Appendix A

Questions Used to Prompt Discussion in Interviews of Skokie Officials

1. Intentionally storing stormwater on streets is unusual, but, in your case, effective. How do you explain the benefits of street storage to citizens and/or elected officials? Stated differently, how do you know that street storage "works?"

2. In your view, what are the key guiding principles in dealing with the public on problems and solutions in the public works field?

3. Street and supplemental storage of stormwater seems to be a cost-effective (lowest cost) solution to basement flooding in Skokie. If you could go back to the beginning of the project (early, 1980's), would you do it again? Or would you "hold out" for a more traditional and more costlier solution?

4. When street storage of stormwater was initially proposed, concern was expressed over accelerated deterioration of pavement. What is your experience?

5. When street storage of stormwater was initially proposed, concern was expressed over dangerous icing of streets during freezing temperatures. What is your experience?

6. Are you aware of any accidents caused by standing water?

7. When street storage of stormwater was initially proposed, concern was expressed over interference with normal movement of vehicles. What is your experience?

8. When street storage of stormwater was initially proposed, concern was expressed over interference with operation of emergency vehicles (e.g., police cars, fire engines). What is your experience?

9. Are you aware of any damage to vehicles directly related to the system or its components?

10. What is the weakest “link” (e.g., hanging traps, berms, subsurface tanks, etc.) in the physical system?

11. Has the Village encountered any legal (e.g., liability) problems as a direct result of street storage?

12. Street and related storage of stormwater typically requires careful maintenance of the drainage system. Examples include keeping inlet grates clear of debris, removing sediment and other deposits from catch basin sumps, and cleaning clogged flow regulators. To what extent has increased maintenance been a financial/personnel burden?

13. How has your method of resolving basement flooding been received by regulatory/operating agencies? That is, has your approach been an advantage, disadvantage or “wash” with other governmental units?

14. How have you funded your “street storage” system? Anything special/different/unique about this means of funding vis-a-vis other public works projects?

15. Have there been any favorable or unfavorable effects on traffic flow such as excessive speed reduction and unwanted diversion of vehicles to other streets?

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Appendix B

Criteria
For
Screening Applicability
Of
Street Storage

Note: Before using this screening instrument, please read the section in Chapter 10 titled "Criteria for Screening the Applicability of Street Storage." In order to appreciate why certain information is being requested, the person(s) involved in the screening should understand the premise, components, and benefits of street storage. For that reason, these three aspects of street storage are summarized here.

PREMISE OF A STREET STORAGE SYSTEM

Temporarily store stormwater on the surface (off-street and on-street) and, as needed, below the surface close to the ***source***, that is, where it falls as precipitation and ***prior to its entry*** into the combined, sanitary, or storm sewer system. Accept the full volume of stormwater runoff into the sewer system but ***greatly reduce the peak rate of entry*** of stormwater into the system.

COMPONENTS OF A STREET STORAGE

- ***Downspout disconnection*** to slow down and possibly infiltrate stormwater

- ***Off-street surface storage*** of stormwater (conventional detention/retention) with regulated outflow

- ***On-street surface storage*** with regulated outflow achieved by an optimum combination of on-street berms and catchbasin flow restrictors

- ***Sub-surface storage*** of stormwater (tanks or oversized sewer segments beneath streets and parking lots) with regulated outlet control using restrictors

BENEFITS OF A STREET STORAGE SYSTEM

Street storage technology has the potential, depending on the situation, to cost-effectively mitigate one or more of the following wet weather condition problems:

- ***Basement flooding*** caused by surcharging of combined and/or sanitary sewers
- ***Overflow*** of combined and/or sanitary sewers and resulting pollution of receiving waters
- ***Excessive peak flow*** at wastewater treatment plants
- ***Nonpoint source pollution***
- ***Surface flooding*** caused by stormwater runoff and/or surcharging of combined or sanitary sewers.

General Information About the Community

1. Name of community/government entity:

   _____

2. Name and affiliation of person(s) responsible for conducting screening:

Person	Affiliation	Telephone Fax/ Email
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

3. Dates or period of screening:

   _____

4. Population of community/government entity:

_____

5. Area of community/government entity:

_____

6. Overall longitudinal street grades (select one):
   - < 0.2% (0.2 feet per 100 ft. along the street centerline)
   - 0.2 < 0.5%
   - 0.5 < %

   Comment: _____

   _____

Combined Sewer System Information

QUESTION	YES OR OFTEN	MAYBE OR SOMETIMES	NO OR RARELY	COMMENTS
Are combined sewers present in at least part of the community?				
If the answer to the first question is “no,” go to the section titled “Concluding Comments” or go to the set of questions under the section titled “Sanitary Sewer System Information” If the answer to the first question is “yes,” the following questions apply only to the areas served by combined sewers.				
Are combined sewers structurally sound?				
Do basements flood because of combined sewer surcharging?				

Do streets flood because of combined sewer surcharging?				
Do combined sewers overflow into surface waters?				
Are off-street sites available for surface detention/retention of stormwater?				
Is nonpoint source pollution a concern?				
Is the wastewater treatment plant operating at or over its treatment capacity?				
Is the wastewater treatment plant operating at or over its treatment capacity?				
Has the community already decided on a solution to its combined sewer problems or is the community still “open” to alternative solutions?				

Sanitary Sewer System Information

QUESTION	YES OR OFTEN	MAYBE OR SOMETIMES	NO OR RARELY	COMMENTS
Is a separate sanitary sewer system present in at least part of the community?				

If the answer to the first question is “no,” go to the section titled “Concluding Comments” or go to the set of questions under the section titled “Stormwater System Information” If the answer to the first question is “yes,” the following questions apply only to the areas served by sanitary sewers.				
Are sanitary sewers structurally sound?				
Do basements flood because of backup or sanitary sewage?				
Do sanitary sewers overflow into surface waters?				
Is infiltration (of groundwater) into sanitary sewers a problem/cause of problems?				
Is inflow of stormwater into sanitary sewers a problem/cause of problems?				
Is the wastewater treatment plant operating at or over its treatment capacity?				
Has the community already decided on a solution to its sanitary sewer problems or is the community “open” to alternative solutions?				

Stormwater System Information

QUESTION	YES OR OFTEN	MAYBE OR SOMETIMES	NO OR RARELY	COMMENTS
Is a separate stormwater system present in at least part of the community?				
If the answer to the first question is “no,” go to the section titled “Concluding Comments.” If the answer to the first question is “yes,” the following questions apply only to the areas served by separate stormwater system.				
Are the storm sewers structurally sound?				
Are residential, business and other buildings and property damaged by stormwater?				
Are off-street surface sites available for surface detention/retention of stormwater?				
Is nonpoint source pollution a concern?				
Does the community have an erosion/ sedimentation/ stormwater control ordinance?				
Does the community have a separate stormwater service fee?				

Has the community already decided on a solution to its stormwater problems or is the community “open” to alternative solutions?				

CONCLUDING COMMENTS

Additional ideas/concerns/questions/suggestions/etc.

_____

_____

_____

_____

_____

_____

_____

_____

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Appendix C

Trouble Shooting Guide
for
Underground and Surface Storage Basins
with
Gravity Dewatering

wp/epastappc

UNDERGROUND AND SURFACE STORAGE BASINS WITH GRAVITY DEWATERING
NORMAL OPERATION, INSPECTION AND TROUBLESHOOTING GUIDE
Skokie, Illinois

NORMAL OPERATION

Storage structures with gravity drainage include relief sewers, underground vaults, and surface storage basins. The normal operating sequence of areas with gravity drainage during a storm event is:

- Rainfall runoff from the streets in these areas drains directly from the inlets to the underground or surface storage basins.
- The basins provide additional sotrmwater runoff storage and protection from combined sewer surcharging and basement flooding.
- The water is discharged by gravity from the storage basin to the combined sewer system. The discharge rate from the storage basin is controlled by a restrictor device at the outlet end. A check valve at the outlet pipe prevents backflow of combined sewage into the separated stormwater runoff system.

INSPECTION AND TROUBLESHOOTING

CONDITION OBSERVED	POSSIBLE CAUSE	CORRECTIVE ACTION
❖ Streets for basin area flooded	Very heavy rainfall filled storage basin.	Extremely heavy rainfall could cause ponding on major streets.
	Associated street inlets plugged.	Check for free flow of stormwater at inlets or flooded street areas. Clear street inlets.
❖ Rain stopped, streets not draining	Restrictor orifice is clogged	Check for free discharge at manhole where basin drainage re-enters combined sewer system. Open bypass valve on street for emergency drainage. Rod or flush out obstruction in orifice or discharge pipe to combined sewer. Flush out basin drainage area with city water.
	Basin has filled. Combined sewer still surcharged.	Drainage will resume when combined sewers are no longer surcharged. No action needed.
❖ Sewage odor after basins have drained	Stagnant water in basin. Check valve not working.	Check manholes with check valve. Check for and remove any debris lodged in check valve.
<u>Dry Weather Inspection and Maintenance</u>		
❖ Inspect street inlets for area basins (Annually in fall).		Clean out any debris that would inhibit drainage into basin.
❖ Inspect condition of check valve and orifice (Annually in fall).		Clear out any debris lodged in check valve or orifice plate.
❖ Exercise bypass drain valve (Annually in fall).		With valve open, inspect for accumulations of grit and sediment. Flush out any excess accumulations with city water.

Appendix D

Trouble Shooting Guide
for
Stormwater Storage Basins -
Dewatering Pump Stations

wp/epastappd

STORMWATER STORAGE BASINS - DEWATERING PUMP STATIONS
INSPECTION AND TROUBLESHOOTING GUIDE
Skokie, Illinois

CONDITION OBSERVED	POSSIBLE CAUSE	CORRECTIVE ACTION
STORMWATER BASINS		
Rain Period - Basin Filling		
❖ Streets for area basins flooded	Very heavy rainfall filled basin.	Extremely heavy rainfall could cause ponding on major streets. Secure appropriate traffic controls.
	Associated street inlets plugged.	Check for free flow of stormwater at inlets or flooded street areas. Clear street inlets.
❖ Rainfall without basins filling	Combined sewers not surcharged.	Rain not sufficient to surcharge combined sewers. Verify by checking that water level is below divider wall on siphon side of inlet structures: 8Z.1 - Area 8; 9P.0 - Area 9.
❖ Area 9 - light rain, combined sewer not surcharged, pumps running	Pumping low flow from Dempster Street.	All flow entering the north basin in Area 9 from Dempster Street must be pumped by the dewatering pumps to reach the combined sewer on Skokie Boulevard. No action needed.
Rain Over - Basin Draining		
❖ Rain stopped, basin not gravity draining	Restrictor orifice is clogged.	Check for free discharge at manhole where basin drainage re-enters combined sewer system: Area 8 - Structure 8P.0 (Oakton Street at Skokie Boulevard); Area 9 - Structure 9P.2 (combined gravity and pumped discharge). Dislodge clogged orifice by rodding or flushing. In Area 8, bypass valve at vault 80.4 can be opened.
	Plug valve failed closed (Area 9)	Depress RESET at control panel to clear fail. If condition remains, open plug valve using manual override. Call electrical service contractor if valve operator or panel malfunction.

STORMWATER STORAGE BASINS - DEWATERING PUMP STATIONS
INSPECTION AND TROUBLESHOOTING GUIDE
Skokie, Illinois

CONDITION OBSERVED	POSSIBLE CAUSE	CORRECTIVE ACTION
STORMWATER BASINS (Continued)		
Basin Draining (Continued)		
❖ Basin drained to gravity point, pumps won't start	Additional rain surcharged the combined sewer.	Pumps won't start if combined sewers still surcharged. Verify that water level is at top of divider walls at control structures.
	Pump Float Switch No. 6 or other controls not working.	Check float condition and levels. Manually trip floats with long pike pole. Check for other pump failure conditions noted below.
❖ Pumps operating, basin not draining	Restrictor orifice is clogged.	See above for no gravity draining.
	Pumps not pumping capacity.	See pumping guidelines below.
❖ Sewage odor after basins have drained	Stagnant water in siphon. Check valve not working.	Check manholes with check valve. Check for and remove any debris lodged in check valve. Dewater siphons by opening drain valve to remove stagnant water.
Dry Weather Inspections		
❖ Prevent basin drain clogging		Clear any accumulated debris from basin drains. Remove debris from perimeter of basin.

STORMWATER STORAGE BASINS - DEWATERING PUMP STATIONS
INSPECTION AND TROUBLESHOOTING GUIDE
Skokie, Illinois

CONDITION OBSERVED	POSSIBLE CAUSE	CORRECTIVE ACTION
PUMPING STATIONS		
❖ Pump operating with severe noise or vibration	Pump not seated properly.	Pull pump and re-seat on guide rail system.
❖ Pumps operating but not pumping capacity	Pump impeller or volute clogged.	Pull pump and unclog.
	Pump discharge clogged.	Check first manhole for pump discharge. Remove pump and rod out or flush discharge line.
	Basin dewatering drain plugged.	Verify by low sump level but considerable water remaining in the basin to pump. Rod out or flush basin drain. Dewater with alternate pump if necessary.
Panel Alarm Indicators:		
❖ Pump Fail	Power failure.	Pump RESET switch must be depressed before restarting pumps in AUTOMATIC mode upon restoration of power after power failure, circuit breaker trip, or any other type of failure listed.
	Other conditions indicated by specific alarm lights:	
❖ Pump High Temperature	Low cooling oil level.	Pull pump and check cooling oil if pump repeatedly overheats.
	Debris in impeller.	Pull pump and remove debris from impeller.
❖ Pump High Moisture	Pump motor seal failed.	Pull pump and inspect stator casing for moisture. Call pump service representative if moisture is in motor housing.
❖ Low Sump Level	Low level or normal pump cutout float switch not working or hung up.	With pumps in AUTOMATIC, use a long pike pole to manipulate floats by hand to trip. Check for correct level of floats. Call electrical service contractor if pump floats have become inoperative.
❖ High Basin Level	Very heavy rainfall filled basin.	Extremely heavy rainfall could cause ponding on major streets. Secure appropriate traffic controls.
❖ Plug Valve Fail (Area 9)	Valve will not reach limit position (open or close). Debris clogging valve.	Manually open valve with override and manually start pumps to flush out debris.
	Limits of valve out of adjustment.	Refer to Limitorque valve operator manual or call electrical service contractor.

Appendix E

Standard Maintenance Procedures
for
Submersible Dewatering Pumps -
Stormwater Storage Basins

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SUBMERSIBLE DEWATERING PUMPS - STORMWATER STORAGE BASINS
STANDARD MAINTENANCE PROCEDURES
Skokie, Illinois

EQUIPMENT CONTRACTORS

PUMP SUPPLIER:

Hydroaire Incorporated
834 West Madison
Chicago, IL 60607
Phone: 312-738-3000
Fax: 312-738-3226
Project No.: AKFL 10280

ELECTRICAL PANEL INSTALLATION:

Aldridge Electric
28572 N. Bradley Road
Libertyville, IL 60048
Phone: 708-680-5200
Fax: 708-680-5298

PUMP LIST

LOCATION:	AREA 4	AREA 8	AREA 8	AREA 9
ITEM				
Pump Tag No.	P-4-1, 4-2	P-8-1	P-8-2	P-9-1, 9-2
Make	Flygt	Flygt	Flygt	Flygt
Model No.	CP-3085	CP-3152	CP-3102	CP-3152
Impeller No.	438	624	442	620
Impeller Size	4"	10"	6"	10"
Horsepower	2.0	14	5	14
Flow, gpm	210	2250	450	3000
Head, feet	12.0	11.5	18.5	12.0

SAFETY PRECAUTIONS

1. Always lock out and tag the submersible pumping equipment before removing it from the sump for inspection or maintenance.
2. Use only the hoisting equipment recommended by the equipment manufacturer to remove the pumps from the sump.
3. Rinse the pump thoroughly with clean water before handling or inspecting the pump.
4. The pumps are designed to be removed from the sumps without anyone entering.
5. If for any reason it becomes necessary to enter the sump, follow proper confined space entry procedures.
6. If checking or changing the oil, hold a rag over the oil casing screw when removing it.

SUBMERSIBLE DEWATERING PUMPS - STORMWATER STORAGE BASINS
STANDARD MAINTENANCE PROCEDURES (Continued)
Skokie, Illinois

MAINTENANCE PROCEDURES

DESCRIPTION	FREQUENCY	LUBRICANT/PARTS	REMARKS
1. Inspect impeller and volute	12 months		Replace severely worn impellers. Check for clogging and remove debris if needed. Have service representative adjust impeller clearance if needed.
2. Inspect motor seal for proper oil level and possible contamination. Replace oil containing water or if cream-like.	12 months	Cooling Oil	Use MobIl Whiterex 309 or ordinary SAE 10W-30.
3. Inspect the stator casing.	24 months	Seal	If oil or water is in the stator housing call the Flygt representative.
4. Complete pump overhaul	5 years		Interval recommended by manufacturer for overhaul. Best performed for Skokie during winter dry weather months.

STATION INSPECTIONS

1. Inspect stations weekly during wet weather months or more frequently during heavy rain events. Note general condition of structure, surrounding ground or grass area, control panel, and signs of forced entry or vandalism.
2. Record the pump hour meter readings and electric meter readings.
3. Observe the electrical panel for any alarm conditions: High water level, low water level, high temperature fail, seal leak. Record alarm occurrences on station inspection form.
4. Check bottom of sump for debris buildup. Remove excess debris as required.
5. Alternate the pump sequence with the LEAD/LAG switches to obtain equal running time for the pumps at Area 9.

   Notes:

   a. The pump station for Area 8 should always have Pump No. 1 as the lead pump and Pump No. 2 as the lag pump. On this station, the pumps will always have unequal run times.

   b. When the pumps at the Area 4 station are set in the ALTERNATE position on the control panel, they will automatically alternate in sequence.

REFERENCE

Flygt Model CP Submersible Pump Installation and Maintenance Manual (provided with each pump).

Village of Skokie Operation and Maintenance Manual, Stormwater Runoff Control Facilities.

SUBMERSIBLE DEWATERING PUMPS - STORMWATER STORAGE BASINS
INSPECTION FORM
Skokie, Illinois

Date	Hour Meters		Electric Meter	Comments
	Pump 1	Pump 2		

PUMP STATION AREA: _____ AREA 4 (OAKTON AND FLORAL)
_____ AREA 8 (GABION POND)
_____ AREA 9 (EVANSTON GOLF CLUB)

Appendix F

Exploratory Analysis of the Impact of a Street Storage System on the Frequency and Volume of Combined Sewer Overflows

Note:

This analysis and its documentation was prepared by Robert W. Carr, PE and Michael C. Morgan, PE of Earth Tech.

Introduction

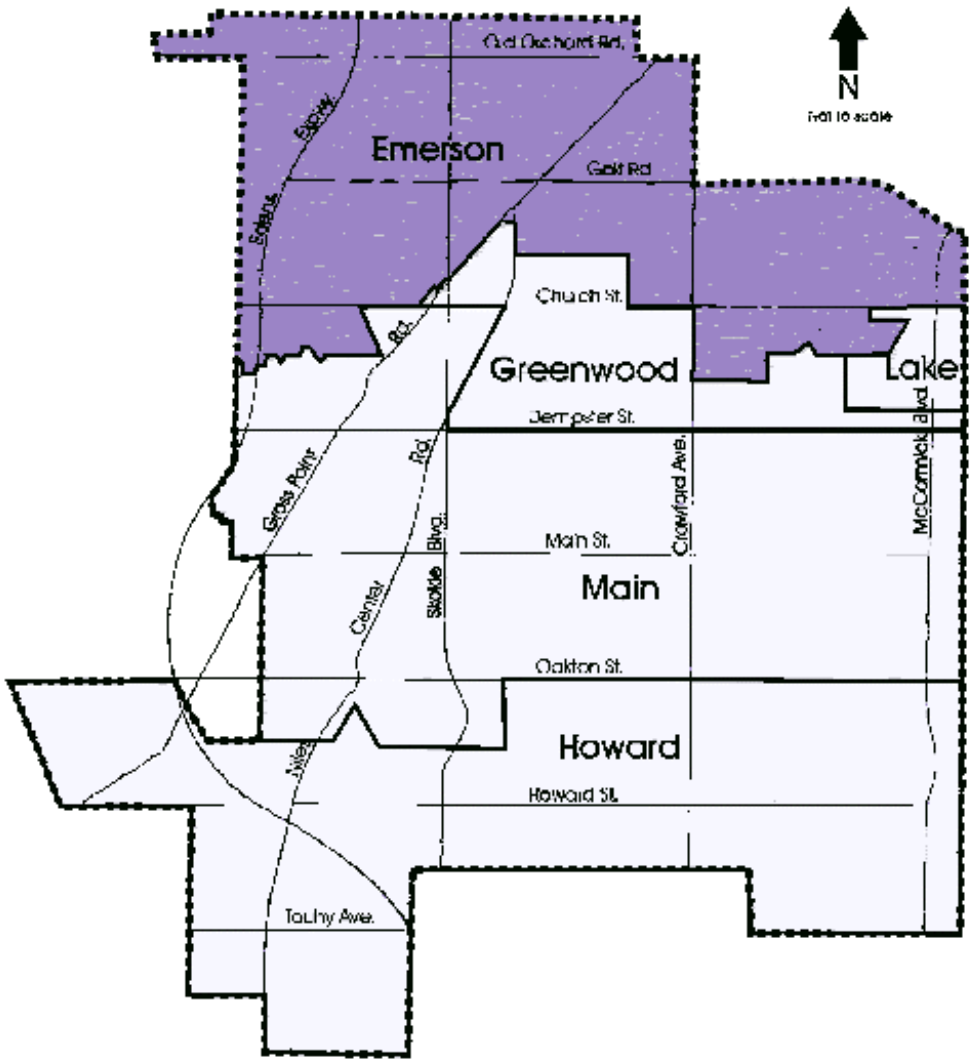
Street storage has been proven to substantially reduce basement flooding in various communities.
It is reasonable to expect that street storage would have a positive impact on the frequency and volume of CSOs and could be used to meet the Nine Minimum Controls established by EPA. The primary purpose of this study was to complete an analysis to evaluate the potential benefits of street storage with respect to reductions in the frequency and volume of CSOs. The analysis was completed using hydrologic and hydraulic computer modeling to represent the performance of the combined sewer system. XP-SWMM computer modeling software was utilized to conduct the analysis.

To efficiently perform the analysis, data previously developed for the Village of Skokie was utilized. The Village of Skokie has implemented a street storage program to provide 10-year protection from basement flooding. The street storage improvements were designed to function with TARP (the Tunnel and Reservoir Plan), deep tunnels constructed to provide an overflow for flows in excess of the interceptor system capacity. During dry weather, flows go from the Village's system to the MWRDGC's interceptor system. During wet weather, flows fill the interceptor sewer system, and then overflow into TARP. CSOs occur to the North Shore Channel when the capacity of the connections between the local systems and TARP is exceeded or when TARP is full.

Street storage combined with a deep tunnel solution to sewer capacity problems is effective in reducing CSOs to waterways, but is not an option in most communities. Therefore, the impacts the use of street storage independent of a TARP system need to be evaluated. This study utilized the data developed for Skokie modified to exclude TARP and replace it with discharge to a WWTP with CSOs to the adjacent waterway. This provided information about a combined sewer system discharging directly to a WWTP, as is the case for most existing combined sewer systems.

Two scenarios were evaluated in the study. The first scenario consisted of "pre-project" conditions, or the combined sewer system without implementation of street or subsurface storage. The second scenario represented conditions with street storage and subsurface storage that has been implemented in a basin in Skokie with characteristics representative of other combined sewer areas. The analysis incorporated flows for dry and wet weather conditions with and without street storage and was completed using the Emerson Street Sewer District (ESSD) basin of the Village (see Figure F-1). A 45-year rainfall record was used as the basis for evaluating potential CSO reductions attainable with street storage. The occurrence of CSOs was defined using "typical" wastewater treatment plant capacity. The number and volumes of combined sewer overflows was determined for scenarios with and without the street storage.

Figure F-1
Sewer Districts in Skokie



Study Area Description

The Village of Skokie is located adjacent to and directly north of the City of Chicago. The 5,510 acre area of the Village is divided into three sewer districts: the 1,255 acre Howard Street Sewer District (HSSD) in the southern part of the Village; the 2,300 acre Main Street Sewer District (MSSD) in the central part of the Village; and the 1,955 acre Emerson and Lake Street Sewer District (ELSSD) in the northern part. As discussed above, the 840 acre Emerson District was included in this analysis.

Precipitation occurs as rain, sleet, hail, and snow and ranges from showers of trace quantities to brief intense storms to longer duration rainfall or snowfall events. Precipitation is distributed throughout the year with an average annual total of 33.3 inches. Circular 172 prepared by the Illinois State Water Survey (1989) estimates that for a one hour storm, the 1, 10, and 100 year recurrence interval rainfall amounts are 1.49, 1.94, and 2.08 inches, respectively. For a 24 hour storm, the 1, 10, and 100 year amounts are 2.21, 3.86 and 6.70 inches, respectively.

Soils in the area are primarily from glacial deposits of the Pleistocene series. These glacial deposits have an approximate depth 60 feet and consist of many types of materials. About 25 percent of the study area are sandy soils, while the remainder has clay soils. Ground water levels tend to remain 10 to 15 feet below ground level in sandy areas with the exception of isolated perched lenses of shallower ground water.

The land in the ESSD generally slopes eastward toward the North Shore Channel. Slopes vary from 0.1 to 1 percent and the overall slope in many areas of the Village is a flat 0.2 percent. Surface runoff flows from the front lawn and driveway areas to the street. Flow in the street is along the curb line and gutters to the nearest inlet. Inlets are generally located midblock and at intersections. Due to the extremely flat conditions, few areas have a continuous drainage pattern from block to block. Trunk sewers in the combined system range in diameter from 30 inches to a maximum of 84 inches. Lateral sewers which are connected to trunk sewers range in diameter from 12 to 27 inches.

Study Approach

Analysis Objectives

The focus of this study was to quantitatively evaluate the potential benefits of street storage with respect to control of CSOs. The approach adopted for this study included components intended to consider “typical” combined sewer systems. The following study objectives were identified and incorporated into the impact analysis:

1. Evaluate the potential effects of street and underground storage for a typical

community that contains a combined sewer service area. Use one sewer district in the Village of Skokie as the basis for the analysis.

2. Assume that an overflow collection system such as TARP does not exist. The flows discharged from the combined sewer system will be directed to the wastewater treatment plant or overflow to a receiving stream.

3. Evaluate the effect of street storage on a community's ability to meet the Nine Minimum Controls, that have been developed by USEPA for control of CSOs.

4. Evaluate the effect of street storage on the frequency and volume of combined sewer overflows.

5. Evaluate the effect of street storage on the community's wastewater treatment facilities.

Analysis Methodology

As previously discussed, detailed models were developed using SWMM to represent the performance of the combined sewer system in the ESSD. Models were developed to simulate performance of the system before and after the runoff control program was implemented. SWMM is an excellent tool for conducting sewer system analysis, however there are limitations to using the EXTRAN module of SWMM for continuous simulation.

To overcome the limitations of the EXTRAN module while utilizing historical precipitation, a two part approach was adopted for this analysis. The first part of the analysis consisted of completing simulations using the SWMM models developed for scenarios with and without street storage. Simulations were conducted to define the minimum rainfall event threshold causing combined sewer overflow. Simulations were completed for both scenarios using rainfall events selected to represent the range of events contained in the historical series. The results of the simulations were used in the second part of the analysis, which consisted of deriving CSO statistics from the entire record of rainfall events. CSO occurrences, volumes and peak flows were derived based on regression techniques applied to the simulation results of the strategically selected rainfall events.

An outline of the procedure used for the impact study is summarized below:

1. Develop SWMM models for the ESSD basin to represent scenarios with and without street storage.

2. Incorporate dry weather flows quantified from previously conducted flow monitoring programs.

3. Incorporate wet weather flows with runoff control facilities.

4. Verify model performance for the 10-year, 6-hour design rainfall event. Adjust parameters as necessary to correctly represent expected system discharge and storage volumes for the design event.

5. Develop model parameters to represent the scenario without runoff control facilities.

6. Verify model performance for the 10-year, 6-hour design rainfall event using earlier study results that quantified approximate surcharging depths.

7. Use the RAIN module of SWMM to convert the 45-year historical continuous precipitation record from the NOAA station at O'Hare International Airport to defined rainfall events.

8. Complete model simulations to determine which rainfall events will result in CSOs for wet weather flows with and without runoff control facilities.

9. Select rainfall events for simulation that are representative of the historical precipitation record. Complete model simulations for both scenarios using the selected rainfall events. Tabulate model results to determine CSO peak flow and CSO volume for each simulated rainfall event simulated.

10. Determine relationship for each scenario between CSO peak flows and CSO volumes with corresponding rainfall event characteristics. Use defined relationship to estimate CSO peak flow and CSO volume for all rainfall events in the 45-year historical series (See no. 7 above).

11. Develop statistics to describe the occurrence of CSO peak flows and CSO volumes to quantify the effects of street storage on CSOs.

Hydrologic and Hydraulic Computer Modeling

Hydrologic and hydraulic modeling supporting the runoff control program dates back to the late 1980's. The original analysis of the ESSD was completed in 1987 using the System Analysis Model (SAM) computer modeling software, which was originally developed by CH_2MHill. The analysis was limited to the major interceptors in the ESSD. The SAM model was run on a VAX computer system. In 1992, the sewer system model was converted into the HYDRA model, developed by Pizer, Inc.

XP-SWMM modeling software was used for this analysis. SWMM was selected because it offers advantages in evaluating CSOs when compared to the capability of models that were previously used for the ESSD. The hydraulic analysis capability of the EXTRAN module of SWMM is superior to the other models. For example, SWMM

explicitly solves the St. Venant equations for each model element at each time step during the model simulation. The ability to explicitly represent system surcharging, storage and volume are essential components to evaluating CSOs for a wide range of rainfall events.

Model Parameters

Pipe and manhole data (pipe diameters, inverts and lengths, and manhole rim elevations) were taken from the existing HYDRA model and input into the EXTRAN module of SWMM. The dry weather flows, consisting of sanitary sewage and infiltration were input as constant point flows into the EXTRAN module of SWMM. The wet weather flows from foundation drains (0.007cfs/acre) and existing on-site detention facilities (41 cfs) were input into the model as a constant flow in the EXTRAN module. A flow rate of 2.0 cfs/acre was applied to the identified 26 acres of internal roof drains using the acreage and the rainfall hyetograph in the RUNOFF module of SWMM. Surface stormwater runoff was represented using the RUNOFF module. The ESSD was divided into 73 subbasins, which were tributary to manholes in the model. The area and percent impervious values were taken from previously completed analysis. The subbasin widths were derived from measurements of each basin and a general slope of 0.2 percent was used. The regulated catch basin flows were represented in the EXTRAN module at each manhole by defining orifice links to control release rates from each storage junction during the analysis. The non-regulated catch basin flows were developed in the RUNOFF module and directed to the appropriate modeled manholes in EXTRAN. The storage volume in each basin were determined and input into the EXTRAN module using the stepwise linear area method.

Dry Weather Flow

Dry weather flows were considered to be sanitary sewage and infiltration. Sanitary sewage is flow from residential, commercial or industrial buildings. The base average daily residential flow was estimated based on the land use and the population served. A per acre contribution was developed for each type of residential land, single family, multi-family (2 to 4) and apartments. Residential flows varied from 0.006 to 0.02 cfs/acre.

The non-residential sanitary flows were divided into industrial and commercial flows. Commercial flows are those flows from offices, gyms, laundries, schools, and other commercial buildings. Sanitary flows from commercial buildings were estimated using the size of the property. Industrial flows are those flows from manufacturing facilities, warehouses, and other industrial buildings. Sanitary flows from industrial buildings were also estimated using the size of the property. Commercial and industrial flows varied from 0.04 - 0.02 cfs/acre.

Infiltration is primarily groundwater which enters the system through defective pipe and manholes or other openings. Infiltration tends to be a steady-state flow as far as

system modeling is concerned. The dry weather flows were all input as constant flows because these flows are very small as compared to the wet weather flows.

Wet Weather Flows

Wet weather flows were considered to be foundation drains, roof drains, on-site detention release rates and surface stormwater runoff. The first three components were determined using flow monitoring and existing data. As part of the flow monitoring program, foundation drains from individual homes in ESSD were monitored. This data was determined to be similar to previous foundation flow monitoring data from the Howard Street and Main Street Sewer Districts. The foundation flow was estimated to be 0.007 cfs/acre and was input into the model as a constant flow.
The second wet weather flow component are roof drains. The Village required all single-family residences to disconnect their downspouts. Buildings without downspouts were assumed to have internal roof drains. It was decided to allow internal roof drains to be connected directly to the combined sewer because of the cost to disconnect them. A maximum peak flow rate of 2.0 cfs/acre was applied to the identified 26 acres of internal roof drains. To maintain the rainfall dependent characteristics of flow from roof drains, the roof area was represented as impervious tributary area in the model.

The third wet weather flow is the flow from existing on-site detention facilities. These flows were represented by the design outflow rate as provided by the Village. Eighty one (81) acres of existing on-site detention facilities were identified with a total release rate of 41 cfs which was input into the model as constant point flows.

Stormwater Runoff

The first three wet weather flow inputs described above are considered to be fixed flows, that is these flows can not be regulated or changed. The fourth and final wet weather flow input is surface stormwater runoff. While the other types of wet weather flows cannot be regulated, the street storage and subsurface storage system was designed to control stormwater runoff component of wet weather flow.

Stormwater runoff was divided into two components, regulated catch basin flows and non-regulated catch basin flows. Regulated catch basin flows require storage of the surplus water not immediately allowed into the sewer within the project area. The regulated catch basin flows and associated storage volumes were determined as part of the runoff control program for the ESSD of Skokie. Non-regulated catch basin areas allow the runoff from rainfall events up to the 10-year design rainfall event to enter the sewer system without any restrictions. These non-regulated flows were only allowed on arterial streets.

Regulated Catch Basin Flows

The first step of the analysis was to determine the capacity of the sewer system

available for carrying stormwater runoff. The total hydraulic capacity of the sewer system depends on the quantity of dry and wet weather flows and the level to which a sewer can surcharge without causing basement flooding or other damage. This capacity is also affected by the back water effect from limited capacity of downstream sewers. The maximum allowable rates at which runoff can be released into the sewer system were determined for all areas of the ESSD. These runoff rates ranged from 0.08 to 1.0 cfs per acre. Using the regulated runoff rate (cfs/acre) and the tributary area, a maximum allowable regulated flow from each catch basin was determined. Results of this analysis formed the basis for the design of the runoff control system and for determining the sewer capacity available for those areas which could not be regulated.

The second step was to determine the location and extent of intentional street ponding which can be achieved through flow regulators and minor street grade modifications (berms). Higher flows were allowed on streets with little storage available. Conversely, on streets which could pond large stormwater volumes, the flows were regulated to use the available storage capacity. The sewer capacity and the storage analyses were conducted concurrently with each analysis providing input to the other. The product of this analysis included delineation of street ponding elevations in allowable areas and identification of the volume of additional runoff which must be detained in other storage locations.

The third step was to site and size the additional storage facilities necessary to store flows in excess of street ponding capacity and where street ponding was not feasible to store runoff in excess of the regulated runoff rate. The locations and volumes of detention facilities needed to store the remaining volume from step two were determined. This step insured that the runoff control system for the ESSD would reduce sewer surcharging to prevent sewer backup into the basement during the 10-year recurrence interval storm.

Non-regulated Catch Basin Flows

The final component of the wet weather flows is the flow from non-regulated catch basins. These catch basins are located on arterial streets and allow the runoff from a 10-year recurrence interval storm to enter the combined sewer system. The Village designated the streets within the ESSD that were to be non-regulated streets. Currently, the Village has reconsidered this assumption and is installing regulators to restrict the runoff into the sewer system to that of a 10-year storm.

Wastewater Treatment Plant Description

The Village of Skokie does not own or operate a wastewater treatment plant (WWTP). Conveyance and treatment facilities are provided by the MWRDGC. Dry weather flows from the ESSD discharge to the MWRDGC interceptor located under McCormick Boulevard. Wet weather flows discharge first to the interceptor sewer system, then to

the TARP and if TARP is full, then to the North Shore Channel. To determine the impact of street storage on the number and volumes of CSOs, a theoretical WWTP was included in the analysis. Earth Tech recently completed a facility plan for the WWTP in Gary, Indiana. Since Gary has a large combined sewer service area, it was used as a basis for the theoretical WWTP for the ESSD. Theoretical ESSD flows were developed by prorating average and peak flows from the Gary WWTP. The Gary WWTP treats an average of 35.6 cfs on a dry day with a peak WWTP flow of 186 cfs. Flows larger than 186 cfs are bypassed into either the Little Calumet River or the Calumet River. The average dry weather flow from the ESSD is 12 cfs. Using the same ratio of average dry weather flow to peak capacity, the peak wet weather flow through the ESSD WWTP would be 65 cfs. A review of the Skokie flows showed that the flows from on-site detention facilities add up to 41 cfs. Therefore, the constant flows equal 53 cfs (12 cfs dry weather and 41 cfs on-site detention facilities. The roof and foundation drains and regulated catch basins also add additional flow. It was determined that 65 cfs was too small to use for this analysis. Because many communities with large peaking factors, both separate and combined systems, ie, Racine, WI, Kenosha, WI, Milwaukee, WI and the Greater Metropolitan Water Reclamation District of Greater Chicago, IL provide either storage or a flow through clarifier (typically with disinfection) for a portion of the flows that exceed the WWTP capacity. Therefore, it was decided to provide a flow through clarifier to allow the ESSD facility to handle a peak wet weather flow of 100 cfs. Therefore, the ESSD treatment facility assumed for this analysis accepts up to 100 cfs prior to the occurrence of a combined sewer overflow.

Model Verification

Flow Monitoring Program

In 1986, a flow monitoring program was conducted in the ESSD. A total of __ flow meters, __rain gauges, and two foundation monitors were installed for __ months. This flow monitoring program provided dry weather and wet weather flow data at strategic points in the districts. In addition to sewer flows, a foundation drain monitoring program was also done. This data was used to develop dry weather flows and verify wet weather flows used in the hydraulic models. The parameter development completed during previous analysis and observed system performance was used as the basis for completing the SWMM models used in this analysis.

Design Storm Simulation

In addition to the flow monitoring data described above, simulation of the system design rainfall event was used for model verification. The 10-year, 6-hour recurrence interval rainfall event was the design storm for the design of the ESSD runoff control system. Therefore, the 10-year, 6-hour rainfall event was simulated. The simulated storage volumes and flows (sanitary, foundation drains, roof drains, existing on-site detention facilities, and regulated catch basin flows) were compared and confirmed with expected

results for the 10-year design storm. The regulated flows were confirmed by comparing design parameters with simulation results for storage volumes and peak flows at regulated manholes. The non-regulated catch basin flows were verified when the simulated peak flow at the outfall matched the design peak flow of 300 cfs. At this point the model was considered to be verified for use in performing additional analysis.

Combined Sewer Overflow Simulation

As previously discussed, detailed SWMM models were developed to represent the performance of the combined sewer system in the Emerson Street study area. Models were developed to simulate performance of the system before and after the runoff control program was implemented. SWMM is an excellent tool for conducting sewer system analysis, however there are limitations to using the EXTRAN Block of SWMM for continuous simulation. Therefore, a two part approach was adopted for this analysis to utilize the rigorous hydraulic analysis capability of the SWMM EXTRAN Block and still obtain results for a long term period of recorded precipitation data. The first part of the analysis consisted of completing simulations using the SWMM models developed for both the pre-project scenario and the street storage scenario. Simulations were conducted to define the minimum rainfall event threshold causing combined sewer overflow. Simulations were then completed for both scenarios for approximately 25 rainfall events. The results of the simulations were used in the second part of the analysis, which consisted of deriving CSO statistics from the entire record of rainfall events. CSO occurrences, volumes and peak flows were derived based on the regression techniques applied to the simulation results of the strategically selected the rainfall events.

Historic Precipitation Record

Historic precipitation data from the NOAA station at Chicago O'Hare International Airport (ORD) was obtained for the period WY1949 to WY1993. Initially, the precipitation record was processed using the RAIN Block of SWMM. The RAIN Block was used to read the continuous rainfall record and define individual rainfall events. For the purpose of this study, a rainfall event was characterized as durations of measured precipitation surrounded by 12-hour intervals during which precipitation was not measured. The 12-hour interval was an arbitrary choice and deemed to be a sufficient recovery time for the Emerson Street system. The continuous record was processed by the RAIN block to gain information such as rainfall depth, maximum rainfall intensity and average rainfall intensity to describe each rainfall event. This information was used to correlate CSO occurrences with defined rainfall events. Table F-1 presents a summary of the defined rainfall events according to rainfall depth and maximum rainfall intensity.

The graphs depicted in Figure F-2, F-3 and F-4 were developed using the rainfall events extracted from the historical precipitation record using the RAIN Block of SWMM. The graphs include plots of rainfall depth, maximum rainfall intensity and

average rainfall intensity for the rainfall events defined in the historical record. As one would expect, the graphs show significant scatter among the simple descriptors such as rainfall depth and rainfall intensity. However, the graphs do indicate trends, upper and lower limits and frequency characteristics that describe the historical rainfall events.

Use of rainfall events from a long term precipitation record was advantageous for a number of reasons. For example, realistic rainfall patterns and system response is represented with the use of recorded rainfall events instead of synthetic design rainfall distributions. The frequent occurrence of CSOs also is better addressed by using a historical precipitation record to derive frequency and performance statistics than by using design rainfall events. Verification of the performance of a street storage system with a variety of rainfall depths, durations and intensities was also an advantage gained from using recorded rainfall.

Correlation of Combined Sewer Overflows and Rainfall

Rainfall events from the record were strategically selected to characterize CSO occurrence for the study area while minimizing the number of simulations required. Initially, simulations were conducted to define the minimum rainfall event threshold causing combined sewer overflow. Simulations were then completed for both scenarios for approximately 25 rainfall events. The simulated events were selected to be representative of the variety in rainfall depth, maximum intensity and average intensity present in the historical precipitation record. Particular emphasis was placed on simulating rainfall events near the threshold at which overflows occur. This approach was adopted to define performance for the most frequent rainfall events, which were also believed to dominate the annual CSO statistics. The results of the simulations were used as the basis for deriving CSO statistics from the entire record of rainfall events. Table F-2 includes summary information for the simulated rainfall events and Table F-3 presents simulation results for each rainfall event.

Table F-1

Rainfall Event Summary

Rainfall Depth (inches)	Number of Occurrences	Cumulative Subtotals	Maximum Rainfall Intensity (inches/hour)	Number of Occurrences	Cumulative Subtotals
10.00	--	--	10.00	--	--
9.00	1	1	9.00	0	0

8.00	0	1	8.00	0	0
7.00	0	1	7.00	0	0
6.00	0	1	6.00	0	0
5.00	0	1	5.00	0	0
4.00	5	6	4.00	0	0
3.00	15	21	3.00	1	1
2.50	27	48	2.50	0	1
2.00	37	85	2.00	2	3
1.50	96	181	1.50	13	15
1.00	241	422	1.00	37	52
0.50	575	997	0.50	205	257
0.20	888	1885	0.20	657	914
0.10	624	2509	0.10	687	1601
0.05	490	2999	0.05	689	2290
0.02	532	3531	0.02	761	3051
0.01	280	3811	0.01	413	3464
0.00	456	4267	0.00	805	4267

Figure F-2
Rainfall Depth vs. Maximum Rainfall Intensity

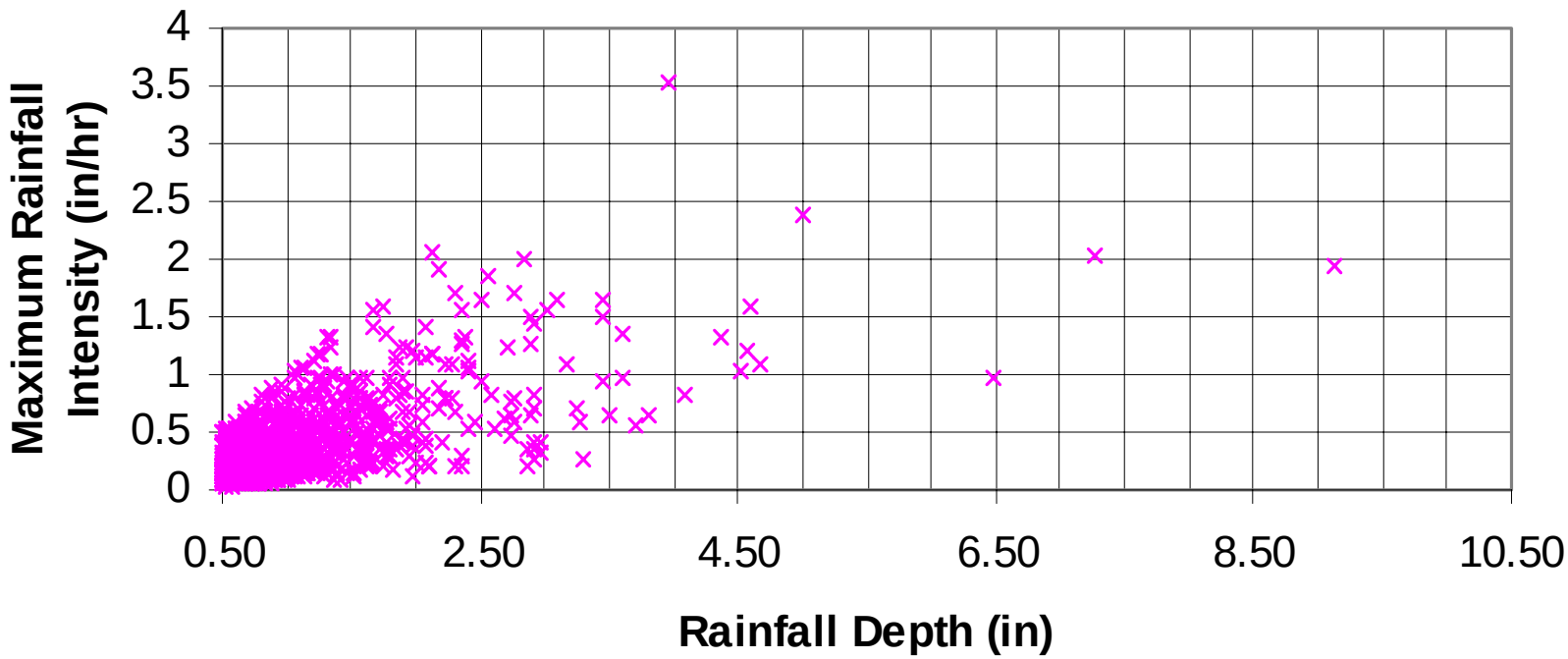


Figure F-3
Maximum Rainfall Intensity vs. Average Rainfall Intensity

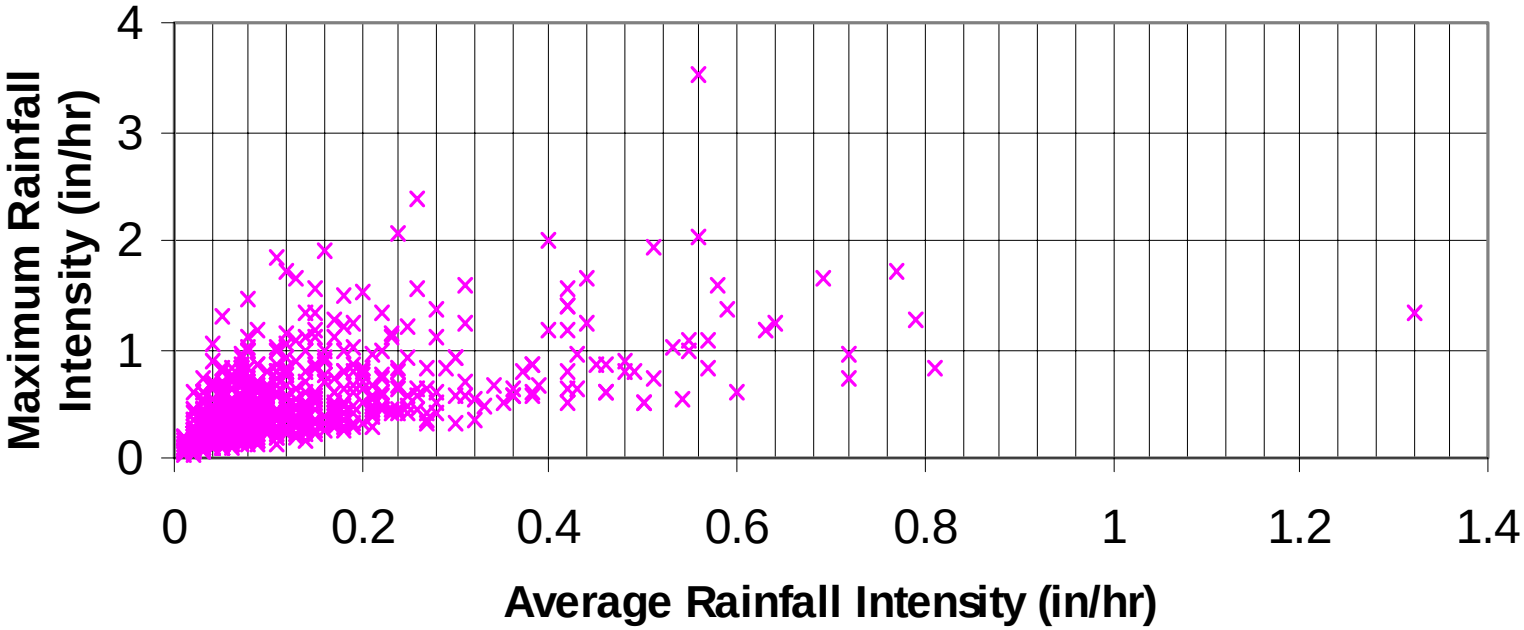


Figure F-4
Rainfall Depth vs. Rainfall Intensity

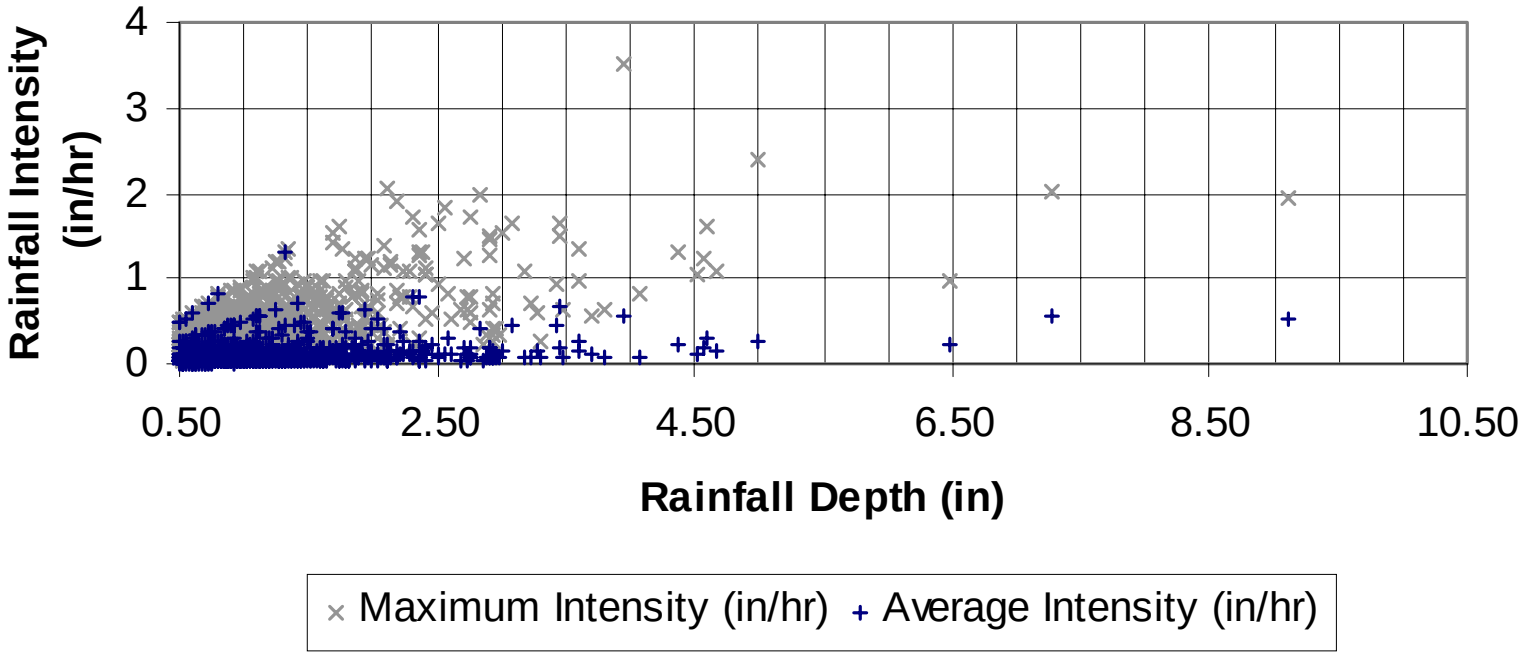


Table F-2

Simulated Rainfall Events

Event Start Date	Event Duration (hours)	Event Volume (inches)	Maximum Intensity (inches/hour)	Average Intensity (inches/hour)
3/19/48	19	5.00	2.39	0.26
10/9/69	33	4.68	1.10	0.14
4/24/54	8	3.70	0.57	0.10
8/17/90	10	3.01	1.55	0.15
11/26/90	10	2.98	0.33	0.08
8/31/89	18	2.56	1.85	0.11
8/29/55	16	2.46	0.60	0.22
6/13/50	4	1.99	1.16	0.40
9/24/61	22	1.98	0.46	0.11
11/4/88	7	1.50	0.92	0.30
4/12/83	18	1.49	0.42	0.03
9/15/92	15	1.25	1.19	0.63
6/4/53	23	1.25	0.52	0.06
9/25/93	11	1.25	0.29	0.07
8/17/83	1	1.00	0.74	0.17
11/13/51	5	1.00	0.32	0.07
9/12/77	11	1.00	0.15	0.04
9/17/49	23	0.75	0.42	0.11
3/28/51	5	0.75	0.17	0.01
12/16/87	20	0.75	0.07	0.02
6/20/68	4	0.60	0.60	0.60
9/23/63	18	0.60	0.30	0.10
7/18/57	12	0.60	0.09	0.02
5/27/56	16	0.55	0.51	0.14
7/1/83	3	0.55	0.33	0.06
12/7/78	3	0.55	0.13	0.03

Table F-3

Overflow Simulation Results

Event Start Date	Pre-project Scenario		Street Storage Scenario		
	Peak Overflow (cfs)	Overflow Volume (acre-feet)	Peak Overflow (cfs)	Overflow Volume (acre-feet)	Overflow Volume Reduction (%)
3/19/48	464.5	115.2	278.3	111.3	3.36
10/9/69	353.1	110.6	229.7	101.3	8.45
4/24/54	116.2	39.0	86.3	35.6	8.72
8/17/90	427.7	67.4	233.7	60.3	10.64
11/26/90	61.8	19.3	55.3	16.9	12.61
8/31/89	418.9	50.1	223.7	44.8	10.60
8/29/55	114.0	31.6	82.7	27.9	11.86
6/13/50	225.7	30.9	150.2	27.2	12.03
9/24/61	66.8	8.8	16.9	0.1	99.06
11/4/88	177.8	19.7	113.3	16.7	15.48
4/12/83	67.1	7.7	--	--	100.00
9/15/92	199.5	15.7	119.0	12.8	18.58
6/4/53	51.2	5.6	26.0	3.0	45.73
9/25/93	45.1	5.6	33.9	4.2	25.35
8/17/83	141.6	14.4	95.9	11.1	22.65
11/13/51	34.8	4.2	25.9	2.8	33.15
9/12/77	--	--	--	--	--
9/17/49	37.1	3.6	22.1	2.0	44.30
3/28/51	--	--	--	--	--
12/16/87	--	--	--	--	--
6/20/68	73.1	5.2	42.3	3.2	38.32
9/23/63	21.7	1.7	11.4	0.6	66.13
7/18/57	--	--	--	--	--
5/27/56	35.8	1.6	9.1	0.3	83.04
7/1/83	--	--	--	--	--
12/7/78	--	--	--	--	--

The simulation results presented in Table F-3 formed the basis for determining CSO occurrence and assigning CSO volumes to rainfall events contained in the historical record. The relationship between rainfall event characteristics and CSO occurrence, flow and volume was determined by regression of the simulated results. A third order polynomial was fitted to the simulated CSO volumes using rainfall depth, maximum intensity and average intensity. Figure F-5, F-6 and F-7 demonstrate the consistency between simulated CSO data and predicted CSO data based on the regression relationship.

Analysis Results

Annual statistics were generated for WY1949 to WY1993. Table F-4 presents the computed statistics, which include annual number of CSO occurrences, annual CSO volume without street storage, annual CSO volume with street storage, annual percent reduction in CSO volume with street storage. In addition to the regression that was completed to assign CSO occurrence and volume to historic rainfall events, the data was further analyzed to investigate the relationships defining CSO peak flow and reductions in CSO volume and peak flow attainable with provision of street storage. Curve fitting techniques available in Microsoft EXCEL were used to quantify the apparent relationships between various data sets.

Figure F-8 presents pre-project overflow volume plotted against overflow volume reduction. The plot shows a well defined relationship between overflow volume reduction and pre-project overflow volume and is well represented by the fitted power function also shown in the figure. The data indicated significant reductions in overflow volumes, especially for events producing overflow volumes that were less than 20 acre-feet. As indicated in Figure F-8, street storage resulted in reductions of at least 20% for overflow volumes of approximately 20 acre-feet. The trend in percent reduction resulting with street storage increased dramatically as overflow volume decreases. The potential benefits from street storage become even more apparent considering that the average overflow volume for pre-project conditions was 15.9 acre-feet and the median overflow volume was 10.0 acre-feet. Applying the fitted curve in Figure F-8, street storage reduced overflow volumes for over half of the individual events by 30% or greater.

Graphs were also developed to examine possible relationships between provision of street storage and reductions in CSO peak flows. As shown in Figure F-9, there does not appear to be a well defined trend between CSO peak flow and rainfall depth. However, there does appear to be a trend in comparisons between CSO peak flow and maximum rainfall intensity. Figure F-10 presents the CSO peak flows resulting from the simulations compared with maximum rainfall intensity from each respective rainfall event incorporated in the simulation. Figure F-10 also contains second order polynomial curves fitted to the CSO peak flows for the pre-project scenario and the

Figure F-5
Overflow Volume vs. Rainfall Depth
Pre-project Scenario

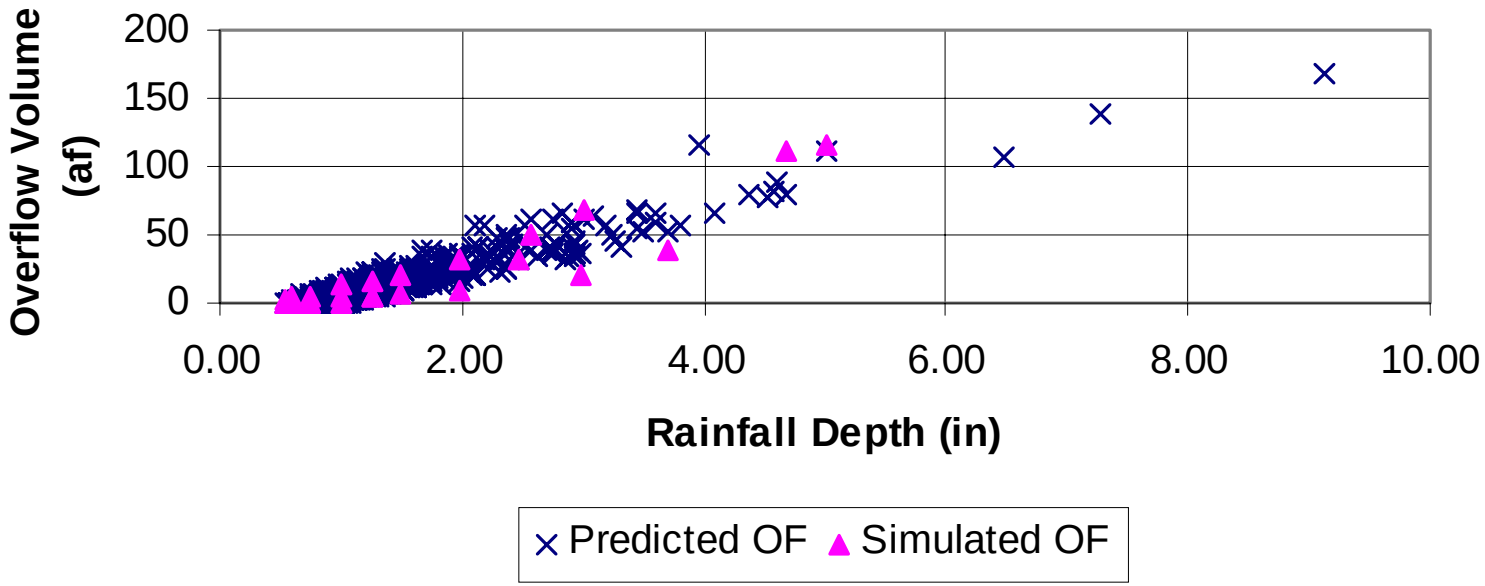


Figure F-6
Overflow Volume vs. Maximum Rainfall Intensity
Pre-project Scenario

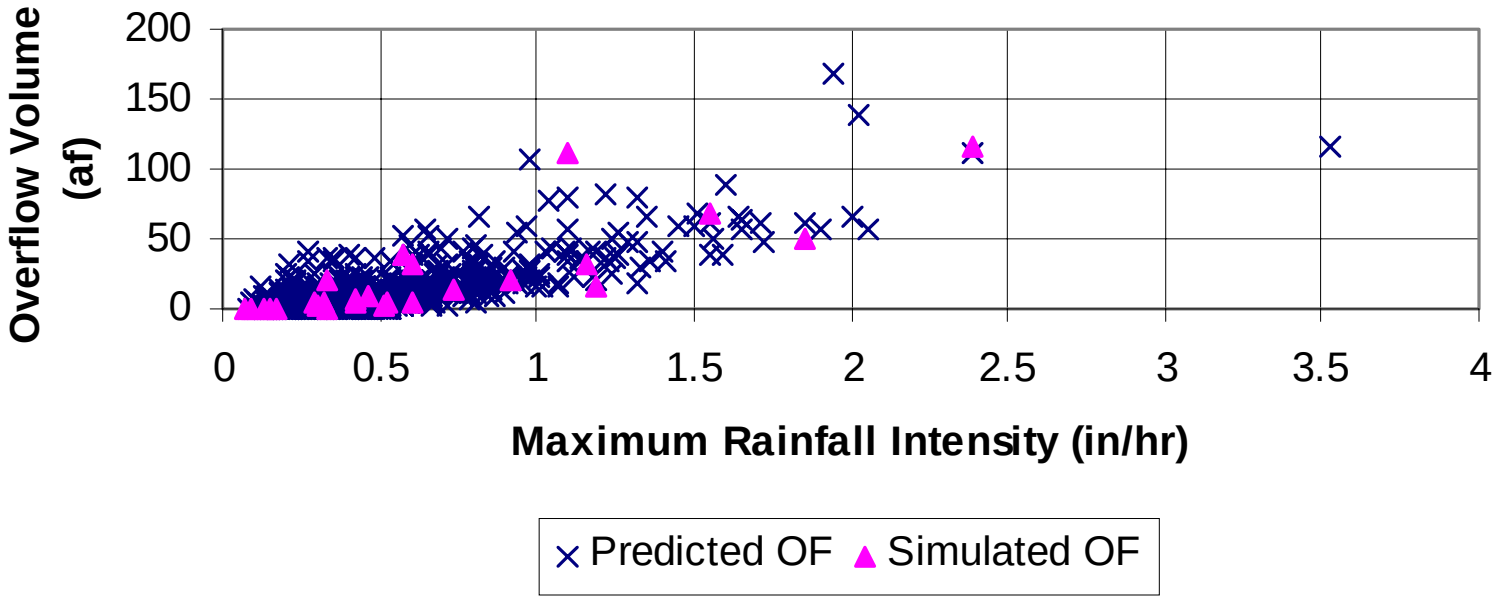


Figure F-7
Overflow Volume vs. Average Rainfall Intensity
Pre-project Scenario

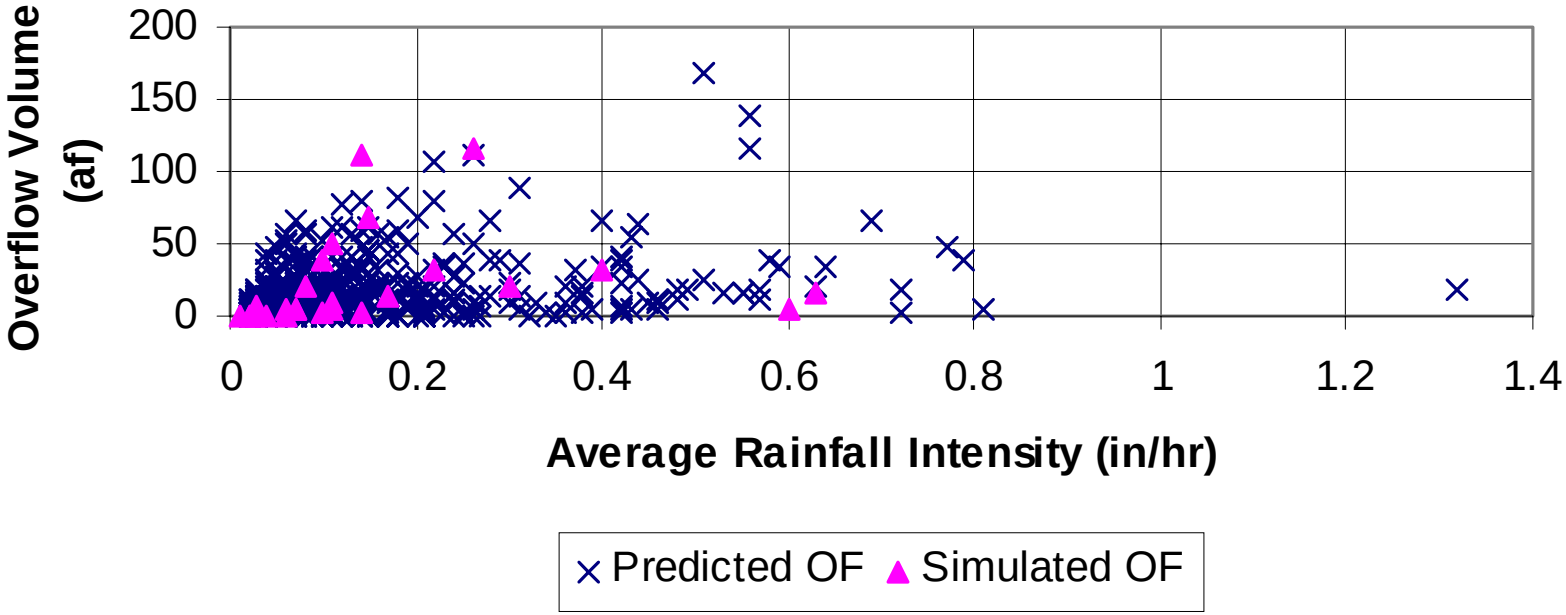
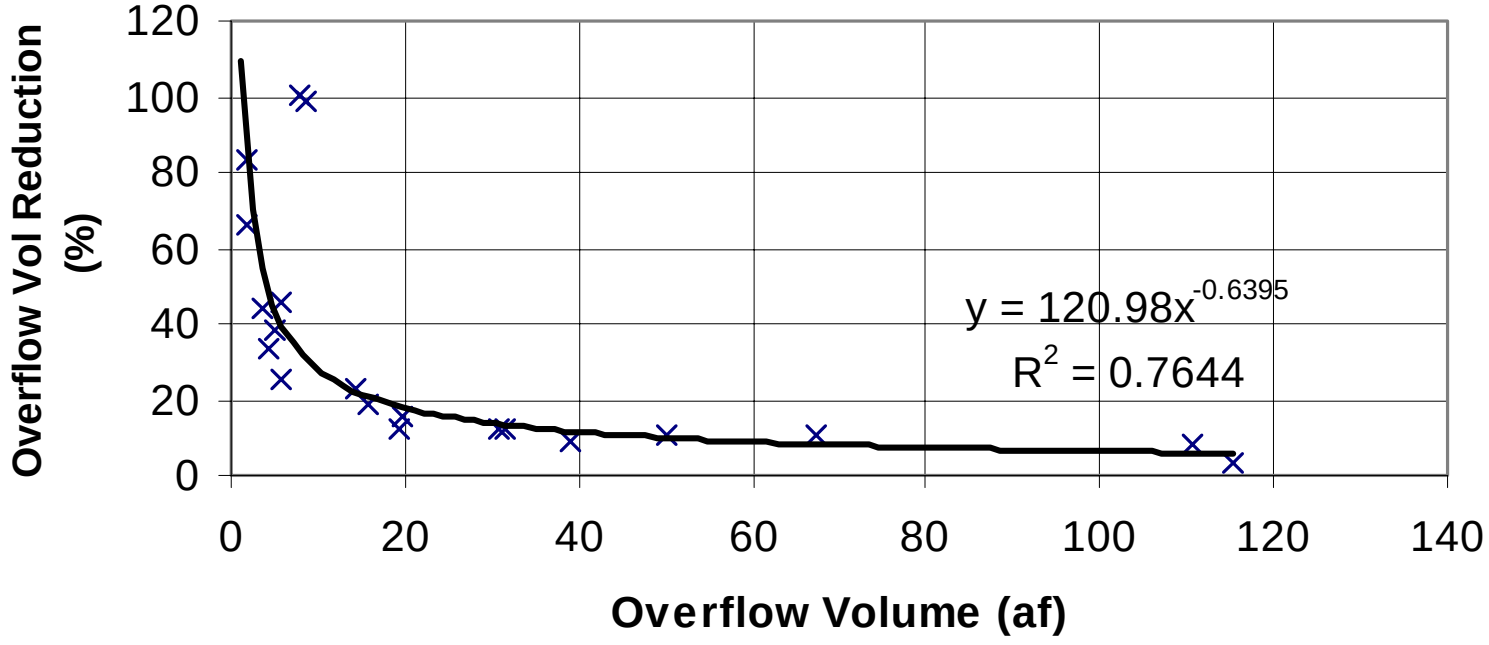


Table F-4

Annual Overflow Statistics

Annual CSO Statistics	Pre-project Scenario		Street Storage Scenario		
	Number of CSOs	CSO Volume (acre-feet)	Number of CSOs	CSO Volume (acre-feet)	CSO Volume Reduction (%)
Annual Average	12.62	197.98	11.24	162.44	19.23
Annual Median	12	187.91	10	147.54	18.79
Annual Maximum	23	478.42	22	415.68	29.48
Annual Minimum	6	86.92	5	63.77	9.24
Annual Standard Deviation	4.00	92.57	3.69	82.05	4.40

Figure F-8
Overflow Volume Reduction vs. Overflow Volume



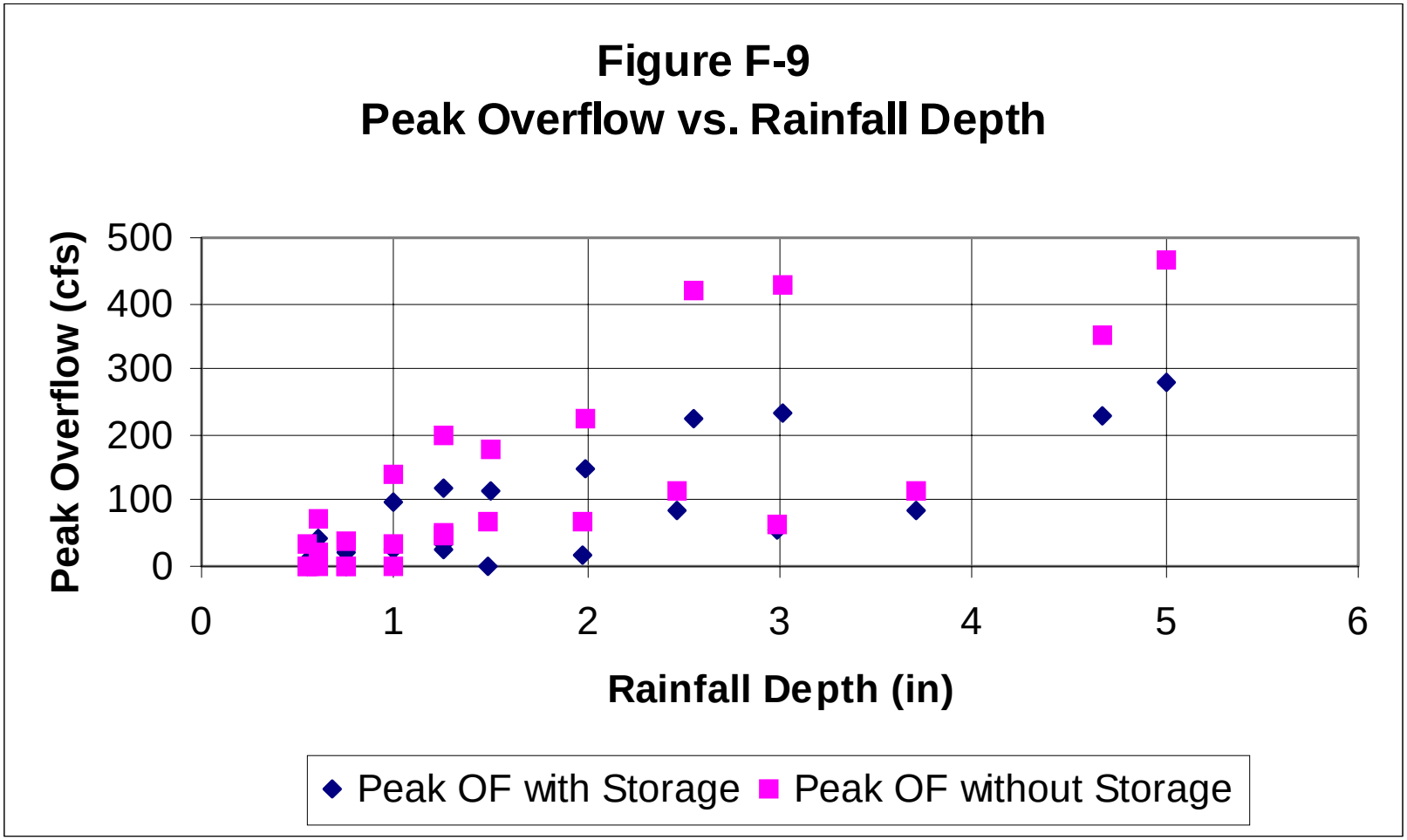
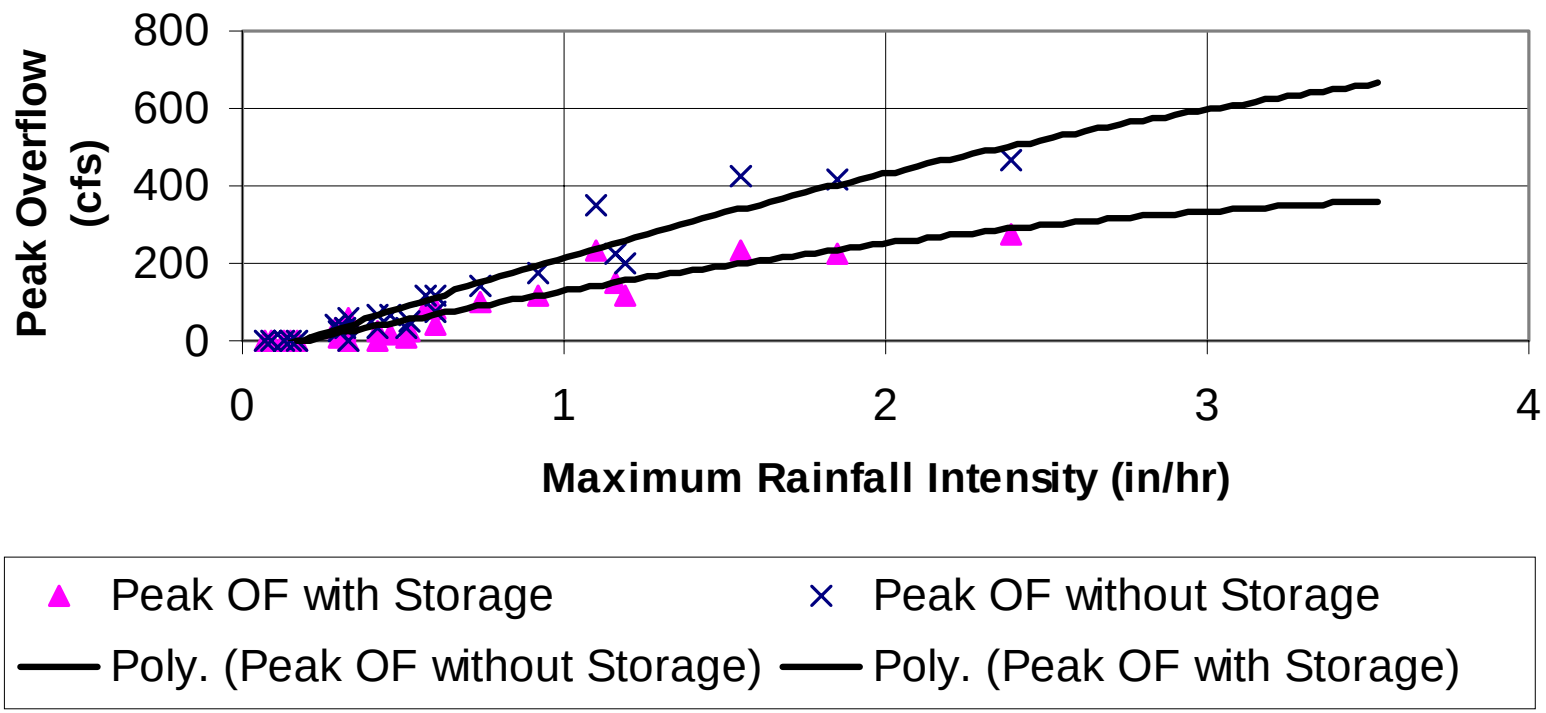


Figure F-9
Peak Overflow vs. Rainfall Depth
Peak Overflow (cfs)
500
400
300
200
100
0
0
1
2
3
4
5
6
Rainfall Depth (in)
Peak OF with Storage
Peak OF without Storage

Figure F-10
Peak Overflow vs. Maximum Rainfall Intensity



street storage scenario.

Conclusions

The graphs and tables summarizing the CSO simulation and annual statistics clearly demonstrate that street storage does contribute to reducing both CSO volumes and peak flows. The data indicated that street storage resulted in a reduction of overflow volume of 30% or greater for approximately half of the overflow occurrences. This trend is consistent with objectives included in the Nine Minimum Controls such as treating the first flush and maximizing system storage.

Unfortunately, the results of this analysis did not indicate significant reduction in CSO occurrence and frequency. The study area selected for this case study was based on an area where street storage improvements have actually been constructed. This fact lends credibility to the improvement components and street storage volumes incorporated into the SWMM models developed for this study. It should be noted, however, that the improvements in the Emerson Street study area were conceptualized and developed to function with the MWRDGC TARP system. As a result, this system provides significantly greater capacity to accept system discharge than would normally be received by typical treatment plant capacities. The street storage system analyzed for this study was optimized to work in conjunction with improved sewer system capacity to provide protection to the residents for the 10-year design rainfall event. The street storage system was not specifically developed or optimized for the specific purpose of eliminating and reducing CSO impacts. It is probable that even greater benefits might have been realized had control of CSOs been an original objective during development of the street storage system.

Provision of street storage as a CSO control technology clearly offers benefits beyond simply controlling CSO impacts. Street storage can provide a cost-effective means for addressing capacity limitations in combined sewer systems that are not addressed by any current CSO control technologies. Based on the potential identified in this case study for street storage to contribute to reductions in both CSO volumes and peak flows, additional research and investigation is recommended to further explore and quantify the benefits of street storage with respect to CSO impacts. Additional research and investigation should be formulated to quantify the benefits of street storage to address CSO water quality, CSO impacts and compatibility with other CSO control technologies. The following are specific examples of additional research and investigation:

- Conduct monitoring of CSO effluent from areas with and without street storage to evaluate potential water quality benefits attainable with provision of street storage.

- Conduct analysis to determine the significance of different land use types on the potential water quality benefits attainable with provision of street

storage.

- Conduct analysis to evaluate the compatibility of street storage with other identified CSO control technologies. Evaluate potential design and cost reductions for CSO control technologies resulting from implementation with street storage.

- Evaluate design modifications required for street storage systems optimized for CSO control compared to street storage systems optimized to prevent basement and surface flooding.

- Conduct analysis to investigate the potential for implementing street storage in various regions of the United States. Identify possible regional limitations for implementing street storage for CSO control.

- Conduct a sensitivity analysis to evaluate the impact of the size of the WWTP along with the street storage on the amount of overflows. This will allow us to further evaluate the effect of street storage on the community's wastewater treatment facilities.

wp/epastappf

Appendix G

Construction Costs
for
Skokie Street Storage System
Adjusted to 1999

SYSTEM COMPONENT	YEARS OF CONSTRUCTION	ORIGINAL CONSTRUCTION COST(1)	ENR INDEX FOR YEAR(S) OF CONSTRUCTION(2)	CONSTRUCTION COST ADJUSTED TO 1999(3)
		$		$
Roadway Berms	1984	42450	4146	61351
Roadway Berms	1985	1325415	4195	1893179
Tanks, Sewer	1985	1689577	4195	2413336
Relief Sewer	1986-87	4930781	4351	6790448
Roadway Berms	1988	1547510	4519	2051932
Surface Detention Facility	1989	835771	4615	1085144
Tanks, Sewer, Surface Detention Facility	1989	7834524	4615	10172149
Tanks, Sewer, Surface Detention Facility	1990	4992485	4732	6321845
Roadway Berms	1990	1170665	4732	1482381
Tanks, Sewer, Surface Detention Facility	1991-92	4712949	4910	5751526
Tanks, Sewer	1992	2998451	4985	3604156
Surface Detention Facility	1994	946480	5408	1048689
Tanks, Sewer	1993-94	3153684	5309	3559404
Tanks, Sewer, Surface Detention Facility	1994-95	4422855	5440	4871645
Tanks, Sewer	1995	1686775	5471	1847406
Tanks, Sewer	1995	766109	5471	839065

Tanks, Sewer Relief Sewer	1996-97	13100078	5723	13715825
Sewer	1997-98	6887763	5873	7027324
Tanks, Sewer Water Main	1998	185023	5920	187273
	1999	3508316	5992	3508316
TOTALS:		66737661		78232393

Footnotes:

1) Based on actual costs with the exception of 19999 which is the engineer's estimate.
Source: Carr, 1999.

2) Engineering News Record (ENR) Construction Cost Indices were obtained from www.enr.com.
The annual average value was used for one year construction periods.
The average of annual averages was used for two year construction periods.

3) ENR index used for 1999 (February) is: 5992

File Name: SkokieStreetStorageCosts

Glossary

Note: Definitions are quoted from USEPA (August, 1998) except for terms denoted with (*) at the end of the definition. Definitions of these terms are developed in this report or taken from indicated sources.

Berm: A low structure constructed across a street, from curb to curb, and intended to temporarily impound water on its upstream side. The crest or top of the berm when viewed along the longitudinal axis of the street, is horizontal. It is in effect, a spillway. (*)

Catch Basin: A chamber or well, usually at the street curbline, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump to retain grit and below detritus the point of overflow; whereas, a stormwater inlet does not have a sump and does not trap sediment.

Combined Sewer: A sewer receiving intercepted surface (dry- and wet-weather) runoff, municipal (sanitary and industrial) sewage, and subsurface waters from infiltration.

Combined Sewer Overflow (CSO): Discharge of a mixture of stormwater and domestic waste when the flow capacity of a sewer system is exceeded during rainstorms.

Computer Model: A model in which the mathematical operations are carried out on a computer.

Cost-Effective Solution: A solution to a problem that has been identified as being financially optional (e.g., the solution associated with the knee-of-the-curve of a cost-benefit relationship).

Detention: The slowing, dampening, or attenuating of flows either entering the sewer system or within the sewer system by temporarily holding the water on a surface area, in a storage basin, or within the sewer itself.

Flow Regulator: A passive, gravity device that regulates the flow of stormwater into a combined sewer. (*)

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 402, 318, and 405 of the Clean Water Act.

Nonpoint Source: Diffuse pollution sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by stormwater. Common nonpoint sources are agriculture, forestry, urban, mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Permit: An authorization, license, or equivalent control document issued by EPA or an approved state agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.

Pollutant: A contaminant in a concentration or amount that adversely alters the physical, chemical, or biological properties of the environment. The term includes pathogens, toxic metals, carcinogens, oxygen-demanding materials, and all other harmful substances. With reference to nonpoint sources, the term is sometimes used to apply to contaminants released in low concentrations from many activities that collectively degrade water quality. As defined in the federal Clean Water Act, pollutant means dredged spoil; solid waste; incinerator residue; sewage; garbage; sewage sludge; munitions; chemical wastes; biological materials; radioactive materials; heat; wrecked or discarded equipment; rock; sand; cellar dirt; and industrial, municipal, and agricultural waste discharged into water.

Pollution: Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical and radiological integrity of water.

Publicly Owned Treatment Works (POTW): Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature that is owned by a state or municipality. This definition includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW providing treatment.

Receiving Waters: Natural or man-made water systems into which materials are discharged.

Sewer: A channel or conduit that carries wastewater and stormwater runoff from the source to a treatment plant or receiving stream. "Sanitary" sewers carry household, industrial, and commercial waste. "Storm" sewers carry runoff from rain or snow. "Combined" sewers handle both.

Source Control: A method of abating storm-generated or CSO pollution at the upstream, upland source where the pollutants originate and/or accumulate.

Storm Sewer: A sewer that carries intercepted surface runoff, street wash and other wash waters, or drainage, but excludes domestic sewage and industrial wastes except for unauthorized cross-connections.

Stormwater: Stormwater runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not infiltrate into the ground or evaporate because of impervious land surfaces but instead flows onto adjacent land or watercourses or is routed into drain/sewer systems.

Street Storage. A system that mitigates surcharging of CSSs, SSSs and stormwater systems by temporarily storing stormwater in a controlled fashion on the surface (mainly on-street but some off-street) and, as needed, below streets. Stormwater is stored close to the source, that is, where it falls as precipitation, and prior to its entry into the sewer system. The full volume of stormwater runoff is accepted into the sewer system but peak rates are reduced, as a result of the storage, to flow that can be accommodated without surcharging. (*)

Surface Runoff: Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.

Surface Water: All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.

Watershed Protection Approach (WPA): The U.S. EPA's comprehensive approach to managing water resource areas, such as river basins, watersheds, and aquifers. WPA has four major features: targeting priority problems, stakeholder involvement, integrated solutions, and measuring success.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Wet-Weather Flow: Usually referred to as the flow in a combined sewer system with stormwater, but may also constitute the flow in a separate storm or sanitary drainage system with stormwater.

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