

**Key Issue:**

**5-Water Quality**

**Climate Zone:**

Cf: Temperate Humid Climate

**Subjects:**

- Monitoring of Water Quality and Ecology Environment at Sun Moon Lake



**Effects:**

- Environmental Impact of Mingtan Project

**Project Name:** Mingtan Pumped Storage Power Project

**Country:** Taiwan

**Implementing Party & Period**

- **Project:** Taiwan Power Company  
1987 - 1994

- **Good Practice:** Taiwan Power Company  
2001 -

**Key Words:**

Water Quality, Ecology Environment, Monitoring

**Abstract:**

The Mingtan Pumped Storage Hydro Power Plant was completed in 1994 as an important facility to control peak hours' electricity demand in Taiwan. It has two reservoirs, one is the existing lake Sun Moon Lake as an upper reservoir and the other is Shui Li reservoir formed by building a dam as a lower reservoir. Sun Moon Lake is famous as sightseeing and resort area for its water's clearness. Taiwan Power Company has been executing investigations for water quality, ecology environment, and environment impact assessment of Sun Moon Lake and Shui Li Reservoir after operation of Mingtan Power Plant. Especially in 2001, earnest investigations for inflow discharge, water quality, ecology in the area were executed. Taiwan Power Company has been making effort to take immediate measures to cope with unusual conditions considering the results of investigation.

**1. Outline of the Project**

To meet demand of ever-increasing peak load and to make the most utilization of the off-peaking remaining power, since 1973, Taiwan Power Company (TPC) has entrusted the European consultant to undertake a synthetic and comparative study on peak power. The study resulted in the superiority of Mingtan pumped storage project over all other new installation of the thermal peak power facilities. To avoid the expansion of the peak power system and to lower the operating costs, the pumped storage is both technical and economical feasible.

Table 1 Specification of the Power Plant

Power Plant Data	Gross head	380.0 m	Upper Reservoir (existing)	Name	Sun Moon Lake
	Installed capacity	1,600 MW		Active storage	142.4×10 <sup>6</sup> m <sup>3</sup>
	Maximum operation flow	492 m <sup>3</sup> /sec	Lower Reservoir (newly installed)	Name	Shui Li Reservoir
	Utilization factor	10.8 %		Active storage	12.0×10 <sup>6</sup> m <sup>3</sup>

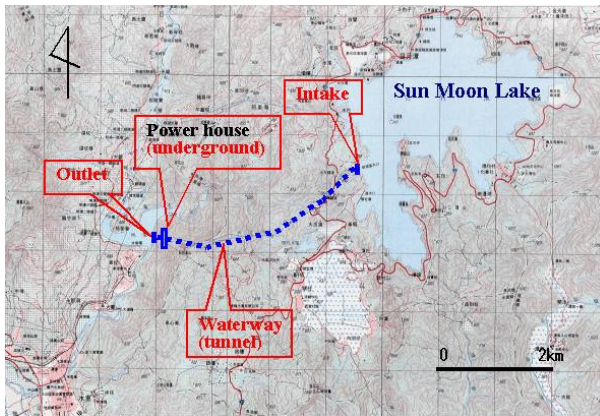


Fig. 1 Location of Mingtan Power Plant



Fig. 2 Sun Moon Lake

## 2. Feature of the Project Area

Project area is located in Nantou Prefecture where is the central part of Taiwan. Annual mean temperature of the project site is 19.5 degrees Centigrade. Annual mean precipitation is about 2,360 mm.

Sun Moon Lake is a natural lake, which is located at the west foot of Taiwan Central Mountain Range. The east side of the lake is mountain area, the west side is plains. In 1934, it was formed as a reservoir for Takuan hydroelectric power plant (100MW) by conducting from neighboring rivers, as a result, the lake had been extended. Two hydroelectric power plants were installed additionally in 1943. In 1981, Minghu (renamed Takuan) pumped storage hydro power plant (1,000MW) using Sun Moon Lake as an upper reservoir was completed. Its water has been very clear so the lake is one of the prominent tourist attractions in Taiwan. The lake has a periphery of about 33 kilometers and an area of 793 ha.

There are many historic spots (for exam. Wen Wu Miao which is a Joss palace of Confucius), a theme park of ethnic villages, scenic spots, and many hotels, lodges around the lake. Especially in summer



Fig. 3 Location of the project

season, many tourists visit there.

### **3. Major Impacts**

This Project uses existing Sun-Moon Lake as upper reservoir and builds a dam in the Sui-Li stream valley as lower pond. In the left side of lower reservoir build underground power plant. This plant uses average 380 meters height difference between upper and lower reservoir as this plant.

In the area surrounding the upper reservoir, there is arboreous forest that is good habitat of animal. This project will change the environment of the habitat of animal to emigrate or die. In the intake area, aquatics, amphibians, and birds will be influenced in the construction period. In the lower reservoir, building a dam will increase the turbidity of water that will influence the fish habitat. The environment will change from stream to lake. The component of aquatic biology will be difference. Therefore the environmental impact assessment was carried out before the construction.

As the result of the assessment, environmental factors considering to be affected to the surrounding area during the construction were as follows.

- 1) The degree of air pollution
- 2) Water discharge of surrounding rivers
- 3) Water quality of the construction sites
- 4) The ecology of the construction sites
- 5) Noise emission

The considerable impacts after operation were as follows.

- 1) Water discharge of surrounding rivers
- 2) Water quality of Sun Moon Lake (upper reservoir) and lower reservoir of this power plant
- 3) The ecology of the lake area
- 4) Beauty of project area landscape

### **4. Mitigation Measures**

After commencement (1994) of operation, water quality has been measured regularly every year. Especially in 2001, measurements and investigations about the above environmental factors were executed thoroughly by Taiwan Power Company as follows. Terms of investigation were from January to December in 2001. Investigation plan for each factor was made cooperated with experts including scholars.

As for water quality, Taiwan Power Company has been measuring continuously.

#### **(1) Water flow discharge of surrounding rivers**

Water flow gauging stations were installed at Toushe river and Shui Li river. They had measured the water level of the rivers everyday, and measured water flow discharge four times or more a month in high water season, two times or more a month in dry season. They had recorded the changes of water level and water discharge.

On the other hand, rainfall gauging stations were installed at Shuishe, Takuan, Jugong, rainfall had been recorded everyday. (As for location, refer to Fig. 4)

**(2) Water quality of Sun Moon Lake (upper reservoir) & lower reservoir of Mingtan power plant**  
 4 sampling spots in Sun Moon Lake and 6 sampling spots in the lower reservoir were set up, and water quality had been measured once in two month in high water season, once in three month in dry season. They had investigated following factors in Table 2. (As for location, refer to Fig. 5)

Table 2 Investigation Plan

Sort	Factor	Frequency	term
Hydrology	Precipitation	Every day	2001.1~
	River water level and flow discharge	Water level; every day Discharge; 4 times or more a months in high water season, 2 times or more a months in dry season	
Water quality	Water temperature, Dissolved oxygen, pH value, Transparency, Suspended particulate matter, Turbidity, Biochemical oxygen demand, Chemical oxygen demand, Coliform group number, Nitrate salt nitrogen, Sub-nitrate salt nitrogen, Ammonia, Organic nitrogen, Total nitrogen, Phosphatic phosphorous, Total phosphorous	Water quality; once in two months in high water season, once in three months in dry season.	2/15~16 4/26~27 6/7~8 8/30~31 11/8~9
Lake area Ecology	Phytoplankton	Once in three months	2/15~16 4/26~27 8/30~31 11/8~9
	Zooplankton		
	Aquatic insect		
	Fishes		
	Turnout of fishery	Once in a year	
Beauty of project area	Landscape beauty Behavioral trait of tourists Impact to landscape by water level change	Once in a year	4/20~21 10/13~14

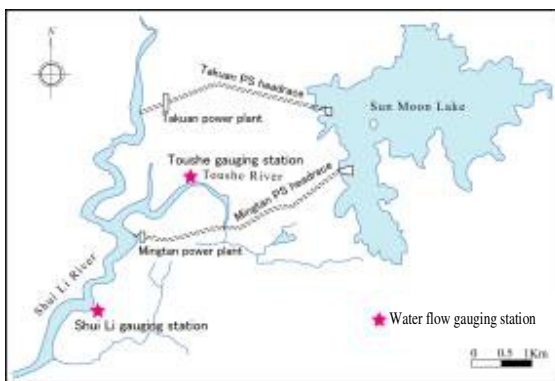


Fig. 4 Water flow gauging station

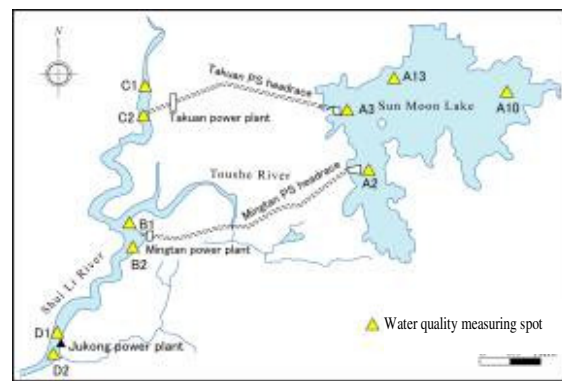


Fig. 5 Water quality measuring spot

**(3) The ecology of the lake area**

4 sampling spots in Sun Moon Lake and 2 sampling spots in the lower reservoir were set up, and following factors in Table 2 had been measured. (As for location, refer to Fig. 6)

**(4) Beauty of project area landscape**

Sun Moon Lake special scenic area, Mingtan Power Plant waterway, lower reservoir area, rock disposal

area, factory for plant material had been investigated on the condition about planting and land slide protection by comparing photographs of the sites. And behavioral trait of tourists, impact to landscape by water level change, had been investigated and evaluated. (As for location, refer to Fig. 7)

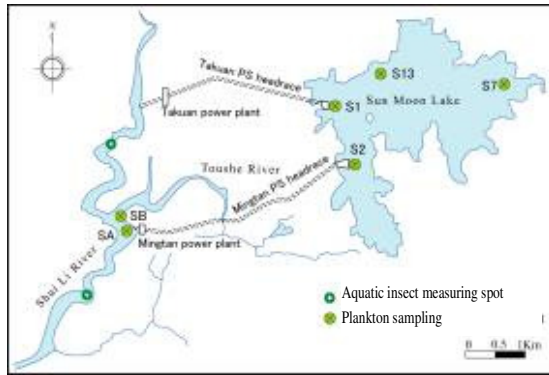


Fig. 6 Aquatic insect, plankton measuring spot

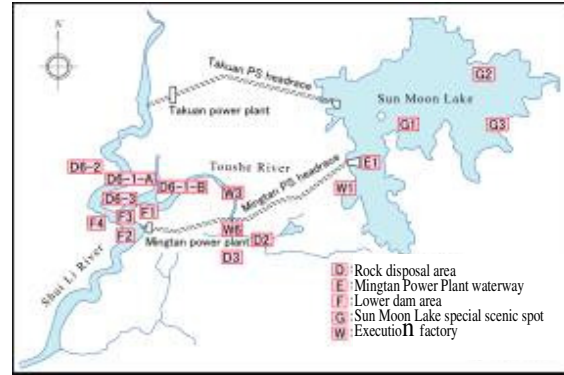


Fig. 7 Landscape investigation spot

## 5. Results of the Mitigation Measures

As a result of the observation in 2001, fluctuation of upper reservoir was 0.32 - 4.03 meters, that of lower reservoir was 8.30 - 24.50 meters. Maximum fluctuation occurred in April.

Investigation for environmental impact is executed steadily from the point of view of environmental protection and energy development. Taiwan Power Company assesses the investigation results objectively and submits the assessment to public offices in order to control impacts.

In case that the impact exceeds the acceptable range or an unacceptable impact occurs, the precise countermeasure shall be taken immediately.

As the result of above activities, the water of Sun Moon Lake is kept clean and clear so that the lake is a place of recreation and relaxation where many tourists visit.

The results of water quality measurement in 2003 are as follows.

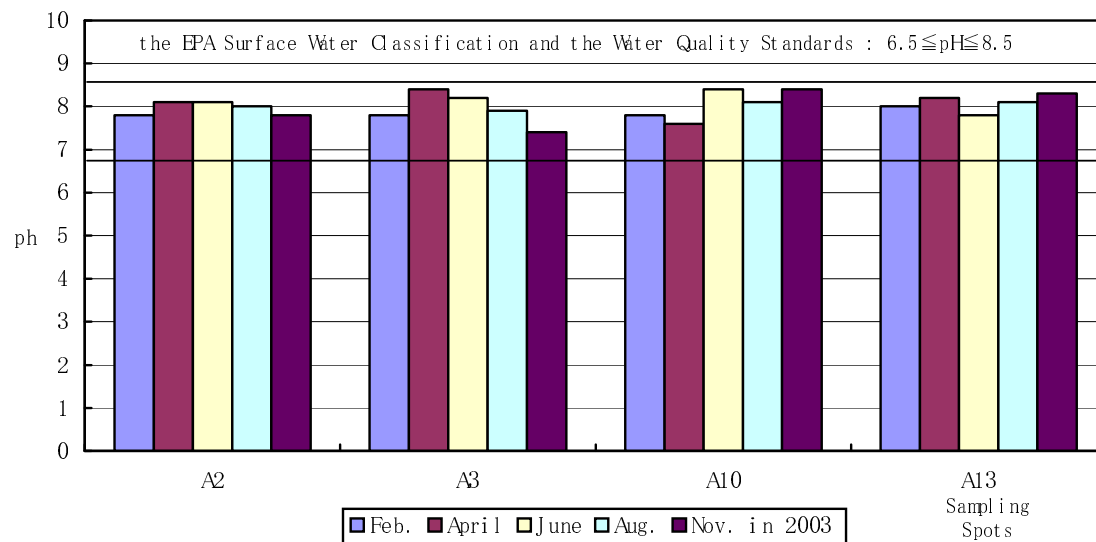


Fig. 8 The variation of pH of Sun-Moon-Lake in 2003

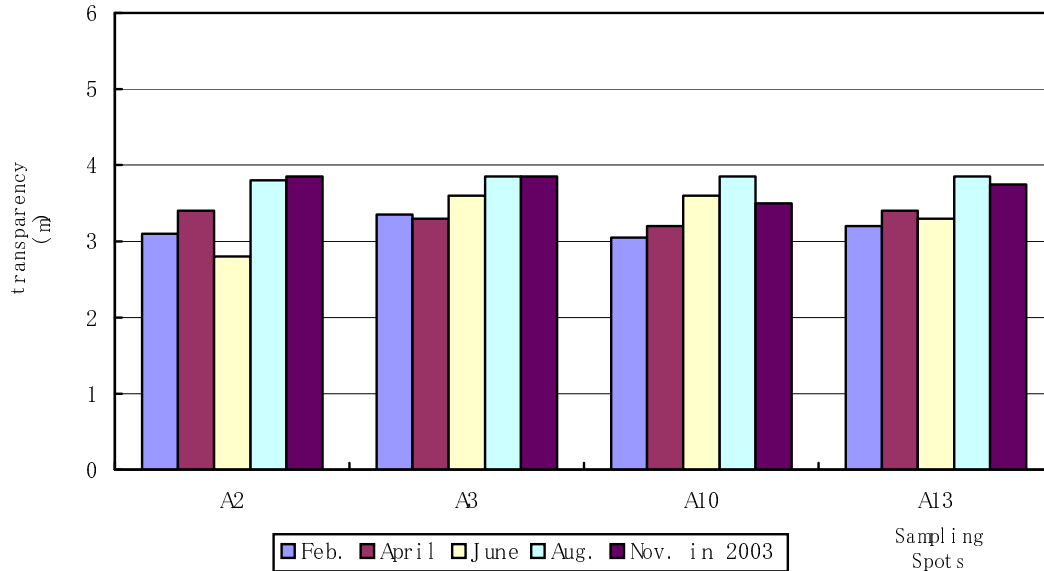


Fig. 9 The variation of transparency of Sun-Moon-Lake in 2003

## 6. Reasons for Success

- Investigation plan was made by experts on each factor.
- Investigations are steady and through, especially Taiwan Power Company has been executing through water quality sampling since the commencement of Mingtan Power Plant operation.
- The results of assessment are submitted to public offices, and they (the company) accept the public opinion.
- The countermeasure shall be taken immediately in case of need.

## 7. Outside comments

As a result of inquiry put into practice to tourists in 2003, it was turned out that almost all tourists are satisfied with the scenery of Sun Moon Lake, and Mingtan Power Plant does not have any bad influence on surrounding areas.

And as a result of overall inquiry survey in 2003, following matters were turned out.

- The percentage of dissatisfied persons to the scenery of Sun Moon Lake was 9.6%, which is lower than before.
- Existence of Mingtan Power Plant does not have anything to do with satisfaction to the scenery directly nor indirectly.
- The percentage of the tourists visiting the lower reservoir dam was 14.2%

## 8. Further Information

### 8.1 References

- 1) Environmental Investigation of Mingtan Power Plant during operation term (2001.1-2001.12)
- 2) PROSPECTIVE VIEW OF MINGTAN PUMPED STORAGE POWER PLANT
- 3) TAIWAN POWER COMPANY 2002 ANNUAL REPORT

4) <http://www.sunmoonlake.gov.tw/smljp/main.php?first=culture&second=history>

## **8.2 Inquiries**

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