Groundwater Situation and Land Subsidence Mitigation in Bangkok and Its Vicinity

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Study Area: Bangkok City & 6 Surrounding Provinces

Chao Phraya River Basin
Hydrogeology of Bangkok Metropolitan Area
Aquifer System of Bangkok Area

1. Bangkok Aquifer (50 m. zone)
2. Phra Pradaeng Aquifer (100 m. zone)
3. Nakhon Luang Aquifer (150 m. zone)
4. Nonthaburi Aquifer (200 m. zone)
5. Sam Khok Aquifer (300 m. zone)
6. Phaya Thai Aquifer (350 m. zone)
7. Thon Buri Aquifer (450 m. zone)
8. Pak Nam Aquifer (550 m. zone)
Groundwater System

- Bangkok Aquifer System composed of 8 confined aquifers
- Most of groundwater extraction from 3 aquifers at depths 100-250 m (PD, NL, and NB Aquifers)
- Nonthaburi (NB) Aquifer one of the most productive, yielding up to 200 m³/hr of excellent quality water
- Deeper aquifers seldom used by domestic wells

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Code</th>
<th>Zone</th>
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<tbody>
<tr>
<td>Bangkok Aquifer</td>
<td>BK</td>
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<td>Phra Pradaeng Aquifer</td>
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<td>Nonthaburi Aquifer</td>
<td>NB</td>
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<td>Sam Khok Aquifer</td>
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<td>Phaya Thai Aquifer</td>
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<td>Thonburi Aquifer</td>
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<td>Pak Nam Aquifer</td>
<td>PN</td>
<td>550-m zone</td>
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</tbody>
</table>
Groundwater Pumpage in Bangkok

- Mid-1950’s: extensive use of groundwater started
- Continuous increase in groundwater use until 1997
- According to DGR, in 2004:
  - Total Groundwater use = 2.2 MCM/d
  - Private Pumpage = 1.8 MCM/d
- Private Users are the largest groundwater consumers
Groundwater Users

- **Agriculture Sector**
  - Relatively small amounts
  - Used as supplement water source
- **Domestic Water Supply**
  - MWA: reduced use but still using
  - PWA: main water source
  - Private users (w/o access to water supply services)
- **Industrial Sector**
  - Relies heavily on groundwater

Total Registered Groundwater Wells per User Sector (Since 1978)

Source: Kasetsart University (for DGR), 2005.
Current Water Use (Bangkok Water Use)

**TOTAL WATER USE = 1,689 MC M**

**SURFACE WATER USE = 1,514 MC M**

**GROUNDWATER USE = 176 MC M**

**DOMESTIC = 730 MC M**

**INDUSTRIAL = 772**

**Agricultural**

**Public Supply & Others = 12 MC M**

**Domestic**

**Industrial**

*Three provinces which are being supplied with pipe water by MWA*
GW Use in 3 Provinces, 2003

Industrial sector is the major user

Groundwater use, MCM

Bangkok: 0.33 (Agriculture), 30.88 (Industrial), 18.29 (Domestic)

Nonthaburi: 0.02 (Agriculture), 9.42 (Industrial), 20.25 (Domestic)

Samut Prakan: 66.47 (Industrial), 27.49 (Domestic)
Public Water Supply

- Metropolitan Waterworks Authority (MWA)
  - For Bangkok, Nonthaburi, and Samut Prakan provinces

- Provincial Waterworks Authority (PWA)
  - For other provinces; Usually in or near town centers

- “Village Piped Water Systems (VPWS)”
  - In rural communities far from town centers

- “Private Piped Water Systems (PPWS)”
  - Subdivisions/ housing developments; Responsibility recently handed over to the government
Groundwater-Use Impacts

• **Groundwater Depletion**
  – Water level drawdown
  – More difficulty in extracting water

• **Land Subsidence**
  – Over-pumping of groundwater
  – Loading and settlement of upper clay layer
  – Damage to infrastructure
  – Flooding
  – Disturb/deteriorate drainage systems

• **Water Quality Deterioration**

Areas close to the sea (such as here in Phra Pradaeng) can be subject to tidal floods during extreme high tide (spring tide). Source: UNESCAP, 2002
Water Level Map of Nakhon Luang (NL)
Recent water level and new cones of depression in the east and west of Bangkok (2005)
Water Level of NB, NL, PD and BK Aquifers at
Department of Mineral Resources, Bangkok

![Graph showing water level changes over years for BK02, PD17, NL34, and NB27 aquifers.]
Water Level of Three Major Aquifers at Eastern Part of BKK: Samut Prakan

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<td>60</td>
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</table>
Water Level of Three Major Aquifers at Western Part of BKK: Samut Sakorn
Land Subsidence in Bangkok

- In 1969, the occurrence of land subsidence in Bangkok and metropolitan area were noticed because of crack buildings and stairs separated from building.

- Well head in some area gradually extruded every year.

- Flooding.
Abandon well head which is effected by land subsidence.
The difference between a recent road level and a previous road level.
The rate of land subsidence is about 1.25 meter (during 1980-2003).

The difference between recent road level and previous road level at one location in Bangkok.
Land subsidence

The decreasing of groundwater level has effected to land subsidence as show in the picture below.

The maximum load subsidence rate was more than 10 centimeters per year during 1978-1981 at Ramkamhaeng University.
Land Subsidence 1997

Subsidence
- About 1 cm/year
- Subsidence rate at 1.5 cm/year
- Subsidence rate at 3.0 cm/year
- Subsidence rate at 3.5 cm/year

Map showing areas with different subsidence rates.
Recent rate of subsidence in Bangkok and its vicinity (2005).

- Land subsidence rate 2-3 cm./yr
- Land subsidence rate 3-5 cm./yr

Elevation (meter)

-0.5 - 0
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 - 4

GULF OF THAILAND

10 km

10° Kilometers
Groundwater Management

• 1. Institutional of Arrangement
• 2. Groundwater Resources Evaluation
• 4. Mitigation of Groundwater Crisis and Land Subsidence
1. Institutional of Arrangement

Ministry of Natural Resources and Environment

Department of Groundwater Resources

Royal Thai Survey Department (Ministry of Defense)

Groundwater Control & Legislation

Groundwater Conservation & Restoration

Groundwater Potential Assessment

Groundwater Exploration & Mapping

Groundwater Drilling

Regional Groundwater Offices

Provincial Groundwater Control Offices
2. Groundwater Resources Evaluation

• Aquifer Evaluation

• Sustainable Yield
3. Groundwater Act

- Groundwater Act of 1977
- and Amendments in 1992 & 2003
  - Control Drilling and Pumpage
  - **Groundwater charge** since 1985
    - Groundwater fee
    - Groundwater Conservation fee
  - Groundwater Fund
1. Groundwater Use Charge / cu.m.

1985 : 1.0 ฿ (0.03 $) (6 provinces)

1994 : 3.5 ฿ (0.09 $) (all provinces)

2000-2003 : 3.5 to 8.5 ฿ (0.09 to 0.21 $) (7 provinces)

2. Groundwater Conservation Charge

2004-2006 : 1 to 8.50 ฿ (0.03 to 0.21 $) (7 provinces)

Total Groundwater Charge = 0.42 $
4. Mitigation of Groundwater Crisis and Land Subsidence

- Critical Areas
- Strictly Control of Groundwater Pumpage
- Establishing Groundwater and Land Subsidence Monitoring Networks
- Stakeholders Meeting for Groundwater Management Policies and Measures
In 1983: Mitigation of Groundwater Crisis and Land Subsidence in Bangkok Metropolis

Critical Areas:

- Critical Zone 1:
  Subsidence rate > 10 cm/yr
- Critical Zone 2:
  Subsidence rate 5-10 cm/yr
- Critical Zone 3:
  Subsidence rate < 5 cm/yr
Critical Zone in 1995

- **Critical Zone 1:**
  - Land subsidence rate: > 3 cm./yr
  - Water level decline: > 3 m./yr

- **Critical Zone 2:**
  - Land subsidence rate: 1-3 cm./yr
  - Water level decline: 2-3 m./yr

- **Critical Zone 3:**
  - Land subsidence rate: 1 cm./yr
  - Water level decline: 2 m./yr
Groundwater monitoring stations

- 1978 First Established
  60 observation wells
- In 1985,
  258 observation wells
- At present,
  521 observation wells
  (163 stations)
Water level from three major aquifers and total land subsidence at Ramkamhaeng University.

PD: aquifer depth 100 meters
NL: aquifer depth 150 meters
NB: aquifer depth 200 meters

Critical Zones:
1st: $0.03$
2nd: $0.09$
3rd: $0.2$
4th: $0.42$

National Plan for Groundwater Projects

- Conjunctive Use
- Aquifer Storage and Recovery (ASR) Projects
Conclusions

• Declining Rate of land subsidence and water level in recent years due to the successful of implementation of
  • Control of groundwater use.
  • Economic measure.
• The two new areas of land subsidence are carefully controlled.
• The important tool for groundwater management is groundwater and land subsidence monitoring system.
Thank you for your attention
Objective of the Remedial Measures:

1. Reduce the water level declining rate to achieve recovery of the near original level.

2. Slow the rate of land subsidence.