

Section 5

Storm Water Management System Analysis

5.1 Introduction

A computer analysis was conducted of the Primary Storm Water Management System (PSMS), in the City of New Berlin. The objectives of this analysis were to:

- evaluate the capacity and performance of major drainage structures,
- determine the extent of floodplain areas,
- assess the magnitude of future increases in flows and flood elevations due to likely future development areas, and
- identify existing and possible future capacity problems.

The results of the computer analysis were incorporated into the system-wide capacity analysis. The results of the analyses provided information for the identification of storm water quantity problems and development of both flood control and water quality solutions.

The system analysis consisted of the following tasks:

- Definition of the Primary Storm Water Management System
- Assembly of watershed surface runoff data
- Preparation of hydrologic model information
- Assembly of conveyance system data
- Formulation of the hydraulic model
- System analysis for existing and future land use

Procedures used to complete the analysis are presented in the following sections.

5.2 Definition of the Primary Storm Water Management System (PSMS)

The Primary Storm Water Management System (PSMS) is the system of channels and culverts designed to safely convey major storm flows to a downstream outfall.

Usually, the PSMS is defined as channels and watercourses draining at least 160 acres and, it is almost always designed to convey the 1 percent chance of exceedance flow rate. The one percent chance flow is also commonly called the 100-year storm event.

The PSMS in New Berlin is divided into seven independent subwatersheds. Three of the subwatersheds drain to the east toward Lake Michigan via Underwood Creek, the

Upper Root River, or Tess Corners Creek, while the remaining four subwatersheds drain to the Muskego Lake or the Fox River, which are part of the Mississippi River Basin. The Fox River tributaries are Deer Creek, Poplar Creek, Calhoun Creek, and Mill Creek.

The boundaries of these major subwatersheds are shown on Figure 1-1. The PSMS in each of these subwatersheds is identified within each watershed and is also shown in Figure 1-1. The extent of the PSMS was defined by tracing the major open channels back to their inceptions as shown on USGS topographic maps. If the drainage area exceeded 160 acres, the system was extended based on New Berlin 1/4 section maps. Data describing the PSMS in each major subwatershed is presented in Table 5-1.

Table 5-1: New Berlin Primary Storm Water Management System

Number	Subwatershed	Area (acres)	Channel Length (miles)	Number of Primary System Culverts
1	Underwood Creek	667	1.28	2
2	Upper Root River	4106	5.55	30
3	Deer Creek	2771	4.25	11
4	Calhoun Creek	4821	6.15	14
5	Tess Corners Creek	1707	0	0
6	Poplar Creek	8992	5.06	17
7	Mill Creek	2393	0	0

A listing of subwatershed parameters, including the anticipated runoff and runoff rate, is provided in Appendix D.

5.3 Hydrologic Model Development

The hydrologic computer model used to evaluate the New Berlin PSMS is the RUNOFF module of the USEPA Storm Water Management Model (SWMM). This model calculates the storm flow hydrograph for each subbasin based on a particular rainfall storm. Key model inputs include subbasin physical parameters such as area, percent impervious, land use, and soils, and the depth and distribution of the desired rainfall. A separate hydrologic model was created for each of the seven major subwatersheds. Models were formulated for both existing and future land use conditions. Verification of modeled flows was conducted based on previous experience with road overtopping and overbank flooding. Model flows were also checked for consistency with the published flood insurance study flows.

To develop the hydrologic model, each major subwatershed was delineated into a series of subbasins. As described in Section 4.3, subbasins were delineated in the

manner necessary to define flows at culvert crossings and major stream confluences and generally ranged in size from 10 to 900 acres. A total of 122 subbasins were delineated.

The hydrologic model requires physical parameters describing the runoff characteristics of each subbasin. The physical parameters and procedures to derive these parameters are:

- Subbasin Area: Delineated on 1"-100' scale Southeastern Wisconsin Regional Planning Commission (SEWRPC) topographic maps. The areas were determined using an electronic planimeter.
- Percent Impervious: Based on proportions assigned to standard land uses identified in Appendix D.
- Current Land Use: Proportion of standard land uses in each subbasin were estimated from aerial photos and compared to the City's land use plan.
- Future Land Use: Future development within each subbasin was determined by using the New Berlin Zoning Map.
- Flow Path Analysis: The length, roughness, and slope of the typical subwatershed overland flow paths are required to calculate the effective subbasin width. This characteristic width is used to compute the overland flow velocity which controls the travel time. The flow path data were measured in each subbasin from the SEWRPC 1"-100' scale maps. The average length and slope of two or three flow paths were used to characterize each subbasin.
- Soils: A map of hydrologic soils groups in New Berlin was developed from the Natural Resource Conservation Service publication *Soil Survey of Milwaukee and Waukesha Counties (1971)*.

5.4 Rainfall Input

Hydrologic analysis was conducted for rainfall event recurrence intervals of 2, 10, 25, and 100-years. Rainfall depths for these frequencies were obtained from data prepared by the Midwest Climate Center and published as Bulletin 71 of the Illinois State Water Survey (1992). Bulletin 71 is an interim source of rainfall information used to replace outdated information previously published by SEWRPC and the National Weather Service. SEWRPC is currently preparing revised design rainfall depths which are anticipated to be published in 1999.

The Bulletin 71 rainfall depth duration data is shown in Table 5-2. The rainfall must be distributed through time for use in the model. This was done according to rainfall distributions published in Bulletin 71. The structure of these distributions is shown in Appendix D.

Table 5-2: Bulletin 71 - Rainfall Depths in Inches

Recurrence Interval (years)	Storm Duration in Hours					
	1	2	3	6	12	24
2	1.27	1.57	1.73	2.03	2.35	2.70
5	1.57	1.93	2.13	2.50	2.90	3.33
10	1.81	2.24	2.47	2.89	3.36	3.86
25	2.19	2.70	2.98	3.49	4.05	4.66
50	2.53	3.12	3.44	4.03	4.68	5.38
100	2.93	3.62	3.99	4.68	5.43	6.24

The total amount of rainfall varies according to the specified storm duration. Longer storms have greater rainfall volume but less rainfall intensity. The New Berlin system was evaluated for several storm durations to determine the combination of duration and intensity that produces the greatest peak runoff rate. The analysis showed that the 3-hour storm produced the greatest peak flow in each subwatershed except for the South Branch of Underwood Creek. The 1-hour storm is the critical event in the South Branch of Underwood Creek subwatershed.

5.5 Conveyance System Data

The conveyance system consists of the stream channels and roadway crossing structures that provide for drainage of storm water flows. The hydraulic analysis required channel data includes, typical channel cross-sections, the Manning roughness coefficient, and the upstream and downstream flow line elevations. The channel data was taken from existing flood insurance study computer models of the stream reaches. Additional cross-sections were obtained from SEWRPC 1" = 100' scale topographic maps. The hydraulic analysis also requires data for culverts and bridges. The required culvert and bridge data include, the upstream and downstream invert elevations, the Manning roughness values, waterway opening dimensions, structure length, and the road overtopping elevation. The culvert data was obtained from the 1" = 100' scale drainage system maps prepared by Ruckert & Mielke.

5.6 Hydraulic Model Development

The EXTRAN module of SWMM was used to conduct hydraulic analysis of the New Berlin PSMS. The objective of the hydraulic analysis is to determine the depth of flow in the open channels that make up the primary system. The hydraulic analysis also evaluates the performance of roadway culverts in the primary system.

Five separate EXTRAN models were developed, one model for each of the five major subwatersheds within the New Berlin study area. There is no primary drainage

system in the Mill Creek or Tess Corners subwatersheds within New Berlin. The miles of channel and number of hydraulic structures represented in each model for each subwatershed is presented in Table 5-1.

5.7 Hydraulic Analysis Results

The hydraulic analysis models were run using the 2-, 10-, 25-, and 100-year recurrence interval storm event runoff flows as input. The models were run under both existing land use and future land use conditions. The results of the hydraulic analysis consist of the flow rate, velocity, and depth at each location considered in the hydraulic model. This information can be used to identify areas of high flood level, channel and culvert capacity shortfalls, and areas of high erosion potential. The complete results of the hydraulic analysis are provided in the Appendix D. Model results at the major culverts within the study area are shown in Table 5-3. Four of the modeled major system culverts have less than the 2-year recurrence interval storm event capacity. Road overtopping in the 25-year recurrence interval storm event or less was detected at 28 of the major culvert locations in the model including 12 locations where overtopping occurs in the 10-year recurrence interval storm event or less.

Differences between existing and future land use flows are shown in Table 5-4 for selected locations in each subwatershed. Flow increases are greatest in the Calhoun Creek, Deer Creek, and Poplar Creek subwatersheds, while flow increases are the smallest in the Underwood Creek and Upper Root River subwatersheds. The flow increases are typically due to future development within the subwatershed.

Table 5-4: Existing and Future Land Use Flows at Selected Locations

Location	Existing Land Use Flow (cfs)	Future Land Use Flow (cfs)	Percent Change (%)
Upper Root River at 124th Street	650	700	8
Deer Creek at Rogers Drive	1,250	1,522	22
Deer Creek at Moorland Road	534	579	8
Deer Creek at National Avenue	489	547	12
Calhoun Creek at City Limit	620	635	11
Calhoun Creek at upstream of Racine Drive	290	310	17
Calhoun Creek at upstream of Calhoun Road	300	320	22
Underwood Creek at Meadow Lane	380	400	6
Poplar Creek at Cleveland Avenue	114	136	19

5.8 Citywide Culvert Capacity Analysis

An extensive culvert capacity analysis was completed to estimate the capacity and level of service provided by all identified culverts in New Berlin greater than 18 inches in size. The nominal capacity of each culvert was calculated based on its size, shape, construction material, and slope. Culverts were assumed to have sufficient headwater to cause them to flow full, and assumed to be unobstructed. Each was evaluated for inlet control and barrel control and the limiting flow condition was taken as the capacity. An entrance loss coefficient of between 0.1 and 0.5 was used to represent entrance conditions. Additional information regarding the capacity analysis calculations is presented in Exhibit C-4 in Appendix D.

Design flows corresponding to the 10-year and 100-year storms were estimated at each culvert location. These flows were determined by delineating the area tributary to each culvert and multiplying the area by unit flows obtained from the SWMM model results.

The capacity analysis results are presented in Appendix D. The level of service provided by each culvert has been determined by comparing the design flows to the nominal capacity. Culverts in the minor storm water management system should provide at least 10-year capacity. Culverts included in the primary storm water management system should provide at least the 100-year level of protection for capacity and road overtopping. The analysis results indicate that 115 of the analyzed culverts do not meet these criteria. Of the 115 undersized culverts, 32 are primary system culverts and 83 are secondary system culverts. A program to address these deficiencies is presented in Section 8 of this plan.

Table 5-3: Flow Capacity and Overtopping Results at Primary System Culverts

Street Name	Subwatershed	Culvert ID	Culvert Description	Capacity (cfs)	Future Conditon Flow (cfs)				Level of Protection		
					2yr	10yr	25yr	100yr	Flow Capacity	Road Overtopping*	
124th Street	Root	24.04.08/09	38" x 54" Arch	180	251	318	434	695	<2 year	2 year	
124th Street		13.02.06/07/08	72" x 100" & 2@ 48"	654	228	417	453	693	<100 year	100 year	
Lagoon Road		12.01.06/07	2 @ 67" x 95" Arch	750	228	360	452	698	100 year	100 year	
Cleveland Avenue		12.01.08	97" x 128" Arch	1069	216	336	418	631	100 year	100 year	
128th Street		12.01.03/12.04.06	2 @ 60" CMP	422	130	220	280	434	<100 year	100 year	
130th Street		12.04.01/02	2 @ 60" RCP	422	124	206	262	408	100 year	100 year	
132nd Street		12.03.16/17	2 @ 48" CMP	242	130	210	262	413	<25 year	25 year	
133rd Street		12.03.13/14	2 @ 48" RCP	242	130	214	266	414	<25 year	25 year	
Dakota Street		12.03.11/12	2 @ 48" RCP	242	42	90	141	204	100 year	100 year	
Sunny Slope Road		11.04.22	60" RCP	211	27	48	76	132	100 year	100 year	
Dakota Street		12.03.08	15" x 30" ACMP	14	24	34	45	68	<2 year	100 year	
128th Street South		12.04.05	48" RCP	121	83	110	127	164	<25 year	25 year	
130th Street		12.04.01	48" RCP	121	93	132	195	266	<10 year	25 year	
National Avenue		12.04.03	48" RCP	211	118	157	217	338	<25 year	2 year	
124th Street		12.04.07	47" x 71" Arch	187	87	121	160	287	<100 year	25 year	
124th Street		24.04.17	69" x 72" Box	308	28	50	78	142	100 year	100 year	
Weatherstone Boulevard		24.01.12/13	38" x 57" & 43" x 64" Arches	253	15	25	40	73	100 year	100 year	
South Carnaby Lane		24.01.18/19	38" x 57" & 43" x 64" Arches	253	15	25	39	73	100 year	100 year	
Victoria Circle		24.01.14/15	38" x 57" & 43" x 64" Arches	281	6	10	15	28	100 year	100 year	
Coldspring Road		24.01.16	24" CMP	21	9	13	17	29	<100 year	100 year	
St. Mary's Drive		36.01.06/07	2 @ 11'x3' Box	416	106	180	236	338	100 year	25 year	
Grange Avenue		25.04.05	48" CMP	287	106	174	230	362	< 100 year	100 year	
Marquette Drive		25.04.14/15/16	3 @ 38" x 57" Arch	327	87	132	170	274	100 year	100 year	
Balboa Drive		25.04.08/09	2 @ 38" x 57" Arch	118	82	118	154	251	< 25 year	25 year	
Cherrytree Lane		25.01.19/20	2 @ 38" x 57" Arch	218	84	118	156	277	<100 year	25 year	
Radisson Court		25.01.12/13	2 @ 38" x 57" Arch	210	94	138	170	275	<100 year	25 year	
Marin Way		25.01.37/38	2 @43" x 68" Elliptical	286	76	118	144	202	100 year	100 year	
Beloit Road		25.01.33/34	2 @ 7'x3' Box	327	48	72	90	125	100 year	100 year	
Rock Freeway (I-43)		25.02.19	5'x5' Box	211	51	79	101	148	100 year	100 year	
Frances Street		36.01.05	35" x 24" Arch	36	15	27	31	87	< 100 year	10 year	
Rock Freeway (I-43)	Calhoun	34.02.09/10	2 @ 30" RCP	74	2	6	7	8	100 year	100 year	
Racine Place		32.04.17	5' x 8' Box	357	161	258	344	457	<100 year	100 year	
College Avenue		32.04.06/07	2 @ 60" RCP	422	103	178	242	324	100 year	100 year	
Racine Drive		105.02.04	72" CMP	333	100	175	236	311	100 year	100 year	
Tans Drive		105.02.01	48" RCP	333	116	187	269	467	<100 year	2 year	
Rock Freeway (I-43)		33.03.08	10'x7' Box	593	131	211	271	404	100 year	100 year	
Rock Freeway (I-43)		33.03.07	18'x8' Box	1762	141	293	440	766	100 year	100 year	
Beres Road		28.04.15/14/13	2 @ 60" CMP	444	148	297	461	825	<25 year	<2 year	
Calhoun Road		27.01.01/02	2 @ 48" x 60" Arch	284	184	274	426	729	<25 year	2 year	
Rock Freeway (I-43)		27.04.06/07	2 @ 48" RCP	224	153	254	336	488	<10 year	25 year	
Rock Freeway (I-43)		26.02.16	42" RCP	87	15	35	62	122	<100 year	100 year	
Rock Freeway (I-43)		26.02.09/10	6'x10' Box	500	61	94	125	188	100 year	100 year	
Martin Road		33.03.05/02.05	2 @ 36" CMP	118	59	90	120	197	<25 year	10 year	
Beloit Road		26.02.07	52" CMP	137	26	36	65	168	<100 year	25 year	
Greenfield Avenue		Deer	03.01.16	6'x10' Box	1069	587	885	1060	1341	<100 year	100 year
C & NW Railroad			03.01.11/12	2 @ 84" CMP	980	562	840	1006	1250	<25 year	100 year
Rogers Drive	03.04.06		5.2'x20' Box	1342	484	741	884	1120	100 year	2 year	
Lincoln Avenue	03.04.05		5.2'x10' Box	527	397	617	744	1100	<10 year	10 year	
Glendale Drive	10.01.01/06		5.8'x12' Box	1320	586	960	1178	1610	<100 year	100 year	
Cleveland Avenue	10.03.01/02/03		3 @ 72" CMP	999	750	1242	1530	2016	<10 year	100 year	
James Drive	10.04.02/03/04		3 @ 5'x10' Concrete Box	1128	600	1008	1269	1737	<25 year	100 year	
Moorland Road	10.04.15/16		2 @ 8'x9' Box	1544	394	668	842	1158	100 year	100 year	
West San Mateo Drive	14.02.05		8'x16' Box	1690	185	314	397	548	100 year	100 year	
National Avenue	14.02.06		10'x10' Box and 63" x 98" Elliptical	366	185	313	398	547	<25 year	100 year	
162nd Street	10.01.06		5' RCP	660	45	73	95	134	100 year	100 year	
Cleveland Avenue	Poplar	09.04.01/02	2 @ 54" RCP	324	230	368	422	502	<10 year	100 year	
Calhoun Road		16.01.08/09/10	3 @ 60" RCP	633	221	363	456	597	100 year	100 year	
Calhoun Road		16.01.11/12/13	3 @ 80" CONC , 2 @ 5' RCP	1302	243	408	612	1191	100 year	100 year	
Coffee Road		16.01.01/02/03	3 @ 66" RCP	804	234	396	630	1179	<100 year	100 year	
Observatory Road		21.01.01	36" x 72" Arch	105	157	239	302	357	<2 year	100 year	
Observatory Road		21.01.03	72" x 102" Arch	453	123	193	318	556	<100 year	25 year	
Cleveland Avenue		08.03.09/10	2 @ 42"	108	94	111	119	136	<10 year	< 2 year	
Cleveland Avenue		09.03.01/02	30" & 60" CMP	246	46	72	95	184	100 year	100 year	
Willow Road		16.02.04	24" x 35" Arch	33	33	40	45	53	2 year	< 2 year	
166th Street		15.02.01/02/03	3 @ 45" x 66" Box	444	39	61	78	113	100 year	100 year	
Victor Road		15.02.06/07	3 @ 36" x 58" Arch	315	99	163	207	287	100 year	25 year	
Ryerson Drive		10.03.06/07	2 @38" x 57" Arch	220	63	104	136	208	100 year	100year	
C & NW Railroad		04.01.18	48" RCP	121	22	58	84	116	100 year	100 year	
Gravel Road		05.03.09	21" RCP	15	6	8	14	27	<100 year	25 year	
Lincoln Avenue		06.04.05	18" x 24" Arch	14	6	9	25	29	<25 year	10 year	
Cleveland Avenue		07.02.01	63" x 87" Arch	369	15	50	82	150	100 year	100 year	
Arcadian Drive		Underwood	01.02.10	47" x 71" Arch	177	127	174	206	272	<25 year	50 year
Elm Grove Road	01.01.12		47" x 71" Arch	138	136	200	245	337	<10 year	2 year	

* Road overtopping can occur even though the flow capacity is not exceeded when there is backwater from downstream.