台灣電力公司
Taiwan Power Company

財團法人中華顧問工程司
CHINA ENGINEERING CONSULTANTS, INC.

Ma'an Hydropower Plant Project

Environmental Impact Assessment Report

April, 1988

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Preamble

I. Project Necessity

The hydropower potential of the Dajia River Basin is the highest among all rivers in Taiwan. The development of hydropower resources has been carried out since the Japanese colonial period. Currently, there are five hydropower plants including Deji, Qingshan, Guguan, Tianlun and Sheliao, the total installation capacity reaches 864,900 kW, which is the main peak power source of Taiwan's power system.

However, the capacity of adjustment pond and headwater tunnel of Tianlun power plant, which built downstream the earliest, was insufficient to regulate the peak power generation tailwaters of the upstream power plants, which greatly affected the power generation efficiency. There is an urgent need to carry out secondary development projects downstream for Dajia water resources to be optimally utilized.

The New Tianlun Hydropower Project and the Ma'an Hydropower Project are the secondary development projects that should be actively promoted. The construction of the New Tianlun hydropower project started in March 1988 and is expected to be completed and commercialized in June 1992.

The Ma'an Hydropower Project is a hydropower resource project at the most downstream of Dajia River developed to coordinate with the operation of the New Tianlun and Tianlun power plants. It can increase the net peak capacity by 133,500 kilowatts, with annual power generation reaches 400 million kWh, which is in line with the government's policy of promoting energy diversification and self-sufficiency, and able to improve the power quality and quite beneficial to reduce dependence on imported energy. After research by Taiwan Power Corporation (Taipower), the Ma'an Hydropower Project is technically feasible, economically and financially qualified, and there is a real need for development.

II. Project environmental impact

The impact of the Ma'an Hydropower Project on the environment is mainly caused by environmental pollution and traffic interference during the construction period, as well as the impact on the river ecological environment caused by the sharp decrease in flow in some river sections after completion and operation.

Environmental pollution and traffic inconvenience during construction are inevitable short-term adverse effects on any construction plan. Fortunately, the area has a sparse population and a small traffic volume. With various pollution (dust, water quality, noise, litter) control and debris adjustment measures on the construction site, should be able to reduce the pollution and inconvenience caused by construction to the minimum level and avoid causing environmental pollution and traffic congestion problems.

The river section between Ma’an project weir and Tianlun rear pond has no water diversion and is not an important habitat for river fish; The sharp decrease in flow has no significant impact on downstream water use, however, will inevitably have a negative impact on the river ecological environment, which the impact is not sensitive and significant.

During the construction and operation stages of this project, monitoring plans for hydrology, water quality, air quality, noise, and river fish biology will be implemented. Based on the monitoring results, construction and operation plans can be adjusted at any time to comply with government regulations on pollution prevention and environmental protection, ensure downstream water rights and maintain the ecological environment, and implement government environmental policies.

III. Project Social Acceptance

According to the result of 93 social questionnaires conducted in the project area, most residents hold a positive attitude towards hydropower development in the Dajia River Basin, 87% of the respondents are in favor of the Ma'an Hydropower Project, while only 2% of the respondents are opposed to it.

This also means that local residents acknowledge decades of efforts and achievements in developing Dajia River's hydropower resources Taipower; the hydropower development project does not consume water resources and pollute water quality, and has a very low impact on the environment, which has been proven by facts. Therefore, the implementation of this plan, as long as the compensation fee is reasonable, will not cause local residents to reject and resist.

IV. Conflicts with Other Projects

In 1985, the Water Resources Agency (WRA, MOEA) began planning a water source expansion and development project in the lower reaches of Dajia River. The Ma'an Hydropower Project will separately build a Ma'an Reservoir (full water level 500 meters, capacity 95.876 million cubic meters) near the Long'an Suspension Bridge on Dajia River upstream, and a Longbao Reservoir (full water level 265 meters, capacity 45.101 million cubic meters; project revoked later) on the Biankeng River at the head of the Wuxi tributary. With cross-regional water diversion from Ma'an Reservoir to Longbao Reservoir to provide future water supply needs for the greater Taichung and Changbin areas.

Based on the "1986 Dajia River Downstream Water Source Expansion Planning Report" proposed by the WRA, Taipower Corporation has devised the dispatch plan of the Ma'an Power Plant's tailwater and the Ma'an and Longbao Reservoirs. The dispatch plan should be able to co-exist with the WRA’s planning.

Summary

I. Project Overview

The Ma'an Hydropower Project is to build a barrage about 900 meters downstream of the tailwater outlet of the Tianlun Power Plant to receive the tailwaters of the upstream power plants and regulate the flow of the uncontrolled watershed between Tianlun Dam and Ma'an Dam. The water inlet is built on the right side of the upstream of the dam body, and water is diverted through a penstock about 7.5 kilometers long in the hillside on the right bank of Dajia River to the newly built semi-underground power plant near Tianlun rear pond (Ma’an Retention Basin) to generate electricity. The maximum water diversion volume is 144.5 m^3/s, and the effective water head is 106.85 meters. After power generation, the tail water is discharged into the adjustment pond of Tianlun.

The main engineering facilities include a concrete gravity barrage, 303 meters long and 18.5 ~ 41.0 meters high;

A graphic cross-section pressure headwater tunnel with an inner diameter of 6.4 meters and a total length of 7.485 meters; A circular cross-section pressure headwater tunnel with an inner diameter of 6.4 meters and a total length of 7.485 meters; A surge tank with an inner diameter of 15 meters and a height of 69.14 meters; An underground penstock with an inner diameter of 3.0~6.0 meters and a total length of 385.14 meters;

There is a semi-underground power plant with a length of 50.3 meters, a width of 20.2 meters, and a height of 35.5 meters, with 2 vertical axis Francis turbine generator units installed in the factory, the designed water consumption of each unit is 72.25 m^3/s, the effective water head is 106.85 meters, the single unit output is 66,750 kilowatts, and the total installed capacity is 133,500 kilowatts; One outdoor switchyard; two circular cross-section pressure tailwater tunnels, with an inner diameter of 3.0 meters and a length of 49.6 meters; two additional sand discharge gates were added to the Tianlun rear pond (Figure 1).

The total project cost is approximately NT$12.06 billion, equivalent to a construction cost of approximately NT$90,000 per kW; the annual net benefit is approximately NT$137 million, with a benefit-cost ratio of 1.113; the return on investment is 10.57%, and the investment payback period is 17.52 years.

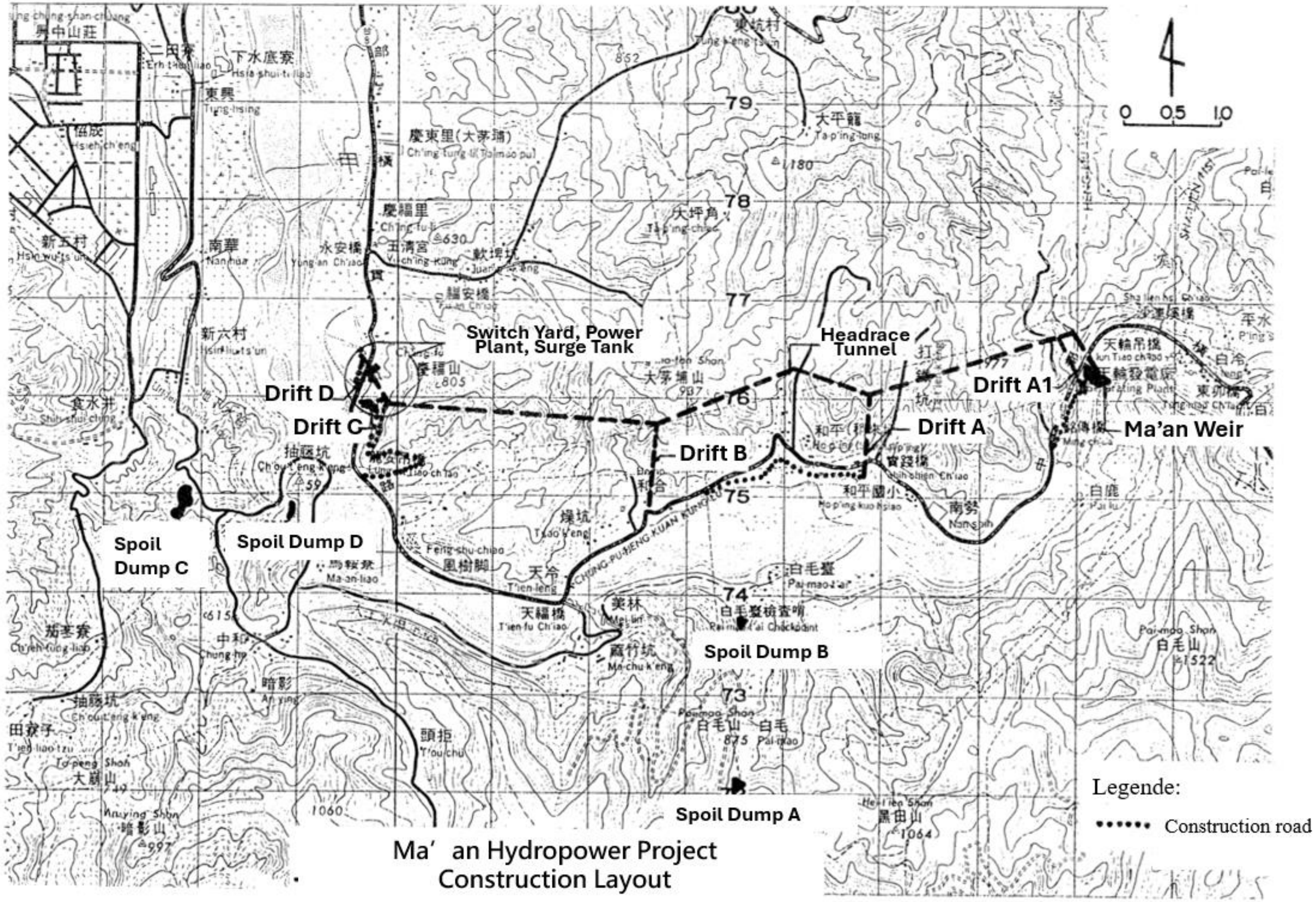

Figure 1 Ma'an Hydropower Project Construction Layout

II. Status Investigation, Forecast Assessment and Corresponding Countermeasures for Various Environmental Items

i. Natural Environment

Item	Current Status (1987)	Ma'an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
				Without Ma'an Project Operation	Ma'an Project Operation	
Geography	The project area includes the Dajia River channel, slopes on both sides and valleys. Parts of the valleys and gentler slopes have been reclaimed as orchards, but the original terrain slope is generally maintained. The strata are Tertiary marine sediments with many faults and fold structures. There are not	Major construction projects such as tunnels, drifts and power plants are mostly underground projects and have little impact on the terrain and surface features. The planned barrage construction will not have much impact on the Dajia	Earth retaining facilities will be installed at the waste dump, and slope protection and temporary drainage facilities will be provided for roads and above-ground buildings to adapt to changes in terrain.	Sloping land development will be developed and utilized under the regulation of the "Slope Land Conservation and Utilization Ordinance", with limited changes to the existing topography.	Once the vegetation coverage of the waste dump is completed, the potential amount of topsoil loss will be greatly reduced.	—

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	many earthquakes and the energy released is not high, so it is a non-significant earthquake area.	River channel and slope. Only the existing terrain and surface features of construction roads, switchyards and planned spoil dumps will gradually change as the project progresses, affecting the original soil and water conservation function of the slope.				

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Air Quality	Except for the exhaust gases emitted by the chimneys of the three sand and gravel quarries located on the right bank of Dajia River and the limited traffic volume of Zhongheng Highway, there are no other pollution sources. The air quality is very good and can meet the general regional air quality standards in Taiwan.	Tunnel blasting and ballast removal, as well as ballast disposal site operations, significantly increase the amount of dust and suspended particles in the air. However, the affected areas are concentrated in sparsely populated operating locations, which will not cause pollution	Before the vehicle leaves the construction area, water spray to clean the tires. Tunnels and drifts ballast exits, earth transport paths and ballast dumps are frequently sprinkled with water to suppress flying dust.	The project area has steep terrain and no development hinterland. It is speculated that it is impossible to introduce a large number of polluting factories to emit waste gas: the air quality should be similar to the current situation.	The operation of hydropower plants does not emit air pollutants and does not affect the air quality of the surrounding areas.	—

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		problems. The dust raised by vehicles moving path is quite sensitive to the impact of adjacent residences and shops.				
Hydrology	Dajia River is one of the major rivers in Taiwan, with a total length of approximately 124 kilometers, a catchment area of approximately 1,236 square kilometers, and an average annual runoff volume of 2,600	The barrage and water inlet are constructed using the river diversion construction method. The stream water can flow down the river from the outside of	—	The WRA plan to expand the water source in the lower reaches of Dajia River (to build Ma'an Dam on the main stream of Dajia River and Longbao Dam on	In the section between Ma'an Barrage and Tianlun rear pond, the flow rate decreases by approximately 87% during dry periods and by	Regularly monitor the flow, water quality and river fish life in the downstream section of the barrage. Based on the monitoring results, the

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	million cubic meters, ranking 9th among the 19 major rivers in Taiwan. The water volume is abundant, the height difference is large, and the water power reserve is the highest among all rivers in the country.	the barrage without affecting the upstream and downstream flows. On peak days, the construction water consumption from Dajia River is approximately 0.06 cubic meters/second, accounting for only 0.3% of the low water flow in this section of the river.		the tributary of Wu River) involves cross-territorial water diversion, and the flow of water downstream of Dajia River will be sharply reduced; however, since this project interacts with the Ma'an Hydropower Project and has a wide range of impacts, it is currently unpredictable	approximately 83% during wet periods.	discharge flow of the barrage will be flexibly adjusted to maintain the minimum flow required for ecology.

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				whether it will be implemented.		
Water body utilization	There are a total of 5 hydropower plants in the Dajia River basin, with a total installed capacity of about 860,000 kW. There are only 12 irrigation canals that divert water from Dajia River. The actual water intake per month ranges from 12 to 40 cubic meters per second. The irrigated area is about 20,000 hectares.	The New Tianlun Hydropower Plant came into operation in 1992, increasing the system installed capacity by 105,000 kW. The Ma'an barrage and water inlet adopt the river construction method, which does not retain the	—	The WRA is planning to expand the water resource development plan in the lower reaches of Dajia River. It is planned to build Ma'an Dam on the main stream of Dajia River and Longbao Dam on the tributary of Wu River in 2004 and	There is no water diversion inlet between the Ma'an barrage and the tailwater discharge port of the power plant to the Tianlun rear pond. Therefore, the operation of the power plant only affects the use of river water downstream of the	During the construction of Ma'an Power Plant, the Tianlun rear pond was dredged 30 cm deep to increase the capacity of the pond to fully meet the demand for reverse regulation of downstream water.

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	The downstream Shigang Dam can provide the Taichung area with a daily public water supply of approximately 420,000 metric tons.	stream water, so it does not interfere with the flow of the downstream river and has no impact on the current water use.		2011, respectively, to divert water from Dajia River to Greater Taichung. As well as the need for water in the Changbin area, it is still uncertain whether this project will be implemented due to its interaction with the Ma'an Hydropower Project and the vast submerged area. The number of	Tianlun rear pond. According to hydrological calculations, the combined operation of Tianlun rear pond and Shigang dam will produce a maximum counter-regulatory capacity of less than 30,000 cubic meters for downstream water demand, and its occurrence rate is only 0.7%.	

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				hydroelectric power plants remains at 6 (a New Tianlun plant has been added compared to the current situation), the irrigation water consumption decreases due to the shrinkage of the irrigation area. The amount of water demand may divert to Fengyuan Second Water Purification Plant	Therefore, the operation of the power plant has an insignificant impact on the utilization of downstream river water.	

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Related facilities or projects	The project area is a non-urban planning area with scattered settlements and relatively backward on general public facilities. There are only junior high schools, elementary schools, electricity, telecommunications and health center, etc., as for the water supply system, sewage and drainage facilities, garbage collection and treatment, and medical facilities are still very lacking. There are currently no	The water, electricity and communication facilities required for construction are limited in quantity and can be obtained nearby. There is no need to expand existing facilities. Fengyuan No. 2 water purification plant may be completed and operational.	—	The population growth in the project area is limited, the demand for public facilities is not great, and the current scale is generally maintained. The Fengyuan Second Water Purification Plant may have been completed and put into operation; the water source	Same as the scenario of Without Ma'an Project Operation	In order to enable the water source expansion development plan for the lower reaches of Dajia River planned by WRA to coexist with the Ma'an project, it is planned to expand the third tank with a capacity of about 500,000 cubic meters in the Tianlun rear pond, and use an inverted

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	specific regional development plans. In terms of water resources planning, there is a plan to build a second water purification plant of Fengyuan, which is being prepared by the water company; and a water source expansion development plan in the lower reaches of Dajia River, which is being planned by the WRA.			expansion plan for the lower reaches of Dajia River has not yet reached its development schedule.		siphon to guide the power generation tail water to the Longbao Reservoir for storage; in order to cooperate with the Ma'an Reservoir, it is planned to build a third tank on the left side of the reservoir. An underground pumping station was built at the heart of the mountain to pump

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						water from the expanded pond during off-peak hours.

ii. biological environment

Item	Current Status (1987)	Ma'an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
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Terrestrial plants	The construction facilities are mainly located in orchards. The remaining secondary forests occupy a very small area and there are	Some orchards must be eradicated at ground engineering facilities and waste dump sites, with	—	Fruit trees are still the main focus, and the planting area and types will change depending on the price of the	Part of the riverbed sweetroot grassland upstream of the barrage was submerged, but nearby orchards	—

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	not many artificial forests. Most of the fruit are peaches and pears. Secondary forests are distributed on both sides of creeks and steep slopes, and are mostly composed of intolerant and pioneer tree species. There are many artificial forests including Chinese fir (福州杉), deciduous tree (油桐) and acacia trees (相思樹). The waste dump is also converted from	the main loss being citrus.		fruit.	were not affected.	

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	orchards, mainly citrus.					
Terrestrial animals	The project area has been cultivated for a long time, and the resources of large mammals and snakes are scarce, but there are many birds and butterflies. Birds are mostly sparrows, House swift (小雨燕), and Light-vented bulbul (白頭翁), and 4 rare species have been found. The section from Bailu to Tianleng and near	Rare birds have a greater impact and are likely to move elsewhere due to construction noise.	—	Close to the current situation.	Only the terrain of each waste dump has changed from a river valley to a gently sloping platform, partially changing the animal habitat environment.	—

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	Tianlun Power Plant has the most abundant butterfly resources and is of great tourist and educational value.					
Aquatic plants	The composition of algae is dominated by dinoflagellates (甲藻). Although there are mesosaprobic (中腐水性) aquatic algae, the number is very small, and the water quality is still oligosaprobic (貧腐水性).	During the construction period, the flow rate did not decrease significantly, the deterioration of water quality was limited, and the river vegetation status should be	Septic tanks are set up in the work area to collect domestic sewage from construction workers; after excavating slopes and repairing new roads, pavement treatment or planting will be	Under the government's vigorous promotion of soil and water conservation and the open import policy of agricultural products, the orchard planting	The water volume of the Dajia River section, which is about 11 kilometers long from the barrage to the Tianlun rear pond, has dropped sharply. Among them, the section from Nanshi to	Conduct regular water quality monitoring at the Tianlun Power Plant, Bailu Suspension Bridge, Long An Suspension Bridge and Yong An Bridge, and flexibly adjust the

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		Similar to the current situation.	carried out immediately to reduce the degree of water pollution.	area may still maintain the current situation. The total amount of pesticides and materials used every year does not change much. The composition and quantity of algae in the waters are similar to the current situation in project area.	Tianlun rear pond has more residents along the way and the water volume has dropped sharply. The pollution level has increased relatively, and pollution-loving algae in the water may have increased accordingly.	discharge volume of the barrage to dilute the water pollution concentration.
Aquatic animals	In the Dajia River section between Dongshi	During the construction of the	Same as Aquatic plants	The hydrological conditions and	In the Dajia River section between the	Conduct regular river fish biological

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	and Guguan, 34 species of fish have been found in surveys in recent years. The dominant species are Acrossocheilus paradoxus (臺灣石賓), Opsariichthys pachycephalus (粗首馬口鱲) and Rhinogobius brunneus (川鰕虎). No rare species have been found. Due to the obstruction of the downstream Shigang Dam, migratory fish are	barrage and the water inlet, the turbidity of the stream increased significantly, which adversely affected the habitat of fish.		current status of the river, except for the continued decrease in the number of migratory fish, should be similar to the current status composition and quantity of water plants.	barrage and the Tianlun Power Plant, the water volume and water depth have decreased, which may result in the inability of some fish and aquatic insects to survive.	tracking surveys in four sections between Tianlun Power Plant and Yongan Bridge, and flexibly adjust the flow rate of the barrage to maintain the minimum water depth required for fish survival.

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	difficult to see.					

iii. socioeconomic environment

Item	Current Status (1987)	Ma’an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
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Community structure	The project area is a low-population-density village with a negative average annual growth rate over the past ten years. Most of the residents in Dongshi and Xinshe Villiage are Hakka, while Nanshi	Qingfuli and Nanshi Village may bring in 2,500 people during the peak construction period. Most of the skilled workers and ordinary workers come from Heping,	—	The community population is still outmigrating, especially the number of young people going out to find jobs and study.	After the power plant was put into operation, most of the engineering personnel were evacuated. The operation of this power plant adopts remote control	—

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	Village is mainly composed of Atayal people.	Dongshi Town and Xinshe Village. They mainly commute to work and have no significant impact on the community structure of nearby villages.			model. The remote control center is located in the main control room of Tianlun Power Plant. The number of additional staff required by Ma'an Power Plant is only about 28 people, and there is no impact on the structure of nearby villages.	
Commercial activities	The industrial and economic activities in	Commercial activities in QinFu	—	Local industrial and economic	Same as the scenario of Without	—

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	the project area are mainly agriculture. The area of fruit trees planted along the hillside and valley plains is extremely vast. The industry and commerce are underdeveloped, with most retail stores and restaurants.	and Nan Shi Village will be more active, mainly for restaurants and grocery retail stores, which will increase business opportunities. The waste dump, switchyard, power plant and road construction will occupy part of the orchard land, but the required land area is limited and		activities are still dominated by the primary industry of fruit planting, and industrial and commercial development is limited, which is similar to the current situation.	Ma’an Project Operation	

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		will have little impact on local agricultural productivity.				
Traffic	The two-lane Zhongheng Highway is the main external road. It connects Provincial Highway No. 3 to the west and can reach Taichung via Shigang and Fengyuan; it connects Provincial Highway No. 9 to the east and can reach Hualien, Yilan and other	Traffic on the approximately 14-kilometer section of the Zhongheng Highway from Damaopu to Bethlehem is slightly affected by the construction of roadside engineering facilities. The entry	The construction progress will be flexibly adjusted in line with the Zhongheng Highway sightseeing season. When necessary, use nighttime ballast removal to reduce interference to road traffic	Similar to Current Situation.	Only 1 to 2 official vehicles and engineering vehicles enter and leave the construction site, which will not affect the traffic of Zhongheng Highway	—

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	places. Generally, road conditions are good. During typhoons and rainstorms, rockfalls and small landslides may occasionally occur on some road sections. Traffic flow is not large, and the daily average traffic volume to capacity ratio is only 0.25. Industrial roads are well developed, generally paved, and about 2 meters wide.	and exit of construction vehicles also interferes with the smooth traffic of Zhongheng Highway. However, the number of vehicles is limited and the impact is minor.	during peak hours.			
Water quality	The Dajia River section	The main pollution	Septic tanks are set	If illegal dumping	There is no	—

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	between Tianlun Power Plant and Shigang Dam is a Category B river. The main sources of pollution are the fertilizer application in the upstream orchards and the discharge of household sewage in Dongshi Town. At present, water quality biochemical oxygen demand, total phosphorus, and ammonia nitrogen content often fall to Category C or below	is the increase in turbidity in water caused by earthmoving operations, which only occurs intermittently during heavy rains. The sewage discharge from construction workers is very limited. During the dry season, the biochemical oxygen demand concentration in	up in the work area to treat the domestic sewage of construction workers; after excavation of slopes and repair of new roads, pavement treatment or planting will be carried out immediately to reduce the degree of water pollution.	of garbage continues the Dajia River riverbed, the water quality of the river will deteriorate day by day. The extent will depend on whether the garbage treatment plan of the towns on both sides of the river can be effectively implemented.	wastewater discharge in the operation of the power plant. There are only about 20 employees. The amount of domestic sewage is very small. It is discharged after treatment in septic tanks, and the increase in the pollution load of the Dajia River water system is very small.	

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	standards. The coliform count and heavy metal content can meet the Class A river standards.	the river section in front of Shigang Dam only increases by about 0.046PPM, which can still maintain Class B river water quality standards.				
Noise and Vibration	The project area is a Category II noise control area. In general areas, the volume at each time period is about 3 dBA higher than the standard, and the day and night volume can meet the	The construction area is narrow, and the number of various types of construction machinery ranges from 2 to 5. The construction noise	Carry out construction noise monitoring and adjust the construction progress and machinery operation time	Close to the current situation.	Close to the current situation.	—

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	standard. The roadside area is much higher than the standard, with the volume being as high as 12dBA in the morning and evening. When large trucks pass by, the vertical vibration level on the roadside reaches more than 70 dBA, and the horizontal vibration level is mostly below 50 dBA.	generated by it can comply with domestic noise control standards. The entry and exit of construction vehicles during peak periods only increases the average daily traffic volume of Zhongheng Highway by approximately 8%, and the increase in traffic noise is limited. Changes in	when it exceeds the standard.			

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		vibration level are difficult to detect.				
Solid waste	The project area is located in a remote mountainous area, where the amount of domestic waste is limited and there are no garbage trucks to transport it. Most of the waste is dumped in valley depressions, buried or burned by residents themselves. The Dajia River Valley has been dumped by Shiganghe	The main sources are discarded materials and domestic waste from construction workers. The waste disposal party has considered a waste dump with sufficient capacity for centralized processing; domestic waste not exceeding 2 tons	—	Whether the illegal dumping of garbage on the Dajia River riverbed can be suppressed depends on whether the urban garbage treatment plan of the towns on both sides of the river can be implemented.	The operation of the hydropower plant does not produce solid waste. The daily amount of garbage generated by the resident staff is less than 10 kilograms, which is coordinated and processed by the remote control center of the	—

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	and Xinshe village.	per day will be disposed of in a landfill designated by the local government or disposed of together with the waste, so as not to cause pollution to the local environment.			Tianlun Power Plant to avoid environmental pollution problems.	

iv. cultural quality

Item	Current Status (1987)	Ma'an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
				Without Ma'an Project Operation	Ma'an Project Operation	
cultural assets	The project area has been inhabited by humans since the late Neolithic Age about 3,000 years ago. Because it is close to the mountains area, the Han people development comes later. 11 prehistoric sites have been discovered, the more important of which is the Babao site in Nanshi Village, which dates back 3,500 to 2,000 years ago. It is the	The Heping(和平) ruins, Zaokeng(燥坑) ruins and Fushan temple (福山宮) ruins are located near Drift A, Drift B and the construction road leading to Drift A. A small part of the ruins may be damaged when the Drift and construction roads are opened and closed.	Pay special attention when excavating Drift A, Drift B and the construction road leading to Drift A. If any monuments or antiquities are unearthed, the work will be stopped immediately and proactively coordinate with the competent authorities to deal with them.	Most of the sites are located on river terraces. Because they are remote mountainous areas, development has been slow. Most of the land use still maintains the current fruit tree planting. There is no deep excavation and only shallow surface plowing. Each site is unlikely to be severely damaged.	Same as the scenario of Without Ma'an Project Operation.	—

Item	Current Status (1987)	Ma'an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
				Without Ma'an Project Operation	Ma'an Project Operation	
	only Yingpu (營埔) cultural site discovered in the middle reaches of Dajia River.					
landscape beauty	The main engineering facilities are located on the north bank of Dajia River, with Zhongheng Highway as the main visual corridor. Near the water inlet and barrage, the terrain contrast is relatively strong; the landscape at the entrance of Drift B is monotonous and damaged by human	Although various construction activities make the work area environment inconsistent with the surrounding environment, they are not the focus of the landscape, and the surrounding land has been	Temporary buildings on the construction site, concrete mixing plant, material storage yard, etc. shall be covered with planting or fences. After excavation and slope trimming, slope protection	Due to the reclamation or abandonment of orchards and the mining of soil and rocks on sloping roads, the quality of the landscape has been slowly deteriorating year by year.	The switch yard and barrage form a new visual focus. The concrete surface of the pit entrance of Drift B is in great contrast with the surrounding orchards. The new land at each waste dump is likely to be	The switchyard close to the Zhongheng Highway and is shaded by tall trees. Drift B will undergo key landscaping.

Item	Current Status (1987)	Ma'an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
				Without Ma'an Project Operation	Ma'an Project Operation	
	activity (orchards); the area around the power plant, switchyard and Tianlun rear pond is the transition zone from mountainous to flatland; waste dumpss are discarded in each area with no special views.	reclaimed, so the contrast is not high. It only takes a few seconds for vehicles to pass by, and the visual sensitivity level is low. Each waste dump site is located in the small valley on the south bank of Dajia River. It is sparsely populated and only causes short-term visual impact to people and vehicles	and beautification projects will be carried out immediately.		restored to fruit tree planting and use, which is consistent with the surrounding land use patterns.	

Item	Current Status (1987)	Ma’an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
				Without Ma’an Project Operation	Ma’an Project Operation	
		passing by on Highway No. 131.				
Sightseeing and recreation	The project area is about 20 kilometers west of Guguan. It does not belong to the Zhongheng Recreation System, nor is it a scenic recreation base. Therefore, there is no development of sightseeing and recreation areas, and there are no large-scale sightseeing and recreation activities. Only a small number of	The location of the main engineering facilities is not within the recreation area and will have no impact on local recreation resources. Recreational activities such as East Guguan (東谷關) and Lishan (梨山) in the project area may be	In line with the Zhongheng Highway sightseeing season, the construction progress will be flexibly adjusted to reduce interference to road traffic during peak hours.	Close to the current situation.	Does not increase local recreational resources. Although the small lake waters upstream of the barrage can attract tourists' attention, they must be equipped with parking and recreational facilities to provide recreational	At the barrage site, a small parking lot and a few recreational service facilities will be added as needed to provide tourists with explanations and opportunities to stop and watch the scenery.

Item	Current Status (1987)	Ma'an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
				Without Ma'an Project Operation	Ma'an Project Operation	
	people go to the suspension bridge and valley on holidays for outing, fishing, swimming and playing in the water.	affected by the construction and the journey will be slightly delayed, but it will not affect the willingness to have fun. The recreational experience has a positive impact on some tourists (providing engineering construction explanation resources), and a negative impact on			opportunities.	

Item	Current Status (1987)	Ma'an Project Construction (1991-1995)	Countermeasures for environmental impact during construction period	Target Year 2001		Countermeasures for environmental impact during Operation period
				Without Ma'an Project Operation	Ma'an Project Operation	
		some tourists, but the degree of impact is slight.				

III. Summary of main environmental impacts

i. Beneficial impact

1. Full utilization of water resources

Dajia River is the river with the richest hydraulic reserves in Taiwan. Currently, there are five hydropower plants in the middle and upper reaches only, and a New Tianlun power plant is under construction, with a total installation capacity of 969,900 kilowatts; however, there is still a drop of more than 100 meters between the New Tianlun power plant and Ma'anliao downstream, which has yet to be fully utilized. The peak power generation tailwater volume generated by the New Tianlun Power Plant and Tianlun Power Plant is 138 m^3/s, adding a power plant near Ma'anliao can increase the net peak capacity by 133,500 kilowatts and increase the annual power generation by more than 400 million kWh. The tailwater from power generation is still discharged into Dajia River for downstream irrigation and public water supply. Therefore, the operation of the Ma'an Hydropower Project does not consume water resources and does not pollute water quality. It is an economical and effective use of the country's overall water resources.

2. Promote local economic activity during construction period

The existing community settlements in the planned area are very small, and industry and commerce are underdeveloped. There are only small restaurants and grocery stores scattered along both sides of the Zhongheng Highway. During the construction phase, a large number of Taipower engineering personnel, contractor supervisors, and technical workers were stationed, which had a positive impact on the promotion prosperity of the catering retail and service industries in nearby areas.

3. Creation of sightseeing and recreation resources

The small lake formed upstream of the Ma'an Project Barrage can improve the landscape quality of the local waters. If a small parking lot and leisure facilities can be built around it, it can form a new tourist and recreational base.

ii. Negative Effects

1. Environmental pollution during construction

During the construction period of any project, it will inevitably cause air and water pollution near the work area, as well as an increase in noise and vibration levels. Good construction management is required to minimize the level of pollution.

The more significant pollution caused by the construction of the Ma'an Hydropower Project is: (1) The concentration of suspended particles and falling dust increases in the work area and along the earth moving path; (2) The excavation of the work area causes an increase in the turbidity of the Dajia River, especially during the rainy season; and (3) The sudden increase in volume level caused by the explosion and the construction noise generated by heavy machinery construction sites, etc.

2. Landscape damage during construction

The surface damage caused by the partial land preparation works at each construction site, the construction of dormitories, and the accumulation of construction machinery and equipment will temporarily damage the existing visual landscape quality of the project area.

3. Traffic disruption during construction

During the period of ballast removal in the work area, a large number of earth-moving vehicles will enter and exit, which will inevitably interfere with the traffic on the Zhongheng Highway. The tourist bases along the Zhongheng Highway in the east of the planned area may be affected by traffic congestion during the peak tourist season.

4. Damage to river ecological environment

During the excavation of the Ma'an Project barrage, the water pollution caused by its downstream to Tianlun rear pond and the flow change caused by the operation of the power plant after completion were not conducive to the habitat of river fish. However, the fish biological resources in this section of the river are not abundant, and the site investigation found no rare species and migratory fish species (the downstream is already blocked by Shigang Dam), so changes in the hydrological and water quality environment will not have a significant impact on the ecological environment of the Dajia River.

5. Loss of land productivity

The waste dump, switchyard, power plant and construction roads occupy part of the orchard land. In addition to the possibility of continuing to plant fruit trees in the new land of the waste dump, the land used for power plant facilities will lose land productivity during the operation period. However, the area is not large and it has no impact on the local agriculture. Production activities will be slightly affected.

IV. Environmental Impact Countermeasures

i. Corresponding countermeasures in the design stage

1. technical countermeasures

(1) Environmental protection engineering design

Environmental protection projects under construction include temporary drainage, gully and surface erosion control, sediment runoff control, waste sewage disposal and garbage disposal, etc. Environmental protection projects in operation are mainly employee domestic sewage and garbage treatment projects, all of which are incorporated. The overall project planning and design of the hydropower project, and the required project funds are included in the project cost.

(2) Enhancement of environmental beautification measures

At the very beginning of engineering construction in mountainous areas, significant damage to the surface landscape was caused by land preparation and filling. The unavoidable adverse effects of this kind of construction can only be compensated by shortening the exposure time of the ground surface and creating new scenery.

For the excavated slopes of power plants, switchyards and construction roads, it is planned to carry out slope stabilization and vegetation slope protection projects immediately after the slopes are trimmed, so that when the factory construction or road paving is completed, the exposed slopes can be partially covered to improve visual landscape.

Engineering facilities within sight of Zhongheng Highway will be beautified or covered from the perspective of landscape design. Permanent facilities such as power plants, etc., focus on the coordination of architectural shapes and colors during planning and design; switching yards, temporary offices, dormitories, etc. have poor views and are covered with planting.

(3) Development of construction plan

To reduce the interference to Zhongheng Highway traffic during the construction period, the construction plan will be developed based on the traffic changes on Zhongheng Highway during peak tourist seasons and holidays. The tunnel's ballast removal progress will be flexibly adjusted to ease the disruption to traffic on the Zhongheng Highway caused by the entry and exit of transport trucks.

In order to comply with various pollution prevention and control regulations by the government, the detailed construction schedule will be determined based on the operating time of high-noise construction machinery and the dilution capacity of the water body to withstand pollution.

2. Administrative Cooperation Countermeasures

(1) public communication

The expropriation of project land will involve issues such as compensation for existing rights and interests of land owners and users, and adjustments to life when changing careers. Multi-faceted communication and coordination will be carried out during the design stage to avoid causing social problems.

Once the land expropriation scope and compensation standards are approved, will immediately invite the relevant resident to explain in detail, so that the people can be fully prepared, respond early, reduce the psychological impact, and have the opportunity to fully understand the compensation details, so as to avoid public resentment caused by misunderstandings.

(2) Good Neighbor Measures

Taiwan adopts a system operation and dispatching method in power system, so it is impossible to delineate the benefit area of any power plant. The area where the power plant is built is often not a direct beneficiary area. Especially when the planned area already has electricity supply, it is more difficult for the local people to understand the need for the power plant building plan. They are faced with major life changes such as land expropriation, house demolition, change of career, etc. When enduring all kinds of pollution and inconvenience during construction, it is inevitable that there will be rejection and resistance to the plan. This depends on the sincerity of the developer to resolve the problem.

During the planning and design stage, human resources for construction projects in nearby villages and people's willingness to participate in the Ma'an Hydropower Project will be investigated. When compiling the contract award documents, it will be stipulated that the contractor must employ a minimum number of local people to ensure that employment priority is given to residents.

For the larger waste dumps acquired through requisition, the new land generated will be consulted with the representatives of the relevant villages to carry out the planning and design of the utilization plan and provide it for the use of each village.

(3) Coordination with relevant agencies

Regarding the issue of garbage disposal during construction and operation, we will first coordinate with Heping Township Office and Xinshe Township Office during the design stage to study the possibility of jointly burying domestic garbage. If it is necessary to find another burial site, we will also work with relevant personnel from the township government to jointly survey and select, and apply for use rights in accordance with regulations.

For drinking water supply issues during construction and operation, the possibility of taking over the water supply from the nearby simple tap water system will be discussed with the local township office during the design stage. If additional surface or underground water sources development is needed, will also first apply for temporary water rights in accordance with regulations.

Regarding the planning, design and operational research of the Tianlun rear pond Improvement Project, we will proactively coordinate with the Water Resources Agency, Taiwan Water Corporation and the Taichung Irrigation Association to carefully study the schedule for power plant operation and downstream water demand.

Regarding the influence between Longbao Reservoir and Ma'an hydropower projects, we will continue to negotiate WRA. Construction will not begin until the plan is approved.

ii. Corresponding countermeasures during the construction stage

1. Prevention of pollution along earth moving paths

Due to the large amount of spoils in this project, most of the transport vehicles used are dump trucks with small bodies and open rear ends. During the transportation process, the spoils carried are easily exposed from the rear ends due to vibration. It overflows from the mouth and both sides of the vehicle and falls onto the road surface; the soil adhering to the tires when the vehicle drives out of the work area will also cause pollution along the way. In order to alleviate this phenomenon, trucks will be strictly controlled not to be overloaded during construction, and a cement-paved cleaning floor will be set up near the exit of the work area. Before the truck leaves, the tires will be spray-washed, and ditches will be set up around the cleaning floor to collect the waste. The muddy water reaches the mud collection pit, where it settles and then flows into the nearby drainage.

2. Dust control

The large amount of dust generated during operations at tunnels and drifts, earth moving paths, and ballast dumps can be reduced by frequent watering.

3. Noise control

During heavy machinery construction, if the noise level in the perimeter exceeds the noise control standards for construction projects, the contractor will be required to replace or adjust the construction machinery, or change the operating hours of each machinery, so that the sound level reaches the standards stipulated by the government.

4. River water quality and ecological environment maintenance

Excavation of slopes and new construction roads will be paved or planted immediately after repair. The dumping operation must be coordinated with rolling to prevent soil loss. Septic tanks are installed in the construction site offices and work dormitories to treat the domestic sewage of construction workers. In order to effectively control the turbidity and pollution concentration of the stream water, and in conjunction with the monitoring plan of water quality and river fish life, the construction plan can be adjusted in a timely manner to reduce the deterioration of water quality and protect the habitat of fish life.

5. Traffic maintenance

In line with the Zhongheng Highway sightseeing season, the construction progress will be flexibly adjusted. If necessary, nighttime ballast removal will be used to reduce the interference to road traffic during peak hours.

6. Landscape maintenance

Temporary buildings on construction sites, concrete mixing plants or construction material storage locations are not harmonious with the surrounding environment and will be blocked from view by planting or fencing. After all excavation slopes have been trimmed, slope protection and beautification projects will be carried out.

7. Cultural asset maintenance

The Heping(和平) ruins, Zaokeng(燥坑) ruins and Fushangong(福山宮)

ruins are located near Drift A, Drift B and the construction road leading to Drift A respectively. Special attention will be paid during the construction. If any ancient ruins or antiquities are unearthed, they will be treated according to the "Cultural Assets Preservation Act", work shall be stopped immediately and proactive coordination shall be made with the competent authorities for disposal.

iii. Corresponding countermeasures during the operation stage

1. Coordination with downstream water needs

The water release operation of the river barrage will be adjusted flexibly based on the hydrology and water quality monitoring results of the downstream river section; the operation of Tianlun rear pond, Shigang dam and Ma'an Power Plant will be coordinated with the water demand schedule of various downstream irrigation roads and public water. The water demand is adjusted and recorded at any time, so that sufficient information is available to develop the best operating rules.

2. Coordination and correction of flood drainage operating system

The flood warning system and joint flood drainage operating rules of the Dajia River Basin will be redeveloped in conjunction with the Ma'an Hydropower Project.

3. Water quality and river ecological environment maintenance

Based on the water quality and river fish biological monitoring results of the downstream reaches of the Ma'an Project barrage, the discharge volume of the Ma'an Project barrage will be flexibly adjusted to dilute the concentration of water pollution and maintain the water source for fish survival.

4. Landscaping

Temporary offices, concrete mixing plants, etc. should be cleaned up after completion to restore the original appearance. The entrances of drifts, waste dumps and construction road slopes will be covered with vegetation to reduce visual impact.

5. Creation of recreational opportunities

At the Ma'an Project barrage site, a small parking lot and a few recreational service facilities will be added as needed to provide tourists with opportunities to explain and stop and view the scenery.

V. Environmental Monitoring Plan

i. Monitoring purpose

In order to accurately understand the degree of environmental impact during the construction stage and completed operation stage, significant and important environmental impact matters must be monitored. The purpose can be summarized as follows:

1. Based on the monitoring results, construction operations will be adjusted in a timely manner to comply with government regulations on pollution prevention and environmental conservation to ensure the smooth implementation of the plan.
2. Based on the monitoring results, timely adjust the operation mode to

ensure the existing rights and interests of downstream water and water rights holders, maintain the quality of local living environment and sensitive ecological environment, and avoid causing complaints from stakeholders or interested parties, to maintain the normal operation of the power plant.

3. Establish a monitoring information system to improve the accuracy of environmental impact prediction and assessment of similar projects in the future.

ii. Monitoring content

Items that should be monitored in this project include items with significant impacts such as hydrology. Environmental pollution items include five items such as water quality, air quality, noise, and river fish species for which current survey data is lacking. Refer to Table 1 for the monitoring locations, monitoring time and frequency, monitoring methods, analysis parameters and supplier recommendations.

Table 1 Ma’an Hydropower Project Environmental Impact Monitoring Plan

Item	Location	Time & Frequency	Method	Parameters	Supplier Recommendation
Hydrology	Bailu Suspension Bridge, Longan Bridge, Shigang Dam	During construction period: —River cross section monitor once a year. —Flow velocity and sand content once a week During operation period: —River cross section once a year —Flow velocity and sediment content are measured every half month in the dry season and once a week in the rainy season.	A self-recorded hydrological station was added at the Long'an Bridge site (Bailu Suspension Bridge and Shigang Dam already had hydrological station)	Water level, flow rate, flow velocity, sand content	Taiwan Power Company
Water Quality	Tianlun Power Plant, Bailu Suspension Bridge, Longan Bridge, Yong'an Bridge	During construction period: —Starting one year before construction, once a month on sunny and rainy days.	Water quality testing	Water temperature, dissolved oxygen, pH value, turbidity, suspended solids, biochemical	Academic institutions

		During operation period: —Once every two months on sunny and rainy days		oxygen demand, coliform count, organic nitrogen, conductivity, ammonia nitrogen, nitrate, orthophosphate, total phosphorus	
Air Quality	Tunnel, drift and waste dump	During construction period: —During the period when tunnels and drift are removing ballast, measurements will be taken one day every two months in Hang Hau(坑口) and Nanshi(南 势) and Tianleng(天冷) communities.	Continuous sampling for 24 hours to get daily average value, and the surface wind direction and wind speed are taken as a representative value for 24 hours.	Suspended particles and surface wind direction and speed	Academic institutions
Noise	15 meters away from the perimeter or close to a safe zone	During construction period: —Testing been carried out once when the pile driver, air compressor, crusher, rock drill, piler, road	For blasting and construction machinery noise, measure the maximum volume. Continuously measure the hourly average	The average volume at each time period, L5, L10, L50, L90, L95 percentage volume and maximum volume throughout the	Academic institutions

		roller and excavator during operation —When blasting tunnels and cross pits, measure the maximum volume at a safe location —At the project perimeter, measure the background volume once a month	volume and maximum volume for 24 hours at the project perimeter	day	
River fish species	Between Tianlun Power Plant and Ma'an Barrage, between Ma'an Barrage and Long'an Bridge, between Long'an Bridge and Tianlun Rear Pond, and between Tianlun Rear Pond and Yong'an Bridge	During construction period: —The water quality sampling carried out one year before the construction period, surveys will be conducted once a month. During operation period: —During water quality sampling period, surveys will be	On-site investigations and laboratory measurements	Type, quantity, weight, length	Academic institutions

		conducted every two months.			

A. Project Overview

A-1 Project Necessity and Purpose

The Ma'an Hydropower Project is mainly based on the policy of diversification and self-sufficiency of electric power energy, fully developing the available hydropower resources of Dajia River, with the goal of reducing dependence on imported energy and improving the peak operating capacity of Taiwan's power system. The necessity and purpose of its plan can be summarized into the following three points:

A-1-1. Meet the demand for diversification and self-sufficiency of electric power energy

Electric energy is derived energy. The power can be stably supplied depends on whether the primary energy source can be secured. The primary energy sources used for power generation in Taiwan mainly include hydropower, coal, oil, natural gas, uranium, etc. Among them, only hydropower is Taiwan's most abundant self-owned energy resource, and most of the rest relies on imports.

In order to ensure the stability of continuous power supply and facilitate the stable growth of domestic industry and economy, diversification and self-sufficiency of electric power energy has become an important energy policy of the government.

Domestic hydropower reserves are abundant. According to the Water Resources Unified Planning Committee of the Ministry of Economic Affairs (the current Water Resource Agency) and the Taiwan Power Company (TPC) in 1959, the theoretical hydraulic reserves of the 61 rivers on Taiwan's main island were estimated to be approximately 12 GW. , about 5.29 GW of water can be technically exploited; as of 1986, the theoretical hydraulic reserves of 15 rivers were reexamined to be about 10.47 GW, and about 4.81 GW can be technically exploited. As of 1986, the completed installated capacity was approximately 1.56 GW (excluding pumped storage); there was still approximately 3.25 GW of technically feasible reserves that could be developed and utilized. Therefore, hydropower resources are the most valuable self-owned energy resources in Taiwan and can best meet the demand for self-sufficiency in electric energy and should be actively developed. The Ma'an Hydropower Project is one of the projects that meets this need.

A-1-2. Improve the peak operation capacity of the power system

Due to industrial and commercial development and economic prosperity, the proportion of industrial electricity consumption has increased. With the popularization and diversification of household electrical equipment, the daily load variation of the electric power system has evolved from a simple peak at night to multiple peaks in daytime. In recent years, due to the surge in air-conditioner users, the daytime peak load has increased rapidly between 3 and 4 o'clock in the summer afternoon, often exceeding the night peak (see Figure 2).

In terms of load throughout the year, the load is highest in July to September in summer and lowest in January to February in winter. Based on electricity consumption statistics in the 1986, the average load in the highest month was approximately 1.46 times that of the lowest month, and the peak load was approximately 1.39 times.

In view of the rapid changes and growth of peak loads, how to improve the peak operation capacity of the power system is as important as the development of large-scale base load power plants.

The Ma'an Hydropower Project aims at peak operation and can increase net peak capacity by 133,500 kW, with annual power generation reaching more than 400 million kilowatt-hours, accounting for approximately 8.7% of the current total installation capacity of 35 conventional hydropower plants in Taiwan, which accounts for 1,535,065 kilowatts. The improvement of peak operation capacity is quite helpful

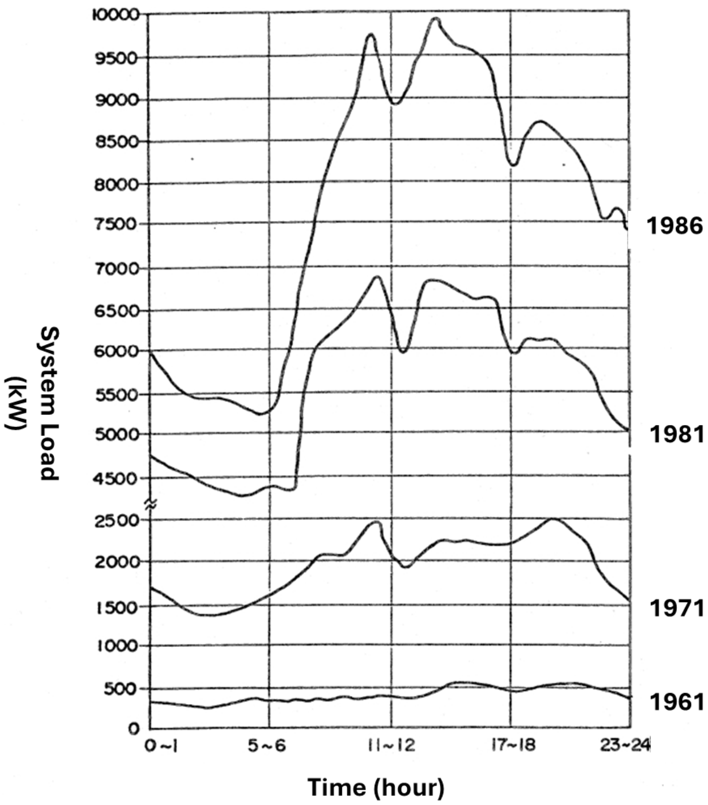


Figure 2 Taiwan’s Electricity Load Changes Throughout The Day In Summer

(Source: Taiwan Power Company)

A-1-3. Make full use of the water power resource contained in Dajia river

The Dajia River basin covers an area of approximately 1,236 square kilometers, with an average annual runoff volume of 2,600 million cubic meters and an average riverbed slope of 1/60. The water volume is abundant and the height difference is large. The water power reserve is the highest among all rivers in Taiwan. The development of water power resources began as early as the Japanese occupation era. The Tianlun Power Plant, completed in 1953, was a pioneer in the development of hydroelectric power in Dajia River.

At present, there are Deji Dam, Qingshan Dam, Guguan Dam, Tianlun Dam and Shigang Dam operating in cascade in the Dajia River Basin. The five hydropower plants installed include Deji, Qingshan, Guguan, Tianlun and Sheliao (see Table 2, Figure 3, Figure 4), with a total installed capacity of 864,900 kilowatts, which is the main peak power supply in the existing power system in Taiwan. In addition to supplying system peak power, it also controls system frequency. .

The Tianlun Power Plant, which was the earliest to be built downstream, had insufficient capacity of the adjustment pond and headwater tunnel to regulate the peak power generation tailwaters of the upstream power plants, causing the loss of power generation efficiency been huge, and a secondary development plan was urgently needed.

The New Tianlun Hydropower Project was approved and implemented by Order No. 04518 of the Executive Yuan Taiwan (76) on June 30, 1987, and construction started in March 1988. It is scheduled to be completed in 1992:

The project will be completed for commercial operation in June; upon completion, the project will solve the bottleneck of the Tianlun Tunnel and enable the upstream power plants to fully utilize peak power generation. The implementation of the Ma'an Hydropower Project is to cooperate with the operation of the new Tianlun Power Plant, fully develop the self-produced hydropower resources in the lower reaches of Dajia River, increase the peak power of the system, and reduce the dependence on imported energy. The feasibility study results have confirmed the technology is feasible, the economic benefits are obvious, and it is worthy of investment, development and construction.

Table 2 Status of Hydropower Development in Dajia River Basin

Item	In operation				Developmen5		
	Deji	Qingshan	Guguan	Tianlun	Sheliao	New Tianlun	Ma’an
Design flow (m^3/s)	200.0	150.8	116.1	68.0	-	70.0	144.5
Effective water head (m)	143.1	275.0	182.0	171.0	27.3	176.0	106.85
Type	Reservoir	Reservoir[1]	Reservoir[1]	Reservoir[1]	Run-of-river	Reservoir[1]	Reservoir[1]
Installed Capacity (MW)	3 @ 78 234	4 @ 90 360	4 @ 45 180	4 @ 22.5 90	2 @ 0.45 0.9	1 @ 105.5 105.5	2 @ 66.75 133.5
Completion (year/ month)	1974/10	1973/7	1962/1~ 1966/12	1952/9~ 1978/11	1922/9	1992/6	1995/12

Note [1]: These power plants are controlled by the Deji Reservoir upstream, they are all classified as reservoir-type hydraulics.

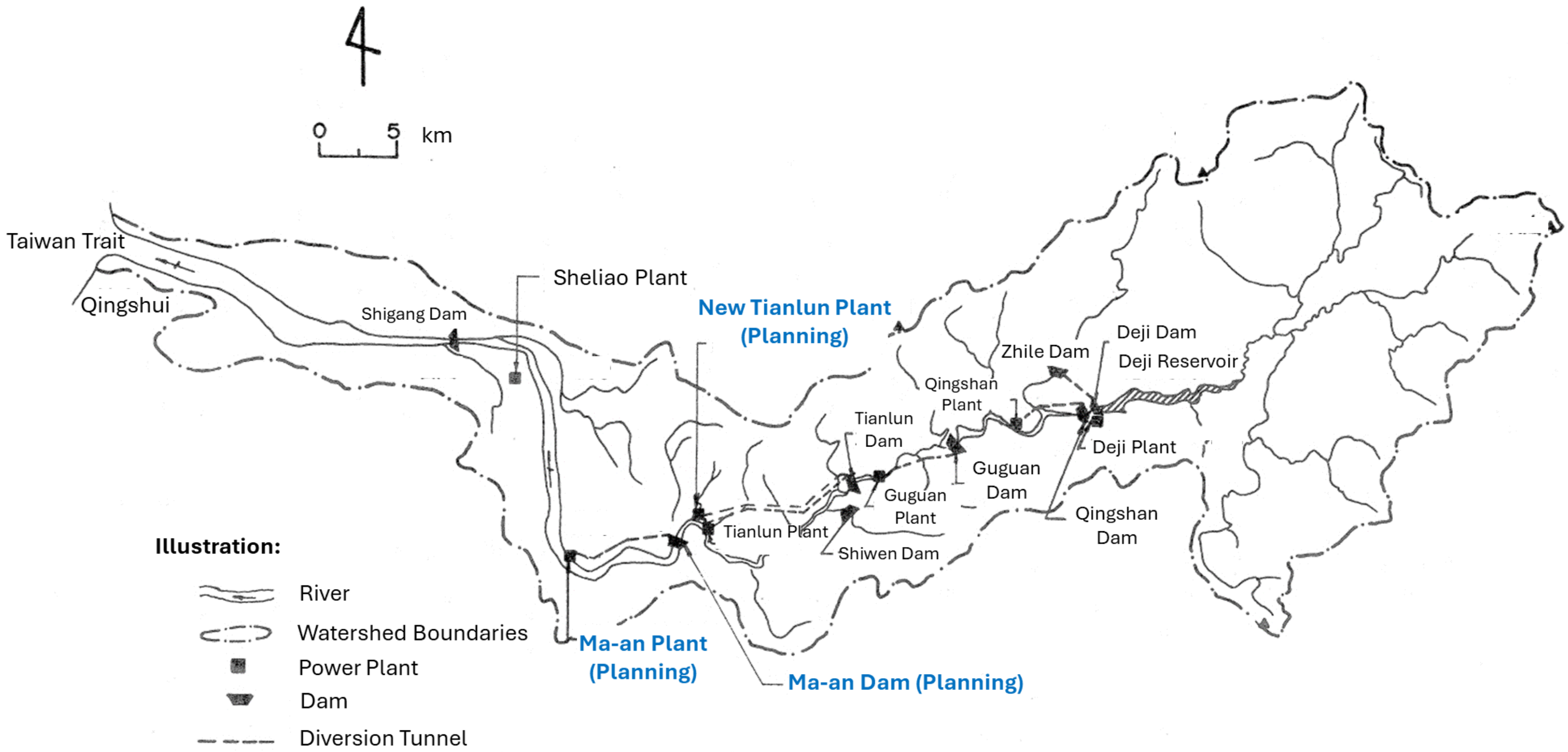


Figure 3 Hydropower Development Facilities in Dajia River Basin

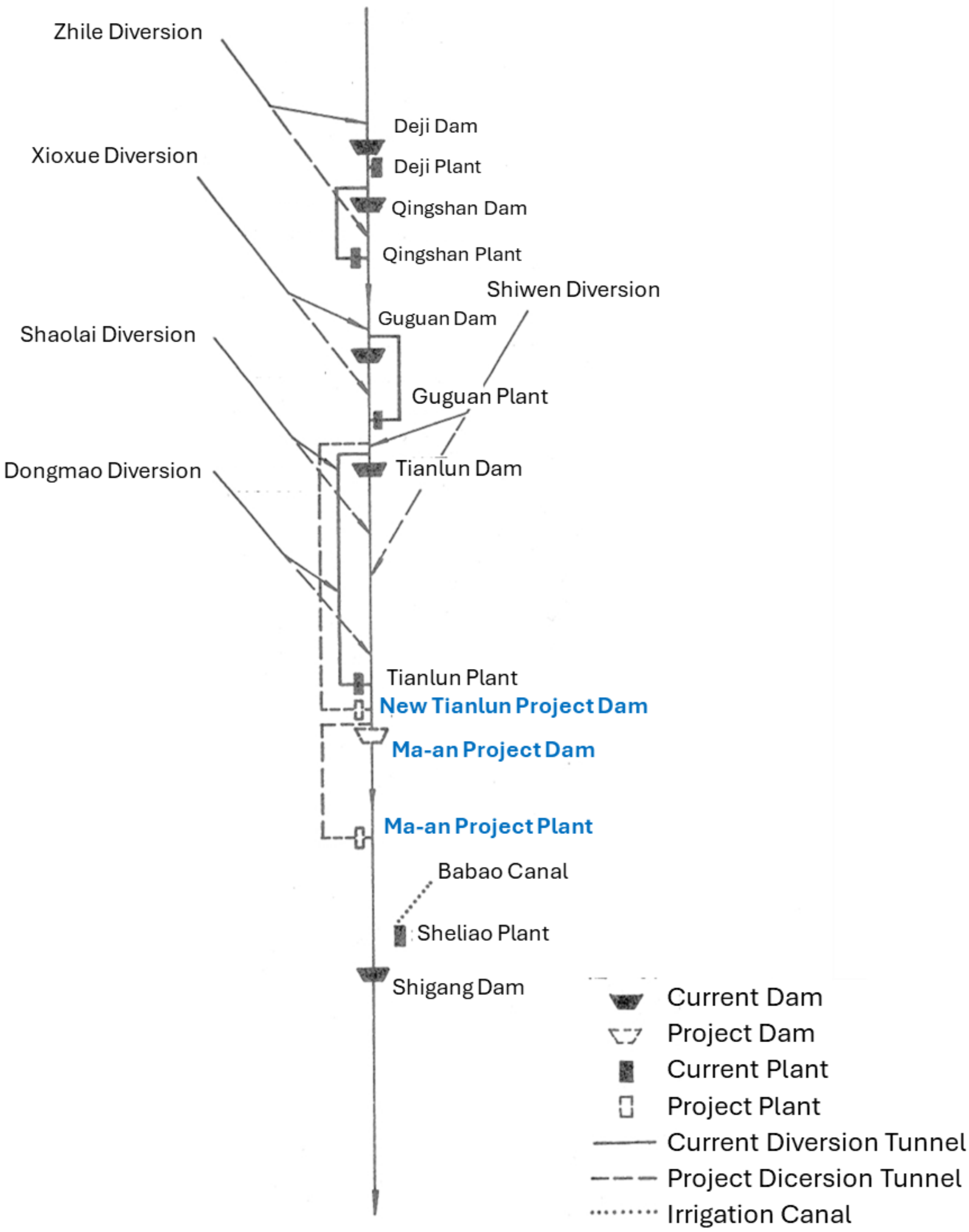


Figure 4 Dajia River Basin Water Respurces System

A-2 Alternative Plans

A-2-1. Alternative plans

Alternative plans for hydropower generation projects can generally be considered at two levels: one is substitution plans for power generation from different energy sources, such as thermal power, nuclear energy, geothermal energy, etc.; another is substitution plans for other hydropower generation projects in different locations.

The power system in Taiwan has gone through decades of development and evolution, from the early period of "hydropower dominated and coal-fire power followed" (1945~1959), " hydropower and coal-fire power with equal emphasis" (1960~1967) to the present day(1988). " coal-fire power and hydropower follows"; the system's base load power generation mainly relies on thermal and nuclear power units, while peak power generation relies mostly on hyropower. Due to the different functions of hydro and thermal power in the system, current hydropower plans rarely consider alternative energy sources such as thermal power or nuclear power.

Hydropower is Taiwan's own non-consumable electrical energy with the most abundant reserves. However, due to limitations of natural conditions such as topography and hydrology, the locations suitable for hydropower development are mostly concentrated in the central and eastern river basins. In order to cooperate with the government's energy diversification and self-sufficiency policy and reduce dependence on imported energy, all hydropower resources with development potential, as long as they are economically qualified (those with thermal power as an alternative plan and a cost-benefit ratio greater than 1.0) should be used in load forecasting. Therefore, most current hydropower plans only study their development priorities and strict development timing, and rarely consider other hydropower alternative plans.

During the feasibility study stage of the Ma'an Hydropower Project, the following three alternatives were drawn up for comparative study, namely: (A) the pressure tunnel semi-underground plant; (B) the gravity-pressure tunnel semi-underground plant; (C) the gravity tunnel semi-underground plant. After analysis and comparison based on engineering technology, economic benefits, operation and maintenance, etc., Plan A, the pressure tunnel semi-underground plant, was selected as the "development plan" as the subject of subsequent design and environmental impact assessment.

The following is a summary of the key points of the analysis and comparison of the three alternatives:

1. engineering technology aspect

The main differences in the engineering layout of the three alternatives are that the headwater tunnel is a pressure type or a gravity type, and that a surge tank or a forebay and a waterway need to be installed.

Plan A is a pressure tunnel with a total length of 7,485 meters and needs to be equipped with a surge tank; Plan B is a gravity-pressure tunnel with a total length of 7,540 meters, with an upstream section of 6,675 meters being a gravity tunnel and a downstream section of 865 meters being a pressure tunnel and requiring a surge tank, forebay and open channel waterway; Plan C uses a gravity tunnel with a total length of 7,480 meters, which requires underground forebay and culvert residual waterway.

The routes of the tunnels in the three scenarios are roughly the same. They all pass through 8 faults along the route. The geology is not ideal and must be strengthened with steel support and grouting. Generally speaking, gravity tunnels are easier to construct than pressure tunnels, but the excavation section is larger.

The geological conditions of the surge tower in Plan A are better, and the project is relatively simple. It is not only easy to construct, but also has low engineering costs; Although the location of the forebay in Plan B is still ideal, the geological structure is sandstone with extremely poor cementation. The foundation must be dug to 20 meters below the ground. The amount of excavation is large, and the left side is the foot of the rock foundation slope, which may cause ground slippage. If possible, the approximately 1.25 kilometers of open channels and residual waterways must be lined. The project cost is huge; The geological structure of the underground forebay in Plan C is interbedded sand and shale, and the lithology is also fragile. The forebay is huge and requires underground steel pipe residual waterways and passages. The construction is extremely complicated and the project cost is higher than surge tank.

2. Economic Benefits Aspect

Among the three alternative plans, Plan A (pressure tunnel semi-underground plant building) selected as the development plan has the highest earnings ratio of 1.113 and the lowest total investment amount of approximately NT$12.1 billion; therefore, from the perspective of economic benefits, Project A is also the best case.

Table 3 Comparison of Economic Benefits of Alternatives to The Ma'an Hydropower Project

Item	Plan A (pressure tunnel semi-underground plant)	Plan B (gravity-pressure tunnel semi-underground plant)	Plan C (gravity tunnel semi-underground plant)
1. Total Investment (NTD: thousand dollars)	12,062,021	13,121,800	13,275,085
2. Annual Cost (NTD: thousand dollars)	1,216,134	1,316,618	1,331,351
3. Annual Benefit (NTD: thousand dollars)	1,353,266	1,354,551	1,367,083
4. Cost-earnings Ratio	1,113	1.029	1.027
5. Annual Net Benefit (NTD: thousand dollars)	137,092	37,933	35,732
6. Annual Generation (MWh)	410.5	408.4	412.2

3. Operation and Maintenance Aspect

Operation: Plan A adopts a pressure tunnel, and the unit can go from zero load to full load in a short time; Plan B and C adopt pressure-gravity and gravity tunnels respectively, and the unit needs a longer time to go from zero load to full load. Therefore, Plan A can better meet the system load demand.

Maintenance: Plan A using pressure tunnel is also equipped with a surge tank, so there is no problem of residual water discharge when tripping. The gravity-pressure tunnel in Plan B and the gravity tunnel in Plan C need to be equipped with a residual water drainage channel so that the residual water input into the forebay through the tunnel can be discharged into the Dajia River when the tripping. From the perspective downstream river safety, causing by large discharge volumn, Plan A is regarded as the superior one.

A-3 Project Content

The Ma'an Hydropower Project is to build a barrage about 900 meters downstream of the tailwater outlet of the Tianlun Power Plant to receive the power generation tailwaters of the upstream power plants and regulate the flow of the uncontrolled watershed between Tianlun Dam and Ma'an Dam. By the construction of water inlet on the right side of the upstream of the dam body, water is diverted through a pressure tunnel about 7.5 kilometers long in the hillside on the right bank of Dajia River to the newly built semi-underground power plant near Tianlun rear pond to generate electricity. The maximum water diversion volume is 144.5 cubic meters/second, and the effective water head is 106.85 meters. After power generation, the tail water is discharged into the rear pond of the Tianlun.

The main project contents are summarized as follows:

A-3-1. Engineering facilities

1. Barrage

- Watershed area: 916.4 square kilometres
- Highest water level: 553.4 meters
- Minimum water level: 550.0 meters
- Effective capacity: 575,000 cubic meters
- Dam type: Concrete gravity dam, 303 meters long, 18.5~41.0 meters high
- Spillway:

  Type: Ogee spillway (臥箕式溢洪槽)

  Gate type: arc gate, 9 @ 10.0 meters wide x 6.7 meters high

  Design flood volume: 5,970 cubic meters/second (T=1,000 years)
- Sand discharge channel:

  Gate type: curved gate, 2 @ 4.5 meters wide x 5.0 meters high

  Threshold elevation: 545.5 meters

2. Water inlet

- Length: 31.0 meters
- Front width: 45 meters
- Height: 23.5 meters
- Water control gate: straight lift type, 1@ width 7.0 meters × height 7.0 meters

3. Headwater Tunnel

- Type: Pressure type
- Length: 7,485 meters

- Inner diameter: 6.40 meters
- Maximum flow rate: 4.50 meters/second
- Section: round, reinforced concrete lining

4. Surge Tank

- Type: hole-making type, open top
- Shaft diameter: 15.0 meters
- Water control hole diameter: 3.08 meters
- Height: 69.14 meters
- Maximum swell level: 580.17 meters
- Minimum swell level: 523.23 meters

5. Penstock

- Type: underground inclined type
- Total length: 385.14 meters
- Inclination angle: 45 degree
- Inner diameter: 3.0~6.0 meters

6. Power plant

- Type: semi-underground
- Dimensions: 50.3 meters long, 20.2 meters wide, 35.5 meters high

7. Tailrace:

- Length: 2 @ 49.6 meters

- Cross section: circular, inner diameter 4.0 meters
- Tailrace gate: straight-lift type, 2@4.0 meters wide x 4.0 meters high

8. Construction drifts(橫坑)

- Length: 5 in total, total length 2,295 meters
- Section: Inverted D-shaped standard section, 5.6~6.5 meters wide, 5.0~6.5 meters high

9. Switch Yard:

- Type: outdoor
- Dimensions: 56 meters long, 43 meters wide; covers an area of 2,408 square meters

10. Mechanical and electrical equipment

- Type: Vertical shaft Francis turbine generator
- Installed capacity: 2@66.750 kilowatts; total 133,500 kilowatts

A-3-2. Construction plan

1. Haulage road

(1) Access road

The transportation of construction equipment and the entry and exit of construction personnel in this plan can be carried out through Provincial Highway No. 3 or the Dongshi branch line of railway (Fengyuan-Wengzi-Shigang-Dongshi) to Dongshi, and then use the middle of the two-lane Central Cross-Island Highway(中部橫貫公路) (Dongshi-Guguan-Deji-Lishan-Tianxiang-Taroko, also known as Provincial Highway No. 8, hereinafter referred to as Zhongheng Highway) goes directly to the vicinity of the work area, and then connects to construction roads to major engineering facilities. .

(2) construction road

The new construction roads required for this project are from Zhongheng Highway Tianlun rear pond, Long'an Bridge, Heping Police Station and Bailu Suspension Bridge to Drift D, Drift C, Surge tank, Drift B, Drift A, Drift A1 and 6 planned barrages are located on the south side of Zhongheng Highway. Except for the construction road about 3 kilometers long to Drift C and the surge tank, which is built along the contour line on the north side of Zhongheng Highway, the rest are on the ground of Dajia River on the south. The construction road adopts the standard design of level 6 roads in mountainous areas, the road surface width is between 3.5 and 7.0 meters, the design speed is 30 kilometers per hour, the minimum radius of the horizontal curve is 30 meters, and the maximum longitudinal slope is 10%. All construction roads will be retained as maintenance roads after completion.

2. Construction method

(1) Barrage and water inlet

The barrage is constructed by half river water diversion construction method(半面河道導水工法). A temporary construction cofferdam of about 4.0 meters high is constructed upstream and downstream of the right spillway to guide the stream water to the left river. The cofferdam will be dismantled after the water inlet, sand discharge channel and spillway are completed, then build cofferdams of the same height upstream and downstream of the dam site on the left to guide the stream water to the river on the right and flow out through the sand discharge channel. After the dam body is completed, the cofferdam will be removed. Because the dam site is located in the accumulation layer of the old river channel, there may be undercurrents, so chemical grouting is considered to stop the water.

(2) Pressure tunnel

Adopting the NATM construction method, four construction drift A1, A, B and C are excavated simultaneously using the advanced step method and the uniform sliding blasting method. The excavated rock ballast is loaded and transported to the designated waste dump for storage. During excavation, the upper half of the section is excavated first, and concrete is sprayed and stone nails are installed as the excavation progresses. If necessary, it is reinforced with steel mesh or steel support; then the lower half, that is, the step portion, is excavated. Once the part is penetrated, it is lined with concrete again.

After the concrete is mixed in the mixing plant, it is transported to the pouring site by mixer truck and poured into the concrete pump for pouring.

(3) Surge tank

Divide the upper and lower working area to excavate vertical drift at the same time: one is excavated from top to bottom from the construction road to the top of the surge tank, and the other is excavated upward from the construction horizontal drift C to the center of the bottom of the surge tank. After the drift is excavated and penetrated, the excavation is expanded from top to bottom and protected with anchor bars, shotcrete, support or pre-lining concrete depending on the geological conditions.

The ballast from the surge tank can be transported from the top through the construction road or from the bottom through the horizontal drift C.

(4) Penstock

The penstock between the surge tank and the power plant is an underground inclined pit with an elevation angle of 45°, with a total length of about 385 meters, and a diameter reduced from 6.0 meters in the upper horizontal section to 3.0 meters in the downstream end of the branch manifold.

Excavate horizontal drift C and D at the same time. After the guide drift is connected, the excavation will be expanded from top to bottom. If necessary, steel supports and pre-lining concrete or shotcrete will be used to protect the excavation. The backfill concrete in the inclined section is placed using the inclined conveying method. To strive for timeliness, when the factory building is excavated to the center line of the turbine, comprehensive excavation of the bifurcated section of the penstock will be carried out at the same time.

(5) Plant building

In a comprehensive excavation method, new earth-moving machinery will be used to prepare the land first to the same height as the Zhongheng Highway road surface, and dump trucks will be used to transport the abandoned rock ballast to the waste dump site C or D. The stepped excavation method is adopted, with full-section excavation layer by layer from top to bottom. The excavation depth of each step is about 8 meters. Depending on the geological conditions, the excavation slopes will be protected with anchor bars, rock anchors and shotcrete; after all excavation is completed, concrete will be poured layer by layer. Since the excavation is 33 meters deep, for safety reasons, a water level and displacement monitoring system will be installed during the construction to carry out various reinforcement measures at any time.

(6) Tianlun rear pond improvement project

The improvement project of the Tianlun rear pond is to add a sand discharge gate and overflow channel on the left side of the upper pool of the Tianlun rear pond, and to add a water release gate (4.0 meters wide and 3.0 meters high) on the middle embankment of the upper and lower pools for drainage of excess flow (68 cubic meters/second). Taking advantage of the dry season, it is planned to add a gate to the left side of the Tianlun rear pond. According to the nearby terrain, a temporary construction cofferdam will be constructed with sand-coated stones, logs, bamboo, stacked mats and other materials, to facilitate foundation excavation and concrete pouring, and make sure that the normal operation of the existing Tianlun rear pond will not be affected during the construction period.

3. Construction site

The temporary offices, dormitories, warehouses, concrete mixing plants, material storage yards, required for this project are located near Baileng (白冷), Heping (和平), rear pond (後池) and Xinbeigong(新伯公).

4. Engineering materials

The main engineering materials for this project are cement, aggregates, fly ash, wood, steel bars and explosives. The cement is Putlan cement produced by domestic cement plants, and the concrete aggregates are taken from the Dajia River bed. General steel materials, timber and explosives are purchased domestically. Fly ash is produced by Taipower's coal-fired thermal power plants.

Mechanical, electrical and hydraulic machinery and equipment and their accessories are imported from abroad.

5. Project contracting

   The civil engineering works of this project are contracted to domestic contractors on a general contracting basis. The contractor shall provide its own construction machinery, construction equipment, labor and materials required for the project. Taipower shall be responsible for project design and inspection. The penstock are designed by Taipower itself and are manufactured and installed by domestic and foreign experienced manufacturers. The main electromechanical equipment, such as hydraulic turbines, generators and main transformers, are designed, manufactured and installed by experienced domestic and foreign manufacturers.

6. Construction schedule

   This project is scheduled to start construction in July 1991 and be completed in December 1995.

A-3-3. Project cost estimation

1. The total project cost is approximately NT$12.06 billion (currency value in the year of completion)
2. Unit construction cost: approximately NT$90,000/kW

A-3-4. Electricity benefit estimation

1. Net peak capacity: 133,500 kW
2. Firm power: 13,890 kW
3. Annual power generation: 410,476,032 kWh

A-3-5. Economic assessment

1. Annual profit: NT$1,353,226,000
2. Annual cost: NT$ 1,216,134,000
3. Annual net profit: NT$137,092,000
4. Earnings to cost ratio: 1.113

A-3-6. Financial analysis

1. Capital cost rate: 7.83%
2. Return on investment: 10.57%
3. Investment recovery period: 17.52 years

B. Environmental Status in Project Area

B-1 Natural environment

B-1-1. Geography

1. Topography

The Ma'an Hydropower Project facilities, except for the weir built on the main stream of the Dajia River for water diversion, include the headrace tunnel, construction cross headings, switch yards, power plants, surge tanks, and penstock. These facilities are all located along the hilly terrain of the right bank between the Tianlun Power Plant and the Tianlun rear pond in the midstream section of Dajia River (see Figure 5).

The elevations of the ridges that the headrace tunnel passes through are mostly between 500 and 1,000 meters, higher in the east and lower in the west. They are part of the low hills of the Jialishan(加里山) Range and have steep slopes, mostly above 30%. Above the tunnel, tributaries of Dajia River such as Hengliu River (橫流溪), Datiekeng River(打鐵坑溪), Shaolaiping River(稍來坪溪) and Zaokeng River(燥坑溪) cross from north to south (see Figure 6).

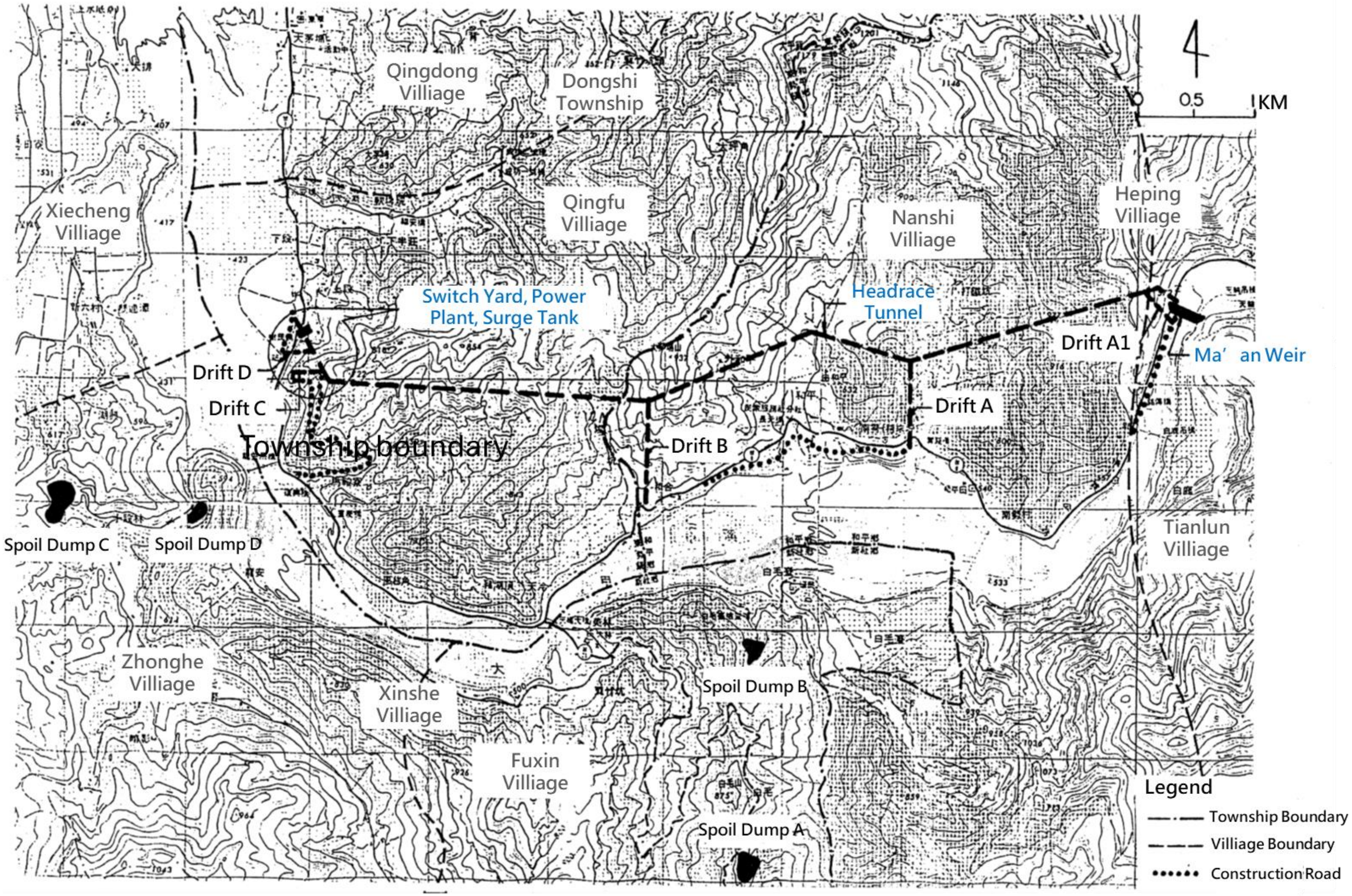


Figure 5 Ma'an Hydropower Project Geographic Location

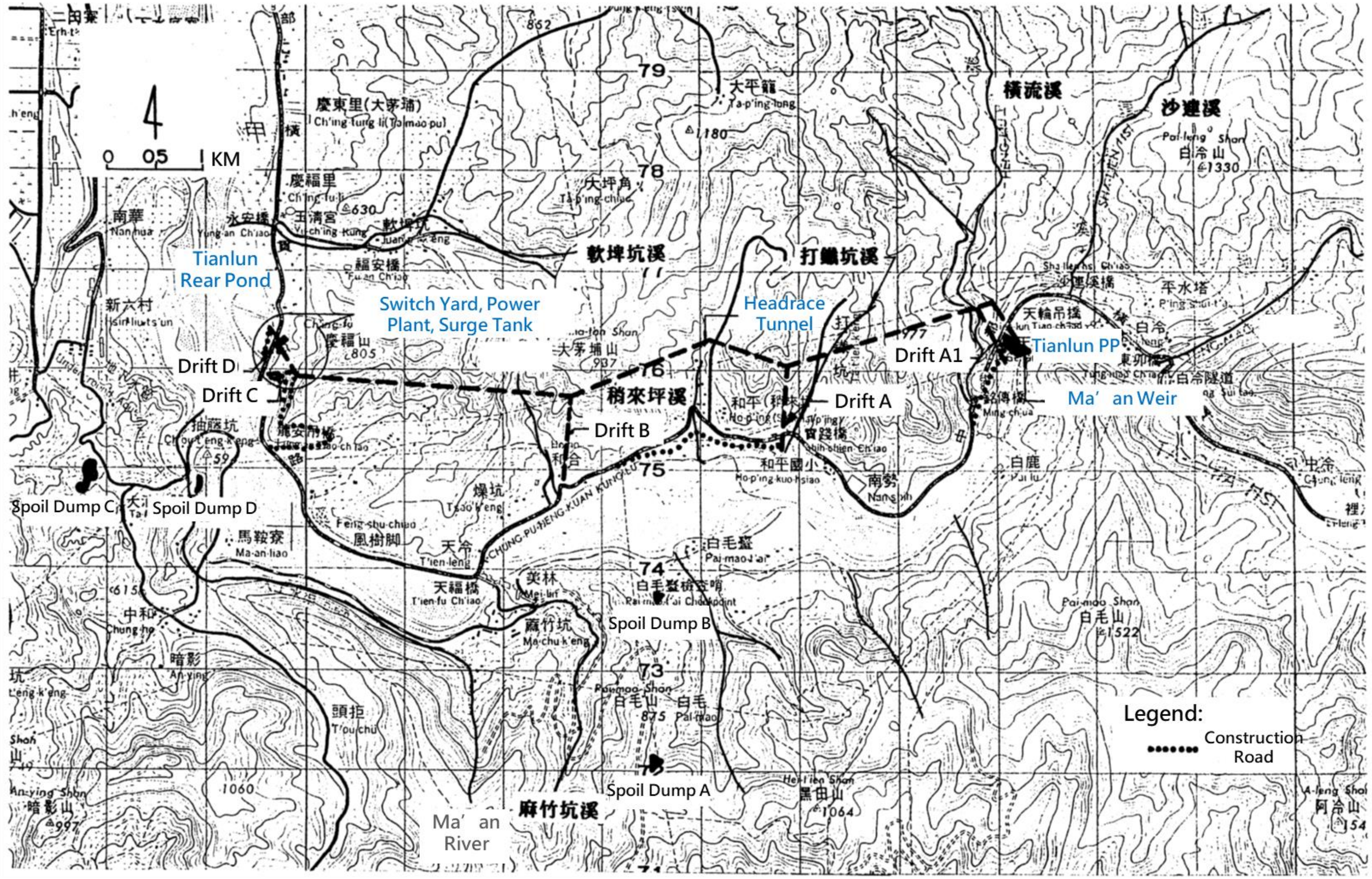


Figure 6 Topography and Water System of the Project Area

2. Geology

The strata of the project area are composed of marine sediments of the Tertiary Period. Except for the modern alluvial deposits in the riverbed of the Dajia River, the hilly terrain on the northern bank, from Baileng to Nanshi, consists of Eocene strata. These strata are composed of slightly metamorphosed quartz sandstone interbedded with hard shale or slate. The area west of Nanshi to Ma'anliao consists of Middle Miocene strata, which is composed of interbedded sandstone, shale, and sand-shale. The rock types are susceptible to weathering, and these strata are faulted against the Eocene strata. The area between Ma'anliao and the afterbay predominantly consists of Late Miocene strata, with only a localized distribution of Pleistocene strata composed of gravel, soil, and sand on the right bank of the Tianlun rear pond. Quaternary terraces, taluses, and alluvial deposits are distributed along the banks of the Dajia River and its main tributaries.

There are numerous faults and folds in the area. The eight faults extending from east to west include the Hengliu River fault, Datiekeng fault, Shaolaiping fault, Shuiliudong fault, Zaokeng fault, Ruanpikeng fault, Ma'ancha fault, and Damaopu fault. Although there are many localized small-scale folds, there is no extensive propagation with only one relatively large syncline near Heping. Most of the structural lines are in the north-northeast direction and are perpendicular to the planned headrace tunnel (see Figure 7).

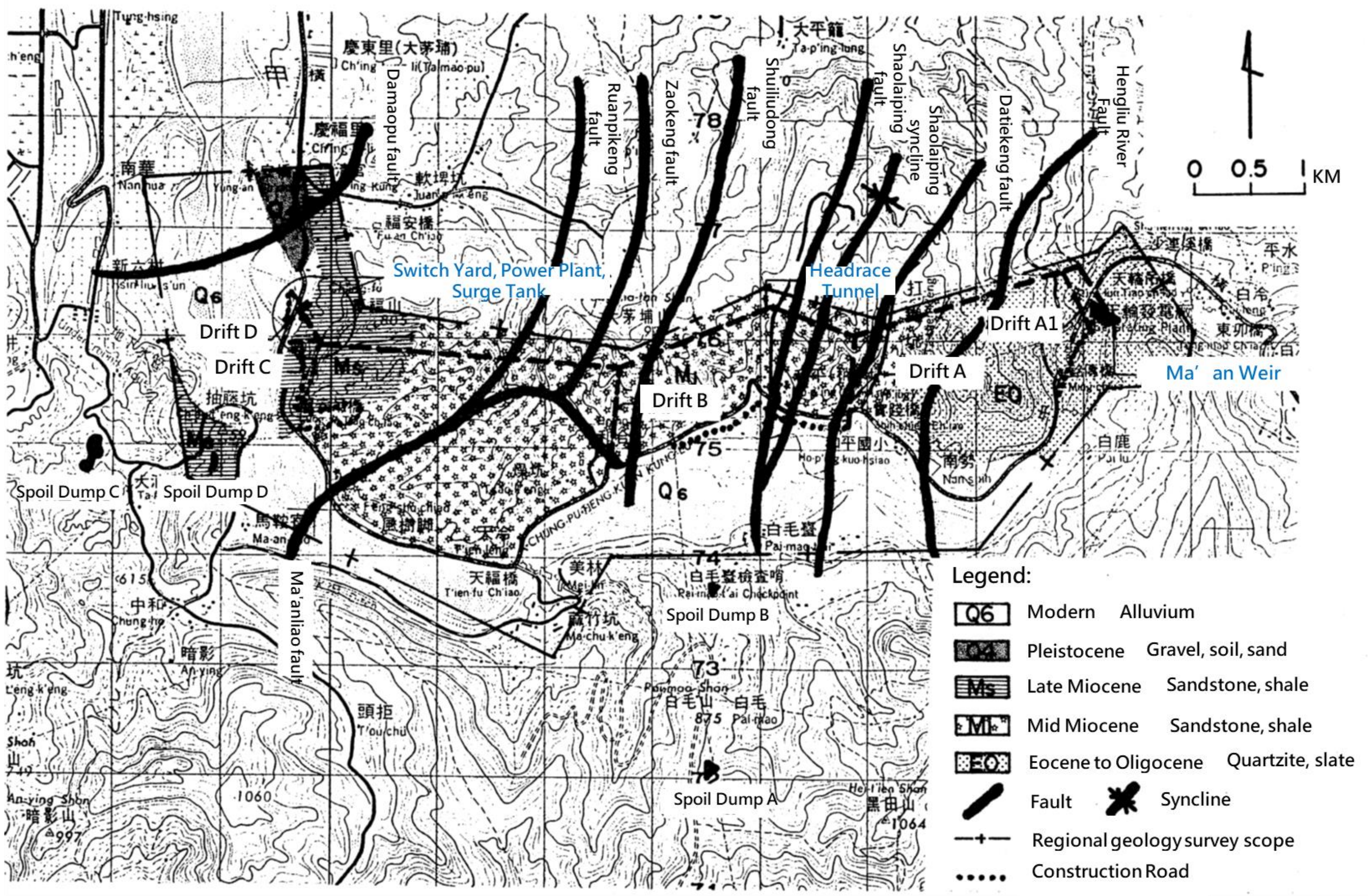


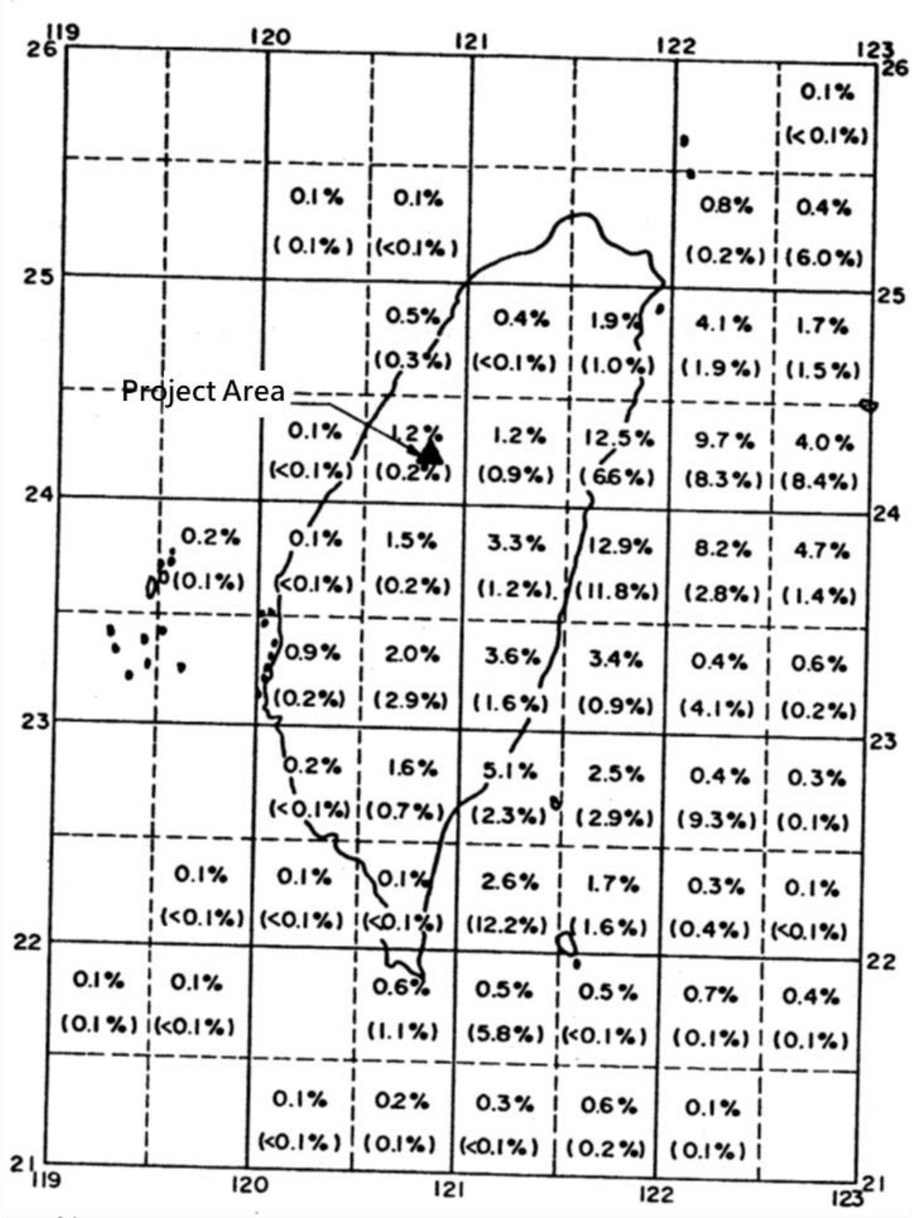
Figure 7 Regional Geology of the Project Area

3. Earthquakes

The main construction sites in the project area are located in Dongshi Township, Heping Township, and Xinshe Township. According to the Building Technical Regulations, the seismic zones in Taiwan are divided such that Dongshi Township is classified as a high seismic zone, while Heping Township and Xinshe Township are classified as moderate seismic zones.

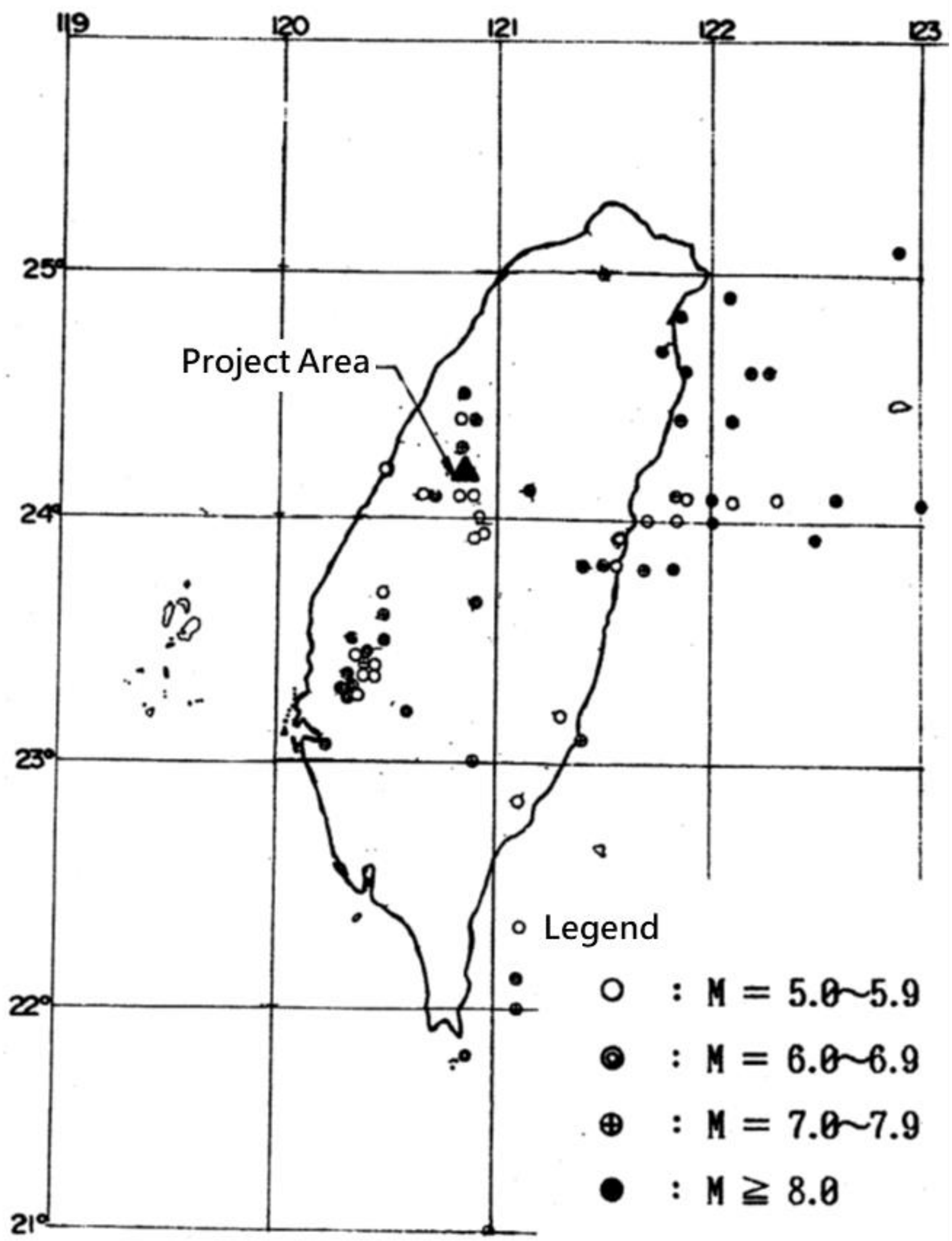
According to statistics compiled by Bai-Hua Li (1983) on the spatiotemporal distribution of earthquakes of a 5.0 magnitude or above in Taiwan and nearby regions from 1935 to 1972, earthquakes in the project area accounted for only 1.2% of the total number of earthquakes and released only 0.2% of the total energy. Therefore, it should be considered a non-significant seismic zone (see Figure 8).

Based on statistics of the epicenter distribution of damaging earthquakes in Taiwan and coastal areas from 1900 to 1970 (see Figure 9), the Dajia River Basin has never been the epicenter of an earthquake with a magnitude greater than 5.0.



Note: The percentage in the box is the percentage of earthquakes.
The percentage in brackets ( ) is the percentage of energy released by the earthquakes.

Figure 8 Number of Earthquakes and Distribution of Energy Released in Taiwan and Nearby Areas



Note: The statistical period is from 1900 to 1970 AD.

Figure 9 Distribution of Damaging Earthquake Epicenters in Taiwan and Nearby Areas

4. Climate

According to the classification of Taiwan's climate zones, the project area west of Tianleng belongs to the northern climate zone, which has a subtropical climate. The area east of Tianleng belongs to the central mountainous climate zone, which has a temperate climate with high humidity.

Based on the observation data of TPC’s Tianshu Climate Station located in Tianlun Village, Heping Township, the average temperature, rainfall, and relative humidity of the project area are as follows:

(1) Air temperature:

The average yearly temperature is 20.3°C; temperatures are lowest in January, about 13.7°C, and highest in July, about 24.9°C.

(2) Precipitation:

The average annual rainfall is 2,504 millimeters, with an average of 123 rainy days per year, mostly concentrated between May and August.

(3) Relative humidity:

The yearly average relative humidity is around 78%; August is the highest, about 80%, and October is the lowest, about 73%.

B-1-2. Air quality

The project area consists of hilly and mountainous terrain, primarily used for agriculture and forestry. Only a few farmhouses are situated along the sides of the Central Cross-Island Highway and the industrial roads. The most notable fixed sources of air pollution are three gravel pits located on the right bank of the Dajia River riverbed, where chimneys occasionally emit exhaust. The Central Cross-Island Highway at the foot of the mountain is the main linear source of air pollution. However, due to the low traffic volume, vehicle emissions do not significantly impact the surrounding air quality.

Taichung City has only three air quality monitoring stations, located in Dali Township (Dali Township Public Health Center Monitoring Station), Wufeng Township (Wufeng Township Public Health Center Monitoring Station), and Fengyuan City (Taichung County Department of Health Monitoring Station). Aside from being all quite distant from the project area (the shortest direct distance is 20 kilometers), these monitoring stations are situated in busy urban areas with heavy traffic, so their observed values cannot represent the air quality in rural mountainous areas. From late November to mid-December 1987, two consecutive 24-hour measurements of carbon monoxide, sulfur oxides, nitrogen oxides, suspended particulates, wind direction, and wind speed were conducted near the Ma'an Project Power Plant site (Qingfu Village, Dongshi Township) and along the Central Cross-Island Highway in Nanshi Village, Heping Township (see Figure 10). The concentrations of these pollutants were all significantly lower than the "Taiwan Region (General Area) Air Quality Standards of the Republic of China" (see Table **4**).

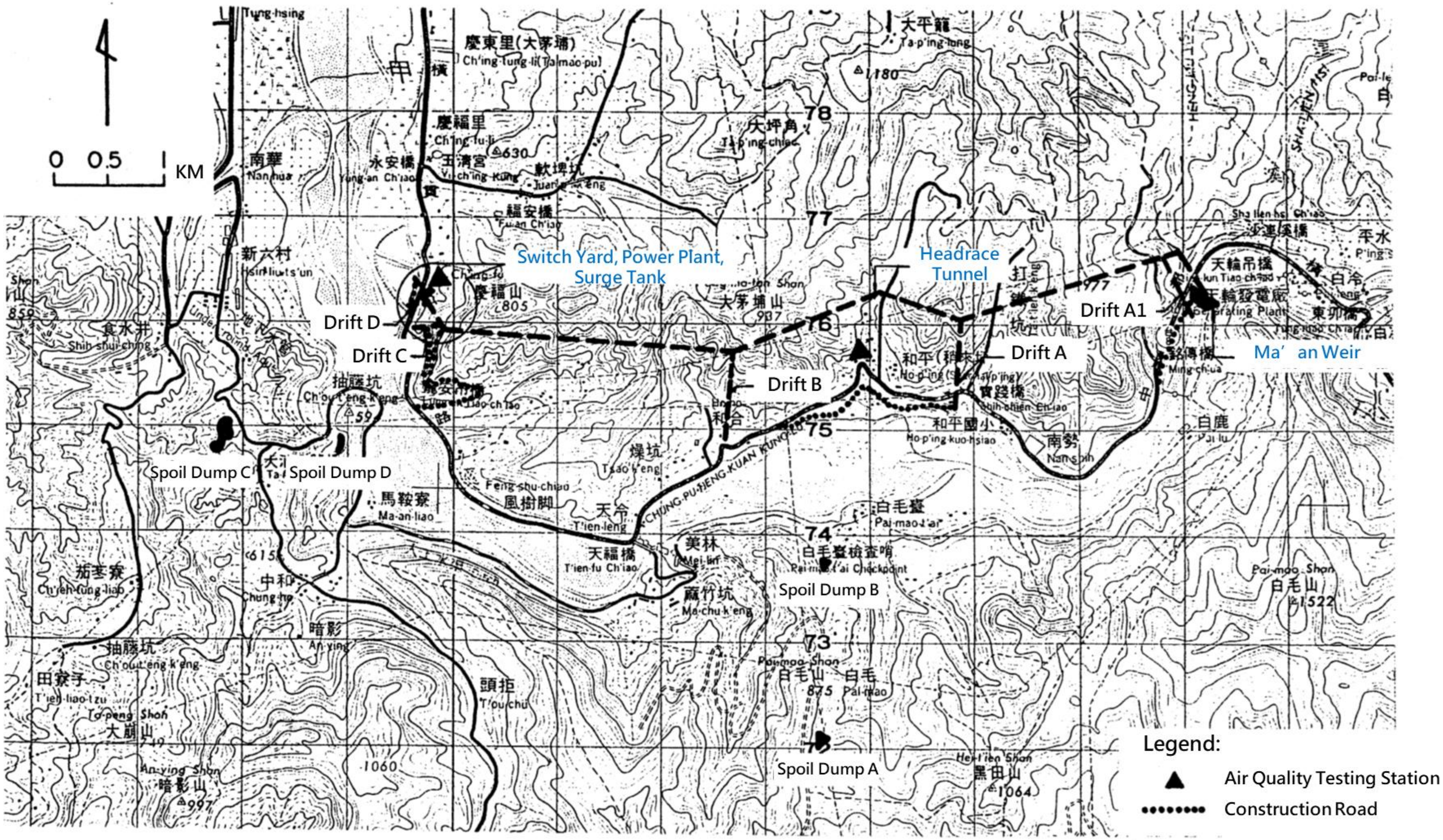


Figure 10 Background Air Quality Monitoring Locations in the Project Area

Table 4 Results of Background Air Quality Testing in the Project Area

Survey location		Carbon monoxide (PPM)		Sulfur oxides (PPM)		Nitrogen oxides (PPM)		Suspended particulates (μg/Nm^3) [[5]]		Average wind speed (meters/second)	Most frequent wind direction
		Daily average	Maximum hourly average	Daily average	Maximum hourly average	Daily average	Maximum hourly average	Daily average	Maximum hourly average		
[1] Off of the Zhongbu Cross-island Highway in Nanshi Village	(1987/11/27) [[3]]	0.41	<0.8	0.0047	<0.024	0.0090	<0.018	83.0	-	0.54	NNW
	(1987/12/11)	0.58	<0.8	0.0034	<0.009	0.0049	<0.017	116.8	-	0.42	ESE
[1] Ma'an Project Power Plant Site	(1987/11/28)	0.33	<0.4	0.0008	<0.007	0.007	<0.012	28.1	-	2.70	N
	(1987/12/12)	0.35	<0.5	0.0019	<0.008	0.0041	<0.015	36.9	-	1.08	E
[2] Tianlun Power Plant	(1985/12/27)	0.22	0.6	0.0030	0.005	0.0041	0.0085	23.1	-	0.64	SE
	(1986/1/10)	0.42	0.6	0.0030	0.007	0.0029	0.0060	57.6	-	0.78	SE
[2] Guguan Recreational Area	(1985/12/18)	0.46	1.2	0.0028	0.005	0.0089	0.021	38.3	-	0.31	NW
	(1986/1/19)	0.54	0.9	0.0037	0.01	0.0088	0.024	61.8	-	0.18	NW
[4] Ambient air quality standards		≦10	≦40	≦0.1	≦0.3	≦0.05	-	The monthly average is ≦ 2.0			

Note [1]: The Engineering Division entrusted the Department of Environmental Engineering and Science of Feng Chia University to conduct testing.

[2]: Excerpted from Taiwan Power Company: "Environmental Impact Assessment Report for the New Tianlun Hydropower Project", August 1986.

[3]: Indicates testing date (month/day/year (ROC))

[4]: Refers to the standards applicable to "general areas" in the "Taiwan Region Environmental Air Quality Standards of the Republic of China".

[5]: The concentration of suspended particulates does not include particles with a grain size greater than 10 μm.

B-1-3. Hydrology

1. Surface water

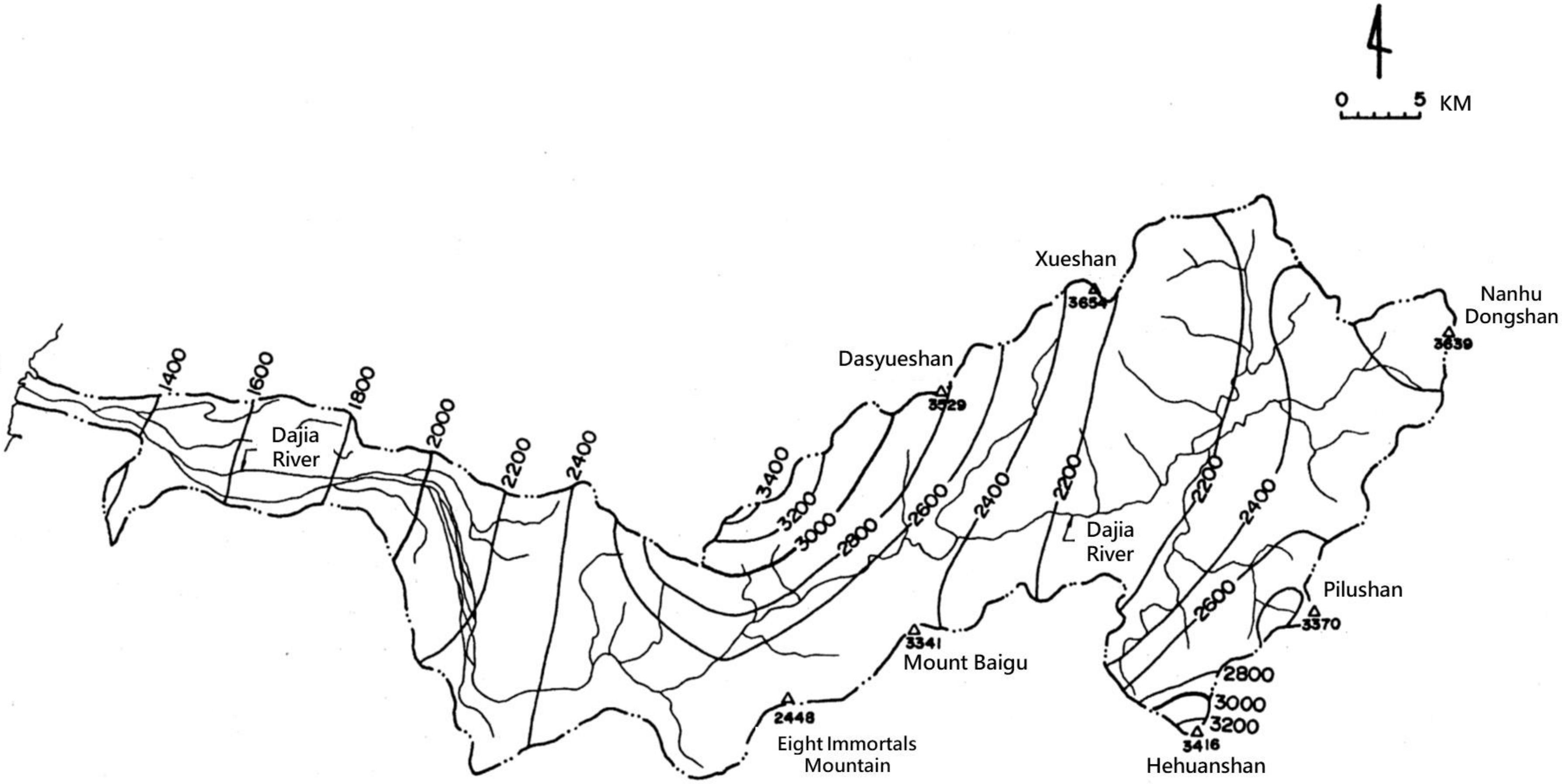
(1) Overview of Dajia River Basin

Dajia River, the upstream of which is Nanhu River, originates from Nanhu Dongshan in the Central Mountain Range (elevation 3,639 meters). After merging with Ikajiu River at Songmao (Taiboku), it is referred to as Dajia River. It flows from east to west through Lishan, Jiayang, Deji, Guguan, Baileng, Ma'anliao, Dongshi, and Shigang, then into the Taiwan Strait in the north of Wuqi. The basin has a total length of 124.2 kilometers, an area of 1,235.7 square kilometers, and a total of 34 tributaries, which merge into the river in a plume shape. Above Ma'anliao, the river valley is steep and rich in hydropower potential. Five hydropower plants have been constructed, and the land utilization on both sides is low. Below Shigang, the river enters a plain, upon which the flow of the river is distributed in a web shape. The river bed is heavily covered with gravel, and the land on both sides has been highly developed. The average annual runoff volume of the basin is approximately 2,566.09 × 106 cubic meters, ranking 9th among the 19 major rivers in Taiwan. The average annual volume of sand transported is approximately 3.565 × 106 metric tons, ranking 12th.

(2) Basin rainfall

The average annual rainfall in Dajia River is approximately 2,370 millimeters. According to the annual average isohyetal map of the Dajia River Basin provided by the Water Resources Unified Planning Commission of the Ministry of Economic Affairs (hereinafter referred to as the Water Resources

Commission) from 1949 to 1979 (see Figure 11), the annual rainfall decreases from 3,200 millimeters in the eastern mountainous area to about 1,400 millimeters in the western coastal area.



Note: The statistical period is from 1949 to 1979 (provided by the Water Resources Commission).

Figure 11 Distribution of Isohyet in the Dajia River Basin

(3) Flow

Due to the cascade operation of multiple upstream power plants in the Dajia River Basin, the flow observed at the downstream hydrological stations is mostly controlled flow rather than natural flow. Due to the different establishment times and observation periods of the hydrological stations within the basin, the natural flow and actual inflow of the Dajia River Basin need to be supplemented with flow data obtained through regression analysis and the area ratio method. Since complete records of actual inflow at Shigang Dam have been collected starting from 1979, to ensure that the comparison between estimated natural inflow and actual inflow has the same time basis, the daily and ten-day flow data from 1979 to 1986 were used to analyze the annual average flow, monthly average flow, and flow duration curve of the Shigang Dam and the Ma'an Project Dam site.

① Natural flow

Shigang Dam is the most downstream hydrological station on the Dajia River. Its drainage area is 1,056.86 square kilometers, which is approximately 85% of the total drainage area of the Dajia River Basin. Using the Dajian Hydrological Station for supplementary estimates [Note 1], the annual average flow from 1979 to 1986 was approximately 67 cubic meters per second. The wet season, from May to September, accounted for about 59% of the total annual flow, with December and January being the driest months. The 26% delayed flow (wet flow) is approximately 76 cubic meters per second, the 50% delayed flow (normal flow) is about 40 cubic meters per second, the 75% delayed flow (low flow) is around 24 cubic meters per second, and the 97%

[1] Q (Shigang) = 1.94Q (Dajien) + 2.29

delayed flow (dry flow) is about 14 cubic meters per second.

Using the Dajian Hydrological Station for supplementary estimation, the natural flow at the Tianlun Hydrological Station (with a catchment area of 953 square kilometers) was calculated. Then, using the area ratio method [Note 2], the annual average flow from 1979 to 1986 at the Ma'an Project Dam site (with a catchment area of 916 square kilometers) was estimated to be approximately 60 cubic meters per second. The 26% delayed flow is approximately 68 cubic meters per second, the 50% delayed flow is about 36 cubic meters per second, the 75% delayed flow is around 22 cubic meters per second, and the 97% delayed flow is about 13 cubic meters per second (see).

② Actual inflow volume

Based on the recorded actual inflow data at Shigang Dam from 1979 to 1986, the estimated annual average actual inflow is approximately 79 cubic meters per second. The 26% delayed flow is approximately 101 cubic meters per second, the 50% delayed flow is about 39 cubic meters per second, the 75% delayed flow is around 21 cubic meters per second, and the 97% delayed flow is about 10 cubic meters per second.

Based on the measured flow records at the Baizhi Hydrological Station of the Water Resources Department (with a catchment area of 916 square kilometers), the annual average actual inflow at the Ma'an Project dam site from 1979 to 1986 is estimated to be approximately 66 cubic meters per second using the area ratio method. The 26% delayed flow is approximately 75 cubic

[2] Q (Tianleng) = 1.78Q (Dajien) + 2.62

Q (Ma'an) = Q (Tianleng) · A (Ma'an) / A (Tianleng) meters per second, the 50% delayed flow is about 34 cubic meters per second, the 75% delayed flow is around 17 cubic meters per second, and the 97% delayed flow is about 5 cubic meters per second (see Figure 12).

Due to the operation of upstream power plants, the actual inflow during the wet season (May to September) at both the Shigang Dam and the Ma'an Project Dam site is higher than the natural flow. This is especially notable in June, when the actual inflow is approximately 67% and 46% higher than the natural flow at Shigang Dam and the Ma'an Project Dam site, respectively (see Figure 13).

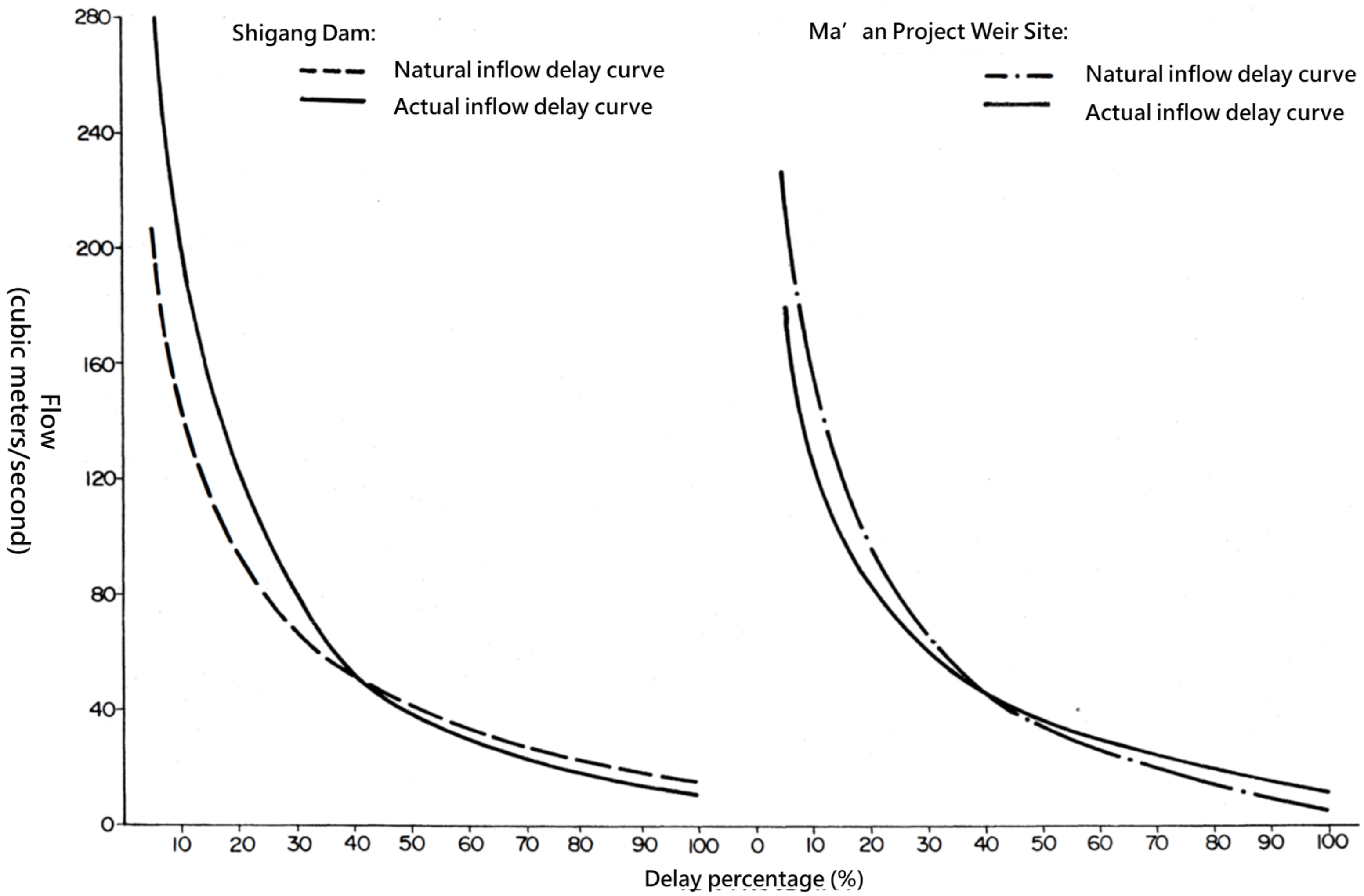


Figure 12 Current Flow Delay Curve of the Dajia River Section in the Project Area

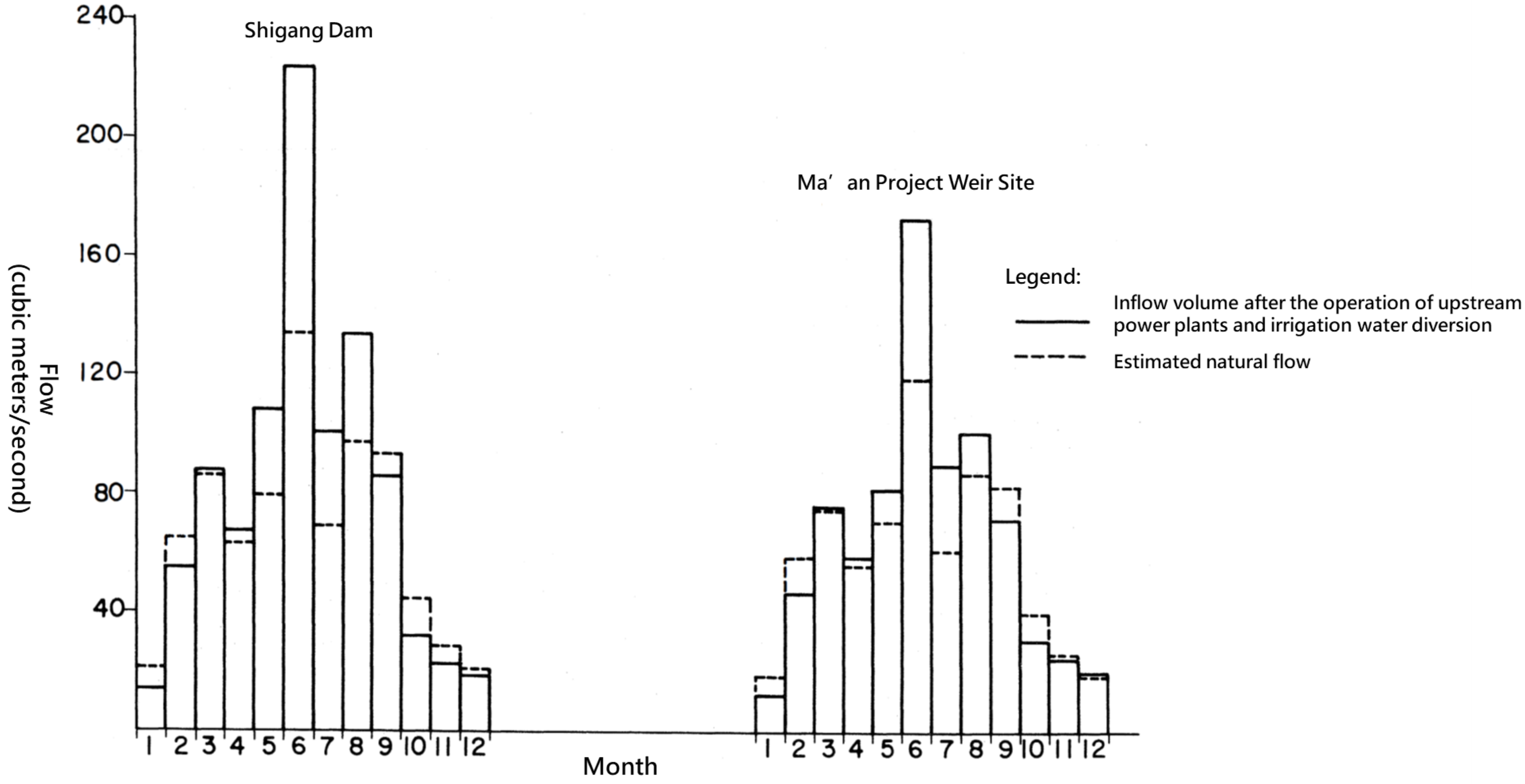


Figure 13 Current Monthly Average Flow Distribution of the Dajia River Section in the Project Area

2. Groundwater

The upstream of the Dajia River is a typical canyon with poor water content in the strata. In the midstream area around Heping, the river valley gradually broadens, the flow velocity slows down, and the riverbed has thick and stable gravel deposits, forming a better aquifer. According to nearby well-drilling data, the groundwater level is quite stable, approximately 4 to 8 meters below the surface. At present, there are simple water plants and wells drilled in schools on both sides of the river to draw groundwater as a source of drinking water.

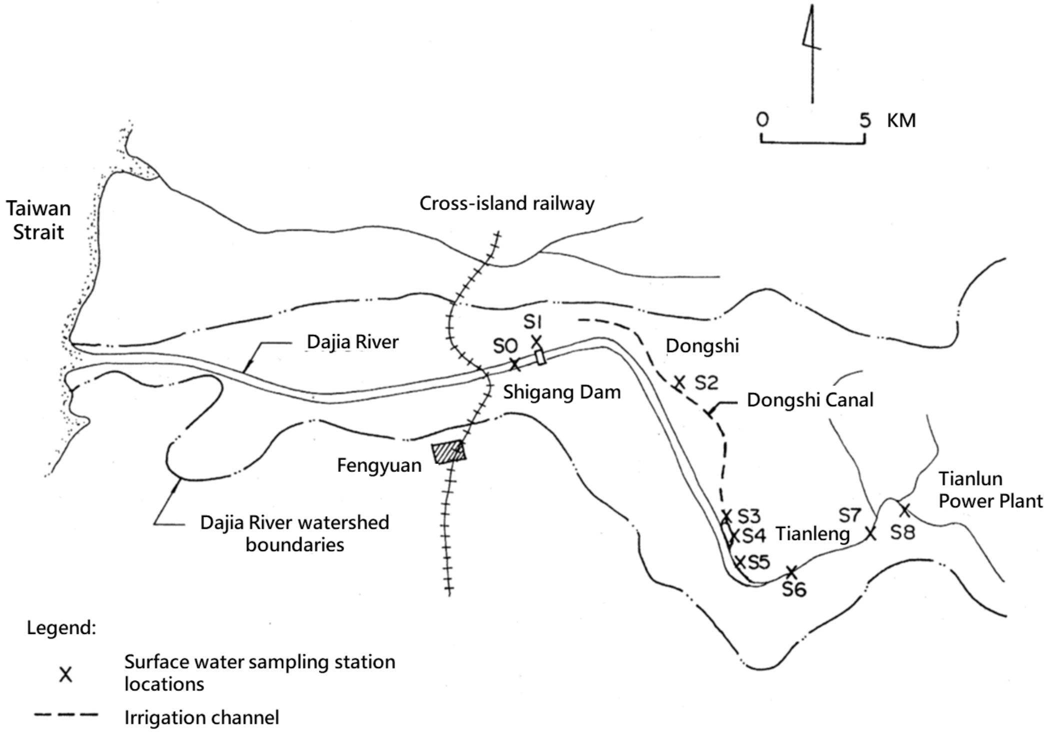
Dajia River is also a natural auxiliary water source for the major groundwater reserves in the Dajia Plain and northern part of Taichung Basin.

B-1-4. Water quality

Land use in the Dajia River Basin can be divided into woodland, orchards, dry land, communities, grassland, and bare land, of which woodland accounts for about 80%. Pollution sources in this basin can be divided into two types: (1) Non-point pollution sources: Including fertilizers and pesticides applied to trees and orchards for farming. (2) Point pollution sources: Including household sewage, livestock wastewater, factory wastewater, etc. The impact on water quality is most significant from non-point pollution sources such as agricultural practices and fertilizers used in orchard operations.

The Dajia River is one of Taiwan's main water resources, and according to river usage classification, it is classified as a Category B river. In addition to hydropower, it also plays an important role in supplying public water and irrigation water in the greater Taichung area, therefore ensuring water quality is extremely important. In 1976, after the discovery of abnormal algae growth in the Techi Reservoir, Taiwan Power Company (TPC) took the issue very seriously. In collaboration with the Water Resources Commission, TPC launched a four-year "Dajia River Basin Water Quality Long-Term Monitoring Plan" starting in 1983. This plan involved a systematic investigation of pollution sources and water quality conditions upstream of the Shigang Dam. The fifth year of the monitoring plan is currently underway. Additionally, the Taiwan Water Corporation conducted one-year studies on water quality and plankton in the Dajia River in 1980 and 1983 to better understand the river's raw water quality.

Combining the water quality investigation results from various organizations over the years with the sampling and testing conducted by the Engineering Division from May to September 1987 near the downstream area from Tianlun Power Plant to Tianlun rear pond (see Figure 14), the analysis results are presented in Table **5**. The current water quality (1986-1987) of the Dajia River segment from Tianlun Power Plant to Shigang Dam shows that the pH value, coliform count, suspended solids, and heavy metal content meet the standards for Category A river water quality. The biochemical oxygen demand (BOD) falls between the standards for Category B and Category C rivers. However, the total phosphorus level exceeds the Category A standard by 160 to 2,800 times, and the ammonia nitrogen levels mostly align with or fall below the standards for Category B and Category C rivers. This is likely due to the improper use of fertilizers in upstream orchards, leading to numerous water quality parameters of the Dajia River not meeting the standards for its classification as a Category B river.



No.	Sampling station name\sampling unit	Water Resources Commission	The Engineering Division	Taiwan Water Corporation	Sinotech Engineering Consultants
S0	Fengyuan water supply plant water inlet			V	
S1	Shigang Dam	V		V	
S2	Dongshi Canal (Dongshi Town)		V		
S3	Dongshi Canal (Yong'an Bridge)		V		
S4	Water outlet of Tianlun Afterbay		V		
S5	Water inlet of Tianlun Afterbay	V	V	V	
S6	Tianfu Bridge		V		
S7	Bailu Bridge		V		
S8	Water outlet of Tianlun Power Plant	V	V	V	V

Figure 14 Distribution of Water Quality Sampling Stations in the Dajia River Section of the Project Area

Table 5 Water Quality Testing Results for the Dajia River Section from Tianlun Power Plant to Shigang Dam

Item / No.	S0			S1				S2	S3		S4		S5			
Location	Near the water inlet of Fengyuan Water Supply Plant			Shigang Dam				Dongshi Canal	Yong'an Bridge Canal		Water outlet of Tianlun rear pond		Water inlet of Tianlun rear pond			
Institute	Taiwan Water Corporation			Water Resources Commission		Taiwan Water Corporation		The Engineering Division					The Engineering Division		Water Resources Commission	
Year	1981	1981	1985	1986	1986	1981	1981	1987	1987	1987	1987	1987	1987	1987	1986	1986
Month/Date	1/	7/	7/	1/15	8/28	1/	7/	7/30	5/29	7/30	5/29	7/30	5/29	7/30	1/15	8/28
1.Water Temperature	18	27	21.3	16	24	18	27	21.5	20	21	20	20	20	20.5	16	23
2.Turbidity	0.7	1.0	-	0.75	5.2	1.2	1.2	2	0.8	37	0.6	17	0.4	18	0	5.5
3.Total alkalinity	-	-	-	-	67	-	-	36	59.1	40.0	57.6	38	61.7	36	-	57
4.pH value	8.0		7.87	7.9	8.0	8.2		7.31	7.97	7.54	7.79	7.58	8.19	7.64	8.3	8.0
5.Hardness	108		-	-	90	107		114.2	72.5	57.3	82.3	53.2	82.3	72.2	-	74
6.Coliform count	3000		6000	-	-	-	-	200	ND	ND	ND	ND	ND	ND	-	-
7.Dissolved oxygen	-	-	8.9	9.4	8.1	8.3		7.3	7.7	8.5	8.3	8.9	8.2	8.3	9.8	8.2
8.Biochemical oxygen demand	-	-	-	-	-	0.9		3.6	1.5	2.4	1.2	1.2	1.2	2.4	-	-
9.Chemical oxygen demand	-	-	4.9	-	-	6.0		27.6	22	19.4	20	16.4	20	19.2	-	-
10.Volume of dissolved solids	168		158.1	150	131	161		190	102	72	102	73	102	72	216	102
11.Volume of suspended solids	0.5	20.5	3.78	6	12	1.0	38.0	0.5	0.5	1.25	1.0	1.0	0.5	1.5	13	20
12.Chloride	2.0		1.8	-	2.3	5.0		12.6	5.0	4.2	5.0	8.3	5.0	8.3	-	0.93
13.Sulfate	34.8		29	-	27	34.3		39.5	22	15.6	22.5	23.4	23	17.1	-	21
14.Free ammonia nitrogen	0.005		0.052	0.19	0.23	0.022		0.22	0.15	0.91	0.13	0.29	0.17	0.25	0.17	0.29
15.Nitrate nitrogen	0.92		0.78	0.78	1.3	1.11		5.63	0.65	0.95	0.49	0.75	0.55	0.61	0.44	0.60

Item	No.	S0			S1				S2	S3		S4		S5			
	Location	Near the water inlet of Fengyuan Water Supply Plant			Shigang Dam				Dongshi Canal	Yong'an Bridge Canal		Water outlet of Tianlun rear pond		Water inlet of Tianlun rear pond			
	Institute	Taiwan Water Corporation			Water Resources Commission		Taiwan Water Corporation		The Engineering Division					The Engineering Division		Water Resources Commission	
	Year	1981	1981	1985	1986	1986	1981	1981	1987	1987	1987	1987	1987	1987	1987	1986	1986
	Month/Date	1/	7/	7/	1/15	8/28	1/	7/	7/30	5/29	7/30	5/29	7/30	5/29	7/30	1/15	8/28
16.Nitrite nitrogen selected		0		0.007	-	-	0.008	-	-	-	-	-	-	-	-	-	-
17.Total phosphorus		11.2	14.5	40	18	14	11.0	57.5	1.75	2.74	1.85	1.63	1.85	1.85	1.92	11	18
18.Electrical conductivity		236		201.6	219	207	237		348	109	125	113	130	110	133	184	171
19.Silver		ND		-	-	-	ND		-	-	-	-	-	-	-	-	-
20.Manganese		0.008	0.012	0.026	-	ND	0.022	0.153	0.02	-	0.05	-	0.02	-	0.05	-	ND
21.Cadmium		ND		-	-	-	ND		-	-	-	-	-	-	-	-	-
22.Lead		0.01		-	-	-	0.01		-	-	-	-	-	-	-	-	-
23.Chromium		0.002		-	-	-	0.002		-	-	-	-	-	-	-	-	-
24.Mercury		ND		-	-	-	ND		-	-	-	-	-	-	-	-	-
25.Iron		0.03	0.04	0.28	-	ND	0.08	0.20	0.01	0.01	0.05	0.02	0.04	-	-	-	0.71
26.Copper		0.029	0.007	0.002	-	-	0.032	0.015	-	-	-	-	-	-	-	-	-
27.Zinc		ND		-	-	-	ND	0.01	-	-	-	-	-	-	-	-	-
28.Calcium		28.8		-	-	60	29.1		45.6	29.0	22.9	32.9	21.3	32.9	28.9	-	48
29.Magnesium		8.7		7.81	-	-	8.6		-	-	-	-	-	-	-	-	-
30.Sodium		-	-	3.7	-	5.3	-	-	-	-	-	-	-	-	-	-	5.2
31.Potassium		-	-	1.0	-	1.4	-	-	4.70	0.47	1.05	0.81	0.87	0.68	0.92	-	1.3
32.Plankton		4000		1900	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: The water quality units are 1. Water temperature (°C), 2. Turbidity (NTU), 6. Coliform count (MPN / 100 ml), 18. Conductivity (µmho/cm), and 32. Plankton (N/ml). The remaining are mg/l.

Item	No.	S6		S7		S8								
	Location	Tianfu Bridge		Bailu Bridge		Near the outlet of Tianlun Power Plant						Water quality standards for bodies of water		
	Institute	The Engineering Division		The Engineering Division		The Engineering Division		Water Resources Commission		Sinotech Engineering Consultants				
	Year	1987	1987	1987	1987	1987	1987	1986	1986	1985	1986	Category A river	Category B river	Category C river
	Month/Date	5/29	7/30	5/29	7/30	5/29	7/30	1/15	8/28	11/15	2/13			
1.Water Temperature		20	20	20	20	20	19.5	14	26	15	12.5	-		
2.Turbidity		0.5	17	0.3	19	0.4	7	0.4	12	1.5	1.5	-		
3.Total alkalinity		61.2	36.0	59.6	30.0	59.4	34	-	55	67.7	70.2	-		
4.pH value		8.13	7.37	7.98	7.71	7.91	7.37	7.9	7.8	8.22	8.03	6.5~8.5	6.0~9.0	6.0~9.0
5.Hardness		74.5	53.4	58.8	72.0	78.4	-	-	70	95.1	115.4	-		
6.Coliform count		ND	ND	ND	ND	ND	ND	-	-	-	-	< 50	< 1000	< 10000
7.Dissolved oxygen		7.6	8.4	8.1	8.4	7.3	8.4	10.3	8.9	9.79	9.8	> 6.5	> 5.5	> 4.5
8.Biochemical oxygen demand		2.6	2.6	1.5	2.4	1.2	1.8	-	-	1.4	1.4	< 1	< 2	< 4
9.Chemical oxygen demand		24	12	18	11.6	18	12.0	-	-	-	2.62	-		
10.Volume of dissolved solids		100	71	99	80	100	57	128	99	138.5	129	-		
11.Volume of suspended solids		1.0	1.5	1.0	1.5	0.25	1.0	2	15	22.5	1.5	≦ 25	≦ 25	≦ 40
12.Chloride		5.0	8.3	5.0	4.2	5.0	8.3	-	ND	23.9	0.2	-		
13.Sulfate		24	16.8	20.5	25.6	20	15.0	-	21	34.7	30.1	-		
14.Free ammonia		0.10	0.68	0.14	0.41	0.13	0.25	0.32	0.34	0.12	0.12	≦ 0.1	≦ 0.3	≦ 0.3

Item	No.	S6		S7		S8								
	Location	Tianfu Bridge		Bailu Bridge		Near the outlet of Tianlun Power Plant						Water quality standards for bodies of water		
	Institute	The Engineering Division		The Engineering Division		The Engineering Division		Water Resources Commission		Sinotech Engineering Consultants				
	Year	1987	1987	1987	1987	1987	1987	1986	1986	1985	1986	Category A river	Category B river	Category C river
	Month/Date	5/29	7/30	5/29	7/30	5/29	7/30	1/15	8/28	11/15	2/13			
nitrogen														
15.Nitrate nitrogen		0.53	0.66	0.38	0.40	0.28	0.65	0.38	0.60	0.55	0.55	-		
16.Nitrite nitrogen selected		-	-	-	-	-	-	-	-	0.01	0.01	-		
17.Total phosphorus		1.74	1.92	1.60	1.75	1.63	1.75	26	28	-	-	≦ 0.01	-	-
18.Electrical conductivity		110	121	107	140	112	102	193	157	160	154	-		
19.Silver		-	-	-	-	-	-	-	-	-	-	< 0.05		
20.Manganese		0.01	0.02	0.01	0.03	-	0.03	-	ND	-	-	< 0.05		
21.Cadmium		-	-	-	-	-	-	-	-	ND	-	< 0.01		
22.Lead		-	-	-	-	-	-	-	-	ND	-	< 0.1		
23.Chromium		-	-	-	-	-	-	-	-	ND	-	< 0.05		
24.Mercury		-	-	-	-	-	-	-	-	ND	-	< 0.002		
25.Iron		0.01	0.01	0.01	0.06	-	0.03	-	0.9	-	-	-		
26.Copper		-	-	-	-	-	-	-	-	-	-	≦ 0.03		
27.Zinc		-	-	-	-	-	-	-	-	0.017	-	≦ 0.5		
28.Calcium		29.8	21.36	23.5	28.8	31.4	22.8	-	46	25.2	30	-		
29.Magnesium		-	-	-	-	-	-	-	-	7.88	9.9	-		
30.Sodium		-	-	-	-	-	-	-	5.0	-	-	-		
31.Potassium		0.58	0.97	0.70	1.45	0.61	0.76	-	1.0	-	-	-		

Item	No.	S6		S7		S8						Water quality standards for bodies of water		
	Location	Tianfu Bridge		Bailu Bridge		Near the outlet of Tianlun Power Plant								
	Institute	The Engineering Division		The Engineering Division		The Engineering Division		Water Resources Commission		Sinotech Engineering Consultants				
	Year	1987	1987	1987	1987	1987	1987	1986	1986	1985	1986	Category A river	Category B river	Category C river
	Month/Date	5/29	7/30	5/29	7/30	5/29	7/30	1/15	8/28	11/15	2/13			
32.Plankton		-	-	-	-	-	-	-	-	-	-	-		

Note: The water quality units are 1. Water temperature (°C), 2. Turbidity (NTU), 6. Coliform count (MPN / 100 ml), 18. Conductivity (µmho/cm), and 32. Plankton (N/ml). The remaining are mg/l.

According to the recent water quality tests conducted by the Taichung County Department of Health on the groundwater wells used as drinking water sources at six schools in Xinshe Township (see Figure 15), the test results (see Table 6) show that, except for the higher coliform counts, all other parameters meet the Taiwan Water Corporation's water quality standards.

Table 6 Groundwater Well Water Quality Testing Results Near the Project Area

Sampling location and number	Testing date	Turbidity (JTU)	pH value	Chloride (mg/l)	Free ammonia nitrogen (mg/l)	Nitrite nitrogen (mg/l)	Total hardness (mg/l)	Volume of dissolved solids (mg/l)	Coliform density (MPN/100ml)
①Kunshan Elementary School	1986/12/23	1	6.2	20	0.1	0	48	100	240
	1987/2/23	1	6.2	14	0	0	92	110	>240
②Xinshe Elementary School	1986/12/23	1	6.2	10	0.1	0.001	56	90	>240
③Xinshe Junior High School	1986/12/30	1	6.2	8	0	0	64	90	35
④Danan Elementary School	1986/12/23	1	6.2	12	0.2	0	52	90	0
⑤Dongxing Elementary School	1987/3/4	1	6.2	8	0	0	64	80	0
⑥Dalin Elementary School	1987/1/12	1	7.4	8	0	0	144	160	>240
Taiwan Region Tap Water Quality Standards [2]		5	6.0~9.0	300	Traces	None	-	1,000	10.0

Note [1]: The source of the data is the Taichung County Government Department of Health.
[2]: Amended by Fu-Wei-2-Zi No. 101386 dated October 16 (1967).

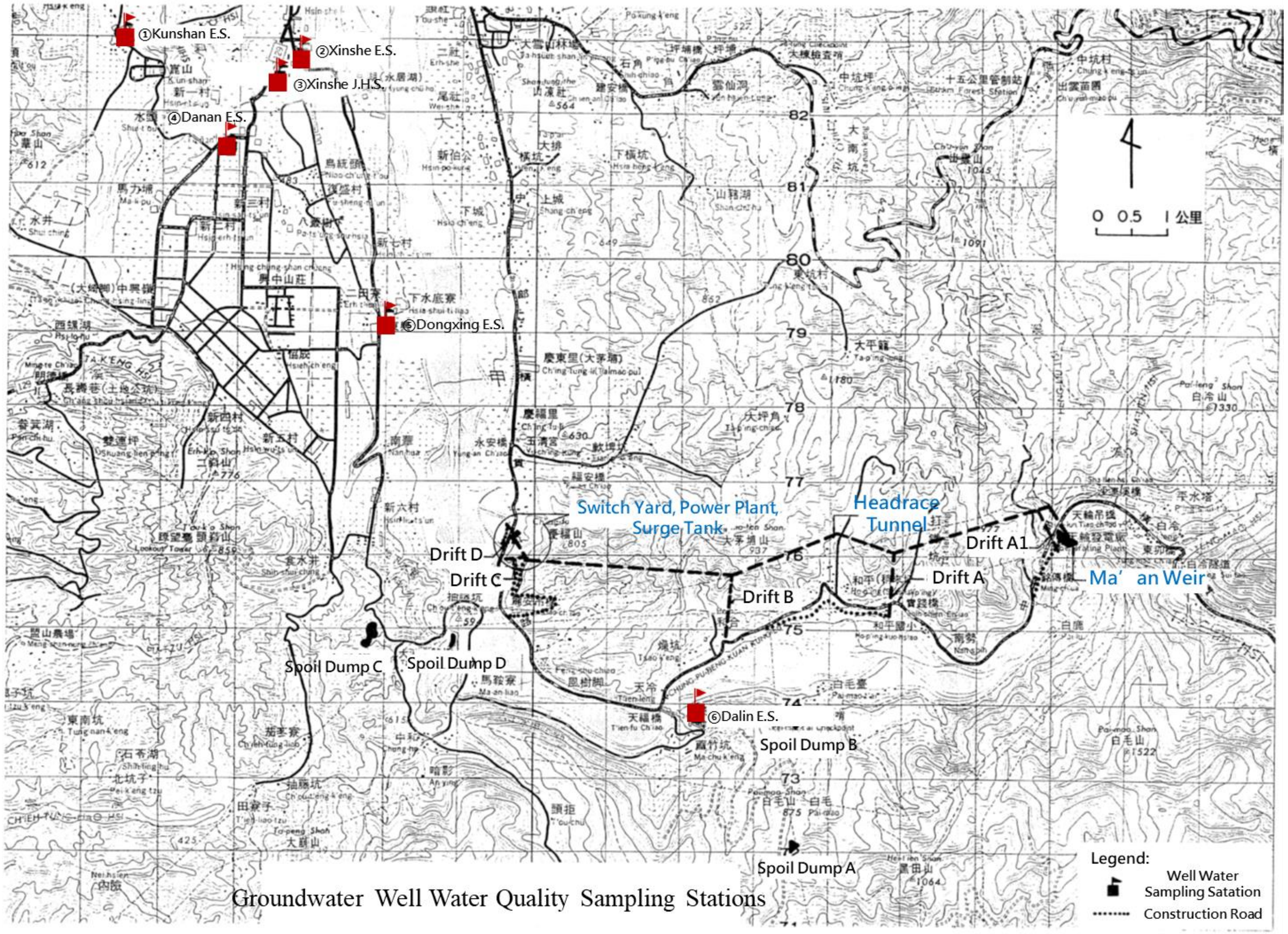


Figure 15 Distribution of Groundwater Well Water Quality Sampling Stations Near the Project Area

B-1-5. Noise and vibration

The project area is a sparsely populated rural region with a quiet environment and is classified as a Category 2 noise control zone. The most significant noise source is traffic noise from the Central Cross-Island Highway. According to the on-site background noise measurements taken in May and July (see Figure 16), the general area's noise levels were only about 3 dBA higher than the standards for a Category 2 noise control zone during various periods. However, both daytime and nighttime noise levels met the standards. In roadside areas, the average noise levels during various periods, as well as both daytime and nighttime noise levels, were significantly higher than the standards for a category 2 noise control zone, with morning and evening noise levels exceeding the standard by up to 12 dBA (see Table **7**).

The project area has no significant sources of fixed vibrations, and the road surface vibrations caused by vehicles passing on the Central Cross-Island Highway are limited. According to the vertical and horizontal vibration levels detected by the Engineering Division at the roadside, the vibration is only significant when large overloaded trucks pass by, and the vertical level can reach more than 70 dB. When small cars pass by, the vertical level is usually below 50 dB, and the horizontal vibration level is usually below 30 dB.

B-1-6. Solid waste

Because the project area is a remote mountainous area with scattered settlements, the amount of domestic waste is limited, mainly food waste. Residents dump most of it in nearby valley depressions, bury it, or burn it, and there are no garbage trucks to remove and dispose of it. Currently, large amounts of garbage have been dumped into the Dajia River Valley in Shigang Township and Xinshe Township, significantly affecting riverbank safety and river water quality. Relevant authorities should address this issue with urgency.

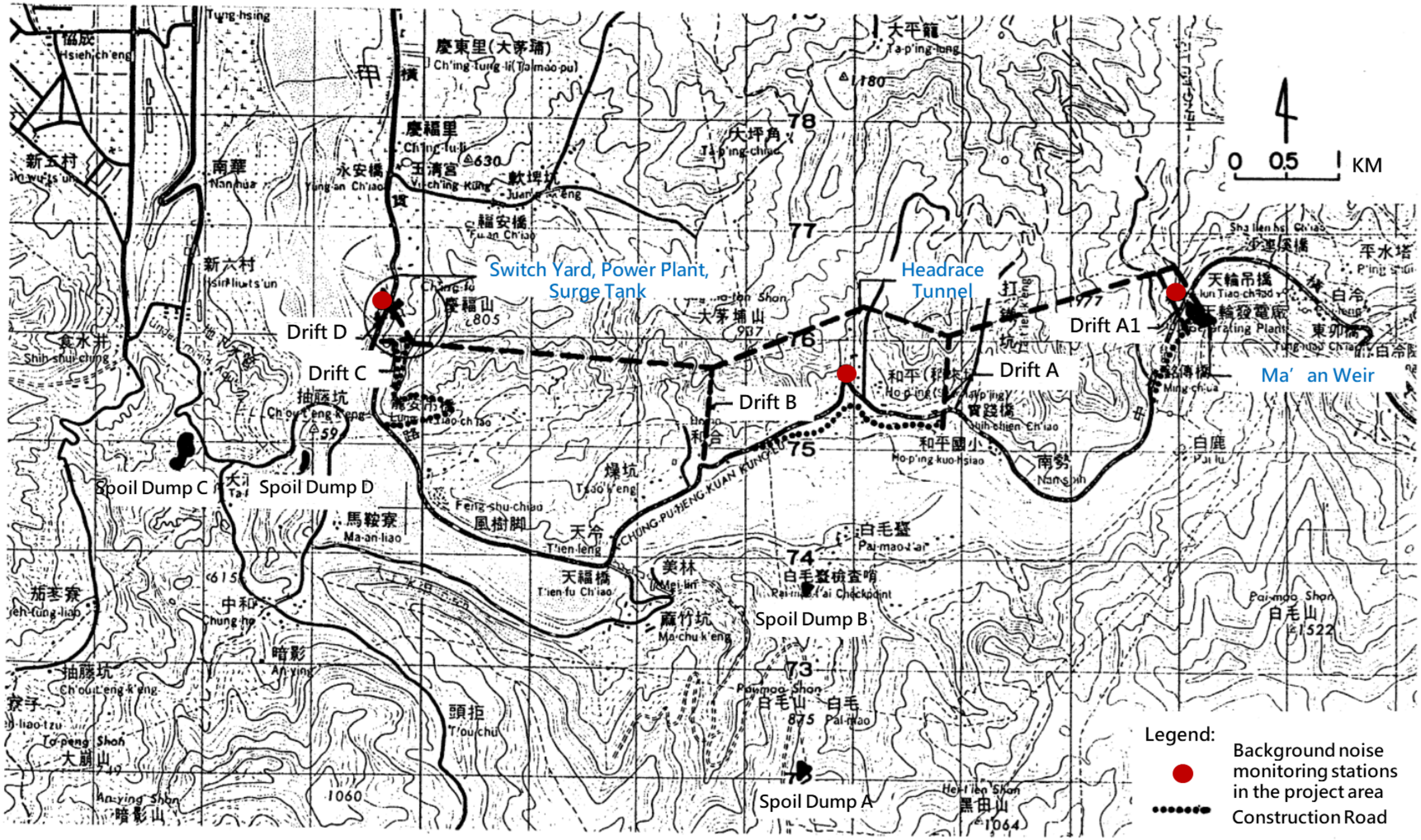


Figure 16 Distribution of Background Noise Monitoring Stations in the Project Area

Table 7 Survey and Analysis of Background Noise in the Project Area

Noise level (dBA)		Survey location and time: General areas — Hillside residences near Bailu Bridge (Tuesday to Wednesday, 7/28/1987 to 7/29/1987)	General areas — Ma'an Project Power Plant Site (Monday to Tuesday, 7/27/1987 to 7/28/1987)	Roadside areas — Heping Township Public Health Center (Friday to Saturday, 5/29/1987 to 5/30/1987)	Roadside areas — Heping Township Public Health Center (Saturday to Sunday, 7/25/1987 to 7/26/1987)	Roadside areas — Tianleng (Wednesday to Thursday, 5/27/1987 to 5/28/1987)	Ambient Noise Quality Standards of the Republic of China[1]: Type 2 General areas	Ambient Noise Quality Standards of the Republic of China[1]: Type 2 Roadside areas [2]
Equivalent energy sound level during each period [3]	Morning and evening	56	58	71	64	72	55	60
	Daytime	59	62	70	65	71	60	65
	Nighttime	55	53	61	62	61	50	55
Volume during the day and night [4]		56.5	60.3	71.4	61.5	72.3	60.5	65.5
Percentage volume [5]	L5	62.3	67.5	72.9	73.5	75.7	-	-
	L10	59.9	62.7	68.4	70.3	71.5	-	-
	L50	54.5	55.1	52.9	54.3	55.1	-	-
	L90	53.1	51.1	42.2	50.1	42.3	-	-
	L95	52.9	50.3	41.8	49.9	41.9	-	-

Note [1]: This standard is the ten-year target standard proposed by the former Health Administration of the Executive Yuan (draft).
[2]: It refers to the roadside areas adjacent to the two roads.
[3]: The different time periods are defined as:
Morning: Refers to 5 am to 7 am; Evening: Refers to 8 pm to 10 pm; Daytime: Refers to 7 am to 8 pm; Nighttime: Refers to 10 pm to 5 am the next day
[4]: The day-night noise level is the average of the hourly equivalent noise levels for the entire day, with an additional 10 dBA added to the levels measured from 10 PM to 7 AM the following morning.

[5]: The percentage volume is defined as
L5: The time exceeding this noise level accounts for 5% of the total observation time.
L10: The time exceeding this noise level accounts for 10% of the total observation time.
L50: The time exceeding this noise level accounts for 50% of the total observation time.
L90: The time exceeding this noise level accounts for 90% of the total observation time.
L95: The time exceeding this noise level accounts for 95% of the total observation time.

B-2 Biological environment

B-2-1. Terrestrial plants

1. Vegetation on the north bank of Dajia River in the project area

The area is primarily composed of orchards, with very little remaining secondary forest and not many man-made forests.

Orchards are scattered across the hillsides and riverbeds of the Dajia River (especially on the lower river terraces around Heping and Nanshi areas). The types of fruit grown include peaches, pears, plums, persimmons, loquats, oranges, lychees, longans, bananas, guavas, wax apples, starfruits, mangoes, lemons, papayas, plums, and grapes, with peaches and pears being the most common.

Secondary forests are distributed along streams and steep slopes. They are primarily composed of pioneer tree species that thrive in sunlight. The main tree species include Trema orientalis, Broussonetia papyrifera, Macaranga tanarius, Mallotus paniculatus, Vernicia montana, and Acacia confusa. Secondary species include Rhus chinensis, Quercus variabilis, Toxicodendron succedaneum, Cinnamomum camphora, Cyclobalanopsis glauca, Morus australis, and Palaquium formosanum. Common shrubs and herbaceous plants include Arenga engleri, Mussaenda pubescens, Alpinia zerumbet, Alocasia macrorrhizos, Mikania micrantha, Duranta erecta, Fallopia multiflora, Paederia scandens, and Manihot esculenta.

Common roadside weeds include Ageratum conyzoides, Ipomoea triloba, Tribulus terrestris, Eleusine indica, Emilia sonchifolia, Sicyos angulatus, Bidens pilosa, Pueraria montana, Miscanthus floridulus, Humulus scandens, and Conyza canadensis.

Common species in man-made forests include Cunninghamia lanceolata, Vernicia fordii, Phyllostachys pubescens, Dendrocalamus latiflorus, Bambusa stenostachya, and Acacia confusa.

2. Vegetation at the Ma'an Project Power Plant site

The site is not large (36 meters x 19 meters) and is located within an orchard that cultivates peaches, pears, betel nuts, etc. Below it is the lower pool and upper pool of Tianlun rear pond. The lower pool is mostly submerged in water, with some areas not submerged covered in ground millet. A few shrubs, such as willow and Boehmeria densiflora, are scattered throughout. Other herbaceous plants growing sporadically include Monochoria vaginalis, Gypsophila paniculata, Eleocharis dulcis, Centipeda minima, Setaria viridis, Ageratum conyzoides, Bidens pilosa, Ipomoea nil, Fallopia multiflora, Dioscorea spp., Alpinia zerumbet, Asplenium nidus, Pueraria montana, Solanum lycopersicum, Portulaca oleracea, Arundinella anomala, Conyza canadensis, Rumex crispus, Hedychium coronarium, Humulus scandens, Paederia scandens, Sporobolus indicus, Murdannia nudiflora, Clematis terniflora, Polygonum hydropiper, etc.

The upper pool has a larger area of grassy ground, with numerous willows. Herbaceous plants are dominated by Centipeda minima and ground millet. Other sporadically distributed species include Gypsophila paniculata, Paspalum conjugatum, Monochoria vaginalis, Lobelia chinensis, Lindernia anagallis, Marsilea quadrifolia, Asplenium nidus, Alisma plantago-aquatica, Cardamine hirsuta, Ageratum conyzoides, Boehmeria densiflora, and Vitis flexuosa (see Figure 17).

3. Vegetation near the water inlet of the Ma'an Project

The riverbed near the intake has some grassy areas, predominantly covered with Saccharum spontaneum. Other common species include Crotalaria juncea, Persicaria lapathifolia, Pueraria montana, Boehmeria densiflora, Miscanthus floridulus, and Conyza canadensis. Other sporadically appearing species include Eupatorium formosanum, Sonchus oleraceus, Bidens pilosa, Paederia scandens, and Leucaena leucocephala.

Along the riverbanks and nearby slopes, there are some trees and herbaceous plants such as Rhus chinensis, Toxicodendron succedaneum, Alnus formosana, Celtis sinensis, Trema orientalis, Gordonia axillaris, Morus australis, Ficus virgata, Broussonetia papyrifera, Macaranga tanarius, Melia azedarach, Acer serrulatum, Hibiscus taiwanensis, Pistacia chinensis, Mallotus japonicus, Pinus taiwanensis, Clerodendrum cyrtophyllum, Amaranthus spinosus, Polygonum chinense, Sterculia nobilis, Celosia argentea, Bidens pilosa, Fallopia multiflora, Rubus rosifolius, Ricinus communis, Portulaca oleracea, Cuscuta australis, Vitis flexuosa, Strobilanthes cusia, Solanum nigrum, Ageratum conyzoides, Alternanthera sessilis, Coreopsis lanceolata, Eulalia quadrinervis, Eleusine indica, Bidens alba, Centella asiatica, Digitaria radicosa, Alpinia zerumbet, Lygodium japonicum, Asplenium nidus, Miscanthus sinensis, and Davallia mariesii.

There are also orchards near the inlet, primarily for growing plum trees, followed by loquats and persimmons. Pears, longan, carambola, guava, and green bamboo are planted sporadically.

4. Vegetation at the planned waste dump site

The planned waste dump sites A, B, C, and D are all located in orchards. These areas are primarily planted with citrus trees. Other fruit trees grown in smaller quantities or sporadically include peaches, bananas, persimmons, longans, papayas, lychees, and grapes. Along the edges of the orchards, there are a few naturally occurring or planted tree species, such as eucalyptus, Fujian cypress, Trema orientalis, Broussonetia papyrifera, tung tree, green bamboo, Gordonia axillaris, Machilus thunbergii, mulberry, willow, Phyllostachys makinoi, and tetrapanax.

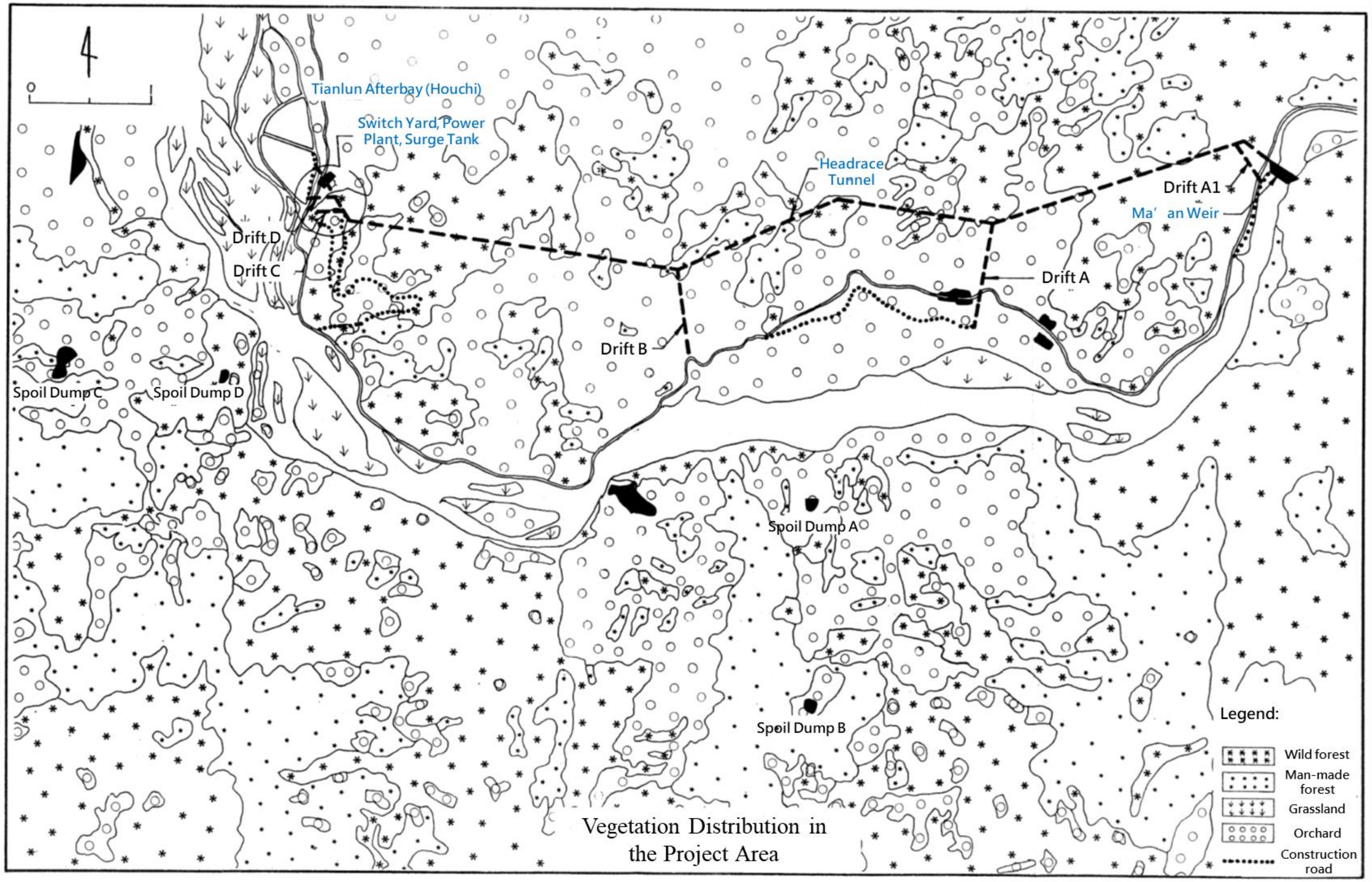


Figure 17 Vegetation Distribution in the Project Area

B-2-2. Terrestrial animals

In addition to reviewing literature and interviewing local residents, between July and November 1987, observations and recordings were made of terrestrial animal species and their numbers in the project area and at the planned waste dump sites. These observations were conducted at an average speed of approximately 2 kilometers per hour and included mammals, birds, reptiles, butterflies, and amphibians. It was found that birds and butterflies were the most abundant onshore animals in the project area (see Annex IV: Survey Results of Animal in Project Area).

1. Mammals

Due to the long-term cultivation of the project area, only small and medium-sized mammals are found. Besides the more abundant small mammals, including the Ryukyu mouse, red-bellied tree squirrel, red giant flying squirrel, spiny rat, and black rat, the only medium-sized mammal observed is the Taiwan macaque (an endemic species to Taiwan). This indicates that the area's mammalian wildlife is quite scarce.

2. Birds

A total of 63 bird species were discovered during the on-site survey. Among these, the Eurasian wryneck is a migratory bird passing through during spring and autumn. The white wagtail, yellow wagtail, grey wagtail, olive-backed pipit, Daurian redstart, dusky warbler, yellow-browed warbler, Arctic warbler, and black-faced bunting appear during the winter. The remaining are resident birds. Only the Taiwan whistling thrush is an endemic species. The rare species include the crested serpent eagle, thick-billed green pigeon, yellow-browed warbler, and collared scops owl. The most numerous and commonly seen species include the Eurasian tree sparrow, Japanese white-eye, Chinese hwamei, house swift, red-billed starling, black bulbul, and light-vented bulbul.

Bird species that rely on the river for their habitat include the house swift, little egret, plumbeous water redstart, night heron, Taiwan whistling thrush, blue rock thrush, striated heron, common sandpiper, brown dipper, yellow wagtail, grey wagtail, and white wagtail, totaling 12 species.

Regarding bird distribution, 53 species were observed between Bailu and Choutengkeng, 37 species at the waste dump sites, and 35 species at the Ma'an Project Power Plant site.

3. Butterflies

During the on-site survey, 90 species were found, among which the red-striped swallowtail butterfly and the giant wavy butterfly are endemic to Taiwan. However, according to years of survey data by Yao-Song Lin and Wei-Shou Chen, there are 158 species of butterflies in the Guguan area, accounting for over 40% of the butterfly species in the entire province. Thus, the region is rich in butterfly diversity.

Each on-site survey in the project area consistently reveals more than 50 species of butterflies, particularly between Bailu and Tianlun and near the Tianlun Power Plant. The butterfly resources in these areas are exceptionally abundant and hold significant value for tourism and education.

Regarding butterfly distribution, 71 species were observed between Bailu and Choutengkeng, 65 species at the waste dump sites, and the fewest at the Ma'an Project power plant site, with only 48 species discovered.

4. Reptiles

There are 11 species of snakes, which include the Taiwan habu, Indo-Chinese rat snake, green tree viper, bamboo pit viper, Chinese cobra, Taiwan pit viper, red-banded snake, water snake, king rat snake, greater green snake, and Taiwan beauty snake. There are 5 species of lizards, which include the elegant skink, gecko, Kikuzato's brook skink, Taiwan grass lizard, and Chinese skink.

The number of snakes has been reduced, and only three species were found, including the small green snake, red bamboo snake, and water snake. Among the lizards, the elegant skink is the most common, and geckos often appear near homes.

5. Amphibians

A total of 8 species were found, including the Pangu toad, brown tree frog, small tree frog, zebra frog, Swinhoe's frog, ventral spotted frog, Ladouchi's frog, and Ehrlich's tree frog. Among them, the brown tree frog is endemic to Taiwan. The more commonly seen species are the Pangu toad, Latouch's frog, and rice field frog. Those that are more dependent on the river include the brown tree frog and Swinhoe's frog.

B-2-3. Aquatic plants

In the Dajia River section between the Tianlun Power Plant and Tianlun rear pond, at locations such as the Baileng Suspension Bridge, Bailu Suspension Bridge, Tianfu Bridge, Long'an Bridge, and near the Ma'an Project power plant, water samples were collected using a 55μm plankton net. The samples were then fixed with Lugol’s solution, dehydrated with glycerin, stained with fast green, and diatoms were treated with acid. The 500 cells of the samples were then observed under a microscope. The species were identified, and their frequency was calculated.

The algal composition of the samples from the five sampling points was quite similar, with dinoflagellates being the dominant group. The sample from the Baileng Suspension Bridge had the highest concentration. Other common algae included Fragilaria, Achnanthes, Cymbella, Ceratium, diatoms, and Nitzschia (see Annex III: Survey Results of Phytoplankton in Project Area).

Based on the types and frequency of algae observed, although there were some mesotrophic algae present, such as Cymbella affinis, Synedra ulna, Navicula cryptocephala, and Navicula viridula, their numbers were very low. Overall, the water quality of the entire water body remains oligotrophic.

B-2-4. Aquatic animals

In the Dajia River section between the Tianlun Power Plant and Tianlun rear pond, fish were collected using electrofishing, and aquatic insects were collected by hand. The results are as follows (see Appendix 4):

1. Fish

According to the fish survey and research conducted by Jian-Ping Zhan from 1983 to September 1987 in the Dajia River Basin, a total of 34 fish species were found in the section of river from Dongshi to Guguan. The species include the Taiwan shovel-jaw carp, Taiwan torrent carp, Puli torrent carp, pale chub, Japanese eel, silver carp, bighead carp, common carp, crucian carp, Chinese perch, grass carp, mud carp, Taiwan gudgeon, Taiwan minnow, bitterling, flowerhorn cichlid, thickhead bleak, barbel chub, weather loach, cobitid loach, Chinese minnow, catfish, bagre, oriental weatherfish, Taiwan yellowfin goby, medaka, Chinese snakehead, Nile tilapia, Taiwan marbled goby, Rhinogobius spp., margined goby, sleeper goby, shortsnout loach, and barcheek goby. Among them, Taiwan torrent carp, Taiwan gudgeon, thickhead bleak, Taiwan shovel-jaw carp, Puli torrent carp, Taiwan yellowfin goby, and shortsnout loach are seven species endemic to Taiwan. Rhinogobius SP is a newly discovered species.

However, during the on-site survey conducted from July to November 1987, only eight fish species were found, including the Taiwan gudgeon, thickhead bleak, Taiwan shovel-jaw carp, Taiwan torrent carp, Taiwan yellowfin goby, Taiwan marbled goby, Rhinogobius spp., and grass carp. Among them, the first six species are endemic to Taiwan, while the Taiwan gudgeon, thickhead bleak, and Rhinogobius spp. are the dominant species.

According to local residents, this river segment used to have a considerable number of migratory species such as sweetfish, bass, and mitten crabs. However, since the construction of the Shigang Dam, these species have been unable to migrate upstream due to the dam's obstruction and have not been seen for a long time.

2. Aquatic insects

A total of 3 orders and 7 families were identified, including Perlidae, Leptoceridae, Limnephilidae, Heptageniidae, Baetidae, Caenidae, and Ephemeridae. Due to the large volume and rapid flow of water in the surveyed river section, the number of aquatic insects collected is not significant.

B-3 Socioeconomic environment

B-3-1. Community structure

The project is located in the downstream section of the Dajia River, between the Tianlun Power Plant and the Tianlun rear pond. The villages mainly affected during the construction and completion periods are Qingfu Village in Dongshi Town, Taichung County, Nanshi Village and Tianlun Village in Heping Township, and Fuxing Village and Zhonghe Village in Xinshe Township (refer to Figure 5). Among them, Heping Township is in a mountainous area. The population, ethnicity, and religious beliefs of the five villages are described as follows (see Table **8**):

1. Population density and growth rate

According to the 1986 population data from the household registration offices of Dongshi Town, Heping Township, and Xinshe Township, Qingfu Village has the highest population among the five villages, with 2,115 people, while Tianlun Village has the lowest population, with only 677 people. The population density is the highest in Qingfu Village, with 102 people/square kilometer. Tianlun Village has the lowest population density, with 23 people/square kilometer. The five villages have low population densities compared to the average of 566 people per square kilometer in Taichung County.

The average annual population growth rate in these five villages has been negative over the past decade (from 1996 to 1986). The negative growth rates are highest in Tianlun Village, Zhonghe Village, and Nanshi Village, reaching -3.64%, -2.67%, and -2.6%, respectively. Compared to Taiwan's population growth rate of 1.69%, the severe outward migration of people is evident. This is a common phenomenon in mountainous villages in Taiwan. On one hand, due to restrictions from mountainous area regulations, there are fewer migrants from other areas. On the other hand, limited employment and educational opportunities in mountainous areas lead to many young people seeking jobs or education in flatland towns or cities. As a result, there is an increasing number of cases of household registration of children being moved out of these areas, contributing to the phenomenon of negative population growth that remains unaddressed.

2. Population structure

In terms of age structure, by the end of 1986, the proportion of the economic population aged 15 to 64 in each village ranged from 67.1% to 78.9%. Tianlun Village had the highest proportion of the economic population.

In terms of gender ratio (male/female × 100), all five villages had a higher male population, with Nanshi Village and Tianlun Village having the highest gender ratios of 127 and 124, respectively. This indicates a more significant outflow of females from mountainous villages compared to flatland villages.

3. Racial composition

Both Dongshi Town and Xinshe Township are major settlements of Hakka people in Taiwan, with early residents originating from Fujian and Guangdong provinces. The Hakka population in Qingfu Village accounts for about 75% of the population, while the current residents of Fuxing Village and Zhonghe Village are mostly of Hakka descent, with a small minority of residents from other provinces and Minnan descent.

Heping Township is a mountainous township, and most of the residents are Atayal. By the end of 1986, 1,775 mountain-born residents lived in Nanshi Village, accounting for approximately 87% of the village's population. There were only 8 mountain-born residents in Tianlun Village, constituting just 1% of the village's population.

4. Religious beliefs

The residents of the five villages are mainly of Hakka and Minnan descent, with their beliefs predominantly centered around folk religions. Mountain-born residents often practice Christianity.

Table 8 Population Composition of the Five Villages in the Project Area in 1986

Village		Total population (persons)	Population density (persons/square kilometers)	Economic population composition (%)		Gender ratio (male/female x 100)	Average annual population [2] growth rate in the past ten years (%)	
				Economic population	Non-economic population			
Dongshi Township	Qingfu Village	2,115	102	68.1	31.9	115	-0.74	(0.05) [3]
Heping Township	Nanshi Village	2,026	35	75.2	24.8	127	-2.60	(1.24)
	Tianlun Village	677	23	78.9	21.1	124	-3.64	
Xinshe Township	Fuxing Village	2,072	96	67.1	32.9	115	-1.97	(0.24)
	Zhonghe Village	944	96	70.8	29.2	121	-2.67	

Note [1]: The data was obtained from the Dongshi Town, Heping Township, and Xinshe Township Household Registration Offices.
[2]: The past ten years refer to 1976 to 1986.
[3]: The number in the brackets ( ) is the average annual growth rate of the township to which the village belongs.

B-3-2. Industrial economic activities

The hills and Dajia River valley along the Central Cross-Island Highway in Dongshi Township, Heping Township, and Xinshe Township are the main fruit-producing areas in Taiwan. The economic activities in these areas are primarily focused on agriculture, with limited development in industry and commerce.

1. Industrial population

The majority of the population of these five villages is primarily engaged in primary industries (agriculture, forestry, fishing, animal husbandry, and hunting), ranging from 51.9% to 80.0% of the total population. Except for Zhonghe Village, the populations of the other four villages engaged in tertiary industries (commerce, transportation, warehousing and communications, finance, real estate, and business services) are higher than those engaged in secondary industries (mining and quarrying, manufacturing, utilities, construction) (refer to Table 9).

Table 9 Industrial Population Structure of the Five Villages in the Project area in 1986

<table>
<tr><th colspan="2" rowspan="2">Village</th><th colspan="2">Primary industries</th><th colspan="2">Secondary industries</th><th colspan="2">Tertiary industries</th></tr>
<tr><th>Population</th><th>Percentage (%)</th><th>Population</th><th>Percentage (%)</th><th>Population</th><th>Percentage (%)</th></tr>
<tr><td>Dongshi Township</td><td>Qingfu Village</td><td>1,128</td><td>80.0</td><td>101</td><td>7.2</td><td>181</td><td>12.8</td></tr>
<tr><td rowspan="2">Heping Township</td><td>Nanshi Village</td><td>952</td><td>71.4</td><td>77</td><td>5.8</td><td>304</td><td>22.8</td></tr>
<tr><td>Tianlun Village</td><td>177</td><td>51.9</td><td>72</td><td>21.1</td><td>92</td><td>27.0</td></tr>
<tr><td rowspan="2">Xinshe Township</td><td>Fuxing Village</td><td>728</td><td>62.8</td><td>209</td><td>18.0</td><td>223</td><td>19.2</td></tr>
<tr><td>Zhonghe Village</td><td>426</td><td>70.5</td><td>105</td><td>17.4</td><td>73</td><td>12.1</td></tr>
</table>

Source: Provided by the Dongshi Town, Heping Township, and Xinshe Township Household Registration

Offices.

2. Agriculture

Agriculture in the area mainly involves fruit tree planting, with few rice fields. There are dozens of types of fruit trees, among which citrus, grape, loquat, pear, orange, peach, plum, and persimmon account for the largest planting areas. Various types of fruit trees are mostly cultivated through cooperative farming.

In recent years, due to the introduction of new technologies, grapes can be harvested two to three times a year, and loquats and pears can also be harvested two times a year. Recent agricultural statistics from Dongshi Township and Xinshe Township show yearly increases in the number of fruit trees planted, the planting area, and the harvest volume. However, due to the influx of imported fruits, the prices of locally produced fruits have generally declined, significantly impacting the income of fruit farmers.

3. Industrial and commercial sector

Due to the hilly terrain, the project area has small-scale settlements and underdeveloped industry and commerce. The main commercial activities consist of scattered eateries and grocery stores along the Central Cross-Island Highway, serving local residents and passing travelers.

B-3-3. Road traffic

1. Connecting roads

The main connecting road in the project area is the Central Cross-Island Highway (Provincial Highway No. 8), starting from Dongshi in the west and passing through Damaopu, Tianlun, Bailu, Guguan, Dajian, Lishan, Dayuling, Tianxiang, and ending at Taroko. It connects to Provincial Highway No. 3 in the west, which leads through Shigang and Fengyuan to Taichung; and to Provincial Highway No. 9 in the east, which goes to Hualien and Yilan. Near Tianlun, it connects south via the Tianfu Bridge to Provincial Highway No. 21, which is under construction, with bus services already available to Puli (see Figure 2-14). The Central Cross-Island Highway is designed as a two-lane road according to the standards for Class 4 mountain roads. The average road width between Dongshi and Guguan is about 7.5 meters. The general road conditions are good, although falling rocks and minor landslides occasionally occur during typhoons and heavy rains.

Regarding travel speed, the section from Dongshi to Guguan is classified as Level D service (travel speed of 35-45 kilometers per hour). Its traffic volume is 15,700 passenger car units per day, and the volume-to-capacity ratio (V/C) must not exceed 0.85.

According to the traffic volume survey conducted by the Highway Bureau in April 1987 at Nanshi, the average daily traffic flow was approximately 3,866 passenger car units, with a V/C ratio of only about 0.25, which meets the Level D service standard.

2. Industrial roads

Due to years of orchard management, the project area has an extensive network of industrial roads. These roads are generally paved and have an average width of about 2 meters. The longitudinal slopes are very steep, with a maximum slope of up to 45°.

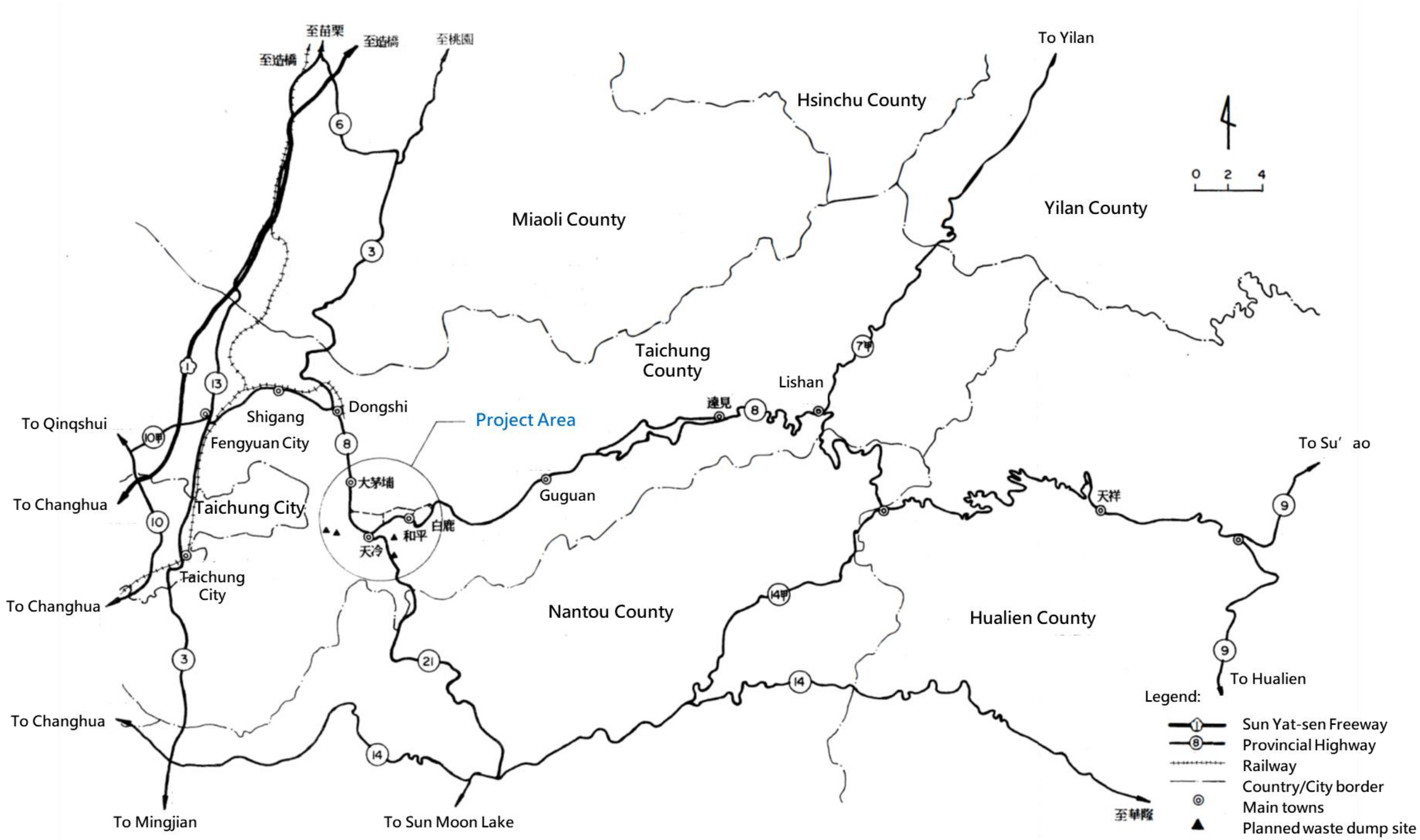


Figure 18 Connecting Road System of the Project Area

B-3-4. Use of water

1. Surface water

Water resources utilization in the Dajia River Basin includes hydropower, irrigation, and public water supply.

(1) Hydropower

From upstream to downstream, there are five hydropower plants, Deji, Qingshan, Guguan, Tianlun and Sheliao (see Figure 3 and Figure 4). Except for Deji, which is a reservoir-type power plant, and Sheliao, which is a run-of-river hydroelectric power plant, all others are regulating pond power plants. However, because they are controlled by Techi Reservoir, they are also classified as reservoir-type power plants. The total device capacity reaches 864,900 kilowatts (see Table 2).

(2) Irrigation

From upstream to downstream, the main irrigation roads include Bailengzhun, Damaopuzhun, Laozhun, Dongshibenzhun, Bitoushanzhun, Babaozhun, Huludunzhun, Neipuzhun, Wufuzhun, Gaomeizhun, Huyenyizhun, and Huyenerzhun. The total registered water rights volume varies monthly from 18.547 to 63.579 cubic meters per second, with the smallest registered water rights volume in January and the largest in August. In 1986, the actual monthly water intake ranged from approximately 12.609 to 37.243 cubic meters per second, with the lowest intake in January and the highest in March. The irrigation area covers a total of 18,649.19 hectares (see Table **10** and Figure 19).

Table 10 Information Related to Dajia River Basin Irrigation Canal Roads

Irrigation canal name	Irrigated area (hectares)	Volume of registered water rights (m3/s)	Actual water consumption in 1986 (m3/s)
Bailengzhun	792.14	2.589	0.584 (6) ~ 1.658 (10) [(3)]
Taimaopuzhun	67.67	0.120 (1) ~ 0.239 (8)	0.019 (5) ~ 0.051 (1)
Laozhun	138.58	0.262 (12) ~ 0.517 (8)	0.111 (5) ~ 0.265 (2)
Dongshi Canal	440.27	0.759 (12) ~ 1.705 (8)	0.367 (5) ~ 1.077 (3)
Pitoushanzhun	26.76	0.085 (7) ~ 0.143 (8)	0.035 (7) ~ 0.054 (2)
Babaozhun	2,102.46	0.635 (1) ~ 1.362 (3)	1.871 (12) ~ 4.582 (3)
Huludunzhun [(2)]	9,521.98	8.914 (12) ~ 33.860 (8)	5.133 (1) ~ 18.336 (3)
Neipuzhun	695.79	1.170 (12) ~ 3.132 (7)	0.186 (1) ~ 2.193 (7)
Wufuzhun	2,544.27	1.975 (1) ~ 10.519 (7)	1.401 (12) ~ 5.181 (3)
Gaomeizhun	873.00	0.615 (1) ~ 4.711 (8)	0.630 (12) ~ 2.327 (7)
Huyenyizhun	714 00	0.503 (1) ~ 3.461 (7)	0.208 (12) ~ 1.773 (8)
Huyenerzhun	732 00	0.495 (1) ~ 3.333 (7)	0.183 (12) ~ 1.665 (9)
Total	18,649.19	18.547 (1) ~ 63.597 (8)	12.609 (1) ~ 37.243 (3)

Note [1]: Source: Provided by Taichung Irrigation Association.

[2]: The registered water rights volume only includes the water rights volume upstream of the Shigang Dam. The water rights volume downstream of the Shigang Dam is included with Huludunzhun.

[3]: The numbers in parentheses () indicate the months with the lowest and highest registered water rights volume and actual water intake.

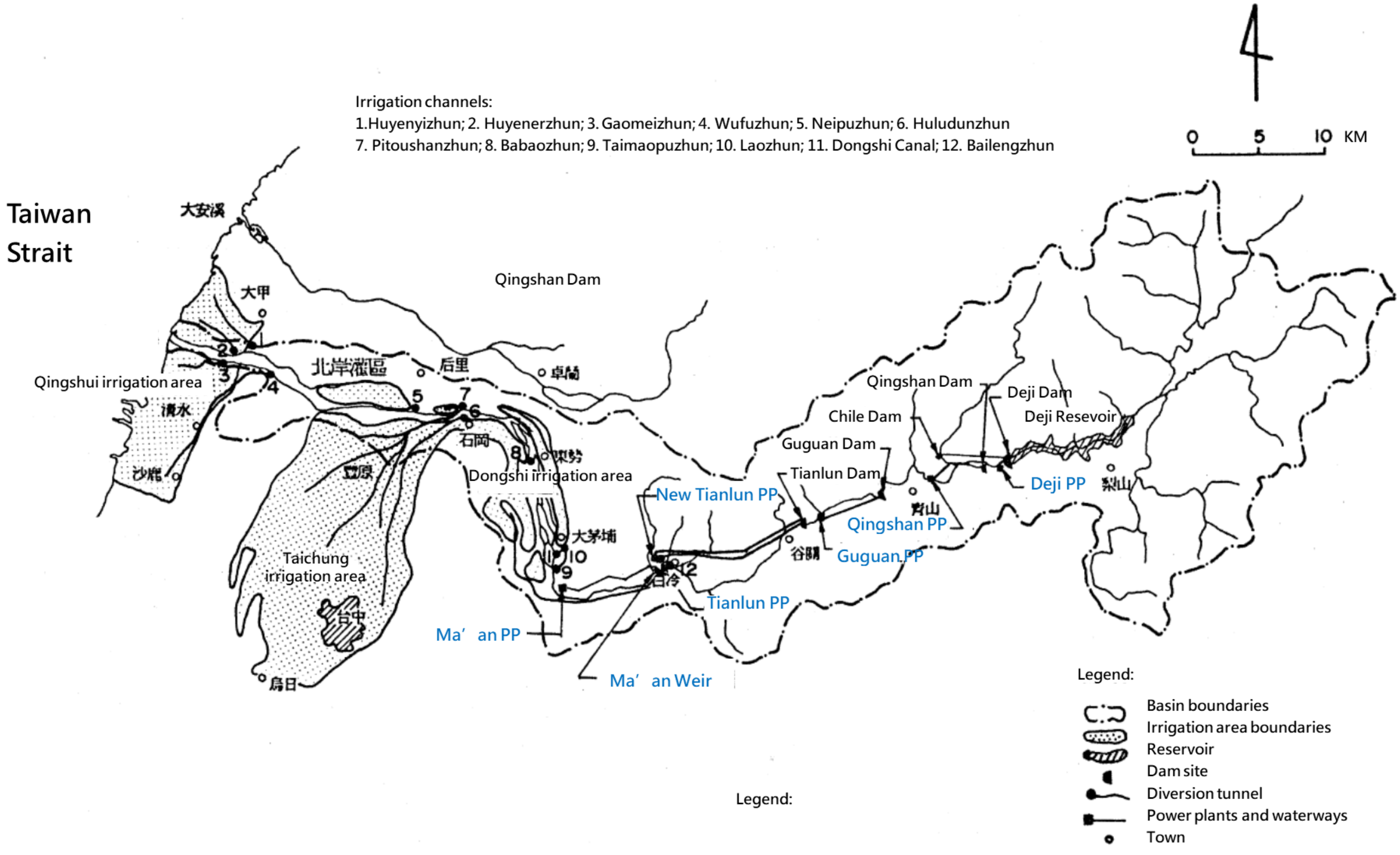


Figure 19 Dajia River Basin Irrigation Roads and Irrigation Area Distribution

(3) Public water supply

The primary public water supply source in the Dajia River Basin is the Shigang Dam. Due to severe sedimentation, the effective capacity of the reservoir once decreased to 170 million cubic meters. However, with continuous dredging efforts by the Shigang Dam Management Committee, the rate of sedimentation has now stabilized. Currently, the dam can provide approximately 420,000 metric tons of public water daily to downstream areas (see Figure 2-16), serving a population of 1.5 million people.

In the remote villages of the upstream basin, simple tap water systems have been established. These systems primarily source water from mountain streams of the Dajia River's tributaries and supplement it with groundwater from wide-mouth wells. Currently, the simple tap water systems in Nanshi, Qingfu, and Fuxing provide approximately 930 metric tons of water for daily use for the main communities.

2. Groundwater

The utilization of groundwater resources in the Dajia River Basin includes the development of hot springs in the upstream Guguan Scenic Recreational Area and the development of wells for agricultural, industrial, and public water supply in the midstream and downstream areas.

The hot springs in the Guguan area have been developed and utilized since the Japanese occupation period. They have abundant water and good quality, providing a year-round supply for the recreational area.

In the midstream area, there is one wide-mouth well each in Nanshi, Qingfu Village, and Fuxing Village, serving as supplementary sources for the local simple tap water systems.

In the downstream Dajia River Plain and the northern part of the Taichung Basin, which are major groundwater reservoirs, thousands of groundwater wells have been drilled, with an annual extraction volume exceeding 200 million cubic meters.

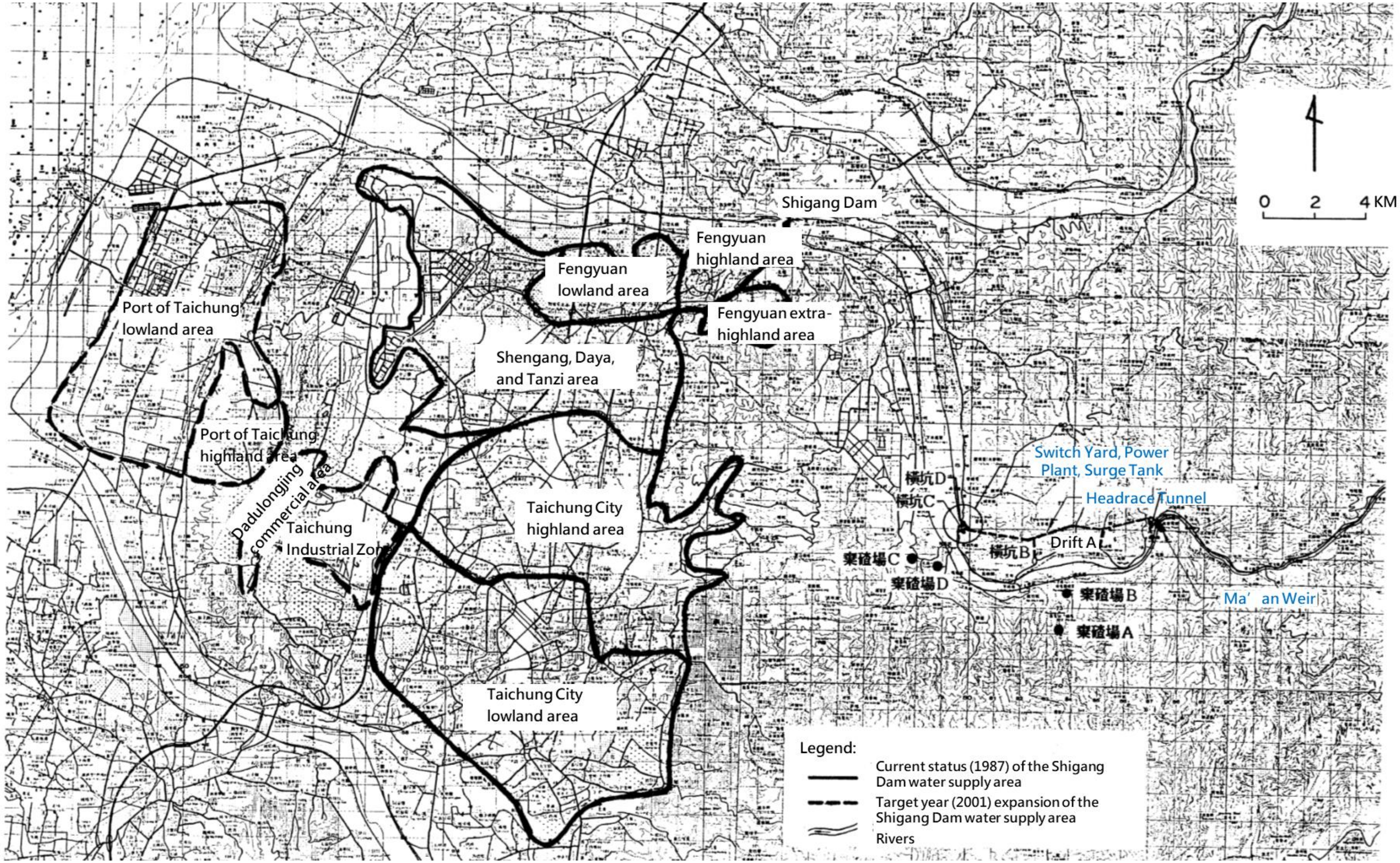


Figure 20 Scope of the Shigang Dam Public Water Supply

B-3-5. Related facilities or projects

1. Public facilities

Since the project area is outside the scope of urban planning, settlements are scattered, and the level of public facilities is much lower than in areas with urban planning, the general public facilities in the five villages are summarized as follows:

(1) Education facilities

Qingfu Village: None

Nanshi Village: Heping Junior High School, Heping Elementary School

Tianlun Village: Baileng Elementary School, Fumin Elementary School

Fuxing Village: Dalin Elementary School

Zhonghe Village: Zhonghe Elementary School

(2) Public health facilities

Medical facilities in the project area are extremely lacking, and public medical institutions only consist of clinics and public health centers. The Heping Township Public Health Center is located in Nanshi Village, with medical staff stationed there to provide treatment. It is the main place where local residents seek medical treatment. In addition, Tianlun Village, Fuxing Village, and Zhonghe Village each have one clinic, which are only able to provide simple medical treatment. There are many private clinics in Dongshi Town, with relatively comprehensive medical standards and equipment.

(3) Communication facilities

There is a post office in Nanshi Village, which is the only place providing communication services in the project area. The use of telephones is very common, and telephones are installed in most households.

(4) Refueling facilities

There is a gas station next to the Central Cross-Island Highway in Nanshi Village.

(5) Power facilities

Electricity is supplied to the five villages.

(6) Water supply facilities

In Qingfu Village, Nanshi Village, and Fuxing Village, where populations are more concentrated. Residents' drinking water is supplied by local simple tap water systems. Tianlun Village and Zhonghe Village do not have tap water supply systems. Instead, several households or dozens of households collectively divert mountain stream water or extract underground water for use.

The simple tap water source in Qingfu Village is located beside the Ruanpikeng Creek, where groundwater is extracted using a wide-mouth well. The water is disinfected with a bleach solution and pumped to a distribution reservoir on the hilltop, from which it is supplied by gravity. The Qingfu Simple Tap Water Management Committee is responsible for operations and charges fees based on meter readings. The water supply area includes Ruanpikeng, Shangduan, and Xiaobanzhuang, currently serving about 750 people with a supply of approximately 250 cubic meters per day.

The simple tap water source for Nanshi Village is located near Hengliu River, with two weirs and one wide-mouth well. The water sources are mountain stream water and groundwater, which are filtered and disinfected before being supplied by gravity to Nanshi and Shaolaiping. The current number of people served is about 1,409 people, with a water supply of approximately 360 cubic meters per day.

The simple tap water source for Fuxing Village is located near Mazhukeng River, which uses mountain stream water and irrigation water from the Baileng Canal. The water flows due to gravity to a collection reservoir, supplying the Mazhukeng and Meilin areas of Fuxing Village. The number of people served is about 575 people, with a water supply of approximately 320 cubic meters per day.

(7) Sewage drainage facilities

The project area does not yet have facilities for collecting and treating wastewater through pipelines. Drainage is carried through roadside ditches into nearby mountain streams, which then flow into the Dajia River.

(8) Waste collection and disposal facilities

Currently, only the Nanshi Village area, where the Heping Township Office is located, has garbage trucks to collect and transport waste to be buried by the Dajia River. In other remote settlements, residents dispose of their waste by dumping, burning, or burying it themselves.

2. Related sub-projects

There are no specific development plans for the project area. However, in terms of water resource utilization, the Taiwan Water Corporation is currently planning the Fengyuan Second Water Treatment Plant project, and the Water Resources Bureau is planning the expanded development project for downstream water sources of the Dajia River.

(1) Fengyuan Second Water Treatment Plant Project

The Fengyuan Second Water Treatment Plant is located between Fengyuan City and Dongshi Township, adjacent to the Fengyuan First Water Treatment Plant. It covers an area of approximately 7.5 hectares and has a designed capacity of 600,000 cubic meters per second. The water source is the Shigang Dam, with the South Main Line serving as the water pipeline. The required water volume, aside from reallocating some irrigation water, will be supplied by the Liyutan Reservoir, which is currently under construction.

(2) Dajia River downstream water source development plan

The plan includes constructing the Ma'an Dam on the mainstream of the Dajia River and the Longbao Dam on the Toubiankeng River, a tributary of the Wu River. The goal is to divert water from the Dajia River to meet the water supply needs of the Greater Taichung and Zhangbin areas. This project involves inter-basin water transfer and has interactions with the Ma'an Hydropower Project. It is currently still in the planning and research stages.

B-4 Culturally aesthetic environment

B-4-1. Cultural heritage

1. Development history

The project area has been inhabited since approximately 3,000 years ago, during the late Neolithic Yingpu Culture period. Early inhabitants appear to have migrated from the lower reaches of the Dajia River and the Wu River, as well as the Taichung Basin, moving upstream to settle in the Xinshe Plateau and the project area. This led to the formation of sites such as Aishanping, Xinliucun, Qifen, and Babao. Before Han Chinese development, the Pazeh, a sub-group of the Plains Indigenous Peoples, already lived in the Dongshi and Xinshe Plateau areas, forming settlements such as Damaqun, Shanding, and Shuidiliao. The current indigenous Atayal Nanshi group, according to their traditions, began migrating into the area during the Qing Dynasty (about 200 years ago) from upstream regions of the Beigang River and the Zhuoshui River in present-day Nantou County (Liao Shouchen, 1984). They continued migrating during the Japanese occupation and after Taiwan's retrocession, leading to their present distribution.

Due to its proximity to mountainous areas, Han Chinese development began relatively late in the area. During the Qianlong period, although Han Chinese had entered the Dongshi area and Xiaoshuidi for cultivation, they frequently clashed with the indigenous people. To prevent these conflicts, the government surveyed and marked boundaries in the first month of the 26th year of Qianlong's reign (1761 AD) and erected a stone stele at Tuniu Village in today's Shigang with the inscription "Boundary Stele Surveyed by Government Decree," prohibiting unauthorized Han Chinese settlement (Chen

Yan-Zheng Chen and Zuo-Jiang Lin, 1987). This slightly hindered Han Chinese expansion into the inner mountains but did not entirely stop it.

Settlements such as Damaopu and Xinbaigong were developed around the 13th year of the Jiaqing period (1808 AD). At that time, the Pazeh community of Damaqun had not yet relocated. It wasn't until the 5th year of the Daoguang period (1825 AD) that they, along with nearby communities such as Shuidiliao and Shanding, moved to the Puli Basin via areas like today's Tianlun, Dalin, Shuichangliu, and Dapingding (Yao-Qi Chang, 1951). During the era when Han Chinese and Plains Indigenous Peoples successively developed the plains, the mountain-dwelling Atayal frequently clashed with the Han Chinese to defend their territory. In the 12th year of the Guangxu Emperor's reign during the late Qing Dynasty (1886), the "Central Defensive Line" at the Beigang River Camp was established. This line extended from Ma'anliao and Shuidiliao through Shuiliudong and Beigang River to Puli (Abe Akio, 1938; Wen Ji, 1957). During the Japanese occupation, although there were extensive efforts to suppress the indigenous people, the overall situation remained similar to that of the late Qing Dynasty. However, there were significant administrative changes, with the establishment of three "Administrative Areas Outside the Indigenous Boundary" in Maifuping, Jiuliangsi, and Jiayang, which were governed by Dongshi County, officially governing the mountainous regions. Most of the project area still belonged to Jiuliangqi District, but a small number of Hakka Han people entered the area to cultivate and refine camphor.

2. Historical site

Based on literature review, two archaeological field surveys, and interviews with elders, the historical sites in the project area can be categorized into three types, which include prehistoric sites, former indigenous settlements and locations of significant events, and historical sites related to Han Chinese development (see Figure 21).

(1) Prehistoric sites

① Bailu Ruins

The river terrace on the south bank of Dajia River is located 1.5 kilometers southwest of Tianlun Power Plant and east of Bailu Suspension Bridge. It is divided into the upper and lower levels. The upper level is about 600 to 650 meters above sea level, and the lower level is about 550 to 580 meters above sea level. The upper and lower river terraces are currently orchards. Prehistoric relics can be found on the plowed surface, including crafted stone hoes, stone axes, and double grooved stone net sinkers (see Figure 22).

② Babao Ruins

Located approximately 300 meters northeast of Nanshi Village in Heping Township, on the north bank of the Dajia River, is a high river terrace with an elevation of 580 to 650 meters. The area it covers is quite extensive, with the surface gently sloping upward towards the mountains. Currently, most of it is abandoned farmland, overgrown with weeds. On the slopes next to the Central Cross-Island Highway, a cultural layer 30 to 50 centimeters deep can be found starting 20 centimeters below the surface. Artifacts are widely and densely distributed. The work team collected 40 knapped stone axes and hoes, 30 pieces of waste stone flakes, 10 scrapers, 1 double grooved stone net sinker, 40 pieces of red sand-tempered pottery, and some partial artifacts within an area of 4 meters by 10 meters (see Figure 23).

③ Nanshi Ruins

Located in Nanshi Village's Nanshi settlement (community) in Heping Township and the orchard behind it, this site is on a low river terrace on the north bank of the Dajia River, with an elevation of approximately 550 to 570 meters. Numerous artifacts can be found on the cultivated surface, primarily consisting of crafted stone axes, stone hoes, and scrapers (see Figure 24).

④ Heping Ruins

Located on the north side of the Heping Branch Office and the west side of Datiekeng Creek in Nanshi Village, Heping Township, this site is on a high river terrace on the north bank of the Dajia River, with an elevation of 600 to 640 meters. The terrace where the ruins is located has been slightly cut by a small stream, forming a minor ravine, and is mainly a pear orchard. Many stone tools are scattered on the plowed ground, primarily crafted stone axes, stone hoes, and scrapers, with one ground stone axe also found.

⑤ Shaolaiping Ruins

It is located on the northern slope of the Shaolaiping settlement in Nanshi Village, Heping Township, and on the southern slope near Heping Junior High School. This site was discovered during the Japanese occupation period (Tadao

Shika, 1930). Surface surveys have found many crafted stone axes, stone hoes, and other stone tool artifacts, consistent with the records from the Japanese occupation period.

⑥ Fushan Temple Ruins

Located on the west side of the confluence of Shaolaiping River and the Dajia River in Nanshi Village, Heping Township, this site is on a low river terrace on the north bank of the Dajia River, with an elevation of 530 to 550 meters. The area is currently planted with pear trees. Numerous stone tools, generally smaller in size, have been found on the surface, primarily consisting of crafted stone axes and stone hoes.

⑦ Zaokeng Ruins

Located on the west side of the Zaokeng River in Qingfu Village, Dongshi Township, this site covers a fairly extensive area, extending approximately 300 meters west from the industrial road, with a width of about 200 meters from north to south. Prehistoric artifacts such as crafted stone axes, stone hoes, stone hammers, and scrapers have been found on the surface.

⑧ Zhuhuding Ruins

It is located approximately 500 meters west of the Tianlun settlement, above the Central Cross-Island Highway. This site is on a gentle slope on the north bank of the Dajia River. Currently, a few households reside here and cultivate fruit trees. Administratively, it belongs to Qingfu Village, Dongshi Township. Sparse stone tool artifacts such as crafted stone axes and stone hoes have been unearthed on the cultivated land.

⑨ Dalin Ruins

Located beside the Dalin settlement in Fuxing Village, Xinshe Township, this site is on a river terrace south of the Tianlun Bridge on Provincial Highway 21, at an elevation of approximately 500 to 515 meters. Currently, pear and grape trees are cultivated here. The survey discovered a significant number of prehistoric artifacts, such as crafted stone axes, stone hoes, stone hammers, and scrapers (see Figure 24), and identified the presence of a cultural layer, proving it to be a site with a long history of human presence.

⑩ Mazhukeng Ruins

Located near the confluence of Mazhukeng River and the Dajia River, near the Mazhukeng settlement in Fuxing Village, Xinshe Township, this site is on a gentle slope on the south bank of the Dajia River, at an elevation of approximately 500 to 560 meters. A large temple, "Futian Temple", is situated to the south and serves as a prominent landmark. Only a few crafted stone tools have been found, suggesting it may have been a worksite rather than a settlement.

⑪ Baimaotai Ruins

It is located on the highest terrace of the Baimoutai plateau on the south bank of the Dajia River, mainly between the Land God Temple of Baimoutai and the settlement, with a forest road running through the middle. Both sides of the road are vineyards, at an elevation of approximately 610 to 620 meters. Numerous stone tools and a cultural layer have been unearthed in the cultivated fields. According to local residents, square-shaped graves originally existed there, with shells and iron artifacts found in the tombs, although the work team did not find these during their investigation.

These 11 prehistoric sites can be broadly divided into two different systems based on artifact characteristics and comparisons with nearby sites:

- Yingpu cultural system: For example, the Babao site dates roughly between 3,500 and 2,000 years ago. This site is currently the only Yingpu Culture site discovered in the middle reaches of the Dajia River. Its content is very extensive, underscoring its undeniable importance.
- Guguan ruins system: It includes sites other than the Babao site. Although the academic community has not yet named the culture of these sites, Mr. Yi-Chang Liu referred to this type of site as the "Guguan System" (see Reference 50 for details). These sites are mainly distributed in the middle and upper reaches of the Da'an and Dajia Rivers. They possibly belong to a late local culture, but it cannot be determined at this time whether they are related to the current indigenous Atayal tribe.

(2) Former indigenous settlements and sites of important historical events

① Saurai

This was the former settlement of the Atayal Nanshi Village Shaolaiping community, referred to as Mai-Saurai by the tribe. It is located on the western mountainside of the midstream section of Datiekeng River. In the early years of the Japanese occupation, the Japanese forced the community to relocate to the mountainside above the present-day Heping Township Office. Later, in response to the 1920 Atayal Beishi group's anti-Japanese incident, the community fled again to the area north of Salianshan. After the incident, some members moved to Maifuping community (Shuangxi), while others returned to the old Shaolai settlement. Shortly afterward, the Japanese police persuaded them to surrender and relocated them to the area near the present-day Heping Township Public Health Center, still named Shaolaiping (Shou-Chen Liao, 1984).

② Migration route of the Bazhai people

The Pazeh people were the main Plains Indigenous group in the central region. During the early Qing Dynasty, under the reign of Emperor Qianlong, both civil and military achievements flourished. The Damaqun, Shanding, and Shuidiliao communities resided within today's midstream areas of the Dajia River, in the Dongshi and Xinshe regions. In the early Daoguang period, due to the unbearable oppression and land seizures by the Han Chinese, various tribes in the central region signed agreements with the Pumei people, the original inhabitants of the Puli Basin, and moved en masse to Puli. In the 5th year of Daoguang (1825 AD), the Pazeh people from Damaqun and other communities relocated to the Puli Basin via present-day Tianlun, Dalin, Shuichangliu, and Dapingding, settling in what is now Ailan Village and still calling it Damaqun. This migration was part of the northern route of the three major migration paths of the Plains Indigenous Peoples at the time, making it an important historical site for the disappearing Plains Indigenous culture.

(3) Historical sites related to the development of the Han people

① "Central Defensive Line" Beigang River Camp

This defensive line stretched from today's Ma'anliao and Shuidiliao, through Yushuixi, Beigangxi, and reached Puli, serving as a clear boundary between the Han Chinese and the indigenous Atayal people at the time. The place names such as Tougui and Ergui along the route indicate the former locations of garrison armories. This line is a historical testament to the late Qing Dynasty policy of "Opening the Mountains and Pacifying the Indigenous People", and it marks a significant site of interactions between the Han Chinese and indigenous groups.

② Han temples

The larger temples are "Futian Temple" in Fuxing Village, Xinshe Township, and "Fushan Temple" in Nanshi Village, Heping Township. Both were constructed or renovated in recent years and do not hold value as historical sites.

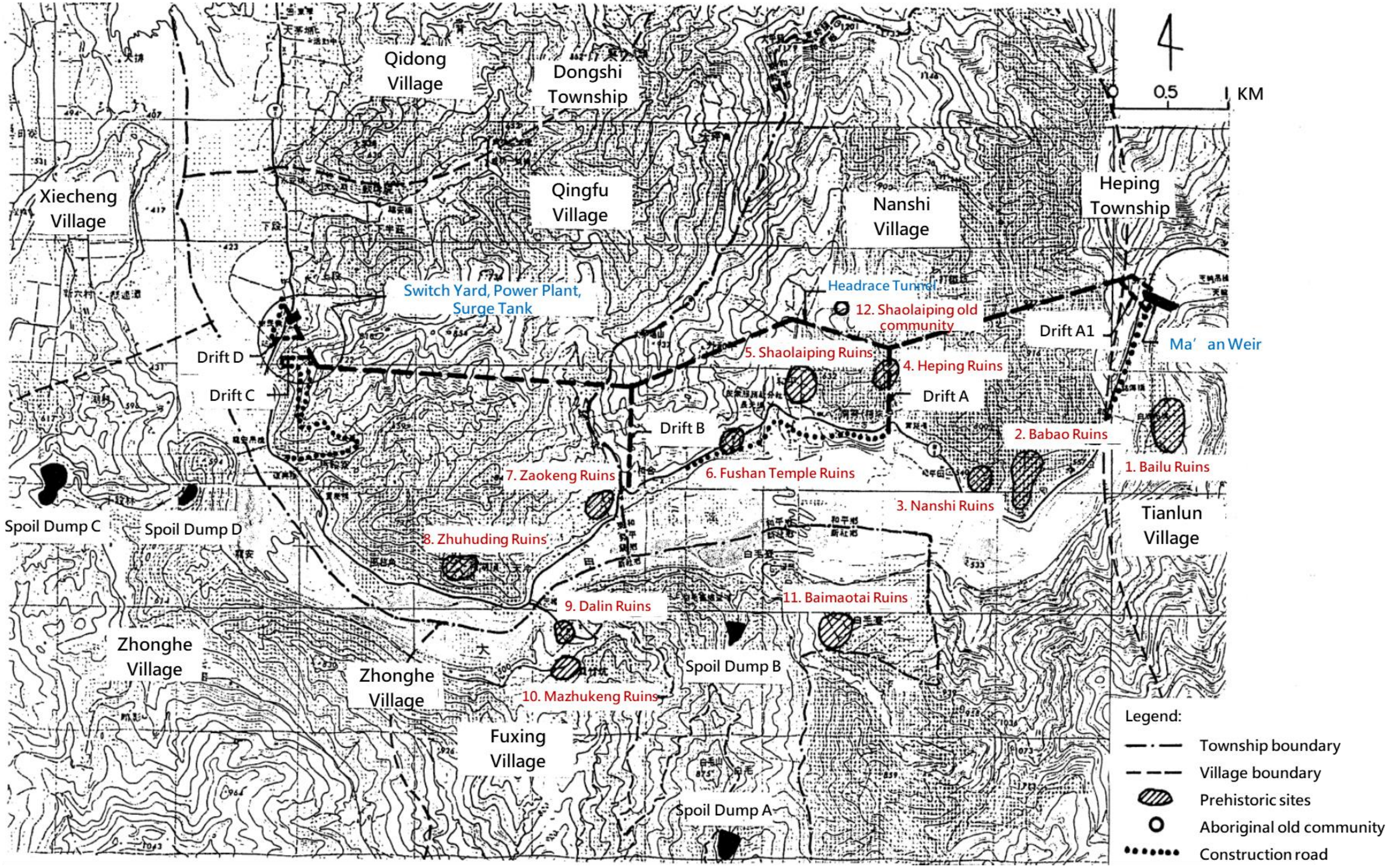


Figure 21 Distribution of Historical Sites in the Ma'an Hydropower Project Area

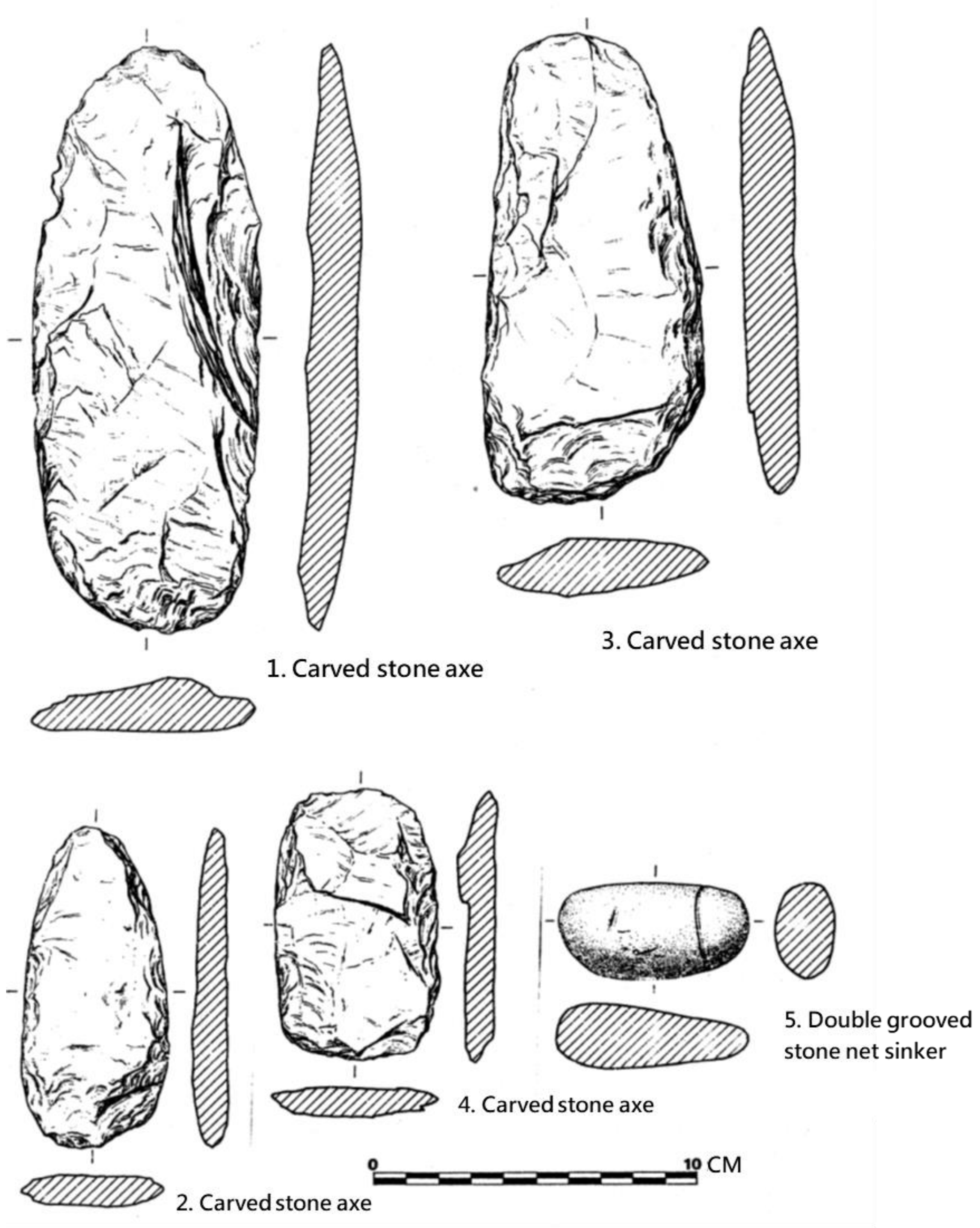


Figure 22 Prehistoric Relics Unearthed from the Bailu Ruins

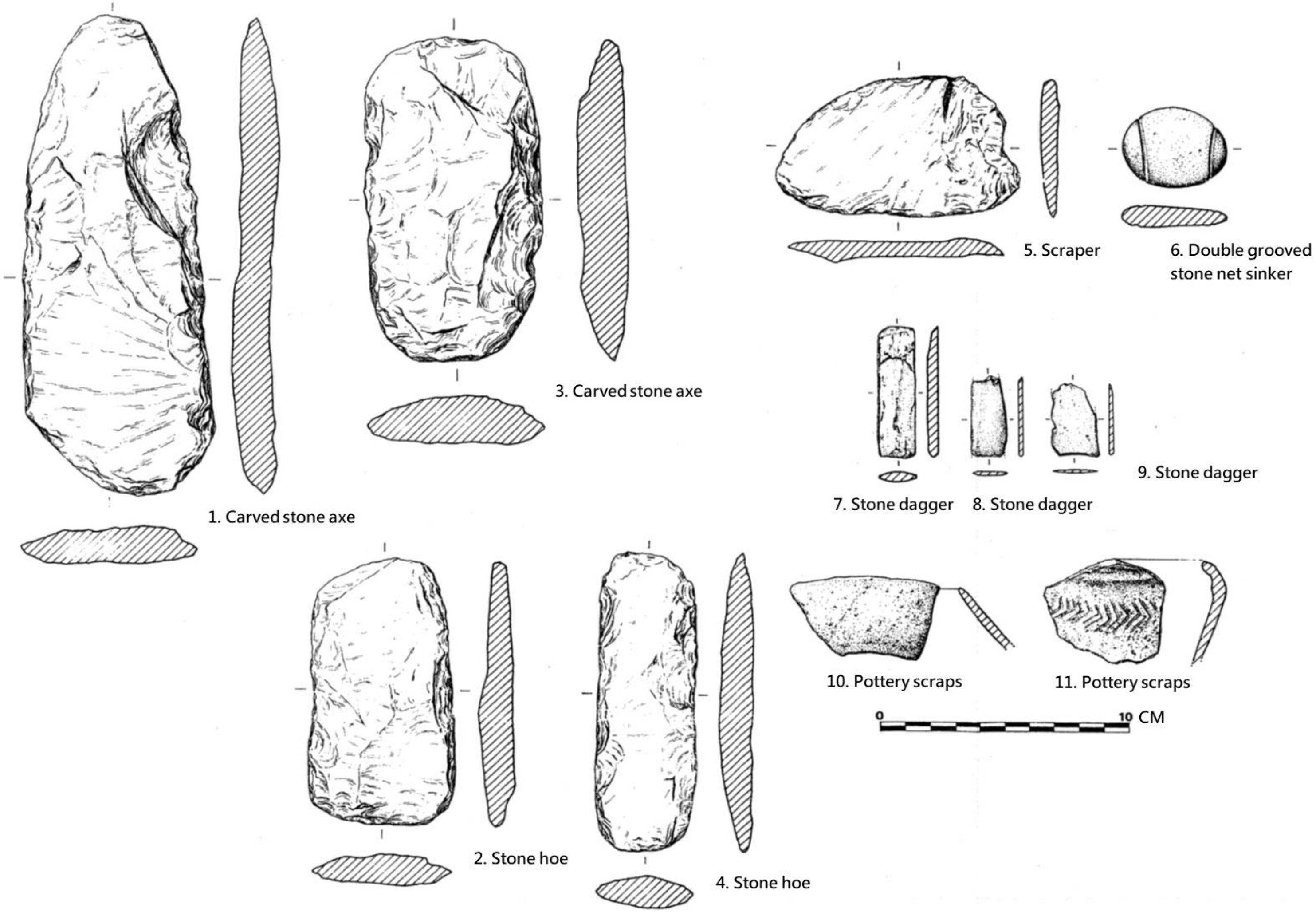


Figure 23 Prehistoric Relics Unearthed from the Babao Ruins

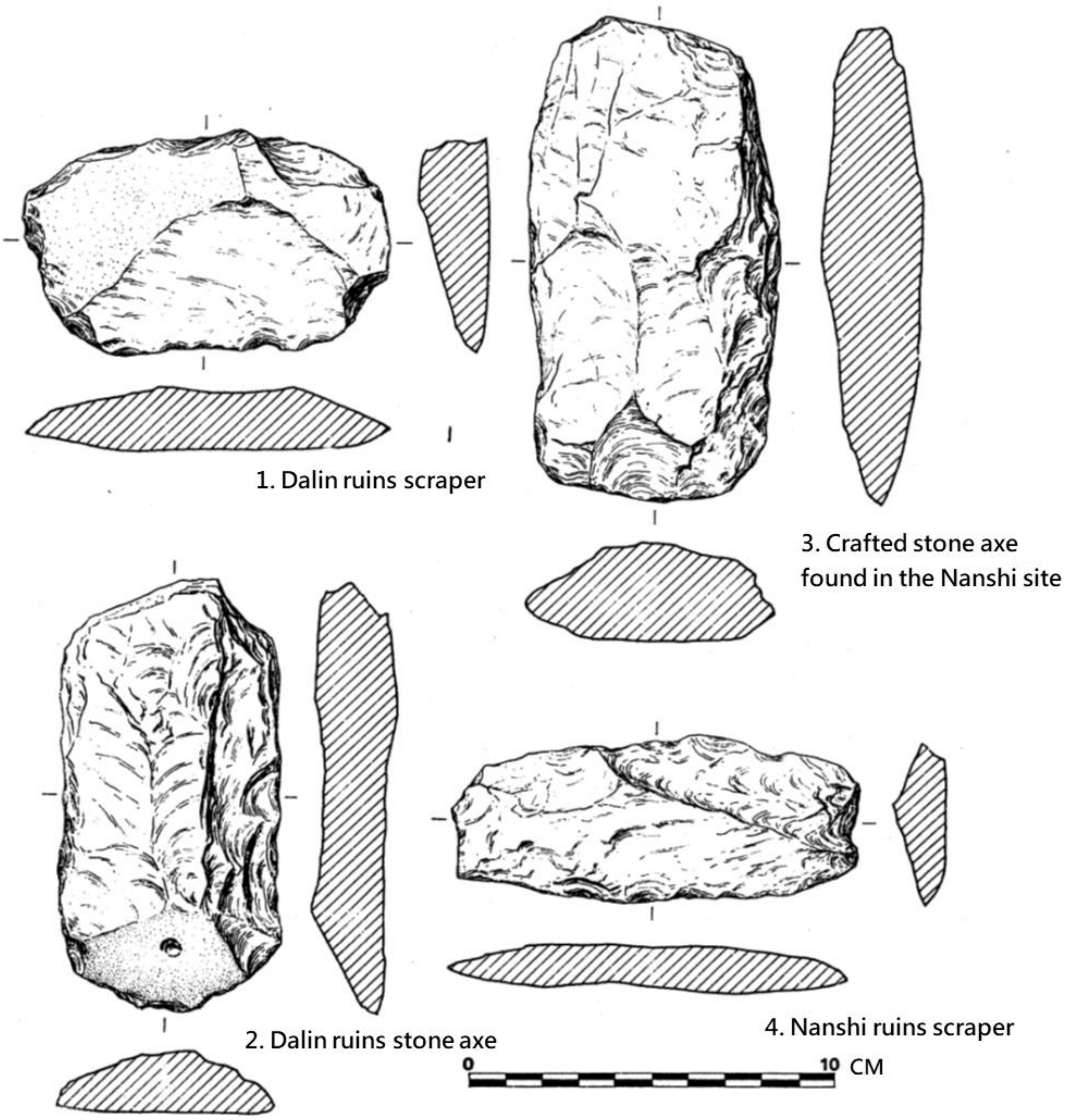


Figure 24 Prehistoric Relics Unearthed from the Nanshi and Dalin Ruins

B-4-2. Scenic beauty

The Zhongheng Highway is the main scenic route in the project area. A comprehensive analysis is provided for the visual corridor formed by the section from Yong'an Bridge to Tianlun Power Plant (including the proposed power plant site, Ma'an Project Dam site, construction roads, and the four planned waste dump sites A, B, C, and D). This analysis considers the vividness, complexity, and rarity of landscape composition elements (terrain, vegetation, water bodies, and man-made structures), as well as the overall unity and integrity of the landscape. The evaluation is based on the "Visual Resource Management System" developed by the U. S. Department of the Interior's Bureau of Land Management (see Table **11**), with higher scores indicating better visual quality.

Table 11 Landscape Quality Scoring Standards

Item	Feature	Comments
1.Topography	● Steep cliffs with significant elevation differences, sharp peaks, large exposed rock formations, and varied surface features such as badlands and sand dunes.	5
	● Canyons, mesas, volcanic cones, and other varied topography.	3
	● Minor landscapes lacking striking features, such as low or gently rolling hills, valley lowlands, etc.	1
2.Vegetation	● A wide variety of plant species with interesting shapes, structures, and forms.	5
	● A small variety of plant species, with a few dominant species.	3
	● The tree species are simple and lack contrast.	1
3.Body of water	● The water quality is clean, with calm waters or waterfalls, and the body of water forms the focus of the landscape.	5
	● There is moving or still water, but it is not the focus of the landscape.	3
	● No body of water is present or noticeable.	0
4.Color	● Rich and radiant, the colors of soil, rocks, and water are in contrast and complement each other.	5
	● The same as above, but it does not constitute the main landscape.	3
	● The changes and contrasts in color are not obvious.	1
5.Impact of nearby landscape	● It can enhance the visual quality of the area.	5
	● It can slightly enhance the visual quality of the area.	3
	● There is no impact on this area.	0
6.Rarity	● A very rare landscape.	6
	● Relatively rare and very distinctive.	2
	● The landscape is beautiful, but not special or unique.	1
7.Human	● Low human impact.	2

Item	Feature	Comments
impact	● There are some uncoordinated human impacts that reduce the original visual quality, but the damage is not severe.	0
	● Human impact is great and the landscape has been mostly changed.	-4

Note [1]: Based on the "Visual Landscape Evaluation System" developed by the U. S. Department of the Interior's Bureau of Land Management in 1978.

[2]: The score of a particular landscape is obtained by summing the evaluation points of landscape elements 1 to 7.

1. The visual corridor along the Central Cross-Island Highway

Based on the topographic zones and visual corridors (see Figure 25), the research area along the highway is divided into several landscape units. Appropriate viewpoints along the Central Cross-Island Highway, the Fumin Industrial Road across the Dajia River, Provincial Highway No. 21, and other roads are selected to assess the current visual quality of each landscape unit (see Figure 26, Table **12**, and Table **13**).

(1) Near Tianlun Power Plant (Landscape Units 1 to 4)

This area does not have particularly unique landscape features. The Dajia River forms a large meander here, and while the water is somewhat lively and the water quality is quite clear, the large gravel bars on both sides of the riverbed appear disorderly. Additionally, the water volume is relatively low, which lowers the overall landscape quality. The cut bank of the meander is on the side of the Central Cross-Island Highway, while an arcuate river terrace appears on the slip-off slope on the opposite side. This river terrace, along with the hills behind it, creates a strong variation in both slope and topography, enhancing the complexity of the landscape and making the landscape unit relatively distinct. The mountain ranges on both sides are continuous and orderly, with good vegetation. The tree species become increasingly uniform, resulting in a landscape that is not chaotic but lush and green. Going east along the Central Cross-Island Highway, the Tianlun Power Plant is directly ahead. Due to its large area and significant man-made structures, it stands out prominently and becomes a focal point for the eyes. Although the power plant has gardens, lawns, and some trees planted, it still does not fully blend in with the landscape.

Overall, the scenic quality of this area is slightly above average but not exceptional, and should be classified as a Level B landscape.

(2) Nanshi to Tianleng (landscape units 5 to 11)

This area does not have any distinctive landscape features. In this section of the Dajia River, the river valley is quite broad, with gravel bars piled up on both sides of the riverbed. The river can be seen from the Central Cross-Island Highway, especially near Tianlun, where it is most clearly visible, creating a dynamic landscape. However, the development of the riverbed and the somewhat disorderly gravel bars on both sides reduce the area's attractiveness. Additionally, the significant elevation difference between the highway and the riverbed reduces the sense of closeness to the water, thereby affecting the overall landscape quality. In this area, orchards are scattered along the hillside on the side of the road. During the winter, most of the fruit trees are deciduous, creating a strong contrast in color with the undeveloped orchard areas. Due to the unplanned development of the orchards, they are interspersed in patches on the vegetated slopes, creating a fragmented appearance. The large, conspicuous exposed areas from quarrying on the north bank of the Dajia River significantly reduce the landscape quality of this area. Several settlements are situated along the route, but none are large in scale. Although a suspension bridge near

Tianlun adds some poetic charm, the adjacent reinforced concrete bridge (Tianfu Bridge) undermines its unique scenery.

Overall, this area should be classified as a Level C landscape.

(3) Tianleng to Yong’an Bridge (landscape units 12 to 18)

Except for the narrow gaps near Ma'anliao caused by hard rock on both sides, the Dajia River valley is quite broad in this section. The riverbed is very wide downstream of Yong'an Bridge, with a low flow volume, and the banks are filled with gravel bars, making the landscape not particularly distinctive. Below Yong'an Bridge (landscape unit 18) is the area where settlements are concentrated, displaying the typical scenery of a rural Taiwanese town. East of Yong'an Bridge, the area gradually transitions into mountainous terrain, with fewer settlements and different development methods, creating a contrast in land use.

Overall, the landscape is similar to that commonly seen throughout Taiwan and should be classified as a Level B landscape.

2. Waste dump site

(1) Waste dump site A

Waste dump site A is located in a small river valley about 250 meters from Provincial Highway 21. The slopes on both sides of the valley have mostly been cultivated, resulting in rather disordered vegetation. The valley opens to the north, offering a distant view of the western flank of Xueshan, with its beautiful, continuous ridge lines.

Overall, it should be classified as a Level C landscape.

(2) Waste dump site B

Waste dump site B is located within Landscape Unit 9. It is the head of a small valley. The nearby land is haphazardly cultivated, with some areas terraced into platforms for planting fruit trees such as oranges, pears, and lemons. The terrain itself does not have any distinctive features.

Overall, it should be classified as a Level C landscape.

(3) Waste dump site C

Waste dump site C is located in a small valley along the branch of Provincial Highway 131 leading to Zhonghe Village. Two or three farmhouses are situated within the valley. Most of the land has been cultivated into orchards with dense foliage, blending harmoniously with the surrounding natural forest. The area is lush and green, representing a typical mountain rural landscape with relatively high scenic quality.

Overall, it should be classified as a Level B landscape.

(4) Waste dump site D

Waste dump site D is located on a river terrace with somewhat distinctive terrain. However, the vegetation next to the water is disorderly, and a nearby chicken farm degrades the surrounding environment.

Overall, it should be classified as a Level C landscape.

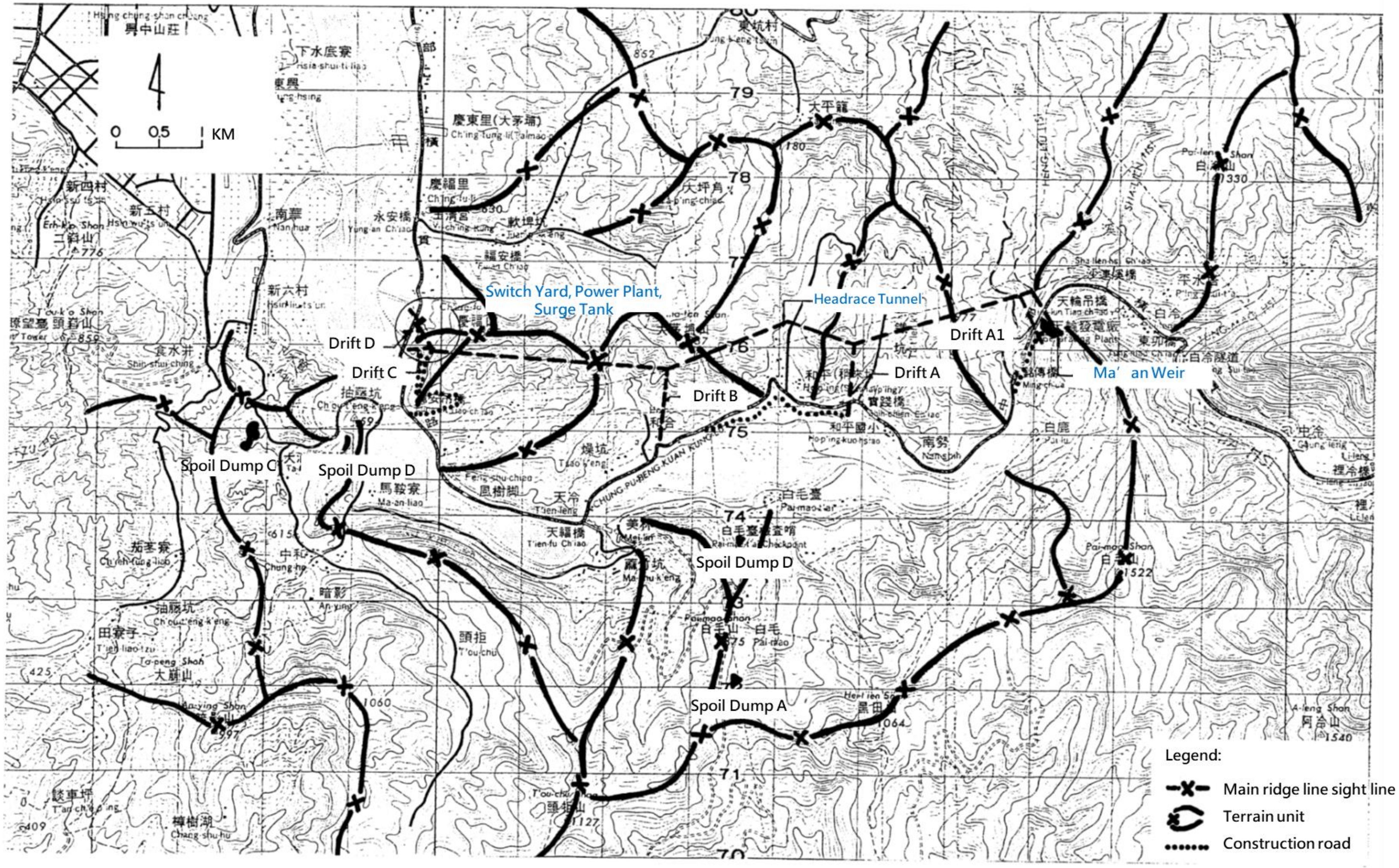


Figure 25 Division of Topographic Visual Units in The Project Area

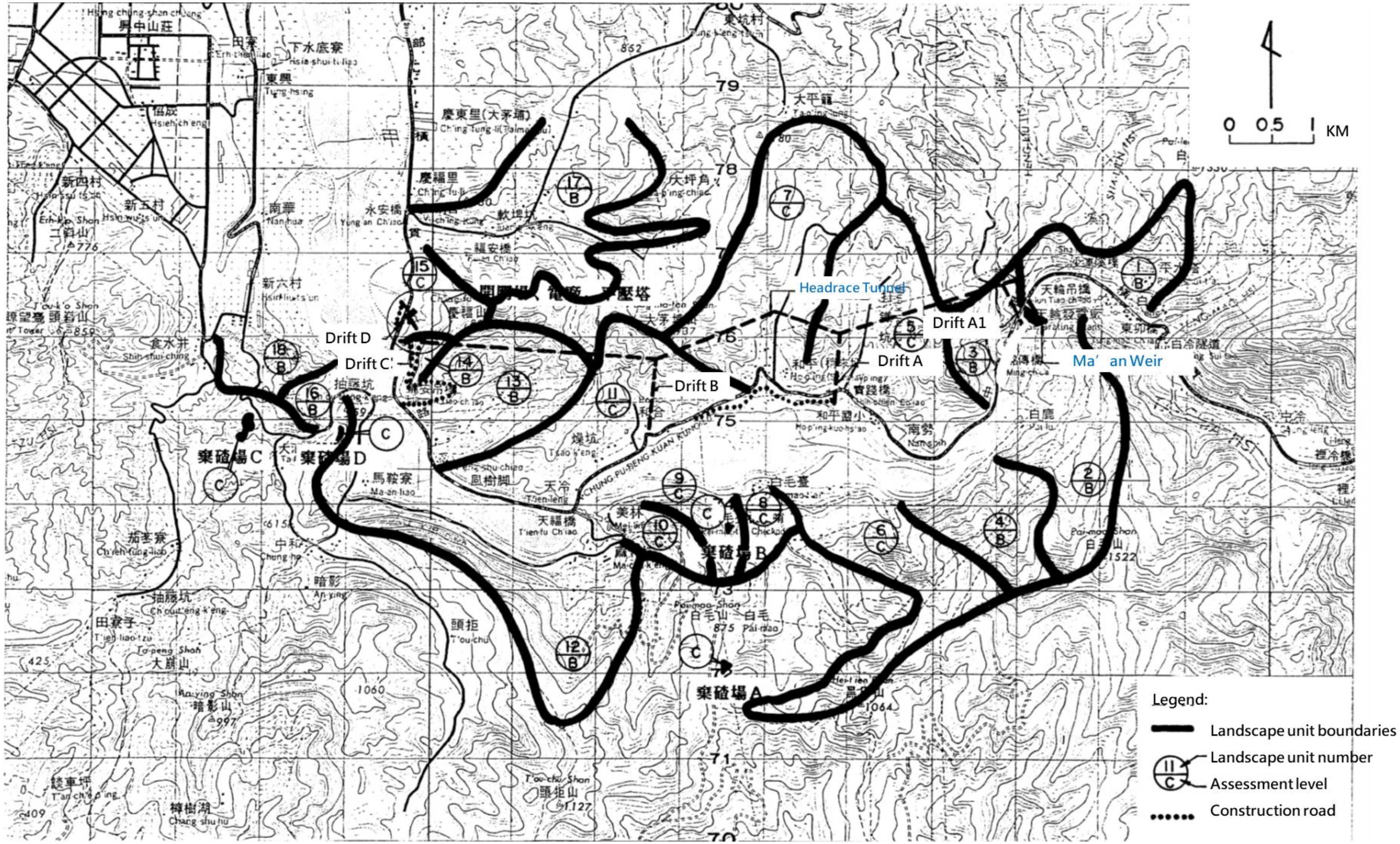


Figure 26 Rating of Visual Quality of Landscape Units in The Project Area

Table 12 Landscape Quality Assessment of The Current Visual Corridor Along The Central Cross-Island Highway in The Project Area

Attributes	Evaluation factor	Near Tianlun Power Plant (Landscape Units 1 to 4)			Nanshi to Tianleng (Landscape Units 5 to 11)			Tianleng to Yong'an Bridge (Landscape Units 12 to 18)		
		Comments	Description and evaluation	Score	Comments	Description and evaluation	Score	Comments	Description and evaluation	Score
Vividness	● Does it have a special landscape?	0	● Description: It does not have special landscape features, the terrain is not particularly steep, and the vegetation composition and color contrast are not distinctive. ● Evaluation: Slightly low vividness	4	0	● Description: No special scenery. The color contrast between the orchards and the natural growth is mixed. ● Evaluation: Relatively low vividness.	2	0	● Description: There are no special landscape features. The terrain is slightly undulating and gradually becomes a plain. ● Evaluation: Relatively low vividness.	2
	● Steepness of terrain	3			1			1		
	● Color contrast of the vegetation structure	1			1			1		
Complexity	● Does it contain a variety of landscape elements?	3	● Description: The contrast between the river terraces and the mountains adds variability to the terrain. The meanders formed by the Dajia River create a distinctive variation in the shape of the water. ● Evaluation: Relatively high complexity.	12	1	● Description: The landscape is monotonous and has no variability. ● Evaluation: Relatively low complexity.	4	1	● Description: The landscape elements have low variability. Only after the Dajia River crosses the water gap near Ma'anliao does it suddenly become wide and slightly varied. ● Evaluation: Relatively low complexity.	6
	● Degree of terrain change	3			1			1		
	● Degree of change in vegetation composition	3			1			1		
	● Changes in water morphology	3			1			3		
Rarity	● Does it have special terrain and geology?	3	● Description: River terraces are special landscape elements. ● Evaluation: Moderate rarity.	6	1	● Description: No special natural landscape. Although the Tianleng Suspension Bridge adds a little vividness, it is degraded by the newly built Tianfu Bridge. ● Evaluation: Relatively low rarity.	4	1	● Description: Although a water gap has formed near Ma'anliao, it is not narrow enough and the elevation difference is small, so it does not create a distinctive landscape. There is a suspension bridge in the area. ● Evaluation: Relatively low rarity.	6
	● Does it have a special vegetation composition?	0			1			1		
	● Does it have a special water morphology?	3			1			3		
	● Does it have a special cultural landscape?	0			1			1		
Integrity	● No man-made facilities	-	● Description: The Tianlun Power Plant is the focus of attention, and its huge structure is incompatible with the surrounding natural landscape. ● Evaluation: Relatively low integrity.	-4	-	● Description: The hillside orchards disrupt the integrity of the original vegetation, and the quarry has created extensive exposed areas. ● Evaluation: Very low integrity.	-4	-	● Description: Further into the plain, there are more settlements. The landscape slowly becomes a cultural landscape. The change is gradual and remains harmonious. ● Evaluation: Moderate integrity.	0
	● There are man-made facilities, but they are in harmony with the landscape.	-			-			0		
	● There are man-made facilities, but they are not in harmony with the landscape.	-4			-4			-		

Attributes	Evaluation factor	Near Tianlun Power Plant (Landscape Units 1 to 4)			Nanshi to Tianleng (Landscape Units 5 to 11)			Tianleng to Yong'an Bridge (Landscape Units 12 to 18)		
		Comments	Description and evaluation	Score	Comments	Description and evaluation	Score	Comments	Description and evaluation	Score
Uniformity	● Is the landscape unit clear?	3	● Description: The crossing of the Dajia River and the contrast between the river terraces and mountains create clearly defined landscape units, with good continuity in the terrain, vegetation, and body of water. ● Evaluation: High uniformity.	12	3	● Description: The terrain and water systems exhibit systematic continuity, making the landscape units easy to distinguish. However, the orchards are scattered haphazardly, resulting in vegetation lacking systematic continuity. ● Evaluation: Ordinary uniformity.	10	3	● Description: The landscape units are still fairly distinct, but the terrain variation gradually diminishes to the point of being unnoticeable, with gradually lessening vegetation. There are still systematic stretches of the water. ● Evaluation: Moderate uniformity.	12
	● Is the terrain composition systematically continuous?	3			3			3		
	● Is the vegetation composition systematically continuous?	3			1			3		
	● Is the body of water systematically continuous?	3			3			3		
Conclusions		The visual quality is slightly above average but not exceptional, making it a Level B landscape.		Total score: 30	The visual quality is below average, the landscape lacks distinctive features, and it is further degraded by human activities (orchards), making it a Level C landscape.		Total score: 16	It is a transitional zone from mountainous areas (dominated by natural landscapes) to flatlands (dominated by cultural landscapes), classified as a Level B landscape.		Total score: 26
Rating criteria		If the total score is > 48, it is classified as a Level A landscape.			If the total score is 24 to 27, it is classified as a Level B landscape.			If the total score is 0 to 23, it is classified as a Level C landscape.		

Table 13 Assessment of The Existing Landscape Quality of The Planned Waste Dump

Attributes	Evaluation factor	Waste dump site A			Waste dump site B			Waste dump site C			Waste dump site D		
		Comments	Description and evaluation	Score	Comments	Description and evaluation	Score	Comments	Description and evaluation	Score	Comments	Description and evaluation	Score
Vividness	● Does it have a special landscape?	0	● Description: It does not possess distinctive landscape features. Although the relative elevation difference is about 200 meters, this effect is diminished in the overall view of the landscape. ● Evaluation: Slightly low vividness	4	0	● Description: It does not possess distinctive landscape features. The terrain is gentle, the vegetation is disorderly, and the colors are not vivid. ● Evaluation: Relatively low vividness.	2	0	● Description: It does not possess distinctive landscape features, but the vegetation is well-organized and the colors are vivid. ● Evaluation: Moderate vividness.	6	0	● Description: It does not possess distinctive landscape features. The terrain is gentle, and the waterside vegetation is somewhat disorderly. ● Evaluation: Relatively low vividness.	2
	● Steepness of terrain	3			1			1			1		
	● Color contrast of the vegetation structure	1			1			5			1		
Complexity	● Does it contain a variety of landscape elements?	3	● Description: No body of water. At an elevation of 800 meters, visual attention starts to focus on the changes in the skyline. Looking northward, the western flank of the Xueshan Range forms a varied skyline. ● Evaluation: Moderate complexity.	7	1	● Description: Low variability in landscape composition. Looking at the landscape on the other bank, nothing special can be seen. ● Evaluation: Relatively low complexity.	4	1	● Description: No body of water. The terrain does not vary much. The vegetation composition is dense, and the variability is slightly better. ● Evaluation: Moderate complexity.	7	3	● Description: On the right side of the river's meander, there is a terrace, where the waste dump site is located. ● Evaluation: Slightly complicated.	10
	● Degree of terrain transformation	3			1			1			3		
	● Degree of change in vegetation composition	1			1			5			1		
	● Changes in water morphology	0			1			0			3		
Rarity	● Does it have special terrain and geology?	1	● Description: There are no special landscape elements. ● Evaluation: Relatively low rarity.	3	1	● Description: There are no special natural landscape-generating elements. ● Evaluation: Relatively low rarity.	4	1	● Description: There are no special landscape elements. ● Evaluation: Relatively low rarity.	5	3	● Description: Meanders and terraces are more distinctive landscape elements. ● Evaluation: Slightly rare.	8
	● Does it have a special vegetation composition?	1			1			3			1		
	● Does it have a special water morphology?	0			1			0			3		
	● Does it have a special cultural landscape?	1			1			1			1		
Integrity	● No man-made facilities	-	● Description: Most of the slopes have been	-4	-	● Description: The nearby land is	-4	-	● Description: There are a few farmhouses,	0	-	● Description: The chicken farm severely	-4

Attributes	Evaluation factor	Waste dump site A			Waste dump site B			Waste dump site C			Waste dump site D		
		Comments	Description and evaluation	Score	Comments	Description and evaluation	Score	Comments	Description and evaluation	Score	Comments	Description and evaluation	Score
	● There are man-made facilities, but they are in harmony with the landscape.	-	cultivated and are slightly messy. Power cables and two transmission towers in the air disrupt the landscape. ● Evaluation: Relatively low integrity.		-	haphazardly cultivated, and the quarry on the Dajia River riverbed is visible. ● Evaluation: Very low integrity.		0	lacking typical rural architecture, but they harmonize with the landscape. ● Evaluation: High integrity.		-	impacts the scenery for the viewer, causing a negative effect. ● Evaluation: Very low integrity.	
	● There are man-made facilities, but they are not in harmony with the landscape.	-4			-4			-			-4		
Uniformity	● Is the landscape unit clear?	3	● Description: No body of water. The terrain composition is systematic, making the landscape units distinct, but the vegetation is disorderly. ● Evaluation: Moderate uniformity.	7	0	● Description: The landscape units are chaotic, and the Dajia River can still be seen. ● Evaluation: Very low uniformity.	3	1	● Description: No body of water. The terrain and vegetation are systematically extended. Due to the lush vegetation, it is difficult to clearly distinguish the individual landscape units. ● Evaluation: Moderate uniformity.	7	1	● Description: The cluttered waterside vegetation reduces the clarity of landscape units and the sense of continuity of the body of water. ● Evaluation: Relatively low uniformity.	4
	● Is the terrain composition systematically continuous?	3			1			3			1		
	● Is the vegetation composition systematically continuous?	1			1			3			1		
	● Is the body of water systematically continuous?	0			1			0			1		
	Conclusions	It is a common mountainous landscape and is classified as a Level C landscape.		Total score: 17	The landscape is ordinary and subject to human impacts and is classified as a Level C landscape.		Total score: 9	It is a typical rural scene, with dense vegetation as the most distinctive feature, and is classified as a Level B landscape.		Total score: 25	The landscape configuration is poor, the quality of the chicken farm has been reduced, and it is a Level C landscape.		Total score: 20
	Rating criteria	If the total score is > 48, it is classified as a Level A landscape.			If the total score is 24 to 27, it is classified as a Level B landscape.						If the total score is 0 to 23, it is classified as a Level C landscape.		

B-4-3. Tourism and recreation

According to the "Taiwan Comprehensive Development Plan" drafted by the Executive Yuan's Council for Economic Planning and Development (referred to as CEPD) in 1979, and the "Central Taiwan Regional Plan" drafted by the Taiwan Provincial Government in 1981, both Guguan and Lishan are classified as regional tourism and recreational areas. They have been approved as designated scenic areas and incorporated into the central region's tourism and recreational area system. These areas are primarily characterized by natural scenery, which is complemented by variations such as forests, gorges, lakes, historic sites, and natural ecology.

The project area, located between Guguan and Dongshi, is not included in the Central Cross-Island Highway recreational system and is not one of the main scenic and recreational spots along the highway. Therefore, there is no tourism or recreational development in the nearby areas, nor are there large-scale tourism and recreational activities. A small number of people visit the suspension bridges and river valleys only on holidays for picnicking, fishing, swimming, and playing in the water.

Since the project area is an area along the scenic route of the Central Cross-Island Highway, the implementation of the hydropower project will inevitably have some impact on the tourism and recreational activities along the highway. The following is a brief description of the relevant recreational systems, recreational spots, and the sources and number of visitors:

1. Guguan Recreational System

According to the "Central Cross-Island Highway Area Tourism and Recreation Development Plan" drafted by the Taiwan Provincial Bureau of Housing and Urban Development (referred to as the Provincial Housing and Urban Development Bureau), commissioned by the Tourism Bureau of the Ministry of Transportation (referred to as the Tourism Bureau) in 1978, six recreational systems have been delineated along the Central Cross-Island Highway. These include Guguan, Lishan, Wuling, Dayuling-Hehuanshan, Wushe-Lushan, and Taroko-Tianxiang. The Guguan recreational system is the closest to the project area, and its current development status is summarized as follows:

- Geographical location and size

Guguan is located within Taichung County, 48 kilometers away from the nearby city of Fengyuan. In 1981, the Guguan Scenic Area was planned by the Provincial Housing and Urban Development Bureau and approved by the provincial government. The project period was from 1978 to 2003, covering an area of 148 hectares. The project was under the jurisdiction of the Taichung County Government.

Guguan mainly consists of a single settlement, with the residential area covering approximately 6.3 hectares and the commercial area covering about 0.6 hectares during the project. The total population is 547 people. It is planned to accommodate 800 people in the future, and the number of tourists is expected to reach 2.04 million.

- Nature of recreational resources

The nature of the Guguan Scenic Area is more of a suburban scenic area. Based on the integrated analysis of three-factor indicators impacting scenic areas: ①. Convenience of man-made facilities, ②. Accessibility of natural scenery, and ③. Attractiveness of recreational activities. Guguan ranks third in quality among the 18 scenic areas in Taiwan, only ranking behind Sun Moon Lake and Shimen Reservoir.

Recreational activities include enjoying natural scenery, camping, walking, visiting and picking fruits at tourist orchards, visiting botanical and zoological gardens, participating in religious and cultural activities, overnight stays, and mechanical amusement activities.

- Transportation service facilities

The existing Central Cross-Island Highway, with a width of approximately 7.5 meters, provides external access. Taiwan Motor Transport and Fengyuan Bus Transportation operate 20 daily bus services, directly reaching Taichung and Fengyuan.

Currently, there is one tourist hotel with 250 rooms, which is operating well. Additionally, there are six hostels (with 400 rooms in total), 15 dining establishments, and 20 specialty shops. Therefore, transportation, dining, and accommodation are all very convenient.

- Development goals

Focusing primarily on domestic tourism, the resource types equally emphasize natural scenery and recreational activities. The future management strategy centers on strengthening management and maintenance.

2. Main recreational locations along the Central Cross-Island Highway

Along the main line of the Central Cross-Island Highway between Dongshi, Guguan, Lishan, and Hehuanshan, as well as the Yilan and Wushe branch lines, the major recreational spots include Shigang Dam, Wufulinmen Sacred Tree, Yong'an Temple and Carp Protection Embankment, Dongshi Tree Farm, Eight Immortals Mountain Forest Recreational Area, Chusyueshan Forest Recreational Area, Longgu Park, Guguan Hot Springs, Zhile River Forest Recreational Area, Dasyueshan Forest Recreational Area, Lishan and Techi Reservoir Scenic Area, Wuling Forest Recreational Area, and Hehuanshan, totaling 13 spots (see Figure 27).

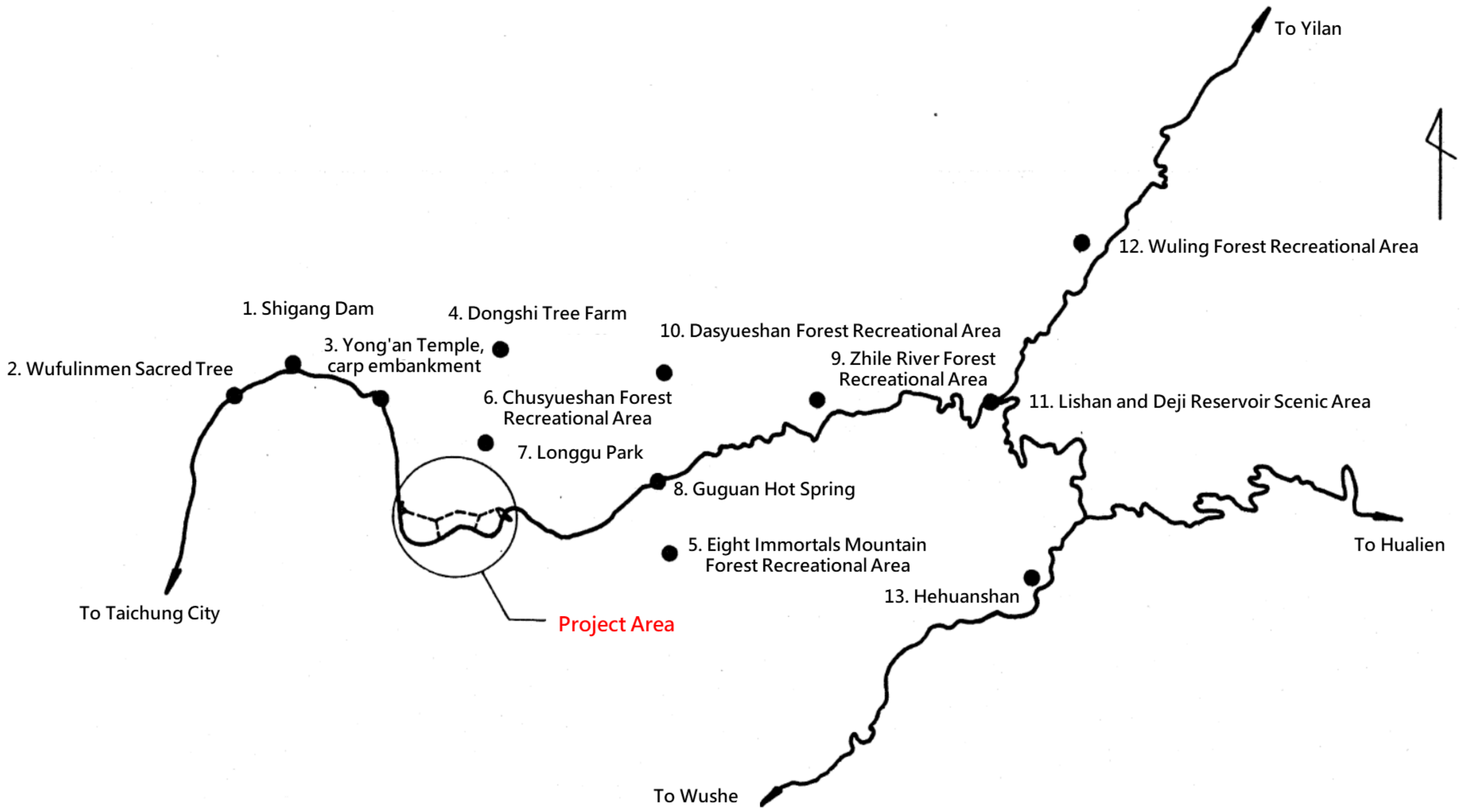


Figure 27 Distribution of Major Recreational Spots Along the Central Cross-Island Highway between Dongshi and Hehuanshan

3. Source and number of visitors

(1) Central Recreational Area

According to the "Central Cross-Island Highway Area Tourism and Recreation Development Plan" study, 34.3% of domestic tourists in the central region come from the northern region. 46.7% are from the central region and 6.8% are from the southern region. 12.2% are from the eastern region. Visitors from the central region account for almost half.

According to statistics from the Tourism Bureau, in 1986, the percentage of domestic tourist visits to eight scenic spots along the Central Cross-Island Highway, including Dasyueshan Forest Recreational Area, Guguan Hot Springs, Longgu Park, Dajian Hot Springs and Techi Reservoir, Lishan, Fushou Farm, Tianchi, and Shigang Dam, showed that Lishan, Guguan Hot Springs, and Longgu Park were more popular (see Table **14**). Besides Lishan, which is primarily visited in the autumn, most tourists visit Guguan Hot Springs and Longgu Park during the spring and summer seasons.

Table 14 Percentage of Tourist Visits to Major Scenic Spots in Central Taiwan in 1987

Scenic area	Q1 (January to March)	Q2 (April to June)	Q3 (July to September)	Q4 (October to December)	Yearly total
(1) Dasyueshan Tree Farm	0.044%	0.051%	0.040%	0.008%	0.037%
(2) Guguan Hot Spring	0.438%	0.714%	0.608%	0.498%	0.562%
(3) Longgu Nature Park	0.258%	0.322%	0.140%	0.213%	0.239%
(4) Techien Hot Spring, Techi Reservoir	0.033%	0.083%	0.047%	0.024%	0.047%
(5) Lishan	0.477%	0.447%	0.869%	0.490%	0.567%
(6) Fushou Farm	0.000%	0.045%	0.013%	0.055%	0.026%
(7) Tianchi	0.016%	0.000%	0.060%	0.000%	0.019%
(8) Shigang Dam	0.132%	0.210%	0.027%	0.142%	0.128%

Source: Tourism Bureau, China Credit Information Service: "Survey Report on National Domestic Tourism in Taiwan in 1986", 1987.

(2) Longgu Recreational Area

According to the study by Shao-Lin Luo and Feng-Long Feng (1983), the majority of visitors to Longgu Park come from the Taichung area, followed by the Taipei area, and then Miaoli, Changhua, and Nantou areas. The number of visitors from other counties and cities is very low (see Table **15**).

Table 15 Approximate Number of Tourists Visiting Major Recreational Areas in Central Taiwan by County and City in 1982

Unit: thousands

Recreational area	Total	Taipei	Keelung	Taoyuan	Hsinchu	Miaoli	Taichung	Changhua	Yunlin	Nantou	Chiayi	Tainan	Kaohsiung	Pingtung	Taitung	Hualien	Yilan	Others
Hehuanshan	130	79	4	12	6	4	2	5	4	0	1	2	6	0	0	2	2	1
Wuling Farm	238	27	1	8	20	11	73	53	9	4	8	8	9	1	0	2	4	0
Longgu Park	335	58	3	9	9	21	159	20	1	22	6	10	12	1	1	0	1	2

Note [1]: Excerpted from "Survey of Taiwan's Forest Recreational Area Resources", Shao-Lin Luo and Feng-Long Feng, 1983

According to the Tourism Bureau's statistics on visitor numbers to Longgu Park from 1980 to 1986, there has been negative growth every year (see Figure 2-24). This is a common phenomenon among early-developed scenic areas in Taiwan in recent years. The presumed reasons are as follows:

① Apart from the waterfall, Longgu Park has no other recreational activities that are unique or designed to match the original local landscape, which is not very attractive to tourists.

② Since the country lifted restrictions on international tourism in 1980, a portion of tourists have switched to traveling abroad, resulting in a sharp decline in the number of domestic tourists.

③ In the early days of the development of various domestic scenic spots, people in Taiwan often went there one after another out of curiosity, resulting in crowding. Over time, they lost the sense of novelty and stopped visiting.

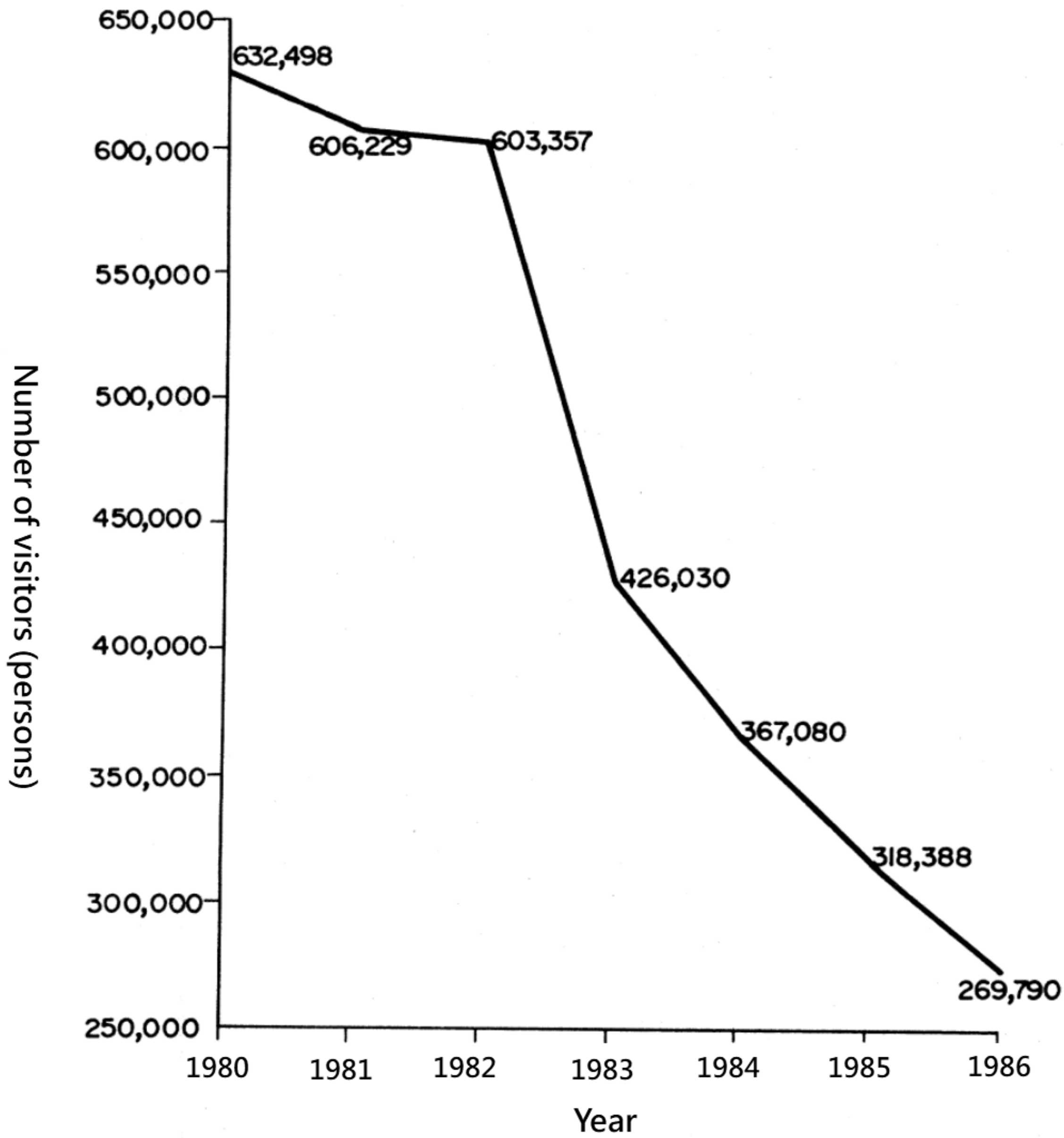


Figure 28 Changes in The Number of Visitors to Longgu Recreational Area over The Years

C. Environmental Impact Prediction and Assessment

C-1 Natural environment

C-1-1. Geography

1. Construction stage

(1) Changes in terrain and geomorphological

The planned power plant site and switch yard(開關場址) with a large scale of land preparation, as well as the spoil dumps for disposing of tunnel waste, are the locations with the most significant changes in terrain and geomorphological. The construction road leading to the Tank (surge) and drift C is about 7.0 meters wide. Although it will also cause zonal terrain changes, the total length is only about 3 kilometers, and the impact on the overall topography of the planned area will be slight.

The planned excavation area of the power plant site and switch yard is about 3.5 hectares in total, which will change the original approximately 45° sloping land adjacent to the Zhongheng highway (中橫公路) into a flat land with no height difference with the road surface. Except for the side of the Zhongheng highway, the remaining three sides are trimmed into slopes with each step 8 meters high, with a slope of 1 (horizontal): 2~3 (vertical).

Spoil dump A, B, C, and D were originally river valley terrains. When they are filled to the planned capacity, they will form gently sloping terraces in the valleys (see Table **16**).

Table 16 Planned Spoil Dump Size and Estimated Usage Time.

Dump No.	Estimated Volume (m^3)	Surface area after filling (m^2)	Usage Time (month)
A	550,000	45,000	24
B	150,000	21,000	12
C	700,000	60,000	30
D	150,000	150,000	12

(2) Soil erosion

The exposed surface area of the planned power plant site and switch yard due to excavation and land preparation is about 3.5 hectares, and soil erosion is unavoidable during the rainy season. However, the land preparation area is not large, and the construction period is short and concentrated. It is estimated that it will only take 8 months from excavation to completion of slope protection, and the topsoil loss will not be serious.

The length of use of each spoil dump depends on the capacity and tunnel construction progress, and is initially estimated to be within 1 to 3 years (see Table **16**). Since the soil retaining and drainage facilities will be completed in each spoil dump before use, there is no risk of waste being lost during use. Before the surface is fully covered but the capacity is filled, there will be surface erosion problems during the rainy season. The universal soil loss equation (USLE) was used to initially estimate the potential soil erosion of each spoil dump before and after use. Based on the current situation, soil erosion is severe. After the capacity is filled and before vegetation coverage, due to the completion of the gentle slope, the amount of average annual soil erosion is about 30% less than the current situation (see Table **17**).

2. Operation stage

(1) Changes in terrain and landforms

It may cause local landform changes, if there is a new land use plan for the gently sloping land filled.

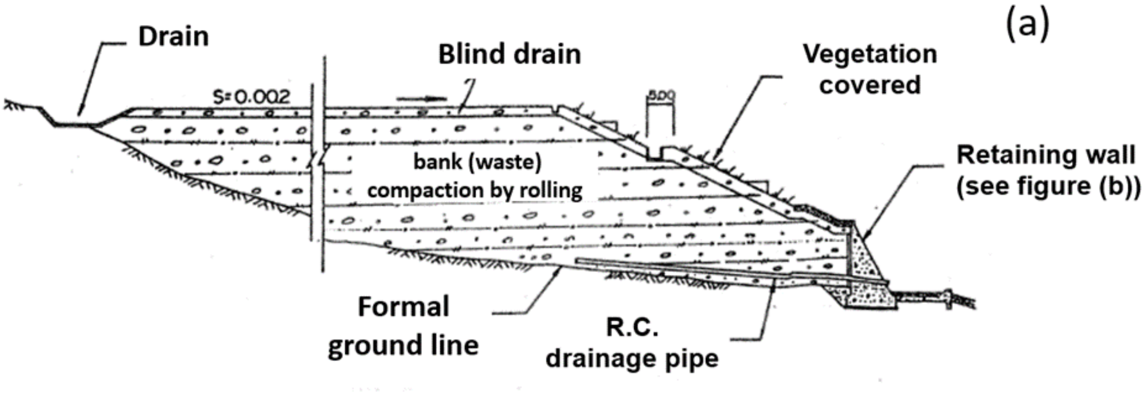
(2) Soil erosion

The surface coverage damaged during the construction period could be completely restored without excavation. The potential soil erosion is only about 10% of the initial level before use, and the erosion phenomenon is greatly reduced (see Table **17**).

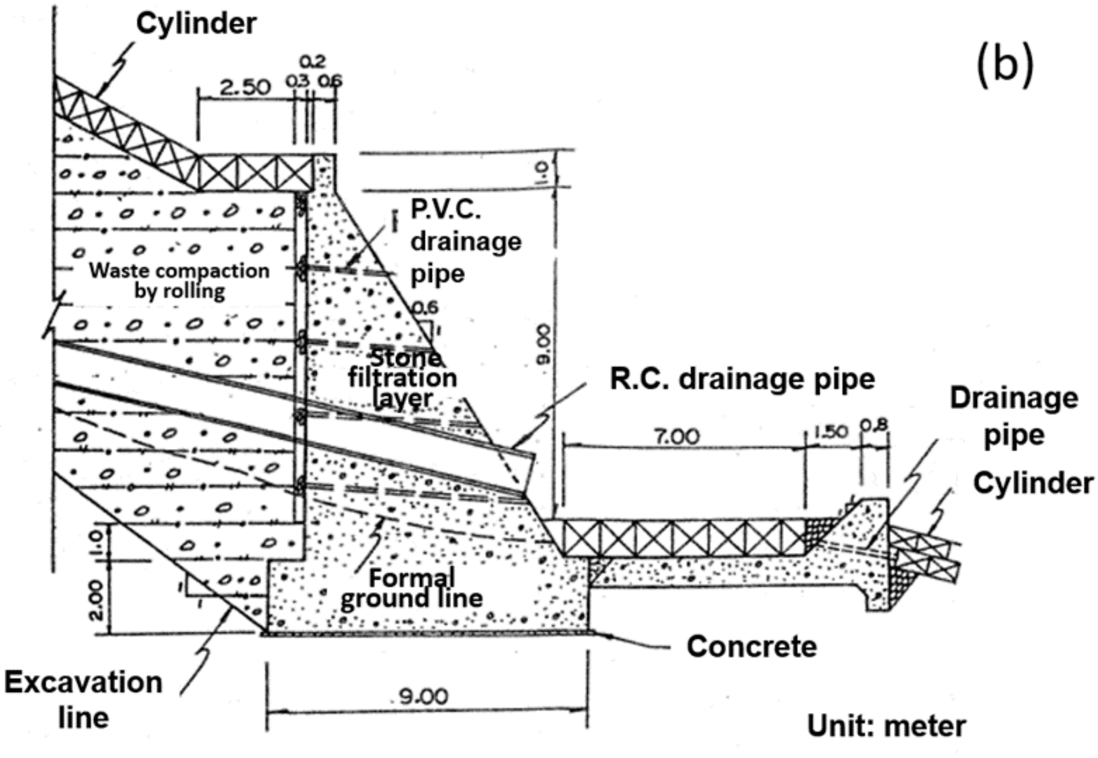
Table 17 Potential Annual Erosion Volume at Different Stages of the Planned Spoil Dump

Spoil Dump No.	Estimation of potential annual erosion volume (m^3/yr)		
	Current Situation	After filling	Operation Stage
A	393	221	21
B	178	100	10
C	408	287	28
D	56	72	8

USLE was applied for estimation, and the slope of the completed spoil dump was set to be 2%.



Waste Disposal Site Elevation View



Standard Cross Section of the Retaining wall

Figure 29 Schematic Diagram of Waste Dump Site Engineering Facilities

C-1-2. Air quality

1. Construction stage

During the construction phase, the air quality in the work area is most affected by the high dust volume and significant suspended particles caused by tunnel blasting and ballast removal, as well as the spoil dump operations. The mostly affected areas are concentrated at the portals, drift portals and spoil dumps. The second is the dust caused by the soil transportation path.

However, since there are no accomodating communities near tunnels, drifts and spoil dumps, the significant increase in the concentration of granular pollutants in a short period of time will not cause public nuisance problems.

The soil transportation path is adjacent to residences and shops on the roadside. During peak periods, about 120 soil transportation vehicles come and go every day. The dust raised has a more sensitive impact on air quality.

As for chemical pollutants such as CO, NOx, and SOx emitted by heavy machinery construction and transportation vehicles. Due to the limited number of heavy machineries, their exhaust gas emissions do not have a significant impact on local air quality.

2. Operation stage

The operation of hydropower plants does not emit air pollutants, so it does not affect the air quality of surrounding areas.

C-1-3. Hydrology

1. Construction stage

(1) Surface water

The change in the flow of Dajia River due to project construction is mainly caused by the diversion of water from Dajia River for construction. Although the barrage and water inlet were constructed in the Dajia River, they were constructed using the half-channel(半面河道) water diversion method. The Dajia River water can flow smoothly down the half-channel outside the cofferdam without affecting the upstream and downstream flows.

Construction water demand is mainly for concrete mixing and domestic water for construction workers, followed by equipment cleaning and environmental cleanup. During the peak construction period of this project in 1981, the barrage, water inlet, pressure tunnel, factory building, and tailrace tunnel were all being constructed at the same time. The peak daily water consumption was estimated to be approximately 498×104 liters/day (see Table C 3), equivalent to 0.0582 m3/s, accounting for only about 0.3% of the low water flow in the river section from the barrage site to Tianlun rear pond (75% delay, the flow rate is 19 m3/s), and has a minor change in flow of the downstream Dajia River.

(2) Ground water

The greatest impact on the groundwater level or flow direction during construction is the excavation of the headwater tunnel. If there are faults or broken rock formations, a large amount of groundwater may seep out. In this case, the construction unit will immediately lay metal mesh, install stone nails and spray concrete to consolidate it.

Weak rock slabs will be grouted first and then excavated; therefore, a large amount of groundwater seepage will not be caused during the construction period. Due to the lack of relevant data on the groundwater layer in the area, it is currently impossible to predict the local groundwater level or flow direction changes caused by this temporary groundwater seepage phenomenon.

Table 18 Estimated Water Demand During Peak Construction Period

Project	Water Type	Usage	Water Consumption (m^3/s)
Water inlet	1. Project water consumption		0.0090
	• Concrete mixing water	The total consumption of concrete is approximately 5,500 m^3. Daily consumption is about 300 m^3.	0.0034
	• Water for drilling		0.00550
	• Cleaning water		0.00006
	2. Domestic water consumption		0.0006
	Subtotal		0.0096
Headwater tunnel	1. Project water consumption		0.0390
	• Concrete mixing water	The length of the headwater tunnel is 7,485m. The total concrete volume is about 133,000 m^3. The total water consumption is about 133,100 m^3. It is placed 3 times a day, 10 m for each time.	0.0060
	• Water for drilling	There are 6 working site, and 4 drilling machines are operating at the same site simultaneously.	0.0333

Project	Water Type	Usage	Water Consumption (m^3/s)
		Water requirement for each machine is 250 liters/min, 8 hours a day.	
	• Cleaning water	10% of domestic water consumption.	0.0001
	2. Domestic water consumption	About 500 staff, 250 liters of water consumption per day per person.	0.0014
	Subtotal		0.0408
	1. Project water consumption		0.0049
	• Concrete mixing water	The total concrete consumption is about 161,000 m^3. The total water consumption is about 161,000 m^3. Daily 400 m^3.	0.0046
	• Cleaning water	10% of domestic water consumption.	0.0003
	2. Domestic water consumption	About 1000 staff, 250 liters of water consumption per day per person.	0.0029
Subtotal			0.0078
Power plant, switch yard, tank*		About 1/7 of the consumption of the water inlet and the headwater tunnel.	0.0070
Total			0.0582

*Directly taken from Tianlun rear pond, and was not added in the total.

2. Operation stage

(1) Surface water

The temporal changes in the flow of Dajia River between the planned Ma'an barrage site and Shi-gang(石岡) Dam are significantly affected by the operation of the power plant. The flow changes in the river below Shi-gang Dam are mainly affected by the operation of Shi-gang Dam and have less direct correlation with the operation of the planned Ma'an Power Plant.

Based on the operation principles of the existing upstream power plants and the planned new Tian-lun power plant provided by Tai-power Corporation, we estimated the flow delay curves before and after the operation of the Ma'an Hydropower Plant (taking into account that the new Tian-lun power plant has joined operation). Including the downstream of the planned Ma'an barrage, water inlet of Tian-lun rear pond and upstream flow of Shi-gang Dam which were shown in Figure C 2. From the planned Ma'an barrage to the Dajia River section between Tian-lun rear pond, the average daily flow during the dry season (October to April of the following year) would reduc by approximately 87% compared to the situation before operation. During the wet season (May to September), it would decrease by approximately 83%.

(2) Ground water

Due to the barrage obstruction and tunnel water diversion, during the operation of the power plant, the flow of the river section between the planned Ma'an Project barrage and Shi-gang Dam will be redistributed as the boundary between the Tian-lun rear pond, and the groundwater subsidy situation could also vary accordingly.

From the planned Ma’an barrage to the Tian-lun rear pond, which is about 11 kilometers long, the daily average flow during operation is about 85% lower than before operation, and its groundwater subsidy may be slightly reduced; due to the rise in water level upstream of the planned Ma’an barrage, it could help groundwater infiltrate. Therefore, for the river section between Tian-lun Power Plant and Shi-gang Dam, the operation of the power plant will not significantly affect the amount of groundwater subsidies in this river section.

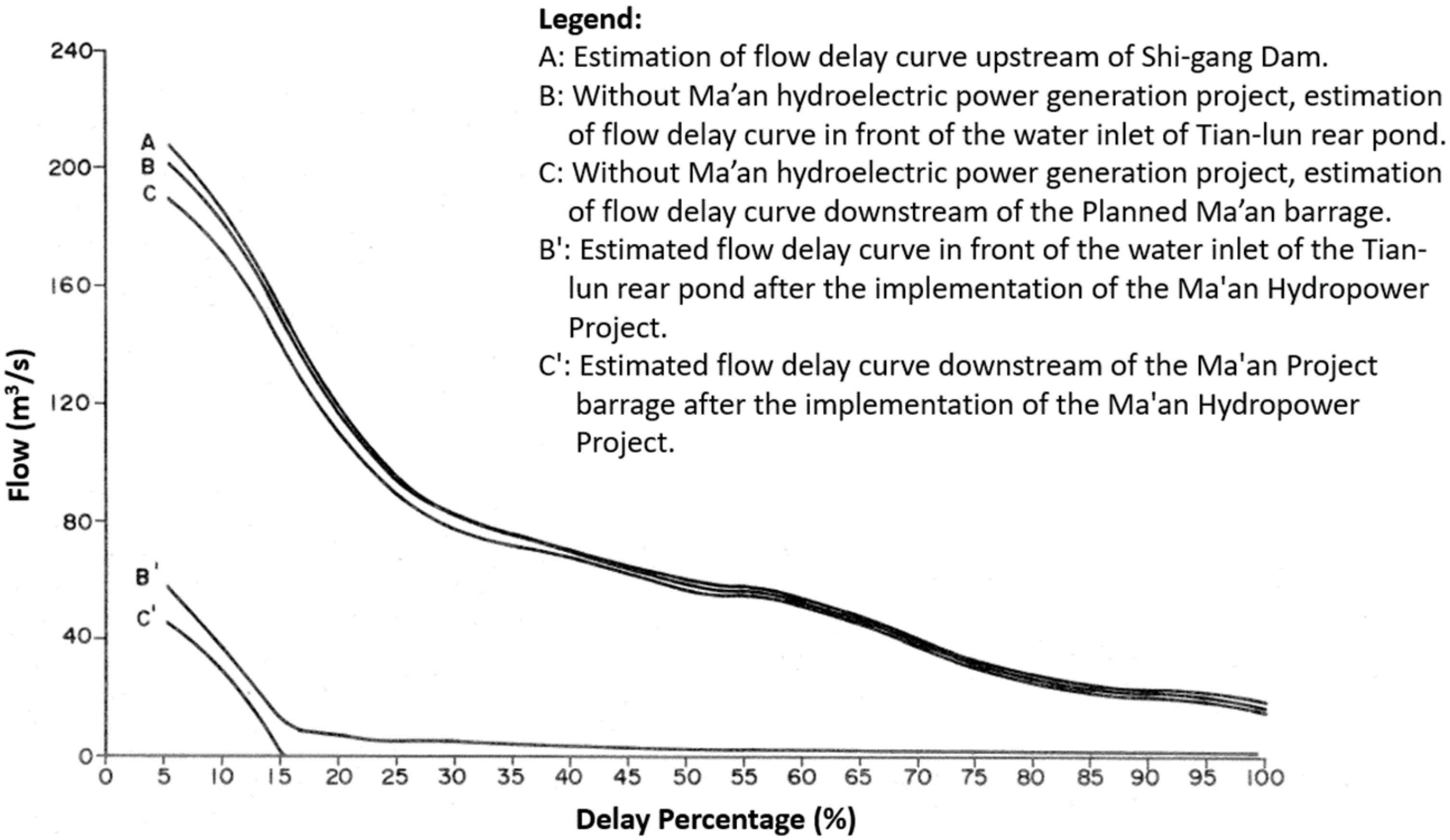


Figure 30 Flow Delay Curve of Tian-lun Rear Pond Inlet, Upstream of Shi-gang Dam and Downstream of the Planned Ma'an Dam.

C-1-4. Water quality

1. Construction stage

Possible sources of pollution are the increased turbidity and suspended solids caused by earthwork operations (excavation, blasting, dumping...), and the increased biochemical oxygen demand, grease, and coliform bacteria caused by the discharge of domestic sewage by construction workers. As for the waste liquid produced by the grouting operation, since a storage tank will be set up in the work area to settle before being discharged, the possible pollution it may cause is not as significant as the aforementioned pollution sources.

Although the cleaning and operation of construction machinery will also produce waste water and waste oil, the working area of this project is narrow and the construction machinery is limited, so the impact of its pollutant discharge on the water quality of Dajia River will be very limited.

Earthwork operations cause increased turbidity in water, which occurs only intermittently during heavy rains. It is mainly caused by soil loss during the excavation and preparation of drifts, switch yards, power plants and construction roads, and before the bare land in the spoil dump is covered. It is initially estimated that due to erosion of the exposed surface during the construction period, approximately 15,000 tons of sediment may be added to Dajia River, increasing the sand content by approximately 3%. However, the water pollution caused by this earthwork operation has a short delay and can be eliminated within 1 to 2 years after the slopes, road surfaces and abandoned sites are covered.

The domestic sewage of construction workers is mainly organic matter, and the BOD value can be the indicator. The construction area is estimated to have a population of about 2,500 people during the peak construction period. Based on an estimated daily sewage volume of 200 liters per person, the daily increase in pollutants is about 75 kilograms. After being removed by the simple septic tank installed on the construction site (about 50% removal rate), it is estimated that 40 kilograms of pollutants are still discharged into Dajia River every day. Using a simple river water quality model, it is estimated that the BOD concentration in front of Shi-gang Dam will only increase by about 0.046 PPM in the dry season, and by about 0.005 PPM in the wet season (Provincial The water supply company took samples from Shi-gang Dam in the 1970s and tested the BOD concentration, which was 0.9 PPM), river water quality of Class B(乙類) standard should still be maintained (BOD concentration must be less than 2PPM).

2. Operation stage

During the operation period, there will be 20 staff in the power plant, and its domestic sewage is discharged after treatment in septic tanks, which will increase the pollution load of the Dajia River water system to a very limited extent.

C-1-5. Noise and vibration

1. Construction stage

The main sound and vibration sources include fixed sources (point sources) generated by the operation of construction machinery and explosions in the work area, and mobile sources (line sources) generated by the movement of transport vehicles. Due to the small construction area, there are few heavy machinery required for construction. There are only about 120 transportation vehicles per day during peak periods, which only accounts for about 8% of the current average daily traffic volume of the Zhongheng highway.

Moreover, due to the sparse residents in the nearby areas, except for In addition to the explosion, although the noise and vibration levels generated during the construction period were significantly higher than the local environmental benchmark values, they had little impact on residents' lives.

The construction area of each work area is narrow, and the number of various types of construction machinery is usually between 2 and 5. Using the CSN Model (Construction Site Noise Model), it is estimated that the average energy volume at a distance of 10 meters from the sound source during the construction stage is about 74 dBA ~ 81 dBA. , the average energy volume at 30 meters is about 68 dBA~72 dBA, which is close to the domestic construction project perimeter noise control standards (see Table C 4). Although the land scope of this project has not yet been determined, the perimeter of the future project should be at least 30 meters away from the sound source.

The portal of drift B is located on the north side of Zhongheng highway, only about 100 meters away from the roadside. The loud noise and vibration caused by the explosion at the portal may frighten nearby homes and passersby on Zhongheng highway. Because the explosions in the drift were covered, the volume became smaller the further inward they were pushed. Since there is no measurement or research data of tunnel blasting noise and vibration in Taiwan for reference, we specifically measured the noise and vibration levels of rock blasting in the Taichung Port Authority mining area near the planned area. About 100 meters away from the blasting point, the instantaneous maximum volume is about 90 dBA, and immediately after the explosion, the volume can be reduced to the background volume; the vibration level has little effect.

Table 19 Noise Control Standards for Construction Projects [1].

(Unit: dbA)

Control area		Pile driver	Air compressor	Crusher, rock drill	Bulldozers, road rollers, excavators, others
Category 1, Category 2	Average volume (Leq)	83→75[2]	80→70	75→70	70
	maximum volume (Lmax)	100	85	85	80
Category 3, Category 4	Average volume (Leq)	88→80	83→75	80→75	75→70
	maximum volume (Lmax)	100	85	85	80

[1] Excerpted from the "Noise Control Standards" published by the Environmental Protection Bureau in February 1985.

[2] The numbers before the arrow(→) are effective from the date of announcement; the numbers after the arrow(→) are effective from July 1, 1990.

2. Operation stage

The main source of sound is the noise generated by the operation of power plants. According to actual measurements conducted by Zhongxing Engineering Consulting at Gu-guan Power Plant and Tian-lun Power Plant in 1974, the noise from the generators, draft tube manholes, water tank tops, pressure oil tank rotary machines and ventilators in the plants was as high as 90 dBA ~100 dBA., but the volume in the main control room was 67 dBA, and the noise in the factory is no longer easily noticeable outside the factory. It is speculated that after the planned Ma'an power plant is put into operation, the noise inside the plant will not affect the ambient sound outside the plant.

C-1-6. Solid waste

1. Construction stage

The main sources are discarded materials and domestic waste generated daily by workers in the work area. Among them, the waste side has considered four waste magnetic fields with sufficient capacity for centralized processing, so that there is no risk of arbitrary dumping and environmental pollution. During the peak construction period, the maximum amount of garbage generated by workers per day will not exceed 2 tons. The construction unit will collect and dispose of it at the landfill designated by the He-ping Township Office or dump it together, so it will not cause pollution to the local environment.

2. Operation stage

The operation of the power plant does not produce solid waste, and the daily amount of garbage generated by the resident staff is less than 10 kilograms. Since it is not part of the He-ping Township garbage collection service area, a small molded incinerator will be set up near the power plant for incineration. There will be no solid waste disposal problems during operation.

C-2 Biological environment

C-2-1. Terrestrial plants

1. Construction stage

During the construction period, the main affected areas are the planned power plant site of Ma’an and the scheduled spoil dump. For the construction of the power plant site, part of the orchards will be eradicated. Since the land preparation area is only about 3.5 hectares, the area of the orchards to be eradicated is not large. The spoil dumps A, B and C are all orchards, except for site D, which is a mixed forest. The main loss will be citrus.

The construction of the Tian-lun water inlet will affect a small amount of grassland and slope vegetation. The excavation of major projects such as tunnels and drifts will not affect ground vegetation.

2. Operation stage

The impact during operation mainly comes from water. The water level difference between the high and low levels of the barrage is 3.4 meters, which will submerge part of the riverbed grassland of wild sugarcane (甜根子草), but will not affect the nearby orchards.

Since the tailwater from the Tian-lun and New Tian-lun power plants will be immediately introduced into the pressure tunnel of the planned Ma'an power plant, the water volume of the Dajia River bed below the planned Ma'an barrage will be drastically reduced.

The reduction in water volume should theoretically lead to the invasion of some riverbed plants such as wild sugarcane and dense-flowered false-nettle (密花苧麻).

However, due to the periodic flushing of large amounts of river water after heavy rains every summer, it is expected that the riverbed vegetation landscape after the operation will not be far from the current situation.

C-2-2. Terrestrial animals

1. Construction stage

Human activities, tunnel blasting, and noise generated by construction machinery during the construction period will cause the wildlife that originally lived in this area to move to other places. However, most of this project is carried out underground, and the number of mammal populations is very low, and its impact is not significant.

Birds in the project area may also move to other places due to construction noise. Rare species such as the oriental turtle dove (金背鳩), mountain scops-owl (黃嘴角鴞), Crested Serpent Eagle (大冠鷲), and yellow-browed warbler (黃眉柳鶯) will be more affected.

2. Operation stage

Only the spoil dump will have some changes to the animal habitat due to the use of new land; other project facility locations should have no impact.

C-2-3. Aquatic plants

1. Construction stage

There are no special water plants in the Dajia River section of the project area. The flow rate did not decrease significantly during the construction period, and the water quality deteriorated to a limited extent. It is speculated that the vegetation condition of the Dajia River bed between Tian-lun Power Plant and Tian-lun rear pond should be like the current situation.

2. Operation stage

At present, the water quality of Dajia River is high. When the planned Ma'an Power Plant is put into operation, although the water volume from Tian-lun to Nan-shi will decrease sharply, the water quality will remain clean because there are few residents along the way and there are few pollutants. From Nan-shi to the planned Ma'an power plant site, there are many residents along the way. After the water volume of Dajia River decreased, the degree of pollution increased relatively.

Highly polluting algae in the water such as Navicula rhychocephala, Gomphonema angustatum, Synedra ulna, Cymbella affinis, etc., may increase accordingly; low-pollution algae such as Peridinium bipes, Fragilaria Virescens, etc., may decrease.

The small lake formed upstream of the barrage is only about 10 meters deep and has an inlet to divert water. The stored water flows frequently and is not suitable for algae growth, so it is unlikely to cause nutrient problems.

C-2-4. Aquatic animals

1. Construction stage

The direct construction in the water of the barrage has led to water pollution and the discharge of wastewater from the work area has led to an increase in the concentration of BOD in the water, which has adverse effects on the habitat of aquatic organisms.

2. Operation stage

In the section of the river between the Ma’an Project barrage site and Tian-lun rear pond, due to the operation of the power plant, the flow rate is reduced most of the time and the water depth is reduced. Some fish and aquatic insects may not be able to survive.

Due to the impact of water storage above the barrage, fish species suitable for living in streams or shallow water may be forced to move upstream to the backwater area.

C-3 Socioeconomic environment

C-3-1. Community structure

1. Construction stage

The main working areas of this project are in Qing-fu Village and Nan-shi Village of Dong-shi Town. It is estimated that among the 2,500 people that may be brought in during the peak construction period, most of them will be except for Taipower engineering personnel, contractor supervision and management personnel, and special technical personnel related to blasting. The skilled workers and general workers will come from the nearby villages of He-ping Township, Dong-shi Town and Xin-she Township, and they will mainly commute to work. Therefore, there will be no significant impact on the community structure of the villages and towns in the work area during the construction period.

2. Operation stage

Only about 20 people are needed to operate the power plant, which will have no impact on the community structure of nearby villages.

C-3-2. Industrial economic activities

1. Construction stage

Mainly changed into secondary industry (construction industry) and tertiary industry (commerce and service industry) induced by construction activities. Except for the construction industry, its circle of influence is mostly limited to Dong-shi Town and He-ping Village near the industrial area; because the construction industry has bidding qualification restrictions and is very professional, participating builders may expand to other areas in Taichung County and City.

The commercial and service industries are mainly small-scale catering, retail, and service industries (barbering, laundry...).

Such shops will be developed along the roadside of Zhongheng highway. It is initially estimated that 10 to 20 such shops may be added.

The land for large-scale engineering facilities such as switchyards, power plants, and construction roads is about 1.5 hectares, mostly located in Qing-fu Village, Dong-shi Town. The area of fruit trees cut down only accounts for 0.05% of the area of fruit trees in Dong-shi Town; abandoned knocking sites The required land area is about 10 hectares, and the administrative division is Xin-she Township. The orchard area to be cut down only accounts for 1.2% of the orchard area in Xin-she Township. Therefore, the construction will have little impact on the original agricultural economic activities in the planned area.

2. Operation stage

The construction industry and industrial and commercial service industries introduced during the construction phase of the planned area will be transferred out or cease operations as the project is completed and many construction workers are evacuated. Some commercial and service shops may continue to exist. However, since there are only about 20 operating personnel in the power plant in operation, and there is no community development hinterland in the nearby area, the population that such shops can serve will be reduced to the situation before construction. It is estimated that more than 70%

of new products/shops introduced during the construction period should be closed down.

C-3-3. The traffic

1. Construction stage

The approximately 14-kilometer section of the Zhongheng highway from Da-mao-pu to Bai-leng was subject to equipment handling and other construction during the construction of the power plant, switch yard, tailwater drainage channel, construction road for drift C and Tank (surge), as well as barrage and water inlet projects. The activities have a huge impact on the traffic on the cross-border highway with an average road width of only 7.5 meters. During the construction of drift B, penstock and headwater tunnels, there were frequent bumps. It is estimated that during the working hours of each construction road entrance from 8 am to 5 pm every day, an average of 8 trucks enter and exit every hour. For Zhongheng highway, although the interference is not as serious as the construction of the aforementioned projects, the impact period is longer.

The factory passage between the tailrace exit and the Ma’an Power Plant is a false tunnel. About 10 meters of the Zhongheng highway must be excavated. After the reinforced concrete passage structure is completed, it will be covered with soil and the road surface will be repaired. To avoid affecting the traffic on Zhongheng highway during the construction, a temporary road of the same width as the factory room will be temporarily closed on the inside of the highway so that vehicles can temporarily change their route.

Therefore, although the construction of the factory channel will temporarily damage the pavement of Zhongheng highway, it will not affect its traffic.

2. Operation stage

Only 1 to 2 official vehicles and engineering vehicles occasionally enter and leave the factory, which does not affect the traffic on Zhongheng highway.

C-3-4. Utilization of four water bodies

1. Construction stage

The river barrage and water inlet adopt the half-channel river construction method, which does not block the stream water, so it does not interfere with the flow of the downstream river, and has no impact on the water diversion of the irrigation road and the pumping of wide-mouth wells as simple tap water sources.

2. Operation stage

There is no water diversion for irrigation between the Ma'an Project barrage and the tailwater discharge port of the Tian-lun rear pond. Therefore, whether the operation of the power plant will affect the use of river water downstream of the Tian-lun rear pond depends on the adjustment capabilities of the joint operation of the rear pond and Shi-gang Dam.

The current effective capacity of Shi-gang Dam is 1.7 million m3, and the Tian-lun rear pond is 700,000 m3. Based on hydrological simulations for 30 years from 1943 to 1972, it is calculated to meet the needs of the maximum capacity of the reverse adjustment tank required for downstream water demand is 2,430,829 m3. Now the total effective capacity of Shi-gang Dam and Tian-lun rear pond is 2.4 million m3, so it is insufficient. The capacity is 30,829 m3, and its occurrence rate is only 0.7%. Taipower Corporation has planned Jun-shen(濬深) rear pond 30 cm deeper to maintain the rear pond capacity to 750,000 m3, which can be fully filled sufficient downstream counter-regulatory capacity. Therefore, the operation of the power plant will not affect downstream irrigation and water supply.

C-3-5. Related facilities or projects

1. Construction stage

Water, electricity, and communication facilities required for construction can all be accessed nearby. The daily construction water consumption of about 0.0582 m3/s can be diverted from nearby stream or pumped from Dajia River. There is no need to expand the local simple tap water supply facilities.

The low-voltage electricity required for construction site lighting can be supplied by the nearby power system; the high-voltage electricity required for heavy machinery operation is supplied by the contractor's own generator, so it does not increase the load on the local power system. There are already telecommunications services in the planned area. The number of telephones required in the work area is less than 10, which is very small. There is no need to expand the scale of existing communication facilities.

The water conservancy facilities of the Dajia River between the Ma'an Project barrage and Shi-gang Dam include the Tian-lun rear pond and four irrigation water inlets. Although the sediment content in the downstream increased during the construction of the barrage, it did not cause siltation of the river bed and affected the river. Operation of rear pool and water inlet.

The planned area is non-urban planning land and there is currently no specific development plan.

2. Operation stage

Only about 20 employees for power plant operation and maintenance are stationed, which does not put any pressure on existing local public facilities.

The operation of the Tian-lun rear pool, Shi-gang Dam and irrigation water inlet is affected by the operation of the power plant, and the flow rate changes drastically during peak and off-peak times. To ensure the safety of the rear pool and normal supply for downstream irrigation and public water use, it is planned to build a water release gate (4.0 m wide and 3.0 m high) on the middle embankment of the back pond. The drainage volume can be increased by 68 m3/s, making the original drainage capacity increased from 80 m3/s to 148 m3/s, which can safely discharge the 144.5 m3/s of tail water designed for the power generation of the Ma'an Project power plant.

The counter-regulatory operation of the Tian-lun rear pond and Shi-gang Dam must strengthen coordination and connection; the operation principle is: before peak power generation, the rear pond maintains a low water level; during peak power generation, in addition to giving priority to Da-mao-pu canal, Lao canal, Dong-shi canal for irrigation water demand (about 1.742 m3/s), try to store it to the highest water level. The remaining water is then discharged through the gate into Dajia River and stored in Shi-gang Dam.

During the off-peak period, when Shi-gang Dam needs water, the water supply from the rear pond can be coordinated by phone at any time.

In 1974, the Water Conservancy Bureau started planning the expansion and development of the water source in the lower reaches of Dajia River. It was planned to build Ma'an Dam and Long-bao Dam respectively near Ma'an Liao (lodging), the main stream of Dajia River and Tou-bian-keng River, the upper tributary of Wu River. A water diversion tunnel is built between the Ma'an and Tou-bian-keng to store the remaining water of the Dajia River in the Ma'an Reservoir of the main stream and the cross-regional storage in the Long-bao Reservoir. It can be supplied to the greater Taichung area through the joint operation of the Ma'an, Long-bao and Shi-gang reservoirs. It can also replace the water supply scope of Jianmin Reservoir and Guoxing Reservoir for tap water needs in Zhang-bin area. The planning of this project is still in progress. The optimal scale and configuration planned in 1975 are shown in Table 20 and Figure 30.

Table 20 Main Planning Data of the Optimal Plan for Water Source Expansion Development Plan in the Lower Reaches of Dajia River

Item		Planning data
Ma’an Dam	Full water level elevation	500 m
	Full water level volume	$95{,}876 \times 10^3$ m^3
Long-boa Dam	Full water level elevation	265 m
	Full water level volume	$45{,}101 \times 10^3$ m^3
Volume of water diversion tunnel		15 m^3/s

Item		Planning data
Shortage Index	Daily water supply	850 m^3/day
	Annual water supply	310,250 m^3/day

Note: Excerpted from Taiwan Provincial Water Conservancy Bureau Planning Corps: "75th Annual Dajia River Lower Water Source Expansion Planning Report", June 1975.

This content of the water source expansion development plan will interact with the Taipower Corporation's Ma'an Hydropower Project to utilize water resources in the basin. To ensure that the planning work of Taipower Corporation and the Water Conservancy Bureau is followed, the Water Resources Unified Planning Committee of the Ministry of Economic Affairs has come forward. After the completion of the Ma'an Hydropower Project, Taipower Corporation has developed a water distribution plan based on the results of previous coordination efforts. The power generation tail water will be used in conjunction with the Water Conservancy Bureau's Ma'an Reservoir and Long-bao Reservoir development plans to optimize the water resources usage in the lower reaches of the Dajia River.

Taipower Corporation has developed the following cooperation plans for the Long-bao Reservoir Project and the Ma'an Reservoir Project with different development schedules:

(1) In line with the Long-bao Reservoir project developed in 1993.

A third pool with a capacity of approximately 500,000 m3 was added to the Tian-lun rear pond. An inverted siphon was used to divert water from the left side of the pool across the Dajia River bed to the left bank, connecting the Jiling water diversion tunnel between Ma'an Reservoir and Long-bao Reservoir. It discharges the tail water from power generation into Long-bao

Reservoir and drain into Long-bao Hydropower Plant at the end of the tunnel.

(2) Coordination with the development plan of the Ma’an Reservoir in 2011.

An underground pumping station is built on the hillside on the left side of the Ma'an Reservoir. The off-peak period is used to pump water from the expanded the Tian-lun rear pond. At the same time, the Long-bao Hydropower Plant can operate as a peak power plant.

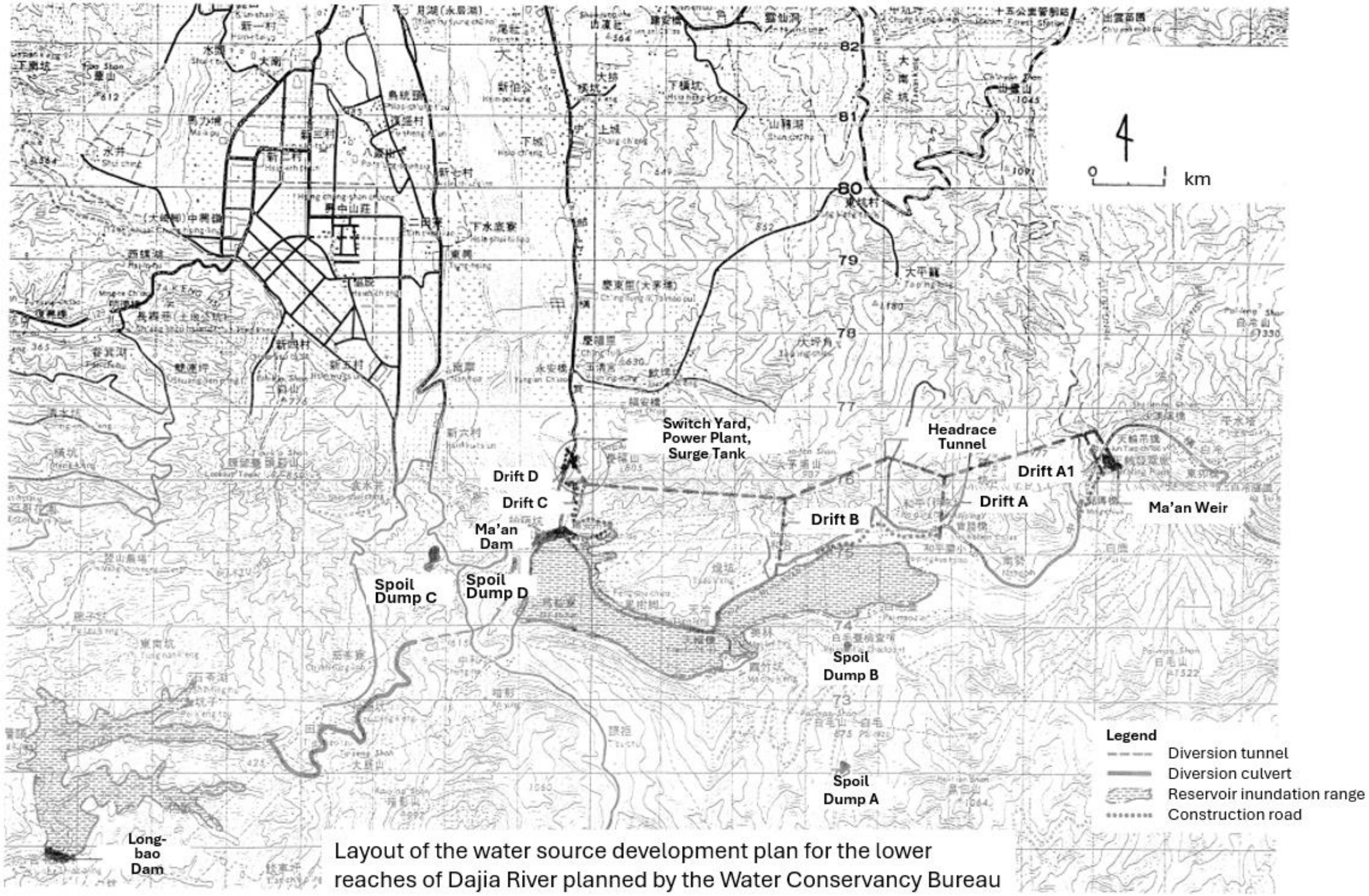


Figure 31 Layout of the Water Source Development Plan for the Lower Reaches of Dajia River Planned by the Water Conservancy Bureau

C-4 Cultural and beautiful environment

C-4-1. Cultural assets

1. Construction stage

The Heping ruins, Zaokeng ruins and Fushan Temple ruins are located near drift A, drift B and the construction road leading to drift A respectively. During the excavation of drifts, a small part of the ruins may be destroyed (see Figure 21).

2. Operation stage

No effect.

C-4-2. Landscape aesthetic

1. Construction stage

(1) Engineering facility location

Except for the barrage, all engineering facilities including power plants, switch yards, Tanks (surges), tunnels and construction pits are built on the north side of the Zhongheng highway. According to the viewshed analysis, the main visual corridor affected is the Zhongheng highway.

Although the surface damage, construction of dormitories, and various construction activities during the construction have made the environment of the work area inconsistent with the surrounding environment, the strong contrast caused by the construction has been weakened because most of the nearby slopes have been reclaimed and planted with fruit trees, giving the landscape features of man-made land use. Moreover, each engineering facility is distributed in a point-like manner and is not a landscape stronghold. It only takes a few seconds for vehicles to pass by, so it is unlikely to arouse significant concern from passengers. The level of visual sensitivity is low, so the negative landscape impact caused by the construction is low.

(2) Spoil dump

Each spoil dump is in a small valley on the south bank of Dajia River. During the use period, the deterioration of landscape quality was mainly caused by the dust in the nearby areas caused by dumping operations and the damage to the valley topography.

① Spoil dump A

The period of use of the spoil dump A is about 24 months. The valley where it is located is a valley-shaped water catchment area. The opening of the valley faces north, and you can overlook the west side of the Snow Mountains. Looking down, you can see the western half of He-ping Township and the quarrying of Ronggong. The field of view are still good. Since the elevation is between 750 and 775 meters, although the opening of the valley is not wide, you can still see a short section of the Zhongheng highway. However, the sight distance is more than 3 kilometers, and coupled with the weather conditions, it cannot always be seen clearly. Therefore, in terms of sight area, the construction of Abandoned Knockout Ground A will not have a great impact on tourists on the Zhongheng highway.

Since the waste magnetic field is located about 700 meters away from Provincial Road No. 21, the spoil dump can be directly seen from Provincial Road No. 21, which has a greater visual impact on passersby. However, the provincial road has not yet been paved. The traffic volume is very small, and its impact is undesirable.

② Spoil dump B

The period of use of the spoil dump B is about 12 months. The valley where it is located is an open-shaped water catchment area. The opening of the valley faces north and is wide, so the dynamics on the other side of the Dajia River can be directly seen. For the Zhongheng highway, the sight distance is within 1 km, the elevation is 550~575 m, and the relative height difference is about 100 m. For passengers along the Zhongheng highway, the visual impact is relatively large.

③ Spoil dump C

The usage period of spoil dump C is about 30 months. The valley where it is located is a circle-shaped water catchment area. The opening faces the southeast and is completely closed to the Zhongheng highway. Therefore, it will not cause visual impact in terms of sight area.

Highway 131 passes above this spoil dump. Looking down from the highway, you can clearly see this spoil dump. It has a great visual impact on the people and vehicles passing by highway 131.

④ Spoil dump D

The spoil dump D will be used for about 12 months. It is located on the terrace on the right side of the meandering stream. It is completely closed to the Zhongheng highway and will not cause visual impact.

Highway 131 runs along the creek, so travelers on this highway will clearly be able to see this waste dump, which has a great visual impact.

2. Operation stage

(1) Engineering facility location

The ground engineering facilities on the north side of the Zhongheng highway and the Dajia River Barrage will form new visual focuses, just like the existing Tian-lun Power Plant.

Drift C is in landscape unit 11. The concrete surface formed by the pit entrance creates a huge contrast with the surrounding orchards, making it extremely uncoordinated in the landscape.

(2) Spoil dump

The right to use each spoil dump is usually obtained through leasing. After the waste disposal is filled, it must still be returned to the owner. Therefore, the newly formed land, after being exposed for a short period of time, is mostly restored to its original use of fruit tree planting, which is consistent with the land use pattern of the surrounding environment, and has little impact on the landscape.

C-4-3. Sightseeing and recreation

1. Construction stage

The locations of major engineering facilities are not within the recreation area, so there will be no impact on local recreation resources.

The recreational bases on the Zhongheng highway to the west of the planned area, such as Shigang Dam, Yong'an temple, and the Five Blessings Sacred Tree, will not be affected by the construction of this project. To the east of Gug-uan, Li mtn., He-huan mtn., etc., the construction may affect the smooth flow of traffic, slightly delaying the journey and reducing the quality of transportation services. However, because many tourists have not been informed of the traffic inconvenience caused by the construction in advance, it will not change their travel. Therefore, the impact on the number of tourists on the Zhongheng highway should be slight.

Since the planned area is not a landscape base, the deterioration of local landscapes during construction will not significantly affect tourists' recreational experience. For some tourists, major engineering construction also constitutes one of the scenic and interpretive resources during the trip; therefore, tourists may have different reactions in terms of recreational experience. For some people, it has a positive impact, and for some people, it has a negative impact, but overall, the impact is not serious.

2. Operation stage

The above-ground facilities added to the planned area are only power plants, switchyards and barrages that are easily visible. Such facilities do not constitute local landscape or recreational resources, so they will have no impact on local recreational activities. The waters upstream of the barrage can change the original creek bed landscape into small lake waters, such as the Gu-guan, Qing-shui and Deji reservoirs next to the Zhongheng highway, which will attract sight of tourists, its impact is positive.

For tourists traveling to scenic spots such as Gu-guan and Li mtn. via the Zhongheng highway, even if the ground engineering facilities are not in harmony with the surrounding environment, they will only pass by for a few seconds and will not affect the recreational experience or the number of tourists.

D. Comprehensive assessment

D-1 Social Questionnaire Survey

In order to understand the opinions of people in the project area on the Ma'an Hydropower Project, an on-site social questionnaire survey was conducted on residents near the project site and the waste dump. In addition to ordinary residents, the interviewees also include people familiar with local public affairs such as relevant personnel of the township government construction section, village chiefs and officials. A total of 93 valid questionnaires were collected. Among them, 16 people live in Qingfu villiage(慶福里), 19 in Nanshi Village(南勢村), 8 in Tianlun Village(天輪村), 13 in Fuxing Village(福興村), 9 in Zhonghe Village(中和村), and other villages (including Shangcheng Village(上城里), Xiacheng Village(下城里), Qingdong Village(慶東里) , Zhaoxing Village(詔興里), Dongxin Village(東新里) , Guangxing Village(廣興里) in Dongxi Township(東勢鎮), Boai Village(博愛村) of Heping Township(和平鄉), and Xinshe Village(新社村) of Xinshe Township(新社鄉)) 28 copies. The educational level of the interviewees, those who have graduated from primary school, has the highest proportion, accounting for 43% ; followed by high school graduates, accounting for 20%. The highest occupation is farming at 40%, followed by civil servants at 20% and businessmen at 16%. In terms of origin, Hakkas(客家人) account for the largest number of 82%, followed by Hokkien(福建人) at 12%, and Aboriginal people at only 5% (see Table 21).

Table 21 Social Questionnaire Survey Sample Structure

Item	Share(%)		Item	Share(%)	
1. Sample number in the village		100	4.Occupation		100
(1) Qingfu village, Dongxi Township	17		(1) Civil servant	20	
(2) Nanshi Village, Heping Township	20		(2) Farmer	47	
(3) Tianlun Village, Heping Township	9		(3) Mining and Quarrying	1	
(4) Fuxing Village, Xinshe Township	14		(4) Worker	3	
(5) Zhonghe Village, Xinshe Township	10		(5) Business	17	
(6) Others	30		(6) Others	12	
2.Gender		100	5.Origin		100
(1) Male	91		(1) Aboriginals	5	
(2) Female	9		(2) Hakkas	82	
3.Education		100	(3) Hokkien	12	
(1)Illiterate	6		(4) Mainlander	1	
(2)Primary School	43		6. Main income source		100
(3)Junior High School	18		(1) Self-employed		76
(4)Senior High School	20		·Agriculture	62	
(5)College	13		·Catering	2	
			·Retail industry	5	
			·Other	7	
			(2) Employed		24

The first part of the questionnaire is about opinions on the current situation of the environment. Generally speaking, there is not much difference in the answers from each village. The main items for respondents who are satisfied with the living environment are fresh air, simple folk customs, good climate and scenery. For those who are dissatisfied with the living environment, most of the reasons cited include poor public facilities, insufficient medical facilities, and lack of entertainment facilities.

As for drinking water for residents, most of it comes from mountain spring water, and in some places are simple tap water. As for garbage disposal, only Nanshi Village near the township office has garbage trucks for collection. In other areas, especially scattered farmhouses or illegal settlements on the hillside, they are burned or abandoned in the fields and ditches (see Table 22).

Table 22 Survey on Local Residents' Opinions on Current Environment

Item	Share(%)
1. Residents' satisfaction with current living environment	
(1) Fresh air	76
(2) Folk customs	73
(3) Weather	62
(4) Scenery	58
(5) Tranquility	41
(6) Transportation	30
(7) Low living cost	12
(8) Employment opportunities	3
2. Residents' dissatisfaction with current living environment	
(1) Public facilities	67
(2) Medical facilities	59
(3) Entertainment facilities	49
(4) Employment opportunities	20
(5) School	16
(6) Transportation	15
(7) High crime rate	11
(8) High living cost	6
3.Drinking water source	
(1) Tap water	72
(2) Mountain spring water	24
(3) River water	2
(4) Underground water	2
4.Garbage disposal methods	
(1) Garbage truck removal	49
(2) Dump casually	19
(3) Self-incineration	18
(4) Self-bury	14

The second part of the questionnaire is about opinions on the power generation project, 24% of people think that the construction period will help provide employment opportunities, while 76% of people think that it will not help with employment opportunities. The main reason is that they already have stable jobs. As for the impact of the construction process, the biggest impact is on the fruit farmers near the planned factory site and the waste dump; 82% of the respondents think it is helpful to promote the prosperity of local business, among which the catering industry and grocery retail industry are the most helpful. Regarding how to use the gently sloping land formed by the dumped ballast site in the future, most people advocated planting trees for greening or letting the people rent it for use. The response rates for the two were 52% and 43% respectively. Regarding the environmental pollution and inconvenience caused during the construction period, the interviewees believed that the constructior should pay special attention to the improvement of noise, especially the horns and explosions caused by large trucks, followed by road pollution, air pollution, water pollution and vibration. Such temporary pollution and inconvenience, 90% of the respondents thought it was bearable, while only 10% thought it was intolerable (see Table 23).

Table 23 Residents' Views on the Ma'an Hydropower Project

Item	Share(%)		Item	Share(%)	
1.Is it helpful to provide employment opportunities?		100	5.Environmental problem should improved during construction period		100
(1) Helpful		24	(1) Noise		88
(2) Unhelpful		76	(2) Road pollution		44
·Already have stable job	57		(3) Air pollution		38
·Long distance	8		(4) Water pollution		29
·Hard working condition	8		(5) Vibration		27
·Competition	6		6.Can you tolerate the pollution and inconvenience during construction?		100
2.Impact on current industry during construction period?		100	(1) Yes		90
(1) Yes		67	(2) No		10
(2) No		33	7.Do you agree with the Ma On Hydropower Project?		100
3.Will it help regional business prosperity during construction?		100	(1) Yes		87
(1) No		18	·Need power construction	75	
(2) Yes		82	·Promote local prosperity	61	
·Catering	62		·Create job opportunity	33	
·Grocery retail	62		(2) No		2
·Rental industry	24		(3) No comment		11
·Barber industry	24		8.Opinions on hydraulic development along Dajia River		
·Entertainment industry	20		(1) Should develop if there's value		68
·Building materials industry	17		(2) Should continue development		65
·Electrical and Mechanical Repair Industry	11		(3) Others		12
4.Renewal utilization of waste dump			(4) No rush to develop		8
(1) Planting trees and greening		52	(5) No need to continue development		2
(2) Rental use		43	Note: the questionnaire contain multiple choice questions.		
(3) Small park		31			
(4) Parking lot		18			
(3) Others		15			
(3) Playground		11			

Regarding the opinion of hydraulic development along Dajia River, the general residents hold a positive attitude, and the vast majority of them believe that as long as it is valuable, it is worth developing. Overall, 87% of the respondents were in favor of the Ma'an Hydropower Project, while only 2%

were opposed. Other relevant opinions are mainly that when Taipower expropriate land for power plant, it should increase the reasonable compensation amount as much as possible (see Table 24).

Table 24 Residents' Views on The Environmental Impact of Ma'an Hydropower Project

Item	Share(%)			
	Beneficial impact	Adverse impact	No impact	No idea
(1) Impact on Taiwan power system	76	0	0	23
(2) Impact on downstream irrigation system	52	6	10	32
(3) Impact on Taichung water supply system	47	4	11	38
(4) Impact on Zhongheng highway tourism and sightseeing	66	2	13	19
(5) Impact on Zhongheng highway transportation	40	16	22	22
(6) Impact on fishing activity in nearby water	27	12	23	38
(7) Impact on nearby village development	57	0	11	32

D-2 Comprehensive Analysis of Weight Scale

In order to expand the level of participation in the assessment work and objectively weigh the relative impact of each environmental project, experts and scholars in different fields and people in the project area are invited to participate in the comprehensive assessment of the weight scale.

D-2-1. Participating members

A total of 24 experts and scholars participated in the comprehensive evaluation (30 questionnaires were distributed, with a response rate of 80%), a total of 25 local residents (26 questionnaires were distributed, a response rate of 96.2%), and a total of 12 members of the project working group. The expertise or background of the participants is hereby summarized into two major fields: natural ecological environment and humanistic, social and economic environment (see Table 25) to facilitate statistical analysis of comment data.

Table 25 Personnel Involved in the Comprehensive Assessment of Weight Scales

Expertise or background	Participating members
Natural ecological environment (A total of 19 members, include 9 from project working group)	Wang Xin▲(王鑫), Wang Zhongkui(王忠魁), Li Sanwei(李三畏), Lu Guangyang(呂光洋), Wu Jianmin(吳建民), Lin Wensong▲(林文松), Lin Suzhen▲(林素貞), Lin Chongmin▲(林崇民), Lin Yaosong▲(林曜松), Liu Gu(柳榗), Chen Mingyi(陳明義), Chen Junhong▲(陳俊宏), Chen Fanshou(陳繁首), Zeng Sigong(曾四恭), Zhang Yuezhu▲(張月珠), Liu Changling(劉長齡), Liu Kunshan(劉崑山), Xie Changfu▲(謝長富), Su Meixin▲(蘇玫心)
Humanistic, social and economic	Wang Qiuzhu△(王秋助), Fang Baisheng△(方柏盛),

environment (A total of 42 members, include 3 from project working group, 25 from project area)	Shi Lei(石磊), Zuo Xianneng(左顯能), Song Guangyu(宋光宇), Yu Qiuyun△(余秋運), Lin Mushao△(林木紹), Lin Kunguang△(林焜光), Lin Yuncai△(林運財), Qiu Jingui△(邱進貴), Hou Jiaju(侯家駒), Shi Shanbao(施善堡), Tu Wu Yingmei△(涂吳英妹), Xu Gu(徐谷), Huang Liang▲(黃良), Huang Yingtu(黃英塗), Huang Chunguang△(黃春光), Chen Shuiyuan(陳水源), Chen Shenxian(陳伸賢), Chen Zhaoming(陳昭明), Chen Zhangpeng▲(陳章鵬), Chen Rongzang(陳榮藏), Zeng Jinyuan△(曾進源), Zhang Dengrong△(張燈榮), Yang Yuanjin(楊垣進), Zhan Qiumei△(詹秋美), Zhan Jinyou△(詹進有), Zhan Desheng△(詹德生), Cai Tiancai(蔡天財), Zhao Luping△(趙魯平), Liao Chentai△(廖辰太), Liao Daming△(廖達明), Liu Yilang△(劉一郎), Liu Yihuo△(劉奕火), Liu Yichang▲(劉益昌), Liu Ruiwen▲(劉瑞文), Deng Chunxiang△(鄧春相), Lai Liu Xiuli△(賴劉秀麗), Xie Dingfa△(謝丁發), Xie Zhishang(謝志尚), Luo Jixing△(羅吉興), Luo Wuneng△(羅武能)

▲: refers to the people in project area; △: refers to project working group member, the rest are experts.

D-2-2. Weight scale evaluation method

1. Environmental unit weight value allocation

The weight values are allocated using the paired comparison method(成偶對比法). From the recycled samples in the two major environmental fields summarized in Table 25, the same number of samples is selected and averaged. When selecting the number of samples, the primary criterion is that the evaluator's expertise or background can cover environmental projects in this field. (See Table 26)

Table 26 Environmental Unit Weight Value Analysis Sample

Environmental field	Sample
Natural ecological environment (A total of 19 members, include 9 from project working group)	Wang Xin▲(王鑫), Wang Zhongkui(王忠魁), Li Sanwei(李三畏), Lu Guangyang(呂光洋), Wu Jianmin(吳建民), Lin Wensong▲(林文松), Lin Suzhen▲(林素貞), Lin Chongmin▲(林崇民), Lin Yaosong▲(林曜松), Liu Gu(柳榗), Chen Mingyi(陳明義), Chen Junhong▲(陳俊宏), Chen Fanshou(陳繁首), Zeng Sigong(曾四恭), Zhang Yuezhu▲(張月珠), Liu Changling(劉長齡), Liu Kunshan(劉崑山), Xie Changfu▲(謝長富), Su Meixin▲(蘇玫心)
Humanistic, social and economic environment (A total of 19 members, include 3 from project working group, 5 from project area)	Shi Lei(石磊), Lin Mushao△(林木紹), Hou Jiaju(侯家駒), Shi Shanbao(施善堡), Xu Gu(徐谷), Huang Yingtu(黃英塗), Huang Chunguang△(黃春光), Chen Shuiyuan(陳水源), Chen Zhaoming(陳昭明), Chen Zhangpeng▲(陳章鵬), Chen Rongzang(陳榮藏), Zeng Jinyuan△(曾進源), Yang Yuanjin(楊垣進), Cai Tiancai(蔡天財), Zhao Luping△(趙魯平), Liu Yihuo△(劉奕火), Liu Yichang▲(劉益昌), Liu Ruiwen▲(劉瑞文), Xie Zhishang(謝志尚)

▲: refers to the people in project area; △: refers to project working group member, the rest are experts.

2. Distribution of environmental project weight values

Each environmental unit contains 3 to 6 environmental items, and their weight values are directly allocated in percentages. The weight distribution of environmental items in the natural environment and biological environment is averaged by all samples in the field of natural ecological environment summarized in Table 25; the weight distribution of environmental items in the socio-economic environment and cultural quality environment is based on Table 25. All samples in the humanities, social, economic and environmental fields are averaged.

3. Impact scale of each environmental item

The evaluation scale adopts the Anchored Interval Scale(等距尺度) at both ends and is divided into seven levels, including 3 adverse impact level, 3 favorable impact level and 1 no impact level.

Favorable impacts and adverse impacts are divided into three levels: significant, moderate and slight impact respectively. The evaluation points range from significant adverse impact to significant beneficial impact, and the order is -3, 2, -1, 0, 1, 2, 3. The statistical sample is assigned the same weight value as the environmental project, but the mode value is used as the representative value of the impact scale evaluation.

D-2-3. Statistical analysis results

Each environmental project may have beneficial or adverse impacts during the construction and operation stages, and the degree of impact also varies. Based on the full range of the maximum impact scale of all adverse or beneficial impact projects, we define those with an impact scale below 1/2 of the total range as relatively slight impacts, those with impact scales between 1/2 and 3/4 as relatively moderate impacts, and 3/4 above are relatively significant impacts to distinguish the relative impact degree of each environmental project. During the construction period, there were 14 adverse impact items, of which 2 were significant; there was 1 favorable impact item, and the degree of impact was not significant. There were 5 items with adverse effects during operation, and the number of items with significant adverse effects was reduced to 1; there was 1 item with favorable effects, and the degree of impact was significant (see Table 27)

Table 27 Relative Weight and Impact Scale of Environmental Projects

Environmental aspect (relative weight)	Environmental item	(relative weight)	Relative impact scale	
			Construction	Operation
Natural environment (30.2%)	Geography	(7.2%)	-0.144▲	0.0
	Air quality	(3.7%)	-0.074	0.0
	Hydrology	(6.4%)	-0.064	-0.128△
	Water quality	(6.0%)	-0.060	0.0
	Noise and Vibration	(3.1%)	-0.031	0.0
	Solid waste	(3.8%)	-0.038	0.0
Biological environment (27.2%)	Terrestrial plants	(6.8%)	-0.068	0.0
	Terrestrial animals	(6.7%)	-0.134▲	-0.067
	Aquatic plants	(5.7%)	-0.057	-0.057
	Aquatic animals	(8.0%)	-0.080	-0.160▲
Socioeconomic environment (19.4%)	Community structure	(3.0%)	0.0	0.0
	Economic activities	(4.6%)	+0.046	0.0
	Transportation	(4.4%)	-0.044	0.0
	Water body utilization	(4.0%)	0.0	-0.040
	Relative facility & project	(3.4%)	0.0	0.0
Cultural beauty environment (23.2%)	Cultural asset	(6.3%)	-0.063	0.0
	Landscape quality	(8.1%)	-0.081	0.0
	Tourism	(8.8%)	-0.088△	+0.176▲

A positive value indicates a beneficial impact, a negative value indicates an adverse impact, and the larger the value, the greater the impact. ▲: refers to significant impact; △: refers to moderate impact; the rest are slight impact.

E. Summary of Main Environmental Impacts

E-1 Beneficial impact

E-1-1. Full utilization of water resources

Dajia River is the river with the richest hydraulic reserves in Taiwan. Currently, there are five hydropower plants in the middle and upper reaches, and the New Tian-lun power plant is under construction, with a total installation capacity of 969,900 kW; however, there is still a drop of more than 100 meters between the New Tian-lun power plant and Ma'an Liao downstream, which has yet to be fully utilized. When the peak power generation tailwater volume generated by the New Tian-lun Power Plant and Tian-lun Power Plant is 138 m3/s, adding a power plant near Ma'an Liao can increase the net peak capacity by 133,500 kW and increase the annual power generation by more than 400 million kWh. The tailwater from its power generation is still discharged into Dajia River for downstream irrigation and public water supply. Therefore, the operation of the Ma’an Hydropower Project does not consume water resources and does not pollute water quality. It is an economical and effective use of the country's overall water resources.

E-1-2. Promote local economic activity during construction

The existing community settlements in the planned area are very small, and industry and commerce are underdeveloped. There are only small restaurants and grocery stores scattered along both sides of the Zhongheng highway. During the construction phase, many TPC engineer, contractor supervisors, and technical workers were stationed, which had a positive impact on the nearby catering, retail and service industries.

E-1-3. Creation of tourism and recreation resources

The small lake formed upstream of the planned Ma'an Barrage can improve the landscape quality of the local waters. If a small parking lot and leisure and interpretation facilities can be built around it, it can form a new tourist and recreational base.

E-2 Adverse effects

E-2-1. Environmental pollution during construction

During the construction period of any project, it will inevitably cause air and water pollution near the work area, as well as an increase in noise and vibration levels. Good construction management must be implemented to minimize the level of pollution.

During the construction of the Ma'an Hydropower Project, the more significant pollutions are: ① The concentration of suspended particles and falling dust increases in the work area and along the earth moving path; ② The excavation of the work area causes the turbidity of Dajia River to increase, especially in the two seasons; as well as the sudden increase in volume level caused by explosions and the construction noise generated by heavy machinery construction sites, etc.

E-2-2. Landscape damage during construction

The surface damage caused by partial land preparation works at each construction site, the construction of work quarters, and the stacking of construction machinery and equipment will temporarily damage the existing visual landscape quality of the planned area.

E-2-3. Traffic interference during construction

During the construction period of the construction area, many earth-moving vehicles will enter and exit, which will inevitably interfere with the smooth traffic flow of the Zhongheng highway. The tourist bases along the Zhongheng highway to the east of the planned area may be affected by traffic congestion during the peak tourist season.

E-2-4. Damages to river ecological environment

During the excavation of the Ma'an Project barrage, the water pollution caused by its downstream to the Tian-lun rear pond and the flow change caused by the operation of the power plant after completion were detrimental to the habitat of river fish. However, the fish biological resources in this section of the river remained unchanged. The investigation found no rare species and migratory fish (the downstream is blocked by Shi-gang Dam), so changes in the hydrological and water quality environment will not have a significant impact on the ecological environment of the Dajia River.

E-2-5. Loss of land productivity

The spoil dump, switch yard, power plant and construction road occupy part of the orchard. In addition to the new land of the spoil dump, fruit trees may continue to be planted. The land used for power plant facilities will lose land productivity during the operation period. However, the area is not large and it has no impact on the local area. The impact on agricultural production activities is slight.

F. Environmental Impact Countermeasures

F-1 Corresponding countermeasures of the design stage

F-1-1. Technical countermeasures

1. Environmental protection engineering design

Environmental protection projects under construction include temporary drainage, gully and surface erosion control, sediment runoff control, waste sewage disposal and garbage disposal, etc. Environmental protection projects in operation are mainly employee domestic sewage and garbage treatment, all of which are incorporated in the overall planning and designing of the hydropower project, and the required funds will be included in the project cost.

2. Strengthening of environmental beautification measures

At the very beginning of project construction in mountainous areas, significant surface landscape damage was caused by land preparation and filling. The unavoidable adverse effects of this kind of construction can only be compensated by shortening the exposure time of the ground surface and creating new scenery.

For the excavated slopes of power plants, switch yards and construction roads, it is planned to carry out slope stabilization and vegetation slope protection projects immediately after the slopes are trimmed, so that when the factory construction or road paving is completed, the exposed slopes can be partially covered, and the visual landscape can be improved.

Engineering facilities within sight of Zhongheng highway will be beautified or covered from the perspective of landscape design. For permanent facilities such as power plants, harmony between architectural shape and color should be emphasized during planning and designing stage; switch yards, temporary offices, dormitories, etc., have poor landscaping and should be covered with vegetation.

3. Development of construction plan

To reduce the degree of interference to Zhongheng highway traffic during the construction period, the construction plan will be developed according to the traffic changes on Zhongheng highway. During peak tourist seasons and holidays, the tunnel excavation progress will be flexibly adjusted to ease the impact of transportation trucks entering and leaving the Zhongheng highway.

To comply with various pollution prevention and control regulations formulated by the government, the detailed construction schedule will be determined based on the operating time of noisy construction machinery and the dilution capacity of the water body to withstand pollution.

F-1-2. Administrative cooperation measures

1. Communication of public opinions

The expropriation of project land will involve issues such as compensation for existing rights and interests of land owners and users, and adjustments to life when changing jobs. Communication and coordination will be made in various aspects during the design stage to avoid social problems.

Once the land expropriation scope and compensation standards are approved, a meeting with stakeholders should be held immediately to explain in detail, so that the people can be fully prepared, respond early, reduce the psychological impact, and have the opportunity to fully understand the compensation details, so as to avoid public resentment caused by misunderstandings.

2. Good neighborly measures

Electricity system in Taiwan operates with a systematically dispatching method, so it is impossible to delineate the benefit area of any power plant. The area where the factory is built is often not a direct beneficiary area. Especially when the planned area already has electricity supply, it is more difficult for the local people to understand the need for the factory building plan. They are faced with major life changes such as land expropriation, house demolition, change of career, etc. When enduring all kinds of pollution and inconvenience during the construction period, it is inevitable that there will be rejection and resistance to the project. This depends on the sincerity of the development unit to resolve the problem.

During the planning and designing stage, the human resources for project construction in nearby villages and the public's willingness to participate in the Ma'an Hydropower Project will be investigated. When compiling the contract award documents, it will be stipulated that the contractor must employ a minimum number of local people to ensure the priority of their employment.

For the larger spoil dumps acquired through requisition, the resulting new land will be consulted with representatives of the relevant villages, and a utilization plan will be planned and designed for use by each village.

3. Coordination with relevant agencies

Regarding the issue of garbage disposal during construction and operation, we will first coordinate with He-ping Township Office and Xin-she Township Office during the design stage to study the possibility of jointly burying domestic garbage with residents in the township. If it is necessary to find another burial site, we will also work with relevant personnel from the township government to jointly survey and select, and apply for use rights in accordance with regulations.

For drinking water supply issues during construction and operation, the local township office will also be consulted at the design stage on the possibility of taking over the water supply from a nearby simple tap water system. If there is need for developing additional surface or underground water sources, applying for temporary water rights is needed in accordance with regulations.

Regarding the planning, design and operational research of the Tian-lun rear pond improvement project, we will proactively coordinate with the Water Conservancy Commission, the Provincial Water Conservancy Bureau, the Provincial Water Company and the Taichung Farmland Water Conservancy Association to carefully study the schedule for power plant operation and downstream water demand.

Regarding the mutual influence between this hydropower project and the Long-bao Reservoir and Ma'an Reservoir projects planned by the Provincial Water Conservancy Bureau, we will continue to negotiate and respect the central decision-making. Construction will not begin until the plan is approved.

F-2 Corresponding countermeasures during the construction stage

F-2-1. Prevention of pollution along soil transportation routes in Taiwan

Due to the large number of wastes in this project, most of the transport vehicles used are dump trucks with small bodies and open rear ends. During the transportation process, the wastes carried would easily fill out from the rear ends due to vibration and fall onto the road surface. When the vehicle drives out of the work area, the soil adhering to the tires will also cause track pollution along the way. To alleviate this phenomenon, trucks will be strictly controlled not to be overloaded during construction, and a cement-paved cleaning floor will be set up near the exit of the work area. Before the truck leaves, the tires will be spray-washed. The muddy water would then reach the mud collection pit around the cleaning floor, where it settles and then flows into the nearby drainage road.

F-2-2. Dust control

The large amount of dust generated during operations at tunnels and drifts, earth moving paths, and spoil dump can be reduced by frequent watering.

F-2-3. Noise control

During heavy machinery construction, if the noise level monitored at the perimeter exceeds the noise control standards for construction projects, the contractor will be instructed to replace or adjust construction machinery or stagger the operating hours of each machinery so that the noise level is reduced to the standards specified by the government.

F-2-4. Water quality and ecological environment maintenance

Excavation of slopes and new construction roads will be paved or planted immediately after repair. The waste disposal operation must be coordinated with compaction by rolling to prevent soil loss. The construction site offices and work quarters are equipped with septic tanks to treat domestic sewage from construction workers. In order to effectively control the turbidity and pollution concentration of the stream water, and in conjunction with the monitoring plan of water quality and river fish, the construction plan can be adjusted in a timely manner to reduce the deterioration of water quality and protect the habitat of fish.

F-2-5. Traffic maintenance

In line with the sightseeing season of Zhongheng highway, the construction progress will be flexibly adjusted. If necessary, waste removal will be carried out at night to reduce interference to road traffic during peak hours.

F-2-6. Landscape maintenance

Temporary buildings on construction sites, concrete mixing plants or construction material storage locations are not harmonious with the surrounding environment and will be blocked from view by planting or fencing. After all excavations and slope trimming, slope protection and beautification projects will be carried out.

F-2-7. Cultural asset maintenance

The He-ping ruins, Zao-keng ruins and Fu-shan Palace ruins are located near drift A, drift B and the construction road leading to drift A respectively. Special attention will be paid during the construction. If any ancient ruins or antiquities are unearthed, they will be treated according to the law of "Cultural Assets In accordance with the provisions of the Preservation”, work shall be stopped immediately and proactive coordination shall be made with the competent authorities for disposal.

F-3 Corresponding countermeasures during the operation stage

F-3-1. Matching downstream water needs

The water release operation of the barrage will be adjusted flexibly based on the hydrology and water quality monitoring results of the downstream river section; the operation of Tian-lun rear pond, Shi-gang Dam and Ma'an Power Plant will be coordinated with the water demand schedule and water demand of various downstream irrigation roads and public water supplies. Adjust when needed and record at any time, to have sufficient information to develop the best operating rules.

F-3-2. Coordination and modification of flood drainage operating system

The flood warning system and joint flood drainage operating rules of the Dajia River Basin will be re-developed in conjunction with the Ma'an Hydropower Project.

F-3-3. Water quality and river ecological environment maintenance

Based on the water quality and river fish biological monitoring results of the downstream reaches of the planned Ma'an Project barrage, the discharge volume of the planned Ma'an barrage will be flexibly adjusted to dilute the concentration of water pollution and maintain the water sources needed for fish survival.

F-3-4. Environment beautification

Temporary offices, concrete mixing plants, etc. should be cleaned up after completion to restore their original appearance. The entrances of drifts, waste dumps and construction road slopes will be covered with vegetation to reduce visual impact.

F-3-5. Creation of recreational opportunities

At the planned Ma'an barrage site, a small parking lot and a few recreational service facilities will be added as needed to provide tourists with opportunities to explain and stop and view the scenery.

G. Environmental Monitoring Plan

G-1 Monitoring purpose

In order to accurately grasp the degree of environmental impact during the construction stage and completed operation stage, significant and important environmental impact matters must be monitored. The purpose can be summarized as the following three points:

a. Based on the monitoring results, construction operations will be adjusted in a timely manner to comply with government regulations on pollution prevention and environmental conservation to ensure the smooth implementation of the plan.
b. Based on the monitoring results, the operation mode shall be adjusted in a timely manner to ensure the existing rights and interests of downstream water users and water rights holders, maintain the quality of local living environment and sensitive ecological environment, and avoid causing complaints from stakeholders or interest groups, in order to maintain the normal operation of power plant
c. Establish a monitoring information system to improve the accuracy of environmental impact prediction and assessment of similar projects in the future.

G-2 Monitor content

The items that should be monitored in this plan include items with significant impact such as hydrology, environmental pollution items such as water quality, air quality, noise, and river fish species for which current survey data are lacking. The monitoring locations, time and frequency, monitoring methods, analysis parameters and suggestions for implementation units are detailed in Table 28 .

Table 28 Ma’an Hydropower Project Environmental Impact Monitoring Plan

Item	Location	Time & Frequency	Method	Parameters	Supplier Recommendation
Hydrology	Bailu Suspension Bridge, Longan Bridge, Shigang Dam	During construction period: —River cross section monitor once a year. —Flow velocity and sand content once a week During operation period: —River cross section once a year —Flow velocity and sediment content are measured every half month in the dry season and once a week in the rainy season.	A self-recorded hydrological station was added at the Long'an Bridge site (Bailu Suspension Bridge and Shigang Dam already had hydrological station)	Water level, flow rate, flow velocity, sand content	Taiwan Power Company
Water Quality	Tianlun Power Plant, Bailu Suspension Bridge,	During construction period: —Starting one	Water quality testing	Water temperature, dissolved oxygen, pH	Academic institutions

	Longan Bridge, Yong'an Bridge	year before construction, once a month on sunny and rainy days. During operation period: —Once every two months on sunny and rainy days		value, turbidity, suspended solids, biochemical oxygen demand, coliform count, organic nitrogen, conductivity, ammonia nitrogen, nitrate, orthophosphate, total phosphorus	
Air Quality	Tunnel, drift and waste dump	During construction period: —During the period when tunnels and drift are removing ballast, measurements will be taken one day every two months in Hang Hau(坑口) and Nanshi(南势) and Tianleng(天冷) communities.	Continuous sampling for 24 hours to get daily average value, and the surface wind direction and wind speed are taken as a representative value for 24 hours.	Suspended particles and surface wind direction and speed	Academic institutions
Noise	15 meters away from the perimeter or close to a safe zone	During construction period: —Testing been carried out	For blasting and construction machinery noise, measure	The average volume at each time period, L5, L10, L50, L90, L95	Academic institutions

		once when the pile driver, air compressor, crusher, rock drill, piler, road roller and excavator during operation —When blasting tunnels and cross pits, measure the maximum volume at a safe location —At the project perimeter, measure the background volume once a month	the maximum volume. Continuously measure the hourly average volume and maximum volume for 24 hours at the project perimeter	percentage volume and maximum volume throughout the day	
River fish species	Between Tianlun Power Plant and Ma'an Barrage, between Ma'an Barrage and Long'an Bridge, between Long'an Bridge and Tianlun Rear Pond, and between Tianlun Rear Pond and Yong'an Bridge	During construction period: —The water quality sampling carried out one year before the construction period, surveys will be conducted once a month. During operation period:	On-site investigations and laboratory measurements	Type, quantity, weight, length	Academic institutions

		—During water quality sampling period, surveys will be conducted every two months.			

Annex I: Assessment Basis

According to the resolution of the 1854th Council Meeting of the Executive Yuan on October 13, 1983, the environmental impact assessments should be completed in advance, submitted for approval, and included in the plan by the Department of Health, when government implementing major economic construction plans, tourism resource development plans, and private construction of large-scale factories that may pollute the environment.

In November 1985, The Department of Health, Executive Yuan formulated the "Strengthening Environmental Impact Assessment Plan," which has clearly stated that for all major projects Before development, the possible impact on the environment should be assessed and corresponding countermeasures should be planned so that the plan can be implemented without causing major adverse effects on the natural environment or human living environment or causing serious public nuisance incidents.

Although it is not specified in the "Strengthening Environmental Impact Assessment Plan", announced by the Department of Health, Executive Yuan. The Ma'an Hydropower Project should undergo an environmental impact assessment, given that the total project cost is more than NT$10 billion and the construction period is as long as four years, it is indeed a major economic construction project of the government; Taipower is concerned about this project, during the construction period, there will be more or less impact on the health of the surrounding environment. In order to ensure the hydropower development and the environmental protection, complying with the environmental protection policies revealed by the government over the years, the environmental impact was proactively carried out during the feasibility study stage of the Ma'an Hydropower Project, and entrusted to China Engineering Consultants, Inc (CECI) for execution.

Annex II: Assessment Framework

I. Assessment Method

According to domestic and foreign experience, the detailed list method is most suitable for environmental impact assessment of water resources development projects. The environmental impact assessment of the Ma'an Hydropower Project also uses the detailed list method as the main body, the environmental projects will be assessed in a qualitative or quantitative manner to assess the degree of impact they may suffer during the construction period and the completion period.

The construction period of this project is from July 1991 to December 1995, and there is a clear timetable. The commercial operation after completion will last for more than 50 years. Considering the short period for the environment to stabilize after the completion of the hydroelectric power plant and the higher prediction accuracy, the year 2001 were used as the prediction period for the operation phase.

Since the environmental aspects and elements involved in development projects are very complex, the evaluation objects and factors to be considered are inherently uncertain and risky. Intuition and subjective judgment are unavoidable in the evaluation operation, which often leads to a decrease in the reliability or dispute of the evaluation results. In order to make up for this shortcoming, comprehensive assessment techniques must be used. During the assessment process, relevant institutions, scholars and experts in related fields, interest groups in different positions, and people in the areas affected by the project are invited to participate in the assessment of environmental impact scales. Through the comprehensive evaluation process, the opinions of all parties are included, which can comply with the principle of openness and fairness, and make the evaluation results have social consensus and be a useful reference for decision-making.

The comprehensive assessment method used in this project is the weighting scaling checklist method(權重尺度明細表法), which first uses hierarchical analysis techniques and depends on the subordinate relationships of environmental factors to create an environmental system correlation tree. The Impact Scenario Writing (環境影響演繹) is created based on the current status, construction and operation environmental quality investigation and prediction results of each environmental project in the correlation tree, and invite relevant institutions, groups or individuals to evaluate the relative importance and impact scale of each environmental item, using the pair-wise comparison technique (成偶對比技巧) under two conditions "under construction" and "in operation". Finally, statistical analysis methods are used to summarize the significant or important environmental impact items of this plan, so that corresponding countermeasures or monitoring plans can be developed.

II. Assessment Process

The China Engineering Consultants, Inc (CECI) mobilized internal personnel with experience in environmental assessment and invited experts and scholars in ecology and archeology who have knowledge of the local environment to form a project working group, in an interdisciplinary integration manner to conduct research on the impact of environmental factors in different fields.

The definition of the assessment scope is a necessary public step in the early stage of the assessment work. The project working group has carefully studied the Ma'an Hydropower Project planning research data and preliminary site investigation, and referred to the information obtained by the Environmental Protection Bureau, the Department of Health (referred to as EPA, after the bureau was restructured into the "Environmental Protection Administration" later), the "Environmental Impact Assessment Report of the New Tianlun Hydropower Project". The project working group draft the assessment items, geographical scope and focus, environmental survey prediction methods and assessment benchmarks, based on the EPA's review comments on previous assessment reports, project characteristics, current laws and regulations and social needs.

On August 14, 1987, relevant institutions, scholars and experts were invited to a symposium to discuss on the scope definition, with on-site inspections in the morning and discussion in the afternoon. Twelve scholars and experts attended or submitted written opinions, including Wang Xin(王鑫), Shi Lei(石磊), Xu Fuxiong(許富雄) on behalf of Lin Yaosong(林曜松), Shi Shanbao(施善堡), Liu Jin(柳榗), Zeng Sigong(曾四恭), Zeng Qingxian(曾晴賢), Zhang Baicheng(張柏成), Yang Yuanjin(楊垣進), Liu Yichang(劉益昌), Fan Guoshu(樊國恕), Xie Changfu(謝長富), etc. Official agency representatives include the Environmental Protection Administration(EPA), State-owned Enterprise Commission(SEC), Water Resources Agency(WRA), Highway Bureau(HB), Forestry and Nature Conservation Agency(FNCA), Taichung Branch of FNCA, Taichung City Government, Taichung City Heping District Office, Shigang Dam Management Center, Taichung Management Office, Irrigation Agency, Ministry of Agriculture and other 13 agencies.

After the assessment scope is defined, the current background information, predicted environmental impacts, and initial countermeasures are established one by one according to each assessment item.

In order to establish the current background environment, in addition to collecting existing information from various organizations and reviewing relevant documents, additional on-site surveys and verifications were conducted, as well as interviews with organizations familiar with the site (such as the Second District Engineering Office of the Highway Bureau and the Taichung Branch of FNCA and Taipower Tianlun Power Plant Management Office etc), and local residents to conduct questionnaire surveys or interviews.

The prediction of various environmental factors is divided into two different time scales, the construction period and the operation stage. Various prediction models established at home and abroad and the professional knowledge of different experts and scholars are used for research and judgment. Since the domestic filing system for basic data is not sound enough and the basic data on which predictions are based are not reliable enough, in order to make the evaluation results more realistic and objective, the project working group formulated the Impact Scenario Writing(環境影響演繹) by the current status, impact predictions and response measures of various environmental items, using the systematic analysis skills of interdisciplinary integration to conduct a comprehensive analysis and evaluation of the weight scaling of each environmental item.

In addition to the project working group, the members participating in the comprehensive evaluation of the weight scale includes experts, scholars and local people in different fields (the number of which is approximately 5 times that of the project working group), using the subjective measurement technique of Delphi Technique(德魯菲主觀衡量技巧), jointly evaluate the relative importance and impact scale of environmental factors to identify the Significant Environmental Impact Factors and then develop corresponding countermeasures or suggestions to mitigate adverse impacts.

The entire assessment process is shown in Figure 32. From the beginning until the completion of the compilation of the first draft of the environmental impact assessment report, experts and scholars outside the project working group, local people or relevant organizations were invited at different stages to conduct questionnaire discussions or consultations. In terms of procedures, it is very consistent with the spirit of group participation, openness and fairness.

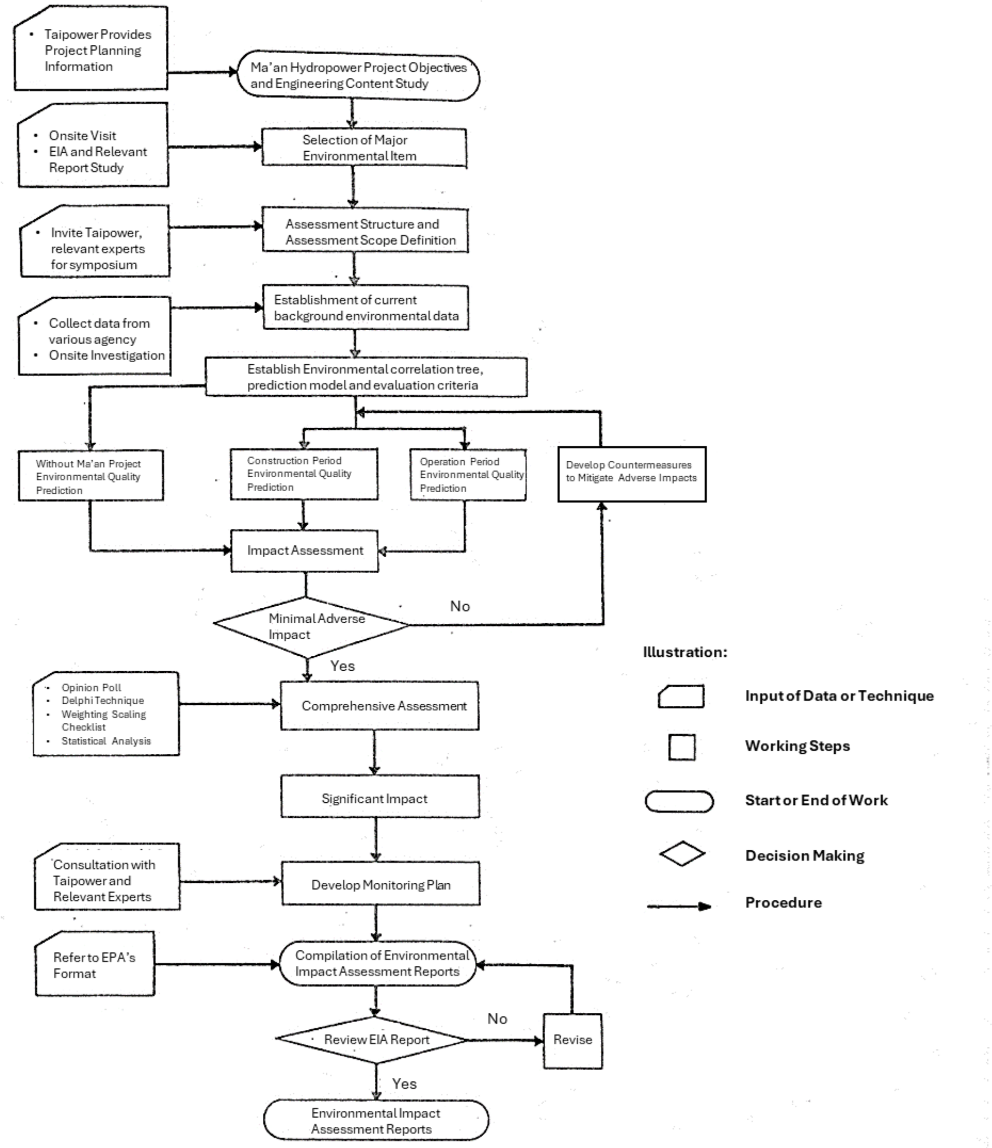


Figure 32 Ma'an Hydropower Project Environmental Impact Assessment Procedure

III. Assessment items and content

The evaluation items originally entrusted by Taipower Corporation include 7 items of natural environment, 2 items of biological environment, 7 items of socio-economic environment and cultural and environmental beauty (see Table 29).

Table 29 Evaluation Item Entrusted by Taipower Company

Environment	Item
1.Natural environment	(1) Hydrology (2) Topography and Geology (3) Meteorology (4) Air quality (5) Water quality (6) Noise (7) Vibration
2.Biological environment	(1) Terrestrial ecology (2) Water ecology
3.Socioeconomic environment	(1) Population (2) Land use (3) Transportation (4) Employment and taxes (5) Economic activity (6) Public Facility (7) Tourism and sightseeing
4.Cutural beauty environment	-

Since this project will use the Weighting Scaling Checklist method for comprehensive assessment, the projects considered in each environmental aspect should be as independent and proportionate as possible. CECI specially evaluates the projects according to the requirements of Taipower Company and taking into account the weight scale to comprehensively assess the operating conditions, to draft the environmental system correlation tree covering the four major aspects of natural environment, biological environment, socio-economic environment and cultural and environmental beauty. Each environmental aspect includes 6 items, 4 items, 5 items and 3 items, the assessment contents are as shown in Table 30.

Table 30 Ma'an Project EIA Framework

1987/08/14

Environmental Unit	Environmental Project	Geographical Scope	Key Assessment Content	Investigative Method	Prediction Method	Evaluation Criteria
Natural Env.	1. Geography	Construction area, construction roads, borrow areas, spoil areas	Changes in terrain and landscape due to excavation and embankment works, and potential risks of collapse and soil erosion.	Interpretation of aerial photographs, collection and analysis of geological and soil data, and on-site reconnaissance.	Empirical judgment, simplified slope assessment method	-
	2. Air Quality	Construction area, construction roads, borrow areas, spoil areas	Increased dust deposition and concentration of exhaust emissions from earthworks and construction vehicle emissions.	Analysis of existing data from nearby stations and on-site detection (at power plant site and Heping Junior High School) of NOx, CO, and suspended particulates.	Referring to similar site measurement data and estimating construction vehicle composition	General regional ambient air quality standards
	3. Hydrology	Construction areas, construction roads, rental areas, and the Dajia River section between Tianlun dam and Shigang dam	Changes in surface water levels due to dam construction and power generation operations in the river, and potential disruption of underground aquifers due to excavation.	Collection and analysis of existing hydrological data.	Surface water - hydrological calculation based on daily flow rates Groundwater - qualitative estimation	-
	4. Water Quality	Dajia River section	Pollution of surface	Analysis and on-site	Simple river water	Water quality

Environmental Unit	Environmental Project	Geographical Scope	Key Assessment Content	Investigative Method	Prediction Method	Evaluation Criteria
		between Tianlun Power Plant and 1 km downstream of Tianlun rear pond	water and groundwater due to discharge of domestic wastewater from construction personnel, grouting activities, and soil erosion.	sampling (6 locations in total, 4 sampling times at each location) based on existing data collection and assessment.	quality dispersion model	standards for Class B and Class D rivers
	5. Noise/Vibration	Construction area, construction roads, and noise-sensitive points in Nanshi Village	Increased noise and vibration levels from construction machinery operations, vehicle traffic, and power plant operations.	On-site measurement of 24-hour environmental background noise (3 locations), assessment of road traffic noise, and detection of vertical vibration levels.	Referring to similar site measurement data and predictive models developed domestically and internationally	Noise control standards and environmental noise quality standards. Vibration control standards for factories and construction operations in Japan.
	6. Waste (Garbage)	Construction area, borrow areas, spoil areas	Waste management issues arising from large amounts of spoil and construction personnel waste.	Existing data collection and on-site investigation and interviews.	Reference and judgment based on similar projects	Regulations on waste disposal
Biological Env.	1. Terrestrial Plant	Construction area, construction road, borrow area, spoil area	Potential impacts on terrestrial plant communities, species, and abundance.	Literature review, aerial photograph interpretation, and on-site investigation	Expert judgment	Regulations related to plant naturalness and protection of rare and unique plants
	2. Terrestrial Animals	Construction area, construction road, borrow area, spoil area	Potential impacts on terrestrial animal species and	Literature review, on-site investigation, and interviews	Expert judgment	Regulations related to protection of rare and endemic

Environmental Unit	Environmental Project	Geographical Scope	Key Assessment Content	Investigative Method	Prediction Method	Evaluation Criteria
			abundance.			animals
	3. Aquatic Plants	Dajia River section between Tianlun Power Plant and 1 km downstream of Tianlun rear pond	Potential impacts on riparian and aquatic plant species and abundance.	Literature review and on-site investigation	Expert judgment	There are regulations related to the protection of rare and endemic plants
	4. Aquatic Animals	Dajia River section between Tianlun Power Plant and 1 km downstream of Tianlun rear pond	Potential impacts on aquatic animal species and abundance.	Literature review, on-site investigation, and interviews	Expert judgment	Regulations related to protection of rare and endemic animals
Socioeconomic Env.	1. Community Structure	Qingfu Village in Dongshi Township, Nanshi Village in Heping Township, and Tianlun Village	Impact of population changes resulting from development plans on local community structure.	Analysis of existing data collection and questionnaire interviews	Reference and judgment based on similar projects	Local medium and long-term development project and regional project.
	2. Industrial Economic Activities	Qingfu Village in Dongshi Township, Nanshi Village in Heping Township, and Tianlun Village	The impact of changes in land use and employment opportunities on local industries and economic activities.	Analysis of existing data collection and questionnaire interviews	Reference and judgment based on similar projects	Local medium and long-term development project and regional project.
	3. Transportation	Provincial Highway No. 8 and other transportation routes between Dongshi and Gukeng	Impact of construction and power plant operations on local road traffic.	Analysis of existing data collection and on-site investigation	Reference and judgment based on similar projects	Local medium and long-term development project and regional project.
	4. Water Usage	Dajia River section from Tianlun Dam to Shigang, including	Impact of construction and power plant	Analysis of existing data collection, interviews with relevant	Hydrological calculations and empirical judgment	Existing water rights allocation

Environmental Unit	Environmental Project	Geographical Scope	Key Assessment Content	Investigative Method	Prediction Method	Evaluation Criteria
		nearby water well distribution area	operations on local surface water rights and groundwater use.	organizations and local residents		
	5. Coordination With Related Facilities or Project	Dajia River basin and Qingfu Village in Dongshi Township, Nanshi Village in Heping Township, and Tianlun Village	Impact of construction and power plant operations on demand for public facilities and the impact on existing water infrastructure and future development plans.	Analysis and assessment of existing data collection, interviews with relevant organizations/institutions	Reference and judgment based on similar projects	Local medium and long-term development projects.
Cultural and Aesthetic Env.	1. Cultural assets	Construction area, construction road, loan area, spoil area	Impact of construction and power plant operations on local history, culture, and historical sites.	Impact of construction and power plant operations on local history, culture, and historical sites	Expert judgment	Cultural Heritage Preservation Act, government-designated historic sites at various levels
	2. Landscape	Construction area, borrow area, spoil area	Impact of site grading and ground construction associated with the project on local landscape.	Impact of site grading and ground construction associated with the project on local landscape	Visibility analysis, visual vulnerability analysis	Characteristics of landscape resources, landscape patterns, dynamic landscapes, number of viewers
	3. Tourism and Recreation	Construction area and Guguan Scenic Area	Impact of construction and power plant operations on local recreational	Impact of construction and power plant operations on local recreational opportunities and quality	Reference and judgment based on similar projects	Local medium to long-term development plans, regional planning

Environmental Unit	Environmental Project	Geographical Scope	Key Assessment Content	Investigative Method	Prediction Method	Evaluation Criteria
			opportunities and quality of recreation.	of recreation		

Note:

1. Env.=Environment
2. The current environmental conditions are based on the period from May to December 1987.
3. The construction period is planned from July 1991 to December 1995.
4. The operational conditions are representative of the year 2001.

Annex III: Survey Results of Phytoplankton in Project Area

Survey period: July to November 1987

Type	Ma'an-Dam Site	Tianfu Bridge	Baileng Suspension Bridge	Water Pollution Index	
				Oligosaprobic	Mesosaprobic
Dinoflagellates					
1. Ceratium hirundinella (0.F.Müller) Schranr	3.0%	4.8%	8.0%		
2. Cryptomonas erosa E.	0.2%	-	-	✓	
3. Peridinium bipes Stein	55.4%	55.0%	80.0%	✓	
Diatons					
4. Achnanthes inflata var. eluta (Lend.-Forta.) Hust.	-	-	0.2%		
5. Cocconeis placentula Ehr.	0.2%	-	-		✓
6. Cymbella affinis Kütz.	1.6%	0.6%	-		✓
7. Cymbella turgidula Grun.	4.8%	2.4%	0.2%		
8. Diatoma vulgare Bory.	1.4%	3.8%	0.2%		✓
9. Fragilaria dorsiventralis 0.Müller	-	0.2%	-		
10. Fragilaria ulna (Nitz.) Lange-Bert.	-	1.0%	-		
11. Fragilaria Viresces Ralfs	14.8%	6.0%	7.0%	✓	
12. Gomphonema angustatum (Kütz.) Rabh.	0.2%	1.2%	-		✓
13. Gomphonema parvulum(Kütz.)Grun	-	2.0%	-		
14. Melosira italica (Ehr.) Kutz.	-	0.4%	0.6%		

Type	Ma'an-Dam Site	Tianfu Bridge	Baileng Suspension Bridge	Water Pollution Index	
				Oligosaprobic	Mesosaprobic
15. Melosira varians Ag.	0.2%	-	-		
16. Navicula cryptocephala Kutz.	-	0.2%	-		✓
17. Navicula pseudomuralis Hust.	-	0.2%	-		
18. Navicula rhychocephala Kutz.	-	0.4%	-		✓
19. Navicula sp.1	-	0.4%	-		
20. Navicula sp.2	1.2%	0.2%	-		
21. Nitzschia amphibia Grun.	0.2%	-	-		
22. Nitzschia frustulum var. perpusilla(Rabh.)Grun.	0.8%	-	-		
23. Nitzschia Kutzschinghiana Hilse	1.0%	0.2%	-		✓
24. Nitzschia paruvla Levis.	0.4%	-	-		✓
25. Surirella robusta var. splendida(E.) Van Heurck	-	0.2%	0.4%		
26. Synedra acus var. radians (Kg.)Hust.	-	0.2%	0.8%		
27. Synedra ulna(Nitz.) Her.	3.0%	0.8%	-		✓
Green Algaes					
28. Chaetophora incrassate (Huds.) Haz.	9.0%	14.8%	0.6%		
29. Spirogyra sp.	0.2%	-	-		✓
30. Staurastrum paradoxum Meyen var. paradoxum	1.2%	1.2%	1.8%		✓

Type	Ma'an-Dam Site	Tianfu Bridge	Baileng Suspension Bridge	Water Pollution Index	
				Oligosaprobic	Mesosaprobic
Blue-Green Algaes					
31. Lymbya sp.1	-	-	0.2%		
32. Lymbya sp.2	-	0.8%	-		
33. Oscillator amoena(Kutz) Gomont	0.6%	-	-		
34. Oscillator irrigua (Kutz.)Gomont	0.4%	-	-		
35. Oscillatoria sp.1	0.2%	-	-		
36. Oscillatoria sp.2	-	3.0%	-		
Total	100.0%	100.0%	100.0%		

Annex IV: Survey Results of Animal in Project Area

Species, distribution and relative abundance of mammals in project area

Survey period: July to November 1987

Scientific Name	Habitat	Relative Quantity
1. Small Mammals		
(1) Bandicota nemorivaga	Grassland	+ +
(2) Callosciurus erythraeus	Forest	+ +
(3) Petaurista petaurista	Forest	+
(4) Rattus coxinga	Grassland	+ +
(5) Rattus rattus	Residential	+ +
2. Medium sized mammals		
(6) Macaca cyclopis	Forest	+

"+" indicates that the number is relatively scarce, "+ +" indicates that the number of relative abundance is widespread

Bird species survey in project area

Scientific Name	Barrage Site	Power Plant Site	Spoil Site
1. (Little Green Heron) Butorides striatus amurensis	+		
2. (Little Egret) Egretta garzetta garzetta	+	+	+
3. Black-crowned Night Heron) Neticorax nycticorax			+
4. (Gray-face Buzzard Hawk) Butastur indicus		+	
5. (Serpent Eagle) Spilornis cheela hoya	+		
6. (Common Kestrel) Falco tinnunculus tinnunculus			+
7. (Bamboo Partridge) Bambusicola thoracica sonorivox	+	+	+
8. (Common Sandpiper) Tringa hypoleucos	+		
9. (Oriental Turtle Dove) Streptopeoia orientalis orii		+	
10. (Spotted-necked Dove) Streptopelia chinensis formosa	+	+	+
11. (Himalayan Cuckoo) Cuculus saturatus horsfieldi	+	+	
12. (Mountain Scope Owl) Otus spilocephalus hambrooki			+
13. (Collard Scops Owl) Otus bakkancena glabripes			+
14. (House Swift) Apus pacificus kuntzi	+	+	+
15. (Miller's Barbet) Megalaima oorti nuchalis	+	+	+
16. (Pigmy Woodpecker) Dendrocopos canicapillus kaleensis	+		
17. (Brown-throated Sand Martin) Riparia paludicola chinensis	+	+	
18. (House Swallow) Hirundo rustica gutturalis	+		

Scientific Name	Barrage Site	Power Plant Site	Spoil Site
19. (Ryukyu Pacific-Swallow) Hirundo tahitica nomiyei	+		+
20. (Eastern Yellow Wagtail) Motacilla flava taivana		+	
21. (Grey Wagtail) Motacilla cinerea robustis	+		
22. (Pied Wagtail) Motacilla alba lugens	+		+
23. (Tree Pipit) Anthus hodgsoni	+		
24. (Grey-throated Minivet) Pericrocotus solaris griseigularis	+		
25. (Finch-billed Bulbul) Spizixos semitorquus cinereicapillus	+	+	+
26. (Chinese Bulbul) Pycnonotus sinensis formosae	+	+	+
27. (Black Bulbul) Hypsipetes madagascariensis nigerrimus	+	+	+
28. (Brown Shrike) Lanius eristatus superciliosus	+		
29. (Black Drongo) Dicrurus macrocercus harterti	+	+	
30. (Crested Hyna) Acridotheres cristatellus formosanus	+		
31. (Gray Tree Pie) Cypsiring formosse formosae	+	+	+
32. (Large-billed Crow) Corvus sacrorhynchos colonorum	+	+	+
33. (Brown Dipper) Cinclus pallasii pallasii	+		
34. (Plumbeous Water-Redstart) Rhyacornis fuliginosus offinis	+	+	+
35. (White-tailed Blue Robin) Myomela leucura montium	+	+	+
36. (Indian Blue Rock Thrush) Monticola solitaria		+	+
37. (Taiman whistling Thrush) Myiophoneus insularis	+		+
38. Rusty-cheeked Scimitar-babbler)Pomatorhinus erythrocn imis	+	+	
39. (Lesser Scimitar-babbler) Ponatorhinus ruficollis musicus	+	+	+
40. (Red-headed Babbler) Stachyris ruficeps praecognitus	+	+	+
41. (Steere's Babbler) Liocichla steeri	+		
42. (Gould's Nun Babbler) Alcippe brunnes brunnen	+	+	+
43. (White-eyed Nun Babbler) Alcippe porrisonia morrisonia	+	+	+
44. (White-eared Sibia) Heterophasia auricularis	+		
45. (White-bellied Yuhina) Yuhina zantholeuca zantholeuca	+	+	+
46. (Vinous-throated Parrotbill) Paradoxornis webbiana bulomachus	+	+	+
47. (Manchurian Bush Warbler) Cettia diphone borealis		+	
48. (Mountain Bush Warbler) Cettia fortipes robustipes	+		+

Scientific Name	Barrage Site	Power Plant Site	Spoil Site
49. (Yellow-browed Villow Warbler) Phylloscopus inornatus	+		+
50. (Arctic Willow Warblet) Phylloscopus borealis borealis	+		
51. (Fulvous-faced Flycatcher Warbler) Abroscopus albogularis fulvifa cies	+	+	+
52. (Tawny Wren Warbler) Prinis subflava formosa	+	+	+
53. (Yellow-belled Wren Warbler) Prinia flaviventris sonitans	+		
54. (Brown Hill Warbler) Prinia criniger striata	+	+	+
55. (Black-naped Blue Flycatcher) Hypothymis azurea oberholseri	+		+
56. (Green-backed Tit) Parus monticolus insperatus	+	+	+
57. (Red-headed Tit) Aegithalos concinnus concinnus			+
58. (Fire-breasted Flowerpecker) Dicaeum ignipectus formosum	+		
59. (Formosa White-eye) Zosterops japanica simplex	+	+	+
60. (Tree Sparrow) Passer montanus saturatus	+	+	+
61. (White-rumped Munia) Lonchura stiata swinhoe	+	+	+
62. (Spotted Munia) Lonchura punctulats topela	+	+	
63. (Black-faced Bunting) Emberiza spodocepbala spododocpbala Pallas	+		
No. of species	53	35	37

Butterfly species survey in project area

Scientific Name	Barrage Site	Power Plant Site	Spoil Site
1. Graphium cloanthus kuge		+	+
2. Graphium sarpedon connectens	+	+	+
3. Pachliopta aristolochiae interposita	+		
4. Papilio bianor takasago			+
5. Papilio castor formosanus	+	+	+
6. Papilio demoleus libanius	+		
7. Papilio helenus fortunius			+
8. Papilio sanon heronus	+		+
9. Papilio nephelus chaonulus	+		+
10. Papilio paris hermosanus	+		+
11. Papilio polytes pasikrates	+	+	+
12. Papilio protenor amaura	+	+	+
13. Papilio xuthus	+		
14. Appias albina semperi		+	
15. Catopsilia pomona pomona	+	+	
16. Cepora nadina euname			+
17. Eurema alitha esakii	+	+	+
18. Eurema brigitta formosana		+	+

Scientific Name	**Barrage Site**	**Power Plant Site**	**Spoil Site**
19. Eurema laeta punctissima		+	
20. Gonepteryx amintha formosana	+		
21. Ixias pyrene insignis	+	+	
22. Leptosia nina niobe	+	+	+
23. Pieris (Artogeia) rapae crucivora		+	+
24. Pleris (Artogeia) canidia canidia	+	+	+
25. Hebomoia glaucippe formosana			+
26. Anosia chrysippus chrysippus			+
27. Argyreus hyperbius hyperbius		+	+
28. Cupha erymanthis erymanthis	+		
29. Euploes muleiber barsine	+		+
30. Euploes tulliolus koxinga	+		+
31. Parantica aglea maghaba	+	+	+
32. Parantica melaneus swinhoei	+	+	+
33. Parantica sita niphonica	+		+
34. Salatura genutia genitia	+		+
35. Tirumala limface limiace			+
36. Elymnias hypermnestra hainana	+		+
37. Lethe chandica ratnacri	+	+	
38. Lethe europa pavida	+	+	+
39. Lethe verma cintamani	+		
40. Melanitis leda leda	+		
41. Melanitis phedian polishana	+	+	+
42. Mycalesis francisca formosana	+	+	+
43. Penthem forzosanum	+	+	
44. Youa sabina vesuki			+
45. Ypthima baldus zodina	+	+	+
46. Ypthima formosana	+	+	+
47. Ypthima multistriata	+		+
48. Ypthima perfecta akragas	+	+	+
49. Acraea issoria formosana	+	+	+
50. Ariadne ariadne pallidior	+	+	
51. Athyma cama zoroastes	+		+
52. Dichorragia nesimachus formosanus			+
53. Dravira chrysolora		+	+
54. Euthalia formosana			+
55. Hestina assimilis formosana ab. hirayamai	+		
56. Hypolimnas bolina kezia	+	+	+
57. Hypolimnas nisippus		+	+
58. Kaniska canace drilon	+	+	+
59. Neptis hylas luculenta	+	+	+
60. Neptis philyra splendens	+	+	+
61. Niptis taiwane	+	+	+
62. Pantoporia hordonia rihodona	+	+	+
63. Polygonia caureum lunulata	+		+
64. Sumalia dudu jinamitra	+	+	
65. Symbrenthia hypselis scatinia	+		+
66. Cyrestis thyodamas formosana	+	+	

Scientific Name	Barrage Site	Power Plant Site	Spoil Site
67. Polyura narcaea meghaduta		+	
68. Stichophthalma howqua formosana	+		+
69. Libythea celtis formosana	+		
70. Acytolepis puspa myla	+	+	+
71. Heliophorus ila matsumurae	+	+	+
72. Jamides alecto dromicus			+
73. Janides bochus formosanus	+	+	+
74. Jamides celeno celeno	+		+
75. Lampides boeticus	+	+	+
76. Megisba malaya sikkima	+	+	+
77. Nacaduba kurava therasia	+		+
78. Neopithecops zalmora zalmora	+		+
79. Phengaris daitozana	+		+
80. Zizeeria maha okinawana	+		
81. Kallima inachus formosana	+		
82. Hasora badra badra	+		
83. Hasora taminatus vairacana	+	+	
84. Isoteinon lamprospilus formosanus	+	+	
85. Notocrypta curvifascia curvifascia	+		+
86. Pelopidas agna agna	+		+
87. Pelopidas mathias oberthueri	+	+	+
88. Precis almana almana	+	+	+
89. Precis iphita iphita	+	+	+
90. Precis lemonias lemonias	+	+	+
Total	71	49	65

Species, distribution and relative quantity of reptiles in project area

Scientific Name	Habitat	Relative Quantity
1. Snakes		
(1) Bungarus multicinctus	Bamboo forest, grassland, woods	+
(2) Ptyas mucosus	thicket	+
(3) Liopeltis major*	Bamboo forest, shrubbery, grass	+
(4) Trimeresurus steinegeri	woods, mountains, shrublands	+ +
(5) Elaphe cariata	Shrubs, forest areas	+
(6) Trimeresurus mucrosquamatus	lush area	+
(7) Elaphe porphyracea*	Densely planted areas	+
(8) Enhydris plumbea*	Woodland beside streams and ditches	+ +
(9) Elaphe taeniura friesei	thicket	+
(10) Zaocys chummades	Grassy and wooded land	+ +
(11) Boiga kraepelini	jungle, thicket	+
2. Lizards		
(1) Eumeces elegans*	bush, grass	

(2) Gekko japonicus*	near residence	+ +
(3) Japalura mitsuikurii mitskuriil*	forest, bush, grass	+ +
(4) Platyplacopus kuehnei*	bush, grass	+ +
(5) Eumeces chinensis*	bush, grass	+ +

"*" indicates field findings, obtained from interviews with local residents.

"+" indicates a relatively small amount, and "+ +" indicates a relatively common amount.

Fish survey results in the Dajia River section of project area

Scientific Name	Relative Quantity
1. Cyprinidae	
(1) Acrossocheilus formosanus	+ +
(2) Varicorhinus tamusuiensis	+
(3) Zacco platypus	+ +
2. Loachidae	
(1) Crossostoma lacustre	+ +
(2) Hemimyzon formosanum	+
3. Gobyidae	
(1) Rhinogobius similis	+ +
4. Yellow Catfish	
(1) Leiocassis adiposalis	+
5. Bream	
(1) Leiobagrus formosanus	+

"+" indicates a relatively small number, "++" indicates a relatively common number.

Species, distribution and relative quantity of frogs in project area

Scientific Name	Habitat	Relative Quantity
(1) Bafo bafo gargarizans Cantor	Forest bottom, river bank	+ +
(2) Buergeria robustus Boulenger	Riverside, rock wall	+
(3) Microhyla ornata (Dumeil & Bibron)	Forest bottom, water swamp	+ +
(4) Rana Kuhlii Dumeil & Bibron	Paddy fields, ponds, pools	+ +
(5) Rana narina swinhoana Boulenger	Near mountain streams and valleys	+
(6) Rana adenopleura Boulenger	Wetting trees and rock crevices	+
(7) Rana latouchi Boulenger	On the banks of mountain streams and at the bottom of woods	+ +
(8) Theroderm eiffingeri	Riverside bushes	+

"+" indicates a relatively small number, "++" indicates a relatively common number.

Survey on aquatic insect species in the Dajia River section of project area

Scientific Name
1. Pleoptera
(1) Perlidae
2. Dioptera
(1) Stenopsychidae
(2) Hydropsychidae
3. Ephemeropterae
(1) Ecdyonuridae
(2) Baetidae
(3) Leptophlebiidae
(4) Zphemerellidae

Annex V: Questionnaire Format Design

I. Questionnaire form on the social environment of Ma’an Hydropower Project area

The Ma'an Hydropower Project is the most exploitable hydropower resource in the Dajia River Basin. You must be very concerned about this economic activity. Please take the time to fill out this form. Your opinions will be useful for us to study the impact of this project on the local social environment. It is of great reference value. Thank you for your cooperation and support.

Sincerely, China Consulting Engineering Department

i. Brief description of Ma’an Hydropower Project

Taiwan Electric Power Company plans to build a 16-meter-high barrage in the river about 900 meters downstream of the Dajia River Tian-lun Power Plant, and use tunnels to send stream water to the newly built semi-underground power plant near Long-an Bridge in Da-mao-pu to generate electricity. The tailwater from the power generation is adjusted by the rear pond weir and then discharged into Dajia River (see Figure 1) for downstream irrigation and public water supply.

Major engineering facilities, such as pressure tunnels, horizontal pits, etc., are mostly underground. The ground projects are mainly switch yards and semi-underground power plants. The land preparation area is not large, about 3.5 hectares.

There are four spoil dumps, located in Zhong-he Village, Xin-she Township, and Xiao-keng Valley in Fu-xing Village. Retaining walls and drainage roads are built first before they can be put into use. After the spoil dumps are filled, grass and trees would be planted above.

Taipower Company expects to start this project immediately after the completion of the New Tian-lun Hydraulic Project (the construction period is from January 1977 to June 1981). The start date is July 1980 and the completion date is December 1984.

ii. Your opinions on the Ma'an Hydropower Project

2.1 The construction period of the Ma'an Hydropower Project is about four and a half years, and it can provide at least about 400 general workers job opportunities every day. Will this employment opportunity be helpful to you or your family?

□ Not helpful because:

□ We all already have stable jobs;

□ The distance is too far and inconvenient;

□ The competition is fierce and there is no opportunity to participate in employment;

□ The work is too hard and physically difficult to perform;

□ Other ;

or

□ It is helpful and may serve as:

□ Ordinary worker, _______ person (people);

□ Porter, _______ person (people);

□ Driver, _______ person (people);

□ Excavator operator, _______ person (people);

□ Waiter, _______ person (people);

□ Other, _______ person (people);

2.2 During the construction of the Ma'an Hydropower Project, will it have any impact on your current industry? (If it is beneficial, check in the box; if it is unfavorable, put "×" inside)

□ Agriculture; □ Forestry; □ Fishing; □ Earth and rock collection (mining);

□ Industry ______; □ Business ______; □Others ______;

2.3 During the construction period, 1,000 to 2,000 construction workers may gather in the area from Bai-leng to Ma'an Liao in He-ping Township. Do you think it will be helpful to the commercial prosperity of nearby towns?

□ Not helpful because:

□ there won’ t be many foreign workers;

□ Others ______________________________;

or

□ Helpful for the following towns: (please prioritize)

□ He-ping Township; □ Dong-shi Town; □ Others _________;

and which industries are benefited more: (please prioritize)

□Catering industry; □Rental industry; □Entertainment industry;

□Mechanical and electrical repair industry;

□Grocery retail industry; □Hairdressing industry;

□Building materials industry; □Other __________________;

2.4 The four spoil dumps in this project can form gently sloping flat land with an area around 1 to 5 hectares. Which of the following usage would be the best choice? (Multiple choices are allowed, and please sort by preference)

□ Planting trees and greening; □ small parks; □ parking lots;

□ sports venues; □ Let the common people rent for use; □ Other _______;

2.5 Environmental pollution and inconvenience will inevitably be caused during construction. What do you think the construction unit should pay special attention to improving? (Please rank in order of importance)

□Noise: □ Explosion sound; □ Big truck horn sound; □ Other _______;

□Vibration;

□Air pollution;

□Road pollution;

□Water pollution;

□Other ____;

Do you think this temporary pollution and inconvenience is still tolerable?

□ Tolerable, because:

□ Most projects are constructed underground and have little impact;

□ All construction start with destruction;

□ It' s far away from home;

□ Other ____;

□ Intolerable because:

2.6 Do you agree with this plan (multiple choices are allowed)

□ Agree:

□ Because electric power construction is very needed;

□ Because it can promote local prosperity;

□ Because it can create job opportunities;

□ Other ____;

or

□ Disagree: because ______________________________________;

or

□ No comment.

2.7 What are your opinions on the hydropower development of Dajia River (four power plants have been completed and the new Tian-lun power plant is about to start construction)? (Multiple choices are allowed)

□ Hydropower is a part of developing local resource and should keep developing;

□ It is worth developing since valuable;

□ Hydropower accounts for a very small proportion in the electricity system and is not in a hurry to develop;

□ Development has made little contribution to the local and there is no need for further developing;

□ Other ____;

2.8 Will the plan of Ma’an Hydropower Plant be beneficial to the followings?

① Electricity system in Taiwan

□ Agree; □ Disagree; □ Neutral; □ Uncertain

② Downstream irrigation system

□ Agree; □ Disagree; □ Neutral; □ Uncertain

③ Supplement of domestic water usage in Taichung district

□ Agree; □ Disagree; □ Neutral; □ Uncertain

④ Tourism of Zhongheng highway

□ Agree; □ Disagree; □ Neutral; □ Uncertain

⑤ Traffic of Zhongheng highway

□ Agree; □ Disagree; □ Neutral; □ Uncertain

⑥ Fishing around nearby water body

□ Agree; □ Disagree; □ Neutral; □ Uncertain

⑦ Development of nearby township

□ Agree; □ Disagree; □ Neutral; □ Uncertain

2.9 Other suggestions:

iii. Background of the interviewee

Name: __________________; M / F ; age: ________________;

Education level:

□ Illiterate; □ Elementary school; □ Middle school;

□ High school; □ College and further.

Occupation:

□ Civil servant; □ Agriculture; □ Forestry;

□ Fishing; □ Earth and rock collection (mining); □ Industry ______;

□ Business ______; □ Others ______;

Address: __________________; Phone number: __________________;

Accommodated for _________ year; Belief: ____________;

Identity: □ Aboriginal; □ Hakka; □ Hokkien; □ Main-land people.

You: □ moved here for work; □ are local people.

3.1 There are ______person/people registered in household with ______; person/people living recently.

Those who live in the household recently:

______is/are employed and work at _________(transport □ on foot; □ by bus; □ by motorcycle; □ by self-owned truck; □ by tiller; □ by other ______);

_____.is/are student and go to school at __________(transport □ on foot; □ by bus; □ by motorcycle; □ by other ______).

3.2 Source of income:

□ Self-owned business: □ Agriculture, crop: ______, area: ______ h,

□ Owned land; □ Leased land.

□ Forestry, species: ______, area: ______ h,

□ Owned land; □ Leased land.

□ Catering; □ Retailer; □ Construction industry; □ Other ______ ;

Or

□ Employed: □ Agriculture; □ Forestry; □ Catering; □ Retailer;

□ Construction industry; □ Civil servant/ Teacher; □ Other ______ .

3.3 Income a year: (NTD)

□ Below 200 k; □ 200k~300k; □ 300k~400k; □ 400k~500k;

□ 500k~600k; □ Above 600k.

3.4 Satisfied points with the living environment recently:

□ kindness of residents; □ beautiful view; □ weather; □fresh air; □ no noise; □ convenient transportation; □ living expense; □ job opportunity; □ other ____.

3.5 Unsatisfied points with the living environment recently:

(Multiple choices are allowed and please sort in unsatisfaction.)

□ crime rate; □ job opportunity; □ living expense; □ few schools;

□ inconvenient transportation; □ few entertainment;

□ public infrastructure; □ medical resource;

□ other ____ .

3.6 Source of drinking water:

□ tap water; □ mountain spring water; □ river water; □ underground water.

3.7 Method of garbage disposal:

□ garbage truck: □ collect daily; □ collect other frequency:___________;

□ leave in nearby ditch or lowland; □ dumped in landfill by oneself;

□ burned by oneself;

□ other____ .

II. Comprehensive Assessment Questionnaire on Weight Scale for Environmental Impact Assessment of Ma'an Hydropower Project

General Information

China Consulting Engineering Corporation, a nonprofit corporation, was entrusted by the Taiwan Power Company to handle the environmental impact assessment of the Ma'an Hydropower Project. The current situation investigation and forecast assessment of each assessment project have been carried out by members of the working group from different fields. To weigh the relative impact of each environmental project fairly and objectively, a comprehensive assessment using the weight scale detailed table method is carried out. It is planned to invite experts and scholars in different fields and people in the project area to participate so that the assessment results can achieve social consensus. We are thankful for your concern about environmental issues. For fair opinions, and respecting all walks of life, we would like to invite you to participate in the comprehensive evaluation.

The following are what our engineering department seeks for your help:

[1] Please read the attached summary description of the Ma'an Hydropower Project (Reference Material 1), environmental system correlation description (reference material 2), and introduction to the pairwise comparison method (reference material 3). Complete Table 1 (yellow paper) according to the pair comparison method with your understanding. Use the relative importance percentage method to distribute importance weight of one or many category in Table 2 (yellow paper) that you are specialized in or familiar with.

[2] Table 3-1 to Table 3-4 (yellow paper) are explanations of the impact of relevant projects in each environmental aspect (natural, biological, socio-economic, and cultural quality). Please refer to any category in which you are specialized or familiar, and evaluate the scale of impact of one or more environmental aspect with "✓" (checks).

Please return the completed questionnaire form (all yellow paper) before

April 7. If you have any questions or have any comments on how to fill in the form, please feel free to call: (02) 7814151~263 (Zhang Yue-zhu, Engineer). Thank you for your cooperation.

Sincerely,

China Consulting Engineering Department,

April 4, 1977.

Reference Material 1:

- Summary description of the Ma'an Hydropower Project -

The Ma'an Hydropower Project is a developable hydropower resource in the lowermost reaches of the Dajia River Basin. To fully develop the self-produced hydropower resources in the lower reaches of Dajia River, increase the peak power of the system, and reduce the dependence on imported energy, Taiwan Power Company plans to build a hydropower station at about 900 meters downstream of the Tian-lun Power Plant. The 16-meter barrage send stream water through tunnels to the newly built semi-underground power plant near Long-an Bridge in Da-mao-pu to generate electricity. The tailwater from the power generation is adjusted by the rear water weir and then discharged into Dajia River (see Figure 1) for downstream irrigation and public water supply.

Major engineering facilities, such as pressure tunnels, horizontal pits, etc., are mostly underground. The ground projects are mainly switchyards and semi-underground power plants. The land preparation area is not large, about 3.5 hectares.

There are four scheduled spoil dumps, located in Zhong-he Village, Xin-she Township, and in Xiao-keng Valley, Fuxing Village. Retaining walls and drainage roads will be built first before they can be put into use. After the spoil dumps are filled, the land will be returned to the original owner if it is a lessee; if it was purchased, grass and trees will be planted above.

Taiwan Power Company plans to start the Ma'an Hydropower Project-related projects immediately after the completion of the New Tian-lun Hydropower Project (the construction period started in March 1977 and is expected to be completed and transferred in June 1981). The scheduled construction period From July 1980 to December 1984.

Reference Material 2:

Description of the environmental system correlation tree of Ma'an hydropower project

This environmental system correlation tree was initially drafted by the working group by taking into consideration the planned regional environment and hydropower project characteristics. In August 1976, 12 experts and scholars and 13 representors from related organizations were invited to discuss and finalize the decision.

Environmental unit	Aspect	Main points for assessment
Natural Environment	Geography	● Changes in terrain and landforms caused by excavation and filling projects and possible collapse and soil erosion.
	Air quality	● Increased dust volume and exhaust gas concentration due to exhaust gas emissions from earthmoving operations and construction vehicles.
	Hydrology	● Changes in surface water volume caused by damming and power generation operations in streams, and underground water veins that may be cut off by excavation.
	Water quality	● Potential surface water and groundwater pollution caused by construction workers' domestic wastewater discharge, foundation grouting, and soil loss.
	Noise and vibration	● The noise level and vibration level may increase due to the operation of construction machinery, vehicle driving and power plant operation.
	Solid waste	● Waste disposal problems that may arise from a large amount of abandoned materials and construction workers' waste.
Biological Environment	Terrestrial plants	● Potentially affected terrestrial plant communities, types and quantities.
	Terrestrial animals	● Types and quantities of terrestrial animals that may be affected.
	Aquatic plants	● The types and quantities of shore plants and aquatic plants that may be affected.
	Aquatic animals	● Types and quantities of water animals that may be affected.
Socioeconomic Environment	Community structure	● The impact of demographic changes caused by planned development on the local community structure.
	Industrial economic activities	● The impact on local industries and economic activities due to changes in land use and employment opportunities.
	The traffic	● The impact on nearby road traffic due to construction and power plant operation.

Environmental unit	Aspect	Main points for assessment
	Utilization of water bodies	● The impact of construction and power plant operation on local surface water rights and groundwater utilization.
	Related facilities or projects	● The impact of construction and power plant operation on the demand for public facilities, existing water conservancy facilities and future development plans.
Cultural and Landscape Environment	Cultural assets	● The impact of construction and power plant operation on local history, culture and monuments.
	Landscape aesthetic	● The impact of the planned land preparation and ground construction on the local landscape.
	Sightseeing and recreation	● The impact of construction and power plant operation on local recreation opportunities and quality.

Reference Material 3:

Description of the pairwise comparison method

The pairwise comparison method uses the Variability Scaling Technique of the Laws of Comparative Judgment to combine all factors into 0.5×n (n-1) pairs, and then compare the pairs. Only two factors are taken for comparison each time, and the more important factor is given a "1", while the less important factor is given a "0"; if the two factors are equally important, each factor is given a "0.5". After such sequential pairwise comparisons, the relative importance of all factors can be determined through algebraic operations. To prevent the relative importance of any factor from producing a zero value, an additional "Dummy Variable" is added. When compared with it, all other factors get "1", and the " Dummy Variable" gets "0".

Here is an example to illustrate the application of the pair comparison method. Assume that someone wants to use the pairwise comparison method to evaluate the relative preference of five fruits such as watermelon, pineapple, mango, pear, and orange. The method is as follows: As for "watermelon" and "pineapple", assume that someone prefers "watermelon", then give "1" and "0" respectively to the positions of "watermelon" and "pineapple" in column ①~②; if someone like "mango" and "pear" equally, then give column ③~④, row "Mango" and "Pear" a "0.5" respectively. By analogy, the value in the subtotal column is the sum of the values in each row, and the total is 0.5×n(n-1) = 0.5×6(6-1) = 15. The value in the relative importance column is the subtotal. Divide each value in the column by 15.

Factor	Relevant importance from pairwise comparison															Sub-total	Relevant importance
	①/②	①/③	①/④	①/⑤	①/⑥	②/③	②/④	②/⑤	②/⑥	③/④	③/⑤	③/⑥	④/⑤	④/⑥	⑤/⑥		
①Watermelon	1	1	1	0	1	＼	＼	＼	＼	＼	＼	＼	＼	＼	＼	4	0.27
②Pineapple	0		＼	＼	＼	1	1	0	1	＼	＼	＼	＼	＼	＼	3	0.20
③Mango	＼	0	＼	＼	＼	0	＼	＼	＼	0.5	0	1	＼	＼	＼	1.5	0.10
④Pear	＼	＼	0	＼	＼	＼	0	＼	＼	0.5	＼	＼	0	1	＼	1.5	0.10
⑤Orange	＼	＼	＼	1	＼	＼	＼	1	＼	＼	1	＼	1	＼	1	5	0.33
⑥Dummy Variable	＼	＼	＼	＼	0	＼	＼	＼	0	＼	＼	0	＼	0	0	0	0
Total																15	1.0

Table 1: The weight of relevant importance of each environmental unit

Please finish and send back before April 7th with the envelope attached.

To determine the relative importance of the four types of environmental units in the Ma'an Hydropower Project, including "natural", "biological", "socioeconomic" and "cultural and landscape", please use the pairwise comparison method described in "Reference material 3", based on your personal understanding and values of Taiwan’s environment, complete the following paired comparison of the relative importance of each environmental unit (fill in only “0” and “1”, or “0.5” and “0.5”).

Environmental unit	Relevant importance from pairwise comparison										Sub-total
	①/②	①/③	①/④	①/⑤	②/③	②/④	②/⑤	③/④	③/⑤	④/⑤	
①Natural				1	＼	＼	＼	＼	＼	＼	
②Biological		＼	＼	＼			1	＼	＼	＼	
③Socialeconomic	＼		＼	＼		＼	＼		1	＼	
④cultural and landscape	＼	＼		＼	＼		＼		＼	1	
⑤Dummy Variable	＼	＼	＼	0	＼	＼	0	＼	0	0	0
										Total	10

Note [1] Boxes with a slash are boxes you don’t need to fill in.

[2] Please make sure the total of sub-total equals 10.

Table 2: Relevant importance of each environmental unit

Please finish and send back before April 7th with the envelope attatched.

Please select any one or more of the following environmental units based on your personal expertise, experience and values, refer to the factors considered in the environmental system correlation tree (Reference matereal 2), and evaluate the relative importance of each environmental project in brackets ( ) (Please note that under each environmental unit, the sum of the relative importance of each environmental item is 100%).

Environmental unit	Aspect	Environmental unit	Aspect
Natural Environment	Geography (%) Air quality (%) Hydrology (%) Water quality (%) Noise & vibration (%) Solid waste (%)	Socioeconomic Environment	Community structure (%) Industrial economic activities (%) The traffic (%) Utilization of four water bodies (%) Related facilities or projects (%)
	Total 100% for 6 aspects		Total 100% for 5 aspects
Biological Environment	Terrestrial plants (%) Terrestrial animals (%) Water plants (%) Water animals (%)	Cultural and Landscape Environment	Cultural assets (%) Landscape aesthetic (%) Sightseeing and recreation (%)
	Total 100% for 4 aspects		Total 100% for 3 aspects

Table 3-1: The impact of relevant projects in each natural environment aspect

Please refer to the impact statement of each environmental project. Put " ✓ " in the bold black box below to evaluate the impact of the Ma’an Hydropower Project during construction period (from 1980 to 1984) and the operation period (with 1998 as the representative year). "0" means no impact, positive value means beneficial impact, negative value means adverse impact; the larger the number, the greater the impact.

<table>
<tr><th rowspan="2">Natural Environment</th><th rowspan="2">Current status without Ma’an hydropower project (1976)
(A)</th><th rowspan="2" colspan="4">Construction period of Ma’an hydropower project (1991-1995)
(B)</th><th rowspan="2" colspan="3">Countermeasures for environmental impacts during construction period</th><th colspan="5">The target year 1990</th><th rowspan="2" colspan="3">Countermeasures for environmental impacts during the operation period</th></tr>
<tr><th>Without Ma’an project (C)</th><th colspan="4">Ma’an hydropower operating (D)</th></tr>
<tr><td rowspan="4">Geography</td><td>The project scope includes the Dajia River channel, slopes and valleys on both sides. Some valleys and gentler slopes have been reclaimed as orchards. The strata are Tertiary marine sediment. It is a non-significant earthquake area.</td><td colspan="4">Major projects such as tunnels, drifts and power plants are mostly underground projects, and have little impact on landscape. Plan of barrage construction does not have much effect on the Dajia River channel. Constructed roads, switchyards and planned spoil dumps will gradually change the terrain as the project progresses, and would affect soil and water conservation.</td><td colspan="3">Retaining wall will be built around spoil dumps. Side-slope protection and drainage infrastructures should be constructed when needed.</td><td>Slope development should follow the regulation of Hillside Land Conservation and Utilization.</td><td colspan="4">After planting over the spoil dumps, the loss of soil will decrease significantly.</td><td colspan="3">—</td></tr>
<tr><td colspan="8">Scale of environmental impact during construction [Comparison of column (B) and column (A)]</td><td colspan="8">Scale of environmental impact during operation [Comparison of column (D) and column (C)]</td></tr>
<tr><td rowspan="2">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td><td rowspan="2">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td></tr>
<tr><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td></tr>
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Natural Environment	Current status without Ma’an hydropower project (1976) (A)	Construction period of Ma’an hydropower project (1991-1995) (B)				Countermeasures for environmental impacts during construction period			The target year 1990					Countermeasures for environmental impacts during the operation period		
									Without Ma’an project (C)	Ma’an hydropower operating (D)						
		-3	-2	-1	0	3	2	1		-3	-2	-1	0	3	2	1
	Put " ✓ "								Put " ✓ "							
Air quality	Except for the chimneys of the three sand and gravel quarries located on the right bank of Dajia River and the exhaust gas emitted by the limited traffic vo-lume of Central High-way, there are no other pollution sources. The air quality is very good and can meet the general regional air quality standards in Taiwan.	The blasting and excavation of tunnels and the operation of ballast disposal plants significantly increase the amount of dust and suspended particles in the air. However, the affected areas are concentrated in sparsely populated operating locations, which will not cause public hazard problems. The dust raised by vehicles on the earth moving path is more sensitive to the impact on adjacent residences and shops.				Before the vehicle leaves the work area, spray-clean the tires. Frequently sprinkle water on tunnels and pit exits, earth moving paths, and dump sites to suppress dust flying.			The planned area has steep terrain and no development hinterland. It is speculated that it is impossible to intro-duce a large number of polluting factories to emit waste gas; the air quality should be similar to the current situation (A).	The operation of hydropower plants does not emit air pollutants and does not affect the air quality of surrounding areas.				—		
	Scale of environmental impact during construction [Comparison of column (B) and column (A)]								Scale of environmental impact during operation [Comparison of column (D) and column (C)]							
	Impact scale classification	Negative effects			No impact	Positive effects			Impact scale classification	Negative effects			No impact	Positive effects		
		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight
		-3	-2	-1	0	3	2	1		-3	-2	-1	0	3	2	1
	Put " ✓ "								Put " ✓ "							

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<tr><th>Without Ma’an project (C)</th><th colspan="4">Ma’an hydropower operating (D)</th></tr>
<tr><td rowspan="6">Hydrology</td><td>Dajia River is one of the major rivers in Taiwan, with a total length of approximately 124 km, a catchment area of approximately 1,236 km^2, and an average annual runoff volume of 2.6 billion m^3, ranking 9th among the 19 major rivers in Taiwan. The water volume is abundant, the height difference is large, and the water power reserve is the highest among all rivers in the country.</td><td colspan="4">The barrage and water inlet are constructed using the half-surface river channel water diversion construction method. The stream water can flow down from the half-surface river channel outside the cofferdam without affecting the upstream and downstream flows. On peak days, the construction water consumption from Dajia River is about 0.06 m^3/s, which only accounts for 0.3% of the low water flow in this section of the river.</td><td colspan="3">—</td><td>The Water Resour-ces Bureau's plan to expand the water source of the lower reaches of Dajia River (to build Ma'an Dam on the main stream of Dajia River and Longbao Dam on the tributary of Wuxi River) involves cross-regional water diver-sion, and the flow of water in the lower reaches of Dajia River will be sharply reduced; however, Since this project interacts with the Ma'an Hydropower Project and has a wide range of impacts, it is currently unpredictable whether it will be implemented.</td><td colspan="4">In the section between Ma'an Barrage and Tian-lun rear Pond, the average daily flow rate decreases by about 87% during the dry season, and decreases by about 83% during the wet season.</td><td colspan="3">In the downstream section of the barrage, the flow, water quality and river life are regularly monitored. Based on the monitoring results, the flow rate of the barrage is flexibly adjusted to maintain the minimum flow required for the ecology.</td></tr>
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<tr><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Natural Environment	Current status without Ma'an hydropower project (1976) (A)	Construction period of Ma'an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma'an project (C)	Ma'an hydropower operating (D)	
Water quality	The Dajia River section between Tianlun Power Plant and Shigang Dam is a Class B river. The main sources of pollution are the fertilizer from upstream orchards and the discharge of household sewage in Dongshi Town. Present water quality, biochemical oxygen demand, total phosphorus, and ammonia nitrogen content often fall to Category C or below standards. The coliform count and heavy metal content can meet the Class A river standards.	The main pollution is the increase in turbidity in water caused by earthmoving operations, which only occurs intermittently during heavy rains. The sewage discharge from construction workers is very limited. During the dry season, the biochemical oxygen demand concentration in the river section in front of Shigang Dam only increases by about 0.046 ppm, which can still maintain Class B river water quality standards.	Septic tanks are set up in the work area to treat the domestic sewage of construction workers; after excavating slopes and repairing new roads, pavement treatment or planting will be carried out immediately to reduce the degree of water pollution.	If illegal dumping of garbage continues on the Dajia River riverbed, the water quality of the river will deteriorate day by day. The extent will depend on whether the garbage treatment plans of the towns on both sides of the river can be effectively implemented.	The power plant operates without wastewater discharge and has only about 28 employees. The amount of domestic sewage is very small. It is discharged after treatment in septic tanks, and the pollution load on the Dajia River water system is slightly increased.	—

Scale of environmental impact during construction [Comparison of column (B) and column (A)]								Scale of environmental impact during operation [Comparison of column (D) and column (C)]							
Impact scale classification	Negative effects			No impact	Positive effects			Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1		-3	-2	-1	0	3	2	1
Put " ✓ "								Put " ✓ "							

Natural Environment	Current status without Ma’an hydropower project (1976) (A)	Construction period of Ma’an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma’an project (C)	Ma’an hydropower operating (D)	
Noise & vibration	Planning area administration category II noise control zone. In general areas, the volume during each time period is about 3 dBA higher than the standard, and the day and night volume can meet the standard. Roadside areas are much higher than the standard, with volume levels up to 12 dBA higher in the morning and evening. When large trucks pass by, the vertical vibration level on the roadside reaches more than 70 dBA, and the horizontal vibration level is mostly below 50 dBA.	The construction area is narrow, and the number of various types of machinery is between 2 and 5. The construction noise generated by it can comply with domestic noise control standards. The entry and exit of construction vehicles during peak periods only increases the average daily traffic volume of Zhongheng highway by approximately 8%, and the increase in traffic noise is limited. Changes in vibration level are difficult to detect.	Carry out construction noise monitoring and adjust the construction progress and machinery operation time when it exceeds the standard.	Similar to current situation (A).	Similar to current situation (A).	—

Scale of environmental impact during construction [Comparison of column (B) and column (A)]							
Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1
Put " ✓ "							

Scale of environmental impact during operation [Comparison of column (D) and column (C)]							
Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1
Put " ✓ "							

Natural Environment	Current status without Ma'an hydropower project (1976) (A)	Construction period of Ma'an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma'an project (C)	Ma'an hydropower operating (D)	
Solid waste	The project area is located in a remote mountainous area, where the amount of domestic waste is limited and there are no garbage trucks to transport it. Most of the waste is dumped in valley depressions, buried or burned by bureau residents themselves. The Dajia River Valley has been dumped by Shigang Township and Xinshe Township.	The main sources are discarded materials and domestic waste from construction workers. The abandoned tea plant has been considered to have sufficient capacity for centralized processing; household waste not exceeding 2 tons per day will be disposed of in landfills designated by the local government or disposed of together with waste, so as not to cause pollution to the local environment.	—	Whether the illegal dumping of garbage on the Dajia River riverbed can be suppressed depends on whether the urban garbage treatment plans in the towns and villages on both sides of the river can be implemented.	The operation of the hydropower plant does not produce solid waste. The daily amount of garbage generated by the resident staff is less than 10 kilograms, which is coordinated and processed by the remote control center of the Tianlun Power Plant. The layout does not cause environmental pollution.	—

Scale of environmental impact during construction [Comparison of column (B) and column (A)]

Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1
Put " ✓ "							

Scale of environmental impact during operation [Comparison of column (D) and column (C)]

Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1
Put " ✓ "							

Table 3-2: The impact of relevant projects in each biological environment aspect

Please refer to the impact statement of each environmental project. Put " ✓ " in the bold black box below to evaluate the impact of the Ma’an Hydropower Project during construction period (from 1980 to 1984) and the operation period (with 1998 as the representative year)."0" means no impact, positive value means beneficial impact, negative value means adverse impact; the larger the number, the greater the impact.

Biological Environment	Current status without Ma'an hydropower project (1976) (A)	Construction period of Ma'an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990: Without Ma'an project (C)	The target year 1990: Ma'an hydropower operating (D)	Countermeasures for environmental impacts during the operation period
Terrestrial plants	The main project facilities are mainly located in orchards, the remaining secon-dary forests occupy a very small area, and there are not many plantations. Most of the fruit trees are peaches and pears. Secondary forests are distributed on both sides of creeks and on steep slopes, and are mostly composed of pioneer tree species. There are many plantations including Fuzhou fir, tung oil trees and acacia trees. The waste dump is also dominated by fruit trees, mainly citrus.	Some orchards need to be eradicated at ground engineering facilities and waste dump sites, with the main loss being citrus.	—	Terrestrial plants will still be fruit trees mainly, and the planting area and types will vary depending on the price of the fruit.	Part of the wild sugarcane grassland upstream of the barrage was submerged, but nearby orchards were not affected.	—

Scale of environmental impact during construction [Comparison of column (B) and column (A)]

Impact scale classification	Negative effects: Significant	Negative effects: Medium	Negative effects: Slight	No impact	Positive effects: Significant	Positive effects: Medium	Positive effects: Slight
	-3	-2	-1	0	3	2	1

Scale of environmental impact during operation [Comparison of column (D) and column (C)]

Impact scale classification	Negative effects: Significant	Negative effects: Medium	Negative effects: Slight	No impact	Positive effects: Significant	Positive effects: Medium	Positive effects: Slight
	-3	-2	-1	0	3	2	1

Biological Environment	Current status without Ma'an hydropower project (1976) (A)	Construction period of Ma'an hydropower project (1991-1995) (B)				Countermeasures for environmental impacts during construction period			The target year 1990					Countermeasures for environmental impacts during the operation period		
									Without Ma'an project (C)	Ma'an hydropower operating (D)						
	Put " ✓ "								Put " ✓ "							
Terrestrial animals	The planned area has been cultivated for a long time, and there are few resources of large mammals and snakes, but many birds and butterflies. Most of the birds are resid-ent birds, mostly spa-rrows, little swifts, and Chinese Bulbuls. 4 rare species have been fou-nd. The section from Bailu to Tian-leng and near Tianlun Power Plant has the most abundant butterfly resources and is of great tourist and educational value.	Rare birds have a greater impact and are likely to move elsewhere due to construction noise.				——			Similar to current situation (A).	Only the terrain of each waste dump has changed from a river valley to a gently sloping platform, partially changing the animal habitat.				——		
	Scale of environmental impact during construction [Comparison of column (B) and column (A)]								Scale of environmental impact during operation [Comparison of column (D) and column (C)]							
	Impact scale classification	Negative effects			No impact	Positive effects			Impact scale classification	Negative effects			No impact	Positive effects		
		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight
		-3	-2	-1	0	3	2	1		-3	-2	-1	0	3	2	1
	Put " ✓ "								Put " ✓ "							

<table>
<tr><td rowspan="2">Biological Environment</td><td rowspan="2">Current status without Ma’an hydropower project (1976)
(A)</td><td rowspan="2" colspan="4">Construction period of Ma’an hydropower project (1991-1995)
(B)</td><td rowspan="2" colspan="3">Countermeasures for environmental impacts during construction period</td><td colspan="5">The target year 1990</td><td rowspan="2" colspan="3">Countermeasures for environmental impacts during the operation period</td></tr>
<tr><td>Without Ma’an project (C)</td><td colspan="4">Ma’an hydropower operating (D)</td></tr>
<tr><td rowspan="6">Water plants</td><td>The composition of algae is dominated by false algae. Although mesosaprobic algae appear, the number is very small, and the water quality is still oligosaprobic.</td><td colspan="4">During the construction period, the flow rate will be significantly reduced, the deterioration of water quality will be limited, and the river vegetation condition should be similar to the current situation (A).</td><td colspan="3">Septic tanks are set up in the work area to treat the domestic sewage of construction workers; after excavating slopes and repairing new roads, pavement treatment or planting will be carried out immediately to reduce the degree of water pollution.</td><td>The orchards in Lishan are indiscri-minately cultivated. Under the governm-ent's vigorous promotion of soil and water conservation and the open import policy of agricultural products, the orchard planting area may still maintain the current scale. The total amount of pesticides and fertilizers used every year will not change much. Dajiaxi in the planned area The composition and quantity of algae in the waters are similar to the current situation (A).</td><td colspan="4">The water volume of the Dajia River section, which is about 11 km long from the barrage to Tian-lun rear pond, has dropped sharply. Among them, the section from Nanshi to Tian-lun rear pond has many residents along the way. After the water volume dropped sharply, the pollution level increased relatively, and the pollution-loving algae in the water may increase accordingly.</td><td colspan="3">Conduct regular water quality monitoring at Tianlun Power Plant, Bailu Suspension Bridge, Long-an Bridge and Yong-an Bridge,
and flexibly adjust the discharge flow of the river to dilute the concentration of water pollution.</td></tr>
<tr><td colspan="8">Scale of environmental impact during construction [Comparison of column (B) and column (A)]</td><td colspan="8">Scale of environmental impact during operation [Comparison of column (D) and column (C)]</td></tr>
<tr><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td></tr>
<tr><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td></tr>
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</table>

<table>
<tr><td rowspan="3">Biological Environment</td><td rowspan="2">Current status without Ma’an hydropower project (1976)
(A)</td><td colspan="4" rowspan="2">Construction period of Ma’an hydropower project (1991-1995)
(B)</td><td colspan="3" rowspan="2">Countermeasures for environmental impacts during construction period</td><td colspan="5">The target year 1990</td><td colspan="3" rowspan="2">Countermeasures for environmental impacts during the operation period</td></tr>
<tr><td>Without Ma’an project (C)</td><td colspan="4">Ma’an hydropower operating (D)</td></tr>
<tr><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Water animals</td><td>In the Dajia River section between Dongshi and Guguan, 34 species of fish have been found in recent surveys. The dominant species are Acrossocheilus paradoxus, Opsariichthys pachycephalus and stream goby. No rare species have been found. Due to the obstruction of the downstream Shigang Dam, it is difficult to see the traces of migratory fish.</td><td colspan="4">During the construction of the barrage and the water inlet, the turbidity of the stream increased significantly, which adversely affected the habitat of fish.</td><td colspan="3">Same as 'water plants'.</td><td>The hydrological conditions of the river are similar to the current situation. Except for the continued decrease in the number of migratory fish, the composition and quantity of animals in other water areas should be similar to the current situation (A).</td><td colspan="4">In the Dajia River section between the barrage and the Tianlun Power Plant, the water volume and water depth have decreased, which may result in the inability of some fish and aquatic insects to survive.</td><td colspan="3">Regular river fish biological tracking surveys are conducted in four sections between Tianlun Power Plant and Yong-an Bridge, and the flow rate of the barrage is flexibly adjusted to maintain the minimum water depth required for fish survival.</td></tr>
<tr><td colspan="8">Scale of environmental impact during construction [Comparison of column (B) and column (A)]</td><td colspan="8">Scale of environmental impact during operation [Comparison of column (D) and column (C)]</td></tr>
<tr><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td></tr>
<tr><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td></tr>
<tr><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 3-3: The impact of relevant projects in each socioeconomic environment aspect

Please refer to the impact statement of each environmental project. Put " ✓ " in the bold black box below to evaluate the impact of the Ma’an Hydropower Project during construction period (from 1980 to 1984) and the operation period (with 1998 as the representative year)."0" means no impact, positive value means beneficial impact, negative value means adverse impact; the larger the number, the greater the impact.

<table>
<tr><th rowspan="2">Socioeconomic Environment</th><th rowspan="2">Current status without Ma’an hydropower project (1976)
(A)</th><th rowspan="2" colspan="4">Construction period of Ma’an hydropower project (1991-1995)
(B)</th><th rowspan="2" colspan="3">Countermeasures for environmental impacts during construction period</th><th colspan="5">The target year 1990</th><th rowspan="2" colspan="3">Countermeasures for environmental impacts during the operation period</th></tr>
<tr><th>Without Ma’an project (C)</th><th colspan="4">Ma’an hydropower operating (D)</th></tr>
<tr><td rowspan="6">Community structure</td><td>The planned area is a village with low population density, and the average annual growth rate over the past ten years has been negative. Most of the residents in Dongshi Town and Xinshe Township are of Hakka origin, while the majority of residents in Nanshi Village are of Atayal (aboriginal).</td><td colspan="4">Qingfuli and Nanshi Village may bring in 2,500 people during the peak construction period. Most of the skilled and ordinary workers come from the villages of Heping Township, Dongshi Town and Xinshe Township. They mainly commute to work and have no significant impact on the community structure of nearby villages. Influence.</td><td colspan="3">—</td><td>The community population is still outmigrating, specially the number of young people going out to find jobs and study continues to increase.</td><td colspan="4">After the power plant was put into operation, most of the engineering personnel were evacuated. The power plant is operated by remote control, and the remote control center is located in the main control room of the Tianlun Power Plant. The Ma'an power plant requires only about 20 additional staff, and will have no impact on the structures of nearby villages.</td><td colspan="3">—</td></tr>
<tr><td colspan="8">Scale of environmental impact during construction [Comparison of column (B) and column (A)]</td><td colspan="8">Scale of environmental impact during operation [Comparison of column (D) and column (C)]</td></tr>
<tr><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td></tr>
<tr><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td></tr>
<tr><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th rowspan="2">Socioeconomic Environment</th><th rowspan="2">Current status without Ma’an hydropower project (1976)
(A)</th><th colspan="3" rowspan="2">Construction period of Ma’an hydropower project (1991-1995)
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<tr><th colspan="3">Without Ma’an project (C)</th><th colspan="5">Ma’an hydropower operating (D)</th></tr>
<tr><td rowspan="6">Industrial economic activities</td><td>The industrial and economic activities in the planned area are mainly agriculture. The area of fruit trees planted along the hillside and valley plains is extremely vast. Industry and commerce are underdeveloped, with most retail stores and restaurants.</td><td colspan="3">Commercial activities in Hing Fuli and Nan Shi Village will be more active, with increased business opportunities mainly for restaurants and grocery retail stores. Abandonment sites, switching yards, power plants and construction roads will occupy part of the orchard land, but the required land area is limited and will have little impact on local agricultural productivity.</td><td colspan="3">—</td><td colspan="3">Local industrial and economic activities are still dominated by the primary industry of planting fruit trees, with limited industrial and commercial development, which is similar to the current situation (A).</td><td colspan="4">Same as situation (C).</td><td colspan="3">—</td></tr>
<tr><td colspan="9">Scale of environmental impact during construction [Comparison of column (B) and column (A)]</td><td colspan="8">Scale of environmental impact during operation [Comparison of column (D) and column (C)]</td></tr>
<tr><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td></tr>
<tr><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td><td>Significant</td><td>Medium</td><td>Slight</td></tr>
<tr><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td></tr>
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<tr><td rowspan="2">Socioeconomic Environment</td><td rowspan="2">Current status without Ma’an hydropower project (1976)
(A)</td><td rowspan="2" colspan="4">Construction period of Ma’an hydropower project (1991-1995)
(B)</td><td rowspan="2" colspan="3">Countermeasures for environmental impacts during construction period</td><td colspan="5">The target year 1990</td><td rowspan="2" colspan="3">Countermeasures for environmental impacts during the operation period</td></tr>
<tr><td>Without Ma’an project (C)</td><td colspan="4">Ma’an hydropower operating (D)</td></tr>
<tr><td rowspan="6">The traffic</td><td>The two-lane Central Cross Highway is the main external road. It connects to Provincial Highway No. 3 in the west and can reach Taichung; it connects Provincial Highway No. 9 in the east and can reach Hualien. The road conditions are generally good. During typhoons and rainstorms, there are occasional rockfalls and small landslides on some road sections. Traffic flow is not large, and the ratio of average daily traffic volume to capacity is only 0.25. Industrial roads are well developed, and the road width is about 2 meters.</td><td colspan="4">Traffic of Damaopu to Baileng of the Zhongheng highway, the approximately 14-km section is slightly affected by the construction of roadside engineering facilities. Although the entry and exit of construction vehicles also interferes with traffic on Zhongheng Highway is smooth, but only cars. The number of vehicles is limited and the impact is minor.</td><td colspan="3">In line with the Central Highway sightseeing season,
the construction progress will be flexibly adjusted. When necessary, arrange nighttime removal to reduce interference to road traffic during peak hours.</td><td>Similar to current situation (A).</td><td colspan="4">Only 1 to 2 official vehicles and engineering vehicles enter and leave the factory, which will not affect the smooth traffic of Zhongheng highway.</td><td colspan="3">—</td></tr>
<tr><td colspan="8">Scale of environmental impact during construction [Comparison of column (B) and column (A)]</td><td colspan="8">Scale of environmental impact during operation [Comparison of column (D) and column (C)]</td></tr>
<tr><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td><td rowspan="3">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact</td><td colspan="3">Positive effects</td></tr>
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<tr><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td><td>-3</td><td>-2</td><td>-1</td><td>0</td><td>3</td><td>2</td><td>1</td></tr>
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</table>

Socioeconomic Environment	Current status without Ma'an hydropower project (1976) (A)	Construction period of Ma'an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma'an project (C)	Ma'an hydropower operating (D)	
Ÿ Utilization of four water bodies	There are 5 hydropower plants in the Dajia River basin, with a total installation capacity of about 860,000 kW. There are only 12 irrigation roads that divert water from Dajia River. The actual water intake per month ranges from 12 to 48 cubic meters per second. The area is about 20,000 hectares. The downstream Shigang Dam can provide the Taichung area with a daily public water supply of approximately 420,000 metric tons.	The New Tianlun Hydropower Plant came into operation in 1811, increasing the system's installation capacity to 105,000 kilowatts. The Ma'an barrage and water inlet adopt the half-channel construction method, which does not retain the stream water, so it does not interfere with the flow of the downstream river. There will be no impact on the current water use.	—	The Water Conserva-ncy Bureau plans to expand water sources in the lower Dajia River by building Ma'an dam and Long-bao dam to divert water to greater Taichung and Chang-bin. The project's implementation is uncertain due to its interaction with the Ma'an Hydropower Project and extensive flooding area. Six hydroelectric power plants are planned, including a new sheave plant. Reduced irriga-tion areas may allow water diversion from irrigation to public use through the Fengyuan Second Water Purifi-cation Plant. This plan aims to address growing water demands in the region while balanc-ing various water use.	There is no water diversion inlet between the Ma'an barrage and the tailwater discharge port of the power plant to the Tianlun rear pond. Therefore, the operation of the power plant only affects the use of river water downstream of the Tianlun rear pond. According to hydrological calculations, the combined operation of Tianlun rear pond and Shigang dam will produce a maximum counter-regulatory capacity of less than 10 days to meet the downstream water demand of about 38,000 m^3. The occurrence rate is only 0.7%. Therefore, the operation of the power plant has an medium impact on the utilization of downstream river water.	During the construction of the Ma'an Power Plant, the back tank of the Tianlun was dredged 30 cm deep to increase the capacity of the back tank to fully meet the demand for reverse regulation of water downstream.

<table>
<tr><td rowspan="5">Socioeconomic Environment</td><td>Current status without Ma'an hydropower project (1976)
(A)</td><td colspan="4">Construction period of Ma'an hydropower project (1991-1995)
(B)</td><td colspan="3">Countermeasures for environmental impacts during construction period</td><td colspan="5">The target year 1990
Without Ma'an project (C) / Ma'an hydropower operating (D)</td><td colspan="3">Countermeasures for environmental impacts during the operation period</td></tr>
<tr><td colspan="8">Scale of environmental impact during construction [Comparison of column (B) and column (A)]</td><td colspan="8">Scale of environmental impact during operation [Comparison of column (D) and column (C)]</td></tr>
<tr><td rowspan="2">Impact scale classification</td><td colspan="3">Negative effects</td><td rowspan="2">No impact
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0</td><td colspan="3">Positive effects</td></tr>
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-2</td><td>Slight
-1</td><td>Significant
3</td><td>Medium
2</td><td>Slight
1</td></tr>
<tr><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Put " ✓ "</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Socioeconomic Environment	Current status without Ma’an hydropower project (1976) (A)	Construction period of Ma’an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma’an project (C)	Ma’an hydropower operating (D)	
Ÿ Related facilities or projects	The project area, located in a non-urban planning zone, has limited public facilities. It includes basic education, electricity, telecommunications, and health clinics, but lacks adequate water supply, sewage, drainage, garbage management, and medical facilities. No specific regional development plan exists. Water resource planning includes two initiatives: the water company's plan for a second water purification plant in lower Fengyuan, and the Water Conservancy Bureau's expansion plan for water sources in the lower Dajia River. These plans aim to improve water infrastructure in this underdeveloped area.	The water, electricity and communication facilities required for construction are limited in number and can be used nearby without the need to expand existing facilities. Fengyuan No. 2 water purification plant may have been completed and operational.	—	The population growth in the planned area is limited, and the demand for public facilities is not great, and the scale of the current situation (A) is roughly maintained. The Fengyuan No. 2 water purification plant may have been completed and put into operation; the development plan to expand the water source downstream of Dajia River has not yet reached the development schedule.	Same as situation (C).	To harmonize the Water Conservancy Bureau's Dajia River downstream water source expansion plan with the Ma'an Hydropower Project, a coordination plan for Ma'an's tailwater has been developed. For the Longbao Reservoir plan, it proposes expanding Tianlun's third pond to 500,000 cubic meters and using an inverted siphon to channel tailwater to Longbao Reservoir. The Ma'an Reservoir plan includes building a third pond on the reservoir's left side and an underground pumping station on the mountainside. This station would pump water from the expanded rear pool during off-peak hours. These measures aim to optimize water usage and storage, balancing the needs of both the water source expansion and hydropower generation while maximizing efficiency in the region's water management system.
	Scale of environmental impact during construction [Comparison of column (B) and column (A)]			Scale of environmental impact during operation [Comparison of column (D) and column (C)]		

Socioeconomic Environment	Current status without Ma’an hydropower project (1976) (A)	Construction period of Ma’an hydropower project (1991-1995) (B)				Countermeasures for environmental impacts during construction period			The target year 1990					Countermeasures for environmental impacts during the operation period		
									Without Ma’an project (C)	Ma’an hydropower operating (D)						
	Impact scale classification	Negative effects			No impact	Positive effects			Impact scale classification	Negative effects			No impact	Positive effects		
		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight
		-3	-2	-1	0	3	2	1		-3	-2	-1	0	3	2	1
	Put " ✓ "								Put " ✓ "							

Table 3-4: The impact of relevant projects in each cultural and landscape environment aspect

Please refer to the impact statement of each environmental project. Put " ✓ " in the bold black box below to evaluate the impact of the Ma’an Hydropower Project during construction period (from 1980 to 1984) and the operation period (with 1998 as the representative year)."0" means no impact, positive value means beneficial impact, negative value means adverse impact; the larger the number, the greater the impact.

Cultural and Landscape Environment	Current status without Ma'an hydropower project (1976) (A)	Construction period of Ma'an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma'an project (C)	Ma'an hydropower operating (D)	
Cultural assets	Human settlement began in the late Neolithic Era, about 3,000 years ago in the project area. The area is closer to the mountains, so the Han people developed it later. 11 prehistoric sites were discovered, which are relatively important This is the Babao Site located in Nanshi Village and was 3,500~2,000 years ago. It was the only Yingpu Cultural Site that was discovered in the middle reaches of Dajia River.	Heping ruins, Zaokeng ruins and Fushan Temple ruins are located near drift A, drift B and the construction road leading to drift A respectively. A small part of the ruins may be destroyed during the construction of drifts and the construction roads.	During the excavation of drift A, drift B and the construction road leading to drift A, one should pay special attention. If any monuments or antiquities are found to be unearthed, work will be stopped immediately,and coordinate with the competent authority to handle the matter.	Most of the sites are located on river terraces. Because they are remote mountainous areas, development has been slow. Most of the land use still maintains the current situation of fruit tree planting. There is no deep excavation and only shallow surface plowing. The sites have suffered. The likelihood of major damage is low	Same as situation (C)	—

Scale of environmental impact during construction [Comparison of column (B) and column (A)]

Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1
Put " ✓ "							

Scale of environmental impact during operation [Comparison of column (D) and column (C)]

Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1
Put " ✓ "							

Cultural and Landscape Environment	Current status without Ma’an hydropower project (1976) (A)	Construction period of Ma’an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma’an project (C)	Ma’an hydropower operating (D)	
Cultural and Landscape Environment	Current status without Ma’an hydropower project (1976) (A)	Construction period of Ma’an hydropower project (1991-1995) (B)	Countermeasures for environmental impacts during construction period	The target year 1990		Countermeasures for environmental impacts during the operation period
				Without Ma’an project (C)	Ma’an hydropower operating (D)	
Landscape aesthetic	The main engineering facilities are located in the north coast of Dajia River. Zhongheng highway is the main visual route gallery. Near the water inlet and barrage, The terrain contrast is relatively strong; the landscape is monotonous and artificial (orchard) near the entrance of drift B; the area around power plants, switchyards and Tianlun rear pond is where the mountainous terrain enters the plains. spoil dumps do not have special scenery.	Construction activities in the work area create some environmental contrast, but they're not the landscape's focal point. The reclaimed surrounding land reduces this contrast. Passing vehicles experience only brief visual exposure, resulting in low visual sensitivity. spoil dumps are situated in small valleys on Dajia River's south bank, in sparsely populated areas. These sites primarily affect the visual experience of people and vehicles passing on Highway 131, but only for a short duration. Overall, the visual impact of these construction and waste disposal activities is limited and temporary.	Temporary structures on construction sites, including concrete mixing plants and material storage yards, should be concealed with vegetation or fencing. Immediately following excavation and slope modification, measures for slope protection and beautification should be implemented.	Due to the reclamation or abandonment of orchards and the mining of soil and rocks on roadside slopes, the beauty of the landscape is slowly deteriorating year by year.	The switch yard and barrage form a new visual focus. The concrete surface of the pit entrance of drift B is in great contrast with the surrounding orchards. It is very likely that the new land at the waste dump will be restored to fruit tree planting and use, which is consistent with the surrounding land use patterns.	The switchyard faces the Zhongheng highway and is shaded by tall trees. pit entrance of drift B will undergo key landscaping.

Scale of environmental impact during construction [Comparison of column (B) and column (A)]								Scale of environmental impact during operation [Comparison of column (D) and column (C)]							
Impact scale classification	Negative effects			No impact	Positive effects			Impact scale classification	Negative effects			No impact	Positive effects		
	Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight		Significant	Medium	Slight
	-3	-2	-1	0	3	2	1		-3	-2	-1	0	3	2	1

Cultural and Landscape Environment	Current status without Ma’an hydropower project (1976) (A)	Construction period of Ma’an hydropower project (1991-1995) (B)				Countermeasures for environmental impacts during construction period			The target year 1990					Countermeasures for environmental impacts during the operation period		
									Without Ma’an project (C)	Ma’an hydropower operating (D)						
	Put " ✓ "								Put " ✓ "							

Annex VI: Ma’an Project Water Quality Report

I. 2023 Q1 Water Quality Report

Project name:	—	Trip code:	ECWA23060274
Requester:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report number:	EC11212774-WAA01
Inspected unit:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report date:	2023/07/25
Sampling location:	No. 89-1, Section 2, Dongguan Road, Heping District, Taichung City	Testing purpose:	other environmental protection regulations
Sampler:	Asia Pacific Environmental Technology Co., Ltd. testing lab	Industry/Regulation:	—
Sampling method:	NIEAW104.52C	Sample properties:	liquid
Inspection number:	WA11208903-01	Sampling time:	2023/06/30 10:17
Sample name:	Ma'an barrage rear pool	Closing time:	2023/07/01 08:00

Certification and Approval Testing Items	Unit	Test results	Detection method	standard value	Method Detection Limit (MDL)
Suspended solid	mg/L	27.6	NIEA W210.58A	-	-
Water temperature	℃	23.0	NIEA W217.51A	-	-
Total nitrogen	mg/L	0.57	NIEA W423.52C	-	-
Ion concentration index (pH value)	-	8.1 (23.0℃)	NIEA W424.53A	-	-
Nitrite nitrogen	mg/L	ND	NIEA W436.52C	-	0.004
Nitrate nitrogen	mg/L	0.45	NIEA W436.52C	-	-
total phosphorus	mg/L	0.021	NIEA W442.51C	-	-
Dissolved oxygen	mg/L	7.2	NIEA W455.52C	-	-
Ammonia nitrogen	mg/L	0.05	NIEA W457.50B	-	-
Blank below					

Statement

1. We hereby guarantee that the contents of this report are in full compliance with the standard methods and quality assurance and quality control regulations of the Environmental Protection Agency of the Executive Yuan and relevant agencies, and sampling and testing are carried out in a fair and honest manner. There is absolutely no hypocrisy. If there is any violation, I am willing to bear joint and several liability for the losses suffered by the government agencies and accept the administrative sanctions and criminal penalties imposed by the competent authorities in accordance with the law.
2. We understand that if we are appointed by a government agency to engage in official duties, we are also civil servants under the criminal law. We also understand that the crime of profiteering under the criminal law, the publication of false and forged official documents by public servants and the relevant provisions of the Corruption Crimes Act, if violated, one is also a he applicable object of criminal laws, and corruption laws. We are willing to be subject to the strictest legal regulations.

Remark

1. The testing items in this report were sampled and tested with permission from the Environmental Protection Administration and in accordance with the announced testing methods.
2. Determinations below the method detection limit are expressed as " ND " (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample and may not be copied at will or used for advertising.
4. Δ in the test results indicates that the analytical concentration value is greater than the detection limit of the method but less than the standard concentration at the first point of the calibration line.
5. The outsourced testing unit, report number, and project information are as follows: Jingzhan Inspection Technology Co., Ltd. ES230B6700: Chlorophyll a.

Person in charge: Huang Junren
Laboratory supervisor/report signatory: Shi Jianzhou

文件編號：EC-F-Q-038(AA)
執行日期：110.04.01
版次：4.1

亞太環境科技股份有限公司

【行政院環境保護署許可證字號：環署環檢第 003 號】

亞太環境科技股份有限公司檢驗室 地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：	—	行程代碼：	ECWA23060274
委託單位：	台灣電力股份有限公司大甲溪發電廠	報告編號：	EC11212774-WAA01
受驗單位：	台灣電力股份有限公司大甲溪發電廠	報告日期：	112/07/25
採樣地點：	台中市和平區東關路二段 89-1 號	檢測目的：	其他環保法規用途
採樣單位：	亞太環境科技股份有限公司檢驗室	行業別/管制：	—
採樣方法：	NIEA W104.52C	樣品特性：	液體
檢驗編號：	WA11208903-01	採樣時間：	112/06/30 10:17
樣品名稱：	馬鞍壩後池	收樣時間：	112/07/01 08:00

認證核可檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限 (MDL)
懸浮固體	mg/L	27.6	NIEA W210.58A	—	—
水溫	℃	23.0	NIEA W217.51A	—	—
總氮	mg/L	0.57	NIEA W423.52C	—	—
氫離子濃度指數(pH 值)	—	8.1(23.0℃)	NIEA W424.53A	—	—
亞硝酸鹽氮	mg/L	ND	NIEA W436.52C	—	0.004
硝酸鹽氮	mg/L	0.45	NIEA W436.52C	—	—
總磷	mgP/L	0.021	NIEA W442.51C	—	—
溶氧量	mg/L	7.2	NIEA W455.52C	—	—
氨氮	mg/L	0.05	NIEA W457.50B	—	—
以下空白					

聲明書
1. 茲保證本報告內容完全依照行政院環境保護署及有關機關之標準方法及品保品管等相關規定，秉持公正誠實進行採樣、檢測。絕無虛偽不實，如有違反，就政府機關所受損失願負連帶賠償責任之外，並接受主管機關依法令所為之行政處分及刑事處罰。
2. 吾人瞭解如自身受政府機關委任從事公務，亦屬於刑法上之公務員，並瞭解刑法上圖利罪，公務員登載不實偽造公文書及貪污治罪條例之相關規定，如有違反，亦為刑法及貪污治罪 條例之適用對象，願受最嚴厲之法律制裁。

備註
1. 本報告內之檢測項目為經環保署許可，並依公告檢測方法採樣檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，不得隨意複製及作為宣傳廣告之用。
4. 檢測結果中 Δ 表示其分析濃度數值為大於方法偵測極限但小於檢量線第一點標準品濃度。
5. 委外檢測單位、報告編號、項目資料如後：精湛檢驗科技股份有限公司 ES230B6700 :葉綠素 a。

報告專用章
亞太環境科技(股)公司
負責人：黃俊仁
檢驗室主管：施建州

負責人：黃俊仁

檢驗室主管/報告簽署人：施建州

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志 電話：07-3928088 地址：高雄市三民區灣興街 39 巷 8 號

Certification and Approval Testing Items	unit	Test results	Detection method	Standard value	method detection limit (MDL)
Transparency	m	1.0	NIEA W220.51C	-	-
Turbidity	NTU	22	NIEA W219.52C	-	-
Total organic nitrogen	mg/L	0.06	Reference NIEA W423.52C	-	-
Carlson Nutritional	-	48.9	See note 4.	-	-

Certification and Approval Testing Items	unit	Test results	Detection method	Standard value	method detection limit (MDL)
Status Index (TSI)					
Blank below					

Remark

1. The testing items in this report are based on the testing shown in the "Testing Method" column.
2. Determinations below the detection limit of the method are expressed as ND" (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample. The report may not be copied at will or used for advertising.
4. Carlson's "Nutritional Status Index" is calculated from total phosphorus, transparency, and chlorophyll.

Person in charge: Huang Junren
Laboratory supervisor/report signatory: Shi Jianzhou

文件編號：EC-F-Q-038(AN)
執行日期：110.04.01
版次：4.1

亞太環境科技股份有限公司

亞太環境科技股份有限公司檢驗室 地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：	—	行程代碼：	—
委託單位：	台灣電力股份有限公司大甲溪發電廠	報告編號：	EC11212774-WAN01
受驗單位：	台灣電力股份有限公司大甲溪發電廠	報告日期：	112/07/25
採樣地點：	台中市和平區東關路二段 89-1 號	檢測目的：	其他環保法規用途
採樣單位：	亞太環境科技股份有限公司檢驗室	行業別/管制：	—
採樣方法：	NIEA W104.52C	樣品特性：	液體
檢驗編號：	WA11208903-01	採樣時間：	112/06/30 10:17
樣品名稱：	馬鞍壩後池	收樣時間：	112/07/01 08:00

檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限 (MDL)
透明度	m	1.0	NIEA E220.51C	—	—
濁度	NTU	22	NIEA W219.52C	—	—
總有機氮	mg/L	0.06	參考 NIEA W423.52C	—	—
卡爾森「營養狀態指數 (TSI)」	—	48.9	見備註 4.	—	—
以下空白					

備註
1. 本報告內之檢測項目為依「檢測方法」欄位所示執行檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，報告不得隨意複製及作為宣傳廣告之用。
4. 卡爾森「營養狀態指數」由總磷、透明度、葉綠素計算而得。

負責人：黃俊仁

檢驗室主管/報告簽署人：施建州

報告專用章
亞太環境科技(股)公司
負責人：黃俊仁
檢驗室主管：施建州

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志 電話：07-3928088 地址：高雄市三民區灣興街 39 巷 8 號

	Plant		
Sample name:	Ma'an barrage rear pool	Sample collection date and time:	10:17, June 30, 2023
Sample number:	23B082154 (WA11208903-01)	Closing date and time:	15:16, July 3, 2023
Sampling unit:	Asia Pacific Environmental Co., Ltd. testing room	Factory entry and exit time:	—
Sampling location:	No. 89-1, Section 2, Dongguan Road, Heping District, Taichung City	Sample characteristics:	filter paper
Testing purpose:	other environmental protection regulations	Report date:	July 18, 2023
Sampling method:	NIEA W104.52C	Contact person:	Chen Yuzheng #200

Certification and Approval Testing Items	Test results and units	Detection method	Remark
Chlorophyll a	2.3 μg/L	NIEA E507.04B	
Blank below			

Remark
1. This report has a total of 1 page and is invalid if used separately. 2. Measurements below the detection limit of the method are expressed as "ND<MDL", and its MDI is the detection limit of the method. 3. This report is only responsible for the sample and may not be copied at will or used for advertising. 4. In this case, the customer took samples and submitted them for inspection. Our laboratory is not responsible for the collection and delivery process and the storage conditions of the samples. We will be responsible for the samples sent. 5. Itinerary number of the inspected unit: ECWA23060274
Statement
1. We hereby guarantee that the contents of this report are sampled and tested in a fair and honest manner in accordance with the standard methods and quality assurance and quality control regulations of the Environmental Protection Agency of the Executive Yuan and relevant agencies. There is absolutely no hypocrisy. If there is any violation, I will be jointly and severally liable for the losses suffered by the government agencies, and I will accept the administrative sanctions and criminal penalties imposed by the competent authorities in accordance with the law. 2. We understand that if we are appointed by a government agency to perform official duties, we are also civil servants under the criminal law. We also understand that the crime of profiteering under the criminal law, the publication of false and forged official documents by public servants and the relevant provisions of the Corruption Crimes Act, if violated, are also criminal laws. Those who are subject to the Corruption Crime Ordinance are willing to be subject to the severest legal sanctions.
Company name: Jingzhan Inspection Technology Co., Ltd. Person in charge (signature): Yu Jianzhong Laboratory Director (Report Signatory) (Signature): Chen Yuzheng

精湛檢驗科技股份有限公司

行政院環境保護署認可證字號:環署環檢字第019號
檢驗室名稱：精湛檢驗科技股份有限公司環境檢驗室

意見回饋

總公司:新北市中和區中正路716號14樓　電話:(02)8228-0770(代表號)
網　址:http//:www.best-lab.com.tw　傳真:(02)8228-0760

水質樣品檢驗報告

客戶名稱：台灣電力股份有限公司大甲發電廠　報告編號：ES230B6700
樣品名稱：馬鞍壩後池　採樣日期與時間：112年06月30日 10:17
樣品編號：23B082154(WA11208903-01)　收樣日期與時間：112年07月03日 15:16
採樣單位：亞太環境股份有限公司檢驗室　進出廠時間：-
採樣地點：台中市和平區東關路二段89-1號　樣品特性：濾紙
檢測目的：其他環保法規用途　報告日期：112年07月18日
採樣方法：NIEA W104.52C　聯絡人：陳育錚 -分機200

檢驗項目	檢測結果與單位	檢驗方法	備註
葉綠素a	2.3　μg/L	NIEA E507.04B	
*~*以下空白*~*			

備註：1.本報告共1頁，分離使用無效。
2.低於方法偵測極限之測定以"ND<MDL"表示，其MDL為方法偵測極限值。
3.本報告僅對該樣品負責，並不得隨意複製及作為宣傳廣告之用。
4.此案為客戶自行採樣送驗，本檢驗室對採樣過程及樣品保存條件不負責，僅對所送樣品負責。
5.受檢單位行程編號：ECWA23060274。

聲明書

(一)茲保證本報告內容完全依照行政院環境保護署及有關機關之標準方法及品保品管等相關規定秉持公正、誠實進行採樣、檢測。絕無虛偽不實，如有違反，就政府機關所受損失願負連帶賠償責任之外，並接受主管機關依法令所為之行政處分及刑事處罰。

(二)吾人瞭解如自身受政府機關委任事公務，亦屬於刑法上之公務員，並瞭解刑法上圖利罪，公務員登載不實偽造公文書及貪污治罪條例之相關規定，如有違反，亦為刑法及貪污治罪條例之適用對象，願受最嚴厲之法律制裁。

公司名稱：精湛檢驗科技股份有限公司
負責人(簽章)：余建中
實驗室主任(報告簽署人)(簽章)：陳育錚 7/18

報告專用章
精湛檢驗科技(股)公司
環境檢驗室
負責人:余建中
檢驗室主任:陳育錚

第1頁　共1頁

II. 2023 Q2 Water Quality Report

Project name:	—	Trip code:	ECWA23080085
Requester:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report number:	EC11216298 -WAA01
Inspected unit:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report date:	2023/08/24
Sampling location:	No. 89-1, Section 2, Dongguan Road, Heping District, Taichung City	Testing purpose:	other environmental protection regulations
Sampler:	Asia Pacific Environmental Technology Co., Ltd. testing lab	Industry/Regulation:	—
Sampling method:	NIEAW104.52C	Sample properties:	liquid
Inspection number:	WA112 11510-01	Sampling time:	2023/08/09 09:45
Sample name:	Ma'an barrage rear pool	Closing time:	2023/07/10 08:00

Certification and Approval Testing Items	Unit	Test results	Detection method	standard value	method detection limit (MDL)
Suspended solid	mg/L	17.4	NIEA W210.58A	-	-
Water temperature	℃	22.1	NIEA W217.51A	-	-
Total nitrogen	mg/L	1.01	NIEA W423.52C	-	-
Ion concentration index (pH value)	-	8.2 (22.2 ℃)	NIEA W424.53A	-	-
Nitrite nitrogen	mg/L	ND	NIEA W436.52C	-	0.004
Nitrate nitrogen	mg/L	0.53	NIEA W436.52C	-	-
Total phosphorus	mg/L	0.028	NIEA W442.51C	-	-
Dissolved oxygen	mg/L	7.9	NIEA W455.52C	-	-
Ammonia nitrogen	mg/L	0.14	NIEA W457.50B	-	-
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Statement
1. We hereby guarantee that the contents of this report are in full compliance with the standard methods and quality assurance and quality control regulations of the Environmental Protection Agency of the Executive Yuan and relevant agencies, and sampling and testing are carried out in a fair and honest manner. There is absolutely no hypocrisy. If there is any violation, I am willing to bear joint and several liability for the losses suffered by the government agencies and accept the administrative sanctions and criminal penalties imposed by the competent authorities in accordance with the law. 2. We understand that if we are appointed by a government agency to engage in official duties, we are also civil servants under the criminal law. We also understand that the crime of profiteering under the criminal law, the publication of false and forged official documents by public servants and the relevant provisions of the Corruption Crimes Act, if violated, one is also a he applicable object of criminal laws, and corruption laws. We are willing to be subject to the strictest legal regulations.
Remark
1. The testing items in this report were sampled and tested with permission from the Environmental Protection Administration and in accordance with the announced testing methods.

2. Determinations below the method detection limit are expressed as " ND " (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample and may not be copied at will or used for advertising.
4. Δ in the test results indicates that the analytical concentration value is greater than the detection limit of the method but less than the standard concentration at the first point of the calibration line.
5. The outsourced testing unit, report number, and project information are as follows: Jingzhan Inspection Technology Co., Ltd. ES230B7786: Chlorophyll a.

Person in charge: Huang Junren
Laboratory supervisor/report signatory: Shi Jianzhou

文件編號：EC-F-Q-038(AA)
執行日期：110.04.01
版次：4.1

亞太環境科技股份有限公司

【行政院環境保護署許可證字號:環署環檢第 003 號】

亞太環境科技股份有限公司檢驗室 地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：—
委託單位：台灣電力股份有限公司大甲溪發電廠
受驗單位：台灣電力股份有限公司大甲溪發電廠
採樣地點：台中市和平區東關路二段 89-1 號
採樣單位：亞太環境科技股份有限公司檢驗室
行程代碼：ECWA23080085
報告編號：EC11216298-WAA01
報告日期：112/08/24
檢測目的：其他環保法規用途
行業別/管制：—

採樣方法：NIEA W104.52C
檢驗編號：WA11211510-01
樣品名稱：馬鞍壩後池
樣品特性：液體
採樣時間：112/08/09 09:45
收樣時間：112/08/10 08:00

認證核可檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限 (MDL)
懸浮固體	m g / L	17.4	NIEA W210.58A	—	—
水溫	℃	22.1	NIEA W217.51A	—	—
總氮	m g / L	1.01	NIEA W423.52C	—	—
氫離子濃度指數(pH 值)	—	8.2(22.2℃)	NIEA W424.53A	—	—
亞硝酸鹽氮	m g / L	ND	NIEA W436.52C	—	0.004
硝酸鹽氮	m g / L	0.53	NIEA W436.52C	—	—
總磷	mgP/L	0.028	NIEA W442.51C	—	—
溶氧量	m g / L	7.9	NIEA W455.52C	—	—
氨氮	m g / L	0.14	NIEA W457.50B	—	—
以下空白					

聲明書
1. 茲保證本報告內容完全依照行政院環境保護署及有關機關之標準方法及品保品管等相關規定，秉持公正誠實進行採樣、檢測。絕無虛偽不實，如有違反，就政府機關所受損失願負連帶賠償責任之外，並接受主管機關依法令所為之行政處分及刑事處罰。
2. 吾人瞭解如自身受政府機關委任從事公務，亦屬於刑法上之公務員，並瞭解刑法上圖利罪，公務員登載不實偽造公文書及貪污治罪條例之相關規定，如有違反，亦為刑法及貪污治罪 條例之適用對象，願受最嚴厲之法律制裁。

備註
1. 本報告內之檢測項目為經環保署許可，並依公告檢測方法採樣檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，不得隨意複製及作為宣傳廣告之用。
4. 委外檢測單位、報告編號、項目資料如後： 精湛檢驗科技股份有限公司 ES230B7786：葉綠素 a。

負 責 人：黃 俊 仁

檢驗室主管/報告簽署人：施建州

報告專用章
亞太環境科技(股)公司
負 責 人：黃 俊 仁
檢驗室主管：施 建 州

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志 電話：07-3928088 地址：高雄市三民區灣興街 39 巷 8 號

Certification and Approval Testing Items	Unit	Test results	Detection method	Standard value	Method detection limit (MDL)
Transparency	m	1.0	NIEA E 2 2 0.5 1C	-	-
Turbidity	NTU	9.3	NIEA W21 9 .5 2 C	-	-

Certification and Approval Testing Items	Unit	Test results	Detection method	Standard value	Method detection limit (MDL)
Total organic nitrogen	mg/L	0.34	Reference NIEA W423.52C	-	-
Carlson Nutritional Status Index (TSI)	-	50.6	See note 4.	-	-
Blank below					

Remark

1. The testing items in this report are based on the testing shown in the "Testing Method" column.
2. Determinations below the detection limit of the method are expressed as ND" (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample. The report may not be copied at will or used for advertising.
4. Carlson's "Nutritional Status Index" is calculated from total phosphorus, transparency, and chlorophyll.

Person in charge: Huang Junren
Laboratory supervisor/report signatory: Shi Jianzhou

亞太環境科技股份有限公司

文件編號：EC-F-Q-038(AN)
執行日期：110.04.01
版次：4.1

亞太環境科技股份有限公司檢驗室 地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：—
委託單位：台灣電力股份有限公司大甲溪發電廠
受驗單位：台灣電力股份有限公司大甲溪發電廠
採樣地點：台中市和平區東關路二段 89-1 號
採樣單位：亞太環境科技股份有限公司檢驗室
採樣方法：NIEA W104.52C
檢驗編號：WA11211510-01
樣品名稱：馬鞍壩後池

行程代碼：—
報告編號：EC11216298-WAN01
報告日期：112/08/24
檢測目的：其他環保法規用途
行業別/管制：—
樣品特性：液體
採樣時間：112/08/09 09:45
收樣時間：112/08/10 08:00

檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限 (MDL)
透明度	m	1.0	NIEA E220.51C	—	—
濁度	N T U	9.3	NIEA W219.52C	—	—
總有機氮	m g / L	0.34	參考 NIEA W423.52C	—	—
卡爾森「營養狀態指數 (TSI)」	—	50.6	見 備 註 4 .	—	—
以下空白					

備註
1. 本報告內之檢測項目為依「檢測方法」欄位所示執行檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，報告不得隨意複製及作為宣傳廣告之用。
4. 卡爾森「營養狀態指數」由總磷、透明度、葉綠素計算而得。

報告專用章
亞太環境科技(股)公司
負責人：黃俊仁
檢驗室主管：施建州

負責人：黃俊仁
檢驗室主管/報告簽署人：施建州

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志 電話：07-3928088 地址：高雄市三民區灣興街 39 巷 8 號

<table>
<tr><th>Certification and Approval Testing Items</th><th>Test results and units</th><th>Detection method</th><th>Remark</th></tr>
<tr><td>Chlorophyll a</td><td>2.3 μg/L</td><td>NIEA E507. 04B</td><td></td></tr>
<tr><td>Blank below</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Remark</td></tr>
<tr><td colspan="4">1. This report has a total of 1 page and is invalid if used separately.
2. Measurements below the detection limit of the method are expressed as "ND<MDL", and its MDI is the detection limit of the method.
3. This report is only responsible for the sample and may not be copied at will or used for advertising.
4. In this case, the customer took samples and submitted them for inspection. Our laboratory is not responsible for the collection and delivery process and the storage conditions of the samples. We will be responsible for the samples sent.
5. Inspected unit: Taiwan Power Co., Ltd. Dajia Power Plant</td></tr>
<tr><td colspan="4">Statement</td></tr>
<tr><td colspan="4">1. We hereby guarantee that the contents of this report are sampled and tested in a fair and honest manner in accordance with the standard methods and quality assurance and quality control regulations of the Environmental Protection Agency of the Executive Yuan and relevant agencies. There is absolutely no hypocrisy. If there is any violation, I will be jointly and severally liable for the losses suffered by the government agencies, and I will accept the administrative sanctions and criminal penalties imposed by the competent authorities in accordance with the law.
2. We understand that if we are appointed by a government agency to perform official duties, we are also civil servants under the criminal law. We also understand that the crime of profiteering under the criminal law, the publication of false and forged official documents by public servants and the relevant provisions of the Corruption Crimes Act, if violated, are also criminal laws. Those who are subject to the Corruption Crime Ordinance are willing to be subject to the severest legal sanctions.</td></tr>
<tr><td colspan="4">Company name: Jingzhan Inspection Technology Co., Ltd.
Person in charge (signature): Yu Jianzhong
Laboratory Director (Report Signatory) (Signature): Chen Yuzheng</td></tr>
</table>

精湛檢驗科技股份有限公司

行政院環境保護署認可證字號:環署環檢字第019號
檢驗室名稱：精湛檢驗科技股份有限公司環境檢驗室

意見回饋

總公司:新北市中和區中正路716號14樓　　電話:(02)8228-0770(代表號)
網　址:http//:www.best-lab.com.tw　　傳真:(02)8228-0760

水質樣品檢驗報告

客戶名稱：亞太環境科技股份有限公司
樣品名稱：馬鞍壩後池
樣品編號：23B086023(WA11211510-01)
採樣單位：亞太環境股份有限公司檢驗室
採樣地點：台中市和平區東關路二段89-1號
檢測目的：其他環保法規用途
採樣方法：-

報告編號：ES230B7786
採樣日期與時間：112年08月09日 09:45
收樣日期與時間：112年08月10日 15:40
進出廠時間：-
樣品特性：濾紙
報告日期：112年08月17日
聯絡人：陳育錚 -分機200

檢驗項目	檢測結果與單位	檢驗方法	備註
葉綠素a	2.5 μg/L	NIEA E507.04B	
*~*以下空白*~*			

備註:
1.本報告共1頁，分離使用無效。
2.低於方法偵測極限之測定以"ND<MDL"表示，其MDL為方法偵測極限值。
3.本報告僅對該樣品負責，並不得隨意複製及作為宣傳廣告之用。
4.此案為客戶自行採樣送驗，本檢驗室對採樣過程及樣品保存條件不負責，僅對所送樣品負責。
5.受驗單位:台灣電力股份有限公司大甲發電廠。

聲明書

(一)茲保證本報告內容完全依照行政院環境保護署及有關機關之標準方法及品保品管等相關規定秉持公正、誠實進行採樣、檢測。絕無虛偽不實，如有違反，就政府機關所受損失願負連帶賠償責任之外，並接受主管機關依法令所為之行政處分及刑事處罰。

(二)吾人瞭解如自身受政府機關委任事公務，亦屬於刑法上之公務員，並瞭解刑法上圖利罪，公務員登載不實偽造公文書及貪污治罪條例之相關規定，如有違反，亦為刑法及貪污治罪條例之適用對象，願受最嚴厲之法律制裁。

公司名稱：精湛檢驗科技股份有限公司
負責人(簽章)：余 建 中
實驗室主任(報告簽署人)(簽章)： 8/17

報告專用章
精湛檢驗科技(股)公司
環境檢驗室
負責人:余建中
檢驗室主任:陳育錚

第1頁　共1頁

III. 2023 Q3 Water Quality Report

Project name:	—	Trip code:	ECW A23 100141
Requester:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report number:	EC112 21549 -WAA01
Inspected unit:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report date:	2023/11/08
Sampling location:	No. 89-1, Section 2, Dongguan Road, Heping District, Taichung City	Testing purpose:	other environmental protection regulations
Sampler:	Asia Pacific Environmental Technology Co., Ltd. testing lab	Industry/Regulation:	—
Sampling method:	NIEAW104.52C	Sample properties:	liquid
Inspection number:	WA112 15274-01	Sampling time:	2023/10/12 10:10
Sample name:	Ma'an barrage rear pool	Closing time:	2023/10/13 08:00

Certification and Approval Testing Items	Unit	Test results	Detection method	Standard value	Method Detection Limit (MDL)
Suspended solid	mg/L	2.8	NIEA W210.58A	-	-
Water temperature	℃	22. 1	NIEA W217.51 A	-	-
Total nitrogen	mg/L	0.95	NIEA W423.52C	-	-
Ion concentration index (pH value)	-	8.1 (22.2 ℃)	NIEA W424.53 A	-	-
Nitrite nitrogen	mg/L	ND	NIEA W436.52C	-	0.004
Nitrate nitrogen	mg/L	0.66	NIEA W436.52C	-	-
Total phosphorus	mg/L	0.055	NIEA W442.51C	-	-
Dissolved oxygen	mg/L	7.8	NIEA W455.52C	-	-
Ammonia nitrogen	mg/L	0.06	NIEA W457.50B	-	-
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Statement

1. We hereby guarantee that the contents of this report are in full compliance with the standard methods and quality assurance and quality control regulations of the Environmental Protection Agency of the Executive Yuan and relevant agencies, and sampling and testing are carried out in a fair and honest manner. There is absolutely no hypocrisy. If there is any violation, I am willing to bear joint and several liability for the losses suffered by the government agencies and accept the administrative sanctions and criminal penalties imposed by the competent authorities in accordance with the law.
2. We understand that if we are appointed by a government agency to engage in official duties, we are also civil servants under the criminal law. We also understand that the crime of profiteering under the criminal law, the publication of false and forged official documents by public servants and the relevant provisions of the Corruption Crimes Act, if violated, one is also a he applicable object of criminal laws, and corruption laws. We are willing to be subject to the strictest legal regulations.

Remark

1. The testing items in this report were sampled and tested with permission from the Environmental Protection Administration and in accordance with the announced testing methods.

2. Determinations below the method detection limit are expressed as " ND " (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample and may not be copied at will or used for advertising.
4. Δ in the test results indicates that the analytical concentration value is greater than the detection limit of the method but less than the standard concentration at the first point of the calibration line.
5. The outsourced testing unit, report number, and project information are as follows: Jingzhan Inspection Technology Co., Ltd. ES230B 9564: Chlorophyll a

Person in charge: Huang Junren
Laboratory supervisor/report signatory: Shi Jianzhou

文件編號：EC-F-Q-038(AA)
執行日期：112.09.01
版次：42

亞太環境科技股份有限公司

環境部許可證字號：環境部國環檢證字第 003 號(原環署環檢字第 003 號)
亞太環境科技股份有限公司檢驗室 地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：—
委託單位：台灣電力股份有限公司大甲溪發電廠
受驗單位：台灣電力股份有限公司大甲溪發電廠
採樣地點：台中市和平區東關路二段 89-1 號
採樣單位：亞太環境科技股份有限公司檢驗室
採樣方法：NIEA W104.52C
檢驗編號：WA11215274-01
樣品名稱：馬鞍壩後池

行程代碼：ECWA23100141
報告編號：EC11221549-WAA01
報告日期：112/11/08
檢測目的：其他環保法規用途
行業別/管制：—
樣品特性：液體
採樣時間：112/10/12 10:10
收樣時間：112/10/13 08:00

認證核可檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限 (MDL)
懸浮固體	mg/L	2.8	NIEA W210.58A	—	—
水溫	℃	22.1	NIEA W217.51A	—	—
總氮	mg/L	0.95	NIEA W423.52C	—	—
氫離子濃度指數(pH 值)	—	8.1(22.2℃)	NIEA W424.53A	—	—
亞硝酸鹽氮	mg/L	ND	NIEA W436.52C	—	0.004
硝酸鹽氮	mg/L	0.66	NIEA W436.52C	—	—
總磷	mgP/L	0.055	NIEA W442.51C	—	—
溶氧量	mg/L	7.8	NIEA W455.52C	—	—
氨氮	mg/L	0.06	NIEA W457.50B	—	—
以下空白					

聲明書
1. 茲保證本報告內容完全依照環境部及有關機關之標準方法及品保品管等相關規定，秉持公正誠實進行採樣、檢測。絕無虛偽不實，如有違反，就政府機關所受損失願負連帶賠償責任之外，並接受主管機關依法令所為之行政處分及刑事處罰。
2. 吾人瞭解如自身受政府機關委任從事公務，亦屬於刑法上之公務員，並瞭解刑法上圖利罪，公務員登載不實偽造公文書及貪污治罪條例之相關規定，如有違反，亦為刑法及貪污治罪 條例之適用對象，願受最嚴厲之法律制裁。

備註
1. 本報告內之檢測項目為經環境部許可，並依公告檢測方法採樣檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，不得隨意複製及作為宣傳廣告之用。
4. 委外檢測單位、報告編號、項目資料如後：精湛檢驗科技股份有限公司 ES230B9564 :葉綠素 a。

報告專用章
亞太環境科技(股)公司
負責人：黃俊仁
檢驗室主管：施建州

負責人：黃俊仁
檢驗室主管/報告簽署人：施建州 11/8

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志 電話：07-3928088 地址：高雄市三民區灣興街 39 巷 8 號

Certification and Approval Testing Items	Unit	Test results	Detection method	Standard value	Method detection Limit (MDL)
Transparency	m	3.3	NIEA E22 0.51C	-	-
Turbidity	NTU	1.9	NIEA W219.52 C	-	-
Total organic nitrogen	mg/L	0.23	Reference NIEA W423.52C	-	-
Carlson Nutritional Status Index (TSI)	-	41.1	See note 4.	-	-
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Remark

1. The testing items in this report are based on the testing shown in the "Testing Method" column.
2. Measurements below the detection limit of the method are expressed as ND" (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample. The report may not be copied at will or used for advertising.
4. Carlson's "Nutritional Status Index" is calculated from total phosphorus, transparency, and chlorophyll.

Person in charge: Huang Junren
Laboratory supervisor/report signatory: Shi Jianzhou

亞太環境科技股份有限公司

亞太環境科技股份有限公司檢驗室 地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：—
行程代碼：—
委託單位：台灣電力股份有限公司大甲溪發電廠
報告編號：EC11221549-WAN01
受驗單位：台灣電力股份有限公司大甲溪發電廠
報告日期：112/11/08
採樣地點：台中市和平區東關路二段 89-1 號
檢測目的：其他環保法規用途
採樣單位：亞太環境科技股份有限公司檢驗室
行業別/管制：—

採樣方法：NIEA W104.52C
樣品特性：液體
檢驗編號：WA11215274-01
採樣時間：112/10/12 10:10
樣品名稱：馬鞍壩後池
收樣時間：112/10/13 08:00

檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限(MDL)
透明度	m	3.3	NIEA E220.51C	—	—
濁度	N T U	1.9	NIEA W219.52C	—	—
總有機氮	m g / L	0.23	參考 NIEA W423.52C	—	—
卡爾森「營養狀態指數 (TSI)」	—	41.1	見 備 註 4 .	—	—
以下空白					

備註
1. 本報告內之檢測項目為依「檢測方法」欄位所示執行檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，報告不得隨意複製及作為宣傳廣告之用。
4. 卡爾森「營養狀態指數」由總磷、透明度、葉綠素計算而得。

負 責 人：黃 俊 仁

檢驗室主管/報告簽署人：施建州 11/8

報告專用章
亞太環境科技(股)公司
負 責 人：黃 俊 仁
檢驗室主管：施 建 州

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志 電話：07-3928088 地址：高雄市三民區灣興街 39 巷 8 號

IV. 2023 Q4 Water Quality Report

Project name:	—	Trip code:	ECW A23110237
Requester:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report number:	EC112 24351 -WAA01
Inspected unit:	Taiwan Power Co., Ltd. Dajia River Power Plant	Report date:	2023/12/06
Sampling location:	No. 89-1, Section 2, Dongguan Road, Heping District, Taichung City	Testing purpose:	other environmental protection regulations
Sampler:	Asia Pacific Environmental Technology Co., Ltd. testing lab	Industry/Regulation:	—
Sampling method:	NIEAW104.52C	Sample properties:	liquid
Inspection number:	WA11217228-01	Sampling time:	2023/11/17 10:21
Sample name:	Ma'an barrage rear pool	Closing time:	2023/11/18 08:00

Certification and Approval Testing Items	Unit	Test results	Detection method	Standard value	Method Detection limit (MDL)
Suspended solid	mg/L	3.6	NIEA W210.58A	-	-
Water temperature	℃	19.3	NIEA W217.51 A	-	-
Total nitrogen	mg/L	0.99	NIEA W423.52C	-	-
Ion concentration index (pH value)	-	8.0 (19.3℃)	NIEA W424.53 A	-	-
Nitrite nitrogen	mg/L	ND	NIEA W436.52C	-	0.004
Nitrate nitrogen	mg/L	0.56	NIEA W436.52C	-	-
Total phosphorus	mg/L	0.0 50	NIEA W442.51C	-	-
Dissolved oxygen	mg/L	8.6	NIEA W455.52C	-	-
Ammonia nitrogen	mg/L	0.08	NIEA W457.50B	-	-
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Statement

1. We hereby guarantee that the contents of this report are in full compliance with the standard methods and quality assurance and quality control regulations of the Environmental Protection Agency of the Executive Yuan and relevant agencies, and sampling and testing are carried out in a fair and honest manner. There is absolutely no hypocrisy. If there is any violation, I am willing to bear joint and several liability for the losses suffered by the government agencies and accept the administrative sanctions and criminal penalties imposed by the competent authorities in accordance with the law.
2. We understand that if we are appointed by a government agency to engage in official duties, we are also civil servants under the criminal law. We also understand that the crime of profiteering under the criminal law, the publication of false and forged official documents by public servants and the relevant provisions of the Corruption Crimes Act, if violated, one is also a he applicable object of criminal laws, and corruption laws. We are willing to be subject to the strictest legal regulations.

Remark

1. The testing items in this report were sampled and tested with permission from the Environmental Protection Administration and in accordance with the announced testing methods.
2. Determinations below the method detection limit are expressed as " ND " (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample and may not be copied at will or used for advertising.
4. Δ in the test results indicates that the analytical concentration value is greater than the detection limit of the method but less than the standard concentration at the first point of the calibration line.
5. The outsourced testing unit, report number, and project information are as follows: Jingzhan Inspection Technology Co., Ltd. ES230B10812: Chlorophyll a

Person in charge: Huang Junren

Laboratory supervisor/report signatory: Shi Jianzhou

文件編號：EC-F-Q-038(AA)
執行日期：112.09.01
版次：4.2

亞太環境科技股份有限公司

環境部許可證字號：環境部國環檢證字第 003 號(原環署環檢字第 003 號)
亞太環境科技股份有限公司檢驗室　地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：	—	行程代碼：	ECWA23110237
委託單位：	台灣電力股份有限公司大甲溪發電廠	報告編號：	EC11224351-WAA01
受驗單位：	台灣電力股份有限公司大甲溪發電廠	報告日期：	112/12/06
採樣地點：	台中市和平區東關路二段 89-1 號	檢測目的：	其他環保法規用途
採樣單位：	亞太環境科技股份有限公司檢驗室	行業別/管制：	—
採樣方法：	NIEA W104.52C	樣品特性：	液體
檢驗編號：	WA11217228-01	採樣時間：	112/11/17 10:21
樣品名稱：	馬鞍壩後池	收樣時間：	112/11/18 08:00

認證核可檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限 (MDL)
懸浮固體	mg/L	3.6	NIEA W210.58A	—	—
水溫	℃	19.3	NIEA W217.51A	—	—
總氮	mg/L	0.99	NIEA W423.53C	—	—
氫離子濃度指數(pH 值)	—	8.0(19.3℃)	NIEA W424.53A	—	—
亞硝酸鹽氮	mg/L	ND	NIEA W436.52C	—	0.004
硝酸鹽氮	mg/L	0.56	NIEA W436.52C	—	—
總磷	mgP/L	0.050	NIEA W442.51C	—	—
溶氧量	mg/L	8.6	NIEA W455.52C	—	—
氨氮	mg/L	0.08	NIEA W457.50B	—	—
以下空白					

聲明書
1. 茲保證本報告內容完全依照環境部及有關機關之標準方法及品保品管等相關規定，秉持公正誠實進行採樣、檢測。絕無虛偽不實，如有違反，就政府機關所受損失願負連帶賠償責任之外，並接受主管機關依法令所為之行政處分及刑事處罰。
2. 吾人瞭解如自身受政府機關委任從事公務，亦屬於刑法上之公務員，並瞭解刑法上圖利罪，公務員登載不實偽造公文書及貪污治罪條例之相關規定，如有違反，亦為刑法及貪污治罪 條例之適用對象，願受最嚴厲之法律制裁。

備註
1. 本報告內之檢測項目為經環境部許可，並依公告檢測方法採樣檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，不得隨意複製及作為宣傳廣告之用。
4. 委外檢測單位、報告編號、項目資料如後： 精湛檢驗科技股份有限公司 ES230B10812 :葉綠素 a。

負責人：黃 俊 仁

檢驗室主管/報告簽署人：施建州

報告專用章
亞太環境科技(股)公司
負責人：黃俊仁
檢驗室主管：施建州

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志　電話：07-3928088　地址：高雄市三民區灣興街 39 巷 8 號

Certification and Approval Testing Items	unit	Test results	Detection method	standard value	method detection limit (MDL)
Transparency	m	2.6	NIEA E220.51C	-	-
Turbidity	NTU	1.3	NIEA W219.52 C	-	-
Total organic nitrogen	mg/L	0.34	Reference NIEA W423.52C	-	-
Carlson Nutritional Status Index (TSI)	-	44.6	See note 4.	-	-
Blank below					

Remark
1. The testing items in this report are based on the testing shown in the "Testing Method" column.

2. Measurements below the detection limit of the method are expressed as ND" (not detected), and the method detection limit (MDL) is indicated thereafter.
3. This report is only responsible for the sample. The report may not be copied at will or used for advertising.
4. Carlson's "Nutritional Status Index" is calculated from total phosphorus, transparency, and chlorophyll.

Person in charge: Huang Junren
Laboratory supervisor/report signatory: Shi Jianzhou

文件編號：EC-F-Q-038(AN)
執行日期：112.09.01
版次：4.2

亞太環境科技股份有限公司

亞太環境科技股份有限公司檢驗室 地址：高雄市三民區灣興街 39 巷 8 號

水質水量檢測類 檢測報告

計畫名稱：	—	行程代碼：	—
委託單位：	台灣電力股份有限公司大甲溪發電廠	報告編號：	EC11224351-WAN01
受驗單位：	台灣電力股份有限公司大甲溪發電廠	報告日期：	112/12/06
採樣地點：	台中市和平區東關路二段 89-1 號	檢測目的：	其他環保法規用途
採樣單位：	亞太環境科技股份有限公司檢驗室	行業別/管制：	—
採樣方法：	NIEA W104.52C	樣品特性：	液體
檢驗編號：	WA11217228-01	採樣時間：	112/11/17 10:21
樣品名稱：	馬鞍壩後池	收樣時間：	112/11/18 08:00

檢測項目	單位	檢測結果	檢測方法	標準值	方法偵測極限 (MDL)
透明度	m	2.6	NIEA E220.51C	—	—
濁度	NTU	1.3	NIEA W219.52C	—	—
總有機氮	mg/L	0.34	參考 NIEA W423.53C	—	—
卡爾森「營養狀態指數 (TSI)」	—	44.6	見備註 4.	—	—
以下空白					

備註
1. 本報告內之檢測項目為依「檢測方法」欄位所示執行檢測。
2. 低於方法偵測極限之測定以"ND"(未檢出)表示，並於其後註明方法偵測極限值(MDL)。
3. 本報告僅對該樣品負責，報告不得隨意複製及作為宣傳廣告之用。
4. 卡爾森「營養狀態指數」由總磷、透明度、葉綠素計算而得。

負責人：黃俊仁
檢驗室主管/報告簽署人：施建州

報告專用章
亞太環境科技(股)公司
負責人：黃俊仁
檢驗室主管：施建州

第 1 頁，報告共 1 頁，分離使用無效
聯絡人：林育志 電話：07-3928088 地址：高雄市三民區灣興街 39 巷 8 號