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(FORM UPDATED: 08/11/2010)

WISCONSIN STATE LEGISLATURE ...
PUBLIC HEARING - COMMITTEE RECORDS

2003-04

(session year)

Joint

(Assembly, Senate or Joint)

Committee on Audit...

COMMITTEE NOTICES ...

- Committee Reports ... **CR**
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INFORMATION COLLECTED BY COMMITTEE FOR AND AGAINST PROPOSAL

- Appointments ... **Appt** (w/Record of Comm. Proceedings)
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  - (**sb** = Senate Bill) (**sr** = Senate Resolution) (**sjr** = Senate Joint Resolution)
- Miscellaneous ... **Misc**

* Contents organized for archiving by: Stefanie Rose (LRB) (September 2012)

TRIAD
ENGINEERING
INCORPORATED

325 East Chicago Street
Milwaukee, Wisconsin 53202
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December 10, 2002

Ms. Nancy U. Schultz, P.E.
Section Manager
Milwaukee Metropolitan Sewerage District
260 West Seeboth Street
Milwaukee, WI 53204-1446

Dear Nancy:

RE: Final Project Summary Report and Technical Memorandums
Conveyance System Monitoring and Regulatory Database
MMSD Contract M009PC201
Triad Engineering Incorporated Project No. W011101

Attached for your use are five (5) sets of the final project summary report and technical memorandums. These updated documents incorporate the MMSD review comments as outlined in our replies transmitted September 24, 2002 along with comparison calculations of selected past CSO events using the revised calculation methods. We have also provided a copy of the HEC-RAS software program and its program output files on CDs for your use.

As noted in our recent monthly progress summary report, the final delivery of the report and memorandums was delayed due to software and hardware implementation issues at MMSD headquarters that were associated with the new SYSMON database system. The implementation issues were researched and resolved through a joint effort of our team and MMSD IT staff and we have scheduled the final SYSMON user training for mid-December.

Our entire project team would like to thank you and your staff for their cooperation and assistance during this comprehensive and challenging project.

Should you have questions or require additional copies, please do not hesitate to call.

Sincerely,

TRIAD ENGINEERING INCORPORATED

Patrick W. Carnahan, P.E.
Project Manager

TRIAD ENGINEERING INCORPORATED

WGonwa

Willie Gonwa, Ph.D., P.E.
Senior Project Engineer

Enclosures

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Introduction

The Conveyance System Monitoring and Regulatory Database project has two major goals. First, it reviews and improves, where necessary, the techniques used to convert measured data into flow estimates at the primary flow elements. Primary flow elements include all flow transmitters used for real time system operations and regulatory reporting purposes. Specifically, primary flow elements compute the conveyance system discharge rates, volumes, or both at the following locations:

- Combined sewer overflows (CSOs) to waterways
- Discharge through dropshafts into the Inline Storage System (ISS)
- Water stored in the ISS
- Diversion of water from the separate sewer MIS into the ISS
- Bypass of water from the MIS to waterways

Second, it improves access to metered data and computed flow rates through updating and upgrading the system monitoring (SYSMON) database. Metered data includes barometric pressure, flow rate from a magmeter, tunnel water elevation, computed flow rate from rating tables, gate position, flow depth, precipitation, river elevation, temperature, tunnel volume, wind direction, and solar radiation. There are data recorded for approximately 845 distinct meters. The effort includes upgrading the computer programs used to compute CSO discharge rates and volumes. These programs are named DSCURV and CSOLOG.

The project focuses on rectifying historical data and detailing procedures to apply the recommendations to process data in the future.

Five technical memorandums detail the results of this project. Technical Memorandum Nos. 1 through 3 discuss flow estimating procedures. Technical Memorandum Nos. 4 and 5 document the revised SYSMON database.

Existing Flow Estimation and Data Management Systems

Existing CSO estimates are based upon techniques developed in 1986 for the Water Pollution Abatement Program (WPAP). To estimate flow, the WPAP created a simplified hydraulic model to compute discharge rates between each diversion structure and its outfall. The model bases its computations on known water levels at each diversion structure and outfall and the geometry of the collection system between the diversion structure and the outfall. The FORTRAN computer model Diversion Structure rating CURVe (DSCURV) converts the theoretical equations into a two dimensional look-up table. The tables are combined with actual monitoring data in the FORTRAN program Combined Sewer Overflow event LOG (CSOLOG) to create flow estimates. CSOLOG, in addition to computing flow rates, generates reports MMSD submits to the DNR documenting CSO events.

Existing estimates of discharge through dropshafts are based upon modeling studies performed by the Iowa Institute of Hydraulic Research (IIHR) in 1983. In 1986, the WPAP developed theoretical relationships to translate the modeling results to as-built conditions. The efforts resulted in theoretical rating curves for each dropshaft.

Existing estimates of water stored in the ISS are based upon a stage-storage curve developed in 1986 for the WPAP. This curve lists the storage volume at 1 foot increments between empty and full. The curve accounts for volume lost due to full and partial lining. Full lining consists of an approximately 1-foot thick layer of protective concrete around the full circumference of the tunnel. Partial lining consists of the same type of lining but only along the bottom 2 feet of the tunnel cross-section. Lining reduces the tunnel cross-section from its originally drilled diameter. Therefore, it reduces the total volume of water the tunnels can store. Volume estimates rely on the assumption of a level hydraulic gradeline throughout the ISS.

Existing estimates of diversion of water from the separate sewer MIS into the ISS are based on rating tables provided by Collection Systems Controls (CSC). These rating tables relate depth of flow in the diversion chamber to discharge rate. Triad Engineering Incorporated (Triad) found no documentation on the development of these rating tables.

Existing estimates of bypass of water from the MIS into watercourses are based on standard weir or orifice equations developed by MMSD system monitoring staff. Pumped bypass volume is based on pump run time multiplied by rated pump capacity.

The existing Systems Monitoring database consists of approximately one ASCII text file for each day. Data are available from 1995 on CD-ROM and on tape from before that time. Each file contains data for approximately 845 monitoring points at 5 minute intervals. Data are identified by a Tag ID which corresponds to a monitoring sites described in the file XFER_TABLE.DAT. Collection Systems Controls compiles the data and transmits it every day to Systems Monitoring. Upon processing the raw data, Systems Monitoring stores partial data sets in the System 1032 database.

The existing system for computing combined sewer overflow discharge rates involves executing a series of FORTRAN computer programs. These programs prepare and process the data to generate estimates of CSO discharge at each outfall. The FORTRAN programs also create daily, event, and quarterly reports tabulating CSO discharge.

Refinement of Flow Estimates

Combined Sewer Overflow Estimates

No meters exist to directly measure CSO discharge rates. Instead, the MMSD uses the following information to estimate discharge rates:

- **Water Level at the Diversion Structure.** When water level in the diversion structure exceeds the height of the overflow weir, water has the potential to discharge through the CSO to the waterway. The higher the water level, the greater the potential discharge rate becomes.

- **Water Level at the CSO Outfall.** Once receiving water level at the CSO outfall rises high enough, it starts to impede discharge through the CSO. If it rises higher than the water level at the diversion structure, it causes CSO discharge to cease because the pressure closes the back water gates. The higher the water level at the outfall, the lower the potential discharge rate becomes.

- **System Geometry and Condition between the Diversion Structure and the Outfall.** Larger pipes, weirs and orifices allow more water to discharge through the outfall than smaller ones.

- **Hydraulic Theory.** Mathematical equations and models can compute the theoretical discharge once one knows the three items listed above. These techniques range from simple to complex. Because of the need to compute discharges for a wide variety of water levels and geometric complexity, more sophisticated models produce better estimates than simple equations.

The MMSD does not measure water level at the diversion structures. Instead, it uses water level measured at the associated junction chamber as a surrogate. Potential inaccuracies in this approach chiefly revolve around conditions that hinder accurate measurement of water level at the junction chamber.

The MMSD does not measure water level at the point where the outfall discharges to the receiving water. Instead, it bases the water level at the discharge on the conditions at one of a handful of river stage monitoring stations operated by the MMSD. Potential inaccuracies revolve around uncertainties in translating the measured river elevation up or downstream to the outfall location and gages that fail to work properly.

Some of the existing rating curves are based upon data obtained from plans, not record drawings. Potential inaccuracies revolve around unanticipated changes in system geometry that could affect system hydraulics. Also, uncertain condition and size of older facilities could cause inaccuracies.

Hydraulic computations always involve some simplification of actual physical conditions in the field. The hydraulic theory used to compute the existing rating curves contains several simplifications that appear to cause overestimation or underestimation of flow rates, depending on the situation.

Improving CSO discharge estimates required a careful review of how MMSD establishes water levels, what system geometry is defined for the CSO, and the hydraulic theory used to compute discharge rates. Our review of the MMSD systems discovered numerous inaccuracies that were analyzed and the effect of the inaccuracy on computed flow rate estimated. These inaccuracies include:

- Measuring water level in the estuary, a key value in computing flow rates at 75 outfalls

- Estimating river stage at outfalls located outside the estuary. This affects 20 outfalls.
- Measuring and using junction chamber levels which is used as a surrogate for the water level at diversion structures.
- Computing and applying theoretical rating curves for each outfall.
- Not utilizing as-built data for structure geometry at all locations.

A sensitivity analysis demonstrated large sensitivity to the relative difference in water elevation between the diversion structure and the outfall at small differentials. Differential elevation errors as small as 1/10th of a foot could result in a computed CSO discharge rate exceeding 100 cfs when no discharge actually exists. Consequently, resolving this inaccuracy took on high importance.

The project developed ten recommendations for improving the accuracy of past CSO estimates:

1. Verify that error in estimating river stage does not create a false reported overflow. Do this by checking for a reported overflow at the two collector systems where river stage does not affect CSOs.
2. Use 1 hour averages to compute discharge rates
3. Eliminate the use of an unreliable estuary gage and adjust the recorded elevation of the other estuary gage to rectify an apparent error in the datum.
4. Use an auto-estimation technique to determine river elevation for CSO outside of the estuary.
5. Use an automatic calibration technique to improve recorded level data at the junction chambers.
6. Verify zero plate elevations in the junction chambers to rectify discrepancies.
7. Use a surrogate location to estimate flows at OF-090 because the junction chamber is hydraulically isolated from the diversion structure
8. Replace rating curves generated by DSCURV with ones generated by more accurate and widely tested HEC-RAS.
9. Revise the interpolation routine used for reading rating curves to provide more accurate interpolations.
10. Incorporate record information on system geometry into the development of rating curves

In addition, the project recommends potential methods for obtaining improved CSO discharge estimates, if the District decides to further improve accuracy. Because this would require changing or installing monitoring equipment, these recommendations are only applicable for improving CSO estimates in the future.

Effect of Implementing Recommendations on Overflow Estimates

Triad incorporated the recommended changes for rectifying historical flow estimates into revised SYSMON Regulatory Database documented in Technical Memorandum Nos. 4 and 5. We then compared overflow volumes computed using existing and recommended procedures for three events.

The following table compares the estimated overflow volumes, with more compete information available in Technical Memorandum No. 1.

COMPARISON OF OVERFLOW VOLUMES FOR THREE EVENTS

Event	Existing Method	Recommended Method	Percent Increase
August 4-12, 1998	468 MG	839 MG	79%
June 10-20, 1999	902 MG	1,603 MG	78%
May 17-20, 2000	1,539 MG	2,448 MG	59%

Comparing the detail output we find the principle causes for the outfalls showing the greatest differences:

- Estuary water levels as measured at Milwaukee River and St. Paul (LT1120100) used by MMSD in current flow estimation read higher than the levels measured at Milwaukee River and 1st Street (LT1140100) used in the recommended method.
- The recommended method adjusts each estuary meter reading downward by 0.37 feet to account for the difference between the MMSD meter and the more accurate NOAA meter.
- The recommended rating curves compute significantly higher flow rates (100 to 200% greater) than the existing curves for the same junction and river elevations.
- NS4 090 cannot be computed using the level in the NS4 junction chamber since it is isolated by a flapgate during high water conditions. Flow at NS5 094 is increased by 58% to account for 090.

Adjustments made that cause a greater difference in junction chamber elevation vs river elevation result in higher flow rates.

Dropshaft Rating Curves

In 1992, the WPAP suggested two methods for calibrating the dropshaft rating curves. Triad reviewed and agreed with the recommendations and carried them out in an effort to refine the flow estimates.

The first method involves passing a known volume of water through a dropshaft and comparing the known and computed volume. This method calibrates individual dropshaft rating curves. The calibration technique involves the following steps:

1. Calculate, based on as-built drawings, the volume of the junction chamber and collector system filled to the level of the lowest overflow or river level, as appropriate.
2. Fill junction chambers and collector sewer systems to the level of the lowest overflow. This has taken place and will continue to take place whenever there is a combined sewer overflow event.
3. Discharge the stored volume in the collector systems into the inline system.
4. Utilize the dropshaft rating curves to compute flow rates at 5 minute intervals from the time the junction chamber gates open until the associated collector sewers system empties.
5. Sum the discharge rates to obtain the total volume discharged upon emptying.
6. Adjust the computed discharge volume, if necessary, for any residual combined sewer discharge entering the collector system after opening the gates.
7. Compare storage and discharge volume for the event.
8. Repeat Steps 2 through 7 for several events to verify consistency of discharge volume computation.
9. Adjust rating curves accordingly to provide best match between computed and known discharge volumes.

The second method involves performing a water balance for a tunnel fill event. This method calibrates all the rating curves jointly. The calibration technique involves the following steps:

1. Review with operations staff the tunnel level meter calibration data to determine the signals that provide the most accurate indication of water level in the inline system.

2. Review with operations staff calibration data for the inline pump-out meters and estimate accuracy.

3. Obtain the most up-to-date inline stage-volume curve and estimate accuracy of volume computations.

4. Obtain historic metering data from three large tunnel storage events.

5. Compute water balance for portions of several events by subtracting the outflows from the inflows and comparing to the change in storage volume. The water balance should be performed over as short a time as possible to minimize any error in estimating tunnel infiltration rates.

6. Adjust rating curves accordingly to provide best water balance, considering the accuracy of the pump-out and tunnel storage volume estimates.

The first method did not provide suitable information for calibrating the rating curves, despite a comprehensive effort to extract the most information from the available data. Data analysis produced inconsistent results. The second method provided useful data for calibration. Triad found that the dropshaft rating curves consistently underestimated inflow into the tunnel by an average of approximately 40 percent. Triad recommends multiplying calculated flow rates at the dropshaft meters by a factor of 1.7 to achieve a more accurate value for ISS inflow.

Subsequent to Triad's investigations, the MMSD installed an area-velocity meter in the NS-5 approach channel. MMSD reports the dropshaft rating curves compute flows approximately 12% lower than the area-velocity meter. This additional data creates uncertainty as to the uniformity of flow underestimation.

Water Stored in the ISS

As part of the second dropshaft calibration method, Triad examined the methods MMSD uses to compute water stored in the ISS. Triad found the current method of using a stage-storage curve and assuming a level hydraulic gradeline provides an accurate method of computing tunnel storage volume. Comparison of five depth meters located along the length of the tunnel shows only small difference elevations along the length of the tunnel, even during rapid fill events.

Triad does recommend comparing depth meter reading of stored water in the ISS (converted to elevations) at various metering locations as a quality control check for the tunnel depth meters.

The investigations also determined the Inline Pump Station meters read approximately 6% too high. Triad recommends multiplying the measured readings by 0.94 to obtain more accurate readings.

MIS to ISS Diversions

There are 19 locations where the MIS is diverted into the ISS. Ten of these divert separate sewage into the ISS. The remainder divert combined sewage into the ISS. Under current operational strategy, these 10 continue to divert water into the ISS until the tunnel is full even after the District stops diverting combined sewage into the ISS.

Triad recommends that MMSD use new interpolation tables. The recommended tables are based upon a more complete hydraulic analysis than used to generate the initial analysis. We recommend that only one group, either SYSMON or CSC, computer overflow rates. Having both groups compute overflows introduces the potential for inconsistent rates. System monitoring and collection system controls should work out which group should perform the computations.

MIS to Receiving Water Bypasses

There are 38 locations where water is bypassed from the MIS into the receiving waters. Of these bypasses, four may be considered combined sewer overflows because the bypasses are located in the combined sewer service area (outfalls 010, 015, 016, and 019).

Five of the bypasses discharge through pumps. Discharge quantities are determined by multiplying pump run time by rated capacity. Actual pump capacity changes over time, depending upon maintenance activities. As such, there is no good method for determining actual pump capacity in the past. Through testing or installation of temporary meters, the present rated capacity can be established. Such an effort would be of limited value to the MMSD because many of these pump stations are scheduled for upgrades soon. Therefore, Triad recommends using the rated pumping capacity for pumped bypasses.

The District uses simple weir or orifice equations to compute discharge through gravity bypasses. Triad recommends that the District use new interpolation tables. The recommended tables are based upon a more complete hydraulic analysis that takes into account the transition from weir to orifice flow. CSC should implement the interpolation table and Systems Monitoring should cease computing discharge independently from CSC.

One gravity bypass, DC-9-2, located at East Bruce and South Water Streets functions more like a CSO diversion structure than a MIS bypass. Triad recommends treating this bypass as a CSO and having its discharge reported by CSOLOG.

Update of SYSMON Database and CSOLOG

SYSMON Database

As mentioned above, the MMSD does not really store data collected by CCS in a database. Instead, it stores information collected for the 845 data "tags" in ASCII flat files, one file per day. Data are stored in 5-minute increments, typically with six columns of values. No data are readily available. Upon request, Systems Monitoring supplies data users with CDs of the flat files. These files are available since 1995. Data prior to 1995 must be restored from tape backups. At best, this data storage system provides extremely inconvenient access to operational data.

Triad recommended converting the data storage system to a stand-alone server on which to store historical and future monitoring data in a SQL Server database. Upon the MMSD's acceptance of the recommendations, Triad purchased a computer system and converted the data. The historical data from 1995 through June 2002 are now loaded into the system. This system allows users to access to nearly 7 years of 5-minute operational data using MS-Access for ad-hoc reports and queries.

The SYSMON information system comprises a modular processing kernel with interfaces to existing data acquisition systems, operator control, and report generation modules. The system was developed on and for an Intel PC-based environment using a mix of standard commercial-off-the-shelf (COTS) components and custom developed modules for analysis and reporting. Application modules were developed from existing FORTRAN analysis routines used in the current system and updated for the new environment.

The server will be installed in the IT department with access granted to users through the MMSD network. Triad is also supplying the district with training, and technical reference and user's manuals. Triad is also supplying programs to allow the District to perform regular uploading of CSC information.

Generating CSO Monitoring Reports

The new SYSMON system includes implementation of this project's recommendations to improve CSO discharge rates estimates. As such, it replaces the current programs CSOLOG and DSCURV. It improves upon the CSOLOG program by implementing the following modern programming practices:

- Modular program design
- Storing all parameters and data in databases with the ability define date ranges of validity for any parameter
- Separating computational modules from reporting systems
- Improved user interface
- Improved report formats

Detailed Documentation

Project analyses, findings, recommendations, and manuals are documented in the five technical memorandums appended to this summary report:

TM	Project Tasks	Title
1	1.1	Estimation of Combined Sewer Overflows
2	1.2, 1.3	Calibration of Dropshaft Rating Curves
3	1.4, 1.5	Flow Estimating (MIS Locations)
4	2.1-2.7	SYSMON Database, Technical Design Document
5	2.8, 2.9	SYSMON Database, User's Manual

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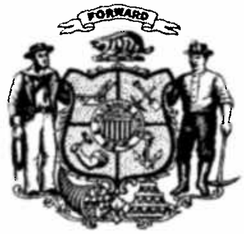

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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December 19, 2003

Editor
Milwaukee Journal-Sentinel
P.O. Box 371
Milwaukee, WI 53201-0371

Dear Editor:

John Norquist's mean-spirited, misleading, and unwarranted attack on SEWRPC and WisDOT in the December 14th "Crossroads" section of the *Journal-Sentinel* cries out for the following response:

- The freeway system has become the lifeblood of our economy and our lifestyles, carrying 40 percent of daily travel in Milwaukee County, as well as serving as a principal southern gateway to Wisconsin. That aging system is crumbling and will need to be rebuilt over the next several decades, beginning next year with the Marquette Interchange. It would be foolish to rebuild that system and not fix the design problems that drivers face every day, particularly the dangerous, at times terrifying, weaving movements that are caused by left hand on and off traffic ramps. Of the $6.2 billion freeway price tag, a full 89 percent, or $5.52 billion, will be required just to rebuild the freeway system and solve those design problems. The remaining $710 million is the cost of adding freeway lane capacity on the most heavily used and most highly congested freeway segments. The great majority of county elected officials and residents in the Milwaukee area support properly rebuilding the freeway system and, when doing so, spending 13 percent more to add from 33 to 50 percent more capacity and avoid the ever-worsening congestion conditions that have been experienced in other metropolitan areas.

- Most of the freeway system widening can be accomplished within the existing freeway rights-of-way. In the City of Milwaukee, the 19 miles of widening on IH 43 and IH 94, so reviled by Norquist, may require the loss of 21 housing units and five commercial/industrial buildings. That loss would represent about $11 million in property tax base, less than 1/10th of 1 percent of Milwaukee's $19 billion tax base. For perspective, consider that the City reports an average annual housing unit loss for all reasons of over 650 units. Accessibility to uncongested freeways has proven over the years to enhance adjacent community tax bases. Why would this not be true in the City of Milwaukee?

- SEWRPC and WisDOT have listened to what the residents of the City and County of Milwaukee have said. Norquist's anti-freeway position is clearly the minority viewpoint. The public opinion record evidences overwhelming support for proper freeway reconstruction and expansion, not only regionwide, but in the County and City of Milwaukee as well.

SEWRPC and WisDOT are committed to building a strong transportation system in Southeastern Wisconsin, and we do not address freeways alone. While the freeway system, because of its age and condition, will necessarily be in the spotlight for a number of years to come, we need to continue to focus also on arterial streets, transit systems, and bicycle-and pedestrian-ways. Transit, in particular, is in trouble, primarily because, unlike nearly every other major metropolitan area in the country, we have not established a nonproperty tax revenue source to fund transit. A decade ago, SEWRPC led an effort to explore the establishment of a regional transportation authority to address this transit funding problem. Despite being a transit advocate, Norquist did nothing to help advance that agenda, and it died. Norquist is now leaving the scene, and one can only hope that the exit of this polarizing force from the Region will help us achieve consensus on a broadly based program to not only rebuild the freeway system, but to strengthen the other elements of our transportation system as well. Indeed, our future economic and social well-being depends on that.

Sincerely,

Thomas H. Buestrin
Chairman
Southeastern Wisconsin Regional Planning Commission

THB/wb/mlh
#89858 v1 - norquist response

cc: Governor Jim Doyle
Frank J. Busalacchi, Secretary, WisDOT
Southeastern Wisconsin Legislators
County Executives
County Board Chairpersons
SEWRPC Commissioners