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Use of a Model in Securing a Water System

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USE OF A MODEL IN SECURING A WATER SYSTEM

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After the terrorist attack of Sep. 11, 2001, water security did not become an issue only in the US. DHI Water and Environment was recently involved in a water security project for the Danish Government, along with all the public and private water works suppliers in Denmark. The task was to secure the Danish water supply against any terrorist attack. At first it was thought that it would be accomplished – that you could be 100% safe. The World Health Organization had lead many to believe that if you put up enough fences and locks, you would be safe from tampering. However, after getting into the work, it quickly became evident that you could not be tamper proof. There are too many people with knowledge of water systems – knowledge they need to do their jobs effectively. It was determined that there were over 2500 trained personnel in Denmark alone with the skills necessary to introduce a toxin in the water supply from almost any point – it is part of their jobs. After deciding on the groundwork that could be done to make all the water utilities equally tamper resistant – through use of fencing, security cameras, locks, barricades, etc. – the work then focused on the reactive side. Since it is impossible to make the system tamper-proof, it was determined that the next most important thing is to have adequate contingency planning in place to deal with whatever toxin that is introduced. This is where modeling is introduced, and is the most important.

When setting up a model to do contingency planning, a 100% physical inspection is recommended. You could be using as-built maps or diagrams that contain errors. A community to should take steps to positively identify where the pipes are, where the shut-offs are, the pressure ratings of all valves, the number of inputs and their locations as well as the outputs. Every valve or other mechanism should be tested and put into working order, or at the very least, not counted as an existing apparatus if it does not work properly.

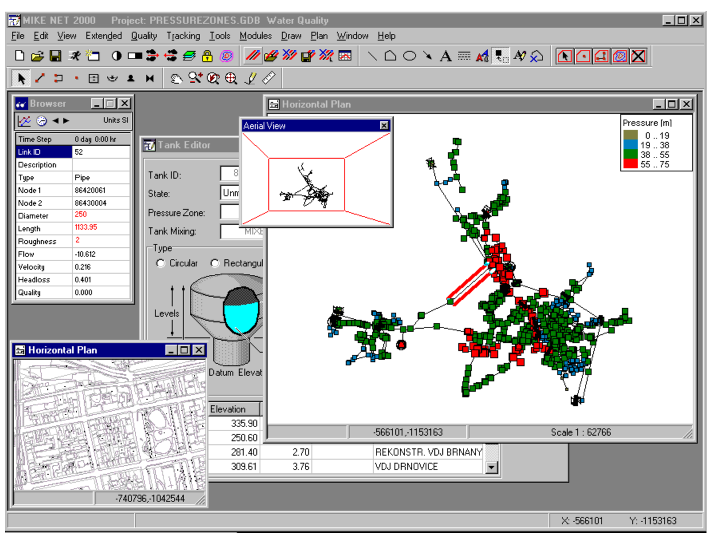

Figure 1 - Completed MIKE NET Water Distribution Model

The Denmark project required a rapid analysis plan be developed – which was done. The Beredskabsstyrelsen, translated as the Serum Institute (SI), was able to develop a 24-hour analysis system that allowed identification of any known toxin. A fingerprint of the water samples is being developed in each system, so that if any substance is introduced – toxic or not – the fingerprint will be changed and can be checked immediately. The Danish Water Works Association (DWWA) is working with the water utilities to generate constant monitoring systems. Additionally, the Danish Army has long had field kits for treating drinking water in the field during times of war, which will be introduced to the public for use in times of emergency.

Figure 2 - Danish Water Tower

The DHI water distribution software, MIKE NET, is for the simulation of flows, pressure distributions and water quality of pressurized water distribution systems. It uses the latest US EPA numerical engine called EPANET. MIKE NET can be used for the computation of both steady state conditions and for extended period analysis of flow and pressure conditions in pipe networks. Tied to a GIS network showing streets, buildings, pipes and waterways, it is very useful for emergency planners.

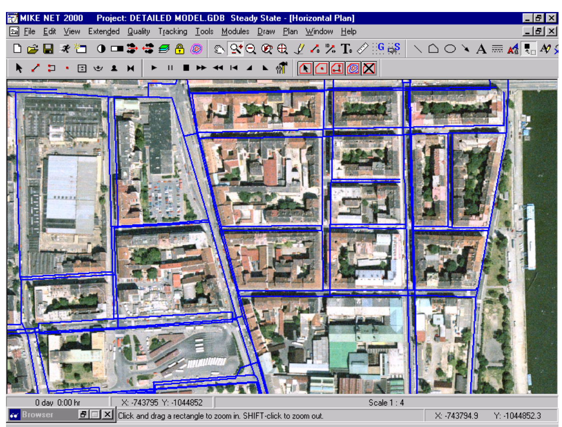

Figure 3 - MIKE NET GIS System

All taps receives water, which arrives though a number of pipes in the supply network, the **transport route**, and ultimately comes from a **source**. However, in order to achieve maximum supply security in case of pipe failures or unusual demand patterns (such as fireflows) water supply networks are generally designed as complicated, looped systems, where each tap typically can receive water from several sources and intermediate storage facilities. This means that the water from any given tap can arrive through several different routes and can be a mixture of water from several sources. The routes and sources for a given tap can vary over time, depending on the pattern of water use.

A model can show:

- Which sources (well-fields, reservoirs, tanks) contribute to the supply of which parts of the city.

- Where the water comes from (% distribution) at any specific location in the system (any given tap or pipe).

- How long the water has been traveling in the pipe system, before it reaches a specific location.

One way to reduce the risk – and simplify the response to incidents – is by compartmentalizing the water supply system. If each tap receives water from one and only one reservoir, then pollution of one reservoir will affect one well-defined and relatively smaller part of the city. If a toxic substance is injected into any section of the water supply system, then one and only one part of the supply system will be polluted, thus reducing the potential risk in terms of the number of people involved. The model will allow you to track the source of the pollutant, as shown in Figure 5.

Compartmentalizing the water supply system will reduce the spreading of toxic substances. On the flip side, it may increase the concentration of the toxic substance. It is also likely to have a negative impact on the supply of water for fireflow and on the robustness of the water supply network in case of failures of pipes or other elements. These problems can be eliminated, if the compartmentalization is done properly, allowing selected valves to be opened in case of fire emergencies or pipe failures.

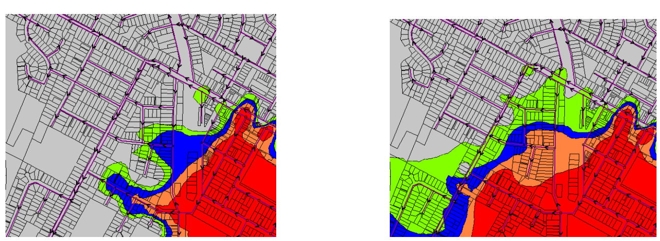

Figure 4 - Demonstration of Pollutant Spread Rate in MIKE NET

The model will be able to simulate a wide range of emergency scenarios, and the results can be condensed into very specific instructions for the emergency officers in charge at the time of the incident – all well in advance. This information can, of course, lead to actions such as sealing off the affected area from not-yet affected areas, warning of people within the affected district, starting medical treatment of people living in the affected area, setting up medical emergency centers, etc.

Another element of the reaction planning is modeling the pollutant spread rate (see Fig.4). Models will be built that show how pollutants will spread, at what speed, and how water flow can be stopped and diverted. In this way, if any parameter or variable changes, it can quickly be changed in a model scenario and help determine what to do next.

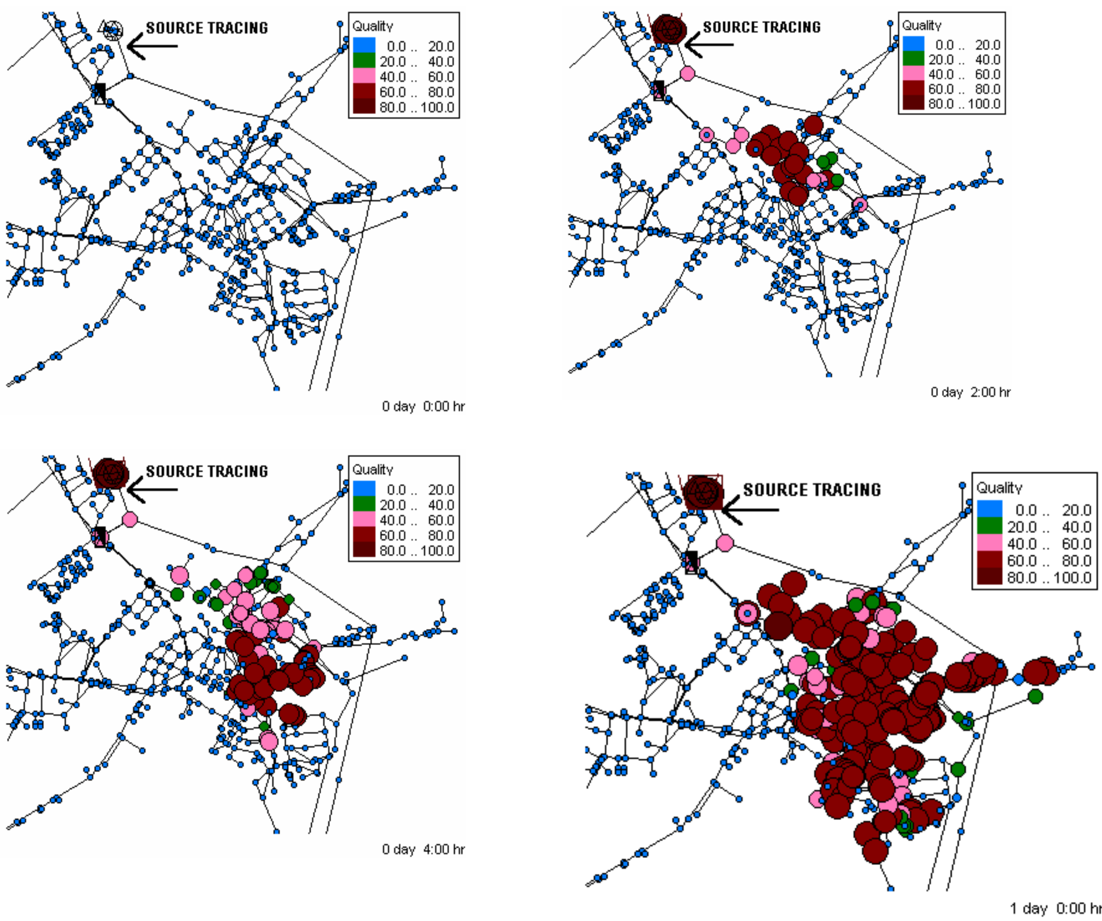

Figure 5 - Tracking the Source of a Pollutant with MIKE NET

DHI is not new to the process of ensuring clean water. It has been part of many Artificial Recharge Technology efforts. The overall objective of such a program is to ensure viability of drinking water production based on artificial recharge of surface water despite the growing appreciation of surface water quality problems. The term Artificial Recharge (AR) covers a range of technologies that typically utilise the natural cleaning capacity of natural subsoil systems to produce drinking water from surface water. The idea is to rapidly infiltrate surface water into the aquifer thereby increasing the groundwater formation and exploration possibilities. At many plants around Europe this is done in large plants where surface water is lead to large basins where it infiltrates. Traditionally these plants are operated based on measurements of water quality on a regular basis and in many cases on real-time measurements of various flow-related parameters.

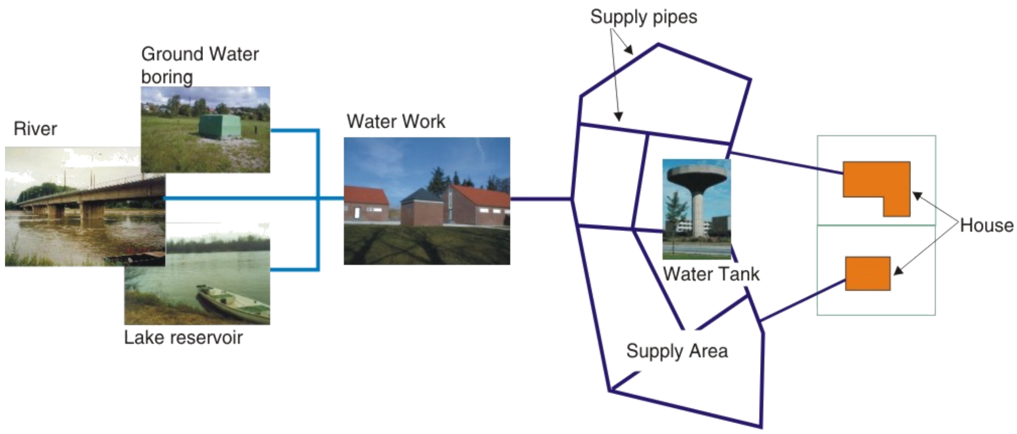

Figure 6 – Artificial Recharge Technology Mixes Sources of Water to a Network

Perhaps one of the most significant results of the Denmark project is the conclusion that the water supply cannot be made 100% safe – no matter what. Danish and EU law requires that citizens be informed of the source of their drinking water – so most information a person wanting to do harm would need to carry out such a plan is readily available. Therefore, the stress needs to rely on the reactive portion of the security system – the contingency plans. While safeguards will be put into place to guard against accidental contaminations and eliminate easy access, most of the work and new measures will be in the emergency action plan if security is breached. In this way it is hoped to minimize the negative impact on life. This approach can be used everywhere. With the funding now available from Congress and the mandate from EPA to write such emergency action plans, there is no reason for a water utility not to go through the exercise and prepare such a plan. There are trained engineers all across the US to help.

REFERENCES

"Denmark Asks for a Secure Water System" - Adam Brun and Hans Jacobsen, DHI, DK, Lars Schrøder, Public Utiilities of Aarhus, DK and Marsha Hosner, DHI Inc, USA.
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