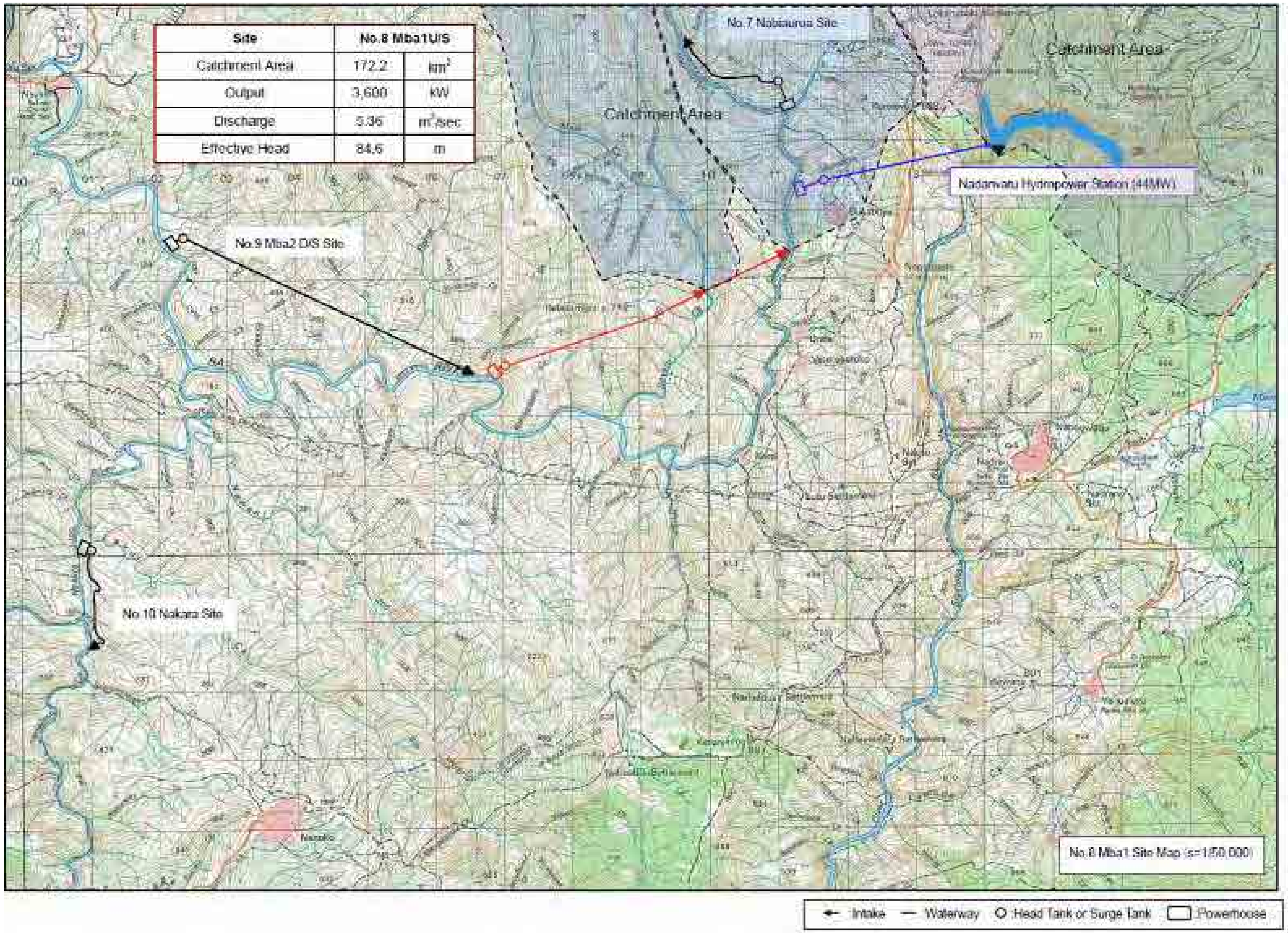


Figure 5-2.2 No.8 Mba 1 Site Map

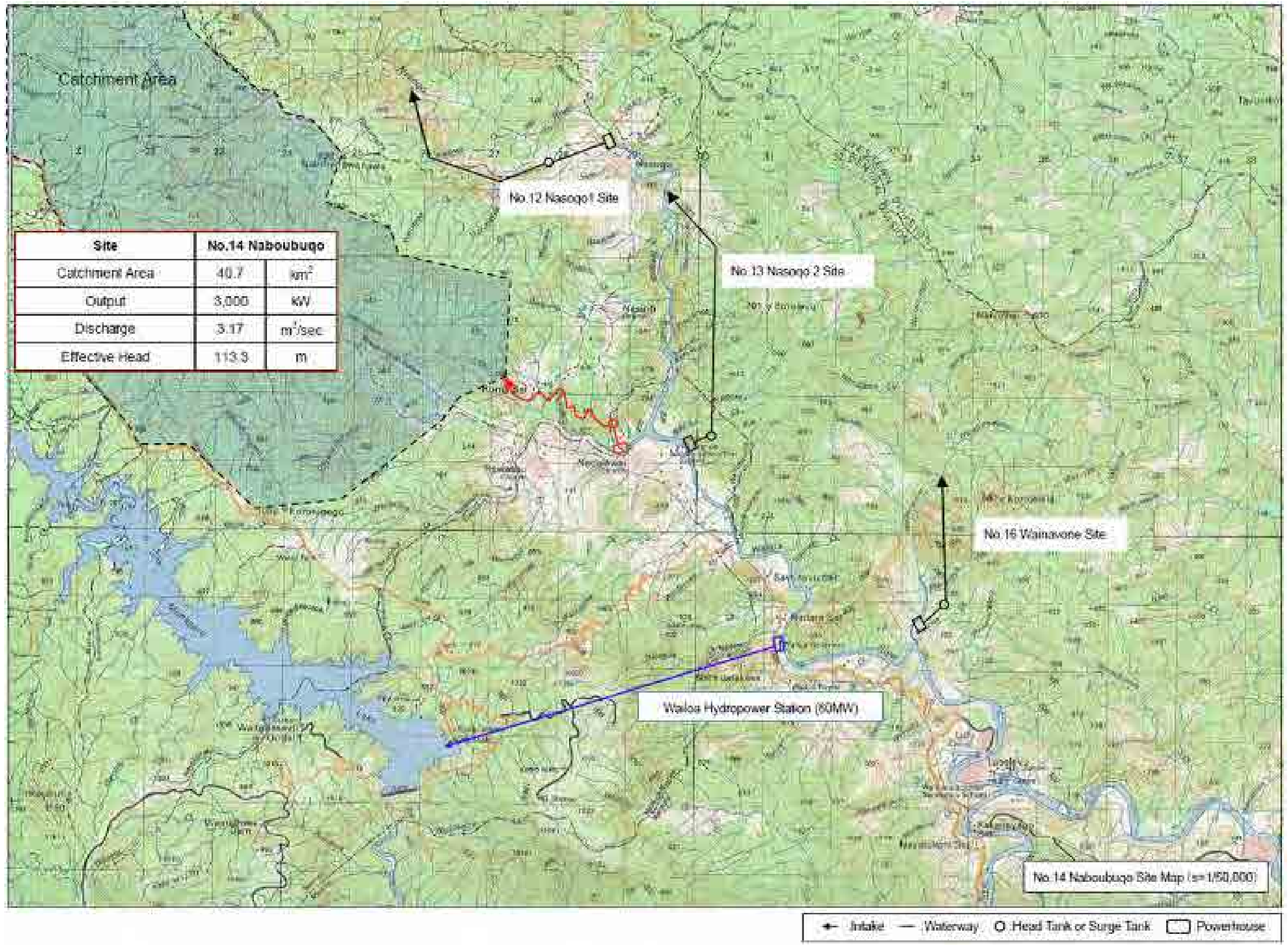


Figure 5-2.3 No.14 Naboubuco Site Map

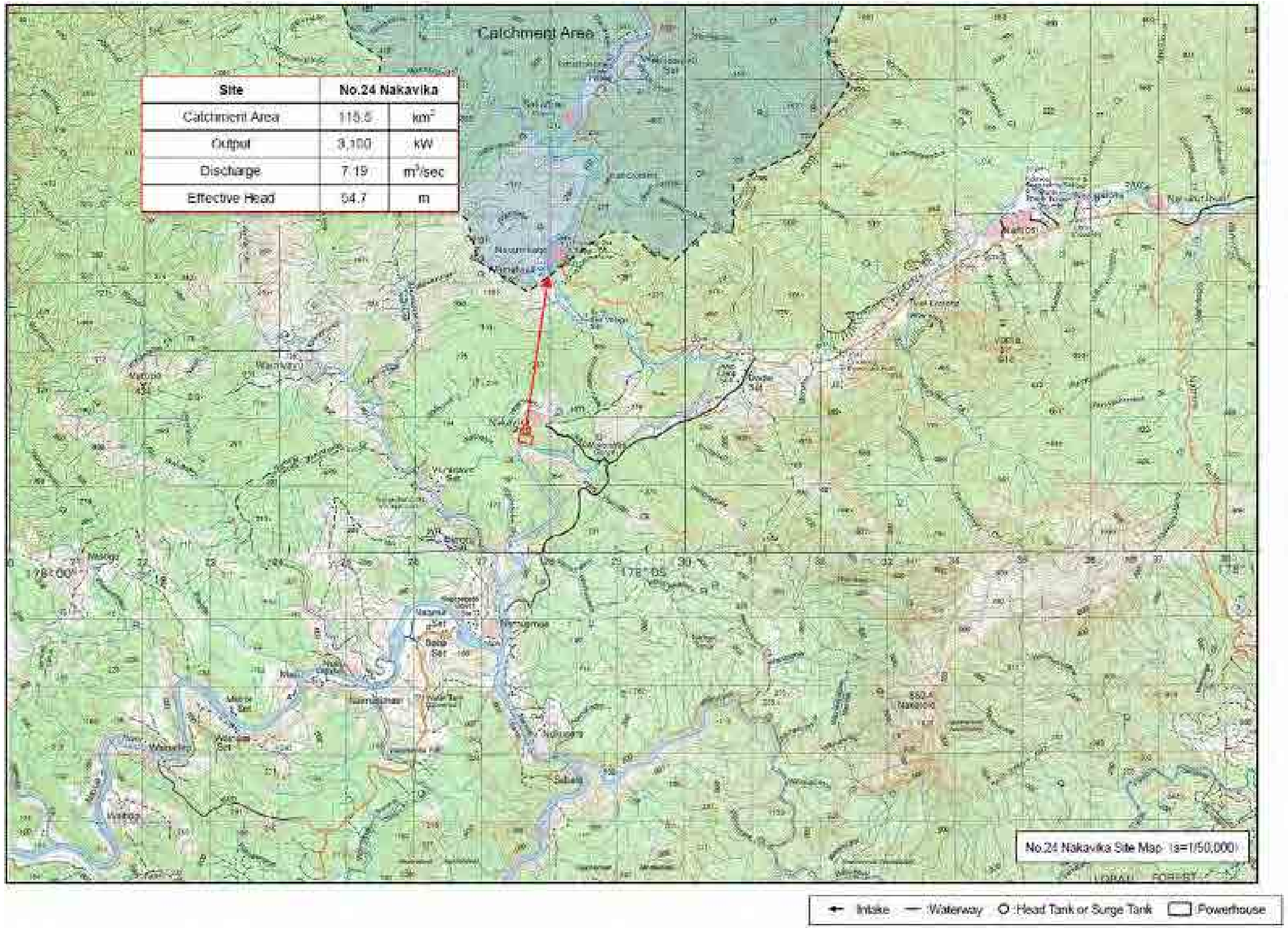


Figure 5-2.4 No.24 Nakavika Site Map

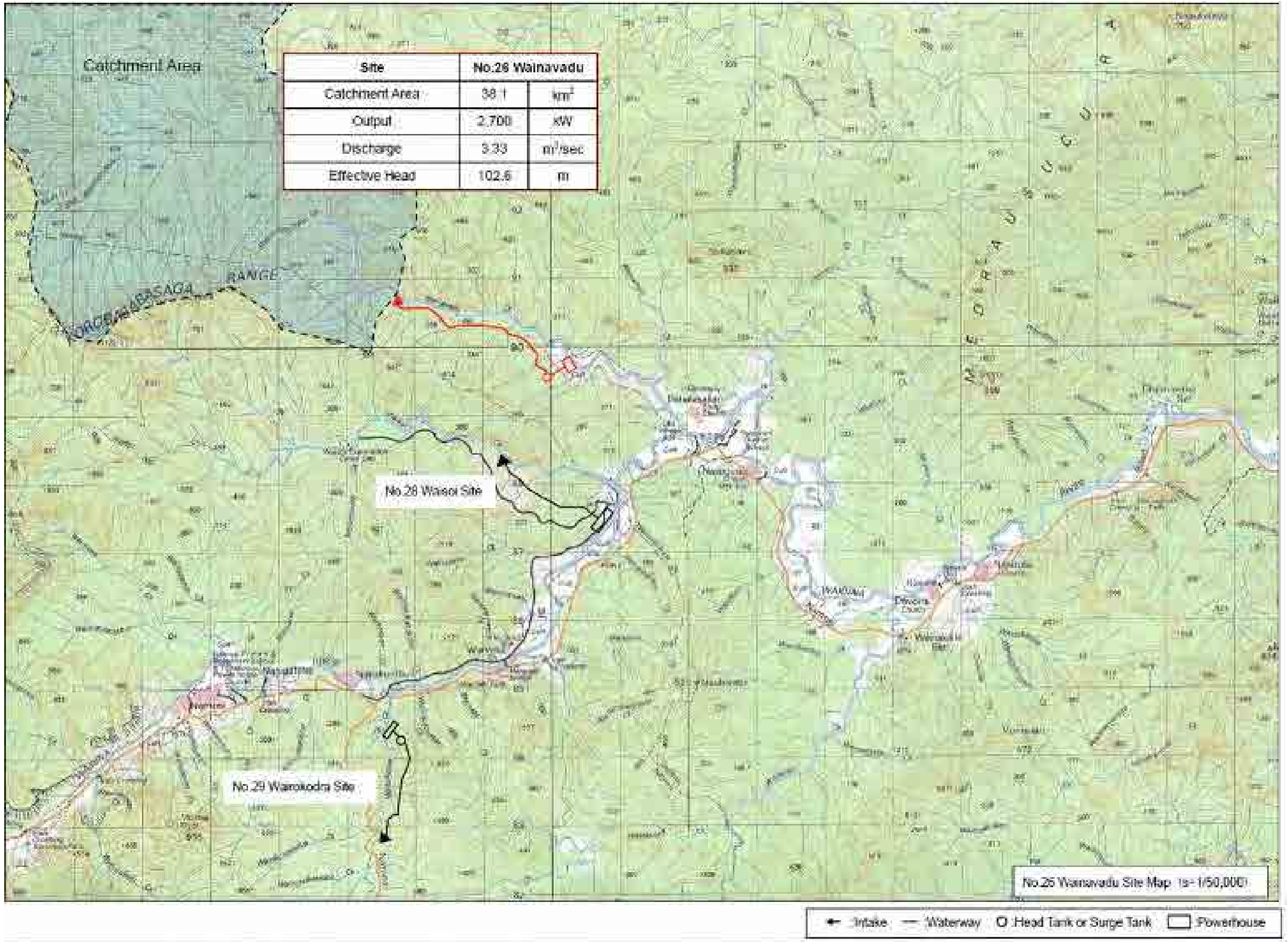


Figure 5-2.5 No.26 Wainavadu Site Map

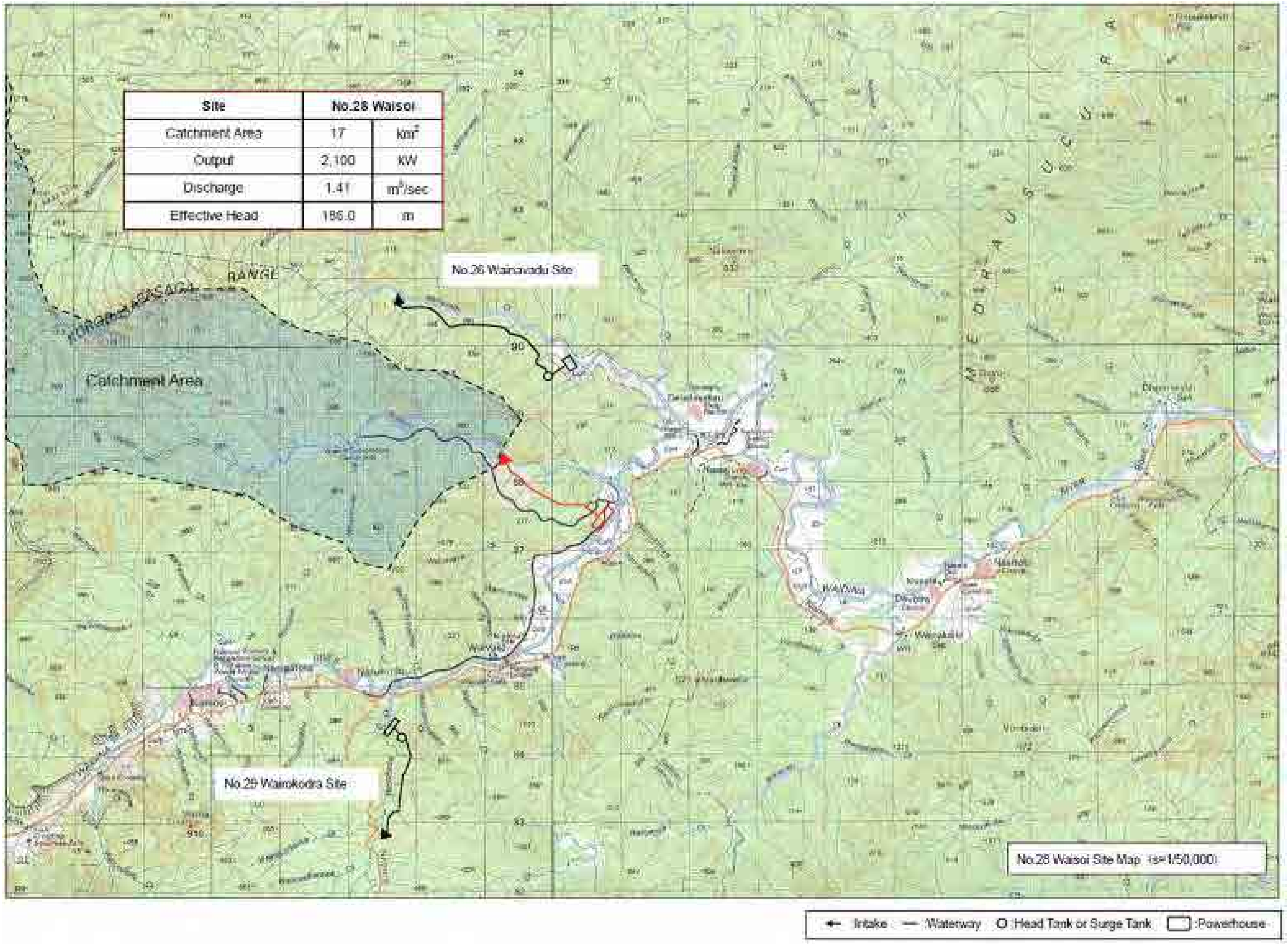


Figure 5-2.6 No.28 Waisoi Site Map

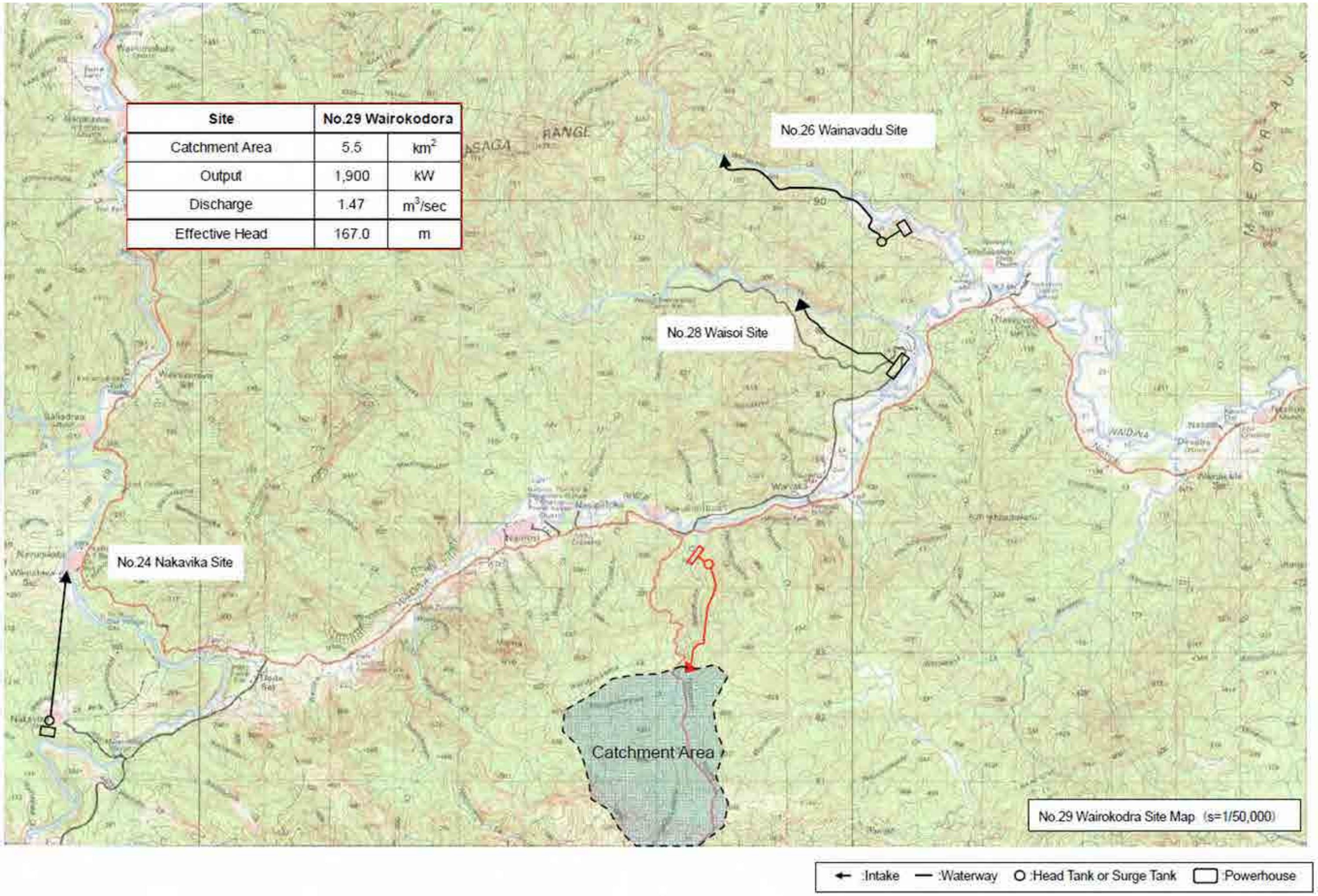
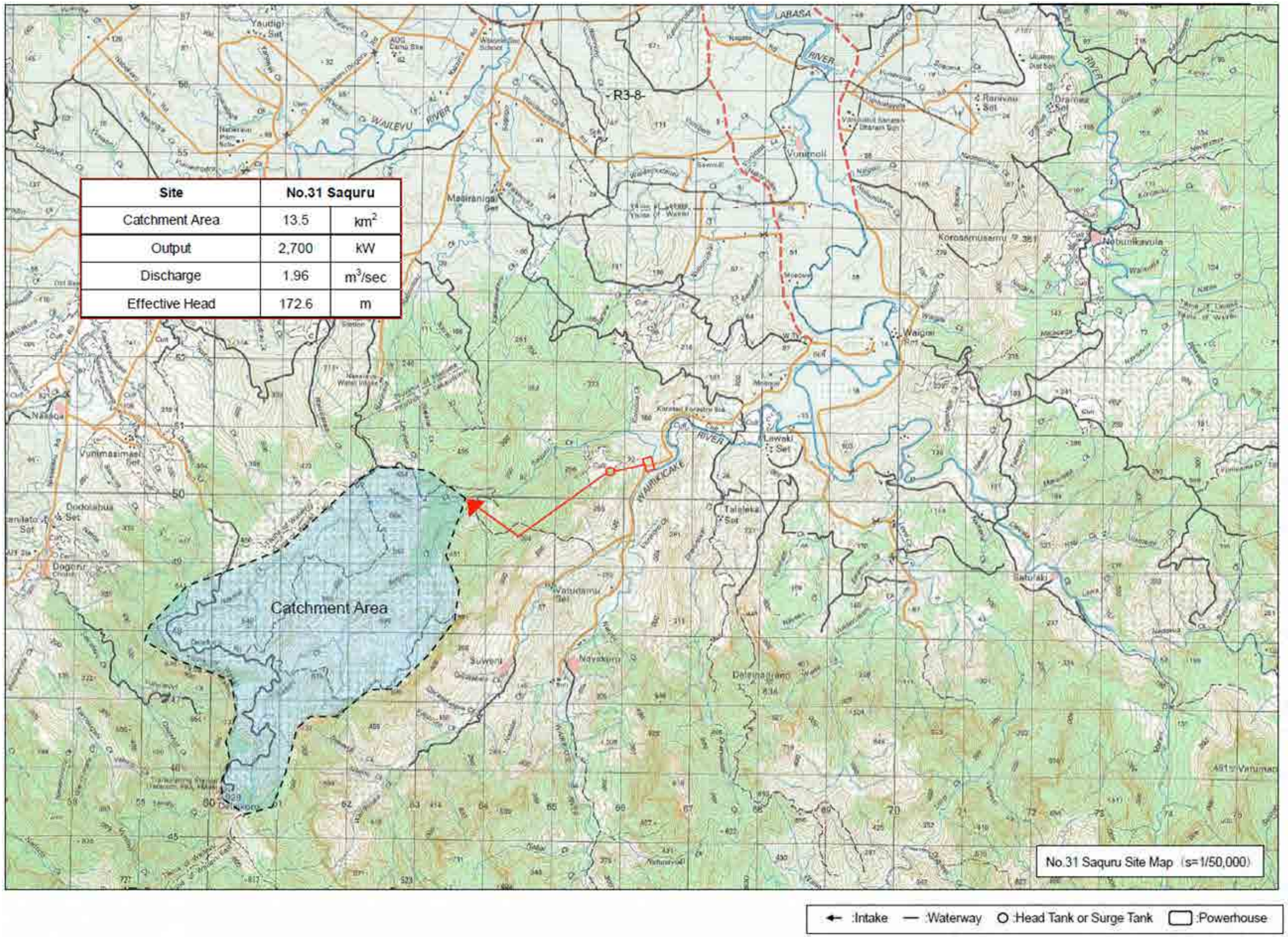
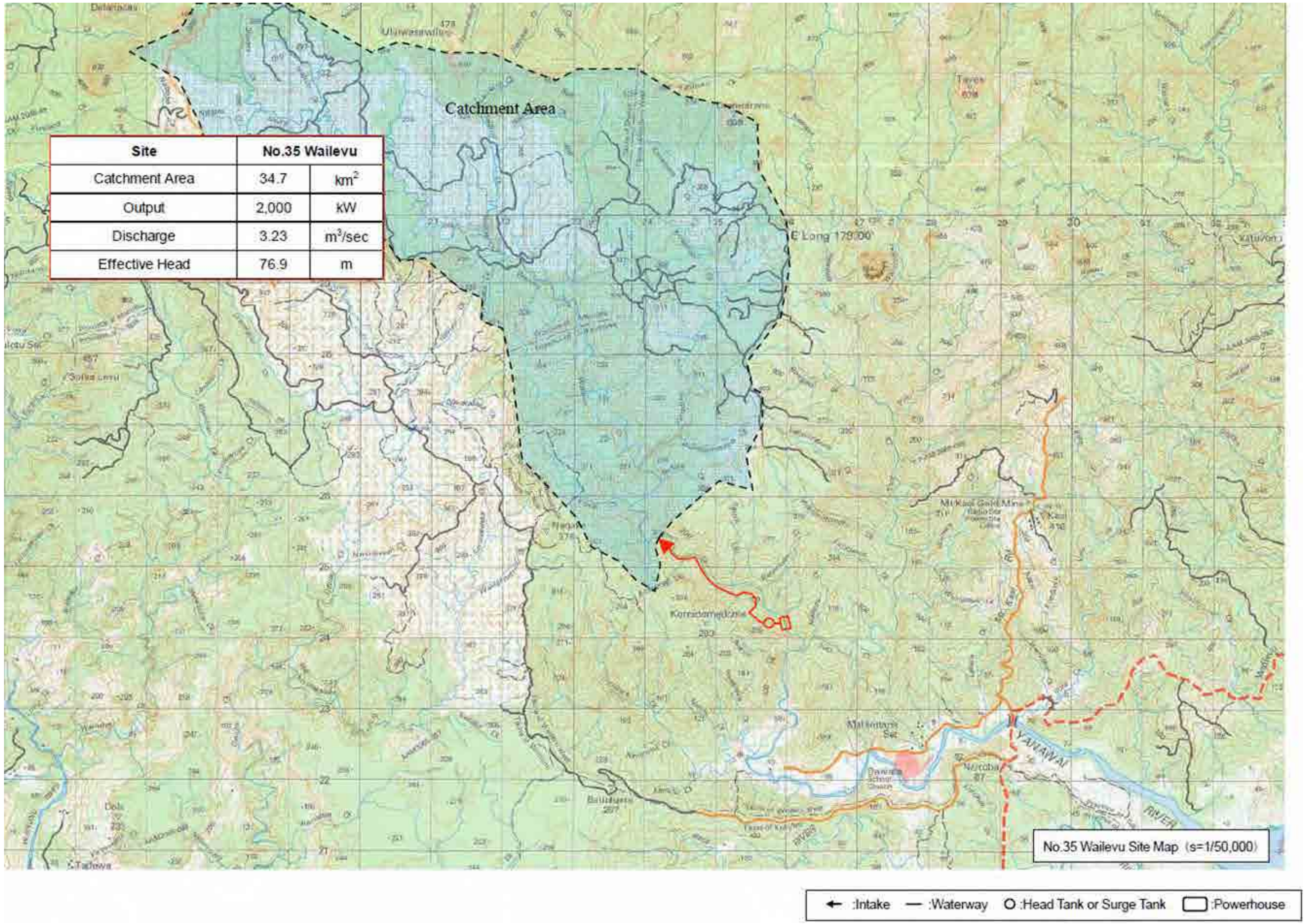


Figure 5-2.7 No.29 Wairokodora Site Map



Site	No.31 Saquru	
Catchment Area	13.5	km^2
Output	2,700	kW
Discharge	1.96	m^3/sec
Effective Head	172.6	m

Figure 5-2.8 No.31 Saqurru Site Map



Site	No.35 Wailevu	
Catchment Area	34.7	km^2
Output	2,000	kW
Discharge	3.23	m^3/sec
Effective Head	76.9	m

Figure 5-2.9 No.35 Wailevu Site Map

Appendix 5-3

Implementation of Site Reconnaissance on

Candidate Potential Sites

Site Name		No.7 Nabiaurua
Location (River name)		Nabiaurua River
Profile	Catchment Area (km²) Installed Capacity P (kW) Design Discharge Q (m³/s) Effective Head H (m)	20.7 1,000 0.64 213.9
Geography / Geology / Hydropower planning	General Geology	- Geology of this area belongs to Mba series in Pliocene, which has 3 natural divisions, summarized from west to east (and oldest to youngest) as: (i) Tuffaceous mudstone and sandstone with minor conglomerate, (ii) Interbedded sandstone and basaltic breccia, and (iii) Interbedded basaltic flows and breccias. (cited from p.7 of Bulletin No.11 issued in 1963) - Rocks which expose in the schemed area are sandstone of (ii) and basaltic flows and breccia of (iii).
	Approach Conditions	– Powerhouse site is accessible on foot from the approach road to Nadarivatu power station. – River inclination is very steep on the way to the powerhouse site and there are water falls of several steps (total height; around 20m).
	Intake	– Intake site located on Nabiaurua Creek (right side tributary) was inaccessible this time, because there are several water falls of around 10m height between the confluence adjacent the powerhouse and the intake site. – Rocks surrounding the intake site could not be seen, but they may be basalt and sandstone based on our survey results on the downstream of the intake. The bedding planes there incline to the upstream side gently. It is estimated that rock quality is enough for the foundation of such a small scale weir which height is only a few meters.

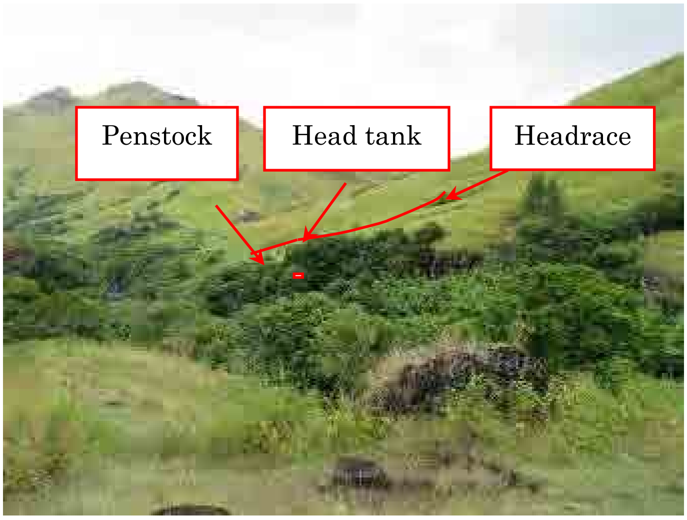
	Waterway / Power House	− Tributary's flow volume rate of the confluence by the eye measurement is as follows. Nabiaurua Creek (right side tributary): more than $1m^3/s$. Naidadara Creek (left side tributary): less than $1m^3/s$. − The powerhouse location is altered from Naidadara Creek (left side tributary) to the left bank of Nabiaurua Creek (right side tributary), because it is possible to shorten the length of waterway according to the topographic condition. − Headrace and penstock planned were seen from Marou Set village which is located along Naidadara Creek (left side tributary). − Since the both banks of the intake site is steep, tunnel type headrace is suitable for between the intake and the place where the slope is gentle. After that, open channel type headrace is suitable up to the head tank position. Penstock is planned to pass along the center of the ridge and connect to the alternative powerhouse. − The riverbed surrounding the powerhouse site forms broad flat plane and the geological boundary between sandstone and basalt inclines gently to the upper stream direction. It is obvious that the plane had been formed by erosion of sandstone which is softer than basalt. Various sizes of pot hole are scattered on the surface of basalt. − There are plenty numbers of huge boulders of basaltic breccia surrounding Marou Set village. Some sorts of succulent plant grow naturally on the top of the boulders.
Natural / Social Environment	Natural Park / Protected Area	- No Protected Area affected by scheme or adjacent to scheme. No Proposed Protected Area affected by scheme or adjacent to scheme. - Not part of a Key Biodiversity Area, Important Bird Area or other identified conservation area.

	Prosperous fauna / flora	- Situated in anthropogenic grassland site of no conservation significance. Catchment area is primarily anthropogenic grassland – poor water catchment characteristics. - No known terrestrial fauna and flora of significance though riparian forest as exists needs to be conserved. - Freshwater fish: This precise sub-catchment has not been surveyed for aquatic fauna. Several sites in the upper Ba river catchment were surveyed in 2003 and fauna found to be generally depauperate, likely due to deforestation, agriculture and presence of invasive species. Fish fauna is largely dominated by invasive species, some of food significance. Migratory species are likely to be present in low numbers but not seen in surveys to date.
	Resettlement / Compensatory assets	- No resettlement of houses required. - Compensation will consist of subsistence agriculture and land lease. Subsistence agriculture minimal but present in pockets which may be affected. - Land ownership (provisional): Power house – Mataqali Taunasagati, Navala village. Intake and catchment area on Mat. Koroilagi, Navala village, Qalivakatini District.
	Historical / Cultural Heritage	- The site visit identified a well preserved historical site on Mat. Taunasagati land, known to guides as Doilevu. The Fiji Museum database includes a site in the same vicinity. - It is a well preserved and large site (>10 yavu). The site is on the opposite bank to the alternative powerhouse. There may be more sites in the vicinity which will need further careful inspection and consultation with landowners. - Further reference to the Fiji Museum data base and the Native Lands Commission is required.
	Others	- Closest village to the scheme is Marou village and these villagers use the river for fishing but they are not the landowners of the scheme. Relatively traditional village.
Others' Special Note		– Since there are water falls of several steps (total height; around 20m) from the downstream of the confluence of Nabiaurua Creek (right side tributary) and Naidadara Creek (left side tributary) to Nadarivatu power station, it will be feasible to develop a run-of-river type hydropower plant by utilizing the above head.

(Photo-1) Condition of water falls (height: around 20m) on the way to No.7 site, geological boundary of sandstone (upper; soft) and basalt (lower; hard).
Sandstone layer deems to be differentially eroded and the riverbed forms flat planes.

(Photo-2) Condition of alternative powerhouse site, which is the downstream of original intake site
Geological condition is that bedding plane inclines gently to the upstream direction.
(View from downstream of right bank (Nabiaurua Creek))

(Photo-3) Condition of confluence of Nabiaurua Creek (right side tributary) and Naidadara Creek (left side



(Photo-4) Condition of alternative headrace, head tank and penstock

(Photo-5) Some sorts of succulent plant grow on the huge boulders surrounding Marou Set Village

(Photo-6) Condition of weir of proposed No.7 downstream power station utilizing the head between the confluence and Nadarivatu power station

<table>
<tr><td colspan="2">Site Name</td><td>No.8 Mba 1 U/S</td></tr>
<tr><td colspan="2">Location (River name)</td><td>Ba River</td></tr>
<tr><td rowspan="4">Profile</td><td>Catchment Area (km^2)</td><td>172.2</td></tr>
<tr><td>Installed Capacity P (kW)</td><td>3,600</td></tr>
<tr><td>Design Discharge Q (m^3/s)</td><td>5.36</td></tr>
<tr><td>Effective Head H (m)</td><td>84.6</td></tr>
<tr><td rowspan="2">Geography / Geology / Hydropower planning</td><td>General Geology</td><td>− Geology of this area belongs to Mba series in Pliocene, which has 3 natural divisions, summarized from west to east (and oldest to youngest) as: (i) Tuffaceous mudstone and sandstone with minor conglomerate, (ii) Interbedded sandstone and basaltic breccia, and (iii) Interbedded basaltic flows and breccias. (cited from p.7 of Bulletin No.11 issued in 1963)
− Rocks which expose in the schemed area are (i) Tuffaceous mudstone and sandstone with minor conglomerate and (ii) Interbedded sandstone and basaltic breccia.</td></tr>
<tr><td>Approach Conditions</td><td>(No.1 Intake site)
− It is accessible from Nadarivatu power station to the intake site by using footpath along the left bank of Ba River.

(No.2 Intake, Powerhouse site)
− It is accessible by vehicle to Koro village which is located on the left bank of Ba River. No.2 intake and powerhouse site planned are accessible from Koro village on foot. However, it is necessary to cross Ba River three (3) times.
− It is accessible to the confluence of Ba River and Savatu Creek by using footpath along Ba River.
− Footpath from the confluence to the head tank planned passes on a gentle slope on the right bank of Ba River.
− After crossing a slightly larger mountain stream that all rocks crop out, the footpath reaches the top of a gentle ridge (EL.210m (GPS)) from where the location of the original powerhouse is visible.</td></tr>
</table>

	Intake	(No.1 Intake site) – Intake site is located at the change point of the river inclination. River at the intake site is about 20m in wide, and river flow volume rate is around $10m^3/s$ by the eye measurement. – Features and operation data of Nadarivatu power station are as follows. [Power station] Elevation of turbine center; El.193.8m Elevation of outlet; El.187.7m (Maximum flood water level at the outlet; El.191.4m) [Dam] H.W.L.; 529m, L.W.L.; 516m Effective storage capacity; About 1 million m^3 [Operation data at 11:00 a.m. on 22 May 2014] Generation discharge; $9.15m^3/s$ Output; No.1 unit 15.6MW, No.2 unit 10MW Water level of Nadarivatu dam; 526m Inflow to Nadarivatu dam; $4.65m^3/s$ – The intake site is located around the boundary of interbedded sandstone and basaltic breccia. The bedding plane inclines around 15 deg. to the upper stream side. Huge boulders are scattered on the riverbed where the river curves due to river erosion. Their mean diameter is 0.5m and 4m at most. Even though the sandstone is soft, the bedrock deems to have sufficient strength as foundation of a small weir of several meters high. – The tree on the slope of the opposite shore (the right bank) is secondary woods (the arboret kind) after burning wildwood. Since the pine trees and vegetation are grown on the lower reach of the river from there, where the settle basin is planned. And the open-channel type headrace is planned up to the place where the tunnel can be constructed. (No.2 Intake site) – Flow volume rate of Savatu Creek at the intake site planned is 1.5 ~ 2.0 m^3/s by the eye measurement. – Almost vertical cliff is formed along the both riverbanks because rock is hard, however, the topographic and geologic conditions of 30m higher could not be seen well due to the steep cliff. – The bedrock the intake site is interbedded tuffaceous mudstone and sandstone of Mba layer group. Their bedding planes are horizontal. Sandstone is massive and quite hard. Though some layer of mudstone had been scooped like a groove, the bedrock is expected to have enough bearing capacity for a dam with around 50m high.

	Waterway / Power House	− The headrace tunnel is planned to pass under the gentle slope of terrain on the right bank of Ba River. The gentle slope topography along the tunnel route is dominated by the geological structure which consists of interbedded sandstone and mudstone. − Since some clusters of bamboo bush are native to the foot of the hill, it is expected that the places are spring points of ground water along the geological boundary. Upon such condition, headrace tunnel is deemed to be excavated safely. However, there is possibility of water leakage from the waterway during operation. − It is difficult to construct the original powerhouse, since it is located on the downstream side of meandering river where bank slope is vulnerable and steep. Therefore, the powerhouse location is altered to the upper stream of 1.5km from the original one. − Since there is a flat area surrounding the alternative powerhouse, it is suitable for the construction of powerhouse including the switching station, etc.
Natural / Social Environment	Natural Park / Protected Area	- No Protected Area affected by scheme or adjacent to scheme. No Proposed Protected Area affected by scheme or adjacent to scheme. - Not part of a Key Biodiversity Area, Important Bird Area or other identified conservation area.
	Prosperous fauna / flora	- Situated in anthropogenic grassland site of no conservation significance. Catchment area is primarily anthropogenic grassland – poor water catchment characteristics. - No known terrestrial fauna and flora of significance though riparian forest as exists needs to be conserved. - Freshwater fish :– These precise sub-catchments have not been surveyed for aquatic fauna to my knowledge. The upper Ba river basin was surveyed in 2003, and found to be a depauperate fauna likely due to deforestation, agriculture and presence of invasive species. - Fish fauna is largely dominated by invasive species, some of food significance. Migratory species are likely to be present in low numbers but not seen in surveys to date.

	Resettlement / Compensatory assets	- No resettlement of houses required, but two farm houses are indicated up the Savatu Creek which will be inundated if the Savatu dam scheme is introduced. There will also be compensation for subsistence/cash agriculture and land lease. - Subsistence agriculture minimal but present in pockets which may be affected. The upper Savatu was not visited but the presence of farm houses there indicates there may be substantial agriculture – to be determined. - Land ownership (provisional): Power house – Site is known at Namosi, Mataqali Tavurua, Navala village. Intake and lower catchment area on Mat. Navakadevo incl. Savatu R., Navala village. Upper catchment area, the same as No 7
	Historical / Cultural Heritage	- According to informants during the visit, there is an old village site at Namosi, somewhere near the power house, called Nabouwalu. This would need to be located. - There may be more sites in the vicinity which will need further careful inspection and consultation with landowners. - Further reference to the Fiji Museum data base and the Native Lands Commission is required.
	Others	- Closest village to the scheme is Koro village and these villagers use the river for fishing but they are not the landowners of the scheme. Relatively traditional village.
Others' Special Note		- Operation data of Nadarivatu power station on 21 May 2014 are as follows. No.1 unit operates from around 7:00 to around 16:30. No.2 unit also operates from around 9:00 to around 20:00. Maximum output is 34.2MW, generation discharge of about 12m^3/s. (14:30～16:15)

(Photo-1) Condition of original No.1 intake site

Topographic condition surrounding it is heaped-up huge boulders on the river bottom where carved by river erosion.

(Photo-2) Condition of alternative dam site for No.2 intake

Topographic condition surrounding it is vertical

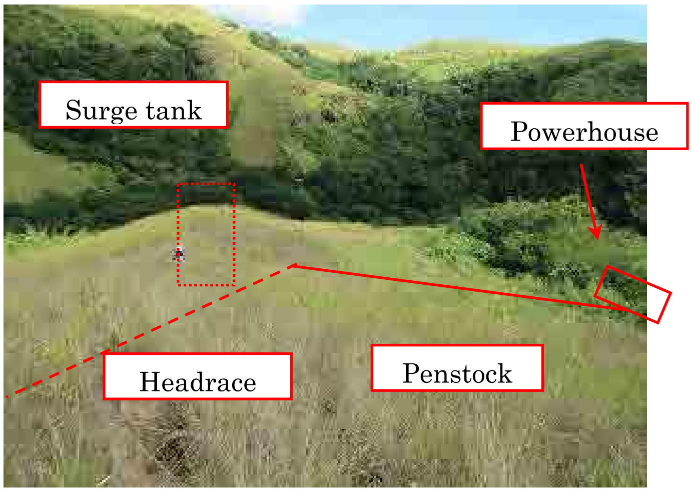
(Photo-3) Condition of alternative dam site for No.2 intake

(View from upstream of the dam site)

(Photo-4) Geological condition surrounding the dam site is Rock characteristics of massive sandstone and grooved mudstone. Even though some layer of

(Photo-5) Condition of alternative dam site for No.2 intake and the confluence of Savatu Creek and Ba River
Topographic condition of the right bank of Ba River along the headrace tunnel is characterized gentle slope and steep cliff.

(Photo-6) Condition of original powerhouse
(View from footpath on the way to original powerhouse)



(Photo-7) Condition of alternative headrace surge tank, penstock and powerhouse
(View from footpath to original powerhouse)

<table>
<tr><td colspan="2">Site Name</td><td>No.14 Naboubuco</td></tr>
<tr><td colspan="2">Location (River name)</td><td>Naboubuco River</td></tr>
<tr><td>Profile</td><td>Catchment Area (km^2)
Installed Capacity P (kW)
Design Discharge Q (m^3/s)
Effective Head H (m)</td><td>40.7
3,000
3.17
113.3</td></tr>
<tr><td rowspan="3">Geography / Geology Hydropower planning</td><td>General Geology</td><td>- Base Geology of the project area are conglomerate, grit* and sandstone of Wainimala series in Oligo-Miocene. Monzonite had intruded them in Pliocene as “sill” form.
(source : Fig.6 on p.14 of Bulletin No.3 issued in 1976. The Figure was revised from original quadrangle.)
*Grit; sandstone composed of angular particles</td></tr>
<tr><td>Approach Conditions</td><td>(Intake site)
- Since it is accessible by vehicle to Rewasau village which is the end of the road, the intake site planned is approachable from there on foot.
- On the way to the intake site, it is necessary to cross a tributary which has a catchment area of 6km^2.
- It is inaccessible to the intake site due to no footpath from the 0.3km downstream side of the site.

(Powerhouse site)
- Since the powerhouse site planned is located on the way to Rewasau village, accessibility is very good.</td></tr>
<tr><td>Intake</td><td>- Flow volume rate of tributary on the way to the intake site which has catchment area of 6km^2 is around 1.5m^3/s by the eye measurement. In order to utilize the above flow, the waterway route is altered from the left bank to the right bank of Naboubuco River.
- River flow volume rate of Naboubuco River is around 5m^3/s by the eye measurement which is more than maximum discharge of the original plan.
- Although the team could not reach the intake site due to its steep terrain, it is expected that there is some sound bedrock of Monzonite. Because rock adjacent to the site is Monzonite (Pliocene) intervened horizontally in the sedimentary rocks of Wainimala series. According to the local guide’s information, there is a water fall of 20m high. The intake site is planned to locate on the right upper stream side of the fall.</td></tr>
</table>

	Waterway / Power House	- The geology of the uppermost stream part along the waterway is Monzonite and the geology of overall downstream part is the sedimentary rock. - Since the topography surrounding the intake site and along the waterway route is steep, the waterway is altered to be a tunnel type except adjacent part of the head tank. - The head tank is altered to construct on the top of the winding hill road to Rewasau village, and penstock is altered to pass along the ridge. - Bedrock surrounding the head tank and through the penstock line is sedimentary rocks. - Powerhouse site location is altered to be on the terrace deposit which is distributed on the right bank of the river, and the geology is composed of sands and gravels.
Natural / Social Environment	Natural Park / Protected Area	- No Protected Area affected by scheme or adjacent to scheme.No Proposed Protected Area affected by scheme or adjacent to scheme. - Upper catchment is within a Key Biodiversity Area (Tomaniivi) and adjacent to but not within two Important Bird Areas (FJ07 Greater Tomaniivi; FJ08 Rairaimatuku Highlands).
	Prosperous fauna / flora	- Part of the upper catchment is high conservation value natural forest. The lower catchment is extensively secondary in nature with a long history of shifting agriculture. - The high conservation value forest in the upper catchment will likely have a significant complement of mid-altitude endemic fauna and flora including species of conservation interest. But no species are currently known only from the catchment. - The precise sub-catchment has not been surveyed for aquatic fauna to my knowledge. A nearby river basin was surveyed in 2006. Fauna is most likely to be composed of primarily migratory species (ie. gobies, gudgeons and eels), which will be of ecological, and food significance. The presence of endemic or endangered species is unknown. If the Wailoa Downstream scheme goes ahead without any migratory fish mitigation measures then these will be irrelevant for the upstream villages such as Rewasau, Roma and Naqelewai.
	Resettlement / Compensatory assets	- No resettlement of houses required. - Compensation will consist of subsistence/cash agriculture and land lease. - The powerhouse site will be located along the Nabubuco R. upstream from Naqelewai. Probably Mat. Burelevu (to be confirmed) – village to be confirmed through a visit to the Naitasiri Provincial Office. Potentially Mat Nasogo, Mat Namataniuba, Mat Vatudramu.

	Historical / Cultural Heritage	- No historical or cultural sites confirmed during the visit. This will need to be confirmed through further careful inspection and consultation with landowners and Provincial Office. - Further reference to the Fiji Museum data base and the Native Lands Commission is required.
	Others	
Others' Special Note		

Photo-1 Condition of Rewasau village and the end of access road

Photo-2 Condition of foot path from Rewasau village to the weirs

Photo-3 Condition of upstream of alternative No.2 intake Tributary flow rate is about 1.5m^3/s.
(View from downstream of the tributary)

Photo-4 Condition of downstream of original No.1 weir Wailoa River flow rate is about 5m^3/s.
(View from downstream of right bank)

Photo-5 Condition of alternative head tank
(View from the access road to Rewasau village))

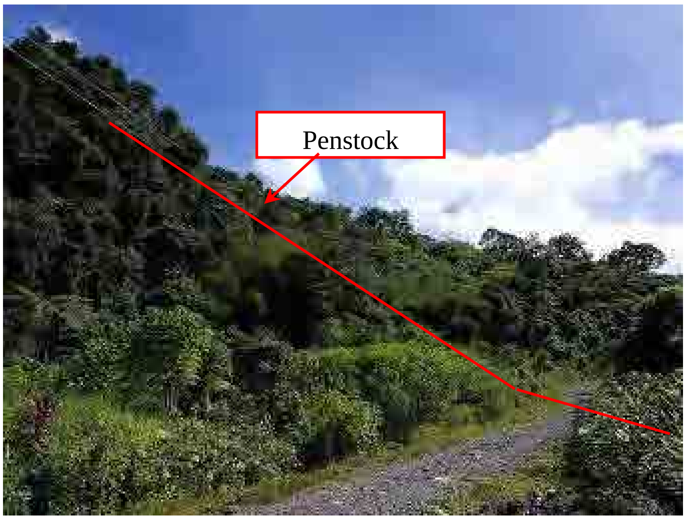


Photo-6 Condition of alternative penstock
(View from the access road to Rewasau village)

Site Name		No.24 Nakavika
Location (River name)		Navua River
Profile	Catchment Area (km^2) Installed Capacity P (kW) Design Discharge Q (m^3/s) Effective Head H (m)	115.5 3,100 7.19 54.7
Geography / Geology / Hydropower planning	General Geology	- Geology of the area consists of well-bedded mudstone and fine-grained sandstone of Navua Mudstone belongs to Mendrausuthu Andesites in Mio-Pliocene. (source : p.17 of Bulletin No.15 issued in 1968)
	Approach Conditions	(Intake site) - Since it takes about 15 minutes from Navunikabi village on foot, accessibility is very good. (Powerhouse site) - Since the both banks of Nakavika River are very steep, it is impossible to approach on foot from Nakavika village to the powerhouse site planned. - However, it may be possible to approach by descending along the northern tributary of Nakavika village.

	Intake	- Since houses in Navunikabi village are built in only about 3m higher positions from the river, it is banked with concrete walls to prevent flood in the rainy season. - The intake site is altered to locate around 300m downstream of Navunikabi village where the width of the river becomes a slightly narrow in order to avoid submerge of houses during floods. - River width of the intake site is about 40 - 50m, and river volume flow rate is around 8 - 10m^3/s by the eye measurement. - Hard and fresh gravels fully cover the riverbed. They are expected suitable material for concrete aggregate. - Most riverbed of the weir site is covered by sands and gravels, however, well-bedded mudstone and fine-grained sandstone of Navua Mudstone (Miocene – Pliocene) crop out on the left abutment of the site. Even though the thickness of overburden is unknown, it is judged these riverbed materials have enough bearing capacity for such a small height weir. - The height of weir is 2 - 3m, and its crest length is around 150 - 160m. - There are villagers' tombs on the top of hill on the right bank of Nakavika River.
	Waterway / Power House	- Waterway route is located on the right bank of the river. Since the bedrock along the waterway route is estimated deeply weathered, therefore, open channel is planned aside the above-mentioned tombs up to another downstream small tributary. After that, the tunnel type headrace is planned. However, it is important to examine carefully weathering condition along the waterway tunnel route. - Although the original headrace and the head tank are planned to locate in Nakavika village, the plan is altered to locate on the west side of Nakavika village. - In line with the above alternation, the powerhouse is also altered on the downstream of the original one. - The powerhouse site planned is inaccessible due to steep topography. Geology of surrounding the powerhouse is deemed similar with the intake site. From the geotechnical view point, though bedrock of the powerhouse site is deemed hard and sound, it may be difficult to construct the powerhouse due to narrow landform. - River flow volume rate is more than 10 m^3/s by the eye measurement.

Natural / Social Environment	Natural Park / Protected Area	- No Protected Area affected by scheme or adjacent to scheme. No Proposed Protected Area affected by scheme or adjacent to scheme. The upper catchment of the Wainikoroiluva River is part of Fiji's first REDD + project site. - The lower catchment is part of the Namosi Key Biodiversity Area; and, is immediately adjacent to (but not within) two Important Bird Areas (FJ09 Sovi Basin and FJ10 Viti Levu Southern Highlands).
	Prosperous fauna / flora	- Part of the upper catchment is high conservation value natural forest (REDD + site). The lower catchment above the intake is extensively secondary in nature with a long history of shifting agriculture. - The high conservation value forest in the upper catchment will likely have a significant complement of mid-altitude endemic fauna and flora including species of conservation interest. But no species are currently known only from the catchment. - This precise sub-catchment not surveyed for aquatic fauna to my knowledge. The upper Navua river basin was surveyed extensively in 2006 and 2009. This site is most likely to have a moderately abundant fish and crustacean fauna with several species of conservation significance. This fauna will be mainly migratory species and contain several species of food significance. - The Modo Gap is downstream from the Intake Site and upstream of the proposed powerhouse. Migratory Freshwater fish are not able to ascend above the waterfalls at this site and so the fish fauna upstream is without many of the species utilized by inland villagers– any special resident species need to be determined.

	Resettlement / Compensatory assets	- The preliminary modified scheme sees the intake downstream from Navunikabi village and immediately above the 'old village site of Bara' Which may or may not be affected. There are seven houses on this site at the moment. Resettlement of these houses may be required. Across the river at the other end of the weir is a prominent knoll with a cemetery on it. - Compensation will consist of subsistence agriculture and land lease (and potentially resettlement). Subsistence agriculture all over the lower catchment and will be affected by the proposed open channel scheme – to be confirmed. - Land ownership: Power house – to be confirmed from Nakavika village. Intake and catchment area - many mataqali residing in the five villages of upstream Wainikoroiluva District. Lower catchment is primarily Mt Nakorowaiwai and Mat. Naqelekauto. To be confirmed at the Namosi Provincial Office. - The 'Bara old village site' is prominently marked on the 1:50,000 Map. It is located immediately below the proposed (modified) weir site. It is of interest that there are now 7 households on this 'old village site'. This is likely to be a sensitive site and situation.
	Historical / Cultural Heritage	- Given the presence of the cemetery on the knoll across the river from the proposed weir site, this will need further careful inspection and consultation with landowners. Further reference to the Fiji Museum data base and the Native Lands Commission is required.
	Others	- There may be more sites along the length of the open channel, but none were reported during the site visit.
Others' Special Note		

Photo-1 Condition of and alternative weir
Nakavika River flow rate is about $10m^3/s$. There are villagers' tombs at the top of the hill on the right bank.
(View from upstream of left bank of Nakavika River)

Photo-2 Condition of Wainatava village
Top level of mound surrounding the villagers' houses is El.130m.
(View from Nakavika River)

Photo-3 Gavels which cover the riverbed is suitable for concrete aggregate.

Photo-4 Outcrop of well-bedded mudstone and fine-grained sandstone on the left abutment of the weir site.

Photo-5 Condition of alternative powerhouse
It is hard to approach powerhouse due to no footpath and steep valley.
(View from upstream of Waidina River)

Site Name		No.26 Wainavadu
Location (River name)		Waunavadu River
Profile	Catchment Area (km2) Installed Capacity P (kW) Design Discharge Q (m^3/s) Effective Head H (m)	38.1 2,700 3.33 102.6
Geography / Geology / Hydropower planning	General Geology	- The geology of the area are coarse and fine volcaniclastics with trachyte and andesite flows and limestone. These rocks belongs to Wainimbuka Trachyte* of Wainimala Group in Eocene-Miocene. - The Wainimbuka Trachyte contains three lithological units (Trachyte*, angular Conglomerate, and Limestone) which are time equivalents within the formation.(source : p.10 of Bulletin No.12 issued in 1965) *Trachyte; a group of fine grained, generally porphyritic, extrusive rocks having alkali feldspar and minor mafic minerals as the main components, and possibly a small amount of sodic plagioclase; also, any member of that group; the extrusive equivalent of Syenite.
	Approach Conditions	- Since it takes a whole day for a round trip to the intake site planned on foot, site reconnaissance was given up. It says that it is possible to approach by helicopter and verify topographical and geological conditions.
	Intake	- River flow volume rate of Wainavadu River around Dalaisakau village is around $5m^3/s$ by the eye measurement which is more than maximum discharge of the original plan. - Since there is a place suitable for dam site on the upstream side of the original plan from the viewpoints of topographic condition, alternative plan of reservoir type, which is able to operate though the year like Wailoa hydropower plant, is proposed. - However, it is necessary to carry out site reconnaissance and verify topographical and geological conditions by helicopter.
	Waterway / Power House	- It is desirable to alter waterway route from the right bank to the left bank of Wainavadu River in accordance with alteration of the intake site location.

Natural / Social Environment	Natural Park / Protected Area	- Until 2013, the Wainavadu River and catchment was part of the Sovi Basin Protected Area – Fiji' foremost and most important protected area. - In 2012, the lower catchment was excised by the Government and leased to the NewCrest-Nittetsu Joint Venture. If the mining project goes ahead, the middle reaches of the Wainavadu (above the gorge) are planned to be used for tailings disposal. - The Wainavadu remains a Key Biodiversity Area (Namosi), an Important Bird Area (FJ09 Sovi Basin) and remains as part of a Site on Fiji's Tentative List for World Heritage status.
	Prosperous fauna / flora	- All Viti Levu's endemic lower, mid montane and higher montane wet forest fauna and flora have been recorded in the Sovi-Wainavadu. It is very well surveyed and it is now even better surveyed during the Namosi Mine EIA – however, this has yet to be completed and made public. - The lower Wainavadu gorge downstream from the Intake Site and upstream of the proposed Power House is an extremely rugged stretch of river with many waterfalls. - This precise sub-catchment was extensively surveyed for aquatic fauna in 2012. This site is of high conservation significance showing high species richness and presence of rare endemic species. - This is also an unusual inland sighting spot for the endemic Orange Spotted Terapon (*Mesopristes kneri*). This is also an important site for food fishes, freshwater eels in particular. All species present are migratory in nature.
	Resettlement / Compensatory assets	- The lower catchment either side of the gorge and up including the middle reaches is leased to the NewCrest-Nittetsu Joint Venture. The land on the west of the river in the lower gorge, belongs to the Mat. Nasava of Namosi village, Wainikoroiluva District, Namosi Province. The land to the east of the river belongs to Mat. Waibasaga of Delailasakau village in Naitasiri District. - No resettlement of houses is required. - As the land is currently leased by the Joint Venture….acquiring the land will require the agreement with relevant compensation of the Joint Venture. The landowners will also be involved in any acquisition. This could be a potentially sensitive and difficult issue to sort out, more so because the river is the boundary between two Provinces Namosi and Naitasiri. - Subsistence and cash agriculture is found around the powerhouse site.

	Historical / Cultural Heritage	- The site was not visited, however, it is well researched as part of the Namosi Mine EIA (not yet submitted or published). - It is very unlikely that there are any old village sites in the gorge. Further work is required around the Power House site.
	Others	
Others' Special Note		

Photo-1 Condition of original/alternative site
(View from approach road to No.28 site along Waisoi River)

Photo-2 Condition of the confluence of Wainavadu River (flow rate: about $5m^3/s$) and Waidina River (flow rate: about $1.5m^3/s$)
(View from right bank of the confluence point)

Photo-3 Condition of the confluence point of Wainavadu River and Waidina River, Survey team is crossing Dilaiasakau River to go to the vllage for protocol (View from right bank of Wainavadu River)

<table>
<tr><td colspan="2">Site Name</td><td>No.28 Waisoi</td></tr>
<tr><td colspan="2">Location (River name)</td><td>Waisoi River</td></tr>
<tr><td>Profile</td><td>Catchment Area (km^2)
Installed Capacity P (kW)
Design Discharge Q (m^3/s)
Effective Head H (m)</td><td>17
2,100
1.41
186</td></tr>
<tr><td rowspan="3">Geography / Geology</td><td>General Geology</td><td>- Geology of this area is Basic volcanic conglomerate with volcanic breccia; minor sandstone and tuff belongs to Numbuonamboto Volcanic conglomerate in Eocene to Miocene. Numbuonamboto Volcanic conglomerate is a member of Mt. Gordon sub-Group of Wainimala Group.
(source : p.10 of Bulletin No.15 issued in 1968)
- Collapsed slopes along the road are seen at many places in this area. Most of the collapsed materials are completely weathered rock with laterization. This is the remarkable characteristics of this area.</td></tr>
<tr><td>Approach Conditions</td><td>(Intake site)
- It is necessary to cross Waidina River by 4WD at around confluence of Waisoi River and Waidina River.
- It is inaccessible to the intake site due to landslide of the approach road to the mining camp on the right bank of Waisoi River.

(Powerhouse site)
- Since there is a landslide of the approach road to Waivaka village, the team approached to the alternative penstock route on foot along the approach road on the left bank of Waidina River and looked down the alternative powerhouse from there.</td></tr>
<tr><td>Intake</td><td>- River flow volume rate of Waisoi River is around $1.5m^3/s$ by the eye measurement.
- The reconnaissance was obstructed by landslide of cutting slope to the site. Therefore, the team could not verify the geology of the scheme area.</td></tr>
</table>

	Waterway / Power House	- Since the original plan is located in the deep weathering zone, all strictures location is altered to shift in parallel to the upstream side based on the topographical condition. - Alternative powerhouse is planned to locate upstream of Waidina River in order to shorten the length of waterway and to acquire yard from topographical condition. - It is necessary to investigate the weathering depth of the alternative powerhouse's foundation, since it is concerned that weathering is deep even though the mountain is broad.
Natural / Social Environment	Natural Park / Protected Area	- No Protected Area affected by scheme although sees No.26 Wainavadu above. No Proposed Protected Area affected by scheme or adjacent to scheme. - Waisoi, despite many years of drilling and mining prospecting remains a Key Biodiversity Area (Namosi).
	Prosperous fauna / flora	- Waisoi catchment retains considerable amount of conservation value forest. The power house and intake are in areas of secondary vegetation. - All Viti Levu's endemic lower, mid montane and higher montane wet forest fauna and flora have been recorded in the Sovi-Wainavadu-Waisoi forests. It is very well surveyed and it is now even better surveyed during the Namosi Mine EIA – however, this has yet to be completed and made public. - *Acmopyle sahniana*, a podocarp (pine) – Gondwanaland relic is found within the Sovi Catchment well above the hydro scheme. It is one of only five known populations in the world. - This precise sub-catchment was extensively surveyed for aquatic fauna in 2012. This site is of low conservation significance with very low species richness and no endemics present. - All species present are migratory in nature. Several species present, however, are of importance for food.
	Resettlement / Compensatory assets	- No resettlement of houses is required. - The whole of the Waisoi catchment is reported to be leased by the Joint Venture….acquiring the land will require the agreement with relevant compensation of the Joint Venture. The landowners will also be involved in any acquisition. This could be a potentially sensitive and difficult issue to sort out. - Subsistence and cash agriculture is found around the Power House Site. Landownership is well determined but confirmation will be required from the Namosi Provincial Office.

	Historical / Cultural Heritage	- No archaeological sites were recorded from the power house site during the visit – the intake could not be visited as the road was affected by a landslide. - Consultation and work for the Namosi Mine EIA will have recorded all the sites in the area. This has yet to be submitted and become a public document.
	Others	- Land issues at Waisoi are extremely sensitive and one can expect significant problems in obtaining the necessary consents from the mine owners and the landowners.
Others' Special Note		

Photo-1 Condition of cross Waidina River in order to approach to weir
River flow rate is about 1.5m^3/s.

Photo-2 Condition of landslide along approach road to weir

Photo-3 Condition of alternative surge tank and penstock
(View from right bank of Waisoi River)

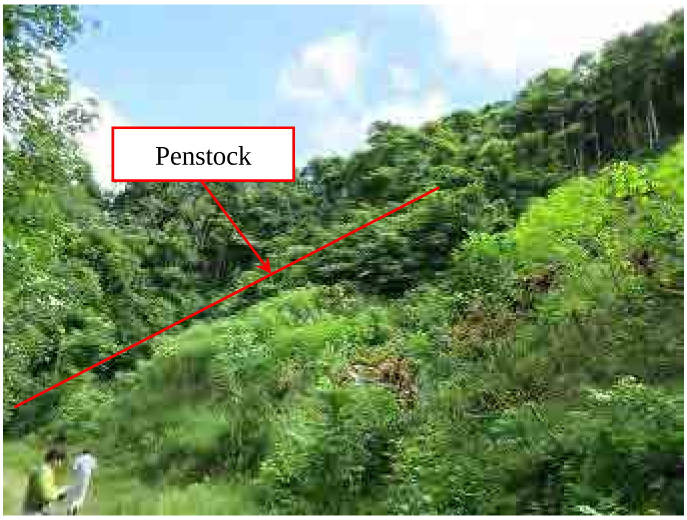


Photo-4 Condition of alternative surge tank and penstock
(View from approach road to Waivaka village)

Photo-5 Condition of landslide near the penstock

Photo-6 Condition of alternative powerhouse
(Vie from the road to Waivaka village)

Site Name		No.29 Wairokodra
Location (River name)		(Wairokodra Creek)
Profile	Catchment Area (km^2) Installed Capacity P (kW) Design Discharge Q (m^3/s) Effective Head H (m)	5.5 1,900 1.47 167
Geography / Geology Hydropower station plan	General Geology	- The bedrock of the area is augite andesite conglomerate belongs to Namosi Andesite of Mendrausuthu Andesite Group in Paleogene. (source : p.14 of Bulletin No.15 issued in 1968 and "Southern Viti Levu and Mbengga" quadrangle)
	Approach Conditions	(Intake site) - It is accessible to the intake site planned on foot around 200m from the bridge which Namosi Road crosses over Wairokodra Creek. (Powerhouse site) - It is accessible to the powerhouse site planned on foot around 300m from where Namosi Road crosses Wairokodra Creek.
	Intake	- Flow volume rate of Wairokodra Creek at the intake site planned is around 1.5 m^3/s by the eye measurement. - Boulders increase to the upstream side from the intake site planned, and river inclination becomes gradually steeper. - Augite andesite crops out on the riverbed of the weir site, and the rock is hard. Generally most outcrops along the creek are hard and fresh, though some hydrothermal alteration is recognized in part. - River becomes narrow and its bank slope is gradually steeper. Also, hard rock crops out on the downstream right bank slope of the intake site. - Under the above conditions, it is possible to increase water head by altering the intake site to the upstream side of the original one. The bedrock is deemed to have enough bearing capacity for the weir with low height.

	Waterway / Power House	- The riverside topography especially right bank is too steep to construct the open channel waterway, though whole route was not able to see from the weir site. - The rocks of the whole the scheme belongs to Namosi andesite according to the geology bulletin, however, any rock outcrops could not be verified at the powerhouse site. Terrace deposits which thickness is estimated several meters overlie on the surface of the site. Hard boulders which mean diameter is 2m are comprised in the terrace deposit. The total thickness of the deposit is estimated as several meters. - Top of the terrace is composed of mud with 1m thick. The gravel layer under the mud layer is deemed suitable for foundation of the powerhouse, since the layer has enough bearing capacity.
Natural / Social Environment	Natural Park / Protected Area	- No Protected Area affected by and no Proposed Protected Area affected by scheme or adjacent to the scheme. - The site is a Key Biodiversity Area (Namosi), and an Important Bird Area (Fj10 Viti Levu Southern Highlands).
	Prosperous fauna / flora	- The natural forest of the Waimanu catchment and southern watershed of the Waidina R. has very high conservation values and the upper catchment of the Wairokodra through which an open channel may be constructed will result in significant loss of high value natural forest. - The high conservation value forest in the upper catchment will likely have a significant complement of lowland mid-altitude endemic fauna and flora including all such species of conservation interest. - A newly described palm *Balaka diffusa* is found in one location in the world which is upstream from the intake site. It may well occur in the forest affected by the open channel. - This precise sub-catchment has not been surveyed for aquatic fauna to my knowledge. However, several nearby sites in the Waidina river basin were surveyed extensively in 2012. - These sites are of moderate species richness and abundance with one widespread endemic fish present. All species present are of migratory nature. Several species are of food significance.
	Resettlement / Compensatory assets	- No resettlement of houses is required. - The open channel will run through virgin forest down to the powerhouse site which is a cattle paddock. - Compensation for foregone timber royalties, loss of pasture and lease requirements can be expected. - The land belongs to Mat. Dakuanibure who reside in Narukunibua village.

	Historical / Cultural Heritage	- No historical sites were reported during the site visit. - The Fiji Museum records two sites in the adjacent Waivaka Creek. Further investigation is required to determine if any sites may be affected. There may be archaeological sites in the vicinity which will need further careful inspection and consultation with landowners. - Further reference to the Fiji Museum data base and the Native Lands Commission is required.
	Others	
Others' Special Note		

Photo-1 Condition of alternative weir
Wairokodra River flow rate is about 1.5m$^{3/}$s.
(View from upstream of Wairokodra River)

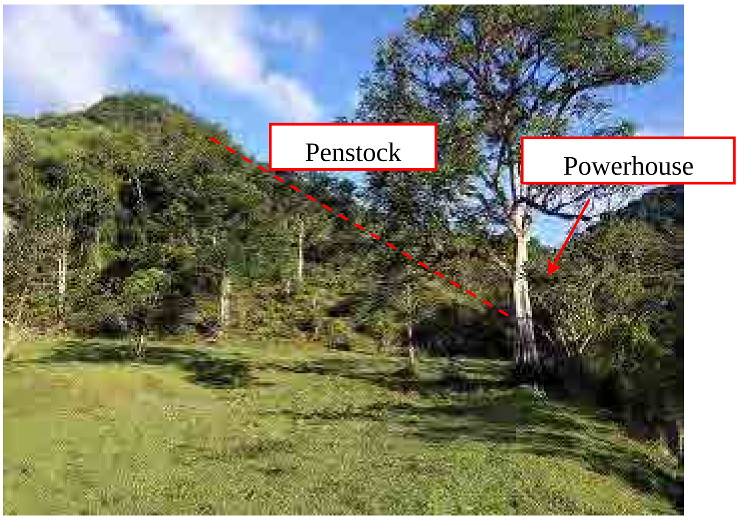


Photo-2 Condition of alternative penstock and powerhouse
(View from approach road)

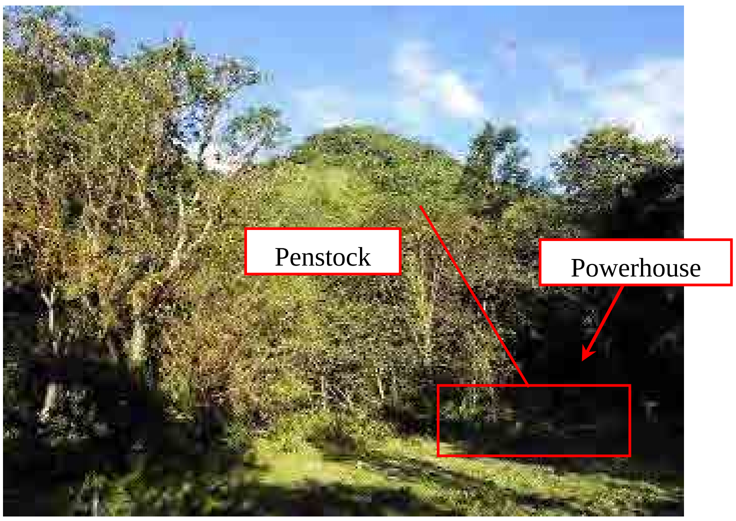


Photo-3 Condition of alternative penstock and powerhouse
(View from surrounding powerhouse)

Site Name		No.31 Saquru
Location (River name)		Saquru River
Profile	Catchment Area (km^2) Installed Capacity P (kW) Design Discharge Q (m^3/s) Effective Head H (m)	13.5 2,700 1.96 172.6
Geography / Geology / Hydropower planning	General Geology	- Rocks around the scheme area are andesite lavas, pyroclastic rocks and epiclastic breccia of Koroutani Andesite belongs to Natewa group in Miocene and Pliocene. (source : p.6 to 7 of "Koroutani Andesite" of Bulletin No.16 issued in 1969)
	Approach Conditions	(Intake site) - It is deemed difficult to approach to the intake site on foot judging from the topographical map. Instead of that, they were looked down from Delaikoro tower which is located at the uppermost watershed of its catchment area. (Powerhouse site) - It is accessible by vehicle from Labasa to the powerhouse site planned.
	Intake	- Rocks which belong to Natewa group are distributed around the whole scheme area. Their outcrops are seen at many places along the Saquru River. Most of them are moderately weathered, and it is deemed to be enough for constructing the small weir, though the rock of the site was not verified directly. - There are planting areas of mahogany surrounding Delaikoro tower of which elevation is 910m measured by portable GPS. - Although catchment area could be seen in a full view, the alternative intake sites could not be seen in the shadow of ridges. Water retention capacity in the catchment area is deemed high in line with uniform dense forest. - Since river inclination becomes steeper in the upstream area of the original plan, the intake location is planned to shift to the around 1km upstream side and two intakes is set in the two tributaries, accordingly, total water head increased around 100m.

	Waterway / Power House	- River flow volume rate of Saquru River is 0.3 - 0.5m^3/s by the eye measurement which is less than maximum discharge of the original plan. - The powerhouse location is altered to shorten the length of waterway in line with the alternation of the intake site locations. - Since there is a possibility of deep weathering zone along the waterway, it is necessary to investigate the geological condition along the waterway tunnel route. However, there is no problem in the case of open channel. - No outcrops of bedrock are seen at the powerhouse site, and red soil which thickness is more than 5m is deposited, sand and gravel layer was observed in the riverside below the red soil. It seems enough bearing capacity for the powerhouse foundation. - Powerhouse site is altered to locate at about 500 m upstream of the original powerhouse location along Wairikicake Creek. It is necessary to plan so that the penstock route is selected along a narrow ridge avoiding some landslide block area which is positioned upstream side of the ridge. Some outcrops of breccia are observed along the penstock line.
Natural / Social Environment	Natural Park / Protected Area	- No Protected Area is affected by scheme. - The Waisali protected area is approximately 10 km away in a different catchment. Vunimoli Nature Reserve is a small protected area (50 acres) also close to the site but not in the catchment, however, its precise location is not documented other than on the legal notice (refer Tabunakawai, K.M. & A Chang 1991. Register of Nature, Forest Reserves and Protected Forests in Fiji. Unpublished Report, Forestry Department, Suva). No Proposed Protected Area affected by scheme or adjacent to scheme. - Within part of Waisali Key Biodiversity Area, and FJ02 Wailevu-Dreketi Highlands Important Bird Area.

	Prosperous fauna / flora	- Formerly the catchment above the intake was an area with high conservation values, however, severe logging was undertaken of the catchment and then it was planted up with Mahogany. This will result in conversion in one or two rotations. The proposed power station is in an area of secondary vegetation mixed with sugar can agriculture. - The Long-legged warbler Trichocichla rufa clunei, a distinctive subspecies of the critically endangered species which is only known from a site in or very close to the upper catchment. It is likely to occur there as well. Additional surveys using call playback will be needed to locate this cryptic species. - Freshwater fish: – This precise sub-catchment has not been surveyed for aquatic fauna. The Upper Labasa catchment was surveyed in 2003 and 2006. The fauna is primarily depauperate due to intensive agriculture and forestry in the catchment. The overall abundance and diversity of fishes and crustaceans low. - One endangered endemic fish is present. Fauna primarily composed of migratory species, with two fish species of food significance.
	Resettlement / Compensatory assets	- No resettlement of houses is anticipated but the site of the power house needs to be finalized. The power house is on native land belonging to Mat Wairikilevu and Mat Korobugani…to be confirmed by visiting the Cakaudrove Provincial office – residential status to be determined. - The site is on the banks of the Saquru River close to the junction with the Wairikicake River. The site is leased to a cane farmer. Acquisition of the site will require settling the leasehold status of the site. - The intake and catchment is in the province of Cakaudrove – land ownership to be determined.
	Historical / Cultural Heritage	- No historical or cultural sites confirmed during the visit. This will need to be confirmed through further careful inspection and consultation with landowners and Provincial Office. - Further reference to the Fiji Museum data base and the Native Lands Commission is required.
	Others	
Others' Special Note		− There was a gauging station upstream (200 - 300m) from crossing point of Saquru River. However it is not working now. − Since this potential site is located near Labasa, it has the advantage that transmission line is short.

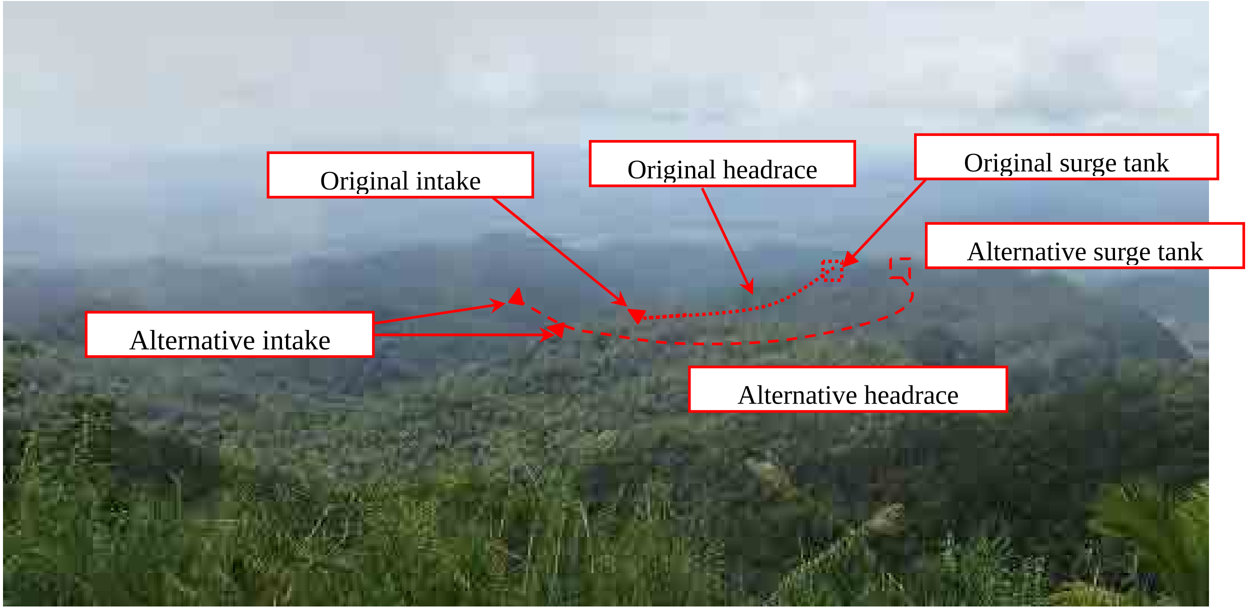


Photo-1 Condition of original and alternative plot plan
(View from Delaikoro tower (EL.920m by portable GPS)

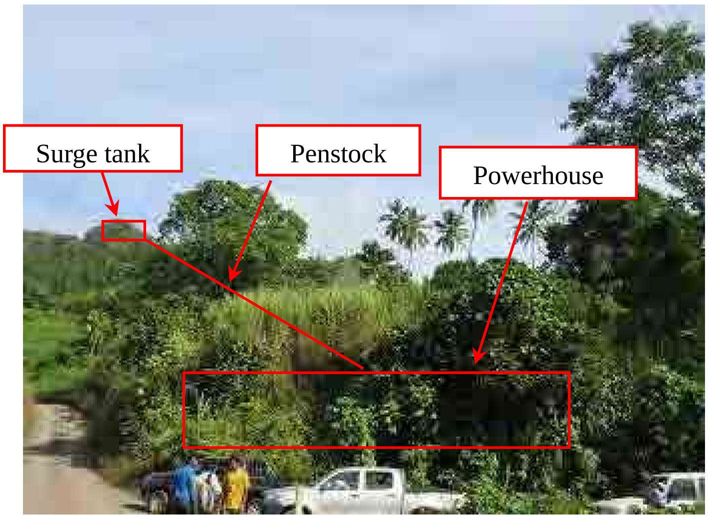


Photo-2 Condition of original surge tank, penstock and powerhouse
(View from downstream surrounding original powerhouse)

Photo-3 Condition of Saquru Creek, which flow rate is about less than 1 m^3/s.
(View from downstream surrounding original powerhouse)

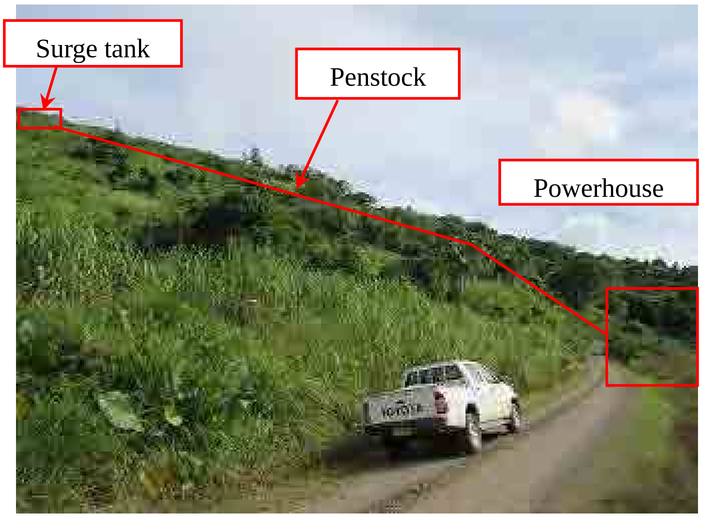


Photo-4 Condition of alternative surge tank, penstock and powerhouse (View from upstream of left bank (Wairikicake River)

Site Name		No.35 Wailevu
Location (River name)		Wailevu River
Profile	Catchment Area (km^2) Installed Capacity P (kW) Design Discharge Q (m^3/s) Effective Head H (m)	34.7 2,000 3.23 76.9
Geography / Geology Hydropower plan	General Geology	− Rock around the whole scheme area is composed of Yanawai volcanics in upper Miocene. It consists of epiclastic polymict conglomerate, reworked lapillistones, breccias and tuffs; basalt, basic andesite and rare dacite and rhyolite lava flow and breccias; lithified oozes. Natewa volcanics belongs to Mathuandrove sub-Group in Natewa volcanic group. (source p.14 to 15 of "Yanawai Volcanic formation" of Bulletin No.1 issued in 1976) − Weathered outcrop is observed in a cutting slope behind the playground of Dawara village elementary school. They are stratified some sedimentary rocks such as epiclastic polymict conglomerate, reworked lapillistones, breccias and tuffs. The strike and dip of the strata is N25W/70NE.
	Approach Conditions	(Intake site) - It is inaccessible to the intake site planned, because both bank slopes of Wailevu River become steep from around powerhouse site to upstream. (Powerhouse site) − Since it is possible to approach by vehicle to Dawara Village which is the end of the road, the powerhouse site planned is accessible from there on foot. − However, it is necessary to cross Wailevu River twice.

	Intake	- According to the geological quadrangle, the scheme area is composed of Yanawai volcanics in upper Miocene. However, the geology of the intake site was not verified in this reconnaissance. Geological condition of the intake site is deemed fair for foundation of the intake judging from the rock conditions of the powerhouse site. - In addition, since there is a possibility of constructing dam on the upper stream of the original plan from topographical condition, alternative plan of reservoir type hydropower plant, which is able to secure maximum output though the year like Wailoa hydropower plant in Viti levu, is added. - If the above plan is feasible, the original plan also can be operated as a reservoir type hydropower plant and be almost the same generation capacity of the additional one.
	Waterway / Power House	− River inclination becomes steeper from around powerhouse planned to the upper stream. − Boulder increases from the upper stream of the powerhouse site planned. River flow volume rate around powerhouse planned is 3-5m^3/s by the eye measurement which is more than maximum discharge of the original plan. − There is a ridge on the downstream side of the original powerhouse and its foot has a flat area. Therefore, penstock is planned to pass the center of the ridge and powerhouse is moved to the downstream side.
Natural / Social Environment	Natural Park / Protected Area	- No Protected Area is affected by scheme. No Proposed Protected Area affected by scheme or adjacent to scheme. - Part of Mt Kasi Key Biodiversity Area, and adjacent to but not within the FJ02 Wailevu/Dreketi Important Bird Area.
	Prosperous fauna / flora	- The water intake and the proposed power station are in natural lowland rain forest (logging status will need to be checked) - Highest known single-site tree richness (alpha diversity) for Vanua Levu based on Forestry surveys, rugged peaks, important watersheds for coastal reefs and Namena Reef, one of Fiji's highest priority reef complexes. Government of Fiji, 1994; Kretzschmar, 2000. - This precise sub-catchment has not been surveyed for aquatic fauna. The nearby Kilaka river basin was surveyed extensively in 2006, 2009 and 2010. - This nearby site is of high conservation significance with high species richness and abundance, several rare endemic species of fishes and several species of food importance. The majority of species are migratory in nature.

	Resettlement / Compensatory assets	- The water intake and the proposed power station are on land belonging to Mat. Naveitolaki who resides in Dawara village, Dreketi District, Macuata. The catchment belongs to Mat. Naveitolaki and part of it is in Wailevu District, Cakaudrove province - No resettlement of houses will be required. - Compensation will include some alluvial agriculture – mainly subsistence, timber royalties. - Part of the mataqali land is leased to a mining company – Mt Kasi Gold Mine. Location of lease boundaries in relation to the scheme will need to be confirmed.
	Historical / Cultural Heritage	- Discussion with elders in Nawara village revealed that no historical sites are known from the scheme location. There are, however, some sites known from further up the catchment. Further investigation will be required to confirm that they are not close to the scheme.
	Others	
Others' Special Note		− The end of transmission line (11kV) and distribution line is located at 13km west from the junction of Cross Island Road. − Mt. Kasi Gold Mining which is close to Dawara village was closure.

Photo-1 - Weathered outcrop is observed in a cutting slope behind the playground of Dawara village elementary school Strike and dip of the strata is N25W/70NE.

Photo-2 Condition of Yanawai River, which flow rate is about 4 m^3/s. (View from downstream of left bank surrounding original head tank)

Photo-3 Condition of Dawara Village and the end of approach road

Photo-4 Condition of original Headrace, Head tank, and alternative penstock (View from upstream of left bank on foot path to weir)

Photo-5 Condition of Yanawai River, which flow rate is about 4 m^3/s. (View from downstream of left bank around alternative powerhouse)

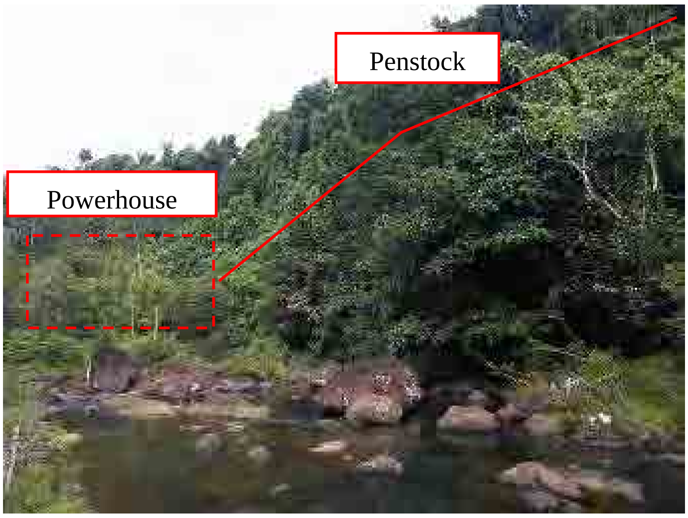


Photo-6 Condition of alternative penstock and powerhouse (View from upstream of left bank)

Appendix 6-1

Geological Conditions of

Three (3) Preliminary Designs

No.8 Mba 1 U/S Hydropower Scheme

(1) General Geology and the scheme

Geological map shown right is made gathering "Mbalevuto (sheet 5)" and a part of "Nandarivatu (sheet 6)" quadrangles.

Most part of the scheme belongs to _Mba series_ in Pliocene. The Mba series has three natural divisions;

(i) Tuffaceous mudstone and sandstone with minor conglomerate,

(ii) Interbedded sandstone and basaltic breccia, and

(iii) Interbedded basaltic flows and breccias.

Figure 0-1 General Geology Plan and the scheme

Figure 0-2 Geology Cross Sectional Profile

"Microsyenite and Basalt sills" occasionally are marked in (i); Tuffaceous mudstone and sandstone with minor conglomerate (see the WNW-ESE direction profile shown right).

Only the No.1 intake site is in the area of (ii); interbedded sandstone and basaltic breccia, and other most part of the scheme belongs to (i) area.

This scheme was improved through the team's repeated reconnaissance. Previous scheme was planned as a run-of-river type connecting two creeks' flow, but finally both the No.2 intake for power generation and the powerhouse site were changed.The primary intake point for run-off-river type was changed about 1.7km downstream as a reservoir type combined with high dam (refer the lay-out figure below).

Figure 0-3 Whole view of the scheme on the GOOGLE EARTH Image

(2) Engineering Geology

a. Weir and No.1 Intake

Photo 0-1

Whole view of the weir and intake from

It is easily accessible from Nadarivatu power station to the site using an old footpath along the left bank of Ba River.

Rocks which expose along Ba River are (i); Tuffaceous mudstone and sandstone and (ii); interbedded sandstone and basaltic breccia.

The weir and intake site is located around the boundary of interbedded sandstone and basaltic breccia. The strike and dip of the bedding plane is EW/15N, which inclines to the upstream direction. Huge boulders are scattered on the hollowed riverbed where the river curved due to river erosion. Their mean diameter is 0.5m and 4m at most.

Even though the sandstone is rather softer, the bedrock deems to have sufficient bearing capacity for a foundation of a small weir of several meters high. The scheme of weir is as follows;

Crest length of Spill way; 60m, Height of Weir; 4m (NWL; 190m, bedrock level; 186m)

b. Connection tunnel and the Outlet (Connection tunnel Length: 1,270m)

An existing footpath to the proposed outlet site is on the right bank of Ba River at the opposite of Koro village, which is in the left bank of Ba River. Though the team could not reach the site due to its topographic difficulty, but was able to gaze from the middle hillside.

There is a steep cliff on the outlet site (see the white circled portion in the left photo below), which rock may be basalt, because its topographic similarity to the opposite of the hill body on the right bank of Ba River as shown in "general geology" above. There is some possibility of mass rock creeping behind the outlet site (edged with yellow on the right photo below), detail survey for the whole slope should be done before detail design.

RMR Value of Connection Tunnel

PARAMETER			RATING
1	Strength	σc	4
2	Drill core	RQD	17
3	Spacing of Discontinuities		15
4	Condition of discontinuities	length	6
		separation	5
		roughness	5
		infilling	6
		weathering	5
5	Ground water		7
Rating adjustment			5
Total			65

The rock hardness grade along the tunnel route which 1270m long may be "R3; medium strong rock", and the estimated RMR value is 65 (refer the right table). It is categorized in "II; Good rock" on the RMR classification.

Photo 0-2
outlet of the Connection tunnel

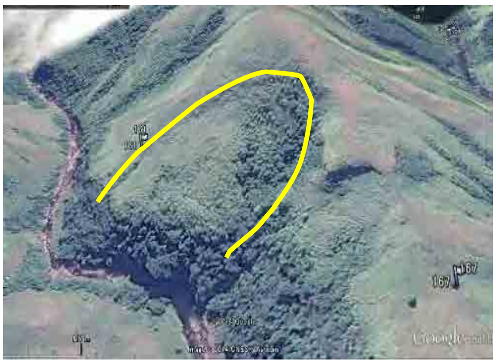


Photo 0-3
possible landslide area on the outlet

c. Dam and No.2 Intake

The valley is asymmetric box-shaped. Alternation of sound massive sandstone and slightly weak thin mudstone layer expose on the vertical cliff which height is about 20 m on the right abutment. Since the dam height is planned 42m, the slope higher part more than 22 m is not visible, therefore, both the topographic and geologic conditions are not clear. On the other hand, blocky sandstone masses scatter on the left abutment which slope is around 30 degrees.
They might have enough bearing capacity for 42 m-high dam and intake, but borings including in-situ tests at least three (on the riverbed and both right and left abutment) and seismic exploration should be executed in the detail design stage.

Huge quantity of construction materials will be necessary especially for concrete aggregate. But it will be easily able to be gathered from riverbed, and tunnel muck will also be usable.

Photo 0-4 Whole view of the dam and intake site (in the right bank) from upstream.

d. No.2 Tunnel

The rock hardness grade along the tunnel route which is planned 2000m may be “R3; medium strong rock”, and the estimated RMR value; 70 (shown in the rating of the right table) is categorized in “II; Good rock” on the RMR classification.

An inferred fault is suggested in the geological plan and schematic profile, and it is pointed on the previous GOOGLE EARTH image. Its characteristic should be made clear by detail surface geological survey and/or geophysical exploration in the next phase.

RMR Value of No.2 Tunnel

PARAMETER			RATING
1	Strength	σc	4
2	Drill core	RQD	17
3	Spacing of Discontinuities		20
4	Condition of discontinuities	length	6
		separation	5
		roughness	5
		infilling	6
		weathering	5
5	Ground water		7
Rating adjustment			5
Total			70

e. **Powerhouse and Penstock**

The powerhouse site is on the terrace which is about 20m high from the riverbed of Ba River.
Since the area is fully covered by tall wild grasses, the team couldn't see and reach the site directly, but it seems the area has enough space not only for the powerhouse but also for some stock yard of construction materials.
Penstock will lay on the broad gentle hill where some weathered mudstone crop out just under the grass land. Therefore, the location has no technical difficulties for the penstock setting.

No.29 Waivaka Hydropower Scheme

(1) General Geology and the scheme

This scheme was improved through the team's repeated reconnaissance. Preveously the scheme was planned by run-of-river type (as No.29) but finally the scheme was changed to present plan gathering two creek's flow (as No.29').

Geological map shown right covers the schemed area which is connected "Navua River (sheet 18 ; top left)", "Namosi (sheet12; bottom left)" and "Mau (sheet 19; right)"quadrangle.

The bedrock of the area is augite andesitic rocks belongs to Namosi Andesites of Mendrausuthu Andesite Group in Paleogene.

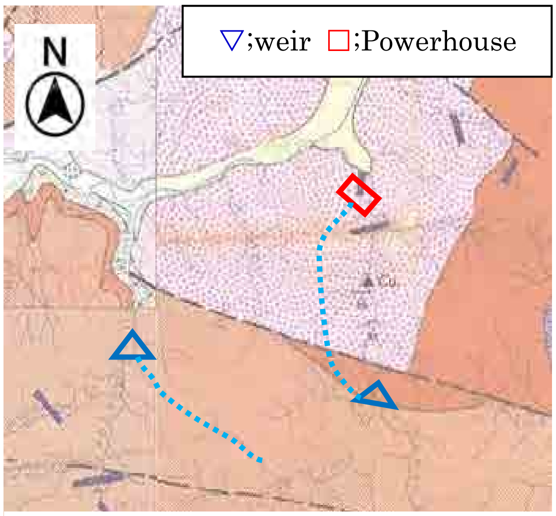


Figure 0-4

General Geology Plan and the scheme

The left figure shows a NW-SE profile which is the Waidina river cross direction at some downstream of the No.1 intake.

According to the profile, both the weir and the dam site belongs to Namosi Andesite, and the headrace to the powerhouse site belongs to Numbounamboto volcanic conglomerates which is older than Namosi Andesite. Numbounamboto volcanic conglomerates are consist of volcanic conglomerate, volcanic breccia, pillow lava, pillow breccia, and volcanic sandstone.

There are two waterways on the latest scheme which the upper one is a small weir and tunnel only for gathering the water and passing it to the different reservoir for the purpose of increasing the water volume, and the other one has a dam and headrace tunnel for power generation.

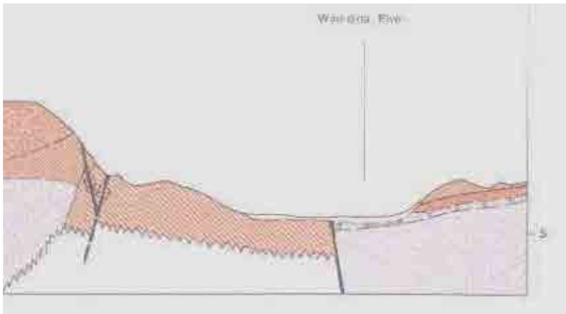


Figure 0-5

Geology Cross Sectional Profile

(2) Engineering Geology

a. No.1Weir and No.1 Intake

The site is just downstream on the confluence of Wainitunikadua and Wainiveikarawa creek. Namosi Andesite might be exposed in the riverbed of the weir site, but the team couldn't reach the point due to its topographic difficulty.

Altered Andesitic rocks are exposed on above 300m upper reach of the site. There are two types which altered, but quite hard Andesite and altered, soften Andesite volcanic conglomerate. The soft weaken zones are exposed frequently along the creek with several meters width which strike and dip is N30W/80NE (see the photos shown next page).

It is estimated that the bedrock will have enough bearing capacity for just only about 5m-height small weir. However, since the weaken layers may often be emerged out at many places, the exact candidate dam site

should be examined by detail surface survey based on the accurate topographic map because the crest of the weir will be about 120m long. The scheme of weir is as follows;
Total Crest length of the weir; 121m, (Spillway part; 25m),
Height of Weir; 5m (NWL; 323m, bedrock level; 318m)

Photo 0-5 Outcrop of Namosi Andesite 300m upstream of the proposed weir site

Photo 0-6 altered, but hard Andesite

Photo 0-7 altered and soften Andesite volcanic conglomerate

b. **Connection tunnel and Outlet**

The bedrock along the connection tunnel route as well the outlet site may be weaken by hydrothermal alteration and weathering.
The rock hardness grade along the tunnel route (length 1700m) may be “R1; very weak rock”, and the estimated RMR value; 39 (refer the right table) is categorized in the lowest level of “IV; very poor rock” on the RMR classification.
Full face reinforced concrete lining with timbering might be required for the whole range of the tunnel route which 1700m long.
Seismic prospecting combined with some borings are necessary on the tunnel route to confirm the rock characteristic in the next stage.

RMR Value of Connection tunnel

PARAMETER			RATING
1	Strength	σc	1
2	Drill core	RQD	5
3	Spacing of Discontinuities		15
4	Condition of discontinuities	length	4
		separation	6
		roughness	6
		infilling	2
		weathering	1
5	Ground water		4
Rating adjustment			5
Total			39

c. **Dam and No.2 intake**

Very fresh and quite hard andesite outcrops are scattered on the riverbed of the proposed dam site. They might have enough bearing capacity for around 40m-high dam and intake, but their distribution should be made clear by detail surface reconnaissance based on the accurate topographic map, because some hydrothermal altered rock is exposed on the next of the fresh rock. Some borings including Lugeon tests and seismic exploration should be carried out to examine the bedrock condition on the same time in the next stage.The scheme of dam is as follows;
Height of dam; 41m (HWL; 309m, bedrock level; 273m), Crest length; 377m.

Photo 0-8 Fresh and hard Andesite on the right bank riverbed of the proposed dam site

Photo 0-9 Andesite outcrops of the proposed dam site viewed from down stream

Photo 0-10　Hydrothermal altered zone on the right bank which is next of the previous outcrop (right edge)

d. **Headrace Tunnel**

Whole route of the scheme belongs to the rocks of Numbuonamboto volcanic conglomerates.
According to the reconnaissance of the powerhouse site, there is exposed excellent rock aside the creek (refer the photo shown next article). It is deemed the rock along the hedrace tunnel route which is planned 1590m long might has no difficult issues accordingly, but some weak zones may hide considering the geological circumstances of this area.
Detail geological reconnaissance along the creek is recommendable to examine the geotechnical condition in the next stage.

e. **Penstock and Powerhouse**

The site is in the confluence of Wainimanumanu Creek (right tributary) and main Creek. The ground surface of the area is covered by natural vegetation and cultivated crops owned by a villager. It is judged the site is suitable for the powerhouse from the topographic and geological view point. The penstock is planned with 465m long. Whole view from the penstock to the powerhouse site is shown below.

Photo 0-11　Planned Penstock line and the proposed Powerhouse site which is on the left bank of Wainimanumanu creek

Photo 0-12　Outcrop of Numbuonamboto volcanic conglomerates
on the left bank just beneath the powerhouse site

No.35 Wailevu Hydropower Scheme

Appendix 6-1-3

(1) General Geology and the scheme

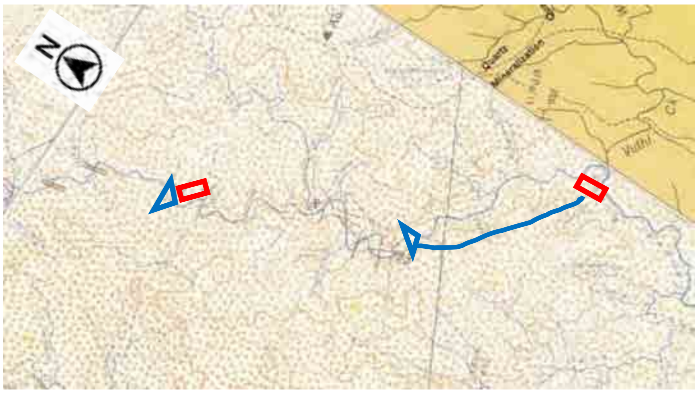


Figure 0-6 General Geology Plan and the scheme

“Wainunu Bay (sheet 10)” and “Savusavu Bay West (sheet 11)” quadrangle cover the schemed area, and the whole area of No.35 scheme belongs to Yanawai volcanics in upper Miocene.

Even though the symbols in both quadrangles are different (shown the right figure), they belongs to the same Yanawai volcanics (which consists of epiclastic polymict conglomerate, reworked lapillistones, breccias and tuffs; basalt, basic andesite and rare dacite and rhyolite lava flow and breccias; lithified oozes).

This scheme was improved through the team’s repeated reconnaissance. Previously the scheme was planned by run-of-river type but finally the scheme was changed to the present plan. There are two power generations which the upper one is a dam type, and the lower one has a small weir and run-of-river type open channel headrace which follows the original plan.

(2) Engineering Geology

(a). No.2 Dam and No.2 powerhouse (Scheme of the dam; height: 32m, crest length: 520 m)

Photo 0-13 Lapillistone on the riverbed of Wailevu creek

Photo 0-14 Lapillistone on the left bank of Wailevu creek

It is accessible on foot from the end of a desolate forest road which is on the right bank of Wailevu creek. The survey team traced the path, and finally reached the riverside where the forest road cross the creek, which is about 2 km upstream from the weir site. There is a broad expose of lapillistone on the river floor (see the right photo). The rock is slightly weathered but sound. Two obvious vertical joints are found on the rock surface, both strikes are N45E and EW.

Outcrops are seen along the creek and one excellent outcrop is occurred on the left bank of the creek where the gorge at around 1 km upstream from the proposed dam site. The rock is sound lapillistone having bedding plane incline 15 degree to SW direction (see the right picture).

The team tried to reach the dam site along and on the creek as well, but at last the team couldn’t get the location caused by various difficulties, in short, the creek

has a moderate slope which affects the creek bed deep, and furthermore both right and left bank of the creek is covered by thick bushes.
Actually just downstream of the above outcrops, there are deep pond because all of them have small falls.
Geological condition of the intake site is deemed fair for above mentioned scale dam based on the reconnaissance result. The topographic characteristic of the end point and the dam site has similar topography, where both side have narrow gorge. The rock expose on the end point is sound and massive.

Huge quantity of Construction materials will be necessary especially for concrete aggregate. It will be brought from a possible quarry site which is about 3km upstream of the dam site.

- **Construction materials for the dam**

Concrete aggregate for the dam shall be get in and surrounding the reservoir area.
One candidate site is on the right bank of Wailevu creek near the desolate forest road. The rock is hard and fresh some basic rock, and will be valuable for the concrete aggregate. The site is easily accessible to the road.

Photo 0-15
A candidate for the quarry along the Wailevu creek near the desolate forest road

Photo 0-16
Hard and fresh basic rock deemed usable for the concrete aggregate

No.1 Weir and intake

The site is also not surveyed because of the topographic difficulty, but the bedrock will has enough bearing capacity for both such small structures.The scheme of weir is as follows;
Total Crest length of the weir; 61m, (Spillway part; 35m),
Height of Weir; 5m (NWL; 140m, bedrock level; 135m)

No.1 Headrace (Length: 2540m)

Open channel headrace was recommended at the time the team's reconnaissance based on the existing topographic map, but tunnel is rather desirable seeing the revised detail topographic map which was made by orthophoto mapping.
Most suitable waterway should be examined based on the accurate topographic map.

Penstock and No.1 Powerhouse (Penstock Length: 387m)

From the view point of physiographic feature, the ridge for the penstock is deemed stable.
No outcrops of bedrock are seen at the planned powerhouse site, but huge hard boulders are scattered surrounding the area and exposure of hard bedrock is found on the opposite side of the creek, therefore, this site will be suitable for the powerhouse yard.
Bank protection works is recommendable for the unusual flood attack on the upstream side of the powerhouse.

Photo 0-17 Planned Penstock line and the Powerhouse site which is on the right bank of Wailevu creek

Criteria for Engineering Geological Assessment

Following criteria are applied for the engineering assessment.

Rock hardness and weathering shown in the tables below are applied in the field. RMR system shown on the tables are applied only for tunnel assessment.

Table 3-1: Field Estimation of Rock Hardness (after ISRM 1981)

Grade	Description	Field Identification	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak rock	Indented by thumbnail.	0.25 - 1
R1	Very weak rock	Material can be shaped with a pocket knife or can be peeled by a pocket knife. Crumbles under firm blows of pick (or point) of geological hammer.	1.0 – 5.0
R2	Weak rock	Knife cuts material but too hard to shape into triaxial specimens or material can be peeled by a pocket knife with difficulty. Shallow indentations (< 5mm) made by firm blow with pick (or point) of geological hammer.	5.0 - 25
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife. Hand held specimens can be fractured with single firm blow of geological hammer.	25 - 50
R4	Strong rock	Hand held specimens requires more than one blow of geological hammer to fracture it.	50 - 100
R5	Very strong rock	Specimen requires many blows of geological hammer to break intact rock specimens (or to fracture it).	100 - 250
R6	Extremely strong rock	Specimen can only be chipped under repeated hammer blows, rings when hit.	> 250

Table 3-2: Weathering Classification (after ISRM 1981)

Term	Symbol	Description	Discoloration Extent	Fracture Condition	Surface Characteristics
Residual Soil	W6	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	Throughout	N/A	Resembles soil
Completely Weathered	W5	100% of rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	Throughout	Filled with alteration minerals	Resembles soil
Highly Weathered	W4	More than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.	Throughout	Filled with alteration minerals	Friable and possibly pitted
Moderately Weathered	W3	Less than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones. Visible texture of the host rock still preserved. Surface planes are weathered (oxidized or carbonate filling) even when breaking the "intact rock".	>20% of fracture spacing on both sides of fracture	Discoloured, may contain thick filling	Partial to complete discoloration, not friable except poorly cemented rocks
Slightly Weathered	W2	Discoloration indicates weathering of rock material on discontinuity surfaces (usually oxidized). Less than 5% of rock mass altered.	<20% of fracture spacing on both sides of fracture	Discoloured, may contain thin filling	Partial discoloration
Fresh	W1	No visible sign of rock material weathering.	None	Closed or Discoloured	Unchanged

Table 4: Rock Mass Rating System (After Bieniawski 1989).

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

	Parameter		Range of values						
1	Strength of intact rock material	Point-load strength index	>10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range - uniaxial compressive test is preferred		
		Uniaxial comp. strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core Quality RQD		90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		> 2 m	0.6 - 2 m	200 - 600 mm	60 - 200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
	Rating		30	25	20	10	0		
5	Groundwater	Inflow per 10 m tunnel length (l/m)	None	< 10	10 - 25	25 - 125	> 125		
		(Joint water press)/(Major principal σ)	0	< 0.1	0.1 - 0.2	0.2 - 0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)

Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100 ← 81	80 ← 61	60 ← 41	40 ← 21	< 21
Class number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK CLASSES

Class number	I	II	III	IV	V
Average stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)	> 400	300 - 400	200 - 300	100 - 200	< 100
Friction angle of rock mass (deg)	> 45	35 - 45	25 - 35	15 - 25	< 15

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY conditions

Discontinuity length (persistence)	< 1 m	1 - 3 m	3 - 10 m	10 - 20 m	> 20 m
Rating	6	4	2	1	0
Separation (aperture)	None	< 0.1 mm	0.1 - 1.0 mm	1 - 5 mm	> 5 mm
Rating	6	5	4	1	0
Roughness	Very rough	Rough	Slightly rough	Smooth	Slickensided
Rating	6	5	3	1	0
Infilling (gouge)	None	Hard filling < 5 mm	Hard filling > 5 mm	Soft filling < 5 mm	Soft filling > 5 mm
Rating	6	4	2	2	0
Weathering	Unweathered	Slightly weathered	Moderately weathered	Highly weathered	Decomposed
Ratings	6	5	3	1	0

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING**

Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip - Dip 45 - 90°	Drive with dip - Dip 20 - 45°	Dip 45 - 90°	Dip 20 - 45°
Very favourable	Favourable	Very unfavourable	Fair
Drive against dip - Dip 45-90°	Drive against dip - Dip 20-45°	Dip 0-20 - Irrespective of strike°	
Fair	Unfavourable	Fair	

* Some conditions are mutually exclusive . For example, if infilling is present, the roughness of the surface will be overshadowed by the influence of the gouge. In such cases use A.4 directly.
** Modified after Wickham et al (1972).

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)

Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Rating	100 ← 81	80 ← 61	60 ← 41	40 ← 21	< 21
Class number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK CLASSES

Class number	I	II	III	IV	V
Average stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)	> 400	300 - 400	200 - 300	100 - 200	< 100
Friction angle of rock mass (deg)	> 45	35 - 45	25 - 35	15 - 25	< 15

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY conditions

Discontinuity length (persistence)	< 1 m	1 - 3 m	3 - 10 m	10 - 20 m	> 20 m
Rating	6	4	2	1	0
Separation (aperture)	None	< 0.1 mm	0.1 - 1.0 mm	1 - 5 mm	> 5 mm
Rating	6	5	4	1	0
Roughness	Very rough	Rough	Slightly rough	Smooth	Slickensided
Rating	6	5	3	1	0
Infilling (gouge)	None	Hard filling < 5 mm	Hard filling > 5 mm	Soft filling < 5 mm	Soft filling > 5 mm
Rating	6	4	2	2	0
Weathering	Unweathered	Slightly weathered	Moderately weathered	Highly weathered	Decomposed
Ratings	6	5	3	1	0

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING**

Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip - Dip 45 - 90°	Drive with dip - Dip 20 - 45°	Dip 45 - 90°	Dip 20 - 45°
Very favourable	Favourable	Very unfavourable	Fair
Drive against dip - Dip 45-90°	Drive against dip - Dip 20-45°	Dip 0-20 - Irrespective of strike°	
Fair	Unfavourable	Fair	

* Some conditions are mutually exclusive . For example, if infilling is present, the roughness of the surface will be overshadowed by the influence of the gouge. In such cases use A.4 directly.
** Modified after Wickham et al (1972).

Appendix 6-2

Design Drawings for

No.8 Mba 1 U/S Hydropower Scheme

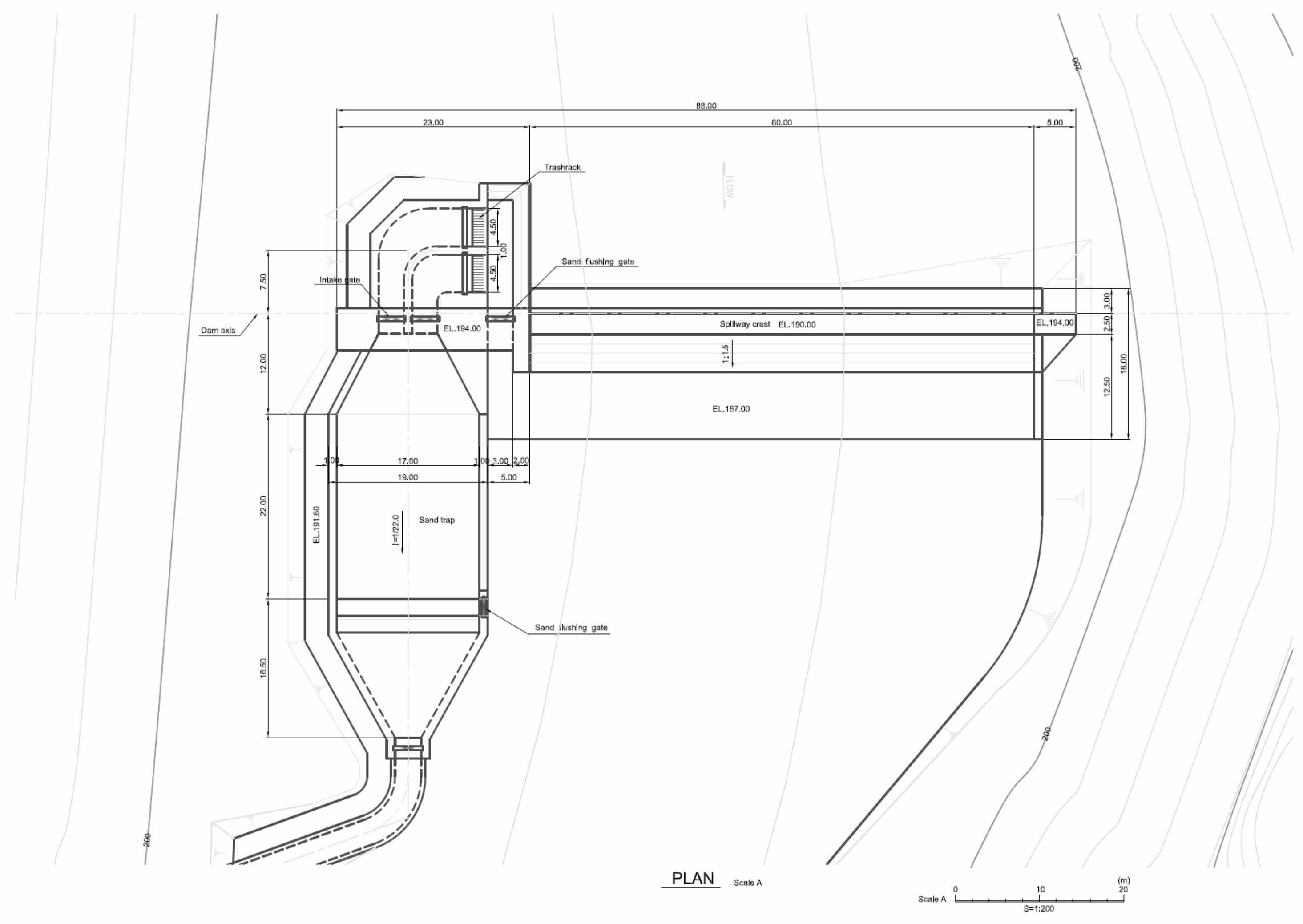


Figure 6-2.1 Plan of No.1 Intake Weir

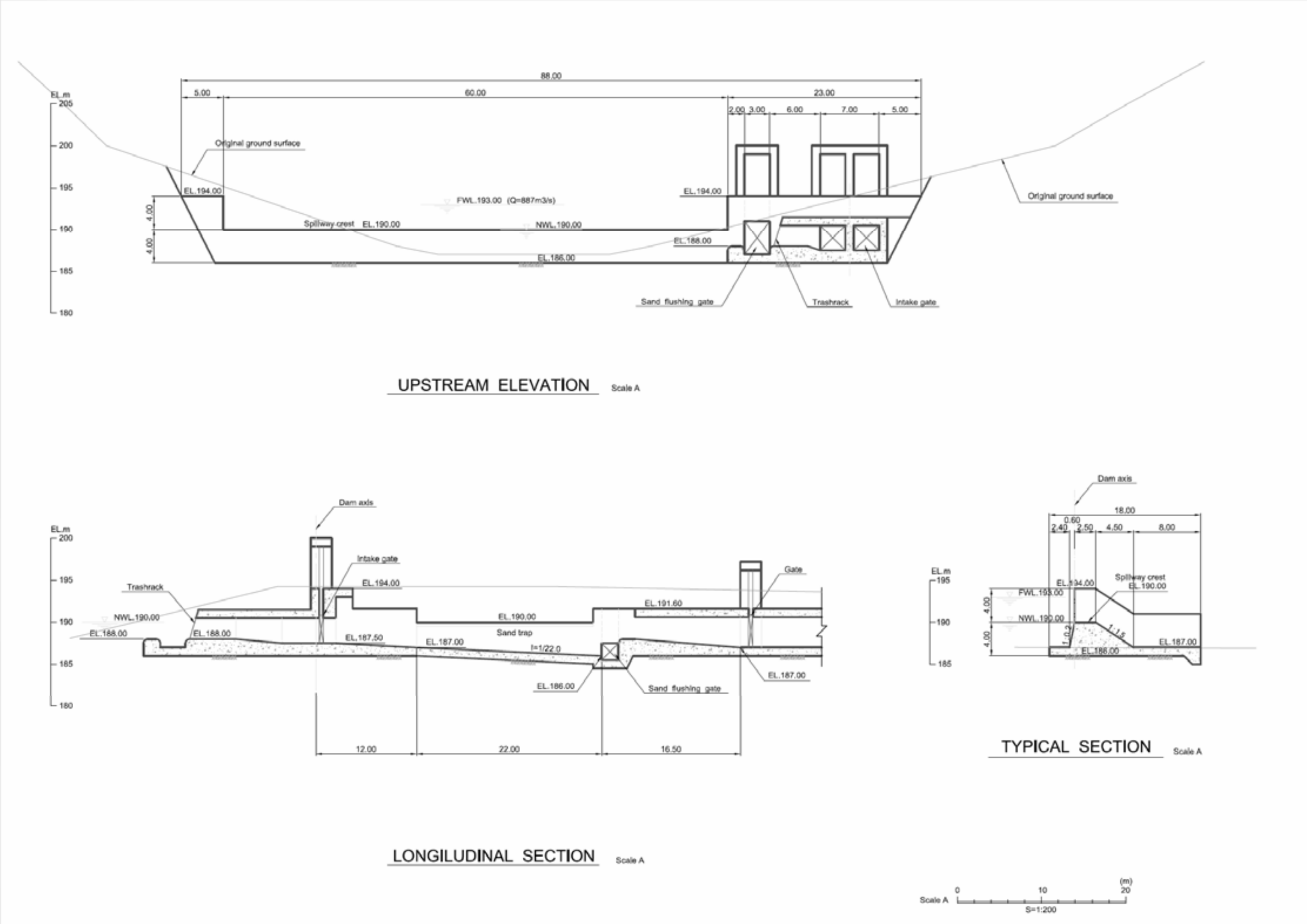


Figure 6-2.2 Elevation and Sections of No.1 Intake Weir

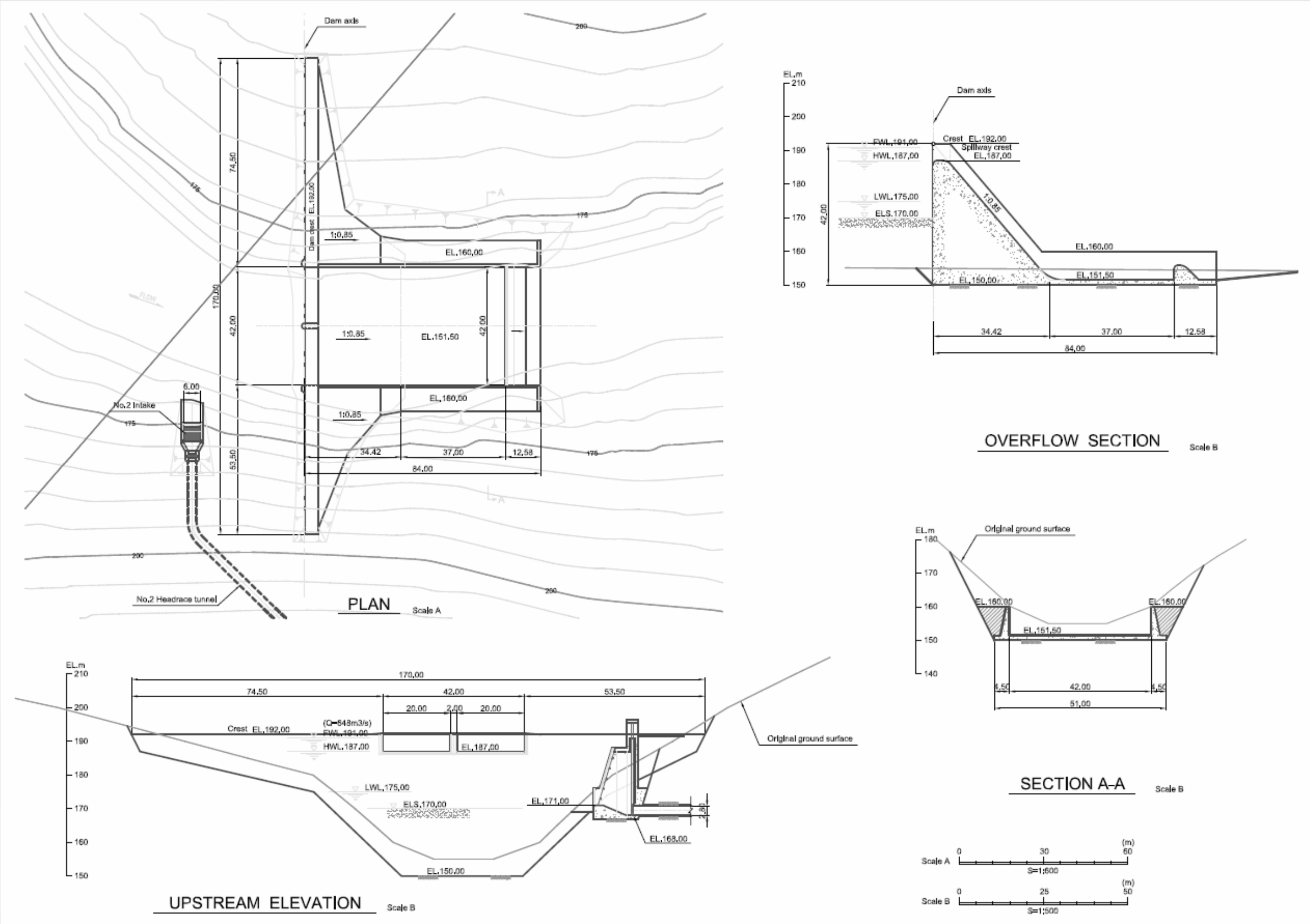


Figure 6-2.3 Plan and Sections of No.2 Dam

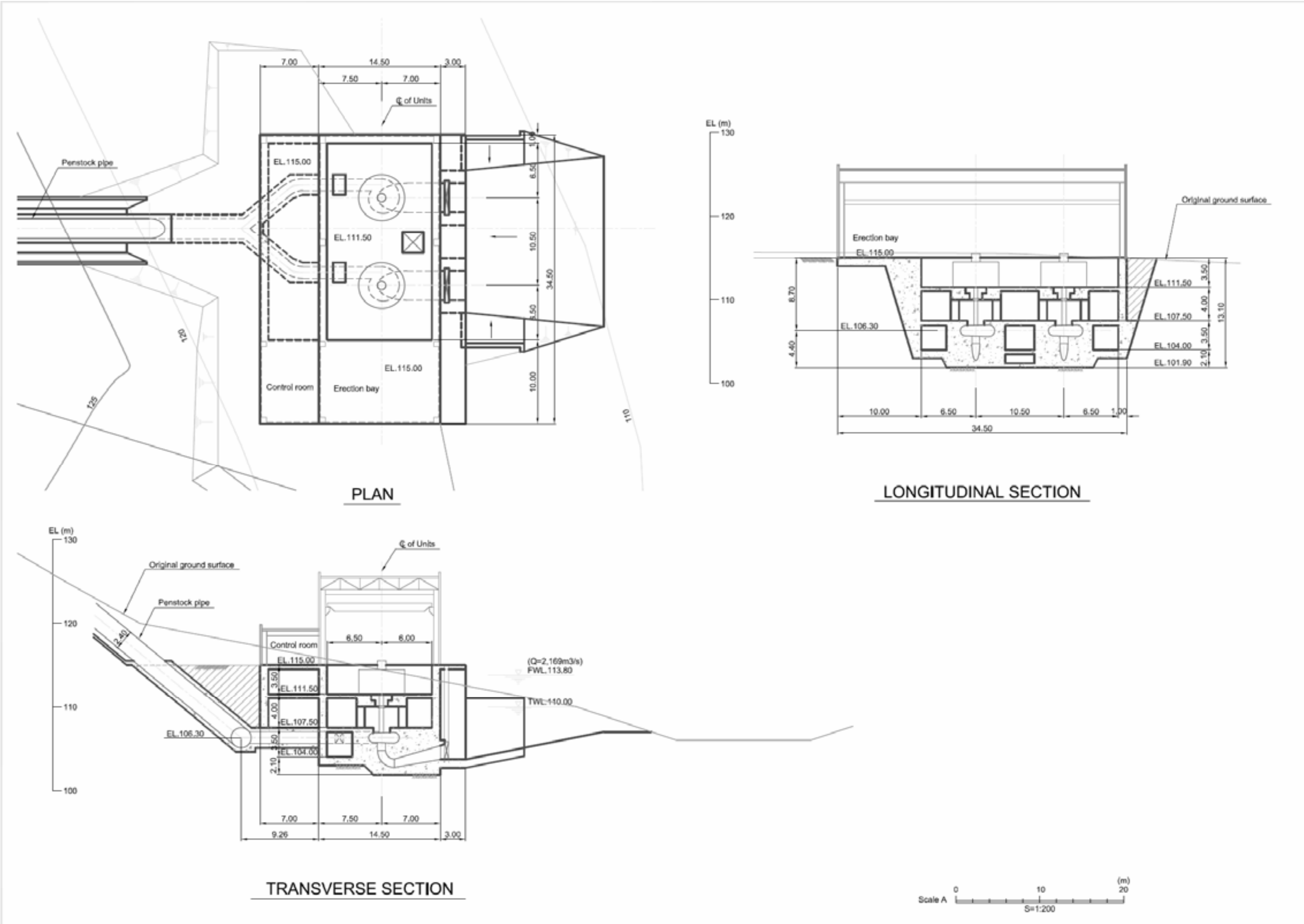


Figure 6-2.4 Plan and Sections of Power House

Appendix 6-3

Design Drawings for

No.29 Waivaka Hydropower Scheme

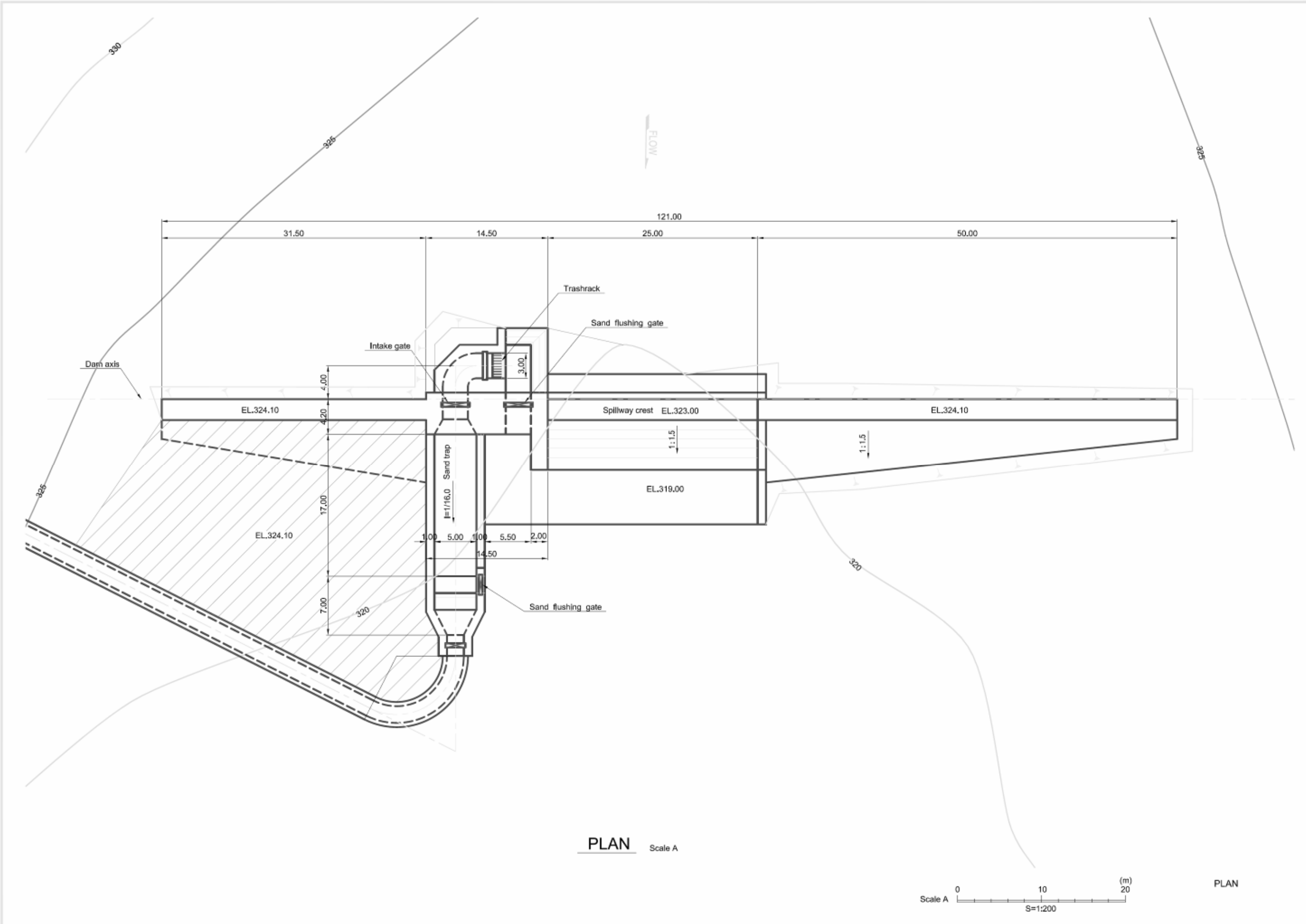


Figure 6-3.1 Plan of No.1 Intake Weir

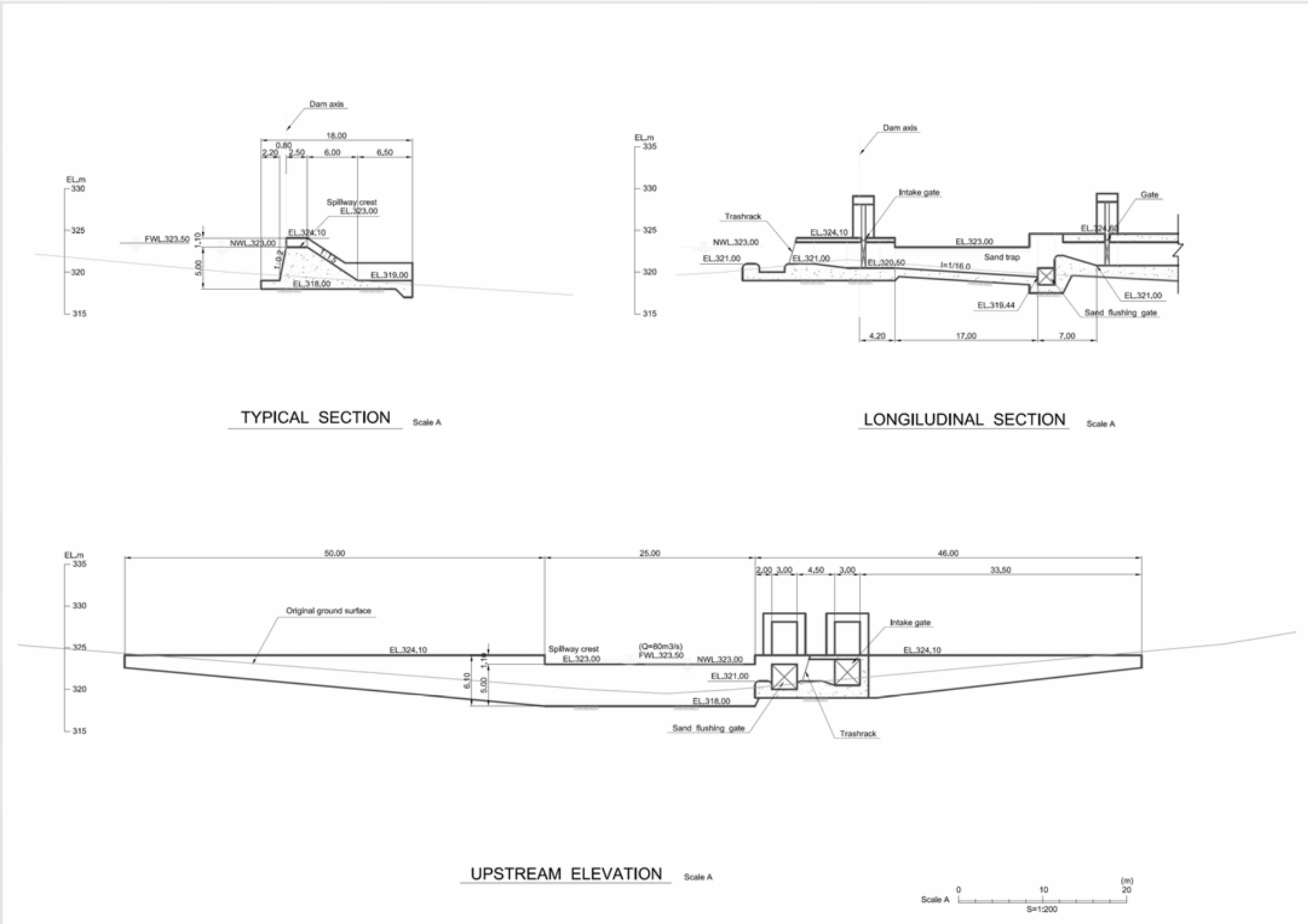


Figure 6-3.2 Elevation and Section of No.1 Intake Weir

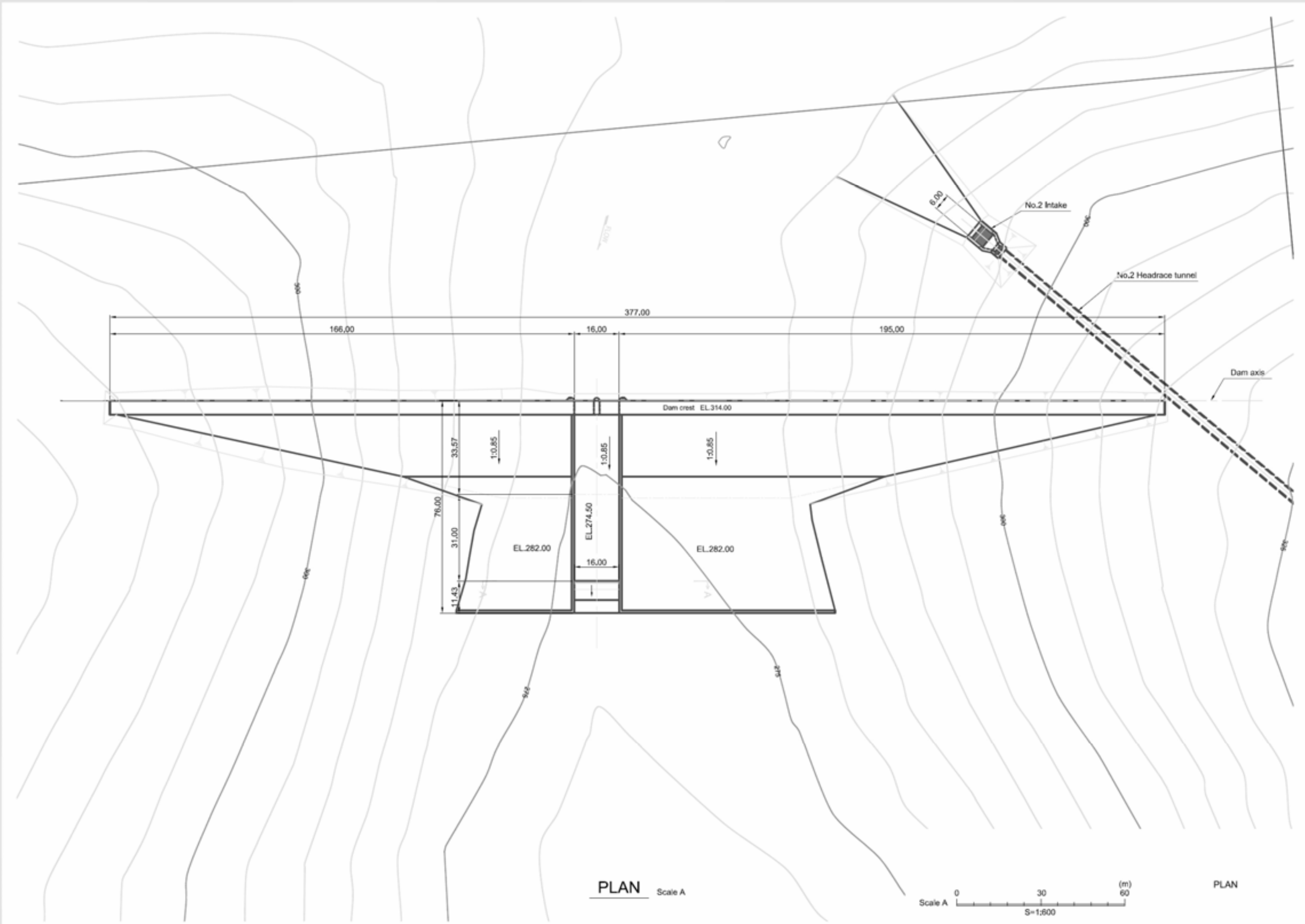


Figure 6-3.3 Plan of No.2 Dam

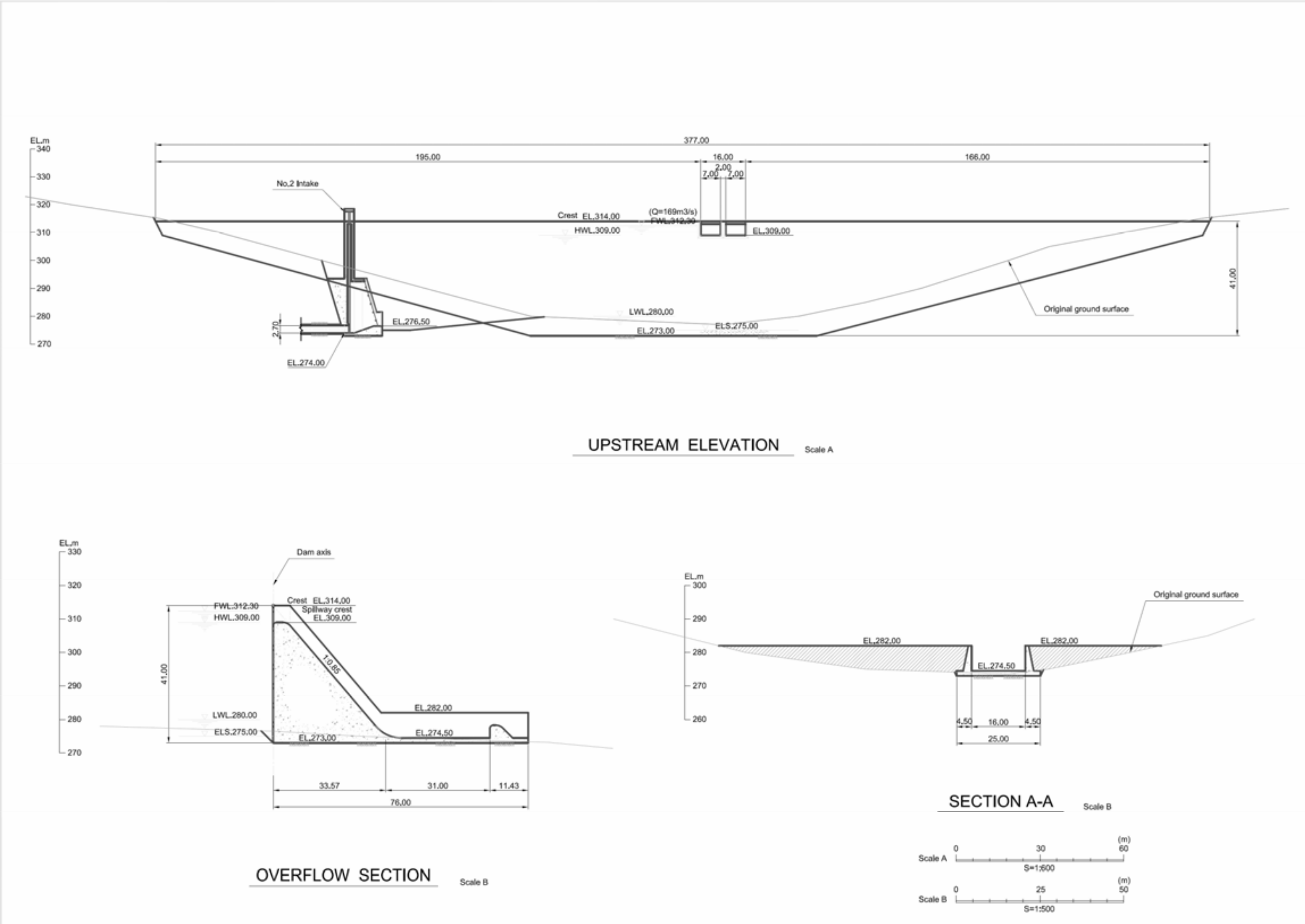


Figure 6-3.4 Plan and Sections of No.2 Dam

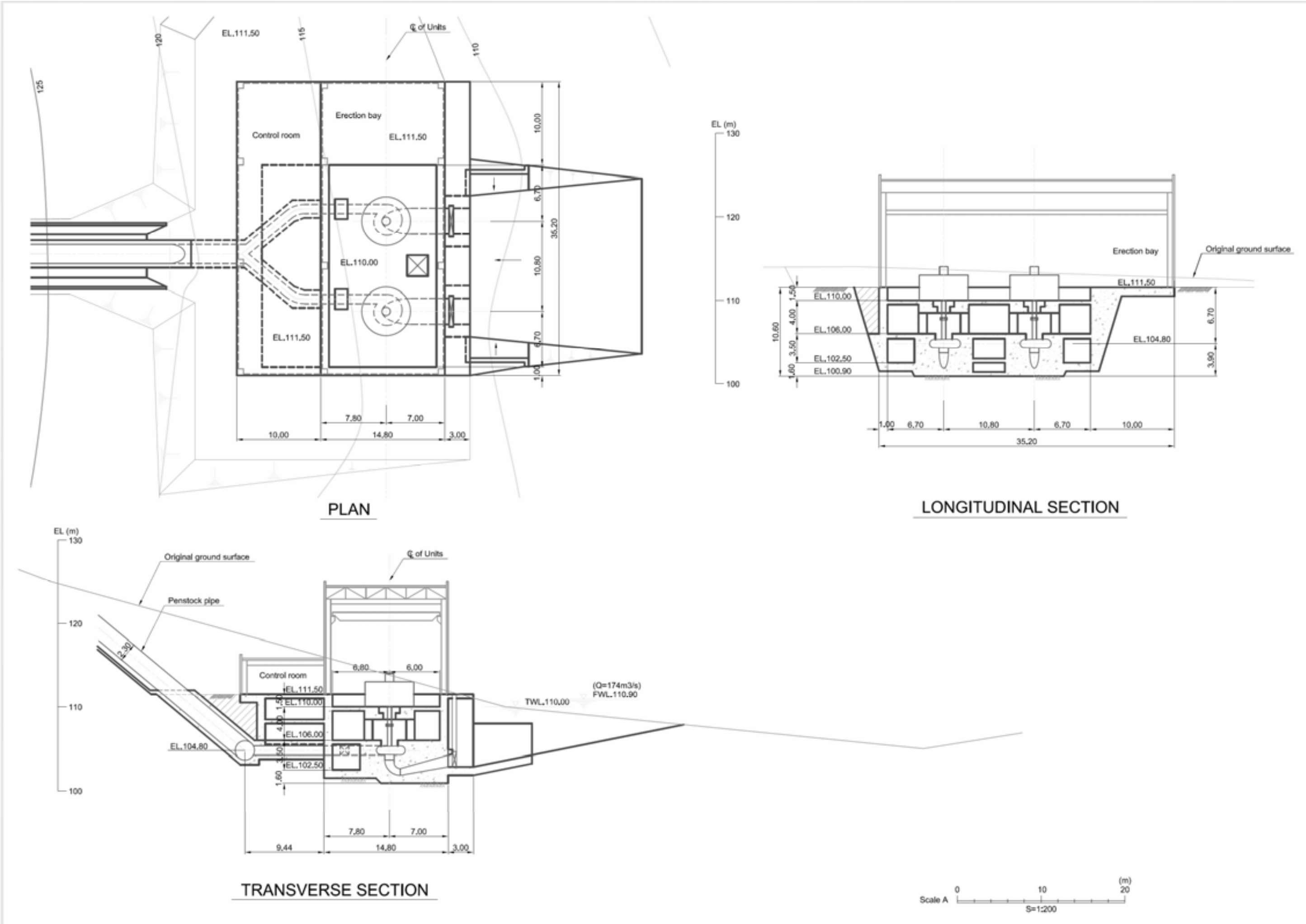


Figure 6-3.5 Plan and Sections of Power House

Appendix 6-4

Design Drawings for

No.35 Wailevu Hydropower Scheme

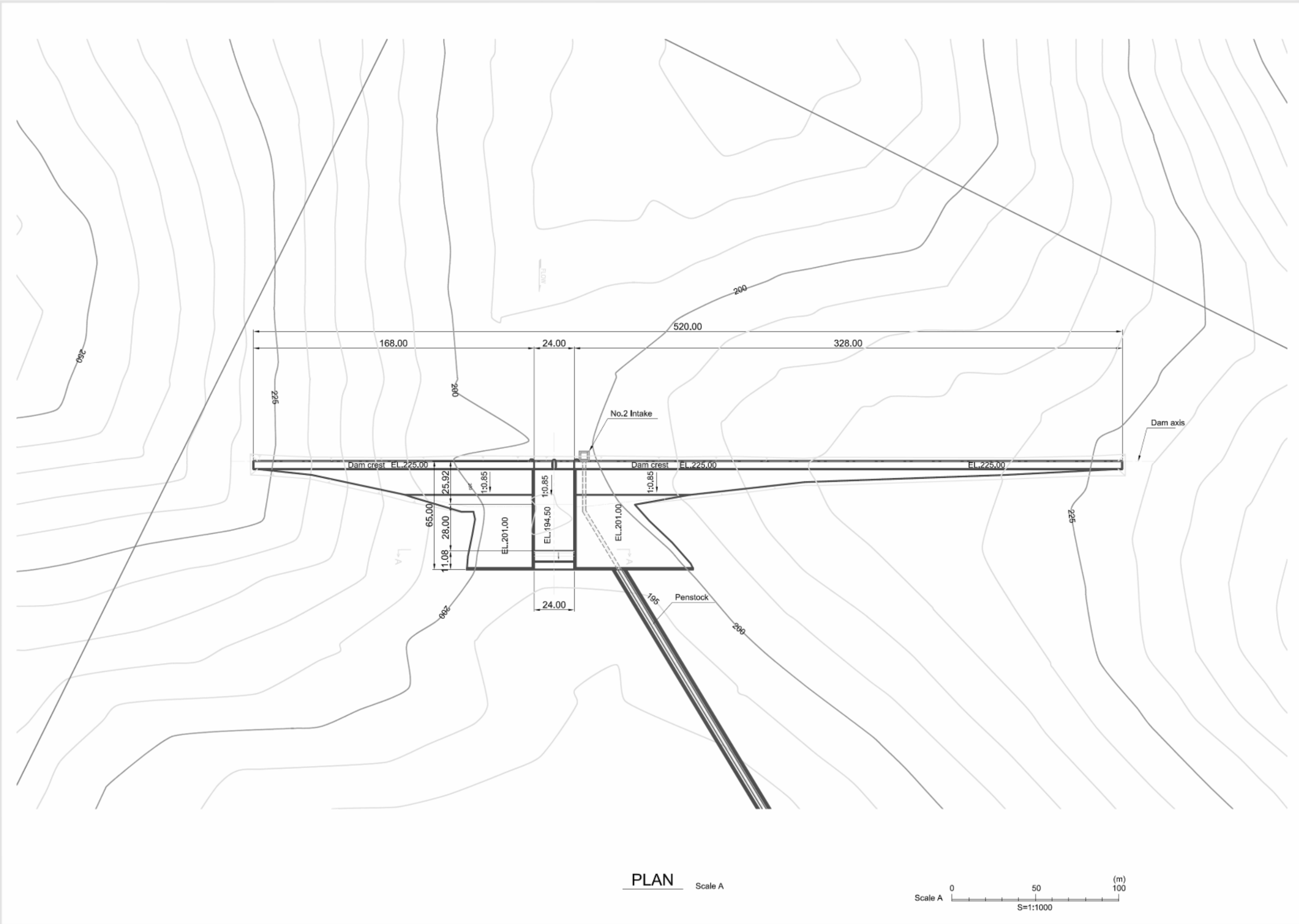


Figure 6-4.1 Plan of No.35-2 Dam

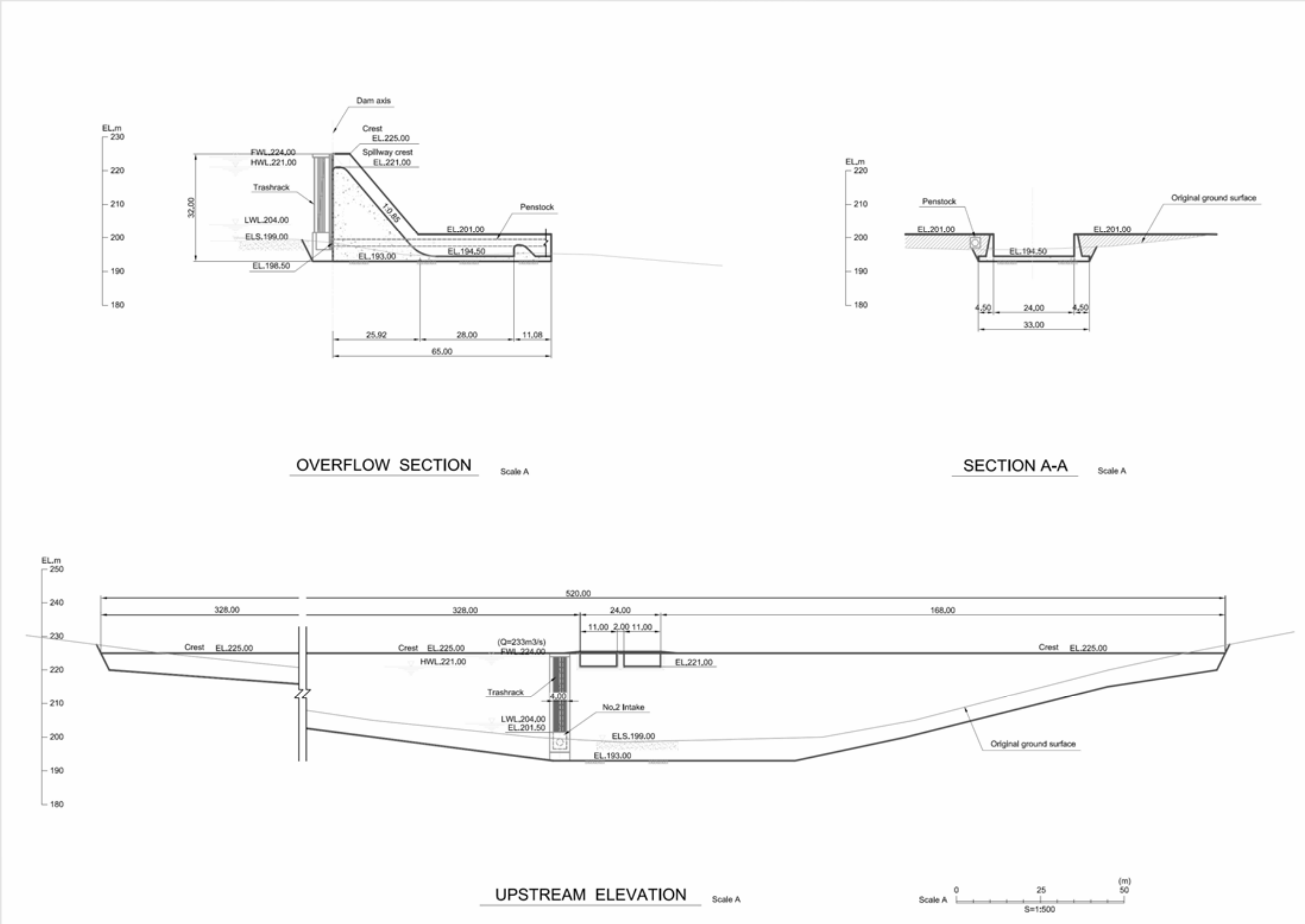


Figure 6-4.2 Elevation and Section of No.35-2 Dam

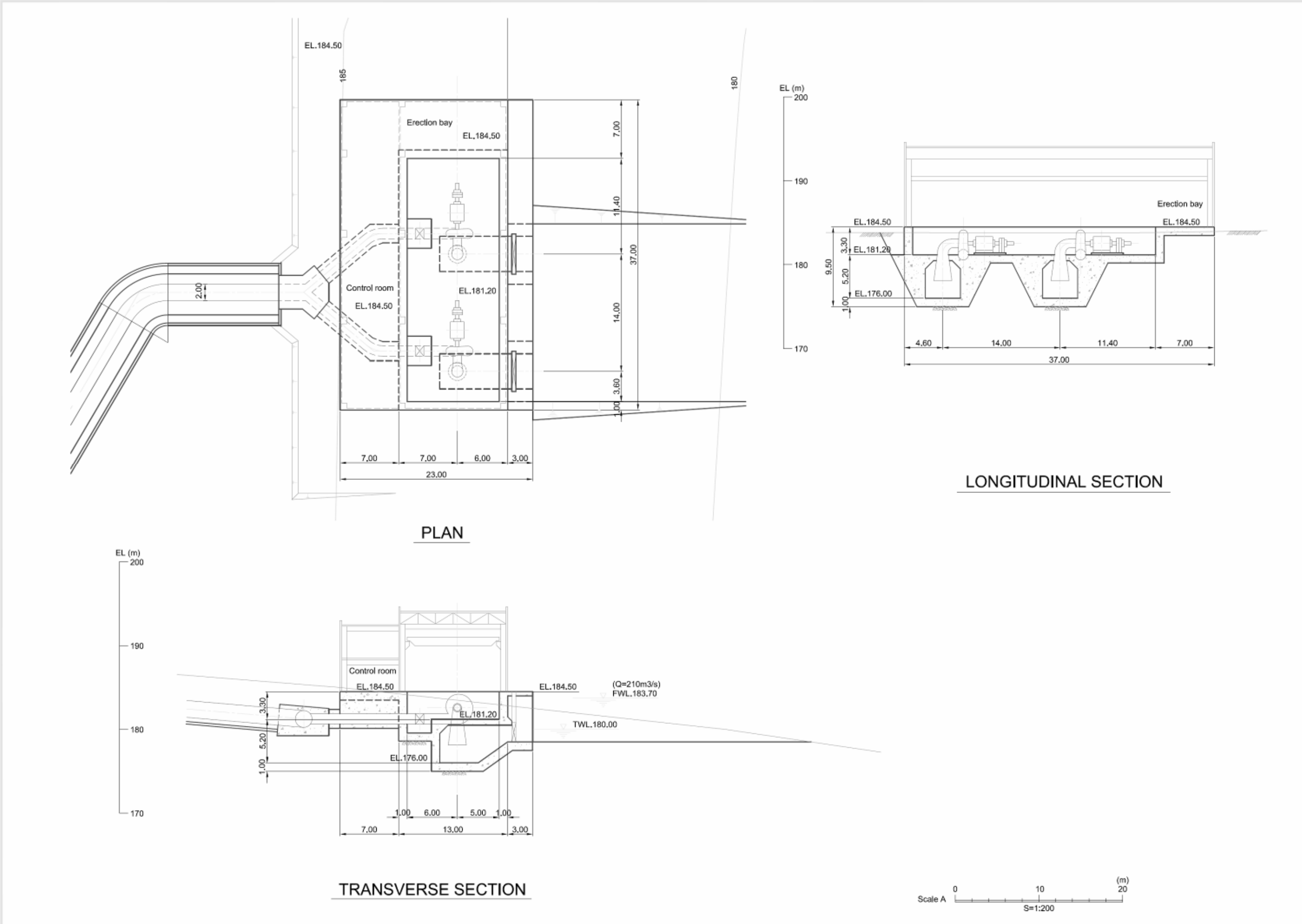


Figure 6-4.3 Plan and Sections of No.35-2 Power House

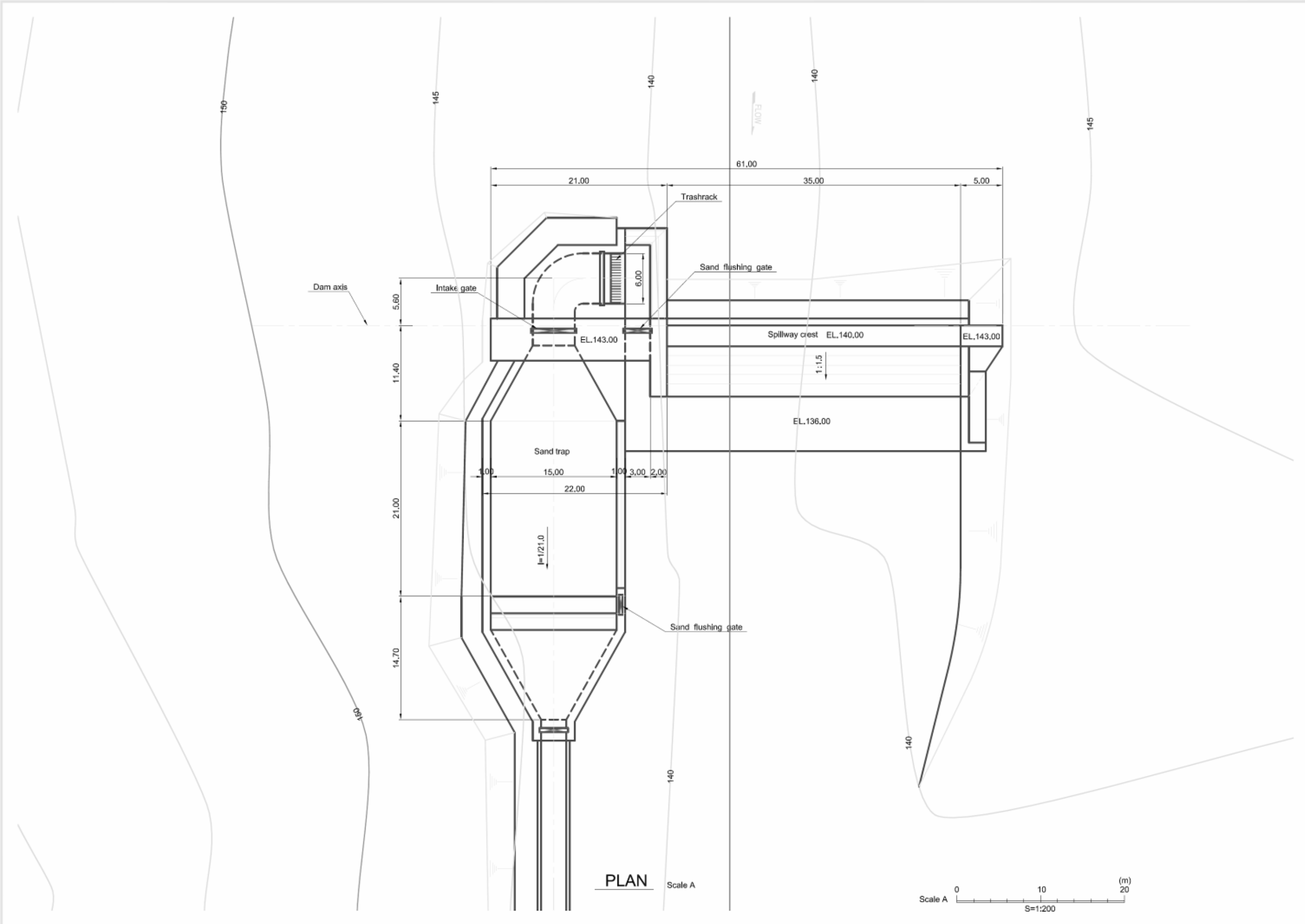


Figure 6-4.4 Plan of No.35-1 Intake Weir

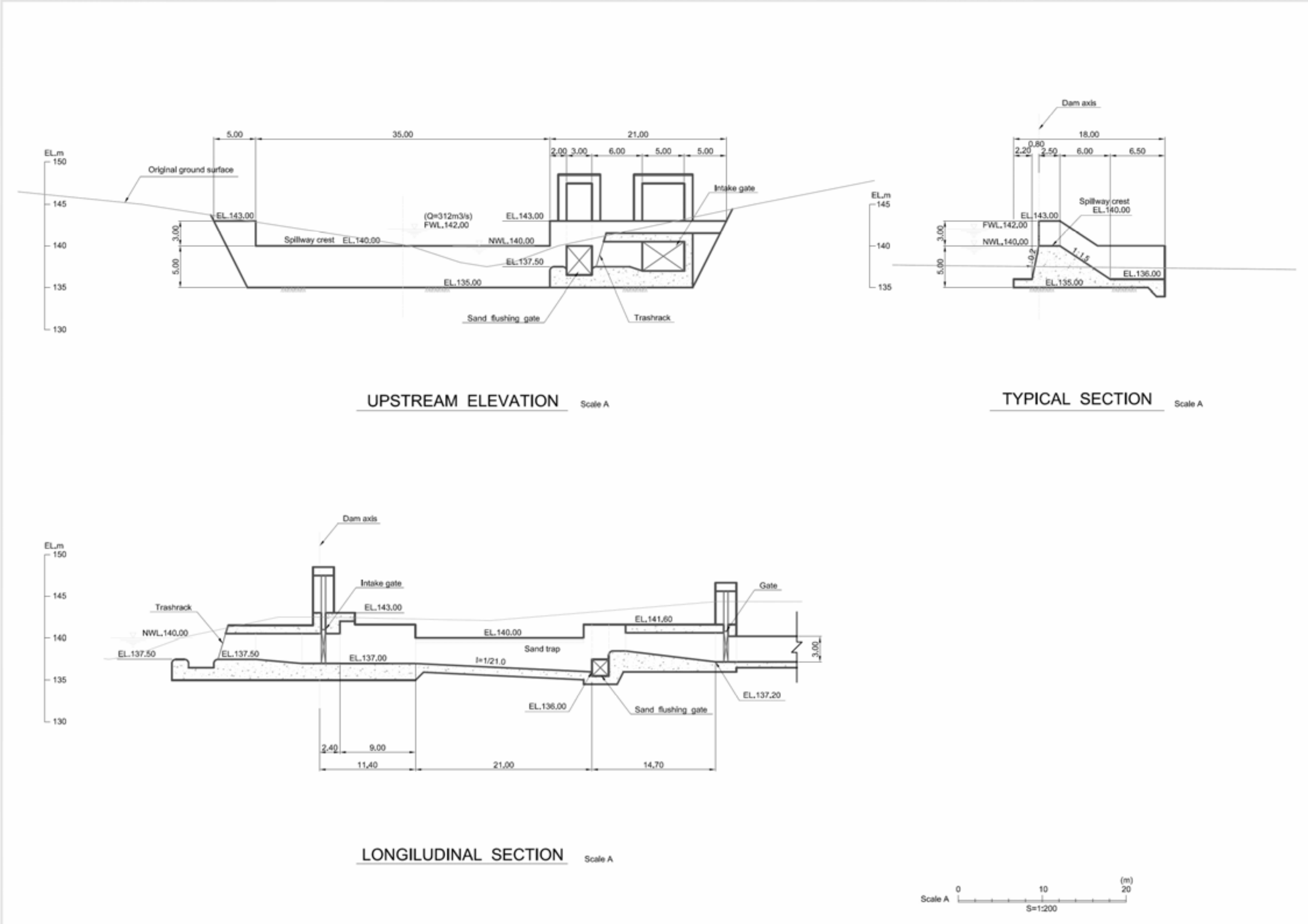


Figure 6-4.5 Elevation and Section of No.35-1 Intake Weir

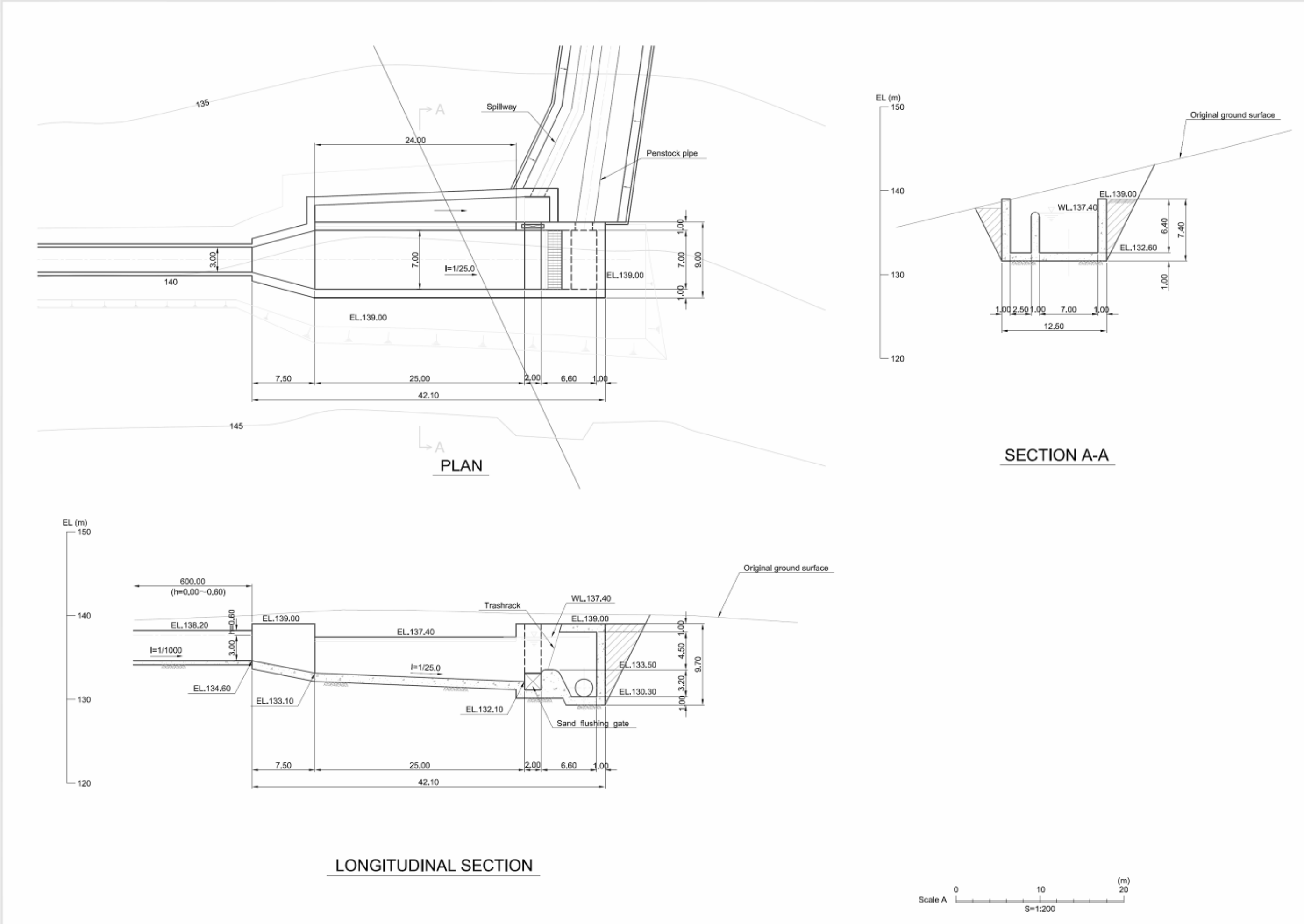


Figure 6-4.6 Plan and Sections of No.35-1 Head Tank

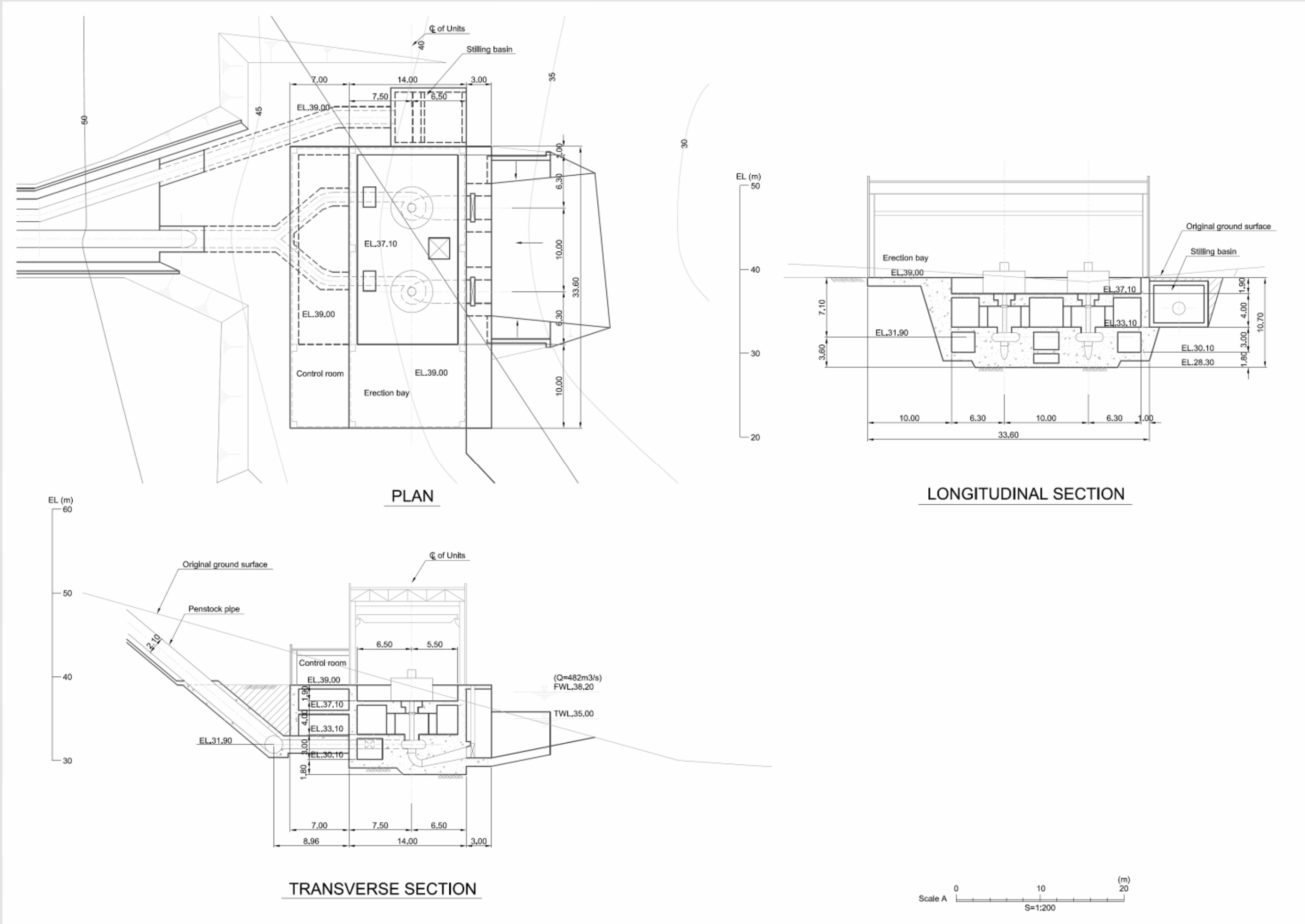


Figure 6-4.7 Plan and Sections of No.35-1 Power House

Appendix 11-1

MINUTES OF MEETING

ON

THE PROJECT

FOR

THE EFFECTIVE AND EFFICIENT USE OF

RENEWABLE ENERGY RESOURCES

IN POWER SUPPLY

The First Joint Coordinating Committee Meeting

MINUTES OF MEETING
ON
THE PROJECT
FOR
THE EFFECTIVE AND EFFICIENT USE OF
RENEWABLE ENERGY RESOURCES
IN POWER SUPPLY
The First Joint Coordinating Committee Meeting

DATE: 15th October, 2013
PLACE: Suva, Fiji

1. General

Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched its Project Team to Fiji for the first Works in Fiji on "the Project for the Effective and Efficient Use of Renewable Energy Resources in Power Supply" (hereinafter referred to as "the Project"). The Project Team members dispatched and their working terms are as follows;

Name	Assignment	Working Term
Masahiko NAGAI	Team Leader/ Power Development Planning	2nd -18th October, 2013
Masayuki ITO	Hydropower Planning/Civil Engineering	2nd -16th October, 2013
Hiroshi WATABE	Electrical Engineering	2nd -18th October, 2013
Shinichi FANABASHI	Power System Planning	7th - 18th October, 2013
Naoyuki TSUDA	Renewable Energy (Biomass)	7th - 18th October, 2013
Tadahisa YOSHIARA	Hydrology & Meteorology Analysis	2nd -16th October, 2013
Nobuki HAYASHI	Environmental & Social Considerations	2nd -16th October, 2013
Kiminori NAKAMATA	Geological Analysis	9th - 14th October, 2013

2. Joint Coordinating Committee

Joint Coordinating Committee (hereinafter refer to as "JCC") was established and the First JCC Meeting was held on 15th October, 2013. Members of JCC were confirmed as shown in the Annex 1.

3. Outline of the Project Team Activities for 1st Works in Fiji

During the period of 2nd to 18th October 2013, the Project Team and the counterpart agencies jointly carried out the following activities in a cooperative manner.

(1) Submission and explanation of the Inception Report

The Project Team submitted ten (10) copies of the inception report to the Department of Energy

(DOE) of the Ministry of Works, Transport and Public Utilities (MWTPU) and Fiji Electricity Authority (FEA) and made brief explanation on the report at the kick-off meeting held at FEA Head Office on 3rd October, 2013. The counterpart agencies principally understood and accepted the report. The participants in the kickoff meeting are as follows;

Organization	Name	Position
DOE	Mr. Peceli Nakavulevu	Director of Energy
	Mr. Jimione Fereti	Principal Technical Officer
	Mr. Inia Saula	Principal Scientific Officer
FEA	Mr. Hasmukh Patel	CEO
	Mr. Eqarawa Tawake	General Manager Generation
	Mr. Karunesh Rao	Executive
	Mr. Epeli Malo	Unit Leader Thermal Generation
JICA Fiji Office	Mr. Kentaro YOSHIDA	Assistant Resident Representative
	Ms. Frances Tavaiqia	Assistant Program Officer
JICA Project Team	Mr. Masahiko NAGAI	Team Leader/Power Development Planning
	Mr. Masayuki ITO	Hydropower Planning
	Mr. Hiroshi WATABE	Electrical Engineering
	Ms. Nobuki HAYASHI	Environmental & Social Considerations
	Mr. Tadahisa YOSHIARA	Hydrology & Meteorology Analysis

(2) 1st Workshop/Seminar for Technology Transfer and Human Resource Development

The First Workshop/Seminar was held as follows;

- Date & Time: 14:00 – 15:30, on 7th October, 2013
- Venue : Conference room of DOE
- Participants : approx. 20 persons

(Main participants)

Mr. Peceli Nakavulevu

Director of Energy, Department of Energy (DOE), MWTPU

Mr. Mikaele Belena

Senior Energy Analyst, DOE, MWTPU

Mr. Epeli Malo

Unit Leader Thermal Generation, FEA

- Agenda

1) Presentation on method of map study for hydropower potential study by the Project Team

2) Q&A

(3) Collection and Analysis of Relevant Data and Information

The Project Team visited the following organizations and sites concerned to collect the relevant data and information for the Project during the 1st Works in Fiji.

Day		Meeting	Remarks
Wed. 2nd Oct.	p.m.	Courtesy visit to JICA Fiji Office	Mr. S. YOSHIARA, Resident Representative Mr. K. YOSHIDA Assistant Resident Representative Mr. Y. OHASHI Assistant Resident Representative
Thu. 3rd Oct.	a.m.	Courtesy visit to Embassy of Japan	Mr. K. NAKAGUN Counsellor and Deputy Chief of Mission Mr. H. KUROKI Second Secretary
	p.m.	Kickoff Meeting @ FEA Head Office	See (1) on page 2
Fri. 4th Oct.	a.m.	Meeting with DOE @DOE Office	Mr. Inia Saula Principal Energy Analyst Mr. Mikaele Belena Senior Energy Analyst
Mon. 7th Oct.	a.m.	Department of Lands & Survey of Meeting with Ministry of Lands and Mineral Resources (for aerial topographic maps)	Mr. Josefa Uluibua
		Meeting with Department of Environment	Ms. Shilpa Singh Technical Office EIA Unit
		Meeting with National Trust of Fiji	Ms. Kasaga Tora Protected Area Project Officer
	p.m.	1st Workshop/Seminar for Technology Transfer and Human Resource Development	See (2) on page 2
		Meeting with Environmental Consultants Fiji PLN Jakarta	Mr. Dick Watling Pricipal
		Meeting with Meteorological Services Center in Suva	Mr. Viliame Vereivalu
Tue. 8th Oct.	a.m.	Site Visit to Butoni Wind Farm	
	p.m.	Meeting with FSC at Lautoka	Mr. Thomas Peters Manager Engineering, FSC Mr. Jakir Hussam Electric Systems Coordinator, FSC
		Site Visit to Sawmill of Tropik Wood	
Wed. 9th Oct.	a.m.	Site Visit to Nadarivatu Hydropower Station	
	p.m.	Site Visit to Wainikasou Power Station, Monasavu dam & reservoir, and Wailoa Power Station	

Day		Meeting	Remarks
Fri. 11th Oct.	a.m.	Meeting with FSC at Labasa and Visit to Sugar Mill @ FSC Labasa	Mr. Vilikesa Vatubuli Chief Engineer, FSC Labasa Mr. Rodrick Simmons Electrical Engineer, FSC, Labasa Mr. Vinesh Prasad Boiler Engineer, FSC, Labasa
	p.m.	Meeting with Valebasoga Tropik boards Limited and visit to its sawmill	Mr. Mukhtar Ali Director, Valebasoga Tropikboards Limited
	p.m.	Site Visit to Hot Springs at Savusavu	
Sat. 12th Oct.	a.m.	Site Visit to Wainikeu Hydropower Station	
		Site Visit to Hot Springs near Labasa	
Mon. 14th Oct.	a.m.	Meeting with Mineral Resources Department	Ms. Margreet S. Soqonaiwasa
	p.m.	Visit to FEA's Cunnigham Sub-Station	
Tue. 15th Oct.	a.m.	Meeting with Ministry of Fishery and Forestry, and Department of Agriculture	
	p.m.	1st Joint Coordinating Committee Meeting	
Thr. 17th Oct.	p.m.	Visit to FEA Vuda Control Center	(planned)

4. Criteria for Selection 10 Candidate Hydropower Potential Sites

DOE, FEA and the Project Team discussed and accepted to the Criteria for Selection 10 Candidate Hydropower Potential Sites as shown in the Annex 2. The Project Team will newly identify 10 candidate hydropower sites in a map study based on these criteria.

5. Environmental and Social Considerations

DOE and FEA confirmed to abide by "JICA Guidelines for Environmental and Social Considerations", .Fiji side regulations such as Environmental Management Act 2005 and Environment Management (EIA Process) Regulations 2007, in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project, as described in the Record of Discussions on the Project for the Effective and Efficient Use of Renewable Energy Resources in Power Supply in Republic of Fiji Agreed upon among Ministry and Works, Transport, and Public Utilities (MWTPU), Fiji Electricity Authority (FEA) and Japan International Cooperation Agency (JICA) dated 25th April 2013.

6. Stake Holder Meetings

The Project Team proposed to hold the following Stake Holder Meetings (SHM) to conduct the Project fully taking into consideration social and environmental issues.

SHM	Period	Agenda
1st SHM	During 2nd Works in Fiji (in mid-May 2014)	The methodology for selection of the targeted areas/sites for preliminary site reconnaissance, the results of site selection including the outline (project profiles, locations, etc.) of 10 candidate hydropower sites and method for site reconnaissance will be explained and discussed with the stakeholders.
2nd SHM	During 3rd Works in Fiji (in end-June 2014)	The results of the surveys carried out until 2nd Works in Fiji, and plans of site reconnaissance and initial environmental examination on the two (2) prospective hydropower sites will be explained and discussed with the stakeholders.
3rd SHM	During 4th Works in Fiji (in end-September 2014)	The study results on the two (2) prospective hydropower projects, including the study for environmental and social considerations, will be explained and discussed with the stakeholders.

DOE and FEA agreed to hold the proposed Stake Holder Meetings.

7. Treatment of Final Report by Government of Fiji

DOE, FEA and JICA mutually confirmed that next power development plan revised by FEA will include contents of the Final Report of the Project, which will include the Hydropower Development Site Map prepared by setting uniform criteria for selection of potential sites, and overall development schedule until 2025 in consideration of power demand forecast and optimum composition of power sources.

8. Treatment of Final Report by JICA

DOE, FEA and JICA mutually confirmed that the Final Repot of the Project will be released on JICA's Home Page.

9. Schedule of Next Works in Fiji

The next Works in Fiji is scheduled in the middle of January 2014. In the Works in Fiji, the Project Team will explain to DOE and FEA the results of selecting 10 candidate hydropower potential sites which will be visited for preliminary site reconnaissance during 2nd Works in Fiji from the middle to the end of May 2014.

10. Required Data and Information for the Project

The Project Team requested DOE and FEA to provide the Project Team with required data and information for the Project. DOE and FEA agreed to provide the Project Team with the available data and information excluding the data and information provided to JICA during "the Detailed Planning Survey for the maximum and effective use of renewable energies in electricity power supply in Fiji" conducted from May to June 2012.

Since detailed operation data of existing power plants are essential to examine power development plan, the Project Team requested National Load Dispatch Center of FEA to provide the Project Team with hourly operational records of all the power stations for at least 5 years (including IPPs' power stations, if possible), and FEA will provide the Project Team with those data.

Suva, 15 October, 2013

Mr. Shumon YOSHIARA
Resident Representative
JICA Fiji Office

Mr. Francis Kean
Permanent Secretary
Ministry Works, Transport, and Public Utilities

Mr. Masahiko NAGAI
Team Leader
JICA Project Team

Mr. Hasmukh Patel
Chief Executive Officer
Fiji Electricity Authority

Annex 1

A List of Members of Joint Coordinating Committee

1. Fiji Side
   Permanent Secretary of MWTPU
   Director of Energy
   Chief Executive Officer of FEA
   General Manager Generation of FEA
   Executive Projects Manager of FEA
   Other Personnel concerned to be proposed by MWPTU and FEA

2. Japanese Side
   Resident Representative of JICA Fiji Office
   JICA Experts of the Projects
   Other Personnel concerned to be proposed by JICA

Proposed Criteria for Selection 10 Candidate Hydropower Potential Sites

The criteria for project finding of hydropower plan are prepared, taking into consideration the following conditions;

- Natural and social environmental conditions
  - Avoid important protected area (National park, Ramsar sites, etc.)
  - No resettlement of villagers

- Topographical and geological conditions
  - Road and traffic condition to the site

- Technological conditions
  - Installed capacity ; More than 1MW
  - Length of waterway (L) ; Less than 5,000 m
  - Length / Head (L/H) ; Less than about 100

- Economic conditions
  - Construction unit cost per kWh ; Less than 1.3 US$/kWh
  - Benefit / Cost ; More than 1.20

Appendix 11-2

Presentation Materials for 1st Stake Holder Meeting

Japan International Cooperation Agency

1st Stake Holder Meeting

The Project for The Effective and Efficient Use of Renewable Energy Resources in Power Supply in Republic of Fiji

Outline of the Project

May 16, 2014

Tokyo Electric Power Services Company, LTD. (TEPSCO)

Outline of the Project

- Outline of the Project
  - Project Title:
    The Project for the Effective and Efficient Use of Renewable Energy Resources in Power Supply (hereinafter referred to as "the Project")
  - Purpose of the Project:
    - To prepare hydropower development site map and overall development schedule until 2025
    - To examine/propound the optimum composition of renewable energy resources in the power sector in Fiji until 2025:

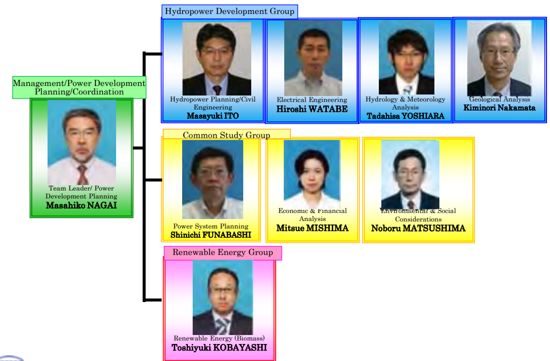
Through the following five (5) activities:
① Collection and Analysis of Relevant Data and Information
② Hydropower Potential Study
③ Implementation of Site Reconnaissance for Prospective Hydropower Project Sites
④ Identification of biomass resources potential sites in both Viti Levu and Vanua Levu.
⑤ Preparation/Recommendations of hydropower development plan and optimum composition of renewable energy resources in the power sector until 2025

Outline of the Project

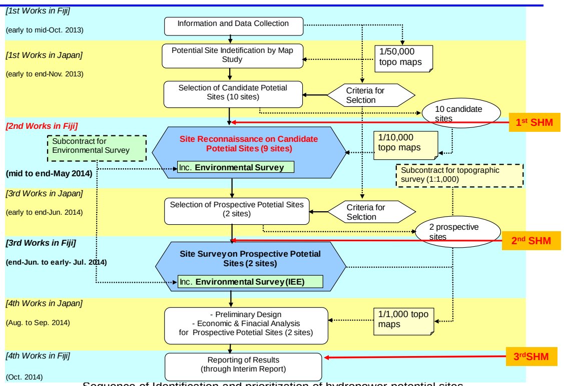
- Project Areas:
  - Viti Levu and Vanua Levu in Fiji
- Relevant Government Offices and Organization
  - Department of Energy, Ministry of Works, Transport and Public Utilities (DOE of MWTPU)
  - Fiji Electricity Authority (FEA)
- Project Period: from September 2013 to December 2014
- Project Team: Nine (9) members form TEPSCO in Japan

Project Team

- Project Team Members



Hydropower Potential Study and Preliminary Design



Sequence of Identification and prioritization of hydropower potential sites

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Recommended Stake Holder Meetings for the Project

Execution Item	Period	Major Stake Holders	Major Agenda
1st Stake Holder Meeting	Mid of May, 2014 (before site reconnaissance for the 9 candidate hydropower sites)	1) DOE and FEA, 2) the relevant central government agencies	Explanation and discussion on method of map study for hydropower potential study
2nd Stake Holder Meeting	Early of July, 2014 (before site survey for the 2 prospective hydropower sites)	1) DOE and FEA, 2) the relevant central government agencies 3) local government agencies covering areas in and around the prospective hydropower sites	The results of the surveys carried out until 2nd Works in Fiji, and plans of site reconnaissance and initial environmental examination on the two (2) prospective hydropower sites will be explained and discussed
3rd Stake Holder Meeting	October , 2014 (after the preliminary design of on the two (2) prospective hydropower projects)	1) DOE and FEA, 2) the relevant central government agencies 3) local government agencies covering areas in and around the prospective hydropower sites	The study results on the two (2) prospective hydropower projects, including the study for environmental and social considerations, are explained and discussed

Schedule of the 2nd Works in Fiji

No.	Date & Day 2013		Team Member: Team Leader/ Power Development Planning — Masahiko NAGAI	Hydropower Planning/ Civil Engineering — Masayuki ITO	Environmental & Social Considerations — Noboru MATSUSHIMA	Hydrology & Meteorology Analysis — Tadahisa YOSHIARA	Geological Analysis — Kiminori NAKAMATA	Electrical Engineering — Hiroshi WATABE
1	13-May	Tue	Leave Japan for Fiji (Tokyo, Narita (KE704) - Seoul (KE137) -)					
2	14-May	Wed	Arrival at Nadi, Move to Suva Meeting with JICA Fiji Office and Emabassy of Japan (EOJ)					
3	15-May	Thu	Meeting with DoE and FEA on candidate hydropower potential sites for 1st site reconnaissance and 1st Stake Holder Meeting (SHM), Subcontract for Environmental survey, Data Arrangement					
4	16-May	Fri	1st SHM at FEA, Data Arrangement					
5	17-May	Sat	Data Arrangement, Preparation of site reconnaissance					
6	18-May	Sun	Data Arrangement, Preparation of site reconnaissance					Leave Japan for Fiji (Tokyo, Narita (KE704) - Seoul (KE137) -)
7	19-May	Mon	Site reconnaissance ((No.26, 28) Wainidina River) *(Staying at Suva)*					Arrival at Nadi, Move to Suva, Data Arrangement
8	20-May	Tue	Site reconnaissance ((No.24) Navua River, (No.29) Wainidina River) *(Staying at Monasavu)*					
9	21-May	Wed	Site reconnaissance ((No. 14) Wailoa River) *(Staying at Ba or Lautoka)*					
10	22-May	Thu	Site reconnaissance ((No.7) Ba River) *(Staying at Ba or Lautoka)*					
11	23-May	Fri	Site reconnaissance ((No.8) Ba River) *(Staying at Nadi)*					
12	24-May	Sat	Arrangement of Site reconnaissance results *(Staying at Nadi)*					
13	25-May	Sun	Move to Labasa (from Nadi) *(Staying at Nabouwalu)*					
14	26-May	Mon	Site reconnaissance ((No.35) Wailwvu River) *(Staying at Labasa)*					
15	27-May	Tue	Site reconnaissance ((No.31) Squru River) *(Staying at Labasa)*					
16	28-May	Wed	Move to Suva (from Labasa), Arrangement of Site reconnaissance results					
17	29-May	Thu	Meeting with DoE and FEA on site reconnaissance results and Next Works in Fiji, Meeting with candidate local consultants for topographical survey Reporting to JICA Office, Leave Suva for Nadi					
18	30-May	Fri	Leave Nadi for Japan (Nadi (KE138) - Seoul (KE705) - Tokyo, Narita)					
Total Days			18	18	18	18	18	13

Site Reconnaissance for 9 Hydropower Potential Sites

1[st] Stake Holder Meeting

Japan International Cooperation Agency

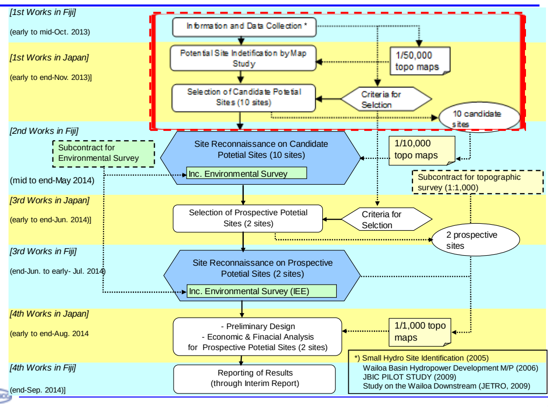
The Project
for
The Effective and Efficient Use
of Renewable Energy Resources in Power Supply
in Republic of Fiji

Prospective Hydropower Potential Sites Screened for the 1[st] Site Reconnaissance

May 16, 2014

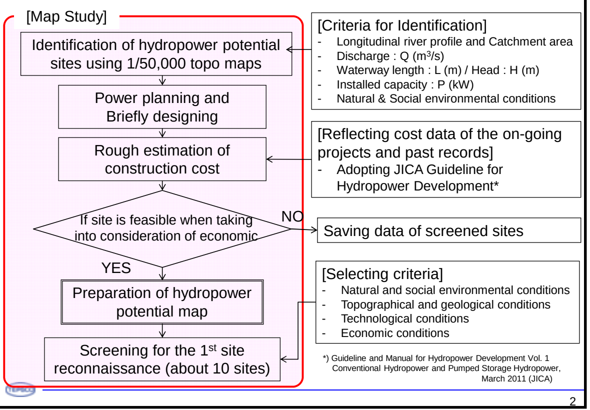
Tokyo Electric Power Services Company, LTD. (TEPSCO)

1. Identification and Prioritization of Hydropower Potential Sites



1

2. Map Study on Identification of Hydropower Potential Sites



*) Guideline and Manual for Hydropower Development Vol. 1 Conventional Hydropower and Pumped Storage Hydropower, March 2011 (JICA)

2

3. Identification Criteria of Hydropower Potential Sites

- Setting criteria
  - Natural and social environmental conditions
    - Avoid important protected area (National park, Ramsar sites etc.)
    - No resettlement of villagers
  - Topographical and geological conditions
    - Road and traffic conditions to the site
  - Technological conditions
    - Installed capacity ; More than 1,000 kW
    - Length of waterway (L) ; Less than 5,000 m
    - Length / Head (L/H) ; Less than about 100

⇒ Identification of hydropower potential sites
- 32 hydropower potential sites in Viti Levu
- 8 hydropower potential sites in Vanua Levu

(Refer to Appendix p.1-4)

3

4. Prospective Hydropower Potential Sites Screened

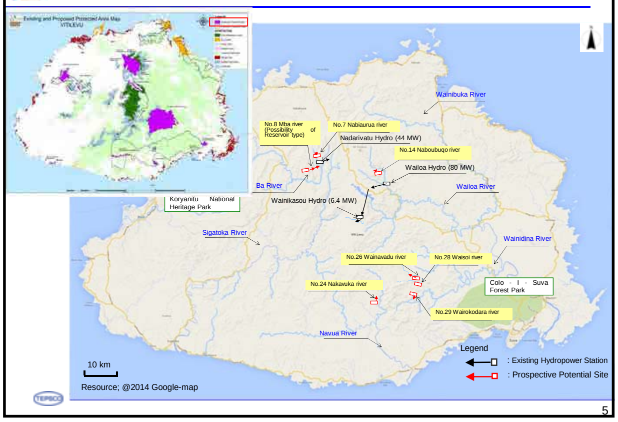
- Setting criteria
  - Economic conditions
    - Benefit / Cost (B/C) ; More than 1.0

Potential site (Generation type)	Previous report's, New site	Features (P, Q, He, Annual generation energy, etc.)	Construction cost (x 1,000 US$)	US$/ kWh	B/C	Evaluation of environmental conditions	Possibility of Reservoir type (Features; P, Q, He)
[Viti Levu]							
7. Nabiaurua (Run-of-river)	Previous	1.0MW, 0.64m³/s, 213.9m, 7,878MWh	10,401	1.32	1.0	No significant impact	
8. Mba 1 U/S (Run-of-river)	New	3.6MW, 5.36m³/s, 84.6m, 21,046MWh	25,147	1.19	1.2	No significant impact	○* (9.6MW, 18.5m³/s, 66.7m)
14. Naboubuqo (Run-of-river)	Previous	3.0MW, 3.17m³/s, 113.3m, 16,046MWh	18,896	1.18	1.2	No significant impact	
24. Nakavika (Run-of-river)	Previous	3.1MW, 7.19m³/s, 54.7m, 16,951MWh	22,560	1.33	1.0	No significant impact	
26. Wainavadu (Run-of-river)	Previous	2.7MW, 3.33m³/s, 160m, 14,975MWh	21,104	1.41	1.0	No significant impact	
28. Waisoi (Run-of-river)	Previous	2.1MW, 1.41m³/s, 186m, 11,321MWh	13,365	1.18	1.2	No significant impact	
29. Wairokodora (Run-of-river)	Previous	1.9MW, 1.47m³/s, 167m, 10,591MWh	12,800	1.21	1.1	No significant impact	
[Vanua Levu]							
31. Saquru (Run-of-river)	Previous	2.7MW, 1.96m³/s, 172.6m, 11,241MWh	17,000	1.20	1.1	No significant impact	
35. Wailevu (Run-of-river)	New	2.0MW, 3.23m³/s, 76.9m, 11,241MWh	11,241	1.48	1.0	No significant impact	○* (3.4MW, 15.0m³/s, 29.7m)

*) Peak duration hours; 8 hours/day

4

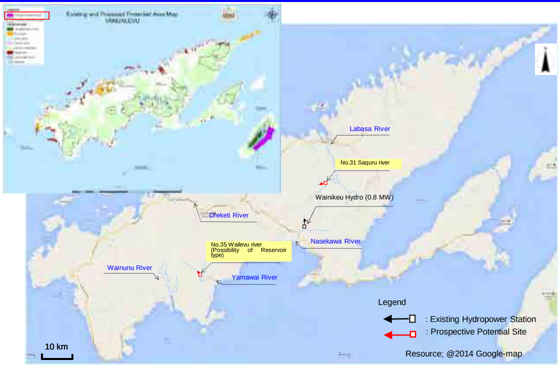
4-1. Prospective Hydropower Potential Sites Map in Viti Levu



Resource; @2014 Google-map

5

4-2. Prospective Hydropower Potential Sites Map in Vanua Levu



1st Stake Holder Meeting

The Project
for
The Effective and Efficient Use
of Renewable Energy Resources in Power Supply
in Republic of Fiji

JICA Guidelines for Environmental and Social Considerations

May 16, 2014

Contents

2

1-1 Basic Policy

1. Promotion of measures
for environmental protection through international cooperation

2. Realization of projects
that contribute to environmental protection in developing countries

3. Mitigation
of any adverse impacts in accordance with these guidelines

3

1-2 Objective of Guidelines

To encourage project supporters

- To **consider** environmental and social impacts in a proper way
- To **ensure** that required examinations are conducted according to JICA guidelines

4

1-3 Basic Principles

1. A wide range of impacts
2. Measures from an early stage to a monitoring stage
3. JICA accountability when realizing cooperation projects
4. JICA asks for stakeholder participation
5. JICA discloses information
6. JICA enhances organizational capacity
7. Serious attempts at promptness

5

2-1 Categorization of Projects

Category	Definition
A	likely to have significant adverse impacts on the environment and society.
B	potential adverse impacts on the environment and society are less adverse than those of Category A projects.
C	like to have minimal or little adverse impact on the environment and society.
FI	JICA's funding of projects is provided to a financial intermediary or executing agency

6

2-2 Example of Categorization: Guwahati Sewerage Project

Project site	Guwahati City, the State of Assam, India
Project Outline	Objective: • sewerage service network building • improving sanitation and living conditions for local people
Category	B
Reason of Categorization	• Probably no significant adverse impact on the environment under the JICA Guidelines

3-1 Scoping - Definition

Determining

- Alternative project sites
- A wide range of impacts
- Examination methods

3-2 Scoping – Check List (1)

Social Environment

No.	Impacts For example	Rating	
		(Pre)construction Stage	Operation Stage
1	Effects on ethnic minorities		
2	Resettlement		
3	Loss of land (agricultural, forest, wetlands)		
4	Encroachment into watershed		
5	Encroachment on historical and cultural values		
6	Inundation of mineral resources		
7	Decline of fisheries		
8	River utilization, especially in downstream areas		

3-2 Scoping – Check List (2)

Natural Environment

No.	Impacts For example	Rating	
		(Pre)construction Stage	Operation Stage
1	Protected Areas, including heritage sites		
2	Fauna & Flora threaten		
3	Important habitats threaten		
4	Encroachment on historical and cultural values		
5	Migration fish species		
6	Effects on scenic value		
7	Poaching and illegal logging due to new access roads		

3-2 Scoping – Check List (2)

Physical environment

No.	Impacts For example	Rating	
		(Pre)construction Stage	Operation Stage
1	Watershed erosion, silt runoff		
2	Effects on groundwater		
3	Downstream flow variations		
4	Ground Subsidence		
5	Noise and vibration		
6	Bottom sediment		
7	Transmission lines and tower hazards		

Other : Accident, earthquake, tropical storms etc.

3-2 Scoping – Rating

A +/-	• Serious positive/negative impact is expected.
B +/-	• Positive / negative impact is expected to some extent.
C +/-	• Extent of impact is unknown (Further examination is needed)
D	• No impact to be expected

4-1 Preparation for IEE-Report

Category B Project

Initial Environment Examination (IEE) Level *
Report is required.

* **IEE Level** A study that includes
•an analysis of alternative plans,
•a prediction & assessment of environmental impacts, and
•a preparation of mitigation measures and
•monitoring plans including simple field surveys.

4-2 Preparation for Report (1)

Table of Contents (Outline)

4-2 Preparation for Report (3)

Table of Contents (Outline)

Thank you for your attention !

Dr. Noboru Matsushima
Japanese Wildlife Research Center, Tokyo
nmatusima@jwrc.or.jp

For further information, please refer to JICA Guideline
http://www.jica.go.jp/english/our_work/social_environmental/guideline/index.html

Appendix 11-3

Presentation Materials for 2nd Stake Holder Meeting

Japan International Cooperation Agency

2nd Stake Holder Meeting

The Project for The Effective and Efficient Use of Renewable Energy Resources in Power Supply in Republic of Fiji

Outline of the Project

July 4, 2014

Tokyo Electric Power Services Company, LTD. (TEPSCO)

Outline of the Project

- Outline of the Project
  - Project Title:
    The Project for the Effective and Efficient Use of Renewable Energy Resources in Power Supply (hereinafter referred to as "the Project")
  - Purpose of the Project:
    - To prepare hydropower development site map and overall development schedule until 2025
    - To examine/propound the optimum composition of renewable energy resources in the power sector in Fiji until 2025:

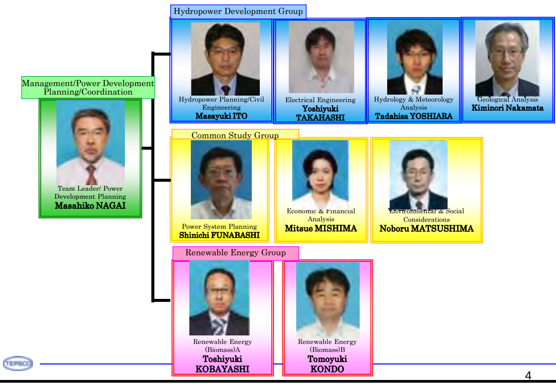
  Through the following five (5) activities:
  ① Collection and Analysis of Relevant Data and Information
  ② Hydropower Potential Study
  ③ Implementation of Site Reconnaissance for Prospective Hydropower Project Sites
  ④ Identification of biomass resources potential sites in both Viti Levu and Vanua Levu.
  ⑤ Preparation/Recommendations of hydropower development plan and optimum composition of renewable energy resources in the power sector until 2025

Outline of the Project

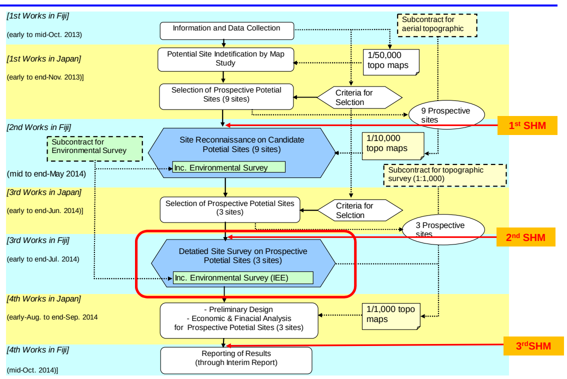
- Project Areas:
  - Viti Levu and Vanua Levu in Fiji
- Relevant Government Offices and Organization
  - Department of Energy, Ministry of Works, Transport and Public Utilities (DOE of MWTPU)
  - Fiji Electricity Authority (FEA)
- Project Period: from September 2013 to December 2014
- Project Team: Nine (9) members form TEPSCO in Japan

Project Team

- Project Team Members



Hydropower Potential Study and Preliminary Design

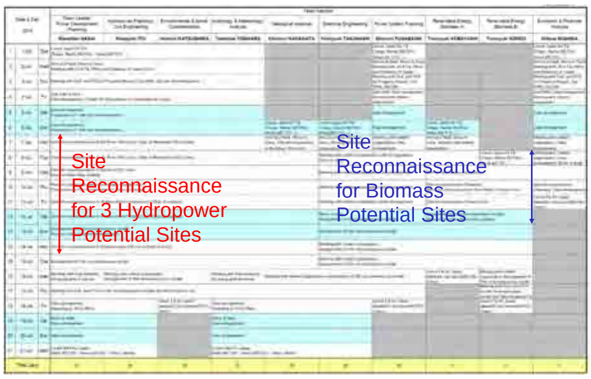


Sequence of Identification and prioritization of hydropower potential sites

Recommended Stake Holder Meetings for the Project

Execution Item	Period	Major Stake Holders	Major Agenda
1st Stake Holder Meeting	Mid of May, 2014 (before site reconnaissance for the 9 candidate hydropower sites)	1) DOE and FEA, 2) the relevant central government agencies	Explanation and discussion on method of map study for hydropower potential study
2nd Stake Holder Meeting	Early of July, 2014 (before site survey for the 2 prospective hydropower sites)	1) DOE and FEA, 2) the relevant central government agencies 3) local government agencies covering areas in and around the prospective hydropower sites	The results of the surveys carried out until 2nd Works in Fiji, and plans of site reconnaissance and initial environmental examination on the two (2) prospective hydropower sites will be explained and discussed
3rd Stake Holder Meeting	October , 2014 (after the preliminary design of on the two (2) prospective hydropower projects)	1) DOE and FEA, 2) the relevant central government agencies 3) local government agencies covering areas in and around the prospective hydropower sites	The study results on the two (2) prospective hydropower projects, including the study for environmental and social considerations, are explained and discussed

Schedule of the 3rd Works in Fiji



Japan International Cooperation Agency

2nd Stake Holder Meeting

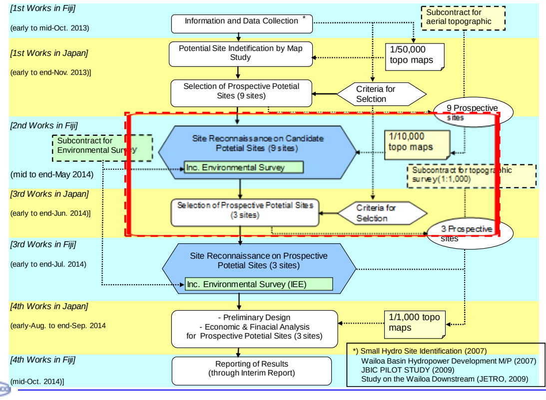
The Project
for
The Effective and Efficient Use
of Renewable Energy Resources in Power Supply
in Republic of Fiji

Prospective Hydropower Potential Sites Screened for the 2nd Site Reconnaissance

July 4, 2014

Tokyo Electric Power Services Company, LTD. (TEPSCO)

1. Prioritization of Prospective Hydropower Potential Sites



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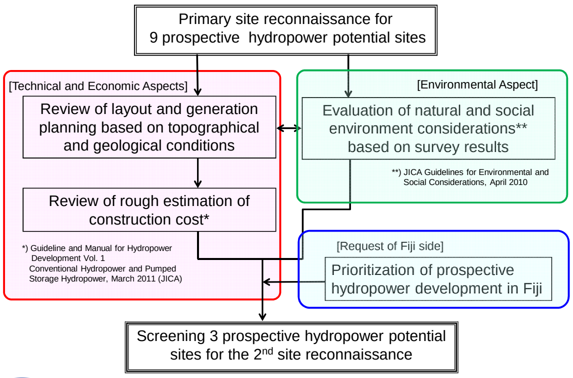
2. Screening Prospective Hydropower Potential Sites



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3-1. Natural and Social Environment Evaluation

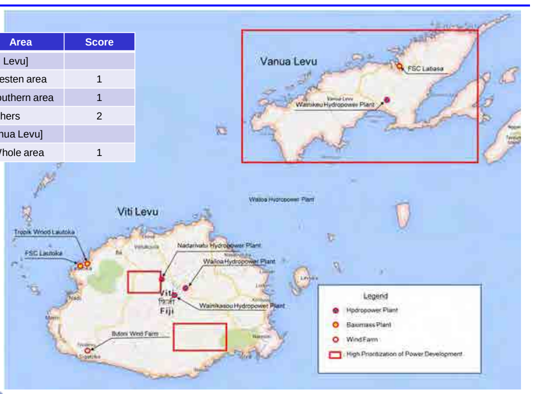
Site	Natural Environment			Social Environment		Average Score
	Protected Area	Flora	Fauna Fish	Resettlement, Compensatory	Cultural Heritage	
[Viti Levu]						
7.Nabiaurua	1	1	1	1	2	1.20
8.Mba 1 U/S	1	1	1	1	2	1.20
14.Naboubuco	1.5	2	1.5	1	1	1.40
24.Nakavika	1.5	2	2	2	2	1.90
26.Wainavadu	2	2	2	2	1	1.80
28.Waisoi	1.5	2	1	2	1	1.50
29.Wairokodora	1.5	2	2	1	1	1.50
[Vanua Levu]						
31.Saquru	1.5	1	1	1	1	1.10
35.Wailevu	1.3	2	2	1	1	1.46

Scores of environmental Expected negative impacts:
3 = Major
2 = Unknown or can be mitigated
1 = No significant impacts

3

3-2. Prioritization of Power supply reliability

Area	Score
[Viti Levu]	
Westen area	1
Southern area	1
Others	2
[Vanua Levu]	
Whole area	1



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3-3. Criteria for Priority Ranking

Priority Rank	Criteria Screened
AA	It is economically superior, there is no significant natural / social environmental impacts and technical problems expected and priority power development area is high in Fiji.
A	It is economically superior and there are significant natural / social environmental impacts or technical problems expected.
B	It is economically feasible and there are significant natural / social environmental impacts or technical problems expected.
C	It is economically feasible and there are significant natural / social environmental impacts or technical problems expected.

5

3-4. Evaluation Criterion by Power Supply Reliability

Power supply reliability: 1		Primary evaluation score of environment		
		$1.0 \leqq y < 1.5$	$1.5 \leqq y \leqq 1.8$	$1.8 < x \leqq 2.0$
Benefit / Cost (B/C)	$x \leqq 1.0$	A	B	C
	$1.0 < x < 1.3$	AA	A	B
	$1.3 \leqq x$	AA	AA	A

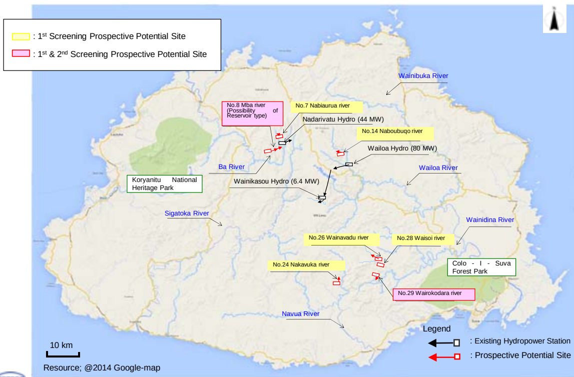
Power supply reliability: 2		Primary evaluation score of environment		
		$1.0 \leqq y < 1.5$	$1.5 \leqq y \leqq 1.8$	$1.8 < x \leqq 2.0$
Benefit / Cost (B/C)	$x \leqq 1.0$	B	C	C
	$1.0 < x < 1.3$	A	B	C
	$1.3 \leqq x$	A	A	B

4-1. Prospective Hydropower Potential Sites Screened

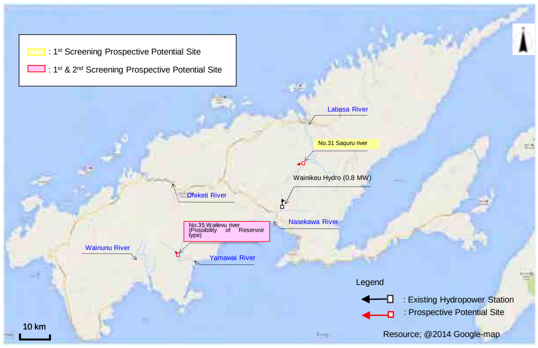
Potential site (Generation type)	Features (P, Q, He, Annual generation energy, etc.)	Construction cost (x 1,000 US$)	US$/ kWh, B/C	Primary evaluation score of environment	Priority score of Power supply reliability	Priority Rank*	Possibility of Reservoir/Poundage type (Features; P, Q, He)
[Viti Levu]							
7. Nabiaurua (Run-of-river)	1.4MW, 0.85m³/s, 216.9m, 8,197MWh	9,619	1.17, 1.2	1.20	1	AA	
8. Mba 1 U/S (Run-of-river)	9.2MW, 15m³/s, 74.7m, 24,836MWh	28,534	1.15, 1.2	1.20	1	AA	Poundage* (12.1MW, 20.2m³/s, 72.5m)
14. Naboubuco (Run-of-river)	2.7MW, 3.53m³/s, 96.9m, 15,308MWh	14,843	0.97, 1.4	1.40	2	A	
24. Nakavika (Run-of-river)	2.6MW, 7.17m³/s, 45.7m, 14,205MWh	20,650	1.45, 0.9	1.90	1	C	
26. Wainavadu (Run-of-river)	2.5MW, 3.23m³/s, 97.04m, 13,749MWh	17,573	1.28, 1.1	1.80	1	A	Poundage* (13MW, 10.43m³/s, 150.4m)
28. Waisoi (Run-of-river)	2.1MW, 1.39m³/s, 190.9m, 11,322MWh	12,874	1.14, 1.2	1.50	1	A	
29. Wairokodra (Run-of-river)	2.6MW, 1.45m³/s, 226.0m, 15,046MWh	12,240	0.81, 1.6	1.50	1	AA	
[Vanua Levu]							
31. Saquru (Run-of-river)	2.0MW, 1.01m³/s, 254.1m, 10,660MWh	14,516	1.36, 1.0	1.10	1	A	
35. Wailevu (Run-of-river)	2.0MW, 3.23m³/s, 76.1m, 10,563MWh	12,002	1.14, 1.2	1.46	1	AA	Reservoir* (No.1; 8.1MW, 13.0m³/s, 76.1m) (No.2; 6.3MW, 8.7m³/s, 88.9m)

*) Peak duration hours; 6 hours/day

4-2. Prospective Hydropower Potential Sites Map in Viti Levu



4-3. Prospective Hydropower Potential Sites Map in Vanua Levu



2nd Stake Holder Meeting

IEE: Initial Environmental Examination

of three prospective hydropower potential sites for 2nd site reconnaissance

July 4, 2014

Noboru Matsushima
Japanese Wildlife Research Center, Tokyo

Contents

1. First Site Reconnaissance:
   Preliminary assessment according to JICA Guidelines* (completed)
2. Second Site Reconnaissance:
   IEE on three prospective project sites (Study – Physical, Biological, Social)
3. IEE Final Study Report

* accepting Environment Management Act 2005, Fiji

1-1 Result of 1st Site Reconnaissance

Important Indicator : Natural/Social Environment
Involved experts : **Dr. Dick Watling**: Flora and fauna (birds)
Aaron Jenkins : Freshwater fish ecologist
Kolinio Moce Qalo: Social environment

- Protected Area: Key Biodiversity Area/ Important Bird Areas
- Flora /natural forest, conservation value: Fauna / Fish / species richness & rare endemic
- Resettlement / cemetery, sensitive and difficult issue (mining company)
- Cultural heritage / historical site

1-1 Result of 1st Site Reconnaissance

Site	Natural Environment			Social Environment		Average Score
	Protected Area	Flora	Fauna Fish	Resettlement, Compensatory	Cultural Heritage	
[Viti Levu]						
7.Nabiaurua	1	1	1	1	2	1.20
8.Mba 1 U/S ●	1	1	1	1	2	1.20
14.Naboubuco	1.5	2	1.5	1	1	1.40
24.Nakavika	1.5	2	2	2	2	1.90
26.Wainavadu	2	2	2	2	1	1.80
28.Waisoi	1.5	2	1	2	1	1.50
29.Wairokodora ●	1.5	2	2	1	1	1.50
[Vanua Levu]						
31.Saquru	1.5	1	1	1	1	1.10
35.Wailevu ●	1.3	2	2	1	1	1.46

Scores for negative impacts: 1 – 3

1-1 Result of 1st Site Reconnaissance

Scoring:

- Score of environmental expected negative impacts:
  - 3 = Major
  - 2 = Unknown or can be mitigated
  - 1 = No significant impact
- Scores of Nine Potential Sites 1.20 – 1.90
- Selected three sites: No. 8, 29 & 35
- For Initial Environmental Examination

1-2 Potential Site One

No.8 Mba: Anthropogenic Grassland

1-2 Potential Site One

No.8 Mba: Anthropogenic Grassland

Site characteristics overview:

- No Natural Park / Protected Area
- No endangered fauna / flora
- No resettlement
- Historical / Cultural Heritage
  - ➤ Existent
  - ➤ Old village site at Namosi,
  - ➤ Called Nabouwalu
  - ➤ Near the planned power house

Overall result of preliminary assessment: no problems found

1-2 Potential Site Two

No.29 Wairokodora: Forest Landscape

1-2 Potential Site Two

No.29 Wairokodora: Forest Landscape

Site characteristics overview:

- No Protected Area, but:
- Key Biodiversity Area and Important Bird Area of Fiji
- Valuable fauna & flora in upper catchment area in natural forest, risk of loss!
- No resettlement
- Historical / Cultural Heritage
  - ➤ Probably not
  - ➤ Further investigation required

Overall result of preliminary assessment: some problems found

1-2 Potential Site Three

No.35 Wailevu: Natural lowland rain forest

1-2 Potential Site Three

No.35 Wailevu: Natural lowland rain forest

Site characteristics overview:

- No Protected Area, but:
- Key Biodiversity Area of Fiji
- Highest known tree diversity for Vanua Levu based on Forestry survey
- Important watershed for coastal reefs (highest priority for Fiji)
- No resettlement
- Historical / Cultural Heritage
  - ➤ Probably not
  - ➤ Further investigation required

Overall result of preliminary assessment: rare endemic species, sensitive place, careful consideration necessary

2. Second Site Reconnaissance: IEE on three prospective project sites

Further investigation of the three sites by Initial Environmental Examination

1. Physical environment:
- Hydrological condition
- Geological condition

2. Biological environment:
- Existing fauna, flora and important habitats, especially fresh water fish
- Existing and planned protected areas, ramsar wetlands, important bird areas and local nature reserves
- Impacts on agriculture and forestry
- Impacts on the landscape

2. Second Site Reconnaissance: IEE on three prospective project sites

Further investigation of the three sites by Initial Environmental Examination

3. Social environment:

- Affected area by proposed project, compensation measures
- River utilization in the project site and vicinity
  - irrigation,
  - drinking water,
  - fishery
- Existence of socially disadvantaged people
- Cultural / archeological heritage, tourism site, mining?
- Conduct stakeholder meetings in the affected communities

3. IEE Final Study Report

Submission of Final Report: September 2014

Tentative Table of Contents of IEE Report

1. Executive Summary
2. Introduction (Background and purpose of the survey)
3. Methodology
4. Project Description
5. Administrative and Regulatory Framework in Fiji
6. Description of Environment of the Project Site
7. Land Acquisition and Compensation
8. Impact Assessment
9. Mitigation measures
10. Monitoring Management Plan
11. Conclusion and recommendations for IEE
12. Annexes

Appendix 11-4

MINUTES OF DISCUSSION

FOR THIRD (3) WORKS IN FIJI

ON

THE PROJECT

FOR

THE EFFECTIVE AND EFFICIENT USE OF

RENEWABLE ENERGY RESOURCES

IN POWER SUPPLY

MINUTES OF DISCUSSTION
FOR THIRD WORKS IN FIJI
ON
THE PROJECT
FOR
THE EFFECTIVE AND EFFICIENT USE OF
RENEWABLE ENERGY RESOURCES IN POWER SUPPLY

DATE: 18th July, 2014
Suva, Fiji

I. General

The Japan International Cooperation Agency (JICA) dispatched the Project Team (Tokyo Electric Power Services CO.,LTD (TEPSCO)) from 1st to 21st July, 2014 for the Third Works in Fiji on the Project for the Effective and Efficient Use of Renewable Energy Resources in Power Sector (the Project) and the Project Team has had discussions and jointly conducted site reconnaissance for hydropower potential sites and site visits for biomass potential survey with officials of Department of Energy (DOE), Fiji Electricity Authority (FEA) and other relevant authorities during the Third Works in Fiji. The Project Team members dispatched and their working terms are as follows;

Name	Assignment	Working Term
Masahiko NAGAI	Team Leader/ Power Development Planning	1st-21st July, 2014
Masayuki ITO	Hydropower Planning/Civil Engineering	1st -21st July, 2014
Yoshiyuki TAKAHASHI	Electrical Engineering	6th -21st July, 2014
Shinichi FUNABASHI	Power System Planning	1st -18th July, 2014
Noboru MATSUSHIMA	Environmental & Social Considerations	1st-21st July, 2014
Toshiyuki KOBAYASHI	Renewable Energy (Biomass) A	6th-16th July, 2014
Tomoyuski KONDO	Renewable Energy (Biomass) B	8th-18th July, 2014
Mitsue MISHIMA	Economic & Financial Analysis	1st-11th July, 2014
Tadahisa YOSHIARA	Hydrology & Meteorology Analysis	1st-21st July, 2014
Kiminori NAKAMATA	Geological Analysis	6th -21st July, 2014

II. Outline of the activities

DOE, FEA and the Project Team hereby mutually confirmed and agreed upon the followings:

1. Meeting with DoE and FEA held on 3rd July 2014

(1) Submission and Explanation of the Progress Report
The Project Team submitted ten (10) copies of the Progress Report to DOE and FEA and explained it at the meeting. The counterpart agency, DOE and FEA, principally understood and accepted the report.

(2) Screening of nine (9) hydropower potential sites after the 1st Site Reconnaissance
The Project Team explained to DOE and FEA on 1) the results of reviewing nine (9) hydropower potential sites, on which the Project Team and the counterpart personnel concerned jointly carried out 1st site

reconnaissance during the Send Works in Fiji in May 2014, and 2) the methods and the results of screening of nine (9) candidate hydropower potential sites.

(3) Preparation for 2nd Stake Holder Meeting
2nd Stake Holder Meeting was held at the conference room of FEA Head office on 4th July, 2014 basically in accordance with draft agenda prepared by the Project Team. In this meeting, three (3) prospective hydropower sites for the preliminary design would be finally selected through the discussions by the stake holders.

(4) Project Team's Planned Activities
The Project Team explained the draft schedule for their planned activities during Third Works in Fiji, and asked for the DOE and FEA's cooperation and arrangement for the Project Team's activities. DOE, FEA and the Project Team hereby mutually confirmed and agreed upon the followings:

1) DOE and FEA had no objection to the Project Team's draft schedule.
2) Accommodations, Personnel to participate in the site reconnaissance, etc. would be decided after the decision of three hydropower potential sites for the preliminary design in the SHM.
3) DOE agreed that DOE's staff members would join the Project Team's site visits to hydropower potential sites and offices and facilities related to biomass power.

2. 2nd Stake Holder Meeting (SHM)

The 2nd Stake Holder Meeting (SHM) was held as follows;

1) General
- Date & Time :10:00 – 12:00, on 4thJuly, 2014
- Venue : Board Room of FEA Head Office
- Participants : 25 persons

Organization	Name	Position
DoE	Mr. Peceli Nakavulevu	Director
	Mr. Inia Saula	Principal Technical Officer
	Mr. Ravinesh Nand	Senior Scientific Officer
	Mr. Mikaele Belena	Senior Scientific Officer
	Mr. Waisale Vulagi	Technical Officer
FEA	Mr. Hasmukh Patel	CEO
	Mr. Karunesh Rao	Executive Projects & Public Relations Manager
	Mr. Jitendra Kumar	GM Network
	Mr. Epeli Malo	Unit Leader Thermal
WAF	Mr. Jone Tubui	Team Leader – Water Resource Limit
Mineral Resource Department	Ms. Venasio Nasara	Assistant Director
	Mr. Raymond Mohammed	Senior Mining Engineer
Ministry of Strategic Planning	Mr. Sandip Kumar	Economic Planning Officer
iTaukei Land Trust Board	Mr. Solomoni Nata	Deputy GM

Ministry of Forestry	Mr. Y Tupua	Forest Officer
National Trust of Fiji	Ms. Elizabeth Erasito	Director
	Mr. Kasaqa Tora	PA Officer
Environment Consultant Fiji	Mr. Dick Waltling	Principal
	Mr. Kolinio Moce	Social scientist
JICA Study Team	Mr. Masahiko Nagai	Team Leader/Power Development Planning
	Mr. Masayuki Ito	Hydropower Planning
	Ms. Mitsue Mishima	Economical and Financial
	Mr. Noboru Matsushima	Environmental & Social Considerations
	Mr. Shinichi Funabashi	Power System Planning
	Mr. Tadahisa Yoshiara	Hydrology & Meteorology Analysis

- Agenda
    a. Outline of the Project (Mr. NAGAI, Project Team)
    b. Selection of three prospective hydropower potential sites for 2nd site reconnaissance (Mr. ITO, Project Team)
    c. Initial Environmental Examination (IEE) of three prospective hydropower potential sites for the 2nd site reconnaissance (Dr. MATSUSHIMA, Project Team)
    d. Discussions (Q and A)

The main purpose of this SHM was to decide three prospective hydropower sites which would be studied at preliminary design level, in consideration of requests of Fiji's stake holders.

2) Major questions and answers in the SHM

a. On the results of reviewing of 9 candidate hydropower potential sites

- Q: In the southern part of Viti Levu, there are some potential sites which were evaluated as economically viable projects. Does the construction cost for these sites include the costs for transmission lines?

  A: Yes, the total construction costs include the rough costs for transmission line construction.

- Q: Explain in more detail about a ranking factor, "Power Security".

  A: Areas, relatively near electricity demand areas such as a capital city with a large population, are given bigger score in terms of power security.

- Q: There are as many as 9 potential sites which were evaluated as economically viable projects. It is desirable to conduct the preliminary design for not just three sites but also remaining sites.

  A: Taking into account the contract with JICA and the Project time schedule, it is impossible to conduct the preliminary design for more than three sites. The remaining sites can be taken up by the Fiji Government or in another assignment.

b. On environmental and social considerations

- Q: Regarding areas around No. 26 site, there are problems related to mining development plan, negotiations for land acquisition with land owners, protected area, etc. Scoring of No.26 site should be reviewed taking into account these risks.

A: The Project Team evaluated the No.26 site as a site where was outside of the protected area.

3) Three (3) Prospective Hydropower Potential Sites to be studied at Preliminary Design Level
After the SHM, Fiji side had a discussion on selection of three prospective hydropower potential sites to be studied at preliminary design level. DOE reported to the Project Team on the results of the discussion and selected three hydropower potential sites as follows:
   1) Western Area of Viti Levu : No.8 Mba U/S 1, located in Ba River Basin
   2) Southern Area of Viti Levu :No.26 Wainavadu, located in Wainavadu River Basin
   3) Vanua Levu :No.35 Wailevu, located in Wailevu River Basin

As for No.26 site, the Project Team carefully checked whether this site area is inside the Sovi River Basin Protected Area because in the SHM it was pointed out that the No.26 site was inside the protected area. As a result of checking by obtaining the latest information and hearing from relevant personnel, at least the dam site and its reservoir area is confirmed to be inside the protected area. Upon confirming this fact, the Project Team suggested that No.26 site should not be selected as a prospective site for preliminary design, because from the earlier Project stage, DOE, FEA and the Project Team have mutually agreed that any potential sites which were located in protected areas or proposed protected areas shall not be selected. The Project Team opted not to select No.26, but No.29 site as a prospective site for preliminary design among the potential sites identified in Sothern Area of Viti Levu. DOE and FEA accepted the Project Team's suggestion and proposal.

3. Project Team's Visits to Sites and Offices

(1) 2nd Site Reconnaissance on Three (3) Prospective Hydropower Site
The Project Team carried out the following site reconnaissance for three (3) prospective hydropower potential sites together with officials of Department of Energy (DOE).

Day		Activities (Site Visit, Meeting, etc.)	Remarks
Tue. 8th Jul.	a.m.	Move from Stone Bowl Lodge to Vatutokotoko village by car. Survey on the sites for No.1 headrace outlet and No.2 intake weir of **No.8 site**	Mr. Waisale Vulagi Technical Officer Mr. Jonati Delaimoala Scientific Officer
	p.m.	Survey on intake of regulating dam of on **No.8 site** Savatu creek. Move from Koro village to Stone Bowl Lodge by car.	
Wed. 9th Jul.	a.m.	Move from Stone Bowl Lodge to Nadi by car	-
	p.m.	Preparation for next site survey	
Thu. 10th. Jul	a.m.	Preparation for next site survey	-
	p.m.	Move from Nadi to Labasa by plane.	
Fri.	a.m.	Move from Labasa to Dreketi area by car.	-

Day		Activities (Site Visit, Meeting, etc.)	Remarks
11th Jul.	p.m.	Surey on upperstream area of No.2 dam site (reservoir type) of **No.35 site.**	
Sat. 12th Jul.	a.m.	Move from Labasa to Dreketi area by car.	Mr. Jonati Delaimoala Scientific Officer
	p.m.	Survey on 1km upstream of No.2 Dam site of **No.35 site.**	
Sun. 13th Jul.	a.m.	Survey on road conditions from Dreketi to Dawara Village.	-
	p.m.	Move from Labasa to Suva by plane.	
Mon. 14th Jul.	a.m.	Move from Suva to Namosi area. Survey on intake site of **No.29 site** (Wairokodra Creek)	Mr. Mikaele Belena Senior Scientific Officer Mr. Waisale Vulagi Technical Officer Mr. Jonati Delaimoala Scientific Officer
	p.m.	Survey on sites for powerhouse, head tank, penstock of **No.29 site** (Wairokodra Creek).	
Mon. 17th Jul.	a.m.	Move from Suva to Namosi area. Survey on intake site of **No.29' site** (Waivaka Creek)	Mr. Mikaele Belena Senior Scientific Officer Mr. Waisale Vulagi Technical Officer
	p.m.	Survey on sites for powerhouse, head tank, penstock of **No.29' site** (Waivaka Creek).	

(2) Meetings and Visits related to Power System and Power Facilities

The Project Team had meetings and conducted sites related to power system and power generation facilities as follows:

Day		Activities (Site Visit, Meeting, etc.)	Remarks
Mon. 7th Jul.	a.m.	Meeting with FEA at FEA Head Office	Mr. Ravind Narayan Unit Leader Substation Mr. Epeli Malo Unit Leader Thermal Generation
Wed. 9th Jul.	a.m.	Meeting with FEA at FEA Lautoka Office	Mr. Om Dutt Sharma General Manager, System Planning & Control Mr. Mohammed Anees Khan Unit Leader - Civil Major Projects & Strategy Mr. Uate Biutanaseva Unit Leader Renewable Generation
Thu. 10th Jul.	a.m.	Meeting with FEA at National Control Center, Visiting 132kV Vuda Substation	Mr. Manoj Kumar Unit Leader System Operation Training Instructor
		Visiting Vuda Power Station	Mr. Ravai Fonmoa Station Manager
	p.m.	Meeting with FEA at FEA Lautoka Office	Mr. Uate Biutanaseva Unit Leader Renewable Generation

Day		Activities (Site Visit, Meeting, etc.)	Remarks
Fri. 11th Jul.	a.m.	Visit to Nadarivatu Hydropower Station	Mr. Uate Biutanaseva Unit Leader Renewable Generation
Mon. 14 th Jul.	a.m.	Meeting with DOE at DOE Office	Mr. Jeke Pai Bio Fuel Department Mr. Francis Pillay Rural Areas Electrification Department
Tue. 15 th Jul.	a.m.	Meeting with FEA at FEA Head Office	Mr. Karunesh Rao Executive Projects & Public Relations Manager

(3) Meetings and Visits related to Biomass Power

The Project Team had meetings and conducted sites related to biomass power as follows:

Day		Activities (Site Visit, Meeting, etc.)	Remarks
Mon. 7th Jul.	p.m.	**Department of Energy (DOE)** Kickoff meeting for biomass	Mr. Inia Saula Principal Energy Analyst
Tue. 8th Jul.	a.m.	**Department of Land** purchasing map	-
		Fiji Bureau of Statistics (FIBO) Inquiry on recent publication on the statistics information	Mr. Eroni Cinavilakebi, Public Library, FIBO
		Forestry Department Inquiry on wood industry list and production statistics.	Mr. Livai Ikanikoda Forestry Officer, Conservation and Trade
	p.m.	**National Trust of Fiji (NTF)** Inquiry on the protected area and Sovi basin map	Ms. Elizabeth Erasito, Director, NTF Ms. Kasaqa Tora, GIS officer
		Forestry Department Inquiry on forestry map to obtain latest forestry map, and identify location of wood industry.	Mr. Viliame Tupua Management Service Div. (Colo, Suva)
Wed. 9th Jul.	a.m.	**Fiji Sugar Corporation (FSC) Head Office** Inquiry on data and information collection regarding production and generation plan.	Mr. Thomas Peters, General Manager, Major Projects, FSC Mr. Shivam Naidu, General Manager –Engineering, FSC Head office
	p.m.	**FSC Lautoka Mill (Lautoka)** Inquiry on data and information collection regarding production and generation plan.	Mr. Naivote Seru, Chief Engineer, Lautoka Mill
		Tropik Wood Industry Ltd. Inquiry on data and information collection regarding production and generation plan.	Mr. Vimlesh Kumar, Company Secretary, General Manager Finance and Administration Mr. Conrad Kumar, Chief Engineer of production

Day		Activities (Site Visit, Meeting, etc.)	Remarks
Thu. 10th Jul.	a.m.	**FSC Rarawai Mill (Ba)** Inquiry on data and information collection regarding production and generation plan.	Mr. Sailasa Waitawa General Manager, Rarawai Mill
	p.m.	Move to Labasa by flight	-
Fir. 11th Jul.	a.m.	**FSC Labasa** Inquiry on data and information collection regarding production and generation plan.	Mr. Vishal Presad Chief Engineer, Labasa Mill
		Valebasoqa Tropikboards Ltd. Inquiry on data and information collection regarding wood production and boiler facility.	Mr. Mukhtar Ali, Director
	p.m.	**Fiji Forest Industry Ltd.** Inquiry on data and information collection regarding wood production and boiler facility.	Mr. Waisale Mata Reserch and development Offiecr
		Waiqele Sawmill Ltd. Inquiry on data and information collection regarding wood production and boiler facility.	Mr. Ahmed Begg, Director
Mon. 14th Jul.	a.m.	**Forestry Depetment** Inquiry on wood industry list and production statistics.(collecting requested data)	Mr. Livai Ikanikoda Forestry Officer, Conservation and Trade
		FEA Inquiry on biomass needs, current status of IPP activity, and tariff status.	Mr. Karunesh Rao Executive Projects and Public Relation Manager
	p.m.	**FSC Penang Mill (Rakiraki)** Inquiry on data and information collection regarding production and generation plan.	Mr. John Chief Engineer
Tue. 15th Jul.	a.m.	**Fiji Sugar Corporation (FSC) Head Office** Inquiry on data and information collection regarding production and generation plan.	Mr. Thomas Peters, General Manager, Major Projects, FSC Mr. Shivam Naidu, General Manager –Engineering, FSC Head office
	p.m.	**DOE** Discussion with DOE	Mr. Inia Saula Principal Energy Analyst

(4) Meetings and Visits related to Economic & Financial Analysis

The Project Team had meetings and conducted sites related to economic and financial analysis as follows:

Day		Activities (Site Visit, Meeting, etc.)	Remarks
Mon. 6th Jul.	p.m.	Inquiry on recent publication on the statistics information at Fiji Bureau of Statistics (FIBO)	Mr. Eroni Cinavilakebi, Public Library, FIBO
Mon. 7th Jul.	p.m.	Meeting with FEA (data and information collection for financial economic analysis at FEA	Mr. Bobby C. Naimawi, Chief Financial Officer (CFO), FEA
Wed. 9th Jul.	a.m.	Meeting with FSC Lautoka (data and information collection) at FSC Lautoka office	Mr. Thomas Peters, General Manager, Major Projects, FSC Mr. Shivam Naidu, General Manager --Engineering, FSC Head office

Day		Activities (Site Visit, Meeting, etc.)	Remarks
	p.m.	Visit FSC Lautoka Factory	
		Meeting with Tropik Wood (data and information collection) at Tropik Wood office	Mr. Vimlesh Kumar, Company Secretary, General Manager Finance and Administration
Thu. 10th Jul.	a.m.	Meeting with Tropik Wood (data and information collection) at Tropik Wood office	Mr. Jim Nabou, General Manager of Production, Tropik Wood
	p.m.	Meeting with FSC Lautoka (data and information collection) at FSC Lautoka office	Mr. Thomas Peters, General Manager, Major Projects, FSC

4. Wrap-up Meeting

The wrap-up meeting was held at conference room of FEA Head Office on 18th July 2014. The Project Team explained to DOE and FEA on the preliminary results of the Project Team's activities during Third Works in Fiji.

DOE, FEA and the Project Team hereby mutually confirmed and agreed upon the followings:

4.1 Changed Plan for No.29 Site

The Project Team proposed to change generation plan of No.29 site in order to increase the maximum capacity of the scheme. The maximum capacity of the changed plan is expected to be around 8 MW in the case of run-of-river type, while in the case of designing this plan as reservoir type, the maximum capacity is expected to be over 20 MW.

DOE and FEA agreed to the changed plan of No.29 site, which will be studied at preliminary design level.

4.2 Schedule of Next Works in Fiji

The next (4th) assignment in Fiji is scheduled from 23rd to 31st October 2014. In the Works in Fiji, the Project Team will explain to DOE, FEA and the relevant stake holders on the results of preliminary design for three (3) prospective hydropower potential sites.

Suva, 18th July, 2014

Mr. Masahiko NAGAI
Team Leader
JICA Project Team

Mr. Peceli Nakavulevu
Director of Energy
Ministry Works, Transport, and Public Utilities

Mr. Karunesh Rao
Executive Projects & Public Relations Manager
Fiji Electricity Authority

Appendix 11-5

Presentation Materials for 3rd Stake Holder Meeting

Japan International Cooperation Agency

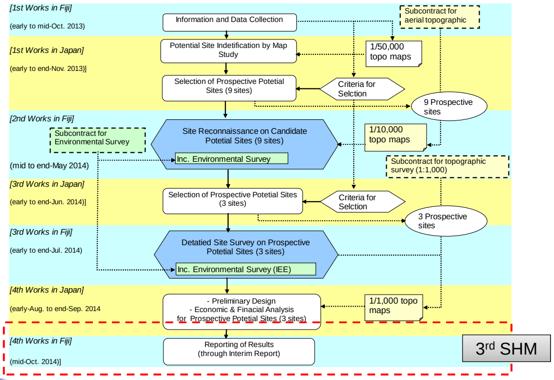
The Project
for
The Effective and Efficient Use
of Renewable Energy Resources in Power Supply
in Republic of Fiji

Results of Preliminary Designs for Three Prospective Hydropower Potential Sites

November 2014

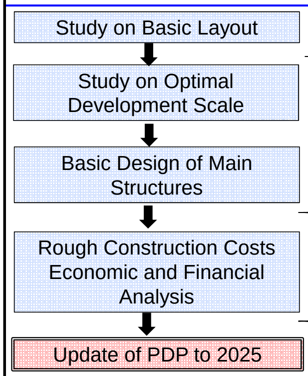
Tokyo Electric Power Services Company, LTD. (TEPSCO)

Hydropower Potential Study and Preliminary Design



2

Flow Chart of Carrying out Preliminary Design



- Hydrological Conditions
- Geological Conditions
- Storage Capacity
- P(kW), Q_{max}(m^3/sec), Generated Energy(KWh), etc.

- Dam, Intake
- Headrace
- Power house
- Turbine and Generator

- Economic Internal Rate of Return(EIRR)
- Financial Internal Rate of Return (FIRR)
- Net Present Value (NPV)
- Benefit / Cost (B/C)

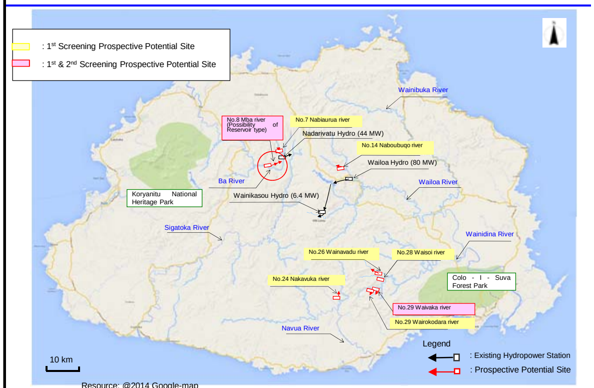
3

No.8 Hydropower Scheme

(One of Three Prospective Potentials Sites)

4

Location of No.8 Hydropower Scheme in Viti Levu

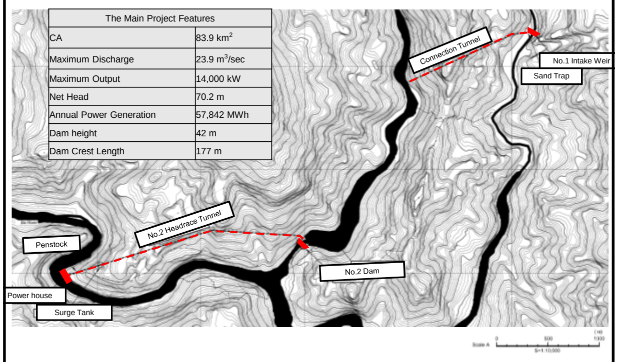


Resource; @2014 Google-map

5

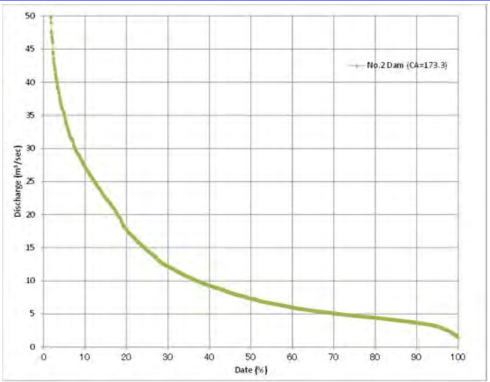
General Layout of No.8 Hydropower Scheme

The Main Project Features	
CA	83.9 km^2
Maximum Discharge	23.9 m^3/sec
Maximum Output	14,000 kW
Net Head	70.2 m
Annual Power Generation	57,842 MWh
Dam height	42 m
Dam Crest Length	177 m



6

Inflow Duration Curve at Project site



Optimum Development Cases for No.8 Hydropower Scheme

Case	Maximum Output (kW)	Maximum Discharge (m3/sec)	Generated Energy (MWh)	Tentative Constriction Cost (10^3 x USD)
1	11,000	18.8	53,754	62,366
2	12,000	20.5	55,232	64,206
3	13,000	22.2	56,389	65,922
4	14,000	23.9	57,842	67,702
5	15,000	25.7	59,367	69,747

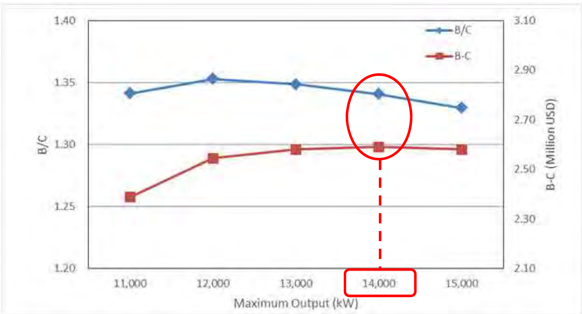
Economic evaluation was determined by Comprehensive Evaluation

- Benefit / Cost ratio (B/C)
- Benefit - Cost (B-C)

kW Value: 175.3 USD/kW※
kWh Value: 0.144※

※Use of Constriction Cost Nearby Alternative Diesel Thermal

Optimum Development Cases for No.8 Hydropower Scheme



Main Features for Optimum Development Plan

CA	83.9 km^2
Maximum Output	14,000 kW
Maximum Discharge	23.9 m^3/sec
Net Head	70.2 m
Annual Power Generation	57,842 MWh
Peak Duration Time	6 hr
Dam Type	Concrete Gravity Dam
Dam Height/ Crest Length	42m / 170 m
Effective Reservoir Capacity	2,300,000m^3
Headrace	2,000 m
Penstock	380 m

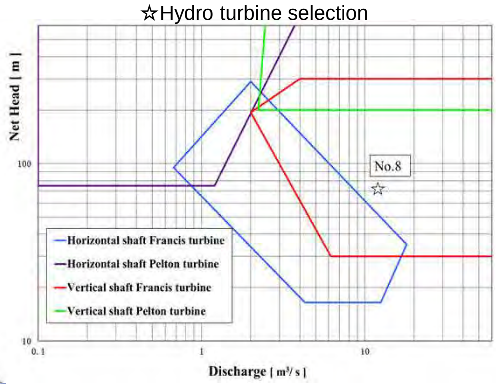
No.8 Outline Design of Generating Equipment (1)

☆Water discharge and net head

site	No.8
Number of Unit	2
Discharge [m3/s]	23.9 (11.9/1 unit)
Net head [m]	70.2
Output [kW]	14,000 kW 7,000kW x 2

No.8 Outline Design of Generating Equipment (2)

☆Hydro turbine selection



No.8 Outline Design of Generating Equipment (3)

■**Rated turbine output : Pt [kW]**

$$Pt = \frac{Pm}{\eta g} \quad (kW)$$

Where,

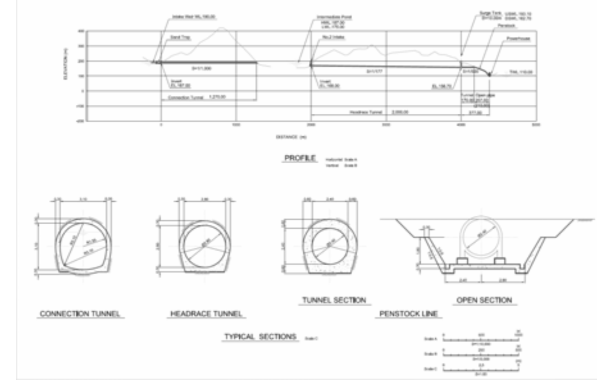
ηg : Generator efficiency at the rated output (0.97)

Pm : maximum output 7,000 [kW]

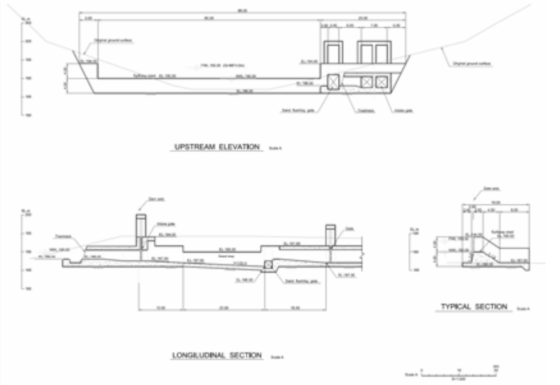
Site	No.8
type	VF
Pt [kW] /1unit	7,250

VF: Vertical Shaft Francis turbine

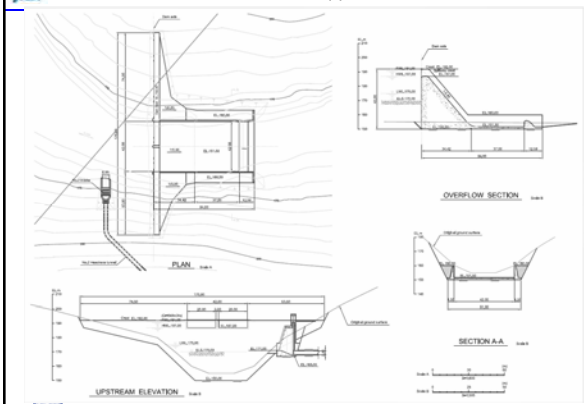
Profile and Typical Sections of Headrace and Penstock



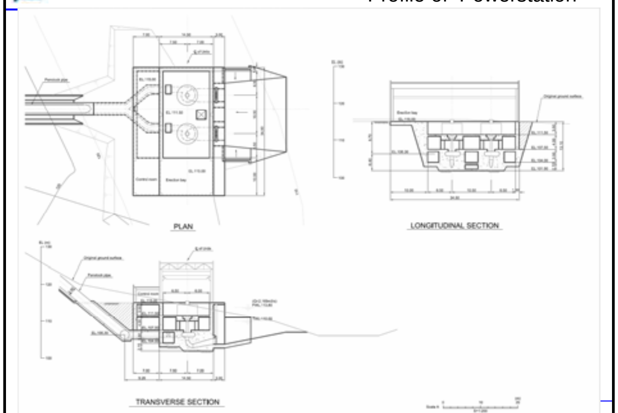
Typical Section of No.1 Intake Weir



Typical Section of No.2 Dam



Profile of Powerstation



Rough Cost Estimation for No.8 Hydropower

1. Preparation and Land Acquisition	1,625,930	Remark
(1) Access Roads	1,056,000	160 US$/6,600m
(2) Camp & Facilities	569,930	3. Civil Works * 2%
2. Environmental Mitigation Cost	854,895	3. Civil Works * 3%
3. Civil Works	28,496,491	
4. Hydro-mechanical Works	1,557,800	
5. Electro-Mechanical Equipment	15,692,340	
Direct Cost (USD)	**48,227,456**	
6. Administration and Engineering Service	7,234,118	Direct Cost * 15%
7. Contingency	4,822,746	Direct Cost * 10%
8. Interest during Construction	1,687,961	(1.+2.+3.+4.+5.+6.+7.)*0.4*i*P
Total Cost (USD)	**61,972,281**	

3. Civil Works	USD
a. Dam and Weir	14,084,769
b. Power Intake and Intake	748,236
c. Sand Trap	810,949
d. Headrace Tunnel and Connection Tunnel	7,735,400
e. Surge Tank	720,423
f. Penstock	668,873
g. Powerhouse	2,140,407
h. Outlet	230,458
i. Miscellaneous	1,356,976
Total	28,496,491

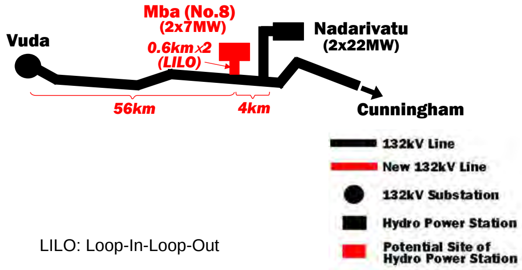
i :Interest rate
=i1 x 0.4 + i2 x 0.6
i1 is 0.02% of local currency
i2 is 0.01% of foreign currency

P: Constriction Period (5 years)

Rough estimation of by Adopting guideline for hydropower development.
Unit of construction cost of "Hydropower Renewable Energy Development Project in The Wailoa Downstream in Republic of the Fiji (JETRO, 2009)"

Transmission Scheme for No.8

- Location of this potential site is immediately adjacent to 132kV S/C line from Vuda to Nadarivatu, Therefore, LILO* of the above-mentioned 132kV line at this potential site is recommended.



LILO: Loop-In-Loop-Out

Rough cost for transmission schemes

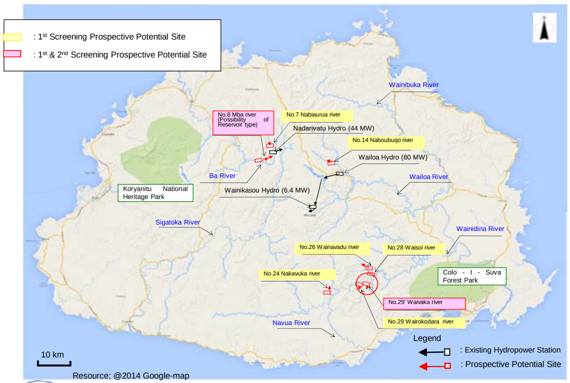
Transmission line name	Length in km	Cost/km in FJD *	Total Cost in FJD
VLIS			
LILO of 132kV S/C line from Vuda to Nadarivatu at Mba (No.8) potential site	0.6×2	396,000	475,200
LILO of 132kV S/C line from Nacocolevu to Hibiscus Park at Waivaka (No.29) potential site	30	396,000	11,880,000
132kV S/C line from Nablaurua (No.7) potential site to Nadarivatu	1.2	396,000	475,200
LILO of 132kV S/C line from Nadarivatu to Wailoa at Naboubuca (No.14) potential site	0.3×2	396,000	2,376,000
Total cost in VLIS			15,206,400
Vanua Levu			
33kV S/C line from Wailevu (No.35) potential site to Dreketi	25	90,000	2,250,000
33kV S/C line from Saquru (No.31) potential site to Cawaira	16	90,000	1,440,000
Total cost is Vanua Levu			3,690,000
Total cost			18,896,400

* Based on the cost of transmission lines in PDP 2011

No.29 Hydropower Scheme

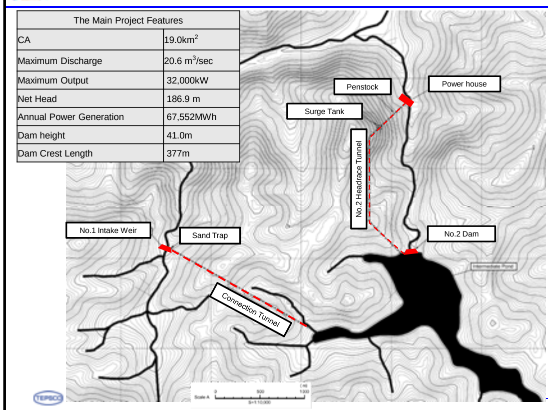
(One of Three Prospective Potentials Sites)

Location of No.29 Hydropower Scheme in Viti Levu

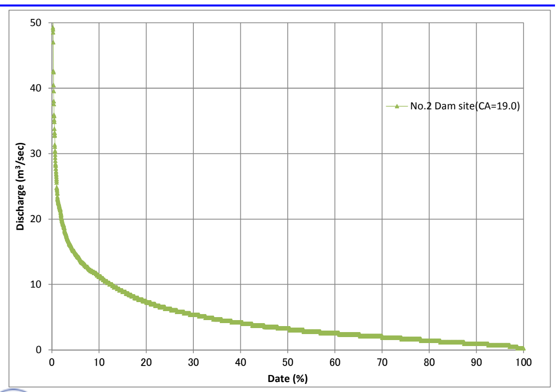


General Layout for No.29 Hydropower Scheme

The Main Project Features	
CA	19.0km^2
Maximum Discharge	20.6 m^3/sec
Maximum Output	32,000kW
Net Head	186.9 m
Annual Power Generation	67,552MWh
Dam height	41.0m
Dam Crest Length	377m



Inflow Duration Curve at Project Site



Optimum Development Cases for No.29 Hydropower Scheme

Case	Maximum Output (kW)	Maximum Discharge (m3/sec)	Generated Energy (MWh)	Tentative Constriction Cost (10^3 x USD)
1	25,000	16.1	68,012	72,145
2	28,000	17.9	67,991	75,410
3	32,000	20.6	67,552	79,944
4	35,000	23.8	67,929	83,667

Economic evaluation was determined
by Comprehensive Evaluation

- Benefit / Cost ratio (B/C)
- Benefit – Cost (B-C)

kW Value: 175.3 USD/kW※
kWh Value: 0.144※

※Use of Constriction Cost Nearby Alternative Diesel Thermal

Optimum Development Cases for No.29 Hydropower Scheme

Main Features for Optimum Development Plan

CA	19.0 km^2
Maximum Output	32,000 kW
Maximum Discharge	20.6 m^3/sec
Net Head	186.9 m
Annual Power Generation	67,552 MWh
Peak Duration Time	6 hr
Dam Type	Concrete Gravity Dam
Dam Height/ Crest Length	41m / 377 m
Effective Reservoir Capacity	29,000,000 m^3
Headrace	1,590 m
Penstock	465 m

No.29 Outline Design of Generating Equipment (1)

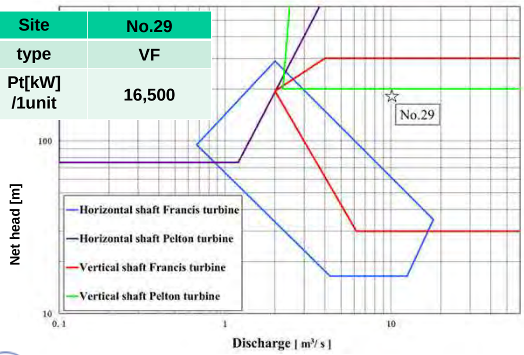
☆Water discharge and net head

site	No.29
Number of Unit	2
Discharge [m3/s]	20.6 (10.3/1 unit)
Net head [m]	186.9
Output [kW]	32,000kW 16,000kW x 2

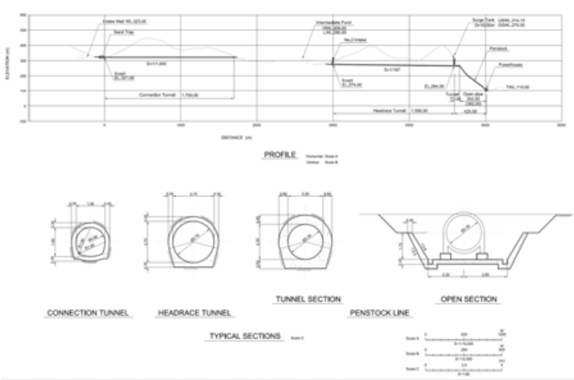
No.29 Outline Design of Generating Equipment (2)

☆Hydro turbine selection

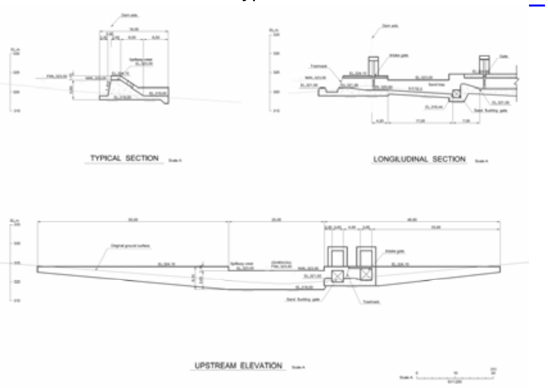
Site	No.29
type	VF
Pt[kW] /1unit	16,500



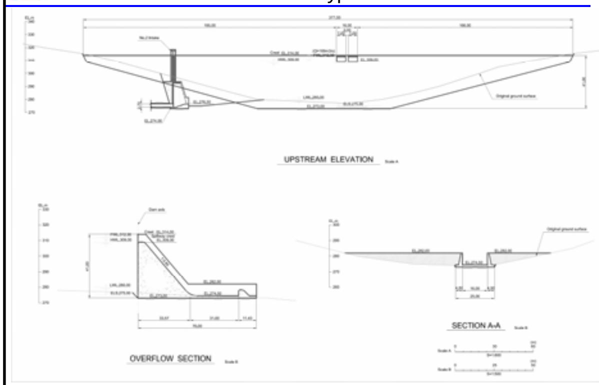
Profile and Typical Sections of Headrace and Penstock



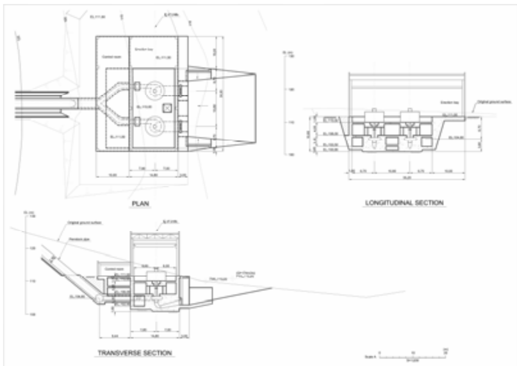
Typical Section of No.1 Intake Weir



Typical Section of No.2 Dam

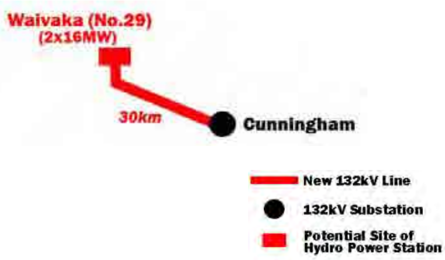


Profile of Powerstation



Transmission Scheme for No.29

- From the viewpoint of generation capacity, connection to the nearest 132kV Cunningham substation through 132kV S/C line of 30km is recommended.



Rough cost for transmission schemes

Transmission line name	Length in km	Cost/km in FJD *	Total Cost in FJD
VLIS			
LILO of 132kV S/C line from Vuda to Nadarivatu at Mba (No.8) potential site	0.6×2	396,000	475,200
LILO of 132kV S/C line from Nacocolevu to Hibiscus Park at Waivaka (No.29) potential site	30	396,000	11,880,000
132kV S/C line from Nablaurua (No.7) potential site to Nadarivatu	1.2	396,000	475,200
LILO of 132kV S/C line from Nadarivatu to Wailoa at Naboubuca (No.14) potential site	0.3×2	396,000	2,376,000
Total cost in VLIS			15,206,400
Vanua Levu			
33kV S/C line from Wailevu (No.35) potential site to Dreketi	25	90,000	2,250,000
33kV S/C line from Saquru (No.31) potential site to Cawaira	16	90,000	1,440,000
Total cost is Vanua Levu			3,690,000
Total cost			18,896,400

* Based on the cost of transmission lines in PDP 2011

Rough Cost Estimation for 29 Hydropower Scheme

1. Preparation and Land Acquisition	1,974,443	Remark
(1) Access Roads	1,200,000	160 US$/7,500m
(2) Camp & Facilities	774,443	3. Civil Works * 2%
2. Environmental Mitigation Cost	1,161,664	3. Civil Works * 3%
3. Civil Works	38,722,144	
4. Hydro-mechanical Works	2,799,115	
5. Electro-Mechanical Equipment	19,521,948	
Direct Cost (USD)	**64,179,314**	
6. Administration and Engineering Service	9,626,897	Direct Cost * 15%
7. Contingency	6,417,931	Direct Cost * 10%
8. Interest during Construction	2,246,276	(1.+2.+3.+4.+5.+6.+7.)*0.4*i*P
Total Cost (USD)	**82,470,418**	

3. Civil Works	USD
a. Dam and Weir	26,501,503
b. Power Intake and Intake	788,347
c. Sand Trap	268,007
d. Headrace Tunnel and Connection Tunnel	5,808,349
e. Surge Tank	974,144
f. Penstock	700,063
g. Powerhouse	1,638,416
h. Outlet	199,403
i. Miscellaneous	1,843,912
Total	38,722,144

i :Interest rate
=i1 x 0.4 + i2 x 0.6
i1 is 0.02% of local currency
i2 is 0.01% of foreign currency

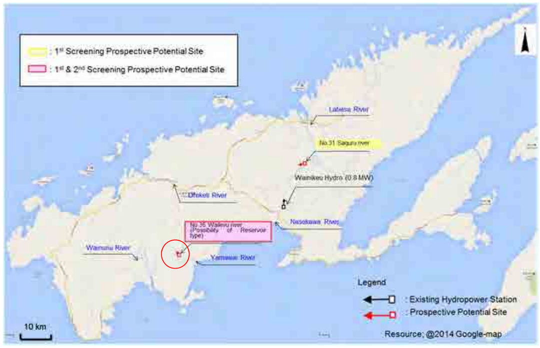
P: Constriction Period (5 years)

Rough estimation of by Adopting guideline for hydropower development.
Unit of construction cost of "Hydropower Renewable Energy Development Project in The Wailoa Downstream in Republic of the Fiji (JETRO, 2009)"

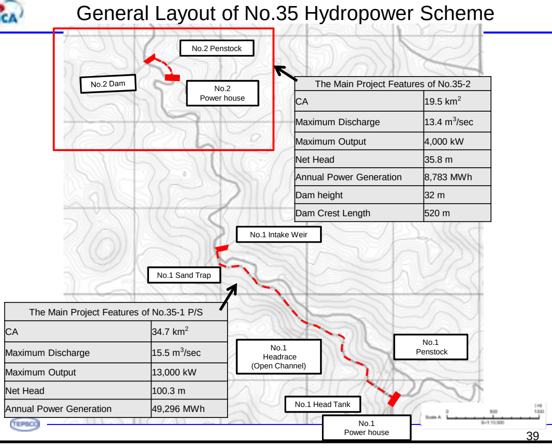
No.35 Hydropower Scheme

(One of Three Prospective Potentials Sites)

Location of No.35 Hydropower Scheme in Vanua Levu



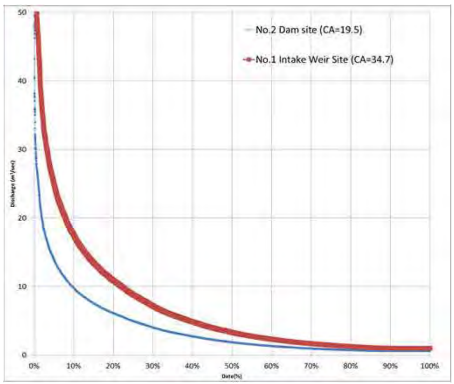
General Layout of No.35 Hydropower Scheme



The Main Project Features of No.35-2	
CA	19.5 km^2
Maximum Discharge	13.4 m^3/sec
Maximum Output	4,000 kW
Net Head	35.8 m
Annual Power Generation	8,783 MWh
Dam height	32 m
Dam Crest Length	520 m

The Main Project Features of No.35-1 P/S	
CA	34.7 km^2
Maximum Discharge	15.5 m^3/sec
Maximum Output	13,000 kW
Net Head	100.3 m
Annual Power Generation	49,296 MWh

Inflow Duration Curve at Project site



Optimum Development Cases for No.35 Hydropower Scheme

Case		No.35-2 4MW	4.5MW	5MW	6MW	
No.35-1	12MW	56,102 75,043	53,667 76,235	52,417 77,378	51,850 79,266	Generated Energy(MWh) Tentative Constriction Cost (10^3 x USD)
	13MW	58,079 76,706	55,854 77,898	54,602 79,041	54,040 80,929	Generated Energy(MWh) Tentative Constriction Cost (10^3 x USD)
	14MW	58,984 78,460	57,712 79,952	56,426 81,095	55,864 82,983	Generated Energy(MWh) Tentative Constriction Cost (10^3 x USD)
	15MW	60,038 80,718	58,913 81,910	57,609 83,053	57,072 84,941	Generated Energy(MWh) Tentative Constriction Cost (10^3 x USD)
	16MW	60,085 82,129	59,775 83,321	58,514 84,321	57,944 86,352	Generated Energy(MWh) Tentative Constriction Cost (10^3 x USD)

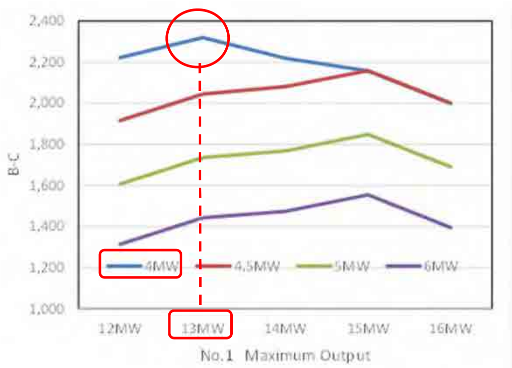
Economic evaluation was determined
by Comprehensive Evaluation

- Benefit / Cost ratio (B/C)
- Benefit - Cost (B-C)

kW Value: 175.3 USD/kW※
kWh Value: 0.144※

※Use of Constriction Cost Nearby Alternative Diesel Thermal

Optimum Development Cases for No.35 Hydropower Scheme



Main Features for Optimum Development Plan

	No.35-2 (Reservoir Type)	No.35-1 (Run-of-River Type)
CA	19.5 km^2	34.7 km^2
Maximum Output	4,000 kW	13,000 kW
Maximum Discharge	13.4 m^3/sec	15.5 m^3/sec
Net Head	35.8 m	100.3m
Annual Power Generation	8,783 MWh	49,296 MWh
Peak Duration Time	6 hr	- hr
Dam Type	Concrete Gravity Dam	Weir
Dam Height/ Crest Length	32m / 520 m	5m / 35 m
Effective Reservoir Capacity	15,000,000 m^3	- m^3
Headrace	-	2,540 m
Penstock	291 m	387 m

No.35-2 Outline Design of Generating Equipment (1)

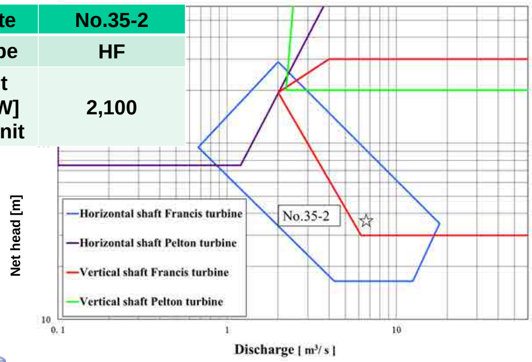
☆Water discharge and net head

Site	No.35-2
Number of Unit	2
Discharge [m3/s]	13.4 (6.7/1 unit)
Net head [m]	35.8
Output [kW]	4,000W 2,000kW x 2

No.35-2 Outline Design of Generating Equipment (2)

☆Hydro turbine selection

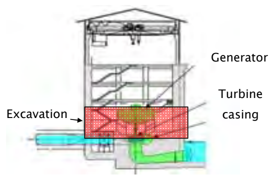
Site	No.35-2
type	HF
Pt [kW] /1unit	2,100



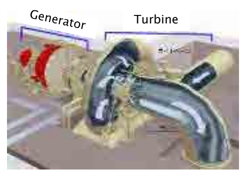
No.35-2 Outline Design of Generating Equipment (3)

☆The comparison between Vertical and Horizontal shaft

	Vertical shaft	Horizontal shaft
Space	Smaller than Horizontal, But excavation required	Planer structure
Capacity	approximately 1MW ～	approximately 0.5MW ～10MW
Maintenance	Difficult	Easy



Vertical



Horizontal

No.35-1 Outline Design of Generating Equipment (4)

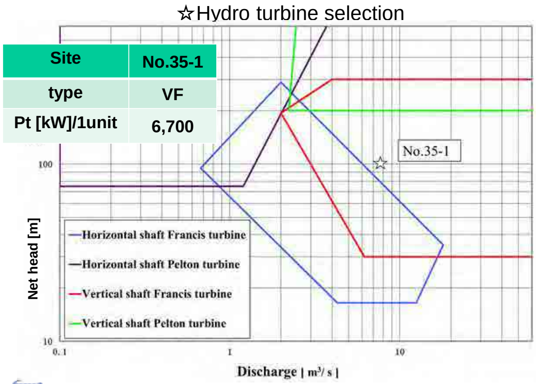
☆Water discharge and net head

Site	No.35-1
Number of Unit	2
Discharge [m3/s]	15.5 (7.8/1 unit)
Net head [m]	100.3
Output [kW]	13,000kW 6,500kW x 2

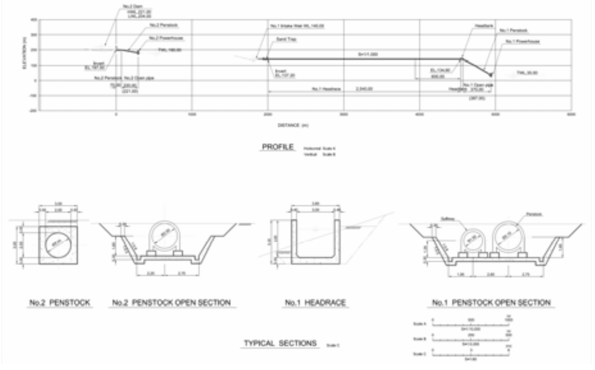
No.35-1 Outline Design of Generating Equipment (5)

☆Hydro turbine selection

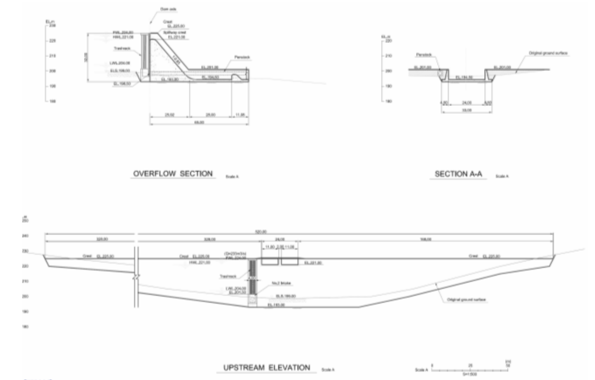
Site	No.35-1
type	VF
Pt [kW]/1unit	6,700



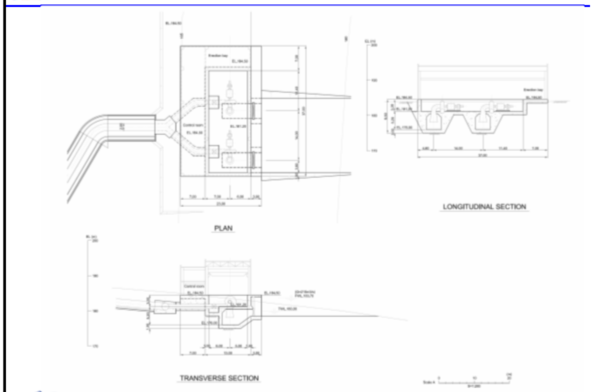
Profile and Typical Sections of Headrace and Penstock



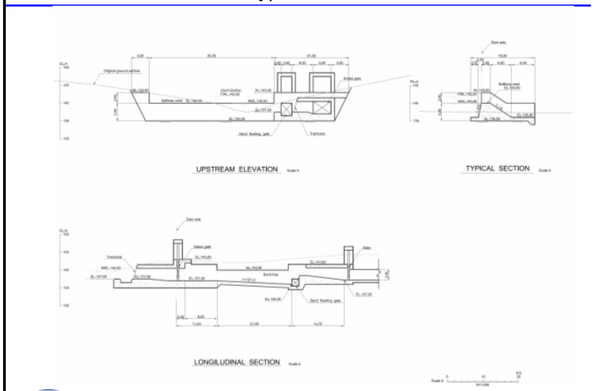
Typical Section of No.35-2 Dam



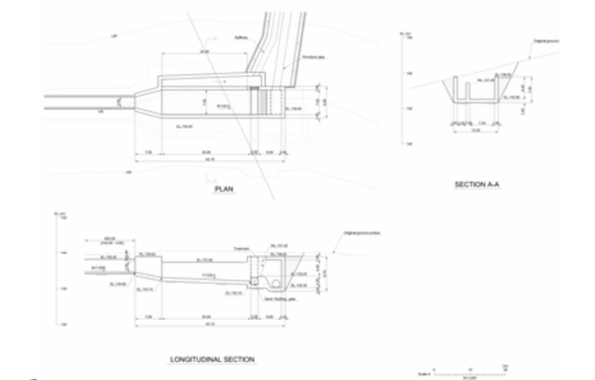
Profile of No.35-2 Powerstation



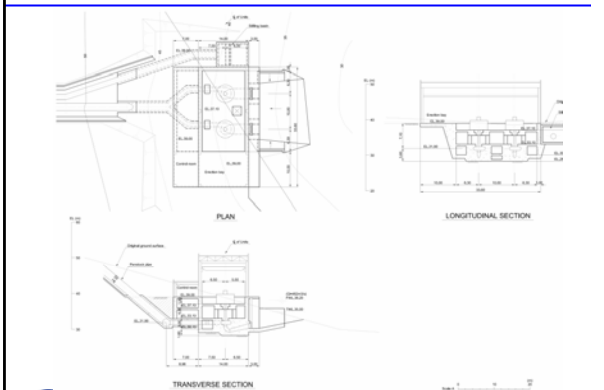
Typical Section of No.35-1 Intake Weir



Plan and Profile of No.35-1 Head Tank



Profile of No.35-1 Powerstation



Rough Cost Estimation of No.35-2 Hydropower

1. Preparation and Land Acquisition	1,024,762	Remark
(1) Access Roads	592,000	160 US$/3,700m
(2) Camp & Facilities	432,762	3. Civil Works * 2%
2. Environmental Mitigation Cost	649,143	3. Civil Works * 3%
3. Civil Works	21,638,105	
4. Hydro-mechanical Works	589,902	
5. Electro-Mechanical Equipment	8,672,070	
Direct Cost (USD)	**32,573,982**	
6. Administration and Engineering Service	4,886,097	Direct Cost * 15%
7. Contingency	3,257,398	Direct Cost * 10%
8. Interest during Construction	1,140,089	(1.+2.+3.+4.+5.+6.+7.)*0.4*i*P
Total Cost (USD)	**41,857,566**	

3. Civil Works	USD
a. Dam and Weir	17,429,432
b. Power Intake and Intake	200,436
c. Sand Trap	0
d. Headrace Tunnel and Connection Tunnel	0
e. Surge Tank	0
f. Penstock	2,120,634
g. Powerhouse	754,824
h. Outlet	102,393
i. Miscellaneous	1,030,386
Total	21,638,105

i :Interest rate
=i1 x 0.4 + i2 x 0.6
i1 is 0.02% of local currency
i2 is 0.01% of foreign currency

P: Constriction Period (5 years)

Rough estimation of by Adopting guideline for hydropower development.
Unit of construction cost of "Hydropower Renewable Energy Development Project in The Wailoa Downstream in Republic of the Fiji (JETRO, 2009)"

Rough Cost Estimation of No.35-1Hydropower

1. Preparation and Land Acquisition	969,659	Remark
(1) Access Roads	800,000	160 US$/5,000m
(2) Camp & Facilities	169,659	3. Civil Works * 2%
2. Environmental Mitigation Cost	254,489	3. Civil Works * 3%
3. Civil Works	8,482,967	
4. Hydro-mechanical Works	1,862,654	
5. Electro-Mechanical Equipment	13,319,366	
Direct Cost (USD)	**24,889,135**	
6. Administration and Engineering Service	3,733,370	Direct Cost * 15%
7. Contingency	2,488,914	Direct Cost * 10%
8. Interest during Construction	871,120	(1.+2.+3.+4.+5.+6.+7.)*0.4*i*P
Total Cost (USD)	**31,982,539**	

3. Civil Works	USD
a. Dam and Weir	523,184
b. Power Intake and Intake	189,671
c. Sand Trap	756,602
d. Headrace Tunnel and Connection Tunnel	3,661,922
e. Surge Tank	0
f. Penstock	831,675
g. Powerhouse	1,374,843
h. Outlet	178,004
i. Miscellaneous	403,951
Total	8,482,967

i :Interest rate
=i1 x 0.4 + i2 x 0.6
i1 is 0.02% of local currency
i2 is 0.01% of foreign currency

P: Constriction Period (5 years)

Rough estimation of by Adopting guideline for hydropower development.
Unit of construction cost of "Hydropower Renewable Energy Development Project in The Wailoa Downstream in Republic of the Fiji (JETRO, 2009)"

Transmission Scheme for No.35

- Connection to the nearest Dreketi 33kV bus through 33kV S/C line of 25km is recommended.

Rough cost for transmission schemes

Transmission line name	Length in km	Cost/km in FJD *	Total Cost in FJD
VLIS			
LILO of 132kV S/C line from Vuda to Nadarivatu at Mba (No.8) potential site	0.6×2	396,000	475,200
LILO of 132kV S/C line from Nacocolevu to Hibiscus Park at Waivaka (No.29) potential site	30	396,000	11,880,000
132kV S/C line from Nablaurua (No.7) potential site to Nadarivatu	1.2	396,000	475,200
LILO of 132kV S/C line from Nadarivatu to Wailoa at Naboubuca (No.14) potential site	0.3×2	396,000	2,376,000
Total cost in VLIS			15,206,400
Vanua Levu			
33kV S/C line from Wailevu (No.35) potential site to Dreketi	25	90,000	2,250,000
33kV S/C line from Saquru (No.31) potential site to Cawaira	16	90,000	1,440,000
Total cost is Vanua Levu			3,690,000
Total cost			18,896,400

* Based on the cost of transmission lines in PDP 2011

Economic and Financial Analysis

Basic Indicators for 3 Prospective Hydro Potential sites

Item	Assumptions: No.8 Site	Assumptions: No.29 Site	Assumptions: No.35 Site
a. Power Production			
Capacity:	14,000 kW	32,000 kW	No.1 13,000 kW No.2 4,000 kW
Firm Peak Capacity:	10,617 kW	28,281 kW	14,640 kW
Capacity Factor:	47.20%	24.10%	No.1 43.30% No.2 25.10%
Annual Generation Energy:	57,842 MWh	67,552 MWh	No.1 49,296 MWh No.2 8,783 MWh
Net Power Production*:	57,611 MWh	67,282 MWh	No.1 49,123 MWh No.2 8,748 MWh
b. Project Cost			
Hydropower Plant Construction Cost	62.0 Million USD	82.5 Million USD	73.9 Million USD
Transmission Cost	0.25 Million USD	6 Million USD	1 Million USD
c. Construction Period	5 years		
d. Project Life	40 years		
e. Transmission & Distribution Loss	10%		
f.Electricity Tariff**	0.19 USD/kWh		
g. Operation Expenses	1% of Construction Cost		
h. Exchange Rate***	1 FJD = 0.52 USD		

Note
* It is assumed auxiliary comsumption rate is 0.4% of total production.
**Weighted Average in Year 2013
***As of October 9, 2014, Reserve Bank of Fiji

Cost Alternative method is utilized for Diesel/HFO thermal power plant.

O&M Cost assumed to be 3% of construction cost.

Alternative Diesel Thermal Power Generation Cost		
Construction Cost	845 USD/KW	(including 30% of Installation Fee)
Annual O&M Cost (3% of Construction Cost)	0.326 USD	(Site No.8)
	0.867 USD	(Site No.29)
	2.252 USD	(Site No.35)
Fuel Cost	0.1440 USD/kWh	

Results of Evaluation for EIRR and FIRR

	No.8	No.29	No.35
Type	Reservoir	Reservoir	No.35-2: Reservoir No.35-1: Run-of-River
Maximum Output	14,000 kW	32,000 kW	No.35-2: 4,000 kW No.35-1: 13,000 kW
Maximum Discharge	23.9 m3/sec	20.6 m3/sec	No.35-2: 13.4 m3/sec No.35-1: 15.5 m3/sec
Generated Energy	57,842 MWh	67,552 MWh	No.35-2: 8,783 MWh No.35-1: 49,296 MWh
Hydropower Construction Cost	62.0 Million USD	82.5 Million USD	73.9 Million USD
Transmission Cost	0.25 Million USD	6 Million USD	1 Million USD
EIRR (B/C)	**13.3% (1.3)**	**18.4% (1.6)**	**11.7% (1.1)**
FIRR (B/C)	**11.54% (1.12)**	**9.19% (0.94)**	**9.38% (0.95)**

61

Result of IEE: Initial Environmental Examination

of three prospective hydropower potential sites for 2nd site reconnaissance

2014.Nov.11

Noboru Matsushima

Japanese Wildlife Research Center, Tokyo

Contents

1. Koro Village near No.8 Project

1. Introduction : JICA Guideline

- The project was classified as a Category B project under JICA Guideline.
- IEE is appropriate for master plane
- A "strategic environmental assessment" is an assessment that is implement at the policy, planning and program level.

1. Introduction : Land Ownership

- Land Ownership of Fiji
- 83% of the total land area of Fiji and belongs to native Fijians (native land)
- Two categories, with some 38% being Native Reserve Land which has been set aside
- However, land required for national development purposes can be "de-reserved" by the Native Lands Commission (NLC).

2. Results of IEE

- There are no requirement to relocate houses or settlement of three prospective hydropower potential sites.
- There are no significant impacts of natural environment: natural forest , rare fauna and flora affected by the project
- However, potential adverse environmental and socio-economic effects will occur by the current projects , for the purpose to clarify the region of issues in earlier stage
- Assessment of environmental effects
- Construction and operational phase

2. Result of IEE of three potential sites
a) Project Site No.8 Upper Ba River

Natural Environment

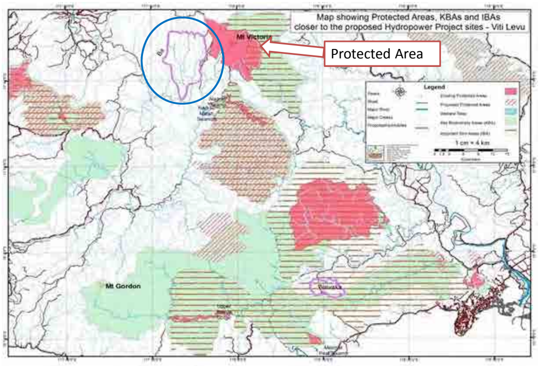
- Anthropogenic Grassland
  - No Natural Park / Protected Area
  - No endangered fauna / flora

Social Environment

- No resettlement
- Two to four farmhouses and scarce farmland will be inundated by the reservoir

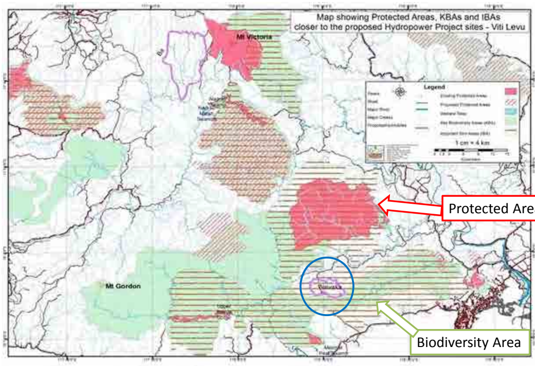
2. Result of IEE
a) Project Site No.8 Upper Ba River

b) Protected and Important Biodiversity Areas near No.8 Upper Ba



c) Project Site No.29 Waivaka

d) Protected and Important Biodiversity Areas near No.29 Waivaka



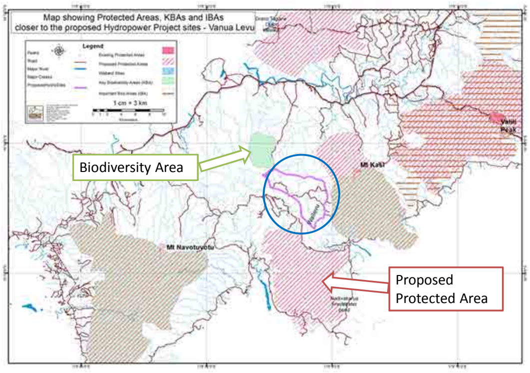
e) Project Site No.35 Wailevu

Environment

- Natural lowland rain forest
  - No Protected Area, but:
  - Loss of altered fresh water ecosystems
  - Erosion risk and sedimentation
  - Diminished water quality downstream
  - Loss of terrestrial ecosystem
- No resettlement
  - Loss of Downstream Fishing Uses
  - Land use issues
  - Loss of archaeological or cultural sites

f) Project Site No.35 Wailevu

g) Protected and Important Biodiversity Areas near No.35 Wailevu



3. Assessment of Environmental Effects

- 6 Issues of Potential Adverse Environmental Effects
- 12 Issues of Potential Adverse Socio-economic Effects
- Representative Potential Adverse Environmental Effects of three projects sites
- Representative Potential Adverse Socio-economic Effects of three projects sites

3. Environmental Impacts the construction phases

- Construction Effects : erosion & sediment
- Minimising the impacts of sedimentation = Rehabilitation of the earthwork
- erosion risk : steep topography, high and intense rainfall, scale of earthworks:
- access road, weir, tunnel , power station, penstock, dam, vegetation clearing,

3. Environmental Impacts the operation phases

- Decrease in the flow : downstream from the weir : Dry season, only ‘residual discharge ’ (minimum ecological flow)
- Improvements in the management of the upper catchment will be require: ex. Ecological management (forest, vegetation, erosion)
- No 8 = reversal of current degradation : repeated annual burning
- No 35 = high-standard management (support of landowners and Fiji Hardwood Corporation)

3. 6 Issues of Potential Adverse Environmental Effects

1) Loss of or altered freshwater ecosystems
2) Erosion risk and sedimentation
3) Diminished water quality downstream
4) Diminished freshwater ecosystems
5) Loss of terrestrial ecosystem
6) Contractor’s camp problems

3. Representative Potential Adverse Environmental Effects of three projects sites

Issue	No 8	No29	No35
Loss of or altered freshwater ecosystems	**High**	**High**	**High**
Construction of weir , dam and diversion of water	Reduced/minimal flow for the remainder		
Loss of terrestrial ecosystem	**Low**	**High**	**High**
Removal of gravel . Earthworks and clearing	Changes in hydrology, increased sedimentation,		
Erosion risk and sedimentation	**High**	**High**	**High**
Sediment discharges from road construction, weir and impoundment earthworks			
Diminished water quality downstream	**Low/ Tunnel, Mode./Impoundment**		
Sedimentation effects on aquatic ecology			

3. 12 Issues of Potential Adverse Socio-economic Effects

1) Poor water quality entering the reservoir

2) Loss of Downstream Fishing Uses, 3) Downstream uses, 4) Visual amenity, 5) Noise, Vibration & Dust, 6) Traffic impacts, 7) Water supply

8) Relocation of village houses, settlements

9) Land use issues, 10) Loss of archaeological or cultural sites, 11) Social problems,

12) Contractor's camp problems

3. Representative Potential Adverse Socio-economic Effects of three projects sites

Issue	No 8	No29	No35
Loss of Downstream Fishing Uses	**High**	**High**	**High**
Reduced/minimal water flow below weir and dam respectively			
Relocation of village houses, settlements	**Not required under current project**		
Relocation and compensation issues			
Land use issues	**Mode.**	**Mode.**	**Mode.**
Relocation and compensation issues	2-3 farm houses & farm	Farm & pasture	Plantation & natural forest
Loss of archaeological or cultural sites	**Not known**	**Not identified**	**No site known**
Sites required for construction or access			

4. Further works

- **MITIGATION MEASURES AND MONITORING PLAN**
- Construction Environmental Management Plan
- Camp and Workers Management Plan
- Community Management Plan
- Traffic Management Plan
- Environmental Monitoring Plan
- Operational Management Plan

Japan International Cooperation Agency

The Project for The Effective and Efficient Use of Renewable Energy Resources in Power Supply in Republic of Fiji

Stakeholders Meeting

November, 2014

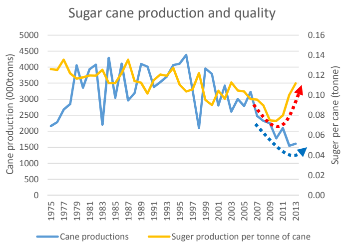
Tokyo Electric Power Services Company, LTD. (TEPSCO)

Biomass Energy Potentials

Tokyo Electric Power Services Company, LTD. (TEPSCO)

2

Sugar cane production and quality



Quantity

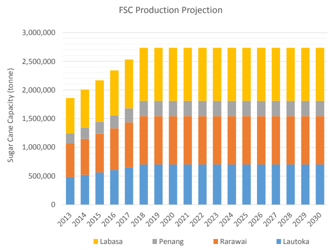
- Sugar cane production has been on a declining trend in a long term
- This trend would reach a turning point in 2011, and has been changed to upward in 2012.

Quality

- Sugar production per tonne of cane as quality indicator, describing yellow line in the figure below, shows an upward tendency from 2010.

3

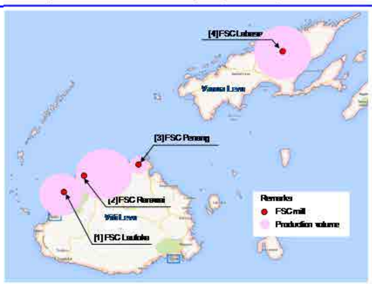
Bagasse production projection



- According to the discussion with FSC, it sets a goal of rolling back to production level of 10 years, which represents a 50 percent increase over last year.
- FSC dwell on their challenging on quantity and quality improvement. Therefore, FSC projection up to 2018 has been adopted and it assumed to be a fixed value until 2030 as a base scenario as shown in the figure below.

4

Bagasse potential map (mill-production basis)



- Bagasse potential map, indicating a location of mills and its production volume. Each red-colored circle indicates the FSM mill location and a size of each pink-colored circle shows the production volume in a relative evaluation.
- The potential of bagasse is eccentrically located in the east to north region where FSC mills are located in in Viti Levu, and its potential in Vanua Levu is focused in one place of Labasa area, since FSC Labasa is the sole source in the island.

5

Theoretical generation capacity (bagasse)

	Sugarcane production ton/year	plant thermal η *1) (LHV) %	Calorific value (dry bagasse kcal/kg	only 22 weeks output MW	off-season mini.Load (=×0.6) MW	offseason required Sugarcane η×0.9 ton/year	22 weeks rev. sugar cane ton/year	22 weeks (off-season mini.L) rev. gross output MW
Lautoka								
2013	484,600	24.0	4,060	19.3	7.2	195,529	289,071	11.5
2018	700,000	26.7	4,060	31.1	6	146,314	553,686	24.6
Rarawai								
2013	581,000	24.0	4,060	23.2	2.4	65,176	515,824	20.6
2018	850,000	30.5	4,060	43.0	2.4	51,286	798,714	40.5
Penang								
2013	180,000	24.0	4,060	7.2	2	54,314	125,686	5.0
2018	250,000	25.3	4,060	10.5	2	51,625	198,375	8.3
Labasa								
2013	612,000	24.0	4,060	24.4	8	217,254	394,746	15.7
2018	930,000	26.5	4,060	40.9	6	147,569	782,431	34.4
Total								
2013	1,857,600	24.0	4,060	74.0	19.6	532,272	1,325,328	52.8
2018	2,730,000	24.0	4,060	108.8	16.4	396,794	2,333,206	107.8

[Conditions]

- Bagasse ratio on sugar cane = 25%
- Moisture ratio on bagasse =48%
- Calorific value of dry-bagasse = 17 MJ/kg (or 4,060 kcal/kg, 1cal=4.187J)
- Power plant thermal efficiency = 24 %
- Generation supply only for 22 week during sugar production season

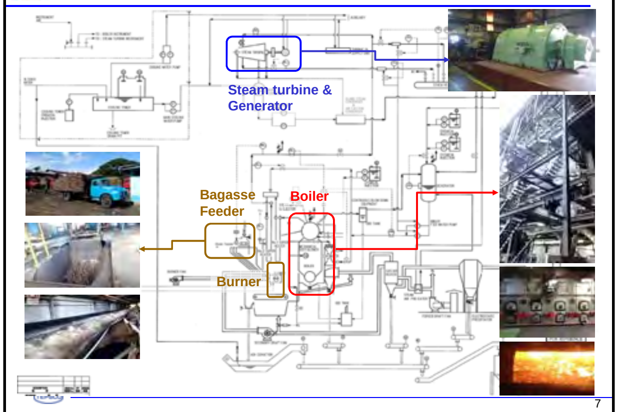
[Theoretical equation]

Theoretical generation (MW) = Calorific value of dry-basis* plant thermal efficiency*sugar cane production volume* bagasse ratio on sugar cane*(1- Moisture ratio on bagasse)/ 860/ (24ht*7days*22weeks)

6

Bagasse generation system flow

Supplemental slide



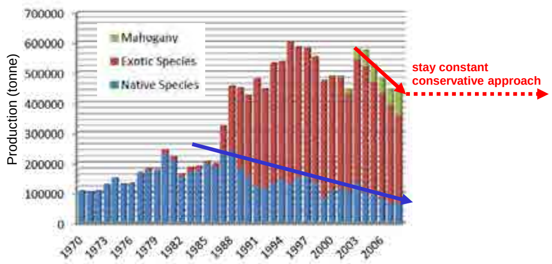
Waste wood potential map (mill-production basis)

Island	Division		No.	company name	capacity (m3)	
					Sawmill	Plywood
Viti Leve	Western	A	A1	Dayals Sawmill Ltd	7,500	
Viti Leve	Western		A2	Tropick Forest Joint Venture	7,000	
Viti Leve	Western	B	B1	Tropicwood Industries Ltd	100,000	100,000
Viti Leve	Western		B2	Lomolomo Sawmill	5,000	
Viti Leve	Western		B3	Best Industries Ltd	7,500	
Viti Leve	Western		B4	Designtech Sawmill	7,000	
Viti Leve	Western	C	C1	K.K.Komove	7,000	
Viti Leve	Western	D	D1	Global Food Import & Export	7,000	
Viti Leve	south	E	E1	Yarawa sawmill	12,000	
Viti Leve	south		E2	Sustainable Mahogany Industries	12,000	
Viti Leve	south	F	F1	Touchwood Investment	17,000	
Viti Leve	south		F2	Timber Utilization Division	3,000	
Viti Leve	south		F3	Southern Forest Wood Product Ltd	17,500	
Viti Leve	south		F4	Vitiana Timbers	7,000	
Viti Leve	south		F5	Newmart	5,000	
Viti Leve	south		F6	Island Tropical Forest	5,000	
Sub-total (Viti Leve)						**100,000**
Vanua Leve	North	G	G1	Fiji Forest Industries Ltd	17,500	17,500
Vanua Leve	North		G2	Waiqele Sawmill	17,500	
Vanua Leve	North		G3	Sam Civil Service	3,000	
Vanua Leve	North		G4	Valebasoga Tropik Board Ltd	17,500	17,500
Vanua Leve	North		G5	Vunimoli Sawmill	5,000	
Vanua Leve	North	H	H1	Taiwan Timber Fiji Ltd	7,000	
Vanua Leve	North	I	I1	J/Narayan & RT Sikeli	1,500	
Vanua Leve	North		I2	Raviravi Sawmill	3,000	
Vanua Leve	North	J	J1	Lumber Processor	7,000	
Vanua Leve	North		J2	Long Investment	7,000	
Sub-total (Vanua Leve)						**35,000**
Total					**312,500**	**135,000**

- Wood industry is also one of the major economic activity in Fiji. According to the Department of Forestry (DOF)
- Major licensed wood mills exist with total production of 312,500 m^3 sawmill and 135,00m^3 plywood

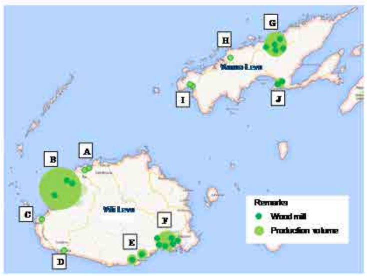
Waste wood production projection

Supplemental slide



- Since 1988, production drastically increased by exotic and mahogany species
- Production of Native species is decreasing on a continuing basis for recent 10 years
- Total production is also decreasing
- **JICA Study Team recognized projection in that, waste wood production stay constant on current position in a conservative approach**

Waste wood potential map (mill-production basis)



- Potential map, indicating a location of mills and its production volume. Each green-colored circle indicates the mill location and a size of each greenish yellow-colored circle shows the production volume in a relative evaluation.
- Unlike in the case of bagasse, locations of the wood mills in both Viti Levu and Vanua Levu are scattered over a large area with a small size except Tropic Industries Ltd, or sole large-scale mills.

Theoretical generation capacity (waste wood)

Island	Division		No.	company name	capacity (m3)		Theoritical Output(MW)
					Sawmill	Plywood	
Viti Leve	Western	A	A1	Dayals Sawmill Ltd	7,500		0.3
Viti Leve	Western		A2	Tropick Forest Joint Venture	7,000		0.3
Viti Leve	Western	B	B1	Tropicwood Industries Ltd	100,000	100,000	5.1
Viti Leve	Western		B2	Lomolomo Sawmill	5,000		0.2
Viti Leve	Western		B3	Best Industries Ltd	7,500		0.3
Viti Leve	Western		B4	Designtech Sawmill	7,000		0.3
Viti Leve	Western	C	C1	K.K.Komove	7,000		0.3
Viti Leve	Western	D	D1	Global Food Import & Export	7,000		0.3
Viti Leve	south	E	E1	Yarawa sawmill	12,000		0.5
Viti Leve	south		E2	Sustainable Mahogany Industries	12,000		0.5
Viti Leve	south	F	F1	Touchwood Investment	17,000		0.7
Viti Leve	south		F2	Timber Utilization Division	3,000		0.1
Viti Leve	south		F3	Southern Forest Wood Product Ltd	17,500		0.7
Viti Leve	south		F4	Vitiana Timbers	7,000		0.3
Viti Leve	south		F5	Newmart	5,000		0.2
Viti Leve	south		F6	Island Tropical Forest	5,000		0.2
Sub-total (Viti Leve)						**100,000**	**10.0**
Vanua Leve	North	G	G1	Fiji Forest Industries Ltd	17,500	17,500	0.9
Vanua Leve	North		G2	Waiqele Sawmill	17,500		0.7
Vanua Leve	North		G3	Sam Civil Service	3,000		0.1
Vanua Leve	North		G4	Valebasoga Tropik Board Ltd	17,500	17,500	0.9
Vanua Leve	North		G5	Vunimoli Sawmill	5,000		0.2
Vanua Leve	North	H	H1	Taiwan Timber Fiji Ltd	7,000		0.3
Vanua Leve	North	I	I1	J/Narayan & RT Sikeli	1,500		0.1
Vanua Leve	North		I2	Raviravi Sawmill	3,000		0.1
Vanua Leve	North	J	J1	Lumber Processor	7,000		0.3
Vanua Leve	North		J2	Long Investment	7,000		0.3
Sub-total (Vanua Leve)						**35,000**	**3.8**
Total					**312,500**	**135,000**	**13.8**

- Sawmill 318,000 m3/year = 159,000 m3/y woodchip = **50% waste ratio**
- Plywood 135,000 m3/year = 27,000 m3/y wood chip = **20% waste ratio**
- Total wood chip =208,000m3/year **→13.8MW theoretical generation**

[Theoretical equation]
Theoretical generation (MW) = Calorific value of wood chips on dry-basis* plant thermal efficiency*waste wood production volume/ (860*24ht*365days)

Co-firing with bagasse with waste wood

Supplemental slide

For Bagasse single use designed boiler, co-firing with bagasse and waste wood drastically damaged.

For **Bagasse single designed boiler**, co-firing with bagasse and waste wood drastically damaged.

- ✓ Due to different moisture, different calorific value, combustion temperature and speed between bagasse and waste wood is different.
- ✓ Bagasse single designed boiler is fixed bed type, for co-firing boiler shall change to fluidized-bed system.
- ✓ Ex; FSC Penang purchases waste wood at 120 F$ /ton form adjacent wood mills. (2,500tonne/year)

Operation patterns on FSC existing generation (2013)

Supplemental slide

			On season					Off season						
			7	8	9	10	11	12	1	2	3	4	5	6
Viti Leve	Lautoka	Internal (MW)	5	5	5	5	5	1	1	1	1	1	1	1
		External (MW)	7	7	7	7	7	0	0	0	0	0	0	0
		Total (MW)	12	12	12	12	12	1	1	1	1	1	1	1
	Rarawai	Internal (MW)	5	5	5	5	5	1	1	1	1	1	1	1
		External (MW)	0	0	0	0	0	0	0	0	0	0	0	0
		Total (MW)	5	5	5	5	5	1	1	1	1	1	1	1
	Penang	Internal (MW)	2	2	2	2	2	1	1	1	1	1	1	1
		External (MW)	1	1	1	1	1	0	0	0	0	0	0	0
		Total (MW)	3	3	3	3	3	1	1	1	1	1	1	1
		Grid supply	**8**	**8**	**8**	**8**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Vanua Levu	Labasa	Internal (MW)	5	5	5	5	5	1	1	1	1	1	1	1
		External (MW)	5	5	5	5	5	0	0	0	0	0	0	0
		Total (MW)	10	10	10	10	10	1	1	1	1	1	1	1
		Grid supply	**5**	**5**	**5**	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Total Generation
Viti Levu : 20MW,
Vanua Levu : 10MW

⇨

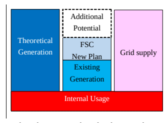
Internal usage
Viti Levu : 12MW
Vanua Levu : 5MW

⇨

Power supply to the national grid
Viti Levu : 8MW
Vanua Levu : 5MW

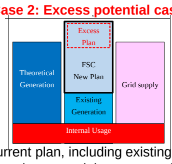
Biomass Energy Potentials
Grid supply potential by FSC Bagasse

Case 1: Additional potential case



Theoretical capacity is less than the total capacity of existing and new plan, so that, an additional potential is available.

Case 2: Excess potential case



Current plan, including existing and new capacity, exceed the amount of theoretical potential.

	unit	2013	2014	2015	2020	2025	2030
[MW basis]							
FSC Lautoka	MW	7.3	7.3	7.3	17.3	17.3	17.3
FSC Rarawai	MW	0.0	0.0	5.0	44.2	44.2	44.2
FSC Penang	MW	1.0	1.0	1.0	6.0	6.0	6.0
VITI LEVU total grid	MW	8.3	8.3	13.3	67.5	67.5	67.5
FSC Labasa	MW	5.0	5.0	5.0	31.8	31.8	31.8
VANUA LEVU total grid	MW	5.0	5.0	5.0	31.8	31.8	31.8
[MWh basis]							
FSC Lautoka	MWh	25,702	25,702	25,702	60,911	60,911	60,911
FSC Rarawai	MWh	0	0	17,604	155,750	155,750	155,750
FSC Penang	MWh	3,521	3,521	3,521	21,125	21,125	21,125
VITI LEVU total grid	MWh	29,223	29,223	46,827	237,786	237,786	237,786
FSC Labasa	MWh	17,604	17,604	17,604	112,123	112,123	112,123
VANUA LEVU total grid	MWh	17,604	17,604	17,604	112,123	112,123	112,123

Thank you for your kind attention

Tokyo Electric Power Services Company, LTD. (TEPSCO)

Japan International Cooperation Agency

The Project for The Effective and Efficient Use of Renewable Energy Resources in Power Supply in Republic of Fiji

Stakeholder Meeting

November, 2014

Tokyo Electric Power Services Company, LTD. (TEPSCO)

Power Development Plan

Tokyo Electric Power Services Company, LTD. (TEPSCO)

2

Diagram for Power Development Plan

Demand Forecast

Power Development (Supply Capacity) Plan

Calculate Relationship between Power Supply Reliability (LOLE) and Reserve Margin — **RETICS**

Is supply reliability proper? (**No** → back to Power Development (Supply Capacity) Plan; **Yes** → next)

Calculate Annual Generation Expense (Fixed & Fuel Cost) — **PDPAT II**

Optimum Development Plan — **Comparison with other development plan**

3

Power Demand Forecast

Up to 2025

Tokyo Electric Power Services Company, LTD. (TEPSCO)

4

Power Demand Forecast

GDP Growth Rate Forecast : 3% Targeted (2.1% for last five years)

Growth Rate Elasticity of Generation Energy against GDP : 1.5

Rural Electrification Process (2015: 90% → 2020: 100%)

Population Growth Rate : 0.8%

Energy Conservation : - 0.5%

Generation Energy Growth Rate Forecast : 5% up to 2020, 4.5% after 2021

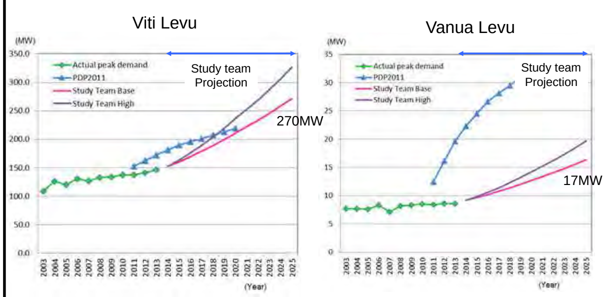
Lead Factor Forecast (64.1% for last 5 years) 2015 : 64% → 2025 : 60% (-0.4% / annum)

Seasonal Difference

Monthly Peak Demand Forecast

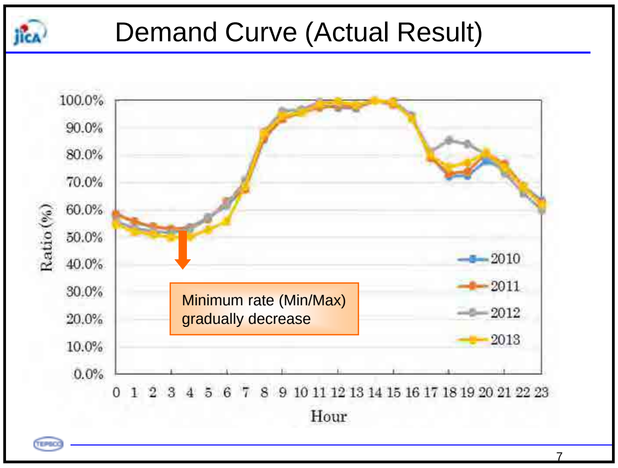
5

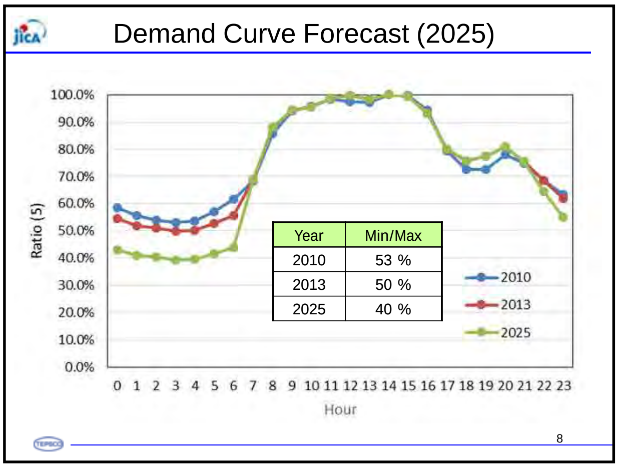
Peak Demand Forecast until 2025

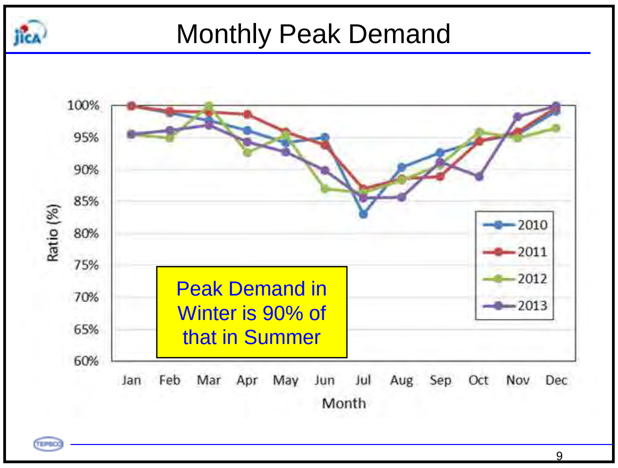


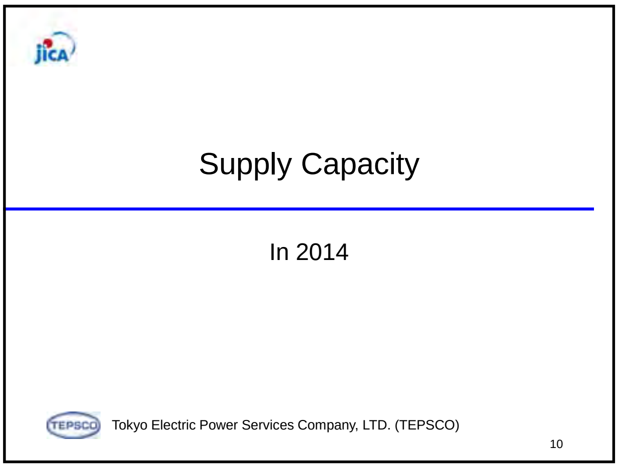
Total Peak Demand in 2025 will be 290MW

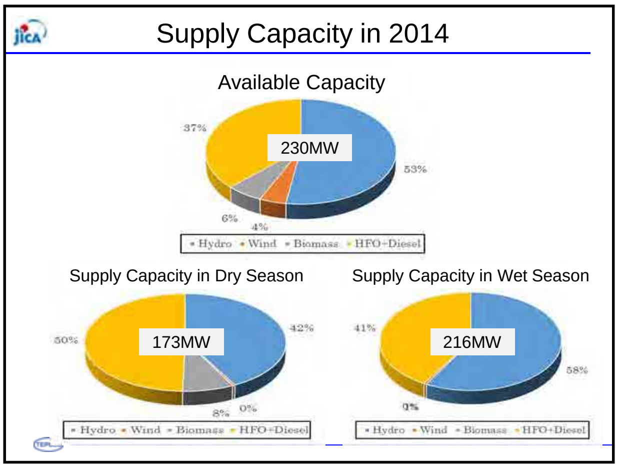
6

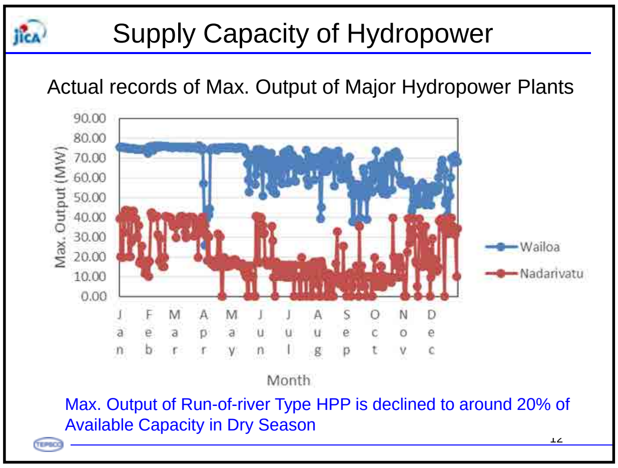

Demand Curve (Actual Result)
Ratio (%)
Hour
2010
2011
2012
2013
Minimum rate (Min/Max)
gradually decrease
7


Demand Curve Forecast (2025)
Ratio (5)
Hour
Year | Min/Max
2010 | 53 %
2013 | 50 %
2025 | 40 %
2010
2013
2025
8


Monthly Peak Demand
Ratio (%)
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2010
2011
2012
2013
Peak Demand in Winter is 90% of that in Summer
9


Supply Capacity
In 2014
Tokyo Electric Power Services Company, LTD. (TEPSCO)
10


Supply Capacity in 2014
Available Capacity
230MW
Hydro Wind Biomass HFO+Diesel
Supply Capacity in Dry Season
173MW
Supply Capacity in Wet Season
216MW


Supply Capacity of Hydropower
Actual records of Max. Output of Major Hydropower Plants
Max. Output (MW)
Month
Wailoa
Nadarivatu
Max. Output of Run-of-river Type HPP is declined to around 20% of Available Capacity in Dry Season

Economical Evaluation of Power Sources

Screening by Generating Cost

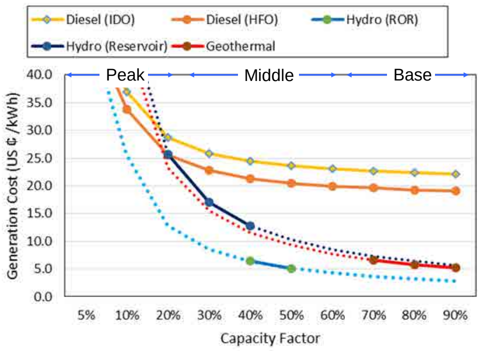
Tokyo Electric Power Services Company, LTD. (TEPSCO)

Generation Cost by Power Source

Power Source	Const. cost (USD/kW)	Fuel cost (USC/kWh)	Generation cost (USC/kWh)		
			L.F=20%	L.F=40%	L.F=80%
Hydro (Run-of-River)	2,000	0.0	---	6.4	---
Hydro (Reservoir)	4,000	0.0	25.6	12.8	---
Diesel (IDO)	8,500	20.3	28.6	24.5	22.4
Diesel (HFO)	8,500	17.2	25.5	21.4	19.3
Geothermal	3,500	0.0	---	---	5.8

Oil Price Assumption : 114 USD/bbl (IDO), 100 USD/bbl (HFO)

Generation Cost by Power Source



Relationship between Power Supply Reliability (LOLE) and Reserve Margin

Tokyo Electric Power Services Company, LTD. (TEPSCO)

Fluctuation Factors on Balancing Demand & Supply

- Reduction of supply capacity caused by Forced Outage
- Fluctuation of the water flow for hydro-power
  - Yearly fluctuation : High water flow or Draught
  - Monthly fluctuation : Firm capacity (90% probability)
- Demand forecast error
  - Increase in demand is equivalent to decline of supply capacity.

Supply Reliability Index

- LOLP (Loss of Load Probability)
  - Probability not to secure balancing supply/demand
- LOLE (Loss of Load Expectation)
  - Expectation hours not to secure balancing supply/demand
  - LOLE = LOLP x 8760 hrs
  - Complex calculations
- Reserve margin
  - Not to indicate clearly its reliability by numerical value
  - Easy calculation (Ratio of reserve supply capacity to demand)

On-going Power Development Projects

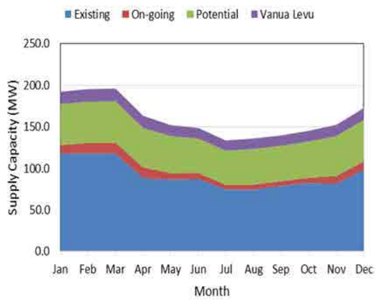
Location	Power Plant Name	Source and Type	Installed Capacity (MW)	Supply Capacity (MW)	Generation Energy (GWh)	Commiss-ioning Year	Current Status
Viti Levu	Kinoya PS Extension	HFO thermal	35	35	-	2015	Procurement by FEA
	Wailoa Downstream	Hydro	7	1.3	33.8	2018	Consultant Selection
	Qaliwana	Hydro	10	1.9	48.2	2018	Consultant Selection
	Wainisavulevu weir raising *1	Hydro	3	1.8	9.2	2015	Under Construction
	Lautoka (FSC)	Biomass	5	4.5	16.6	2017	Committed by FEA
	Rarawai (FSC)	Biomass	5	4.5	16.6	2015	Committed by FEA
			40	36	133.1	2016	Committed by FEA
	Penang	Biomass	5	4.5	16.6	2017	Committed by FEA
	Sub-total		110	89.5	274.2		
Vanua Levu	Labasa	Biomass	10	9	33.3	2016	Committed by FEA
	Sub-total		10	9	33.3		
	Total		120	98.5	307.4		

*1 : One of 2units of Wainikasou HPP under rehabilitation will be restart

Renewable Energy Power Source Potentials

Location	Power Plant Name	Source and Type	Installed Capacity (MW)	Supply Capacity (MW)	Generation Energy (GWh)
Viti Levu	Mba (No.8)	Hydro	14	10.9	59.5
	Waivaka (No.29)	Hydro	32	28.6	68.2
	Nablaurua(No.7)	Hydro	1.4	0.6	8.3
	Naboubuca (No.14)	Hydro	2.7	0.9	20.4
	Lautoka (FSC)	Biomass	5	4.5	16.6
	Tavua	Geothermal	6	6	44.7
	Busa	Geothermal	4	4	29.8
	Sub-total		65.1	55.5	173.0
Vanua Levu	Wailevu (No.35)	Hydro	17	12.2	49.3
	Saquru (No.31)	Hydro	2	0.2	9.6
	Labasa	Biomass	10	9	33.3
			3	2.7	10.0
			4	3.6	13.3
	Savusavu	Geothermal	8	8	59.6
	Waiqele	Geothermal	8	8	59.6
	Sub-total		44	35.7	175.0
	Total		109.1	91.2	348.0

Monthly Firm Capacity of Hydropower

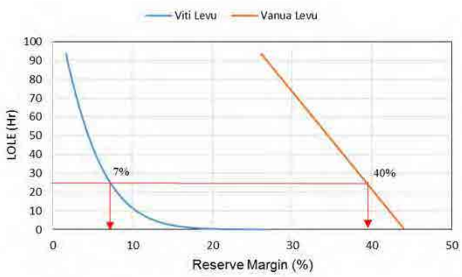


- Total Max. Firm Capacity in Mar. is 196MW
- This accounts for 64% of required Supply Capacity in 2025
- The other required supply capacity of 110MW should be covered by thermal power.

Data of Fluctuation Factors for Calculation of Relationship between LOLE and Reserve Margin

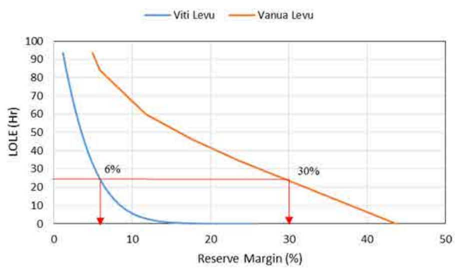
- Reduction of supply capacity caused by Forced Outage
  - Thermal power (Diesel) FOR : 8 -10%
  - Biomass power FOR : 10%
  - Hydropower FOR : 2 %
- Fluctuation of the water flow for hydro-power
  - Yearly fluctuation : 6% (10 MW in Viti Levu, 1MW in Vanua Levu) is set as the standard deviation
  - Monthly fluctuation : Firm capacity (90% probability)
- Demand forecast error
  - 2% of the forecasted demand is set as Error in the demand forecast

Relation between LOLE and Reserve Margin in 2020



- Reserve margin required to secure the comparable supply reliability level is 7% in Viti Levu.
- Reserve margin required is about as large as 40% in Vanua Levu, since Biomass power in winter has large FOR.

Relation between LOLE and Reserve Margin in 2025



- Reserve margin required to secure the comparable supply reliability level can be about 1% lower than 2020 in Viti Levu.
- Reserve margin required can be about 10% lower than 2020 in Vanua Levu, since the ratio of unit capacity newly developed against its peak demand is getting smaller.

Necessity of interconnection between islands

- It is expected that interconnection between Viti Levu and Vanua Levu has large advantage.
  - To reduce necessary reserve margin and to increase the share of generation energy by renewable energy.
  - To make use of abundant renewable energy potential in Vanua Levu.

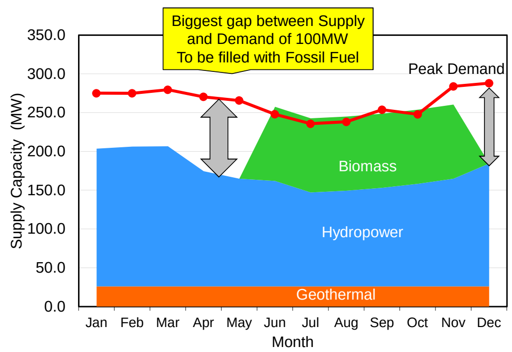
Study on Optimal Power Supply Configuration in 2025

Tokyo Electric Power Services Company, LTD. (TEPSCO)

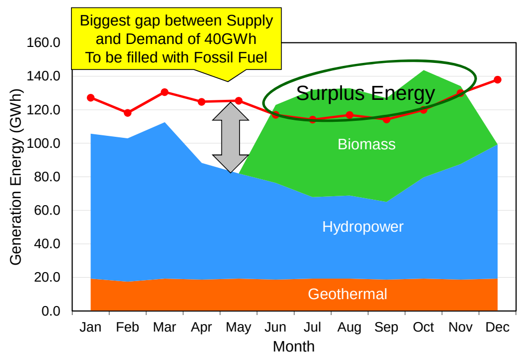
Power Development Policy

- All Potential of Every Renewable Energy Source is to be developed by 2025
- Biomass Energy by Waste Wood is not taken into account as the above potential.
  - Not economical due to deconcentration of sawmills
  - Not environmentally friendly
- Fossil fuel consumption for power is to be reduced as much as possible

Supply and Demand Balance (kW) in 2025



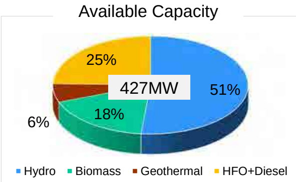
Supply and Demand Balance (kWh) in 2025

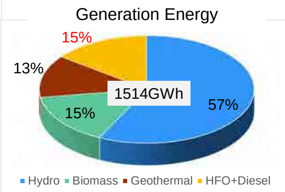


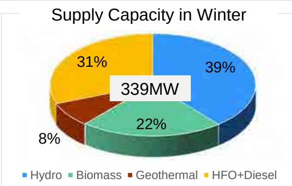
Optimal Power Supply Configuration in 2025

- Development of biomass energy potential in Vanua can be delayed from the viewpoints of Energy Balance. Around 24MW
- Gap (from December to May) between supply capacity of renewable energy sources and demand be filled with Fossil fuel such as a Diesel with HFO.
- Viti Levu and Vanua Levu power system should be interconnected.

Optimal Power Supply Configuration in 2025







Generation energy by RERs could account for 85%

Thank you for your kind attention

Tokyo Electric Power Services Company, LTD. (TEPSCO)

Appendix 11-6

MINUTES OF DISCUSSION

FOR FOURTH (4) WORKS IN FIJI

ON

THE PROJECT

FOR

THE EFFECTIVE AND EFFICIENT USE OF

RENEWABLE ENERGY RESOURCES

IN POWER SUPPLY

MINUTES OF DISCUSSTION
FOR FOURTH WORKS IN FIJI
ON
THE PROJECT
FOR
THE EFFECTIVE AND EFFICIENT USE OF
RENEWABLE ENERGY RESOURCES IN POWER SUPPLY

DATE: 12th November, 2014
Suva, Fiji

I. General

The Japan International Cooperation Agency (JICA) dispatched the Project Team (Tokyo Electric Power Services CO.,LTD (TEPSCO)) from 6th to 14th November, 2014 for the Fourth Works in Fiji on the Project for the Effective and Efficient Use of Renewable Energy Resources in Power Sector (the Project) and the Project Team has had discussions with officials of Department of Energy (DOE), Ministry of Infrastructure and Transport, Fiji Electricity Authority (FEA) and other relevant authorities during the Fourth Works in Fiji. The Project Team members dispatched and their working terms are as follows;

Name	Assignment	Working Term
Masahiko NAGAI	Team Leader/ Power Development Planning	6th -14th November, 2014
Masayuki ITO	Hydropower Planning/Civil Engineering	6th -14th November, 2014
Yoshiyuki TAKAHASHI	Electrical Engineering	6th -14th November, 2014
Shinichi FUNABASHI	Power System Planning	6th -14th November, 2014
Noboru MATSUSHIMA	Environmental & Social Considerations	6th -14th November, 2014
Toshiyuki KOBAYASHI	Renewable Energy (Biomass) A	9st -14th November, 2014
Tadahisa YOSHIARA	Hydrology & Meteorology Analysis	6th -14th November, 2014

II. Outline of the activities

DOE, FEA and the Project Team hereby mutually confirmed and agreed upon the followings:

1. Meeting with DoE and FEA held on 10th November 2014

(1) Submission and Explanation of the Interim Report

The Project Team submitted ten (10) copies of the Interim Report to DOE and FEA and explained it at the meeting. The counterpart agency, DOE and FEA, principally understood and accepted the report.

The Project Team informed DOE and FEA that the draft Final Report would be submitted in the middle of December 2014 and then Final Report would be finalized in consideration of the comments and opinions made from Fiji's side and submitted in February 2015.

(2) Explanation and Discussions on Preliminary Designs for Three Prospective Hydropower Potential Sites and Power Development Plan until 2025.

The Project Team explained to DOE and FEA on:

1) the results of preliminary designs for three (3) prospective hydropower sites, which were selected at the 2nd Stake holder Meeting held on 4th July, 2014
2) the results of the initial environmental examinations (IEE) on the prospective hydropower potential sites
3) Power Development Plan until 2025.

(3) Preparation for 3rd Stake Holder Meeting
DOE, FEA and the Project Team decided that 3rd Stake Holder Meeting would be held at the conference room of Tanoa Plaza Suva on 11th November, 2014, in accordance with draft agenda prepared by the Project Team.

2. 3rd Stake Holder Meeting (SHM)

The 3rd Stake Holder Meeting (SHM) was held as follows;

1) General
- Date & Time :10:00 – 13:00, on 11th November, 2014
- Venue : Conference Room of Tanoa Plaza Hotel, Suva
- Participants : 30 persons

Organization	Name	Position
DoE	Mr. Peceli Nakavulevu	Director
	Mr. Inia Saula	Principal Technical Officer
	Mr. Ravinesh Nand	Senior Scientific Officer
	Mr. Mikaele Belena	Senior Scientific Officer
	Mr. Waisale Vulagi	Technical Officer
	Mr. Jeke Pai	Biofuel Engineer
	Mr. Paula Katirewa	Assistant Director
	Mr. Jonati Delaimoala	Scientific Officer
	Mr. Ulaiasi Butukoro	Scientific Officer
	Ms. Susana Pulini	Project Manager FREPP
	Mr. Vamarasi Kafoa	Project Manager SEFP
FEA	Mr. Karunesh Rao	Executive Projects Public Relations Manager
	Mr. Epeli Malo	Unit Leader Thermal
Mineral Resource Department	Ms. Agnes Peter-Hansen	Senior Scientific Officer
Ministry of Strategy Planning	Mr. Sandip Kumar	Economic Planning Officer
	Ms. Malvina Singh	Economic Planning Officer
Ministry of iTaukei Affairs	Ms. Salaseini Naiduki	Clerical Officer
Ministry of Forestry	Ms. Anjeshai Narayan	REDD Coordinator
Department of Environment	Ms. Eleni Tokaduadua	Principal Environment Officer
iTaukei Land Trust	Ms. Varanisese Veitala	Estate Officer

Board		
Investment Fiji	Ms. Malika Kumar	Senior Investment Officer
JICA Fiji Office	Mr. Katsuhiko Ohara	Assistant Resident Representative
	Ms. Seema Chand	Program Office
JICA Study Team	Mr. Masahiko Nagai	Team Leader/Power Development Planning
	Mr. Masayuki Ito	Hydropower Planning
	Dr. Noboru Matsushima	Environmental & Social Considerations
	Mr. Shinichi Funabashi	Power System Planning
	Mr. Yoshiyuki Takahashi	Electrical Engineering
	Mr. Toshiyuki Kobayashi	Renewable Energy (Biomass) A
	Mr. Tadahisa Yoshiara	Hydrology & Meteorology Analysis

- Agenda
  a. Introduction (Mr. NAGAI, Project Team)
  b. Results of Preliminary Designs for Three Prospective Hydropower Potential Sites (Mr. YOSHIARA, Project Team)
  c. Initial Environmental Examination of Three Prospective Hydropower Potential Sites (Dr. MATSUSHIMA, Project Team)
  d. Biomass Energy Potentials (Mr. KOBAYASHI, Project Team)
  e. Power Development Plan until 2025 (Mr. ITO, Project Team)
  f. Discussions (Q and A)

The main purpose of this SHM was to discuss the Interim Report of the three prospective hydropower sites.

2) Major questions and answers in the SHM
- Q: Explain in more detail about the interconnection transmission line between Viti Levu and Vanua Levu mentioned in "Power Development Plan until 2025".

A: The details of the interconnection transmission line will be studied and prepared in the draft final report.

3. Presentation for FEA Management

The Project Team made a presentation on the Interim Report to the FEA management at the conference room of FEA head office on 12th November 2014.

4. Wrap-up Meeting

The wrap-up meeting was held at the conference room of DOE Office on 12th November 2014. The Project Team explained to DOE and FEA on the results of the Project Team's activities during Fourth Works in Fiji. DOE, FEA and the Project Team hereby mutually confirmed and agreed upon the followings:

4.1 Schedule of Next Works in Fiji

The next (5th) Works in Fiji is scheduled from 4th to 9th January 2015. In the Fifth Works in Fiji, the Project Team will discuss the draft final report of the Project with DOE and FEA. After the Fifth Works in Fiji, the Project Team will prepare the final report based on the comments made by DOE and FEA.

Suva, 12th November, 2014

永井 雅彦

Mr. Masahiko NAGAI
Team Leader
JICA Project Team

Mr. Peceli Nakavulevu
Director of Energy
Ministry of Infrastructure and Transport

Mr. Karunesh Rao
Executive Projects & Public Relations Manager
Fiji Electricity Authority

Appendix 11-7

Presentation Material for 1st Work Shop

1st Workshop

Japan International Cooperation Agency

The Project for The Effective and Efficient Use of Renewable Energy Resources in Power Supply in Republic of Fiji

Map Study on Hydropower Potential Sites

October, 2013

Tokyo Electric Power Services Company, LTD. (TEPSCO)

Contents

Chapter 1 Outline of the Project

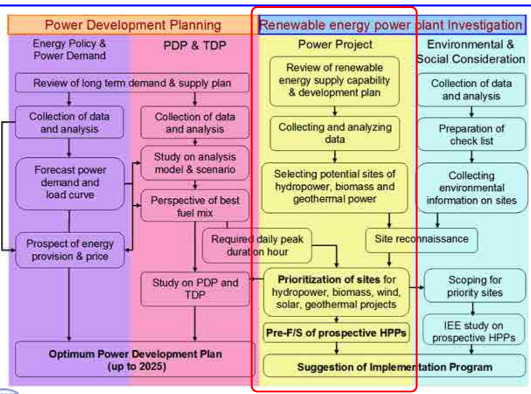
1.1 Purpose of the Project:

- To prepare hydropower development site map and overall development schedule until 2025
- To examine/propound the optimum composition of renewable energy resources in the power sector in Fiji until 2025:

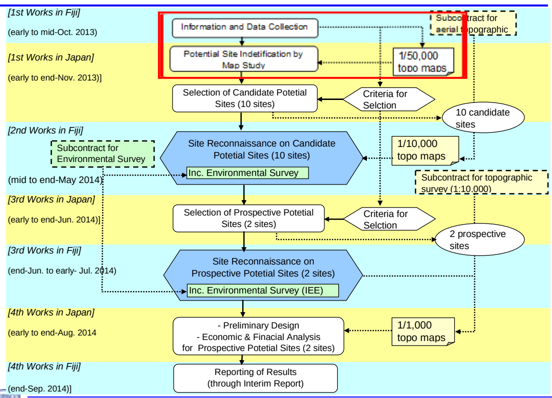
Through the following five (5) activities:

① Collection and Analysis of Relevant Data and Information
② Hydropower Potential Study
③ Implementation of Site Reconnaissance for Prospective Hydropower Project Sites
④ Identification of biomass resources potential sites in both Viti Levu and Vanua Levu
⑤ Preparation/Recommendations of hydropower development plan and optimum composition of renewable energy resources in the power sector until 2025

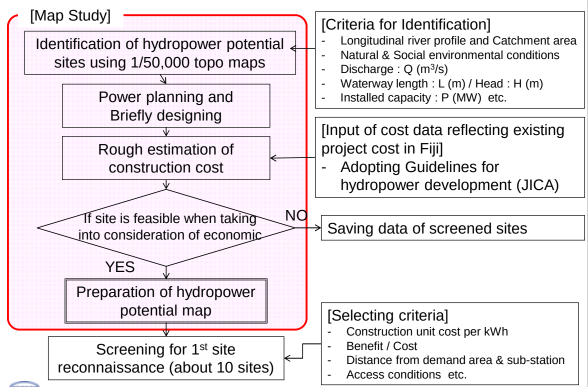
1-2. Overall Sequence of the Project



1-3. Identification and prioritization of hydropower potential sites

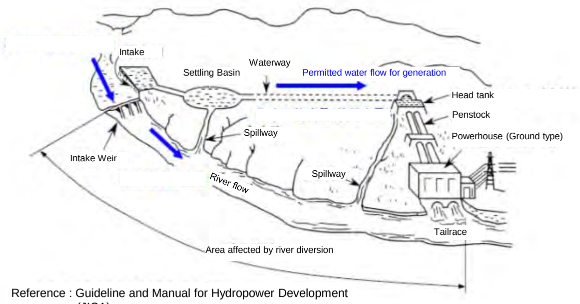


Chapter 2. Map study on Identification of hydropower potential sites



Chapter 3. Outline of Hydropower Generation and Planning

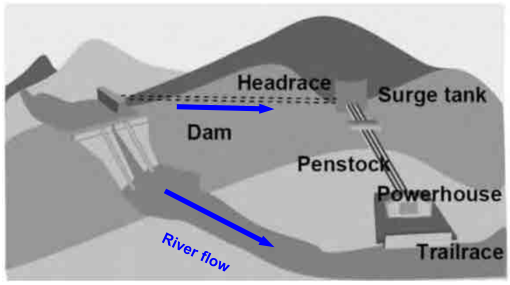
- General layout of Hydropower plant (Run-of-river-type)



Reference : Guideline and Manual for Hydropower Development (JICA)

3-1. Outline of Hydropower Generation

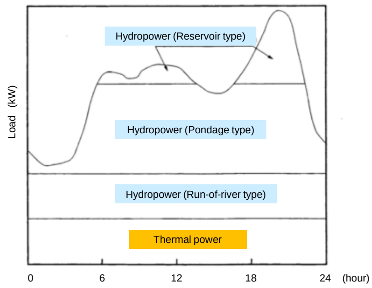
- General layout of Hydropower plant (Pondage and Reservoir type)



Source: Flow and Head of Hydropower Stations (Denki-Shoin)

3-1. Outline of Hydropower Generation

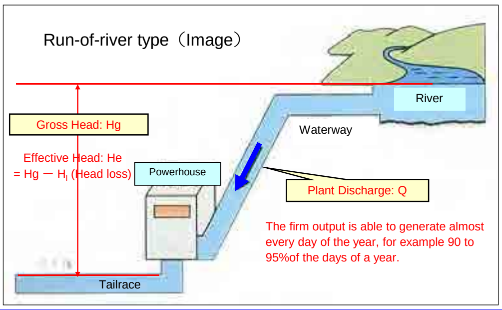
- Power Demand and Supply
  - Example of Daily Load Curve (System Mainly of Hydropower)



3-2. Terminology of Hydropower Planning (1/6)

Output : P (kW) = 9.8×Q×He×η

Q : Plant Discharge (m^3/s), He : Effective Head (m), η : Turbine & Generator Efficiency



3-2. Terminology of Hydropower Planning (2/6)

- Firm peak output and firm plant discharge
  - The firm peak output is able to product power energy almost every day (95% of the days of a year) continuously for specified time during the peak demand.
  - The firm plant discharge can be used during peak demand by regulating the firm discharge in a reservoir or pond.

- Annual plant factor

$$\text{Plant factor (\%)} = \frac{\text{Annual energy generation (kWh)}}{\text{Maximum output (kW) X 8,760 (hr)}} \text{ X 100}$$

- Load factor
  - Power demand is called the load at the power supply side.

$$\text{Load factor (\%)} = \frac{\text{Mean load (kW)}}{\text{Maximum load (kW)}} \text{ X 100}$$

3-2. Terminology of Hydropower Planning (3/6)

- Regulating capacity factor of reservoir (RCF)

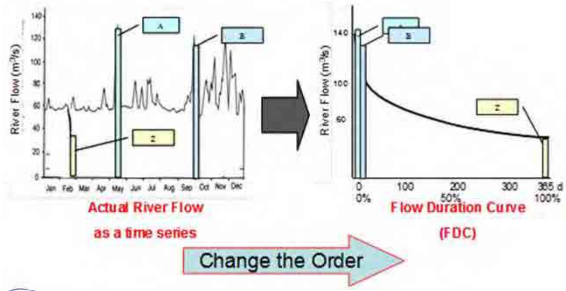
$$\text{Regulating capacity factor (\%)} = \frac{\text{Active storage capacity } (m^3)}{\text{Annual inflow } (m^3)} \text{ X 100}$$

- Regulating pond
  - The regulating pond regulates flow for a day or a week by storing water when the load is low at midnight or on Sunday, and then using it at peak demand.

- Reservoir
  - Plant discharge can be increased by storing surplus water in the wet season and then releasing it in the dry season.
  - A relatively equalized discharge can be obtained and stable electric power can be generated.

3-2. Terminology of Hydropower Planning (4/6)

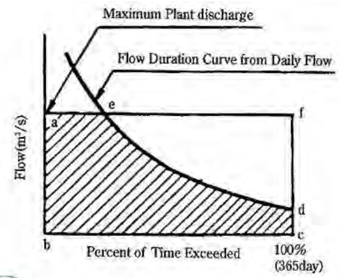
- Flow duration curve
  - Plotting of the magnitude of flow on ordinate against the corresponding percent of time on abscissas is called "flow duration curve".



3-2. Terminology of Hydropower Planning (5/6)

- Flow utilization factor

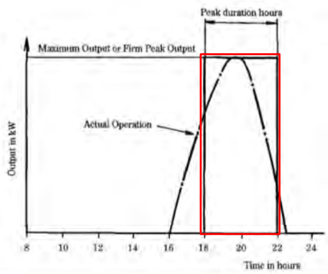
$$\text{Flow utilization factor (\%)} = \frac{\text{Annual plant discharge (m}^3\text{)}}{\text{Max. plant discharge (m}^3\text{/s) X 365 X86,400 (s)}} \text{ X 100}$$



$$= \frac{\text{(abcde Area)}}{\text{(abcf Area)}} \text{ X 100}$$

3-2. Terminology of Hydropower Planning (6/6)

- Peak duration hours
  - The peak duration hours are used for planning of the reservoir and pondage type project to supply power for peak demand.
  - The peak duration hours used in planning is generally 4 to 8 hours in area where the power system is interconnected.

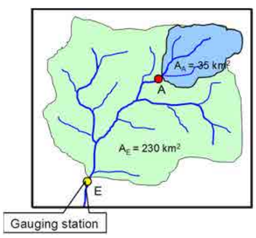


3-3. Planning of Conventional Hydropower Project

- Selection of Power generation type
  - The power supply (peak power and/or base power) required in the future
  - Topographical conditions

3-3-1. Study on Run-off-river type (1/3)

- Calculation of flow at dam site and flow duration curve
  - Runoff data
  - Calculation of river flow at dam site (A)



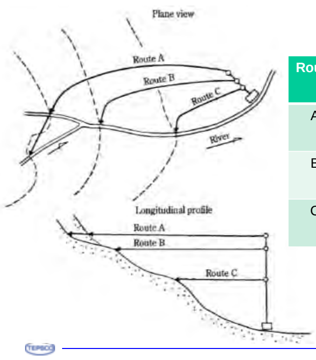
$Q_A = Q_E \times A_A / A_E$

Where,
Q_A :Discharge at A
Q_E :Discharge at E
A_A :Catchment area at A
A_E :Catchment area at E

  - Preparation of flow duration curve

3-3-1. Planning of Conventional Hydropower Project (2/3)

- Decision of waterway route and its type

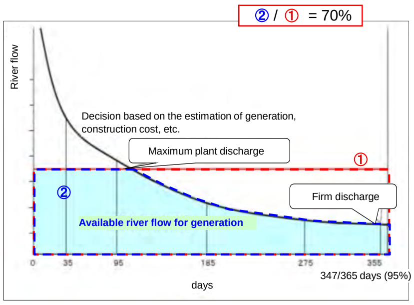


Feature of waterway route

Route	C.A.	River flow	Head	Waterway length
A	Small	Small	Large	Large
B	Medium	Medium	Medium	Medium
C	Large	Large	Small	Small

3-3-1. Planning of Conventional Hydropower Project (3/3)

- Decision of the plant discharge
  - Determination of firm discharge (347days (95%) of the duration curve)
  - Temporary setting of maximum plant discharge

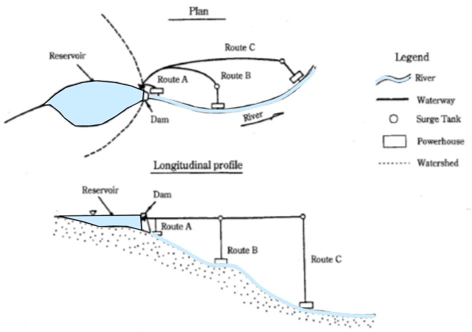


3-3-2. Study on Reservoir type (1/7)

- Selection of dam site
  - A large storage capacity can be obtained with a dam of relatively small volume.
  - Water leakage from reservoir or pondage presents a problem in calcareous rock zone.
  - When a large head is obtained by the waterway, the suitable dam site is just upstream of the river where a gentle gradient changes to a steep gradient.
  - No serious compensation and/or resettlement problems are foreseen.
  - Roads exist nearby, and access to the site is easy.

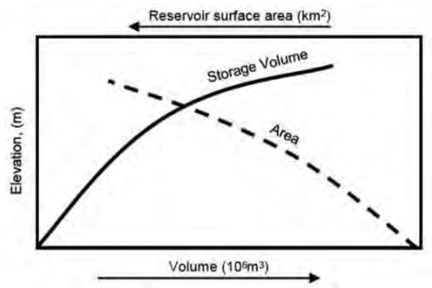
3-3-2. Study on Reservoir type (2/7)

- Selection of powerhouse site and waterway route



3-3-2. Study on Reservoir type (3/7)

- Preparation of storage capacity curve

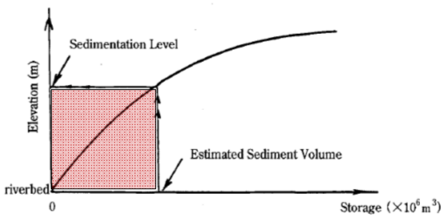


3-3-2. Study on Reservoir type (4/7)

- Estimation of sediment volume and setting sedimentation level

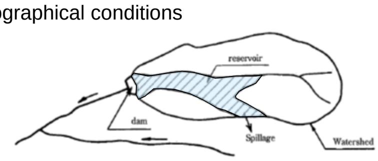
Vs = qs X CA (d) X 100

Vs : Sediment volume for n years (m^3)
Qs : Specific sediment yield ($m^3/km^2/year$)
CA (d): Catchment area at dam site (km^2)
N : Calculation period of sediment volume (year)



3-3-2. Study on Reservoir type (5/7)

- Determination of effective storage capacity
  - Topographical conditions



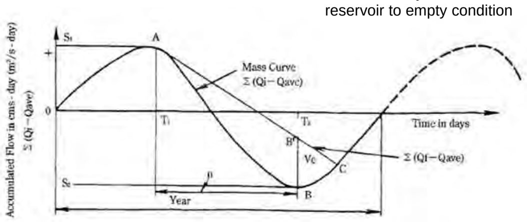
  - Constraints on economic view point
  - Lower limit of low water level considering turbine characteristics

3-3-2. Study on Reservoir type (6/7)

- Decision of the plant discharge

$$Q_f = \frac{S_2 + V_e - S_1}{n \times 86{,}400\ (s)} + Q_{ave}$$

S_1 : Accumulated flow at T_1 (m^3)
S_2 : Accumulated flow at T_2 (m^3)
Q_{ave} : Annual mean inflow (m^3)
Q_f : Firm discharge (m^3/s)
V_e : Effective storage capacity (m^3)
N : Number of days from full reservoir to empty condition

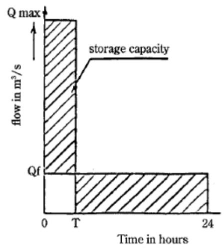


3-3-2. Study on Reservoir type (7/7)

- Setting of the maximum plant discharge

$$Q_{max} = \frac{Q_f \times 24}{T}$$

Q_{max} : Maximum plant discharge (m^3/s)
Q_f : Firm discharge (m^3/s)
T : Peak duration hours (hour)



3-3-3. Rough estimation of construction cost

- Rough estimation of construction cost by adopting guidelines for hydropower development (JICA)
  - Input of cost data reflecting existing project cost in Fiji

Items	Cost	Note
1. Preparation and Land acquisition		
2. Environmental mitigation cost		3. X 3%
3. Civil works		
4. Hydraulic equipment		
5. Electro-mechanical equipment		
6. Transmission line		
Direct cost		1.+2.+3.+4.+5.+6.
7. Administration and engineering service		(Direct cost) x 15%
8. Contingency		(Direct cost) x 10%
9. Interest during construction		(1.+2.+3.+4.+5.+6.+7.+8.) x 0.4 x I x T
Total cost		1.+2.+3.+4.+5.+6.+7.+8.+9.

3-3-4. Optimization of the scale

- Economic analysis (Simplified method)
  - An economic analysis of a hydropower project is made by a method to compare its benefit (B) and cost (C).
  - (B) of a hydropower project is the cost of an alternative thermal power that supplies electric power equivalent to the hydropower project.
  - (C) is derived from the construction cost of the hydropower project.

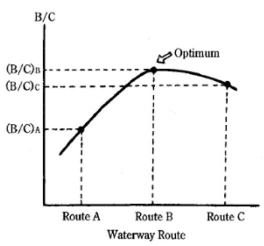
B/C > 1.0 --→ Hydropower project > Thermal power
B/C < 1.0 --→ Hydropower project < Thermal power
(Diesel power plant : in Fiji)

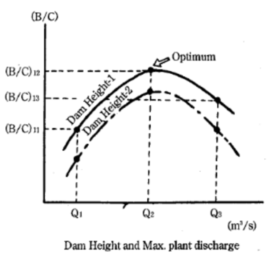
- Unit construction cost method (Run-of-river type)

$$\text{Unit construction cost (USD/kWh)} = \frac{\text{Construction cost (USD)}}{\text{Annual energy generation (kWh)}}$$

3-3-5. Optimization of the scale

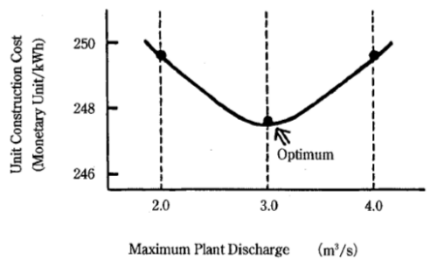
- Determination of optimum scale of development (Reservoir type)





3-3-5. Optimization of the scale

- Determination of optimum scale of development (Run-of-river-type)



Chapter 2. Map study on Identification of hydropower potential sites *(Re-discription)*

[Map Study]

- Identification of hydropower potential sites using 1/50,000 topo maps
- Power planning and Briefly designing
- Rough estimation of construction cost
- If site is feasible when taking into consideration of economic — NO → Saving data of screened sites
- YES → Preparation of hydropower potential map
- Screening for 1st site reconnaissance (about 10 sites)

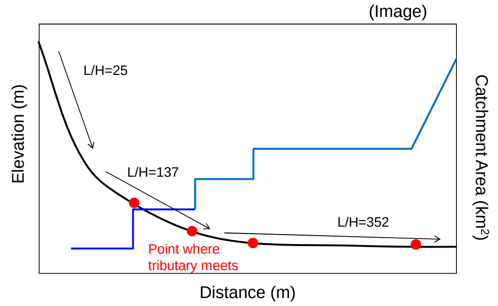
[Criteria for Identification]
- Longitudinal river profile and Catchment area
- Natural & Social environmental conditions
- Discharge : Q (m^3/s)
- Waterway length : L (m) / Head : H (m)
- Installed capacity : P (MW) etc.

[Input of cost data reflecting existing project cost in Fiji]
- Adopting Guidelines for hydropower development (JICA)

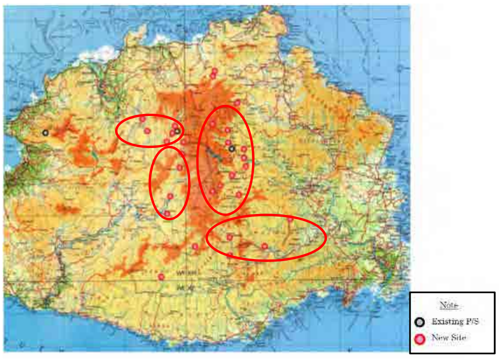
[Selecting criteria]
- Construction unit cost per kWh
- Benefit / Cost
- Distance from demand area & sub-station
- Access conditions etc.

Chapter 4. Map study on hydropower potential sites

- Longitudinal river profile and Catchment area
  (Ba River, Shigatoka River, Lawaki River, Wailoa River)

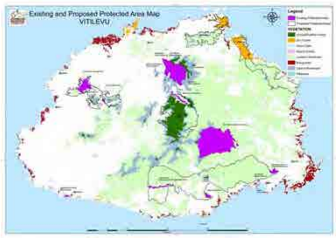


4-4-1. Preparation of tentative hydropower potential sites



4-1-1. Criteria for Identification

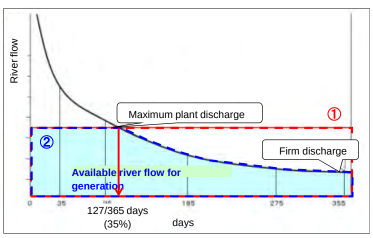
- Natural environmental conditions
  - Beyond the confines of Protected area
  - Avoid the critical habitats etc.
- Social environmental conditions
  - Avoid mining concession
  - Avoid submerging historical and culture heritage
  - Fewer submerged houses etc.



Source: National Trust of Fiji Islands

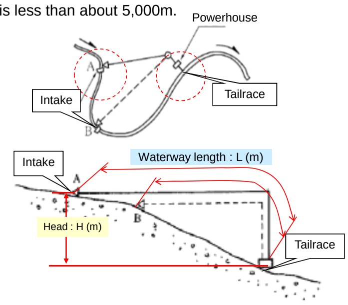
4-1-1. Criteria for Identification

- Decision of the plant discharge
- Utilizing the existing below report hydrological data
  - Small Hydro Site Identification in Fiji / Barefoot Power Pty. Ltd
  - Wailoa Basin Hydropower Development Master Plan / Hydro Tasmania
- Selecting the maximum plant discharge as around the 127days (35%) of the flow duration curve



4-1-1. Criteria for Identification

- Topographical conditions
- Selecting the site where is shorter waterway length and higher head
- L/H is less than about 100.
- Waterway length is less than about 5,000m.



4-1-1. Criteria for Identification

- Installed capacity : P (kW)

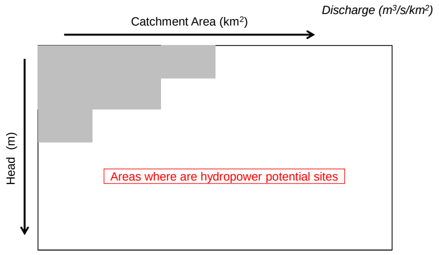
$P = 9.8 \times Q \times He \times \eta$

Q : Discharge (m^3/s)

H_e : Effective Head (m)

η : Turbine & Generator Efficiency

P : More than1,000kW



4-2. Power planning & Brief designing

- Power planning and Brief designing for hydropower potential sites using 1/50,000 topographical maps

4-3. Rough estimation of construction cost

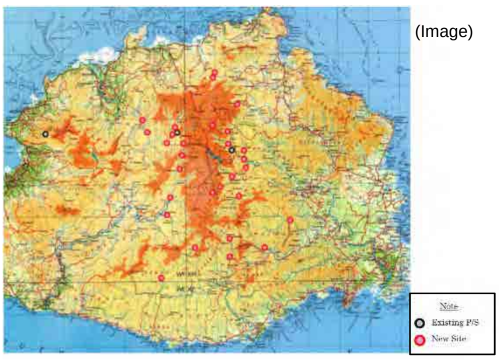
- Rough estimation of construction cost by adopting guidelines for hydropower development (JICA)
  - Input of unit cost data of "Hydropower Renewable Energy Development Project in Republic of the Fiji Islands (JETRO, 2009)"

Items	Cost	Note
1. Preparation and Land acquisition		
2. Environmental mitigation cost		3. X 3%
3. Civil works		
4. Hydraulic equipment		
5. Electro-mechanical equipment		
6. Transmission line		
Direct cost		1.+2.+3.+4.+5.+6.
7. Administration and engineering service		(Direct cost) x 15%
8. Contingency		(Direct cost) x 10%
9. Interest during construction		(1.+2.+3.+4.+5.+6.+7.+8.) x 0.4 x I x T
Total cost		1.+2.+3.+4.+5.+6.+7.+8.+9.

4-4-1. Tentative evaluation of results on Map study (Draft)

Project site	Features	Economic Value (USD/kWh)	B/C	Tentative evaluation of Environmental conditions
[Viti Levu]				
1.Wainvau		2.71	0.60	No significant impact
2.Nasa		2.98	0.60	No significant impact
3.Sigatoka 1		1.44	1.20	No significant impact
･ ･ ･				
24.Sovi		2.09	0.80	Significant impact
25.Wainavadu		0.94	1.80	Little significant impact
26.Wainamoli		1.24	1.30	No significant impact
[Vanua Levu]				
27.Nadamanu		6.73	0.20	?
28.Saqru		3.43	0.50	?

4-4-2. Preparation of hydropower potential map (Draft)



(Image)

Chapter 5. Selecting tentative criteria for 1st site reconnaissance

- Natural and social environmental conditions
- Topographical and geological conditions
  - Road and traffic condition to the site
- Technological and economic conditions
  - Construction unit cost per kWh
  - Benefit / Cost
  - Distance from demand areas and the nearest sub-station