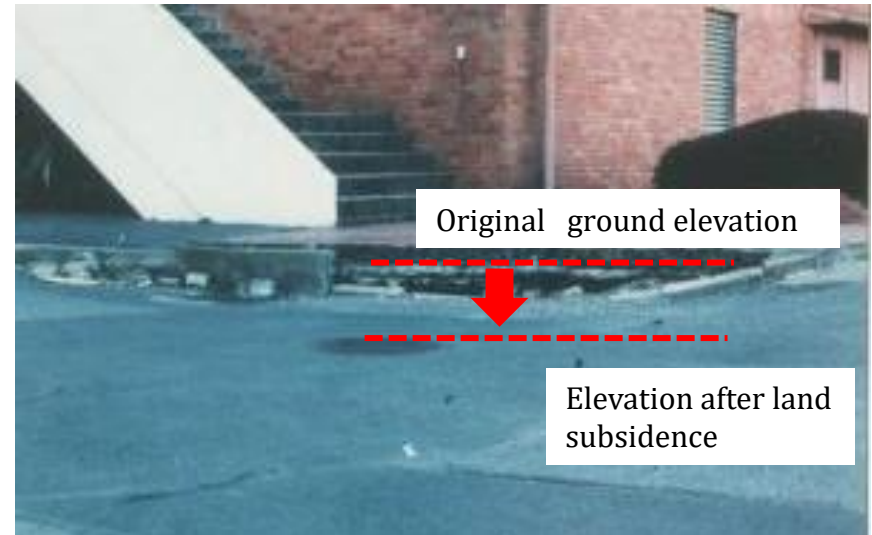


Sustainable Groundwater Use and Prevention of Land Subsidence: Osaka City and Saitama Prefecture



Depression caused by land subsidence
<https://www.pref.saitama.lg.jp/a0505/901-20091202-17.html>

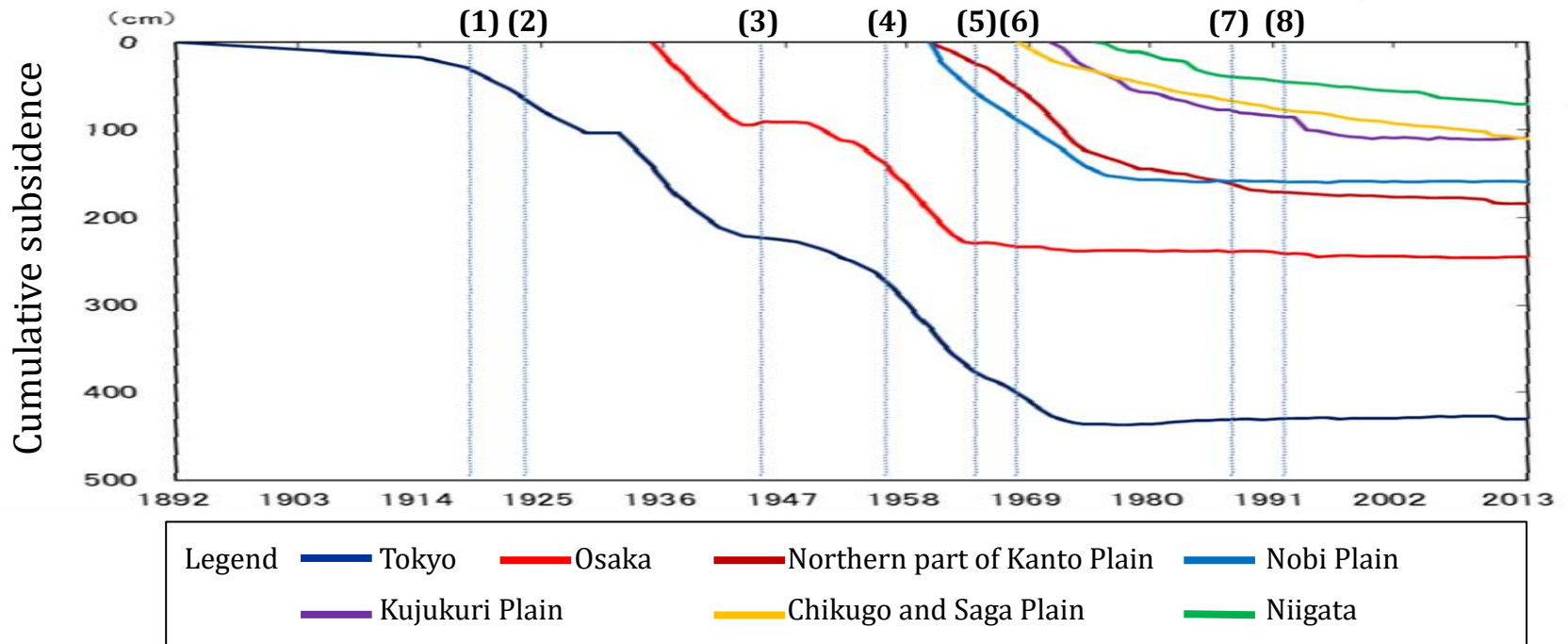
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1. Introduction

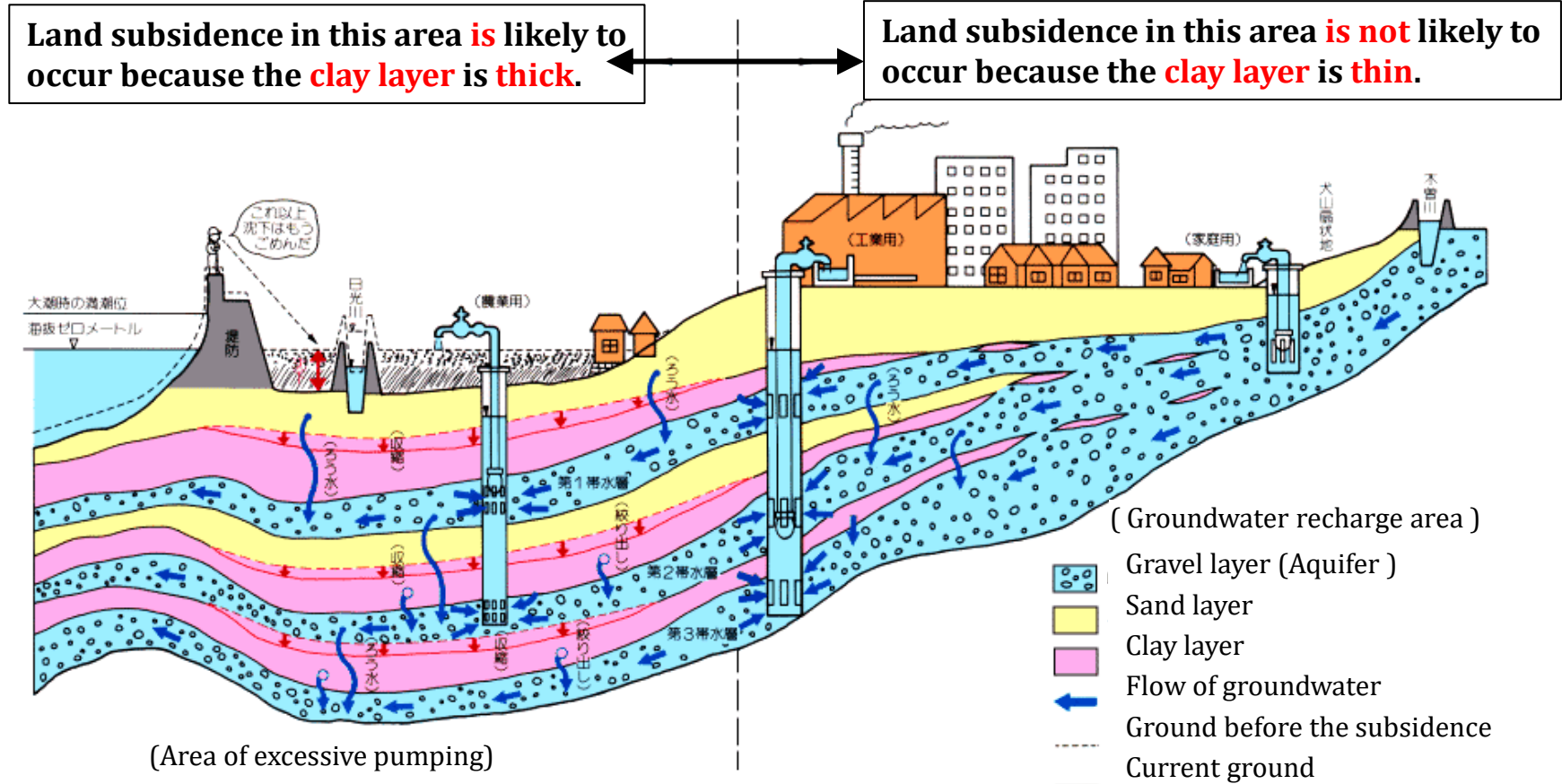
- (1) Beginning of borehole drilling in various regions
- (2) Great Kanto Earthquake
- (3) World War II
- (4) Enactment of "Industrial Water Act"
- (5) Enactment of "Building Water Act"
- (6) Enactment of "Basic Law for Environmental Pollution Control"
- (7) Guideline on Countermeasures for Prevention of Land Subsidence (Chikugo Saga plain and Nobi Plain)
- (8) Guideline on Countermeasures for Prevention of Land Subsidence (Northern part of Kanto Plain)



Changes in land subsidence in Japan 1892-2013

Ministry of the Environment, <http://www.env.go.jp/water/jiban/gaikyo/gaikyo26.pdf>

2. Land Subsidence and Preventive Measures



How excessive pumping of groundwater can cause land subsidence

Aichi prefectural government, "Outlines of land subsidence,"
<http://www.pref.aichi.jp/soshiki/mizu/0000035197.html>

2. Land Subsidence and Preventive Measures

(1) Causes of Land Subsidence

Land subsidence may be accelerated by increased water demand and excessive groundwater pumping.

- Increase of industrial water demand
- Development of pump technology
- Advances in borehole drilling technology

1923 The first recognition of land subsidence
(Surveying after the Great Kanto Earthquake)

- Increasing use of groundwater
- Lowering of groundwater level
- Shrinkage of clay layer

1950s Recognized as a social problem



Land subsidence

2. Land Subsidence and Preventive Measures

(2) Industrial Water Act and Building Water Act

In Japan, the key countermeasures against land subsidence are regulations to control groundwater pumping. Two laws to **control groundwater withdrawal targeting factories and buildings** have been effective in stopping land subsidence.

【 Countermeasures against land subsidence 】

- 1956

Industrial Water Act

Regulation for controlling groundwater withdrawal for industrial water use in designated areas

- 1962

Act on the Regulation of Pumping-up of Groundwater for Use in Buildings
(Building Water Act)

Regulation for controlling groundwater withdrawal for buildings

2. Land Subsidence and Preventive Measures

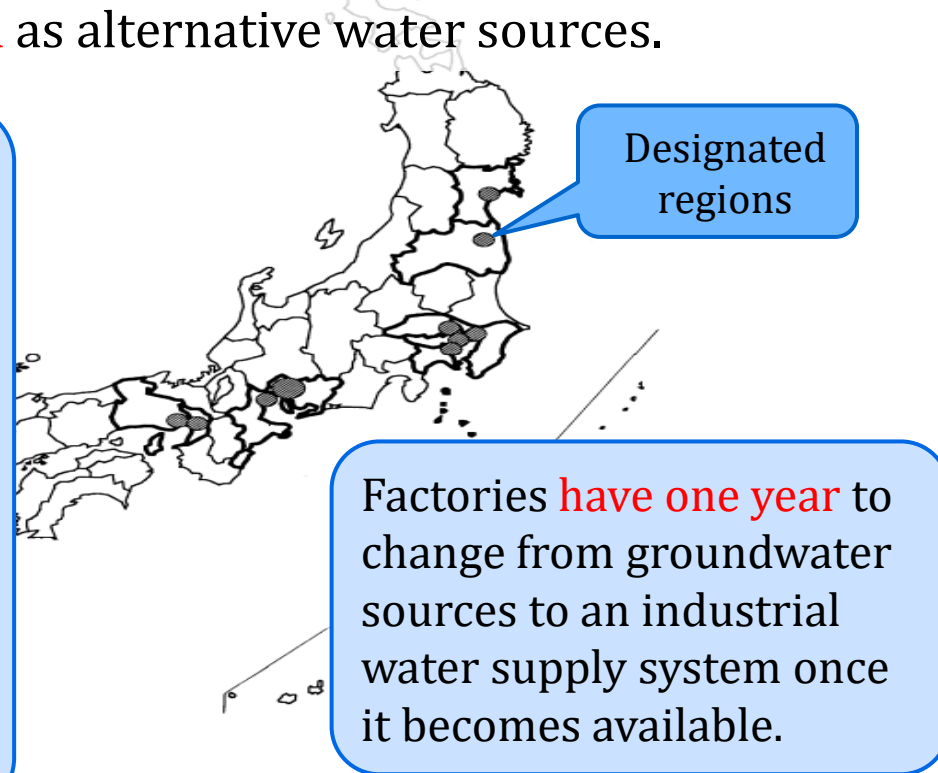
The Industrial Water Act is designed to ensure a reliable supply of water for industry, conserve groundwater and contribute to the prevention of land subsidence. When the Act was drafted there was a debate about how to regulate wells and it was decided as follows:

- Regulate newly drilled wells only
 - Exempt small household wells (smaller than 21 cm² in cross-sectional area of a discharge outlet of a pump)
 - Do not regulate the distance between wells
 - Supply alternative sources from publicly owned water supply systems
- The prefectural governor has the authority to order additional restrictions on groundwater withdrawal to protect the groundwater source in the case of emergencies.
 - Officials designated by ministers in charge or prefectural governors have the authority to conduct on-site inspections.

2. Land Subsidence and Preventive Measures

The Industrial Water Act regulates the groundwater pumping in the region where the **excessive pumping had caused land subsidence** and **industrial water systems are/will be constructed** as alternative water sources.

- Criteria for designated regions
 - i) **Occurrence of subsidence**, etc.
 - ii) **Large demand** for industrial water
 - iii) **Industrial water supply systems** are/will be constructed as an alternative water source.
- **17 regions in 10 prefectures**
- **Position of a strainer** of a well and a **cross-sectional area of a discharge outlet** of a pump



Designated regions targeted by the Industrial Water Act

Ministry of Economy, Trade and Industry, "Overview of groundwater protection," 2009,
http://www.meti.go.jp/policy/local_economy/kougyouyousui/chikasuitaisakunogaikyo21fy.pdf

2. Land Subsidence and Preventive Measures

The Act on the Regulation of Pumping-up of Groundwater for Use in Buildings (Building Water Act) is designed to prevent land subsidence. Withdrawal of groundwater to supply a building in a designated region (some parts of Osaka, Tokyo, Saitama and Chiba prefectures) requires approval from a prefectural governor if the well is above a certain scale.

Other ordinances by many local governments (311 cities, towns or villages of 27 prefectures out of 47, as of March 2015) have also been enacted to regulate groundwater withdrawal, reflecting local conditions. These local ordinances complement the broader national laws that target the significant large-scale land subsidence that has occurred in some regions of Japan.

2. Land Subsidence and Preventive Measures

Prevention of Land Subsidence through the Industrial Wastewater Regulation

The **Water Pollution Control Act** enacted in 1970 inadvertently contributed to decreasing the volume of groundwater withdrawn.

Discharge standards restrict **the concentration** of pollutant load in the effluent

Meaningless approach to achieve the standards by diluting with water.

Reduction in the amount of wastewater and introduction of wastewater treatment
(Large consumers)

Water saving and promotion of reuse

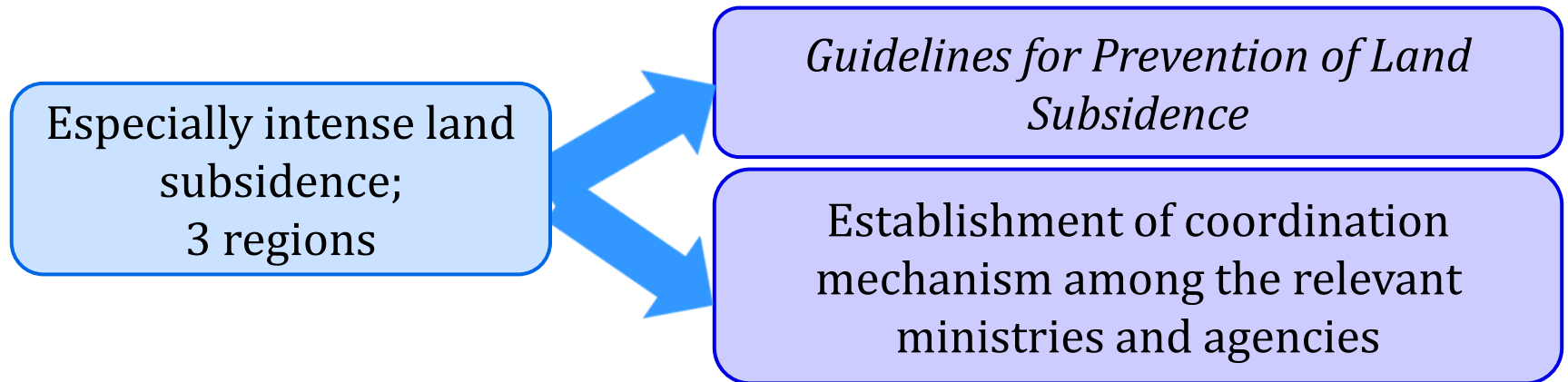
Reduction of water intake for industrial water

Reduction in the amount of groundwater withdrawal
(Unexpected benefit)

Effect of the Water Pollution Control Act (1970)

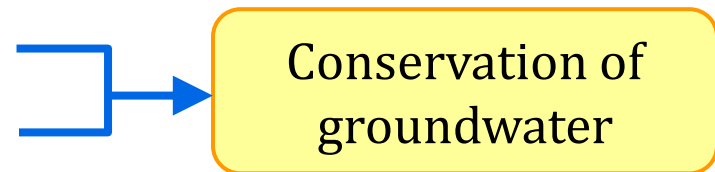
2. Land Subsidence and Preventive Measures

(4) Comprehensive Preventive Measures: *Guidelines for Prevention of Land Subsidence*

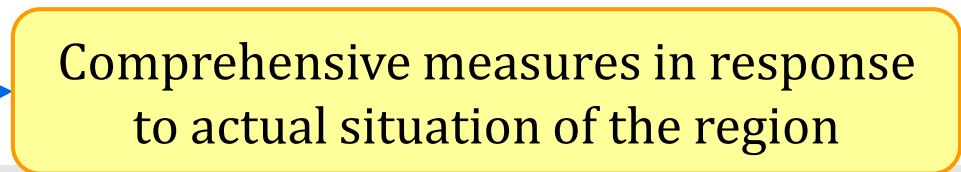


【The comprehensive countermeasures】

- Regulation to prevent over pumping
- Ensure alternative water source



- Prevention of disasters
- Restoration after damage



2. Land Subsidence and Preventive Measures

(4) Comprehensive Preventive Measures: *Guidelines for Prevention of Land Subsidence*

The monitoring of land subsidence and ground water levels is important to formulate appropriate regulations and analyze their impact.

Construction of nationwide broad-based observation network

- Regular monitoring of the effects of regulation and alternative water supply

- Hydrogeology
- Land subsidence
- Quantity of groundwater usage
- Groundwater level
- Groundwater quality

Information disclosure on the Ministry of the Environment website

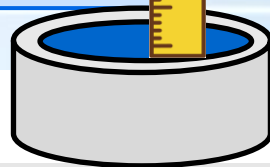
- Usage of groundwater
- Land subsidence situation

2. Land Subsidence and Preventive Measures

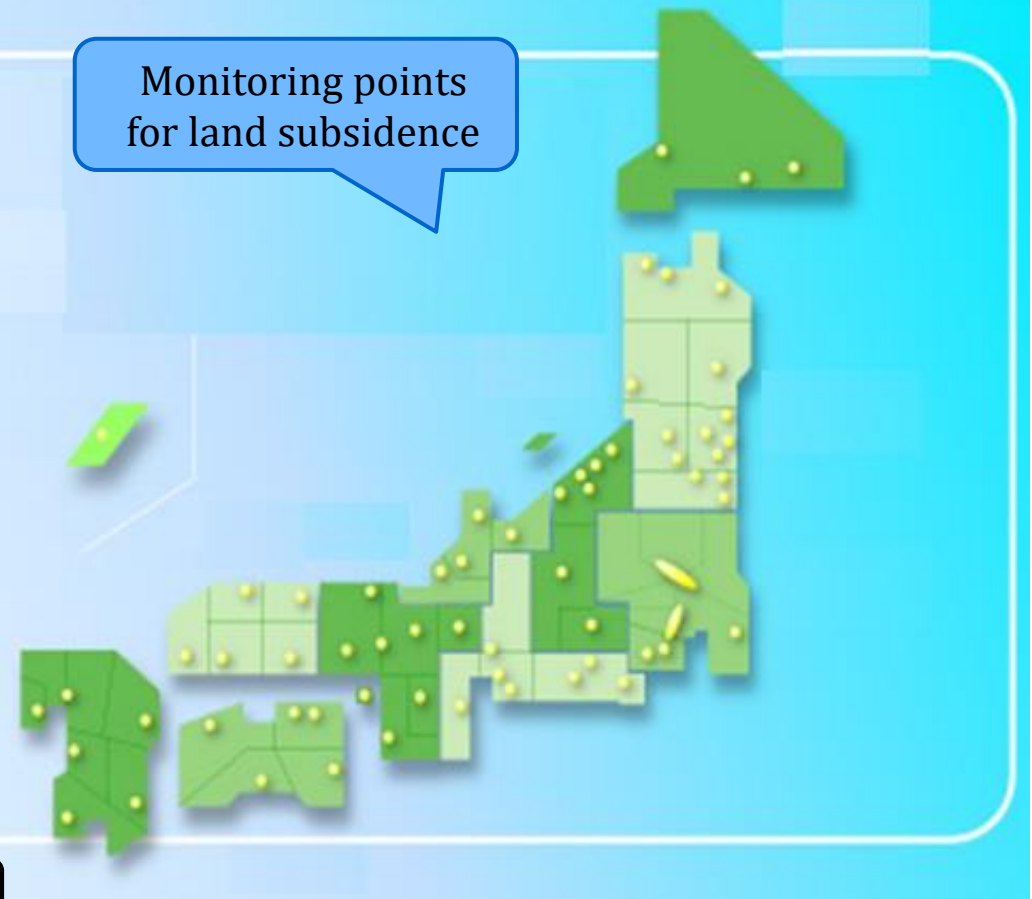
(5) Monitoring of Groundwater Level and Land Subsidence

Land subsidence has almost stopped in Japan, but the ground levels shall never come back to the levels before land subsidence took place.

Early countermeasures are important to prevent land subsidence from causing serious problems.



Monitoring points for land subsidence



Ministry of the Environment , *Monitoring points directory*
<http://www.env.go.jp/water/jiban/directory/index.html>

2. Land Subsidence and Preventive Measures

In Japan, the land owner has right to use groundwater defined by the Civil Code. This caused difficulties for implementing groundwater regulation.

Establishment of the Basic Act on Water Cycle in 2014

Groundwater is regarded as a precious public commodity.

3. Case 1 : Osaka City

(1) History of Groundwater Use and Land Subsidence

1930 - 1940s

Land subsidence became a serious social issue.

- Damage to buildings by uneven settlement
- Inundation by storm surge

ca. 1945

Decrease in economic activity due to war. Land subsidence temporarily halted.

ca. 1950

Resumption of land subsidence

The first recorded occurrence of land subsidence in Konohana Ward, Osaka City

The cumulative amount of land subsidence
= More than 270cm (by 1964)

3. Case 1 : Osaka City

(2) Industrial Water Supply

1954

Start of industrial water supply system, before legislation is enacted

1956

Enactment of the *Industrial Water Act*

1959

Establishment of the Osaka Coastal Industrial Water Supply Authority to accelerate the supply of water distribution system for Industry.

1968

A ban on groundwater withdrawal

Land subsidence has been almost stopped today.

4. Case 2 : Saitama Prefecture

(1) History of Groundwater Use and Land Subsidence



Location of
Saitama Prefecture

Soft geological formations extend into the eastern part of Saitama Prefecture. This is a contributing factor to serious land subsidence.

- **Monitoring stations at 36 places** in the prefecture
- **Real-time observation** of land subsidence and groundwater levels
- Setting **the maximum volume** of **groundwater abstraction**

4. Case 2 : Saitama Prefecture

1935



Monitoring of land subsidence started by Ministry of the Environment.

→ Cumulative subsidence in Saitama Prefecture
Koshigaya City = About 150 cm
(Since 1935)

Pumping of groundwater has been drastically reduced.

BUT

Still, land subsidence proceeds at 1 – 2 cm/year even now.

4. Case 2 : Saitama Prefecture

(2) Industrial Water Supply

ca.
1955

Factories increased in the southern area of Saitama Prefecture.

Increased use of groundwater

Problem of land subsidence

Saitama Prefecture Bureau of Public Enterprise started supplying industries with water in 1964.



Kakinoki purification plant

Supply area: 6 cities,
153 business sites
Supply amount: 195,280 m³/day
Tariff: 22.53 yen/m³

5. Lessons Learned (1)

- **(Monitoring)** Land subsidence can occur naturally or can be caused by excessive groundwater pumping. It is essential to **monitor ground level and groundwater level continuously** in areas where land subsidence occurs. It is also important to **understand the relationship between groundwater usage and land subsidence** so that the **use of groundwater can be regulated**.
- **(Alternative Water Sources)** The prevention of land subsidence can be greatly augmented by developing **alternative water supplies** such as industrial water supply.
- **(Regulations)** **The Industrial Water Act, the Act on the Regulation of Pumping-up of Groundwater for Use in Buildings and local ordinances** in some prefectures and cities provide the **effective legislative framework** for controlling groundwater use.

5. Lessons Learned (2)

- **(Stakeholder Involvement)** It was effective to arrange the discussions for **all the stakeholders** including **government authorities** implicated in the regulation of groundwater usage and **work together** to find solutions for groundwater depletion and land subsidence.
- **(Prevention in the entire Groundwater Basin)** Preventive measures for land subsidence need to be implemented **comprehensively in the entire region** which constitutes the **groundwater basin**. Groundwater **monitoring** and **regulations** for groundwater pumping have been implemented in the whole region in order to limit groundwater withdrawal and to prevent further land subsidence.