Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

# RESEARCH AND DEVELOPMENT DEPARTMENT

**REPORT NO. 07-82**

**ENVIRONMENTAL MONITORING AND RESEARCH DIVISION**

**2006**

**ANNUAL REPORT**

**DECEMBER 2007**

***Metropolitan Water Reclamation District of Greater Chicago***
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# ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

# 2006

# ANNUAL REPORT

**Research and Development Department**
**Louis Kollias, Director**

**December 2007**

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## ACKNOWLEDGMENTS

This 2006 Annual Report is the result of the efforts of not only the scientists and engineers who perform the monitoring and research initiatives of the Department, but also the impressive efforts of support staff and other personnel who contribute their valuable time, energy, and know-how to the production of the report. These individuals deserve special recognition and thanks.

Special thanks are due to Laura Franklin, Rhonda Griffith, Deborah Messina, Joan Scrima, Nancy Urlacher, and Sabina Yarn for their immaculate typing, zealous adherence to Department formatting tradition, responsiveness to turnaround times, and dedication to moving the report forward.

## DISCLAIMER

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## STRUCTURE AND RESPONSIBILITIES OF THE ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

The Environmental Monitoring and Research (EM&R) Division has 67 employees, and is comprised of seven Sections. These are illustrated in Figure 1 and Appendix V with a breakdown of the number of employees. The seven Sections are:

1. Administrative
2. Wastewater Treatment Process Research
3. Biosolids Utilization and Soil Science – Stickney
4. Land Reclamation Laboratory - Fulton County
5. Analytical Microbiology and Biomonitoring
6. Aquatic Ecology and Water Quality
7. Radiochemistry

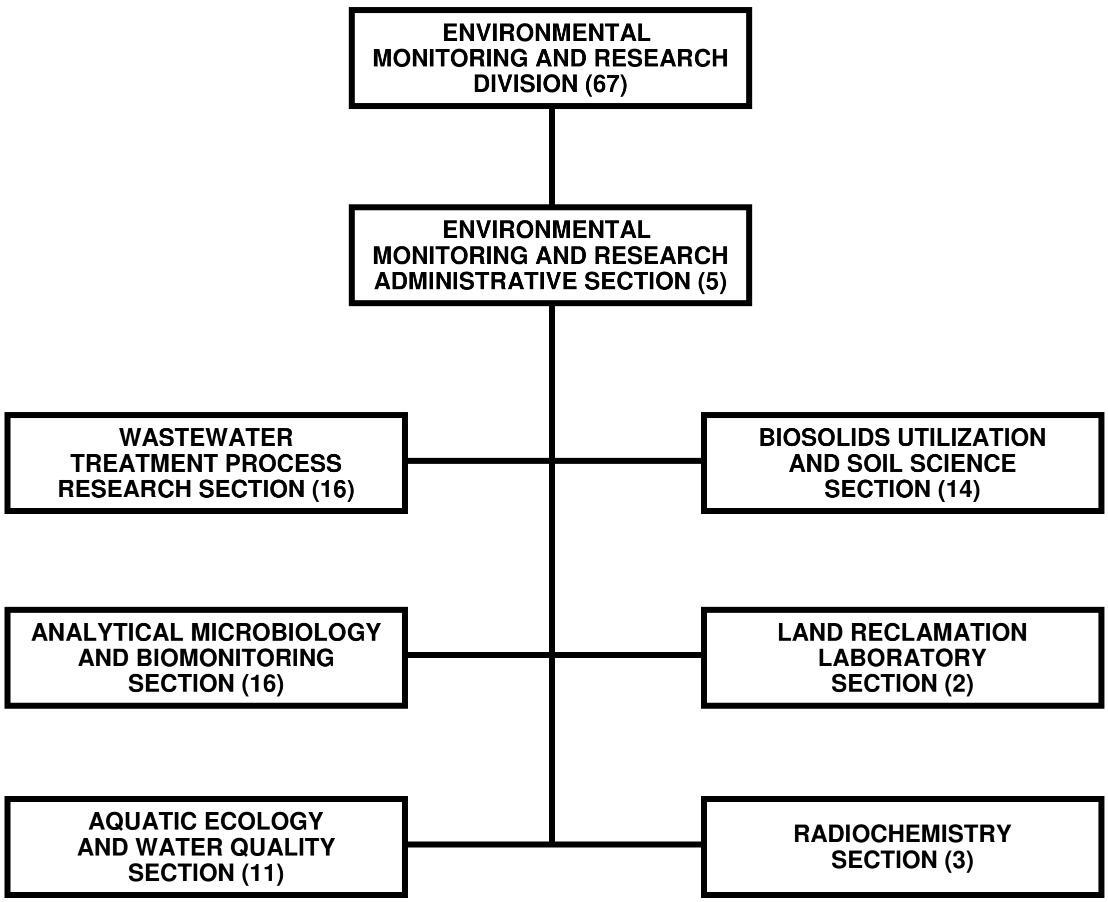
The major areas of focus of the Division were as follows:

- Monitoring the environmental quality of Lake Michigan, area rivers and canals, and the Illinois River to document the effectiveness of the District's wastewater treatment program.
- Assisting in the resolution of sewage treatment and solids disposal operation problems.
- Providing technical assistance to other departments and agencies with respect to issues related to wastewater treatment; combined sewer overflow (CSO) management; waterways management; and solids processing, utilization, and marketing.
- Conducting applied and operations research to achieve improvement and cost reductions in District wastewater treatment, waterways management, and solids processing and biosolids utilization activities.
- Assessing the impacts of new or proposed regulations on District activities.
- Generation and transmittal of environmental monitoring reports to regulatory agencies to ensure compliance with requirements of Tunnel and Reservoir Plan (TARP), water reclamation plant NPDES, and biosolids processing and utilization permits.

- During 2006, the EM&R Division participated in numerous Meetings and Seminars (Appendix I), presented several papers, Power Point presentations, and poster presentations (Appendix II), and also published several papers (Appendix III).

## FIGURE 1

## ENVIRONMENTAL MONITORING AND RESEARCH DIVISION ORGANIZATION CHART (WITH THE NUMBER OF EMPLOYEES)



## ADMINISTRATIVE SECTION

The Administrative Section provides technical guidance, scientific review, and administrative support for the work being carried out by the EM&R Division staff. The Section also organizes a monthly seminar series, open to all District employees, that presents information on areas of interest to the wastewater field. In 2006, 1,894 people attended these seminars. A list of the seminar topics is shown in Appendix IV

In addition to the overall administrative and supervisory functions performed by the Administrative Section, the Experimental Design and Statistical Evaluation Group, which is part of the Administrative Section, provided the following support to the rest of the EM&R Division.

### Experimental Design and Statistical Evaluation Group

The Experimental Design and Statistical Evaluation Group is responsible for providing assistance in the design of laboratory and full-scale experiments, collection of appropriate data, development of guidelines for data collection methodology, and statistical analyses. Since 1999, Section personnel have been performing these tasks using PC computing media. They also developed programs to interconnect LATEX and Visual Basic Programs with SAS, Access, Excel, Outlook, and Power Point software programs. This computer automation has enabled the Section to produce reports, tables, and texts in suitable designs, and to respond to many requests in a shorter period of time.

**Statistical and Computing Support.** During 2006, a Biostatistician provided statistical and computing support to various projects. The following is a description of some of the activities.

1. Statistical support was provided to the Wastewater Treatment Process Research Section on reduction of frequency of monitoring of TARP groundwater monitoring wells in response to questions from Illinois Environmental Protection Agency. The statistical analysis was completed in June 2006.

2. Statistical support was provided to the Analytical Microbiology and Biomonitoring Section on a project entitled: "Effect of Secondary Sewage Treatment on the Total Numbers and Percentages of Antibiotic Resistant Fecal Coliforms in Municipal Raw Sewage." The statistical analysis for the project was completed in January 2006.

3. Statistical support was provided to the Analytical Microbiology and Biomonitoring Section to study impacts of water reclamation plant effluents on levels and distribution of fecal coliform (FC) resistant to different antibiotics in the Chicago Waterway System.

4. Continuous support is being provided to the Biosolids Utilization and Soil Science Section to produce quarterly reports on biosolids management at the District's Biosolids Management Areas to meet IEPA permit requirements.

5. Statistical support and consulting was provided to the Biosolids Utilization and Soil Science Section on projects including the USX Demonstration Project and the St. David Coal Refuse Reclamation Project.

6. Statistical support was provided to the Biosolids Utilization and Soil Science Section for a research project on dioxin in land applied biosolids.

7. Continuous support is being provided to the Aquatic Ecology and Water Quality Section on the production of Continuous DO Monitoring Reports (Deep-Draft, and Wadeable) annually.

8. Statistical support and consulting was provided on data management, automation of reports, etc. to various sections in the Division.

9. Four Ambient Water Quality Monitoring Exceedance Reports were produced by this Section for the last quarter of 2005 and the first three quarters of 2006.

10. Numerous support was provided to clients who requested data and statistical analyses.

**Water Quality Data.** Each year, the Experimental Design and Statistical Evaluation Group summarizes results of the District's Ambient Water Quality Monitoring program for the Chicago Waterway System. In 2006, the surface water quality data for 2006 were evaluated regarding compliance with water quality standards set by the Illinois Pollution Control Board (IPCB). In 2006, 68 water quality parameters including biochemical oxygen demand; carbonaceous biochemical oxygen demand; dissolved oxygen; temperature; pH; alkalinity (total); chloride; turbidity; total kjeldahl nitrogen; ammonium nitrogen; unionized ammonia; organic nitrogen; nitrite plus nitrate nitrogen; total solids; total suspended solids; volatile suspended solids; total dissolved solids; sulfate; fats, oils, and greases; total phosphorus; total cyanide; weak acid dissociable cyanide; fluoride; total organic carbon; fecal coliform; escherichia coli; total calcium; total magnesium; hardness; gross alpha radioactivity; gross beta radioactivity; chlorophyll *a*; benzene; ethylbenzene; toluene; xylene; total silver; total arsenic; total barium; total boron; total cadmium; total copper; total chromium; total hexavalent chromium; total iron; total lead; total nickel; total manganese; total mercury; total zinc; total selenium; soluble calcium; soluble magnesium; soluble silver; soluble arsenic; soluble barium; soluble boron; soluble cadmium; soluble copper; soluble chromium; soluble iron; soluble lead; soluble nickel; soluble manganese; soluble mercury; soluble zinc; and soluble selenium were analyzed and reported in R&D Report No. 07-38.

*General Use Water.* In 2006, 31 water quality parameters had IPCB General Use standards. Benzene and total mercury had IPCB Human Health standards.

Twenty-one water quality parameters were in total compliance with the standards in all river systems. They were ammonium nitrogen, phenols, weak acid dissociable cyanide, gross beta radioactivity, benzene, ethylbenzene, toluene, xylene, total silver, total barium, total boron, total selenium, total arsenic, soluble cadmium, soluble copper, soluble chromium, soluble iron, soluble lead, soluble nickel, soluble mercury, and soluble zinc. Benzene had total compliance with the Human Health standard in all river systems. Eight of the remaining 10 parameters, viz., dissolved oxygen, temperature, pH, chloride, sulfate, fluoride, total hexavalent chromium, and total manganese had compliance rate greater than 86.5 percent in all river systems. Total dissolved solids had a compliance rate greater than 76.5 percent in all river systems. Fecal coliform had the lowest compliance rate, and it was in the range of 38.6 to 45.8 percent in the Chicago, Calumet, and the Des Plaines River Systems. The compliance rates of total mercury with respect to IPCB Human Health Standard were 70.6, 73.6, and 85.0 percent, respectively, in the Chicago, Calumet, and Des Plaines River Systems.

*Secondary Contact Water.* Twenty-three water quality parameters measured in the secondary contact waters during 2006 had applicable IPCB standards. Sixteen parameters were in complete compliance with the IPCB standards for the Chicago and the Calumet River Systems in 2006. They were temperature; phenols; fats, oils, and greases; total cyanide; fluoride; total silver; total arsenic; total barium; soluble cadmium; total copper; total hexavalent chromium; total nickel; total manganese; total zinc; total selenium; and total iron. The percent compliance of the remaining 7 parameters (dissolved oxygen, pH, un-ionized ammonia, total dissolved solids, total iron, total lead, and total mercury), which were not in total compliance in both the river systems varied from 94.2 percent to total compliance.

# WASTEWATER TREATMENT PROCESS RESEARCH SECTION

## WASTEWATER TREATMENT PROCESS RESEARCH SECTION

The Wastewater Treatment Process Research (WTPR) Section is responsible for conducting basic, applied, and problem solving research with regard to various wastewater and sludge treatment processes currently utilized by the District. Technical assistance is provided to the Maintenance and Operations (M&O) Department for solving water reclamation plant (WRP) operating problems. This Section also investigates innovative treatment processes for future use.

The work of the WTPR Section originates from several sources. Current operations may be investigated as the result of a WRP problem, or interest in arriving at new knowledge concerning certain aspects of a waste treatment process. Studies of future operations are concerned with maximizing the efficiency of an existing process at the lowest cost, or the development of new processes. Investigations may take the form of surveys, literature reviews, laboratory bench testing, pilot plant studies, full-scale testing, special analyses, or a combination or progression of any or all of the above. Plans and specifications are also reviewed at the request of the Engineering Department for the purpose of optimizing process design criteria.

In 2006, the Section was primarily concerned with studies relating to polymer testing, odor monitoring and control, sludge treatment technologies, oxygen transfer efficiency, ammonia loads to the Stickney WRP, and settling and chemical characteristics of combined sewer overflows. The Section also participated in the Stickney and Calumet WRP Master Plans and the operation of the Tunnel and Reservoir Plan (TARP) System. Studies initiated in 2006 included preliminary evaluation of ultraviolet disinfection, a study to quantify and compare volatile organic compound concentrations in discharges to TARP dropshafts that receive flow from predominantly residential sources versus flows from sources with substantial industrial sources, application of GPS-X model to evaluate Stickney and Kirie WRPs performance, and Unsteady Flow Water Quality Modeling for the Chicago Waterways. The main projects performed by the Section are summarized below.

### Polymer Testing Programs

During 2006, a comparison of winter and summer polymers used in the centrifugal dewatering of anaerobically digested sludge was carried out at the Stickney WRP. The testing is done because the sludge characteristics change during these seasons at this WRP.

### Odor Monitoring Programs

As part of the District's continuing odor surveillance program, the EM&R Division conducts odor monitoring at the Harlem Avenue Solids Management Area (HASMA), Vulcan, the Lawndale Avenue Solids Management Area (LASMA), Marathon Solids Drying Area (SDA), and Calumet SDAs. A similar odor monitoring program was initiated in the spring of 2001 at the Stony Island and the Ridgeland Avenue Solids Management Area (RASMA) SDAs. The programs are a part of the NPDES permits for the solids management areas. Odor monitoring is also conducted at the Calumet WRP, the John E. Egan WRP, the Stickney WRP, the James C. Kirie WRP, and the North Side WRP.

A similar protocol for monitoring odors is used at each location. Either R&D or M&O Department personnel visit the monitoring stations at each site on a regular basis. Frequency can range from once per week (as with the John E. Egan WRP), or daily (as with the Kirie WRP), depending on the program. The odor monitoring personnel make subjective observations regarding the character and intensity of odors at each of the stations. The odor intensities are ranked on a scale from 0, no odor, to 5, very strong odor. These data are tabulated monthly.

The objective of the program is to collect and maintain a database of odor levels within and around each WRP, and associated solids processing areas. The data are used to study the trends in odor levels associated with WRP operations, and to relate odor levels to changing conditions within the WRP, such as installation of odor control equipment.

Since several residential areas surround the WRPs in the program, the odor monitoring activities also provide early warning of odorous conditions that develop within the WRPs, to allow for corrective action before they become a nuisance to area residents.

**Odor Monitoring at the Calumet WRP and Calumet Solids Drying Areas.** The Calumet WRP odor monitoring program which was initiated in March 1992 is a cooperative effort of the R&D and M&O Departments. The Calumet odor monitoring program involves the daily visitation of 22 stations around the WRP and biosolids processing areas.

Tables II-1 and II-2 summarize the observations of easily noticeable, strong, and very strong odors made during 2006 in terms of frequency of occurrence for the Calumet WRP and the Calumet Drying Areas, respectively. The odors were at generally low levels in 2006, with only two very strong odors observed at the Calumet WRP, or 0.1% of all observations. There were no very strong odors observed at the Calumet Drying Areas. A few instances of strong odor were observed over the year, mainly at the sludge concentration building and preliminary tanks at the Calumet WRP. Easily noticeable odor observations varied between 12.6 and 34.2% of the monthly observations at the Calumet WRP and between 8.7 and 37% at the drying areas.

**Odor Monitoring at the Stickney WRP.** The Stickney WRP odor monitoring program initiated in May 1991 is a cooperative effort between the R&D and M&O Departments. Either R&D or M&O personnel visit each of the 19 established stations within and around the Stickney WRP on five days each week.

The 19 stations are located at treatment process operation sites where potentially odorous activities, such as sludge dewatering and anaerobic digestion, take place. Also included are locations along the perimeter of the WRP where odors might be detected by the public.

The percentage of visits at which easily noticeable, strong, and very strong odors were observed in 2006 are presented in Table II-3. Easily noticeable odors were observed less than 29% of the time during every month of the year. A single very strong odor was observed in the months of June and July. Strong odor observations varied from 0.7 to 5.7% of the total monthly observations throughout the year.

**Odor Monitoring at the HASMA, Vulcan, and Marathon Solids Drying Areas and the LASMA Solids Processing Area.** This odor monitoring program was initiated in 1990. Anaerobically digested solids lagoon-aged for one and one-half years and/or centrifuge cake is dried on paved drying cells to a solids content greater than 60%. The solids drying process is enhanced by agitation using auger-equipped tractors. Experience has indicated that agitation is important for reducing odors during the operation.

R&D personnel visited 16 stations throughout the three solids drying areas (HASMA, Vulcan, and Marathon) and the lagoon area (LASMA) at least three times a week.

For each month, average odor intensity data from the 16 stations were calculated. Table II-4 summarizes the observations of odor monitoring personnel during 2006, presented as percentage of visits at which easily noticeable, strong, and very strong odors were observed. Easily noticeable odor observations ranged between 20 and 49% of the monthly visits during the year. The strong odor observations ranged between zero and 2.5% of the monthly observations. There were only six very strong odor observations out of 2,364 total yearly observations.

**Odor Monitoring at the RASMA Solids Drying Area.** The odor monitoring program at the Ridgeland Solids Management Area was started in May of 2001. R&D Department personnel visit four stations located around the boundary of the drying cells one to two days per week.

A monthly summary of the observations of easily noticeable, strong, and very strong odors made during 2006 is presented in Table II-5 expressed as frequency of occurrence. No very strong or strong odors were observed. Easily noticeable odors were detected between 0 and 41.7% of the time, with the highest frequency in September 2006.

**Odor Monitoring at the Stony Island Solids Drying Area.** The odor monitoring program at the Stony Island Solids Management Area was started in June of 2001. R&D Department personnel visit four stations located around the boundary of the drying cells at least once per week.

Table II-6 summarizes the observations of easily noticeable, strong, and very strong odors made during 2006 in terms of frequency of observation. There were no very strong odor observations. Strong odors were only observed in August, September, and December, and varied between 2.8 and 3.6% of total monthly observations during those months.

**Odor Monitoring at the John E. Egan WRP.** The John E. Egan WRP odor monitoring program, initiated in October 1993, is also a joint effort between the R&D and M&O Departments. Seven stations within the WRP boundaries are visited at least once a week by R&D personnel. For each month, average odor intensity data from the seven stations were calculated. The percentage of observations at which easily noticeable, strong, and very strong odors were observed during 2006 is presented in Table II-7. Odor of an easily noticeable intensity was observed from 8.6 to 41.4% of the monthly observations made at the John E. Egan WRP. No very strong odors were observed in 2006, and only one strong odor was observed in October and November of 2007.

**Odor Monitoring at the James C. Kirie WRP.** The James C. Kirie WRP odor monitoring program is a joint effort between the R&D and M&O Departments, and was initiated in September 1996. The program includes monitoring of 15 locations within the WRP boundaries and two locations in the nearby community. R&D Department personnel monitor once a week, and during the summer months M&O Department personnel monitor three times a day, seven days a week.

Table II-8 summarizes the observations of odor monitoring personnel during 2006. There were no very strong odors and only two strong odor total observations. Easily noticeable odors were detected in less than 3.5% of the observations during the summer months, when odor observations are made around the clock.

**Odor Monitoring at the North Side WRP.** The North Side WRP is located in close proximity to residences and several light industrial facilities. There is little buffer between the WRP, residences, and industrial facilities, particularly along the Howard Street boundary of the WRP.

R&D personnel visited 13 stations within and around the WRP boundaries at least once a week. Table II-9 summarizes the monthly observations of odor monitoring personnel in 2006. No very strong odors were observed during the year, and some strong odors were observed in July through November 2006. The easily noticeable odors ranged from 20 to 44% of the monthly observations.

**Estimation of Emission of Hazardous Air Pollutants (HAPs)**

Under Section 112 of Title I of the Clean Air Act, a publicly owned treatment works (POTW) is considered a major source of HAPs if it emits or has the potential to emit 10 tons per year or more of any HAP or 25 tons per year or more of any combination of HAPs.

Samples of the influent sewage to each of the District's WRPs are collected twice a year and analyzed by the Organic Chemical Analytical Laboratory for 65 of the HAP compounds of concern to POTWs. Estimates of the emissions of these HAPs from the wastewater treatment process units (grit chamber, primary settling tanks, aeration tanks, and secondary settling tanks) are made using the Bay Area Sewage Toxics Emissions (BASTE) computer model developed by CH2M Hill. The average concentration of each HAP detected in the influent sewage was used as an input to the model along with the annual average operating conditions. The physical properties of the individual compounds were taken from the United States Environmental Protection Agency (USEPA) database.

During 2006, influent samples were collected in February and July. The average influent concentrations found are presented in Table II-10 for the three major District WRPs. The estimated emissions of individual HAPs for the three major District WRPs are summarized in Table II-11.

According to the BASTE model, all of the individual HAP emissions were less than the 10 tons/year criterion. Toluene was the predominant compound emitted from the wastewater treatment processes at the Stickney and Calumet WRPs. The HAP emissions from the North Side WRP were very low, all less than 0.57 ton/yr. The total measured HAP emissions were substantially less than the 25 ton/year threshold at each of the three WRPs. The wastewater treatment process units at the District's WRPs are not a major source of HAPs.

**Phosphate Detergents**

In view of pending requirements for the removal of phosphorus from WRP effluents, the District has supported a bill introduced in the Illinois General Assembly by the Illinois Association of Wastewater Agencies. This legislation is to limit phosphorus in automatic dishwasher detergents (ADWDs) and other cleaning products used in business and homes. It has been estimated that phosphorus loading due to ADWDs District-wide accounts for 6.2% of the total phosphorus (TP) load to all the District's WRPs. Discussions with the Soap and Detergent Manufacturers' Association regarding the proposed ban were initiated in 2006.

**Characterization of Solids in Primary Effluent at Calumet and Stickney WRPs**

At the request of the Engineering Department, laboratory-scale settling tests were conducted to determine the settleable solids portion and bulk settling velocity of the influent to the primary settling tanks at the Calumet WRP. Samples were also submitted to the Illinois Institute of Technology for determination of the influent particle size distribution.

**UV Disinfection**

The Master Plan consultants recommended UV disinfection for all three major WRPs in anticipation of future NPDES permit requirements. The EM&R Division of the R&D Department compiled published and nonpublished literature on the applicability of UV disinfection at the District's WRPs. A survey of numerous wastewater treatment plants in North America was also conducted and information on maintenance and operation of various UV systems was obtained. A paper based on the study, "Survey of Large UV Installations," was accepted for publication for the Water Environment Federation Disinfection 2007 Conference.

A sampling program was carried out at six District WRPs (all but the Lemont WRP) for one year beginning in November 2005 to characterize the effluent with respect to the applicability of UV disinfection and evaluate whether filtration before UV disinfection would have any benefit.

In order to evaluate the impact of filtration on UV disinfection, plant effluent samples composited over a 24-hour period were collected biweekly during November 2005 through November 2006 and analysis of specific parameters such as carbonaceous oxygen demand (COD), UV transmittance, and inorganic chemistry was conducted. Grab samples of secondary effluent (at the Egan and Hanover Park WRPs only) and plant effluent were also collected on the same day as the composite samples for conducting microbiological analyses (total coliforms, *E. coli*, and fecal coliforms). The sampling of the Egan and Hanover Park WRPs was discontinued after the start of the chlorination season (May 1 through October 31). Both composite and grab samples were analyzed before and after laboratory-scale filtration. The average results for the three major District WRPs are presented in <u>Tables II-12</u> and <u>II-13</u> for the Hanover Park and John E. Egan WRPs, respectively.

The effluent characterization of microbiological and physicochemical parameters indicated that all District plant effluents would be suitable for UV disinfection. Neither laboratory-scale nor full-scale filtration significantly improved the UV transmittance.

In cooperation with the Engineering and M&O Departments, a pilot-scale study at the Hanover Park WRP is planned for 2007 to compare side by side various UV systems available in the market.

**Potential Effects of Ferric Chloride Addition for Phosphorus Removal on GBT Performance at Egan WRP**

During the course of a six-month full-scale study conducted in 2005 at the Egan WRP as part of Water Environment Research Foundation (WERF) Project No. 02-CTS-1 (Technologies to Achieve Low Nitrogen and Phosphorus Effluents), approximately 30 to 45 mg/L of ferric chloride ($FeCl_3$) was applied to mixed liquor (mL) to achieve low levels of phosphorus as a part of a nutrient removal strategy. The waste activated sludge (WAS) subsequently accumulated $FeCl_3$ over the experimental period. The M&O Department staff at the Egan WRP observed poor performance of the gravity belt thickener (GBT) during the experimental period and related it to the $FeCl_3$ application.

In anticipation of an analogous long-term phosphorus removal study to be conducted at the Egan WRP during 2007, the Egan M&O Department staff were concerned about the potential for similar poor performance of the GBTs. In addition, the Engineering Department is concerned about the influence of $FeCl_3$ on the thickening of WAS by the GBTs. These concerns have been raised in light of GBTs being designed for both the Stickney and Calumet WRPs in which $FeCl_3$ may be used for phosphorus removal.

With a view to verifying the likely interference of $FeCl_3$ with GBT performance, laboratory filtration experiments on WAS were conducted. The results suggested that the application of $FeCl_3$ during the WERF study at the Egan WRP may have negatively influenced the performance of the GBTs as the operators suspected.

A full-scale monitoring program is planned to verify the laboratory test results during the 2007 phosphorus removal study at the Egan WRP.

**Synergistic Inhibitory Effects of Heavy Metals Mixture on Activated Sludge Nitrification**

The Calumet WRP experienced inhibited nitrification during April 2005. The nitrification-inhibiting substance(s) responsible for the interference could not be identified based on our intensive analytical and investigative efforts. Analytes such as cyanide, phenol, influent ammonia, heavy metals, and other various organic pollutants were not found at high enough levels to cause such an upset. This left the possibility that a mixture of heavy metals, a metal cocktail (MC), may have exerted a synergistically inhibitive effect on the nitrifying activated sludge process.

A literature review did not reveal any study that specifically addressed synergism of heavy metals on the nitrification process. Several studies with a wide range of experiments using combinations of metals with respect to nitrification inhibition showed mixed results.

Laboratory-scale tests were conducted during 2006 to evaluate the possible effects of various combinations of heavy metals on nitrification. The heavy metals of concern based on analysis of data in the Calumet WRP upset were cadmium (Cd), hexavalent chromium ($Cr^{+6}$), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn). Ten treatments, consisting of a control, six with individual metals, and three with different combinations of metals were prepared by adding metals to the collected ML sample as summarized in Table II-14. Each of the six individual metals was added at a concentration of 10 ppm. The Calumet MC treatment (Treatment 8) was prepared to replicate the heavy metal concentrations observed during the Calumet WRP upset. This is the most dilute treatment of the MC treatments (total metal concentration of 2.0 ppm) while MC5 treatment is the strongest treatment with a total metal concentration of 30 ppm. The MC1.67 treatment had a combined metal concentration of 10 ppm. These treatments were investigated on ten separate days with freshly collected ML. The salt addition in the solutions contributed less than 0.25% of the total volume of the treated ML and therefore did not dilute the ML. For each treatment, three samples were analyzed with three different contact times: at or very close to the time the metal solutions were added, and 2 hours and 6 hours after the metal solutions were added.

Each of the three treated ML samples ($T$ = 0, 2, and 6 hrs) were tested for nitrification rates. Approximately 2000 mL of sample were added to a 4000-mL beaker. One end of tygon tubing was attached to an air spigot while the open end was centered at the bottom of the vessel. Air was bubbled at a constant pressure for two minutes to provide aeration and adequate mixing of the ML. The airflow was then stopped, and three samples were withdrawn, 80 mL, 80 mL, and 100 mL for pH, $NH_3$, and $NO_3^-$ analysis, respectively. The tygon tubing was immediately placed back in the vessel, and the treated ML was aerated for another 22 minutes, and again the three aliquots were taken for pH, $NH_3$, and $NO_3^-$ analysis. Nitrification rates were determined as ammonia depletion in the primary analysis and as nitrate production as a corroborative analysis. In addition, each of the ML samples ($T$ = 0, 2, and 6 hrs) was also subjected to oxygen uptake rate (OUR) tests to determine microbial respiration.

Based on the nitrification results of the individual metal treatments, the order of metal inhibition is as follows: Cr > Ni > Cu > Pb > Cd > Zn. The order of inhibition for the MC treatments is MC5 > MC1.67 > Cal MC. This trend is reasonable since inhibition should increase with increasing heavy metal concentrations. Figures II-1a and 1b present total metal concentrations of the MCs vs. their respective $NR_{NO3}$ and $NR_{NH3}$ rates. Figure II-1a shows a linear trend, while Figure II-1b shows an exponential trend. The linear trend may reflect an additive effect, whereas the exponential trend may reflect a synergistic effect. It appears that an additive effect may be occurring considering $NR_{NO3}$, but a synergistic effect is observed considering $NR_{NH3}$ rates. It is not clear, however, that what R&D interpret as synergy of heavy metals is indeed occurring or apparent synergy is attributed due to increase in total metal concentrations. Based on the test results, it is very difficult to distinguish the impact on nitrification caused due to synergism of metals and increase in total metal concentrations.

Based on the SOUR results of the individual metals, the order of metal inhibition is as follows: Cr > Ni > Cu > Cd > Pb > Zn. This is the same trend observed with the nitrification analysis with the exception of the Cd and Pb placement. Based on nitrification rates, Cd was found to be less inhibitory than Pb. The order of increasing inhibition for the MC treatments is: Cal MC < MC1.67 < MC5. This is the same trend observed with the nitrification analysis. Thus, nitrification rates determined in this study corroborate OURs/SOURs. However, in order to qualify our findings SOUR results within 15% of the control value are not considered significantly different from the control. Percent difference in SOUR from Control varied from 11.8 to -55.3%. Based on this study, the treatments can be grouped according to their inhibitory effect on SOUR: 1) Cr and MC5 had a severe effect; 2) Ni, Cu, and Cd had a medium effect; and 3) Pb, Zn, Cal MC, and MC1.67 had a negligible effect.

Figure II-2 shows the total metal concentrations of the MCs vs. their respective SOURs. The linear trend line fit to the data reflects more of an additive effect. Much like nitrification analysis, while an additive effect may be occurring, there is no clear synergistic effect caused by the MCs reflected in the oxygen uptake.

A report on this study will be prepared in 2007.

**Siloxanes in Digester Gas at the Stickney WRP**

The Research and Development (R&D) Department has conducted a study to determine the concentration of siloxane in digester gas. The study included a series of sampling events of the digester gas line at three different locations in the Stickney Water Reclamation Plant (WRP), and contracted an outside laboratory to run the analysis for a series of siloxanes. The studies were requested by Stickney Master Plan Project Consultants (Black and Veatch [BV] and Greeley and Hansen [GH]) to evaluate the need for systems to remove the siloxanes from the digester gas line, because the Stickney Master Plan consultants detected siloxanes in their cursory investigation of the siloxane content of Stickney WRP digester gas.

The sampling technique employed to collect siloxane included passing the digester gas at a prescribed flow rate (112 mL/min) through a pair of methanol filled vials connected to two midget impingers (A and B) in accordance with the procedure provided by Air Toxics Ltd., Folsom, California. The impingers were immersed in an ice bath and the siloxane in the digester gas was absorbed in the chilled methanol. Each sample was collected over a 3-hr period. The samples were shipped overnight to Air Toxics Ltd for analysis of five siloxanes (D4, D5, D6, MM, and MDM).

The sampling for siloxane was conducted in the same locations as was used by the consultants (BV and GH) in their initial study and initially included:

1. At the sludge gas compressor building on the compressor discharge header and upstream of the Sulfatreat units.

2. At the boiler building on the compressor discharge header and downstream of the Sulfatreat units.

3. Upon initial evaluation of the results, a third location of the discharge at the outlet of the Sulfatreat unit was added in June 2006.

Sampling for this study was conducted from December 2005 through December 2006. The sampling included 14 events and a total of 58 samples. Sampling of the digester gas was conducted once a month for 11 months except for three months in which the samples were collected twice.

Fourteen sampling events were completed from December 2005 through December 2006, and the results of analysis are tabulated in Table II-15. Only D4 and D5 were detected. The results show wide variations in concentration and on a number of occasions show an increase in concentration in the boiler room downstream of the Sulfatreat system samples as compared to the samples at the compressor room. Also, alternating the sampling time from AM to PM (Table II-15) did not affect the general trend in siloxane concentrations between the compressor room and boiler room.

The range of measured concentrations for D4 was 1,500 and 3,500 $\mu g/m^3$ in the compressor room gas, and 1,600 and 7,700 $\mu g/m^3$ in the boiler room gas. D4 was not detected in 56% of the compressor room and boiler room gas samples. D5 was observed in the boiler room gas and at the outlet of the Sulfatreat system but not in the compressor room gas. The lowest and highest measured concentrations for boiler room gas were 1,300 and 5,500 $\mu g/m^3$, and 4,200 and 5,000 $\mu g/m^3$ at the outlet of the Sulfatreat system. The occurrence of nondetectable D5 in the digester gas at the boiler and at the outlet of the Sulfatreat system was 67%.

## Calumet WRP and North Side WRP Master Plans

The District hired consulting firms to conduct studies on future infrastructure and process needs for the Calumet and North Side WRPs. These studies are referred to as the Calumet Master Plan Study and the North Side Master Plan Study. The WTPR Section involvement included attending workshops conducted by the consultant teams to discuss and evaluate the alternatives for improving and updating the infrastructure and process facilities of these WRPs to meet future needs. Also, the WTPR Section coordinated sample collection and analysis to provide any requested data to aid the consultants. Another major task of each project was to review and provide comments on the documents generated by the consultant teams.

The Calumet WRP Master Plan Study has been completed. Two workshops were attended and two documents from the study were reviewed in 2006.

The North Side WRP Master Plan Study consists of assessing the future infrastructure and process needs for the North Side WRP, which is called the North Side Master Plan (NSMP), and evaluating water quality improvement alternatives for the Chicago Area Waterway System (CAWS), which is called Water Quality Study (WQS). The details of the North Side Master Plan Study were described in the 2005 R&D annual report. In 2006, the major task was to review the documents generated by the consultant team, check the accuracy and suitability of documents pertinent to the study, and to make comments on the documents for improving the quality of the report. Seventeen reports generated by the consultant team for the North Side Master Plan project were reviewed. Eight of the 17 reports were for the NSMP, assessing the future infrastructure and process needs for the North Side WRP. Six of the 17 reports were for the WQS, evaluating the alternatives proposed by a Use Attainability Analysis (UAA) for the CAWS by the Illinois Environmental Protection Agency (IEPA), for improving water quality in the CAWS. Three of the 17 reports were CDRs, describing the design basis for future infrastructure upgrades for meeting the process needs under the projected future conditions.

**Additional Digestion Tests for Calumet and John E. Egan Water Reclamation Plants**

This project was to determine whether the requirements for vector attraction reduction could be met through anaerobic digestion of biosolids at any District Water Reclamation Plant (WRP), using Option 2 of Section 503.33(b) of the 40 CFR Part 503 Regulation. Option 2 states that vector attraction reduction is demonstrated if after anaerobic digestion of the biosolids, the volatile solids in the biosolids are reduced by less than 17% in an additional 40 days bench-scale anaerobic digestion at a temperature between 30° and 37°C. The main reason for employing this option and conducting additional bench-scale laboratory anaerobic digestion tests is that volatile solids reduction of 38% may not be achieved occasionally at a District WRP.

In 2006, conducting additional anaerobic digestion tests was a routine monitoring program by the WTPR Section. These tests were conducted in the R&D WTPR laboratory at the Lue-Hing Research and Development Complex. The test procedure proposed in Appendix D of the White House Document by the United States Environmental Protection Agency (USEPA) (EPA/625/R-92/013, Revised October 1999) was generally followed in each test.

A total of 16 tests were conducted in 2006. Fourteen of the 16 tests were conducted for the Calumet WRP as a part of its routine monitoring program for the biosolids. One test was conducted each month except for May and August, in which two tests were conducted. The total and volatile solids contents of the Calumet digester draw samples from its second step digesters, which were used in the 14 additional digestion tests, ranged from 1.95 to 3.28% with an average of 2.54% and from 43.5 to 61.6% with an average of 51.4%, respectively (Table II-16). These values were comparable to the plant monitoring values for the digester draw, which are presented in Table II-

17. This indicated that the digester draw samples collected for the additional digestion tests could represent well the normal digester draw at the plant.

The 40-day additional volatile solids reduction from the 14 additional digestion tests conducted for the Calumet WRP in 2006 is presented in Table II-16. The volatile solids reduction through an addition digestion test was calculated using both Van Kleeck equation and mass balance method in the table, and the Van Kleeck equation method is recommended by the USEPA. As can be seen in Table II-17, of the 14 tests conducted in 2006, the additional volatile solids reduction in 13 tests was less than 17%. The only test, in which the additional volatile solids reduction was slightly greater than 17%, were conducted in August of 2006. However, two tests were conducted in August 2006 and the average of the two test results was below 17%. According to the USEPA guidance document, the monthly average value could be used for compliance check (EPA/625/R-92/013, Revised October 1999).

Two of the 16 tests in 2006 were conducted for the John E. Egan (Egan) WRP upon a request from the Egan Maintenance and Operations (M&O) staff for evaluating the compliance with the vector attraction reduction requirements in October 2006. The test results are listed in Table II-18. As can be seen, the additional volatile solids reduction was less than 17% in either test. Therefore, the vector attraction reduction requirements were satisfied for the biosolids generated at the Egan WRP in October 2006.

## Unsteady Flow Water Quality Modeling for the CAWS

An unsteady flow water quality model for the CAWS was developed by Marquette University to simulate various scenarios related to the water quality concerns in the CAWS. The water quality model for the CAWS was built on the platform of Duflow Modeling Studio. The model was calibrated and verified using part of the 2001 and 2002 hydraulic and water quality monitoring data, respectively, and was delivered to the District in August 2005. In 2006, the water quality model was used to study the impact of gravity combined sewer overflow (CSO) discharges and various options of discretionary lake diversion at three locations on the water quality, particularly dissolved oxygen (DO) concentrations, in the CAWS. The water quality model was also updated using 2005 hydraulic data.

**Impact of Gravity CSOs.** There are approximately 240 gravity CSO outfalls along to the CAWS. In order for the model to properly handle the gravity CSOs, these gravity CSO outfalls were consolidated into 28 representative locations in the development of the Water Quality Model for the CAWS. Table II-19 summarizes the numbers of representative gravity CSO discharge locations and the receiving stream reaches. The flow discharged at each of these 28 locations was calculated based on its portion of the total CSO drainage area and the total CSO discharge flow that was estimated from the flow balance for the entire system covered by the model.

The evaluation of the impact of eliminating gravity CSOs to the CAWS was made by performing simulations with the water quality model under two scenarios, Baseline and No Gravity CSOs. The first scenario, Baseline, was used to simulate the conditions that were represented by the calibrated (Year 2001) and verified (Year 2002) model. The original model was used in the simulation except for a portion of the downstream hydraulic boundary conditions that were converted from stage to discharge (flow). The second scenario, No Gravity CSOs, was used to simulate the conditions with no gravity CSOs discharging into the CAWS. This scenario used a modified downstream flow boundary condition, which was derived by subtracting the total gravity CSO flows from the flow at Romeoville at the corresponding times, and all 28 gravity CSO flows were eliminated by setting the flow to zero at each gravity CSO location in the model. In practice, the captured CSOs are stored in reservoirs and are eventually returned to the CAWS after full secondary treatment at the Calumet and Stickney WRPs. However, since it is not yet known when the captured and stored CSOs would be returned to the CAWS, this returned flow was not being accounted for in this modeling exercise.

Model simulations were separately performed for two simulation periods from July 12 to November 9 of 2001 and from May 1 to September 23 of 2002. During the simulations, all other parameters, boundary and initial conditions, input waste loadings from CSO pumping stations and four WRPs discharging to the CAWS, and oxygen loadings from the two existing instream aeration stations and four SEPA stations, remained unchanged. The date of a gravity CSO occurrence, duration of each event, and mean flow and total discharge volume of each gravity CSO included in the 2001 and 2002 models are listed in Tables II-20 and II-21, respectively.

From each simulation run, simulated hourly DO concentrations at 37 locations along the CAWS were retrieved and examined. At each location, number and percent of DO concentrations greater than 4, 5 and 6 mg/L, respectively, during a given simulation period for each scenario were calculated. Figure II-3 shows an example of the calculation results. A brief summary report including all the calculation results was prepared in 2006 and will be included in a future R&D report in 2007 or 2008.

The impact of eliminating gravity CSOs on DO concentrations in the CAWS was evaluated by comparing the percent of DO concentrations greater than the same target value, such as 5 mg/L, between the two scenarios for the same simulation period. For example, the numbers of simulated hourly DO concentrations greater than 4, 5 and 6 mg/L at Oakton Street on the NSC upstream of the North Side WRP increase from 759, 284 and 48 to 2,262, 1,046 and 409, respectively, in the simulation period of July 12 to November 9, 2001, after eliminating gravity CSOs. The simulation results indicated that a significant increase in DO concentrations could take place at this location after the two representative gravity CSOs in the Upper NSC (UNSC) were eliminated.

In summary, the results obtained through the model simulations under two different scenarios revealed that eliminating gravity CSOs could increase stream DO concentrations in the entire CAWS at different degrees under the summer conditions in 2001 and 2002. The DO increase due to the elimination of gravity CSOs was most significant in the UNSC, in which the stream flow was dominated by gravity CSOs. The impact of eliminating gravity CSOs on stream DO concentrations was the least in the Calumet-Sag Channel (CSC), likely due to the relatively high DO concentrations under the Baseline conditions, the operation of SEPA stations, dilution by the tributary flows, the large resident volume of water in the CSC and relatively diluted CSOs. Gravity CSOs had a prolonged impact on stream DO concentrations in the CAWS after a large storm. Such impact could last up to a few weeks at some locations.

**Evaluation of Discretionary Lake Diversion.** To improve the water quality in CAWS, good quality lake water from Lake Michigan is purposely diverted, particularly in the summer times, into the CAWS at three different locations. These locations are Wilmette Lock (Wilmette) on the NSC, Chicago River Control Works (CRCW) on the Chicago River and O'Brien Lock and Dam (O'Brien L&D) on the Calumet River. Lake water is also introduced into the Chicago River and the Calumet River through lockage for boat traffic between the rivers and the lake and through occasional navigational makeup after pre-storm drawdown for potential storm runoff conveyance. However, the diversion of lake water is limited by the Supreme Court Order for the conservation of Lake Michigan Water.

To evaluate the options of effectively using the limited discretionary lake diversion water to improve DO concentrations in the CAWS, the water quality model for the CAWS developed by Marquette University using Duflow Modeling Studio software was used. Although Wilmette, CRCW and O'Brien L&D were used as the upstream boundaries to set up the physical network of the model, the boundary conditions (model input data) at these locations were defined using the data collected at the USGS gage stations on the channel and the rivers inside the corresponding locks. Furthermore, in the calibrated and verified models, surface water elevations were used at CRCW and O'Brien L&D as the hydraulic boundaries conditions. Inflows from Lake Michigan at these boundaries were not readily quantified. Therefore, the calibrated and verified models (original models) have to be modified in order to simulate various scenarios of using different discretionary lake diversion flows at the three locations.

In 2006, the flow data at the three upstream boundaries were collected and the corresponding model input data files were prepared. The upstream hydraulic boundary conditions of the water quality model were modified. Simulations were performed with the modified upstream boundary conditions to test the model. The model was prepared for scenarios simulation in 2007.

**Water Quality Model with 2005 Hydraulic Data.** Hydraulic data, including flows and water surface elevations at the upstream and downstream boundaries and flows at all the inflow locations in the water quality model for the CAWS, were collected for the time period of May 1 to October 31, 2005 in order to develop a 2005 water quality model. The sources of the data are the USGS and the M&O Department of the District. The data collected were screened and model input files using the data were prepared. The preliminary hydraulic simulation of the model with the 2005 input data was successful. In the future, the model will be further adjusted for overall hydraulic balance and water quality input data will also be added to complete the water quality model for 2005.

## Chemical Phosphorus Removal at the Egan WRP

For the Salt Creek Phosphorus Reduction Demonstration Project, the phosphorus (P) concentrations in the final effluent of the Egan WRP need to be reduced to about 0.5 mg/L as total phosphorus (TP). Chemical precipitation of P with ferric chloride ($FeCl_3$) was selected for removing P at the Egan WRP. $FeCl_3$ is added into the ML at the end of aeration tanks and P is removed from the wastewater by precipitating the ferric phosphate in the secondary clarifiers. The $FeCl_3$

dosing system was designed by the Engineering Department and constructed by IHC in 2005 and 2006.

In 2006, the construction of the $FeCl_3$ dosing system was complete. However, even flow distribution between the two batteries was a problem. The WTPR Section assisted the Engineering Department and IHC in testing the $FeCl_3$ dosing system and solving the flow distribution problem. Also the WTPR Section developed monitoring programs to assist M&O to ensure smooth plant operation and collecting information on dosing requirement and chemical sludge production during the chemical P removal study.

### Settleability Tests for District WRPs

To collect data on settling characteristics of ML at the District WRPs, settling tests with the ML samples from aeration tanks of the District WRPs were performed in a 6-foot column in the pilot plant room of the R&D WTPR laboratory. The 6-foot settling column is equipped with a bar mixer that turns at about 1 rpm (revolution per minute) and a recirculation pump that can generate upwards velocities ranging from 50 to 400 fpd (feet per day). The dynamic conditions in a secondary clarifier can be simulated in the settling column and interfacial settling velocities, which are a more useful parameter for process control and modeling, can be measured. The test procedure was briefly described in the 2005 R&D annual report.

In 2006, 12 tests were conducted for the ML samples from the Hanover Park, Egan, Kirie, Stickney, and North Side WRPs. For the settling test, ML samples from different batteries or tanks of a plant were collected under dry weather conditions. For each aeration battery or tank tested, duplicate tests were normally performed on two separate days. The settling tests will continue in the future as a tool to characterize ML settling under various conditions.

### Tunnel and Reservoir Plan Groundwater Study

The District's TARP Groundwater Monitoring Program was implemented in 1976 to assess the impact on groundwater quality and quantity due to operating the TARP tunnels. The TARP tunnels were constructed from 100 to 350 feet underground and function as a part of a region-wide pollution and flood control system, capturing and temporarily storing CSOs. The CSOs are a mixture of raw sewage and storm runoff and are subsequently treated at District WRPs.

During normal dry weather conditions, a small amount of groundwater infiltrates the tunnels due to a naturally higher pressure gradient favoring the groundwater table. During a major storm the tunnels may become full of CSOs, producing an internal pressure that causes exfiltration of small amounts of CSOs into the surrounding groundwater. After the storm subsides and the tunnel has been dewatered, infiltration occurs and small amounts of the surrounding groundwater are drawn into the tunnel. Groundwater monitoring wells have been installed to verify the infiltration/exfiltration process, which may occur in strategic locations of the TARP tunnel operation and verify that the TARP system is not adversely affecting the local groundwater.

The TARP groundwater monitoring program currently includes 128 monitoring wells and 34 observation wells in the Calumet, Mainstream, Des Plaines, Upper Des Plaines, and Chicagoland Underflow Plan (CUP) Reservoir systems anchoring the Upper Des Plaines and Calumet TARP systems (Figure II-4). Of these 128 water quality monitoring wells, 120 are currently being monitored. The remaining wells (QM-51, QM-52, QM-54, QM-55, QM-57, QM-59, QM-60, and QC-8.1), are not required to be monitored. Four of the monitoring wells are located around the perimeter of the O'Hare Reservoir, which anchors the Upper Des Plaines (O'Hare) TARP system. Another four monitoring wells were added in 2002 to the perimeter of the Thornton Transitional Flood Control Reservoir, which anchors the Calumet TARP system.

The IEPA gave the District permission to monitor the water quality monitoring wells at the following frequency. Mainstream water quality wells QM-53, QM-56, QM-58, QM-61, QM-66, QM-68 through QM-74, QM-76, QM-77, and QM-81 are monitored three times per year. The remaining Mainstream water quality wells (QM-62 through QM-65, QM-67, QM-75, QM-78 through QM-80, and QM-82) are monitored six times per year. Calumet water quality wells QC-2.1, QC-2.2, QC-3 through QC-7, and QC-9 through QC-28 are monitored three times per year. The remaining Calumet water quality wells (QC-1, QC-2, and QC-29 through QC-37) are monitored six times per year. Des Plaines water quality wells QD-21 through QD-26, QD-28 through QD-32, QD-35, QD-36, and QD-38 through QD-60 are monitored three times per year. The remaining Des Plaines water quality wells (QD-27, QD-33, QD-34, and QD-37) are monitored six times per year. Upper Des Plaines water quality wells MW-2 through MW-6 are monitored six times per year. The remaining Upper Des Plaines water quality well, MW-1, is monitored three times per year. The O'Hare CUP Reservoir is sampled four times per year. The TARP System observation wells along the Mainstream TARP System are sampled once every two months, and those along the Calumet TARP System are sampled once every two weeks.

The water quality wells are sampled for the following parameters: ammonia nitrogen ($NH_3$-N), chloride, electrical conductivity, fecal coliform bacteria, hardness, pH, sulfate, total organic carbon, and total dissolved solids. Water level elevation is measured at all TARP wells. Data collected from the TARP wells are routinely submitted annually to the Illinois Environmental Protection Agency.

The overall results obtained from regularly monitoring and sampling TARP wells indicate that operation of TARP tunnels and reservoirs has had no adverse effect on local groundwater system.

**Pollutants Captured by TARP**

The EM&RD has been calculating the removal of certain pollutants including suspended solids (SS), both carbonaceous and nitrogenous oxygen-demanding substances, and flow of CSO by the TARP system.

The purpose of building the TARP system was to prevent CSOs from entering Lake Michigan and the CAWS. Calculating the pollution removal gives an indication how well TARP is protecting the CAWS. The pollutants captured by the TARP system would have otherwise been discharged into area waterways.

Tables II-22, II-23, and II-24 contain data pertaining to CSO volume captured, total SS and oxygen-demanding substances removed, respectively, by the TARP systems during the period of 1982 through 2006. As can be seen from these tables, during 2006 the Stickney WRP treated 34.52 billion gallons of CSO captured in the Stickney WRP TARP system, resulting in the removal of 82.63 million pounds of SS and 37.23 pounds of oxygen-demanding substances (both carbonaceous and nitrogenous). The Calumet WRP treated 24.31 billion gallons of CSO captured in the Calumet WRP TARP system, resulting in the removal of 33.65 million pounds of SS and 28.12 million pounds of oxygen-demanding substances (both carbonaceous and nitrogenous). The Kirie WRP diverted 2.54 billion gallons of CSO into the Kirie TARP system, resulting in the removal of 4.03 million pounds of SS and 5.32 million pounds of oxygen-demanding substances (both carbonaceous and nitrogenous).

Again referring to Tables II-22, II-23, and II-24, it can be seen that since TARP has gone on line a total of 885.08 billion gallons of CSO, 1.72 billion pounds of SS, and 916.57 million pounds of oxygen-demanding substances (both carbonaceous and nitrogenous) have been removed due to the TARP system which otherwise would have been discharged into the CAWS. Broken down by TARP system during 1982 through 2006, the Stickney WRP has treated a total of 589.30 billion gallons, the Calumet WRP has treated a total of 229.30 billion gallons, and the Kirie WRP has treated a total of 66.48 billion gallons of CSO. During the same period the Stickney WRP treated a total of 1.35 billion pounds of SS, the Calumet WRP treated 297.09 million pounds of SS, and the Kirie WRP has treated a total of 72.10 million pounds of suspended solids. Again during 1982 through 2006, the Stickney WRP has removed a total of 587.15 million pounds of oxygen-demanding substances, the Calumet WRP has removed 250.01 million pounds of oxygen-demanding substances and the Kirie WRP has removed a total of 79.41 million pounds of oxygen-demanding substances.

## Monitoring of the Thornton Transitional Flood Control Reservoir

**Introduction.** The purpose of this monitoring is to meet the reporting requirements of the IEPA relative to annual flood control utilization for the Thornton Transitional Flood Control Reservoir (Reservoir) for 2006. The specific informational requirements are described in the June 26, 2001, Scope of Work (SOW) for Groundwater Quality Monitoring of the reservoir. The SOW was approved in a letter from the IEPA dated August 6, 2001.

The reporting requirements are listed in Section 7 of the SOW. The requirements for the annual flood control utilization of the reservoir shall include:

1. The year’s monitoring wells sample analysis results.

2. Reservoir content grab sample results.

3. Detailed review and comparison of the monitoring well sampling analysis results, utilizing the monitoring well statistical background determination.

**Objective.** The objective of collecting groundwater samples from the four monitoring wells (QT-1 through QT-4) and reservoir content grab samples is to assess any possible contamination of the groundwater which may result from seepage from the reservoir during the fill event. The pertinent water quality parameters are listed in Table 2 of the SOW (Table II-25).

**Project Description.** The Thornton Reservoir is in the West Lobe of the Thornton Quarry, southeast of the intersection of the Tri State Tollway and Halsted Street in Thornton, Illinois (Figure II-5). The reservoir is the final structure constructed for the Little Calumet Watershed under the NRCS Little Calumet Watershed Plan of November, 1998. The reservoir will provide 3.1 billion gallons of floodwater storage which represents the capture of a 100 year storm event from Thorn Creek in the vicinity south of the Tri State Tollway.

**Field Sampling.** There were four fill events at the Thornton Reservoir during the year 2006, April 17, 2006, August 29, 2006, September 13, 2006, and December 1, 2006.

The first fill event began on April 17, 2006, and ended on April 19, 2006, resulting in 1.880 billion gallons (BG) of CSO being stored in the reservoir. The second fill event took place on August 29, 2006, and ended on August 30, 2006, resulting in 790 million gallons (MG) of CSO being stored in the reservoir. The third fill event began on September 13, 2006, and ended on September 14, 2006, resulting in 660 MG of CSO being stored in the reservoir. The fourth fill event took place on December 1, 2006, and ended on December 1, 2006, resulting in 442 MG of CSO being stored in the reservoir.

During these fill events in accordance with SOW, samples were collected from the four monitoring wells surrounding the reservoir and grab samples were taken from the reservoir.

**Discussion of Results.** During the April 17, 2006, fill event significant changes (upper confidence limit from the background sampling was exceeded) for the parameters listed in the IEPA's SOW were observed for the following wells: QT-1 chloride, sulfate, and nitrate nitrogen, QT-2 iron, sulfate, and manganese, QT-3 chloride and lead, and QT-4 cadmium and nitrate nitrogen. There were still some significant changes from the background values once the reservoir was dry on May 10, 2006: QT-1 chloride, QT-2 iron, sulfate, and manganese, QT-3 chloride and lead, and none were observed for QT-4.

During the August 29, 2006, and September 13, 2006, fill events significant changes (upper confidence limit from the background sampling was exceeded) for the parameters listed in the IEPA's SOW were observed for the following wells: QT-1 chloride and total dissolved solids (TDS), QT-2 iron, sulfate, TDS, and manganese, QT-3 chloride, mercury, and manganese, and QT-4 mercury and nitrate nitrogen. There were still some significant changes from the background values once the reservoir was dry on October 8, 2006: QT-1 chloride and TDS, QT-2 iron and manganese, QT-3 chloride and manganese, and none were observed for QT-4.

During the December 1, 2006, fill event significant changes (upper confidence limit from the background sampling was exceeded) for the parameters listed in the IEPA's SOW were observed for the following wells: QT-1 chloride, copper, and TDS, QT-2 showed no water quality exceedances from background concentrations, QT-3 chloride, and QT-4 showed no water quality exceedances from background concentrations. There were still some significant changes from the background values once the reservoir was dry on December 11, 2006: QT-1 chloride and TDS, QT-2 no water quality exceedances, QT-3 chloride, and none were observed for QT-4.

## Dynamic Model Development for the Stickney WRP Imhoff Tanks

**Introduction.** The development of the Imhoff tank computer model was undertaken to evaluate the Stickney WRP process during construction related to the Stickney Master Plan upgrades. The Stickney Master Plan calls for the replacement of the Imhoff tanks with new primary clarifiers.

The influent to the Stickney WRP is split between two main influent sources, the West Side influent and the Southwest influent. The Imhoff tanks handle the West Side influent, which is slightly over 50% of the total Stickney WRP flow. The West Side Imhoff tank effluent is combined with the Southwest primary clarifier effluent before secondary treatment.

The model was used to simulate the Imhoff tank effluent and the effect on the secondary process.

**Materials and Methods.** The Hydromantis Inc. GPS-X 5.0 software was used for the computer simulation. The Imhoff tanks are rectangular and are divided into three compartments as shown in Figure II-6:

1. The upper section or sedimentation compartment.

2. The lower section known as the digestion compartment.

3. The last section is the gas vent and scum section.

The direction of flow into the Imhoff tanks is reversed to prevent excessive deposition of solids at one end of the sedimentation compartment. Periodically reversing the flow results in an even sludge accumulation across the bottom of the tank. In operation, all of the wastewater flows through the upper compartment. Solids settle to the bottom of the sloped compartment, slide down and pass through a slot to the digestion compartment. One of the bottom slopes extends beyond the slot. This forms a trap to prevent gas or digesting sludge particles in the lower section from entering the waste stream in the upper section. The gas and any rising sludge particles are diverted to the gas vent and scum section.

The GPS-X software does not provide an Imhoff tank process object. To model Imhoff tank operations, a combination of primary clarifier, anaerobic digester, and a dewatering unit was configured in the model to simulate the Imhoff tank operation. The model was then calibrated allowing for the differences between the basic unit processes and the Imhoff tank characteristics.

*Layout.* The Imhoff tank process train consists of three batteries in parallel, each battery with 36 tanks, 80 feet long. Two of the batteries are identical, Battery A and Battery B. The top compartments of each tank in Batteries A and B are 34.16 feet wide with a depth of 13.46 feet, surface area of 196,308 square feet. Battery C is 26.33 feet wide and 10.54 feet deep, surface area of 150,720 square feet. The top compartment was modeled using a GPS-X object for a rectangular one-dimensional primary clarifier. The Imhoff tank surface areas were used for the primary clarifier model.

The lower compartment and gas vent volume is 123,056.62 cubic feet for each tank in Batteries A and B. The Battery C tank volume is 166,807.35 cubic feet. The anaerobic compartment was modeled using GPS-X module for digesters. The volume was used as the digester design parameter.

The daily model output for the Imhoff effluent data combined with 2005 daily Southwest primary effluent data was used as the input for a dynamic simulation of the secondary treatment process for the Stickney WRP.

*Historical Data.* Historical operations data was obtained from M&O for 2005. The average annual flow into each Imhoff battery was 103, 86, and 146 MGD for Batteries A, B, and C, respectively. Battery A had one tank out of service for the entire year. The other batteries had all 36 tanks in service. The flow into Batteries A and B was not reversed during 2005. The flow into Battery C was reversed approximately every two weeks. The sludge drawn off all three batteries had an average daily volume of 553 cubic yards and an average daily weight of 24 dry tons.

Historical analytical data was obtained from the laboratory information management system database. The 2005 daily West Side influent analytical data was used for the influent into the Imhoff tank GPS X model. The West Side flow, SS concentration, TP concentration, total Kjeldahl nitrogen (TKN) concentration and the five-day carbonaceous biological oxygen demand ($CBOD_5$) concentration were used.

The Imhoff tank effluent model output was compared to the actual 2005 daily analytical data from the Imhoff tanks. The parameters used were SS, TKN, TP and $BOD_5$ concentration. The $CBOD_5$:$BOD_5$ ratio determined from the influent data was used to compare the model output as $CBOD_5$ with the actual data as $BOD_5$.

The Southwest 2005 daily influent flow, $CBOD_5$, and $BOD_5$ were used along with the 2005 Southwest primary effluent concentrations of SS, TKN, and $BOD_5$ to set up the model input for secondary treatment evaluation. The 2005 daily Stickney WRP final effluent was compared to the secondary treatment model output.

The P load in the sludge was used along with the influent and effluent data to perform a mass balance, as a check on the reliability of the operational and analytical data used as inputs.

*Special Sampling for Wastewater Characterization.* The routine plant sampling was used where possible, West Side influent and Imhoff effluent. Additional sampling and analysis was needed to characterize the wastewater into and out of the Imhoff tanks. Twenty-four hour composite and diurnal grab samples were analyzed. The composite samples were collected over 14 consecutive days, beginning August 14, 2006.

The West Side influent composite special samples were analyzed for 21-day biological oxygen demand, total chemical oxygen demand (COD), glass filtered COD, flocculated and filtered COD, glass filtered TKN, flocculated and filtered TKN, glass filtered P, and flocculated and filtered P.

The effluent weir composite samples of Batteries A and B were analyzed for $BOD_5$, pH, SS, and $NH_3$-N. The COD, TKN, and P were analyzed for total concentration, concentration after glass filtration, and concentration after flocculation and filtering.

The Imhoff effluent composite samples were also analyzed for COD, TKN, and P. The analyses were for total concentration, concentration after glass filtration, and concentration after flocculation and filtering.

Diurnal grab samples were collected at the West Side influent, the combined Imhoff effluent and at the effluent weirs of two of the Imhoff batteries. The diurnal samples were collected bi-hourly over a 24-hour period. There were three dry days and three wet days of diurnal sampling. Wet weather is defined as a rain event greater than 0.1 inch.

*Dynamic Calibration and Verification.* The dynamic calibration was undertaken based on the Hydromantis Inc. recommendations. The wastewater characterization based on the two week sampling schedule was evaluated and adjusted with the Influent Advisor Tool provided with GPS-X.

The dynamic calibration is based on the first sixty days of 2005. The West Side influent flow, $CBOD_5$, TKN, P, and SS were used as the dynamic input. There was at least one rain event during this time, January 12 and 13, 2006, both days had over 600 MGD.

The physical, operational and settling parameters were adjusted in the GPS-X model. The base model for the first sixty days of 2005 was tuned until the trends agreed with the daily plant data trends of the Imhoff effluent. The remainder of the daily 2005 data was used as a verification of the model.

**Results and Discussion.** The daily 2005 Imhoff effluent plant data was compared to the results from four computer simulations. The first simulation modeled the Imhoff tanks with Batteries A, B, and C in service. This is the baseline simulation which tracks the trends of the Imhoff effluent concentration data. Figure II-7 shows the suspended solids concentration trends of the baseline model compared to the daily 2005 Imhoff effluent concentration plant data. Similarly, Figure II-8 shows the $CBOD_5$ concentration trends of the baseline model compared to the daily 2005 Imhoff effluent plant data. The $CBOD_5$ concentration was used since it is the output in the GPS-X software. The daily Imhoff effluent $CBOD_5$ concentration plant value was calculated from daily Imhoff effluent $BOD_5$ concentration and the ratio of the daily West Side influent $CBOD_5$ concentration to the daily West Side influent $BOD_5$ concentration. Figures II-7 and II-8 show a good fit between the baseline and the actual data trends for the Imhoff effluent suspended solids and $CBOD_5$ concentrations.

The baseline simulation is a simplified representation of the Imhoff tank process. The baseline was developed with daily West Side influent flows ranging from 141 MGD to 603 MGD. The WERF “Wastewater Characterization and Activated Sludge Modeling” recommends dynamic modeling parameters should be matched within 10%; up to 40% for temporary deviations. In order to quantitatively evaluate the baseline model calibration, the data was divided into deciles. The decile representations, Figures II-9 and II-10, of the daily 2005 Imhoff plant data compared to the baseline model results are less than 10% difference on average. The baseline model suspended solids concentration values are within eight percent of the daily 2005 plant data and the baseline model $CBOD_5$ concentration values are within three percent of the daily 2005 plant data. The values closer to the median have the best fit between the baseline model and the observed values. The values at either extreme, the first and ninth deciles, have larger deviations between the model and the plant values.

Additional GPS-X simulations were run, decreasing the number of Imhoff batteries in service successively. Figures II-11 and II-12 show the changes in Imhoff effluent suspended solids and $CBOD_5$ concentrations, respectively, for simulations with two Imhoff batteries in service. The suspended solids concentrations and the $CBOD_5$ concentrations increase as the Imhoff batteries are taken out of service as expected.

The average suspended solids concentration and average $CBOD_5$ concentration for the 2005 daily plant data and the simulations are shown in Table II-26. Compared to the baseline model simulation, the average Imhoff effluent concentrations increased when Imhoff batteries were taken out of service. The suspended solids increase was 17%, 28%, and 57% when one, two or three Imhoff batteries were taken out of service, respectively. Similarly, the average increase in $CBOD_5$ concentrations was 4%, 21%, and 53%, when one, two or three Imhoff batteries were taken out of service, respectively.

Finally, the Imhoff effluent SS and $CBOD_5$ output concentrations from the model were used as inputs, along with the Stickney primary effluent concentrations, to the Stickney secondary treatment model. The secondary effluent concentrations from the model were compared to the Stickney final effluent SS and $CBOD_5$ concentrations. Imhoff model outputs from scenarios with one Imhoff battery out of service did not have a significant effect on the simulated final effluent concentrations compared to the simulation with three Imhoff batteries in service.

TABLE II-1: ODOR MONITORING AT THE CALUMET WRP—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 21.3 | 0.9 | 0.0 | 221 |
| February | 12.6 | 2.2 | 0.0 | 182 |
| March | 23.6 | 1.1 | 0.0 | 272 |
| April | 21.1 | 0.4 | 0.0 | 247 |
| May | 21.9 | 1.6 | 0.0 | 247 |
| June | 34.2 | 0.0 | 0.0 | 234 |
| July | 23.1 | 2.4 | 0.0 | 247 |
| August | 22.2 | 2.4 | 0.0 | 283 |
| September | 19.6 | 1.4 | 0.5 | 219 |
| October | 18.8 | 1.7 | 0.4 | 228 |
| November | 25.6 | 0.4 | 0.0 | 246 |
| December | 15.4 | 1.0 | 0.0 | 194 |
| Yearly | 22.0 | 1.3 | 0.1 | 2,820 |

TABLE II-2: ODOR MONITORING AT THE CALUMET SOLIDS DRYING AREAS—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 13.4 | 2.0 | 0.0 | 149 |
| February | 8.7 | 0.8 | 0.0 | 126 |
| March | 15.8 | 0.0 | 0.0 | 183 |
| April | 14.0 | 1.2 | 0.0 | 171 |
| May | 16.4 | 1.8 | 0.0 | 171 |
| June | 36.7 | 0.0 | 0.0 | 158 |
| July | 25.5 | 0.0 | 0.0 | 165 |
| August | 24.0 | 1.6 | 0.0 | 192 |
| September | 23.2 | 0.0 | 0.0 | 151 |
| October | 22.1 | 0.0 | 0.0 | 163 |
| November | 18.7 | 0.0 | 0.0 | 171 |
| December | 11.9 | 0.0 | 0.0 | 135 |
| Yearly | 19.5 | 0.7 | 0.0 | 1,935 |

TABLE II-3:  ODOR MONITORING AT THE STICKNEY WRP—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 21.4 | 2.5 | 0.0 | 398 |
| February | 21.9 | 3.3 | 0.0 | 361 |
| March | 28.8 | 5.7 | 0.0 | 493 |
| April | 20.0 | 2.5 | 0.0 | 444 |
| May | 23.3 | 1.1 | 0.0 | 437 |
| June | 22.3 | 3.0 | 0.2 | 494 |
| July | 23.8 | 4.8 | 0.2 | 416 |
| August | 21.5 | 4.4 | 0.0 | 475 |
| September | 20.1 | 5.3 | 0.0 | 437 |
| October | 20.2 | 3.1 | 0.0 | 455 |
| November | 21.7 | 0.7 | 0.0 | 456 |
| December | 19.1 | 1.4 | 0.0 | 380 |
| Yearly | 25.9 | 3.5 | 0.0 | 5,246 |

TABLE II-4: ODOR MONITORING AT THE HASMA, VULCAN, AND MARATHON SOLIDS DRYING AREAS AND THE LASMA SOLIDS PROCESSING AREA—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 20.0 | 1.1 | 0.0 | 180 |
| February | 22.0 | 0.7 | 0.0 | 150 |
| March | 31.7 | 0.5 | 0.5 | 218 |
| April | 23.5 | 0.5 | 0.5 | 196 |
| May | 30.7 | 1.6 | 1.0 | 192 |
| June | 35.3 | 2.5 | 0.8 | 238 |
| July | 31.3 | 0.5 | 0.0 | 217 |
| August | 41.7 | 2.3 | 0.0 | 216 |
| September | 49.0 | 1.6 | 0.0 | 192 |
| October | 45.9 | 2.0 | 0.0 | 196 |
| November | 42.7 | 1.6 | 0.0 | 185 |
| December | 31.5 | 0.0 | 0.0 | 184 |
| Yearly | 34.2 | 0.9 | 0.3 | 2,364 |

TABLE II-5: ODOR MONITORING AT THE RASMA SOLIDS DRYING AREA—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 5.0 | 0.0 | 0.0 | 20 |
| February | 0.0 | 0.0 | 0.0 | 10 |
| March | 0.0 | 0.0 | 0.0 | 16 |
| April | 6.3 | 0.0 | 0.0 | 16 |
| May | 0.0 | 0.0 | 0.0 | 20 |
| June | 6.3 | 0.0 | 0.0 | 16 |
| July | 0.0 | 0.0 | 0.0 | 8 |
| August | 4.0 | 0.0 | 0.0 | 20 |
| September | 41.7 | 0.0 | 0.0 | 12 |
| October | 0.0 | 0.0 | 0.0 | 16 |
| November | 25.0 | 0.0 | 0.0 | 16 |
| December | 0.0 | 0.0 | 0.0 | 8 |
| Yearly | 9.6 | 0.0 | 0.0 | 178 |

TABLE II-6: ODOR MONITORING AT THE STONY ISLAND SOLIDS DRYING AREA—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 10.7 | 0.0 | 0.0 | 28 |
| February | 11.8 | 0.0 | 0.0 | 17 |
| March | 12.1 | 0.0 | 0.0 | 33 |
| April | 12.5 | 0.0 | 0.0 | 32 |
| May | 28.6 | 0.0 | 0.0 | 28 |
| June | 27.8 | 0.0 | 0.0 | 36 |
| July | 27.8 | 0.0 | 0.0 | 36 |
| August | 16.7 | 2.8 | 0.0 | 36 |
| September | 35.7 | 3.6 | 0.0 | 28 |
| October | 28.6 | 0.0 | 0.0 | 28 |
| November | 37.5 | 0.0 | 0.0 | 24 |
| December | 50.0 | 3.6 | 0.0 | 28 |
| Yearly | 24.9 | 0.8 | 0.0 | 354 |

TABLE II-7: ODOR MONITORING AT THE JOHN E. EGAN WRP—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 21.4 | 0.0 | 0.0 | 28 |
| February | 21.4 | 0.0 | 0.0 | 28 |
| March | 20.6 | 0.0 | 0.0 | 34 |
| April | 10.7 | 0.0 | 0.0 | 28 |
| May | 17.1 | 0.0 | 0.0 | 35 |
| June | 17.9 | 0.0 | 0.0 | 28 |
| July | 17.9 | 0.0 | 0.0 | 28 |
| August | 8.6 | 0.0 | 0.0 | 35 |
| September | 41.4 | 0.0 | 0.0 | 29 |
| October | 25.9 | 3.7 | 0.0 | 27 |
| November | 20.0 | 2.9 | 0.0 | 35 |
| December | 25.0 | 0.0 | 0.0 | 28 |
| Yearly | 20.4 | 0.6 | 0.0 | 363 |

TABLE II-8: ODOR MONITORING AT THE JAMES C. KIRIE WRP—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 29.4 | 0.0 | 0.0 | 68 |
| February | 11.8 | 0.0 | 0.0 | 68 |
| March | 25.0 | 0.0 | 0.0 | 84 |
| April | 19.1 | 0.0 | 0.0 | 68 |
| May | 3.5 | 0.0 | 0.0 | 850 |
| June | 3.3 | 0.0 | 0.0 | 1,521 |
| July | 1.1 | 0.0 | 0.0 | 1,599 |
| August | 2.1 | 0.0 | 0.0 | 1,582 |
| September | 1.4 | 0.1 | 0.0 | 1,501 |
| October | 2.4 | 0.0 | 0.0 | 962 |
| November | 29.4 | 1.2 | 0.0 | 85 |
| December | 32.4 | 0.0 | 0.0 | 68 |
| Yearly | 3.4 | 0.0 | 0.0 | 8,456 |

TABLE II-9: ODOR MONITORING AT THE NORTH SIDE WRP—2006

| Month | Percent of Visits Odors Were Observed | | | Total Number of Observations |
|---|---|---|---|---|
| | Easily Noticeable | Strong | Very Strong | |
| January | 31.4 | 0.0 | 0.0 | 51 |
| February | 25.0 | 0.0 | 0.0 | 52 |
| March | 27.7 | 0.0 | 0.0 | 65 |
| April | 30.8 | 0.0 | 0.0 | 52 |
| May | 20.0 | 0.0 | 0.0 | 65 |
| June | 34.6 | 0.0 | 0.0 | 52 |
| July | 25.0 | 1.9 | 0.0 | 52 |
| August | 27.7 | 1.5 | 0.0 | 65 |
| September | 44.2 | 1.9 | 0.0 | 52 |
| October | 34.6 | 0.0 | 0.0 | 52 |
| November | 42.2 | 3.1 | 0.0 | 64 |
| December | 40.4 | 0.0 | 0.0 | 52 |
| Yearly | 31.8 | 0.7 | 0.0 | 674 |

TABLE II-10: INFLUENT HAZARDOUS AIR POLLUTANT CONCENTRATIONS AT THE DISTRICT'S MAJOR WRPs IN 2006

| HAP Organic Compound | Concentrations in µg/L[1] | | |
|---|---|---|---|
| | Stickney | Calumet | North Side |
| Dichloromethane | 0.80 | NF | 4.00 |
| Chloroform | 2.80 | 3.00 | 3.45 |
| Benzene | NF | 1.40 | NF |
| Tetrachloroethene | NF | NF | 1.20 |
| Toluene | 20.00 | 13.30 | 2.25 |
| Carbon disulfide | NF | 3.60 | NF |
| Methyl ethyl ketone | 10.10 | 10.90 | NF |
| Styrene | 0.50 | NF | NF |
| Xylene (total) | 0.90 | NF | NF |
| Cresol (total) | 2.10 | NF | 4.10 |
| Acetophenone | NF | 22.25 | NF |
| Cumene | NF | 10.85 | NF |

[1]Average results of the two influent samples collected in February and July 2006.
NF = Not found.

TABLE II-11: HAZARDOUS AIR POLLUTANT EMISSIONS FROM THE DISTRICT'S MAJOR WRPs IN 2006[1]

| HAP Organic Compound | Emissions in tons/yr | | |
|---|---|---|---|
| | Stickney | Calumet | North Side |
| Dichloromethane | 0.1 | 0 | 0.20 |
| Chloroform | 0.31 | 0.1 | 0.14 |
| Benzene | 0 | 0.05 | 0 |
| Tetrachloroethene | 0 | 0 | 0.15 |
| Toluene | 1.96 | 0.43 | 0.07 |
| Carbon disulfide | 0 | 0.2 | 0 |
| Methyl ethyl ketone | 0.12 | 0.03 | 0 |
| Styrene | 0.04 | 0 | 0 |
| Xylene (total) | 0.08 | 0 | 0 |
| Cresol (total) | 0.01 | 0 | 0.01 |
| Acetophenone | 0 | 0.02 | 0 |
| Cumene | 0 | 0.40 | 0 |
| Total | 2.62 | 1.23 | 0.57 |

[1]Emissions estimated using the BASTE model.

TABLE II-12: CHARACTERIZATION OF UNFILTERED AND LABORATORY-FILTERED OUTFALL SAMPLES FROM MAJOR DISTRICT WRPs[1]

| Parameter | Calumet WRP | | Stickney WRP | | North Side WRP | |
|---|---|---|---|---|---|---|
| | Final Effluent | Laboratory-Filtered | Final Effluent | Laboratory-Filtered | Final Effluent | Laboratory-Filtered |
| Fecal Coliform, cfu/100 mL[1] | 10,804 | 1,062 | 19,227 | 2,316 | 13,254 | 1,542 |
| *E. coli*, cfu/100 mL[1] | 9,878 | 1,270 | 15,655 | 2,582 | 11,825 | 1,635 |
| Total Coliforms, cfu/100 mL[1] | 120,321 | 7,427 | 144,678 | 12,043 | 147,140 | 5,958 |
| COD, mg/L[2] | 27 | 24 | 25 | 21 | 26 | 21 |
| Absorbance Units[2] | 0.147 | 0.144 | 0.124 | 0.121 | 0.116 | 0.113 |
| Transmittance, %[2] | 71.34 | 71.81 | 75.15 | 75.73 | 76.70 | 77.20 |

[1]Average values collected over period of November 15, 2005, to November 28, 2006.
[2]Grab samples.
[3]24-hour composite samples.

TABLE II-13: COMPARISON OF UNFILTERED, LABORATORY-FILTERED, AND FULL-SCALE POST-FILTER SECONDARY EFFLUENT SAMPLES FROM HANOVER PARK AND EGAN WRPs

| Parameter | Hanover Park WRP | | | Egan WRP | | |
|---|---|---|---|---|---|---|
| | Secondary Effluent | Full-Scale Post-Filter | Laboratory-Filtered | Secondary Effluent | Full-Scale Post-Filter | Laboratory-Filtered |
| Fecal Coliform, cfu/100 mL[1] | 11,490 | 7,091 | 1,545 | 3,864 | 2,092 | 532 |
| *E. coli*, cfu/100 mL[1] | 11,102 | 6,925 | 1,856 | 4,610 | 2,125 | 510 |
| Total Coliforms, cfu/100 mL[1] | 76,182 | 69,674 | 8,094 | 52,621 | 19,387 | 2,895 |
| COD, mg/L[2] | 53 | 34 | 30 | 29 | 24 | 26 |
| Absorbance Units[2] | 0.156 | 0.146 | 0.139 | 0.131 | 0.130 | 0.124 |
| Transmittance, %[2] | 69.84 | 71.46 | 72.68 | 74.02 | 74.13 | 75.25 |

[1]Average values of samples collected over period of November 16, 2005, to April 19, 2006.
[2]Grab samples.
[3]24-hour composite samples.

TABLE II-14: MIXED LIQUOR TREATMENTS EXAMINED FOR NITRIFICATION TESTS

| Treatment Number | Treatment Name | Metal Salts Used | Specification |
|---|---|---|---|
| 1 | Control | None | ML (control) |
| 2 | Zn | $ZnSO_4 \cdot 7H_2O$ | ML + 10 ppm Zn |
| 3 | Cr | $K_2Cr_2O_7$ | ML + 10 ppm Cr |
| 4 | Cd | $Cd(NO_3)_2 \cdot 4H_2O$ | ML + 10 ppm Cd |
| 5 | Ni | $NiSO_4 \cdot 6H_2O$ | ML + 10 ppm Ni |
| 6 | Pb | $Pb(NO_3)_2$ | ML + 10 ppm Pb |
| 7 | Cu | $CuSO_4 \cdot 5H_2O$ | ML + 10 ppm Cu |
| 8 | Cal MC | All the above | ML + Calumet cocktail concentrations* |
| 9 | MC1.67 | All the above | ML + 1.67 ppm of each metal of concern |
| 10 | MC5 | All the above | ML + 5 ppm of each metal of concern |

*Cal MC Zn 1.2777 mg/L, Cr 0.0814 mg/L, Cd 0.0024 mg/L, Ni 0.1306 mg/L, Pb 0.1612 mg/L, and Cu 0.3422 mg/L.

TABLE II-15: RESULTS OF SILOXANE ANALYSIS FOR STICKNEY WRP DIGESTER GAS INCLUDING TIME OF SAMPLING

| Date of Sample | Locations, Concentrations (μg/m$^3$), and Time of Sampling (AM/PM) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Compressor Room | | | Sulfatreat Outlet | | | Boiler Room | | |
| | D4 | D5 | Time | D4 | D5 | Time | D4 | D5 | Time |
| 12/7/2005 | ND | ND | PM | — | — | — | ND | ND | AM |
| 1/23/2006 | 1,600 | ND | PM | — | — | — | 4,000 | 1,400 | AM |
| 1/26/2006 | ND | ND | PM | — | — | — | 1,600 | ND | AM |
| 2/15/2006 | 2,300 | ND | PM | — | — | — | 4,200 | 1,300 | AM |
| 3/16/2006 | 1,500 | ND | AM | — | — | — | 7,700 | 5,500 | PM |
| 4/24/2006 | ND | ND | PM | — | — | — | ND | ND | AM |
| 5/25/2006 | ND | ND | PM | — | — | — | ND | ND | AM |
| 6/15/2006 | 3,500 | ND | AM | 12,000 | 4,200 | PM | 6,500 | ND | PM |
| 7/25/2006 | ND | ND | AM | 7,600 | 5,000 | PM | — | — | — |
| 7/26/2006 | 2,600 | ND | AM | 2,200 | ND | PM | — | — | — |
| 8/30/2006 | ND | ND | PM | ND* | ND* | AM | — | — | — |
| 10/3/2006 | ND | ND | AM | ND** | ND** | PM | — | — | — |
| 10/31/2006 | ND | ND | AM | ND** | ND** | PM | — | — | — |
| 12/19/2006 | ND | ND | PM | — | — | — | ND** | ND** | AM |

ND = Not detected.
— Not measured.
*South vessel not in service.
**South and north vessel not in service.

TABLE II-16: RESULTS OF ADDITIONAL ANAEROBIC DIGESTION TESTS FOR CALUMET WRP IN 2006

| Test Start Date | Before Test | | After Test[1] | | Volatile Solids Reduction (%) | |
|---|---|---|---|---|---|---|
| | TS (%) | %VTS (%) | TS (%) | %VTS (%) | By Equation[2] | By Mass |
| 1/5/2006 | 1.95 | 61.57 | 1.78 | 57.85 | 14.3 | 14.6 |
| 2/2/2006 | 2.09 | 60.48 | 1.90 | 56.03 | 16.7 | 16.0 |
| 3/2/2006 | 2.10 | 59.38 | 1.89 | 56.75 | 10.2 | 14.3 |
| 4/6/2006 | 2.40 | 56.91 | 2.18 | 52.50 | 16.3 | 16.1 |
| 5/4/2006 | 2.53 | 53.29 | 2.34 | 49.73 | 13.3 | 13.6 |
| 5/18/2006 | 2.56 | 51.10 | 2.39 | 47.16 | 14.6 | 13.9 |
| 6/1/2006 | 2.55 | 49.00 | 2.44 | 45.27 | 13.9 | 11.5 |
| 7/6/2006 | 2.67 | 49.22 | 2.53 | 44.93 | 15.8 | 13.4 |
| 8/3/2006 | 2.80 | 49.29 | 2.69 | 44.59 | 17.2 | 12.8 |
| 8/24/2006 | 3.14 | 43.72 | 2.97 | 41.85 | 7.4 | 9.3 |
| 9/7/2006 | 3.28 | 43.78 | 3.12 | 42.05 | 6.8 | 8.5 |
| 10/5/2006 | 2.93 | 43.46 | 2.81 | 42.90 | 2.3 | 5.5 |
| 11/9/2006 | 2.63 | 47.37 | 2.43 | 44.49 | 11.0 | 13.1 |
| 12/7/2006 | 2.00 | 51.18 | 1.87 | 47.44 | 13.9 | 13.3 |
| August 2006 | | | | | | |
| Mean | 2.97 | 46.50 | 2.83 | 43.22 | 12.3 | 11.1 |
| Yearly | | | | | | |
| Mean | 2.54 | 51.41 | 2.38 | 48.11 | 12.4 | 12.6 |
| Min. | 1.95 | 43.46 | 1.78 | 41.85 | 2.3 | 5.5 |
| Max. | 3.28 | 61.57 | 3.12 | 57.85 | 17.2 | 16.1 |

[1]After 40 days of incubation at 35.5°C in bench-scale reactors.
[2]The Van Kleeck Equation was used in calculations.

TABLE II-17: MONTHLY MEAN VOLATILE SOLIDS REDUCTION THROUGH 2-STEP ANAEROBIC DIGESTION AT CALUMET WRP IN 2006

| | Digester Feed | | Digester Draw | | VS Reduction (%) |
|---|---|---|---|---|---|
| Month | TS (%) | %VTS (%) | TS (%) | %VTS (%) | By Equation[1] |
| Jan. | 3.57 | 73.4 | 2.05 | 59.9 | 45.8 |
| Feb. | 3.62 | 75.0 | 2.04 | 58.3 | 53.3 |
| Mar. | 3.77 | 69.9 | 2.18 | 58.7 | 38.8 |
| Apr. | 3.70 | 66.7 | 2.43 | 54.6 | 40.0 |
| May | 3.71 | 62.6 | 2.55 | 50.9 | 38.1 |
| Jun. | 3.49 | 60.6 | 2.66 | 47.5 | 41.1 |
| Jul. | 4.08 | 58.0 | 2.74 | 47.0 | 35.8 |
| Aug. | 4.58 | 52.5 | 3.14 | 43.8 | 29.5 |
| Sep. | 4.38 | 52.0 | 3.32 | 42.6 | 31.4 |
| Oct. | 3.88 | 55.2 | 2.90 | 41.8 | 41.7 |
| Nov. | 3.59 | 65.9 | 2.44 | 45.7 | 56.4 |
| Dec. | 3.38 | 64.2 | 1.90 | 49.4 | 45.6 |
| Mean | 3.81 | 63.0 | 2.53 | 50.0 | 41.5 |
| Min. | 3.38 | 52.0 | 1.90 | 41.8 | 29.5 |
| Max. | 4.58 | 75.0 | 3.32 | 59.9 | 56.4 |

[1]The Van Kleeck Equation was used in calculations.

TABLE II-18: RESULTS OF ADDITIONAL ANAEROBIC DIGESTION TESTS FOR THE EGAN WRP IN 2006

| Test Start Date | Before Test TS (%) | Before Test %VTS (%) | After Test[1] TS (%) | After Test[1] %VTS (%) | Volatile Solids Reduction (%) By Equation[2] | Volatile Solids Reduction (%) By Mass |
|---|---|---|---|---|---|---|
| 10/30/2006 | 2.48 | 62.06 | 2.30 | 58.65 | 13.3 | 12.5 |
| 10/31/2006 | 2.40 | 61.55 | 2.26 | 58.70 | 11.2 | 10.1 |
| Mean | 2.44 | 61.80 | 2.28 | 58.68 | 12.2 | 11.3 |

[1]After 40 days of incubation at 35.5°C in bench-scale reactors.
[2]The Van Kleeck Equation was used in calculations.

TABLE II-19: NUMBERS AND LOCATIONS OF CSO DISCHARGES IN THE CAWS WATER QUALITY MODEL

| Number of CSO Discharge Locations | Stream Receiving CSO Discharge |
|---|---|
| 2 | Upper North Shore Channel (upstream of NSWRP) |
| 2 | Lower North Shore Channel (downstream of NSWRP) |
| 5 | North Branch of Chicago River |
| 1 | Chicago River Main Branch |
| 2 | South Branch of Chicago River |
| 6 | Chicago Sanitary and Ship Canal |
| 4 | Little Calumet River North |
| 3 | Little Calumet River South |
| 3 | Calumet-Sag Channel |

TABLE II-20: GRAVITY CSOs INCLUDED IN THE 2001 WATER QUALITY MODEL FOR THE CAWS

| Event Date | Duration hour | Mean Flow MGD (cfs) | Total Discharge Volume MG |
|---|---|---|---|
| 7/25/2001 | 10 | 1,410 (2,170) | 585 |
| 8/2-3/2001 | 17 | 4,430 (6,850) | 3,136 |
| 8/25/2001 | 9 | 4,330 (6,710) | 1,625 |
| 8/30-31/2001 | 9 | 1,800 (2,780) | 673 |
| 9/19/2001 | 9 | 2,680 (4,150) | 1,005 |
| 9/20-21/2001 | 13 | 1,510 (2,330) | 817 |
| 9/23/2001 | 8 | 2,320 (3,590) | 773 |
| 10/5/2001 | 10 | 1,500 (2,320) | 624 |
| 10/12/2001 | 7 | 2,330 (3,600) | 679 |
| 10/13-14/2001 | 27 | 2,410 (3,730) | 2,709 |
| 10/23/2001 | 5 | 1,490 (2,310) | 311 |

MGD = Million gallons.

TABLE II-21: GRAVITY CSOs INCLUDED IN THE 2002 WATER QUALITY MODEL FOR THE CAWS

| Event Date | Duration hour | Mean Flow MGD (cfs) | Total Discharge Volume MG |
|---|---|---|---|
| 5/11/2002 | 5 | 2,610 (4,040) | 544 |
| 5/12/2002 | 25 | 10,440 (16,100) | 10,872 |
| 5/16/2002 | 8 | 1,070 (1,660) | 356 |
| 6/11/2002 | 4 | 5,450 (8,430) | 908 |
| 7/9/2002 | 4 | 1,870 (2,900) | 312 |
| 8/22-23/2002 | 37 | 981 (1,520) | 1,512 |

TABLE II-22: COMBINED SEWER OVERFLOWS CAPTURED BY THE TUNNEL AND RESERVOIR SYSTEMS DURING THE PERIOD 1982 THROUGH 2006

| Date | Stickney[1] Flow (billion gallons) | Calumet[1] Flow (billion gallons) | Kirie[2] Flow (billion gallons) | Total (billion gallons) |
|---|---|---|---|---|
| 1982 through 1993[3] | 206.20 | 60.20 | 37.30 | 303.70 |
| 1994 | 18.74 | 7.83 | 1.44 | 28.01 |
| 1995 | 22.84 | 9.08 | 2.60 | 34.52 |
| 1996 | 21.54 | 12.02 | 2.23 | 35.79 |
| 1997 | 29.10 | 8.44 | 1.50 | 39.04 |
| 1998 | 34.31 | 13.23 | 2.69 | 50.23 |
| 1999 | 27.20 | 11.77 | 3.15 | 42.12 |
| 2000 | 28.55 | 11.55 | 2.14 | 42.24 |
| 2001 | 48.43 | 16.34 | 3.24 | 68.01 |
| 2002 | 41.17 | 11.15 | 2.39 | 54.71 |
| 2003 | 27.22 | 14.88 | 1.48 | 43.58 |
| 2004 | 28.05 | 15.55 | 2.67 | 46.27 |
| 2005 | 21.43 | 12.95 | 1.11 | 35.49 |
| 2006 | 34.52 | 24.31 | 2.54 | 61.37 |
| Total | 589.30 | 229.30 | 66.48 | 885.08 |

[1]Stickney and Calumet Data were taken from TARP Pumpback reports.
[2]Kirie data were taken from LIMS KRRAW69 Report. CSO capture was calculated by subtracting the average dry weather flow from the average daily flow. The flow data were provided by the Maintenance and Operations Department (Technical Projects).
[3]Data were supplied by Engineering Department.

TABLE II-23: TOTAL SUSPENDED SOLIDS REMOVED THROUGH THE COMBINED SEWER OVERFLOWS CAPTURED BY THE TUNNEL AND RESERVOIR SYSTEMS DURING THE PERIOD 1982 THROUGH 2006

| Date | Mainstream (Million Pounds) | Calumet (Million Pounds) | Kirie (Million Pounds) | Total (Million Pounds) |
|---|---|---|---|---|
| 1982 through 1993[1] | 413.20 | 69.00 | 25.20 | 507.40 |
| 1994 | 41.31 | 12.60 | 1.90 | 55.81 |
| 1995 | 67.75 | 9.93 | 3.50 | 81.18 |
| 1996 | 56.57 | 12.43 | 3.30 | 72.30 |
| 1997 | 62.14 | 14.28 | 1.88 | 78.30 |
| 1998 | 107.02 | 16.00 | 3.08 | 126.10 |
| 1999 | 71.69 | 15.31 | 6.63 | 93.63 |
| 2000 | 114.52 | 18.59 | 3.95 | 137.06 |
| 2001 | 88.78 | 18.53 | 5.89 | 113.20 |
| 2002 | 66.85 | 13.18 | 4.26 | 84.29 |
| 2003 | 67.38 | 23.71 | 2.43 | 93.52 |
| 2004 | 62.89 | 18.55 | 4.42 | 85.86 |
| 2005 | 51.14 | 21.33 | 1.63 | 74.10 |
| 2006 | 82.63 | 33.65 | 4.03 | 120.31 |
| Total | 1,353.87 | 297.09 | 72.10 | 1,723.06 |

[1]Data were supplied by Engineering Department.

TABLE II-24: OXYGEN DEMANDING POLLUTANTS REMOVED[1] THROUGH COMBINED SEWER OVERFLOWS CAPTURED BY THE TUNNEL AND RESERVOIR SYSTEMS DURING THE PERIOD 1982 THROUGH 2006

| Date | Mainstream (Million Pounds) | Calumet (Million Pounds) | Kirie (Million Pounds) | Total (Million Pounds) |
|---|---|---|---|---|
| 1982 through 1993[2] | 189.56 | 59.22 | 24.68 | 273.46 |
| 1994 | 15.00 | 8.46 | 2.24 | 25.70 |
| 1995 | 15.77 | 9.79 | 3.58 | 29.14 |
| 1996 | 18.60 | 12.96 | 4.14 | 35.70 |
| 1997 | 26.03 | 9.16 | 2.31 | 37.50 |
| 1998 | 30.86 | 13.57 | 4.81 | 49.24 |
| 1999 | 22.84 | 13.39 | 6.36 | 42.59 |
| 2000 | 35.91 | 13.61 | 4.55 | 54.07 |
| 2001 | 50.67 | 16.82 | 5.95 | 73.44 |
| 2002 | 54.49 | 12.41 | 4.71 | 71.61 |
| 2003 | 36.09 | 16.56 | 3.15 | 55.80 |
| 2004 | 28.22 | 16.72 | 5.47 | 50.41 |
| 2005 | 25.88 | 19.22 | 2.14 | 47.24 |
| 2006 | 37.23 | 28.12 | 5.32 | 70.67 |
| Total | 587.15 | 250.01 | 79.41 | 916.57 |

[1]CBOD + (Ammonia*4.6), except for Kirie WRP which uses BOD + (Ammonia*4.6). Kirie WRP does not report CBOD.
[2]Data were supplied by Engineering Department.

TABLE II-25: LIST OF PARAMETERS TO BE ANALYZED ACCORDING TO TABLE 2 FROM THE IEPA'S SCOPE OF WORK

| | |
|---|---|
| Arsenic | Ammonia |
| Boron | Barium |
| Chloride | Cadmium |
| Copper | Chromium |
| Fecal Coliform | Cyanide |
| Iron | Fluoride |
| Lead | Manganese |
| Mercury | Nickel |
| Phenols | Silver |
| Sulfate | Temperature |
| Total Dissolved Solids | Nitrate |

Biochemical Oxygen Demand (5-day and 21-day)

TABLE II-26: SUSPENDED SOLIDS AND $CBOD_5$ CONCENTRATION FOR 2005 PLANT DATA AND GPS-X SIMULATIONS

| | Annual Average Concentration | |
|---|---|---|
| | SS mg/L | $CBOD_5$ mg/L |
| 2005 Daily Plant Data | 142.22 | 74.84 |
| Simulation—3 Imhoff Batteries in Service | 142.40 | 78.04 |
| Simulation—2 Imhoff Batteries in Service | 167.18 | 81.55 |
| Simulation—1 Imhoff Battery in Service | 182.53 | 94.62 |
| Simulation—0 Imhoff Batteries in Service | 223.77 | 119.07 |

FIGURE II-1: PLOT OF TOTAL METAL CONCENTRATIONS OF EACH METAL COCKTAIL TREATMENT VS. (A) $NR_{NO3}$ AND (B) $NR_{NH3}$

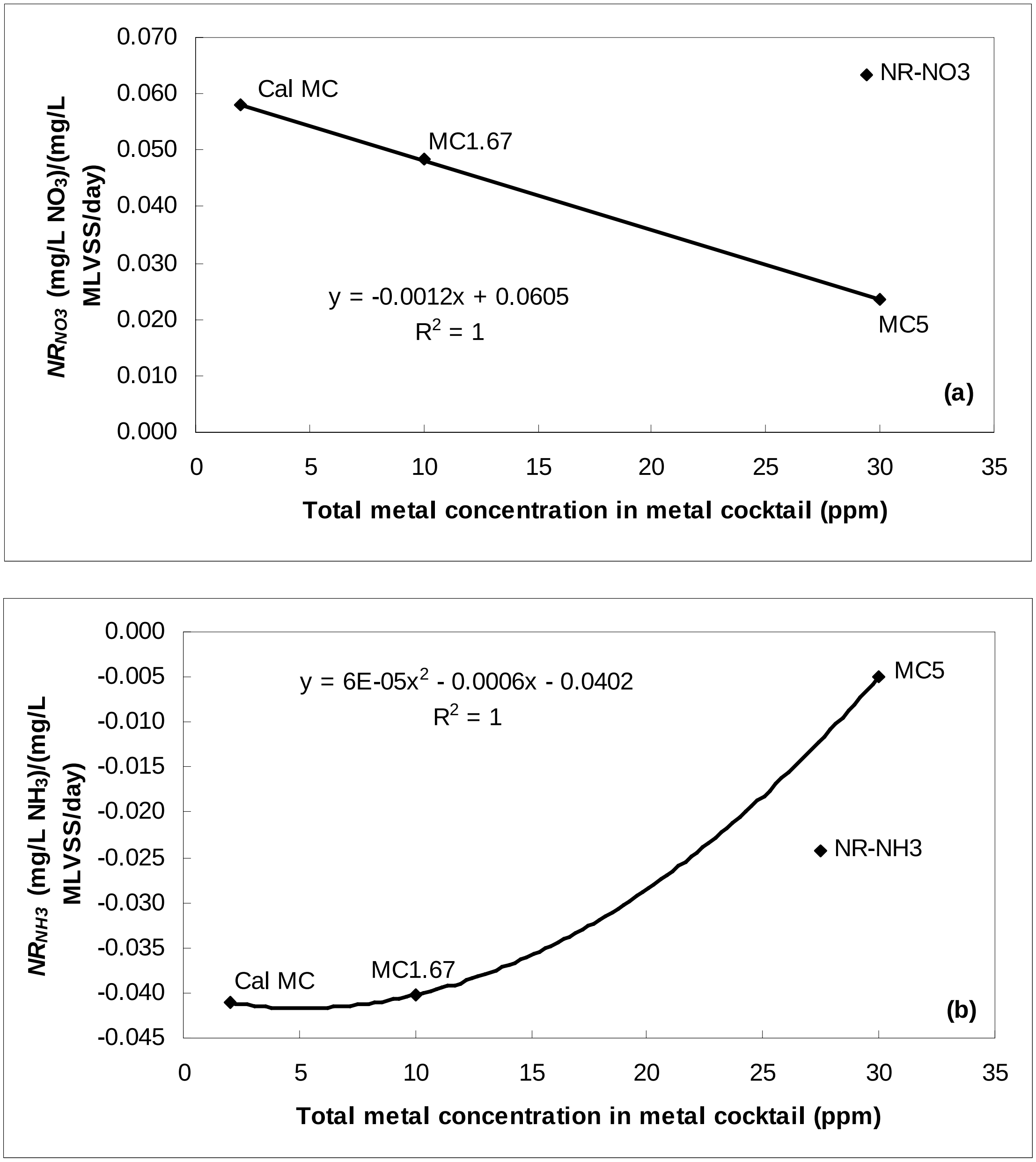


FIGURE II-2: PLOT OF TOTAL METAL CONCENTRATIONS OF EACH METAL COCKTAIL TREATMENT VS. SPECIFIC OXYGEN UPTAKE RATES

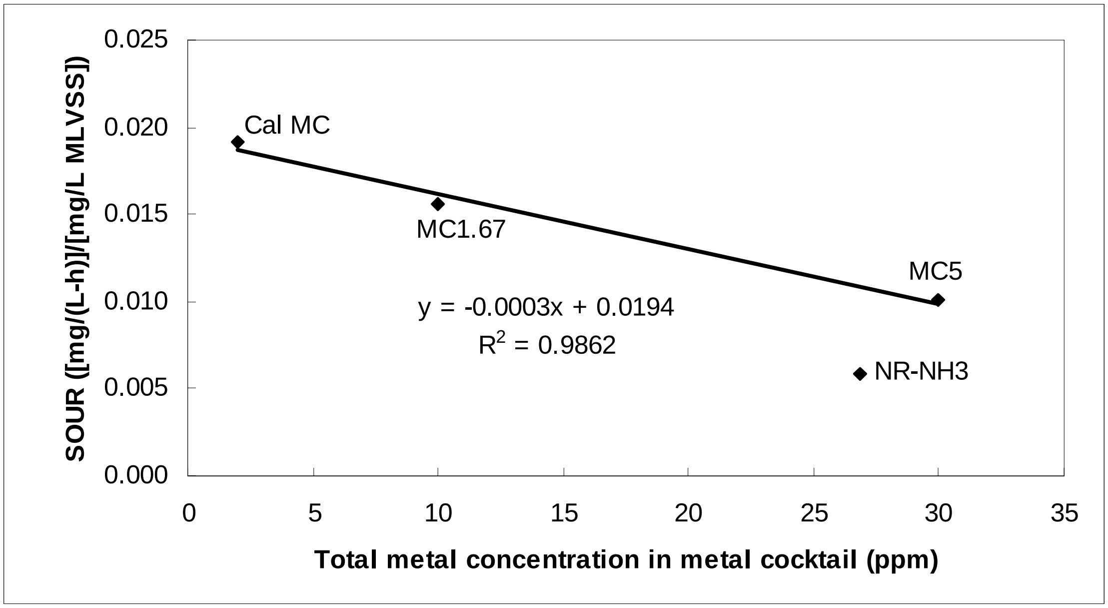


FIGURE II-3: PERCENT OF SIMULATED HOURLY DO CONCENTRATIONS GREATER THAN THE TARGET VALUES IN THE CHICAGO RIVER SYSTEM DURING THE 2001 SIMULATION PERIOD OF JULY 12 TO NOVEMBER 9, 2001

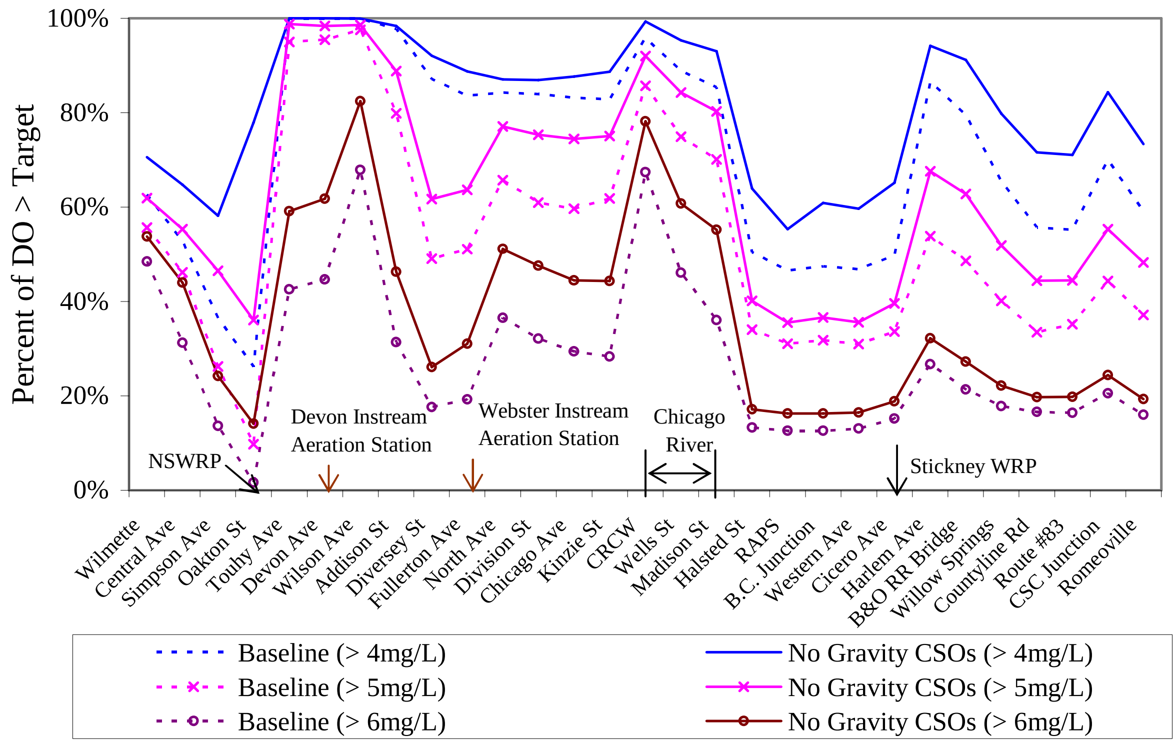
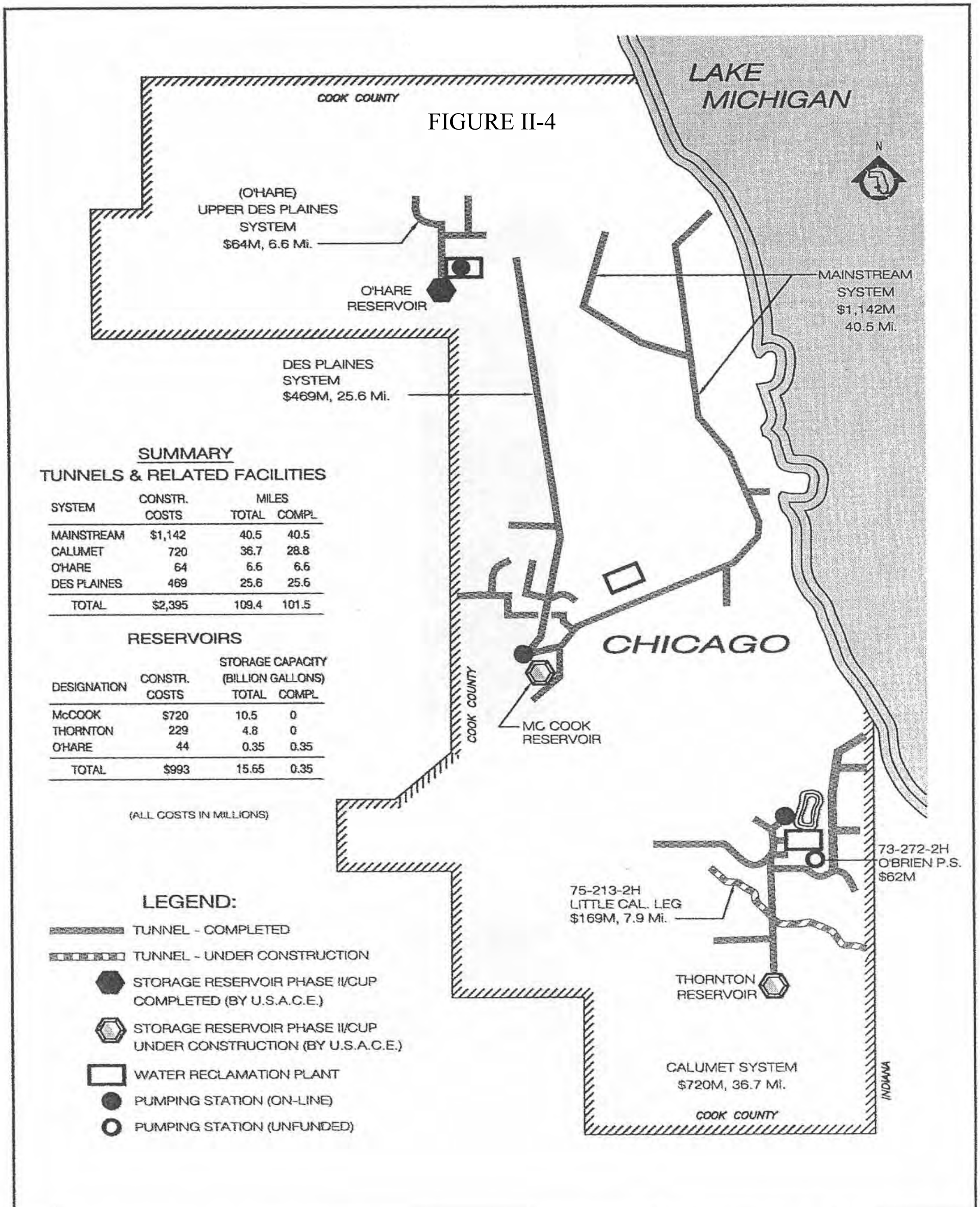


FIGURE II-4




SUMMARY

TUNNELS & RELATED FACILITIES

| SYSTEM | CONSTR. COSTS | MILES TOTAL | MILES COMPL |
|---|---|---|---|
| MAINSTREAM | $1,142 | 40.5 | 40.5 |
| CALUMET | 720 | 36.7 | 28.8 |
| O'HARE | 64 | 6.6 | 6.6 |
| DES PLAINES | 469 | 25.6 | 25.6 |
| TOTAL | $2,395 | 109.4 | 101.5 |

RESERVOIRS

| DESIGNATION | CONSTR. COSTS | STORAGE CAPACITY (BILLION GALLONS) TOTAL | STORAGE CAPACITY (BILLION GALLONS) COMPL |
|---|---|---|---|
| McCOOK | $720 | 10.5 | 0 |
| THORNTON | 229 | 4.8 | 0 |
| O'HARE | 44 | 0.35 | 0.35 |
| TOTAL | $993 | 15.65 | 0.35 |

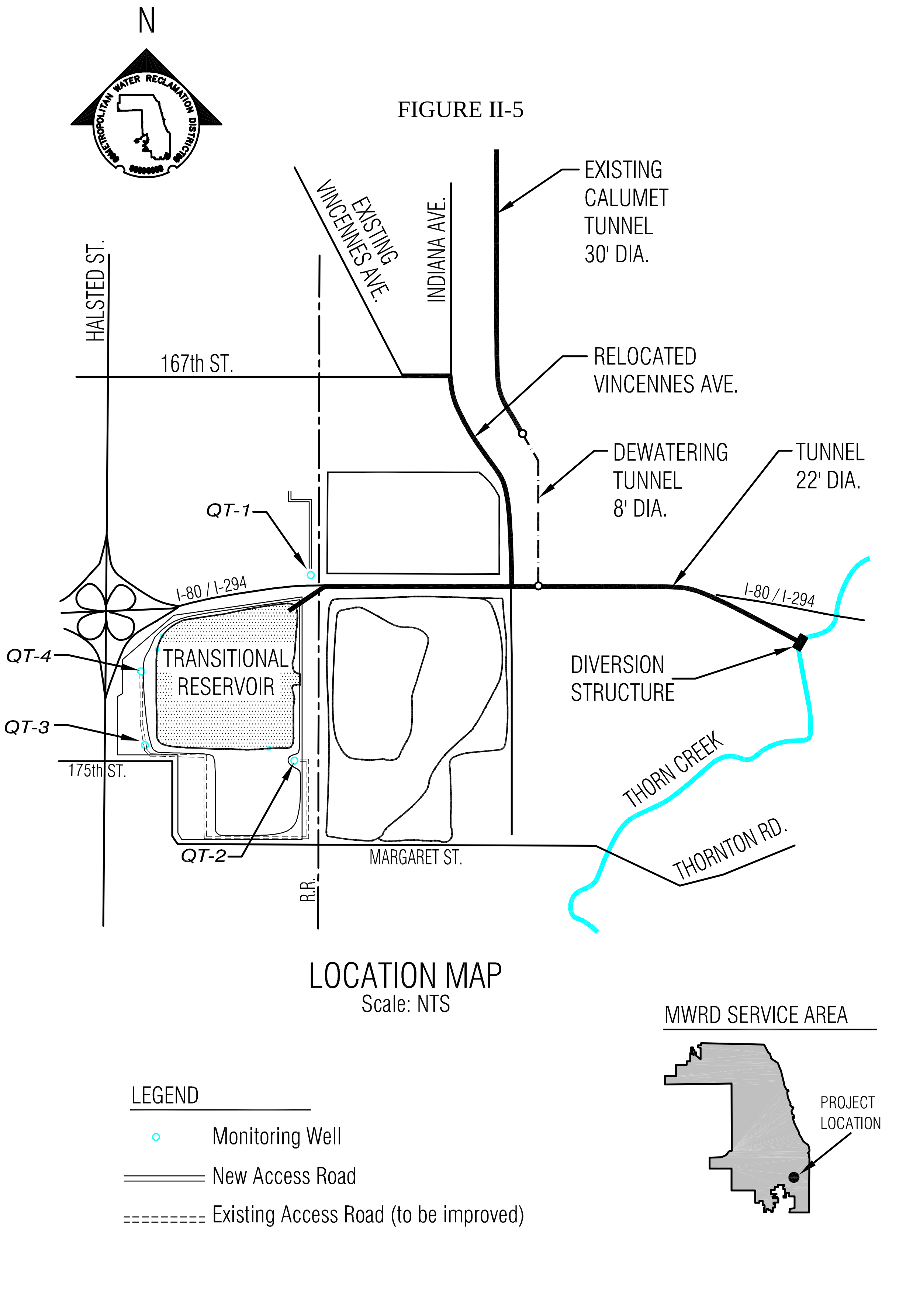
(ALL COSTS IN MILLIONS)

**TUNNEL AND RESERVOIR PLAN PROJECT STATUS**

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO
ENGINEERING DEPARTMENT
2-04 TARP WSS:JJK

H:\BILLs\TARPUpdatedStatus2004CAFR.dwg, 02/09/04 at 14.29

FIGURE II-5




# THORNTON TRANSITIONAL RESERVOIR MONITORING WELL LOCATIONS

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO
ENGINEERING DEPARTMENT
11-03 PLANNING JJK

H:\DMAC\ThorntonTransitional2003.dwg, 07/08/05 at 11.55

FIGURE II-6: IMHOFF TANK DIAGRAM

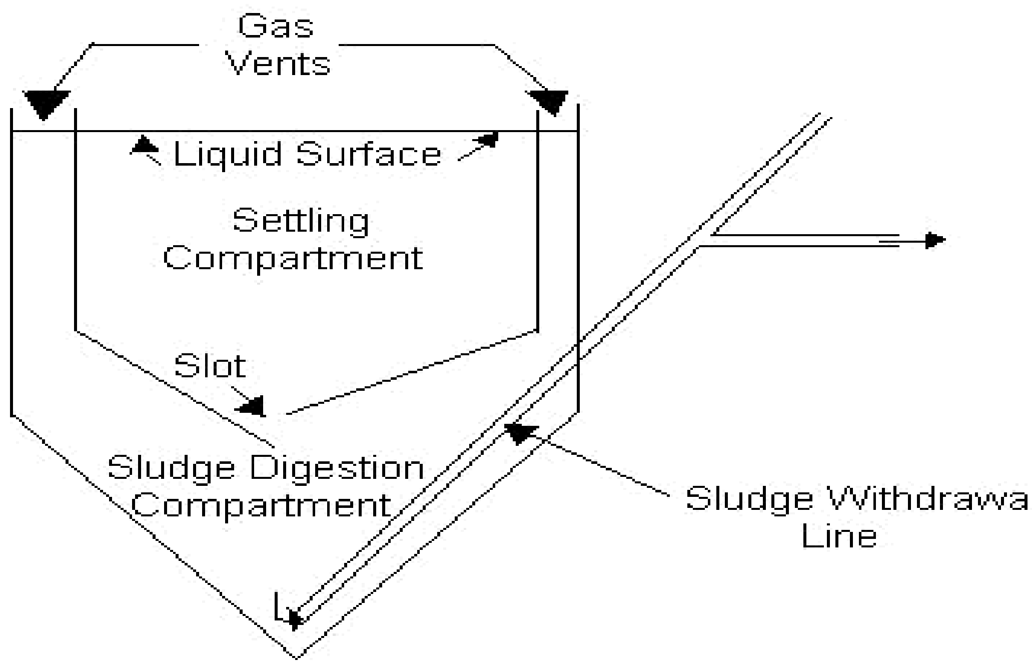


FIGURE II-7: IMHOFF EFFLUENT SUSPENDED SOLIDS, 2005 DAILY PLANT DATA COMPARED TO GPS-X SIMULATION WITH THREE IMHOFF BATTERIES IN SERVICE

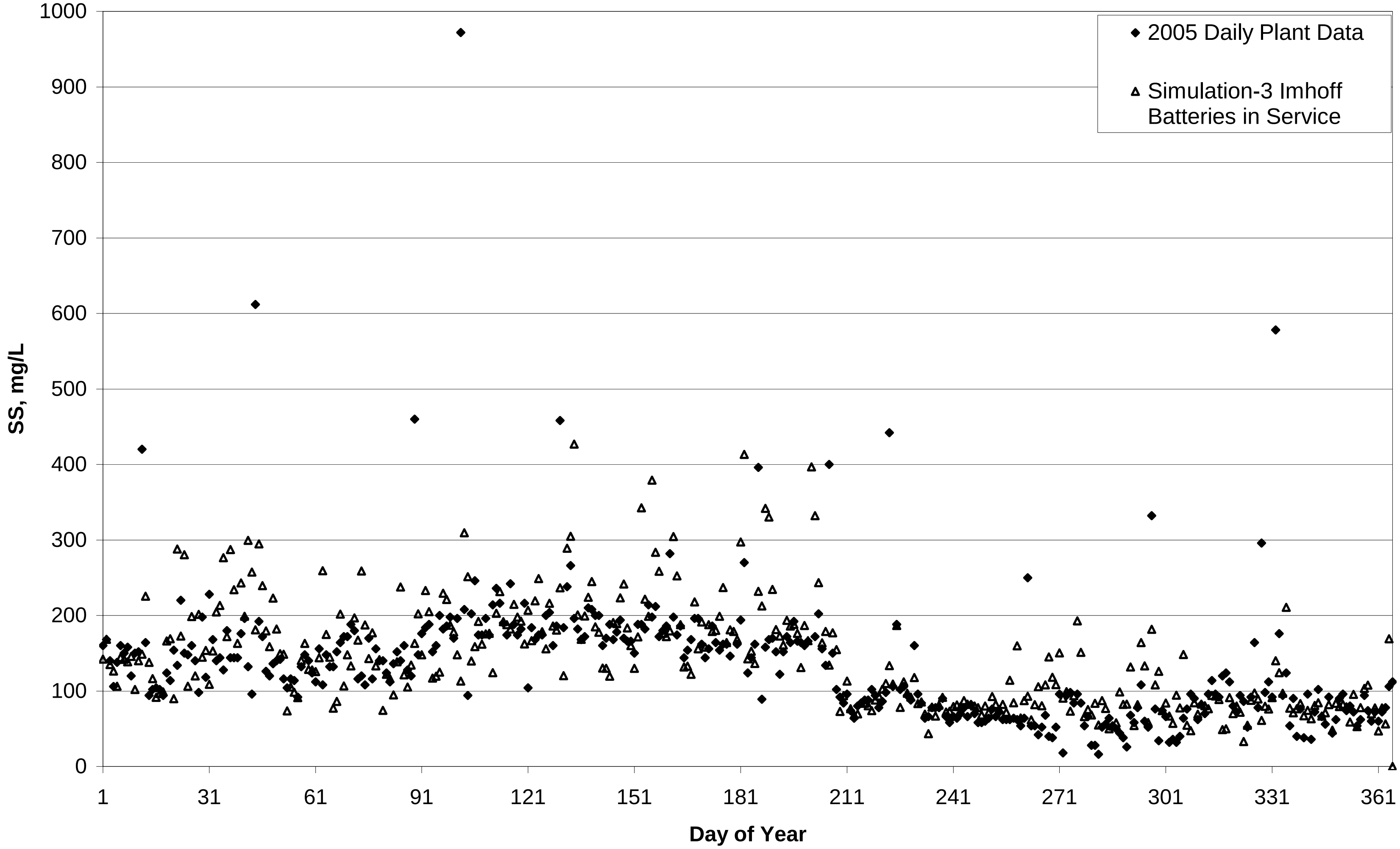


FIGURE II-8: IMHOFF EFFLUENT $CBOD_5$, 2005 DAILY PLANT DATA COMPARED TO GPS-X SIMULATION WITH THREE IMHOFF BATTERIES IN SERVICE

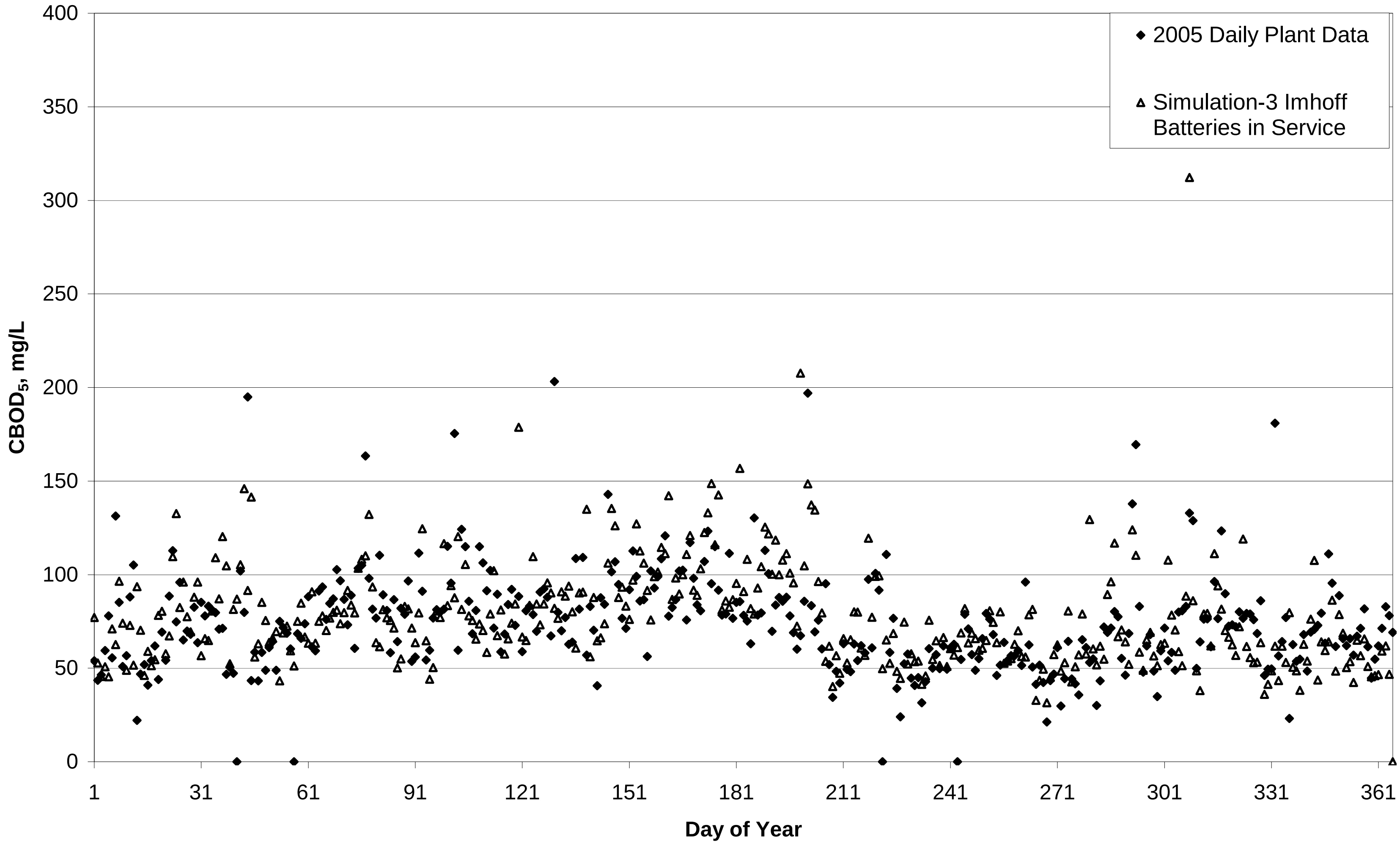


FIGURE II-9: IMHOFF EFFLUENT SUSPENDED SOLIDS DECILE COMPARISON OF 2005 DAILY PLANT DATA AND GPS-X SIMULATIONS

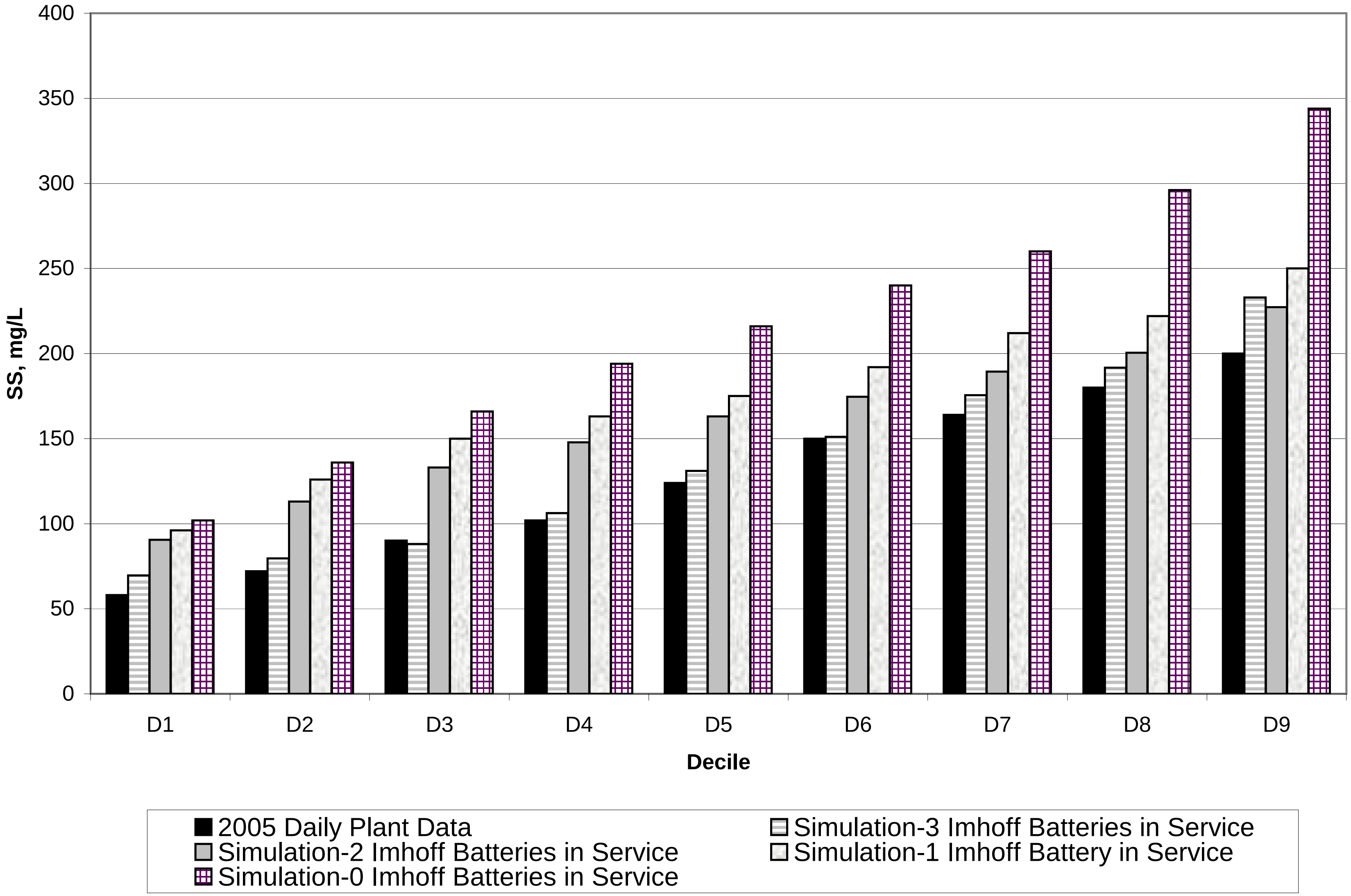


FIGURE II-10: IMHOFF EFFLUENT $CBOD_5$ DECILE COMPARISON OF 2005 DAILY PLANT DATA AND GPS-X SIMULATIONS

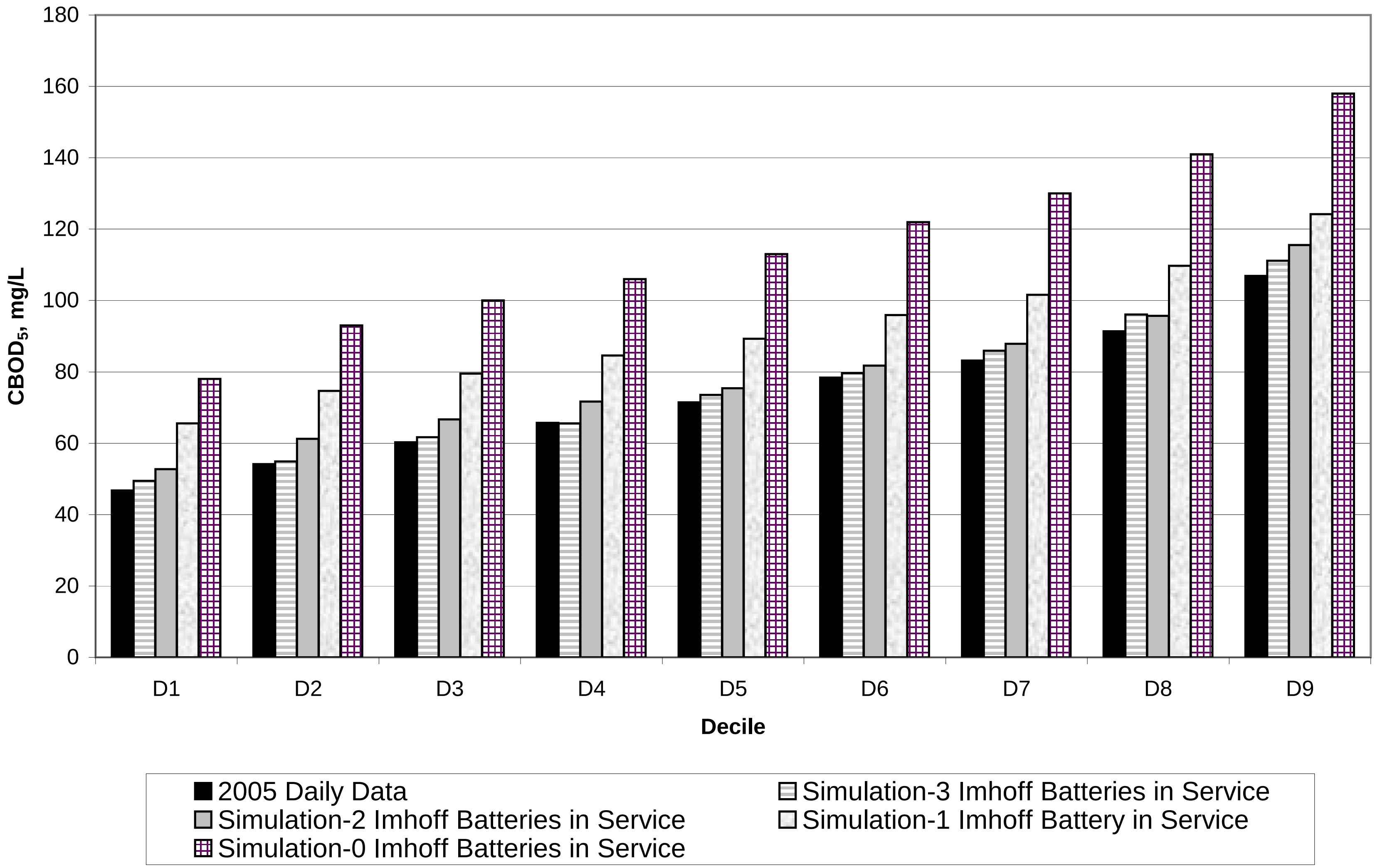


FIGURE II-11: IMHOFF EFFLUENT SUSPENDED SOLIDS, 2005 DAILY PLANT DATA COMPARED TO GPS-X SIMULATION WITH TWO IMHOFF BATTERIES IN SERVICE

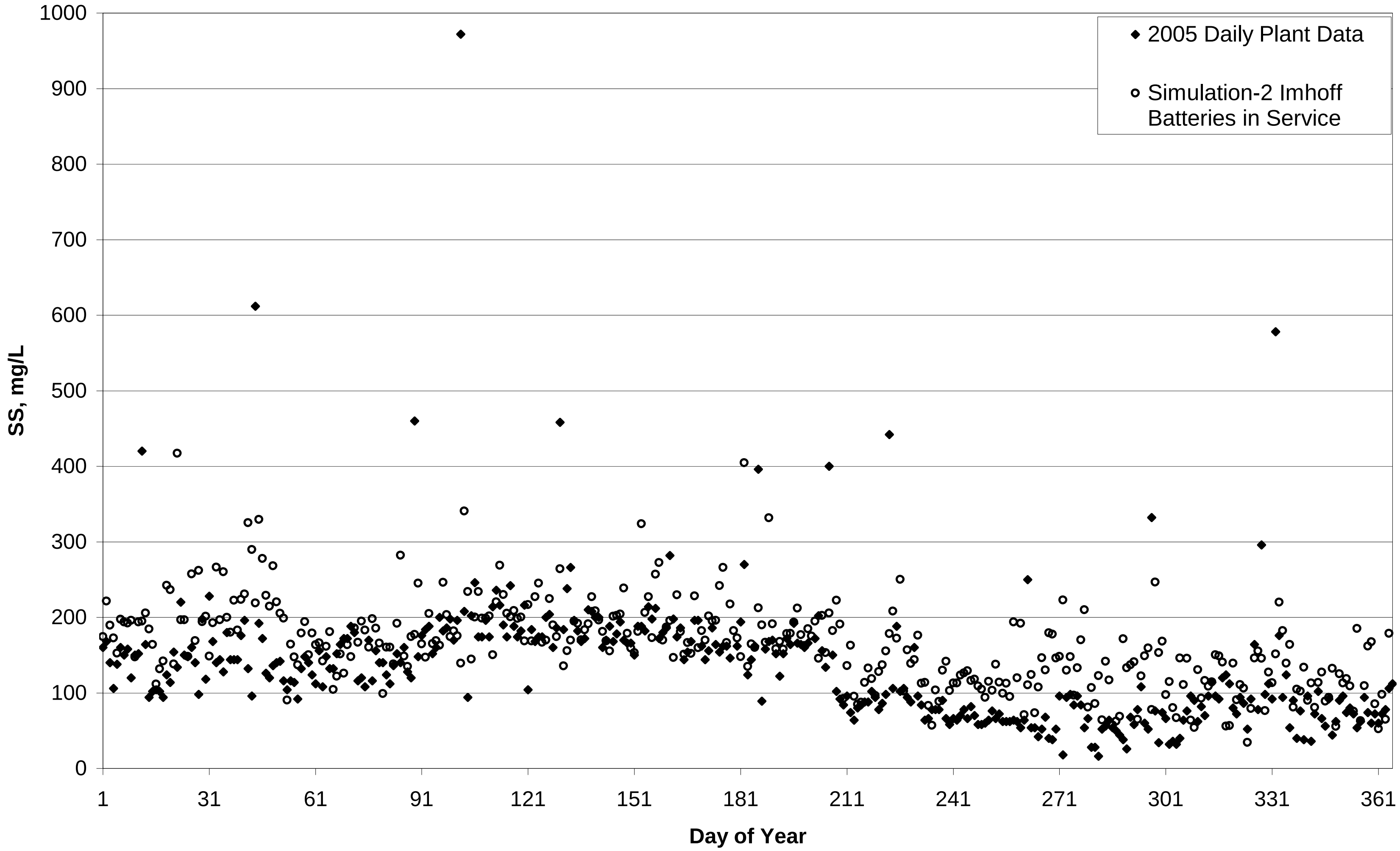
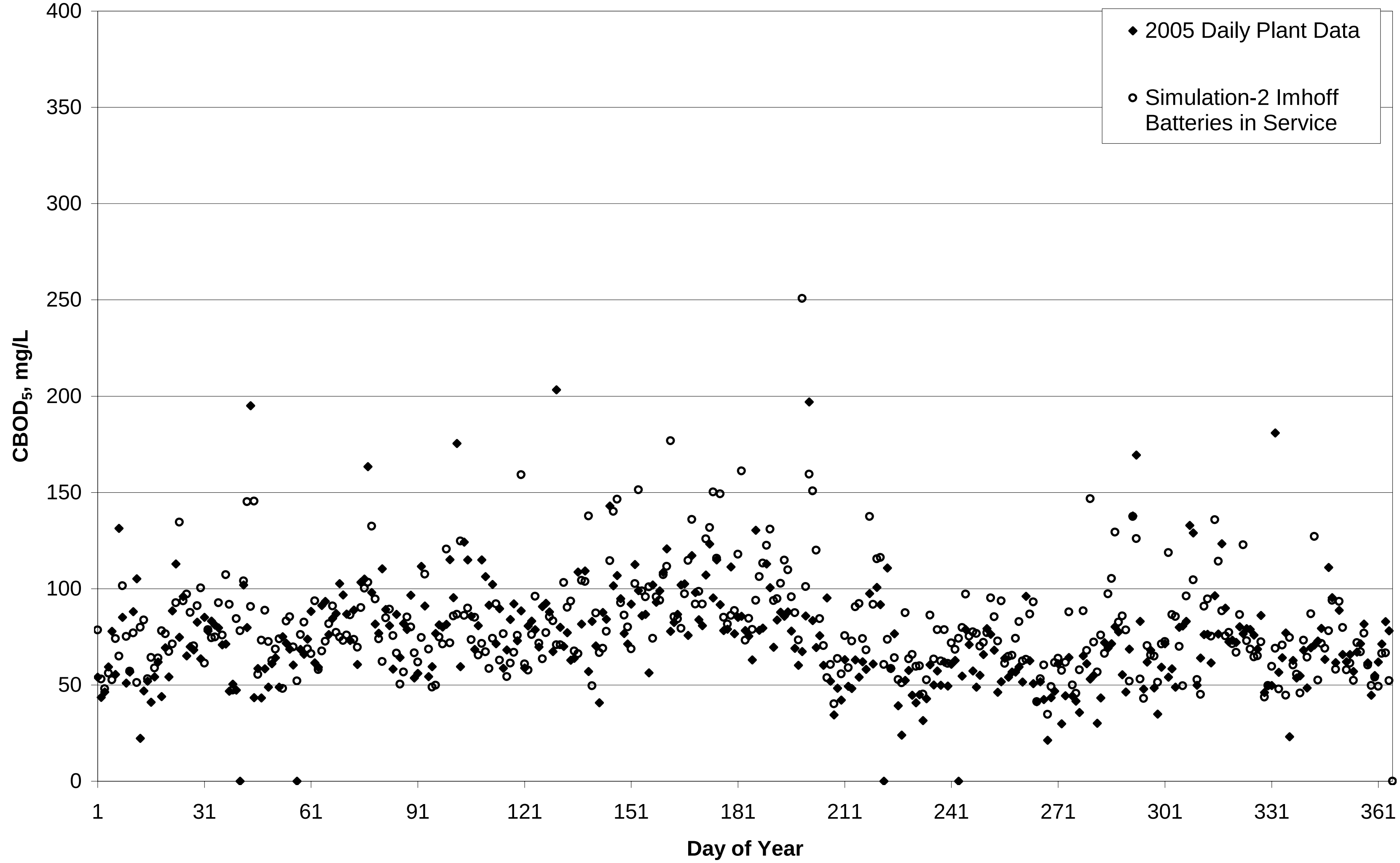


FIGURE II-12: IMHOFF EFFLUENT $CBOD_5$, 2005 DAILY PLANT DATA COMPARED TO GPS-X SIMULATION WITH TWO IMHOFF BATTERIES IN SERVICE



# BIOSOLIDS UTILIZATION AND SOIL SCIENCE SECTION

# BIOSOLIDS UTILIZATION AND SOIL SCIENCE SECTION

The Biosolids Utilization and Soil Science Section is responsible for determining, through monitoring and research activities, the environmental impact of the District's biosolids applications on agricultural fields, disturbed and urban lands, and landfill sites. The environmental monitoring component of the program includes the sampling and analysis of biosolids, waters, soils, and plant tissue as required at biosolids land application sites, landfills, and biosolids drying facilities. The results of this monitoring program are reported to the IEPA and the USEPA. The research component consists of demonstrations and applied research to support the local marketing of biosolids, address regulatory concerns, and provide technical support for biosolids marketing. The section is responsible for providing technical support for biosolids marketing and oversight of technical aspects of biosolids land application contracts. The section also provides technical support to the native landscape conversions at the District's water reclamation plants, and the District's stormwater management program.

## Fulton County Environmental Monitoring

The Fulton County Land Reclamation Site is a large tract of land, 6,122.5 hectares (15,264.5 acres), owned by the District in Fulton County, Illinois. Approximately 600 hectares (1,483 acres) were sold through auction in fall 2004. The site is used to recycle biosolids for the purpose of reclaiming mine soil and fertilizing agricultural crops. To satisfy the permit requirements of the IEPA for operation of the site, the District established an environmental monitoring program to ensure that the land application of biosolids would not adversely affect surface waters, groundwaters, soils, and crops. The Land Reclamation Laboratory is responsible for collecting and analyzing environmental monitoring samples from the Fulton County site. Monthly reports are generated that summarize the monitoring data required to demonstrate compliance with the IEPA, and USEPA regulations for land application of biosolids.

**Summary**. No supernatant or biosolids were applied to Fulton County fields during 2006. Supernatant was last applied in 1995 and biosolids were last applied in 2004.

During 2006, the water monitoring included:

- quarterly sampling of 20 groundwater monitoring wells.
- sampling of surface waters from 10 streams, 8 reservoirs, and 2 SP sites in the supernatant application area three times per year between April and November.
- Sampling of 10 field runoff retention basins as needed.
- sampling of 19 lysimeters and three drainage tiles at the St. David coal refuse pile quarterly.

- sampling of three lysimeters at the Morgan Mine coal refuse pile quarterly.

- sampling of 10 lysimeters at the United Electric Company (UEC) coal refuse pile quarterly.

Water monitoring also included sampling of the discharges from the Acid-Mine Lake receiving drainage from the UEC coal refuse pile for monthly and quarterly reports.

In 2006, the District began to summarize the historical monitoring data collected from the Fulton County site to prepare requests to the IEPA for termination of environmental monitoring specified in the site permit. On September 27, 2006, the IEPA granted termination of monitoring of crops, soil, surface water, and groundwater at the site. Monitoring termination requests are being prepared for Acid Mine Lake and the coal refuse reclamation sites and will be submitted to the IEPA in early 2007.

**General Application Fields**. Soil samples were collected from fields in 2006 for chemical analysis. Plant tissue samples were collected from hay fields, soybean fields, and corn fields. Chemical analyses were performed on these samples during 2006. Climatological conditions were monitored at the project weather station.

Biosolids have been applied to fields at the Fulton County site since 1972. Table III-1 shows the concentrations of all measured parameters in field soils (0- to 15-cm depth), which received different cumulative rates of biosolids, and were sampled in 2006. The crops planted on these fields and yields for 2006 are shown in Table III-2.

Plant tissue samples (grain, leaf, and/or stover) are collected annually from fields leased to local farmers at the Fulton County site. Analyses for the total concentrations of metals found in the 2006 corn grain, corn leaf, hay, and soybean grain are shown in Tables III-3 through 6, respectively.

**Acid Mine Lake**. As part of the purchasing agreements for the parcels of land comprising the Fulton County Land Reclamation Project, the District also took ownership of the old UEC Cuba Mine No. 9 site, which included an impoundment that collected surface water from exposed gob and coal fines areas. The original pH of Acid-Mine Lake water ranged from 1.8 to 2.0. After the UEC property was reclaimed with applications of lime, clay, and biosolids, the lake pH has been elevated to its current level, which ranges between 6.0 and 8.0 and requires no treatment when discharged. The only parameters currently required to be monitored are pH and settleable solids.

**St. David, Morgan Mine, and United Electric Coal Refuse Reclamation Sites**. In 1987, the District initiated an experiment on a coal refuse pile at St. David, Illinois, to determine the rates of anaerobically digested biosolids, agricultural lime, and clay necessary for long-term reclamation of coal refuse material (Table III-7). The experiment was initiated with the approval of the IEPA.

In 2000, Plot 1 was totally reclaimed by applying 1,000 dry tons biosolids/acre and 80 tons limestone/acre. Plot 1 served as the control plot, but was no longer used after the original experiment ended in 1996. The portions of Plot 2 next to Plot 1 that had eroded were also reclaimed in the same manner.

Data generated by this reclamation work were used to establish the reclamation protocols for the remainder of the St. David coal refuse pile. The reclamation of Morgan Mine and UEC Cuba Mine No. 9 coal refuse pile properties also followed this protocol in 1991 and 1990, respectively, in Fulton County. The final reclamation of these coal refuse piles consisted of applying 1,000 dry tons biosolids/acre and 70 tons limestone/acre. This work also formed the basis for the demonstration and research project that the District recently conducted at the USX property on Chicago's southern lakefront.

Water was collected from the coal refuse pile lysimeters on a quarterly basis in 2006. Yearly means of four selected chemical parameters for 2001 through 2006 are presented in Tables III-8 through 10 for the lysimeters from these three reclaimed areas.

**Hybrid Seed Database**. The Land Reclamation and Soil Science Section is conducting a program to obtain hybrid seed information from each farmer for plantings in 2001 through 2006. These data will be correlated with biosolids application and yield data to produce recommendations leading to increased productivity for not only the Fulton County site, but farms in the Chicagoland area that are receiving biosolids from the District's water reclamation plants.

**Miscellaneous Initiatives**. The vast accumulation of data from the inception of the project in 1971 to the current time continued to be organized into various databases as a more convenient format for use by District personnel and other agencies. The databases are made available for public access on the District's web site as they are completed. In 2006, data on surface water and groundwater monitoring were placed on the web site.

**Corn Fertility Experiment on Calcareous Mine Spoil**. Since 1973, the District has had a corn fertility experiment on calcareous mine spoil at the Fulton County site. The purpose of this experiment is to evaluate the effect of long-term applications of anaerobically digested biosolids on crop yields, crop chemical composition, and mine spoil chemical composition. The experiment was designed to simulate biosolids application to fields at the site at agronomic and reclamation rates, and to provide information that can be used for management of biosolids and crops.

This is the longest running continuous biosolids research experiment in the country. Data on the metals uptake in corn tissues from these plots were used in the risk assessments conducted by the USEPA to develop the 40 CFR Part 503 biosolids regulation, which was promulgated in

1993. All 34 years of soil and plant tissue samples are available in the sample repository at the Fulton County R&D Laboratory.

The study consists of four treatments of biosolids or commercial fertilizer applied to the plots each year. The amounts of biosolids or commercial fertilizer added annually for each treatment are listed in Table III-11, along with the cumulative totals of biosolids applied per plot through 2006. Table III-12 shows a four-year comparison (2003-2006) of soil data from the experimental plots. Table III-13 shows the nutrient and metal concentrations in corn grain for the four treatments. Table III-14 shows the comparison of the corn grain and stover yields for 2004 through 2006.

**Phosphorus Studies**. As part of the studies that are conducted to address biosolids phosphorus in 2006, work was done on the Biosolids P Runoff Study located in Field 63 and the Biosolids P Availability Study located in Field 83 at the Fulton County site. Details on this work are presented in the Biosolids P Studies section of this chapter of the report.

## Hanover Park Fischer Farm

The Hanover Park Fischer Farm is a 48-hectare (120 acres) tract of land, which utilizes all biosolids generated at the Hanover Park WRP. The farm, located on the south side of the WRP grounds, has seven gently sloping fields, each surrounded by a berm to control surface runoff. An underground tile drain system collects surface and subsurface drainage, which is returned to the Hanover Park WRP for treatment.

Anaerobically digested biosolids are applied by injection from tank trucks. The IEPA operating permit (No. 2002-SC-0672) for the site limits the annual biosolids application rate to 56 dry Mg/ha (25 dry tons/acre). The crop plan for 2006 included the cultivation of corn in the seven biosolids-treated fields, and 7,766 bushels were harvested, averaging 77 bushels per acre. A total of 15.46 million gallons (MG) of biosolids was applied to the fields during 2006, as opposed to 7.37 MG in 2005. Of the total amount, 5.53 and 8.67 MG were applied in the summer and fall, respectively. No biosolids were applied in the spring. In addition, under a supplemental permit issued by the IEPA, 1.26 MG (2,025 dry tons) of sediment excavated from combined sewer overflow retention ponds at the Hanover Park WRP was applied to Fields 1 and 2 at a rate of approximately 89 dry tons/acre.

Groundwater monitoring is required by the IEPA operating permit. Fields and monitoring locations at the Fischer Farm site are shown in Figure III-1. Four monitoring wells (W-5, W-6, W-7, and W-8) on the farm have been sampled twice monthly since biosolids applications began in 1979. The analytical data for groundwater sampled from these wells were submitted to the IEPA in the quarterly monitoring reports of 2006 (Report Nos. 06-29, 06-51, 06-71, and 07-9). The data show that, overall, the application of biosolids for 27 years has not significantly affected groundwater quality at the Hanover Park Fischer Farm site.

Two shallow wells (W-1 and W-3) located adjacent to the experimental fields have been sampled twice per month since 1988 to monitor the chemical composition of the groundwater. The analytical data for these samples were submitted to the IEPA in quarterly monitoring reports during 2006.

In 2004, several fields were reconfigured by removing the berm between adjacent fields to create new fields as designated in Figure III-1. The five experimental fields were reconfigured to create three separate fields. Seven new farm fields were created by reconfiguring the twelve original fields and designated as follows:

- Field No. 1 - Old Field Nos. 1, 4, and 7
- Field No. 2 - Old Field Nos. 2 and 5
- Field No. 3 - Old Field Nos. 3 and 6
- Field No. 4 - Old Field No. 8
- Field No. 5 - Old Field Nos. 13 and 14
- Field No. 6 - Old Field Nos. 15 and 16
- Field No. 7 - Old Field No. 12

**Groundwater Quality Monitoring at Solids Management Areas**

The Groundwater Quality Monitoring at Solids Management Areas (SMAs) are paved cells used for air drying of lagoon aged or centrifuge cake biosolids to a solids content of 60% or greater.

**Groundwater Quality Monitoring at the John E. Egan WRP SMA**. In 1986, paved solids drying areas were constructed at the John E. Egan WRP facility. However, since all biosolids generated at the Egan WRP are currently utilized as fresh centrifuge cake through the farmland application program, the Egan drying site is no longer being used. The IEPA operating permit (No. 2005-AO-4282) for this drying facility does not require groundwater monitoring unless drying resumes at the site. In October 1986, lysimeters were installed at the John E. Egan WRP for sampling groundwater immediately below the drying site. From June 12, 2003 sampling was discontinued following the IEPA's approval of a request from the District to discontinue monitoring. Hence, the submission of groundwater analytical data in quarterly monitoring reports to the IEPA is not currently required.

**Groundwater Quality Monitoring at the Calumet WRP SMA**. In 1986, a paved solids drying area, the Calumet West SMA, was constructed at the Calumet WRP. In November 1990, a second paved solids drying area, the Calumet East SMA, was put into service at the Calumet WRP. The Calumet East and West SMAs have been continuously utilized for drying biosolids every year since their installation.

The IEPA operating permit (No. 2005-AO-4281) for these facilities requires groundwater monitoring. Lysimeters were installed at the Calumet West SMA in October 1986 for sampling groundwater immediately below the drying site. In November 1990, lysimeters were installed at the Calumet East SMA. The locations of lysimeters at the Calumet East and the Calumet West SMAs are presented in Figures III-2 and 3, respectively.

In May 2005, a replacement lysimeter (L-1N) was installed south of the original device (L-1) at the Calumet East SMA. Both devices are being sampled simultaneously since June 2005 to validate the performance of L-1N. The data collected so far indicated that L-1N is functioning as desired. After one year of simultaneous monitoring, a request was submitted in September 2006 to the IEPA for approval to abandon the old lysimeter L-1.

During 2006, samples were taken once per month at both Calumet drying sites. Analytical data were submitted to the IEPA in the quarterly reports for water samples taken in 2006 from the three lysimeters at the Calumet West SMA (Report Nos. 06-25, 06-52, 06-77, and 07-13) and from the six lysimeters at the Calumet East SMA (Report Nos. 06-26, 06-52, 06-76, and 07-12).

**Groundwater Quality Monitoring at LASMA**. In 1983, the District began biosolids drying operations on clay surface cells at LASMA. These drying surfaces were paved with asphalt in 1984.

The IEPA operating permit for this site (No. 2005-AO-4283) requires groundwater monitoring. Five wells were drilled into the limestone aquifer underlying the site, and were sampled every two weeks, beginning in spring 1983. After one year of biweekly sampling, a quarterly sampling schedule was instituted.

In July 1984, three functional lysimeters (L-1, L-3, and L-4) were installed to facilitate biweekly sampling of groundwater immediately above the limestone bedrock, which is located 6-12 m (20-40 ft) below the surface in this area. In early 1985, six additional lysimeters (L-2, L-5, L-6, L-7, L-8, and L-9) were installed at the site. By April 1985, a total of nine lysimeters were installed at LASMA as required by the IEPA operating permit. A site plan of lysimeters and monitoring wells at LASMA is attached (Figure III-4).

In 1991, increased Hg levels were discovered in lysimeter L-9. An investigation determined that the Hg increase was due to contamination through a particular air pump that was used to sample groundwater in 1991. Other lysimeters were also affected by use of this air pump in 1991, but Hg levels in all lysimeters, except in L-9, decreased after purging the lysimeters with deionized water. A new lysimeter (L-9N) was installed in June 2002, in proximity to the contaminated L-9. Both lysimeters, L-9N and L-9, were sampled simultaneously through 2003 in order to verify that the Hg originated from an external source. Within a few months, the source of contamination was indeed confirmed as external since L-9N samples contained only traces of Hg. Approval was obtained from the IEPA (2000-AO-1384-2) on March 24, 2004 to abandon L-9, and L-9N is the designated replacement for monthly monitoring.

In May 2005, lysimeters L-6, L-7, and L-8 at the LASMA site were replaced with devices L-6N, L-7N, and L-8N, respectively. In December 2005, three additional lysimeters, L-3, L-4, and L-5, were replaced with L-3N, L-4N, and L-5N, respectively. The old and new lysimeters are monitored simultaneously to validate the performance of the new devices. After one year of simultaneous monitoring, a request was submitted in September 2006 to the IEPA for approval to abandon the old lysimeters L-7 and L-8. Monitoring of the old lysimeter L-6 will be continued in 2007 to collect additional data before a request for its abandonment is submitted to the IEPA.

The operating permit for LASMA requires monthly monitoring of 28 parameters in lysimeter samples and 30 parameters in well samples. The analytical results for lysimeter and well samples collected in 2006 were submitted to the IEPA in quarterly monitoring reports (Report Nos. 06-22, 06-55, 06-79, and 07-15).

**Groundwater Quality Monitoring at RASMA**. The solids drying area at RASMA was originally constructed with a clay base. Drying on a clay surface was in progress as early as 1987, until the area was paved with asphalt in 1992 and 1993. Drying operations on asphalt began in June 1993. Lysimeter locations at the RASMA site are shown in Figure III-5.

The IEPA operating permit for this site (No. 2005-AO-4283) requires groundwater monitoring. Four lysimeters were installed approximately 20 feet deep and biweekly groundwater sampling began in September 1993. Three of the four lysimeters rarely yielded water samples. The installation contractor inspected and tested the lysimeters in June 1994 and found that the lysimeters were functioning with no problems. The contractor determined that, due to soil conditions, there was little free water available at the depths at which these three lysimeters were installed. The lysimeters were also inspected in 1999 and 2002. In December 2003, the contractor performed several soil borings in the vicinity of these three devices, and confirmed that they were inadvertently positioned in areas that were not conducive to moisture uptake and/or retention.

In May 2005, new lysimeters L-1N, L-2N, and L-3N were installed as replacements for L-1, L-2, and L-3, respectively. In December 2005, L-4N was installed as a replacement for L-4. The old and new lysimeters are monitored simultaneously to validate the performance of the new devices. After one year of simultaneous monitoring, a request was submitted in September 2006 to the IEPA for approval to abandon the old lysimeters L-1, L-2, and L-3.

The current IEPA operating permit requires biweekly monitoring of 25 groundwater parameters. Analytical results for the lysimeter samples collected during 2006 at this site were submitted to the IEPA in quarterly monitoring reports (Report Nos. 06-30, 06-57, 06-80, and 07-16). During 2006, groundwater quality was consistent with that of previous years.

**Groundwater Quality Monitoring at HASMA**. In 1990, the District began biosolids drying operations at HASMA. The IEPA operating permit for this site (No. 2004-AO-2591) requires biweekly groundwater monitoring. Three lysimeters were initially installed for sampling groundwater immediately below the drying site. A site plan of lysimeter locations at HASMA is shown in Figure III-6.

In 1996, a new lysimeter, designated L-1N, was installed. The NH4-N concentrations in this lysimeter have been high from the time of lysimeter installation, and have been decreasing with time, but biosolids processing at this site is not considered a contributing factor.

A new lysimeter, L-1N-1, was installed in May 2005 as a replacement for L-1N to determine if the high NH4-N concentrations are due to localized contamination at L-1N. The old and new lysimeters are monitored simultaneously to validate the performance of the new device. After one year of simultaneous monitoring, a request was submitted in September 2006 to the IEPA for approval to abandon the old lysimeter L-1N. Analytical data for water sampled from the four lysimeters in 2006 were submitted in quarterly reports to the IEPA (Report Nos. 06-34, 06-54, 06-78, and 07-14).

**Groundwater Quality Monitoring at the 122nd and Stony Island SMA**. In 1980, drying of biosolids at the SMA at 122nd Street and Stony Island Avenue was started on clay surface drying cells. The drying cells were paved in 1992. In 2006, the site was used to dry digested, centrifuged biosolids from the Stickney and Egan WRPs. The dried biosolids were utilized at landfills as daily and final cover to enhance vegetative growth at these sites.

The IEPA operating permit for this drying facility (No. 2005-AO-4283) requires groundwater monitoring. Four lysimeters were installed in September 1991 for sampling groundwater immediately below the drying site. Figure III-7 shows the location of lysimeters at the Stony Island drying site. Analytical results for water sampled monthly during 2006 from the four lysimeters at this drying facility were submitted to the IEPA in quarterly monitoring reports (Report Nos. 06-31, 06-56, 06-81, and 07-17). In 2006, groundwater quality was similar to that of the previous years.

## Biosolids Phosphorus Studies

Land application of biosolids and other soil amendments can cause phosphorus (P) in soils to increase to excessive levels that can potentially contaminate water bodies through surface runoff. Currently, a large portion (over 35 percent) of the District's biosolids is managed through the farmland application program in which Class B centrifuge cake biosolids are used as fertilizer on area farms. In an effort to minimize P contamination of surface waters, many states are beginning to implement phosphorus-based (P-based) agronomic biosolids application rates in place of the nitrogen-based (N-based) application rates that are currently used. Phosphorus-based application rates are developed based on P content of both the amendments and the soil, and on site characteristics that affect the potential for surface runoff to water bodies. The P-based agronomic biosolids application rates are much lower than the N-based rates. The P-based rates may substantially reduce the viability of land application programs in Illinois, because the low application rates of biosolids could be operationally impractical and unattractive to farmers.

In 2003, the Biosolids Utilization and Soil Science Section began to collaborate with the IEPA to initiate studies to address the potential for environmental impacts associated with application of District biosolids to cropland. Studies were developed to address the following objectives:

1. To determine the bioavailability of P in District biosolids.

2. To estimate the critical biosolids P application rate (environmental impact threshold) to farmland above which the potential for P losses in surface run-off water increases significantly.

3. To evaluate potential for P losses in runoff following recent application of centrifuge cake biosolids and aged air-dried biosolids which are either surface applied or incorporated in soil.

4. To evaluate the effectiveness of two lengths of vegetated buffer strips established in the setback zones of land application fields in controlling P runoff. The information obtained from this objective will be used to determine if buffer strips can be used within the required setback zone to allow the land application of biosolids to be continued at N-based rates without the potential for significant P runoff losses from farmland, where soil test P exceeds environmental impact thresholds.

In 2006, work was conducted on the following studies:

- Bioavailability of P in District biosolids - Greenhouse study
- Bioavailability of P in District biosolids - Field study
- Potential of phosphorus runoff in biosolids amended soils
- Biosolids P runoff field study

**Bioavailability of P in District Biosolids – Greenhouse Study**. The greenhouse study was started in 2004. The study was designed to evaluate the bioavailability of P in the District's air-dried Class A biosolids and centrifuge cake Class B biosolids, relative to triple superphosphate (TSP) fertilizer P (Objective 1). Seven-kilogram portions of a P-deficient sandy soil were blended with each of these three P sources to apply similar total P rates of 25, 50, 100, 150, 200, and 300 mg P/kg soil. An unamended control was also included. Four replicates of each treatment were prepared. The treated soils were placed in plastic bags and wetted to approximately 80 percent of field capacity moisture content, then incubated for 3 weeks in the laboratory. Following incubation, a sample of the amended soils was taken, then the soils were placed in pots in the greenhouse to form a 15-cm amended soil layer on top of a 20-cm deep layer of unamended soil. Wheat (*Triticum aestivum* cv. Patton) was planted in the pots in May 2004. The foliage of the wheat crop was clipped every 35 to 40 days and allowed to regrow. This sequence was continued for a total of four cycles. Following the fourth wheat clipping, a sample of the 0 to 12.5-cm soil layer was collected, then the pots were planted with ryegrass (*Lolium perene* cv. Pleasure) for another four cycles. In order to deplete all pots of the applied P, as indicated by consistent P deficiency levels in the harvested foliage, this sequence of alternating wheat and ryegrass cropping was continued for a total of 18 foliage clippings (after the 16 clippings, an additional two clippings of wheat were done).

The foliage at each clipping were weighed to determine dry matter yield, then analyzed for total P content. For each greenhouse pot, P uptake in the crop foliage was calculated as the product of foliage P concentration and dry matter yield. Soil samples collected from the pots at the beginning of each cropping cycle were analyzed for total P, water soluble P (WSP), and soil test P by the Bray P1 and Mehlich 3 methods.

The effect of P added through the application of the Class A and Class B biosolids and the TSP on cumulative P uptake in the eighteen foliage clippings are presented in Figure III-8. The data show that for each of the four cropping sequences, the cumulative P uptake from the three P sources was similar up to the 50 mg P/kg (350 mg P/pot) application rate. At the higher application rates, cumulative P uptake during the first sequence (Clippings 1-4) was much lower in the biosolids treatments than in the TSP treatment. The data in Figure III-8 show that subsequently (Clippings 5-8, 9-12, and 13-18), less additional P was taken up in the fertilizer treatments compared to the biosolids treatments, such that cumulative P uptake in the biosolids treatments tended to approach the uptake observed in the TSP treatments. These data indicate that immediately following application at rates above approximately 50 mg P/kg to a P-deficient soil, fertilizer P is more bioavailable than biosolids P and levels in the soil are depleted faster over time. The bioavailability of biosolids P is lower, but is sustained over a longer period.

**Bioavailability of P in District Biosolids – Field Study**. A study was initiated in 2005 at the District's Fulton County site at Field 83, which consists of non-mined soil, to test the bioavailability of biosolids P under field conditions (Objective 1). Before starting the study, the field was cropped for three years without fertilizer P application to deplete the soil to a P deficient level (less than 20 mg P/kg Bray P1 soil test level). This study will evaluate crop P uptake in soil amended with two P sources: Class A air-dried biosolids from the Calumet WRP and TSP fertilizer. The experimental layout is a randomized complete block design with four blocks of 10 treatments. The treatments include a control of zero application, sets of four each of TSP and biosolids application established based on the total P loadings associated with biosolids application rates, ranging up to 22.4 Mg/ha (10 dry tons/ac), and a high biosolids rate of 33.6 Mg/ha (15 dry tons/ac). The 10 dry tons/ac rate is equivalent to the average agronomic rate of Class B biosolids utilized in the District's farmland application program. The high biosolids rate of 15 dry tons/ac was used based on the preliminary results from the greenhouse component of the bioavailability study, which indicated that the bioavailability of the biosolids P is much lower than TSP fertilizer P. In November 2005, the treatments (biosolids and TSP fertilizer) were applied to plots 90 feet wide by 120 feet long (0.25 acres) and incorporated into the plow layer (approximately 6 inches). Corn will be planted as the test crop in the spring of 2006, 2007 and 2008, with only application of supplemental K and N fertilizer, and no additional application of biosolids or TSP treatments. Soil samples will be collected at the beginning of each growing season to measure soil P concentration. Crop samples will be collected to measure grain and dry matter yields and tissue P concentration.

**Potential for P Runoff in Biosolids Amended Soils**. This study was conducted to address Objective 3, to evaluate potential for P losses in runoff following recent applications of centrifuge cake biosolids and aged air-dried biosolids that are either surface applied or incorporated in soil. This P runoff experiment was done using the protocol of the National P Research Project (NPRP) which was established by the Southern Extension Research Activity (SERA-17). The SERA-17 group was organized through the Cooperative State Research, Education, and Extension Service of the US Department of Agriculture (USDA). The group consists of scientists from Land Grant Universities and the USDA Agricultural Research Service.

In 2006, a simulated P runoff experiment was conducted with following treatments:

- Three P Sources – Centrifuge cake biosolids, aged air-dried biosolids, and TSP
- Two application methods – surface and incorporation
- Two P Rates – N-based (P rate associated with agronomic N rate) and P-based (based on agronomic P requirement)

The soil was amended with biosolids according to above treatments. In case of TSP treatments, incorporation was the only application method, because this is the conventional method of application. An unamended control was also included. Three replicates of each treated soil and the control were packed into 5 cm deep metal trays (100-cm long x 20-cm wide x 7.5-cm high), then wetted to saturation and placed on racks at a 5 percent slope under a rainfall simulator canopy. Simulated rainfall was applied as reverse osmosis water through a TeeJet 1/2 HH SS 50 WSQ nozzle at a rate of 7.0 cm/hr. The runoff generated during a 30-min period was collected and the trays were stored. A total of three rainfall events were conducted on each tray, on days 1, 3, and 7 after the initial wetting. Samples of the runoff water were analyzed for Dissolved Molybdate Reactive P (DMRP), Particulate P, Dissolved Organic P and Total P content.

Table III-15 shows the content of DMRP, Dissolved Organic P, Particulate P, and Total P losses in runoff from various treatments. Runoff P losses decreased from day 1 to day 7, and were generally higher in biosolids than in TSP treatments. Runoff P losses were significantly lower when biosolids were incorporated compared to surface application and at P-based rate compared to N-based rate. In general, DMRP losses were in the order aged air-dried biosolids> centrifuge cake biosolids>TSP. However, particulate P and total P losses were greater in centrifuge cake biosolids treatments than aged air-dried biosolids treatments. In all treatments, most of the total P loss in runoff was particulate P. These data show that P runoff losses are lower when biosolids are incorporated compared to surface application, and management practices which reduce erosion and transport of particulate matter in runoff will reduce P losses in biosolids amended fields.

**Biosolids P Runoff Field Study**. This study was designed to address Objective 3, to evaluate the effectiveness of different lengths of vegetated buffer strips. In 2004, five noncontiguous locations in Field 63 at the Fulton County site were selected as main plots. Each of the main plots was 0.72-ha (1 ac), 122 m (400 ft) long along the slope by 61 m (200 ft) wide, and was split into two subplots 30.5 m (100 ft) wide by 61 m (200 ft) long. The plots were graded lightly to improve surface uniformity such that the slope throughout most of the plots ranged from 3 to 5 percent. A vegetated buffer area was established by planting a mixture of alfalfa (*Medicago sativa* L.) and bromegrass (*Bromus inermis*) on the entire 61-m length of the down-slope portion of the main plots. In each subplot, runoff collection devices were installed at the up-slope end, the middle (30.5 m), and the down-slope end (61 m) of the buffer strip. The typical layout of the main plots is shown in Figure III-9. This setup will allow us to evaluate the effectiveness of two lengths of vegetative buffer strips, 30.5 m and 61 m, in controlling P runoff from the amended portion of the subplots. The current surface water setback in the IEPA Part 391 design criteria for land application of biosolids is 61 m.

In spring 2005, biosolids were applied to the up-slope half of eight of the subplots at two loading rates of 11.25 and 22.5 Mg/ha (5 and 10 dry tons/ac), such that there were four replicates of each amended plot and two unamended control plots. The 22.5 Mg/ha biosolids rate represent the typical N-based application rate of District biosolids. Only a few samples were collected in 2006, due to inadequate design of the runoff collection system. The runoff collection system in the plots is being redesigned so that in 2008, we can collect data on not only concentrations of dissolved and particulate P in runoff water, but also can collect data on runoff volumes to evaluate mass of P runoff.

## Farmland Application of Class B Biosolids Project

A major portion of the District's biosolids is managed through farmland application of Class B centrifuge cake. Farmland application of Class B biosolids is cost-effective to the District and the nutrients in biosolids provide tremendous savings in fertilizer costs to the farmers. However, the practice of Class B biosolids application to farmland remains controversial and has been persistently attacked by the environmentalists. Most of the concerns stem from misinformation about the potential human health and environmental risks from pathogens and trace metals in the Class B biosolids applied to farmland. These concerns need to be addressed to protect the viability and sustainability of the District's Class B centrifuge cake biosolids application to farmland program.

In the fall of 2004, the District began a research and demonstration project on farmers' fields in Will and Kankakee Counties to demonstrate the safety of farmland application of Class B centrifuge cake biosolids and to improve the overall public perception and understanding of communities residing in the vicinities of biosolids-amended farmlands. A large proportion of the District's Class B biosolids is currently being applied to farmland in these two counties.

**Plots and Treatments**. The project was designed to evaluate and compare the impact of various rates of biosolids (0 to 200 percent of conventional agronomic application rate) and commercial N fertilizer (0 to 150 percent of agronomic N application rate) application on soil fertility, corn yield, and subsurface water quality. Plots were established on a 40-acre parcel of clayey soil in the township of Florence in Will County and on a 20-acre parcel of sandy soil in the township of Saint Anne in Kankakee County. Prior to biosolids application, lysimeters were installed at each site for monitoring the impact of biosolids application on subsurface water quality. Details of plot layout, treatments, and location of lysimeters are given in Figure III-10. The anticipated duration of the research and demonstration project is three years.

Following the conventional practices in each county, the biosolids and fertilizer treatments are applied in the fall at the Will County site and in the spring just before planting at the Kankakee County site each year. The fall application in Will County is done to reduce the amount of field work required in the spring because the heavy textured soils drain slowly, and tend to stay wet for longer periods of time, which may leave only a narrow window for completing the required field work before planting. The treatments are applied similarly each year for the duration of the project. Keeping this in mind, the treatments were applied in fall 2004, 2005, and 2006 at the Will County site and in spring 2005, 2006, and 2007 at the Kankakee County site.

**Sampling and Analyses**. Details of the sampling schedule and analysis of soil, plant tissues, and water samples are given in Table III-16. Soil sampling was done at both sites prior to application of biosolids and after harvesting corn in the fall. At the Will County site, soil was sampled at four depths (15, 30, 60, and 90-cm depths). At the Kankakee County site, soil was sampled at four depths (15, 30, 60, and 120-cm depths). The soil samples were air-dried, ground, and sieved through a 2-mm sieve and stored in plastic bottles for chemical analysis.

**Soil Fertility**. The results of soil analysis for the 0- to 6-inch depth for both the Will and Kankakee County plots are presented in Table III-17. In the Will County plots, the inorganic N levels in soil fluctuated, but overall N levels showed increase after biosolids application (Table III-17). In the Kankakee County plots, the data show that most of the applied N was removed from the plow layer (0 to 6 inches), except in the highest rates of biosolids plots in which some accumulation of residual inorganic N was observed in the plow layer. The relatively low levels of residual inorganic N observed in soil compared to the amount of N applied indicate that most of the applied N was utilized by the crop, especially at the Will County site where very little movement of inorganic N is expected below the plow layer (Table III-17).

**Nutrients and Trace Metals in Subsurface Water**. The mean concentrations of nutrients and trace metals in the subsurface water samples collected from lysimeters in the Will and Kankakee County plots during March through November 2006 are presented in Tables III-18 and III-19, respectively. In the Will County plots, there was no noteworthy trend in TKN, $NO_3$-N and total P concentrations in lysimeter samples over time. The highest $NO_3$-N value was observed in the lysimeters from the 40 wet tons/ac biosolids and 260 lbs/ac N plots (Table III-18). Interestingly, the mean $NO_3$-N in the lysimeter from the 80 wet ton/ac biosolids plot was considerably lower than in the 40 wet tons/ac biosolids and 260 lbs/ac N fertilizer plots.

Similarly, in the Kankakee County lysimeters, there were no noteworthy trends in TKN, $NH_3$-N and total P concentrations over time. The mean $NO_3$-N concentrations ranged from 3.8 to

22.3 mg/L and the highest values were observed in the lysimeters from 30 wet tons/ac biosolids plot (Table III-19).

The mean trace metal concentrations observed for most of the lysimeters at both Will and Kankakee County plots were very low and were either below or close to the detection limits (Tables III-18 and III-19). There was no trend among the plots amended with various rates of fertilizers and biosolids. The data suggest that there was no leaching of trace metals from biosolids-amended soils.

**Grain Yield**. The corn yield response to application rates of fertilizer N and biosolids in the Will and Kankakee County plots are presented in Figure III-11. For the biosolids treatments, the amount of plant available N was calculated using the conventional formula. At the Will County plots, corn grain yields generally increased with increasing rates of fertilizer N and biosolids (Figure III-11A). The highest corn grain yield in the fertilizer treatments (189 bu/ac) was observed in the 370 lbs/ac N plot, and the highest corn yield in the biosolids treatments (201 bu/ac) was observed in the 80 wet ton/ac biosolids plot.

In the Kankakee County plots the corn grain yield generally increased with application of fertilizer N, except in the biosolids plots in which the highest yield was observed in the 10 wet ton/ac biosolids treatment. This was caused by the lack of moisture because the biosolids plots, except the 10 wet ton/ac biosolids treatment, were outside the irrigation pivot range and were not properly irrigated (Figure III-11B).

## Technical Support for Biosolids Management

The Biosolids Utilization and Soil Science Section provides technical support for biosolids management to both the M&O Department and biosolids users. This ensures full regulatory compliance of these projects and enhances the successful and safe use of the District's biosolids. The Section is also responsible for conducting and communicating the results of applied research on the beneficial use of the District's biosolids. The objectives of this research are to provide information on agronomic and environmental impacts of biosolids and to promote the beneficial use of biosolids. The support the section provides to the biosolids management program consists of the following:

1. Monitoring of air-dried biosolids products for compliance with USEPA and IEPA standards.

2. Collecting samples for internal studies and external requirements.

3. Reporting relevant data and information to contractors, biosolids users, IEPA, and USEPA.

4. Providing oversight support for District contracts for application of Class B centrifuge cake biosolids to farmland.

5. Educating biosolids users to ensure compliance with state and federal regulations governing biosolids use, and to provide technical information related to specific planned uses of biosolids.

6. Documenting biosolids use at major projects to produce case studies to promote future use of biosolids.

7. Initiating and documenting demonstration scale projects using biosolids to increase public acceptance and promote future projects.

8. Providing surveillance and documentation of management practices at local biosolids use projects.

9. Maintaining year-round demonstrations of biosolids as a soil conditioner in the Lue-Hing R&D Complex greenhouse and hosting tours to educate potential biosolids users and promote local marketing.

10. Conducting applied research on agronomic and environmental aspects of biosolids use as a fertilizer, soil conditioner and topsoil substitute.

11. Presenting information at local and national scientific conferences and at meetings with potential biosolids users, promoting the beneficial use of the District's biosolids.

12. Interacting with state and federal regulators to defend the District's biosolids management activities, review and comment on development of new regulations, and obtain permitting or approval for new biosolids projects.

13. Providing technical support on District initiative on stormwater management.

In 2006, the Section provided technical support, in the form of one or more of the activities listed above for several biosolids projects and potential users. Examples of biosolids projects conducted, or supported, by the section in 2006 include:

1. Rehabilitation of fairways using biosolids as a soil conditioner and topsoil substitute at the Chalet Hills, Longwood Country Club, and Cinder Ridge golf courses.

2. Development of athletic fields using biosolids as a soil conditioner by Westmont Park District, Village of Evergreen Park, St. Laurence High School, University of Chicago, Notre Dame High School, University of Illinois-Chicago, Crete-Monee School District, Plainfield School District, and Village of Steger.

3. Use of biosolids as a topsoil substitute in the final protective layer at various landfills.

4. Maintenance of plots to demonstrate the beneficial use of Class B biosolids on farmland.

5. Collaborate with the University of Florida, Pennsylvania State University, and the IEPA on field and rainfall simulation studies at Fulton County and in the greenhouse at Stickney to evaluate the environmental impacts of phosphorus in land applied biosolids.

6. Continue collaborative research with North Shore Country Club to assess the effectiveness of biosolids as a substitute for peat and other soil amendments typically utilized in construction of golf course greens and fairways.

7. Collaborate with University of Illinois to operate research and demonstration plots at various golf courses and recreational fields.

8. Collaborate with the city of Chicago to evaluate and promote the use of biosolids for development of parks and recreational areas in Chicago.

9. Review field information packets for potential application fields under the Class B biosolids to farmland contract. This includes reviewing the field location, buffers established for surface water, roads and dwellings, contacts made with neighbors and public officials, and soil pH and liming. Approval or disqualification of the proposed fields is recommended to the M&O Department.

10. Preparation of biosolids information pamphlets to promote local marketing of biosolids.

11. Marketing of biosolids through attendance and exhibitions at various local conferences, mass mailing of promotional materials and phone calls to school districts and other potential biosolids users.

**Technical Support for Native Landscaping**

During 2006, the section provided technical support for installation and maintenance of native prairie landscaping at the District's WRPs. The activities included review of contracts prepared by the M&O Department, project-planning meetings with M&O and contractors, herbicide application, and onsite visits to assist in conducting performance evaluation of the native landscaping.

**Technical Support for Stormwater Management**

During 2006, the section worked with the Engineering and the Maintenance and Operations Departments to evaluate options for stormwater management. The activities include:

1. Member of the green roofs task group – One product of the task group was a position paper on the potential use of green roofs at District facilities.

2. A literature review on green roof technology.

3. Attendance at local seminars and demonstrations.

TABLE III-1: MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2006[1]

| Field Number | Cumulative Biosolids Applied[2] | | pH | EC | Organic Carbon | TKN | Tot.-P | $NH_3$-N[3] | $NO_2$-N+ $NO_3$-N[3] | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mg/ha | tons/acre | | (dS/m) | (%) | Mg/kg | | | | | | | | | |
| 1 | 1,736 | 775 | 6.5 | 0.39 | 5.26 | 5277 | 10429 | 17.4 | 45.2 | 1025 | 62.4 | 499 | 743 | 108 | 234 |
| 2 | 1,816 | 811 | 6.4 | 0.54 | 5.18 | 5693 | 10985 | 14.0 | 88.2 | 998 | 56.6 | 463 | 677 | 99.6 | 224 |
| 3 | 1,815 | 810 | 6.4 | 0.39 | 5.88 | 6281 | 9624 | 18.9 | 49.4 | 890 | 49.3 | 417 | 574 | 82.9 | 213 |
| 4 | 1,522 | 680 | 6.5 | 0.42 | 5.01 | 5351 | 9162 | 14.4 | 66.6 | 834 | 45.4 | 389 | 566 | 85.2 | 190 |
| 5 | 1,565 | 699 | 6.5 | 0.68 | 4.97 | 5699 | 9861 | 12.6 | 113.4 | 904 | 46.2 | 423 | 588 | 87.6 | 199 |
| 6 | 614 | 274 | 7.2 | 0.15 | 2.29 | 2259 | 2616 | 4.9 | 1.9 | 294 | 17.7 | 131 | 230 | 44.9 | 69.8 |
| 7E | 1,494 | 667 | 6.7 | 0.20 | 4.30 | 4486 | 7801 | 12.1 | 10.2 | 836 | 52.1 | 404 | 634 | 93.2 | 197 |
| 7W | 1,494 | 667 | 7.0 | 0.16 | 2.51 | 2697 | 4368 | 5.1 | 7.3 | 421 | 24.0 | 188 | 303 | 52.4 | 98.3 |
| 8 | 1,320 | 589 | 6.6 | 0.19 | 4.14 | 4881 | 10133 | 10.8 | 11.7 | 906 | 56.6 | 451 | 684 | 93.5 | 216 |
| 9 | 1,605 | 717 | 6.7 | 0.60 | 4.58 | 4054 | 6582 | 10.0 | 81.8 | 640 | 32.8 | 303 | 427 | 70.9 | 137 |
| 10 | 1,073 | 479 | 6.3 | 0.21 | 4.68 | 4545 | 10642 | 6.7 | 19.2 | 1132 | 79.0 | 597 | 985 | 119 | 302 |
| 11 | 1,486 | 663 | 6.7 | 0.26 | 4.35 | 4442 | 9624 | 4.4 | 26.3 | 929 | 59.9 | 433 | 717 | 102 | 239 |
| 12 | 1,397 | 624 | 6.8 | 0.20 | 3.35 | 3678 | 7666 | 4.6 | 13.6 | 743 | 46.7 | 362 | 554 | 82.8 | 185 |
| 13 | 1,367 | 610 | 6.5 | 0.27 | 4.55 | 4508 | 9778 | 7.2 | 28.0 | 927 | 55.1 | 443 | 646 | 88.8 | 219 |
| 14 | 1,472 | 657 | 6.6 | 0.32 | 4.13 | 4890 | 11288 | 9.1 | 39.4 | 933 | 55.2 | 454 | 678 | 95.6 | 227 |
| 15 | 1,482 | 662 | 6.7 | 0.33 | 4.07 | 4849 | 9970 | 9.8 | 37.4 | 819 | 42.5 | 383 | 536 | 78.7 | 184 |
| 16E | 1,510 | 674 | 6.6 | 0.34 | 3.12 | 3693 | 7935 | 6.4 | 56.5 | 713 | 45.8 | 349 | 561 | 77.9 | 179 |
| 16W | 1,510 | 674 | 6.5 | 0.40 | 3.38 | 3785 | 8523 | 6.4 | 92.0 | 759 | 48.5 | 372 | 589 | 80.7 | 189 |
| 17 | 1,724 | 769 | 6.6 | 0.56 | 5.57 | 5557 | 12619 | 7.0 | 86.2 | 993 | 55.3 | 497 | 673 | 102 | 236 |
| 18 | 1.0 | 0.5 | 6.9 | 0.17 | 1.72 | 1386 | 461 | 5.7 | 3.2 | 54.3 | 0.98 | 15.3 | 21.2 | 16.9 | 13.3 |
| 19 | 644 | 287 | 6.7 | 0.16 | 2.17 | 2134 | 4185 | 5.4 | 12.4 | 515 | 33.3 | 241 | 408 | 55.7 | 135 |

TABLE III-1 (Continued): TABLE III-1: MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2006[1]

| Field Number | Cumulative Biosolids Applied[2] | | pH | EC | Organic Carbon | TKN | Tot.-P | $NH_3$-N[3] | $NO_2$-N+ $NO_3$-N[3] | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mg/ha | tons/acre | | (dS/m) | (%) | ---------------------------------------------- | | | Mg/kg | | | | | | ---------------------------------------------- |
| 20 | 531 | 237 | 6.3 | 0.46 | 3.34 | 3353 | 5169 | 21.2 | 83.8 | 609 | 40.9 | 301 | 499 | 66.8 | 158 |
| 21 | 618 | 276 | 6.7 | 0.17 | 2.29 | 2139 | 4047 | 5.5 | 15.3 | 546 | 37.0 | 252 | 431 | 60.1 | 143 |
| 22 | 455 | 203 | 6.6 | 0.18 | 2.93 | 3008 | 5955 | 6.0 | 16.8 | 672 | 46.5 | 324 | 551 | 72.7 | 181 |
| 23 | 473 | 211 | 6.5 | 0.15 | 2.51 | 2466 | 4898 | 5.9 | 12.4 | 569 | 38.7 | 268 | 452 | 64.7 | 149 |
| 24 | 1.1 | 0.5 | 7.5 | 0.16 | 1.16 | 836 | 371 | 1.9 | 5.2 | 58 | 1.21 | 18 | 25.6 | 23.9 | 10.9 |
| 25 | 870 | 388 | 6.7 | 0.44 | 4.55 | 4483 | 6626 | 8.0 | 26.9 | 771 | 43.6 | 348 | 521 | 74.9 | 185 |
| 26 | 1,087 | 485 | 6.9 | 0.45 | 3.67 | 4281 | 7284 | 7.3 | 27.7 | 746 | 43.6 | 350 | 507 | 83.5 | 175 |
| 27 | 847 | 378 | 6.8 | 0.27 | 3.64 | 4822 | 8548 | 9.3 | 18.9 | 867 | 50.4 | 404 | 572 | 89.6 | 199 |
| 28 | 903 | 403 | 7.0 | 0.30 | 4.07 | 4715 | 8225 | 7.8 | 22.3 | 812 | 49.8 | 415 | 605 | 98.2 | 193 |
| 29 | 1.2 | 0.5 | 7.7 | 0.15 | 0.96 | 878 | 436 | 3.7 | 2.3 | 55.3 | 1.05 | 15.4 | 21.2 | 20.3 | 10.7 |
| 30 | 1,169 | 522 | 7.0 | 0.28 | 3.67 | 4751 | 8419 | 9.2 | 20.1 | 843 | 45.9 | 387 | 546 | 90.4 | 186 |
| 31 | 557 | 249 | 6.7 | 0.14 | 2.17 | 1512 | 3176 | 6.5 | 6.5 | 442 | 28.6 | 202 | 343 | 55.4 | 112 |
| 32 | 602 | 269 | 6.9 | 0.30 | 4.11 | 4212 | 8574 | 10.2 | 21.4 | 634 | 33.0 | 296 | 398 | 72.3 | 140 |
| 33 | 1,110 | 495 | 6.8 | 0.39 | 5.09 | 4896 | 11000 | 13.9 | 36.4 | 914 | 49.8 | 464 | 613 | 94.5 | 194 |
| 34 | 567 | 253 | 6.8 | 0.19 | 2.54 | 1910 | 4840 | 6.2 | 19.3 | 615 | 42.0 | 303 | 506 | 69.9 | 162 |
| 35 | 1,049 | 468 | 6.7 | 0.23 | 3.49 | 3432 | 8180 | 11.4 | 18.8 | 757 | 41.3 | 351 | 508 | 70.5 | 167 |
| 36 | 1,083 | 483 | 6.7 | 0.23 | 3.49 | 3438 | 7888 | 12.2 | 14.3 | 853 | 49.2 | 400 | 594 | 82.1 | 189 |
| 37 | 802 | 358 | 6.7 | 0.19 | 2.87 | 2717 | 6326 | 8.5 | 11.3 | 753 | 44.6 | 351 | 541 | 79.4 | 168 |
| 38A | 9.4 | 4.2 | 7.4 | 1.02 | 1.51 | 1953 | 749 | 2.1 | 5.1 | 126 | 1.89 | 26.7 | 33.9 | 43.2 | 24 |
| 38C | 9.4 | 4.2 | 7.7 | 0.19 | 1.60 | 1017 | 508 | 1.5 | 8.5 | 82.4 | 1.62 | 22.2 | 32.8 | 29.7 | 17.1 |
| 39 | 646 | 288 | 7.0 | 0.32 | 3.49 | 4072 | 8358 | 8.9 | 21.9 | 633 | 29.6 | 291 | 360 | 64.9 | 125 |

TABLE III-1 (Continued): TABLE III-1: MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2006[1]

| Field Number | Cumulative Biosolids Applied[2] | | pH | EC | Organic Carbon | TKN | Tot.-P | $NH_3$-N[3] | $NO_2$-N+ $NO_3$-N[3] | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mg/ha | tons/acre | | (dS/m) | (%) | Mg/kg | | | | | | | | | |
| 40 | 497 | 222 | 5.3 | 0.19 | 3.66 | 3120 | 5607 | 4.5 | 13.6 | 727 | 49 | 371 | 591 | 83.8 | 184 |
| 41 | 979 | 437 | 6.9 | 0.35 | 4.90 | 5382 | 9172 | 10.5 | 24.2 | 686 | 27.5 | 319 | 339 | 59.4 | 131 |
| 42 | 858 | 383 | 6.9 | 0.23 | 3.96 | 3968 | 8018 | 10.8 | 12.3 | 799 | 48.8 | 397 | 585 | 83.1 | 189 |
| 43 | 983 | 439 | 6.9 | 0.41 | 4.11 | 5151 | 9730 | 10.2 | 35.8 | 726 | 33.5 | 349 | 393 | 63.4 | 152 |
| 44 | 805 | 360 | 6.8 | 0.31 | 3.97 | 5063 | 8956 | 10.7 | 19.3 | 754 | 39.3 | 387 | 455 | 75.6 | 157 |
| 45 | 845 | 377 | 6.9 | 0.29 | 3.78 | 3797 | 7282 | 8.4 | 15.8 | 653 | 32.9 | 320 | 409 | 64.5 | 142 |
| 47 | 1,121 | 500 | 6.6 | 0.38 | 5.09 | 5019 | 10415 | 12.1 | 30.5 | 1008 | 48.7 | 477 | 613 | 87.7 | 205 |
| 50 | 6.6 | 3.0 | 7.0 | 0.12 | 1.41 | 1095 | 419 | 3.2 | 6.0 | 49.7 | 1.10 | 15 | 22.2 | 20.0 | 12.3 |
| 51 | 47 | 21 | 7.1 | 0.17 | 1.16 | 1051 | 609 | 4.2 | 5.6 | 73.2 | 1.9 | 23.1 | 33.4 | 20.7 | 21.2 |
| 52 | 9.1 | 4.1 | 6.9 | 0.12 | 1.05 | 1101 | 406 | 3.0 | 6.8 | 58.1 | 1.12 | 16.4 | 23.0 | 22.8 | 10.8 |
| 53 | 5.2 | 2.3 | 7.6 | 0.25 | 1.88 | 1772 | 457 | 4.1 | 2.6 | 56.2 | 1.20 | 17.1 | 20.4 | 22.5 | 9.68 |
| 54 | 14 | 6.4 | 7.6 | 0.23 | 1.51 | 1415 | 563 | 2.6 | 7.9 | 69.6 | 1.36 | 21.1 | 24.1 | 32.4 | 12.6 |
| 55 | 9.4 | 4.2 | 7.1 | 0.49 | 1.70 | 1641 | 588 | 3.4 | 10.1 | 67.1 | 1.35 | 22.4 | 25.0 | 33.1 | 14.7 |
| 56 | 13 | 5.9 | 7.5 | 0.20 | 0.98 | 1033 | 662 | 2.7 | 5.4 | 56.4 | 1.22 | 19.7 | 24.4 | 31.6 | 13.7 |
| 57 | 2.9 | 1.3 | 7.7 | 0.19 | 1.04 | 1184 | 453 | 1.8 | 0.7 | 49.1 | 1.13 | 16.7 | 22.5 | 24.7 | 7.55 |
| 58 | 5.4 | 2.4 | 7.6 | 0.24 | 1.98 | 1872 | 489 | 1.8 | 5.3 | 53.9 | 1.19 | 16.4 | 21.8 | 24.9 | 7.88 |
| 59 | 2.5 | 1.1 | 6.7 | 0.12 | 1.23 | 1205 | 424 | 3.3 | 10.5 | 48.1 | 0.85 | 12.4 | 17.8 | 14.0 | 18.1 |
| 60 | 3.2 | 1.5 | 7.6 | 0.20 | 1.51 | 2082 | 573 | 0.7 | 11.8 | 51.4 | 1.11 | 19 | 22.2 | 24.9 | 9.18 |
| 61 | 2.3 | 1.0 | 7.6 | 0.41 | 1.98 | 1420 | 639 | 0.6 | 10.9 | 67 | 1.36 | 22.2 | 23.8 | 31.4 | 12.3 |
| 62 | 5.4 | 2.4 | 7.5 | 0.17 | 1.60 | 1345 | 467 | 1.2 | 6.2 | 50.8 | 1.10 | 17.6 | 23.7 | 23.9 | 10.2 |
| 63 | 22 | 9.6 | 7.3 | 0.25 | 1.98 | 1888 | 492 | 0.9 | 13.3 | 54.5 | 1.10 | 20.5 | 24.6 | 26.3 | 9.38 |

TABLE III-1 (Continued): TABLE III-1: MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2006[1]

| Field Number | Cumulative Biosolids Applied[2] | | pH | EC | Organic Carbon | TKN | Tot.-P | $NH_3$-N[3] | $NO_2$-N+ $NO_3$-N[3] | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mg/ha | tons/acre | | (dS/m) | (%) | Mg/kg | | | | | | | | | |
| 64 | 2.3 | 1.0 | 7.5 | 0.37 | 1.70 | 1292 | 715 | 1.1 | 9.7 | 89.9 | 1.38 | 22.3 | 25.0 | 34.3 | 14.4 |
| 65 | 0.4 | 0.2 | 7.3 | 0.46 | 1.08 | 1152 | 670 | 1.4 | 6.7 | 82.7 | 1.29 | 23.0 | 26.1 | 34.0 | 14.3 |
| 73 | 0 | 0 | 7.8 | 0.23 | 0.94 | 1034 | 451 | 3.2 | 6.1 | 58.9 | 1.19 | 18.4 | 22.9 | 25.0 | 11.4 |
| 75 | 336 | 150 | 7.2 | 0.16 | 1.45 | 1594 | 2755 | 3.1 | 15.3 | 332 | 23.3 | 159 | 279 | 45.5 | 95.0 |
| 76 | 0 | 0 | 7.4 | 0.23 | 1.06 | 1028 | 411 | 2.7 | 25.0 | 53.8 | 1.40 | 16.4 | 23.4 | 20.7 | 10.3 |
| 80 | 0 | 0 | 5.6 | 0.12 | 0.90 | 1023 | 395 | 4.3 | 15.6 | 50.8 | 0.75 | 10.2 | 17.4 | 15.9 | 14.4 |
| 81 | 0 | 0 | 6.3 | 0.09 | 1.51 | 1538 | 418 | 2.8 | 2.8 | 44.4 | 0.67 | 8.28 | 16.7 | 15.0 | 13.5 |
| 82 | 0 | 0 | 5.9 | 0.11 | 1.28 | 1174 | 431 | 4.9 | 10.5 | 52.0 | 0.90 | 10.4 | 17.4 | 15.4 | 16.9 |
| 83 | 0 | 0 | 5.9 | 0.16 | 1.28 | 1213 | 441 | 3.4 | 19.1 | 55.0 | 0.87 | 10.2 | 14.7 | 12.4 | 16.9 |
| 84 | 0 | 0 | 7.5 | 0.13 | 1.17 | 1068 | 481 | 2.4 | 9.0 | 68.2 | 1.26 | 17.4 | 23 | 23.6 | 11.5 |

[1]Sampling depth 0-15 cm.
[2]Through 2006.
[3]1-M KCl-extractable.

TABLE III-2: 2006 FULTON COUNTY CROP YIELD DATA

| Field Number | Soil Type[1] | Cumulative Biosolids Applied[2] | | Corn | Soybeans |
|---|---|---|---|---|---|
| | | Mg/ha | tons/acre | bu/acre | bu/acre |
| 1 | MS | 1,736 | 775 | | 28 |
| 2 | MS | 1,816 | 811 | 110 | |
| 3 | MS | 1,815 | 810 | | 28 |
| 4 | MS | 1,522 | 680 | 110 | |
| 5 | MS | 1,565 | 699 | 25[3] | |
| 7E | MS | 1,494 | 667 | | 43 |
| 7W | MS | 1,494 | 667 | | 43 |
| 8 | MS | 1,320 | 589 | | 43 |
| 9 | MS | 1,605 | 717 | 100 | |
| 11 | MS | 1,486 | 663 | 121 | |
| 12 | MS | 1,397 | 624 | 120 | |
| 13 | MS | 1,367 | 610 | | 37 |
| 14 | MS | 1,472 | 657 | | 37 |
| 15 | MS | 1,482 | 662 | | 23 |
| 16E | 1/4 MS | 1,510 | 674 | 110 | |
| 16W | 1/4 MS | 1,510 | 674 | 110 | |
| 17 | MS | 1,724 | 769 | 110 | |
| 18 | 1/2 MS | 1 | 0.5 | | 42 |
| 19 | PL | 644 | 287 | | 45 |
| 20 | PL | 531 | 237 | 126 | |
| 21 | PL | 618 | 276 | | 45 |

TABLE III-2 (Continued): 2006 FULTON COUNTY CROP YIELD DATA

| Field Number | Soil Type[1] | Cumulative Biosolids Applied[2] | | Corn | Soybeans |
|---|---|---|---|---|---|
| | | Mg/ha | tons/acre | bu/acre | bu/acre |
| 22 | PL | 455 | 203 | | 45 |
| 23 | PL | 473 | 211 | | 40 |
| 24 | MS | 1 | 0.5 | | 23 |
| 25 | MS | 870 | 388 | | 42 |
| 26 | MS | 1,087 | 485 | | 43 |
| 27 | 2/3 MS | 847 | 378 | | 35 |
| 28 | MS | 903 | 403 | | 35 |
| 30 | MS | 1,169 | 522 | | 48 |
| 31 | PL | 557 | 249 | | 45 |
| 32 | MS | 602 | 268 | | 26 |
| 33 | MS | 1,110 | 495 | | 26 |
| 34 | PL | 567 | 253 | | 45 |
| 35 | PL | 1,049 | 468 | | 42 |
| 36 | PL | 1,083 | 483 | | 40 |
| 37 | PL | 802 | 358 | | 42 |
| 38A | MS | 9 | 4 | | 29.9 |
| 38C | MS | 9 | 4 | | 29.6 |
| 39 | MS | 646 | 288 | | 21 |
| 40 | 1/2 MS | 497 | 222 | | 40 |
| 41 | MS | 979 | 437 | | 42.3 |
| 42 | MS | 858 | 383 | | 47 |

TABLE III-2 (Continued): 2006 FULTON COUNTY CROP YIELD DATA

| Field Number | Soil Type[1] | Cumulative Biosolids Applied[2] | | Corn | Soybeans |
|---|---|---|---|---|---|
| | | Mg/ha | tons/acre | bu/acre | bu/acre |
| 43 | MS | 983 | 439 | | 45.5 |
| 44 | MS | 805 | 359 | | 44 |
| 45 | 3/4 MS | 845 | 377 | | 39 |
| 47 | MS | 1,121 | 500 | | 39.7 |
| 50 | 5/6 MS | 7 | 3 | | 40 |
| 51 | 1/4 MS | 47 | 21 | | 28 |
| 52 | MS | 9 | 4 | | 40 |
| 54 | MS | 14 | 6 | | 44 |
| 55 | MS | 7 | 4 | | 31 |
| 56 | MS | 13 | 6 | | 45 |
| 59 | PL | 3 | 1 | 120 | |
| 60 | MS | 3 | 1.5 | | 40 |
| 61 | MS | 2 | 1 | | 40 |
| 63-1-1 | MS | 22 | 10 | | 40 |
| 63-8 | MS | 22 | 10 | | 39 |
| 64 | MS | 2 | 1 | | 37 |
| 65 | MS | 0.4 | 0.2 | | 34 |
| 75 | MS | 336 | 150 | | ND |
| 80 | PL | 0 | 0 | | 20 |
| 82 | PL | 0 | 0 | | 20 |

TABLE III-2 (Continued): 2006 FULTON COUNTY CROP YIELD DATA

| Field Number | Soil Type[1] | Cumulative Biosolids Applied[2] | | Corn | Soybeans |
|---|---|---|---|---|---|
| | | Mg/ha | tons/acre | bu/acre | bu/acre |
| 83 | PL | 0 | 0 | 77 | |
| 84 | MS | 0 | 0 | | ND |

[1]MS = mine-spoil; fractions appearing before MS indicate the proportion of the field that consists of mine-spoil with the remainder of the surface being placed land. PL = placed land indicating that the field has not been strip mined.
[2]Through 2006.
[3]Low yield due to hail damage.
ND = Not determined; no harvestable crop.

TABLE III-3: MEAN CONCENTRATIONS OF METALS IN CORN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|
| | --------- | --------- | --------- | --------- | -mg/kg- | --------- | --------- | --------- | --------- |
| 2 | 32.4 | 0.08 | 1.78 | 0.24 | 0.72 | 0.24 | 3,253 | 38.9 | 1,156 |
| 4 | 36.6 | 0.11 | 2.35 | 0.14 | 0.73 | 0.16 | 3,842 | 49.0 | 1,295 |
| 5 | 34.5 | 0.07 | 1.81 | 0.29 | 0.72 | <0.15 | 3,601 | 35.9 | 1,251 |
| 9 | 35.7 | 0.06 | 2.60 | 0.19 | 0.63 | <0.15 | 3,467 | 45.1 | 1,409 |
| 11 | 33.7 | <0.01 | 1.60 | 0.18 | 0.68 | <0.15 | 3,729 | 40.1 | 1,407 |
| 12 | 29.8 | 0.02 | 2.03 | 0.12 | 0.54 | <0.15 | 3,258 | 43.8 | 1,245 |
| 16E | 33.1 | 0.02 | 2.27 | 0.14 | 0.71 | <0.15 | 3,841 | 45.8 | 1,516 |
| 16W | 37.1 | 0.12 | 2.65 | 0.13 | 1.14 | <0.15 | 3,580 | 41.3 | 1,370 |
| 17 | 35.3 | 0.12 | 2.74 | 0.16 | 1.02 | <0.15 | 3,434 | 43.8 | 1,267 |
| 20 | 27.0 | <0.01 | 1.87 | 0.14 | 0.57 | <0.15 | 3,576 | 39.2 | 1,237 |
| 59 | 28.2 | <0.01 | 2.07 | 0.16 | 0.90 | <0.15 | 4,548 | 40.6 | 1,431 |
| 83 | 29.6 | <0.01 | 2.50 | 0.17 | 0.78 | <0.15 | 4,115 | 51.1 | 1,073 |

TABLE III-4: MEAN CONCENTRATIONS OF METALS IN CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number[1] | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|
| | mg/kg | | | | | | | | |
| 2 | 76.9 | 6.59 | 11.1 | 0.27 | 0.33 | <0.3 | 15,399 | 7,145 | 4,378 |
| 4 | 80.5 | 4.35 | 10.1 | 0.25 | 0.25 | <0.3 | 20,721 | 6,682 | 3,048 |
| 5 | 90.0 | 6.86 | 11.8 | 0.21 | 0.27 | <0.3 | 17,832 | 6,710 | 3,595 |
| 9 | 62.8 | 6.50 | 10.3 | 0.21 | 0.28 | <0.3 | 20,068 | 6,049 | 2,591 |
| 11 | 54.3 | 3.24 | 9.5 | 0.24 | 0.31 | <0.3 | 17,935 | 6,327 | 3,201 |
| 12 | 63.2 | 4.73 | 11.0 | 0.26 | 0.23 | <0.3 | 15,128 | 6,690 | 3,464 |
| 16E | 85.0 | 6.25 | 10.5 | 0.26 | 0.38 | <0.3 | 13,713 | 8,131 | 4,365 |
| 16W | 68.2 | 4.23 | 10.3 | 0.27 | 0.38 | <0.3 | 16,230 | 7,081 | 3,530 |
| 17 | 97.8 | 10.24 | 13.6 | 0.22 | 0.40 | <0.3 | 19,171 | 6,542 | 2,610 |
| 20 | 74.3 | 3.63 | 9.9 | 0.33 | 0.38 | <0.3 | 10,707 | 9,906 | 7,111 |
| 59 | 21.2 | <0.02 | 10.5 | 0.27 | <0.2 | <0.3 | 14,838 | 8,564 | 5,968 |
| 83 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not determined.

TABLE III-5: MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number[1] | Cutting | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ---------- | ---------- | ---------- | ---------- | mg/kg | ---------- | ---------- | ---------- | ---------- |
| 10-1 | 1 | 98.4 | 4.32 | 9.80 | 0.85 | 8.87 | <0.15 | 15,551 | 11,642 | 3,055 |
| 10-2 | 1 | 112.8 | 0.92 | 4.95 | 0.35 | 2.30 | <0.15 | 15,075 | 3,396 | 1,628 |
| 29-1 | 1 | 14.5 | <0.01 | 3.12 | 0.18 | 0.13 | <0.15 | 12,052 | 2,283 | 1,280 |
| 29-2 | 1 | 17.8 | <0.01 | 3.84 | 0.17 | 0.13 | <0.15 | 13,068 | 2,575 | 1,532 |
| 62-1 | 1 | 14.2 | <0.01 | 4.70 | 0.21 | 0.37 | <0.15 | 14,003 | 4,018 | 2,012 |
| 62-2 | 1 | 28.5 | 0.06 | 6.79 | 0.15 | 0.28 | <0.15 | 20,709 | 7,885 | 1,581 |
| 63-1-2 | 1 | 10.6 | <0.01 | 3.10 | 0.16 | 0.23 | <0.15 | 14,014 | 3,600 | 1,708 |
| 63-2-1 | 1 | 16.3 | <0.01 | 4.77 | 0.15 | 0.31 | <0.15 | 21,580 | 3,104 | 1,477 |
| 63-2-2 | 1 | 16.7 | <0.01 | 5.73 | 0.13 | 0.52 | <0.15 | 20,101 | 2,804 | 1,823 |
| 63-3-1 | 1 | 13.6 | <0.01 | 2.99 | 0.30 | 0.21 | <0.15 | 11,634 | 3,173 | 1,504 |
| 63-3-2 | 1 | 12.1 | <0.01 | 3.28 | 0.27 | 0.18 | <0.15 | 13,595 | 2,859 | 1,561 |
| 63-4-1 | 1 | 15.4 | <0.01 | 4.35 | 0.21 | 0.31 | <0.15 | 16,243 | 2,898 | 1,504 |
| 63-4-2 | 1 | 14.0 | <0.01 | 5.95 | 0.12 | 0.66 | <0.15 | 16,645 | 7,244 | 1,946 |
| 63-5-1 | 1 | 12.7 | <0.01 | 4.59 | 0.12 | 0.26 | <0.15 | 17,604 | 4,114 | 1,769 |
| 63-5-2 | 1 | 11.0 | <0.01 | 4.98 | <0.1 | 0.37 | <0.15 | 17,422 | 4,576 | 1,797 |
| 63-6-1 | 1 | 14.5 | <0.01 | 5.65 | <0.1 | 0.34 | <0.15 | 14,163 | 4,885 | 2,139 |
| 63-6-2 | 1 | 15.7 | <0.01 | 5.84 | <0.1 | 0.33 | <0.15 | 14,863 | 5,755 | 1,822 |
| 63-7-1 | 1 | 19.2 | <0.01 | 3.36 | 0.14 | 0.61 | <0.15 | 17,121 | 3,107 | 1,730 |
| 63-7-2 | 1 | 15.4 | <0.01 | 3.87 | <0.1 | 0.26 | <0.15 | 16,806 | 2,804 | 1,267 |
| 73-1 | 1 | 14.3 | <0.01 | 4.55 | 0.10 | 0.46 | <0.15 | 17,977 | 4,531 | 1,446 |

TABLE III-5 (Continued): MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number[1] | Cutting | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ---------- mg/kg ---------- | | | | | | | | |
| 73-2 | 1 | 21.7 | <0.01 | 4.83 | 0.10 | 0.16 | <0.15 | 21,473 | 3,099 | 970 |
| 76-1 | 1 | 18.2 | <0.01 | 4.49 | 0.51 | 0.71 | <0.15 | 17,610 | 4,194 | 2,095 |
| 76-2 | 1 | 13.2 | <0.01 | 4.16 | 0.50 | 0.79 | <0.15 | 19,558 | 3,063 | 1,615 |
| 10-1 | 2 | 72.7 | 3.76 | 9.64 | 4.72 | 7.72 | 0.43 | 14,964 | 9,927 | 2,443 |
| 10-2 | 2 | 87.0 | 2.08 | 9.17 | 2.35 | 6.98 | <0.15 | 22,130 | 7,907 | 2,749 |
| 63-1-2 | 2 | 20.4 | <0.01 | 7.88 | 0.57 | 0.64 | <0.15 | 23,830 | 5,336 | 1,923 |
| 63-2-1 | 2 | 28.2 | <0.01 | 9.06 | 0.46 | 1.03 | <0.15 | 22,435 | 7,177 | 2,735 |
| 63-2-2 | 2 | 26.5 | <0.01 | 8.98 | 0.54 | 1.05 | <0.15 | 21,804 | 6,670 | 2,733 |
| 63-3-1 | 2 | 17.3 | <0.01 | 7.57 | 0.39 | 0.81 | <0.15 | 24,174 | 8,206 | 2,562 |
| 63-3-2 | 2 | 17.2 | <0.01 | 9.01 | 0.36 | 0.55 | <0.15 | 21,967 | 9,844 | 2,478 |
| 63-4-1 | 2 | 21.3 | <0.01 | 7.95 | 0.39 | 0.47 | <0.15 | 20,147 | 6,942 | 2,476 |
| 63-4-2 | 2 | 19.6 | <0.01 | 8.25 | 0.45 | 0.52 | <0.15 | 20,608 | 6,132 | 2,209 |
| 63-5-1 | 2 | 14.9 | <0.01 | 7.65 | 0.38 | 0.60 | <0.15 | 19,385 | 8,211 | 2,383 |
| 63-5-2 | 2 | 25.3 | <0.01 | 8.53 | 0.47 | 0.35 | <0.15 | 30,686 | 5,443 | 2,294 |
| 63-6-1 | 2 | 17.0 | <0.01 | 8.16 | 0.38 | 0.92 | <0.15 | 20,114 | 8,796 | 2,416 |
| 63-6-2 | 2 | 20.9 | <0.01 | 9.52 | 0.40 | 1.06 | <0.15 | 20,827 | 8,779 | 2,770 |
| 63-7-1 | 2 | 25.2 | <0.01 | 7.36 | 1.00 | 0.98 | <0.15 | 21,464 | 5,089 | 2,298 |
| 63-7-2 | 2 | 18.4 | <0.01 | 8.24 | 0.54 | 0.90 | <0.15 | 16,181 | 8,460 | 2,702 |
| 73-1 | 2 | 21.6 | <0.01 | 6.74 | 0.41 | 1.49 | <0.15 | 19,071 | 6,413 | 2,699 |
| 73-2 | 2 | 22.8 | <0.01 | 6.55 | 0.49 | 0.44 | <0.15 | 20,671 | 7,469 | 1,998 |

TABLE III-5 (Continued): MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number[1] | Cutting | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ----- | ----- | ----- | ----- | mg/kg | ----- | ----- | ----- | ----- |
| 76-1 | 2 | 17.9 | <0.01 | 8.04 | 0.47 | 0.50 | <0.15 | 15,606 | 7,917 | 2,736 |
| 76-2 | 2 | 17.4 | <0.01 | 7.29 | <0.1 | 0.66 | <0.15 | 16,929 | 6,522 | 2,859 |
| 10-1 | 3 | 95.8 | 5.09 | 13.2 | 7.59 | 10.4 | 1.53 | 23,311 | 11,586 | 3,508 |
| 10-2 | 3 | 80.8 | 3.65 | 12.7 | 3.02 | 9.75 | <0.15 | 22,197 | 11,592 | 3,001 |
| 73-1 | 3 | 23.0 | <0.01 | 6.83 | 0.39 | 0.97 | <0.15 | 16,374 | 6,061 | 2,129 |
| 73-2 | 3 | 22.6 | 0.02 | 7.27 | 0.31 | 0.55 | <0.15 | 17,245 | 5,478 | 1,693 |
| 76-1 | 3 | 20.4 | <0.01 | 7.80 | 0.66 | 0.60 | <0.15 | 23,001 | 5,159 | 2,976 |
| 76-2 | 3 | 25.3 | <0.01 | 8.22 | 0.50 | 0.57 | <0.15 | 21,338 | 6,852 | 2,750 |

TABLE III-6: MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|
| | mg/kg | | | | | | | | |
| 1 | 59.0 | 0.63 | 15.5 | 0.25 | 12.1 | <0.15 | 21,004 | 2,557 | 3,185 |
| 3 | 54.6 | 0.46 | 15.7 | 0.29 | 8.9 | <0.15 | 20,107 | 2,977 | 3,403 |
| 7E | 55.1 | 1.03 | 11.3 | 0.27 | 6.1 | <0.15 | 20,235 | 2,269 | 2,744 |
| 7W | 52.4 | 0.29 | 15.8 | 0.24 | 2.6 | <0.15 | 20,467 | 2,585 | 2,711 |
| 8 | 56.7 | 1.23 | 11.4 | 0.26 | 9.7 | <0.15 | 20,638 | 2,117 | 2,801 |
| 13 | 56.5 | 0.65 | 15.3 | 0.26 | 9.7 | <0.15 | 21,944 | 2,731 | 3,288 |
| 14 | 56.5 | 0.66 | 16.1 | 0.38 | 9.9 | <0.15 | 21,700 | 2,806 | 3,344 |
| 15 | 54.9 | 0.54 | 14.9 | 0.23 | 5.6 | <0.15 | 21,358 | 2,647 | 3,106 |
| 18 | 36.8 | <0.01 | 12.8 | 0.21 | 4.6 | <0.15 | 19,437 | 3,053 | 2,905 |
| 19 | 54.5 | 0.88 | 11.4 | 0.25 | 11.6 | <0.15 | 20,457 | 2,787 | 2,787 |
| 21 | 55.1 | 1.05 | 11.4 | 0.26 | 14.3 | <0.15 | 22,292 | 2,684 | 2,898 |
| 22 | 61.3 | 1.24 | 12.2 | 0.43 | 12.6 | <0.15 | 21,242 | 2,510 | 2,896 |
| 23 | 58.8 | 1.18 | 11.4 | 0.27 | 12.1 | <0.15 | 20,766 | 2,445 | 2,797 |
| 24 | 42.6 | 0.06 | 16.5 | 0.22 | 3.1 | <0.15 | 19,764 | 2,806 | 2,507 |
| 25 | 60.3 | 0.82 | 13.5 | 0.23 | 6.2 | <0.15 | 21,472 | 2,087 | 2,611 |
| 26 | 52.4 | 0.57 | 11.8 | 0.26 | 6.4 | <0.15 | 22,256 | 2,028 | 2,726 |
| 27 | 49.4 | 0.62 | 14.4 | 0.25 | 5.5 | <0.15 | 23,626 | 2,580 | 2,871 |
| 28 | 49.7 | 0.64 | 14.3 | 0.24 | 5.3 | <0.15 | 22,660 | 2,564 | 2,762 |
| 30 | 53.5 | 1.03 | 14.6 | 0.28 | 6.0 | <0.15 | 22,378 | 2,251 | 2,960 |
| 31 | 43.2 | 0.47 | 15.5 | 0.24 | 8.2 | <0.15 | 20,660 | 2,656 | 2,550 |
| 32 | 56.6 | 0.72 | 15.3 | 0.27 | 5.7 | <0.15 | 21,654 | 3,083 | 3,456 |
| 33 | 60.9 | 0.93 | 14.3 | 0.31 | 7.9 | <0.15 | 20,081 | 3,023 | 3,410 |

TABLE III-6 (Continued): MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|
| | mg/kg | | | | | | | | |
| 34 | 61.0 | 1.86 | 10.2 | 0.33 | 13.4 | <0.15 | 20,900 | 2,966 | 2,838 |
| 35 | 54.6 | 0.76 | 9.8 | 0.32 | 10.0 | <0.15 | 20,550 | 2,609 | 3,021 |
| 36 | 54.6 | 0.77 | 9.7 | 0.32 | 10.0 | <0.15 | 20,740 | 2,626 | 3,028 |
| 37 | 51.4 | 0.74 | 10.5 | 0.33 | 8.4 | <0.15 | 20,640 | 2,621 | 2,968 |
| 38A | 48.0 | <0.01 | 18.2 | 0.28 | 3.6 | <0.15 | 19,756 | 2,422 | 2,631 |
| 38C | 49.6 | <0.01 | 17.2 | 0.29 | 3.1 | <0.15 | 19,633 | 2,654 | 2,419 |
| 39 | 58.0 | 0.88 | 11.9 | 0.28 | 4.7 | <0.15 | 19,829 | 2,426 | 2,952 |
| 40 | 37.2 | <0.01 | 12.2 | 0.28 | 4.0 | <0.15 | 19,377 | 2,628 | 2,852 |
| 41 | 54.1 | 1.00 | 12.9 | 0.33 | 6.2 | <0.15 | 20,124 | 2,429 | 2,947 |
| 42 | 53.1 | 0.41 | 14.5 | 0.56 | 5.5 | <0.15 | 20,144 | 2,049 | 2,788 |
| 43 | 55.8 | 0.61 | 14.9 | 0.30 | 5.0 | <0.15 | 18,113 | 2,614 | 2,858 |
| 44 | 47.3 | 0.13 | 14.4 | 0.30 | 1.9 | <0.15 | 19,942 | 2,215 | 2,676 |
| 45 | 54.6 | 0.40 | 15.7 | 0.53 | 5.6 | <0.15 | 20,812 | 2,121 | 2,858 |
| 47 | 50.5 | 0.25 | 12.9 | 0.25 | 7.7 | <0.15 | 20,156 | 2,110 | 2,658 |
| 50 | 41.2 | <0.01 | 17.0 | 0.29 | 7.1 | <0.15 | 21,824 | 2,585 | 2,416 |
| 51 | 36.6 | <0.01 | 14.1 | 0.33 | 5.7 | <0.15 | 21,268 | 2,935 | 2,705 |
| 52 | 44.1 | <0.01 | 18.9 | 0.27 | 2.5 | <0.15 | 18,847 | 2,707 | 2,544 |
| 54 | 42.3 | <0.01 | 17.4 | 0.22 | 3.1 | <0.15 | 21,566 | 2,126 | 2,552 |
| 55 | 43.3 | <0.01 | 17.5 | 0.23 | 7.7 | <0.15 | 21,867 | 2,253 | 2,581 |
| 56 | 43.3 | <0.01 | 17.6 | 0.25 | 3.7 | <0.15 | 21,305 | 2,320 | 2,489 |
| 60 | 45.2 | <0.01 | 17.8 | 0.19 | 3.0 | <0.15 | 18,372 | 2,655 | 2,520 |
| 61 | 45.9 | <0.01 | 17.8 | 0.29 | 3.2 | <0.15 | 18,472 | 2,728 | 2,503 |

TABLE III-6 (Continued): MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Field Number | Zn | Cd | Cu | Cr | Ni | Pb | K | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|
| | mg/kg | | | | | | | | |
| 63-1-1 | 46.4 | <0.01 | 18.5 | 0.20 | 3.1 | <0.15 | 18,729 | 2,673 | 2,511 |
| 63-8 | 43.6 | <0.01 | 18.5 | 0.18 | 2.9 | <0.15 | 19,098 | 2,586 | 2,316 |
| 64 | 44.8 | <0.01 | 17.3 | 0.20 | 5.0 | <0.15 | 19,925 | 2,383 | 2,470 |
| 65 | 45.2 | <0.01 | 17.3 | 0.21 | 3.4 | <0.15 | 20,344 | 2,294 | 2,483 |
| 75 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 80 | 35.4 | <0.01 | 12.1 | 0.29 | 5.5 | <0.15 | 19,360 | 2,838 | 2,578 |
| 82 | 36.1 | <0.01 | 12.4 | 0.29 | 5.8 | <0.15 | 19,498 | 2,819 | 2,593 |
| 84 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = Not determined; no harvestable crop.

TABLE III-7: AMENDMENTS USED IN RECLAMATION OF COAL REFUSE AT ST. DAVID, ILLINOIS

| Plot Number | Treatment Composition[1] | | | | | |
|---|---|---|---|---|---|---|
| | Biosolids | | Lime | | Clay | |
| | Mg/ha | tons/acre | Mg/ha | tons/acre | cm | Inches |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 784 | 350 | 0 | 0 | 0 | 0 |
| 3 | 784 | 350 | 179 | 80 | 0 | 0 |
| 4 | 784 | 350 | 179 | 80 | 10.2 | 4 |
| 5 | 1,568 | 700 | 0 | 0 | 0 | 0 |
| 6 | 1,568 | 700 | 179 | 80 | 0 | 0 |
| 7 | 1,568 | 700 | 179 | 80 | 10.2 | 4 |
| 8 | 2,240 | 1,000 | 0 | 0 | 0 | 0 |
| 9 | 2,800 | 1,250 | 0 | 0 | 0 | 0 |
| 10 | 3,360 | 1,500 | 0 | 0 | 0 | 0 |

[1]Application rates for biosolids and lime are on a dry weight basis.

TABLE III-8: YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE ST. DAVID, ILLINOIS, COAL REFUSE PILE RECLAMATION SITE 2002 - 2006

| Chemical Parameters | Year | Plot Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 2002 | 7.1 | 7.0 | 7.0 | 7.2 | 7.2 | 7.1 | 6.8 | 6.8 | 7.0 | 6.9 |
| | 2003[1] | 7.1 | 7.6 | 7.2 | 7.3 | 7.4 | 7.8 | NA | 7.6 | 7.6 | NA |
| | 2004 | 7.5 | 7.8 | 7.0 | 7.7 | 7.2 | 8.0 | NA | NA | 8.0 | NA |
| | 2005 | NA | 7.6 | 6.9 | 7.0 | 7.6 | NA | 7.6 | NA | NA | NA |
| | 2006 | 7.6 | 7.9 | 7.5 | 6.9 | 7.8 | 7.1 | 6.6 | 7.2 | 6.9 | 7.4 |
| | | mg/L | | | | | | | | | |
| $SO_4^{=}$ | 2002 | 5,040 | 1,628 | 1,598 | 1,828 | 1,351 | 1,988 | 1,430 | 1,024 | 1,745 | 1,932 |
| | 2003 | 2,105 | 2,098 | 1,140 | 1,540 | 1,407 | 1,794 | NA | 578 | 1,909 | NA |
| | 2004 | 2,840 | 2,168 | 1,650 | 1,745 | 1,444 | 2,205 | NA | NA | 1,960 | NA |
| | 2005 | NA | 2,046 | 965 | 1,632 | 1,499 | NA | 1,178 | NA | NA | NA |
| | 2006 | 2,457 | 1,940 | 1,631 | 1,628 | 1,499 | 2,464 | 1,502 | 8,240 | 1,958 | 1,780 |
| $NH_4$-N | 2002 | 0.45 | 0.15 | 0.14 | 0.11 | 0.07 | 0.13 | 0.51 | 0.15 | 0.21 | 0.17 |
| | 2003 | 0.12 | 0.04 | 0.03 | 0.06 | 0.11 | 0.04 | NA | <0.01 | 0.03 | NA |
| | 2004 | 0.22 | 0.11 | 0.08 | 0.11 | 0.10 | 0.17 | NA | NA | 0.20 | NA |
| | 2005 | NA | 0.08 | 0.11 | 0.09 | 0.04 | NA | 0.02 | NA | NA | NA |
| | 2006 | 0.11 | 0.04 | 0.05 | 0.08 | 0.05 | 0.04 | 0.85 | 0.08 | <0.02 | <0.02 |
| $NO_2$+$NO_3$-N | 2002 | 270 | 1.72 | 0.73 | 2.69 | 4.09 | 1.02 | 18.8 | 3.80 | 64.9 | 41.9 |
| | 2003 | 94.3 | 1.56 | 1.20 | 3.00 | 4.30 | 1.44 | NA | 3.13 | 85.3 | NA |
| | 2004 | 79.5 | 1.46 | 0.64 | 3.20 | 3.36 | 0.72 | NA | NA | 115 | NA |
| | 2005 | NA | 1.51 | 0.23 | 2.19 | 4.57 | NA | 6.72 | NA | NA | NA |
| | 2006 | 38.5 | 1.68 | 1.37 | 1.86 | 3.73 | 0.78 | 10.2 | 1.53 | 61.7 | 41.9 |

[1]From 2003 onward, lysimeters were sampled quarterly, rather than monthly.
NA = No samples available, due to insufficient precipitation.

TABLE III-9: YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE MORGAN MINE COAL REFUSE RECLAMATION SITE 2002 - 2006

| Chemical Parameters | Year | Lysimeter Number 1 | Lysimeter Number 2 | Lysimeter Number 3 |
|---|---|---|---|---|
| pH | 2002 | 6.9 | 6.9 | 6.6 |
| | 2003[1] | 6.8 | 6.9 | 6.7 |
| | 2004 | 6.7 | 6.9 | 7.1 |
| | 2005 | 7.0 | 7.1 | NA |
| | 2006 | 6.9 | 7.3 | NA |
| | | ----------mg/L---------- | | |
| $SO_4^{=}$ | 2002 | 1,621 | 2,019 | 2,520 |
| | 2003 | 1,727 | 1,866 | 2,623 |
| | 2004 | 1,621 | 2,068 | 2,090 |
| | 2005 | 1,361 | 1,842 | NA |
| | 2006 | 2,119 | 2,154 | NA |
| $NH_4$-N | 2002 | 0.96 | 1.68 | 0.98 |
| | 2003 | 1.36 | 4.79 | 1.14 |
| | 2004 | 0.73 | 0.67 | 0.70 |
| | 2005 | 0.32 | 1.98 | NA |
| | 2006 | 0.55 | 0.75 | NA |
| $NO_2$+$NO_3$-N | 2002 | 3.35 | 3.97 | 38.2 |
| | 2003 | 2.34 | 3.63 | 43.1 |
| | 2004 | 4.48 | 8.74 | 12.5 |
| | 2005 | 6.32 | 12.63 | NA |
| | 2006 | 2.10 | 10.8 | NA |

[1]From 2003 onward, lysimeters were sampled quarterly, rather than monthly.
NA = No samples available, due to low precipitation

TABLE III-10: YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE UNITED ELECTRIC COAL REFUSE PILE RECLAMATION SITE 2002 - 2006

| Chemical Parameters | Year | Lysimeter Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 2002 | NA | 7.2 | 7.4 | 7.2 | 7.4 | 4.8 | 7.4 | 7.0 | 7.3 | NA |
| | 2003[1] | NA | 7.2 | 7.4 | 7.1 | 7.3 | 6.6 | 7.4 | 7.1 | 7.3 | NA |
| | 2004 | NA | 6.8 | 7.3 | 6.9 | 7.1 | NA | 7.3 | 7.0 | 7.2 | NA |
| | 2005 | NA | NA | NA | NA | NA | NA | NA | NA | 7.3 | NA |
| | 2006 | NA | 7.2 | 7.4 | 7.5 | 7.4 | 3.1 | 7.3 | 7.2 | 7.4 | NA |
| | | | | | | mg/L | | | | | |
| $SO_4^{=}$ | 2002 | NA | 978 | 1,675 | 2,323 | 2,057 | 1,541 | 1,929 | 4,076 | 3,140 | NA |
| | 2003 | NA | 1,439 | 1,751 | 2,089 | 2,063 | 1,415 | 1,736 | 3,772 | 2,722 | NA |
| | 2004 | NA | 1,446 | 1,428 | 2,244 | 1,918 | NA | 1,698 | 3,780 | 2,585 | NA |
| | 2005 | NA | NA | NA | NA | NA | NA | NA | NA | 3,322 | NA |
| | 2006 | NA | 1,620 | 1,752 | 2,218 | 2,021 | 2,123 | 1,718 | 3,940 | 3,345 | NA |
| $NH_4$-N | 2002 | NA | 0.31 | 0.43 | 0.47 | 0.34 | 0.64 | 0.27 | 11.9 | 0.38 | NA |
| | 2003 | NA | 0.25 | 0.40 | 0.45 | 0.37 | 0.36 | 0.20 | 9.10 | 0.36 | NA |
| | 2004 | NA | 0.37 | 0.50 | 0.50 | 0.47 | NA | 0.32 | 14.3 | 0.59 | NA |
| | 2005 | NA | NA | NA | NA | NA | NA | 7.6 | NA | 0.36 | NA |
| | 2006 | NA | 0.01 | 0.12 | 0.04 | 0.08 | 2.02 | 0.11 | 12.8 | 0.03 | NA |
| $NO_2$+$NO_3$-N | 2002 | NA | 31.6 | 32.7 | 17.5 | 3.47 | 14.2 | 32.7 | 2.83 | 1.46 | NA |
| | 2003 | NA | 47.6 | 26.9 | 25.9 | 3.46 | 22.5 | 15.4 | 3.54 | 1.53 | NA |
| | 2004 | NA | 82.0 | 15.8 | 63.5 | 1.18 | NA | 24.2 | 2.73 | 1.23 | NA |
| | 2005 | NA | NA | NA | NA | NA | NA | 7.6 | NA | 0.73 | NA |
| | 2006 | NA | 90.6 | 10.1 | 66.3 | 1.98 | 6.97 | 18.6 | 3.52 | 2.67 | NA |

[1]From 2003 onward, lysimeters were sampled quarterly, rather than monthly.
NA = No samples available, due to low precipitation.

TABLE III-11: FULTON COUNTY RESEARCH AND DEVELOPMENT LABORATORY
2006 UICF BIOSOLIDS APPLICATION RATES

| Treatment[1] | Biosolids Application Rate (Dry Weight Basis) | | | |
|---|---|---|---|---|
| | Annual | | Cumulative | |
| | Mg/ha | tons/acre | Mg/ha | tons/acre |
| Control | 0.0 | 0.0 | 0.0 | 0.0 |
| 1/4 Max | 16.8 | 7.5 | 539 | 242 |
| 1/2 Max | 33.6 | 15.0 | 1,078 | 481 |
| Max | 67.2 | 30.0 | 2,152 | 961 |

[1]Control plots receive 336-224-112 kg/ha of N-P-K annually and biosolids amended plots receive 112 kg K/ha annually.

TABLE III-12. MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS IN SURFACE SOIL[1] FROM THE CORN FERTILITY EXPERIMENTAL PLOTS AT THE FULTON COUNTY RECLAMATION SITE FOR 2003 - 2006

| | | | | Organic | 0.1N HCl Extracted | | | | | | Concentrated $HNO_3$ Extracted | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot[2] | Year | pH | EC | Carbon | Zn | Cd | Cu | Cr | Ni | Pb | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Tot-P |
| | | | dS/m | % | ---------------------------------------------------------mg/kg--------------------------------------------------------- | | | | | | | | | | | | | |
| Check | 2003 | 7.2 | 0.50 | 1.01 | 123 | 9.68 | 51.6 | 15.9 | 12.2 | 23.4 | 174 | 10.4 | 84.3 | 137 | 40.7 | 41.4 | 1,170 | 2,665 |
| | 2004 | 6.7 | 0.68 | 0.92 | 113 | 8.61 | 45.9 | 14.4 | 10.4 | 21.5 | 144 | 8.60 | 73.8 | 116 | 36.5 | 35.1 | 1,485 | 2,611 |
| | 2005 | 7.4 | 0.36 | 1.51 | 200 | 13.6 | 79.1 | 22.4 | 11.3 | 28.1 | 254 | 12.1 | 123 | 174 | 44.4 | 54.7 | 1,728 | 2,828 |
| | 2006 | 7.3 | 0.48 | 1.46 | 187 | 13.0 | 78.0 | 22.7 | 13.7 | 29.3 | 253 | 13.6 | 126 | 173 | 45.6 | 54.8 | 1,440 | 2,468 |
| 1/4 | 2003 | 7.6 | 0.19 | 1.62 | 219 | 15.9 | 96.1 | 28.7 | 15.9 | 39.3 | 298 | 16.7 | 151 | 220 | 49.2 | 66.4 | 1,701 | 2,781 |
| | 2004 | 7.4 | 0.23 | 1.76 | 251 | 17.8 | 106 | 32.3 | 15.8 | 43.1 | 299 | 16.4 | 144 | 218 | 47.7 | 66.1 | 2,384 | 4,330 |
| | 2005 | 7.4 | 0.40 | 2.39 | 366 | 25.1 | 143 | 41.7 | 18.6 | 46.5 | 435 | 24.1 | 212 | 306 | 58.5 | 96.1 | 2,465 | 4,536 |
| | 2006 | 7.2 | 0.41 | 2.20 | 326 | 22.6 | 134 | 40.1 | 20.1 | 46.3 | 422 | 23.7 | 212 | 295 | 59.0 | 92.6 | 2,152 | 3,936 |
| 1/2 | 2003 | 7.4 | 0.30 | 2.74 | 410 | 27.4 | 166 | 49.0 | 23.8 | 49.8 | 495 | 27.8 | 241 | 350 | 64.3 | 106 | 2,823 | 5,121 |
| | 2004 | 7.0 | 0.33 | 2.59 | 408 | 26.9 | 164 | 48.7 | 22.5 | 52.3 | 451 | 24.8 | 221 | 321 | 59.8 | 98.5 | 2,327 | 4,868 |
| | 2005 | 7.1 | 0.59 | 2.64 | 446 | 28.5 | 163 | 44.1 | 21.7 | 37.3 | 486 | 27.1 | 248 | 344 | 62.9 | 110 | 2,945 | 6,169 |
| | 2006 | 7.0 | 0.78 | 2.51 | 377 | 23.8 | 141 | 39.9 | 21.8 | 34.4 | 465 | 25.7 | 243 | 316 | 60.9 | 102 | 2,825 | 5,705 |
| Max | 2003 | 7.1 | 0.31 | 4.46 | 698 | 43.7 | 275 | 76.8 | 37.7 | 54.5 | 807 | 44.5 | 389 | 653 | 88.3 | 169 | 3,735 | 9,669 |
| | 2004 | 7.0 | 0.49 | 3.73 | 613 | 38.1 | 240 | 68.7 | 31.9 | 56.6 | 622 | 34.0 | 314 | 430 | 73.1 | 133 | 3,046 | 5,847 |
| | 2005 | 7.2 | 0.53 | 3.48 | 562 | 35.9 | 206 | 58.8 | 27.6 | 49.2 | 629 | 35.5 | 320 | 446 | 72.8 | 140 | 3,531 | 7,362 |
| | 2006 | 6.9 | 0.60 | 2.77 | 462 | 29.4 | 174 | 48.9 | 26.0 | 44.9 | 533 | 29.8 | 271 | 366 | 66.5 | 116 | 2,769 | 5,371 |

[1]Sampling depth = 0-15 cm.

[2]Check = No biosolids application - inorganic fertilizer. 1/4, 1/2, and Max = 16.8, 33.6, and 67.2 Mg/ha/yr biosolids loading rates, respectively.

TABLE III-13. MEAN CONCENTRATIONS OF TKN, PHOSPHORUS, AND METALS IN 33P69 HYBRID CORN GRAIN COLLECTED FROM THE CORN FERTILITY EXPERIMENTAL PLOTS AT THE FULTON COUNTY RECLAMATION SITE IN 2006

| Analyte[2] | Treatment[1] | | | |
|---|---|---|---|---|
| | Control | 1/4-Max | 1/2-Max | Max |
| | mg/kg | | | |
| TKN | 14,844 | 14,210 | 16,217 | 15,246 |
| P | 2,955 | 2,708 | 3,226 | 2,853 |
| Zn | 25.3 | 26.0 | 32.0 | 32.3 |
| Cd | <0.01 | <0.01 | <0.01 | <0.01 |
| Cu | 1.6 | 1.8 | 1.9 | 1.9 |
| Cr | 0.23 | 0.15 | 0.26 | 0.26 |
| Ni | 0.70 | 0.83 | 0.95 | 0.90 |
| Pb | 0.18 | <0.15 | <0.15 | 0.16 |
| K | 4,107 | 3,862 | 4,043 | 3,963 |
| Ca | 51.2 | 39.1 | 34.7 | 38.5 |
| Mg | 1,413 | 1,297 | 1,422 | 1,409 |

[1]Control = No biosolids application - inorganic fertilizer. 1/4-Max, 1/2-Max, and Max represent biosolids application rates of 16.8, 33.6, and 67.2 Mg/ha/yr, respectively.
[2]Tissue digested with $HNO_3$ for metals. TKN = Total Kjeldahl-N.

TABLE III-14: AVERAGE CORN GRAIN AND CORN STOVER YIELDS FOR HYBRID 33P69 GROWN AT THE CORN FERTILITY EXPERIMENTAL PLOTS FROM 2004 - 2006

| | | Treatment[1] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Control | | | 1/4-Max | | | 1/2-Max | | | Max | | |
| Harvested Tissue | Unit | 2004 | 2005[2] | 2006 | 2004 | 2005 | 2006 | 2004 | 2005 | 2006 | 2004 | 2005 | 2006 |
| Grain | bu/acre | 38 | 6.8 | 43 | 61 | 9.4 | 70 | 72 | 6.4 | 84 | 83 | 6.8 | 90 |
| | Mg/ha | 2.4 | 0.43 | 2.7 | 3.8 | 0.59 | 4.4 | 4.5 | 0.40 | 5.3 | 5.2 | 0.43 | 5.6 |
| Stover | tons/acre | 1.7 | 1.1 | 2.2 | 1.7 | 0.81 | 2.6 | 0.8 | 0.92 | 2.9 | 0.9 | 1.1 | 3.3 |
| | Mg/ha | 3.9 | 2.4 | 5.0 | 3.9 | 1.8 | 5.9 | 1.7 | 2.1 | 6.4 | 2.0 | 2.6 | 7.5 |

[1]Control = No biosolids application - inorganic fertilizer. 1/4-Max, 1/2-Max, and Max represent biosolids application rates of approximately 16.8, 33.6, and 67.2 Mg/ha/yr, respectively.
[2]Severe drought year.

TABLE III-15: RUNOFF P LOSSES THROUGH SIMULATED RAINFALL APPLIED TO SOIL AMENDED WITH TREATMENTS OF BIOSOLIDS AND TRIPLE SUPERPHOSPHATE AS P SOURCES

| Treatment | Application Method[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sur | Incor | Sur | Incor | Sur | Incor | Sur | Incor |
| | ------ Day 1 ------ | | ------ Day 3 ------ | | ------ Day 7 ------ | | ------ Total ------ | |
| | *mg P/L* | | | | | | | |
| | *DMRP*[2] | | | | | | | |
| **N-Based** | | | | | | | | |
| Aged Air Dried | 4.08 | 0.56 | 2.66 | 0.32 | 2.40 | 0.36 | 9.14 | 1.25 |
| Centrifuge Cake | 2.37 | 1.18 | 1.84 | 0.72 | 1.38 | 0.39 | 5.58 | 2.29 |
| TSP | | 4.15 | | 1.99 | | 1.29 | | 7.42 |
| **P-Based** | | | | | | | | |
| Aged Air Dried | 0.62 | 0.45 | 0.47 | 0.20 | 0.30 | 0.28 | 1.38 | 0.92 |
| Centrifuge Cake | 0.92 | 0.38 | 0.63 | 0.23 | 0.34 | 0.27 | 1.89 | 0.88 |
| TSP | | 0.25 | | 0.25 | | 0.15 | | 0.65 |
| Control | 0.26 | | 0.25 | | 0.13 | | 0.64 | |
| | *DMRP + Dissolved Org. P* | | | | | | | |
| **N-Based** | | | | | | | | |
| Aged Air Dried | 1.19 | 1.74 | 2.66 | 0.32 | 0.36 | 0.17 | 2.42 | 2.19 |
| Centrifuge Cake | 1.72 | 0.45 | 1.84 | 0.72 | 0.61 | 0.34 | 3.15 | 2.73 |
| TSP | | 2.52 | | 1.99 | | 0.13 | | 2.56 |
| **P Based** | | | | | | | | |
| Aged Air Dried | 0.52 | 0.81 | 0.47 | 0.20 | 0.75 | 0.31 | 2.30 | 1.73 |
| Centrifuge Cake | 1.62 | 1.57 | 0.63 | 0.23 | 0.89 | 0.44 | 4.64 | 1.35 |
| TSP | | 0.23 | | 0.25 | | 0.68 | | 0.93 |
| Control | 0.08 | | 0.20 | | 0.23 | | 0.51 | |
| | *Particulate P* | | | | | | | |
| **N-Based** | | | | | | | | |
| Aged Air Dried | 12.94 | 3.16 | 6.18 | 1.05 | 8.81 | 2.89 | 27.93 | 10.09 |
| Centrifuge Cake | 60.02 | 10.94 | 42.77 | 7.93 | 24.68 | 3.63 | 128.47 | 22.50 |
| TSP | | 5.69 | | 6.25 | | 6.04 | | 17.98 |
| **P-Based** | | | | | | | | |
| Aged Air Dried | 3.37 | 3.45 | 2.98 | 2.32 | 1.52 | 2.70 | 7.87 | 8.48 |
| Centrifuge Cake | 14.84 | 4.56 | 4.97 | 4.84 | 3.56 | 7.11 | 23.37 | 16.51 |
| TSP | | 3.16 | | 3.84 | | 2.06 | | 9.06 |
| Control | 2.64 | | 2.43 | | 2.51 | | 7.57 | |
| | *Total P* | | | | | | | |
| **N-Based** | | | | | | | | |
| Aged Air Dried | 18.61 | 5.18 | 9.71 | 4.65 | 11.57 | 3.42 | 39.48 | 13.24 |
| Centrifuge Cake | 65.11 | 12.39 | 45.42 | 10.59 | 26.67 | 4.36 | 137.20 | 27.35 |
| TSP | 12.36 | | 8.14 | | 7.45 | | 27.96 | |
| **P-Based** | | | | | | | | |
| Aged Air Dried | 4.15 | 4.71 | 4.48 | 3.14 | 2.57 | 3.29 | 11.20 | 11.13 |
| Centrifuge Cake | 17.21 | 5.52 | 7.73 | 5.54 | 4.79 | 7.82 | 29.73 | 18.74 |
| TSP | | 3.65 | | 4.11 | | 2.89 | | 10.64 |
| Control | 2.98 | | 2.88 | | 2.87 | | 8.72 | |

[1]Sur – surface applied; Incor – Incorporated.
[2]DMRP = Dissolved molybdate reactive P.

TABLE III-16: SAMPLING SCHEDULE AND ANALYSES OF SOIL, PLANT TISSUES, AND SUBSURFACE WATER SAMPLES FOR THE FARMLAND APPLICATION OF CLASS B BIOSOLIDS PROJECT

| Sampling Event* | Sample Type | Parameters Analyzed |
| --- | --- | --- |
| 1 | Deep soil cores | TKN, TP, KCl-ext. ($NO_3$-N, $NH_3$-N), Avail. P, Exch. Bases, $HNO_3$ acid-metals, 2:1 $H_2O$-ext. (pH, EC, $SO_4$-S, $NH_3$-N, $NO_3$-N), Hg, and OC |
| 2 | Shallow soil cores | KCl-ext. ($NO_3$-N, $NH_3$-N) and 2:1 $H_2O$-ext. ($NH_3$-N, $NO_3$-N) |
| 3 | Leaf tissues | TKN |
| 4 | Stover, stalk, and grain tissues | TKN, P, S, and $HNO_3$ acid-metals |
| 5 | Subsurface water | pH, P, EC, TKN, TP, $NO_3$-N, $NO_2$-N, $NH_3$-N, Ca, Na, K, Mg, Fe, Cd, As, Cr, Cu, Ni, Pb, Zn, Mo, Mn, and Co |

*Sampling Event 1 first occurred before biosolids application and then repeats every year after crop harvesting; Sampling Event 2 occurs approximately two weeks after planting the corn and repeats every month until the silking stage; Sampling Event 3 occurs approximately one month after planting and repeats every month until the silking stage; Sampling Event 4 occurs at the time of harvesting; Sampling Event 5 occurs every month or after a 1 to 2-inch rainfall event.

TABLE III-17: MEAN LEVELS OF SOIL FERTILITY PARAMETERS IN SURFACE (0- TO 6-INCH) SOIL LAYER OF THE WILL AND KANKAKEE COUNTY RESEARCH AND DEMONSTRATION FIELDS BEFORE APPLICATION OF BIOSOLIDS AND INORGANIC FERTILIZERS, AND IN THE INDIVIDUAL PLOTS IN 2006 AFTER HARVESTING CORN

| Treatment[1] | Will County Plots | | | | Kankakee County Plots | | | |
|---|---|---|---|---|---|---|---|---|
| | pH[2] | EC[2] | Avail. P[3] | Inorg. N[4] | pH[2] | EC[2] | Avail. P[3] | Inorg. N[4] |
| | | dS/m | mg/kg | mg/kg | | dS/m | mg/kg | mg/kg |
| Before[5] | 7.1 | 0.10 | 14 | 9.1 | 6.6 | 0.04 | 70 | 3.4 |
| Control | 7.2 | 0.14 | 31 | 6.8 | 6.5 | 0.05 | 92 | 1.9 |
| BS-1 | 7.0 | 0.27 | 140 | 17.6 | 6.6 | 0.06 | 72 | 4.6 |
| BS-2 | 6.4 | 0.21 | 178 | 22.2 | 6.4 | 0.05 | 99 | 3.8 |
| BS-3 | 6.4 | 0.22 | 153 | 24.5 | 6.2 | 0.07 | 96 | 5.9 |
| BS-4 | 6.6 | 0.25 | 292 | 26.7 | 6.0 | 0.20 | 197 | 23.8 |
| BS-5 | 6.5 | 0.22 | 256 | 21.3 | 6.3 | 0.21 | 182 | 23.2 |
| F-1 | 7.4 | 0.13 | 38 | 5.7 | 6.2 | 0.05 | 109 | 3.3 |
| F-2 | 6.9 | 0.12 | 58 | 6.1 | 6.2 | 0.05 | 99 | 3.7 |
| F-3 | 6.5 | 0.12 | 46 | 11.6 | 6.0 | 0.04 | 89 | 3.1 |
| F-4 | 7.0 | 0.13 | 34 | 9.9 | 6.0 | 0.05 | 92 | 2.9 |
| F-5 | 7.2 | 0.16 | 37 | 9.1 | 6.2 | 0.04 | 82 | 1.9 |
| F-6 | 7.6 | 0.20 | 20 | 11.9 | 6.1 | 0.04 | 75 | 2.1 |

[1]Control = no N and recommended rate of P. For Will County plots, BS-1 to BS-5 = 20, 30, 40, 50, and 80 wet tons biosolids per acre; and F-1 to F-6 = 72, 118, 210, 260, 300, and 370 lbs N per acre. For Kankakee County plots, BS-1 to BS-5 = 10, 20, 30, 40 and 60 wet tons biosolids per acre; and F-1 to F-6 = 54, 77, 128, 160, 192, and 238 lbs N per acre. Nitrogen was applied as polymer-coated urea in Will County and as urea in Kankakee County. All plots received K at the recommended agronomic rate.

[2]1:2 (soil:water) ratio.

[3]Bray P1 method.

[4]Sum of KCl-extractable $NH_4$-N, $NO_2$-N, and $NO_3$-N.

[5]Soil samples were collected prior to application of biosolids and fertilizers in November 2004 in Will County and March 2005 in Kankakee County.

TABLE III-18: MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE METALS[1] IN WATER SAMPLES TAKEN FROM THE LYSIMETERS[2] IN WILL COUNTY RESEARCH AND DEMONSTRATION PLOTS FROM MARCH 2006 THROUGH NOVEMBER 2006

| | | Treatment | | | |
|---|---|---|---|---|---|
| Parameter | Unit | Control[3] | 40 wet tons biosolids/ac[4] | 260 lbs N/ac[5] | 80 wet tons biosolids/ac[4] |
| TKN | mg/L | 0.83 | 0.56 | 0.40 | 0.91 |
| $NH_3$-N | " | 0.04 | 0.03 | 0.02 | 0.05 |
| $NO_3$-N[6] | " | 24.2 | 67.7 | 45.8 | 38.2 |
| Total P | " | 0.06 | 0.07 | 0.08 | 0.06 |
| Hg | µg/L | 0.06 | 0.06 | 0.06 | 0.06 |
| As | mg/L | 0.012 | 0.010 | 0.010 | 0.008 |
| Ba | " | 0.158 | 0.181 | 0.127 | 0.171 |
| Cd | " | 0.0005 | 0.0005 | 0.0004 | 0.0004 |
| Cr | " | 0.001 | 0.001 | 0.001 | 0.001 |
| Cu | " | 0.003 | 0.003 | 0.002 | 0.002 |
| Mn | " | 0.054 | 0.071 | 0.012 | 0.049 |
| Mo | " | 0.013 | 0.010 | 0.012 | 0.010 |
| Ni | " | 0.002 | 0.004 | 0.003 | 0.007 |
| Pb | " | 0.007 | 0.007 | 0.006 | 0.006 |
| Sb | " | 0.042 | 0.046 | 0.038 | 0.037 |
| Se | " | 0.024 | 0.021 | 0.022 | 0.025 |
| Tl | " | 0.008 | 0.007 | 0.007 | 0.006 |
| V | " | 0.034 | 0.030 | 0.023 | 0.013 |
| Zn | " | 0.008 | 0.011 | 0.008 | 0.025 |

[1]In calculating mean concentrations of trace metals, method detection limits were used in place of non-detectable levels.
[2]Lysimeters were installed at 3.5-ft. depth.
[3]Received no N and recommended agronomic rate of P and K.
[4]Received recommended aronomic rate of K.
[5]Received recommended agronomic rate of P and K. Nitrogen was applied as polymer-coated urea.
[6]Sum of $NO_2$-N and $NO_3$-N.

TABLE III-19: MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE METALS[1] IN WATER SAMPLES TAKEN FROM THE LYSIMETERS IN KANKAKEE COUNTY RESEARCH AND DEMONSTRATION PLOTS FROM MARCH 2006 THROUGH NOVEMBER 2006

| | | Treatment/Sampling Depth | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control[2] | | 160 lbs N/ac[3] | | 30 wet tons biosolids/ac[4] | |
| Parameter | Unit | 5 ft | 10 ft | 5 ft | 10 ft | 5 ft | 10 ft |
| TKN | mg/L | 0.84 | 0.49 | 0.61 | 0.32 | 0.27 | 0.34 |
| $NH_3$-N | " | 0.029 | 0.021 | 0.020 | 0.020 | 0.020 | 0.020 |
| $NO_3$-N[5] | " | 5.3 | 4.1 | 11.1 | 11.3 | 21.1 | 25.7 |
| Total P | " | 0.11 | 0.06 | 0.06 | 0.06 | 0.06 | 0.16 |
| Hg | µg/L | 0.07 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| As | mg/L | 0.0131 | 0.0092 | 0.009 | 0.010 | 0.010 | 0.009 |
| Ba | " | 0.065 | 0.041 | 0.055 | 0.099 | 0.088 | 0.034 |
| Cd | " | 0.0006 | 0.0004 | 0.0004 | 0.0004 | 0.0006 | 0.0004 |
| Cr | " | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 |
| Cu | " | 0.006 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| Mn | " | 0.003 | 0.003 | 0.017 | 0.008 | 0.037 | 0.003 |
| Mo | " | 0.006 | 0.002 | 0.003 | 0.003 | 0.002 | 0.005 |
| Ni | " | 0.003 | 0.001 | 0.003 | 0.001 | 0.007 | 0.001 |
| Pb | " | 0.006 | 0.004 | 0.004 | 0.005 | 0.005 | 0.005 |
| Sb | " | 0.023 | 0.013 | 0.015 | 0.020 | 0.020 | 0.027 |
| Se | " | 0.026 | 0.018 | 0.019 | 0.020 | 0.021 | 0.020 |
| Tl | " | 0.008 | 0.006 | 0.006 | 0.006 | 0.007 | 0.007 |
| V | " | 0.018 | 0.010 | 0.009 | 0.009 | 0.006 | 0.005 |

TABLE III-19 (Continued): MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE METALS[1] IN WATER SAMPLES TAKEN FROM THE LYSIMETERS IN KANKAKEE COUNTY RESEARCH AND DEMONSTRATION PLOTS FROM MARCH 2006 THROUGH NOVEMBER 2006

| | | Treatment/Sampling Depth | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control[2] | | 160 lbs N/ac[3] | | 30 wet tons biosolids/ac[4] | |
| Parameter | Unit | 5 ft | 10 ft | 5 ft | 10 ft | 5 ft | 10 ft |
| Zn | " | 0.007 | 0.009 | 0.007 | 0.006 | 0.009 | 0.005 |

[1]In calculating mean concentrations of trace metals, method detection limits were used in place of non-detectable levels.
[2]Received no N and recommended agronomic rate of P and K.
[3]Received recommended agronomic rate of P and K. Nitrogen was applied as urea.
[4]Received recommended agronomic rate of K.
[5]Sum of $NO_2$-N and $NO_3$-N.

FIGURE III-1. LOCATION OF THE FISCHER FARM FIELDS AND WELLS AT THE HANOVER PARK WRP

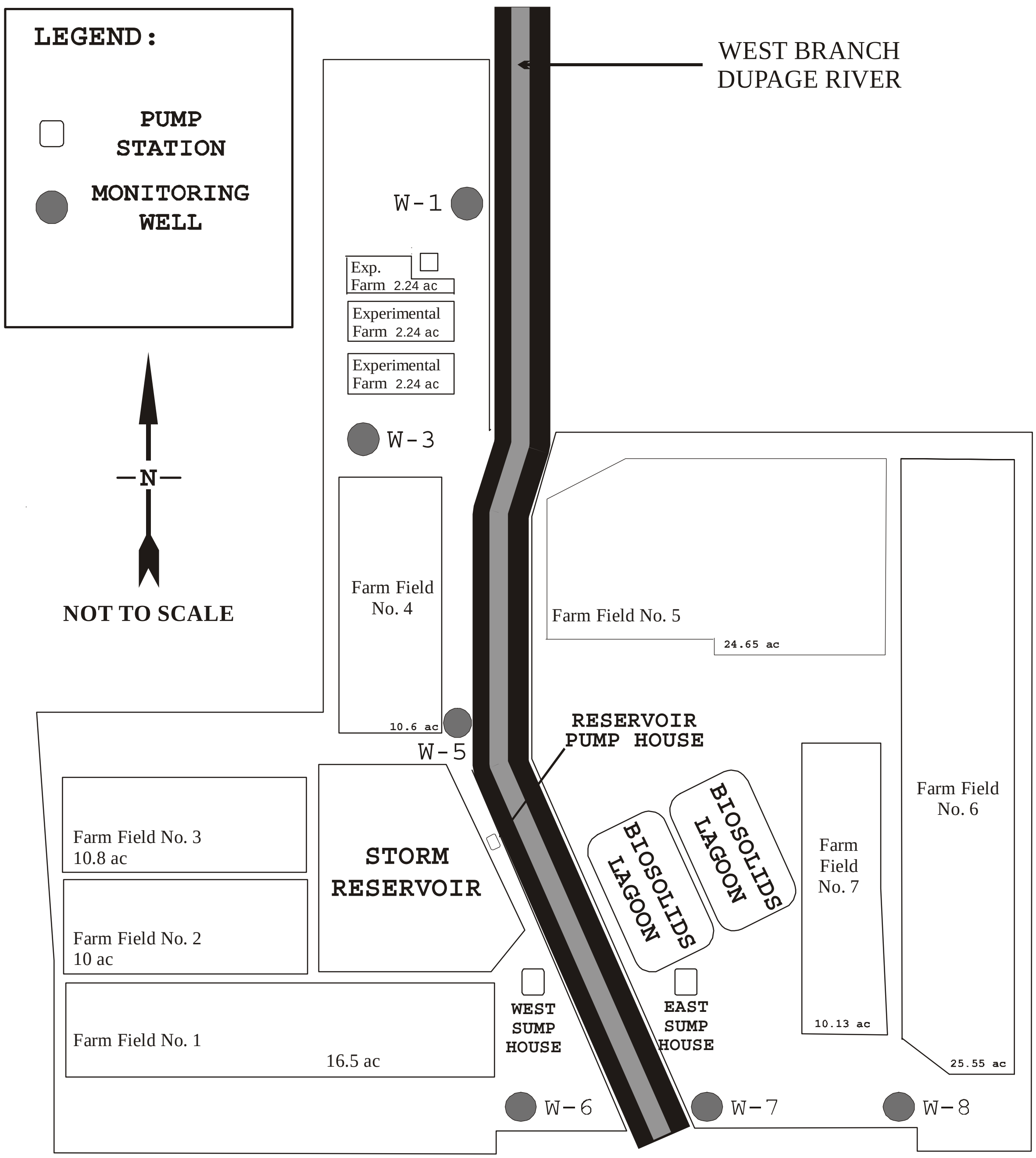


FIGURE III-2. LOCATION OF THE LYSIMETERS AT THE CALUMET EAST SOLIDS MANAGEMENT AREA

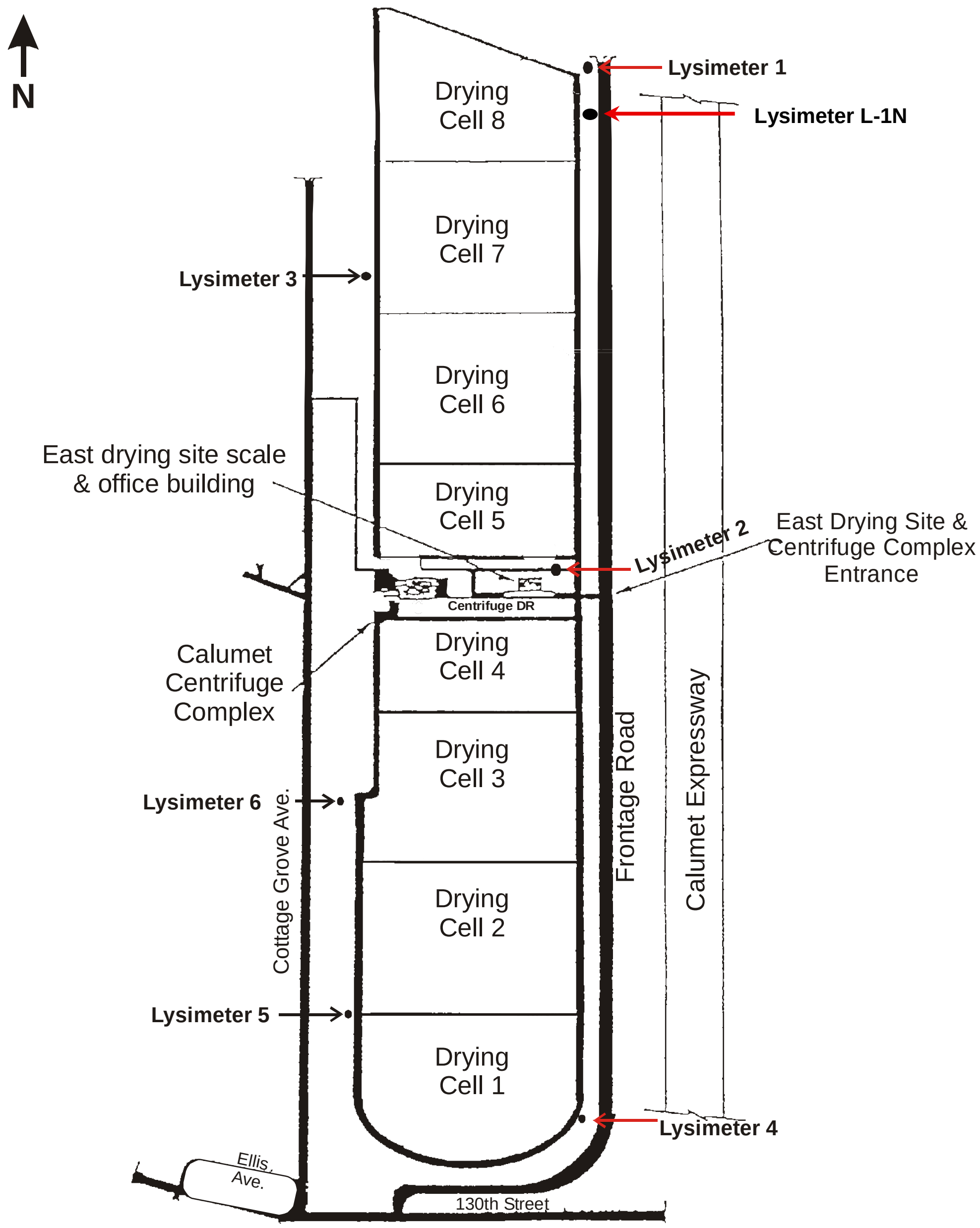


FIGURE III-3. LOCATION OF THE LYSIMETERS AT THE CALUMET WEST SOLIDS MANAGEMENT AREA

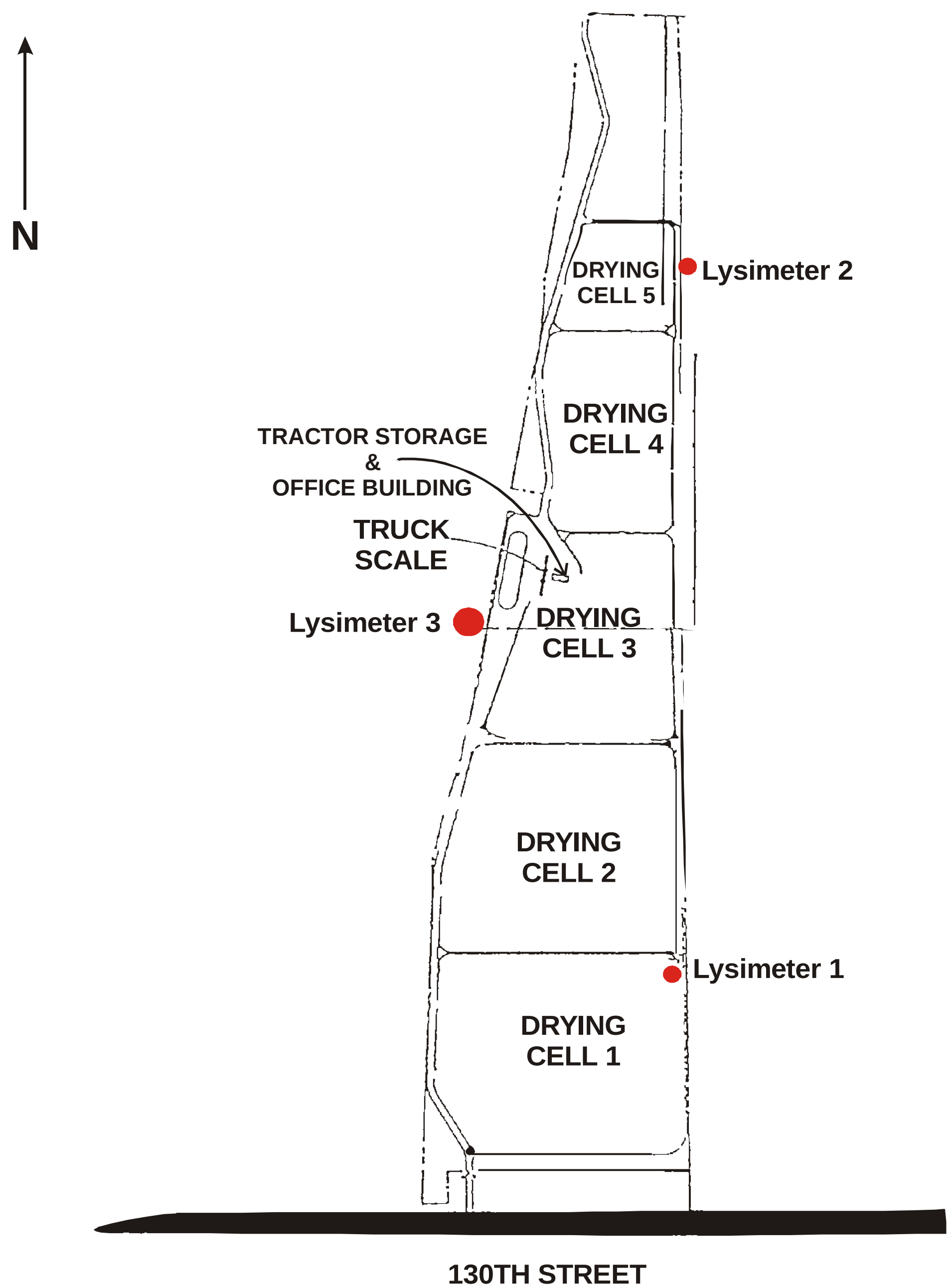


FIGURE III-4. LOCATION OF THE MONITORING WELLS AND LYSIMETERS AT LASMA

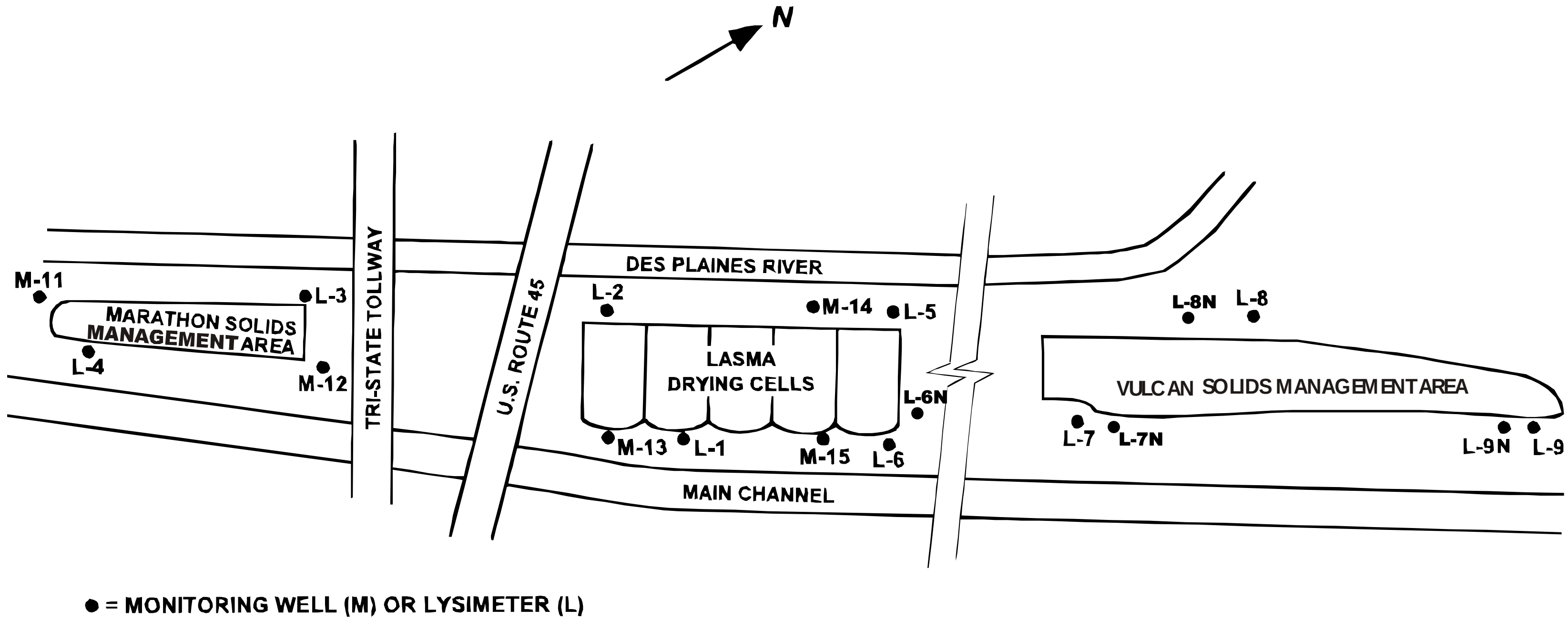


FIGURE III-5. LOCATION OF THE LYSIMETERS AT RASMA

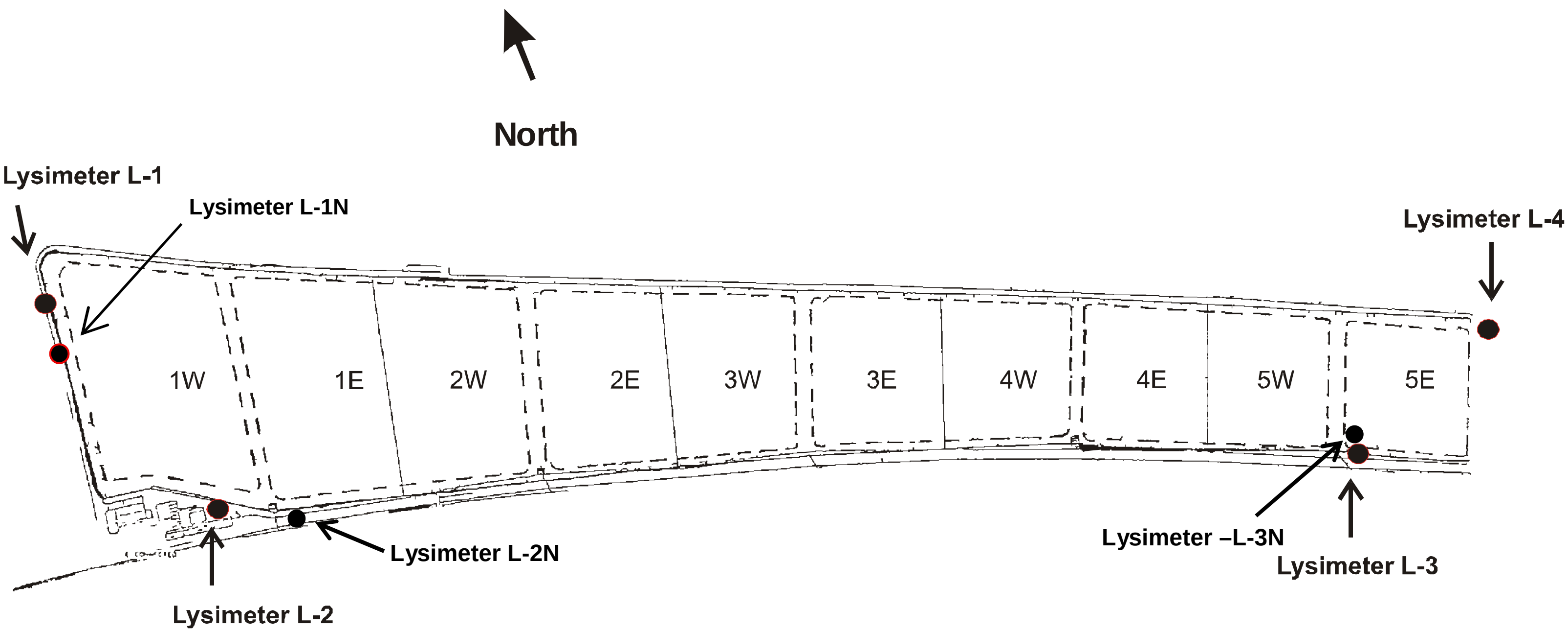


FIGURE III-6. LOCATION OF THE LYSIMETERS AT HASMA

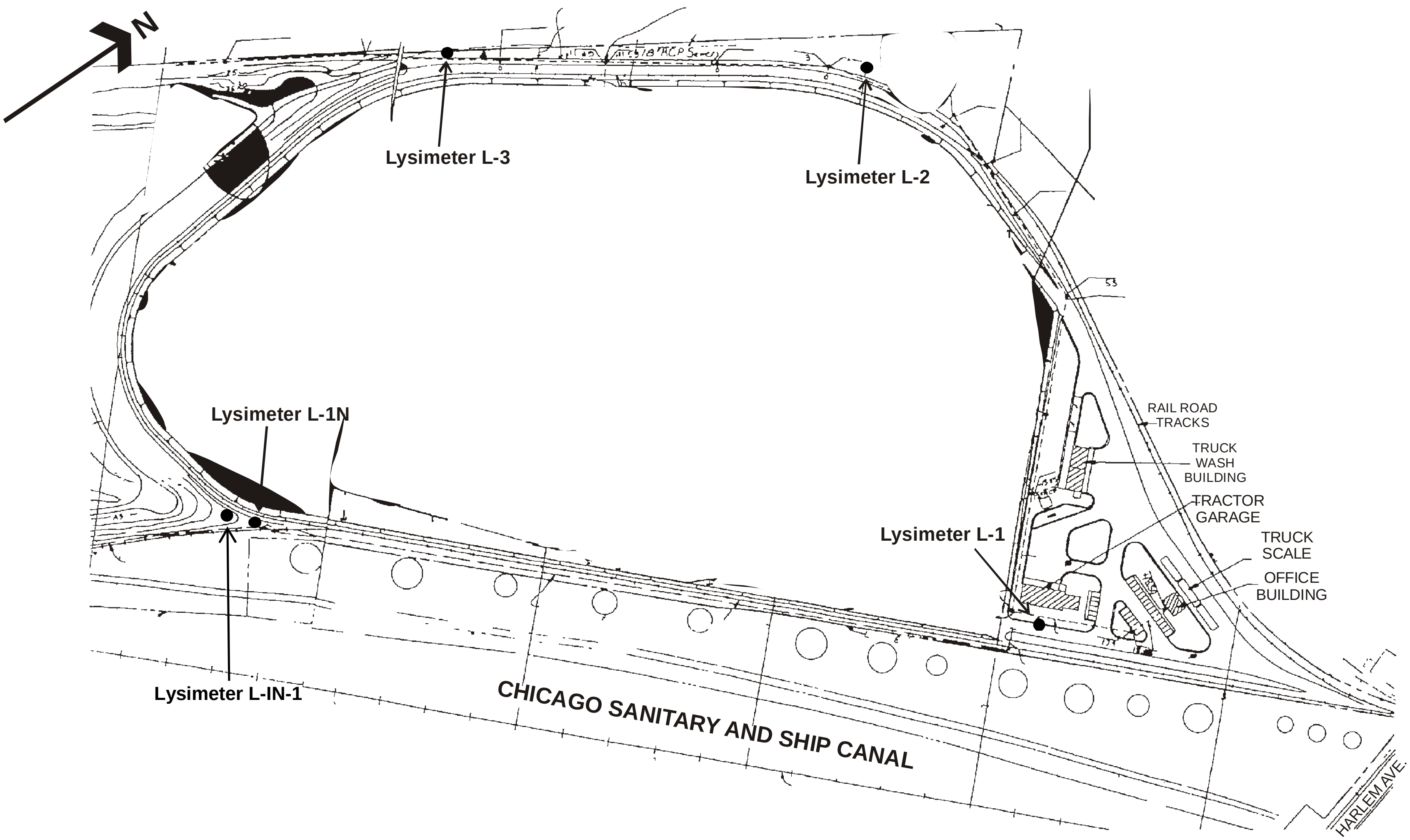


FIGURE III-7. LOCATION OF THE LYSIMETERS AT THE STONY ISLAND AVENUE SOLIDS MANAGEMENT AREA

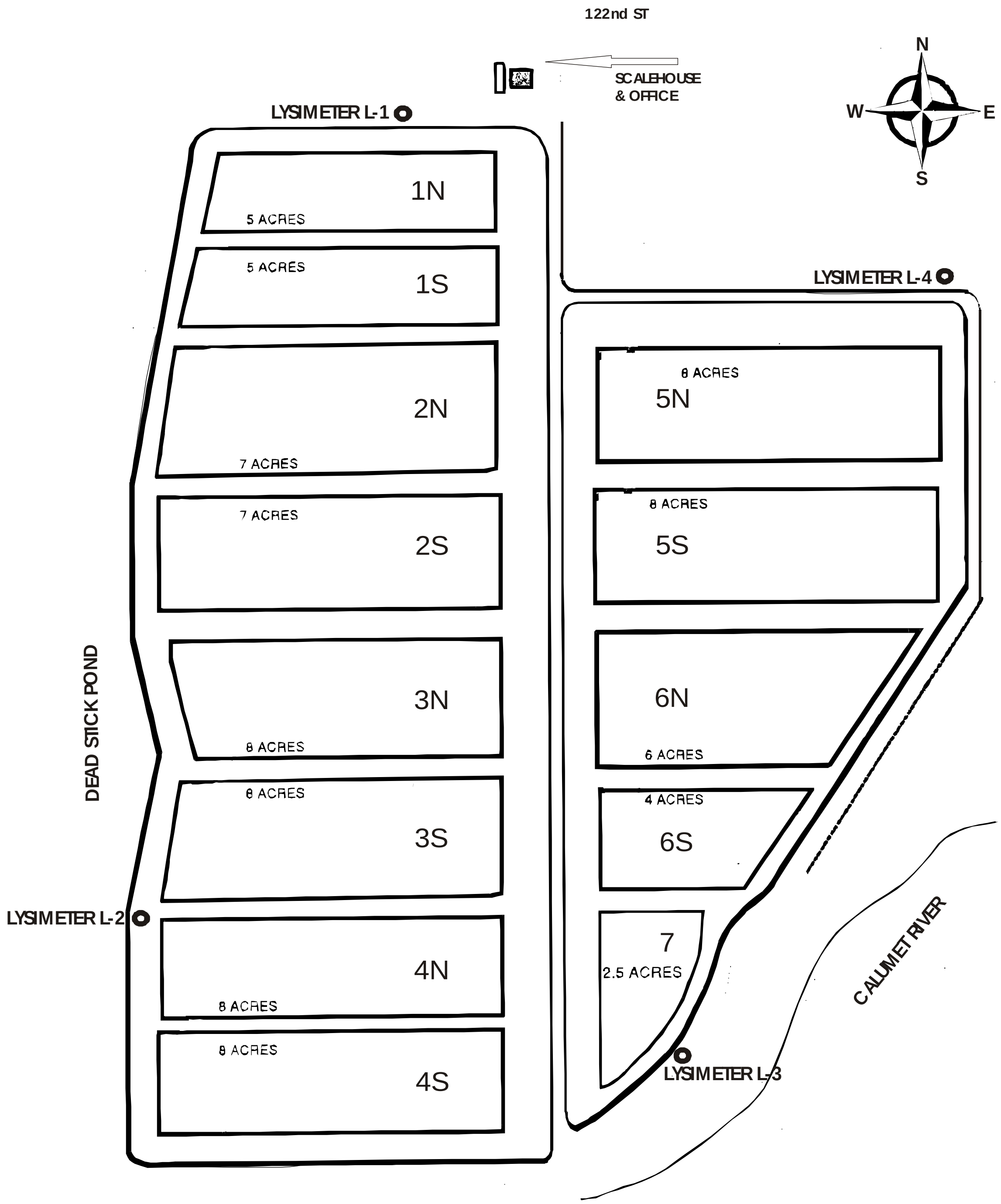
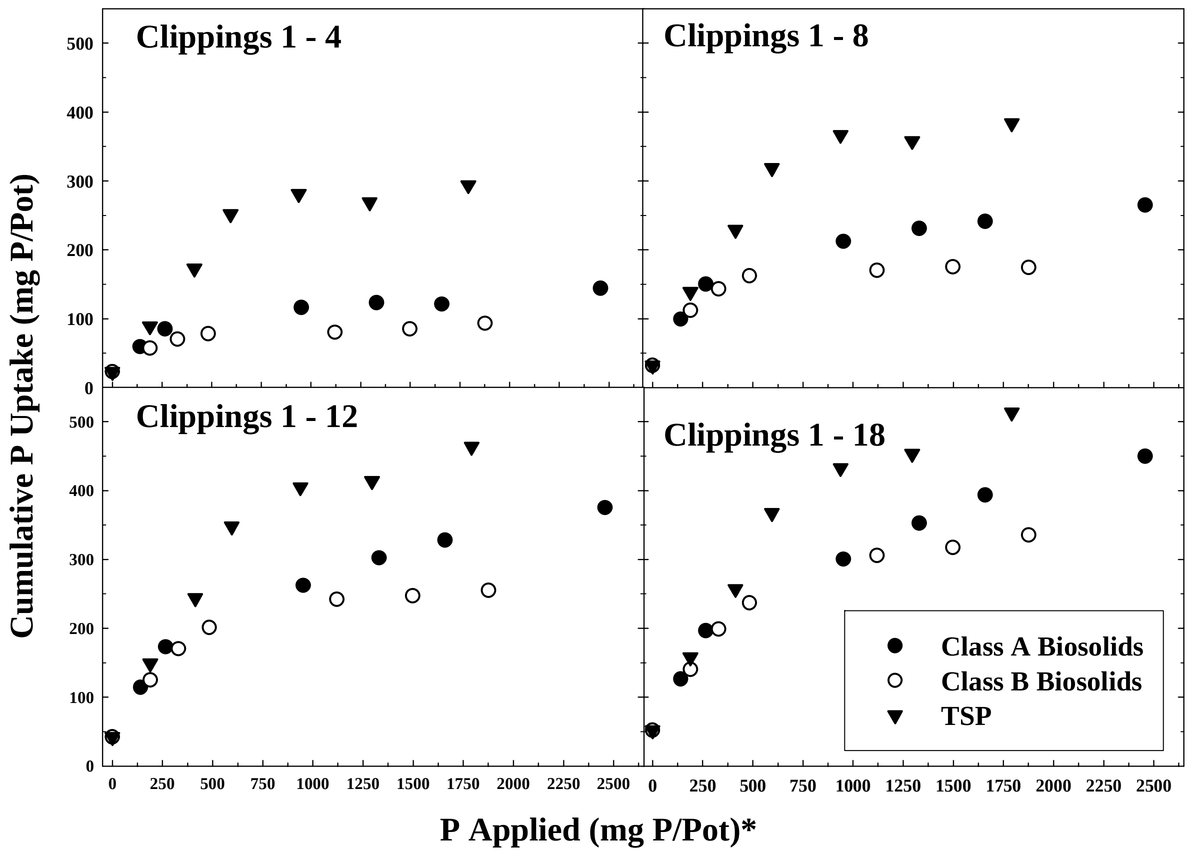


FIGURE III-8. CUMULATIVE P UPTAKE IN CONSECUTIVE FOLIAGE CLIPPINGS GROWN AS ALTERNATING SERIES OF WHEAT (CLIPPINGS 1-4, 9-12, 17, AND 18 ) AND PERENNIAL RYEGRASS (CLIPPINGS 5-8 and 13-16) CROPS IN THE GREENHOUSE IN SOIL AMENDED WITH SIX TOTAL P RATES APPLIED THROUGH CLASS A AND CLASS B BIOSOLIDS AND TRIPLE SUPERPHOSPHATE (TSP)




*Total P applied (mg P/pot) was calculated as [measured total P content in the amended soils (mg P/kg) - total P content in the unamended soil (mg P/kg)] x 7 kg soil.

FIGURE III-9. SKETCH OF TYPICAL DESIGN OF MAIN PLOT, SUBPLOT, AND LOCATION OF RUNOFF COLLECTION DEVICES IN THE BIOSOLIDS P RUNOFF FIELD STUDY

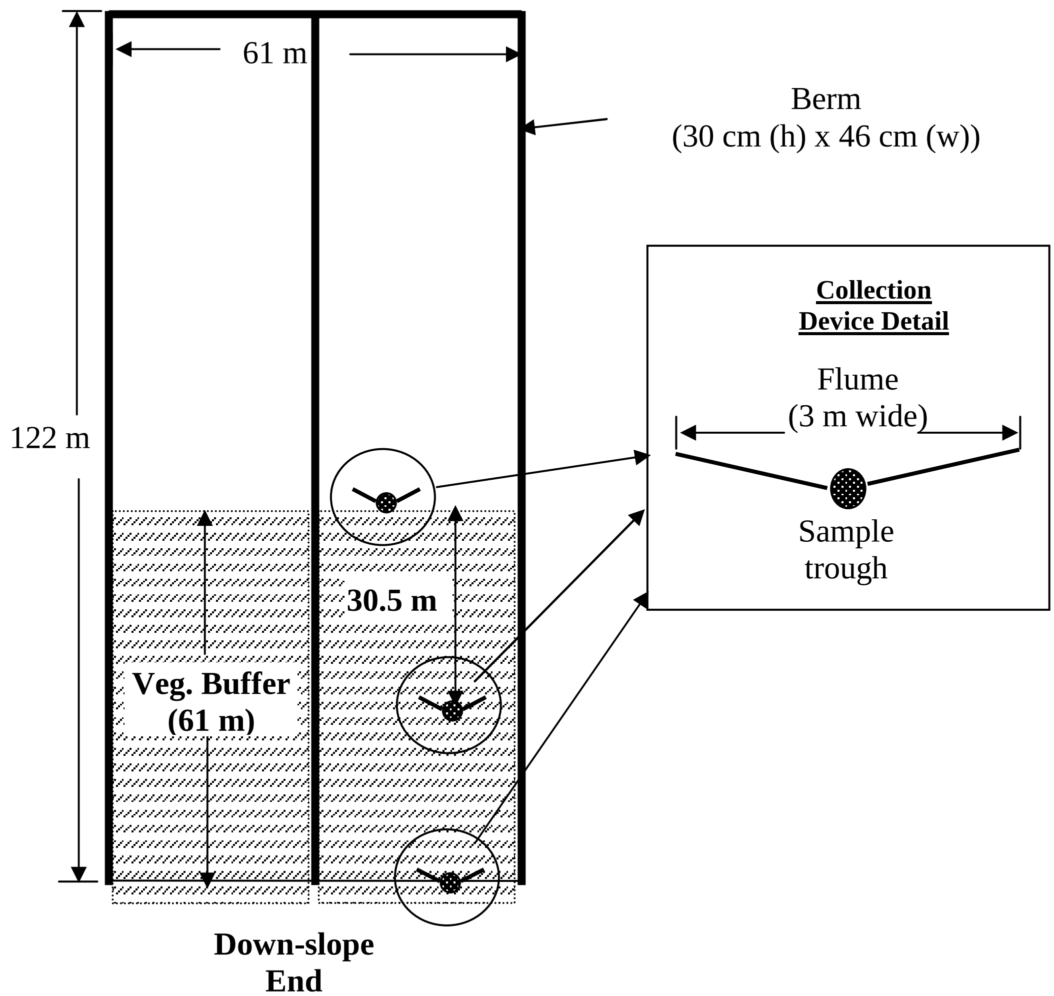
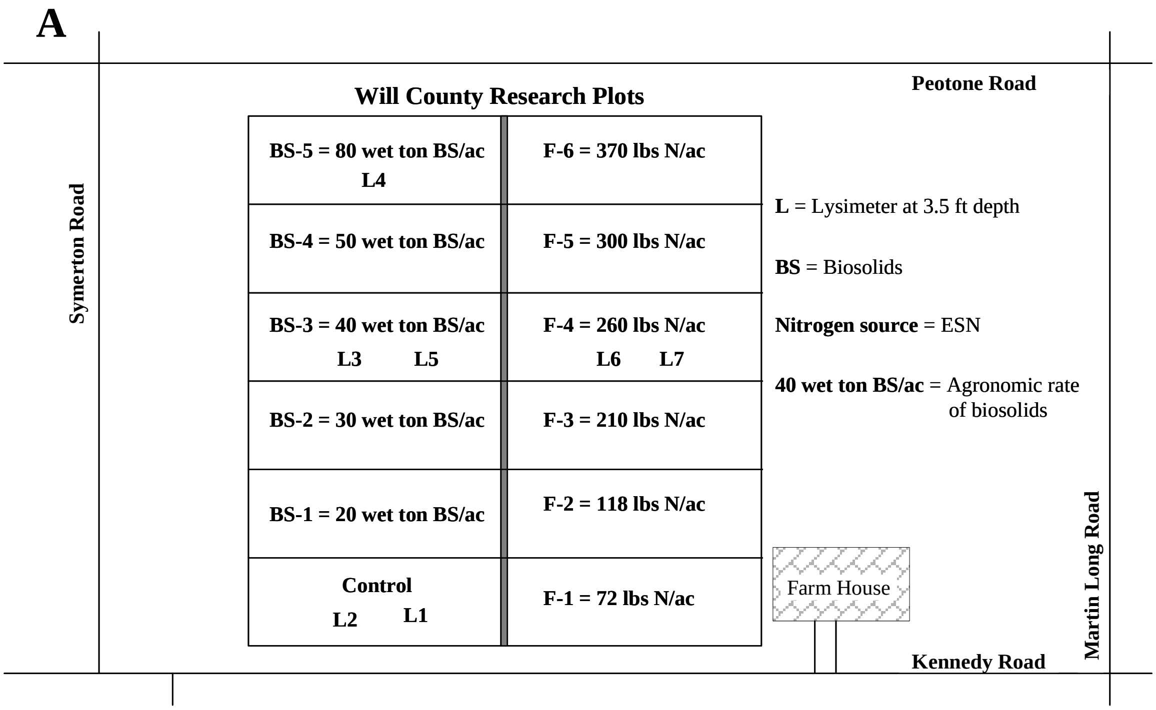


FIGURE III-10: SCHEMATIC OF THE RESEARCH PLOTS LOCATED IN WILL (A) AND KANKAKEE (B) COUNTIES SHOWING THE TREATMENTS AND LOCATIONS OF LYSIMETERS



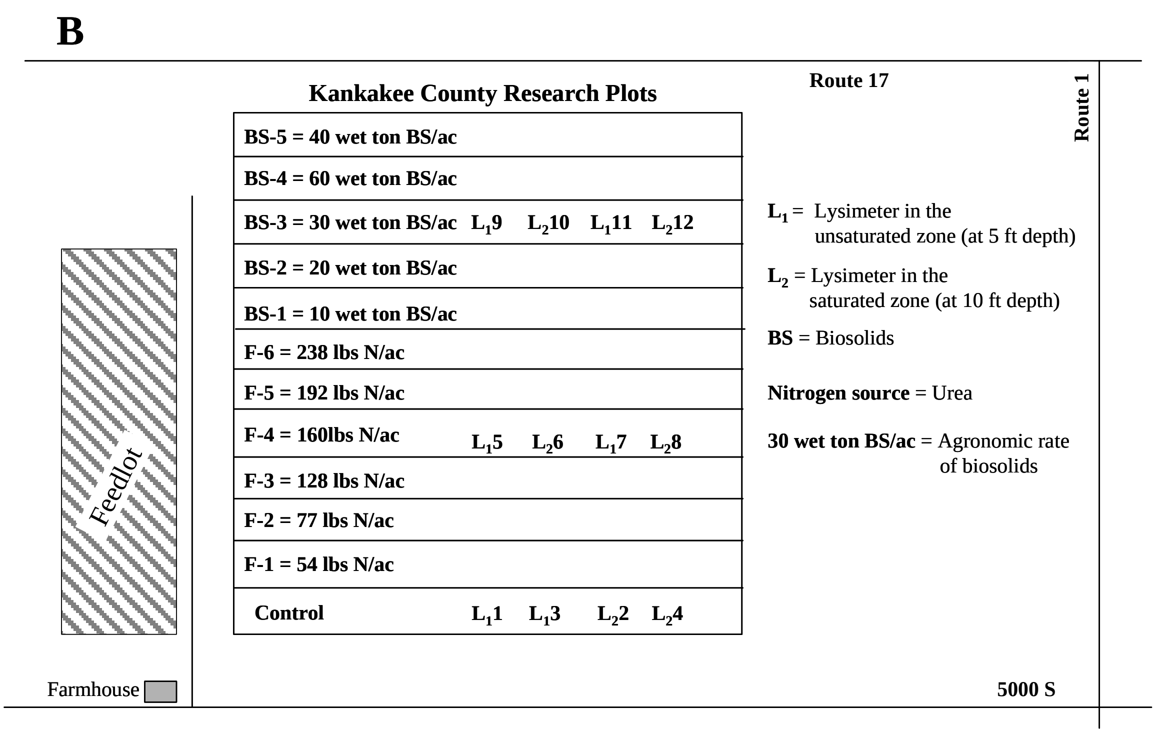
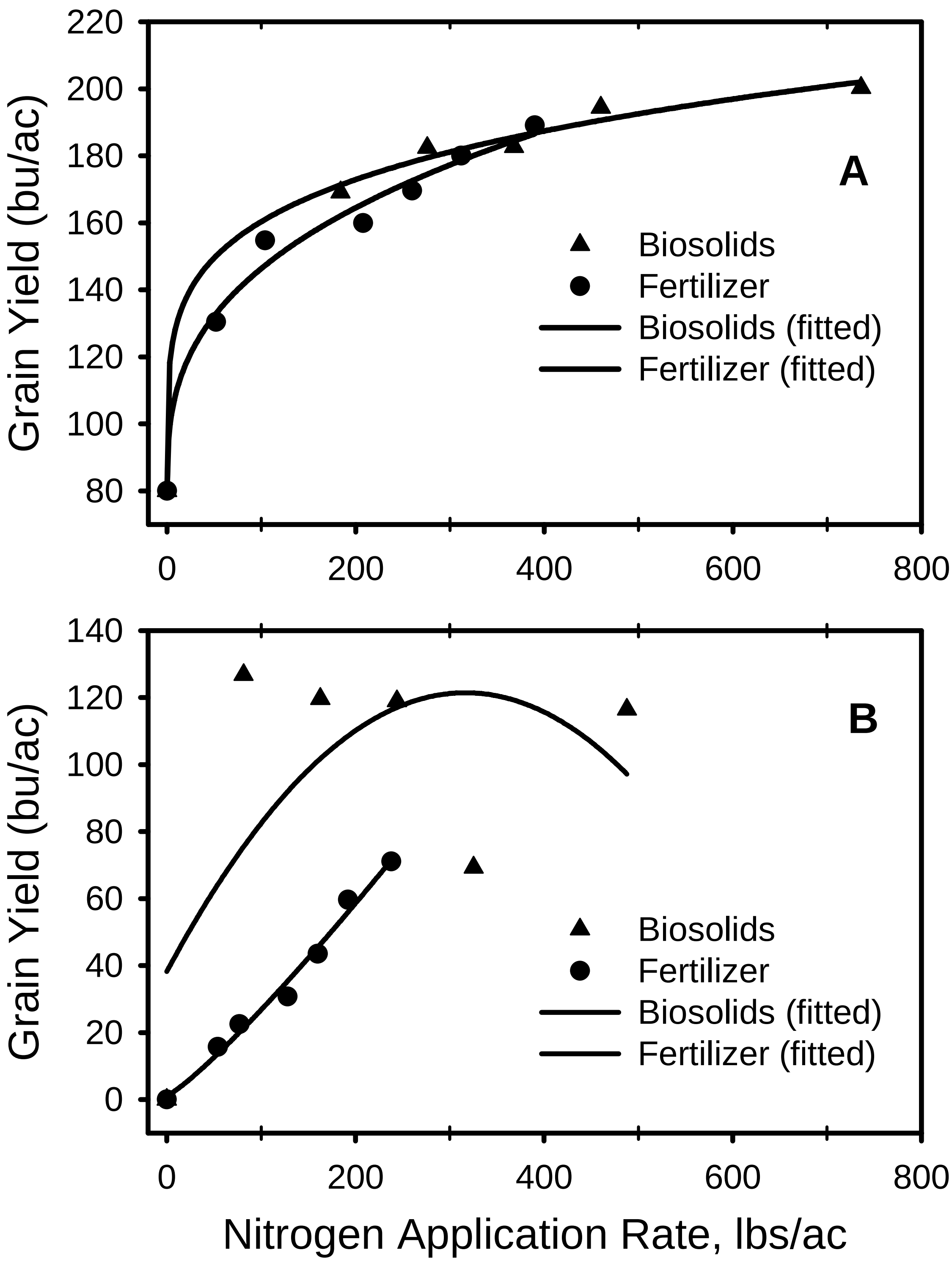



FIGURE III-11: CORN GRAIN YIELD FROM THE RESEARCH AND DEMONSTRATION PLOTS AT THE WILL (A) AND KANKAKEE (B) COUNTY SITES IN 2006.



# ANALYTICAL MICROBIOLOGY AND BIOMONITORING SECTION

# ANALYTICAL MICROBIOLOGY AND BIOMONITORING SECTION

The Analytical Microbiology and Biomonitoring Section is comprised of four professional and 12 technical personnel who are organized into four groups to perform specific monitoring or research activities. These four groups are:

I. Analytical Microbiology

II. Virology

III. Parasitology

IV. Biomonitoring

Section personnel are often involved in studies of wastewater treatment, biosolids assessment, and environmental monitoring, which require the application of specific microbiological disciplines and expertise. The areas of study in which the Section personnel can be involved during the course of a given year include, but are not limited to:

- Public health risk assessment.
- Ecological risk assessment.
- Water quality monitoring.
- Ecotoxicology and biomonitoring.
- Bioassay (whole effluent toxicity) methodology.
- Microbial processes.
- Enumeration of viral, microbial, and parasitic indicators.
- Enumeration of specific pathogens.
- The microbiology of specific wastewater or biosolids treatment options.
- Epidemiological study of recreational use of the Chicago Area Waterways.
- Emerging organic contaminants including endocrine disrupters, pharmaceuticals, and personal care products.

## Overview of Section Activities

In 2006, personnel in the Section participated in a variety of monitoring and research activities. Listed below are the most important of these activities separated according to the group with the most direct participation.

### Analytical Microbiology Group.

a. Water Reclamation Plant (WRP) Quality Control. Monitoring WRP effluents for the presence and density of fecal coliforms (FC) for disinfection control.

b. Chicago Waterways System (CWS). Monitoring District waterways in Cook County upstream and downstream of the Calumet, North Side, Stickney, and Lemont WRPs.

c. Groundwater Monitoring Wells - TARP. Monitoring FC presence and density in groundwater monitoring wells near TARP tunnels, as required by Illinois Environmental Protection Agency (IEPA) operational permits.

d. Groundwater Monitoring Wells - Land Reclamation. Monitoring the presence and density of FC in groundwater monitoring wells around biosolids processing and application handling sites in Cook County.

e. Part 503 Compliance Monitoring. Analysis of Class A and B biosolids for FC.

f. Biosolids Beneficial Use Support. Monitoring bacterial (FC and *Salmonella* spp.) densities in farm soil after application of biosolids.

g. Potable Water Analysis. Monitoring drinking water at District WRPs, and other locations.

h. Study of Antibiotic Resistant Bacteria (ARB). Monitoring of ARB in Wastewater and the CWS.

i. Disinfection Study. Bacterial density monitoring at three major WRPs.

j. Research Study. Dry and wet weather risk assessment of human health impacts of disinfection vs. no disinfection of the CWS.

k. Reviews. Review of the United States Environmental Protection Agency (USEPA) Water Quality Criteria for Bacteria. Review research reports and proposed regulations to determine the impact on District operations.

**Virology Group.**

a. Part 503 Compliance Monitoring. Analysis of biosolids for enteric viruses.

b. Process Certification for Class A Biosolids. Analysis of biosolids for enteric viruses to demonstrate that the District's codified Process to Further Reduce Pathogens (PFRP) treatment processes consistently produce Class A biosolids as defined in the Part 503 Regulations.

c. Monitoring of Biosolids for Coliphages (Somatic and Male-specific RNA). Research on the use of coliphages as indicators for enteric viruses in biosolids.

d. Biosolids Beneficial Use Support. Monitoring virus densities in farm soil after application of biosolids.

e. Establishment of Molecular Microbiology Laboratory. Polymerase Chain Reaction (PCR) technology capability to meet the future demands for microbial source tracking, pathogen monitoring, and genetic analysis of ARB.

f. Reviews. Review research reports and proposed regulations for any impact on District operations.

**Parasitology Group.**

a. Part 503 Compliance Monitoring. Analysis of biosolids for viable *Ascaris* ova.

b. Process Certification for Class A Biosolids. Analysis of biosolids for viable *Ascaris* ova to demonstrate that the District's codified PFRP treatment processes consistently produce Class A biosolids as defined in the Part 503 Regulations.

c. Biosolids Beneficial Use Support. Monitoring viable *Ascaris* ova densities in farm soil after application of biosolids.

d. Reviews. Review research reports and proposed regulations for any impact on District operations.

**Biomonitoring Group.**

a. Whole Effluent Toxicity (WET) Testing for National Pollutant Discharge Elimination System (NPDES) Permits. Use of fathead minnow *(Pimephales* *promelas)* and daphnids *(Ceriodaphnia dubia)* to assess acute and chronic toxicity of effluents from District WRPs.

b. The Algal Growth Test (AGT). To assess the Salt Creek nutrient reduction demonstration project at Egan WRP. To assess stream response to nutrient reduction at the Lemont WRP expansion project.

c. Reviews. Review research reports and proposed regulations for any impact on District operations.

**Analytical Microbiology Group Responsibilities**

The Analytical Microbiology Laboratory has been certified by the Illinois Department of Public Health (IDPH) for the bacterial analysis of water since 1979. Monitoring the densities of FC bacteria in WRP effluents was first mandated by NPDES permits in 1972; at present, the Analytical Microbiology Group is responsible for all bacterial population density analyses used in WRP effluent monitoring. Monitoring of the Chicago beaches is conducted when river reversals to Lake Michigan occur following large amounts of rainfall. In 2006, there were no reversals to Lake Michigan. The Analytical Microbiology Group also conducts microbiological analyses in support of other Sections.

Table IV-1 summarizes the number and types of analyses performed by the Analytical Microbiology Group in 2006. Bacterial analyses for total coliforms (TC), FC, and *Escherichia coli (*EC) are used by the District as indicators of the sanitary quality of water. The heterotrophic plate count (HPC) is a procedure for estimating the number of viable heterotrophic bacteria in water. Bacteria are identified to species (ID-CONF) using specific biochemical metabolic characteristics.

**Certification by the IDPH.** The Analytical Microbiology Group is certified by the IDPH, Registry #17508, for the following laboratory examinations:

- HPC for water.
- TC with EC broth verification examination of water from public water supplies and their sources (membrane filtration [MF] and multiple tube fermentation [MTF]).
- FC examination of water from public water sources (MF and MTF).
- TC and EC examination of samples of water from public water supplies and their sources (minimal medium orthonitro-phenyl-β-D-galactopyranoside-4-methylumbelliferyl-β-D-glucuronide [MMO-MUG]).

The Analytical Microbiology Group's facilities, equipment, and procedures were the subject of the biennial on-site evaluation for certification by the IDPH on October 18, 2006, and were found to be in general compliance with the provisions of 18th Edition of *Standard Methods for the Examination of Water and Wastewater* (SM 18th ed.) and the Illinois Rules for Certification and Operation of Environmental Laboratories, Title 77, Part 465. The Group collects and analyzes potable water samples from District facilities as required.

**NPDES Compliance Monitoring.** Fecal coliform data from disinfected effluents are made available to the Hanover Park, James C. Kirie, and Egan WRPs within 24 hours of sample collections. These data are used as a guide in maintaining proper chlorination at these District WRPs and for reporting compliance with NPDES permit regulations. All District WRPs with NPDES disinfection requirements have a seasonal exemption from November 1 through April 30 of each year and are not subject to any effluent disinfection requirements during this period.

NPDES permits also require additional monitoring when increased flow due to storms exceeds the design maximum treatment capacities of the WRPs. These storms can cause the WRPs to divert a portion of their influent, which is then given minimal treatment before being delivered to the receiving stream. These storm-related excess flow discharges must be monitored for the FC bacteria levels. In 2006, the Analytical Microbiology Group performed three analyses of FC bacteria on three storm-related excess flow discharge events at the Egan WRP service area on March 13, October 3, and December 22.

**Part 503 Compliance Monitoring.** In 2006, the Analytical Microbiology Group performed MPN analyses for FC bacteria on 30 samples of biosolids to determine if they met the Class A pathogen requirement of less than 1,000 FC MPN/g (dry weight) specified in the Part 503 Regulations. The results were reported to the Maintenance and Operations (M&O) personnel responsible for the District's Controlled Solids Distribution Program at the solids management areas. The District has more distribution options for biosolids demonstrated to be Class A than for non-Class A biosolids.

**Monitoring Bacterial Densities in Farm Soil.** In 2006, the Analytical Microbiology Laboratory continued monitoring FC and *Salmonella* spp. densities in farm soil after application of biosolids. These analyses were conducted as part of full-scale studies being conducted in Will and Kankakee Counties to demonstrate the benefits and safety of applying Class B centrifuge cake biosolids to farmland. See the Biosolids Utilization and Soil Science Section chapter of this report for more details on this project.

**Study of Antibiotic Resistant Bacteria (ARB) in Wastewater.** A study to understand the fate of antibiotic resistant fecal coliform bacteria in the influent and effluent samples at all seven water reclamation plants (WRPs) was undertaken. The density of antibiotic resistant FC were determined on m-FC agar containing ampicillin (AMP-R: 16 μg/mL), gentamicin (GEN-R:

8 μg/mL), tetracycline (TET-R: 8 μg/mL), or a mixture of all three antibiotics. The study was conducted to determine whether secondary wastewater treatment at the District WRPs reduces the quantity of antibiotic resistant FC bacteria. The results support the conclusion that secondary sewage treatment in the District effectively reduces the number of antibiotic resistant FC and that the environments of the District's seven WRPs are not conducive to the propagation or survival of antibiotic resistant fecal coliform bacteria. The results of this work is summarized in Research and Development (R&D) Report No. 06-32 titled, "The Effect of Secondary Sewage Treatment on the Total Numbers and Percentages of Antibiotic Resistant Fecal Coliforms in Raw Sewage Entering the Seven Water Reclamation Plants of the Metropolitan Water Reclamation District of Greater Chicago."

**Study of ARB in Chicago Waterways System (CWS).** The District expanded the ARB study to survey the CWS. The purpose of expanding is to determine whether ARB present in the final effluents (FE) of the Stickney, Calumet, and North Side WRPs are affecting the number and spatial distribution of ARB in the CWS. In addition, the study is intended to further investigate whether secondary sewage treatment at the Stickney, Calumet, and North Side WRPs is adequately reducing the concentration of ARB present in wastewater. The study consists of three objectives to survey the total numbers and percentages of ARB at the following WRP waterway locations:

1) Chicago Sanitary and Ship Canal (CSSC) upstream and downstream of the Stickney WRP (SWRP).

2) The North Shore Channel (NSC) upstream and downstream of the North Side WRP and in the North Branch of the Chicago River (NBCR) downstream of the North Side WRP.

3) The Little Calumet River upstream and downstream of the Calumet WRP and in the Calumet-Sag Channel downstream of the CWRP.

An experimental plan, titled "Monitoring the Total Numbers, Percentages, and Antibiotic Resistance Patterns of Antibiotic Resistant Fecal Coliforms in the Chicago Waterways System" was written, and the study commenced in the winter of 2005-2006. The first objective of this study investigated the impact of Stickney WRP FE, which was pursued by the collection and analyses of four sets of water samples from one upstream and four downstream locations in the CSSC in the winter of 2005-2006, and in spring, summer, and fall of 2006. The second objective of this study is still in progress. The data collection will be completed in 2008.

**Disinfection Study.** In 2006, the District was involved in monitoring bacterial densities to assess its future disinfection needs at the Stickney, Calumet, and North Side WRPs. The District performed 723 analyses of the TC, FC, and EC content of 244 WRP final effluent samples.

**Review of the USEPA Water Quality Criteria for Bacteria.** As part of the Use Attainability Analysis (UAA) study of the CWS, the District commissioned an Expert Review Panel (Panel) comprised of Drs. Herbert E. Allen, Abdel El-Shaarawi, Charles N. Haas, and Joan B. Rose, to conduct a review of the USEPA November 2003 Implementation Guidance for Ambient Water Quality Criteria. The Panel was charged with determining whether the 2003 Guidance provides the proper scientific/technical basis for establishing bacterial water quality standards for the CWS. Dr. Haas served as the chairperson of the Panel, assigned specific tasks to the other members of the Panel, compiled and edited contributions from other members of the Panel, and prepared the final report. A report titled, "Expert Review Report Regarding the United States Environmental Protection Agency's Water Quality Criteria for Bacteria – 1986: Application to Secondary Contact Recreation," R&D Report No. 2006-38 was published.

**Dry and Wet Weather Risk Assessment of Human Health Impacts of Disinfection vs. No Disinfection of the Chicago Waterways System (CWS).** As part of the Use Attainability Analysis (UAA) study of the CWS, the District, working with consultants, is evaluating the human health impact of disinfecting versus not disinfecting effluents from the District's Calumet, North Side, and Stickney WRPs, which discharge into the CWS. The consultant is the GeoSyntec Team (GST), which includes GeoSyntec Consulting and its subcontractors; Patterson Environmental Consultants; Cecil Lue-Hing & Associates; Dr. Charles Gerba of the University of Arizona; Dr. John Colford, M.D., of the University of California at Berkeley; Hoosier Microbiological Laboratory, Inc.; and Clancy Environmental Consultants.

The main objectives of the study were to: 1) prepare a sampling and analysis plan (SAP) and Quality Assurance Project Plan (QAPP) for generating microbial analytical results that would form the basis of the microbial risk assessment; 2) provide field training to District's sampling personnel; 3) perform a literature review of pathogen disinfection effectiveness; 4) perform a microbial exposure assessment by literature review; 5) perform a microbial infection dose-response analysis by literature review; 6) perform a microbial risk characterization of three waterway segments in the vicinity of the North Side, Stickney, and Calumet WRPs. Sampling and monitoring activities associated with the dry weather assessment of the study were completed between July and September of 2005. An interim report on the dry weather risk assessment study was completed in 2006 and is on the District website.

The wet weather sampling was completed in 2006 because of the extended dry weather in 2005.

**Epidemiological Research Study of Recreational Use of the Chicago Area Waterways.** In 2006, the District initiated a scope of work for an Epidemiological Study of Chicago Area Waterways to verify the results of the District's Dry and Wet Weather Microbial Risk Assessment Study and to gain knowledge on the science-based protective bacterial water quality standards for the CWS.

**Support to Other Sections**. The Analytical Microbiology Group supported a variety of Environmental Monitoring and Research and Industrial Waste Division programs in 2006: effluent analysis, land reclamation and sludge indicator organism densities, District waterway surveys, Lake Michigan monitoring, WRP monitoring, TARP monitoring, research support, industrial waste surveys, the Illinois waterway survey, and other miscellaneous samples. Table IV-2 is a summary of the major programs receiving support from 2005 through 2006 and the number of analyses performed for each program.

## Virology Group Activities

In 2006, the Virology Group analyzed 12 biosolids samples for site-specific Processes to Further Reduce Pathogens (PFRP) equivalency monitoring and for compliance with the Part 503 biosolids regulations. Enteric virus densities in all samples of biosolids produced by the District's codified PFRP processing trains were determined to be below the detectable limit, which is less than one plaque forming unit (PFU) per four grams total solids (dry weight basis). Positive recovery studies were performed on these samples for quality assurance purposes. The mean recovery of spiked viruses was 58 percent. Recoveries ranged from 43.8 to 75.1 percent and were dependent upon the sample spiked. Results of these analyses are shown in Table IV-3.

The analytical method used by the District for determining the density of enteric viruses in biosolids was published and approved by the USEPA (Appendix H, EPA/625/R-92/013). The analytical method for enteric viruses involves the elution of viruses from solids, concentration of the eluates, and an assay for plaque-forming viruses using BGM-K cells.

**Monitoring of Biosolids for Coliphages (F Specific and Somatic).** The USEPA coliphage method was modified and adapted in the District to determine coliphage concentrations in Class A and B biosolids. Research is currently being conducted to evaluate the usefulness of coliphages as an alternative indicator for the presence of enteric viruses in biosolids. In 11 samples of biosolids produced by the District's codified process, the concentrations of F Specific Coliphages (FP) were determined to be below the detectable limit (less than one plaque forming unit [PFU] per gram total solids [dry weight basis]). In 8 samples of biosolids produced by the District's codified process, the concentrations of somatic coliphages (SP) were determined to be below the detectable unit (less than one plaque forming unit [PFU] per gram total solids [dry weight basis]). Results of these analyses are shown in Tables IV-4.

Data collected to date suggest that FP coliphages are a good alternate indicator for predicting the presence or absence of enteric viruses in biosolids.

**Monitoring Virus Densities in Farm Soil.** In 2006, the Virology Laboratory continued monitoring virus densities in farm soil after application of biosolids. These analyses were conducted as part of full scale studies set up in Will and Kankakee Counties to demonstrate the benefits and safety of applying Class B centrifuge cake biosolids to farmland. See the Biosolids Utilization and Soil Science Section chapter of this report for more details on this project.

**Establishment of Molecular Microbiology Laboratory.** The District completed its plans in 2006 to construct a molecular microbiology research laboratory at the Cecil Lue-Hing R&D Complex to meet the future demands for microbial source tracking, pathogen monitoring, and genetic analysis of ARB. It is anticipated that the laboratory will open in 2008.

## Parasitology Group Activities

In 2006, the Parasitology Group analyzed 12 biosolids samples for site-specific PFRP equivalency monitoring and for compliance with the Part 503 biosolids regulations. Viable *Ascaris* ova densities in all samples of biosolids produced by the District's codified PFRP sludge processing trains were determined to be below the detectable limit, which is less than one viable *Ascaris* ovum per four grams of total solids (dry weight basis). Results of these analyses are shown in Table IV-5. Since 1996, when the District began monitoring the levels of FC bacteria (see Analytical Microbiology Group Activities above), enteric viruses (see Virology Group Activities above), and viable *Ascaris* in its dried biosolids product for compliance with the Class A biosolids criteria in the Part 503 biosolids regulations, all biosolids produced by the District's codified PFRP sludge processing trains have been in compliance with the Class A criteria for shipment and use under the District's Controlled Solids Distribution Program.

The analytical method used by the District for enumerating Viable *Ascaris* ova in sludge was published and approved by the USEPA (Appendix I, EPA/625/R-92/013). The *Ascaris* method employs a combination of sieving, flotation, centrifugation, incubation, and microscopic analysis to extract and enumerate viable *Ascaris* ova.

**Monitoring Viable *Ascaris* Densities in Farm Soil.** In 2006, the Parasitology Laboratory continued monitoring viable *Ascaris* ova in farm soil after application of biosolids. These analyses were conducted as part of full scale studies set up in Will and Kankakee Counties to demonstrate the benefits and safety of applying Class B centrifuge cake biosolids to farmland. See the Biosolids Utilization and Soil Science Section chapter of this report for more details on this project.

**Microscopic Image Analysis.** The District uses microscopic image analysis (MIA) as an aid to monitor viable *Ascaris* ova in biosolids. The MIA system, mounted on a Nikon Eclipse E600 phase contrast microscope, includes a digital camera with a video image acquisition mode to transmit microscopic images from slides to a computer workstation (Figure IV-1). Digital images are stored and analyzed using the MetaMorph™ imaging system (Figure IV-2). The MIA system has proven to be a useful tool for the verification and monitoring of biosolids for Part 503 compliance. For each digital image the following information is automatically stored in a computer file by the imaging software: 1) length of the ovum; 2) width of the ovum; 3) date and time the image was recorded; and 4) sample identification number. A series of digital video images is recorded for each ovum examined when larval movement is observed in order to document viable *Ascaris* ova.

## Biomonitoring Group Activities

**NPDES Compliance Biomonitoring.** In 2006, acute whole effluent toxicity (WET) tests with fathead minnow (*Pimephales promelas)* and daphnids (*Ceriodaphnia dubia)* were conducted on effluent samples from the Egan and Lemont WRPs for NPDES Permit compliance. No acute toxicity was observed. Chronic WET tests were also conducted on effluent samples from the Hanover Park WRP for NPDES Permit compliance. No chronic toxicity was observed. These data are shown in Table IV-6. Biomonitoring reports for these WRPs were submitted to the IEPA in compliance with the respective NPDES permits.

**The Algal Growth Test (AGT)**. The *Selenastrum capricornutum* Printz Algal Assay Bottle Test (AGT) was developed by the USEPA to determine algal growth potential and nutrient limitation in natural waters (EPA-600/9-78-018). By measuring the algal growth potential of water, a differentiation can be made between the total nutrient in the sample (as determined by chemical analysis) and the nutrient forms that are actually available for algal growth. The District initiated AGT research primarily to study the biological available phosphorus (BP) in the Egan and Lemont WRPs final effluent and in upstream and downstream locations, in conjunction with a planned demonstration project to study river response to phosphorus reduction at WRPs. The AGT was developed using a standard test organism *Pseudokirchneriella subcapitata*, formerly known as *Selenastrum capricornutum*.

Eight valid AGTs were conducted to measure BP in effluent samples from the Egan WRP and samples from three monitoring stations on Salt Creek (Busse Reservoir Dam, Kennedy Blvd., and Thorndale Ave). Four valid AGTs were conducted in effluent samples from the Lemont WRP and samples from three monitoring stations on the Chicago Sanitary and Ship Canal (CSSC). The samples were collected and analyzed once each quarter. The AGT results (Tables IV-7 and IV-8) showed that the mean BP (mg/L) values measured in the Egan and Lemont WRP effluent samples and the two downstream monitoring stations on Salt Creek and CSSC were lower than the total phosphorus (mg/L) measured chemically. The results of the AGTs are important in the District's effort to maintain the biotic integrity of waterways (Salt Creek and CSSC) and the IEPA's effort to develop nutrient standards for the State of Illinois.

TABLE IV-1: ANALYTICAL MICROBIOLOGY GROUP SAMPLES AND ANALYSES 2005 AND 2006

| | | Analysis or Test Performed[1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Samples | TC | FC | FS | PA | SAL | HPC | EC | ENT | IQC | ID-CONF | Total |
| 2005 | 2,787 | 135 | 2,748 | 0 | 0 | 14 | 33 | 485 | 0 | 7,796 | 113 | 11,324 |
| 2006 | 3,140 | 305 | 3,195 | 0 | 0 | 9 | 39 | 491 | 0 | 8,210 | 191 | 12,440 |

[1]TC = Total Coliform; FC = Fecal Coliform; FS = Fecal Streptococcus; PA = *Pseudomonas aeruginosa*; SAL = *Salmonella* spp.; HPC – Heterotrophic Plate Count; EC = *Escherichia coli*; ENT = Enterococcus spp.; IQC = Internal Quality Control testing (reported as the number of procedures performed); ID-CONF = Organism Identification using specific multiple biochemical metabolic characteristics.

TABLE IV-2: INDICATOR BACTERIA ANALYSES PERFORMED BY THE ANALYTICAL MICROBIOLOGY GROUP FOR VARIOUS DISTRICT PROGRAMS 2005 THROUGH 2006

| Program | Total Coliform | | Fecal Coliform | | Escherichia *coli* | |
|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| Effluent Analysis | 12 | 12 | 703 | 711 | - | - |
| Land Reclamation | -[a] | - | 181 | 171 | - | - |
| Biosolids Indicator Organism Density | - | - | 59 | 55 | - | - |
| District Waterway Surveys | - | - | 847 | 1065 | 217 | 231 |
| Industrial Waste Surveys | - | - | 5 | 6 | 5 | - |
| Research –Support[1] | 41 | 246 | 68 | 364 | 41 | 245 |
| Lake Michigan Monitoring[2] | - | - | - | - | - | - |
| Major Treatment Facility Monitoring | 1 | - | 300 | 271 | 192 | - |
| Illinois Waterway | - | - | - | - | - | - |
| TARP | - | - | 566 | 567 | - | - |
| Other[3] | 43 | 59 | - | - | - | 15 |
| Total | 97 | 317 | 2,729 | 3,210 | 455 | 491 |

[a]No samples analyzed.
[1]Includes disinfection study and support to plant operations.
[2]Includes festivals and District bypasses to Lake Michigan.
[3]Includes drinking water.

TABLE IV-3: VIROLOGICAL ANALYSIS OF CLASS A BIOSOLIDS IN 2006[1]

| WRP Sample Location | Number Samples Positive/Number Samples Collected | Total Number of Samples that Meet Class A Pathogen Requirement[2] | PFU/4g Dry Wt Range[3,4] | Percent Recovery of Seeded Viruses[5] Range |
|---|---|---|---|---|
| Calumet | | | | |
| East and West | 0/9 | 9 | <0.8000 - <0.8003 | 43.8 – 75.1 |
| Stickney | | | | |
| HASMA[6] | 0/1 | 1 | <0.8000 | 71.7 |
| LASMA[7] | 0/1 | 1 | <0.8000 | 53.0 |
| Marathon | 0/1 | 1 | <0.8004 | 56.2 |

[1]Results of analyses performed in the District's Virology Laboratory for site-specific PFRP equivalency monitoring.
[2]Total Culturable Enteric viruses are less than 1 plaque forming unit (PFU) per 4g total dry solids.
[3]Confirmed plaque forming units/4g.
[4]Failure to detect viruses in solids eluates are recorded as less than (<) the limit of test sensitivity.
[5]Positive recovery controls: percent recovery of 400 plaque forming units of poliovirus 1 Sabin seeded into a 4g aliquot of sample. A positive recovery control was performed for each sample analyzed.
[6]Harlem Avenue Solids Management Area.
[7]Lawndale Avenue Solids Management Area.

TABLE IV-4: COLIPHAGE (SOMATIC [SP] AND F SPECIFIC RNA [FP]) ANALYSIS OF CLASS A BIOSOLIDS IN 2006[1]

| WRP/Sample Location | Total Solids (TS)[2] | Coliphage MPN/Gram Dry Wt[3,4] | |
|---|---|---|---|
| | | SP | FP |
| Calumet | | | |
| East, Cell 1 | 67.80 | <0.1475 | <0.1475 |
| East, Cell 4 | 65.43 | 45.0000 | <0.1528 |
| East, Cell 1 | 79.65 | <0.1225 | <0.1255 |
| East, Cell 3 | 69.01 | <0.1449 | <0.1449 |
| West, Cell 5 | 77.65 | 30.0000 | <0.1288 |
| West, Cell 1 | 78.04 | <0.1281 | <0.1281 |
| West. Cell 4 | 77.37 | 10.0000 | <0.1292 |
| West, Cell 3 | 80.69 | <0.1239 | <0.1239 |
| West, Cell 5 | 63.23 | <0.1582 | <0.1582 |
| Stickney | | | |
| HASMA[5] | 69.40 | <0.1441 | <0.1441 |
| LASMA[6] | 86.91 | <0.1151 | <0.1151 |
| Marathon | 77.24 | 7.0000 | 7.0000 |

[1]The coliphages were enumerated according to the USEPA Method 1601: Male -specific (F+) and Somatic Coliphage in Water by Two-step Enrichment Procedure (EPA/821-R-01-030). The method was modified to increase the sensitivity of the method for biosolids monitoring.
[2]TS=Percent Total Solids.
[3]Most Probable Number of FP and SP Based on Dry Weight of 1g of as-received biosolids.
[4]Failure to detect coliphages in biosolids is recorded as less than (<) the limit of test sensitivity.
[5]Harlem Avenue Sludge Management Area.
[6]Lawndale Avenue Sludge Management Area.

TABLE IV-5: VIABLE *ASCARIS* OVA ANALYSIS OF CLASS A BIOSOLIDS IN 2006[1,2]

| WRP Sample Location | Range of TS[3] | Number of Samples Collected | Total Number of Samples that Meet Class A Pathogen Requirement[4] | Range of Total Viable Ascaris per 4 Gram Dry Weight[5] |
|---|---|---|---|---|
| Calumet | | | | |
| East and West | 63.23 - 80.69 | 9 | 9 | <0.0133 – 0.0800 |
| Stickney | | | | |
| HASMA[6] | 69.40 | 1 | 1 | <0.0800 |
| LASMA[7] | 86.91 | 1 | 1 | <0.0800 |
| Marathon | 77.24 | 1 | 1 | 0.1600 |

[1]Test Method for Detecting, Enumerating, and Determining the Viability of *Ascaris* Ova in Sludge, Appendix I, Environmental Regulations and Technology, EPA/625/R-92/013, Revised 2003.

[2]United States Environmental Protection Agency, Region V, has approved the practice of analyzing 50g Dry Weight Samples of Biosolids for the determination of *Ascaris* Ova densities with every sixth sample being 300g Dry Weight as required in the District's site-specific PFRP compliance monitoring.

[3]TS=Percent Total Solids.

[4]Viable *Ascaris* ova are less than 1 viable *Ascaris* ovum per 4g total dry solids.

[5]Failure to detect viable ova in biosolids is recorded as less than (<) the limit of test sensitivity.

[6]Harlem Avenue Sludge Management Area.

[7]Lawndale Avenue Sludge Management Area.

TABLE IV-6: RESULTS OF WHOLE EFFLUENT TOXICITY TESTS CONDUCTED ON WATER RECLAMATION PLANT EFFLUENTS FOR NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT COMPLIANCE DURING 2006

| Effluent Tested | Sample Collection Date(s) | WET Test[1] | | Results[2] |
|---|---|---|---|---|
| Egan WRP | 02/06 - 02/07 | Acute *P. promelas* | (Survival) | NTE |
| | | Acute *C. dubia* | (Survival) | NTE |
| Lemont WRP | 03/20 - 03/21 | Acute *P. promelas* | (Survival) | NTE |
| | | Acute *C. dubia* | (Survival) | NTE |
| Egan WRP | 05/01 - 05/02 | Acute *P. promelas* | (Survival) | NTE |
| | | Acute *C. dubia* | (Survival) | NTE |
| Hanover Park WRP | 05/15 - 05/16 | Chronic *P. promelas* | (Survival) | NTE |
| | 05/17 - 05/18 | | (Growth) | NTE |
| | 05/19 - 05/20 | | | |
| | | Chronic *C. dubia* | (Survival) | NTE |
| | | | (Reproduction) | NTE |
| Lemont WRP | 08/21 - 08/22 | Acute *P. promelas* | (Survival) | NTE |
| | | Acute C. *dubia* | (Survival) | NTE |
| Lemont WRP | 09/25 - 09/26 | Acute *P. promelas* | (Survival) | NTE |
| | 10/09 - 10/10 | Acute *C. dubia* | (Survival) | NTE |

[1]WET Tests: Acute *Pimephales promelas* (Survival) and Acute *Ceriodaphnia dubia* (Survival), EPA 821-R-02-012, (Fifth Edition), 2002; Chronic *Pimephales promelas* (Survival, Growth) and Chronic *Ceriodaphnia dubia* (Survival, Reproduction), EPA 821/R-02/013, (Fourth Edition), 2002.
[2]Results: NTE = no toxic effect.

TABLE IV-7: RESULTS OF ALGAL GROWTH TEST CONDUCTED ON EGAN WATER RECLAMATION PLANT FINAL EFFLUENT AND SALT CREEK SAMPLES IN 2006

| SAMPLE COLLECTION DATE | LIMS NUMBER | SAMPLING POINT | ORTHO-PHOS Ortho-phosphate mg/L | TOT_PHOS Tot Phos mg/L | ALGAL Algal_t mg P/L |
|---|---|---|---|---|---|
| 01/05/06 | 4809129 | BUSSE_FIL[1] | 0.051* | 0.01 | <0.0100 |
| 01/05/06 | 4809128 | EGAN_FIL[2] | 2.412 | 2.42 | 1.0205 |
| 01/05/06 | 4809130 | JFK_FIL[3] | 0.616* | 0.75 | 0.0434 |
| 01/05/06 | 4809131 | THRNDL_FIL[4] | 0.708* | 0.79 | 0.3415 |
| 04/05/06 | 4868738 | BUSSE_FIL[1] | 0.022* | 0.10 | <0.0100 |
| 04/05/06 | 4868734 | EGAN_FIL[2] | 1.555 | 1.89 | 0.9628 |
| 04/05/06 | 4868741 | JFK_FIL[3] | 0.361* | 0.49 | 0.3760 |
| 04/05/06 | 4868742 | THRNDL_FIL[4] | 0.298* | 0.37 | 0.2516 |
| 06/07/06 | 4922330 | BUSSE_FIL[1] | 0.017* | 0.04 | <0.0100 |
| 06/07/06 | 4922325 | EGAN_FIL[2] | 3.879 | 4.77 | 1.0372 |
| 06/07/06 | 4922333 | JFK_FIL[3] | 3.325* | 3.93 | 0.3062 |
| 06/07/06 | 4922335 | THRNDL_FIL[4] | 3.133* | 3.83 | 0.3202 |
| 08/02/06 | 4966112 | BUSSE_FIL[1] | 0.012* | 0.07 | <0.0100 |
| 08/02/06 | 4966110 | EGAN_FIL[2] | 3.311 | 4.51 | 1.2070 |
| 08/02/06 | 4966122 | JFK_FIL[3] | 3.310* | 3.84 | 1.0620 |
| 08/02/06 | 4966124 | THRNDL_FIL[4] | 3.306* | 3.85 | 0.2888 |
| 09/20/06 | 5003730 | BUSSE_FIL[1] | 0.022* | 0.05 | 0.0438 |
| 09/20/06 | 5003729 | EGAN_FIL[2] | 5.026 | 5.15 | 1.1938 |
| 09/20/06 | 5003731 | JFK_FIL[3] | 2.578* | 2.86 | 0.9322 |
| 09/20/06 | 5003734 | THRNDL_FIL[4] | 2.645* | 2.87 | 0.8849 |

TABLE IV-7 (CONTINUED): RESULTS OF ALGAL GROWTH TEST CONDUCTED ON EGAN WATER RECLAMATION PLANT FINAL EFFLUENT AND SALT CREEK SAMPLES IN 2006

| SAMPLE COLLECTION DATE | LIMS NUMBER | SAMPLING POINT | ORTHO/PHOS Ortho/phosphate mg/L | TOT_PHOS Tot Phos mg/L | ALGAL Algal_t mg P/L |
|---|---|---|---|---|---|
| 10/04/06 | 5014412 | BUSSE_FIL[1] | 0.012* | 0.04 | 0.0267 |
| 10/04/06 | 5014410 | EGAN_FIL[2] | 1.255 | 1.44 | 0.8868 |
| 10/04/06 | 5014413 | JFK_FIL[3] | 0.099* | 0.28 | 0.1663 |
| 10/04/06 | 5014414 | THRNDL_FIL[4] | 0.145* | 0.15 | 0.0054 |
| 11/01/06 | 5031075 | BUSSE_FIL[1] | 0.027 | 0.10 | <0.0100 |
| 11/01/06 | 5031073 | EGAN_FIL[2] | 3.748 | 4.18 | 0.8209 |
| 11/01/06 | 5031076 | JFK_FIL[3] | 1.740 | 1.92 | 0.8016 |
| 11/01/06 | 5031077 | THRNDL_FIL[4] | 1.780 | 1.96 | 0.8492 |
| 12/06/06 | 5058693 | BUSSE_FIL[1] | 0.011* | 0.11 | <0.0100 |
| 12/06/06 | 5058692 | EGAN_FIL[2] | 2.672 | 3.26 | 1.1740 |
| 12/06/06 | 5058694 | JFK_FIL[3] | 0.865* | 1.14 | 0.7178 |
| 12/06/06 | 5058695 | THRNDL_FIL[4] | 0.788* | 1.08 | 0.6659 |

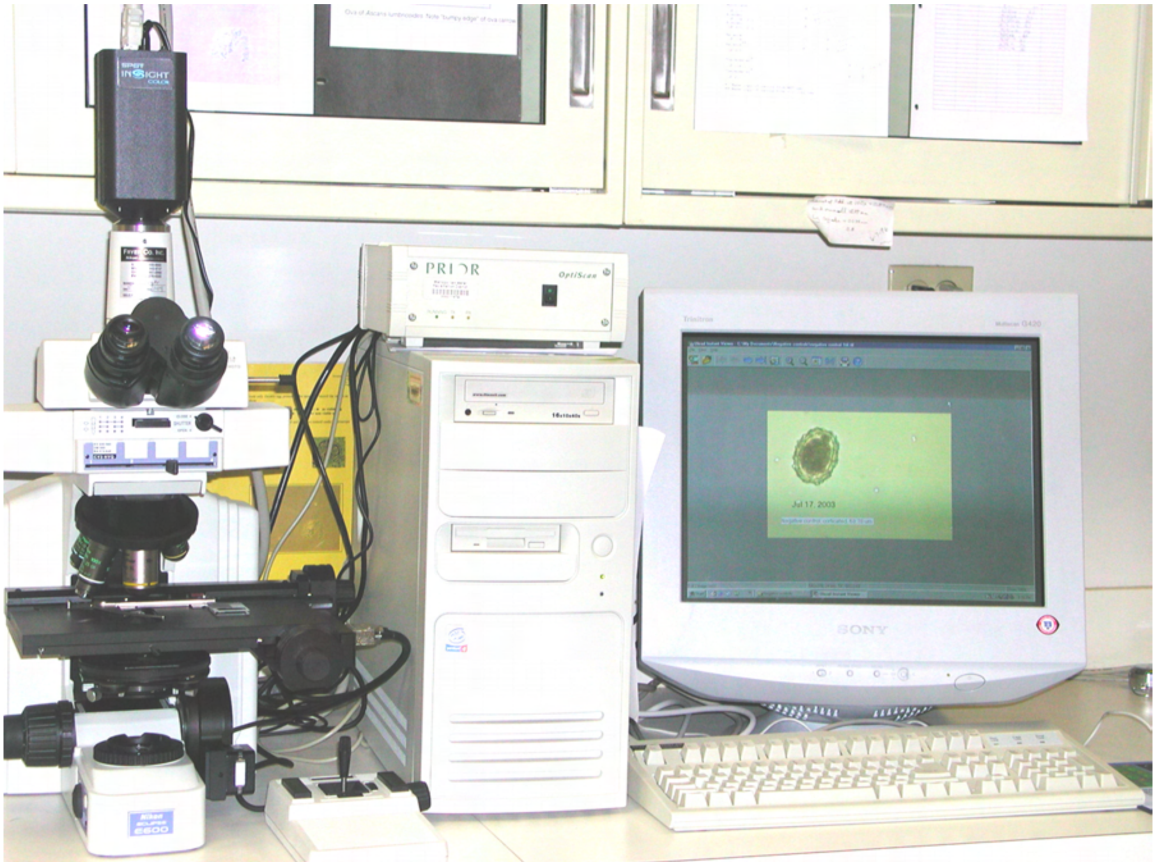
*Results from unfiltered sample.
[1]Busse Dam (0.1 mile upstream).
[2]Egan WRP Final Effluent.
[3]JFK Boulevard (0.7 mile downstream).
[4]Thorndale Avenue (2.4 miles downstream).

TABLE IV-8: RESULTS OF ALGAL GROWTH TEST CONDUCTED ON LEMONT WATER RECLAMATION PLANT FINAL EFFLUENT AND CHICAGO SANITARY AND SHIP CANAL SAMPLES IN 2006

| SAMPLE COLLECTION DATE | LIMS NUMBER | SAMPLING POINT | ORTHO/PHOS Ortho/phosphate mg/L | TOT_PHOS Tot Phos mg/L | ALGAL Algal_t mg P/L |
|---|---|---|---|---|---|
| 02/21/06 | 4840258 | LEPUPSFIL[1] | 0.646 | 0.91 | 0.7093 |
| 02/21/06 | 4840256 | LEPOUTFIL[2] | 2.412 | 2.91 | 0.5973 |
| 02/21/06 | 4840257 | LEPSTEVFIL[3] | 0.836 | 1.03 | 0.7868 |
| 02/21/06 | 4840239 | LEP299.9FIL[4] | 0.762 | 0.93 | 0.8093 |
| 05/16/06 | 4904813 | LEPUPSFIL[1] | 0.508 | 0.58 | 0.5085 |
| 05/16/06 | 4904805 | LEPOUTFIL[2] | 2.239 | 2.44 | 0.8651 |
| 05/16/06 | 4904812 | LEPSTEVFIL[3] | 0.624 | 0.73 | 0.4632 |
| 05/16/06 | 4904803 | LEP299.9FIL[4] | 0.770 | 0.79 | 0.5651 |
| 08/21/06 | 4978841 | LEPUPSFIL[1] | 0.515 | 0.62 | 0.2969 |
| 08/21/06 | 4978837 | LEPOUTFIL[2] | 3.653 | 4.05 | <0.0100 |
| 08/21/06 | 4978838 | LEPSTEVFIL[3] | 0.583 | 0.68 | 0.2543 |
| 08/21/06 | 4978835 | LEP299.9FIL[4] | 0.593 | 0.71 | 0.4035 |
| 11/20/06 | 5047955 | LEPUPSFIL[1] | 0.748 | 0.85 | 0.8105 |
| 11/20/06 | 5047942 | LEPOUTFIL[2] | 2.855 | 3.13 | 1.2360 |
| 11/20/06 | 5047953 | LEPSTEVFIL[3] | 0.803 | 0.88 | 0.7535 |
| 11/20/06 | 5047940 | LEP299.9FIL[4] | 0.855 | 0.90 | 0.7969 |

[1]Upstream 302.6 (1.9 miles upstream).
[2]Lemont Final Effluent.
[3]Downstream Stephens Street (0.1 mile downstream).
[4]Downstream 299.9 (0.6 mile downstream).

FIGURE IV-1: MICROSCOPIC IMAGE ANALYSIS SYSTEM



Nikon E600 Research Phase Contrast Microscope with a Digital Snap Video Camera Transmitting Microscopic Images from Slide to a Computer Workstation with a Metamorph Software Program.

FIGURE IV-2: DIGITAL IMAGES OF *ASCARIS LUMBRICOIDES*

**A**


**B**


A. Non viable ovum; 67.34 µm long
B. Viable, fertile ovum; 61.61 µm long.

# AQUATIC ECOLOGY AND WATER QUALITY SECTION

# AQUATIC ECOLOGY AND WATER QUALITY SECTION

The Aquatic Ecology and Water Quality Section is primarily responsible for assessing the water and sediment quality in both shallow water (wadeable) and deep-draft waterways in the District's service area. The biological monitoring program, which runs in conjunction with the Ambient Water Quality Monitoring (AWQM) Program, includes chlorophyll monitoring, the study of the benthic invertebrate and fish communities, characterization of the physical habitat, and assessment of sediment toxicity and sediment chemistry. The primary objective of the monitoring program is to provide scientific data to the District and the Illinois Environmental Protection Agency (IEPA) regarding the biological condition of the Chicago Waterway System (CWS). The IEPA uses the data to assess the biological integrity, physical habitat, and sediment quality in waterways in the District's service area. These assessments are summarized in the IEPA's 305(b) Use Assessment Report. Results from the 305(b) report are used by IEPA to prepare a list of impaired waters through the 303(d) listing process.

The biological portion of the AWQM Program, as it currently exists, began in 2001 and is conducted from June through September at 59 stations on the CWS (Figure V-1). Fifteen of the 59 sampling stations are assessed annually, with the remaining 44 stations assessed once every four years.

Additional water and sediment quality monitoring is conducted outside of the District's service area in the lower Des Plaines River and the Illinois River. Special water quality surveys are also conducted to provide technical assistance for the Maintenance and Operations (M&O) and Engineering Departments.

## Fish Monitoring 2006

During June through October of 2006, fish were collected by electrofishing and seining at 23 biological monitoring stations on the CWS, plus at 4 Sidestream Elevated Pool Aeration (SEPA) Stations (Numbers 1, 2, 4, and 5). In 2006, 4,750 fish composed of 40 species and 4 hybrid species were identified, weighed, and measured for length. The fish were also examined for parasites and disease.

Data from these collections are shown in Table V-1 for the deep-draft waterways and in Table V-2 for the wadeable waterways. The most abundant species in the deep-draft waterways included gizzard shad, carp, largemouth bass, bluntnose minnow, pumpkinseed sunfish, and emerald shiner. In the wadeable waterways, green sunfish, bluntnose minnow, and spotfin shiners were the most abundant.

## Chlorophyll Monitoring 2006

As a photosynthetic component of all algae cells, the determination of chlorophyll *a* is an accepted way of quantifying algal biomass in lakes and streams. Chlorophyll *a* values are of interest to regulatory agencies since it is also widely accepted that high algae concentrations may indicate nutrient impairment. The IEPA is cooperating with other state and local agencies to promulgate regional water quality criteria for nutrients and possibly chlorophyll. In light of this consideration, the District began monitoring chlorophyll on a monthly basis in August 2001 as part of the AWQM Program. Results from 2006 are shown in Table V-3. The highest mean values of chlorophyll *a* occurred at Frontage Road (33 µg/L) on the Skokie River, Material Service Road (26 µg/L) on the Des Plaines River, and Burnham Avenue (25 µg/L) on the Grand Calumet River.

**Illinois Waterway Monitoring**

In 1984, the R&D Department established a long-term water and sediment monitoring program along the Illinois Waterway from the Lockport Lock to the Peoria Lock, a distance of approximately 133 miles. The purpose of the monitoring program is to assess the chemical and microbiological quality of the water and to characterize the chemical quality of the sediments.

In 2006, water samples were collected during May, August, and October from each of the 49 sampling stations (Figures V-2 and V-3). During October, sediment samples were collected at 14 selected stations. Data for these sampling events were compiled in R&D Report No. 07-39 entitled, "Water and Sediment Quality Along the Illinois Waterway from the Lockport Lock to the Peoria Lock During 2006."

**Council on Food and Agricultural Research Nutrient Study**

A cooperative study regarding nutrients in waterways throughout Illinois was undertaken with the University of Illinois and the Illinois Council on Food and Agricultural Research (CFAR). The results of this study will be considered by IEPA when promulgating water quality nutrient standards. Five monitoring stations were chosen on the Des Plaines River, Salt Creek, and the North Branch of the Chicago River for this three-year project. Starting in April of 2004, water samples were collected two times per month through November, and once in December through March (winter sampling only once per month), and on four consecutive days during three rain events. Water samples were analyzed for nutrients and other relevant constituents. The results from 2006 CFAR sampling are shown in Table V-4.

**Salt Creek Nutrient Reduction Demonstration Project**

Baseline chemical and biological monitoring began in 2005 and continued throughout 2006 in advance of a demonstration project to lower total phosphorus in effluent from the John E. Egan (Egan) WRP. Total phosphorus reduction to approximately 0.5 mg/L will be achieved through ferric chloride addition throughout 2007 and 2008, and impacts on water quality in Salt Creek will be monitored. Water samples collected from one station upstream of the Egan WRP (Busse Lake Dam) and two stations downstream (J. F. Kennedy Boulevard and Thorndale Avenue) were analyzed for 16 relevant water quality constituents, including chlorophyll *a*. These samples were collected twice per month during April through November, once per month in January through March and December, and for four sequential days following rain events, which occurred in April, May, and August of 2006. Biological monitoring including fish and macroinvertebrate collection and a physical habitat assessment was performed once at each station during 2006, along with sediment chemistry analysis. R&D Report 07-24 entitled, "Salt Creek Phosphorus Reduction Demonstration Project Interim Report: Pre-Phosphorus Reduction Conditions," includes all background monitoring data that was collected during 2005 and 2006.

**Continuous Monitoring of Dissolved Oxygen**

In order to gain a better understanding of the oxygen dynamics in deep-draft sections of the CWS, the EM&R Division developed a comprehensive continuous dissolved oxygen (DO) monitoring program beginning in August 1998 in the Chicago River System, July 2001 in the Calumet River System, and in the Des Plaines River System in July 2005.

Dissolved oxygen was measured hourly using remote (in-situ) water quality monitors deployed in protective stainless steel housing enclosures. As shown in Figure V-1, in the Chicago River System the monitors were located at 14 stations on the North Shore Channel, North Branch of the Chicago River, Chicago River, South Branch of the Chicago River, Bubbly Creek, and the Chicago Sanitary and Ship Canal. In the Calumet River System, the monitors were located at nine stations on the Calumet River, Grand Calumet River, Little Calumet River, and the Calumet-Sag Channel. Nine stations were located in the Des Plaines River System on the Des Plaines River and Salt Creek.

A summary of the DO results, including the number and percent of DO values measured with the monitors during the period from January through December of 2006 that were above the Illinois Pollution Control Board (IPCB) DO standards, are presented in Table V-5. All of the DO results for 2006 can be located in the reports entitled, "Continuous Dissolved Oxygen Monitoring in the Deep-Draft Waterways of the Chicago Waterway System During 2006" (R&D Report No. 07-25) and "Continuous Dissolved Oxygen Monitoring in the Wadeable Streams of the Chicago Waterway System During 2006" (R&D Report No. 07-28).

**Fecal Coliform Densities in District Waterways During Dry and Wet Weather**

In 2004, a three-year study was initiated to predict the die off of fecal coliform (FC) in the receiving streams downstream of the North Side and Calumet WRPs. These streams included the North Shore Channel and the North Branch of the Chicago River (North area), and the Little Calumet River and Calumet-Sag Channel (South area), respectively. Sampling locations are displayed in Figure V-4. Currently the effluents of these WRPs are not disinfected. Fecal coliform densities upstream and downstream of the North Side and the Calumet WRPs were measured during dry and wet weather.

The purpose of this study was to predict from the collected data whether disinfection of the effluents from these WRPs would significantly reduce the FC load in the receiving streams and result in compliance with the IPCB General Use stream standard of less than 200 cfu/100 mL.

Fecal coliform densities downstream of these WRPs were shown to die off at an exponential rate, and FC densities at specific locations downstream of these WRPs were predicted using the equation $FC_m = FC_0 \times e^{-km}$ where $FC_m$ = FC concentration m miles downstream of the WRP outfall, $FC_0$ = FC concentration 0 miles downstream at the WRP outfall, m is miles downstream of the WRP outfall and k is the decay rate constant.

Predicted dry weather FC values were subtracted from the predicted wet weather FC values to estimate FC densities that might occur in the waterways during wet weather if disinfection eliminated the FC burden in the WRP outfalls.

Analysis of the collected data indicated that FC densities less than the IPCB General Use stream standard were predicted to occur at North area stations 19 miles downstream of the North Side WRP during dry weather and 26 and 130 miles downstream during light rain and heavy rain wet weather, respectively. The analysis predicted that disinfection of the North Side WRP effluent would only marginally improve the microbiological water quality downstream of the North Side WRP in that the IPCB standard could be met at 24 miles downstream of the WRP during light rain wet weather and no improvement during heavy rain wet weather. Fecal coliform densities less than the IPCB General Use stream standard were predicted to occur at South area stations 11 miles downstream of the Calumet WRP during dry weather and 15 and 90 miles downstream during light rain and heavy rain wet weather, respectively. The analysis predicted that disinfection of the Calumet WRP effluent would only marginally improve the microbiological water quality downstream of the Calumet WRP in that the IPCB standard could be met at 12 miles downstream of the WRP during light rain wet weather and no improvement during heavy rain wet weather.

The results of this study indicate that disinfection of the North Side and Calumet WRP effluents during wet weather would not improve the microbiological water quality downstream of these WRPs in terms of compliance with the IPCB General Use standard. The results of this study are consistent with a previous study (Haas et al., 1988) which suggested that beyond a certain zone, disinfection of an effluent may not improve microbiological water quality. Analysis of the data collected during 2004 is available in the interim report: "Fecal Coliform Densities in Chicago Area Waterways During Dry and Wet Weather" (R&D Report No. 05-15). A final report on 2004–2006 data will be available in 2007.

**Chicago Waterway System Sediment Oxygen Demand Measurements**

In order to quantify uptake of oxygen by sediment at various locations throughout the CWS, in-situ sediment oxygen demand (SOD) was measured during 2006 at 11 sites in the system suspected of being significant DO sinks. These data were requested in order to verify the estimated SOD values used in the CWS Water Quality Model and to identify reaches that would benefit from sediment remediation.

Descriptions of the SOD measurement locations are presented in Table V-6. Each site consisted of an off-channel embayment or side channel location and SOD was measured at the site, as well as, at locations in the main channel upstream and downstream of the site. In addition, a transect across the channel at each SOD measurement location was probed with a calibrated leveling rod to quantify the area covered by at least six inches of soft sediment. This measurement gives some indication of the amount of oxygen consuming sediment present across the channel width. The percent composition of a sediment grab sample collected at each SOD measurement location was also qualitatively characterized by observation in a plastic tray.

A semi-cylindrical, 29 L, open-bottomed chamber containing a YSI Model 600 recording DO monitor was used to determine oxygen uptake by bottom sediment at each measurement location. The slope of a linear portion of the DO uptake curve measured inside the chamber was used to calculate SOD according to the formula:

$$SOD = (1440SV)/10^3A$$

Where:

SOD = sediment oxygen demand in $g/m^2/day$
S = slope of the DO utilization curve in mg/L/min
V = volume of the SOD chamber (29 L)
A = area covered by SOD chamber ($0.21m^2$).

All SOD values were corrected to 20°C using the formula:

$$SOD_{20} = SOD_T/(1.047^{T-20})$$

Where:

$SOD_{20}$ = SOD rate at 20°C
$SOD_T$ = SOD rate at ambient temperature
T = Average water temperature inside SOD chamber during measurement period.

SOD rates measured at all 26 locations are shown in Figure V-5. SOD rates measured during the study ranged from 0.23 $g/m^2/day$ upstream of Wisconsin Steel Slip to 4.81 $g/m^2/day$ at an off-channel embayment near Diversey Parkway. Average of all main channel SOD rates was 1.56 $g/m^2/day$ and the average of all side/off-channel SOD rates was 2.46 $g/m^2/day$ indicating that, overall, side/off-channel rates were nearly 60 percent higher than main channel rates.

Table V-7 compares SOD rates at main channel and side/off-channel locations in various portions of the CWS. The lowest average main channel SOD rate, 0.41 $g/m^2/day$, was found in the Calumet River. This low rate may be explained by the lack of significant CSO inputs, consistently high water column DO, and clay sediment with low oxygen demand in this reach of the Calumet River. The highest average main channel SOD rate, 2.62 $g/m^2/day$, was found in the Little Calumet River. This was probably due to a decrease in current velocity in the wide river cross-section that encouraged oxygen-demanding solids deposition at the measurement location. Lowest average side/off-channel SOD rate, 0.40 $g/m^2/day$, was found in the Calumet River probably for the same reason that the rates at the corresponding main channel locations were low. Highest average side/off-channel SOD rate, 3.26 $g/m^2/day$, occurred in Bubbly Creek.

Both measurement locations in Bubbly Creek had relatively wide channel cross-sections that encouraged deposition of oxygen-demanding suspended solids from upstream CSOs.

Probing of the channel bottom with a leveling rod revealed that all side/off-channel locations had, on average, 83 percent of the channel transect covered by soft sediment. Soft sediment coverage of the channel transect at all main channel locations averaged 60 percent. Generally, locations in the Calumet Waterway System had the lowest percentage of the channel transect covered by soft sediment. Shallower channel depths and more frequent commercial and recreational navigation may cause sediment to be scoured from main channel locations in the Calumet System.

Overall, observations of sediment composition at SOD measurement locations showed little correlation with SOD rates. However, locations with substantial quantities of sediment identified as sludge tended to have higher SOD rates.

TABLE V-1: FISH COLLECTED FROM DEEP-DRAFT WATERWAYS DURING 2006

| Station No. | Location | Number of Fish Collected | Weight (kg) of Total Catch | Number of Fish Species | Number of Game Fish Species | Most Abundant Fish Species |
|---|---|---|---|---|---|---|
| | | North Shore Channel | | | | |
| 36 | Touhy Avenue | 496 | 119.5 | 16 | 7 | Gizzard shad |
| | | North Branch Chicago River | | | | |
| 46 | Grand Avenue | 158 | 27.3 | 10 | 5 | Gizzard shad |
| | | Chicago River | | | | |
| 74 | Lake Shore Drive | 83 | 26.9 | 7 | 5 | Gizzard shad |
| 100 | Wells Street | 250 | 59.3 | 10 | 7 | Gizzard shad |
| | | South Branch Chicago River | | | | |
| 39 | Madison Street | 99 | 10.8 | 6 | 3 | Spotfin shiner |
| 108 | Loomis Street | 142 | 84.5 | 13 | 6 | Carp |
| | | Bubbly Creek | | | | |
| 99 | Archer Avenue | 156 | 10.6 | 13 | 7 | Gizzard shad |
| | | Chicago Sanitary and Ship Canal | | | | |
| 40 | Damen Avenue | 164 | 95.5 | 12 | 6 | Carp |
| 75 | Cicero Avenue | 205 | 30.4 | 11 | 5 | Pumpkinseed |
| 41 | Harlem Avenue | 388 | 42.2 | 15 | 7 | Pumpkinseed |
| 42 | Route 83 | 10 | 0.3 | 5 | 1 | Pumpkinseed |
| 48 | Stephen Street | 24 | 1.4 | 5 | 0 | Gizzard shad |
| 92 | 16th St., Lockport | 64 | 46.3 | 8 | 5 | Gizzard shad |
| | | Calumet River | | | | |
| SEPA 1 | Torrence Avenue | 543 | 64.6 | 15 | 6 | Bluntnose minnow |
| 55 | 130th Street | 233 | 100.7 | 15 | 6 | Largemouth bass |
| | | Little Calumet River | | | | |
| SEPA 2 | 127th Street | 218 | 27.4 | 12 | 6 | Emerald shiner |
| 76 | Halsted Street | 405 | 113.6 | 22 | 12 | Carp |
| | | Calumet-Sag Channel | | | | |
| 59 | Cicero Avenue | 216 | 36.5 | 15 | 6 | Gizzard shad |
| SEPA 4 | Harlem Avenue | 79 | 65.5 | 9 | 2 | Emerald shiner |
| SEPA 5 | Junction CSSC/ Calumet-Sag Channel | 71 | 11.3 | 12 | 7 | Bluntnose minnow |

TABLE V-2: FISH COLLECTED FROM SHALLOW WATERWAYS DURING 2006

| Station No. | Location | Number of Fish Collected | Weight (g) of Total Catch | Number of Fish Species | Number of Game Fish Species | Most Abundant Fish Species |
|---|---|---|---|---|---|---|
| | North Branch Chicago River (Shallow Portion) | | | | | |
| 96 | Albany Avenue | 24 | 139.0 | 4 | 1 | White sucker |
| | Higgins Creek | | | | | |
| 78 | Wille Road | 73 | 778.0 | 6 | 1 | Fathead minnow |
| | Des Plaines River | | | | | |
| 13 | Lake-Cook Road | 122 | 11,088.0 | 13 | 6 | Spotfin shiner |
| 22 | Ogden Avenue | 42 | 574.2 | 8 | 4 | Bluntnose minnow |
| 91 | Material Services Rd. | 36 | 1,384.4 | 11 | 3 | Blackstripe topminnow |
| | Salt Creek | | | | | |
| 18 | Devon Avenue | 63 | 13,093.4 | 9 | 4 | Green sunfish |
| | West Branch DuPage River | | | | | |
| 64 | Lake Street | 180 | 4,418.8 | 10 | 3 | Green sunfish |

TABLE V-3: MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2006

| Station No. | Location | Number of Samples | Mean (µg/L) | Minimum (µg/L) | Maximum (µg/L) | Standard Deviation (µg/L) |
|---|---|---|---|---|---|---|
| | West Fork North Branch Chicago River | | | | | |
| 106 | Dundee Road | 5 | 11 | 4 | 21 | 7 |
| 103 | Golf Road | 12 | 13 | 4 | 32 | 9 |
| | Middle Fork North Branch Chicago River | | | | | |
| 31 | Lake-Cook Road | 11 | 12 | 1 | 27 | 9 |
| | Skokie River | | | | | |
| 32 | Lake-Cook Road | 12 | 7 | 1 | 14 | 3 |
| 105 | Frontage Road | 12 | 33 | 5 | 91 | 26 |
| | North Branch Chicago River (Wadeable Portion) | | | | | |
| 104 | Glenview Road | 12 | 20 | 4 | 45 | 12 |
| 34 | Dempster Street | 12 | 17 | 4 | 44 | 11 |
| 96 | Albany Avenue | 12 | 14 | 3 | 49 | 13 |
| | North Shore Channel | | | | | |
| 35 | Central Street | 9 | 5 | 1 | 30 | 10 |
| 102 | Oakton Street | 12 | 23 | 0 | 190 | 55 |
| 36 | Touhy Avenue | 12 | 2 | <1 | 9 | 2 |
| 101 | Foster Avenue | 12 | 2 | <1 | 8 | 2 |
| | North Branch Chicago River (Deep-Draft Portion) | | | | | |
| 37 | Wilson Avenue | 12 | 5 | 1 | 12 | 4 |
| 73 | Diversey Avenue | 12 | 4 | 1 | 10 | 3 |
| 46 | Grand Avenue | 12 | 6 | 2 | 19 | 5 |
| | Chicago River | | | | | |
| 74 | Lake Shore Drive | 11 | 1 | 1 | 5 | 1 |
| 100 | Wells Street | 12 | 3 | 1 | 12 | 3 |

TABLE V-3 (Continued): MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2006

| Station No. | Location | Number of Samples | Mean (µg/L) | Minimum (µg/L) | Maximum (µg/L) | Standard Deviation (µg/L) |
|---|---|---|---|---|---|---|
| | South Branch Chicago River | | | | | |
| 39 | Madison Street | 12 | 4 | 1 | 15 | 4 |
| 108 | Loomis Street | 12 | 6 | 1 | 29 | 7 |
| | Bubbly Creek (South Fork South Branch Chicago River) | | | | | |
| 99 | Archer Avenue | 7 | 6 | 2 | 12 | 3 |
| | Chicago Sanitary and Ship Canal | | | | | |
| 40 | Damen Avenue | 12 | 5 | <1 | 28 | 7 |
| 75 | Cicero Avenue | 12 | 5 | 1 | 12 | 3 |
| 41 | Harlem Avenue | 12 | 3 | <1 | 10 | 2 |
| 42 | Route 83 | 12 | 4 | <1 | 12 | 4 |
| 48 | Stephen Street | 12 | 4 | <1 | 10 | 3 |
| 92 | Lockport | 51 | 4 | 1 | 13 | 3 |
| | Calumet River | | | | | |
| 49 | Ewing Avenue | 12 | 1 | 1 | 4 | 1 |
| 55 | 130th Street | 12 | 3 | 1 | 9 | 2 |
| | Wolf Lake | | | | | |
| 50 | Burnham Avenue | 12 | 5 | 1 | 21 | 5 |
| | Grand Calumet River | | | | | |
| 86 | Burnham Avenue | 11 | 25 | 2 | 91 | 32 |
| | Little Calumet River (Deep-Draft Portion) | | | | | |
| 56 | Indiana Avenue | 12 | 24 | 2 | 134 | 37 |
| 76 | Halsted Street | 12 | 8 | <1 | 28 | 8 |
| | Thorn Creek | | | | | |
| 54 | Joe Orr Road | 8 | 12 | 2 | 59 | 19 |
| 97 | 170th Street | 11 | 8 | 3 | 18 | 5 |

TABLE V-3 (Continued): MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2006

| Station No. | Location | Number of Samples | Mean (µg/L) | Minimum (µg/L) | Maximum (µg/L) | Standard Deviation (µg/L) |
|---|---|---|---|---|---|---|
| | Little Calumet River (Wadeable Portion) | | | | | |
| 52 | Wentworth Avenue | 12 | 4 | 1 | 10 | 3 |
| 57 | Ashland Avenue | 12 | 5 | 1 | 10 | 2 |
| | Calumet-Sag Channel | | | | | |
| 58 | Ashland Avenue | 12 | 9 | 1 | 32 | 9 |
| 59 | Cicero Avenue | 12 | 8 | 1 | 34 | 9 |
| 43 | Route 83 | 12 | 6 | 2 | 18 | 5 |
| | Buffalo Creek | | | | | |
| 12 | Lake-Cook Road | 9 | 20 | 7 | 33 | 9 |
| | Higgins Creek | | | | | |
| 77 | Elmhurst Road | 7 | 12 | 4 | 19 | 6 |
| 78 | Wille Road | 11 | 3 | 1 | 6 | 2 |
| | Des Plaines River | | | | | |
| 13 | Lake-Cook Road | 12 | 17 | 6 | 32 | 7 |
| 17 | Oakton Street | 12 | 13 | 2 | 32 | 9 |
| 19 | Belmont Avenue | 12 | 12 | 1 | 28 | 9 |
| 20 | Roosevelt Road | 12 | 11 | 1 | 29 | 8 |
| 22 | Ogden Avenue | 12 | 15 | 2 | 50 | 15 |
| 23 | Willow Springs Road | 12 | 14 | 2 | 35 | 10 |
| 29 | Stephen Street | 11 | 17 | 5 | 39 | 11 |
| 91 | Material Service Road | 12 | 26 | 7 | 78 | 19 |
| | Salt Creek | | | | | |
| 79 | Higgins Road | 12 | 16 | 4 | 45 | 11 |
| 80 | Arlington Heights Road | 12 | 16 | 4 | 45 | 11 |
| 18 | Devon Avenue | 12 | 18 | 5 | 47 | 12 |
| 24 | Wolf Road | 12 | 12 | 3 | 26 | 8 |
| 109 | Brookfield Avenue | 12 | 16 | 2 | 67 | 19 |

TABLE V-3 (Continued): MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2006

| Station No. | Location | Number of Samples | Mean (µg/L) | Minimum (µg/L) | Maximum (µg/L) | Standard Deviation (µg/L) |
|---|---|---|---|---|---|---|
| | | | <u>West Branch DuPage River</u> | | | |
| 110 | Springinsguth Road | 11 | 15 | 4 | 43 | 13 |
| 89 | Walnut Lane | 12 | 5 | 1 | 13 | 5 |
| 64 | Lake Street | 12 | 20 | 5 | 54 | 15 |
| | | | <u>Poplar Creek</u> | | | |
| 90 | Route 19 | 12 | 14 | 3 | 27 | 8 |

TABLE V-4: SUMMARY OF WATER QUALITY FROM FULLERTON AVENUE ON THE NORTH BRANCH CHICAGO RIVER, IRVING PARK ROAD AND OGDEN AVENUE ON THE DES PLAINES RIVER, AND JFK BOULEVARD AND WOLF ROAD ON SALT CREEK DURING 2006 FOR CFAR PROJECT

| Station Name | Sampling Date | Chl. *a* (μg/L) | $NH_4$-N (mg/L) | $NO_3$-N (mg/L) | $NO_2$-N (mg/L) | TKN (mg/L) | TN (mg/L) | Ortho-Phosphate (mg/L) | TP (mg/L) | TSS (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fullerton Ave. | 1/4/06 | 4 | 0.21 | 4.569 | 0.251 | 1.24 | 6.06 | 0.480 | 0.56 | 10 | 13.6 |
| | 2/1/06 | 8 | 0.16 | 6.466 | 0.197 | 1.16 | 7.82 | 0.581 | 0.65 | 15 | 6.5 |
| | 3/1/06 | 10 | 0.56 | 8.488 | 0.170 | 1.89 | 10.55 | 1.373 | 1.62 | <3 | 5.7 |
| | 4/4/06* | 10 | 0.32 | 3.873 | 0.095 | 1.62 | 5.59 | 0.320 | 0.65 | 20 | 25.8 |
| | 4/5/06* | 9 | 0.48 | 6.867 | 0.191 | 1.58 | 8.64 | 0.395 | 0.53 | 13 | 10.7 |
| | 4/6/06* | 10 | 0.53 | 6.372 | 0.231 | 1.88 | 8.48 | 0.498 | 0.71 | 10 | 11.9 |
| | 4/7/06* | 11 | 0.48 | 7.096 | 0.206 | 1.74 | 9.04 | 0.639 | 0.83 | 19 | 7.0 |
| | 4/19/06 | 8 | 0.23 | 6.577 | 0.138 | 1.43 | 8.15 | 0.555 | 0.70 | 3 | 6.1 |
| | 5/2/06* | 8 | 0.40 | 6.321 | 0.178 | 2.10 | 8.60 | 0.454 | 0.64 | 10 | 8.7 |
| | 5/3/06* | 13 | 0.63 | 4.595 | 0.185 | 1.92 | 6.70 | 0.556 | 0.68 | 8 | 6.6 |
| | 5/4/06* | 7 | 0.63 | 6.197 | 0.295 | 1.84 | 8.33 | 0.768 | 0.99 | 5 | 4.4 |
| | 5/5/06* | 11 | 0.35 | 5.517 | 0.169 | 1.63 | 7.32 | 0.911 | 1.11 | 6 | 7.9 |
| | 5/17/06 | 13 | 0.34 | 5.559 | 0.149 | 1.88 | 7.59 | 0.706 | 0.87 | <3 | 6.7 |
| | 6/7/06 | 2 | 0.81 | 5.064 | 0.349 | 2.27 | 7.68 | 1.056 | 1.50 | 12 | 10.6 |
| | 6/21/06 | 4 | 0.66 | 4.864 | 0.371 | 2.03 | 7.27 | 0.924 | 1.22 | 11 | 9.9 |
| | 7/5/06 | 4 | 0.30 | 5.038 | 0.124 | 1.35 | 6.51 | 0.554 | 0.74 | 12 | 11.7 |
| | 7/19/06 | 2 | 0.54 | 4.493 | 0.180 | 1.54 | 6.21 | 0.235 | 0.48 | 8 | 11.0 |
| | 8/2/06 | 2 | 0.93 | 4.420 | 0.260 | 1.92 | 6.60 | 0.377 | 2.05 | 12 | 18.3 |
| | 8/16/06 | 1 | 0.78 | 5.113 | 0.166 | 1.60 | 6.88 | 0.834 | 0.98 | 11 | 14.4 |
| | 8/29/06* | 3 | 0.32 | 3.281 | 0.079 | 1.24 | 4.60 | 0.753 | 0.89 | 8 | 14.0 |
| | 8/30/06* | 1 | 1.50 | 3.902 | 0.210 | 2.48 | 6.59 | 0.918 | 1.05 | 11 | 11.7 |
| | 8/31/06* | 2 | 0.14 | 5.730 | 0.060 | 1.06 | 6.85 | 0.662 | 0.78 | 20 | 13.8 |
| | 9/1/06* | 6 | 0.14 | 6.022 | 0.042 | 1.17 | 7.23 | 0.763 | 0.92 | 13 | 12.3 |
| | 9/6/06 | 4 | 0.22 | 4.882 | 0.035 | 1.16 | 6.08 | 0.646 | 0.82 | 13 | 14.3 |
| | 9/20/06 | 3 | 0.19 | 6.111 | 0.029 | 1.44 | 7.58 | 0.887 | 1.03 | 19 | 15.4 |
| | 10/4/06 | 7 | 0.28 | 2.673 | 0.062 | 1.91 | 4.65 | 0.199 | 0.46 | 68 | 48.4 |
| | 10/18/06 | 4 | 0.10 | 2.901 | 0.046 | 1.27 | 4.22 | 0.238 | 0.36 | 11 | 16.8 |

TABLE V-4 (Continued): SUMMARY OF WATER QUALITY FROM FULLERTON AVENUE ON THE NORTH BRANCH CHICAGO RIVER, IRVING PARK ROAD AND OGDEN AVENUE ON THE DES PLAINES RIVER, AND JFK BOULEVARD AND WOLF ROAD ON SALT CREEK DURING 2006 FOR CFAR PROJECT

| Station Name | Sampling Date | Chl. *a* (µg/L) | $NH_4$-N (mg/L) | $NO_3$-N (mg/L) | $NO_2$-N (mg/L) | TKN (mg/L) | TN (mg/L) | Ortho-Phosphate (mg/L) | TP (mg/L) | TSS (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fullerton Ave. (Cont.) | 11/1/06 | 3 | 0.25 | 6.024 | 0.085 | 1.34 | 7.45 | 1.057 | 1.17 | 8 | 9.4 |
| | 11/15/06 | 9 | 0.24 | 5.577 | 0.095 | 1.60 | 7.27 | 0.847 | 1.01 | 5 | 10.5 |
| | 12/6/06 | 5 | 0.17 | 5.518 | 0.104 | 1.11 | 6.73 | 0.619 | 0.86 | 9 | 7.8 |
| Irving Park Rd. | 1/4/06 | 15 | 0.30 | 4.451 | 0.097 | 1.51 | 6.06 | 0.698 | 0.84 | 22 | 23.3 |
| | 2/1/06 | 22 | 0.08 | 3.649 | 0.092 | 1.26 | 5.00 | 0.235 | 0.38 | 33 | 20.8 |
| | 3/1/06 | 8 | 0.10 | 7.226 | 0.285 | 1.85 | 9.36 | 0.745 | 0.98 | 6 | 9.8 |
| | 4/4/06* | 16 | 0.27 | 3.393 | 0.076 | 1.79 | 5.26 | 0.303 | 0.53 | 33 | 30.7 |
| | 4/5/06* | 16 | 0.27 | 3.839 | 0.040 | 1.35 | 5.23 | 0.290 | 0.47 | 34 | 25.9 |
| | 4/6/06* | 13 | 0.09 | 3.534 | 0.059 | 1.35 | 4.94 | 0.285 | 0.45 | 33 | 25.5 |
| | 4/7/06* | 13 | 0.19 | 3.969 | 0.063 | 1.59 | 5.62 | 0.324 | 0.54 | 46 | 16.4 |
| | 4/19/06 | 10 | 0.08 | 4.044 | 0.056 | 1.33 | 5.43 | 0.418 | 0.50 | 7 | 12.4 |
| | 5/2/06* | 16 | 0.32 | 2.724 | 0.060 | 1.75 | 4.53 | 0.290 | 0.55 | 35 | 23.9 |
| | 5/3/06* | 15 | 0.12 | 3.419 | 0.054 | 1.60 | 5.07 | 0.348 | 0.61 | 22 | 15.8 |
| | 5/4/06* | 17 | 0.11 | 3.485 | 0.055 | 1.33 | 4.87 | 0.427 | 0.57 | 23 | 15.1 |
| | 5/5/06* | 23 | 0.11 | 3.595 | 0.078 | 1.44 | 5.11 | 0.406 | 0.68 | 33 | 20.0 |
| | 5/17/06 | 5 | 0.15 | 5.372 | 0.065 | 2.20 | 7.64 | 0.314 | 0.60 | 32 | 22.3 |
| | 6/7/06 | 3 | 0.12 | 5.431 | 0.060 | 1.77 | 7.26 | 0.481 | 0.61 | 25 | 18.7 |
| | 6/21/06 | 56 | 0.23 | 4.876 | 0.143 | 1.98 | 7.00 | 0.717 | 1.02 | 24 | 18.7 |
| | 7/5/06 | 8 | 0.11 | 3.582 | 0.047 | 1.15 | 4.78 | 0.618 | 0.86 | 22 | 14.5 |
| | 7/19/06 | 3 | 0.28 | 5.099 | 0.095 | 1.57 | 6.76 | 1.016 | 1.50 | 8 | 12.3 |
| | 8/2/06 | 2 | 0.15 | 5.877 | 0.084 | 1.50 | 7.46 | 0.971 | 1.91 | 5 | 15.3 |
| | 8/16/06 | 2 | 0.23 | 8.345 | 0.051 | 1.33 | 9.73 | 1.173 | 1.43 | 25 | 19.9 |
| | 8/29/06* | 4 | 0.09 | 4.215 | 0.062 | 1.40 | 5.68 | 0.711 | 0.88 | 49 | 10.1 |
| | 8/30/06* | 4 | 0.18 | 3.322 | 0.054 | 1.25 | 4.63 | 0.639 | 0.76 | 36 | 32.9 |
| | 8/31/06* | 2 | 0.04 | 3.833 | 0.052 | 1.17 | 5.06 | 0.715 | 0.80 | 31 | 25.4 |

TABLE V-4 (Continued): SUMMARY OF WATER QUALITY FROM FULLERTON AVENUE ON THE NORTH BRANCH CHICAGO RIVER, IRVING PARK ROAD AND OGDEN AVENUE ON THE DES PLAINES RIVER, AND JFK BOULEVARD AND WOLF ROAD ON SALT CREEK DURING 2006 FOR CFAR PROJECT

| | Sampling Date | Chl. *a* (µg/L) | $NH_4$-N (mg/L) | $NO_3$-N (mg/L) | $NO_2$-N (mg/L) | TKN (mg/L) | TN (mg/L) | Ortho-Phosphate (mg/L) | TP (mg/L) | TSS (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Irving Park Rd. (Cont.) | 9/1/06* | 2 | 0.06 | 4.570 | 0.050 | 1.45 | 6.07 | 0.823 | 1.00 | 26 | 14.6 |
| | 9/6/06 | 2 | 0.13 | 6.317 | 0.046 | 1.32 | 7.68 | 1.124 | 1.37 | 37 | 24.1 |
| | 9/20/06 | 2 | 0.06 | 4.859 | 0.036 | 1.47 | 6.37 | 0.694 | 0.88 | 53 | 42.0 |
| | 10/4/06 | 11 | 0.18 | 2.256 | 0.044 | 1.52 | 3.82 | 0.271 | 0.40 | 38 | 44.2 |
| | 10/18/06 | 4 | 0.02 | 3.637 | 0.022 | 1.47 | 5.13 | 0.518 | 0.69 | 28 | 27.6 |
| | 11/1/06 | 17 | <0.02 | 4.399 | 0.015 | 1.25 | 5.66 | 0.519 | 0.59 | 12 | 13.9 |
| | 11/15/06 | 20 | 0.08 | 3.998 | 0.019 | 1.39 | 5.41 | 0.402 | 0.55 | 9 | 16.6 |
| | 12/6/06 | 13 | 0.17 | 4.384 | 0.066 | 1.30 | 5.75 | 0.412 | 0.68 | 20 | 20.1 |
| JFK Blvd. | 1/4/06 | 14 | 0.13 | 3.505 | 0.018 | 1.28 | 4.80 | 0.616 | 0.73 | <3 | 3.6 |
| | 2/1/06 | 12 | 0.10 | 0.936 | 0.035 | 1.10 | 2.07 | 0.696 | ND | 18 | 11.5 |
| | 3/1/06 | 7 | 0.02 | 11.698 | 0.008 | 1.34 | 13.05 | 1.703 | 2.88 | 5 | 4.9 |
| | 4/4/06* | 28 | 0.21 | 3.019 | 0.029 | 1.37 | 4.42 | 0.238 | 0.39 | 13 | 15.1 |
| | 4/5/06* | 22 | 0.27 | 3.887 | 0.024 | 1.28 | 5.19 | 0.361 | 0.57 | 18 | 13.3 |
| | 4/6/06* | 21 | 0.04 | 4.832 | 0.019 | 1.13 | 5.98 | 0.594 | 0.73 | 13 | 12.0 |
| | 4/7/06* | 23 | 0.06 | 5.605 | 0.023 | 1.36 | 6.99 | 0.779 | 0.96 | 18 | 11.6 |
| | 4/19/06 | 36 | 0.04 | 4.523 | 0.071 | 1.40 | 5.99 | 0.707 | 0.92 | 4 | 9.4 |
| | 5/2/06* | 46 | 0.05 | 2.785 | 0.010 | 1.67 | 4.47 | 0.453 | 0.63 | 21 | 15.7 |
| | 5/3/06* | 44 | 0.02 | 4.136 | 0.013 | 1.83 | 5.98 | 0.745 | 1.00 | 23 | 16.6 |
| | 5/4/06* | 64 | 0.00 | 4.086 | 0.007 | 1.32 | 5.41 | 0.820 | 0.99 | 9 | 7.6 |
| | 5/5/06* | 38 | 0.00 | 6.613 | 0.015 | 1.62 | 8.25 | 1.215 | 1.52 | 7 | 10.4 |
| | 5/17/06 | 28 | 0.18 | 5.109 | 0.011 | 1.59 | 6.71 | 0.939 | 1.15 | 14 | 7.2 |
| | 6/7/06 | 4 | 0.05 | 15.891 | 0.022 | 1.28 | 17.19 | 3.325 | 3.81 | ND | 3.6 |
| | 6/21/06 | 6 | 0.05 | 16.029 | 0.021 | 1.36 | 17.41 | 3.594 | 4.30 | 8 | 3.5 |
| | 7/5/06 | 13 | <0.02 | 6.341 | 0.012 | 1.07 | 7.42 | 1.377 | 1.65 | 11 | 7.9 |
| | 7/19/06 | 18 | 0.19 | 7.264 | 0.014 | 1.31 | 8.59 | 1.250 | 2.33 | 10 | 11.4 |

TABLE V-4 (Continued): SUMMARY OF WATER QUALITY FROM FULLERTON AVENUE ON THE NORTH BRANCH CHICAGO RIVER, IRVING PARK ROAD AND OGDEN AVENUE ON THE DES PLAINES RIVER, AND JFK BOULEVARD AND WOLF ROAD ON SALT CREEK DURING 2006 FOR CFAR PROJECT

| Station Name | Sampling Date | Chl. *a* (µg/L) | $NH_4$-N (mg/L) | $NO_3$-N (mg/L) | $NO_2$-N (mg/L) | TKN (mg/L) | TN (mg/L) | Ortho-Phosphate (mg/L) | TP (mg/L) | TSS (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JFK Blvd. (Cont.) | 8/2/06 | 4 | 0.07 | 16.703 | 0.013 | 1.29 | 18.01 | 3.310 | 3.85 | 4 | 14.4 |
| | 8/16/06 | 2 | 0.16 | 19.945 | 0.019 | 1.70 | 21.66 | 4.663 | 5.49 | 6 | 3.2 |
| | 8/29/06* | 28 | 0.42 | 5.221 | 0.012 | 1.55 | 6.78 | 1.693 | 1.88 | 16 | 12.2 |
| | 8/30/06* | 22 | 0.28 | 5.100 | 0.011 | 1.37 | 6.48 | 2.418 | 2.66 | 12 | 17.4 |
| | 8/31/06* | 17 | 0.11 | 8.355 | 0.013 | 1.38 | 9.75 | 2.897 | 3.11 | 9 | 9.9 |
| | 9/1/06* | 13 | 0.07 | 10.943 | 0.014 | 1.32 | 12.28 | 3.583 | 4.04 | 10 | 9.4 |
| | 9/6/06 | 42 | 0.13 | 7.319 | 0.006 | 1.48 | 8.81 | 1.892 | 2.09 | 9 | 12.0 |
| | 9/20/06 | 28 | 0.04 | 8.422 | 0.016 | 1.41 | 9.85 | 2.578 | 2.88 | 15 | 10.2 |
| | 10/4/06 | 26 | 0.19 | 1.399 | 0.038 | 1.26 | 2.70 | 0.099 | 0.22 | 32 | 41.2 |
| | 10/18/06 | 18 | 0.03 | 2.493 | 0.029 | 1.30 | 3.82 | 0.487 | 0.64 | 12 | 15.5 |
| | 11/1/06 | 15 | 0.02 | 7.103 | 0.019 | 1.13 | 8.25 | 1.772 | 1.98 | 7 | 11.3 |
| | 11/15/06 | 11 | 0.10 | 5.678 | 0.021 | 1.44 | 7.14 | 1.228 | 1.43 | 4 | 7.4 |
| | 12/6/06 | 10 | 0.08 | 5.164 | 0.011 | 1.07 | 6.25 | 0.865 | 1.10 | 9 | 10.9 |
| Ogden Ave. | 1/4/06 | 10 | 0.25 | 4.088 | 0.074 | 1.36 | 5.52 | 0.690 | 0.92 | 28 | 25.3 |
| | 2/1/06 | 19 | 0.09 | 3.811 | 0.065 | 1.33 | 5.21 | 0.315 | 0.47 | 35 | 22.1 |
| | 3/1/06 | 10 | 0.04 | 8.075 | 0.153 | 1.26 | 9.49 | 1.070 | 1.28 | 11 | 9.1 |
| | 4/4/06* | 17 | 0.29 | 3.530 | 0.086 | 1.61 | 5.23 | 0.345 | 0.71 | 52 | 43.5 |
| | 4/5/06* | 18 | 0.39 | 3.583 | 0.045 | 1.46 | 5.09 | 0.299 | 0.55 | 46 | 33.7 |
| | 4/6/06* | 17 | 0.06 | 3.746 | 0.038 | 1.48 | 5.26 | 0.312 | 0.53 | 31 | 27.0 |
| | 4/7/06* | 16 | 0.15 | 3.843 | 0.056 | 1.34 | 5.24 | 0.324 | 0.54 | 41 | 23.7 |
| | 4/19/06 | 13 | 0.04 | 3.579 | 0.033 | 1.25 | 4.86 | 0.413 | 0.59 | 8 | 15.9 |
| | 5/2/06* | 22 | 0.33 | 3.093 | 0.049 | 2.01 | 5.15 | 0.368 | 0.67 | 46 | 32.2 |
| | 5/3/06* | 15 | 0.12 | 2.842 | 0.046 | 1.54 | 4.43 | 0.403 | 0.60 | 40 | 25.1 |
| | 5/4/06* | 15 | 0.10 | 3.307 | 0.052 | 1.28 | 4.64 | 0.416 | 0.62 | 27 | 18.6 |
| | 5/5/06* | 19 | 0.08 | 3.536 | 0.054 | 1.28 | 4.87 | 0.534 | 0.66 | 20 | 16.3 |

TABLE V-4 (Continued): SUMMARY OF WATER QUALITY FROM FULLERTON AVENUE ON THE NORTH BRANCH CHICAGO RIVER, IRVING PARK ROAD AND OGDEN AVENUE ON THE DES PLAINES RIVER, AND JFK BOULEVARD AND WOLF ROAD ON SALT CREEK DURING 2006 FOR CFAR PROJECT

| Station Name | Sampling Date | Chl. *a* (μg/L) | $NH_4$-N (mg/L) | $NO_3$-N (mg/L) | $NO_2$-N (mg/L) | TKN (mg/L) | TN (mg/L) | Ortho-Phosphate (mg/L) | TP (mg/L) | TSS (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ogden Ave. (Cont.) | 5/17/06 | 36 | 0.13 | 4.101 | 0.035 | 1.94 | 6.08 | 0.392 | 0.96 | 45 | 26.5 |
| | 6/7/06 | 3 | 0.10 | 5.780 | 0.046 | 1.41 | 7.24 | 0.634 | 0.76 | 31 | 19.5 |
| | 6/21/06 | 5 | 0.09 | 6.362 | 0.048 | 1.33 | 7.74 | 1.049 | 1.33 | 17 | 14.2 |
| | 7/5/06 | 6 | 0.11 | 4.102 | 0.050 | 1.09 | 5.24 | 0.794 | 0.99 | 28 | 20.8 |
| | 7/19/06 | 3 | 0.34 | 4.274 | 0.065 | 1.50 | 5.84 | 0.930 | 1.30 | 15 | 17.0 |
| | 8/2/06 | 3 | 0.15 | 5.646 | 0.055 | 1.28 | 6.98 | 1.122 | 1.30 | 14 | 24.4 |
| | 8/16/06 | 2 | 0.22 | 8.880 | 0.044 | 1.63 | 10.55 | 1.842 | 1.93 | 25 | 18.8 |
| | 8/29/06* | 6 | 0.04 | 3.467 | 0.047 | 1.54 | 5.05 | 0.641 | 0.94 | 75 | 56.4 |
| | 8/30/06* | 3 | 0.16 | 3.948 | 0.049 | 1.33 | 5.33 | 0.599 | 0.95 | 44 | 41.4 |
| | 8/31/06* | 4 | 0.03 | 3.767 | 0.040 | 1.22 | 5.03 | 0.797 | 0.91 | 36 | 27.8 |
| | 9/1/06* | 3 | 0.07 | 4.079 | 0.031 | 1.16 | 5.27 | 1.030 | 1.22 | 18 | 24.6 |
| | 9/6/06 | 5 | 0.30 | 4.518 | 0.034 | 1.42 | 5.97 | 0.950 | 1.17 | 34 | 29.0 |
| | 9/20/06 | <1 | 0.05 | 5.010 | 0.039 | 1.38 | 6.43 | 0.922 | 1.04 | 37 | 26.9 |
| | 10/4/06 | 8 | 0.30 | 2.085 | 0.056 | 1.43 | 3.57 | 0.305 | 0.53 | 68 | 59.5 |
| | 10/18/06 | 6 | <0.02 | 2.933 | 0.030 | 1.28 | 4.24 | 0.504 | 0.72 | 37 | 20.5 |
| | 11/1/06 | 4 | <0.02 | 4.198 | 0.024 | 1.56 | 5.78 | 0.589 | 0.67 | 8 | 10.0 |
| | 11/15/06 | 20 | 0.00 | 3.566 | 0.019 | 1.13 | 4.72 | 0.416 | 0.53 | 10 | 16.0 |
| | 12/6/06 | 10 | 0.08 | 3.854 | 0.027 | 1.12 | 5.00 | 0.379 | 0.58 | 22 | 21.3 |
| Wolf Rd. | 1/4/06 | 14 | 0.34 | 4.049 | 0.152 | 1.71 | 5.91 | 0.860 | 1.07 | 29 | 23.8 |
| | 2/1/06 | 17 | 0.09 | 4.462 | 0.032 | 1.17 | 5.66 | 0.418 | 0.55 | 31 | 22.3 |
| | 3/1/06 | 13 | <0.02 | 10.552 | 0.038 | 1.47 | 12.06 | 1.785 | 2.35 | 16 | 9.0 |
| | 4/4/06* | 31 | 0.18 | 4.211 | 0.078 | 1.82 | 6.11 | 0.538 | 0.96 | 55 | 36.2 |
| | 4/5/06* | 26 | 0.18 | 3.922 | 0.025 | 1.43 | 5.38 | 0.330 | 0.57 | 43 | 25.8 |
| | 4/6/06* | 23 | 0.05 | 4.447 | 0.026 | 1.29 | 5.76 | 0.402 | 0.64 | 26 | 21.0 |
| | 4/7/06* | 18 | 0.13 | 5.487 | 0.049 | 1.31 | 6.85 | 0.589 | 0.77 | 22 | 14.5 |
| | 4/19/06 | 27 | 0.05 | 3.733 | 0.000 | 1.58 | 5.31 | 0.524 | 0.72 | 21 | 19.7 |

TABLE V-4 (Continued): SUMMARY OF WATER QUALITY FROM FULLERTON AVENUE ON THE NORTH BRANCH CHICAGO RIVER, IRVING PARK ROAD AND OGDEN AVENUE ON THE DES PLAINES RIVER, AND JFK BOULEVARD AND WOLF ROAD ON SALT CREEK DURING 2006 FOR CFAR PROJECT

| Station Name | Sampling Date | Chl. *a* (µg/L) | $NH_4$-N (mg/L) | $NO_3$-N (mg/L) | $NO_2$-N (mg/L) | TKN (mg/L) | TN (mg/L) | Ortho-Phosphate (mg/L) | TP (mg/L) | TSS (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wolf Rd. (Cont.) | 5/2/06* | 24 | 0.13 | 2.279 | 0.033 | 1.91 | 4.22 | 0.333 | 0.63 | 66 | 43.2 |
| | 5/3/06* | 30 | 0.09 | 3.183 | 0.024 | 1.66 | 4.87 | 0.427 | 0.72 | 41 | 23.9 |
| | 5/4/06* | 26 | 0.07 | 3.725 | 0.026 | 1.32 | 5.07 | 0.574 | 0.81 | 28 | 20.7 |
| | 5/5/06* | 22 | 0.08 | 4.686 | 0.039 | 1.34 | 6.07 | 0.845 | 1.02 | 23 | 17.7 |
| | 5/17/06 | 33 | 0.11 | 4.570 | 0.027 | 1.58 | 6.18 | 0.782 | 1.26 | 27 | 15.8 |
| | 6/7/06 | 3 | 0.16 | 10.130 | 0.090 | 1.36 | 11.58 | 1.847 | 2.27 | 15 | 10.2 |
| | 6/21/06 | 3 | 0.14 | 10.260 | 0.074 | 1.35 | 11.68 | 2.093 | 2.59 | 21 | 15.6 |
| | 7/5/06 | 4 | 0.14 | 5.618 | 0.057 | 1.07 | 6.75 | 1.144 | 1.49 | 20 | 14.2 |
| | 7/19/06 | 7 | 0.41 | 7.359 | 0.090 | 1.46 | 8.91 | 1.995 | 2.55 | 16 | 16.6 |
| | 8/2/06 | 0 | 0.14 | 10.575 | 0.092 | 1.22 | 11.89 | 2.216 | 2.64 | 8 | 23.8 |
| | 8/16/06 | 2 | 0.26 | 14.104 | 0.076 | 1.56 | 15.74 | 2.022 | 3.13 | 24 | 18.6 |
| | 8/29/06* | 11 | 0.19 | 4.314 | 0.066 | 1.20 | 5.58 | 1.062 | 1.11 | 49 | 19.9 |
| | 8/30/06* | 10 | 0.18 | 5.492 | 0.048 | 1.26 | 6.80 | 1.324 | 1.51 | 42 | 30.4 |
| | 8/31/06* | 10 | 0.09 | 5.423 | 0.049 | 1.43 | 6.90 | 2.002 | 2.24 | 42 | 27.4 |
| | 9/1/06* | 7 | 0.10 | 6.485 | 0.047 | 1.26 | 7.79 | 2.036 | 2.35 | 24 | 21.4 |
| | 9/6/06 | 12 | 0.11 | 5.357 | 0.032 | 1.43 | 6.82 | 1.529 | 1.71 | 42 | 32.0 |
| | 9/20/06 | 5 | 0.08 | 4.331 | 0.031 | 1.25 | 5.61 | 1.080 | 1.26 | 38 | 24.3 |
| | 10/4/06 | 15 | 0.22 | 2.014 | 0.048 | 1.47 | 3.53 | 0.235 | 0.43 | 51 | 46.8 |
| | 10/18/06 | 9 | 0.06 | 3.918 | 0.039 | 1.54 | 5.50 | 0.778 | 1.03 | 41 | 31.0 |
| | 11/1/06 | 8 | <0.02 | 4.911 | 0.025 | 1.12 | 6.06 | 1.090 | 1.27 | 11 | 14.5 |
| | 11/15/06 | 9 | <0.02 | 4.647 | 0.023 | 1.27 | 5.94 | 0.731 | 0.94 | 23 | 20.9 |
| | 12/6/06 | 9 | 0.08 | 4.734 | 0.014 | 0.98 | 5.73 | 0.623 | 0.89 | 19 | 16.1 |

*Denotes rain event sampling.
ND = No data.

TABLE V-5: NUMBER AND PERCENT OF DISSOLVED OXYGEN VALUES MEASURED ABOVE THE ILLINOIS POLLUTION CONTROL BOARD (IPCB) WATER QUALITY STANDARD DURING 2006[1]

| Monitoring Station | Location | IPCB DO Standard | Total Number DO Values | Number Above IPCB Standard | Percent Above IPCB Standard |
|---|---|---|---|---|---|
| | Chicago River System | | | | |
| Main Street | North Shore Channel | 5 | 8,109 | 7,338 | 90 |
| Foster Avenue | North Shore Channel | 4 | 8,400 | 8,399 | >99 |
| Central Park Avenue | North Branch Chicago River | 5 | 8,567 | 7,834 | 91 |
| Addison Street | North Branch Chicago River | 4 | 8,571 | 8,563 | >99 |
| Fullerton Avenue | North Branch Chicago River | 4 | 8,398 | 8,338 | 99 |
| Kinzie Street | North Branch Chicago River | 4 | 8,734 | 8,621 | 99 |
| Clark Street | Chicago River | 5 | 8,375 | 8,375 | 100 |
| Loomis Street | South Branch Chicago River | 4 | 8,734 | 8,708 | >99 |
| 36th Street | Bubbly Creek | 4 | 8,384 | 2,338 | 28 |
| Interstate Hwy. 55 | Bubbly Creek | 4 | 8,189 | 6,279 | 77 |
| Cicero Avenue | Chicago Sanitary and Ship Canal | 4 | 8,567 | 8,199 | 96 |
| B&O Central RR | Chicago Sanitary and Ship Canal | 4 | 8,732 | 8,588 | 98 |
| Route 83 | Chicago Sanitary and Ship Canal | 4 | 6,899 | 5,874 | 85 |
| Lockport Powerhouse | Chicago Sanitary and Ship Canal | 4 | 8,392 | 6,742 | 80 |
| | Calumet River System | | | | |
| Hohman Avenue | Grand Calumet River | 5 | 3,274 | 433 | 13 |
| Torrence Avenue | Grand Calumet River | 4 | 8,251 | 6,173 | 75 |
| C&W Indiana RR | Little Calumet River | 4 | 8,562 | 8,424 | 98 |
| Halsted Street | Little Calumet River | 4 | 8,393 | 8,388 | >99 |
| Wentworth Avenue | Little Calumet River | 5 | 8,484 | 6,489 | 76 |
| Ashland Avenue | Little Calumet River | 5 | 8,375 | 6,628 | 79 |
| Cicero Avenue | Calumet-Sag Channel | 3 | 8,563 | 8,563 | 100 |
| 104th Avenue | Calumet-Sag Channel | 3 | 7,161 | 7,158 | >99 |
| Route 83 | Calumet-Sag Channel | 3 | 8,732 | 8,705 | >99 |
| | Des Plaines River System | | | | |
| Busse Lake Dam | Salt Creek | 5 | 8,499 | 8,291 | 98 |
| JFK Boulevard | Salt Creek | 5 | 8,736 | 8,736 | 100 |
| Thorndale Avenue | Salt Creek | 5 | 7,557 | 7,454 | 99 |
| Wolf Road | Salt Creek | 5 | 8,543 | 8,161 | 96 |
| Devon Avenue | Des Plaines River | 5 | 8,397 | 7,259 | 86 |
| Irving Park Road | Des Plaines River | 5 | 8,550 | 7,573 | 89 |
| Ogden Avenue | Des Plaines River | 5 | 8,735 | 8,695 | >99 |
| Material Service Road | Des Plaines River | 5 | 7,813 | 7,733 | 99 |
| Jefferson Street | Des Plaines River | 4 | 8,565 | 8,124 | 95 |

[1]Dissolved oxygen was measured hourly using a YSI model 6920 or model 6600 continuous water quality monitor.

TABLE V-6: DESCRIPTION OF SEDIMENT OXYGEN DEMAND (SOD) MEASUREMENT LOCATIONS IN THE CHICAGO WATERWAY SYSTEM

| SOD Measurement Location | Waterway | River Mile | Latitude | Longitude |
|---|---|---|---|---|
| Diversey Parkway (upstream[1]) | North Branch Chicago River | 330.2 | 41.9335145 | 87.6830979 |
| Diversey Parkway (off-channel) | North Branch Chicago River | 330.0 | 41.9314100 | 87.6809349 |
| Diversey Parkway (downstream[1]) | North Branch Chicago River | 329.7 | 41.9302929 | 87.6803154 |
| Division Street (upstream[1]) | North Branch Chicago River | 327.8 | 41.9104747 | 87.6563073 |
| Division Street (side channel) | North Branch Chicago River | 0.4 | 41.9033434 | 87.6490951 |
| Division Street (downstream[1]) | North Branch Chicago River | 326.4 | 41.8965985 | 87.6445415 |
| Mooring Slips[2] (upstream[1]) | South Branch Chicago River | 322.7 | 41.8488973 | 87.6468414 |
| Stetson's Slip (side channel) | South Branch Chicago River | 321.9 | 41.8500339 | 87.6623939 |
| Arnold's Slip (side channel) | South Branch Chicago River | 321.7 | 41.8484322 | 87.6648060 |
| Santa Fe Slip (side channel) | South Branch Chicago River | 321.3 | 41.8411146 | 87.6713265 |
| Mooring Slips[2] (downstream[1]) | South Branch Chicago River | 321.2 | 41.8424505 | 87.6729497 |
| 33rd Street (side channel) | Bubbly Creek | 0.7 | 41.8346582 | 87.6603740 |
| South Branch Turning Basin (side channel) | Bubbly Creek | 0.1 | 41.8440416 | 87.6653794 |
| Damen Avenue (upstream[1]) | Chicago Sanitary and Ship Canal | 321.1 | 41.8412870 | 87.6751620 |
| Damen Avenue (off-channel) | Chicago Sanitary and Ship Canal | 321.0 | 41.8423543 | 87.6777578 |
| Damen Avenue (downstream[1]) | Chicago Sanitary and Ship Canal | 320.4 | 41.8364657 | 87.6878172 |
| Wisconsin Steel Slip (upstream[1]) | Calumet River | 330.6 | 41.7020082 | 87.5461372 |
| Wisconsin Steel Slip (side channel) | Calumet River | 330.1 | 41.6966549 | 87.5563134 |
| Wisconsin Steel Slip (downstream[1]) | Calumet River | 328.6 | 41.6744504 | 87.5513628 |

TABLE V-6 (Continued): DESCRIPTION OF SEDIMENT OXYGEN DEMAND (SOD) MEASUREMENT LOCATIONS IN THE CHICAGO WATERWAY SYSTEM

| SOD Measurement Location | Waterway | River Mile | Latitude | Longitude |
|---|---|---|---|---|
| Torrence Avenue (upstream[1]) | Calumet River | 325.9 | 41.6467165 | 87.5609788 |
| Torrence Avenue (side channel) | Grand Calumet River | 0.1 | 41.6453092 | 87.5588396 |
| Torrence Avenue (downstream[1]) | Little Calumet River | 325.3 | 41.6390782 | 87.5655288 |
| | | | | |
| Acme Bend (upstream[1]) | Little Calumet River | 321.6 | 41.6582156 | 87.6192679 |
| Acme Bend[3] (off-channel) | Little Calumet River | 321.5 | 41.6619023 | 87.6191290 |
| Acme Bend[4] (off-channel) | Little Calumet River | 321.3 | 41.6631140 | 87.6204781 |
| Acme Bend (downstream[1]) | Little Calumet River | 320.8 | 41.6594580 | 87.6271968 |

[1]Main channel locations.
[2]Also used as upstream and downstream main channel measurements for Bubbly Creek.
[3]Upstream Calumet WRP outfall.
[4]Downstream Calumet WRP outfall.

TABLE V-7: AVERAGE SEDIMENT OXYGEN DEMAND (SOD) IN THE MAIN CHANNEL AND IN SIDE/OFF CHANNEL AREAS OF THE CHICAGO WATERWAY SYSTEM

| Waterway | Average SOD in Main Channel | Average SOD in Side/Off Channel Area | Percent Difference* |
|---|---|---|---|
| North Branch Chicago River | 2.06 | 3.02 | 47 |
| South Branch | 1.27 | 1.78 | 40 |
| Bubbly Creek | 1.38 | 3.26 | 137 |
| Calumet River | 0.41 | 0.40 | -1 |
| Grand Calumet River | 1.22 | 3.22 | 165 |
| Little Calumet River | 2.62 | 3.08 | 18 |

*Main channel to side/off channel areas.

FIGURE V-1: AMBIENT WATER QUALITY MONITORING AND CONTINUOUS DISSOLVED OXYGEN MONITORING SAMPLE STATIONS

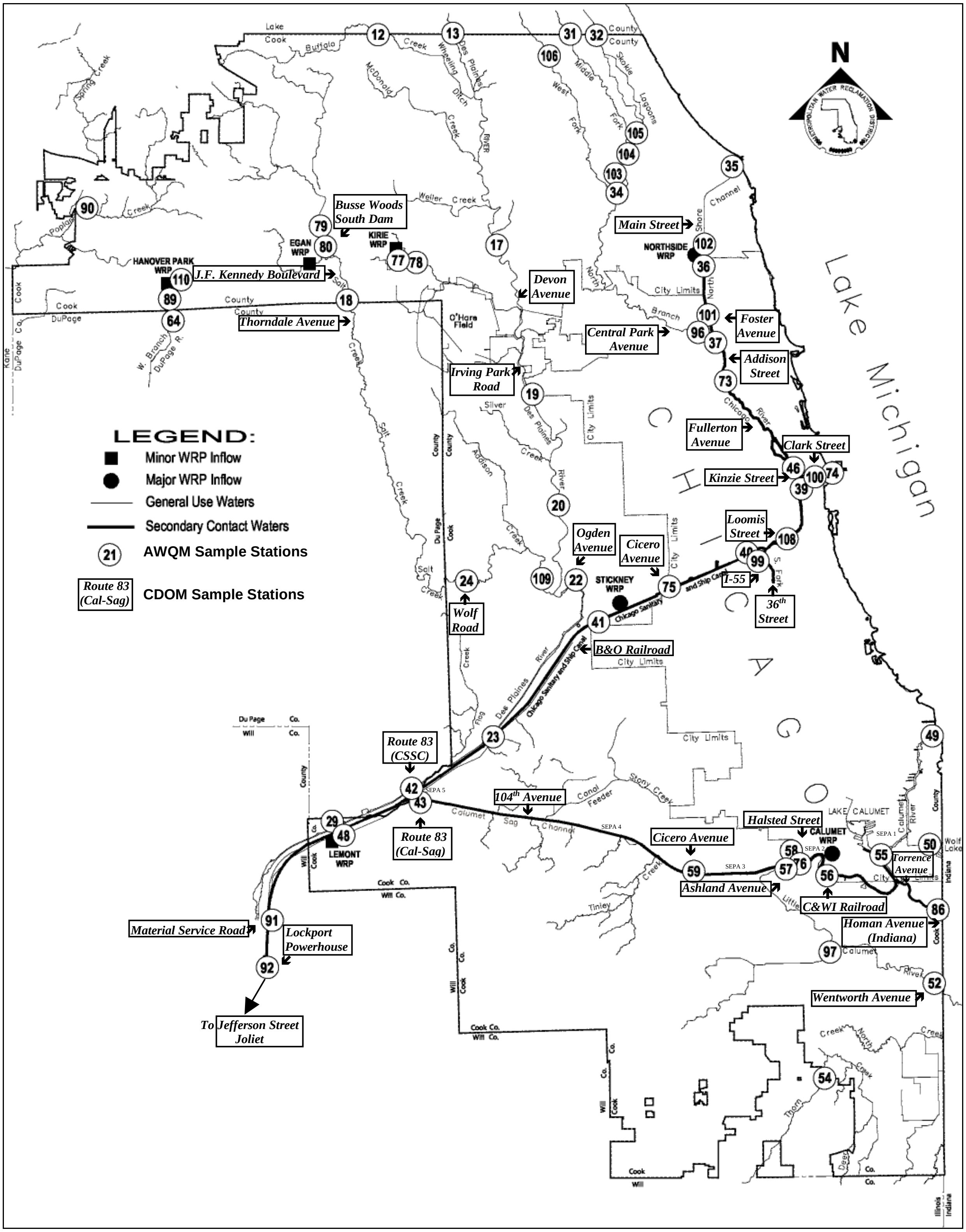


FIGURE V-2: MAP OF THE ILLINOIS WATERWAY FROM LOCKPORT TO MARSEILLES SHOWING SAMPLING STATIONS 1 TO 21

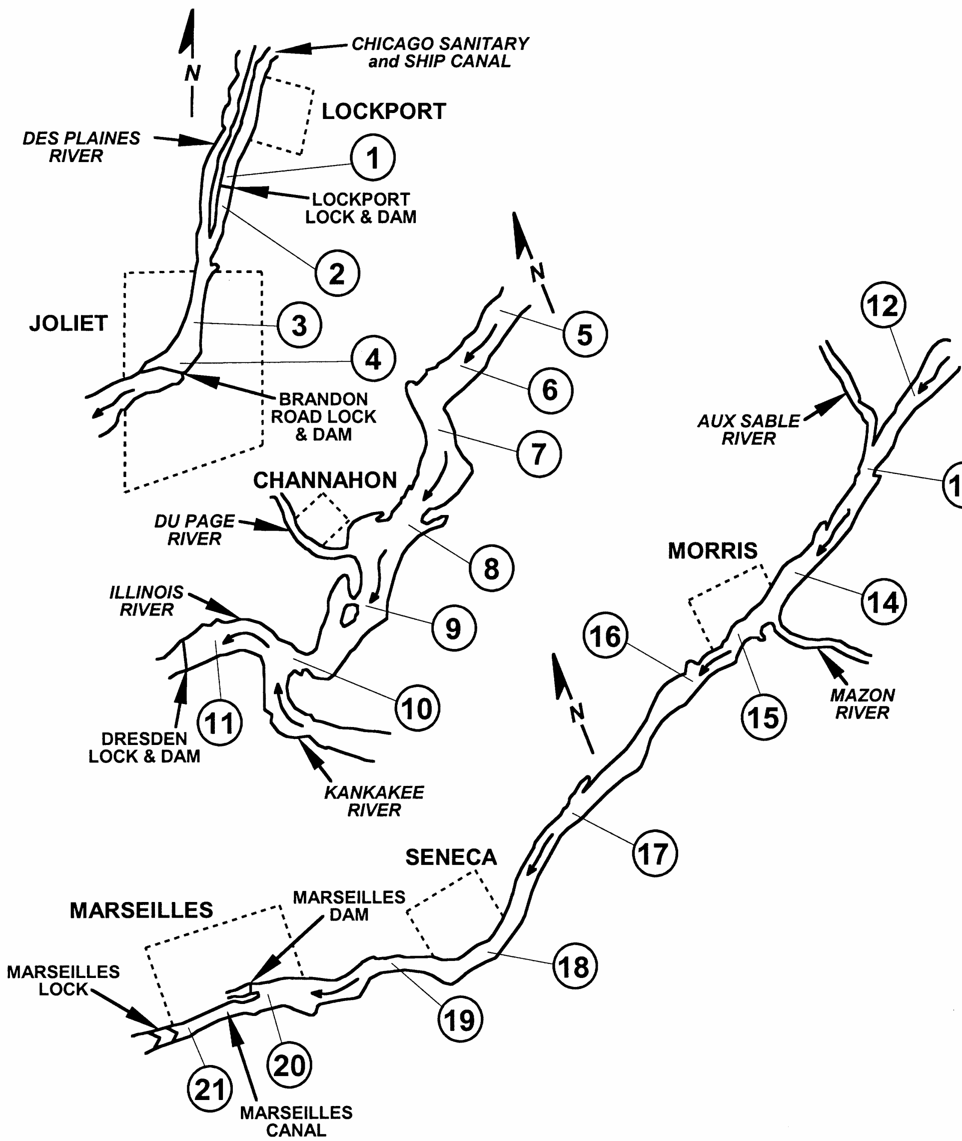


FIGURE V-3: MAP OF THE ILLINOIS WATERWAY FROM OTTAWA TO PEORIA SHOWING SAMPLING STATIONS 22 TO 49

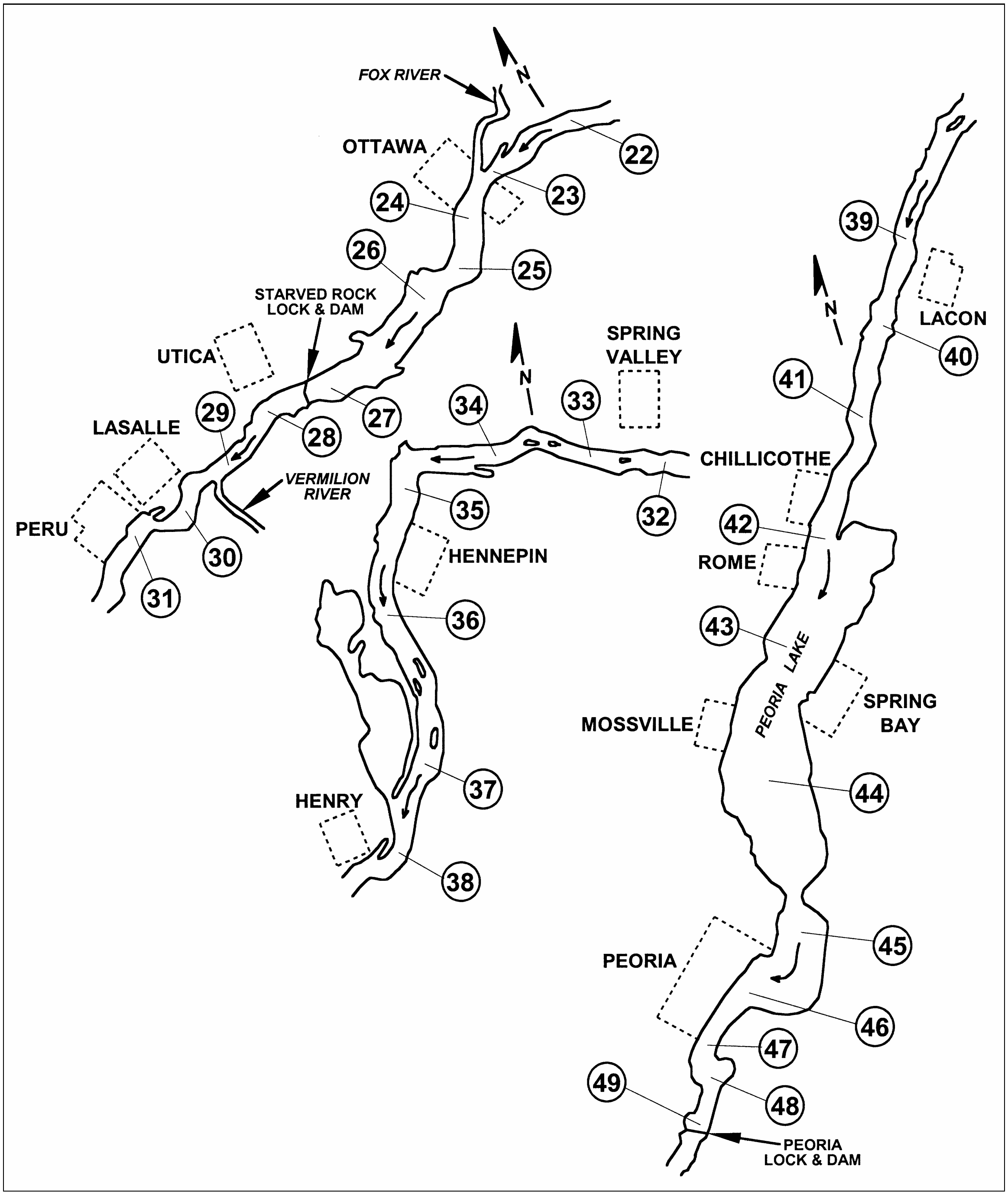


FIGURE V-4: CHICAGO WATERWAY SYSTEM SAMPLE STATIONS FOR FECAL COLIFORM DENSITY STUDY

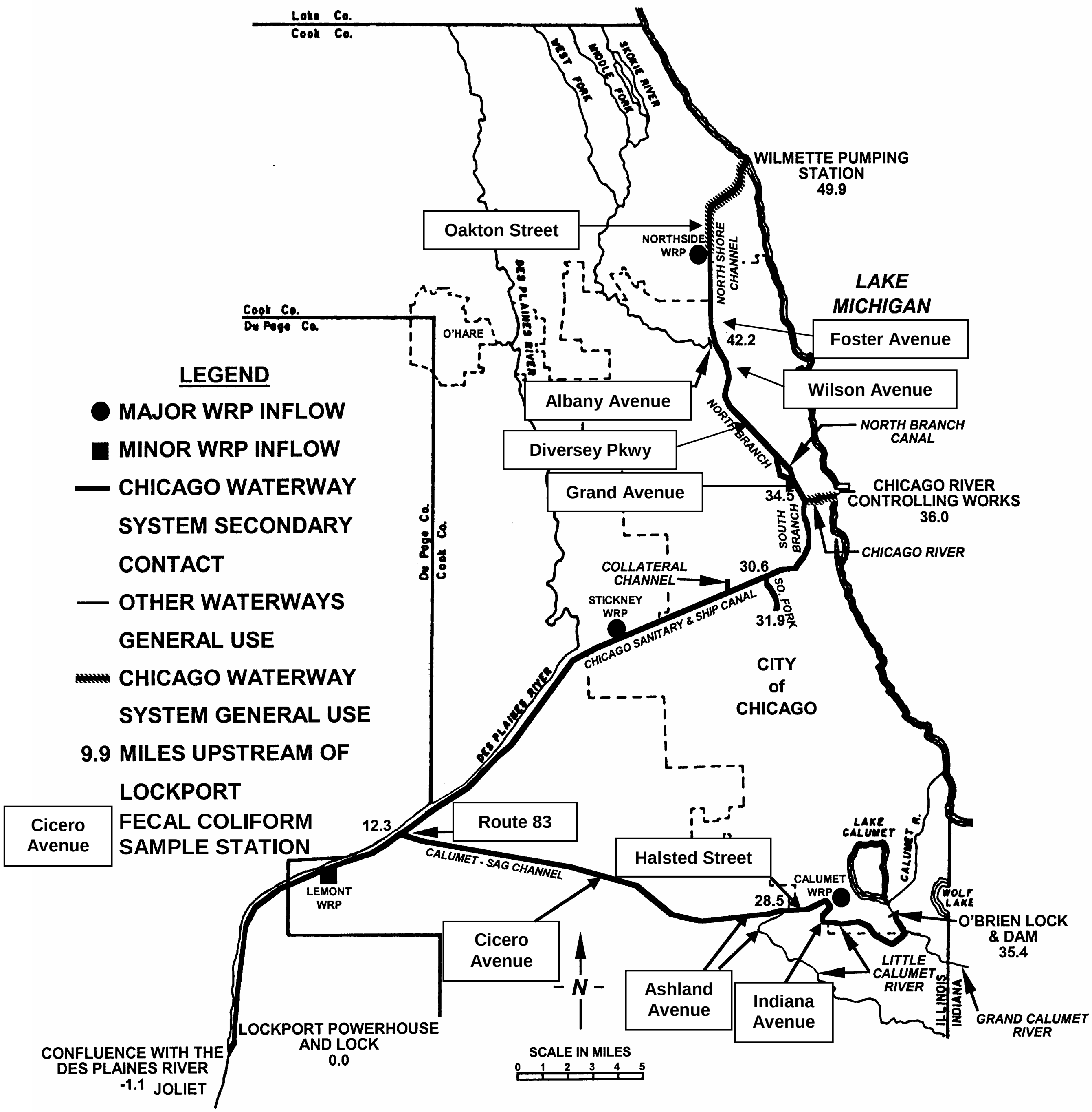
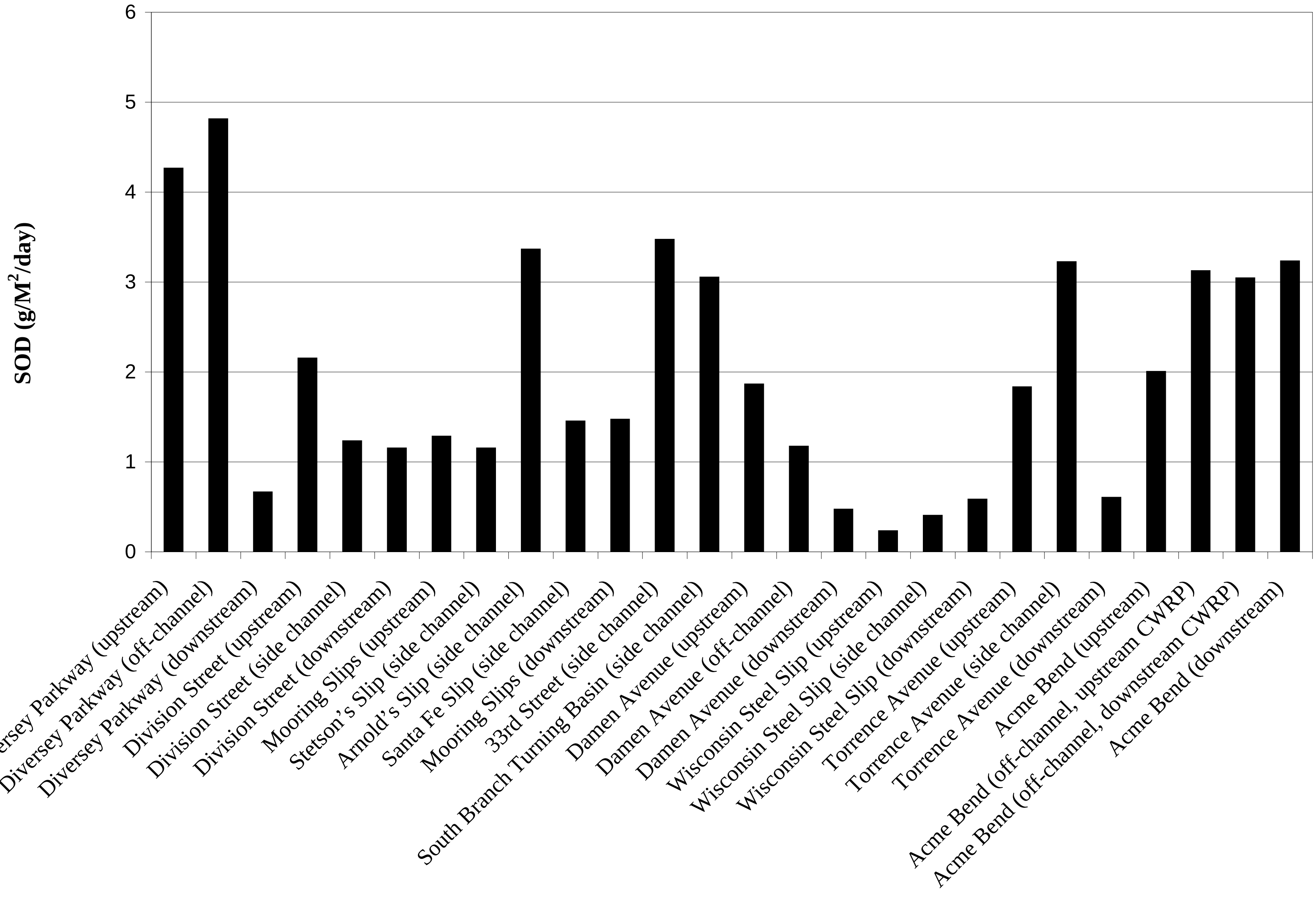


FIGURE V-5: SEDIMENT OXYGEN DEMAND MEASURED AT VARIOUS LOCATIONS IN THE CHICAGO WATERWAY SYSTEM



# RADIOCHEMISTRY SECTION

# RADIOCHEMISTRY SECTION

The Radiochemistry Section is responsible for the radiological monitoring of waters, wastewaters, sludges, and biosolids, and the maintenance of radiation safety at the District. It also performs special tasks involving the use of ionizing radiation and radioisotopes.

The section also maintains a radioactive material license issued to the District by the Illinois Emergency Management Agency, Division of Nuclear Safety (IEMA-DNS), assuring that the activities involving use of radioactive material are conducted according to the license conditions and regulations.

The Radiochemistry Laboratory is certified by the IEMA-DNS and is approved for the examination of gross alpha/beta, tritium, and photon emitting radionuclides in public water supplies.

The laboratory participates in the Environmental Resource Associates (ERA) RadChem Proficiency Testing (PT) water study as required by the IEMA-DNS for maintaining laboratory certification. The section also participates in the ERA's MRad Multi-Media Radiochemistry PT Soil Study. This involvement contributes to the state of the profession and further validates the analysis performed by the laboratory.

The radiological monitoring of raw and treated wastewaters from the District's WRPs was initiated in 1967 as the State of Illinois Sanitary Water Board developed effluent criteria (Technical Release 20-22, April 1, 1967). Although the present NPDES permits from the IEPA do not include limits for radioactivity in the District's effluents, monitoring has continued into 2006 since there are radioactivity parameters in the water quality standards for the General Use waters.

Since 1978, the section has conducted radiological monitoring of biosolids from both the LASMA and HASMA solids drying sites. Beginning in 1993, the solids survey was expanded to include raw sludge and digested biosolids from District WRPs and air-dried biosolids ready for final use at all of the Stickney and Calumet solids management areas.

The Radiochemistry Section participates in the ambient water quality monitoring program of the Chicago Waterway System (CWS). The radiological monitoring of area waterways under the jurisdiction of the District includes the Calumet, Chicago, and Des Plaines River systems.

## Radiation Safety

The Radiochemistry Section continues to maintain a radiation safety program for the District. The program includes:

- maintaining the IEMA-DNS radioactive material license;

- managing low-level radioactive waste;
- monitoring personnel for radiation exposure;
- testing the operation of radiation survey meters;
- surveying of the Radiochemistry Laboratory work areas for radiation;
- leak testing the radioactive sealed sources; and
- maintaining a physical inventory of licensed radioactive materials.

The District possesses a radioactive material license from the IEMA-DNS. The radiation protection program is conducted in accordance with the license conditions and regulatory requirements of IEMA-DNS.

The Illinois Low-Level Radioactive Waste Management Act requires all generators and brokers of low-level radioactive waste (LLRW) in Illinois to file an annual survey form with the IEMA-DNS. In 2006, the relevant forms were received from the IEMA-DNS, completed, and returned to the IEMA-DNS.

The monitoring of District employees for radiation exposure was carried out using dosimeter badges and finger ring dosimeters. The dosimeters are worn by laboratory personnel, and users of moisture/density gauges. A total of 252 dosimeters were analyzed in 2006. No District employee was exposed to an overdose of radiation.

The operational checks of radiation survey meters were carried out on the day radioactive materials were used or at least once a month. A record was maintained for the operational checks of radiation survey instruments.

The Radiochemistry Laboratory is regularly surveyed for radiation contamination. A total of 120 wipe tests were performed in 2006. No contamination was found in any work area.

As per IEMA-DNS regulations, radioactive sealed sources are tested for leakage or contamination at intervals not to exceed six months. All of the radioactive sealed sources used by the District personnel were tested for leakage twice in 2006.

Nickel-63 sources constitute a part of the electron capture detectors of gas chromatographs used by the R&D Department. Leak tests were performed on six detectors from three gas chromatographs in 2006. No leaks were discovered in any detectors used by the District.

Two leak tests each were performed in 2006 on the APD2000 CW Detector, and an XRF Paint Analyzer, owned by the Safety Section of General Administration. The APD2000 CW detector is equipped with a nickel-63 sealed source and the XRF Paint Analyzer is equipped with a Cobalt-57 sealed source. No leaks were discovered in the detectors.

Leak tests were also performed on four Troxler surface moisture/density gauges used by the Construction Division of the Engineering Department. A total of 16 leak tests were performed in 2006. No leaks were discovered in any of these gauges.

A physical inventory of the radioactive sealed sources possessed by the District was carried out twice in the year 2006. A record of this inventory was maintained as per license requirements.

**Certification by the IEMA-DNS**

The Radiochemistry Laboratory was certified by the Illinois Department of Nuclear Safety, now the IEMA-DNS, on October 2, 2001 and has maintained its certification status. The laboratory is approved for the examination of gross alpha/beta, tritium, and photon emitting radionuclides in public water supplies.

**Participation in the ERA Proficiency Testing Program**

The Radiochemistry Section participated in the ERA RadChem PT water study and the MRad Multi-Media Radiochemistry PT soil study, along with other certified laboratories. The participation in the RadChem PT water study is an IEMA-DNS requirement to maintain laboratory certification.

During 2006, the Radiochemistry Section analyzed four water samples for gross alpha, gross beta, barium-133, cobalt-60, cesium-134, cesium-137, zinc-65 and tritium radioactivity. The section also analyzed two soil samples for actinium-228, bismuth-212, bismuth-214, cesium-137, lead-212, lead-214, and potassium-40. The analytical results were reported to the ERA. Acceptable results were obtained on all the samples.

**Levels of Radioactivity in Raw and Treated Wastewaters**

Radiological monitoring of raw wastewaters and final effluents from the District's seven WRPs continued in 2006. Data from the monitoring serves as a measure of present-day radioactivity levels in comparison to levels in past years. The IPCB has established General Use water quality standards for radioactivity in the waters of Illinois. According to IPCB regulations (Title 35, Chapter 1, Section 302.207) gross beta concentration shall not exceed 100 pCi/L, and the strontium-90 concentration must not exceed 2 pCi/L. The annual average radium-226 and 228 combined concentration must not exceed 3.75 pCi/L in General Use waters. There are no IPCB or USEPA radioactivity standards for raw sewage or final effluents. However, the District uses the IPCB General Use waters limits for gross beta concentration as the standard for monitoring effluents.

The radioactivity analysis was conducted on 24-hour composite samples of raw sewage and final effluent. The samples were processed using USEPA, Environmental Monitoring and

Support Laboratory procedures, March 1979, and counted for gross alpha and gross beta radioactivity on a Tennelec LB5100 alpha/beta gas proportional counter. The gas proportional counter was calibrated for alpha efficiency using thorium-230, and for beta efficiency using cesium-137 standards obtained from North American Scientific, California.

Table VI-1 presents the 2006 yearly averages of gross alpha radioactivity for the raw sewage and final effluent from the District's seven WRPs. Slightly elevated levels of radioactivity in Lemont raw sewage have been observed since 1989. This is because the Village of Lemont began utilizing a water treatment process to remove radium from their water supply and discharged the backwash water into the Lemont WRP. However, this backwash from the Lemont drinking water system does not pose a threat to the District's compliance status.

Table VI-2 presents the 2006 yearly averages for gross beta radioactivity in raw sewage and final effluent from the District's seven WRPs.

**Levels of Radioactivity in Sludge and Biosolids**

In 1993, the Radiochemistry Section revised and expanded its radiological monitoring program of District sludges in response to the increased emphasis on monitoring biosolids quality brought about by adoption of the USEPA’s Part 503 Sewage Sludge Regulations. Although there are no standards for radioactivity in these regulations, it was felt that the District should expand its database on the radiological characteristics of its sludge and biosolids.

During 2006, sludge or biosolids samples were collected monthly at all WRPs. Biosolids samples were also collected monthly from the seven solids drying sites of the District from May through September.

Sludge and biosolids samples were processed according to the Standard Methods (20th Edition, 1998) procedures, and counted for gross alpha and gross beta radioactivity using a Tennelec LB5100 alpha/beta counting system. The instrument was calibrated with a thorium-230 standard for gross alpha, and a cesium-137 standard for gross beta radioactivity determinations. The results, in pCi/g of dry weight (DW), were averaged and tabulated in tables VI-3 and VI-4.

Table VI-3 presents the gross alpha and gross beta radioactivity data of the District’s sewage sludge and biosolids.

Table VI-4 presents the gross alpha and gross beta radioactivity data for air-dried biosolids from the District’s solids management areas.

Sludge and biosolids samples were also processed for the determination of gamma-emitting radionuclides. The samples were dried on hot plates, ground and passed through a 30-mesh sieve. The samples were packed in three-ounce canisters and sealed with a vinyl electrical tape to avoid loss of the gaseous progeny of uranium and thorium. The samples were stored for at least 30-days for radium-radon to reach equilibrium before counting. The samples were analyzed by a gamma spectroscopy system equipped with a high-purity germanium detector and Genie-2000 spectroscopy software analysis package from Canberra Industries.

Eleven specific radionuclides, with a potential for reconcentration in sludge, were analyzed. Only three of these elements were detected at measurable levels. The radium-226 activity concentration was calculated from the 186 keV photopeak, cesium-137 radioactivity concentration was calculated from the 661.6 keV photopeak, and potassium-40 radioactivity from the 1461 keV photopeak. Two of these three radionuclides, radium-226 and potassium-40, are of natural origin. The third radionuclide, cesium-137, is man-made and may have arisen from fallout of nuclear weapons testing in the middle of the 20th century.

Table VI-5 presents the potassium-40, radium-226, and cesium-137 concentrations in the District's sewage sludge and biosolids.

Table VI-6 presents the potassium-40, radium-226, and cesium-137 concentrations in the District's biosolids from the solids management areas.

**Radiological Monitoring of the Chicago Waterway System**

Radiological monitoring is a part of the overall monitoring program of the water quality within the District's waterways. Radiological monitoring involves the determination of gross alpha and gross beta radioactivity of samples collected from the waterways. The program includes the Calumet, Chicago, and Des Plaines River systems comprising 170 miles (273.6 km) of waterways. There were sixteen sampling locations on the Chicago River system, nine on the Calumet River system, and twenty on the Des Plaines River system. Each location was sampled once per month.

The waterways samples were processed using USEPA, Environmental Monitoring and Support Laboratory procedures, March 1979, and the gross alpha and gross beta radioactivity was counted using a Tennelec LB5100 gas proportional counter.

Table VI-7 presents the 2006 average values for gross alpha and gross beta radioactivity for the CWS at each of the 45 sampling locations. The concentrations of radioactivity in all samples analyzed were well within the USEPA Drinking Water Standards of 15 pCi/L for gross alpha (excluding radon and uranium), and 50 pCi/L (screening level) for gross beta particle activity minus the naturally occurring potassium-40 beta particle activity.

TABLE VI–1: AVERAGE GROSS ALPHA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs – 2006

| WRP<br>Type of Sample | Gross Alpha Radioactivity<br>(pCi/L) |
|---|---|
| <u>Stickney</u> | |
| Raw (West Side) | <4.8 |
| Raw (Southwest) | <7.5 |
| Secondary – Final Effluent | <4.8 |
| <u>Calumet</u> | |
| Raw | <5.3 |
| Secondary – Final Effluent | <5.0 |
| <u>North Side</u> | |
| Raw | <4.8 |
| Secondary – Final Effluent | <4.8 |
| <u>Hanover Park</u> | |
| Raw | <5.0 |
| Tertiary – Final Effluent | <4.6 |
| <u>John E. Egan</u> | |
| Raw | <4.8 |
| Tertiary – Final Effluent | <4.8 |
| <u>Lemont</u> | |
| Raw | 16.2 |
| Secondary – Final Effluent | <10.1 |
| <u>James C. Kirie</u> | |
| Raw | <5.3 |
| Tertiary – Final Effluent | <4.8 |

< = Less than the lower limit of detection.

TABLE VI–2: AVERAGE GROSS BETA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs - 2006

| WRP<br>Type of Sample | Gross Beta Radioactivity<br>(pCi/L) |
|---|---|
| Stickney | |
| Raw (West Side) | 11.3 |
| Raw (Southwest) | 20.4 |
| Secondary – Final Effluent | 8.4 |
| Calumet | |
| Raw | 11.4 |
| Secondary – Final Effluent | 8.1 |
| North Side | |
| Raw | 10.0 |
| Secondary – Final Effluent | 8.0 |
| Hanover Park | |
| Raw | 12.9 |
| Tertiary – Final Effluent | 11.2 |
| John E. Egan | |
| Raw | 13.0 |
| Tertiary – Final Effluent | 11.0 |
| Lemont | |
| Raw | 26.4 |
| Secondary – Final Effluent | 21.7 |
| James C. Kirie | |
| Raw | 13.4 |
| Tertiary – Final Effluent | 12.6 |

TABLE VI–3: GROSS ALPHA AND GROSS BETA RADIOACTIVITY OF WRP SLUDGES AND BIOSOLIDS - 2006

| WRP Type of Sample | No. of Samples | Gross Alpha (pCi/g DW) | | | Gross Beta (pCi/g DW) | | |
|---|---|---|---|---|---|---|---|
| | | Average | Minimum | Maximum | Average | Minimum | Maximum |
| Calumet Digester Draw | 12 | 12.8 | 8.8 | 15.4 | 26.2 | 22.3 | 31.2 |
| John E. Egan Digester Draw | 12 | 9.8 | 7.0 | 15.3 | 18.5 | 14.4 | 22.6 |
| Lemont[1] Activated Sludge | 12 | 90.0 | 51.5 | 117.3 | 64.2 | 38.4 | 92.1 |
| Hanover Park Digester Draw | 12 | 7.5 | 4.0 | 13.0 | 13.6 | 10.4 | 15.4 |
| James C. Kirie[1] Activated Sludge | 12 | 6.8 | 3.4 | 9.0 | 13.7 | 9.9 | 15.9 |
| North Side[1] Activated Sludge | 12 | 7.2 | 4.7 | 8.7 | 14.4 | 11.5 | 17.7 |
| Stickney Digester Draw | 12 | 10.4 | 7.1 | 14.5 | 25.4 | 15.0 | 29.4 |

[1]No digesters at this WRP.

TABLE VI–4: GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN DISTRICT SOLIDS MANAGEMENT AREA BIOSOLIDS - 2006

| Drying Site Location | No. of Samples | Gross Alpha (pCi/g DW) | | | Gross Beta (pCi/g DW) | | |
|---|---|---|---|---|---|---|---|
| | | Average | Minimum | Maximum | Average | Minimum | Maximum |
| LASMA | 5 | 10.2 | 5.9 | 14.2 | 27.0 | 26.4 | 27.6 |
| Calumet East | 5 | 10.9 | 8.7 | 13.2 | 25.2 | 20.0 | 27.1 |
| Calumet West | 3 | 14.9 | 13.5 | 17.1 | 24.4 | 23.1 | 25.4 |
| HASMA | 5 | 12.8 | 3.8 | 20.6 | 27.5 | 22.4 | 30.4 |
| Marathon | 5 | 12.6 | 7.8 | 15.1 | 27.9 | 24.2 | 38.3 |
| Stony Island | 5 | 12.7 | 7.4 | 17.9 | 27.1 | 23.4 | 30.6 |
| Vulcan | 5 | 8.9 | 4.1 | 12.6 | 25.5 | 18.3 | 29.2 |

TABLE VI–5: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WRP SLUDGE AND BIOSOLIDS – 2006

| Sample Location WRP | No. of Samples | Potassium-40 (pCi/g DW) | | | Radium-226 (pCi/g DW) | | | Cesium-137 (pCi/g DW) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average | Min. | Max. | Average | Min. | Max. | Average | Min. | Max. |
| Calumet | 4 | 9.4 | 8.1 | 10.4 | 4.5 | 4.1 | 5.1 | 0.06 | 0.04 | 0.07 |
| John E. Egan | 4 | 8.9 | 7.4 | 10.3 | 3.9 | 3.7 | 4.3 | ND | ND | ND |
| Hanover Park | 4 | 5.3 | 5.1 | 5.6 | 3.8 | 3.4 | 4.1 | ND | ND | ND |
| Stickney | 4 | 10.3 | 9.2 | 11.5 | 3.4 | 3.2 | 3.4 | 0.05 | 0.04 | 0.06 |
| Lemont | 4 | 6.7 | 5.5 | 7.3 | 56.7 | 45.0 | 68.2 | ND | ND | ND |

ND – Not Detected

TABLE VI–6: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT SOLIDS MANAGEMENT AREA BIOSOLIDS – 2006

| Sample Location | No. of Samples | Potassium-40 (pCi/g DW) | | | Radium-226 (pCi/g DW) | | | Cesium-137 (pCi/g DW) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average | Min. | Max. | Average | Min. | Max. | Average | Min. | Max. |
| Calumet East | 5 | 8.6 | 7.6 | 9.5 | 4.5 | 3.8 | 5.1 | 0.07 | 0.05 | 0.08 |
| Calumet West | 3 | 7.6 | 7.4 | 7.8 | 4.9 | 4.6 | 5.3 | 0.06 | 0.05 | 0.06 |
| Stony Island | 5 | 8.9 | 7.7 | 10.5 | 4.2 | 3.9 | 4.7 | 0.07 | 0.05 | 0.09 |
| HASMA | 5 | 9.2 | 7.0 | 10.8 | 3.9 | 3.4 | 4.6 | 0.07 | 0.04 | 0.09 |
| LASMA | 5 | 12.5 | 8.6 | 15.2 | 3.0 | 2.7 | 3.4 | 0.04 | ND | 0.06 |
| Marathon | 5 | 12.1 | 9.7 | 15.1 | 3.2 | 2.5 | 3.8 | 0.05 | ND | 0.08 |
| Vulcan | 5 | 9.6 | 8.9 | 10.4 | 3.7 | 3.4 | 4.1 | 0.07 | 0.04 | 0.08 |

ND – Not Detected

TABLE VI–7: AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY FOR THE CHICAGO WATERWAY SYSTEM - 2006

| Location | Gross Alpha (pCi/L) | Gross Beta (pCi/L) |
|---|---|---|
| Lake-Cook Rd., Des Plaines River | <4.8 | 10.1 |
| Oakton Street, Des Plaines River | <5.0 | 9.1 |
| Belmont Ave., Des Plaines River | <5.1 | 10.2 |
| Roosevelt Road, Des Plaines River | <5.3 | 9.7 |
| Ogden Avenue, Des Plaines River | <5.0 | 9.3 |
| Willow Springs Rd., Des Plaines River | <5.0 | 9.5 |
| Stephen Street, Des Plaines River | <5.4 | 10.4 |
| Material Service Rd., Des Plaines River | <5.2 | 9.9 |
| Lake-Cook Rd., Buffalo Creek | <5.1 | 7.4 |
| Elmhurst Rd., Higgins Creek | <6.7 | 8.8 |
| Wille Rd., Higgins Creek | <4.8 | 12.6 |
| Higgins Rd., Salt Creek | <5.3 | 7.7 |
| Arlington Heights Rd., Salt Creek | <5.6 | 10.1 |
| Devon Ave., Salt Creek | <5.5 | 9.3 |
| Wolf Rd., Salt Creek | <5.0 | 11.1 |
| Brookfield Ave., Salt Creek | <5.2 | 10.5 |
| Route 19, Popular Creek | <5.7 | 7.2 |
| Springinsguth Rd., W. Br. Dupage River | <7.0 | 8.0 |
| Walnut Lane, W. Br. Dupage River | <5.0 | 9.9 |

TABLE VI-7: (Continued) AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY FOR THE CHICAGO WATERWAY SYSTEM - 2006

| Location | Gross Alpha (pCi/L) | Gross Beta (pCi/L) |
|---|---|---|
| Lake St., W. Br. Dupage River | <5.1 | 10.4 |
| Central St., N. Shore Channel | <3.1 | 4.5 |
| Oakton St., N. Shore Channel | <3.6 | 7.0 |
| Touhy Avenue, N. Shore Channel | <3.7 | 7.9 |
| Dundee Rd., W. Fork N. Branch, Chicago River | <6.0 | 11.6 |
| Golf Rd., W. Fork N. Branch, Chicago River | <5.7 | 9.9 |
| Lake-Cook Rd., Middle Fork, N. Branch, Chicago River | <4.9 | 7.4 |
| Glenview Rd., Middle Fork, N. Branch, Chicago River | <5.4 | <9.1 |
| Lake-Cook Rd., Skokie River | <5.0 | 8.2 |
| Frontage Rd., Skokie River | <4.8 | 9.6 |
| Dempster St., N. Br., Chicago River | <5.+0 | 9.4 |
| Albany Ave., N. Br., Chicago River | <5.0 | <7.9 |
| Lake Shore Dr., Chicago River | <3.1 | 4.5 |
| Wells St., Chicago River | <3.4 | 5.2 |
| Cicero Ave., Chicago Sanitary & Ship Canal | <3.8 | 6.9 |
| Harlem Ave., Chicago Sanitary & Ship Canal | <3.9 | 8.3 |
| Lockport, Chicago Sanitary and Ship Canal | <4.1 | 8.2 |
| Ewing Ave., Calumet River | <3.6 | 5.4 |
| 130$^{th}$ St., Calumet River | <3.5 | 6.5 |
| Burnham Ave., Wolf Lake | <3.4 | 6.1 |

TABLE VI-7: (Continued) AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY FOR THE CHICAGO WATERWAY SYSTEM – 2006

| Location | Gross Alpha (pCi/L) | Gross Beta (pCi/L) |
|---|---|---|
| Indiana Ave., Little Calumet River | <3.6 | 7.8 |
| Halsted St., Little Calumet River | <4.1 | 9.0 |
| Wentworth Ave., Little Calumet River | <4.2 | 10.4 |
| Ashland Ave., Little Calumet River | <5.1 | 10.2 |
| Joe Orr Road, Thorn Creek | <6.2 | 10.9 |
| $170^{th}$ St., Thorn Creek | <5.4 | 10.7 |

< = Less than the lower limit of detection.

# APPENDIX I

## APPENDIX I

MEETINGS AND SEMINARS 2006
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

1. Calumet Research Summit, Hammond, Indiana, *January 2006*.

2. DuPage River, Salt Creek Watershed Workgroup Meeting (and follow-up committee meetings throughout the year), Elmhurst, Illinois, *January 2006*.

3. Illinois/Indiana Sea Grant, Aquatic Nuisance Species Dispersal Barrier Committee Meeting, Chicago, Illinois, *January 2006*.

4. Illinois River, Coordinating Council Meeting, Chicago, Illinois, *January 2006*.

5. Illinois Water Environment Association, Government Affairs in Water Pollution Control Seminar, Lisle, Illinois, *January 2006*.

6. Midwest Water Analysts Association, Winter Expo 2006, Kenosha, Wisconsin*, January 2006*.

7. North Carolina Soil Science Society, Annual Meeting, Raleigh, North Carolina, *January 2006*.

8. United States Department of Agriculture, Cooperative State Research, Education, and Extension Service Regional Research Committee W-1170 Annual Meeting, Las Vegas, Nevada, *January 2006*.

9. Illinois Environmental Protection Agency, Nutrient Standards Workgroup and Science Committee Meeting, Springfield, Illinois, *February 2006*.

10. Illinois/Indiana Sea Grant, Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, *February 2006*.

11. United States Environmental Protection Agency, Region V, 2006 Midwest Surface Water Monitoring and Standards (SWiMS) Meeting, Chicago, Illinois, *February 2006*.

12. United States Environmental Protection Agency, Wetlands Trading Summit, Chicago, Illinois, *February 20006*.

13. Calumet Government Working Group, 2006 First Quarter Meeting, Chicago, Illinois, *March 2006*.

14. City of Chicago, Department of Environment, Bubbly Creek Active Sediment Capping Committee Meetings (and follow-up committee meetings throughout the year), *March 2006*.

## APPENDIX I

MEETINGS AND SEMINARS 2006
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

15. Cornell University, Workshop, "Detection of *Ascaris* and Other Parasites Eggs and Cysts in Sewage Sludge," Ithaca, New York, *March 2006*.

16. Illinois Chapter of American Fisheries Society Meeting, Whitington, Illinois, *March 2006*.

17. Illinois/Indiana Sea Grant, Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, *March 2006*.

18. Illinois Section of the American Water Works Association and the Illinois Water Environment Association, 2006 Joint Water Conference, Springfield, Illinois, *March 2006*.

19. Illinois Water Environment Association, 27th Annual Conference (and follow-up committee meetings throughout the year), Springfield, Illinois, *March 2006*.

20. Iowa Water Pollution Control Association, 15$^{th}$ Annual Biosolids Specialty Conference, Des Moines, Iowa, *March 2006*.

21. Water Environment Federation and Air and Waste Management Association, Odors and Air Emissions 2006 Specialty Conference, Hartford, Connecticut, *March 2006*

22. Water Environment Federation, Biosolids 2006 Conference, Cincinnati, Ohio, *March 2006*.

23. City of Chicago, Earth Day Celebration, Chicago, Illinois, *April 2006*.

24. American Society for Microbiology, 106$^{th}$ General Meeting, Orlando, Florida, *May 2006*.

25. Midwest Water Analysts Association, 2006 Spring Meeting, Milwaukee, Wisconsin, *May 2006*.

26. United States Fish and Wildlife Service, Hines Emerald Dragonfly Critical Habitat Planning Meeting (and follow-up committee meetings throughout the year), Romeoville, Illinois, *May 2006*.

27. Water Environment Federation, 2$^{nd}$ National Water Quality Trading Conference, Pittsburgh, Pennsylvania, *May 2006*.

28. Air and Waste Management Association, 99$^{th}$ Annual Conference, New Orleans, Louisiana, *June 2006*.

29. Calumet Government Working Group, 2006 Second Quarter Meeting, Chicago, Illinois, *June 2006*.

MEETINGS AND SEMINARS 2006
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

30. North American Benthological Society, Annual Meeting, Anchorage, Alaska, *June 2006*.

31. Greater DuPage Chapter, Wild Ones, Native Plants, Natural Landscapes, 27th National Wild Ones Conference, Naperville, Illinois, *July 2006*.

32. International Union of Soil Science, 18th World Congress of Soil Science, Philadelphia, Pennsylvania, *July 2006*.

33. National Association of Clean Water Agencies, 2006 Summer Conference, Seattle, Washington, *July 2006*.

34. Illinois/Indiana Sea Grant, Aquatic Nuisance Species Dispersal Barrier Committee Meeting, Chicago, Illinois, *August 2006*.

35. United States Environmental Protection Agency, Amendments for Ecological Restoration Workshop, Chicago, Illinois, *August 2006*.

36. American Fisheries Society, Annual Meeting, Lake Placid, New York, *September 2006*.

37. Calumet Government Working Group, 2006 Third Quarter Meeting, Chicago, Illinois, *September 2006*.

38. Malcom Pirnie, Seminar, "Managing Liabilities for Persistent Bioaccumulative and Toxic Chemicals," Chicago, Illinois, *September 2006*.

39. Upper Mississippi River, Sub-Basin Hypoxia Nutrient Committee Workshop, Moline, Illinois, *September 2006*.

40. Air and Waste Management Association, Lake Michigan Section, 2006 Air Quality Management Conference and Clean Air Act Primer, Oak Brook, Illinois, *October 2006*.

41. American Water Works Association, Chlorination and Alternative Disinfection Methods Workshop, Joliet, Illinois, *October 2006*.

42. Calumet Government Working Group, 2006 Fourth Quarter Meeting, Chicago, Illinois, *October 2006*.

43. Chicago Wilderness, Urban Ecology, Glencoe, Illinois, *October 2006*.

44. Midwest Water Analysts Association, 2006 Fall Meeting, Brookfield, Illinois, *October 2006*.

**APPENDIX I**

MEETINGS AND SEMINARS 2006
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

45. National Association of Clean Water Agencies, 2006 Pretreatment Conference, New Orleans, Louisiana, *October 2006*.

46. National Beaches Conference, Niagara Falls, New York, *October 2006*.

47. United States Environmental Protection Agency, Regional Workshop on Nutrient Characterization & Control in the NPDES Context, Chicago, Illinois, *October 2006*.

48. Water Environmental Federation, 79th Annual Technical Exhibition and Conference, Dallas, Texas, *October 2006*.

49. City of Chicago, Department of Environment, Chicago River Charette, Chicago, Illinois, *November 2006*.

50. Illinois Sports Turf Managers Association, Illinois Professional Turf Conference, St. Charles, Illinois, *November 2006*.

51. Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, "Science Symposium: Source, Transport, and Fate of Nutrients in the Mississippi and Atchafalaya River Basins," Minneapolis, Minnesota, *November 2006*.

52. Soil Science Society of America, Annual Meeting, Indianapolis, Indiana, *November 2006*.

53. DePaul University, Soil in Restoration Ecology Conference, Chicago, Illinois, *December 2006*.

54. Great Lakes Byproducts Management Association, Annual Meeting, Columbus, Ohio, *December 2006*.

55. Illinois River, Coordinating Council Meeting, Grayslake, Illinois, *December 2006*.

56. United States Environmental Protection Agency, Multi-Stakeholder Meeting for Input on New Recreational Water Quality Criteria, Washington, D.C., *December 2006*.

57. Water Environment Research Foundation, Program Area Research Meeting, Baltimore, Maryland, *December 2006*.

# APPENDIX II

## APPENDIX II

PRESENTATIONS 2006
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

1. "Benefits and Safety of Using Biosolids as a Soil Conditioner and Fertilizer." Presented at the Calumet Research Summit, Hammond, Indiana, by Thomas C. Granato. *January 2006*. PP

2. "Managing Chicago's Biosolids Through Land Application." Presented at the North Carolina Soil Science Society, Annual Meeting, Raleigh, North Carolina, by Thomas C. Granato. *January 2006*. PP

3. "Assessment of Transfer of Radioactivity to Soil and Crops from Long Term Land Application of Chicago Biosolids." Presented at the Water Environment Federation, Biosolids 2006 Conference, Cincinnati, Ohio, by Thomas C. Granato. *March 2006*. B

4. "Beneficial Use of Biosolids in the Chicago Metropolitan Area Iowa Water." Presented at the Iowa Water Pollution Control Association, 15$^{th}$ Annual Biosolids Specialty Conference, Des Moines, Iowa, by Albert E. Cox and Thomas C. Granato. *March 2006*. PP

5. "Review of Bioassays Used to Measure the Activity of Organic Contaminants in Wastewater and Biosolids and Their Application to Assessing the Efficiency of Wastewater and Biosolids Treatment." Presented at the Illinois Water Environment Association, 27$^{th}$ Annual Conference, Springfield, Illinois, by Geeta Rijal. *March 2006*. PP

6. "Review of Whole Effluent Toxicity (WET) Results by Wastewater Treatment Plant Management." Presented at the Illinois Water Environment Association, 27$^{th}$ Annual Conference, Springfield, Illinois, by James Zmuda. *March 2006*. PP

7. "The Metropolitan Water Reclamation District of Greater Chicago's Efforts to Reduce Pharmaceuticals that Enter the Water Reclamation Plants." Presented at the Illinois Section of the American Water Works Association and the Illinois Water Environment Association, 2006 Joint Water Conference, Springfield, Illinois, by Catherine O'Connor. *March 2006*. PP

8. "Densities of Pathogens and Indicator Microorganisms in Class B Biosolids Produced at the Metropolitan Water Reclamation District of Greater Chicago." Presented at the American Society of Microbiology, 106$^{th}$ General Meeting, Orlando, Florida, by Geeta Rijal, James Zmuda, Richard Gore, Thomas C. Granato, and Richard Lanyon. *May 2006*. PS

9. "The Effect of Secondary Sewage Treatment on the Total Numbers and Percentages of Antibiotic Resistant Fecal Coliforms in Municipal Raw Sewage." Presented at the American Society of Microbiology, 106$^{th}$ General Meeting, Orlando, Florida, by James Zmuda, Zainul Abedin, Richard Gore, Thomas C. Granato, and Richard Lanyon. *May 2006*. PS

**APPENDIX II**

PRESENTATIONS 2006
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

10. "Suitability of Biosolids for Use in the City of Chicago." Calumet Government Working Group, 2006 Second Quarter Meeting, Chicago, Illinois, by Albert E. Cox, Lakhwinder Hundal, and Thomas C. Granato. *June 2006*. PP

11. "Effectiveness of Biosolids Amendments in Enhancing Soil Fertility and Microbial Ecology in Golf Course Greens." International Union of Soil Science, 18$^{th}$ World Congress of Soil Science, Philadelphia, Pennsylvania, by Guanglong Tian, Thomas C. Granato, Frank Dinelli and Albert E. Cox. *July 2006*. PS

12. "Issues Related to Disinfection of Water Reclamation Plant Effluent." Presented at the National Association of Clean Water Agencies, 2006 Summer Conference, Seattle, Washington, by Catherine O'Connor. *July 2006*. B

13. "The Metropolitan Water Reclamation District of Greater Chicago's Call to Action Regarding Triclosan and Triclocarban." Presented at the National Association of Clean Water Agencies, 2006 Pretreatment Conference, New Orleans, Louisiana, by Catherine O'Connor. *October 2006*. PP

14. "Does Long-term Land Application of Biosolids Result in 4-NP and PBDEs Accumulation in Soil?" Presented at the Soil Science Society of America, Annual Meeting, Indianapolis, Indiana, by Lakhwinder Hundal, Kang. Xia, Albert E. Cox, Kuldip Kumar, Thomas C. Granato, Louis Kollias, Richard Lanyon, and Kevin Armbrust. *November 2006*. PP

15. "Occurrence of Chemicals of Emerging Concern in Biosolids: Implications for Land Application." Presented at the Soil Science Society of America, Annual Meeting, Indianapolis, Indiana, by Thomas C. Granato. *November 2006*. PP

16. "Occurrence of Estrogenic Compounds in Swine Manure and Biosolids." Presented at the Soil Science Society of America, Annual Meeting, Indianapolis, Indiana, by Kuldip Kumar, Satish Gupta, Ashok Singh, Yodesh Chander, Lakhwinder Hundal, Albert E. Cox, and Thomas C. Granato. *November 2006*. PP

17. "An Evaluation of the Benefits and Limitations of the Use of Biosolids to Produce Topsoil for Turfgrass." Presented at the Great Lakes Byproducts Management Association, Annual Meeting, Columbus, Ohio, by Thomas C. Granato. *December 2006*. PP

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*P = Available as a paper
B = Available as both a paper and PowerPoint Presentation
PP = Available as PowerPoint Presentation
PS = Poster Presentation

# APPENDIX III

**APPENDIX III**

PAPERS PUBLISHED 2006
ENVIRONMENTAL MONITORING & RESEARCH DIVISION


1. Granato, T. C., A. Khalique, A. Cox, and R. I. Pietz, "Assessment of Transfer of Radioactivity to Soil and Crops from Long Term Land Application of Chicago Biosolids." Proceedings of the Water Environment Federation, Biosolids 2006 Conference, Cincinnati, Ohio, *2006*.

2. Rijal, G., J. T. Zmuda, R. Gore, T. Granato, and R. Lanyon, "Densities of Pathogens and Indicator Microorganisms in Class B Biosolids Produced at the Metropolitan Water Reclamation District of Greater Chicago." Proceedings of the American Society of Microbiology, 106th General Meeting, Orlando, Florida, *2006.*

3. Tian, G., T. C. Granato, R. I. Pietz, C. R. Carlson, and Z. Abedin, "Effect of Long-Term Application of Biosolids for Land Reclamation on Surface Water Chemistry." *Journal of Environmental Quality*, 35: 101-113, *2006*.

4. Zmuda, J. T., Z. Abedin, R. Gore, T. Granato, and R. Lanyon, "The Effect of Secondary Sewage Treatment on the Total Numbers and Percentages of Antibiotic Resistant Fecal Coliforms in Municipal Raw Sewage." Proceedings of the American Society of Microbiology, 106th General Meeting, Orlando, Florida, *2006*.

# APPENDIX IV

## METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO
## RESEARCH AND DEVELOPMENT DEPARTMENT 2006 SEMINAR SERIES

| Date | Subject |
|---|---|
| **January 27, 2006** | ***Endocrine Disruption in Aquatic Organisms Exposed to Fluoxetine (Prozac®)*** <br> Professor Marsha Black, University of Georgia, Athens, Georgia |
| **February 24, 2006** | ***Wastewater Infrastructure Vulnerability, Security, and Funding Issues: An Overview*** <br> Dr. Cecil Lue-Hing, Cecil Lue-Hing & Associates, Chicago, Illinois |
| **March 24, 2006** | ***Scale Issues in Urban Watershed Management*** <br> Professor Edwin Herricks, University of Illinois, Champaign, Illinois |
| **April 28, 2006** | ***Identification of the Sources of Nitrate in the Illinois River Using Isotopic and Chemical Techniques*** <br> Mr. Samuel V. Panno, Illinois State Geological Survey, Champaign, Illinois |
| **May 19, 2006** | ***Electrical Energy Management at the Metropolitan Water Reclamation District of Greater Chicago*** <br> Mr. Sanjay Patel, AETPO, Maintenance and Operations Department, Metropolitan Water Reclamation District of Greater Chicago (District), Chicago, Illinois |
| **June 23, 2006** | ***Potential Ecological Significance of Consumer Product Chemical Flux through Major Wastewater Treatment Facilities*** Dr. Larry Barber, United States Geological Survey, Boulder, Colorado |
| **July 28, 2006** | ***Evaluation of Cost and Benefits of CSO Treatment, Flow Augmentation, and Supplemental Aeration to Improve Water Quality in the Chicago Area Waterways*** <br> Dr. David R. Zenz, CTE/AECOM Engineers, Chicago, Illinois |
| **August 25, 2006** | ***Biosolids Use in Park Land Development at the Former U. S. Steel Southworks Brownfield Site*** <br> Dr. Lakhwinder Hundal, Soil Scientist, Research and Development Department, District, Cicero, Illinois |
| **September 29, 2006** | ***Watershed Approach for Meeting West Branch DuPage River/Salt Creek TMDLs*** <br> Mr. Larry Cox, Downers Grove Sanitary District, Downers Grove, Illinois |
| **October 27, 2006** | ***North Side Water Reclamation Plant Master Plan*** <br> Mr. Robert Kulchawik, CTE/AECOM Engineers, Chicago, Illinois |
| **November 17, 2006** | ***Microbial Risk Assessment of Human Health Impacts of Disinfection vs. No Disinfection for the Chicago Waterway System*** Dr. Chriso Petropoulou, Geosyntech Consulting, Inc., Chicago, Illinois |
| **December 8, 2006** | ***Overview of the Metropolitan Water Reclamation District of Greater Chicago's New Stormwater Management Program for Cook County*** Mr. Joseph Sobanski, Chief Engineer, Engineering Department, District, Chicago, IL |

**RESERVATIONS REQUIRED (at least 24 hours in advance)**
**CONTACT: Dr. Thomas C. Granato, Assistant Director of Research and Development, EM&R Division, (708) 588-4264 or (708) 588-4059**
**LOCATION: Stickney Water Reclamation Plant, Lue-Hing Research and Development Complex**
**6001 West Pershing Road, Cicero, Illinois 60804-4112**
**TIME: 10:00 A.M. (Picture ID required for plant entry)**
**(Note: These seminars are eligible for Professional Development Credits/CEUs)**

# APPENDIX V

# Environmental Monitoring and Research Division

## Section 121 – Administrative Section

*Granato, Thomas*, Assistant Director of R&D
*Messina, Deborah*, Secretary
*O'Connor, Catherine*, Research Scientist 4
*Abedin, Zainul*, Biostatistician
*Urlacher, Nancy*, Administrative Assistant

## Section 122 – Wastewater Treatment Process Research Section

*Jain, Jain*, Research Scientist 3
*Lordi, David*, Research Scientist 3
*Franklin, Laura*, Prin. Office Support
*Patel, Kamlesh*, Research Scientist 2
*Zhang, Heng*, Research Scientist 2
*Bernstein, Doris*, Research Scientist 1
*Kozak, Joseph*, Research Scientist 1
*MacDonald, Dale*, Research Scientist 1
*Oskouie, Ali*, Research Scientist 1
*Haizel, Anthony*, Lab Tech 2
*Reddy, Thota*, Lab Tech 2
*Bodnar, Robert*, Lab Tech 1
*Byrnes, Marc*, Lab Tech 1
*Kowalski, Shawn*, Lab Tech 1
*Pierson, Rodney*, Lab Tech 1
*Swies, Christopher*, Lab Tech 1

## Section 123 – Biosolids Utilization and Soil Science Section

*Cox, Albert*, Soil Scientist 3
*Yarn, Sabina*, Prin. Office Support
*Hundal, Lakhwinder*, Soil Scientist 2
*Tian, Guanglong*, Soil Scientist 2
*Lindo, Pauline*, Soil Scientist 1
*Kumar, Kuldip*, Soil Scientist 1
*Dennison, Odona*, Sanitary Chemist 1
*Patel, Minaxi*, Sanitary Chemist 1
*Mackoff, Ilyse*, Lab Tech 2
*Tate, Tiffany*, Lab Tech 2
*Adams, Richard*, Lab Tech 1
*Burke, Michael*, Acting Lab Tech 1
*Holic, Lawrence*, Lab Assistant
*Lukina, Erna*, Lab Assistant

## Section 124 – Analytical Microbiology and Biomonitoring Section

*Rijal, Geeta*, Microbiologist 4
*Griffith, Rhonda*, Prin. Office Support
*Gore, Richard*, Acting Microbiologist 3
*Vacant*, Microbiologist 2
*Yamanaka, Jon*, Biologist 1
*Billett, George*, Lab Tech 2
*Jackowski, Kathleen*, Lab Tech 2
*Maka, Andrea*, Lab Tech 2
*Rahman, Shafiq*, Lab Tech 2
*Shukla, Hemangini*, Lab Tech 2
*Hussaini, Syed*, Lab Tech 1
*Kaehn, James*, Lab Tech 1
*Mangkorn, Damrong*, Lab Tech 1
*Roberts, David*, Lab Tech 1
*Vacant*, Lab Assistant
*Latimore, Thomas*, Lab Assistant

## Section 125 – Land Reclamation and Soil Science – Fulton County

*Boucek, Jr., Emil*, Field and Lab Tech
*Swango, Rosalie*, Field and Lab Tech

## Section 126 – Aquatic Ecology and Water Quality Section

*Dennison, Sam*, Biologist 4
*Scrima, Joan*, Prin. Office Support
*Sopcak, Michael*, Biologist 3
*Wasik, Jennifer*, Biologist 2
*Minarik, Thomas*, Biologist 1
*Gallagher, Dustin*, Lab Tech 2
*Joyce, Colleen*, Lab Tech 2
*Schackart, Richard*, Lab Tech 2
*Vick, Justin*, Lab Tech 2
*Lansiri, Panu*, Lab Tech 1
*Whitington, Angel*, Lab Tech 1

## Section 128 – Radiochemistry Section

*Khalique, Abdul*, Radiation Chemist
*Abdussalam, Tasneem*, San Chemist 1
*Robinson, Harold*, Lab Tech 1

**Rev. 11-1-06**