Impact of Climate and Land Use Changes on Recharge and Managed Aquifer Recharge: Case of Udon Thani and Prachinburi Cities

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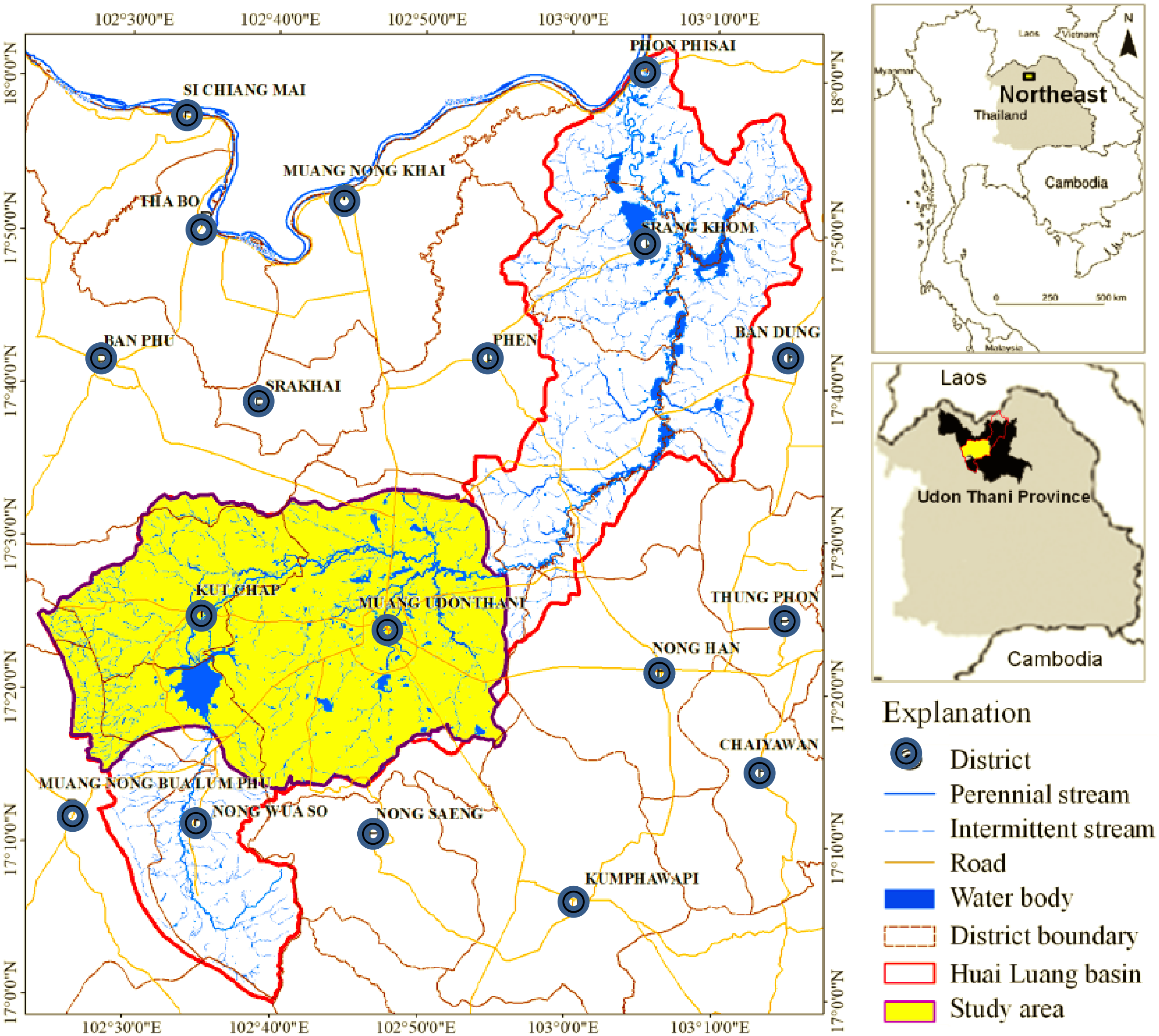
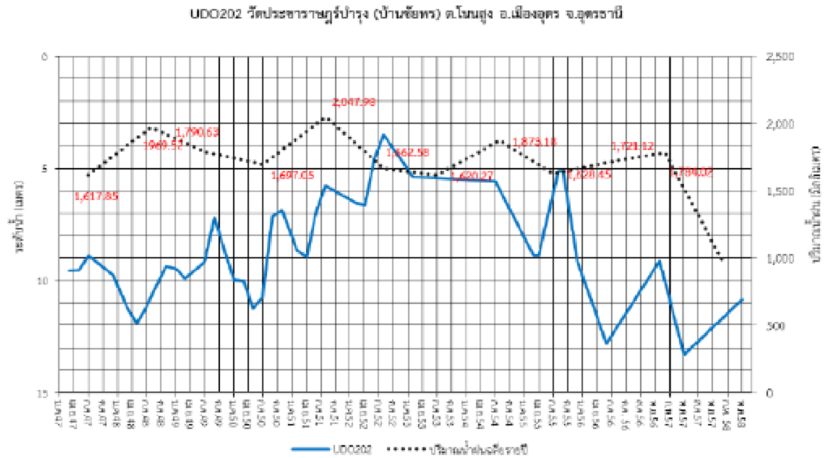
Impact of Climate Change on Groundwater Recharge ,Yield and Salinity : case of Udon Thani City



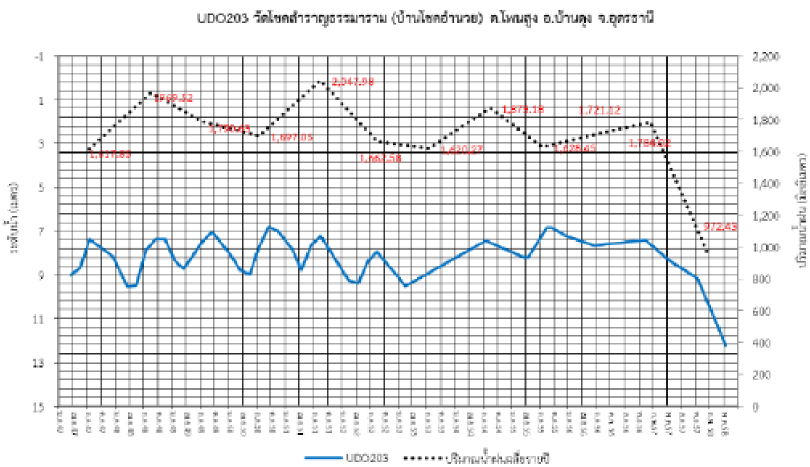
This study is a part of the main Thailand Research Fund (TRF) project under the name of *"Potential Impact of Climate Change on Salt-Affected Areas in Important Rice Production Areas of Udon Thani Province"* (TRF, 2017).

- Important area in terms of socio-economic of the second biggest, province in Northeastern region.
- The variety of salt affected areas, highly saline soils and groundwater.
- The study area was selected due to the fact that the area is highly potential for growing rice.

Rainfall and groundwater monitoring in Udon Thani



สำนักอนุรักษ์และฟื้นฟูทรัพยากรน้ำบาดาล
กรมทรัพยากรน้ำบาดาล
หมายเลขบ่อ UDO202 ความลึก 53 เมตร ระยะท่อกรอง 42 - 50 เมตร



สำนักอนุรักษ์และฟื้นฟูทรัพยากรน้ำบาดาล
กรมทรัพยากรน้ำบาดาล
หมายเลขบ่อ UDO203 ความลึก 53 เมตร ระยะท่อกรอง 42 - 50 เมตร

UDO202

UDO203

(DGR, 2016)

Objective

- characterize soils, hydrologic, hydrogeologic conditions, salinization processes and climate change in a specific watershed that currently encountered with salinity in NE Thailand and produce comprehensive scientific information,

- apply groundwater modeling to simulate climate changes effecting groundwater recharge, flow and saline groundwater distributions,

- determine the sustainable yield of groundwater under the impact of climate change and
- assess distribution of soil salinity risk areas under impacts of climate changes.

Research methodology

PHYSICAL AND CHEMICAL CHARACTERIZATION

- Climate and hydrology data
- topography, land use and soil, soil salinity data
- geology and hydrogeology data

GROUNDWATER FLOW AND SALT TRANSPORT MODELING

- Conceptual Model

  groundwater recharge model (HELP3) , groundwater flow and salt transport (SEAWAT)
- Model design

  grid cell, boundary conditions, recharge zones and assign hydraulic and concentration properties
- Model calibration, validation and sensitivity analysis

  (comparison with observation data)

ALTERNATIVE HYDROGEOLOGICAL CONCEPTUAL MODELS

plausibility of Hydraulic property distributions and boundary conditions

PREDICTION IMPACTS OF CLIMATE CHANGE

on groundwater flow, waterlogging area, saline distribution and sustainable yield using future climate data scenarios (RCPs 2.6, 4.5 and 8.5) over the period of 201-2045

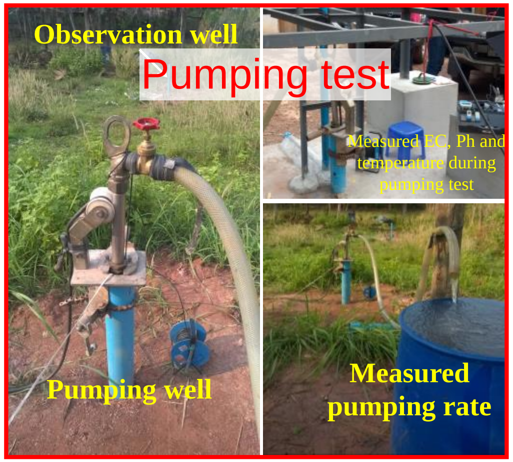
SOIL SALINITY RISK ASSESSMENT MODEL

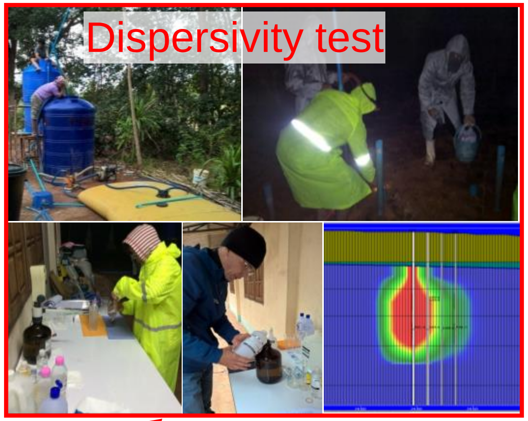
Weighting and overlaying GIS Technical

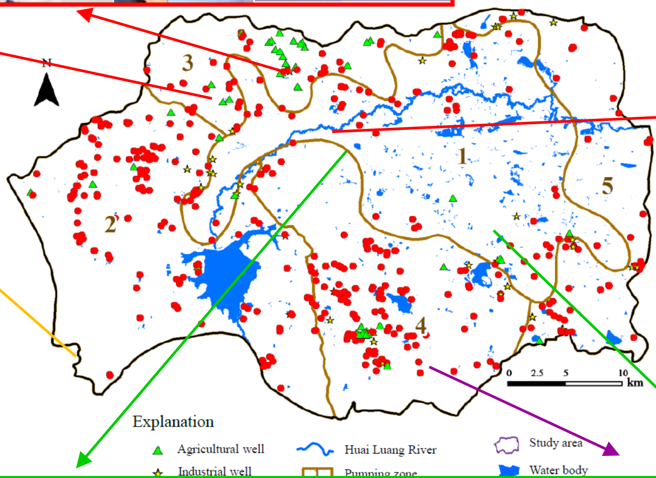
- **Thematic static maps of** soil salinity, soil group and irrigation area
- **Waterlogging and saline groundwater areas** under climate change impact

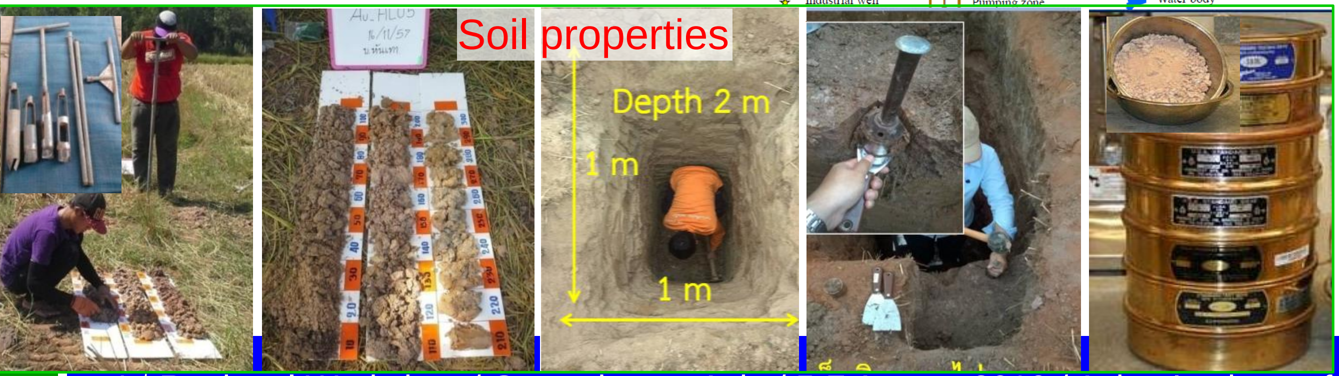
Soil salinity risk areas distribution under climate change impact

Site Investigations

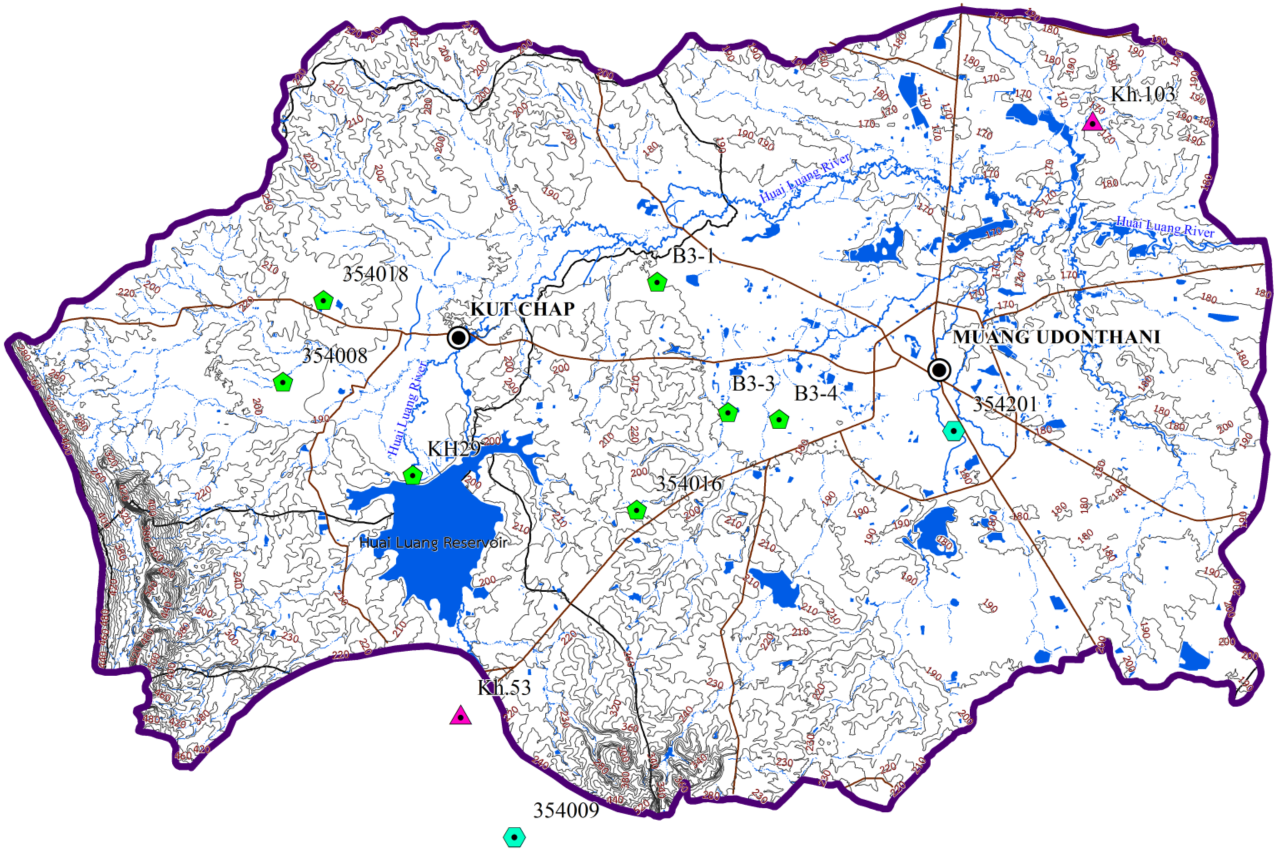








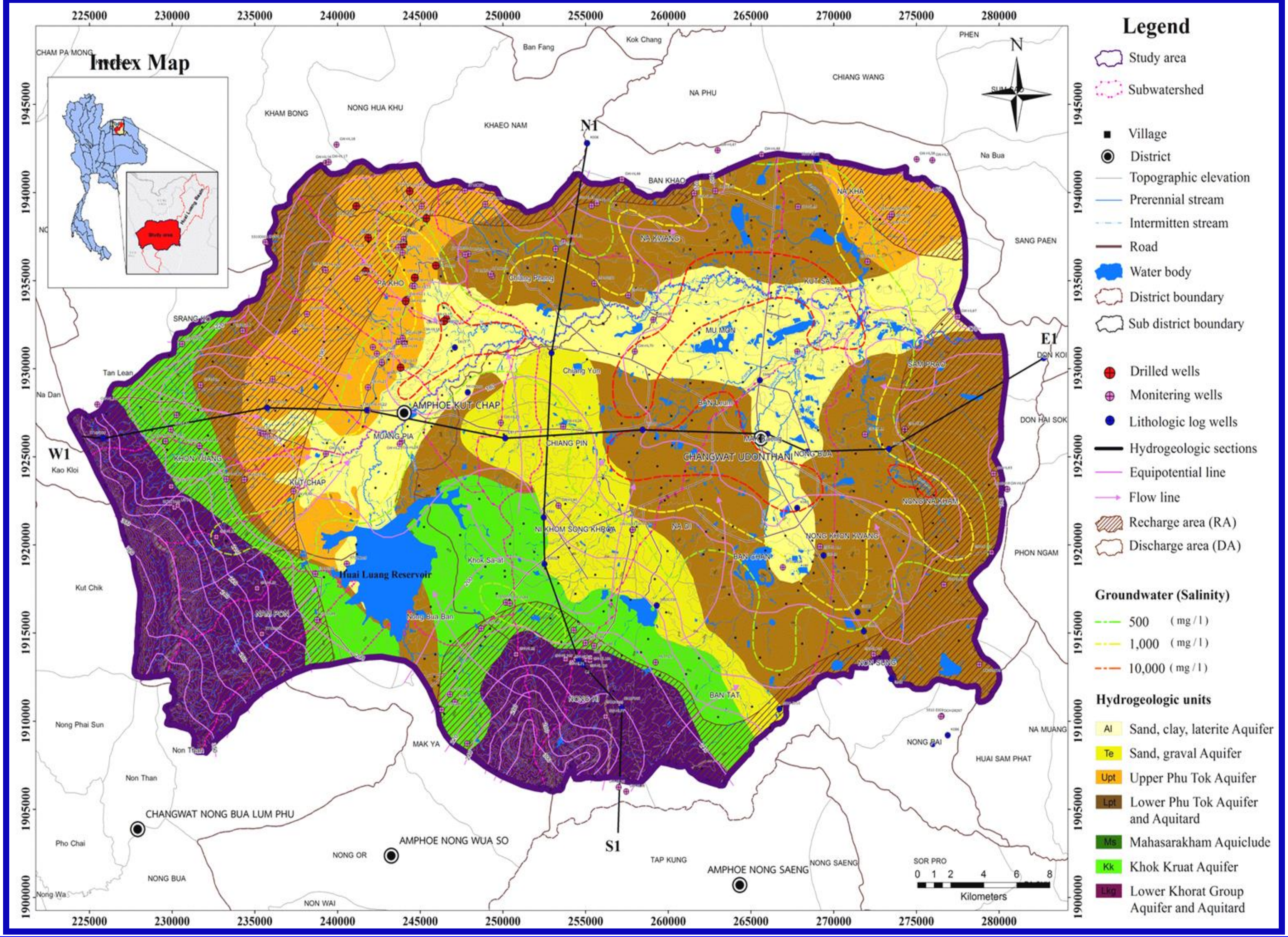
Topography, Climate and Hydrology



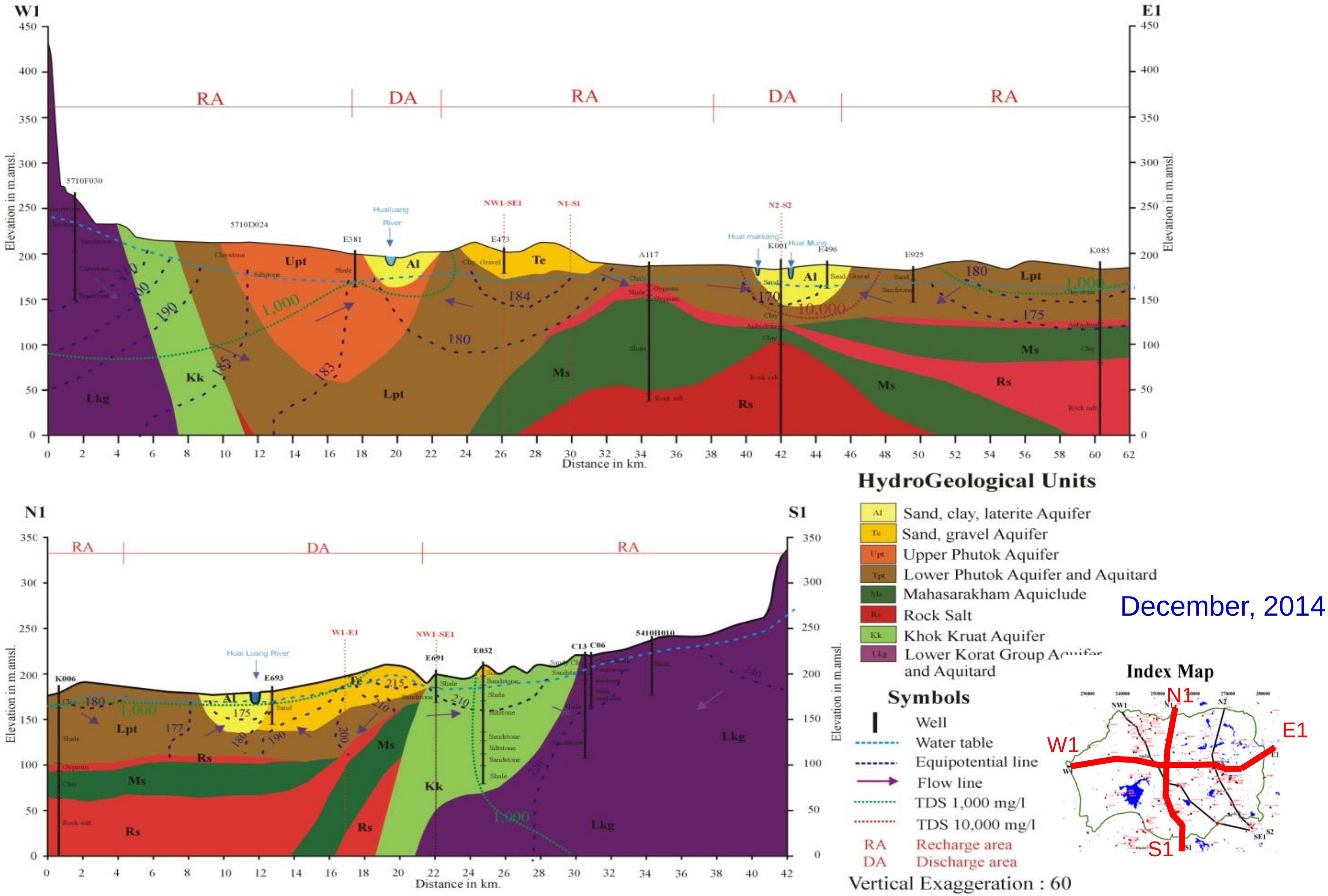
- Cover an area of 1,529 km^2
- Topographic elevations vary from 160 to 564 m amsl
- 448,000 persons (29% of the Udon Thani Province population)
- Annual rainfall 1,268 mm/yr with average potential evaporation 1,683 mm/yr and average daily temperature is 27.0 ^{o}C

- Total volume of the flow throughout CHLB is around 262.4 MCM/year (Mm^3/year)
- Huai Luang dam with capacity of 234 Mm^3/year is a major source for Udon Thani water supply and irrigation.
- Huai Luang River width and depth of 50-90 m. and 5-7 m, respectively

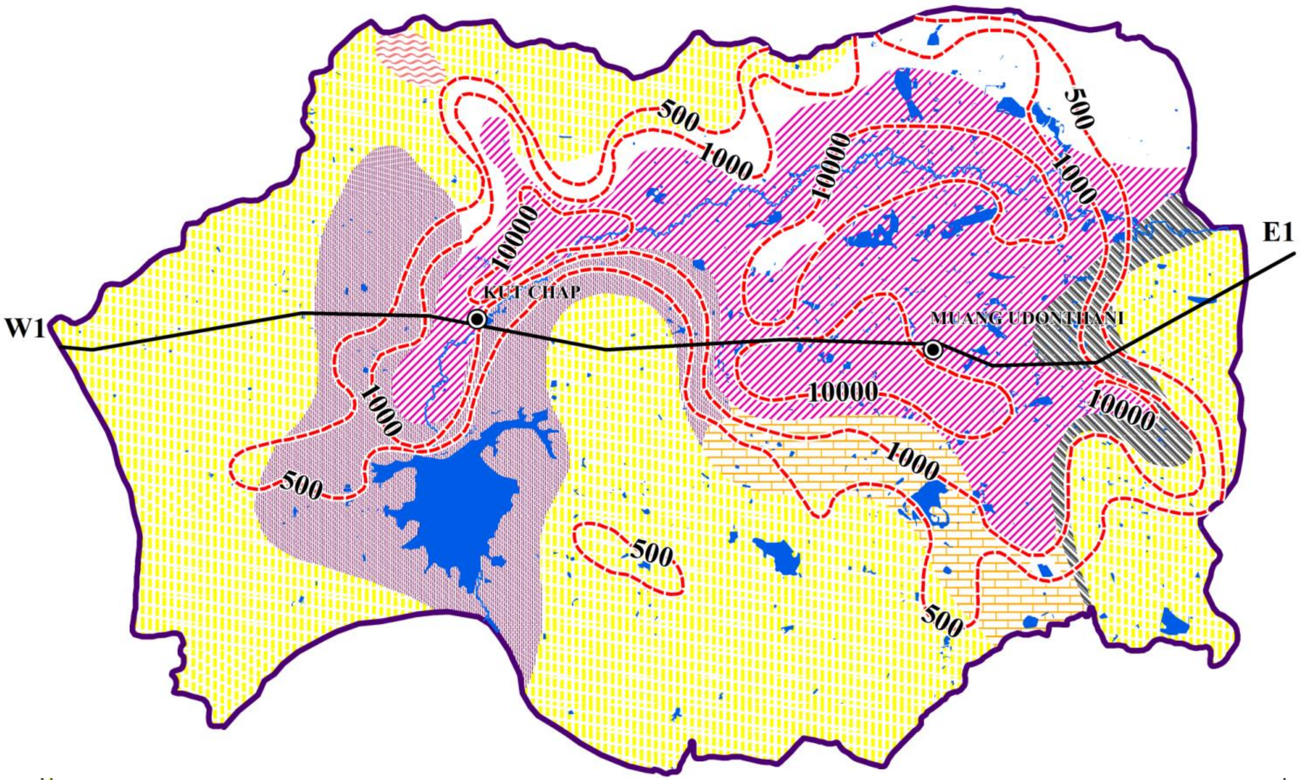
Hydrogeologic map

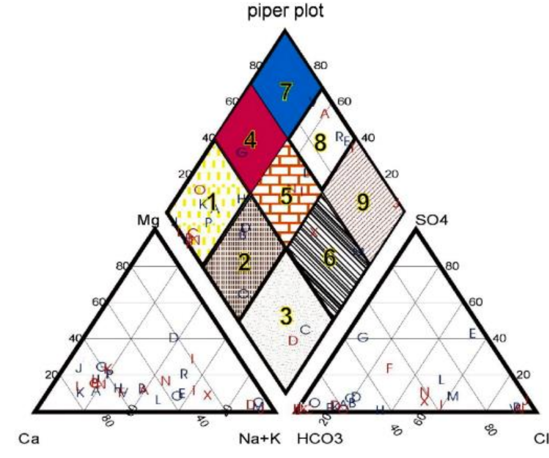


Hydrogeological cross sections



Hydrochemical Facies

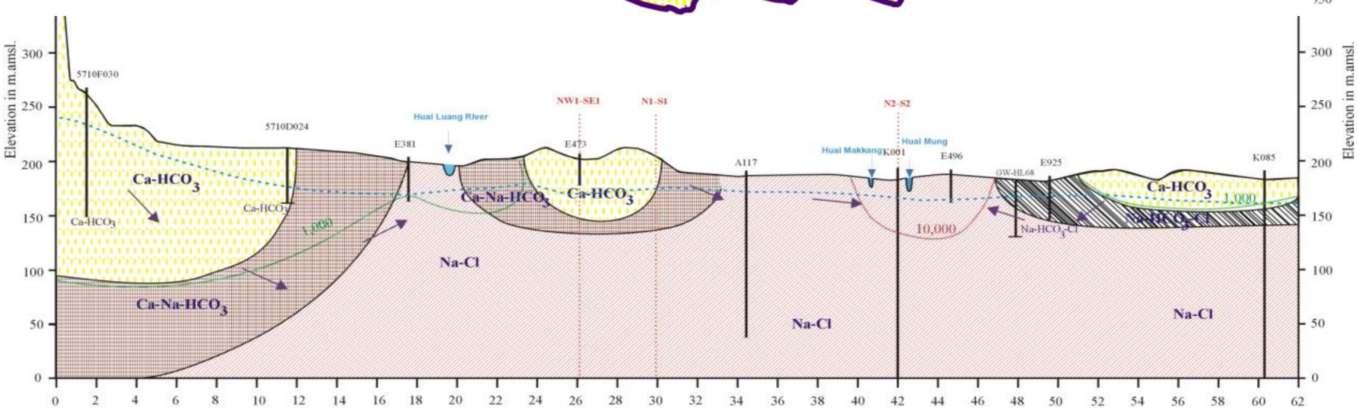




Hydrochemical facies classification

Groundwater facies

- Ca-HCO_3
- Ca-Na-HCO_3
- Na-HCO_3
- Ca-Na-HCO_3-Cl
- Na-HCO_3-Cl
- Ca-Na-Cl
- Na-Cl



Piper Diagram

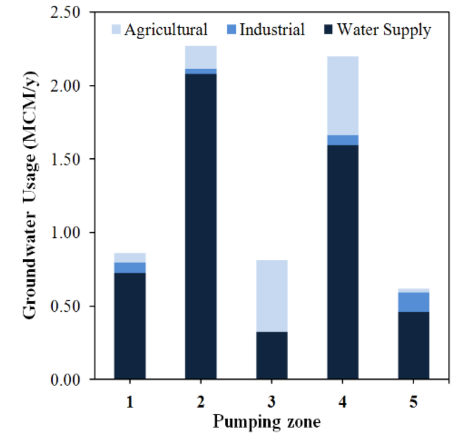
Explanation

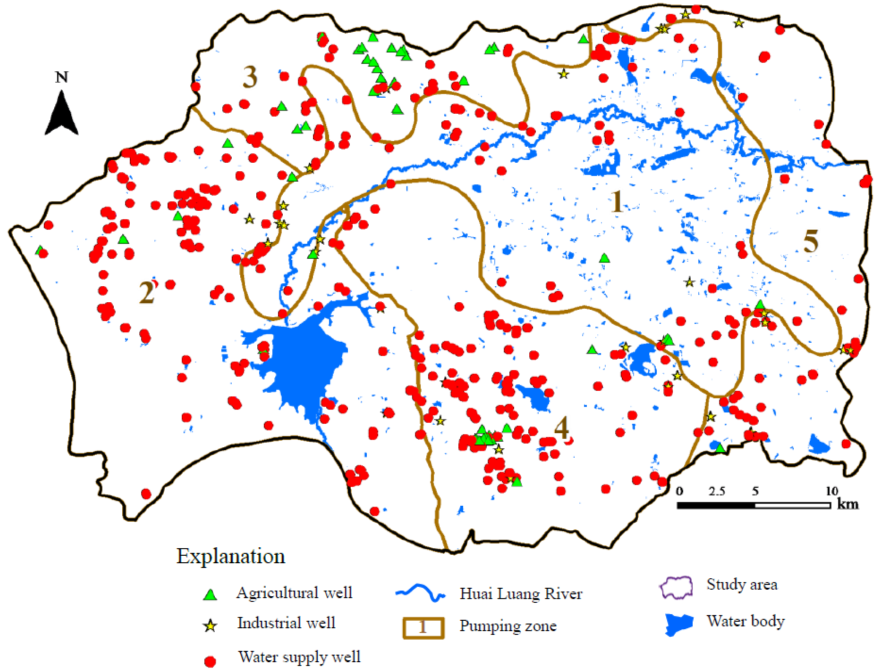
- Huai Luang River
- 500 TDS (mg/l)
- Study area
- Water body

Groundwater Exploitation

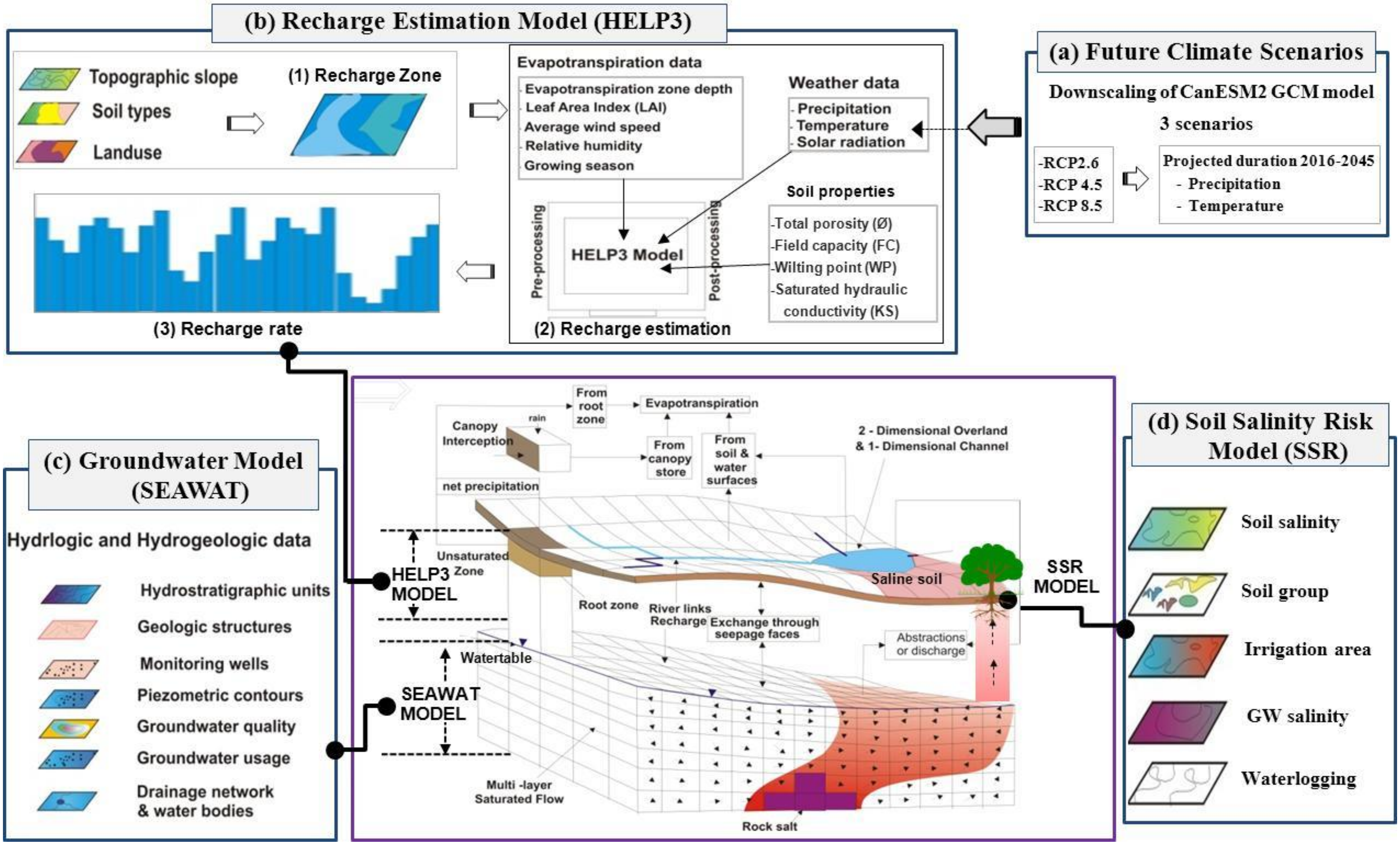
- There are 650 water wells.
- About 75%, 20% and 5% of the wells are use for domestic consumption, agricultural and industrial, respectively.
- Water wells depth ranges of about 20 to 122 m bgs.

Groundwater usage is estimated about 6.76 Mm^3/yr

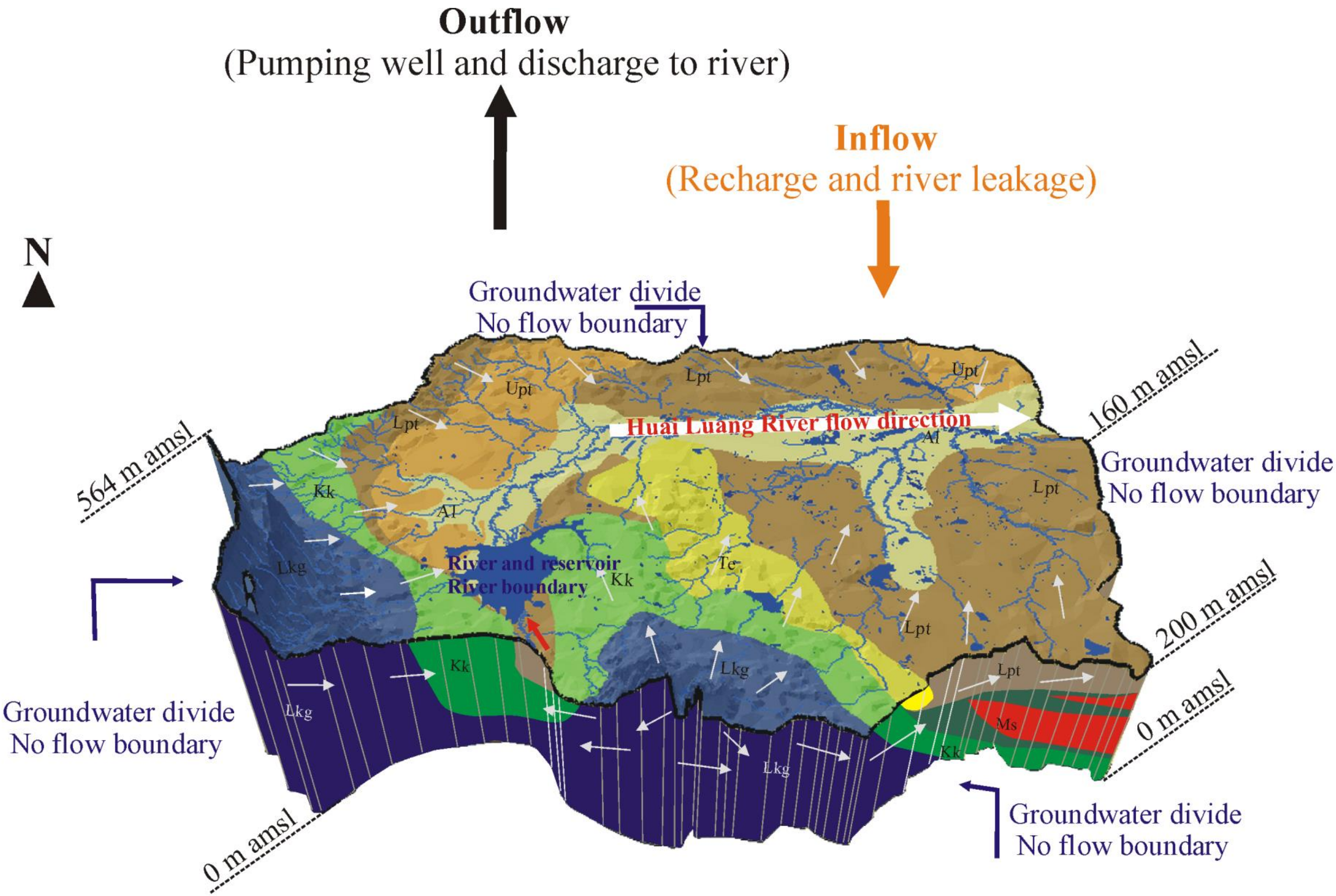




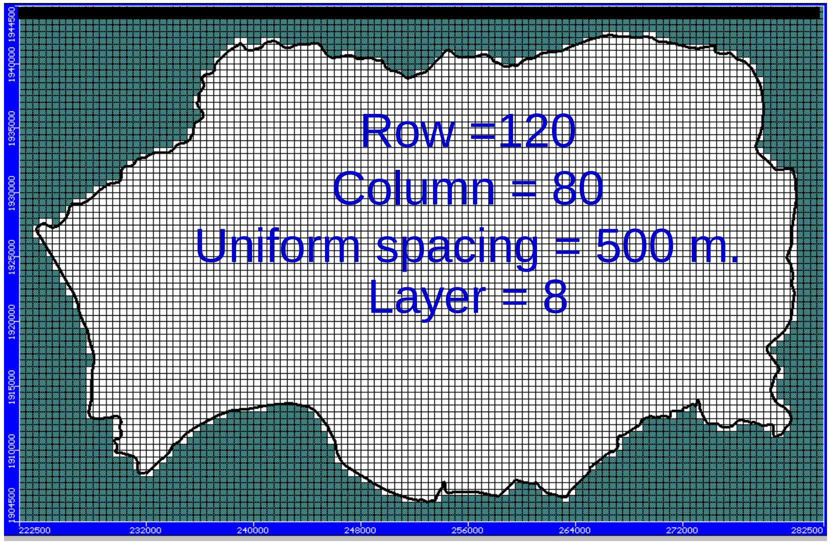
Protocol of the Modeling Approach

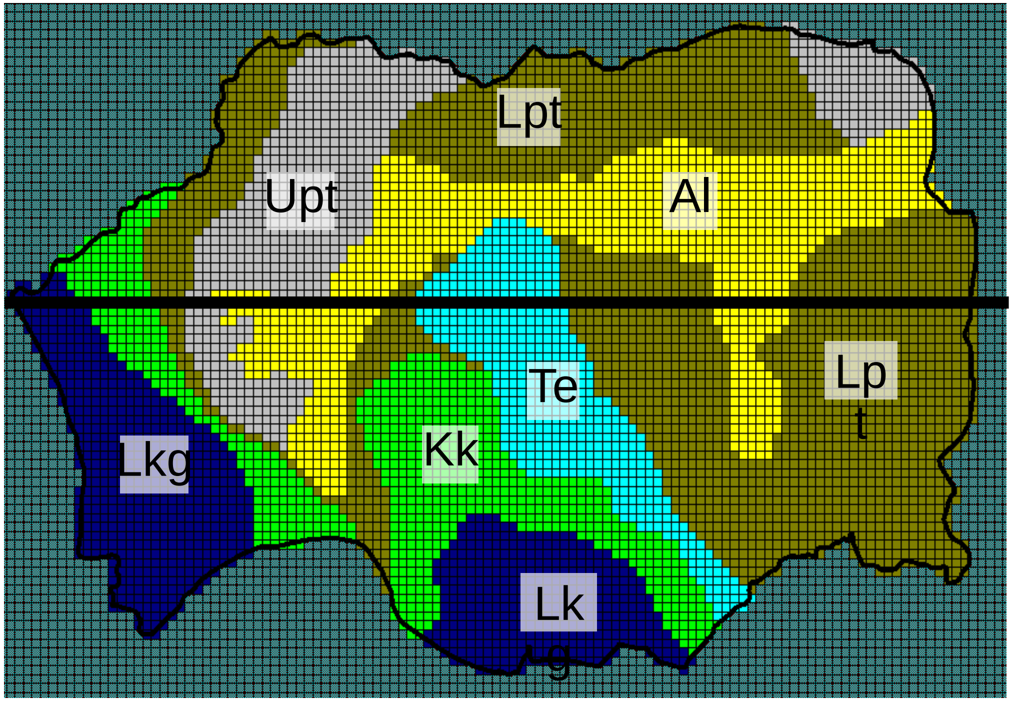


Hydrogeological conceptual model

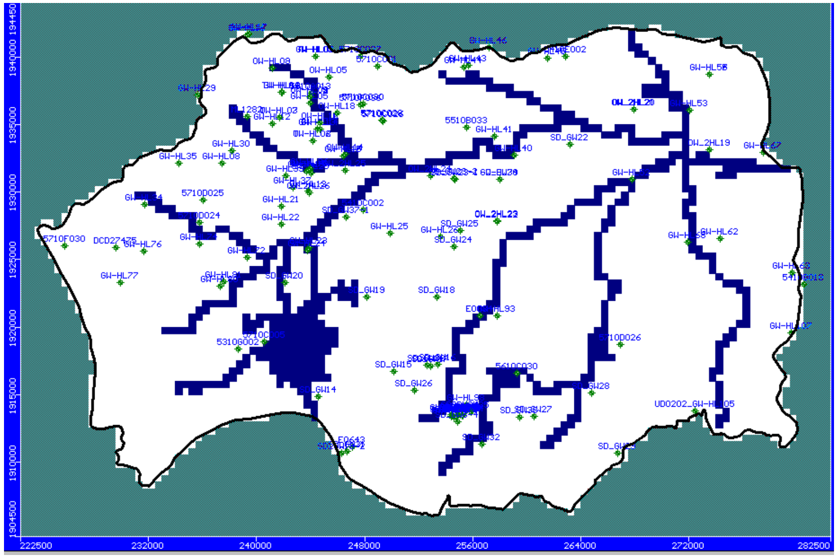


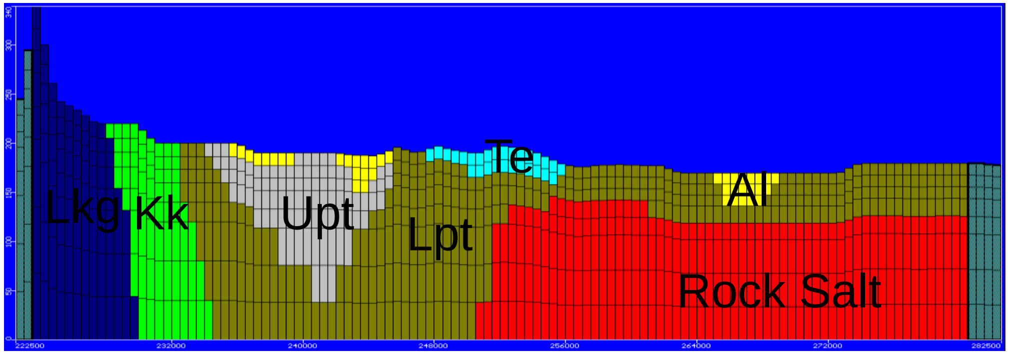
Grid design, hydraulic properties and observation wells



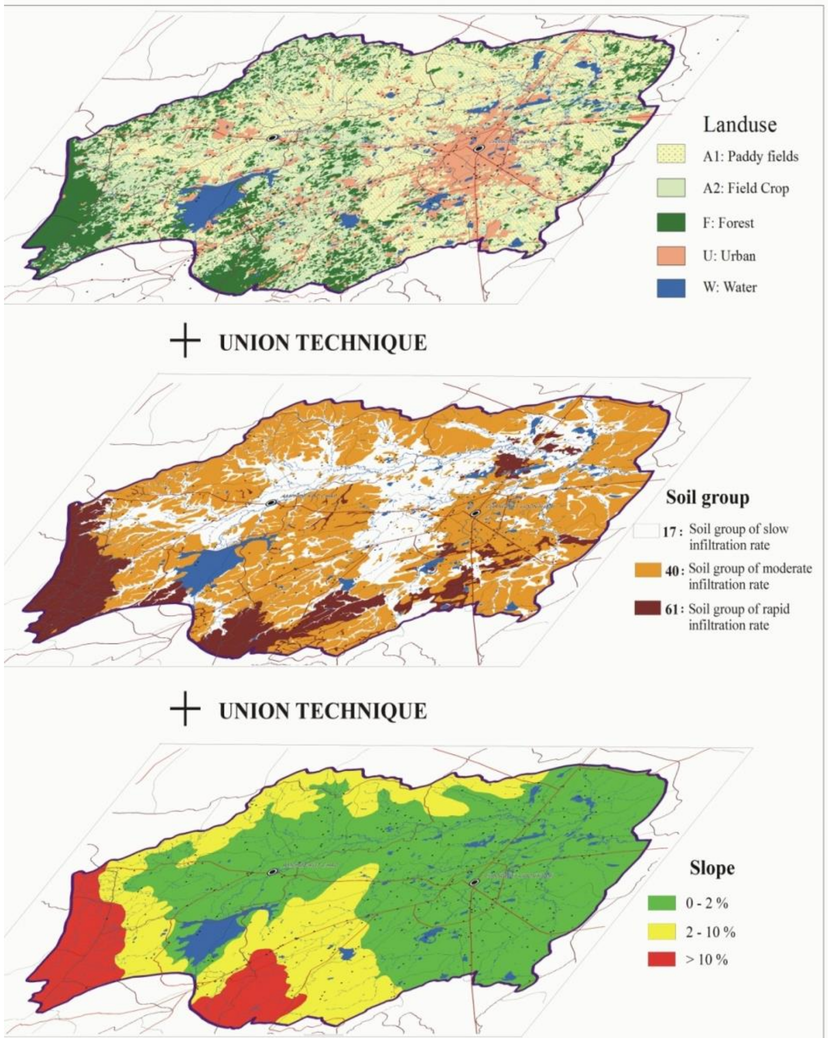


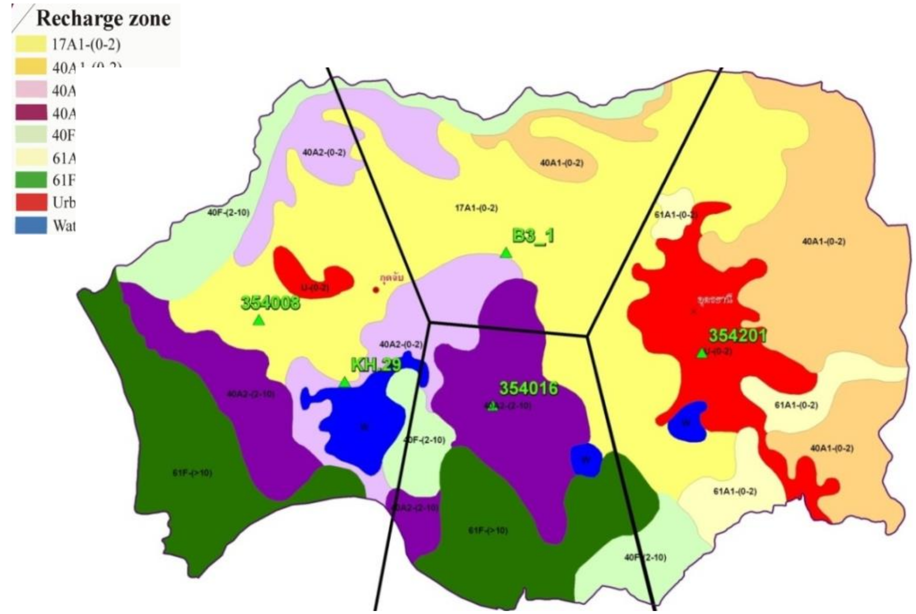
Distribution of hydraulic conductivity

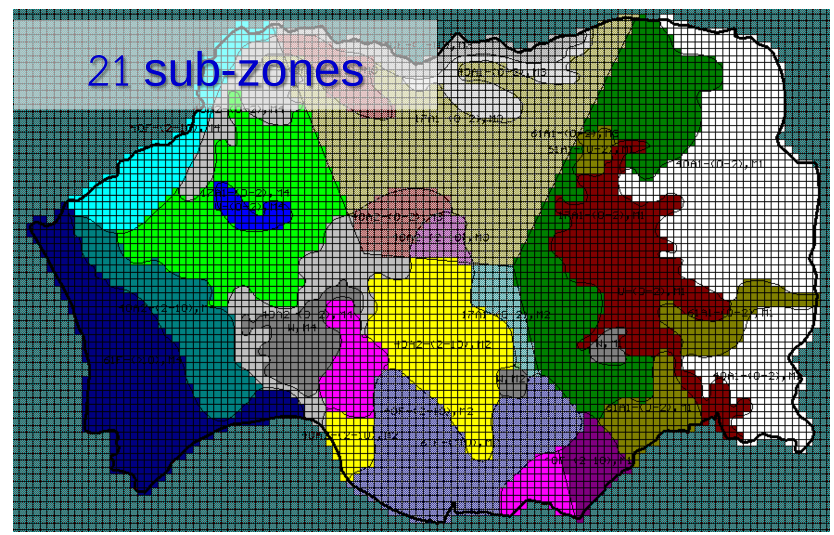




Groundwater Recharge Estimation Processes

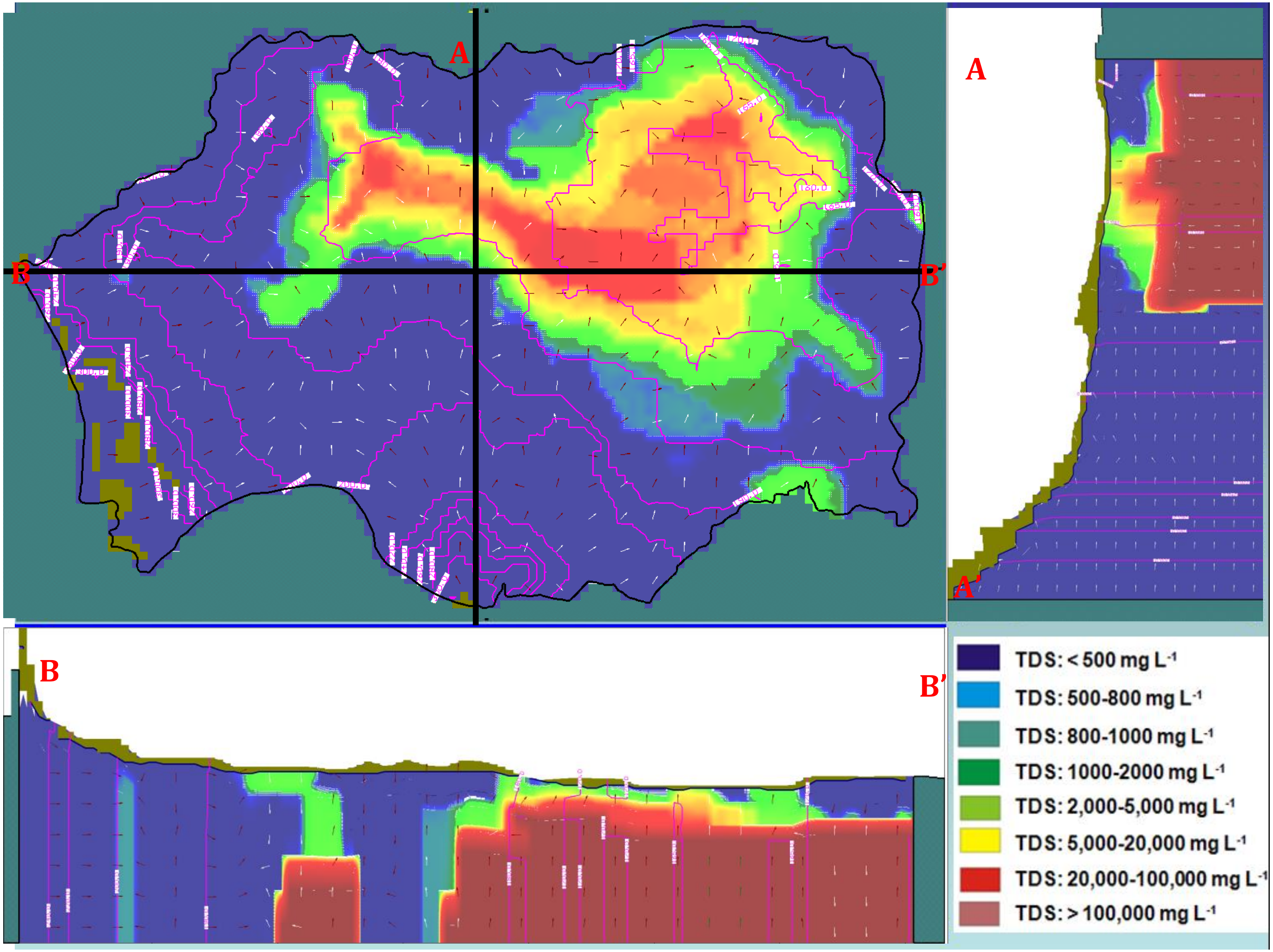






Recharge zones estimated by an integration of land use, soil types, and topographic slopes

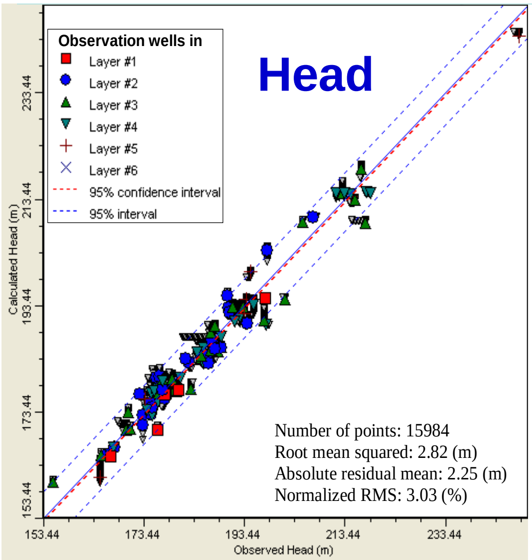
Simulation result

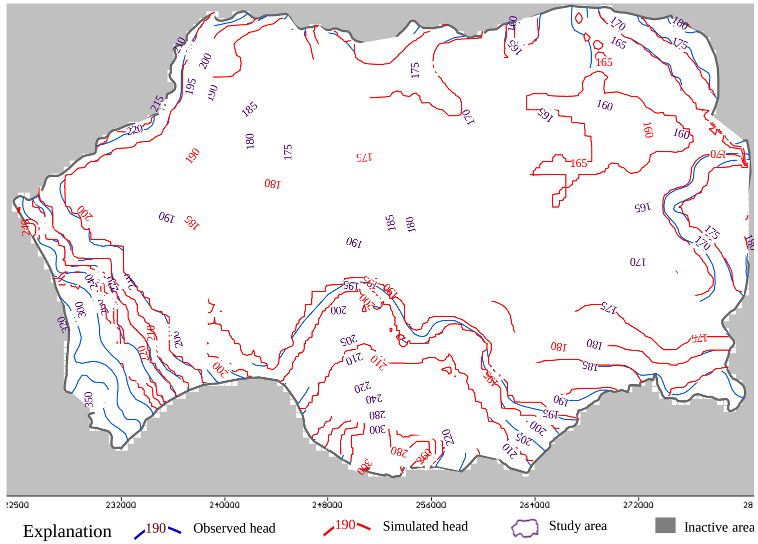


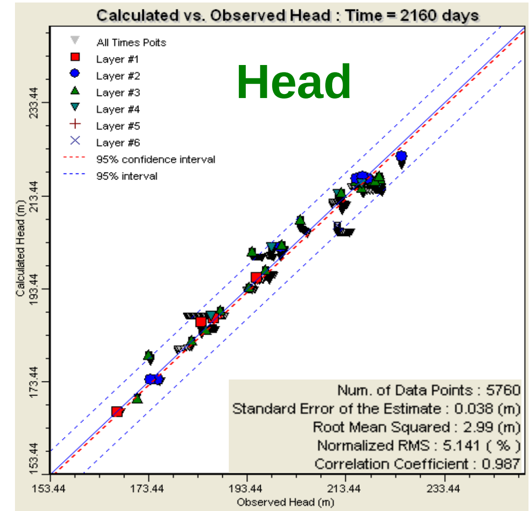
Calibration and verification results

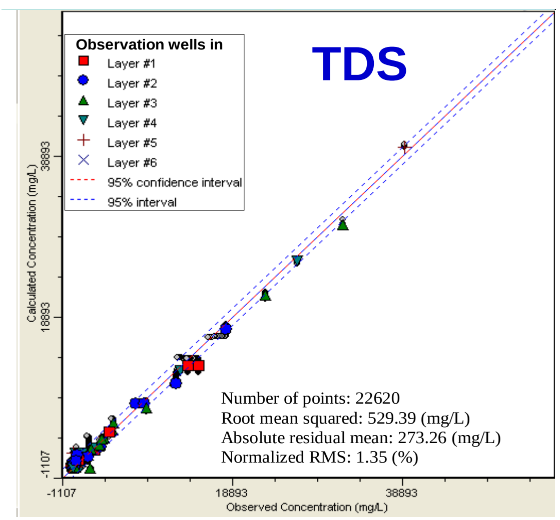
Calibration : 2014-2015

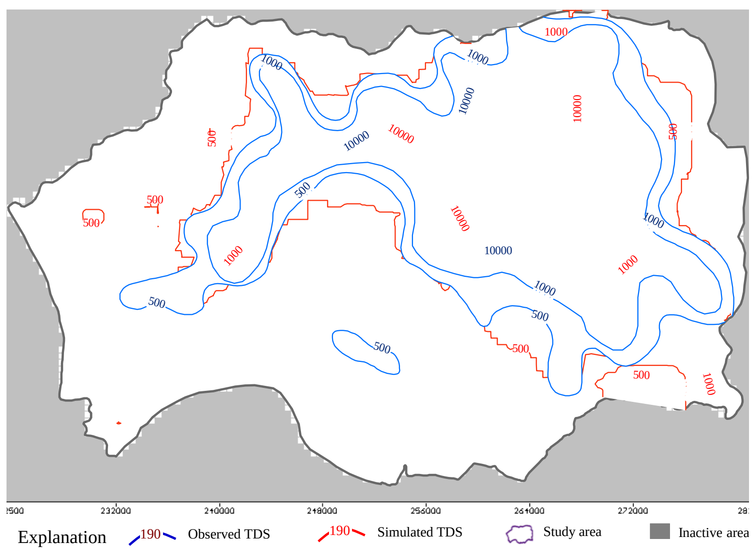
Verification: 2010-2012

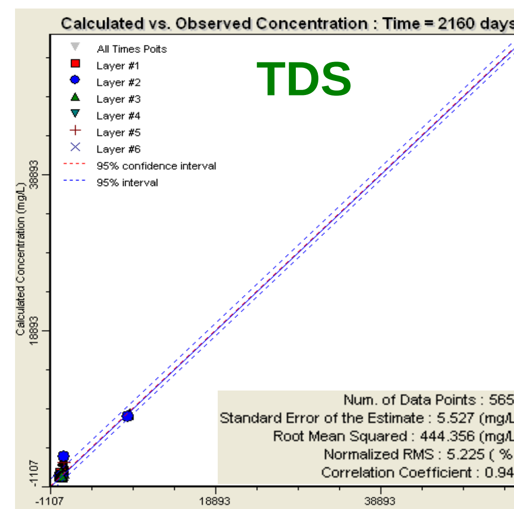




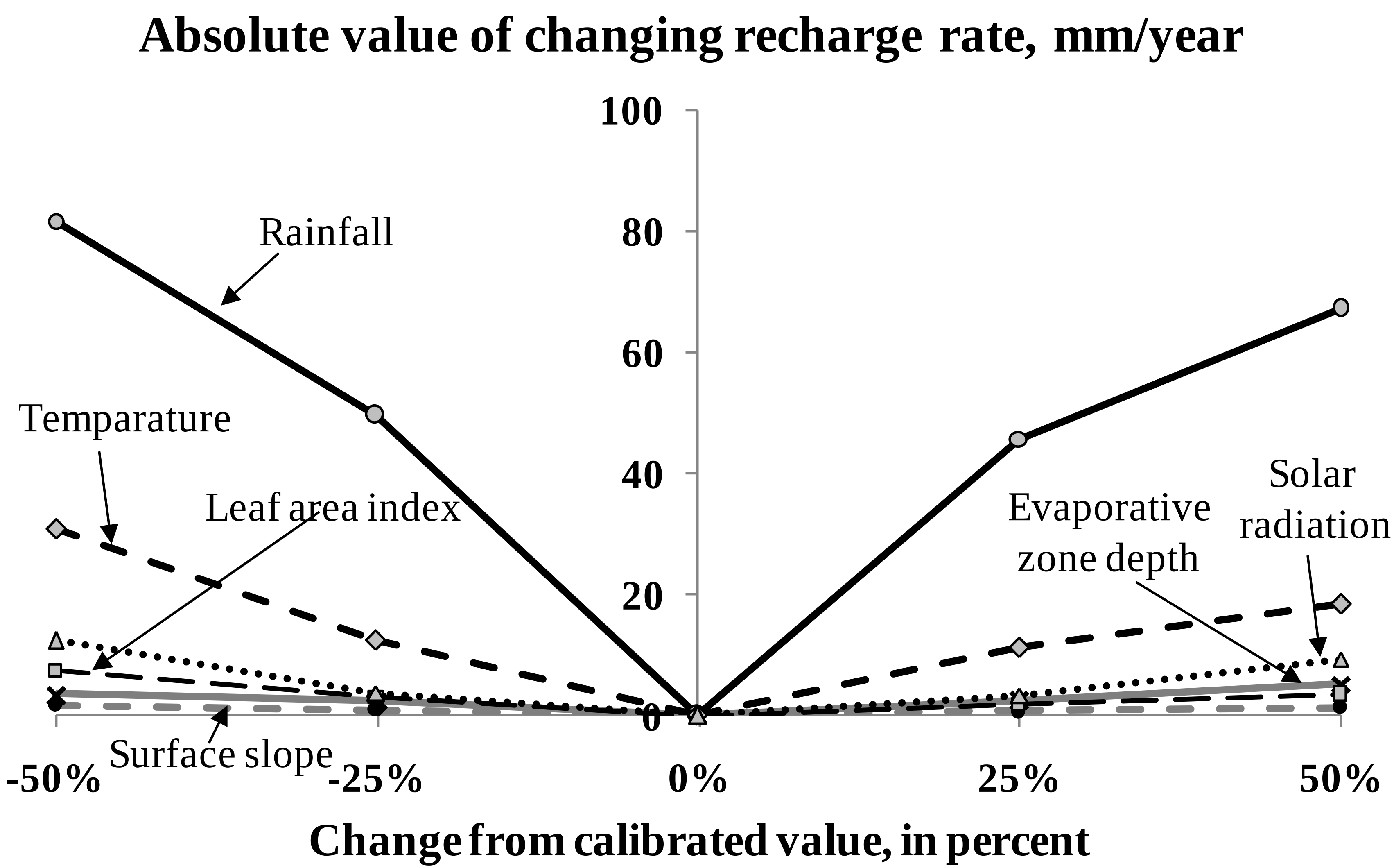




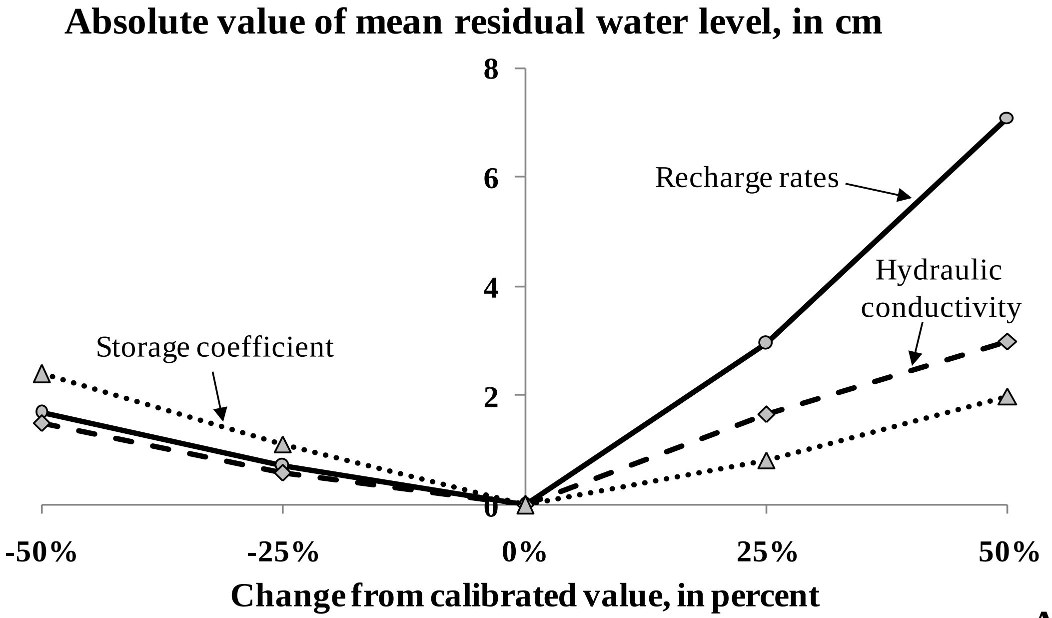




Sensitivity Analysis of Recharge input Parameters

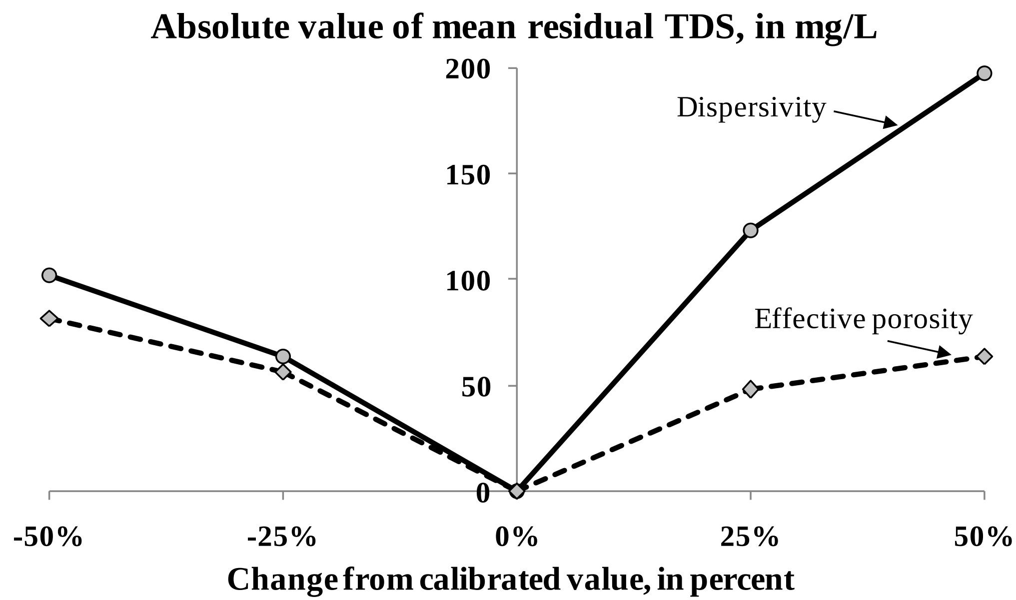


Sensitivity Analysis of Flow and Salt Transport Model

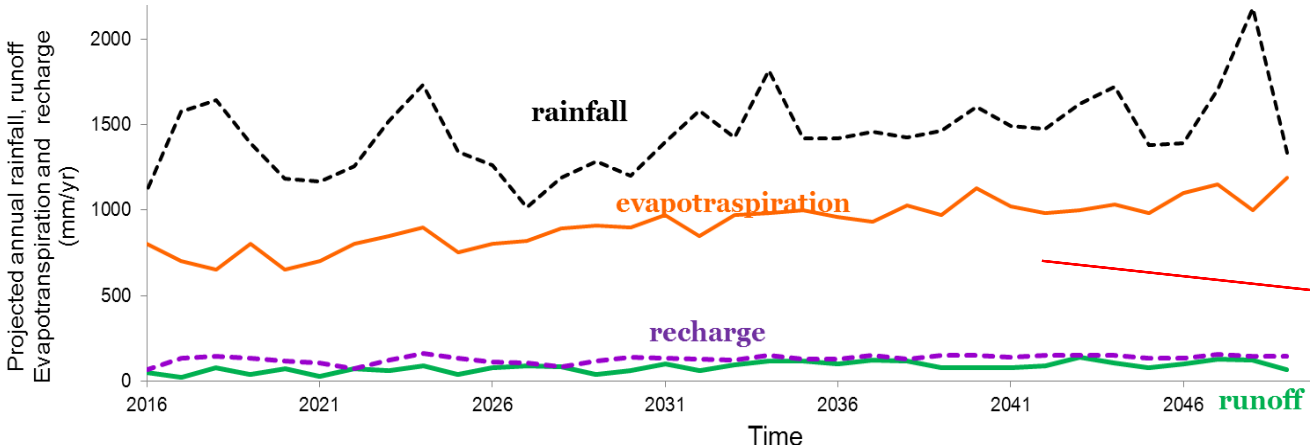


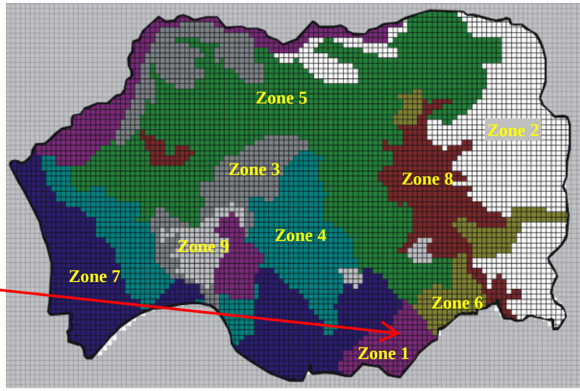
Sensitivity analysis of groundwater level

Sensitivity analysis of groundwater salinity

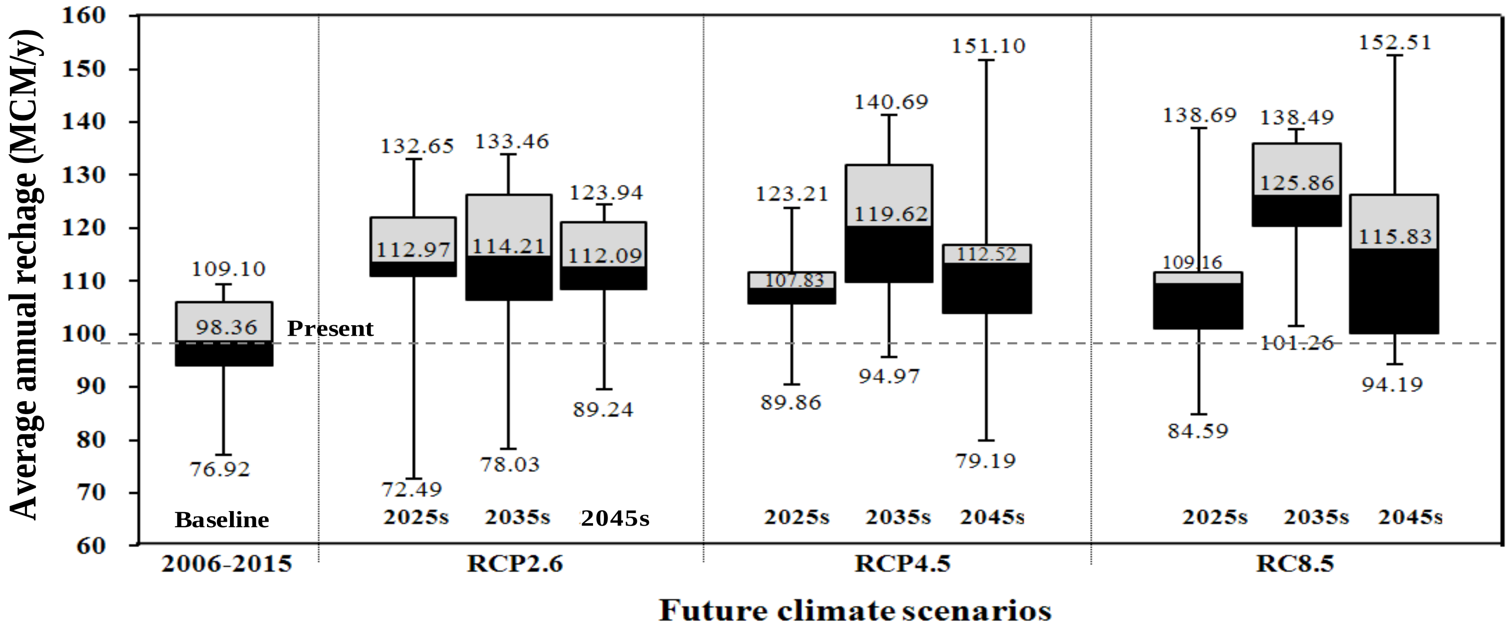


Example of projected annual rainfall, evapotranspiration, runoff and groundwater recharge from 2016 to 2045 for RCP8.5 scenario in recharge zone 1

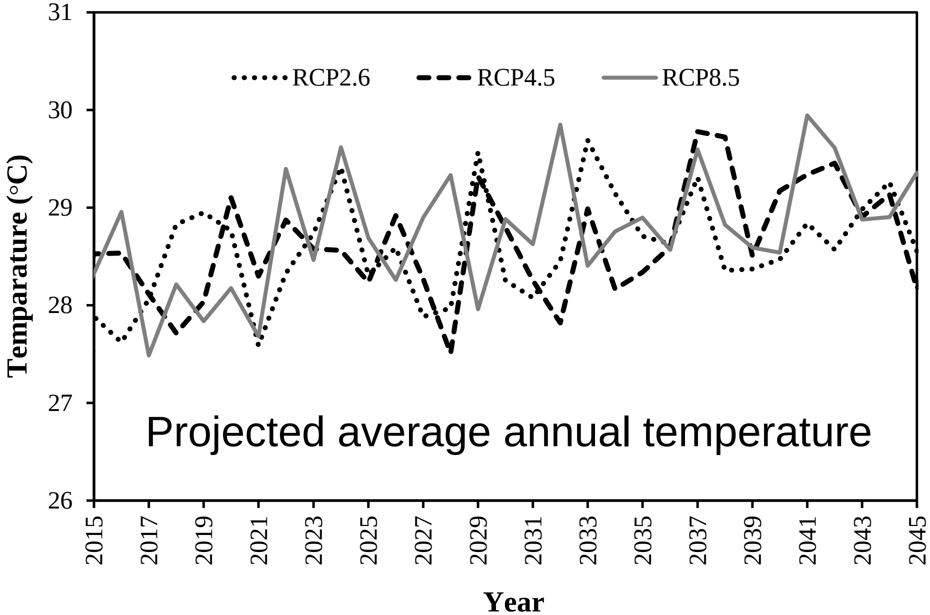


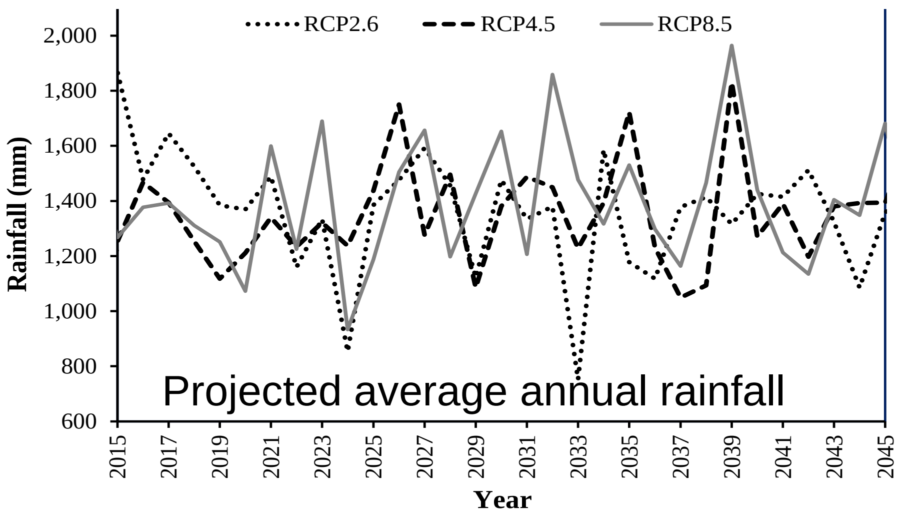


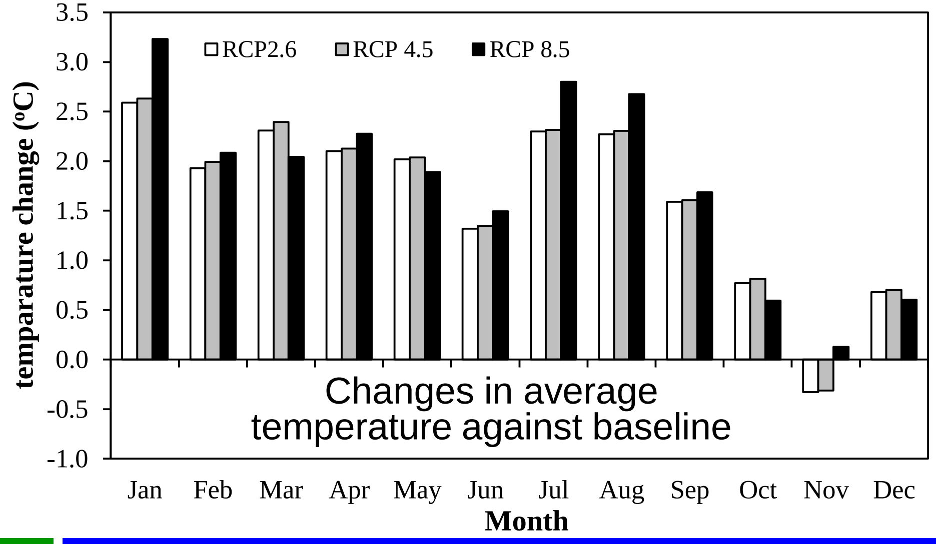
Simulations of future Annual Groundwater Recharge

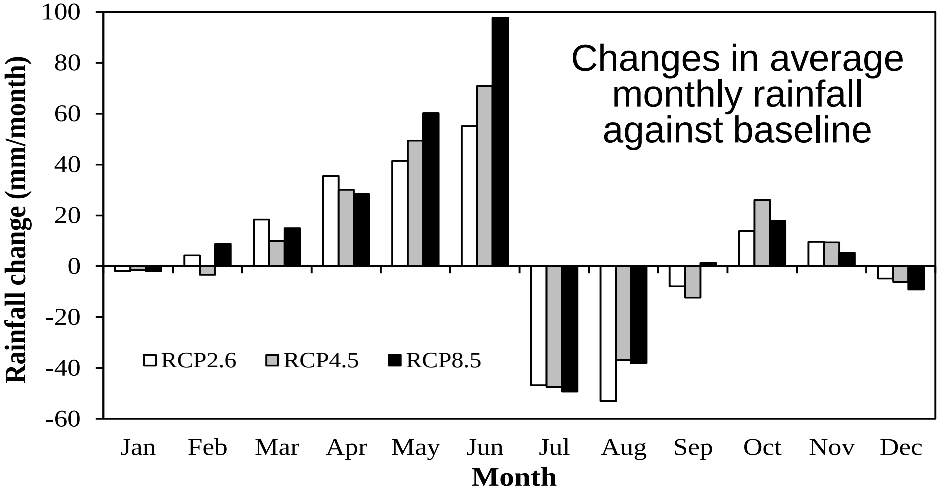


Projected Climate Scenarios

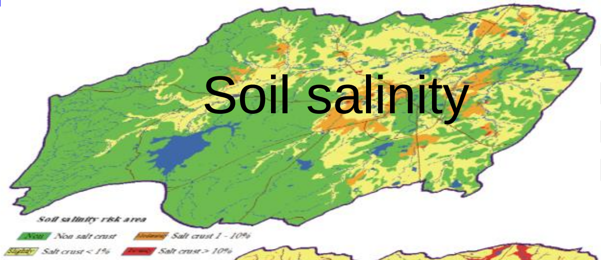




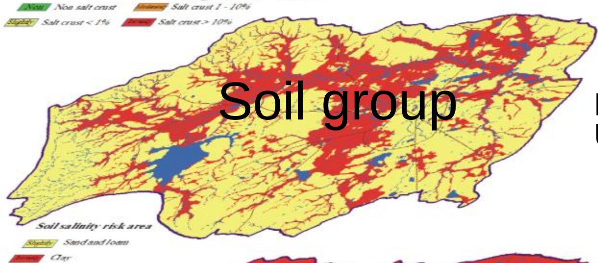




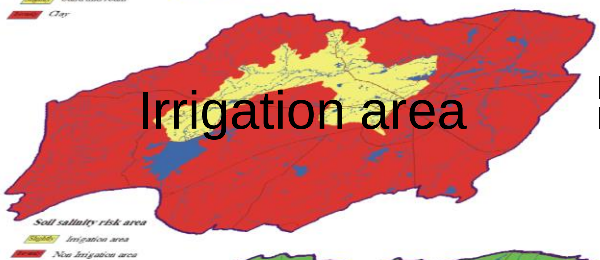
Soil Salinization Risk Assessments



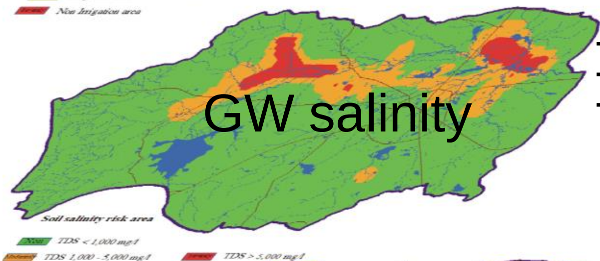
ECe <2 dS/m,
ECe 2-4dS/m,
ECe 4-8 dS/m,
ECe > 8 dS/m



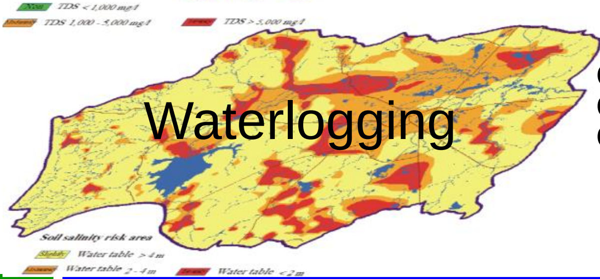
Lowland soil
Upland soil



Irrigated
Non irrigated



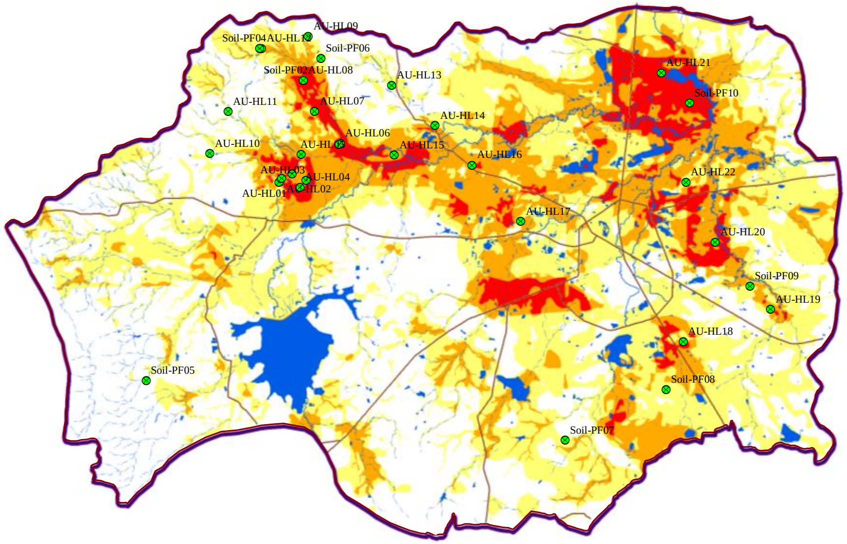
TDS <1,000 mg/l,
TDS 1,000-5,000 mg/l
TDS > 5,000 mg/l



GW level > 4 m. bgs.
GW level 2-4 m. bgs.
GW level <2 m. bgs.

Classes of Soil Salinization Risk Maps

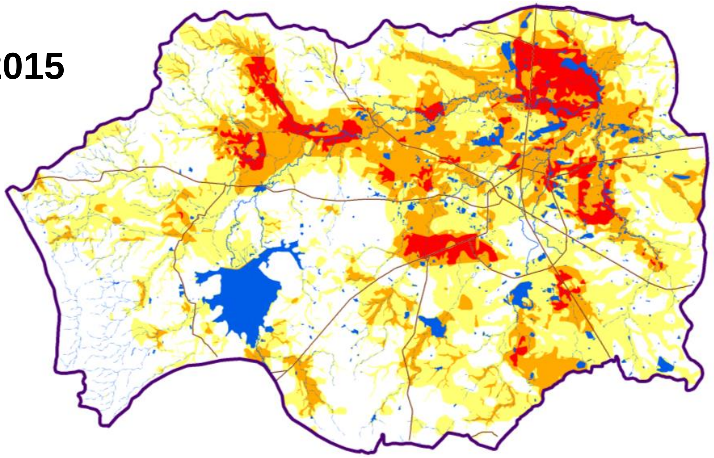
Risk classes	Risk score	Degree of soil salinity	Ece (dS/m)
No risk	16.5-21	Non saline	< 2
Slight risk	>21-26	Slightly saline	2 – 4
Moderate risk	>26-31	Moderately saline	4 – 8
Severe risk	>31	Severely saline	>8



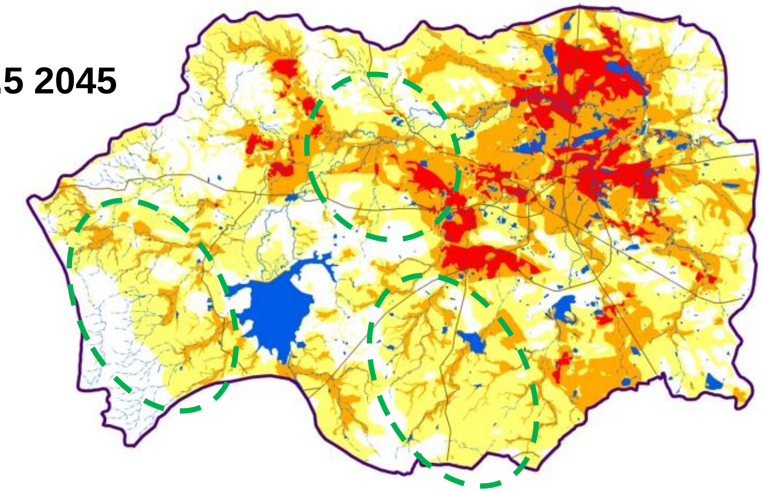
Soil salinity risk map in 2015

Projected Soil Salinity Risk Areas

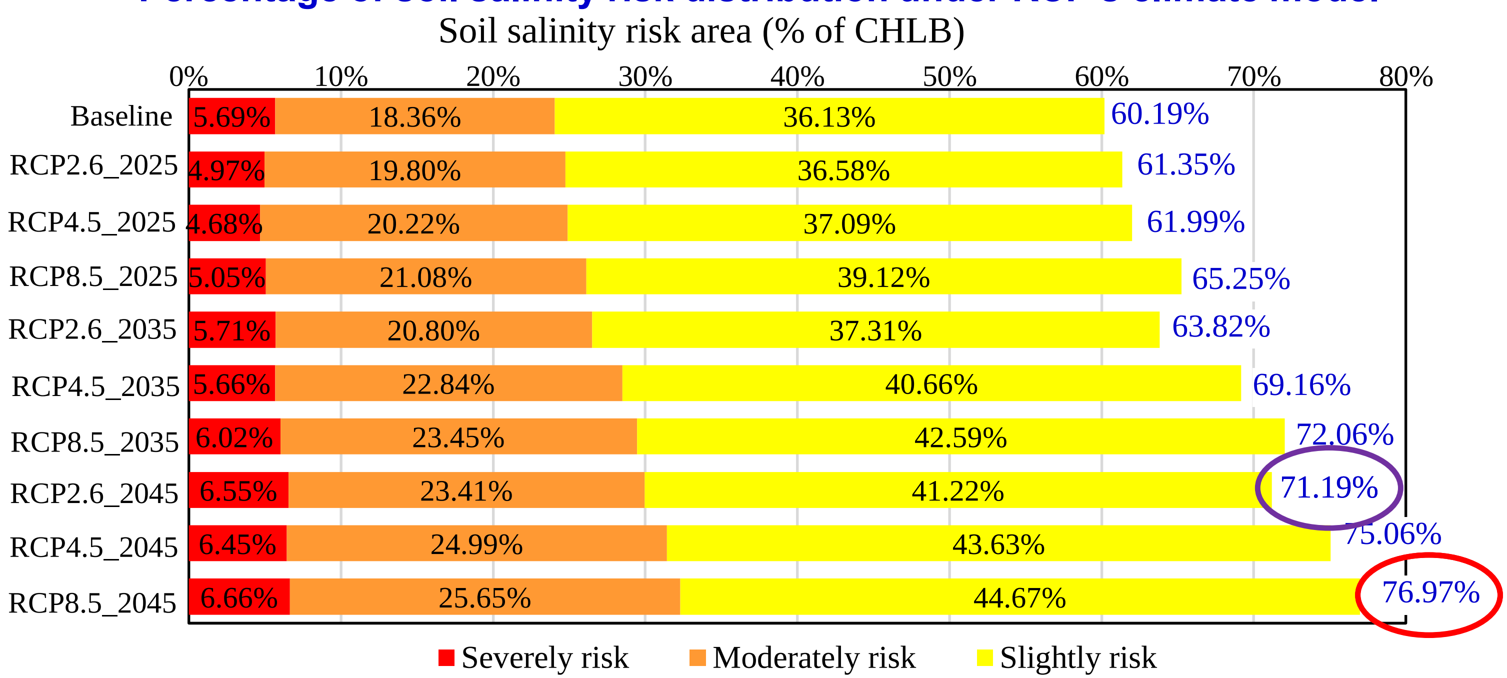
2015



RCP 8.5 2045



Percentage of soil salinity risk distribution under RCP's climate model



Conclusions

1. The groundwater recharge rates will be higher than the present trend through the next 30 years (2045) under climate change scenarios of RCPs 2.6, 4.5 and 8.5. It is due to the fact that precipitation is the most sensitive parameter. Whereas temperature is less sensitive than precipitation to recharge processes.

2. Affected saline groundwater areas will be slightly increased in all climate change scenarios. But waterlogged areas is significantly increased for both climate change scenarios. RCP8.5 climate scenario was shown the most increasing both saline groundwater and waterlogging areas.

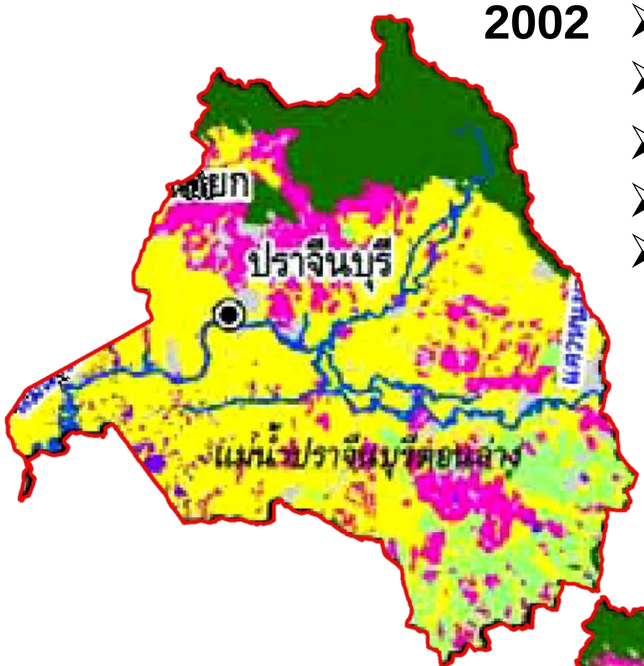
3. Affected soil salinity risk areas will be increased in all climate change scenarios. It is the consequent affects of climate change on saline groundwater and waterlogged areas.

Recommendations

- The study area is a relatively large and complicated dynamic basin, there are many uncertainty factors involved in this study, Therefore,
- The long-term monitoring of the water level measurement and soil salinity fluctuation should be continuously carried out.
- Landuse, groundwater usage changes, an impact on rice production and field crops in the CHLB would be essential for the next step for detailed study.
- The research on waterlogging and salinity control measures such as ecohydrological management, water resources management is significantly important for NE Thailand.

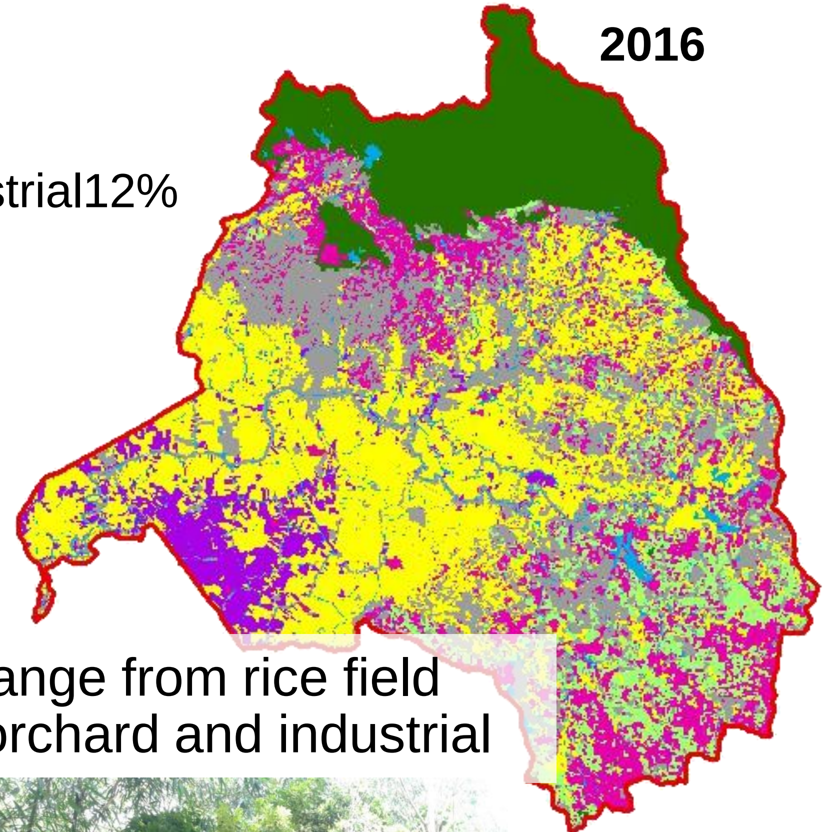
Impact of Land use Change on Groundwater balance and Managed Aquifer Recharge Practice: case of Prachinburi City

2002

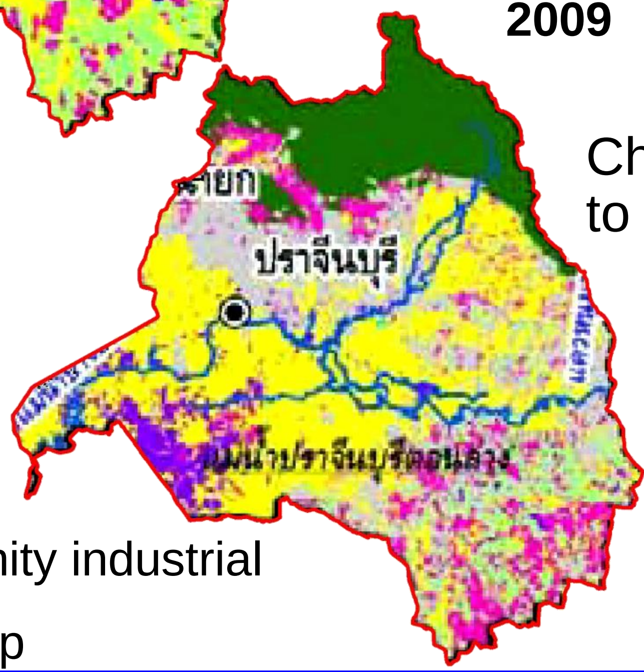


- Rice 31%
- Forest 15%
- Orchard 14%
- Community industrial12%
- Field crop8%

2016



2009



Change from rice field
to orchard and industrial

Rice

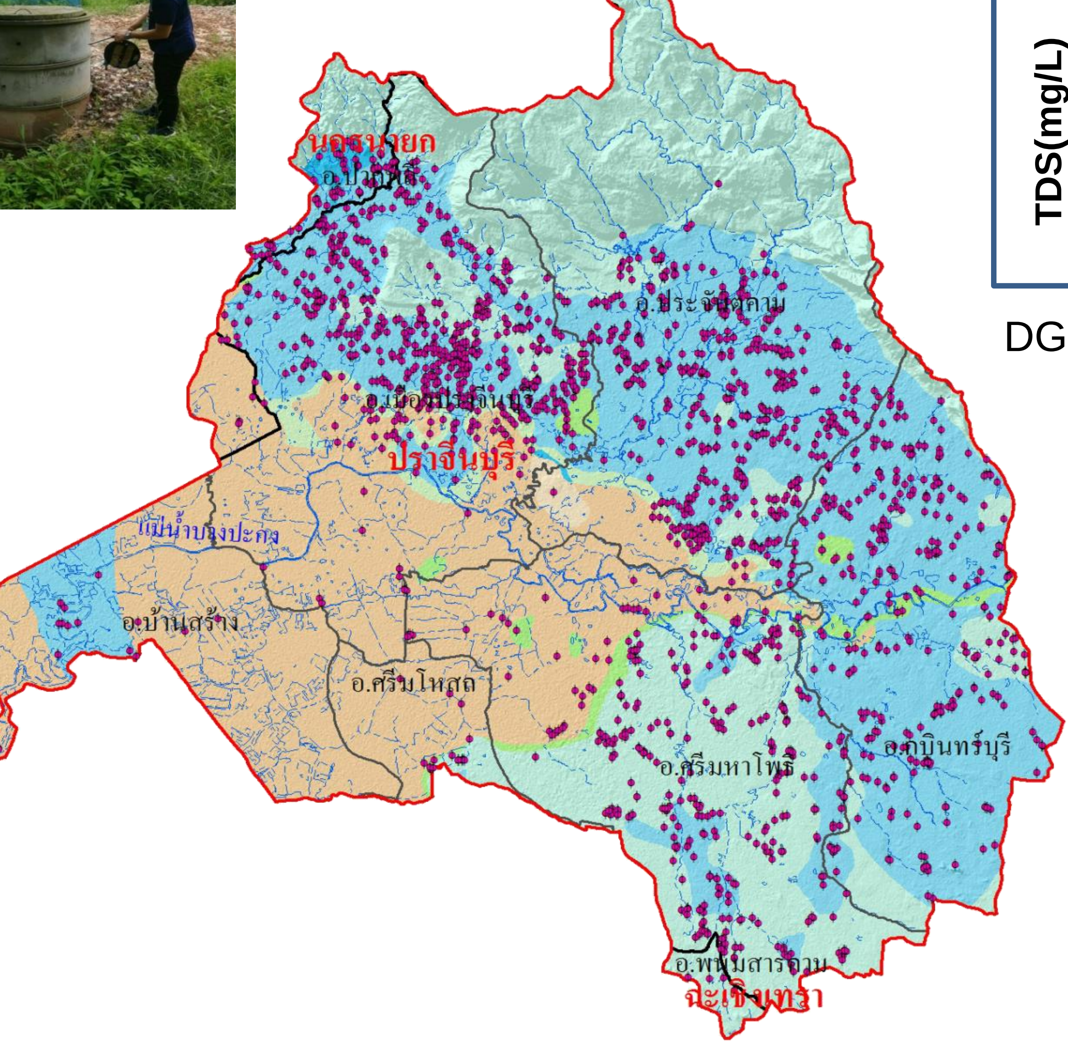
Forest

Orchard

Community industrial

Field crop

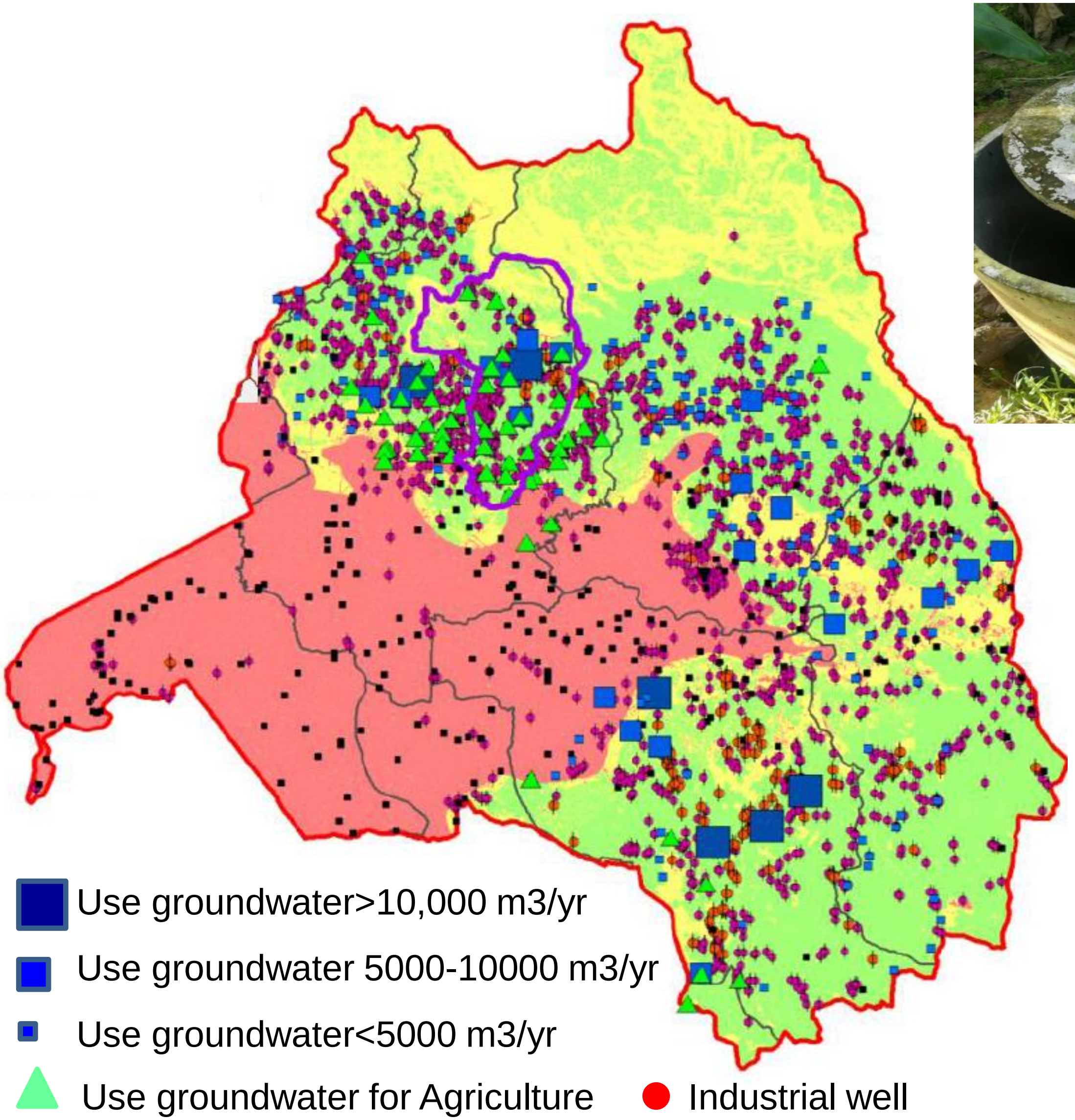
Groundwater potential



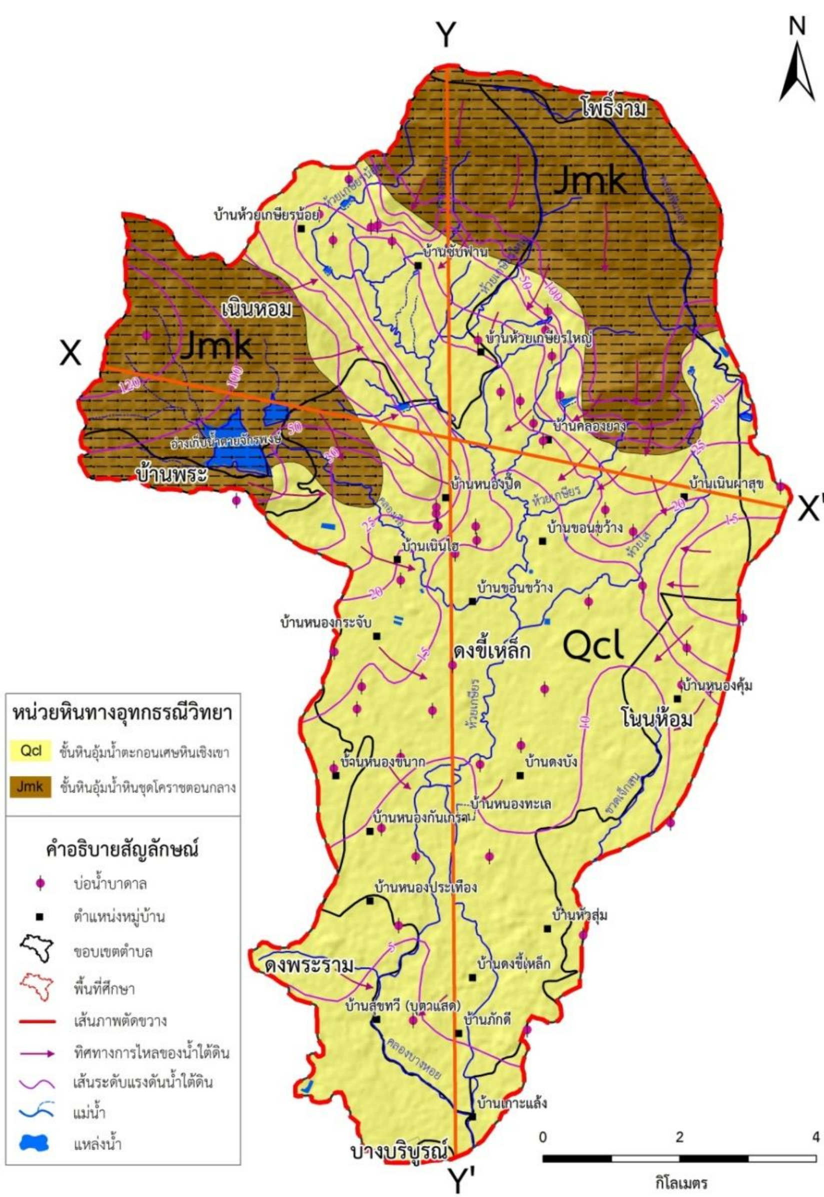
TDS(mg/L)	Water potential (m3/hr) < 2	2 - 10	10 - 20	> 20
< 750				
750 - 1,500				
> 1,500				

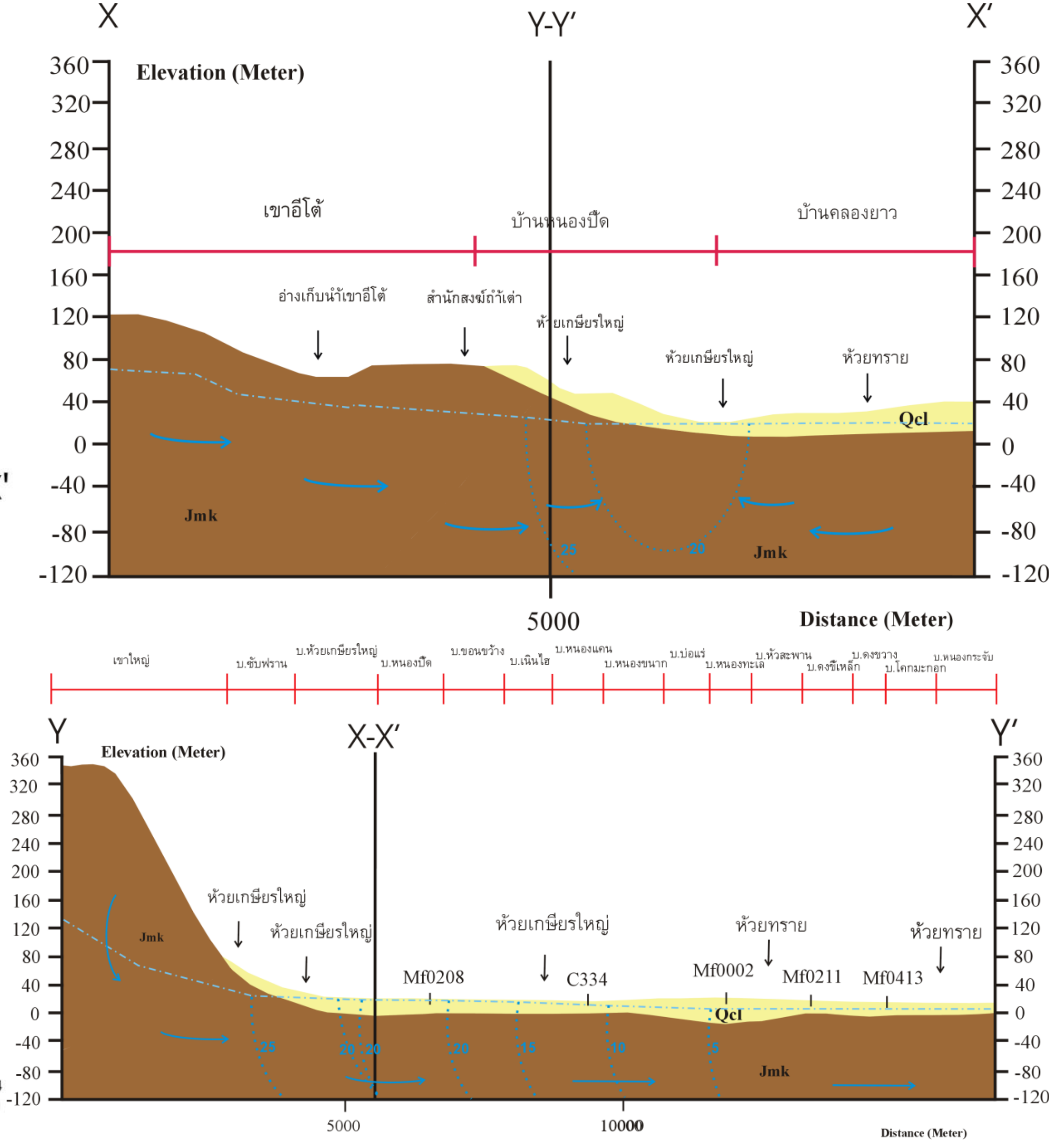
DGR, 2000

Groundwater Usage Survey in Prachinburi Province



Hydrogeological map of pilot area (Dong Keelek)





Groundwater usage in pilot study area

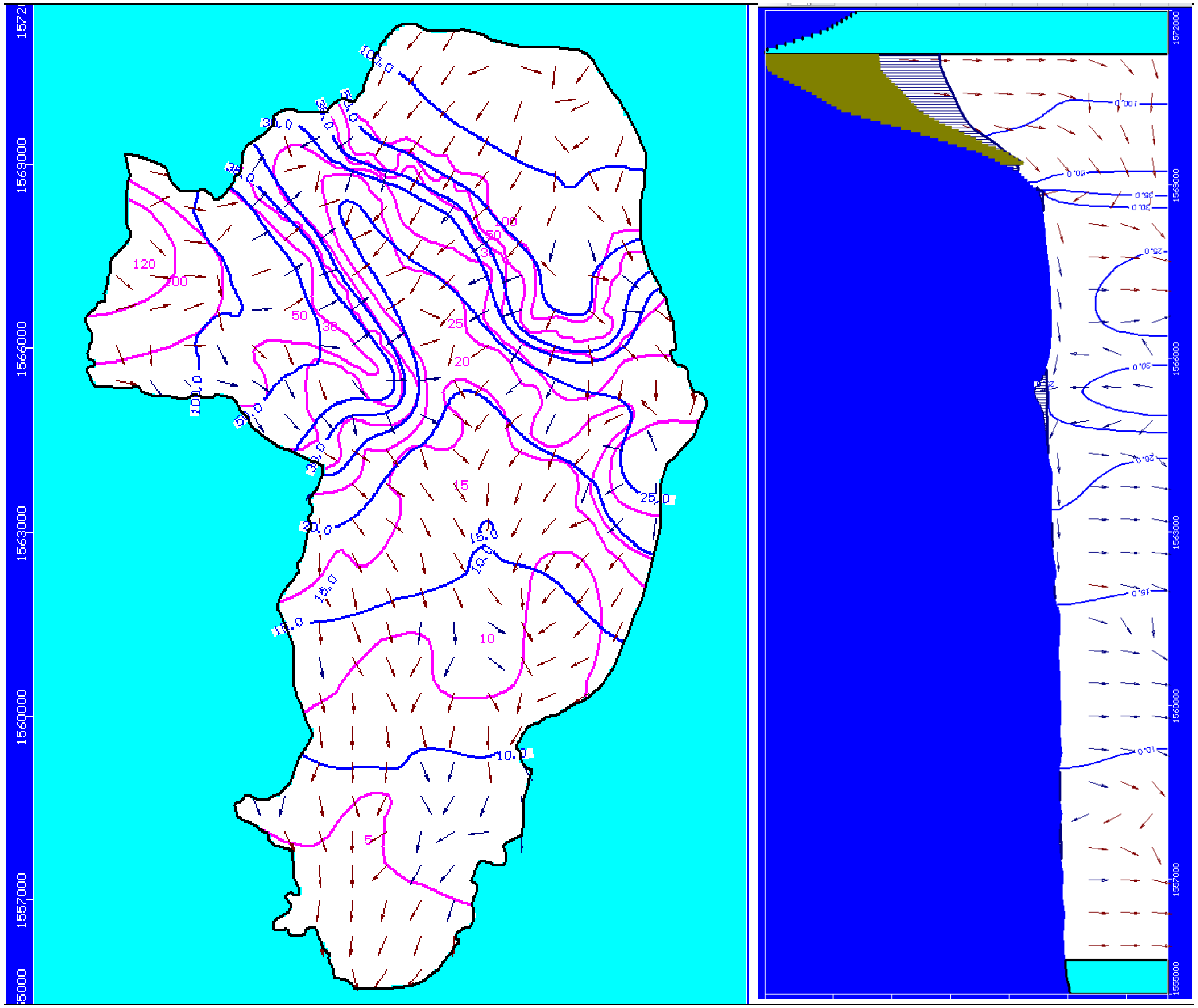
Shallow well

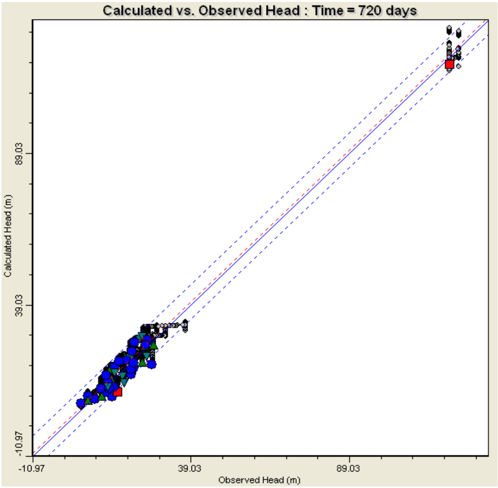
Deep well

Water consumption

Items	Area (Rai)	Water usage (MCM/yr)		Total
		SW	GW	
Agriculture	**22,525**	**14.85**	**43.24**	**58.08**
Domestic	**-**	**0.09**	**0.83**	**0.92**
Industrial	**654**	**1.05**	**0.43**	**1.48**
Total	**56,772**	**15.99**	**44.50**	**60.49**

Groundwater flow simulation and calibration

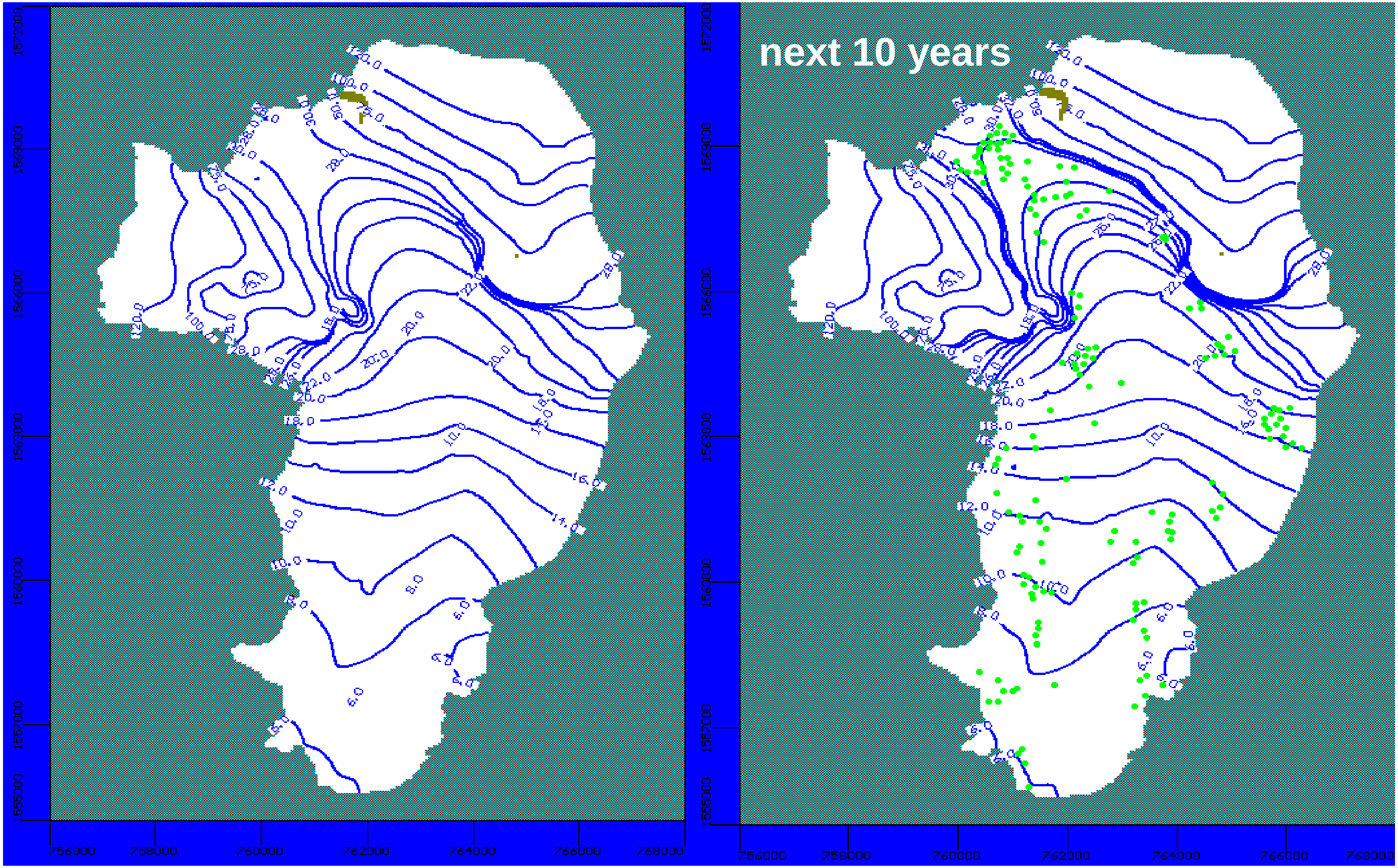




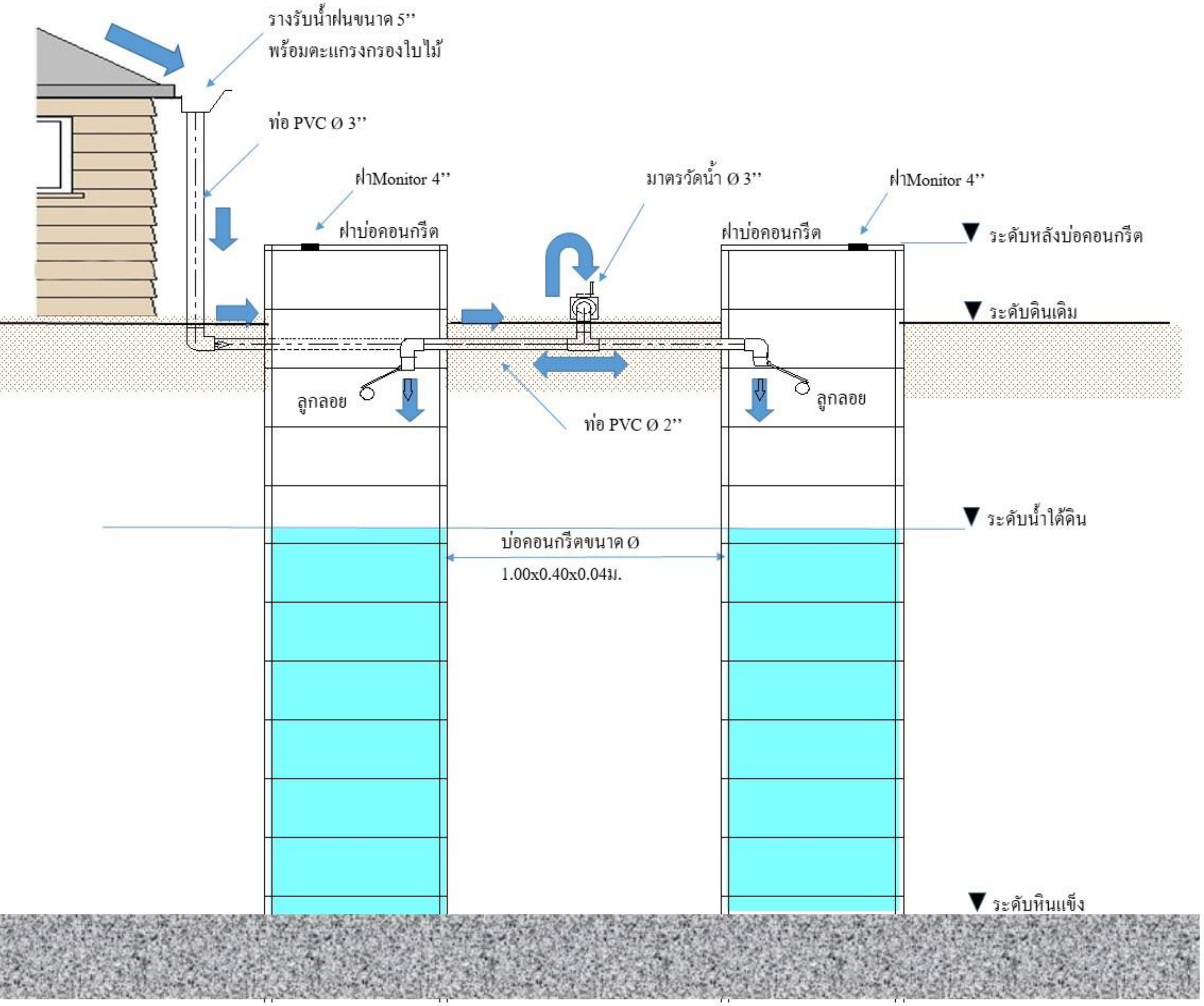
Water balance from flow simulation

Inflow (m3/yr)		Outflow (m3/yr)	
Recharge	40,472,220	Well	44,518,500
River	11,127,960	River	11,036,310
		GHB	74,790
Total	**51,600,180**	**Total**	**55,629,600**
Change in storage = - 4,029,420 m3/yr			

Projection of MAR implementation on flow and water table in pilot area



MAR System Design (Rainfall Harvesting System)



MAR wells drilling and construction

MAR system and monitoring well

Rainfall harvesting system

Monitoring well

MAR system

Ongoing monitoring and evaluation

Acknowledgments

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Thai Meteorological Department

Land Development Department