



## **Environmental Challenge**

...a student team competition

## **2011 PROBLEM**

### **Purpose**

The Student Environmental Challenge sponsored by the Upper Midwest Section of the Air & Waste Management Association and Central States Water Environment Association gives students who are interested in a career in environmental engineering and science a ‘real-world’ and a ‘local’ experience in environmental problem solving. To that end, the “Problem” is based on current issues being debated by policy makers and project proponents in Minnesota. You will have the opportunity to present your problem solution to a panel of environmental professionals.

We hope to give you a glimpse of a real-world issue in need of creative solutions. We want to hear about the issues involved, how you interpret the problem, how you got to your conclusions, and how well you can communicate your thoughts. We want you to have fun! This exercise provides a broad opportunity for participation and gets the professionals of tomorrow to interact with the professionals of today.

### **Problem Description**

You are the director of the water utility in Mill City, a large, growing city in central Minnesota. Your water utility provides services related to the potable water and wastewater systems in Mill City. The potable water system consists of wells, storage, and distribution of potable water to residential, commercial, and industrial customers. The wastewater system consists of the collection, treatment, and permitted discharge of treated wastewater from the Publicly Owned Treatment Works (POTW) to a nearby river with strict water quality limits.

Your water utility must prepare a plan to respond to two important environmental issues: a new phosphorus discharge limit that is being imposed on the wastewater system, and a goal to reduce the city’s demand for potable water from the underground aquifer source by 20%.

Mill City is a free-standing urban center in a predominantly agricultural region of the state. The city is a commercial business hub that supports its own population of 40,000 people as well as the surrounding rural and agricultural populations. Mill City offers several of the amenities of the Twins Cities Metropolitan Area such as retail shopping districts, a college, hospital, parks, golf courses and other recreational facilities, theaters and other entertainment, a regional airport, rail service, and many employment opportunities.

The city’s electrical needs are met by a local, natural-gas fired power plant. Among the major industries in the city are an ethanol plant and a dairy. Both are large consumers of water provided by the water utility. The dairy discharges a high-strength wastewater to the city’s collection and treatment system.

## Environmental Challenge

...a student team competition

Land use outside city limits is agricultural. Soils are sandy loam and support a variety of crops. Ground slopes are moderate to flat. The sub-surface aquifer in the region is a reliable source for the utility's water system. The nearby river that receives treated wastewater from the POTW is the predominant surface water resource in the area.

### *Issue No 1: Phosphorus TMDL*

The river to which the POTW is permitted to discharge is subject to a new, stringent water quality standard. The new standard is known as a *total maximum daily load* (TMDL) for phosphorus. The TMDL goal is to reduce the phosphorus input from all permitted discharges to the river and reverse the phosphorus-related degradation of the river's water quality. Elevated phosphorus levels in the river have been attributed to excessive algal growth in downstream river pools and segments, with the ultimate die-off of algae depleting oxygen levels in those pools and segments. Oxygen depletion is the water quality degradation that has prompted state and federal regulatory agencies to issue the phosphorus TMDL.

To address this problem, the TMDL will assign phosphorus waste load allocations to all current phosphorus dischargers to the river. Mill City's allocation is based on "freezing" its discharge loading to the river at a level that is 50% of the current annual mass discharge. This load limit is to be maintained indefinitely in the future, even after growth in population and commerce increases the wastewater flow and loading to the treatment facility. A frozen mass limit means that as the wastewater flow increases in volume in the future, the concentration of phosphorus in the discharge must decrease.

The TMDL must be addressed even though the POTW currently uses a chemical treatment system to remove enough phosphorus to meet a 1.0 mg/l effluent discharge limit as required by the POTW's current discharge permit.

Mill City can reduce its discharge loading by upgrading the POTW's capability to remove phosphorus, by limiting incoming phosphorus discharges to the POTW, by diverting a portion of treated wastewater to a discharge point that does not impact the receiving stream, or by a combination of methods.

The TMDL includes a feature that gives Mill City and other affected dischargers an option for complying with the phosphorus load limit. Dischargers can meet their load allocations by trading effluent credits with each other. In a trading situation, a discharger that reduces its loading to a level less than its TMDL allocation—thus, creating a "credit" equal to the amount by which it exceeded its goal—may offer the credit for sale to another discharger. The "buyer" would be a discharger purchasing credits to meet its allocation rather than initiating treatment or other control measures designed to meet the allocation. The buying discharger must purchase enough credits to offset the difference between its allocation and actual loading.

## Environmental Challenge

...a student team competition

### *Issue No 2: Wastewater Reclamation*

Your City Council wishes to promote Mill City as a sustainable, environmental-friendly community and has directed your utility to find ways to reclaim treated wastewater for use in place of potable water. The Council has established as a goal that the City's demand for potable water from the underground aquifer source be reduced by 20%. The 20% water reclamation requirement is an annual goal, separate from the TMDL, to ensure the sustainability of the groundwater resource.

It is understood that the direct injection of treated wastewater into the system that provides drinking water to homes and businesses is not socially acceptable, but there are certain potable water uses that could be served by recycled wastewater. Consider evaluating large industrial, municipal, or institutional demands for water that could present feasible substitution opportunities. The wastewater quality must meet the standards for these uses.

Alternatively, the 20% water reclamation goal can be met by discharging treated wastewater on-land or sub-surface such that it recharges the aquifer used as the public water supply. This "indirect" recycling approach has been accepted as a method for replacing a portion of the potable water demand with treated wastewater, as long as quality standards are met.

Given the population and size of Mill City, the TMDL will impact the city's wastewater discharge greater than other dischargers affected by the TMDL. Consequently, it has been determined that no other discharger has the potential to sell enough phosphorus credits to offset the reductions Mill City needs to meet its loading allocation. Furthermore, to remain in economic development competition with other cities, Mill City may wish to prepare itself to become a potential seller of phosphorus credits.

Some key parameters in the evaluation of solutions are listed below.

#### *Demographics of Mill City*

---

Population	40,000
Estimated Growth Rate	1.5% per year

#### *POTW Data*

---

Description of Plant	Activated sludge with chemical phosphorus removal
Wastewater Average flow	5.0 million gallons per day
Influent wastewater characteristics	220 mg/l CBOD and 250 mg/l TSS

## Environmental Challenge

...a student team competition

Wastewater phosphorus concentration (influent)	6 mg/l
Current effluent phosphorus concentration	1 mg/l (to meet current permit requirements)
Current effluent nitrogen content	10 mg/l (no permit requirement)
Other effluent characteristics	15 mg/l CBOD and 30 mg/l TSS (permit requirements)

## Dairy Wastewater Characteristics

---

Average Flow to POTW	300,000 gpd
Phosphorus Concentration (to POTW)	12 mg/l
Other Waste Characteristics	900 mg/l CBOD and 500 mg/l TSS

## Ethanol Plant Water/Wastewater Data

---

Potable Water Use for Non-Contact Cooling	1,000,000 gallons per day
Wastewater Discharge	To river, via its own discharge permit
Phosphorus Concentration of Discharge	1 mg/l (by permit)

Much of the other data needed to fully evaluate the options is to be assumed. Good sources of data are:

- Wastewater Treatment and Disposal, Metcalf & Eddy, McGraw-Hill
- Design of Municipal Wastewater Treatment Plants, WEF/ASCE, McGraw-Hill
- Minnesota Rules Chapters 7050—7100 (available online from Minnesota Pollution Control Agency)
- Design Guidance for Large Subsurface Treatment Systems (LSTS) (available online from Minnesota Pollution Control Agency)
- Guidance and Submittal Requirements for Rapid Infiltration Basin Wastewater Treatment Systems, March 2005 (available online from Minnesota Pollution Control Agency)
- Understanding the LSTS Ground Water Nitrate Nitrogen Policy (available online from Minnesota Pollution Control Agency)
- Water Reuse: Issues, Technologies, and Applications, Metcalf & Eddy - AECOM, McGraw-Hill, 2007
- Nutrient Control Design Manual  
EPA/600/R-10/100, August 2010
- Biological Nutrient Removal Processes and Costs  
EPA/823/R-07/02, 2007, 15 pages

Please clearly state your assumptions. For example, costs of conveyance of treated wastewater should be based on assumptions about the size of a growing city of 40,000 and distances from the center of the city to potential sites outside the limits of development and areas of population



## **Environmental Challenge**

...a student team competition

density. Similarly, the economic feasibility of some options will be affected by proximity to the City versus prices farther from the city.

At a minimum, your project should address:

1. Financial feasibility with respect to the long-term costs of options (capital and operating costs)
2. The selling price of phosphorus (per lb.) to compare scenarios that generate phosphorus credits for sale
3. Public perception of and opposition to competing options
4. The long-term issues/benefits of options, if different from immediate issues/benefits
5. Political issues
6. The benefit of promoting your city as a “growing” city that values economic development
7. The benefit of promoting your city as a “green” city that values an emphasis on sustainability
8. Long-term energy aspects of each of your options

Present your recommended plan to meet both initiatives simultaneously, including descriptions of relative advantages and disadvantages compared to other options considered. Just as important as the economic analysis will be the analysis of the non-cost issues (e.g., public perception, political).