

Streamflow Changes of Dajia River Associated with Chi-Chi Earthquake

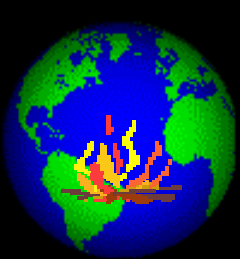


Youe-Ping Lee

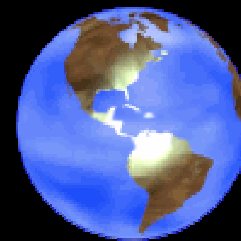
Water Resources Agency, Ministry of Economic Affairs,
Taiwan, R.O.C.

September 24, 2002

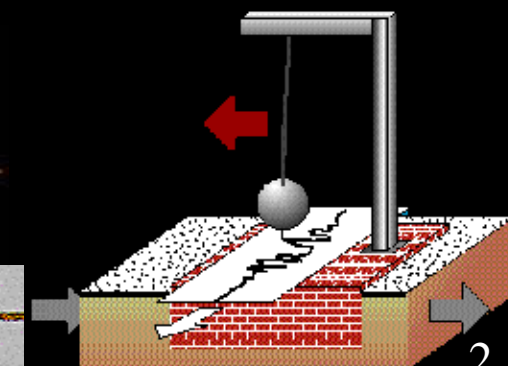




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INTRODUCTION



- ✦ The Chi-Chi earthquake ($M_L=7.3$), which occurred on September 21, 1999, is one of the greatest shallow inland earthquakes in Taiwan.
- ✦ It killed at least 2200 people, toppling buildings and trapping hundreds in the wreckage.
- ✦ The epicenter, near a small town Chi-Chi was 160 km south-south west of Taipei.

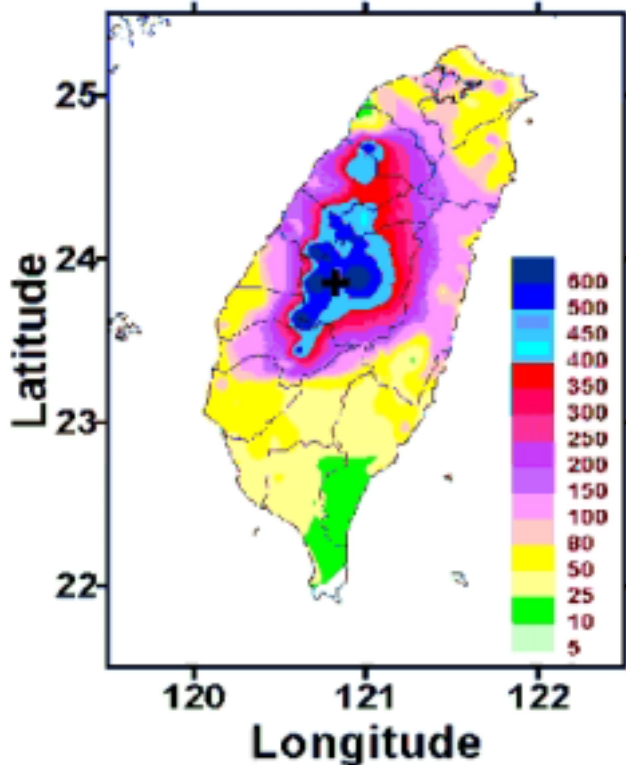


INTRODUCTION

0921,1999 Chi-Chi Earthquake

PGA Time History

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- ✦ The depth of the Chi-Chi earthquake was 1.1 km, which was a shallow inland earthquake.
- ✦ The surface rupture was observed along about 100 km.
- ✦ The variation of peak ground acceleration (PGA) is shown in the figure.
- ✦ The local largest intensity of the Dajia river basin is about 6.



Fault surface rupture across Shigung Dam.

STUDY AREA

- ✦ The Dajia river basin locates at the north of epicenter and defines as a region of 1235.73 Km² in area.
- ✦ The mountainous area is in the upstream of the Shigung dam (about 90% of the basin); the other is the plain area.
- ✦ The elevation increases from 0m to 3000m, and the stream gradient ranges from 0.011 to 0.028 m/m.
- ✦ The wet season is generally from April to September. There is 73% of the annual rainfall in the wet season and the mean annual rainfall is about 2500mm.



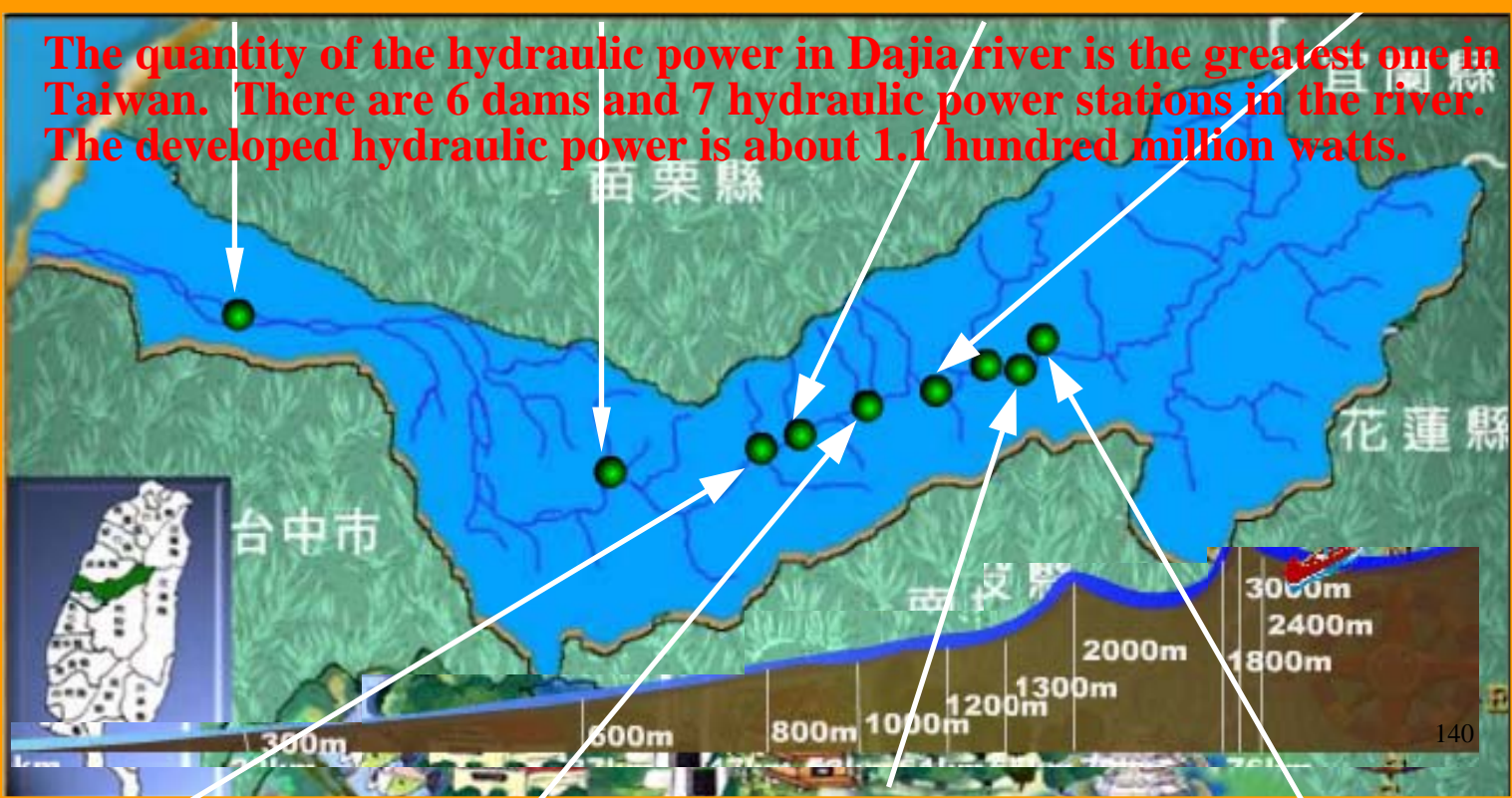
Shigung Dam

Maan Dam

Maan Dam

Qingshin Power Station

The quantity of the hydraulic power in Dajia river is the greatest one in Taiwan. There are 6 dams and 7 hydraulic power stations in the river. The developed hydraulic power is about 1.1 hundred million watts.



Tailun Dam

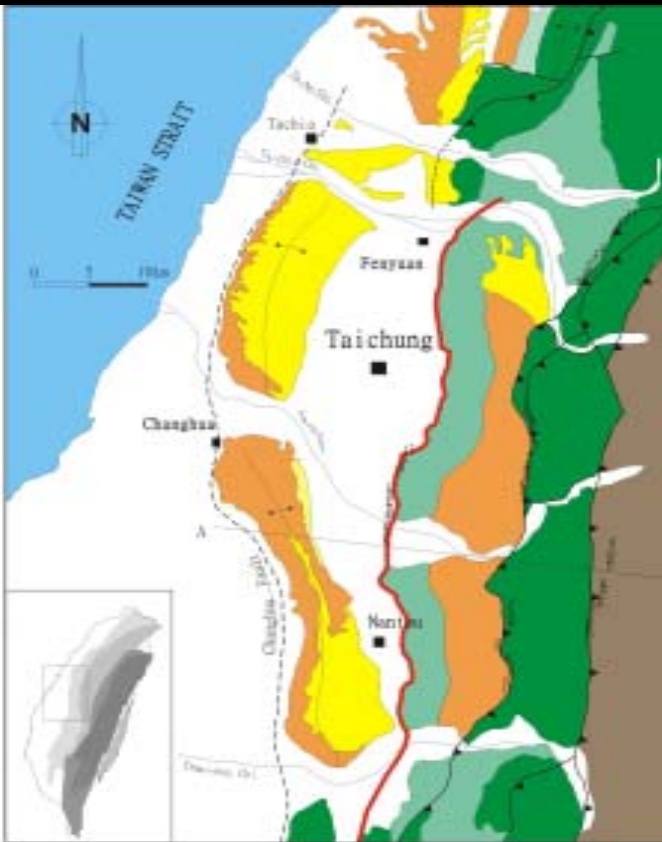
Guguan Dam

Deji Power Station

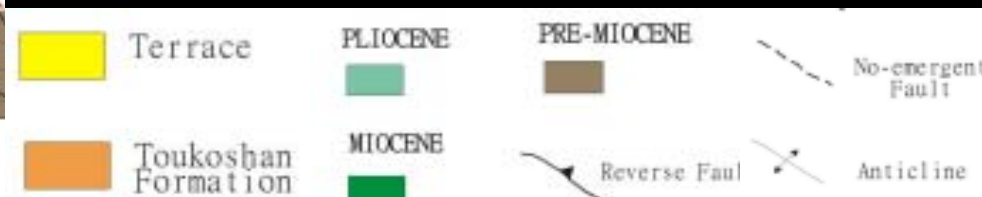
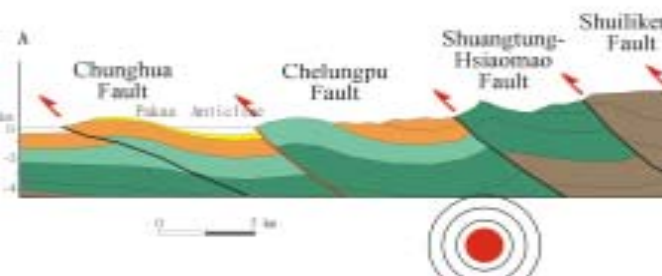
Deji Dam



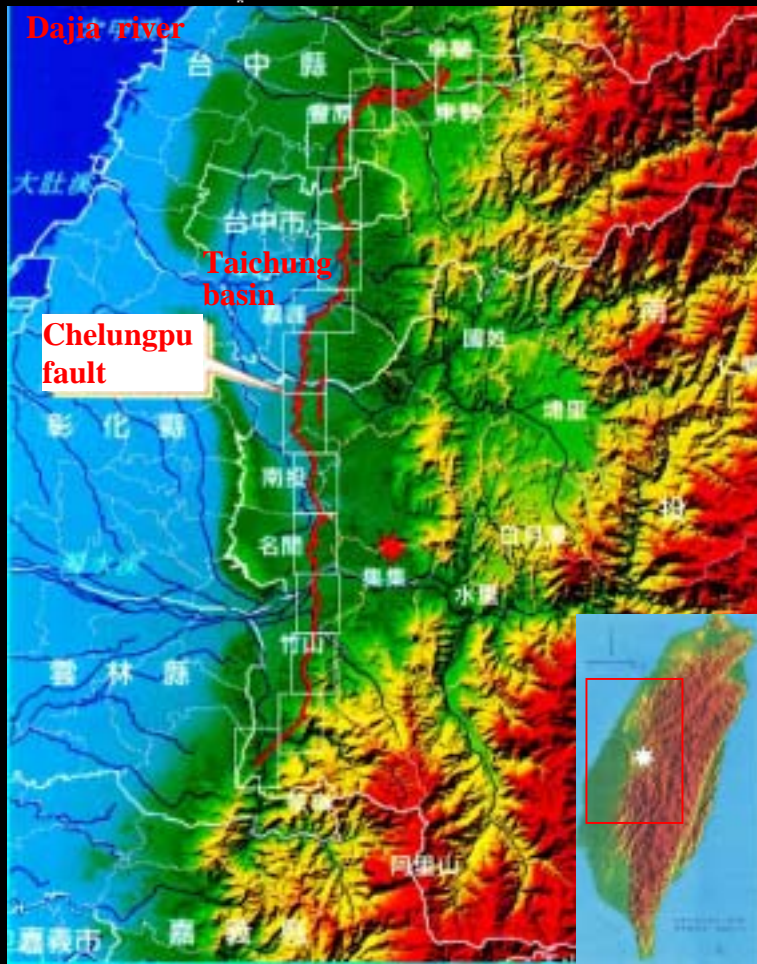
GENERAL GEOLOGY in STUDY AREA



- ✦ In west-central Taiwan, there are three important Quaternary faults trending nearly north-south with dips moderately towards east.
- ✦ From east to west, they are the Shuangtung fault, the Chelungpu fault and the Changhua fault.
- ✦ The west directed Shuangtung fault is thrusting over the Quaternary Toukoshan Formation and the Chelungpu fault is thrusting over the younger alluvium deposits of the Taichung basin.
- ✦ The Changhua fault is the frontal thrust fault and partially covered by recent alluvium deposits.



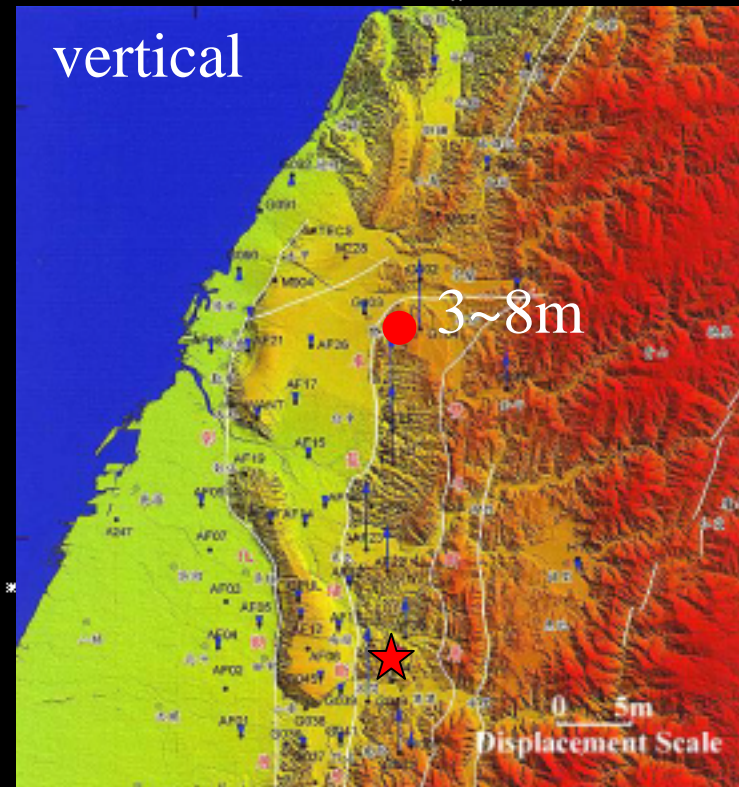
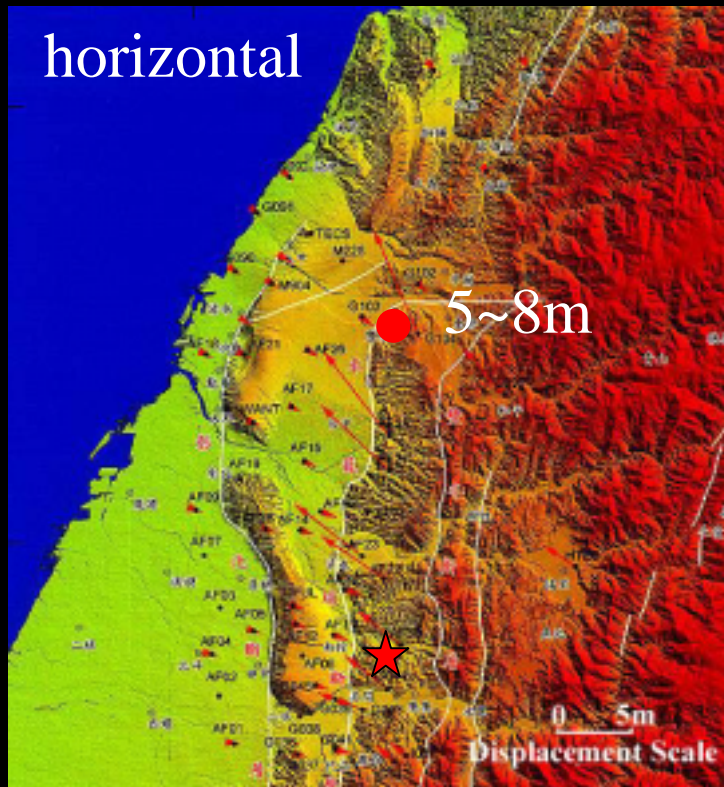
CHELUNGPU FAULT



- ✦ The Chelungpu thrust fault is one of the major geological structures in the west-central Taiwan. It runs approximately along the western margin of the Taichung basin and extends north-southwards.
- ✦ Geographically, the Chelungpu fault is passing through the Dajia river.
- ✦ From the result of geodetic survey, the activity of the Chelungpu fault is the strongest among the three thrust faults in this region.
- ✦ The devastated areas struck by the Chi-Chi Earthquake with severe crustal deformation are more or less located along the Chelungpu fault and further towards east.

DEFORMATION of STUDY AREA

- ✦ Geographically, the Dajia river basin is penetrated by the Chelungpu fault and stroke by the Chi-Chi earthquake with severe crustal deformation.
- ✦ The horizontal displacement in the vicinity of the Shigung dam is 5~8m, and the vertical displacement is 3~8m.

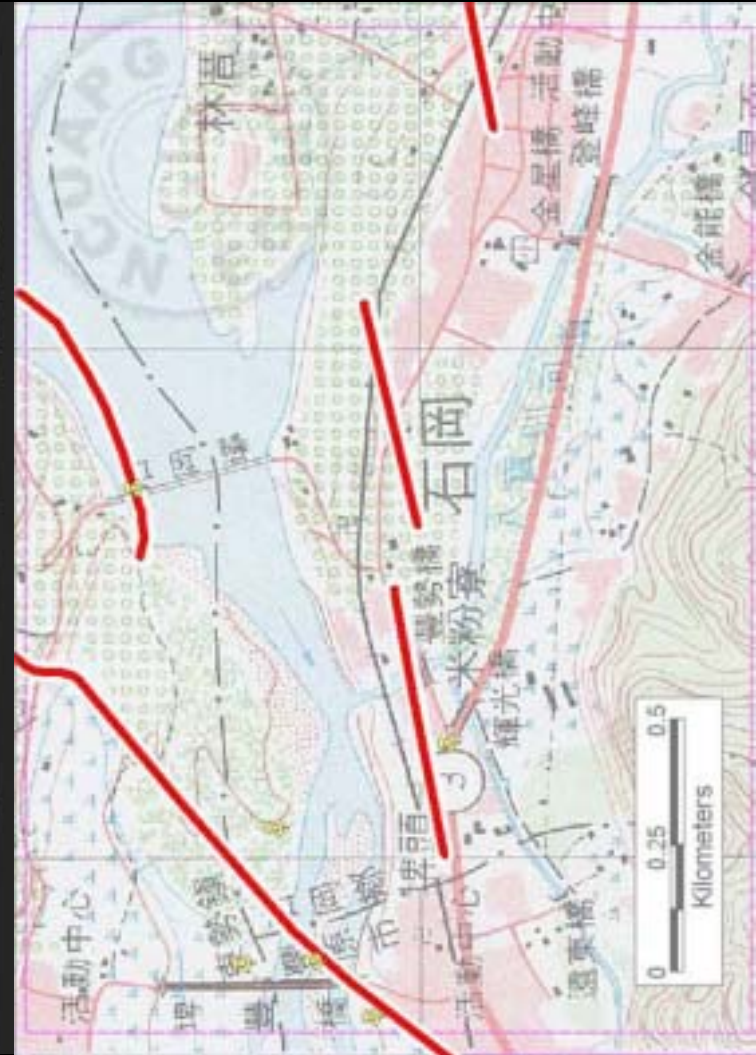


DAMAGE of SHIGUNG DAM

The features of Chelungpu fault in this areas are reverse fault with minor left-lateral displacement.



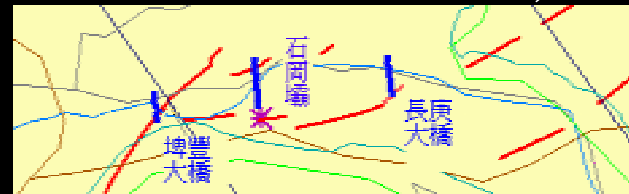
aerial photograph



DAMAGE of SHIGUNG DAM



- ✦ The Chi-Chi earthquake destroys the Shigung dam.
- ✦ The effective storage is reduced to 1.35 million m³, which is 50% of the designed storage.



GAUGING STATIONS

- ✦ Streamflow and rainfall have been monitored continuously by the Taiwan Power Company for developing of hydraulic power since 1958.
- ✦ The Tainleng gauging station is located at the downstream about 6Km away from Bailuchiao gauging station.
- ✦ There is not any branches in this section of the Dajia River.
- ✦ The Tainlun dam, which is a hydraulic power station operated by Taiwan Power Company is at the upstream side about 5Km away from Bailuchiao gauging station.

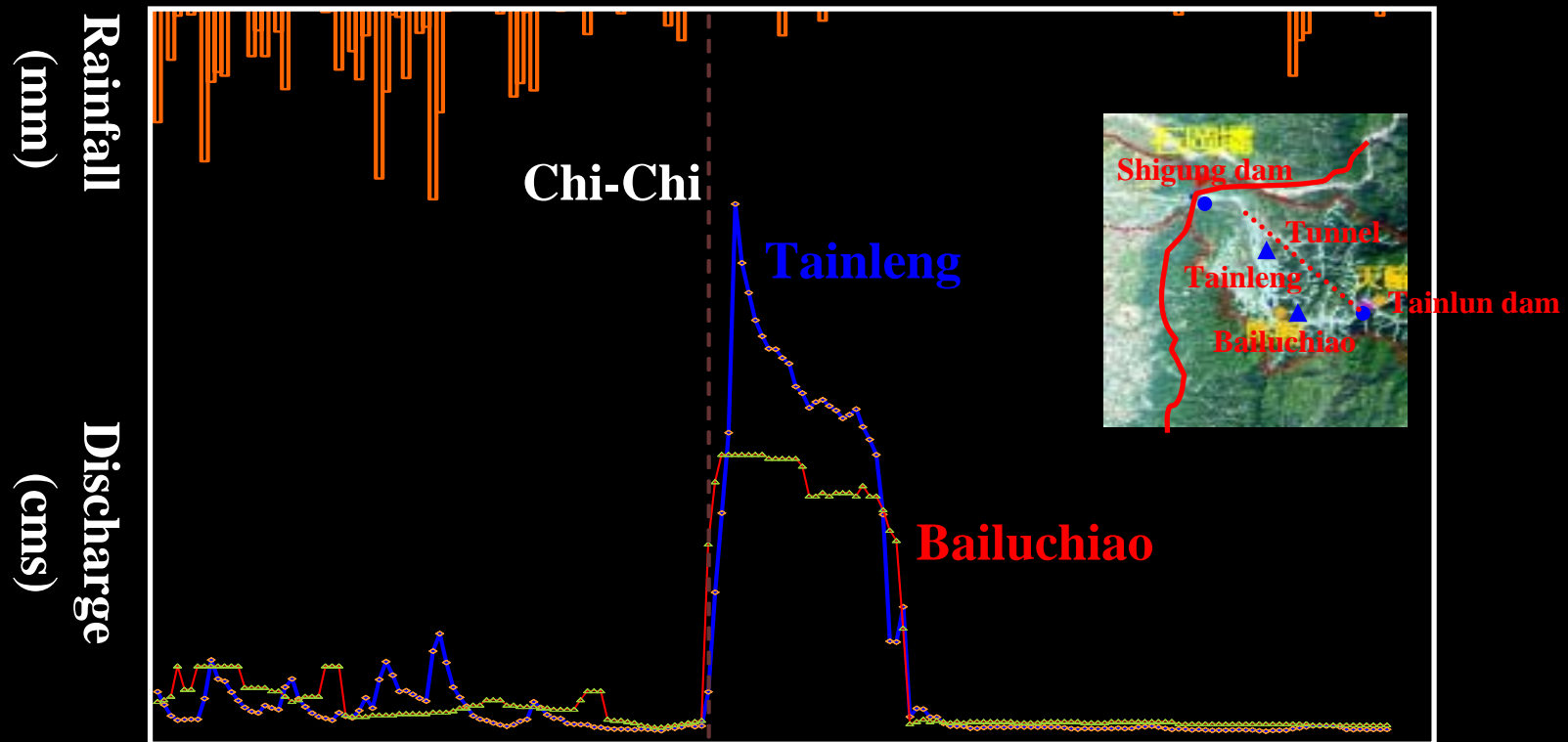


GUAGING STATIONS

- ✦ As the hydraulic power station operate, the streamflow will flow from Tainlun dam to Shigung dam, bypassing the Tainleng and Bailuchiao gauging stations. So, only baseflow discharge can be measured by these two gauging stations.
- ✦ The hydraulic power station shut down a short period after Chi-Chi earthquake (from Sep.21 to Oct.20, 1999).
- ✦ During that time, the water overflows the Tainlun dam to the downstream, then the discharge can be recorded by the Tainleng and Bailuchiao gauging station.



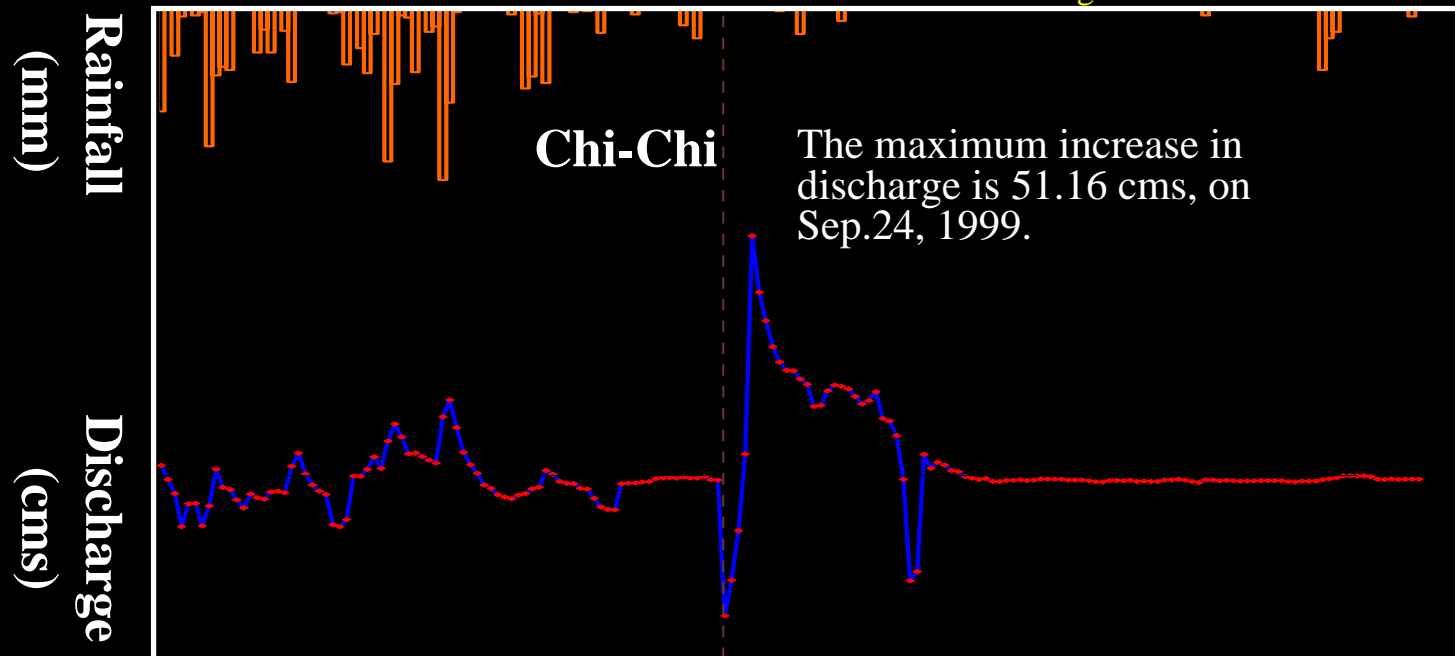
STREAMFLOW CHANGES



- ✦ The discharges had co-seismically increased since the hydraulic power station shut down.
- ✦ Although the total precipitation is only 180mm in that month and there is no other branch inflow between these two gauging stations, the discharge of Tainleng gauging station is much larger than Bailuchiao gauging station.

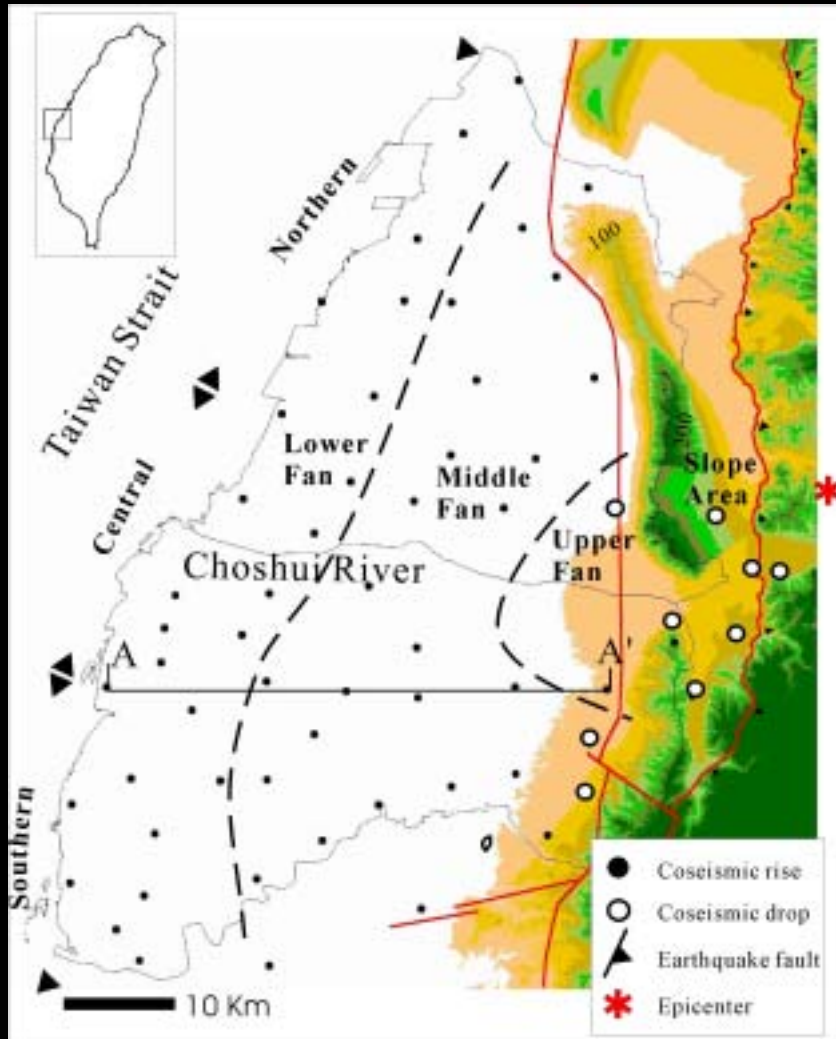
STREAMFLOW CHANGES

The difference of the discharges between those two streamflow gauging stations (ie. $Q_{\text{Taileng}} - Q_{\text{Bailuchiao}}$).

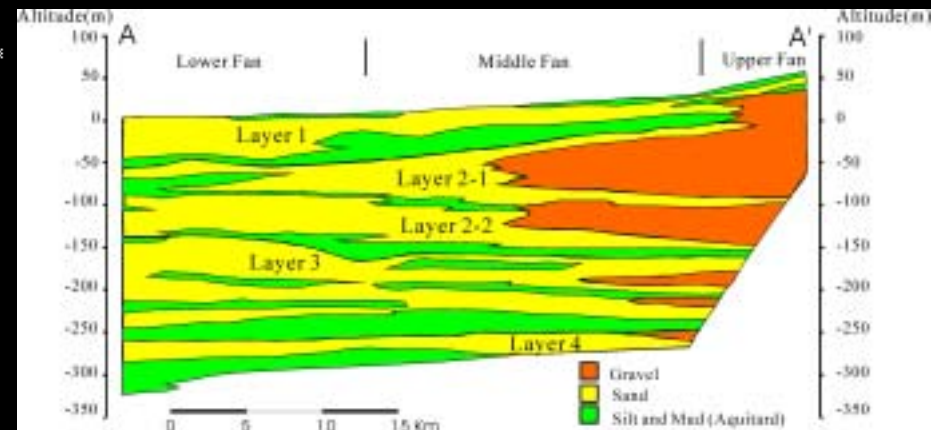


- ✦ The amount of this anomalistic excess-streamflow is about 21.7million m^3 in one month after earthquake.
- ✦ The residents in the vicinity of the Shigung dam also reported that some wells had lost water and the yields had significantly decreased after earthquake.
- ✦ Unfortunately, we don't have any observational well in that area.
- ✦ The excess-streamflow maybe come from the groundwater.

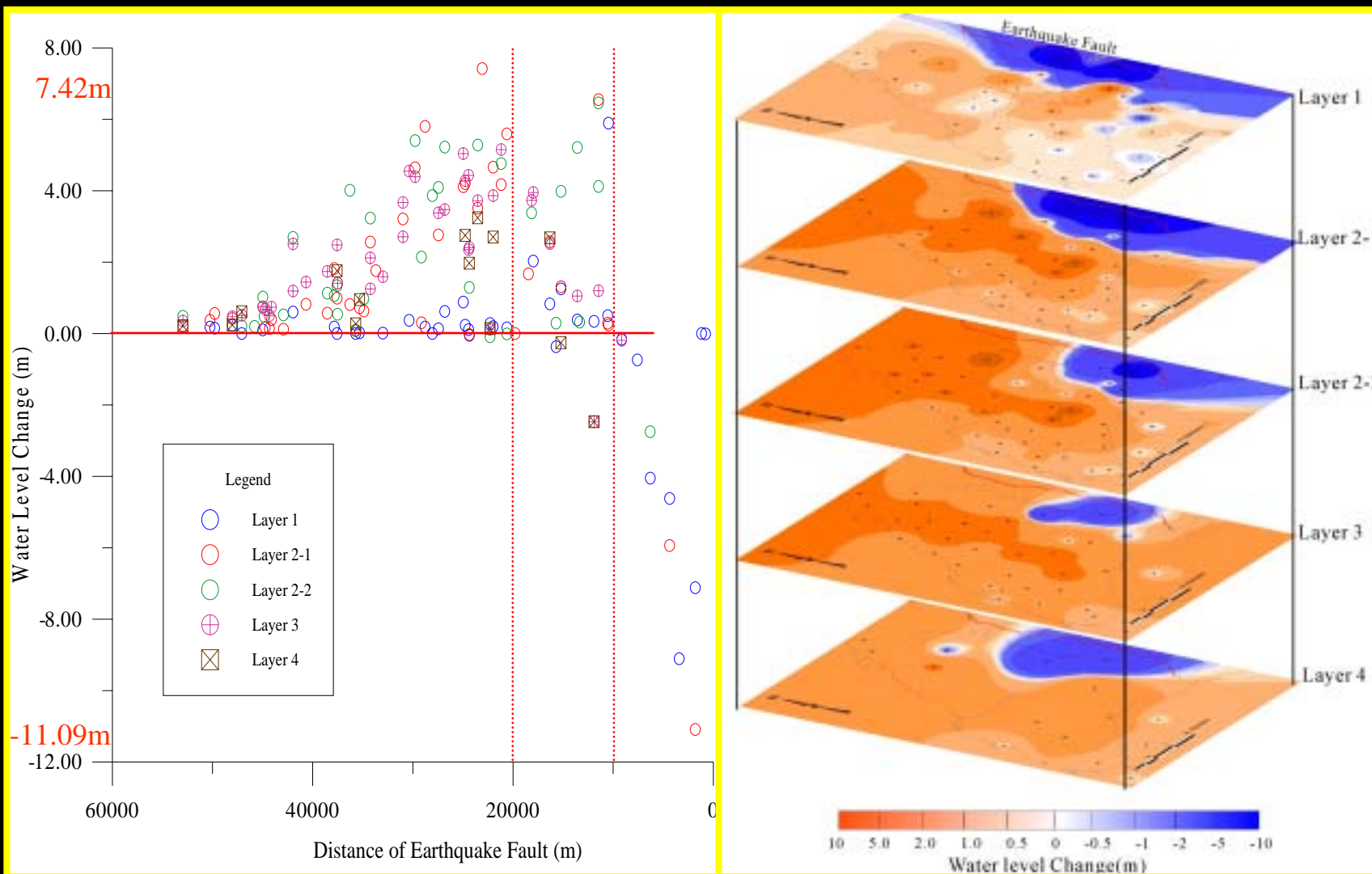
GROUNDWATER CHANGES



- ✦ The Choshui river alluvial plain is the largest plain in Taiwan.
- ✦ It is located at the west of the epicenter.
- ✦ There are 188 observation wells in this plain.
- ✦ The deepest well is 415m in depth.
- ✦ There are 5 aquifers in the plain.
- ✦ The groundwater level changes were observed in 168 wells.



GROUNDWATER CHANGES



CONCLUSIONS

- ✦ This study focuses on the response of the streamflow in Dajia river basin, which's caused by the Chi-Chi earthquake.
- ✦ The discharges of streamflow are co-seismic increased and the yields had significantly decreased in some wells.
- ✦ It indicates that the streamflow changes maybe due to extensive permeability changes within the basin.



The end
Thank you

