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with its vulnerable location, make it the world's slowest quicksand pit — or perhaps more accurately "shrink-sand pit."

Situated at the mouth of the Chao Phraya river, Bangkok is built on layers of soft clay and sandy sediment. The sedimentary layers contain huge amounts of water in natural storage reservoirs, or aquifers.

Thousands of wells in the city pump out more than a million cubic metres of water every day, slowly draining these aquifers. But the pumping also drains some of the moisture from the clay, compressing and shrinking it. This underground process is responsible for the land subsidence at the surface.

Root of the Problem

The enormous water demands of Bangkok's expanding population have placed a strain on the city's water supply, forcing people to drill deeper and deeper for wells. This continuous draining of the underground aquifers is leaving the city lying on a shrinking foundation.

"The root cause of the problem," writes Prinya, "appears to be a direct function of excessive and long-term groundwater withdrawal."

Groundwater pumping began in 1954 when the city's reliance on surface water could no longer meet Bangkok's needs. Originally, aquifers yielded water from as close to the surface as 5 or 6 m. By 1969, Prinya notes, that layer was dry and they were drilling through the underlying clay to 24 m deep. Today, some of the wells for large housing developments must go 200-m deep to be productive.

Prinya estimates that up to 30% of Bangkok's daily water needs are met by groundwater pumping.

This excessive groundwater extraction is not unusual among southeast Asian cities. Indeed, other cities in China, India, and the Philippines face similar problems of land subsidence. But Bangkok's situation is unique.

Situated right on the Gulf of Thailand, the city's surrounding regions are remarkably low-lying and flat. Most areas of Bangkok are only 1.5 m above sea level, leaving the entire area very susceptible to flooding. Floods are occurrences with which the city's residents are all too familiar.

It is one of the world's most flood-prone cities. The region's exceptionally heavy monsoon rains add to the water level of the Chao Praya river. The river, which winds its way through the city before releasing into the nearby Gulf, often swells because of tides and torrential downpours. When this happens the city goes underwater.

On 8 May 1986 a record downpour of 381 mm fell on the region. Observers said it was the heaviest rainfall in 500 years, flooding the river and leaving hundreds of thousands of motorists and bus commuters stranded in thigh-deep water.

In 1983, a 3-month flood cost the city an estimated 6600 million baht (US$30 million).

Looking for Answers

Prinya and Yong say these disastrous floods will only get worse if land subsidence continues. This is why IDRC funded a project for the geotechnical researchers to look at the problem and propose solutions.

They spent the first part of their project measuring the amount of land subsidence in Bangkok, using bench-marks placed in the 1930s. They knew there was a problem when they measured the maximum subsiding areas of the city to be greater than 160 cm.

Prinya and Yong also started to look at the composition of the land underneath the city. They found that the aquifers containing the water were blocked by large deposits of clay,"aquitards" in hydrogeological terms. The accelerating well pumping caused a vacuum effect in which the draining of each successive aquifer managed to put pressure on, and draw water from, the aquitards. The result was a shrinking of land.

The solution? Prinya and Yong reasoned that, because natural water resources were rechargeable, outside water should be pumped into the aquifers. The idea is to try to draw clear water from the rivers upstream, above the city, and drive it through large pipes into the underground sand layers. They want to balance what is taken out with what is put back in.

This balance will hopefully mean no more suction is created in the sand and no more water drained out of the clay. Water could still be pumped from the reservoirs without shrinking the clay, thereby keeping the land from sinking any lower.

Although the idea may seem fairly rudimentary, the reality of the situation is far from simple. One problem is the expense of the process — the researchers have only vague estimates about the cost. More research would also have to go into the make-up of the underground aquifers, whether they can simply be recharged with large doses of river water.

All of this makes for a difficult but, according to Prinya and Yong, extremely necessary plan of action.

The two engineers realize they cannot lift Bangkok back to its previous level. Land subsidence is an irrevocable process. They simply want to slow and hopefully halt the pace in which the ground is sinking — before the city's residents become painfully aware of more than just the symptoms.

By Craig Harris.

Researcher: Prinya Nutalaya
Dept of Geotechnical and Transportation Engineering
AIT PO Box 2754
Bangkok 10501, Thailand
FAX:(66-2)5280374

Shopkeepers coping in spite of more frequent and serious flooding. Bangkok sinks lower every year.